**BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF COLORADO**

*** * * * ***

RE: IN THE MATTER OF THE APPLICATION OF PUBLIC SERVICE COMPANY OF COLORADO FOR AN ORDER GRANTING A CERTIFICATE OF PUBLIC CONVENIENCE AND NECESSITY FOR DISTRIBUTION GRID ENHANCEMENTS, INCLUDING ADVANCED METERING AND INTEGRATED VOLT-VAR OPTIMIZATION INFRASTRUCTURE	**))))))))))**	**PROCEEDING NO. 16A-____E**

DIRECT TESTIMONY AND ATTACHMENTS OF WENDALL A. REIMER

ON

BEHALF OF

PUBLIC SERVICE COMPANY OF COLORADO

August 2, 2016

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF COLORADO

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RE: IN THE MATTER OF THE APPLICATION OF PUBLIC SERVICE COMPANY OF COLORADO FOR AN ORDER GRANTING A CERTIFICATE OF PUBLIC CONVENIENCE AND NECESSITY FOR DISTRIBUTION GRID ENHANCEMENTS, INCLUDING ADVANCED METERING AND INTEGRATED VOLT-VAR OPTIMIZATION INFRASTRUCTURE	**)**	**PROCEEDING NO. 16A-____E**

SUMMARY OF THE DIRECT TESTIMONY OF WENDALL A. REIMER

Mr. Wendall A. Reimer is Director, AGIS Portfolio Delivery for Xcel Energy Services Inc. In this position he is responsible for the delivery of all technology and systems that are part of the Advanced Grid Intelligence and Security (“AGIS”) initiative for Public Service Company of Colorado ("Public Service" or "Company"), one of four utility operating company subsidiaries of Xcel Energy Inc. His duties include, among other things, the oversight and sponsorship of critical capital deployment of new technology that is included in the AGIS initiative, including the Field Area Network (“FAN”) and other applications and systems that are integral to AGIS.

In his testimony, Mr. Reimer provides a description of the FAN as a key component of Public Service’s AGIS initiative. The AGIS initiative is a comprehensive plan that will make Public Service’s electric distribution system more automated and interactive by utilizing advances in sensing, controls, information, computing, communications, materials, and components. The more intelligent distribution system will be able to better meet customers' energy needs, while also integrating new sources of energy and delivering power over a network that is increasingly interoperable, efficient, and resilient.

Mr. Reimer explains that the FAN is a wireless communications network that will enable two-way communication of information and data between Public Service's substations and field devices, up to and including the customer meter. It will use two wireless technologies: (a) a Wireless Smart Utility Network ("WiSUN") mesh network; and (b) a Worldwide Interoperability for Microwave Access ("WiMAX") network. The FAN will enable and support several new AGIS technologies, with the WiSUN network directly supporting the Advanced Metering Infrastructure ("AMI") and the Integrated Volt-VAr Optimization ("IVVO") that are the subject of this Application for a certificate of public convenience and necessity (collectively, the "CPCN Projects"). Therefore, the WiSUN mesh network is covered by the CPCN Projects Application in this proceeding. Although the WiMAX network is not covered by the CPCN Projects Application, it is also discussed by Mr. Reimer because the entire FAN is an integral part of the AGIS initiative. Overall, the FAN will securely and reliably address the need for increased communication capacity that arises from distribution grid advancements.

Mr. Reimer also provides a description of the implementation plan for Public Service's FAN, noting that Public Service plans to install and deploy FAN-specific components approximately six months in advance of the deployment of AMI meters and IVVO field devices in order to support the full functioning of these applications and devices.

Mr. Reimer next provides an overview of the costs and benefits that will be facilitated by the deployment of the FAN. He explains that as a communications network, the FAN will not directly provide customers with benefits but rather facilitates communications for advanced applications like AMI and IVVO and other components of AGIS. These capabilities will also provide dependability and reliability benefits to Public Service.

Finally, Mr. Reimer discusses the advantages of Public Service's FAN proposal to alternatives. Specifically, a private, Company-owned network solution provides for greater security and efficiency and avoids requiring the Company to incur monthly usage fees paid to private vendors.

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DIRECT TESTIMONY AND ATTACHMENTS OF WENDALL A. REIMER

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GLOSSARY OF ACRONYMS AND DEFINED TERMS

Acronym/Defined Term	Meaning
ADMS	Advanced Distribution Management System
AGIS	Advanced Grid Intelligence and Security
AMI	Advanced Metering Infrastructure
AMR	Automated Meter Reading
ANSI	American National Standards Institute
BPL	Broadband over Power Line
C&I	Commercial and Industrial
CAIDI	Customer Average Interruption Duration Index
CBA	Cost-Benefit Analysis
CIS	Customer Information System
CMO	Customer Minutes Out
Commission	Colorado Public Utilities Commission
Company	Public Service Company of Colorado
CPCN	Certificate of Public Convenience and Necessity
CPCN Projects	AMI, IVVO, and the components of the FAN that support these components.
CPE	Customer premise equipment
CRS	Customer Resource System
CSF	Cyber Security Framework
CVR	Conservation Voltage Reduction
DA	Distribution Automation
DDOS	Distributed Denial of Service
DER	Distributed Energy Resources
DOS	Denial-of-service
DR	Demand Response
DSM	Demand Side Management
DVO	Distribution Voltage Optimization
EPRI	Electric Power Research Institute
ERT	Encoder Receiver Transmitter
ESB	Enterprise Service Bus
FAN	Field Area Network
FLISR	Fault Locate Isolation System Restoration

Acronym/Defined Term	Meaning
FLP	Fault Location Prediction
GFCI	Ground Fault Circuit Interrupter
GIS	Geospatial Information System
HAN	Home Area Networks
ICE	Interruption Cost Estimation
IDS	Intrusion Detection System
IEEE	Institute of Electrical and Electronics
IPS	Internet Provider Security
IT	Information technology
IVR	Interactive Voice Response
IVVO	Integrated Volt-VAr Optimization
kVAr	Kilovolt-amperes reactive
kVArh	Reactive power
kW	Kilowatt
kWh	Kilowatt hours
LTCs	Load Tap Changers
LTE	Long-Term Evolution
MDM	Meter Data Management
MitM	Man-in-the-Middle Attack
MPLS	Multiprotocol Label Switching
NCAR	National Center for Atmospheric Research
NOC	Network Operations Center
NPV	Net Present Value
O&M	Operations and Maintenance
OMS	Outage Management System
OT	Operational Technology
PTMP	Point-to-multipoint
Public Service	Public Service Company of Colorado
RF	Radio frequency
RFP	Request for Proposal
RFx	Request for Information and Pricing
RTU	Remote Terminal Units

Acronym/Defined Term	Meaning
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
SGCC	Smart Grid Consumer Collaborative
SGIG	Smart grid investment grants
SIEM	Security Incident and Event Management
SVC	Secondary static VAr compensators
TOU	Time-of-use
USEIA	United States Energy Information Administration
WACC	Weighted Average Costs of Capital
WAN	Wide Area Network
WiMAX	Worldwide Interoperability for Microwave Access
WiSUN	802.15.4g Standard
Xcel Energy Inc.	Xcel Energy
XES	Xcel Energy Services Inc.

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DIRECT TESTIMONY AND ATTACHMENTS OF WENDALL A. REIMER

I. INTRODUCTION, QUALIFICATIONS, PURPOSE OF TESTIMONY

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. My name is Wendall A. Reimer. My business address is 414 Nicollet Mall, 4th Floor, Minneapolis, Minnesota 55401.

Q. BY WHOM ARE YOU EMPLOYED AND IN WHAT POSITION?

A. I am employed by Xcel Energy Services Inc. ("XES") as Director, AGIS Portfolio Delivery. XES is a wholly-owned subsidiary of Xcel Energy Inc. ("Xcel Energy"), and provides an array of support services to Public Service Company of Colorado ("Public Service" or "Company") and the other utility operating company subsidiaries of Xcel Energy on a coordinated basis.

Q. ON WHOSE BEHALF ARE YOU TESTIFYING IN THE PROCEEDING?

A. I am testifying on behalf of Public Service.

Q. PLEASE SUMMARIZE YOUR RESPONSIBILITIES AND QUALIFICATIONS.

A. As the Director, AGIS Portfolio Delivery I am responsible for leadership of Xcel Energy delivery of all technology associated with the Advanced Grid Intelligence and Security ("AGIS") initiative, including the Field Area Network ("FAN") described in this testimony, as well as applications and infrastructure for the Advanced Distribution Management System ("ADMS"), Advanced Metering Infrastructure ("AMI"), and associated programs. A description of my qualifications, duties, and responsibilities is set forth after the conclusion of my testimony in my Statement of Qualifications.

Q. WHAT IS THE PURPOSE OF YOUR DIRECT TESTIMONY?

A. I provide a description of Public Service's proposed FAN in Colorado. The FAN communications network will support Public Service's advanced electric distribution grid. In particular, the FAN will enable and support several new technologies on the grid, including two for which the Company is seeking a certificate of public convenience and necessity ("CPCN") in this proceeding: AMI and the Integrated Volt-VAr Optimization ("IVVO") (collectively, with the relevant portions of the FAN, the "CPCN Projects"). These technologies, as well as the Company's ADMS, and Fault Location Isolation and Service Restoration ("FLISR") function including the Fault Location Prediction ("FLP") component, are critical parts of Public Service's AGIS initiative. The AGIS initiative is a comprehensive plan that will advance Public Service's distribution system, provide customers with more choices, and enhance the way the Company serves its customers. AGIS will lay the foundation for an interactive, intelligent, and efficient grid system that will be even more reliable and better prepared to meet the energy demands of the future.

