Critical National Infrastructure Series

THE CRUCIAL ROLE OF SATELLITE CONNECTIVITY IN **SAFEGUARDING NATIONAL ELECTRICAL UTILITIES INFRASTRUCTURE**

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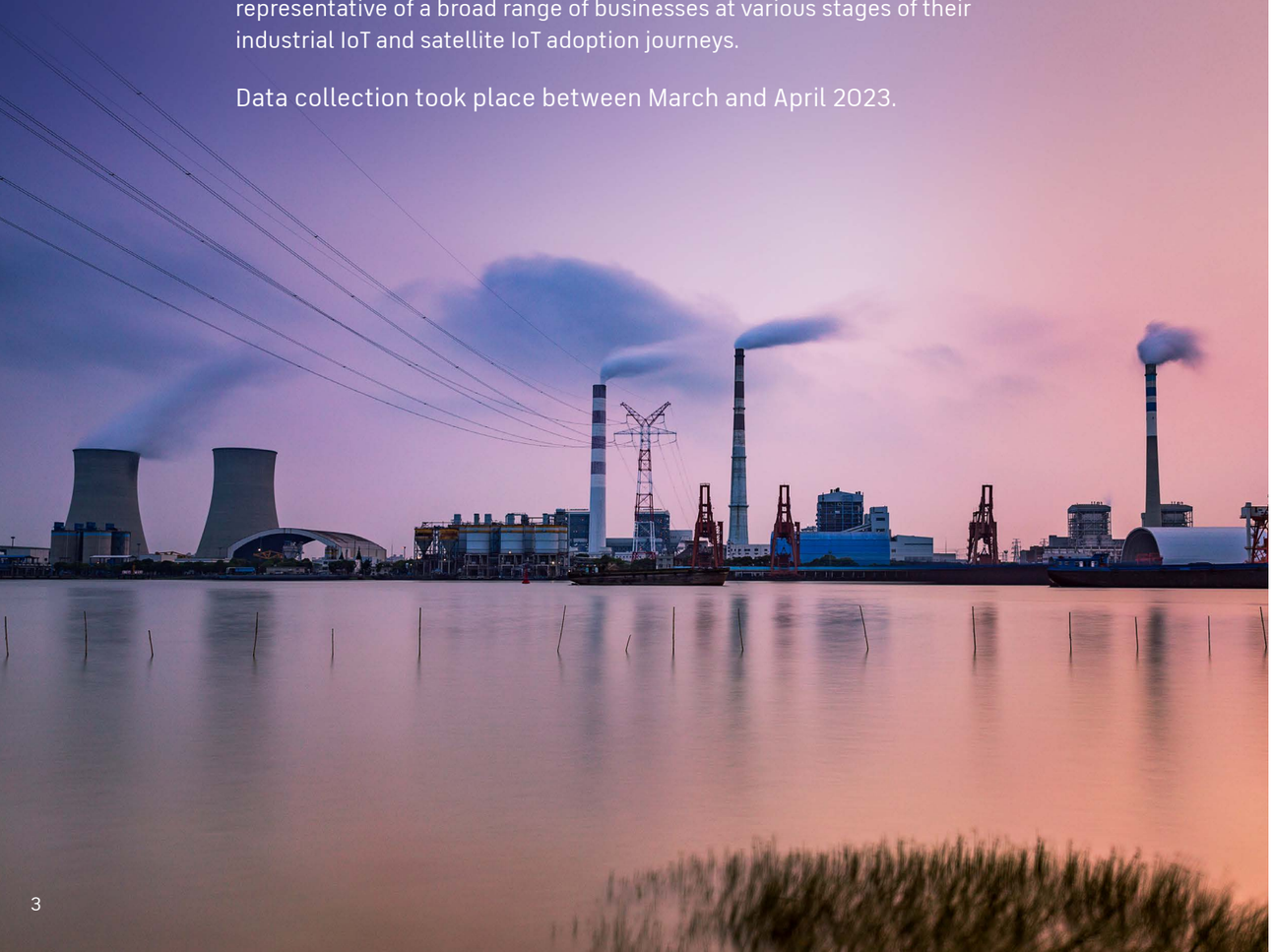
METHODOLOGY

This report is based on independent research conducted by Censuswide on behalf of Viasat, surveying more than 125 Business Owners, C-suite executives and Senior Management professionals with decision making power working in the electrical utilities industry. They represent a range of business sizes, from £100m-£500m, £500m-£999m, £1bn-£1.99bn, £2-4.99bn and £5bn or over in annual turnover.

Respondents spanned across all major continents including Europe, North America, South America, Africa and Asia, and work under many different national and regional regulatory frameworks. As such, the results are representative of a broad range of businesses at various stages of their industrial IoT and satellite IoT adoption journeys.

Data collection took place between March and April 2023.



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INTRODUCTION

The electrical utilities industry is poised at a moment of critical change. As the world faces new and unprecedented threats from a rapidly changing climate to rising cyberinsecurity and an ever-growing demand for reliable, affordable and sustainable energy to power our increasingly interconnected societies, electrical utilities providers find themselves at the centre of many competing forces, and under pressure to adapt to a fast-evolving industry.

Whether driving industrial processes, supporting communication networks, facilitating transportation systems, or enabling countless essential services, the pivotal role of power generation in society is undeniable. The reliable, efficient generation and distribution of electricity is vital for economic growth, public safety, and quality of life. As a result, electrical utilities are a crucial element of critical national infrastructure (CNI) across the globe, and any interruption to these power supplies can disrupt the prosperity, security and wellbeing of nations.

However, a global survey of 125 senior professionals in the electrical utilities industry, including business owners, C-level executives and senior management, identified a worrying number of risks to national grid stability over the next five years. These included: ageing and increasingly vulnerable infrastructure, risks posed by climate change and natural disasters, vulnerability to cyberthreats, and challenges in finding, retaining and training a skilled workforce capable of running and maintaining the resilient and reliable services needed to power the demands of our modern world.

Despite these threats, however, this survey highlights reasons for optimism across the industry. New and emerging technologies are being adopted, and 3 in 4 of those surveyed identified satellite Internet of Things (IoT) technology as having a crucial role to play in mitigating major threats facing the industry. Moreover, more than half of senior industry professionals surveyed (57%) trust satellite communications (satcom) to help improve their business performance through its ability to enhance efficiency, reduce costs, and risks to field workforces through remote monitoring and controlling of assets.

Satellite connectivity can provide electrical utilities operators with significant support in their digital transformation mission to meet today's requirements for more reliable, secure and resilient CNI. By providing improved access to real-time electrical consumption data, infrastructure monitoring capabilities, and maintaining critical contact with remote workforces across entire distribution networks, satellite IoT has the potential to help utilities infrastructure become more efficient, effective and secure.

With proven suppliers and solutions already established in the market, it is essential that electrical utilities operators promote more widespread adoption of satellite technology and the opportunities it provides if the industry is to effectively meet the challenges it faces in the next five years, and beyond.

This white paper outlines the challenges industry leaders believe lie ahead, while identifying the solutions that satellite IoT technologies can provide. Finally, it considers the requirements the sector should take into account if the widespread adoption of these technologies is to be successful.

3 IN 4

OF THOSE SURVEYED IDENTIFIED SATELLITE INTERNET OF THINGS (IOT) TECHNOLOGY AS HAVING A CRUCIAL ROLE TO PLAY IN MITIGATING MAJOR THREATS FACING THE INDUSTRY.

CHAPTER 1:

GLOBAL THREATS AND CHALLENGES FACING THE ELECTRICAL UTILITIES INDUSTRY

The electrical utilities industry currently faces unprecedented challenges on many fronts and is under increasing government scrutiny due to the vital role its infrastructure plays within societies and economies. In 2020, the UK's National Cyber Security Centre[1] identified two significant threats to CNI, that are widely recognized as key global issues facing the industry:

- Natural or climate-induced disasters, including hurricanes, floods, and wildfires
- Cyberthreats, including state-sponsored attacks, hacktivism, and criminal activities

The dramatic rise of extreme weather events in recent years has been a wake-up call for the world. Just five years ago, who would have predicted forest fires on the outskirts of London? And in British Columbia, a Canadian province renowned for its lush forests, a similar story has emerged with increasingly severe wildfire seasons in recent years – as is tragically being witnessed at the time of writing in June 2023, as the resultant smoke suffocates the skies of cities as far away as Quebec and New York. But with annual wildfires now a common global phenomenon and weather events like 2021's Storm Arwen causing regular and widespread power outages[2], infrastructure resilience is top of mind for national security advisors. As a result, national and global regulatory frameworks are having to evolve at an unprecedented rate to keep pace.

