Case study

Spectrum simplified

What utilities need to know about spectrum

The utilities sector is experiencing major flux as it undergoes digital transformation. Utilities are investing in new technologies to modernize the grid and improve existing grid's security, reliability and resiliency.

As a result, utilities increasingly require access to a wireless network with superior coverage and adequate capacity to address their security, reliability and independence needs. One of the fundamental building blocks in any radio communications system is spectrum.

This guide is designed to demystify spectrum for utilities decision-makers. It will help you understand what spectrum is, the difference between licensed and unlicensed spectrum and how to choose among the many varieties of spectrum for different utilities use cases.

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Introduction

"Many utilities rely on wireless communications. Like any wireless network, utility ICT systems need radio-frequency spectrum to function, and the reliability of the wireless communications may be affected by radio-frequency interference. Therefore, access to adequate and interference-free spectrum is a requirement if these networks are to work as intended."

— Utilities Technology Council™ FCC filing, 2018

Smart grids get smart about spectrum

As providers of mission-critical services, utilities put a high priority on security, reliability and independence in the design of wireless network quality. Utilities want a network unaffected by the vagaries of a shared public consumer network and its load-dependent reliability.

As a result, utilities are adopting 3GPP technologies such as Private LTE (PLTE) as a primary communications technology for reliable and secure wireless networks. New innovations, driven by vendor research and development (R&D) investments, are fostering the growth of a broader ecosystem of interconnected networks and devices enabling the application of telecommunications networks to new industries and novel use cases. Radio spectrum enables and even defines this telecommunications ecosystem by setting the parameters for performance, reach and economics.

To understand the spectrum possibilities for the PLTE networks being deployed in Investor-Owned Utility (IOU) networks today and in the future, we must first investigate how spectrum is defined for use in standards, regulatory, administration and industry forums.

How utilities use wireless networks

Wireless spectrum can be leveraged by utilities to facilitate the communication and coordination of many of their operations. There are multiple use cases that can be served using wireless technologies for utilities, such as:

Smart grid—An intelligent electrical grid that uses both advanced communications and control techniques to optimize the operational efficiency of the generation, transmission and distribution resources. Utilities can use a wireless infrastructure to enable connectivity throughout the smart grid.

Distribution automation—Enablement of real-time communication between the grid and control center can help utilities to minimize disruptions in the field and better manage downtime. Distribution automation would involve very small amounts of traffic, but that could be continuous in nature (10s kbps).

Advanced metering—Remote monitoring and management of consumption can provide tools to the utilities that serve grid optimization and reliability by timely collection and processing of meter data. This is especially important to a Distributed Energy Resource (DER) where consumer-generated energy has to be balanced on the grid with power station generated energy. Advanced metering would involve small amounts of traffic (100s kbps) that is periodic, occurring multiple times an hour to few times a day.

Reduction of opex—PLTE enables predictive maintenance and remote monitoring of assets. Utilities can save time and money on truck rolls and proactively reduce the risk of safety incidents for workers. Asset management can help utilities optimize the use of their assets and reduce the need for new investments.

A private network that is tailored to serve the sensor and control needs of smart grid and enable audio/video monitoring of sensitive assets on the grid also enables the utility's workforce, such as engineers, technicians and other personnel, to communicate securely and efficiently with each other without any dependency on public networks.

Spectrum choices

Choosing your flavor of spectrum

Spectrum can be categorized into three main categories:

- Low-band (450 MHz–1 GHz)
- Mid-band (1 GHz–6 GHz)
- High-band (24 GHz–71 GHz)

The use cases govern the choice of spectrum for the wireless networks. An advanced 5G/LTE network of today typically supports all three ranges.
Based on the multiple use cases mentioned above, all three bands are applicable to utilities and can benefit the industry when setting up wireless infrastructure. Today, both low-band and mid-band are available to the industry.

Low-band:
In 2019, the FCC approved Anterix's proposal to transition its narrowband Land Mobile Radio (LMR) spectrum in the 900 MHz band to a contiguous block of PLTE airwaves designed to support mission-critical broadband applications for utilities and other enterprises. Referred to as B8 / B106 in 3GPP, this particular band is a valuable asset for the utilities industry and its use cases. Since low-band has the advantage of being able to propagate over long distances as well as penetrating indoors, it can provide the utilities with a macro footprint for their network. Recently in 3GPP to align with US allocations B106 was specified. This band aligns with the US allocation of 900 MHz by the FCC.

