MISSOURI SMART GRID REPORT

Missouri Public Service Commission

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MISSOURI SMART GRID REPORT

"PROCEED AT THE RATE OF VALUE"[1]

[1] Theme from NARUC Summer conference, July, 2010.

I. EXECUTIVE SUMMARY

In this updated report, Staff discusses the various Smart Grid technologies, provides a status update on various Smart Grid opportunities in Missouri and presents issues and concerns related to Smart Grid deployment. Staff ultimately recommends the Missouri Public Service Commission (MoPSC) hold periodic workshops to engage stakeholders in meaningful Smart Grid-related discussions. Following is a summary of points highlighted in the report.

- Smart Grid is a rapidly developing, evolving technology with significant promise in several areas for utilities and consumers. Most of the activity in past years has been on the utility grid system but presently there is a major focus and emphasis on smart meter deployments and pilot projects stimulated by American Recovery and Reinvestment Act (ARRA) funding.
- A truly 'Smart' Grid requires in-home and outside-the-home communications systems. This should provide incentives to consumers to reduce energy consumption through demand response (DR).
- Smart Grid technology applied to the electric system transmission and distribution grid should be integrated with two-way communications systems and sensors to allow grid operators to optimize grid performance in real-time and allow the integration of renewable energy sources and distributed generation into the grid.
- Many benefits of the Smart Grid can be realized prior to full Advanced Metering Infrastructure (AMI) smart meter deployment but a complete Smart Grid system includes two-way communications between meters and utilities.
- Missouri has experienced modest growth in advanced meter reading (AMR) and AMI deployment. For Missouri, the top three AMI deployments are Laclede Electric Cooperative with 36,000, Kansas City Power and Light with 14,000 and the City of Fulton with 5,000. The top AMR deployment is Ameren Missouri with 1.2 million meters deployed since 2000.
- Missouri currently has several Smart Grid projects underway in various degrees of development and implementation.

- Communications with customers, consumer education and customer empowerment are just as important as the implementation of new technology in realizing the projected Smart Grid benefits.
- Several industry standards for this evolving technology have been developed and some are still under development. The expectation of seamless integration of new 'smart' technologies with legacy systems and devices cannot be achieved without great attention to the principal of interoperability. Standards-based communications protocols and open architecture must be used. The NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 2.0, provides an overview of the status of standards development.[2]
- There are several communications technologies available to support Smart Grid implementations.

II. INTRODUCTION

Smart Grid is the integration of advanced metering, communications, automation, and information technologies on the electric distribution system to provide an array of energy saving choices and integration of distributed generation while lowering operating costs and maintaining or improving service.[3] Nearly one in every three households has a smart meter accounting for 36 million meters nationwide with projections exceeding 65 million by 2015.[4]

A Smart Grid system could be the enabling technology to allow curtailment of electric usage at critical times, thus, reducing peak demand by not using the most expensive energy sources.

The term 'Smart Grid' does not have a precise definition and there are not exact specifications for the quantity or arrangement of components that make up the Smart Grid deployment, including the equipment, devices, software, processes and procedures required to make the Smart Grid operational in the various unique geographical and cultural locations. The Smart Grid can best be described in terms of the following ability:

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[2] http://www.nist.gov/smartgrid/upload/NIST_Framework_Release_2-0_corr.pdf
[3] CNN report "U.S. electricity blackouts skyrocketing", August 2010.
[4] http://www.greenbang.com/how-many-smart-meters-are-there-in-the-us_21821.html

- To develop, store, send and receive digital information concerning electricity use, costs, prices, time of use, nature of use, and storage, to and from the electric utility system.
- To program any end-use device such as appliances and heating, ventilating and air conditioning (HVAC) systems to respond to communications automatically.
- To sense and localize disruptions or changes in power flows on the grid and communicate such information instantaneously and automatically for purposes of enabling automatic protective responses to sustain reliability and security of grid operations.
- To detect, prevent, respond to, and recover from system security threats such as cyber-security threats and terrorism, using digital technology.
- To use digital controls to manage and modify electricity demand, enable congestion management, assist in voltage control, provide operating reserves, and provide frequency regulation.[5]

III. HISTORY

During the past two decades, non-disaster related outages affecting at least 50,000 consumers increased by 124 percent.[6] The historic August 2003 blackout was initiated by trees falling on power lines causing a cascading set of faults to travel across the overloaded regional grid which left 50 million people without power in eight northeastern states and Canada. [7]

On December 19, 2007, the U.S. Energy Independence and Security Act of 2007 (EISA) was signed into law.[8] Title XIII of EISA is dedicated to the Smart Grid, which according to EISA, is a "modernization of the country's electric power transmission and distribution (T&D) system aimed at maintaining a reliable and secure electricity infrastructure that can meet the increasing demand for electricity." A fundamental assertion of EISA is that

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[5] Energy Independence and Security Act of 2007, Section 1306(d)

[6] CNN report U.S. electricity blackouts skyrocketing, August, 2010 http://www.cnn.com/2010/TECH/innovation/08/09/smart.grid/index.html

[7] Id.

[8] United States Congress (H.R. 6, 110th), Energy Independence and Security Act of 2007 (GovTrack.us database of federal legislation: December 19, 2007); http://www.govtrack.us/congress/bill.xpd?bill=h110-6 (accessed Dec 2, 2008). (U.S.Congress-1)

the existing T&D infrastructure is capable of delivering greater efficiencies, and simply adding more generators and transmission lines is not the sole answer to America's energy needs going forward.[9]

The goal is to use advanced, information-based technologies to increase power grid efficiency, reliability, and flexibility and reduce the rate at which additional electric utility infrastructure needs to be built.[10]

In 2009, the U.S. Congress passed the American Recovery and Reinvestment Act (ARRA), which allocated approximately $3.4 billion in stimulus grant funding for Smart Grid investments. The ARRA provided awarded entities up to 50 percent of the cost of deployment of Smart Grid technologies, including AMI, with a cap of $200 million.

Also in 2009, Congress directed the Federal Communications Commission (FCC) to develop a National Broadband Plan to ensure every American has "access to broadband capability." The National Broadband Plan has recommendations for state regulators that include: [11]

- Requiring electric utilities to provide consumers access to, and control of, their own digital energy information, including real-time information from smart meters and historical consumption, price and bill data over the Internet.
- Carefully evaluating a utility's network requirements and commercial network alternatives before authorizing a rate of return on private communications systems and consider letting recurring network operating costs qualify for a rate of return similar to capitalized utility-build networks.

In recent decades there has been a growing trend toward energy conservation in all aspects of society. Major energy providers have been out in front, minimizing their energy usage through the implementation of energy efficiency measures. Recently, minimizing energy usage and maximizing efficiency has trickled down to end-use industrial, commercial, and residential customers who have implemented measures that include utilizing energy-efficient appliances, equipment and devices.

[9] NEMA. Standardizing the Classification of Intelligence Levels and Performance of Electricity Supply Chains. Rosslyn, VA: December 2007.

[10] Overview of the Smart Grid-Policies, Initiatives, and Needs, ISO New England, Inc., February 17, 2009.

[11] Connecting America; The National Broadband Plan; http://www.broadband.gov/plan/

In addition to lowering energy usage, there is an increased awareness of the amount of carbon dioxide released into the environment and an interest in moving away from fossil fuels utilized for electric generation and transportation. There is also movement to shift to renewable energy sources (solar, wind, biomass, etc.) that will produce electricity in smaller quantities in more diverse, geographically distributed locations than the traditional central power stations common today.

As these trends mature and gain greater acceptance and implementation, they will place a substantially higher demand on an electric grid system that has aged and was not designed to accommodate an increasing amount of smaller, distributed renewable energy power sources.

IV. SMART GRID IMPACT ON THE ELECTRIC POWER GRID

The electric transmission and distribution grid is evolving into a more reliable system through the integration of two-way communications systems and sensors that allows the optimization of the grid operations in real-time. Staff's research indicates that the current design of the existing grid is based upon the concept of 'one-way' power flow from a generating source, to a transmission line, to a distribution system and then to a commercial, industrial or residential load.

Today's increased emphasis on distributed generation and renewable energy sources will require substantive changes to the, electric grid system Distributed generation sources may include:

- Smaller Fossil-fueled generation
- Combined Heat and Power (CHP)
- Solar Power
- Wind Power
- Stored Energy Sources (batteries, flywheels, compressed air, etc…)
- Plug-in Hybrid Electric Vehicles (PHEVs)
- Electric Vehicles (EV)
- And other potential sources

Modernizing the electric power grid to improve grid operations can include the following enhancements:

A. Installation on the transmission system of Phasor Measurement Units (PMU)

After the August 2003 blackout, the New York State Reliability Council (NYSRC) created a Defensive Strategies Working Group (DSWG) to evaluate ways to mitigate major disturbances on the New York control area. It was determined that under frequency load shedding (UFLS) should be a first line of defense to mitigate major disturbances. NYSRC advocated for the installation of Phasor Measurement Units (PMU) on the transmission system because such devices may offer a simpler method, at reduced costs, for separating sections of the transmission system.

Benefits of a PMU network include enhancements to: network situation alarming; oscillation detection; power plant integration, monitoring and control; planned system separation, reclosing and restoration; and post-event analysis.[12]

B. Overhead and Underground Distribution Sectionalizing Switches

The scope of this enhancement includes the installation of supervisory control and data acquisition (SCADA), or controlled, primary sectionalizing switches on targeted network feeders, to improve the reliability of the overhead distribution systems by enabling rapid isolation of faulted segments of primary feeders and re-energizing the non-faulted portion of the feeder.

C. Capacitor Bank Installations and Phase Monitoring

Installation of automatically controlled or switched capacitor banks will reduce system losses by correcting the power factor and thereby reducing the flow of reactive power through transmission lines, cables, and transformers. Installation will also improve reliability by improving system voltage profile, increasing generator reserve, and improving interface transfer capability to optimize distribution system VAR support for both on-peak and off-peak conditions.

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[12] "Order Authorizing Recovery of Costs Associated with Stimulus projects", Cases 09-M-0074 and 09-E-0310, July 27, 2009, by the New York Public Service Commission.

D. Distribution Grid Modernization

This enhancement will modernize the distribution backbone and will include additional distribution capacitor banks, installation of central transformer load tap change (LTC) controller software, installation of SCADA equipment and the development of grid modeling software. These modifications will increase efficiency by reducing losses and increasing reliability by mitigating grid cascades through automated load shedding.

E. Remote Monitoring System (RMS) and High Tension (HT) Feeders

This enhancement includes installation of RMS transmitters on network transformer vault locations to allow operators and engineers to dynamically monitor transformer tank pressure, oil temperature and the oil level that will enable rapid operator response to changes in system conditions.

