Strategic Technology Plan








Riverside, California

WATER | ENERGY | LIFE

CITY OF RIVERSIDE

PUBLIC UTILITIES

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ACKNOWLEDGMENTS

In 2009, Riverside Public Utilities (RPU) completed an Electric System Master Plan for Energy Delivery (Master Plan) that included recommendations for technology to support the Utility Department. One Master Plan recommendation was for RPU to develop its own Strategic Technology Plan, separate from the City of Riverside Enterprise Strategic IT Plan. Now, RPU is at a critical junction regarding its technology, and the need for a Strategic Technology Plan is clear, especially with respect to the following factors:

- Major federal and state policies and market influences are driving significant technology changes in the utility business.
- Smart Grid technologies are maturing and becoming more affordable and widely adopted.
- RPU has special operational needs for technology staffing beyond traditional IT professionals.
- Customers are expecting more from utilities, such as additional electric/water usage information, optional rate structures, new technologies, and more choices.

The Strategic Technology Plan addresses these concerns and outlines a comprehensive plan for addressing technology issues that affect RPU's business. RPU also created this Strategic Technology Plan to explain and justify the business need for technology upgrades, pave a strategic technology roadmap, and develop tactical implementation plans to structure technology investments.

Within the Strategic Technology Plan, RPU made a business case to provide financial justification for technology that complements the business objective-driven needs for technology. In making its business case for technology investments, RPU included a list of intended benefits from the perspective of its customers, as opposed to providing only Utility revenue benefits.

The RPU Management Team is grateful for the harmonization efforts of the City of Riverside Innovation and Technology Department, as well as contributions from RPU staff subject matter experts (SMEs) for providing input, expertise, guidance, and document review to Leidos during development of this Strategic Technology Plan. For its customers to receive the intended benefits from investments in technology, RPU intends for the Strategic Technology Plan to be a living document, with periodic updates to keep the Plan current and in alignment with business objectives.

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EXECUTIVE SUMMARY

Technology is a critical requirement for the operation of electric and water utility systems. In addition to being integral to system operations, technology is used by every utility employee, touches almost every business process, and, when properly implemented, provides added value to every customer. Strategic investment in new technologies allows utilities to enhance operational efficiency, improve productivity and reliability, and increase customer engagement and satisfaction.

This Strategic Technology Plan for the City of Riverside Public Utilities Department (the Utility or RPU) describes RPU's strategic roadmap for implementing specific operational technology (OT) and information technology (IT) applications and systems in three phases over the next 10 years. The IT projects included in the Plan involve customer-based applications. The Plan does not address certain IT applications that are best addressed by the City of Riverside IT department, including office productivity, email, phones, and desktop computers.

Electric and water utilities have had to become more flexible and agile due to constantly changing regulatory requirements, state and federal energy policies, and economic conditions, and RPU is no exception. The strategic technology roadmap is structured to provide a flexible approach to achieving RPU's technology vision.

Rather than making wholesale system changes that have long-term impacts, RPU will implement a series of technology improvement projects in three manageable phases over a 10-year period. This phased implementation will allow RPU to complete projects and assess their impact on other systems more quickly and efficiently, and then adjust tactics as needed to achieve the next near-term objective. RPU must remain flexible in its outlook and, based on business drivers, be able to change the projects being considered in each phase and the speed of implementation.

Figure 1 outlines the three phases of the strategic technology roadmap. Other options to phase these projects may also be beneficial and should be evaluated as needed. Phase I includes building an effective OT organization and completing in-flight projects. Phase II focuses on implementing operational technologies already proven to provide customer value. Implementation of advanced technologies is planned for Phase III, to allow time for those technologies to mature.

Figure 1: Three Phases of Strategic Technology Roadmap

Phase I 2016–2017	Phase II 2018–2020	Phase III 2021–2025
• Complete in-flight projects. • Develop future business needs. • Establish OT office. • Develop technology governance (cybersecurity) measures.	• Improve operational effectiveness. • Improve work/asset/inventory management, outage management, and communications infrastructure. • Complete advanced technology pilots.	• Implement advanced technologies that provide customer value. • Implement AMI, ADMS, and other technologies, based on customer value.

