WHITE PAPER

Guide to Wireless Communication in Smart Grid Deployments

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Executive Summary

A smart grid is a modernized electrical grid that uses automated digital communications technology to gather and act on real-time data about the behaviors of suppliers and consumers, in order to maximize the throughput of the system and improve overall energy efficiency. The monitoring, analysis and control capabilities that come with a modernized grid ultimately improve the reliability, economics and overall sustainability of the production and distribution of electricity.

Originally, the electric power grid was a centralized unidirectional system, but in the 20th century, local grids grew and were eventually interconnected to boost efficiency and reliability and establish load balances between different generation plants and consumers, and also between countries.

The electric grids of developed countries have now become very large, mature and highly interconnected, with hundreds of central power generation stations delivering power to major load centers via high capacity power lines. These power lines are branched and divided to provide power to smaller industrial and domestic users over the entire supply area, making the entire electricity distribution process more powerful, economical and efficient.

To employ reliable communications networks in densely populated areas with high amounts of distribution lines in mesh topologies, wireless technologies are the most suitable communication technology. This paper will address the key considerations and challenges around implementing wireless technology in smart grid deployments.

Brief History of the Smart Grid

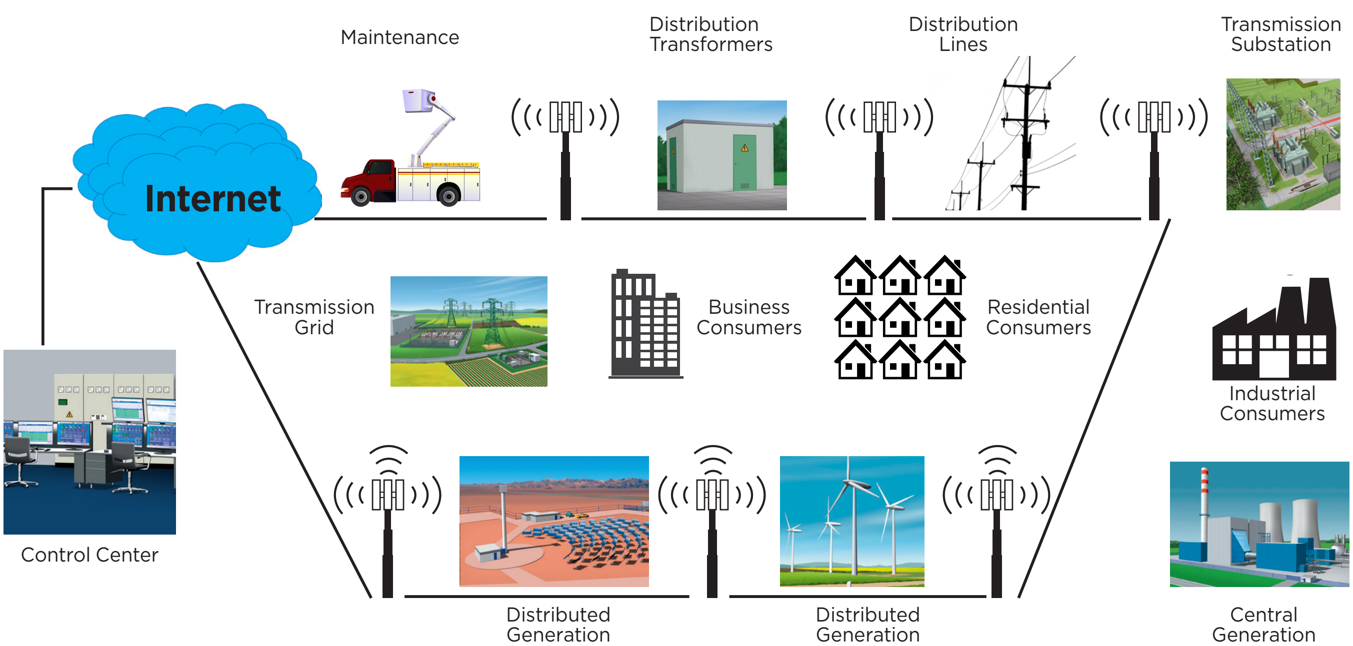
The earlier attempts in the 1980s to introduce electronic control, monitoring and metering, and the technological innovations of the 1990s – digital control systems, graphical interfaces and software – were the seeds of the current smart grid. These developments made two-way communication implementation in the electrical grid possible.

The inclusion of different distributed power generation sources, mainly renewables and storage devices like electrical vehicles (EV) or batteries, created a change in the paradigm of the electrical grid. In the past, there were hundreds of centralized generation sources and one-way distribution networks, but with this shift, thousands of distributed generation sources and bi-directional networks were possible, increasing the complexity of the electricity distribution process.

