McKinsey&Company

The Digital Utility:

New challenges, capabilities, and opportunities

June 2018

McKinsey's *Digital Utility Compendium* is written by experts and practitioners in the Digital Utility service line, McKinsey & Company's Electric Power & Natural Gas practice.

To send comments or request copies, email us: McKinsey_on_Digital_Utility@mckinsey.com

Art Direction and Design:
Leff Communications

Cover Illustration:
Wenjie Dong/Getty Images

The Digital Utility:

New challenges, capabilities, and opportunities

June 2018

Table of contents

Foreword

In 2010, the largest five companies in the world were Exxon, Apple, PetroChina, Shell, and ICBC. Today, it is Apple, Google, Microsoft, Amazon, and Facebook. There is no doubt that digital is fundamentally changing the world and reshaping how companies and society operate.

Every sector is affected—but some faster than others. Many utilities are initiating their journey, while others have accelerated, launching a myriad of agile or digital factories, attracting new profiles, and building in-house applications to tap into the potential of automation, analytics, and mobile to transform their core business processes.

In this compendium, we draw on the experience of these companies. In a series of articles, we discuss the opportunities and obstacles to digital transformation typically faced by utilities, and ways to overcome them. And they explain why digital transformations must trigger true cultural change, if their benefits are to be captured and sustained over the long run.

The first set of articles look at the context of the digital utility, the value at stake if you get it right, illuminating what a transformation at scale really looks like, explaining the traits of a successful transformation and walking you through the common steps of a such journey.

In the second set of articles, we highlight the important ingredients for such a transformation. Put simply, we explore analytics, the importance of modernizing IT architecture, the value of customer experience for regulated utilities, and we look at Blockchain—one of the “next horizon” technologies—and describe its impact on the sector.

In the final set of articles, we take a deeper look at some foundational capabilities that are needed to enable the digital transformation, such as cloud computing and design thinking. Both were foreign concepts for most utilities just a few years ago, and yet today this is changing at a rapid pace.

Digital has helped many companies generate greater efficiencies across their operational business units, significantly improve customer experience, and accelerate innovation to allow companies to stay ahead of the competition in rapidly changing markets. We believe the time is ripe for utilities to reap the benefits of this approach with a clearer understanding of the challenges that await and their solutions.

We hope that you find this compendium insightful and helpful in accelerating the use of digital across our sector. Should you have comments or questions, or if you would like to visit a company that has is using digital innovations at scale, please contact us at McKinsey_on_Digital_Utility@mckinsey.com.

Adrian Booth
Senior Partner
San Francisco office
Adrian_Booth@mckinsey.com

Eelco de Jong
Partner
Charlotte office
Eelco_de_Jong@mckinsey.com

Peter Peters
Partner
Düsseldorf office
Peter_Peters@mckinsey.com

Accelerating digital transformations: A playbook for utilities

Utilities trying to reinvent themselves as digital enterprises have found it hard to scale up from digital pilots. Adopting digital ways of working, adding talent, and modernizing IT will hasten transformation.

Adrian Booth, Eelco de Jong, and Peter Peters

For utility companies, transforming operations and systems with digital technologies can create substantial value: a reduction in operating expenses of up to 25 percent, which can translate into lower revenue requirements or higher profits. Performance gains of 20 to 40 percent in such areas as safety, reliability, customer satisfaction, and regulatory compliance are also achievable. These prospects have led utilities to launch all sorts of efforts to use digital technologies: reimagining customer journeys, adding digital leak detectors to gas grids, using predictive models to schedule maintenance and other asset-management activities, and equipping field workers with mobile devices that let them access technical instructions while in the field, to name a few (see sidebar, "Digital opportunities in the utility sector").[1]

Many utilities initiate these efforts with larger ambitions, like establishing a new way of operating based on agile management methods and other practices, and incorporating digital technologies across the enterprise, including interactions with customers, employees, suppliers, regulators, and partners.[2] Yet few of the digital pilot projects we've seen at utilities have created momentum for comprehensive digital transformations. Research by the McKinsey Global Institute bears this out: a study of US companies showed that utilities have achieved only a moderate level of digitization—well below that of other industries. Significant potential to digitize the assets of utilities further and to deepen their digital engagement with customers remains.[3]

That's understandable. In our experience working with utilities and speaking with their executives, we have learned that three issues appear to inhibit their digital transformation. First, the working methods of the typical utility company are built around safeguarding large, long-lived assets and minimizing operational risks. Because of this mind-set, utilities are typically cautious about embracing digital ways of working that involve constant experimentation and could have unintended consequences. Second, the popular perception of utilities as analog-era companies makes it hard for them to attract people to fill digital-economy roles, such as data scientists. Third, utilities typically have complex legacy operations and IT environments that inhibit rapid innovation.

None of these conditions is easy to remove, but some utilities are showing that this can be done. Here, we offer a closer look at the issues, along with insights into how leading companies have resolved them (exhibit).

Adopting digital ways of working

The conventional wisdom in the sector is that utilities need to be stable, reliable, and secure above all. We agree that these are important virtues. However, utilities face fresh competitive threats and heightened customer expectations because advances in digital technology have enabled companies in all sectors to operate in a more agile, innovative manner. Digital-native and digitally transformed businesses take risks with their innovations because fast-moving processes and flexible systems let them correct mistakes before serious harm occurs. These companies use design thinking to understand customer needs, conceive suitable products and services quickly, launch them as soon as they are viable, and make improvements in short cycles of testing and collecting feedback.

To thrive in the digital economy, utilities need to increase their agility—their capacity for sensing challenges and opportunities and for quickly mobilizing the organization in response. Agility need not destabilize a utility's assets or operations. Indeed, greater agility can actually make assets safer and more reliable by enabling utilities to anticipate, detect, and resolve problems faster than they can today. Making that happen, though,

Exhibit

Utilities can accelerate digital transformation by focusing on changes in three main areas.

Focus area	**Adopting digital ways of working**	**Attracting and retaining digital talent**	**Modernizing the IT architecture and environment**
Key tasks	• Gain the support of senior leaders so a digital transformation has high priority • Build a digital factory to produce new applications and insights using digital-native methods	• Highlight the intellectual challenge and social value of the utility's work • Tap into a broad pool of digital specialists who value the balance and stability that a utility offers	• Simplify the utility's product portfolio and business processes • Shift from all-in-one, monolithic IT systems to modular IT architectures

Source: McKinsey analysis

requires support from senior leaders and, ultimately, from the entire company.

Getting senior leaders on board

One challenge for many utilities will be persuading senior leaders, many of whom have spent almost all of their careers in the sector's more predictable former environment, to adopt digital ways of working. Another challenge is prioritizing a digital transformation over other important endeavors. Digital opportunities are evolving quickly: McKinsey research suggests that digital first movers and fast followers capture more value within their industries than slower-moving companies. In our experience, utilities that take the lead on digital technologies generally got a fast start after concluding that the potential downside of investing too little was greater than the downside of investing significantly and gaining little in return.

Executives who are unsure about the need to digitize would do well to spend time at digital-native companies and digitally transformed incumbents—not just in the utility sector but in others as well. Seeing digital technologies and ways of working, and hearing firsthand about digital transformations, can assuage the concerns of utility executives that digitization will throw off their companies' fine-tuned processes and systems. And learning from fellow executives about the pressure they face from digital competitors should remove any doubts about whether utilities ought to go digital.

Even in the best situations, with executives who fully support the digital-transformation agenda, it can take years for an entire utility—with thousands of employees, a vast asset base, and extensive regulatory requirements—to embrace the methods of digital-native businesses. One utility executive we know lamented that it took his company several years just to establish an in-house digital start-up. So how can a utility start to transform its working style?

Building a digital factory

Some utilities have acquired or partnered with smaller digital businesses to develop new products and services. Several large European utilities have opened Silicon Valley offices that participate in the start-up scene and invest in relevant digital enterprises. Such arrangements do help utility companies to augment their capabilities, but we have rarely seen them exert much influence on the utilities' own ways of working.

A more effective approach is to set up an in-house digital factory devoted to producing digital applications and advanced analytic insights by using the latest technologies and ways of working, such as agile and DevOps. While such a digital factory can be modest in size at the outset—20 to 50 people—it should have a strong, well-positioned leader who can marshal resources and ensure its direct visibility to the CEO and executive team. The factory's staff should include business leaders who can act as product owners, along with designers and a range of technical specialists, including software architects, scrum masters, data scientists, and developers. Some can be internal transfers, while others will need to be new hires or outside contractors (as we discuss in the following section).

Within the company, a digital factory can occupy any number of positions—at the corporate level, within a business unit, inside the IT department, or adjacent to it. Some utilities might choose to set up more than one digital factory, each serving a different part of the company. To help a digital factory forge a distinct identity, it can be physically located in a space that reflects its ways of working, away from the utility's main office.

The offsite location of a digital factory speaks to a critical feature: it needs to be as autonomous and self-contained as possible so it can operate at a faster speed. Achieving a high level of autonomy might mean liberating a digital factory from dependencies on some enterprise-level processes, like hiring, planning, and budgeting. (In this respect, too, a strong digital-factory leader can help a great deal by taking responsibility for decisions that would otherwise be made in other parts of the company.) Most digital factories will conduct those activities on their own—for instance, by using recruiters who specialize in hiring for digital roles. In other cases, a utility might need to establish separate processes, like quarterly planning-and-budgeting cycles and performance reviews that let executives track the contributions of digital factories more closely.

The exceptions that a utility makes to accommodate a digital factory should come with the expectation that it will have a transformative impact. Leading utilities hold their digital factories accountable for staggering performance gains, like reducing inbound-call volumes by 30 percent within a year or reducing maintenance costs by $50 million within 18 months. When utilities call for big changes, their digital factories think big and discover more opportunities as their efforts progress. One utility began by digitizing a paper-based compliance process and ended up identifying a much greater opportunity to improve overall asset utilization.

Attracting and retaining digital talent

As a digital factory proves that it can successfully deliver new products, it should continue to add staff and tackle more assignments, with the aim of working on all the value pools the utility wishes to address. Tripling the group's headcount within a year (or adding more factories) while gradually replacing external contractors with internally trained or newly hired colleagues is the norm rather than the exception because most utilities have a major digital-talent gap to close. For a full digital transformation, many utilities will need to hire hundreds of product owners, experience designers, front-end/full-stack developers, DevOps engineers, analytics and machine-learning engineers, and other digital specialists—few of whom work at utilities today.

This type of scale-up requires utilities to enter the competitive market for digital talent with a sense of

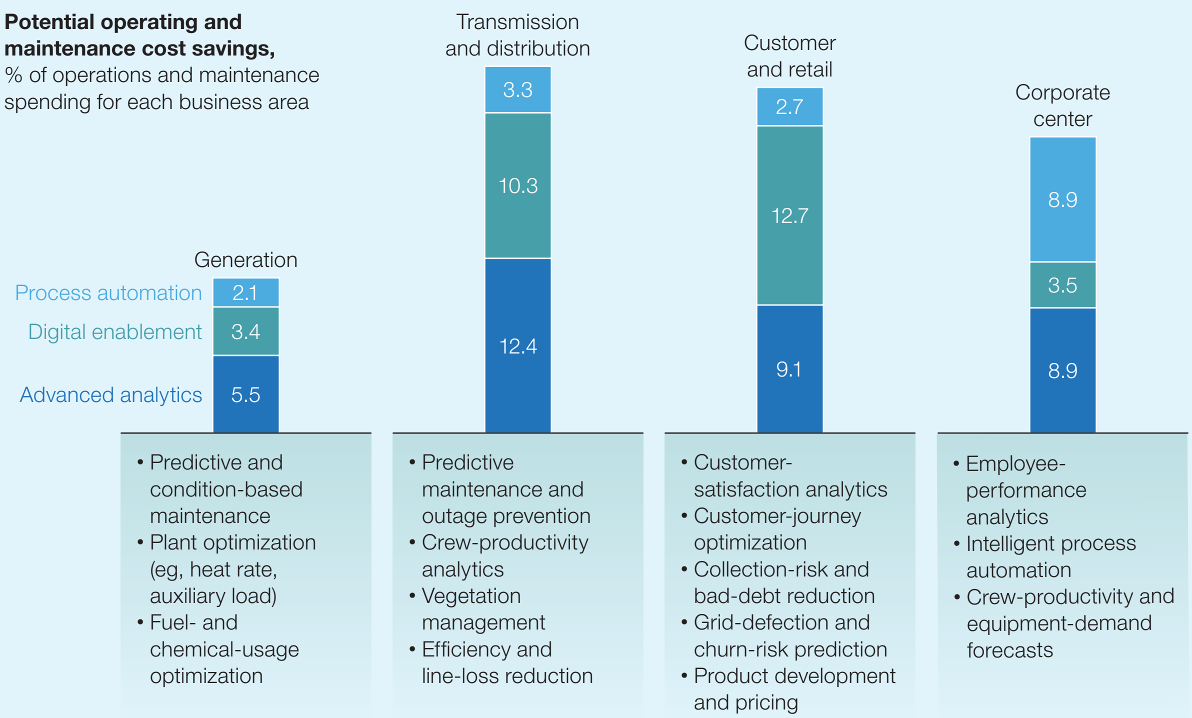
Digital opportunities in the utility sector

Digital-transformation programs in the utility sector must meet requirements that don't always apply to others. A significant proportion of utility assets and operations have zero tolerance for safety and performance deviations beyond a specific range. Plant-control and grid-management systems, for example, need to be risk proof and predictable. For these reasons, utilities should pay special attention to safety and performance expectations when they digitize, particularly in their high-sensitivity business functions. With those expectations in mind, utilities can benefit greatly from implementing digital technologies and adopting digital ways of working all along their value chains (exhibit).

Opportunities will vary for different types of utilities; for example, fully integrated ones in regulated markets tend to seek operational-expense savings, as well as higher productivity and network reliability. Many utility operations, such as asset management, can be streamlined through automation. Utility executives and managers can make better decisions when they get insights from artificial-intelligence (AI) applications that

Exhibit

Digitization can create value across the utility value chain.



Source: McKinsey analysis

crunch large data sets. Safety and regulatory-compliance programs can be reinforced with advanced systems for directing employees and collecting their observations.

Additional opportunities can be found in customer operations. Digital-native companies and digitally transformed incumbents outside the utility sector have taught their residential and commercial customers to expect more seamless, flexible, and personalized customer service. Utilities that fall short of those expectations stand to lose business—which is already happening in Europe, where deregulation has pushed customer-churn rates as high as 25 percent. And digital-native companies have begun to disrupt the utility sector by offering lower-cost, higher-value services, as they have in the telecom and cable industries.

To counter these pressures, some utilities are replicating the sophisticated customer-service practices of digital-native companies. The most ambitious are looking at how to use virtual agents, AI, and "one-click" mobile experiences to help customers resolve their concerns quickly and easily.

urgency, especially because they are seldom seen as innovative, cutting-edge businesses. We've seen several tactics help utilities vie successfully for digital hires. One is to play up the intellectual challenge and reward of the utility's digital agenda. Utilities can appeal to the hearts of digital specialists, as well, in ways that many other enterprises can't. For one thing, they can highlight their socially valuable mission of providing a community with reliable energy. They can also show that their digital jobs have more meaning for the people who hold them than jobs at a lot of other companies.

For instance, one European utility presents its approach to digital technology as an important part of its efforts to lower its environmental impact—and it has success stories and a generation portfolio to back up its claims. Another utility, PG&E, set up a digital center of excellence, which it called Digital Catalyst. This group, for example, sent digital specialists to shadow electricity and gas field workers for hundreds of hours to uncover ways of aiding their work. That method, based on design thinking, led the Digital Catalyst team to create a mobile app to help field crews complete asset inspections more efficiently and safely by furnishing them with real-time information. The solution was so innovative that the company won a cross-industry award from *InformationWeek*.[4] Showcasing achievements like these can demonstrate to prospective digital hires that utilities provide genuine opportunities to improve the lives of customers and colleagues.

Another digital-recruiting tactic that utilities have used successfully is to go after a broad, diverse pool of digital professionals. While there's some truth to the stereotype of the young, single-minded software developer who thrives on energy drinks, 16-hour workdays, and a high-pressure start-up environment, that stereotype tends to limit the imagination of incumbent-company recruiters seeking digital talent. Plenty of digital specialists value a reasonable work–life balance and the stability of a large, established company. Utilities can typically provide both. PG&E's Digital Catalyst, for example, has a mission to deploy innovative digital solutions "for our people, by our people," in the words of CIO Karen Austin.[5] That has required PG&E to hire digital specialists in California's San Francisco Bay Area, perhaps the world's hottest market for digital talent. Utilities with headquarters outside pricey metropolitan areas, where many digital-native companies are based, can also offer prospective hires the chance to live in places where their salaries go further than they might in high-cost cities.

Finally, some utilities have chosen to form partnerships with nearby universities as a way of sourcing digital talent as well as fresh ideas. To attract graduates in digital fields, one European utility has taken practical measures such as sponsoring sector-relevant courses and research, providing students with internships, and allowing managers to take sabbaticals from their utility jobs to teach.

Modernizing the IT architecture and environment

Most utilities have managed their IT architectures and environments much as they have their physical assets. Utilities were early adopters of large-scale software packages such as customer-information systems, distribution-management systems, asset-management systems, and outage-management systems. They invested in solutions that offer maximum stability and performance and then customized them as their requirements outgrew the systems' standard features.

Many of those large-scale software systems have now been in place for decades. Some utilities are running several systems of the same type side by side, after merging with or acquiring companies that had their own legacy systems. As a result, the IT architectures of utilities have become steadily bigger, more cumbersome, and harder to maintain, with millions of lines of custom code written in obsolescent programming languages, such as COBOL, by developers who have long since retired or moved on to other jobs.

