MarshMcLennan

Making the switch

Navigating the smart grid transition

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KEY TAKEAWAYS

Smart grids…	utilize novel combinations of technologies to address existing operational risks and create new revenue streams.
1) are emerging in some countries and incorporating new capabilities in countries with preexisting smart grid infrastructure.	The convergence of advanced technologies is creating innovative opportunities to enhance existing power grids. Stakeholders across the value chain will have to navigate this transition carefully, balancing the imperative to modernize with the financial obligation to fully capitalize on existing infrastructure.
2) are necessary to overcome operational disruptions and meet sustainability expectations.	Widespread disruption from extreme weather and cyber events, volatile energy demand and supply patterns, and sustainability concerns make now the appropriate time to assess and selectively incorporate smart grid technologies.
3) provide attractive commercial opportunities.	Smart grid technologies create many opportunities for utility providers. A few examples include: • Efficiency and reliability gains from optimizing supply and load balancing • Dynamic pricing and responsive demand adjustment • Better, more predictive maintenance for grid infrastructure
4) bring with them additional stakeholder responsibilities.	Grid modernization initiatives are complex projects that require additional due diligence as they involve multiple stakeholders with sometimes competing objectives. Adopters must also be capable stewards of data — securing sensitive information and protecting consumer privacy.
5) require a considered approach to manage the transition and ensure successful implementation.	To justify investment decisions, utility providers and investors will need to assess the capabilities and economics of various technologies in conjunction with existing regulatory constraints and incentives. Successful implementation of smart grid technologies requires careful planning and deployment in coordination with the retirement of existing grid infrastructure.

Contents

Introduction

Innovative combinations of advanced technologies have the potential to transform the energy sector. The revenue streams unlocked by these opportunities can help the energy sector migrate to a cleaner “smart grid 2.0.” But business leaders must not be complacent. Poorly executed planning and deployment can lead to disaster and open the door for technology disruptors.

Power grids worldwide are under pressure from a more volatile climate, growing demand for renewable energy, and rising urbanization. Existing grid networks are vulnerable to extreme weather events and cyberattacks, with power outages in the US alone costing businesses around $150 billion a year.[1] Traditional grid technology holds back the integration of distributed energy sources and restricts consumer energy contributions. With the global population expected to increase by 2.5 billion people by 2050 — two-thirds of whom are expected to live in urban areas — energy demand will only increase the load on existing infrastructure.[2]

As the energy industry gradually adopts smart technologies, some more developed markets have established a “smart grid 1.0” — a trend that is also emerging in other countries. New, more sophisticated technologies on the horizon will accelerate the transition towards a “smart grid 2.0.” This will combine expanded 5G network bandwidth with AI/ML-fueled predictive analytics to help balance load and prevent outages. Deployment will also embed other capabilities such as reinforcement learning, real-time remote diagnosis, and automated repair (self-healing). Moreover, these technologies will smooth the integration of renewable energy sources, enabling a pivot towards a greener energy economy. This progress will also bring with it revenue opportunities from new products and services as well as the potential to monetize more expansive data streams.

To navigate this next-stage transition successfully, stakeholders across the value chain — utility providers, transmission and distribution operators, and others — must balance the imperative to modernize with the financial need to capitalize on existing infrastructure assets and the societal obligation to maintain reliability. Technology selection decisions should be prioritized according to the scale of their expected benefit, tailored and timed according to regional operational dynamics and in anticipation of evolving regulations. Expanded risks associated with the transition — new cyber vulnerabilities, data privacy protection obligations, and gaps in workforce talent — must be mitigated.

This report explores ways in which existing energy grids can benefit from smart technologies and provides practical guidance for overcoming challenges as energy system players set a course to the future.

The case for grid modernization

Changing supply and consumption patterns are complicating energy sector demand planning and investment decisions. This is exacerbated by more frequent climate-influenced operational disruptions and tougher sustainability obligations.

Energy providers are grappling with a volatile, less predictable mix of factors that at times impact operational reliability. Legacy grid infrastructure often struggles to keep pace with these dynamics, underscoring the importance of an accelerated yet considered transition towards a smarter, more resilient grid (see Exhibit 1).

Exhibit 1: The need for smarter grids — in numbers

Increasing operational disruption

50%
of all power outages in the US are caused by extreme weather events[3]

$4.65 million
average cost of a data breach in the energy industry globally[4]

Growing and shifting energy demand and supply

30%
projected increase in global energy consumption by 2050[5]

2x
global consumption of renewable energy between 2020-2050[6]

Adoption of smart & sustainable technology

$17.4 billion
global market size for vehicle-to-grid technologies by 2027[7]

47%
of all domestic meters in the UK are smart[8]

64%
decrease in price of storage supporting lithium-ion batteries globally[9]

Source: Marsh McLennan Advantage

Power grid failures shutter businesses, impact supply chains, inconvenience households, and trigger accidents and deaths. They can also lead to substantial maintenance and repair costs. Extreme weather presents one challenge. Severe winter storms in Texas in February 2021 resulted in economic losses of $129 billion, 246 fatalities, and power outages for more than 10 million residents.[10,11] Cyber threats present another hazard. In 2019, 155 different groups specifically targeted elements of the global energy sector (see Exhibit 2).[12] As illustrated by the oil and gas industry's Colonial Pipeline and Ukraine power grid failure (2015) events, successful attacks have negatively impacted large populations.[13,14] Failure to prevent or adequately respond to such events exposes utility firms and governments to liability risk, reputational harm, and worse.

Exhibit 2: Disruption threats in the energy sector

79%

increase in climate-related disasters in the period 2000-2019 vs. 1980-1999

80%

increase in cyberattack groups targeting the energy industry between 2015-2019

Source: Our World in Data/EM-DAT, World Energy Council

Energy demand and supply patterns are changing as well. Increased urbanization, often accompanied by more sophisticated and energy-intensive consumers, is driving a rise in demand as per capita energy consumption and city populations grow. Industries that use power-hungry technologies such as data centers and blockchain are also expanding. If digital currencies, web 3.0, and other Metaverse-enabling technologies achieve wider adoption, this trend will certainly grow in scale. On the supply side, the ramp-up of renewable energy generation in many countries is challenging existing grid infrastructure geared towards traditional sources.

Currently, about 30 percent of global electricity output, renewable energy sources will account for 95 percent of the increase in power capacity through 2026.[15,16] A widely recognized challenge, the unidirectional power flow of traditional grids does not support the storage and distribution of excess energy. The bi-directional energy flow of smart grids can help manage peak load events and address supply shortages associated with the intermittence of renewable energy sources. Of course, load management and forecast accuracy also benefit from the bi-directional flow of energy and information. For example, better predictive analytics and responsive load management can help address increased volatility caused by the adoption of electric vehicles and demand spikes from residential heating and cooling systems. Smart grid technology will be crucial to respond to these challenges by improving load balancing, incorporating smart energy storage infrastructure, and facilitating data-driven decision-making.

