

WHITEPAPER

Why Unlicensed Spectrum Dominates the Smart Grid

CII power utilities use 902-928 MHz, often via Silver Springs, for their "smart-meter" major component of "smart grid." This is not AMTS.

Also, smart grid wireless links fixed-wireless, where the link paths can be determined and configured for far better gains, and overall Carrier-to-Interference, vs. wide area mobile wireless links. AMTS is best for mobile wide area wireless, and higher bands are better for fixed wireless. That is easy to demonstrate. See SkyTel petitions to deny the CII entities applications to get assignmnets of the MCLM AMTS spectrum. These entities did nto refute SkyTel on this, or its other major points in the petitions to deny, and they cannot reopen those closed pleadings by now seeking footnote-7 type relief.

Executive Summary

Wireless communications is a key enabler of the emerging smart grid. While the smart grid is far from complete, utilities have successfully deployed millions of smart meters and are leveraging two-way wireless communications to relay usage data accurately, implement energy awareness and demand response programs, and run other smart grid applications.

Smart meter connectivity and other Neighborhood Area Network (NAN) communications can take place over privately licensed spectrum or license-free 900 MHz spectrum. With limited experience operating their own private wireless networks and an abundance of marketing messages from some purveyors of licensed systems, some utilities may incorrectly attribute significant advantages to solutions using privately licensed spectrum. Among the most prominent myths are:

Myth 1: Licensed solutions avoid interference, making them more robust than unlicensed solutions.

Reality: Any wireless communications, whether licensed or unlicensed, face the risk of interference. Claims of interference in the 900 MHz unlicensed bands are largely overstated, and technology implementations, such as frequency hopping spread spectrum (FHSS), mitigate remaining interference issues.

Myth 2: Licensed solutions are more secure than unlicensed solutions.

Reality: Security is unrelated to whether a wireless system operates on licensed or unlicensed spectrum. In fact, licensed solutions that operate on fixed frequencies are often susceptible to malicious interference. A well-designed unlicensed solution offers greater protection against intentional interference or jamming.

Myth 3: Licensed spectrum ensures a long-term guarantee of availability.

Reality: Spectrum licenses last for only a fixed time with no guarantee they will be available in the future. Given the widespread commercial use of unlicensed spectrum, its future is near certain.

Myth 4: Because licensed solutions can transmit at higher powers, they provide an automatic cost advantage resulting from the need for less network infrastructure.

Reality: Licensed solutions have other “hidden” costs that increase the total cost of ownership while a well-designed unlicensed solution reduces both capital and operational costs.

Lost in many of these false arguments for advancing the use of privately licensed spectrum are four simple but compelling facts about unlicensed spectrum:

Unlicensed spectrum:

- » Is regulated by the FCC
- » Has supported utility communications for nearly two decades
- » Is used for other critical communications
- » Is suitable for both dense urban and sparse rural environments

To date, the majority of smart meters deployed in the United States use unlicensed spectrum. The reason for the overwhelming success of this approach is simple – compared with solutions that rely on privately licensed spectrum, solutions utilizing unlicensed spectrum are the most reliable, proven and cost-effective choice for smart grid communications. Silver Spring Networks is a leading smart grid solution provider whose communications platform, based on unlicensed 900 MHz spectrum, has been selected to power more than 17 million smart meters in the United States and abroad.

Licensed and Unlicensed – Two Options for Smart Grid Communications

Radio frequency (RF) spectrum is a scarce resource. To maximize use of this resource, most countries have government agencies tasked with allocating and managing spectrum. In the United States, the Federal Communications Commission (FCC) administers all non-governmental spectrum use. To date, the FCC has not reserved or apportioned any spectrum specifically for utility applications. Therefore, wireless communications for the smart grid must take place within the FCC’s existing commercial spectrum allocations. Broadly speaking, commercial spectrum in the United States is divided into two categories – licensed and unlicensed.

With **licensed spectrum**, companies purchase spectrum licenses from the FCC, giving them exclusive access to certain frequencies within a geographic area. The FCC allows licensed radio systems to use high-power transmissions on their assigned frequencies. A small number of smart grid vendors use privately licensed spectrum between 700 and 960 MHz. Licensed spectrum is a scarce resource that is difficult and expensive to acquire in large blocks. Because of these constraints, these vendors often possess just several hundred kHz of spectrum, providing only a handful of channels.

The majority of leading smart grid vendors leverage unlicensed spectrum in the 900 MHz band.

