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THE SMART GRID OF TOMORROW

THE ROLE OF SATELLITE CONNECTIVITY

NETWORK INNOVATIONS
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EXTENDING THE RELIABILITY, EFFICIENCY AND SECURITY OF TOMORROW'S SMART GRID

To help monitor, manage, automate and ultimately improve the quality and reliability of energy being supplied to consumers, the utilities sector has become a pioneer of digital transformation, deploying more advanced technologies across their networks to build 'smarter' grids. These technologies are numerous, but predominantly include centralised automated reclosers, advanced metering infrastructure (AMI) and substation automation.

Connectivity technologies have been around for the past two decades to underpin this expansion of smart grid applications, but mainly through a combination of technologies – such as radio and cellular networks – that are not the best choice for every application. Further, the challenge faced by many utility companies continues to be that large areas of their networks have coverage dark spots, which is where terrestrial connectivity fails to provide the reliable communications backbone that is needed to build efficient, reliable and secure smart utilities networks.

Satellite is an important tool in the arsenal of any reliable and secure utilities network. On the one hand, it eliminates coverage dark spots in a cost-effective way, while it also can work as a highly reliable backup communications system when terrestrial connectivity networks fail.

In the past, satellite-enabled solutions that provide 'always-on' connectivity for utilities have been deemed cost-prohibitive or overly reliant on bulky hardware, but much has changed in recent years.

This paper addresses the next era of smart grid development and maps out the path to accelerating further digitisation across the utilities sector – focusing particularly on the automation of electricity distribution and delivery – assessing the most reliable, economical and secure solutions employing satellite-based technology for utility companies and technology providers.

THE EVOLUTION OF THE 'SMART' GRID

Electric grid management has always been a complex task. On the one hand, grid managers need to ensure they meet fluctuations in consumer demand and provide a high quality of service that improves people's lives. On the other, they must be able to dynamically respond to surges and keep downtime to a minimum. These challenges are being compounded by the fact that both governments and the C-suite are now pushing the switch towards a distributed-generation, low-carbon economy, which is set to transform how power is both being produced and consumed by end users across the globe.

All this means is that the grid is now permanently in a state of flux – no one day is ever the same. The challenge for utility companies in this constantly changing environment is, therefore, to ensure they have the tools to meet growing demands of end-users, increase power efficiency, reliability and quality, ensure they are meeting environmental targets and be ready for the assimilation of renewable energy sources into traditional networks.

This, however, has not always been possible. The traditional electrical grid was a 'one-way' system, with power going from the grid operator to the customer, without any feedback and data going back to the provider.

Consequently, the last two decades have seen a huge influx of automation devices, communications and control technologies being increasingly applied to create a 'two-way' system that ensures distributors can monitor, manage, automate and improve the quality of energy being supplied to consumers. These 'smarter', two-way power grids mean that not only can electricity be provided to end customers, but distributors and suppliers can also get heads-up feedback on parameters such as system outages and electrical use. With this data, grid managers can optimise the performance of the network, ensuring they can accommodate peak loads, as well as anticipate disturbances in the network.

THE MODERN SMART GRID

The new metering, communications and control technologies that are now contributing the modern smart grid are numerous, but three core applications include:

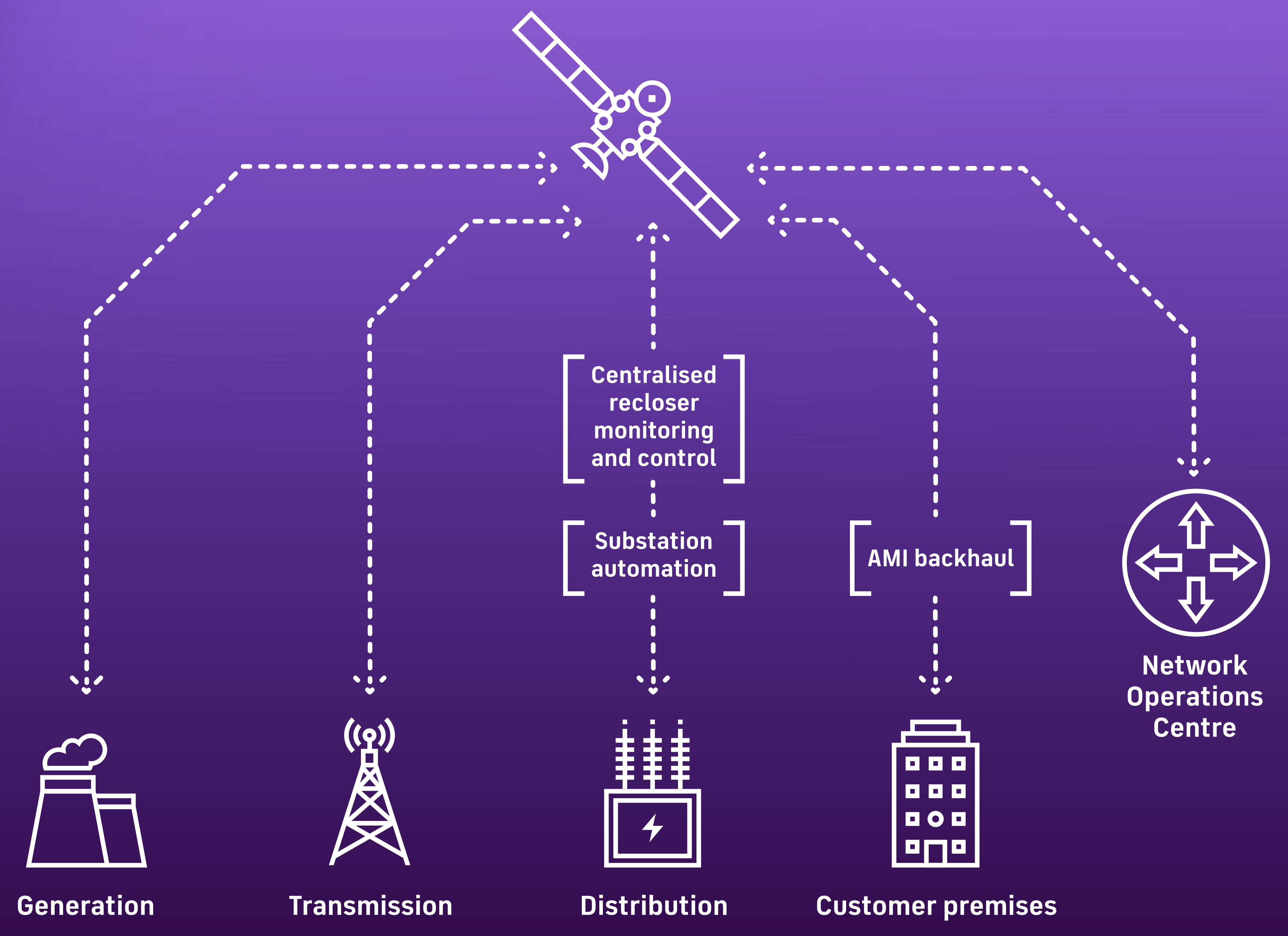
- Centralised automated reclosers.
- Advanced metering infrastructure (AMI).
- Substation automation.

Centralised automated reclosers are arguably the most important smart grid application, as they allow utility companies to sense and interrupt currents in the event of a fault, giving them the tools to automatically reconfigure the network to isolate faults and restore supply. In doing so, this can help maintain maximum continuity of service and minimise outages, which is critical if they are to consistently improve service quality to end-users.

These technologies are enabled by supervisory and control (SCADA) systems, which provide an end-to-end system that acquires data from the field through Remote Terminal Units (RTUs) or Intelligent Electrical Devices (IEDs) and connects it to sensors through a communications network.

These technologies are all making field data more accessible and reliable than ever before, helping grid managers to make smarter, more informed decisions. In doing so, utility companies now have the toolkit to:

- Enhance visibility over metering and grid networks.
- Fewer and shorter outages.
- Reduce peak consumption by shifting demand loads.
- Optimise electricity generation and distribution, helping to reduce carbon footprints.
- Lower maintenance costs.



THE LIMITS OF TERRESTRIAL AND PRIVATE NETWORKS

With most utility and energy companies relying on new technologies to help make the distribution smart grid more flexible, stable, resilient and secure, the same qualities must be true of its communication network. The sector has historically deployed a mix of communications solutions to meet the demand of smart grid applications, including radio and cellular-based technologies. However, there are a number of important limitations to these communications solutions.