Battery technology advances are enabling more sustainable smart homes as well. By producing and storing electricity, consumers can provide energy back to the grid when appropriate conditions arise. Additionally, the rise in remote working and consumer preference for connected Internet of Things (IoT) devices is driving the adoption of smart home appliances that can be integrated with grid technology, enabling demand-side management capabilities. Governments are playing a role in changing expectations. As part of the 20/20/20 initiative to achieve a 20 percent reduction in energy consumption by 2020, EU member states deployed around 150 million smart meters in homes before the close of 2020.[17]

Legislation incentivizing a shift towards EVs as part of broader efforts to curb emissions is also driving demand for grid modernization. The Netherlands, Norway, and Ireland aim to stop registering and selling gasoline-powered vehicles by 2030.[18]

As the industry grapples with disruption threats and sustainability concerns, utility providers will need to identify specific areas of technological advancement that effectively address operational challenges.

Sidebar: Recent technological advances

TECHNOLOGY	FEATURES	VALUE	ESTIMATED ANNUAL MARKET SIZE (BY 2028)
Fifth-generation mobile network (5G)	Engineered to increase the speed and responsiveness of wireless networks greatly Compared to 4G networks, 5G download speeds are estimated to handle downloads 20 times faster and support 100 times more traffic	Greater bandwidth, higher speed, ultra-low latency, and improved reliability	$665 billion at a CAGR of 46%
Edge Computing	A distributed computational framework, edge computing brings data storage closer to the site of data production (the edge)	Rather than store data at a centralized location, edge computing takes place closer to users of data Edge computing supports real-time data crunching and minimizes latency issues	$61 billion at a CAGR of 38%, enabled by integration with Internet of Things (IoT) devices
Industrial Internet of Things (IIoT)	IIoT refers to the interconnected system of devices, controllers, and sensors that generate vast amounts of valuable data	Focused on industrial safety and efficiency, IIoT includes instruments such as drones/robots that can carry out site inspections in less time and with more efficiency, eliminating physical risks to people	$1 trillion at a CAGR of 23%
Artificial Intelligence (AI)/ Machine Learning (ML)	AI involves the training of machines to mimic human cognition and learning abilities ML is a subset of AI that provides algorithms to enable the machine to learn from its previous experiences	AI reduces the time taken by a task and can help eliminate the necessity for humans to perform repetitive/tedious tasks ML enables the machine to autonomously train itself to improve accordingly	AI: $998 billion at a CAGR of 40%
Augmented Reality (AR)/ Virtual Reality (VR)	AR is an interactive, three-dimensional experience that combines a view of the real world with computer-generated elements VR refers to the creation of a completely synthetic world, where the user is placed in a 3D environment and can interact with computer-generated elements	By overlaying virtual elements onto the real world, AR can interpret, manipulate, and enhance the view of the real world in real-time	AR: $340 billion at a CAGR of 44% VR: $70 billion at a CAGR of 18%

Note: CAGR numbers for the period 2021-2028.

Source: Marsh McLennan Advantage; Grand View Research, Retrieved March 15, 2022

The promise of smart grid technology

Smart grid technologies enhance reliability, optimize load balancing, and create new commercial opportunities for utility providers. But adopters of this technology must be trustworthy data stewards, safeguarding access to consumer data and ensuring that, when assets are monetized, it is done so prudently and as intended.

Evolution of the smart grid

Historically, grid systems have been characterized by a unidirectional energy flow from centralized generation sites. Technology improvements have gradually enabled the energy industry to move towards a grid network with improved flexibility, efficiency, and transparency — the “smart grid 1.0” (see Exhibit 3 for key characteristics).

The additional benefits provided by novel combinations of 5G, AI/ML, and IoT are driving the evolution to “smart grid 2.0.” In addition to incorporating distributed energy resources (DERs) for generation, increased automation offers reliable energy distribution, while real-time communication enhances services for consumers.

Exhibit 3: The smart transition and corresponding grid characteristics

	1880s	**2010s**	**2030**
	LEGACY GRID	**SMART GRID 1.0**	**SMART GRID 2.0**
Generation	Centralized generation and reliance on fossil fuel energy sources	Increased capacity for renewable energy integration	Ability to support large-scale deployment of renewable energy generation sources, including distributed energy resources (DER)
Transmission and distribution	One-way flow of energy, limited information flow ability	Introduction of infrastructure to support bi-directional flow of energy and information (limited) Demand and supply optimization (limited)	Dynamic, two-way flow of information and energy Real-time demand and supply optimization
Consumer participation	Limited scope	Improved transparency and quick communication facilitated through advanced metering infrastructure (AMI)	Ability for consumers to generate, store, and sell energy to the grid Automated demand response and real-time supplier-consumer communication
Maintenance and repair	Vulnerable to prolonged disruption and costly, manual repair	Advanced remote fault detection and load optimization systems	Automated self-healing and supply re-direction capabilities
Key technological features	Transmission power lines, circuit breakers & switches, capacitors, substation voltage management capabilities	Smart meters and sensors, remote monitoring systems, advanced supervisory control and data acquisition systems (SCADA), 4G-powered consumer communication	AI/ML, 5G, cloud computing, IoT, digital twin models, smart home and EV technology integration

Source: Marsh McLennan Advantage

Technology convergence across the grid

Different smart technology combinations enable new capabilities across the four core elements of the energy system and its underlying grid — generation, transmission, distribution, and consumption (see Exhibit 4).