The remote monitoring of the HT feeders includes upgrading the existing meters with a radio frequency (RF) communications module, which enables improved system planning, remote metering of HT customers and critical load data during contingency situations.

F. Dynamic Secondary Network Modeling and Visualization

This enhancement includes the integrated development and operation of distributed secondary network load flow models that provide near real-time load profiles for customer locations and validates model load flows from secondary models, utilizing the data provided by new remote devices at strategic customer locations. This will help system operator situational awareness and minimize secondary cable failures during peak loading conditions and network outages due to secondary events in the summer.

G. Demand Response Initiatives

This enhancement includes the implementation of a DR monitoring system and deployment of innovative controllable technologies. The DR monitoring system will be a comprehensive software deployment that will aggregate all DR participation in real-time during events. The second component of the DR program will include the installation of equipment and devices such as controllable room and rooftop air conditioning units, Home Area Network (HAN) systems and automatic enabled systems.

The Peak Load Management Alliance (PLMA), founded in 1999 as the national voice of demand response practitioners[13], is a non-profit organization dedicated to providing resources and advocacy toward critical energy management initiatives. This organization consists of experts applying knowledge and skills to address the challenges and opportunities in the rapidly changing energy landscape.

Open Automated Demand Response (OpenADR) provides a non-proprietary, open standardized DR interface that allows electricity providers to communicate DR signals directly to existing customers using a common language and existing communications such as the Internet[14]. OpenADR is currently deployed worldwide and in 2012, the state of California had an enrollment of 260 MW.

H. Combined Heat and Power (CHP)

CHP systems are an efficient form of distributed generation, typically designed to power a single large building, campus or group of facilities and provide power to critical infrastructure during interruptions of service from the electric grid. CHP systems are typically comprised of on-site electrical generators (primarily fueled with natural gas) that achieve high efficiency by capturing heat, a byproduct of electricity production that would otherwise be wasted. The captured heat can be used to provide steam or hot water to the facility for space heating, cooling, or other processes. Capturing and using the waste heat allows CHP systems to reach fuel efficiencies of up to 80 percent, compared with about 45 percent for conventional separate heat and power. CHP systems can use the existing, centralized electricity grid as a backup source to meet peak electricity needs when the CHP system is down for maintenance or in an emergency outage.[15]

On October 28, 2012, Superstorm Sandy caused widespread damage and economic losses across New Jersey, New York, and Connecticut with extended power outages affecting the region for days.

In response to Executive Order 13632, in August 2013, the Federal Hurricane Sandy Rebuilding Task Force published a Hurricane Sandy Rebuilding Strategy that describes how CHP played a successful role in keeping a number of college campuses, multifamily housing,

[13] http://www.peaklma.org/
[14] http://www.openadr.org/
[15] https://www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_critical_facilities.pdf

critical medical facilities, sewage treatment plants and other facilities running during and after the storm. The DOE published the "Guide to Using Combined Heat and Power for Enhancing Reliability and Resiliency in Buildings" in September 2013.[16] In March 2013, ICF International published a report titled "Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities" for the Oak Ridge National Laboratory.[17]

These reports provide an overview of CHP and examples of how this technology can help improve the resiliency and reliability of key infrastructure, although Missouri-specific information is limited.

V. ELECTRIC USAGE METERS

One of the key components of the Smart Grid that has received a lot of media attention is the electric meter whose basic functions are to measure the amount of electricity used by the consumer and also provide the physical interface point between the consumer and electricity supplier. There are basically three types of electric usage meters in use today: – electro-mechanical meters, automated meter reading, automated metering infrastructure.

A. Electro-mechanical Meters.

The most common type of electricity meter used by electric utilities is the Thomson or electro-mechanical induction watt-hour meter, invented by Elihu Thomson of the American General Electric Company around 1889. In 1894, Oliver Shallenberger of the Westinghouse Electric Corporation refined this induction meter to produce a watt-hour meter of the modern electro-mechanical form, using an induction disk whose rotational speed was made proportional to the power in the circuit.[18] The electro-mechanical induction meter operates by counting the revolutions of an aluminum disc which is made to rotate at a speed proportional to the power. The meter is reportedly very robust and reliable with accuracy typically of 1 percent and a range of 1 percent - 2 percent as governed by American National Standards Institute (ANSI) standard C12.1. In 1998, there were only four US vendors offering electro-mechanical meters and, currently, they are primarily being manufactured in China.

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16 http://www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_for_reliability_guidance.pdf
17 https://www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_critical_facilities.pdf
18 Wikipedia

B. Automated Meter Reading (AMR).

Automated meter reading, or AMR, is the technology of automatically collecting consumption, diagnostic, and status data from electric metering devices and transferring that data via one-way communication, to a central database for billing, troubleshooting, and analyzing. This advancement mainly saves utility providers the expense of periodic trips to each physical location to read a meter. AMR technologies include handheld, mobile and network technologies based on telephony platforms (wired and wireless), RF, or power-line transmission for communications of the data.

C. Advanced Metering Infrastructure (AMI).

Advanced Metering Infrastructure or AMI refers to systems that measure, collect and analyze energy usage, and interact with advanced devices such as electric meters through various two-way communications media either on request (on-demand) or on pre-defined schedules. The required infrastructure to support AMI applications includes hardware, software, communications, consumer energy displays and controllers, customer associated systems, and communications networks and interfaces.

The Department of Energy (DOE) reports an increasing amount of collaboration and alliance between smart meter vendors and other vendors providing software and hardware that support smart meter deployment.[19] "The meter is very accurate with an accuracy of typically .5 percent and a range of .5 percent -1 percent as governed by ANSI standard C12.20." Today there are at least six vendors offering these types of meters.

Type & Number of US Utilities with AMI by Customer Type[20]

Utility Type	Utilities	Residential	Commercial	Industrial	Transportation	Totals
Investor	73	25,891,279	2,886,498	78,688	4	28,856,469
COOP	311	5,017,654	495,609	47,667	0	5,560,930
Muni	84	1,116,675	149,323	4,870	0	1,270,868
Public & State	24	1,427,940	150,729	23,434	3	1,602,106
Totals	493	33,453,548	3,682,159	154,660	7	37,290,374

[19] http://www.energy.gov/news/documents/Smart-Grid-Vendor.pdf
[20] http://www.eia.gov/tools/faqs/faq.cfm?id=108&t=3

The following US utilities were scheduled to complete their AMI deployments by the end of 2012:[21]

- Alabama Power (AL)
- Pacific Gas & Electric (CA)
- Sacramento Municipal Utility District (CA)
- San Diego Gas & Electric (CA)
- Southern California Edison (CA)
- Black Hills Energy Corp (CO)
- Pepco (DC)
- Delmarva Power (DE)
- Gulf Power (FL)
- Georgia Power (GA)
- Idaho Power (ID);
- Bangor Hydro Electric Company (ME)
- Central Maine Power (ME)
- NV Energy (NV); Idaho Power (OR)
- Portland General Electric (OR)
- PPL (PA)
- Black Hills Power (SD)
- Austin Energy(TX)
- CenterPoint Energy (TX)
- Oncor (TX)
- Wisconsin Power and Light (WI)
- Cheyenne Light, Fuel, and Power (WY)
- Black Hills Power (WY)

In Missouri, the top three AMI deployments are Laclede Electric Cooperative with 36,000, Kansas City Power and Light (KCP&L) with 14,000 and the City of Fulton with 5,000.

Issues with AMI Implementation

Issues with smart meter deployment have involved customer outrage directed at PG&E in California and ONCOR in Texas. Further, the Maryland Public Service Commission (MdPSC) recently rejected Baltimore Gas and Electric's (BG&E) plan for deployment.[22] In April 2010, a state senate hearing forced PG&E to disclose information concerning problems with smart meters. PG&E found issues with faulty installations, loss of customer usage information and trouble sending information back to the utility.[23] Only a very small percentage of meters had accuracy issues.[24] The Texas Public Utility Commission ordered an independent investigation into the accuracy of installed meters. Independent

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[21] http://www.edisonfoundation.net/iee/Documents/IEE_SmartMeterRollouts_0512.pdf
[22] Anti-Meter Fever Spreads as Regulator and Customer Mistrust Grows, SmartGridNews.com, February, 2010
[23] Consumers wary of smart meters, stateline.org story, July 23, 2010.
[24] "PG&E Advanced Metering Assessment" report, September 2, 2010, by the California Public Utilities Commission prepared by Structure Consulting Group, LLC.

accuracy tests were conducted by Navigant Consulting, LLC, which found that 99.96 percent meters were determined to be accurate to ANSI standards.[25]

In Order No. 83410, Case NO. 9208, the MdPSC noted the following involving the rejection of BG&E's $835 million smart-meter installation plan:

- BG&E ratepayers should not be exposed to all the financial risk of an unproven and evolving technology and the accuracy of the assumptions used in the BG&E business case.
- The MdPSC will not approve cost recovery by way of a surcharge and prefers recovery through a regulatory asset because the project is viewed as a classic utility infrastructure investment.
- Before implementing time of use rates, it is critical that customers be provided sufficient education to understand the new tariff and how their behavior and decisions will impact their bill.
- Customers need to be provided sufficient enabling technology such as in-home displays (IHDs), energy orbs, messaging, etc., to provide the information that will trigger behavior changes aimed at reducing their electric bill.[26]

The MdPSC approved a revised BG&E submittal that incorporates its direction that the Smart Grid project be treated as a regulatory asset, similar to a new power plant, and BG&E should recoup its costs through base-rate increases, not through surcharges. The MdPSC said it would perform an ongoing review of BG&E's costs and recovery, allowing the company to raise rates, once it has 'delivered a cost-effective AMI system.'[27]

The Hawaii Public Utilities Commission (HPUC) denied a request by Hawaiian Electric Company (HECO) to extend pilot testing for its AMI project to 5,000 smart meters because of cost concerns.

HECO said that additional pilot testing would be necessary to understand, in detail, how advanced metering would work with a new customer information system. The HPUC said that HECO could not proceed with the plans outlined in its original application without

[25] Evaluation of Advanced Metering System (AMS) Deployment in Texas, Report of Investigation, July 30, 2010. http://www.puc.state.tx.us/electric/reports/ams/PUCT-Final-Report_073010.pdf
[26] "Maryland Regulators Approve BGE's Revised Smart Grid Proposal", August 17, 2010, SustainableBusiness.com News; http://www.sustainablebusiness.com/index.cfm/go/news.display/id/20873
[27] Ibid

engaging in the extended pilot testing and wrote that "any new AMI or, preferably, AMI/Smart Grid application should include or be preceded by an overall Smart Grid plan or proposal filed with the [HPUC]."[28]

Communication Networks and Protocols

A logistical area of concern is that, traditionally, electric utilities have no precedent or demonstrated skill at successfully building and operating telecommunications networks comprised of vast numbers of nodes that are required to provide high-accuracy and reliability for daily transport of meter-derived power consumption data.