A more thorough discussion of Public Service's AGIS initiative and the Company's request to grant the CPCN Projects Application is provided in the CPCN Projects Application and in the Direct Testimonies of Company witnesses Ms. Alice K. Jackson and Mr. John D. Lee.

Q. ARE YOU SPONSORING ANY ATTACHMENTS AS PART OF YOUR DIRECT TESTIMONY?

A. Yes, I am sponsoring the following:

- Attachment WAR-1: Field Area Network Diagram
- Attachment WAR-2: AMI FAN Cost Summary
- Attachment WAR-3: IVVO FAN Cost Summary

II. FIELD AREA NETWORK TECHNOLOGY

Q. WHAT IS PUBLIC SERVICE'S AGIS INITIATIVE?

A. As described in more detail in the CPCN Projects Application and in the Direct Testimonies of Company witnesses Ms. Jackson and Mr. Lee, AGIS is a comprehensive plan to advance Public Service's distribution system to a state where (1) operators have more visibility into the system; (2) customers are able to access more information in near real-time; and (3) future products and services are enabled through technology. AGIS will help to bring about an intelligent, automated, and interactive electric distribution system that will utilize advances in sensing, controls, information, computing, communications, materials, and components to optimize the performance of the electric distribution system and ensure safe operation. The more intelligent distribution system will be able to better meet customers' energy needs, while also integrating new sources of energy and delivering power over a network that is increasingly interoperable, efficient, and resilient.

Q. WHAT ARE THE FOUNDATIONAL PROGRAMS MAKING UP THE AGIS INITIATIVE?

A. Each of the foundational programs, or technical components, of the AGIS initiative is discussed in detail later in my testimony or in the testimony of the Company's other technical witnesses; therefore, below I only summarize the components of AGIS:

- **ADMS:** ADMS is the central platform that manages each of the other AGIS components by providing integrated operating and decision software and hardware to assist control room, field personnel, and engineers with the monitoring, control and optimization of the electric distribution system in near real-time. ADMS is discussed in more detail in the Direct Testimony of Company witness Mr. Chad S. Nickell.

- **AMI:** AMI meters are able to measure and transmit data regarding voltage, current, customer usage, and power quality data and can provide near real-time monitoring between the meter, the AMI head-end, and ADMS. "AMI head-end" is the software that facilitates the sending of commands to the field devices and receives the data back from the field devices. These meters also allow remote service disconnects and reconnects. The AMI is discussed in more detail in the Direct Testimony of Company witness Mr. Russell E. Borchardt.
- **FAN:** The FAN is the communications network that will enable communications between the communications infrastructure that already exists at the Company's substations, the AMI head-end, the ADMS, and new intelligent field devices. The FAN is discussed in more detail later in my testimony.
- **IVVO:** IVVO is a software application that automates the operation of the distribution voltage regulating and VAr control devices to reduce electrical losses, electrical demand, and energy consumption, and provides

increased capacity to host Distributed Energy Resources ("DERs").[1]

- **Geospatial Information System (“GIS”):** GIS provides location information about all physical assets that make up the distribution system. GIS provides this data to ADMS to maintain the as-operated electrical model and advanced applications.

Q. WHICH COMPONENT OF AGIS WILL YOU DISCUSS IN YOUR TESTIMONY?

A. As noted above, I discuss the FAN. My testimony also explains how the FAN will interact with the other foundational programs of AGIS. Public Service’s CPCN Projects Application covers the FAN technology necessary to support the AMI program and the IVVO application.

A. Overview of the Field Area Network and Public Service’s Existing Communications Network

Q. WHAT IS THE FAN?

A. Public Service’s FAN will be a resilient communications network that enables communications between the Company’s existing substations and new or planned field devices. The principal purpose of the FAN is to enable two-way communication of information and data to and from the existing infrastructure at the Company’s substations and the field devices. A FAN will securely and reliably address the need for increased communication capacity that arises from grid advancements.

[1]Additional intelligent field devices include Fault Location Isolation and Service Restoration (“FLISR”), Fault Location Prediction (“FLP”). FLISR involves automated switching devices to decrease the duration and number of customers affected by any individual outage. FLP is a subset application of FLISR that leverages sensor data from field devices to locate a faulted section of a feeder line and reduce patrol times needed to physically locate the fault. IVVO, FLISR, and FLP are discussed in more detail in the Direct Testimony of Mr. Nickell.

The FAN will be a single, general-purpose, wide area wireless networking resource that will be capable of simultaneously accessing these diverse types of endpoints, each with their own performance requirements, on Public Service's electric system. These endpoints will include a variety of field devices including reclosers, feeders, electric meters, capacitor banks, and virtually any other field device capable of communications, including gas regulators at a future time. The FAN will be able to communicate with other endpoints in the future as those devices are installed or upgraded with communications modules, and those devices could become part of the Wireless Smart Utility mesh network. Public Service's FAN will consist of layers (also referred to as "tiers") of secure wireless radio networks and supporting information technology ("IT") infrastructure that are designed to provide network access to utility endpoints, and to serve as a reliable communications medium for the wide variety of legacy, current-, and future-state monitoring and control applications.

Q. WHAT ARE THE PRINCIPAL TECHNOLOGIES THAT WILL BE USED BY PUBLIC SERVICE'S FAN?

A. The FAN will provide connectivity between the substation and field devices, up to and including the customer meter. It will use two wireless technologies: (a) a Wireless Smart Utility Network ("WiSUN") mesh network; and (b) a Worldwide Interoperability for Microwave Access ("WiMAX") network. I describe these two components in more detail below. Public Service's CPCN Projects Application in this proceeding covers the WiSUN mesh network, which is the specific technology necessary to support the AMI program and the IVVO application.

Q. WILL THE FAN BE CONNECTED TO PUBLIC SERVICE'S CURRENT COMMUNICATIONS NETWORK?

A. Yes, the FAN will be connected to Public Service's pre-existing Wide Area Network ("WAN"). The connections will be primarily at substations on the distribution system.

Q. PLEASE DESCRIBE THE WAN.

A. Public Service's WAN is a communications network primarily composed of private optical ground wire fiber and a collection of routers, switches, and private microwave communications that are supplemented by leased circuits from a variety of carriers as well as satellite backup facilities. The WAN is an intermediate link in the Company's communication system that provides high-speed, two-way communications capabilities and connectivity in a secure and reliable manner between Public Service's core data centers and its service centers, generating stations, and substations. The WAN is monitored at all times by the Network Operations Center ("NOC").

Q. WHAT DOES THE WAN DO?

A. The WAN is designed to communicate to and through substations (transmission and distribution) to ensure the security and future-proofing of the network. This design allows for security measures to be implemented at each substation, providing layered security as well as the ability for distributed computing capabilities in the future. The WAN also provides primary and backup communication capabilities to the service centers, office locations, and generation facilities in Public Service's areas of operation.

The WAN, which resides upstream of the FAN, will be Public Service's primary means of transporting communications data within its area of operation between the Company's major computing centers on the one hand, and the FAN and facilities such as generating plants and service centers on the other hand. The FAN, in turn, will provide the connectivity to intelligent devices installed across the distribution system. While the WAN will be the main linkage for transporting data from the WiMAX network to the Company's data centers upstream, it already carries a lot of other traffic (that is, the actual digits and bytes of data that flow over the wired and wireless networks) to support utility operations. The data centers are the locations that house the Company's computers (servers) and store data. The data centers will also house the advanced applications associated with AGIS (such as ADMS and AMI, and the sub-applications, including IVVO, FLISR, FLP and GIS). The advanced applications are discussed in the Direct Testimonies of Company witnesses Messrs. Lee (AGIS generally and GIS), Borchardt (AMI), and Nickell (ADMS, IVVO, and FLISR/FLP).

Each WAN component also provides redundant communication capabilities to primary and secondary data centers to support the Company's response to emergency situations and disaster recovery.

Q. DOES THE COMPANY PLAN TO UPGRADE ITS WAN TO SUPPORT THE FAN?

A. Yes. Public Service plans to increase the WAN's capacity, security, and capabilities to support the anticipated volume of data that will be communicated over the network, for reasons both independent of and including the network performance required by the FAN deployment. This includes increasing the reach of the network as well as improving the redundancy of various components to meet the requirements of the applications using the FAN.

Q. ARE WAN UPGRADES PART OF THE CPCN PROJECTS APPLICATION?

A. No. The WAN is part of Public Service's pre-existing infrastructure. The CPCN Projects Application does not cover any upgrades to the WAN. Although the WAN will eventually transport data that will be communicated by the AGIS advanced applications, as noted above, it already carries (and will continue to carry) other kinds of data and communications traffic. Unlike the WiSUN mesh network and the WiMAX network, the WAN is not dedicated to AGIS, nor to the components of AGIS that are the subject of the CPCN Projects Application. Instead, the WAN is a major component of the Company's current communications infrastructure that broadly supports corporate and utility operations. The upgrades to the WAN are part of a network strategy that supports not only the FAN but other Public Service communication needs in the Company's operating territory.

