US CITEL PCC II

FACT SHEET

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Document Title: REPORT OF THE ELECTRONIC CORRESPONDENCE GROUP TO STUDY THE SPECTRUM NEEDS FOR THE CONTINUAL MONITORING, CONTROL AND PROTECTION OF THE CRITICAL INFRASTRUCTURE USED BY UTILITIES

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Purpose/Objective: To a) review the existing studies within the ITU-R and ITU-T on the topic of importance of the need of spectrum for the continual monitoring, control and protection of the critical infrastructure used by utilities (Reference: Input contribution 3926); and b) consider future action within CITEL and/or the ITU in order to promote the use of these applications, including measures such as harmonization of spectrum.

Abstract: During the last PCC.II meeting in Ottawa, Canada on August 21, 2015, CITEL decided to create an electronic correspondence group within the Terrestrial Fixed and Mobile Working Group to study spectrum needs for the continual monitoring, control and protection of the critical infrastructure used by utilities. This document is the report of the electronic correspondence group to the PCC.II meeting Bogota, Columbia.

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REPORT OF THE ELECTRONIC CORRESPONDENCE GROUP TO STUDY THE SPECTRUM NEEDS FOR THE CONTINUAL MONITORING, CONTROL AND PROTECTION OF THE CRITICAL INFRASTRUCTURE USED BY UTILITIES

Introduction

Utilities around the world operate private communications networks to support the safe, secure and reliable delivery of essential electric, gas and water services to the public at large.

Utilities use wireless technologies, for voice, control and data communications to support the operation of their critical systems. However, as described more fully below, they lack access to sufficient and suitable spectrum to support the ever-growing demand and heightened performance requirements associated with system visibility, operation and management, e.g. smart grids.

Existing spectrum is narrowband (e.g. channels of 25 kHz bandwidth, or less) and is subject to interference and congestion from a wide variety of other co-channel and adjacent channel operations, because the spectrum is shared with a broad class of industrial/business operations and those operations are coordinated in close geographic and spectral proximity to one another. Non-wireless alternatives are impractical for many applications due to the desired service area coverage and cost. For example, it is impractical to run fiber and other non-wireless technologies to millions of smart grid devices, many of which may be located in remote and otherwise inaccessible areas over wide utility service territories. Finally, public communication service offerings often do not meet utility standards for service levels and/or performance requirements, particularly for mission critical applications that ensure reliability and safety of energy and water services. For example, public communications communication service offerings do not have the same back-up power (e.g. 72 hours of back-up power at every wireless site) as utility communications systems, and they do not meet latency requirements (e.g. 20 ms or less) to support certain utility applications.

Utilities urgently need access to additional spectrum that can support higher capacity applications and provide sufficient coverage over a wide area in order to fulfill regulatory and industry requirements related to safety, reliability, efficiency, security, and environmental quality. In order to provide sufficient capacity, utilities will need access to spectrum in wider blocks that are contiguous or nearly contiguous with each other. In order to provide suitable coverage, utilities will need access to spectrum in a frequency range that provides favorable propagation and is not subject to line-of-sight limitations (i.e. spectrum in a frequency range below 2 GHz). The need for this spectrum is urgent because regulatory and industry demands, such as those that require utilities to reduce carbon emissions -- will drive a proliferation of wireless devices all across energy and water distribution infrastructure. That will increase the need for coverage and capacity dramatically.

Utilities are implementing additional renewable sources of energy, such as wind and solar, which are intermittent sources of energy by their nature. Suitable communications technologies are the critical enabler in order to manage and control the flow of energy onto the distribution infrastructure. Utilities are also implementing newer distribution automation technologies in order to meet new reliability, safety and security requirements, thereby enabling utilities to maintain power resilience and restore power more quickly in the aftermath of an outage. These changes will mean new and improved security controls in order to protect critical assets against physical and cyber-attacks. These are just some of the utility applications that are creating additional demands for new wireless communications capacity and coverage. In addition, cyber security, data analytics, and workforce mobility will require increased capacity and coverage, as well. Hence, utility communications will increase to support these additional utility applications and operational requirements.

