Powering an “always on” world >

How smart infrastructures work

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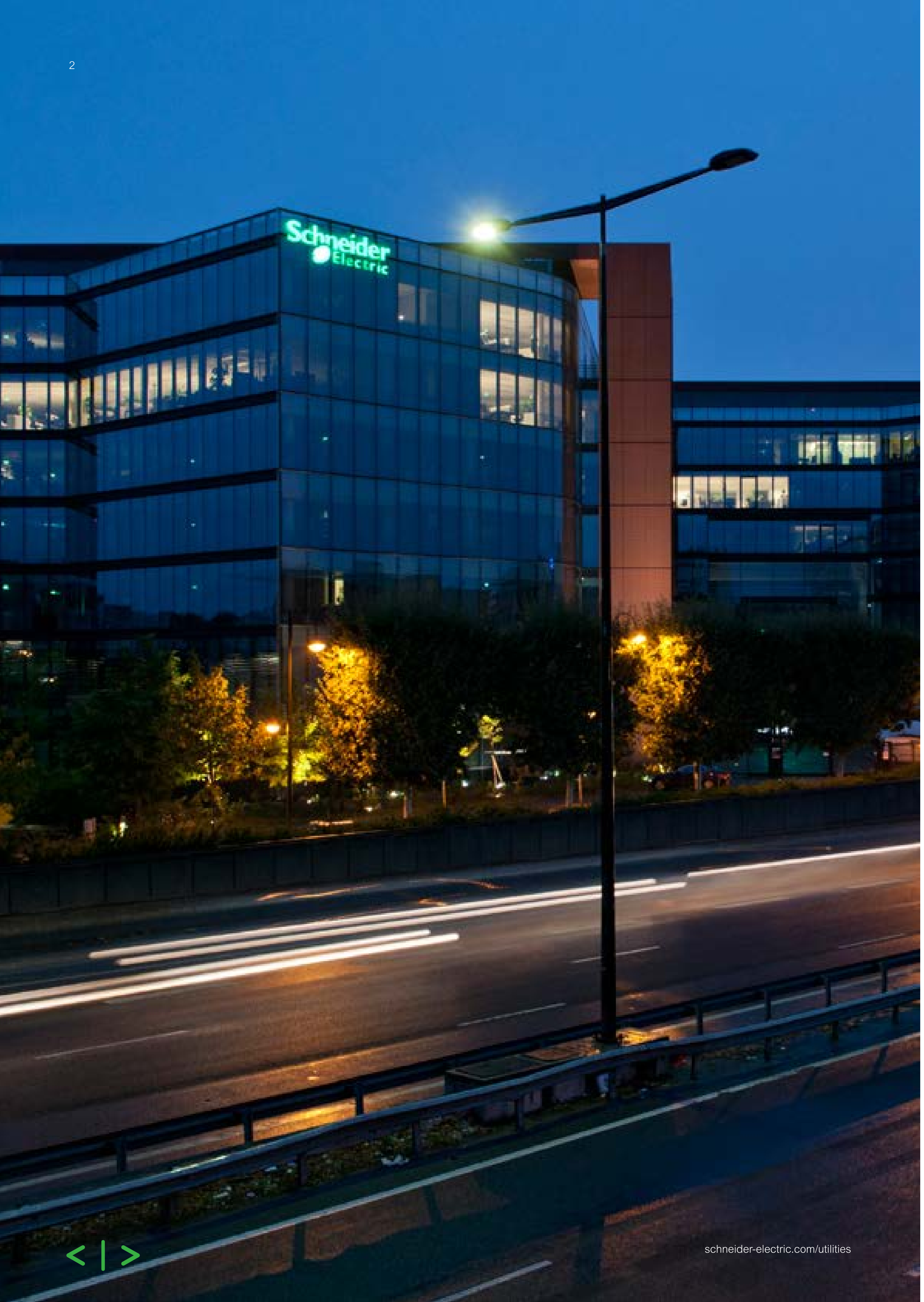

Foreword

Today's utilities have to transform into smart utilities. Those that succeed in this transition will operate an efficient smart grid, decarbonize their generation, and provide new services to their customers.

Xavier MOREAU

Strategic Marketing Director, Electric Utilities Segment

This book shares the vision of Schneider Electric on how utilities get started on this journey to becoming smarter utilities. The authors of this book, who are top experts in their fields at Schneider Electric, offer their perspectives on how to address new business models while still attaining a high degree of grid reliability and safety.

Schneider Electric has a long history of involvement with the utility industry. Since the end of the 19th century, our experts have worked hand-in-hand with our utility partners to deliver stable power to homes and businesses. Now the stakes are higher because the world is digitally connected, and human prosperity hinges upon the ability of power networks to deliver 24/7 around the globe. Our people believe that our joint mission, if properly executed, can make life better for businesses and for the 1.3 billion people who have yet to access utility power. We are also keenly aware of the impact of power generation activities on the well-being of the planet.

We wrote this book to describe how automation will help utilities modernize and extend their grid. We address how utilities can bridge the gap between information systems and operations to leverage data for improved customer service. We discuss how utilities can better manage flexible demand to mitigate variable generation. We also explore how utilities can cost-effectively enhance their plants, integrate renewables, and build microgrids to generate cleaner, safer power.

How to read this book

Although one can read this book continuously from start to end, it has been designed as a multimedia document that is easy to browse through. Solution "callouts" and "micro" success stories are dispersed throughout the text to provide additional inputs to the ideas that are presented. Links to product information are provided for those who wish to skip ahead to recommended solutions. Upon request we can also provide you with a print version of this book.

Please consider this book to be the start of a dialogue. Engage us and challenge our ideas for how to mold a better future. In the meantime, enjoy this book and may it help you on your journey to a smarter utility!

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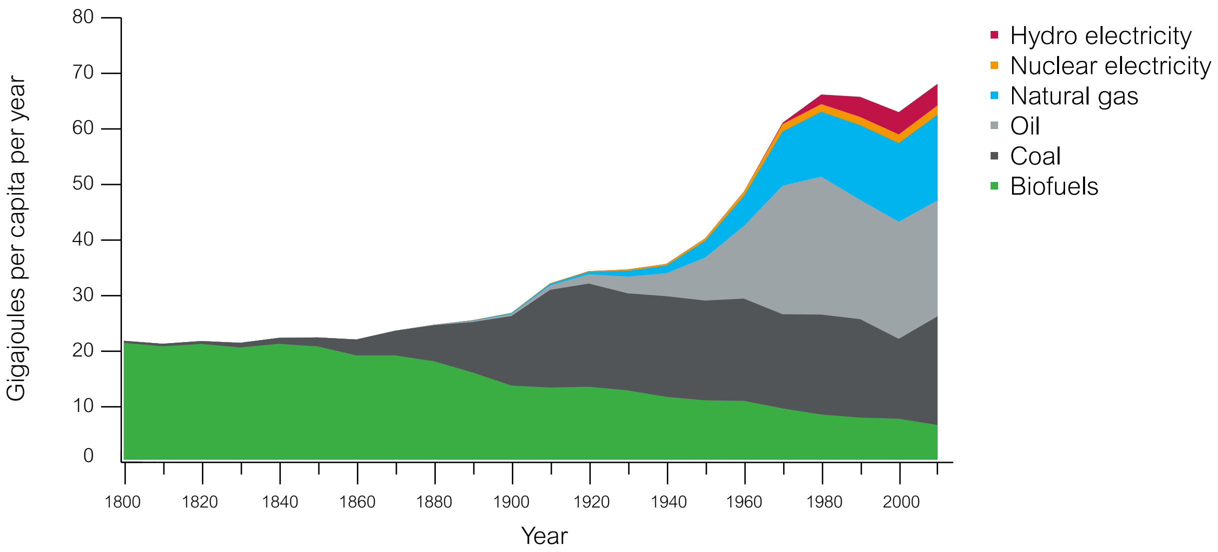
Renaissance
Emory Crawford Long Hospital