The detailed roadmap is provided in **Figure 16** on page 30.

Why the Strategic Technology Plan is Important to RPU

Customers and utility regulators alike are expecting more from utilities in the form of new services, optional rate structures, and access to detailed account information. They expect RPU to offer the same level of interaction and choice of services they already receive from their cellular, Internet, and cable TV providers, including:

- selecting from a wide range of service plans and costs;
- accessing and interacting with the Utility 24/7 using smart phones and tablets to request service, pay bills, manage accounts, and review usage information; and
- implementing new technologies (such as rooftop solar panels, battery energy storage, and electric vehicles) without significant additional charges from the Utility.

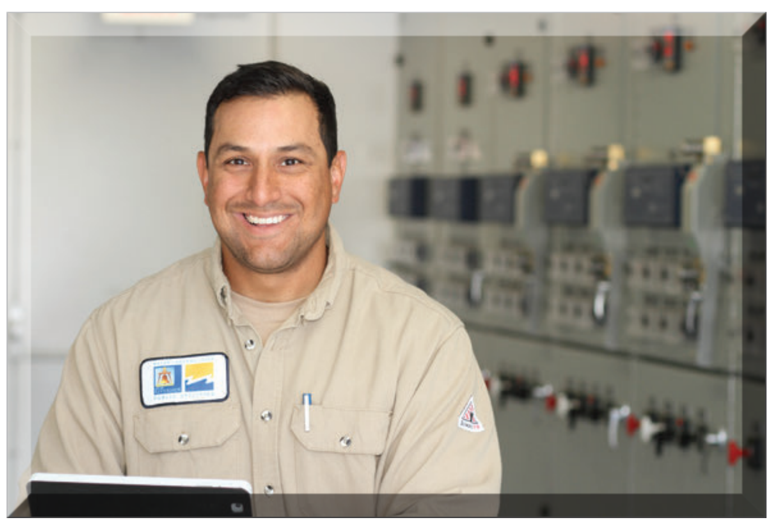
RPU is at a critical point in time where business as usual will prevent successful adoption of some of the new technologies identified in this Strategic Technology Plan. The current pace at which RPU is moving is too conservative and will result in the technology gap widening. As this gap widens month after month, RPU will face a steeper adaptation curve when it finally decides to adopt modern technology.

RPU must move toward a more progressive trajectory of new technology implementation, or they may fall so far behind the competition that catching up would be very difficult. As technologies mature, business cases are becoming more attractive to utilities like RPU that have been waiting for maturation of these technologies in order to save money and avoid being "early adopters." Most of the technologies identified in the Strategic Technology Plan are already being utilized by many of RPU's peers.

Real-time monitoring and control systems have always been in the domain of RPU staff, as opposed to services provided by the City's Department of Innovation and Technology. Other technologies blur the lines of distinction between City IT and RPU operational technology. Where ownership lines are blurred, RPU has understood for some time that existing staff has, at times, struggled to manage new technology projects, given their existing work commitments.

To ensure successful adoption of the proposed technology investments and realize their anticipated benefits, RPU must create a new organizational structure, add new resources, and provide training for existing staff to use and maintain newly implemented technologies.

RPU must also put new resources and organizational structures in place for ownership and adaptation of each new technology. Following through with implementation of the technologies outlined in the Strategic Technology Plan and developing new skills within the existing staff will also be vital to ensure that anticipated benefits are realized from the new technologies.



Alignment with Enterprise Vision and RPU Strategic Technology Vision

To establish a future vision for the strategic roadmap, RPU considered external and internal drivers and utility industry trends. Through a series of workshops and interviews, RPU narrowed the focus for its strategic technology vision on operational efficiency, reliability, customer satisfaction, and economic development.