[1] https://www.ncsc.gov.uk/files/Annual-Review-2020.pdf

At the same time, the industry is evolving and adapting to new technologies. The utilities sector has become a pioneer of digital transformation in recent years, driven by a need to monitor, manage, automate and ultimately improve the quality and reliability of electricity supplied to consumers. But, while utilities companies have long been aware of increasing cyberrisk, increasingly, cybercriminals are targeting industrial control systems (ICS), sometimes potentially laying the groundwork to do physical damage to national grids.

54%

OF UTILITIES COMPANIES CLAIMED THEY EXPECTED A CYBERATTACK IN 2020.

HOWEVER, ONLY

42%

RATED THEIR OWN READINESS AND RESPONSE TO CYBERATTACKS AS "HIGH".

[2] https://www.ofgem.gov.uk/publications/storm-arwen-report

Against this backdrop, grid modernization becomes ever more challenging. Despite huge advantages that come from modernizing the grid, digitization can also increase a utility's "attack surface," (vulnerabilities hackers can exploit to enter utility systems). As grids become increasingly "smart," with embedded information and communications technologies, and devices embedded throughout, systems become increasingly complex and points of vulnerability increase as the number of access points rise.[3] Secure systems, vulnerability monitoring and effective back-up protocols are essential if we are to protect national grids from bad actors. According to a recently released cybersecurity report by Siemens and the Ponemon Institute, 54% of utilities companies claimed they expected a cyberattack in 2020. However, only 42% rated their own readiness and response to cyberattacks as "high".[4]

Additionally, the relationship between consumers and operators is changing. The industry faces a growing global, reputational backlash from consumers who feel their expectations of electrical services are not being met. Significant price hikes across energy bills, aggravated by the war in Ukraine, and ageing infrastructures that have not kept pace with digital and sustainability-focused progress are leaving consumers frustrated and dissatisfied. This is further complicated as customers increasingly become part of the distribution system; demanding new tariff models and exercising more control over the power they consume through innovations like at-home smart meters.[5]

It is critical to national infrastructures that the electrical utilities industry rises to meet these new challenges. If we are to power the societies and economies of the future, we must first develop contemporary, effective, and secure solutions that can withstand these threats, while delivering flexible and affordable services for customers. However in order to understand how this can be managed, we must first recognize the imminent challenges as identified by our sample of industry leaders.

WHAT DO YOU SEE AS THE BIGGEST MAJOR RISK TO THE STABILITY OF YOUR GRID OVER THE NEXT 5 YEARS?

OVER 26%
Sum of natural disasters and general climate/weather change

13%
Cyber threats/bad actors

15%
Managing fluctuating supply and demand

19%
Retention and availability of skilled workforce

22%
Aging infrastructure/lack of investment

5%
No one is a major risk

[3] Deloitte Insights, Managing cyber risk in the electric power sector; by Steve Livingston, Suzanna Sanborn, Andrew Slaughter, Paul Zonneveld https://www2.deloitte.com/us/en/insights/industry/power-and-utilities/cyber-risk-electric-power-sector.html (accessed, 28 June 2023).

[4] World Economic Forum: Are utilities doing enough to protect themselves from cyberattack? Jan 15, 2020; https://www.weforum.org/agenda/2020/01/are-utilities-doing-enough-to-protect-themselves-from-cyberattack/

[5] https://www2.deloitte.com/us/en/pages/energy-and-resources/articles/utility-customer-experience-insights.html

AGEING INFRASTRUCTURE

From substations to the copper cabling beneath our feet, global electrical infrastructure is often decades old. And as society requires ever more power, and consumers expect its seamless provision, the demand on this infrastructure can be greater than it was designed to deliver. The need for extensive repairs, retrofitting, and modernization is urgent and substantial, requiring significant financial investment.

42% of survey respondents cited lack of infrastructure investment as a risk to their grids in the next five years, rising to 52% among those in the Asia Pacific region, where rapid industrialization, urbanization, and population growth have led to increased stress on ageing grids, particularly in densely populated urban areas[6]. Similar effects are being felt in South America fuelled by growing economic expansion in the region.

It is predicted that by 2040, 65% of the world's energy consumption will come from developing countries, predominantly India and China (which is still deemed a developing country under the criteria of most international organizations). In 2021 global electricity demand grew by 6% - the largest surge in percentage terms since 2010. Around half of this increase came just from China, with an estimated national usage growth of 10%. This surge outstripped sources of electricity in many major markets, leading to spikes in electricity prices, negative effects on power generators and prolonged power outages across India and China[7].

But it is not just in developing countries that surging demand is putting pressure on existing infrastructure. The American Society of Civil Engineers (ASCE) consistently rates the country's electrical grid as 'poor' or 'mediocre' in their infrastructure reports. In a recent report the ASCE identified an expected $200bn shortfall in system infrastructure upgrade requirements by 2029[8], and most of this shortfall is attributed to under investment in power generation and transmission.

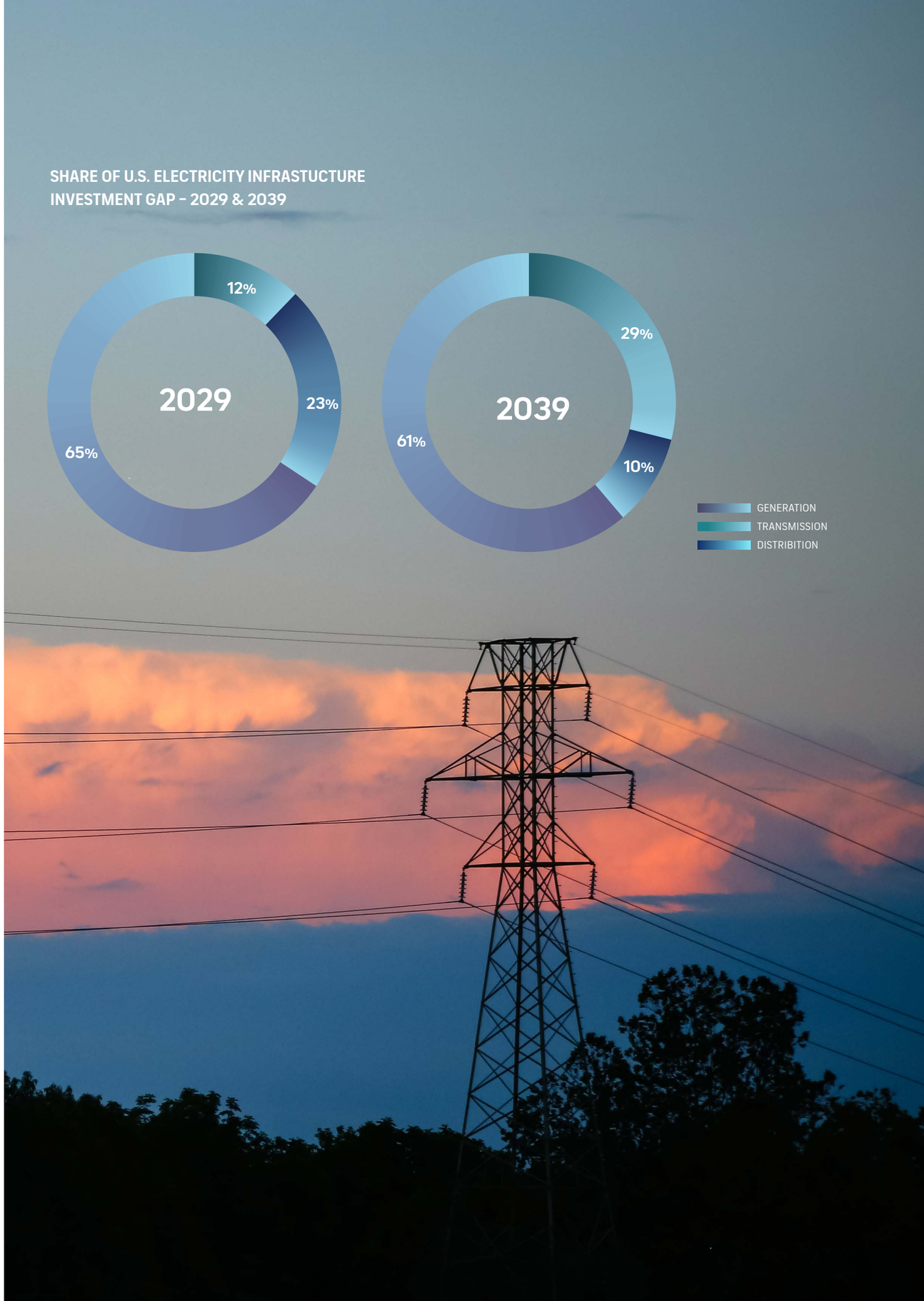
[5] http://koreascience.or.kr/article/JAK0202124553348171.page
[6] https://www2.deloitte.com/us/en/pages/energy-and-resources/articles/utility-customer-experience-insights.html
[7] https://www.iea.org/news/surging-electricity-demand-is-putting-power-systems-under-strain-around-the-world
[8] https://www.power-grid.com/td/american-society-of-civil-engineers-grades-u-s-energy-infrastructure-at-c-cites-200b-funding-gap/#gref

The fact is, many power grids and transmission systems are simply reaching the end of their operational lifespan and in need of significant investment to not only meet growing demand but also bring them in line with the requirements of the smart grids of the future. With these approaching sector shifts, greater connectivity is just one of the areas in which satellite IoT can make a difference, allowing for better infrastructure monitoring and control, as well as collection of data in order to improve operational decision-making to keep grid uptime within an acceptable range. However, in some cases, the terrestrial connectivity traditionally used has also reached the end of its useful life.