Preface

Energy at a pivotal moment

World energy consumption per capita by source, 1800-2000



Although there are still some debates among experts on the causal relationship between Gross Domestic Product (GDP) and energy, no one would argue that energy has the power to propel people out of poverty, improve economic conditions, and provide a better quality of life for billions of people. It's a basic human need.

Take the United States and India for example. More than half a century ago, their living conditions differed greatly. In 1960, an average American worked 40 hours a week[1] and earned €4,842 a year.[2] To get from their home in a sprawling new suburban community to work and back, they owned one car that could be fueled at 22 cents per gallon.[3] At home, they had a radio — maybe a TV; and they consumed 4,000 kWh of electricity a year.[4] These American workers could expect to have considerable discretionary spending until they died at the old age of 70.[5]

Meanwhile, halfway around the world in India, life was often considered nasty, brutish, and short. In 1960, the country had one of the lowest per capita incomes in the world. The average Indian earned €53 a year and lived in a one-room dwelling with no electricity[6] and no car. Life expectancy was only 42.[5]

Now, in 2016, an average person in both countries is likely to live in a sprawling metropolis. An average American works 47 hours a week,[7] earning €47,548 a year.[8] He has one or two cars that he fuels for around €2.20 per gallon.[9] Possessions include TVs, a computer, and a smartphone. He consumes approximately three times the energy of his 1960 counterpart, about 13,200 kWh per year.[4]

In India, the average Indian has gone from consuming 0 kWh to consuming 680 kWh each year.[4] One-third of the country's labor force is employed in service-oriented industries[10] — mostly IT and business — working their way into the middle class, buying their first cars, and spending discretionary money.

Graph Source: Max Roser (2016) – 'Energy Production & Changing Energy Sources'. Published online at OurWorldInData.org. Retrieved from: https://ourworldindata.org/energy-production-and-changing-energy-sources/ [Online Resource]

1. Economic History Association: Hours of Work in U.S. History 2. Dollars and Dreams: The Changing American Income Distribution by Frank Levy, from Wikipedia, standard of living United States 3. The People History: 1960s News, Events, Popular Culture and Prices 4. The World Bank 5. World Life Expectancy: Life Expectancy 1960-2011 6. Journal of the International Association for Research in Income and Wealth 1951-2011 7. Gallup: 'The "40-Hour" Workweek Is Actually Longer — by Seven Hours' 8. CNN Money: 'Income is on the rise ... finally!' 9. ABC News: 'Falling Gas Price Hitting The Economy' 10. CIA World Factbook

The average American consumes approximately three times the energy of his 1960 counterpart, about 13,200 kWh per year.[4] In India, the average Indian has gone from consuming 0 kWh to consuming 680 kWh each year.[4]

Driving economic growth while decreasing energy reliance

Developed countries are rebuilding their aging infrastructures and economies to compete in the global economy. Developing countries face the ongoing challenges of industrialization and urbanization. Let us not forget that there are still 1.3 billion people who lack access to any energy at all. Hence, the world maintains a seemingly insatiable demand for energy, which is expected to double by 2050; yet at the same time, scientists warn that to avoid disastrous (and costly) events from climate change, while the world increases its energy resources, it must also reduce its greenhouse gas emissions (mainly CO_2) by half.

The world cannot afford an ever-increasing cost of energy due to the difficulty of increasing energy resources, such as with deep offshore oil and gas drilling, and higher risks associated with getting energy from harsh or unstable regions of the world.

But is the situation impossible? No. Schneider Electric can help utilities and other stakeholders provide **safe**, **reliable**, **affordable**, **and clean energy** for their economies and people — **enabling the decoupling of economic growth from the growth of energy demand**.

We know that progress is possible, and we are committed to leading the movement to create a more efficient, sustainable, and connected world. Leveraging advancements in operational technologies, we can offer the unprecedented opportunity to empower our industries and cities to deliver a better quality of life. In the following chapters, we explore today's energy trends and challenges, and how they affect the utility industry and its customers in particular. We also present opportunities that can provide a strategic foundation for future growth, comfort, and prosperity.

Chapter 1

The utility industry: A current assessment

The utility industry: A current assessment

With the current business models of utilities being focused on selling energy, one quickly figures that reducing a customer's bill alone will lead to a dead end.

Our devices are getting smarter. Our vehicles are getting smarter. The world around us is getting smarter with more embedded computing and communicating capabilities. So it's only natural that the energy that powers our world should follow suit.

So what does smart energy really mean and how will people know what it is when they see it? The monthly utility bill is one logical place to begin the conversation. Once today's homeowner receives his bill, for example, he may see a bar graph that displays his year-to-date energy usage. He may notice that his consumption either went up, down, or even stayed the same.

However, he generally has no idea why the bill went up or down — and worse, he has no clear idea of what steps to take to better control his energy consumption in the future. The homeowner might speculate that a harsh winter caused the bill to go up, or that his old refrigerator is inefficient, or that his teenager has been leaving lights on in the basement. But he has no data to justify any actions.

Enter smart energy. The smart energy consumer today is empowered by data. Through detailed information and controls provided by the utility, he now understands the real reasons why the energy bill is going up, and sometimes can compare with owners of similar houses. He also knows how to control his bill to the extent that he might even receive rebates from the utility for using less energy or for using energy at specific times during the day when there is low demand.

The workplace is also ripe for smart energy management practices to take hold. In electro-intensive industries, such as steel making, stakeholders could view patterns in energy usage and isolate areas where efficiencies could be applied. The same goes for corporate office buildings, where the very individuals who consume the most energy never see the bill. Smarter energy management practices could put knowledge into the hands of these individuals so they could actively participate in curbing costly usage. And, in fact, if they somehow manage to get a copy of the building's utility bill, they would be hard-pressed to figure out what it all means and how they can best cut their energy costs. However, once these business consumers learn the "language" of utility bills, they quickly realize that powerful financial incentives exist for consuming energy in preset, predictable patterns.

From the control room of a power utility to the electrical outlets in the homes of consumers, technology is making our use of energy smarter and more efficient. Within the realm of power generation, distribution, and consumption, a multitude of existing operating equipment is being enhanced through the integration of sensors, information technology (IT), and communications subsystems, making power generation, delivery, and consumption more adaptive and energy efficient.