Supporting the strategic technology vision is the enterprise vision, which focuses on innovation and sustainability. Both vision statements (**Figure 2**) stress the importance of quality of life for RPU's customers.

Figure 2: Enterprise Vision and Strategic Technology Vision Statements

ENTERPRISE VISION

Our customers will recognize Riverside Public Utilities as a unique community asset with a global reputation for **innovation**, **sustainability**, and an enhanced **quality of life**.

RPU STRATEGIC TECHNOLOGY VISION

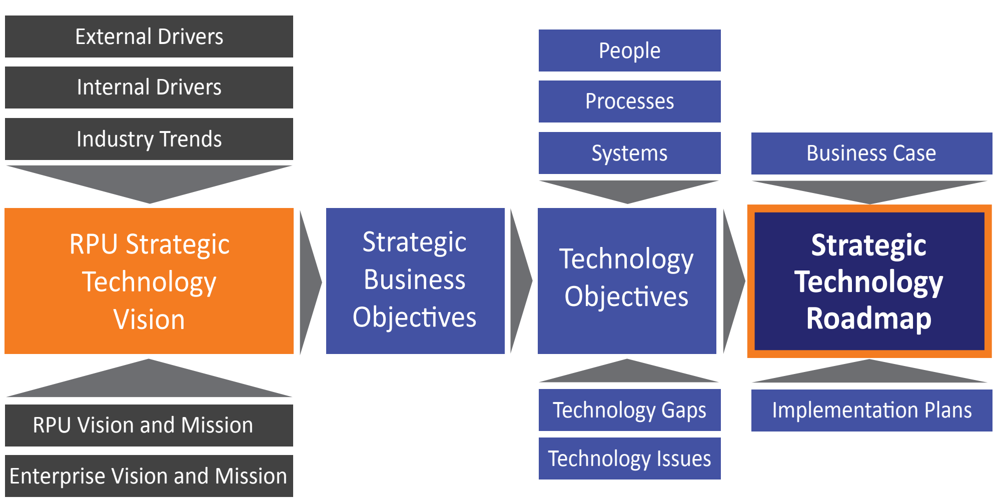
Integration of advanced technology, people, and processes will improve utility operational efficiency, reliability, and customer satisfaction.
Advanced technology will enable RPU to deliver a customer experience that enhances quality of life and promotes economic development.

DEVELOPMENT OF STRATEGIC TECHNOLOGY ROADMAP

To develop the strategic technology roadmap (illustrated in **Figure 3**), RPU first established a strategic technology vision that is consistent with the enterprise vision statement and reflects the influence of internal drivers, external drivers, and industry trends. RPU then developed a series of strategic business objectives and technology objectives in alignment with the technology vision.

The resulting strategic technology roadmap includes specific project investments that provide a balance of required infrastructure technology upgrades (to ensure continued delivery of safe, reliable, low-cost water and electricity) and enhanced services and technologies (to provide value and convenience customers).

Figure 3: Strategic Technology Roadmap Development Process



DRIVERS AND TRENDS

Influencing RPU's strategic technology vision are the external and internal drivers and utility trends described below and summarized in **Figure 4**.

External Drivers: Significant external drivers are the policies and regulations intended to protect the environment, including water and energy conservation, efficient use of resources, and reduction of greenhouse gas (GHG) emissions. These external drivers are prompting development of technologies that increase the efficiency of water and electricity delivery, allow for integration of distributed renewable resources, especially solar photovoltaic (PV) electricity generation, and reduce the energy footprint of water collection, treatment, storage, and delivery systems.

Internal Drivers: Internal drivers include maintaining low costs, increasing workforce efficiency, managing aging infrastructure, and ensuring the reliability, security, and resiliency of electric and water delivery systems. Technologies evolving as a result of these internal drivers include advanced water and electric metering, work and asset management, and customer service and engagement.