The FCC has also allocated huge amounts of **unlicensed spectrum** for commercial use that is available at no cost. Unlicensed spectrum includes the 900 MHz ISM band, extending from 902 to 928 MHz, and the 2.4 GHz and 5 GHz bands. To minimize interference, the FCC restricts the maximum transmit power for unlicensed devices and requires the use of spread spectrum technologies. 900 MHz provides superior propagation characteristics, allowing the signal to travel longer distances and penetrate obstructions better than signals at other unlicensed frequencies. For these reasons, the majority of leading smart grid vendors offer Advanced Metering Infrastructure (AMI) and other smart grid solutions powered by radios operating within the 900 MHz band.

Common Myths about Licensed Spectrum

Until recently, most utilities have had limited or no experience with building and operating their own large-scale private RF networks. At the same time, purveyors of licensed-spectrum systems have been eager to position the licensed RF choice as a key advantage. As a result, some utilities may incorrectly attribute certain benefits to systems using privately licensed spectrum. Among the most common myths are:

Myth #1: Licensed solutions avoid interference, making them more robust than unlicensed solutions.

With any form of wireless communications, interference is a major concern. Interference acts as noise in a wireless system, preventing two devices from being able to “hear” each other. Vendors using licensed spectrum claim they are immune from such interference because they have exclusive access to their assigned frequencies. The truth, however, is that no wireless system is immune to interference. In fact, licensed systems are especially susceptible to a type of interference known as *out-of-band interference*.

Licensed spectrum is partitioned into channels that are stacked next to each other, with limited spacing in between. Powerful and noisy transmitters, such as legacy pager systems, often occupy the channels directly adjacent to those licensed by smart grid vendors. The RF energy from these powerful systems creates interference when it “bleeds over” into the adjacent channels. This effect is analogous to a narrow highway where cars can drift into adjacent lanes. Compounding this issue is the fact that such out-of-band interference is permissible, so long as the offending transmitters are operating within the guidelines established by the FCC when they licensed the spectrum. Complex legal battles that take a long time to resolve often result.

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Spectrum testing by utilities and many large-scale smart grid deployments have consistently shown a lack of noise in the unlicensed 900 MHz band.

In the early 2000s, many public radio systems used by police and fire departments began experiencing interference issues. These systems operated on FCC licensed frequencies at 800 MHz, which happened to be right alongside frequencies assigned to Nextel Communications. As Nextel expanded its nationwide footprint by deploying stronger radios, they began disrupting the public radio systems on their adjacent channels. Given the structure of the band, no easy solution was possible, and it ultimately took the FCC several years to resolve the issue. In July 2004, the FCC issued its long-awaited decision to completely reorganize the 800 MHz band and move Nextel away from the public radio systems.

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Despite the interference risks within licensed spectrum, some industry participants argue that unlicensed 900 MHz spectrum is not suitable for smart grid communications because of interference challenges. They argue that the large number of devices sharing this spectrum creates significant amounts of noise and in-band interference. In reality, spectrum tests conducted by utilities along with many large-scale smart grid deployments have proven that noise is not a major issue. Several factors account for the relative lack of noise in the unlicensed 900 MHz band:

- » Devices shifting to higher frequencies - In recent years, many household devices and new technologies that do not need to transmit long distances have moved to the larger unlicensed spectrum bands at 2.4 GHz and 5 GHz, including wireless in-home networks.
- » Prevalence of low power devices - Many of the devices that do operate at 900 MHz, such as some cordless phones, operate at very low power levels to conserve battery life. Lower-power devices generate less noise within the band.

When noise is present, a well-designed unlicensed system can still provide robust communications. Utilities considering solutions that operate in unlicensed spectrum should look for systems that offer the following capabilities:

- » Rapid frequency hopping across many channels to sidestep interference from other sources
- » Communications protocols that reduce the probability of collisions when transmitting
- » A self-forming mesh network architecture to route around noisy RF areas

Myth #2: Licensed solutions are more secure than unlicensed solutions.

Spectrum is unrelated to security architecture. Indeed, it's possible for vendors of systems operating in either licensed or unlicensed spectrum to design an insecure system. Strong security comes not from the characteristics of the frequency band but from the specific measures a vendor implements to protect its communications within that band.

Many of the techniques that make well-designed unlicensed 900 MHz solutions robust against background interference also provide protection against malicious interference. Frequency hopping, a technology first developed by the military, rapidly shifts the signal across a large number of channels throughout the spectrum band. Systems using such techniques are extremely difficult to jam since no one knows when they will be transmitting on a particular frequency.

In contrast, licensed systems often operate on just a handful of frequencies due to the difficulty and cost of acquiring private spectrum. Utilities should be aware that systems that operate in such a manner pose a potential security risk. Consider that all FCC frequency allocation information is publicly available. Armed with this information, a would-be attacker with unsophisticated radio equipment can easily jam these frequencies and successfully disrupt smart grid communications.