Utilities require highly reliable and resilient communications in order to ensure operational safety, reliability and security of the underlying electric, gas and water services that they support. This includes extended back-up power and diverse and redundant routing of backhaul communications networks at every wireless site. In addition, energy networks require extremely low latency services in order to ensure that utility teleprotection systems and synchrophasors operate to prevent faults on the grid from cascading and causing widespread outages and/or safety issues. Ensuring that these systems are secure and can be delivered in a cost-effective way is a high priority within the industry. Finally, utility networks are highly ruggedized for extreme conditions within the substation environment and have traditionally used extended depreciation cycles; so that the equipment must last for an extended period of time. These are just some of the characteristics of utility networks and their functional requirements. As such, they underscore the need for utilities to identify suitable spectrum to meet their future needs in response to the challenges being set by governments and regulatory authorities across the world and to meet these special requirements and enable the creation of smart utility networks.

Studies have shown that there is a compelling socio-economic justification for ensuring that utilities have access to sufficient suitable radio spectrum to enable them to better manage operations of the electricity networks for the benefit of the whole nation. Current data suggests that the use of radio spectrum in providing reliable utility services has great socio-economic value to the US economy, with society valuing reliable electricity significantly above the market rate.[1]

Therefore, the question on the issue of utility communications is not if or should utilities need access to spectrum, but what kind, how much, and what frequency range. To answer this question, it is necessary to model the different types of field area networks that utilities are operating. Next, it is important to estimate the approximate amount of data traffic and the bandwidth that would be necessary to support different types of utility field area networks. Having determined the traffic and the bandwidth for different utility field area networks, candidate spectrum bands can be identified that would be suitable to support utility spectrum needs.

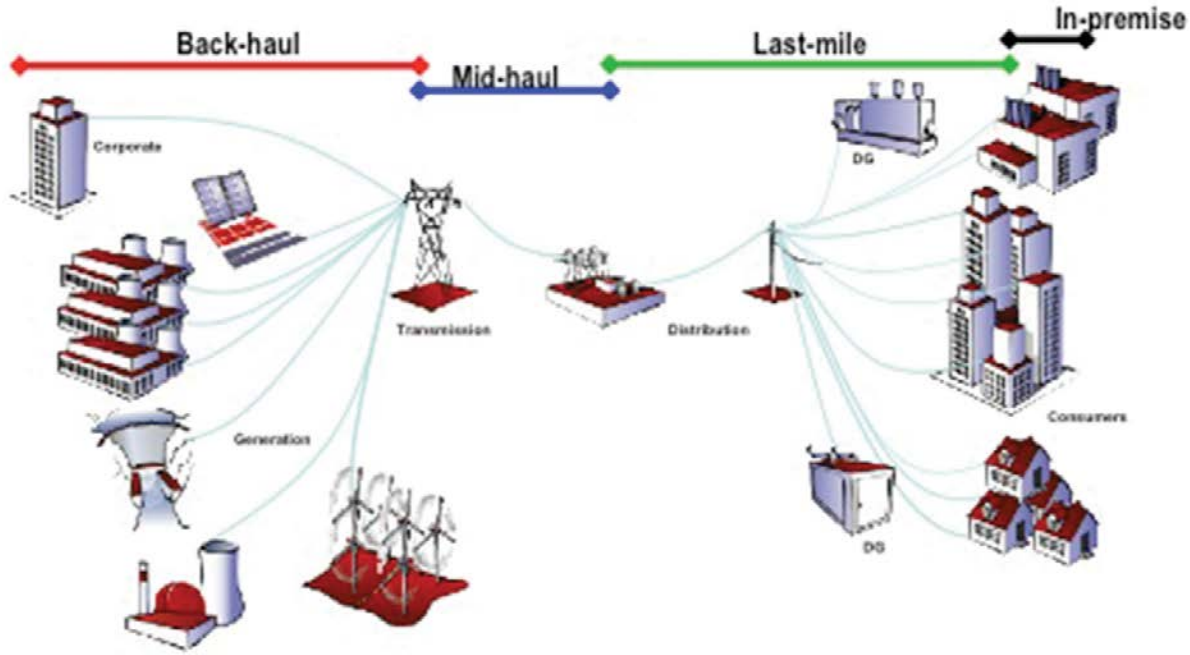
Studies have been conducted that model the different field area networks, estimate the traffic and bandwidth requirements for these field area networks, and identify suitable candidate spectrum bands to support utility communications needs. This report of the Electronic Correspondence Group identifies those studies, which serve to provide the evidentiary support of the amount and the frequency range for additional spectrum that utilities need to meet their increasing communications needs.

