

Private 5G: The smart network for the smart grid

Connecting assets, people and system
across the grid with mission-critical
wireless connectivity



Druid

Contents

Executive Summary	2
Introduction	2
Why Private 5G, and Why Now	2
Powering Generation with Private 5G	3
Securing the Transmission Network with Private 5G	4
Optimizing Distribution with Private 5G	6
What Makes Private 5G Different: Core Capabilities for Utility Operations	7
Private 5G Reference Architecture: Designed for Autonomy, Built for Scale	10
How it works: Private 5G Reference Architecture	10
Conclusion: A Smarter Grid Needs a Smarter Network	12
Solutions offered by Druid Software	12

Executive Summary

Utilities don't have the luxury of delay. When a storm knocks out power or a substation goes silent, response time isn't just measured in minutes - it's measured in consequences.

In these high-stakes moments, the ability to see what's happening across the grid, send instructions to the edge, and coordinate field teams in real time becomes non-negotiable. That's where Private 5G enters the picture not as another wireless option, but as a mission-critical foundation for modern utility operations.

Across generation, transmission, and distribution, Utilities are becoming more connected, more dynamic, and more reliant on data. Millions of devices, from reclosers and sensors to AR headsets and smart meters, need secure, low-latency communication. And they need it everywhere, even where fibre doesn't reach or public networks can't be trusted.

This white paper walks through how Private 5G is changing the way Utilities manage their networks - from real-time fault detection and predictive maintenance to secure field communications and autonomous grid operations. It also outlines the specific capabilities that make Private 5G not just a fit, but the future.

Introduction

Why Private 5G, and Why Now

Let's be clear: not every utility application needs 5G. But when it comes to real-time grid operations, SCADA responsiveness, edge computing, and field coordination, nothing else delivers the same combination of speed, security, and scalability.

Operating on licensed or dedicated spectrum, Private 5G supports high-availability configurations, and prioritizes utility-grade traffic using network slicing and QoS policies. It's powering substations in rural areas, connecting mobile crews over wide geographies, and enabling predictive maintenance across generation fleets.

At the same time, Utilities are under pressure to move beyond compliance. In addition to meeting standards for reliability, safety, and cybersecurity, they must integrate renewables, reduce emissions, and optimise performance to manage costs.

While Wi-Fi, public LTE, and fibre each serve useful roles, only Private 5G combines the performance, flexibility, and control required for real-time, grid-wide operations. Built on 3GPP standards, it delivers ultra-low latency and high-capacity connectivity with the added benefit of network redundancy and built-in resilience. This makes it ideal for maintaining reliable, secure communications across geographically dispersed infrastructure especially in environments where uptime and safety are non-negotiable.

The table in figure 1 compares Private 5G with alternative network technologies, highlighting their strengths and the roles they're best suited to play across utility operations.

Technology	Latency	Reliability	Mobility	Security	Edge Support	Best For
Private 5G	Ultra-Low	Very High	High	High	Yes (MEC)	Critical applications & Real-Time Monitoring
Wi-Fi	Moderate	Medium	Low	Low	Limited	Indoor, non-critical data
Public LTE/4G	Moderate	High	High	Medium	Partial	General field communications
Fibre	Very Low	Very High	None	High	No	Fixed infrastructure, network backbone.

Figure 1 - Technology Comparison Table for Electrical Utility Communications Needs

The following sections break down how this technology is being applied today starting with how it's making electricity generation safer, smarter, and more self-sufficient.

Powering Generation with Private 5G

Modern power generation sites, whether wind, solar, or thermal, are increasingly remote, complex, and highly distributed. Operators need to monitor performance, prevent faults, and keep personnel safe across a mix of automated systems and aging infrastructure. But most importantly, they need to do all of this in real time. This is where Private 5G makes a measurable impact. By enabling secure, ultra-low-latency wireless communication, it becomes the digital nervous system of generation operations.

Need to inspect a turbine after a storm? Private 5G gives autonomous drones the bandwidth and responsiveness to stream video and thermal data live to engineers onshore. AI enabled applications at the edge analyses these feeds, detecting microfractures or ice buildup before they become mechanical failures. Maintenance teams are dispatched only when there's confirmed issue cutting costs and increasing safety.

