The Kentucky Smart Grid Roadmap Initiative

SMART GRIDS IN THE COMMONWEALTH OF KENTUCKY

FINAL REPORT OF THE KENTUCKY SMART GRID ROADMAP INITIATIVE

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6/29/2012

About this Document

The Kentucky Smart Grid Roadmap Initiative (KSGRI) was tasked with the development of a technical roadmap for the development and deployment of smart grid technologies throughout the Commonwealth. This "Kentucky Smart Grid Roadmap" will provide recommendations and best practices to utilities and utility stakeholders to guide individual smart grid deployment approaches.

In support of this effort, the KSGRI developed a series of interrogatories to collect information from utilities regarding smart grid deployments in seven infrastructure areas: general smart grid, advanced metering, distribution, transmission, asset management, consumer education, and distributed energy resources. Additionally, the KSGRI hosted a series of three Kentucky Smart Grid Workshops to gather leading electric power stakeholders to discuss issue pertinent to grid modernization. This report is a compendium of documents produced as part of these interrogatories and workshop events.

Two chapters are devoted to each of the infrastructure areas. In the first chapter, a general overview is given of the infrastructure area. This includes technology definitions, standards, deployment examples, benefits, risks, and barriers. In the second chapter, the state of the infrastructure area for the state is given in specific detail. The last chapter of this document summarizes the proceedings of the three workshop events. All interrogatories used to collect data are included as appendices.

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CHAPTER 1: KENTUCKY SMART GRID ASSESSMENT MODEL DEFINITION

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ABSTRACT

The Kentucky Smart Grid Assessment Model (KSGAM) is a tool to: (1) measure the extent of smart grid deployment and capability within the jurisdictional Kentucky electric utilities, (2) identify objectives and priorities for smart grid deployment and implementation statewide, and (3) provide a metric for evaluation of progress towards established objectives. The KSGAM consists of two model definition documents, the Electric Utility KSGAM (EU-KSGAM) and the Stakeholder KSGAMs (S-KSGAM). Each of the model definition documents has an associated assessment survey used for data collection from the appropriate party.

The EU-KSGAM model describes the smart grid according to 10 Smart Grid Classes and 6 Development Levels. Smart Grid Classes are groupings of related capabilities and attributes relevant to smart grid deployment and operations. Development Levels measure maturity progression within each class, and are described by a list of characteristics and capabilities for each development level and each class. The EU-KSGAM is based on a simplification of the Carnegie Melon Software Engineering Institute Smart grid Maturity Model, the Department of Energy Office of Electricity Delivery and Energy Reliability Modern Grid Strategy documents, and input from representatives of the KY electric utilities. The EU-KSGAM Assessment Survey is utilized to collect information from the KY electric utilities on operations, assets, and customer profiles.

The S-KSGAM model describes smart grid deployment according to technology independent characteristics. The S-KSGAM is based on the DOE OE Modern Grid Strategy documents, and input from representative of the KY electric utilities. The S-KSGAM Assessment Survey is utilized to collect information from non-utility stakeholders, such as customers, government, and regulators.

INTRODUCTION

ABOUT THIS DOCUMENT

The Kentucky Public Service Commission, the University of Louisville, and the University of Kentucky have partnered under the “Kentucky Smart Grid Roadmap Initiative” (KSGRI) to develop a technical roadmap for the development and deployment of smart grid technologies throughout the Commonwealth. This “Kentucky Smart Grid Roadmap” will provide recommendations and best practices to utilities and utility stakeholders to guide individual smart grid deployment approaches. More information regarding the work of the KSGRI is located in the document *The Kentucky Smart Grid Roadmap Initiative: Smart Grid Road Map Work Plan*.

The purpose of this document is to define the Kentucky Smart Grid Assessment Model (KSGAM), in fulfillment of Work Plan Goal 3 (WPG3) of *Smart Grid Road Map Work Plan*. The KSGAM will be used to develop an understanding of the “As-is” state of the electric power grid in Kentucky, focusing on the technical, regulatory, and consumer environment. Additionally, the KSGAM will be used to identify aspects of the smart grid that are most important to the future development of electrical power generation, transmissions, distribution, and consumption in Kentucky.

DOCUMENT OVERVIEW

The following two sections define the KSGAM models: Section 3 is the EU-KSGAM Definition, a model intended for use by electric utilities. Within this section the Development Levels (DLs) are explained and the Smart Grid Classes (SGCs) are defined. Section 5 is the S-KSGAM Definition, a model intended for use by non-utility stakeholders. Within this section the smart grid Characteristics are defined.

Section 6 describes how the KSGAM can be utilized to provide a framework for the understanding of the currents state of smart grid deployment within Kentucky and to establish future deployment goals. This includes an explanation of the development of individual utility customer and asset profiles, the development of individual utility smart grid maturity profiles, the use of the KSGAM for goal planning, and the KSGAM assessment process.

The two concluding sections contain the assessment surveys. Section 7 is the EU-KSGAM Assessment Survey, in which the expected characteristics of each DL for the SGCs are listed. Section 8 is the S-KSGAM Assessment Survey.

ELECTRIC UTILITY KENTUCKY SMART GRID ASSESSMENT MODEL DEFINITION

INTRODUCTION

This section defines the Development Levels (DLs) and Smart Grid Classes (SGCs) used in the Electric Utility Kentucky Smart grid Assessment Model (EU-KSGAM). A utilities maturity in each SGC is measured by completion of the EU-KSGAM Survey.

DEVELOPMENT LEVELS

The KSGAM Developments Levels (DLs) quantify each of the 10 SGCs into 6 ranked levels, DL0 through DL5. Successive DLs are achieved by meeting characteristics and capabilities defined for each SGC, as measured by the EU-KSGAM survey. In this manner, a DL score is assigned for each of the SGCs, showing the state and/or priorities of the organization for each class.

Development Level 0

DL0 is the default level of each class, indicating no development towards any of the expected characteristics for the SGC.

Development Level 1

DL1 is the initiating level of each class, indicating that decisions have been made to begin implementation of the SGC.

Development Level 2

DL2 is the enabling level of each class, indicating that features have been implemented to enable development of the SGC.

Development Level 3

DL3 is the integrating level of each class, indicating that the SGC is integrated into the operations of the organization.

Development Level 4

DL4 is the optimization level of each class, indicating the smart grid implementations within a given SGC are being fine-tuned to further increase performance.

Development Level 5

DL5 is the pioneering level of each class, indicating the state of breaking new ground and advancing the state of practice for the SGC.

SMART GRID CLASSES

SGCs are groupings of related capabilities and/or characteristics relevant to Smart grid for which a maturity progression can be defined using the SGC DLs. The EU-KSGAM defines 10 SGCs:

1. Strategy and Management (SM)
2. Organization and Structure (OS)
3. Technology (TECH)

4. System Architecture and Operation (SAO)
5. Demand and Supply Management (DSM)
6. Work and Asset Management (WAM)
7. Physical and Cyber Security (SEC)
8. Government and Regulation (GR)
9. Customer (CUST)
10. Environment and Society (ENV)

Strategy and Management (SM)
The Strategy and Management (SM) SGC represents the competencies and attributes related to a smart grid vision and strategic planning, internal governance and management processes, and collaboration with internal and external stakeholders.

Organization and Structure (OS)
The Organization and Structure (OS) SGC represents the competencies and attributes related to workplace structure, training, communications, and knowledge management within the utility.

Technology (TECH)
The Technology (TECH) SGC measures the extent to which the utility has evaluated deployment of and enabled effective strategic planning of technologies such as: integrated communications, sensing and measurement, advanced components, advanced control methods, and improved visual interfaces and decision support software. This SGC also measure the utility's establishment of engineering and business process for the evaluation, acquisition, integration, and testing of technologies.

System Architecture and Operation (SAO)
The System Architecture and Operation (SAO) SGC represents the operation of the power grid as an automated system with a high degree of local, regional, and national situational awareness to improve efficiency, security and safety. These architectures are often divided between four operational gateways: advanced metering infrastructure (AMI), advanced distribution operations (ADO), advanced transmission operations (ATO), and advanced asset management (AAM).

Demand and Supply Management (DSM)
The Demand and Supply Management (DSM) SGC represents the ability to dynamically manage both the supply and demand in the production and delivery of electricity, based on near real-time information in the areas of load management, distributed energy resources, and new market opportunities.

Work and Asset Management (WAM)
The Work and Asset Management (WAM) SGC represents the capabilities that support optimal management of grid assets and workforce resources, toward a utility that bases operation and maintenance decisions on real-time performance data instead of best practices or historical precedent, resulting in a change from preventative and reactive resource usage to predictive and planned resource management.

Physical and Cyber Security (SEC)

The Physical and Cyber Security (SEC) SGC represents the protection of new and legacy equipment and system data from cyber and physical security attacks. This SGC measures the extent to which a security architecture and overlay is in place, the performance of risk assessment activities, and conformance to emerging NIST cyber security standards.

Government and Regulation (GR)

The Government and Regulation (GR) SGC represents the role of the state governments and the Kentucky Public Service Commission in the development of smart grid operations. This SGC measures the extent to which regulators authorize smart grid investments on both visible deployments and supporting infrastructure projects, authorize smart grid demonstration projects, approve innovative regulatory strategies, and facilitate intra-utility optimization. This SGC also measure the state investment, in terms of cost recovery authorizations or grants, in smart grid deployments.

Customer (CUST)

The Customer (CUTS) SGC represents the role of customer participation and experience, pricing, education, and advanced services. Customer participation may range from fully passive to fully active, with a goal of fully empowering customers to make decisions regarding the usage, source, and cost of energy.

Environment and Society (ENV)

The Environment and Society (ENV) SGC represents the contributions of the utility to achieving societal goals regarding reliability, safety, security, energy sources, energy source impacts, and quality of life. This includes the promotion of conservation and green energy initiatives, the integration of alternative and distributed energy resources, and GHG emission reduction programs.

STAKEHOLDER KENTUCKY SMART GRID ASSESSMENT MODEL DEFINITION

INTRODUCTION

This section defines the characteristics and benefits used in the Stakeholder Kentucky Smart Grid Assessment Model (S-GSGAM). Stakeholder inputs are measured by completion of the S-KSGAM Survey.

CHARACTERISTICS

Characteristics are technology independent abilities that may be achieved by smart grid deployment for which stakeholder priorities can be defined. The S-KSGAM defines 7 Characteristics:

1. Active Participation by Consumers
2. Accepts All Power Generation and Storage
3. Enables New Products and Services
4. Improved Power Quality
5. Efficient Operation and Use of Assets
6. Self-Healing
7. Defends Against Attack and Natural Disaster

Active Participation by Consumers

Active Participation by Consumers is the characteristic that describes the increased interaction of consumers with the grid. Such interaction is characterized by the use of price based signals and demand response programs to give customers choice regarding if and when to purchase power, the decisions on the source of purchased power, the use of distributed energy resources, and the use of home automation networks and intelligent load end-use devices such as smart appliances.

Accepts All Power Generation and Storage

Accepts All Power Generation and Storage is the characteristic that describe the integration of diverse resources with "plug-and-play" connections to multiply the options for electrical generation and storage. This includes the accommodation of large centralized power plants, and distributed energy resources such as renewables, distributed generation, and energy storage devices. This characteristic represents the transition to a more decentralized supply model.

Enables New Products and Services

Enables New Products and Services is the characteristic that describes three changes in the electricity market. First is the direct linking of the buyers and sellers of electricity (e.g. RTO to consumer), allowing real time interaction with the market. Second, the advent of new commercial goods and services will results in the creation of new electricity markets and choice such as green power products and electric vehicles. Third, a restructuring of markets will achieve consistency of operation across the U.S.

Improved Power Quality

Improved Power Quality is the characteristic that describes the delivery of "clean" power. Such digital-grade power is characterized by a reduction in system interruptions due to under voltage sags, voltage spikes, frequency harmonics, and phase imbalances. The delivered power may be available in "grades", varying from standard to premium, and will depend on customer requirements.

Efficient Operation and Use of Assets

Efficient Operation and Use of Assets is the characteristic that describes the use of real time information from advanced sensors to allow operators to better understand the state of the system. Such information can be used to perform risk assessment, optimize system planning, reduce transmission congestion, extend asset life, and to perform proactive maintenance.

Self-Healing

Self-Healing is the characteristic that describes the grids ability to identify, isolate, and restore problematic sections of the grid with little or no manual intervention. Today, such capabilities are largely isolated to substation automation. Future systems may use sensors, weather data and analytic programs to detect precursors to faults including voltage, power-quality, dynamic instabilities, congestion issues, equipment failures, and downed power lines. Automatic network reconfiguration could be employed to link energy sources and loads to both restore power and to implement real-time contingency strategies.

Defend Against Attack and Natural Disaster

Defend Against Attack and Natural Disaster is the characteristic that describes the grids ability to protect against physical attacks (explosive, projectiles, and natural disaster) and cyber (computer-based) attacks. These attack strategies may have two forms: attacks in which the grid itself is the primary target, or attacks in which the power system network is used to take down other important infrastructure systems (banks, government, etc.).

BENEFITS

Benefits are areas in which smart grid deployment can offer advantages to society as compared to the current grid. The S-KSGAM defines 5 benefits:

1. Reliable
2. Secure and Safe
3. Economic
4. Efficient
5. Environmentally Friendly

Reliable

Reliable describes a grid with a reduction in power outage duration and frequency, a reduction in momentary power quality disturbances, and a reduction in blackouts and brownouts.

Secure and Safe

Secure and Safe describes a grid that is less vulnerable to attack and natural disaster, and is safer to be near for both the public and utility workers.

Economic

Economic describes a grid with decreased/mitigated electricity prices, and with new options for market participants such as new load management, distributed generation, grid storage, and demand-response options.

Efficient

Efficient describes a grid that uses technology to allow for greater utilization of existing assets, enables optimal loading of assets, and provides detailed awareness of component and equipment condition, with the goal of cost effective asset utilization and increased system capacity.

Environmentally Friendly

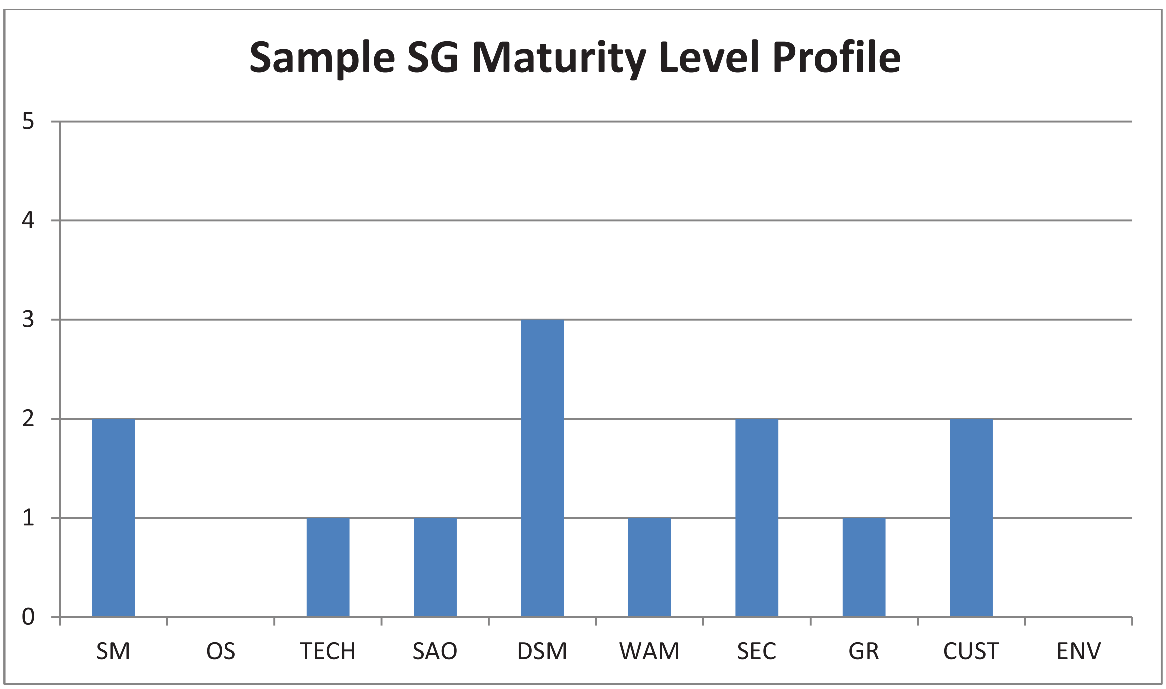
Environmentally friendly describes a grid that allows for a much wider deployment of environmentally friendly resources, that allows for the deferral of new construction projects, and has reduced electrical losses.

USING THE KSGAM

INTRODUCTION
This section describes how the KSGAM will be utilized to provide a framework for the understanding of the currents state of smart grid deployment within Kentucky and to establish future deployment goals.

USING THE KSGAM TO DEVELOP UTILITY PROFILES
Completion of the EU-KSGAM Survey section "Utility Profile" provides a record of the electric utility's customer base, T&D assets, and performance data. This information enables assessment of individualities amongst the jurisdictional utilities.

USING THE KSGAM TO DEVELOP SG MATURITY PROFILES
Utilities achieve maturity ratings for each of the Smart Grid Classes by completion of the "Smart Grid Class Assessment" portion of the EU-KSGAM Survey. The maturity rating for each of the SGCs is based on the SGC-specific survey questions for each SGC. Each survey presents a list of "expected characteristics" of the SGC for each DL. Higher DL ratings within the SGCs reflect increasing smart grid maturity levels. Ratings in one SGC do not affect ratings in other SGCs. Once the KSGAM is assessed by the KSGRI team, a "Smart Grid Maturity Level Profile" is formed, containing DL ratings for each of the SGCs. A sample Maturity Level Profile is shown in Fig. 1.



Stakeholder priorities are measured by completion of the "As-is State of Smart grid Survey", within the S-KSGAM Survey. The rating for each of the Characteristics is based on survey questions for each Characteristic. Each survey question measures stakeholder perceived penetration of that Characteristic in the current electric power industry on a scale from 0 (no penetration) to 5 (full penetration). The rating for each of the Benefits is based on survey questions for each benefit. Each survey questions measures stakeholder perceived valuation of that Benefit in the current electric power industry on a scale from 0 (provides no benefit) to 5 (provide maximum benefits).

Using the KSGAM for Goal Planning

Utilities can provide feedback into the future state of smart grid deployments in Kentucky by using the EU-KSGAM Survey to identify the "desired future state" DL for each SGC. The assessments enable the creation of a "Smart Grid Maturity Goal Profile", containing desired maturity ratings for each of the SGCs. The Maturity Goal Profile will be similar to Fig. 1

Stakeholders can provide feedback into the desired future state of Smart grid Deployment in Kentucky by using the S-KSGAM Survey. Stakeholders will rank priorities in each of the Characteristics and Benefits on a scale from 0 (not important) to 5(very important).

The KSGAM Assessment Process

Assessment via the KSGAM is performed by distribution of the EU-KSGAM to electric utilities and of the S-KSGAM to interested stakeholders. Surveys completed by utilities/stakeholders will then be evaluated by the KSGRI team. Data from the surveys will be used to create a "As-Is KY Smart Grid Profile" report, detailing the status of smart grid deployment within the state and perception of smart grid deployments by stakeholders, both in terms of maturity and benefit. Additionally, information from the surveys will be used to create a "Desired Future KY Smart Grid Profile" report for the state, detailing the desired state of smart grid deployments, from both a utility perspective and a stakeholder perspective.

Chapter 2: Overview of Smart Grid in the Commonwealth of Kentucky

ABSTRACT

The "Overview of Smart Grid in the Commonwealth of Kentucky" report presents a high level summary of the current state of smart grid deployments and capabilities within the electric utilities of Kentucky, as well as identifies areas of future development that are of significant interest, from the perspectives of both utility companies and grid stakeholders. It is meant to serve as an introductory assessment, and will be supported with additional documentation and reports on the Key Infrastructure Areas identified by the Kentucky Smart Grid Roadmap Initiative (KSRGI) team.

The data presented in this report was gathered using the "Electric Utility-Kentucky Smart Grid Assessment Model" (EU-KSGAM) and the "Stakeholder-Kentucky Smart Grid Assessment Model (S-KSGAM). The EU-KSGAM gathered utility profile/performance data and measured smart grid deployments according to 10 logical functional areas, or Smart Grid Classes, each with six possible maturity rankings, or Development Levels. The S-KSGAM measured stakeholder input in the areas of seven Smart Grid Characteristics and five Benefits. Smart Grid Characteristics were ranked on a scale that included five possible maturity rankings. Smart Grid Benefits were evaluated using a simple financial assessment.

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The purpose of this document is to summarize the results of the Kentucky Smart Grid Assessment Model (KSGAM), in fulfillment of Work Plan Goals 4, 5 and 6 (WPG4-WPG6) of *Smart Grid Road Map Work Plan*. The EU-KSGAM was distributed to 23 jurisdictional electric utilities to develop an understanding of the "As-is" state of the electric power grid in Kentucky, focusing on the technical, regulatory, and consumer environment. Additionally, the EU-KSGAM was used to identify aspects of the smart grid that are most important to the future development of electrical power generation, transmissions, distribution, and consumption in Kentucky. The S-KSGAM was distributed to grid stakeholders to gauge their opinion as to the aspects of the smart grid that are of the highest importance. The collected data was utilized to perform a gap analysis in which technology, functionality, and regulatory gaps were identified. Data collected from jurisdictional utilities was via self-reporting by a Smart Grid Contact person from each utility.

DOCUMENT OVERVIEW

The following section is an executive summary of the entire report, highlighting important details of the KY Smart Grid Assessment. Detailed summaries are then provided in subsequent sections for each of the following areas: EU-KSGAM Utility Profiles, EU-KSGAM As-Is State of Smart Grid, and the EU-KSGAM Desired Future State of Smart Grid. A gap analysis of the utility supplied data is then presented that identifies Smart Grid Classes of particular importance to KY utilities. This is followed by a detailed summary of the S-KSGAM and a gap analysis of the stakeholder supplied data to identify Smart Grid Characteristics of particular importance to KY grid stakeholders. The report concludes by presenting the complete details of the "As-Is" and Future states of the Smart Grid Classes and Smart Grid Characteristics, as well as complete details of the stakeholder Smart Grid Benefits valuations.

EXECUTIVE SUMMARY

KENTUCKY UTILITY PROFILES

Kentucky's jurisdictional utilities include three investor owned utilities (IOUs)[1], two generation and transmissions cooperatives (G&Ts) and 19 distribution cooperatives. Of the 23 utilities that participated in the KSGAM, five utilities operate in the generation and transmission markets, 21 operate in the distribution market, and two operate in the whole-sale power market. In all, the responding jurisdictional utilities employ approximately 6310 workers in Kentucky and provided service to 1,572,922 residential customers, 219,603 commercial/industrial customers, and 15,974 other customers (largely street lighting).

The average size of the service territory in KY is 1,971 square miles, with a statewide average of 11.1 customers per line mile of distribution. The utilities collectively operate 33,844 miles of transmission and 98,399 miles of distribution within KY. There are approximately 2008700 electric meters, with a total penetration rate of AMI-capable "smart" meters of 22%.

The statewide average System Average Interruption Frequency Index (SAIFI) is 1.4 interruptions per customers (U.S. median is 1.10). The statewide average System Average Interruption Duration Index (SAIDI) is 137 (U.S. median is 90 minutes). The average duration of planned outages is 70.8 minutes, effecting .2% of customers. Statewide, the average duration of unplanned outages is 138,469 minutes, effecting 4.44% of customers. The statewide average distribution system line loss is 4.675%.

The reported cost to operate the electric transmission system is $74,067,312 annually (excluding Duke Energy). The reported cost to operate the electric distribution system is $375,480,680 annually (excluding Duke Energy, and Grayson RECC). This equates to an average cost per customer of $552.85.

Demand Response (DR) offerings consist primarily of the use of a remotely-addressable switch to interrupt customer loads such as air conditioning units, pool pumps, heat pumps and electric water heaters. Statewide, over 167,000 (~9%) customers participate in direct load control programs, with average peak reductions ranging from 6.7 MW to 116 MW (summer). All responding utilities reported that they are not currently prepared to implement dynamic pricing

Other modernization practices have been limited in deployment. Those reported include smart meter pilots, conservation voltage reduction, and automatic circuit reconfiguration for outage management/self-healing. Of the responding utilities, six indicated having multi-year plans specifically targeting smart grid deployments. Of these six, three are specifically focuses on AMI deployments.

Regarding the development of the modern grid, utilities have identified transmission limitations and constraint as top priorities, followed by generation constraints. Specific concerns regarding the implementation of smart grid programs include the need for cost recovery / economic justification of programs, technical obsolescence, and regulatory mandates.

[1] Louisville Gas & Electric and Kentucky Utilities considered as a single entity.

EU-KSGAM As-Is and Desired Future State of Smart Grid In Kentucky

The current (As-Is) state of smart grid was measured for the entire state via aggregation and statistical analysis of the individual responses by 23 jurisdictional Kentucky utilities to the EU-KSGAM survey. Each Smart Grid Class (SGC) was graded by the utilities with a maturity ranking (Development Level, DL) ranging from 0 (DL0) to 5 (DL5). Additionally, the momentum of the SGC (modifier) was measured as either Emergent (just reaching the DL), Stable (at the DL for some time), or Growing (approaching the next DL). Finally, the relative agreement amongst the reporting utilities was ranked as either: low, medium, or high as measured by calculation of a standard deviation. The following table summarizes the As-Is results of the EU-KSGAM for each SGC. Analysis indicates that Kentucky utilities are, overall, mature in the Strategy and Management and Customer classes, and immature in the Environment and Society class.

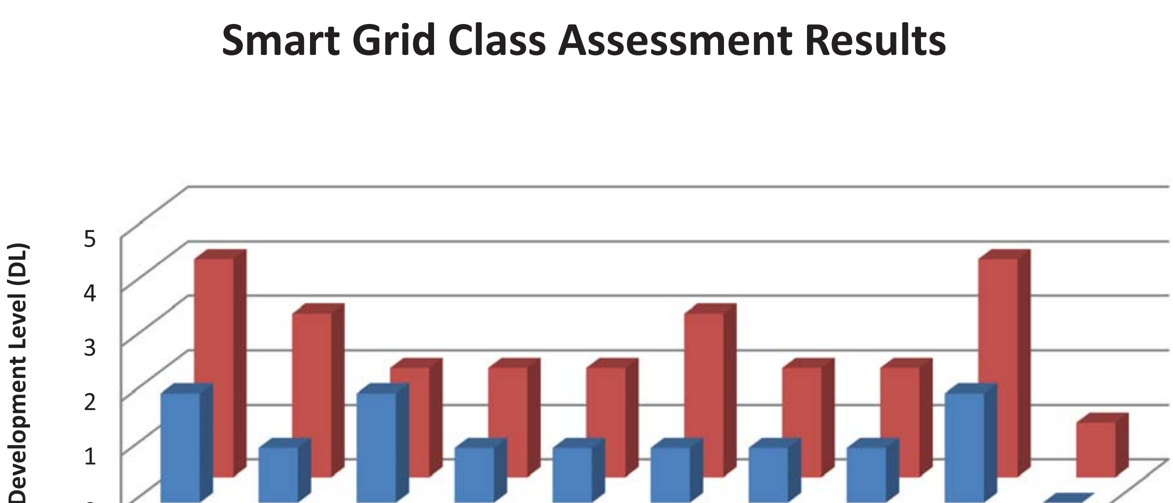
EU-KSGAM As-Is State of Smart Grid in Kentucky by Smart Grid Class

Smart Grid Class	Modifier	Development Level	Agreement
Strategy & Management	Growing	Enabling (DL2)	Low
Organization & Structure	Emergent	Initiating (DL1)	Low
TECHnology	Emergent	Enabling (DL2)	Medium
System Architecture & Operation	Emergent	Initiating (DL1)	Medium
Demand & Supply Management	Stable	Initiating (DL1)	High
Work & Asset Management	Stable	Initiating (DL1)	Medium
Cyber and Physical SECurity	Stable	Initiating (DL1)	Medium
Government& Regulation	Stable	Initiating (DL1)	High
CUSTomer	Growing	Enabling (DL2)	Low
ENVironment & society	Growing	Default (DL0)	High

The desired future (Future) for smart grid development was measured in a manner similar to the As-Is state for both utility agreement and the Development Levels. The strength of the preference for each SGC (modifier) was measured as either Weak (low no. of characteristics desired), Stable (medium no. of characteristics desired), or Strong (most characteristics desired). The following table summarizes the Desired Future results of the EU-KSGAM for each SGC. Analysis indicates that Kentucky utilities would like to be mature in the areas of Strategy and Management and Customer classes, with roughly equal, but lower, emphasis on the maturity importance of the remaining SGCs.

EU-KSGAM Desired Future State of Smart Grid in Kentucky by Smart Grid Class			
SMART GRID CLASS	MODIFIER	DEVELOPMENT LEVEL	AGREEMENT
Strategy & Management	Weak	Optimizing (DL4)	Low
Organization & Structure	Strong	Integrating (DL3)	Low
TECHnology	Strong	Enabling (DL2)	High
System Architecture & Operation	Stable	Enabling (DL2)	Medium
Demand & Supply Management	Weak	Enabling (DL2)	High
Work & Asset Management	Stable	Integrating (DL3)	Medium
Cyber and Physical SECurity	Stable	Enabling (DL2)	Medium
Government& Regulation	Stable	Enabling (DL2)	High
CUSTomer	Weak	Optimizing (DL4)	Low
ENVironment & society	Strong	Integrating (DL3)	Medium

The following chart compares the calculated statewide Desired Future results of the EU-KSGAM to the As-Is results for each SGC.



	SM	OS	TECH	SAO	DSM	WAM	SEC	GR	CUST	ENV
As-Is	2	1	2	1	1	1	1	1	2	0
Future	4	3	2	2	2	3	2	2	4	1

AS-IS AND DESIRED FUTURE STATE OF SMART GRID CHARACTERISTICS

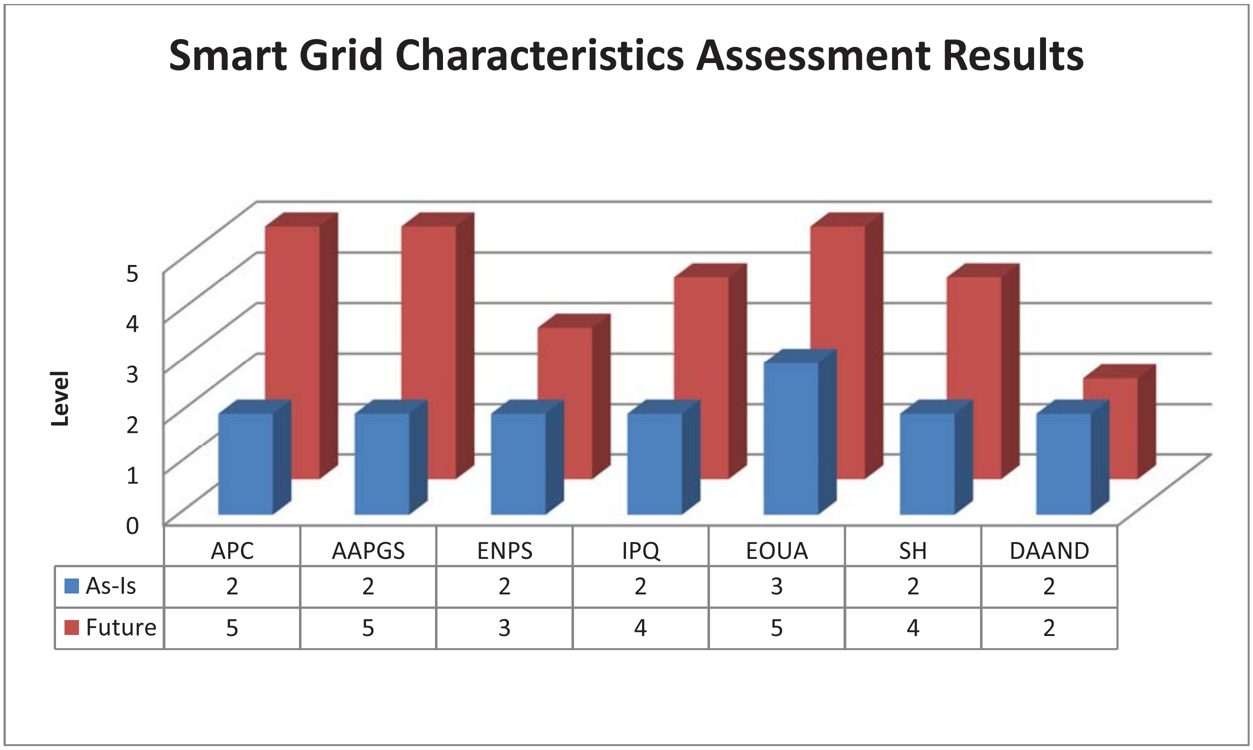
The current (As-Is) state of Smart Grid Characteristics were measured via aggregation and statistical analysis of the individual responses by 11 stakeholders to the S-KSGAM survey. Each Characteristic was given a maturity ranking ranging from one to five. A modifier and agreement assessment was performed as described previously. The following table summarizes the As-Is results of the S-KSGAM for each Characteristic. Analysis indicates that stakeholders view Kentucky utilities to be mature in Efficient Operation and Use of Assets.

S-KSGAM As-Is State of Smart Grid in Kentucky by Smart Grid Characteristics			
Smart Grid Characteristic	**Modifier**	**Level**	**Agreement**
Active Participation by Consumers	Stable	2	High
Accepts All Power Generation and Storage	Stable	2	Medium
Enables New Products and Services	Stable	2	High
Improved Power Quality	Growing	2	Low
Efficient Operation and Use of Assets	Stable	3	Low
Self Healing	Stable	2	High
Defend Against Attack and Natural Disaster	Stable	2	Medium

The desired future (Future) for smart grid development was measured in a manner similar to the As-Is state for both utility agreement and the level. The following table summarizes the Desired Future results of the S-KSGAM for each Characteristic. Analysis indicates that stakeholders want Kentucky utilities to be mature in the areas of Active Participation by Consumers, Accepts All Power Generation and Storage, and Efficient Operation and Use of Assets. The Characteristic Defend Against Attack and Natural Disaster had the lowest measured importance.

S-KSGAM Future State of Smart Grid in Kentucky by Smart Grid Characteristics			
Smart Grid Characteristic	**Modifier**	**Level**	**Agreement**
Active Participation by Consumers	Weak	5	High
Accepts All Power Generation and Storage	Weak	5	Low
Enables New Products and Services	Weak	3	Low
Improved Power Quality	Stable	4	Medium
Efficient Operation and Use of Assets	Stable	5	High
Self Healing	Stable	4	Medium
Defend Against Attack and Natural Disaster	Strong	2	Medium

The following chart compares the calculated statewide Desired Future results of the S-KSGAM to the As-Is results for each Smart Grid Characteristic.



Valuation of Smart Grid Benefits

The valuation of Smart Grid Benefits was measured via aggregation and statistical analysis of the individual responses by 11 stakeholders to the S-KSGAM survey. Also the relative agreement amongst the reporting stakeholders was measured by calculation of a standard deviation figure. Agreement was ranked as either: Low, Medium, or High. The following table summarizes results of the S-KSGAM for each Benefit, and indicates that Kentucky stakeholders place a large value on an Environmentally Friendly Smart Grid.

S-KSGAM Valuation of Smart Grid in Kentucky by Smart Grid Benefit		
Smart Grid Benefit	Valuation	Stakeholder Agreement
Reliable	$18.55M	Medium
Secure and Safe	$17.13M	High
Economic	$19.95M	High
Efficient	$19.63M	Medium
Environmentally Friendly	$24.75M	Low

EU-KSGAM Gap Analysis

A Gap Score for each SGC was calculated using the DLs, the modifiers, and the agreement indicators for both the "Desired Future" state and the "As-Is" state of the EU-KSGAM. The Gap Score for each SGC indicates the relative need for improved development of that SGC as compared to the group. The GS can therefore be used to identify areas of priority in crafting the KY Smart Grid Roadmap Document.

Results of the Gap Score indicate a high priority for assistance with development within the Organization and Structure and Work and Asset. In contrast, the results indicate that the

Strategy and Management, and Customer SGCs have a low emphasis, indicating that the responding utilities are satisfied with their progress toward established objectives within these SGCs. The remaining SGCs all are calculated as Medium priorities.

EU-KSGAM Gap Analysis by Smart Grid Class		
SMART GRID CLASS	GAP SCORE	PRIORITY LEVEL
Strategy & Management	1	Low
Organization & Structure	5	High
TECHnology	2.5	Medium
System Architecture & Operation	3	Medium
Demand & Supply Management	2	Medium
Work & Asset Management	5	High
Cyber and Physical SECurity	2	Medium
Government& Regulation	3	Medium
CUSTomer	1	Low
ENVironment & society	2	Medium

S-KSGAM GAP ANALYSIS

A Gap Score for each Smart Grid Characteristic was calculated using the Level, the modifiers, and the agreement indicators for both the "Desired Future" state and the "As-Is" state of the S-KSGAM. The Gap Score for each Characteristic indicates the stakeholder opinions regarding the need for improved development of that Characteristic as compared to the other Characteristics. The GS can therefore be used to identify areas of priority in crafting the KY Smart Grid Roadmap Document.

Results of the Gap Score indicate a high priority for development in the areas of Active Participation by Consumers, Accepts All Power Generation and Storage, and Self Healing. In contrast, the results indicate that the Enables New Products and Services, and Defined Against Attack and Natural Disaster are sufficiently developed. The remaining Characteristics all are calculated as Medium priorities.

S-KSGAM Gap Analysis by Smart Grid Characteristics		
SMART GRID CHARACTERISTIC	GAP SCORE	PRIORITY LEVEL
Active Participation by Consumers	6	High
Accepts All Power Generation and Storage	4.5	High
Enables New Products and Services	1	Low
Improved Power Quality	2.5	Medium
Efficient Operation and Use of Assets	4	Medium
Self Healing	4.5	High
Defend Against Attack and Natural Disaster	1	Low

List of Participating Utilities

Big Rivers Electric Corporation
- Jackson Purchase Energy
- Kenergy Corp.
- Meade County RECC

Duke Energy

East Kentucky Power Cooperative Inc.
- Big Sandy RECC
- Bluegrass Energy Cooperative
- Clarke Energy Cooperative Inc.
- Cumberland Valley Electric
- Farmers RECC
- Fleming Mason Energy
- Grayson RECC
- Inter-County Energy
- Jackson Energy Cooperative
- Nolin RECC
- Owen Electric Cooperative Corporation
- Salt River Electric Cooperative Corporation
- Shelby Energy
- South Kentucky RECC
- Taylor County RECC

Kentucky Power Company

Louisville Gas & Electric and Kentucky Utilities

EU-KSGAM UTILITY PROFILE SUMMARY

INTRODUCTION

The EU-KSGAM Utility Profile Survey was completed by 23 of the jurisdictional utilities. It collected information regarding demographics, performance data, demand response programs, and smart grid programs. The following section summarizes the collected responses to the survey.

DEMOGRAPHIC SUMMARY

Markets

Kentucky's jurisdictional utilities include three investor owned utilities (IOUs), two generation and transmissions cooperatives (G&Ts) and 19 distribution cooperatives. Of the 23 utilities that participated in the KSGAM, five utilities operate in the generation and transmission markets, 21 operate in the distribution market, and two operate in the whole-sale power market.

Employees

The reporting utilities range in size from 38 to 2791employees (in state), including temporary, part-time, and full-time, with a statewide average of 275. The employee average for IOUs (only) is1179, for G&Ts (only) is 653 and cooperatives (only) is 82. In all, the jurisdictional utilities employ approximately 6310 workers in Kentucky.

Customers

The responding utilities provide service to 1,572,922 residential customers, 219,603 commercial/industrial customers, and 15,974 other customers (largely street lighting). Residential customer counts range from 12,106 to 771,000. Commercial/industrial customer counts range from 333 to 125,000. IOUs average 344,745 residential customers and 57,122 commercial/industrial customers. Cooperatives average 29,927 residential customers and 2,680 commercial/industrial customers.

Size and Density

The average size of the service territory in KY is 1,971 square miles (excluding G&Ts), and range in size from 40 to 7,300 square miles. The average size of IOUs is 3,854 square miles, and 1,617 square miles for cooperatives. This translates to a statewide average of 11.1 customers/line mile of distribution, with a range between 6 and 42.3. The customer/line mile average for IOUs is 42.3, and is 9.3 for cooperatives.

EQUIPMENT SUMMARY

Electric Meters

The responding utilities collectively operate approximately 2,008,700 electric meters, with 314,223 identified as AMR capable and 442,332 identified as AMI capable, statewide. This corresponds to a total penetration rate of 37.7% for remotely readable readers (inclusive of AMI), and a 22% penetration rate of AMI-capable "smart" meters. IOUs report, on average, a 45% penetration ratio of remotely readable meters, and of 8.7% for "smart" meters. Cooperatives report, on average, 74% remotely readable meters, with 61.5% also AMI capable. Individual utility averages for both have a range from 0 to 100%.

Interconnect

Responding jurisdictional utilities collectively operate 33,844 miles of transmission and 98,399 miles of distribution within KY.

PERFORMANCE INFORMATION

Reliability Indicators

The statewide average System Average Interruption Frequency Index (SAIFI) is 1.4 interruptions per customers, and ranges from a minimum of 0.1772 to a maximum of 3.91. According to IEEE Standard 1366-1998, the median U.S. value is 1.10. The IOU average SAIFI is 1.61, 0.355 for G&Ts, and 1.48 for coops. The statewide average System Average Interruption Duration Index (SAIDI) is 137, and ranges from a minimum of 0.295 to a maximum of 418. According to IEEE Standard 1366-1998, the median U.S. value is 90 minutes. The IOU average SAIDI is 209.7, 19.95 for G&Ts, and 137.8 for coops. Insufficient information was provided by the responding utilities to provide representative data on predicted SAIFI and SAIDI.

Outages

Statewide, the average duration of planned outages is 70.8 minutes, effecting .2% of customers. The individual utility average durations range from 1min to 300 min, and affect an average percentage of customers ranging from .0004% to 1.55%. The average planned outage duration for IOUs is 140.5 minutes, effecting 0.06% of customers. The average for Cooperatives is 54.8 minutes, effecting 0.13% of customers. Data was not calculated for G&T providers only.

Statewide, the average duration of unplanned outages is 138,469 minutes, effecting 4.44% of customers. The individual utility average durations range from 32.1 minutes to 2,766,729 minutes, and affect an average percentage of customers ranging from .0002% to 41.16%. The average unplanned outage duration for IOUs is 207.9 minutes, effecting 13.7% of customers. The average for Cooperatives is 162,868 minutes, effecting 2.56 % of customers. Data was not calculated for G&T providers only.

Line Losses and Utilization

The statewide average distribution system line loss is 4.675%, and ranges from 1.9% to 6.7%. Statistics on transmission system line losses and capacity where not calculated due to insufficient data.

Operating Costs

The reported cost to operate the electric transmission system is $74,067,312 annually (excluding Duke Energy). The state average is $18,516,828 per transmission operator, and ranges from $5,783,922 to $30,550,820. The reported cost to operate the electric distribution system is $375,480,680 annually (excluding Duke Energy, and Grayson RECC). The state average is $19,762,141 per distribution operator, and ranges from $2,141,244 to 110,705,978. This equates to an average cost per customer of $552.85, with a range from $40.60 to $2571.68. The IOU only average is $65.72 per customer and averages $610.28 for cooperatives. Insufficient data was reported for calculation of statistics regarding work orders and estimated restoration time.

DEMAND RESPONSE DEPLOYMENT IMPACT EXPERIENCES

Program Overview

Demand Response (DR) offerings in the form of direct load control are fairly uniform across the state, and consist primarily of the use of a remotely-addressable switch to interrupt customer loads such as air conditioning units, pool pumps, heat pumps and electric water heaters. Such programs are offered by EKPC to all customers of their member distribution cooperatives, by Kentucky Power, and by Louisville Gas & Electric and Kentucky Utilities. Statewide, over 167,000 customers participate in direct load control programs, equating to roughly 9% participation statewide. However this figure is heavily dominated by LG&E's DLC program which with over 160,000 participants has a penetration rate of 17% of the entire customer base. The typical incentive for customer participation is a monetary credit for each controlled unit, either on a monthly basis when activated, or as a yearly bill credit. Customers are invited to participate in such programs via direct mailing, and radio, television and online advertising. Peak load reduction by DR programs will vary with the number of units called upon to participate by the utilities, and is therefore difficult to quantify. Utilities have reported average reduction in peak ranging from 6.7 MW to 116 MW, with the majority of reduction taking place during the summer season. However, these load reductions do not reduce overall energy consumption, and instead shift power delivery to off-peak hours.

Both EKPC and Big Rivers Electric Corporation have established special contracts with commercial and industrial customers to implement curtailment. EKPC has chosen to implement an interruptible rate program, in which credits to the demand rate are offered in response to load curtailment requests. Big Rivers Electric Corporation issues load curtailment requests based on market energy prices. Both programs are voluntary, and buy-through options are available. Both programs report low participation rates, ranging from 0 to 7%, with rates reported to vary directly in relation to changing market energy prices.

Four EKPC member cooperatives (Blue Grass Energy Cooperative Corporation, Licking Valley RECC, Nolin RECC and Owen Electric Cooperative) and Louisville Gas & Electric and Kentucky Utilities offer dynamic pricing programs. EKPC reports no customer participation in their program.

Benefits of DR programs are reported to include alleviating the need to purchase power, a reduction in peak demand, the deferment of construction of generation assets, increased load factor, customer satisfaction due to participation in environmental programs, and customer satisfaction due to decreased cost of service.

Customer DR Experiences

Utilities have reported a wide variety of responses when asked to comment on customer acceptance, participation, and education. Most utilities express difficulties encouraging program participation. Hesitance to participate is largely reported as due to concerns over "giving up control", however this is reported to be less of a concern as market electricity prices rise. It has also been reported that there is increasing customer demand for additional information regarding energy efficiency resulting from a desire of customers to make smart decision regarding their own energy consumption. Customer education on energy efficiency and participation in DR programs was reported to be an area of need by more than 75% of responding utilities.

Readiness for Dynamic Pricing
All responding utilities reported that they are not currently prepared to implement dynamic pricing. This is largely due to the need to install metering and communications infrastructure, meter data management capabilities, and the need for integration with IT systems.

Other Grid Modernization Practices
Other modernization practices have been limited in deployment. Those reported include smart meter pilots, conservation voltage reduction, and automatic circuit reconfiguration for outage management/self-healing.

Multi Year Smart Grid Planning
Of the responding utilities, six indicated having multi-year plans specifically targeting smart grid deployments. Of these, three are specifically focuses on AMI deployments.

Weakness of Kentucky Electric Grid
Utilities have reported the following when asked to comment on their opinion regarding the overall weakness of the KY electric grid: transmission limitation/constraint (11), threat to right of way and line clearance by vegetation (2), generation constraints (4), low generation source diversity (1), reliability to natural forces including storms (1), and technical obsolescence (1).

Additional Concerns Related to Smart Grid
Utilities have reported the following when asked to comment on their concerns related to smart grid deployments: ability to provide sufficient security (1), decreased grid reliability (1), cost recovery / economic justification (10), technical obsolescence (4), regulatory mandates not in line with business model (4), electric vehicle integration (1), need for pilot studies (1), customer education and acceptance (3), changing business models (1), and change management (1).

SMART GRID FUNCTIONALITIES AND ENABLING TECHNOLOGY

The responding electric utilities were given a listing and description of smart grid functionalities, each followed by a listing of technologies that enable such functions. The following section summarizes their responses to the use of installed technology to achieve smart grid function.

Increased National and Information Security Increased power efficiency – Reduce transmission and distribution loss, reduce customer load loss, and increase efficiency on electrical generation. Enabling technologies:

- Transmission SCADA/EMS: 6 deployed
- Distribution SCADA/DMS: 13 deployed, 1 in development
- Optimized voltage and reactive power control: 5 deployed, 2 in development
- Smarting metering: 13 deployed, 1 in development
- Solid-state transformer: 0 deployed
- Superconducting transmission: 0 deployed
  High voltage DC transmission: 0 deployed

Increase thermal efficiency of generation: 2 deployed
Any additional technology you may have deployed: NONE

Increased power transfer capability – Increase the power transfer capability of transmission systems in Kentucky. Facilitate regional system interconnection. This is important if Kentucky is going to purchase large amount of renewable energy from other states.

Phasor measurement unit technology: 0 deployed
Dynamic thermal rating of transmission line: 2 deployed
Transmission SCADA/EMS: 4 deployed: 0 deployed
High voltage DC transmission: 0 deployed
Any additional technology you may have deployed: NONE

Increased system reliability – Anticipate and respond to system disturbances, operate resiliently against attack and natural disaster, curtail the duration of power outage, isolate power outage area to only fault vicinity by automated system reconfiguration. Enabling technologies:

Fault detection and location system: 10 deployed, 1 in development
Automated system reconfiguration and restoration: 6 deployed
Outage management system: 11 deployed
Transmission SCADA/EMS: 3 deployed
Distribution SCADA/DMS: 13 deployed, 1 deploying
Phasor measurement unit technology: 2 deployed
Superconducting magnetic energy storage system: 0 deployed
Short-circuit current limiting: 3 deployed
Any additional technology you may have deployed: 0 deployed

Improved power quality – Provide power quality for the digital economy, reduce economic loss caused by power quality issues, offer flexible level of power quality based on customer demand. Enabling technologies:

Power quality monitoring system: 8 deployed
Energy storage technology: 0 deployed
Capacitive compensation: 7 deployed
Any additional technology you may have deployed: zero crossing switches

Optimized asset utilization and efficient operation – Optimally manage generation plant, substation and power line, increase the utilization of line capacity by adjusting thermal ratings in real-time. Enabling technologies:

Dynamic thermal rating of transformer and transmission line: 1 deployed
Condition based operation & maintenance: 7 deployed
Any additional technology you may have deployed: on-line DGA for some transformers,
Breaker wear algorithms

Facilitates integration of distributed generations including renewable energy – Offer the possibility to accommodate various types of power generation, i.e. coal, hydro, wind, solar, biomass, etc.; offer the opportunity for net-metering, stimulate the development of energy storage system, reduce reliance on imported fuel. Enabling technologies:

Net-metering: 16 deployed
Energy storage system, large capacity battery: 0 deployed
Microgrid: 0 deployed

Integration with electric vehicles (PEV): 1 deployed
Any additional technology you may have deployed: NONE

More effective consumer load control – Implement effective demand side management, offer the opportunity of incentive pricing strategy, e.g. real-time pricing, peak/off-peak pricing, enable active participation by consumers, offer the opportunity for customers to control their energy consumption, increase customer choice on selection of generation as power supply. Enabling technologies:

Demand side management: 16 deployed
Smart metering: 14 deployed, 1 pilot
Home energy management system, e.g. In-home display, web portal: 5 deployed
Any pricing strategy, e.g. real-time pricing, dynamic pricing, critical pricing: 4 deployed, 1 pilot
Consumer load control technology such as programmable thermostat: 12 deployed
Any additional technology you may have deployed: Electric thermal storage

Enhanced grid awareness – Enable more effective grid monitoring and acquire better knowledge of grid conditions by utilizing advanced sensing and measurement technology. Enabling technologies:

SCADA: 10 deployed, 1 deploying
Breaker monitoring system: 6 deployed
Wide-area monitoring system: 4 deployed
Phasor measurement unit: 3 deployed
Geographic information system: 12 deployed
Digital event recording device: 7 deployed
Transmission line sag monitoring: 0 deployed
Any additional technology you may have deployed: IV Dip calculation

Increased national and information security – Through deterrence of organized attacks on the grid, protect data and information privacy, and enhance cyber security. Enabling technologies:

Techniques related to cyber security: 10 deployed
Techniques related to data privacy: 10 deployed
Any additional technology you may have deployed: 0 deployed

EU-KSGAM "As-is" State of Smart Grid Summary

Introduction

The EU-KSGAM "As-Is" State of Smart Grid Survey was completed by 23 of the jurisdictional utilities. The survey identified 10 areas of smart grid functionality, or Smart Grid Classes (SGCs). Each SGC was described by Development Levels (DL) ranging from zero to five. The DLs for each SGC were described by specific functionalities. Utility representatives were asked to read the DLs for each SGC, and to evaluate their own utility's currents state for each SGC by choosing the DL that most accurately identified the utility. Complete descriptions of the SGCs and associated DLs can be found in the document *The Kentucky Smart Grid Roadmap Initiative: Kentucky Smart Grid Assessment Model.*

Method

For each SGC, descriptive statistics were calculated for mean, median, mode, max, min, range, and standard deviation. To determine a statewide Development Level for each SGC, the mean (rounded to nearest integer), median, and mode were compared. In all cases, two of the descriptive statistics were found to be in agreement, and this value was assigned as the state DL.

The outlying value, if present, was then used to inform the direction of movement within the DL. Outliers lower than the calculated state DL indicate that the DL has recently been reached in the state, or is **emergent**. Outliers above the calculated state DL indicate that the DL is trending towards the next higher DL, or is **growing**. No outlier indicates that the calculated state DL is **stable**.

The standard deviation was utilized to indicate the agreement on each SGC DL by the responding utilities. Standard deviations within the top 1/3, ascending, are said to be in **low** agreement, middle 1/3 are said to be in **medium** agreement, and within the bottom 1/3, are said to be in **high** agreement.

Strategy and Management (SM)

The SM SGC has mean, median, and mode ranking of 1.7, 2, and 3 respectively (9^{th}, 9^{th}, and 9^{th} overall, ascending) indicating an Enabling "As-is" maturity level (DL2) statewide that is Growing. The standard deviation of the responses was 1.3 (1^{st} overall, descending) indicating a Low amount of agreement between utilities.

Organization and Structure (OS)

The OS SGC has mean, median, and mode ranking of 1.4, 1, and 0 respectively (7^{th}, 7^{th}, and 3^{rd} overall, ascending) indicating an Initiating "As-is" maturity level (DL1) statewide that is Emergent. The standard deviation of the responses was 1.3 (2^{nd} overall, descending) indicating a Low amount of agreement between utilities.

Technology (TECH)

The TECH SGC has mean, median, and mode ranking of 1.4, 1.5, and 2 respectively (8^{th}, 8^{th}, and 8^{th} overall, ascending) indicating an Enabling "As-is" maturity level (DL2) statewide that is Emergent. The standard deviation of the responses was 1.0 (4th overall, descending) indicating a Medium amount of agreement between utilities.

SYSTEMS ARCHITECTURE AND OPERATION (SAO)
The SAO SGC has mean, median, and mode ranking of .95, 1, and 0 respectively (3rd, 3rd, and 2nd overall, ascending) indicating an Initiating "As-is" maturity level (DL1) statewide that is Emergent. The standard deviation of the responses was .93 (6th overall, descending) indicating a Medium amount of agreement between utilities.

DEMAND AND SUPPLY MANAGEMENT (DSM)
The DSM SGC has mean, median, and mode ranking of 1, 1, and 1 respectively (4th, 4th and 5th, overall, ascending) indicating an Initiating "As-is" maturity level (DL1) statewide that is Stable. The standard deviation of the responses was .79 (8th overall, descending) indicating a High amount of agreement between utilities.

WORK AND ASSET MANAGEMENT (WAM)
The WAM SGC has mean, median, and mode ranking of 1.2, 1, and 1 respectively (6th, 6th and 7th, overall, ascending) indicating an Initiating "As-is" maturity level (DL1) statewide that is Stable. The standard deviation of the responses was .9 (7th overall, descending) indicating a Medium amount of agreement between utilities.

PHYSICAL AND CYBER SECURITY (SEC)
The SEC SGC has mean, median, and mode ranking of 1.1, 1, and 1 respectively (5th, 5h and 6th, overall, ascending) indicating an Initiating "As-is" maturity level (DL1) statewide that is Stable. The standard deviation of the responses was .97 (5th overall, descending) indicating a Medium amount of agreement between utilities.

GOVERNMENT AND REGULATION (GR)
The GR SGC has mean, median, and mode ranking of 1, 1, and 1 respectively (2nd, 2nd and 4th, overall, ascending) indicating an Initiating "As-is" maturity level (DL1) statewide that is Stable. The standard deviation of the responses was .7 (8th overall, descending) indicating a High amount of agreement between utilities.

CUSTOMER (CUST)
The CUST SGC has mean, median, and mode ranking of 1.7, 2, and 3 respectively (10th, 10th and 10th, overall, ascending) indicating an Enabling "As-is" maturity level (DL2) statewide that is Growing. The standard deviation of the responses was 1.2 (3rd overall, descending) indicating a Low amount of agreement between utilities.

ENVIRONMENT AND SOCIETY (ENV)
The ENV SGC has mean, median, and mode ranking of .52, 0, and 0 respectively (1st, 1st, and 1st, overall, ascending) indicating a Default "As-is" maturity level (DL0) statewide that is Growing. The standard deviation of the responses was .73 (9th overall, descending) indicating a High amount of agreement between utilities.

EU-KSGAM Desired Future State of Smart Grid Summary

Introduction

The EU-KSGAM Desired Future State of Smart Grid Survey was completed by 23 of the jurisdictional utilities. The survey identified 10 areas of smart grid functionality, or Smart Grid Classes (SGCs). Each SGC was described by Development Levels (DL) ranging from zero to five. The DLs for each SGC was described by specific functionalities. Utility representatives were asked to read the DLs for each SGC, and to evaluate their own utility desired future state for each SGC by choosing the DL that most accurately identified the utility's future goals. Complete descriptions of the SGCs and DLs can be found in the document *The Kentucky Smart Grid Roadmap Initiative: Kentucky Smart Grid Assessment Model.*

Method

For each SGC, descriptive statistics were calculated for mean, median, mode, max, min, range, and standard deviation. To determine a statewide Development Level for each SGC, the mean (rounded to nearest integer), median, and mode were compared. In all cases, two of the descriptive statistics were found to be in agreement, and this value was assigned as the state DL.

The outlying value, if present, was then used to further refine the DL. Outliers lower than the calculated state DL indicates that the DL has reported lower emphasis by the state utilities, or is **weak**. Outliers above the calculated state DL indicate that the DL has higher emphasis by the state utilities, or is **strong**. No outlier value indicates that the calculated state DL is **stable**.

The standard deviation was utilized to indicate the agreement on each SGC DL by the responding utilities. Standard deviations within the top 1/3, ascending, are said to be in **low** agreement, middle 1/3 are said to be in **medium** agreement, and within the bottom 1/3, are said to be in **high** agreement.

Strategy and Management (SM)

The SM SGC has mean, median, and mode ranking of 2.85, 3.5, and 4 respectively (9^{th}, 9^{th}, and 10^{th} overall, ascending) indicating an Optimizing "Future" maturity level (DL4) statewide that is Weak. The standard deviation of the responses was 1.8 (1^{st} overall, descending) indicating a Low amount of agreement between utilities.

Organization and Structure (OS)

The SM SGC has mean, median, and mode ranking of 2.7, 3, and 4 respectively (8^{th}, 8^{th}, and 9^{th} overall, ascending) indicating an Integrating "Future" maturity level (DL3) statewide that is Strong. The standard deviation of the responses was 1.7 (3^{rd} overall, descending) indicating a Low amount of agreement between utilities.

Technology (TECH)

The TECH SGC has mean, median, and mode ranking of 2.2, 2, and 4 respectively (6^{th}, 6^{th}, and 8^{th} overall, ascending) indicating an Enabling "Future" maturity level (DL2) statewide that is Strong. The standard deviation of the responses was 1.5 (8^{th} overall, descending) indicating a High amount of agreement between utilities.

SYSTEMS ARCHITECTURE AND OPERATION (SAO)

The SAO SGC has mean, median, and mode ranking of 2.1, 1, and 1 respectively (3rd, 5th, and 5th overall, ascending) indicating an Enabling "Future" maturity level (DL2) statewide that is Stable. The standard deviation of the responses was 1.6 (4th overall, descending) indicating a Medium amount of agreement between utilities.

DEMAND AND SUPPLY MANAGEMENT (DSM)

The DSM SGC has mean, median, and mode ranking of 2.2, 2, and 1 respectively (4th, 4th, and 2nd overall, ascending) indicating an Enabling "Future" maturity level (DL2) statewide that is Weak. The standard deviation of the responses was 1.5 (9th overall, descending) indicating a High amount of agreement between utilities.

WORK AND ASSET MANAGEMENT (WAM)

The WAM SGC has mean, median, and mode ranking of 2.5, 3, and 3 respectively (7th, 7th, and 6th overall, ascending) indicating an Integrating "Future" maturity level (DL3) statewide that is Stable. The standard deviation of the responses was 1.5 (5th overall, descending) indicating a Medium amount of agreement between utilities.

