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Optimizing Grid Performance through Advanced Operations

Accenture's Digitally Enabled Grid program

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Contents

Introduction

While many factors and trends are driving changes in the way power grids are operated, a few key areas are having the most impact, including outage management, security and the successful integration of distributed energy resources. These factors and trends provide a catalyst for change in what utilities measure and analyze, and ultimately result in operational and, potentially, financial changes.

Utilities are currently upgrading existing systems and deploying new ones to improve reliability, security and maintain reliable operations as distributed energy resources are added to the grid. Some utilities are already discovering limitations in the systems they have deployed, while other leading-edge companies are exploring next-generation solutions.

The data and analysis used to determine necessary operational changes are opening doors for potential new ways to operate the grid, including the opportunity for implementing value-oriented approaches. The wealth of data and analytics will also drive, in coordination with the regulatory environment, the next wave of funding in smart grid solutions.

Trends impacting grid operations

Transmission and distribution network operators around the world are having to respond to a number of major challenges to ensure ongoing safe, reliable delivery of electricity. Specifically, we believe three key trends will drive the evolution of grid operations in the coming years:

- Reliability, resiliency and outage management
- Security concerns
- Distributed energy resources and microgrids

Reliability, resiliency and outage management

Recent experience with severe weather, particularly in the United States, has raised regulatory scrutiny in many regions, and utilities have placed renewed emphasis on outage intelligence, management and restoration. Further, in many urban areas around the world, the cost of traditional reliability improvements, such as fortification or replacement, create an associated rise in retail electricity costs that is problematic in most regions.

Many utilities are testing new technologies and enhancing their business processes to be more resilient and consumer focused. Consumers are pushing the utilities toward the conflicting priorities of increasing reliability while reducing the cost of electricity. Utilities are being forced to examine new ways to address these challenges through smart technologies and solutions in an environment where consumers will increasingly have a choice in moving toward clean self-generation.

Adding to the complexity is a trend toward having virtual capacity via demand response, rather than passive capacity in the form of more wires and transformers. This trend implies active management of the grid and its assets, rather than the typical "install-and-forget" strategy.

An increasingly intelligent, digital grid is emerging—one controlled by digital technologies rather than analog circuitry and electro-mechanical controls. New operational schemes involving automation, grid-level power electronics, distributed generation, microgrids and storage are becoming more prevalent and will continue to do so in the future. These systems all require coordination with the grid in a way that typically involves some level of automation to ensure reliability. The control strategies deployed to support these new technologies differ as they are intended to support multiple flows of generated power from distributed sources, in addition to the traditional centralized generation scheme's singular power flow.

Improving reliability and service restoration: A US example

One US-based utility is embarking on a new wave of process and technology change to improve reliability and service restoration. While the utility performed well in storm restoration efforts during the past several years, it also recognized that consumer expectations have continued to escalate and, as such, it must pursue continuous improvement practices to stay ahead.

In 2012, the utility launched an outage management process and technology review project to position the utility as a leader in storm restoration in the future.

Accenture worked with project leadership from the electric operations, emergency management and information resources departments to update and augment existing benchmarking efforts, with a focus on improvement opportunities.

The project involved an end-to-end review of the restoration processes and technologies, including resource deployment, work planning, outage communication and restoration coordination, to identify a comprehensive improvement plan. The scope of the project included the business processes and technologies used during overhead storm restoration. Primary project objectives included:

1. Documenting end-to-end outage management processes.
2. Reviewing industry practices.
3. Identifying process and technology improvement opportunities.
4. Developing an improvement plan for planning and analysis of improvement initiatives.

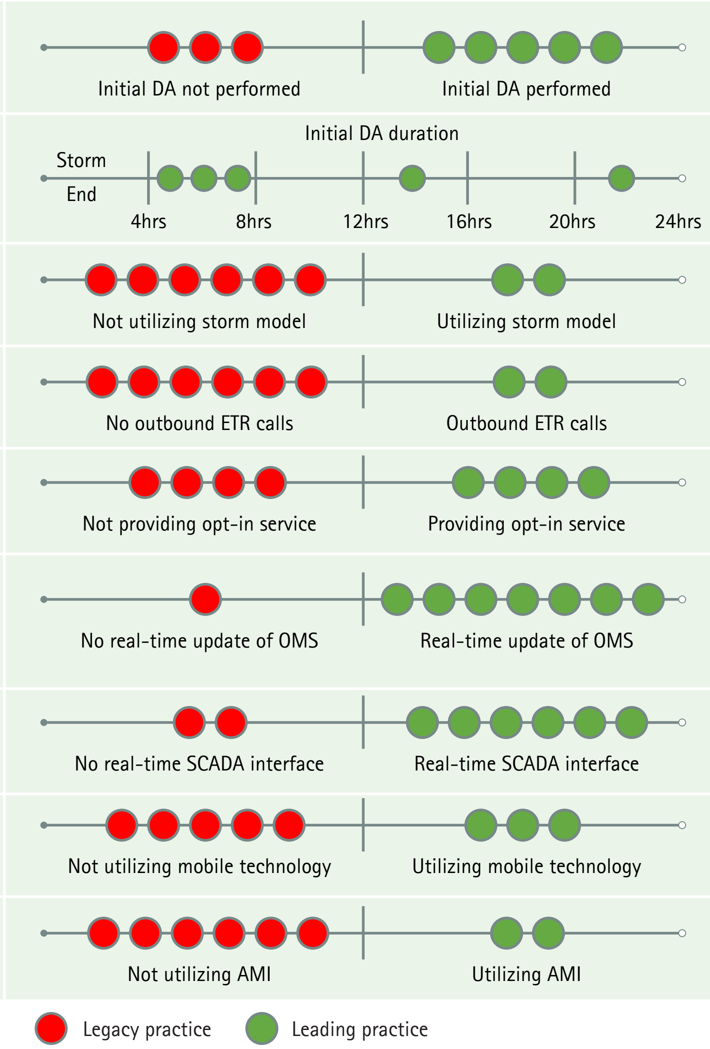
As part of the project, knowledge-sharing sessions with other utilities were used to gain a better understanding of their most recent undertakings and practices in a variety of activities, such as developing an estimated time for restoration (ETR). A data summary from the utility interactions appears in Figure 1.[1]

While some basic capabilities such as timely outage management system (OMS) updates appear to be widely adopted, the analysis reveals a wide gap between leaders and more traditional utilities and reinforces the significant opportunity for improvement that exists in the industry, including the use of advanced metering infrastructure (AMI) data and associated analytics to drive a true step change in outage restoration performance.

Accenture's global utilities executive survey shows that the majority of respondents indicate smart technology solutions will be a significant part of their outage management solutions in the future (see Figure 2).

Figure 1. Outage management review: Benchmarking results summary.

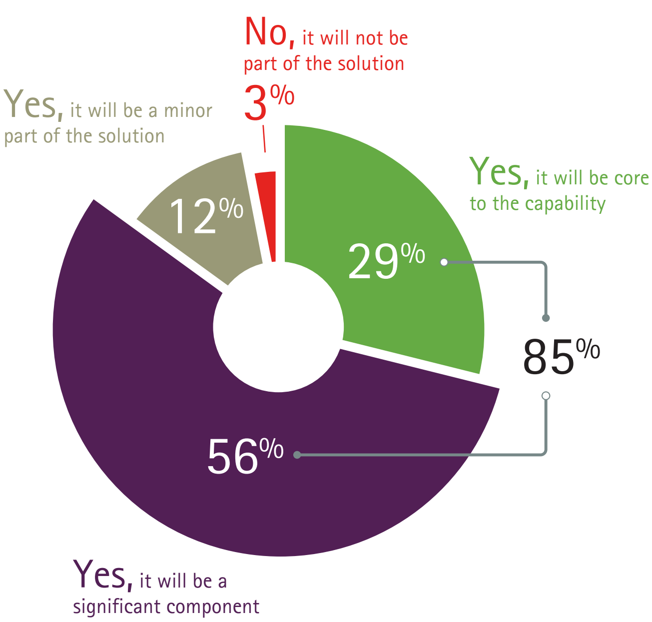
- **Initial Damage Assessment (DA):** Performing an initial/rapid damage assessment after a storm's end enables utilities to provide a reliable global estimated time for restoration (ETR).
- **Initial Damage Assessment Duration:** Leading utilities put in place effective, efficient processes to perform the initial damage assessment soon after storm ends.
- **Storm Modeling Tool:** In-house developed and vendor-provided storm modeling tools enable utilities to approach the development of the global ETR in a systematic way.
- **Outbound Calls for ETR:** Some utilities make outbound calls to consumers who called in when outage-specific ETRs are set or updated.
- **Opt-in Communication:** Consumer expectation for proactive, opt-in capability for communication of outage information is increasing.
- **Outage Management System (OMS) Update:** The OMS model is the system of records for network and outage status information. Timely and consistent update of the OMS model is, therefore, a critical process during the storm.
- **Real-time SCADA Interface:** Organizations are increasingly turning to an integrated SCADA/OMS approach to improve their operational processes.
- **Mobile Technology:** Utilizing mobile technology for field data collection during storms (for damage assessment and restoration) leads to improved planning and information management.
- **Utilizing AMI for Outage Intelligence:** AMI outage and restoration notification, as well as meter ping capability can greatly enhance restoration efficiency during storms.