At the generation site, smart IoT sensors, controllers, and 5G-connected cameras monitor and stream real-time data, such as vibration, pressure, thermal output to perform predictive maintenance, eliminating unnecessary site visits, and help extend asset life while ensuring continuous uptime.

Private 5G also supports ISO 50001¹ energy management frameworks. With real-time insight into power usage, load balancing, and equipment efficiency, generation sites can operate more sustainably & efficiently.

Whether its automated inspections or optimized efficiency, Private 5G gives Utilities the reliable, secure, and intelligent network layer needed to modernize generation at scale.

¹ ISO 50001 standard page: <https://www.iso.org/iso-50001-energy-management.html>

Scenario

Remote Wind Farm

On a remote wind farm off the west coast of Ireland, powerful Atlantic gusts feed energy into giant turbines—but with that power comes risk. Maintenance crews used to travel hours by boat to inspect turbine blades after every storm.

Now, 5G-connected drones autonomously fly out after each weather event, capturing high-resolution video and thermal imagery in real-time. These images are analysed at the network edge using AI to detect microfractures or ice buildup that could cause mechanical failure. Maintenance crews are only dispatched if and when there's an actionable issue, cutting costs and improving crew safety.

And inside the turbines? 5G sensors feed vibration and torque data directly to a centralized dashboard. Anomalies are flagged instantly, preventing a catastrophic failure weeks before it would have happened.



Securing the Transmission Network with Private 5G

When a fault hits the transmission grid, milliseconds matter. Utilities can't afford to wait for public network congestion to clear or for polling cycles to catch up. Transmission networks require constant awareness and the ability to act on that awareness immediately whether isolating faults, rebalancing loads, or guiding field teams to critical infrastructure. Private 5G gives Utilities that real-time control.

With ultra-reliable, low-latency communication and edge intelligence, Private 5G enables a faster, smarter, and more secure transmission network. Here's how:

Real-Time SCADA and Fault Isolation



Supervisory Control and Data Acquisition (SCADA) systems depend on immediate, deterministic communication. Private 5G ensures low-latency, high-availability links between substations, sensors, and control centres - so Utilities can detect faults and act on them before they cascade across the grid.

AR-Enabled Field Response



Transmission crews equipped with AR headsets can receive real-time diagnostics and guided repair instructions, even in remote areas. Private 5G delivers the bandwidth and responsiveness needed to stream video, overlay schematics, and support live collaboration with engineers back at HQ.

Grid Balancing at the Edge



Through 5G-connected IoT devices and edge-hosted AI, Utilities can monitor load flow and adjust transmission strategies dynamically. Private 5G allows these systems to operate independently of the cloud, ensuring resilience and speed especially during outages or backhaul disruptions.

Whether it's a high-voltage corridor through the mountains or a substation on the urban fringe, Private 5G provides the secure, responsive communications layer needed to make the transmission network smarter and more self-healing.

Scenario



Rural Transmission Line

A lightning strike hits a rural high-voltage transmission line in Florida. Normally, grid operators might notice a fluctuation — after it's cascaded across the network. But not today.

Thanks to 5G-connected Phasor Measurement Units (PMUs) installed across the grid, the event is detected in less than a second. These sensors send synchronized measurements back to the control centre via ultra-reliable low latency communication (URLLC).

The control system, running at the edge, auto-triggers a reroute protocol, redistributing load across healthy lines and isolating the affected section. Engineers, equipped with 5G-enabled AR headsets, arrive onsite guided by live diagnostics and GPS-tagged fault points, eliminating the usual trial-and-error search. Power stays up. Customers never notice. That's the power of self-healing grid technology powered by 5G.



Optimizing Distribution with Private 5G

The distribution network is where the grid meets the customer and where complexity has surged. Distributed energy resources, smart meters, and growing electrification demand real-time insight and control at the edge. At the same time, crews need seamless coordination to detect, diagnose, and resolve issues quickly.

Private 5G provides the foundational infrastructure to meet these needs head-on.

With secure, high-capacity connectivity across substations, poles, transformers, and homes, Private 5G gives Utilities complete visibility into the low-voltage network and enables real-time responsiveness across devices and teams.

Here's how it's transforming distribution:

End-to-End Grid Awareness



Smart meters and sensors connected over Private 5G stream live consumption, voltage, and fault data back to the control centre. Utilities gain real-time visibility into grid performance across neighbourhoods, businesses, and critical infrastructure allowing faster fault isolation and more precise demand response.