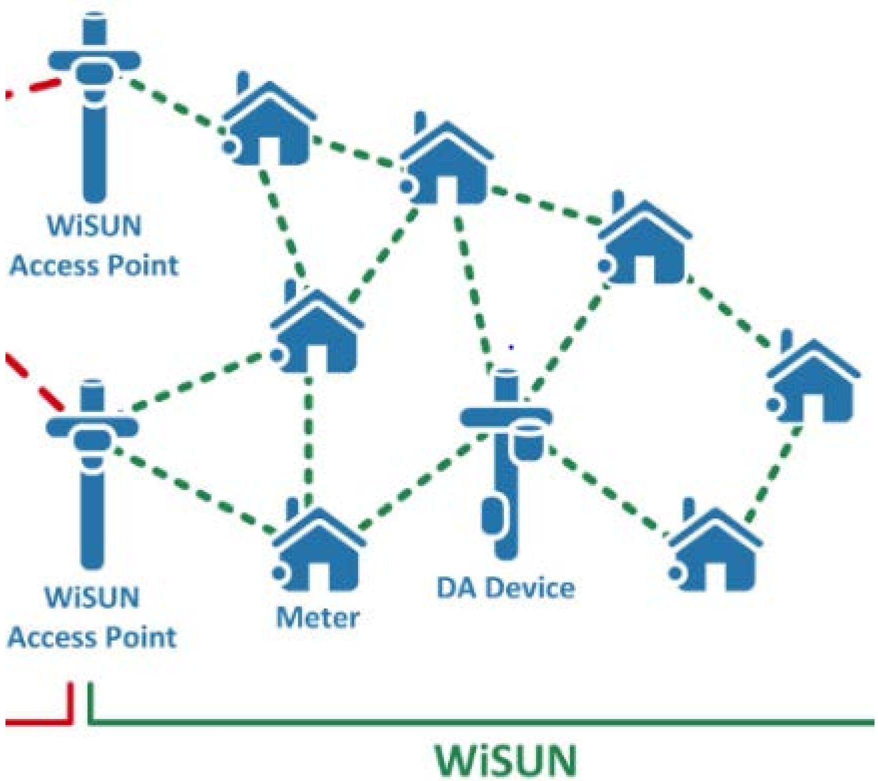
B. <u>Components of the FAN</u>

Q. WHAT ARE THE PRINCIPAL COMPONENTS OF THE FAN?

A. As previously noted, the FAN will be a wireless communications network that provides connectivity between the substation and field devices, up-to and including the customer meter. The FAN will consist of two separate wireless technologies: (a) a lower-speed mesh network called WiSUN; and (b) a high-speed point-to-multipoint ("PTMP") network referred to as WiMAX. Attachment WAR-1 provides an illustration of the principal components of the FAN.

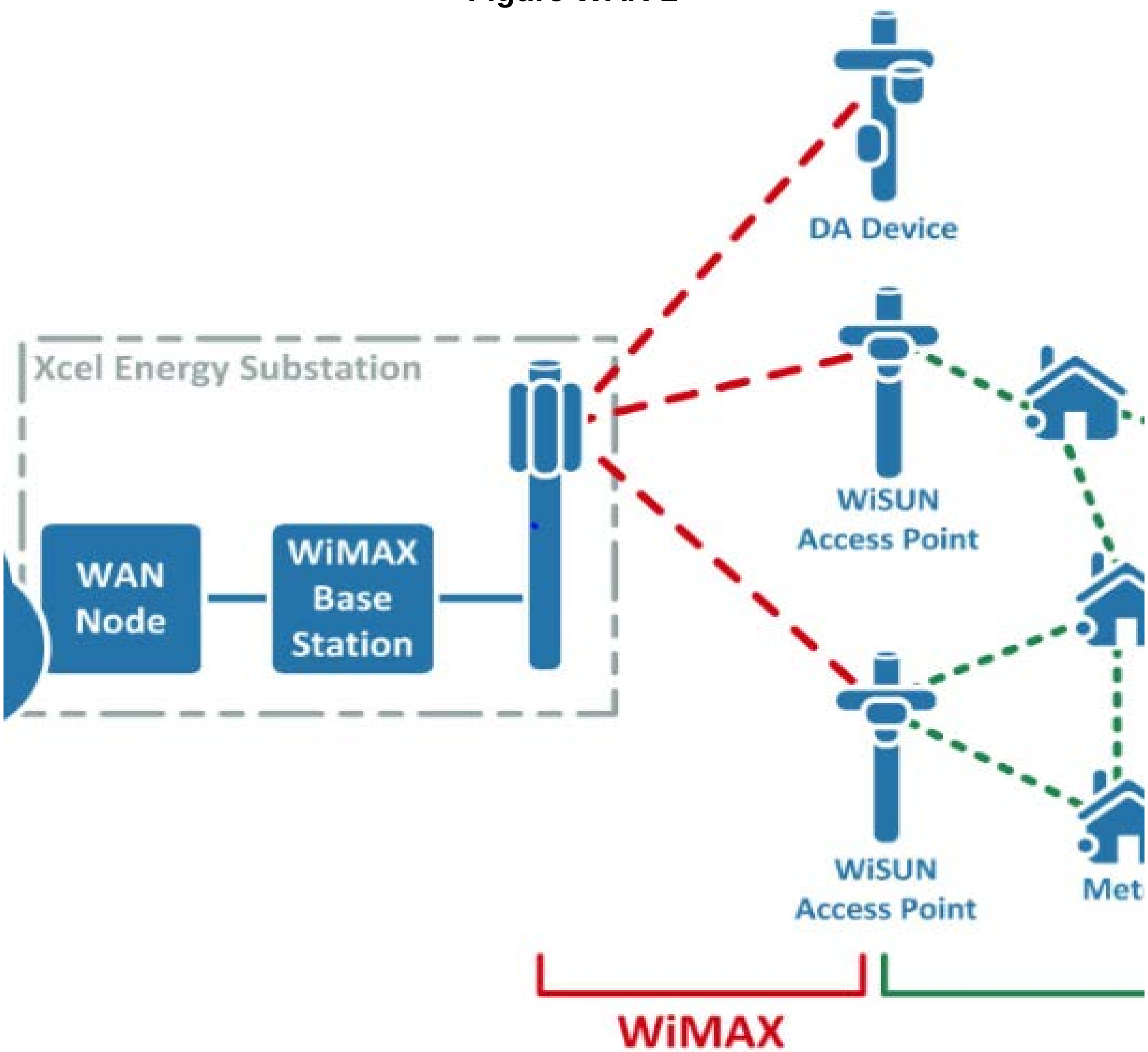
The WiSUN mesh network will communicate directly with the AMI infrastructure (such as the meters) and the Distribution Automation ("DA") field devices used for the IVVO advanced application. The flow of communications between field devices, meters, and WiSUN access points through a mesh-styled network is shown in Figure WAR-1, below, which is a portion of Attachment WAR-1. The components of the WiSUN network are discussed in more detail later in my testimony.

Figure WAR-1



The WiMAX network, illustrated below in Figure WAR-2 (also a portion of Attachment WAR-1), will provide redundant, reliable, and secure connectivity between the WiSUN mesh network and the Company's WAN. The DA and WiSUN devices connect to the WiMAX base stations via wireless communication modules that are integral to those devices. The components of the WiMAX network are discussed in more detail later in my testimony.

Figure WAR-2



Through the substation's connectivity to the WAN, the FAN (including the downstream WiSUN mesh network and the WiMAX network) will enable the Company's advanced applications (such ADMS and AMI, and sub-applications, including IVVO, FLISR, FLP, and GIS) to communicate with the field devices that implement those applications and sub-applications.

Q. PLEASE DESCRIBE THE INFRASTRUCTURE AND DEVICES THAT WILL BE INSTALLED AS PART OF THE WiSUN MESH NETWORK TO SUPPORT AMI AND IVVO.

A. The core mesh infrastructure will consist of two main device types: (1) access points, and (2) repeaters.

An access point is a device that will link the Company's endpoint devices that are enabled with wireless communication modules with the rest of the Company's communications network. The access points will wirelessly connect directly to backhaul (which is an intermediate link in the communications network—WiMAX, in this case) in order to pass traffic between the mesh network and the WAN. The term "traffic" refers to the actual digits and bytes of data that flow over the wired and wireless networks. Access points will extend the reach of Public Service's communications network and will define the boundary of the mesh itself.

Repeaters are range extenders and are used to fill in coverage gaps where devices would be otherwise unable to communicate.

These two device types will be principally located on distribution poles and other similar structures.

Other devices that will participate in the mesh include AMI meters and DA devices, such as the intelligent FLISR and IVVO field devices, that have built-in mesh radios. The former will be located on customer premises; the latter will be co-located with either pole-mounted or pad-mounted distribution devices. The radio frequency ("RF") communication modules in these devices will enable two-way communication between the AMI meters and the mesh network.

The term "mesh" refers to the network's topology, which resembles the interlaced design of mesh material, as shown in Figure WAR-1. All nodes on the network will relay data and cooperate in the distribution of that data in the network. The mesh design provides redundancy benefits, which are described in more detail below.

Q. PLEASE EXPLAIN THE TERM "WISUN."

A. WiSUN is the commercialized (public) name for the Institute of Electrical and Electronics Engineers' ("IEEE") 802.15.4g standard, and operates on the unlicensed 900 MHz spectrum. (The WiSUN naming convention is similar to how "Wi-Fi" is the commercial name for IEEE's 802.11 standard, which is used throughout the general public.) This standard for local and metropolitan area networks is well-accepted in the utility and communications industries. WiSUN can wirelessly connect meters, sensors, distribution devices, street lights, and signal repeaters to create a robust and reliable wireless network. Xcel Energy, on behalf of Public Service and the other operating companies, participates as a full member in the WiSUN Alliance with other utilities and equipment manufacturers. By selecting a technology that conforms to the IEEE standard, Public Service will ensure the interoperability of the FAN with other systems.

