Item #180361

GRU
More than Energy

Gainesville Regional Utilities Advanced Metering Infrastructure (AMI) Assessment/Feasibility Study

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Acronyms/Definitions

Acronyms	Definition
AC	Alternating Current
AMI	Advanced Metering Infrastructure
AMI/MDM	Advanced Metering Infrastructure/Meter Data Management
AVL	Automatic Vehicle Location
AWWA	American Water Works Association
C&I	Commercial & Industrial
CapEx	Capital Expenditures
CCS	Customer Care & Service
CEP	Complex Event Processing
CIP	Critical Infrastructure Protection
CIS	Customer Information System
Comm.	Commercial
CRM	Customer Relationship Management
CSR	Customer Service Representative
CVR	Conservation Voltage Reduction
DC	Direct Current
DCU	Data Concentrator Unit
DHS	Department of Homeland Security
DNP3	Distributed Network Protocol 3
DSM	Demand-Side Management
EPRI	Electric Power Research Institute
FCC	Federal Communications Commission
FERC	Federal Energy Regulatory Commission
GIS	Geographic Information System
GRU	Gainesville Regional Utilities
ICS	Industrial Control System
ICS-CERT	Industrial Control Systems Cyber Emergency Response Team
IT	Information Technology
IVR	Interactive Voice Response
kVAR	Kilovolt-Ampere Reactive
kW	Kilowatt
LAN	Local Area Network
lb	Pound
LED	Light Emitting Diode
$Li\text{-}SOCl_2$	Lithium-thionyl Chloride
MDM	Meter Data Management (System)
MDMS	Meter Data Management System
MG	Million Gallons
MG/Yr	Million Gallons per Year
MGD	Million Gallons per Day
MIU	Meter Interface Unit
MVAR	Megavolt-Amperes Reactive
MW	Megawatt
NARUC	National Associate of Regulatory Utility Commissioners
NIST	National Institute of Standards and Technology

NPV	Net Present Value
O&M	Operations & Maintenance
OMS	Outage Management System
OpEx	Operational Expenses
OSI	Open Systems International
OT	Operation Technology
OTJ	On the Job
PSIG	Pounds per Square Inch Gauge
PV	Photovoltaic
QA	Quality Assurance
Res.	Residential
RF	Radio Frequency
RFP	Request for Proposals
ROI	Return on Investment
SAAS	Software as a Service
SCADA	Supervisory Control and Data Acquisition
SOW	Scope of Work
T&D	Transmission & Distribution
TOU	Time-of-Use
UWC	UtiliWorks Consulting, LLC
VAR	Volt-Ampere Reactive
VEE	Validation, Editing, and Estimation
VVO	Volt/VAR Optimization
WAN	Wide Area Network
WO	Work Order

Section A - Executive Summary

UtiliWorks Consulting, LLC, ("UtiliWorks", "UWC") was engaged by Gainesville Regional Utilities ("GRU") to assess the feasibility of deploying an Advanced Metering Infrastructure ("AMI") system and Meter Data Management ("MDM") system across their Electric, Water/Wastewater, and Gas utilities. The first steps in this process were to identify goals for the project, assess readiness for AMI technology, develop a business case, and identify potential operational gaps that could pose a challenge during an implementation and beyond. Across the Customer Operations, Electric, water, gas and IT departments, UtiliWorks examined GRU's current utility operations, meter hardware and communications equipment, systems and software, and staffing. The information was acquired via data requests and through a series of on-site stakeholder interviews with respective departmental teams in October 2017.

Some of the top GRU goals related to an AMI Implementation project that were gathered during the Assessment Project are as follows;

- Improved safety for both customer and GRU personnel
- Promote superior information gathering and sharing
- Promote improved customer choices and engagement
- Increase customer service and satisfaction
- Deliver advanced world class utility services
- Improve electric, water and gas service reliability and quality

Based on the results of the gap analysis, GRU appears to be well informed on the technology is suitably equipped to proceed with an AMI and MDM implementation project. The stakeholders have given much consideration to the project staffing needs along with the new data and information that will be available and how it can be leveraged to meet the goals across the GRU operating environment. A detailed review of the Current State of Operations can be found in Section C. The results of the current state gap analysis are discussed in Section D along with key recommendations, and the analysis itself is in Appendix II.

The business case included in this assessment report considers the deployment of an AMI and MDM system that will provide near real-time hourly data (or sub-hourly data for commercial & industrial (C&I)) electric, water, and gas usage to GRU. The underlying objective of the Business Case was to arrive at a realistic and conservative result – not to overestimate potential benefits and not to underestimate project costs.

Table 1 outlines key indicators of the project economics:

Table 1: Business Case Results

Net Present Value ($000)	$48,573
Internal Rate of Return	16.3%
Return on Investment	174%
Payback Period	9 years
Total CapEx ($000)	$67,629

AMI and MDM technologies introduce great opportunities across organizations, but also bring many new challenges. To prepare GRU for what's potentially ahead, UtiliWorks has outlined a recommended approach including a Pilot Verification phase and proposed project staffing in Section F. Section H looks beyond the deployment, highlighting the organizational and business process changes required to support this program and maximize the potential benefits of an AMI and MDM investment.

UtiliWorks may continue to be engaged with GRU to assist with the Procurement process. Support will include system requirements documentation development, Request for Proposals (RFP) development, and proposal evaluation support. Beyond these tasks, UtiliWorks has significant proven experience in providing program management support during installation and is often engaged by other clients in this role if they choose to move forward.

The work represented in this report does not constitute a detailed requirements or design effort, nor does it layout a detailed, customized project plan at this early stage. However, that information will be needed later to bring more definition and clarity to the effort. Wherever appropriate, this report flags where more detailed planning and design activities are required.

Section B - Introduction

1. Purpose

The pursuit of an AMI and MDM implementation program that supports advanced metering functions and digital data requires a well-thought out deployment plan prior to an implementation project commencement. A strategic assessment and plan is required to identify which platforms may be most worth pursuing, how and why existing systems and assets can best be utilized, and which technologies offer the best fit for GRU's short and long-term goals.

GRU completed an AMI pilot and evaluation project in 2016 which resulted in a decision to not move forward to a full regional deployment. This decision is now being revisited again and the results of the UtiliWorks AMI Business Case and Assessment will contribute to the outcome of this effort.

GRU has contracted with UtiliWorks to develop a comprehensive Business Case and AMI/MDM technology analysis and assessment for multiple service types at GRU. The analysis for the AMI deployment contained within this assessment considers the operational impacts of other GRU technology projects and staffing requirements.

The goal of this AMI assessment is to provide GRU with a business case; outline the quantitative and qualitative benefits that can be realized with an AMI program; and chart out a proposed implementation plan, which includes the impact of other Utility Technology Roadmap items on the AMI project. This foundation will prepare GRU for a subsequent AMI/MDM Systems Specification & Procurement Phase (Phase 2).

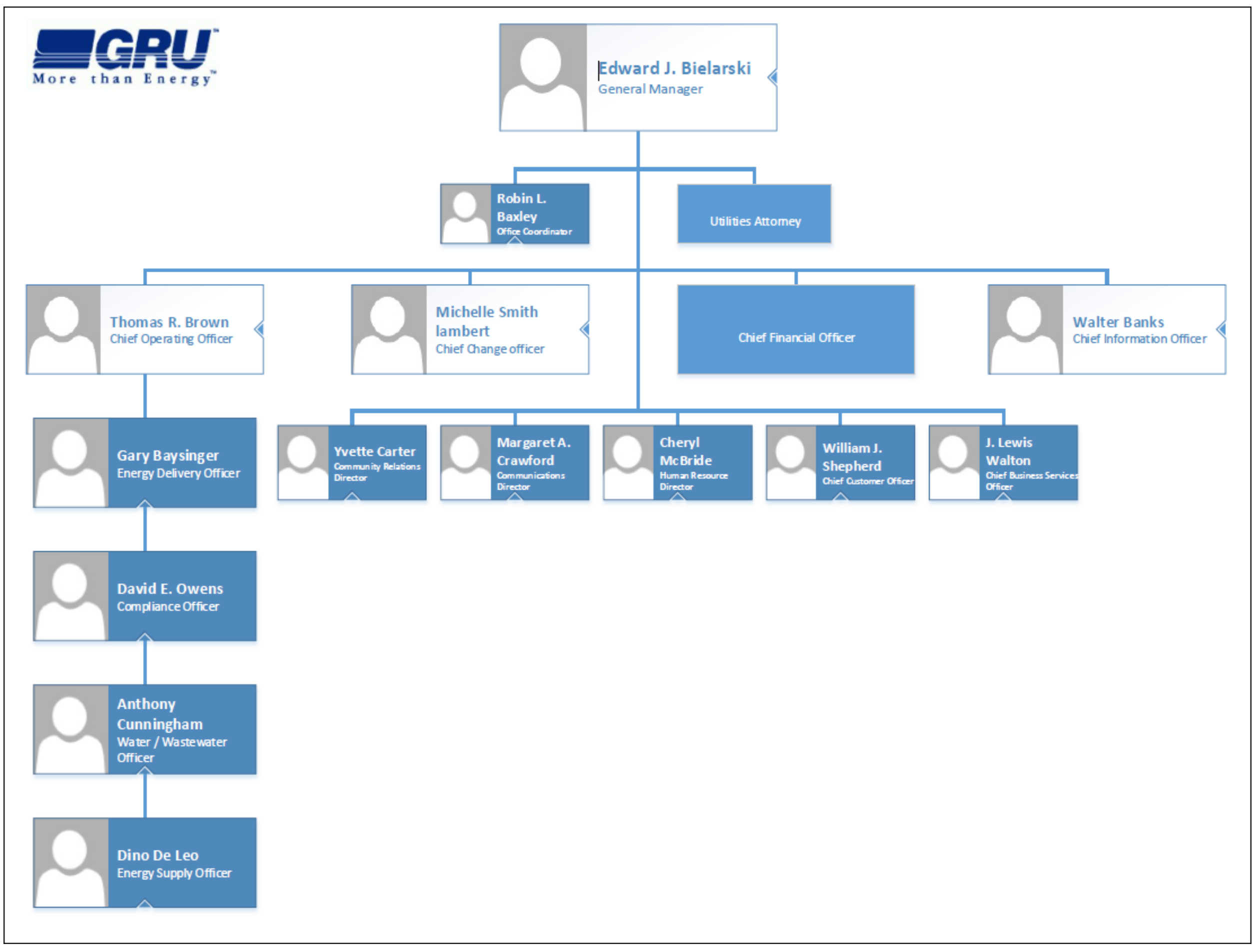
2. Utility Background

Gainesville Regional Utilities provides electric, water, gas and reclaimed water services to customers in Gainesville, Florida geographic area. Gainesville is a community of approximately 63 square miles located approximately 100 miles north of Orlando. GRU is the fifth largest municipal electric utility in the state of Florida, and serves over 95,983 electric connections, over 72,652 water connections, and over 36,021 gas connections.

GRU is led by the General Manager ("GM") who is a Charter Officer appointed by the City of Gainesville's elected commissioners. Line functions reporting to the GM are the Chief Operating Officer ("COO") with divisions supporting Electric Delivery ("ED"), Energy Supply ("ES"), and Water/Wastewater ("W/WW"); the Chief Financial Officer ("CFO"); the Chief Information Officer ("CIO"); the Chief Change Officer; the Chief Customer Officer; and the Chief Business Services Officer. Additional administrative functions reporting directly to the GM include Legal, Human Resources, Communications and Community Relations.

GRU employs 826 FTE's with a significant commitment to the ownership and operation of its numerous facilities and assets.

Figure 1: Gainesville Regional Utility Organizational Chart



3. Scope of Work

Per Purchase Order #4510037865, executed on October 9th, 2017, UtiliWorks has performed this Advanced Metering Infrastructure Assessment/Feasibility Study to baseline GRU operations and assess readiness for AMI implementation success. This assessment includes a business case analysis and findings from an AMI financial model. To further understand the context of an AMI Implementation Program within other GRU technology projects, UtiliWorks has developed an AMI Implementation Plan also contained within this Assessment Report. The assessment report and associated business case effectively provides GRU management with a go/no-go decision point on whether to proceed with an AMI and MDM Implementation Project.

To effectively assess complex technology, UtiliWorks employs a proven delivery mechanism called the UtiliWorks Advantage™ detailed in Appendix VI. UtiliWorks' assessment approach facilitates the identification of the business drivers motivating the effort to undertake an AMI implementation project. It also identifies the critical success factors to support implementation and risks that could undermine success.

- **State of the Industry** – personalized, on-site presentation outlining the current state of the AMI industry and discussing important design considerations unique to GRU
- **Discovery** – stakeholder interviews to identify opportunities, gaps, and risks to be addressed in preparation for an AMI implementation
  - Operational, financial, and system data collection from selected internal stakeholders
  - Goals & Objectives identification
- **System Readiness and Gap Analysis**
  - Current state operational gap analysis and recommendations
  - Identify and analyze key operational areas/functions that will be impacted to minimize risk during and after AMI system deployment
  - Assess IT systems readiness
- **Business Case/Financial Analysis** – provide a current cost/benefit analysis underlying an AMI & MDM project, including electric, water, and gas deployment
- **Project Planning & Implementation** – further detail on a proposed AMI/MDM project schedule, recommended project phasing, and staffing from Pilot Verification through full deployment and beyond
- **Final Recommendations -** summarized in the report, and presented to the GRU Team.

Section C - Discovery

1. Goals & Objectives

Gainesville Regional Utilities has been assessing advanced metering infrastructure technologies since 2007. To better understand the most recent and current drivers for re-considering an AMI & MDM implementation in 2018, UtiliWorks met with the GRU assessment project team members to collect and establish GRU's cross-cutting goals and objectives from all impacted departments and stakeholders. The approach involved a series on meetings by department to evoke departmental visions and strategies. UtiliWorks has taken the data that was collected and formed a cohesive and comprehensive set of Goals and Objectives as shown below.

Table 1: Goals & Objectives

Goals	Objectives
Reduce billing adjustments	Use the AMI VEE data to avoid potential human error in meter reading and billing processes
Reduce the number of back bills for stopped meters by identifying meter issues sooner	Use the AMI and/or MDM systems to find stopped meters sooner to reduce the loss of revenue
Offer improved and more flexible billing options for customers	Improve customer service by providing the ability for customers to receive a bill when they want it
Implement a pre-paid metering and billing system	Reduce write offs due to bad debt and make it easier for customers to proactively manage their own accounts and bills
Reduce the time it takes to process delinquent accounts	Reduce interaction with code 2 customers and associated costs
Improved customer-side leak detection	Reduce the time (latency) to detect customer-side leaks thereby reducing the number and cost of write offs due to high bills
Provide near real time detailed customer consumption data to internal and external consumers	Use the AMI and MDM systems to improve the level of detail available to CSRs and customers to reduce the number of customer inquiries and effort required to resolve billing disputes while improving customer service, satisfaction, and trust
Provide special needs shelters restoration data during emergency conditions.	Increase customer service by providing restoration updates without having to roll a truck to validate a restoration condition.
Reduce the average ‘speed of answer’ to industry standards (80% of the calls answered in 30 seconds)	Implement a customer engagement platform to increase the ability for customers to self-serve to reduce the number of customer inquiries, freeing up current staffing levels to respond to calls more quickly
Reduce the average call handle time to industry standards	Implement a more automated payment arrangement process to reduce the length of calls required to process these customer requests
Reduce the number and length of calls	Increase the quality and quantity of data available to CSRs to use when responding to customer inquiries to reduce the length of calls while increasing customer service and trust

Goals	**Objectives**
Utilize standard best practice integration protocols to improve the integration of technology platforms in near real time	That all current and future integrations can be easily introduced and maintained; reduce overhead costs, increase reliability, and create an ecosystem that will utilize enterprise solutions and best practices
Install and implement an AMI system to reduce the number of trips and time on-site required by meter services and operations resources	Save time and money, reduce GRU's carbon footprint, prevent and reduce injuries to GRU staff, reduce medical costs due to dog bites and other physical risks
Identify downed Aerial Distribution Cables during severe weather events	Use the AMI system to rapidly find, validate, and repair downed cables to reduce public safety hazards and issues
Perform remote on-demand outage or restoration validation	Increase the ability to prioritize field service WOs in emergency conditions to increase the value of deployments, reduce wasted trips, and reduce costs
Use AMI outage & restoration data in the OMS	Speed up the restoration process, deploy service techs more accurately to save costs, increase revenue, and confirm restoration
Implement a TOU program	Increase customer service and satisfaction while reducing operational cost by balancing load factors. NOTE: LED street lights will factor into overall daily load balancing
Improve the ability to find and interpret blinks	Identify potential problems before they occur; enable the utility to identify and proactively address locations requiring preventive maintenance (i.e., trees) increasing reliability and revenue capture
Maximize transformer utilization and performance	Reduce capital costs, right size transformer installations for predictive analytics, and validate planning models
Measure photovoltaic (PV) energy going into feeders	Use the AMI system to determine how much capacity is available for contractors; maximize the PV capacity available for customers
Minimize electric losses and provide improved voltage profiles for customers	Monitor power quality remotely, validate cap bank locations, and strategize cap bank locations for VAR control
Model solar generation in near real time	Increase reliability and situational awareness for the system operators (fixed generation load forecast) so they can optimize supply requirements

Goals	Objectives
Optimize power quality issues and management	Increase customer satisfaction by reducing damage to their sensitive equipment; reduce the cost of field investigations by troubleshooters when responding to customer inquiries and complaints
Implement a DSM Program	Implement a financial incentive program to motivate customers to change their behavior to provide GRU with the ability to avoid large capital investments.
Implement a Demand Response Program	Implement a DR Program to increase control of dedicated consumer appliances and revenue while mitigating operational costs to GRU.
Implement a Demand Load Program	Implement a DLC Program that would provide credits to customers to incentivize them to allow GRU to control dedicated consumer appliances for a brief period to reduce demand during peak times of days in specific weather conditions.
Improve the ability to track and locate stolen meters	Use the AMI system to increase the ability to catch and fine potential thieves to protect revenue
Increase real time theft alerts to reduce the amount of time required (latency) to detect and identify theft of product	Use the AMI system to increase the ability to catch and fine potential thieves to protect revenue; recover more than $250,000 in electric losses
Reduce meter test and re-read service orders	Use the AMI and MDM systems to reduce the cost of truck rolls; in addition, use the digital data to satisfy customer high bill inquiries without having to order meter tests and associated costs
Reduce the number of implausible meter reads	Implement AMI & VEE systems to reduce the number of implausible meter reads, reducing truck roles and associated costs
Increase self-service options for customers	Reduce the number of customer inquiries and costs

2. Discovery Data Collection & Current State Findings

Billing

The Billing staff consists of five to ten resources depending on the activities being performed. GRU currently uses SAP Customer Care System (CCS) CRM v4 to support Billing and Customer Service activities; an upgrade is planned for the CCS with a projected completion date of Q1 2021. The data integrity of the CIS is reported to be "strong".

GRU produces bills every day and sends a monthly bill to each customer. The bill contains whatever combination of products a customer buys from GRU. There are approximately 101,000 bills produced and sent every month. Bills are estimated when necessary. It takes 4 days on average to produce a bill from when the read is taken to when it's sent to the customer. Customers have 21 days to pay a bill before a delinquent notice is sent. Only one notice is sent, and delinquent accounts are shut off 14 days after the due date if no request for payment arrangements have been made. Billing processes bills for refuse as well.

Meter Reading

GRU's meter reading team consists of 25 team members who cover over 100 square miles on 21 cycles and more than 500 routes. There are 12-meter reading vehicles used daily by the team, though the routes themselves are mostly walked. Approximately 10,000 meters are read concurrently every day in accordance with a formal, published, monthly schedule. Some electric, water, and gas routes overlap one another, and there are some water or gas only routes. The meter reading team reads all three services at one time; compound water meters are read as a single read, and vacant accounts are read as part of the normal reading routine.

GRU uses Itron MV-RS and MV-90 reading software, which works in conjunction with the meter readers' handheld devices. The routes are downloaded daily, with the reads uploaded daily and sent to Billing for processing. MV-90 meters are used for more than 200 customers and are read daily. The data is backhauled via cell modem, and there is 15-minute interval data for key accounts who have access to that data (approximately 30 accounts; kW and kVAR data are collected from these meters. There are approximately 400 re-reads per month, and service orders are issued from the mobile service software system to support this process.

Meter Services provides the support required for all delinquent shut-offs and turn-ons as well as all move-in and move-out requirements. Additionally, Meter Services performs after-hours reconnects when payment is made for delinquent accounts.

There is a formal meter testing program and process, as well as on-demand meter testing in response to customer requests; meters are changed out as required. GRU experiences approximately 100 tamper and theft cases per month, depending on the number of delinquent accounts, and carry a $150 penalty fee.

GRU performed an AMI pilot project where more than 1,400 electric meters were installed, but the data from these pilot AMI meters is not currently being used for billing purposes.

Customer Operations

Customer Service consists of 50 team members, including 38 customer service representatives (CSRs). The CSRs are responsible for assisting customers in processing payments, resolving billing discrepancies, handling delinquent accounts, and resolving disputes. The top three typical calls from customers are payment arrangements, complaints of high bills, and requests to stop and/or start services. GRU receives approximately 500,000 calls per year, and the average call length is five minutes and 45 seconds. In addition to calling, customers can also pay bills or make inquiries in person at the Administration Building or pay bills at participating retail stores.

GRU also has a customer web portal on the utility's website. The Customer Engagement Platform uses a third-party service to accept payment for amounts owed across all three services (electric, water, and gas). Furthermore, the web portal also allows customers to view consumption history, schedule stop and/or stop service, request tree trimming, and more services. Customers can choose to pay using a one-time or recurring payment with a credit, debit, or ATM card, as well as a one-time or recurring payment with a bank draft.

Electric Meter Shop

The electric meter shop presently has 5 test boards which range from less than 5 years old to 30 years old. The test boards are calibrated annually. GRU also has some portable meter testing sets. There is a formal meter testing and retirement program in place, which supports random sampling tests as well as stopped meter testing. All meters purchased from meter vendors are inspected and tested upon receipt. To support data integrity, the meters are purchased with bar coded name plates for scanning upon receipt. The meter shop personnel have extensive computer and software experience and can work with new modern technologies as the need arises. They have adequate warehouse and inventory capacity to support an AMI implementation.

Electric Operations

GRU owns and manages more than 2,500 linear miles of primary distribution equipment in and around the City of Gainesville; GRU also rents streetlights to the city. There is a SCADA system under contract from OSI that not only provides full T&D functionality but also monitors the status of 17 substations with 100 SCADA-controlled reclosers. SCADA also monitors MW, MVARS, amps, and voltage in real-time values for situational awareness at the individual substation level; the electric distribution team can operate and control substation voltage and transmission capacity banks from the control center. The transmission cap banks are operator controlled by SCADA Distribution Cap Banks Eaton - Yukon Capacitor bank controller. Yukon monitors VARs at the feeder level and automatically operates cap banks as needed to minimize losses. Communications between the control center and substations uses DNP3.