Another low-band available in the market is the upper 700 MHz A block. This is a narrowband (NB)-IoT band, defined as B103 that was added to 3GPP in 2022. This 1 MHz block can offer NB-IoT services that require low data rates and indoor penetration.

Mid-band:
CBRS is a lightly licensed spectrum that was released and auctioned in 2020 by FCC. It is a valuable mid-band spectrum in the range of 3550 MHz–3700 MHz that can complement the low-band.

As part of the auction, some utilities bought Priority Access Licenses (PALs). Beyond PALs, the spectrum also offers up to 80 MHz of general authorized access (GAA) licenses, which can also be used based on availability. The participation of utilities in the auction is an indicator of how valuable mid-band licenses are for their infrastructure.

	3550 MHz					3650 MHz		3700 MHz	
Federal / 5G	• Incumbent Access • Priority Access • General Authorized Access					• Incumbent Uses • General Authorized Access			C-Band
	10 MHz	10 MHz	10 MHz	10 MHz	10 MHz	10 MHz	10 MHz	10 MHz	
	10 MHz	10 MHz	10 MHz	10 MHz	10 MHz	10 MHz	10 MHz	10 MHz	

Each PAL is a 10 MHz channel in the 3550-3650 MHz band. No more than seven PALs per county, with a maximum of four 10 MHz PAL channels allocated to a single licensee.

High-band:
The 37.0–37.6 GHz is the lower band segment of the 37 GHz band. This segment will be fully available for use by both federal and non-federal users on a coordinated co-equal basis. Non-federal users, identified as Shared Access Licensees (SAL), will be authorized by rule. A sharing framework is yet to be adopted. This particular band can provide specific use cases for the industry that is more localized and requires high bandwidths and low latency.

Wireless spectrum is available in licensed, shared license and unlicensed forms

Licensed spectrum is auctioned by regulatory bodies such as the FCC and driven by high market demand to be highly priced. This spectrum is reliable as it is dedicated to use by a single provider.

Most spectrum has been acquired by carriers serving consumer traffic for smartphones and fixed wireless applications or is in use by defense organizations. Licensed spectrum in Band 8[1], Band 26 and, recently, in B41 has been acquired or leased by utilities.

Unlicensed spectrum, such as Wi-Fi, is built for use in real-time by any user that requires it, with mechanisms built in for coexistence of multiple simultaneous users. Unlicensed spectrum is considered unreliable for mission-critical applications due to the inherent risk of interference from multiple users sharing the unlicensed spectrum.

Utilities companies may choose to use unlicensed spectrum for certain applications, such as low-power wireless sensors for best-effort monitoring purposes.

Shared spectrum can be considered pseudo-licensed spectrum. It's provided for use by the commercial industry, but can be preempted for real-time use by the Department of Defense as needed. Utilities use cases that are non-mission-critical could be used in this spectrum, though access to shared spectrum is not guaranteed, under risk of preemption. Mid-band CBRS (3.5 GHz Band 48) is an example of shared spectrum.

1. This band number may change in the future due to ongoing 3GPP work items.

Licensed or unlicensed?

How much spectrum?

Which band should you play in? Factors to consider.

As with any wireless planning or deployment activity, a primary question is: How much spectrum is required? Two major aspects have to be considered to answer this question:

Coverage:
For the utilities use cases that are coverage-intensive, with devices in rural areas or installed deep within foliage or buildings, coverage is more important than speed/capacity. As shown in Figure 1, low-band spectrum provides increased coverage at the expense of speed/capacity.

Capacity:
For utilities use cases that need volumes of data to be sent to the network, capacity is important to allow for transmission in Mbps over a short period of time. Video surveillance of utilities assets or video communication from employees in the field are examples for such use cases. As shown in Figure 1, mid-band spectrum provides increased capacity due to larger channel bandwidths, but has reduced coverage due to its propagation characteristics. Carrier aggregation and new technology evolutions such as Uplink and Downlink beamforming are methods that can be used in some situations to increase coverage and capacity.