Q. PLEASE DESCRIBE THE INFRASTRUCTURE AND DEVICES THAT WILL BE INSTALLED AS PART OF THE WIMAX NETWORK.

A. The WiMAX network will consist of two main components: (1) base stations, and (2) customer premise equipment ("CPE"). To provide context, CPE is a common term in the network industry that refers to specific equipment. In the term "CPE", the "customer" refers to Public Service (or a similarly-situated entity using this equipment), which is a customer of the equipment manufacturer. It does not refer to any specific customers of Public Service, or to Public Service's customers generally.

Base stations will serve as the key communication points between the substation WAN and the WiSUN (mesh) network. At substations, there will be a base station with up to three radios that will communicate multi-directionally with CPEs out in the field of operations. Where possible, the base stations at the substations will be mounted on existing poles or structures in order to ensure an appropriate height. In some cases, new poles may need to be deployed if a structural analysis of the designated existing poles indicates that added weight would cause a stability issue. CPEs will be mounted on distribution poles in the field of operation.

Q. PLEASE DESCRIBE THE FUNCTION OF EACH OF THESE DEVICES.

A. Base stations will communicate with CPEs in the field and, through the substations' connection to the WAN, enable end-to-end communication between the intelligent field devices and the Company's advanced applications and other back office applications. "Back office" applications and systems are those that actually use and manipulate the data and perform specific business functions, including energy management system applications.

In the case of a CPE that is connected to a WiSUN access point, this will further enable the back office applications to communicate with any device accessible to that access point's connections to the mesh network. For any particular mesh "cluster" (that is, a logical collection of mesh nodes), there will be multiple access points connected to WiMAX that will provide redundant paths of communication to the WAN. This will result in a more reliable, robust field area network.

Q. PLEASE EXPLAIN THE TERM "WIMAX."

A. WiMAX is the commercialized name for the IEEE's 802.16 series of standards. The WiMAX PTMP network will be based in Public Service's substations and will enable high-speed connectivity at locations across the distribution system. The WiMAX network will wirelessly connect directly to devices on the Company's distribution feeder lines as well as provide the secure, reliable connectivity between Public Service's WAN and WiSUN networks. Xcel Energy, on behalf of Public Service and the other operating companies, participates fully as a member of the WiMAX Forum, an industry group tasked with the continued development, maintenance, and certification of products for the 802.16 standards. By selecting a technology that conforms to the IEEE standards, Public Service will ensure the interoperability of the FAN with other systems.

Q. HOW WILL THE WIMAX NETWORK BE CONNECTED TO, AND INTERFACE WITH, THE WISUN MESH NETWORK?

A. The WiMAX network and WiSUN mesh network will communicate wirelessly as the WiSUN mesh access points communicate with the CPEs that make up the WiMAX network, and the CPEs in turn communicate back to the base stations at the substation.

Q. HOW WILL THE WIMAX NETWORK BE CONNECTED TO, AND INTERFACE WITH, THE COMPANY'S WAN?

A. The WiMAX base stations will be connected to the pre-existing WAN connections at the substation, which, in turn, will enable connectivity back to the data center locations. This connection at the substation will be via private fiber or alternate cabling within the substation from the WiMAX base station radios to the routers at the substations which are connected to the WAN. There may be rare instances in which WiSUN devices will be connected directly to the WAN, when WiMAX is not needed.

Q. WILL THE WISUN AND WIMAX NETWORKS BE DEPLOYED THROUGHOUT THE COMPANY'S ENTIRE SERVICE TERRITORY?

A. No. In limited circumstances where deployment of the WiSUN mesh and WiMAX networks is not practical (such as remote locations on the edge of Public Service's distribution system), Public Service may utilize cellular or other wireless technologies as part of its comprehensive FAN solution. While these technologies are not adequate to support AMI as a whole, as I discuss later in my testimony, they provide alternatives in limited situations. In these instances, information such as data from AMI meters will be transmitted to the Company's WAN over an alternate technology.

C. <u>The FAN is an Integral Part of the AGIS Infrastructure</u>

Q. WILL COMPONENTS OF THE FAN INTERACT WITH OTHER AGIS INFRASTRUCTURE AND TECHNOLOGIES PROPOSED BY THE COMPANY IN THE CPCN PROJECTS APPLICATION?

A. Yes. Elements of the FAN will support both the AMI and IVVO programs that are the subject of the CPCN Projects Application. The FAN will also support other AGIS infrastructure that Public Service will deploy and that will require communication to field devices, such as ADMS and the FLISR application.

Q. CAN YOU PROVIDE MORE CONTEXT WITH RESPECT TO AMI?

A. Yes. As noted above, AMI stands for Advanced Metering Infrastructure, which is an integrated system of advanced meters, communication networks, and data management software that enables two-way communication between utilities' business data systems and customer meters. AMI is discussed in more detail in the Direct Testimony of Company witness Mr. Borchardt.

Q. WILL COMPONENTS OF AMI SUPPORT AND CONSTITUTE PART OF THE FAN?

A. Yes. In addition to their metering function, the advanced meters will have embedded communication modules that will allow the devices to communicate as part of the WiSUN network. The Company estimates that the AMI meters themselves (and their communications modules) will make up over 90% of devices that will communicate as part of the mesh network. In most cases this communication will be with the WiSUN mesh radios via IEEE's 802.15.4g standard described above.

Q. HOW WILL THE FAN SUPPORT AMI?

A. The WiSUN mesh network, including the meters' communication nodes that will communicate as part of the network, will support AMI through the meters' communication function. The FAN will provide the transport for data transfer between the meters and the AMI head-end application, including interval reads, register reads, voltage information, and power quality data. It will also provide the sending and receiving of commands like power outage notifications and remote connect/disconnect commands.

Q. CAN YOU PROVIDE MORE CONTEXT WITH RESPECT TO IVVO?

A. Yes. As noted above, IVVO stands for Integrated Volt-VAr Optimization, which is an advanced function that automates and optimizes the operation of the distribution voltage regulating devices and VAr control devices. IVVO is discussed in more detail in the Direct Testimony of Company witness Mr. Nickell.

Q. WILL COMPONENTS OF IVVO SUPPORT AND CONSTITUTE PART OF THE FAN?

A. Yes. Most IVVO devices (such as capacitors and voltage monitors) will have communication modules that will allow them to communicate as part of the WiSUN mesh network or directly on WiMAX. In most cases the IVVO devices will communicate as part of the WiSUN mesh network; however, in certain instances, it will be more efficient or economical for a device to connect directly with a WiMAX component facility.

Q. HOW WILL THE FAN SUPPORT IVVO?

A. As noted above, the WiSUN mesh network will ensure adequate and appropriate connectivity of most IVVO devices. The FAN will provide the transport for data transfer between the IVVO devices in the field (sensors, regulators, capacitors) and the ADMS. This will enable the field devices to report their current operating conditions and allow the ADMS to send commands to the devices, thereby enabling the entire system to dynamically react to changing load conditions and voltage levels.

Q. CAN YOU PROVIDE MORE CONTEXT WITH RESPECT TO FLISR AND FLP?

A. Yes. As noted above, FLISR stands for Fault Location Isolation and Service Restoration. FLISR will constitute the deployment of automated switching devices with the objective of decreasing the duration and number of customers affected by any individual outage. Fault Location Prediction, or FLP, is a subset application of FLISR that indirectly considers sensor data from field devices (such as AMI meters) when locating a faulted section of a feeder line, by using data provided by a separate outage prediction application. FLISR and FLP are discussed in more detail in the Direct Testimony of Company witness Mr. Nickell.

Q. HOW WILL THE FAN SUPPORT OR INTERACT WITH FLISR (AND FLP)?

A. The FLISR/FLP distribution equipment (*i.e.*, feeder-level devices) will have embedded communication modules that will communicate with access points in the mesh network or directly to WiMAX CPEs.

Q. CAN YOU PROVIDE MORE CONTEXT WITH RESPECT TO ADMS?

A. YES, AS noted above, ADMS stands for Advanced Distribution Management System. ADMS is a foundational system that consists of a collection of hardware and software applications designed to monitor and control the entire electric distribution system safely, efficiently, and reliably. An ADMS acts as a centralized decision support system that assists the control room, field operating personnel, and engineers with the monitoring, control, and optimization of the electric distribution system. ADMS will enable access to real-time and near real-time data to provide all information on operator console(s) at the control center in an integrated manner. ADMS will enable the improvement of reliability and quality of service in terms of reducing outages, minimizing outage time, and maintaining acceptable voltage levels on the system. It will manage the complex interaction of distributed energy resources, outage events, feeder switching operations and advanced applications such as FLISR and IVVO. ADMS is discussed in more detail in the Direct Testimony of Company witness Mr. Nickell.

Q. HOW WILL THE FAN SUPPORT OR INTERACT WITH ADMS?

A. The FAN infrastructure will provide data from field devices to a common Enterprise Service Bus ("ESB") via the WAN, which will then deliver data to ADMS. An ESB is a software architecture used for enabling communication between multiple mutually interacting software applications. The ESB will also receive commands from ADMS that will be delivered to the devices connected to the FAN via the WAN. The FAN enables data and information from field devices to be communicated to ADMS, and also enables commands to be transmitted to the field devices from ADMS. IT infrastructure and integration are discussed in more detail in the Direct Testimony of Company witness Mr. David C. Harkness.