PHYSICAL AND CYBER SECURITY (SEC)

The SEC SGC has mean, median, and mode ranking of 2.1, 2, and 2 respectively (2nd, 3rd and 4th overall, ascending) indicating an Enabling "Future" maturity level (DL2) statewide that is Stable. The standard deviation of the responses was 1.6 (8th overall, descending) indicating a Medium amount of agreement between utilities.

GOVERNMENT AND REGULATION (GR)

The GR SGC has mean, median, and mode ranking of 2.3, 2, and 2 respectively (5th, 2nd, and 3rd overall, ascending) indicating an Enabling "Future" maturity level (DL2) statewide that is Stable. The standard deviation of the responses was 1.5 (10th overall, descending) indicating a High amount of agreement between utilities.

CUSTOMER (CUST)

The CUST SGC has mean, median, and mode ranking of 3.1, 4, and 4 respectively (10th, 10th, and 7th overall, ascending) indicating an Optimizing "Future" maturity level (DL4) statewide that is Weak. The standard deviation of the responses was 1.7 (2nd overall, descending) indicating a Low amount of agreement between utilities.

ENVIRONMENT AND SOCIETY (ENV)

The ENV SGC has mean, median, and mode ranking of 1.8, 1, and 1 respectively (1st, 1st and 1st overall, ascending) indicating an Initiating "Future" maturity level (DL1) statewide that is Strong. The standard deviation of the responses was 1.6 (7th overall, descending) indicating a Medium amount of agreement between utilities.

EU-KSGAM Gap Analysis

Introduction

A gap analysis was performed comparing the calculated statewide values of the EU-KSGAM "As-Is" and Desired Future State of Smart Grid Surveys. The gap analysis identifies, for the state on average, the relative importance of each SGC, as reported by jurisdictional utilities.

Method

To calculate a Gap Score for each SGC, numerical weights were given to the "As-is" SGC descriptors as follows: +2 points for each Development Level (i.e. a DL of 3 receives 6 points), -1 for Emergent, +0 for Stable, and +1 for the Growing modifiers, respectively. Numerical weights were given to the "Future" SGC descriptors as follows: +2 points for each Development Level, -1 for Weak, +0 for Stable, and +1 for the Strong modifiers, respectively. The delta between these values was then calculated (Future – As-Is). This weighting was again modified using the SGC Agreement indicator for both "As-Is" and "Future" states as follows: -.5 for Low, +0 for Medium, and +.5 for High

$$\text{Gap Score} = (2{*}DL_{Future} + Modifier_{Future}) - (2{*}DL_{As\text{-}Is} + Modifier_{As\text{-}Is}) + Agreement_{Future} + Agreement_{As\text{-}Is}$$

Strategy and Management (SM)

The "Future" maturity level is Weak and Optimizing (DL4) with Low agreement. The SM SGC has a Growing and Enabling (DL2) "As-is" maturity level with Low agreement.

$$GS = (2{*}4 + -1) – (2{*}2+ 1) + -0.5 +-0.5 = \mathbf{1}$$

Organization and Structure (OS)

The "Future" maturity level is Strong and Integrating (DL3) with Low agreement. The OS SGC has an Emergent and Initiating (DL1) "As-is" maturity level with Low agreement.

$$GS = (2{*}3 + 1) – (2{*}1+ -1) + -0.5 +-0.5 = \mathbf{5}$$

Technology (TECH)

The "Future" maturity level is Strong and Enabling (DL2) with High agreement. The TECH SGC has an Emergent and Enabling (DL2) "As-is" maturity level with Medium agreement.

$$GS = (2{*}2 + 1) – (2{*}2+ -1) + 0.5 +0.0 = \mathbf{2.5}$$

Systems Architecture and Operation (SAO)

The "Future" maturity level is Stable and Enabling (DL2) with Medium agreement. The SAO SGC has an Emergent and Initiating (DL1) "As-is" maturity level with Medium agreement.

$$GS = (2{*}2 + 0) – (2{*}1+ -1) + 0 + 0 = \mathbf{3}$$

Demand and Supply Management (DSM)

The "Future" maturity level is Weak and Enabling (DL2) with High agreement. The DSM SGC has a Stable and Initiating (DL1) "As-is" maturity level with High agreement.

GS = (2*2 + -1) – (2*1+ 0) + 0.5 +0.5 = **2**

Work and Asset Management (WAM)

The “Future” maturity level is Stable and Integrating (DL3) with Medium agreement. The WAM SGC has a Stable and Initiating (DL1) “As-is” maturity level with Medium agreement.

GS = (2*3 + 0) – (2*1+ -1) + 0 + 0 = **5**

Physical and Cyber Security (SEC)

The “Future” maturity level is Stable and Enabling (DL2) with Medium agreement. The SEC SGC has a Stable and Initiating (DL1) “As-is” maturity level with Medium agreement.

GS = (2*2 + 0) – (2*1+ 0) + 0 + 0 = **2**

Government and Regulation (GR)

The “Future” maturity level is Stable and Enabling (DL2) with High agreement. The SM SGC has a Stable and Initiating (DL1) “As-is” maturity level with High agreement.

GS = (2*2 + 0) – (2*1+ 0) + 0.5 +0.5 = **3**

Customer (CUST)

The “Future” maturity level is Weak and Optimizing (DL4) with Low agreement. The CUST SGC has a Growing and Enabling (DL2) “As-is” maturity level with Low agreement.

GS = (2*4 + -1) – (2*2+ 1) + -0.5 +-0.5 = **1**

Environment and Society (ENV)

The “Future” maturity level is Strong and Initiating (DL1) with Medium agreement. The SM SGC has a Growing and Default (DL0) “As-is” maturity level with High agreement.

GS = (2*1 + 1) – (2*0+ 1) + 0 + 0 = **2**

S-KSGAM Summary

Introduction

The S-KSGAM Survey was completed by 11 stakeholders. The survey identified seven Smart Grid Characteristics. Each Characteristic was described by a short paragraph with details specific to the Characteristic. Stakeholders were asked to read the description and rank the current electric power system of Kentucky on a scale from one to five for each of the Characteristics. The task was then repeated for the desired future state of the Characteristic. Additionally, the survey identified five Smart Grid Benefits. Each Benefit was described by a short paragraph with details specific to the Benefit. Stakeholders were asked to read all of the descriptions, and then to allot $1M (USD) of investment amongst the five Benefits. Complete descriptions of the Characteristics, Benefits and rankings can be found in the document *The Kentucky Smart Grid Roadmap Initiative: Kentucky Smart Grid Assessment Model.*

Demographic Information

Of the 11 respondents, 11 identified themselves as residential electric customers in the state of Kentucky, 3 identified themselves as commercial customers, 2 identified themselves as members of state the KY state government, 1 identified as a member of the KY Energy and Environment Cabinet, and 6 identified as a member of a stakeholder group.

Of the 11 respondents, five identified themselves as "*I understand most of the electric power system. I understand concepts relating to grid operations and components such as substations, transformers, and frequency.*" Three identified themselves as "*I have a thorough understanding of the electric power system. In understand concepts such as SCADA, demand response, distributed energy resources, AMR and energy markets*". One identified as "*I have an advanced understanding of the electric power system that includes AMI, substation energy storage, automated VAR correction, and dynamic pricing.*" One identified as "*I am on the cutting edge of electric power research and understand systems such as microgrids, solid state transformers, CVR, and real time pricing.*" One participant did not indicate their level of knowledge regarding the electric utility industry.

Smart Grid Characteristics Survey

Method

For each Smart Grid Characteristic, descriptive statistics were calculated for mean, median, mode, max, min, and standard deviation for both the "As-Is" and "Future" states. To determine a statewide consensus for each Characteristic, the mean (rounded to nearest integer), median, and mode were compared. In all cases, two of the descriptive statistics were found to be in agreement, and this value was assigned as the state value.

The outlying value, if present, was then used to inform the direction of movement within the Characteristic. For the "As-Is" state, outliers lower than the calculated state value indicate that the Characteristic has recently been reached statewide, or is **emergent**. Outliers above the calculated statewide Characteristic indicate that the Characteristic is trending towards the next higher level, or is **growing**. No outlier indicates that the calculated statewide Characteristic is **stable**. For the "Future" state, outliers lower than the calculated statewide Characteristic indicate that the Characteristic has reported lower emphasis by the stakeholders, or is **weak**.

Outliers above the calculated statewide Characteristic indicate that the Characteristic has higher emphasis by stakeholders, or is **strong**. No outlier value indicates that the calculated statewide Characteristic is **stable**.

The standard deviation was utilized to indicate the agreement on each Smart Grid Characteristic by the responding stakeholders. Standard deviations within the top 1/3, ascending, are said to be in **low** agreement, middle 1/3 are said to be in **medium** agreement, and within the bottom 1/3, are said to be in **high** agreement.

Active Participation by Consumers
The Active Participation by Consumers Characteristic has an "As-Is" mean, median, and mode ranking of 2, 2, and 2 respectively indicating an "As-Is" maturity level of 2 statewide that is Stable. The standard deviation of the responses was .47 indicating a High amount of agreement between stakeholders. The Characteristic has a "Future" mean median, and mode ranking of 4.3, 4.5 and 5 indicating a "Future" desired maturity level of 5 statewide that is Weak. The standard deviation of the responses was .95 indicating a High amount of agreement between stakeholders.

Accepts All Power Generation and Storage
The Accepts All Power Generation and Storage Characteristic has an "As-Is" mean, median, and mode ranking of 2.3, 2, and 2 respectively indicating an "As-Is" maturity level of 2 statewide that is Stable. The standard deviation of the responses was .82 indicating a Medium amount of agreement between stakeholders. The Characteristic has a "Future" mean median, and mode ranking of 3.9, 4.5 and 5 indicating a "Future" desired maturity level of 5 statewide that is Weak. The standard deviation of the responses was 1.29 indicating a Low amount of agreement between stakeholders.

Enables New Products and Services
The Enables New Products and Services Characteristic has an "As-Is" mean, median, and mode ranking of 1.7, 2, and 2 respectively indicating an "As-Is" maturity level of 2 statewide that is Stable. The standard deviation of the responses was .49 indicating a High amount of agreement between stakeholders. The Characteristic has a "Future" mean median, and mode ranking of 3.3, 3.5, and 2 indicating a "Future" desired maturity level of 3 statewide that is Weak. The standard deviation of the responses was 1.45 indicating a Low amount of agreement between stakeholders.

Improved Power Quality
The Improved Power Quality Characteristic has an "As-Is" mean, median, and mode ranking of 2.5, 2, and 2 respectively indicating an "As-Is" maturity level of 2 statewide that is Growing. The standard deviation of the responses was 1.35 indicating a Low amount of agreement between stakeholders. The Characteristic has a "Future" mean median, and mode ranking of 3.7, 4, and 4 indicating a "Future" desired maturity level of 4 statewide that is Stable. The standard deviation of the responses was 1.6 indicating a Medium amount of agreement between stakeholders.

Efficient Operation and Use of Assets
The Efficient Operation and Use of Assets Characteristic has an "As-Is" mean, median, and mode ranking of 2.8, 3, and 3 respectively indicating an "As-Is" maturity level of 3 statewide that is Stable. The standard deviation of the responses was 1.14 indicating a Low amount of agreement between stakeholders. The Characteristic has a "Future" mean median, and mode

ranking of 4.5, 5, and 5 indicating a "Future" desired maturity level of 5 statewide that is Stable. The standard deviation of the responses was .71 indicating a High amount of agreement between stakeholders.

Self Healing
The Self Healing Characteristic has an "As-Is" mean, median, and mode ranking of 2.1, 2, and 2 respectively indicating an "As-Is" maturity level of 2 statewide that is Stable. The standard deviation of the responses was .33 indicating a High amount of agreement between stakeholders. The Characteristic has a "Future" mean median, and mode ranking 4.1, 4, and 4 indicating a "Future" desired maturity level of 4 statewide that is Stable. The standard deviation of the responses was .99 indicating a Medium amount of agreement between stakeholders.

Defends Against Attack and Natural Disaster
The Defends Against Attack and Natural Disaster Characteristic has an "As-Is" mean, median, and mode ranking of 2.3, 2, and 2 respectively indicating an "As-Is" maturity level of 2 statewide that is Stable. The standard deviation of the responses was 1.12 indicating a Medium amount of agreement between stakeholders. The Characteristic has a "Future" mean median, and mode ranking of 1.6, 2, and 3 indicating a "Future" desired maturity level of 2 statewide that is Strong. The standard deviation of the responses was 1.05 indicating a Medium amount of agreement between stakeholders.

SMART GRID BENEFITS SURVEY

Method
For each Smart Grid Benefit, descriptive statistics were calculated for mean, median, mode, max, min, and standard deviation. The mean value was used as the statewide consensus for each Benefit. The standard deviation was utilized to indicate the agreement on each Smart Grid Benefit by the responding stakeholders. Standard deviations within the top 1/3, ascending, are said to be in **low** agreement, middle 1/3 are said to be in **medium** agreement, and within the bottom 1/3, are said to be in **high** agreement.

Reliable
The Reliable Benefit has an average valuation of $18.55M, with a Standard Deviation of $11.4M, indicating a Medium amount of agreement between stakeholders.

Secure and Safe
The Secure and Safe Benefit has an average valuation of $17.1M, with a Standard Deviation of $9.9M, indicating a High amount of agreement between stakeholders.

Economic
The Economic Benefit has an average valuation of $19.95M, with a Standard Deviation of $9.61M, indicating a High amount of agreement between stakeholders.

Efficient
The Efficient Benefit has an average valuation of $19.63M, with a Standard Deviation of $14.6M, indicating a Medium amount of agreement between stakeholders.

Environmentally Friendly

The Environmentally Friendly Benefit has an average valuation of $18.55M, with a Standard Deviation of $25.4M, indicating Low amount of agreement between stakeholders.

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S-KSGAM GAP ANALYSIS

INTRODUCTION

A gap analysis was performed comparing the calculated statewide values of the S-KSGAM "As-Is" and Desired Future State of Smart Grid Surveys. The gap analysis identifies, for the state on average, the relative importance of each Smart Grid Characteristic, as reported stakeholders.

METHOD

To calculate a Gap Score for each Smart Grid Characteristic, numerical weights were given to the "As-is" Characteristic descriptors as follows: +2 points for each Level (i.e. a Level of 3 receives 6 points), -1 for Emergent, +0 for Stable, and +1 for the Growing modifiers, respectively. Numerical weights were given to the "Future" Characteristics descriptors as follows: +2 points for each Level, -1 for Weak, +0 for Stable, and +1 for the Strong modifiers, respectively. The delta between these values was then calculated (Future – As-Is). This weighting was again modified using the Characteristic Agreement indicator for both "As-Is" and "Future" states as follows: -.5 for Low, +0 for Medium, and +.5 for High

$$\text{Gap Score} = (2*DL_{Future} + Modifier_{Future}) - (2*DL_{As\text{-}Is} + Modifier_{As\text{-}Is}) + Agreement_{Future} + Agreement_{As\text{-}Is}$$

ACTIVE PARTICIPATION BY CONSUMERS

The "Future" level is a Weak Level 5 with High agreement. The "As-Is" level is a Stable Level 2 with High agreement.

GS = 6

ACCEPTS ALL POWER GENERATION AND STORAGE

The "Future" level is a Weak Level 5 with Low agreement. The "As-Is" level is a Stable Level 2 with Medium agreement.

GS = 4.5

ENABLES NEW PRODUCTS AND SERVICES

The "Future" level is a Weak Level 3 with Low agreement. The "As-Is" level is a Stable Level 2 with High agreement.

GS = 1

IMPROVED POWER QUALITY

The "Future" level is a Stable Level 4 with Medium agreement. The "As-Is" level is a Growing Level 2 with Low agreement.

GS = 2.5

EFFICIENT OPERATION AND USE OF ASSET

The "Future" level is a Stable Level 5 with High agreement. The "As-Is" level is a Stable Level 3 with Low agreement.

GS = 4

Self Healing

The "Future" level is a Stable Level 4 with Medium agreement. The "As-Is" level is a Stable Level 2 with High agreement.

GS = 4.5

Defend Against Attack and Natural Disaster

The "Future" level is a Strong Level 2 with Medium agreement. The "As-Is" level is a Stable Level 3 with Medium agreement.

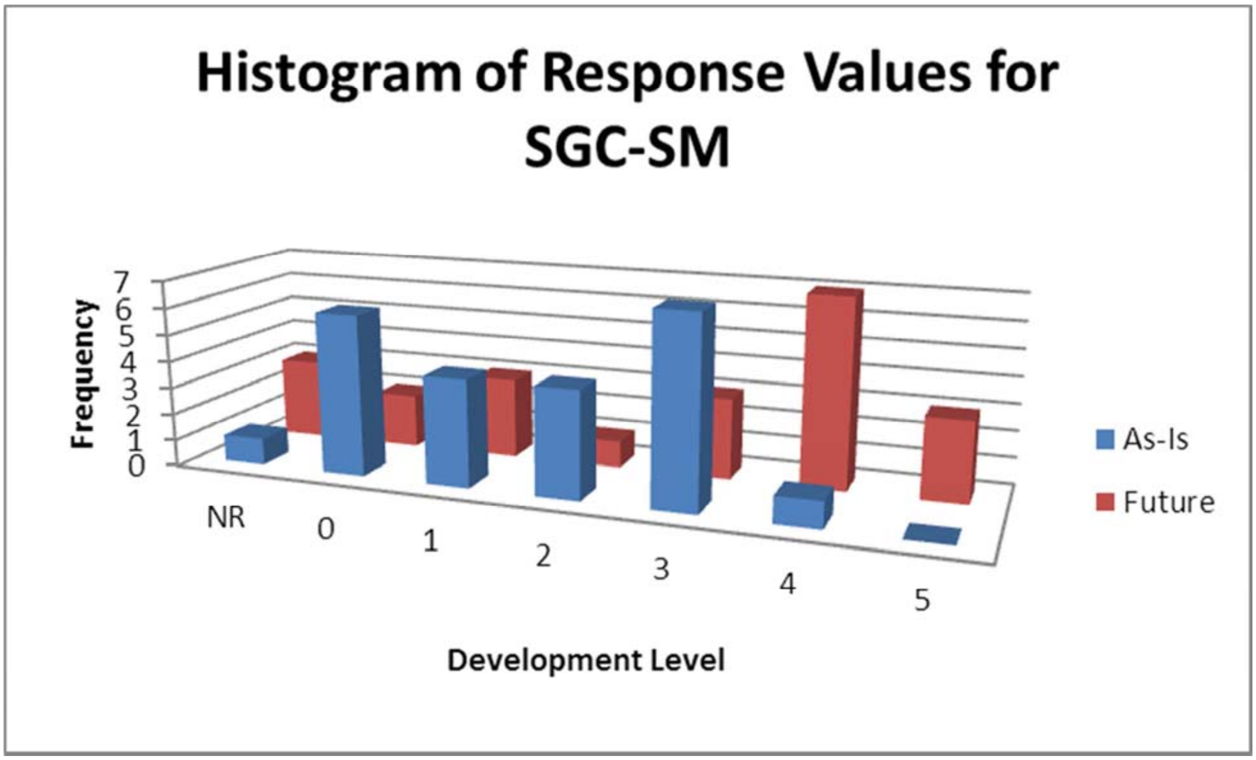
GS = 1

“AS-IS” AND “FUTURE” STATE DETAILS FOR SMART GRID CLASSES

This section summarizes the responses of the 23 jurisdictional utilities for each of the 10 Smart Grid Classes (SGCs) of the Electric Utility - Kentucky Smart Grid Assessment Model (EU-KSGAM). For each SGC, the model definition is presented along with a histogram and descriptive statistical data.

STRATEGY AND MANAGEMENT (SM)

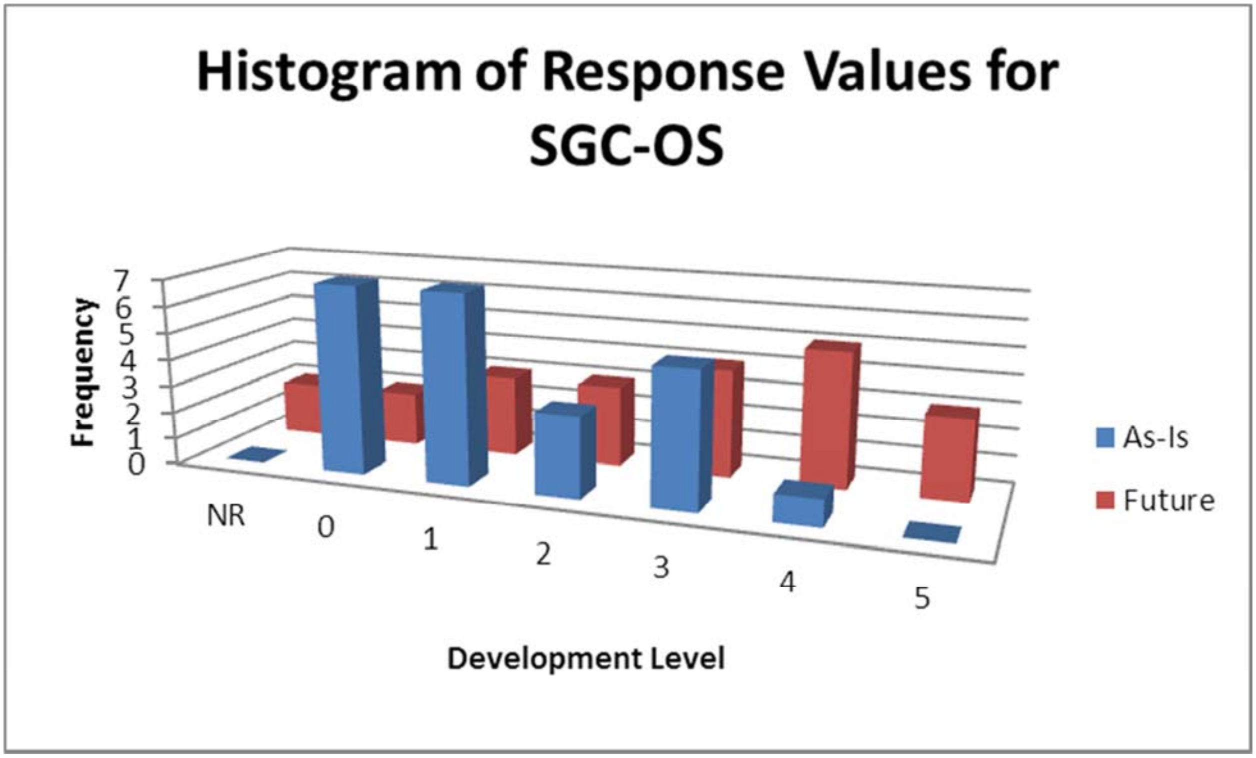
The Strategy and Management (SM) SGC represents the competencies and attributes related to a smart grid vision and strategic planning, internal governance and management processes, and collaboration with internal and external stakeholders. For a complete description of each Development Level for the SM SGC, refer to Pg. 14 of the document “Kentucky Smart Grid Assessment Model Electric Utility – Survey”.



Descriptive Statistics			
	As-Is	**Future**	**Δ**
Mean	1.681818	2.85	1.168182
Median	2	3.5	1.5
Mode	3	4	1
Maximum	4	5	
Minimum	0	0	
Range	4	5	
Standard Dev.	1.323285	1.755443	

Organization and Structure (OS)

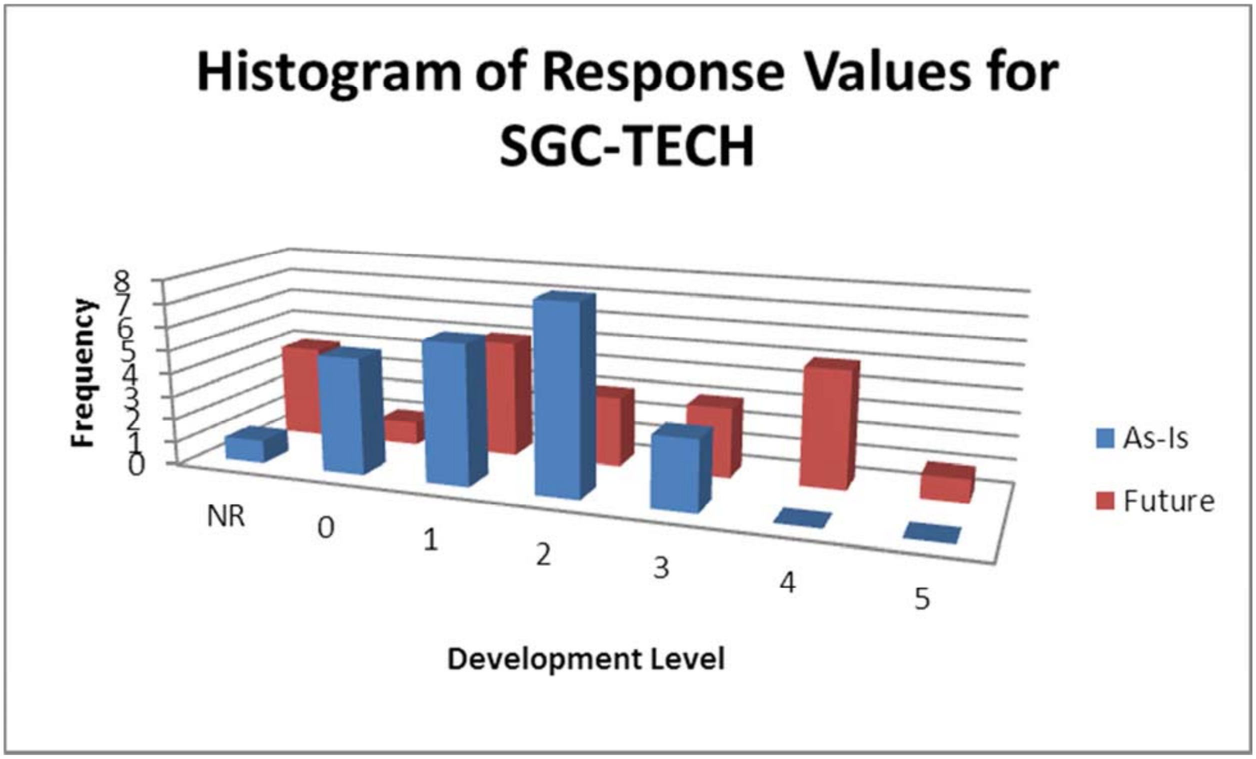
The Organization and Structure (OS) SGC represents the competencies and attributes related to workplace structure, training, communications, and knowledge management within the utility. For a complete description of each Development Level for the OS SGC, refer to Pg. 15 of the document "Kentucky Smart Grid Assessment Model Electric Utility – Survey".



Descriptive Statistics			
	As-Is	Future	Δ
Mean	1.391304	2.666667	1.275362
Median	1	3	2
Mode	0	4	4
Maximum	4	5	
Minimum	0	0	
Range	4	5	
Standard Dev.	1.269901	1.683251	

TECHNOLOGY (TECH)

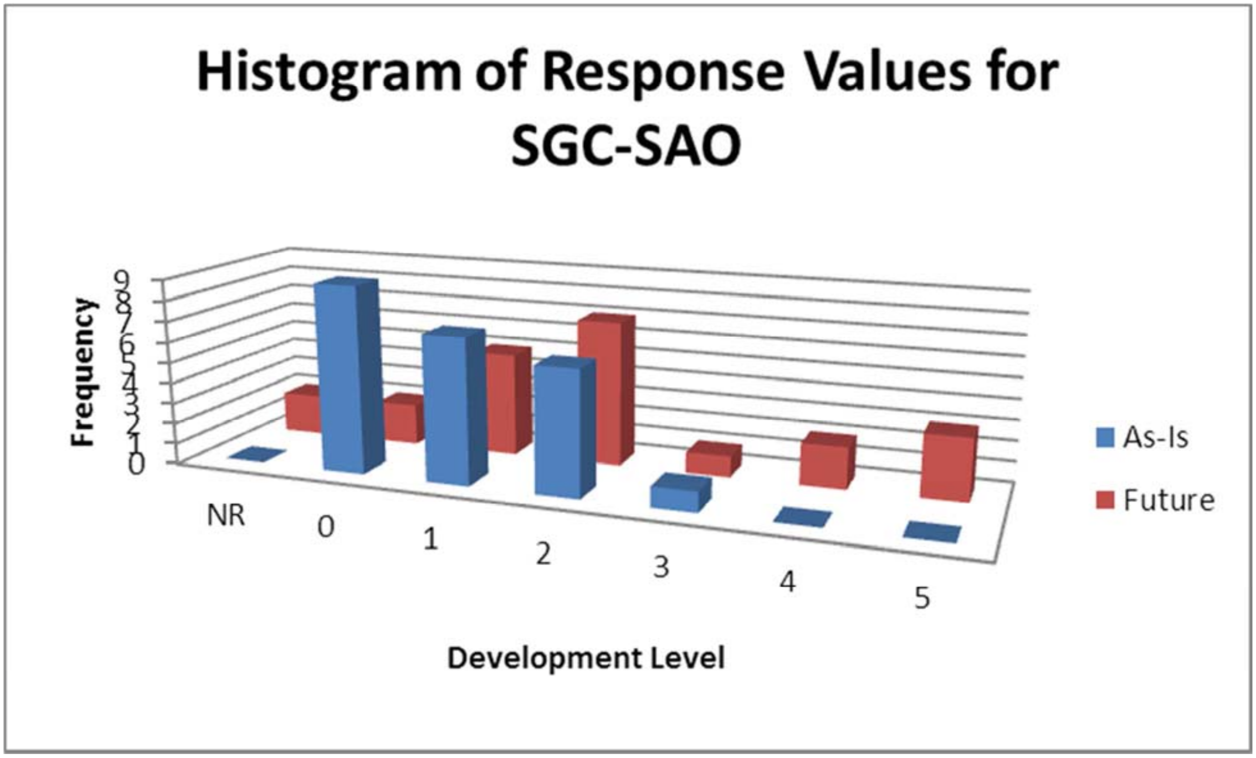
The Technology (TECH) SGC measures the extent to which the utility has evaluated deployment of and enabled effective strategic planning of technologies such as: integrated communications, sensing and measurement, advanced components, advanced control methods, and improved visual interfaces and decision support software. This SGC also measure the utility's establishment of engineering and business process for the evaluation, acquisition, integration, and testing of technologies. For a complete description of each Development Level for the TECH SGC, refer to Pg. 16 of the document "Kentucky Smart Grid Assessment Model Electric Utility – Survey".



Descriptive Statistics			
	As-Is	Future	Δ
Mean	1.409091	2.368421	0.95933
Median	1.5	2	0.5
Mode	2	4	2
Maximum	3	5	
Minimum	0	0	
Range	3	5	
Standard Dev.	1.007547	1.535163	

Systems Architecture and Operation (SAO)

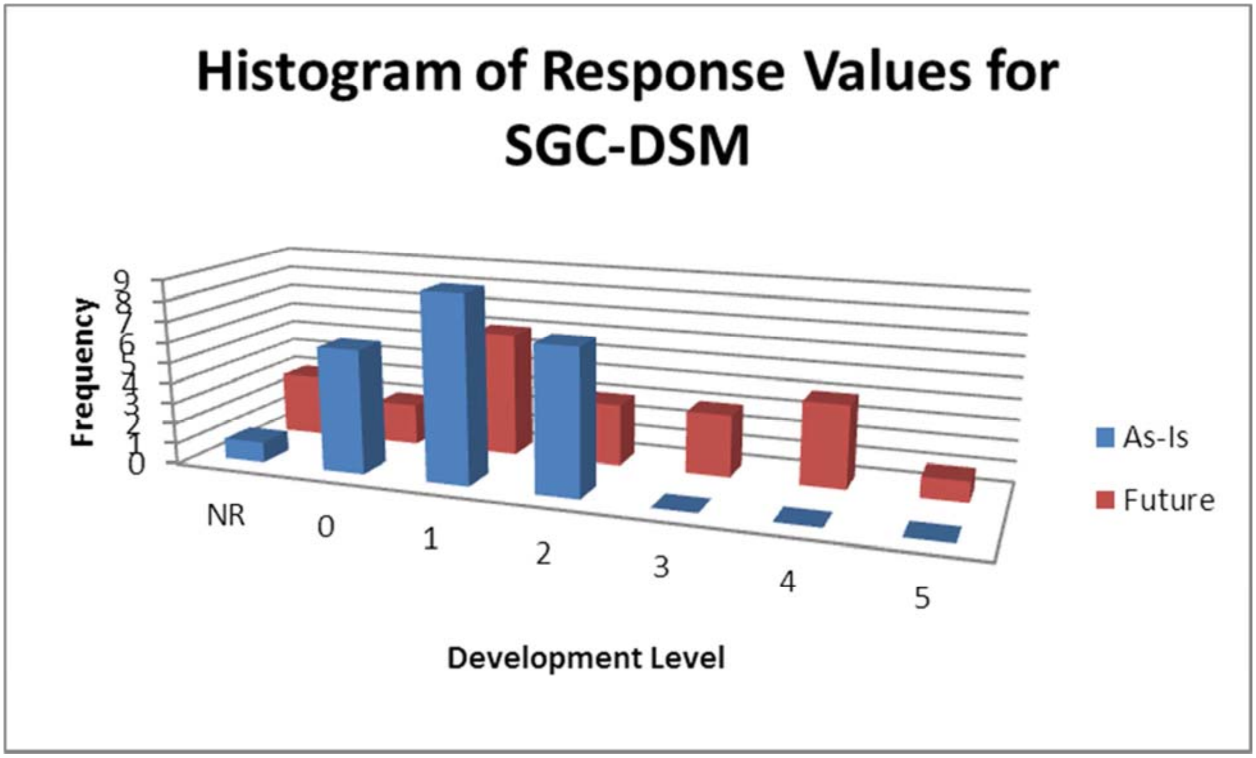
The System Architecture and Operation (SAO) SGC represents the operation of the power grid as an automated system with a high degree of local, regional, and national situational awareness to improve efficiency, security and safety. These architectures are often divided between four operational gateways: advanced metering infrastructure (AMI), advanced distribution operations (ADO), advanced transmission operations (ATO), and advanced asset management (AAM). For a complete description of each Development Level for the SAO SGC, refer to Pg. 17 of the document "Kentucky Smart Grid Assessment Model Electric Utility – Survey".



Descriptive Statistics			
	As-Is	**Future**	**Δ**
Mean	0.956522	2.142857	1.186335
Median	1	2	1
Mode	0	2	2
Maximum	3	5	
Minimum	0	0	
Range	3	5	
Standard Dev.	0.928256	1.621287	

DEMAND AND SUPPLY MANAGEMENT (DSM)

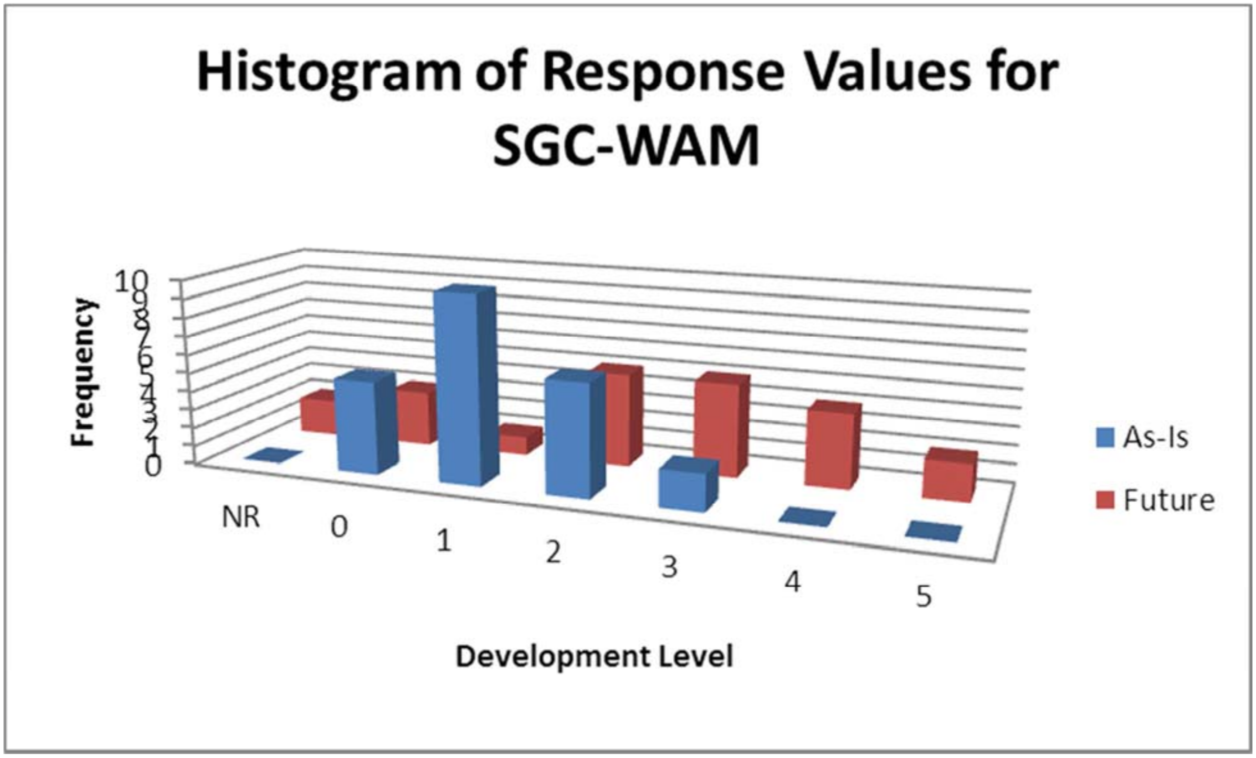
The Demand and Supply Management (DSM) SGC represents the ability to dynamically manage both the supply and demand in the production and delivery of electricity, based on near real-time information in the areas of load management, distributed energy resources, and new market opportunities. For a complete description of each Development Level for the DSM SGC, refer to Pg. 18 of the document "Kentucky Smart Grid Assessment Model Electric Utility – Survey".



Descriptive Statistics			
	As-Is	Future	Δ
Mean	1.045455	2.2	1.154545
Median	1	2	1
Mode	1	1	0
Maximum	2	5	
Minimum	0	0	
Range	2	5	
Standard Dev.	0.785419	1.472556	

WORK AND ASSET MANAGEMENT (WAM)

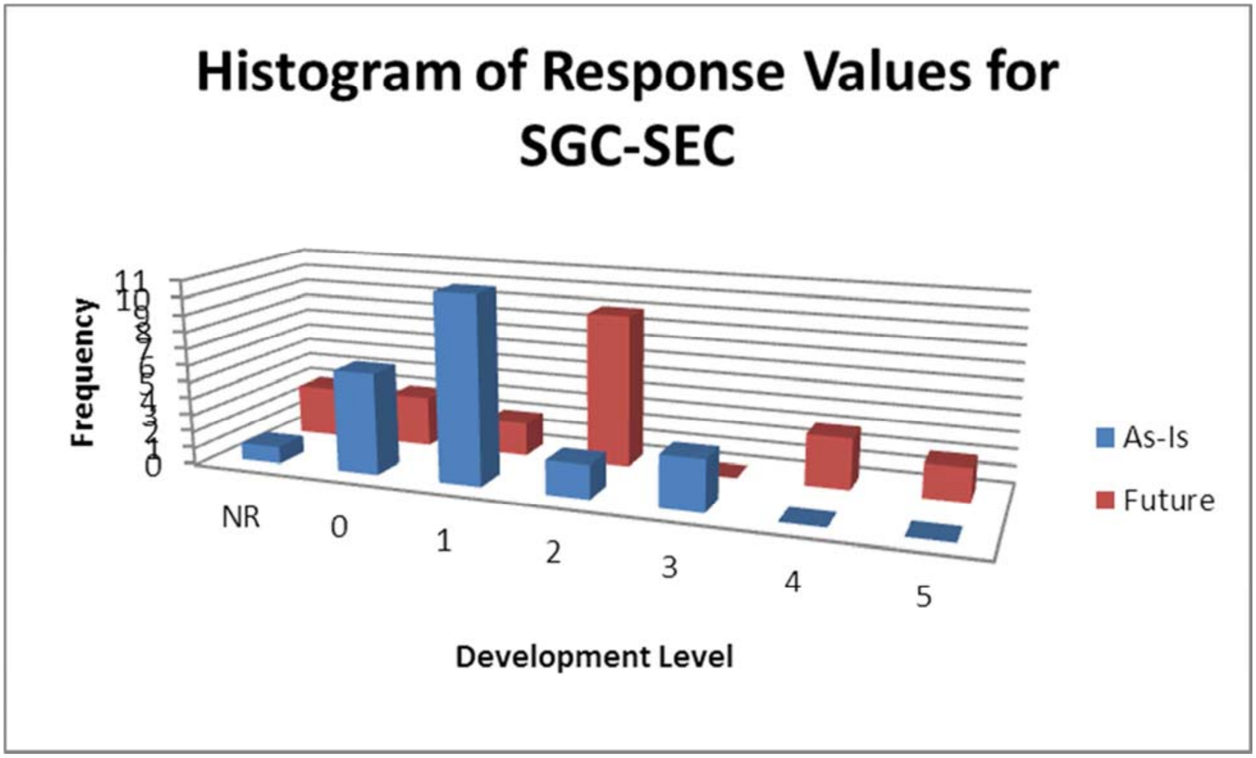
The Work and Asset Management (WAM) SGC represents the capabilities that support optimal management of grid assets and workforce resources, toward a utility that bases operation and maintenance decisions on real-time performance data instead of best practices or historical precedent, resulting in a change from preventative and reactive resource usage to predictive and planned resource management. For a complete description of each Development Level for the WAM SGC, refer to Pg. 19 of the document "Kentucky Smart Grid Assessment Model Electric Utility – Survey".



Descriptive Statistics			
	As-Is	**Future**	**Δ**
Mean	1.217391	2.47619	1.258799
Median	1	3	2
Mode	1	3	2
Maximum	3	5	
Minimum	0	0	
Range	3	5	
Standard Dev.	0.902347	1.600595	

PHYSICAL AND CYBER SECURITY (SEC)

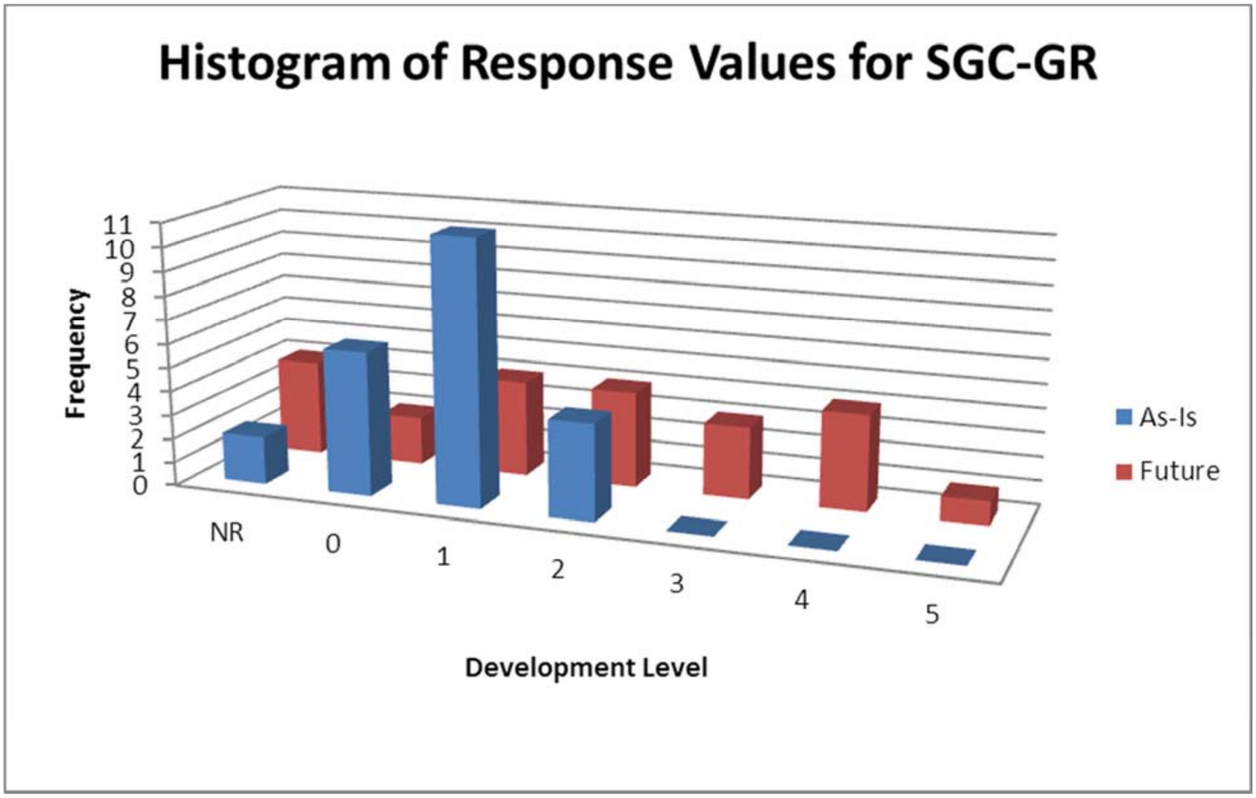
The Physical and Cyber Security (SEC) SGC represents the protection of new and legacy equipment and system data from cyber and physical security attacks. This SGC measures the extent to which a security architecture and overlay is in place, the performance of risk assessment activities, and conformance to emerging NIST cyber security standards. For a complete description of each Development Level for the SEC SGC, refer to Pg. 20 of the document "Kentucky Smart Grid Assessment Model Electric Utility – Survey".



Descriptive Statistics			
	As-Is	**Future**	**Δ**
Mean	1.090909	2.1	1.009091
Median	1	2	1
Mode	1	2	1
Maximum	3	5	
Minimum	0	0	
Range	3	5	
Standard Dev.	0.971454	1.586124	

Government and Regulation (GR)

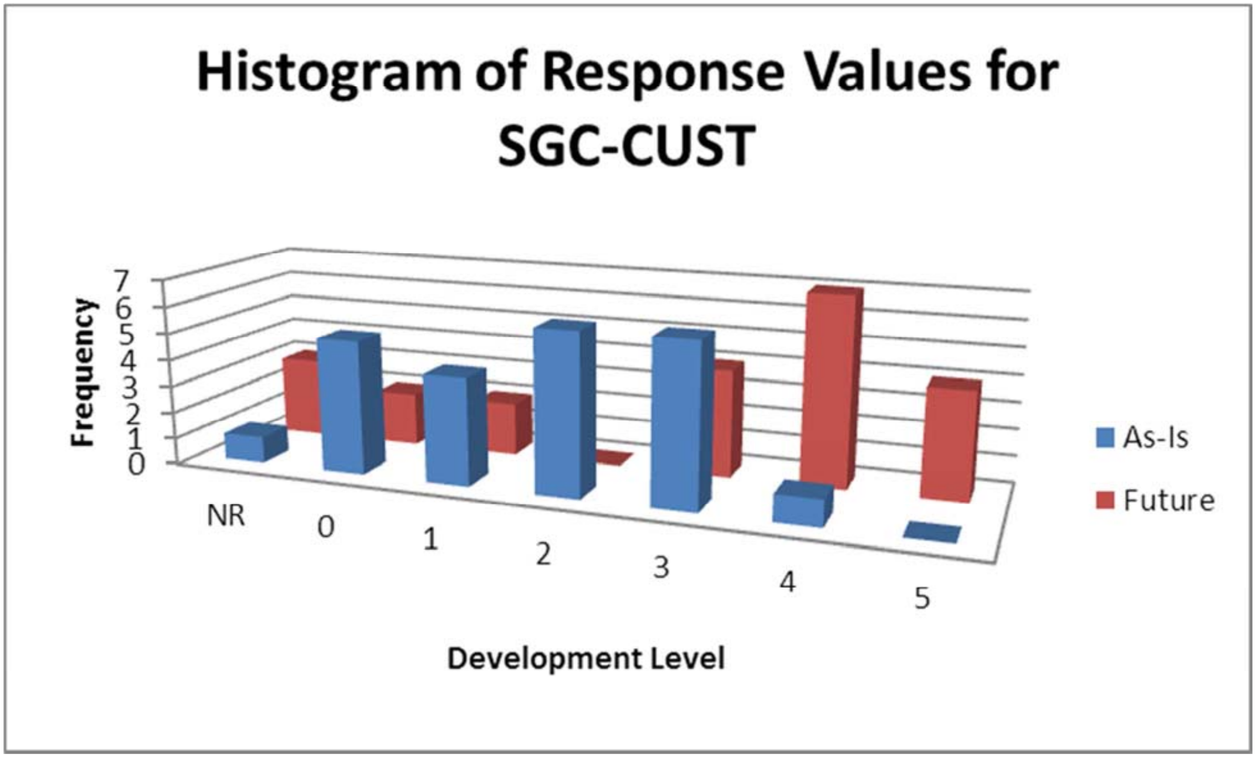
The Government and Regulation (GR) SGC represents the role of the state governments and the Kentucky Public Service Commission in the development of smart grid operations. This SGC measures the extent to which regulators authorize smart grid investments on both visible deployments and supporting infrastructure projects, authorize smart grid demonstration projects, approve innovative regulatory strategies, and facilitate intra-utility optimization. This SGC also measure the state investment, in terms of cost recovery authorizations or grants, in smart grid deployments. For a complete description of each Development Level for the GR SGC, refer to Pg. 21 of the document "Kentucky Smart Grid Assessment Model Electric Utility – Survey".



Descriptive Statistics			
	As-Is	Future	Δ
Mean	0.904762	2.315789	1.411028
Median	1	2	1
Mode	1	2	1
Maximum	2	5	
Minimum	0	0	
Range	2	5	
Standard Dev.	0.70034	1.454977	

CUSTOMER (CUST)

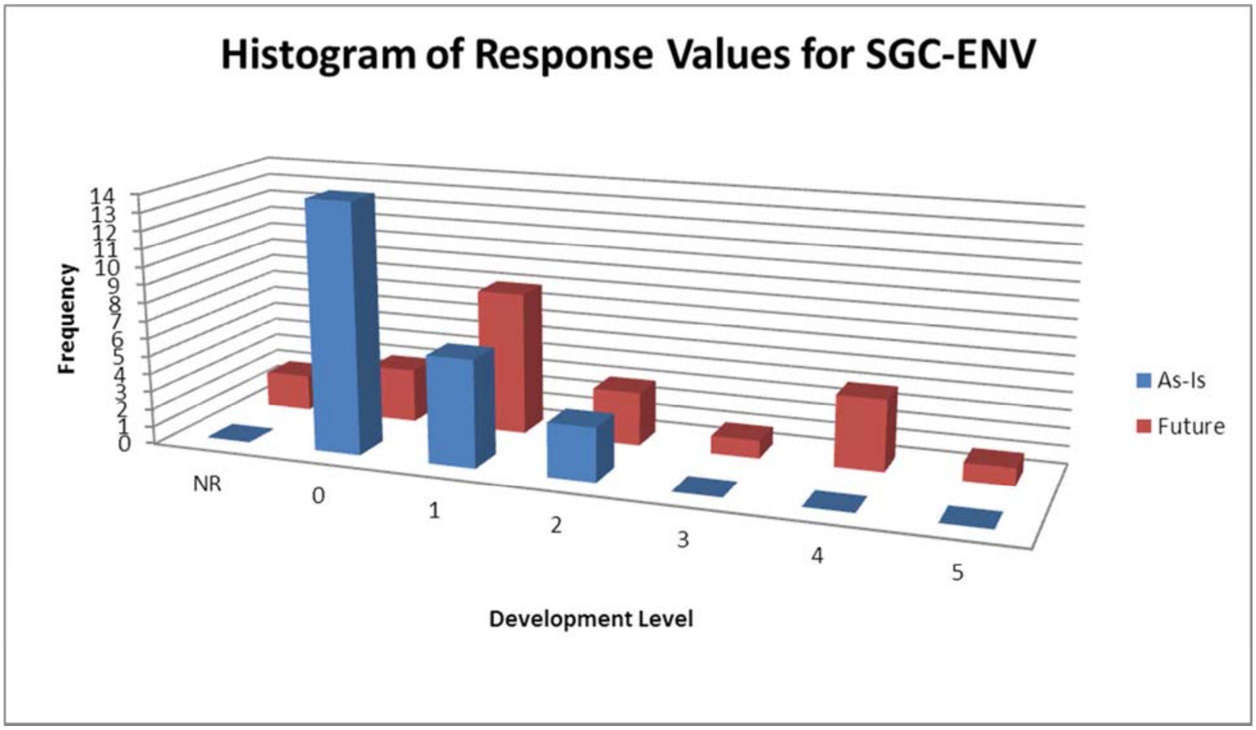
The Customer (CUTS) SGC represents the role of customer participation and experience, pricing, education, and advanced services. Customer participation may range from fully passive to fully active, with a goal of fully empowering customers to make decisions regarding the usage, source, and cost of energy. For a complete description of each Development Level for the CUST SGC, refer to Pg. 22 of the document "Kentucky Smart Grid Assessment Model Electric Utility – Survey".



Descriptive Statistics			
	As-Is	Future	Δ
Mean	1.727273	3.1	1.372727
Median	2	4	2
Mode	3	4	1
Maximum	4	5	
Minimum	0	0	
Range	4	5	
Standard Dev.	1.241421	1.744163	

ENVIRONMENT AND SOCIETY (ENV)

The Environment and Society (ENV) SGC represents the contributions of the utility to achieving societal goals regarding reliability, safety, security, energy sources, energy source impacts, and quality of life. This includes the promotion of conservation and green energy initiatives, the integration of alternative and distributed energy resources, and GHG emission reduction programs. For a complete description of each Development Level for the ENV SGC, refer to Pg. 22 of the document "Kentucky Smart Grid Assessment Model Electric Utility – Survey".



Descriptive Statistics			
	As-Is	**Future**	**Δ**
Mean	0.521739	1.809524	1.287785
Median	0	1	1
Mode	0	1	1
Maximum	2	5	
Minimum	0	0	
Range	2	5	
Standard Dev.	0.730477	1.569046	

"As-Is" and "Future" State Details for Smart Grid Characteristics

This section summarizes the responses of the 11 grid stakeholders for each of the seven Smart Grid Characteristics of the Stakeholder - Kentucky Smart Grid Assessment Model (S-KSGAM). For each Characteristic the model definition is presented along with a histogram and descriptive statistical data.

Level Descriptions

Level 1: The current electric power system does not implement any aspects of this characteristic. Level 2: The current electric power system implements some aspects of this characteristic. Level 3: The current electric power system implements many aspects of this characteristic. Level 4: The current electric power system implements most aspects of this characteristic. Level 5: The current electric power system implements all aspects of this characteristic.

Active Participation by Consumers

Active Participation by Consumers is the characteristic that describes the increased interaction of consumers with the grid. Such interaction is characterized by the use of price based signals and demand response programs to give customers choice regarding if and when to purchase power, the decisions on the source of purchased power, the use of distributed energy resources, and the use of home automation networks and intelligent load end-use devices such as smart appliances

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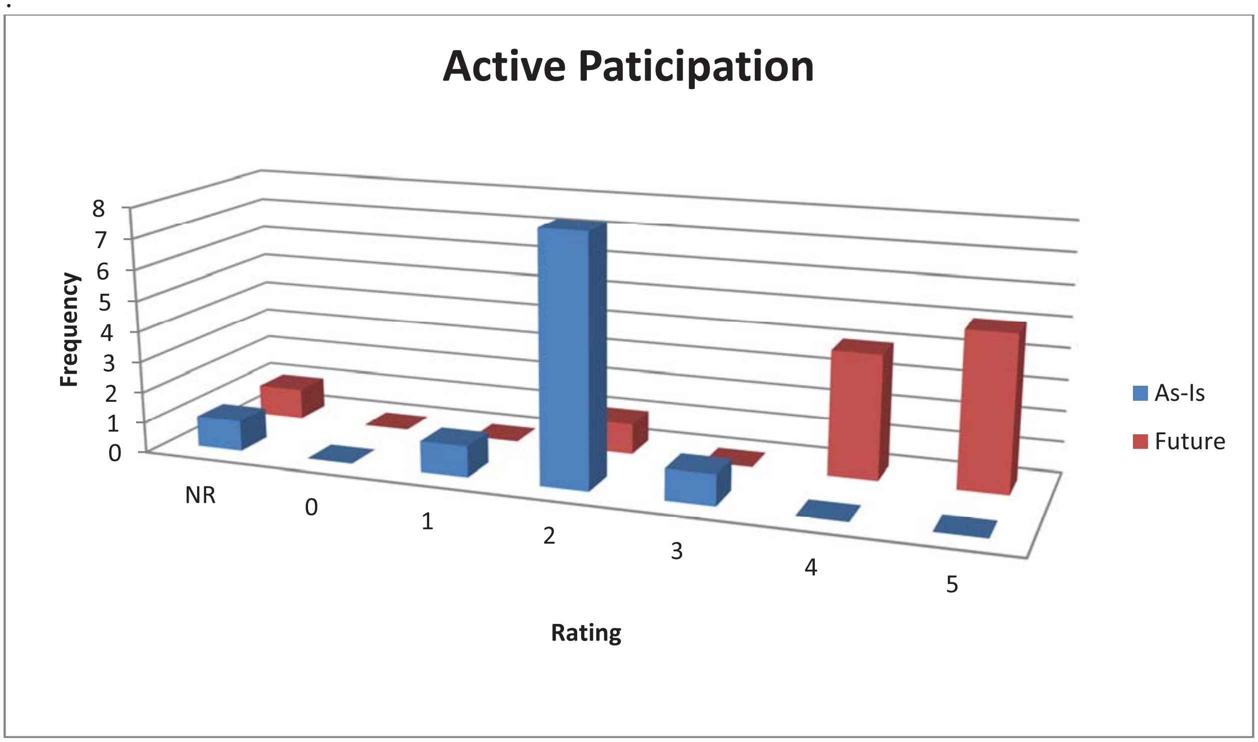
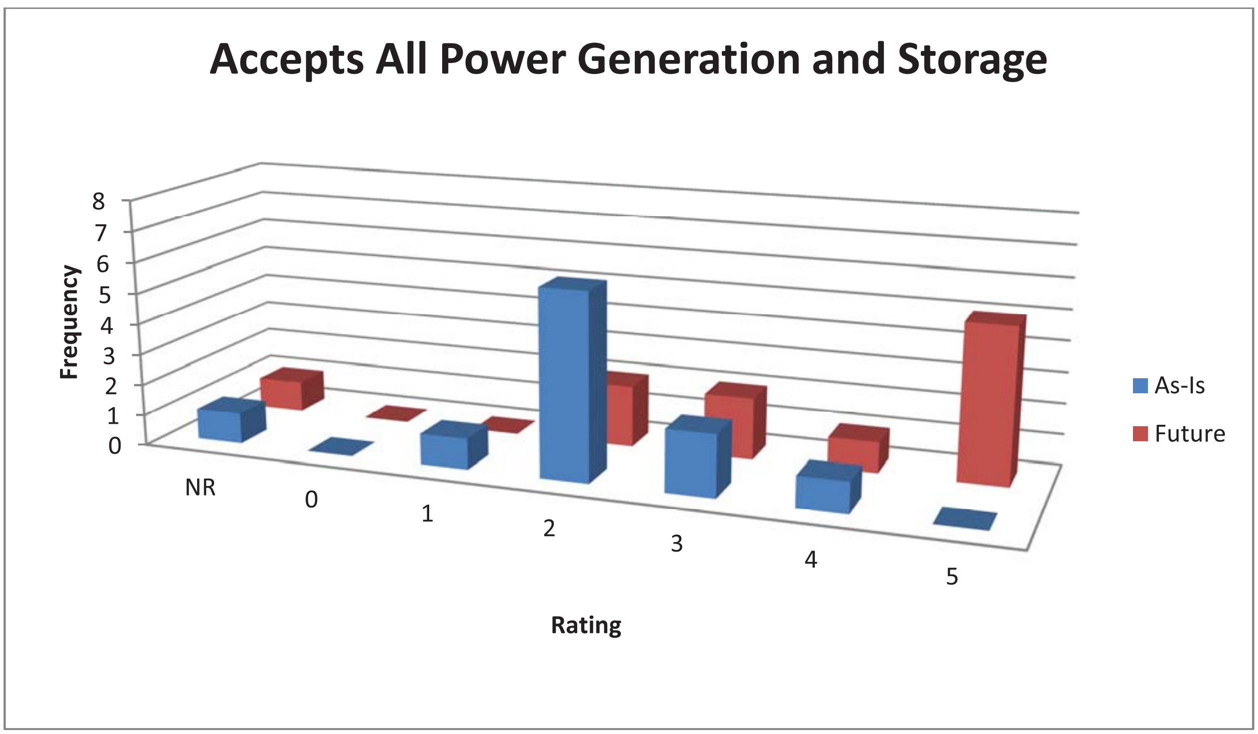


Descriptive Statistics			
	As-Is	Future	Δ
Mean	2	4.3	2.3
Median	2	4.5	2.5
Mode	2	5	3
Maximum	3	5	
Minimum	1	2	
Standard Dev.	0.471405	0.9486833	

ACCEPTS ALL POWER GENERATION AND STORAGE

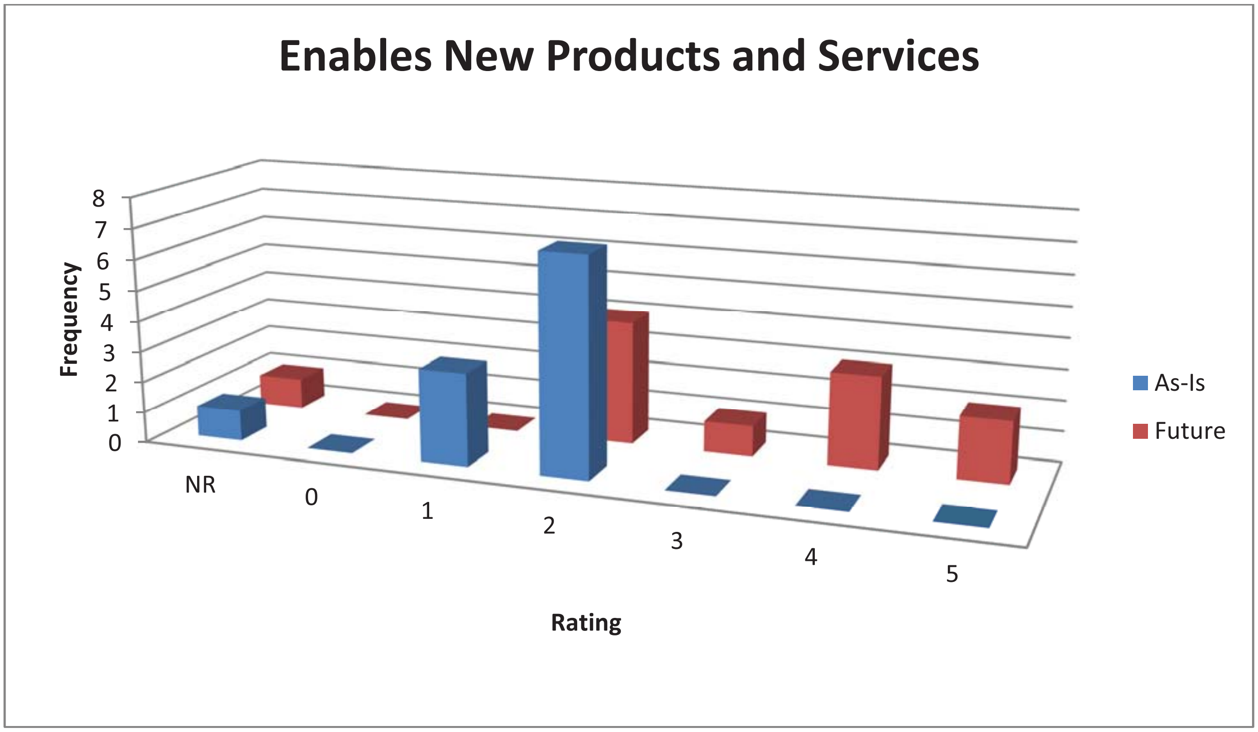
Accepts All Power Generation and Storage is the characteristic that describe the integration of diverse resources with "plug-and-play" connections to multiply the options for electrical generation and storage. This includes the accommodation of large centralized power plants, and distributed energy resources such as renewables, distributed generation, and energy storage devices. This characteristic represents the transition to a more decentralized supply model.