Source: Utility benchmarking results, Fall 2012, Accenture.

Figure 2. The impact of outage management on the use of smart technology solutions by 2020.

Will smart technology solutions (e.g., auto-reclosers, outage location analysis from smart metering data, analytics, etc.) be part of your outage management solution by 2020?



Base: All respondents, grid operations section.
Source: Accenture's Digitally Enabled Grid program, 2013 executive survey.

Security concerns

As the grid continues to become more complex, digital and automated, the associated cyber security threat will also continue to evolve. As such, grid operators' response to these threats needs to evolve commensurately or utilities and their consumers may suffer. The United States has experienced significant year-to-year increases in control system cyber incidents as reported in Table 1.

These threats, combined with new regulations, are changing the way grid operators think and act with regard to defense of critical assets such as substations, SCADA systems and AMI infrastructure. Utilities are focusing on the following four areas to address the challenge.

Cyber security capacity building: At a high level, companies are taking steps to defend their portions of the grid by proactively engaging critical infrastructure protection subject matter experts including the government, systems integrators and grid security firms to help enhance their security profiles. This is being achieved through a combination of vulnerability assessments, penetration testing, security risk management, cyber security capacity building and physical and cyber security controls including technical security infrastructure. Growth in these efforts is expected to help understand, strengthen, monitor and continuously improve their security operations.

Enhanced grid-state awareness: From a grid monitoring perspective, grid operations organizations are starting to leverage "big data" tools to mine grid network and end-device data to provide insight into what is going on in the grid. Simultaneously, grid operation teams are combining operational data on assets with cyber security techniques to develop a "quality of trust" or level of trust for each operated asset and applying trusted data tag concepts (differentiating safe data from uncertain data) to significantly enhance grid state situational awareness.

Supply chain security: Developments in the cyber world are also driving utilities to be more conscientious of how, what and from whom they buy critical infrastructure. While there are yet to surface any verified instances of malicious supply chain compromises of smart grid devices, recent reports of "pre-hacked" networking equipment are causing many utilities to revisit their buying habits and vendor contractual requirements for assurance that they adhere to some standard of cyber threat risk management. Most often, this is realized as sweeping updates to vendor master service agreements with very specific, legally binding language regarding requirements for secure life-cycle development measures.

Bridging the IT/OT gap: Increasingly, utility cyber security teams are leveraging leading practice guidance to strengthen the security posture of their smart grid operations centers by rigorously segmenting them—logically and physically—away from noncritical business assets and processes using advanced firewalls, demilitarized zones, and NERC CIP-like physical protections (e.g., intense physical logging, video surveillance of grid ops control areas and "six-wall" control rooms).

Table 1. Year-on-year increase in control system cyber incidents, United States.

ICS – CERT Fiscal Year Metrics	2010 Totals	2011 Totals	2012 Totals
ICS incident reported (tickets)	39	140	197
Distributed or downloaded The Cyber Security Evaluation Tool (CSET®)	2,400	5,100	6,631
On-site assessments	57	81	89
ICSJWG* membership	600	1,012	2,327

Note: Fiscal year 2010 represents the time period of October 1, 2009 - September 30, 2010, 2011 represents the time period of October 1, 2010 - September 30, 2011, and 2012 represents the time period of October 1, 2011 - September 30, 2012.
*Industrial Control Systems Joint Working Group (ICSJWG), established by the U.S. Department of Homeland Security Control Systems Security Program.
Source: 2012 "Year in Review" report, the Department of Homeland Security's Industrial Control Systems – Cyber Emergency Response Team (DHS ICS-CERT).

Distributed energy resources and microgrids

The facilitation of demand growth in the developing economies, the desire for greater reliability and resiliency, and mandates for increased use of renewables are leading to significant growth in distributed energy resources and microgrids (see Figure 3). Distributed energy resources such as solar energy are growing significantly, having grid parity in many countries from a cost perspective.

In addition, the emergence of new types of generation technologies (renewables, distributed, fuel substitution) and loads (the wider, wiser use of electricity enabled by power electronics) further catalyzes the need for a more distributed approach to control the grid in the future.

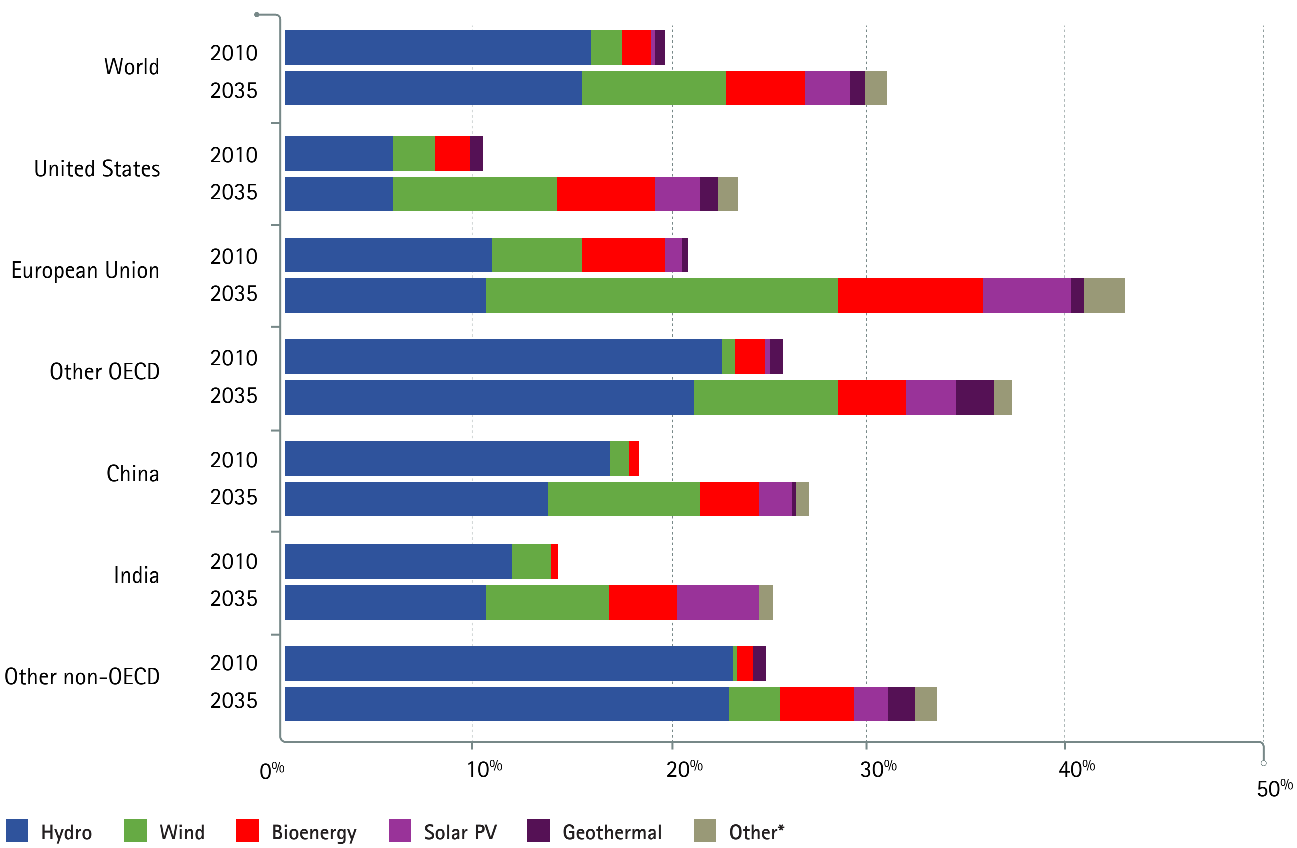
As countries are attempting to achieve targets for greenhouse gas emissions, such as those agreed within the UN Framework Convention on Climate Change by 2020 and beyond, many are moving to a more distributed supply system that necessitates significant increases in grid capacity to manage the flows associated with distributed energy resources. In addition, technological innovation in transport and consumer end use could have a significant impact on peak load and could give rise to significant technical issues, such as power quality impairment by harmonics.