There is an outage management system (OMS) currently in use, though there are plans to move to a new OMS by mid-2018; the new OMS will be interfaced with the legacy IVR, RIS, and CIS. GRU doesn't own any distributed generation equipment but works with customers who own solar generation equipment. Currently, there are no direct load control or demand-side management programs in place.

There are some power importing, generation, and availability constraints reported for the Deerhaven area, but there are transmission and distribution contingencies available during times of exceptional conditions. There is a new transmission corridor project planned that is scheduled to begin in 2020.

Gas Operations

GRU is a distributor of natural gas with nearly 800 miles of distribution lines and no gas storage capacity. There are no compressors used on the distribution system. There is a SCADA system in place which is being used just to monitor. There are remote monitoring capabilities for pressure, temperature, and flow at key locations, but no remote-control devices in the field. There are 41 regulator stations with real-time alarms and reporting available. The Gas Operations team has a high level of metering accuracy with a low rate of lost gas; theft and unmetered consumption is not considered to be an issue at this time. Currently there is a 999-home subdivision, with approximately 150+ homes already built, being built over the next 5-8 years. GRU is also building back feeds for other large neighborhoods that only have a single source feed. Additionally, GRU is in discussion regarding a new gate station, but there is nothing solid on this project yet.

Gas Meter Shop

The Gas Meter Shop has one meter testing bench, which is more than 20 years old. It is calibrated every five years and recertified every two years. There is a formal meter testing program in place. GRU has some pressure compensated gas meters, which are identified in the CIS. There are also some temperature compensated meters with electronic flow computers that are monitored by the SCADA system.

Water Operations

GRU's water service area covers more than 100 square miles and provides water to more than 70,000 customers. The raw water source is the Floridan aquifer which is drawn from 16 wells. The distribution system has more than 1,000 miles of main lines and is managed using a SCADA system. Isolated parts of the distribution system are flushed periodically for water quality. These flushing activities amount to .28MG per year. All distribution system meters larger than 3" are tested and calibrated as part of a formal annual maintenance program. There is also a formal leak detection program in process to manage the ongoing breaks that occur every year. There are 55 breaks per year on average at .5MG per break. Pressure reductions are monitored at the plant. All detected and/or reported leaks are addressed within a couple days. There is a complete water audit performed annually.

Wastewater Collection & Treatment

There are nearly 800 miles of wastewater lines that collect 18.6MGD and transport it to two wastewater treatment plants that have reclamation systems. Wastewater has its own SCADA system.

Water Meter Shop

The Water Meter Shop does not have a test bench of its own, but it utilizes a vendor test bench that supports an annual field testing program for all meters 3” and larger. There is an 18 year change out program in process for residential meters.

Water Conservation

There is no conservation standard designated by the state of Florida, however GPU measures and tracks the per capita use and produces an annual report. There is a water conservation goal to not exceed 30 MGD through 2033, as it relates to aquifer recharge. The water conservation programs in place include shower heads, irrigation timers, and a toilet retrofit program. There is limited funding for conservation programs.

Communications

The existing communications infrastructure appears to be capable of supporting products from a variety of AMI providers, as related to backhaul and data security. Depending on the selected vendor, tower height and availability could be a concern, as tower height has a significant impact on RF range for meter communications; if a mesh network is selected, this is not a major concern.

IT

The existing IT environment does not present any major concerns related to the introduction of AMI and MDM. However, it is important to recognize that it can be complicated to integrate the current CIS environment (SAP) with both AMI and with MDM, as 'native' support for integration platforms such as MultiSpeak (Versions 3.0, 4.1, or 5.0) have not been fully supported in the past. MultiSpeak provides a relatively simple and standard integration path for AMI and MDM with advanced capabilities, including remote connect/disconnect, from within the CIS without complex development. It will be necessary to further discuss MultiSpeak support with SAP.

Section D - Current State Gap Analysis & Recommendations

UtiliWorks has provided support and guidance to several multi-service utilities as they plan, design, develop, test, train, deploy, and accept AMI systems. The first step in this process is to assess readiness and identify potential operational gaps that could pose a challenge during implementation and with ongoing system maintenance and support.

The UtiliWorks team has examined GRU’s current utility operations spanning the 13 departments invited to this assessment development effort. Meter hardware, communication equipment, software systems, reporting capabilities, and personnel have been included in this work. The information was acquired via data requests and through a series of on-site and off-site stakeholder interviews with the 13 respective departmental teams.

UtiliWorks' findings can be broken into several categories:

- Hardware/Software
- Backup and Disaster Recovery
- Security
- Data Network Physical Diagram
- Application and network monitoring capabilities
- Integration readiness
- IT Support (skills/capabilities)
- Business Process Related Functions

GRU team members across the organization discussed potential opportunities and constraints in their operations which could impact the implementation of an AMI system. This information was reviewed and analyzed to establish GRU's reference point upon which to identify anticipated gaps. This information was also used to establish the necessary assumptions to develop the business case analysis. Review of these functions also provides a baseline for the current state business process designs so that required process changes can be identified, defined, and discussed.

UtiliWorks conducted a State of the Industry presentation to a large cross-section of the organization. In general, the GRU team appears well-equipped and well-informed. Staff has also given much consideration to the project staffing needs, along with the new opportunities that will be available.

Beyond their current operations, UtiliWorks worked with team members across the organization to understand the goals and potential gaps which could impact the implementation of an AMI and Meter Data Management System. This information was reviewed and analyzed to establish GRU's reference point upon which to identify anticipated gaps in technology or resources.

In general, GRU's technology environment is suitable for an upgrade to AMI and MDM technology. The CIS system, from a functionality standpoint, will be able to integrate with almost any mainstream AMI and MDM system solution; there are some concerns with SAP support for MultiSpeak integration, which is highly preferred for AMI and MDM integration to mitigate integration time and costs.

The existing backup and disaster recovery environment is well-architected and certainly can support 'on-premises' AMI and MDM and would be able to provide necessary redundancy for 'hosted' or SaaS AMI and/or MDM.

While UtiliWorks hasn't conducted a full security assessment including penetration testing, the information provided by GRU indicates that GRU has implemented appropriate levels of security for each of its services provided to customers. Alternatively, GRU has some gaps when it comes to adequate staffing to support an automated metering program. New roles and responsibilities will be created, and positions need to be filled to realize the full benefit and value of an AMI and MDM system. See the implementation strategy section for an estimated level of effort per position required to support an AMI deployment and post-deployment operations.

NOTE: The tables located in Appendix II identify key desired state functions and outlines UtiliWorks observations of potential gaps specific to GRU that could threaten a successful deployment and provides recommendations to close them.

Section E - Business Case & Financial Analysis

The foundation of GRU's business case is the implementation of a comprehensive AMI solution. This includes an AMI system, an MDM, a Customer Engagement Platform (portal), and the necessary integration of these systems to produce an accurate bill. As part of this effort, GRU will need to replace some meters and retrofit other meters so that all electric, water, and gas meters are equipped with AMI technology. The meter replacement determinations are discussed in greater detail within the Assumptions section below. These programs all leverage the AMI technology and would therefore not be feasible without the implementation of AMI in GRU's service area.

UtiliWorks developed a comprehensive financial model, which represents the deployment of these various technologies. There are three primary areas that comprise the business case:

- Capital Costs (i.e., AMI infrastructure, equipment, installation, professional services, etc.)
- Ongoing Operation and Maintenance (O&M) Costs (i.e., annual fees related to software hosting and licensing, staffing, etc.)
- Anticipated Benefits (i.e., potential operational savings, revenue enhancement, recovery of losses, etc.)

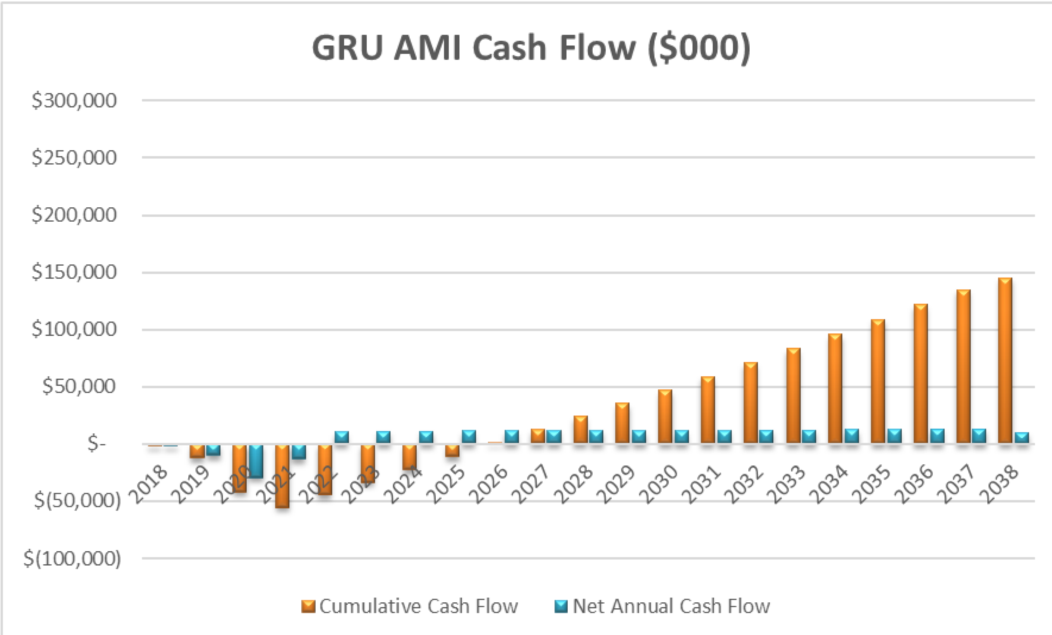
UtiliWorks' general approach when developing the model is to review the assumptions with the respective GRU staff and ultimately arrive at a conservative result. This section provides the business case results summary, project assumptions, and a breakdown of costs and benefits used in calculations. The detailed model inputs provided by GRU along with assumptions underlying the cost and benefit calculations are provided in Appendix III and Appendix IV. The Microsoft Excel-based financial model can facilitate changes to the underlying assumptions and examine various scenarios with relative ease. For purposes of this report, UtiliWorks modeled a single base case scenario that includes all desired functionality.

The model provides a variety of financial metrics for GRU to evaluate the financial viability of the AMI project, including the Net Present Value (NPV), the estimated payback period, and Return on Investment (ROI). Please see Table 3 below for the summary of Business Case results based on deployment of AMI, MDM, and Customer Engagement Platform with add-on programs: Prepay, Water Distribution Pressure Monitoring and Water Leak Detection.

Table 3: Business Case Results

Net Present Value ($000)	$48,573
Internal Rate of Return	16.3%
Return on Investment	174%
Payback Period	9 Years
Total CapEx ($000)	$67,629

Figure 2: Project Breakeven



1. <u>Assumptions</u>

To arrive at the business case results, UtiliWorks incorporated some basic assumptions underlying the AMI project. Please see the following overview of major assumptions that are incorporated into the business case analysis:

- GRU is considering contracting the AMI meters installation but will assign GRU resources to oversee all installation activities. The business case assumes a 1-year Pilot Verification starting in October 2018, followed by a 2-year AMI deployment.
- Hosted services are assumed for the AMI headend and MDM applications. Software hosting and maintenance fees have been applied as future operating expenses.
- A concurrent AMI deployment for electric, water, and gas.
- General model assumptions are shown in Table 4 below.

Table 4: General Assumptions

Assumption	Metric
Annual Electric Meter Growth Rate	0.86%
Annual Water Meter Growth Rate	1.12%
Annual Gas Meter Growth Rate	1.03%
Depreciation Period	20 years
Deployment Period	2.5 years
Discount Rate	6.5%

For purposes of the business case, all electric meters will be replaced (95,983). The new meters will come with the AMI radio device embedded in the meter. Approximate meter counts as they relate to relevant electric meter characteristics are outlined in Table 5.

Table 5: Electric Meter Population Characteristics

Electric Meter Type	Replace Count
Single Phase - 1S w/ Remote Disconnect	650
Single Phase - 2S CL 200 & 320 w/ Remote Disconnect	87,140
Single Phase - 3S	9
Single Phase - 4S (Voltage Specific 240V & Multi Form)	217
Poly Phase - 5S 45, CL20	8
Poly Phase - 9S (8S), CL20	1,317
Poly Phase - 12S & 25S, CL 100, 200 & 320 w/ Remote Disconnect	3,792
Poly Phase - 16S (14S, 15S), CL200, 320 &480)	2,850
TOTAL	**95,983**

GRU has a total installed water meter population of approximately 72,652. All water meters size 5/8” will be replaced, along with 3/4” and 1” iPERL (Sensus) meters. It is estimated that 50% of meters size 1 1/2” – 10” are OMNI (Sensus) meters and will be replaced. All other water meters will be retrofitted with the necessary connector and encoded register and will only require the installation of the AMI radio/endpoint. These numbers may change once a meter/AMI vendor is selected. Water meter population, by size, is provided in Table 6.

Table 6: Water Meter Population

Water Meter Type	Replace Count	Retrofit Count
5/8" x 3/4"	62,937	-
3/4"	6,373	-
1"	1,608	-
1-1/2"	388	375
2"	398	375
3"	41	42
4"	23	24
6"	21	22
8"	9	10
10"	3	3
TOTAL	**71,802**	**850**

GRU has a total installed gas meter population of approximately 36,021. The decision to replace versus retrofit meters are based on the age of meters; 10 years and older are replaced while the newer meters are retrofitted. The decision on replacing meters are also based on if a known issue is discovered during the process of changing out the meter. Gas meter population, by CFH rating, is provided in Table 7.

Table 7: Gas Meter Population

Gas Meter Type, Sorted by CFH rating	Replace Count	Retrofit Count
175	2,773	-
250	18,825	11,913
425	958	477
630	295	233
800	164	56
900	-	3
1,000	-	103
1,400	-	32
1,500	-	2
2,000	20	-
2,300	-	22
3,000	22	33
3,500	-	11
5,000	2	29
7,000	16	17
10,000 – 60,000	-	15
TOTAL	**23,075**	**12,946**

2. Cost Estimate

UtiliWorks utilizes up-to-date vendor pricing for all model cost estimates. Figures are obtained based on recent market quotes from manufactures and suppliers, as well as a vendor database that reflects pricing obtained for recent projects. Whenever conflicting pricing is recognized, UtiliWorks will present a blended rate or upper estimate in the financial model cost assumptions. This method is used to ensure that GRU is provided with a conservative estimate.

Accurate pricing for GRU is anticipated to be slightly lower than these results, however until proposals are received, actual costs cannot be verified.

Based on the assumptions used, the total capital outlay is projected to be $67.6 million. Table 8 shows a summary of all estimated project costs including capital and ongoing operations and maintenance (O&M) costs. Note, these costs will not all be incurred in the first year, but rather over the designated deployment periods that were discussed in the Assumptions section. Individual costs that make up each cost category can be explored in full detail in Appendix III.

Table 8: Estimated Project Cost

Cost Category	Total Capital Cost ($)	Annual O&M Cost ($)
AMI Costs		
AMI Network Infrastructure & Head End Software, MDM, Customer Engagement Platform	$ 1,500,000	$ 575,000
Program Management Services (Vendors, Consultants, Integrations)	$ 4,881,938	$ -
GRU Project Team	$ -	$ -
Electric Meter/Equipment Costs		
Electric Meters	$ 11,102,165	$ -
Electric Meter Installation Services	$ 3,084,659	$ -
Contingency (10%) + Hardware Sales Tax (9%)	$ 2,780,690	$ -
Water Meter/Equipment Costs		
Water Meters and Lids	$ 17,244,790	$ -
Water Meter Installation Services	$ 3,477,868	$ -
Contingency (10%) + Hardware Sales Tax (9%)	$ 3,619,638	$ -
Gas Meter/Equipment Costs		
Gas Meters	$ 12,261,666	$ -
Gas Meter Installation Services	$ 4,656,852	$ -
Contingency (10%) + Hardware Sales Tax (9%)	$ 2,435,192	$ -
Prepay		
Prepay Software	$ 100,000	$ 22,000
Professional Services	$ 50,000	$ -
Contingency (10%)	$ 15,000	$ -
Water Pressure Monitoring		
Water Distribution Pressure Sensors	$ 55,225	$ 14,675
Professional Services	$ 5,500	$ -
Contingency (10%)	$ 6,073	$ -
Water Leak Detection		
Leak Detection Sensors + Software + Integration Services	$ 320,000	$ 61,000
Contingency (10%)	$ 32,000	$ -

The estimate percentage breakdown of capital expenses by utility is as follows: Electric + AMI network 35%, Water 36% and Gas 29%.

3. Benefits Estimate

GRU completed an initial financial data request, followed by the model assumptions and results review with UtiliWorks. All benefits used in the financial model are based on the annual operating expenses and capital budget costs for GRU. Table 9 summarizes all benefits areas, their value driver with key calculation assumptions, and annual value for the first year of full operation. Full details of the Benefits Assumptions can be found in Appendix IV.

Table 9: Project Benefits Summary

Benefit Area	Key Assumption(s)	Annual Benefit ($)
Electric AMI Deployment Benefits		
Meter Reading Reduction	95% reduction	$1,423,954
Electric Re-Read Reduction	90% reduction	$47,303
Electric Move-In/Out Reads Reduction	90% reduction	$596,119
Electric Customer Service Engagement Expense	90% reduction	$376,194
Electric Non-Pay Disconnect Non-Payment Labor	90% reduction	$1,429,144
Conductor Repair	5% reduction	$60,900
Annual Recovery of Revenue due to Outage Management	20% reduction in response time	$20,746
Outage Labor Reduction	20% reduction in response time	$11,167
Electric Theft Identification	95% theft identification	$10,795
Electric Annual Meter Replacement Budget	90% reduction rate for the first 10 years	$155,590
Electric Bad Debt Reduction	25% reduction (assuming all electric meters have remote disconnect)	$181,620
Electric Meter Scrap Value	Scrap value = $0.45/lb. for electric meters, Res. meters = 2 lbs., Comm.= 4 lbs.	$90,346
Revenue Capture from Improved Electric Meter Accuracy	90% improvement for replaced electromechanical meters	$618,381
Water AMI Deployment Benefits		
Water Meter Reading	95% reduction	$1,077,828
Water Re-Read Reduction	90% reduction	$133,965
Water Move-In/Out Reads Reduction	75% reduction	$355,587
Water Customer Service Engagement Expense	90% reduction	$284,751
Water Non-Pay Disconnect Non-Payment Labor	90% reduction	$357,263
Water Theft Identification	95% theft identification	$6,216
Water Annual Meter Replacement Budget	90% reduction rate for the first 10 years	$352,500
Water Bad Debt Reduction	90% reduction	$21,377
Water Meter Scrap Value	Scrap value = $1.20/lb. for water meters, Res. meters = 3 lbs., Comm.= 5 lbs.	$260,609
Revenue Capture from Improved Water Meter Accuracy	90% improvement for replaced meters over 15 years	$487,248

Main Breaks Prevention/Reduction	5% improvement in prevention	$170,625
Pumping Schedule (Lower Pumping Costs)	10% reduction	$105,757
Gas AMI Deployment Benefits		
Gas Meter Reading	95% reduction	$534,389
Gas Re-Read Reduction	90% reduction	$15,768
Gas Move-In/Out Reads Reduction	90% reduction	$94,119
Gas Customer Service Engagement Expense	90% reduction	$141,180
Gas Non-Pay Disconnect Non-Payment Labor	90% reduction	$198,480
Gas Theft Identification	95% theft identification	$3,571
Gas Annual Meter Replacement Budget	90% reduction rate for the first 10 years	$300,523
Gas Bad Debt Reduction	90% reduction	$61,178
Gas Meter Scrap Value	Scrap value = $0.20/lb. for gas meters, Res. meters = 3 lbs., Comm.= 5 lbs.	$14,652
Revenue Capture from Improved Gas Meter Accuracy	90% improvement for replaced meters over 15 years	$23,022
PrePay Benefits		
Billing/CS Handling Expense - PrePay	10% reduction	$84,295
Prepay Write Off Reduction	10% reduction	$103,198
Water Pressure Monitoring		
Pumping Schedule (Lower Pumping Costs)	10% cost savings	$211,514
Main Breaks Prevention/Reduction	10% improvement in prevention	$341,250
Water Leak Detection		
Water Loss Reduction due to Detected Leaks	5% reduction	$249,380

It is important to remember that while the business case results provide a fairly accurate estimate of the expected project costs and payback, this model merely represents a conservative estimate of the full value of an AMI project.

AMI technology fundamentally changes the meter-to-cash process. What is not easily recognized is that, depending on the supporting technology and business process changes employed, a utility can realize even greater benefits through the proactive use of the data and information made available through AMI. Leveraging AMI technologies will significantly improve the measurement and management of utility resources and will bring direct benefit and value to customers.

The following section will outline the potential benefits that can be realized with the data yielded from an AMI system along with add-on technologies. UtiliWorks worked with staff at GRU to derive the necessary data and assumptions to calculate the potential benefits and factored those conclusions into the business case analysis in Section E. The potential qualitative benefits that are more difficult to quantify are also discussed.

4. Quantitative Benefits

a. AMI Benefits

- **Meter Reading Reduction** – Elimination of on-cycle manual meter reading expenses, including staff time, fuel, and vehicle maintenance costs and safety issues.
- **Billing Services and Exception Handling Reduction** – Reduction in billing service expenses associated with increased efficiencies. A modern MDM will contain advanced Validation, Editing, and Estimation (VEE) functionality and accurate real-time and historical meter data information. This can translate to fewer bill estimations, billing errors, adjustments and customer inquiries.
- **Re-Read Reduction** – Elimination of most check-read/skip/no-read field activities and expenses for reviewing skips report, processing service orders and rolling trucks to collect re-reads. A revised billing process will have a range of dates a read may be pulled from to use to produce a bill (e.g. read date or two days prior) and/or a read may be collected via on-demand reading functionality. The elimination of field service activities can increase billing throughput.
- **Customer Call Cost Reduction** – Reduction of cost related to decreased number and length of customer calls. This reduction occurs from a combination of detailed online usage information now available to a CSR to better respond to customer inquiries, in addition to customers having access to their own information by way of a Customer Engagement Platform. Customers can be able to leverage the technology for themselves to configure usage notifications via text or email. Customers self-serving has the potential to free up existing CSR resources to reduce call wait times.
- **Move-In / Move-Out Read Reduction** – Elimination of most off-cycle read field activities when customers move in and out of a premise. This savings will result from new presentation of daily AMI reads and the ability to collect on-demand out and/or in reads.
- **Non-Pay Disconnect Reduction** – Reduction in collections labor and field activities for non-paying customers. Most trips to a premise can be avoided leveraging remote disconnect/connect capability of electric, water or gas AMI meters.
- **Electric Distribution System Asset Performance Improvement** – Reduction in O&M costs from utilizing real-time AMI data to assist with operational management decisions. Manual adjustments or integration with a SCADA system can result in performance improvements via electrical distribution system controls.
- **Electric Meter Accuracy Improvement** – Electromechanical electric meters degrade over time. According to a study performed by the Electric Power Research Institute (EPRI), electromechanical meters register at a slower rate if not calibrated; the slower rate ranges from 0.5% after five years to 2.75% after 20 years. Electromechanical meters older than 20 years account for approximately 71% of GRU's electric meter population.
- **Water Meter Accuracy Improvement** – Mechanical water meters experience a degradation of accuracy over time. This degradation is a function of several factors, such as wear, water quality, and throughput volume. However, utilities will often use an AMI project as an opportunity to replace older meters and realize lost revenue.
- **Theft Identification Revenue** – Alarms triggered in the AMI meters and software can identify both electric and water meter tampering and product diversion. This

is a valuable tool for the revenue assurance function to identify theft in near real time as compared to monthly when the meter reader puts eyes on a meter and increase the chances of catching violators in the act.