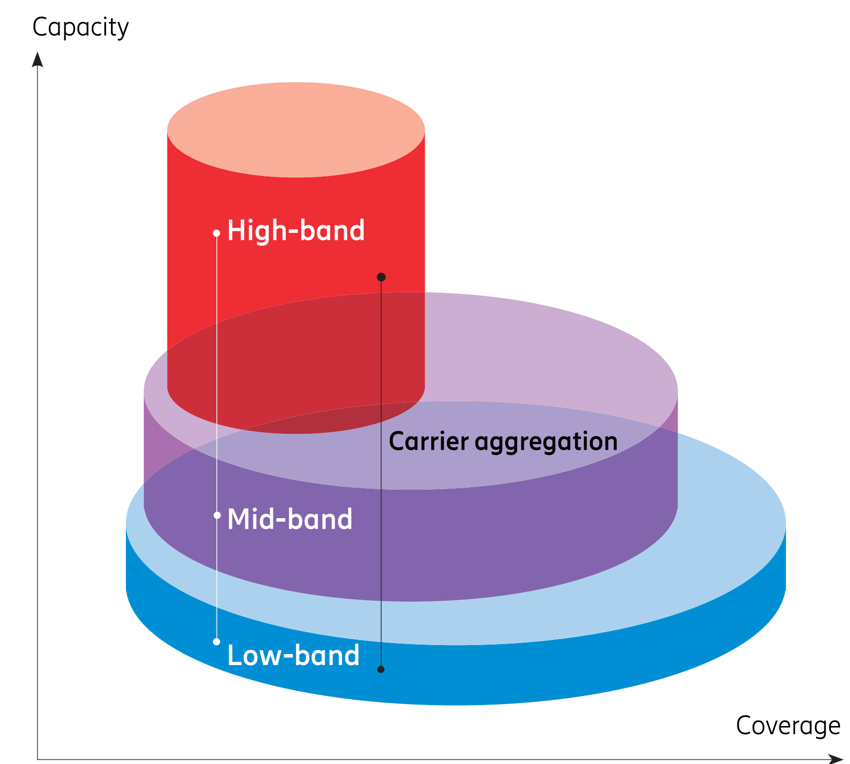


Figure 1: Low-band provides coverage, while mid-band provides capacity.

The amount of spectrum needed is directly correlated with the total volume of traffic to be carried by a single wireless site. LTE is a technology that schedules data per millisecond (ms) depending on demand, making it possible to service thousands of devices per minute (each device sends few kilobytes of information per minute) or hundreds of devices per minute (each device sends 10s of kilobytes of information per minute). In addition to this, if the devices communicate infrequently (as in the smart grid), the number of devices that can be served will be increased by a factor of 10x or greater by using sophisticated scheduling techniques with different quality of service and traffic model characteristics.

How do utilities decide which spectrum to use?

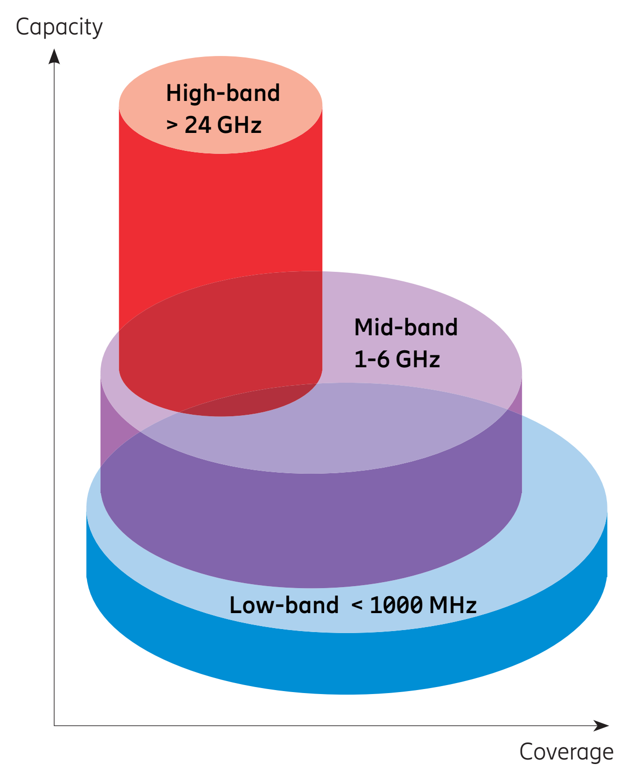
To select the optimal band for your application, consider the capabilities of the spectrum and the capabilities you require for your use case. For instance, do you need wide coverage or focused capacity? Mission-critical or non-mission-critical security? This chart sums up the key factors to consider.

Low-band for smart grid sensor applications:
Low-band spectrum (< 1 GHz or 1000 MHz) is well suited for most smart grid sensor applications with their needs for wide coverage, infrequent communication and relatively lower traffic volumes. The amount of spectrum recommended here is 3+3 or higher depending on the volume of traffic. As shown in Figure 2 on the right, coverage is high, capacity is lower and air interface latency is about 8 ms.