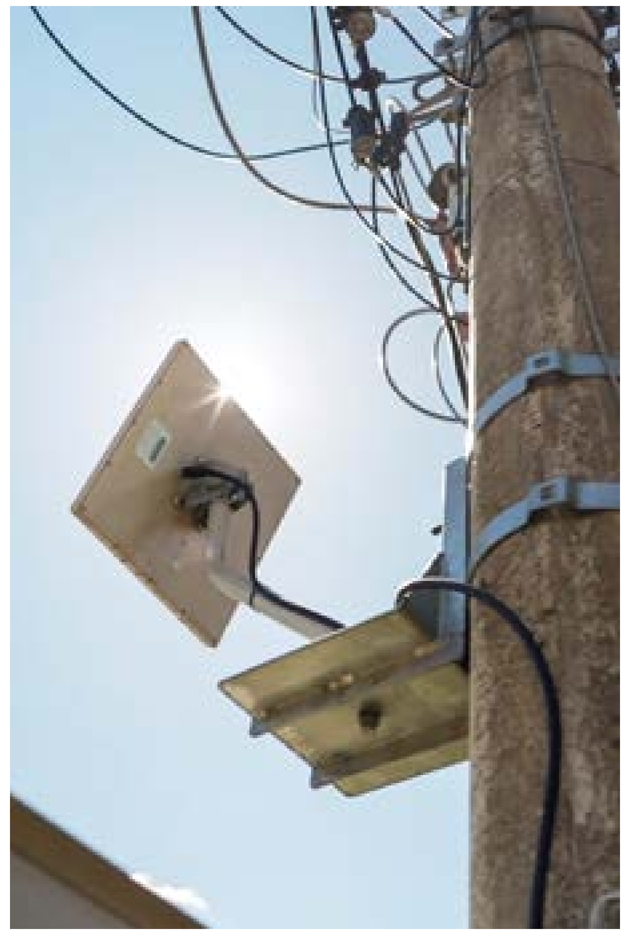
For example, while radio provides dedicated coverage across a network, the initial costs are high and it limits where and how equipment can be connected. For remote SCADA systems that require a highly reliable monitoring and controlling network, an unreliable communications backbone involving meshed networks, may significantly limits a grid manager's ability to, for example, pinpoint malfunctions and dynamically respond to outages.

Cellular-based technologies are designed for consumers using smartphones and large amounts of data and suffer from congestion and intermittent availability, which does not give the reliability utility companies need at mission critical moments. Have you tried to place a call or send a text at a local sports event or concert only to experience nonstop failed attempts? The nearby cellular-enabled utility infrastructure is competing for that same shared consumer bandwidth. Further, coverage dark spots tend to appear at the limits of cellular connectivity, where coverage is either weak and highly unreliable or completely non-existent. This is usually in remote or rural environments with low population density, where the terrain makes the construction of private cellular infrastructure challenging and costly, or where the public cellular networks don't exist.

In situations where public cellular networks aren't readily available, one course of action distributors often take is a 'do nothing' approach. This means that, in areas without public cellular connectivity, maintenance crews and technicians have to be, for example, deployed to manually read meters or restore the functionality of locked out reclosers. In many instances still, utilities don't even know there is a power outage until their customers call to inform them.

As the utility sector relies more and more on the use of technology to improve its resilience and efficiency, a lack of available and reliable terrestrial communication is a barrier to enhancing capabilities and making the most of smart grid applications and solutions. This means that, whether it is smart meters or digital sensors and switches, the infrastructure advancements that now allow utilities to more efficiently deliver customers energy, improve customer engagement, and increase grid resiliency and monitoring cannot be optimised, whilst in some remote areas they are simply not possible.

