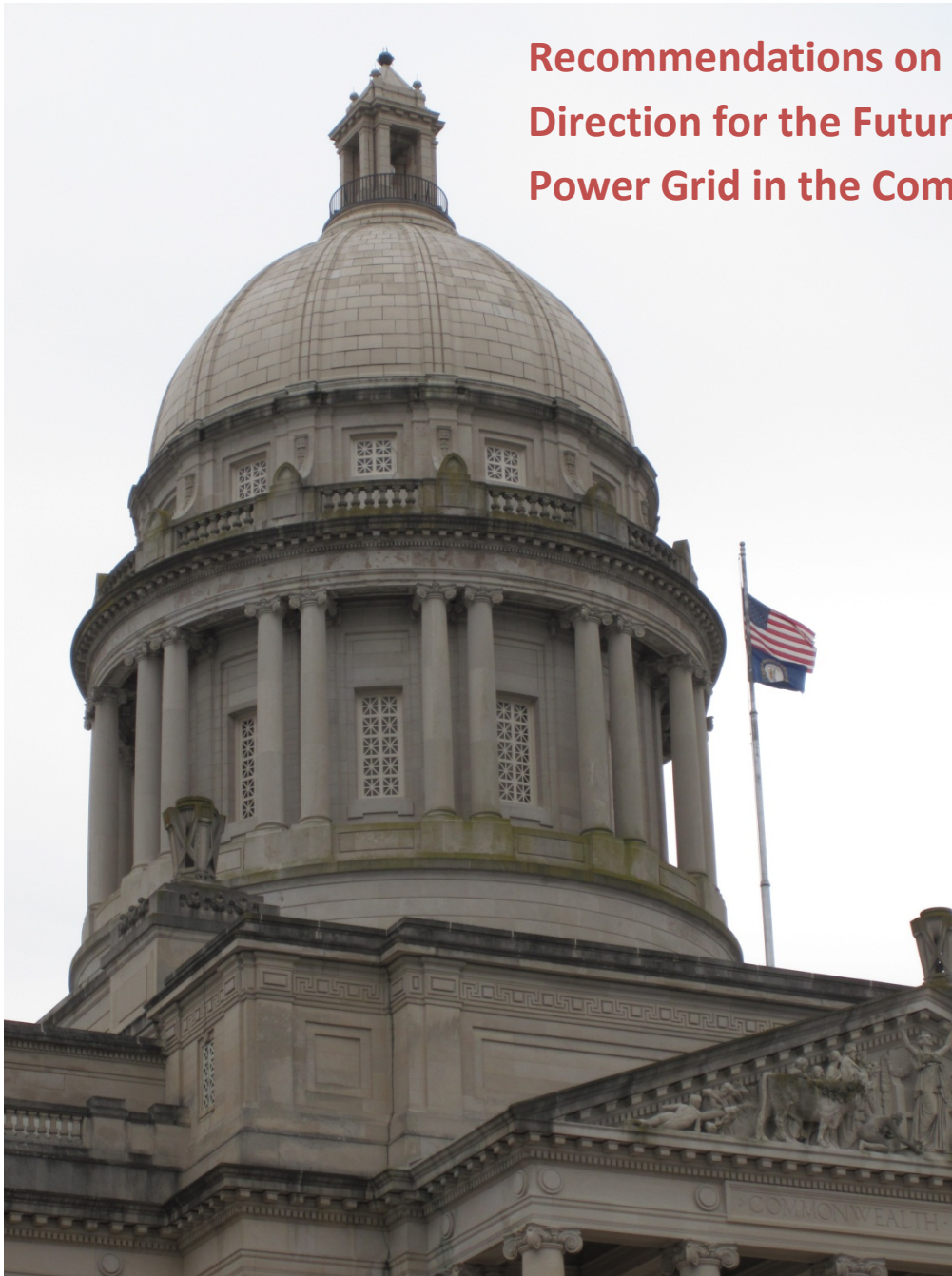


Kentucky's Smart Grid Roadmap



**Recommendations on a Vision and
Direction for the Future of the Electric
Power Grid in the Commonwealth**

The Kentucky Smart Grid Roadmap Initiative

Submitted to Kentucky Public Service Commission on 9/18/2012

PURPOSE

The Kentucky Smart Grid Roadmap Initiative (KSGRI) is an effort to identify a path towards electric grid modernization in the Commonwealth of Kentucky. The KSGRI includes inputs from academic, electric utility, governmental, and stakeholder representatives.

The KSGRI is led by the University of Louisville's Conn Center for Renewable Energy Research ("Conn Center") and the University of Kentucky's Power and Energy Institute of Kentucky ("PEIK"). The Conn Center and PEIK were engaged by the Kentucky Public Service Commission ("Kentucky Commission") to develop a technical roadmap for developing and deploying "Smart Grid" technology throughout the Commonwealth. Their efforts were monitored and reviewed by Staff from the Kentucky Commission; however, this report, its conclusions and recommendations do not reflect the opinion or position of the Staff of the Kentucky Commission or of the Commission, itself. The KSGRI has also brought together broad representation from the electric utility industry, state government, and other closely related industries for information and consultation.

The Kentucky Smart Grid Roadmap is the end result of a 2 year project by the KSGRI to analyze the existing power infrastructure in Kentucky and to develop recommendations for future grid modernization efforts. The goals of the Kentucky Smart Grid Roadmap are to facilitate the following outcomes:

1. Maintain Kentucky's energy security through prudent deployment of advanced Smart Grid technologies.
2. Improve electric energy efficiency, reliability, and safety of the Kentucky electric power system.
3. Facilitate academic, industrial, and governmental partnerships to position Kentucky at the forefront of Smart Grid analysis in the areas of technology development and deployment, and public policy.
4. Educate consumers, utility representatives, government representatives, and others on the benefits, risks, and barriers associated with Smart Grid technology deployments.

It is our belief that adoption of Smart Grid technologies will bring improvements to the Kentucky electrical grid in the areas of reliability, safety, security, price, environmental impacts, and efficiency.

CONTRIBUTORS

KY SMART GRID ROADMAP INITIATIVE COMMITTEE

Primary Authors

Mr. Yan Du - *Department of Electrical and Computer Engineering, University of Kentucky*
Dr. Matthew Turner - *Conn Center for Renewable Energy Research, University of Louisville*

Contributing Authors

Dr. Adel Elmaghraby - *Department of Computer Engineering and Computer Science, University of Louisville*
Dr. James Graham - *Department of Electrical and Computer Engineering, University of Louisville*
Dr. Yuan Liao - *Department of Electrical and Computer Engineering, University of Kentucky*
Dr. John Naber - *Department of Electrical and Computer Engineering, University of Louisville*
Dr. Mahendra Sunkara - *Conn Center for Renewable Energy Research, University of Louisville*

KENTUCKY PUBLIC SERVICE COMMISSION ADVISORY PANEL

Ms. Kimra Cole - *Engineering Division, Kentucky Public Service Commission*
Mr. Jeff Derouen, J.D. - *Executive Directors Office, Kentucky Public Service Commission*
Mr. James Gardner, J.D. - *Vice Chairman, Kentucky Public Service Commission*
Mr. Aaron Greenwell - *Executive Directors Office, Kentucky Public Service Commission*
Dr. John Rogness - *Division of Financial Analysis, Kentucky Public Service Commission*

CONTRIBUTING UTILITY PARTNERS

Mark Abner - *Cumberland Valley Electric, Inc.*
Avery Adams – *Duke Energy*
Tracy Bensley - *Jackson Purchase Energy Corporation*
James Bridge - *Owen Electric Cooperative*
Ken Cooper - *Bluegrass Energy Cooperative*
Rocco D’Ascenzo - *Duke Energy*
Tim Duff - *Duke Energy*
Paul Dollof - *East Kentucky Power Cooperative*
Mike French - *Meade County RECC*
David Graham - *Shelby Energy Cooperative, Inc.*
Marvin Graham - *Inter-County Energy Cooperative*
Gary Grubbs - *Shelby Energy Cooperative, Inc.*
Greg Harrington - *Nolin RECC*
Roger Hickman - *Big Rivers Electric Corporation*
Dennis Holt - *South Kentucky RECC*

David Huff - *Louisville Gas & Electric and Kentucky Utilities, LLC*
Brandon Hunt - *Fleming Mason Energy*
Rick Lovekamp - *Louisville Gas & Electric and Kentucky Utilities, LLC*
Lila Munsey - *Kentucky Power*
Jeff Myers - *Louisville Gas & Electric and Kentucky Utilities, LLC*
John Newland - *Kenergy Corp.*
John Patterson - *Taylor County RECC*
Todd Peyton - *Clark Energy Cooperative*
Russ Pogue - *Big Rivers Electric Corporation*
Brian Poling - *Grayson RECC*
Jeff Prater - *Big Sandy RECC*
Mike Scaggs - *Taylor County RECC*
Isaac Scott - *East Kentucky Power Cooperative*
James See - *Owen Electric Cooperative*

Tim Sharp - *Salt River Electric*
Mark Stallions - *Owen Electric Cooperative*
Scott Sidwell - *Clark Energy Cooperative*

Tom Weaver – *AEP, Kentucky Power*
Carol Wright - *Jackson Energy Cooperative*

CONTRIBUTING STAKEHOLDER PARTNERS

Bill Burke – *GE Consumer and Industrial*
Paul Centolella – *Commissioner Emeritus, PUC Ohio*
Rick Clewett – *Sierra Club*
Bill Dawson – *Greater Louisville Inc.*
Steve Dale – *Kentucky Department for Energy Development and Independence*
Tom Dorman – *Office of Kentucky Representative Rock Adkins*
Robert Duff – *Kentucky Department for Energy Development and Independence*
Venkat Krishnan – *GE Consumer and Industrial*
Robert Amato - *Kentucky Energy & Environment Cabinet, Department for Energy Development and Independence*
Jeff Auxier - *Kentucky Solar Energy Society*

Alfred Gaspari - *Greater Cincinnati Energy Alliance*
B. Russell Harper - *Kentucky Council of Area Development Districts*
Dan Hoffman - *RegenEn Solar*
Dennis Howard – *Kentucky Agriculture Cabinet*
Paul Hornack - *Kentucky State Senate*
Susan Lambert - *Earthworks, LLC*
Alan Manche – *Schneider Electric*
Wallace McMullen - *Cumberland Sierra Club*
John Robbins – *Sierra Club*
Ron Willhite - *Kentucky School Board Association*

TABLE OF CONTENTS

- Purpose 2
- Contributors 3
 - KY Smart Grid Roadmap Initiative Committee..... 3
 - Kentucky Public Service Commission Advisory Panel 3
 - Contributing Utility Partners 3
 - Contributing Stakeholder Partners 4
- Table Of Contents 5
- Executive Summary and Key Recommendations..... 7
- Chapter 1: About the Kentucky Smart Grid Roadmap Initiative..... 8
- Chapter 2: A Smart Grid Primer 10
 - What is the “Grid”? 10
 - What is a “Smart Grid”? 11
 - The Six Smart Grid Infrastructure Areas 12
- Chapter 3: The Smart Grid Value Chain 15
 - How does Smart Grid benefit consumers? 15
 - How does Smart Grid benefit utilities? 16
 - How does Smart Grid benefit society at large? 16
- Chapter 4: Smart Grid Technology Adoption..... 18
 - A 50,000 Foot Overview of The Kentucky Electrical Grid 18
 - Where Are We Now and Where Do We Want to Go?..... 19
 - The State of Advanced Metering Infrastructure..... 21
 - The State of Distribution..... 25
 - The State of Transmission..... 29
 - The State of Asset Management..... 32
 - The State of Distributed Energy Resources 34
 - The State of Consumer Education 37
- Chapter 5: Summary of Kentucky Smart Grid Workshop Series Results and Key Action Items 39
 - Workshop Key Results 39
- Chapter 6: Barriers to Smart Grid Deployments..... 41
 - Customer Acceptance Barriers 41

Technological Barriers.....	41
Regulatory and Policy Barriers.....	42
Business and Financial Challenges.....	42
Chapter 7: The Kentucky Smart Grid Roadmap.....	43
Kentucky Smart Grid Taskforce.....	43
Infrastructure Deployments.....	43
Awareness, Marketing and Education.....	46
Research and Development and Pilot Programs.....	47

EXECUTIVE SUMMARY AND KEY RECOMMENDATIONS

The Kentucky Smart Grid Roadmap is focused on the modernization of the electric power grid in the state of Kentucky in the areas of generation, transmission, distribution, metering, and the end-use of electricity, as well as consumer education. Its goal is to make recommendations that will guide capital and resource investment decisions made by utilities, regulatory and policy decisions made by state government, and research and development activities of universities.

Grid modernization is of critical importance, both nationally and within the Commonwealth. Broadly, this means the ability to meet ever increasing standards in reliability, security, cost of service, power quality, efficiency, environmental impact and safety, and the ability to measure our progress towards these goals. Deployments of smart grid technology can create a grid that is self-healing, optimizes the utilization of system assets, enables new energy markets, encourages the integration of all types of electricity generation and energy storage, provides digital grade power, and is resistant to attack and natural disaster. However, the technologies that enable Smart Grid are still emergent and the economic justification is still evolving.