Descriptive Statistics			
	As-Is	**Future**	**Δ**
Mean	0	5	
Median	2.3	3.9	1.6
Mode	2	4.5	2.5
Maximum	2	5	3
Minimum	4	5	
Standard Dev.	1	2	

Enables New Products and Services

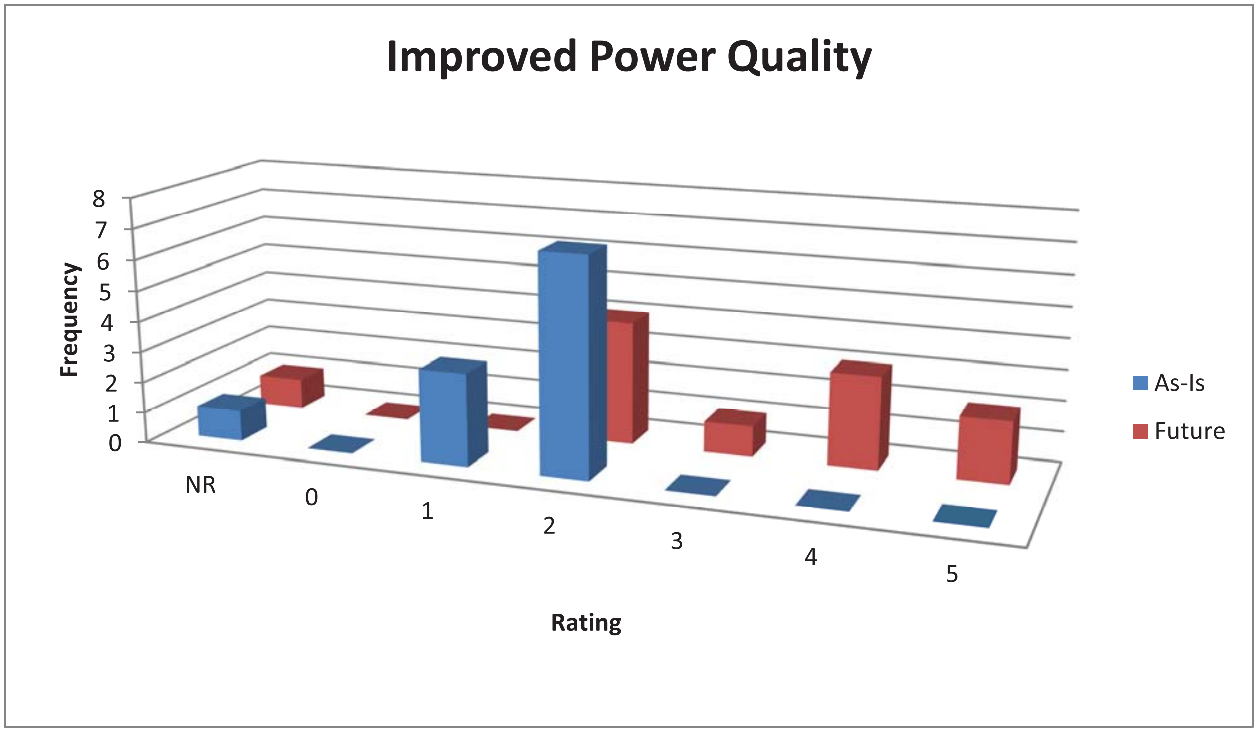
Enables New Products and Services is the characteristic that describes three changes in the electricity market. First is the direct linking of the buyers and sellers of electricity (e.g. RTO to consumer), allowing real time interaction with the market. Second, the advent of new commercial goods and services will results in the creation of new electricity markets and choice such as green power products and electric vehicles. Third, a restructuring of markets will achieve consistency of operation across the U.S.



Descriptive Statistics			
	As-Is	Future	Δ
Mean	1.7	3.3	1.6
Median	2	3.5	1.5
Mode	2	2	0
Maximum	2	5	
Minimum	1	2	
Standard Dev.	0.483045892	1.251666	

Improved Power Quality

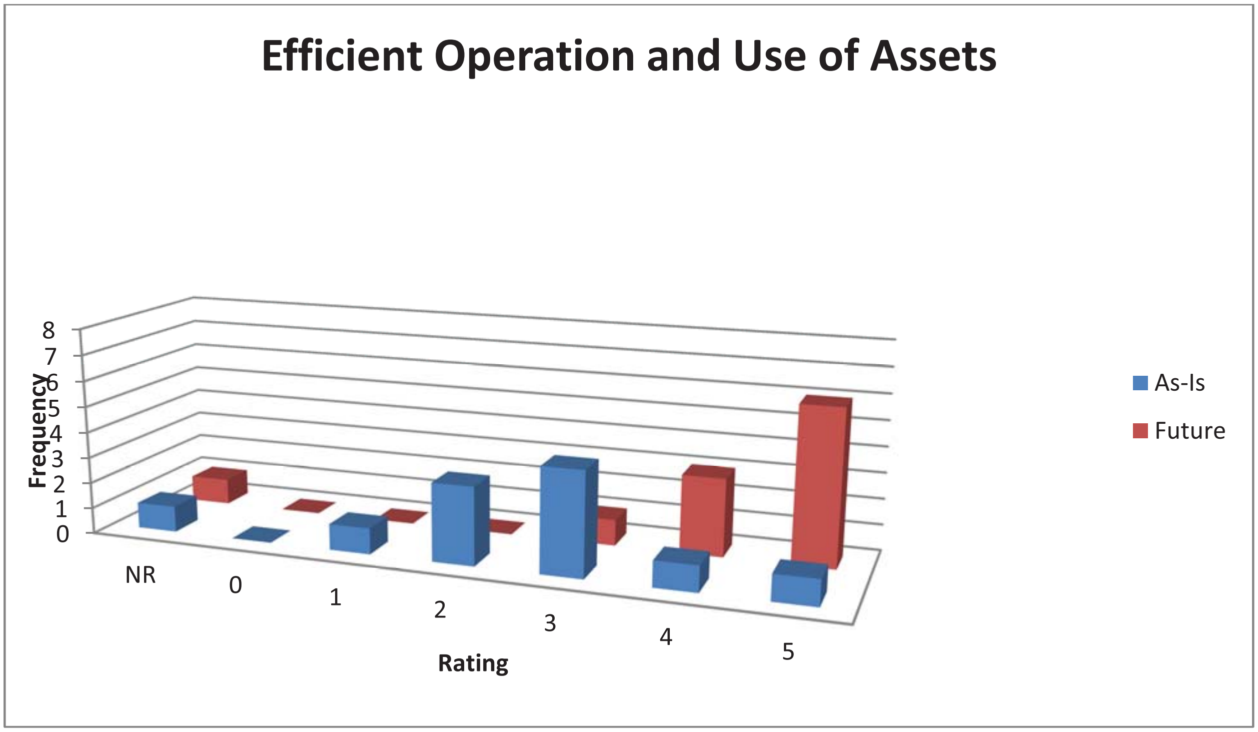
Improved Power Quality is the characteristic that describes the delivery of "clean" power. Such digital-grade power is characterized by a reduction in system interruptions due to under voltage sags, voltage spikes, frequency harmonics, and phase imbalances. The delivered power may be available in "grades", varying from standard to premium, and will depend on customer requirements.



Descriptive Statistics			
	As-Is	Future	Δ
Mean	2.5	3.7	1.2
Median	2	4	2
Mode	2	4	2
Maximum	5	5	
Minimum	1	2	
Standard Dev.	2.5	3.7	1.2

EFFICIENT OPERATION AND USE OF ASSETS

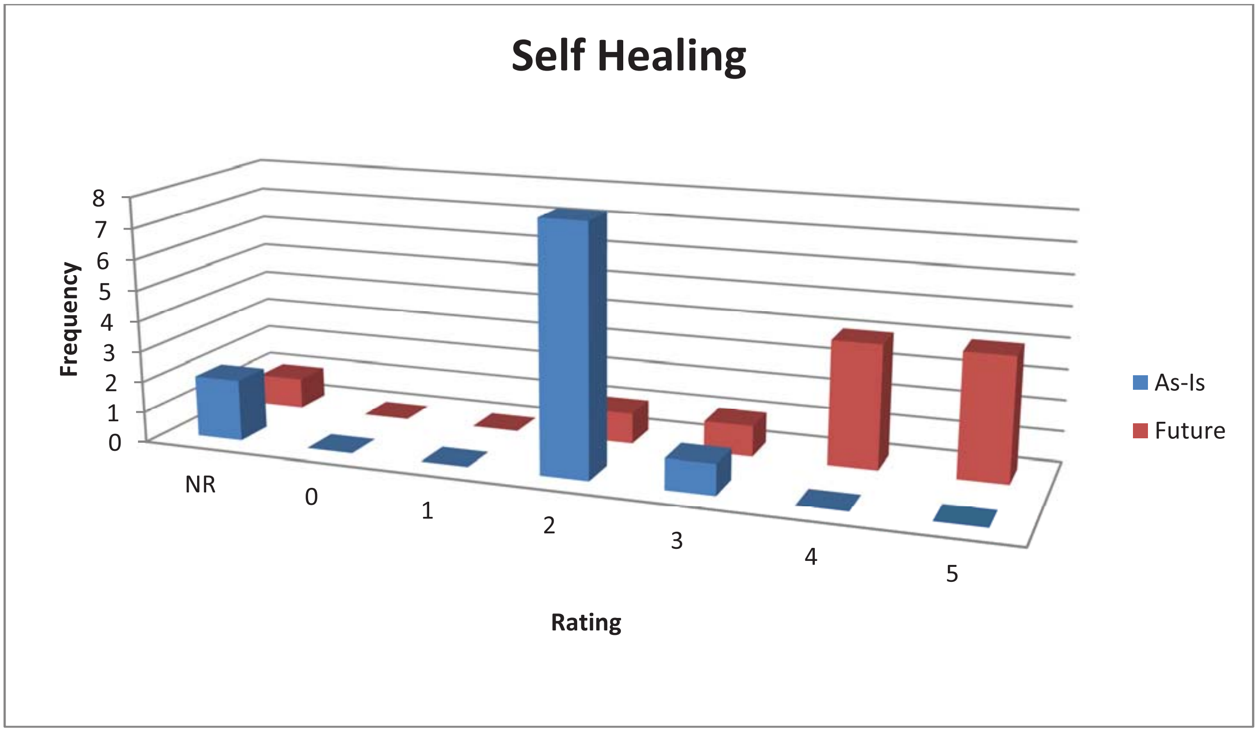
Efficient Operation and Use of Assets is the characteristic that describes the use of real time information from advanced sensors to allow operators to better understand the state of the system. Such information can be used to perform risk assessment, optimize system planning, reduce transmission congestion, extend asset life, and to perform proactive maintenance.



Descriptive Statistics			
	As-Is	Future	Δ
Mean	2.8	4.5	1.7
Median	3	5	2
Mode	3	5	2
Maximum	5	5	
Minimum	1	3	
Standard Dev.	1.135292	0.707106781	

Self-Healing

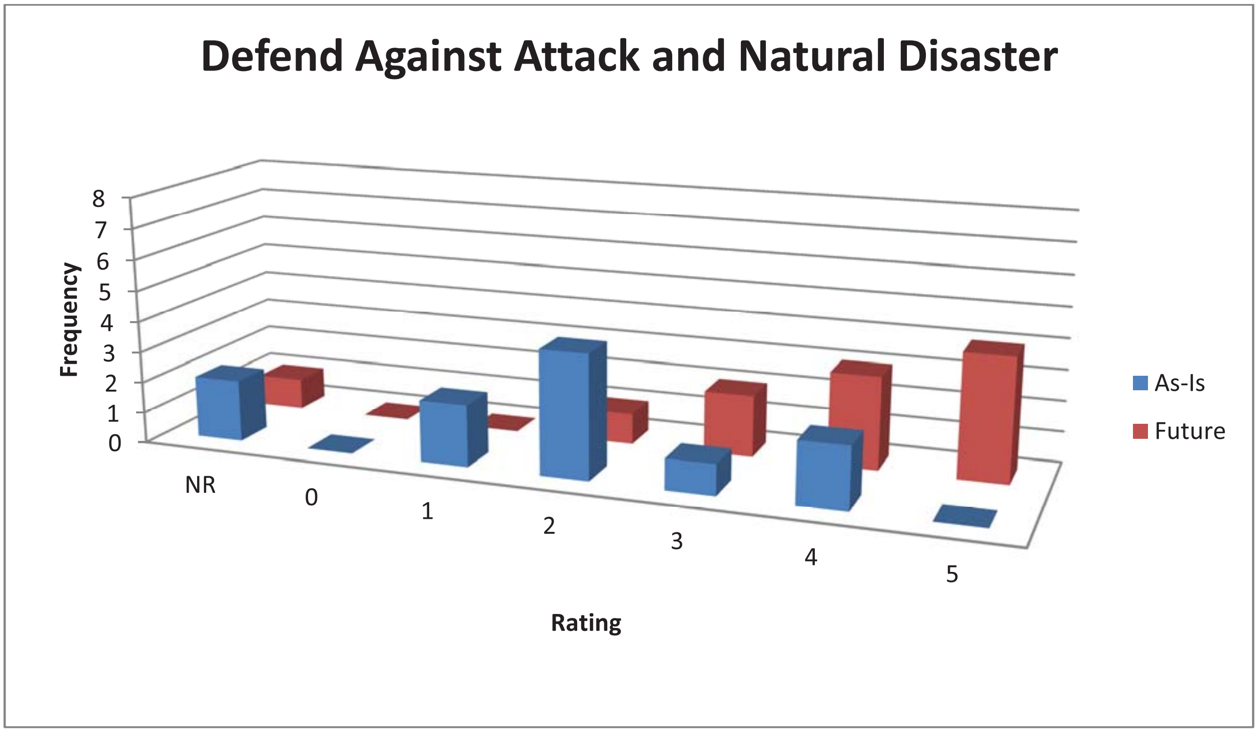
Self-Healing is the characteristic that describes the grids ability to identify, isolate, and restore problematic sections of the grid with little or no manual intervention. Today, such capabilities are largely isolated to substation automation. Future systems may use sensors, weather data and analytic programs to detect precursors to faults including voltage, power-quality, dynamic instabilities, congestion issues, equipment failures, and downed power lines. Automatic network reconfiguration could be employed to link energy sources and loads to both restore power and to implement real-time contingency strategies.



Descriptive Statistics			
	As-Is	**Future**	**Δ**
Mean	2.111111	4.1	1.988888889
Median	2	4	2
Mode	2	4	2
Maximum	3	5	
Minimum	2	2	
Standard Dev.	0.333333	0.994429	

DEFEND AGAINST ATTACK AND NATURAL DISASTER

Defend Against Attack and Natural Disaster is the characteristic that describes the grids ability to protect against physical attacks (explosive, projectiles, and natural disaster) and cyber (computer-based) attacks. These attack strategies may have two forms: attacks in which the grid itself is the primary target, or attacks in which the power system network is used to take down other important infrastructure systems (banks, government, etc.).



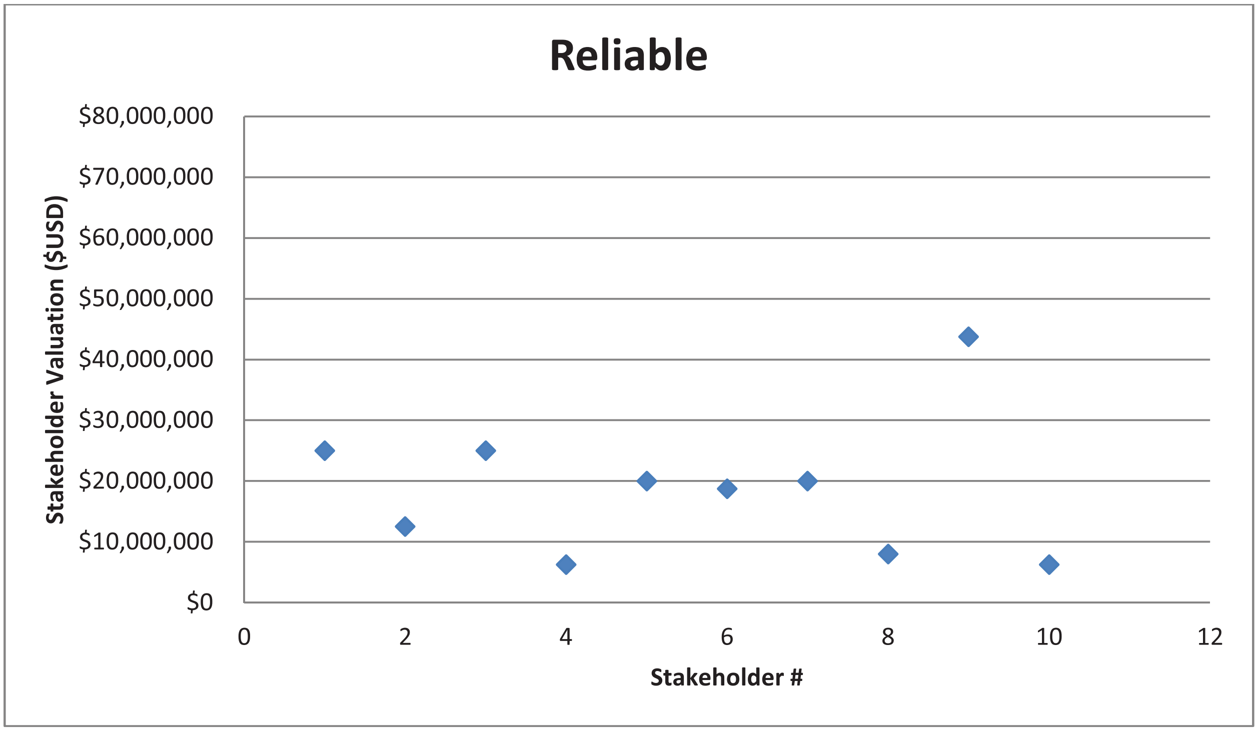
Descriptive Statistics			
	As-Is	Future	Δ
Mean	2.333333	4	1.666666667
Median	2	4	2
Mode	2	5	3
Maximum	4	5	
Minimum	1	2	
Standard Dev.	1.118034	1.054092553	

Valuation Details for Smart Grid Benefits

This section summarizes the responses of the 11 grid stakeholders for each of the five Smart Grid Benefits of the Stakeholder - Kentucky Smart Grid Assessment Model (S-KSGAM). For each Benefit the model definition is presented along with a histogram and descriptive statistical data.

Reliable

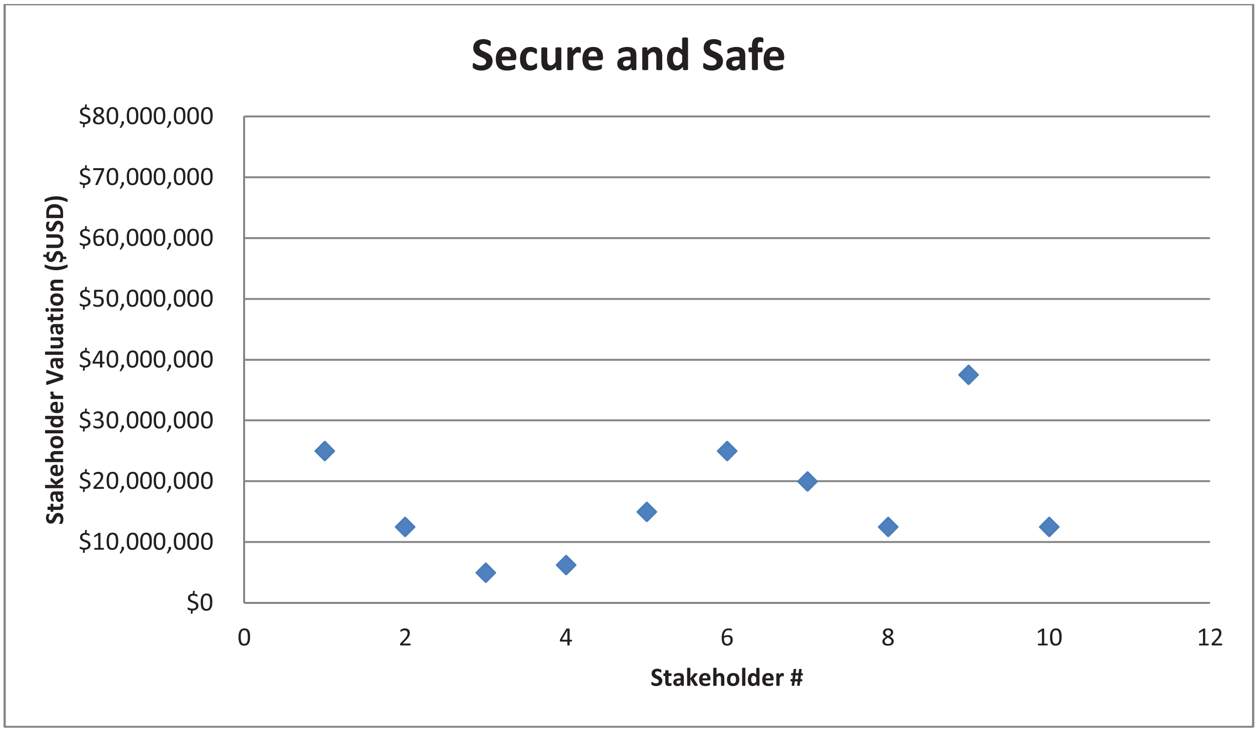
Reliable describes a grid with a reduction in power outage duration and frequency, a reduction in momentary power quality disturbances, and a reduction in blackouts and brownouts.



Descriptive Statistics	
	Valuation
Mean	$18,550,000
Median	$19,375,000
Mode	$25,000,000
Maximum	$43,750,000
Minimum	$6,250,000
Range	$37,500,000
Standard Dev.	$18,550,000

SECURE AND SAFE

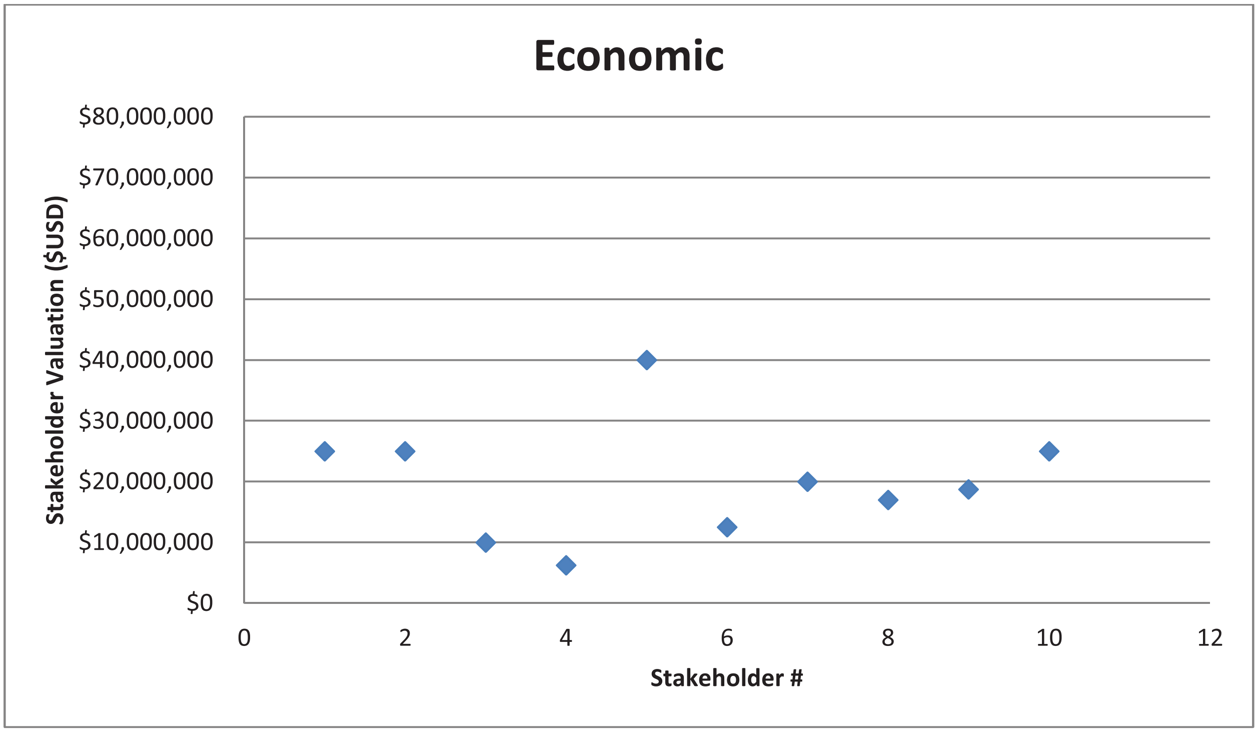
Secure and Safe describes a grid that is less vulnerable to attack and natural disaster, and is safer to be near for both the public and utility workers.



Descriptive Statistics	
	Valuation
Mean	$17,125,000
Median	$13,750,000
Mode	$12,500,000
Maximum	$37,500,000
Minimum	$5,000,000
Range	$32,500,000
Standard Dev.	$17,125,000

Economic

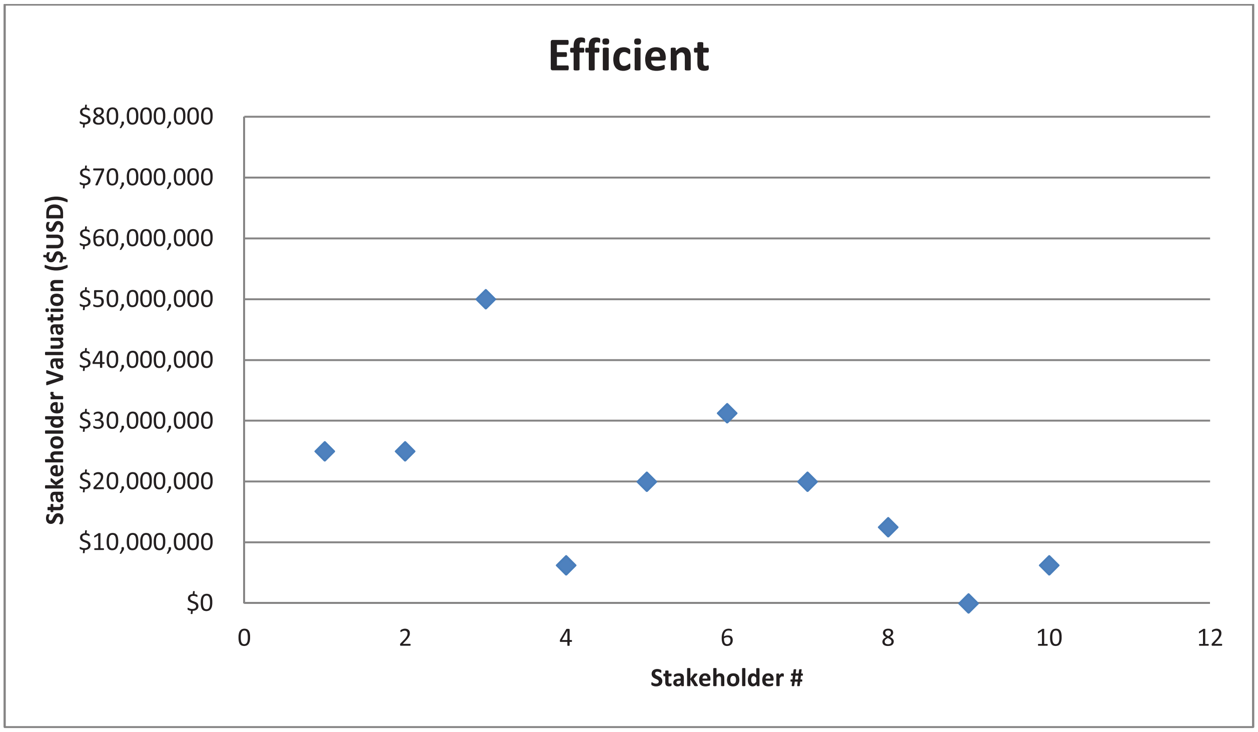
Economic describes a grid with decreased/mitigated electricity prices, and with new options for market participants such as new load management, distributed generation, grid storage, and demand-response options.



Descriptive Statistics	
	Valuation
Mean	$19,950,000
Median	$19,375,000
Mode	$25,000,000
Maximum	$40,000,000
Minimum	$6,250,000
Range	$33,750,000
Standard Dev.	$19,950,000

EFFICIENT

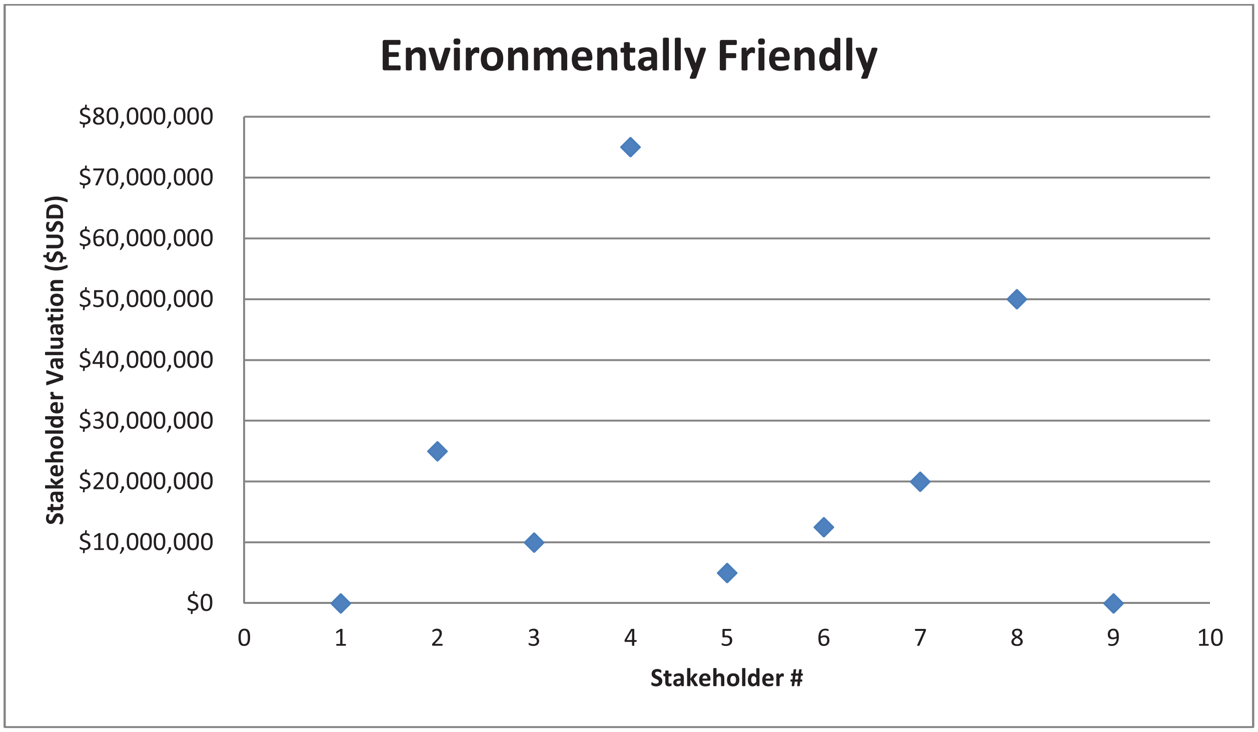
Efficient describes a grid that uses technology to allow for greater utilization of existing assets, enables optimal loading of assets, and provides detailed awareness of component and equipment condition, with the goal of cost effective asset utilization and increased system capacity.



Descriptive Statistics	
	Valuation
Mean	$19,625,000
Median	$20,000,000
Mode	$25,000,000
Maximum	$50,000,000
Minimum	$0
Range	$50,000,000
Standard Dev.	$19,625,000

Environmentally Friendly

Environmentally friendly describes a grid that allows for a much wider deployment of environmentally friendly resources, that allows for the deferral of new construction projects, and has reduced electrical losses.



Descriptive Statistics	
	Valuation
Mean	$24,750,000
Median	$16,250,000
Mode	$0
Maximum	$75,000,000
Minimum	$0
Range	$75,000,000
Standard Dev.	$24,750,000

Chapter 3: Advanced Metering Infrastructure Overview

TABLE OF CONTENTS

INTRODUCTION

The Kentucky Public Service Commission, the University of Louisville, and the University of Kentucky have partnered to develop a technical roadmap for the development and deployment of Smart Grid technologies throughout the Commonwealth. This "Kentucky Smart Grid Roadmap" will provide recommendations and best practices to utilities and utility stakeholders to guide individual Smart Grid deployment approaches.

The purpose of this document is 1)an analysis of: AMI systems, the benefits associated with AMI deployments, key enabling technologies, consumer behavior issues, and other issues associated with the deployment, and 2) the of evaluation of Advanced Metering Infrastructure (AMI) deployments in the jurisdictional utilities of Kentucky These purposes are in fulfillment of KSGRI Work plan Goals #2 and #7.

Additionally, data resulting from this report will serve to inform on the evaluation of PSC administrative Case 2008-00408.

OVERVIEW OF AMI

AMI (Advanced Metering Infrastructure) refers to the integration of a variety of systems in order to establish two way communications between the customer and the utility and to provide each with time stamped system information. Therefore we refer to AMI as an **infrastructure area**, as opposed to a technology.

From a systems perspective AMI typically refers to **smart metering** (measurement and data collection system including meters at end-users), **home area networks** (in home displays, distributed energy resources, and load control devices)**, integrated communications** (the communication infrastructure which connects consumers and their service providers), **meter data management systems** (to process obtained meter data), and standardized software interfaces.

Figure 1 shows a typical residential AMI configuration. The smart meter is installed at the residential house, and has the capability to record, transmit, receive, and display usage information on an in home display. The in-home display serves at the foundation of the home area network. Additionally, the smart meter communicates with an integrated communications device installed at a nearby utility pole. Two-way communications take place between residence and utility office via the integrated communications systems. The utility office implements the Meter Data Management system to collect and analyze data, as well as to enable interaction with other information systems. Industrial and commercial AMI have similar configurations.

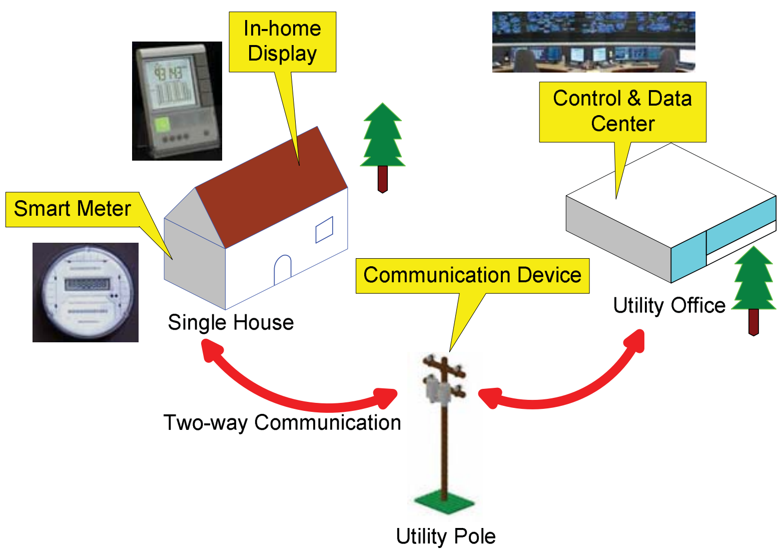


Figure 1. Advanced Metering Infrastructure Deployment

AMI enables consumers to have a better understanding of their energy usage in real-time and provides them an opportunity to control energy consumption, thus potentially changing consumer behavior. The energy usage data obtained from AMI system allows the utility to better understand the demand and consumer energy usage patterns, which is essential for demand side management. In addition, AMI serves as a platform on which a variety of functions and strategies can be enabled such as: differentiated pricing strategies, peak\ shifting, load leveling, and demand response.

AMI AND THE SMART GRID

As defined by the Department of Energy (DOE):

> "*The smart grid is the electric delivery network from electrical generation to end-use customer, integrated with the latest advances in digital communications and information technology for enhanced grid operations, customer services, and environmental benefits*".

Therefore, the Smart Grid refers to an intelligent power delivery system that utilizes new power technologies and digital communications technology to improve reliability, security, and efficiency of the electric system. The information communication networks are employed to link almost all the components in the electric system, e.g. meters, substations, transformers, etc. The scope of Smart Grid is so broad that it covers from the generation and delivery infrastructure to the end-user systems, along with the information networks and integrated management system.

From an infrastructure point of view, the Smart Grid is divided into four broad infrastructure areas, **Advanced Metering Infrastructure** (AMI), **Advanced Distribution Operations** (ADO), **Advanced Transmission Operations** (ATO), and **Advanced Asset Management** (AAM), as shown in Figure 2.

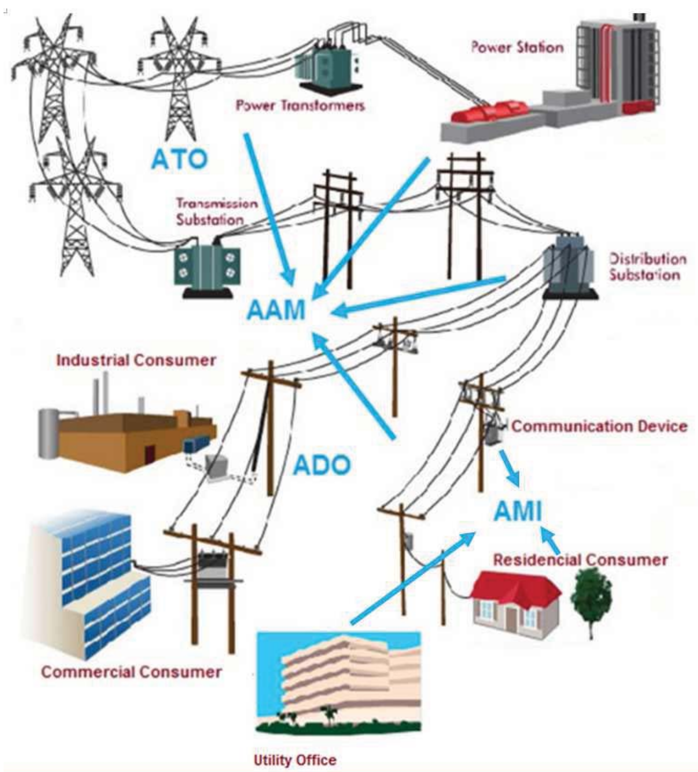


Figure 2 Smart Grid Infrastructure.

AMI serves a foundational role in the development of the above system, as it establishes communications with the consumer and provides time stamped system information. The communication system of AMI can then be used to collect distribution information and the information generated by AMI can be used to improve operations, in support of Advanced Distribution Operation.

Additionally, AMI supports the principal characteristics of DOE's Modern Grid Strategy0:

- *Motivation and inclusion of the consumer* is enabled by AMI technologies that provide the fundamental link between the consumer and the grid.
- *Generation and storage options* distributed at consumer locations can be monitored and controlled through AMI technologies.
- *Markets are enabled* by connecting the consumer to the grid through AMI and permitting them to actively participate, either as load that is directly responsive to price signals, or as part of load resources that can be bid into various types of markets,
- AMI smart meters equipped with *Power Quality* (PQ) monitoring capabilities enable more rapid detection, diagnosis and resolution of PQ problems.
- AMI enables a more distributed operating model that reduces the *vulnerability of the grid to terrorist attacks*.
- AMI provides for *self healing* by helping outage management systems detect and locate failures more quickly and accurately. It can also provide a ubiquitous distributed communications infrastructure having excess capacity that can be used to accelerate the deployment of advanced distribution operations equipment and applications.
- AMI data provides the granularity and timeliness of information needed to greatly *improve asset management and operations*.

AMI TECHNOLOGY OPTIONS

An AMI system is composed of four technology areas that operate as a single system:

1. Smart Meters
2. Wide-area Communications Infrastructure
3. Home (local) Area Networks (HANs)
4. Meter Data Management Systems (MDMS)

In addition, AMI systems must interface with many system-side applications, and therefore can be considered as an

5. Operational Gateway

SMART METERS

A smart meter is a solid state (non-electromechanical) meter that provides increased functionality as compared to the conventional electromechanical mater. These functions include:

- Time based pricing.
- Consumption data for consumer/utility.
- Net metering.
- Loss of power notification.
- Remote turn on/turn off operations.
- Load limiting/demand response.
- Energy prepayment
- Power quality/voltage level monitoring.
- Tamper and theft detection.
- Communication with in home devices/appliances.
- System interoperability.

WIDE-AREA COMMUNICATIONS

The communications infrastructure is necessary to support the continuous transmission of two-way data between then utility and customer. Typically, a local concentrator is used to collect data from groups of smart meters and to transmit that data to a central server via a backhaul channel. The technologies most commonly used for this purpose are:

- Power line carrier.

- Broadband over power line.
- Fiber networks.
- Radio frequency, centralized or mesh.
- Internet:
- Combinational infrastructure architectures.

Home Area Networks

The HAN is an interface that links smart meters to the customer residence, including an in home display and controllable electrical devices. It can also serve as an energy management systems with typical functions including:

- In home display of energy usage and cost.
- Management of energy use through DR and smart appliances in response to price signals based on customer preferences.
- Set point to limit utility control actions.
- Automated load control.
- Consumer over-ride capability

Meter Data Management Systems

A MDMS is an analytical tool that utilizes a database to enable interaction with and validation of meter data. The primary function of the MDMS is to perform validation, editing, and estimation of AMI data to ensure accuracy and completeness of incoming meter data. The analytics of the MDMS support the use of AMI data in other information systems such as:

- Transformer Load Management: use obtained meter data to determine the rating for transformer based on real load conditions.
- Outage management systems: fault location based on the power loss signal generated from smart meter.
- Load forecasting systems: improve accuracy of load forecast using more detailed and frequent AMI load data.
- Power quality management: obtain power quality data by implementing power quality monitoring function into smart meter.
- Consumer information systems: energy usage information display by in-home devices
- Billing systems: offer both consumers and utilities the convenience of billing and price information.

- Utility website: build utility service website to let consumer have access to their private account information integrated with AMI database.
- Geographic Information Systems: upgrade geographic information system (GIS) system with the integration of real-time AMI data.

Operational Gateway

Evaluate the ability for AMI systems to interface system level applications for:

- Advanced Distribution Operations: enable improved voltage regulation and reactive power optimization, more accurate fault location, isolation and system recovery.
- Advanced Asset Management: AMI may provide utilities real-time loading conditions of assets such as distribution transformers, based on which overloading or other abnormal conditions may be detected. Transformers may be upgraded or maintained based on this.
- Advanced Transmission Operations: although AMI system is directly involved with distribution systems, accurate real-time load data will ultimately improve the efficiency and reliability of transmission systems. Especially with deeper penetration of intermittent renewable energy sources into the power grid, AMI will play a bigger role in both distribution and transmission system operation.

AMI STANDARDS

National Institute of Standards and Technology (NIST), North American Electric Reliability Corporation (NERC), and Institute of Electrical and Electronics Engineers (IEEE) are the primary governing bodies for the development of smart grid standards.

Many existing and developing standards are related to AMI hardware equipment (i.e. smart meters), to information communication protocols, and interoperability and cyber security. Referred description and application area of corresponding standards are discussed below.

1. NIST is a non-regulatory federal technology agency of the US Department of Commerce that works with industry to develop and apply technology, measurements, and standards. The current important standards related to AMI on Smart Grid includes:

    a. Summary of Use, Application, Cyber security, and Functionality of Smart Grid Interoperability Standards Identified. There is a series of standards released in October 2010, which include but not limit to:

        i. IEC 61968 Application Integration at Electric Utilities. This standard describes a series of application messaging interfaces based on and extending the IEC 61970 Common Information Model standard. These interfaces describe the interactions between software applications that are used for managing the utility electrical distribution networks. They provide for interoperability among different computer systems, platforms, and languages. This standard applies to the following key priorities:

            - Wide area situational awareness
            - Electric storage
            - Demand response
            - Electric vehicles
            - Distribution grid management

        ii. IEC 61850 Communication Networks and Systems for Power Utility Automation. This standard specifies abstract information models and communication services between power utility field devices. This standard applies to devices used for substation automation for protection, monitoring and metering. Originally designed for substation only, but the scope of this standard has been expanded to include substation-to-substation and substation-to-control center communication. Similar standardization priorities are identified as IEC 61968.

        iii. IEC 61870 Telecontrol Application Service Element. This standard is for communication between electric power control centers, and used for communication of electric power system measurements status and control messages.

iv. IEC 62351 part 1-7. The scope of IEC 62351 series is information security for power system control operations. The primary objective is to undertake the development of standards for security of the communication protocols standardized by IEC 60870, IEC 61850, IEC 61970, and IEC 61968 series. This standard applies to the key priority of communication and coordination across inter-system interfaces.

b. Guideline for Smart Grid Cyber Security. The initial version of Guidelines for Smart Grid Cyber Security was developed as a consensus document by the Cyber Security Working Group of the Smart Grid Interoperability Panel, a public-private partnership launched by NIST in January 2010. The Guidelines report is a companion document to the NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0, which NIST issued on January 19, 2010. The three volumes Guidelines make up the initial set of guidelines that are intended primarily for individuals and organizations responsible for addressing cyber security for Smart Grid systems and the constituent subsystems of hardware and software components. The report presents an actionable initial and analytical framework that organizations can use to develop effective cyber security strategies and solutions tailored to their particular combinations of Smart Grid related characteristics, risks, and vulnerabilities.

c. NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0. This document is the output through an open public process that engaged the broad spectrum of Smart Grid stakeholder communities and the general public by three workshops in 2009 and extensive public review and discussion. It describes a high-level conceptual reference model for the Smart Grid, identifies 75 existing standards that are applicable to the ongoing development of the Smart Grid, specifies 15 high-priority gaps and harmonization issues for which new or revised standards and requirements are needed, documents action plans with aggressive timelines by which designated standards-setting organizations will address these gaps, and describes the strategy to establish requirements and standards to help ensure Smart Grid cyber security. Eight priorities for standardization include:

- Demand response and consumer energy efficiency
- Wide-area situational awareness
- Energy storage
- Electric transportation
- Advanced metering infrastructure
- Distribution grid management
- Cyber security
- Network communications

2. NERC is the electric reliability organization certified by the Federal Energy Regulatory Commission (FERC) to establish and enforce reliability standards for the bulk-power system.

NERC has updated its complete set of the Reliability Standards for the Bulk Electric Systems for North America in 2010. In this set of standards, the following two standards are especially related to AMI development and deployment:

a. Critical Infrastructure Protection Standards (CIP). NERC Standards CIP-002-2 through CIP-009-2 provide a cyber security framework for the identification and protection of Critical Cyber Assets to support reliable operation of the bulk electric system.

   These standards recognize the different roles of each entity in the operation of the bulk electric system, the criticality and vulnerability of the assets needed to manage bulk electric system reliability, and the risks to which they are exposed.

   Business and operational demands for managing and maintaining a reliable bulk electric system increasingly rely on cyber assets supporting critical reliability functions and processes to communicate with each other, across functions and organizations, for services and data. This results in increased risks to these cyber assets. In this set of standards, selective sub-standards on the cyber security category showing below are associated closely with the AMI deployment.

   i. CIP-002-3 Cyber Security — Critical Cyber Asset Identification
   ii. CIP-003-3 Cyber Security — Security Management Controls
   iii. CIP-004-3 Cyber Security — Personnel & Training
   iv. CIP-005-2 Cyber Security — Electronic Security Perimeter(s)
   v. CIP-005-3 Cyber Security — Electronic Security Perimeter(s)
   vi. CIP-006-3 Cyber Security — Physical Security of Critical Cyber Assets
   vii. CIP-007-2a Cyber Security — Systems Security Management
   viii. CIP-007-3 Cyber Security — Systems Security Management
   ix. CIP-008-3 Cyber Security — Incident Reporting and Response Planning
   x. CIP-009-3 Cyber Security — Recovery Plans for Critical Cyber Assets

b. Communications standards (COM)

   - COM-001-1.1 Telecommunications. Each Reliability Coordinator, Transmission Operator and Balancing Authority needs adequate and reliable telecommunications facilities internally and with others for the exchange of Interconnection and operating information necessary to maintain reliability.
   - COM-002-2 Communication and Coordination. To ensure Balancing Authorities, Transmission Operators, and Generator Operators have adequate communications and that these communications capabilities are staffed and available for addressing a real-time emergency condition. To ensure communications by operating personnel are effective.

3. IEEE is the world largest non-profit professional association dedicated to advancing technological innovation related to electricity. Its sub-division IEEE Standards Association also develops guidelines and standards for Smart Grid related deployment. IEEE has more than 100 standards and standards in development relevant to the Smart Grid. The current important standards related to AMI on Smart Grid includes:

    - Wireless Medium Access Control and Physical Layer Specifications for Low Rate Wireless Personal Area Networks
    - Local Area Network/Wide Area Network (LAN/WAN) Node Communication Protocol to complement the Utility Industry End Device Data Tables
    - Low Frequency (less than 500 kHz) Narrow Band Power Line Communications for Smart Grid Applications
    - Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System, and End-Use Applications and Loads
    - IEEE 1901: Broadband over power line standards, considered a key enabling technology for smart grid applications, local area networks and transportation. The standard is expected to benefit utilities and consumer electronics companies involved in smart grid technologies and applications. The IEEE 1901TM Broadband over Power Line (BPL) standard was finalized in December 2010 and is now published.
    - IEEE 1815 Distributed Network Protocol (DNP3) standard. The standard for electric power system communications, which is considered to be an adaptable basis for better device interoperability and security in information gathering, exchange and use.
    - IEEE C37.239 COMFEDE standard. This standard defines a Common Format for Event Data Exchange (COMFEDE) among power systems. By helping utilities efficiently integrate and analyze event data from across multi-vendor equipment, the interoperability standard is designed to contribute to improving the reliability of the Smart Grid.

4. Additional AMI related standards on board from other organizations.

    a. A standard for Open Automated Demand Response (OpenADR) will cut the cost, improve reliability and speed up automated demand response and smart grid deployments throughout the country, according to a new coalition, the OpenADR Alliance. The alliance is formed by Honeywell, Lawrence Berkeley National Laboratory, Pacific Gas & Electric and SoCal Edison to lobby for the adoption of an automated demand response (Auto-DR) standard and compliance. Auto-DR encourages businesses and homeowners to cut power use during peak demand or in response to market price changes by automating message delivery from the utility to the customer. Adoption of OpenADR standard would lead to an Auto-DR message format so that dynAMIc price and reliability signals can be sent in a uniform and interoperable data model by utilities, independent system operators and customer energy management systems. The OpenADR Alliance plans to work with other smart grid groups and stakeholders such as the Smart Grid Interoperability Panel, North American Energy Standards Board, the Wi-Fi Alliance and the Zigbee Alliance to promote the standard.

b. IEC 61850 data communication standards by *International Electrotechnical Commission, also identified by NIST*. Standardized communication provides a cost-effective, open solution for the utility industry, with IEC 61850-specific benefits including optimizing systems for efficient and reliable data transfer, establishing designs for use over a high-speed network, and providing for operational advantages. IEC 61850 is a standard language that enables grid component vendors to produce interoperable plug-and-play equipment.

AMI AND CYBER SECURITY

Cyber Security utilizes a series of computer technology known as information security as applied to computers and networks, protecting computer and internet based information by preventing, detecting, and responding to attacks. The objective of cyber security includes protection of information and property from theft, corruption, or natural disaster, while allowing the information and property to remain accessible and productive to its intended users. Since the power electric grid, especially the AMI system with smart meter incorporated enables not only a great amount of information communication between utilities and their customers but also the data process and storage at the central information management facilities, it is of great importance that the cyber security issue has to be taken into account.

Strategically, cyber security can be taken into consideration in the following four categories:

> **Prevention**: take actions and measures for the continuous assessment and readiness of necessary actions to reduce the risk of threats and vulnerabilities, to intervene and stop an incident, or to mitigate negative effects. The first step is to identify examples of potential risks associated with the implementation of AMI. Potential risks may caused by the great complexity of the network with exposure to attackers, thieves and unintentional errors. The more frequent information transfer within the network may cause potential cascading failures. More interconnections present increased opportunities for attacks or compromised hardware. Extensive data recording and two-way information flow may increase the possibility for compromise of data confidentiality and breach of customer privacy and personal data. Advanced computer technology should be employed to build effective firewall to block any suspicious entrance while maintaining the normal access. The authorization of data encryption and decoding standard should be treated rigorously as well. Another aspect of prevention is associated with the cyber security concerns when establishing various standards. As the cyber security issue draws more and more concerns, it becomes more and more necessary to examine whether or not and how well the cyber security is addressed in developing standards. If adequate cyber security requirements have been addressed in the standards through gap identification and those standards have been met during implementations, the system should be more reliable and less vulnerable.
>
> **Detection**: find approaches to identify abnormal behaviors and discover intrusions; detect malicious code and other activities that can disrupt electric power grid operations. It requires the techniques for digital evidence gathering ability and the decision making process for judging whether there are attacks or data has been compromised. Firewalls should also have the capability of detecting and alerting suspicious access. This detection process requires not only reliability and accuracy, but also quickness as any wrong or slow activity detection will potentially results in tremendous loss for the entire electric power grid.
>
> **Response**: take countermeasures in order to alert and stop counter-security activities immediately after the detection. Responses including generating alarm signal from automatic incident detection, alerting associated grid operators at different parties with pre-defined code, pinpointing the location and type of attacks, stopping the data and information attacks as soon as they occur. Sometimes it is necessary to discontinue the data

transmit to avoid more exposure. This response action also requires accuracy and quickness. In addition, find out and summarize the cause and document all the incidents after the cyber-attack, and upgrade system weak point to avoid similar future attacks.

Recovery: develop plans to figure out what data and information has been suffered from attacks, compromised or completely lost. Set up mechanism to backup system data on a regular basis. Remedy or recover lost data from backup database. The objective of this strategy is to recover as much data as possible and minimize the impact and loss resulted from the cyber-attacks.

AMI DEPLOYMENT BENEFITS

The benefits resulting from deployment of AMI include improved system operation and reliability, increased ability for customer to manage energy use, and reduced peak demand.

Deployment of AMI may significantly improve operational efficiency of distribution systems. A power distribution system serves to deliver power to end power consumers, or loads through main feeders, laterals and transformers. There are also controlling devices such as capacitor banks and voltage regulators installed in the system to control the power flow and voltage profile in the system. These controlling devices can improve power factors, reduce losses due to the resistance of conductors, and maintain node voltages within specified limits. To make the most of the controlling devices, a process called Reactive Power and Voltage Regulation optimization (RPVRO) is usually adopted in utilities. RPVRO is a procedure to optimize the operation of capacitor banks and voltage regulators so that the energy loss is minimized or the total demand is minimized depending on the chosen objective, while at the same time all operating constraints such as the required voltage levels and current ratings are satisfied. To implement RPVRO, the loads across the system are required to transmit to the central control center near real time say every hour. Without AMI, the load data have to be estimated based on historical data which may be from a long time ago. Deployment of AMI will provide near real time load data, and this will greatly enhance the accuracy of RPVRO analysis and enhance the efficiency of the system.

AMI deployment can also enhance the system reliability. Real time power flow and state estimation analysis enabled by AMI will accurately identify abnormal operating conditions such as transformer and cable overloading, and allow operators to take prompt actions to remedy the situation. AMI may also facilitate identifying consumer outages and thus enable faster fault identification and location, and system restoration, and hence reduce outage time.

With AMI providing pricing signals to consumer appliances, price-based demand response programs can be implemented, where at times of peak demand; the appliances may be cycled off. As a result, the system peak load may be substantially reduced and hence the need for utilities to construct peak leveling generation plants may be eliminated or deferred. The consumers will be able to know their energy usage and energy cost near real time. Various home energy management systems and tools may become available for consumers to manage and control their electricity usage.