The next chapter in the energy evolution begins with learning how to leverage the exponential growth of data.

By enhancing operational technologies with a layer of intelligence, connected solutions are energizing workspaces and living spaces. The efficiency of businesses and homes is improving while power consumption is being radically reduced.

Because utilities by nature are operating systems, they must adopt a system-thinking approach. Changing one thing in one place might have dire consequences elsewhere. They must avoid the pitfalls of local optimization, instead aiming for systemwide optimization. This widely connected intelligence is of critical importance for utilities.

But where is this new energy journey taking us? How do utility industry stakeholders improve their business models so the dream of clean and plentiful energy can be fulfilled?

The next chapter in the energy evolution begins with learning how to leverage the exponential growth of data. Almost 90 percent of all the data in the world has been generated over the past two years alone. People and machines are gaining easier access to more and more intelligence, and they expect solutions that connect to that intelligence and help them make sense (and good use) of this avalanche of data.

Transforming business and operating models at the same time … and while running!

A quiet revolution is taking place within the walls of utility corporate boardrooms. The centrally managed, fossil-fuel-dominated approach of our recent past is being challenged as new energy technologies emerge and regulatory agencies push for a greater proportion of decentralized power sources. That same drive for change is being reflected in the way power networks are being designed and upgraded.

However, as in all industries, changes have a financial cost. This is especially true in Europe, where the popularity of feed-in tariffs places an additional burden on operations. The tariffs — which generously rewarded electricity generation from renewable energy sources such as solar panels and wind turbines — came at a time of overcapacity in centralized production of electricity. Subsequently, low energy prices discouraged investment in gas-burning generation, and, worse, provided a temporary reprieve to the burning of coal as the cheapest way to mitigate the variability of renewable energy due to the variations of the sun shining or wind blowing. As a result, this lack of economical coordination of renewable integration with centralized generation has impeded the reduction of CO_2 emissions in some countries in Europe.

In other parts of the world, legacy equipment and aging infrastructure are also delaying the move away from a centralized power structure. In a perfect world, outdated equipment, substations, and transmission networks could simply be ripped out and replaced to accommodate modernized infrastructure capable of controlling wind, solar, and other renewables. But the smart grid is not a start-from-scratch process. It requires a reconfiguration — a reimagining — of the existing network, which in most cases works reliably and in which capital investment has not been fully depreciated. This experience could be compared to changing the (not-so-old) wheels on a car without stopping.

For this reason, investors and stakeholders are realizing that much greater cost control gains can be had within the operations realm by improving the efficiency of the grid and lowering the operating expenses of utility business processes.

But how can operational expenditures win out in the decentralized smart grid era? Naturally, through the intelligent use of data. New data-intensive approaches have emerged that fully leverage the power of network connectivity and the rapid processing of huge amounts of data. This is helping utilities rapidly understand the complexity of the grid, automate the distribution of electricity, and enhance customer satisfaction.

These capabilities will become critical as residences, businesses, data centers, hospitals, transportation, and advanced manufacturing facilities grow more dependent on reliable power of high quality. Automated systems and greater visibility of both the network and the consumer will empower grid operators to reconfigure the grid and adjust both generation and consumption faster than ever before while limiting manual interventions. Utilities will also be able to use data to help customers better understand their energy consumption patterns and identify areas where they can save money on their energy bills.

Forward-looking utilities should view these changes as an opportunity for rebirth, a chance to rebuild trust with their customers and to offer them new services. However, transition is never easy. Skills gaps and technology adoption within an existing grid and entrenched culture require that utilities manage this transition carefully with the support of a trusted partner like Schneider Electric.

In addition to achieving operational excellence through a managed transition, utilities will seek new revenues by offering new services. Utilities will need to focus on their customers' new requirements for services and technologies to support safe and reliable decentralized power sources on the grid, lower demand, and manage new energy assets (storage, microgrids) to retain large industrial customers and promote the electrification of other industrial sectors, such as transportation (cars, trains), farming, water distribution, etc.

New data-intensive approaches have emerged that fully leverage the power of network connectivity and the rapid processing of huge amounts of data.

Read more about this topic

Inertia of regulation and politics across the globe

While providing an essential service to society, the utility industry has had its fair share of controversy, sometimes mislabeled as a "dirty industry" of "fat cats" by outspoken environmentalists, some consumer associations, and the media. Fossil fuels are synonymous with air pollution and global warming; and nuclear power evokes the notorious environmental disasters of Three Mile Island, Chernobyl, and Fukushima. In the same vein, customers in many parts of the world are seeing higher energy bills and fewer choices for purchasing energy. They are also unsure of whether that power is generated from cleaner energy sources.

Regulators at the local, national, and international levels are attempting to address these issues and are catering to the concerns of their constituents through policy reform, penalties, and an increased hand in the market — all of which impact the way utilities operate.

For example, in 2005, a U.S.-based utility was required to pay a €530,070 fine for exceeding the permitted sulfur dioxide emission limit. In another incident, as a result of a series of storm-related outages in 2011, several utilities were fined €22 million for a less-than-stellar performance in getting the lights back on after the storms passed through. And just recently, the British regulator Ofgem required new rules to compel the six biggest U.K. utilities to make costs clearer for customers.

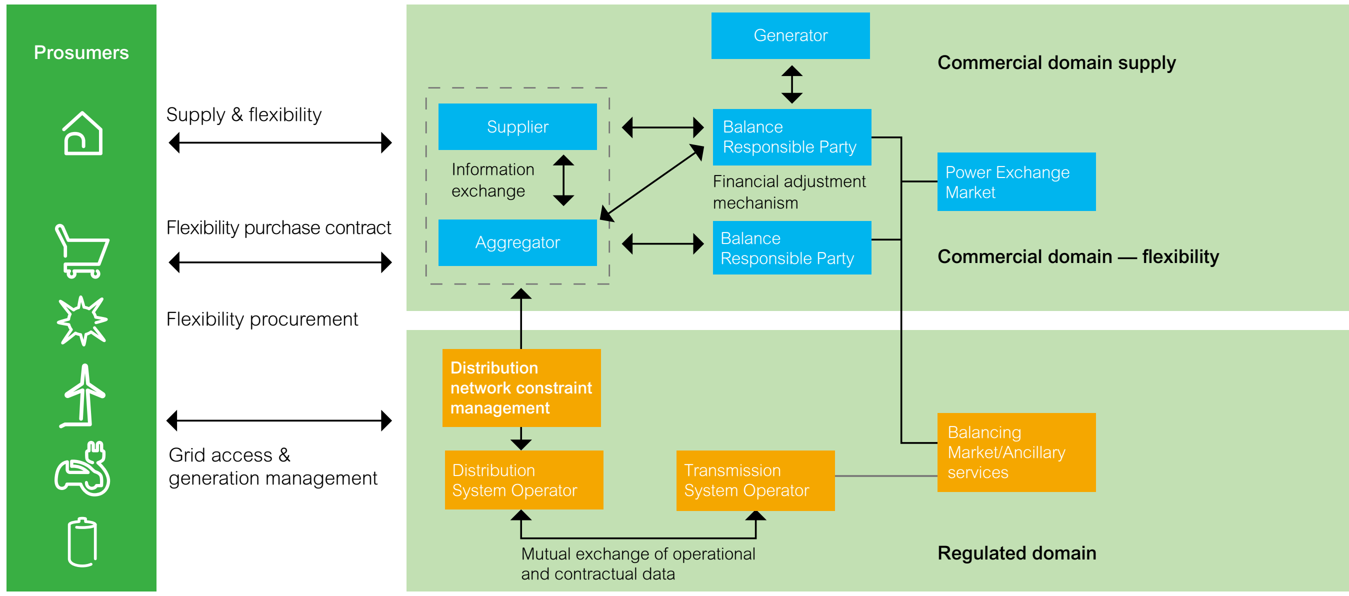
From national governments down to the local level, regulators are demanding that utilities comply with ever-changing requirements for aspects such as reliability, renewable portfolio size, and time-of-use or critical-peak pricing.