Modelling Utility Field Area Networks

Utilities are implementing new systems to automate operations and enhance their monitoring and control capabilities. These systems support a variety of applications, including advanced metering, demand response, distribution automation, and wide area measurement, protection and control (WAMPC). Overall, these systems will improve operational efficiency, safety and reliability by extending communications further into the distribution network and improving their performance.

The network architectures for these systems are varied. Some utilities deploy networks using centralized network architecture, such as point-to-multipoint networks; while others rely on decentralized network architecture, such as mesh networks. There are also hybrid networks that include combinations of network architectures, as well. The FAN is expected to bridge the backhaul network to the field devices. The figure below shows a combination of networks in a suburban configuration. A utility must manage the spectrum needs of its applications across the entire geographic footprint and account for the different device densities, geography, zoning regulations, and other technical and non-technical limitations.

Suburban Utility Distribution Networks. Source: Horizon Energy Group. Used with permission.



There will be numerous applications, including several that require significantly greater bandwidth. While utilities may not implement all of these applications, they will need to design the FAN so that all of the applications that they do implement can be supported both now and in the future as demands increase. In addition, the network needs to be designed so that it is reliable and provides coverage and low latency to meet their functional requirements effectively. Flowing from the applications and their functional requirements, utilities may choose the network architecture that best supports their needs – and there are advantages and disadvantages to each.

Communications Requirements of Smart Grid Communications Technologies, Department of Energy, Appendix A (Aug. 2010).

Network Requirements					
Application	**Bandwidth**	**Latency**	**Reliability**	**Security**	**Backup Power**
AMI	10-100 kbps/node, 500 kbps for backhaul	2-15 sec	99-99.99%	High	Not necessary
Demand Response	14kbps-100 kbps per node/device	500 ms-several minutes	99-99.99%	High	Not necessary
Wide Area Situational Awareness	600-1500 kbps	20 ms-200 ms	99.999-99.9999%	High	24 hour supply
Distribution Energy Resources and Storage	9.6-56 kbps	20 ms-15 sec	99-99.99%	High	1 hour
Electric Transportation	9.6-56 kbps, 100 kbps is a good target	2 sec-5 min	99-99.99%	Relatively high	Not necessary
Distribution Grid Management	9.6-100 kbps	100 ms-2 sec	99-99.999%	High	24-72 hours

Getting the data from field devices to the electric utility's back office system, or getting commands to devices from back office systems, relies upon a secure, reliable network covering a geographical footprint that can vary from dense urban areas to remote locations with virtually no population. This data is often critical in managing the power system. Simultaneously being able to respond to events via central commands adds to the complexity needed to manage the communications network. Thus, the network needs to be able to support the increased bandwidth requirements, as well as ongoing wide-area coverage and low-latency communications requirements necessary to effectively monitor and control operations. While some applications are non-mission critical and can be supported using unlicensed spectrum, many of the applications must meet higher standards for reliability and latency due to their impact on operational safety and security – and will demand access to licensed spectrum, which is generally less susceptible to interference, operates at higher power and provides greater overall reliability. However, certain applications require greater bandwidth than can be supported using available licensed spectrum. For these applications, access to licensed spectrum with greater bandwidth is necessary to support increasing communications requirements.[2]

Estimating Smart Grid Communications Requirements

In order to determine how much spectrum that utilities will need to support all of the applications on their field area network, the traffic from the various applications needs to be estimated and the bandwidth required to support this traffic needs to be calculated based upon the network design. As noted above, different utilities will have different applications and different network designs using different spectrum bands and different types of spectrum. Even though the networks and the applications may differ between utilities, there is a way to estimate how much spectrum would be necessary to support these applications based upon the network design.