Currently, the higher the proportion of intermittent distributed energy resources (wind and solar predominantly) providing the power supply, the greater the need for some form of balancing reserve. Often, this reserve is in the form of natural-gas-powered generation, and in some jurisdictions, the amount of gas consumed has increased with an increase in wind/solar generation. Another side effect has been an overall decrease in grid reliability, leading to load shedding or even brownout conditions.[2]

Accenture's Digitally Enabled Grid program: 2013 executive survey methodology

Accenture conducted an executive survey among utilities executives worldwide involved in the decision-making process for smart grid-related matters in their company. The survey results are based on questionnaire-led interviews with 54 utilities executives in 13 countries, conducted via telephone in 2013 for Accenture by Kadence.*

Figure 3. Share of renewables in electricity generation by region in the New Policies Scenario.



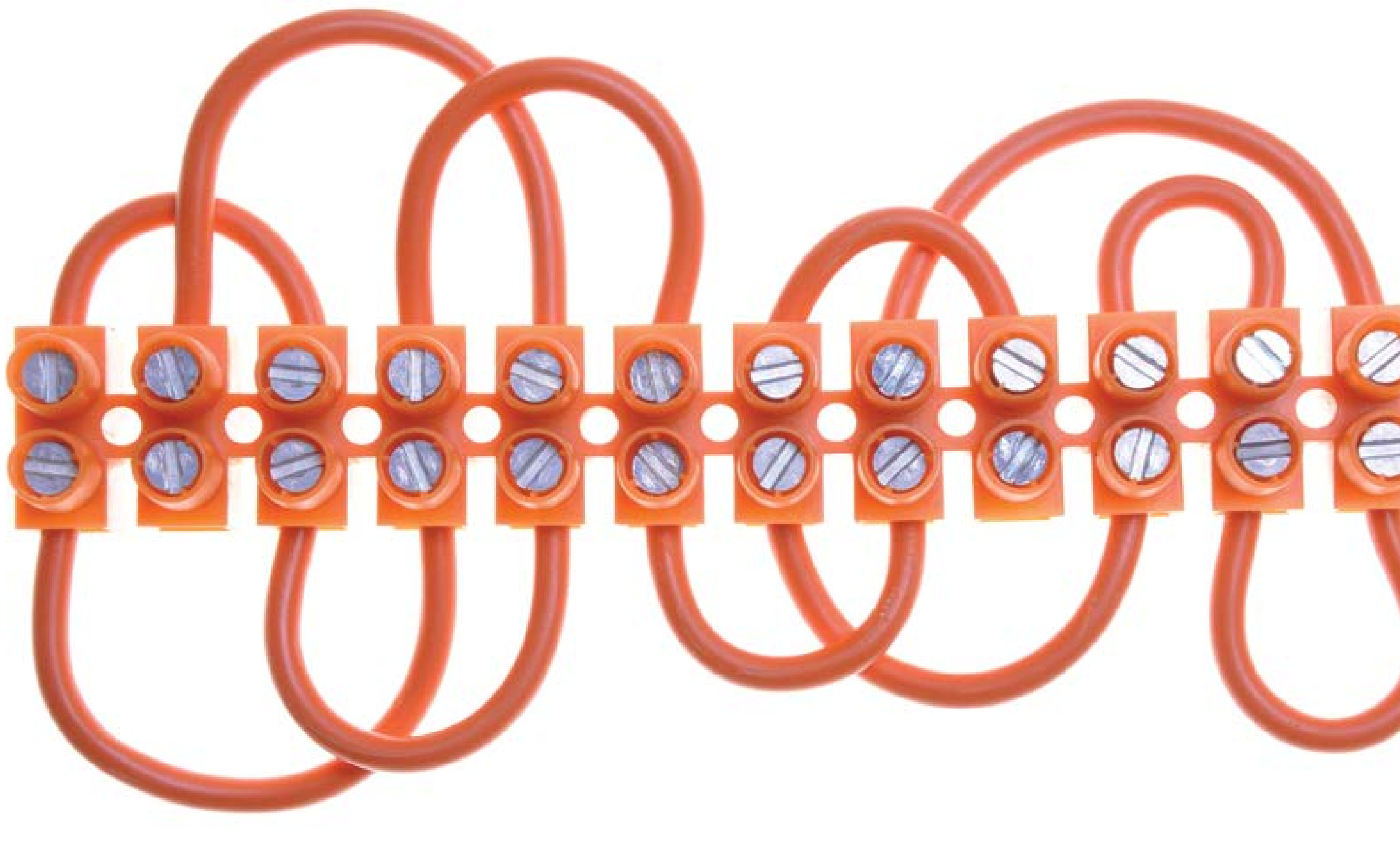
*Other includes concentrating solar power and marine.
Source: © OECD/IEA, World Energy Outlook 2012, used by permission.

In the future, a combination of intelligent systems for grid operation, combined with greater consumer interactivity, will lead to a more tightly bound connection between generation and load. This would allow for a larger proportion of grid energy to be derived from variable, green sources, while simultaneously increasing system reliability.

The pace at which distributed generation sources are incorporated into the grid has the single biggest impact to grid operations. Further, diverse ownership (consumer and/or utility owned) and control (controlled by a local energy management system or coordinated via an independent or regional system operator) of the generation source further adds to the complexity. Consumer-controlled resources could transform utilities into acting as second-tier suppliers or providers of last resort to more disadvantaged consumers that cannot afford distributed energy.

Many regions of the world are challenged to maintain voltage control and stability as levels of installed intermittent generation technologies, such as wind or solar power, added to the grid exceed what can easily be managed with conventional tools, techniques and algorithms. For example, the Hawaiian Islands have adopted some counterintuitive generation control techniques to deal with the increased penetration of distributed generation, such as the "loosening of the automatic generation control (AGC) settings" to avoid control system issues. Also, southern California is seeing rapid swings in available capacity with the greater connection of intermittent generation, much greater than previously managed. In discussions with experts attending the recent North American Electric Reliability Corporation Reliability Impacts of Climate Change Initiatives Task Force Meetings, it was noted that areas of the Midwestern United States need to disconnect some intermittent sources from the grid at night in order to maintain voltage stability and satisfactory voltage profiles.[3] Much of Western Europe, and in Germany in particular, has seen voltage regulation and system stability issues requiring the continued operation of base-load generation just to counteract the operational issues associated with distributed resources while new technologies and techniques are tested to address these issues. This has led to an increase in carbon dioxide (CO_2) emissions in countries such as Germany—the very problem distributed generation is attempting to solve.