When reliability and safety are taken for granted, consumers do not make the link with the associated costs reflected on their bills.

On the other hand, governments are also providing grants, acts, and initiatives to encourage the research and development of clean and efficient energy, while also fielding calls for energy independence and the need to secure domestic infrastructure from foreign security threats. Utilities today must also comply with the standards and recommendations of multiple national and international agencies for cyber security.

These challenges add up to difficulty of site location, interoperability, regulatory approval, financing, and are all significant to the process of upgrading to a smarter grid. Utilities today have to plan strategically for the modernization of the grid and transformation of their business, taking into account the regulatory risks and consumer trends. Otherwise they risk making costly missteps that will result in stranded assets as the energy market evolves.

Possible relations between market roles



The fundamental shift in asset management and operation

The ultimate goal is to be able to operate physical assets as close as possible to their physical limits.

With limited asset information from substations, remote terminal units (RTUs), relays, transformers, meters, and transmission lines, utilities were once able to guarantee the safety and reliability of the grid. However, it has become more difficult to maintain these assets and prolong their lives as the grid faces increasing disturbances. Also the operation of the grid was relying on an overdesigned system allowing a large margin of error and strong redundancy. With limited investment (CapEx) and with increasing pressure on operating cost (OpEx), utilities must turn to IT to better manage their assets.

But utilities have struggled to gather and process information involving the wide variety of assets that support operation, including engineering, accounting, and other business processes.

The ultimate goal is to be able to operate physical assets as close as possible to their physical limits thanks to streamlined operations and dynamically fine-tuned settings, thus maximizing investments.

With asset management functionality spread across several software applications, grid owners have had to manage a tedious process across multiple databases. This has often led to a decoupling from operation and planning and has prevented strategic planners from depicting a holistic view and anticipating grid weaknesses.

Utilities also often try to adapt asset management systems (AMSs) initially intended for power stations (which are centralized) to management of the grid (which is geographically distributed). Within grid infrastructures, the topology of the network changes frequently and a vast amount of asset information is added each day through meters, home automation devices, sensors, and other hardware.

From an operations management perspective, asset data needs to be integrated into systems and applications in such a way as to allow operators to deal with "a single version of the truth."

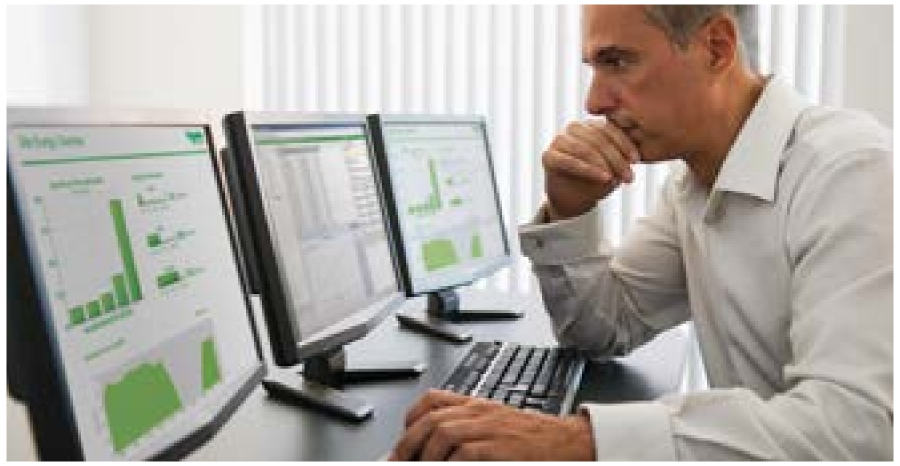
As smart grid operation becomes a sustainability goal, asset management is entering a new phase where both IT and operations technology (OT) will function together in harmony, at the core of the utility network.

For many years, traditional IT, managing information for humans (e.g., customer database, billing systems, call-center software, workforce management tools), and OT, managing data for machines (e.g., metering data, transformers and switches status, relays position), coordinated in Supervisory Control and Data Acquisition (SCADA) software systems, remained distinct domains managed by different corporate resources. But this paradigm is undergoing a radical change as OT systems are now connected through recognizable Internet Protocol (IP) addresses to the same networks as IT resources.

These new technologies also allow new predictive models, where weakened assets can be both discovered and proactively replaced, saving hundreds of hours and tens of thousands of euros or more per year.

This convergence of IT and OT is one of the key drivers of the Internet of Things (IoT) (i.e., objects connected to the Internet and communicating directly with each other) and the proliferation of "Big Data." It's the cornerstone of asset management in the digital age. This free-flowing yet structured management of data allows utilities and related stakeholders to improve real-time energy tracking in order to lower energy spend and helps grid operators across the globe meet accelerating and decelerating energy traffic demands in inventive ways.

One of the ways for utilities to control cost and enhance safety is through more accurate weather forecasting and tracking services. For example, Schneider Electric is currently working on a storm damage assessment solution that will intersect forecasted storm parameters such as high winds, lightning, etc., with utility asset data to identify probable areas of most damage from an incoming storm. This helps utilities be best prepared for severe weather events in terms of resources and inventory and speeds up restoration efforts after a storm.



Read more about this topic

Maintenance practices are also an area where large cost-saving opportunities exist. Routine maintenance programs are a major part of the asset management process, yet they represent a huge time drain for grid managers. As updated hardware and software applications are integrated into the network, however, equipment performance out in the field can be measured remotely via a central control panel. These new technologies also allow new predictive models, where weakened assets can be both discovered and proactively replaced, saving hundreds of hours and tens of thousands of euros or more per year. Ideally, grid assets are monitored so their useful life is maximized but crew intervention can be anticipated to avoid sudden failure.

Advanced metering and Customer Relationship Management (CRM) platforms are delivering a new level of clarity to customer service representatives who can use local data to help customers solve common problems. For example, should a customer call to report an outage, the customer service representative can ping the meter to check its status and check other consumers' meters in the same vicinity to confirm the kind of outage the caller is experiencing. He may then troubleshoot remodeling by acting on the smart meter. This two-way communication between the utility and the customer can also open the door to energy incentive programs, where the customer is rewarded for shifting energy use to off-peak times.

As the smart grid era advances, the integration of IT and OT will be critical to the development of efficient asset management programs.