Studies have estimated that utilities would need between 6-8 MHz of spectrum, which may be higher or lower depending on the frequency range, as well as the density of the deployment in an urban, suburban, or rural area. This is based upon aggregating the estimated data requirements of various individual utility applications, including Supervisory Control and Data Acquisition (SCADA), synchrophasors, distributed generation (DG) controls and monitors, distributed energy resources (DER), and other intelligent electronic devices associated with monitoring and operating the grid itself. In addition, the FAN traffic would include AMI communications (either providing backhaul for neighborhood collection points or, more efficiently, connecting directly to meters), mobile workforce voice (MWF) and data communications, security monitoring (possibly including streaming video), and/or other enterprise communications not directly related to grid operations. The total throughput and coverage requirements can then be used to arrive at the overall bandwidth requirements for a given base station using various spectrum bands. As such, several studies that have been published or are in development around the world have concluded that utilities will need between 6-8 MHz of spectrum to meet their communications needs.[3]

Identifying Candidate Bands

Utilities will need access to a spectrum band or several spectrum bands that are suitable to meet their increasing communications needs. There are several candidate bands that have been identified, but the consensus is that the 400 MHz band could serve as a spectrum home for utility communications needs worldwide. In addition, some studies have identified other potential candidate bands, including VHF spectrum and in the 1400 MHz band, as well as licensed spectrum at 2.1 GHz, 2.4 GHz, 3.5 GHz, 700 MHz and1.7 GHz.

The 400 MHz band was identified based upon several factors, including the amount of spectrum required, the propagation characteristics of the candidate bands and the ability to meet utility requirements for coverage and reliability, as well as the availability of standardized equipment to operate in the spectrum. Preliminary indications are that various segments of the 400 MHz band would be available in North and South America, as well as in other parts of the world. Further study could confirm this preliminary finding and to what extent similar spectrum would be available in certain countries. This band would provide favorable propagation characteristics for utility communications, both in terms of coverage and penetration through buildings and foliage.

Finally, this spectrum would support standardized LTE, CDMA and TETRA equipment for either broadband or narrowband data communications.[4]

The other spectrum bands were identified as well because of their availability, the potential build-out cost of the network, and the availability of standardized equipment. The availability of these spectrum bands may vary from country to country in North America and South America, and further study is necessary to determine the extent to which these bands would be available in this region of the world. While they do not provide the same favorable propagation as the 400 MHz band, they may provide greater capacity for backhaul of utility communications in a point-to-point or point-to-multipoint network configurations. In addition, they may provide the potential for greater frequency reuse in for local area network coverage in urban and suburban areas, which may be necessary where there are higher populations and hence higher density of network deployments would be necessary.

Conclusion

The foregoing report of the Electronic Correspondence Group identifies the studies on the topic of the communications needs for the continual monitoring, control and protection of the critical infrastructure used by utilities, as directed by CITEL.[5] It identifies the studies that describe utility field area networks and their design considerations, including the requirements for utility applications, such as bandwidth, latency, dependability, reliability, resiliency, and security. It identifies the studies that estimate the traffic on utility smart grid communications networks, including the amount of spectrum that would be necessary to support utility requirements. Finally, it identifies the studies that describe the candidate bands that would be suitable to support utility communications requirements.

Next steps for the Electronic Correspondence Group are to further study the availability of the potential candidate bands in member countries of CITEL and their suitability for the continual monitoring, control and protection of the critical infrastructure used by utilities. The Electronic Correspondence Group looks forward to the participation of the members and working with CITEL and the Terrestrial Fixed and Mobile Radiocommunication Services Working Group.