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Utilities should not confuse RF security with smart grid security.

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Similar attacks have occurred in the past. In 2006, a court in Southern California sentenced a man to seven years in prison for repeatedly interfering with police radio systems operating on licensed frequencies. Because fixed-frequency systems are so easy to jam, no military in the world uses this form of wireless communications.

Most importantly, utilities should not confuse RF security with smart grid security. While strong physical-layer protection is important, all smart grid systems require multiple layers of security to provide adequate protection. In addition to RF security, a complete smart grid solution should provide the following security mechanisms:

- » Firmware protection
- » Security certificates
- » Link-layer protection
- » Application-layer protection
- » LAN-WAN border protection
- » Back-office protection

Myth #3: Licensed spectrum ensures a long-term guarantee of availability.

FCC spectrum licenses are not permanent. Smart grid vendors owning privately licensed spectrum must continuously renew their licenses or risk losing the spectrum. In addition, the FCC can reallocate spectrum for other uses and has done so in the past. In the 1990s, the FCC reassigned the private spectrum used by approximately 4500 point-to-point microwave links in the 1850–1990 MHz band to create space for new nationwide cellular networks. The incumbent microwave link operators, which included several utilities, were compensated for their costs to switch their equipment to other frequencies. However, in many cases these incumbents had only a two-year period to negotiate these costs and relinquish the band. Utilities deploying smart grid equipment based on privately licensed spectrum today may face similar relocation issues in the future.

A separate but related issue can arise when a smart grid vendor does not actually own spectrum but instead leases the right to use spectrum controlled by a third party. Such arrangements create additional availability risk for utilities. A disagreement, for example over commercial terms, between the smart grid solution provider and the spectrum owner may lead to a temporary service disruption or even the need to abandon the band permanently.

In the constantly evolving spectrum landscape, the future availability of unlicensed spectrum for utility applications is near certain. Since the FCC first opened the 900 MHz band in 1985, unlicensed spectrum has paved the way for many innovative new technologies and is used by millions of devices. Reallocating the spectrum used by this many devices is virtually impossible and if anything, the FCC will make even more unlicensed spectrum available in the coming years.

Myth #4: Because licensed solutions can transmit at higher powers, they provide an automatic cost advantage resulting from the need for less network infrastructure.

The FCC allows licensed systems to transmit at higher power levels than unlicensed systems can use. Because signals that are more powerful travel farther, most smart grid vendors using licensed spectrum have adopted a tower-based network architecture. With this type of network architecture, meters communicate directly with radio equipment mounted on tall towers that may be many miles away.

Licensed solutions can have “hidden” costs often not revealed during proposal pricing.

Licensed vendors tout the cost advantages of this approach by pointing to the lack of additional network equipment needed between the meter and the tower. However, such high-powered solutions can have “hidden” costs often not revealed during proposal pricing, significantly increasing the overall total cost of ownership. These costs include:

- » Tower costs – Radio towers are expensive to build, often exceeding \$100,000 for a single tower serving 20,000 homes. In environments where mountains or other obstructions block the signal, utilities may have to build towers just to reach a small number of customers.
- » Coverage gaps – The higher power levels of licensed systems typically still cannot reach meters located in underground basements or the middle of high-rise buildings. In these cases, utilities are forced to continue with manual meter reading.
- » Spectrum costs – Demand for spectrum increases each year, which is driving up its cost. Utilities relying on licensed spectrum may suffer these cost increases as they continue to roll out new smart grid applications.

A well-designed unlicensed system minimizes the amount of network infrastructure utilities need to deploy without creating any of these additional challenges. To reduce total system costs, utilities should look for unlicensed solutions that offer the following characteristics:

- » Radios offering the highest permissible power to penetrate walls, basements and other “hard-to-hear” areas
- » Meters that act as network relays to boost signal reach and improve coverage
- » Support for large numbers of meters at a single network takeout point to lower the infrastructure costs associated with excessive takeout points

Four Facts about Unlicensed Spectrum

Missing from many discussions about utility use of unlicensed spectrum are several important realities about its operation that positively benefit utilities.

Fact #1: Unlicensed spectrum is regulated by the FCC.

The FCC defines strict rules to ensure the coexistence of unrelated devices operating within unlicensed bands. For example, FCC “Part 15” rules state that unlicensed devices cannot transmit at more than one watt of power and must employ spread spectrum technology. For smart grid devices meeting these requirements, FCC “safe harbor” provisions protect utilities from claims of interference or harm by others users of the spectrum.

Fact #2: Unlicensed spectrum has supported utility communications for nearly two decades.