The KSGRI brought together more than 70 stakeholders from academia, the electric utility industry, governmental agencies, non-profit groups, and industrial and consumer energy users. These stakeholders provided insight into the operation of the Kentucky electric power system, identified opportunities and barriers for grid modernization, and provided opinions used to form key recommendations on a plan that will ensure an integrated and comprehensive approach to Smart Grid deployments in the Commonwealth.

The 5 key recommendations of the KSGRI are:

1. Encourage investments focused on future-proof data network architecture, preferably one that is Internet Protocol based.
2. Creation of an official Kentucky Smart Grid Council composed of academic, industrial, governmental, and stakeholder members.
3. Funding of energy /technology policy and technology development research within the state university system.
4. Creation of regulatory mechanisms to foster increased investments in both cost-effective demand response programs and energy efficiency technologies such as Volt/VAR.
5. Allow for real-time and multi-tariff pricing.
6. Establishment of clear metrics to establish priorities and goals for Smart Grid deployments in KY.

Funding for the KSGRI comes from the United States Department of Energy's National Energy Technology Laboratory through the American Renewal and Reinvestment Act and is sponsored by the Kentucky Public Service Commission.

CHAPTER 1: ABOUT THE KENTUCKY SMART GRID ROADMAP INITIATIVE

Our challenge is to consider current electrical infrastructure, existing and emerging technologies, societal and consumer value, and economic and political conditions to create a grid vision that is appropriate for Kentucky. Once defined, this Smart Grid vision will help to guide infrastructure and technology investments made in Kentucky.

The Kentucky Public Service Commission engaged the University of Louisville and the University of Kentucky to form a partnership, the KSGRI, to develop analyses, recommendations, and a technical roadmap for the development and deployment of Smart Grid technologies throughout the Commonwealth regarding:

1. the condition of Kentucky's existing electric transmission grid;
2. which existing and emerging technologies are most likely to yield operational efficiencies and reliability benefits to Kentucky's electric transmission grid if appropriately deployed by utilities;
3. the degree to which Kentucky's electric generating utilities have already incorporated advanced technology in their transmission systems;
4. the "smartness" of Kentucky's existing electric distribution system;
5. which existing and emerging technologies are most likely to yield operational efficiencies and reliability benefits to Kentucky's electric distribution system if appropriately deployed by utilities;
6. the degree to which Kentucky's electric distribution utilities have already incorporated advanced
7. the availability of technologies and equipment/appliances to establish smart-grid facilities (i.e. residences, small business, etc.);
8. the extent to which Kentucky utilities may assure that any Smart Grid technologies deployed in the short-term will be compatible with future technology advances;
9. a timeline for deploying Smart Grid technology throughout Kentucky's transmission, distribution and facility-level networks;
10. a survey and analysis of available funding sources (i.e. rates, grants, loans, etc.) for Smart Grid technology;
11. the rate structures that will be necessary to make Smart Grid technology economically feasible (i.e. time of day rates, peak pricing, etc.); and
12. any legal barriers to development and deployment of Smart Grid technology.

This “Kentucky Smart Grid Roadmap” provides recommendations and best practices to utilities and utility stakeholders to guide individual Smart Grid deployment approaches. As part of the roadmap development, the KSGRI team analyzed existing and planned Smart Grid deployments within the commonwealth.

Analysis of existing and planned Smart Grid deployments were performed using interrogatories sent to all jurisdictional utilities. These self-reporting surveys collected information in the areas of general Smart Grid deployments and planning, advanced metering, distribution operations, transmission operations, asset management, distributed energy resource deployments, and customer education programs. An analysis and summary of these interrogatories was performed and reported in *Smart Grids in the Commonwealth of Kentucky: Final Report of the Kentucky Smart Grid Roadmap Initiative*.

In tandem to the analysis of the existing deployments, the KSGRI hosted a series of Smart Grid workshops that gathered key stakeholders from academia, the utility industry, state government, and other organizations to discuss Smart Grid issues as they relate to the Commonwealth. These workshops addressed factors likely to inhibit or encourage Smart Grid deployments, the current state and future needs of KY’s electrical infrastructure and technologies, and market and public policy approaches to facilitate Smart Grid deployments.

Combined, the above efforts provide the inputs which the KSGRI utilized to form the recommendations presented in this document. As such, these recommendations do not necessarily represent the individual views of either the contributing partners or the Public Service Commission Advisory Panel.

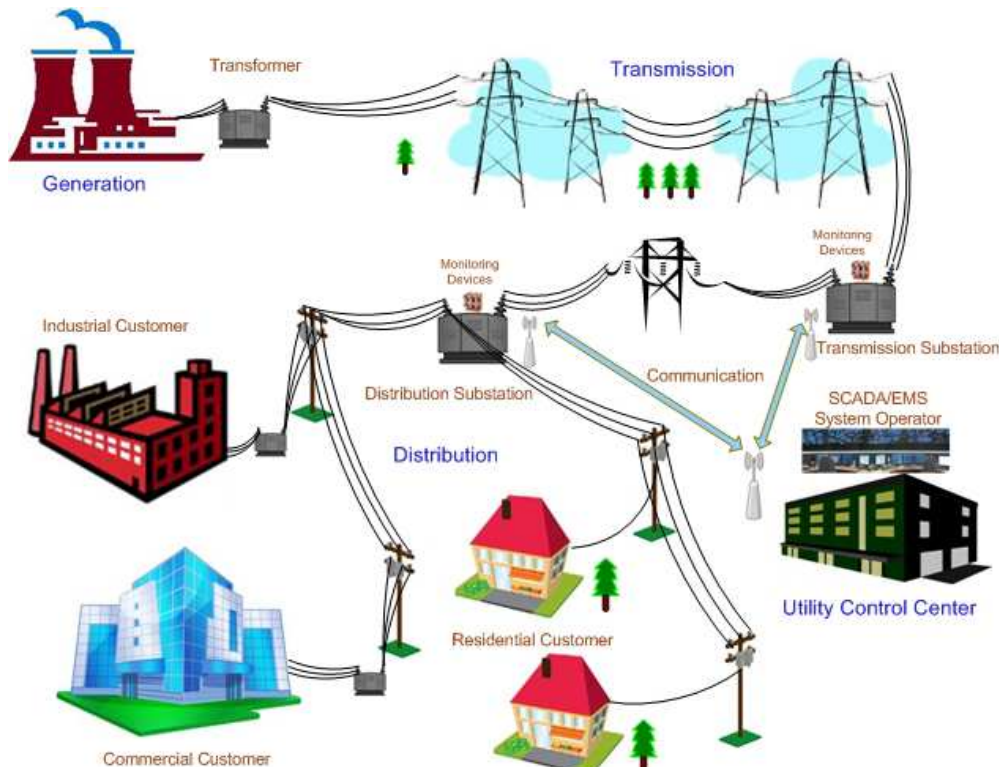
CHAPTER 2: A SMART GRID PRIMER

WHAT IS THE “GRID”?

In the power industry, the term “electric grid” or “the grid” refers to an interconnected network responsible for delivering electricity from electrical generators to electricity consumers. Generally, the grid is made up of three primary components:

1. Power generation—where various energy sources are converted into electricity. Power plants are usually centralized stations and utilize energy sources such as coal, hydro, nuclear, natural gas, solar and wind to generate large amount electricity, although there are also small amount distributed generations such as residential roof-top solar panels. The electricity generated at the power plants is stepped up to a transmission voltage by transformers which are connected to the transmission lines.
2. Power transmission—which is an interconnected network for carrying high voltage bulk electricity from power plants through long distance transmission lines until it reaches distribution systems where the electricity will be stepped down to a distribution voltage for local dispatch.
3. Power distribution—which is the local network for delivering electricity at the distribution voltage from distribution substations to electrical service locations where the electricity is further stepped down to the service voltage before it is ready to be consumed by customers.

The traditional electric grid has been in place since mid-19th century. Although it keeps evolving with the change of the external and internal environment including new regulations, a changing economy, evolving technologies, etc., the basic infrastructure remains what it looked like half century ago. Below is an illustration of the primary components of the traditional grid.

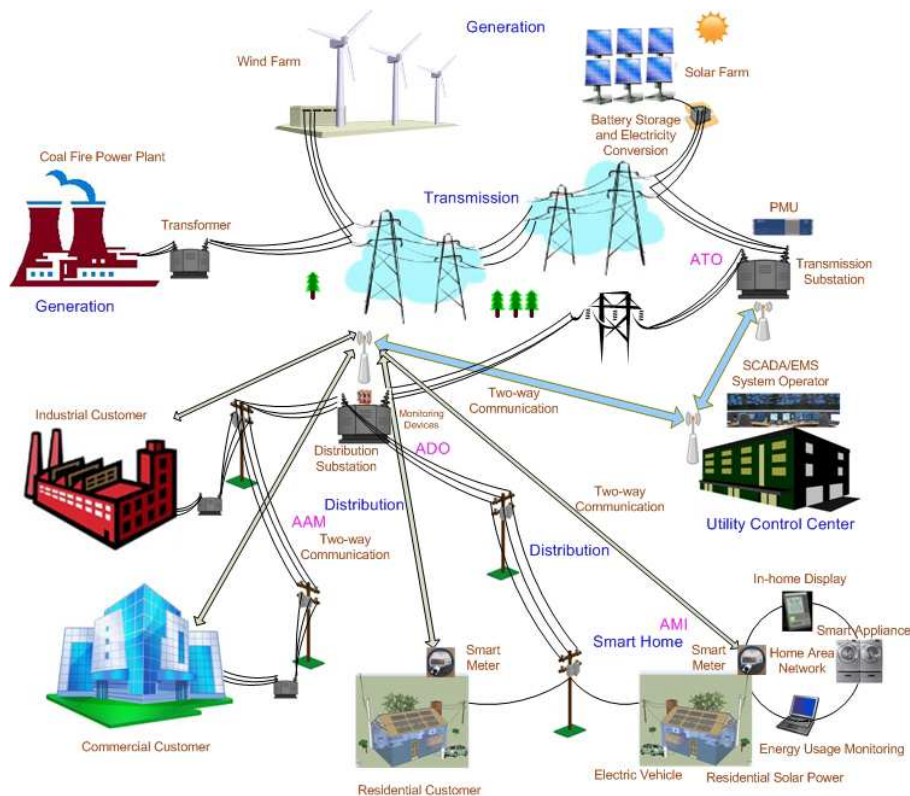


WHAT IS A “SMART GRID”?

The electric power grid operated by Kentucky’s jurisdictional electric utilities serves more than 1.8 million customers that are connected together by more than 33 thousand miles of transmission and 98 thousand miles of distribution lines. This grid has served as the backbone of the modern energy economy of Kentucky, and has provided residents of the commonwealth with safe, reliable, and low-cost electrical power for generations. However, the current electric grid faces unprecedented pressures, including aging infrastructure, outdated technologies, increasing energy costs, and increased environmental scrutiny.

A Smart Grid addresses these emerging issues through the application of modern technologies, digital communications infrastructure, and new business and operational methodologies applied to the operation of the electric power system. Many of these technologies can be deployed within the very near future or have already been deployed in Kentucky. For example, Supervisory Control and Data Acquisition (SCADA) systems enable auto-restoration and real-time monitoring of critical power system elements.

However there also exists an opportunity to greatly improve the overall future intelligence and operational efficiency of the grid by strategically investing in the network technologies that will allow the leveraging of energy information to create an architecture that is robust, flexible, and adaptable. The illustration below presents a probable design, although the exact technological makeup of a Smart Grid will vary from utility to utility.



THE SIX SMART GRID INFRASTRUCTURE AREAS

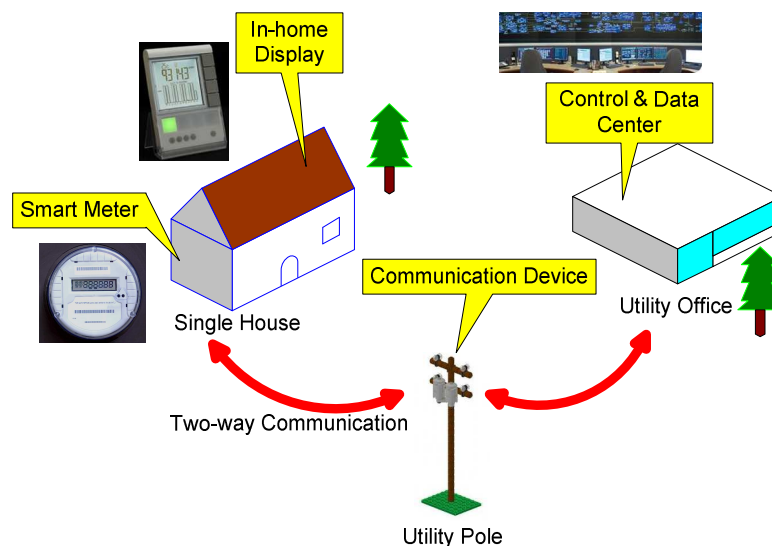
Smart Grid is more than just new devices. At its core, Smart Grid is about the combination of new technologies with data network architecture to gain efficiency and create new operational models. As such, the KSGRI divides Smart Grid into six Infrastructure Areas:

1. Advanced Metering
2. Advanced Distribution
3. Advanced Transmission
4. Advanced Asset Management
5. Consumer Education
6. Distributed Energy Resources

Advanced Metering Infrastructure (AMI)

AMI 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.