Progress toward a smarter grid

Consumers want to benefit from the technologies that can empower them and put them in control of their energy.

Every day, the expectations of energy consumers increase in terms of grid reliability and energy's environmental impact. Anyone who runs a business, large or small, has networks and devices dependent upon the stable availability of power. Beyond having the assurance that all of their electronic devices will be supplied, consumers want to benefit from the technologies that can empower them and put them in control of their energy.

To address these growing expectations, the way energy is produced, distributed, and consumed must evolve. The solution involves both smarter demand and smarter supply.

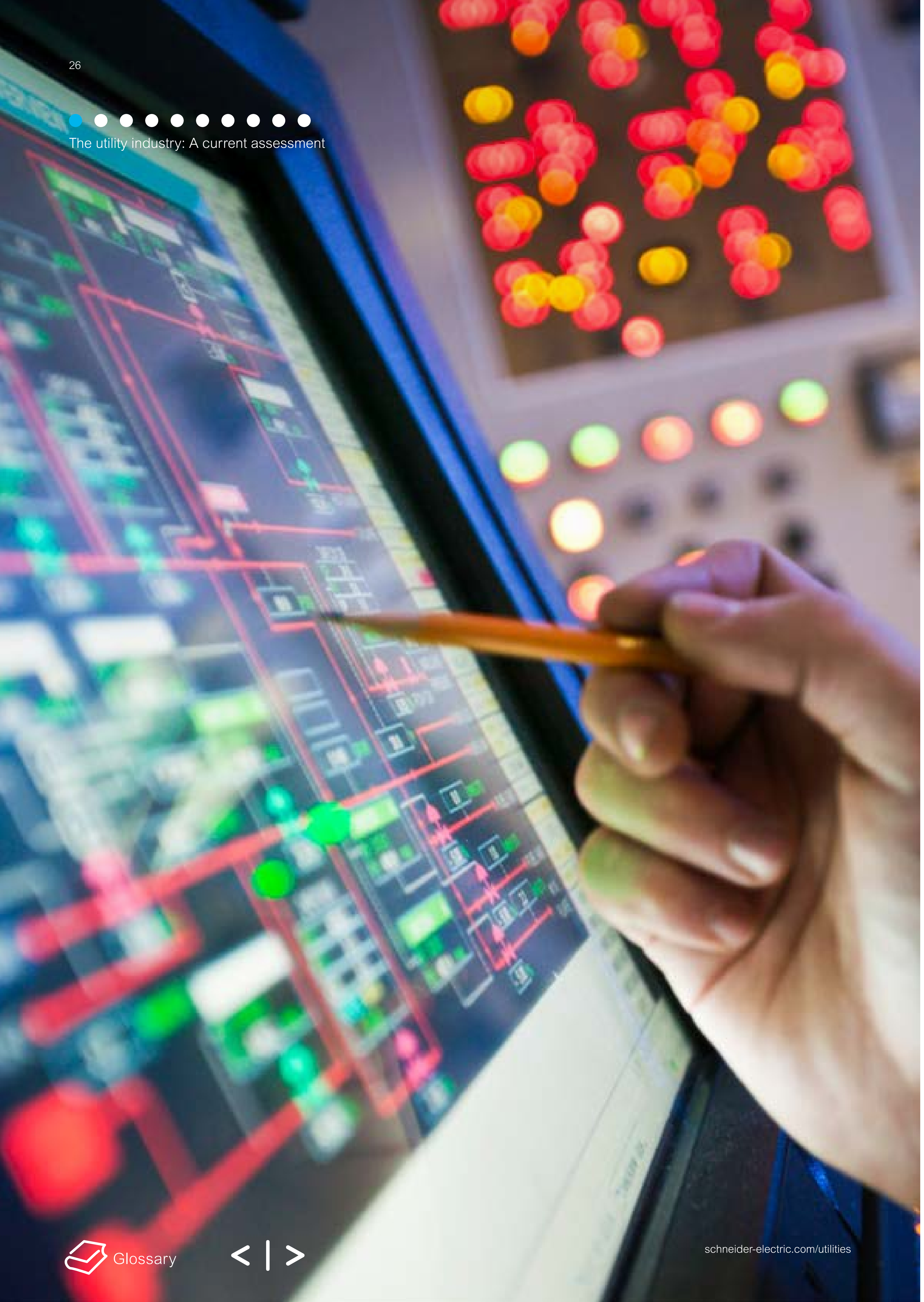
These solutions will also allow utilities to overcome many challenges: reduction of peak demand, optimization of renewable energy resources, improvement of fault and outage management, minimization of network losses, enhancement of asset management, and compliance to regulatory requirements, to name just a few of the key drivers.

Every utility in the world has requirements and aspirations that could be delivered through the smart grid. Some companies have extensive internal teams and consultants mapping out an advanced strategy, while many others are struggling to find the right place to start.

While there is a competitive "rush" to launch smart grid initiatives, care must be taken in mapping each utility's own individual journey. The regulatory and operational landscape of moving to become a smarter utility is highly complex.

Fortunately, utilities are not alone in the struggle to modernize their grids. One of the most important side benefits of smart grid evolution is how government and industry groups are working in collaboration to develop industry standards. Interoperability standards play a key role in supporting grid modernization. Interoperability will give utilities more freedom of choice and enable smooth integration of equipment that can operate with the legacy grid.

The work of the National Institute of Standards and Technology (NIST), industry associations such as the International Electrotechnical Commission (IEC), the Electric Power Research Institute, the Smart Grid Interoperability Panel, and trade groups like the GridWise Alliance and GridWise Architecture Council all contribute to establishing the definitions and specifications for connecting grid devices. These groups have enabled a rapid movement forward in the development of the smart grid.



Processes are already in place to close the gaps in current standards. Most grid-focused interoperability projects that adhere to the current standards can now move forward with a higher degree of confidence.

Another factor to consider is how a new level of grid monitoring is helping to enhance operational awareness. In this domain, the size and complexity of the distribution network model presents a management challenge. The modern grid system must be able to handle the large quantity of information and must also quickly sort through and identify the monitored data points with operational relevance. The challenge is to avoid flooding the operators with a deluge of information. By automating easy decisions, this frees up time for them to focus on the more complex ones.

As more connected devices are added to the grid, and as Distribution Supervisory Control and Data Acquisition (DSCADA) systems expand both inside and outside the substation fence, management systems need to process ever-greater volumes of data while assessing the grid's current state. Critical limitations of traditional "dumb" OT equipment present a major obstacle. Many utilities realize this. It is projected that about €400 billion will be spent on electrical networks and smart grids in Europe by the year 2020.[1] Most legacy field devices rely on proprietary communication protocols not designed for upgrading or refreshing. Integrating these devices with more modern, open technologies is a critical task for making grids smarter.

Traditional meter data management (MDM) tools and enterprise data mining systems are usually not up to the task of recognizing and extracting valuable grid operational information in a timely fashion. Deployment of an operational data store, based on a platform designed to manage and interpret data in real-time or near real-time, can help achieve this goal.