One prominent example of this is landline technology. The electrical utilities sector has traditionally relied on the 'landline' Public Switched Telephone Network (PSTN) to send much of its data, including telemetry services and alarms which monitor existing infrastructure from remote sites. Whilst the global phase out of the PSTN is set for 2030, the UK has an expedited deadline of 2025. This presents a huge contemporary challenge for the utilities industry in the UK[9], now faced with finding costly terrestrial alternatives, new installations and the associated cybersecurity measures required to maintain reliability and safety across its networks.

But there are solutions available today that are influencing the modernization agenda. While the traditional electrical grid was a 'one-way' system, 'smarter' two-way grids give distributors and suppliers feedback on system outages and local variations in electrical use. This provides grid managers the data needed to optimize the performance of the network, ensuring they can accommodate peak loads and anticipate any disturbances in supply.

Satellite-enabled technology can provide reliable, fast, and cost-effective infrastructure connectivity upgrade alternatives to the industry. It offers highly effective connectivity as well as the potential to support this data analysis at scale through IoT solutions. These advances can help the industry not just to maintain and prepare for future smart grids but improve existing grids and systems through the early detection, identification and subsequent mitigation of risks, future-proofing infrastructure to the modern-day levels that regulators and consumers expect.



[9] https://www.callcentrehelper.com/phasing-out-of-pstn-pots-203179.htm

TOWARDS A GREENER FUTURE

Of those polled, more than 3 out of 5 see the effects of climate change or natural disasters as a major risk to national grids, and this rises to 2 in 3 among C-Suite executives. It's a position that is shared by The International Energy Agency (IEA), an international organization working with governments and industry to shape global renewable energy provision.

A recent IEA statement concluded, "The increasing adverse impacts of a changing climate on electricity systems highlight an urgent need for action by policy makers, utilities and relevant stakeholders around the world to enhance their systems' resilience to climate change."[10]

The impact of climate change on utilities and energy suppliers has been made all too clear in recent times. In testimony to US Congress, John MacWilliams, Senior Fellow at the Center on Global Energy Policy at Columbia University, claimed that California-based Pacific Gas & Electric (PG&E)[11] was "the first climate change bankruptcy". Certainly, PG&E's collapse owed much to the increasing prevalence of climate-related wildfires in North America, and in particular the 'Camp Fire' of November 2018 in Northern California.

[10] https://www.iea.org/reports/power-systems-in-transition/climate-resilience

[11] https://www.energypolicy.columbia.edu/publications/out-control-impact-wildfires-our-power-sector-and-environment/

Wildfires not only pose physical infrastructure threats through their destructive force, but a new and emerging trend has further underscored the problem in the region: preventative power shutoffs. In efforts to combat wildfire ignitions, California has instituted the Public Safety Power Shutoff (PSPS) program, in which the state's utility companies pre-emptively shut off electricity services when high-risk weather conditions suggest a heightened possibility of electrical equipment wildfire ignition. This means customers are being subjected to highly disruptive impacts to their everyday lives that go beyond the immediate dangers of roaring flames and suffocating smoke.

"THE ENERGY TRANSITION TO MORE SUSTAINABLE ENERGY PRODUCTION WON'T HAPPEN BY SIMPLY ABANDONING FOSSIL FUELS ALL AT ONCE. THE PROCESS OF ELIMINATION WILL HAVE TO BE GRADUAL AND CAREFULLY HANDLED IN ORDER TO GUARANTEE GRID STABILITY, RESILIENCE, AND EFFICIENCY."

ENEL Greenpower
https://www.enelgreenpower.com/learning-hub/energy-transition/decarbonizati

While the scientific community points towards climate change - driven by fossil fuel consumption as a reason for an increase in extreme weather events, the global push to decrease this usage in favour of cleaner energy is forcing electrical utilities to rethink their approaches to grid management. In 2022, renewable energy, energy transmission networks and storage accounted for 80% of global investment, outstripping oil and gas[12]. While renewable energy technologies have made significant strides in recent years, integrating them into existing electrical grids poses a host of challenges.The intermittent nature of renewable energy sources like solar, hydroelectric and wind power necessitates the development of new energy storage solutions that can ensure consistent supply.

Fluctuating supply and demand is a risk to grid stability for 43% of our respondents. As the world weans itself off oil and gas, and its alluring ability to provide energy consistently, there is a dual focus for producers: i) develop more sustainable and efficient solutions to handle energy derived from fossil fuels, which still makes up a significant percentage of global production, and ii) find ways to effectively incorporate different energy sources to manage this challenge, including a mix of renewables and oil and gas. Meeting this dual challenge will be crucial for national grids moving forward.

During this transition, the monitoring of power efficiency and storage is a critical factor that the industry must manage. Finding ways to balance load and supply effectively and efficiently, while bringing alternative energy sources online, will be crucial. Regulatory oversight is likely to continue its focus on not only driving efforts to reduce environmental impact, but also to mitigate risks to networks. Solutions that meet these expectations will almost certainly require connected, real-time data monitoring and management that allows utilities to optimize the safe and efficient integration of a variety of energy sources into the grid as efficiently as possible.

[12] https://www.scientificamerican.com/article/renewable-energy-is-surging-but-trouble-looms/

EVOLVING REGULATORY ENVIRONMENT

It is not just the infrastructure, grids and technologies that must transform if the electrical utilities industry is to keep pace with the demands of a changing world. As the industry transforms, so too does regulation, and as a global regulatory framework evolves, the industry's business models must adapt to keep pace.

Industry professionals are aware of the financial implications that come from operational disruption. Whether they are due to infrastructure upgrades, weather events or even vandalism, any unreliability, or vulnerability to CNI can result in regulatory penalties. And these fines are a front-of-mind concern for the industry. 58% of respondents cited regulatory imposed fines as a primary concern for their business, with customer compensation (50%), costs to rectify (49%) and loss of revenue (47%) also scoring highly among financial considerations.

Across South America these worries are even more prevalent, highlighting the vulnerability of existing systems across the region. Costs to rectify concerns rose to 72% (vs 49% global average) and customer compensation to 68% (vs 50% global average). And as regulatory policies vary from country to country, it can be challenging for utilities with global operations to navigate and comply with diverse requirements

The transition to cleaner energy sources and the complexities of managing decentralized and diversified power grids are necessitating changes to the way the electrical utilities industry operates. Evolving regulations, governing how alternative energy sources can be bought, sold, and stored, impacts revenue and profitability. Modified pricing structures, business models and a whole new relationship with consumers need to be navigated.

Regulations are also placing greater focus on workforce safety and welfare. This is an area where respondents saw a greater role for new digital solutions. 55% saw IoT developments as offering potential solutions for workforce safety and half identified that real-time data from the field can help enable greater operational reliability through remote technical support. This rises to 76% in Europe where remote technical support is already gaining considerable traction.

For the electrical utilities sector to effectively keep pace with this changing regulatory environment, operators understand that they need greater access to real-time monitoring of data across their networks to provide them with the insights needed to develop accurate pricing structures based on customer's consumption patterns, as well as providing the early warning systems required to identify potential and actual disruptions quickly and effectively in order to avoid or minimize systems downtime.

58%

OF RESPONDENTS CITED REGULATORY IMPOSED FINES AS A PRIMARY BUSINESS CONCERN.