AMI DEPLOYMENT RISKS

As the energy demand has skyrocketed, today's grid is struggling to keep up, further impacting grid efficiency and reliability. There are many risks that are associated with the entire Smart Grid development, causing reliability, efficiency, environmental, financial, security and customer choice risks. Specifically with AMI deployment, risks mainly exist in the following categories:

- Reliability: there have been five massive blackouts over the past 40 years caused by various reasons such as lack of automation or situational awareness, slow investment and development of modern technology in replacement of mechanical switches. With the comprehensive deployment of AMI, it is uncertain to claim that the reliability of the grid will improve, or in the even worse situation that the implementation of AMI system will become a potential risk causing future blackout.
- Efficiency: the energy efficiency has always been an important issue considered in the grid improvement. Obviously there are terrific opportunities for improvement to lower demand and save energy. With the installation of smart meter and smart in-home appliances under AMI deployment, there is no solid and direct evidence showing the improvement of energy efficiency.
- Future technology compatibility: the AMI deployment involves massive implementation of software, hardware and electronic equipment based on current technology. The market becomes vender-driven and nobody can guarantee that their technology will be compatible and interoperable in the future with newer technology. Finding a way of using future compatible technology is a big concern for decision making, otherwise, it will be a huge waste of investment.
- Uncertainty on return on investment (ROI) for utility: For any business case we make for AMI deployment, ROI is always considered seriously. It remains the fact that nobody can guarantee that it will achieve considerable ROI from AMI implementation. The risk associated with whether utility will gain more benefits and revenue by implementing AMI system remains a question. In fact, it is still uncertain where the investment grant comes from.
- Cyber security: in short, the more extensive the AMI deployment is, the more risks associated with cyber security are. How to keep grid safe and secure, how actually well the security standards are established and executed are still under discussion.
- Customer benefits: the customer benefits risk is associated with the consideration that whether customers really benefited from the smart meter and information system to have digital channel for two-way communication, allow dynamic pricing, gain more choice to control their energy source and usage, save energy bill and enhance satisfaction. In certain point of view, it may be beneficial for certain group of customers who have relatively high income and are willing to participate, but at this stage of development, it is more beneficial for the utilities rather than the customers, especially the lower income group.
- Customer acceptance: the risk associated with customer acceptance of the AMI deployment is vital to the success of overall Smart Grid. Customers should be fully entitled to have the choice of participation, thus utility here cannot control whether a good

result of customer acceptance will be achieved or not. There are still a lot work to do on customer education and engagement.

- Environmental impacts: the corresponding risk with AMI deployment on environmental impacts is mainly the radio frequency and electromagnetic wave by the wired or wireless data transmission. We have heard the news that customers have complaint to have bad health symptoms, such as headache and insomnia about the radiation and noise by the smart meter, resulted that smart meter is banned by some counties in California.

BARRIERS TO AMI DEPLOYMENTS

- Customer acceptance: so far as we see, customer acceptance and willingness to participate in the pilot deployment of AMI system is one of the strongest barriers. Again as implied previously, without the active participation from customers, the chance of successful AMI deployment is close to zero, no matter how willingly the government and utilities want to deploy AMI. Customers are still not very clear about what exact benefits they will get and how much savings they could achieve by participating in AMI implementation in a long term. This barrier is often associated with the risks mentioned in the previous section and is expected to see when the deployment is carried out.
- Technology barriers (equipment, communication, cyber security…): obviously, there are always technological and technical barriers in any science and engineering projects. Those barriers associated with AMI deployment will mostly be attached to hardware equipment, communication network, standards, interoperability and cyber security. What's coming in front is the slowness of applicable and interoperable standards, followed by the insufficient technology development of equipment functionalities and future compatibilities. The cyber security will always be a major concern by the government and grid regulators.
- Regulatory barrier: possible barriers may include those policies that cause
    - Inability to use appropriate rate structures
    - Unwillingness or little incentive for utilities to invest in and deploy Smart Grid technologies
    - Difficulty for individuals to sell electricity back to utilities
    - Different executive procedures, state laws/regulations and insufficient cooperation among different states
    - Difficulty for regional and interstate coordination

AMI Deployment Experiences

There are so many activities and tremendous efforts associated with AMI deployment going on or coming in the near future all over the country that it is unrealistic for us to cover all of them and present experiences in this report. However we can select some of those representative cases to analyze real-world projects and identify experiences.

As published by the DOE in the Smart Grid introduction brochure, some states are already deploying pilot projects toward the realization of Smart Grid. Those representative pilot projects explore examples to deploy new ways utilizing new technology to achieve the smartness of the power electric grid. Such technologies are commonly related to demand side management, electric vehicles, energy efficiency, communications, advanced electronics, and advanced sensing and material technology applied on power transmission system. Since AMI is closely associated with the advanced electronics and communications applied on the distribution side of the grid, this section will identify and evaluate these existing AMI related deployment experiences recommended by DOE. In addition, other sources such as individual utility company website, public service/utility commission website, professional or consulting company in power industry website, national laboratory resources and Smart Grid news website will also be studied.

1. Distribution Management System Platform by the University of Hawaii.

   The integrated energy management platform developed in Maui, Hawaii, employs advanced functions for home energy management for consumers and improved distribution operations for utilities. This platform has integrated AMI as the home interface for demand response, home energy efficiency and conservation, distributed generation, storage and load control. The home energy management will allow consumers to control their energy consumption based on their personal preferences. The home automation is enabled based on the smart meter and eco-dashboard equipment from General Electric (GE), where the smart meter communicates with household appliances based on Zigbee network.

2. West Virginia Super Circuit by Allegheny Energy

   The super circuit project is built to demonstrate the ability to automatically reconfigure the circuit, isolating faulty segment during a fault to keep the network remain uninterrupted. This advanced distribution circuit will integrate advanced monitoring and control, and protection technologies, as well as the integration of distributed generation and energy storage with AMI and mesh Wi-Fi communication network for fault location and restoration. Again, this is an example for the AMI to be employed in the fault location and protection application.

3. Beach Cities Microgrid by San Diego Gas & Electric

   A small scale microgrid project is designed to demonstrate the ability of a microgrid to isolate from main grid during a large grid disturbance. In this configuration, both utility generation and customer generation along with energy storage will be integrated with AMI system to realize advanced control and communication. This pilot project also serves as a guide for improved asset management and improved distribution operation.

4. American Electric Power (AEP) Ohio gridSMART

   The initiative of gridSMART by AEP started in 2007, mainly located in northeast central Ohio, which includes AMI, distribution grid management and home area network (HAN), along with the supportive information technology systems. Before the project, AEP did a lot of market research to identify key benefits and preferred communication methods, and AEP is proactive to communicate with consumers, educate consumers, create awareness and drive program participation expected from target market. In this pilot, AMI uses communications network to deliver real-time energy usage and load information to both AEP and customers. Besides, AMI is also capable to monitor operating status of equipment power quality, and enable customers to control their energy consumption. This project also builds a customer web portal to let them be aware and actively participated. The valuable experience we learned here is that customer knowledge, acceptance and engagement have been paid great attention by AEP in order for this project to be successful.

5. Smart metering pilot in Washington, D.C

   Results from a smart metering pilot project in Washington, D.C. showed that residential customers there responded to dynamic pricing and saved money by cutting their consumption. The pilot worked so well that Pepco, the electric utility that serves D.C. and surrounding areas, plans to install smart meters and other smart grid technologies throughout its D.C. service territory before the end of 2011. The PowerCents DC pilot was sponsored by the non-profit Smart Meter Pilot Program (SMPP), which includes Pepco, the D.C. Office of the People's Counsel, the D.C. Consumer Utility Board, the International Brotherhood of Electrical Workers and the D.C. Public Service Commission. Customers' reaction was strongest to "critical peak pricing," which hiked electricity rates to five times over normal for about 60 hours during the year. Rates reflected slight discounts during the rest of the year.

In addition, a key component to successful analysis of AMI deployment is to communicate with utilities in Kentucky. Some utilities have begun AMI deployment in other regions of the country. Reports and responses regarding these projects, and proposed rollouts within Kentucky should be reviewed and assessed for their applicability to the Smart Grid Roadmap development.

AMI AND CONSUMER BEHAVIOR

AMI enables the consumers to know the prevailing electricity price, up-to-date energy consumption, and enables utilities to control the consumer appliances. AMI also allows utilities to collect real time electricity consumption data from consumers for control purposes.

Responding to the pricing signals, the consumers may be willing to change their energy usage behaviors. Normally, consumers may be willing to use less energy when the price is high during peak demand period and use more energy when the price is low during off-peak demand period. Through AMI, utilities can design various price-based demand response programs for customers to participate in, where the consumers allow utilities to automatically control the energy usage of consumer appliances. For example, a customer allows the utility to turn on his/her heater at night when system demand is low. As a result, this can substantially reduce the peak load of the system, and hence eliminate or defer the need to construct peak leveling generation plants.

But if the consumers are unwilling to participate in the demand response programs, then the realization of this specific goal, i.e., peak load reduction, will be adversely affected. Possible reasons for consumers unwilling to participate in the program are discussed as follows. The first reason is consumer data privacy concern. Consumers are reluctant to disclose their energy usage data to other entities like utilities. This is a consumer acceptance barrier, in which consumers do not trust and refuse to accept the technology. Appropriate legislation for protecting consumer data privacy and security may help to remove this barrier.

Second, consumers may worry about cyber-security of the AMI system through which a hacker may tamper consumer appliance operations by intruding into the system. Again, a hacker may steal consumer data from the computer and communication network. This may also be classified as consumer acceptance barrier. Pilot projects and proven technologies may increase customer acceptance.

Third, consumers simply do not want to change their electricity usage style. For example, some consumers may be disinclined to allow utilities to cycle off their air conditioner periodically, or raise the temperature setting of the air conditioner during a hot summer day. This is a consumer behavior barrier, in which the consumer doesn’t have an incentive or doesn’t want to make a change in his/her life style. Consumer education on the benefits brought about by demand response programs may help to remove this barrier.

Real time consumer data may also help a utility to enhance its real time operation and control. Data privacy and security concern of consumers may be a barrier for utilities to collect load data from consumers. Again, proper legislation may help remove this problem.

So consumer data privacy protection, data security hardening, and consumer education are essential for successful AMI deployment and achievement of its goals.

IMPACTS OF EMERGENT TECHNOLOGY ON AMI SYSTEMS

Emergent technologies such as electric vehicles (EVs) and distributed energy resources (DERs) will have great impacts on the operation on power distribution systems. EVs could behave as a source to the system in the discharging mode, or behave a load in the charging mode. When supplying power to the power system, EVs can be considered as a kind of DERs. EVs can be connected to the power system at a random time. DERs like wind and solar energy are of intermittent nature.

Therefore, EVs and DERs could significantly change the power flow patterns of the distribution system. Consequently, operations in areas of voltage and reactive power control, peak load reduction, protective relay settings and relay coordination, and fault detection, isolation and system restoration, etc. will be greatly affected.

With an AMI system, the real time load data can be transferred to the utility control center so that appropriate real time operation and control decisions can be made considering effects of EVs and DERs. Therefore, AMI system will become more important when more EVs and DERs come into being and interact with the power system.

SMART METER VENDORS

A recent report from International Data Corporation (IDC) Energy Insights offers a detailed assessment and ranking for seven major vendors in the smart metering communication network market. The report, "*IDC MarketScape: North American AMI Communication Network 2011 Vendor Assessment*", lists scalability, integration, interoperability and customer service as the most important evaluation criteria utilities should use when weighing their choice for an AMI communication network solutions vendor.

The report's focus is the smart meter communication networks that use wireless communication network technology in the North American marketplace, where the vast majority of the infrastructure will operate on wireless technology.

The study evaluates seven companies, breakdown by category:

- Leaders: Landis+Gyr
- Major Players: Elster, Itron, Silver Spring Networks, Trilliant and Sensus
- Contenders: Aclara

Brief online research regarding the above major vendors in terms of their main products and basic functions is conducted and described as below:

1. Landis+Gyr (http://www.landisgyr.com/na//en/pub/index.cfm) ranks as the worldwide leader in electricity metering with a preeminent position in advanced or "smart metering systems". They offer a broad portfolio of products and services in the electricity metering industry including integrated Automated Meter Reading (AMR) /AMI solutions, distribution automation, personal energy management, communication systems and software, meters, meter data management, services and financing.

    - Residential meters include: E330 FOCUS® AX and E350 FOCUS® AX-SD (Advanced function with service disconnect option) and E130 FOCUS® AL (Solid-state single-phase meter)
    - Advanced meters include: Airpoint (high-power mobile AMR, compatible with Mobile Collection System1.0 and 2.0), TS1 (Fixed network AMR, PLC monitoring technology), ecoMeter (In-home display using wireless Zigbee), Gridstream PLC (AMI solution utilizing TS2 power line carrier technology), Gridstream RF (multi-functional solution supporting advanced multi-energy metering, personal energy management and distribution automation applications)

2. Elster Group is a world leader in AMI and integrated metering and utilization solutions to the gas, electricity and water industries. Elster carries a large variety of single phase meters, polyphase meters and metering systems (AMR/AMI) within the electricity metering products & solutions. Specific meter product can be referred on the company's website at http://www.elstermetering.com/en/index.html

3. Itron is dedicated to delivering end-to-end Smart Grid and smart distribution solutions to electric, gas and water utilities around the globe, the world's leading provider of smart

metering, data collection and utility software systems. Offerings include electricity, gas, water and heat meters; network communication technology; collection systems and related software applications; and professional services. Currently available metering product can be inquired at the company's website: https://www.itron.com/na/Pages/default.aspx under the Electricity Meters + Modules catalog:

- Advanced residential metering: CENTRON R300 (solid-state, single-phase)
- Advanced Commercial + Industrial Metering: CENTRON Polyphase R300 and SENTINEL R300
- Smart Residential Metering: OpenWay® CENTRON® (smart device used to collect, process and transmit vital energy information to utility systems, Zigbee radio communication)
- Smart Commercial + Industrial Metering: OpenWay® CENTRON® Polyphase Meter (compliant with the ANSI C12.19 and C12.22 standards for storage and transport)

4. Silver Spring Networks is Smart Grid solution company, enabling utilities to achieve operational efficiencies, reduce carbon emissions and empower their customers to monitor and manage their energy consumption, with a large set of utility companies as their customers. More product details can be consulted on website: http://www.silverspringnet.com/products/.

5. Trilliant (http://www.trilliantinc.com/) provides utilities with wireless equipment and management software for Smart Grid communication networks that improve energy efficiency, lower operating costs, and integrate renewable energy resources. CellReader® Digital Cellular Meters are their main products for AMI and Smart Grid remote data applications. These cellular communications products are a system-wide complement to Trilliant's earlier history of telephone-based AMR products and Trilliant's current industry-leading wireless SecureMesh products for Smart Grid applications.

6. Sensus provides real world, proven solutions of high-value metering, AMR and AMI system solutions for water, gas, electric and heat utilities. Sensus continues to be the measure of the future, having one of the largest installed AMI bases in the world. A global leader that aggressively pushes the boundaries of utility management with innovative communication systems that enable customers to intelligently utilize their resources with unprecedented efficiency. Details on products can be found at http://www.sensus.com/Module/Catalog/ElectricCatalog.

   - FlexNet® AMI system, offered exclusively from Sensus, empowers proven means to increase meter reading efficiency, reduce overhead costs and enhance customer service simply, reliably, and with unlimited flexibility.
   - Residential and Commercial / Industrial Smart Meters: iCon A Residential Meter and iCon APX C&I meter

7. The Aclara® brand represents the industry's leading Intelligent Infrastructure™ technologies for providing device networking, data-value management, and customer communications to water, gas, and electric utilities globally. Aclara integrates the strengths of the industry's

most proven technologies – the Aclara STAR® Network RF-based AMI, Aclara TWACS® power-line AMI technology, Aclara Software® operational-efficiency and customer-care applications, and Aclara Smart Communications standards-based, wide-area. The Aclara STAR® Network Electric Meter Transmission Unit is the main product for Star Network AMI system. Additional product and solution details are listed at http://www.aclara.com/AclaraRF/Pages/starsystem.aspx.

REFERENCES

[1] U.S. Department of Energy Office of Electricity Delivery and Energy Reliability (2000). *NETL Modern Grid Strategy: A Vision for the Smart Grid* [White paper].Retrieved from http://www.netl.doe.gov/smartgrid/referenceshelf/whitepapers/Whitepaper_The%20Modern%20Grid%20Vision_APPROVED_2009_06_18.pdf

Chapter 4: Overview of Advanced Metering Infrastructure in the Commonwealth of Kentucky

ABSTRACT

The "Overview of Advanced Metering Infrastructure in the Commonwealth of Kentucky" report presents a summary of the current state of AMI deployments and capabilities within the electric utilities of Kentucky. It is a thorough technology assessment, and provides details to support the document "Overview of Smart Grid Deployments in the Commonwealth of Kentucky".

The data presented in this report was gathered using the "AMI Deployment Survey for Jurisdictional Utilities" (AMI Survey). The AMI Survey gathered utility deployment data in 4 areas: Smart Meters, Wide Area Communications, Home Area Networks, and Meter Data Management Systems. Additionally, system cost, savings, and benefits were reported.

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Introduction

About This Document

The Kentucky Public Service Commission, the University of Louisville, and the University of Kentucky have partnered under the "Kentucky Smart Grid Roadmap Initiative" (KSGRI) to develop a technical roadmap for the development and deployment of smart grid technologies throughout the Commonwealth. This "Kentucky Smart Grid Roadmap" will provide recommendations and best practices to utilities and utility stakeholders to guide individual smart grid deployment approaches. More information regarding the work of the KSGRI is located in the documents *The Kentucky Smart Grid Roadmap Initiative: Smart Grid Road Map Work Plan*, *The Kentucky Smart Grid Roadmap Initiative: Kentucky Smart Grid Assessment Model*, and *The Kentucky Smart Grid Roadmap Initiative: Overview of Smart Deployments in the Commonwealth of Kentucky*.

The purpose of this document is to summarize the results of the AMI Deployment Survey for Jurisdictional Utilities, in fulfillment of Work Plan Goals 4 of *Smart Grid Road Map Work Plan*. The AMI Survey was distributed to 23 jurisdictional electric utilities to develop an understanding of the "As-is" state of the electric power grid in Kentucky, focusing on Advanced Metering Infrastructure. Data collected from jurisdictional utilities was via self-reporting by a Smart Grid Contact person from each utility.

Document Overview

The following section is an executive summary of the entire report, highlighting important details of the AMI Survey. Detailed summaries are then provided in subsequent sections for each of the following areas: Smart Meters, Wide Area Communication System, Home Area Networks, Meter Data Management Systems, Costs, Savings, and Benefits. The report concludes by presenting feedback from the participating utilities.

EXECUTIVE SUMMARY

SMART METERS

Of the responding utilities, seven operate systems that contain meters capable of Automated Meter Reading (AMR) function only. Many of these systems utilize mixed communication technology for data reading, with Power Line Carrier (PLC) and Hand Held or Drive-by Remote Reading Units being the most common. Fifteen utilities report some level of Advanced Metering Infrastructure (AMI) capabilities within their system. All 15 operate systems containing solid state Smart Meters with AMI capabilities and six also contain electromechanical meters retrofitted with AMI modules. Penetration rates amongst the utilities are evenly distributed, with eight utilities reporting residential AMI penetrations rates of less than 30% and ten utilities reporting residential AMI penetration rates of more than 90%. The most common OEM suppliers of the meters are Landis & Gyr, Itron, Aclara, and General Electric. All of the AMI meters in KY are capable of reporting kWh. The majority (>50%) also report demand (kW) and voltage (V). To communicate between the utility data center and the Smart Meters, 11 utilities utilize local concentrators, with the vast majority of these systems utilizing PLC communication architectures

WIDE AREA COMMUNICATION SYSTEMS

14 utilities reported operating Wide Area Communication System (WAC) systems. In all cases, the WACS is divided into two sides, the meter to substation infrastructure and the substation to utility data office infrastructure. In all cases, the communication architecture utilized between the AMI Smart Meters and the local substation is Power Line Carrier (PLC). The communication architectures implemented between the substation and utility data office are highly variable, with the most popular choice being some variety of internet. Four utilities report utilizing Wide Area Communication System infrastructure for grid support purposes that include direct load control (1), supervisory control and data acquisition (SCADA) systems (2), distribution automation (2), and reactive power (VAR) compensation (1). No utilities report utilizing the WAC systems to offer new products or services such as broadband internet to their customers. One utility reports limitations to their WAC system. This utility has indicated that geographic restrictions limit their ability to serve the entire customer base.

HOME AREA NETWORKS

Two of the responding utilities report using Home Area Networks (HAN) as part of their AMI systems. In both cases, the network device is a radio located within the Smart Meters that communicates to in home devices. Both utilities utilize programmable communicating thermostats (PCTs) and load control switches. One also communicates with programmable electric water heaters, and the other communicates to an in-home-display. In both cases, the customer can interface the HAN through a web interface or the PCT/home-display.

METER DATA MANAGEMENT SYSTEMS

Four of the responding utilities report utilizing a Meter Data Management System (MDMS) as part of their AMI system, and one responding utility reports plans to implement a MDMS system by 2012. The functions served by the MDMS include: upload of billing data (3), voltage check function (1), transformer loading check (1), and billing read estimation (1). The utility systems with which MDMS most often interact are Consumer Information Systems, Billing Systems, Outage Management Systems, and Geographic Information Systems.

Costs

Total capital costs were reported for 12 reported AMI deployments were $78,636,140. Capital costs ranged from $2,536,000 to $20,000,000, with an average of $7,148,740. On a per Smart Meter basis this equates to an average cost of $216.70 statewide. Individual utility per Smart Meter costs range from $91.25 to $490.80. Total annual Operations and Maintenance (O&M) costs were reported by 11 utilities. Total annual O&M costs are $2,762,745. The minimum yearly figure was $45,500, the max $1,110,000, and the average $251,158.64.

Savings

Total reported per year savings due to installation of AMI meters is $6,230,670. Most of these savings came from reduction in meter reading costs ($3,464,707) and savings due to improved accuracy of solid state meters ($1,174,983). The most commonly cited savings areas were reduced meter reading costs (contract cancellation, personnel reduction, claim reduction), field service savings (fewer missed meter readings, service disconnect, personnel reduction), under registration, and outage response (reduced service interruption rate, improved situational awareness).

Benefits

Of the non-monetary benefits of AMI installations, the most commonly cited are improved customer satisfaction related to field service, the ability to introduce new billing services, and customer enablement through access to energy consumption data. The benefit least commonly cited were environmental benefits due to construction deferment and pollution reduction.

LIST OF PARTICIPATING UTILITIES

Big Rivers Electric Corporation
- Jackson Purchase Energy
- Kenergy Corp.
- Meade County RECC

East Kentucky Power Cooperative Inc.
- Big Sandy RECC
- Bluegrass Energy Cooperative
- Clarke Energy Cooperative Inc.
- Cumberland Valley Electric
- Farmers RECC
- Fleming Mason Energy
- Inter-County-Energy
- Jackson Energy Cooperative
- Nolin RECC
- Owen Electric Cooperative Corporation
- Salt River Electric Cooperative Corporation
- South Kentucky RECC
- Taylor RECC

Kentucky Power Company

Louisville Gas & Electric and Kentucky Utilities

SUMMARY OF THE AMI SYSTEM ASSESSMENT SURVEY

INTRODUCTION

The AMI Deployment Survey for Jurisdictional Utilities (AMI Survey) was completed by 20 jurisdictional utilities. The System Assessment portion of the AMI Survey collected information regarding Smart Meters, Wide Area Communication System, Home Area Networks, and Meter Data Management Systems. The following section summarizes the collected responses to the AMI System Assessment Survey.

SMART METERS

Automated Meter Reading

Of the responding utilities, seven operate systems that contain meters capable of Automated Meter Reading (AMR) function only. The following table provides a summary of AMR data collection methods.

AMR Data Collection Technologies	
COMMUNICATION TECHNOLOGY	UTILITY COUNT
Power Line Carrier	5
Broadband Internet	1
Dialup Internet	1
Remote Cell Modem	1
Remote Reading Unit	2

Solid State and Under-glass Smart Meters with AMI Capability

In total, 15 of the responding utilities report some level of Advanced Metering Infrastructure (AMI) capabilities within their system. Of these, all 15 operate systems that contain some solid state Smart Meters with AMI capabilities. Six also operate systems in which electromechanical meters have been retrofitted with AMI modules. The following table provides a summary of total Smart Meter deployment penetration rates separated by customer class.

Utility AMI Penetration Rate Count Separated by Customer Class			
PENETRATION RATE	Residential	Industrial	Commercial
0%	3	8	5
1 to 9%	3	1	3
10 to 19%	1		
20 to 29%	1	1	1
30 to 39%			
40 to 49%		1	
50 to 59%		1	1
60 to 69%			
70 to 79%			1
80 to 89%			
90 to 99%	2		

100%	8	6	7
Not Applicable	2	2	2

Smart Meters Vendors
Six of the responding utilities have AMI systems composed of Smart Meters sourced from a single OEM, with the remaining nine of the responding utility using Smart Meters provided by multiple OEMs. The following table summarizes the original equipment manufacturers that provide the Smart Meters.

OEM of Smart Meters in KY	
OEM NAME	UTILITY COUNT
Aclara	6
Cannon	1
Centron	1
Cooper	1
General Electric	5
Hunt Technologies	1
Itron	7
Landis & Gyr	10
Sensus	2
Sentinal	1
Vectorn	1

Meter Data
Utilities were asked to provide the data types collected by the Smart Meters devices. The following table summarized these responses.

Utility AMI Data Type Collection	
DATA TYPE	UTILITY COUNT
Energy (kWh)	15
Demand (kW)	12
Max Demand Only (kW)	2
Reactive Power (KVAR)	1
Voltage (V)	9
Voltage Min/Max (V)	2
Current (Amps)	2
Power Factor	3
Outages	5
Blink Count	2

Use of Local Concentrators to Interface AMI Meters
Utilities were asked if a local concentrator was used to collect data from groups of meters. Review of utility responses indicates when local concentrators are utilized they are located at the

substation, without exception. This is in contrast to the intent of the question, which sought to evaluate the use of concentrators for small groups of meters, or neighborhood concentrators. Of the responding utilities, 11 report using local concentrators for AMI data collection, while the remaining four have AMI meters that communicate directly with the utility data center. Of those that utilize local concentrators, 10 utilize Power Line Carrier (PLC) and 1 utilized a wireless RF mesh network to communicate between the AMI meters and the substation concentrator.

WIDE AREA COMMUNICATION SYSTEM

Architectures

Of the responding utilities, 14 operate Wide Area Communication System (WAC) systems. In all cases, the WACS is divided into two sides, the meter to substation infrastructure and the substation to utility data office infrastructure. In all cases, the communication architecture utilized between the AMI Smart Meters and the local substation is Power Line Carrier (PLC). The communication architectures implemented between the substation and utility data office are summarized in the following table. Three of the responding utilities have AMI WACS systems composed of multiple architectures, with the remaining 11 of the responding utility using a single architecture for this purpose.

WACS Architecture Types	
DATA TYPE	UTILITY COUNT
Power Line Carrier	2
Internet	4
Radio	4
Broadband	1
Dial-up	2
Satellite	1
Fiber Optic	1

Grid Support

Four utilities report utilizing Wide Area Communication System infrastructure for grid support purposes other than supporting AMI systems. These purposes include direct load control (1), supervisory control and data acquisition (SCADA) systems (2), distribution automation (2), and reactive power (VAR) compensation (1).

Ancillary Services

No utilities report utilizing the WAC systems to offer new products or services such as broadband internet to their customers.

Architecture Limitations

One utility reports limitations to their WAC system. This utility has indicated that geographic restrictions limit their ability to serve the entire customer base.

Home Area Networks

Architectures

Two of the responding utilities report using Home Area Networks (HAN) as part of their AMI systems. In both cases, the network device is a radio located within the Smart Meters that communicates to in home devices. Both utilities utilize programmable communicating thermostats (PCTs) and load control switches. One also communicates with programmable electric water heaters, and the other communicates to an in-home-display. In both cases, the customer can interface the HAN through a web interface or the PCT/home-display.

Meter Data Management Systems

Architectures

Four of the responding utilities report utilizing a Meter Data Management System (MDMS) as part of their AMI system, and one responding utility reports plans to implement a MDMS system by 2012. The functions served by the MDMS include: upload of billing data (3), voltage check function (1), transformer loading check (1), and billing read estimation (1).

Interaction with Other Systems

Utilities were asked to provide the systems with which the MDMS interfaces. The following table summarized these responses.

Utility MDMS System Interaction	
System Type	Utility Count
Consumer Information System	4
Billing System	4
Utility Web Site	1
Outage Management System	2
ERP* for Load Forecasting	1
ERP for Power Quality Monitor	0
Geographic Information System	2
Transformer Load Management	0
Power Factor	0
Other	0

*ERP: Enterprise Resource Planning

SUMMARY OF THE AMI COST AND BENEFIT SURVEY

INTRODUCTION

The Cost and Benefit portion of the AMI Survey (AMI Survey) was completed by 12 of the jurisdictional utilities (2 utilities responded with data for AMR systems and were not included in this summary). It collected information regarding installation and operation & maintenance costs, savings enabled by AMI, and ancillary benefits of AMI installations. The following section summarizes the collected responses to the AMI Cost and Benefit Survey.

COSTS

Capital Costs of AMI Deployments

Total capital costs related to the 12 reported AMI deployments were $78,636,140. Capital costs ranged from $2,536,000 to $20,000,000, with an average of $7,148,740. On a per Smart Meter basis this equates to an average cost of $216.70 statewide. Individual utility per Smart Meter costs range from $91.25 to $490.80. These values do not consider dual usage of AMI infrastructure to support AMR-only meters. The following table provided a breakdown of AMI infrastructure capital costs by type.

Percentage of AMI Capital Costs by Category			
CATEGORY	MIN %	MAX %	AVERAGE %
Endpoint Hardware	35	87.9	67.6
Network Hardware	10	16	13.26
Installation	0	40	14.97
Project Management	0	10	2.5
IT	10	15	2.9

Operation and Maintenance Costs of AMI Deployments

Total annual Operations and Maintenance (O&M) costs were reported by 11 utilities. Total annual O&M costs are $2,762,745. The minimum yearly figure was $45,500, the max $1,110,000, and the average $251,158.64. The following table provides a breakdown of O&M costs by category.

Percentage of AMI O&M Costs by Category			
CATEGORY	MIN %	MAX %	AVERAGE %
Comm. Network	3	50	19.7
AMI Meters	13.4	94	62.14
MDMS	0	77.4	18.1

Other AMI Costs

One of the responding utilities reported additional costs of AMI deployments to be $60,000 per year for the salary of a full time technical coordinator.

Savings

Meter Reading Savings

The following table reports the number of utilities response types to each of the AMI Meter Reading Savings categories.

AMI Meter Reading Savings Responses by Category				
Category	# Unknown	# Unquantifiable	# No Reduction	# Reduction
LDV Fleet Reduction	1	1	11	2
Personnel Reduction	0	0	12	3
Contract Cancellation	0	0	8	7
Claim Reduction	2	1	10	1

The following table summarizes the reported savings for each of the AMI Meter Reading Savings categories. Calculations were made inclusive of all utilities, and exclusive of those utilities reporting unknown, unquantifiable, or no reduction to the survey question.

AMI Meter Reading Savings by Category					
Category	Average of All Responding Utilities	Average of Utilities Reporting Reduction (Only)	Total Savings	Min Reported Reduction	Max Reported Reduction
LDV Fleet Reduction	$8,461	$55,000	$110,000	$33,000	$77,000
Personnel Reduction	$31,265	$156,326	$468,980	$87,400	$288,000
Contract Cancellation	$192,275	$412,018	$2,884,126	$200,000	$732,000
Claim Reduction	$133	$1,600	$1,600	$1,600	$1,600

Field Services Savings

The following table reports the number of utilities response types to each of the AMI Reductions of Field Service Visits Savings categories.

AMI Reduced Field Service Visits Savings Responses by Category				
Category	# Unknown	# Unquantifiable	# No Reduction	# Reduction
Missed Meter Readings	1	1	7	6
Service Disconnect	1	1	8	5
Personnel Reduction	0	0	15	0

The following table summarizes the reported savings for each of the AMI Reductions of Field Service Visits Savings categories. Calculations were made inclusive of all utilities, and exclusive of those utilities reporting unknown, unquantifiable, or no reduction to the survey question.

AMI Reduced Field Service Visits Savings by Category					
Category	Average of All Responding Utilities	Average of Utilities Reporting Reduction (Only)	Total Savings	Min Reported Reduction	Max Reported Reduction
Missed Meter Readings	$6,023	$13,049	$78,296	$50,000	$380,000
Service Disconnect	$58,207	$176,672	$756,689	$87,400	$288,000
Personnel Reduction	$0	$0	$0	$0	$0

Billing Savings
Billing savings through enhanced process efficiency and reduced time to address service requests due to AMI installation was reported to be not quantifiable by 6 utilities, and was reported to provide $0 in savings by 7 utilities. The remaining two utilities indicated estimated savings in this area of $25,000 and $45,000.

Outage Response Savings
The following table reports the number of utilities response types to each of the AMI Outage Response Savings categories.

AMI Outage Response Savings Responses by Category				
Category	# Unknown	# Unquantifiable	# No Reduction	# Reduction
Reduced Service Interruption Time	3	1	8	3
Improved Situational Awareness	4	2	7	2

The following table summarizes the reported savings for each of the AMI Reductions of Field Service Visits Savings categories. Calculations were made inclusive of all utilities, and exclusive of those utilities reporting unknown, unquantifiable, or no reduction to the survey question.

AMI Outage Response Savings by Category					
Category	Average of All Responding Utilities	Average of Utilities Reporting Reduction (Only)	Total Savings	Min Reported Reduction	Max Reported Reduction
Reduced Service Interruption Time	$6,682	$24,500	$73,500	$6,000	$40,000
Improved Situational Awareness	$3,722	$27,500	$33,500	$6,000	$27,500

Call Center Savings
The following table reports the number of utilities response types to each of the AMI Call Center Savings categories.

AMI Call Center Savings Responses by Category				
Category	# Unknown	# Unquantifiable	# No Reduction	# Reduction
Reduction in Billing Inquiries	3	2	7	3
Personnel Reduction	0	1	13	1
Auto ID of Billing Malfunctions	4	2	9	0

The following table summarizes the reported savings for each of the AMI Call Center Savings categories. Calculations were made inclusive of all utilities, and exclusive of those utilities reporting unknown, unquantifiable, or no reduction to the survey question.

AMI Call Center Savings by Category					
Category	Average of All Responding Utilities	Average of Utilities Reporting Reduction (Only)	Total Savings	Min Reported Reduction	Max Reported Reduction
Reduction in Billing Inquiries	$4,212	$14,040	$42,120	$3,120	$29,000
Personnel Reduction	$3,357	$47,000	$47,000	$47,000	$47,000
Auto ID of Billing Malfunctions	$0	$0	$0	$0	$0

Collection Write Off Savings
Collection savings through a reduction in bad debt write offs associated with missed reads and/or estimated bill due to AMI installation was reported as: not quantifiable by 1 utility, unknown by 1, and $0 in savings by 7 utilities. Collection write off savings averaged across all utilities is $22,373, with a total savings of $268,475. For the three utilities who indicated savings due to collection write off, the minimum reported was $318, the maximum was $198,157, and the average was $84,492.

Under Registration Savings
Under registration savings through improved accuracy of solid state AMI meters was reported as: not quantifiable by 1 utility, unknown by 3, and $0 in savings by 4 utilities. Under registration savings averaged across all utilities is $106,816, with a total savings of $1,174,983. For the seven utilities who indicated savings due to collection write off, the minimum reported was $45,000, the maximum was $360,000, and the average was $167,854.

Energy Diversion Savings
Collection savings through the ability to more accurately detect energy theft due to AMI installation was reported as: not quantifiable by 2 utilities, unknown by 4, and $0 in savings by 5 utilities. Theft detection savings averaged across all utilities is $27,675, with a total savings of $221,400. For the three utilities who indicated savings due to collection write off, the minimum reported was $5000, the maximum was $210,000, and the average was $73,800. One utility reported energy diversion savings as 25,398 kWh.

Benefit Evaluation

The following table summarizes the responses of the jurisdictional utilities when asked to "Indicate if the impacts of the following possible benefits have been evaluated due to"

AMI Benefit Evaluation by Category

Type	Category	Yes	No	No Response	Not Applicable
Meter Reading	Improved Customer Privacy	6	8	3	3
	Emission Reduction	7	7	3	3
	Risk Reduction	7	7	3	3

Field Service	Enhanced Customer Satisfaction	10	4	3	3
Billing	Enhanced Customer Satisfaction	8	6	3	3
	Potential for New Billing Services	8	5	3	4
Outage Response	Enhanced Customer Satisfaction	6	8	3	3
Load Research	New Rate Design	5	9	3	3
	DR Programs	5	9	3	3
	More Accurate Load Forecasts	6	8	3	3
Customer Enablement Programs	Energy Usage Awareness	8	6	3	3
	Participation in Load Management	7	7	3	3
	Full Scale DR	5	8	3	4
Environment	Pollution Reduction	4	10	3	3
	Construction Deferment	4	10	3	3

Feedback Summary

Introduction

Responding utilities were encouraged to provide feedback to be included in the AMI report. This section summarizes those responses.

Cumberland Valley Electric

CVE meters were previously self-reported by customers

Jackson Energy Cooperative

The benefits section asked for estimates or actual savings in many categories. These savings exist but cannot be quantifiable. Most, if not all, of the savings and/or benefits in these categories have not been tracked since our system was installed in 2003. We are not comfortable providing an estimate as it would only be an educated guess. We feel "estimates" should not be used in any formal report for policy decisions or regulations.

Louisville Gas and Electric

LG&E/KU continues to monitor and research emerging SG technologies such that investments occur at the speed of value. SG technologies are analyzed utilizing historical investment methods to determine when value will be achieved and thus directing the future state of SG.

Meade County RECC

MRECC installed the Landis+Gyr Gridstream solution as a meter readings system to replace contract meter readings. As this system is a two way communication system, it does have several AMI capabilities; however for MCRECC to implement HAN devices, a special meter is needed with a Zigbee chip to communicate with these devices. The system that MCRECC currently has installed is only able to read meters on a daily interval. The best that the Landis & Gyr system is capable of is hourly reading utilizing the PLC. This solution requires new substation collectors and new meters and/or modules. Not all meter can be read on an hourly basis as the substation collectors cannot hand this. Therefore, only a portion of the system could be read on an hourly basis if this was implemented. This would be at a great cost to MCRECC and its members for only the few that would benefit from this at the present time.

CHAPTER 5: ADVANCED DISTRIBUTION OPERATIONS OVERVIEW

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INTRODUCTION

The Kentucky Public Service Commission, the University of Louisville, and the University of Kentucky have partnered to develop a technical roadmap for the development and deployment of Smart Grid technologies throughout the Commonwealth. This "Kentucky Smart Grid Roadmap" will provide recommendations and best practices to utilities and utility stakeholders to guide individual Smart Grid deployment approaches.

The purpose of this document is 1) an analysis of: Advanced Distribution Operation systems, the benefits associated with ADO deployments, key enabling technologies, consumer behavior issues, and other issues associated with the deployment, and 2) the of evaluation of ADO deployments in the jurisdictional utilities of Kentucky These purposes are in fulfillment of KSGRI Work plan Goal #7.

OVERVIEW OF ADO

ADO (Advanced Distribution Operations) provide increased information, enable granular control needed for "self-healing" operations, and improves automation as well as reliability to the power distribution systems. Like AMI, we refer to ADO as a Smart Grid **infrastructure area**, as opposed to a specific technology.

ADO is the syntheses of an integration of applied functions, applications, and technologies and the correlation between other SG infrastructure areas and emerging technologies. The main objective of ADO is to improve the reliability and efficiency of distribution systems and provide functional support for other applications that are aggregated into ADO, making the distribution systems much smarter.

SG infrastructure areas and major ADO functions discussed in this report are summarized in Figure 1 below.

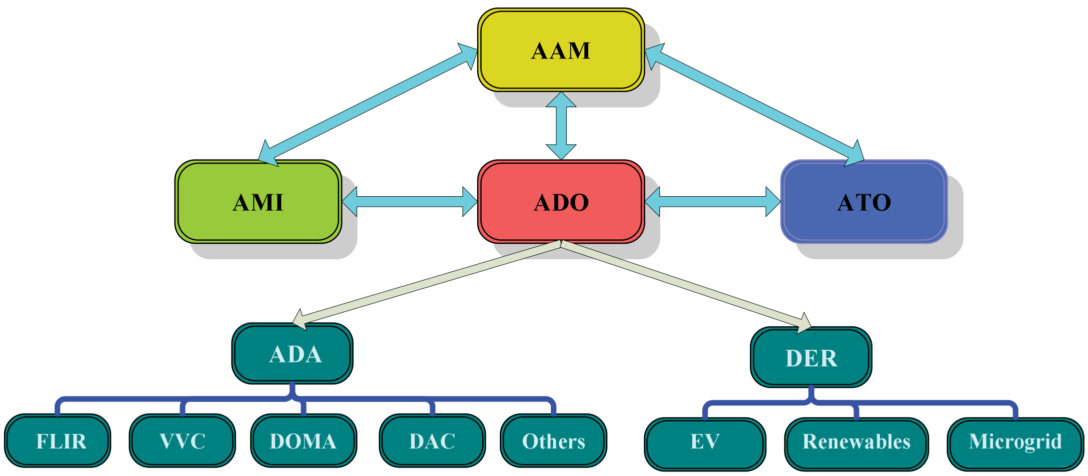

Figure 1. Summary of SG Infrastructures and ADO Functions

From a systems perspective, ADO includes **distribution management systems** (DMS) with advanced monitoring and ubiquitous sensors and intelligence, computer-based **advanced outage management systems** (OMS), **advanced distribution automation** (ADA) with intelligent control over electrical power grid functions(fault detection and location, system restoration and reconfiguration, real power and reactive power control), and **Volt/VAR Control** . ADO also aids deployment of **distributed energy resources** (DER), such as renewable energy resources and electric vehicles (EV), and enables operation of **microgrids**. It is also integrated with a distribution geographical information system (GIS) and distribution supervisory control and data acquisition (SCADA) system for improved grid awareness.

ADO closely interacts with the AMI SG infrastructure area for the purposes of microgrid operations, high-speed information processing, and advanced protection and control. Since ADO and AMI are both distribution focused, they together provide systems that enable for demand side management (DSM) and demand response (DR) programs in order to reduce or shape peak loads.

ADO also provides support for Advanced Transmission Operation (ATO), which integrates the distribution system with regional transmission organization (RTO) operational and market applications to enable improved overall grid operations and reduced transmission congestions.

ADO has close relationship with Advanced Asset Management (AAM) by making use of a great amount of power electronic devices and equipment, not only installed at distribution substations, but also at utility control centers, as well as widely dispersed distribution lines.

With more extensive penetration of SG technologies, ADO will become a core component of SG. In this report, we will analyze enabling technologies classified by different functionalities, and identify the impacts of DER on ADO, and then discuss various aspects associated with ADO development, such as applicable standards, benefits, risks and barriers, cyber security issues, development experiences. In addition, we will look for some major vendors with their distribution products in the market.

ADO AND THE SMART GRID

As defined by the Department of Energy (DOE):

> "*The smart grid is the electric delivery network from electrical generation to end-use customer, integrated with the latest advances in digital communications and information technology for enhanced grid operations, customer services, and environmental benefits*".

Therefore, the Smart Grid refers to an intelligent power delivery system that utilizes new power technologies and digital communications technology to improve reliability, security, and efficiency of the electric system. The information communication networks are employed to link almost all the components in the electric system, e.g. meters, substations, transformers, etc. The scope of Smart Grid is so broad that it covers from the generation and delivery infrastructure to the end-user systems, along with the information networks and integrated management system.

From an infrastructure point of view, the Smart Grid is divided into four broad infrastructure areas, **Advanced Metering Infrastructure** (AMI), **Advanced Distribution Operations** (ADO), **Advanced Transmission Operations** (ATO), and **Advanced Asset Management** (AAM), as shown in Figure 2.

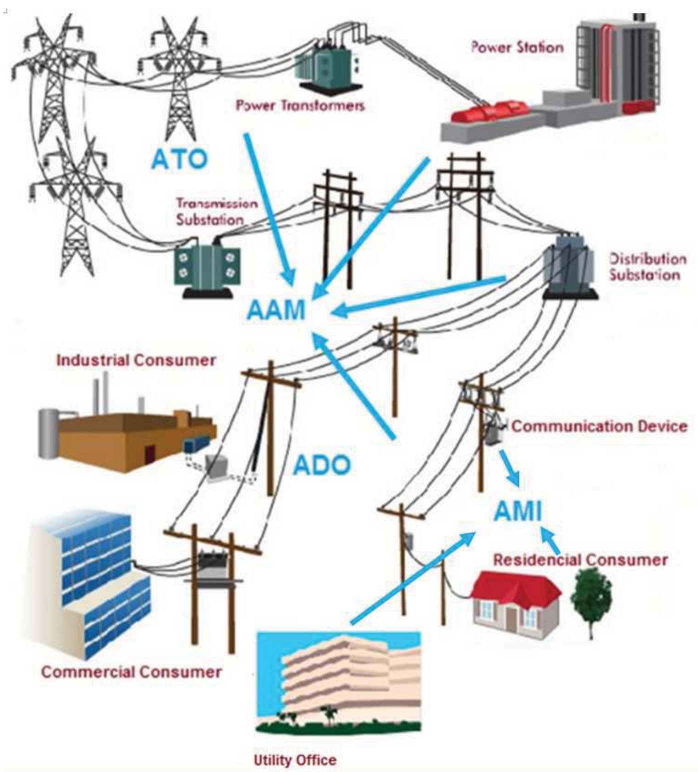

Figure 3 Smart Grid Infrastructure.

ADO serves a foundational role in the development of the above system, as it enables self healing and optimization of distribution system operation. Additionally, ADO supports all of the principal characteristics of DOE's Modern Grid Strategy0.

ADO TECHNOLOGY OPTIONS

Power distribution systems are among the key components of the SG deployment and development, where distribution operations are becoming increasing automated for demands such as higher reliability, improved power quality, lower costs, demand response capabilities, the interconnection with DER, and newly enabled technologies.

This section analyzes representative power system functions and technologies that enable the operations of advanced distribution. Some of these functions have already been widely employed throughout power distribution systems, while others with more advanced technologies and upgrades are being adopted by utilities in the near future; nevertheless, they all provide significant technological solutions and functionalities in realizing ADO.

ADA is a term coined by the Electric Power Research Institute (EPRI) in the IntelliGrid project [2] to describe the extension of intelligent control over electrical power grid functions to the distribution level and beyond. The objective of ADA functions [3] is to enhance the power quality, reliability and efficiency, by automating the following three processes of distribution operations: data preparation in near real-time; optimal decision-making; and the control of distribution operations in coordination with transmission and generation operations.

The scope of ADA [3] includes, but not limit to the data gathering, distribution system modeling and analysis, system event prediction, decision making, recording and reporting, contingency analysis, volt/VAR optimization, fault location, isolation and service restoration. And these processes are executed through direct interfaces with various systems and databases, such as energy management system (EMS), OMS, SCADA, and GIS.

FAULT LOCATION, ISOLATION AND SERVICE RESTORATION (FLIR)

According to a new report from IDC Energy Insights [4], utility executives are showing a high level of interest in implementing new distribution optimization applications, one of which, rated highest for technical feasibility, is the fault location, isolation and service restoration (FLIR). This application detects the fault, determines the faulted section and location, and suggests an optimal solution of isolating the faulted section of the affected distribution feeder and the procedures for the restoration of services to its normal condition. The key sub-functions performed by this application are [5]:

1. **Fault Location**: This sub-function is initiated by data inputs from SCADA and OMS, and in the future, by inputs from fault prediction devices. It determines the specific protective device, which clears the fault, identifies the faulted sections, and estimates the probable location of the actual or expected fault. It has the capability to distinguish faults cleared by controllable protective devices from those cleared by fuses, momentary outages, or inrush/cold load currents.

2. **Fault Isolation and Service Restoration**: This sub-function supports three modes of operations [5]:

    a. Closed-loop mode, which is initiated by the fault location sub-function. It generates a switching order for the remotely-controlled switching devices to isolate the faulted sections, and restore service to the non-faulted sections. The switching order is automatically executed via SCADA.

    b. Advisory mode, which is also initiated by the fault location sub-function. It generates a switching order for both remotely- and manually-controlled switching devices to isolate the faulted sections, and restore service to the non-faulted sections. The switching order is presented to operator for approval and execution.

    c. Study mode, which is initiated by the users. It analyzes a saved case modified by the users, and generates a switching order under the operating conditions specified by the users.

In current ADA applications, the centralized fault location architecture is heavily based on SCADA-supported fault indications, trouble-call systems, and sometimes, on fault location devices. In the SG environment, the smart meters, customer EMS, and fault predictors, all of which are widely dispersed over the distribution lines, will become vital sources of data for fault location. The processing of these massive data will need to be accomplished in a very short time interval.

The switching orders generated by the FLIR application, will include switching devices and feeder paralleling, as well as separations of microgrid, synchronization of disconnected DER, and the enabling of DR. The solutions should be dynamically optimized based on the expected operating conditions during the time of service restoration.

VOLTAGE AND VAR CONTROL (VVC)

Referring to the same report mentioned above [4], one of the best near-term chances for adoption is the integrated voltage and VAR control (VVC), which would be utilized for energy efficiency, is rated highest for economic feasibility. This application calculates the optimal settings of voltage controllers of load tap changers (LTC), voltage regulators, DERs, power electronics, and compensative capacitor statuses, optimizing the operations by either satisfying different objectives during different periods, or considering a combination of weighted objectives. Such objectives supporting this application include, but by no means, limited to [6]:

1. Minimize kWh consumption at given power quality limits.

2. Minimize feeder segment(s) overload.

3. Reduce load given voltage tolerance.

4. Conserve energy via voltage reduction.

5. Reduce or eliminate overload on transmission lines.
6. Provide reactive power support for distribution buses.
7. Provide spinning reserve support.
8. Minimize cost of energy
9. Provide compatible combinations of above objectives

Like FLIR, this VVC application also supports three modes of operations [6]:

1. Closed-loop mode, in which the application runs either periodically (e.g., every 15 min) or is triggered by an event based on real-time information. The application's recommendations are executed automatically via SCADA system.
2. Study mode, in which the application performs "what-if" studies, and provide recommendations to the operators.
3. Look-ahead mode, in which conditions expected in the near future, can be studied by the operators.

VVC is a major multi-objective ADA application performing dynamic optimization of distribution operations. It should actively exchange information with other applications and IT systems in different power system domains. In the SG environment, in addition to the current control of voltage controller settings, the application should be able to control the reactive power of DER and other dynamic sources of reactive power. Under some objectives, the application should be able to control the DR means and the real power of DER. Therefore, the Volt/VAR optimization becomes a Volt/VAR/Watt optimization.

Distribution Operation Modeling and Analysis (DOMA)

The distribution operation modeling and analysis (DOMA) is based on the modeling and analysis of distribution power flow under dynamically changing distribution operating conditions. It provides operators with the summary of results of real-time power flow simulations with contingency analyses. The model is updated in real-time with changes of network topology, model parameters, load profiles, and relevant information of the transmission system. This application can estimate measurements of the distribution system, and be used as a basis for other ADA applications and to provide the operators with the distribution system behavior.

DOMA supports three modes of operations [7]:

1. Real-time mode, which reflects current conditions in the power system.
2. Look-ahead mode, which reflects conditions expected in the near future.
3. Study mode, which provides the capability of performing the "what if" studies.

The key sub-functions performed by the application are as follows [7]:

1. Modeling Transmission/Sub-Transmission System: This sub-function provides related impact of the distribution systems on the transmission systems

2. Modeling Distribution Circuit Connectivity: This sub-function is supported by up-to-date inputs comes from SCADA/EMS, Distribution SCADA, operators/engineers, GIS, and OMS databases.

3. Data Management Issues between GIS, CIS and ADA Distribution Connectivity Database: This sub-function in under development with standard interfaces between different GIS databases, customer critical information databases, data converters, and ADA database for practical use.

4. Modeling Distribution Nodal Loads: This sub-function provides characteristics of real and reactive loads connected to distribution substations. These characteristics are sufficient to estimate kW and kVAR at a distribution node at any given time, including the load shapes. In real-time mode, the nodal loads are balanced with real-time measurements. The load model inputs come from distribution SCADA, CIS supported by AMR and linked with GIS, and weather forecast systems.

5. Modeling Distribution Circuit Facilities: This sub-function models the following distribution circuit facilities:

    a. Overhead and underground lines.

    b. Switching devices.

    c. Substation and distribution transformers.

    d. Station and feeder capacitors and controllers.

    e. Feeder series reactors.

    f. Voltage regulators and controllers.

    g. LTCs and their controllers.

    h. Distribution generators and synchronous motors.

    i. Load equivalents for higher frequency models.

6. Distribution Power Flow: This sub-function provides the power flow analysis and solves radial and meshed networks with multiple generation busses in different modes of operations in the SG environment.

7. Evaluation of Transfer Capacity: This sub-function estimates the available bi-directional transfer capacity for each designated tie switch.

8. Power Quality Analysis: This sub-function performs the power quality analysis by:

    a. Comparing measured and calculated voltages under limits

    b. Determining the portion of time due to the out-of-limit voltage or imbalance

    c. Determining the amount of energy consumed during various voltage deviations and imbalance

    d. Recording the time when voltage violations occur

    e. Performing modeling of higher harmonics propagation and resonant conditions

    f. Performing modeling of rapid voltage changes

9. Loss Analysis: This sub-function concerns the economic analysis on power losses by different elements of the distribution system.

10. Fault Analysis: This sub-function calculates fault currents for each protection zone associated with feeder circuit breakers and reclosers.

11. Evaluation of Operating Conditions: This sub-function determines the difference between the existing substation bus voltages and their limits and also estimates the available real and reactive load obtainable via VVC, which can be used for load reduction. In addition, this sub-function provides operational parameters of transmission buses.

The DOMA application provides the situational awareness of distribution systems. Currently, it is based on input data collected from various databases, such as SCADA, GIS and distribution models. In the SG environment, the multifunctional AMI system, customer EMS, weather forecast system will become significant sources of information support for this application.

DATA ACQUISITION AND CONTROL (DAC)

The data acquisition and control (DAC) function, used both in transmission and distribution systems, consists of multiple types of mechanisms for data retrieval and control commands issuing to power system equipment and devices in the field. These mechanisms are often used in conjunction with each other to provide the full range of DAC interactions, and are often used by other functions, such as SCADA, EMS, protection and relaying, and ADA. The objective of DAC function is to provide real-time data, statistical data, and other information from the power system to other applications. And it is designed to support the issuing of control commands to power system equipment and parameter settings in intelligent electronic devices (IED) and other field systems. DAC function comprises the following five major areas [8]:

1. Direct Power Equipment Monitoring and Control: Direct power equipment monitoring and control is performed by an IED, a remote terminal unit (RTU), and/or other microprocessor-based controllers, based on control commands generated either internally or externally.
2. Local IED Interactions: Local interactions among IEDs are undertaken to only respond to local situations. The typical communications media are LANs, cables, and radio frequency channels.
3. Computerized Field Systems Monitoring and Control: Perform monitoring and control of field equipment via IEDs, such as a data concentrator or substation master, or Automated Control and Data Acquisition (ACADA). These are generalized systems, as opposed to IEDs or controllers, and usually monitor and/or control more than one power system device. The typical communications media are LANs, cables, microwave, radio, leased telephone lines, and cell phones.
4. DER Management Systems Monitoring and Control: Perform monitoring and control of a DER device, either at a local customer site or within a substation or from a utility's distribution control center. DER management systems could be a DER owner's SCADA system, a customer's building automation system, an energy aggregator's system, or a distribution SCADA system. Communications media can include virtually any type.
5. SCADA Systems Monitoring and Control: SCADA systems, which are typically located in a utility control center, perform remote monitoring and control of field equipment and IEDs. SCADA system monitoring can use communication channels directly to IEDs, via RTUs, through a data concentrator, a substation master, or a DER management system. The communications media can include virtually any type.

Distributed Energy Resources and Microgrids

Distributed generation or DER is increasingly important in power grids around the world. This type of generation can help support local power grids in case of outages or blackouts, and ease the loads on long-distance transmission lines, but it can also destabilize the grid if not managed appropriately. Emergent technologies such as EVs, renewable energy resources and microgrids could have great impacts on the operation of power distribution systems, by significantly changing the power flow patterns of the distribution system. Consequently, operations in areas of FLIR, VVC, DOMA, peak load reduction, protective relay operations, etc. will be greatly affected. Usually, utility control centers are unable to manage distributed generations directly, and this may be of interest as a valuable territory for R&D in the future.

EV

Plug-in EVs (PEV) get their power from the electric grid. There are two kinds of PEVs: (1) Plug-in hybrid electric vehicles (PHEV) use both gasoline and electricity stored in large batteries; (2) Battery EVs use only electricity.

EVs could behave as a source to the system in the discharging mode, or behave as a load in the charging mode. When supplying power to the power system, EVs can be considered as a kind of DERs and can be connected to the power system at random time. Therefore, the use of EVs dynamically changes the power distribution modeling and the power flow patterns. Additionally, it will also change the load shape and bring about uncertainties to service providers.

Renewable Energy Resources

Renewable energy resources are naturally replenishing but flow-limited, which means that they have the intermittent nature and are not available 24/7 to generate electricity. Renewable energy resources include: biomass, hydro, geothermal, solar, wind, ocean thermal, wave and tidal action, which are widely distributed all over the world.

Usually renewable power is generated locally where the renewable energy resources are and transmitted through connections of transmission/sub-transmission lines after voltage step-up. Because of its intermittent characteristic, sometimes it is unpredictable for the personnel to schedule and dispatch generation resources, and resulted in large variations of power flow situations.

Microgrid

Microgrid is a localized grouping of electricity sources and loads that normally operate connected to and synchronous with the centralized grid, but can disconnect and function autonomously as physical and/or economic conditions dictate. Microgrid generation resources could include fuel cells, wind, solar, or other energy sources. The multiple dispersed generation sources and ability to isolate the microgrid from the macrogrid would provide reliability to the power system. Microgrid is an ideal way to integrate renewable resources on the community level and allow for customer participation.

However, the operations of microgrid bring about several issues that need to be taken into account. Firstly, voltage, frequency and power quality are three main parameters need to be considered and controlled. Then the synchronization and interconnection issues from microgrid to the utility grid should be ensured for consistency. Also the protection issue of microgrid is facing challenges when implementing microgrid. Last but not the least, there is usually a lack of control availabilities for the high-leveled utilities over the microgrid. All of these issues play an important role in impacting ADO.

ADO AND PARALLEL INFRASTRUCTURE AREAS

None of the SG fundamental characteristics [1, 9] can be achieved by just accomplishing short- and long-term goals only in one infrastructure area. The fulfillment of each infrastructure area as SG milestones requires the deployment and integration of all processes, functions, technologies and applications. And all infrastructure areas should function in a way that they coordinate and support each other. Thus it is very important to fully understand how the four infrastructure areas and their associated processes, functions, technologies and applications depend on each other and how they contribute towards the SG characteristics.

RELATIONSHIP WITH AMI

Among the rest SG infrastructure areas, ADO has a close relationship with AMI since they both belong to the distribution side of the overall power delivery chain. As mentioned previously, ADO is responsible for delivering reliable and high quality power efficiently from transmission terminals to electricity end-users, while AMI, denoting a communication system with electricity meters that measure and record usage data at a predetermined intervals, and provide usage data to both consumers and utilities, is mainly responsible for collecting and providing electricity usage data. The collection process is made possible through those AMI enabled smart meters that are widely installed at residential, industrial and commercial level of the distribution systems and are able to collect information and data more extensively and comprehensively than traditional distribution systems can do. Those measurements obtained from AMI system contain a great amount of valuable information regarding the status of grid operations and are made available for supporting ADO functions through various interfaces and databases. With the enhanced grid awareness and data support from AMI, the performance of many ADO functions can be improved, which will result in better distribution operations.

RELATIONSHIP WITH ATO

As we know, power distribution system serves as the downstream portion after bulk power has been delivered by transmission systems from power plants. In SG environment, ADO is integrated with ATO, together constituting the power delivery network chain for improved overall grid operations. Both of them have direct/indirect impacts on each other in many ways. Additionally, similar types of technological functions and applications can be found in both infrastructure areas, such as substation automation (SA), GIS, SCADA/EMS, wide area monitoring system (WAMS), FLIR, OMS, VVC, DER, modeling and analysis, etc.

RELATIONSHIP WITH AAM

AAM integrates the grid intelligence acquired in achieving the other infrastructure areas with new and existing asset management applications. This integration enables utilities to reduce operations, maintenance and capital costs and better utilize assets during daily operations. Such assets include physical assets (meters, IEDs, sensors, etc.), personnel assets (maintenance crews, management, customer service, etc.), energy assets (renewables, storage, etc.), and “soft” assets (planning, engineering design, construction, etc.). ADO functions cannot be accomplished without the “healthy” and optimized management of these assets. More in a broad sense of SG viewpoint, integration of AMI, ADO, and ATO with AAM will dramatically improve overall grid operations and efficiency.

ADO STANDARDS

Various guidelines and industry standards applicable to different areas of ADO deployment and development have been established by several organizations, including National Institute of Standards and Technology (NIST), North American Electric Reliability Corporation (NERC), Institute of Electrical and Electronics Engineers (IEEE), and others. Here we briefly identify some of those guidelines and industry standards that are involved in ADO. More details associated with each standard can be referred through relevant organizations.

