Grid Modernization for Public Power and Cooperatives

Creating a Roadmap for Investments

a Quanta Technology white paper by

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In this White Paper

What is Grid Modernization and Why Is It Important?

More than 2,000 communities in the United States are served by public power utilities. These utilities typically provide electric, water, or gas service. Similarly, there are over 900 electric cooperatives that cover more than half of the nation's landmass and serve more than 40 million people. Both public power utilities and electric cooperatives are vital parts of local economies, as they have a strong focus on serving their communities. Electric power grid and water services are delivery systems that interface to each home and business in a community. Historically, the utilities' primary concern was the delivery of reliable power and water to its customers. However, the utility landscape is changing due to technical and societal drivers. Grid modernization allows preparing the power delivery grid to address these drivers, which include:

- Evolving expectations of customers regarding reliability and resilience
- Increasing dependency of our digital economy on electric power
- Evolving changes to weather patterns (e.g., more frequent and more severe storms and catastrophic events, such as tornados and hurricanes)
- Impacts of human events (e.g., sabotage, terrorism, etc.)
- Stress imposed on the existing grid by the adoption of new technologies, such as distributed energy resources (DER) and transportation electrification
- Increased residential demand due to epidemic or pandemic events

Grid modernization enables key capabilities and features for a modern and future grid, including [1]:

- Greater RESILIENCE to hazards of all types
- Improved RELIABILITY for everyday operations
- Enhanced SECURITY from an increasing and evolving number of threats
- Additional long-term AFFORDABILITY to maintain our economic prosperity
- Superior FLEXIBILITY to respond to the variability and uncertainty of conditions at one or more timescales, including a range of energy futures
- Increased SUSTAINABILITY through energy-efficient and renewable resources

Examples of grid evolution and modernization drivers include the growing frequency and impact of major weather events, and the increasing adoption of renewable generation (particularly wind and solar) and electric transportation, as shown in Figure 1, Figure 2 and Figure 3.

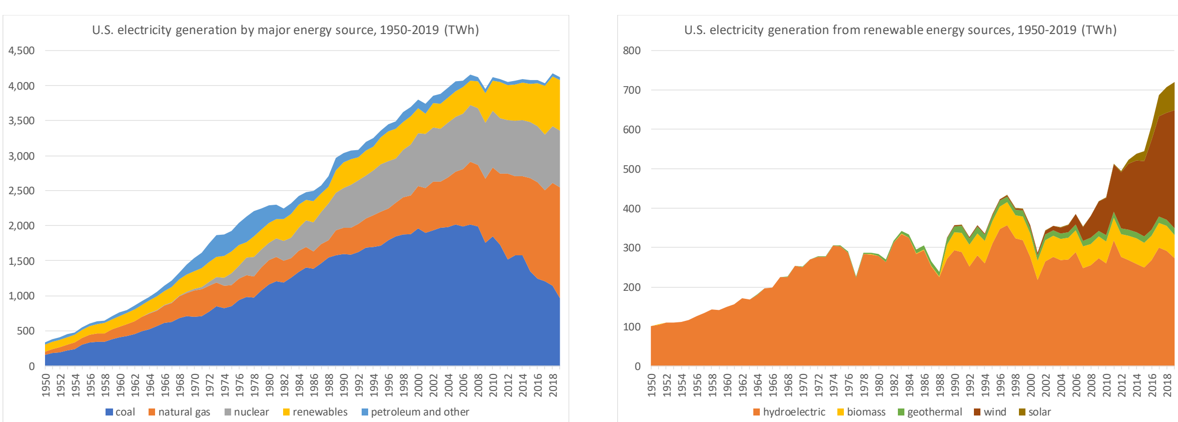

Figure 1. U.S. Electricity Generation by Major Source (1950–2019). *Source EIA [2]*