- **Meter Scrap Revenue** – Added revenue from the scrap of old meters during replacement. Local market pricing is utilized for all scrap values and the weight is determined by the number and size of meters to be replaced as part of the project.
- **Annual Meter Replacement Savings** – Eliminate current annual meter replacement spending for faulty meters by installing new AMI-ready meters with long-term warranties. Any capital cost for new meters will be accounted for in the capital costs of the financial model, so this is added as a benefit to avoid any double counting of the meter replacement budget.

b. Prepay Benefits

- **Prepay Billing Services and Exception Handling Reduction -** Further reduction in billing service expenses associated with increased efficiencies upon the implementation of a prepay program. Self-serve kiosks and services online can reduce payment handling and payment plan monitoring around peak bill due dates.
- **Outstanding Payments/Write-Off Reduction** – Reduction of debt through the prepay program's requirement to pay for services "up front." Bad debt write-offs can be reduced from transitioning frequent non-pay disconnect customers to a prepay program.

c. Water Distribution Pressure Monitoring

- **Distribution System Cost Reduction** – A significant savings can result from efficiency gains from proactive distribution system monitoring via pressure monitoring. UtiliWorks uses a conservative estimate of 0.5% efficiency gains applied to distribution O&M costs.

d. Acoustic Leak Detection

- **Unaccounted for Water Loss Savings** – A significant savings of unaccounted for losses may be recovered via acoustic leak detection. This technology allows the utility to identify leaks through remote devices that piggyback on the AMI network. The devices are placed in strategic locations throughout the water distribution system to provide full system monitoring.

5. Qualitative Benefits

In addition to those benefits that can be quantified and included in the business case analysis, GRU can realize numerous intangible/soft benefits. While many of these benefits are not easily measured, they are certainly real and achievable with the successful deployment of an AMI system.

- **Improved System Planning Capabilities -** Information that can be produced and analyzed from an AMI system can facilitate improved management and monitoring of electric, water, wastewater, and gas system performance. This information can lead to improved capital investment decisions, such as load peaks (gas, water, or electric), including specific contributors as well as potential impacts to the wastewater system. System engineering and maintenance programs can readily be supported with better and more frequent access to more granular data provided by the AMI system.

- **Energy Management -** Using interval consumption data (consumption, power factor, voltage, etc.), GRU's C&I customers can more effectively manage their energy usage. Of even more value to the utility, detailed information from high-consumption customers will provide data necessary to build more effective predictive power consumption models based on weather, season, and/or other events. The AMI system will enable GRU to more effectively model overall system demand and facilitate proactive management of the industrial customer base including proactive demand-response incentives as well as definitively measure the results of demand-response programs.

- **Improved Water Resource Management –** With the use of interval consumption data, customers can more proactively and effectively manage their water consumption. The AMI system will enable GRU to model overall system demand, identify customer leaks, and facilitate proactive management of the industrial and residential customer base.

- **Water Distribution System Asset Performance Improvement** – Reduction in O&M costs from utilizing real-time AMI data to assist with operational decisions. Manual adjustments or integration with a SCADA system can result in performance improvements via water distribution system controls.

- **Prevention of Customer Claims -** An AMI system can identify events and alarms such as high voltage alarms from a customer-owned meter. Such information, delivered to appropriate GPU staff can lead to preventative maintenance of assets in the field that will either avoid or mitigate customer-side equipment damage.

- **Voltage Optimization -** An AMI system, with properly programmed electric meters, can capture and record voltage readings which can help determine voltage levels throughout a feeder. Equipped with this information, operators can adjust line equipment and tap changers to optimize voltage throughout the distribution line, reducing overall system generation (or power purchase) requirements.

- **Meter Right-Sizing –** Data and alarms produced by an AMI system will provide the utility with the ability to detect if a water meter is 'oversized' or 'undersized.' Inappropriate meter sizing results in inaccurate consumption data, as well as potentially incorrect billing.

- **Unauthorized Use Detection -** Current generation AMI systems provide flags, high priority alerts, or reports for reverse water flow and tamper detection. This information will be of significant benefit to GRU and should also facilitate identification and reduction of unauthorized usage or theft.

- **Improved Safety -** Ensuring safety for utility employees and for customers is essential. With the introduction of Advanced Metering Infrastructure, GRU will have the ability to remotely read meters, initiate on-demand meter reads, and remotely disconnect/reconnect customers. This will dramatically reduce exposure to risky conditions on the road and at a customer premises, such as weather conditions, unfriendly pets, physically hard to access meters, and theft. As a side note, CenterPoint Energy in Houston has reported that their AMI system helped reduce the number of truck rolls in a very 'overwhelmed' environment, while still producing accurate 'billing' information for over 98% of their customers, despite major flooding and hurricane damage.

- **Reduced Carbon Footprint -** Reductions in truck rolls and drive time for Meter Reading and field activities related to non-pay disconnect/reconnect, re-reads, and move-in/out reads will all contribute to a reduction in carbon output by GRU.

- **Compliance with Future Legislative Requirements -** The Energy Policy Act of 2005 placed a requirement on states and non-regulated utilities to investigate and consider AMI for their customers. With the introduction of AMI, GRU will better prepare itself to address future federal, state, and local requirements regarding conservation, time-based-rates, and other energy-related issues.

7. Technology Systems Suppliers & Capabilities

The AMI and MDM provider information shown below is based on recent submitted proposals for projects where UtiliWorks Consulting was engaged to provide support for a Request for Proposals. The information provided does not include every potential vendor for products in these categories but does list vendors that provide products that are consistent with the multiple services provided by GRU and have demonstrated capacity for utilities the size of GRU in terms of customers and meters.

Table 10: AMI Software Suppliers

Provide Name	Meters	Head End Software	Electric	Water	Gas	MDM
Aclara	Yes	Yes	Yes	Yes	Yes	Yes
Eaton/Cooper	No	Yes	Yes	Yes	No	No
Honeywell/Elster	Yes	Yes	Yes	Yes	Yes	Yes
Itron	Yes	Yes	Yes	Yes	Yes	Yes
Landis + Gyr	Yes	Yes	Yes	Yes	Yes	Yes
Sensus	Yes	Yes	Yes	Yes	Yes	Yes
Tantalus	No	Yes	Yes	Yes	Yes	Yes

Table 11: MDM Software Suppliers

Provider Name	MDM System	Other Enterprise Software	Communication Networks	Meters
Aclara	iiDEAS	CSS	Yes	Yes
Honeywell/Elster	Connexo Insight		Yes	Yes
Harris	MeterSense	CIS, Analytics	No	No
Itron	IEE MDM	Analytics	Yes	Yes
Landis+Gyr	Gridstream		Yes	Yes
Oracle	OU MDM	CIS, Analytics, MWM, WAM, CSS, ODM, NMS	No	No
Siemens-eMeter	EnergyIP	Analytics	No	No
Tantalus	TUNet	TRUTrack, TRUView	Yes	No

Selecting AMI and/or MDM systems is a complex undertaking and can be very challenging considering the substantial number and variety of decisions that must be made before final selections can be made. UtiliWorks has been providing guidance to navigate the selection process and has devised tools to support this process to ensure that the best selections and configurations of software and hardware are made. The first step in this selection process is to establish priorities for the capabilities and attributes required to meet the goals and objectives of the proposed system designs. Detailed capability requirements and related priorities for the systems included in this Assessment have been documented and can be found in **Appendix V** for reference. They include:

- AMI System
- Customer Engagement Platform
- Electric Metering System
- Gas Metering System
- MDM System
- Prepay System
- Water Metering System

Section F - Project Planning & Implementation

1. Project Phasing – Scope & Schedule

With an enterprise project of this scope, it is important to track the effectiveness of the implementation and how it meets the pre-established acceptance criteria. Project phasing is a critical aspect of the approach when implementing AMI and MDM systems given the multi-faceted and cross cutting nature of these technologies. This approach divides the project work into specific phases, each with its own measurable outcome which builds from the previous phase. Performing work in this manner reduces the risk that the effort does not get off-track or otherwise proceed without the prerequisite steps successfully completed.

UtiliWorks recommends that GRU undertake and document the following planning activities at the appropriate time during the program:

- Generate a Project Execution Plan
- Generate a Pilot Verification Implementation Plan
- Design and develop all required Test Plans
- Develop Training Plans
- Develop Mass Meter Change-Out Plans
- Define and develop Field/Data Quality Assurance Plans

The business case, as presented, represents a 2-year production deployment duration that was requested by the GRU Team and can be adjusted depending on project financing, resource availability, and other variables specific to GRU. The following sections describe UtiliWorks' recommended deployment approach in more detail.

A. Procurement & Contract Negotiation

The Procurement Phase takes the deliverables from the Assessment Phase and uses them as the basis to prepare the Request for Proposal (RFP) documents that are published to solicit proposals from equipment, systems, integration, and/or professional services vendors. Deeper requirements gathering activities will be necessary to ensure that the RFP communicates GRU needs comprehensively. Evaluation criteria are developed to ensure an objective evaluation of all proposals submitted. UWC conducts the necessary due diligence to arrive at a recommended "short list." The short-listed vendors are invited to present their solution. The shortlist candidates are again evaluated, and final vendors are selected.

UtiliWorks can provide guidance and support to GRU during contract negotiations with the selected vendor. Our experts can review and provide editorial for the proposed vendor contract and SOW, determine whether the SOW complies with GRU requirements and negotiate terms that are as favorable as possible to GRU. Procurement and Contract Negotiation are typically the next projects in the UtiliWorks Advantage Program. UtiliWorks estimates a 6 to 8-month project duration.

B. AMI Pilot Verification

During the past few years, AMI as a technology has matured. There was a transition period after the time when two-way communications between the meter and the 'head-end' system was introduced. During the transition period, utilities began to realize more and more the value of conducting a Pilot Verification Project by building a working "Pilot" system environment. The intent was to reduce risks by testing and verifying the proposed technology to confirm that it functioned within the utility's service area configuration/topology/meter population. UtiliWorks advises our clients to continue to take this approach for AMI systems design and deployment despite the maturity of the technology. Specifically, we recommend a Pilot Verification as a prerequisite to full production deployment.

The underlying philosophy of the Pilot Verification approach is to minimize risk and commit minimal project funding, while reaching basic system functionality as soon as possible. This approach allows GRU to work with each vendor to identify and address issues, test the necessary system integrations with other systems, and to design, develop, and test future state business processes prior to full deployment. **Error! Not a valid bookmark self-reference.**outlines key Pilot Verification attributes and success criteria on the following page.

Table 12: Pilot Verification Success Criteria

Pilot Verification Attributes	Pilot Verification Success Criteria
Establish Business Needs for an AMI System	Set goals and objectives for the AMI system that meet the needs across the organization. Test the AMI systems capability to meet the utility business requirements.
Key Utility Staff Education and Training	At the outset of an AMI effort, identify key utility staff for education and training across all aspects of the program including hardware and software.
Meter Technology Functionality	Establish the Pilot Verification so that all meter variations are tested to minimize meter compatibility issues in the field upon full deployment.
AMI System Functionality	Perform RF surveys for the service area and determine optimum collector locations to provide desired system redundancy. Evaluate, select, and install Collector sites based on criteria for antenna height, power availability, backhaul requirements, and accessibility. Identify RF-challenged locations and a plan for full coverage. Test AMI functionality for the most difficult areas.
AMI Software Functionality	Establish thresholds for alarm criteria and validate proper meter readings are being recorded in the data base. Test all AMI software maintenance alarms.
AMI Work Processes	Identify and estimate work process resource requirements and evaluate actual resource requirements against the Pilot Verification. Test AMI-related work processes for normal operations and exceptions processing and assess staff ability to resolve all foreseeable issues.
Integration Functionality	Test AMI data transfer to the CIS. Verify proper data transmission, test billing flags, and identify data or related work process resolutions. Generate bills for all meter / cycles / routes in the Pilot Verification and resolve issues.
Customer Outreach / Communications	Develop specific communication and customer outreach goals and programs. Identify expected trouble areas/customers and test the communications plan. Develop action plans to address customer concerns.

Based on our experience in deploying AMI and MDM technologies, UtiliWorks recommends the Pilot Verification be split into 2 phases, each described in more detail below.

Phase 1 of the Pilot Verification

The purpose of the Phase 1 Pilot Verification is to establish and test basic connectivity with a cross-section of the meter population in a controlled environment (i.e., meter shop). The goal, at a minimum, is to ensure connectivity between the meter, the collector(s), the AMI head-end, and the MDM. For a more comprehensive Phase 1, the utility can go the extra step to integrate with a test instance of the CIS and produce a bill from automated AMI meter data.

UtiliWorks recommends the use of a dedicated meter test bench, if available, during Phase 1. If not, a limited quantity of metering hardware can be field-deployed during this phase so long as it is easily accessible for troubleshooting and testing. The team will also start work to deploy a limited number of collectors that are able to communicate with the Phase 1 meters. It is recommended that any work required to deploy the full backhaul infrastructure is coordinated and completed during Phase 1 in preparation for Phase 2 of deployment.

During Phase 1, the vendors will install and configure the software, most typically the AMI head-end and MDM system. Prior to installation and configuration, vendors will meet with the GRU team to gather the necessary software/configuration requirements. Systems integration requirements will also be captured. Interfaces and integrations that need to be in place for Phase 1 will proceed through design/development/testing. Phase 2 interface design and development should only proceed once Phase 1 is complete.

Business process re-engineering should be initiated during the initial stages of Phase 1. UtiliWorks recommends that that GRU map out the current state processes as soon as possible and overlap the mapping of future state business processes with the MDM requirements/configuration. Pilot Verification Test Plans and Training Plans will be produced by the vendors for GRU to review, comment and approve. Each vendor should specify what will be required to satisfy Phase 1 and Phase 2, respectively.

UtiliWorks estimates a 5 to 6-month Phase 1 project duration. Quality gates will be planned and executed at the end of Phase 1 with specific acceptance criteria for each vendor that signals their completion.

Phase 2 of the Pilot Verification

Phase 2 begins with limited field deployment of a pre-determined quantity of metering hardware and the remaining backhaul network infrastructure. Since Phase 2 cannot be entered without successful completion of Phase 1, basic meter reading, and billing functionality is available immediately, allowing routes to be moved to automated billing immediately upon route acceptance (if desired). The balance of required systems interfaces should be developed and fully tested during Phase 2.

If GRU decides to employ a third-party installation contractor, it will be necessary to configure and test the interface(s) with the contractor’s work order management system. It is highly recommended that this integration is completed prior to Phase 2 field deployment to provide an opportunity to troubleshoot and resolve issues prior to full deployment efforts. If GRU opts to self-deploy, it will be necessary to assess the in-house work order management system and determine if configuration changes are required to support the full deployment.

Business process reengineering improvements are finalized and tested, to allow for debugging and approval prior to full production deployment. This provides the end users time to adjust to new processes and procedures and builds familiarity with the new systems and methods to be employed. Additional functionality is added and tested in stages, with the goal to complete system integration and process documentation activities prior to user training and system acceptance testing.

User training runs in parallel with the end of Phase 2, typically beginning approximately two months before the end of Phase 2. A “train the trainer” approach is recommended and GRU SME’s are expected to be named to support the impacted business processes. The respective users/system owners and system administrators are trained on full use of the AMI head-end software, MDM software, and Customer Engagement Platform. Much of the field training has been completed (OTJ – On the Job) for the GRU staff given the work performed during both Phase 1 and Phase 2.

There is a comprehensive quality assurance (QA) effort that must be planned for during Phase 2. Phase 2 is also the time to plan for parallel testing and the desired timing to “go-live” with AMI meter reads for billing.

Phase 2 is complete with GRU system acceptance. This serves as the quality gate to move forward to full deployment. UtiliWorks estimates a 4 to 6-month Phase 2 project duration.

C. Full Production Deployment

With planning, preparation, testing, and training complete, full production deployment is managed more like a construction project in contrast to the Pilot Verification Project. The assumption is that full system functionality is available, with route acceptance to switch a meter from manual to AMI reads for billing. This approach has several advantages, including pushing back warranty start dates until functionality can be used, and the ability to realize the full benefit of deployed devices from the moment they are installed.

Keys to project success include the accurate recording and timely delivery of serial numbers, out and in-reads, various meter characteristics, geographic coordinates, digital pictures, and install notes to the appropriate departments and systems. GRU staff must play an active role in monitoring data and equipment installation quality throughout full deployment.

Full deployment for GRU is estimated to take approximately 24 months with the use of a third-party installation contractor.

D. Supplemental Technology Systems

In addition to updating IT infrastructure to leverage the data generated in an AMI system, GRU has expressed interest in several technologies to improve efficiencies. UtiliWorks recommends that utilities include these elements in the RFP and indicate intent to deploy during the Phase 2 Pilot Verification to leverage the AMI communications network. The outcome of this testing will assist utilities in a comprehensive system and program design, and conclude how best and when to deploy these technologies across both legacy and future GRU system environments.

Prepay Billing

With the advent of AMI and remote disconnect meters, utilities now can remotely shut off and reconnect an electric/water/gas meter. However, the credit/collections processes and the associated planning, organization, and tracking costs of bad debt still occur. The bulk of the savings is limited to the cost of disconnect and reconnect truck roll.

Acoustic Leak Detection

By attaching an acoustic sensor to the AMI or AMI endpoint, GRU's utility will be able to monitor its distribution system along with customer service lines to get complete system coverage. The acoustic sensor will monitor pipe conditions, looking for changes in the sound that travels down the pipe. The sensor has been designed to listen for a certain frequency range that represents the frequency a leak would produce. The sensors will leverage the AMI communications network to provide a snapshot of its system as often as it obtains the network reads. This leak detection system should be integrated with the AMI utility management platform established by the utility.

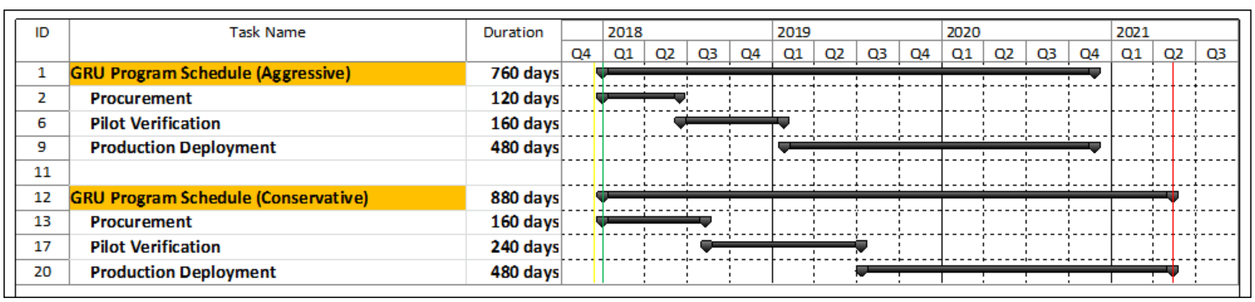
Pressure Monitoring

A remote pressure monitoring system can be deployed in parallel with an AMI network deployment, leveraging the communication infrastructure. The pressure sensors are installed throughout the distribution area, typically two sensors per district metering area or pressure zone – ideally at high-pressure and low-pressure zones. They can either be installed into the distribution main or placed inside a meter vault. The pressure sensors can typically measure pressure from 0 to 200 psig and transmitted securely to the utility office where it is monitored.

E. Schedule

Figure 3 depicts an aggressive and conservative estimated project-level timeline underlying the deployment of a complete AMI and MDM program based on current assumptions. There are many factors that could affect a project timeline; however, based on the request made by the GRU team for a two-year deployment, UtiliWorks has provided the draft schedule shown below which includes 2 predecessor phases to production deployment which are Procurement and Pilot Verification. These predecessor phases are critical to a successful deployment and full realization of benefits.

Figure 3: Proposed AMI & MDM Program Timeline



Section G - Project Staffing

Some business cases depend on a relatively quick deployment of features. For example, decreasing the time required to deploy AMI endpoints can accelerate the ROI. Even in the largest utility, rapid deployment can place tremendous strain on internal staff already dedicated to existing business functions. UtiliWorks recommends that GRU actively engages staff from customer service to billing, engineering, IT, meter shop, operations/maintenance, and field services throughout the effort. Buy-in and support is needed from the top down to ensure an efficient discovery process and smooth deployment. Staff augmentation is also an important consideration given the added strain on resources already dedicated to existing business functions.

Based on UtiliWorks experience with the deployment of AMI technology, the roles discussed below are critical to facilitate project success.

Table 13 provides a rough estimate of time required for each role; however, it should be noted that the estimates are variable depending on vendor/consultant involvement in the project.

Executive Project Sponsor

To achieve success for any large-scale project, an Executive Project Sponsor is necessary to drive initiatives internally and lead the organization to set and achieve the project's vision. The Executive Project Sponsor should have overall responsibility of the project and have authority over project members to ensure project management is on track and achieving project objectives. Upon project completion, the Executive Sponsor should stay engaged with the dedicated AMI staff and tangential business process leads to understand the success of the Project. This role should also strive to stay current on modern technology or capabilities of the AMI system.

Program Manager

A Program Manager experienced in leading complex integration projects is strongly recommended. This role is often contracted to a third party as the experience of repeated similar projects is very difficult to find within the utility. The Program Manager will engage with all teams involved in deployment and integration efforts during the anticipated project duration.

Project Manager

A Project Manager within the Utility is recommended to drive the completion of efforts within the Utility and coordinate with the Program Manager and vendors to maintain project continuity. UtiliWorks estimates the project will require one FTE during the implementation of the project. Post-implementation, the PM's duties will decrease. However, there will be ongoing duties related to Executive Level reporting and system oversight once the project is completed. This future workload should be considered when selecting a Project Manager internally.

Systems Integration Specialist

With the deployment of AMI, systems integration is always a requirement to ensure the Asset Management/CIS/MDM/AMI headend systems are synchronizing as anticipated. Although vendors provide some integration services, GRU will require an internal IT Integration resource to perform the required legacy utility-system interface development to support the project effort. UtiliWorks estimates this will require approximately one FTE during the Pilot Verification phase of the AMI project for approximately nine months.