WHAT IF ANY, ARE THE FINANCIAL IMPLICATIONS OF OPERATIONAL DISRUPTION/DOWNTIME? OVERALL

- **58%** Regulatory imposed fines
- **50%** Customer compensation
- **47%** Loss of revenue
- **49%** Cost to rectify
- **2%** We experience no financial implications of operations disruption/downtime

WHAT IF ANY, ARE THE FINANCIAL IMPLICATIONS OF OPERATIONAL DISRUPTION/DOWNTIME? SOUTH AMERICA

- **52%** Regulatory imposed fines
- **64%** Customer compensation
- **38%** Loss of revenue
- **72%** Cost to rectify

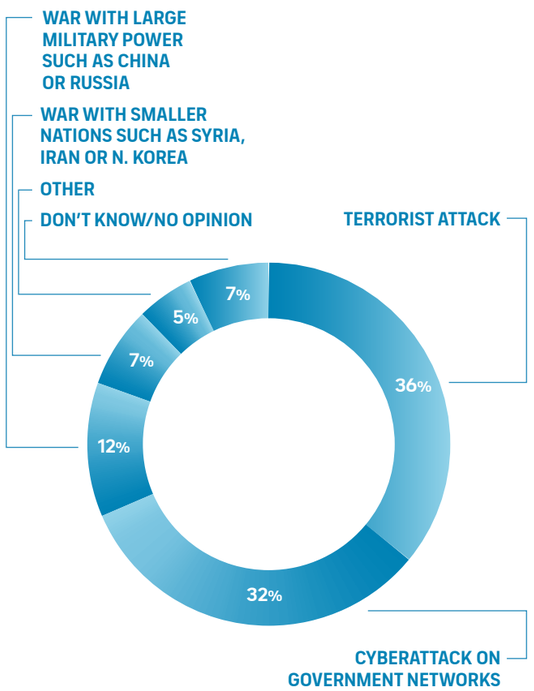
CYBERSECURITY RISKS

While the transition to more advanced smart grids and interconnected supply networks is crucial to meeting the challenges of global net zero and sustainability goals, the more reliant the industry becomes on digital technology, the greater the risk of catastrophic cybersecurity breaches.

Certainly, from a CNI perspective, the electrical utilities industry has the potential to be a target for state sponsored attacks or cybercriminals seeking to exploit vulnerabilities in national grids to cause economic and social destabilization. After 'terrorist attack', a 'cyberattack on government networks and infrastructure' (specifically electrical infrastructure) was seen as the second biggest threat to national security facing the United States in a recent survey of government officials (see figure XX). And a recent report from the Ponemon Institute and Siemens suggested that 54% of Utilities expected an attack on critical infrastructure in the next 12 months[13].

The most well-known cyberattack on an electrical grid, occurred in 2015 when hackers knocked out power to almost a quarter of a million people in the Ukraine. The attack, widely attributed to Russia-backed hackers, was made possible because of lack of isolation between the IT and OT (operational technology) systems. Hackers compromised IT systems via a successful phishing email attack and were then able infiltrate the utility's energy management system. By introducing malicious firmware the hackers were able to take control of key equipment within the network as well as impair the grid operators' ability to communicate with substations.

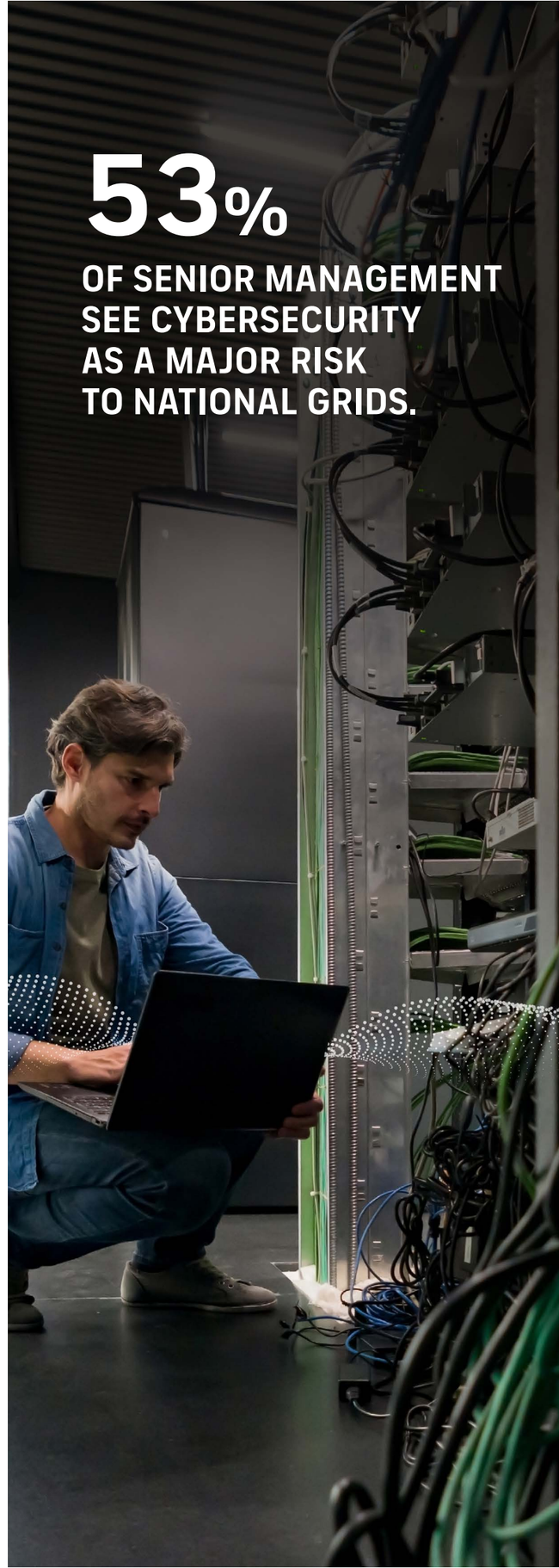
WHICH OF THE FOLLOWING DO YOU FEEL IS THE BIGGEST NATIONAL SECURITY THREAT TO THE UNITED STATES?



More recently, the 2020 SolarWinds attack on the North American Electric Reliability Corp. (NERC) exposed a quarter of the electric utilities it regulates to vulnerability. Sophisticated malware was inserted into the software supply chain and experts estimate that the electric sector could take years to determine the ongoing impact of the attack.

The industry however is acutely aware of these threats and is constantly iterating mitigation plans for potential attacks, designed to either cause damage through service disruption or for widespread theft of customer or organizational data. It is for this reason that more than half of senior management survey respondents cited cybersecurity as a major risk to grid stability. To address these fears and safeguard CNI within the electrical utilities sector, governments and industry stakeholders must prioritize investments in cybersecurity measures, and disaster preparedness. Robust risk management strategies, including regular assessments, constant monitoring of on-site and remote data, advanced threat detection systems and automated alarms, as well as cybersecurity training for employees are necessary to mitigate these risks effectively.

It is critical that these security concerns are shared by the industry and its supply chain, especially those that enable monitoring and control across increasingly complex digital systems. How the industry manages and moves data around their networks is a challenge. From how and where data is encrypted, to the routing of traffic to avoid contact with public internet access points, there are a multitude of approaches to consider in the complex world of data security, explored further in the next chapter of this paper.

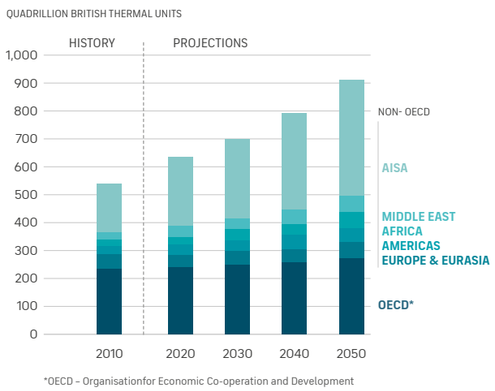


[13] https://assets.siemens-energy.com/siemens/assets/api/uuid:c723efb9-847f-4a33-9afa-8a097d81ae19/siemens-cybersecurity.pdf

CHANGING CONSUMER EXPECTATIONS

Almost half of survey respondents identified increased energy demand as a significant trend driving Internet of Things (IoT) and connectivity requirements within their organisations. As requirements for electricity increase, so do the demands and expectations of consumers. In 2014, global demand for energy was estimated by the International Energy Agency (IEA) to be at 167 million tonnes (of oil equivalent). This figure had nearly doubled to 328 million tonnes by 2018 – and shows no sign of slowing. To meet this growing demand, the electrical utilities industry will need to invest significantly in new platforms, services and advanced metering and monitoring infrastructure, or risk losing customers to new industry players who will.

GLOBAL PRIMARY ENERGY CONSUMPTION BY REGION (2010-2050)



*OECD – Organisationfor Economic Co-operation and Development

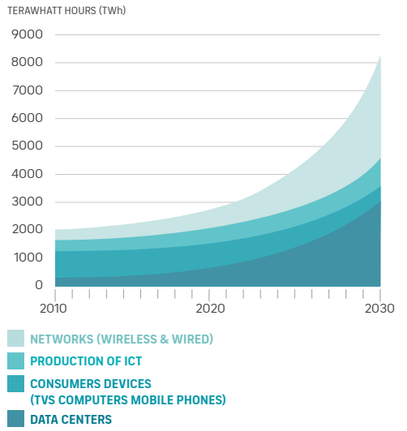
One of the key drivers of this increased demand for electricity is the exponential rise of information and communications technology (ICT) in an increasingly interconnected world. As more of the world comes online and rising prosperity in developing nations promotes greater consumption of connected devices, this sector could account for up to 20% of total electricity demand. Connecting and powering our increasingly digital world is a challenge for the utilities industry globally.