The design and operation of the transmission networks will change significantly not only as a result of the changing energy mix, but also as a result of the connection of offshore transmission assets. The capability of the network must meet the requirements that will be placed upon it from the increased contribution of variable generation and demand profiles. The efficient development and design of the network will lead to a more complex control environment as more quadrature boosters (QBs), high-voltage, direct-current (HVDC) cables and compensation equipment are incorporated.[4]



Industry response, actions and a path forward

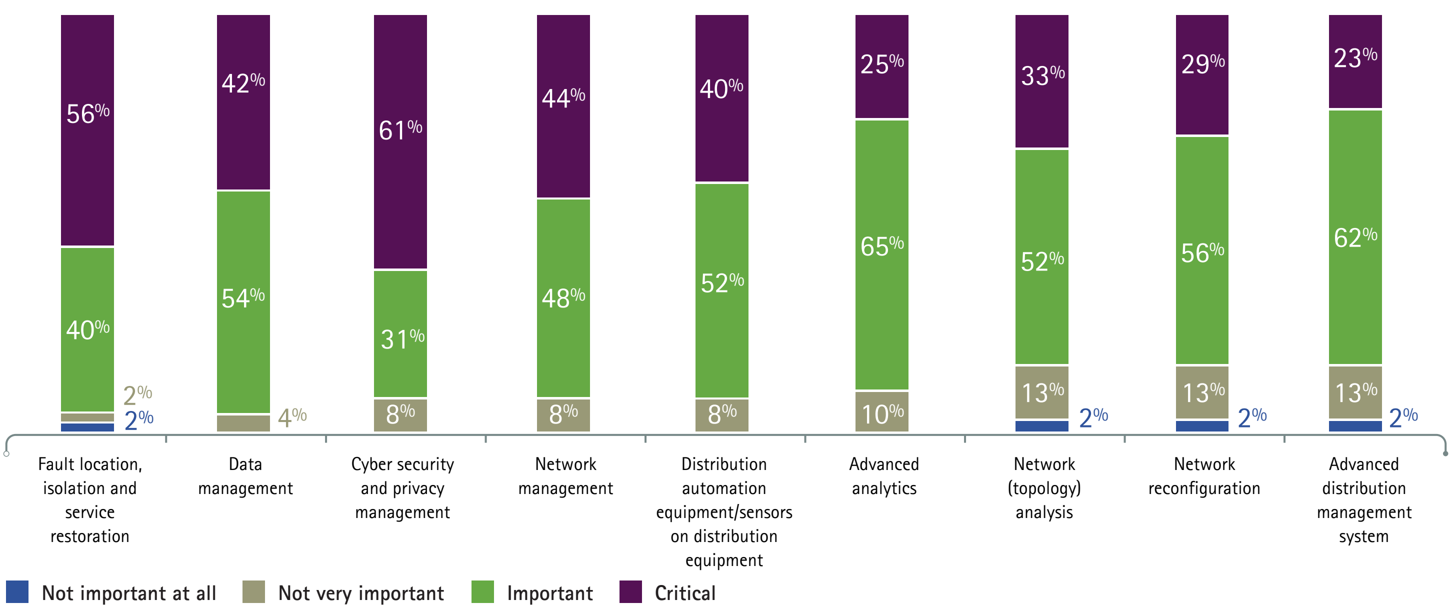
The progression of these trends is having the following implications on grid operations:

- New applications to more effectively manage the grid
- Heightened focus on grid and power economics
- Enterprise integration and IT/OT convergence
- Shift to distributed intelligence

Most utilities expect to see increasing complexity in their grid operations in the future and believe that enhancements in capabilities will be needed across all areas, a point reinforced by Accenture's recent executive survey (see Figure 4), but it will more likely evolve, rather than occur as a step function or "big bang." It is more likely that incremental benefits will be achieved from managing the existing network more effectively, while new management and control strategies are developed and refined to address the progression of challenges envisioned. And while there is no consensus on the most effective way to control this more complicated, interconnected future grid, nearly all the respondents in the Accenture survey responded that they view the smart grid as a natural extension of the continually evolving electricity network (see Figure 5). For more detailed global insights regarding the future of the grid, please see Accenture's related paper, *Forging a Path toward a Digital Grid: Global perspectives on smart grid opportunities.*[5]

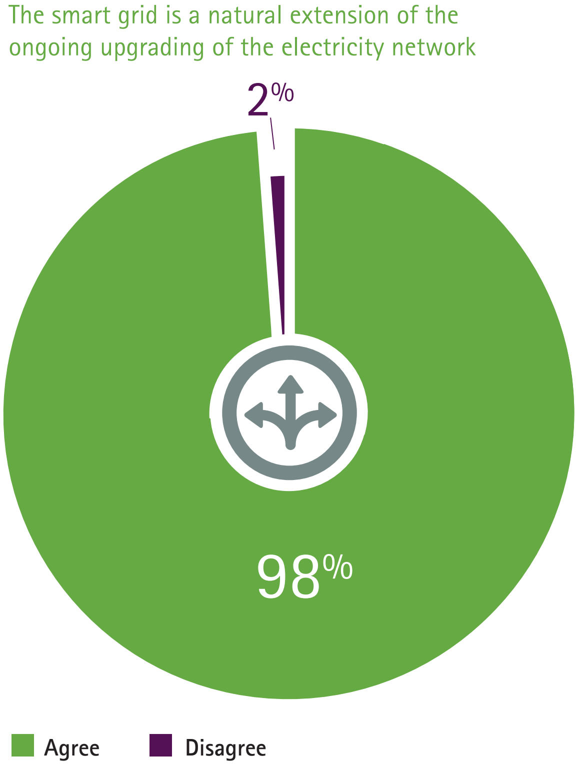
Figure 4. Capability enhancements required to manage grid complexity in the future.

How important is it for your company to enhance its capabilities in each of the following areas by 2020 in order to successfully manage the complexity of the network?



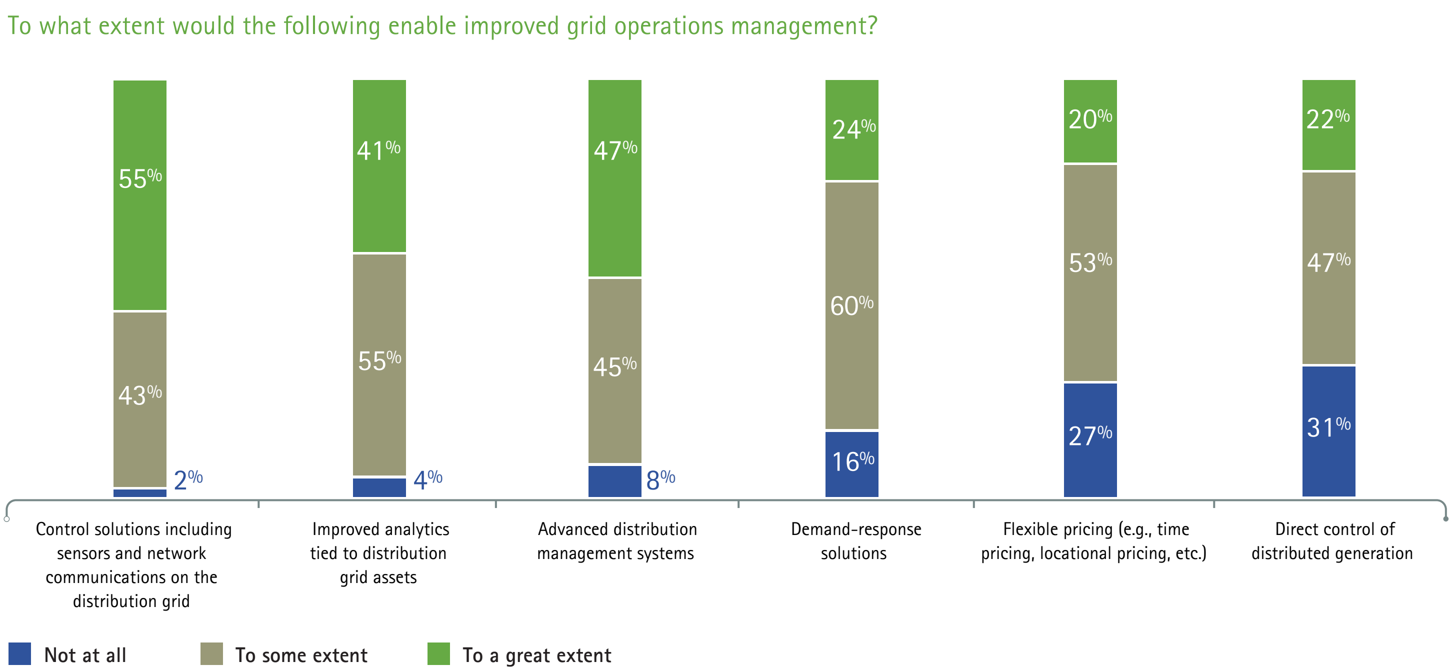
Base: All respondents, grid operations section.
Source: Accenture's Digitally Enabled Grid program, 2013 executive survey.