Exhibit 4: Technology convergence opportunities across the smart grid

🟩 Generation 🟨 Transmission 🟥 Distribution 🟦 Consumption

📶 **5G** 🖥 **Edge computing** 📱 **IIoT** AI **AI/ML** 🥽 **AR/VR**

Grid-wide capabilities

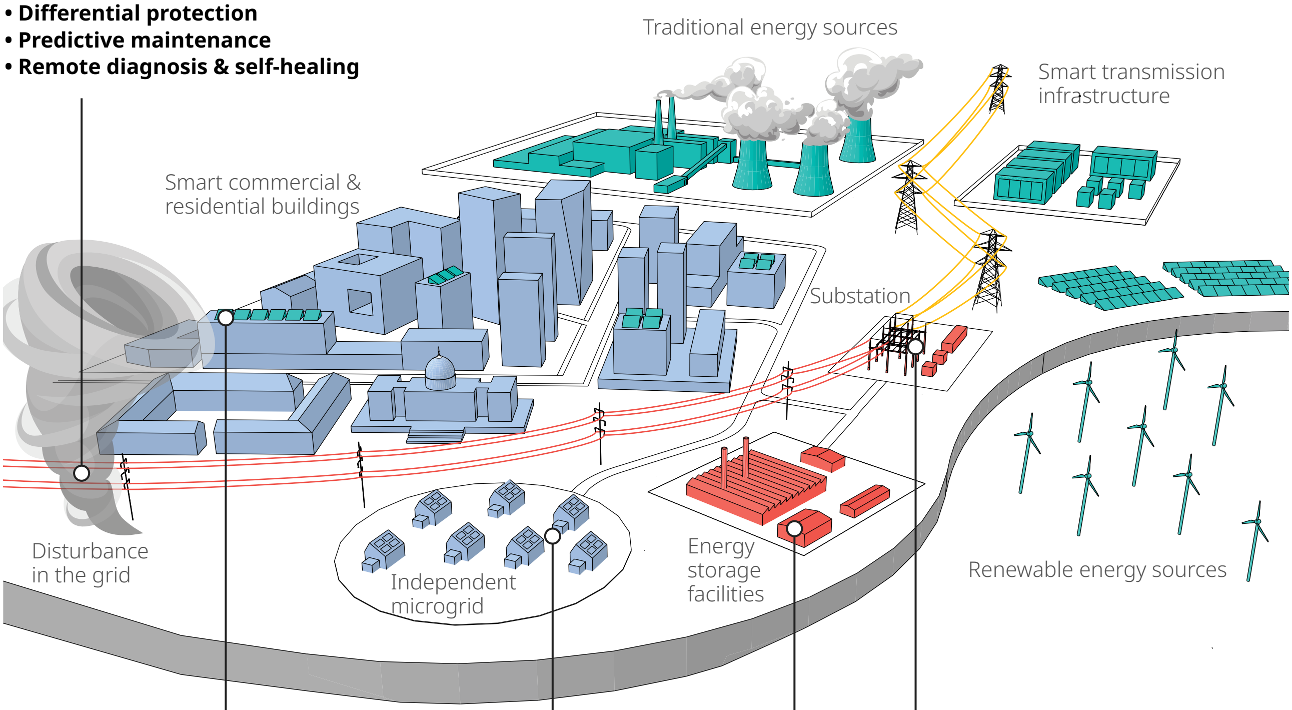
📶 + 🖥 **Interoperability**

AI + 📱 **Grid virtualization**

📶 **Network slicing**

📶 + AI

- **Differential protection**
- **Predictive maintenance**
- **Remote diagnosis & self-healing**



📶 + AI **Supply optimization & load balancing**

📶 + AI + 🖥 **Dynamic pricing & demand adjustment**

📶 + AI **Reinforcement learning**

AI **Automated monitoring & usage of stored energy**

📱 + 🥽 **Expedited maintenance & repairs**

Source: Marsh McLennan Advantage

As energy firms calibrate their appetite for innovation and weigh the costs and benefits of investing in smart grid 2.0 technologies, it is helpful to review how these capabilities might impact each aspect of the value chain.

Generation: Advanced smart storage facilities can leverage AI/ML-enhanced forecasting to optimize load balancing and support large-scale renewable energy sources. AI/ML can also enable automated monitoring and redistribution of excess stored energy, a key feature for addressing the previously noted intermittency of distributed energy resources (DERs).

Transmission & Distribution: Supply disruption can be minimized through remote diagnosis and self-healing abilities. Utilizing differential protection strategies can efficiently disconnect potential points of grid failure and prevent knock-on disruption, while predictive analytics can expedite equipment repairs with heightened safety. Through expedited maintenance capabilities, grid infrastructure operators can remotely install equipment and assess the impact of disruption from safer vantage points.

Consumption: Utility firms can provide better pricing transparency and accuracy to consumers. Consumers can better understand their energy usage in real time and adjust their demand according to dynamic prices. Reinforcement learning can allow smart homes to analyze and reduce energy use based on historical data. Consumers can also utilize DERs, supported by behind-the-meter smart technologies, to improve performance and efficiency. For example, heat pumps — dual heating/cooling appliances that capture heat from outdoors or remove heat from indoors — are critical enablers of electrification and can be enhanced by IoT devices for improved fault detection and energy efficiency.

Grid-wide capabilities: Distributed generation sources such as solar panels and battery storage facilities can be located at or close to the site of consumption. This allows faster real-time communication and interoperability of multiple 5G-connected devices. Through network slicing, 5G networks can be divided into a set of logical networks with a common underlying infrastructure. Each “slice” can then be customized to fit the requirements of various grid elements. 5G also facilitates the participation of consumers, who are increasingly likely to produce and supply power to the grid themselves. Virtual grid technology can also create a “digital twin” for power plant management, remote grid assessment, workforce training, and simulation exercises.

Stakeholder responsibilities across the smart grid

Depending on the national context, the energy sector landscape can be a complicated one with many interconnected players responsible for different segments of the value chain. In addition to utility providers accountable for generation, energy systems can have numerous T&D operators, while governmental institutions and regulators may also initiate, fund, or inspect grid projects. Smart(er) grids also lead to the increased participation of technology vendors.

The inclusion of smart technology also adds another layer of responsibility for stakeholders to appropriately govern the data crucial for advanced modeling, forecasting, and decision-making. This governance obligation manifests itself at both the company and system levels. The latter can require nuanced practices specific to the technology solution. For example, AI applications require additional safeguards to ensure unbiased and explainable outputs. As grids become increasingly smarter, additional obligations arise with respect to grid maintenance as well as data ownership and access (see Exhibit 5).

The inclusion of smart technology in the grid adds another layer of responsibility for stakeholders to appropriately manage the data collected. A multi-stakeholder approach is needed to ensure proper implementation.