Upgrading hardware and software does not automatically enable a utility to operate a smarter grid. Managing an IT-OT-converged distributed smart grid network is both easier and more difficult than a traditional system. On one hand, more data and enhanced functionality mean more informed and faster decision-making. On the other hand, added complexity can increase the risk of operational errors. In many utilities, operators will struggle to process the higher volumes of information and will need to select operating options from an increased set of alternatives.

Furthermore, silo applications (i.e., that operate in isolation, in their sole area) won't support efficient operation of the distribution system. Imagine the control room scenario during an emergency switching operation. The operator has to restore service to an entire neighborhood or to a commercial customer such as a shopping mall. Now picture the distribution system operator (DSO) trying to pay attention to three different systems. The operator has to monitor the DSCADA system for alarms and network parameters while keeping an eye on the distribution management system (DMS) to determine whether any switching might be possible for restoration. Meanwhile, the operator needs the outage management system (OMS) to identify the likely source of the outage, visualize any reported hazards, obtain a count of how many customers are out, and determine where the crews are that can be dispatched to help. This is a daunting task, especially when performed under the pressure of a major service interruption.

One approach that some leading utilities and their vendor partners take is to integrate distribution operational applications into a single platform. This helps to streamline the management of the overall system, offers improved workflow, and simplifies task execution.

Often referred to as Advanced DMS (ADMS), this approach merges DSCADA, OMS, and DMS into a single platform. By equipping users with a single tool that presents an integrated flow of information in a unified, straightforward user experience, operations and analysis of the distribution grid are simplified, and high-speed, high-quality decisions are enabled.

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It is projected that about €400 billion will be spent on electrical networks and smart grids in Europe by the year 2020.[1]

Read more about this topic

[1] European Commission, ENTSO-E & EDSO

Shifting sands within the nuclear power industry

The current level of nuclear generation helps the world avoid an estimated 2.9 billion tons of CO_2 emissions per year.

The amount of electricity generated via nuclear power plants is expected to increase from 12 percent in 2011 to 17 percent of global electricity supply by 2050.[1]

Why the expected growth? Nuclear energy not only remains a reliable source of power, it also contributes significantly to the reduction of greenhouse gas from the electricity supply sector — a powerful influencer as governments continue to search for solutions for climate change.

The current level of nuclear generation helps the world avoid an estimated 2.9 billion tons of CO_2 emissions per year (approximately 24 percent of yearly power sector emissions). From now until 2050, nuclear power is expected to remain a cost-effective method for helping reduce energy-related CO_2 emissions by 50 percent.[1]

These factors have led to a renewed interest in building new nuclear power plants in some parts of the world.

Yet even as nuclear continues to prove its viability, some countries are shifting away from nuclear generation, or shutting down plants that are no longer sustainable from a financial perspective. Local and national governments are struggling to figure out whether or not to replace aging nuclear plants or move capacity to other power sources.

Past nuclear power accidents still influence opinion today. In the 1980s, problems at the Three Mile Island plant in the United States and the Chernobyl plant in the Soviet Union led to antinuclear political movements, as well as to the decision of some U.S. states and certain European countries to stop nuclear expansion and phase out existing operations. More recently, the problems at the nuclear plant in Fukushima, Japan, have cast a dark cloud over nuclear.

[1]IEA Energy Technology Perspectives 2014

Read more about this topic

For nuclear energy to be widely accepted, safety measures must be strengthened in order to prepare for even the most improbable events. With this in mind, nuclear safety authorities are now demanding that existing plants be brought as close as possible to the safety levels of new builds. As a result, many plants will be required to have a consistent supply of electricity, whatever the circumstances — come earthquake, tsunami, or any other disaster.

In response to these demands, utilities are deploying new methodologies to achieve the highest level of certification. Empowered by a desire to secure base power, enable prolonged operational life, and address the shortcomings of past nuclear disasters, many utilities are retrofitting nuclear plants through the aid of strategic partners, while others are building more resilient plants that can last for 60 years.

Modernizing the instrumentation and control of existing plants is also a way to capitalize on existing investment while meeting the highest safety standards and extending the operational life of the plant.

In the years to come, the nuclear industry and all of its participants will endeavor to change the face of nuclear through improved safety measures and by promising a highly efficient, clean, and large-scale energy supply that meets the intensifying demand for dependable power.

Management and integration of renewable energy sources

One of the biggest challenges on the roadmap to the smart grid is the responsibility (and obligation, in many cases) to combine established power sources with alternative energy in order to lower the impact on the environment and to secure additional energy for the future.

This transformation is partly due to pressure from private and public third-party groups and government regulators. The former (e.g., conservation advocacy groups, consumers, shareholders) view alternative energy as a means to a cleaner environment, and many are already installing energy-saving systems in their own homes and buildings. While the latter, government regulators, are interested in encouraging the use of environmentally friendly energy sources, while at the same time improving efficiencies through improved supply and demand.

However, as new sources of local production come online in the wake of these pressures, utilities are struggling to find effective ways to combine traditional power sources with renewables without compromising the way the network is managed.

Most renewable energy sources are very diffuse and scattered, while energy demand is more intense, such as with heat pumps, and load centers are more concentrated, such as cities.

New targets for renewable energy source deployment can be met with accurate and highly networked sensors, actuators, and management systems. Poorly or partially instrumented networks downstream of secondary substations will need to be upgraded. Network architecture designed when generation was centralized and at times when there was little if any communication and intelligence in networks must be reinvented to accommodate for dispersed production not necessarily close to the new load centers. And the variable nature of most renewable generation, as well as the emergence of significant new loads like electric vehicles (EVs), can complicate load balances on lines, leading to voltage instability and even failures.

Nevertheless, as great as these obstacles are, they are not insurmountable.

New technologies, including weather forecasting software and remote management, are redefining the impact of renewable energy sources. A grid operator can now evaluate the performance of an individual wind turbine and make adjustments from a control center thousands of kilometers away. Improved operations management and streamlined maintenance plans are also yielding a greater return on investment.

The price of renewables is also coming down. The cost of solar has never been more competitive with fossil fuels than it is now, both in terms of its physical equipment and the actual market rate. Hydro has proven to be a highly predictable energy resource and a worthy replacement for backup diesel power plants due to its immense storage capabilities.

Without question, renewable energy integration will bring more advantages than drawbacks for utilities that move toward the smart grid. And while the roadmap may seem unclear, experienced intermediaries such as Schneider Electric and the right technology mix can make the transition much easier.

Read more about this topic

Demand management and the role of "prosumers"

Now imagine a world where a typical business or home is savvy about Its energy consumption, or is actually in a position to generate revenue through the energy it does NOT consume.

The energy industry's business model has remained fundamentally unaltered over the last century. It's a model that emerged out of the Edison age, where the utility was responsible for generating power and selling it to the customer. Usage meters were read and billing was based on simple bulk consumption.

Imagine that energy customers are able to proactively choose which energy source they want to consume. Imagine that green, renewable sources are supplying most or all of the energy needed for every purpose: lighting, heating, processes, and transportation. Imagine an electricity supply that is completely reliable. As part of smart grid modernizations, new programs are being launched or expanded that encourage energy customers to adjust their consumption in response to pricing signals, penalties, or curtailment requests.