The protocol debate promises to become one of the dominant issues in Smart Grid over the next several years. Various vendors have proposed solutions for linking homes, substations, transformers and all of the other machines that bring electricity to the house. Some companies have also proposed licensable proprietary standards that potentially could become de facto standards. Utilities have responded by either adopting these technologies for commercial Smart Grid deployments or at least agreeing to test them in trials.

Several electric cooperatives in Missouri utilize the MultiSpeak® Initiative for efficient communication integration, including: Boone Electric Cooperative, CO-MO Electric Cooperative, Laclede Electric Cooperative, Platte-Clay Electric Cooperative, Southwest Electric Cooperative and White River Valley Electric Cooperative. The MultiSpeak® Initiative is a collaboration of the National Rural Electric Cooperative Association (NRECA) and software vendors supplying the utility market and utilities, and is a project that is gaining national and international acceptance. (NIST, ANSI, IEC Wg14)[29] NRECA's MultiSpeak® is an industry-wide software standard that facilitates interoperability of diverse business and automation applications used in electric utilities. The MultiSpeak® Initiative has developed and continues to modify the specification that defines standardized interfaces among software applications commonly used by electric utilities so that software products from different suppliers can interoperate without requiring the development of extensive custom interfaces.[30] MultiSpeak® provides the following functions:

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[28] Power news article, August 10,2010, http://www.powermag.com/smart_grid/Hawaii-PUC-Rejects-Smart-Grid-Proposal_2917.html

[29] Technical Presentation by Gregory Wolven, WinEnergy, at Tech Advantage 2010 Conference and Expo.

[30] http://www.multispeak.org/About/whatIsMultiSpeak.html

i. Distribution System Monitoring that includes meter reading, load profile creation and connect/disconnect functions.
ii. Business Functions External to Distribution Management that includes meter data management, finance and accounting, customer billing, customer relationship management, end device testing and receiving, payment processing and prepaid metering.
iii. Distribution Operations that include call handling, outage detection and management, load management, distribution automation data, supervisory control and data acquisition, and distribution automation control.
iv. Distribution Engineering, Planning, Construction, and Geographic Information Systems that include engineering analysis and field design.[31]

Radio Frequency (RF) radiation concerns

There is debate concerning the amount of radio frequency (RF) radiation that is emitted from AMI or smart meters. RF and microwave (MW) radiation are electromagnetic radiation (non-ionizing[32]) in the frequency ranges 3 kilohertz (kHz) - 300 Megahertz (MHz), and 300 MHz - 300 gigahertz (GHz), respectively.[33] Smart Meters typically contain two wireless transmitters; one to transmit information back to the utility via the Wide Area Network (WAN) at a nominal power output range of .25 to 1 watt at a nominal frequency range of .8 to 1.9 GHz and a second to transmit inside the building using the Home Area Network (HAN) at a typical power level of .2 watts at a frequency of 2.4 GHz.[34] The current Federal Communications Commission (FCC) guidelines on exposure to RF radiation were published in 1996 and provide an adequate level of safety against known thermally induced health impacts of smart meters.[35] The CCST report entitled "Health Impacts of Radio Frequency from Smart Meters"released in March 2011[36] stated that the RF emissions levels of Smart Meters are measurably less than from microwave ovens or cell phones and scientific studies have not identified or confirmed negative health resulting from the RF emissions of

[31] http://www.multispeak.org/About/whatIsMultiSpeakcovers.htm
[32] http://en.wikipedia.org/wiki/Radiation
[33] https://www.osha.gov/SLTC/radiofrequencyradiation/
[34] http://www.ccst.us/publications/2011/2011smart.php
[35] http://www.metering.com/node/18864
[36] http://www.ccst.us/news/2011/20110111smart.php

common household appliances or smart meters.[37] A typical power output from a home wireless network router is .25 watt with a peak limit of 1 watt.[38]

The peak magnitude of RF emissions from smart meters is greatest at the front of the meter (facing away from the building or house and transmitting to the WAN requires more power due to the distance required versus the HAN) and decreases in magnitude as a function of the distance from the meter. In addition, these meters only emit the peak RF emissions when they are transmitting information back to the utility's network and the frequency of transmission can vary depending on the type of installed communication network. [39]

Communication Systems & Networks of AMI Meters:

Several network infrastructures and information technologies are available to support AMI deployment that include Microwave, Wireless Metropolitan Area Network (WIMAX), Outdoor Wireless Mesh Network (WMN or MESH), Long Term Evolution (LTE), 3G Cellular, Power Line Carrier, Wireline Broadband, Wireless Local Area Network (WLAN) and Zigbee.[40] While there are several technologies to consider, there are basically three separate communications systems required: the Wide or Wireless Area Network (WAN) from the utility access point back to the utility, the Neighborhood Area Network (NAN) outside from the meter to the utility access point and the Home Area Network (HAN) inside the residential home, commercial business or industrial facility.

The Neighborhood Area Network (NAN):

One communications system with two different networks is required to transmit data between the meter and the utility's collection or infrastructure support system. The first network supports communications between the meter and the utilities data collection point and is commonly referred to as a the NAN.

The Home Area Network (HAN):

Inside the home or business, a second communications system is required. Commonly referred to as the HAN, it also has some options for network architecture and communications protocols.

[37] http://www.ccst.us/publications/2011/2011smart.php
[38] http://www.wirelessforums.org/alt-internet-wireless/output-power-linksys-router-20811.html
[39] http://www.eiwellspring.org/smartmeter/Measured_RF_from_smartmeters.htm
[40] Smart Grid Wireless Technology Comparison Chart from Aviat Networks; http://www.aviatnetworks.com

The current in-home applications, which utilize smart thermostats, individual receptacle switches, and specific device switches for water heaters, central air conditioners and smart appliances, require low speed and bandwidth.

For these types of applications, a HAN Device Portal Architecture consisting of a communication gateway with a Zigbee Smart Energy Profile is the most widely used.[41] A recent General Electric paper concluded that the two wireless communication technologies that best meet the overall requirements for this application are Wi-Fi (IEEE 802l.11) and Zigbee (IEEE 802.15.4), with Zigbee preferred based upon lower energy consumption.[42] The Zigbee Smart Energy Profile has been endorsed by NIST as a national, U.S. Smart Grid standard.[43]

The Communication Gateway:

A communication gateway device is required to facilitate communication between the NAN and HAN networks.

The gateway device serves as a 'translator' for the two-way communications that are required between the NAN and HAN networks, which have different communication protocols or 'speak different languages'. This separate device should be external to the Smart Meter so communication protocol changes can be made without changing out the installed Smart Meter.[44]

Open technology and open non-discriminatory access to data can lead to new levels of services to consumers in the areas of demand response, information technology and price offerings.[45] While there is a lot of attention on the electric meter, a June 29, 2010 American Council for an Energy-Efficient Economy (ACEEE) report indicates in its opinion, smart meters alone are not sufficient for customers to realize energy savings; customer education is

[41] PennEnergy report; "The Home Area Network; Architectural Considerations for Rapid Innovation." http://www.pennenergy.com/index/power/smart-grid/display/3151828412/articles/pennenergy/ugc/smart-grid/the-home-area-network-architectural-considerations-for-rapid-innovation.html
[42] General Electric Paper, "Energy Efficiency Comparisons of Wireless Communication Technology Options for Smart Grid Enabled Devices", December 9, 2010.
[43] Smart Grid Watch, "Is it Game Over for the Winning Home Area Network Wireless Standard" http://www.emeter.com/2010/is-it-game-over-for-the-winning-home-area-network-wireless-standard/
[44] PennEnergy report; "The Home Area Network; Architectural Considerations for Rapid Innovation. http://www.pennenergy.com/index/power/smart-grid/display/3151828412/articles/pennenergy/ugc/smart-grid/the-home-area-network-architectural-considerations-for-rapid-innovation.html
[45] "Order Authorizing Recovery of Costs Associated with Stimulus projects", Cases 09-M-0074 and 09-E-0310, July 27, 2009, by the New York Public Service Commission.

required to meet projected energy savings goals.[46] As an example of the importance of consumer education, the Denmark energy company SEAS-NV initiated a competition where customers submit monthly meter readings via the internet or cellular phone text for a chance to win a monthly prize. The readings were also used to classify each contestant in an energy class in order to raise awareness of their energy consumption and provide customers individualized consulting on how to reduce their consumption. Customers who participated in this project reduced their consumption by an average of 17%.[47]

VI. CUSTOMER EDUCATION, INDUSTRY INITIATIVES AND STANDARDS

A. Customer Education

In the emerging Smart Grid, many studies have been done that are leading to the same general conclusion. A rational, technical, and one-sided approach, alone, will not be effective in driving Smart Grid customer engagement. The experience of the customer must be positive, and balance both the rational (price incentive, multiple forms of relaying information) and emotional (normative comparisons, environmental advantages, social implications) relationships.

There are multiple ways to build and foster this positive relationship and as the engagement and relationships evolve, the utility has to be willing to enhance its customer care to maintain these relationships. The utilities must also receive and give persistent feedback to evaluate where they are and in which direction their ideas/pilots/projects need to go. Some customer segments will react well to certain approaches, some segments to other approaches.[48] The utilities should evolve the approaches that work using a positive feedback loop, alternate approaches, or cut the ineffective approaches.[49]

There are many means currently available to communicate energy usage to consumers. Single socket plug-ins, whole-home energy trackers, energy ratings, etc. are currently in the

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[46] Special Report Number E105, Advanced Metering Initiatives and Residential Feedback Programs: A Meta-Review for Household Electricity-Saving Opportunities by ACEEE on Advanced Metering, June, 2010.
[47] European Utility Awards; http://www.european-utility-awards.com/EUA/Past_Winners_2290.aspx
[48] Customers as Co-Creators of Value: A Social Roadmap for the Smart Grid Peter C. Honebein | © 2010 Customer Performance Group | IEE Webinar August 16, 20101
[49] The OPOWER Approach: Advanced Customer Engagement (ACE)

market ready to be used, and are being utilized in many cases. Making these tools readily available and informing the public are the two main hurdles.

It is not necessary to have a Smart Grid in place to enable a significant and positive behavior change. Right now, statistical methods that analyze existing utility and other available data can be used to provide useful and educational consumer feedback. … Another existing technology approach that can enable both demand response and a more compelling energy efficiency behavior is to tap into mobile phone technology. In 2012, 88 percent of Americans had mobile phones and 46 percent of those were smartphones.[50] It is reported that if even 20 percent of homeowners managed their energy load using their mobile phone, it could result in a major reduction in electricity waste.[51]

The estimated amount of consumer energy cost savings are often quite different than the actual savings realized by the customer. Benefits are often stated in the 10-14 percent range while, once implemented and measured, the savings are more in the 5-8 percent range. Managing customer expectations is crucial to program success. If savings are much lower than anticipated, the whole program could receive negative feedback.