Industry Trends: Significant industry trends shaping RPU's technology future include engaging customers to reduce energy and water consumption through social media, the Internet, and smart device communications; advanced distribution automation to increase the efficiency and capability of water and electric delivery; increased integration of intermittent resources and energy storage; and electric transportation.

Figure 4: Drivers and Trends Influencing RPU's Technology Future

External Drivers

- Customer expectations for improved customer service, higher reliability, enhanced information and interaction, and Mobile Apps and service.
- GHG emission reduction (AB32).
- Renewable portfolio standards.
- Distributed energy resource targets (SB-1).
- Energy storage targets.
- Energy efficiency, conservation, and demand management.
- Regulations for grid reliability and security, including CPUC GO 165, 170, and 174, and the NERC CIP standards.
- Electric transportation goals.
- Energy Independence and Security Act.
- American Recovery and Reinvestment Act.
- 20% reduction in water consumption by 2020 (SB X7-7).
- Integrated water management, increased water efficiency, reduced energy footprint for water delivery, and use of advanced metering in water delivery systems (CA Water Plan 2013 Update).

Internal Drivers

- Developing and maintaining an effective workforce.
- Enhancing customer experience.
- Improving operational efficiency.
- Improving distribution system efficiency.
- Managing aging infrastructure.
- Maintaining and ensuring system reliability, security, and resiliency.

Industry Trends

- Transition from one-way to two-way power delivery grid, providing integration of widely distributed electric generation, energy storage, and energy management technologies
- Technology is embedded in utility infrastructure and core to the business.
- Legacy customer information and billing systems becoming roadblocks to IT/OT convergence.
- Advanced metering to be the foundation for transforming business models.
- Work management and mobile computing central to an effective workforce.
- Asset management to address aging infrastructure.
- Advanced distribution automation to enable integration of distributed generation and electric transportation.
- GIS as a primary business tool.
- Engaging customers.

STRATEGIC BUSINESS OBJECTIVES

RPU identified the five primary strategic business objectives described on the following pages. Properly implemented operational technologies can help RPU achieve each objective.

1. **Customer Service:** *Enhance the customer service experience and boost customer satisfaction.*
2. **Reliability:** *Improve reliability, safety, and resiliency.*
3. **Operational Efficiency:** *Increase operational efficiency.*
4. **Community Service:** *Increase community service and enhance the quality of life for RPU customers.*
5. **Economic Development:** *Promote economic development in RPU's service area.*

Customer Service: *Enhance the customer service experience and boost customer satisfaction.*

RPU can enhance the customer service experience and increase customer satisfaction with technologies that allow customers to interact with the Utility 24/7 by telephone, computer, or smart device. This will reduce the time it takes for the Utility to respond to customer needs and requests, engage customers through social media, and provide customers with detailed information about their energy and water usage. These technologies will:

- empower customers to make choices that sustain and improve their quality of life;
- address the customer's desire for 24/7 interaction, near real-time delivery of accurate information about outages, and detailed water and electricity consumption information; and
- allow customers to review and pay bills using technology-based methods.

Reliability: *Improve reliability, safety, and resiliency.*

Reliability, safety, and resiliency are an essential triad for operating water and electric utilities. Customers' increasing dependence on technology at home and work necessitate ever-increasing levels of operational reliability.

The use of the electric distribution system as a collection system for distributed generating resources adds a dangerous new element to system operations that requires advanced sensing and control to protect workers. The ability to recover from severe storms, earthquakes, and other disasters requires a level of resiliency that cannot be achieved without the technologies that provide remote sensing and control of water and electric systems.

Operational Efficiency

Operational Efficiency: *Increase operational efficiency.*

Managing the cost of water and distribution system operations is a very high priority for RPU. It also presents a challenging balance among maintaining high reliability, operating safely, and enhancing the customer experience, all of which tend to drive operating costs upward. Technology allows RPU to look for new operational savings from the following opportunities:

- Streamlining work processes by providing mobile computing to field personnel.
- Using an effective work management system to improve the ability to plan, prioritize, and execute work.
- Employing remote disconnect and reconnect for meters, instead of rolling out a truck and service person.
- Using automation to reduce the amount of labor required to operate delivery systems.
- Increasing the physical efficiency of RPU's delivery systems by using voltage optimization and transformer load management to reduce electrical losses and using advanced water system operations to reduce the amount of energy required to collect, store, and deliver water.