This state of affairs severely limits the ability of utilities to adopt the modern technologies and flexible IT-management practices of digital businesses. Digital-native companies base their decisions on real-time data from many sources. They deploy new software functions every few weeks and make updates even more frequently, sometimes daily. Their processes are easy to reconfigure when they identify new customer or employee needs. Complex, monolithic IT systems are poorly suited to these operational demands, but replacing such systems can take five years or more and cost hundreds of millions of dollars. Instead, utilities should modernize their IT architectures and environments progressively.

A necessary first step is to simplify the utility's product portfolio and business processes. Many utilities have seen their offerings, and the corresponding operational requirements, proliferate in response to changing customer needs and regulations. One European utility's portfolio comprises thousands of products and services, ranging from traditional energy products with different rate structures to new offerings for energy efficiency and distributed generation. Each product or service puts unique demands on the

One challenge for many utilities will be persuading senior leaders, many of whom have spent almost all of their careers in the sector's more predictable former environment, to adopt digital ways of working.

utility's IT architecture. After the company decided to allow only offerings that can be supported by one of four variants of standard back-office processes, it reduced its portfolio to 150 offerings that still met 95 percent of its customers' needs. By reducing the number of functions software must undertake, winnowing down a bloated portfolio obviously makes it easier for a utility to modernize its IT architecture. Simplifying lineups of offerings also allows utilities to streamline their operations, which shrinks their demand for new technology solutions.

A core tenet of efforts to modernize IT is the need to shift from all-in-one, monolithic systems to a modular IT architecture. In such an architecture, currently used or off-the-shelf software packages provide a stable backbone for business functions with standardized requirements, such as billing, customer-relationship management, or work and asset management. Companies should select standard software packages that meet their essential needs rather than opting for best-of-breed solutions that cost extra and have superfluous features.

With a stable backbone in place, utilities can develop custom applications for functions such as customer service, product development, analytics, or mobile-enabled field operations, where unique capabilities can provide competitive advantages that software from outside vendors often lacks. This way, companies can benefit from the economy and reliability of standard software packages, as well as the sophisticated, leading-edge features that add a great deal of value.

Economy and rich features aren't the only advantages of modular IT architectures. Ease of managing the entire IT environment is another. A modular architecture helps a utility's IT department deliver more services more quickly because smaller teams can focus on specific software packages or end-to-end processes, without having to master huge systems. It also allows a utility to draw on a diverse ecosystem of partners: traditional vendors offering standard applications, start-ups and crowd-sourcing forums that help develop homegrown applications, and system integrators to make all the pieces work together.

How utilities can jump-start their digital transformations

According to McKinsey research, the opportunity for incumbents to get ahead of the pack on digitization can be narrow: by the time industries near the 40 percent digitization mark, digital leaders have already secured large market shares. For utilities, these dynamics make it imperative to get digital transformation under way as soon as possible. Three steps can help utilities set a fast pace.

Build an executive-led digital mind-set

When utility executives adopt digitally savvy behavior, that has a constructive influence on the rest of the organization. Some utility executives we know hold regular meetings with technology executives, venture capitalists, and entrepreneurs so they can keep up with developments in the digital economy and collect ideas to share with their teams. Other key moves are to put a single executive, with a direct reporting line to the CEO, in charge of technology and to encourage the board to devote some of its agenda to technology and the strategic implications of digitization.

Start small, but with big ambitions in mind

Since a digital transformation should ultimately cover the entire organization, utility executives sometimes find it hard to decide where to begin. In our experience, it helps to identify a single business domain (such as customer experience, asset operations, or the execution of large projects) where a digital transformation could provide ample value and to begin the transformation there. The choice of domain should thus determine where the digital unit is placed in the organization and what it does first. Most utilities have 15 to 20 customer journeys and business processes that will be strong candidates for digital transformation, including maximizing the efficiency of plants, conducting predictive maintenance, assisting field crews, and onboarding customers. Within the starting domain, utilities should prioritize one or two high-value, highly feasible digital applications and gradually move toward the end-to-end transformation of journeys and business processes.

Ideally, the initial digitization effort will generate enough cost savings to offset any necessary spending in the first year. Subsequent cost savings can be reinvested in later waves of digitization. In addition, the initial effort should produce other impressive outcomes, such as enthusiastic employee feedback, higher customer satisfaction, or notable performance gains. (These early successes can also help convince naysayers that the digital transformation is worth the effort and doesn't compromise safety, reliability, or the customer experience.) Once the transformation of the initial domain is well under way, executives can lay out a long-term road map for transforming other business domains and for building the capabilities to do so.

Make anchor hires to attract digital talent

Digital specialists want to work with and learn from people who have a track record of leading teams that envision, develop, and deliver innovative solutions to major business problems. When a utility hires high-caliber digital leaders, this sends a signal to prospective employees that the company recognizes the value of digital technology and appreciates the need for quality people. Anchor hires can also provide digital recruits with compelling reasons to come and work on the utility's digital transformation. The senior head of design at one utility, for example, has helped attract new hires by sharing the story of how her team developed a mobile app that made it easier for thousands of line workers to do their jobs well.

■ ■ ■

Even in the most optimistic scenario, it takes years to transform a utility so that it can take full advantage of digital technologies and methods. We believe the ultimate outcome is worthwhile: an organization that can deliver greater value in the near term, as well as the infrastructure to identify and pursue growth opportunities while adapting to economic and regulatory developments in the long term. To achieve that end state, a utility first needs to adopt digital ways of working, build up its digital workforce, and modernize its IT environment. Companies that can make these enabling changes quickly will stand a better chance of securing market share against digital attackers and transformed incumbents. ■

---

[1] For more, see Adrian Booth, Niko Mohr, and Peter Peters, "The digital utility: New opportunities and challenges," May 2016, McKinsey.com.

[2] For more on digital transformation, see Peter Dahlström, Driek Desmet, and Marc Singer, "The seven decisions that matter in a digital transformation: A CEO's guide to reinvention," February 2017, McKinsey.com, as well as "ING's agile transformation," *McKinsey Quarterly*, January 2017, McKinsey.com.

[3] For more, see James Manyika, Sree Ramaswamy, Somesh Khanna, Hugo Sarrazin, Gary Pinkus, Guru Sethupathy, and Andrew Yaffe, "Digital America: A tale of the haves and have-mores," McKinsey Global Institute, December 2015, McKinsey.com.

[4] Sara Castellanos, "How PG&E's CIO sped up mobile app deployment," *Wall Street Journal*, April 11, 2017, wsj.com, and "Innovative app for PG&E field crews earns *InformationWeek* IT Excellence Award," PG&E, May 22, 2017, pge.com.

[5] "Innovative app for PG&E field crews earns *InformationWeek* IT Excellence Award," PG&E, May 22, 2017, pge.com.

Adrian Booth is a senior partner in McKinsey's San Francisco office, **Eelco de Jong** is a partner in the Charlotte office, and **Peter Peters** is a partner in the Düsseldorf office.

Fueling utility innovation through analytics

Utilities around the world are making big investments in advanced analytics. Getting the full value, however, requires rethinking their strategy, culture, and organization.

Marcus Braun, Eelco de Jong, Alfonso Encinas, and Tim Kniker

Advanced analytics (AA) can deliver enormous value for utilities and drive organizations to new frontiers of efficiency—but only with the right approach. There's little to be gained from just bolting on a software solution. The real value comes from embedding data analytics as a core capability in the organization and using it to detect pain points, design solutions, and enable decision making. Conservative estimates supported by rigorous use-case analysis suggest that AA can boost profitability by 5 to 10 percent, while increasing satisfaction for customers and improving health and safety for employees. But capturing impact on this scale is no easy feat, and utilities often struggle with the same few challenges, which undermines the success of an analytics transformation. Below, we look at these challenges and show how they can be overcome.

Challenge 1: Developing an analytics strategy that's clear about what to prioritize and why

As new applications proliferate across the energy value chain (see sidebar, "Applying advanced analytics at utilities"), advanced analytics poses a strategic challenge. How do utilities prioritize use cases and set appropriate aspirations for business impact? Without clarity on these matters, companies can easily lay themselves open to excessive influence from external vendors or get caught up in chasing the latest viral use case. One US utility partnered with a technology supplier and invested millions in wind-forecasting software only to discover that the effort wouldn't yield any returns. Another large utility spent years building in-house analytics capabilities and developing more than a dozen use cases before realizing it had yet to make any headway on the biggest and most valuable opportunities.

We advise analytics leaders to work through four steps to establish their business priorities:

Develop a comprehensive inventory of use cases spanning the whole value chain, including operations and support processes. Utilities often focus on customer or operational applications first, but smart companies place equal emphasis on support functions such as human resources, procurement, safety, and internal audit—all of which can drive just as much bottom-line value.

Structure your use-case inventory into groups of applications that resolve similar pain points or address the same business processes. Applications focused on areas such as asset maintenance, contractor productivity, employee safety, or reporting are likely to span multiple business units and deliver value across the entire enterprise, rather than within a single silo.

Using simple valuation methods, quickly estimate the potential business impact for each application across all applicable dimensions, including cost, revenue, safety, reliability, and employee engagement. This requires close collaboration between business owners, analytics specialists, and the financial planning and analysis team to ensure consistency in quantification and overall approach.

Prioritize the applications using multiple criteria, including value, feasibility, alignment with corporate strategy, and business engagement. How much weight to give each factor depends on the stage a utility has reached in its AA journey. When it is starting out, business excitement and engagement are critical to achieving buy-in. At later stages, value and feasibility become more important. By the end of the journey, analytics is so critical that priorities are dictated by overall corporate strategy.

Working through these steps need not take long. One utility took just a few weeks to develop a list of nearly 200 use cases, prioritize them based on feasibility and business impact, and select a handful of products to start building immediately. In mature digital organizations, the list of potential applications can be integrated into product strategies and constantly

Applying advanced analytics at utilities

The energy industry has already developed hundreds of uses for advanced analytics, and use cases will continue to proliferate as data availability, computing power, and analytical techniques improve (see exhibit).

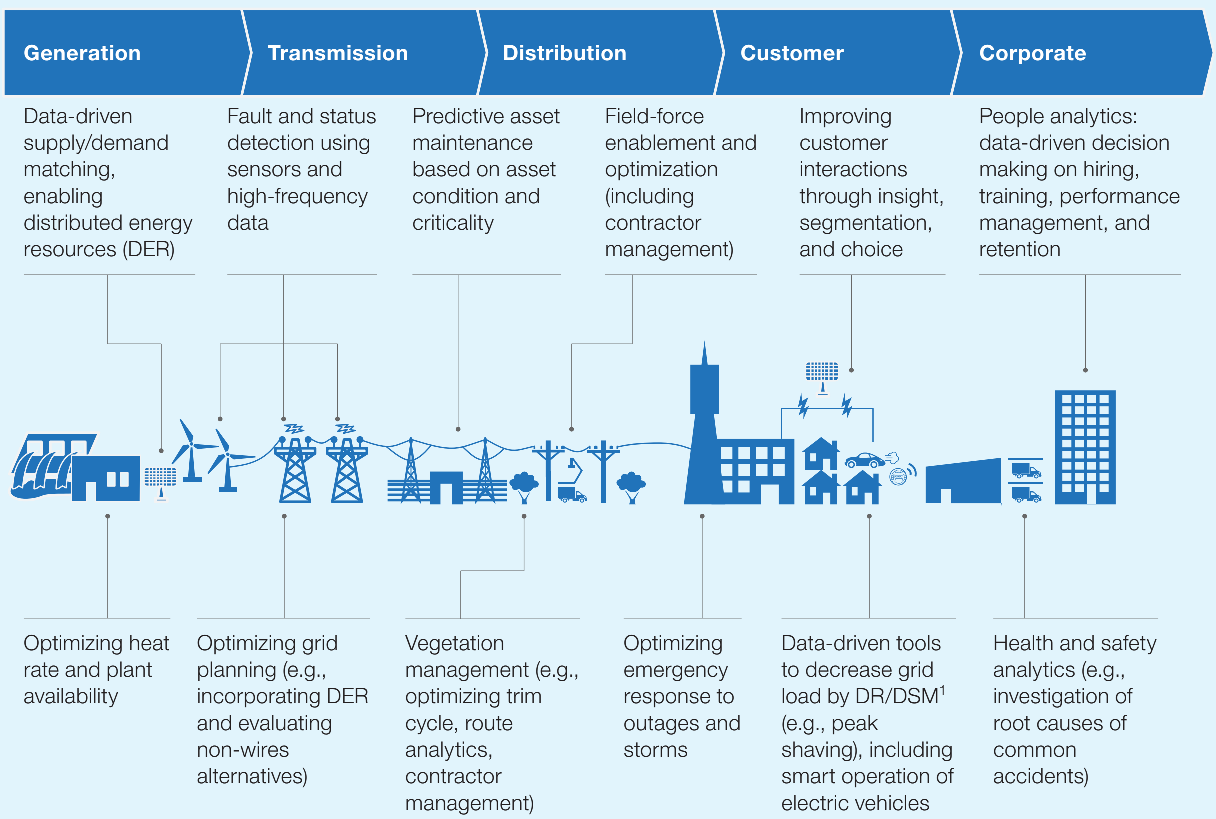
Industry leaders are using advanced analytics in increasingly innovative and unconventional ways, including:

- Automatic inspection of power lines and vegetation management using drones, image processing, and LIDAR (light detection and ranging—a remote-sensing method using pulsed lasers)
- Voice analytics applied to call-center recordings to gain deeper insight into customer interactions and behaviors

Exhibit

Analytics has multiple applications along the utility value chain.

Examples: not exhaustive



[1] Demand response/demand-side management

- Machine learning for predictive maintenance (for instance, anticipating the likelihood of breaker failures)
- HR analytics that raise employee productivity, reduce attrition, optimize training spend, and provide a fact base for succession planning
- Health and safety predictive models that identify which assets, teams, or individuals are most vulnerable to incidents and suggest levers to reduce risk

The value derived from these efforts includes:

- Operational benefits in the form of lower operating expenditures, greater capital efficiency, extended asset lifetimes, and safer operations
- Improved customer service with a better understanding of customer needs, a superior customer experience, and increased reliability
- Better employee engagement, since less time is wasted in lower-value tasks, and travel and schedules are optimized
- The creation of new businesses in areas such as home energy management, smart energy efficiency, advanced demand response, and microgrid optimization

updated and reprioritized against other ideas. Relative newcomers often start with a simple yearly process to evaluate, update, and reprioritize the list.

Do

- Build a prioritized roadmap of use cases to pursue, based on vetted value estimates and alignment with the organizational strategy

Don't

- Chase after viral use cases without assessing the value at stake
- Leave it entirely to business teams and departments to prioritize use cases

Challenge 2: Converting hype into measurable bottom-line impact

Many utilities launch use cases but struggle to capture tangible value. Success requires the coordination of a complex series of steps, and the collective impact is only as good as the weakest link. Common facets of this challenge include:

Not understanding the impact at stake and the process changes needed to capture it. We've seen several companies make large investments in analytics projects without a clear business case or a monetization plan. Other utilities have developed promising predictive models but failed to implement the associated process changes needed to foster adoption.

Struggling to get access to data or use all the data available. Many energy companies have observations and maintenance tickets that could yield valuable data for predictive maintenance, safety, and other use cases, yet all too often this data is wasted because digital observation tools and text-mining capabilities are lacking. Another great source of data is utilities' vast archives of recorded calls from call centers, which can be used—but seldom are—to create insights using voice-mining analytics. External data sets such as social-media and weather data are also commonly overlooked.

Being unable to deliver an analytics solution that works well. Adoption often suffers because of a lack of collaboration with business users during the development phase. Too often, organizations rely on senior managers or subject-matter experts from the business, but fail to involve the front-line crew members who will use the tool on a day-to-day basis.

Moving on to the next use case before value has been captured. We've seen utilities have success with an initial pilot but then be too quick to redeploy resources and funding before the effort has properly bedded in. The result is lackluster front-line engagement, limited adoption, and forfeited value.

Not having the necessary capabilities and talent. That doesn't just mean data scientists, but all the roles involved in capturing business value, such as the designers and product managers who act as "translators" between data engineers, data scientists, and the core business. Other roles often overlooked include DevOps experts and the data architects who enable access to clean data. Though expensive, these capabilities can save money in the long run by simplifying data curation and processing needs in future.

Leaders in analytics avoid these pitfalls by:

Involving actual users in the solution design, not only during pilots but from the planning stage through to implementation. This is the easiest, most cost-effective way to capture valuable feedback, build engagement, and ensure adoption.

Following a business-centric approach that starts with developing a solid understanding of the performance of an entire work flow, such as plant outage management, asset maintenance, or record-to-report in the back office. From this understanding, an organization can identify all the levers available to drive a faster, safer, and more productive way to do business. Rather than focusing only on pain points in the current process, utilities should instead map out a fully reimagined three- to five-year vision for the whole work flow as well as a prioritized set of the technical solutions required to realize the vision.

Building a strong product-management capability that is structured around business processes rather than technical solutions. Product managers have full visibility and ownership of an end-to-end business process, drive the development of the future vision for it, identify which data sources and technology solutions are needed to achieve the vision, and manage rollout and the training of end users.

Developing a set of key performance indicators (KPI) that measure progress at every stage from model development and testing to user adoption and value capture. This ensures that lessons are learned from experience and errors are quickly corrected.

Developing an inventory of required capabilities by translating planned use cases into a roadmap for talent that includes all the skills—technical and nontechnical—needed to deliver an analytics project. This effort should also include defining a framework for assessing "make or buy" decisions based on technology complexity, use-case criticality, the scale and pace of the use-case rollout, and the utility's long-term analytics strategy. For example, a utility aspiring to become a leader in renewables may prefer to develop an asset-maintenance solution internally to create a competitive advantage over competitors that use off-the-shelf products from vendors.