Real time communications, bi-directional transformers and sound network topology transformed consumers into prosumers, with the ability to act as a consumer at certain hours of the day and an electricity supplier during other hours. For example, consumers could now store energy at night within batteries and support energy consumption at peak demand times in the morning. This type of network communication already existed in the HV substations and in most of the MV substations; the challenge of the smart grid is to bring this communication to the distribution grid and from the LV transformers to house meters.

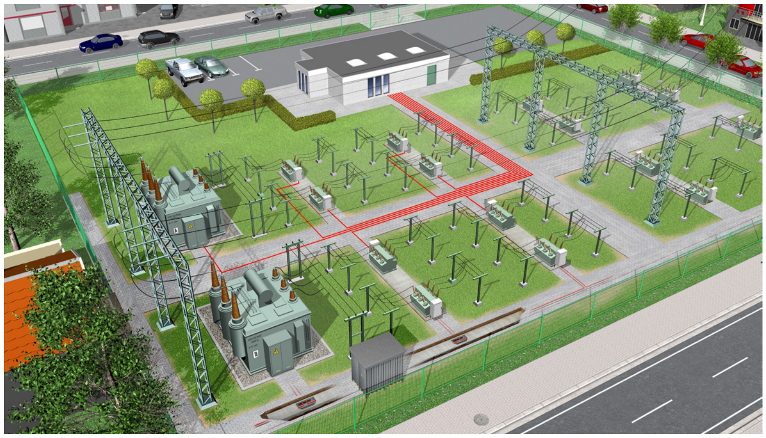
Advanced communications are essential for enabling modern grid applications, such as grid visualization, real-time load monitoring, automated demand response, advanced protection, asset monitoring, smart metering and consumer load control. What are the combined communication requirements of the modern grid?

- **Bandwidth:** Each single device needs a stable bandwidth to allow for services planning; the bandwidth needs to be the same for all the devices.
- **Latency:** Time delay in the communication needs to be known and tied. Time critical applications in electric utilities are direct in fiber, so latency shouldn't be a big challenge in smart grid applications.
- **Security:** Any communication network needs to provide mechanisms to prevent and monitor unauthorized access, misuse, modification, or denial of access to both data and physical assets.
- **Reliability:** Dependability, or reliability, describes the ability of a system or component to function under stated conditions for a specified period of time or at a specified moment or interval of time.



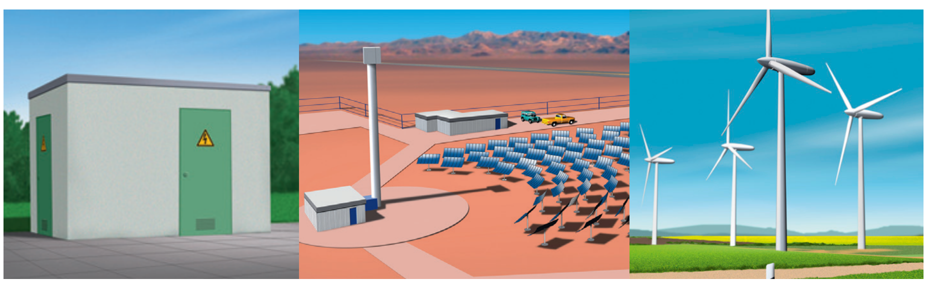
Smart Grids allow real-time information exchange between all the stakeholders in the electricity chain

HV Substation: EAGLE LTE



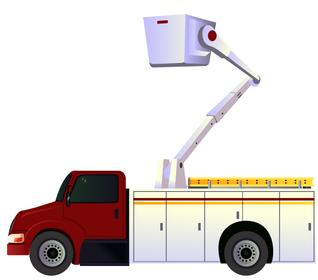
- Compact 6 Ethernet Port LTE router
- Integrated firewall
- Two SIMS for network redundancy
- IEC61850 certified
- Two serial ports
- Two Gigabit Ethernet SFP
- Built-in GPS for geospatial localization

Secondary Substation and Distributed Generation: OWL LTE



- Compact 2 Ethernet port LTE router
- Integrated firewall
- Two SIMS for network redundancy
- One serial port
- Built-in GPS for geospatial localization