Community Service

Community Service: *Increase community service and enhance the quality of life for RPU customers.*

RPU's role in increasing community service and enhancing the quality of life for its customers includes tangible impacts such as improved air quality and reduced GHG emissions, reliable and affordable water and electricity, and the jobs and revenues that result from economic development. More difficult to quantify but not hard to observe are the impacts RPU can have as a good corporate citizen by supporting community programs, educating the community on the value of public power, and providing a revenue stream to support other services. Technology can help RPU achieve its expectations for this objective by:

- allowing for increased penetration of clean, renewable distributed generation, such as photovoltaic (PV) generation;
- allowing for integration of electric vehicle charging; and
- streamlining the work of operating equipment, thereby reducing emissions from operating vehicles.

The result is an overall reduction in GHG emissions and improved local air quality.

Economic Development

Economic Development: *Promote economic development in RPU's service area.*

Attracting residents to RPU's service territory usually means taking them from SCE's service territory, and SCE's electric service is much more technology-based than RPU's. Implementing technologies that allow RPU's commercial customers to manage energy and water costs, use renewable sources of energy, and innovate the use of water and energy in their processes will attract new healthcare, education, research, and technology employers to the community. As a consumer-owned utility, RPU is uniquely positioned to provide energy and water delivery and services that reflect the values and priorities of the community, because the strategic direction and key decisions regarding operation and growth of the Utility are made by community members.

TECHNOLOGY OBJECTIVES

The landscape of technology options RPU considered in this roadmap is defined primarily by utility industry trends. RPU's technology strategy, like most consumer-owned utilities in the nation, is designed intentionally to follow trends in the industry at a pace that minimizes the risk of obsolescence and stranded investment. Instead, Riverside looks for the appropriate balance between cost, risk, and customer value in determining when and how to invest in technology.

A key strategy in the Strategic Technology Plan is not deviating from what has worked well in the past. RPU will continue to invest in technology, but only after its value is understood and its uncertainties mitigated. The challenge RPU faces today is not falling so far behind the industry that the cost of catching up exceeds the value to the customer. Accordingly, it is important to consider the trends and drivers that contribute to RPU's technology strategy.

Technology Categories

To better respond to industry trends and understand how technology addresses business objectives, RPU assessed various technologies relative to future-state objectives and organized them into three primary categories based on function, business use, organizational needs, and technology governance (**Figure 5**):

1. **Customer-Focused Technologies:** *Customer management and interaction.*
2. **Information-Based Technologies:** *Data analysis, decision management, and process implementation.*
3. **Operational Technologies:** *Real-time operation and control of water and energy delivery systems.*

Figure 5: Technology Categories

CUSTOMER-FOCUSED — Directly influence customer experience and provide customer interaction.

1. Customer Information System (CIS)
2. Customer Relationship Management (CRM)
3. Interactive Voice Response (IVR)
4. Customer Web Portal (CWP)

INFORMATION-BASED — Provide decision and analysis, data management,and process implementation (primarily large databases).

5. Asset Management System (AMS)
6. Work Management System (WMS)
7. Warehouse Inventory System (WIS)
8. Geographic Information System (GIS)
9. Mobile Applications (Mobile Apps)
10. Operational Data Management System (ODMS)

OPERATIONAL — Provide real-time operation and control of water and energy delivery systems.