Scalable IoT Connectivity



With the ability to support thousands of devices per cell, Private 5G makes it possible to scale smart metering, remote monitoring, and automated control across an entire service territory. And because it's a private network, Utilities can manage bandwidth, quality of service, and security without interference from public traffic.

Crew Coordination with Mission-Critical Comms



Field teams stay connected with high-definition video, push-to-talk voice, and real-time location tracking. All on a single device, over a single network. Whether they're troubleshooting a transformer or restoring power after a storm, crews have the information and support they need without depending on congested public networks.

Support for DER Integration and Load Flexibility



As homes and businesses begin exporting power back to the grid, Private 5G enables Utilities to manage bidirectional flow, balance localized generation, and protect equipment from overloads. This creates a smarter, more flexible grid which is built for the realities of modern demand.

From smart suburbs to rural substations, Private 5G helps Utilities deliver a more agile, efficient, and customer-centric distribution network.

Scenario

Rooftop Solar

In a leafy Paris suburb, 300 homes have installed rooftop solar, and the local distribution grid is now more dynamic than ever. Energy is being produced, consumed, and sometimes even sent back to the grid.

The local utility deploys a private 5G network that connects every smart meter, transformer, and low-voltage line sensor. As demand spikes on a cold evening, AI at the network edge balances input from battery storage in EVs, home solar panels, and the main grid.

One home's meter flags an anomaly — possibly tampering. The system sends a silent alert to the compliance team. Meanwhile, the homeowner next door gets a real-time alert that their power usage is unusually high, likely due to a faulty appliance.

Result: More efficient load balancing, less energy waste, faster fault detection, and a grid that's as smart as the homes it serves.



What Makes Private 5G Different: Core Capabilities for Utility Operations

In utility environments, connectivity isn't about convenience but about control. Private 5G isn't just another wireless option; it's an architecture designed to handle the realities of critical infrastructure. From substations to service vehicles, it delivers predictable performance, enterprise-grade security, and the flexibility to scale with evolving grid needs.

Private 5G networks built on 3GPP standards offer more than just compatibility — they provide long term reliability, security, and control that align with the operational and regulatory needs of utility environments. Besides consistent performance of all 3GPP-compliant devices across various vendors and firmware versions including wide choice of UEs, Utilities can plan an upgrade of their networks from 4G to 5G in stages while maintaining service continuity and network interoperability.

Unlike Wi-Fi networks, which always operate in an ISM band², 3GPP private networks use dedicated frequencies reserved for mobile operators, private mobile networks, and PPDR (Public Protection and Disaster Relief) agencies and are therefore free from interference generated by consumer products & secure by design.

² ISM bands, in the context of radio frequencies, stands for Industrial, Scientific, and Medical bands. These are specific portions of the radio frequency spectrum that are reserved for use by devices in those three categories, often without requiring a specific license.

In addition, private 5G puts Utilities in charge of their network – and their data. With centralized policy enforcement, SIM-based authentication, and on-premises control, it offers a level of security and predictability that public networks simply can't match.

Here's how it's built to perform when it matters most:

High Availability

Downtime is not an option when you're operating critical infrastructure. Private 5G networks are designed with high availability in mind using redundant core components, overlapping radio cells, and automated failover. Even during link loss or hardware failure, communications stay up and grid operations continue uninterrupted.

Autonomy from Public Networks

Private 5G gives Utilities complete independence from public mobile networks, which are prone to congestion and outages especially during weather events or emergencies. By owning the network end-to-end, Utilities maintain full visibility, control, and uptime even in moments when public connectivity disappears.

4G/5G Technologies Built for Utility Demands

Unlike Wi-Fi or other general-purpose wireless tech, private 4G/5G networks are built for high-demand industrial environments. They support:

- Native voice and video
- SIM-based authentication
- Quality of Service (QoS) controls
- High throughput across large service areas
- Real -Time Location management to monitor the movement of assets and crews in real time

These capabilities improve response times, coordination, and overall operational safety making them ideal for mobile command centres, AR field support, and remote diagnostics.

Ultra-Reliable Low-Latency Communication (URLLC)

Applications like SCADA control and fault isolation rely on sub-second responsiveness. Private 5G delivers sub-10ms latency links, allowing utilities to execute critical commands with the precision and speed required to maintain grid stability.

