NAVIGANT RESEARCH

## WHITE PAPER

# The Urgent Need for a Licensed Broadband Spectrum Allocation for Critical Infrastructure

## Why the Utility Industry and Regulators Must Come Together in Support of Interoperable, Future-Proof Smart Grid Networks

**Commissioned by pdvWireless**

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# Section 1
## EXECUTIVE SUMMARY

More than 3,000 electric utilities across the US are each managing multiple—sometimes more than a dozen—wireless networks in support of grid operations, workforce management, and customer service. Typically, these networks have been developed in an ad hoc manner for application-centric purposes. They have often been deployed within organizational silos, without planning or coordination across divisions. And many of these wireless networks rely upon unlicensed spectrum or narrowband licensed spectrum and utilize outdated technology standards. To manage these incompatible and sometimes redundant systems, each utility employs an internal team of networking specialists. It is a hugely inefficient approach. The challenges that lie ahead for electric utilities cannot be adequately met with these fragmented, often aging legacy networks.

During the next decade, Navigant Research expects the number of connected devices within the average utility to grow by an order of magnitude—at least—and the volume of data coming from each connected device will also climb. At the same time, the number of non-utility connected devices leveraging unlicensed spectrum bands will increase by 400% or more. The exponentially growing use of unlicensed bands could affect utility network performance and grid reliability. Add in the numerous operating and business model pressures that utilities today face, and it becomes clear that there is a pressing need for a nationwide, standardized licensed spectrum band around which power utilities and other critical infrastructure providers can build their critical networks.

Utilities are facing a perfect storm of disruption to their century-old operating model. Without robust, interoperable, and ubiquitous networking, their futures could well be in peril. As described throughout this paper, a nationwide licensed broadband spectrum allocation combined with buildouts based on commercial technology standards will ensure that utilities are able to implement the solutions necessary to manage not only reliable and affordable power delivery, but also financial stability in the rapidly changing energy economy.

If utilities and regulatory bodies can work together to rally around a single spectrum band, this would solve an urgent and growing need of the industry and facilitate roaming and cooperation by personnel from disparate utilities. Vendors could standardize on the band, bringing substantial economies of scale—particularly if the de facto commercial wireless technology standard—LTE—is used.

In this white paper, Navigant Research describes the critical drivers behind utilities' need for licensed, standardized broadband spectrum in the US. These include the integration of rapidly growing distributed energy resources (DER) into the power supply mix, growing concern over grid resiliency and the increased risk of cyber attack, and the changing requirements competition places on customer service organizations.

The disruption of the traditional regulated monopoly business model that utilities face may be one of the most important factors to consider when evaluating the need for licensed broadband utility networks. These networks have the potential to create a platform upon which utilities can respond nimbly to new challenges and deliver new services. The paper also outlines the mechanics of spectrum licensing and availability in the US and summarizes the suitability of several potential spectrum bands. These include options in the low-band spectrum—400 MHz, 700 MHz, 800 MHz, and 900 MHz—as well as options in the high-band spectrum—Citizens Broadband Radio Service (CBRS) and 4.9 MHz. Options for a nationwide broadband spectrum allocation dedicated to utilities are few and far between and still require some degree of regulatory action.

Under the best of circumstances, the legacy utility practice of managing dozens of unlicensed and licensed narrowband wireless networks is already uneconomical and presents a multitude of risks to grid performance and operational security. Looking ahead, the changing energy landscape and transition to a more distributed, services-based energy economy will obsolete this practice—or the utilities that maintain it. An alternative strategy must be found.

Utilities must converge on spectrum bands that provide the capacity to support a diverse set of use cases and, at the same time, present a means to evolve technologically and provide network owners with a future-proof, secure, and interoperable platform. Leaders at utilities, regulatory agencies, and vendors should come together now to ensure their common goals of affordable, reliable, flexible, and efficient power service can continue to be met.

# Section 2
# WHY PRIVATE BROADBAND WIRELESS?

## 2.1 Utility Connectivity Requirements Are Poised to Explode

Utility networking needs are growing exponentially. Ubiquitous, integrated, and seamless connectivity will play a fundamental role as the power industry transforms over the next decade and beyond. The centralized generation and distribution model of old is rapidly giving way to a more distributed, interactive, and competitive utility operating environment.

To survive, electric utilities will depend upon a vast network of connected devices throughout the grid and at customer premises across their operating territories. Applications ranging from those that support grid resiliency and operational efficiency and the integration of distributed energy resources (DER) to those that empower end users and enable new service offerings will depend upon real-time data. This data—snowballing both in terms of volume and velocity—will need to be shared not only across historically siloed operating divisions within a utility, but also across and between multiple utilities and with new third-party actors within the energy ecosystem.

The many diverse, narrowband, application-centric wireless networks that have been used in the utility industry for decades will, quite simply, not cut it. There is an urgent need for utilities and regulatory bodies—at local, state, and federal levels—across the US to come together in support of licensed spectrum bands and technical standards best able to meet critical infrastructure providers' need for a secure, reliable, and interoperable solution.

### 2.1.1 The Status Quo Will Not Suffice

The electric power industry is more than a century old, but only within the past few decades have technological advances begun to work their way into the legacy electromechanical grid. Beginning with the advent of supervisory control and data acquisition (SCADA) systems deployed throughout critical transmission networks in the 1960s, a multitude of applications that depend upon connectivity have been implemented by utilities across the US.

Due to the vast number of utilities with different operating environments and mandates, as well as the complex regulatory schemes under which utilities operate, these networks have been deployed on different timelines, using different technologies and performing different functions. For certain applications—most notably, substation connectivity—dedicated wired networks (increasingly, fiber) may make sense, but fiber cannot be cost-effectively deployed everywhere. Yet, for many other applications, wireless technologies are widely used. A secure, standardized wireless solution for utility applications across the US, however, is nonexistent.

One large investor-owned utility (IOU) reports more than two dozen different wireless networks in use across its service territory when multiple spectrum bands and/or technology standards are factored in. These networks and their technical characteristics are shown in Table 2-1. Some of these networks support multiple applications while others may be dedicated to a specific function within a specific operating division.

Notably, many of the networks operate in unlicensed spectrum bands. These bands, as explained more fully below, may put the entire utility network at risk for interference and security breaches.

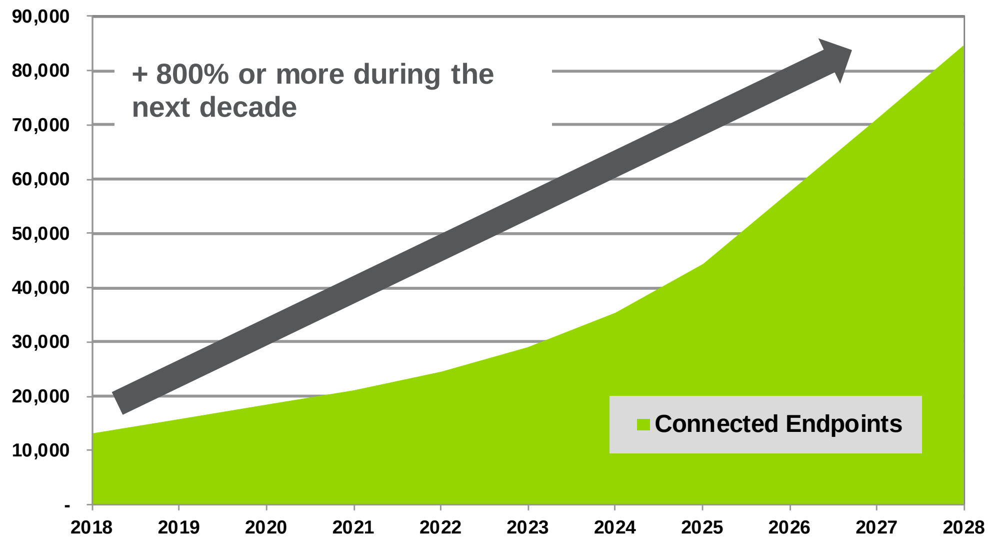
***Table 2-1. Wireless Networks in Use – Example IOU***

| Networking Technology (Licensed Spectrum) | Networking Technology (Unlicensed Spectrum) |
|---|---|
| Cellular Voice (AT&T/Verizon 2G/3G) | Wi-Fi (2.4 GHz, 5.8 GHz 802.11a/b/g/n/ac) |
| Land Mobile Radio (UHF, VHF) | WiSUN Unlicensed Mesh (900 MHz 802.15.4g) |
| Cellular Data (AT&T and Verizon, 3G, 4G LTE) | GridStream Unlicensed Mesh (900 MHz) |
| Licensed Microwave (2 GHz, 6 GHz, 11 GHz) | Unlicensed Microwave (2.4 GHz, 5.8 GHz, 80 GHz) |
| Licensed 800 MHz, Harris P.25 | Proprietary Unlicensed Mesh (900 MHz) |
| Licensed 800 MHz, Motorola P.25 | WiMAX (3.65 GHz 802.16e) |
| | Unlicensed 900 MHz |
| | Multiple Address System, Unlicensed (900 MHz) |
| | Protective Relaying/Transfer Trip, Unlicensed (900 MHz) |

*(Source: Ameren)*

Looking ahead, the typical utility will manage an order of magnitude more connected devices within the next decade versus today—and that only accounts for known application endpoints such as for distribution automation, smart metering, smart solar inverters, etc.