Due to this potential flexibility, customers' energy-consuming loads and any on-site energy generation capabilities are now considered important distributed energy resources (DERs), critical to helping balance the grid.

At the same time, many customers have begun taking more direct control of the cost, reliability, and green mix of their energy supply. City districts, educational campuses, military bases, hospitals, commercial buildings, factories, and even residential homes are becoming proactive energy consumers, or "prosumers," that consume energy, produce energy, and control it. They are enabled on this journey by a convergence of new, widely available technologies that can automate and fully monetize their energy resources.

It is estimated that 3 million energy users in Europe are already generating at least some of their own power. By adding an energy management system (EMS) or an energy storage system, customers are maximizing self-consumption of this energy and gaining more control over when to use it.

These prosumers are taking energy consumption and management into their own hands through a variety of activities, including purchasing "smart" products that turn on or off in response to changes in energy pricing and/or peak loads. For utilities, the prosumer revolution represents an opportunity to go behind the meter in order to manage assets and bring an extra layer of flexibility to modern-day grid constraints. The term "demand management" is used to describe one of the major change drivers in the industry today. "Demand" refers to everything behind the meter or any load pulling electricity from the network; and "management" applies to the level of control over that load. Load here being net apparent load, which is subtracting any local generation or storage from the total consumption.

The goal of demand management is to provide utilities with an alternative to building more power plants to meet capacity needs. By having the ability to modify energy usage on the demand side through smarter technology, education, and energy-efficiency improvements, utilities can both save money and accommodate the demands of the prosumer movement.

For example, a grid operator could switch off a piece of equipment at a factory for a few seconds in order to thwart the need for bringing a marginal peaking unit online. In another example, a homeowner could remotely configure a load of laundry to run during off-peak hours, based on real-time data from the utility. The trick is to do this automatically, and not only using day-ahead or hour-ahead signals for voluntary load reductions. Today, Schneider Electric is the leader, with Energy Pool, in "Automated Demand Response," where individual processes within industrial facilities can be controlled and managed as part of a real-time demand response portfolio across multiple sites.

On the demand side, this approach can save customers money through load flexibility, either for curtailment or for consumption stimulation. On the supply side, the utility can improve the reliability, efficiency, and sustainability of modern-day energy without necessarily relying on a decrease in total energy consumption. Also, demand management, by matching controllable demand closer to variable generation, will enable a higher integration of variable renewable generation in the mix.

A customer's energy-consuming loads and any on-site energy generation capabilities are now considered important DERs.

Read more about this topic

The evolution of microgrids

The stability and resiliency of electric grids all over the world are under the stress of increased energy demand, fluctuating markets, natural disasters, cyberattacks, and aging infrastructure. Since worldwide energy demand is projected to grow 41 percent by 2035, the situation, if unchecked, will grow worse.

We now see clearly that in rich and mature economies, where GDP is high but does not grow quickly, energy is produced more and more by local owners with strong energy efficiency programs resulting in a flat or declining demand growth as viewed by the utilities.

In new emerging economies, where GDP growth depends on access to energy, we also see a need for distributed energy to accelerate the electrification of the cities, industrial areas, and rural areas without waiting for a complete grid infrastructure to be built.

Stricter environmental regulations in some countries mean that adding traditional power generation capacity, such as diesel generators, is less viable. And even as more renewable energy is connected to the grid, the variable nature of these power sources only adds complexity to both operations and pricing structures.

One answer being proposed to this dilemma is to allow for the proliferation of microgrids as pockets of stability and resiliency. Microgrids are already being deployed across the world in many military bases and campus environments.

Microgrids are unique from utility companies in that they can function either autonomously or in coordination with the main grid. The handlers of the microgrid, often comprised of large businesses or other private sector organizations, are able to summon local sources of energy to generate electricity, regulate the amount of electricity being used, and make repairs when needed.

But what is a microgrid, exactly? The term has been used for years, but there is much debate over the true definition. Rob Thornton, president and CEO of the 105-year-old International District Energy Association, says that microgrids are “more than diesel generators with an extension cord.”

In other words, a microgrid is not just backup generation but should be a robust, 24/7/365 asset that provides primary energy services to a single critical facility or community of residential, commercial, and industrial customers. A microgrid can provide backup generation, but it offers additional, more intricate services as well.

Microgrids are poised to become an integral part of the energy transformation.

Global interest has grown in these "mini" versions of the larger grid for the following reasons:

1. Lower fuel prices make microgrids increasingly cost effective to operate. Prices are also declining for renewable energy and storage, allowing for more effective use of local energy in microgrids.
2. Software and inverter advancements resulting in smart controls make it much easier for operators to manage microgrids.
3. Resiliency where microgrids can keep the lights on during a large storm by islanding from the main grid and assist in faster recovery of the main grid using coordinated black start processes.

Until now, microgrids have operated as a niche technology, workable and financially feasible mostly on college campuses, army bases, or in remote locations as an addition to a diesel genset (a combination of diesel engine and electric generator). Today, however, microgrids are poised to become an integral part of the energy transformation.

How quickly microgrid expansion occurs depends on the disposition of policy and regulation. Policymakers, regulators, and grid operators are just beginning to consider the rules that will govern the next phase of microgrid development and operation.

Therefore, the microgrid industry finds itself at a nascent and crucial stage. Schneider Electric is committed to partnering with utilities in innovation for microgrids. Clearly the operation and maintenance of microgrids can easily be a core competency of utilities and with Schneider Electric as a partner, together we can design microgrids that will be robust and easy to operate.

Read more about this topic

Threats to system and network security

Over the past decade, the demand for digitized, connected, and integrated operations has increased across all industries. Compared to the IT industry, the energy industry is late to the connectivity game.

The pressing need to improve critical power distribution infrastructure uptime is accelerating the rate of change in this domain. However, as the power networks merge and become “smarter,” the benefits of improved connectivity also open the door to more cyber security risks.

According to the U.S. Department of Homeland Security’s Industrial Control Systems Computer Emergency Response Team (ICS-CERT), 53 percent of cyber security incidents reported and investigated by the agency in the first half of 2013 were related to the energy industry.

Now that cyber security is a top-of-mind concern, utility stakeholders are applying processes from their IT peers and are investing to put their infrastructure security house in order. Within substations, proprietary devices once considered for specialized applications are now vulnerable. Sensitive information (such as online documentation that describes how these devices work) can often be accessed via the Internet by anyone, including those with malicious intent who wish to cause disruption.