Summary of Use, Application, Cyber Security, and Functionality of Smart Grid Interoperability Standards Identified, a series of standards released by NIST in 2010, including IEC 61968, IEC 61970, IEC 61850, IEC 61870, IEC 62351, and IEC 60870.

NIST Framework and Roadmap for Smart Grid Interoperability Standards, considering DR and consumer energy efficiency, wide-area situational awareness, energy storage, electric transportation, AMI, distribution grid management, cyber security, and network communications.

Guideline for Smart Grid Cyber Security, a companion document to the NIST Framework and Roadmap for SG Interoperability Standards, is intended primarily for individuals and organizations responsible for addressing cyber security for SG systems and subsystems of hardware and software components.

IEEE has more than hundreds of standards and standards in development relevant to SG. The current important standards related to ADO include: C37, C57, IEEE 80, IEEE 802, IEEE 1031, IEEE 1059, IEEE 1250, IEEE 1325, IEEE 1379, IEEE 1547, IEEE 1588, IEEE 1615, IEEE 1675, IEEE 1686, IEEE 1701-1702, IEEE 1775, IEEE1901, etc.

ADO AND CYBER SECURITY

Cyber Security utilizes a series of computer technology as applied to computers and networks, protecting computer- and internet-based information by preventing, detecting, and responding to attacks. The objective of cyber security includes protection of information and property from theft, corruption, or natural disaster, while allowing the information and property to remain accessible and productive to its intended users.

Today's power distribution systems in SG environment are undergoing immense changes. Generally, cyber security issues in ADO include all information and communications that affect the operation of distribution systems. As the electric grid is modernizing, it is becoming highly automated and full of information and data that are exposed for intrusions, treats and attacks. In a sense, cyber network of the grid can be considered as another vital infrastructure ensuring the safe and reliable delivery of electricity. It is indispensable for the grid operators, managers, and regulators to attach great importance to cyber security area.

Cyber security could have been ensured by taking the following actions effectively:

Prevention: take actions and measures for the continuous assessment and readiness of necessary actions to reduce the risk of threats and vulnerabilities, to intervene and stop an incident, or to mitigate negative effects. It is highly effective to establish and implement preventive requirements and standards before malicious activities could take place.

Detection: find approaches to identify abnormal behaviors and discover intrusions; detect malicious code and other activities that can disrupt electric power grid operations. It requires the techniques for digital evidence gathering ability and the decision making process for judging whether there are attacks or data has been compromised.

Response: take accurate countermeasures in order to alert and stop counter-security activities immediately after the detection. In addition, find out and summarize the cause and document all the incidents after the cyber-attack, and upgrade system weak point to avoid similar future attacks.

Recovery: develop plans to figure out what data and information has been suffered from attacks, compromised or completely lost. The objective of this action is to recover as much data as possible and minimize the impact and loss resulted from cyber-attacks.

ADO Deployment Benefits

ADO concepts that increase the strategic value of new distribution systems with the integration of abundant functional applications and technological solutions will be developed to provide a number of benefits. Such benefits are summarized in Figure 2 below, with each of them described subsequently.

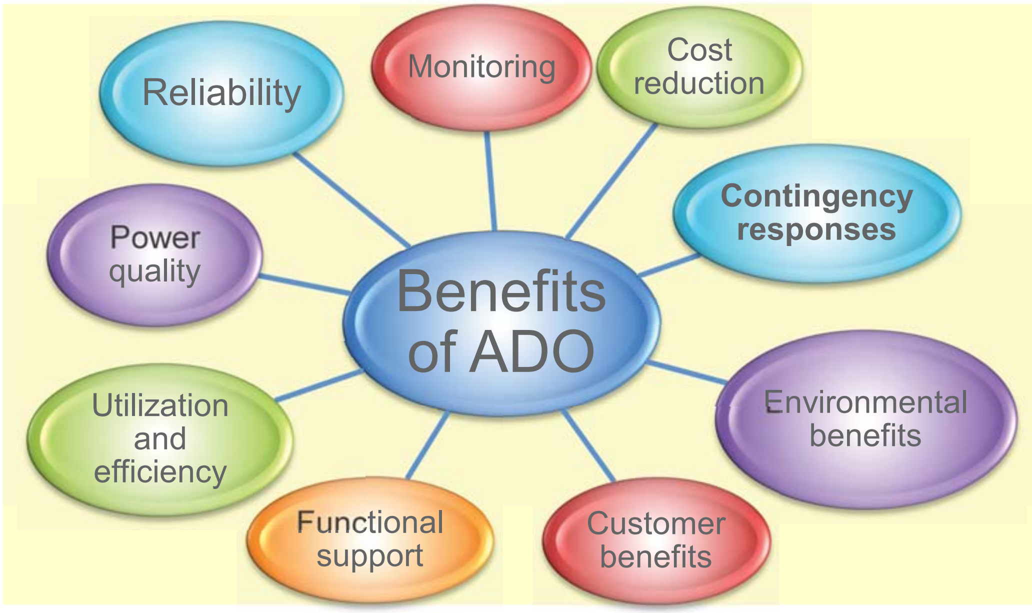

Figure 2. Benefits of ADO

Improved reliability and performance of distribution systems: one of the main benefits of ADO is to improve the system reliability by anticipating and responding promptly to system disturbances and faults with advanced monitoring, preventing, mitigating or eliminating power outage by implementing FLIR and automated OMS, operating resiliently against attacks and natural disasters.

Improved power quality: the implementation of ADO will provide better power quality for the digital economy, reduce losses caused by power quality issues, and offer flexible levels of power quality based on different customer demands.

Increased utilization and efficiency of existing infrastructure: the new system concepts will enable more efficient operation of distribution systems, allowing better control of voltage profiles (e.g. VVC), reducing distribution losses and maximizing energy throughput.

Support all generation and storage options: ADO offers possibilities to accommodate various types of power generation, supports DER integration and the opportunity for net-metering, and stimulates the development of energy storage systems.

More effective distribution monitoring: ADO enables more effective distribution monitoring by utilizing advanced sensing and measurement technologies in power distribution systems with DAC function.

Reduced operating costs: with increased reliability, efficiency and power quality, the improved operations will reduce operating costs virtually anywhere within or beyond the distribution systems; better AAM can generate tremendous savings by managing existing infrastructure in a more efficient manner and cutting down new investment.

Enhanced contingency responses: DOMA category within ADA functions offers more accurate and detailed modeling and analysis of the distribution systems, provides not only computer simulations but also real-time grid information of power flow analysis under contingencies.

Increased customer service options and benefits: the deployment of ADO will enable better customer service provided by utilities, offer more customer choices and better fulfill customer demands, enhance customer experience and satisfaction.

Reduced environmental impact: ADO will result in reduction of greenhouse gas emission, facilitation of more effective land use and vegetation management, assurance of better natural environment and sustainable development.

ADO DEPLOYMENT RISKS

As today's energy demand skyrockets, the conventional grid is struggling to keep up, further affecting the progress of grid modernizations. The development of SG yields many risks that are associated with reliability, efficiency, environmental, financial, security, consumer and other issues. Specifically with ADO deployment, risks mainly exist in the following categories:

Reliability: Although one of the objectives of ADO deployment is to improve system reliability, with the comprehensive implementation of various ADO technologies, applications and solutions, it is uncertain to claim that the reliability of the grid will improve, or in the even worse situation that the massive implementation and the overemphasis on new technologies will become a potential risk causing future instability and uncontrollability.

Efficiency: the energy efficiency has always been an important issue considered during the grid advancement. Obviously there are terrific opportunities for improvement to lower demand and save energy. The risks associated with distribution system improvement by employing ADO functions may be in coexistence with other risks.

Future technology compatibility: ADO deployment involves massive implementation of software, hardware and electronic equipment based on current technology. The market becomes vender-driven and nobody can guarantee that their technology will be compatible and interoperable in the future with newer technology. Finding a way of using future compatible technology is a big concern for decision making, otherwise, it will be a huge waste of investment.

Uncertainty on return on investment (ROI) for utilities: distribution automation (DA) technologies are commercially available for wide scale utility deployment. The key is identifying and unlocking the values which provide the best ROI in ways that can be measured by utilities. It remains the fact that nobody can guarantee that it will achieve considerable ROI from ADO implementations.

Cyber security: briefly speaking, the more extensive the ADO deployment is, the more risks associated with cyber security are. How safe and secure the cyber data and information is kept, and how well the standards are established and executed remains questions.

BARRIERS TO AMI DEPLOYMENTS

The progress for each infrastructure area is impacted by a number of barriers. These barriers need to be identified up-front if progresses need to be made. Some of the barriers are common to the whole industry. Others may be unique to a specific utility or region which may depend on the current state of grid modernization. They may come from various perspectives, including management reformation, regulatory policy changes, consumer attitudes and acceptance, financial issues, technical barriers and others. Most of the barriers will have impacts on more than one infrastructure area. Metrics should be developed to monitor progress for each infrastructure area to ensure the impacts of barriers are minimized.

Obviously, there have always been technological and technical barriers in any science and engineering projects. Those barriers associated with ADO deployment will mostly be attached to hardware equipment, smart sensors, IEDs, databases, monitoring systems, communication networks, standards, interoperability and cyber security issues.

Regulatory barriers may include those policies that will cause unwillingness or little incentive for utilities to invest in and deploy ADO functions. The future compatibility of technologies and cyber security issues will always be major concerns by the government and grid regulators. In addition, the current recession of economics should also be a factor when considering major capital investment.

ADO DEPLOYMENT EXPERIENCES

Current experience of ADO development, mainly associated with distribution utilities, such as DMS, ADA, distribution SCADA, DER, etc. can be found all over the world. Here we briefly identify some of those real-world pilot projects (In no particular order) as representatives for demonstration [10].

The City Public Service (CPS) of San Antonio, Texas

CPS is undertaking a system-wide DA project using telecommunications networking and integrated technology. This project includes the DA pilot project, consisting of the design, specification, and implementation of automated switches, voltage regulators, capacitor bank switches, reclosers, LTC controllers, and substation RTUs, The communication protocol for interacting with all of these IEDs is the Utility Communications Architecture (UCA) for substations and feeders.

The Jacksonville Electric Authority (JEA), Florida and the Oklahoma Gas and Electric Company (OGE), Oklahoma

Both projects consist of a DA and telecommunications project. The primary objective is to develop a comprehensive DA system and a two-way telecommunications system. Analytic models of both distribution systems for the situations before-DA and after-DA are created, demonstrating the improvement of operations due to DA and thorough costs and benefits analyses are performed.

Omaha Public Power District (OPPD), Nebraska

An Automation Plan for OPPD is developed, covering several issues such as DA, SA, AMR, SCADA/EMS requirements, integration standards, and communication protocols. Specific recommendations for ADO on issues such as DAC, DA cost-benefit analysis and DER are provided.

BC Hydro, British Columbia, Canada

The Window 2000 DA Project is aimed at automating the entire B.C. Hydro distribution system in its several networked operating regions, performing the following tasks: system-wide cost-benefit study, distribution operation and control review, pilot project data architecture, telecommunications and SCADA systems, and integrated load control.

Progress Energy Florida (PE-F), Florida and Progress Energy Carolina (PE-C), North and South Carolina

A DA Pilot Project is conducted by modeling the distribution systems of PE-F and PE-C both before and after the implementation of DA. The comparisons of these two models demonstrate the improvement in operations and allow detailed analyses of cost-benefit.

Tenaga National Berhad (TNB), Malaysia

A system-wide DA project is planned and specified by performing a feasibility study on ADA functions, including distribution SCADA, voltage regulators and substations, OMS, substation and maintenance management, and VVC.

China Light & Power Company (CLP), China

CLP has initiated a ten-year DA project, with the primary goals of lowering costs and achieving higher availability and reliability of electrical power provided to customers. A master plan for DA and telecommunication systems is prepared, providing details of the management planning process and a schedule of costs, staffing requirements, and budget. CLP's DA project design focuses on the following major functional objectives: DMS/ SCADA, FLIR, SA, DOMA, VVC, distributed computing, and digital wide-area telecommunications.

The Manila Electric Company (Meralco), Philippines

Meralco project consists of a strategic plan on DMS, telecommunication systems, and SCADA/EMS study. Meralco initiated the DA project with the goal of improving the reliability of service.

Georgia Power Company (GPC), Atlanta, Georgia

The GPC pilot Project is carried out as a study for DMS and telecommunication systems. Detailed models of the pilot distribution systems are developed, and VVC functions are simulated by using these models to study the costs and benefits given various objectives. A feasibility study on power equipment is also conducted.

Hawaiian Electric Company (HECO), Hawaii

A DMS feasibility study for HECO is performed with main objectives of identifying and analyzing DA functions associated with a cost-benefit analysis, recommending specific DA functions and a telecommunication infrastructure to support the recommended DA functions, and suggesting an implementation plan.

Northern States Power (NSP), Minnesota

The NSP project is composed of DA and a volt/VAR optimization pilot, with a high-level cost-benefit study of DA.

Duke Energy (DUKE), Ohio, Indiana, and Kentucky

The Comprehensive grid modernization project for DUKE’s Midwest electric systems, encompassing the state of Ohio, Indiana, and Kentucky. It includes installing open, interoperable, two-way communications networks, deploying smart meters, automating advanced distribution applications, developing dynamic pricing programs, and supporting the deployment of plug-in EVs [11].

American Electric Power (AEP), Ohio, Texas

THE AEP's overall gridSMART^{SM} demonstration project initiative enables multiple SG applications over a unified network, including DA, home area networking (HAN) and AMI. Through gridSMART^{SM}, AEP will upgrade its existing energy infrastructure using SG technologies and consumer programs. This transition is intended to empower consumers, reduce operational costs and enable new technologies, such as smart appliances, home automation, PHEV and the integration of renewable energy like wind and solar power onto the grid. The DA and SG initiatives at AEP currently have over 30 projects managed by its own operating companies at different service territories [12].

In addition, a key component to successful analysis of ADO deployment experience is to communicate with electric utilities in Kentucky regarding their ADO deployment in state or other regions of the country. An associated assessment survey on ADO will be provided in conjunction with this report. Materials and responses regarding these projects, and proposed rollouts within Kentucky will be reviewed and assessed by the SG roadmap research team.

ADO VENDORS

In today's power market, power products designed and manufactured by different vendors are the key components of distribution systems. They are the main enablers for ADO functions, applications, and technologies. There is a wide selection of products in the power industry, especially used in distribution systems, including meters, transformers, switches, circuit breakers, capacitors, power electronics, voltage regulators, cables, relays, and more.

In this section, we briefly look for some major vendors (In no particular order) associated with their products and services in the SG infrastructure area of ADO in the market, only for illustrative purposes, and not intend to make suggestions or recommendations.

ABB [13] is one of the largest engineering companies, specialized in power and automation technologies, providing utilities, industries and other groups with access to a rich portfolio of power products. Such products are divided by:

- High voltage products & systems, offering capacitors and filters, switchgears and modules, circuit breakers, instrument transformers, and surge arresters.
- Medium voltage products & systems, offering circuit breakers, contactors, E-Houses, fuses and cutouts, OEM switchgear, surge arresters, switchgear and motor control, compact secondary substations, distributed energy storage modules, fault current limitation & arc protection, instrument transformers & sensors, reclosers & sectionalizers, smart voltage components, switches & disconnectors, vacuum interrupters & poles.
- Low voltage products & systems, offering automation controls, circuit breakers, contactors, control relays, current monitors, disconnect switches, electronic relays, industrial controls, liquid level monitors, motor starters, phase voltage monitors, pilot devices, safety devices, softstarters, terminal blocks, and timers.
- Transformer products, offering both dry-type and liquid-filled transformers.

Siemens [14] is a global powerhouse in electronics and electrical engineering, and operates in the industry, energy and healthcare sectors. Power distribution products and solutions offered by Siemens include: access/power monitoring, medium voltage switchgear, busway, motor control centers, circuit breakers, panelboards, controls, switchboards, critical power switches, lighting control, surge protection, low voltage switchgear, and transformers.

Schneider Electric [15] is a global specialist in energy management, with solutions for power and control, critical power, energy efficiency, automation and renewable energy. Schneider Electric offers various products and services in the electric distribution sector, such as busway & cable management, capacitors, inductances & harmonic filters, circuit breakers & switches, contactors & protection relays, energy management services, fuse switches, industrial plugs and sockets, insulation monitors, panelboards & switchboards, power & energy monitoring system, signaling units, software, and surge arresters.

GE [16] is a global conglomerate corporation, dedicated to innovation in energy, health, transportation and infrastructure. The electrical distribution products and services offered by GE

Energy Industrial Solutions include: arc flash solutions, arresters, automatic transfer switches, busway, capacitors, circuit breakers, communications & networking, contactors, conversion kits and trip units, drives, lighting control, load centers, metering, modular metering, motor control centers, motors, panelboards, power equipment buildings, push buttons & pilot devices, reactors, relays & timers – control, relays – protective, resistors, solenoids & limit switches, starters, surge suppression, switchboards, switches & disconnects, switchgear, terminal blocks, transformers, uninterruptible power supplies, ventilation fans, and voltage regulators.

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Chapter 5: Overview of Advanced Distribution Operations in the Commonwealth of Kentucky

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ABSTRACT

The "Overview of Advanced Distribution Operations in the Commonwealth of Kentucky" report presents a summary of the current state of ADO deployments and capabilities within the electric utilities of Kentucky. It is a thorough technology assessment, and provides details to support the documents "Overview of Smart Grid Deployments in the Commonwealth of Kentucky" and "Overview of Advanced Metering Infrastructure in the Commonwealth of Kentucky".

The data presented in this report was gathered using the "ADO Deployment Survey for Jurisdictional Utilities" (ADO Survey). The ADO Survey gathered utility deployment data in 4 areas: Distribution Operation Modeling and Analysis, Fault Location, Isolation and Service Restoration, Data Acquisition and Control, and Volt/VAR Control. Additionally, system cost, savings, and benefits were reported.

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INTRODUCTION

ABOUT THIS DOCUMENT

The Kentucky Public Service Commission, the University of Louisville, and the University of Kentucky have partnered under the "Kentucky Smart Grid Roadmap Initiative" (KSGRI) to develop a technical roadmap for the development and deployment of smart grid technologies throughout the Commonwealth. This "Kentucky Smart Grid Roadmap" will provide recommendations and best practices to utilities and utility stakeholders to guide individual smart grid deployment approaches. More information regarding the work of the KSGRI is located in the documents *The Kentucky Smart Grid Roadmap Initiative: Smart Grid Road Map Work Plan*, *The Kentucky Smart Grid Roadmap Initiative: Kentucky Smart Grid Assessment Model*, *The Kentucky Smart Grid Roadmap Initiative: Overview of Smart Grid Deployments in the Commonwealth of Kentucky*, and *The Kentucky Smart Grid Roadmap Initiative: Overview of Advanced Metering Infrastructure in the Commonwealth of Kentucky*.

The purpose of this document is to summarize the results of the ADO Deployment Survey for Jurisdictional Utilities, in fulfillment of Work Plan Goals 4 of *Smart Grid Road Map Work Plan*. The ADO Survey was distributed to 23 jurisdictional electric utilities to develop an understanding of the "As-is" state of the electric power grid in Kentucky, focusing on the status of modernization of the electric distribution system. Data collected from jurisdictional utilities was via self-reporting by a Smart Grid Contact person from each utility.

DOCUMENT OVERVIEW

The following section is an executive summary of the entire report, highlighting important details of the ADO Survey. Detailed summaries are then provided in subsequent sections for each of the following areas: Distribution Operation Modeling and Analysis, Fault Location, Isolation and Service Restoration, Data Acquisition and Control, and Volt/VAR Control, Costs, Savings, and Benefits. The report concludes by presenting feedback from the participating utilities.

Executive Summary

Distribution Operation Modeling and Analysis

The utilization of real time data from the distribution system to perform distribution system analysis and modeling in Kentucky is currently only being evaluated in one pilot project. Two utilities have reported plans for near term deployments (<5 years). Most utilities do utilize DOMA for offline modeling to calculate "what-if" power flow values, and these practices are well established within the industry. However, few utilities extend the DOMA analysis to the transmission and/or sub-transmission systems. Additionally, few utilities utilize a wide range of data sources within their DOMA models, with most utilizing only three of the eight indicated sources.

Fault Location, Isolation, and Service Restoration

Three utilities operate Fault Location, Isolation, and Service Restoration pilot projects, with one utility indicated planning to implement FLIR as part of future Distribution Management System upgrade. Currently, overall penetration rates are low (<4%). All three pilot systems are capable of performing automatic location, isolation, and restoration of faulted circuits, and are operated in the closed loop mode. The FLIR data sources utilized in these programs come only from SCADA systems and do not interact with other advanced data sources.

Data Acquisition and Control

Ten of the responding utilities report utilization of distribution level DAC for data retrieval and control commands issued to power system equipment and devices in the field, largely identified as a component of distribution level SCADA systems. Penetration rates of DAC vary widely across the state, raging to 0% of distribution level substations to 100%. One utility has extended the use of DAC to facilitate monitoring control of distributed generation and microgrids.

Volt/VAR

No utilities reported utilization of Volt/VAR. Two utilities have indicated planned Volt/VAR pilots.

Costs

Total capital costs related to the 5 reported DO deployments were $115,550,000. Capital costs ranged from $150,000 to $108,400,000, with an average of $23,110,000. The majority (59.75%) of capital costs were related to the procurement of endpoint hardware. Total annual O&M costs are $19,699,392 and the average per utility was calculated at $3,939,878.

Savings

No significant analysis of potential savings due to ADO deployments was reported by utilities.

Benefits

No utilities reported an evaluation of non-monetary benefits due to ADO deployments.

LIST OF PARTICIPATING UTILITIES

Jackson Purchase Energy
Big Sandy RECC
Bluegrass Energy Cooperative
Cumberland Valley Electric
Farmers RECC
Fleming Mason Energy
Grayson RECC
Jackson Energy Cooperative
Nolin RECC
Owen Electric Cooperative Corporation
Salt River Electric Cooperative Corporation
Shelby Energy
Taylor RECC
Duke Energy
East Kentucky Power Cooperative (G&T Only)
Kentucky Power Company
Louisville Gas & Electric and Kentucky Utilities

SUMMARY OF THE ADO SYSTEM ASSESSMENT SURVEY

INTRODUCTION

The ADO Deployment Survey for Jurisdictional Utilities (AMI Survey) was completed by 17 jurisdictional utilities. The System Assessment portion of the ADO Survey collected information regarding Distribution Operation Modeling and Analysis, Fault Location, Isolation and Service Restoration, Data Acquisition and Control, and Volt/VAR Control. The following section summarizes the collected responses to the ADO System Assessment Survey.

DISTRIBUTION OPERATION MODELING AND ANALYSIS

DOMA Utilization

Currently, only Owen Electric Cooperative Corporation performs distribution system analysis and modeling based on dynamically changing distribution operating conditions. This implementation is part of a pilot project that covers a portion of a circuit (<1% of the distribution circuits). This R&D project utilizes data from CG Automation SCADA system, a Cooper Industries AMI system, and Outage Management Software from Milsoft Utility Solutions. Currently, the pilot performs real-time power flow calculations, with plans to implement look-ahead power calculations if more advanced AMI and Wide Area Communications systems are also implemented. Owen Electric did not report on the DOMA sub-functions supported by their pilot project. Two additional utilities (Duke Energy and Kentucky Power Company) have indicated plans to make investments in this area in the near term.

DOMA Sub-Functions

11 utilities (including Owen Electric) reported utilizing Distribution Modeling and Analysis software in an "offline" mode that does not utilize dynamically changing distribution operating conditions to perform "what if" power flow calculations. The following table summarizes the supported sub-functions.

# of Utilities with Supported DOMA Sub Functions	
SUB FUNCTION	# UTILITIES SUPPORTING
Modeling of impacts of the low-voltage distribution system on transmission/sub-transmission	2
Modeling of distribution circuit connectivity	6
Data Management between legacy databases	6
Modeling of distribution nodal loads for kW	5
Modeling of distribution nodal loads for kVA	5
Modeling of distribution circuit facilities	5
Distribution power flow	5
Evaluation of transfer capacity of tie switches	5
Power quality analysis	3
Loss analysis	5
Fault analysis	6
Evaluation of operating conditions	3

*Note: Not all utilities reporting the utilization of "what-if" static distribution modeling and analysis reported supported sub functions.

DOMA Vendors
Nine or the responding utilities utilize Milsoft Windmil for Distribution System Modeling and Analysis. One uses Alstom and one uses Stoner Software.

DOMA Data Sources
The following table summarizes the data sources and/or database types that input for the DOMA models are sourced from.

Sources of Data for	
DATA SOURCE	UTILITY COUNT
SCADA	6
GIS	9
Distribution System Models	3
AMI Data	6
Customer EMS	1
Weather	2
Outage Management System	1
Consumer Information System	1

FAULT LOCATION, ISOLATION, AND SERVICE RESTORATION

FLIR Utilization
Of the responding utilities, 3 operate Fault Location, Isolation, and Service Restoration. Additionally, one utility indicated plans to implement FLIR as part of future Distribution Management System upgrade. All three of the systems are capable of performing automatic location, isolation, and restoration of faulted circuits. In all cases the FLIR systems operate in a closed loop mode in which the FLIR generates a switching order for remotely-controlled switching devices and auto-executes switches via a SCADA system.

FLIR Data Sources
The following table summarizes the data sources and/or database types that are utilized as input to the FLIR system.

Sources of Data for	
DATA SOURCE	UTILITY COUNT
SCADA	3
Trouble Call System	0
On Fault Location Devices	0
Smart Meters	0
Customer EMS	0
Fault Predictors	0

FLIR Penetration Rates

Reported FLIR penetration rates (% of circuits served by FLIR) are <1%, 1%, and 4%. Salt River RECC indicates a current rollout of FLIR that when complete will effect up to 40% of their distribution system.

FLIR Vendors
Two of the utilities utilize FLIR systems provided by S&C Electric (Kentucky Power Company and Salt River RECC). Owen Electric Cooperative Corporation utilizes a system provided by Cooper Power Systems. Duke Energy reports plans to install FLIR provided by Cooper Power Systems as part of their 2012 DMS upgrade.

DATA ACQUISITION AND CONTROL

DAC Utilization
Ten of the responding utilities report utilization of distribution level DAC for data retrieval and control commands issued to power system equipment and devices in the field. The following table is a summary of the utilization of DAC to directly control field power equipment by type.

Utilization of DAC for Power Equipment Control	
DEVICE TYPE	UTILITY COUNT
Intelligent Energy Device	6
Remote Terminal Unit	9
Other Microprocessor Based Controller	6

Of those utilities that utilize DAC to directly monitor and control local IEDs, 3 extend this capability to facilitate local interaction amongst IEDS to only respond to local situations. The communication channels utilized to achieve local IED interaction are: cellular, 900 MHz Radio, fiber, and telephone.

Additional DAC Functions
Two utilities report utilizing DAC through Computerized Field Systems Monitoring and Control in which the monitoring and control of field equipment is performed via a data concentrator, substation master, or Automated Control and Data Acquisition (ACADA). These systems are more generalized than IEDs or controllers, and usually monitor and/or control more than one power system device. One utility reports the utilization of DAC to support DER management to perform monitoring and control of a DER device. 10 utilities report utilizing DAC as part of their SCADA Systems

DAC Penetration Rates
Seven utilities reported DAC penetration rates. All of these reported percentage of substations equipped with distribution level SCADA. Four reported 100% penetration at the substation level, and one each reported 85%, 45%, and 30%.

DAC Vendors
The following table summarizes the vendors of the installed DAQ systems.

DAC Vendors by Utility	
DAC Vendor	Utility Count
CG Automation (Formerly QEI)	4
Alstom	1
ABB	2
Harris	1
Advanced Computer Systems	1

Volt/VAR Control

Volt/VAR Utilization
No utilities reported utilization of Volt/VAR. Owen Electric and Duke Energy both reported a planned Volt/VAR pilot, but did not provided further information.

ADO Integration with Distributed Energy Resources

Microgrid Integration
Duke Energy reported utilizing DAC to facilitate the control of two distributed energy storage systems (DESS) that meet the definition of a microgrid. The DAC is used to observe DESS alarms and to control remote devices.

Renewable Energy Resource Integration
Duke Energy reported utilizing DAC to facilitate the integration of a large PV installation connected to a distribution circuit. The information collected via DAC from the PV installation is used to coordinate the use of an energy storage system.

Electric Vehicle Integration
No utilities reported the utilization of DAC to facilitate electric vehicle charging.

ADO Integration with Advanced Metering Infrastructure

No utilities reported any interaction between their AMI level systems and their distribution level systems.

SUMMARY OF THE ADO COST AND BENEFIT SURVEY

INTRODUCTION

The Cost and Benefit portion of the ADO Survey (ADO Survey) was completed by 5 of the jurisdictional utilities. It collected information regarding installation and operation & maintenance costs, savings enabled by ADO, and ancillary benefits of ADO installations. The following section summarizes the collected responses to the ADO Cost and Benefit Survey.

COSTS

Capital Costs of ADO Deployments

Total capital costs related to the 5 reported ADO deployments were $115,550,000. Capital costs ranged from $150,000 to $108,400,000, with an average of $23,110,000. The following table provided a breakdown of ADO infrastructure capital costs by type.

Percentage of ADO Capital Costs by Category			
CATEGORY	MIN %	MAX %	AVERAGE %
Endpoint Hardware	45	92	59.75
Network Hardware	2	25	17.5
Installation	4	20	11.25
Project Management	1	10	4.75
IT	1	10	6.5

Operation and Maintenance Costs of ADO Deployments

Total annual Operations and Maintenance (O&M) costs were reported by 5 utilities. Total annual O&M costs are $19,699,392. The minimum yearly figure was $1,000, the max $10,700,000, and the average $3,939,878. The following table provides a breakdown of O&M costs by category.

Percentage of ADO O&M Costs by Category			
CATEGORY	MIN %	MAX %	AVERAGE %
DOMA	.11	20	7.78
FLIR	.09	85	41
DAC	5	20	11.3
Volt/VAR	0	58	19.7
Other	0	12	4

SAVINGS

Efficiency Savings

No utilities reported any significant savings in energy efficiency due to ADO deployments. Bluegrass Energy Cooperative reported and estimated savings of $132,000 for Volt/VAR implementation.

Outage Response Savings
No utilities reported any significant savings in outage response due to ADO deployments. Bluegrass Energy Cooperative reported and estimated savings of $132,000 for Volt/VAR implementation.

BENEFIT EVALUATION

One utility, Big Sandy RECC, performed the benefit evaluation for ADO deployment. Big Sandy RECC indicate that ADO distribution benefits had been evaluated for the categories of: Outage Management: Customer satisfaction due to improved system management, and Outage Management: Customer Satisfaction due to informed customer service representatives.

FEEDBACK SUMMARY

INTRODUCTION
Responding utilities were encouraged to provide feedback to be included in the ADOI report. This section summarizes those responses.

GRAYSON RECC
Grayson Rural Electric has not advanced to the technologies that allow for system automation. We are resource limited causing advancement in these areas to be slow.

LOUISVILLE GAS AND ELECTRIC
LG&E/KU continues to monitor and research emerging Smart Grid technologies such that investments occur at the speed of value. Smart Grid technologies are analyzed utilizing historical investment methods to determine when value will be achieved and thus directing the future state of Smart Grid.

SHELBY ENERGY
Shelby Energy has recently deployed an AMI system and GIS system. Shelby Energy's SCADA system has been deployed for approximately 12 years.

Chapter 7: Advanced Transmission Operations Overview

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INTRODUCTION

The Kentucky Public Service Commission, the University of Louisville, and the University of Kentucky have partnered to develop a technical roadmap for the development and deployment of Smart Grid technologies throughout the Commonwealth. This "Kentucky Smart Grid Roadmap" will provide recommendations and best practices to utilities and utility stakeholders to guide individual Smart Grid deployment approaches.

The purpose of this document is 1) the analysis of: Advanced Transmission Operation systems, key enabling technologies and functionalities, applicable standards, the deployment benefits and other issues associated with the deployment, and 2) served as a companion document of the KSGRI ATO Deployment Survey for the evaluation of ATO deployment by jurisdictional utilities in Kentucky. These purposes are in fulfillment of KSGRI Work plan Goal #7.

OVERVIEW OF ATO

ATO (Advanced Transmission Operations) improves transmission reliability, utilization, and efficiency. ATO also manages congestion, scheduling, and planning for the power transmission system. In addition, ATO integrates certain aspects of distribution system operations with transmission operations. ATO includes substation automation, advanced and automated protection and control, modeling, contingency analysis, wide area monitoring and control, simulation and visualization tools, advanced grid control devices and materials, and the integration of all these tools with markets and Regional Transmission Organization (RTO) as well as Independent System Operators (ISO) operations and planning functions. Like AMI (Advanced Metering Infrastructure), we refer to ATO as a Smart Grid key infrastructure area, as opposed to a specific technology.

The purpose of transmission systems is to provide secure and efficient operating conditions when the power system is in normal operations, and to minimize the loss to the customers and the system components when the system is under emergency. The transmission area of concentration focuses primarily on real-time network analysis under normal or emergency operations of the transmission grid.

With Smart Grid concepts, technologies and applications widely penetrate into the power systems, ATO will become an important backbone for the realization of the future grid. In this brief overview report, we will analyze enabling technologies classified by different functionalities, and then discuss various aspects associated with ATO development, such as applicable standards, cyber security issues, development benefits and experiences.

ATO Technology Options

Automated Control Baseline

Transmission Automated Control (Baseline) describes a set of functions that are typically automated within a substation, but are not directly associated with protection, fault handling, or equipment maintenance. In general, they serve to optimize the operation of the power system and ensure its safe operation by preventing manually generated faults.

These functions include:

- **System voltage regulation by changing transformer taps**

  In voltage regulation, the automation system ensures a constant voltage on the substation bus by adjusting the tap of one or more transformers. This can be done by monitoring IED and computerized logic control.

- **Voltage and reactive load control by adjusting capacitor banks**

  In capacitor bank control, the automation system optimizes the voltage and reactive load on a line or bus by switching on or off one or more capacitor banks. It prevents the imaginary part of the load from becoming too large, which will reduce voltage and the efficiency of the system. The banks may be widely located across the power system, or within a substation. The function uses wide area monitoring and logic control.

- **Interlocking of controls**

  Interlocking prevents unsafe operation of the various switches and breakers within a substation. Suppose an Operator or software application attempts to operate a control, the automation system evaluates the state of the entire system and may reject the control request based on pre-programmed logic. This function emphasizes the importance of system reliability and redundancy.

- **Sequencing controls to ensure safe operation**

  Sequenced controls automate some portion of the operator’s tasks to eliminate the possibility of an invalid control being issued.

- **Load balancing**

  Load balancing is typically an operation performed between two transformers within a substation, but may also be performed in transmission systems between substations. The proportion of load on each line or feeder may be balanced in order to reduce system wear and resistive losses

- **Automated system restoration**

Substation computers control the switches and breakers based on information from monitoring IEDs when a fault occurs, while utilities may still require an operator approve the decision. Automated service restoration is typically a distribution operation, but may be performed between substations.

Emergency Control Baseline

Emergency operations are organizational sequences of activities that involve multiple integrated actors exchanging information when a fault is detected on a power system. These activities are integrated through the use of Wide Area Control and Monitoring Systems (WAMACS) that provide operational control over the distributed network of actors that comprise the SCADA system. Each utility maintains own WAMACS but in the future these systems must be linked to provide overall control and monitoring across multiple organizations to meet the future demands of the suppliers and users of electrical power.

The purpose of the WAMACS - Emergency Operations function is to provide communications services permitting an operator to take the following actions in response to a fault in the power system:

- Locate the fault
- Verify that protection has operated correctly to clear the fault
- Shed load to ensure that the fault does not cause an overload of unaffected lines
- Manually re-route power to restore service
- Dispatch crews and emergency teams to fix the fault
- Capture fault recordings to analyze the cause of the fault later

Transmission System Contingency Analysis

Contingency Analysis (CA) is a "what if" scenario simulator that evaluates, provides and prioritizes the impacts on an electric power system when problems occur. Contingency Analysis is essentially a "preview" analysis tool. It simulates and quantifies the results of problems that could occur in the power system in the immediate future.

CA is used as a study tool for the off-line analysis of contingency events, and as an on-line tool to show operators what would be the effects of future outages. This allows operators to be better prepared to react to outages by using pre-planned recovery scenarios.

Contingency Analysis (CA) is one of the "security analysis" applications in a power utility control center that differentiates an Energy Management System (EMS) from a less complex SCADA system. Its purpose is to analyze the power system in order to identify the overloads and problems that can occur due to a "contingency". A contingency is the failure or loss of an element (e.g. generator, transformer, transmission line, etc.), or a change of state of a device (e.g. the unplanned opening of a circuit breaker in a transformer substation) in the power system. Therefore contingency analysis is an application that uses a computer simulation to evaluate the effects of removing individual elements from a power system.

Current electric utility operating policies (such as NERC's) require that each utility's power system must be able to withstand and recover from any "first contingency" or any single failure.

Future policies may extend this to withstanding a "second contingency" or any subsequent single failure. Therefore contingency analysis is one of the tools used primarily by power system planners and engineers to "test" the power system (using a software model) for its strengths and weaknesses, and for compliance with the operating policies. CA has always been an important part of electric utility system planning and operations, even before there were computers to assist the analysis, when manual calculations were used.

CA is a primary tool used for preparation of the annual maintenance plan and the corresponding outage schedule for the power system. This outage schedule requires modification to reflect changes in the operating conditions over time, and so CA is used repeatedly to refine the schedule of planned outages, for long term and short term planning

Wide Area Monitoring and Control Advanced Auto Restoration

The purpose of advanced auto-restoration is to automatically restore power to un-faulted sections of a line or feeder, after a fault is isolated, in networks having complex topologies and multiple organizational boundaries.

Currently, automatic restoration of service is performed only within a restricted set of conditions and network topologies. In the near future, it is expected that these restrictions will be removed and the automation system will be able to restore power in systems.

Performing advanced auto restoration will require the following measures beyond those required for existing auto-restoration mechanisms:

- Real-time sharing of data between Substation Computers
- Calculation of loads on each feeder or line section, and storing these recent historical values in the Substation Computer.
- More advanced logic in each Substation Computer to evaluate each possible switching action
- Reliable communications between neighboring operators

System-wide Automated Voltage Control

Perform wide-area voltage control through closed loop control by measuring the wide area voltages, computing a control solution, and effecting wide area control

System wide voltage and subsequent power flow can be optimized by looking at the voltage profile for a large segment of the power grid.

Synchro-Phasor

This system provides synchronized and time-stamped voltage and current phasor measurements to any protection, control, or monitoring function that requires measurements from different locations. This is an extension of single phasor measurements, commonly made with respect to a local reference. The concept behind this system is the system wide synchronization of measurement sampling clocks to a common time reference.

In addition to providing synchronized measurements, the synchro-phasor system distributes the measurements where voltage and currents are measured at many buses throughout the power grid.

Self-Healing Grid

The objective of the Self-Healing Grid (SHG) applications is to evaluate power system behavior in real-time, prepare the power system for withstanding credible combinations of contingencies, prevent wide-area blackouts, and accommodate fast recovery from emergency state to normal state.

The SHG function comprises a set of computing applications for information gathering, modeling, decision-making, and controlling actions. These applications reside in central and/or in widely distributed systems, such as relay protection, remedial automation schemes (RAS), local controllers, and other distributed intelligence systems. All these applications and system components operate in a coordinated manner and are adaptive to the actual situations.

The conventional methodology for emergency control is based on off-line studies for selection of the local emergency automation schemes, their locations, and their settings.

The SHG will be supported by fast data acquisition systems (Wide Area Measurement Systems and SCADA) and will include fast simulation and decision-making applications observing wide power system areas. These wide-area applications will coordinate the behavior of distributed control systems (regional EMS, DMS, Plant EMS, RAS, and relay protection).

The future control system for the self-healing grid will differ from the current approaches by implementing significantly more automated controls instead of supervisory controls by the operators and by aiming at preservation of adequate integrity of the generation-transmission-distribution-customer system instead of self-protection of equipment only.

ATO Standards and Regulations

Various guidelines, compliances and industry standards applicable to different areas of ATO deployment and development have been established by several organizations, including National Institute of Standards and Technology (NIST), Federal Energy Regulatory Commission (FERC), North American Electric Reliability Corporation (NERC), U.S. Department of Energy (DOE), U.S. Department of Homeland Security (DHS), Institute of Electrical and Electronics Engineers (IEEE), and North American Energy Standards Board (NAESB). Here we briefly identify some of those guidelines and industry standards that are involved in ATO.

Summary of Use, Application, Cyber Security, and Functionality of Smart Grid Interoperability Standards Identified, a series of standards released by NIST in 2010, including IEC 61970, IEC 61850, IEC 61870, IEC 62351, and IEC 60870.

NIST Framework and Roadmap for Smart Grid Interoperability Standards, considering DR and consumer energy efficiency, wide-area situational awareness, energy storage, electric transportation, cyber security, and network communications.

Guideline for Smart Grid Cyber Security, a companion document to the NIST Framework and Roadmap for SG Interoperability Standards, is intended primarily for individuals and organizations responsible for addressing cyber security for SG systems and subsystems of hardware and software components.

NERC-Critical Infrastructure Protection (CIP) Standards, an assembly of several necessary documentations approved by Federal Energy Regulatory Commission (FERC) with the intent of the proposed cyber security standards is to ensure that all entities responsible for the reliability of the bulk electric systems in North America identify and protect critical cyber assets that control or could impact the reliability of the bulk electric systems.

Open Access Transmission Tariff (OATT) Reform, issued by FERC which required public utilities to provide open access transmission service on a comparable basis to the transmission service they provide themselves.

IEEE has hundreds of standards and standards in development relevant to SG in the transmission system area.

Critical Infrastructure and Key Resources Energy Sector-Specific Plan to the National Infrastructure Protection Plan, issued by U.S. Department of Homeland Security and U.S. Department of Energy

ATO AND CYBER SECURITY

Cyber Security utilizes a series of computer technology as applied to computers and networks, protecting computer- and internet-based information by preventing, detecting, and responding to attacks. The objective of cyber security includes protection of information and property from theft, corruption, or natural disaster, while allowing the information and property to remain accessible and productive to its intended users.

Today’s power transmission systems in Smart Grid environment are undergoing immense changes. Generally, cyber security issues in ATO include all information and communications that affect the operation of transmission systems. As the electric grid is modernizing, it is becoming highly automated and full of information and data that are exposed for intrusions, treats and attacks. In a sense, cyber network of the grid can be considered as another vital infrastructure ensuring the safe and reliable delivery of electricity. It is indispensable for the grid operators, managers, and regulators to attach great importance to cyber security area.

Cyber security could have been ensured by taking the following actions effectively:

Prevention: take actions and measures for the continuous assessment and readiness of necessary actions to reduce the risk of threats and vulnerabilities, to intervene and stop an incident, or to mitigate negative effects. It is highly effective to establish and implement preventive requirements and standards before malicious activities could take place.

Detection: find approaches to identify abnormal behaviors and discover intrusions; detect malicious code and other activities that can disrupt electric power grid operations. It requires the techniques for digital evidence gathering ability and the decision making process for judging whether there are attacks or data has been compromised.

Response: take accurate countermeasures in order to alert and stop counter-security activities immediately after the detection. In addition, find out and summarize the cause and document all the incidents after the cyber-attack, and upgrade system weak point to avoid similar future attacks.

Recovery: develop plans to figure out what data and information has been suffered from attacks, compromised or completely lost. The objective of this action is to recover as much data as possible and minimize the impact and loss resulted from cyber-attacks.

ATO Deployment Benefits

ATO concepts that increase the strategic value of the future power transmission systems with the integration of abundant functional applications and technological solutions, which will be developed to provide a number of benefits. Such benefits are summarized in Figure 1 below.

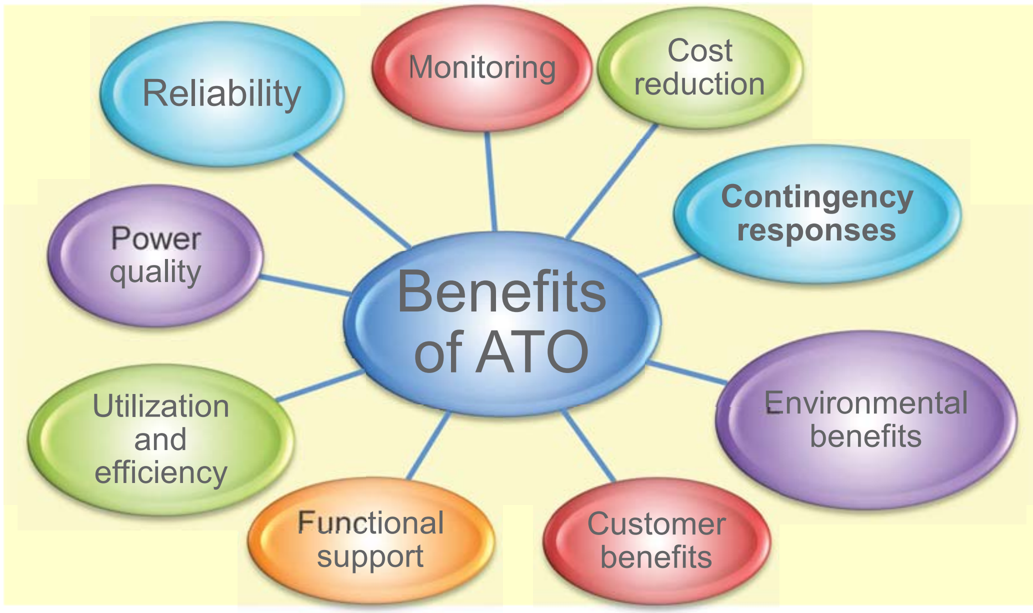

Figure 1. Benefits of ATO

Improved reliability and performance of transmission systems: one of the main benefits of ATO is to improve the system reliability by anticipating and responding promptly to system disturbances and faults with advanced wide area monitoring, preventing, mitigating or eliminating power blackouts and outages, operating resiliently against attacks and natural disasters.

Improved power quality: the implementation of ATO will provide better power quality; reduce losses caused by power quality issues

Increased utilization and efficiency of existing infrastructure: the new system concepts will enable more efficient operation of transmission systems, reducing energy losses and maximizing energy throughput.

Support all generation and storage options: ATO offers possibilities to accommodate various types of power generation, supports DER integration, and stimulates the development of energy storage systems.

More effective system monitoring: ATO enables more effective wide area monitoring and situational awareness by utilizing advanced sensing and measurement technologies in power transmission systems.

Reduced operating costs: with increased reliability, efficiency and power quality, the improved operations will reduce operating costs.

Enhanced contingency responses: contingency analysis provides not only computer simulations but also real-time grid information of power flow analysis under contingencies.

Increased customer service options and benefits: the deployment of ATO will enable better customer service and better fulfill customer demands.

Reduced environmental impact: ATO will result in reduction of greenhouse gas emission, facilitation of more effective land use and vegetation management, assurance of better natural environment and sustainable development.

ATO DEPLOYMENT EXPERIENCES

Transmission system technology development and deployment experiences with pilot programs and projects are ongoing rapidly all over the world. There are more than 50 types of transmission lines in use, with even more under R&D. The goals are to reduce line losses and faults, and improve overall grid awareness, reliability and efficiency. We briefly identify a series of notable Smart Grid technologies development and deployment experiences in the power transmission field in this section.

A new report from Pike Research suggests high-voltage direct current (HVDC) transmission will be a big growth in the expansion of the transmission system over the next five years. The transmission system is not ready yet but should be prepared for the Smart grid technologies and renewables

Transmission owners have already begun implementing advanced power electronic technologies for a variety of applications. These applications include dynamic reactive power and series compensation. One step further, they are implementing coordinated schemes using static and dynamic sources of reactive power to strengthen their systems and account for variable power flows that result from wind and solar penetration. KEMA is working with a major Texas transmission operator to implement a Dynamic Reactive Control System (DRCS) that will also realize benefits that include deferred capital, improved control, enhanced performance, efficiency and security, and better system reliability.

Developed by Hydro-Quebec, LineScout is a high-performance robot that uses inspection equipment and advanced technology to complete detailed inspection of energized transmission lines.

University of Houston mechanical engineering department is developing high-temperature superconducting wires that could drastically improve the electric grid's efficiency and reliability.

Midwest ISO will be the first regional transmission operator (RTO) to conduct a grid-scale synchrophasor deployment with assistance from a DOE Smart Grid stimulus grant. More than 150 synchrophasors, or PMUs, will be installed by transmission owners to more accurately measure voltage and current in the eastern interconnection.

There's a 33-mile under water transmission line that spans San Francisco Bay. There's another one in New Jersey and more ambitious underwater projects in process. While laying cable under water presents a unique set of challenges, public opposition to overhead lines and other issues have been blocks for integrating renewable energy with Smart Grid.

Electric Power Research Institute (EPRI) researchers have an ongoing effort to develop sensor technologies and the associated infrastructure to aid utilities in addressing the aging transmission fleet, as well as to increase the capacity of existing assets, and help develop the next generation of equipment and technologies.

Electric utilities have been pursuing fault current limiters (FCLs) have the potential to significantly alleviate power system stress in locations where fault current magnitudes are expected to increase beyond the ability of ordinary circuit breakers.

American Transmission Company (ATC) has won two DOE Recovery Act Smart Grid investment grants which will allow the utility to extend its use of PMUs for grid monitoring technology and the fiber optics communications technology.

PJM Interconnection, a RTO in the Eastern Interconnection, and 12 member transmission owners are deploying more than 80 additional synchrophasors to optimize the transmission system and its reliability. Supported by a $14 million DOE matching stimulus grant, the Smart Grid technology deployment will give grid operators much more information about the condition of the transmission grid and at a much faster rate.

EPRI is working with a number of leading utility organizations to explore needs and research gaps in the area of reducing transmission losses and improving transmission system's efficiency and ultimately helping reduce the carbon footprint.

Researchers at the FREEDM Systems Center on the North Carolina State University Centennial Campus have come up with what they call a "smart transformer", capable of managing electricity flow in both directions and interconnections with rooftop solar installations and plug-in EVs.

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Chapter 8: Overview of Advanced Transmission Operations in the Commonwealth of Kentucky

ABSTRACT

The "Overview of Advanced Transmission Operations in the Commonwealth of Kentucky" report presents a summary of the current state of ATO deployments and capabilities within the electric utilities of Kentucky. It is a thorough technology assessment, and provides details to support the documents "Overview of Smart Grid Deployments in the Commonwealth of Kentucky" , "Overview of Advanced Metering Infrastructure in the Commonwealth of Kentucky", and "Overview of Advanced Distribution Operations in the Commonwealth of Kentucky".

The data presented in this report was gathered using the "ATO Deployment Survey for Jurisdictional Utilities" (ATO Survey). The ATO Survey gathered utility deployment data in seven areas: Automated Control Baseline, Emergency Control Baseline, Transmission System Contingency Analysis, Wide Area Monitoring and Control Advanced Auto Restoration, Transmission System Automate Voltage Control, Synchrophasors, and Self-Healing Functionality. Additionally, system cost, savings, and benefits were reported.

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INTRODUCTION

ABOUT THIS DOCUMENT

The Kentucky Public Service Commission, the University of Louisville, and the University of Kentucky have partnered under the "Kentucky Smart Grid Roadmap Initiative" (KSGRI) to develop a technical roadmap for the development and deployment of smart grid technologies throughout the Commonwealth. This "Kentucky Smart Grid Roadmap" will provide recommendations and best practices to utilities and utility stakeholders to guide individual smart grid deployment approaches. More information regarding the work of the KSGRI is located in the documents *The Kentucky Smart Grid Roadmap Initiative: Smart Grid Road Map Work Plan*, *The Kentucky Smart Grid Roadmap Initiative: Kentucky Smart Grid Assessment Model*, *The Kentucky Smart Grid Roadmap Initiative: Overview of Smart Grid Deployments in the Commonwealth of Kentucky*, *The Kentucky Smart Grid Roadmap Initiative: Overview of Advanced Metering Infrastructure in the Commonwealth of Kentucky*, and *The Kentucky Smart Grid Roadmap Initiative: Overview of Advanced Distribution Operations in the Commonwealth of Kentucky*.

The purpose of this document is to summarize the results of the ATO Deployment Survey for Jurisdictional Utilities, in fulfillment of Work Plan Goals 4 of *Smart Grid Road Map Work Plan*. The ATO Survey was distributed to 23 jurisdictional electric utilities to develop an understanding of the "As-is" state of the electric power grid in Kentucky, focusing on the status of modernization of the electric transmission system. Data collected from jurisdictional utilities was via self-reporting by a Smart Grid Contact person from each utility.

DOCUMENT OVERVIEW

The following sections are detailed summaries of each of the following areas: Automated Control Baseline, Emergency Control Baseline, Transmission System Contingency Analysis, Wide Area Monitoring and Control Advanced Auto Restoration, Transmission System Automate Voltage Control, Synchro-Phasors, Self-Healing Functionality, Costs, Savings, and Benefits. The report concludes by presenting feedback from the participating utilities.

List of Participating Utilities

Big Rivers Electric Corporation
East Kentucky Power Cooperative
Kentucky Power Company
Louisville Gas & Electric and Kentucky Utilities

SUMMARY OF THE ATO SYSTEM ASSESSMENT SURVEY

INTRODUCTION

The ATO Deployment Survey for Jurisdictional Utilities (AMI Survey) was completed by four jurisdictional utilities. The System Assessment portion of the ATO Survey collected information regarding Automated Control Baseline, Emergency Control Baseline, Transmission System Contingency Analysis, Wide Area Monitoring and Control Advanced Auto Restoration, Transmission System Automate Voltage Control, Synchrophasors, and Self-Healing Functionality. The following section summarizes the collected responses to the ATO System Assessment Survey.

AUTOMATED CONTROL BASELINE

Automated Control of the baseline functions of the transmission are a set of functions that are automated within transmission substation to optimize the operation of the power system and ensure its safe operation by preventing manually generated faults.

System Voltage Regulation

In voltage regulation, the automation system ensures a constant voltage on the substation bus by adjusting the tap of one or more transformers. This function is automated on 100% of Big Rivers Electric Corporation substations. EKPC has manual autotransformers on all switching stations and 99.5% of substations have voltage regulators. No other utilities report automation of system voltage regulation functions.

Voltage and Reactive Load Control

In voltage and reactive load control, the automation system optimizes the voltage and reactive load on a line or bus by switching on or off one or more capacitor banks. East Kentucky Power Cooperative reports 100% of their 69 kV transmission system to be covered by auto-switched capacitor banks for load control. Kentucky Power operates a voltage and reactive load control system through the use of voltage controlled relays (no percentage of substations/circuits reported). Neither LG&E nor Big Rivers reported automation switching of capacitor banks for voltage and reactive load control. LG&E/KU did report 21% of substations to have capacitor banks installed.

Interlocking and Sequencing of Controls

Interlocking prevents unsafe operation of the various switches and breakers within a substation. via the computerized evaluation of the state of the entire system in response to the control. Only LG&E reported use of Interlocking controls, as a “small percentage”.

Sequenced controls automate some portion of the operator’s tasks to eliminate the possibility of an invalid control being issued. No utilities report the utilization of sequenced controls.

Load Balancing

Auto load balancing via the automatic adjustment of the proportion of load on each line or feeder in order to reduce system wear and resistive losses is enabled on 100% of circuits on both the Big Rivers and EKPC transmissions systems. EKPC indicates that this functions is achieved via and automatic generation control routine that is part of an Energy Management System.

Automated System Restoration
The use of substation computers to control the switches and breakers based on information from monitoring IEDs during fault occurrences was reported at 100% by Big Rivers, 90% by Kentucky Power, and 0% by EKPC and LG&E/KU.

Vendors
Vendors of the systems utilized in Kentucky include General Electric, ABB, McGraw, Beckwith, and Schweitzer.

Emergency Control Baseline

Emergency operations activities involve the exchange of information when a fault is detected on a power system. These activities are integrated through the use of Wide Area Control and Monitoring Systems (WAMACS) that provide operational control over the distributed network of actors that comprise the SCADA system. The following table summarizes the percentage of the transmission systems capable of implementing Emergency Control Baseline functionalities, by category.

# of Circuits Supporting Emergency Control Functions by Category

	Percentage of Circuits			
Function	Big Rivers	EKPC	Kentucky Power	LG&E/KU
Fault Location	15	60	NR	NR
Protection and Clearing Verification	0	100	NR	NR
Load Shedding	30	100	NR	NR
Re-routing of Power	0	0	NR	NR
Repair Crew Dispatch	0	100	NR	NR
Fault Recording	5	60	NR	NR

Note: Fault recording figures reported for EKPC are for transmission line breakers.

Vendors
Vendors of the systems utilized in Kentucky include Schweitzer Engineering Laboratories, ERL Phase Power Technologies, General Electric, ABB, McGraw, and Beckwith.

Transmission System Contingency Analysis

Contingency Analysis simulation provides and prioritizes the impacts on an electric power system when problems occur. All four reporting utilities utilize simulation tools to perform N-1 contingency analysis on their transmission systems. EKPC reports also evaluating double contingencies and multiple/extreme contingencies.

Wide Area Monitoring and Control Advanced Auto Restoration

Advanced auto-restoration of un-faulted sections of a lines or feeders after a fault has been isolated utilizing WAMCS is not performed by any transmission providers in Kentucky.

System-wide Automated Voltage Control

System wide voltage and power flow optimization through closed loop control, measurement, and computing, was reported to cover 100% of the EKPC system. No other utilities reported utilization of system-wide automated voltage control.

Synchro-Phasor

No transmission operators in Kentucky reported the use of Synchro-phasor devices to provide synchronized and time-stamped voltage and current phasor measurements from different locations. LG&E/KU reports that some of their Schweitzer relays are syncrho-phasor capable.

Self-Healing Grid

Self-Healing Grid (SHG) applications that evaluate power system behavior in real-time, prepare the power system for withstanding credible combinations of contingencies, prevent wide-area blackouts, and accommodate fast recovery from emergency state to normal state were reported by Big Rivers and EKPC.

Big Rivers utilizes line automated reclosers that will close the circuit breaker, restoring the line following a line trip.

EKPC has implemented two automated switching schemes that couples motor operated air break switches with conventional breaker reclosing schemes. Under certain conditions, the MOABS will automatically open in an attempt to allow one of the breakers to remain in service by removing faulted line sections from the system. The MOABs auto-detect voltage loss and operate automatically. These self-healing functions cover <1% of the transmission system.

Dynamic Line and Equipment Rating

The dynamic operation of transmission system equipment based on environmental measurements is performed by EKPC and LG&E/KU.

EKPC operates ten transmission lines and three power transformers dynamically using EPRI's Dynamic Thermal Circuit Rating technology.

LG&E/KY utilized real time ambient temperature to calculated line rating for transmission lines as part of their EMS system.

Both EKPC and Big Rivers report using environmental measurements for load forecasting. In the EKPC system this is performed utilizing two fully instrumented weather stations that communicated with the EPRI DTCR software. In the Big Rivers system load forecasts are made using temperature data.

Advanced Components

The following table summarizes the advanced components utilized in each transmission system...

Advanced Components in the Transmission System				
	Utility			
Component	Big Rivers	EKPC	Kentucky Power	LG&E/KU
FACTS	No	No	Yes	No
VFT	No	No	No	No
Solid State Transformer	No	No	No	No
Superconducting Condenser	No	No	No	No
HVDC	No	No	No	No
Fault Current Limiter	No	Series Reactor	Series Reactor	No
High Temp/Capacity Cable	ACSS Conductor	ACSS Conductor	No	No
Advanced Storage	No	No	No	No

Summary of the ATO Cost and Benefit Survey

Introduction

The Cost and Benefit portion of the ATO Survey was completed by four of the jurisdictional utilities. It collected information regarding installation and operation & maintenance costs, savings enabled by ATO, and ancillary benefits of ATO installations. The following section summarizes the collected responses to the ATO Cost and Benefit Survey.

Costs

Capital Costs of ATO Deployments

No utilities provided information regarding capital costs related to ATO deployments.

Operation and Maintenance Costs of ATO Deployments

No utilities provided information regarding O&M costs specific to ATO deployments.

Savings

EKPC reported an actual benefit ratio of 3.1:1 for the DTCR project in 2006 and a projected benefit ratio of 7.7:1 for 2007.

Benefit Evaluation

No utilities completed the benefit evaluation portion of the ATO Cost and Benefit Survey.