Support for 5G RedCap IoT Devices

Utilities operate thousands of smart meters, sensors, and control points that don't require full 5G throughput. Designed to support connectivity for large numbers of low-cost devices, 5G RedCap (Reduced Capability) enables the mMTC (massive Machine Type Communications) allowing Utilities to scale & expand grid intelligence without overbuilding the network or compromising on reliability. RedCap (Reduced Capability) devices offer a cost-effective solution supporting:

- Battery-efficient performance enabling long-term field operation
- High device density per cell, essential for dense metering and sensor deployments
- Maintain reliable connectivity in remote or shielded environments

5GLAN: Wireless Ethernet for Legacy Systems

With 5GLAN, Utilities can integrate Ethernet-based systems like relays, PLCs, and SCADA controllers directly into their 5G infrastructure—without changing protocols or ripping out old equipment. This ensures that legacy devices, such as transformers and circuit breakers can connect directly and efficiently to the 5G network, facilitating a smooth transition and interoperability. It enables smoother transitions to modern architectures.

Multicast and Broadcast Messaging (5GMBS)

When an alert needs to go to every crew in the field or every substation in a region, 5G Multicast and Broadcast Services (5GMBS) ensure it gets there fast and efficiently without overloading the network. This capability is ideal for critical safety alerts, situational awareness updates, real-time video distribution, and coordinated outage response during emergencies. Whether it's sharing evacuation instructions or streaming live drone footage from a fault site, 5GMBS allows Utilities to communicate at scale clearly, securely, and in real time.

Private 5G Reference Architecture: Designed for Autonomy, Built for Scale

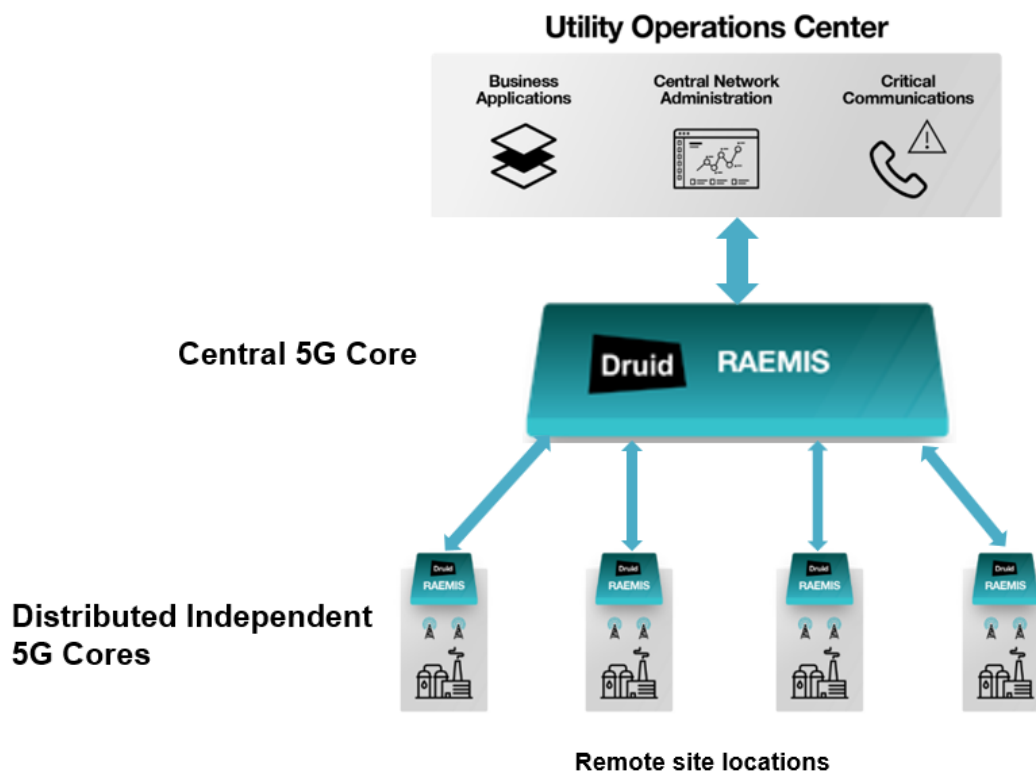
A modern utility network doesn't pause for connectivity issues or operate in one place - it spans cities, regions, and rural landscapes. That's why Private 5G isn't just another connectivity solution, it's a foundational layer for modern grid operations. One that gives Utilities the flexibility to centralize management, while empowering each remote site with the tools to operate independently when needed.