Some key communication lessons include:

- AMI represents just one of several means of providing households with real-time feedback.
- The success of the Smart Grid, advanced metering, and energy management and home automation technologies depends heavily on consumer acceptance and participation.
- Third-party providers are likely to be important players in feedback solutions, whether working in conjunction with or independently of utilities.
- Feedback gadgets alone are unlikely to maximize household energy savings.
- The best feedback approaches are likely to be incremental in nature and will 'evolve' as technologies become more sophisticated.

[50] http://pewinternet.org/Reports/2012/Smartphone-Update-2012/Findings.aspx

[51] Special Report Number E105, Advanced Metering Initiatives and Residential Feedback Programs: A Meta-Review for Household Electricity-Saving Opportunities by ACEEE on Advanced Metering, June, 2010.

- The future of home energy management is likely to involve a complex network of wireless, consumer-controlled, home automation systems; although less sophisticated automation devices can be supported presently.[52]

B. Green Button Initiative

"'Green Button' is an industry-led effort that responds to a White House call-to-action to: Provide electricity customers with easy access to their energy usage data in a consumer-friendly and computer-friendly format via a "Green Button" on electric utilities' website. Green Button is based on a common technical standard developed in collaboration with a public-private partnership supported by the Commerce Department's National Institute of Standards and Technology. Voluntary adoption of a consensus standard by utilities across the Nation allow software developers and other entrepreneurs to leverage a sufficiently large market to support the creation of innovative applications that can help consumers make the most of their energy usage information.

Initially launched in January 2012, utilities committed to provide Green Button capability to nearly 12 million households in 2012. Two utilities - Pacific Gas & Electric and San Diego Gas & Electric - have implemented live functionality on their websites. Recently, nine major utilities and electricity suppliers signed on to the initiative, committing to provide more than 15 million households secure access to their energy data with a simple click of an online Green Button. In total, these commitments ensure that 27 million households will be able to access their own energy information, and this number will continue to grow as utilities nation-wide voluntarily make energy data more available in this common, machine-readable format."[53]

C. Industry Standards

The National Institute of Standards and Technology (NIST) is the governing body charged with developing nation-wide standards for all areas of Smart Grid. NIST is currently involved with more than 100 organizations and stakeholders. NIST developed the Smart Grid Interoperability Panel (SGIP) to guide and nurture the long-term Smart Grid evolution. NIST

[52] Special Report Number E105, Advanced Metering Initiatives and Residential Feedback Programs: A Meta-Review for Household Electricity-Saving Opportunities by ACEEE on Advanced Metering, June, 2010.
[53] http://www.greenbuttondata.org/greenabout.html

also developed 17 priority action plans (PAPs). The PAPs define the problem, establish the objectives, and identify the likely standards bodies and user associations pertinent to standards modifications, enhancements, and harmonization.[54]

Standard(s) development began in 2007. The FERC initiated a formal rulemaking proceeding on October 7, 2010 by creating docket RM11-2-000 for consideration of the five groups of Smart Grid operability standards identified by the NIST.[55] These five groups of standards will address open and non-proprietary communications protocols and cyber security. The NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 2.0,[56] includes a description of the Smart Grid conceptual reference model and conceptual architectural framework under development by the SGIP's Smart Grid Architecture Committee (SGAC), an update to the progress of the PAPs, a listing of new standards emerging from the PAPs, a description of the recently formed Smart Grid Interoperability Panel (SGIP), a Cybersecurity section and a testing and certification section.

The North American Energy Standards Board (NAESB) is involved in developing smart grid standards and serves as an industry forum for the development and promotion of standards which will lead to a seamless marketplace for wholesale and retail natural gas and electricity, as recognized by its customers, business community, participants, and regulatory entities.[57] The Smart Grid Interoperability Panel maintains a catalog compendium of Smart Grid Standards.[58]

The New York Public Service Commission stated, "The expectation of seamless integration of new 'smart' technologies with legacy systems and devices cannot be achieved without great attention to the principal of interoperability. … Interoperability promotes technology innovation, operational efficiency and facilitates the scalability, security, and reliability of Smart Grid deployments. Although development of a comprehensive set of Smart Grid standards is not entirely complete, the principals of interoperability, standards-based communications protocols, and open architecture must be incorporated in current Smart Grid deployments. It is essential that the concept of interoperability not be limited to

[54] http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/WebHome

[55] FERC Docket No. RM11-2-000, "NOTICE OF DOCKET DESIGNATION FOR SMART GRID INTEROPERABILITY STANDARDS"

[56] http://www.nist.gov/smartgrid/upload/NIST_Framework_Release_2-0_corr.pdf

[57] http://www.naesb.org/

[58] http://collaborate.nist.gov/twiki-sggrid/pub/SmartGrid/StandardOperatingProcedures/Standards_Catalog_Process_and_Structure_V1_0.pdf

informational compatibility between Smart Grid systems. Greater interoperability and standards development should also drive innovation and competition among device manufacturers, increasing vendor choice and communications technology alternatives, ultimately leading to more cost-effective deployments."[59]

VII. PROCESSES, ISSUES & GOALS FOR MISSOURI

There are many unique processes and goals in the Smart Grid discussion Openly discussing these issues with all stakeholders is key to developing a pathway that is best for the state of Missouri.

Planning and implementation are the key foundational processes that must be addressed before any significant progress can be made. There are key planning and implementation issues that many IOUs in Missouri are addressing:

- Ameren Missouri[60] has cost benefit studies that indicate replacing AMR meters before their normal replacement interval and transitioning to an AMI implementation would not be cost effective. Ameren Missouri is now planning a transition to AMI meters starting in 2015.
- Kansas City Power & Light is well into the implementation phase for its pilot project in the Kansas City area.
- Empire District Electric is currently in the early planning stages of its Smart Grid initiatives.

The MoPSC has held stakeholder meetings and technical workshops/conferences for dialogues and collaboration between businesses, customers, utilities and regulators. Major goals of the planning and implementation phases are to consider all alternatives and select the alternatives that would be beneficial to the most customers without having negative consequences in the areas of reliability, costs or availability.

Different IOUs are in different stages of implementation, and as implementation begins, issues will inevitably arise. Cost recovery, security, customer relations, benefits with the new systems, and reliability are all major concerns for new systems.

[59] "Order Authorizing Recovery of Costs Associated with Stimulus projects", Cases 09-M-0074 and 09-E-0310, July 27, 2009, by the New York Public Service Commission.
[60] As used in this report, AmerenUE is the same as Ameren Missouri.

These concerns should be addressed in workgroups now and as they represent potential hurdles in the future. The overall goal of implementation is to smoothly deploy Smart Grid and all necessary hardware and software without any loss of reliability. Periodic workshops/technical conferences are suggested to address new issues as they arise, and to resolve any current or past conflicts that have not been properly addressed. These workshops/technical conferences have been very successful and well received by all stakeholders and bring in a wide variety of experience, solutions and/or ideas that can help navigate the ever-evolving Smart Grid.

VIII. SMART GRID PILOT/DEMONSTRATION PROJECTS IN MISSOURI

A. The City of Fulton[61]

The City of Fulton municipal electric utility was one of 100 recipients of the DOE's Smart Grid Grant awards on October 30, 2009. The City's share of the grant award is just over $1.5 million, which was matched by the city. The City's project will replace more than 5,000 electric meters with an AMI smart meter network that includes a dynamic pricing program with in-home energy displays to reduce consumer energy use.

The City also made an additional commitment of $1 million for gas and water meter improvements and will also include the installation of 2-3 vehicle charging stations. In April 2011, the City awarded a $2.14 million contract to Tantalus for system integration and implementation.[62] The Electric AMI meters are GE single phase residential with a remote disconnect feature. Customers do not have an "Opt Out" option for the new AMI meters and the city is looking at different rate structures to offer new tiered rate structure and time-of-use rate to customers.

The City has a "Smart Grid Bill of Rights"[63] that outlines the rights of customers with respect to the Smart Grid and guarantees the following:

- The Right To Be Informed
- The Right To Privacy

[61] http://psc.mo.gov/CMSInternetData/Electric/Smart%20Grid/Happening%20in%20MO/Kyle%20Bruemmer%20presentation.pdf
[62] http://www.fultonsun.com/news/2011/apr/15/council-oks-smart-grid-bid/
[63] http://fultonmo.org/departments/utilities/smart-grid/sg-bor/

- The Right To Options
- The Right To Data Security

The gas and water meters are upgraded to AMR and fitted with a Badger module to communicate over the Tantalus network. There are a total of 5,505 AMI meters deployed with 4,359 of these for residential, 916 for commercial and 50 for industrial customers. The network communications protocol is Multi-Speak and the city is deploying a Meter Data Management system to create a customer web portal and customer usage reports. The Home Area Network is a 900 MHz mesh network, and there are approximately 100 programmable smart communicating thermostats being deployed.

The City plans to use the AMI system to also deploy demand response to decrease the amount of purchased power required and plans to pass the savings on to its customers. The City wants to deploy a demand response program similar to KCPL's "M Power". The City is also in the initial planning stages to deploy a voltage control system similar to Ameren Missouri which they estimate will result in a 3 percent energy savings.[64]

B. KCP&L Company's Smart Grid Demonstration Project[65]

The KCP&L Smart Grid demonstration project (Project) is included in the Department of Energy (DOE) and Electric Power Research Institute (EPRI) demonstration programs.[66] The Project is located in an economically challenged area of Kansas City, Missouri. The Project's expectations are that the Project will deliver benefits to the immediate targeted end-users and provide valuable experience and lessons for future applications. Project funding consists of approximately $48.1 million to be spent from 2010 through 2014, of which $13.8 million (29%) is KCP&L-funded, $10.2 million (21%) is partner/vendor-funded and $24.1 million (50%) is federally-funded through the ARRA.[67] KCP&L teamed with Siemens Energy, Inc., Open Access Technology, Inc. (OATI), Landis&Gyr AG, GridPoint, Inc., Kokam America, Inc., EPRI and Honeywell International, Inc.[68]

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[64] http://energy.gov/sites/prod/files/SGIG%20Awards%20%20By%20State%202011%2011%2015.pdf and http://www.smartgrid.gov/project/city_fulton_missourismart_grid_project/latest_data

[65]: http://ala.kcpl.com/about/policycenter/SmartGridGIZmap.pdf and http://www.kcpl.com/about/policyctr.html

[66] Smart Grid Demonstration Project presentation to EEI Strategic Issues Roundtable, October 20, 2010.

[67] KCP&L Green Impact Zone Smart Grid Demonstration submitted to the DOE, August 26, 2009.