FEEDBACK SUMMARY

INTRODUCTION

Responding utilities were encouraged to provide feedback to be included in the ATO report. This section summarizes those responses.

LOUISVILLE GAS AND ELECTRIC

LG&E/KU continues to monitor and research emerging Smart Grid technologies such that investments occur at the speed of value. Smart Grid technologies are analyzed utilizing historical investment methods to determine when value will be achieved and thus directing the future state of Smart Grid.

Chapter 9: Advanced Asset Management Overview

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INTRODUCTION

The Kentucky Public Service Commission, the University of Louisville, and the University of Kentucky have partnered to develop a technical roadmap for the development and deployment of Smart Grid technologies throughout the Commonwealth. This “Kentucky Smart Grid Roadmap” will provide recommendations and best practices to utilities and utility stakeholders to guide individual Smart Grid deployment approaches.

The purpose of this document is 1) the overview of: Advanced Asset Management, key enabling technologies and main functionalities, and 2) served as a companion document of the KSGRI AAM Deployment Survey for the evaluation of AAM deployment by jurisdictional utilities in Kentucky. These purposes are in fulfillment of KSGRI Work plan Goal #7.

OVERVIEW OF AAM

AAM (Advanced Asset Management) integrates the grid intelligence acquired in achieving the other milestones, such as AMI, ADO, and ATO with new and existing asset management applications. This integration enables utilities to reduce operations, maintenance, and capital costs, and better utilize assets efficiently during day-to-day operations. Additionally, it significantly improves the performance of capacity planning, forecast, maintenance, engineering and facility design, customer service processes, and work and resource management. Like AMI (Advanced Metering Infrastructure), we refer to ATO as a Smart Grid key infrastructure area, as opposed to a specific technology.

AAM can spread over a broad range of electric power system infrastructures, from generation, transmission to distribution and consumption. It includes but not limit to asset "health" information, system and facility maintenance, transmission and distribution planning and expansion, system operating information. The realization of Smart Grid AAM requires the collaboration with other infrastructure areas. Also, the integration of both operational and asset condition information will improve the effectiveness of asset management systems.

With Smart Grid concepts, technologies and applications widely penetrate into the power systems, AAM will become an important backbone for the realization of the future grid. In this brief overview report, we will summarize enabling technologies and main functionalities of AAM.

AAM TECHNOLOGIES AND FUNCTIONALITIES

While the concept of power delivery asset management has been around for many years, utilities have to settle to make decisions based on incomplete system information and limited communication and data collection systems. With the rapid development progress of Smart Grid with its advanced communication infrastructure and advanced sensing and measurement technologies, asset managers will be able to identify the "health" condition and system performance of those assets. This brings a new topic of Advanced Asset Management in Smart Grid environment.

Performance-based asset management provides a useful tool for utilities to utilize in coordination with Smart Grid key technologies: **Integrated Communications, Sensing and Measurement, Advanced Components, Advanced Control Methods, Improved Interfaces and Decision Support [1].** However, it is critical that the asset management applications should be considered along with other Smart Grid applications.

Currently, there exists a great lack of information regarding the actual power flow through specific equipment, and the ability to monitor that equipment. In this case, asset managers relay on intuition, estimates, averages, or expensive field inspection, and have been forced to build redundant facilities in case estimates went wrong.

The next-generation asset management should change this way. With the extensive penetration of Smart Grid technologies, especially the smart meters, various sensors, mobile devices, IEDs, etc., utilities are now getting more and more raw data about their assets. The next step is to turn those raw data into useful information, with necessary process of the analysis of asset profiles, failure events, and costs. Asset managers can use obtained information to feed asset planning and create reports or visual graphics for assistance. Also, system models and simulations can be created to make effective strategies before making costly investment.

Brief review of some asset management technologies and functions are listed below.

Schedule-based Preventive Maintenance

Most preventive maintenance works on the idea of regularly inspecting or servicing equipment to address potential failures before they occur. This is typically set to six months. However, with the changing operating conditions and environment, the standard interval between inspections may be too long to catch critical emerging problems.

Condition-based/monitoring Maintenance

This type of maintenance utilizes a number of monitoring devices and maintenance tools, such as intelligent electronic devices (IEDs), to set up a maintenance basis for all assets. It monitors the system's "health" information in real-time and it will generate alarm signals and send to central control room when some failures or malfunctions are triggered. However there is always a considerable delay because of this passive characteristics and the real failures have already happened.

Reliability-based Maintenance

This type of maintenance is carried out based on the reliability index of each device or equipment among all assets. The reliability may be constituted by the amount of power losses, the duration of losses, the severity of losses. In summary, the reliability index says that you want to operate as long as possible without losses and when you have losses you want to fix them as quickly as possible.

Predictive Maintenance

Predictive analytics identifies impending problems by detecting subtle changes in equipment operations. It finds problems earlier than condition monitoring based schemes. Predictive analytics compares real-time data to software models of equipment when operating in good condition, and compensates for normal variations due to load and ambient conditions. Further, the method uses software models customized for individual pieces of equipment to provide the earliest possible warning of emerging problems.

Unit Commitment

Unit commitment problems involve the scheduling of power generators with the most economic production and trade, subject to power consumption and the technological and economical parameters of the power sources.

Economic Dispatch

Economic dispatch is a process for optimally determining the output of generators that are turned on to meet the daily demand of the system.

Computerized maintenance management system (CMMS)

In power system asset management, CMMS maintains a computer database of information about an organization's maintenance operations, i.e. computerized maintenance management information system (CMMIS). This information is to help manage maintenance more effectively and to help make informed decisions. CMMS data may also be used to verify regulatory compliance.

CMMS can record data about equipment and property, including maintenance activities, work orders, specifications, purchase date, expected lifetime, warranty information, service contracts ad history, etc.

Optimized asset utilization

Optimized asset utilization facilitates the elimination of extra generation plant construction, the management of regular plant as well as peaker plant utilization by real-time demand prediction, increasing the utilization of line capacity by adjusting thermal dynamic ratings in real-time.

Transmission planning

Transmission expansion requires good planning under appropriate regulations. The purpose of transmission planning is to determine the type and timing of new transmission facilities required, with an acceptable level of reliability. The transmission planning process relies upon the definition of the locations of the new generations and the expected growth in demand for certain region.

Distribution planning

On the power distribution system side, planning is a complex task that it must ensure there is adequate transformer capacity and feeder capacity to meet the load demands. Decisions such as allocation of power flow, installation of feeders and substations, and scheduling maintenance must be evaluated carefully.

References

[1] M. Turner, Y. Du, *et al*, "KY Smart Grid Roadmap Initiative Work Plan", 2011. Internal document retrievable online.

Chapter 10: Overview of Advanced Asset Management in the Commonwealth of Kentucky

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ABSTRACT

The "Overview of Advanced Asset Management in the Commonwealth of Kentucky" report presents a summary of the current state of AAM deployments and capabilities within the electric utilities of Kentucky. It is a thorough technology assessment, and provides details to support the documents "Overview of Smart Grid Deployments in the Commonwealth of Kentucky" , "Overview of Advanced Metering Infrastructure in the Commonwealth of Kentucky", Overview of Advanced Distribution Operations in the Commonwealth of Kentucky and "Overview of Advanced Transmission Operations in the Commonwealth of Kentucky".

The data presented in this report was gathered using the "AAM Deployment Survey for Jurisdictional Utilities" (AAM Survey). The AAM Survey gathered utility deployment data in the areas of the gathering and distribution of asset data, the use of asset data to support optimization of asset utilization and planning, advanced asset management methods, and performance standards as applied to asset management and utilization.

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INTRODUCTION

ABOUT THIS DOCUMENT

The Kentucky Public Service Commission, the University of Louisville, and the University of Kentucky have partnered under the "Kentucky Smart Grid Roadmap Initiative" (KSGRI) to develop a technical roadmap for the development and deployment of smart grid technologies throughout the Commonwealth. This "Kentucky Smart Grid Roadmap" will provide recommendations and best practices to utilities and utility stakeholders to guide individual smart grid deployment approaches. More information regarding the work of the KSGRI is located in the documents *The Kentucky Smart Grid Roadmap Initiative: Smart Grid Road Map Work Plan*, *The Kentucky Smart Grid Roadmap Initiative: Kentucky Smart Grid Assessment Model*, *The Kentucky Smart Grid Roadmap Initiative: Overview of Smart Grid Deployments in the Commonwealth of Kentucky*, *The Kentucky Smart Grid Roadmap Initiative: Overview of Advanced Metering Infrastructure in the Commonwealth of Kentucky*, *The Kentucky Smart Grid Roadmap Initiative: Overview of Advanced Distribution Operations in the Commonwealth of Kentucky* and *The Kentucky Smart Grid Roadmap Initiative: Overview of Advanced Transmission Operations in the Commonwealth of Kentucky*..

The purpose of this document is to summarize the results of the AAM Deployment Survey for Jurisdictional Utilities, in fulfillment of Work Plan Goals 4 of *Smart Grid Road Map Work Plan*. The AAM Survey was distributed to 23 jurisdictional electric utilities to develop an understanding of the "As-is" state of the electric power grid in Kentucky, focusing on the status of modernization of asset management systems. Data collected from jurisdictional utilities was via self-reporting by a Smart Grid Contact person from each utility.

DOCUMENT OVERVIEW

The following sections are detailed summaries are then provided in subsequent sections of the following areas: Gathering and Distributing Data, Distribution, Operations, and Planning Optimization, Applications and Device Technologies, and Performance Standards. The report concludes by presenting feedback from the participating utilities.

List of Participating Utilities

Big Rivers Electric Corporation
- Jackson Purchase Energy
- Kenergy Corp.

East Kentucky Power Cooperative Inc.
- Big Sandy RECC
- Bluegrass Energy Cooperative
- Farmers RECC
- Fleming Mason Energy
- Jackson Energy Cooperative
- Licking Valley RECC
- Nolin RECC
- Owen Electric Cooperative Corporation
- Salt River Electric Cooperative Corporation
- South Kentucky RECC

Kentucky Power Company

Louisville Gas & Electric and Kentucky Utilities

SUMMARY OF THE AAM SYSTEM ASSESSMENT SURVEY

INTRODUCTION

The AAM System Assessment Survey for Jurisdictional Utilities (AAM Survey) was completed by sixteen jurisdictional utilities. The System Assessment portion of the AAM Survey collected information regarding Gathering and Distributing Data, Distribution, Operations, and Planning Optimization, Applications and Device Technologies, and Performance Standards. The following section summarizes the collected responses to the AAM System Assessment Survey.

GATHERING AND DISTRIBUTING DATA

Traditionally the gathering of asset health related measurements has been a manual task performed as part of routine maintenance. In the context of the AAM survey techniques, we instead refer to the automated gathering of real-time raw data from Smart Grid technologies including smart meters, various sensors, mobile devices, and Intelligent Energy Devices.

Sensors

Two utilities report the utilization of automated sensors to monitor factors such as vibration, chemical analysis, acoustics, temperature, or other non-electrical parameters used in the delivery of electricity. East Kentucky Power Cooperative has 38 dissolved gas analyzers (DGA) installed on step-up power transformers. The units are provided by Severon, Hydran, and Kelman. Additionally, EKPC has installed 20 transformer temperature monitoring units (Advanced Power Technologies) and 16 intelligent transformer monitoring units (Qualitrol). Louisville Gas & Electric and Kentucky Utilities has installed online oil monitors on ~5% of transformers. However it is not clear that this data is used for asset management, but rather to sound alarms at predetermined oil gas and moisture contents. Owen Electric reports the planned installation of a transformer IED to monitor transformer temperature and gas analysis to determine deterioration and maintenance requirements.

Kenergy Corp utilizes thermal imaging to evaluate substations on annual basis, and utilizes heat sensors to generate alarm data for large backup generators and in the in house UPS system.

Common Information Model

A Common Information Model provides a system-wide commonality of data to measure the condition of equipment. Kentucky Power Company reports the use of non-automated common information collection for all major assets including power transformers, circuit breakers, reclosers, tap changers, regulators, batteries, and stations service transformers. This data is uploaded to a server and is migrated to the Maintenance Management Software. Louisville Gas & Electric and Kentucky Utilities recently introduced the use of transmission and distribution substation construction and maintenance software to track asset maintenance history and condition, although this software does not appear to be directly connected to sensors connected to devices.

Substation Automation

Other than the substation automation reported in *The Kentucky Smart Grid Roadmap Initiative: Overview of Advanced Distribution Operations in the Commonwealth of Kentucky*, no utilities reports the use of sensors for substation automation in response to asset management requirements.

Operation and Planning Optimization

Real time sensor data can be utilized to optimize both the operation and the planning of the transmission and distribution system. Primarily this refers to real time circuit reconfiguration for electrical loss minimization, increasing the utilization of line and transformer capacity by adjusting thermal dynamic ratings in real-time, and in T&D system planning

Circuit Reconfiguration for Loss Minimization

Kentucky Power utilizes S&C Intelliteam software to analyze distribution circuits for reconfiguration based on loss. This analysis is presently applied to 4.4% of KPCo's distribution circuits with an end of 2012 goal of 6.8% of circuits. Owen Electric uses a similar program provided by Cooper to analyze 1% of their circuits. These numbers are for reconfiguration based on real time data and do not account for distribution planning based on "what-if" planning operation. Such operations are covered in *The Kentucky Smart Grid Roadmap Initiative: Overview of Advanced Distribution Operations in the Commonwealth of Kentucky*

Dynamic Asset Ratings

Eleven transmission lines in the EKPC system are operated dynamically in response to changing weather variables including: ambient temperature, wind speed and direction, humidity, emissivity, and rain fall. The EKPC system also rates three power transformers dynamically. Louisville Gas & Electric and Kentucky Utilities utilize dynamic operation of transmission lines and transmission transformers based on temperature only. No utilities operate distribution level equipment dynamically, disregarding summer/winter base rating and overload ratings.

System Planning

No utilities reported the use of real time data on assets from sensors/IEDs utilized in system planning.

Advanced Asset Maintenance

Most preventive maintenance works on the idea of regularly inspecting or servicing equipment to address potential failures before they occur. Increased data from sensors and IEDs can be utilized to facilitate new maintenance methodologies that include Probabilistic Risk Assessment, Condition-Based Monitoring and Maintenance, Reliability-Based Maintenance, and Predictive Maintenance.

Condition Based Maintenance

This type of maintenance utilizes a number of monitoring devices and maintenance tools, such as intelligent electronic devices (IEDs), to set up a maintenance basis for all assets. It monitors the system's "health" information in real-time and it will generate alarm signals and send to central control room when some failures or malfunctions are triggered. However there is always a considerable delay because of this passive characteristics and the real failures have already happened.

Blue Grass Energy reports utilizing condition based monitoring and maintenance to produce SCADA alarm signals in real time in response to asset health information. Kentucky Power Corp also produces SCADA alarms for high temperatures on power transformers, voltage alarms for tap changers, and alarms for loss of DC battery voltage. LG&E utilizes condition based maintenance at its transmission Substations, including the status of microprocessor relays and transformer cooling mechanisms (such as pumps & fans), transformer oil level and SF6 circuit breaker gas pressure and estimation of breaker contact wear (based on actual fault current interrupted and manufacturer recommendation). Salt River generates alarms in real time through their SCADA system for voltage or current issues.

Reliability Based Maintenance
This type of maintenance is carried out based on the reliability index of each device or equipment among all assets. The reliability may be constituted by the amount of power losses, the duration of losses, the severity of losses. In summary, the reliability index says that you want to operate as long as possible without losses and when you have losses you want to fix them as quickly as possible.

Kentucky Power Company, Louisville Gas & Electric and Kentucky Utilities, Nolin RECC, Owen Electric, and Salt River indicated utilization of RBM methods. Salt River specifically indicates that reliability based maintenance is being used on a limited basis for reclosers.

Predictive Maintenance and Probabilistic Risk Assessment
Predictive analytics identifies impending problems by detecting subtle changes in equipment operations. It finds problems earlier than condition monitoring based schemes. Predictive analytics compares real-time data to software models of equipment when operating in good condition, and compensates for normal variations due to load and ambient conditions. Further, the method uses software models customized for individual pieces of equipment to provide the earliest possible warning of emerging problems.

No utilities reported utilizing predictive maintenance and/or probabilistic risk assessment in the context of the AAM survey.

PERFORMANCE STANDARDS

Although several utilities reported on general performance standards as related to the operation of their individual electric power system, none of the responses directly addressed the use of performance standards as it applies to asset management.

FEEDBACK SUMMARY

INTRODUCTION
Responding utilities were encouraged to provide feedback to be included in the AAM report. This section summarizes those responses.

LICKING VALLEY RECC
At this time we have the Hunt Technologies TS1 system fully deployed. We are in the process of converting to the TS2 system which will give us more information to better implement the things discussed in this survey.

LOUISVILLE GAS AND ELECTRIC
LG&E/KU continues to monitor and research emerging Smart Grid technologies such that investments occur at the speed of value. Smart Grid technologies are analyzed utilizing historical investment methods to determine when value will be achieved and thus directing the future state of Smart Grid.

NOLIN RECC
How many staff engineers do you think work at electric cooperatives? In your best estimate, how much money would it take to create a system, highlighted in yellow, you opened with at the beginning of this survey?

"AAM (Advanced Asset Management) integrates the grid intelligence acquired in achieving the other milestones, such as AMI, ADO, and ATO with new and existing asset management applications. This integration enables utilities to reduce operations, maintenance, and capital costs, and better utilize assets efficiently during day-to-day operations. Additionally, it significantly improves the performance of capacity planning, forecast, maintenance, engineering and facility design, customer service processes, and work and resource management. Like AMI (Advanced Metering Infrastructure), we refer to AAM as a Smart Grid key infrastructure area, as opposed to a specific technology."

Do you really believe that something as described by your “team”, highlighted in yellow, can be accomplished without a large team of engineers and IT people?

CHAPTER11: CONSUMER EDUCATION OVERVIEW

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INTRODUCTION

The Kentucky Public Service Commission, the University of Louisville, and the University of Kentucky have partnered to develop a technical roadmap for the development and deployment of Smart Grid technologies throughout the Commonwealth. This "Kentucky Smart Grid Roadmap" will provide recommendations and best practices to utilities and utility stakeholders to guide individual Smart Grid deployment approaches.

The purpose of this document is 1) an overview of: Consumer Education and Acceptance of the Smart Grid, the concerns, issues, challenges, and benefits for consumers and utilities with the adoptions of Smart Grid technologies, 2) to serve as a companion document of the KSGRI Consumer Education and Acceptance Deployment Survey for the evaluation of Consumer Education and Acceptance by jurisdictional utilities in Kentucky. These purposes are in fulfillment of KSGRI Work plan Goal #7.

OVERVIEW OF CONSUMER EDUCATION AND ACCEPTANCE

Smart Grid depends on consumer

When it comes to Smart Grid, the least talked about but the most importance part is what's always ignored – Consumer. The Smart Grid is coming, faster and sooner than maybe you and I could expect. Government, electric utilities, energy providers and stakeholders are in support of Smart Grid. New technologies are being announced and penetrated almost every day and everywhere. Whoever understands Smart Grid would agree that it is the key in helping solve the energy challenges. However, many would also agree that its ultimate success will largely depend on its acceptance and involvement of this new, intelligent technology by the consumer. As it was claimed that consumer education is an essential cornerstone of the energy industry's Smart Grid transition, thus it's critical to have a clear understanding of customers' needs and behaviors.

Consumers' understanding from national surveys

Survey after survey revealed with fairly consistent results that approximately 2/3 to ¾ of Americans have never even heard the term "Smart Grid", neither understand what it could mean for them. However, researches also show that Americans are very supportive once the technologies have been explained to them. Many consumers want to reduce their negative impact on the environment and take a more active role in personal energy management. And when consumers get educated by the benefits of Smart Grid and more advanced technologies that may be possibly realized for residential use, the majority of consumers tend to like Smart Grid, think implementing Smart Grid is a priority, and want to participate in the transition given they are clear of the cost-benefit of new technologies.

"Change" or "not change"

As the time to rebuild the electricity infrastructure with 21st century technologies, we need to help consumers adapt to change. Speaking of "change", typically, people are unwilling to change, unless the new technological products, experience and benefits are clearly much better than the current ones they have. The Smart Grid will allow consumers and utilities to manage energy through better usage information, two-communications, more choices on energy consumptions, more flexible electricity rate structures, and so on. Smart grid technology is likely to give consumers wide varieties of options as well as benefits for managing their home energy consumption, and providing these options in a way that fits consumers' lifestyles and meets their needs.

While educated consumers tend to be positive about the benefits of Smart Grid, many consumers have revealed concerns about health, privacy, availability of control, and bill accuracy. This isn't to understate the legitimate concerns around the Smart Grid. However, for common concerns among consumers, such as new technologies raising the cost of energy bills or smart meter being a serious health threat, an education program is an absolutely necessary component of clarifying and addressing those issues to consumers. Its one thing to install millions of smart meters in the next few years, and it's another thing to make sure that your customers are part of the process, and are supportive with the technology advancements and rollouts.

Empowering our energy future through conversation, collaboration and education

Engagement and dialogue: Two-way communication with consumers will be critical to Smart Grid success. With a clear understanding of consumer motivations, we are likely to see clear market change.

Industry-wide collaboration: The Smart Grid space is brimming with stakeholders who have the consumer's best interests in mind. From regulators to consumer advocates, and even the mainstream media, there are many voices influencing the consumers' perception of Smart Grid. Only through industry-wide collaboration among consumer "influencers" can we expect to reach this target audience.

Education: Armed with a clear picture of our consumers, an understanding of what drives them, and a network of industry-wide supporters, the industry can begin effective outreach and education. Long-term consumer engagement will depend on innovative products and solutions that consumers will race to embrace.

Consumer acceptance and demand for Smart Grid technologies will ultimately ease the minds of regulators and consumer advocates when it comes to future Smart Grid investments, while making the transition smoother for utilities. If we do this right, I predict we'll see a technology revolution.

Challenges

The Smart Grid roadmap recognizes customers must actively participate in energy management to realize full benefits of Smart Grid deployment and development. The challenges to engage consumers could be:

- Limited consumer understanding and acceptance of technologies and value
- The uncertainties of new technologies and potential benefits, even utilities
- The cost and investment in education, who pays for it
- Customers have traditionally been passive recipients of electricity services
- Customer engagement has been predominantly event-driven
- The current status of delivering safe, reliable electricity has resulted in customers not needing to change, little incentive
- Elevated customer expectations due to hype
- Utilities and regulators know only part of the customer experience and behaviors

Successful consumer education requires effective and coordinated communications planning and execution. Stakeholders may have unique insights into the perspectives, concerns, and needs of the constituencies, as well as trusted relationships that could enhance the credibility and effectiveness of consumer education efforts. Therefore, utilities should work collaboratively with stakeholders in the design of consumer education programs and in the development, targeting, and message delivery.

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CHAPTER 12: OVERVIEW OF CONSUMER EDUCATION PROGRAMS IN THE COMMONWEALTH OF KENTUCKY

ABSTRACT

The "Overview of Consumer Education Programs in the Commonwealth of Kentucky" report presents a summary of the current state of consumer education programs within the electric utilities of Kentucky. It is a brief assessment, and provides details to support the documents "Overview of Smart Grid Deployments in the Commonwealth of Kentucky", "Overview of Advanced Metering Infrastructure in the Commonwealth of Kentucky", Overview of Advanced Distribution Operations in the Commonwealth of Kentucky, "Overview of Advanced Transmission Operations in the Commonwealth of Kentucky", and" Overview of Advanced Asset Management in the Commonwealth of Kentucky".

The data presented in this report was gathered using the "CE Deployment Survey for Jurisdictional Utilities" (CE Survey). The CE Survey polled utilities on their consumer education programs in the areas of General Smart Grid, Advanced Metering, Demand Response Programs, Distribution Automation, Energy Efficiency, Distributed Energy Resources, and Integration of Electric Vehicles.

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INTRODUCTION

ABOUT THIS DOCUMENT

The Kentucky Public Service Commission, the University of Louisville, and the University of Kentucky have partnered under the "Kentucky Smart Grid Roadmap Initiative" (KSGRI) to develop a technical roadmap for the development and deployment of smart grid technologies throughout the Commonwealth. This "Kentucky Smart Grid Roadmap" will provide recommendations and best practices to utilities and utility stakeholders to guide individual smart grid deployment approaches. More information regarding the work of the KSGRI is located in the documents *The Kentucky Smart Grid Roadmap Initiative: Smart Grid Road Map Work Plan*, *The Kentucky Smart Grid Roadmap Initiative: Kentucky Smart Grid Assessment Model*, *The Kentucky Smart Grid Roadmap Initiative: Overview of Smart Grid Deployments in the Commonwealth of Kentucky*, *The Kentucky Smart Grid Roadmap Initiative: Overview of Advanced Metering Infrastructure in the Commonwealth of Kentucky*, *The Kentucky Smart Grid Roadmap Initiative: Overview of Advanced Distribution Operations in the Commonwealth of Kentucky, The Kentucky Smart Grid Roadmap Initiative: Overview of Advanced Transmission Operations in the Commonwealth of Kentucky*, and *The Kentucky Smart Grid Roadmap Initiative: Overview of Advanced Asset Management in the Commonwealth of Kentucky*.

The purpose of this document is to summarize the results of the CE Deployment Survey for Jurisdictional Utilities, in fulfillment of Work Plan Goals 4 of *Smart Grid Road Map Work Plan*. The AAM Survey was distributed to 23 jurisdictional electric utilities to develop an understanding of the "As-is" state of the electric power grid in Kentucky, focusing on the status of consumer education programs. Data collected from jurisdictional utilities was via self-reporting by a Smart Grid Contact person from each utility.

List of Participating Utilities

Kenergy Corp.
Meade County RECC
East Kentucky Power Cooperative Inc.
Big Sandy RECC
Bluegrass Energy Cooperative
Farmers RECC
Jackson Energy Cooperative
Nolin RECC
Owen Electric Cooperative Corporation
Salt River Electric Cooperative Corporation
South Kentucky RECC
Kentucky Power Company
Louisville Gas & Electric and Kentucky Utilities

SUMMARY OF THE CONSUMER EDUCATION SURVEY

INTRODUCTION

The CE Survey for Jurisdictional Utilities (CE Survey) was completed by fourteen jurisdictional utilities. The CE Survey polled utilities on their consumer education programs in the areas of General Smart Grid, Advanced Metering, Demand Response Programs, Distribution Automation, Energy Efficiency, Distributed Energy Resources, and Integration of Electric Vehicles.

General Smart Grid Education Programs

Two (14.3 percent) responding utilities responded Yes when asked if their organization "*has a consumer education program specific to General Smart Grid*". The following table summarizes the intended goals of these education programs:

Intended Outcomes Of General Smart Grid Education Programs		
DESIRED OUTCOMES	# UTILITIES SUPPORTING	% UTILITIES SUPPORTING
A basic understanding of the technologies being used or new options available to the consumer.	2	100
Understanding of any associated rate structure changes or options. The role of the utility and third parties	2	100
Understanding of the goals of the program, including potential individual and societal costs and benefits	2	100
Understanding of the potential implications (benefits, costs, and risks) associated with their participation (or non-participation) in a smart grid program or rate option	2	100
Information regarding resources and tools available to them than can be employed to estimate potential effects of participation in the program	2	100

Advanced Metering Education Programs

Four (28.6 percent) responding utilities responded Yes when asked if their organization "*has a consumer education program specific to Advanced Metering ("smart meters")*". The following table summarizes the intended goals of these education programs:

Intended Outcomes Of Advanced Metering Education Programs		
DESIRED OUTCOMES	# UTILITIES SUPPORTING	% UTILITIES SUPPORTING
A basic understanding of the technologies being used or new options available to the consumer.	4	100

Understanding of any associated rate structure changes or options. The role of the utility and third parties	4	100
Understanding of the goals of the program, including potential individual and societal costs and benefits	3	75
Understanding of the potential implications (benefits, costs, and risks) associated with their participation (or non-participation) in a smart grid program or rate option	4	100
Information regarding resources and tools available to them than can be employed to estimate potential effects of participation in the program	4	100

Demand Response Education Programs
Seven (50 percent) responding utilities responded Yes when asked if their organization "*has a consumer education program specific to Demand Response Programs*". The following table summarizes the intended goals of these education programs:

Intended Outcomes Of Demand Response Programs Education Programs

Desired Outcomes	# Utilities Supporting	% Utilities Supporting
A basic understanding of the technologies being used or new options available to the consumer.	7	100
Understanding of any associated rate structure changes or options. The role of the utility and third parties	5	71.4
Understanding of the goals of the program, including potential individual and societal costs and benefits	7	100
Understanding of the potential implications (benefits, costs, and risks) associated with their participation (or non-participation) in a smart grid program or rate option	5	71.4
Information regarding resources and tools available to them than can be employed to estimate potential effects of participation in the program	7	100

Distribution Automation Education Programs
1 (7.1 percent) responding utilities responded Yes when asked if their organization "*has a consumer education program specific to Distribution Automation*". The following table summarizes the intended goals of these education programs:

Intended Outcomes Of Distribution Automation Education Programs

DESIRED OUTCOMES	# UTILITIES SUPPORTING	% UTILITIES SUPPORTING
A basic understanding of the technologies being used or new options available to the consumer.	1	100
Understanding of any associated rate structure changes or options. The role of the utility and third parties	1	100
Understanding of the goals of the program, including potential individual and societal costs and benefits	1	100
Understanding of the potential implications (benefits, costs, and risks) associated with their participation (or non-participation) in a smart grid program or rate option	1	100
Information regarding resources and tools available to them than can be employed to estimate potential effects of participation in the program	1	100

Energy Efficiency Programs

Fourteen (100 percent) responding utilities responded Yes when asked if their organization "*has a consumer education program specific to Energy Efficiency*". The following table summarizes the intended goals of these education programs:

Intended Outcomes Of Energy Efficiency Education Programs		
DESIRED OUTCOMES	# UTILITIES SUPPORTING	% UTILITIES SUPPORTING
A basic understanding of the technologies being used or new options available to the consumer.	14	100
Understanding of any associated rate structure changes or options. The role of the utility and third parties	9	64.3
Understanding of the goals of the program, including potential individual and societal costs and benefits	13	92.8
Understanding of the potential implications (benefits, costs, and risks) associated with their participation (or non-participation) in a smart grid program or rate option	10	71.4
Information regarding resources and tools available to them than can be employed to estimate potential effects of participation in the program	13	92.8

Distributed Energy Resource Education Programs

Two (14.3 percent) responding utilities responded Yes when asked if their organization "*has a consumer education program specific to Distributed Energy Resources*". The following table summarizes the intended goals of these education programs:

Intended Outcomes Of Distributed Energy Education Programs		
DESIRED OUTCOMES	# UTILITIES SUPPORTING	% UTILITIES SUPPORTING
A basic understanding of the technologies being used or new options available to the consumer.	2	100
Understanding of any associated rate structure changes or options. The role of the utility and third parties	2	100
Understanding of the goals of the program, including potential individual and societal costs and benefits	1	50
Understanding of the potential implications (benefits, costs, and risks) associated with their participation (or non-participation) in a smart grid program or rate option	2	100
Information regarding resources and tools available to them than can be employed to estimate potential effects of participation in the program	2	100

Integration of Electric Vehicles Education Programs
One (7.1 percent) responding utilities responded Yes when asked if their organization "*has a consumer education program specific to Integration of Electric Vehicles*". The following table summarizes the intended goals of these education programs:

Intended Outcomes Of Electric Vehicle Integration Education Programs		
DESIRED OUTCOMES	# UTILITIES SUPPORTING	% UTILITIES SUPPORTING
A basic understanding of the technologies being used or new options available to the consumer.	1	100
Understanding of any associated rate structure changes or options. The role of the utility and third parties	0	0
Understanding of the goals of the program, including potential individual and societal costs and benefits	0	0
Understanding of the potential implications (benefits, costs, and risks) associated with their participation (or non-participation) in a smart grid program or rate option	0	0

Information regarding resources and tools available to them than can be employed to estimate potential effects of participation in the program	0	0

Methods of Customer Engagement
The following table summarizes the methods utilities utilize to facilitate customer engagement:

Methods of Customer Engagement		
METHOD	# UTILITIES SUPPORTING	% UTILITIES SUPPORTING
Direct Mailing	12	85.7
Call Center	8	57.1
Web Site	14	100
Television	3	21.4
Radio	9	64.3
Social Media (Facebook, Twitter, etc.)	6	42.9
Customer Advisory Board	3	21.4
Other	8	57.1

The responses to "Other" included (# of responses in parenthesis): newspapers (4), member newsletter (2), community events (1), handouts 91), billboards (1).

Methods of Customer Engagement
Five utilities (35.7 percent) responded affirmatively when asked "*Does your organization utilize consumer education as part of cost-benefit analysis regarding smart grid deployments?"*

CHAPTER 13: DISTRIBUTED ENERGY RESOURCES OVERVIEW

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INTRODUCTION

The Kentucky Public Service Commission, the University of Louisville, and the University of Kentucky have partnered to develop a technical roadmap for the development and deployment of Smart Grid technologies throughout the Commonwealth. This "Kentucky Smart Grid Roadmap" will provide recommendations and best practices to utilities and utility stakeholders to guide individual Smart Grid deployment approaches.

The purpose of this document is 1) an introduction and analysis of: Distributed Energy Resources (DER), enabling technologies, the benefits associated with DER deployments, and DER experience 2) to serve as a companion document of the KSGRI DER Deployment Survey for the evaluation of DER deployment by jurisdictional utilities in Kentucky. These purposes are in fulfillment of KSGRI Work plan Goal #7.

OVERVIEW OF DER

Distributed energy resources (DER), or distributed energy/generation are small, modular, decentralized energy generation and storage technologies that can produce electricity where energy is needed. They are "distributed" because they are located at or close to the point of energy consumption, unlike traditional "centralized" systems, where electricity is generated at a remote large-scale power plant and then delivered through power lines to the consumers. Typically, DER systems produce less than 10 MW of power. They are integrated systems that can include effective means of power generation, energy storage, and delivery. DER systems may be either connected to the local grid or off the grid in stand-alone applications. DER deployments will enable the generation portfolio and diversity towards a more decentralized model that will include a balance of large, centralized generating plants as well as small-scale distributed generations.

DER includes renewable energy resources, distributed generations, energy storages and electric vehicles (EV). DER encompasses a wide range of technologies, such as: wind turbines/wind energy systems, diesel engines, photovoltaics (PV), concentrating solar systems, fuel cells, microturbines, reciprocating engines, combustion turbines, cogeneration, small modular biopower, and energy storage systems. The effective use of grid-connected distributed energy resources also require power electronic interfaces, communications, and control devices for efficient operations.

Distributed energy technologies are playing an increasingly important role in the nation's energy portfolio. They can be used as base load power, peak load power, backup power, remote power, as well as cooling and heating needs.

DER has the potential to mitigate congestion in transmission lines, reduce the impact of energy price fluctuations, enhance energy security, and improve power reliability and stability. DER increases the utilization and efficiency of existing infrastructure. DER also has significant impact on the environment and natural resources.

The deployment of renewable energy technologies for DER applications depends on a series of things, including: local renewable resources availability, the cost of energy at the site, available financial incentives, and specific application factors.

DER Technology

Distributed Energy Resources

DER is becoming increasingly important in power grids in recent years. This type of generation can help support local power grids in case of outages or blackouts, and ease the loads on long-distance transmission lines, but it can also destabilize the grid if not managed appropriately. Emergent technologies such as renewable energy resources, distributed generations, energy storages, EVs, could have great impacts on the operation of power transmission and distribution systems, by significantly changing the power flow patterns of the grid. Usually, utility control centers are unable to manage distributed generations directly, and this may be of interest as a valuable territory for R&D in the future.

Renewable Energy Resources

Renewable energy resources are naturally replenishing but flow-limited, which means that they have the intermittent nature and are not available 24/7 to generate electricity. Renewable energy resources include: biomass, hydro, geothermal, solar, wind, ocean thermal, wave and tidal action, which are widely distributed all over the world.

Usually renewable power is generated locally where the renewable energy resources are and transmitted through connections of transmission/sub-transmission lines after voltage step-up. Because of its intermittent characteristic, sometimes it is unpredictable for the personnel to schedule and dispatch generation resources, and resulted in large variations of power flow situations.

Energy Storage

Energy storage is accomplished by physical media of certain devices that can store energy to perform useful operations at a later time. Grid energy storage (or large-scale energy storage) allows energy producers to send excessive electricity to temporary electricity storage sites that become energy producers when needed.

Most renewable energy sources (i.e. solar and wind) produce intermittent power, which requires the energy storage option to be in place. Other options include recourse to peaking power plants, methane storage and smart demand side management, which involves making electrical equipment and appliances able to adjust to time-of-use rate. On a grid with a high penetration of renewables, low spot prices would correspond to times of high availability of wind and/or solar.

Developing technology to store electrical energy so it can be available to meet demand whenever needed would represent a major breakthrough in the future. Helping to try and meet this goal, electricity storage devices can manage the amount of power required to supply customers at times when demand is greatest, which is during peak load. These devices can also help make renewable energy, whose power output cannot be controlled by grid operators, smooth and dispatchable. Thus, energy storage and power electronics hold substantial promise for transforming the electric power industry.

EV

Plug-in EVs (PEV) get their power from the electric grid. There are two kinds of PEVs: (1) Plug-in hybrid electric vehicles (PHEV) use both gasoline and electricity stored in large batteries; (2) Battery EVs use only electricity.

EVs could behave as a source to the system in the discharging mode, or behave as a load in the charging mode. When supplying power to the power system, EVs can be considered as a kind of DERs and can be connected to the power system at random time. Therefore, the use of EVs dynamically changes the power distribution modeling and the power flow patterns. Additionally, it will also change the load shape and bring about uncertainties to service providers.

DER Technology

Many combinations of technologies and fuel options are possible to take advantage of the way individual technologies complement each other and to make them as robust and cost-effective as possible. Currently, notable DER technologies include:

Diesel Engine is a proven, cost-effective, extremely reliable and widely used technology. They are manufactured in a wide range of sizes and can be cycled frequently to operate as peak-load power plants or as load-following plants; they can also run in base load mode in off-grid systems. Major drawbacks include very high levels of emissions and the loud engine noise.
Dual-Fuel Engine consists of a diesel-cycle engine modified to use a mixture of natural gas and diesel fuel connected to an electric generator. The small amount of diesel fuel allows the use of compression ignition and the high percentage of natural gas in the mix results in much lower emissions than those of a diesel engine.
Natural Gas Engine is made up of a reciprocating natural gas-fueled engine using a spark-ignition system coupled to an electric generator. In most other respects, natural gas engines perform similarly to diesels and dual-fuel engines, but have the potential for the lowest emissions of all types of reciprocating engines.
Combustion Turbines burn gas or liquid fuel to produce electricity. While they may take a few more minutes to get up to speed compared with reciprocating engines, gas turbines are well suited for peaking and load-following applications and for base load operation in larger sizes. Installed costs are somewhat higher than those of reciprocating engines, and maintenance costs are slightly lower. Turbines are efficient and relatively clean.
Microturbines are smaller, somewhat less efficient versions of combustion turbines. Microturbines targeted to the small industrial and commercial markets and are designed to be compact, affordable, reliable, modular and simple to install.

Fuel Cells produce DC electricity by a thermo-chemical process, and the DC power is inverted to AC for grid operation. Byproducts are heat, water, and carbon dioxide, making fuel cells one of the cleanest sources of energy. Fuel cells are efficient, quiet, and modular.
Photovoltaic Cells are thin layers of a semiconductor that convert sunlight directly to DC electricity; an inverter converts the DC to standard AC power for connection to utility systems. The panels are modular and can be configured into larger arrays to match almost any load requirement. Noise and emissions are negligible, and maintenance is minimal.
Wind Turbines, another renewable energy technology, contain blades that turn the energy in the wind into rotational motion to drive a generator. Applications include remote power systems, small-scale or residential electricity production, and utility-scale power generation.

Storage Devices take energy from the electric grid or another source such as renewable DER and store it, making it available at a later time when needed. Storage technologies currently available have a range of characteristics for various applications. Batteries are the most common type of electric energy storage. Superconducting magnetic energy storage (SMES) uses a magnetic coil cooled to very low temperatures to store electric energy with little loss; it uses an inverter to convert DC to AC that can be connected to the grid.

Hybrid Systems are combinations of these technologies, designed for specific or unusual applications. Renewable energy technologies such as wind and solar systems, e.g., depend on energy sources that cannot be controlled. Therefore, it is necessary to combine them in a hybrid system, such as a PV system with battery backup, to collect energy for use when needed. Nonrenewable hybrid DER systems are also used; one example is a battery system packaged with a microturbine, to ride through short outages with the batteries and use backup power from the microturbine for sustained outages.

DER Deployment Benefits

Distributed power generators are small compared with typical central-station power plants and provide unique benefits that are not available from centralized electricity generation. Many of these benefits come from the fact that the generating units are inherently modular, which makes distributed power highly flexible. It can provide power where it is needed, when it is needed. And because they typically rely on natural gas or renewable resources, the generators can be quieter and less polluting than large power plants, which make them suitable for on-site installation in some locations.

The use of distributed energy technologies can lead to improved efficiency and lower energy costs, particularly in combined cooling, heating, and power (CHP) applications. CHP systems provide electricity along with hot water, heat for industrial processes, space heating and cooling, refrigeration, and humidity control to improve indoor air quality and comfort.

Grid-connected distributed energy resources also support and strengthen the centralized model of electricity generation, transmission, and distribution. While the central generating plant continues to provide most of the power to the grid, DER can be used to meet the peak demands of local distribution feeders or major customers.

Improved reliability and stability of power systems: one of the main benefits of DER is to improve the system reliability the system is experiencing disturbances and faults by providing supplement or backup power.

Improved power quality: the implementation of DER will provide better power quality for the digital economy; reduce losses caused by power quality issues, and offer flexible levels of power quality based on different customer demands.

Increased utilization and efficiency of existing infrastructure: the new system concepts will enable more efficient operation of transmission as well as distribution systems. Distributed energy technologies can relieve transmission bottlenecks by reducing the amount of electricity that must be sent long distances down high-voltage power lines. DER can also provide efficient, low-cost heat and power to a facility and provide energy to off-grid or remote facilities.

Support all generation and storage options: DER offers potentials to accommodate various types of power generation, supports renewables and non-renewables, small-scale distributed generations, EVs and stimulates the development of energy storage systems.

Increased customer service options and benefits: the deployment of DER will enable batter and more customer choices to choose between traditional electricity generated by bulk power plant and more clean and sustainable electricity generated by renewable energy resources and better fulfill customer demands, enhance customer experience and satisfaction.

Reduced environmental impact: DER will result in reduction of greenhouse gas emission by utilizing more efficient and clean generation options, facilitation of more effective land use, assurance of better natural environment and sustainable development.

DER systems can also enhance energy security at a site by helping diversify the energy supply and by providing prime power to mission-critical loads. Provide standby power for critical loads. DER also provides peak power and low-cost energy where electricity rates are high.

References

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Chapter 14: Overview of Distributed Energy Resources Deployed in the Commonwealth of Kentucky

ABSTRACT

The “Overview of Distributed Energy Resources Deployed in the Commonwealth of Kentucky” report presents a summary of the current state of distributed energy resource deployments within the electric utilities of Kentucky. It is a brief assessment, and provides details to support the documents “Overview of Smart Grid Deployments in the Commonwealth of Kentucky”, “Overview of Advanced Metering Infrastructure in the Commonwealth of Kentucky”, Overview of Advanced Distribution Operations in the Commonwealth of Kentucky, “Overview of Advanced Transmission Operations in the Commonwealth of Kentucky”, ”Overview of Advanced Asset Management in the Commonwealth of Kentucky”, and ”Overview of Consumer Education Programs in the Commonwealth of Kentucky”.

The data presented in this report was gathered using the “DER Deployment Survey for Jurisdictional Utilities” (DER Survey). The DE Survey polled utilities on their deployment of fuel based distributed energy resources, renewable distributed energy resources, energy storage devices, electric vehicle integration strategies, and DER integration into the low voltage distribution system.

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INTRODUCTION

ABOUT THIS DOCUMENT

The Kentucky Public Service Commission, the University of Louisville, and the University of Kentucky have partnered under the "Kentucky Smart Grid Roadmap Initiative" (KSGRI) to develop a technical roadmap for the development and deployment of smart grid technologies throughout the Commonwealth. This "Kentucky Smart Grid Roadmap" will provide recommendations and best practices to utilities and utility stakeholders to guide individual smart grid deployment approaches. More information regarding the work of the KSGRI is located in the documents *The Kentucky Smart Grid Roadmap Initiative: Smart Grid Road Map Work Plan*, *The Kentucky Smart Grid Roadmap Initiative: Kentucky Smart Grid Assessment Model*, *The Kentucky Smart Grid Roadmap Initiative: Overview of Smart Grid Deployments in the Commonwealth of Kentucky*, *The Kentucky Smart Grid Roadmap Initiative: Overview of Advanced Metering Infrastructure in the Commonwealth of Kentucky*, *The Kentucky Smart Grid Roadmap Initiative: Overview of Advanced Distribution Operations in the Commonwealth of Kentucky, The Kentucky Smart Grid Roadmap Initiative: Overview of Advanced Transmission Operations in the Commonwealth of Kentucky*, *The Kentucky Smart Grid Roadmap Initiative: Overview of Advanced Asset Management in the Commonwealth of Kentucky*, and *The Kentucky Smart Grid Roadmap Initiative: Overview of Consumer Education Programs in the Commonwealth of Kentucky*.

The purpose of this document is to summarize the results of the DER Deployment Survey for Jurisdictional Utilities, in fulfillment of Work Plan Goals 4 of *Smart Grid Road Map Work Plan*. The DER Survey was distributed to 23 jurisdictional electric utilities to develop an understanding of the "As-is" state of the electric power grid in Kentucky, focusing on the status of distributed energy resources (DERs). Data collected from jurisdictional utilities was via self-reporting by a Smart Grid Contact person from each utility.

List of Participating Utilities

Big Rivers Electric Cooperative
- Kenergy Corp.
- Meade County RECC

East Kentucky Power Cooperative Inc.
- Big Sandy RECC
- Bluegrass Energy Cooperative
- Farmers RECC
- Jackson Energy Cooperative
- Nolin RECC
- Owen Electric Cooperative Corporation
- Salt River Electric Cooperative Corporation
- South Kentucky RECC

Kentucky Power Company

Louisville Gas & Electric and Kentucky Utilities

SUMMARY OF THE DISTRIBUTED ENERGY RESOURCE SURVEY

INTRODUCTION

The DER Survey for Jurisdictional Utilities (DE Survey) was completed by fifteen jurisdictional utilities. The DER Survey polled utilities The DE Survey polled utilities on their deployment of fuel based distributed energy resources, renewable distributed energy resources, energy storage devices, electric vehicle integration strategies, and DER integration into the low voltage distribution system.

FUEL SOURCED DISTRIBUTED ENERGY RESOURCES

The following table summarizes the collected utility responses regarding the total nameplate capacity and the total number of end devices installed for fuel sourced DER technologies, and those planned for installation within the next year.

Fuel Sourced DER Installed at the Distribution System Level

DER TYPE	INSTALLED KW	# INSTALLED END DEVICES	PLANNED KW INSTALLATIONS	# PLANNED INSTALLATIONS
Fuel Cell	0	0	0	0
Diesel Engine	4377	3	1000	Unknown
Natural Gas Engine	14400	6	0	0
Dual-Fuel Engine	0	0	0	0
Natural Gas Microturbine	0	0	0	0

Renewable Distributed Energy Resources

The following table summarizes the collected utility responses regarding the total nameplate capacity and the total number of end devices installed for renewable energy DER technologies, and those planned for installation within the next year.

Renewable Energy DER Installed at the Distribution System Level				
DER Type	Installed kW	# Installed End Devices	Planned kW Installations	# Planned Installations
Microturbine Hydro	0	0	0	0
Solar PV	20	2	0	0
Wind Turbine	0	0	0	0

Energy Storage Distributed Energy Resources

The following table summarizes the collected utility responses regarding the total nameplate capacity and the total number of end devices installed for energy storage DER technologies, and those planned for installation within the next year.

Energy Storage DER Installed at the Distribution System Level				
DER Type	Installed kW	# Installed End Devices	Planned kW Installations	# Planned Installations
Thermal Storage	0	0	0	0
Battery	0	0	0	0
Pumped Hydro	0	0	0	0
Compressed Air	0	0	0	0
Flywheel	0	0	0	0
Storage Capacitor	0	0	0	0

Electric Vehicle Integration Strategies

One utility, Louisville Gas & Electric and Kentucky Utilities, described a strategy for the integration of electric vehicles into the low voltage distribution system: "*LG&E and KU's position on EVs is to support individual customer decisions with no bias to a particular vehicle make, model, manufacturer or fuel source. LG&E and KU offer a Low Emission Vehicle rate which is limited to 200 customers (100 LG&E, 100 KU) as per a tariff which is a time-of-use rate that applies to the customer's whole house. Additionally, as EV owners are identified, a review of the customer's intention to add EV charging load on the distribution infrastructure (e.g., transformer, service conductor, etc.) is performed to assure ongoing reliability of service.*"

Systems Integration

The following categories relate to the integration of DER devices into the low voltage distribution system.

Protection Device Operational Issues

Utilities were asked to indicate their level of concern for five operational issues related to the impacts of DER devices on protection devices in the low voltage system. The possible responses were: A-Not very concerned, B-Somewhat Unconcerned, C-Neither Concerned nor

Unconcerned, D- Somewhat Concerned, E-Very Concerned. Not all utilities responded to all operation issues.

Concerns of DER Influence on Protection Devices					
OPERATIONAL ISSUE	# OF RESPONSES				
	A	B	C	D	E
Nuisance Fuse Blowing	1	0	1	7	2
Unwanted Operations (Reclosers, Sectionalizers, and Fuses)	1	0	1	7	2
Failure of Sectionalizers to Operate When They Should	1	0	2	3	5
Desensitization of Breakers and Reclosers	1	0	2	6	2
Increased Fault Current Levels	0	0	1	7	3

Communications and Standards

When asked “What type of communication technologies are used to communicate to the DERs in your system” utilities responded with the following (# of responses in parenthesis): Telephone (1), Fiber (3), RF Radio (2), PLC (1).

When asked “What type of communication technologies are you considering installing in order to communicate with the DERs in your system?”, utilities responded with the following (# of responses in parenthesis): RF Mesh (2), Cellular (2), 2-GHz Spread Spectrum (1), Fiber (2), microwave (1).

When asked “What information standards do you utilize to communicate amongst the DERs?” utilities responded with the following (# of responses in parenthesis):DNP3 (2), proprietary (3), PLC (1).

When asked “What information standards are you considering?” utilities responded with the following (# of responses in parenthesis): DNP3 (3), TCP/IP (1), proprietary (1), none (1).

When asked “What is your impression of the relative maturity of the DER that are currently deployed at your organization?” utilities responded with the following (# of responses in parenthesis): “Technologies are very mature and widely implemented” (2), “Technologies are moderately mature” (2), “Technologies are fairly new” (1), and “Technologies are leading edge ore experimental, with unproven interfaces” (1).

When asked "Describe the level of effort that is anticipated to integrate DER into your system." utilities responded with the following (# of responses in parenthesis): "Extensive changes will be needed" (3), "Moderate changes will be needed" (4), "Few changes will be needed" (2), and "No changes will be needed" (0).

When asked "Describe the decision making process regarding utilization of your current DER architecture." utilities responded with the following (# of responses in parenthesis): "Dispatched / Centrally managed" (3), "Autonomous / Self managed" (2), and "Mix of centralize and autonomous" (2).

When asked "Describe the decision making process regarding utilization of your planned DER architecture." utilities responded with the following (# of responses in parenthesis): "Dispatched / Centrally managed" (2), "Autonomous / Self managed" (2), and "Mix of centralize and autonomous" (1).

The following table summarized utilities reported concerns/issues for DER deployment and configurations.

General Concerns of DER Deployments
Each case would be specific and most likely added to distribution rather than transmission
For all rotating equipment DER deployments, EKPC mandates that the DER
One of the major concerns is economics. The economics of any DER project must benefit the consumers of Jackson Energy Cooperative.
Need for internal technical expertise is the primary concern. Should number and size of DER's interconnected at the distribution level increase, concerns would be on system loading, potential for unintended islanding, system reliability/stability and safety of utility workers.
Each type DER deployment has their own set of benefits and issues and will have to be considered on case by case bases until the technology matures.
Currently, we have not had enough exposure to large DER projects to comment.

Feedback

East Kentucky Power Cooperative

"The EKPC Landfill Gas Power Plants are connected either to an existing distribution power line owned and operated by an EKPC Member Systems or directly to a distribution substation. All other DER interconnections at the distribution level will be EKPC Member System specific. EKPC currently has 6 Landfill Gas Power Plants."

Kenergy Corp.

"Kenergy has no plans for DER deployment at this time."

LG&E and KU

"LG&E/KU continues to monitor and research emerging Smart Grid technologies such that investments occur at the speed of value. Smart Grid technologies are analyzed utilizing historical investment methods to determine when value will be achieved and thus directing the future state of Smart Grid."

Meade County RECC

"MCRECC does not have any DER other than a few small consumer solar"

Owen Electric

"Owen has two landfill gas generating facilities located within their territory. Both are owned and operated by East Kentucky Power (EKPC). One has its own distribution line owned by EKPC and the other ties to one of Owen's distribution lines. Each have four 800 kW generators.

Even though Owen is a distribution cooperative only, we continually look for opportunities of DER. The issue we face is that none of the technologies have shown to be economically viable yet. We have applied for a solar grant but did not succeed and have another one pending at this time.

Once a DER technology becomes viable at Owen Electric it will be developed"

Chapter 15: Proceedings of the Kentucky Smart Grid Work Shop Series

ABSTRACT

The "Proceedings of the Kentucky Smart Grid Workshop Series" report presents a summary of the three part "Kentucky Smart Grid Workshop Series", held between April 9 and June 21, 2012. The workshops served as a platform to bring together representatives from universities, government, industry, and other interest groups to develop a common vision for the future KY electric power system, concentrating on modernization of generation, transmission, distribution, storage, end use, and regulatory framework.

The workshops included technical presentations, facilitated discussions, and breakout groups to address the following three topics:

1. Technology, market, and policy factors that will have the greatest impact on the development and modernization of the Kentucky electric power system.
2. The current state, the optimal future state, and the gap between for Kentucky's electric infrastructure in the areas of technology, applications and solutions, and research and development.
3. Business models and regulatory approaches available to electric utilities and government regulators to encourage grid modernization that ensure equitable and efficient regulatory and investment processes.

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INTRODUCTION

ABOUT THIS DOCUMENT

The Kentucky Public Service Commission, the University of Louisville, and the University of Kentucky have partnered under the "Kentucky Smart Grid Roadmap Initiative" (KSGRI) to develop a technical roadmap for the development and deployment of smart grid technologies throughout the Commonwealth. This "Kentucky Smart Grid Roadmap" will provide recommendations and best practices to utilities and utility stakeholders to guide individual smart grid deployment approaches.

The purpose of this document is to summarize the results of the three part "Kentucky Smart Grid Workshop Series", held between April 9 and June 21, 2012. The workshops served as a platform to bring together representatives from universities, government, industry, and other interest groups to develop a common vision for the future KY electric power system concentrating on modernization of generation, transmission, distribution, storage, end use, and regulatory framework.

WORKSHOP 1: "SMART GRID FACTORS"

INTRODUCTION

The purpose of the workshop was to identify the elements that will have the greatest impact on the KY electric power system over the next 25 years. Presentations and facilitated discussions addressed technologies, market factors, and policy issues that either enable or inhibit modernization.

DATE AND LOCATION

Monday, April 9, 2012

Conn Center for Renewable Energy Research, University of Louisville, Louisville KY

OPENING SESSION

Welcome and Introduction

Dr. Mickey Wilhelm, Dean Emeritus, Speed School of Engineering

- The Conn Center for Renewable Energy Research can serve as a research leader and facilitator of partnership building between universities, the private sector, and the government.
- Speed School of Engineering will train the engineers necessary to enable the Smart Grid transformation. Education of the future workforce will be a critical component of the grid modernization effort.
- Research and scholarship performed at the Speed School of Engineering will continue to advance the knowledge of Smart Grid systems, and will foster economic development of the regional, state, and national economies through technology transfer.

Opening Remarks

Dr. Len Peters, Cabinet Secretary, Kentucky Energy and Environment Cabinet

- Governor Steve Beshear has established an ambitious 18% cut in energy usage by 2020 which can be achieved through 1-2% improvements per year. Even if this is an unrealistic target, it is one worth trying to achieve.
- Smart Grid can be seen as an enabling technology that can help the state meet these ambitious targets. Additionally, Smart Grid can help to increase Kentucky's Use of Renewable Energy.
- Coal will continue to provide significant energy to Kentuckians for the foreseeable future, including coal-to-liquids and coal-to gas. It is important to balance support for environmental regulations with support for legitimate business activities that contribute to the economic health of Kentucky.
- Kentucky can learn from national Smart Grid demonstration projects, like those performed as part of the Pacific Northwest Smart Grid Demonstration Project.

PRESENTATIONS

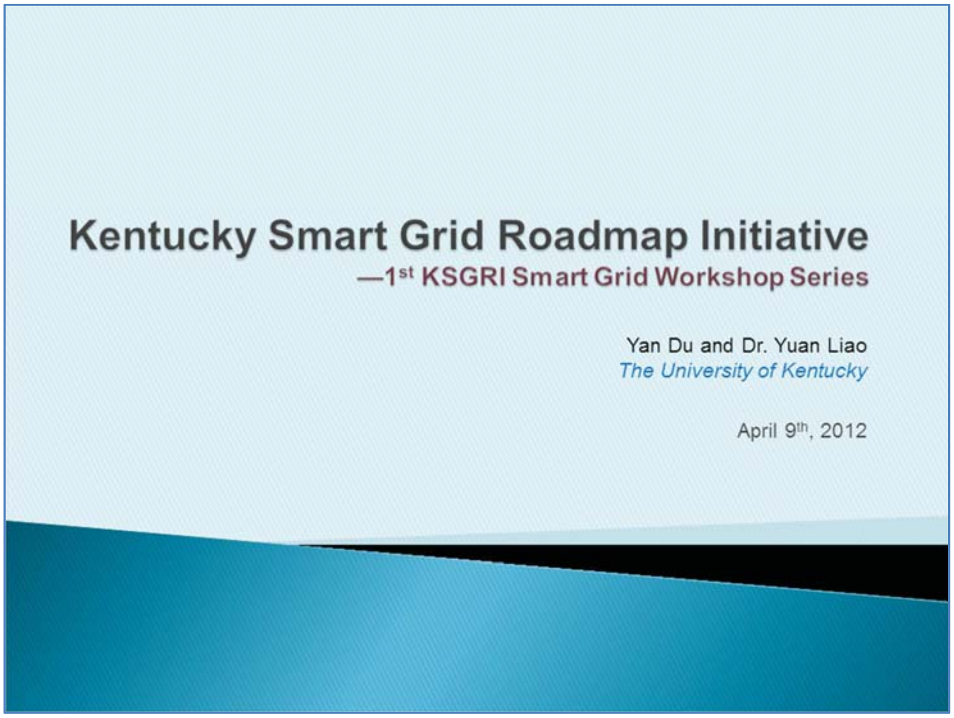
Kentucky Regulatory Policies

Mr. Aaron Greenwell, Deputy Executive Director, KY Public Service Commission

A National Perspective on Smart Grid Programs

Dr. Matthew Turner, Post-Doctoral Scholar, Conn Center for Renewable Energy Research

Overview of Smart Grid in Kentucky & Kentucky Grid 2040
Mr. Yan Du, Principle Investigator, Kentucky Smart Grid Roadmap Initiative



BREAKOUT SESSIONS

Grid Modernization Technology Drivers
Moderated by Adel Elmaghraby, Chair, Computer Engineering, University of Louisville

Focus Question: Considering the many factors that will influence electric grid modernization in Kentucky, what technology factors will most **support** electric grid modernization over the next 30 years?

Enabling Technology Factors	
Low cost energy storage	Use of more advanced materials
Pervasive high speed communications	Miniaturization of technologies
Standardization	Focus on reliability as related to renewable/alternative energy sources
Growth in distribution generation	Ubiquitous communication between customer and utility
Growth in renewable generation	Smart meter deployments
Smart appliances	Smart phone apps
Home energy management systems	Outage detection
Distributed system detection tools	Availability of enriched energy consumption information

Focus Question: Considering the many factors that will influence electric grid modernization in Kentucky, what technology factors will most **inhibit** electric grid modernization over the next 30 years?