Do

- Involve users in solution design from the planning stage onward, not just during pilots
- Follow a business-centric approach linking analytics solutions to a clear plan for process optimization and monetization
- Create a standard framework to measure, track, and report on impact until full run-rate value has been captured
- Allocate time in project schedules for change management and end-user training
- Build a strong product-management capability with end-to-end responsibility for work processes, not technologies
- Look for talent beyond data scientists and hire translators, DevOps experts, cloud specialists, and data engineers as well

Don't

- Deliver a solution to end users and then immediately switch all resources to the next project
- Think analytics talent = data scientists

Challenge 3: Making data enable productivity, not inhibit it

In our experience, analytics organizations often struggle to develop the data-governance and platform practices they need to deliver value. When a clear data strategy is lacking, the data ecosystem will be underdeveloped, making the development of new use cases costly and slow. Key aspects of this challenge include:

Undocumented data sources and multiple sources of truth. Alarmingly, organizational surveys often report that data users don't believe their company has a clear data-ownership structure or feel confident that data objects are precisely defined or accurate, particularly when it comes to similar objects from different sources. In many cases, organizations have trouble simply establishing whether data exists. It's also common for the business to have little trust in new data systems, and little comfort in using them.

Unclear access rights and privileges. It's not unusual for some parts of an organization to limit or block access to data that's critical for decision making or analytics, often citing data confidentiality or cybersecurity as the reason.

Insufficient tools and capabilities for preparing data for analysis. Many utilities struggle to ingest and curate data efficiently, which increases the time and difficulty of developing new digital tools. When building an analytics product, industry leaders spend no more than 20 to 30 percent of the development time on data cleaning, preparation, and blending—tasks that may take 60 to 80 percent of the time for laggards.

A "build it and they will come" mind-set. Some utilities commit to major projects in building data platforms or data-storage infrastructure in the belief that once data is available, the business will want to use it. But they can end up investing tens

Conservative estimates supported by rigorous use-case analysis suggest that AA can boost profitability by 5 to 10 percent, while increasing satisfaction for customers and improving health and safety for employees.

of millions of dollars in new systems without any real business benefits to show for it.

Best-in-class data-governance practices allow industry leaders to fast-track value capture by:

Defining a target data structure that is aligned with the organization's needs, enforces standardization, and serves as a catalog providing a sound basis for key use cases. To manage this data structure, organizations need to align on clear data-ownership and governance policies—who has access to what data—that are respected and enforced across the organization.

Using an agile approach to build the data platform and defining a minimum viable product (MVP) that delivers just enough functionality to allow the first few products to be developed. An MVP often relies on quickly deployable open-source technologies, easily obtained data, and tools such as Tableau and Alteryx that speed up the production of a proof of concept. More advanced or specialized components and data are often added iteratively in future releases.

Do

- Define organization-wide processes and rules for data curation, documentation, sharing, and ownership
- Develop and maintain a central catalog of data
- Develop a data strategy that supports the wider analytics strategy

Don't

- Have unclear data rights and governance
- Skimp on investments in data-cleansing, processing, and visualization capabilities
- Invest heavily in collecting and cleaning data before starting to develop individual use cases

Challenge 4: Embedding analytics transformation in your culture and organization

A successful AA transformation depends on the right culture and organization. That means cross-functional teams working through short, iterative, test-and-learn cycles—an unfamiliar prospect for utilities accustomed to long development time-lines. Navigating this transition will involve:

Creating an environment conducive to experimentation and learning while taking care not to jeopardize strategic pillars such as reliability and customer satisfaction. Adopting agile practices and launching short sprints to test new ideas in the real world (rather than debating them in theory) can often feel uncomfortable at first—but falling back on rigid waterfall processes will result in endless planning iterations, blown deadlines, persisting pain points, and a failure to create value.

Working out what kind of structure will best support the analytics transformation: centralized, decentralized, or hybrid. Many utilities are too decentralized, leaving them unable to reap the benefits of standardization and best-practice sharing. All too often, a utility deploys different solutions from different vendors to build what is essentially the same product in different business units. Lessons learned aren't shared, and scale benefits aren't captured. On the other hand, a fully centralized model is seldom the answer. We've seen utilities where the analytics organization and the business work at arm's length, at the cost of misaligned priorities and—worse—the development of products that disappoint the end user.

Securing senior management commitment and appointing the right leader to act as a bridge between the CEO, the analytics team, and other parts of the organization. In some utilities, senior executives in charge of analytics are hidden three or four levels down in the organization, leaving them powerless to remove any roadblocks that arise. In other companies, their responsibilities are too broad and unfocused.

In our experience, most analytics leaders have a good grasp of the organizational model best suited to their company. This enables them to:

Establish the right culture, starting with top executives who are curious to explore new analytics solutions, have a bias to action, and strike a good balance between delegation and control. This starts at the top, with the CEO and senior team emphasizing the importance of analytics, providing the right incentives, and role modeling desired behavior. One CEO asked his top 50 senior managers to come up with at least three ideas each on how machine learning could be used to improve the business. In doing so, he not only created a vast array of use cases in a short time but also role modeled the intellectual curiosity and bias toward business impact that he expected from his leaders.

Shape a digital and analytics organization that fits the company's governance model, maturity, and potential for standardization and best-practice sharing. This includes ensuring that the executive driving the analytics transformation has direct lines of communication to the CEO, even if the role doesn't always report there. Most analytics teams adopt a hybrid model, with data governance, tools, and standards defined centrally; a close-knit community of data scientists working both centrally and within the business; and clear roles for product owners, who form cross-functional teams to drive the day-to-day execution of use cases and have direct ties to business executives.

Do

- Align your analytics organizational structure with your overall business strategy, governance model, and level of maturity
- Develop a structure that ensures best practices are shared enterprise-wide yet enables business units to be closely involved in solution development
- Embed critical analytics capabilities across the whole organization, not just in an analytics center of excellence

Don't

- Limit your analytics transformation to new software development and overlook culture and project management
- Expect the analytics teams to develop their own mandate for driving change across the organization

Advanced analytics is transforming industries worldwide and enabling organizations to achieve unprecedented levels of productivity. For utilities, which lag other industries in digital maturity, the value at stake from such a transformation is substantial. However, making the leap is far from easy, and many utilities place big bets only to fall short of their objectives. By adopting best practices and defining the strategy, culture, and organization they need to achieve their analytics aspirations, utilities can maximize their odds of capturing the step-change improvements that industry leaders already enjoy. ■

Marcus Braun is a consultant in McKinsey's Minneapolis office, **Eelco de Jong** is a partner in the Charlotte office, **Alfonso Encinas** is an associate partner in the Washington, DC, office, and **Tim Kniker** is a senior expert in the Boston office.

The authors wish to thank Adrian Booth and Prasoon Sharma for their contributions to this article.

Harnessing the power of advanced analytics in transmission and distribution asset management

Advanced analytics is helping T&D operators improve performance, reduce asset-management costs, and capture value. Here's how successful utilities approach the transition.

Rui de Sousa, David González, Jesús Rodríguez González, and Humayun Tai

Imagine a world where transmission and distribution (T&D) operators use the abundant data at their disposal to target maintenance activities to the needs and risks of individual assets; where they set priorities and organize schedules on the basis of highly accurate predictions rather than ad-hoc reporting after the event; and where they update network information and manage assets in close to real time.

That world is within operators' reach, yet remarkably few have managed to grasp it. In principle, the process sounds simple: gather data, use it to predict the probability of asset failure, and then use those predictions to target maintenance activities to the assets that need them most. As an alternative to the routine- or time-based preventive methods that most utilities still rely on, predictive maintenance holds out the promise of greater accuracy and reliability at lower cost.

And the savings are significant, especially in the context of a lean industry accustomed to annual gains of 1 to 2 percent in real terms, at best. We have seen operators reduce their costs by 10 percent in medium-voltage distribution grids, 15 percent in high- and medium-voltage overhead lines and underground cables, and 20 percent in high- and medium-voltage substations, while improving asset reliability. Even in an environment where tariffs are adjusted at the end of regulatory period to account for industry cost performance, operators can benefit from a first mover advantage, capturing higher returns on capital and a more likely repeat of outperformance in the following regulatory periods. Such improvements will become all the more critical in an industry where electric-vehicle connections, distributed generation, and other complex systems are proliferating.

Advanced analytics also provides significant other benefits when implemented as part of a broader performance-improvement program. These include smarter and faster data-driven decision making, improved capex and people management, increased safety, greater compliance with regulatory targets, and better regulatory-driven investments. In fact, using advanced analytics to reinvent asset management helps deliver impressive short-term impact while kick-starting analytics transformations in other parts of the business.

But as many operators have found, moving to analytics-powered asset-management approaches is easier said than done. Our estimates indicate that only 5 percent of maintenance activities in the electric-power industry are based on a data-driven predictive approach. All too often, gaps in data quality, IT architecture, advanced analytics capabilities, and maintenance strategies prevent operators from capturing this considerable opportunity. In this article, we reflect on our experience of helping T&D operators to overcome these obstacles and use advanced analytics in asset management to reduce costs and risk, ensure regulatory compliance, and improve asset reliability.[1]

Some answers before you begin

We've found that operators often ask the same few questions as they embark on their advanced-analytics journey. Here are our answers:

Do we need to spend money installing sensors across our network to capture real-time data?

No. Sensors may be justified for critical equipment such as interconnectors, but the length of T&D networks and the very low probability of failure for most assets mean sensors are not warranted across the board.

Do we need big data?

No. Companies often assume they need massive amounts of data from anywhere they can get it.

That's not necessary to start. But you need all your available data, plus a few other types of data that you may not have readily available in house, such as weather forecasts.

Can we get a plug-and-play solution?

No. Each operator needs at least a semi-tailored approach that fits its starting position, performance level, and aspirations, while allowing for rapid and efficient implementation.

Can we do it gradually?

Yes. Most of the operators we've worked with started with a priority use case, whether it be low-voltage distribution poles or transformers, and moved on to explore other asset types or extend implementation from a pilot region across their entire geographic footprint.

What results can we expect?

It will depend on your specific circumstances, but other operators' successes are encouraging. One transmission operator achieved a 10 to 15 percent saving on circuit-breaker maintenance by rescheduling inspection frequency; another reduced opex spending on inspections by 25 percent in HV overhead lines and 10 to 15 percent in HV underground cables. And one distribution operator both improved supply quality and saved 10 to 15 percent of its maintenance spending on distribution feeders by delaying inspections in areas with very low probability of failure.

How do we get started?

Having decided to proceed with a specific asset, an operator has three main steps to complete:

Step 1: Capture and clean up your data

The operator begins by capturing information about each of its assets. The level of detail varies by asset. As an example, transformers typically require data on about 200 variables.

Most operators tell us their data is scarce, patchy, or not even digitized. Getting it into good shape can seem an overwhelming task. Fortunately, advanced analytics can help. Data-validation algorithms raise alarms to enable anomalous data or trends to be corrected; heuristic algorithms can cover data holes; optical character-recognition techniques can be used to digitize documents even if they are in poor condition; and natural-language processing classifiers can help to capture data from free text.

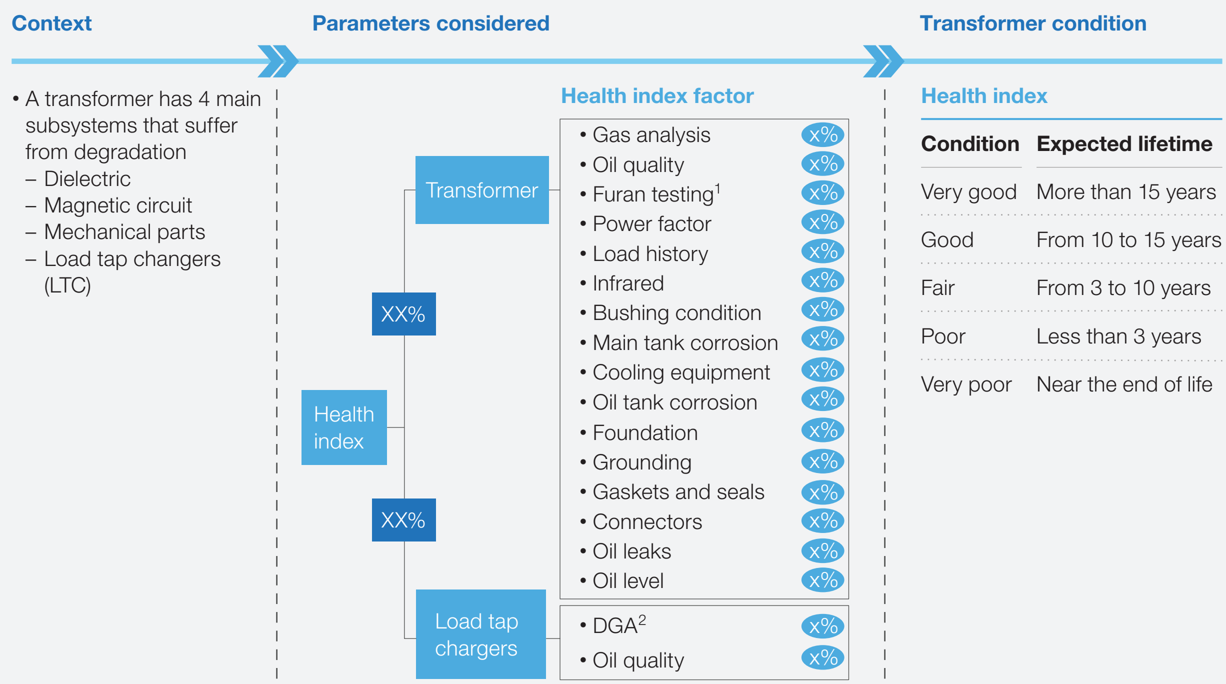
As part of this step, operators also use advanced analytics to reconstruct any networks where failures have occurred to identify the assets or elements affected. Some operators have this information stored in their supervisory control and data acquisition (SCADA) systems, but in any case, they will need to examine additional data such as work orders, previous anomalies, historical load, meteorological information, asset age, and other structural properties. After assembling and correlating these elements, operators can then rank assets by probability of failure.

Step 2: Quantify your health and criticality levels

Determining the health and criticality of each asset is the starting point in determining overall risk levels and segmenting asset-management strategies and maintenance and replacement activities.

To determine the health or condition of an asset, an operator will need to assess multiple technical variables—probably somewhere between 10 and 40, depending on the asset type. It will also need to consider factors relevant to its specific situation, such as technical thresholds set by local regulatory authorities, and temperature if it operates in a region with an extreme climate. As an example, Exhibit 1 illustrates the parameters and factors used to determine the health of transformers.

Exhibit 1 **Calculating asset health: A transformer example**



[1] Test used to determine a transformer's remaining life expectancy
[2] Dissolved gas analysis

To determine the criticality of an asset, an operator will need to assess not only its reliability, safety, and local environment, but also economic factors. The importance of specific factors varies widely across operators and regions. For instance, one operator we worked with in Asia–Pacific considers proximity to remote or disadvantaged locations and industrial hubs as a major factor, while for one US operator, proximity to forests and susceptibility to fire are key. Exhibit 2 illustrates typical variables used in assessing the criticality of substation assets.

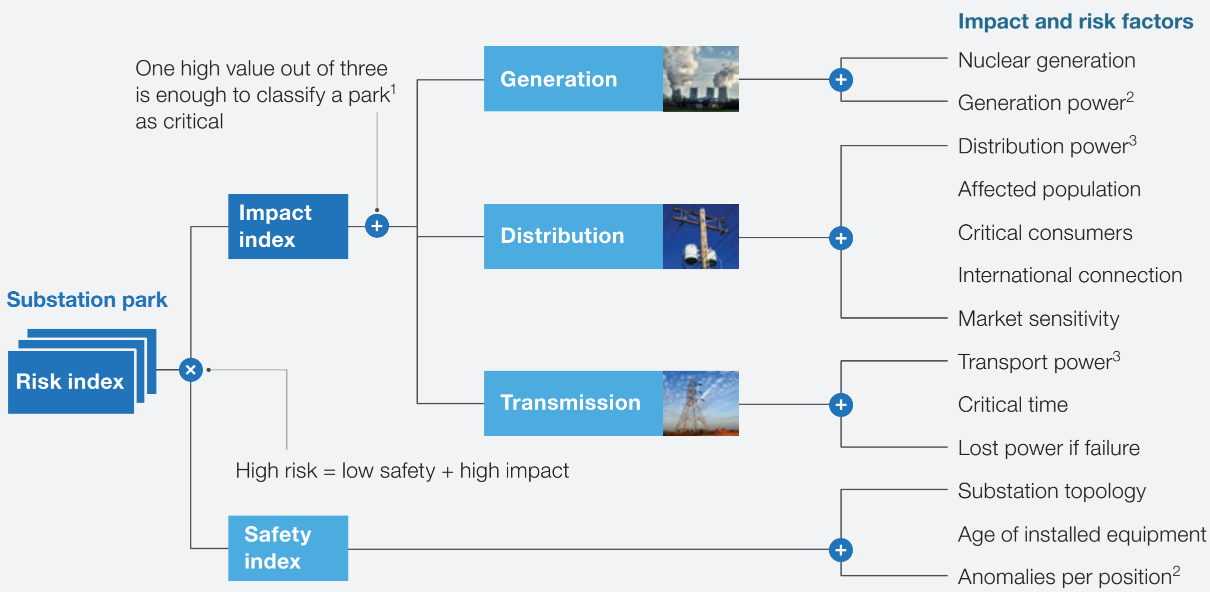
The drivers of asset health are subject to technical judgment, engineering models, and individual experience. Even at the same operator, different people may have different opinions on the variables that matter most. To overcome subjectivity, operators should use engineering scoring models—predictive models based on electrical engineering science, institutional knowledge, and practical experience.

However powerful advanced analytics techniques may be, they can only be effective at optimizing maintenance if they compute the right data and logic. Senior leaders at one company were astonished to discover that one of the best predictors of a circuit breaker's condition was the time it took to open a switcher—something that long-serving field technicians would have been able to tell them for years, if only they had been asked.