CHANGING THE SATELLITE PERCEPTION

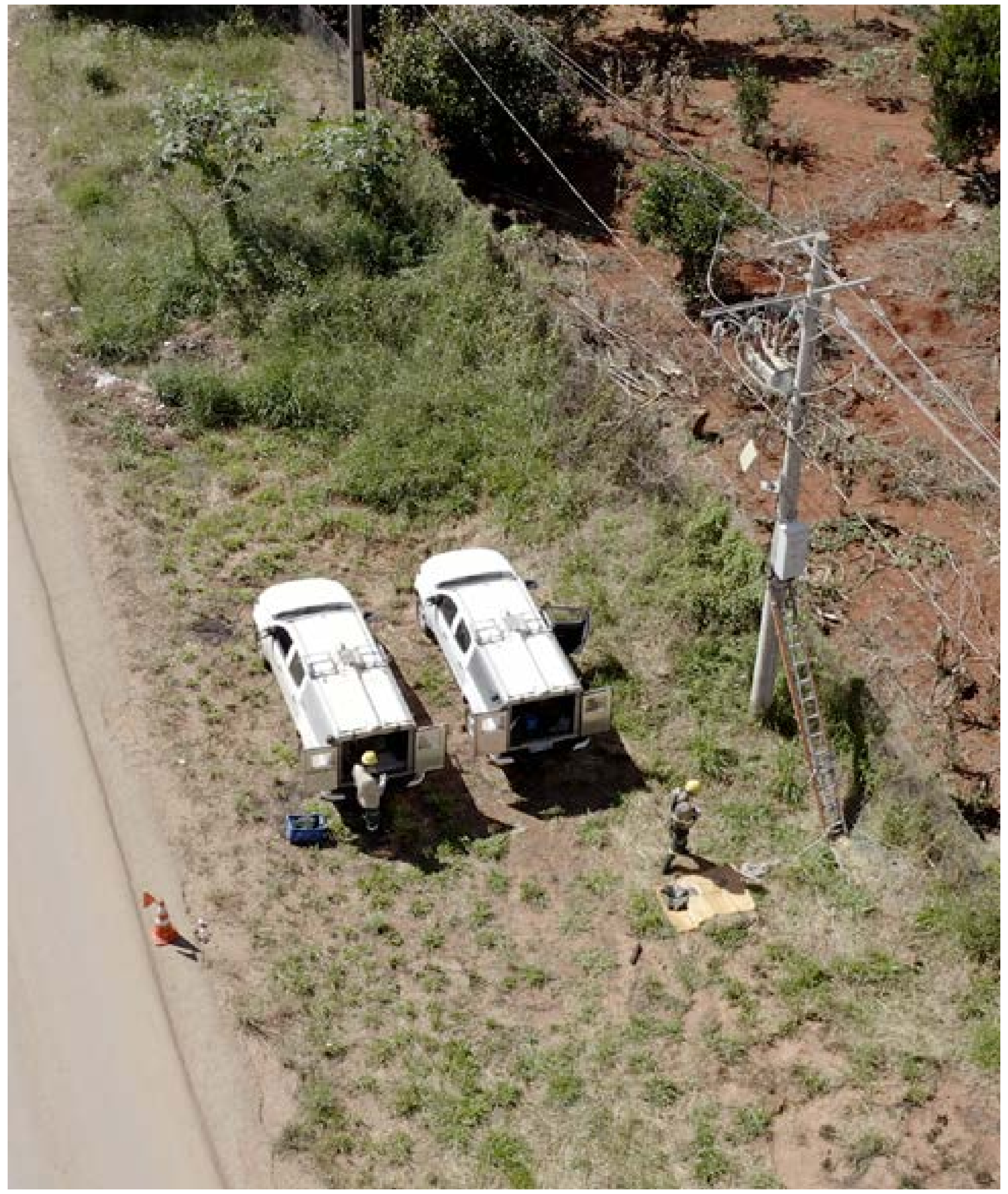


With this in mind, there is a key role for satellite networks to play in providing the cost-effective, ubiquitous connectivity needed for a range of smart grid applications, ensuring that data from applications out in the field is both reliable and continually available.

In the past, there has been a perception that satellite communications are an expensive and restrictive communications solution, requiring large, power-hungry terminals that don't integrate well with other, sector-specific, smart applications.

However, the technology behind satellite networks has advanced considerably in recent years. Nowadays, two-way communication systems, such as those providing IP services for M2M applications, are increasingly becoming common, particularly in rural areas that are poorly served by other communication technologies or as an independent backup connection.