Figure 5. View of smart grid as mainstream for the future electricity network.



Base: All respondents.
Source: Accenture's Digitally Enabled Grid program, 2013 executive survey.

Figure 6. Capabilities to enable improved grid operations management.



Base: All respondents, grid operations section.
Source: Accenture's Digitally Enabled Grid program, 2013 executive survey.

New applications to more effectively manage the grid

New assets, demand response and operational pressures require faster system response times to confirm grid stability. Intermittent generation sources and solid-state switches can require "milliseconds" response times of their supporting communications and control systems. As such, the grid cannot be manually managed as easily as in the past. The changing grid asset mix requires additional steps to verify safety and improved understanding of the impact of events to understand grid stability and security. In Figure 6, survey respondents highlighted control solutions, improved analytics and advanced distribution management systems key to enable improved grid operations management.

An increasing abundance of data will continue to be available to assist in operations. Access to high-resolution data means that information can be made accessible to visualize the current and more importantly forecasted operational characteristics. However, much of the technology to convert the data to meaningful information to act on, and ultimately automate many of the functions of grid operations, are still in varying stages of deployment.[6]

Early stimulus-funded work in the United States, Europe and Asia has subsidized an expansion in the penetration of SCADA and automation technologies. These predominantly centralized technologies provide a significant amount of additional data on the state of the system. The desire to turn this new data into more meaningful intelligence is leading to installation of new centralized applications such as distribution management systems (DMS) as well as centralized data warehouses and associated analytic solutions. In addition, outage management systems are being replaced or upgraded to better address the changing needs of dealing with changing consumers and the risk of enhanced natural threats.

Heightened focus on grid and power economics

The convergence of ubiquitous sensing and communications with new management and analytical tools is providing new ways to look at the traditional power delivery business. For example, by combining the knowledge of the cost structure of the utility with near-real-time operational and asset data, a utility can begin to determine the margin on the power delivered. While not a typical metric reported in the current regulatory environment, in ways it allows for greater optimization of the power system in terms of total economics.

Efforts to optimize the operation of the power delivery system, as well as efforts to identify and mitigate theft of service, have created processes and systems that can be extended through additional analysis to, in essence, optimize the margin through automated control and analytics. Optimization and theft-mitigation activities typically focus on the reduction of losses, both technical and non-technical. These concepts can be combined with other actions, such as implementing demand response, and extended to achieve additional operational control as initially witnessed at Xcel Energy when Accenture piloted a demand-response system. The system implemented demand response through a rule-based solution that sought to maximize network efficiency through the operational decisions taken in additional to potential incentives or disincentives that could be offered.

Steps are being taken to combine bottom-up analytics with hybrid control schemes and distributed intelligence to control the grid in ways that allow utilities to achieve new metrics such as margin on power delivered. Using techniques such as conservation voltage reduction and voltage and reactive power optimization, and coordinating utilization through demand-side management, one can manage operational parameters to compensate for variations in load, weather, supply cost and availability, emissions, among others. We anticipate that there will be a gradual expansion to the use of traditional metrics to evaluate grid operations (SAIDI, CAIDI) to include metrics that support value-oriented approaches to manage grid operations, unless a regulatory change catalyzes the activity. These new control schemes will be implemented initially in a semi-automated fashion until confidence is established and full automation is trusted. In addition, the current regulatory and utility make-up could limit the value of such techniques. Incurring transmission and distribution costs to reduce generation demand may not be fiscally material or prudent for some utilities. However, it would seem only a matter of time before industry changes would support the trend of managing operational systems directly for better economic performance.

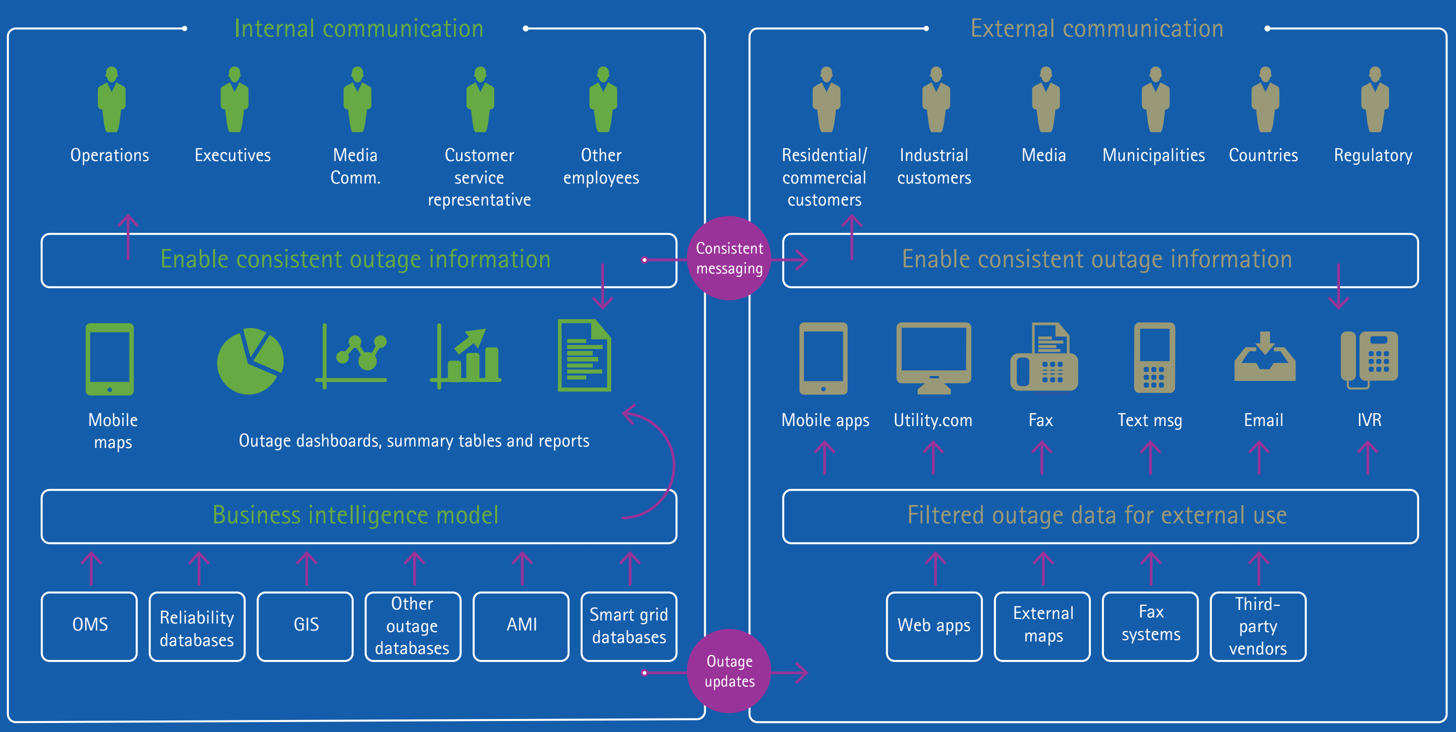
Case in point: Focusing on outage communications at ComEd[7]

In 2011, US-based Commonwealth Edison Company (ComEd) experienced some of the most severe storms in the company's history, which caused nearly 2.6 million customer outages during the year. The company's storm response came under significant scrutiny from regulators, municipalities and the general public. As a result, ComEd made a commitment to improve outage communications and storm response decision-support capabilities through delivery of timely, consistent outage information to internal and external stakeholders.