D. Industry Adoption

Q. IS PUBLIC SERVICE'S FAN PROPOSAL CONSISTENT WITH CURRENT DEVELOPMENTS WITHIN THE ELECTRIC UTILITY INDUSTRY?

A. Yes, the Company's FAN proposal is consistent with developments within the electric utility industry. Each element of the proposal is premised on current industry standards that have been adopted by vendors, organizations, and other electric utility companies. As noted above, the WiSUN and WiMAX networks are standards-based network solutions that conform to IEEE standards. Xcel Energy, on behalf of Public Service and the other operating companies, participates actively with industry standards organizations and alliances—such as the Electric Power Research Institute ("EPRI") and IEEE—to ensure that the Company's requirements and assumptions are aligned with the standards and resulting products being deployed throughout the industry.

In addition, the Company has benchmarked technical solutions as well as cost elements with EPRI and other utilities that have deployed similar solutions, as well as through the Company's third-party Systems Integrator, a utility industry consultant that has worked on FAN deployment for other utilities, to ensure consistency and alignment with vendors and other peer utilities. The Company has received information from industry experts and systems integrators on actual installations of the FAN technology, public records on other utility implementations, and information through participation in industry research programs such as EPRI.

Q. WHY IS IT IMPORTANT TO IMPLEMENT THE FAN NOW?

A. The Company should deploy a standards-based communications network solution to ensure consistency, lower cost of current and future technology and infrastructure deployment, and ongoing support. A communications network is required to support the deployment of the AMI meters and will facilitate the operation of IVVO and FLISR. Deploying solutions such as AMI without the FAN would be considerably more expensive to install and operate and would limit the Company's ability to gain full value from their capabilities. The dynamic and changing demands placed on the distribution system have led to the need for these devices and technologies.

Implementation of the FAN will also provide reliable communication capabilities to all participating field devices, regardless of the device's use. This standards-based solution will ensure interoperability of components and technologies; therefore, the FAN will provide the same, reliable communication to multiple business applications and devices. Furthermore, Public Service's ownership of the FAN will allow the Company to ensure through measurement and control that the network will consistently satisfy performance, security, and reliability needs.

In addition to supporting the AGIS infrastructure, the FAN will support the ability to deploy computing capability closer to the field devices (for example, in substations) that will allow for quicker identification of potential issues and immediate resolution. This deployment will enable Public Service to monitor and manage impacts of distributed energy resources (for example, solar resources) and other events occurring on the grid in a more timely manner.

Q. DOES PUBLIC SERVICE HAVE ANY EXPERIENCE WITH A PROGRAM LIKE THE PROPOSED FAN?

A. Yes. The Company has experience with this type of program through smaller deployments of field communication systems in localized areas within Public Service's area of operation. The Company has also recently implemented a limited deployment pilot of this technology just south of Denver to prove out and test all aspects of the technology and measure performance.

Q. WHICH COMPONENTS OF THE FAN'S TECHNOLOGY ARE PART OF THE PILOT?

A. Public Service has deployed a limited-scale version of the FAN in the area of Highlands Ranch, Colorado. Currently, a total of three (3) WiMAX base station sites are installed at Public Service-owned facilities and contain a full complement of base station radios, antennas, firewalls, routers, and switches needed to operate each location, including the WAN. There is also a very small mesh network in place that consists of one access point, one mesh-equipped capacitor bank, and one test electric meter. The mesh access point connects to the WiMAX network using a CPE in order to connect to the Public Service corporate network. In this way, devices in this geographic footprint are connected to either the WiSUN or WiMAX network, and they are able to communicate with applications located in the Company's data centers. There are also two in-service capacitor banks that communicate with the Public Service Supervisory Control and Data Acquisition ("SCADA") system through the limited network available today.

Q. WHAT HAS PUBLIC SERVICE LEARNED FROM THE DEPLOYMENT OF THE PILOT?

A. The limited deployment of the pilot afforded Public Service the opportunity to work through the technical and process-related challenges that always arise from deploying new technology. Public Service was able to identify resolutions and assure itself that both the technology and architecture will meet the needs of the future advanced grid. Technical hurdles included integration with current network routing, building proper security protections, and the specifics of the wireless radio configuration - all of which have been resolved. Other addressed challenges included determining necessary Federal Communications Commission ("FCC") registrations, permitting of locations, and coordination of internal construction resources.

E. <u>Information Technology and Cyber security</u>

Q. HOW WILL THE INSTALLATION AND DEPLOYMENT OF THE FAN BE INTEGRATED WITH THE COMPANY'S EXISTING INFORMATION TECHNOLOGY AND BACK OFFICE SYSTEMS?

A. The FAN will provide connectivity to all back office and head-end systems via the WAN and ESB in a standard data delivery format. A "head-end" system is an operating software system that receives data and signals and can remotely control other devices. A head-end system typically receives data directly from the

FAN or the WAN and then disperses that information to appropriate applications that typically run in the data center. Head-end systems are basically the applications or systems that control the FAN and WAN and endpoint devices, and ensure safe, secure, and timely delivery of data to and from the field devices. The interaction of the FAN and existing IT is described in the Direct Testimony of Company witness Mr. Harkness.

Q. WILL THERE BE NEW INFORMATION TECHNOLOGY REQUIRED BY THE INSTALLATION AND DEPLOYMENT OF THE FAN?

A. New IT associated with the FAN, including the technology of the FAN itself and its head-end system, is described in the Direct Testimony of Mr. Harkness.

Q. WILL THE COMPANY UNDERTAKE CYBER SECURITY MEASURES ASSOCIATED WITH THE INSTALLATION OF THE FAN AND THE IMPLEMENTATION OF THE AGIS INITIATIVE?

A. Yes, cyber security measures are built in to the FAN at all levels and the FAN will utilize a layered defense model. The Company's security principles and their implementation are discussed in the Direct Testimony of Mr. Harkness.

III. <u>FIELD AREA NETWORK IMPLEMENTATION</u>

Q. WHEN WILL THE FAN DEVICES BE DEPLOYED WITH RESPECT TO THE OTHER AGIS TECHNOLOGIES DESCRIBED ABOVE?

A. Public Service's current plan is to install and deploy FAN-specific components (such as the WiMAX and WiSUN network devices) and complete the installation approximately six months in advance of the deployment of AMI meters and IVVO devices. In some instances, field devices may be installed in advance of FAN operability. Those devices will begin using the FAN for communication once the FAN components have been deployed and the network is operational in the area where the devices are located.

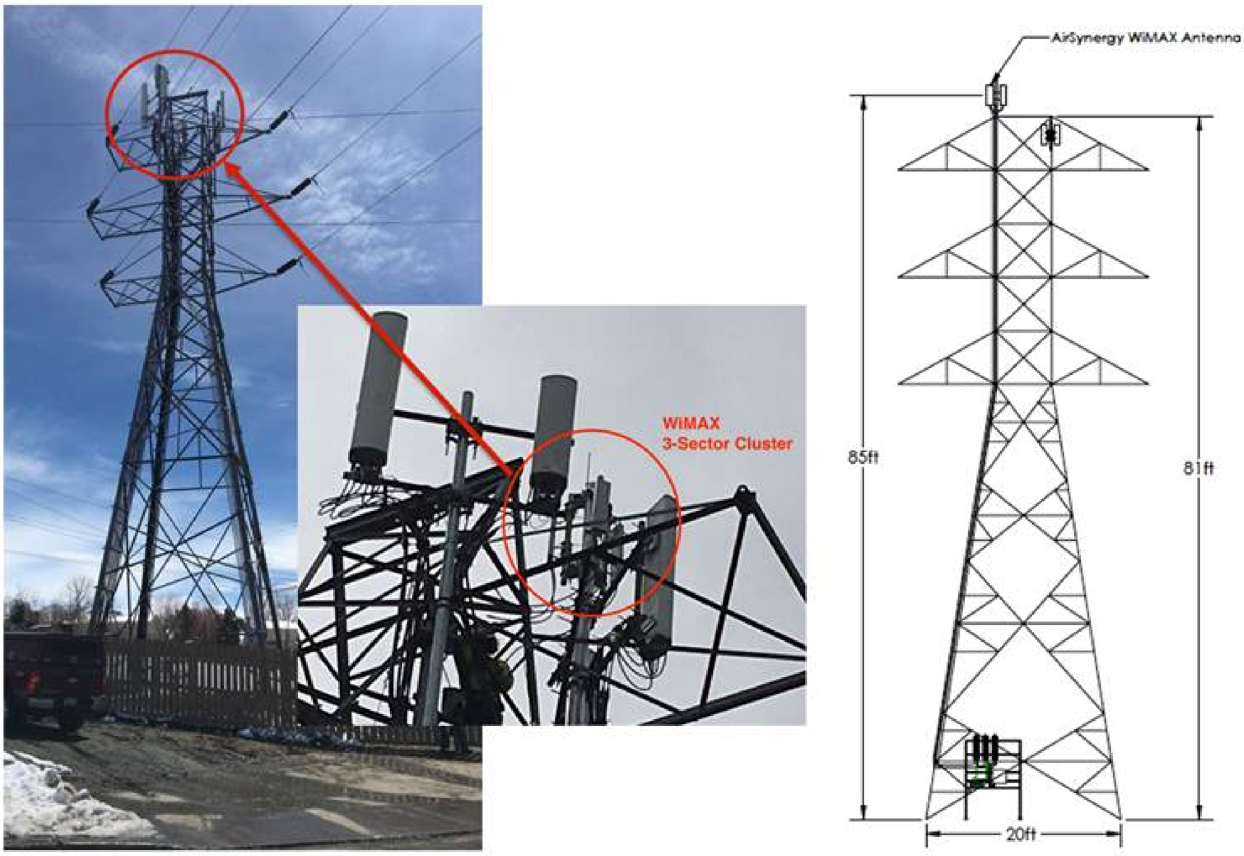
Q. WHY WILL THE FAN DEVICES BE INSTALLED AND DEPLOYED IN ADVANCE OF THE OTHER TECHNOLOGIES?