***Figure 2-1. Example of Projected Growth in Connected Endpoints for a 1 Million Meter IOU: 2018-2028***




*(Source: Navigant Research analysis of Ameren data)*

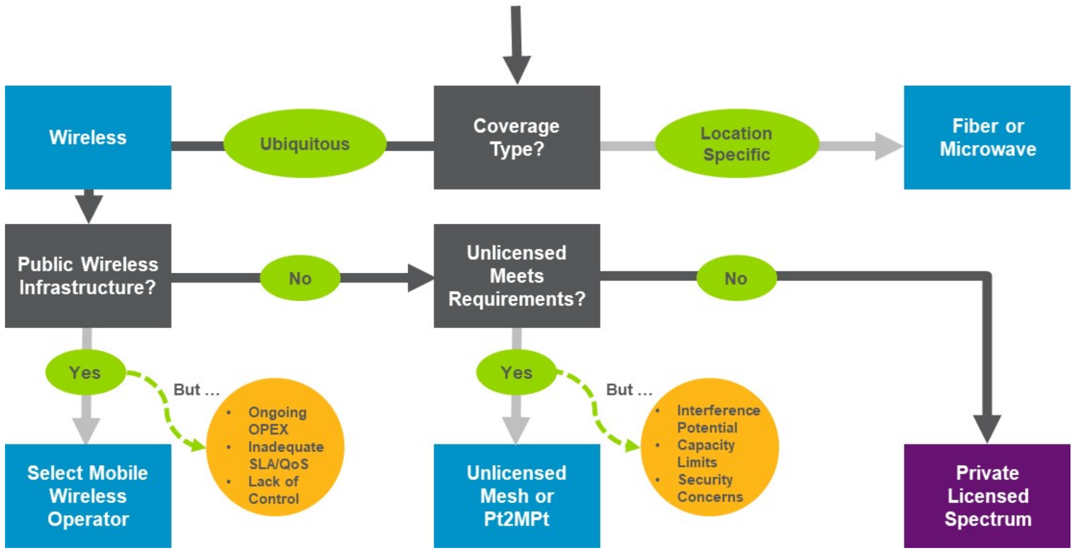
With sensing and analytics technologies growing more powerful and affordable by the year, these forecasts for connected utility endpoints could be conservative. Moreover, utilities will need more bandwidth to handle the growth in data traffic from each connected device. Finally, cybersecurity requirements will become more stringent for each network as growing volumes of critical safety, operational, and customer data are transmitted.

In order to support so many networks, utilities often employ whole divisions of communications specialists. Networks must be monitored, maintained, upgraded, and replaced as standards advance and vendors discontinue outdated equipment.

At the end of the day, the economics of maintaining dozens of limited purpose networks—and the staff to support them—will become impossible to justify. Reliance upon a vast array of incompatible networks, within and among the more than 3,000 power utilities operating across the US, is inefficient and will ultimately become unmanageable. Access to a licensed broadband spectrum band with a clear technical evolution path will provide utilities and other critical infrastructure providers with a migration path to consolidate their numerous incompatible networks onto a single platform capable of accommodating a growing number of use cases and connectivity needs.

As shown in Figure 2-2, the decision-making process for utility networking managers increasingly points to a standardized, licensed broadband solution.

***Figure 2-2. Utility Networking Technology Selection Map***




*(Sources: Navigant Research, Electric Power Research Institute)*

## 2.2 What Is Driving Growth in Utility Demand for Connectivity?

Utilities today face a perfect storm of technological, societal, and regulatory stresses to their legacy business. A decade ago, the so-called "utility death spiral" was an alarmist headline; today, the existential concerns of the traditional vertically integrated, regulated monopoly utility are real.

The utility of tomorrow will operate in a competitive environment where the cost of green DER such as solar plus storage is at parity with utility energy prices (or lower). End users—residential, small and medium business (SMB), and commercial and industrial (C&I)—will expect more from their energy providers, both in terms of greener, renewable generation sources and their customer service capabilities. They will expect real-time consumption data and proactive programs to help them reduce their energy usage and carbon footprints. If utilities do not meet these expectations, providers such as Google or Amazon very well might—the utility of tomorrow will operate in a vastly more competitive environment.

Meanwhile, regulators in progressive states are already assessing new business models where utility income is decoupled from the sale of kilowatt-hours. The goal is to incentivize greater energy efficiency and competitive models of operation.

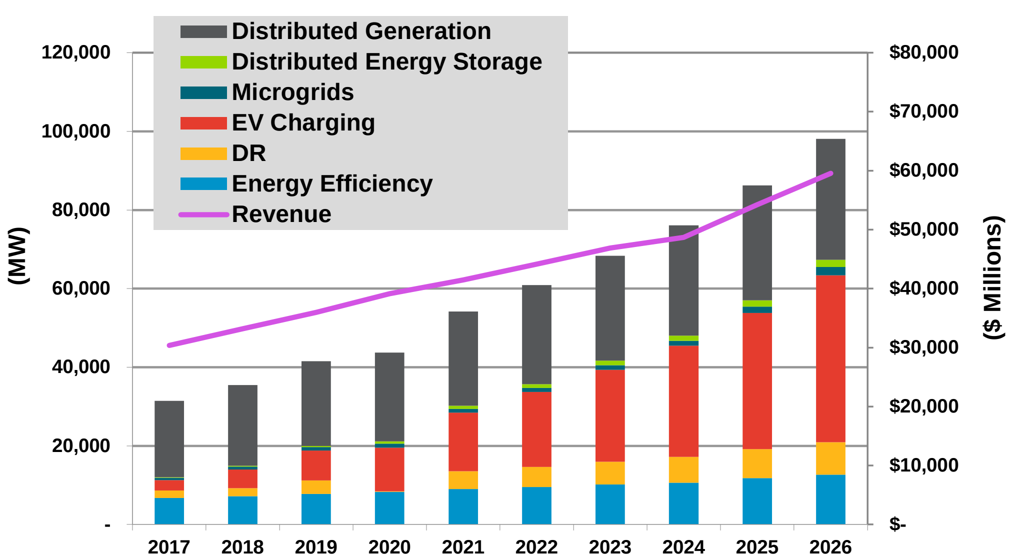
In order to manage these many diverse new demands, utilities will require high capacity, low latency communications networks across their service territories. The key trends that underlie growing utility networking needs are described in more detail in the following sections.

### 2.2.1 Available and Affordable DER

An explosion in affordable DER technologies is anticipated over the next decade. Big corporate initiatives often make headlines—Walmart has plans to go 100% renewable, for example, and Apple announced in April 2018 that its global facilities are now 100% powered with clean energy, including retail stores, offices, data centers, and colocated facilities in 43 countries. But the trend toward DER is strong with residential consumers, SMBs, and large industrial customers as well.

Navigant Research estimates that 35.5 GW of new DER capacity will be installed across North America in 2018—7 times the amount of new centralized generation. Of that, distributed generation technologies (including solar, wind, fuel cells, and natural gas and diesel gensets) will account for 58%. By 2026, 98.1 GW of DER capacity is projected to be installed in North America, nearly triple current levels. Detailed forecasts for DER capacity additions across North America are shown in Chart 2-1.

***Chart 2-1. Annual Installed Total DER Power Capacity and Revenue by Technology, North America: 2017-2026***




*(Source: Navigant Research)*

The implications for utility grid operators are great. Solar and wind are intermittent, and when end-user power generation exceeds demand, that power is pushed back out into the grid. This may, in turn, affect the stability of a network designed for one-way power flow.