Communications Network Engineer

This role will be responsible for working with the AMI vendor to design, implement and administer backhaul communications (and the underlying security) going forward with the AMI system. Some duties will likely include review of propagation studies for data collector deployment, establishing VPN access for vendors and modem configuration. It is anticipated this support will be required for approximately nine months during planning, design and implementation.

Subject Matter Experts (SMEs)

Beyond those team members that are specified above, GRU will need to identify appropriate staff members from across the organization to represent their respective functional area and participate in workshops and meetings to support project implementation. Activities will include: weekly or bi-weekly project status meetings, design and planning discussions, coordination of meter and communication network installation, business process re-engineering, procedural development, training, system testing, quality assurance, and public relations campaigns. While utility staffing requirements will ebb and flow during the project, GRU can anticipate that SMEs will be involved throughout the planning phase and Pilot Verification. Many of the SMEs will continue in roles that are identified and discussed in Section F – Operational Impacts.

Table 13: Estimated AMI Project Resource Requirements

Role	Avg. Time Commitment
Executive Project Sponsor	1 hr./week
Program Manager (Consultant??)	20 hrs./week
Project Manager	40 hrs./week
IT Integration Specialist	40/16 hrs./week[1]
Communications Network Engineer	16/40 hrs./week[2]
Subject Matter Experts (SME)	24 to 10 hrs./week[3]

[1] 40hrs/week during pilot verification and 16hrs/week during the production installation

[2] 16hrs/week during pilot verification and 40hrs/week during the production installation

[3] 24hrs/week during pilot verification and 10hrs/week during the production installation

Section H - Operational Impacts (post-deployment)

AMI technology has the potential to touch the entire organization. As the Utility transitions, there will be numerous operational impacts that require identification, definition, planning, development, testing and training. The volume of data that will be available to GRU will be substantially larger than the norm. This increased granularity and sheer volume of data is what opens new value streams, but these areas must be properly managed. Determining the operational impacts inherent to an AMI deployment is an extremely important process that can have material impacts on the realization of business case benefits. The operational impacts can be broadly categorized in the following areas:

1. Personnel/Human Resources
2. Business Process Re-Engineering
3. Data/Information Processing

Each of these areas needs to be well defined to maximize ROI. The following sections will provide a high-level outline of the types of changes in each area that may be necessary as GRU moves forward.

1. Personnel / Human Resources

Once the system is fully deployed, the future state of operations at GRU will yield opportunity for new roles within the organization that deal directly with the systems and data from AMI. GRU will need to consider contracting, hiring, reassigning, or retraining personnel to support the operation and maintenance of the modern technology. This will be addressed throughout the project deployment as new processes are defined. Additionally, much of the project staff will naturally transition into roles with AMI data since they will be familiar with the tasks from Full Deployment. The following is our recommended roles to be created with the implementation of AMI many of which to be identified during implementation.

Program Manager

The GRU Project Manager will have on-going responsibilities as the 'AMI Project' transitions into an 'AMI Program'. This manager will ensure that the proper system oversight and QA functions are occurring as expected. This role will also keep their finger on the pulse of the AMI system at a higher level and track KPIs that may be monitored as part of future state operations.

AMI System Operations Lead(s)

UtiliWorks recommends GRU identify multiple FTEs from Electric, Water/Wastewater and Gas to be a dedicated AMI System Tech along with a dedicated backup for each. They will be cross trained to work with all service types. It is not necessary to hire to fill this role if GRU can identify internal staff that is interested and capable of fulfilling the responsibilities. UtiliWorks recommends a resource(s) who will work to understand the communications network, metering technology, systems and software to train and lead other staff members. It is best to include those identified during project planning and deployment. Upon completion of deployment, each AMI Tech will continue as a full time FTE(s) focused on identifying, troubleshooting, and dispatching staff to resolve issues in the field.

AMI Information System Analyst(s)

UtiliWorks recommends GRU identify at least one FTE each from Electric, Water/Wastewater and Gas to be dedicated as an Information Analyst to support, administer and use the AMI and MDM system data and reports. Similar to the AMI System Tech role, it is not necessary to hire to fill this role if GRU can identify internal staff that is interested and capable of fulfilling the responsibilities. It is also recommended GRU involve these team members throughout project planning and deployment, so they are actively involved in the system configuration and training.

In addition to new roles, there will be reduction and expansion of workload in other departments. These departments should consider hiring, reassigning and retraining personnel:

AMI Communications Infrastructure O&M

New equipment in the field for network communications and AMI related equipment such as collectors and backhaul will need to be monitored and maintained. This is commonly performed by those staff responsible for the Communications network or SCADA.

Meter Reading

With the automation of the process, truck rolls to read meters, re-read meters, and perform move in/out reads, will be significantly reduced no longer be required. The need instead will shift to data management and exception handling. This offers the opportunity for retraining the meter reading personnel.

IT / Systems Administration

Even if GRU were to outsource and contract with a 3rd party to host new AMI and MDM software, there will be an ongoing need for GRU IT to monitor each database and ensure the interfaces are working properly. There will also be a need for IT staff to assist with troubleshooting.

2. Future State Business Process Re-Engineering

Advanced utility technology is highly integrated and especially sensitive to variances in the quality of data input, which requires adopters to practice strong discipline with regard to data integrity and maintenance processes. Due to the potential for disruption of business processes by technology, Business Process Re-Engineering should commence in the design phase of the project and continue through project completion followed by a continuous improvement philosophy. Initial efforts during this Assessment to describe and quantify the current state business processes are a baseline for future business process re-design efforts. The gaps and pain points identified in the current state workshops will provide an initial glimpse of how future state operations can be re-designed to meet the utility’s needs.

Adoption of AMI technology requires significant re-design of current utility business processes to fully satisfy acceptance criteria and expected payback. It is often overlooked in terms of how critical business process design is to the success of any project. UtiliWorks recommends that the following business processes, at a minimum, undergo a complete current state process definition and mapping to provide the basis for future state process design:

- **Meter Reading** – The meter reading process will be impacted the most of any business process, in that it will require the development of an entirely new process. The management of the consumption data and its quality will become a daily responsibility. Resources will have to be assigned to monitor and manage the exception reports, which ensures the quality of the data that the billing function depends upon. The reassignment and training of resources will be crucial for the transition to a network-based data driven reading system. New processes will need to be developed for exception investigation and handling.

- **Billing Process** – The consumption validation process will change by having quality assurance processes set up in the MDM system for meter reads before the CIS receives the meter reads for billing. The AMI and MDM systems will be used earlier on in the data flow to identify missing reads, investigate, and resolve issues. Billing will continue to run its quality assurance processes and will remain as the last line of defense against inaccurate bills going to customers.

- **Move-In/Move-Out** – CSRs will be able to provide a higher level of customer service by scheduling the start and stop of services for customers. Remote meter reading, and remote disconnect/connect capabilities will allow CSRs to capture the out/in-reads and to disconnect/connect electric, water and gas service with the push of a button. Existing business processes will need to be maintained along with development of new processes to manage remote reads. Decisions and permissions will need to be set up to support the personnel who will be authorized to perform this process from the office.

- **Service Disconnect for Non-Payment** – Like Move-In/Out, CSRs will have the ability to use the capabilities of the system to remotely disconnect/connect service for non-paying customers. Process and policy development will be required to determine the best methodology for performing this activity; there will be workflow alterations, policy shifts, and other changes required to the process.

- **Customer Inquiries (High Bill Complaint)** – If GRU elects to implement a fully integrated customer engagement platform, CSRs will be able work with customers and teach them how to access detailed information on their own pertaining to bills, consumption, and rates. Even without the deployment of a Customer Engagement Platform, the role of the CSR will move toward educating and coaching which will pay dividends for both the customer and the utility over time.

- **Mass Meter Exchange** – Whether GRU selects an outside contractor to perform the meter change-outs or does the work in-house, the process will need to detail all rules from how contact with a customer is made to how an issue or materials damage is addressed. It will be necessary to clearly engineer all aspects of the full deployment meter change-out process to ensure data integrity in the AMI/MDM/CIS systems (i.e., meter attributes/characteristics), maintain consistent communication with customers, and ensure deployment success. UtiliWorks cannot over-emphasize how critical it is to ensure and maintain meter data integrity across these software applications throughout and beyond an AMI/MDM deployment.

- **Single Meter / Endpoint Exchange** – After deployment of the metering project, GRU will need to adhere to proper processes and procedures to maintain data integrity within the systems. Single meter exchanges will include some additional data tracking which will require workflow alterations.

- **Utility Operations** – Better information will improve GRU's ability to monitor distribution infrastructure to a higher level of control for electric, water and gas. More granular measurement information will identify questionable areas and will require the training of personnel to interpret the findings, address them, and convert the results into savings and operational improvements. Current processes and reporting will need to be reviewed and revised to take advantage of the information that will be available.

With more in-depth requirements development during the initial stages of the project, other business processes will likely emerge that require adjustments, along with identification of new processes that don't currently exist.

3. Data / Information Processing and Reporting

It is important to focus on the data and information that will be captured by the AMI system and stored in the MDM to make the most of the AMI infrastructure investment. Decisions regarding what to do with the resulting expansion of data available to utility staff is a key driver regarding the design and configuration of the system. Both the AMI and MDM systems will offer more robust exception, troubleshooting, and diagnostic reporting options, along with alarms and alerts. However, it will be necessary for GRU to invest the time and effort up front to clearly define business requirements and understand the respective reporting capabilities of each system to maintain a manageable workload.

As part of an RFP process, UtiliWorks recommends that GRU thoroughly investigates the underlying data retention, notifications, reporting, and alarm functionality of all considered systems, requests samples of any preconfigured reports, and verifies that the system will facilitate customized development at the user level (if so desired).

Definition of reports and report distribution is a critical dependency to business process engineering. Once deployed, many of the reports will be business critical and will need to be reviewed by the utility on a consistent, daily basis to ensure system functionality and data integrity. This activity should be undertaken as part of a continuous improvement program to maintain the business systems functionality of the overall system. The expanded responsibilities within Information Processing most closely resonate with the staff that will fill the Data Analyst and AMI System Tech roles, with some cross over with billing staff.

The AMI and MDM systems will need to be integrated with the current and future customer information system. The same will hold true for the current and future versions of the CRM system should business needs and benefits influence a decision to build that integration. The integration for system data synchronization between a CIS, AMI and MDM systems typically includes data elements such as meter numbers, ID's, size, premise, addresses, locations and inventory statuses. Other data elements can be included once business needs are understood and established. VEE for all billing data determinants are typically processed in the new MDM system, and most CIS exception reports will continue to be used for the short-term future at a minimum. VEE data will be used to provide quality data with integrity to a customer engagement platform should one be implemented. The MDM system will need to be configured to reflect the business rules of GRU's choice. The CIS typically continues to be the system used by Billing and CSR's to initiate, process and close Service Orders. All impacted Service Order types will need to be redesigned to incorporate how users will collect the data required to process and complete functions like off cycle reads, demand reads and resets, move in/move out reads and delinquent off and on reads as well as respond to customer inquiries. Integrations of the AMI and MDM systems to other systems like GIS, WMS and OMS to name a few will remain to be determined by business needs and requirements. The timing of implementing and AMI and MDM systems with the legacy CIS and then upgrading the CIS may add some complexities that will need to be considered but have not been fully vetted. These potential complexities will be impacted by the detailed requirements of the integrations which have not been fully defined at this time.

Section I - Recommendations and Next Steps

1. Recommendations

Based on our discovery activities and findings, GRU appears to be well-informed regarding AMI and MDM technology and is adequately well-informed to proceed with an AMI and MDM implementation project. This conclusion is further supported by a positive business case that we also believe is conservative relative to the benefits that can be realized with a well-designed AMI and MDM implementation program. Key recommendations are outlined below:

- Do not underestimate the amount of time and effort it takes to acquire the necessary internal approvals during procurement and contract negotiations.
- UtiliWorks recommends that GRU actively engage staff from across the organization throughout this effort.
    - Buy-in and support is needed from the top down to ensure an efficient implementation and smooth deployment.
- As discussed and shown in Section F, UtiliWorks recommends a phased approach to deployment including a Pilot Verification to establish complete systems integration, testing, training, new/revised business processes, and system acceptance prior to full deployment.
- Overlapping the Pilot Verification, GRU will need to establish a Customer Outreach Campaign to inform and educate customers of the coming improvements and the benefits they will realize from the program.
- GRU should consider staff augmentation during the project given the added demand on resources already dedicated to existing business functions and potentially competing projects. A clear understanding of the ability of your staff to support the project as well as the ongoing operation and maintenance of the system will be valuable.
- Consider hiring, reassigning, or retraining personnel to support the operation and maintenance of the modern technology once deployed.

2. Next Steps

UtiliWorks will stay engaged with GRU to assist with the procurement process if contracted to do so. This support would include:

- Detailed System Requirements Development
- Procurement Strategy Materials
- AMI & MDM Vendor Requirements
- Request for Proposal (1)
- Proposal solicitation, Vendor(s) Evaluation / Selection Assistance
- Vendor Contracting Support
- Participant Responsibilities Documentation
- Systems Acceptance Criteria
- High-level System Integration Documentation

- Communications Backhaul Documentation

Overlapping the procurement effort; UtiliWorks recommends that GRU at Gainesville focuses on the following near-term tasks:

1. Establish a formal proposal evaluation function to assess the vendor responses received
2. Formalize a project governance function
3. Secure/confirm project financing and investigate other funding sources that may be available, such as grants

Section J - Appendices

Appendix I - GRU Current IT Systems & Applications by Function

Table 12: GRU Current IT Systems & Applications by Function

System Type	Name of Application	Manufacturer
Accounting/Financial/Purchasing	SAP version 1503	SAP
AMI (Pilot)	Tunet	Tantalus
Asset Management	Multiple	Multiple
CIS/Billing/Service Orders	SAP ECC6.0 / CRM version 4.7R3	SAP
Call Center Software	Cisco Call Center	Cisco
Conservation Portals	Home Energy Advisor	Apogee
Customer Web Portal	hybrid/custom	
Customer Web Bill Pay Portal	hybrid/custom	IT web applications group
GIS	ArcGIS	Esri
Interactive Voice Response (IVR)	Cisco Call Center	Cisco
Meter Reading - Water, Gas & Electric	MV-RS / MV90 [commercial gas & electric]	Itron
Outage Mgt (OMS)	Responder	Schneider Electric
SCADA - Water/Wastewater	VTScada	Trihedral
SCADA - Natural Gas	Talon	Eagle technologies
SCADA - Electric	Monarch	OSI
Work Order Management System	GRU Works	GRU Works
Local Area Network (LAN)	see communications sheet	
Wide Area Network (WAN)	see communications sheet	
Emergency Notification System	EverBridge	EverBridge
Automatic Vehicle Location (AVL)	Motorola	Motorola
BI/Reporting Software	BW	Cisco / SAP

Appendix II – GRU Current State Gap Analysis & Recommendations

Tables begin on the following page.

Table 15: Desired State Functions

Function	Desired State (Goals)	Present State	Gap Description	Recommendations
Application & Network Monitoring Capabilities	Ability to monitor network traffic in relation to network capacity and to monitor server performance in terms of processor utilization and thread utilization on a real-time basis	Solar Winds is being used. No detail was provided on which modules are implemented. Nagios is being used	Depending on Solar Winds modules currently deployed, there could be a need to deploy additional modules, additionally, Nagios is deployed, depending on what functions are enabled, additional modules could be useful; AMI and MDM add significant network, server, and database loads	Depending on GRU preference, UtiliWorks recommends that at a minimum the following monitoring is available: network traffic with granularity to identify AMI traffic, AMI and MDM database performance (typically Oracle-based), server performance monitoring for AMI and MDM servers.
Back Up & Disaster Recovery	Fully redundant or failover environment with full disaster recovery capabilities	Information provided indicates that there is a full backup system that is regularly tested	Detailed information regarding disaster recovery and redundancy has not been provided, although meeting notes indicate that there is a disaster recovery plan with redundancy. This may be a matter of documentation provision subject to NDA approval	Based on verbal information, incorporation of AMI and MDM into the 'standard' environment would be sufficient.
Communication Network	Network capable of backhauling an AMI system	The IT Team has reported that the current fiber network has plenty of capacity and can be expanded if/where required to support AMI requirements	n/a	None

Function	Desired State (Goals)	Present State	Gap Description	Recommendations
Cyber Security	Security measures in place that are compliant with NERC/CIP appropriate to utility type, consistent with AWWA and AGA recommendations as well as other state and local requirements for customer data and metering data	GRU has indicated that several security measures are in place, but has not provided detailed information related to NERC/CIP and other required security	Release of information to UtiliWorks apparently pending NDA approval	Review of NERC/CIP compliance documentation to ensure that the added components of AMI and MDM are compliant.
Data Network Physical Diagram	Segmented data network with appropriate firewalls and dmz's to protect customer and operational system	Undetermined	Data Network Physical Diagram has not been received; notes indicate that provision of this information is subject to NDA approval	Recommendation pending receipt/review of physical network diagram
Hardware	Servers and client machines capable of supporting all required software systems	Sufficient client/server capacity to support AMI and MDM systems was reported during the discovery interviews	n/a	None
Integration Readiness	To have a reliable and interoperative integration environment for all current and future systems	There are numerous point-to-point integrations	There are opportunities to use MultiSpeak and other Web Services integration technologies	Review existing integrations to ensure that 'point to point' integrations are minimized

Function	Desired State (Goals)	Present State	Gap Description	Recommendations
Software	AMI system, MDM system, customer engagement platform	There is a small, limited number of AMI meters that were installed as part of a pilot project between 2007 and 20113; they are not currently being used as designed and anticipated to deliver consumption and billing data	A decision will need to be made to retain or replace the pilot AMI meters that are currently installed, other than those, an entire AMI system will need to be procured, installed, and implemented; there is no MDM system currently and a system of that type will need to be procured, installed, and implemented	Develop plan to replace existing AMI pilot project meters that includes prioritization.
Project staffing/ System Integration Specialist	A System Integration Specialist is recommended for an AMI & MDM implementation project	There are resources with the skill sets required to support this requirement and are typically assigned to multiple projects	There will probably be multiple projects competing for this resource type which could potentially pose a threat to the project quality and schedule	Resource staffing levels should be reviewed and considered to minimize negative impacts to a project
Project staffing/ Communication Network Engineer	A Communications Network Engineer is recommended for an AMI & MDM implementation project	There are resources with the skill sets required to support this requirement and are typically assigned to multiple projects	There will probably be multiple projects competing for this resource type which could potentially pose a threat to the project quality and schedule	Resource staffing levels should be reviewed and considered to minimize negative impacts to a project
Project staffing/ Subject Mater Experts	Subject Matter Experts are recommended for an AMI & MDM implementation project	There are resources with the skill sets required to support this requirement and are typically assigned to multiple projects	There will probably be multiple projects competing for this resource type which could potentially pose a threat to the project quality and schedule	Resource staffing levels should be reviewed and considered to minimize negative impacts to a project

Table 16: Business Gap Analysis

Department	Desired State (Goals)	Present State	Gap Description	Recommendations
Customer Operations	Improve customer-side leak detection	Customer-side leaks can only be discovered based on monthly data	GRU does not have the hardware and software required to improve this service to customers	The implementation of an AMI system that can provide hourly consumption data and exception reports will improve this process
Customer Operations	Implement a pre-paid metering system	This type of service is not currently available to GRU customers	GRU does not presently have the hardware and software required to support this goal	The implementation of an AMI system and pre-pay software system are required to achieve this goal
Customer Operations	Reduce the average call handle time to industry standards (approximately six minutes per call)	There is a large customer service staff using many applications to address customer inquiries	The data available to respond to customer inquiries is currently limited to monthly data and may not present a customer with the clarity required to quickly address their concerns	The implementation of an AMI system would provide finer granular detail (daily and hourly) to reduce the time required to satisfy customer inquiries
ED Engineering	Provide restoration information to special needs shelters during emergency conditions	The data required to support this process is collected by physical means for the most part and has a high degree of latency	The restoration data required to support this goal need to be collected remotely to reduce the latency to an acceptable level	Implement an AMI & MDM system capable of providing the data required in near real time
Electric T&D	Identify downed Aerial Distribution Cables during severe weather events	The primary means of notification for this condition is a customer call which could be subject to any degree of latency	There is little if any ability to detect this condition on the current hardware and software being used	Implement an AMI & MDM system capable of detecting this condition and providing the exception data required in near real time
Electric T&D	Ability to model solar generation in near real time	There is currently little or no ability to model PV energy in near real time	AMI/MDM hardware and software are required to support this goal	Utilize a Virtual Meter function in an MDM system to support this goal

Department	Desired State (Goals)	Present State	Gap Description	Recommendations
Electric T&D	Ability to measure the PV energy going into feeders	There is no current ability to measure the amount of PV energy going into feeders	AMI/MDM hardware and software are required to support this goal	Utilize a Virtual Meter function in an MDM system to support this goal
Electric T&D	Ability to perform an on-demand meter outage or restoration validation	This requirement is not possible on the currently installed meter and software technology	AMI/MDM hardware and software are required to support this goal	Implement an AMI system and meters capable of satisfying this requirement
Electric T&D	Maximize transformer utilization and performance	The ability to improve transformer utilization and performance is limited based on the currently installed technology	The ability to improve transformer utilization and performance is limited based on the currently installed technology	Implement an MDM system that can provide a virtual meter function to aggregate demand on individual transformers
Electric T&D	Minimize electric losses and provide improved voltage profiles for customers	Undefined	Unknown	Implement a volt/VAR control program utilizing AMI meters to more accurately measure current conditions on selected end points rather than estimating voltages
Electric T&D	Detect and locate service blinks	There is little or no current ability to support this function and requirement	There is little if any data available to use to find and eliminate the cause of the blinks	An AMI / MDM system can provide the exceptions required to identify potential problems before they occur; early detection will allow the utility to identify the locations requiring maintenance (i.e., trees) before there's a larger issue or failure
Electric T&D	Ability to use AMI outage and restoration data in the OMS	There is little or no current ability to support this function and requirement	GRU does not have the hardware and software required for to support this goal	Implement an AMI system capable of providing the type of data and minimum latency to support this program

Department	Desired State (Goals)	Present State	Gap Description	Recommendations
Electric T&D	Validate outage or restoration conditions in near real time	There is little or no current ability to support this function and requirement	The data required to support this goal needs to be collected remotely to reduce the latency to an acceptable level	Implement an AMI & MDM system capable of providing the functionality and data required in near real time
Electric T&D	Implement a TOU program	There is little or no current ability to support this function and requirement	GRU does not have the hardware and software required for to support this goal	Implement an AMI system capable of providing the interval data required to support this program
Energy & Business Services	Implement a TOU Program	There is little or no current ability to support this function and requirement	GRU does not have the hardware and software required for to support this goal	Implement an AMI system capable of providing the interval data required to support this program
Energy & Business Services	Implement a DSM program	Undefined	Unknown	Implement a financial incentive program to motivate customers to change their behavior to provide GRU with the ability to avoid the need for large capital investments
Energy & Business Services	Implement a Demand Response Program	Undefined	Unknown	Implement a DR Program to increase control of dedicated consumer appliances and revenue while mitigating operational costs to GRU