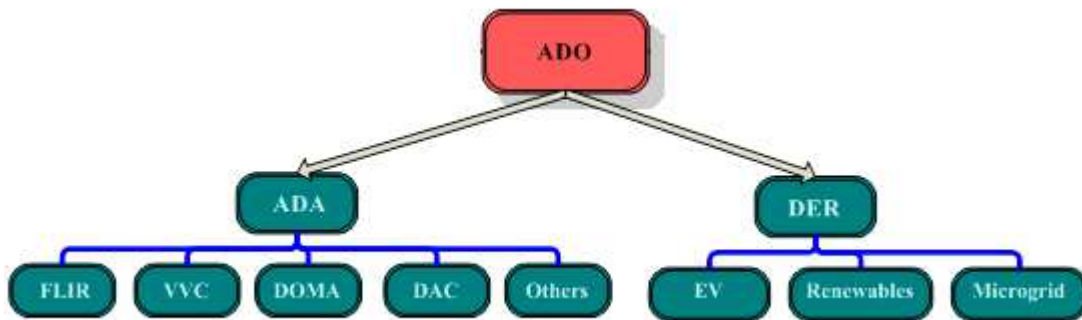
The following figure shows a typical residential AMI configuration. The smart meter is installed at the residential house, and has the capability to record, transmit, receive, and display usage information on an in home display or a computer. The in-home display serves at the foundation of the home area 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.



Advanced Distribution Operation (ADO)

The main objective of ADO is to improve the reliability and efficiency of distribution systems and to provide functional support for other applications that are aggregated into ADO, making the distribution systems much smarter.

The following figure provides a summary of ADO functions. From a systems perspective, ADO includes Advanced Distribution Automation (ADA) that enables intelligent control over electrical power grid functions such as Fault Location, Isolation and Service Restoration (FLIR), Conservation Voltage Reduction (also known as Volt/VAR control or VVC), Distribution system Operation Modeling and Analysis (DOMA), Data Acquisition and Control (DAC), and other sub-functions. ADO also aids deployment of distributed energy resources (DER), such as renewable energy resources and electric vehicles (EV), and enables the operation of microgrids. It can be integrated with a distribution-level geographical information system (GIS) and distribution supervisory control and data acquisition (SCADA) system for improved grid awareness.



Advanced Transmission Operation (ATO)

The purpose of ATO is to increase the intelligence and capacity of the nation’s high-voltage electric transmissions system through the application of advanced digital technology and power electronic devices to gain improvements in transmission reliability, utilization, and efficiency. This includes an improved ability to manage congestion, scheduling, and planning for the system, an increase in substation automation, improvements to automated protection and control, more accurate and more frequent system modeling and simulation, and the use of advanced grid control devices and materials. Additionally, ATO can help to integrate operation and planning functions among power markets, Regional Transmission Organizations (RTO) and Independent System Operators (ISO).

Advanced Asset Management (AAM)

AAM is the use of the grid intelligence to improve system asset management applications in order to reduce operations, maintenance, and capital costs, and to better utilize assets efficiently during day-to-day operations. AAM can help to significantly improve the performance of capacity planning, forecasting, maintenance, engineering and facility design, customer service processes, and work and resource management. AAM is not limited to one part of the electric grid, and can be applied to generation, transmission, distribution, and end-use of electricity by the consumer.

Consumer Education (CE)

Many of the advanced solutions Smart Grid can offer are dependent upon the acceptance of new technologies and the behaviors of end-use consumers. However up to 75 percent of the population are

unfamiliar with the Smart Grid concept. Through education programs, customers can become better informed and take a more active role in personal energy management. Of particular importance are programs to inform customers on smart meters, demand response programs, energy efficiency program, and distributed energy resources.

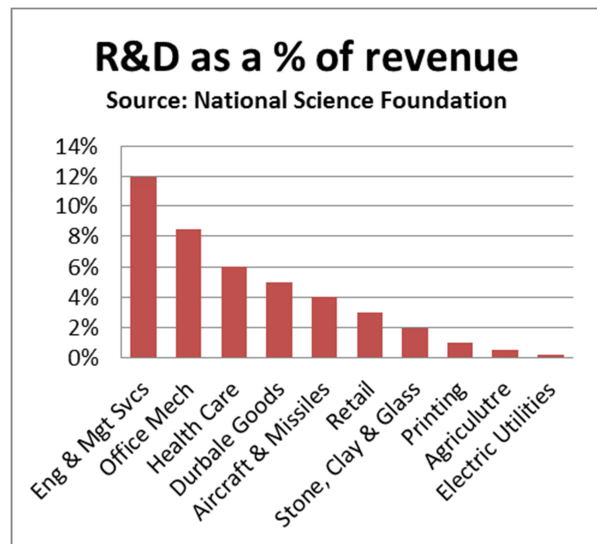
Distributed Energy Resources (DER)

DERs 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. DER includes renewable energy resources, distributed generations, and energy storage resources, and it is playing an increasingly important role in the nation's energy portfolio. DER has the potential to mitigate congestion on transmission lines, reduce the impact of energy price fluctuations, enhance energy security, improve power reliability and stability, and can have significant impact on the environment and natural resources.

CHAPTER 3: THE SMART GRID VALUE CHAIN

Today's economy and lifestyle have become inextricably linked to electricity, with a dependence on devices such as computers, networks, robotics, medical devices, and air conditioning. Additionally, electricity has come to support an increasingly digital modern world. For example, in the early 80's the percentage of electrical load composed of digital semi-conductor devices was negligible and today has eclipsed 20 percent while showing signs of continued growth. Therefore proper infrastructure that supports a digital economy and that facilitates continued economic growth is critical to the success of every Kentuckian. Reliable electrical infrastructure is a critical component to establishing global competitiveness. As other regions in the world upgrade their electrical power systems, the U.S. will have no choice but to follow suit in order to create and maintain a competitive advantage.

Problems with the American grid have already been identified. Nationally, 70 percent of transmission lines and transformers are 25 years old or older and 60 percent of circuit breakers are 30 years old or older. Much of the system was designed in the 1950's and was installed in the 60's and 70's before the microprocessor revolution. Despite this, electric utility funded R&D nationally has been minimal. In fact, a National Science Foundation survey shows the national average to be 0.2 percent of net revenue, placing electric utilities at 1/20th the average of all U.S. industries.



Studies by the Department of Energy's National Engineering Technology Laboratory and the Electric Power Research Institute have estimated the total cost of upgrading the American power grid to be \$165 Billion over the next 20 years, with \$127B for distribution level systems and \$38B for transmission. This equates to a total required additional national investment of \$8.3B per year for 20 years, which is incremental to the current annual investment of \$18B. However, the same studies have quantified the benefits of grid modernization as between \$638B and \$802B over the next 20 years with an overall benefit to cost ration of 4:1 to 5:1:

"Thus, based on the underlying assumptions, this comparison shows that the benefits of the envisioned Future Power Delivery System significantly outweigh the costs. (EPRI, 2004¹)"

HOW DOES SMART GRID BENEFIT CONSUMERS?

1

http://www.netl.doe.gov/smartgrid/referenceshelf/presentations/E_forum_2_SG%20Benefits%20and%20Challenges_APPROVED_2008_06_02.pdf

The Smart Grid can deliver significant benefits to consumers by transforming access to information. By providing utility customers with detailed energy consumption information, Smart Grid technology can facilitate new controls and options that include:

- The ability to manage energy consumption.
- The ability to better enable customers to participate in demand response programs.
- Convenient interconnection of distributed generation such as roof-top solar.
- Reduction in the number and duration of outages.
- And an improved overall level of service quality and reliability.

HOW DOES SMART GRID BENEFIT UTILITIES?

By upgrading the grid with smart technologies, utilities can increase customer satisfaction and reduce operation ,maintenance, personnel, and capital costs. An integration of a digital network across generation, transmission, distribution, and end-use of electricity by consumers can enable operational efficiencies in the areas of:

- Metering and billing
- Outage management
- Process improvement
- Work force management
- Reduced losses (energy)
- Asset utilization

Additionally, data from these systems can be leveraged to gain improvements in asset management for:

- System planning
- Maintenance practices
- Engineering
- Grid monitoring

HOW DOES SMART GRID BENEFIT SOCIETY AT LARGE?

The benefits of Smart Grid deployments are not limited to customers and utilities. Improved operating and market efficiencies can lead to downward pressure on electricity prices that increase the competitiveness of American business both domestically and internationally, which in turn can improve job and GDP growth. By increasing the robustness of the grid improvements are made in national security as well as public and worker safety. Plug and play integration of distributed energy resources such as renewable generation improves the security of the American energy supply against changes in international fuel supplies. Integration of renewables and a reduction in energy losses facilitated by Smart Grid can reduce emissions from carbon based fuel sources. Finally, the Smart Grid presents the opportunity to revolutionize the transportation sector, moving to electrified transit that is quieter, cleaner, and potentially cheaper.

Although the benefits of Smart Grid deployment can be significant, Smart Grid technologies are not a silver bullet to solve the challenges facing the American electric grid and potential deployments must be evaluated. The following examples illustrate different regulatory approaches utilized to evaluate Smart Grid:

Vermont Department of Public Service

Vermont House Bill 313 directed the pursuit of the American Recovery and Reinvestment Act (ARRA) funding opportunities by the Department of Public Service to implement Smart Grid technologies, projects, and workforce training.

A grant application known as eEnergy Vermont was filed by Vermont Electric Power Company (VELCO) with DOE, on behalf of Vermont's 20 distribution utilities, with the support of the Department of Public Service, Efficiency Vermont, the Office of Economic Stimulus and Recovery, as well as Vermont's congressional delegation.

In October 2009, Vermont's electric utilities were awarded approximately \$69 million in ARRA funds to cover half of the cost of modernizing the electric grid over the next three years. The project will move the state toward development of a statewide Smart Grid, using digital technology to convert the electric infrastructure to a two-way information system. These grid updates will lay the foundation for a fully integrated Central Vermont Public Service SmartPower system.

Specific eEnergy Vermont goals are to:

- Deploy smart meters to over 90 percent of Vermont premises.
- Pilot the use of in-home devices for communicating and controlling consumer energy patterns.
- Study dynamic rate structures enabled by smart meter technology.
- Deploy automated controls to the grid and substations.

Because of a high level of cooperative effort among Vermont's utilities and public entities, Vermont has an opportunity to build a statewide Smart Grid that can serve as a model for the rest of the country. "

Maryland Public Utility Commission on Delmarva Power's AMI proposal

The Public Utility Commission of Maryland opened an administrative case with an order approving an AMI proposal from Delmarva Power, stating that "Delmarva's modified business plan complies with the AMI Order, satisfies our previous concerns and likely will be cost-effective to Delmarva ratepayers." However, some significant caveats were also included along with the approval in the order. Smart Grid analysts (SmartGridNews.com) have interpreted the ruling to say that though PUC granted the authorization to allow Delmarva to proceed with the deployment of the AMI program, it did not mean that the program is prudent, and the PUC will require Delmarva to demonstrate that the AMI project is a cost-effective program for its Maryland customers before PUC issues cost recovery authorization. If the AMI proposal later falls short of the standard as implemented, Delmarva will need to bear the risks, not the ratepayers, and the PUC will determine the level of cost recovery the public requires.

CHAPTER 4: SMART GRID TECHNOLOGY ADOPTION

A 50,000 FOOT OVERVIEW OF THE KENTUCKY ELECTRICAL GRID

As of February 2012, Kentucky's jurisdictional utilities include three investor owned utilities (IOUs)², two generation and transmissions cooperatives (G&Ts) and 19 distribution cooperatives. Of the 23 utilities that participated in the KSGRI, five utilities operate in the generation and transmission markets, and 21 operate in the distribution 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 line (state average of 9.8 customers/line mile for cooperatives and 22 customers/line mile for investor owned utilities). The utilities collectively operate 33,844 miles of transmission and 98,399 miles of distribution within KY. There are approximately 2,008,700 electric meters, with a total penetration rate of AMI-capable "smart" meters of 22 percent.

The statewide average System Average Interruption Frequency Index (SAIFI) is 1.4 interruptions per customers, as compared to the U.S. median of 1.10. The statewide average System Average Interruption Duration Index (SAIDI) is 137, compared to a U.S. median of 90 minutes. The statewide average distribution system line loss is 4.675 percent.

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 percent) 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 focused on AMI deployments.

Regarding the development of the modern grid, utilities have identified transmission limitations and constraints 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.

² Louisville Gas & Electric and Kentucky Utilities considered as a single entity.

WHERE ARE WE NOW AND WHERE DO WE WANT TO GO?

The KSGRI created the Kentucky Smart Grid Assessment Mode (KSGAM) to measure the extent of Smart Grid deployments, operations, and planning in Kentucky, to determine priorities for areas of improvement within the state electrical grid, and to include stakeholder input as to what our societal priorities for a modern grid should be.