In keeping with ComEd's promise to introduce an action plan, ComEd leadership announced the Outage Communication System (OCS) project. Independent of its outage-response time, ComEd took a multi-faceted approach to communication, not only providing more information at the same or greater speeds, but also increasing management and consistency across all its current information channels (see Figure 7). OCS information also benefited municipalities and other emergency services within affected territories in their planning during periods of service disruption. The project started in October 2011 and successfully went live with its final release in January 2013. The outage communication system is fully operational, providing consistent outage communication to nearly 2,500 internal users and approximately 4 million external consumers across all consumer communication channels.

Several of the outage communication and storm-response technologies, including a state-of-the-art mobile command center to deploy to hardest-hit areas and customer service enhancements such as an interactive online outage map, smartphone application, mobile-enabled website, and two-way text messaging, were identified as a "best practice" for utilities by J.D. Power.[8] The analytical and reporting capabilities implemented in OCS also allowed the company to improve its communications to municipal committees, regulators and other stakeholders. OCS has enabled ComEd to retire legacy processes for estimating time of restoration (ETR) and outage communication management, as well as position itself to retire several widely used home-grown reporting applications in the near future, thereby reducing costs, improving maintainability and verifying long-term support.

Figure 7. ComEd's outage communication vision.



Source: ComEd Outage Communication System project, 2013.

Enterprise integration and IT/OT convergence

The digitization of the grid is leading to a convergence of information technology (IT) and operational technology (OT). IT tools and methods are essential to process and analyze the volume of data generated from operational devices and true insight from this data requires pulling together data from traditional IT systems (CIS, work management, financials, meter data management) and correlating this with traditional OT systems (outage management, distribution management, SCADA, energy management). While this convergence may appear simple to execute on paper, it is much more complex in practice: first, there is a cultural and often trust divide between IT and the business in most corporations including utilities and, secondly, it is becoming difficult to locate workforce with both the necessary engineering and IT skills and understanding.

The following section outlines a few key examples of IT/OT convergence that are driving business results for utilities.

Most new outage management system technologies leverage the ubiquitous sensing and communications networks provided by smart metering and more tightly integrate with SCADA and DMS technology to better assess and communicate the characteristics of an outage. This improved intelligence is shared across a variety of stakeholders through the creation of synchronized outage communications systems (OCS), and is a concept currently implemented by Commonwealth Edison Company (ComEd) (see sidebar on page 13).

Similarly, energy management systems (or energy control centers—EMS or ECC) are also being replaced or upgraded to better deal with the changes under way on the distribution system. Existing EMS technology tends to look at the distribution system as a "black box" from an operational perspective. As the distribution system evolves, the traditional assumptions about the distribution grid are changing and tighter operational integration between distribution and bulk power will be required.[9] For example, in the United Kingdom, National Grid and Western Power Distribution (WPD) have areas of electrical network configuration and information of mutual interest to both companies, but which can only be viewed from their individual SCADA systems. As visibility of this data is becoming important to the companies, National Grid and WPD are working to create an environment to share visibility of data within each other's SCADA systems.[10]

In addition, as the assets that compose the grid continue to evolve, we see the blending of what have been traditional enterprise information technologies with operational systems. The sharing of common network protocols, network management systems and security approaches and technologies are emerging examples.[11]

Historically, grid operations were based on paper maps and required knowledgeable operators/dispatchers to track system configuration and crew locations. The application of smart technologies is leading to increasing levels of integration with IT systems, including GIS and outage management and DMS. Coupled with an ever-increasing level of grid automation, the dynamic has begun to change. We are seeing a trend to place more technically skilled staff into operations roles to deal with more complex operating schemes and more detailed operational analyses. This shift has been the case in Europe for some time—partly historical and cultural, reinforced by the need to integrate distributed generation. Accenture also sees a trend to consolidate control centers meaning that fewer staff is supervising a wider range of grid assets.

This convergence will require a new generation of workers that will need to be both skilled engineers and information technologists comfortable with analytic and visualization tools. The workforce element of this transition is potentially the greatest challenge utilities will face.

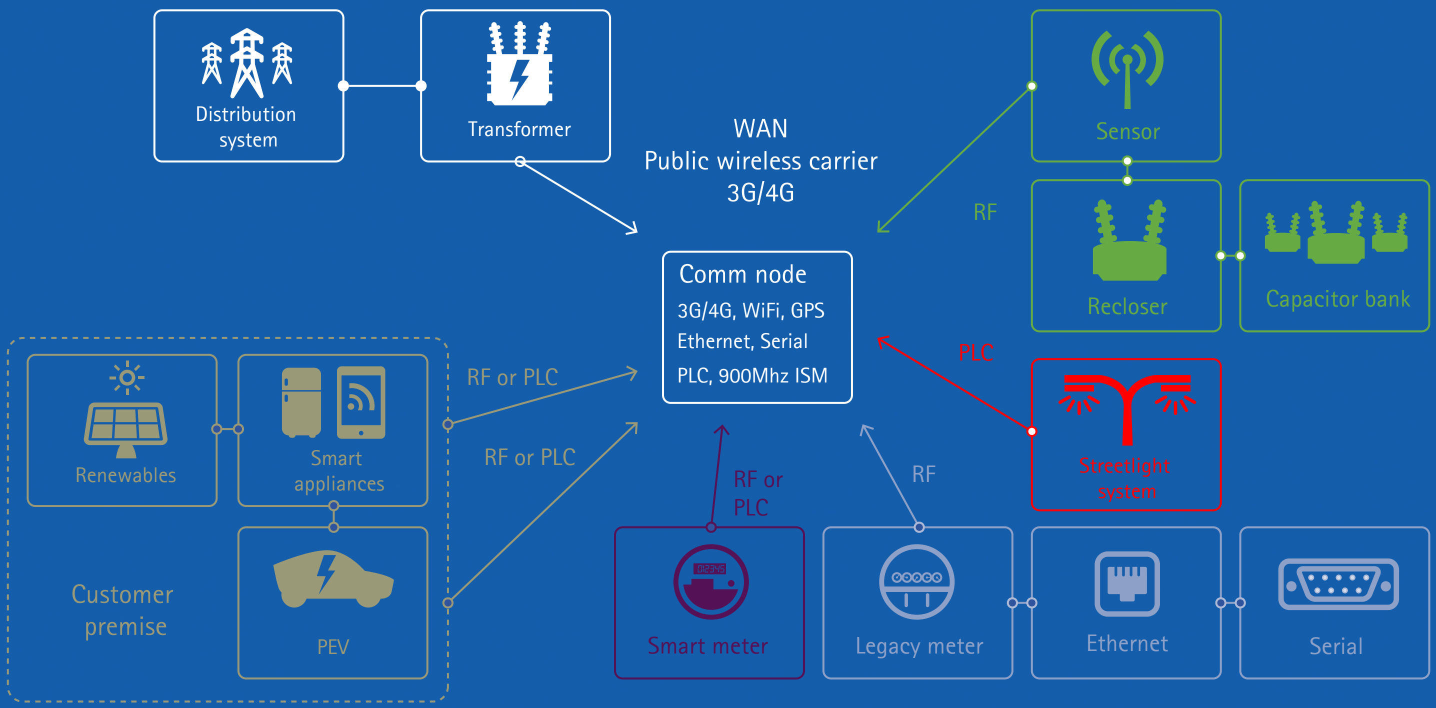
Case in point: Duke Energy's colation to build a distributed intelligence application

Duke Energy, Accenture and several additional companies have joined to build a distributed intelligence application and demonstration to eliminate operational silos and improve grid performance, while allowing grid assets to be interoperable. This coalition will demonstrate that disparate assets, data, and control commands can be shared across multiple platforms to achieve interoperability with lower costs and faster response times. The first phase of this project will be to develop a voltage management function to run on a distributed platform, accomplished by utilizing a "communications node" and a standards-based messaging architecture to enable peer-to-peer communications and to federate data from previously isolated systems.

A high-level representation of the architecture is illustrated in Figure 8. The communications node aggregates data collected for analysis locally or can route the various data streams to central locations, performing communications asset consolidation. Duke Energy's coalition participants are exposing select data that would normally travel directly to a central head-end application, locally via a standards-based interface.