Department	Desired State (Goals)	Present State	Gap Description	Recommendations
Energy & Business Services	Implement a Demand Load Control program	Undefined	Unknown	Implement a DLC Program that would provide credits to customers to incentivize them to allow GRU to control dedicated consumer appliances for a brief period to reduce demand during peak times of days in specific weather conditions
Revenue Protection	Reduce the time it takes to process delinquent accounts	All cut-offs require a truck to be scheduled and rolled to manually cut off the account, and the same to turn it back on	Remote cut-off capabilities would be required to significantly reduce the amount of time required to schedule, drive to the premises, and manually cut off and/or turn on the service	Implement an AMI system with remote batch cut-off/turn-on capabilities
Revenue Protection	Obtain real time theft alerts remotely	GRU currently relies on physical information provided by meter readers and technicians to identify potential instances of theft	GRU does not have the hardware and software required to remotely and quickly identify theft	Implement an AMI & MDM system capable of detecting this condition and providing the exception data required in near real time
Revenue Protection	Detect and identify illegal taps remotely	GRU currently relies on physical information provided by meter readers and technicians to identify potential instances of theft	GRU does not have the hardware and software required for to support this goal	Implement an AMI & MDM system capable of detecting this condition and providing the exception data required in near real time
Revenue Protection	Ability to locate stolen meters remotely	GRU currently relies on physical information provided by meter readers and techs to identify potential instances of theft	GRU does not have the hardware and software required for to support this goal	Implement an AMI & MDM system capable of detecting this condition and providing the exception data required in near real time

Department	Desired State (Goals)	Present State	Gap Description	Recommendations
Water Department	Ability to detect a stopped meter sooner	GRU does not currently have the hardware and software required to detect this condition by using exception data	The application of AMI technology would significantly reduce the length of time required to detect this condition and respond	Implement an AMI & MDM system capable of detecting this condition and providing the exception data required in near real time
Water Department	Ability to detect exceptional amounts of back flow remotely	GRU does not currently have the hardware and software required to detect this condition	The application of AMI technology would significantly reduce the length of time required to detect this condition and respond	Implement an AMI & MDM system capable of detecting this condition and providing the exception data required in near real time
Water Department	Ability to detect empty pipe conditions (or no service pressure) remotely	GRU does not currently have the hardware and software required to detect this condition	The application of AMI technology would significantly reduce the length of time required to detect this condition and respond	Implement an AMI & MDM system capable of detecting this condition and providing the exception data required in near real time

Appendix III – Cost Estimate – Cap Ex and Op Ex

Capital Expense

AMI/MDM + Electric Deployment	Quantity		Price		Total
	-		-		-
AMI					
AMI Head End Software	1	$	350,000	$	350,000
Network Infrastructure (Collectors and Associated Infrastructure)	1	$	775,000	$	775,000
TOTAL				**$**	**1,125,000**
MDMS+Customer Engagement Platform					
MDMS+Customer Engagement Platform	1	$	375,000	$	375,000
TOTAL				**$**	**375,000**
Professional Services					
Program Management (Proof of Concept)	1	$	1,000,000	$	1,000,000
Program Management (Change Management)	1	$	500,000	$	500,000
Program Management (Field Deployment Quality Assurance)	1	$	500,000	$	500,000
Communications Campaign	1	$	135,000	$	135,000
CIS Integration	1	$	200,000	$	200,000
MDM Vendor	1	$	650,000	$	650,000
AMI Vendor	1	$	775,000	$	775,000
Cap Installation Program Management (10% Installation Cost)	1	$	1,121,938	$	1,121,938
TOTAL				**$**	**4,881,938**
Client Costs					
Procurement Support	-	$	-	$	-
Warehousing Costs	-	$	-	$	-
TOTAL				**$**	**-**
AMI Electric Meters					
Single Phase - 1S w/ Remote Disconnect	650	$	110	$	71,500
Single Phase - 2S CL 200 & 320 w/ Remote Disconnect	87,140	$	110	$	9,585,400
Single Phase - 3S	9	$	225	$	2,025
Single Phase - 4S (Voltage Specific 240V & Multi Form)	217	$	225	$	48,825
Poly Phase - 5S 45, CL20	8	$	225	$	1,800
Poly Phase - 9S (8S), CL20	1,317	$	225	$	296,325
Poly Phase - 12S & 25S, CL 100, 200 & 320 w/ Remote Disconnect	3,792	$	120	$	455,040
Poly Phase - 16S (14S, 15S), CL200, 320 &480)	2,850	$	225	$	641,250
TOTAL				**$**	**11,102,165**
AMI Electric Meters Installation (Labor Cost)					
Residential Electric Exchange	91,582	$	32	$	2,930,624
C&I Electric Exchange	4,401	$	35	$	154,035
TOTAL				**$**	**3,084,659**
Other Costs					

Contingency	10%			$ 1,711,745
Hardware Sales Tax	9%			$ 1,068,945
	-	$	-	$ -
TOTAL				**$ 2,780,690**
Total AMI/MDM Network + Electric Deployment CapEx				**$ 23,349,452**

Water Deployment					
	Quantity		Price		Total
			-		
AMI Water Meters, Registers, Endpoints & Lids			-		
Water Meter Lids - Drilling	3,451	$	15	$	51,765
Water Meter Lids - Replacement	69,019	$	35	$	2,415,679
Water Meter Endpoints	72,652	$	75	$	5,448,900
5/8" x 3/4" (Meter Replacement)	56,643	$	95	$	5,381,114
3/4" (Meter Replacement)	5,736	$	95	$	544,892
5/8" x 3/4" + Remote Shut Off (Meter Replacement)	6,931	$	350	$	2,425,850
1" (Meter Replacement)	1,608	$	165	$	265,320
1-1/2" (Meter Replacement)	388	$	380	$	147,440
2" (Meter Replacement)	398	$	510	$	202,980
3" (Meter Replacement)	41	$	1,255	$	51,556
4" (Meter Replacement)	23	$	2,000	$	46,525
6" (Meter Replacement)	21	$	3,500	$	74,490
8" (Meter Replacement)	9	$	4,600	$	43,259
10" (Meter Replacement)	3	$	5,900	$	17,521
Registers Only - Residential	-	$	60	$	-
Registers Only - C&I	850	$	150	$	127,500
TOTAL				**$**	**17,244,790**
AMI Water Meter Installation & Retrofit (Labor Cost)					
Water Meter Exchange (5/8" - 1")	70,918	$	45	$	3,191,310
Water Meter Exchange (1 1/2")	388	$	200	$	77,600
Water Meter Exchange (2")	398	$	275	$	109,450
Water Meter Exchange (3")	41	$	500	$	20,540
Water Meter Exchange (4")	23	$	1,000	$	23,263
Water Meter Exchange (6")	21	$	1,150	$	24,475
Water Meter Exchange (8")	9	$	1,150	$	10,815
Water Meter Exchange (10")	3	$	1,150	$	3,415
Water Meter Retrofit	850	$	20	$	17,000
Water Meter Box Replacement	-	$	-	$	-
TOTAL				**$**	**3,477,868**
Other Costs					
	-	$	-	$	-
Hardware Sales Tax	9%			$	1,547,372
Contingency	10%			$	2,072,266

TOTAL				**$**	**3,619,638**
Total Water Deployment CapEx				**$**	**24,342,296**

Gas Deployment					
	Quantity		Price		Total
			-		
AMI Gas Meters, Registers, Endpoints & Lids			-		
175 (Meter Replacement + Index)	2,773	$	226	$	626,698
250 (Meter Replacement + Index)	18,825	$	226	$	4,254,450
425 (Meter Replacement + Index)	958	$	772	$	739,576
630 (Meter Replacement + Index)	295	$	1,256	$	370,520
800 (Meter Replacement + Index)	164	$	2,291	$	375,724
900 (Meter Replacement + Index)	-	$	4,073	$	-
1000 (Meter Replacement + Index)	-	$	4,073	$	-
1400 (Meter Replacement + Index)	-	$	1,490	$	-
1500 (Meter Replacement + Index)	-	$	1,490	$	-
2000 (Meter Replacement + Index)	20	$	1,748	$	34,960
2300 (Meter Replacement + Index)	-	$	1,740	$	-
3000 (Meter Replacement + Index)	22	$	1,900	$	41,800
3500 (Meter Replacement + Index)	-	$	-	$	-
5000 (Meter Replacement + Index)	2	$	2,545	$	5,090
7000 (Meter Replacement + Index)	16	$	3,093	$	49,488
>7000 (Meter Replacement + Index)	-	$	-	$	-
Endpoints	36,021	$	60	$	2,161,260
Gas Meter Remote Disconnect	36,021	$	100	$	3,602,100
TOTAL				**$**	**12,261,666**
AMI Gas Meter Installation & Retrofit (Labor Cost)					
Gas Meter Exchange	23,075	$	192	$	4,422,093
Gas Meter Retrofit (Small)	11,913	$	17	$	202,521
Gas Meter Retrofit (Medium)	872	$	27	$	23,544
Gas Meter Retrofit (Large)	161	$	54	$	8,694
TOTAL				**$**	**4,656,852**
Other Costs					
	-	$	-	$	-
Hardware Sales Tax	9%			$	1,103,550
Contingency	10%			$	1,331,642
TOTAL				**$**	**2,435,192**
Total Gas Deployment CapEx				**$**	**19,353,710**

Prepay	Quantity		Price		Total
	-		-		-
Prepay Costs					
Prepay Software	1	$	100,000	$	100,000
Professional Services	1	$	50,000	$	50,000
Other Costs					
CLIENT PM	-	$	-	$	-
Professional Services + Procurement	1.00	$	-	$	-
Contingency	10%	$	-	$	15,000

Water Pressure Monitoring	Quantity		Price		Total
	-		-		-
Water Distribution Pressure Sensors					
Mobile Pressure Sensors (Hydrant)	5	$	2,225	$	11,125
Static Pressure Sensors (Pit Mounted)	10	$	2,935	$	29,350
Set up Fees	15	$	50	$	750
Software	1	$	14,000	$	14,000
Other Costs					
Installation Equipment (Laptop)	1	$	500	$	500
Professional Services	1	$	5,000	$	5,000
Contingency	10%			$	6,073

Water Leak Detection					
GRU has a Leak Detection Program in place performed by contractor, these are estimates if GRU to manage by themselves	Quantity		Price		Total
	-		-		-
Acoustic Leak Detection					
Static Leak Detection Sensors	-	$	-	$	-
Mobile Leak Detection Sensors	50	$	800	$	40,000
Acoustic Leak Detection Software+Conservation Manager+Integration Services	1	$	280,000	$	280,000
Other Costs					
Contingency	10%			$	32,000

Annual Operational Expense

AMI/MDM	Quantity		Price		Total
Annual SaaS Fees					
AMI Head End	1	$	125,000	$	125,000
MDMS + Customer Portal	1	$	450,000	$	450,000
TOTAL				**$**	**575,000**

Prepay	Quantity		Price		Total
	-		-		-
Prepay Costs					
Annual Software Maintenance Fee	1	$	22,000	$	22,000

Water Pressure Monitoring	Quantity		Price		Total
	-		-		-
Annual Fees					
Annual Hosting Fee	15	$	245	$	3,675
Annual Cell Modem Data Service	1	$	8,000	$	8,000
Software Maintenance Fee	1	$	3,000	$	3,000

Water Leak Detection	Quantity		Price		Total
	-		-		-
Annual Fees					
Annual Hosting Fee	1	$	61,000	$	61,000
Annual Cell Modem Data Service	-	$	-	$	-
Software Maintenance Fee	-	$	-	$	-

Appendix IV - Benefits Assumptions

AMI/MDM + Electric Deployment		
Electric Meter Reading	Yes	
Annual Meter Reading Expense	$ 3,195,970	
Vehicle Cost		*$ 45,223*
Labor & Benefits Cost		*$ 3,048,450*
Overhead/Other/Non-Labor Cost		*$ 102,296*
Worker's Compensation Insurance		*$ -*
Expense Reduction		95%
Electric Service Proportion by Total Meter Count		47%
Annual Savings	**$ 1,423,954**	
Electric Re-Read Reduction	Yes	
Electric Annual Re-Reads		1,191
Cost per Re-Read	$ 44.13	
Expense Reduction		90%
Annual Savings	**$ 47,303**	
Electric Move In/Out Reads Reduction	Yes	
Electric Annual Move In/Out Reads		13,155
Total Annual Move In/Out Reads (All Services) Expense	$ 50.35	
Expense Reduction		90%
Annual Savings	**$ 596,119**	
Electric Customer Call Reduction (incorporated in CSR Engagement Expense)	No	
Annual Call Center Expense	$ 1,717,993	
Expense Reduction		30%
Electric Service Proportion by Total Meter Count		47%
Annual Savings	**$ -**	
Customer Service Engagement Expense (Electric)	Yes	
Electric Service Proportion by Total Meter Count		47%
Total CSR Expense	$ 2,970,834	
Estimated CSR Time Spent on Meter-related Engagement Work		30%
Total Annual Expense (Electric)	$ 417,993.45	
Expense Reduction		90%
Annual Savings	**$ 376,194**	
-		
Electric Non-pay Disconnect Non-Payment Labor	Yes	
Electric Annual Metering Delinquent Shut Offs/Turn Ons		31,538
Delinquent shut off/turn on expense per case	$ 50.35	
Cut/Connect Non-Payment Reduction		90%
Annual Savings	**$ 1,429,144**	

Electric Billing Exception Handling Expense (incorporated in CSR Engagement Expense)		No
Total Billing & Billing Exceptions Expense	$	57,016
Reduction of Exception Handling, Billing Issues		50%
Electric Service Proportion by Total Meter Count		47%
Annual Savings	**$**	**-**
Distribution Transformer Asset Management		No
Percentage of Transformers Oversized		75%
Assumed Cost Difference of Right-Sized and Oversized Transformer	$	-
Number of Transformers Purchased in a Year		415
Annual Savings	**$**	**-**
-		
Conductor Repair		Yes
Conductor Failures per Year		87
Cost per Conductor Splice Failure	$	14,000
Reduction Rate		5%
Annual Savings	**$**	**60,900**
Outage Management		Yes
Customer Hours Out Year		520,243
Average kWh Used per Customer per Hour		1.50
Outage Response Reduction		20%
kWh Rate	$	0.1328
Annual Recovery of Revenue	**$**	**20,746**
Outage Labor Reduction		Yes
Annual Feeder Related Outages		37
Outage Response Reduction		20%
Labor Hours / Outage		8
Labor Rate Serviceman / hr	$	89
Bucket Truck Rate / Hr	$	100
Annual Savings	**$**	**11,167**
Electric Theft Identification		Yes
Estimated Tampering Cases per Year		159
Estimated Theft Total kWh		85,567
kWh Rate	$	0.1328
Identification of Theft with AMI		95%
Annual Savings	**$**	**10,795**
Electric Annual Meter Replacement Budget		Yes
Electric Meter Replacement Budget ($)	$	172,878
Reduction Rate		90%
Annual Savings	**$**	**155,590**
Bad Debt Reduction		Yes
Annual Write-off Electric	$	726,481
Estimated % of Electric Customers on Remote Disconnect		100%
Late Payment Reduction with Remote Disconnect		25%

Annual Savings	**$**	**181,620**
Electric Meter Scrap Value		Yes
Total Residential Meters		91,582
Total Commercial Meters		4,401
Residential Meter Weight (lbs)		2
Commercial Meter Weight (lbs)		4
Electric meter scrap value per lb.	$	0.45
One Time Savings	**$**	**90,346**
-		
Revenue Capture from Improved Electric Meter Accuracy		Yes
FY16 Revenue Residential (Annual $)	$	48,414,299
Average electric meter inaccuracy		2%
Percentage Electromechanical Meters Over 20 years		71%
Accuracy Improvement (%)		90%
Annual Savings	**$**	**618,381**
-		
Total AMI/MDM Network + Electric Deployment Benefits	**$**	**5,022,261**

Water Deployment		
Water Meter Reading		Yes
Annual Meter Reading Expense	$	3,195,970
Expense Reduction		95%
Water Service Proportion by Total Meter Count		35%
Annual Savings	**$**	**1,077,828**
Water Re-Read Reduction		Yes
Water Annual Re-Reads		3,373
Cost per Re-Read	$	44.13
Expense Reduction		90%
Annual Savings	**$**	**133,965**
Water Move In/Out Reads Reduction		Yes
Water Annual Move In/Out Reads		7,847
Total Annual Move In/Out Reads (All Services) Expense	$	50.35
Expense Reduction		90%
Annual Savings	**$**	**355,587**
Water Customer Call Reduction (incorporated in CSR Engagement Expense)		No
Annual Customer Inquiry & Adj Expense	$	1,717,993
Expense Reduction		30%
Water Service Proportion by Total Meter Count		35%
Annual Savings	**$**	**-**
Customer Service Engagement Expense (Water)		Yes

Water Annual Metering Service Orders		8,176
Water Service Proportion by Total Meter Count		35%
Total CSR Expense	$	2,970,834
Estimated CSR Time Spent on Meter-related Engagement Work		30%
Total Annual Expense (Water)	$	316,390
Expense Reduction		90%
Annual Savings	**$**	**284,751**
<u>Water Non-pay Disconnect Non-Payment Labor</u>		Yes
Water Annual Metering Delinquent Shut Offs/Turn Ons		7,884
Delinquent shut off/turn on expense per case	$	50.35
~~Estimated % of Customers on Remote Disconnect (Residential)~~		-
Cut/Connect Non-Payment Reduction		90%
Annual Savings	**$**	**357,263**
<u>Water Billing Exception Handling Expense (incorporated in CSR Engagement Expense)</u>		No
Billing & Billing Exceptions Expense	$	57,016
Reduction of Exception Handling, Billing Issues		50%
Water Service Proportion by Total Meter Count		35%
Annual Savings	**$**	**-**
<u>Water Theft Identification</u>		Yes
Estimated Theft Consumption		2,670,667
Water Rate ($/1000 gal, Residential 1 tier)	$	2.45
Identification of Theft with AMI		95.00%
Annual Savings	**$**	**6,216**
<u>Water Annual Meter Replacement Budget</u>		Yes
Water Meter Replacement Budget ($)	$	391,667
Reduction Rate		90%
Annual Savings	**$**	**352,500**
<u>Water Bad Debt Reduction</u>		Yes
Annual Write-off ($) Water	$	237,521
Estimated % of Customers on Remote Disconnect (Residential)		10%
Late Payment Reduction with Remote Disconnect		90%
Annual Savings	**$**	**21,377**
<u>Water Meter Scrap Value</u>		Yes
Total Residential Meters		70918
Total Commercial Meters		884
Residential Meter Weight (lbs)		3
Commercial Meter Weight (lbs)		5
Water meter scrap value per lb.	$	1.20
One Time Savings	**$**	**260,609**
<u>Revenue Capture from Improved Water Meter Accuracy</u>		Yes
Annual Sales of Water, Residential (2016)	$	33,048,658
Average Water Meter Inaccuracy		5%

Percentage Nutating Disc Meters more than 15 years		33%
Accuracy Improvement		90%
Annual Savings	**$**	**487,248**
Main Breaks Prevention/Reduction		Yes
Annual reported breaks and leaks		975
Cost to replace/ repair water mains	$	3,500
Improvement in water main breaks prevention		5.0%
Annual Savings	**$**	**170,625**
Pumping Schedule (Lower Pumping Costs)		Yes
Annual Pumping Costs	$	2,115,141
Electricity Cost Savings		5.0%
Annual Savings	**$**	**105,757**
Total Water Deployment Benefits	**$**	**3,613,727**

Gas Deployment		
Gas Meter Reading		Yes
Annual Meter Reading Expense	$	3,195,970
Expense Reduction		95%
Gas Service Proportion by Meter Count		18%
Annual Savings	**$**	**534,389**
Gas Re-Read Reduction		Yes
Gas Annual Re-Reads		397
Cost per Re-Read	$	44.13
Expense Reduction		90%
Annual Savings	**$**	**15,768**
Gas Move In/Out Reads Reduction		Yes
Gas Annual Move In/Out Reads		2,077
Total Annual Move In/Out Reads (All Services) Expense	$	50.35
Expense Reduction		90%
Annual Savings	**$**	**94,119**
Gas Customer Call Reduction (incorporated in CSR Engagement Expense)		No
Annual Customer Inquiry & Adj Expense	$	1,717,993
Expense Reduction		30%
Gas Service Proportion by Meter Count		18%
Annual Savings	**$**	**-**
Customer Service Engagement Expense (Gas)		Yes
Gas Annual Metering Service Orders		4,134
Gas Service Proportion by Meter Count		18%
Total CSR Expense	$	2,970,834

Estimated CSR Time Spent on Meter-related Engagement Work		30%
Total Annual Expense (Gas)	$	156,867
Expense Reduction		90%
Annual Savings	**$**	**141,180**
Gas Non-pay Disconnect Non-Payment Labor		Yes
Gas Annual Metering Delinquent Shut Offs/Turn Ons		4,380
Delinquent shut off/turn on expense per case	$	50.35
Estimated % of Customers on Remote Disconnect		100%
Cut/Connect Non-Payment Reduction		90%
Annual Savings	**$**	**198,480**
Gas Billing Exception Handling Expense (incorporated in CSR Engagement Expense)		No
Billing & Billing Exceptions Expense	$	57,016
Reduction of Exception Handling, Billing Issues		50%
Gas Service Proportion by Total Meter Count		18%
Annual Savings	**$**	**-**
Gas Theft Identification		Yes
Annual Sales of Gas, Residential (2016)		7,142,586
Estimated % Recovered from Tampering Cases		0.05%
Annual Savings	**$**	**3,571**
Gas Annual Meter Replacement Budget		Yes
Gas Meter Replacement Budget ($)	$	333,915
Reduction Rate		90%
Annual Savings	**$**	**300,523**
Gas Bad Debt Reduction		Yes
Annual Write-off ($) Gas	$	67,975
Estimated % of Customers on Remote Disconnect		100%
Late Payment Reduction with Remote Disconnect		90%
Annual Savings	**$**	**61,178**
Meter Scrap Value		Yes
Total Residential Meters		21,598
Total Commercial Meters		1,477
Residential Meter Weight (lbs)		3
Commercial Meter Weight (lbs)		5
Gas meter scrap value per lb.	$	0.203
One Time Savings	**$**	**14,652**
Revenue Capture from Aging Gas Meters		Yes
Annual Sales of Gas, Residential (2016)	$	7,142,586
Average Gas Meter Inaccuracy		1.08%
Inaccurate gas meters, over 20 years (% in field)		33%
Improvement (% incorrect)		90%
Annual Savings	**$**	**23,022**