Since the early 1990s, utility commissions across the country have approved billions of dollars of rate-recoverable utility assets based on unlicensed spectrum. Historically, unlicensed spectrum has been used for one-way automated meter reading (AMR) and for SCADA systems that need to communicate with power control devices deployed across a utility’s distribution network. Today, many of the largest AMI deployments in the world use unlicensed spectrum, including:

United States

- » Pacific Gas and Electric
- » Florida Power & Light
- » Pepco Holdings
- » Southern California Edison
- » San Diego Gas & Electric
- » Oncor
- » CenterPoint Energy

Canada

- » Toronto Hydro
- » Hydro One

Australia

- » Jemena
- » CitiPower & Powercor

Fact #3: Unlicensed spectrum is used for other critical communications.

In addition to serving the needs of utilities, major cities across the United States such as New Orleans, Las Vegas, and Spokane, Wash. use unlicensed spectrum for public safety communications, video surveillance and emergency disaster response.

Fact #4: Unlicensed spectrum is suitable for both dense urban and sparse rural environments.

Unlicensed spectrum performs well in any RF environment, provided the system is well designed. For urban areas with higher levels of RF noise, sensitive receivers and sophisticated frequency hopping techniques ensure the signal gets through. In rural areas, one-watt transmitters, long-range antennas and pole-top equipment mounting can carry a 900 Mhz signal for several miles between devices.

The Silver Spring Approach

Silver Spring enables utilities to rapidly and cost effectively deploy a broad set of smart grid initiatives. Whether a utility starts with Advanced Metering or Distribution Automation or focuses on consumers with Demand Response or Electric Vehicle projects, Silver Spring delivers the unified smart grid platform needed for these missions to succeed.

The Silver Spring Smart Energy Platform incorporates standards-based network infrastructure, software, and services – all tailored to a utility’s particular project goals, service territory and terrain requirements, regulatory model and operational structure. The smart grid network consists of intelligent endpoints and network infrastructure that connect utilities to their smart meters and remote DA equipment. These devices, operating over unlicensed 900 MHz spectrum, work in concert to create a self-configuring, highly redundant mesh network with ubiquitous coverage, strong security, and the scale and performance demanded by utilities.

The majority of solution providers for the smart grid use unlicensed 900 MHz spectrum. However, not all these solutions are created equal. Unlike other vendors, Silver Spring provides utilities with:

- » **Robust communications, free from interference issues.** Silver Spring radios avoid interference issues using sophisticated frequency hopping spread spectrum (FHSS) that rapidly switches the signal across 83 available channels. Data packets are highly optimized and overall packet size is kept relatively low, which makes collisions less likely and recovery from collisions less costly as less data needs to be retransmitted. At the network level, the Silver Spring RF mesh provides multiple communications paths and automatically re-routes traffic around noisy RF areas.
- » **Protection against RF attacks and eavesdropping.** The use of FHSS provides inherent protection against jamming and eavesdropping. Each Silver Spring radio has a different hopping sequence, and radios hop to different channels anywhere from 50 to 100 times per second, making it extremely difficult for outsiders to track and lock onto the signal.
- » **Lowest network infrastructure requirements.** The Silver Spring 900 MHz radios incorporate a full one-watt transmitter, the maximum power allowed by the FCC. Each meter in the RF mesh network acts a repeater, or relay, for other meters in the network, greatly reducing the need for additional network infrastructure. Silver Spring Access Points are low-cost devices that terminate the RF mesh and connect to a utility's backhaul network. Each Access Point supports up to 5000 endpoints, so a utility supporting one million customers could deploy as few as 200 takeout points to service all those customers.

Unlicensed spectrum is the preferred choice for smart grid communications.

Conclusion

Smart grid wireless communications rely on either privately licensed or unlicensed spectrum. Despite the claims of some industry participants, unlicensed spectrum is the preferred choice for smart grid communications. Leveraging unlicensed 900 MHz spectrum, the Silver Spring Smart Energy Platform is the most reliable, proven and cost-effective choice for utilities undertaking Advanced Metering, Distribution Automation or any other smart grid initiative. These factors account for the widespread adoption of the Silver Spring solution across a varied set of utilities worldwide.

About Silver Spring Networks

Silver Spring Networks is a leading smart grid networking platform technology and solutions provider. We have connected over 10 million homes and businesses throughout the world with the goal of achieving greater energy efficiency for the planet. Our innovative products enable utilities to gain efficiencies, integrate renewable energy sources and empower customers to monitor and manage energy consumption. Silver Spring Networks' clients include Baltimore Gas & Electric, CitiPower & Powercor, Florida Power & Light, Jemena Electricity Networks Limited, Pacific Gas & Electric and Pepco Holdings, Inc. among others. For more information please visit www.silverspringnet.com.

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