Maintenance Vehicles: OWL LTE-T

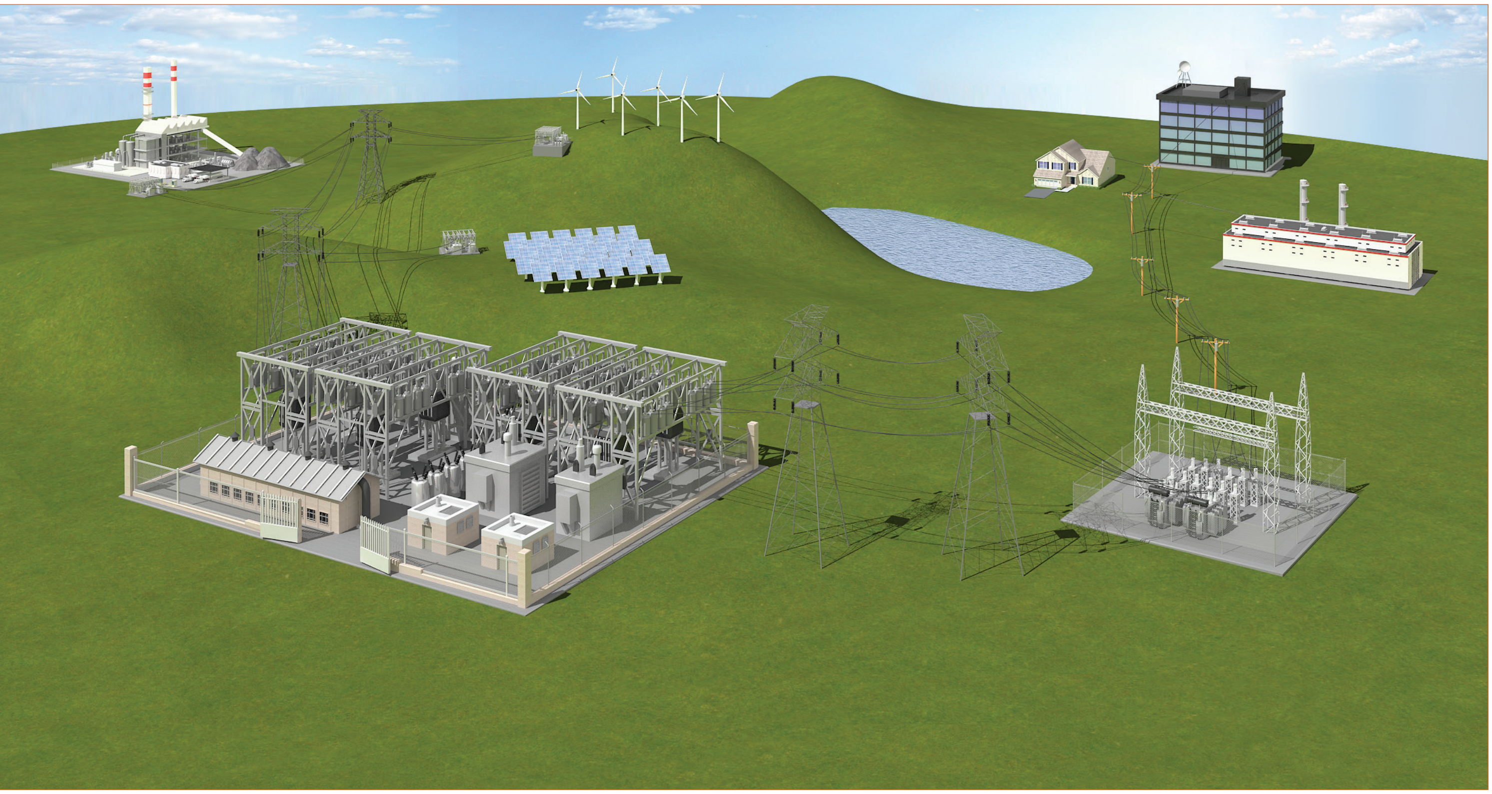


- Compact 2 Ethernet port LTE router
- Integrated firewall
- Two SIMS for network redundancy
- One serial port
- Built-in GPS for geospatial localization
- High vibration-proof M12 connectors