The use of advanced analytics enables operators to test technical knowledge and engineering logic

Exhibit 2 **Calculating asset criticality: A substation example**

Calculation methodology for criticality index of substations



[1] A park is a group of substations or other critical assets in the same locality.
[2] The parameters used in this model allow different weights to be assigned to different generation technologies, anomalies to be filtered by criticality level, and the value of the security index to be adjusted to different topologies.
[3] For any points in the network lacking information on distribution or transport power, the number of machines or lines should be identified and standard values should be assigned for nominal power, depending on voltage levels.

rigorously and efficiently against failures or anomalies. The more data a model processes, the more accurate its estimates and predictions become. Computing power and mathematical knowledge converge to help operators frequently update and improve their methods for calculating the health of an asset. Mathematical and statistical techniques such as machine learning (including random forests, gradient boosting, and neural networks), fuzzy logic, and natural-language processing (including semantic analyzers and Bayesian classifiers) can be introduced, depending on the asset type.

By combining insights into the health and criticality of each asset, an operator can determine its risk level, as shown in the example for distribution feeders in Exhibit 3. Having assessed the risk level for all of its assets, the operator can then move to the third and final step.

Step 3: Tailor your asset-management strategy

This step involves reviewing monitoring and inspection frequency, adjusting routine and scheduled maintenance practices, and considering corrective maintenance and replacement suggestions. Utilities looking to improve their system performance, reduce costs, or both, can adopt this segmented approach to achieve their objectives. They capture benefits from extending asset life, from grouping similar anomalies for resolution by the same crews, and from multiple other opportunities, such as the optimization of pruning costs based on the risk of vegetation failure.

One operator we worked with decided to replace some ailing assets earlier than expected because they were critical, while allowing others to fail before they were replaced so that resources were not wasted on maintaining less critical assets. The operator also increased the frequency of inspection for some relatively healthy assets because any failure would have had a disproportionate effect on its network. Even though activity levels rose for the most critical assets and those needing replacement, the operator managed to reduce its total expected costs by 10 percent.

T&D companies can apply the same logic to every component of their network from substations to customer connections. A few operators have gone further and consolidated their approach across multiple asset types. This has given them a holistic perspective that allows them to optimize opex and capex allocation across multiple asset classes based on the expected risk of supply, bringing incremental savings of 5 percent on top of the 15 percent savings captured in the asset class originally addressed.

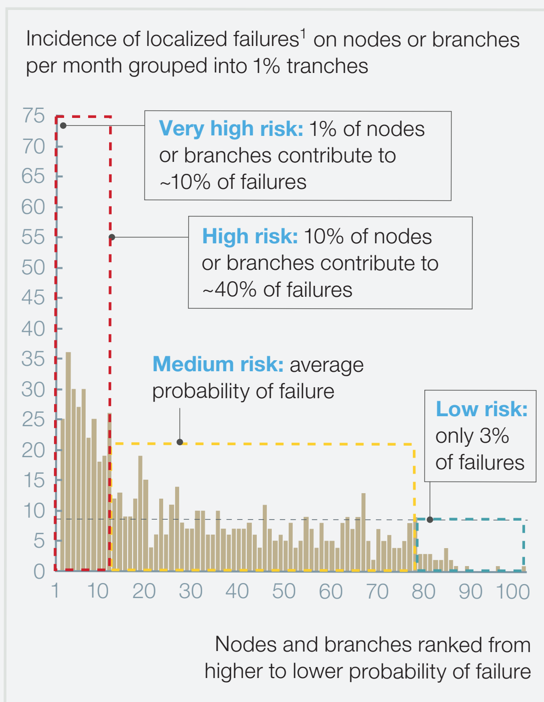
Exhibit 3 **Modeling failure probability: A distribution feeder example**

Key inputs

Use machine-learning algorithm to **predict the failure**[1] of a distribution feeder element **within 1 to 6 months using:**

- SCADA events
- Historical anomalies
- Maintenance and inspection work
- Construction characteristics
- Geographical information
- Meteorological information
- Measurements of power quality

Output of advanced analytics model



Impact

Depending on operator needs and regulatory incentives, the model can be used to

- Improve quality of service at same level of expenditure by redeploying inspections
- Reduce maintenance opex by 10–15% by avoiding non-productive inspections in areas with very low probability of failure
- Trade off cost and quality of service taking into account regulatory incentives

[1] Defined here as any failure causing sustained customer outages

Some leading-edge companies are starting to adopt powerful software tools that present critical data in an easy-to-understand visual format—often in tablet apps —and suggest the optimal maintenance or replacement action for a given asset at a given moment. A field engineer, technician, or manager can adopt or reject the suggestion with a single click. A “yes” decision automatically triggers the system to generate the necessary work orders and put crews and resources in place.

Capturing value beyond asset management

Operators that use advanced analytics methods to optimize maintenance also reap additional gains that extend beyond asset management.

First, by using an extract, transform, load (ETL) process, operators can take data that resides in multiple databases and is organized in different ways, pull it out, and place it in a single consistently categorized database. Having data in a format from which it can be easily accessed and used by any part of the organization provides a reliable base—a single source of truth—for all asset-management decisions, eliminating the ambiguity and contradictions that come from juggling data from many sources. After spending a month implementing this step, one operator confessed that even if its transformation program had stopped there, the value of getting its data crystal clear would have made the whole effort worth while.

Second, data can be integrated in apps that allow frontline management to optimize the routing of maintenance crews based on distance, traffic flows, weather conditions, and so on. One operator went a step further and developed an app that enabled technicians to use their observations on the ground to update information on network health in real time via their tablets.

Third, the granular information delivered by advanced analytics gives operators better insight into crew performance and enables them to manage contractors more effectively. One US utility was paying contractors hundreds of millions of dollars to prune branches and remove fallen trees close to its distribution power lines. After analyzing and modeling its data, the company was able to optimize scheduling and increase trim productivity by comparing and scoring crew performance and flagging variations to supervisors. This enabled it to improve its negotiations with contractors and save 25 percent of its contract spending, with 5 percent savings captured in the first year alone.

Fourth, the use of sophisticated analytics enables operators to be more prudent in their capex as distributed generation grows. This trend may drive some customers out of the grid system altogether, leaving remaining grid operators (and their customers) to pay for upgrades to power infrastructure and stranded assets.

Fifth, as regulatory frameworks such as totex[2] and RIIO[3] evolve, they increasingly acknowledge the need for operators to invest more, adopt new technologies, and improve reliability, energy efficiency, and other quality indicators. Introducing advanced analytics enables operators to tick most of these boxes.

Ingredients for success

Having worked with many companies in electric power and other industries, we know from experience that integrating analytics into asset management is not easy. We’ve found, however, that most successful transformations have a number of foundation stones in common:

Having the business work hand in hand with analytics and IT to address opportunities in an agile manner. Analytics translates business needs into IT needs, and IT focuses on delivering the greatest value possible to all parts of the organization. At companies where IT or analytics leads the change, the business side can often be disengaged and skeptical, and vice versa. In our experience, real progress can only be made when IT, analytics, and the business are in close alignment, follow a collaborative and iterative approach, and respond quickly and flexibly to change.

Basing maintenance strategy entirely on asset health and criticality. Putting robust criticality and health indices for all components of the T&D network at the center of a reliability-focused approach will enable operators to cut costs without compromising reliability and open up opportunities to reallocate funds to where they are most needed. In our discussions with operators, many have seen this approach as a way of facilitating more risk-based discussions on capital allocation.

Ensuring IT systems are properly integrated and data is well structured. Data from relevant systems (ERP, SCADA, and so on) will need to be seamlessly combined in asset health and criticality assessments and decision models. Operators sometimes delegate some of these systems to technical partners, but they will need to develop a holistic perspective across all their systems to understand how they can help meet business objectives.

Fine-tuning organizational structures and processes. The key steps here include dismantling silos, moving decision-making authority from departments to senior leaders, and implementing processes that integrate business needs, technical knowledge, and analytical insights, as well as fostering continuous improvement. In our experience, the development of success stories for different asset types and regions will help to overcome any organizational resistance to these kinds of changes.

Building stakeholder (and especially regulatory) management skills. Regulators may be uncomfortable at first with new asset-management approaches, particularly where they involve reducing monitoring frequency for assets in good health or low criticality. One company that wanted to reduce monitoring frequency from every two years to every five had its plans blocked by the regulatory authorities. Concerns about the integrity of power networks will need to be addressed constructively and in a way that highlights the reliability of predictive maintenance and its benefits for customers as well as the operators themselves.

Ensuring leadership from the top. Introducing advanced analytics at the point where the core business intersects with IT and data systems is a complex undertaking, and utilities often struggle to achieve the results they expect. Securing a strong collaboration between IT and technical and engineering teams is key. To make the transformation a reality, top management needs to make digitization a priority and instill urgency across the organization.

■ ■ ■

Companies often assume they need massive amounts of data from anywhere they can get it. That's not necessary to start . . .

After decades of sweating their assets, T&D operators are running out of options when it comes to managing costs and protecting margins. Adopting advanced analytics to power predictive maintenance offers a new avenue to improve performance while reducing asset-management costs by as much as 10 to 20 percent. ■

---

[1] Advanced analytics can also be applied to improve grid development planning and construction, customer experience, and grid operations, including dispatching, losses, load balancing, and fraud detection, but these topics fall outside the scope of this article.

[2] Totex is an advanced model that sets regulatory targets to generate capex and opex efficiencies through agreement with operators on targets and outputs.

[3] The RIIO (revenue = incentives + innovation + outputs) regulatory model builds on the classic RPI-X (retail price index minus efficiency savings) framework, focuses on outputs to drive price controls, and takes into account innovation, incentives, long-term investments, and performance variance among operators.

Rui de Sousa is the solution manager for Utilityx in McKinsey's London office, **David González** is a senior partner in the Madrid office, where **Jesús Rodríguez González** is an expert partner, and **Humayun Tai** is a senior partner in the New York office.

The authors wish to thank Adrian Booth, Jiri Franca, José Luis Gonzalez, and Eelco de Jong for their contributions to this article.

The revival of customer loyalty: How regulated utilities can reshape customer engagement

Improving the customer experience is imperative for utilities facing rising customer expectations, new competitive threats, and mounting cost pressures. Adopting an agile, digitally informed, and design-based approach to reshaping customer journeys will help them thrive in the coming era of energy choice.

Aaron Finegold, Scott Perl, and Alfonso Pulido

© ipopba/Getty Images

In the past few years, utilities have taken a growing interest in customer experience (CX). As leading digital natives increasingly shape customer expectations, utilities are facing growing pressure to create compelling customer experiences in their own industry. With the decline in costs of solar, storage, and other distributed-generation technologies, they fear losing customers, or part of their usage, to companies like Tesla Energy. And as demand slows, infrastructure ages, and cost pressures mount, utilities are looking for ways to reduce operational and maintenance spending without affecting their service delivery and customer experience.

However, utilities' initial efforts to create better customer experiences have had mixed results. Heavy investment in flashy concepts and tools have made little difference. Many utilities have struggled to move fast enough and take advantage of the many digital tools and techniques at their disposal. As a result, most have been unable to capture the business value that banks, telecom companies, and others have achieved from their CX efforts.

In this article, we draw on McKinsey's extensive work on CX benchmarking and customer-journey redesign with leading companies from a range of industries and share our insights into how customer expectations are developing in the digital age. Below, we frame an approach to CX transformation that will help utilities capitalize on this important opportunity to reduce costs, preserve revenues, maximize customer satisfaction, and boost employee engagement.

A proven three-pronged approach

Through our experience of supporting CX transformations across industries, we have developed and tested a three-part approach that utilities can adopt to elevate their customer experience to best-in-class level.

1. Align around customer journeys and focus on what matters most

They will need to take the following steps.

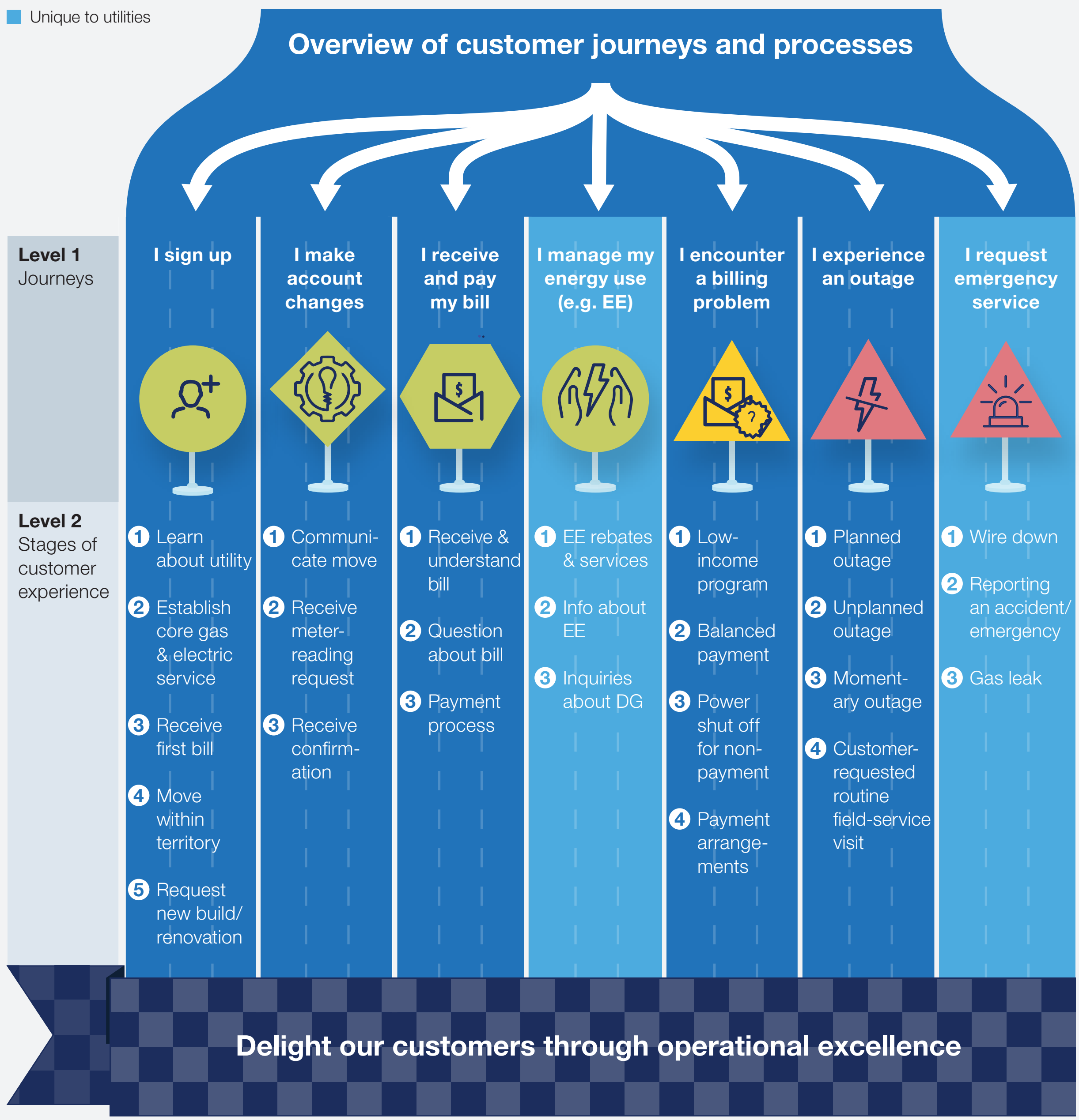
Organize around journeys, not touchpoints

Companies in many industries have transformed their customer experience through an approach based on customer journeys. A journey is the process a customer goes through to complete a particular task, such as opening an account or resolving an error. It typically cuts across multiple functions within the organization and can last for minutes, months, or anything in between. For example, a customer journey to request a new service might involve touchpoints in multiple channels—web research, phone calls, a technician visit—and take several weeks to execute from initial enquiry to billing. The exhibit illustrates the seven customer journeys and associated customer processes that are most critical for utilities.

The advantage of organizing around entire journeys is that unlike touchpoints, they capture the totality of a customer's experience. Even if a particular touchpoint scores high for satisfaction—perhaps because a customer-service agent was especially courteous and helpful—that doesn't mean the same is true of the entire journey. The customer may well have encountered delays, contradictory advice from different channels, or a second-rate experience of some other kind. In fact, it's common to see customers report very high satisfaction with specific channels and touchpoints, yet low satisfaction with the journeys and relationships in which they are embedded. By examining the customer's journey from beginning to end, companies can identify the breaks in the process that are damaging satisfaction and creating unnecessary contacts and cost.

Consider the example of a US utility that struggled to manage customer sign-up effectively. The difficulty lay in the gap between customer service, Exhibit

Isolating the key steps in the most important customer journeys



The advantage of organizing around entire journeys is that unlike touchpoints, they capture the totality of a customer's experience.

which managed requests for service via the utility's website and call center, and field services, which turned on the power supply. Delays or issues in the field were not effectively communicated to customer service, prompting many customer complaints. Because the utility saw these processes as separate transactions in separate business units, it struggled to resolve the issue. But once it started to look at sign-up from the perspective of the customer journey, it was able to identify the hand-off and communication problem and quickly address it.

Focus on the journeys that matter

All journeys are not born equal. McKinsey's annual North American customer-experience survey for utilities has shown that four journeys contribute the most to customer satisfaction. The billing-and-payments journey comes first, followed by managing energy usage, outage, and resolving billing and payment issues. Taken together, these journeys are responsible for roughly two-thirds of customer satisfaction.

Though it's clearly important to deliver good service across all journeys, utilities should pay most attention to those that will move the needle on both customer satisfaction and cost so as to focus the organization and deliver results faster. Most companies find it best to pursue no more than one or two journeys at a time to avoid overwhelming the organization and improve the odds of a successful transformation. One utility chose to focus on sign-up, one of the most important journeys for its small and mid-sized business customers. It identified issues with new construction projects and business rules that prevented online sign-up, and tackled them head on. This effort succeeded in providing customers with a meaningfully different experience while also cutting costs through an increase in self-service.