[68] Ibid

The Project is being promoted as an end-to-end Smart Grid that will include advanced metering infrastructure (AMI), renewable generation, energy storage resources, leading edge substation and distribution automation and control, energy management interfaces, and innovative customer programs to include time of use (TOU) rate structures. The Project will focus on the area served by KCP&L's Midtown Substation across 2 square miles, impacting about 14,000 commercial and residential customers across ten circuits with total electric demand of 69.5 Mega Volt Amperes (MVA). The Smart Grid Project includes over 25 stakeholder groups including: Mid-America Regional Council (MARC), Missouri Electric Cooperative (MEC), Missouri Gas Energy (MGE), University of Missouri at Kansas City (UMKC), the Missouri Public Service Commission, The Kansas Corporation Commission, City of Kansas City, Missouri and several local neighborhood groups.[69]

Within the Smart Grid Project boundaries lies the Green Impact Zone project, a 150 square block area of inner-city neighborhoods in Kansas City. The primary goal of the Green Impact Zone Project is to transform distressed urban neighborhoods into a sustainable community.[70]

The Project will be based upon the guidance found in the proposed National Institute of Standards (NIST) interim Smart Grid Interoperability Standards Roadmap, the EPRI IntelliGrid Architecture and the GridWise Architectural Council recommendations.[71]

The primary, overall focus for the Project will be to implement next-generation, end-to-end Smart Grid components that will include Distributed Energy Resources (DER), enhanced customer facing technologies, and a distributed-hierarchical grid control system that includes the following key elements:[72]

- Upgrade the Midtown Substation to create a next generation "Smart Substation;" with multiple distribution circuits that have a variety of feeder-based instrumentation and control devices for monitoring and control, and a Grid management infrastructure to support the upgraded grid, back office and substation requirements (see detailed description below);

[69] Smart Grid Demonstration Project presentation to EEI Strategic Issues Roundtable, October 20, 2010.
[70] KCP&L Green Impact Zone Smart Grid Demonstration Abstract.
[71] KCP&L Green Impact Zone Smart Grid Demonstration submitted to the DOE, August 26, 2009.
[72] KCP&L Green Impact Zone SmartGrid Demonstration submitted to the DOE, August 26, 2009.

- Smart Meters (14,000) with AMI installed at all customer sites to provide consumers with enhanced information on energy use and the opportunity to utilize residential TOU rate structures.
- Integration of distributed generation that includes an Exergonix 1 MW Superior Lithium battery storage system that was delivered and installed at the Midtown Substation in April 2013;
- Distributed roof-top solar photovoltaic systems that include installations at Paseo High School, Blue Hills Community Center, UMKC Student Union and Flarsheim Hall, and Midwest Research Institute;[73]
- Distributed electrical vehicle charging stations. Currently the Company has 20 charging stations at various locations and is monitoring usage patterns. The Company may install additional charging stations depending upon future market developments, and;
- Demonstration House (Project Living Proof) that is located at 917 Emanuel Cleaver II Blvd and is open to the public. KCP&L has partnered with the Metropolitan Energy Center to show case products and technology applications that include smart washers and dryers, smart water heaters, roof top solar, battery storage and associated DC to AC inverter, alternative heating and cooling equipment, an electrical vehicle charging station, sustainable landscaping, energy efficiency measures, and devices and web based tools utilized by customers in the Smart Grid demonstration project as described below.

Consumers within the Smart Grid demonstration project boundaries will be offered a wide range of products and services with the following expected level of participation[74]:

- Customer's with internet will have access to real-time energy usage by viewing a personalized web page via a web portal ("MySmart Portal");
- 1,600 residential and commercial customers are expected to have in home/business energy displays ("MySmart Display") that indicate real-time information and demand response thermostats ("MySmart Thermostat");
- 400 residential users are expected to utilize an Energy Management System (EMS);

[73] http://www.kcplsmartgrid.com/about-kcpl-smartgrid/solar-installation.
[74] http://www.burnsmcd.com/benchmark/Article/In-the-Heart-of-America-Smart-Grid-Demonstration

- 2 commercial users are expected to utilize an EMS;
- 10 LED area street lights will be installed at UMKC;
- 64 residential users are expected to utilize hyper-efficient appliances;
- 5 commercial and 10 residential users are expected to utilize roof-top solar; and
- 20 distributed vehicle charging stations will accommodate Plug in Hybrid Electrical Vehicles (PHEV).

KCP&L is in the final phase of this demonstration project that includes activities such as data collection, reporting and project conclusion, operating the integrated Smart Grid demonstration systems, collecting 24 months of grid data, evaluating systems and analyzing performance. KCP&L has completed the Smart Grid Demo home preparation, Smart Meter Acceptance test and the Home Energy Portal. The Smart Meter deployment with enhanced security implementation is complete.

Midtown Substation[75]

The Midtown Substation is located at 47th and Forest and is one of the oldest substations, built in the early 1960s. The new substation upgrades replace the existing substation controls and monitoring and older communication protocols. The upgraded Substation includes many upgrades for controls, automation and monitoring as described below.

[75] https://www.kcpl.com/troost/051308_mtgSumm.pdf & http://tdworld.com/distribution/wired-success

Control and automation functionality includes:

- Control and Data Acquisition
- Voltage and VAR control
- Power Flow
- Fault location, isolation and service restoration

Monitoring is implemented for the following:

- Transformers
- Circuit Breakers
- Exergonix 1 MW Superior Lithium battery storage system.
- Cables
- Surge Arrestors
- Access and activity

IEC 61850 Communications

- o At the core or heart of the substation upgrade is the implementation of an IEC 61850 (International Electrotechnical Commission) communication and control network protocol communicating on redundant Ethernet-based communication networks.
- o There are four primary automation schemes being implemented to provide automatic load transfer upon transformer lockout, fast clearing of bus load upon a feeder breaker failure, backup overcurrent protection for the bus differential relay protection and communication between devices to identify distribution system events.

Redundant Ethernet Communications Network

- o The substation is being retrofitted with redundant fiber optic LANs (Local Area Networks) using network equipment from two hardware vendors, Cisco and RuggedCom.
- o The LANs are segmented for smart grid security and the NISTIR (National Institute for Standards Interagency) 7628 standards to maintain secure communications within the EMS (Energy Management System) to meet NERC requirements for a critical infrastructure protection system critical asset.

Distribution Management System (DMS) & Distributed Energy Resource Management (DERM)

- These systems provide centralized oversight of the smart grid operations and perform economic evaluations for Demand Response (DR) implementation.

Microprocessor-based Relaying

- The substation is deploying a number of SEL (Schweitzer Engineering Laboratories)[76] relays for feeder and transformer protection that are compatible with the IEC-61850 standard protocol.[77]

Transformer Insulating Oil Dissolved Gas Monitors

- This equipment provides real time monitoring of the temperature and the moisture and combustible gases that are dissolved in the insulating oil of the substation transformers. The detection of certain combustible gases and moisture provides an early warning system of an impending transformer internal fault that will destroy the transformer and cause significant collateral damage.

Automatic Voltage Regulation and Control

- Load tap changers on the substation transformers are automated to adjust system voltage from the automated substation control system.

Battery Energy Storage System (BESS) [78]

- An Exergonix[79] 1 MW Superior Lithium battery storage system[80] is installed at the substation. The storage system consists of the battery, inverter and control system that will be utilized to store energy during off-peak times and provide energy during peak power periods.

For Smart Grid Components outside the Substation on the Distribution System see the Appendix.

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[76] http://www.selinc.com/smartsolutions/

[77] http://www.burnsmcd.com/Resource_/PressRelease/2535/FileUpload/article-TDWorld-Wired-for-Success-Olson.pdf

[78] http://www.sustainablebusinessoregon.com/national/2011/02/exergonix-tests-1-mw-battery-in-kansas.html & http://www.prnewswire.com/news-releases/kcpl-exergonix-mriglobal-pilot-new-energy-storage-system-173916571.html

[79] http://www.exergonix.com/index.php

[80] http://www.exergonix.com/battery_energy_storage_systems.php

C. The Boeing Company Smart Grid Regional Demonstration Project[81]

The Boeing Company Smart Grid Regional Demonstration Project will demonstrate an advanced Smart Grid software technology with military-grade cyber security for improving regional transmission system planning and operation. Boeing was selected on November 9, 2009, to receive an $8.5 million DOE grant to lead one project team and is a sub-recipient on two others -- one led by Consolidated Edison of New York and one by Southern California Edison. The project includes PJM, Midwest Independent Transmission System Operator (MISO), and Public Service Electric and Gas Company (PSE&G), a diversified energy company in New Jersey, who collectively serve all or part of 21 states and more than 90 million people.

These projects are designed to achieve the following goals:

- increase grid reliability
- reduce system demands and costs
- increase energy efficiencies
- rapidly allocate energy when and where it is needed
- provide greater network security and flexibility to accommodate new energy technologies

D. White River Valley Electric Co-op[82]

White River Valley Electric Co-op has a full deployment of AMR meters throughout its service area. In 2008, it began a beta testing phase for Google PowerMeters utilizing the MultiSpeak® specification. This approach gives customers access to daily energy usage and allows customers to track energy usage constantly. This provides a way for customers to better understand energy usage throughout the home and to minimize that usage. Google retired its PowerMeter Program on September 16, 2011.[83] A similar home energy management software service provided by Microsoft called Hohm was terminated on

[81] http://boeing.mediaroom.com/index.php?s=43&item=976 & http://www.boeing.com/news/frontiers/archive/2010/june/i_bds01.pdf
[82] http://www.whiteriver.org/default.aspx)
[83] http://www.google.com/powermeter/about/

May 31, 2012.[84] Both Google and Microsoft indicated that slow market adoption did not justify continued development.

E. Co-Mo Electric Cooperative[85]

Co-Mo Electric Cooperative has been fully deployed with AMI meters since 2002. The company uses multiple avenues to show customers their hourly and daily usage through the "Power ByThe Hour" program[86] that utilizes a Two-Way Automatic Communications System (TWACS) using the MultiSpeak® specification. The AMI meter deployment has allowed the company to move into prepay electricity accounts with its customers, which would not have been realistic prior to AMI deployment.