Critical Features for Successful Wireless Connections*

	Cellular 3G/LTE	SCADA & Point to Multipoint Radio	MESH	Comments about cellular technology
Initial Investment	●●●●	●	●	With cellular technology, the initial investment is very minimal as the infrastructure is already in place to allow a single remote connection.
Reliability	●●●	●	●●●	The use of double SIM cellular routers allows a user to connect to different base stations from different network operators.
Bandwidth	●●	●●	●●	Each single device has a direct connection to the base station and the backbone; the available bandwidth is the same for all devices.
Latency	●	●●	●●	Wide area, time critical applications in electric utilities are direct in fiber, so latency is not a limitation for smart grid applications.
Scalability	●●●●	●●	●●	From the first device you have the full network services at your disposal. The increase of the amount of subscribers does not represent a problem in the architecture and doesn't imply topology changes.
QoS	●	●●	●●	Over cellular networks the quality of services (QoS) is managed by the service provider.
Coverage	●●●●	●●	●●	Electric distribution networks are located in populated areas with good coverage, so it doesn't make sense to deploy a new infrastructure.
Mobility	●●●●	●	●●●	Mobility is allowed through dynamic and autiomatic registration to the base stations. Hand over between base stations is possible at high speeds.
Security	●●●	●●●	●●●	The service provider is already delivering security at the internet backbone and at the base station level. Cellular routers also provide security features like encryption, firewall and tunnelling.
Standards-based	●●●●	●	●	Strong, clear and adheres to industry standards. Multivendor and future compatibility is assured.

*Table created and contributed by German Fernandez



Advantages of Cellular Wireless Communications over Public Networks

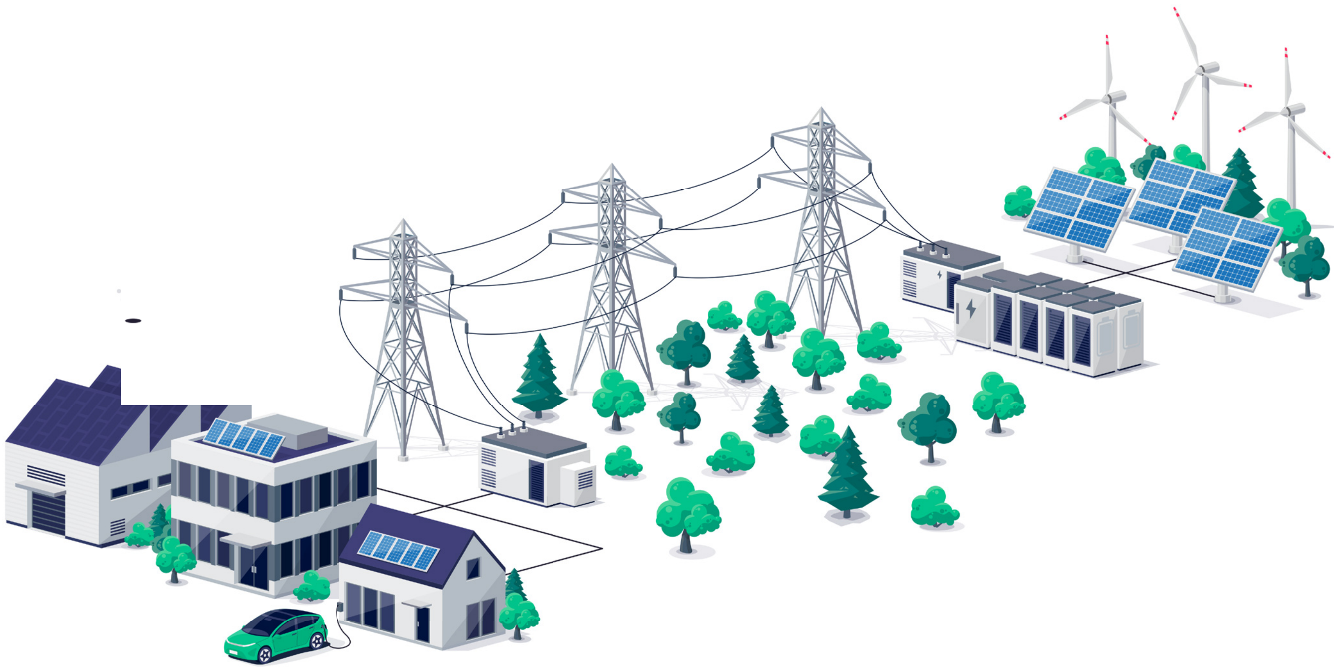
Using cellular over public networks combines the benefits of high penetration frequencies with the already available backbone from the telecom utilities connected to the Internet. High speed data access over cellular communications is a new choice for reaching local assets in remote utility facilities and third party installations.

The cellular technology is used to transfer data in a secure and reliable way and provide connectivity over a public network to utility substations, energy generation locations, utility offices and secondary transformation centers.

This 4G technology is ideal for smart grids, as it allows for the two-way communication, remote monitoring and control of the grid, quick and easy installation and broadband speeds. With 4G, utilities can remotely locate, isolate and restore power outages, thereby increasing the stability of the grids. The multiple megabits supported by 4G significantly outpace the bandwidth supported by outdoor WiFi, digital cellular or proprietary solutions, giving grid operators an ability to not only address the primary meter communications requirements of the network, but also to leverage a common platform for real property management, mobile workforce connectivity (including VoIP support) and CCTV camera security backhaul.