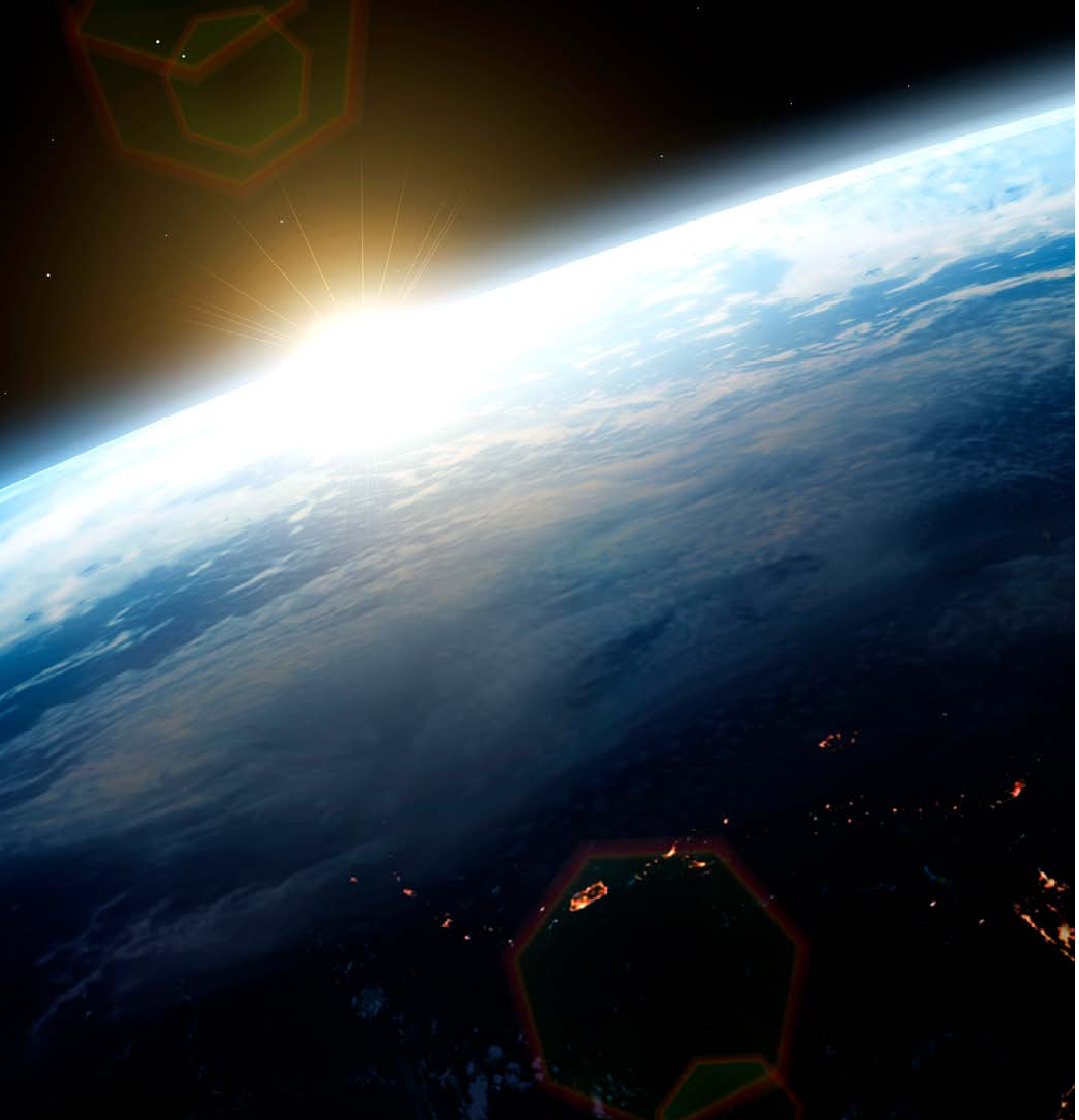
Consequently, today's satellite terminals are able to provide an easy to integrate, real-time, IP-based connectivity service, making them ideal for backhauling data from smart grid applications installed anywhere in the power grid, enabling utilities to have greater command and control across entire networks.



For example, deploying SCADA controlled centralised reclosers, which support the always on control that is needed to allow much greater visibility and control over a grid, is not possible in many remote areas where cellular connectivity is intermittent and not fit for purpose. By choosing satellite, utility companies can access a reliable and cost-effective option to remotely monitor and control reclosers in areas where terrestrial connectivity is unreliable, making it easier to reduce maintenance and site visits and keep downtime to a minimum.

Further, satellite is a more cost-effective connectivity option than people think. Robust terminals often have a lifespan of more than ten years, while the data cost is closer to cellular than you would expect. In summary, this means that total cost of ownership (TCO) over a satellite terminals lifetime is low – satellite simply isn't the big, scary and expensive connectivity service that has been previously thought.

Coupling this with the reduction of costs and the Quality of Service (QoS) requirements now expected by regulators and consumers, it is easy to see why utilities are increasingly choosing satellite communications for a whole range of different functions, whether it's to extend the reach of existing communication networks, ensure continuous, real-time and cost-effective visibility over their networks and enable greater command, control and monitoring capabilities.



CHOOSING THE RIGHT SATELLITE CONNECTIVITY PARTNER

However, it is important to point out here that not all satellite services are the same. Due to the unique nature of the requirements of the smart grid, understanding the differences and limitations of different satellite services is crucial

In particular, the adoption of VSAT satellite systems has increased in the sector over the past few years, but there are notable limitations to this approach. VSAT works with bulky terminals, which look like typical satellite dishes, making them an obvious target for theft or vandalism. They also rely on a high power draw which means they can cease working in the event of a power cut, with solar power often not an option. Furthermore VSAT is harder to install and to point at satellites, meaning they often lose connection if wind or other environmental factors move the terminal.

This not only impacts the continuity of service, but also means trained technicians, accompanied by a member of the utilities provider, often need to be redeployed to re-point the terminal, which adds significant costs to an operation.

So, while the VSAT service may be cheaper in terms of ongoing airtime cost when compared to other satellite services, the terminals are not fit for purpose so the overall TCO is likely to be higher. In contrast, Inmarsat's BGAN M2M service is providing utility companies with the reliable and proven satellite connectivity needed to build tomorrow's smart grid. The BGAN M2M service operates on Inmarsat's L-band network, which was created for government and emergency applications and is as reliable as satellite gets. L-band is the ideal satellite network for enabling centralised recloser monitoring control in particular, as it provides up to 99.9% uptime even in the most extreme weather conditions, where other types of satellite services fail.