Figure out what drives performance on key journeys

Which elements of a journey have the most influence on customer satisfaction is seldom obvious at first sight. To find out, utilities need to conduct customer surveys and subject the data to advanced statistical analysis and conduct qualitative research with customers. Through such a process, McKinsey's Journey Pulse customer survey in utilities[1] has shown, for instance, that using easy-to-understand language and graphics to demonstrate how a customer's bill relates to their energy usage is a core driver of satisfaction with the billing-and-payments journey. This level of insight helps utilities quickly craft tactical initiatives, redesign journeys, and prioritize where they spend their time.

Deliver 'wow' moments

Recent research from McKinsey's Journey Pulse survey in utilities shows that delivering standout moments that go above and beyond customers' expectations can lead to dramatically higher satisfaction. Utilities typically lag other industries in creating these "wow" moments, with just 33 percent of customers experiencing one of these experiences in the past year as compared with 58 percent for airlines, for example. To identify possible "wow" moments, utilities can seek inspiration by scrutinizing complaints and compliments on social media and checking out what other leaders are doing. One utility is rethinking its handling of power outages. As an experiment, it is issuing field crews with equipment such as wilderness blankets, water bottles, flashlights, charging stations, and even a Wi-Fi hotspot to help customers with no power. The idea was inspired by primary research and a look outside the industry to see how exemplary companies go to great lengths to recover from disappointing customer experiences.

2. Reimagine journeys using design thinking and a digital-first lens

Having identified the most important customer journeys and considered possible ways to improve them, a utility can then tackle the next steps.

Understand where you're starting from

To get a clear perspective on their customer experience and any underlying processes that might be creating pain points, friction, or rework, utilities can use the powerful techniques of ethnographic research and journey mapping. Ethnographic research is a method of observing users as they complete tasks or interact with an organization and can be used to probe unmet needs. One utility observed customers using its new website and noticed they had a need that wasn't being met: an easy way to split bills between multiple tenants at the same address. By providing a solution, it eliminated this pain point and delivered a "wow" moment.

Journey mapping, on the other hand, captures customer's goals, expectations, and emotions as they work through a journey and interact with people, processes, and technology. Using this technique, another utility discovered that customers trying to update their account details often felt frustrated because they had to repeat the same process with their bank, telecom company, and other service providers. In response, the utility built mechanisms into multiple touchpoints in the customer journey to promote empathy and address some of these challenges. By matching up journey maps with operational data, utilities can not only tackle pain points but also uncover opportunities to delight customers.

Reimagine what's possible using a digital-first mind-set

Using the techniques described above, a utility can radically rethink what its future experience should look like. Creating better journeys invariably means making more use of digital technologies, since customers increasingly want to engage digitally. McKinsey's recent e-care survey indicates that 60 percent of customers were less than fully satisfied with the channels available for contacting the utility, and almost 45 percent would prefer to use digital channels as their primary means of interacting with it, though only 22 percent were actually doing so.

Enabling more customers to use digital channels also brings big benefits for the utility: shifting customers from call centers to digital channels drives down costs, while capital investments in technology can add to the rate base. Indeed, many companies are adopting a digital-first mind-set in which digital channels are the first line of contact in the customer journey, reflecting the fact that self-service can often be more satisfying for customers than speaking to someone in person. Other industries can offer a source of inspiration. One pay-TV provider managed to reduce its volume of customer calls about payment arrangements by nearly 12 million a year by analyzing its customer journey, improving its digital channels and tools, and encouraging customers to use online and mobile channels instead of calling. Within six months, the company not only cut costs significantly but also improved customer satisfaction.

Adopt design thinking and cocreate solutions with your customers

Bringing different functions and organizational units together to work on a journey of the future is a powerful way to gain support and traction. Before venturing into the design exercise, it's important to find a seasoned guide: introducing a designer and facilitator into the design team is one of the secrets of success. Another is to rapidly mock up the ideas for the journey and get them in front of customers as quickly as possible. When promising concepts emerge, build high-fidelity prototypes and test them with customers to see how they interact with them. Even a rough version of a proposed app on an iPad will yield better insights than simply explaining the idea ever could. Failing to engage customers in the development process is likely to produce tools that fall flat and don't deliver what customers want, leading to wasted investment and declining customer satisfaction.

3. Execute in an agile manner to generate impact quickly

The pace of change in customer-facing functions is so fast that a delay between concept and execution could render ideas obsolete before they are rolled out. To move rapidly from design to implementation, utilities need to take the following steps.

Set up a cross-functional team of experts

As in the design phase, the team working to execute ideas should include members from every business unit that touches the journey, since any improvements are likely to require work in all of them. For sign-up, for instance, the functions involved would probably include customer care, field operations, marketing and communications, and IT. Most if not all teams will have a strong IT component, since the developers and technical experts who craft new digital experiences will play a big part in capturing impact. Whenever a new product or feature is introduced, it is critical for it to connect with the utility's customer-information system and customer-service system in real time. Imagine how frustrating it is for a customer who is moving to change her address on the utility's website, only to call its call center sometime later and be advised her old address is still on file.

Execute in an agile fashion

Many companies are adopting agile methods to pursue CX transformations in technology and nontechnology areas alike. That means getting cross-functional teams to work iteratively to implement ideas quickly, rather than spending years developing a new journey in a big-bang once-and-for-all effort. Capturing early wins shows both customers and the rest of the organization that change is possible and can be implemented at speed. And demonstrating the value that flows from better journeys will win over any leaders who are still skeptical of the value of CX and help build support in the organization for future efforts.

Measure progress

To build a culture of continuous improvement, leading companies set clear aspirations and establish metrics to track performance and impact. These metrics should measure both customers' satisfaction with journeys and the operational indicators that underlie each journey. Some businesses are using measurement platforms for this job, but it's important to ensure customer insights as well as operational performance are used to steer the business.

By measuring results continuously and making data available to the teams who touch the customer experience, utilities have attained a greater level of agility that allows them to make operational adjustments in close to real time. A tactic that one utility implemented was to place customer-satisfaction metrics on the executive dashboards of top managers throughout the organization and to adjust compensation for the whole company when results dipped below the benchmark. This reinforced the idea that customer experience was everyone's responsibility and everyone's business.

■ ■ ■

Like others before it, the utility industry is under pressure to deliver a better customer experience at a lower cost. With customer expectations rising and new enabling technologies continuing to emerge, customer transformations can never be over. Companies must be prepared to adapt and refresh their offerings and processes, time after time. Utilities that take an agile, digitally informed, and design-based approach to this constant renewal will deliver a better customer experience that helps them thrive in the coming era of energy choice. ■

[1] The survey, conducted in 2015 to 2017, included more than 12,000 respondents who were customers of 100 North American utilities. The research is structured to isolate the key drivers of customer satisfaction in specific customer journeys and customer processes.

Aaron Finegold is a consultant in McKinsey's Los Angeles office, **Scott Perl** is a partner in the Washington, DC, office, and **Alfonso Pulido** is a partner in the San Francisco office.

Why utility boards should care about IT architecture

Many utilities struggle to match the customer and commercial expectations set by digital leaders. Investing in faster, more flexible IT architecture can accelerate their digital modernization.

Eelco de Jong, Anand Mohanrangan, Aditya Pande, and Parker Shi

Digital companies make decisions using real-time data from many sources, reconfigure processes to meet new customer needs, deploy new functionality every few weeks, and update systems every few days. Imagine how a utility with these capabilities could respond to a power outage. Using live operational metrics, meteorological information, drone images, customer data, and social-media feeds, it could warn customers in advance about likely outages, dispatch crews before the event, and issue regular updates on when power will be restored. Should an outage be widespread or protracted, the company could scale systems seamlessly and maintain outage services flawlessly.

This probably sounds like science fiction to an executive at an average utility with IT systems dating back decades. Those systems will have grown bigger, more cumbersome, and harder to maintain over the years, with millions of lines of custom code written in legacy programming languages such as COBOL by developers who have long since moved on. For the many utilities that have undergone M&A, the blending of IT systems will have created yet more complexity. And when the stormy season arrives, it can bring unplanned disruption to utility business services that are critical for managing customer outages. Little wonder that leaders battling so much uncertainty are on edge, hoping that systems stay on.

Serving customers better will inevitably mean updating this IT architecture. But replacing a whole stack of legacy systems is costly, slow, and risky. Fortunately, digital innovators have shown there's a better way, one that delivers rapid impact and more long-term business value at lower risk.

Five inconvenient truths that hold utilities back

The challenges utilities face are similar to those tackled in recent years by banks, telecom operators, and retailers, among others. Taking lessons from their experience, we describe five inconvenient truths that hold utilities back—and suggest how to address root causes and secure long-term impact.

Inconvenient truth #1: It doesn't make sense to replace one dinosaur with another

Responding to customer and industry trends, many utilities are investing in new websites, field-force functionality, CRM tools, and the like. These usually involve a one-shot replacement of a legacy system—a customer-information system, an outage-management system, or some other piece of IT infrastructure. But the trouble with replacing millions of lines of legacy code with an equivalent system in a modern language is that it simply saddles the utility with another dinosaur a decade down the road.

Research we conducted in collaboration with the University of Oxford shows that these big-bang programs, however effective they may be for engineering projects, are highly risky when it comes to IT. Among a cross-industry sample of 2,175 IT projects, including 452 costing €10 million or more, 64 percent suffered cost overruns and 78 percent overran their schedules (Exhibit 1).

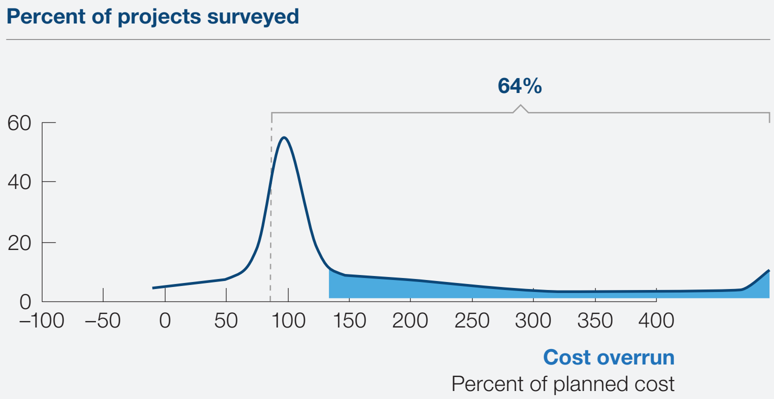
Soon after one Asian bank replaced its legacy system with a comprehensive platform from a vendor, it hit a problem. It wanted to re-engineer customer engagement in the branch, but its teller system and middleware couldn't accommodate the changes, and seemingly simple enhancements, such as adding more currencies to the trading system, could cost a year of effort. Even as the bank identified more and more needs its system couldn't meet, it had to spend more and more to keep the platform operating. Eventually, after having invested more than $1 billion in a system expected to last decades, it decided to start again from scratch. This time it opted for a modular approach, with systems that could be designed, piloted, refined, launched, and updated separately without knock-on effects for other systems or parts of the business.

Exhibit 1 **Major IT projects often suffer cost and schedule overruns.**

Sample: 2,175 projects, including 452 worth more than €10 million[1]

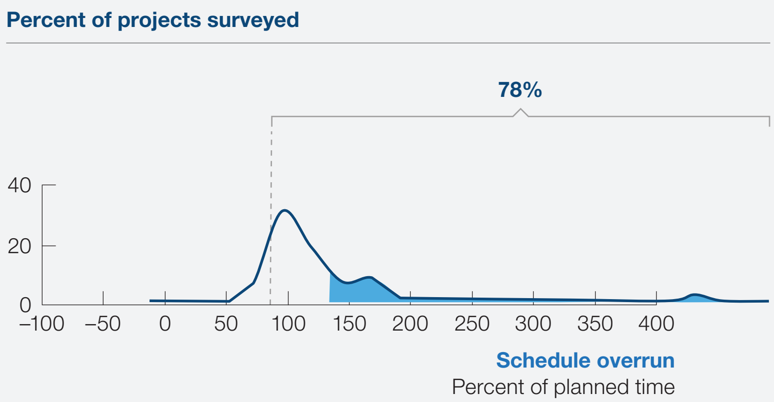
Black swans

Cost overruns



For projects >€10M:
- Nearly 2 out of 3 face cost overrun
- Average overrun: 78%
- 25% are >50% over budget (black swans)

Schedule overruns



For projects >€10M:
- 78% face schedule overrun
- Average overrun: 35%
- 24% are >50% over budget (black swans)

One of the advantages of a modular approach is that a utility can test and release hundreds of lines of code at a time instead of millions. This takes some of the complexity out of software development and allows new hires to become productive much earlier. Instead of spending months familiarizing themselves with the system, they can focus on a few micro-services and get to work straight away.

Admittedly, a modular approach does make the technology architecture itself more complex: instead of one system, you now have many. And as organizations speed up their adoption of new technologies and try to be more agile and open, that complexity will continue to increase. However, as leading organizations are finding, the risks and costs are manageable and easily outweighed by the business value delivered by an accelerated rather than big-bang approach to IT architecture modernization (Exhibit 2).

Inconvenient truth #2: Opportunities to create business value are often overlooked

Utility leaders tend to operate their IT systems like their physical assets. They plan for a year, build for three, run the new entity for decades until it falls apart, and then replace it, aiming to recoup the cost over five to ten years. The trouble is that a replacement system created in this way will reflect old ways of doing business and miss the opportunity to harness new technologies to simplify processes and embrace new possibilities.

Moreover, utilities are all too often content to cover the cost of their new system instead of aspiring to generate twice or three times as much in new value. By adopting a more radical and ambitious vision, they could improve not only the efficiency of their operations and the stability of their legacy systems, but customer satisfaction as well, enabling them to capture additional business value from new revenue streams. The greatest benefits come when this value is of board-level relevance—such as a lift in customer satisfaction or a drop in outages—and when it is captured not after a six-year program, but six months into a project and regularly thereafter.

Smart utilities start by identifying key business outcomes—game changers—and assessing the value they drive. Then they work out which capabilities they need to realize these outcomes, which ones are missing, and whether the gaps are best filled by processes or technology. Finally, they identify the minimum viable set of IT changes needed to deliver the desired results.

This approach allows utilities to make progress while identifying areas that need deeper changes: rewriting some bits of legacy COBOL functionality as microservices, for instance, while flagging others for longer-term replacement. In the old days, this would have involved collecting thousands of business requirements and spending years developing solutions; now it's about IT and the business working closely together to build functionality incrementally and keep it aligned with strategic value.

Exhibit 2 **An accelerated approach to IT architecture modernization can deliver significant value.**

Sources of value from an accelerated approach

Category	Examples of impact achieved
Improve effectiveness	• Improve conformity to service-level agreements • Reduce the most severe incidents by 50%+
Improve efficiency	• Reduce spend on core maintenance by 10–20% • Reduce time to market for simple changes from months to weeks or days
Reduce risk of modernization efforts	• Avoid the cost and scheduling risks of a typical mega project
Enable technology evolution	• Reducing investment in core IT allows increased spending on initiatives to grow the business, from 20% to almost 40%

Inconvenient truth #3: Firefighting by heroes compensates for structural challenges and weak business engagement

At most utilities, the IT people who have been around longest know the most. They probably built the legacy system and have operated it ever since. They know how to make just about anything work, how to resolve technical issues in the most expedient way, and what shortcuts to take to meet aggressive deadlines from business leaders. For these heroic efforts, they are justly recognized across their organizations.

But however effective this firefighting may be, it tends to obscure fundamental issues such as weak technology processes, poorly disciplined change management, the build-up of multiple overlapping technologies (in integration layers, for instance), and the presence of numerous emergency shortcuts (such as direct reads to a core-system database

Exhibit 3

Cultural issues can impair an organization's ability to build and operate systems reliably.

Quotes

"Some people are insecure or don't feel they trust their peers."

Key observations

- Teams look to deflect accountability for system-wide issues
- Unclear ownership of data and middleware

Quotes

"We find a problem but no one investigates the root cause"

"Once we throw it over the wall it's their responsibility"

"There are standards at the enterprise level, and the BU architects feel that there are standards for their BU. And sometimes these can be at odds"

Key observations

- Teams look to deflect accountability for system-wide issues
- Unclear ownership of data and middleware

Quotes

"Whenever there is a system outage, everyone jumps on a bridge and we do whatever it takes to solve the problem"

Key observations

- When system outages occur, teams revert to an "all hands on deck" approach
- No proactive steps are taken to prevent system disruptions

Quotes

"My system was fine during the hurricane"

"It gets down to what group you are in, rather than guiding principles"

Key observations

- Owners are concerned about showing that their system didn't cause failure rather than working together to prevent issues

The culture feedback loop leads to a highly siloed organization that impedes change and slows defect resolution.

to check for payment status). Over time, issues like these increase the fragility of the legacy system and the cost of replacing it. Often the root cause of such issues lies in a tendency for IT to accommodate every business request that comes its way without highlighting the technical complexities involved or proposing simpler alternatives. Another common cause is cultural shortcomings such as a lack of accountability and a siloed IT organization (Exhibit 3).

Many organizations believe that a major system change is the answer to problems like these. Yet system changes rarely address underlying IT processes or change the middleware that integrates core systems with channels and other systems. Organizations that tackle this challenge successfully tend to take a multipronged approach. They set up teams to upgrade middleware and data-access layers and replace the legacy system with a consistent set of technologies based on the latest thinking about scalable and flexible technology design. They also strengthen key technology processes to ensure that the organization reduces errors in running and operating systems.

Inconvenient truth #4: Running legacy systems and designing new architecture require different skills

While legacy IT talent's understanding of business processes and the working of the old system will be invaluable in developing the new one, it won't be enough. That's because modern approaches to system development, such as distributed databases and concurrent read/writes, aren't compatible with the best practices these seasoned experts deploy to maintain legacy systems.