A. The communication network is necessary for the other technology components to operate. As an example, if a set of meters in a particular area is replaced with AMI meters, but the FAN has not been deployed and is not operating, those meters will not be able to be read automatically. That would result in manual meter reads until the FAN is operational for those meters because the AMI meters would not be able be by read by the drive-by Automated Meter Reading ("AMR") system. However, if the FAN is deployed prior to AMI meters being installed, the meters would be able to immediately communicate with the network. This would allow the back office systems to verify that the meters were installed correctly, that they are associated with the correct customer, and that they are reporting to the back office appropriately. This would also help reduce the risk that additional truck rolls to an area will be required at a later date.

Q. HOW WILL THE INFRASTRUCTURE BE INSTALLED?

A. WiMAX base stations will be primarily installed at substations. Antennas will need to be installed at appropriate heights to provide optimal coverage of the WiMAX signal. Installation can be on existing transmission towers where possible and allowable under safety guidelines, as Public Service restricts the mounting of communication equipment to below conductor-level to ensure safety and the reliable operations of its electric transmission system. Where there are no suitable transmission structures, a monopole will be erected on which to mount the antennas. The radio equipment will be mounted at ground level at the base of the structure and will connect to the substation's Electronic Equipment Enclosure ("EEE") via trenched cabling. The equipment will connect to the WAN in the substation's EEE. Figure WAR-3 below shows this equipment installed at one of Public Service sites.

Figure WAR-3: WiMAX Infrastructure



WiSUN equipment consists of access points and repeaters. These devices will be mounted primarily on distribution poles in order to provide adequate height for the radio signal to propagate. In areas where Public Service has underground service, arrangements will be made to mount the devices on streetlights or other structures with appropriate height. It is important to note that both the WiSUN and WiMAX infrastructure require sufficient height for installation.

IV. BENEFITS AND COSTS

A. Benefits

Q. WILL PUBLIC SERVICE'S CUSTOMERS DIRECTLY BENEFIT FROM THE INSTALLATION OF THE FAN ALONE?

A. No. The FAN, in and of itself, will not provide direct benefits to customers. Benefits to customers (as well as to the distribution system) will be realized through the FAN's support of, and interaction with, other programs and technologies.

Q. WHAT KIND OF QUALITATIVE BENEFITS WILL THE FAN PROVIDE TO PUBLIC SERVICE?

A. Deployment of the FAN will provide several benefits to Public Service, particularly with respect to dependability, reliability, and managing outages. The network design, along with the design and existing structure of the WAN, will provide a highly reliable and redundant communications network to provide more timely and accurate information to personnel responding to outages and other conditions in the field. Both Public Service and its customers will benefit from the programs and technologies that will be enabled by the FAN.

Q. HOW WILL THE FAN SUPPORT THE BENEFITS THAT WILL BE ENABLED THROUGH OTHER AGIS PROGRAMS AND TECHNOLOGIES?

A. As discussed previously, the FAN will enable the communications capabilities for AMI, IVVO, and FLISR and FLP. The combination of the WiSUN and WiMAX networks will enable substations to communicate with all of the field devices and, through the WAN connection, will allow the back office applications to send commands to those field devices. For AMI, it will allow consumption data to be collected at frequent intervals, allow the sending of remote connect and disconnect signals, and enable the voltage data from the meters to be used in conjunction with IVVO. The FAN will allow the capacitors and voltage sensors in the field to report their conditions to the back office and then transmit commands back to the field devices to ensure the most effective voltage optimization. Public Service's FAN architecture also will enable the ADMS to communicate directly with the FLISR devices to not only determine current operational status, but also to send commands to reconfigure the network with minimal latency. It will also allow those FLISR devices to communicate with each other directly to support in-field decision-making, thereby reducing the time for network reconfiguration.

Q. PLEASE DESCRIBE THE DEPENDABILITY BENEFITS OF IMPLEMENTING THE FAN.

A. The FAN's redundancy will facilitate overall dependability of communications. For example, if a device fails on the WiSUN network and can no longer communicate, the mesh-type configuration of the system will allow that node to be bypassed so other nodes will be unaffected and network communications will continue. Every device on the mesh network will maintain a primary and secondary access point, so that in the case of an access point failure the nodes will automatically route communications to a secondary access point. If the access point outage persists, the entire network will reconstruct itself so that every device will have a primary and secondary access point. The design also calls for access points to be served by multiple WiMAX base stations, so that in the event of a WiMAX base station going offline the mesh nodes will still be able to route communications through a different access point and WiMAX base station. The redundancy provided by the FAN will enable endpoint devices to continuously communicate both with each other and with head-end systems.

Q. HOW WILL THE FAN DEVICES OPERATE IN THE EVENT OF A POWER FAILURE OR OUTAGE?

A. The core infrastructure on both WiSUN and WiMAX are also backed up by batteries to enable continued functionality and operations in the case of a power failure to that device – a situation where the continued functionality of those networks is critical. These battery systems also self-monitor and will automatically report any issues to ensure prompt repair. Specific DA devices will also have battery power, either supplied by the device itself or through a supplemental battery system, to enable continued operations during an outage. An example of this would be the FLISR devices, whose current status and remote operation is critical during distribution outages. Some devices, such as capacitors, do not require battery systems as there is less need to optimize voltage levels when a portion of a feeder is de-energized.

Q. WHAT ARE THE RELIABILITY BENEFITS OF THE FAN?

A. There are reliability benefits for both the electric distribution system and the communications system itself.

Q. WHAT ARE THE RELIABILITY BENEFITS FOR THE DISTRIBUTION SYSTEM?

A. Both the Distribution Control Center and ADMS require consistent, reliable communications in order to operate at peak efficiency. For example, the IVVO program operates best when there is reliable information from all of the field devices. Without reliable communications, ADMS may only receive a portion of the data it needs to make decisions, and will err on the side of caution, thereby reducing the IVVO application's effectiveness. For FLISR, unreliable communications would mean that devices may not be visible to the head-end systems, and, therefore, could not be remotely controlled. This could prevent ADMS from initiating a FLISR switch plan as it would not have all of the information needed to make an accurate decision. The FAN helps avoid these reliability concerns.

The Distribution Control Center will also benefit for similar reasons—being able to "see" the status of particular devices. Visibility of the system will enable Distribution Control Center personnel to better respond to outage situations as they can see, in near real-time, when reclosers are operating or when a particular set of meters has experienced an outage. All of this information helps them make more informed decisions when they coordinate and dispatch field crews.

Q. WHAT ARE THE RELIABILITY BENEFITS FOR THE COMPANY'S COMMUNICATION NETWORK?

A. The WiSUN mesh system, in particular, benefits from the availability of additional devices. For most traditional PTMP communication systems, like cellular carriers (or the WiSUN system if it were deployed independently), adding more devices results in splitting resources between those devices. However, since WiSUN is a "mesh" network, adding more nodes to the network means the devices have more options to communicate with their access point. For example, adding a new capacitor bank could mean that meters nearby would have a more reliable and efficient way to reach their communications destination through the network. Further, if other devices are added, such as streetlights, there would be additional nodes located at greater heights (which can "see" more physical space) to the system, which could mean a meter may only be two communication "hops" (that is, one portion of a communication signal's journey from one device to the next—here, between two devices in the mesh network) away from an access point rather than three—reducing the latency of that communication. In addition, the mesh network will be able to reconfigure itself to respond to any ongoing environmental change, such as radio frequency interference, outages, and traffic congestion on the network itself. In short, the network improves as more devices are brought online and within the FAN.

As a point-to-point network, WiMAX does not have these capabilities, but it does use advanced radio technologies to ensure reliability. An example is Multiple-Input Multiple-Output antenna systems, where the base station actually transmits multiple copies of the same message so that the end device will be able to reconstruct a communication in case parts of it were lost during transmission. The existence of WiMAX will also enhance and optimize the WiSUN network by enabling access points to be placed in the field to maximize their scope and performance rather than restricting access points to locations at the substation. WiMAX infrastructure will enable high-speed communication connectivity to those access points. The combination of these technologies and functionality will provide Public Service with the reliability and performance necessary to meet the requirements of AMI, IVVO, and FLISR.

Q. HOW WILL THE FAN ASSIST IN MANAGING OUTAGES?

A. As discussed above, the core infrastructure of both WiMAX and WiSUN will be on battery backup. DA devices that are critical for outage operations will also be on battery backup. This means that the Distribution Control Center will still have visibility into the current status of the grid and remote control capabilities for devices like reclosers. Although AMI meters will not have battery backup, they will have the capability to send "last gasp" messages (that is, a final message transmitted by the meter upon detection of an outage) over the FAN to let the head-end system know that particular customers do not have power service. Once those customers have been reenergized, those meters will once again be able to communicate on the FAN and the head-end system will be able to remotely verify that customers have been reconnected. The additional visibility will also aid with the restoration of nested outages by showing that certain customers remain without power even when the surrounding issue was resolved. This will help the control center identify those situations and reduce the time to restoration.

B. Costs

Q. WHICH COMPONENTS OF THE FIELD AREA NETWORK ARE PART OF THE CPCN PROJECTS APPLICATION?

A. The FAN components that primarily support AMI and IVVO—namely, the WiSUN mesh network—are part of the CPCN Projects Application. The development of cost estimates for these components is discussed below. As this discussion underscores, we utilized very similar processes to develop cost estimates for FAN components associated with (i) AMI and (ii) IVVO.