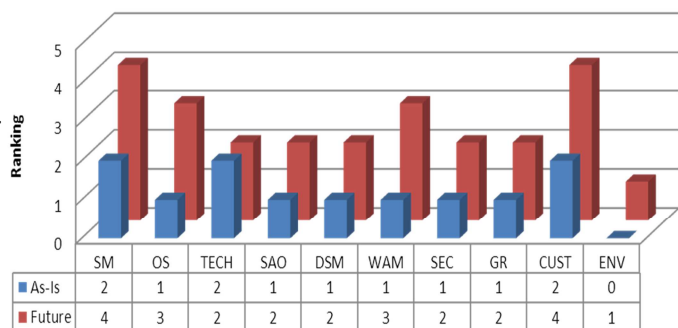
The KSGAM divided Smart Grid operation into 10 groupings of related characteristics defining Smart Grid operations. These groupings, called Smart Grid Classes, are:

1. Strategy and Management (SM): Smart Grid vision and strategic planning, internal governance and management processes, and collaboration with internal and external stakeholders.
2. Organization and Structure (OS): workplace structure, training, communications, and knowledge management within the utility.
3. Technology (TECH): deployment evaluation and strategic planning of advanced technologies.
4. System Architecture and Operation (SAO): operation of the power grid as an automated system with a high degree of situational awareness.
5. Demand and Supply Management (DSM): dynamic management of supply and demand based on real-time information, particularly for load management and distributed energy resources.
6. Work and Asset Management (WAM): optimal management of grid assets and workforce resources, with decisions based on real-time data.
7. Physical and Cyber Security (SEC): protection of equipment and data from cyber and physical security attacks through security architectures, risk assessments, and cyber security standards.
8. Government and Regulation (GR): the extent to which regulators authorize Smart Grid investments, approve innovative regulatory strategies, and facilitate intra-utility optimization.
9. Customer (CUST): the role of customer participation and experience, regarding pricing, education, and advanced services.
10. Environment and Society (ENV): contributions of the utility to achieving societal goals regarding reliability, safety, security, energy sources, energy source impacts, and quality of life.

For each of these 10 groupings, the utilities were given a list of characteristics divided into five levels, ranging from level 0 to level 5. Using these lists, utilities indicated the “As-Is” state of their systems. Statewide, utilities report that they are advanced in the areas Strategy and Management and Customer and immature in the area of the Environment and Society. Additionally utilities were asked to identify their targeted goals for each of the groupings. Overall, Kentucky utilities reported they would

like to be mature in the areas of Strategy and Management and Customer classes, with roughly equal, but lower, emphasis on the importance of the remaining areas.

Smart Grid Class Assessment Results



The KSGAM also identified seven technological independent abilities of the Smart Grid. These abilities, called Smart Grid Characteristics, are:

1. Active Participation by Consumers (APC): increased interaction of consumers with the grid, characterized by the use of price based signals and demand response programs to give customers choice and control regarding power purchasing.
2. Accepts All Power Generation and Storage (AAPGS): integration of diverse resources with “plug-and-play” connections to multiply the options for electrical generation and storage, including large centralized power plants, distributed energy resources and energy storage devices.
3. Enables New Products and Services (ENPS): Direct linking of the buyers and sellers of electricity, the advent of new commercial goods and services and a restructuring of power markets.
4. Improved Power Quality (IPQ): The delivery of “clean” digital-grade power characterized by a reduction in under voltage sags, voltage spikes, frequency harmonics, and phase imbalances.
5. Efficient Operation and Use of Assets (EOUA): Use of real time information from advanced sensors to allow operators to better understand the state of the system.
6. Self-Healing: The grids ability to identify, isolate, and restore problematic sections of the grid with little or no manual intervention.
7. Defend against Attack and Natural Disaster (DAAND): The grids ability to protect against physical attacks (explosive, projectiles, and natural disaster) and cyber (computer-based) attacks.

Stakeholders were given detailed descriptions of each of characteristic and were asked to rank them on a scale from 1 to 5, with 1 indicating that the current electric power system does not implement any aspects of the ability, and 5 indicating that system implements all aspects of the characteristic. Stakeholders also reported the level of advancement they felt was important to a future modern grid, using the same scale. The survey indicates that stakeholders perceive the current grid to be most advanced in Efficient Operation and Use of Assets and that the desired future grid is

advanced in the areas of Active Participation by Consumers, Accepts All Power Generation and Storage, and Efficient Operation Asset Use.

Smart Grid Characteristics Assessment Results



Economic Valuation of Smart Grid Benefits	
SMART GRID BENEFIT	AVE. VALUATION
Reliable	\$18.55M
Secure and Safe	\$17.13M
Economic	\$19.95M
Efficient	\$19.63M
Environmentally Friendly	\$24.75M

Stakeholders were also asked to allocate \$100 million amongst improvements in the electric power system in five areas. This activity indicated that Kentucky stakeholders would most like to see improvements regarding the environmental impact of the electric grid.

THE STATE OF ADVANCED METERING INFRASTRUCTURE

The fundamental purpose of AMI is to establish two-way communication with the consumer and to provide time stamped system information regarding electrical power data.

AMI Nationally

Nationally, AMI deployments have received a great deal of interest from both utilities and regulatory commissions due to their ability to facilitate the usage of time-based rates. Although some case studies have shown great benefit, others have been met with resistance, particularly when customer's consumption behavior does not change.

PowerCentsDC

The PowerCentsDC pilot was initiated to test the impacts on consumer behavior of dynamic pricing and smart metering in the District of Columbia. From July 2008 through October 2009, approximately 900 residential customers were randomly selected across D.C. area to participate in the pricing pilot on three price plans: critical peak pricing, critical peak rebate, and hourly pricing. Results from the pilot project showed that residential customers responded to dynamic pricing and saved money by cutting their electricity consumption. The results also suggest that the critical peak pricing which hiked electricity rates to five times than normal led to the greatest peak demand reductions while the critical peak rebate was most popular. It was found that limited-income customers signed up at higher rates and resulted in less peak reductions than others on the program. Over 74 percent of participants were satisfied with the program, over 93 percent expressed a preference over the default pricing plan³, and about 89 percent would recommend the pilot to their friends and family according to the customer surveys conducted following the completion of collection of data in November 2009.

Pacific Gas and Electric

The AMI system is composed of a number of integrated technologies that include:

Smart Meters

Smart Meters are solid state programmable devices that improve upon electromechanical and AMR meters in that they offer additional functions that include support for time-based pricing, consumption data for consumers and the utility, , and communication with intelligent energy devices within the customer home. Additional advantages of smart meters are that they can be used to enable a variety of additional Smart Grid projects such as advanced Demand Response and Volt/VAR control and they help to facilitate greater energy efficiency through information feedback to consumers.

Meter Data Management System

A MDMS is a database system that is combined with analytical tools that enables Smart Meter data to be utilized in conjunction with other information systems such as Consumer Information Systems, Geographic Information Systems, and Transformer Load Management.

³ (http://www.pepco.com/res/documents/DCRates_R.pdf)

A lawsuit was filed on behalf of customers in Bakersfield, California where a \$2.2 billion smart meter project was rolled out by PG&E. Bakersfield residents experienced much higher electricity bills than before and believed that malfunctions of the newly installed smart meters were the reason. Contrarily, PG&E claimed higher bills were due to high rates of peak pricing, an unusually warm summer (2009) and customers' not shifting demand to lower off-peak rates. Critics contend that PG&E was unsuccessful in informing customers about the value of shifting demand or the time of energy consumption to lower-priced off-peak time. Additionally, PG&E neither rolled out in-home displays along with their smart meter rollouts, nor did they have an effective system in place where customers could access energy usages, see electricity rates, or receive alerts.

The AMI system is composed of a number of integrated technologies that include:

Wide Area Communication Systems

A digital communication infrastructure must be deployed to enable bi-directional data flow between the customer smart meter and the utility. While various media can be employed, the WACS system can serve as the foundation for a multitude of Smart Grid applications beyond AMI.

Home Area Networks

The HAN interfaces the Smart Meter with controllable electrical devices within the consumer premise. It support energy management functions including in-home displays to provide consumers with usage data, responsiveness to price signals, control of load such as smart appliances and smart thermostats, and consumer over-ride capability.

AMI Deployment Highlights in Kentucky

Overview

In Kentucky, 15 of the 23 jurisdictional utilities operate systems containing smart meters, and penetrations rates vary from 1 percent to 100 percent of residential customers, with an overall penetration rate of 22 percent. All of the AMI capable utilities have implements Power Line Carrier as the WACS architecture. Two utilities utilize HANs to communicate with in home devices, including programmable communicating thermostats, load control switches, programmable water heaters, and in-home-displays. Four of the utilities utilize a MDMS to enable AMI data to support other Smart Grid functions.

Jackson Energy Cooperative's Prepay Metering

Jackson Energy Cooperative (JEC) serves consumers in fifteen counties in SE Kentucky, three of which are low in median household income. Currently, JEC has 100 percent of customers are served by AMI, and JEC has leveraged the AMI system through the implementation of Prepay metering in order to assist members in energy conservation and bill reduction, and to enable customers to take control of their monthly electric bills. The Prepay program was rolled out to all cooperative members on June 27, 2011 and currently has 1,303 member participants. Members pay for their electricity before they use it, in dollar amounts and times of their choosing, using the same payment methods available to all Jackson Energy members. JEC issues an in-home display (IHD) to the member and installs a disconnect collar at the member's meter base, enabling the monitoring of electric usage via and In Home Display showing usage patterns and daily kWh consumption.

The ability to monitor and manage energy usage helps participants to conserve energy which has resulted in an average reduction of 1312 kWh (≈13 percent) as compared to those not on Pre-pay metering. The average monthly reduction is 312 kWh. Additionally, deposits are not needed and there are no late payment penalties, saving members hundreds of dollars in additional costs to obtain electric service. All of these items give cooperative members greater flexibility in paying for electricity. The cooperative benefits from a reduction in costs related to disconnects/reconnects and a reduction in bad debt or write-offs. All of the above results in higher member satisfaction.

Owen Electric's Smart Home Project

Owen Electric is researching emerging and innovative energy management programs and viable rate designs for the benefit of members. They are currently recruiting participants for a Smart Home pilot that will evaluate smart home technologies and capabilities by offering detailed energy usage information through a home energy network. In addition, the Smart Home pilot will enable members to automate aspects of their energy usage through a home wireless network controlled within the home and remotely through a website or mobile phone. Lastly, the pilot will incentivize members to reduce peak usage through the deployment of a time of day (TOD) rate.

Approximately 300 customers will participate in the pilot: 100 with web experience only, 100 low income families with web experience and smart water heater control device and a smart thermostat, and 100 none-low income families with web experience and smart water heater control device and smart thermostat. One of the goals of the project is to create a smart home that is projected to be economically viable and is eventually planned to be a standard offering with an approved PSC tariff. The total pilot will cost approximately \$1.1M with half of that being paid for by a DOE grant. As stated above the member savings benefit will be based on their energy reduction and shifting from peak to off peak and Owen's savings will come from the monthly demand reduction. The viability of the project will be determined by those factors.

Key Recommendations on AMI

Critical benefits can be leveraged by installing WACS architectures that support not just AMI,

but any Smart Grid application. Therefore the choice of WACS architecture should start at the network layer as opposed to the application layer. The recommendation of the KSGRI is, therefore, the use of a deliberate architecture designed using Internet Protocol ("IP") based networks that support any application. This focus on the network is in stark contrast to the traditional use-case that starts with a compelling application and then installs the communication infrastructure to supports it. Two reasons drive this recommendation: 1. based on trends in a variety of other industries and on successful

The screenshot displays the Owen Electric website interface. At the top, there is a navigation menu with options: Overview, Your Energy Use (selected), Ways To Save, Expert Advice, and Your Community. The main content area is titled 'YOUR ENERGY USE - SUMMARY' and provides a detailed breakdown of energy usage for the period of June 1, 2012, to July 1, 2012. It includes a bar chart comparing 'Your Use So Far' (\$27), 'Your Expected Use' (\$90), 'Your Goal' (\$87), and 'Similar Home' (\$88). A 'Home Profile' section shows a 36% savings goal, and a 'Your Savings Goal' section highlights a 15% goal. A 'How You Compare' section features a line graph showing energy usage trends from July 11 to May, comparing 'Similar Homes' and 'Your Use'.

An online energy information system provides detailed utilization data to consumers, enabling informed decision making regarding the use of electricity.

deployments nationally, it is the opinion of the KSGRI that fundamentally, Smart Grid will be driven by two-way data transfer and long-term successful implementations are those that design a network to support this, as choosing different network architectures for different applications will create long term integration problems that can be fatal to the overall Smart Grid value equation. 2, an IP network is the best candidate for a future-proof WACS architecture that can support any and all smart Grid applications, including those beyond AMI deployments. Additionally, the majority of use cases have shown that to gain full demand response benefits from AMI deployments, a holistic approach must be taken that includes both dynamic rates and automated customer control. Therefore, it is the recommendation of the KSGRI that AMI deployments must address the following criteria:

1. Provide electronically communicated digital price signals: Automated price, reliability, and event signals should be provided to customers along with a means to display information on a wide variety of interfaces.
2. Provided signals should follow open, non-proprietary standards that can be used to directly activate customer energy related systems and controls such as smart appliances and energy management systems.
3. Provided signals should integrate prices and incentives that motivate customer to purchase more efficient appliances and to provide price-responsive demand. Such incentives should be ongoing and integrated into the underlying rate/price signal.

It is important to note that even good rate designs that are badly executed or not accompanied by appropriate customer education, tools and technology can produce ineffective results, therefore the KSGRI recommends that all AMI deployments proposals be accompanied by a practical implementation plan that address the following key issues:

1. The transition of customers from existing flat and tiered rates to dynamic rates.
2. The education of customers regarding both the opportunities and risks.
3. Technology assessment regarding availability of devices to enable customer automation of response.
4. Plans to identify and mitigate potential adverse bill impacts.