The BGAN M2M service features robust and compact terminals, 2/3 the size of a laptop, such as the Hughes BGAN 9502, which are easy to install and can withstand hostile environmental conditions with a lifespan up-to ten years or greater. With a low monthly data usage and long lifespan of the hardware, the total cost of ownership for the service is minimal compared to the cost of dispatching technicians to resolve issues and with all the benefit of achieving a higher continuity of service.

To illustrate how satellite communications can support a utility's daily operations and further extend the reach of smart grid applications, let's look at the role of BGAN M2M in a range of use cases that use sensing and monitoring devices and command and control technologies, which require two-way high-speed communications.

USE CASES FOR SATELLITE AND BGAN M2M CONNECTIVITY

CONNECTIVITY FOR ENERGY

CENTRALISED RECLOSER MONITORING AND CONTROL

Electricity providers are under pressure to consistently improve service quality and minimise outages as mandated by public procurement contracts. Circuit reclosers are considered an essential device to maintain maximum continuity of service, with their ability to sense and interrupt currents in the event of a fault. Decentralised reclosers operate in isolation and are programmed to trip and reset without the need for connectivity networks, while centralised reclosers are connected to a central control room and allow much greater visibility and control over a grid.

While providers often use a variety of both types, the problems with decentralised reclosers are they cannot be monitored or operated remotely, and once tripped they often transition to a lockout state, which means engineers need to travel to restore functionality, causing lengthy outages and costing the provider money. With many providers operating over wide and remote geographies, smart grid management using SCADA controlled centralised reclosers is increasingly desirable. The challenge, however, is twofold. Firstly, without connectivity, many companies are forced to use reclosers that work as part of a distributed or decentralised automation. Secondly, the challenge with centralised reclosers is getting connectivity that is reliable enough to support always on control, as in many remote areas cellular connectivity is intermittent and not fit for purpose.

Consequently, satellite provides the most reliable and cost-effective option to remotely monitor and control centralised reclosers in areas where terrestrial connectivity is unreliable. Inmarsat's BGAN M2M service is used on more than ten thousand reclosers around the world and has been trusted as the industry standard by electricity providers for over ten years.

The service also features robust and compact terminals such as the Hughes BGAN 9502 which are easy to install and can withstand hostile environmental conditions with a lifespan up-to or beyond ten years. With a low monthly data usage and long lifespan of the hardware, the total cost of ownership for the service is minimal compared to the cost of dispatching technicians to resolve issues and benefit of achieving a higher continuity of service.