Demand response (DR) and other energy efficiency programs also depend upon real-time communications for successful program participation. And the high growth expected in EV charging capacity has implications for peak load generation and forecasting, as EVs are most often charged overnight. Without visibility into all these grid-tied DER assets, utilities will be unable to ensure grid reliability.

#### 2.2.2 Pressure for Greater Grid Resiliency

The Federal Energy Regulatory Commission (FERC) is in the process of evaluating the resiliency of the American power grid. FERC has proposed defining resiliency as:

> *The ability to withstand and reduce the magnitude and/or duration of disruptive events, which includes the capability to anticipate, absorb, adapt to, and/or rapidly recover from such an event.*

Debate around the details of this definition—and how it compares with "reliability," which is already mandated for grid operators—is ongoing in Washington, DC and around the country. But semantics aside, communications is at the core of reliable and resilient power supply, as was highlighted in a report prepared for the US Department of Energy in 2016 (emphasis added):

> *The U.S. electricity system is a critical infrastructure that supports human well-being, economic growth, and national security. Comprised of four core components—generation, transmission, distribution, and end use, and,* ***increasingly, dependent on supporting infrastructure such as communication*** *and fuel supply—the electricity system has multiple vulnerabilities to both natural and human risks. These risks range from the routine and predictable, such as weather events that disrupt transmission or distribution, to high impact, low frequency risks such as catastrophic hurricanes. In addition to such well-defined, discrete risks, electricity systems can also be challenged by complex risks associated with multiple, interacting threats, and/or indirect effects. Not all of the various risks to which electricity systems are exposed can be readily quantified, predicted, or even anticipated. Hence, the federal emphasis on*

*resilience reflects the growing awareness of the need for more robust approaches to addressing risks to the nation's critical infrastructure and support systems.*[1]

As storm severity continues to grow and other disasters such as drought and wildfires become more common, regulatory bodies, grid operators, and power balancing authorities nationwide will be under increasing pressure to improve grid resilience. This cannot be achieved without a robust communications infrastructure—infrastructure that, to be most effective, should be standardized and interoperable across utility and state boundaries for ease of support and mutual aid in times of crisis.

### 2.2.3 Utility Deregulation and Competition

In the US, there are currently 18 states that have deregulated electricity markets in some form, including California, Illinois, Texas, and much of New England, among others. Within deregulated electricity markets, energy retailers are subject to customer choice and must increasingly differentiate themselves. According to one analytics solutions vendor, one in three customers is dissatisfied with their electricity provider or has switched providers.

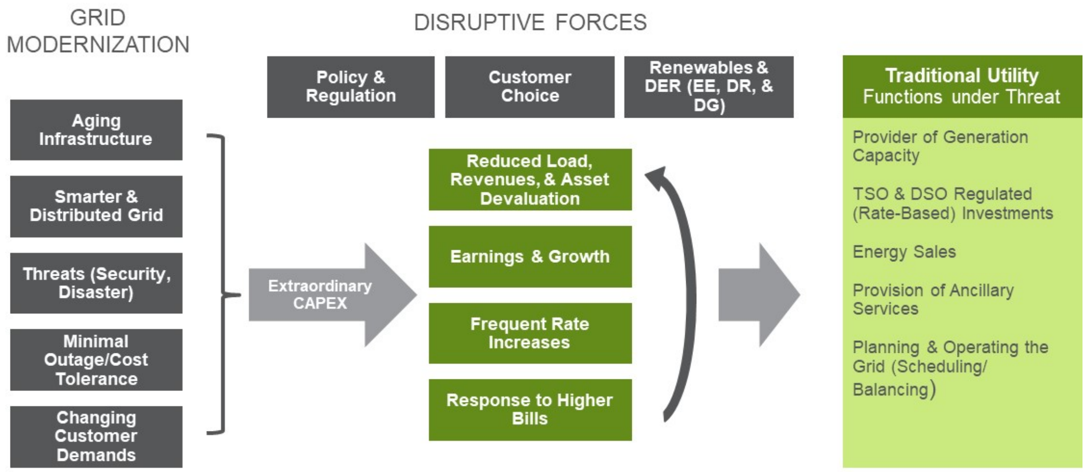
In response, utilities today have a greatly increased focus on customer experience and satisfaction. Innovative solutions providers are developing analytics-based approaches to customer engagement—and these solutions depend on reliable customer data, whether it be demographic data, car and home ownership data, power usage data, etc. Furthermore, utilities are working hard to improve their customer service organizations and tying together call centers with websites, online chat capabilities, mobile apps, and more. All these efforts require reliable and interoperable data networking.

[1] *Resilience of the U.S. Electricity System: A Multi-Hazard Perspective*, prepared for the US Department of Energy's Office of Energy Policy and Systems Analysis (EPSA), August 2016.

### 2.2.4 A Perfect Storm Threatens the Traditional Utility Model

Like many industries currently being disrupted by technological innovation and changing societal priorities, the traditional regulated monopoly utility is facing new challenges from all sides, as shown in Figure 2-3.

***Figure 2-3. Utilities Face a Host of Challenges***




*(Source: Navigant Research)*

Today, a growing number of solutions are coming to market to help utilities achieve their financial goals while also meeting the demands of regulators and customers. Virtually all these solutions will depend upon a robust communications network to succeed.

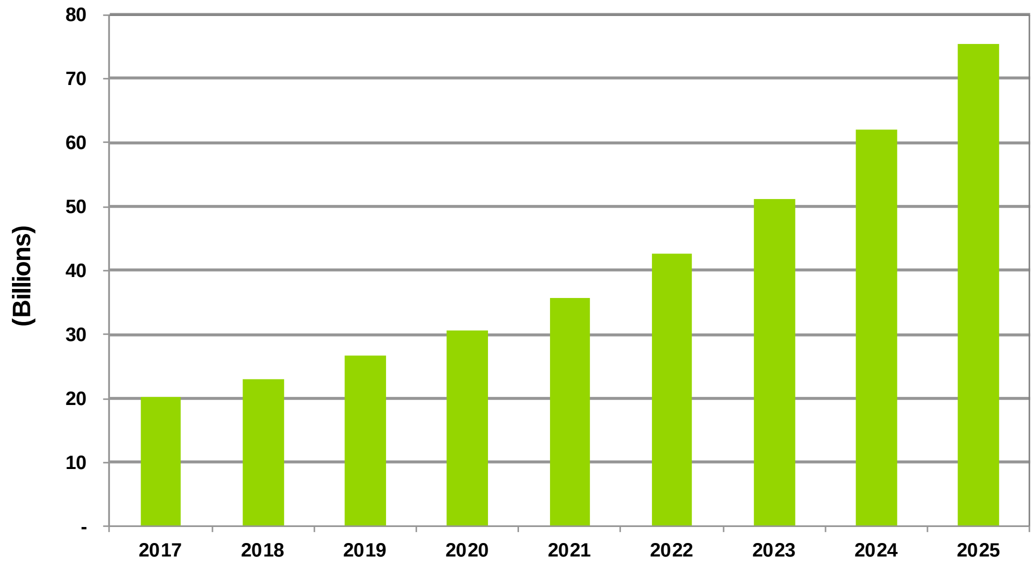
## 2.3 The Private Wireless Solution Advantage

As noted in Section 2.1.1, utilities today are managing an unwieldy number of application-centric networks, often within operational silos and with no regard to what other divisions may be doing—much less what neighboring utilities may be doing.

This lack of coordinated and standardized best practices results in inefficient and less cost-effective networking solutions in the best of times. In times of crisis, the lack of standardization across utility territories can hamper utilities' efforts to assist one another due to incompatibility between networks and communicating devices. One key benefit to a standardized band and technology protocol for utility broadband networks will be roaming capabilities, making it vastly easier for utility teams to assist one another across territory boundaries.

Looking ahead, as the Internet of Things (IoT) becomes reality, tens of billions of devices are expected to become connected. Over the next 7 years, the number of connected devices is expected to increase nearly fourfold (Chart 2-2), and a significant percentage of these will employ unlicensed spectrum bands for data transmission.

***Chart 2-2. IoT Connected Devices, World Markets: 2017-2025***




*(Source: Statistica)*

The risk of interference and increased security threats related to these unlicensed bands will grow in step with the number of devices using these limited airwaves. These are risks that utilities and other critical infrastructure providers cannot afford to take.