THE STATE OF DISTRIBUTION

Advanced Distribution Operations enable a grid that self-heals through auto-detection of faults and auto-reconfiguration of circuits, that is more efficient due to advanced system modeling and analysis and Volt/VAR control, that is more flexible and situationally aware due to advanced sensing, data acquisition, and automated control. The distribution system of the future will enable both the incorporation of Distributed Energy Resources and will operate with novel circuit configurations such as microgrids.

ADO Nationally

Nationally, ADO deployments have been evenly divided between automating many of the functions of the low voltage distribution system (distribution level SCADA deployments), particularly at the sub-station-level, and of energy efficiency improvements such as capacitor installations and Volt/VAR.

SmartSacramento Project

Sacramento Municipal Utility District's (SMUD) Smart Sacramento Project is evaluating the benefit of a partial deployment of advanced distribution assets that equipped distribution circuits with automated control and operation capabilities, as well as the integration of plug-in electric vehicle charging stations to assess their effects on electric distribution system operation. SMUD installed distribution automation equipment on 16percent of circuits in the range of 12kV to 69kV. This included a communications network, automated circuit switches, automated capacitors, and equipment monitors. The equipment automatically responds to power disturbance and provided voltage regulation and isolates interrupted circuits. The goal is to evaluate the system for potential to reduce service interruptions, the frequency and duration of outages, and the number of truck visits. SMUD also expects DA too assist the grid integration of solar and wind installed at the distribution level. Results from the SMUD deployment are expected for release in Q1 of 2013.

AEP'S gridSMART

American Electric Power's griSMART deployments include Volt/VAR optimization on 11 circuits in AEP Ohio. The Volt/VAR optimization project, a technique also known as conservation voltage

ADO infrastructure utilizes the following technologies to improve the reliability and efficiency of the distribution system:

Fault Location, Isolation and Service Restoration

FLIR technologies automatically detect faults, determine the faulted section and location, and calculate optimal solutions for restoring service.

Data Acquisition and Control

DAC (i.e. distribution SCADA) is the collection and use of real time data to issue control commands to automate power system equipment operation and parameter settings.

Distribution System Modeling and Analysis

DOMA is the modeling and analysis of distribution power flow under dynamically changing operating conditions. It is used to provide system operators with real-time power flow simulations and contingency analyses for system optimization.

Volt/VAR Control

VVC is the calculation of the optimal settings of voltage controls for distribution equipment. The most common uses of VVC are Volt/VAR Optimization, the control of voltage to optimize power transfer, and Conservation Voltage Reduction, energy conservation by reduction of the voltage supplied to the end-user.

reduction or Volt VAR control (VVC), utilizes communications and computerized intelligence to control voltage regulators and capacitors on the distribution grid which will optimize voltage and power factor based upon selected parameters. Computer algorithms use monitoring and feedback to ensure that the minimum voltage requirements of the end-of-line are maintained. By tightly operating the distribution system at the lower end of the service voltage, AEP Ohio has shown a reduction in customer energy consumption of 2.9 percent and a peak demand reduction of between 2 percent and 3 percent. Through VVC AEP Ohio has shown a potential reduction in demand of 10's of MW, thereby reducing the amount of capacity to be replaced or upgraded. Additional benefits are related to meeting state energy efficiency targets, reducing emissions, and relieve transmission congestion.

ADO infrastructure utilizes the following technologies to improve the reliability and efficiency of the distribution system:

Distributed Energy Resourced and Microgrids

DERs can help support local power grids in case of outages or blackouts and can ease the loads on long-distance transmission lines. However, they can also destabilize the grid if not managed appropriately. A microgrid is a localized group of electricity sources and loads that can disconnect from the larger system to operate autonomously.

ADO Deployment Highlights in Kentucky

Overview

Use of real time data from the distribution system to perform distribution system analysis and modeling is infrequent in Kentucky and is currently only being evaluated in one pilot project. However, two utilities have reported plans for near term deployments (<5 years). Most utilities do utilize DOMA for off-line 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. Three utilities operate Fault Location, Isolation, and Service Restoration (FLIR) pilot projects, and one utility indicated planning to implement FLIR as part of future Distribution Management System upgrade. Currently, overall penetration rates are low (<4 percent). 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. 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, ranging to 0 percent of distribution level substations to 100 percent. One utility has extended the use of DAC to facilitate monitoring control of distributed generation and microgrids. No utilities reported utilization of Volt/VAR. Two utilities have indicated planned Volt/VAR pilots.

Kentucky Power's Automated Circuit Reconfiguration

Kentucky Power has installed Automated Circuit Reconfiguration (CR) on seven circuits that serve approximately 11,000 (6 percent) of its customers. CR utilizes communications and intelligence to automatically open (de-energize) switches to isolate a faulted section of line and then automatically close (re-energize) tie switches to restore service to the customers in the un-faulted zones. Only the customers in the section of line where the fault occurs experience a sustained outage. Customers in the

other line sections are immediately transferred to another source thus limiting their outage to only a momentary interruption. The CR installations utilize S&C IntelliTeam technology applied to substation circuit breakers, line reclosers, and line switches. SCADA is utilized to provide dispatchers with visibility of circuit conditions and the ability to remotely operate devices.

So far, the installation cost is approximately \$2.5 million. Costs of future CR are challenging to predict due to the effect of Eastern Kentucky terrain on communication requirements and the need to modernize SCADA communications at most of the substations. Industry experience projects a 30 percent to 50 percent reduction in sustained customer outages when this technology is utilized. To date, CR technology has saved approximately 18,000 customer outages and 4,800,000 customer minutes of

outages on the seven circuits. CR is being planned for an additional seven circuits serving approximately 7,500 customers in 2012. Upon completion, it is expected a total of 14 circuits serving 18,500 (11 percent) of Kentucky Power customers will have CR in operation. Additional installations are being studied along with more traditional reliability improvement alternatives to develop future reliability improvement plans.

Kentucky Power's Volt/VAR Optimization

Kentucky Power is considering installation and operation of Volt/VAR technology on approximately 25 circuits. This is estimated to reduce peak demand by approximately 7 MW and energy usage by approximately 34,000 MWh/year. These levels of demand and energy benefits are achieved by installing distribution automation Volt/VAR control schemes which integrate distribution capacitor/regulator banks and transformer load tap changers with a centralized control system to flatten the voltage profile and lower the delivery voltage level at the substation by approximately 3 percent to 4 percent. These systems have been demonstrated elsewhere and have been able to maintain voltage above the ANSI standard service range of 114 volts for all customers on a distribution feeder. In addition to achieving the demand reduction and energy efficiency savings, the deployment of this technology will provide a technology infrastructure that could be combined with a distribution management system to provide operational and other reliability improvements. Installation of VVC equipment on the initial distribution feeders in Kentucky is estimated to cost approximately \$250,000, however, costs may be higher due to the effect of Eastern Kentucky terrain on communication requirements and the need to modernize SCADA communications at most of the substations.



Automated switches mounted to utility poles can be used to create self-healing grids that improve reliability by isolating faulted sections of the distribution system.

Owen Electric's Volt/VAR Optimization Project

Owen Electric is enhancing its knowledge of the effects of optimizing system voltage and kVAR profiles in respect to peak electrical demand and energy usage. The Volt/VAR optimization project involves six feeders fed from two substations and is sequenced in four phases:

1. Verify and correct system data so that engineering models are accurate in all critical areas.
2. Analyze and optimize feeders for phase balancing and power factor.
3. Test and evaluate effects of reducing voltages on the feeders.
4. Deploy IVVC (integrated Volt/VAR control) system at one of both test substations

The technology and equipment used in the project include:

1. Global Positioning System Equipment
2. ABB GridSync Monitors
3. Voltage Regulators
4. Switched and Fixed Capacitor Banks
5. Engineering Analysis Software
6. IVVC Equipment

Cost projections at this time are \$537,200. Throughout the project cost/benefit analysis will determine the benefit of project continuation and/or expansion. Regardless of the outcome, the Volt/VAR project will serve as a case-study for Kentucky distribution companies.

Key Recommendations on ADO

Conservation voltage reduction (CVR) pilots such as those performed by EPRI and AEP have shown overall energy savings from 1 percent to 6 percent, with 2 percent to 3 percent quite typical. Kentucky regulations should therefore ensure that saving energy on the “customer side” of the meter through conservation programs such as CVR Volt/VAR does not reduce utility revenue. Additionally, advanced distribution system modeling and analysis is not being utilized in Kentucky. It is the recommendation of the KSGRI that such tools be utilized in all future resource planning in the state, particularly to evaluate the benefits of energy efficiency and renewable energy technologies against the addition of generation capacity from fuel-based sources.

THE STATE OF TRANSMISSION

Advanced Transmission Operations utilize advanced digital technologies and new power electronics to increase system performance, enable the interconnection of isolated power systems, improve the size and capacity of existing transmission assets and improve the ability of system operators to control the system across markets.

ATO Nationally

Nationally, Advance Transmission (“ATO”) deployments have focused on the installation of synchrophasor technology to improve transmission reliability and operation. Synchrophasor technologies use Phasor measurement units, Phasor data concentrators, and wide area communications networks to create time-stamped data regarding current and voltage across the transmission system, often referred to as an “EKG of the electric system”. Additionally, technologies are being deployed to dynamically rate and operate transmission assets based on environmental variables. Currently there is also a great deal of discussion regarding creation of high capacity high voltage direct current (HVDC) transmission that will connect large central wind and solar farms to load center. Thus far, little investment has been made in development of such a system.

Western Interconnection Synchrophasor Program

The Western Electricity Coordinating Council and eight member transmission companies are deploying synchrophasor technology throughout the Western Interconnection. The purpose of the project is to improve electric system reliability and restoration procedures and to prevent the spread of localized outages. Additionally, the project will improve the ability of the Western Interconnect to integrate large renewable resources. 341 phasor measurement units, 50 phasor data concentrators, transmission system communication equipment, and advanced software applications will increase grid operators’ visibility of the bulk power system, enabling them to visualize the conditions in near-real time. Such fine-grained visibility will enable earlier detection of problems, facilitates the sharing of information with neighboring control areas, and allows the continued improvement of power system models and analysis tools.

ATO Deployment Highlights in Kentucky

ATO infrastructure increases the size, capacity, and intelligence of the existing transmission system:

Automated Control

Remotely controllable equipment and advanced computer algorithms can automatically control the voltage, load, and circuit configuration. This can be applied to optimize normal operations or to quickly address emergency situations.

Wide Area Monitoring

The deployment of synchrophasor technology will give an unprecedented level of detail of the grid operations and health. By sharing PMU and SCADA data nationally, transmission operators can more finely control the transmission system, helping to prevent both congestion and systemic failure.

Dynamic Equipment Rating

New technologies allow equipment to be utilized closer to actual capacity, which can increase overall system capacity and extend equipment lifetimes.

Advanced Components

New components will extend the amount and distance over which electrical power can be efficiently transmitted.

Overview

Overall the transmission system of Kentucky is highly sophisticated and interconnected. However, the degree to which new smart transmission operations have been applied in Kentucky varies greatly across the four transmission operators. Automated Control (“AC”) of the baseline functions of the transmission system in Kentucky include automatic voltage regulation and automatic reactive load control, interlocking and sequencing of controls within transmissions substations to prevent unsafe operations, automatic load adjustment of load to balance line-loading conditions, and automated system restoration via computer control of switches and breakers. In emergencies, the utilities can automatically isolate faults and can shed load. Some of the transmission system is equipped with automated reclosers and motor operated air break switches, but the penetration of such technologies statewide is minimal. Several transmission operators are utilizing dynamic ratings for transmission line utilization, however the sophistication of these approaches varies dramatically amongst the operators. Relatively few advanced components have been utilized in the Kentucky transmission system. Upgrades have been focused on high temperature and high capacity cable and fault current limiters, with one flexible AC transmission system installation.

LG&E-KU Energy Smarter Transmission System

LG&E-KU Energy, is creating a smarter transmission system through the use of microprocessor based relays, local substation networks, and communications processors. The use of microprocessor based relays provides numerous benefits over the traditional electromechanical relay including capture of event data with a high precision time stamp. These relays also provide numerous functions within a single box, replacing up to nine discrete devices with a single relay. A local network connecting the microprocessor relays provides automation and labor savings through remote access that allows:

1. gathering detailed event data remotely
2. querying and updating relay settings remotely
3. monitoring the status of the system and equipment in greater detail
4. gathering and distributing Synchrophasor data



LG&E-KU is implementing these new technologies through the use of drop-in control houses that are built off site with the new technologies pre-installed and wired, which enables LG&E-KU to install, test, and commission new equipment in a relatively short time frame, reducing system impacts.

Dynamic Ratings at East Kentucky Power Cooperative

The amount of current that equipment can carry is a function of ambient temperature and cooling provided by the wind and often “benchmark” environmental conditions and other factors are combined to calculate seasonal ratings for equipment. At times, there is significantly more transmission line and transformer capacity than the standard static ratings state. Capturing this additional capacity is the essence of dynamic ratings, such as the Dynamic Thermal Circuit Rating (DTCR) technology utilized by EKPC.