Total Gas Deployment Benefits	**$**	**1,386,883**

Prepay

Billing/CS Handling Expense - PrePay		Yes
Billing & Adj Expense & Payment Plan Monitoring Cost	$	24,602
3rd Party Bill Generation Savings	$	596,926
Reduction of Bill Handling		10%
Annual Savings	**$**	**84,295**
Prepay Write Off Reduction		Yes
Annual Bad Debt (Electric, Water & Gas)	$	1,031,977
Bad Debt Reduction with PrePay		10%
Annual Savings	**$**	**103,198**

Water Pressure Monitoring

Pumping Schedule (Lower Pumping Costs)		Yes
Annual Pumping Costs	$	2,115,141
Electricity Cost Savings		10.0%
Annual Savings	**$**	**211,514**
Main Breaks Prevention/Reduction		Yes
Annual reported breaks and leaks		975
Cost to replace/ repair water mains	$	3,500
Improvement in water main breaks prevention		10.0%
Annual Savings	**$**	**341,250**

Water Leak Detection

Water Loss Reduction due to Detected Leaks		Yes
Water Production (MGD)		7,805,218
Annual Cost to Treat and Distribute Water	$	31,172,460
Water Loss %		16%
Estimated Reduction of Loss with Water Leak Detection		5%
Annual Savings	**$**	**249,380**

Appendix V – GRU Technology Capabilities

Table 12 – MDM System Capabilities

Gainesville Regional Utility
MDM System Capabilities

Category	ID	Capability	Priority	Comments
		The MDM System Shall:		
General MDMS	1	MDMS shall store meter data, including business critical meter and account characteristics.	H	
General MDMS	2	Receive and store register meter reads.	H	
General MDMS	3	Receive and store interval usage data.	H	
General MDMS	4	Receive and store events and alarms originating from the AMI Headend.	H	
General MDMS	5	Provide a Graphical User Interface (GUI) for internal system users and customer portal users.	H	
General MDMS	6	Provide meter connection status for all meters.	H	
General MDMS	7	Provide ability to aggregate meters (i.e., virtual metering) for analytics.	H	
General MDMS	8	Provide reporting capabilities and exportability to other file formats (such as .csv and .xlsx)	H	
General MDMS	9	Retain a minimum of three (3) years of interval and register reads for immediate access.	H	
General MDMS	10	Archive a minimum of ten (10) years of interval and register reads.	H	
General MDMS	11	Process and report all events and alarms from the AMI Headend System.	H	
Systems Integration	12	Interface with the CIS via the current MVRS file format for billing reads.	H	
Systems Integration	13	Be capable of transferring data to and from the AMI Headend via MultiSpeak (minimum version 4.1) and/or file transfer.	M	
Systems Integration	14	Be capable of transferring meter or operational data to applications other than CIS, such as GIS, WOMS, Asset Management, etc. via MultiSpeak (minimum version 4.1) and/or file transfer.	H	
Systems Integration	15	Accept data through manual entry.	H	
Systems Integration	16	Receive interval reads and perform VEE on hourly interval data from AMI Headend system for water meters.	H	
Systems Integration	17	Receive interval data and perform VEE on 15 minute intervals from AMI Headend system for electric meters.	H	
Systems Integration	18	Receive and process daily register meter reads from AMI Headend.	H	
Systems Integration	19	Accept scheduled batch files.	H	
Systems Integration	20	Originate and receive real-time data transfers with the AMI headend (i.e., on demand read request/response). Provide protocol/method (e.g. MultiSpeak 4.1)	H	
Systems Integration	21	Provide interval meter read data for use by other authorized applications, such as Customer Portal or CIS via file based transfers.	H	

Systems Integration	22	Be able to convert the unit of measure.	H	
Reporting	23	Provide notification of meters that are non-communicating for more than 24 hours.	H	
Remote Connect/ Disconnect	24	Provide the capability to schedule a remote connect/disconnect operation for all services to be initiated at a specified time.	H	
Remote Connect/ Disconnect	25	Allow for remote connects/disconnects to be manually initiated by a user via the MDMS GUI.	H	
Remote Connect/ Disconnect	26	Identify and report failed remote connect/disconnect operations.	H	
Remote Connect/ Disconnect	27	Identify emergency and critical needs customers to prevent remote connect/disconnect.	H	
VEE	28	Automatically estimate meter data to fill gaps in interval usage data.	H	
VEE	29	Allow manual editing of interval usage data.	H	
VEE	30	All validation parameters shall be configurable by an authorized user without the need for new code development.	H	
VEE	31	A mechanism shall exist to identify failed automatic estimations.	H	
Security	32	Have a secure login feature and support user authentication and authorization by action, process, or view.	H	
Security	33	Provide necessary security to prevent access by unauthorized users.	H	
Security	34	Store audit logs.	H	
Security	35	Provide authorized users' access to audit logs that shall track all changes to interval usage, register meter reads and configuration data.	H	

Table 13 – AMI System Capabilities

Gainesville Regional Utility
AMI System Capabilities/Priorities

Category	ID	Capability	Priority	Comments
		The AMI System Shall:		
General AMI	1	Not significantly limit the brands of electric, water or gas meters that the Utility can install.	M	
General AMI	2	Be compatible with the Utility's Customer Information/Billing System (Local Government)	H	
General AMI	3	Not interfere with the Utility's current Utility, SCADA, Public Safety or any other current communications system.	H	
General AMI	4	Provide full system redundancy.	M	
General AMI	5	Provide a solar power option for collectors.	H	
General AMI	6	Be MultiSpeak 4.0 certified OR IEEE CIM compliant.	M	
General AMI	7	Support common information model (MultiSpeak, CIM) structures, commercial EAI interfaces, and service oriented integration patterns for IT systems integration with Meter Data Management System (MDMS) and other enterprise IT systems.	H	
General AMI	8	System must be capable of securing hourly reads (water and gas) and quarter hour reads (electric).	H	
General AMI	9	System must be capable of delivering reads to head-end at least 4 times per day.	H	
General AMI	10	Support interval data collection for measured product.	H	
General AMI	11	The Headend system must be able to store 90 days of interval data.	H	
General AMI	12	Support bi-directional commodity (electric) flow metering. (i.e. net metering)	H	
General AMI	13	Distinguish between a missing interval and zero consumption.	H	
General AMI	14	Store data for each product measured in separate tables.	H	
General AMI	15	Issue an on-demand read request initiated from another authorized Utility systems (i.e., CIS)	H	
General AMI	16	Deliver the results of all received alarms, outages and remote testing and diagnostic results to the MDMS in near-real time.	H	
General AMI	17	Log all messages sent to and received from all AMI components with the message date/time, event/message type identifier, and source/target(s) identifier.	H	
General AMI	18	Log each instance when an event message has been sent to an AMI component, but no acknowledgement is received within the configured time frame.	H	

General AMI	19	Utilize two-way secure communications with all authorized systems and devices. This applies to all communication interfaces including optical ports, Field Tool Connections, and AMI network communications.	H	
General AMI	20	Support communications technology between the collector and the head-end including:	H	
General AMI	21	Cellular	L	
General AMI	22	Phone/Modem	L	
General AMI	23	Radio Frequency	M	
General AMI	24	Fiber	H	
Remote Connect/ Disconnect	25	Allow for remote connect/disconnects (electric/water/gas) to be automatically initiated based on commands by an authorized application other than the AMI Headend (i.e., MDMS or CIS)	H	
Remote Connect/ Disconnect	26	Provide the capability to perform a remote connect/disconnect for an electric meter, water meter and gas meter.	H	
Remote Connect/ Disconnect	27	Provide the capability to schedule a remote connect/disconnect operation to be initiated at a specified time.	H	
Remote Connect/ Disconnect	28	Allow for remote connects/disconnects to be manually initiated by a user via AMI Headend GUI.	H	
Remote Connect/ Disconnect	29	Identify and report failed remote connect/disconnect operations.	H	
Remote Connect/ Disconnect	30	Identify emergency and critical needs customers to prevent remote connect/disconnect.	H	
Remote Connect/ Disconnect	31	AMI system shall provide a platform to provide connectivity (status and control) to public street lights and rentable private lighting.	H	
Remote Connect/ Disconnect	32	Support and provide backhaul communications for water pressure monitoring devices.	H	
Remote Connect/ Disconnect	33	Support and provide backhaul communications for leak detection devices.	H	
Remote Connect/ Disconnect	34	Detect and report all alarms and events in near-real time to the Headend system.	H	
Events/Alarms	35	Provide mechanism to communicate events and alarms to designated recipients via email.	H	
Events/Alarms	36	Detect and report power quality excursions (IEEE 1159) for an electric meter.	H	
Events/Alarms	37	Detect and report power on events for an electric meter.	H	
Events/Alarms	38	Detect and report demand threshold reached for an electric meter.	H	
Events/Alarms	39	Detect and report load side voltage with service switch in OPEN state for an electric meter.	H	

Events/Alarms	40	Detect and report loss of AC Power ("Last Gasp" Message) for an electric, water and gas meter.	M	
Events/Alarms	41	Detect and report reverse power flow for non-Net electric meters or not programmed for kWh received.	H	
Events/Alarms	42	Detect and report loss of power on a single phase or all phases for an electric meter.	H	
Events/Alarms	43	Detect and report meter removal for an electric, water and gas meter.	H	
Events/Alarms	44	Detect and report meter tilt of an electric, water and gas meter.	H	
Events/Alarms	45	Detect and report max amps for an electric meter has been reached.	H	
Events/Alarms	46	Detect and report min amps for an electric meter has been reached.	H	
Events/Alarms	47	Receive process requests from other Utility systems, such as the CIS.	H	

Table 14 - Electric Metering Capabilities

Gainesville Regional Utility
Electric Metering Capabilities

Category	ID	Capability	Priority	Comments
		The Electric Meters Shall:		
Electric Meters and Meter Equipment	1	Be supplied with a scannable bar code label affixed to the meter.	H	
Electric Meters and Meter Equipment	2	Have a certification for accuracy test results in electronic format.	H	
Electric Meters and Meter Equipment	3	Be equipped with a diagnostic self-test of the register software in the event of errors or warning displays.	H	
Electric Meters and Meter Equipment	4	Accept remote configuration changes via the AMI Headend.	H	
Electric Meters and Meter Equipment	5	Be able to accept and process a remote demand reset command from the AMI Headend system.	H	
Electric Meters and Meter Equipment	6	Be able to support load limiting functionality.	H	
Electric Meters and Meter Equipment	7	Be able to accept and process a remote load limiting command from the AMI Headend system.	H	
Electric Meters and Meter Equipment	8	Be equipped with a diagnostic self-test of the register software in the event of errors or warning displays and provide notification back to the Headend.	H	
Electric Meters and Meter Equipment	9	Must meet or exceed the accuracy specifications contained in ANSI specifications over its entire service life without the need for adjustment.	H	
Electric Meters and Meter Equipment	10	Documentation of meter programming parameters and procedures must be provided for each distinct meter type.	H	
Electric Meters and Meter Equipment	11	Vendor shall replace the meter at its cost and reimburse the City for labor and materials for failure rates execeeding 1.5% during the warranty period.	?	
Electric Meters and Meter Equipment	12	Allow for remote disconnect and reconnect functionality for all meters that are single phase, 200 amps or less.	H	
Electric Meters and Meter Equipment	13	Be able to supply 15-minute interval reads to the AMI endpoint.	H	
Electric Meters and Meter Equipment	14	Be able to support remote configuration of the read interval.	H	
Electric Meters and Meter Equipment	15	Be able to support net metering functionality.	H	
Electric Meters and Meter Equipment	16	Be able to log an event for loss of power to meter.	H	

Electric Meters and Meter Equipment	17	All three phase meters must provide a phase angle measurement both positive (leading angle) and negative (lagging angle).	H	
Electric Meters and Meter Equipment	18	All three phase meters must provide a kVAR and kQ measurement.	H	
Electric Meters and Meter Equipment	19	All meters must provide an amperage and voltage reading, on demand and a maximum amperage and max/min voltage reading for interval readings.	H	

Table 15 - Water Metering Capabilities

Gainesville Regional Utility
Water Metering Capabilities

Category	ID	Capability	Priority	Comments
		The Water Meters / Registers Shall:		
Water Meters and Meter Equipment	1	Contain no lead according to CFR 141.43 outlined by the Environmental Protection Agency.	H	
Water Meters and Meter Equipment	2	Meet NSF/ANSI Standard 61 (Annex F), Standard 372, NSF 61-G.	H	
Water Meters and Meter Equipment	3	All meters and registers must allow for and be compatible with future upgrades of the manufacturer's product.	H	
Water Meters and Meter Equipment	4	All meter accuracy tests must be conducted in accordance with AWWA meter requirements (C-700, C-710).	H	
Water Meters and Meter Equipment	5	The meter manufacturer must furnish to the Utility an electronic copy of the test results for all meters shipped.	H	
Water Meters and Meter Equipment	6	Be supplied with the serial number embossed to the meter body and register.	H	
Water Meters and Meter Equipment	7	Be supplied with a scannable bar code label affixed to the meter.	H	
Water Meters and Meter Equipment	8	Measure consumption in gallons (unit) down to 10 gallon (resolution) for manual read.	H	
Water Meters and Meter Equipment	9	Be compatible with proposed AMI Endpoint.	H	
Water Meters and Meter Equipment	10	Be made of non-corrosive material.	H	
Water Meters and Meter Equipment	11	For meter pit installations, the meter must be capable of continous operation in a submerged environment.	H	
Water Meters and Meter Equipment	12	For meters to be used in meter pits or vaults, all connections must be waterproof and corrosion proof.	H	
Water Meters and Meter Equipment	13	The meter register must be factory potted.	?	
Water Meters and Meter Equipment	14	Each register must have a unique identification number.	H	
Water Meters and Meter Equipment	15	Be able to supply hourly interval reads to the AMI endpoint.	H	
Water Meters and Meter Equipment	16	Be able to support remote configuration of the read interval.	H	

Table 16 – Gas Metering Capabilities

Gainesville Regional Utility
Gas Metering Capabilities

Category	ID	Capability	Priority	Comments
		The Gas Meters Shall:		
Gas Meters and Meter Equipment	1	Be supplied with a scannable bar code label affixed to the meter.	H	
Gas Meters and Meter Equipment	2	Must meet or exceed the accuracy specifications contained in ANSI specifications over its entire service life without the need for adjustment.	H	
Gas Meters and Meter Equipment	3	Documentation of meter programming parameters and procedures must be provided for each distinct meter type.	H	
Gas Meters and Meter Equipment	4	Be able to supply hourly interval reads to the AMI endpoint.	H	
Gas Meters and Meter Equipment	5	Be able to support remote configuration of the read interval.	H	
Gas Meters and Meter Equipment	6	Measure consumption in cubic feet (unit) down to 100 cubic feet (resolution) for manual read.	H	

Table 17 – Prepay System Capabilities

Gainesville Regional Utility Prepay System Capabilities				
Category	**ID**	**Capability**	**Priority**	**Comments**
		The Prepay System Shall:		
Overall System Capabilities	1	Customer will be able to monitor their electric usage and account balances through user friendly interfaces	H	
Overall System Capabilities	2	The prepay process will use a Web portal for access from the internet.	H	
Overall System Capabilities	3	Customers will be able to receive notifications and view their remaining balance in days and hours.	H	
Overall System Capabilities	4	Customers will be able to receive notifications and view their remaining balance in dollars.	H	
Overall System Capabilities	5	Customers can select to receive notifications of their balance based on user defined thresholds.	H	
Overall System Capabilities	6	Ability to remotely connect and disconnect a customer's electric service will be available. Both manual and automated capability will exist. A business decision will be required to use the automated capability or not.	H	
Overall System Capabilities	7	Prepay "Terms and Conditions" Privacy Policy, and Disclaimer statements will be available to the Customer when using the Web portal.	H	
Overall System Capabilities	8	Customer will accept the "Terms and Conditions" Privacy Policy, and Disclaimer statements before processing payments from the Web portal.	H	
Overall System Capabilities	9	Creating and canceling of prepay accounts can only be done at utility walk-in payment locations.	L	
Overall System Capabilities	10	Processes for Credit and Debit cards will be PCI compliant.	H	
Overall System Capabilities	11	A notice of pending disconnection due to account balance being depleted will be provided before a customer's service is disconnected. The timeframe in which the alert is sent will be determined by the utility.	H	
Overall System Capabilities	12	The utility will have the capability to include outstanding balances when post pay customers enroll in prepay. The payment structures for customers with outstanding balances	H	

Table 18 - Customer Engagement Platform Capabilities

Gainesville Regional Utility
Customer Portal System Capabilities

Category	ID	Capability	Priority	Comments
		The Customer Portal Shall:		
Customer Portal	1	Have a configurable utility-branded GUI interface.	H	
Customer Portal	2	Feature user-centric design that is compatible with mobile devices (smart phone, tablet) and web broswers.	H	
Customer Portal	3	Include data on usage and energy profile information for each customer account.	H	
Customer Portal	4	Support log in with email and password.	H	
Customer Portal	5	Support monitoring of multiple accounts with a single account sign on.	H	
Customer Portal	6	Be capable of interfacing with existing billing portal using SSO.	H	
Customer Portal	7	Be capable of interfacing with Prepay system using SSO.	H	
Customer Portal	8	Contain fully configurable reports with daily, monthly and yearly usage that is available to view in graphical and tabular formats.	H	
Customer Portal	9	Provide for direct export of reports to other file formats (such as .csv and .xlsx)	H	
Customer Portal	10	Provide display for customers that use net metering.	H	
Customer Portal	11	Provide educational information and cost-saving tips to customers upon log-in if appropriate.	M	
Customer Portal	12	Provide mechanisms to send alerts on thresholds for consumption, including leak notifications.	H	
Customer Portal	13	Provide a self-serve mechanism to update preferences related to threshold levels for high-bills and alerts.	H	
Customer Portal	14	Provide a self-serve mechanism to update preferences related to communications (SMS text message, email) for alerts and messaging.	H	
Customer Portal	15	Be capable of displaying a minimum of two (2) years of customer data for historical comparison.	H	
Customer Portal	16	Support a lockout for a configurable amount of time after a failed login/access attempt.	H	
Customer Portal	17	Allow user to reset their passwords.	H	
Customer Portal	18	Encrypt all personal identifiable information stored outside of the CIS or MDM system.	H	

Appendix VI – Utility Operational Technology

Historically, Operation Technology (OT) and Information Technology (IT) have been managed as two different domains by most industries, including utilities. However, as connectivity and real-time data becomes more prominent in the last few years, OT has started to adopt IT-like technologies. This convergence of IT and OT is expected to enhance performance and operational flexibility with the better optimization of data. Utilities can gain the most benefits in converging IT and OT. Most of a utility's operational assets (transmission equipment, substations, and meters) can be increasingly connected with intelligence while the performance data can be collected in real time.

For example, utility metering was traditionally part of the OT world – while utility billing was traditionally part of the IT world. Now with advanced metering infrastructure, these two functions can be connected, bringing an end-to-end smart metering (meter-to-bill) where bills are produced based on exact meter readings – no longer on estimates. This section attempts to provide a description of the relevant technologies that potentially will transform utility operations and improve their performance and service to its customers.

1. Managed Services

There are a multitude of permutations of AMI/MDM system platform alternatives available that can mitigate staff expansion by the client utility. The total cost of ownership evaluation will, of course, be required before deciding. In some cases, the total cost may be 'higher' by selecting a hosted solution, but other factors may make the hosted solution a 'better' choice.

The following are some of the options:

1. <u>On-premises</u>
   a. GRU licenses AMI 'head-end' software and MDM software
      i. GRU provides hardware that meets vendor requirements (this should be virtualized via VMware or another server virtualization platform)
         1. Memory
         2. Storage
   b. CPU 'Cores'
      i. GRU licenses required third-party software specified by vendor
         1. Server operating system(s)
         2. Database software
            a. Oracle
      ii. Preferably 'concurrent' user license
         1. Microsoft SQL
      iii. Preferably 'concurrent' user license
         1. Other 'utility' software including web servers such as Apache
      iv. GRU provides backup and disaster recovery services
      v. GRU internal staff provides first-line support for all aspects, including application support and monitoring

2. <u>On-premises ‘managed service’</u>
    a. GRU licenses AMI ‘head-end’ software and MDM software
        i. GRU provides hardware that meets vendor requirements (this should be virtualized via VMware or another server virtualization platform)
            1. Memory
            2. Storage
    b. CPU ‘Cores’
        i. GRU licenses required third-party software specified by AMI/MDM vendor.
            1. Server operating system(s)
            2. Database software
                a. Oracle
                    i. Preferably ‘concurrent’ user license
                b. Microsoft SQL
                    i. Preferably ‘concurrent’ user license
            3. Other ‘utility’ software including web servers such as Apache
        ii. GRU provides backup and disaster recovery services
        iii. Vendor provides first-line and above level support for all aspects including application support and monitoring
            1. This can be ‘broken out’ in any way that GRU would like, for example: the AMI vendor provides managed services, but the MDM vendor does not provide managed services

3. Off-premises hosted and managed service
    a. GRU pays a monthly fee to the vendor(s)
    b. Each vendor provides the following:
        i. Application licensing
        ii. Server licensing
        iii. Database licensing
        iv. Utility licensing
        v. Internet connectivity/integration as required
        vi. All required hardware: CPU, memory, storage.
        vii. All required security: physical and cyber security to standard required by the client
        viii. Backup and disaster recovery services
    c. GRU provides first-line application support to internal customers
    d. Vendor(s) provide all other support and services
    e. This can be a ‘mix and match,’ for example: AMI is fully hosted by the vendor and the MDM is ‘on-premises’ either managed by GRU or by the MDM vendor as a managed service

2. Advanced Metering Infrastructure (AMI)

AMI is a transformational technology. This technology provides an excellent data collection platform, a bi-directional control network, and automates a very expensive and at times challenging business function. The deployment of an AMI system opens the door to a wealth of data previously unavailable to utilities and their customers. Previously, a customer's meter consisted of a simple read once/month. Once the data was collected, all but the largest customers with specially designed meters generated a single data element per month: a billing read. In contrast, AMI provides a steady stream of meter reading and diagnostic data at regular intervals, as well as event-driven urgent messages.