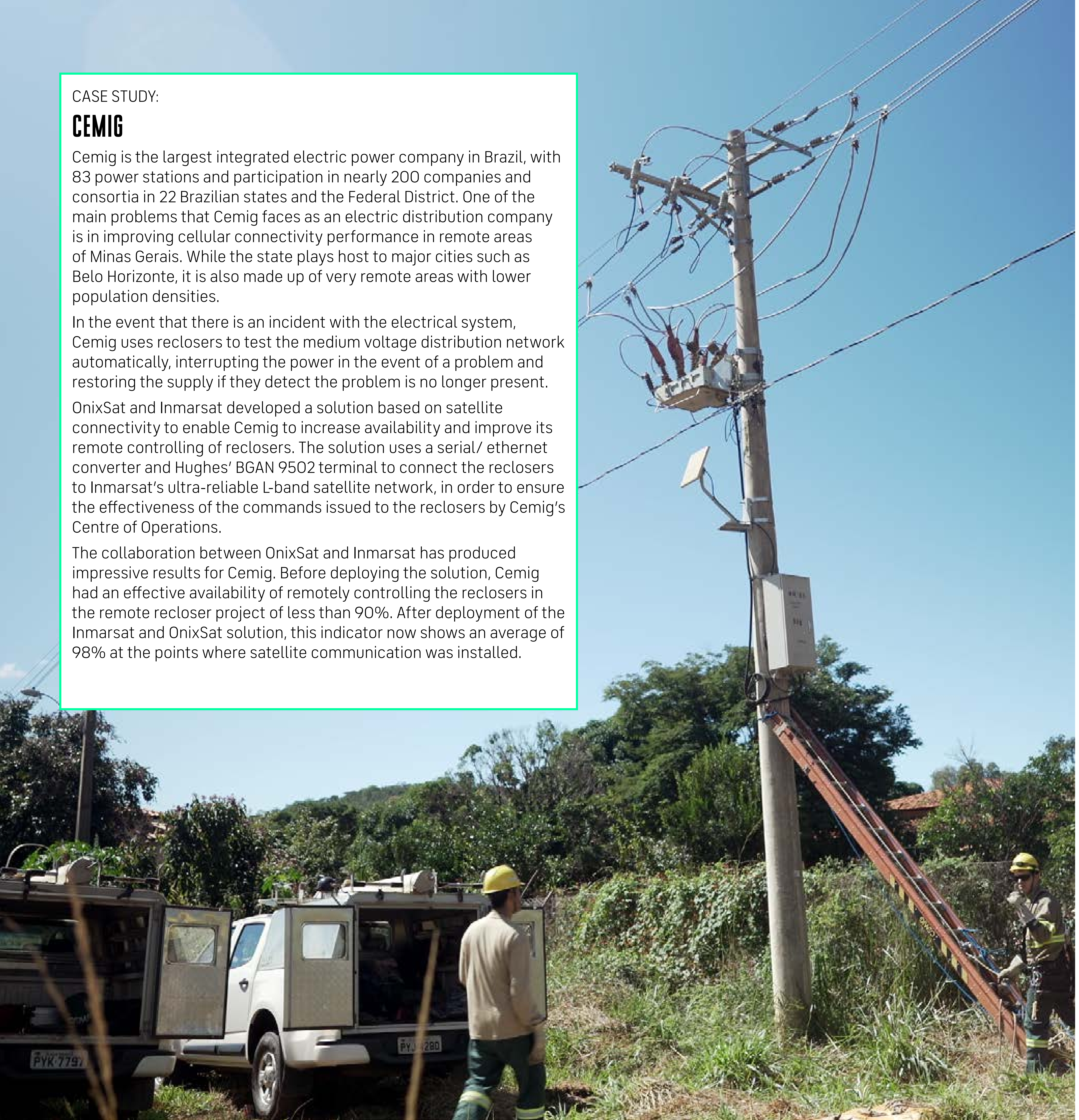
CASE STUDY:

ERGON ENERGY

Ergon Energy maintains and manages the regional electric distribution network across Queensland, Australia. They provide energy for more than 720,000 homes and businesses, covering 97% of the state of Queensland.

Ergon Energy have installed hundreds of reclosers throughout their network, with a significant number operating in the most isolated parts of the state, areas in which traditional connectivity methods, such as cellular and terrestrial, are limited or not available. Their requirements for remote connectivity were a single, ubiquitous, reliable network that was impervious to natural disasters and weather events, while providing a high level of security.

Inmarsat's BGAN M2M service met those requirements, providing a seamless, easy to integrate, real-time, IP-based connectivity service, to remotely monitor, control, and manage their recloser network. BGAN M2M provided the reliability, cost effectiveness, security and ease of use that Ergon Energy were looking for to automate and monitor their distribution network, and with the service expected to have an operational lifetime well into the 2020s, BGAN M2M will continue to serve efficiently and effectively for many years to come.



CASE STUDY:

CEMIG

Cemig is the largest integrated electric power company in Brazil, with 83 power stations and participation in nearly 200 companies and consortia in 22 Brazilian states and the Federal District. One of the main problems that Cemig faces as an electric distribution company is in improving cellular connectivity performance in remote areas of Minas Gerais. While the state plays host to major cities such as Belo Horizonte, it is also made up of very remote areas with lower population densities.

In the event that there is an incident with the electrical system, Cemig uses reclosers to test the medium voltage distribution network automatically, interrupting the power in the event of a problem and restoring the supply if they detect the problem is no longer present.

OnixSat and Inmarsat developed a solution based on satellite connectivity to enable Cemig to increase availability and improve its remote controlling of reclosers. The solution uses a serial/ ethernet converter and Hughes' BGAN 9502 terminal to connect the reclosers to Inmarsat's ultra-reliable L-band satellite network, in order to ensure the effectiveness of the commands issued to the reclosers by Cemig's Centre of Operations.

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.

ADVANCED METERING INFRASTRUCTURE (AMI)

Smarter power networks also require 'smart meters' to help consumers and businesses manage their energy consumption. In doing so, utility companies can gain access to consumption patterns, enabling them to implement tariffs based on time of use and real-time local demand. As they are located at end points on the grid, smart meters also provide utility companies with early warnings of power fluctuations, outages and fraudulent activity, as well as the ability to meet regulatory requirements to read meters on a regular basis.

These devices are a key element of AMI and typically sit within wireless mesh grids, collecting usage data from consumers and businesses in a limited geographical area, transmitting it back to the utility's data centre – usually via a cellular network.