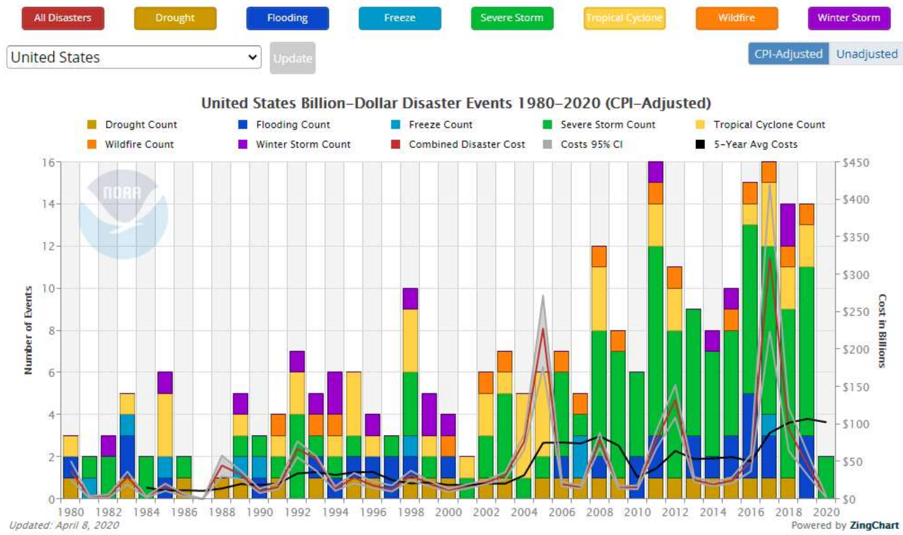

Figure 2. U.S. Billion-Dollar Disaster Events 1980–2020 (CPI Adjusted). *Source: NOAA [3]*

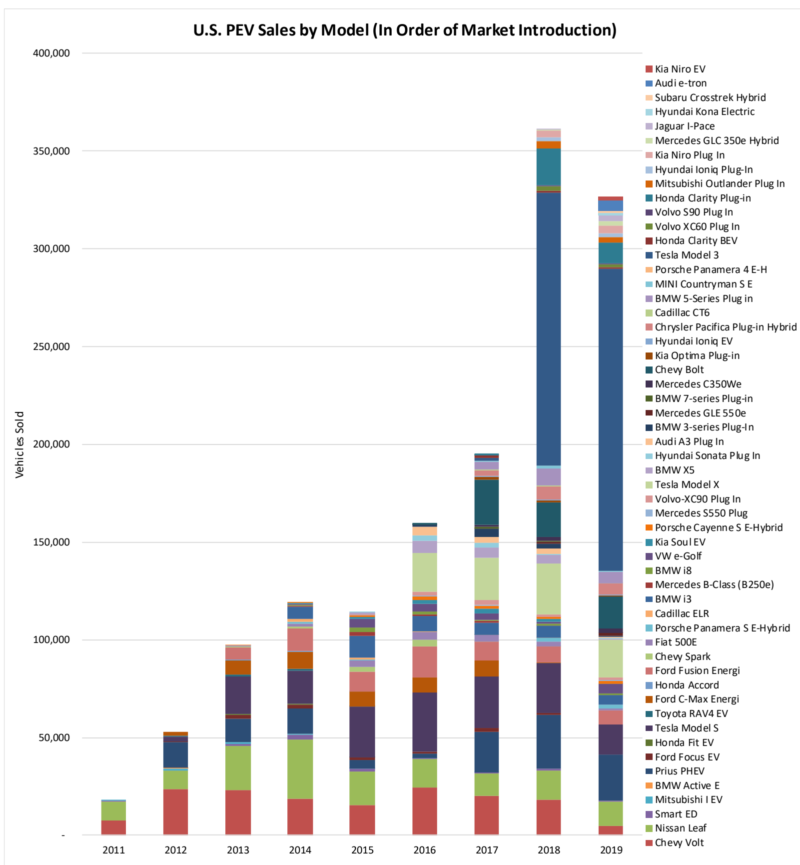

Figure 3. U.S. Plug-In Electric Vehicle (PEV) Sales by Model. *Source: U.S. DOE [4]*

Grid Modernization Roadmap

The objectives of a grid modernization roadmap are to enhance and strengthen grid planning, operations, and engineering activities, as well as to identify and prioritize key infrastructure investments in support of the utility vision and goals. A grid modernization roadmap allows for the identification and prioritization of strategic programs to realize a modern and future grid. The grid modernization program goals are to:

- Increase reliability and resiliency
- Increase real-time monitoring, protection, automation, and control
- Increase overall operational efficiency
- Comply with regulatory and policy requirements (e.g., electrification, distributed energy resources, emissions reduction, etc.)

The key steps for a grid modernization effort are shown in Figure 4. To take a utility's vision and create a roadmap, it is important to have a planning team involved from beginning to end. The planning team should be cross-functional and multidisciplinary to have all key areas represented. The communication plan should include the utility departments, but also include members of the board of directors and key customers. Due to the evolving drivers for grid evolution and modernization previously discussed, a utility may want to start by reviewing their vision to make sure it aligns with their present mission.

Figure 4. Key Steps for Developing a Grid Modernization Roadmap

> "Our utility saw a strategic benefit in working with Quanta to develop a coordinated Modernization Roadmap as part of a long-term plan to modernize core operational systems and technology. It is critical to appropriately select an order of these investments to maximize operation benefits and improve customer experience at an effective cost and in a planned manner."
>
> Joseph G. Bunch | General Manager and CEO
> Utilities Commission, City of New Smyrna Beach

This paper focuses on the development of a grid modernization roadmap. A grid modernization roadmap leverages industry best practices to set the basis for transforming and preparing for the future according to the utility's vision and goals. The roadmap outlines key initiatives or programs needed for the organization to improve the overall performance of the power delivery system. This involves taking full advantage of planning-team discussions and workshops to develop a roadmap that meets a utility's needs. For example, a utility focused on improved reliability might consider implementing grid modernization programs such as feeder automation, targeted undergrounding, and/or Outage Management System (OMS) deployment.