Druid Software has worked with many customers around the world to develop a reference architecture for Private 5G networks. Engineered for optimal functionality, efficiency and security, Druid's Private 5G architecture is purpose-built for Utilities: resilient at the edge, intelligent at the core, and designed to keep the grid online, no matter what.

How it works: Private 5G Reference Architecture

Centralized Intelligence, Distributed Control

At the heart of the network is a central 5G core hosting overall network management, orchestration and analytics applications, with distributed fully functional, self-contained 5G cores at each critical remote location. Both central and distributed remote cores are built on Druid's Raemis™ platform.



The central 5G core brings everything together from coordinating policy, provisioning and subscriber management to hosting advanced AI/ML analytics capabilities that support

nationwide grid optimization. It also connects to public cloud services and disaster coordination centres and manages roaming with commercial mobile networks.

Feature	Enabled During Backhaul Outage	Enabled During Power Disruption (with backup)
Local SCADA/Telemetry over 5G	✓	✓
AI-Based fault detection at the edge	✓	✓
Worker Push-To-Talk, alerts, location tracking	✓	✓
Local policy enforcement (QoS, Slicing)	✓	✓
Central analytics, system wide machine learning	✗	✓

Each remote 5G core operates under zero-trust principles. Sensitive data is processed locally and only transmitted to central systems if explicitly required supporting GDPR, NIS2, and regional data protection laws.

This architecture ensures that even in worst-case scenarios natural disasters, cyberattacks, or fibre cuts remote utility sites continue functioning, safely and securely.

Conclusion: A Smarter Grid Needs a Smarter Network

The modern utility is no longer just a power provider. It's a data-driven, digitally coordinated infrastructure operator balancing distributed energy, integrating smart devices, and responding to real-time demands across an increasingly complex grid.

In that world, communications network is no longer a supporting service but a strategic asset.

Private 5G brings the reliability, control, and scalability that Utilities need to operate with confidence, even under pressure. From autonomous substations to AI-assisted maintenance and secure crew coordination, it enables the kind of grid that anticipates, adapts, and endures.

Druid's Private 5G architecture is designed specifically for modern Utilities reality. It combines a central 5G core for orchestration and analytics with fully autonomous, distributed cores at remote generation, transmission, and distribution sites. This architecture ensures operational continuity during backhaul outages, supports edge-based applications with ultra-low latency, and meets regulatory requirements for reliability and resilience.

Whether it's about modernizing a transmission site, digitizing field operations, or preparing for tomorrow's grid challenges, Private 5G delivers the foundation Utilities can build on, operate smarter and stay in control.

Solutions offered by Druid Software

With over 5,000 deployments globally, Druid Software is the global leader in providing specialized core network software. Raemis™, Druid's cellular technology platform, is extensively deployed to implement private core, public core and neutral host solutions. Raemis™ delivers dedicated, resilient, secure wireless infrastructure for the exclusive use of Utilities around the world. In addition to current deployments at utilities, applications of Raemis™ include mobile edge computing, fixed wireless access, Industry 4.0 and public safety environments.

Raemis™ supports 5G, 4G, 3G and 2G technologies on a single platform. We also provide customization and technical consultancy services. Our solutions are delivered via a global network of value-added resellers, systems integrators, and other partners.

For more information, email enquiries@druidsoftware.com or please visit www.druidsoftware.com. To stay up to date with everything private networks follow us on [X](#), [LinkedIn](#) and [YouTube](#).

The logo for Druid Software, featuring the word "Druid" in white, bold, sans-serif font inside a black, trapezoidal shape that tapers to the right.

About Druid Software

Druid Software, founded in 2000 and headquartered in Ireland, is the industry-leader in private mobile network technology, and provides an enterprise-focused core network platform to enhance connectivity and enable simplified private network management.

Druid's technology is extensively deployed around the world to deliver dedicated, resilient, secure wireless infrastructure for the exclusive use of utilities and energy providers.

Our private 5G and 4G solutions implement high-quality networks that connect applications to devices, and provide voice, messaging and high-speed data services to field engineers and other utilities personnel.

For more information, email enquiries@druidsoftware.com or visit www.druidsoftware.com.