With a greater awareness of sustainability issues as well as resentment and distrust over historically high unit prices and supply challenges, consumer demands and expectations are seeing unprecedented changes, and they expect their concerns to be reflected by the energy providers they choose. Technology like smart meters, controlled by online apps and providing real-time data on household energy spending, have become commonplace in some regions and increasingly consumers are demanding greater control over their energy consumption, as well as assurances that the energy they do consume is generated sustainably, and delivered responsibly.

Meanwhile, customers are evaluating their relationship with electrical utilities where they are becoming increasingly involved in the supply network. The rise of domestic energy generating technologies, such as solar panels, heat and air pumps and domestic wind turbines is also forming

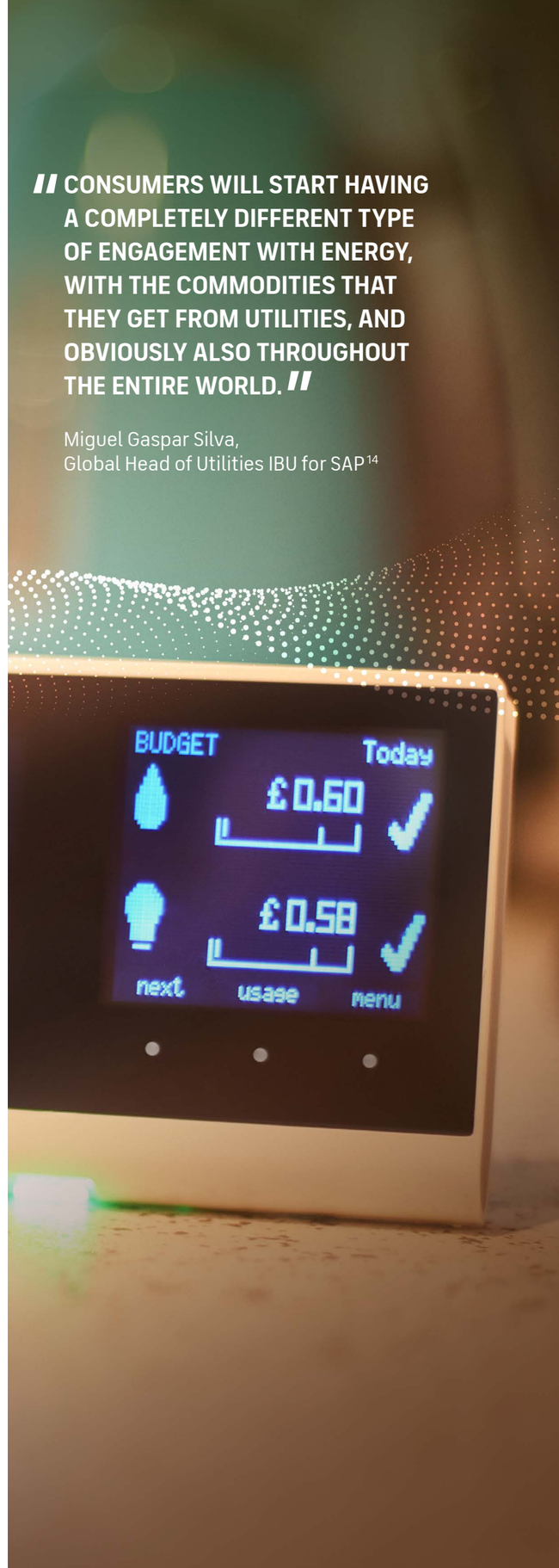
ENERGY FORCAST

Widely cited forcasts suggest that the total electricity demand of information and communications technology (ITC) will accelerate in the 2020's and that Data Centers will take a larger slice.



an entirely new kind of customer, known as prosumers. These prosumers are generating their own energy and feeding it back to the grid and in return they expect more flexible billing options, greater communication, and much higher levels of customer engagement. New tariffs (such as feed-in tariffs) need to be explored and renewable portfolio standards reviewed to accommodate this changing landscape. And while this trend is currently predominant in developed nations, developing countries are not far behind, with China, India and Brazil featuring in the top 10 countries for energy transition investment.

> "CONSUMERS WILL START HAVING A COMPLETELY DIFFERENT TYPE OF ENGAGEMENT WITH ENERGY, WITH THE COMMODITIES THAT THEY GET FROM UTILITIES, AND OBVIOUSLY ALSO THROUGHOUT THE ENTIRE WORLD."
>
> Miguel Gaspar Silva,
> Global Head of Utilities IBU for SAP[14]



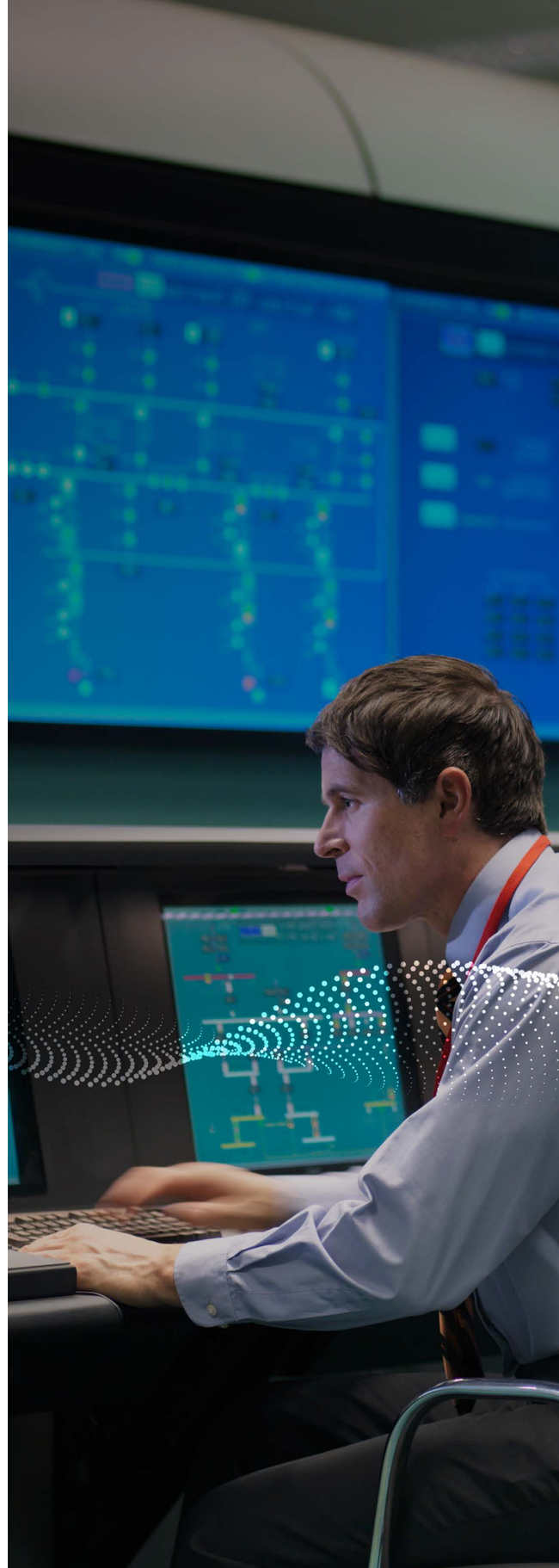
[14] https://www.visualcapitalist.com/ranked-the-top-10-countries-by-energy-transition-investment/

CHAPTER 2:

THE ROLE OF SATELLITE CONNECTIVITY IN THE FUTURE OF ELECTRICAL UTILITIES INFRASTRUCTURE

"THE UTILITIES SECTOR HAS BECOME A PIONEER OF DIGITAL TRANSFORMATION IN RECENT YEARS, DRIVEN BY A NEED TO MONITOR, MANAGE, AUTOMATE, AND ULTIMATELY IMPROVE THE QUALITY AND RELIABILITY OF ENERGY BEING SUPPLIED TO CONSUMERS. SATELLITE CONNECTIVITY IS PLAYING AN INCREASINGLY IMPORTANT ROLE IN THIS."

Energy Digital[15]



Across the board, those surveyed identified increased satellite connectivity and IoT technology as offering solutions to the significant challenges discussed in Chapter 1. In fact, 75% of industry C-level executives, business owners and senior managers acknowledge that satellite IoT is already playing a role in mitigating the biggest risks facing the industry. However, priorities for satellite IoT use may vary depending on geography.:

For those in North America, renewable energy and increased energy demands were the primary drivers for increased satellite connectivity requirements. In the Middle East & Africa (MEA) region, electric vehicle (EV) charging infrastructure is the dominant trend driving the need for greater connectivity. While in South America, increased supply costs are pushing IoT solutions to the forefront of respondents' needs.

For regions such as the MEA and parts of South America, satellite connectivity's ability to extend the reach of smart electrical grids to remote and underserved areas is helping to bridge the digital divide, fostering economic development and improving quality of life. In others, such as North America, satcom technology is also supporting solutions that are designed to enhance grid stability. Backed by its reliable and resilient connectivity, even in the face of natural disasters or infrastructure failures, satellite technology enables utilities to optimize operations, reduce energy waste, and unlock new avenues for innovation, even in the face of natural disasters or infrastructure failures. And as adoption of satcom is already gaining traction within the electrical utilities sector, its impact is only set to increase.