The development of a grid modernization roadmap includes the following steps:

1. Identify key components of the utility's vision and goals.
2. Develop a preliminary list of key programs needed for achieving the utility's goals.
3. Benchmark existing utility practices and potential programs against industry trends and leading practices.
4. Develop a benefit-cost analysis to create a metric for prioritizing the grid modernization programs. Costs and benefits should be weighted by relative importance to meet utility goals (e.g., reliability and resilience, sustainability, efficiency, etc.) and parameters such as investment, risk, complexity, maturity, and others.
5. Sequence and categorize programs. Once the programs are prioritized, proper sequencing of the programs must be considered. Programs are categorized as foundational and non-foundational. Foundational programs impact one or more other subsequent programs and are direct pre-requisites. Foundational programs must be deployed first and are given higher priority in the overall roadmap timeline.

The process for creating a grid modernization roadmap shown in Figure 5. The team must determine the appropriate balance of quantitative and qualitative analysis. Utility goals, best practices, cost, risk, and technical options all play a role in the overall evaluation.

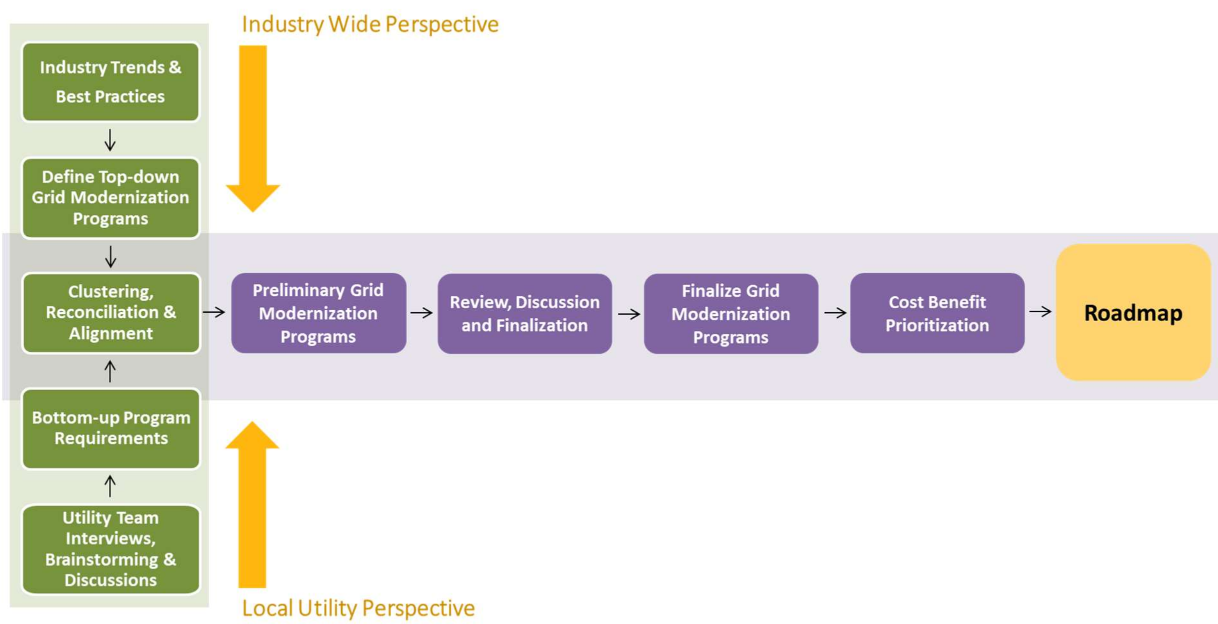

Figure 5. Grid Modernization Process Overview

Programs – Building Blocks for Grid Modernization

A grid modernization roadmap consists of a prioritized portfolio of programs. Programs are projects or initiatives that can be implemented to realize the desired functionality, capability, or other specific utility goals. For example, if one of the utility's key drivers is reliability improvement, then programs that reduce the frequency and duration of service interruptions are potential options to be considered (e.g., implementing feeder automation [5], deploying an OMS, or enhancing vegetation management practices). If a utility wants to support providing enhanced information to customers, program options could include website upgrades to enhance customer interaction or an interface to hourly consumption from an Advanced Metering Infrastructure (AMI) program with smart meters. Note: A program can support several utility's drivers. For example, AMI will improve reliability, this is accomplished by faster notification of service interruptions via last gasp messages (instead of customer trouble calls) and will enhance customer information by providing usage information. Figure 6 shows examples of potential grid modernization programs.