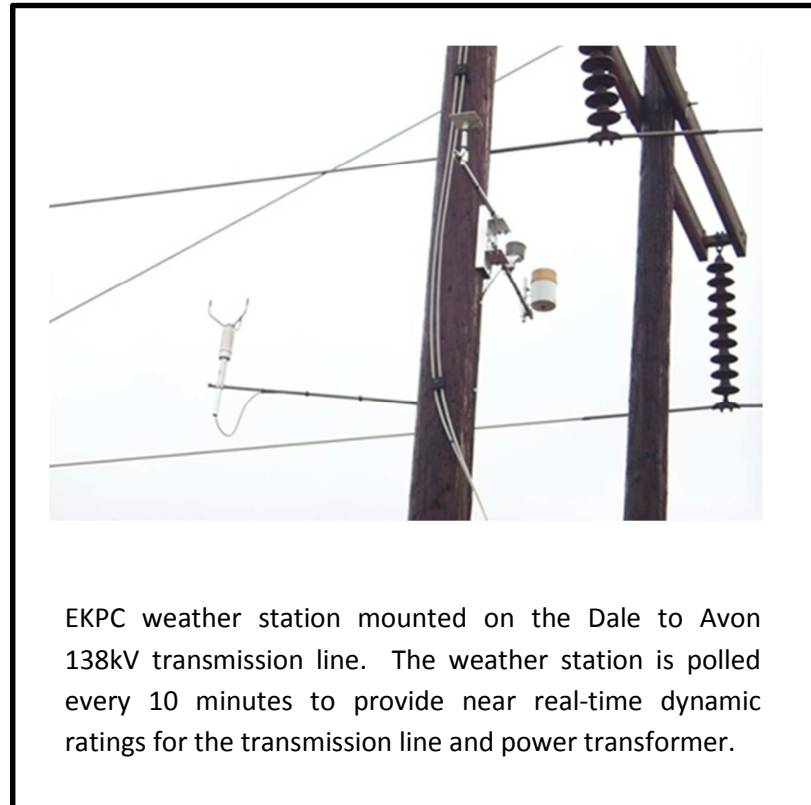
The first phase of this project provided dynamic ratings for a 138kV transmission line and a 345/138kV power transformer. A fully instrumented weather station was installed near the assets and is polled every 10 minutes. The DTCR software combines weather data with real-time transmission line and transformer power flow data via an Energy Management

System interface to provide a near real-time dynamic rating. A graphical user interface (GUI) was developed in-house at EKPC to display dynamic ratings on a dedicated screen readily available to the transmission dispatcher. In phase II, EKPC dynamically rated an additional six 138kV transmission lines, two 345/138kV power transformers, and installed a second weather station.

In the summers of 2006 and 2007, EKPC was experiencing extremely high power flows on a 345kV transmission line due to huge non-contracted north to south power transfers between neighboring utilities. During these power trades additional capacity provided by dynamic ratings allowed delaying of re-dispatching efforts, saving EKPC nearly \$1.5M.

Key Recommendations on ATO

Based on the current situation in Kentucky, the KSGRI would recommend several promising technologies in order to improve the overall reliability of the transmission system. The dynamic thermal rating application may be utilized by transmission operators in Kentucky to increase the utilization of existing transmission assets without significant investment to build additional lines. More advanced fault location and restoration systems can be employed to protect the system from disturbances, and reduce outage time. Synchrophasor technology using PMUs may be deployed to provide transmission operators with improved wide area grid monitoring and awareness, and may help prevent large-scale blackouts along with the SCADA system.



THE STATE OF ASSET MANAGEMENT

Utilities are getting more detailed data about equipment from meters, sensors, and intelligent energy devices. Advanced asset management is the utilization of that data to make better informed decisions regarding the utilization and operation of assets.

AAM Nationally

Unlike AMI, ADO, and ATO, asset management has not seen federally funded demonstration projects. Instead, AAM has been developed by data analytics companies including Boeing, IBM, Cisco, and Utilicase. Advanced asset management (“AAM”) can provide benefits such as a more comprehensive picture of asset health, prevention of catastrophic failure, improved return on investment on maintenance, and more intelligent investment decisions and sophisticated risk analyses. Additionally, AAM can increase the utilization factors of grid assets, thereby eliminating, reducing in scope, or deferring the construction of capital resources.

National Statistics

Estimates from the Horizon Energy Group show the national capacity factor of the U.S. generation portfolio to be approximately 47 percent. This suggests that additional capacity is available for production. On average, transmission lines are loaded to 43 percent and distribution asset utilization is 34 percent; however, line flows can be limited due to congestion at specific times. Also, over 12 million distributed generation resources are located on consumer premises, with the vast majority of them not grid connected. This all suggests that opportunities exist to better utilize existing resources as opposed to new construction.

Hydro-Québec TransÉnergie

Hydro-Quebec TransÉnergie operates the largest transmissions system in North America, consisting of 514 substations and over 33,630 km of transmission line, much of which was built between 1960 and 1980. By the mid-2000s much of the transmission system equipment was beginning to near its useful lifespan. For example, the average age of circuit breakers, with a useful lifespan of 30 years, was 23 years.

To facilitate the necessary upgrades of the transmission equipment, Hydro-Quebec installed strategic asset management tools that collect data from the transmission data acquisition system and perform analytics to improve asset utilization. The system implemented by Hydro-Quebec focused on maintenance optimization and software upgrades that assist in maintenance planning, helping the utility to decide which equipment has reached the end of its useful life cycle. The software implementation consisted of three modules. An equipment module created a digital inventory of equipment that groups equipment as systems to manage relationships between systems and their constituent components. The laboratory and reading module transmits equipment field test data to a secure data center. When field tests are performed, information and instructions are available to field preparation on line. By reporting via online forms, out of range test values are immediately flagged for additional verification by on-site personnel. The analysis module provides statistical and analytical reports on equipment behavior. This information is sent to decision support tools that re-orient management parameters to

optimize maintenance. This module also includes a digital maintenance log that provides a statistical failure comparison of preventive maintenance costs vs. repair costs after equipment failure.

AAM Deployment Highlights in Kentucky

Overview

Overall advanced asset management is immature in Kentucky, particularly with regard to automated gathering of real-time raw data to support asset management decisions. Instead, most strategic asset management investments have continued to rely on manually collected data, with a slow change from condition and reliability based maintenance and utilization to predictive maintenance and probabilistic risk assessment. Three 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, while overall penetration rates of such technologies are very low (<5 percent). However, even when these sensors are installed, they are not linked to data input into a common information model. Such models are infrequently utilized by the Kentucky utilities, and require manual input of data. As such, there is limited use of real time data to improve maintenance and repair schedules. As a result, most utilities still perform reliability based maintenance, although some do utilize real asset data to calculate reliability indices. Some condition based maintenance programs have been implemented, particularly as related to SCADA. In regards to operational optimization, no utilities currently utilize automation to actively optimize asset utilization, although there are a small number of circuits in the state which are reconfigurable to minimize system loss. While there is some dynamic operation of transmission lines and transmission transformers, penetration of such operation is very small and has not been applied to distribution level equipment.

Key Recommendations on AAM

Advanced asset management is not currently being performed in Kentucky. To enable AAM, the KSGRI recommends increased deployment of sensors that provide the operational and health status of all important assets, and the installation of analytical tools and capabilities to better optimize system and human assets. It is the opinion of the KSGRI that the wide area communication infrastructure necessary to enable ubiquitous AAM throughout Kentucky should be considered in any business and/or rate case related to any or all of the following: AMI, ADO, and ATO.

THE STATE OF DISTRIBUTED ENERGY RESOURCES

Distributed Energy Resources that include distributed generation, electric vehicles, and energy storage devices can help increase grid reliability, can help to manage peak loads and defer capital investments in T, D, and G, can lower emissions, and can improve overall system security. However, most are not yet cost-competitive with traditional generation sources and will require more sophisticated integration strategies as penetration rates increase, as well as new pricing models for electricity.

DER Nationally

The U.S. Department of Energy has funded nine renewable and distributed systems integration demonstration projects that utilize microgrids and DERs to achieve a 15 percent reduction in peak load on distribution feeders and substations. Additionally, the systems are designed to operate in grid parallel or as islanded systems.

The Pecan Street Energy Internet Demonstration Project

The Pecan street project developed and implemented an Energy Internet microgrid in a large mixed-use infill development in Austin Texas. The redesigned energy system integrates energy efficiency, distributed renewable energy, local energy storage, and enhanced user-controlled energy management tools that include smart appliances all through an open architecture for “plug-and-play. Currently, the Austin-based Incernergy LLC has deployed a home Smart Grid system that captures minute-to-minute energy usage for the whole home and six major appliances or systems at an installed cost of \$341 per home. The systems have been deployed in 100 homes, 11 of which have rooftop solar PV systems. During this first phase, researchers are learning about how homeowners use electricity, gas and specific appliances through the day. Using the information from the initial deployment, next generation home Smart Grid systems will be developed and deployed in 1,000 residential and 75 commercial customers. These systems will also integrate 100 Chevrolet Volts with in-home charging capacity. All participation in the project is voluntary.

SmartGridCity project by Xcel Energy Boulder, Colorado

The SmartGridCity project by Xcel Energy in Boulder, Co. is one of the most widely publicized experiments in bringing Smart Grid to an entire city, and has been seen as a pioneer for demonstrating some of the most important Smart Grid technologies. There's no doubt that SmartGridCity has achieved impressive grid optimization applications and reliability improvements. However regulators and ratepayers believe it has been a massive failure in terms of the cost overruns and the fact that customers still don't have sufficient tools to easily monitor and reduce energy usage. According to multiple sources, several key factors that have contributed to the problems are:

1. Xcel didn't file a Certificate of Public Convenience and Necessity (CPCN) before the project started in 2008, because they didn't think it was needed for a research project. Without a CPCN, there was no opportunity for the Public Utility Commission to consider capping costs to protect ratepayers
2. A traditional simple cost-benefit analysis wasn't performed prior to the initiative, and the project costs ballooned from the original estimate of \$15.3 million to last reported \$44.8 million

mainly due to higher costs of permits, tree trimming, software; and installing fiber optic communication lines. Xcel sought from the PUC to approve a rate increase to recover some of its project costs. That was when the PUC decided Xcel needed a CPCN to prove the project is prudent and in the public interest

3. Several key Xcel project executives left early in 2009 which had a negative impact on the project management.
4. As the project approaches completion, only 43 percent of Boulder residents have smart meters, which is a very low number for a supposed Smart Grid leader. Additionally, the metering system is not providing as many in-home benefits anticipated as part of a Smart Grid program.

Fort Collins 3.5MW Mixed Distributed Resources for Peak Load Reduction

The FortZED project is an integrated system of 3.5 MW of mixed distributed resources in Fort Collins, Colorado to achieve a 20-30 percent peak load reduction on two distribution feeders. The integrated DERs are at the following sites:

- Site 1: New Belgium Brewing -- deploys new 200 kW PV arrays with AE inverters; a 292-kW methane-based Gauscor CHP; a 650 kW CAT 3508C methane-based CHP; a 135 kW new thermal storage; and a 160-kW load shedding potentials.
- Site 2: InteGrid Laboratory -- deploys 2x80 kW Onan natural gas genset; a 300 kW CAT natural gas genset; an 80 kW Ingersoll Rand microturbine; an 80 kW Bowman microturbine; a 100 kW wind turbine simulator; and a 10 kW fuel cells.
- Site 3: City of Fort Collins Facilities -- deploys a 50 -kW conventional generator with Woodward controls and Eaton switchgear; a 92 kW thermal storage; a 5 kW PV array; a 62 kW HVAC and DSM; and 2x10 kW Ford Escapes (PHEVs).
- Site 4: Larimer County -- deploys a 10 kW new PV array; and a 2x1 HP motors for water fountain control.
- Site 5: Colorado State University - deploys an 80 kW thermal storage; an 80 kW fan variable speed drives; a 21.6 kW water fountain pumps; a 3.6 kW hot water heater controls; a 6 kW daylight control, and a 950 kW conventional gensets with Woodward controls and Eaton switchgear.

DER Deployment Highlights in Kentucky

Overview

Installation of DERs in Kentucky is primarily composed of fuel sourced combustion generators, with 4.4 MW of diesel generation and 14.4 MW of natural gas generation. Also, as reported by utilities, there are 20 kW of installed solar PV on the Kentucky distribution system. The members of the KSGRI recognize that this number is artificially low, as many roof-top solar installations were not reported. Currently, no distributed storage is deployed in Kentucky. While EV penetration in the state is unknown, only one utility reported having a structured Electric Vehicle integration strategy.

The KSGRI characterizes the development of DERs in Kentucky as very immature. This is largely due to the factor of the low electricity rates in the state and the use of net metering agreements as opposed to

feed-in tariffs coupling to create an economic climate that is unfavorable for DER adoption by customers.

Key Recommendations on DER

Although not currently cost competitive with tradition fuel based energy sources, locating DERs physically near load centers can reduce the need for capital upgrades to the transmission and distribution systems. Therefore, the KSGRI strongly supports the State Commission's requirement that savings due to capital investment deferrals enabled via DERs be included in all evaluations of capacity increases in the generation fleet of Kentucky utilities. This recommendation extends to all three types of DERs studied herein, fuel sourced, renewable, and energy storage.