Mid-band for real-time communication traffic:
Mid-band spectrum (1 GHz–6 GHz) provides higher capacity and lesser coverage than low-band. For utilities applications that use real-time communication traffic, or higher volume video surveillance or drone traffic, mid-band spectrum provides focused capacity to supplement the coverage of low-band spectrum. The amount of spectrum recommended here is 10 MHz or higher, depending on the volume of traffic to be served—and could use shared spectrum like CBRS, if the traffic is non-mission-critical. As shown in Figure 2 on the right, coverage is medium, capacity is medium and air interface latency is about 6 ms.

High-band for real-time communication traffic:
While high-band spectrum (> 24 GHz, e.g., mmWave frequencies) has not been applied to utilities as yet, it has potential in 5G use for extremely low latency. The amount of spectrum recommended here is 50 MHz or higher depending on the volume of traffic. As shown in Figure 2 on the right, coverage is low, capacity is high and air interface latency is about 2 ms.

Spectrum	Best suited for	For applications requiring	Amount of spectrum
Low-band	Smart grid sensor applications	Wide coverage, infrequent communication and lower traffic volumes	3+3 MHz / 5+5 MHz
Mid-band	Real-time communication traffic, higher volume video surveillance, drone traffic	Focused capacity to supplement the coverage of low-band spectrum.	10 MHz or higher, or shared spectrum such as CBRS
High-band	Low latency applications deployed in a specified footprint	Use cases that need a latency of <10 ms with focused coverage	100 MHz or more of mmWave spectrum



5G/ NR	SCS (kHz)	Slot duration	Example carrier
LB	15	1 ms	900 Mhz
MB	30	0.5 ms	CBRS (B48), B41
HB	120	0.125 ms	mmWave

Downlink accumulated one way radio interface delay for 5G/NR UE with basic capabilities (ms)

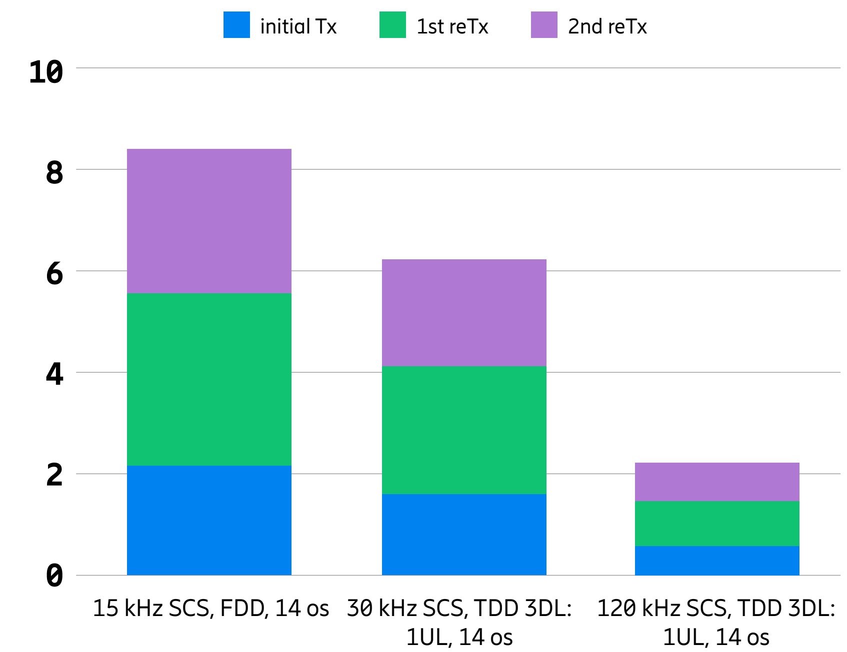


Figure 2: Subcarrier spacing (SCS) correlates to latency and reduces with increasing frequency.

Calculating ROI

Why "MHz per pop" isn't a good currency: A techno-economic analysis for spectrum

When planning your wireless communication infrastructure, cost is a key component that can either hinder or promote the use for utilities, since fees can be a significant expense for utilities.

The lessor of the spectrum to utilities should look at models that promote the affordability of their spectrum to targeted geography and offer leases that are cost-effective for the utilities. The service territories for utilities do not always align with how spectrum has been allocated.