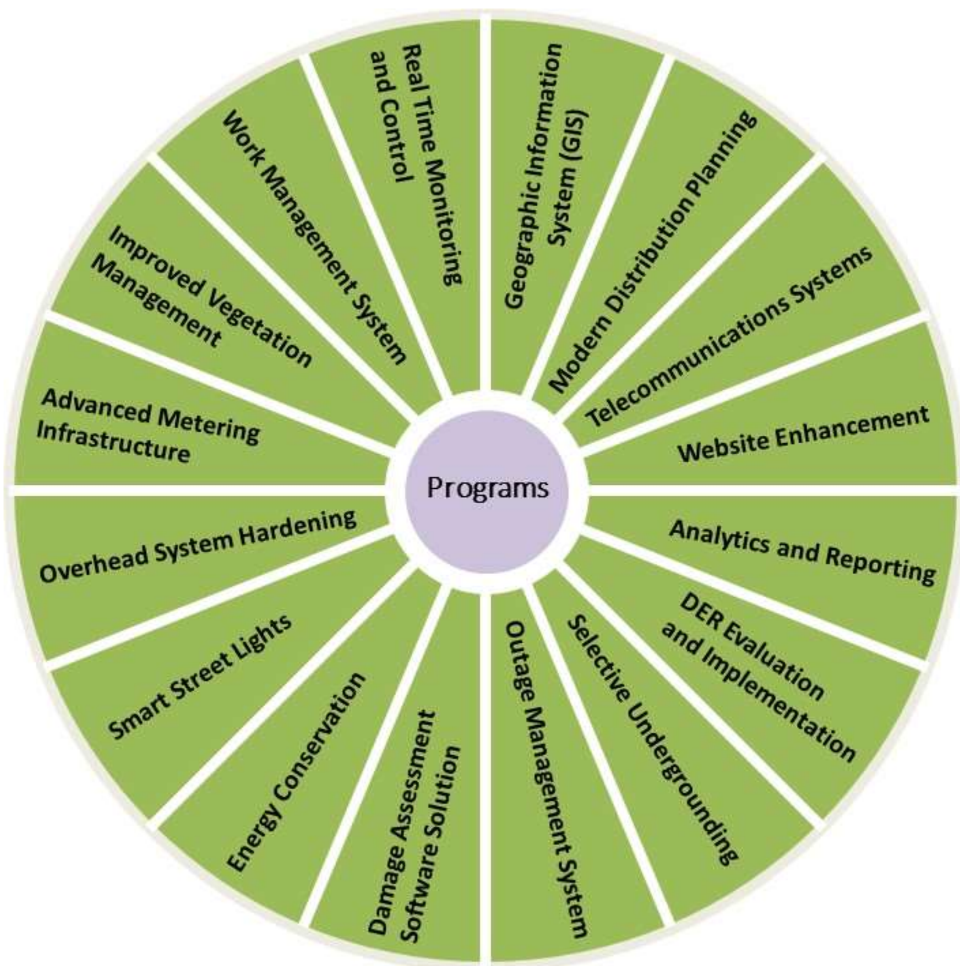

Figure 6. Programs Realize Key Features and Capabilities of a Modernized Grid

Once a program is identified, it is prioritized based on information such as:

- Benefits: Quantitative and qualitative benefits from implementing the program
- Capital costs: Initial, fixed, one-time investment required to implement program
- O&M costs (annual): Recurring costs, including operations, maintenance, licenses, etc.
- Anticipated savings: Qualitative discussion of areas for expected savings
- Assumptions: Relevant assumptions used to calculate costs (e.g., unit costs, customer base, etc.)

Additional factors such as program complexity, technology maturity, implementation risks, organizational readiness, etc., can be considered in the benefit-cost analysis and prioritization. Figure 7 shows examples of prioritized programs.

Figure 7. Prioritized Programs are the Building Blocks of a Grid Modernization Roadmap

For the development of the grid modernization roadmap, however, the sequencing and scheduling of the prioritized programs must be considered (see Figure 8). Foundational programs are required for other programs (e.g., AMI is a prerequisite for OMS, telecommunications is a prerequisite for real-time monitoring and control, etc.), and they can be sorted into priority levels for implementation. Foundational programs are considered strategic and are often the highest priority from a roadmap perspective.