Exhibit 5: Mapping stakeholder responsibilities

	MAINTENANCE & MANAGEMENT	DATA OWNERSHIP/ RESPONSIBILITY	DATA ACCESS
Utility providers	Manage power plants and employ support services (e.g., turbine inspections, mechanical upgrades) Oversee T&D infrastructure in regulated markets*	Primary owner of data Legally responsible for its ethical usage and privacy policies	Complete access to self-collected data. Ability to sell data to other stakeholders
Transmission & distribution (T&D) operators	Manage T&D infrastructure and associated technologies Partner with utility firms	Primary owner of data generated through T&D technology	Possibility to enter data-sharing agreements with utility firms for service advancements
Governments	Provide funding to technology companies and utility providers Partner with utility firms/ T&D operators to maintain & upgrade infrastructure	-	Data sharing can be mandated through legislation or public-private partnership agreements
Regulatory industry bodies	Approve new infrastructure projects; commission R&D projects by utility providers Ensure reliability of existing grid infrastructure	-	Can request access to data from multiple stakeholders in the event of investigation, penalties, or to enhance policy formulation
Technology companies	Provide specialized hardware and software to utility providers (e.g., advanced sensors) Collaborate with stakeholders across grid functions (e.g., providing enhanced metering analytics to consumers)	Primary owner of data generated by equipment owned	Access to additional data depending on partnership/ service agreements
Adjacent industries**	Independently manage products/services that can enhance grid capabilities (e.g., EVs, telecom lines, etc.)	Primary owner of data generated by products/ services	Access to additional data depending on partnership/ service agreements

* In a regulated market, transmission and distribution services are handled by the utility themselves. A deregulated market allows for independent T&D operators.

** Adjacent industries refer to sectors where developments would impact smart grid deployment (e.g., telecommunications, mobility, etc.)

Source: Marsh McLennan Advantage

Challenges on the horizon

Although smart grid technology deployment benefits are substantial, many risks accompany their implementation and use. As business leaders navigate towards smart grid 2.0 capabilities, they must be mindful of technology-related pitfalls, economic constraints, regulatory dynamics, and workforce realities.

Technology is rarely a silver bullet, and the migration to smart grid 2.0 will be no exception. The scale of this challenge is already becoming evident, as demonstrated by the statistics below (see Exhibit 6).

Exhibit 6: Smart grid challenges — in numbers

1. Mitigating technology risks

Appropriate utilization of AI/ML capabilities

85%

of respondents in the energy industry believe that the primary challenge to AI adoption is "resistance to change/ conservatism"[19]

Heightened cyber risk

53%

of businesses in the UK utilities sector were targets of cyberattacks in 2020-2021[20]

Interoperability challenges

7,600+

distribution system operators across 175 countries with varying access to advanced technologies[21]

2. Managing infrastructure and attracting investment

Phase-out of legacy grid components

70%

of large transformation facilities and power distribution lines in the US are older than 25 years[22]

Investment appetite

9.5% lower

global investment in electricity networks between 2019-2021 than 2016-2018[23]

3. Tracking regulatory developments

Complicated governmental frameworks

141

pending state legislation efforts in the US focused on electric grid and transmission[24]

Resistance from communities and restrictions on land use

40%

of respondents do not trust businesses in the energy industry to do "what is right"[25]

4. Assessing workforce strategies

Managing the skills gap

~50%

of US energy sector employees are 45+ years old, 26% are 55+[26]

Source: Marsh McLennan Advantage

Mitigating technology risks

When AI/ML-fueled analytics tools are supplied with an inadequate data sample, misinformed outputs can lead to sub-optimal operational outcomes, potentially biased decisions, and financial and reputational risks. As an industry that has only recently started to integrate smart technologies, utility firms should be cautious when operationalizing AI tools, taking care not to underestimate the scale of data collection required. Ensuring appropriate governance processes and safeguards are in place to oversee the various technologies and their underlying data is paramount.[27]

The increased number of devices and their connectivity will also widen the cyberattack surface, creating new vulnerabilities for threat actors to exploit (see Exhibit 7).

Exhibit 7: Cyber threats in the energy sector

55%

of all data breaches in the energy sector are caused by malicious attacks

$4.4 million

cost of ransomware payment by a leading US utility provider in 2021

Source: IBM, The Wall Street Journal

Data misuse — profit motivated or unintentional — can also negatively impact brand image and stakeholder trust dynamics. As utilities make up part of a nation's critical infrastructure, a potential cybersecurity attack could jeopardize an entire grid's functionality and, in turn, pose national security risks.[28] Nation state-backed cyberattacks are becoming more prevalent, the most recent having taken place in the Russia-Ukraine conflict. Grid operators will need to work harder than ever to enhance their cybersecurity resilience.

The development of additional standards is also critical to ensuring the interoperability of the multiple generations of hardware that will ultimately co-exist across the smart grid. These standards invariably move more slowly than the technology itself, complicating related selection and integration decisions.[29] Compatibility of standards is also difficult in cross-border smart grid projects — as observed in the effort to create the "ASEAN Power Grid."[30] Vendor-set enhancement roadmaps also constrain energy providers. Many factors — product pipeline, profitability considerations, legacy technology sunset plans, among others — influence how these roadmaps are set, and they rarely align cleanly across different generations of technology.

Managing infrastructure and attracting investment

A 2021 survey of utilities in the US found that 50 percent of respondents considered "other competing priorities" a major barrier to grid modernization.[31] Utility providers will need to time the deployment and integration of smart technology solutions while maintaining and operating existing grid systems.

Managing this transition requires navigating a labyrinth of differing federal and state regulations and incentives; utility providers must engage effectively with these regulators to maintain transition timelines and profitability. A comprehensive review of regulatory constraints and incentives can help justify investment decisions, but care must be taken to avoid regulatory blind spots for emerging technologies.

At times, data privacy and energy efficiency imperatives find themselves in conflict with one another, as the sharing of consumer data is a key enabler for improving efficiency. To avoid an overly optimistic business case, regulatory uncertainties like these should be factored into the reliability of expected future revenue streams.

Additionally, investor appetite for grid infrastructure upgrades often depends on a range of factors such as community sentiment, shifting regulations, and industry dynamics. Currently, investment in smart grid networks has remained geographically restricted, with China and the US receiving more than half of global investment in 2021.[32] Defining a good business case carries a measure of uncertainty when it evaluates technologies that haven't yet been proven at scale. As events previously mentioned have shown, unreliable modeling of climate-driven extreme scenarios can also lead to misinformed decision-making and underinvestment.[33]

Tracking regulatory developments

Complex governmental frameworks involving multiple institutions also hinder implementation timelines and access to funding. In the UK, although the National Grid Corporation oversees and owns the electricity grid system, six regional generation and distribution network operators are responsible for connecting the grid to individual homes, along with multiple additional retail companies catering to the end consumer.[34] Utility providers often navigate these relationships and work with multiple partners to plan and execute modernization efforts when initiating smart grid projects. Advance planning and scoping for these efforts can help to ensure that resource allocation is commensurate with the anticipated complexity.