F. Laclede Electric Cooperative[87]

Laclede Electric Cooperative (Laclede) deployed a wireless advanced metering infrastructure (AMI) system in 2008, as its first step toward the development of a smart grid that will enhance customer service, improve overall electrical network efficiencies, reduce operating costs, and automate the way energy is monitored and managed.[88] Laclede selected a Tantalus Utility Network (TUNet) for flexibility, scalability, and capability to serve as a single communications backbone that supports the full range of smart grid functionality.[89]

The Smart Grid initiative includes a full change-out of approximately 36,000 existing electromechanical meters with Itron CENTRON® solid-state meters.[90] The new meters will monitor consumption and power quality, pinpoint outages by individual meter or in aggregate and integrate customer data into backend billing, load forecasting, and other applications.[91] Laclede also entered into a contract to provide Ft. Leonard Wood with commercial and industrial energy management services.[92]

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[84] http://en.wikipedia.org/wiki/Hohm
[85] http://www.co-mo.coop/usageinfo.aspx
[86] Ibid
[87] http://www.lacledeelectric.com/
[88] T-Net News, October 7, 2009.
[89] Tantalus Laclede Electric Case Study: http://tantalus.com/cs_laclede.php
[90] Presentation by Terry Rosenthal, Laclede Electric Engineering Manager at Tech Advantage 2010 Conference and Expo.
[91] Tantalus News Laclede Electric Press Release, November 4, 2008.
[92] T-Net News, October 7, 2009.

G. Black River Electric Cooperative (BREC)

Black River Electric Cooperative (BREC) was formed in 1938 to provide electricity to a service area that encompasses the southeast Missouri counties of Bollinger, Cape Girardeau, Dent, Iron, Madison, Perry, Reynolds, Shannon, St. Francois and Wayne.[93] BREC signed an agreement with Aclara Systems to install the TWACS advanced metering infrastructure solution in its service territory and implementations started in 2008. The Aclara TWACS systems uses power lines to transmit data to and from the smart meters installed at customer locations. The system makes it easy to use existing power lines to reach all customers, even those in remote locations. The technology provides a solid metering foundation and delivers valuable data for timely billing, load control, demand response, and outage detection and assessment. [94]

IX. MISSOURI INVESTOR-OWNED UTILITIES SMART GRID STATUS[95]

A. Ameren Missouri[96]

Smart Meters

Ameren Missouri has been 100 percent deployed with AMR since 2000 with 1.2 million meters in total, all owned by Ameren Missouri. There are approximately 100 'net metering' applications to date, 18,000 meters are configured for time-of-use/demand reporting and 5,000 are configured for 15-minute interval reporting for industrial and large commercial customer use. The remaining meters report daily kWhs for residential and small commercial customer use. In September 2009, Ameren Missouri conducted a study comparing the costs and benefits of AMR versus AMI and concluded the following:

- AMR achieves most of the operational benefits of AMI without the two-way communications – automatic 'reads,' outage notification; tamper detection, system load data.

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[93] Smart Grid Information Clearing House; http://www.sgiclearinghouse.org/ProjectMap?q=node/2061

[94] Smart Grid Information Clearing House; http://www.sgiclearinghouse.org/ProjectMap?q=node/2061.

[95] Information for this section was provided by the individual IOU's through presentations, company websites and information provided during workshops and meetings with the MoPSC.

[96] http://www.ameren.com/sites/aue/Pages/home.aspx

- The operational benefits offered exclusively by AMI include remote connect/disconnect and remote meter programming/configuration.
- Conversion to AMI would require new meters, new communications infrastructure, a new operating system, and billing system integration with a total conversion estimated at over $300 million.
- As stated in the Ameren Missouri 2011 Integrated Resource Plan (IRP), the planning team assumed that the existing AMR technology will begin to be converted to AMI technology beginning in 2015 when the existing AMR system would be approximately 20 years old.
- The Company is currently upgrading and modernizing its AMR system with the deployment of new field equipment that will provide increased network capacity for adding additional meters and increased communication flexibility.[97]

New field equipment includes Concentrators and Collectors in addition to the existing Cell Masters[98] and Micro Cell Controllers ("MCC").[99] The Concentrator receives wireless radio broadcasts from the electric meters and then transmits digital information to the Collectors. The Collector receives the information from the Concentrators and then transmits bundled digital information in "packets" to a central operating system for processing. Currently there are three Collectors, 226 Concentrators, 90 Cell Masters and 8,155 MCCs in the Ameren Missouri's service territory. Additional Cell Masters and Micro Cell Controllers will be added as required to maintain the current MCC and AMR coverage areas.

Electric Vehicle and Plug-In Hybrid Electric Vehicles

The auto industry has already standardized 120V and 240V charging characteristics and the associated plug-in connectors (i.e. 'interfaces'). Ameren Missouri placed a plug-in hybrid (diesel fuel and electric powered) bucket truck in service in the St. Louis metropolitan area in 2011 as part of an Electric Power Research Institute (EPRI) demonstration project. Ameren Missouri is also participating on a Plug-In Readiness Task Force with St. Louis Clean Cities as a means of monitoring initial discussions on how to create a local market for new

[97] Ameren's Smart Grid report dated February, 2012.
[98] A wireless high capacity router device that receives and collects wireless data from Micro Cell Controllers and then transmits this data via a leased line to the central operating system.
[99] A small pole mounted data collection device that receives wireless AMR data and transmits this data to a Cell Master.

plug-in hybrid electric vehicles. The Company has a Chevrolet Volt hybrid automobile that employees are testing and evaluating. An August 2009 technology study concluded that there would be no significant system effects or impacts anticipated on Ameren Missouri's service territory until PHEV penetration approached approximately 150,000 vehicles.[100]

Electric Grid

Ameren Missouri's investments are focused on the electric system grid to improve service reliability, operating efficiency, asset optimization, and a robust energy delivery infrastructure. Ameren Missouri has approximately 2,300 line capacitors that are automated via one-way radio communications and approximately 800 tap changing substation transformers that are automated to adjust system voltage from commands issued by Distribution Control Offices. System voltage reduction has proven to work and Ameren Missouri-documented cases over 15 years show 1.0-1.2 percent demand reductions after programmed calls for 2.5 percent voltage reductions. Significant future infrastructure investments are required to take full advantage of this system optimization feature and the 1980s era legacy system of line capacitor control will need to be replaced.

A new communications network infrastructure is required to support two-way communications with intelligent line devices like capacitors along with a new distribution management system platform. Ameren Missouri smart grid components on the electric grid are described in the Appendix.

Customer Electric Usage Information[101]

Customers can view daily usage, create a profile for their house and explore options for energy savings by utilizing the Ameren Energy Savings Toolkit on the Company's website.

[100] Ameren Missouri Presentation; "The Smart Grid @ AmerenUE", May 18, 2010, item 84, EFIS File No. EW-2009-0292

[101] http://www.ameren.com/sites/aue/csc/Pages/EnergySavingsToolkit.aspx

B. KCP&L[102]

Smart Meters

AMR deployment consists of 500,000 one-way communications meters that are read daily and were deployed starting in 1995. KCP&L currently has an 'MPOWER' program for energy curtailment and real-time pricing programs for customers.

The Smart Grid Demonstration Project deploys approximately 14,000 AMI Smart Meters with two-way communications reads on 15-minute intervals, utilizing a single field communications network for the infrastructure required for the project.

The 14,000 AMI Smart Meters replace existing AMR meters, but there will only be 1,600 energy displays and smart thermostats to utilize the additional information available through the AMI Smart Meters.

Electric Vehicles and Plug-in Hybrid Electric Vehicles

PHEV charging will be deployed as part of the Smart Grid Demonstration Project. With electric cars expected to soon hit the market, KCP&L plans to have 20 charging stations in place. The University of Missouri-Kansas City intends to install an electric charging station that will be available to the public. It will also be used to charge the university's first electric truck upon purchase. KCP&L has hybrid electric/E85 fuel vehicles as part of a pilot program with Ford Motor Company.

Electric Grid

The KCP&L electric grid infrastructure focuses on the pursuit of service reliability, operating efficiency, asset optimization, and building a secure, robust energy delivery infrastructure. KCP&L utilizes line capacitors that are automated via one-way radio communications, and tap-changing substation transformers that are automated to reduce system voltage from remote commands. Within KCP&L's Smart Grid Demonstration Project, as discussed in Section VIII.B., the Smart Distribution project will include a smart substation with a Distribution Management System (DMS) and an IP/RF 2-way Field Area Network (FAN). The grid will also include distributed generation that will include Smart Generation consisting of residential/commercial rooftop solar and residential battery storage.

Customer Electric Energy Information[103]

[102] http://www.kcpl.com/ and Section VIII.B on the KCP&L Smart Grid Demonstration Project
[103] http://www.kcplsave.com/residential/connections/default.html

Customers can view daily usage through home energy web portals, create a profile for their house and explore options for energy savings by utilizing the KCP&L Connections website. It should be noted that not all households have Internet access and there are no libraries in the Green Impact Zone to provide this access.

C. Empire District Electric [104]

Smart Meters

Currently only electro-mechanical meters are deployed. Smart meter deployment was attempted earlier but abandoned due to failures in the communications infrastructure deployment. In March 2010, Empire District Electric assembled a team to develop a pilot program that would research and test the available metering products and technologies for an advanced metering infrastructure system. The team determined it would need to visit with a number of manufacturers, vendors, and other utility companies. The team determined it was also necessary to identify the required interfaces and to define the corporate resources needed to ensure a successful pilot implementation.

The proposed pilot program will include residential, commercial, and industrial customers, which will cover single-phase and three-phase applications. It is anticipated that implementation will include two different communications technologies via two separate phases. The scale, location, and timeline are pending approval.

Electric Vehicles and Plug-in Hybrid Electric Vehicles

No current plans for charging stations to accommodate EV and PHEV vehicles.

Electric Grid

Empire District Electric grid infrastructure focuses on service reliability, operating efficiency, asset optimization, and building a secure, robust energy delivery infrastructure. New substation relays and automated recloser switch controls utilize digital communications. Almost all power transformers have automatic load tap changers and those that do not have line voltage regulation in the substation. Empire's smart grid components on the electric grid are described in the Appendix.

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[104] Information for this section was provided by Empire District in response to Data Request 0213 in Rate Case ER-2012-0345, Empire's presentations in workshops and meetings with the Staff and : https://www.empiredistrict.com/

Customer Electric Energy Information[105]

Customers can view daily usage through home energy web portals, create a profile for their house and explore options for energy savings by utilizing the Empire District Electric website.

X. ISSUES REQUIRING FURTHER EMPHASIS BY MISSOURI STAKEHOLDERS

Planning

Defining project goals based upon stakeholder input is essential. Stakeholder and customer engagement that leads to some ownership of the project plan are key elements that must be obtained. The MoPSC has initiated several workshops and conferences to discuss the future of Smart Grid in Missouri. All known stakeholders, including the IOUs of Missouri, other government organizations, potential vendors, consumer advocates, and other stakeholders have been involved in the workshops. There are also multiple pilot projects by IOUs and municipals that will provide more information. The path forward will be determined to a large extent from the information obtained through these efforts.

Large Scale Implementation

For any task as large as updating the electric grid, implementation should evolve through the execution of an overall plan in a phased approach.