Utilities' stringent standards on security, reliability, and resilience demand a deployment model not offered by commercial networks. In addition, the need for priority access and full control of operations dictates that utilities will be best served with a private network model where spectrum, technology, and operations are under the management of the entity they serve.

### 2.3.1 Broadband Capacity Is Key

A key reason for utility—and regulator—aversion to utility ownership of licensed broadband spectrum historically has been its high cost relative to the use cases utilities are permitted to leverage. And while there are several narrowband or wideband spectrum options available for utility application and purchase today, utilities can expect their data traffic and capacity needs to increase by an order of magnitude or more in coming years, as described previously.

A study conducted by the Electric Power Research Institute (EPRI) in 2015[2] found that, depending on the spectrum band analyzed, utilities will need between 2 MHz and 6 MHz of dedicated spectrum to meet their field area network (FAN) needs over the next decade—and that was based on a capacity study conducted in 2010. It is quite possible those estimates will prove conservative.

Thus, narrowband options may provide a Band-Aid for the near term. However, to prepare for and compete in the rapidly changing energy economy over the next several decades, only broadband capacity will suffice.

Utilities must not sit by and let others accumulate the licenses to airwaves that could mean the difference between evolution and stagnation for their business. And regulators must support their efforts to gain access to licensed spectrum and invest in future-proof networks. As the world becomes increasingly connected, utilities with exclusive rights to spectrum will own an ever more valuable asset—one with the potential to become a real competitive advantage in the coming decades. More importantly, dedicated, interoperable, and migration-ready wireless solutions across the US may be the best way for regulators and utilities to ensure continued reliable, efficient, and affordable access to energy.

### 2.3.2 Licensed Spectrum and Cybersecurity

The growing role of wireless networking and sophisticated IT solutions in managing the grid brings many benefits to grid operators—but it also opens this critical infrastructure up to vulnerabilities.

In September 2017, it was reported that hackers had broken into dozens of American energy firms looking for weaknesses to exploit. And in March 2018, the Department of Homeland Security and the FBI issued a joint alert about cyber actors within the Russian government that have been targeting US critical infrastructure sectors, including energy, nuclear, and commercial facilities, since at least March 2016. The risks are real—a so-called Black Sky event could cripple cellphones, erase bank accounts, devastate hospitals, and disrupt every sector of the economy. In 2015, Russian hackers disrupted power to some 200,000 people in the Ukraine.

NERC CIP regulations are compliance-based and focused on generation and transmission-level power network assets, leaving serious vulnerabilities in the distribution grid. Meanwhile, utilities are struggling to find adequate cybersecurity talent. According to the Signal, Information, Networks and Energy Laboratory (SINE Lab) at Arizona State University, 84% of US utilities have non-specialists making cybersecurity decisions.

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[2] Electric Power Research Institute, *Assessment of Licensed Communications Spectrum for Electric Utility Applications*, April 2015.

A standardized spectrum band for critical utility broadband networks will make the US grid inherently more secure. The protocols for unlicensed standards—such as Wi-Fi—were not developed with security as a top priority. In contrast, standard technologies such as LTE benefit from the largest equipment and security vendor ecosystems in the world. They have deep security expertise and economies of scale to support ongoing cybersecurity R&D. The large and diverse utility community across the US stands to benefit from that expertise by standardizing on a commercially supported protocol and by using equipment, including chipsets and modules, that currently exist.

### 2.3.3 Standards and Interoperability Improve Resiliency at a Lower Cost

Coordination on standards and interoperability will also bring benefits to utilities in terms of costs. As noted above, millions and millions of devices are expected to be connected throughout the power grid and in behind-the-meter installations such as for residential solar. Such high volumes will translate into measurable savings in actual network deployment and maintenance.

Perhaps even more important, utilities with standardized networking protocols will be readily able to assist neighboring—or even distant—utilities in times of crisis. With standardized networking in place, utility teams from any part of the country will be able to assist when the next major hurricane hits Florida or the Gulf Coast. Neighboring utilities in the Northeast can pick up data traffic and reroute it for those that lose cell sites during a nor'easter.

This is similar to the driver behind the Federal Communications Commission's (FCC's) allocation of dedicated 700 MHz spectrum to public safety agencies across the country. The First Responder Network (FirstNet) is described in more detail in Section 3.1.3.1. But because public safety agencies have not proven amenable to providing priority access to power utilities, utilities must invest in dedicated networks to have the guaranteed access they require in times of emergencies. Nonetheless, the FirstNet initiative demonstrates the potential for network standardization to dramatically improve power utility coordination, grid resiliency, and efficiency—at a lower cost to all.

## 2.4 Challenges to Dedicated Utility Broadband Wireless Networks

Given the overwhelming advantages to utilities that a standardized licensed spectrum band for broadband wireless networks would afford, it may seem shocking that such a solution has not evolved in the utility industry. The Utilities Technology Council (UTC) has been working for years to promote the need for dedicated critical infrastructure spectrum at the FCC—but to no avail. This is even more surprising since, as UTC president and CEO Joy Ditto recently stated, "Over the past ten years or so, utility needs have only increased for spectrum."

The reasons why range from the escalating cost of licensed spectrum to an uncoordinated vendor and utility ecosystem to the perception that narrowband and unlicensed bands provide a suitable solution at no (or minimal) cost. Each of these challenges is described more fully in the following sections.

### 2.4.1 Spectrum Cost and Availability Challenges

The single biggest barrier to utility licensed spectrum ownership has been cost—which is also directly related to availability. The explosion in mobile devices—and their ever growing need for bandwidth—provides wireless carriers with the business case to drive spectrum values higher and higher. Meanwhile, many regulated utilities are restricted from providing the services, such as broadband, that would support the economic case for licensed spectrum acquisition.

And if the Verizons and AT&Ts of the world have been willing to spend tens of billions of dollars on licensed spectrum, the Treasury Department has been more than willing to sell those licenses at auction, raising vast sums for the US government. While many utilities have participated in various spectrum auctions over the years, and many own a variety of licensed bands, the most attractive broadband licenses have generally gone to carriers.

Yet, until recently, some utilities could not foresee a need for dedicated broadband spectrum. The smart grid activities of the past decade have been reasonably well-served by narrowband and unlicensed bands. Going forward, however, this will not be the case.

There are few remaining options for utilities to gain access to dedicated licensed spectrum. It is time to seize the opportunity and coalesce around a solution that meets the needs of both utilities and regulators.

### 2.4.2 Technology and Standards Challenges

Added to the cost of licensed spectrum is the cost of the networking infrastructure itself. The wireless vendor community has not been known for embracing standards, particularly when it comes to solutions geared toward private utility smart grid networks. Even within standardized categories of solution (e.g., 900 MHz advanced metering infrastructure [AMI]), proprietary layers within the solution typically force the utility into vendor lock-in—and the necessity to rip and replace later should a new vendor/technology become more attractive.

Standardization around a commercial technology, such as LTE, would allow utilities to work with numerous vendors for standardized and interoperable solutions. Such competition will mean lower prices and reduced vendor risk for utilities.

### 2.4.3 Regulatory and Cost Recovery Challenges

State public utilities commissions (PUCs) are tasked with ensuring that regulated monopoly utilities provide reliable and affordable electric power to individuals and businesses across their states. This generally applies to large IOUs, which are required to file highly detailed rate cases every 3 or so years to have their rates approved. Only by deploying their networks under a capital investment (CAPEX) model will the investment yield a return for the utility, which is capped by the PUC, typically at between 8%-10% of invested capital.

Municipal utilities and cooperative (member-owned) utilities follow similar guidelines, although they are not necessarily restricted to making a return on invested capital, and as such, are more likely to invest in carrier or third-party networks. The network as a service model is presently gaining some traction among this class of utility.

IOUs account for nearly three-quarters of all electric meters (customers) in the US, however. Fifty different PUCs regulate more than 100 IOUs, many of which operate in multiple states—and each state is at a different stage in moving beyond the legacy rate of return business model. While progressive states such as California and New York are working to decouple utility income from energy sold—to motivate utilities to adopt more energy efficiency measures and embrace distributed renewables—other states are firmly operating under backward-looking models.

In order for utilities—and their customers—to benefit from a national standard in licensed broadband utility networking, each of these 50 PUCs must cooperate to develop business models which will support such forward looking investments in spectrum and networking infrastructure, including support for new product and service offerings. Further, the FCC must participate in the process to ensure that the most appropriate spectrum bands are made available nationwide for critical infrastructure providers such as utilities.