1. Costs for AMI Support

Q. PLEASE DESCRIBE THE FAN'S CAPITAL COSTS ASSOCIATED WITH SUPPORTING AMI.

A. As noted in Attachment WAR-2, the FAN's capital items will be composed of its network infrastructure, including costs for hardware, installation, and project management, as well as preparation (or make ready).

To support AMI, the hardware devices will be installed at locations that will enable them to communicate with the modules located in the AMI meters throughout the Company's service territory. Because the AMI meters will be located at every customer premise, there will be a substantially larger number of these devices than of the intelligent field devices located on feeders that will implement IVVO. As such, AMI deployment will require a substantial amount of FAN equipment and devices to ensure the reliability and performance of the network. The capital costs reflected in Attachment WAR-2, particularly for hardware, installation, and project management, were developed based on information obtained by the Company's Distribution personnel from the Company's Systems Integrator. The cost forecasts are consistent with the Company's research into costs associated with AMI and mesh network solutions. These costs include the devices themselves, staging and delivery, installation and testing, and finally turn-up of the RF mesh with the devices that constitute IVVO.

Q. PLEASE DESCRIBE THE FAN'S "MAKE READY" CAPITAL COSTS.

A. Public Service will incur costs associated with specific work that will need to be planned and executed for FAN equipment that will be located on distribution poles or other structures. This includes RF frequency studies to determine locations for the RF mesh equipment to ensure optimal performance of the RF mesh solution in a particular area or geography. Once those studies are completed, specific distribution poles or other structures will be assigned to have devices installed on them. Those poles and structures will then be reviewed to ensure that the mounting of devices will be consistent with Company standards. If so, Public Service will undertake structural loading and preparation for the mounting for pole attachments. Other additional work that may be needed on a case-by-case basis including pole extension, cabinets prepared for new equipment, new transformers if required and any relocation of any existing equipment.

The make ready work will be performed by Company personnel resources or by certified vendors, based on considerations of workload, location, and timing. The projected costs associated with project employees are based on typical Company wages, and contractor costs are costs of contractors at estimated wage scales. The cost forecasts were developed in consultation with the Company's Distribution personnel regarding standards and processes for pole attachments to help ensure that all possible scenarios were considered in light of the number and location of devices that would be required. The cost forecasts are consistent with the Company's research into costs associated with AMI and mesh network solutions.

These inputs were used in the cost-benefit analysis discussed in the Direct Testimony of Company witness Mr. Samuel J. Hancock.

Q. IS PUBLIC SERVICE ASSIGNING A CONTINGENCY AMOUNT FOR THE FAN'S NETWORK INFRASTRUCTURE ASSOCIATED WITH SUPPORTING AMI?

A. Yes. As noted in Attachment WAR-2, Public Service has developed a contingency amount for the FAN's network infrastructure. The Company has assigned the same contingency for the FAN components supporting AMI as for the components supporting IVVO because the devices and potential issues are the same. A contingency level of 40% of capital costs was developed in consultation with the Company's Distribution personnel based on the range of conditions that might present additional challenges to this project. The potential cost expenditures include those for additional "make ready" work such as more than expected pole extensions, additional poles, and additional RF mesh equipment to increase coverage and network performance in certain areas due to terrain or unexpected network or frequency interference. The list of contingencies was reviewed by the Company's Systems Integrator and will be further refined through the upcoming Request for Proposal ("RFP") process discussed below and in the Direct Testimony of Company witness Mr. Borchardt. These inputs were used in the cost-benefit analysis discussed in the Direct Testimony of Company witness Mr. Hancock.

Q. PLEASE DESCRIBE THE FAN'S OPERATIONS AND MAINTENANCE COSTS ASSOCIATED WITH SUPPORTING AMI.

A. As noted in Attachment WAR-2, the FAN's operations and maintenance ("O&M") costs will include costs for infrastructure and hardware, operations (including equipment and personnel), and preparation (or "make ready"). These costs include the field level support for fixing broken and damaged equipment, additional NOC personnel to monitor and manage the FAN, other "make ready" work that is designated as O&M, hardware and software maintenance, and training. Personnel will include both Company employees and contractors, which will be used based on workload, location, and timing. Most incremental work will be performed by contractors. The projected costs associated with project employees are based on typical Company wages, and contractor costs are costs of contractors at estimated wage scales. The costs to fix and replace broken and damaged equipment are based on expected failure and damage rates for these devices. These inputs were used in the cost-benefit analysis discussed in the Direct Testimony of Company witness Mr. Hancock.

Q. IS PUBLIC SERVICE ASSIGNING A CONTINGENCY AMOUNT FOR THE FAN'S O&M COSTS ASSOCIATED WITH SUPPORTING AMI?

A. Yes. As noted in Attachment WAR-2, Public Service has developed a contingency amount for the FAN's O&M costs. The 40% contingency level for O&M, including personnel costs, is the same as for capital because any additional support expenses (O&M costs) will be correlative to the additional equipment and pole maintenance (capital costs), and are based on the scale of deployment. These inputs were used in the cost-benefit analysis discussed in the Direct Testimony of Company witness Mr. Hancock.

Q. HOW WILL THE COMPANY SELECT A VENDOR AND HARDWARE FOR THE MESH NETWORK?

A. The selection of the vendor and hardware for the mesh network is highly reliant on the selection of an AMI solution vendor. As discussed in the Direct Testimony of Company witness Mr. Borchardt, that decision will be made through a formal RFP process currently planned for vendor selection later in 2016. The results of that RFP will provide the selection of the mesh solution that will be used as part of the FAN.

The selection processes for the AMI and FAN mesh solutions are related because the meters themselves and their embedded communications modules participate in, and make up the majority of, the devices that will communicate as part of the mesh network. The Company has engaged leading vendors in a Request for Information and Pricing ("RFx") and is issuing an RFP to better understand the functionality, capability, and costs associated with the deployment of mesh networks. Much of the information obtained by Public Service through these processes is covered by non-disclosure agreements with the participating vendors.

2. Costs for IVVO Support

Q. PLEASE DESCRIBE THE FAN'S CAPITAL COSTS ASSOCIATED WITH SUPPORTING IVVO.

A. As noted in Attachment WAR-3, the greatest costs will be the capital costs associated with the FAN infrastructure, including costs for hardware, installation, and project management, as well as preparation (or "make ready").

To support IVVO, many of these hardware devices will be installed at or near the feeders where the IVVO technology is being deployed. The capital costs reflected in Attachment WAR-3, particularly for hardware, installation, and project management, were developed based on information obtained by the Company's Distribution personnel from the Company's Systems Integrator, who has experience with the deployment of communications networks for other utilities. The cost forecasts are consistent with the Company's research into costs associated with IVVO and mesh network solutions. These costs include the devices themselves, staging and delivery, installation and testing, and finally turn-up of the RF mesh with the meters in that area.

These inputs were used in the cost-benefit analysis discussed in the Direct Testimony of Company witness Mr. Hancock.

Q. CAN YOU DESCRIBE THE "MAKE READY" CAPITAL COSTS ASSOCIATED WITH IVVO?

A. Yes. As with AMI, Public Service will incur costs associated with specific "make ready" work that will need to be planned and executed for FAN equipment that will be located on distribution poles or other structures. This includes RF frequency studies to determine locations for the RF mesh equipment, in order to ensure optimal performance of the RF mesh solution in a particular area or geography. Once those studies are completed, specific distribution poles or other structures will be assigned to have devices installed on them. Those poles and structures will then be reviewed to ensure that the mounting of devices will be consistent with Company standards. If so, Public Service will undertake structural loading and preparation for the mounting for pole attachments. Other costs include expenses for additional work that will be needed on a case-by-case basis including pole extension, cabinets prepared for new equipment, new transformers if required and any relocation of any existing equipment.

The make ready work will be performed by Company personnel resources or by certified vendors, based on considerations of workload, location, and timing. The projected costs associated with project employees are based on typical Company wages, and contractor costs are costs of contractors at estimated wage scales. The cost forecasts were developed in consultation with the Company's Distribution personnel regarding standards and processes for pole attachments, to ensure that all possible scenarios were considered in light of the number and location of devices that would be required. The cost forecasts are consistent with the Company's research into costs associated with AMI and mesh network solutions.

These inputs were used in the cost-benefit analysis discussed in the Direct Testimony of Company witness Mr. Hancock.

Q. IS PUBLIC SERVICE ASSIGNING A CONTINGENCY AMOUNT FOR THE FAN'S NETWORK INFRASTRUCTURE ASSOCIATED WITH SUPPORTING IVVO?

A. Yes. As noted in Attachment WAR-3, Public Service has developed a contingency amount for the FAN's network infrastructure. The Company has assigned the same contingency for the FAN components supporting IVVO as for the components supporting AMI because the devices and potential issues are the same. The contingency level of 40% of capital costs was developed in consultation with the Company's Distribution personnel, based on the range of conditions that might present additional challenges to this project. The potential cost expenditures include those for additional "make ready" work such as more-than-expected pole extensions, additional poles, and additional RF mesh equipment to increase coverage and network performance in certain areas due to terrain or unexpected network or frequency interference. The list of contingencies was reviewed by the Company's Systems Integrator and will be further refined through the upcoming RFP process. These inputs were used in the cost-benefit analysis discussed in the Direct Testimony of Company witness Mr. Hancock.