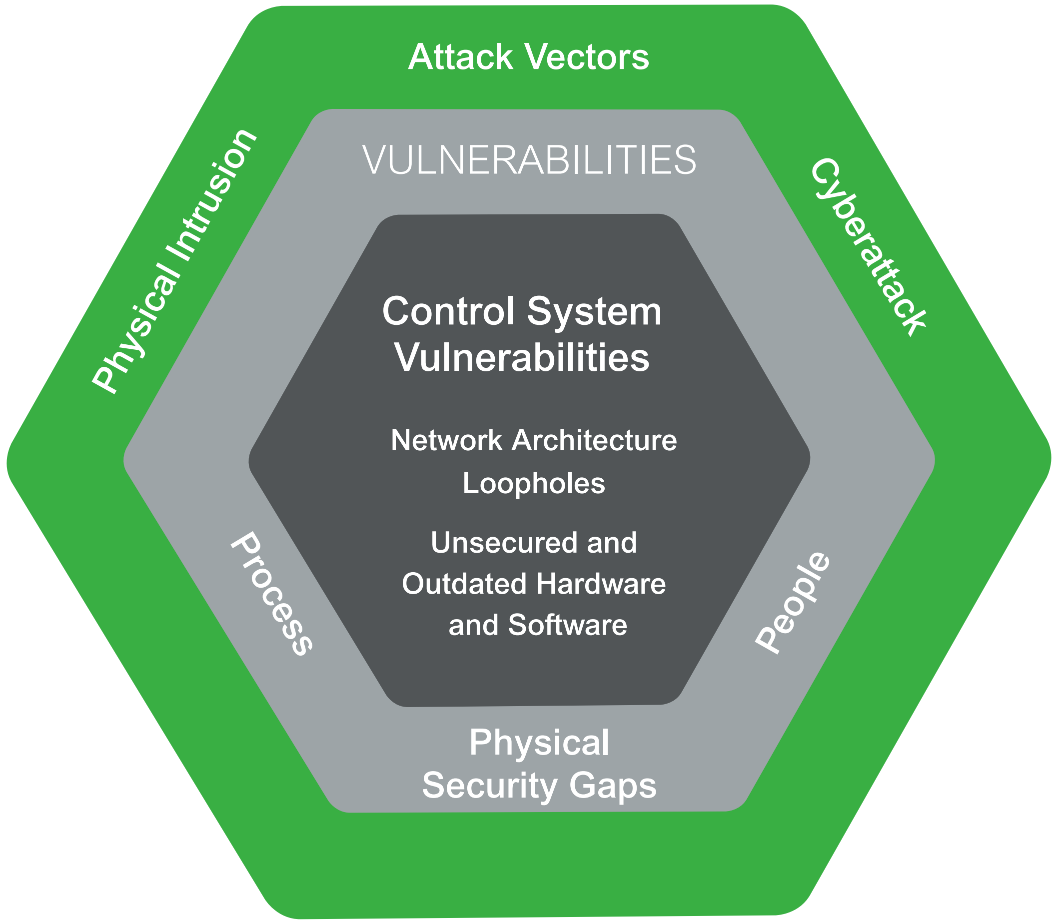
With the right skill, someone can hack a utility and damage systems that control the grid and affect the economy and security of a country or region.

Utilities will be able to make the successful shift toward securing their operations by relying on control solutions providers that treat security as core to their offerings. Of course, it is vital that organizations realize this is a joint process where vendors and clients need to work together to achieve agreed-upon objectives.

53%

53 percent of cyber security incidents reported and investigated by ICS-CERT in the first half of 2013 were related to the energy industry.

Read more about this topic



The impact of intermediaries and the importance of skill development

Another significant challenge is the age profile of operators and supervisors in utilities environments, creating a skills and knowledge gap.

The utility industry has also lost some of its shine and seems less attractive to young, highly skilled graduates as compared to high-tech and Web industries, for example, making the sourcing of new skills through hiring a challenge.

In addition, the increased complexity of typical utility processes, the higher speed of process changes and system upgrades, the increased frequency of new product introductions, and the amalgamation of various operations is driving demand for effective education and training.

To that end, only solution providers with expertise in utilities and grid technology can train collaborators for utilities as well as provide consulting services and expertise. They are an important resource because they can easily transfer the knowledge and enhance the utilities' skill base while speaking the same language and understanding the key issues of safety, reliability, and flexibility.

The importance of education and training is increasing as we exit the baby-boomer era with many experienced workforce staff nearing retirement. Most mature industries (e.g., mining, oil & gas, primary metal, fabricated metal, textile, chemicals, plastics, machinery, utilities) that rely on process control solutions are the same industries that undertook most of their hiring decades ago. Therefore baby boomers comprise a larger share of their workforce than that of emerging industries.

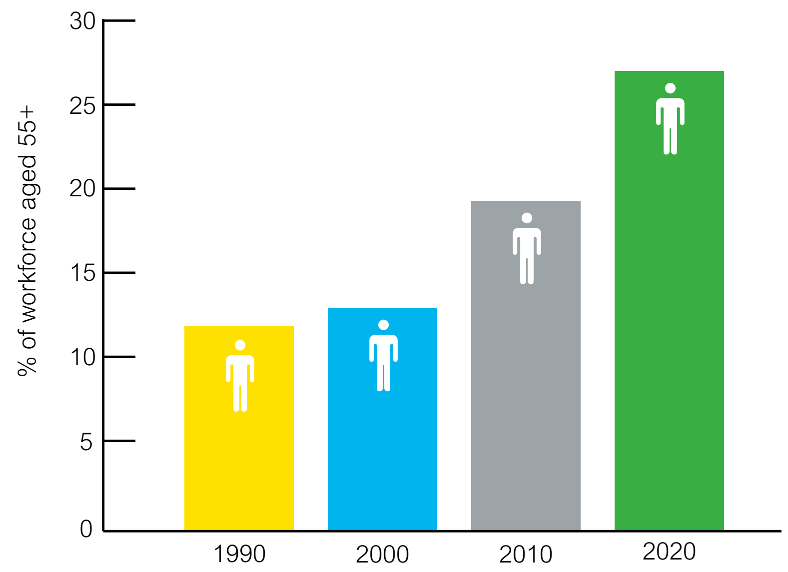
As experience is lost, training needs increase. Schneider Electric strives at developing training programs with utilities so that knowledge can be transferred from older operators to younger staff while taking advantage of the new technology.

A cultural shift is taking place, one that moves from viewing training as a necessary chore to an environment where training is regarded as a must-have opportunity for productivity and profit gains. The system and technology provider's knowledge base is leveraged and considered a "skills base" of understanding the technology and how it works so that utilities can focus on their core areas of expertise: delivering clean, stable power to consumers.

All utility employees, through training, will develop the ability to think from an "integrated solutions" perspective so that overall utility performance can be maximized.

Read more about this topic

Aging workforce



Source: Toossi, M. (2012). Labor force projections to 2020: a more slowly growing workforce. Monthly Lab. Rev., (January), 2010-2020

Summary

We stand at a pivotal moment in time. The global need for reliable power has never been greater. The way in which we deliver that energy has never been more fragile. At the heart of it all, power utilities are given the mission to bring balance to that equation.

The choices we make now will be the choices that bring the world smarter, more collaborative, and common-sense energy.

We now know where the new energy journey is taking us: through changing business models and renewable energy, through smart grids and prosumers, right down to the homeowner's electric bill. And even if that journey is beset by challenges and opportunities, utility industry stakeholders must assume a leadership role and act.

In the next chapters, we'll describe that journey in more detail, beginning with how utilities can excel in their core business of supplying electricity in an ever-safer and more reliable manner by leveraging data and modern asset management solutions to stabilize the grid and reduce operational costs.