Herding these regulatory cats, as it were, may be the greatest challenge facing supporters of a dedicated wireless utility solution today.

## 2.5 Challenges Must Be Faced by a United Front

Owning spectrum does not fix the problem of utilities' changing business dynamic. Market forces will, over the next decade and beyond, irreversibly affect the industry regardless of regulatory participation or prescience.

Dedicated broadband spectrum will, however, provide a platform for future offerings, ensuring that utilities can dynamically implement the technologies needed to manage burgeoning DER and leverage analytics and other customer experience technologies. Doing so will enable utilities to maintain customer engagement and ensure resiliency in the face of growing cybersecurity and climate-based threats.

One of the most important decisions utility managers will make over the next decade will not be about which smart metering platform to deploy or whether feeder automation is necessary territory-wide. Rather, it will be about what new services and business models they move toward as their operating environment irrevocably changes.

If utilities and governmental bodies work together to rally around one or a handful of available spectrum bands, their market influence could be great. Not only does that drive vendors to coordinate around that band, but it also paves the way for utilities to develop innovative solutions and applications that ride on that network—and the R&D can be spread over hundreds of participants. Pilot results and best practices can be shared and final solutions adjusted such that they meet the needs of the most players for the lowest cost.

A coordinated effort for an interoperable, standardized, broadband wireless solution—with a clear migration path to future technology standards—should yield a win-win-win-win for utilities, vendors, regulators, and customers.

# Section 3
# PRIVATE WIRELESS OPTIONS FOR UTILITY NETWORKS

## 3.1 Possible Utility Broadband Spectrum Bands

Numerous spectrum bands might be suitable for coordinated broadband wireless solutions for utilities and other critical infrastructure providers in the US. The most relevant are described in the following sections. A primer on wireless licensing practices can be found in Section 5, "Appendix A."

### 3.1.1 406 MHz-420 MHz

The UTC has advocated for the shared use of licenses held by the federal government at 406 MHz-420 MHz, noting that it has sufficient capacity and would provide favorable coverage for utilities to communicate over wide areas. The band is in a similar frequency range as many existing utility ultra-high frequency (UHF) systems, which would allow utilities to leverage existing infrastructure. It is supported by several wireless standards, but not LTE.

The UTC and utilities are proposing to share 406 MHz-420 MHz spectrum with federal government users. They have shared this proposal with the National Telecommunications and Information Administration's (NTIA's) Interdepartmental Radio Advisory Committee.

The UTC notes that spectrum sharing would enable use more quickly than reallocating and that it would also avoid disruption of federal government incumbents. It also says that usage by federal employees is light, indicating that there is ample capacity for shared use.

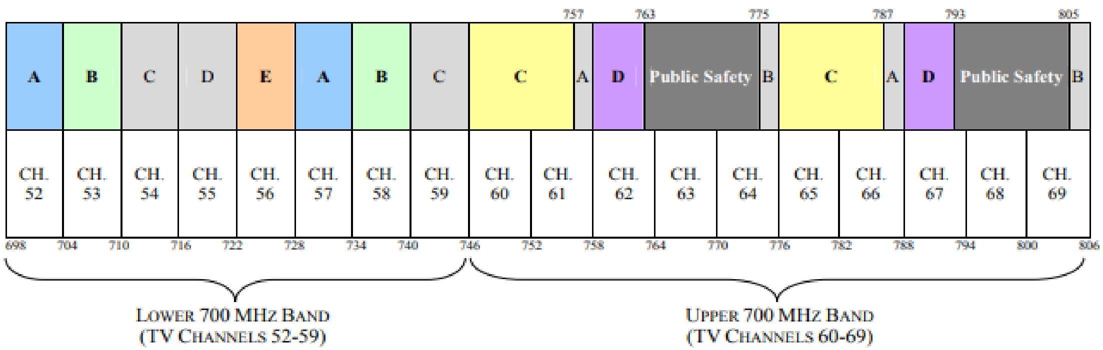
### 3.1.2 450 MHz-470 MHz

In the US, Aclara owns hundreds of licenses in this band with which it offers its Synergize radio frequency (RF) point-to-multipoint (Pt2MPt) smart grid communications solution. The 450 MHz band has also been widely used by utilities outside the US; as such, infrastructure is available through multiple vendors.

### 3.1.3 700 MHz (Multiple Bands)

Several swaths of 700 MHz spectrum have been considered or are in use by US utilities.

***Figure 3-1. 700 MHz Band Plan***




*(Source: Federal Communications Commission)*

#### *3.1.3.1 Public Safety (FirstNet)*

There have been efforts on the part of the UTC and some networking vendors to urge sharing of the FirstNet 700 MHz Public Safety Broadband Network with utilities. 20 MHz of spectrum, assigned to public safety organizations by the FCC, will be built out with an LTE network by AT&T over the next 5 years at a cost of $40 billion. At the end of 2017, AT&T announced that all 50 states, 2 territories, and Washington, DC had opted into the FirstNet plan. Despite the efforts of the UTC and some utilities, however, utilities are not confident that they would have priority access to the network or operational control of the network—making it untenable for most utilities.

An organized arrangement with FirstNet would provide the nationwide high bandwidth, compatible network utilities need. Yet, without guarantees of priority access, a widespread partnership between utilities and FirstNet seems unlikely.

#### *3.1.3.2 Utility-Telco Partnerships*

In 2008, the FCC auctioned off nearly 1,100 licenses in the A, B, C, and E blocks of the 700 MHz band, raising more than $19 billion. While the majority of these licenses were acquired by carriers, many were also purchased by independent telephone companies. In some cases, utilities have partnered with the local telco to share the LTE network. Green Mountain Power in Vermont is one example. Because most of these licenses are held by carriers, however, the opportunity for a coordinated nationwide scheme is limited.

#### 3.1.3.3 *Upper A Block*

The Upper A block (757 MHz-758 MHz/787 MHz-788 MHz) licenses are available across much of the US. They have been acquired by several utilities, including FirstEnergy, Great River Energy, Northwestern Energy, Portland General Electric, and Salt River Project (SRP).

The 700 MHz Upper A block is allocated in a 1x1 MHz paired block of spectrum. The band is affordable and available, but limited by a total of just 2 MHz of capacity. SRP was one of the early movers in the 700 MHz Upper A block, buying its license in early 2015. The company plans to use it for various applications, including volt/volt-ampere reactive control, feeder automation, circuit sensors, remote fault indicators, and eventually, to connect thousands of smart solar inverters. It acknowledges, though, that with just 2 MHz, the license does not provide enough capacity to support its AMI network.

### 3.1.4 800 MHz

800 MHz Specialized Mobile Radio (SMR) spectrum was traditionally used by dispatch radio system operators, including police and other emergency service providers, along with private dispatch operators such as taxi cab companies. Throughout the 1990s and early 2000s, many of these licenses were aggregated by Nextel, which was acquired by Sprint in 2005. The FCC adopted a comprehensive plan in 2004 to reconfigure the band to protect access by public safety agencies. While Sprint owns the bulk of these licenses today, Southern Company subsidiary Southern Linc has operated in the band since the 1990s in portions of the four states where its regulated electricity sister companies operate.

#### 3.1.4.1 *Southern Linc*

Southern Linc owns more than 400 SMR licenses in the 800 MHz band and has operated as a regional carrier using Motorola's Integrated Digital Enhanced Network (iDEN) technology since 1996. iDEN is the push-to-talk technology originally deployed by Nextel. Sprint shut down the iDEN network in 2013.

Southern Company is the parent of four electric utilities in the Southeast: Alabama Power, Georgia Power, Gulf Power, and Mississippi Power, which are also Southern Linc customers. In addition, Southern Linc provides wireless communications service, including mobile phones, to a wide range of businesses and consumers across Alabama, Georgia, southeastern Mississippi, and the Florida Panhandle.

Today, Southern Linc is building a private LTE network to replace the outdated iDEN system and has said the new CriticalLinc LTE network will be operational in 2018. Ericsson and Cisco are the vendors.

The CriticalLinc private LTE broadband network will be used by Southern Company utilities for numerous use cases, including AMI backhaul, C&I metering, distribution line devices, transmission line devices, transmission and distribution substation connectivity, smart street lighting, gas metering, transmission tower lighting, transformer monitoring, and more.