The exposed data is also analyzed locally, resulting in faster system response and control. The voltage management phase of this project is being tested in Duke Energy's McAlpine Smart Grid test area in Charlotte, North Carolina. The distributed voltage management application will reside on field communication nodes, run on a variety of field message buses, and be tested on both 3G and 4G LTE wireless networks.

Figure 8. Duke Energy's distributed intelligence architecture.

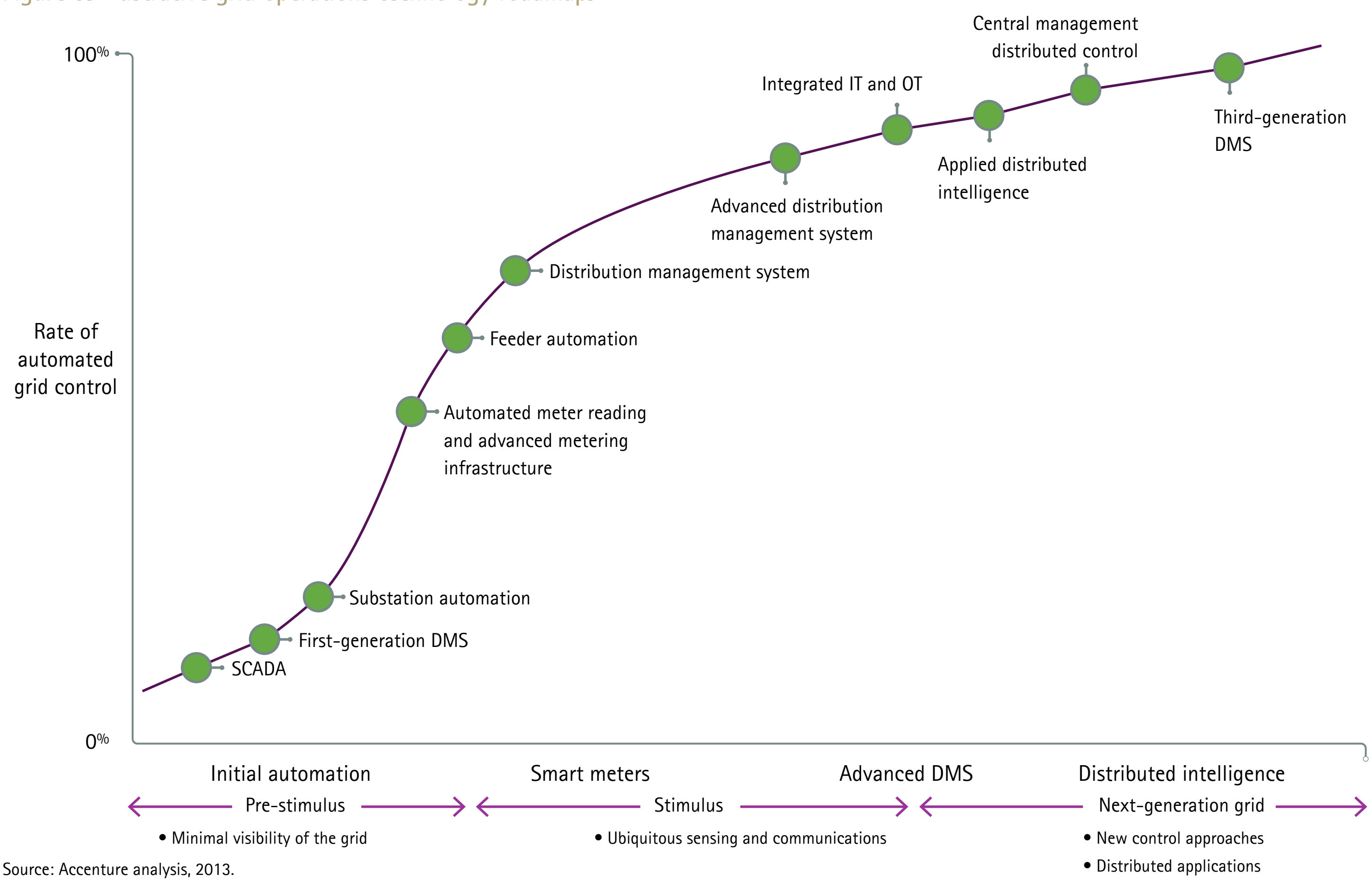


Shift to distributed intelligence

As the amount of installed distributed energy resources and new loads with new characteristics increases, a point will be reached when additional distributed capability to control the grid will become essential, creating what we call a hybrid control approach. This hybrid control approach will be needed, as the control algorithms currently employed do not easily support a high penetration of distributed generation on the distribution system. Additionally, utilities looking to combine utility assets and consumer loads into optimization algorithms to improve operational efficiency are discovering limitations in performance. This appears to be in part due to the nonlinear nature of how power grid assets are analyzed and how small loads on the system may be modeled linearly when analyzing consumer systems. By developing a hybrid control approach, consumer loads can be analyzed with distributed intelligence and the outcome of the analysis can be provided in a way that a centralized distribution management system can more easily accept, therefore facilitating a more coordinated optimization result and higher system efficiency. Utilities such as Duke Energy are currently experimenting with this (see sidebar on page 15).

This hybrid control approach, using a DMS as well as distributed intelligence, will support an increased penetration of the more complex supplies and loads on the distribution system. However, the introduction of this additional capability creates a significantly more complex overall or macro control system in which both distributed and central control approaches must be coordinated. For example, if a distributed intelligence application and a central DMS application are both trying to perform control on the same assets, system inefficiencies and possibly system misoperation could occur. As more distributed intelligence is added to the grid, there is concern that a tipping point will be reached. The coordination needed for all of these disparate systems tied to a central application will likely surpass the ability to control the system in this hybrid fashion, and the associated control strategies will not function properly. As a result, there is a perspective in the utilities industry that another management approach is required, and that we will see an evolution to a centralized management of all assets (grid components, enabling technologies such as telecommunications, and security) along with the migration to a fully distributed control approach, splitting the two functions. However, there is not yet consensus on this evolutionary path.[12] A roadmap of Accenture's expected evolution in grid operations technology appears in Figure 9. We believe that it is still too early to conclude whether the centralized approach on managing assets, while allowing distributed control, will reach full industry acceptance. While appearing technically viable, it does not line up well with the present regulatory model in most regions and, as such, does not currently offer the proper incentives for such technology adoption.

Figure 9. Illustrative grid operations technology roadmap.



Source: Accenture analysis, 2013.

Factors pacing the rate of change for grid operations

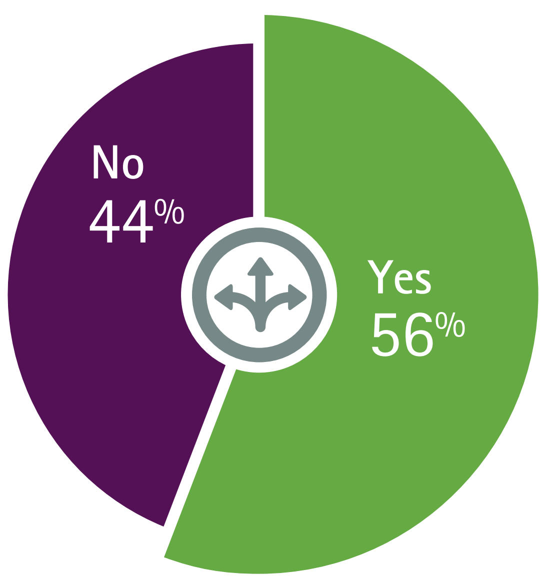
The power delivery industry is generally risk averse, and significant due diligence is typically required to make major changes in operations and supporting technologies. The present state of the utilities industry indicates that the ability to understand and leverage data provided by ubiquitous sensing, communications and expanded automation and intelligence is lagging capital investments. Many utilities are collecting operational data, but lack the tools or capabilities to appropriately analyze it in such a way to improve operational intelligence and effect change. Further, many are seeking leading practices, proven methodologies and operational changes that will allow risk-reduced operational change.[13]

Regulation is suspected to be the most significant factor in determining the pace of change for grid operations. The bulk of the global power delivery system is regulated and the acceptable risk and rate of return allowed will continue to drive the pace of change. The regulatory model, at least in North America, was set up to incent electrification in the 20th century. As electrification has been accomplished, other issues involving environmental stewardship, efficiency and the like have emerged that are not well supported in the traditional regulatory construct. As such, we also expect to see regulatory evolution in parallel with the changes in grid operations. This evolution may have an additive effect in terms of accelerating the pace of change. In Accenture's survey, more than half of respondents believe that regulatory or legislative changes are necessary to help them effectively manage the grid (see Figure 10).