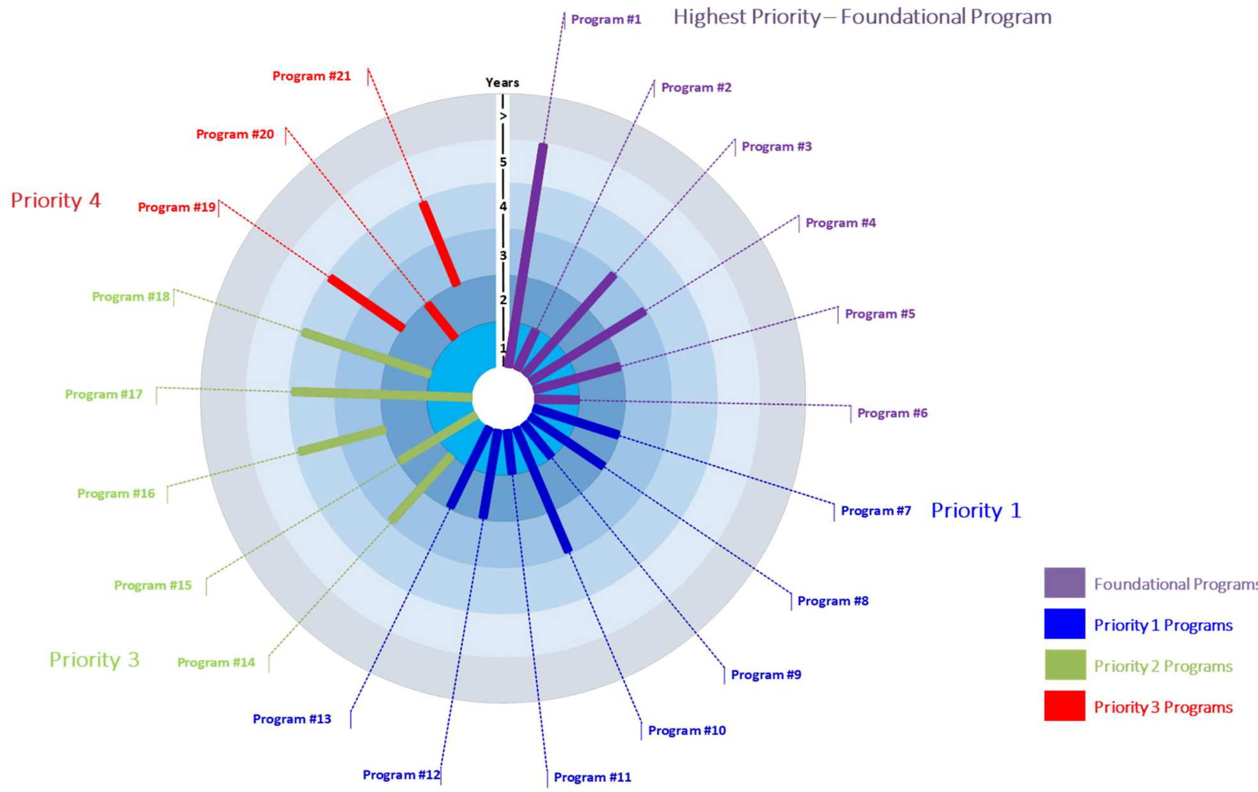

Figure 8. Grid Modernization Roadmap

Once the roadmap is complete, the team needs to communicate it to stakeholders and begin to develop an action plan for the program rollouts. It is important to plan periodic reviews of the program implementation and overall status.

AMI and Smart Meters

AMI and smart meters are typically foundational since AMI provides significant information on grid operation, enables new functions critical to renewables, and provides timely information to a utility and customer. For smaller utilities, an AMI program may be the major basis for a grid modernization plan. For this reason, we will provide additional information on AMI systems and their role in grid modernization.