Utilities might ordinarily use MHz per pop to calculate ROI. After all, MHz/pop calculation is historically tied to return on investment in consumer applications expected to be deployed on consumer/smartphone-focused spectrum assets. Higher population densities for a given region means faster ROI, leading to a higher MHz/pop measure. This model, however, does not map to spectrum leased or sold to utilities.

A better model for calculating cost and ROI

Although there is a correlation to number of smart grid devices to the population density in an area, the investment in critical infrastructure should also be the price driver for the spectrum, rather than ROI-focused MHz/pop.

A better measure of the scope of device coverage in a geography is the number of substations covered in the transmission/distribution grid and the number of communities served in the distribution/Advanced Metering Infrastructure (AMI) grid. The number of Distributed Energy Resource (DER) assets forecasted in the distribution grid is another consideration.

One other factor should be considered: the criticality of grid modernization, based on age of the present grid infrastructure. Classification of a certain geography for urgent modernization as compared to an area with more recent infrastructure could be a market driver in setting the market price for spectrum there.

A combination of these approaches leads to a MHz/device model that is fine-tuned based on the criticality for wireless grid modernization in the geography where the spectrum is being leased/auctioned. This model would result in a higher price for spectrum in rural areas where there are more smart grid devices per capita with single family dwellings, balanced by a lower price in metro areas where there are fewer smart devices per capita with multi-family dwellings.

Why do I have to pay for spectrum in a state when I only need three sites?

Spectrum is sold in economic areas today that may vary in size, based on auction strategy for the specific licensed spectrum. The county level is usually the minimum size. Keeping a minimal geographic size to spectrum allocation actually works well from a wireless network design standpoint. Having a minimum size for the average wireless site helps avoid interfering wireless coverage between sites.

A prudent minimum geographic coverage for license should consider the right combination of areas of coverage for a municipal co-op (covering the part of a county) and an IOU (covering a major part of a state). One can address this by allowing for flexibility in sub-leasing spectrum in parts to the smaller municipal utilities, which have more limited geography for the spectrum. This would enable quicker adoption of spectrum by smaller utilities, leading to acceleration in wireless grid modernization.

Final considerations for your spectrum decision

In this guide, you've learned the basics for making an informed decision about your spectrum needs. Spectrum comes in three "flavors":

- Low-band (450 MHz–1 GHz) is best for use cases requiring communication over long distances and indoors.
- Mid-band (1 GHz–6 GHz) includes CBRS to complement low-band.
- High-band (24 GHz–71 GHz) offers solutions for localized, high-bandwidth and low latency use cases.

Licensed spectrum should be considered by utilities for its reliability, security and mission-critical performance, but utilities may choose unlicensed spectrum, including Wi-Fi, for certain applications. Among the options in licensed spectrum, 3GPP-based PLTE and private 5G networks provide the widest range of solutions for utilities' mission-critical applications.

Conclusion

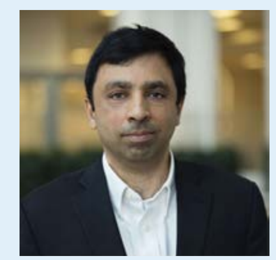
Making the most of your spectrum

As spectrum occupies the lion's share of a utility's investment in wireless grid modernization, it is important that it is selected based on use case capacity and coverage. Having a price point for leased spectrum that is proportional to the size of the smart grid would enable the rapid adoption of PLTE in the smart grid.

Ericsson has extensive experience collaborating with utilities to accelerate LTE and 5G solutions for power, gas and water utilities. Our cellular technology is empowering energy utility companies to adapt to a rapidly changing technological and business environment through digital transformation.

Learn more about Ericsson's solutions for utilities.

Authors



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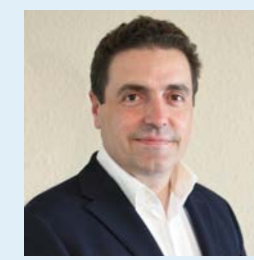
Gautam focuses on delivering innovations that bring wireless and advanced communications to grid modernization through his deep expertise around enabling technology transformation, developing global mobile broadband solutions, strategy and 3GPP standards.



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Michael is an instrumental figure in the development of 4G and 5G technology solutions for mission-critical networks at utility companies. With over 20 years of experience in the telecommunications industry, Michael has garnered valuable insights on harnessing the power of 4G and 5G technologies for utilities and the modernization of the energy grid. He is a respected leader in driving innovation and progress of telecommunications in the energy utilities sector.

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