It is the opinion of the KSGRI that inclusion of renewable sourced DERs will strengthen the diversity of Kentucky's generation supply to changes in federal regulatory policy and to increasing variability in the availability and cost of carbon based fuels. The KSGRI therefore recommends state government support of DER adoption by both utilities and utility customers. It is also our recommendation that to encourage the adoption of renewable sourced DERs, Kentucky should create a taskforce to investigate the development of a statewide DER customer incentive program.

Strategic investments in the Wide Area Communications infrastructure chosen to support AMI, ADO, ATO, and AAM can also be leveraged to facilitate large scale DER integration, particularly (but not limited to) a reduction in the last-mile communication costs. Therefore, it is the recommendation of the KSGRI that the ability to support DER integration should be given consideration in all cost/benefit analysis of Smart Grid related cases considered by the Kentucky Public Service Commission.

Because energy storage offers the benefit of "time shifting" electricity, emergent technologies can have a variety of different benefits that blur the lines between traditional value chain positions. Therefore, the regulatory treatment of storage assets must be evaluated and made clear in order to resolve capital risk scenarios. The KSGRI recommends the state of Kentucky to evaluate the Storage Technology of Renewable and Green Energy (Act of 2009) (s.1091) for possible models to use in the commonwealth.

THE STATE OF CONSUMER EDUCATION

Due to the major changes in the electricity industry that may occur due to Smart Grid deployments, it is necessary that a customer education program be part of the obligation of service providers, which must be optimized for both cost-effectiveness and success at achieving its goals. Unlike other regulated utility activities, successful education of consumers regarding Smart Grid will require the cooperation and participation of non-utilities.

CE Nationally

Smart Grid Consumer Survey

Pike Research's report "Smart Grid Consumer Survey" based on a survey of more than 1,000 U.S. adults, analyzed consumer demand, preferences, attitudes, and price sensitivity related to four key Smart Grid product and service categories: smart meters, home energy management, demand response, and smart appliances. According to the report, 47 percent of consumers would be "extremely" or "very" interested in home energy management products and services that would allow them to monitor and control energy usage in their home. Similarly, 45 percent of survey respondents stated that they would be interested in connected smart appliances that would help them manage their electricity consumption more efficiently.

Consumer Electronics Associations Survey

A Smart Grid survey from the Consumer Energy Alliance found that consumers are concerned about the cost of their energy use, yet lack awareness of emerging energy management systems. The survey of 1,250 adults sought to better understand consumer awareness and attitudes regarding energy management. 55 percent of consumers expressed interest in an electricity management program sponsored by a utility or electric company; although 64 percent were unaware as to if their utility offered such programs.

CE Deployment Highlights in Kentucky

Overview

Installation of DERs in Kentucky is primarily composed of fuel sourced combustion generators, with 4.4MW of diesel generation and 14.4MW of natural gas generation. Also, as reported by utilities, there are 20kW of installed solar PV on the KY distribution system. The members of the KSGRI recognize that this number is artificially low.

Key Recommendations on CE

As consumer-oriented Smart Grid programs have been shown to be dependent on active and informed consumers, it is the recommendation of the KSGRI that consumer education programs should be required for all programs that include advanced metering, demand response, distribution automation, energy efficiency, distributed resources, and integration of electric vehicles. Additionally, utilities should work collaboratively with stakeholders in the design of consumer education programs and in the development, testing and delivery of program messages. These education programs should be an element of cost-benefit analysis in any Smart Grid proceeding.

The program-specific education projects recommended above should be designed to achieve the following four objectives:

1. An understanding of the nature of the program, including the basics technologies being used, the associated rate structures, and the role of the utility and third parties
2. An understanding of the goals of the program, including potential individual and societal costs and benefits.
3. An understanding of the potential implications (benefits, costs, and risks) associated with their participation and/or non-participation in a program or rate option that considers the customers personal electricity needs and usage profile. This should include identified environmental and societal impacts, as well as risk implications such as price volatility, potential higher bills, and data privacy/access issues.
4. An understanding of the resources and tools available to customers that can estimate the potential effect of their participation in the program. These tools may include rate comparison tools, energy consumption comparisons, in-home devices, and smart appliances.

CHAPTER 5: SUMMARY OF KENTUCKY SMART GRID WORKSHOP SERIES RESULTS AND KEY ACTION ITEMS

This Chapter presents a summary of the three part “Kentucky Smart Grid Workshop Series”, held on April 9th, May 18th, and June 21th, 2012, respectively. The workshops served as an open platform to bring together representatives from research institutions, government, utility industry, non-profit organizations, and other interest groups to develop a common vision for the future KY electric power systems and infrastructure, focusing on the modernization and deployments of power generation, transmission, distribution, energy storage technology, end-use electricity consumption, and regulatory framework.

The workshops included technical presentations, facilitated discussions, and breakout sessions 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’s electric power system.
2. The current state, the optimal future state, and the gap in-between for Kentucky’s electric infrastructure in the areas of Smart Grid deployments and technology, applications and solutions, along with research and development that enable the modernization of KY power grid.
3. Business models and regulatory approaches available to electric utilities and government regulators to encourage grid modernization that will ensure equitable and efficient regulatory and investment processes.

WORKSHOP KEY RESULTS

1. “Smart Grid Factors” Workshop

During the breakout sessions of the first workshop, which is the “Smart Grid Factors” workshop, participants were firstly asked what technology factors will most support electric grid modernization over the next 30 years, considering many factors that will influence the modernization of electric grid in Kentucky. Key results yielded from the discussion include the need for technology on renewable/alternative energy, distributed energy generation as well as energy storage, smart meter deployments along with other smart appliances within the home area network and home energy management systems. The standardization of technology and communication tools was also considered as one of the enabling factors.

By comparing the enabling Smart Grid factors, participants were then asked for providing the most inhibiting technology factors that will have impacts on the KY’s grid modernization. The obtained results were mainly associated with the cost of technologies R&D as well as implementation and applications. Other issues such as technology obsolescence and interoperability were also among the inhibiting factors.

2. “KY Grid 2040” Workshop

The second workshop was aimed at identifying the current state, the future state, and the gap in-between of the Smart Grid deployment and development for Kentucky. After the presentation sessions, participants were divided into groups to continue discussing the aforementioned three aspects respectively. The common results on the current state of electric infrastructure in KY were high reliance on coal generation with low penetration of renewables, aging equipment and facilities, and lack of R&D on new technologies. The collective results regarding the future state of the grid consisted more diversity on generation portfolio while maintaining low energy cost and the reliability, the utilization of more advanced technologies, such as dynamic thermal rating, synchrophasors, Volta/VAR control, and energy storage. And the improved communication and better industrial standards were also envisioned. The gaps between the current state and the future state were also identified accordingly by members in each group. Those gaps existed in technology, policy and regulation, economics, education, as well as consumer acceptance and participation.

3. “Market and Policy” Workshop

The third also the last workshop focused specifically on the discussion of Smart Grid markets and policy about 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. Again, it followed the same process like the previous two workshops that the multiple key results yielded during the breakout sessions. Participants were given the questions on how can regulators and utility work together towards that changes that will enable an efficient and equitable regulatory and investment process to encourage grid modernization, how different of this approach from business as usual, and its consequences. Key results include 1) the limitation of capital resources for investment by utilities; 2) the increase of utility involvement in researching and recommending regulatory improvements and in developing sound business cases and improved feedback from the regulators regarding strategy and implementation, considering the special case of Kentucky and the need of creating a different value equation than other states; 3) the re-evaluation of current state laws governing the electric and energy market, and utility’s ability; 4) the necessity of the development of clear state policy framework appropriate for the modern grid; 5) the need for improvement in the transition and continuity between PSC commissioners and the additional resources for PSC to facilitate Smart Grid competency; 6) the need to continue to promote informal interactions between utility, state government, regulators, stakeholders, and customers 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 transitional planning within the state and ensuring continuity in regulation and legislation.

CHAPTER 6: BARRIERS TO SMART GRID DEPLOYMENTS

There are numerous barriers and challenges currently facing the Smart Grid. They may come from various perspectives, including customer acceptance, technological barriers, regulatory and policy changes, as well as business and financial challenges. Some of the barriers have been common to the whole power industry for a long time. Others may be unique for a specific geographical region or a specific entity such as a utility company or a stakeholder, depending on the current state of the electric grid modernization. Most of the barriers have direct or indirect impacts on the deployment and development of Smart Grid on one or more infrastructure areas. No matter the impact, those barriers need to be identified up-front if the development of Smart Grid needs to be proceeded. Metrics should be developed to monitor the progress for each infrastructure area to ensure the negative impacts of various barriers are minimized.

The most significant challenge facing development of Smart Grids in Kentucky are the associated cost of technology deployments and the development of the value proposition to utilities, which are similar to those identified nationally. Additionally, uncertainty regarding future developments in technology, energy mix, and federal/state energy policies can discourage investments. While there is a risk that poorly executed regulation can impede the benefits that Smart Grid can deliver, the argument can be made that flexible regulation should be applied to encourage growth. Other technical and financial barriers are discussed in the following sections.

CUSTOMER ACCEPTANCE BARRIERS

Customer acceptance is one of the major barriers so far associated with the deployment and development of Smart Grid. The willingness from customers to participate either in the pilot programs or in the long-term Smart Grid planning project is so crucial that it could be the main driver to successfully achieve the Smart Grid. Ultimately customers or ratepayers should receive the desired value and benefits of Smart Grid while the electricity rate is maintained at an affordable level. There are uncertainties whether the capital investments in upgrading the infrastructure and implementing new technologies will be recovered and provide potential savings for customers. It is a predicament that, based on our research, customers are not clear about what exact benefits they will get and how much savings they can achieve by participating in Smart Grid related programs in a long term, and sometimes even for the utility, there is a lack of explicit understanding about the functionalities and benefits by implementing new technologies. Federal and state government along with utilities should take the responsibility to educate customers and address their concerns before the rollout of Smart Grid.

TECHNOLOGICAL BARRIERS

New technologies need to be developed and implemented to have deep penetrations on the existing grid infrastructure in order to achieve the Smart Grid. However various technologies and hardware devices designed and manufactured by different vendors are still evolving. There are many technological challenges and barriers that need to be overcome. For instance, one of the most common developments is AMI technology which utilizing smart meters to achieve two-way information flow between the

utility's operation & control center and the customer's facility. Under AMI technology, customers should be able to receive real-time price signals of the market and monitor the electricity usage information, and the electricity service providers should be able to have certain control over the energy usage by the customers to achieve demand side management. The smart meter should have "all-in-one" and "plug-and-play" type of functions and should be able to talk to all the "smart" appliances within the home area network on the customer's premise, and deliver bi-directional data and information securely and effectively. It's a tough challenge to meet all these requirements with a cost-effective design, implementation, and maintenance of the technology with future-proof capability. Otherwise, the technology will not be affordable, accountable, and flexible enough to meet the requirement of Smart Grid. AMI technology is just an example of all possible technologies that will be realized with the deployment and development of Smart Grid. Additional technologies including sensing and measurement, distributed generation, energy storage, EV/PHEVs, etc. will all be available in the market if the Smart Grid continues to make its progress in the near future. All these technologies will face their technical challenges respectively before they are able to achieve high penetration and become interoperable.

REGULATORY AND POLICY BARRIERS

Barriers also come from government agencies and grid regulators. Regulatory barriers may include those policies that will cause unwillingness or little incentive for utilities to invest in and deploy Smart Grid projects. The future compatibility of new technologies can cause another issue because regulators certainly do not want to see the "new" technologies become vastly obsolete only in a couple years. Cyber security will always be a major concern by the government and grid regulators since the grid may become more vulnerable with the integration of diverse communication technologies and the massive transmission of data and information. There are also uncertainties that regulations, policies and standards at federal or state level are still reforming and it takes a long process for the development of policies and standards. In addition, the current recession of economics could also be a prohibitive factor for regulators and utilities to make their decisions when considering capital investments.

BUSINESS AND FINANCIAL CHALLENGES

The investments on Smart Grid are predicted to be multi-billion business and Smart Grid projects often require significant upfront costs. Thus the business case for Smart Grid deployment should be firmly established before capital investments can take place. It is vitally important to convince utilities, regulators, stakeholders and ratepayers that the return on investment is guaranteed for a certain Smart Grid project and the project can generate considerable savings and benefits in a long term run. Smart grid pilot programs can be useful demonstrations not only in testing new technologies but also evaluating cost effective business cases. The challenge is to prove that out with field deployments. If cost recovery mechanism can be first established in place, it is no doubt that the progress of Smart Grid will be much faster. High levels of market penetration of new technologies yielding tremendous benefits for consumers will become more realistic and we will see more and more successful deployments as the consumer acceptance and participation increases.