Also, grid modernization can be disruptive to communities and is often subject to land-use restrictions, environmental protections, and noise regulations. Initiating projects such as building new transformer substations in inner-city zones, expanding existing facilities, or changing the usage of existing facilities can prove difficult without community support.[35] Moreover, any interruption to existing services during transition can also break trust and run afoul of authorities.[36] Attention should be given up front through awareness campaigns, adoption incentives, and broad community outreach to educate the public on the benefits of smart grid technologies. In situations where upcoming projects are negatively perceived by the impacted community, providing forums for debate can help communities engage in the process and work towards mutually beneficial outcomes.

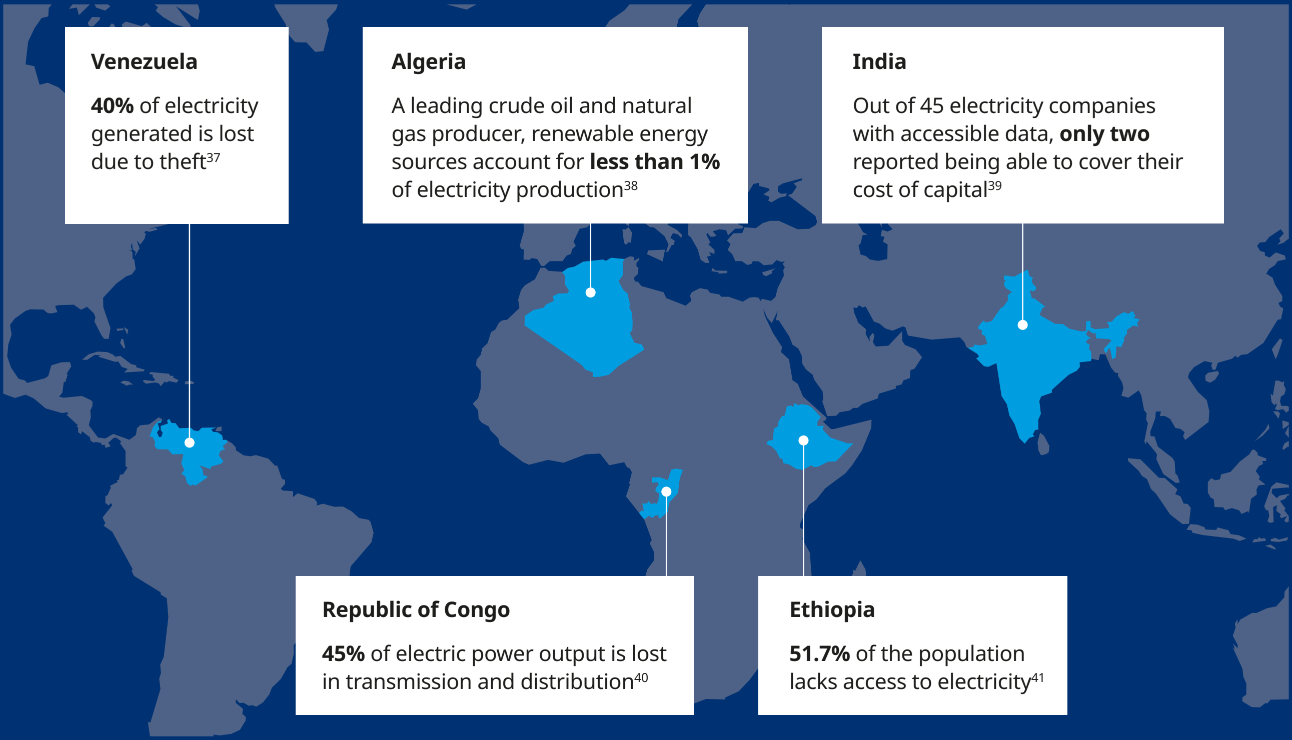
Assessing workforce strategies

Last, as the energy sector competes with other industries to attract scarce tech-fluent talent, with much of its workforce nearing retirement, the smart grid transition will further complicate workforce strategies. To meet evolving technical skills requirements, utility providers must compete for specialized talent or find ways to source from within.

Sidebar: Smart grids in emerging markets

Developing nations face unique challenges to smart grid implementation (see Exhibit 8). Many countries still grapple with ensuring access to electricity. Where access is present, reliability issues due to inefficiencies in T&D infrastructure or theft often affect the quality of service. Many utilities are already struggling financially, leading to a vicious cycle of structural underinvestment in technology. Developing nations also face difficulties balancing climate management strategies with economic realities.

Exhibit 8: Challenges in developing countries



Venezuela

40% of electricity generated is lost due to theft[37]

Algeria

A leading crude oil and natural gas producer, renewable energy sources account for **less than 1%** of electricity production[38]

India

Out of 45 electricity companies with accessible data, **only two** reported being able to cover their cost of capital[39]

Republic of Congo

45% of electric power output is lost in transmission and distribution[40]

Ethiopia

51.7% of the population lacks access to electricity[41]

Source: Marsh McLennan Advantage

Taking charge: Managing the transition

The smart grid transition will blur the lines between traditional grid providers and technology disruptors. Smart grid initiatives should be evaluated in terms of the efficiencies they provide and their potential to create new revenue streams. The way forward will also require technology adopters to plan and time investments, mitigate execution risks, and engage effectively with the broader energy community.

Industry participants — utility providers, T&D operators, technology vendors — must overcome economic constraints while simultaneously addressing the evolving needs of consumers, regulators, and investors. Grid modernization — whether greenfield or retrofitted — should be implemented in phases to minimize disruption and mitigate execution risks. Justifying investments based on the merits of each unique technology application will allow investors to make targeted technology decisions and better quantify their benefits. As business leaders plan for the path forward, steps can be taken up front to minimize economic risks and ensure a successful transition (see Exhibit 9).

Exhibit 9: Smart grid transition considerations

KEY ECONOMIC DRIVERS		IMPLEMENTATION CONSIDERATIONS		
Strategies to improve efficiencies	**Strategies to generate additional revenue and value**	**Securing funding and timing investment**	**De-risking the transition**	**Fostering an ecosystem of collaboration**
Achieve economies of scale	Data monetization	Managing sources of financing	Mitigating cyber risks and ensuring consumer trust	Consider M&A and other partnership possibilities
Managing transition of energy sources	Utility lease agreements	Ensuring appropriate timing for investment	Addressing workforce gaps	Identify opportunities to share resources for accelerated deployment
Strategic integration of grid efficiency technologies	BESS-enabled capabilities		Exploring innovative risk transfer and asset management solutions	
Dynamic pricing	Curation of additional products and services			
	Flexible tariff options			

Source: Marsh McLennan Advantage

Business rationale: Identify economic drivers for smart grid implementation

Strategies to improve efficiencies

Firms will need to balance the phaseout of already capitalized and depreciated legacy infrastructure with new investments. The shift from large fossil power plants to DERs will reduce on-site operational costs and, in some instances, secure carbon tax payments. It can also free up funds that can be redirected towards grid modernization efforts. According to International Renewable Energy Agency (IRENA) estimates, around four-fifths of coal power plants in the US have higher operating costs than the cost of introducing new renewable power sources such as solar or wind.[42]

Unlike transmission line upgrades, which can take years to permit and construct, battery energy storage systems (BESS) can be delivered in months and scaled up faster.