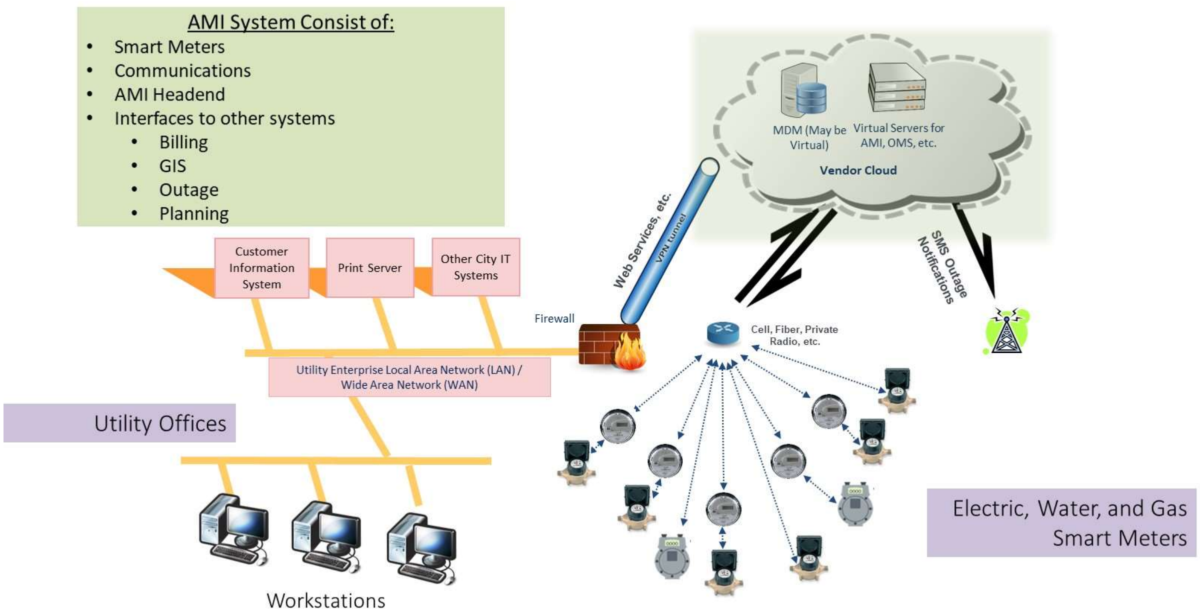

Figure 9. AMI System Overview

> "Like most small cities that operate utilities, Newberry's elected officials are very much in tune with the sentiments of our customer base. Our staff presented the concept of automated metering infrastructure to our city commission as a means to address some deficiencies in meter reading. The city commission quickly realized the value in providing daily and hourly utility consumption data to our customers, and the opportunities it would provide in making decisions related to utility consumption. The commission directed staff to initiate a project to implement AMI technology in Newberry. Our team recognized the complexity of deploying AMI, and while all are experts in their area of operation, they wisely recommended that we partner with a third-party consultant to make sure we realized the benefit of a consultant's experience. We selected Quanta Technology after a thorough evaluation of several firms. Their expertise and experience in successful AMI deployment projects was key to their selection as our project partner."
>
> Mike New | City Manager
> City of Newberry, FL

AMI Relationship to Grid Modernization

As previously noted, AMI has a strong relationship to grid modernization since it supports many other programs that can be implemented. An AMI system provides a utility and its customers with higher-resolution consumption data and two-way communications, which support key elements of a modern grid [6].

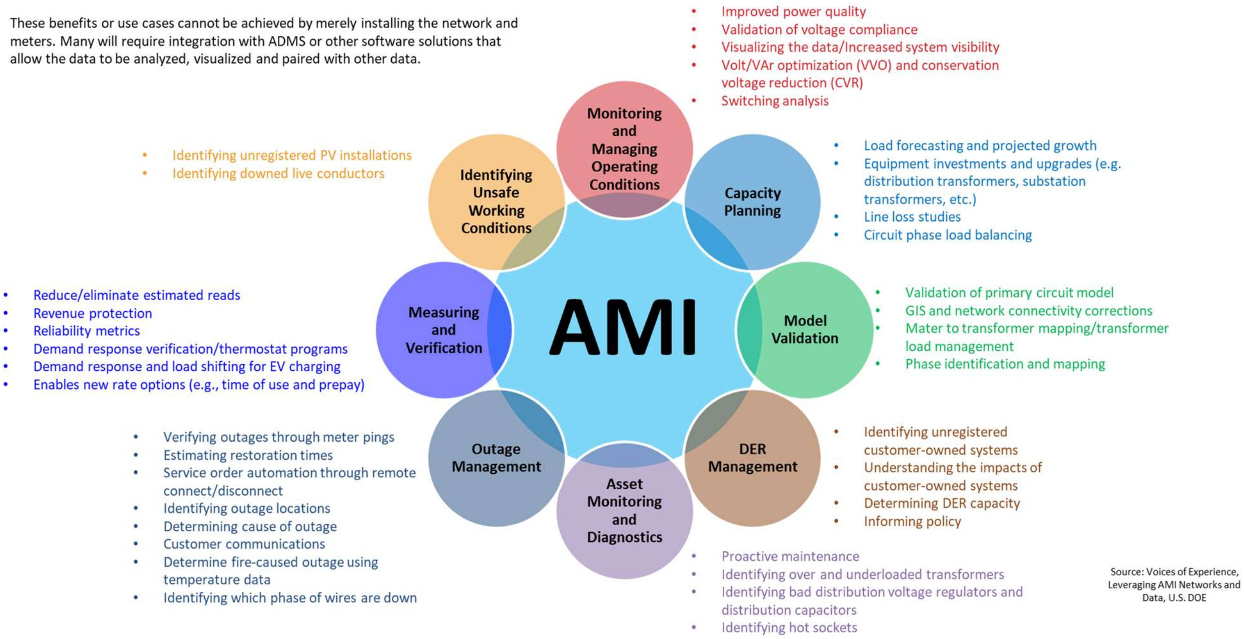

Figure 10. AMI and Grid Modernization

AMI Benefits and Savings

An AMI system offers many benefits to a utility. These benefits include the following:

- Use of net metering to enable more widespread use of solar or other renewables
- Improved customer satisfaction with customer web portal features such as:
  - Detailed views into electric and water usage during the month with at least an hourly granularity
  - Flexible payment options including bill-date selection, different rates (TOU, demand, etc.), prepay, and levelized billing
  - Alternate rate comparison capability to allow customers to examine “what if” scenarios had they been on an alternate rate
  - Customer alerts and notifications based on budget and/or electric consumption targets, outages, leaks, etc.
  - Ability to schedule power re-connect/disconnect
  - Improved city outage response and restoration speed with detailed knowledge about location and extent of outages in near-real-time (each meter provides outage information to an OMS system for processing to determine the location)

- Promotes environmental responsibility by reducing truck rolls and enabling remote resolution to address customer concerns such as billing-read verification
- Tamper and theft notification
- Improves overall conservation with features such as:
  - Detailed customer electricity and water usage information to identify high electric or water usage in shorter timeframes before they become critical
  - Identification of water leaks in shorter timeframes
  - Identification of system losses with system water balance and electric consumption analysis
- A communications canopy that other programs can utilize

An AMI system will also result in savings for a utility. Examples of savings include the following:

- Administrative cost reduction – bill-check/re-reads and estimates
- Elimination of route meter reading
- Less on-site time for outage restoration
- Removal of on-site meter connects/disconnects
- Reduced non-technical losses of electric and water
- Improved electric and water revenue from replacing slow meters
- Detection of water leaks
- Vehicle costs/fuel reductions
- Overtime cost reduction for after-hours reconnects
- Rapid tamper detection – revenue loss reduction
- Cash float – shorter read-to-bill cycles
- Meter replacement recovery (partial)
- Reduced sewer forgiveness on service-side leaks
- Water balance – loss reduction

Many of the quantifiable benefits (hard savings) are shown in Table 1. This list includes specific items that should be used in a benefit-cost analysis. This list may be expanded for any utility based on other hard savings they might identify. Benefits that are harder to quantify (i.e., "soft benefits") are also shown in Table 1. Although difficult to do, it is possible to quantify some benefits depending on the utility's decision to pursue a particular program (e.g., the employee safety line item). For instance, a utility could gather information on lost time and other expenses associated with accidents on customer premises related to meter reading. Many other soft benefits can be identified depending on each utility's drivers. For example, one might list improved environmental responsibility as a soft benefit of reduced truck rolls.

Table 1. AMI Benefit-Cost Analysis Topics

Hard Savings		Soft Benefits
Administrative cost reduction – bill-check/re-reads and estimates		Employee safety – reduced on-customer-premises time
Elimination of route meter reading		Customer usage data and alerts
Less outage/restoration on-site time		Faster detection of theft
No on-site power quality checks		Faster notification of outage and restoration

Hard Savings		Soft Benefits
Removal of on-site connect/disconnect		Faster notification of customer-side leaks
Reduced non-technical losses, electric		Better power quality monitoring – Voltage
Reduced non-technical losses, water		Enabler for future tariffs
Improved water revenue from replacing slow meters		Flexible billing dates (if CIS supports)
Improved electric revenue from replacing slow meters		Aggregated billing (if CIS supports)
Water leaks		Prepay option – Less deposit – Improved cash management
Vehicle costs/fuel reductions		Support for future grid modernization activities - electrification/solar/load control
Overtime cost reduction for after-hours reconnects		
Rapid tamper detection – Revenue loss reduction		
Cash float – Shorter read to bill cycles		
Meter replacement recovery – Partial		
Reduced sewer forgiveness on service side leaks		
Water balance – Loss reduction		

What about water? Many public power utilities and co-ops implement AMI systems without going through a benefit-cost analysis since the operational efficiencies and customer benefits are believed to be self-evident. However, Quanta Technology has been involved in benefit-cost analyses for public power utilities, and some surprising results have emerged. One of these surprising benefits is the value of an AMI system in identifying and localizing water leaks. Literature shows that municipal unaccounted-for water losses average 16% with losses over 26% being seen [7,8]. These unaccounted-for losses generally appear to be due to older, slower water meters under-registering, as well as real losses due to service-side distribution system leaks and leaks in transmission and distribution mains [8]. Strategic placement of non-billing AMI meters at system boundaries and other key distribution system locations can help identify actual losses, while newer water meters can help eliminate these apparent losses. Other losses identified in the AWWA Water Balance can often be identified and mitigated via a water system audit.

"The City of Clewiston had been interested in updating its utility metering with an AMI system for some time to modernize our utility operations. Through Florida Municipal Power Association (FMPA), we were introduced to Quanta Technology who has been a very valuable resource to help the City navigate the complexities and cost associated with a procurement of this nature. Quanta's expertise and their professionalism has been extremely valuable in assisting Clewiston in the process. I am glad they will continue to be working closely with our team on the deployment of the much-anticipated AMI system in our community."