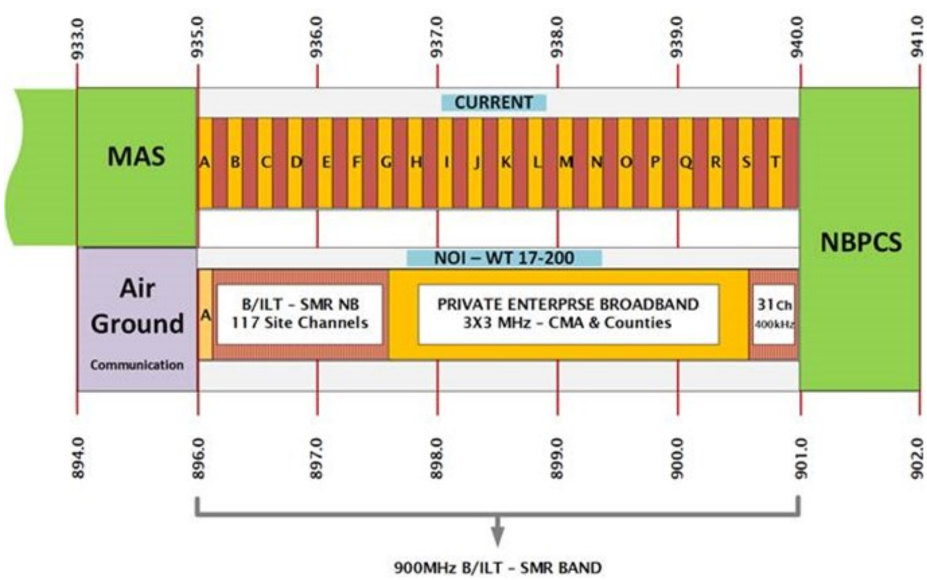
### 3.1.5 900 MHz

In 2014, pdvWireless (PDV), along with the Enterprise Wireless Alliance (EWA), petitioned the FCC for a realignment of the 896 MHz-901 MHz and 935 MHz-940 MHz bands to create a private broadband allocation for critical infrastructure concerns, including utilities. PDV is a national wireless provider that delivers commercial workforce solutions using licensed 900 MHz band spectrum.

In May 2018, PDV filed a modification to its original realignment petition that could facilitate bringing this spectrum opportunity to the critical infrastructure community more quickly, giving utilities the option to gain broadband spectrum licenses. Presently, the 900 MHz band is divided into narrow, dispersed channels, but PDV has proposed the FCC realign the band such that it will include a 3x3 MHz broadband channel within the 5x5 MHz band allocation. The modified plan leaves a total of 4 MHz of 900 MHz spectrum within the band allocation for existing narrowband applications and services, including utilities that utilize land mobile radio (LMR) systems in those frequencies.

Many utilities support the PDV proposal and agree that the 3 MHz wide paired bands would provide valuable capacity for utility networking needs. Figure 3-2 shows the PDV spectrum realignment proposal. A decision by the FCC on realignment is expected in 2018.

***Figure 3-2. EWA/PDV Proposed Spectrum Reallocation***




*(Source: pdvWireless)*

### 3.1.6 3.5 GHz Citizens Broadband Radio Service (CBRS)

In 2015, the FCC authorized the use of the 3.5 GHz band (3,550 MHz-3,700 MHz) for shared wireless access, opening previously protected spectrum used by the US Navy and other US Department of Defense (DoD) members. However, the spectrum is not yet available due to ongoing debate over the proposed license sizes. Furthermore, the Citizens Broadband Radio Service (CBRS) band is unique due to its shared spectrum assignment characteristics.

To use CBRS spectrum, one must request and be assigned a band by a spectrum allocation server (SAS) programmatically. The SAS calculates RF density and channel availability using terrain and radio propagation data before authorizing the request. When the use of the spectrum is no longer required, the channel is freed up for use by other requesters. At the end of 2016, the FCC approved seven SAS system administrators: Amdocs, Comsearch, CTIA-The Wireless Association (CTIA), Federated Wireless, Google, Key Bridge, and Sony Electronics. As of early 2018, standards and certified devices and the SAS are pending.

FCC rules define three levels of priority access in descending order for assigning use of CBRS spectrum:

- **Incumbents:** Existing users (e.g., US Naval Radar, DoD) get permanent priority as well as site-specific protection for registered sites.
- **Priority access licenses (PALs):** Organizations can pay a fee (at auction) to request up to four PALs in a limited geographic area for 3 years. Only the lower 100 MHz of the CBRS band will be auctioned off, with restrictions of a maximum of seven concurrent 10 MHz PALs allocated within the same region. The cost of PALs will be proportional to the population density of the geographic location, which enables rural network operators to protect their license at a lower cost. This rule is currently pending modification at the FCC.
- **General authorized access (GAA):** The rest of the spectrum will be open to GAA use, and coexistence issues will be determined by SAS providers for spectrum allocation.

The result of the CBRS band is that PALs should cost less than traditional licensed spectrum, making it easier for private entities such as utilities to access. However, all the major cellular carriers are also interested in accessing the 3.5 GHz band. In February 2018, Comcast filed with the FCC to test CBRS equipment in support of its mobile offering.

Furthermore, the CBRS band includes spectrum at 3.65 GHz, where many utilities have existing networks. High demand for the CBRS band may make it difficult for a coordinated nationwide standard network to be realized.

### 3.1.7 4.9 GHz

The UTC has been actively working to get the FCC to make public safety bands at 4,940 MHz-4,990 MHz accessible by utilities. In late 2016, it filed comments in support of a proposed band plan put together by the National Public Safety Telecommunications Council that would make utilities eligible to hold these licenses.

In March 2018, the FCC issued a draft version of a Further Notice of Proposed Rulemaking that considers expanding eligibility in the 4.9 GHz band to include utilities. A ruling is expected later in 2018. For now, utilities can only access the band if they are endorsed by a governmental entity (i.e., public safety) and they use the network in support of public safety. The only exception is for municipal utilities, which can apply for a license themselves. Even upon FCC approval of utility access to 4.9 GHz spectrum, however, public safety organizations will have first priority in the band.

## 3.2 Pros and Cons of Possible Coordinated Utility Broadband Spectrum Bands

Table 3-1 summarizes the relevant characteristics of the spectrum bands described in Section 3.1 and summarizes their overall suitability for a nationwide broadband wireless network dedicated to utilities and grid modernization.

***Table 3-1. Spectrum Band Suitability for Utility Broadband Wireless Networks across the US***

| Spectrum Band | Spectrum Position | Nationwide Availability? | Adequate Capacity? | Utility Priority? | Breadth of Applications Supported | Est. Availability for Broadband | Overall Suitability for Utility Applications |
|---|---|---|---|---|---|---|---|
| 406 MHz-420 MHz | Good propagation; antennas may be large | Yes, if approved by the NTIA | Yes | No; shared access | Unknown | 5-10 years | Medium if approved; shared access and infrastructure challenges |
| 450 MHz-470 MHz | Poor; licensing is too fractured | No, disparate licensees, including smart grid vendor Aclara | No, due to large number of incumbent LMR users | Yes, if owned or leased | Good | Unlikely for broadband | Medium; licenses not available nationwide |
| 700 MHz (FirstNet) | Very good; LTE standards exist | Yes, in theory; in practice, local partnerships required | Yes | No; public safety priority access | Good | 3-5 years | Low without utility priority access agreements |
| 700 MHz (Upper A Block) | Very good; WiMAX technology being developed to serve | Nearly nationwide available; some utilities have already acquired | 2 MHz not typically adequate for all utility needs | Yes, if owned or leased | Moderate | Available, but not for broadband | Medium; inadequate capacity for long term |

| Spectrum Band | Spectrum Position | Nationwide Availability? | Adequate Capacity? | Utility Priority? | Breadth of Applications Supported | Est. Availability for Broadband | Overall Suitability for Utility Applications |
|---|---|---|---|---|---|---|---|
| 700 MHz (Telco Partnership) | Very good; LTE standards exist | No | Yes | Yes, if provided by contract | Good | Available if negotiated | Low; no nationwide opportunity |
| 800 MHz | Very good; LTE standards exist | No | Yes | Yes, if provided by contract | Good | Mostly owned by Sprint | Low; no nationwide opportunity |
| 900 MHz | Very good; LTE standards exist | Yes, if PDV spectrum realignment approved | Yes, if PDV spectrum realignment approved | Yes, if owned or leased | Good | ~2 years if spectrum realignment approved | High if spectrum realignment approved |
| 3.5 GHz CBRS | Lower propagation; requires more cell sites | Yes | Yes | No; shared access | Moderate | 2-5 years Proceeding ongoing at FCC | Medium; high demand for access by carriers and other mobile operators |
| 4.9 GHz | Lower propagation; may require line of sight | Yes, if approved by FCC | Yes | No; shared access | Low, substation connectivity and backhaul | FCC order expected in 2018 | Medium; limited useful applications and shared access |

*(Source: Navigant Research)*

## 3.3 LTE Is the Technology of Choice

A multitude of connectivity choices are available to utilities today, as discussed throughout this paper. But only one standard can meet all the needs of utilities wishing to deploy a holistic, interoperable, broadband network across their territory for a multitude of applications and at a reasonable price: LTE.