Q. PLEASE DESCRIBE THE FAN'S O&M COSTS ASSOCIATED WITH SUPPORTING IVVO.

A. As noted in Attachment WAR-3, the FAN's O&M costs will include non-capitalized costs for infrastructure and hardware, operations and equipment, and preparation (or make ready). These costs include the field level support for fixing broken and damaged equipment, additional NOC personnel to monitor and manage the FAN, other make ready work that is designated as O&M, hardware and software maintenance, and training. Personnel will include both Company employees and contractors, which will be used based on workload, location, and timing. Most incremental work will be performed by contractors. The projected costs associated with project employees are based on typical Company wages, and contractor costs are costs of contractors at estimated wage scales. The costs to fix and replace broken and damaged equipment are based on expected failure and damage rates for these devices. These inputs were used in the cost-benefit analysis discussed in the Direct Testimony of Company witness Mr. Hancock.

Q. IS PUBLIC SERVICE ASSIGNING A CONTINGENCY AMOUNT FOR THE FAN'S O&M COSTS ASSOCIATED WITH SUPPORTING IVVO?

A. Yes. As noted in Attachment WAR-3, Public Service has developed a contingency amount for the FAN's O&M costs. The 40% contingency level for O&M, including personnel costs, is the same as for capital because any additional support expenses (O&M costs) will be correlative to the additional equipment and pole maintenance (capital costs), and are based on the scale of the deployment. These inputs were used in the cost-benefit analysis discussed in the Direct Testimony of Company witness Mr. Hancock.

Q. WHAT ARE THE KEY DRIVERS OF THE DIFFERENCES BETWEEN FAN COSTS TO SUPPORT AMI AND FAN COSTS TO SUPPORT IVVO?

A. Because the AMI meters will be located at every customer premise, there will be a substantially larger number of these devices than of the intelligent field devices located on feeders that will implement IVVO. As such, AMI deployment greatly increases the number of devices that will need to communicate over the FAN, and will require a substantial amount of FAN equipment and devices to ensure the reliability and performance of the network.

V. ALTERNATIVES CONSIDERED

Q. DID PUBLIC SERVICE CONSIDER ALTERNATIVES TO THE FAN PROPOSAL WITH RESPECT TO TECHNOLOGY NECESSARY TO SUPPORT AMI?

A. Yes, the principal alternative to the FAN for supporting AMI is the use of cellular carrier solutions. This would require Public Service to deploy a cellular modem in every single meter and pay monthly fees for usage and for the private internet protocol service for every device. This alternative would cause the Company to incur substantial monthly and annual expenses. In particular, when comparing cellular carrier solutions and the FAN, Public Service determined that device costs were fairly similar but monthly and annual expenses were considerably higher with the use of public cellular. Other key decision criteria such as security, reliability, latency, and support costs all weighed into the decision to choose the FAN.

Q. WHAT ARE THE OTHER ADVANTAGES OF A FIELD AREA NETWORK OWNED BY PUBLIC SERVICE RATHER THAN UTILIZING A CELLULAR OR MOBILE SERVICE?

A. The most significant advantage of a Company-owned FAN is security. A private network allows Public Service to better control the integrity of the devices on its network and the data exchanged with those devices. The alternative—a public network—would expose the devices and Public Service to increased risk because the Company would not be in control of the network.

In addition, the private network solution allows Public Service to utilize the network's full bandwidth and all capacity is dedicated to the Company's use, which is particularly critical during emergency and outage situations.

Another advantage to having a private network is flexibility; replacing a meter or adding a new meter to the Company's WiSUN network will be a straightforward process that will be handled internally by Public Service personnel, whereas provisioning a meter on a third party or public network could take as long as days or weeks.

A private mesh network will also afford the AMI meters the ability to communicate directly with one another on the WiSUN network. This will enable future distributed intelligence and computing capabilities so that applications running on the system will be able to respond quickly to changing load conditions that occur behind a transformer. This is becoming increasingly critical to energy operations as a larger number of distributed energy resources connect to the distribution grid. Public networks and cellular communication alternatives would prevent or hinder this capability.

Q. WOULD IT BE POSSIBLE TO IMPLEMENT AMI WITHOUT A FAN OR SIMILAR INFRASTRUCTURE?

A. It would be possible to provide cellular equipment to every individual meter, but as described above, that alternative is costly and not practical for most of Public Service's distribution system. Meter vendors may offer their own communications solution to support their metering devices, but these are either functionally similar to WiSUN or they actually are WiSUN networks that would be owned by the meter vendor rather than by Public Service.

Q. DID PUBLIC SERVICE CONSIDER ALTERNATIVES TO THE FAN PROPOSAL WITH RESPECT TO TECHNOLOGY NECESSARY TO SUPPORT IVVO?

A. IVVO will utilize WiSUN, so the reasons for choosing a Company-owned FAN to support IVVO are very similar to the reasons discussed above with respect to AMI, particularly as it concerns security. In addition, Public Service evaluated private Long-Term Evolution ("LTE") systems as an alternative to its private WiMAX network.

Q. WHY DID PUBLIC SERVICE SELECT WIMAX INSTEAD OF AN LTE SYSTEM?

A. In principle the two networks are very similar: both would provide a high speed point-to-point network, both would require construction of base stations at substations, and both would interface with the WAN in a similar manner. However, the LTE system architecture requires all traffic to route through a back office server (called the Evolved Packet Core), which means field devices would not be able to communicate directly with one another. Rather, communications would traverse the entire network to reach the data center then traverse back through the network again to reach the other end device. In addition to increasing latency (that is, the time for data to travel between two devices) it would also increase network traffic due to the "round trip" messaging to the data center and back.

WiMAX base stations, on the other hand, allow CPEs to communicate with other CPEs through the base stations' directly-connected router, which will reduce latency and network congestion.

An LTE deployment for Public Service also would have been restricted to one-half of the 3.65GHz band, whereas WiMAX can be deployed in the full 3.65GHz or the 5.8GHz band. LTE infrastructure is also more expensive to deploy than WiMAX.

However, if LTE technology evolves to meet utility requirements and becomes more cost effective, the WiMAX network architecture Public Service will deploy will be capable of integrating LTE at that time.

For Public Service, and based on consultations with industry experts and critical vendors concerning the investment in and manufacturing of WiMAX equipment and infrastructure, WiMAX is the most viable solution for current needs and those of the foreseeable future.

Q. WERE THERE ANY OTHER ALTERNATIVES TO THE WIMAX NETWORK THAT PUBLIC SERVICE CONSIDERED?

A. Another potential alternative would have been to use public cellular networks instead of a private WiMAX network to backhaul all of the WiSUN traffic as well as to connect directly to some IVVO and most of the planned FLISR and FLP devices. As discussed previously, this would expose Public Service to an unnecessary and avoidable security risk as well as to increased expenses on a monthly and annual basis.

This alternative would also be disruptive to distributed computing capabilities at substations and on the distribution grid. Under the chosen solution (Company-owned WiMAX and WiSUN networks), substations will effectively become miniature, remote data centers where field data is aggregated at the substation for remote decision-making, and only that subset of data that is needed for the head-end data center applications will be transmitted there via the WAN. For example, by using WiMAX and WiSUN, data will reach the substation in less than one second. In the case of the cellular data alternative, this data would be routed to a cell tower, then onto a regional data center via the cellular carrier network, then to a core network switching station before finally traversing the internet to arrive at an application's head-end system. Once there, the traffic would still need to travel over Public Service's WAN before reaching the substation. This entire process would take several seconds and the data would be out-of-date (*i.e.*, no longer accurate) upon arrival. This would not facilitate the Company's ability to take effective action in the most timely manner possible. As a result, the use of public cellular networks would not facilitate the deployment of distributed computing for Public Service, or the Company's goal of utilizing the most effective applications for its customers and its distribution system.

Q. WILL THERE BE LOCATIONS WHERE PUBLIC SERVICE WILL IMPLEMENT AN ALTERNATIVE TO THE WISUN AND WIMAX NETWORKS?

A. Yes. As previously noted, in limited circumstances where deployment of the WiSUN mesh and WiMAX networks is not practical (such as remote locations on the edge of Public Service's distribution system), Public Service may utilize other wireless technologies such as satellite or cellular as part of its comprehensive FAN solution. In these instances, information such as data from AMI meters will be transmitted to the Company's WAN over an alternate technology.

Q. DOES THIS CONCLUDE YOUR TESTIMONY?

A. Yes, it does.

Statement of Qualifications

Wendall A. Reimer

As the Director, AGIS Portfolio Delivery, I am responsible for the delivery of all technology and systems that are part of the Advanced Grid Intelligence and Security ("AGIS") initiative for Public Service Company of Colorado ("Public Service" or "Company"), one of four utility operating company subsidiaries of Xcel Energy Inc. My duties include, among other things, the oversight and sponsorship of critical capital deployment of new technology that is included in the AGIS initiative, including the Field Area Network ("FAN") and all applications and systems that are integral to AGIS.

I joined Xcel Energy in 2014, and have 14 years of experience in the utility industry. I began working with Xcel Energy on a contract-basis as a Program Manager in 2009, overseeing the deployment of significant network and telecommunication projects across all regions and facets of the company. Prior to working with Xcel Energy, I provided a variety of services to energy businesses including the design and deployment of new technology at an energy company's new headquarters, development of new data centers and security solutions for energy companies, and multiple network and communications projects for non-utility organizations.

I graduated in 1981 from Concordia College, where I earned a Bachelor's degree in Business Administration, with minors in Math and Computer Science and a series in Accounting.