Inhibiting Technology Factors	
High costs of technology	Increased rate technological obsolescence
Costs of smart appliances	Low cost Centralized generation
Lack of R&D	Need for backup of distributed generation
Replacing perfectly good hardware	Aging workforce
Unsophisticated adoption strategies	Maintenance
Lack of interoperability standards	

Grid Modernization Public Policy Drivers
Moderated by Bob Amato, Director, Energy Generation, Transmission and Distribution, KY EEC

Grid Modernization Market Drivers
Moderated by David Huff, Director, Energy Efficiency and Smart Grid Strategy, LG&E/KU

Feedback

Attendees were presented with feedback forms to comment upon their experiences during the Kentucky Smart Grid Workshop Series.

Form Question: Please us this form to suggest topics for future workshops.

Feedback Results
More details on pilots
Overview of the grid & generation system in KY -> Supply Chain
Presentation from utilities on what they are doing.
Discussion of legislation and regulatory changes that enable smart grid, possible financial mechanisms, relationship of state scene to regional entities such as MISO, FERC, and federal legislation.
Communications to devise and end user. Value to end user and utility.

Voltage reduction conservation, communication standards.
TVA and/or municipal utilities and smart grid issues.
Consumer aspects of smart grid, “behind the meter”, products and services, market inputs, etc.
Economic development generates from roadmap initiatives.
Research and development opportunities. What can “you/we” do? <- utility, stakeholders, regulator, private sector.
What are the smart grid components that have been implemented in other states that could provide quick success in Kentucky. Presentations from vendor’s suppliers of smart grid components with the inclusion of costs.
Mechanics of incorporating large RE into grid
Invite researchers to talk in general about their research. Invite stakeholders to talk about what universities can do to help them.

Form Question: We would love to hear your comments about today’s workshop. Please use this form to provide us with your thoughts.

Feedback Results
Good interaction, but can do with a larger room
Very good group – experienced participants
A good gathering of people with varied knowledge and backgrounds. Useful information was exchanged.
Very helpful to hear the vision from Len Peters and the regulatory framework from Aaron Greenwell. Breakout groups were a bit disorganize, especially instructions for ranking options.
The meeting was insightful given the various stakeholders with differing views.
The ranking exercise was not well designed.
Excellent format, but need a break before lunch.
This session was very beneficial for an overview and brainstorming of smart grid issues. It may be an improvement to separate topics by functions (i.e. advanced metering, distribution

automation, renewable/distributed energy integration ...)
You probably should have held these sessions a couple of months ago.
Informative workshop. As a solar installer, I would like to see more on how renewables tie in to the smart grid. Specifically, how energy storage and renewable play a role in a large scale. If we ramp up renewables at what point do we need energy storage? 20% renewable production? 30% etc.?
I think the group discussions were very informative and provided a great forum to share viewpoints in a structured format. I would encourage this activity for future workshops.
Very well put together and a great opportunity to provide input to a delicate topic.
Effective, proactive learning and discussion.
Good breakout sessions to drive discussion, but now sure how this helps define the smart grid. Good focus on the vision of the Commonwealth of Kentucky.
The facilitated discussion sessions were somewhat awkward. Somewhat dominated by advocates for or against. Need to define some boundaries for such discussion
Would like copy of presentations, some of the data would be helpful.
The workshop is very nicely organize and is fruitful to me. The afternoon breakout sessions are good.

Form Question: Please suggest future participants in the KSGRI Smart Grid Workshop Series

Feedback Results
Kentucky Association of Electric Cooperatives
OEM Providers
Meter Manufacturers
Community Action Council
FCC
Big Industrial Manufacturers
Commercial/Industrial Customers

KY League of Cities

LIST OF ATTENDEES

Name		Affiliation
Avery	Adams	Duke Energy
Bob	Amato	Kentucky Energy and Environment Cabinet
Venkat	Atkrishnan	GE Consumer & Industrial
Jeff	Auxier	Kentucky Solar Energy Society
Lihui	Bai	University of Kentucky
Tendai	Charasike	Greater Louisville Inc.
Rick	Clewett	Sierra Club
Kimra	Cole	Kentucky Public Service Commission
Ken	Cooper	Bluegrass Energy
Bill	Dawson	Greater Louisville Inc.
Yan	Du	University of Kentucky
Adel	Elmaghraby	University of Louisville
James	Graham	University of Louisville
Aaron	Greenwell	Kentucky Public Service Commission
Dan	Hoffman	RegenEn Solar
Dennis	Howard	Kentucky Agriculture Cabinet
David	Huff	Louisville Gas And Electric and Kentucky Utilities
Yuan	Liao	University of Kentucky
Rick	Lovekamp	Louisville Gas And Electric and Kentucky Utilities
Wallace	McMullen	Sierra Club, Cumberland Chapter
Jeff	Myers	Louisville Gas And Electric and Kentucky Utilities
Len	Peters	Kentucky Energy and Environment Cabinet
Isaac	Scott	Eastern Kentucky Power Cooperative
Mahendra	Sunkara	University of Louisville
Matt	Turner	University of Louisville
Mickey	Wilhelm	University of Louisville
Ron	White	Kentucky School Board Association

WORKSHOP 2: "KY GRID 2040"

INTRODUCTION

The purpose of the workshop was to serve as a platform for participants to identify the current state, the desired future state, and the gap in between for KY's electric infrastructure over the next 25 years, focusing specifically on Smart Grid deployments and technologies, applications and solutions, research and development, and other issues that enable the modernization of KY power grid.

DATE AND LOCATION

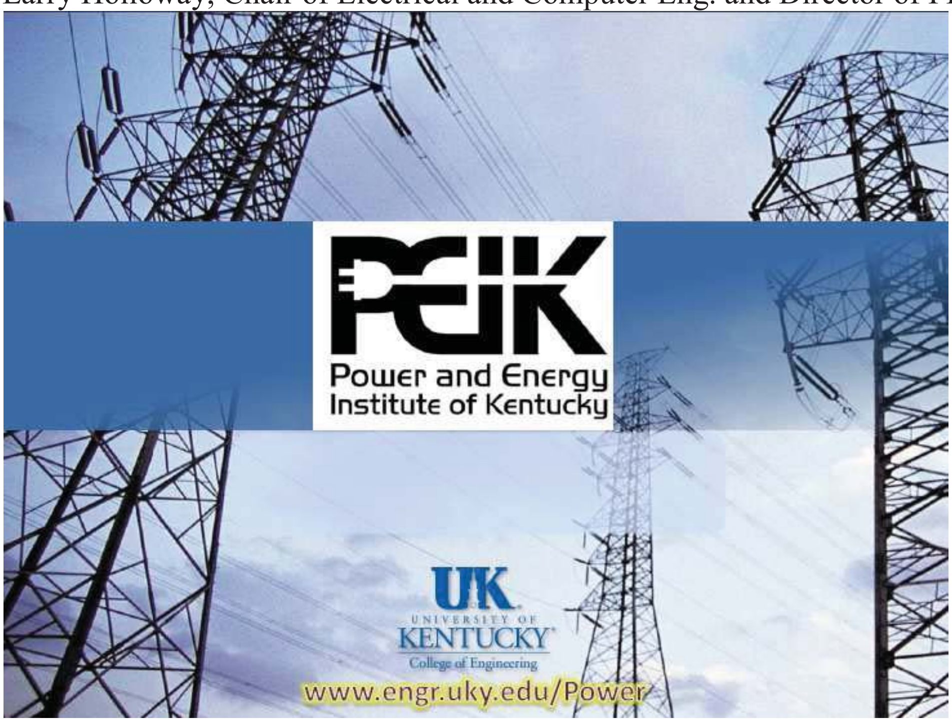
Friday, May 18, 2012

Room 206, UK Student Center 404 South Limestone St, University of Kentucky, Lexington, KY

OPENING SESSION

Welcome and Introduction

Dr. Larry Holloway, Chair of Electrical and Computer Eng. and Director of PEIK



PRESENTATIONS

DEDI Smart Grid Grants

Mr. Bob Amato, Director, Energy Generation, Transmission, and Distribution, KY Department for Energy Development and Independence (DEDI)

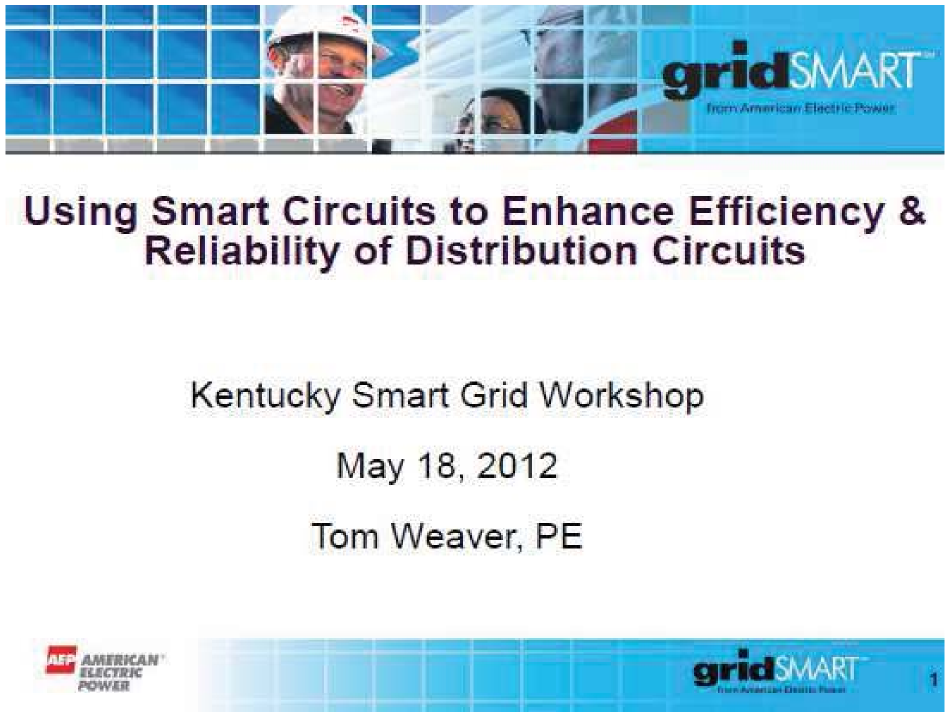
Consideration of Smart Grid Technology
Mr. Aaron Greenwell, Deputy Executive Director, KY Public Service Commission

Smart Grid Strategy
Mr. David Huff, Director, Customer Energy Efficiency & Smart Grid Strategy, LG&E-KU

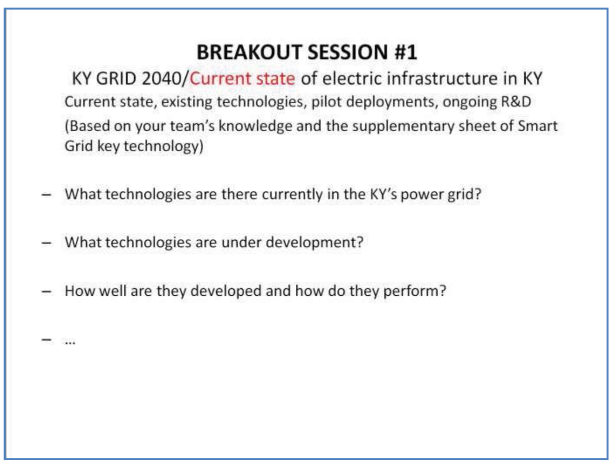
Smart Grid Factors Ranking Exercises
Dr. Matt Turner, Conn Renewable Center, University of Louisville, KSGRI Team

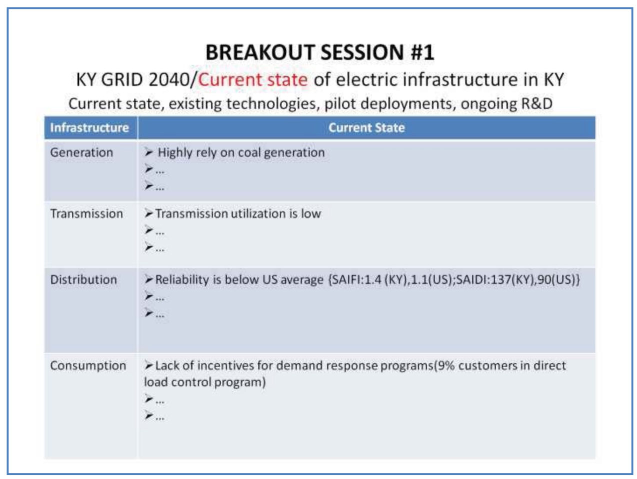
Using Smart Circuits to Enhance Efficiency & Reliability of Distribution Circuit system Planning

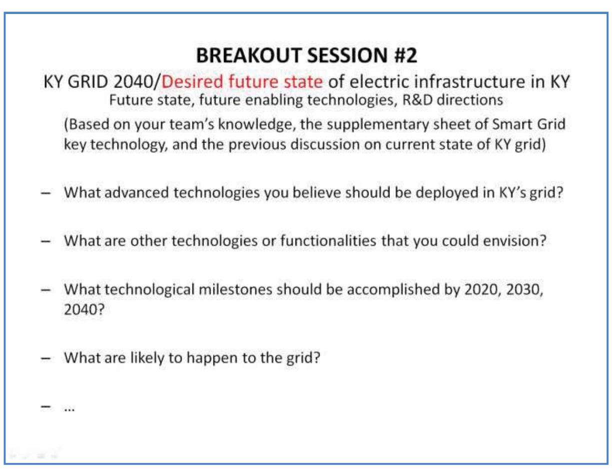
Mr. Tom Weaver, Manager, Distribution System Planning, AEP Kentucky Power

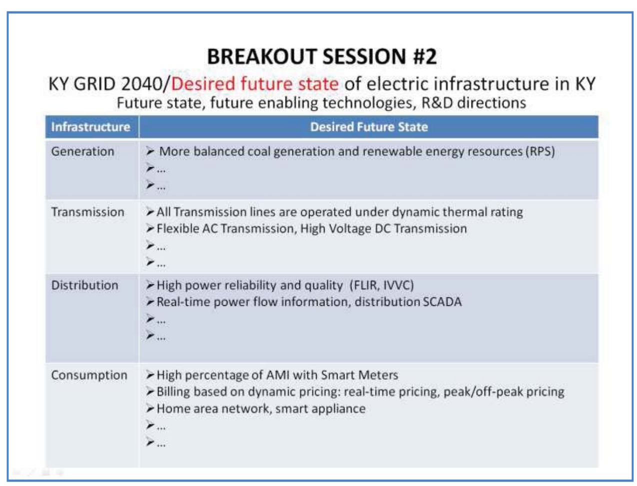


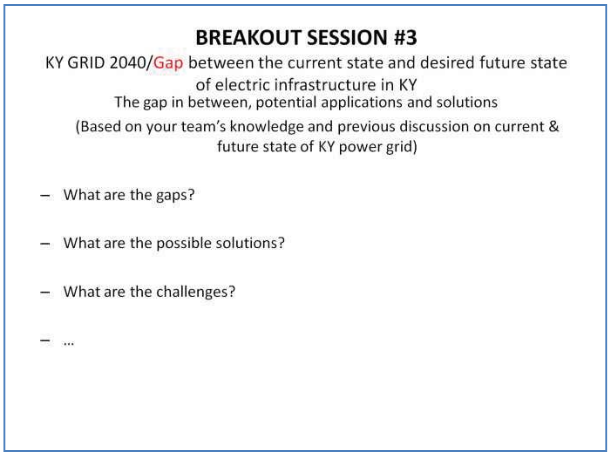
BREAKOUT SESSIONS

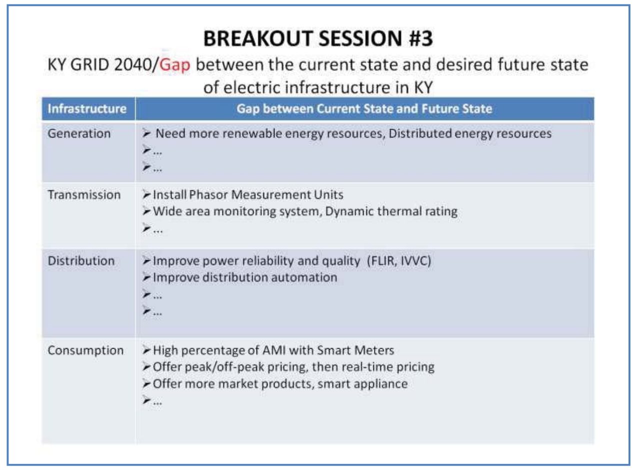












TEAM BRIEFING AND RESULTS

Attendees were divided into three teams and presented with results summary sheets to comment upon their experiences during the Kentucky Smart Grid Workshop Series. All results from three breakout sessions are attached below.

BREAKOUT SESSION #1 Team Blue

KY GRID 2040/Current state of electric infrastructure in KY

Current state, existing technologies, pilot deployments, ongoing R&D, etc.

- Generation

Baseload Coal –scrubbed , old

Peaking Gas

Limited renewable-hydro

Other renewable, landfill gas solar

- Transmission

Large amount and reliance on 69kv transmission

SCADA deployment high

Reliability and capacity is monitored studied by reliability coordinators, improvements made as necessary

Low penetrator of synchrophasor

Aging infrastructure

- Distribution

Aging infrastructure

SCADA is to distribution substations but not beyond

Limited 2-way communication

- Consumption

Above average

No real-time tariff

Limited consumer information

BREAKOUT SESSION #1 Team Green

KY GRID 2040/Current state of electric infrastructure in KY

Current state, existing technologies, pilot deployments, ongoing R&D, etc.

- Generation

Low penetration of renewables

No legislation to encourage renewables

High reliant on coal

Aging facilities

Low cost generation

- Transmission

Better networking/control

Robust (good capacity)

Geographically close to other regional grids, but not necessarily well connected

- Distribution

Aging infrastructure

Low-tech infrastructure

Rural-vulnerable to weather

Rural-> distance challenge, scarcity of population, rugged terrain, reliability issue/costly

- Consumption

High energy intensity users-industry expecting low cost

Little incentive for efficiency due to low cost, high consumption per person

Electric resistance heat

Poor insulation

Poor customer awareness and interest of usage/efficiency

Difficulty finding energy efficiency information

BREAKOUT SESSION #1 Team Red

KY GRID 2040/Current state of electric infrastructure in KY

Current state, existing technologies, pilot deployments, ongoing R&D, etc.

- Generation

Highly reliance coal, sensitivity of fuel diversity

2% renewable

17 mw landfill gas, 120-140 mw potential

50 mw biomass cited

Access to fuels limits > political issues, infrastructure

Hyped net zero

Aging resources

- Transmission

SCADA deployed
Ability to purchase power may be limited
Current approach synchrophasors
aging

- Distribution

SCADA not universally deployed
Voltage regulator/capacitors
AMR/AMI not widely deployed

- Consumption

Quantification of reduction
Customer perceptions, disjointed
DR participation is low

BREAKOUT SESSION#2 Team Blue

KY GRID 2040/Desired future state of electric infrastructure in KY

Future state, future enabling technologies, R&D directions, etc.

- Generation

More diversified generation portfolio
Reduced emissions
More distributed generation
High density/low cost energy storage

- Transmission

Dynamic thermal rating
Advanced materials/conductors
High penetration of synchophasors
Increased looping of circuits

- Distribution

Increased looping of circuits, automated switching
Increased volt/VAR control
Increased SCADA visibility
Fault location
Fault anticipation

- Consumption

Greater and easier ability to control energy use
Remote control of home use
Smart appliances

Demand response increase
Consumer education improvement

BREAKOUT SESSION#2 Team Green
KY GRID 2040/Desired future state of electric infrastructure in KY
Future state, future enabling technologies, R&D directions, etc.

- Generation

Remain nationally competitive on cost
Have a more balanced/diversified portfolio
Reliable generation
Low-greenhouse gases
Distributed generation

- Transmission

Energy storage
Better transmission interconnects (meet winter/summer peakers)
Reliability

- Distribution

Energy storage
Distributed generation into the grid
Improved communication
Better industry standardization of technology
Reliability

- Consumption

Higher penetration of EV
Automated appliances
Incentives for efficiency
Keep our jobs (keep industry)
Increased energy efficiency (industry/consumers)
Rate structure that have good behaviors
Better consumer awareness/knowledge

BREAKOUT SESSION#2 Team Red
KY GRID 2040/Desired future state of electric infrastructure in KY
Future state, future enabling technologies, R&D directions, etc.

- Generation

Exploration of increase in utilization of hydroelectric
Highly accurate forecasting of weather for utilization of solar/wind balance
Generation agnostic deployed as-is; cost effective to economic health/reliability/environmental
Appropriate mixture of distributed/centralized

Generation through energy efficiency

- Transmission

Increased infrastructure utilization to open markets

- Distribution

Addition of new tech to support DER/Grid storage full-scale SCADA

DC distribution bus

- Consumption

Regional pricing signal

End users active in electricity markets

“road-sigh” for consumers

Greatly expanded communications/improved interaction by consumers

Consumers access to open markets

Larger diversity of energy plans

More control/elimination of phantom loads

BREAKOUT SESSION #3 Team Blue

KY GRID 2040/Gap in between

The gap between the current state and desired future state, potential applications and solutions, etc.

- Generation

Resolve policy issues

Technology advancement in energy storage

Reduced cost in renewable, distributed energy

- Transmission

2-way power flow, accommodation

Interoperability/open standards/common information model

Data analysis

2-way communication bandwidth

Cyber security

Solidification of standards

- Distribution

Data analysis

2-way power flow accommodation

Interoperability/open standards/common information model

Cyber security

- Consumption

Education
Price point for participation
3rd party products for energy management
Data privacy/data sharing

BREAKOUT SESSION #3 Team Green
KY GRID 2040/Gap in between
The gap between the current state and desired future state, potential applications and solutions, etc.

- Generation

Unknown current/future regulation
Policy changes and new technologies to make renewables attractive
Unknown future costs of energy sources
Do we really know our solar wind resource potential? need for new technologies

- Transmission

How to encourage and pay for improved interconnects
Adequate market?
Take advantage of geographic connections—N/S/E/W
How to develop energy storage?
Capital cost
Cyber security

- Distribution

What is the cost of high reliability?
What is consumers' expectation?
How to handle/integrate distributed generation?
How to develop energy storage?
How to handle microgrids/islanding/distributed generation?
Capital cost
Cyber security

- Consumption

Better educated/informed consumer
More sustained efforts on efficiency
Infrastructure for EV
Programs to improve efficiency (industry, consumer)
Changing net-metering limits

BREAKOUT SESSION #3 Team Red
KY GRID 2040/Gap in between

The gap between the current state and desired future state, potential applications and solutions, etc.

- Generation

Provider of last resort/reliability < open question

Uncertainty in supply (natural gas, solar resource/ wind resource)

Gap

- Transmission

Infrastructure/capacity upgrades needed

- Distribution

Gap in intelligence > SCADA and AMI

Reliability increases

One way power flow

Control of DERs

How is it paid for?

- Consumption

End user education technologies

Appropriate product/service design & pricing

In-ability to interact with market; tech market opportunities

Low participation in DR programs

Determination of practical limits

Appropriate determination of cost recovery/ROI

List of Attendees

Affiliation	Name (First Last)	Team
University of Kentucky	Yan Du	BLUE
University of Kentucky	Yuan Liao	RED
University of Kentucky	Larry Holloway	GREEN
University of Kentucky	Aaron Cramer	RED
University of Louisville	Matt Turner	RED
University of Louisville	Mike McIntyre	GREEN
LGE-KU	David Huff	BLUE
LGE-KU	Rick Lovekamp	GREEN
LGE-KU	Jeff Myers	RED
Owen Electric Cooperative	Mark Stallons	BLUE
Owen Electric Cooperative	James Bridges	RED
AEP-Kentucky Power	E. J. Clayton	GREEN
AEP-Kentucky Power	Tom Weaver	BLUE

National Energy Education Development	Karen Reagor	GREEN
Sierra Club, EarthWorks, and KY Sustainable Energy Alliance	Susan Carson Lambert	GREEN
Sierra Club	John Robbins	RED
Lexington-Fayette Urban County Government (LFUCG)	James Bush	BLUE
KY Dept. for Energy Development and Independence (DEDI)	Bob Amato	BLUE
KY Dept. for Energy Development and Independence (DEDI)	Steve Dale	GREEN
KY Dept. for Energy Development and Independence (DEDI)	Robert Duff	RED
Kentucky Public Service Commission (KPSC)	Kimra Cole	GREEN
Kentucky Public Service Commission (KPSC)	John Rogness	RED
Kentucky Public Service Commission (KPSC)	Aaron Greenwell	BLUE
Schneider Electric	Alan Manche	BLUE

WORKSHOP 3: “SMART GRID MARKETS AND POLICY”

INTRODUCTION

The purpose of the workshop was to serve as a platform for participants to discuss the different approaches available to electric utilities and public utility commissions to encourage grid modernization, and how efficient and equitable regulatory and investment processes can best be ensured for the KY electric power system over the next 25 years. Presentations and facilitated discussions addressed emergent business models, the Kentucky regulatory process, and the value equation for utilities and regulators

DATE AND LOCATION

Thursday, June 21, 2012

Conn Center for Renewable Energy Research, University of Louisville, Louisville KY

OPENING SESSION

Welcome and Introduction

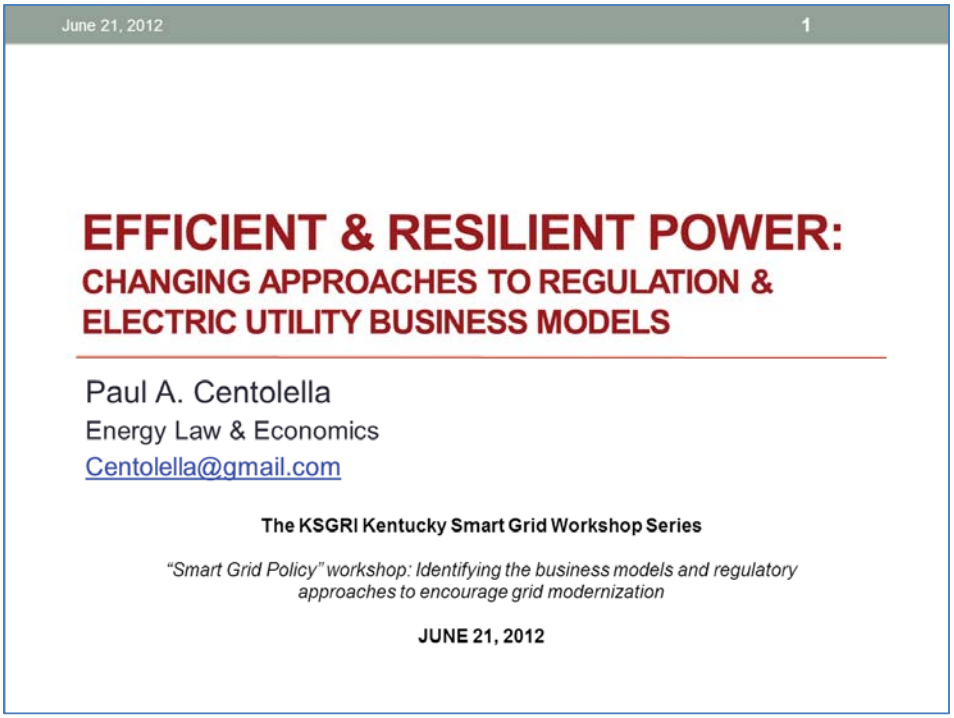
Dr. Mahendra Sunkara, Acting Director, Conn Center for Renewable Energy Research

- Conn Center leads Kentucky’s efforts in renewable energy and sustainability research, advances the goal of renewable energy, and promotes technologies that increase energy efficiency utilization.
- By developing the manufacturing of renewables and energy efficient technologies, the Conn Center is helping to define the future of Kentucky’s economy.
- This transition must occur in concert with policy development that supports renewable energy technology research and the training of technologists. The Conn Center is uniquely positioned to provide guidance in this area, and seeks to continue to develop programs in energy engineering and public policy.

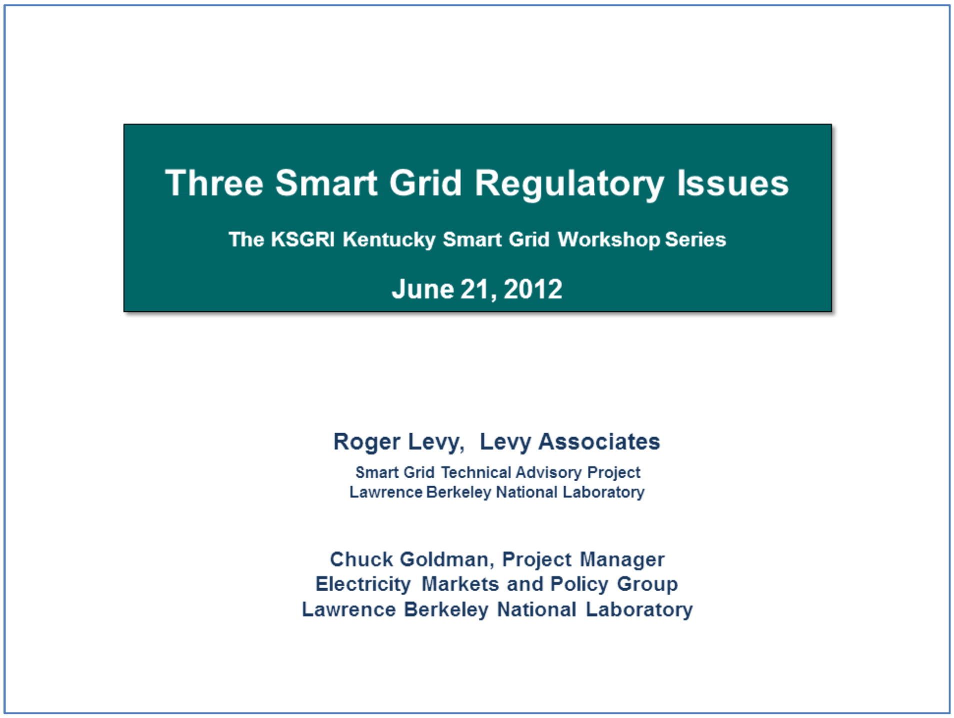
PRESENTATIONS

Regulatory Policies

Mr. Paul Centolella, Commissioner Emeritus, Public Utilities Commission of Ohio



Three Smart Grid Regulator Issues
Mr. Roger Levy, Manager, Lawrence Berkley National Lab Smart Grid Technical Assistance Effort



BREAKOUT SESSIONS

Identifying the Smart Grid Value Equation for Both Utilities and Regulators

Moderated by Matthew Turner, Coordinator, Kentucky Smart Grid Workshop Series

Focus Question:

The following question was posed to the attendees by the session moderator.

> "How can regulators and utility executives work together towards the changes that will enable an efficient and equitable regulatory and investment process to encourage grid modernization?
>
> How does this approach differ from business as usual (e.g. protection of consumer interest vs. acceptance of increased investment risk)?
>
> What are the consequences, if any, of not adopting this approach in KY?"

The attendees then participated in small group discussions. The following bullets document the major points addressed during these discussions.

- Utilities have limited capital resources, and many investment opportunities will compete for the same capital. This can be intra-state, such as deciding to invest in distribution maintenance over a smart grid pilot, or inter-state, such as deciding to invest capital in a more regulatory certain market.
- The low electric rates in Kentucky require the creation of a different value equation than many of the "smart grid success" states. Therefore, the utilities of Kentucky need to be provided an opportunity to try new strategies, with the possibility of failure. There are

questions to be resolved regarding who should bear the investment risks in these experiments, either electric consumers or the utilities themselves. In either case, there should be increased utility involvement in researching and recommending regulatory improvements and in developing sound business cases and improved feedback from the public service commission regarding strategy and implementation.

- The laws in Kentucky should be evaluated for their ability to allow utilities to do more than "sell electrons". Examples include the utility as an energy service provider, the ability to increase the variability amongst rate design, and unbundling of generation, transmission and distribution services.

- The development of clear state policy framework appropriate for the modern grid is necessary. This should begin with the clarification of state goals regarding interactions between the following: carbon reduction, asset utilization renewable portfolio standards, reliability, affordability and safety. However, changes in legislation can greatly complicate the business case and all decisions must be made considering the system holistically.

- The current regulatory model utilized in Kentucky is sufficient to support grid modernization. However, there is a need for improvement in the continuity between PSC commissioners, particularly in regards to transitional periods. Additionally, the Public Service Commission of Kentucky should be provided with additional resources to facilitate Smart Grid competency within the commission.

- Grid modernization needs to be approached holistically and involve utility operators, state government and regulators, stakeholders, and customers. This would be best achieved by continuing to promote informal interactions between these groups at events such as the Kentucky Smart Grid Workshop Series. Additionally, the state should create a Kentucky Task Force on Smart Grid that will form recommendations regarding transition planning within the state and ensuring continuity in regulation and legislation. These meetings can also serve educational purposes, to encourage the sharing of information and procedures amongst those interested.

List of Attendees

Name		Affiliation
Avery	Adams	Duke Energy
Bill	Burke	General Electric
Paul	Centolella	Commissioner Emeritus, PUC Ohio
Steve	Dale	Kentucky Energy and Environment Cabinet
Tom	Dorman	Office of Rep. Adkins
Yan	Du	University of Kentucky
Robert	Duff	Kentucky Energy and Environment Cabinet
Adel	Elmaghraby	University of Louisville
David	Huff	Louisville Gas & Electric and Kentucky Utilities
Rick	Lovekamp	Louisville Gas & Electric and Kentucky Utilities

Jeff	Myers	Louisville Gas & Electric and Kentucky Utilities
John	Naber	University of Louisville
John	Rogness	Kentucky Public Service Commission
Isaac	Scott	East Kentucky Power Cooperative
Jim	See	Owen Electric Cooperative
Mahendra	Sunkara	Conn Center for Renewable Energy Research
Matthew	Turner	Conn Center for Renewable Energy Research
Tom	Weaver	Kentucky Power
Ron	Willhite	Kentucky School Board Association

APPENDIX A: EU-KSGAM ASSESSMENT SURVEY

EU-KSGAM ASSESSMENT SURVEY

INTRODUCTION

The "Electric Utility Kentucky Smart Grid Assessment Survey" (assessment survey) is a survey based assessment of smart grid maturity intended for completion by the electric utilities of Kentucky. The questions within the assessment survey collect demographic data, performance data, and characterize the maturity level of responding utilities smart grid implementation in the context of the KSGAM Definition.

The assessment survey consists of two sections. Section one is the "Utility Profile"; it collects company information, identifies an EU-KSGAM contact at the responding utility, and collects demographic and performance data on the utility under assessment. Section two is the "Smart Grid Class Assessment", which utilizes questions based on the EU-KSGAM to perform an "As-Is" assessment of the grid and to identify the utility's "Desired Future State" of the grid.

Doe

Demographic Information

1. Provide the number of employees in KY (including temporary, part-time, and full-time).

2. Provide the total customer count in KY. Divide the totals among the following customer categories:

   a. Residential

   b. Commercial and Industrial

   c. Other (Specify)

3. Provide the size of KY service territory in mi^2

4. Provide the average number of customers per line mile of distribution.

5. Indicate in which markets the organization operates. Circle Y/N for each of the following:

   d. Generation Y/N

e. Transmission Y/N

f. Distribution Y/N

g. Other (Specify) Y/N

Equipment Information

1. Provide the utilities meter count. Divide the totals among the following meter categories:
    a. Electromechanical

    b. AMR Enabled

    c. AMI Enabled

2. Provide information regarding delivered power:
    a. Megawatt hours of generation served.

    b. Peak demand (15 minute averaged MW for the year).

    c. Level of distributed generation (MW-hrs).

    d. Level of renewable generation (kW-hrs)

    e. Level of net metered generation (kW-hrs)

3. Provide the number of line miles of transmission, if applicable.

4. Provide the number of line miles of distribution, if applicable.

5. Provide the number of substations in KY by voltage class.
    a. < 13kV
    b. 13kV – 35kV
    c. 35kV-69kV
    d. 69kV-115kV
    e. 115kV-230kV
    f. 230kV-345kV
    g. 345kV-765kV
    h. 765kV-1100kV
    i. > 1100 kV

Performance Information

Please provide the following performance data for the prior year:

1. Provide the following data for the prior year:
    a. Predicted SAIFI
    b. Actual SAIFI calculated according to IEEE Std. 1366-2003

c. Predicted SAIDI

d. Actual SAIDI calculated according to IEEE Std. 1366-2003

2. Provide the following data regarding planned outages:
    a. Average duration of planned outages in minutes (min).

    b. Average percentage of customers impacted by typical planned outage.

    c. Total number of planned outages.

    d. Cumulative duration of planned outages in minutes (min).

3. Provide the following data regarding unplanned outages:
    a. Average duration of unplanned outage in minutes (min).

    b. Average percentage of customers impacted by typical unplanned outage.

    c. Total number of unplanned outages.

    d. Cumulative duration of unplanned outages in minutes (min).

4. Provide the total line loss % across the grid based on source energy.
    a. For the transmission system alone:

    b. For the distribution system alone:

5. Provide the estimated utilization data for transmission line capacity.

6. Provide the measurement of power quality level of your system.

7. Provide the following regarding operating costs:
    a. Total operating costs related to transmission (personnel, systems, overhead, outsourcing, other)

    b. Total operating costs related to distribution (personnel, systems, overhead, outsourcing, other)

8. Provide the total number of work orders initiated for field visit operations (truck rolls).

9. Provide the utilities estimate restoration time (ERT).

Deployment Impact and Experiences

1. Regarding Demand Response (DR) programs:

    a. Does your utility offer DR programs?

    b. How many customers are invited and how many customers participated in the program?

    c. How is pricing information communicated to customers?

    d. Are other incentives provided to customers?

    e. How much peak load reduction is achieved?

    f. Is the total energy consumption reduced?

    g. What benefits have been yielded by this program to the utility? To the customers?

h. If you plan on implementing Dynamic Pricing in the future, do you consider your company is ready based on the current infrastructure and resource you have?

2. Regarding the DR programs above, comment on your experiences regarding customer acceptance, participation and education

3. Has your organization implemented other grid modernization practices such as Conservation Voltage Reduction (CVR), grid scale energy storage, advanced asset management, or others?

   a. Describe interoperability issues you have encountered regarding system integration.

   b. Describe the use of open architectures in such systems.

4. Does your organization have a multi-year Smart Grid plan? What time period does this cover (i.e. no plan, <3 yr., 3-7 yr., >7yr.)?

5. Describe your opinion on the weakness of the overall power system in Kentucky.

6. Describe your major concerns on the Smart Grid deployment in Kentucky including your top priorities for areas of action.

Additional Information

The following is a list of smart grid functionalities. Some technologies that realize the corresponding functionality are listed. Indicate which technologies are deployed in your system. If certain technology is not deployed yet, please indicate future deployment plans.

1. **Increased power efficiency** – Reduce transmission and distribution loss, reduce customer load loss, and increase efficiency on electrical generation. Enabling technologies:
    a. Transmission SCADA/EMS
    b. Distribution SCADA/DMS
    c. Optimized voltage and reactive power control
    d. Smarting metering
    e. Solid-state transformer
    f. Superconducting transmission
    g. High voltage DC transmission
    h. Any technology that increases generation thermal efficiency
    i. Any additional technology you may have deployed

2. **Increased power transfer capability** – Increase the power transfer capability of transmission systems in Kentucky. Facilitate regional system interconnection. This is important if Kentucky is going to purchase large amount of renewable energy from other states.
    a. Phasor measurement unit technology
    b. Dynamic thermal rating of transmission line
    c. Transmission SCADA/EMS
    d. High voltage DC transmission
    e. Any additional technology you may have deployed

3. **Increased system reliability** – Anticipate and respond to system disturbances, operate resiliently against attack and natural disaster, curtail the duration of power outage, isolate power outage area to only fault vicinity by automated system reconfiguration. Enabling technologies:
    a. Fault detection and location system
    b. Automated system reconfiguration and restoration
    c. Outage management system
    d. Transmission SCADA/EMS
    e. Distribution SCADA/DMS
    f. Phasor measurement unit technology
    g. Superconducting magnetic energy storage system
    h. Short-circuit current limiting
    i. Any additional technology you may have deployed

4. **Improved power quality** – Provide power quality for the digital economy, reduce economic loss caused by power quality issues, offer flexible level of power quality based on customer demand. Enabling technologies:
    a. Power quality monitoring system
    b. Energy storage technology
    c. Capacitive compensation
    d. Any additional technology you may have deployed

5. **Optimized asset utilization and efficient operation** – Optimally manage generation plant, substation and power line, increase the utilization of line capacity by adjusting thermal ratings in real-time. Enabling technologies:
    a. Dynamic thermal rating of transformer and transmission line
    b. Condition based operation & maintenance
    c. Any additional technology you may have deployed

6. **Facilitates integration of distributed generations including renewable energy** – Offer the possibility to accommodate various types of power generation, i.e. coal, hydro, wind, solar, biomass, etc.; offer the opportunity for net-metering, stimulate the development of energy storage system, reduce reliance on imported fuel. Enabling technologies:
    a. Net-metering
    b. Energy storage system, large capacity battery
    c. Microgrid
    d. Integration with electric vehicles(PEV)
    e. Any additional technology you may have deployed

7. **More effective consumer load control** – Implement effective demand side management, offer the opportunity of incentive pricing strategy, e.g. real-time pricing, peak/off-peak pricing, enable active participation by consumers, offer the opportunity for customers to control their energy consumption, increase customer choice on selection of generation as power supply. Enabling technologies:
    a. Demand side management
    b. Smart metering
    c. Home energy management system, e.g. In-home display, web portal
    d. Any pricing strategy, e.g. real-time pricing, dynamic pricing, critical pricing
    e. Consumer load control technology such as programmable thermostat
    f. Any additional technology you may have deployed

8. **Enhanced grid awareness** – Enable more effective grid monitoring and acquire better knowledge of grid conditions by utilizing advanced sensing and measurement technology. Enabling technologies:
    a. SCADA
    b. Breaker monitoring system
    c. Wide-area monitoring system
    d. Phasor measurement unit

e. Geographic information system
f. Digital event recording device
g. Transmission line sag monitoring
h. Any additional technology you may have deployed

9. **Increased national and information security** – Through deterrence of organized attacks on the grid, protect data and information privacy, and enhance cyber security. Enabling technologies:
    a. Techniques related to cyber security
    b. Techniques related to data privacy
    c. Any additional technology you may have deployed

10. What other smart grid technologies have been deployed by the utility?

11. Describe your cyber security concerns.

12. Does your grid have power flow congestion issues?

13. Describe the preparedness for terrorist attacks and natural disasters.

14. Describe capability of accommodating any type of energy generation/storage.

Smart Grid Class Assessment

The following pages contain one assessment form for each of the Smart Grid Classes (10 forms in total). For each of the 10 SGCs, place a mark in the "As-is" column next to the **one** Development Level that best represents the current state of the utility. Also place a mark in the "Future" column next to the **one** DL that best represents the desired future state of the utility. Use the remaining white space to provide any comments. For the Government and Regulation (GR) SGC evaluations are to be made regarding the KY regulatory environment (KY PSC, governments, etc.)

Strategy and Management (SM)
Vision and Planning, Internal Governance, Stakeholder Collaboration

As-is	Future			
€	€	SM DL0	DFAULT	Default / No characteristics have been implemented.
€	€	SM DL1	INITIATING	The utility develops and begins to implement a SG vision. Discussions with regulators and other stakeholders about the vision and its implementation take place. • SG vision that addresses operational improvement. • Support for pilots of SG concepts. • Discussions with regulators about the SG vision.
€	€	SM DL2	ENABLING	The utility moves to implement a SG vision with a distinct budget. Decisions increasingly implement this vision. Relationships with stakeholders are established to implement the SG vision. • Internal strategy plan approved by management and accepted across most lines of business. • Budgets for proof-of-concept projects and operational investments
€	€	SM DL3	INTEGRATING	SG strategy is integrated into the overall vision and management processes across LOBs. There is organization-wide commitment to and increased cooperation with stakeholders on an integrated SG strategy and plan. • SG governance model established. SG leaders and tools ensure implementation. • Authorizations for SG investments secured.
€	€	SM DL4	OPTIMIZING	SG modernization drives business strategy and provides opportunities for enhanced business models and synergistic external relationships. There is increase information sharing and collaboration within the organization and with external stakeholders. • SG is a core competency across all functions of the utility. • SG strategy is shared and revised collaboratively with external stakeholders.
€	€	SM DL5	PIONEERING	All stakeholders, internal and external, are involved in all relevant aspects of the business and have a goal of innovation/. • Utilization of SG as a foundation to introduce new services and products. • Financially self-sustaining SG business activities, to the point of expansion. • SG capabilities result in new business models.

Organization and Structure (OS)
Structure, Training, Communications, Knowledge Management

As-is	Future			
€	€	OS DL0	DFAULT	Default / No characteristics have been implemented.
€	€	OS DL1	INITIATING	The utility recognizes the need to achieve a SG transformation and takes initial steps to begin building the necessary competencies. • Articulation of need to build Smart grid competencies into workforce. • Allocation of resources/budget to SG education and hiring by leadership • Company-wide SG awareness efforts.
€	€	OS DL2	ENABLING	The utility works across functional units to enable the realization of its SG vision. The utility is overcoming barriers related to the workforce through active engagement. Long-term organizational impacts with respect to SG are recognized and proactively addressed. • Formation of SG implementation/deployment teams • SG education/training methods identified and made available. • Performance reviews include the completion of Smart grid milestones.
€	€	OS DL3	INTEGRATING	The SG vision is being integration into the organizational structure. The SG vision affects strategic priorities and fundamental aspects such as culture, role definition, performance evaluation, and compensation. • Leadership provides a consistent Smart grid vision and strategy. • Compensation linked to Smart grid performance/milestones. • Education and training aligned to exploit SG capabilities.
€	€	OS DL4	OPTIMIZING	The utility is structured to achieve its SG vision. Operation visibility extends across the organization, enabling the desired cultural and organizational transformation. • Decentralized real time decision making and real time corrections capabilities provided through SG. • E end-to-end grid observability leveraged by internal and external stakeholders. • Organizational structures and the increased availability of information
€	€	OS DL5	PIONEERING	Stakeholders are involved in most aspects of the business, and the organization is concentration on innovation. • Collaboration with external stakeholders to optimize overall grid operations and health. • Support of new ventures, products, and services as they emerge as a result of SG. • IP harvested and developed. Rewards to those that advance processes, workforce competencies, and technology.

Technology (TECH)

IT Architecture, Standards, Infrastructure, Integration, Tools

As-is	Future	Level	Stage	Characteristics
€	€	TECH DL0	DFAULT	Default / No characteristics have been implemented.
€	€	TECH DL1	INITIATING	The utility explores standardized but flexible IT systems that can be used as a solid technical foundation on which to build a robust SG information infrastructure. • Development of IT architecture to support SG applications. • Processes in place to evaluate and select technologies in alignment with SG vision. • Opportunities to improve performance (e.g. cost reduction, workflow improvement) via technology are identified.
€	€	TECH DL2	ENABLING	A tech strategy is defined that recognizes LOB interdependence for achieving SG goals. Early SG deployments of tech are underway. • IT investments aligned with strategic directions needed to implement SG benefits. • IT architecture standards support the SG strategy and a common technology evaluation process is applied to all SG activities. • A grid data communication strategy exists. • Distributed IED pilots (e.g. PQ monitoring and control for automation)
€	€	TECH DL3	INTEGRATING	The utility implements its technology strategy for SG and integrates organizational systems • Systems adhere to an enterprise IT framework for SG (e.g. IEC 61850) • SG specific tech is implemented to improve cross-LOB performance (e.g. peak demand management, fault detection, VVO) • Advanced distribution intelligence and analytical capabilities. • An advance sensor plan exists. • Detailed data communication strategy/tactics in place, crossing LOBs.
€	€	TECH DL4	OPTIMIZING	Systems are interconnected through an enterprise-wide IT architecture that has been optimized to support SG services, with visibility across LOBs. Security, privacy, and performance issues have been addressed. • Data flows end-to-end, from customer to generation. • Real-time monitoring and control via wide area situational awareness. • Predictive modeling and near real-time simulation optimize support processes.
€	€	TECH DL5	PIONEERING	Systems have the ability to adapt to internal and external influences to (1) continue to meet SG goals despite a rapid onset of adverse circumstances, (2) take advantage of new opportunities that arise due to SG capabilities. • Autonomic computing using machine learning. • Leading-edge grid stability systems deployed. • Automatic optimization of business processes in response to conditions via advanced tech. • Partnerships to develop innovative solutions to meet future SG needs.

System Architecture and Operation (SAO)
Efficiency, Observability, Control, Automation

As-is	Future			
€	€	SAO DL0	DEFAULT	Default / No characteristics have been implemented.
€	€	SAO DL1	INITIATING	The utility evaluates potential opportunities for automation in grid operations and explores process optimization capabilities that a SG will enable. • Evaluation of sensors, switches, and communications technologies for monitoring and control. • Grid monitoring/control proof-of-concept and component testing. • Evaluation of outage and distribution management system linked to substation automation beyond SCADA.
€	€	SAO DL2	ENABLING	The utility starts to deploy initial grid monitoring and control tied to the SG vision with an emphasis on communications to support automation. • Initial distribution to substation automation. • Advanced outage restoration schemes implemented. • Remote asset monitoring of key grid assets supports manual decision making. • Expansion of data communications networks in support of grid operations.
€	€	SAO DL3	INTEGRATING	Analytics, automation, and control operate across multiple systems and organizational functions. • Information to support analysis and decision making for grid operations available across multiple systems. • Implementation of control analytics to improve cross LOB decisions. • Fact-based grid operation planning using SG grid data. • Smart meters as grid management sensors • Automated decision making within protection schemes.
€	€	SAO DL4	OPTIMIZING	Grid operations are integrated into and drive enterprise processes, enabling a transition towards automated decision making. • Operational data from SG deployments used to optimize processes. • Dynamic grid management based on near real-time. • Operational forecasting based on SG gathered data. • End-to-end observability. • Automated decision making within protection schemes base on wide-area-monitoring.
€	€	SAO DL5	PIONEERING	Increased observability and control drives innovation with the utility. Ubiquitous system-wide dynamic control becomes the goal, and results in new opportunities as a result of the integrated view of customers, assets, and operations. Reliability is increased for the utility, and at the regional and national levels. • Self-healing capabilities present. • System-wide analytics-based and automated grid decision making.

Demand and Supply Management (DSM)

Energy Assets, Customer Control

As-is	Future	Level	Stage	Description
€	€	DSM DL0	DFAULT	Default / No characteristics have been implemented.
€	€	DSM DL1	INITIATING	The utility is creating a strategic plan to address dynamic supply and demand management. • Identification of assets/programs to facilitate load management. • Identification of DG resources and energy storage options and support capabilities for both. • Initial strategy for developing, enabling, and managing a diverse resource portfolio.
€	€	DSM DL2	ENABLING	Implementation of systems for a network of alternate generation sources managed for downstream load management. • Support for energy management systems for residential customers. • Pilots on DG, DSM, DR, and/or energy storage. • Analysis of DG, micro-generation, energy storage to redefine value-chain.
€	€	DSM DL3	INTEGRATING	Systems are interconnected to promote dynamic management through network interaction with the value chain. • An integrated resource plan targets new resources and technologies, to establish a balance between types of generation and a balance of supply and demand. • Customer energy premise energy management systems with market and usage information.
€	€	DSM DL4	OPTIMIZING	Business processes support the dynamic capture and utilization of information relevant to distributed generation and load management. • Energy resources such as Volt/VAR, DG, and DR, are dispatchable and tradable. • Implementation of portfolio optimization models that encompass available resources and real-time markets. • Secure two-way comm. With Home Area Networks. • Integrated visibility and control of large-demand residential appliances.
€	€	DSM DL5	PIONEERING	Dynamic management and automation of assets realizes greater value and benefits, providing leadership in regional and national grid management capabilities. • The optimization of energy assets is automated across the value-chain. • Resources are adequately dispatchable and controllable so that the utility can take advantage of granular market options. • Automated control and resource optimization schemes consider and support regional/national grid optimization.

Work and Asset Management (WAM)
Asset Monitoring, Tacking and Maintenance

As-is	Future	Level	Stage	Description
€	€	WAM DL0	DEFAULT	Default / No characteristics have been implemented.
€	€	WAM DL1	INITIATING	The utility is exploring the use of SG to enhance asset at workforce management. • Potential uses of remote asset monitoring are being evaluated. • Asset and workforce management equipment and systems are evaluated.
€	€	WAM DL2	ENABLING	The utility is making investments into technologies that support asset monitoring and has started pilot activities. • Development of an approach for using SG capabilities to create inventories, maintain event histories, and track assets. • Pilot integration of GIS and asset monitoring to achieve increased operational visibility based on location, status, and interconnectivity. •
€	€	WAM DL3	INTEGRATING	The utility connect SG technologies and asset management systems to support and optimize asset maintenance and workforce deployment • Performance, trend analysis, and event data available. • Condition based maintenance programs. • Integration of remote asset monitoring and asset management. • Integration of GIS and asset monitoring for one asset class. • Asset inventory track using automation from sourcing to utilization • Modeling of asset investments for key components.
€	€	WAM DL4	OPTIMIZING	Utility fully leverages connection between SG deployment and asset management. • Complete view of asset classes (status, connectivity, and proximity). • Asset models based on real performance and monitoring data. • Performance and usage of assets optimized in consideration of entire asset fleet and across classes. • Service life of key grid components managed through condition based and predictive maintenance, using real data...
€	€	WAM DL5	PIONEERING	The utility tunes the used of assets across the entire supply chain. Strategic investment decisions are based on the best asset ownership and utilization model. • Optimization of asset utilization between and across supply chain participants. • Assets leveraged to maximize utilization, including just-in-time retirement based on SG data.

Physical and Cyber Security (SEC)

Standards, Risk Identification, Automated Protection Schemes

As-is	Future			
€	€	SEC DL0	DFAULT	Default / No characteristics have been implemented.
€	€	SEC DL1	INITIATING	The utility is applying enterprise IT infrastructure to SG and has begun to build a SG security framework. • Safety/security requirements considered in all grid operations initiatives. • Awareness of NIST and IEC SG interoperability and cyber security requirements, specifically IEC 62351. • Traditional enterprise IT controls are in place.
€	€	SEC DL2	ENABLING	The utility develops and applies physical and security principles to their industrial control systems. • Safety and security considerations built into all smart grid initiatives from the outset, based on IEC 6235. • The utility works to develop internal metrics for the assessment of security investments. • Application of risk management activities to identify critical sites and systems that are protected by surveillance and physical barriers.
€	€	SEC DL3	INTEGRATING	Grid data is used to support situational awareness and diagnostic activities (e.g. smart meters that auto notify if tampered with). • Correlation of anomalous grid activities with anomalous network and device activities. Islanding of vulnerable areas. • The utility participates in Smart Grid Cyber Security Working Groups to refine IEC and FERC Smart Grid standards.
€	€	SEC DL4	OPTIMIZING	Grid data is used to implement protections schemes and the utility participates in cyber-risk assessment audits. • Some automated decision making within protections schemes based on WAMS exists. • Security strategy and tactics continually evolve based on changes in the operational environment and lessons learned. • Security management and monitoring processes are deployed to protect the interactions with an expanded portfolio of value chain partners.
€	€	SEC DL5	PIONEERING	System wide analytic based automated grid decision making is in place. • Enterprise IT architecture automatically identifies, mitigates, and recovers from cyber incidents. • The organization is monitoring and actively engaged in community efforts to develop and refine standards.

Government and Regulation (GR)

Investments, Demonstration Projects, Regulatory Strategies, Intra-utility Optimization

As-is	Future			
€	€	GR DL0	DEFAULT	Default / No characteristics have been implemented.
€	€	GR DL1	INITIATING	The regulatory body and government have begun initial investigations into the regional implications of smart grid deployments with a focus on first costs and rate designs. • Demonstration projects and pilot programs are allowed, but not through rate case funding.
€	€	GR DL2	ENABLING	The regulatory body and government have implemented policies enabling utilities to pursue smart grid projects with a focus on system lifetime costs. • Cost recovery rate cases consider total lifetime cost savings. • Pilot programs funded through rate cases.
€	€	GR DL3	INTEGRATING	Regulatory and governmental policies encourage smart grid deployments within utilities with policies that are in favor of smart grid. • Cost recovery rate cases consider total lifetime cost savings. • Rate cases are structured such that financial risks are shared appropriately between utilities and consumers • Commission analyzes projects with an understanding that operational costs savings will lag deployments.
€	€	GR DL4	OPTIMIZING	Regulatory and governmental policies encourage smart grid deployments between utilities and enable innovative business models to fund such projects. • All barriers to efficiency investments have been removed. • Decoupling to break link between kWh sales and profits • Cost recovery for early asset retirement due to SG deployments. • A state-wide policy exists addressing the needs of all stakeholders.
€	€	GR DL5	PIONEERING	The regulatory body and government drive smart grid deployments through innovative policies and funding methods. • State Commission mandate included environmental goals. • State commission partners with utilities to pursue federal funding for SG deployments. • SG deployment is driven by innovative policies that serve as a national model.

Customer (CUST)

Pricing, Customer Participation, Advanced Services

As-is	Future	Level	Stage	Characteristics
€	€	CUST DL0	DEFAULT	Default / No characteristics have been implemented.
€	€	CUST DL1	INITIATING	Utility explores new ways to enable customer participation toward achieving SG goals and enhancing customer experience. • Research into the use of SG technology to enhance customer experience, benefits, and participation • Communication to customers of SG vision. • Consultation with PSC concerning SG strategy impact on customer.
€	€	CUST DL2	ENABLING	Utility undertakes piloting and investment in SG technology to enable customer participation, improve the customer experience, and enhance business efficiency. • Pilot of AMI • Frequent (> monthly) knowledge or residential customer usage. • Modeling the reliability of grid equipment. • Remote connect/disconnect pilots. • Assessment of impacts of new services on the customer.
€	€	CUST DL3	INTEGRATING	New systems and processes increase efficiency and interaction to improve customer satisfaction and to provide new services. • Tailoring of programs to specific customer segments. • Two-way meter comm. For most customers w/ daily usage data. • Remote connect/disconnect for most customers. • Demand response / load control available to most customers. • Automatic outage detection @ substation level. • Customer education program for peak curtailment.
€	€	CUST DL4	OPTIMIZING	Increased observability and control enable some tailoring of services for individual customers based on usage histories, profiles, and preferences. • Support to customers for analysis of usage against available pricing programs. • Automatic outage detection @ circuit level. • Customer access to near-real time usage data. • Automatic response to pricing signals for major appliances. • In-home net billing.
€	€	CUST DL5	PIONEERING	Products and services can be specifically and extensively tailored at a fine grained level to individual customer profiles and desires. • Customer management of end-to-end supply and usage levels. • Automatic outage detection at the premise level. • Plug-and-play consumer based generation. • Leadership role in industry-wide information sharing and standards development.

Environment and Society (ENV)

Responsibility, Sustainability, Efficiency

As-is	Future	Level	Stage	Characteristics
€	€	ENV DL0	DFAULT	Default / No characteristics have been implemented.
€	€	ENV DL1	INITIATING	Societal and environmental issues are addressed as an integral part of strategic planning for the smart grid. • SG strategy addresses role in societal and environmental issues. • Environmental benefits of the smart grid vision are publicly promoted. • Environmental compliance performance records available for public inspection. • SG vision specifies the organization's role in protecting the nation's critical infrastructure.
€	€	ENV DL2	ENABLING	Decisions, investments, and networks are managed in a way that facilitates sustainable, efficient energy utilization. • SG work plan address societal and environmental issues. • Energy efficiency programs for customers established. • "Triple bottom line" view when making decisions. • Environmental pilot projects underway to demonstrate SG benefits. • Increasingly granular/frequent consumption information available to customers.
€	€	ENV DL3	INTEGRATING	Organizational units share a common focus on societal and environmental issues. • Performance of societal/environmental programs quantified. • Info on environmental/societal benefits/costs available to customers. • Programs to encourage off-peak usage by customers are in place. • Regular reports on the sustainability and the societal and environmental impacts of SG programs and technologies.
€	€	ENV DL4	OPTIMIZING	Business processes deliver an environmentally friendly energy network while minimizing costs and sustaining profitability. • Cooperation w/ stakeholders to address environmental/societal issues. • A public environmental and societal scorecard is maintained. • Programs are in place to shave peak demand. • End-user energy usage actively managed through the utility's network. • Fulfillment of critical infrastructure assurance goals for resiliency, and contributed to those of the region and nation.
€	€	ENV DL5	PIONEERING	Integration of technology, business processes, and assets to the regional and national grids to maximize societal value and environmental benefits. • Triple bottom line goals align national objectives. • Customers control energy-based environmental footprints via auto-optimization of their end-to-end energy supply and usage levels. • Utility is a leader in developing/promoting industry-wide resilience best practices and technologies for protection of the national critical infrastructure.