So utilities need to find a way to keep their old hands on board while introducing new thinking and call out blind spots and unconscious biases. Bringing in an external hire with recent architecture experience can help strike the right balance between skepticism and a can-do attitude. Another proven approach is to team seasoned IT staff with young hires fresh from digital companies. One utility hired recent graduates and paired them with experienced legacy-system developers who supported them through a year of classroom and on-the-job training. Within six months, the new hires were able to address issues independently; after two years, they worked as developers in their own right. The approach also freed up seasoned experts to help with implementing new systems.

Inconvenient truth #5: Architecture transformation hasn't yet made it to the top of the CIO's agenda

Architecture is the outcome of the tough—and sometimes irreversible—choices that technologists make in designing a system. It's often criticized as too visionary, out of touch, and difficult to implement or, conversely, as too tactical and focused on current transactional needs. Tight deadlines frequently force project managers to take shortcuts they plan to remediate later but never do. And so the technology "debt" mounts ever higher.

To make matters worse, architecture functions are notoriously understaffed, and report far too low down in the IT organization—typically two or three levels below the CIO. It's hardly surprising, then, that modernization plans are rarely ambitious and seldom make it onto the agenda of the CIO, let alone the executive team or board. But this must change if companies want to move forward. In particular, the CIO needs a detailed understanding of architecture needs and gaps, a ring-fenced budget, and a SWAT-style team to make things happen.

One retail CIO elevated IT architecture to report directly to him. He got enterprise and project architects working together to ensure new systems were properly implemented and set aside an annual budget to fund modernization and pay off the technology debt. Updating IT architecture is like doing preventive maintenance at a power plant: if it doesn't happen, the plant will collapse.

These inconvenient truths should ring bells for most utilities, but they need to be aware that some large retail utilities, especially in Europe, have already recognized the challenges and made great strides in modernizing their technologies. Having done so, many quickly realize that they need to address regulatory constraints that may require an even bigger rethinking of their technology platform.

The digital modernization journey

Having learned from these inconvenient truths, utilities should be ready to plan their digital modernization. The CIO will need to set up a SWAT-style team to drive execution and rapid decision making, with a leader who is a direct report. Another vital step is to enhance governance and discipline around key IT processes, such as change and release management and infrastructure design. Third and last, the CIO will need to develop a business case and roadmap of changes that can be shared with the business. This roadmap is best planned in three phases:

Phase 1: Pilot journeys and 'hot spots' to capture early wins and gain credibility

In this phase, the utility takes one business process—ideally from a customer-facing journey such as payment—and brings in a small "business + IT" product team comprising process owner, designer, IT architect, engineers, and data scientists, supported by experts in agile, cloud, DevOps, and cybersecurity. The team quickly extracts functionality for the process from legacy systems and rewrites it as services on a modern integration layer, creating API end points to the legacy system where applicable.

We've found that many of the near-term issues caused by poor architecture can be addressed by focusing on a handful of "hot spots." Taking this more tactical approach can create early wins and earn the credibility needed to proceed with longer-term initiatives. Some of the hot spots we've seen companies tackle in this way include simplifying multiple middleware systems, creating scalable data stores to improve access to customer and outage data, and testing performance under storm conditions to develop better approaches to system resiliency.

Phase 1 demonstrates the value that can be created at speed through targeted architectural changes. The limited scope of each release means it carries much lower risk and allows utilities to commit funding in much smaller increments of, say, \$5 million to \$25 million.

Phase 2: Scale up journey implementation and replace selected systems

Once the utility has learned from the pilots and demonstrated early wins, it's time to address journeys that can be modernized without replacing the legacy billing and calculation engine. The first step is to identify elements of the architecture that are fit for purpose or modifiable, and then build on them to deliver customer journeys and functionality in the short to medium term. This effort will also highlight legacy elements that are difficult to modify or need rebuilding from scratch. Targeted changes such as creating a data lake can often unlock value quickly and create capabilities that will still be needed when the new system is implemented.

In parallel, the utility identifies the technology needed to stitch together all the journeys and new modules being delivered. This integration layer may include functionality for microservices and workflow and a business-rules engine. The utility also isolates the core transaction system so that it can, if necessary, be replaced more easily in phase 3. By the end of phase 2, the utility should have a short- to medium-term roadmap that specifies milestones, dependencies, sequencing, and duration for all planned activities.

Phase 3: Extend the transformation to the core transaction architecture

Many customer journeys and processes will by now have been implemented in a separate layer on top of the legacy billing and calculation engine. Sometimes, though, this engine has constraints that can't be addressed during phase 2, such as an inability to support net metering or time-of-use rates. So it's worth examining whether there is still value to be captured by replacing it, and if there is, building the business case.

That involves planning the phasing in of the replacement, taking into account the size of the customer base, the demand for new functionality, the need for customer education, and the complexity of testing and migration. Though still a significant undertaking, this replacement will be far less complex than a big-bang replacement would have been. Much of the remaining legacy back end will already have been decoupled from other systems while APIs were being built and functionality was being extracted into services. The separation between systems allows new customer-facing functionality to be delivered even while the back-end system is being replaced, taking much of the time pressure off the modernization effort.

Key questions to help CIOs get started

Answering these questions will help IT architecture replacements get off to a good start.

- How well defined are the nonfunctional requirements of key business processes? How do major projects address them?
- How do business requirements drive technological complexity?
- How mature are key IT processes? How do inconsistencies in them contribute to issues with system stability?
- What are the hot spots in the technology landscape, from architecture to infrastructure? How do they affect stability and flexibility? Are they being addressed through major projects?
- What are the gaps between system design and actual usage?
- How does the culture of the IT organization enhance or hinder the modernization and maintenance of a reliable technology architecture?

Replacing legacy architecture is one of the biggest technology challenges a utility can face. Adopting a modular approach doesn't only help reduce risk and improve returns; it also builds an organization's capability to deliver other systems and positions it to succeed in a digital era.

Eelco de Jong is a partner in McKinsey's Charlotte office; **Anand Mohanrangan** is a senior expert in the Silicon Valley office, where **Aditya Pande** is a partner; and **Parker Shi** is a senior partner in the New Jersey office.

What every utility CEO should know about blockchain

Blockchain technology can streamline transactions along the utility value chain. Here is a look at six emerging applications.

Kimberly Henderson, Matt Rogers, and Emily Knoll

Bitcoin has attracted wide interest in recent months, but it's blockchain—the technology that underpins bitcoin and other cryptocurrencies—that has the potential to remake important aspects of the utility industry. Leading utilities have begun to ask how they could take advantage of these uses while withstanding threats from blockchain-enabled challengers. The emergence of blockchain introduces a new measure of uncertainty at a time when the industry is changing rapidly due to renewable and distributed energy, energy efficiency, energy storage, and digitization.

Blockchain technology could provide the infrastructure for sophisticated networks that manage payments, sales, trading, and distribution (Exhibit 1). Given their potential to streamline transactions and cut costs, blockchains and smart contracts could help to remove pain points and friction throughout the power value chain (see sidebar, "Blockchain 101"). That said, blockchain technologies are still in their infancy, and questions remain about security, scalability, and governance.

In this article, we look at six ways that energy players are beginning to use these technologies, and we consider the prospects for blockchain's development within the industry.

1. Issue and trade renewable-energy certificates

Renewable energy certificates (RECs) are currently given to solar producers based on generation

Exhibit 1 **Blockchain technology can coordinate traditionally centralized data flows throughout the power system.**

Generation	Transmission and distribution	End user

Generation	Transmission and distribution	End user
Secure power generation and supply data transcribed to blockchains allow for visibility, security, and accuracy.	**Wholesale power is traded via smart contracts** that minimize the need for brokers and indexing agencies.	**Real time customer-utility interactions** facilitate faster payment cycles, more efficient energy use, and streamlined account management.
Renewable energy credits based on actual production are semi-autonomously awarded and traded.	**Blockchain-enabled sensors and controls** allow for secure, centralized data and improved grid resilience.	Peer to peer microgrids run autonomously, with **blockchains managing contracts for energy flows and instant payments.**
		Electric vehicles seamlessly connect with infrastructure executing transactions through 'smart wallets.'
		Smart home appliances coordinate electricity purchase and use with the grid, promoting grid efficiency and extending appliances' useful life.

Blockchain 101

In a conventional transaction, institutions such as banks and utilities centralize the flow of information. These intermediaries provide the security, transaction integrity, and official certifications that allow contracting parties to create value. Companies with scale and strong enterprise-software IT platforms have an advantage.

Costs associated with intermediated transactions, however, can create inefficient markets. For example, institutions use their own accounting systems and must reconcile entries with counterparties. This creates the possibility of error and dispute in the absence of a common real-time view. Additionally, relatively high operating costs can preclude smaller or less liquid vendors from participating.

Blockchain technology remedies these inefficiencies by enabling parties to transact directly using digitally encrypted, decentralized ledgers. Identical copies of the ledgers are shared and viewable by all members of the network, and a consensus process is used to agree on additions. The database itself can be used to confirm identities, apply time stamps, conduct transactions, and create records. So-called smart contracts can also be set up on a blockchain to execute processes according to predetermined rules.

By establishing an indelible "golden copy" of asset provenance and transaction history, these capabilities minimize the potential for fraud and for legal disputes over whether contracts have been fulfilled. Once a transaction is validated, it cannot be changed or removed. Since this permanent ledger is stored on each node of the network, no single member can tamper with the ledger. In this way, blockchain is both transparent and secure.

In a public blockchain like bitcoin, the validation process is based on game-theory concepts and theoretically prevents single or multiple validators from controlling the ledger. Computational power is used as a kind of validation currency, and several "miners" work to solve a highly complex math problem that validates the transaction and adds it to the blockchain. Blockchains can also be private—accessible only to invited members and validated by administrator(s) or a semi-autonomous guiding algorithm. Public blockchains are truly open disintermediated networks, but private blockchains are often used to coordinate closed networks holding sensitive information. These private blockchains will likely be the prevailing means for storing disintermediated energy information like meter and payment data.

estimates and forecasts rather than on actual generation. Inaccuracies could be reduced using sensors paired with smart contracts that record data to a blockchain ledger and issue or trade RECs based on actual energy produced. There is no need for a central agency to verify generation data or work through costly and inaccurate estimates because accurate data is instantly viewable and actionable on the secure ledger. Blockchain can reduce costs for public agencies administering RECs by streamlining trade verification and data indexing.

Companies such as Volt Markets (an energy origination, tracking, and trading platform powered by smart contracts on the Ethereum blockchain), solar-panel designer Ideo CoLab, sensor maker Filament, and exchange operator Nasdaq are experimenting with services that allow power generators and others to sell certificates arising from energy generation. Ideo CoLab, for example, has integrated its capabilities with Nasdaq's Linq platform as well as Filament's hardware—which uses digital sensors with blockchain capabilities—to issue RECs to producers for each kWH their solar panels generate, enabling even small solar producers to easily track, prove, and trade power.

2. Enable peer-to-peer power generation and distribution through microgrids

Blockchain technology's relatively low transaction costs allow smaller energy producers to sell excess energy, thereby increasing competition and grid efficiency. Smart contracts facilitate the real-time coordination of production data from solar panels and other installations, and execute sales contracts that allow for two-way energy flows throughout the network.

The State of New York, for example, is working to rebuild its power grid as a distributed platform, leveraging a framework that allows power companies and new entrants to collaborate. Start-up LO3 is using the Ethereum blockchain to allow consumers to buy power either directly from local producers or from a microgrid that sits on existing infrastructure. Brooklyn Microgrid, a project supported by LO3 and Siemens, is working to create such a microgrid in the New York City borough of Brooklyn (Exhibit 2). Blockchain-enabled metering allows power to be exchanged between members of the microgrid without a centralized authority or expensive infrastructure to manage flows. Members can control their energy-use preferences with a mobile app or smart-home system; their blockchain meters will purchase energy from solar owners based on preset cost preferences.

3. Electrify undeveloped markets

Many regions around the world have limited access to energy. Blockchains, combined with smart financing schemes, mobile applications, and digital sensors, can help distribute energy in small, discrete packets in these regions, allowing a local owner of a solar-generation system to sell power to neighbors. The solar-system owner installs a blockchain-enabled solar panel on credit from the installer, using a mobile phone to pay for the hardware in installments and incurring minimal fees. Once the solar installation is paid for, the owner can sell small, discrete amounts of solar power to nearby consumers as they need energy. Power requests and payments can be made via mobile phone. The lighter fixed infrastructure involved with blockchain and mobile micropayments allows these networks to thrive where other infrastructure—wires, traditional loan structures, and centralized energy authorities, for example—would be too cumbersome.

In one pioneering social initiative, the crowdfunding platform Usizo connected to blockchain-enabled smart meters in underfunded South African schools so that donors can pay the school's electricity bills. Blockchain-based payments allow donors to ensure that 100 percent of each donation is used for its intended purpose. Similar methods can be used to provide electricity to new or underserved markets. M-PAYG, a Danish company, provides prepaid solar-energy systems to people living below the poverty line in developing markets and is leading a major project to electrify Uganda's largest refugee camp.

For the power industry, the result is more individuals with power access and an increasing number of microgrids to support the main grid infrastructure. Owners of small solar-generation systems gain access to new income streams.

Exhibit 2 **Create peer to peer microgrids powered by local producers and run by smart contracts.**

Solar "prosumers"—entities who produce and consume grid energy—and **local consumers set up a solar microgrid**

Participants install **blockchain-enabled smart meters** that track energy usage and generation

A **mobile application** enables members to **track their energy usage and trades on the microgrid**

Prosumers **produce excess energy** at certain points in the day

Blockchain meters match excess energy to consumption nodes, automatically generating smart contracts based on users' price preferences

All **transactions are recorded accurately** and permanently in the blockchain leger, which is **viewable on the mobile app**

Potential impact on power industry

Lower barriers to entry for small prosumers to sell excess energy	More efficient power allocation based on real time demand	Greater grid resilience to emergencies and blackouts by diversifying power sources at the edge of the grid	Limited role of centralized trade exchanges and trade verification agencies

4. Enable real-time transactions to balance supply and demand

As solar and wind energy scale, power markets are increasingly challenged to balance supply and demand. Power supply was once provided by mostly "on call" or dispatchable sources of energy, such as coal and gas generation. In many markets, power supply varies with the wind and the sunshine. This has created demand for new "flexibility" services, to either adjust power demand to better match supply, or compensate backup sources of supply that can respond quickly in times of shortage.

The Northern European transmission-system operator TenneT has launched pilots in Germany and the Netherlands to use blockchain technology to provide such flexibility services to the grid. TenneT's pilots integrate storage assets, from electric cars and household batteries, into power markets.

UK-based Electron is using blockchain to develop a platform for a flexibility marketplace, to allow real-time transactions to balance power supply and demand. This has been dubbed an "energy eBay," as it opens up participation in power markets. The trading platform would compensate consumers for adjusting their energy consumption, encouraging higher consumption in periods of high renewable power supply and lower consumption in periods of relatively low supply. It allows power generators and storage providers to transact in response to real-time price signals.

The flexibility marketplace leverages a blockchain-based asset register that Electron has been developing over the past two years. The register does not require a central coordinator and aims to ultimately allow for direct transactions between all included assets, such as smart-home technologies.

5. Manage infrastructure in real time

Blockchain can enable more efficient monitoring and maintenance of power-industry infrastructure, based on secure, real-time data communicated by sensors. If an anomaly is detected, maintenance can be facilitated and paid for by smart contracts, leading to faster response times. Data is secure because it is only available to nodes in the blockchain network. Again, blockchain adds a layer of security and coordination to current digital pilots, enabling quick, accurate data gathering and communication between hardware suppliers, utility maintenance, and emergency response teams.

6. Connect electric-vehicle charging stations

In transport, blockchain offers opportunities to coordinate electric-vehicle (EV) charging. Blockchain facilitates energy payments at charging stations, allowing EV drivers to view maps of the charging network that highlight choices based on each user's preference and real-time pricing data. If blockchain microgrids have been set up in the area, power prices at each station can be established by grid and residential power suppliers. Drivers can pay securely and instantly using a blockchain wallet.