This step can be one of the hardest steps as efforts can fail for numerous reasons. It has been the experience of Staff that the IOUs are trying to implement Smart Grid technology in a piecemeal fashion. They are developing test markets to research the areas of concern. By closely studying the results of workgroups, conferences, and pilots in the state and across the nation, a phased implementation plan can be developed. Taking the time to plan all phases and steps is critical to reducing mistakes and to implementing a Smart Grid that is capable of handling the future energy needs.

Cost Recovery

IOUs will need some form of cost recovery in order to be incentivized to deploy Smart Grid technology. The deployment of Smart Grid will include many resources and if the

[105] https://www.empiredistrict.com/login.aspx

consumer does not realize the promised benefits, the Smart Grid system does not achieve the desired results.

The MoPSC and stakeholders must work closely together to ensure that the technology that is implemented is prudent and beneficial for the IOU and the consumer. Some state commissions have taken action on the cost recovery aspect.[106] These actions, and the results of these actions, should be taken into consideration as Missouri moves forward and cost recovery becomes a prominent issue. The MoPSC should consider opening a docket to address this issue specifically, as it is one of the most important to all stakeholders.

Cyber Security and Data Privacy

With the introduction of a two-way communications system, there is a great concern about security and data privacy. A safe and reliable network is paramount for consumer confidence and the acceptance of Smart Grid. Although this issue is currently in the news and on the minds of many consumers, these issues have been addressed in several industries that include financial, defense, telecommunications, broadband wireless, Internet, Internet commerce, medical, etc. ... In a Privacy by Design report[107] entitled: "Achieving the Gold Standard in Data Protection for the Smart Grid," the following "Best Practices" are promoted:

1. Smart Grid systems should feature privacy principles in their overall project governance framework and proactively embed privacy requirements into their designs in order to prevent privacy-invasive events from occurring;
2. Smart Grid systems must ensure that privacy is the default – the 'no action required' mode of protecting one's privacy;
3. Smart Grid systems must make privacy a core functionality in the design and architecture of Smart Grid systems and practices;
4. Smart Grid systems must avoid any unnecessary trade-offs between privacy and legitimate objectives of Smart Grid projects;
5. Smart Grid systems must build in privacy end to end, throughout the entire life cycle of any personal information collected;

[106] The New York Public Service Commission in Case 09-M-0074 issued on April 14, 2009, a proposed framework for the Benefit-Cost Analysis of Advanced Metering Infrastructure to provide a generic approach for guidance to the utilities. The Commissions in California, Texas and Vermont have provided similar guidance.
[107] Privacy by Design report entitled: "Achieving the Gold Standard in Data Protection for the Smart Grid", June 2010; http://www.privacybydesign.ca/content/uploads/2010/03/achieve-goldstnd.pdf

6. Smart Grid systems must be visible and transparent to consumers to ensure that new Smart Grid systems operate according to stated objectives;
7. Smart Grid systems must be designed with respect for consumer privacy as a core foundational requirement.[108]

The US DOE published a report titled "Study of Security Attributes of Smart Grid Systems-Current Cyber Security Issues" in April 2009 that concludes that Smart Grid cyber security must be a coordinated and ongoing effort through the full development lifecycle of Smart Grid implementation.[109] The Missouri Public Service Commission published an article titled "Cybersecurity: Guarding Against Threats to Utilities" in its December 2012 edition of PSConnection.

President Obama issued an executive order on February 12, 2013, directing "the Director of the National Institute of Standards and Technology (NIST) to lead the development of a framework to reduce cyber risks to critical infrastructure (the "Cybersecurity Framework")." As outlined by the White House, "the Cybersecurity Framework shall include a set of standards, methodologies, procedures, and processes that align policy, business, and technological approaches to address cyber risks."[110]

Currently, NIST is developing Cyber Security Standards for Smart Grid applications and it will be beneficial for all IOUs to comply with approved NIST standards.

Customer Acceptance and Involvement

With Smart Grid deployment in different geographical locations throughout the country, there are various approaches to customer education and communication. A multiple-pronged approach that can be tailored to specific customer types has shown to be the most effective way to maximize customer involvement in energy savings through smart applications. Access to real-time information, daily, hourly, and possibly in smaller increments, in relevant formats, mail, email, Internet portals, cell phone messages, phone calls, in-home monitors, etc., will give the customers the tools necessary to be more aware of their usage levels.

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[108]Ibid.

[109] http://http://www.inl.gov/scada/publications/d/securing_the_smart_grid_current_issues.pdf

[110] http://sgip.org/nist-to-play-major-role-in-administrations-executive-order-on-improving-critical-infrastructure-cybersecurity/

Customer Savings and Benefits

Customer savings will be a natural by-product of having knowledge about usage and being empowered to control usage levels through a choice of options best suited for the individual customer.

Customer savings may also be directly linked to demographics, education and income levels. Based on the observation and research of Staff, more affluent and educated customers, and those who own their own home, are generally more likely to spend extra money for energy efficient and smart appliances to realize energy savings over time. Low income, elderly and those customers that rent will generally be less likely to be in a position to spend extra money on energy efficient appliances, but will be more interested in actions they can take that require minimal investment. Reaching out to customers and customizing the approach to the type of customer will be a key issue. Advertised customer benefits should be conservative and realistic. Energy savings benefits to consumers ranges between 4-12 percent based upon the type of customer feedback provided.[111]

Industry Standards

NIST, in partnership with DOE and more than 100 stakeholders, has developed 5 main areas of focus for industry standards as follows:

[111] Special Report Number E105, Advanced Metering Initiatives and Residential Feedback Programs: A Meta-Review for Household Electricity-Saving Opportunities by ACEEE on Advanced Metering, June, 2010.

- Transmission and Distribution
- Building to Grid
- Industry to Grid
- Home to Grid
- Business and Policy

What will smart meters look like? How will they operate? Will smart appliances and smart meters be interoperable? Will smart meters and appliances be transferrable and/or transportable? As shown by the questions above, standards must reach a certain threshold to assuage basic concerns before a Smart Grid deployment makes sense. Smart Grid infrastructure deployment for Missouri should conform to a common set of approved standards to assure compatibility and uniformity across the state. The expectation of seamless integration of new 'smart' technologies with legacy systems and devices cannot be achieved without great attention to the principal of interoperability. The NIST Framework and Roadmap for Smart Grid Interoperability Standards Release 2.0,[112] provides an overview of the status of standards development.

With proper planning and implementation, which includes standards, customer education programs, and installation and maintenance, research suggests there should be an increase in the reliability of the generation, transmission, and distribution of power to customers.

Distributed Generation through CHP deployment

The Industrial/Commercial/Institutional Boiler maximum achievable control technology (MACT) rule to limit emissions from new and existing boilers was finalized on March 21, 2011 and amended on December 20, 2012.

With nearly half of the US boiler population over 40 years old, a natural gas CHP with a net metering application is one option that could be analyzed as a boiler replacement strategy in lieu of emissions control system modifications.

Low interest and creative financing programs could be considered and implemented on a case-by-case basis, tailored for each specific application such that the initial capital cost of the CHP system could be equal to other boiler replacement options and have lower overall life cycle costs. The differential in cost between the CHP system and other boiler options

[112] http://www.nist.gov/smartgrid/upload/NIST_Framework_Release_2-0_corr.pdf

could be funded through energy efficiency savings and sale of energy such that the economic breakeven point would occur before the system end of life.

Stakeholder Concerns

Stakeholders have several concerns with regard to Smart Grid implementation. Questions raised by stakeholders including the following:

- Data Privacy
  - Who owns the data? Who has access to the data? How will the data provided via Smart Meters be used? What consequences are there to unauthorized access to this data? How vulnerable is my personal data?
- Cyber Security
  - How safe or vulnerable is the Smart Grid to a cyber-attack? What are the potential consequences to a cyber-attack on the grid or in the home? Can someone access my Smart Meter data without my or the utility's knowledge?
- Cost Benefit
  - What is the rate of return and cost benefit for the Smart Grid infrastructure investment? Are projected consumer electrical energy savings realistic? Is the consumer paying the majority of the Smart Meter implementation costs while the utility realizes the majority of the benefits? Are consumers not on a Smart Grid paying for the implementation costs for those consumers that are on a Smart Grid?
- Impact on Electrical Rates
  - How will Smart Grid infrastructure investments impact electric rates? Can the Smart Grid be implemented such that the cost savings offset the implementation costs?
- Reliability Concerns
  - Will the additional Smart Grid infrastructure equipment, components and devices increase or decrease overall electric system reliability?
- Safety Concerns
  - What is the amount of radio frequency (RF) radiation that is emitted from AMI or smart meters? Will the RF radiation impact my health or make me sick?

- Equipment Ownership
  - Will the Smart Grid Infrastructure up to and including the Smart Meter be owned by the electric utility and the equipment inside the residence or business be owned by the consumer?
- Technology Obsolescence and Compatibility
  - What is the realistic life of the equipment? How will it get upgraded? Who pays for what? Will the Smart Grid Infrastructure support software technology upgrades without hardware replacement?
- Technology Standardization and Acceptance
  - If I move, will my appliances and equipment that I currently have in my home work in my new home with a new electric service provider? How complicated, sophisticated is the equipment that will be installed in my home? Can I just "set and forget" or will the new technology require me to monitor my electric usage and take action on a daily basis? How convenient is it to use? Can I control my appliances over the Internet? Can I use a Smart Phone application?
- Customer Service
  - If I have a problem, do I make one call or several to resolve my problem? Will I speak with my local electric service provider or be routed to an automated call processing center outside my area?

XI. RECOMMENDATIONS FOR REGULATORY INVOLVEMENT

To what extent should the MoPSC be involved in all aspects of the Smart Grid issue? As discussed above, regulatory involvement will be important in the development of all areas of Smart Grid. Staff recommends the MoPSC hold a Smart Grid workshop or technical conference periodically for information exchange, sharing of best practices and educational purposes. Issues for discussion should include such things as cost recovery, cyber security and industry standards. The MoPSC should consider opening a docket to address the cost recovery issue specifically, as it is one of the most important issues applicable to all stakeholders.

With proper planning and implementation, which includes standards, customer education programs, and installation and maintenance, research suggests there should be an increase in the reliability of the generation, transmission, and distribution of power to customers.

APPENDIX: IOU ELECTRIC SYSTEM SMART GRID COMPONENTS

A. Ameren Missouri[113]

Ameren Missouri states that it has focused investments to improve its electric system grid service reliability, operating efficiency, asset optimization, and the energy delivery infrastructure. Ameren Missouri has deployed both technology solutions on its system as follows.