The evolution of grid operations, as depicted in Figure 9, would require the adoption of a holistic approach to change that encompasses people, process and technology. It translates into a major overhaul of utility organization beyond grid operations (affecting all operational groups as well as others such as information technology and security). It also requires development of several new skills, enhanced risk management and migration to a new set of supporting systems, as previously described. This change would be required to allow effective management of the assets, as well as the extremely large investments recently made and those that are planned.

Figure 10. The impact of regulatory or legislative changes on the management of the grid.

Do you believe that regulatory or legislative changes are necessary to help you manage the grid effectively?



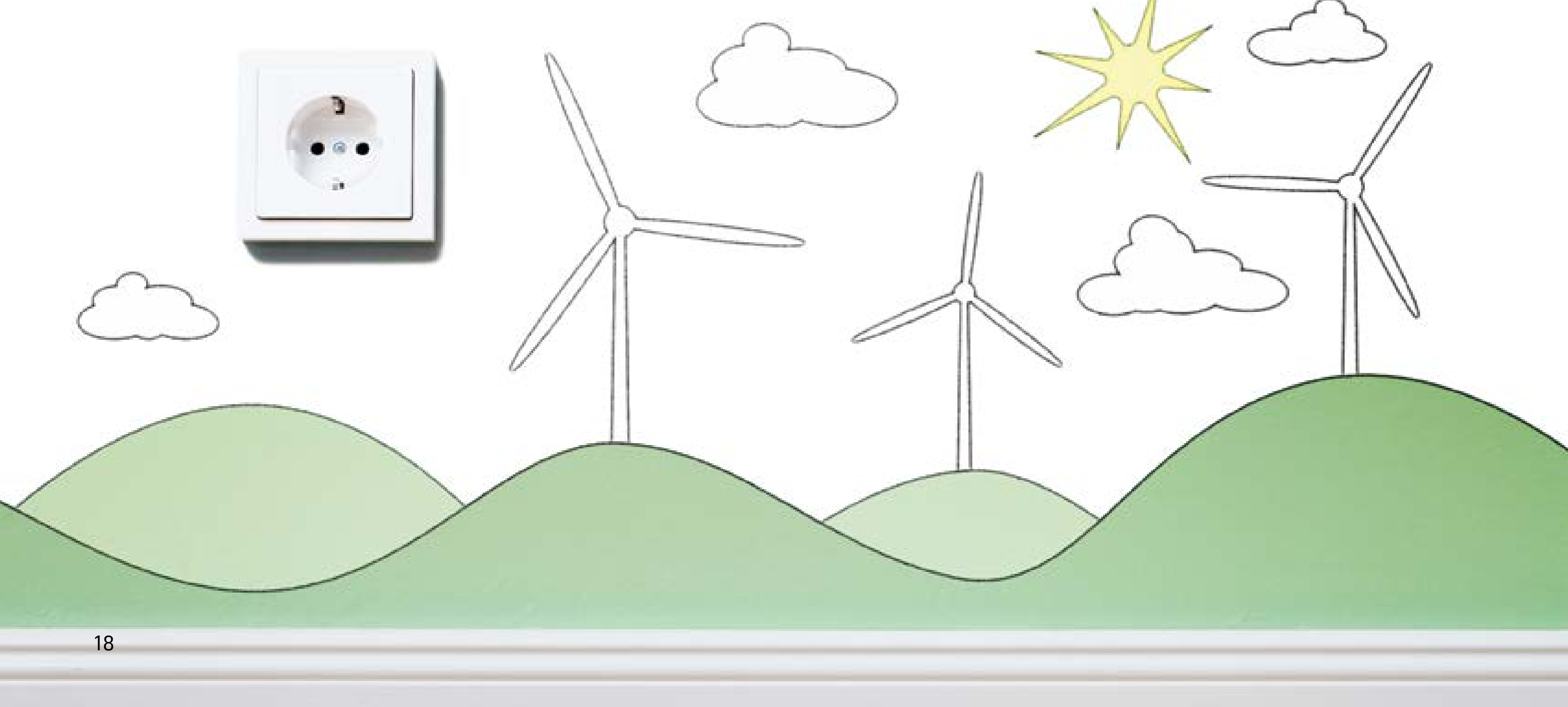
Base: All respondents, grid operations section.
Source: Accenture's Digitally Enabled Grid program, 2013 executive survey.

Conclusion: The future role of smart grid solutions

The broad array of what encompasses smart grid technologies and solutions can become both an asset and a challenge in operating the grid. For example, renewable distributed generation can be instrumental to many operational solutions, supporting pockets of high demand and prolonging the need for new capital expenditure associated with distribution circuit upgrades. But the same technology can create operating challenges such as back-feed conditions and harmonics caused by the associated power electronics interfaces. As such, nearly all the emerging smart grid technologies bring trade-offs, impacting operations technically and economically.

Although utilities in the United States, Europe and parts of Asia have accelerated their implementation of smart grid technologies and solutions in the past five years through use of programs such as "stimulus funding," many have yet to realize all the targeted benefits. It appears that the amount of growth in implementation may slow in the next few years as adopters seek to further realize the anticipated benefits of their current investments. Many seem prepared to propose more modest implementations as the regulatory environment shifts in some regions to require more due diligence and utilities accommodate "true-ups" to verify that rates are aligned with realized benefits and costs. In parallel, we see a shift to developing metrics to help establish leading practices. In the post-stimulus funding era, leaders will likely identify discrete, surgical opportunities to implement improved monitoring and control where there is a clear business case. These smaller-scale deployments will limit the risks related to large-scale changes in operations and they may remain under manual rather than automated control in the shorter term until an operational need requires the change. For example, automation can be used in a reactive fashion to an event (line fault), but by gradually switching to a more proactive control scheme, such as anticipating operation changes and modifying protection and control settings to also anticipate change, a utility could increase the robustness of the network to adverse weather conditions. This type of progression is expected over the medium to long term.

We also see utilities developing an increasing interest in analytical tools and methodologies to help most effectively derive value from smart grid technologies. This was not previously practical as many utilities did not have enough intelligent devices in the field or enough acquired data to feed analytical tools. Accenture's perspective is that this focus on analytics and the achieved results will trigger the next wave of significant spending on smart grid solutions. We expect practical applications of distributed intelligence to arrive in the market at a similar time and that the combination of smart grid technologies, analytical tools and bundled distributed intelligence will allow utilities to manage their operations in a significantly different manner. Concepts such as managing the margin on the power delivered reflect another level of benefits that could be achieved from smart grid solutions and could help reshape the regulatory landscape and also help incent the next wave of significant spending.



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* Countries in scope for Accenture's Digitally Enabled Grid program executive survey: Argentina, Australia, Brazil, Canada, France, Germany, Italy, Japan, Netherlands, Spain, Singapore, United Kingdom, United States.

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For more information on Accenture's Digitally Enabled Grid program, go to www.accenture.com/digitallyenabledgrid.

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Accenture Smart Grid Services focuses on delivering innovative business solutions supporting the modernization of electric, gas and water network infrastructures to improve capital efficiency and effectiveness, increase crew safety and productivity, optimize the operations of the grid and achieve the full value from advanced metering infrastructure (AMI) data and capabilities. It includes four offering areas which cover consulting, technology and managed solutions: Work, Field Resource Management; Transmission & Distribution Asset Management; Advanced Metering Infrastructure and Grid Operations.

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