More granular usage data and system information can be transmitted digitally over the AMI network. If managed properly, this data can be used by many different applications, ranging from customer presentation of consumption profiles to usage of the data by engineering and operations to monitor system health and predict where upgrades to the system will have the most favorable return on investment. A key element here is that a customer engagement platform can provide this information to customers on a 'near real time' basis. However, data needs to be 'cleansed' before it is presented to customers. Many utilities have encountered significant public relations concerns when they provided 'raw' data to customers. Customer engagement can range from a 'simple' Web presentation model to a complex environment that includes sending alerts/alarms to customer's Smart Phones. This is very dependent upon the existing environment, as well as the utility's goals to increase customer service. Customer engagement platforms are available from a variety of sources:

1. From the utility's Customer Information/Billing system vendor – typically an MDM or AMI vendor can provide a 'link' from an existing platform that will maintain the same 'look and feel' that customers are accustomed to.
2. Third party – these can be 'on-premise' or Software as a Service (more prevalent) and can provide customer access from a variety of platforms including 'smart phones'. A 'buyer beware' observation is that monthly fees and 'custom integrations' can have a significant impact on budget.
3. From the MDM vendor – some of the MDM vendors provide a platform that can be provided directly to a customer or as a 'link' (noted above). The functionality is somewhat limited as the MDM platform is NOT a full-featured customer service environment.

An AMI system can be configured so that a customer service representative can request an on-demand meter read. By relaying that information to the customer immediately (over the phone or at the billing and collection location), issue resolution can be accelerated. An AMI system, along with the data it delivers, can facilitate numerous improvements; however, a solid plan to design and deploy the system and business process changes is essential to project success.

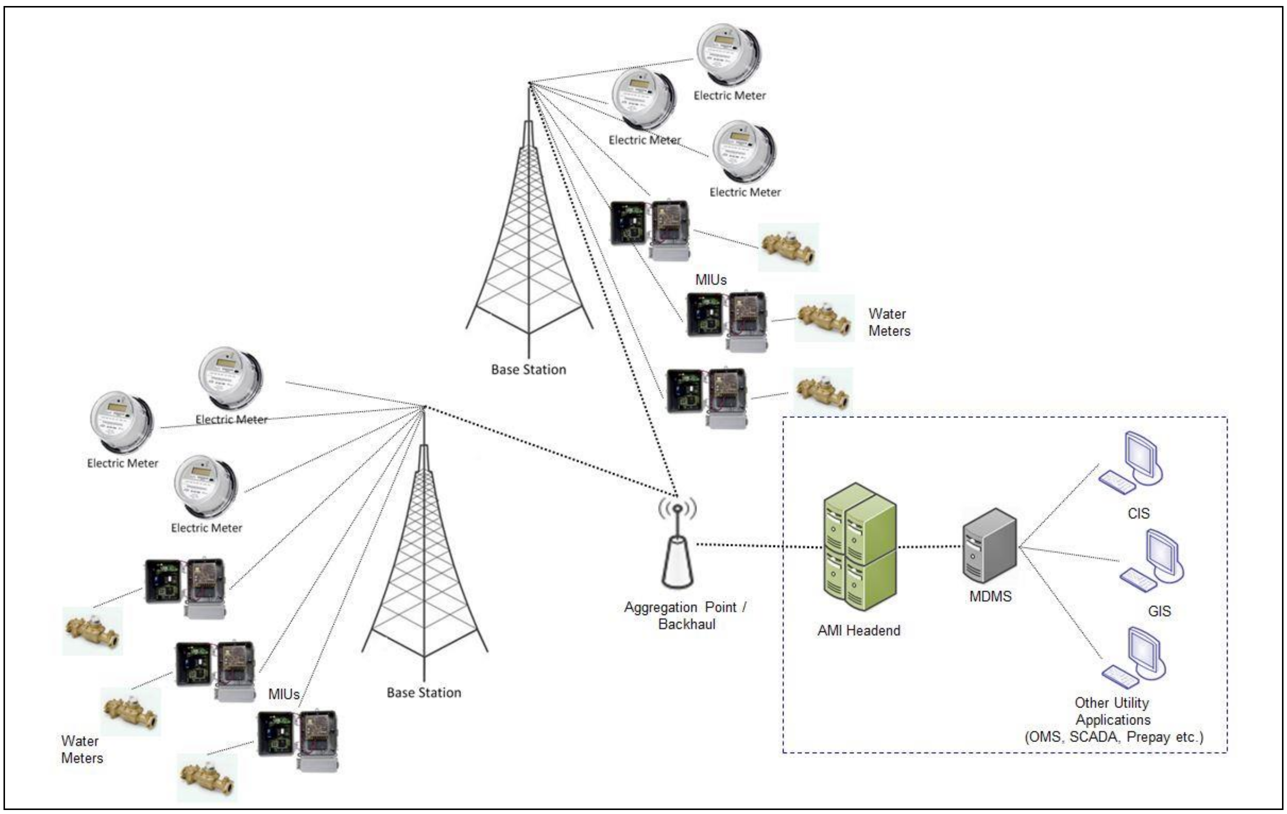
AMI implementation must be approached wisely in preparation for drastic changes in data volume and variety. A successful path to AMI includes careful advanced planning and preparation regarding data distribution to all stakeholders involved.

AMI System Details

AMI systems allow meters to be read remotely from a central location through a fixed communications network. There are various AMI network designs available, including radio-frequency based, powerline carrier, or via broadband powerline. Today's AMI systems suitable for GRU are radio-frequency based. Radio-frequency based products operate on either licensed or unlicensed frequencies. A license covers the use of a specific frequency in a given area. The licensed band normally permits a higher power signal, which enables greater distance between the transmitter and receiver units. Unlicensed radio frequency systems operate under greater Federal Communications Commission (FCC) imposed frequency and power level constraints but with increased channel width and thus higher bandwidth capabilities. The same band can be shared by other devices using specialized modulation and frequency hopping techniques which make the systems inherently more interference tolerant.

The most advanced metering systems use one-way or two-way communications to get the data to and from the meter through a transmit/receive endpoint or meter interface unit (MIU) connected to the meter encoder/register. These MIUs talk to nearby collectors, also known as gateways or data concentrator units (DCUs). It is not uncommon for AMI systems to also use a series of network repeaters to ensure adequate communications. The collectors are then networked to the utility head-end system through a fixed communication backhaul network. This backhaul network typically uses an Ethernet transport and can leverage GRU fiber, radio systems, cellular modems, or any combination. Communications between the meter and the collectors are specific to each vendor and use proprietary protocols. The components of an advanced metering infrastructure system are illustrated in Figure 4 below.

Figure 4: Sample AMI System Diagram (Point to Multipoint Network)



**The diagram above illustrates a point to multipoint communication network, utilizing a radio frequency system. Although there are instances where the communication systems for electric and water are different and communicate to separate base stations/DCUs, in this diagram, both electric and water MIUs are presented communicating to the same base stations/DCUs. In future AMI network design, the network can be leveraged to support additional applications such as: distribution automation, demand response, SCADA 'lite', street lighting management, plug-in hybrid electric vehicles, etc.*

Many AMI systems collect interval (e.g., hourly or sub-hourly) data. Two-way systems enable the system to collect on-demand reads, send control signals, firmware updates, and time synchronization signals to the MIU at the meter. Other sensors, such as acoustic leak detectors, can passively gather information and send it along periodically. Actuators, such as remote shut-off valves, can be triggered in response to commands from the head-end software.

Typically, at pre-programmed intervals, MIUs at the customer premises transmit meter readings to nearby permanently positioned DCUs, which in turn relay the readings back to the head-end. Fixed network MIUs typically collect readings from the meter several times per day and transmit them at least once per day.

Most AMI systems rely on a relatively large number of low cost DCUs closely spaced on power poles or rooftops. The distance between the MIU and the data collector might be less than one mile. Other systems (sometimes referred to as “tower-based” AMI) use fewer more expensive collectors located on tall towers or buildings. These systems operate at higher power and the signals can propagate farther. The use of repeaters between MIUs and data collection units is common to fill in gaps and create a more uniform communications network.

Point to Multipoint Networks

A point to multipoint connection refers to a type of architecture for fixed wireless data communications, as described in the previous figure. A point to multipoint network configuration has a communication link between an “access point” radio and associated “remote” endpoints at the meter level. All meters can talk to the collector in this scenario and the collector can talk back to the individual meters. Thus, this scenario is classified as a two-way communication architecture. However, the meters cannot communicate to each other. In this setup, only data packets sent to the access point are acknowledged. Point to multipoint networks are licensed spectrum networks and are classified as private.

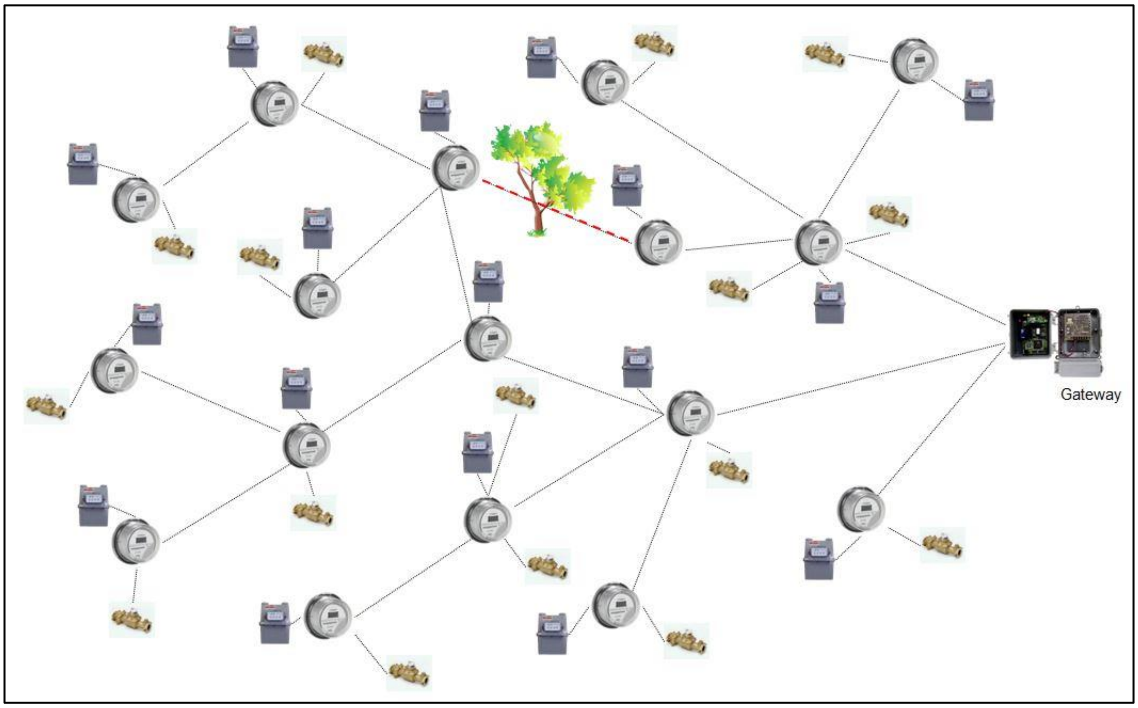
Mesh Networks

Another variant of fixed network AMI uses a mesh network. In mesh networks, MIUs (“nodes”) themselves serve as relaying devices for data and instructions. Information “hops” from MIU to MIU until the head-end destination is reached. These mesh networks are generally self-forming and self-healing. Since GRU’s system will encompass electric, water, and gas, the combination network will allow meters to be routed to hop through the closest meter of any type.

Most mesh networks use low power transmissions in the unlicensed bands, and MIUs must be reasonably close together (typical ranges up to 1,000 feet). Using the relaying scheme, a data collector can cover greater distances than some networks that rely on local data collectors. However, each hop adds latency to the network, thus it is important to avoid excessive hops through good planning of DCU locations.

Typically, AMI mesh network design is not recommended for a water-only utility, as the power required for the daily multiple hops may cause the meter interface unit battery (at the water meter) to drain more quickly. It can be considered for utilities such as GRU which is a combination of electric, gas, and water, as the water or gas meter interface unit can communicate only to the nearest electric meter and have the electric meter interface unit (which does not require battery) perform the multiple hops to send data thus prolonging the battery life of the water or gas meter interface unit.

Figure 5: AMI Mesh Network Illustration



**MIUs in mesh networks communicate to each other, relaying data and commands. In the illustration above a tree is blocking/preventing one route of MIU communication, causing the network to re-route the information hop to an alternative path until it reaches head-end. This describes the "self-forming" and "self-healing" capabilities of an AMI Mesh Network.*

Table 19: Point to Multipoint vs. Mesh Network

Characteristic	Point-to-Multipoint Network	Mesh Network
Spectrum	Operates on a private licensed spectrum Requires annual licensing fee Interference less likely because of licensing, but systems are more susceptible to interference if there is source	Operates on a public unlicensed spectrum Does not require annual licensing fee Higher chance of interference but systems are also more interference tolerant
Signal-to-Noise Ratio	Has a low noise floor Can maintain Signal-to-Noise Ratio at a high level	Has a high noise floor Can rapidly reduce Signal-to-Noise Ratio when high noise levels are generated in shared frequencies
Signal Range (Coverage)	Can use higher level of output to extend range	Range is limited due to one watt of power output limit Remediated by locating points close together
Latency	Signal moves through few or no mid-point nodes, thus latency is minimal	Signal has to go through multiple 'hops' which increases latency Hops can be reduced by adding more backhaul
Communicated Data Retrieval	Higher risk of losing communication with endpoint due to relying on one communication path AMI network needs to be designed carefully to ensure full coverage	"Self-forming" and "self-healing" capability - network can re-route information to an alternative communication path
Infrastructure	Higher cost of collectors (Base Stations) Less complex/requires less equipment	Lower cost of collectors (Gateways) More complex/requires more equipment

Meter Interface Units

The MIU either interrogates the encoded register of the meter or accumulates electronic pulses corresponding to consumption from the meter and transmits this and other information (such as identification numbers or tamper flags) to the utility. Most MIUs are equipped with some tamper-resistant features and may generate electronic "flags" if tampering occurs, such as a cut wire, a tilted meter, a tilted register, etc.

Most of the leading electric meter vendors have their own electric meters designed with their MIUs incorporated in the meter casing ("under-the-glass"). However, as is the case with water meters, the electric meter vendors have provided their meters compatibility to integrate with different MIU brands.

Water meter registers are connected to stand-alone MIUs using a cable. Stand-alone MIUs are sometimes square or rectangular boxes, a few inches on each side and usually not more than two inches thick. The circuitry is usually encased to resist corrosion. A cast iron lid and supporting ring of a water meter pit will diminish transmission signal strength. For fixed AMI systems, the MIU should be mounted with its antenna protruding through the iron lid, or a composite lid may be used. AMI-ready meter lids can be purchased, or a hole can be drilled in a current cast iron or concrete lid so the MIU can fit.

MIUs are equipped with lithium (lithium-thionyl chloride or $Li\text{-}SOCl_2$) batteries designed to last 10-20 years, depending on the MIU model and its frequency of transmission. If the MIU is set to transmit above certain design parameters, the battery will wear out prematurely. For example, an MIU designed to transmit a simple reading twice per day will run down its battery quickly if reprogrammed to transmit every 15 minutes. MIU batteries are generally not field replaceable. MIU warranties are typically tied to battery life. For an initial period, manufacturer's warranties will replace the MIU with a new MIU for no cost (equipment only). Past a certain age, manufacturers will replace the MIU under a pro-rated warranty at a cost based on the "list" price. All AMI manufacturers use batteries from the same few providers and have generally comparable life and warranty periods.

Data Collection Units and Backhaul

Data collectors are typically mounted on light or utility poles, rooftops, or on top of water tanks. Depending on the vendor and local operating conditions, they may be configured to use AC electrical power or DC solar cells.

Transferring information from data collectors to the AMI head-end requires a wide area network (WAN). AMI vendors do not typically provide the WAN. Instead, they work with the utility to identify and use locally provided telecommunications facilities. Backhaul may be accomplished over fiber, radio frequency systems or cellular networks.

Cities will sometimes develop in-house multi-function wireless communications systems (e.g. SCADA, AMI, Workforce Management, etc.) to further leverage investment. Backhaul over commercial networks such as cell phone service or private, proprietary, or dedicated networks will generally require monthly service charges.

Meter Data Management System (MDM)

UtiliWorks highly recommends that utilities implement MDM systems in conjunction with the implementation of AMI system. With AMI, utilities will receive significant amounts of data, however without a proper data management system the data will be rendered meaningless as no appropriate action can be taken. An MDM provides the capabilities for AMI data cleansing, calculating, providing data persistency, and disseminating metered consumption data. The partitioned data can be utilized by different utility technology functions (i.e. billing, customer service, operational, outage management, water leak detection, etc.) to inform and make better decisions. This is where the true business value of an AMI system is realized.

MDM is an essential technology for AMI if predicted benefits outlined in the business case are to be realized. AMI systems generate an amount of data that exceeds both the capacity and analytical capabilities of both CIS and AMI system environments, which are not designed for this function. Typically, the MDM requirements are shaped by needs in the electric power utility, as it has a higher complexity in managing the commodity (as electricity can rarely be stored) while

MDM requirements for water utility are subsets of the MDM requirements for electric utility – from functional and performance/scalability standpoints.

If GRU is to proceed with an AMI implementation for both electric, water, and gas utilities, it is recommended that the implementation is complemented with an MDM. This is taken under consideration of the size and complexity of GRU's AMI implementation with over 95,000 electric, 70.000 water meters and 36,000 gas meters, and the availability of dedicated IT staff.

Most currently available AMI headend systems typically store data for one to thirteen months. The MDM database, analytics, and complex event processing (CEP) engines provide functionality bridging the gap between the AMI headend and other business systems within the utility. The MDM is designed to analyze and manage the large data volumes generated by AMI, and to serve this data to other systems as needed. By design, it will become the system of record for meter consumption data.

The storage and capability of the analytic engine of the MDM also makes it an ideal nexus for combination of SCADA and Meter Data. Data can be extracted from SCADA historians for offline queries and use in other analytic tools, or read-only views into SCADA Historian databases can be created for real-time queries and to avoid data replication. This is optional but highly recommended, as the value is quite high and the incremental cost to implement is quite low.

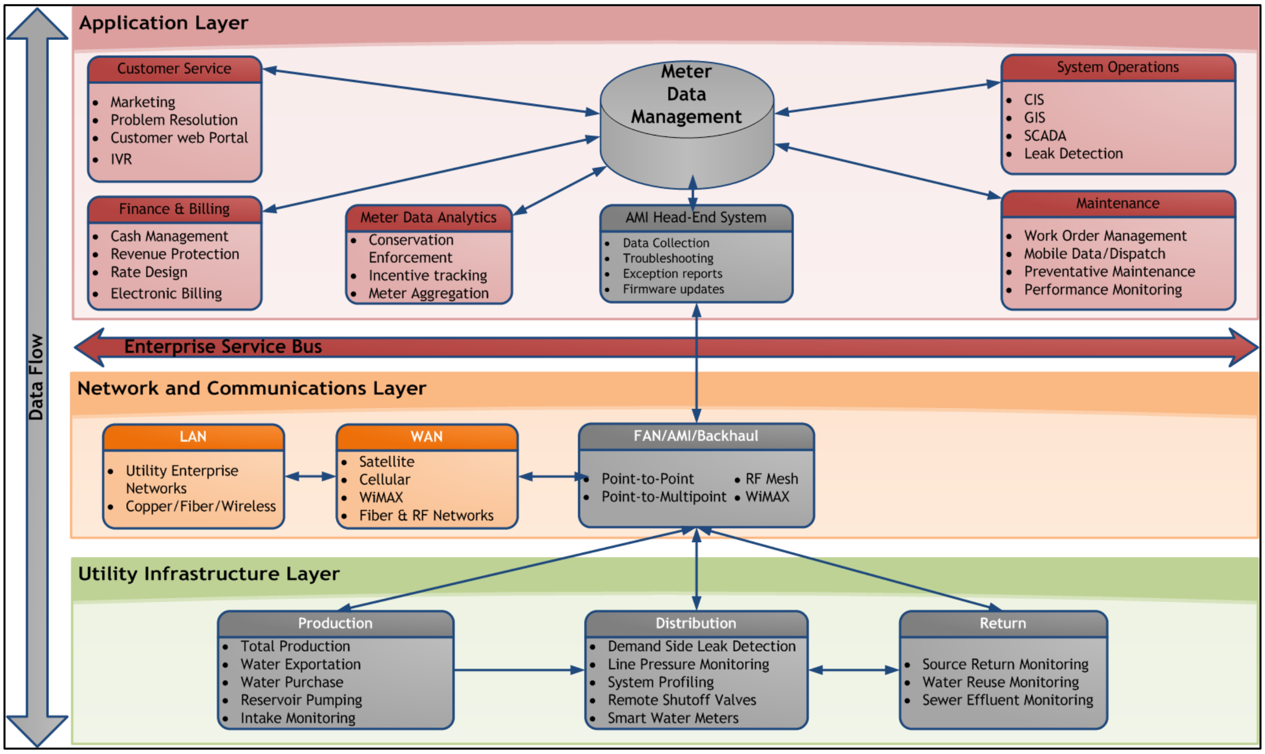
The MDM provides tiered data storage for multiple years of interval data, and provides advanced analytics, reporting, and complex event processing based on meter interval data. In addition, the MDM:

- Validates meter reading data based upon utility configured validation rules
- Reporting engine delivers preconfigured and ad-hoc reports to users
- Provides validated billing determinants to CIS

Certain functionality offered by MDM systems can overlap with functionality offered by AMI systems. During the RFP and requirements definition phase of the project, it is necessary to establish the specifics of what that functionality is for each system and why the use of one system would be more advantageous than the other.

To provide customers with access to their historical consumption data, configurable alerts, and push notifications, a web-based portal should be procured as a companion product to the MDM. It is common for the MDM vendor to offer this functionality; however, the underlying requirements definition along with a design effort will be necessary. Figure 6 below provides a detailed look at the data flow throughout the resulting AMI/MDM system.

Figure 6: AMI/MDM Data Flow Diagram



Prepay

With the advent of AMI and remote disconnect meters, utilities now have the ability to remotely shut off and reconnect an electric/water/gas meter. However, the credit/collections processes and the associated planning, organization, and tracking costs of bad debt still occur. The bulk of the savings is limited to the cost of disconnect and reconnect truck roll.

The concept of prepay itself is not particularly new in utilities, particularly electric. Around the world, in countries such as the United Kingdom, Ireland, South Africa, New Zealand, India, Argentina, and many developing nations, prepaid electricity has long been offered and is considered a standard utility service. In the United States, the ability to prepay for utility services has been available for over 20 years, although only a few utilities in the US support it today. Prepayment is typically accepted via "tokens" or a "smartcard". In this traditional concept of prepay, special prepaid meters are required, which requires the meter to be swapped out to switch customers between prepayment and postpaid billing and also requires dual billing systems to manage. Real-time usage typically can only be viewed on the meter screen, while customer "top-ups" are reliant on the vending infrastructure.

Alongside with the recent AMI technology development, prepay technology has been upgraded as well and offers more flexibility for both the utility and its customers. With advanced/smart meters, there is no need to differentiate meters provided they are equipped with a remote disconnect/reconnect functionality and customers can be easily switched between prepayment and postpaid billing without the need for a site visit and meter change out. Today, prepay vendors have extended that electric service model to accept any postpaid, cycle-based, metered or flat rate service, and convert it to a prepaid utility service. Prepay applications are now capable of utilizing Validation, Editing, and Estimation (VEE) functionality for estimating reads from a non-electric meter, such as water or gas, or prorating a flat charge like refuse collection and sewer fees.