Appendix B: EU-KSGAM Assessment Survey

S-KSGAM Assessment Survey

Introduction

The "Stakeholder Kentucky Smart Grid Assessment Survey" (assessment survey) is a survey based assessment of smart grid characteristics and benefits for completion by electric power stakeholders. The questions within the assessment survey collect demographic data and characterize the "understanding" of smart grid implementation in the context of the KSGAM Definition.

The assessment survey consists of three sections. Section one is the "Stakeholder Profile Survey"; and collects respondent demographic information. Section two is the "Characteristics of Smart Grid Survey", which is used to assess stakeholder understanding of smart grid deployments. Section three is the "Benefits of Smart Grid Survey", an assessment of the perceived importance of the benefits that smart grid could provide.

Stakeholder Profile Survey

Stakeholder Information

1. Please provide the following:

    Your name (optional):

    Name of your home electric power utility:

    Contact information (optional):

Demographic Information

1. Please circle the statement(s) that best describes your relationship to the electric utility industry:

    a. Residential customer

    b. Industrial customer

    c. Commercial customer

    d. Utility industry employee

    e. Utility industry stakeholder, other (please identify):

    f. Stakeholder group representative/member (please identify):

    g. Member of KY PSC

    h. Member of KY Energy and Environment Cabinet

    i. Member of KY government, other (please identify):

    j. Other (please identify):

2. Please circle the statement that best describes your knowledge of the electric utility industry:

    a. I do not understand the operation of the electric power system, aside from paying my electric bill.

    b. I understand how electricity is generated, transmitted, and used on a basic level.

    c. I understand most of the electric power system. I understand concepts relating grid operations and components such as substation, transformers, and frequency.

    d. I have a thorough understanding of the electric power system. I understand concepts such as SCADA, demand response, distributed energy resources, AMR, and energy markets.

    e. I have an advanced understanding of the electric power system that includes AMI, substation energy storage, automated VAR correction, and dynamic pricing.

    f. I am on the cutting edge of electric power research and understand systems such as microgridding, solid state transformers, CVR, and real time pricing.

    g. Other (please explain):

Characteristics of Smart Grid Survey

The following pages contain an assessment for smart grid deployments in Kentucky. In this assessment, you will read a description of seven characteristics of the smart grid. After each description there is a form to evaluate the state of that characteristic as it applies to Kentucky's electric power system.

For each characteristic, you will be asked to rate the "As-is" state of the electric power grid on a scale from 1 to 5, according to the descriptions provided on each form. This rating describes your assessment of the current state of the electric grid. Place a mark in the **one** column that best describes your assessment.

Also, for each characteristic, you will be asked to rate the "Future" state of the electric power grid on a scale from 1 to 5, according to the descriptions provided on each form. This rating describes your opinion on what is important to a future electric power system. Place a mark in the **one** column that best describes your assessment.

1. Active Participation by Consumers

Active Participation by Consumers is the characteristic that describes the increased interaction of consumers with the grid. Such interaction is characterized by the use of price based signals and demand response programs to give customers choice regarding if and when to purchase power, the decisions on the source of purchased power, the use of distributed energy resources, and the use of home automation networks and intelligent load end-use devices such as smart appliances.

As-Is (Mark One)

€	1	The current electric power system does not implement any aspects of this characteristic.
€	2	The current electric power system implements some aspects of this characteristic.
€	3	The current electric power system implements many aspects of this characteristic.
€	4	The current electric power system implements most aspects of this characteristic.
€	5	The current electric power system implements all aspects of this characteristic.

Future (Mark One)

€	1	The future electric power system should not implement any aspects of this characteristic.
€	2	The future electric power system should implement some aspects of this characteristic.
€	3	The future electric power system should implement many aspects of this characteristic.
€	4	The future electric power system should implement most aspects of this characteristic.
€	5	The future electric power system should implement all aspects of this characteristic.

2. Accepts All Power Generation and Storage

Accepts All Power Generation and Storage is the characteristic that describe the integration of diverse resources with "plug-and-play" connections to multiply the options for electrical generation and storage. This includes the accommodation of large centralized power plants, and distributed energy resources such as renewables, distributed generation, and energy storage devices. This characteristic represents the transition to a more decentralized supply model.

As-Is (Mark One)

€	1	The current electric power system does not implement any aspects of this characteristic.
€	2	The current electric power system implements some aspects of this characteristic.
€	3	The current electric power system implements many aspects of this characteristic.
€	4	The current electric power system implements most aspects of this characteristic.
€	5	The current electric power system implements all aspects of this characteristic.

Future (Mark One)

€	1	The future electric power system should not implement any aspects of this characteristic.
€	2	The future electric power system should implement some aspects of this characteristic.
€	3	The future electric power system should implement many aspects of this characteristic.
€	4	The future electric power system should implement most aspects of this characteristic.
€	5	The future electric power system should implement all aspects of this characteristic.

3. Enables New Products and Services

Enables New Products and Services is the characteristic that describes three changes in the electricity market. First is the direct linking of the buyers and sellers of electricity (e.g. RTO to consumer), allowing real time interaction with the market. Second, the advent of new commercial goods and services will results in the creation of new electricity markets and choice such as green power products and electric vehicles. Third, a restructuring of markets will achieve consistency of operation across the U.S.

As-Is (Mark One)

€	1	The current electric power system does not implement any aspects of this characteristic.
€	2	The current electric power system implements some aspects of this characteristic.
€	3	The current electric power system implements many aspects of this characteristic.
€	4	The current electric power system implements most aspects of this characteristic.
€	5	The current electric power system implements all aspects of this characteristic.

Future (Mark One)

€	1	The future electric power system should not implement any aspects of this characteristic.
€	2	The future electric power system should implement some aspects of this characteristic.
€	3	The future electric power system should implement many aspects of this characteristic.
€	4	The future electric power system should implement most aspects of this characteristic.
€	5	The future electric power system should implement all aspects of this characteristic.

4. Improved Power Quality

Improved Power Quality is the characteristic that describes the delivery of "clean" power. Such digital-grade power is characterized by a reduction in system interruptions due to under voltage sags, voltage spikes, frequency harmonics, and phase imbalances. The delivered power may be available in "grades", varying from stand to premium, and will depend on customer requirements.

As-Is (Mark One)

€ 1 The current electric power system does not implement any aspects of this characteristic.

€ 2 The current electric power system implements some aspects of this characteristic.

€ 3 The current electric power system implements many aspects of this characteristic.

€ 4 The current electric power system implements most aspects of this characteristic.

€ 5 The current electric power system implements all aspects of this characteristic.

Future (Mark One)

€ 1 The future electric power system should not implement any aspects of this characteristic.

€ 2 The future electric power system should implement some aspects of this characteristic.

€ 3 The future electric power system should implement many aspects of this characteristic.

€ 4 The future electric power system should implement most aspects of this characteristic.

€ 5 The future electric power system should implement all aspects of this characteristic.

5. Efficient Operation and Use of Assets

Efficient Operation and Use of Assets is the characteristic that describes the use of real time information from advanced sensors to allow operators to better understand the state of the system. Such information can be used to perform risk assessment, optimize system planning, reduce transmission congestion, extend asset life, and to perform proactive maintenance.

As-Is (Mark One)

€	1	The current electric power system does not implement any aspects of this characteristic.
€	2	The current electric power system implements some aspects of this characteristic.
€	3	The current electric power system implements many aspects of this characteristic.
€	4	The current electric power system implements most aspects of this characteristic.
€	5	The current electric power system implements all aspects of this characteristic.

Future (Mark One)

€	1	The future electric power system should not implement any aspects of this characteristic.
€	2	The future electric power system should implement some aspects of this characteristic.
€	3	The future electric power system should implement many aspects of this characteristic.
€	4	The future electric power system should implement most aspects of this characteristic.
€	5	The future electric power system should implement all aspects of this characteristic.

6. Self-Healing

Self-Healing is the characteristic that describes the grids ability to identify, isolate, and restore problematic sections of the grid with little or no manual intervention. Today, such capabilities are largely isolated to substation automation. Future systems may use sensors, weather data and analytic programs to detect precursors to faults including voltage, power-quality, dynamic instabilities, congestion issues, equipment failures, and downed power lines. Automatic network reconfiguration could be employed to link energy sources and loads to both restore power and to implement real-time contingency strategies.

As-Is (Mark One)

€	1	The current electric power system does not implement any aspects of this characteristic.
€	2	The current electric power system implements some aspects of this characteristic.
€	3	The current electric power system implements many aspects of this characteristic.
€	4	The current electric power system implements most aspects of this characteristic.
€	5	The current electric power system implements all aspects of this characteristic.

Future (Mark One)

€	1	The future electric power system should not implement any aspects of this characteristic.
€	2	The future electric power system should implement some aspects of this characteristic.
€	3	The future electric power system should implement many aspects of this characteristic.
€	4	The future electric power system should implement most aspects of this characteristic.
€	5	The future electric power system should implement all aspects of this characteristic.

7. Defend Against Attack and Natural Disaster

Defend Against Attack and Natural Disaster is the characteristic that describes the grids ability to protect against physical attacks (explosive, projectiles, and natural disaster) and cyber (computer-based) attacks. These attack strategies may have two forms: attacks in which the grid itself is the primary target, or attacks in which the power system network is used to take down other important infrastructure systems (banks, government, etc.).

As-Is (Mark One)

€	1	The current electric power system does not implement any aspects of this characteristic.
€	2	The current electric power system implements some aspects of this characteristic.
€	3	The current electric power system implements many aspects of this characteristic.
€	4	The current electric power system implements most aspects of this characteristic.
€	5	The current electric power system implements all aspects of this characteristic.

Future (Mark One)

€	1	The future electric power system should not implement any aspects of this characteristic.
€	2	The future electric power system should implement some aspects of this characteristic.
€	3	The future electric power system should implement many aspects of this characteristic.
€	4	The future electric power system should implement most aspects of this characteristic.
€	5	The future electric power system should implement all aspects of this characteristic.

Benefits of Smart Grid Survey

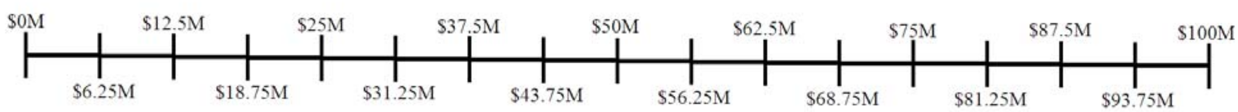
The following pages contain an assessment of the benefits of smart grid deployments in Kentucky. In this assessment, you will read a description of five benefits of the smart grid. After each benefit description there is a form to evaluate the importance of that benefit to you.

The evaluation of each benefit is to be performed by allocating funds to that benefits. You have $100M USD to divide amongst the five areas. You may assign as much or as little funds to each benefit as you choose. The total amount of funding assigned for all five categories should sum to $100M. To allocate funds, either circle a dollar amount along the number line, or write in a figure along the line in the appropriate location.

Please be aware that this is an effort to measure stakeholder priorities and <u>does not represent an allocation of real funds.</u>

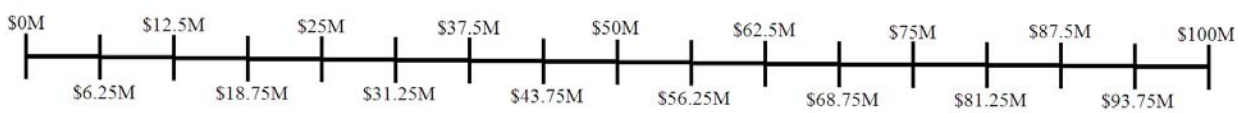
Reliable

Reliable describes a grid with a reduction in power outage duration and frequency, a reduction in momentary power quality disturbances, and a reduction in blackouts and brownouts.



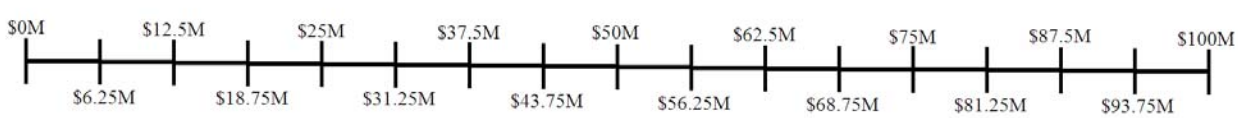
Secure and Safe

Secure and Safe describes a grid that is less vulnerable to attack and natural disaster, and is safer to be near for both the public and utility workers.



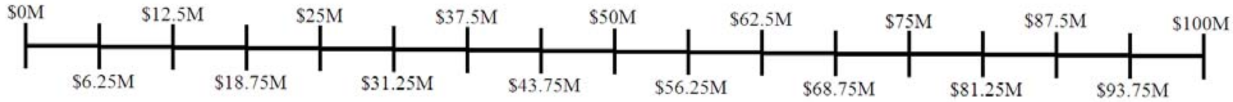
Economic

Economic describes a grid with decreased/mitigated electricity prices, and with new options for market participants such as new load management, distributed generation, grid storage, and demand-response options.



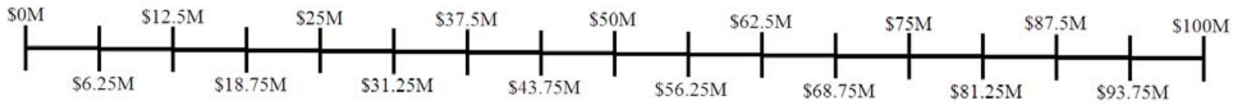
Efficient

Efficient describes a grid that uses technology to allow for greater utilization of existing assets, enables optimal loading of assets, and provides detailed awareness of component and equipment condition, with the goal of cost effective asset utilization and increased system capacity.



Environmentally Friendly

Environmentally friendly describes a grid that allows for a much wider deployment of environmentally friendly resources, that allows for the deferral of new construction projects, and has reduced electrical losses.



Appendix C: AMI Deployment Survey for Jurisdictional Utilities

TABLE OF CONTENTS

INTRODUCTION

The "AMI Deployment Survey for Jurisdictional Utilities" (AMI Survey) is a self-reporting survey based assessment of AMI deployment and deployment plans intended for completion by the electric utilities of Kentucky.

The AMI Survey consists of three sections. Section one is the "System Assessment Survey"; it collects information pertinent to the metering, communication infrastructure, home area networks, and meter data management systems currently installed, or planned for installation, in the distribution system. Section two is the "Cost and Benefit Survey"; it collects information on deployment approaches and the business case considerations that support/do-not-support AMI. Section three is the "Demand Response Survey"; it collects information regarding the existing DR programs at each utility.

The AMI Survey concludes by providing the respondent an opportunity to document any additional support/concerns with AMI. These can include, but are not limited to: barriers to implementation, policy issues, or business valuation.

OVERVIEW OF AMI

AMI (Advanced Metering Infrastructure) refers to the integration of a variety of systems in order to establish two way communications between the customer and the utility and to provide each with time stamped system information. Therefore we refer to AMI as an **infrastructure area**, as opposed to a technology.

From a systems perspective AMI typically refers to **smart metering** (measurement and data collection system including meters at end-users), **home area networks** (in home displays, distributed energy resources, and load control devices)**, integrated communications** (the communication infrastructure which connects consumers and their service providers), **meter data management systems** (to process obtained meter data), and standardized software interfaces.

Figure 1 shows a typical residential AMI configuration. The smart meter is installed at the residential house, and has the capability to record, transmit, receive, and display usage information on an in home display. The in-home display serves at the foundation of the home area network. Additionally, the smart meter communicates with an integrated communications device installed at a nearby utility pole. Two-way communications take place between residence and utility office via the integrated communications systems. The utility office implements the Meter Data Management system to collect and analyze data, as well as to enable interaction with other information systems. Industrial and commercial AMI have similar configurations.

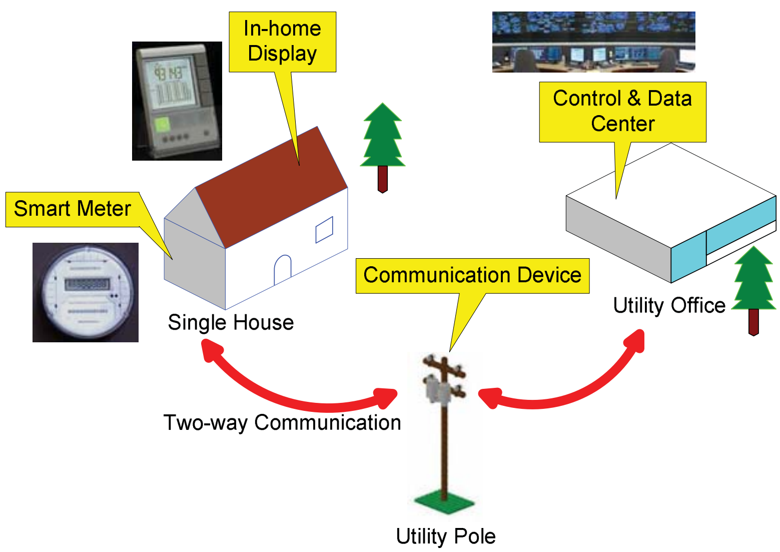


Figure 4. Advanced Metering Infrastructure Deployment

AMI enables consumers to have a better understanding of their energy usage in real-time and provides them an opportunity to control energy consumption, thus potentially changing consumer behavior. The energy usage data obtained from AMI system allows the utility to better understand the demand and consumer energy usage patterns, which is essential for demand side management. In addition, AMI serves as a platform on which a variety of functions and strategies can be enabled such as: differentiated pricing strategies, peak\ shifting, load leveling, and demand response.

UTILITY PROFILE

Company Information

1. Provide the following regarding the organization being assessed:

    Company Name

    Address

    Web Site

2. Provide the end date of the year period for which you will be providing data for this assessment (mm/dd/yyyy).

Contact Information

1. Provide the following regarding the person responsible for completion of the Assessment Survey:

    Name

    Title

    Address

    Phone

    Email

AMI System Assessment Survey

The AMI System Assessment Survey collects information pertinent to the metering, communication infrastructure, home area networks, and meter data management systems currently installed, or planned for installation, in the distribution system. For the following questions please indicate of the system/technology is installed in your system. If the system/technology is not installed, but installation plans are in development, please indicate this as appropriate.

Smart Meters

1. Does your company have distribution level automated meter reading (AMR) enabled meters with-out AMI capability?

2. How is AMR kWh data collected?

3. Does your company have distribution solid-state AMI meters (smart meters)?

4. Does your company have "under-the-glass" electronic meter modules installed on legacy electromechanical meters?

5. If yes in (3/4), what percentage of distribution customers are served by smart meters?

   Please divide data between the residential, industrial, and commercial classes.

   - Residential

   - Industrial

- Commercial

6. If yes in (3/4), provide the vendor(s) of the smart meters and/or electronic modules installed in your system.

7. If yes in (3/4), provide the data types collected by your smart meters (e.x. volt, pf, max 15 kVA demand, etc.) and the frequency of data collection.

8. If yes in (3/4), is a local concentrator used to collect data from groups of meters, or do the meters communicate directly with the utility data center?

9. If in (8) local concentrators are utilized for data transmission, what communication technology is used to send data between the smart meters and the concentrator?

Wide-Area Communications Infrastructure

1. Does your distribution system utilize a wide area communications infrastructure to support AMI? If so, indicate which architecture(s) is implemented. In the case of multiple architectures, briefly explain the purpose of the combined technology.

    a. Power line carrier.
    b. Broadband over power line.
    c. Fiber networks.

d. Radio frequency, centralized or mesh.
e. Internet.
f. Public Network (paging, satellite, cell)
g. Combinational infrastructure architectures.
h. Other____________________

2. Is your wide area communications infrastructure utilized for other grid support purposes, such as distribution automation? If so please explain.

3. Is your wide area communications infrastructure utilized to provide additional services to your customers, such as communications or internet access? If so please explain.

4. Is your wide area communications infrastructure able to reach your entire customer base? If not, please elaborate on the limitations of your system.

Home (local) Area Networks

1. Does your AMI system utilize Home Area Networks at the customer level?

2. Is the HAN within the meter, within the neighborhood collector, a stand-alone utility supplied gateway, or a stand-alone supplied by the customer?

3. If yes in (1) describe the level of utilization. This could be as simple as displaying energy consumption and costs on an in-home-display, or could be more advanced such as the automatic control of HVAC or other controllable electrical devices such as smart appliances.

4. If yes in (1), describe the methods by which the customer my interface and interact with the HAN. This could be as simple as an in-home-display, or could be more advanced, such as the use of web-based customer energy management systems/profiles, or smart phone applications.

Meter Data Management Systems

1. Does your utility utilize a MDMS to interface the AMI generated data?

2. If yes in (1), Describe the functions of your MDMS. This could be as simple as integrating with the billing system, or more advanced, such as the performing of validation, editing, and estimation (VEE) on AMI data.

3. Indicate which of the following other information systems your MDMS interfaces with:
    a. Consumer Information System
    b. Billing System

c. Utility Web Site.
d. Outage management systems.
e. Enterprise Resource Planning Systems for load forecasting.
f. Enterprise Resource Planning Systems for power quality management.
g. Geographic Information Systems.
h. Transformer Load Management Systems
i. Other____________________

AMI COST AND BENEFIT SURVEY

The AMI Cost and Benefit Survey collects information on deployment approaches and the business case considerations that support/do-not-support AMI. . For the following questions please indicate of the costs/benefits incurred by the system. If your company has not evaluated certain costs/benefits, please indicate this also. If AMI has not been deployed in your system, but you have performed a cost/benefit analysis, please provide those results where appropriate.

Costs

1. Provide the total capital costs related to AMI deployment.

2. Provide a breakdown of AMI capital system costs, by percentage, over the following categories:

    a. Endpoint Hardware

    b. Network Hardware

    c. Installation

    d. Project Management

    e. IT

3. Provide an estimate of the O&M costs for annual operating and maintenance expenses.

4. Provide a breakdown of O&M costs, by percentage, over the following categories:

a. Communication and Network (LAN and WAN) – Maintenance and repair of the AMI communications network, leased backhaul, tower leasing, network management upgrades:

b. AMI Meters – Labor and expenses associated with meter repair:

c. Meter Data Management – Maintaining and upgrading MDM, including hardware and software upgrades.

5. Indicate other costs that have been evaluated that were not addressed by 1-4.

Benefits

1. Meter Reading Savings - Provide the actual or estimated savings due to elimination/reduction of manual meter reading for the following categories:
    a. Savings due to LDV fleet reduction.

    b. Savings due to personnel reduction.

    c. Savings due to cancellation of meter reading contracts.

    d. Savings due to reduction in claims associated with meter reading.

2. Field Services Savings - Provide the actual or estimated savings due to reduction of field service visits for the following categories:

    a. Savings due to reduction in field service visits to obtain missed meter readings.

b. Savings due to reduction in field service visits to turn off/on service.

c. Savings due to personnel reduction.

3. Billing Savings - Provide the actual or estimated savings of billing services for the following categories:

    a. Enhanced customer satisfaction due to increased process efficiency and reduced time to address service requests: (y / n)

4. Outage Response Savings - Provide the actual or estimated savings of improved outage response for the following categories:

    a. Savings due to reduction in time spent locating causes of service interruptions.

    b. Savings due to improved situational awareness of completed restoration activities (i.e. reduced # of customer call backs to verify restoration status).

5. Call Center Savings - Provide the actual or estimated savings of call center operations for the following categories:

    a. Savings due to reduction in billing inquiries/adjustments.

    b.

    c. Savings due to personnel reduction.

d. Savings due to identification of billing malfunctions automatically, instead of from customer complaints.

6. Collection Write Off Savings - Provide the actual or estimated savings of collection write offs for the following categories:

   a. Savings due to reduction in bad debt write-offs associated with missed reads and/or estimated billing.

7. Under Registration Savings - Provide the actual or estimated savings due to under registration for the following categories:

   a. Savings due to improved accuracy of solid state meters as compared with electromechanical meters, particularly compared to aged meters.

8. Energy Diversion Savings - Provide the actual or estimated savings due to energy diversion for the following categories:

   a. Savings due to ability to more accurately detect energy theft by the inclusion of tamper alarms and data analytics warning of potential irregularities and theft of service.

Benefits

1. Meter Reading Benefits - Indicate if the impacts of the following possible benefits have been evaluated due to reduced/eliminated meter readings:

   a. Improved protection of customer physical privacy: (y / n)

b. Reduction in emissions due to reduction in meter reading vehicles: (y / n)

c. Reduced risk to personnel from indoor meter reads, animals, and environmental factors: (y / n)

2. Field Services Benefits - Indicate if the impacts of the following possible benefits have been evaluated due to reduced/eliminated field services:

b. Enhanced customer satisfaction due to increased process efficiency and reduced time to address service requests: (y / n)

9. Billing Benefits - Indicate if the impacts of the following possible benefits have been evaluated for billing services:

a. Enhanced customer satisfaction due to increased bill accuracy: (y / n)

b. Potential for new billing services such as flexible due dates and time-differentiated rates.

10. Outage Response Benefits - Indicate if the impacts of the following possible benefits have been evaluated for improved outage response capabilities:

a. Enhanced customer satisfaction due to improved outage management: (y / n)

11. Outage Response Benefits - Indicate if the impacts of the following possible benefits have been evaluated for call center operations:

a. Enhanced customer satisfaction due to improved situational awareness by customer service representatives via information provided from AMI: (y / n)

12. Customer Load Research - Indicate if the impacts of the following possible benefits have been evaluated for customer load research:

a. Improvements in the utilities ability to perform load research needed for new rate design: (y / n)

b. Improvements in the utilities ability to perform load research needed for new rate design to implement DR programs: (y / n)

c. Improvements in the utilities ability to perform load research needed to develop more accurate load forecasts: (y / n)

13. Customer Enablement Programs - Indicate if the impacts of the following possible benefits have been evaluated for customer enablement programs, which can result in a deferral of new generation capacity requirements:

a. Customer access to detailed data which increases personal awareness of energy usage and demand: (y / n)

b. Ability to actively participate in load management programs: (y / n)

c. Full scale deployment of demand response programs that are predicated on the implementation of various rate incentives, requiring AMI metering capabilities.

14. Environment - Indicate if the impacts of the following possible benefits have been evaluated for the environment:

    a. AMI system enablement of conservation programs helping to defer construction of new facilities and reduction of additional pollutants: (y / n)

DEMAND RESPONSE SURVEY

The Demand Response Survey collects information regarding the existing DR programs at the utility.

1. Describe the demand response programs implemented at the utility. For each program, address the following:

    a. Provide a brief description of the program.

    b. Describe the hardware/software installed to support the program.

    c. How many customers were invited, how many customers accepted the invitation and participated in the program? Have customers quit the program?

    d. What incentives are provided for customers?

    e. What are the breakdowns of the approximate costs of implementing the program?

    f. How much peak load reduction has been achieved?

    g. Is the total energy consumption for a period of time for the participants reduced?

    h. What other benefits have been yielded by this program to utilities and customers?

SURVEY FEEDBACK

Please use the remaining space to provide any additional feedback or comments for review by the Smart Grid Road Map Initiative Team.

APPENDIX D: ADO DEPLOYMENT SURVEY FOR JURISDICTIONAL UTILITIES

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INTRODUCTION

The "ADO Deployment Survey for Jurisdictional Utilities" (ADO Survey) is a self-reporting survey based assessment of ADO deployment and deployment plans intended for completion by the electric utilities of Kentucky.

The ADO Survey consists of two sections. Section one is the "System Assessment Survey"; it collects information pertinent to FLIR, VVC, DOMA, DAC, and DER systems currently installed, or planned for installation, in the distribution system. Section two is the "Cost and Benefit Survey"; it collects information on deployment approaches and the business case considerations that support/do-not-support ADO

The ADO Survey concludes by providing the respondent an opportunity to document any additional support/concerns with ADO. These can include, but are not limited to: barriers to implementation, policy issues, or business valuation.

OVERVIEW OF ADO

ADO (Advanced Distribution Operations) provide increased information, enable granular control needed for "self-healing" operations, and improves automation as well as reliability to the power distribution systems. Like AMI, we refer to ADO as a Smart Grid **infrastructure area**, as opposed to a specific technology.

ADO is the syntheses of an integration of applied functions, applications, and technologies and the correlation between other SG infrastructure areas and emerging technologies. The main objective of ADO is to improve the reliability and efficiency of distribution systems and provide functional support for other applications that are aggregated into ADO, making the distribution systems much smarter.

SG infrastructure areas and major ADO functions discussed in this report are summarized in Figure 1 below.

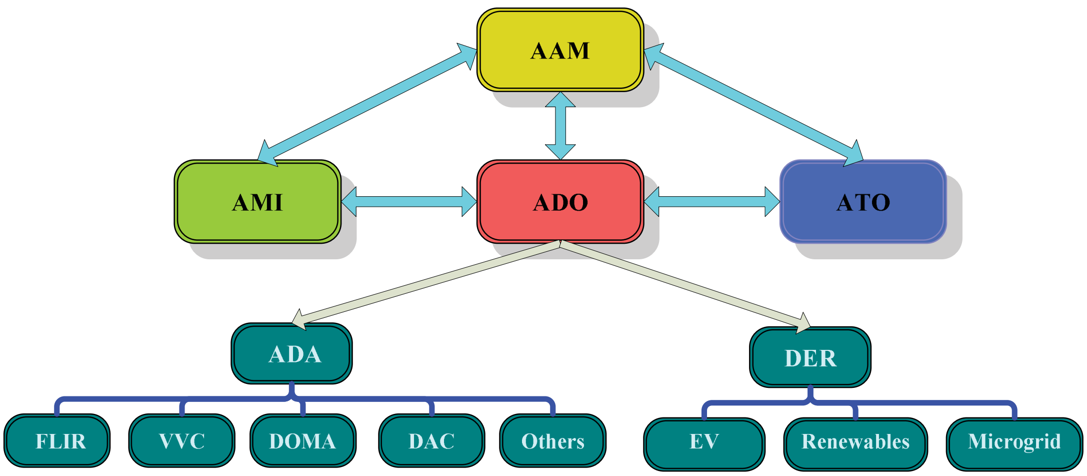

Figure 1. Summary of SG Infrastructures and ADO Functions

From a systems perspective, ADO includes **distribution management systems** (DMS) with advanced monitoring and ubiquitous sensors and intelligence, computer-based **advanced outage management systems** (OMS), **advanced distribution automation** (ADA) with intelligent control over electrical power grid functions(fault detection and location, system restoration and reconfiguration, real power and reactive power control), and **Volt/VAR Control** . ADO also aids deployment of **distributed energy resources** (DER), such as renewable energy resources and electric vehicles (EV), and enables operation of **microgrids**. It is also integrated with a distribution geographical information system (GIS) and distribution supervisory control and data acquisition (SCADA) system for improved grid awareness.

ADO closely interacts with the AMI SG infrastructure area for the purposes of microgrid operations, high-speed information processing, and advanced protection and control. Since ADO and AMI are both distribution focused, they together provide systems that enable for demand side management (DSM) and demand response (DR) programs in order to reduce or shape peak loads.

ADO also provides support for Advanced Transmission Operation (ATO), which integrates the distribution system with regional transmission organization (RTO) operational and market applications to enable improved overall grid operations and reduced transmission congestions.

ADO has close relationship with Advanced Asset Management (AAM) by making use of a great amount of power electronic devices and equipment, not only installed at distribution substations, but also at utility control centers, as well as widely dispersed distribution lines.

UTILITY PROFILE

Company Information

3. Provide the following regarding the organization being assessed:

    Company Name

    Address

    Web Site

4. Provide the end date of the year period for which you will be providing data for this assessment (mm/dd/yyyy).

Contact Information

2. Provide the following regarding the person responsible for completion of the Assessment Survey:

    Name

    Title

    Address

    Phone

    Email

ADO SYSTEM ASSESSMENT SURVEY

The ADO Survey collects information pertinent to Distribution Managements Systems, Advanced Outage Management Systems, Distribution Automation, Volt/VAR Control, Distributed Energy Resources, and microgrids currently installed, or planned for installation, in the distribution system. For the following questions please indicate of the system/technology is installed in your system. If the system/technology is not installed, but installation plans are in development, please indicate this as appropriate.

Distribution Operation Modeling and Analysis

1. Does your company utilize DOMA, as defined in the document "KSGRI- ADO Overview" for:

    a. Real-time power flow calculations?

    b. Look-ahead (near future) power flow calculations?

    c. "What if" power flow calculations?

2. Identify the sub-functions supported by your DOMA system:

    a. Modeling of impacts of the low-voltage distribution system on transmission/sub-transmission.

    b. Modeling of distribution circuit connectivity.

    c. Data management between legacy databases.

    d. Modeling of distribution nodal loads:

        i. For kW.

        ii. For kVA.

    e. Modeling distribution circuit facilities (5a-i, pg. 11, "KSGRI-ADO Overview).

    f. Distribution power flow.

    g. Evaluation of transfer capacity of tie switches.

    h. Power quality analysis (8a-f, pg. 12, "KSGRI-ADO Overview").

    i. Loss analysis.

    j. Fault analysis

k. Evaluation of operating conditions.

3. Provide the vendor(s) of the modeling and/or analysis software utilized.

4. Identify the data sources and/or database types that input for the DOMA models are sourced from (SCADA, GIS, distribution models, AMI data, customer EMS, weather forecasts, etc.)

Fault Location, Isolation and Service Restoration

1. Does your company utilize FLIR, as defined in the document "KSGRI- ADO Overview" for:

    a. Automated locations of faulted circuits?

    b. Automated isolation of faulted circuits?

    c. Automated restoration of faulted circuits?

2. If yes in 1b/1c, indicate which modes of isolation/restoration (2a-c, pg. 9, "KSGRI-ADO Overview").:

    a. Closed loop.

    b. Advisory.

    c. Study.

3. If yes in 1, indicate those databases and/or systems that are utilized by FLIR (circle those that apply): SCADA, trouble-call systems, on fault location device, smart meters, customer EMS, fault predictors, other_______________.

4. If yes in 1, what percentage of your distribution system is served by the FLIR system?

5. Provide the vendor(s) of the FLIR system utilized.

Data Acquisition and Control

6. Does your company utilize DAC (As defined in "KSGRI- ADO Overview") for Direct Power Equipment Monitoring and Control via:

    a. Intelligent Energy Devices (IEDs)?

    b. Remote terminal units (RTUs)?

    c. Other microprocessor-based controllers?

7. Does your company utilize DAC to facilitate Local IED Interactions?
8. If yes in 2, indicate the communication channel utilized: LANs, cables, radio frequency channels, other_______________.
9. Does your company utilize DAC for
    a. Computerized Field Systems Monitoring and Control?
    b. DER Management Systems Monitoring and Control?
    c. SCADA Systems Monitoring and Control?
10. Estimate the percentage of your distribution system served by DAC systems.
11. Provide the vendor(s) of the DAC system utilized.

Volt/VAR Control

1. Does your company utilize Volt/VAR control for:
    a. Closed loop control of Volt/VAR settings?
    b. What if mode?
    c. Look-ahead (near future) calculations?
2. Indicate the system components that are controlled by Volt/VAR automation:
    a. LTC.
    b. Voltage regulator.
    c. DER
    d. Compensation capacitor.
    e. Other________________.
    f. Estimate the percentage of your distribution system served by Volt/VAR.

Distributed Energy Resources

1. Does your company utilize ADO to enable microgrids? If so, provide a description of your system.

2. Does your company utilize ADO to enable the integration of renewable energy resource? If so, provide a description of how this is accomplished.

3. Does your company utilize ADO to support/manage charging of Electric Vehicles? If so, provide a description of your system.

Interaction with AMI

1. Describe how your systems ADO utilize the following areas of the AMI system, if applicable:

    a. Smart Meters

    b. Home Area Network

    c. Integrated Communications

    d. Meter Data Management System

ADO COST AND BENEFIT SURVEY

The ADO Cost and Benefit Survey collects information on deployment approaches and the business case considerations that support/do-not-support ADO . For the following questions please indicate of the costs/benefits incurred by the system. If your company has not evaluated certain costs/benefits, please indicate this also. If ADO has not been deployed in your system, but you have performed a cost/benefit analysis, please provide those results where appropriate.

Costs

6. Provide the total capital costs related to ADO deployment.

7. Provide a breakdown of ADO capital system costs, by percentage, over the following categories:

    a. Endpoint Hardware

    b. Network Hardware

    c. Installation

    d. Project Management

    e. IT

8. Provide an estimate of the O&M costs for annual operating and maintenance expenses.

9. Provide a breakdown of O&M costs, by percentage, over the following categories:

    a. DOMA:

b. DAC:

c. FLIR

d. Volt/VAR

10. Indicate other costs that have been evaluated that were not addressed by 1-4.

Savings

15. Efficiency Savings - Provide the actual or estimated savings due to improved distribution efficiency for the following categories:

    a. Savings due to construction deferral resultant from optimal utilization of distribution assets.

    b. Savings due to reduced system energy losses.

    c. Savings due to improved VAR compensation.

    d. Savings due to enhanced demand reduction abilities.

    e. Savings due to Conservation Voltage Reduction (CVR).

16. Outage Response Savings - Provide the actual or estimated savings of improved outage response for the following categories:

    a. Savings due to reduction in time spent locating causes of service interruptions.

    b. Savings due to improved situational awareness of completed restoration activities (i.e. reduced # of customer call backs to verify restoration status).

    c. Savings due to reduced Operation and Maintenance expenditures resulting from improved asset monitoring.

Benefits

3. Outage Management/Response Benefits – Indicate if the impact of the following possible benefits have been evaluated due to improved outage management capabilities:

    a. Enhanced customer satisfaction due to improved outage management: (y / n)

    b. Enhanced customer satisfaction due to improved situational awareness by customer service representatives via ADO: (y / n)

17. DER Integration Benefits

    a. Deferral of construction programs due to larger integration of DER: (y / n)

18. Customer Enablement Programs - Indicate if the impacts of the following possible benefits have been evaluated for customer enablement programs, which can result in a deferral of new generation capacity requirements:

    a. Ability to actively participate in load management programs via CVR: (y / n)

    b. Improved ability to manage/support Electric Vehicle charging: (y / n)

    c. Improved ability to manage/operate microgrids: (y / n)

19. Environment - Indicate if the impacts of the following possible benefits have been evaluated for the environment:

    a. ADO system enablement of conservation programs helping to defer construction of new facilities and reduction of additional pollutants: (y / n)

    b. ADO system enablement of DER integration helping to defer construction of new facilities and reduction of additional pollutants: (y / n)

SURVEY FEEDBACK

Please use the remaining space to provide any additional feedback or comments for review by the Smart Grid Road Map Initiative Team.

Appendix E: ATO Deployment Survey for Jurisdictional Utilities

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INTRODUCTION

The “ATO Deployment Survey for Jurisdictional Utilities” (ATO Survey) is a self-reporting survey based assessment of Advanced Transmission Operations deployment and deployment plans intended for completion by the electric utilities of Kentucky.

The ATO Survey consists of two sections. Section one is the “System Assessment Survey”; it collects information pertinent to substation automation, advanced and automated protection and control, modeling, contingency analysis, wide area monitoring and control, simulation and visualization tools, and advanced grid control devices and materials that are currently installed, or planned for installation, in the transmission system. Section two is the “Cost and Benefit Survey”; it collects information on deployment approaches and the business case considerations that support/do-not-support ATO

The ATO Survey concludes by providing the respondent an opportunity to document any additional support/concerns with ATO. These can include, but are not limited to: barriers to implementation, policy issues, or business valuation.

Overview of ATO

ATO (Advanced Transmission Operations) improves transmission reliability, utilization, and efficiency. ATO also manages congestion, scheduling, and planning for the power transmission system. In addition, ATO integrates certain aspects of distribution system operations with transmission operations. ATO includes substation automation, advanced and automated protection and control, modeling, contingency analysis, wide area monitoring and control, simulation and visualization tools, advanced grid control devices and materials, and the integration of all these tools with markets and Regional Transmission Organization (RTO) as well as Independent System Operators (ISO) operations and planning functions. Like AMI (Advanced Metering Infrastructure), we refer to ATO as a Smart Grid key infrastructure area, as opposed to a specific technology.

The purpose of transmission systems is to provide secure and efficient operating conditions when the power system is in normal operations, and to minimize the loss to the customers and the system components when the system is under emergency. The transmission area of concentration focuses primarily on real-time network analysis under normal or emergency operations of the transmission grid.

With Smart Grid concepts, technologies and applications widely penetrate into the power systems, ATO will become an important backbone for the realization of the future grid. In this brief overview report, we will analyze enabling technologies classified by different functionalities, and then discuss various aspects associated with ATO development, such as applicable standards, cyber security issues, development benefits and experiences.

UTILITY PROFILE

Company Information

1. Provide the following regarding the organization being assessed:

    Company Name

    Address

    Web Site

2. Provide the end date of the year period for which you will be providing data for this assessment (mm/dd/yyyy).

Contact Information

1. Provide the following regarding the person responsible for completion of the Assessment Survey:

    Name

    Title

    Address

    Phone

    Email

ATO System Assessment Survey

The ATO Survey collects information pertinent to Transmission Automation, Emergency Control Automation, Contingency Analysis, Wide Area Monitoring and Control for Advanced Auto Restoration, System-wide Automated Voltage Control, Syncho-Phasors, and Self-Healing Capabilities currently installed, or planned for installation, in the transmission system. For the following questions please indicate of the system/technology is installed in your system. If the system/technology is not installed, but installation plans are in development, please indicate this as appropriate.

Automated Control Baseline

1. Please provide the percentage of your transmission system implementing the following Automated Control Baseline functionalities, as defined in the document "KSGRI –ATO Overview:
   a. System voltage regulation by changing transformer taps
   b. Voltage and reactive load control by adjusting capacitor banks
   c. Interlocking of controls
   d. Sequencing controls to ensure safe operation
   e. Load balancing
   f. Automated system restoration
2. Provide the vendor(s) of the system utilized.

Emergency Control Baseline

1. Please provide the percentage of your transmission system capable of implementing the following Emergency Control Baseline functionalities, as defined in the document "KSGRI – ATO Overview:
   a. Fault location
   b. Protection and clearing verification
   c. Load shedding
   d. Re-routing of power
   e. Repair crew dispatch
   f. Fault recording

2. Provide the vendor(s) of the system utilized.

Transmission System Contingency Analysis

1. Does your utility utilize simulation tools to perform contingency analysis?
2. If yes in 1, to what contingency level is the system evaluated (i.e. first contingency, second contingency, etc.)

Wide Area Monitoring and Control Advanced Auto Restoration

1. Does your utility utilize WAMCS to perform auto restoration of the transmission system?
2. If yes in 1, what percentage of your transmission system does this function serve?

System-wide Automated Voltage Control

1. Does your utility utilize system-wide automated voltage control?
2. If yes in 1, what percentage of your transmission system does this function serve?

Synchro-Phasor

1. Does your utility utilize transmission level synhro-phasor devices?
2. If yes in 1, what percentage of your transmission system do these devices monitor?
3. If yes in 1, describe the utilization of the synchrophasor data (i.e. identification of thermal overloads, voltage constraints, or voltage instabilities).

Self-Healing Grid

1. Please describe any self-healing capabilities your transmission system possesses including relay protection, remedial automation schemes, and local controllers.

2. Are these functions fully automated? Please elaborate.

Dynamic Line and Equipment Rating

1. Does your transmission system operate equipment dynamically based on environmental measurements such as temperature, wind speed, or incident sunlight?
2. If yes in 1, please describe.

3. Are environmental measurements used to forecast load? If yes, please describe.

Advanced Components

1. Does your transmission system utilize advanced flow control devices including: Flexible AC transmission (FACTS), variable frequency transformers (VFT), solid state transformers, superconducting condensers, high voltage DC (circle those that apply).

2. Does your transmission system utilize fault current limiting devices? If yes, please describe.

3. Does your transmission system utilize high temperature / high capacity transmission cable?

4. Does your transmission system utilize advanced storage such as advanced batteries, compressed air, pumped hydro, or others? If yes, please describe.

ATO COST AND BENEFIT SURVEY

The ATO Cost and Benefit Survey collects information on deployment approaches and the business case considerations that support/do-not-support ATO. For the following questions please indicate of the costs/benefits incurred by the system. If your company has not evaluated certain costs/benefits, please indicate this also. If ATO has not been deployed in your system, but you have performed a cost/benefit analysis, please provide those results where appropriate.

Costs

1. Provide the total capital costs related to ATO deployment.

2. Provide a breakdown of ATO capital system costs, by percentage, over the following categories:

    a. Endpoint Hardware

    b. Network Hardware

    c. Installation

    d. Project Management

    e. IT

3. Provide an estimate of the O&M costs for annual operating and maintenance expenses.

Savings

1. Efficiency Savings - Provide the actual or estimated savings due to improved transmission efficiency.

2. Outage Response Savings - Provide the actual or estimated savings of improved outage response.

Benefits

1. Outage Management/Response Benefits – Indicate if the impact of the following possible benefits have been evaluated due to improved outage management capabilities:
    a. Enhanced customer satisfaction due to improved outage management: (y / n)

2. Environment - Indicate if the impacts of the following possible benefits have been evaluated for the environment:
    a. ATO system enablement of conservation programs helping to defer construction of new facilities and reduction of additional pollutants: (y / n)

SURVEY FEEDBACK

Please use the remaining space to provide any additional feedback or comments for review by the Smart Grid Road Map Initiative Team.

Appendix F: AAM Deployment Survey for Jurisdictional Utilities

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INTRODUCTION

The “AAM Deployment Survey for Jurisdictional Utilities” (AAM Survey) is a self-reporting survey based assessment of Advanced Asset Management deployment and deployment plans intended for completion by the electric utilities of Kentucky.

The AAM Survey consists of one section. Section one is the “System Assessment Survey”; it collects information pertinent to system maintenance, planning, and utilization.

The AAM Survey concludes by providing the respondent an opportunity to document any additional support/concerns with AAM. These can include, but are not limited to: barriers to implementation, policy issues, or business valuation.

OVERVIEW OF AAM

AAM (Advanced Asset Management) integrates the grid intelligence acquired in achieving the other milestones, such as AMI, ADO, and ATO with new and existing asset management applications. This integration enables utilities to reduce operations, maintenance, and capital costs, and better utilize assets efficiently during day-to-day operations. Additionally, it significantly improves the performance of capacity planning, forecast, maintenance, engineering and facility design, customer service processes, and work and resource management. Like AMI (Advanced Metering Infrastructure), we refer to ATO as a Smart Grid key infrastructure area, as opposed to a specific technology.

AAM can spread over a broad range of electric power system infrastructures, from generation, and transmission to distribution and consumption. It includes, but is not limited to, asset "health" information, system and facility maintenance, transmission and distribution planning and expansion, and system operating information. The realization of Smart Grid AAM requires the collaboration with other infrastructure areas. Also, the integration of both operational and asset condition information will improve the effectiveness of asset management systems.

With Smart Grid concepts, technologies and applications widely penetrate into the power systems, AAM will become an important backbone for the realization of the future grid. In this brief overview report, we will summarize enabling technologies and main functionalities of AAM.

Utility Profile

Company Information

3. Provide the following regarding the organization being assessed:

   Company Name

   Address

   Web Site

4. Provide the end date of the year period for which you will be providing data for this assessment (mm/dd/yyyy).

Contact Information

2. Provide the following regarding the person responsible for completion of the Assessment Survey:

   Name

   Title

   Address

   Phone

   Email

AAM SYSTEM ASSESSMENT SURVEY

The AAM Survey collects information pertinent to Advanced Asset Management. For the following questions please indicate of the system/technology is installed in your system or if identified procedures are utilized. If the system/technology is not installed, but installation plans are in development, please indicate this as appropriate. If new management procedures are being evaluated, please indicate this where appropriate as well.

Gathering and Distributing Data

3. Please describe the use of the following technology tools in your asset management system:

   a. Sensors and/or Intelligent Electronic Devices (IEDs): Describe the use of sensor to monitor factors such as vibration, chemical analysis, acoustics, temperature, or other electrical parameters used in the delivery of electricity. To what assets are these sensors/devices applied? Describe the factors monitored by the sensors for each asset type. What percentage of system assets utilize such devices?

   b. Common Information Model: Does your utility utilize a Common Information Model (CIM) to provide a system-wide commonality of data to measure the condition of equipment? If so, which asset types are represented in the CIM? Do you have plans to extend the CIM to more asset types? If so, please indicate which asset types will be included.

   c. Widespread Communications: Describe the method by which sensor data is transmitted from the sensor/IED to the asset manager / AAM software systems.

d. Substation Automation: Describe how sensor data is utilized to support substation automation.

4. Provide the vendor(s) of the AAM software systems utilized.

Distribution, Operations, and Planning Optimization

3. Does your system utilize software to analyze distribution circuits for reconfiguration based on loss minimization? To what percentage of distribution system circuits are these analysis applied?

4. If yes in 1, provide the vendor(s) of the optimization software utilized.

5. Does your system utilize real-time dynamic ratings of lines based on real time data (i.e. temperature, wind speed, etc.)?

    a. What percentage of transmission lines are operated dynamically?

    b. What measurements are included in the dynamic operation of transmission lines?

    c. What percentage of distribution lines are operated dynamically?

    d. What measurements are included in the dynamic operation of distribution lines?

6. Does your system utilize real-time dynamic ratings of transformers based on real time data (i.e. temperature, wind speed, etc.)?

    a. What percentage of substation transformers are operated dynamically?

    b. What percentage of distribution (feeder) transformers are operated dynamically?

    c. What measurements are included in the dynamic operation of transformers?

7. Is real time data on assets from sensors/IEDs utilized in system planning? Please describe how the data is utilized.

Applications and Device Technologies

3. Does your utility utilize Probabilistic Risk Assessment (PRA) to assist in operation and maintenance decisions?

    a. How is the probability of asset failure determined and for what assets are failure probabilities calculated?

    b. How is the consequence of an asset failure determined and for what assets are failure consequences determined?

4. Does your utility utilize Failure Rate Analysis (FRA) to assist in operation and maintenance decisions?

    a. For what asset types is FRA employed?

b. What data is analyzed in failure rate analysis? Underline those that apply: asset nameplate information, cause of failure, utilization history, operating cycle, percent loading, environmental variables, GIS information, other (please specify) .

5. Does your utility utilize Condition-based monitoring maintenance to monitor system's "health" information in real-time to generate alarm signals?

   a. For what asset types is condition-based monitoring maintenance employed?

   b. What data is collected for condition-based monitoring maintenance? How is this data collected?

6. Does your utility utilize Reliability-based Maintenance using a reliability index of each device or equipment?

   a. For what asset types is reliability based maintenance employed?

   b. How are reliability indexes for these assets calculated?

7. Does your utility utilize Predictive Maintenance to identify impending problems by detecting subtle changes in equipment operations?

   a. For what asset types is predictive based maintenance employed?

   b. What data is analyzed in predictive based maintenance?

Performance Standards

3. Describe the reliability standards utilized in your system and how they are utilized. Examples may include CAIDI, Forced Outage Rate, and Equipment Failure Rate.

4. Describe the economic standards utilized in your system and how they are utilized. Examples may include Cost per delivered MW, Cost per installed MW, Cost per MW transformed.

SURVEY FEEDBACK

Please use the remaining space to provide any additional feedback or comments for review by the Smart Grid Road Map Initiative Team.

APPENDIX G: CONSUMER EDUCATION SURVEY FOR JURISDICTIONAL UTILITIES

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INTRODUCTION

The “Consumer Education Survey for Jurisdictional Utilities” (CE Survey) is a self-reporting survey based assessment of Consumer Education programs intended for completion by the electric utilities of Kentucky.

UTILITY PROFILE

Company Information

5. Provide the following regarding the organization being assessed:

   Company Name

   Address

   Web Site

6. Provide the end date of the year period for which you will be providing data for this assessment (mm/dd/yyyy).

Contact Information

3. Provide the following regarding the person responsible for completion of the Assessment Survey:

   Name

   Title

   Address

   Phone

   Email

CONSUMER EDUCATION SURVEY

The CE Survey collects information regarding consumer education programs related to smart grid deployment.

5. Indicate if your organization has a consumer education program specific to the following areas of smart grid:

    a. General Smart Grid

    b. Advanced Metering ("smart meters")

    c. Demand Response Programs

    d. Distribution Automation

    e. Energy Efficiency

    f. Distributed Energy Resources

    g. Integration of Electric Vehicles

6. Regarding the CE programs identified in question 1, indicate the programs that are designed to achieve the following (circle all programs that apply for each outcome):

    a. A basic understanding of the technologies being used or new options available to the consumer:

        A B C D E F G

    b. Understanding of any associated rate structure changes or options. The role of the utility and third parties:

        A B C D E F G

    c. Understanding of the goals of the program, including potential individual and societal costs and benefits:

        A B C D E F G

d. Understanding of the potential implications (benefits, costs, and risks) associated with their participation (or non-participation) in a smart grid program or rate option:

A B C D E F G

e. Information regarding resources and tools available to them than can be employed to estimate potential effects of participation in the program: A B C D E F G

A B C D E F G

7. Regarding your CE programs, indicate if your programs utilize the following methods of customer engagement:

   a. Direct Mailing

   b. Call Center

   c. Website

   d. T.V.

   e. Radio

   f. Social Media (Facebook, Twitter, etc.)

   g. Customer Advisory Board

   h. Other (please specify)

8. Does your organization utilize consumer education as part of cost-benefit analysis regarding smart grid deployments?

APPENDIX H: DER DEPLOYMENT SURVEY FOR JURISDICTIONAL UTILITIES

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INTRODUCTION

The “DER Deployment Survey for Jurisdictional Utilities” (DER Survey) is a self-reporting survey based assessment of Distributed Energy Resources deployment and deployment plans intended for completion by the electric utilities of Kentucky.

The DER Survey consists of two sections: the first collects information regarding installed resources quantities and nameplate capacity, and the second collects information regarding system integration of DERs. The DER Survey concludes by providing the respondent an opportunity to document any additional support/concerns with ADO. These can include, but are not limited to: barriers to implementation, policy issues, or business valuation.

OVERVIEW OF DER

Distributed energy resources (DER), or distributed energy/generation are small, modular, decentralized energy generation and storage technologies that can produce electricity where energy is needed. They are "distributed" because they are located at or close to the point of energy consumption, unlike traditional "centralized" systems, where electricity is generated at a remote large-scale power plant and then delivered through power lines to the consumers. Typically, DER systems produce less than 10 MW of power. They are integrated systems that can include effective means of power generation, energy storage, and delivery. DER systems may be either connected to the local grid or off the grid in stand-alone applications. DER deployments will enable the generation portfolio and diversity towards a more decentralized model that will include a balance of large, centralized generating plants as well as small-scale distributed generations.

DER includes renewable energy resources, distributed generations, energy storages and electric vehicles (EV). DER encompasses a wide range of technologies, such as: wind turbines/wind energy systems, diesel engines, photovoltaics (PV), concentrating solar systems, fuel cells, microturbines, reciprocating engines, combustion turbines, cogeneration, small modular biopower, and energy storage systems. The effective use of grid-connected distributed energy resources also require power electronic interfaces, communications, and control devices for efficient operations.

Distributed energy technologies are playing an increasingly important role in the nation's energy portfolio. They can be used as base load power, peak load power, backup power, remote power, as well as cooling and heating needs.

DER has the potential to mitigate congestion in transmission lines, reduce the impact of energy price fluctuations, enhance energy security, and improve power reliability and stability. DER increases the utilization and efficiency of existing infrastructure. DER also has significant impact on the environment and natural resources.

The deployment of renewable energy technologies for DER applications depends on a series of things, including: local renewable resources availability, the cost of energy at the site, available financial incentives, and specific application factors.

UTILITY PROFILE

Company Information

7. Provide the following regarding the organization being assessed:

    Company Name

    Address

    Web Site

8. Provide the end date of the year period for which you will be providing data for this assessment (mm/dd/yyyy).

Contact Information

4. Provide the following regarding the person responsible for completion of the Assessment Survey:

    Name

    Title

    Address

    Phone

    Email

DER SYSTEM ASSESSMENT SURVEY

The DER Survey collects information regarding deployment of and deployment plans for distributed generation, renewable generation, and energy storage. It also collects stakeholder feedback on system integration challenges for DERs. For the following questions please indicate of the system/technology is installed in your system. If the system/technology is not installed, but installation plans are in development, please indicate this as appropriate.

Distributed Energy Resources

9. Indicate the size of your organizations DER capability (in nameplate kW) for the following categories of distributed generation installed at the distribution system level (only). Also indicate the total number of DER end devices for each category.

    a. Fuel Cell

    b. Diesel Engine

    c. Natural Gas Engine

    d. Dual-Fuel Engine

    e. Natural Gas Microturbine

10. Indicate the size of your organizations planned DER expansion (in nameplate kW) over the next year for the following categories of distributed generation installed at the distribution system level (only). Also indicate the total number of DER end devices that will be added for each category.

    a. Fuel Cell

    b. Diesel Engine

    c. Natural Gas Engine

    d. Dual-Fuel Engine

    e. Natural Gas Microturbine

11. Indicate the size of your organizations DER capability (in nameplate kW) for the following categories of renewable generation installed at the distribution system level (only). Also indicate the total number of DER end devices for each category.

    a. Microturbine Hydroelectric

b. Solar Photovoltaic

c. Wind Turbine

12. Indicate the size of your organizations planned DER expansion (in nameplate kW) over the next year for the following categories of renewable generation installed at the distribution system level (only). Also indicate the total number of DER end devices that will be added for each category.

    a. Microturbine Hydroelectric

    b. Solar Photovoltaic

    c. Wind Turbine

13. Indicate the size of your organizations DER capability (in nameplate kW) for the following categories of energy storage installed at the distribution system level (only). Also indicate the total number of DER end devices for each category.

    a. Thermal Energy Storage

    b. Battery Energy Storage

    c. Pumped Hydro Storage

    d. Compressed Air Storage

    e. Kinetic Energy Storage (Flywheel)

    f. Super/Ultra Capacitors

    g. Superconducting Magnetic Energy Storage

14. Indicate the size of your organizations planned DER expansion (in nameplate kW) over the next year for the following categories of energy storage installed at the distribution system level (only). Also indicate the total number of DER end devices that will be added for each category. Thermal Energy Storage

    a. Battery Energy Storage

    b. Pumped Hydro Storage

    c. Compressed Air Storage

    d. Kinetic Energy Storage (Flywheel)

e. Super/Ultra Capacitors

f. Superconducting Magnetic Energy Storage

15. Does your organization have an Electric Vehicle Integration Strategy? If so, please briefly describe this strategy.

System Integration

1. For each of the following influences on protection devices, please indicate your level of concern with each operational issue: A-Not very concerned, B-Somewhat Unconcerned, C-Neither Concerned nor Unconcerned, D- Somewhat Concerned, E-Very Concerned

   a. Nuisance fuse blowing

   b. Unwanted operations (reclosers, sectionalizers, and fuses)

   c. Failure of sectionalizers to operate when they should

   d. Desensitization of breakers and reclosers

   e. Increased fault levels

2. What type of communication technologies are used to communicate to the DERs in your system (Examples include RF mesh, Broadband, PLC, telephone, cellular, paging network)? Do they communicate directly to the DERs or to a meter connected to the DER device?

3. What type of communication technologies are you considering installing in order to communicate with the DERs in your system ?

4. What information standards do you utilize to communicate amongst the DERs (Examples include DNP3, IEC 61850, ModBus, Proprietary)?

5. What information standards are you considering?

6. What is your impression of the relative maturity of the DER that is currently deployed at your organization?
    a. Technologies are very mature and widely implemented
    b. Technologies are moderately mature
    c. Technologies are fairly new
    d. Technologies are leading edge ore experimental, with unproven interfaces
7. Describe the level of effort that is anticipated to integrate DER into your system.
    a. Extensive changes will be needed
    b. Moderate changes will be needed
    c. Few changes will be needed
    d. No changes will be needed
8. Describe the decision making process regarding utilization of your current DER architecture:
    a. Dispatched / Centrally managed
    b. Autonomous / Self managed
    c. Mix of centralize and autonomous
9. Describe the decision making process regarding utilization of your planned DER architecture:
    a. Dispatched / Centrally managed
    b. Autonomous / Self managed
    c. Mix of centralize and autonomous
10. Describe any concerns/issues for your organization regarding DER deployment and configurations.

SURVEY FEEDBACK

Please use the remaining space to provide any additional feedback or comments for review by the Smart Grid Road Map Initiative Team.