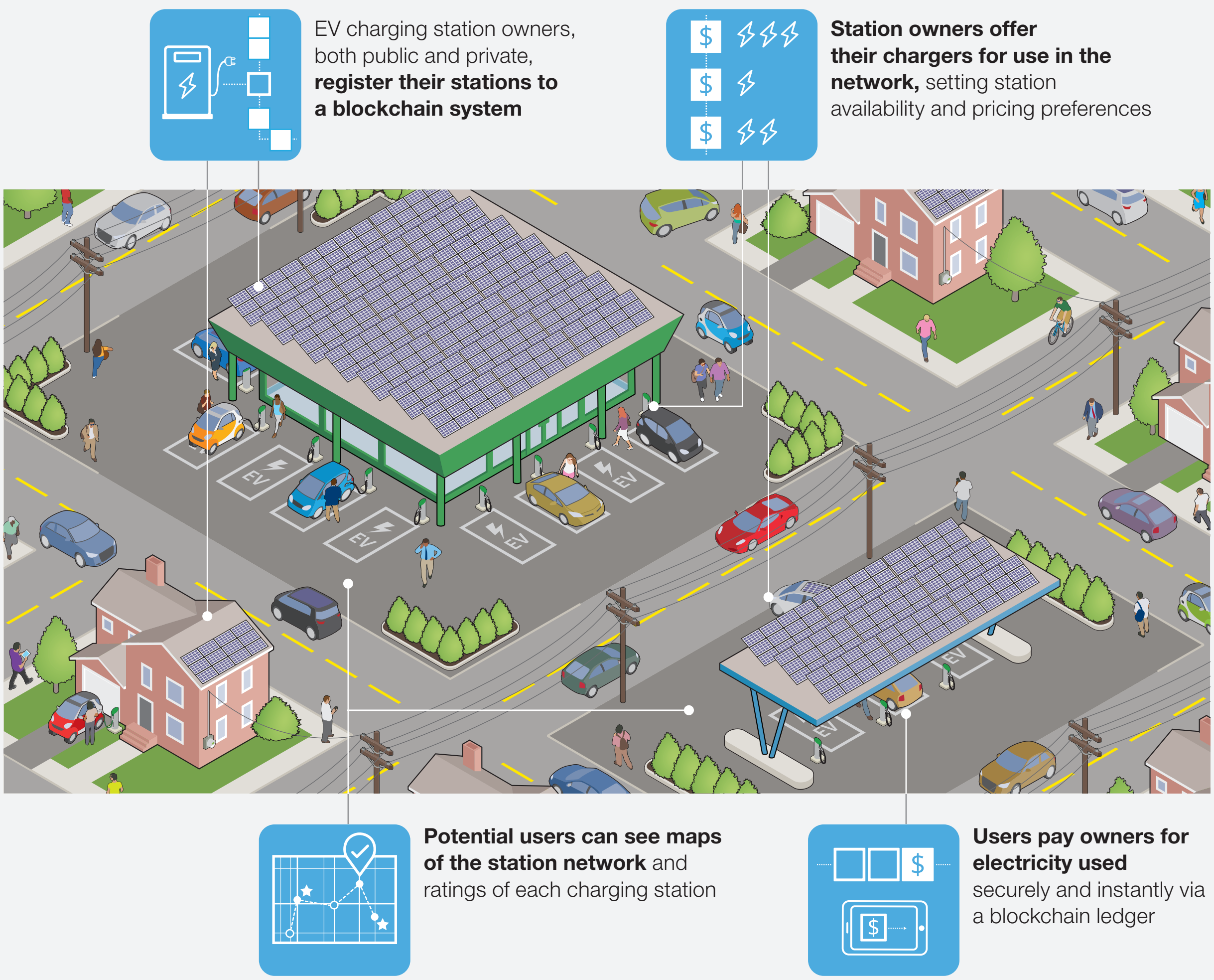
By facilitating a larger and more efficient charging network, blockchain can catalyze faster adoption of electric vehicles. Blockchain coordinates the charging-station network autonomously, showing drivers where nearby stations are located and how they are being used (Exhibit 3). Smart contracts allow for automatic, secure, peer-to-peer energy payments. In Germany, Share&Charge is an app based on Ethereum technology that connects electric cars with available residential and commercial charging stations and facilitates payments. The technology has also been piloted in California using eMotorwerks' JuiceBox EV chargers.

The future is uncertain, but some are taking a lead

For utilities, blockchain is a double-edged sword. New challengers can use blockchain to displace incumbents, but incumbents that use blockchain wisely stand to realize substantial benefits.

By applying blockchain to their vast stores of data, utilities can unlock new revenue streams from better-coordinated markets, "smarter" hardware, and wider electrification. And all of this activity will depend on solving some of the problems that could prevent blockchain technology from being used at scale (see sidebar, "Overcoming early hurdles").

Exhibit 3 **Connect EV charging stations to nearby drivers to optimize pricing.**



Potential impact on power industry

Larger, more efficient EV charging station network	Faster adoption of EVs due to greater ease of use	Helps flatten the demand curve and alleviate power pricing issues, increasing energy used at midday

Overcoming early hurdles

While blockchain has the potential to transform transaction-based networks, several characteristics of the technology must first be resolved. The challenges listed below are three of the early hurdles blockchain must overcome in order to scale.

1. **Energy use:** As public blockchains (like bitcoin) grow, they require increasingly complex validation methods and more validators, which results in multiple miners working on the same high-energy validation. The amount of computing power, and therefore energy, required to validate each transaction also increases. Experts are experimenting with new ways to grow these public blockchains more efficiently. However, this is not a challenge for all blockchains. Private blockchains that use administrators instead of miners to validate transactions do not encounter this problem and are able to execute faster transactions with minimal energy use.

2. **'Off-chain' security:** Although blockchains themselves have never been hacked, off-chain fraud may be as rife as ever. In July 2017, for example, a hacker stole $31 million of the popular cryptocurrency Ethereum. This theft exploited a vulnerability, not in the blockchain itself but in the encryptions that protect each member's secure key. Still, recent hacks prudently demonstrate that a network employing blockchains can be manipulated if improperly guarded.

3. **Governance:** A lack of blockchain procedures and global regulation also means that the procedure for disputes, wrongdoings, and transaction reversals is inconsistent and legally uncertain. It is still unclear how decentralized networks will be treated in a largely centralized world, but some blockchain investors and developers have prioritized working with governments to ensure blockchains are regulated thoughtfully and collaboratively.

Many utilities have started to assess the potential of blockchain technology to create both internal and industry-wide efficiencies. Some have gone a step further and launched pilots in such areas as trading, distribution, and data management. Europe has emerged as the leading region for blockchain innovation, with companies launching a range of initiatives. RWE is piloting an electric- vehicle charging-station network based on smart contracts, while Vattenfall has launched a pilot peer-to-peer energy-trading network. In Asia, energy manager and power-marketing company Eneres is partnering with Aizu Laboratories to launch a peer-to-peer network. Development in the United States has tended to be led by players outside the power industry, including the Department of Energy.

Blockchains enable "trustless" transactions ruled by incorruptible algorithms and free of intermediaries, governments, and industry watchdogs. There are not yet consistent, coordinated rules for markets based on the technology, but standard-setting efforts are ramping up. The Energy Web Foundation (EWF), for example, which comprises more than thirty affiliates around the world, is working with regulators and technology providers to catalyze technological and regulatory advances. EWF's goal is to support development and create open-source blockchains with common standards and features specific to the energy industry. Additionally, energy-specific forums, such as China's Wanziang Blockchain labs and Endesea Blockchain labs, host summits and challenges aimed at helping standardize processes and catalyze solutions.

Conclusion

Even in this initial phase of commercial pilots, there is clear potential for blockchain technology to catalyze current disruptions transforming the power industry. Equally clear is that some stakeholders will benefit, others will see their business models change, and others could lose out. Among the former group are likely to be consumers, owners of solar-generation systems, microgrid participants, electric-vehicle owners, and others whose energy use involves the Internet of Things. Utilities and equipment and device makers may see their roles evolve, while the impact on exchanges, information providers, and administrators may be more disruptive as they are replaced by automated processes.

As the technological playing field takes shape, a diverse range of opportunities should appear for power-industry participants. For companies taking a medium-term view, that means acting now to put in place the strategic tools to respond to blockchain. Utilities should consider how it might create either a competitive advantage or risk of disintermediation. Utilities that participate in collaborative blockchain consortia and understand the risks and opportunities of the technology will be better prepared to act when the time is right. ■

Kimberly Henderson is an associate partner in McKinsey's Chicago office, **Emily Knoll** is a consultant in the Michigan office, and **Matt Rogers** is a senior partner in the San Francisco office.

The authors wish to thank Anton Derkach, Alfonso Encinas Fernandez, Matt Higginson, Ian De Bode for their contributions to this article.

Illustrations by Vic Kulihin.

Cloud adoption to accelerate IT modernization

The cloud is a means, not an end. Success in modernizing IT through the cloud is driven by a complete standardization and automation strategy.

Nagendra Bommadevara, Andrea Del Miglio, and Steve Jansen

Cloud-computing adoption has been increasing rapidly, with cloud-specific spending expected to grow at more than six times the rate of general IT spending through 2020.[1] While large organizations have successfully implemented specific software-as-a-service (SaaS) solutions or adopted a cloud-first strategy for new systems, many are struggling to get the full value of moving the bulk of their enterprise systems to the cloud.

This is because companies tend to fall into the trap of confusing simply moving IT systems to the cloud with the transformational strategy needed to get the full value of the cloud. Just taking legacy applications and moving them to the cloud—"lift-and-shift"—will not automatically yield the benefits that cloud infrastructure and systems can provide. In fact, in some cases, that approach can result in IT architectures that are more complex, cumbersome, and costly than before.

The full value of cloud comes from approaching these options not as one-off tactical decisions but as part of a holistic strategy to pursue digital transformation. Such a strategy is enabled by the standardization and automation of the IT environment through an open API model, adopting a modern security posture, working in an automated agile operating model, and leveraging new capabilities to drive innovative business solutions. While cloud is not a prerequisite for any of these features, it does act as a force multiplier. Companies that view cloud capabilities in this way can create a next-generation IT capable of enabling business growth and innovation in the rapidly evolving digital era.

Lift-and-shift is not enough

Cloud services such as Amazon Web Services (AWS), Microsoft Azure, and Google Cloud appeal to many organizations because of their stated features: pay-per-use, ability to scale up or down based on usage, high resiliency, self-service, etc. All these benefits are expected to lead to much lower IT costs, faster time-to-market and better service quality compared with traditional IT offerings.

However, traditional enterprises run into two major issues when moving to cloud:

- The existing business applications were created using the traditional IT paradigm. As a result, these applications are typically monolithic and configured for fixed/static capacity in a few data centers. Simply moving them to the cloud will not magically endow them with all the dynamic features of the cloud.

- The typical technology workforce of an enterprise is well versed in developing business applications in the traditional IT framework. Most of them need to be reskilled or upskilled for the cloud environment.

IT security is a good example. Most traditional IT environments adopt a perimeter-based "castles and moats" approach to security, whereas cloud environments are more like modern hotels, where a keycard allows access to certain floors and rooms. Unless the legacy applications that have been developed and deployed for a castles-and-moats security model are reconfigured for the new security model, migrating to the cloud may have an adverse impact on cybersecurity.[2]

Enterprises have been successful in adopting SaaS solutions mainly because SaaS addresses these constraints in a simple fashion: they replace the existing business applications and leave the development of new features to the SaaS provider. SaaS solutions have therefore become very popular for business functions such as marketing and sales, back office (HR), and communication and collaboration. However, in most sectors, there are no mature SaaS solutions for core business functions such as billing for the utilities sector and core/online banking for financial services.

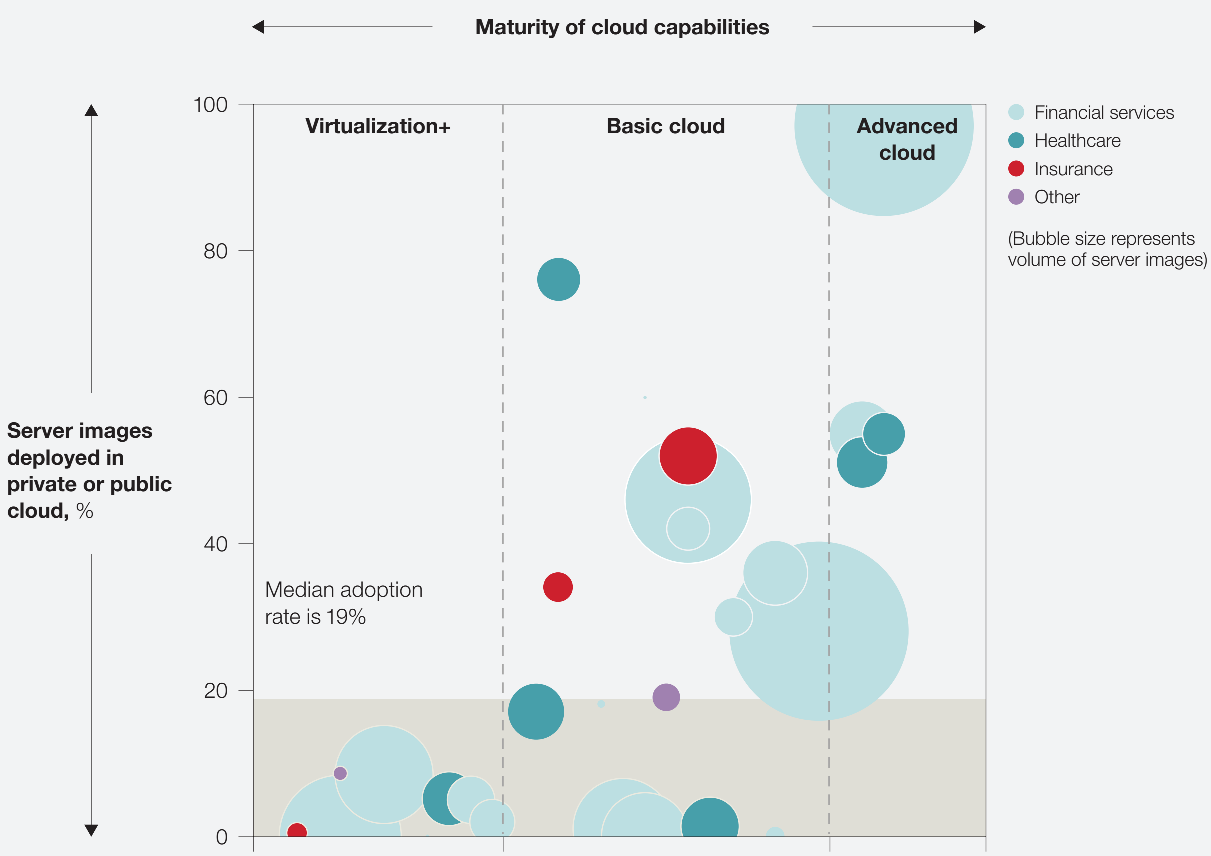
As a result, despite overall increased cloud investment, enterprise cloud adoption is maturing slowly.[3] Many enterprises are stuck supporting both their inefficient traditional data-center environments and inadequately planned cloud implementations that may not be as easy to manage or as affordable as they imagined. While some forward-thinking companies have been able to pursue advanced enterprise cloud implementations, the average enterprise has achieved less than 20 percent public or private cloud adoption (Exhibit 1).

Benefits of automating IT processes through the cloud

Historically, enterprise business applications have been designed to run on custom-configured IT systems, each application requiring its own heavily customized configuration of computer storage and network resources. As a result, IT needed armies of administrators just to keep systems updated and running, to manually add new capacity when demand is high, or apply quick fixes for issues such as low performance. As the number of IT solutions has increased, so has the overhead necessary

Exhibit 1 **On average, enterprise cloud adoption remains low, at around 20 percent.**

Volume of server images deployed, by industry, compared to maturity of cloud capabilities



Source: McKinsey Enterprise Cloud Infrastructure Survey, 2016 for testing, integration, and maintenance. In a typical enterprise, just a fraction of IT personnel is focused on designing and developing the market-differentiating solutions the business cares about; the rest are working simply to keep the lights on.

Standardizing system configurations and automating IT support processes can reverse that ratio. By enabling enterprises to better manage their infrastructures, companies can not only save on costs but also shorten times to market and improve service levels.

Adopting the cloud is a massive enabler of the necessary standardization and automation. With the cloud, companies can:

A tale of an all-in transformation

A Fortune 100 company with a $2.2 billion annual IT spend ($800 million on infrastructure costs alone), was struggling with the cost and complexity of its legacy IT environment. Its IT department was supporting 8,000 applications (including 150 instances of SAP) and 20,000 workloads. Not surprisingly, provisioning was slow. It took more than 45 days to set up a server, and the company knew this was not sustainable.

Consequently, the company invested more than $200 million in aggressive digital transformation. It was a significant effort, but the company achieved a return on its investment in less than four years.

The company first defined its cloud sourcing strategy, grounding it in an aggressive move to a hybrid (public and private) cloud model as public cloud options were still maturing in late 2013. It opted for a single strategic partner for each cloud and recently added a second public cloud partner. It then created a cloud operating model, setting up a new 100-person team working within an agile operations framework.

Then, beginning in 2015, the company began its legacy-remediation work, moving all its applications to a private cloud, heavily incentivizing its application teams. It took an opportunistic approach to upskilling IT: every application team that wanted to use cloud had to go through an in-house training program.

Within the first six months, the company had moved its complex SAP environment to private cloud and adopted a cloud-first policy for all new applications. It replaced expensive colocated contracts and moved its systems to a software-defined data center.

Less than three years in, the company has moved more than 2,000 workloads and two petabytes of data to the public cloud. The company reduced costs by $90 million at the two-year mark and is on track to cut another $60 million. Automation also significantly improved performance and agility. With the transformation on track to completion in 2018, the company is now one of the largest enterprises operating on cloud.

- Reduce IT overhead costs by 30 to 40 percent
- Help scale IT processes up and down as needed, optimizing IT asset usage
- Improve the overall flexibility of IT in meeting business needs such as more frequent releases of business features; cloud providers are increasingly offering much more sophisticated solutions than basic computing and storage, such as big-data and machine-learning services
- Increase the quality of service through the "self-healing" nature of the standard solutions (for example, automatically allocating more storage to a database). We have seen enterprises reduce IT incidents by 70 percent by using cloud computing as an opportunity to rethink their IT operations

Capturing these benefits from cloud adoption requires more than just lift-and-shift when the business-application system configurations are heavily customized and IT processes are mostly manual. It requires a certain level of remediation to make IT systems more cloud-oriented.

Netflix is one of the most public examples of this kind of commitment to and investment in cloud-enabled, next-generation infrastructure. It spent seven years on its transformation, adopting a cloud-native approach, rebuilding all its technology, and restructuring the way it operated. It employed application program interfaces (APIs) to reduce its monolithic legacy applications into smaller components, make them more flexible, and then move them to AWS. As a result, service availability has increased, nearing the company's stated goal of 99.99 percent of uptime. And Netflix has seen IT costs for streaming fall to a fraction of what they were in its own data center.

Recently, many established companies have made aggressive moves to adopt public cloud solutions. Capital One is running the bank's mobile app on AWS; GE Oil & Gas is migrating most of its computing and storage capacity to the public cloud; Maersk is migrating its legacy systems to reduce cost and operational risk while enabling advanced analytics to streamline operations.

Pioneer organizations are also actively seeking ways to leverage the new services on cloud to create innovative business solutions. Progressive Insurance deployed its Flo chatbot on public cloud; NASCAR is leveraging machine-learning solutions on cloud to analyze real-time and historical race car data to improve performance and simulate scenarios.

Even "born digital" companies that initially chose, for strategic reasons, to have their own IT infrastructure and systems are now opting to move to cloud to leverage the scalability and the higher order functionality it offers. Spotify is a prime example.