- **Smart Line Capacitors**. Ameren Missouri has approximately 2,300 distribution line (less than 20kV) automated capacitors that account for approximately 50 percent of its distribution feeders and approximately 3 percent of its sub-transmission feeders (20kV to100kV). Ameren Missouri plans to upgrade the control scheme for all of these smart line capacitors by 2014.
- **Automatic Voltage Regulation and Control**. Ameren Missouri has deployed tap changing substation transformers on approximately 65 percent of its distribution substation units and approximately 73 percent of its sub-transmission (34kV to 69kV) units that are automated to adjust system voltage from commands issued by Distribution Control Offices. Documented cases over 15 years have shown system voltage reduction has worked, with a 1.0-1.2 percent demand reduction resulting from a 2.5 percent voltage reduction.
- **Microprocessor Relaying.** Ameren Missouri has 72 percent line terminals in transmission (over 100kV) substations, 31 percent line terminals in sub-transmission substations, 72 percent line terminals in transmission switchyards and 17 percent line terminals in distribution substations converted from electro-mechanical to digital relaying that provide improved operating performance and self-diagnostic checks. Future plans are to upgrade 12 line terminals and four 69kV network terminals annually for a goal of complete deployment by 2020.
- **Supervisory Control and Data Acquisition (SCADA).** These systems are deployed in all the switchyards and provide real-time outage notification for enhanced outage response performance, improved operating flexibility and to prevent overloads.

[113] Ameren's Smart Grid report dated February, 2012

- **Smart Line Switches.** These devices detect line disturbances and provide communication of events to system operations personnel, isolate faulted lines, and restore service via alternate paths. There are 250 switches automating 17 percent of the sub-transmission line feeders and 250 switches automating 4 percent of the distribution lines with annual additions based upon system needs.
- **Smart line capacitors.** Capacitor banks control or stabilize the system voltage by minimizing voltage drops and absorbing energy from a line spike. The banks provide voltage stability by switching in capacitor banks to provide reactive power when large inductive loads occur, such as when air conditioners, furnaces, dryers, and/or industrial equipment start. They are deployed on 3 percent of the subtransmission feeders. There are 2,300 capacitors automating 50 percent of the distribution lines with additions deployments based upon system needs.
- **Automatic Supply Line Transfer.** These systems detect supply line disturbances and automatically reconfigure distribution substation switching to restore power following an outage. Ameren Missouri currently has 51 percent of its distribution substations deployed with this technology and will add this capability to new and existing substations.
- **Outage Management System.** This system provides outage management services that includes collecting customer call data and creates and prioritizes work orders to optimize Ameren Missouri's response to outages by shortening the outage duration and improving efficiency.

New technology solutions include the following:

- **Transformer Insulating Oil Dissolved Gas Monitors.** This equipment provides real-time monitoring of the moisture and combustible gases that are dissolved in the insulating oil of generator step-up transformers (20kV to 138 or 345kV), large power, transmission substation, subtransmission substation, and distribution substation transformers. The detection of certain combustible gases and moisture provides an early warning system of an impending transformer internal fault that will destroy the transformer and cause significant collateral damage.

  Ameren Missouri has deployed this system on 25 percent of its Generator Step-Up transformers, 5 percent of its transmission substation autotransformers, 2 percent of its sub-transmission substation transformers and 1 percent of the distribution substation transformers and plans to continue deployment on the remaining transformers based upon periodic maintenance schedules.

- **High Voltage Bushing Monitors.** These are devices that are installed on each high voltage bushing of generator step-up transformers, transmission substation autotransformers,[114] and subtransmission and distribution substation transformers to monitor the insulating oil quality or integrity. These monitors detect small degradations in the insulating level of the bushing that if allowed to continue, would decrease the insulating capability of the bushing to the point of failure causing collateral damage to transformer. Ameren Missouri has currently deployed this system on 25 percent of its generator step-up transformers, 5 percent of its transmission substation autotransformers, 2 percent of its sub-transmission substations and 1 percent of its distribution substation transformers.

Ameren plans to continue deployment on new transformers and the remaining transformers based upon periodic maintenance schedules.

- **Fiber Optic Winding Temperature Sensor.** These devices monitor the condition of transformer and autotransformer cooling systems and allow more accurate loading to the actual operating capability of the transformer. The sensors are currently deployed on 1 of the 19 transmission substation autotransformers and 2 percent of the sub-transmission substation transformers with plans to deploy on all new and replacement autotransformer installations.
- **Comprehensive Analysis Monitor.** This equipment uses weather data and online transformer sensor inputs to calculate accurate dynamic transmission substation autotransformer ratings. This equipment will allow closer operating margins and more accurate determination of the autotransformer rating. The equipment is currently deployed on 1 of the 19 autotransformers with plans to deploy on all new and replacement autotransformer installations.
- **Multi-Function Transformer Temperature Monitor.** These monitors perform simulation of several autotransformer and transformer winding temperatures to allow

[114] An autotransformer utilizes one set of windings with multiple connection points to change voltage levels.

optimum cooling during high transformer loading and predict unstable temperature conditions. Currently deployed on 42 percent of the autotransformers in the transmission substations, 35 percent of the sub-transmission substations and 25 percent of the distribution substation units with plans to deploy on all new and replacement transformer installations.

- **Phase Measurement Units (PMUs).** These devices provide highly accurate voltage, current and frequency monitoring at strategic transmission points to provide wide area situational awareness to detect impending serious upset conditions and allow correction actions to be taken to mitigate the event. Currently deployed on 16 of 319 (5%) transmission substation and switchyard line terminals..
- **Faulted Circuit Indicators (FCI).** These devices provide information on subtransmission (20kV to 100kV) and distribution (under 20kV) line disturbances and communicate this information to system operators in near real time. There are 10 indicating sets on 5 of the 2,184 distribution line feeders and 40 indicating sets on 25 of the 501 sub-transmission line feeders with plans to deploy with smart line switches in the future.
- **Smart Line Regulators.** The devices monitor and regulate line voltage via remote control of the regulator's tap changing mechanism. These regulators are currently deployed on less than 1% of the distribution lines with additional deployment based upon system requirements.
- **Wide Area Networks (WAN).** A WAN is a high capacity communications backbone network that transports large quantities of smart field device data to the Company's control centers. Ameren Missouri currently has 50 percent of its substations and 25 percent of its switchyards deployed with this technology and will add this capability to new and existing substations that are being upgraded with the long term goal of 100 percent deployment.
- **Field Area Networks (FAN).** A FAN is a wireless communication network that collects transmitted data from smart field devices and relays this information via traditional radio/cellular based networks. There are nearly 400 intelligent sub-transmission line and 2,500 distribution line devices using this type of network with annual additions bases upon system needs.

- **Local Area Network (LAN).** These networks aggregate data and provide communications from smart field to the WAN. LANs are currently deployed in 2 percent of the sub-transmission substations and less than 1 percent of the distribution substations. Future LAN deployment will be based upon the electrical grid requirements.

B. Kansas City Power & Light (KCP&L)

The Smart Grid electrical infrastructure components on the electric system grid that are outside of the Midtown Substation include the following:

- **Faulted Circuit Indicators (FCI).** There are 48 devices providing information disturbances that communicate this information to system operators in near real time. There are 10 indicating sets on five of the 2,184 distribution line feeders (less than 1 percent) and 40 indicating sets on 25 of the 501 (5 percent) subtransmission line feeders with plans to deploy smart line switches in the future.
- **Smart Line Switches or Reclosers.** These devices detect line disturbances, provide communication of events to system operations personnel, isolate faulted lines, and restore service via alternate paths. There are 22 reclosers for automatic reconfiguration or load balancing.
- **Smart line capacitors.** Thirty capacitor banks control or stabilize the system voltage by minimizing voltage drops and absorbing energy from a line spike. The banks provide voltage stability by switching capacitor banks to provide reactive power when large inductive loads occur, such as when air conditioners, furnaces, dryers, and/or industrial equipment start.
- **Automated Metering Infrastructure (AMI).** Communications between all the devices utilize an AMI mesh network.

C. Empire

The Smart Grid electrical infrastructure components currently in operation or planned for the future (Smart Meters and Outage Management System upgrades) include the following:

- **Transformer Insulating Oil Dissolved Gas Monitors**. This equipment provides real time monitoring of the moisture and combustible gases that are dissolved in the insulating oil of three transmission (over 100 KV) autotransformers[115]. The detection of certain combustible gases and moisture provides an early warning system of an impending transformer internal fault that will destroy the transformer and cause significant collateral damage:
- **Smart line capacitors.** Capacitor banks control or stabilize the system voltage by minimizing voltage drops and absorbing energy from a line spike. The banks provide voltage stability by switching in capacitor banks to provide reactive power when large inductive loads occur, such as when air conditioners, furnaces, dryers, and/or industrial equipment start. These capacitors are automatically controlled by a microprocessor based program that actuates based upon time, temperature, voltage and reactive power inputs.
- **Smart Line Switches.** These devices are installed in Branson, MO, and detect line disturbances and provide communication of events to system operations personnel, isolate faulted lines, and restore service via alternate paths.
- **Faulted Circuit Indicators** These devices provide information on line disturbances and communicate this information to system operators in near real time for faster identification of problems and locating faulted circuits. These devices are currently installed where the three-phase supply service splits to serve two different loads.
- **Automatic Voltage Regulation and Control.** Automatic voltage regulation is installed at the majority of all distribution substations and consists of voltage regulators and/or transformer load tap changers.
- **Automatic Supply Line Transfer.** These systems are installed in Branson, MO to detect supply line disturbances and automatically reconfigure distribution substation switching to restore power following an outage.
- **Microprocessor Relaying.** For the past fifteen years, Empire has been changing from electro-mechanical to digital relaying that provides improved operating performance and self-diagnostic checks.

[115] An autotransformer utilizes one set of windings with multiple connection points to change voltage levels

- **Supervisory Control and Data Acquisition (SCADA).** These systems are deployed in the switchyards and provide real time outage notification for enhanced outage response performance, improve operating flexibility and prevent overloads. Open Systems International (OSI)[116] Energy Management System (EMS) system upgrades were completed in September of 2013.
- **Outage Management System (OMS).** This Intergraph InService Outage Management System[117] provides outage management services that include collecting customer call data and creates and prioritizes work orders to optimize the Company's response to outages by shortening the outage duration and improving efficiency. System upgrades, including the interface with the SCADA system, are scheduled for completion by the end of this year.

- **Wide Area Networks (WAN).** A WAN is a high capacity communications backbone network that transports large quantities of data to the Company's data centers, most service centers and customer service offices. Empire owns and operates its own fiber optic WAN.
- **Field Area Network (FAN).** A FAN is a wireless communication network. The OMS system utilizes a cellular wireless network for communication with Empire's service trucks.
- **Local Area Network (LAN).** This network aggregates data and interfaces with the WAN to provide internal company communications.

[116] http://www.osii.com/index.asp?nsgc
[117] http://www.intergraph.com/utilities/oms.aspx