Lithuania is developing its first grid-scale battery initiative (virtual transmission line project), aiming to prove the efficiency advantages of using batteries as an alternative to building out expensive transmission infrastructure, which would take decades to construct. Similar projects are underway in France, Australia, and parts of the US.[43,44]

Vehicle-to-grid technologies can also facilitate the ability to send surplus power back into the grid at cheaper rates. In California alone, V2G technologies are estimated to provide annual grid benefits of around $1 billion in 2030.[45] Managed EV charging entails vehicle-to-grid (V2G) integration, enabling smart time-of-use (TOU) charging. Under TOU charging, drivers are incentivized by a lower electricity rate to charge during off-peak hours. This helps reduce grid operating costs, emissions, and energy use inefficiencies. Utilizing smart-charging technologies for residential EVs can save up to 41 percent for utilities.[46]

Strategies to generate additional revenue and value

Integrating new grid technologies — like smart meters, which collect data more frequently — will allow businesses to collect valuable data. Firms can utilize this data to optimize operations, inform pricing strategies, and sell collected data to other companies (see Exhibit 10). As attractive as this new revenue stream may be, firms must still prioritize the ethical use of the collected data.

Exhibit 10: Collection and monetization of data

3000x

larger dataset generated by smart meters that take readings every 15 minutes compared to traditional meters

$20 billion

estimated market size for data monetization in the utility sector by 2030

Source: Energy Renewals, Indigo Advisory

Using 5G, AI, and advanced analytics, utility providers can explore entering “utility-lease” agreements with third parties. Under this partnership, utility firms can install and lease grid communications infrastructure to internet service providers (ISPs). Leveraging this excess bandwidth can provide long-term revenue opportunities for the energy sector. A US-based utility firm recently entered a 15-year initial lease agreement with an ISP for an initial infrastructural investment of $120 million.[47]

Utility providers can leverage BESSs for “black starts” instead of relying on external transmission resources or backup fossil fuel-based options.[48] Energy rate arbitrage can also serve as an additional revenue source for utility firms. BESSs can charge batteries when prices are low or during periods of excess renewable generation and discharge during peak hours. This will help reduce renewable energy underproduction and maximize the value of stored energy when it is sold to the market.

Firms can also leverage smart technologies to provide new products and services. For example, 5G connectivity coupled with IoT devices can provide enhanced energy efficiency services for consumers looking to understand their consumption patterns and adjust energy flow in real time. Customers can also receive usage and outage alerts from the utility providers and earn rewards based on their energy consumption patterns. Utility firms can provide specialized grid management services for larger clients such as load forecasting, demand response, supply optimization, etc. Firms can also capitalize on their technological capabilities to offer new commercial solutions for independently operated microgrids. In the US alone, there are 575 microgrid installations.[49]

Lastly, utility firms can provide consumers with a range of flexible tariff options through real-time ratings and dynamic processing. Complementing these capabilities with customer support offerings can further enhance the customer experience. A study in the UK found that more than a third of energy bill payers prefer a flexible time-of-use tariff approach, representing further market potential.[50]

Making the transition work: Considerations for ensuring successful implementation

Securing funding and timing investment

Public authorities, policymakers, and regulatory bodies will need to incentivize investment in smart grid projects. Direct funding and financial incentives (such as tax credits) can serve as strategies to accelerate investment. This boost in spending is even more crucial considering that the increasing penetration of “behind-the-meter” energy generation will likely reduce the customer base in the coming years. To address this, utility providers may also seek permission to charge consumers an increased initiation fee for future services and planned technology enhancements, provided they raise consumer awareness of the benefits.

Varying investor attitudes towards grid modernization efforts will influence deployment plans. Some investors and utility providers may desire to use fully capitalized legacy infrastructure while deprioritizing technology upgrades. Conversely, other asset owners may leverage new technology, retire outdated systems, and adjust their land requirements by downsizing or repurposing unused land. Timing technology upgrades appropriately will be essential, as they must align with other dependencies, such as the rollout of 5G infrastructure.

De-risking the transition

Industry stakeholders should prepare for a widened cyber-attack surface by addressing new IT infrastructure vulnerabilities and instituting sound firm-wide cyber hygiene practices. Embedding "privacy-by-design" features can help ensure data safety. To address stakeholder concerns about data security, firms should promote and communicate privacy protection practices and a resilient cyber posture. Securing trust can help firms responsibly scale data collection capabilities to enable AI/ML-fueled analytics, produce accurate predictions, and avoid biased decision-making.

Utility providers must also prioritize competitive recruitment of specialized talent while being mindful of the needs of the existing workforce. Over 70 percent of employees in the energy sector intend to work beyond their retirement age.[51] Given this trend, industry participants must invest in upskilling/reskilling opportunities to meet changing technological requirements. Clearly communicating with employees about the risks and opportunities associated with the smart grid transition while providing skills training paths can help maintain workforce trust and ensure readiness.