11. Network Communications System (NCS)
12. Land Mobile Radio (LMR)
13. Advanced Metering Infrastructure (AMI)
14. Meter Data Management System (MDMS)
15. Automatic Vehicle Location (AVL)
16. Distribution Automation (DA)
17. Substation Automation (SA)
18. Outage Management System (OMS)
19. Supervisory Control and Data Acquisition (SCADA) and Advanced Distribution Management System (ADMS)

Alignment of Technology Priorities with RPU Business Objectives

In developing the technology roadmap, RPU sought alignment between regulatory and legislative drivers; industry trends and RPU experience; and technology alternatives and strategic business objectives. Technologies that addressed most of the business objectives were identified as RPU's top technology priorities. With the priorities identified, it was necessary to define a future state for each objective and each technology and assess the current state of each objective and technology in order to identify the people, processes, and system gaps the roadmap must address.

Understanding utility industry trends and having a clear set of business objectives frames the overall strategic technology roadmap. Industry trends define the currently available technologies, and RPU's business objectives provide a basis for determining the degree to which each technology can help RPU achieve its vision.

What remains is establishing the priority in which each new technology will be implemented. For the Strategic Technology Plan, priorities were established based on the following factors:

- Technology investments that meet multiple business objectives were given higher priority.
- Technology investments that are already started must be quickly reevaluated, adjusted (if necessary), and successfully completed.
- Technology investments that have a higher risk of obsolescence, higher operational complexity, and value that is difficult to measure were given lower priority.

RPU examined 19 technologies to determine the degree to which each technology meets each of RPU's five primary business objectives, based on the following ratings:

1. **Essential:** *The technology is required for meeting the business objective.*
2. **Important:** *The technology contributes to meeting the business objective.*
3. **Related:** *The technology is closely related to another technology that is rated as either "essential" or "important" for meeting the business objective.*

Each of the 19 proposed technology projects achieved a rating of "essential" for at least two of the five business objectives. Of particular interest are the technologies that achieved the most "essential" ratings (see **Figure 6**).

Figure 6: Alignment of Technology Priorities with RPU Business Objectives

Technology	Business Objective				
	Customer Service	Reliability	Operational Efficiency	Community Service	Economic Development
Customer-Focused Technologies / IT Realm					
1. Customer Information System (CIS)	●	■	■	■	●
2. Customer Relationship Management (CRM)	●	▲	■	■	●
3. Interactive Voice Response (IVR)	●	●	●	■	●
4. Customer Web Portal (CWP)	●	▲	▲	■	●
Information-Based Technologies / IT Realm					
5. Asset Management System (AMS)	▲	●	●	■	■
6. Work Management System (WMS)	■	●	●	■	■
7. Warehouse Inventory System (WIS)	▲	●	●	▲	■
8. Geographic Information System (GIS)	■	●	●	■	●
9. Mobile Applications (Mobile Apps)	■	●	●	●	●
10. Operational Data Management System (ODMS)	▲	●	●	■	■
Operational Technologies / OT Realm					
11. Network Communications System (NCS)	■	●	●	●	●
12. Land Mobile Radio (LMR)	▲	●	●	●	●
13. Advanced Metering Infrastructure (AMI)	●	●	●	■	●
14. Meter Data Management System (MDMS)	●	●	●	■	■
15. Automatic Vehicle Location (AVL)	■	●	●	■	■
16. Distribution Automation (DA)	■	●	●	●	●
17. Substation Automation (SA)	■	●	●	●	●
18. Outage Management System (OMS)	●	●	●	●	●
19. Supervisory Control and Data Acquisition (SCADA) and Advanced/Distribution Management System (ADMS)	■	●	●	●	●

● Essential ■ Important ▲ Related

Importance of Technology to RPU Operations and Customers

Technology is an essential tool for meeting RPU's strategic business objectives. Identifying and implementing the right technologies requires understanding industry trends and experience; strategic business needs and what is important both operationally and to RPU's customers. **Figure 7** provides descriptions of each major technology area for RPU, as well as the importance of each to RPU operations and customers.