Randy Martin | City Manager
City of Clewiston, FL

Typical Phases of an AMI Project

Figure 11 shows the 3-phase approach that Quanta Technology has used for some municipal AMI projects, which allows commissions to approve each phase prior to initiation. We have found this incremental approach has been well-received by municipal councils.

Phase 1 is the initial part of the project. It includes internal assessments, such as IT systems, utility system priorities and resulting draft RFP development are included in this phase.

Phase 2 is the portion of the project where the RFP is finalized, issued, and evaluated, and a contract is awarded.

Phase 3 is the deployment phase. This includes IT system integration, overall system testing, field mobilization, and field deployment.

Phase 1 Planning

1. Assessments (readiness and gaps)
2. Priorities defined
3. Cost Benefit Analysis
4. Strategy development
5. Draft RFP development

Phase 2 Selection

1. Finalize RFP & Issuance
2. Bid evaluation
3. Reference visits
4. Contract finalization

Phase 3 Implementation

1. Project initiation
2. IT system integration
3. System testing
4. Full deployment

Figure 11. Phases of an AMI Project

Conclusions

The grid modernization roadmap sets the basis for transforming and preparing utilities for the future. It is a practical method to prioritize investments to realize a future based on a utility's vision and goals. By using a defined process that integrates a utility's vision and industry best practices, key functionalities and programs can be combined to provide a prioritized list of initiatives for investment. The grid modernization roadmap should enhance and strengthen a utility's grid planning, operations, and engineering activities, and identify and prioritize key infrastructure investments in support of their local vision for supporting the community and meeting the needs of the 21st century.

About the Authors

David G. Hart, PhD, *Vice President, Protection, Control & Automation*, has more than 25 years of experience in the power industry including protection and control, power system automation, smart metering, and various research experience. He has been involved with the development of Automated Metering Infrastructure (AMI) products and systems for over 10 years, directing the product management, engineering, and quality teams. As head of Protection, Control & Automation, he is responsible for overall business strategy, client and program proposals, and project execution for the business area. David holds 30 patents and is a Senior Member of IEEE/PES.

Julio Romero Agüero, PhD, *Vice President, Strategy and Business Innovation*, has 25 years of industry experience. Julio provides leadership to Quanta Technology in the areas of technology and business strategy, grid modernization, distribution systems analysis, planning and engineering, distributed energy resources, and emerging technologies. He has assisted electric utilities and regulatory boards in the U.S., Canada, Latin America, the Caribbean, and Asia. He is a Senior Member of the IEEE, he currently serves as Chair of the 2021 IEEE PES Innovative Smart Grid Technologies (ISGT) Conference and Chair of the Energy Storage Track of DISTRIBUTECH 2021. He has served as Chair of the IEEE Distribution Subcommittee, Chair of the IEEE Working Group on Distributed Resources Integration, Editor of IEEE Transactions on Power Delivery, and Editor of IEEE Transactions on Smart Grid.

Bob Dumas, PhD, PE, *Lead AMI, Protection, Control & Automation (PCA)*, has over 40 years of experience with increasing levels of organizational responsibility in electrical, nuclear, mechanical, and environmental engineering positions associated with electric utility generation, transmission operations, and advanced metering infrastructure (AMI) smart-grid solutions for some of the largest utilities in the U.S. and internationally. This experience includes 17+ years with Virginia Power Nuclear Design Engineering and 17 years in the AMI industry with Elster Solutions (formerly ABB) and Itron Inc. With Quanta Technology, he has been responsible for project execution of the multi-million-dollar Wide-Area Protection project for National Grid Saudi Arabia, as well as ongoing AMI consulting projects.

Donald F. Hall, PE, *Executive Advisor, Distribution & Asset Operations,* is a seasoned leader with proven experience in the Engineering, Operations, and Regulatory areas of the Distribution & Transmission segments of the electric utility industry. Recent focus includes business and technical integration of Distributed Energy Resources/Non-Wires Alternatives (DER/NWAs), Distribution System Load Forecasting methods incorporating DER, the addition of stakeholder involvement and transparency in the Distribution System Planning process, and initial development of performance indicators to be used in performance-based rate-making proposals. Extensive background in state and federal regulatory proceedings including serving as an expert witness. Donald is a licensed PE in Washington D.C., Delaware, and Maryland, has been published and is active in standards development (IEEE/PES), and was an adjunct college engineering instructor.

Mike Longrie, *Principal Advisor, Business Development Manager, Central-East Region,* has more than 30 years of experience in the electric utility industry. His experience includes advanced metering infrastructure (AMI), substation design, and automation systems. During his career in the electric power industry, he has been involved with customer requirements gathering and product/solution development. He has held various management roles in sales, technical marketing, and product management.

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