There are a number of advantages for using wireless communications networks in smart grid deployments, including:

- **Access:** Gain access to information, anytime, anywhere
- **Mobility:** Mobile workforce connected to company intranet or to systems with no cables
- **Interoperability:** Countrywide networks via different mobile operators allow redundancy and backup systems
- **Reduced cost and complexity of network deployments:** No fixed infrastructure deployment needed, uses existing infrastructure and the air
- **Availability of technologies with different characteristics from which to choose:** Short range WiFi or ZigBee, city range via cellular 3G or 4G-WiMax or Radio, long range via radio-microwave or operator's backbone



With these advantages come a variety of questions to consider, including:

- Which technology do we choose for our specific application? What characteristics do we look for?
- What implications does this wireless technology have for the specific environment?
- Are there any deployment or interference issues?
- Are there scalability issues?
- Would using a public network compromise the security or redundancy of the network?

Choosing the right wireless solution

Network engineers need a complete solution for smart grid applications, from the cables, connectors, patch cords and patch panels, to a broad portfolio of wireline and wireless switches, routers and firewalls for harsh environments. What should engineers look for when choosing the right wireless solution?

- Compact Ethernet port LTE router for unlimited network connectivity
- Integrated firewall for maximum perimeter protection of the network
- Dual SIMS for network redundancy to ensure connectivity availability in case of network failure
- GPS for geospatial localization allows engineers to check the connection status of each device and ensure network security and availability

A few solutions for effective cellular communications include:

Conclusion

Data networks for smart grid applications need to operate reliably in harsh environments and withstand high electromagnetic interferences (EMI), large temperature variations, shocks, vibrations and dust. This requires special performance features and a high degree of resilience.

Smart grid communications networks are becoming even more sophisticated, and data rates are increasing to support new grid applications, such as distribution automation devices, metering infrastructure, security and mobile devices. Wireless technologies are the ideal solution for ensuring the reliability of these communication networks. The monitoring, analysis and control capabilities that come with wireless solutions and a modernized grid ultimately improve the reliability, economics and overall sustainability of the production and distribution of electricity, and help smart grid engineers keep their networks up and running.

Frequently Asked Questions

How does Cellular fit with communication requirements of the modern grid?

- **Bandwidth:** Each single device has direct connection to the base station and the backbone; the available bandwidth is stable, the same for all the devices and know in advance.
- **Latency:** With modern wireless technology, such as LTE and the emergence of micro cells interconnected via a 40G or even 100G Backbone, latency it is not a huge issue for smart grid applications. The scalability of this technology assures low latency.
- **Security:** The service provider is already delivering security at the Internet backbone and at the base station level. Cellular routers also provide security features like encryption, firewall and tunnelling.
- **Reliability:** The use of double SIM cellular routers allows a user to connect to different base stations from different network operators, making the network more reliable than private networks.

Where can I find copies of the test reports and certifications for your products?

Copies of detailed test results as required for certification against external standards are not held on our publicly accessible Internet site. If you would like to see copies of these test results for a specific reason, please contact either your local sales representative, or our vertical marketing manager; german.fernandez@belden.com.

Can I mix your devices with other vendor devices in the same network?

We comply with main industry standards. As long as the other equipment uses standard protocols, there will be no interoperability problems. We have implemented many projects in conjunction with different brands with no issues. For more details, please contact your local sales representative.

Is Belden offering WiMax equipment?

No, Belden is not developing WiMax because we do not see it as the best technology for this application.

WiMax is a cellular radio point to multipoint based on interconnected and proprietary base stations. Specific knowledge is needed to develop this kind of network, and initial investment to deploy the backbone infrastructure is really high. It has scalability limitations and a frequency planning study needs to be conducted. In addition to deploying a WiMax network, you need to hold a radiofrequency spectrum, and in many countries it is not available or it is extremely expensive.

Networks based on 3G or LTE have worldwide coverage via multiple public network operators in each country. To provide connectivity to one specific site, the only investment needed is to buy a router and a SIM card. The initial investment in base stations is done by the operators. The interoperability between routers and base station vendors is assured by industry standards.

About Belden

Belden Inc. delivers the infrastructure that makes the digital journey simpler, smarter and secure. We're moving beyond connectivity, from what we make to what we make possible through a performance-driven portfolio, forward-thinking expertise and purpose-built solutions. With a legacy of quality and reliability spanning 120-plus years, we have a strong foundation to continue building the future. We are headquartered in St. Louis and have manufacturing capabilities in North America, Europe, Asia, and Africa.

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