3 in 4 of our electrical utilities leaders see satellite IoT as an essential technology if the industry is to meet the demands of consumers and governments and secure its CNI commitments. The following section will detail how satcom technology can deliver improved infrastructure efficiency, provide greater coverage and accessibility, ensure reliability and digital security, and drive sustainable innovation.

[15] https://energydigital.com/technology-and-ai/role-satellite-smart-grid-development

IMPROVING INFRASTRUCTURE EFFICIENCY

Improved infrastructure efficiency is a key requirement for modern electrical utilities. By reducing waste, developing mechanisms to deliver electricity that matches peaks in demand, and identifying needs for system upgrades, operators can significantly improve the efficiency of their networks. These solutions are critical if the industry is to effectively manage the challenges of ageing infrastructure, and three quarters of respondents identify that satellite IoT offers solutions to mitigate these risks.

Satellite connectivity enables a variety of technology-based solutions to help identify and minimize inefficiencies within the grid system. By providing unparalleled connectivity, even across parts of the globe that conventional terrestrial networks cannot reach, satellite IoT technologies enable utility companies to gather extensive data on energy consumption patterns, load distribution, and network performance, while delivering the technical capabilities they were designed to offer. IoT solutions can then analyse these results and provide demand response programs, or identify required network upgrades and maintenance, reducing waste and enhancing efficiency.

Satellite IoT can also facilitate remote control, monitoring and Supervisory Control and Data Acquisition (SCADA) management of electrical grids. Commonly used in manufacturing and industrial automation since the late 1990s, SCADA is used to monitor and control industrial processes and critical infrastructure systems and provides real-time data acquisition and remote management capabilities. Matching this proven technology with satellite connectivity's global reach, reliability and rapid deployment creates an ideal opportunity to help future-proof the industry's infrastructure. By enabling real-time adjustments to the grid to increase operational efficiency, enhanced connectivity can reduce network downtime and develop greater system resilience. It also significantly improves a grid manager's ability to pinpoint malfunctions and dynamically respond to power outages.

The benefits of satellite connectivity can also extend beyond operational efficiencies and into the world of cost management in a way that might surprise those in the industry. 44% of respondents identified satellite-based solutions as being capable of creating cost efficiencies over terrestrial connectivity. Satellite connectivity enables ready-to-deploy solutions, without the need for developing costly additional terrestrial communications infrastructure. This has implications not just for remote areas, but urban ones, too, where geographical or terrain constraints might limit terrestrial network coverage or expansion, or where budgets don't allow for the significant additional investment of terrestrial communications infrastructure. All these efficiency-enhancing requirements open up substantial opportunities for utilities to more precisely tailor their IoT ambitions and developments to match their grid operations.

CASE STUDY:

CEMIG

In December 2015, the Brazilian Ministry of Mines and Energy granted Cemig the contract to distribute electric power to its customers in Minas Gerais for 30 years. However, the contract came with new service limits established by the National Electric Energy Agency which Cemig had to comply with. The main supply quality indicators are the Equivalent Interruption Duration per Consumer (EDC) and the Equivalent Interruption Frequency per Consumer (EFC). The limits of these quality indicators are progressively decreased each year for the duration of the contract, which means that Cemig has to constantly improve the supply of electrical energy for its customers.

One of the main problems that Cemig faces in improving the EDC is the performance of cellular connectivity in remote areas of Minas Gerais, which, despite having major cities such as Belo Horizonte, also has very remote areas with a lower population density. In the event of an incident with the electrical system, reclosers (the switches that test the medium voltage distribution network automatically, interrupting the power in theevent of a problem and restoring the supply if they detect the problem is no longer present) would normally bring power back online.

However, the lack of connectivity in remote areas hampered communication with Cemig's Centre of Operations meaning it wasn't possible to send remote commands to the automated reclosers in the field. So OnixSat (a South American IoT solution provider) and Inmarsat developed a satellite connectivity solution to enable Cemig to improve the availability of remotely controlling its reclosers. The Inmarsat satellite communications network has been crucial for assuring connectivity, reaching reclosers in very remote locations in the Cemig distribution network. Its coverage enables Cemig's field equipment to send and receive data regardless of its location, and its 99.9% uptime ensures that they will always remain connected, even in adverse weather conditions.

The collaboration between OnixSat and Inmarsat has produced impressive results for Cemig. Before deploying the solution, Cemig had an effective availability of remotely controlling the reclosers in the remote recloser project of less than 90%. After deployment of the Inmarsat and OnixSat solution, this indicator now shows an average of 98% at the points where satellite communication was installed. Such was the success of the solution based on connectivity via satellite that, after starting by deploying the solution in 150 reclosers, Cemig now plans to install 760 further satellite terminals, to be applied in its distribution networks and substations.

"NOW WE RARELY SEND TEAMS TO REMOTE AREAS WHERE THE SATELLITE COMMUNICATION SOLUTION WASINSTALLED, REDUCING THE NEED TO TRAVEL FOR SEVERAL HOURS TO OPERATE OUR RECLOSERS MANUALLY ON SITE. WITH ONIXSAT'S SATELLITE COMMUNICATIONS SOLUTION, WE ARE ABLE TO ASSURE AVAILABILITY AND AUTOMATICALLY ACTIVATE THE EQUIPMENT REMOTELY. THE SOLUTION HAS HELPED US TO RESTORE THE POWER SUPPLY MORE QUICKLY, THUS ENABLING AN IMPROVED SERVICE PROVISION TO OUR CUSTOMERS."

Flavio Henrique Martins Vieira,
Distribution Automation and Protection Engineer, Cemig

ENHANCING COVERAGE AND REDUCING CONTENTION

While it is often assumed that we live in a fully connected, digital world, the truth remains that our ability to get online still depends largely on where we live. Inhabitants of many of the world's largest cities and towns take connectivity for granted, but around 90% of the world's surface has no terrestrial connectivity available at all, including huge areas where electricity is generated and distributed across national grids. Indeed, over a third of the world's population, almost 3 billion people, have never even been online[17] and it's estimated that more than 727 million people still have no domestic electricity supply.

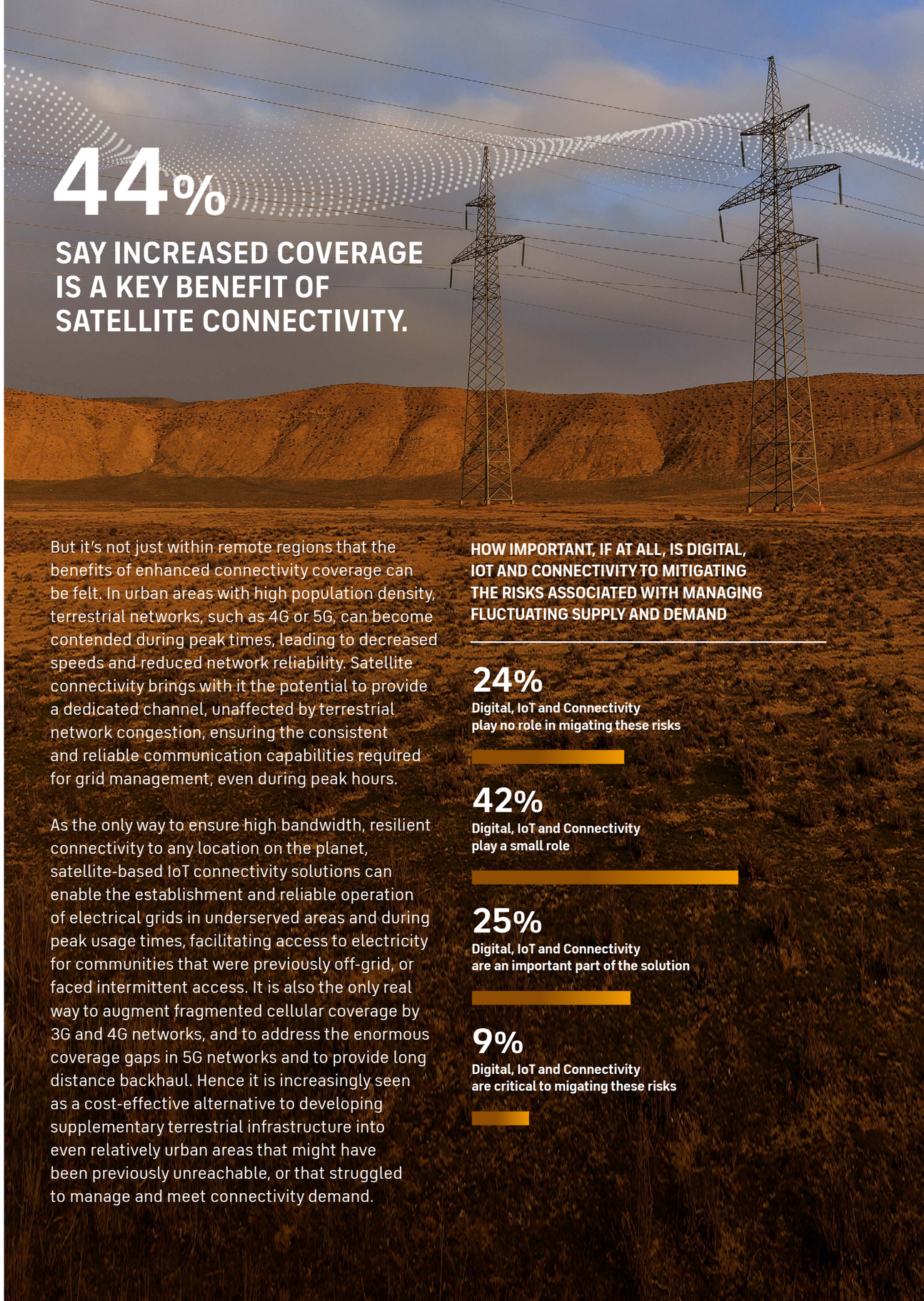
A lack of available and reliable terrestrial communication is a huge barrier to enhancing the capabilities of a connectivity network and making the most of smart grid applications and solutions. Whether it is smart meters or digital sensors and switches, such infrastructure advancements cannot be optimized (or are simply not possible) without reliable connectivity.