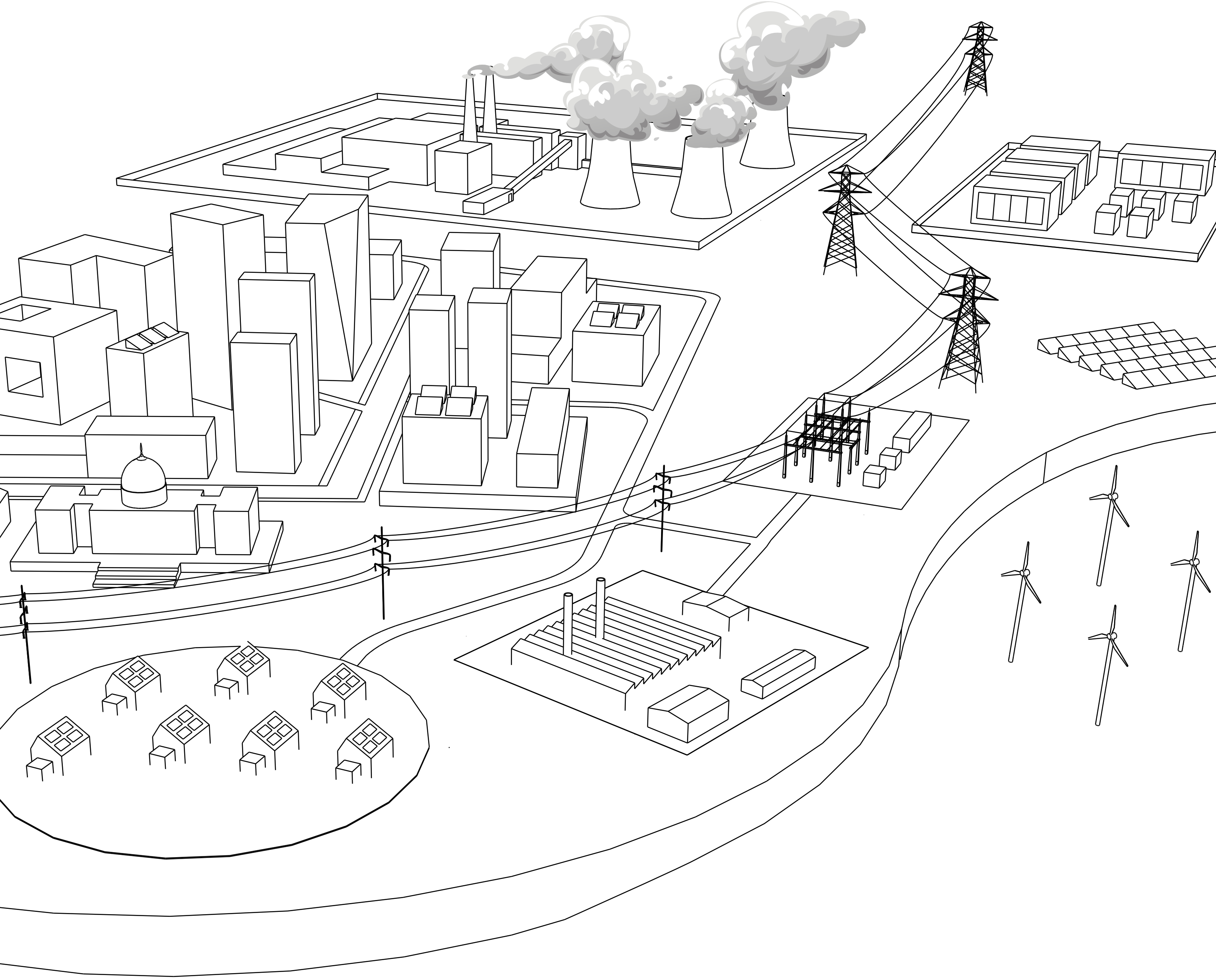
To manage disruption, alternative risk transfer solutions such as CAT bonds and parametric insurance policies can help mitigate long-term exposure and build resilience. Presently, more than $2 billion (USD) of capacity is available for energy and renewable energy-related risks in the global insurance market.[52] As frequent cyberattacks and extreme weather events threaten to increase premiums, proactively negotiating these arrangements is essential to ensure insurance affordability. Furthermore, investors and asset managers can assess and plan investments using intelligent resource planning tools that monitor asset health conditions and maximize utilization rates. For example, the UK's National Grid Corporation has established an information-sharing platform that supports functions ranging from maintenance and lifecycle management to project management and data integration.[53]

Fostering an ecosystem of collaboration

Public-private partnerships can also leverage the technical expertise of the private sector and the funding avenues available to the public sector. In Singapore, a technology firm has partnered with a university research institute on a government-backed smart grid project that focuses on transformer innovation.[54] Where feasible, governments can also incentivize R&D efforts for private partners. For instance, the Canadian government has allocated C$100 million for utility-led modernization initiatives.[55] As deployment progresses, new challenges — such as the issue of "abandoned electricity" due to insufficient storage capacity and the environmental considerations associated with decommissioning renewable assets — can prove to be attractive cooperation opportunities. Data is also an area where incentives may be sufficiently aligned to allow for broad collaboration. The UK's Data and Analytics Facility for National Infrastructure (DAFNI) is a database with which energy sector participants could share smart grid data streams and in turn, benefit from and benchmark their performance against aggregated perspectives.

Learning from success stories in different regions can guide the adoption of pilot programs, build a testbed for scaling, and reduce disruption risks. Singapore, for instance, recently launched a pilot project to test the potential of EVs as small energy storage systems to address the intermittency of renewables.[56] Sharing research data (where appropriate) and open-source software in industry forums can also expedite implementation. For example, the recently announced International Community for Local Smart Grids (ICLSG) provides an opportunity for industry participants to learn from each other's experiences and encourages local implementation.[57] As another example, a leading Spanish utility firm launched a Global Smart Grids Innovation Hub to support industry R&D efforts.[58]

As with any period of transition, modernizing grids comes with challenges. But, in a world increasingly defined by disruption, smart grids equipped with advanced technologies are necessary to tackle complex global risks. Planning for short-term implementation pains while building for long-term value capture can give businesses a competitive advantage.



Endnotes

1 Pew Research Center. (2015). *America's Electric Grid: Growing Cleaner, Cheaper and Stronger.*

2 United Nations. (2018, May 16). *68% of the world population projected to live in urban areas by 2050, says UN*. Retrieved March 15, 2022.

3 Shield, S.A., et al. (2021). Major impacts of weather events on the electrical power delivery system in the United States, Energy, Volume 218, 2021, 119434, ISSN 0360-5442, *https://doi.org/10.1016/j.energy.2020.119434*.

4 IBM. (2021). Cost of a Data Breach Report 2021.

5 International Atomic Energy Agency. (2020). *Energy, Electricity and Nuclear Power Estimates for the Period up to 2050*. Reference Data Series. No.1.

6 US Energy Information Administration. (2021, October 6). *EIA projects accelerating renewable consumption and steady liquid fuels growth to 2050*. Retrieved March 15, 2022.

7 Precedence Research. (n.d.). *Vehicle-to-Grid Technology Market Size, Share and Growth Analysis*. Retrieved March 15, 2022.

8 UK Department for Business, Energy & Industrial Strategy. (2021, November 25). *Smart Meter Statistics in Great Britain: Quarterly Report to end September 2021*. Retrieved March 15, 2022.

9 Deely, J. (2021, December 16). EnergyCentral. *Battery Pack Prices Cited Below $100/kWh for the First Time in 2020, While Market Average Sits at $137/kWh*. Original article published on Bloomberg. Retrieved March 15, 2022.

10 Texas Department of State Health Services. (2021, December 31). *February 2021 Winter Storm-Related Deaths — Texas*. Retrieved March 15, 2022.