CHAPTER 7: THE KENTUCKY SMART GRID ROADMAP

The KSGRI believes that Smart Grid technology has the potential to significantly improve energy security and reliability, increase generation supply and diversity, and reduce energy demands while stimulating job growth and economic development in Kentucky by creating a new energy economy and by helping to maintain Kentucky's low electricity rates. The Smart Grid market in Kentucky is largely uncoordinated at this point, and creation of an organize approach can position Kentucky as a leader in deployments, public policy, and technological research. The recommendations contained herein seek to achieve this in a logical and cost effective manner. Recommendations on a deployment timeline are grouped into four categories:

1. Organization and Oversight
2. Infrastructure Deployments
3. Awareness, Marketing and Education
4. Research & Development and Pilot Programs

KENTUCKY SMART GRID TASKFORCE

The KSGRI recognizes that the technology options on which Smart Grid deployments and operations are built are constantly evolving and that changes in these technologies will necessitate changes in deployment plans and system operations. Additionally, the KSGRI recognizes that any proposed roadmap will require support and a concerted effort from all stakeholders. Therefore, the KSGRI recommends the creation of the Kentucky Smart Grid Taskforce. This taskforce should be composed of representatives from utilities in Kentucky, the Kentucky Energy Cabinet, the Kentucky Public Service Commission, the state University system, end-use electricity consumers and other industry stakeholders. The taskforce will serve to organize, develop and oversee the implementation of the recommendations within the Kentucky Smart Grid Roadmap and to re-evaluate them if necessary. It is the recommendation of the KSGRI that the Kentucky Smart Grid Taskforce also be tasked with the creation of Kentucky Smart Grid Metrics that can be used to objectively evaluate statewide development of Smart Grid and to use these Metrics to perform an annual KY Smart Grid Evaluation Study which will objectively evaluate each public utility using the Kentucky Smart Grid Metrics, as appropriate.

INFRASTRUCTURE DEPLOYMENTS

The KSGRI recommendations regarding the deployment sequence for Smart Grid implementation in Kentucky based on surveys of a variety of national deployment projects⁴ and implementations plans as well as input gathered during the Kentucky Smart Grid Workshop series.

AMI

As it is the recommendation of the KSGRI that KY Smart Grid deployments focus on broadband or near broadband communication networks capable of supporting any applications (refer to Key

⁴ One example: http://www.netl.doe.gov/energy-analyses/pubs/WV_SGIP_Final_Report_rev1_complete.pdf

Recommendations on AMI) and as many Smart Grid implementations have a natural dependency on (or at least benefit from) smart meters, AMI is the ideal lead deployment project to provide the communication and metering infrastructure requirements for later ? missing word? . Additionally, the majority of implementation analyses have found that beginning with AMI deployments results in the overall optimal business case. While specific deployment timelines will vary amongst utilities, the KSGRI recommends the following general AMI deployment sequence, which can be adjusted to fit a variety of deployment timelines.

Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6
Planning and Strategy					
Requirement Definitions					
Pilot Projects					
			Systems Integration		
			Meter , Network, and MDMS Installation		
		Employee Training			
		Consumer Education Programs			

IT

Regardless which infrastructure area is chosen as the lead Smart Grid implementation project, transformations in Information Technology services will be required to ensure entire system interoperability and security and to leverage the benefits made possible by systems integration and data analytics across operational units. The most common approach for IT transformation has been the adoption of Service Oriented Architectures (SOA). The KSGRI recommends the adoption of such architectures to provide the rules, interoperability, and systems integration methods that enable seamless deployments and provide the capabilities of automating and providing intelligence for business rules and processes. In short, Information Technology departments should be elevated from their traditional support roles to operate as core business units centrally involved in the design and deployment of any Smart Grid application. While specific change timelines will vary amongst utilities, the KSGRI recommends the following general IT change sequence, which can be adjusted to fit a variety of change timelines.

Phase 1	Phase 2	Phase 3	Phase 4
Planning			
Requirement Definitions			
Design			
Development			
			Integration
			Deployment
			O&M

Demand Response and Distributed Energy Resources

With the onset of high penetration rates of AMI systems that enable two-way communication in near real-time between the electric utility and end-use customers, implementation of greatly expanded Demand Response and Distributed Energy Resources programs become realistic objectives. Such programs can manage energy efficiency, increase system reliability, provide financial benefit to customers, and can defer the need for utilities to purchase or build capacity in addition to other market performance benefits⁵. As DR and DER programs can operate synergistically to solve dispatch and intermittency issues, the DR and DER deployment recommendation timelines have been combined. As with AMI deployments and IT change, specific timelines will vary amongst utilities, the KSGRI recommends the following general deployment sequence:

Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Planning				
	Pre-Deployment			
	Software and System Configuration			
	Process Development			
	Demand Resource and DER Installation			
		Pilot		
	Training			
	Consumer Education			

Advanced Distribution Operations

ADO deployment has the potential to improve grid operation primarily in the areas of reliability and efficiency. Projects such as distribution level SCADA can decrease interruption durations and Volt/VAR projects can decrease both end-use power consumption and system losses as well as reduce the need for capacity upgrades in the distribution system. The KSGRI recommends that ADO deployments be scheduled to occur either concurrently with or subsequent to AMI deployments. This recommendation is meant to support the implicit AMI recommendation that the two way communication and increased granularity of consumption data provided by AMI deployments is of higher strategic value than the benefits provided by ADO. This recommendation is not meant to imply that ADO deployments would not immediately benefit Kentucky. On the contrary, it is the recommendation of the KSGRI that selective ADO deployment, particular Volt/VAR, be rigorously evaluated by all utilities when considering the need for capacity expansion of either the distribution network or generation fleet.

⁵ <http://eetd.lbl.gov/ea/ems/reports/congress-1252d.pdf>

Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7
Planning						
	Pre-Deployment					
		Software & System Configuration				
		Process Development				
			Pilot Program			
				Field Resource Installation		
				Testing		
				Training		
		Consumer Education				

Advanced Asset Management

The KSGRI has no specific deployment recommendations regarding an AAM deployment sequence other than it occur either parallel or subsequent to AMI and ADO deployment.

Advanced Transmission Operations

The KSGRI has no specific deployment recommendations regarding an ATO deployment sequence other than it occur either parallel or subsequent to AMI and ADO except for situations in which the utility is transmission limited.

AWARENESS, MARKETING AND EDUCATION

Create a Smart Grid Resource for Kentucky

A Smart Grid Website should be created to provide a centralized resource for Smart Grid in Kentucky and should be governed by a partnership between the major research universities in Kentucky in order to answer questions from the KY public and to distribute information about Smart Grid initiatives within the state. This “Kentucky Smart Grid Clearinghouse” would provide information in the following areas: Consumers, Smart Grid 101, KY Smart Grid deployment projects, and Technologies. In addition to serving as a gateway to connect KY electricity consumers with relevant sources of information, the website would serve as a tool to aid state agencies in deliberations for rate-case hearings and policy formulation.

Consumer Education Programs by Electric Utilities

Consumer education programs should be developed by each utility for all programs that include advanced metering, demand response, distribution automation, energy efficiency, distributed resources, and integration of electric vehicles. Additionally, utilities should work collaboratively with stakeholders in the design of consumer education programs and in the development, testing and delivery of program messages.

Drive Adoption of Demand Response through Tax Credit Programs

Current tax incentive programs for energy efficiency should be expanded to include energy management devices, particularly those that are capable of cooperative communication between networked devices

and the Smart Grid. These tax credits could be modeled on current Home Energy Rebate Programs and/or on HB240.

RESEARCH AND DEVELOPMENT AND PILOT PROGRAMS

Creation of a Smart Grid Research Center

The KY Smart Grid Research Center would be a collection of researchers and technicians across the state that are tasked with creating and evaluating Smart Grid integration, security, and deployment plans that benefit KY as a single entity. Currently, there is no group technically evaluating the structure and operation of the KY grid with the goal of optimizing across utilities. Additionally, many of the utilities do not have the resources or expertise to conduct such detailed assessments of their own systems. The KY Smart Grid Research Center would serve as a not-for profit and unbiased entity, much like the Electric Power Research Institute. Unlike EPRI, The KY Smart Grid Research Center would focus strictly on regional issues and provide direct technical assistance to the Public Service Commission and to all KY electric utilities. Additionally, the Smart Grid Research Center would help to attract new manufacturing to the state as it would allow for strong academic-industrial collaborations and support local development of Smart Grid technology solutions.

To facilitate the development of the KY Smart Grid Research Center, the mandate of the Conn Center for Renewable Energy Research should be extended to include research in smart energy systems and energy policy.

Creation of a Smart Grid Integration and Test Lab

A KY Smart Grid Integration and Test lab would be an advanced testing facility that would feature a controlled Smart Grid environment that would test interoperability of products and service, test compliance of products and services with Smart Grid standards , perform proof of concept and experimental testing , and provide training for Smart Grid system installations, operations, and diagnostics. The KY Smart Grid Integration and Test Lab would aid utilities in identifying best in class Smart Grid solutions, would improve the quality and timeliness of Smart Grid deployments, and would support development of in-state Smart Grid manufacturing capability by providing a convenient test platform.

AMI Rate Design Pilot and Demand Response Pilot

The electric utilities of KY should collaborate on a statewide pilot project to thoroughly evaluate rate design and demand response in the commonwealth. Issues to be addressed in the rate design portion of the pilot include the selection of rate forms, mandatory vs. voluntary participation, low income and senior bill impacts, and “unknowns”. Issues to be addressed in the demand response portion of the pilot include the choice of market model type, control strategies, participation mechanisms, rates and incentives, and the role of automation. It is the recommendation of the KSGRI that this state-wide pilot be coordinated through the Smart Grid Research Center in conjunction with the Smart Grid Technical Advisory Project or other comparable advisory group.

Near Term (1-3 Years)

Organization and Oversight

KY Smart Grid Taskforce

- Identify Founding Taskforce Members
- Develop Organization Structure
- Recruit Voting/ Advisory Members
- Evaluate and Endorse Smart Grid Roadmap as Appropriate
- Identify and Endorse Smart Grid Metrics
- Form Evaluation Plan
- Perform 1st KY Smart Grid Evaluation
- Release Results on SG Evaluation w/ Implementation Recommendation Plan

Infrastructure Deployments

Industry

- AMI Deployments Phase 1-3 (for early adoption)
- IT Deployments Phase 1-3 (for early adoption)
- ADO Phase 1-3 (for simultaneous AMI/ADO deployment – ALT1)

Awareness, Marketing, Education

Industry

- Work w/ Government to Identify Funding Mechanisms to Support KY Smart Grid Clearinghouse
- Launch Initial Smart Grid Educational Campaigns

Government

- Work w/ Industry to Develop Requirements for SG Education Programs
- Support Development of Smart Grid Clearinghouse
- Develop Recommendations for Demand Response Tax Credits

Research & Development and Pilot Programs

Industry & Government

- Identify Funding Mechanisms for KY Smart Grid Research Center and KY SG Test Lab.
- Identify Infrastructure and Human Resources for Research Center and Test Lab.
- Open Research Center and Test Lab
- Identify and Hire Smart Grid Consultant for KY AMI Pilot
- Perform Initial AMI Pilot Design and Participant Recruitment
- Perform 1 YR AMI/Dynamic Pricing Pilot

Mid Term (4 - 10 Years)

Organization and Oversight

KY Smart Grid Taskforce

- Collect Industry/Stakeholder Input on 1st KY Smart Grid Evaluation
- Re-Evaluate Smart Grid Metrics and Implementation Recommendations as Necessary
- Perform KY Smart Grid Evaluations on 3 Year Intervals
 - Update Metrics and Implementation Recommendations as Necessary w/ Input from Stakeholders.
 - Release Evaluation/Progress Reports

Infrastructure Deployments and Pilot Programs

Industry

- AMI Deployments Phase 4-6
- IT Deployments Phase 4
- DER Phase 1 -5
- ADO Phase 4-7 – ALT 1
- ADO Phase 1-6 – (for Delayed ADO Deployment – ALT 2)

Awareness, Marketing, Education

Industry

- Bring KY Smart Grid Clearinghouse Online
- All Utilities Have Smart Grid Education Programs In Place According to Government Requirements
- Continue to Fund KY Smart Grid Clearinghouse

Government

- Implement DR Tax Credits
- Evaluate Utilities SG Consumer Education Programs.

Research and Development

Smart Grid Research Center
and Testing Lab

- Work w/ SG Taskforce to ID Research Areas
 - Focus on Cost Reduction and Energy Efficiency
 - Focus on New Technology Development
- Support Needs of KY SG Taskforce
- Support Industry in SG Deployments as Needed

Government

- Evaluate AMI Pilot. Expand if Necessary to Form Recommendations.
- Implement KY DER Pilot

Long Term (11 - 25 Years)

Organization and Oversight

KY Smart Grid Taskforce

- Perform KY Smart Grid Evaluations on 3 Year Intervals
 - Update Metrics and Implementation Recommendations as Necessary w/ Input from Stakeholders
 - Release Evaluation/Progress Reports

Infrastructure Deployments and Pilot Programs

Industry

- ADO Phase 7 (ALT 2)
- AAM Full Deployments
- ATO Full Deployment

Awareness, Marketing, Education

Industry

- Continue to Support SG Education Programs
- Continue to Support Smart Grid Clearinghouse
- Work with Government to Evaluate Further Needs for SG Clearinghouse

Government

- Evaluate Effectiveness of Tax Incentives for Demand Response to Consider Program Expansion or Termination Based on Efficacy.

Research and Development

Smart Grid Research Center and Testing Lab

- Support Transfer of New SG Technology to Market
- Continue to Support KY SG Task Force and Industry in SG Deployment and Analysis for Future Needs

Kentucky's Smart Grid Roadmap



Recommendations on a Vision and
Direction for the Future of the Electric
Power Grid in the Commonwealth

UNIVERSITY OF
LOUISVILLE
CONN CENTER FOR RENEWABLE
ENERGY RESEARCH