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[1] *See The Socio-economic Value of Spectrum in Providing Utility Services to Support their Operations*, The Joint Radio Company Ltd and European Utilities Telecom Council (Jan. 2014). *See also* U.S. Department of Energy. 2013. *Economic Impact of Recovery Act Investments in the Smart Grid*, visited at: http://energy.gov/sites/prod/files/2013/04/f0/Smart%20Grid%20Economic%20Impact%20Report%20-%20April%202013.pdf, and *Estimating the Costs and Benefits of the Smart Grid: A Preliminary Estimate of the Investment Requirements and the Resultant Benefits of a fully functioning Smart Grid*. Electric Power Research Institute. (2011), visited at: http://www.rmi.org/Content/Files/EstimatingCostsSmartGRid.pdf.

[2] Sources: *Field Area Networks*, Utilities Telecom Council and Edison Electric Institute (Jan. 2014), visited at http://www.eei.org/about/meetings/Meeting_Documents/Field%20Area%20Networks.pdf and *Communications Requirements of Smart Grid Communications Technologies*, Department of Energy (Aug. 2010), visited at http://energy.gov/gc/downloads/communications-requirements-smart-grid-technologies.
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[3] *See Assessment of Licensed Communication Spectrum for Electric Utility Applications*, Electric Power Research Institute (April 2015), visited at http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002005851; and *Estimating Smart Grid Communications Traffic*, Bell Labs & Alcatel-Lucent (Mar. 2014), visited at https://our.utc.org/eweb/DynamicPage.aspx?Action=Add&ObjectKeyFrom=1A83491A-9853-4C87-86A4-F7D95601C2E2&WebCode=ProdDetailAdd&DoNotSave=yes&ParentObject=CentralizedOrderEntry&ParentDataObject=Invoice Detail&ivd_formkey=69202792-63d7-4ba2-bf4e-a0da41270555&ivd_cst_key=613d53c3-0150-4340-b180-342f43dddf99&ivd_cst_ship_key=613d53c3-0150-4340-b180-342f43dddf99&ivd_prc_prd_key=9426B8E0-3193-4609-BB8E-F73285FBAB7A. *See also* Smart Grid Systems and Other Radio Systems Suitable for Utility Operations, and Their Long-term Spectrum Requirements (Draft), ETSI TR 103 401 V0.0.3 (2016-01), visited at http://stakeholders.ofcom.org.uk/binaries/spectrum/spectrum-industry-groups/business-radio-interest-meetings/23-july-2015/ERM_TGDMR_340v111_001.pdf .

[4] *See Assessment of Licensed Communication Spectrum for Electric Utility Applications*, Electric Power Research Institute (April 2015), visited at http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002005851. *See also*, *The 450 MHz Band for the Smart Grid and Smart Metering*, CDG 450 Connectivity Special Interest Group (Sep. 2013), visited at http://www.cdg.org/resources/files/white_papers/CDG450SIG_450MHz_Band_Smart_Grid_Smart_Metering_Concept-SEPT2013.pdf. *And see*, *Serviços de Engenharia Consultiva para Identificação de Faixas de Frequência para os Sistemas de Comunicação da Utilities Telecom Council América Latina (UTCAL) Relatório de Identificação de Faixas de Frequência para Serviços de Comunicação de Missão Crítica (SCMC) das Utilities*, UTC America Latina (Nov. 2015); and *Communication Technologies and Networks for Smart Grid and Smart Metering*, 450 MHz Alliance, visited at http://450alliance.org/wp-content/uploads/2014/05/WhitePaper_Comm_Tech_Networks_for_SmartGrid_SmartMetering.pdf.

[5] Final Report of CITEL from the PCC.II Meeting in Ottawa, Canada on August 17-21, 2015, CITEL PCC.II, CCP.II-RADIO/doc. 4024/15 at 78, PCC.II/DEC. 181 (XXVI-15)(Sep. 2015), visited at https://www.citel.oas.org/en/collaborative/pccii/26_CAN_15/Pages/default.aspx.