The prepay application calculates the total of all of utility services fees and calculates the estimated number of days remaining for the combined services. Every day the prepay application recalculates the remaining number of service days. Depending on the preset notification threshold, the prepay application will notify a customer if the balance is low and it's time to replenish before services are disconnected.

Additionally, prepay offers an enforceable method to collect a customer's prior debt. When enrolling a customer in a prepay program, some applications allow the utility to enter all the customer's outstanding receivables along with a debt repayment timeline. The prepay application then calculates the percentage of the customer's payments that will automatically satisfy the debt. This could be 10%, 25%, or more of each payment. As long as the customer continues to prepay for utility services, a portion, and eventually all, of their debt can be satisfied.

Thus, the offering of prepay services with an AMI implementation can facilitate multiple benefits to both the utility and customer. These benefits include:

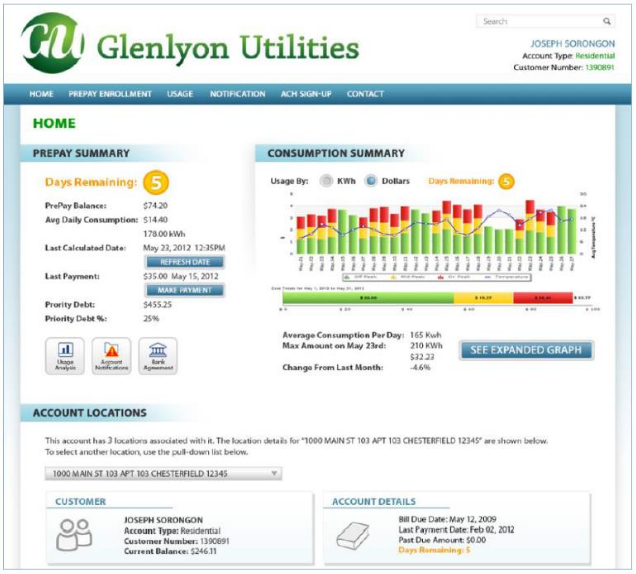
For the Utility

- Reduce the need of running a separate prepaid system
- Reduce truck rolls
- Increase cash flow
- Reduce printing costs (reminder notices, disconnect notices, etc.)
- Reduce overhead costs associated with customer service and collections
- Reduce write-offs
- Lower risk associated with bad debt
- Increase customer satisfaction

For Customers

- Eliminates high customer deposits
- Allows the customer to adhere to a predictable budget for utility payments
- Provides the flexibility to monitor usage, payment, and balance information via web and/or smartphone applications
- Easy monitoring of consumption helps drive conservation and usage reduction

Figure 7: Prepay Interface Sample for Utility Customers



**Sample customer interface to monitor their electric usage and prepay balance from two vendors; the left image is Cayenta's prepay customer interface and the right image is Exceleron's prepay customer interface*

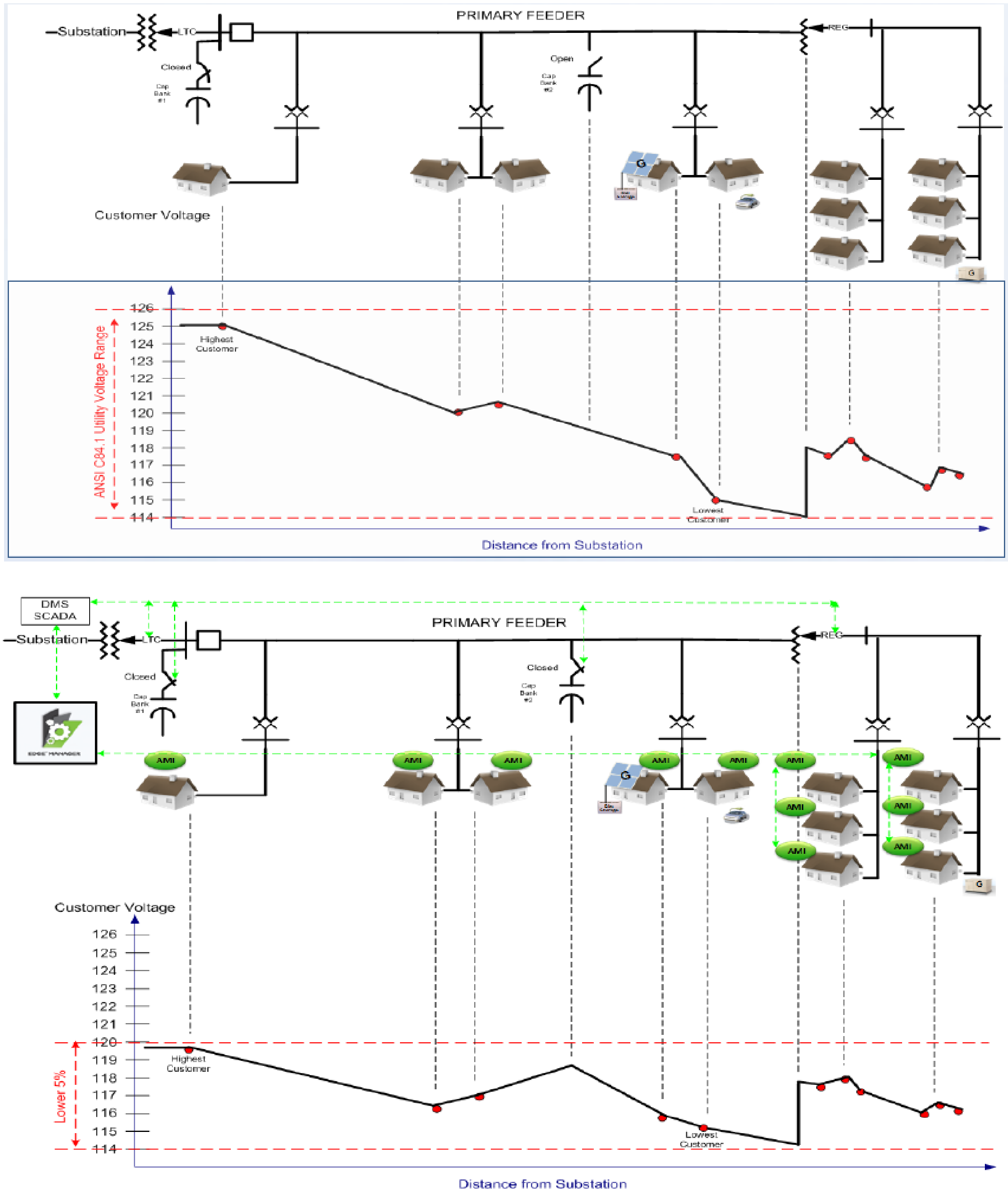
Volt/VAR Optimization (VVO)

The traditional Volt/VAR management technologies have been used by the power industry for over 30 years and are utilized to reduce electric line losses and increase grid efficiency. This technology has been improved today to include sophisticated VVO sensors, equipment, and software and claimed to be capable to reduce overall distribution line losses by 2% - 5% through tight control of voltage and current fluctuations. However, these VVO systems have not been widely deployed in the US, as traditional utility fee structures fail to provide revenue recovery or ROI to pay the investment needed. Thus, in November 2012, the National Association of Regulatory Utility Commissioners (NARUC) encouraged the State Public Service Commissions to evaluate the energy efficiency and demand reduction opportunities that can be achieved with the deployment of VVO technologies and also encouraged them to consider appropriate regulatory cost recovery mechanisms.

Voltage regulation refers to the management of voltages on a feeder with carrying load conditions, as the utility needs to deliver power to consumers within a predefined voltage range. VAR is reactive power that is unused and can result in voltage drop and losses due to increased current flow. VAR regulation is achieved by switching capacitors on when demand is high (higher VAR during heavy load conditions) and off when demand is low. Both voltage and VAR affects one another, positively and negatively, and they can be best managed if their regulation is well integrated.

The advent of widely deployed sensor technology, including AMI systems and advanced software algorithms has opened the possibility to maximize VVO at the feeder, substation, or utility level. This is possible thanks to the development of microprocessor-based controls and computing platforms, as well as pervasive and high-performance communication technologies. Utilities now have higher visibility of their system and control, resulting in the possibility of peak demand reduction, energy loss minimization by targeting power factor levels, or Conservation Voltage Reduction (CVR).

Figure 8: Illustration of VVO



**Graphics adopted from Utility Case Study: Volt/VAR Control at Dominion Voltage Inc. (2012). Graphic on the bottom, illustration with VVO controls in place, presents a lower starting customer voltage required compared to the traditional design on the top. This is achieved by optimizing voltage profiles and VAR flow, thus lowering overall system voltage and increasing efficiency.*

Water Leak Detection and Pressure Monitoring Technology

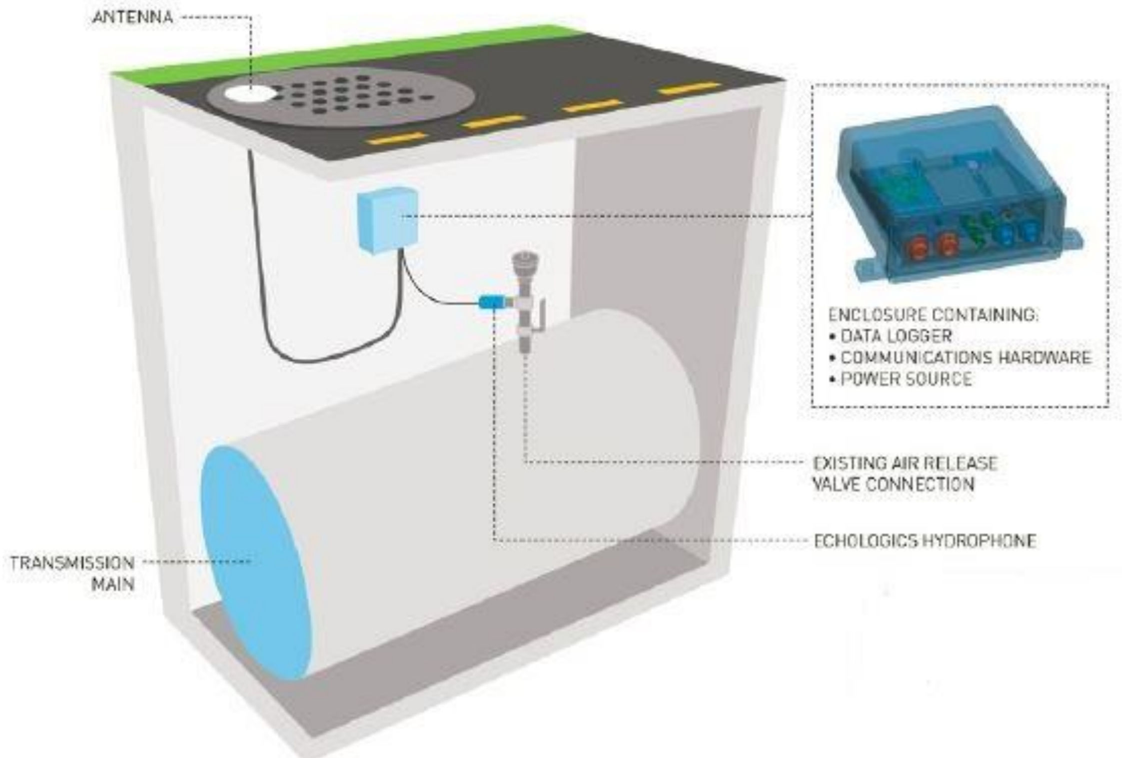
It is estimated by GRU that distribution water system losses are approximately 7-10%. In past years, GRU has been attempting to target older neighborhoods for leaks using a “leak noise correlator” which resulted in the discovery of some water leaks. A leak noise correlator is an electronic device that is used to 1) detect the presence of water/gas leak; and, 2) pinpoint the location of the leak. It utilizes acoustic sound sensors to record the sound that is produced by the leak. Using mathematical algorithms, the location of the leak can be estimated/pinpointed by translating the time delta it takes for the noise to travel (from the leak site to the sound sensors in between) into distance. This current method takes a lot of manual “trial and error” in guessing where a water leak may occur in the distribution of the system.

Alongside with an AMI network implementation, a sophisticated acoustic water leak detection and pressure monitoring system will improve the water leak detection efforts. The implementation of advanced/smart meters will provide granular real-time data to the utility with information which will indicate potential customer-side leaks, illustrate high water use translating to possible waste, and identify theft of water use for accounts that are not considered active by the utility. The ability to produce and analyze interval data by the AMI and MDM will also allow the utility to proactively identify leaks or water mismanagement.

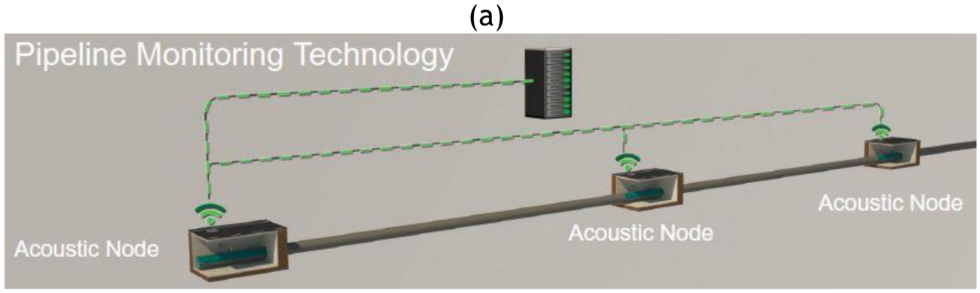
The two technologies that the utility can leverage for the purpose of water leak detection are:

- **Acoustic Sensors -** By attaching an acoustic sensor to the AMI or AMI endpoint, GRU's utility will be able to monitor its distribution system along with customer service lines to get complete system coverage. The acoustic sensor will monitor pipe conditions, looking for changes in the sound that travels down the pipe. The sensor has been designed to listen for a certain frequency range that represents the frequency a leak would produce. The sensors will leverage the AMI communications network to provide a snapshot of its system as often as it obtains the network reads. This leak detection system should be integrated with the AMI utility management platform established by the utility.

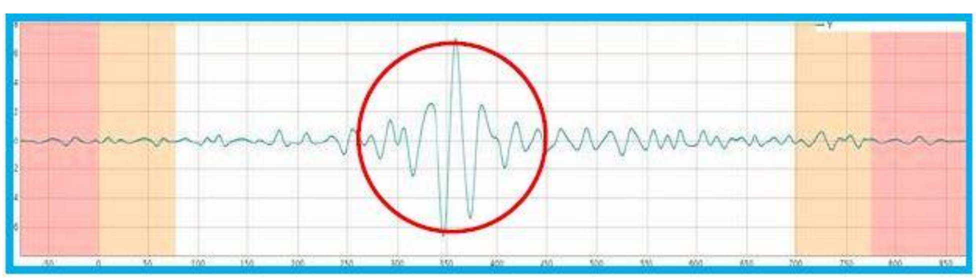
Figure 9: Acoustic Leak Detection Technology



(a)



(b)



(c)

**Images adopted from National Institute of Standards and Technology (NIST)'s Case Study – Las Vegas Valley Water District Water Leak Detection. Figure (a) illustrates location of acoustic sensor/node in the distribution, (b) illustrates multiple acoustic nodes monitored in real time, (c) presents a detected increase of acoustic signal compared to the normal acoustic noises in the water main, indicating a potential water leak.*

The acoustic nodes/loggers are deployed throughout the areas of the water distribution system and provide continuous monitoring of leakage. There are logger types that can be permanently fixed on the main pipe and loggers that can be repositioned/moved around, retained in a place with a strong magnet. Leak detection using the acoustic method is straightforward: sound waves detected by the sensors are converted to electric signals and are sent to the management software. An increase of voltage levels compared to the baseline indicates a potential leak in the system. The position of the leak can be estimated from the time delay when the sound wave arrives to the two sensors in between. The time delay, correlated with other information such as the distance between sensors, pipe material, and velocity of the sound wave, enables the leak detection software to pinpoint the location of potential leak in the system.

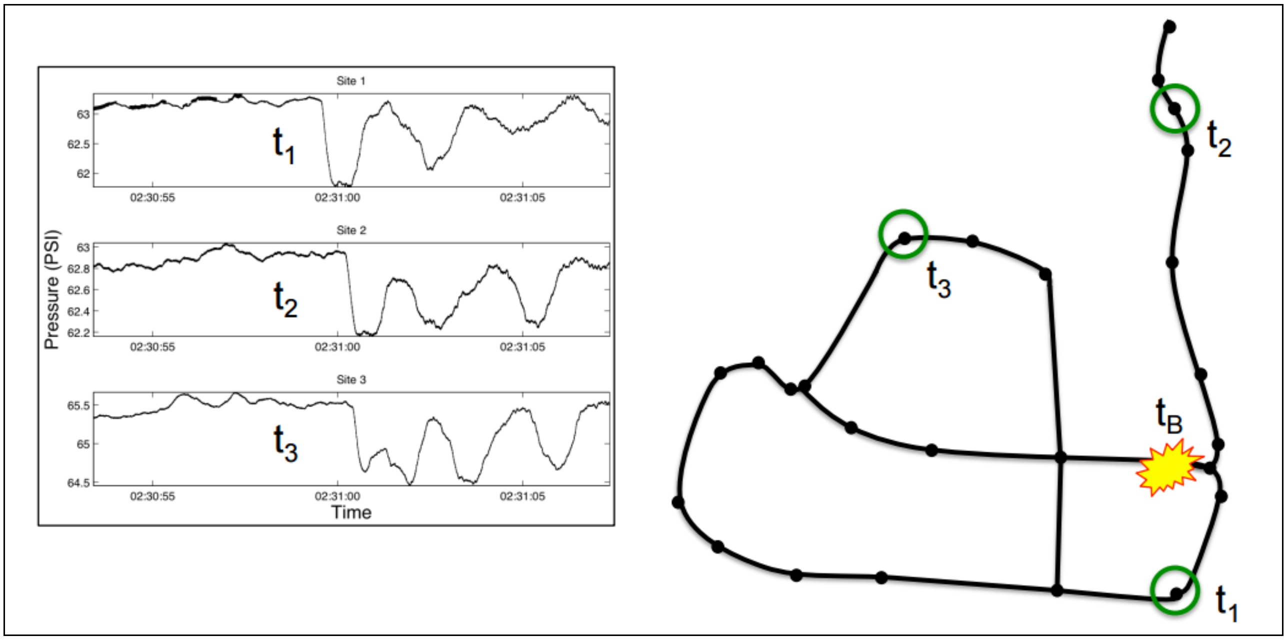
- **Flow or pressure change -** This technique relies on the assumption that an abnormally high rate of change of flow or pressure at the inlet or outlet of a distribution section is indication of the probably the occurrence of a new leak. If the flow or pressure rate of change is higher than a predefined limit within a specific time period, then a leak alarm is generated, and further investigation and subsequent repairs are triggered.

A remote pressure monitoring system can be deployed in parallel with an AMI network deployment, leveraging the communication infrastructure. The pressure sensors are installed throughout the distribution area, typically two sensors per district metering area or pressure zone – ideally at high-pressure and low-pressure zones. They can either be installed into the distribution main or placed inside a meter vault. The pressure sensors can typically measure pressure from 0 to 200 psig and transmitted securely to the utility office where it is monitored.

Pressure monitoring technology purpose goes beyond just water leak detection. An accurate, real-time pressure monitoring allows the water utility to optimize the system operation and to reduce the duration and disruptions of repairs and maintenance. Accurate pressure data and management allows water utilities to:

- Reduce leakage which in turn reduces cost (supply and energy)
- Reduce customer complaints
- Reduce unaccounted for non-revenue water
- Prevent potential infrastructure failures related to pressure fluctuations
- Improve public health and safety (loss of pressure can allow ground water to contaminate distribution system)

Figure 10: Water Burst Detection with Pressure Monitoring Technology



**Graphic and illustration adopted from Whittle et. al., 2013, Sensor Networks for Monitoring and Control of Water Distribution Systems. Graphic on the left side presents the pressure vs travel time from three points of the system, t_1, t_2, and t_3 as described in the figure on the right. Meanwhile t_B indicates a potential burst/water leak which was detected by a drastic loss of pressure as can be seen in the graph. Using the same principals as acoustic leak detection, location of the potential leak can be pinpointed by correlating the travel time, wave speed, and pipe properties.*

By leveraging the AMI communications network, water leak detection technology can be monitored in close to real time and allow utilities to proactively locate and fix leaks instead of allowing them to continue, causing significant water and revenue loss.

Information and Cyber Security

The reliable availability of critical infrastructure, such as the electric grid and water supply infrastructure, is essential to the wellbeing and security of the country. Utilities are making concerted efforts to identify and address security risks across electric, water, and gas utility system assets and their connectivity points. Especially with an implementation of advanced metering infrastructure, these industrial control systems (ICSs) are vulnerable to cyber-attacks. This includes attacks to steal customer personal information or energy consumption behavior, and attacks to the utility infrastructure controls itself.

In 2009, the Wall Street Journal reported that spies hacked into the US electric grid and left behind computer programs that could disrupt services. In Harrisburg, Pennsylvania, in 2006, foreign hackers penetrated security of a water filtering plant through the internet. The hackers planted malicious software (mal-ware) that affected the plant's water treatment operations. Unauthorized changes to programmed instructions in local processors could lead an individual remotely taking control of a utility's distribution, resulting in disabled service or worst-case scenario, terrorist activities.

Utilities can reduce vulnerabilities from cyber-attacks or events by following the steps below:

1. Identify systems that needs to be protected
2. Separate systems into functional groups
3. Implement tiered defenses around each system
4. Control access into and between each group

There are various standards that utilities can refer to regarding cyber security. In January 2016, the Federal Energy Regulatory Commission (FERC) issued revised Critical Infrastructure Protection (CIP) reliability standards for electric utilities. The updated standards provide guidance in preparing for cyber security, including cyber security training once a quarter for large utilities, closing unneeded networking ports, and developing procedures for the storage information. Water utilities can also refer to American Water Works Association (AWWA)'s Water Security Roadmap. Another useful resource for all utilities is the Department of Homeland Security (DHS)'s Industrial Control Systems Cyber Emergency Response Team (ICS-CERT, https://ics-cert.us-cert.gov/). The ICS-CERT works to reduce risks within and across all critical infrastructure sectors by partnering with law enforcement agencies and the intelligence community and coordinating efforts among federal, state, local, and tribal governments and control systems owners, operators, and vendors.

It is recommended for every utility deploying or implementing an advanced metering infrastructure to have IT resources on staff not only to maintain the AMI network system, but also trained with cyber security issues and with an understanding of how to mitigate the anticipated risk. Given the practical need to secure the utility system infrastructure, manage costs effectively, and achieve compliance with regulations, utilities must adopt a life cycle approach to cyber security.

Figure 11: Cyber Security Life Cycle