LTE technology has emerged as the de facto standard for commercial wireless carriers worldwide and is widely deployed across a variety of spectrum bands, including 600 MHz, 700 MHz, 800 MHz, 850 MHz, 900 MHz, 1.7 GHz, 1.8 GHz, 1.9 GHz, 2.3 GHz, 2.5 GHz, and 2.6 GHz. As a result, LTE-compatible infrastructure equipment and user devices are manufactured in high volumes by many companies, and competition has driven down prices. LTE networks have been in large-scale commercial operation for many years, so new networks can be deployed with minimal technical risk. Furthermore, new spectrum bands are regularly added to the 3GPP LTE standard association's list of standard bands for LTE. Several of the bands discussed in Section 3.1 are served by LTE-based systems.

The technical evolution and refinement of LTE standards are ongoing and will continue for at least another decade. Robust product support for LTE infrastructure should continue for an additional 10 years or more. In contrast, the other 4G network standard in use by some utilities—WiMAX—is not widely adopted, and it is questionable how much longer vendors will support the standard (outside of specialized use cases, predominantly in airports).

Furthermore, vendors are creating a backward-compatible migration path for LTE to transition to the next-generation technology—5G—which will become widely available over the next decade.

LTE offers the data speeds, technical flexibility, signal prioritization, and security necessary for utility applications. It provides both fixed and mobile service and over-the-air upgrades facilitate network optimization and maintenance. Enormous global volume in production today makes LTE the most economical network to offer such flexibility. In its 2015 report *Assessment of Licensed Communication Spectrum for Electric Utility Applications,* EPRI only considered LTE technology in evaluating spectrum options for utility FANs.

Due to these many benefits, private LTE networks are of growing interest to utilities in the US. But because of the lack of consensus around and availability of suitable spectrum for utilities, few private networks have been completed to date. Some utilities are considering unlicensed LTE options that are also under development. As described previously, however, unlicensed spectrum brings its own set of risks over the longer term.

# Section 4
## INDUSTRYWIDE COORDINATION IS IMPERATIVE

The electric power industry across the US is highly fractured, with nearly 3,200 individual companies overseen by 50 state-level regulatory bodies as well as numerous federal agencies. The level of maturity when it comes to smart grid technology deployment ranges widely across the country and within each state, as do demands upon power networks and priorities for solution deployment. Availability of adequate internal resources for networking, and cybersecurity in particular, also vary widely.

That said, C-suite executives at every single utility in the country today understand how their business is changing. For some, the impacts are clear already, as in Hawaii, where residential solar penetration reached 20% in 2017. Elsewhere, pure economics may drive decisions for, as an example, smart meter deployments. But the writing is on the wall when it comes to how the power utility industry will be disrupted over the next decade.

To meet the resiliency and security challenges described in this paper and reinvent their businesses in the face of growing competition and a rapidly changing operating dynamic, utilities will require a robust holistic broadband wireless network across their territories. And to achieve that goal in the most efficient and mutually beneficial way, industrywide coordination and advocacy is needed.

The UTC supports utility efforts with the FCC and has supported numerous proposed spectrum bands for utility use. But not all these options meet all the needs and priorities of power utilities, particularly the need for standardization and interoperability nationwide. Several spectrum bands described in Section 3.1 could do the job—if the industry and the FCC, as well as state regulators, agree to fight for access to the appropriate licensed spectrum bands. Utilities need priority access to a broadband allocation of spectrum where they can own or lease the spectrum, controlling their own networks and deployments. They must also be able to coordinate with neighboring utilities and third-party DER providers.

Coordination with other critical infrastructure providers—water and gas, for example—could strengthen the case with the FCC. And loosened restrictions on new service offerings—such as providing commercial wireless service to third parties, as in the Southern Company example—would go a long way toward justifying the economics of investing in licensed spectrum and building a private LTE network for critical infrastructure.

As of today, such activity is restricted in roughly 20 states thanks to litigation on the part of cable and telco broadband service providers. But in Chattanooga, Tennessee, where the Electric Power Board (EPB) has deployed a fiber-to-the-meter broadband network throughout its territory, those commercial broadband revenues have supported a network that has created billions in economic value and saved millions of outage minutes. This

Utelco model makes economic sense for power utilities that need a dedicated broadband wireless solution. It also makes sense for their customers, who will benefit from improved power reliability, efficiency, and customer service, as well as lower rates.

Access to adequate licensed spectrum is the first step. By working together, utility executives, state and federal regulators, FCC commissioners, and networking vendors have a chance to help this vision come to fruition.

# Section 5
# APPENDIX A

## 5.1 Spectrum 101

Radio spectrum—the airwaves around us—used for wireless data transmission ranges from the single kilohertz (kHz) level all the way up to hundreds of gigahertz (GHz).

### 5.1.1 Licensed, Unlicensed, or Shared

In the US, spectrum is carved into hundreds of thousands of licenses divided into hundreds of licensed and unlicensed bands with defined use cases. The FCC oversees spectrum allocation, use case definitions, licensing, and auctions. Newer spectrum-sharing schemes have also been approved. Each of these means of accessing spectrum is described below.

#### *5.1.1.1 Unlicensed Spectrum*

In spectrum that is designated as unlicensed or license-exempt, any user can operate in the band without a government-issued license. They must, however, use certified radio equipment and comply with technical requirements, including transmission power limits. This is to minimize interference; yet, because users do not have exclusive access to the spectrum, as usage increases, the likelihood of interference grows. Range limits and higher latency may also result.

Unlicensed bands commonly used by utilities are typically in what are known as the industrial, scientific, and medical (ISM) bands. These include the 902 MHz-928 MHz band, the 2.4 GHz band, and the 5.8 GHz band.

#### *5.1.1.2 Licensed Spectrum*

Licensed spectrum allows for exclusive use of frequencies or channels in specific locations. They generally offer higher transmit power (which also means fewer nodes and lower infrastructure costs) and better signal-to-noise ratios.

In the US, the rights to use commercial spectrum have generally been auctioned and licensed by geographic area, such as Economic Areas (EAs) or Cellular Market Areas (CMAs), among others. They may be vast—there are only six Economic Area Groupings (EAGs) nationwide in the US. Or they may be made up of only a few counties (e.g., there are more than 700 CMAs in the US). These areas may also be further divided into smaller licenses by dividing the band into narrower spectrum slices (disaggregating) or dividing the geographic area into smaller regions (partitioning; e.g., into a single county or an even smaller area).

Licensed spectrum bands (or partitioned or disaggregated portions of the license) may be bought and sold or leased. Approval by the FCC is needed for transfer or lease of a license, although there are streamlined procedures under certain circumstances.

Many utilities own licensed spectrum. Yet, as the spectrum needs of mobile carriers have grown exponentially over the past 2 decades, the cost of acquiring licensed spectrum has also increased dramatically—and utilities' ability to acquire them has been reduced.

There are two ways a utility may use licensed spectrum in its networking: it may acquire infrastructure and services from a vendor that owns the spectrum and leases it to the utility, or it may acquire its own licenses and equipment and deploy and operate independently. Many utilities do both, using different bands and technologies for different applications.

#### *5.1.1.3 Shared Spectrum*

Finally, in addition to strict licensed and unlicensed options, newer shared spectrum options are emerging. Spectrum sharing is the simultaneous usage of a specific RF band in a specific geographical area by several independent entities, leveraged through mechanisms other than traditional multiple- and random-access techniques. In addition to governmental regulatory bodies like the FCC, private companies such as Google, Intel, and Qualcomm are promoting shared spectrum standards.