With this context in mind, it's not surprising that more than 2 in 5 of our global respondents cited increased coverage, defined as being used where terrestrial connectivity services are unreliable or unavailable, as a primary benefit of satellite connectivity in improving infrastructure reliability and stability. This rises to over 1 in 2 in Europe and South America, where 56% of respondents agree.

The vast continent of South America encompasses diverse geographical landscapes (many of which are prone to natural disasters such as earthquakes, floods, and hurricanes), including remote regions, dense jungles, and mountainous areas, where deploying terrestrial network infrastructure can be challenging and costly. Satellite connectivity plays a vital role in providing communication services to local communities and underpins the reliable supply of energy even in the most remote areas.

> **"ONLY 10% OF THE EARTH'S SURFACE HAS TERRESTRIAL CONNECTIVITY.[16]"**

Similarly in Europe, remote regions that suffer from inadequate terrestrial connectivity due to their geographical characteristics and low population density can be found more commonly than you might think. For instance, in countries like Norway, Sweden, Finland, and Scotland, satellite connectivity is essential to connecting isolated communities in mountainous and Arctic regions, where terrestrial networks are impractical or economically unfeasible.



[16] https://www.abiresearch.com/press/new-satellite-networks-will-enable-24-million-iot-connections-and-provide-seamless-global-connectivity-2024/

[17] https://www.washingtonpost.com/world/2021/12/01/global-internet-usage/

ENSURING DIGITAL SECURITY & RELIABLE CONNECTIVITY

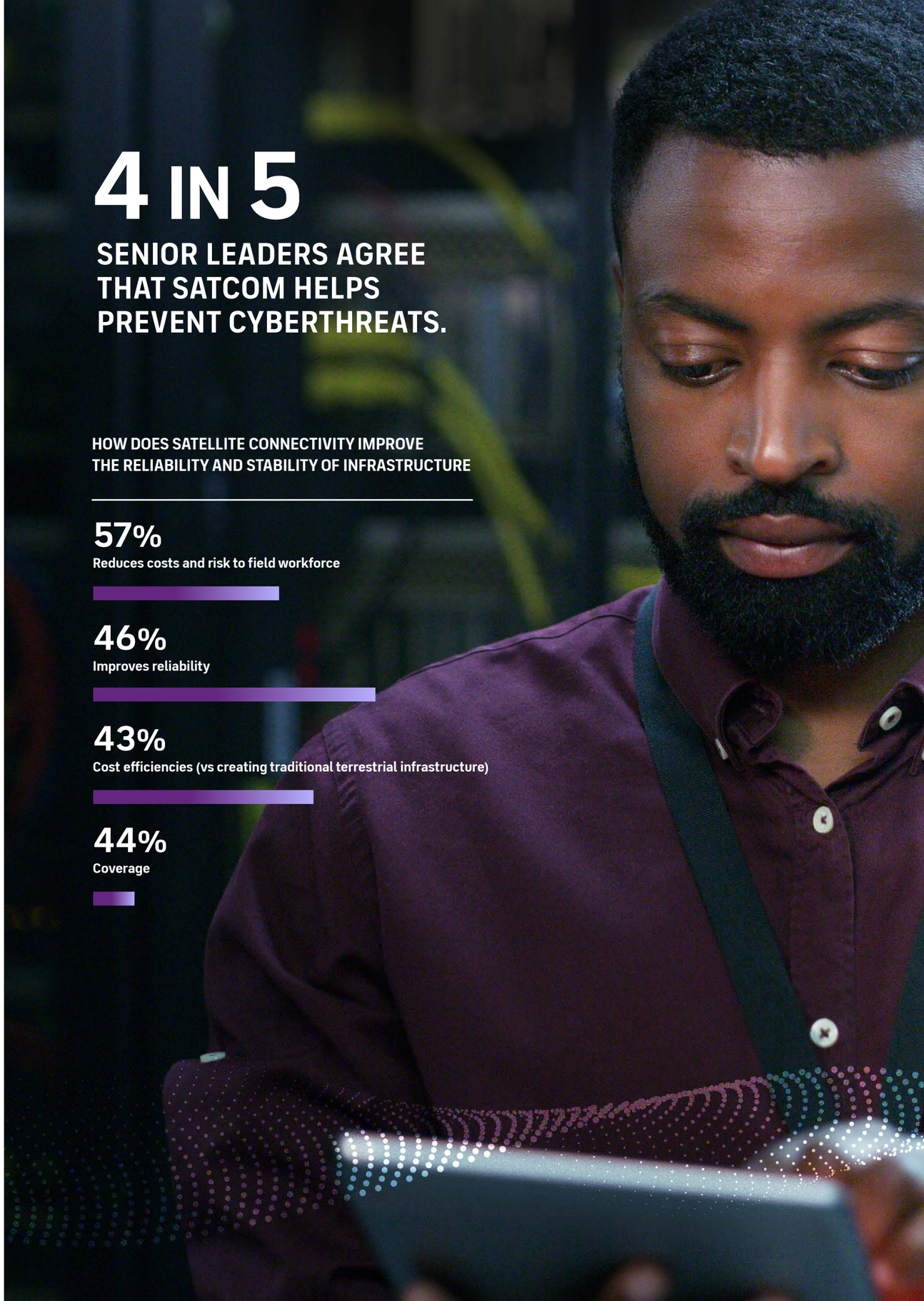
With critical national infrastructure (CNI) regulatory commitments front of mind for the electrical utilities industry, the security and stability of national grid and power networks are crucial considerations when addressing technology needs.

When it comes to digital security, 79% of respondents recognize that satcom is playing a role in mitigating the risks associated with cyberthreats. The advanced encryption and authentication mechanisms offered by certain satellite networks can be a key differentiator for digital protection across national grids. Beyond the security services offered by these satcom providers, operators can also enhance protection through incorporating their own end-to-end encryption protocols when implementing satcom solutions.

While encryption is an undeniably critical part of the security equation, operators should also factor in the importance of how traffic is routed. Satellite connections benefit from the differentiating factor of avoiding contact with public internet traffic, a defining digital safety consideration for utility operators. The ability of certain satellite networks to provide secure traffic routing links in this way is vital to ensuring vulnerabilities in the system are mitigated.

But it is not just the security aspect that makes satcom so attractive for the industry. 76% of respondents agreed that satcom can play a role in improving network reliability. By leveraging satellite networks to monitor all aspects of the grid system, from power generation, transmission, through to distribution, in real time, the technology allows operators to identify faults as they happen and, in some cases, enables predictive maintenance.

This constant data transmission and remote monitoring enabled by satellite connectivity can enhance grid resilience and reduce downtime, even during natural disasters, contributing to the overall reliability of electrical utilities. In addition, satellite connectivity offers vital backup systems through solar-powered redundancy designs, enabling rapid response during emergencies or periods of unstable terrestrial network coverage.



DRIVING SUSTAINABLE INNOVATION

More than two-thirds of senior leaders in the electrical utilities industry agree that climate change or natural disasters pose a significant threat to national grids over the next five years. There is also global pressure on the sector to reduce carbon emissions in order to meet net zero goals by 2030.

Satellite-enabled technologies have the potential to remove an estimated 1.9 billion tons of CO2 from the atmosphere annually, if more widely adopted across the industry. That is the equivalent of removing the total CO2 emissions of New York City for over 30 years[19].