How to approach the cloud transformation

Fully embracing cloud can have a significant upside but also requires substantial upfront investments in what is often a multiyear journey. For this reason, an all-in transformation approach needs active commitment and a clear mandate from the CEO and board over the long term (see sidebar, "A tale of all-in transformation").

Specifically, there are four key topics companies should address for successful cloud adoption at scale:

1. Decide on sourcing. It's difficult for most companies to build their own cloud technology stack and even harder to maintain it. Partnering with public cloud providers to build and manage the cloud stack is the more typical approach. In most cases, the pragmatic

way to start is with a single cloud service provider while adopting the necessary guiding principles to avoid being locked into one provider. After achieving a certain scale and level of maturity—in our experience, a good rule of thumb is to plan for an annual run rate of $30 million with the primary cloud service provider—an enterprise can explore a second or third service provider for scaling up.

2. Create a public-cloud operating model. Unlike traditional operating models, the public cloud requires IT to manage infrastructure as code. This requires software engineers who understand the compute, storage, and security protocols of public cloud (as opposed to network engineers or system administrators). For most enterprises, this translates to a massive upskilling of the infrastructure organization and the operating model in which they work. Specific teams need to be assigned to configure and manage the production environment.

3. Legacy-application remediation. Existing applications will need to be refactored at the infrastructure and application layers to align with the security and capacity requirements of the public cloud. Security must be baked into these applications, and they must work in a more automated fashion. This requires significant attention from application teams, which can be hard to get.

   Companies can address this hurdle by creating a clear business case for legacy-application modernization, aligning the migration schedule with major application upgrades or replacements, and adopting foundational solutions (such as API frameworks) to make the remediation easier.

4. Cultivating the right skills. Professionals must be able to develop applications on the cloud (specifically on the vendor's system) securely and quickly. To do this, companies will need to hire and train cloud experts and then introduce them into development teams, retrain or upskill the existing workforce, and set up digital-innovation labs as needed with an emphasis on cloud development.

This aggressive approach relies on true commitment from leadership in the form of money (one financial-services business is investing $300 million in a cloud transformation) and time (these programs can take two to three years). That's because, in executing a cloud transformation, multiple things need to happen at the same time. In many cases, for example, a core group of cloud engineers preps for the cloud migration by setting up the cloud environment, hardening it, looking at applications to move, and creating tools for migration. Meanwhile, the main IT team is being trained in how to work in an agile way. This approach has significant management challenges, but with strong leadership, it's the fastest path to transformation.

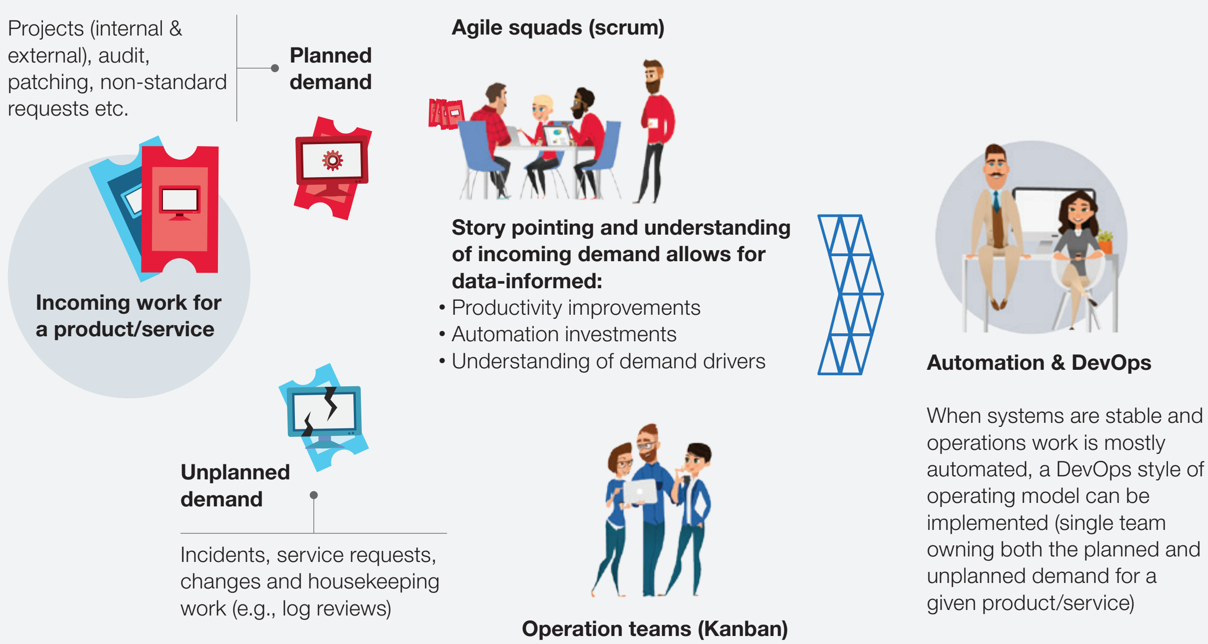
Many enterprises, however, are not yet ready to take the full plunge into cloud, perhaps because organizational buy-in is lacking, or there is a reluctance to invest the required resources in a multiyear effort, or in some cases due to regulatory constraints. These organizations can achieve significant benefits in the short-to-medium term, albeit on a smaller scale, by adopting the cloud's agile and automated operating model within their traditional IT. This approach builds important organizational capabilities and prepares the business for a cloud transformation when it is ready.

Companies have eagerly adopted agile methods for application development and are actively pursuing automation/DevOps (such as continuous integration and continuous delivery), but the same approach can have an even greater impact on IT operations and infrastructure. By organizing the infrastructure function into tribes of small cross-functional, self-directed squads with product owners to prioritize work and scrum masters responsible for removing barriers, IT can prioritize work in ways that increase productivity, quality, and speed. In addition, the continuous automation program, over time, can further infuse cloud-like capabilities into traditional IT, such as APIs for interactions between developers and infrastructure (Exhibit 2).

With the goal of improving service levels and reducing costs, one major life insurance company adopted an agile approach within its 250-person IT operations groups. The company began by assessing the state of its current infrastructure—its core processes, organizational model, metrics and KPIs, and historical demand—and developed a hypothesis about what it might achieve with a more agile approach. It created a leadership program appropriate to agile methods, adopted the necessary tools, and conducted an agile-for-infrastructure boot camp for stakeholders.

Within six weeks, the IT infrastructure group started planning for ongoing projects, conducted training sessions for senior leaders and infrastructure teams, and set a goal for what ongoing operations should look like. It fully leveraged scrum methodology for planned work such as projects, and Kanban, a methodology for managing the creation of products emphasizing continual delivery, for unplanned work such as incidents and service requests. By the end of the second month, the company had achieved the operational model it envisioned and was able to begin designing

Exhibit 2 **The agile/DevOps operating model is proving to be even more applicable in infrastructure than in application development.**



service-management processes and launching automation initiatives.

It completed the initial transformation in six months, cutting IT costs by more than 35 percent and doubling productivity. The insurer plans to automate up to 80 percent of its operations work, driving costs down even further and significantly improving its service levels. Today, it is well-positioned to move more aggressively to the cloud in the future.

The rules of the cloud game

There are many actions enterprises can take that have proved valuable to early adopters of cloud-enabled next-generation infrastructure. These include, but are not limited to:

- Evaluating the current IT portfolio. Before beginning any cloud development or migration, take a dispassionate look at the existing IT portfolio to determine what is suited for public cloud platforms or SaaS alternatives.

- Choosing your transformation approach. Involve all key stakeholders in determining whether your enterprise will be an aggressive or opportunistic transformer.

- Articulating IT and business goals. Create a well-defined set of outcome-oriented aspirations for both the short and long term in line with your approach.

- Securing buy-in. Ensure commitment and investment from senior management, particularly finance leaders, who must support the transfer from capital to operations and maintenance investments/accounting.

- Addressing change management. A heavily automated agile operating model will require significant shifts in IT behaviors and mindsets. Invest in both change management and the development of cross-functional skills across infrastructure, security, and application environments.

- Adopting new KPIs. Measure and reward your technology team for standardization and automation rather than, say, for availability.

By viewing cloud computing as a starting point for IT automation, companies may be able to have it all: scalability, agility, flexibility, efficiency, and cost savings. But that's only possible by building up both automation and cloud capabilities. ■

---

[1] IDC, "The Salesforce Economy," September 2016, salesforce.com.

[2] Forrester, "Benchmark Your Enterprise Cloud Adoption," January 3, 2017, reprints.forrester.com.

[3] The overall cloud security model is more complicated than the above analogy—we are simply making the point on why lift-and-shift is not likely a good strategy for cloud adoption.

Nagendra Bommadevara is a partner in McKinsey's New York office, **Andrea Del Miglio** is a partner in the Milan office, and **Steve Jansen** is a senior digital expert in the Charlotte office.

The authors wish to thank Thomas Delaet, James Kaplan, Pankaj Sachdeva, and Anand Swaminathan for their contributions to this article.

Digital-experience design for the field workforce

By focusing on valuable and meaningful workforce experiences, utilities can move from incremental improvements to transformative ones.

Robert Bales, Adrian Booth, and Lois Schonberger

Digital transformation has become the norm in industries such as banking, healthcare, and insurance. Driven by rapidly shifting customer expectations, organizations in these sectors have turned their operating models inside out, with lean, powerful digital teams delivering customer-centric solutions that have tremendous impact on the bottom line. But what about those left behind—companies with complex physical assets and high-risk operations that depend on a field force to keep things humming day after day? What does "going digital" mean, in fact, for utilities, oil and gas majors, telecommunications companies, and the like?

When you 'go digital' you can choose to optimize or invent

Some companies might have dabbled in digital transformation by picking off low-hanging fruit—via back-office process automation or fleet optimization using GPS data, for example. These low-risk, low-reward interventions might improve efficiency, but they pale in comparison with the disruptive value that digital solutions have delivered in other industries. To catch up, leaders in lagging sectors need to think in much broader terms: not about pursuing individual digital projects or solutions but about reinventing entire business processes from beginning to end to drive efficiency, slash costs, and ensure a safe environment for employees. Work must be redesigned to focus on high-value tasks and eliminate waste, wandering, repetition, and risky practices. Digital tools can help with this, of course. But if a company wants to turbocharge adoption and transformation, it needs to reimagine radically the way it builds and releases solutions.

Too often, companies think up ways to "help" field employees do their jobs better without understanding what these jobs actually entail. Pushing one-off solutions and off-the-shelf applications from the center out to the field, they too often miss the mark while fostering resentment and mistrust. Field employees can become worn down by cycle after cycle of half-baked solutions, each with some minor but annoying tweak in process or paperwork. All the while, these seasoned professionals know better than anyone how to improve their day-to-day work. But no one thinks to ask them nor even how to include them.

So, what is the answer? In short: pair design and digital thinking to get people working together in a broader organizational and cultural transformation. Include field employees in the design process, make them allies, plumb their deep expertise, and think about how they spend their days—not just the actual jobs—to build solutions that field workers not only use but also love. There is nothing revolutionary about focusing on customer experience; it has been key to innovation for some time. It is no secret that successful disruptors, at their core, have a maniacal focus on the customer. The new factor is how it is done: by turning the lens inward toward employees and focusing the *internal* customer experience on value creation. Companies that get it right boost adoption, rejuvenate relationships among employees, and improve productivity, all while delivering products more quickly and cost-effectively.

That result sounds good, but how do you do it? The process of designing great solutions for employees is much the same as doing it for customers, but there are a few important differences and some simple principles to raise the odds of success. Following the seven principles we outline can dramatically improve not only the products field-force employees use but, more importantly, the processes used to design and deliver them. A digital transformation in field-force operations based on such principles helped a utility become one of the most innovative in the world (see sidebar, "How a utility designed field tools that technicians want to use").

How a utility designed field tools that technicians want to use

Building a product-design function at a utility might seem counterintuitive, but one US utility has done just that and seen safety, reliability, and efficiency soar—to the tune of $10 million in annual savings. By adopting design thinking and following a few simple guidelines, the utility not only created tools to improve the productivity of its field-operations specialists but was able to slash change-management costs and the price of adoption. And because the workforce and IT team built solutions together, the finished product was exactly what both the end users and the company needed.

The utility maintains assets, including poles, power lines, and plants, worth hundreds of millions of dollars. Maintaining that infrastructure is the job of its compliance department, a team of workers who patrol and inspect every facility in the service area. Until recently, they documented their inspections on paper forms filed away in boxes in local offices. Numerous IT efforts had tried to replace this inefficient, cumbersome process with streamlined digital solutions and had spent nearly $50 million with nothing to show for it. But it was a design-thinking approach that finally unlocked the solution.

The team spent hundreds of hours in the field with technicians, shadowing their work and understanding everything that went into their important and often dangerous jobs. Together, the designers and operations employees identified key needs in getting the jobs done, including virtual maintenance records, navigation services, better information about access to customer sites, and improved safety alerts. The team then produced an iPad application that worked offline and had automatic updates—a first for the utility.

But the effort did not stop there. Designers developed concepts, such as real-time video-collaboration tools and a "find-a-friend" layer on the map that shows the location of other compliance team members should someone need backup (or just want to meet for lunch). Previous efforts would have designated these features as low-value, "nice-to-have," or too difficult to build. By thinking about the compliance inspectors' entire experience—and what was *valuable to them*—rather than just digitizing their work processes, designers could foster a genuine sense of empathy with them and give user-centric collaborative features high priority in product roadmaps.

This new trust changed the calculus around digital technology for field operations. Once a cost center, it became a source of cost savings. By building products that users wanted to use, the utility saw adoption rates soar and the cost of rolling out new technology plummet. In the process, it became one of the most innovative utilities in the world.

1. Get out of the office

Designers and developers can talk to process owners and lean experts all they like, but unless they spend real time with employees as well, everything they think happens in the field will be an educated guess. Get them to ride along with a service representative for the day, spend time with a supervisor in the office, and then map out how the two interact. There is no substitute for first-hand knowledge, contextual insights, or relationships built during a day on the front line. And they shouldn't be afraid to ask "dumb" questions; most experts love explaining what they do. Importantly be sure to quickly share the insights broadly. Empathy empowers the organization, and product-design debates can be settled quickly with "This is how the users want it."

2. Avoid digitizing the status quo

Do not just digitize what field employees already do. Use the design process to ask hard questions about real needs and find opportunities to *invent*. Challenge any "this is how we've always done it" mentality. Taking a paper form, digitizing it, and putting it on a tablet, for example, is an easy fix but almost never the right one. Reimagining the entire process of data generation, capture, and validation from a user's point of view is the only way to unlock real value and real improvement.

3. Use mobile solutions for the right work

Mobile technology or a mobile-first solution is not suitable for everything. A desktop component might always be necessary for tasks that make considerable demands on people's time and attention. But if context is key and users need information during task flow, a mobile solution might be the answer. Making the right decision calls for an intimate understanding of the work gained through immersive research and observation. Only then can an organization design new ways of working that use digital channels to the best advantage rather than simply because they are there.

4. Make the most of employees' expertise

Most field employees are highly trained professionals who know their work inside out. If solutions try to replace their expertise instead of bolstering and supporting it, collaboration and adoption will suffer. For a development team that truly understands, empathizes with, and respects field users, *pushing* solutions onto the field force will meet with resistance. When a team treats field employees as peers and invites them into the design process through design workshops and product demonstrations, it will create real pull for solutions and important advocates among the field workers. Identifying and engaging with the experts as early as possible will not only improve the eventual solution but also reduce the need for complex adoption and change-management efforts when the product is ready for release.

5. Look for common ground

It can be tempting to think that every kind of field work requires a separate application designed to suit its specific characteristics, but this is not so. Some field activities are unique, but many share common tasks—such as inspect, record, locate, and report—that a single suite of solutions can scale across multiple business units or field teams. By focusing on uncovering the similarities among processes rather than looking for the differences, companies can simplify their portfolios, speed up releases, and broaden the impact of their solutions. To achieve that goal, product teams should have a bias toward reusability from the outset, always searching for modular solutions that can solve more than one problem.

6. Treat the field force as the end user

Do research. Build empathy. Be transparent. Ask questions. Test often. Follow the "do-no-harm" principle. Act as an enabler and facilitator rather than just a solutions provider. Involve field workers, inspectors, engineers, and plant supervisors in every stage of product development.

Invite them in for design reviews. Hold product demonstrations in every sprint, and get the field-force response to features during the product's evolution. Put rough-and-ready prototypes into their hands to get insight into possible refinements. Replace big-bang product rollouts and elaborate change-management campaigns with iterative releases that allow plenty of time for solutions improvement. Build impact metrics that consider end-user satisfaction as a critical measure of success.

7. Take advantage of the familiar

Thanks to the ubiquity of mobile technology, we are all acquainted with basic interaction models: swipe right to "go back," check out the hamburger icon to access the menu, let form fields autofill. Great product teams exploit as many of these standards as they can. By frequent testing with users, designers can uncover and steal user-experience ideas that users already know and like. Even the most technology-averse people probably use smartphones in their personal lives, and by keeping things simple and familiar, companies can both reduce time to market and cut the cost of training and change management.

■ ■ ■

At companies with large, distributed workforces, there is often a divide between the users in the field and the team members in the office who make tools for them. Adopting design methods and deeply collaborating across the organization can help bridge that divide. The benefit is too great to ignore: generating a step change in employees' productivity and happiness is possible by fashioning the kind of delightful experiences that everyone craves, whether at home or at work. By keeping a few simple rules in mind, product teams can save time, build relationships, and deliver fantastic solutions that their field-force customers will not only use but really love. ■

Robert Bales is a senior expert in McKinsey's San Francisco office, where **Adrian Booth** is a senior partner; **Lois Schonberger** is a senior expert in the Washington, DC, office.

The authors would like to thank Mahin Samadani for his help with this article.

We wish to thank our practice leaders and all colleagues for their support and contribution to this compendium.

June 2018

Printed in the United States
of America.