The bands being explored are typically underutilized, such as 150 MHz partially controlled by the US military at 3.5 GHz, also known as CBRS. Table 5-1 summarizes the characteristics of licensed, unlicensed, and shared CBRS spectrum.

***Table 5-1. Traditional Licensed and Unlicensed Spectrum vs. CBRS***

| Metric | Licensed | Unlicensed | CBRS |
|---|---|---|---|
| License Rights | Exclusive | Non-exclusive | Use it or share it |
| License Area | Defined geographies | N/A | Variable, with real-time management |
| License Cost | Variable | Free | Monthly fee for SAS, additional local protection for a fee at auction |
| Enforcement | Regulatory | Power limits | Central coordination service (SAS) |
| Technologies | LTE, GSM, CDMA, Pt2MPt, LMR | Wi-Fi, MulteFire | LTE |
| Deployed by | Carriers, critical infrastructure, public safety | Anyone | Enterprises, carriers, managed service providers |

*(Source: Navigant Research)*

### 5.1.2 Low-Band versus High-Band

A broad range of spectrum bands can be used in utility applications. The most relevant—in terms of propagation and corresponding infrastructure—for a dedicated utility broadband network generally lie below the 3 GHz level. However, bands as high as 4.9 GHz have been proposed by the UTC.

Low-band spectrum generally refers to those frequencies below 1 GHz. Sub-1 GHz bands are particularly attractive because of their strong propagation characteristics.

Greater propagation means that fewer cell sites can cover a similar geography versus spectrum at higher frequencies, which translates to lower costs. That said, at very low levels (sub-400 MHz), the infrastructure (antennas) becomes very large, making it more difficult to deploy, particularly in an urban environment. Another problem with the use of very low frequencies is that they tend to penetrate manmade structures with minimal attenuation. While this enhances coverage, lack of propagation restriction also makes it more difficult to intensely reuse spectrum in dense urban areas where such reuse might be necessary to achieve the required network capacity.

At the higher spectrum bands, from 1.8 GHz and higher, the main constraint is that the signal may be severely attenuated by urban structure—in other words, they require more infrastructure. For frequencies above 3 GHz, coverage tends to become largely limited to line of sight. Thus, for robust coverage in these bands, cell sites must be closer together and coverage per square mile will cost more.

### 5.1.3 Narrowband versus Broadband

Many utility applications have historically been well-served by narrowband networks. Where very low latency communications were needed (e.g., for teleprotection applications), a wired connection has often been used. For example, landline or T-1 connections from the local telco were often leased for critical substation/SCADA communications.

Increasingly, however, utilities need greater bandwidth—even beyond the substation. At the same time, telcos are sunsetting their leased line businesses, leaving utilities scrambling to replace those critical connections. But the business case for fiber cannot always be made, particularly in dense urban environments. Fiber to the substation also does not achieve coverage throughout the distribution grid, where so many new applications are found.

A single broadband network with adequate capacity can serve utilities' high bandwidth needs (e.g., video cameras for security at critical substations). It can also serve as the network for lower capacity data transmissions from smart meters, connected solar inverters, distribution line and transformer monitors, asset health and management sensors, and more.

### 5.1.4 Public Carrier Spectrum

In the US, public cellular networks are not popular with utilities for a variety of reasons. Because public networks are built first and foremost for the needs of mobile subscribers, utilities have not always been able to obtain the service-level agreements needed to guarantee reliability for critical applications. Pricing was also historically high, and the monthly service model prevented utilities from earning a return on CAPEX.

More recently, there have been some efforts on the part of public carriers to attract utility interest in dedicated access to their licensed spectrum bands through lease agreements for a disaggregated or partitioned swath. The leased spectrum model provides the utility with dedicated access to the band and may also be structured as a capital investment, so the utility may recover the cost in a rate case.

The most notable effort was AT&T's and Nokia's announcement in February 2016 that they would partner to offer utilities dedicated spectrum and infrastructure for private LTE networks. While there was utility interest, AT&T has since backed away from the partnership possibly due to limitations and issues with the neighboring Sirius XM satellite radio network. To date, there have not been any major announcements between utilities and carriers for spectrum leases for private FANs.

Section 6
# ACRONYM AND ABBREVIATION LIST

2G .......... Second Generation

3G .......... Third Generation

3GPP .......... 3rd Generation Partnership Project

4G .......... Fourth Generation

5G .......... Fifth Generation

AMI .......... Advanced Metering Infrastructure

C&I .......... Commercial and Industrial

CAPEX .......... Capital Expenditure

CBRS .......... Citizens Broadband Radio Service

CDMA .......... Code-Division Multiple Access

CEO .......... Chief Executive Officer

CMA .......... Cellular Market Area

CTIA .......... CTIA-The Wireless Association

DER .......... Distributed Energy Resources

DG .......... Distributed Generation

DoD .......... Department of Defense (US)

DR .......... Demand Response

DSO .......... Distribution System Operator

EA .......... Economic Area

EAG .......... Economic Area Grouping

EE .......... Energy Efficiency

EPB .......... Electric Power Board

EPRI ........ Electric Power Research Institute

EV ........ Electric Vehicle

EWA ........ Enterprise Wireless Alliance

FAN ........ Field Area Network

FBI ........ Federal Bureau of Investigation (US)

FCC ........ Federal Communications Commission (US)

FERC ........ Federal Energy Regulatory Commission (US)

FirstNet ........ First Responder Network Authority

GAA ........ General Access Authorization

GHz ........ Gigahertz

GSM ........ Global System for Mobile Communication

GW ........ Gigawatt

iDEN ........ Integrated Digital Enhanced Network

IoT ........ Internet of Things

IOU ........ Investor-Owned Utility

ISM ........ Industrial, Scientific, and Medical

IT ........ Information Technology

kHz ........ Kilohertz

LMR ........ Land Mobile Radio

LTE ........ Long-Term Evolution

MAS ........ Multiple Access Spectrum

MHz ........ Megahertz

NBPCS ........ Narrowband PCS

NERC CIP ........ North American Electric Reliability Corporation Critical Infrastructure Protection

NTIA ........ National Telecommunications and Information Administration

PAL ........ Priority Access License

PDV ........ pdvWireless

Pt2MPt ........ Point-to-Multipoint

PUC ........ Public Utilities Commission

QoS ........ Quality of Service

R&D ........ Research and Development

RF ........ Radio Frequency

SAS ........ Spectrum Access System

SCADA ........ Supervisory Control and Data Acquisition

SINE Lab ........ Signal, Information, Networks and Energy Laboratory

SLA ........ Service-Level Agreement

SMB ........ Small and Medium Business

SMR ........ Specialized Mobile Radio

SRP ........ Salt River Project

TSO ........ Transmission System Operator

UHF ........ Ultra-High Frequency

US ........ United States

UTC ........ Utilities Technology Council

VHF ........ Very High Frequency

WiMAX ........ Worldwide Interoperability for Microwave Access

# Section 7
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# Section 8
## SCOPE OF STUDY

Navigant Research has prepared this white paper to provide an independent analysis of the necessity of a coordinated, interoperable nationwide broadband wireless solution for critical infrastructure providers. It also aims to provide an evaluation of the licensed spectrum bands potentially available for such an endeavor. This Navigant Research white paper is intended for utility managers, PUCs and other regulators, FCC officials, power balancing authorities, and other critical infrastructure managers. It provides an objective assessment of why and how the need for dedicated broadband wireless spectrum and technology standardization for utility and critical infrastructure networks will expand in coming years.

## SOURCES AND METHODOLOGY

Navigant Research's industry analysts utilize a variety of research sources in preparing research reports. The key component of Navigant Research's analysis is primary research gained from phone and in-person interviews with industry leaders including executives, engineers, and marketing professionals. Analysts are diligent in ensuring that they speak with representatives from every part of the value chain, including but not limited to technology companies, utilities and other service providers, industry associations, government agencies, and the investment community.

Additional analysis includes secondary research conducted by Navigant Research's analysts and its staff of research assistants. Where applicable, all secondary research sources are appropriately cited within this report.

These primary and secondary research sources, combined with the analyst's industry expertise, are synthesized into the qualitative and quantitative analysis presented in Navigant Research's reports. Great care is taken in making sure that all analysis is well-supported by facts, but where the facts are unknown and assumptions must be made, analysts document their assumptions and are prepared to explain their methodology, both within the body of a report and in direct conversations with clients.

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