The integration of satcom technology with smart grids, through a variety of data rich IoT devices distributed across them, is acting as a vital catalyst for innovation across the energy sector. By enabling effective data collection and analytics through advanced remote monitoring and control systems, utilities are gaining valuable insights into grid performance, predictive maintenance, and energy consumption patterns. This information can then be utilized to drive innovation in demand management, renewable energy integration, and customer engagement strategies. The rewards are considerable, not least from a CNI perspective. The industry is moving from a centralized model, where power generation has been centred in relatively few fixed power stations, to a decentralized position where thousands of new energy sources are tied to the grid. And while this makes grids more complex to operate, it has exciting potential to bring alternative energy sources online within efficiently managed, innovative smart grids.

> **"INNOVATION IS ESSENTIAL FOR FUTURE POWER SYSTEMS TO BE SAFE AND SECURE, CLEAN AND SUSTAINABLE, AFFORDABLE AND EQUITABLE, AND RELIABLE AND RESILIENT."**
>
> Berkeley Lab [18]

In fact, 70% of industry leaders endorse satellite technology as already playing a role in helping mitigate the risks associated with climate change or natural disasters. Examples of such innovations include environmental monitoring and early warning systems in efforts to anticipate and respond to potential climate related risks to infrastructure, remote asset management in regions prone to climate-related challenges such as floods or wildfires, and resilient communication links in the event of disaster response requirements, particularly where terrestrial services might have been damaged or disrupted.

[18] https://emp.lbl.gov/publications/role-innovation-electric-utility

[19] https://www.inmarsat.com/en/insights/corporate/2022/space-around-us.html

CHAPTER 3:

CONSIDERATIONS FOR CHANGES TO AN ELECTRICAL UTILITY CONNECTIVITY SYSTEM

While respondents were overwhelmingly positive about the potential for satellite-enabled technology in CNI grids and networks, there remain some concerns and challenges among sector professionals about how these integrations can be implemented practically, cost-effectively and securely.

The electrical utilities industry is transforming the way it operates. Challenges with supply and demand, climate, cyberthreats and regulation, mean evolution of the sector is inevitable. It is only natural that a degree of cautiousness accompanies the prospect of implementing operational changes to national grids. This is particularly the case when IT and network infrastructure are involved, due to a need to mitigate risks of operational impact, or the unintentional creation of cybervulnerability points.

REALISING THE EXCITING OPPORTUNITIES AHEAD WILL INVOLVE TAKING INTO ACCOUNT THE FOLLOWING CONSIDERATIONS.

SECURITY IMPLICATIONS

As previously illustrated in this paper, the importance of digital security considerations cannot be underestimated. More than half (53%) of respondents identified security implications as a primary concern when considering upgrades to connectivity systems. CNI presents an attractive target for cyberattacks, requiring particular care when integrating digitally enabled solutions to avoid increasing system vulnerabilities that cybercriminals can take advantage of.

When implementing new connectivity systems, the industry must ensure the security of data transmission, authentication, and access control. Systems that provide robust encryption, firewalls, intrusion detection systems, and continuous monitoring, provided by organizations with proven track records in this space, will be crucial when considering upgrade projects. Utilities operators will want to work with providers that enable them to manage traffic routing directly into connectivity networks, limiting points of risk and increasing their overall control and oversight.

INTEGRATION AND IMPLEMENTATION CAPABILITY AND COSTS

The ability of utilities to effectively implement these technology upgrades remains a concern for the industry, as well as the costs associated with large scale infrastructure upgrades. Over half (58%) of respondents identified costs and capabilities as a primary concern when it came to implementing upgrade projects to protect CNI capabilities.

Implementing new connectivity systems within electrical utilities can be daunting and complex, and integration of modern technologies within existing infrastructure can be challenging. For many industry professionals, the fear of operational impact caused by system and technology compatibility can be off-putting.

The industry needs to find simple solutions that promote incremental and manageable change. Identifying solutions and suppliers that do not require wholesale replacement of existing infrastructure, heavy additional investment in new hardware or software solutions, nor the need for specialist or skilled employees to operate new systems will be crucial for successful project implementations. The relative 'plug and play' nature of satellite IP-based services will be highly relevant during transitions away from legacy connectivity networks, such as the PSTN.

INTEROPERABILITY OF SYSTEMS

Related to the theme of integration is that of interoperability and compatibility. 64% of respondents in North and South America identify Interoperability of systems as a primary concern when thinking about new connectivity solutions, although this drops to just 32% across Europe where there is greater industry-level compatibility and integration compliance.

As with all large infrastructure projects, changes in connectivity systems may require standardization of protocols, data formats, and communication interfaces to enable smooth information exchange and interoperability across different systems and devices.

In a multi-stakeholder industry like electrical utilities, including power generators, transmission operators, distribution companies, and customers, seamless communication and interoperability among these entities is crucial for efficient operations. Organizations experienced in navigating these complexities will be preferred suppliers for transformation projects of this nature.

TRAINING AND WORKFORCE SKILLS

Finally, attracting, retaining, and training new and existing workforces with the skills required to implement and run these new systems effectively presents another challenge for the sector.

For 44% of industry professionals, finding and retaining the skilled workforce required to implement and run new connectivity systems remains a risk. With a widening skills gap in digital technology emerging across the globe, utilities providers must ensure that their existing workforce is adequately trained or upskilled to operate and maintain new systems effectively.

To ensure smooth transitions and efficient integration troubleshooting, utilities providers should look for organizations and implementation partners who bring a proven value chain of experienced service providers to ease the challenges inherent in these complex deployments. Coupling this level of experience with solutions that offer as close as possible to 'plug and play' implementation is a powerful approach to delivering effective network upgrades with minimal disruption.

CONCLUSION

Satellite connectivity supports proven and reliable technologies to help the electrical utilities industry tackle the challenges of ageing infrastructure, climate challenges and evolving regulatory requirements, particularly regarding energy efficiency and resilience, as well as workforce management and safety. These technologies also enable innovation in the monitoring and handling of data associated with renewable energy production, collection, and storage, as well as helping deliver the real-time efficiencies and customer intelligence required to develop the tariffs and billing models of the future.

By working with mature and tested supply partners, the industry can mitigate many of the cybersecurity challenges and threats it faces, while maximizing the benefits that improved connectivity is already delivering to the sector.

There is evidently potential for satellite connectivity technology to do more for the utilities industry. Organizations are increasingly seeing collaborative partnerships with established players in the satcom sector as crucial for achieving their goals over the next five years to improve reliability and resilience, boost security, meet new customer demands and improve workforce safety.

There is a sizeable opportunity for utilities to leverage their satcom partners' expertise, specialized solutions, and robust connectivity networks to address the industry's primary concerns, and future-proof their infrastructure to deliver a truly modern network.

5 THINGS TO LOOK FOR IN A SATELLITE IOT CONNECTIVITY PARTNER

1 INTEGRATION CAPABILITIES.
A reliable satellite connectivity supplier with expertise in the electrical utilities industry can offer comprehensive integration support, providing seamless integration of new systems with existing infrastructure and processes. Solutions should be adaptable to meet specific requirements, reducing the complexity and costs associated with implementation.

2 PRIORITIZING SECURITY.
Reputable suppliers invest in robust security measures to protect critical infrastructure. Such suppliers deploy advanced encryption, authentication protocols, and continuous monitoring to safeguard data transmission and mitigate cyberthreats. They comply with industry-specific security standards and regulations and can support specific traffic routing preferences.

3 STANDARDIZATION OF SYSTEMS.
While a level of adaptability is attractive, well-established suppliers facilitate interoperability by providing standardized protocols, data formats, and communication interfaces. They act as a bridge between stakeholders, ensuring seamless communication and data exchange across diverse systems, hardware, and software.

4 SCALABILITY.
Trusted partners understand the evolving needs of the industry and offer scalable solutions that can accommodate growth and technology development. They provide flexibility of bandwidth allocation, network expansion, and system upgrades, allowing utilities to adapt their connectivity systems without significant disruptions or additional costs.

5 ONGOING SUPPORT AND LONGEVITY OF SERVICE.
Collaborative partners provide ongoing support and technical assistance, access to the latest innovations and enabling your workforce to troubleshoot issues efficiently, minimizing downtime. They will demonstrate a commitment to the longevity of services they are providing to avoid risk of surprise through end-of-life product cycles.

ABOUT VIASAT

Viasat is a global communications company that believes everyone and everything in the world can be connected. With offices in 24 countries around the world, our mission shapes how consumers, businesses, governments and militaries around the world communicate and connect. Viasat is developing the ultimate global communications network to power high-quality, reliable, secure, affordable, fast connections to positively impact people's lives anywhere they are—on the ground, in the air or at sea, while building a sustainable future in space. On May 30, 2023, Viasat completed its acquisition of Inmarsat, combining the teams, technologies and resources of the two companies to create a new global communications partner.

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