However, cellular networks are not always ideal for data backhaul for several reasons, including limited range, restricted bandwidth and tendency to congestion, as well as vulnerability to natural disasters and extreme weather. There are also many geographic areas where cellular coverage does not reach, and maybe never will. This may lead to the 'do nothing' scenario outlined above, where technicians are deployed to manually collect data from meters in rural areas, adding further cost and inefficiency to an operation.

To remedy this, utility companies have experimented with, and then often abandoned VSAT-based satellite services for AMI backhaul. As mentioned previously, while these services may be cheaper in terms of ongoing airtime cost, they have significant limitations. On the one hand, VSAT terminals are bulky, making them obvious targets for thieves. On the other, they are also harder to install on pole tops and point at a satellite, making it difficult to retain a connection and increasing the likelihood of deploying a trained technician to re-point the terminal.

In contrast, BGAN M2M offers a high-quality, low-cost alternative to backhaul meter traffic from wireless collector points for AMI deployments, providing real-time, anytime access to meter data, while lowering the cost of manual collection in the previously unconnected areas. BGAN M2M provides ubiquitous, global coverage, and – as it is a secure network and does not traverse the open internet or other public networks – is not susceptible to public usage. Furthermore, advanced antenna design – such as on the compact Hughes 9502 terminal – allows for easier installation to accommodate mounting on pole tops. The compactness of the terminal also means that it is a less obvious target for theft, while it can also retain a connection to the network even when its direction has shifted up to 30 degrees, which may happen when there is extreme weather or seismic activity.

Ultimately, satellite communications can help extend AMI, down every dirt road, to every meter across a network, enabling real-time meter reads, as well as offering the tools for instant remote connect and disconnect. Further, by extending two-way communication to every meter, providers can also track outage restoration progress, as well as reduce any unnecessary dispatching of technicians to fix issues and outages.

SUBSTATION AUTOMATION

Substations are a critical component for maintaining electrical supply and load control in electrical distribution networks. In order to ensure the proper functioning of substations and connected equipment in the field, such as line-mounted switches, most utilities now use SCADA systems to automate monitoring and control.

For example, if the voltage level is outside of a normal range, grid managers and maintenance teams can fix the issue accordingly. The SCADA system, therefore, allows substation engineers to visualise everything within the network in real-time, such as where a failure occurs, as well as providing monitoring and control both in data networking and acquisition. This live monitoring capability also avoids the need for maintenance crews having to manually find problems with equipment in the field, saving costs and keeping downtime to a minimum.

However, being connected to a substation and retrieving vital information has always been a challenge. Not all the substations are of the same size or importance, while some are in remote areas where public cellular networks are non-existent.

While substation sites in urban and suburban markets can be mostly connected to the grid via existing terrestrial communications networks, in order to create a fully-automated, reliable grid, rural and remote sites must also be accommodated and backup systems need to be in place for critical sites. This is where satellite connectivity can ensure remote substations stay connected. Satellite can also act as backup communications at any substation, which would automatically take over when the primary link fails.

Another key area where satellite can support in a substation setting is enabling security camera monitoring. Using satellite to enable movement triggered streaming means control centres can get a real time view of the security situation at key substations, alerting them of potential arson attacks or weather events. With innovative technologies like Digigone compressing and decompressing video so that the data sent is optimised for satellite, this can be an inexpensive and valuable use case.

CONCLUSION

It is no longer acceptable for utilities providers to have smart grid capabilities in urban and densely populated areas, while neglecting remote areas. The modern smart grid is now spreading across geographies and into the worlds remotest areas, which in turn requires a flexible, stable, resilient and secure communication backbone to underpin it.

Advancements in satellite communications can enable electricity companies to overcome these new challenges, while enjoying the benefits of reliability, ease of deployment, and network reach. Whether it is providing centralised recloser automation or AMI backhaul, satellite-based solutions provide the most cost-effective and reliable communications solution in a number of key smart grid areas.

This also places satellite at the forefront of the next wave of development in smart grid applications and technologies. From supporting the integration of smart grids into smart cities, to providing the infrastructure needed to enable the efficient use of this new generation of Plug-in electric vehicles (PEVs), the global reach and reliability that satellite communications offers makes it a key component in building tomorrow's smart grid.

WHAT NEXT?

For more information, please contact:
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Since 1989, Network Innovations (NI) has grown to be a global leader in connecting people, places, and things with always available solutions. Network Innovations headquarters from Calgary, Canada with regional offices in Tampa/Fort Lauderdale/Houston/San Diego/ Seattle/Kodiak/Dutch Harbor-USA, the Netherlands, /Sweden-EU, England-UK, Singapore & Australia
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