11 Busby, J.W., et al. (2021). *Cascading risks: Understanding the 2021 winter blackout in Texas*. Energy Research & Social Science, Volume 77, 102106. *https://doi.org/10.1016/j.erss.2021.102106*

12 World Energy Council. (2019). *Cyber challenges to the energy transition*.

13 Eaton, C., & Volz, D. (2021, May 19). *Colonial Pipeline CEO Tells Why He Paid Hackers a $4.4 Million Ransom*. The Wall Street Journal. Retrieved March 15, 2022.

14 BBC News. (2017, January 11). *Ukraine power cut 'was cyber-attack'*. Retrieved March 15, 2022.

15 Bahar, H. (2020). *The coronavirus pandemic could derail renewable energy's progress. Governments can help*. International Energy Agency. Retrieved March 15, 2022.

16 International Energy Agency. (2021). *Renewable electricity growth is accelerating faster than ever worldwide, supporting the emergence of the new global energy economy.* Retrieved March 15, 2022.

17 Smart Energy International. (2021). *Europe replaces 50% of electricity meters with smart models*. Retrieved March 15, 2022.

18 Coltura. (2021). *Gasoline vehicle phaseout advances around the world*. Retrieved March 15, 2022.

19 Siemens. (2020). *Next-Gen Industrial AI: The expansion and evolution of AI within industrial organizations until 2022*.

20 Veritas. (2021). *News release: Utilities sector under siege.* Retrieved March 15, 2022.

21 Kufeoglu, S., Pollitt, M., & Anaya, K. (2018). Electric Power Distribution in the World: Today and Tomorrow. *https://doi.org/10.17863/CAM.27667*

22 US Department of Energy. (2015). *Quadrennial Technology Review 2015, Chapter 3: Enabling Modernization of the Electric Power System, Technology Assessments*.

23 International Energy Agency. (2021). *Investment spending in electricity networks by region, 2016-2021.* Retrieved March 15, 2022.

24 National Council of State Legislatures. (2022). *Energy State Bill Tracking Database*. Retrieved March 15, 2022.

25 Edelman. (2022). *Edelman Trust Barometer 2022*.

26 POWER Magazine. (2021, June 1). *Prioritizing the Workforce Is Critical to Utility Transformation*. Retrieved March 15, 2022.

27 Marsh McLennan. (2020). *Governing artificial intelligence: managing business risks in a digital world*.

28 Smith-Bingham, R. (2021). *Partnering with purpose: Strengthening national-level resilience in the UK through more dynamic public-private interactions*. National Preparedness Commission & Marsh McLennan Advantage.

29 International Energy Agency. (2020). *Tracking Smart Grids 2020*.

30 Fitzgerald, M. (2021, November 23). *A Step Forward for ASEAN Interconnectivity*. EnLit Asia. Retrieved March 15, 2022. Black & Veatch. (2021). Smart Utility eBook.

31 Black & Veatch. (2021). *Smart Utility eBook*.

32 International Energy Agency. (2021). *Investment spending in electricity networks by region, 2016-2021.* Retrieved March 15, 2022.

33 Climate Nexus. (n.d.). *Climate Impacts & The Power Grid*. Retrieved March 15, 2022.

34 EDF Energy. (n.d.). *The National Grid and what it does*. Retrieved March 15, 2022.

35 Hitachi Energy. (n.d). Smart grid and urban substations. Retrieved March 15, 2022.

36 Marsh McLennan. (2021). *Built to Last: Infrastructure and trust in a changing world*.

37 Sabatini, C. & Patterson, W. (2021). *Reforming Venezuela's electricity sector*. Chatham House.

38 Ritchie, H., & Roser, M. (2020). Energy. OurWorldInData.org. Data from The World Bank. Retrieved March 15, 2022.

39 The Economic Times — Energy World. (2020, April 3). *Why India's booming power market is bad for business.* Original article published on Bloomberg. Retrieved March 15, 2022.

40 The World Bank. (n.d.). *Electric power transmission and distribution losses (% of output)*. Data from OECD and IEA.

41 See note 39.

42 IRENA. (2021). *Renewable Power Generation Costs in 2020*.

43 Colthorpe, A. (2021, September 21). *Lithuania connects first battery system to transmission network ahead of 200MW rollout.* Retrieved March 15, 2022.

44 St. John, J. (2021, February 21). *How US Grid Operators Plan to Tackle Energy Storage at Gigawatt Scale*. Green Tech Media. Retrieved March 15, 2022.

45 EPRI Journal. (n.d.). *Vehicle-to-Grid: $1 Billion in Annual Grid Benefits?*. Retrieved March 15, 2022.

46 Pecan Street. (2021). Charging Smart: Analysis & Recommendations for Next Generation Home EV Charging.

47 Cole, E. (2021, June 11). *Future of Fiber: CU, Lumen partnership to offer citywide, high-speed internet connection*. SBJ. Retrieved March 15, 2022.

48 Power Magazine. (2020, May 1). *Benefits of Battery Storage-Based Black-Start Capability*. Retrieved March 15, 2022.

49 US Department of Energy. (n.d.). *Combined Heat and Power and Microgrid Installation Databases*. Retrieved March 30, 2022.

50 Nicolson, M., et al. (2016). Are consumers willing to switch to smart time of use electricity tariffs? The importance of loss-aversion and electric vehicle ownership. UCL Energy Institute. Energy Research & Social Science, Volume 23. *https://doi.org/10.1016/j.erss.2016.12.001*

51 Mercer. (2022). *Global Talent Trends 2022*. Roberts, H., Markovic, T., & Robson, N. (2021). *Risk transfer solutions for the renewables lifecycle*. Marsh McLennan.

52 Roberts, H., Markovic, T., & Robson, N. (2021). *Risk transfer solutions for the renewables lifecycle*. Marsh McLennan.

53 Wang, K., et al. (2021). Full Life Cycle Management of Power System Integrated With Renewable Energy: Concepts, Developments and Perspectives. Frontiers in Energy Research. *https://doi.org/10.3389/fenrg.2021.680355*

54 Nhede, N. (2021, March 30). *Singapore innovates transformer technology to accelerate smart grid development*. Smart Energy International. Retrieved March 15, 2022.

55 Government of Canada. (n.d.). *Smart Grid Program*. Retrieved March 15, 2022.

56 Enlit Asia. (2021, August 10). *Vehicle to Grid Pilot Project Launched in Singapore*. Retrieved March 15, 2022.

57 International Community for Local Smart Grids. (n.d.). *Sharing knowledge and solutions to enable a local net zero transition*. Retrieved March 15, 2022.

58 Iberdola. (2020, August 22). *Iberdrola creates its Global Smart Grid Innovation Hub to lead the energy transition*. Retrieved March 15, 2022.

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