Figure 7: Importance of Technology to RPU Operations and Customers

Technology Description	Importance to RPU Operations	Importance to RPU Customers
CUSTOMER-FOCUSED TECHNOLOGIES (IT REALM)		
1. Customer Information System (CIS)		
CIS is an enterprise software application used for maintaining customer account, consumption, billing, payment, and service data for all services provided by RPU. CIS is highly integrated with other applications and serves as the single source of RPU customer data. RPU is currently completing a multi-year project for replacement of its legacy CIS.	Accurate customer data is a critical requirement for all customer-facing applications, including service orders, marketing, OMS, EMS, and public safety. Secure transmission of accurate customer data to all applicable Utility applications and personnel improves operational efficiency.	Implementation of the new CIS will ensure that customer data is accurate and secure. Customers will receive accurate and timely bills and improved customer service. The new CIS will also support outage notification, CWP access, and enhanced service options.
2. Customer Relationship Management (CRM)		
CRM is a software application that is highly integrated with CIS and allows customer service representatives and key account managers to better interact with customers. CRM tracks all customer contacts and interactions, supports the review and selection of service options, and allows key account managers and customers to view and use the same account information. RPU will be implementing CRM in future CIS phases.	CRM is an essential tool to actively manage the complete relationship between the customer and the Utility. CRM is primarily used by key account managers for large and complex accounts. CRM enables key account managers to promote energy and water efficiency programs, analyze service options, and monitor and track the quality of services where and when it best suits the needs of the customer.	Customers, especially large commercial and industrial customers, will receive improved service through the ability to receive high-quality, near real-time data about usage levels, service quality, cost-saving programs, incentives, rebates, and alternative rate structures. CRM reduces energy and water costs for customers, while enhancing their service experience.
3. Interactive Voice Response (IVR)		
IVR is a telecommunication system that provides automated customer call handling. The IVR system routes inbound calls to the applicable Utility department based on caller responses to prompts. The IVR system also generates outbound calls to notify customers regarding service outages and restoration, storm preparation, and appeals for water and energy conservation.	IVR reduces the need for Utility staff to receive and route calls. It is an essential tool for outage management by reducing the time it takes to locate outages and identify outage causes. During outages and other periods of operational distress, personnel can focus on operational priorities while the IVR system sends and receives customer calls and collects customer information.	An IVR system can reduce customer hold time and call duration and allows the Utility to receive and send customer calls 24 hours a day. Customers have the option to receive automated calls regarding service outages and restoration, storm preparation, and potential service interruptions.
4. Customer Web Portal (CWP)		
The CWP provides customers real-time access to RPU. Customers can start, stop, and manage services; review energy and water consumption and costs; explore alternative rate and service options; obtain information about outages and restoration times; and review their service quality. Customers access the CWP via smart phones, tablets, home computers, customer service kiosks, and anywhere they can access the Internet. RPU will be implementing an enhanced CWP in future phases of the CIS project.	The CWP can significantly increase customer satisfaction. Customers expect the Utility to provide the same service channels as their other service providers (cellular, cable TV, financial, etc.). With an enhanced CWP, the Utility can provide accurate, timely information to customers at reduced operating costs.	Customers can access and interact with the Utility any time of day or night. Interaction does not require speaking to a customer service agent and is not limited to business hours. The ability for customers to request and manage services, make payments, and review account information 24/7 is essential for any customer-service oriented business.

Technology Description	Importance to RPU Operations	Importance to RPU Customers
INFORMATION-BASED TECHNOLOGIES (IT REALM)		
5. Asset Management System (AMS)		
AMS is a highly integrated application closely related to WMS and GIS that focuses on the complete lifecycle of utility assets, from planning to installation to maintenance to replacement. AMS allows planners and operators to understand the specific needs of each asset while maintaining a system-wide view of priorities. AMS tracks the location, condition, cost, maintenance/inspection requirements, and life expectancy of each operating asset. RPU's current AMS is only partially implemented and underutilized.	An effective AMS can significantly improve reliability and manage operating costs. Utility personnel use AMS to track the condition of assets and predict future operating costs. AMS also helps the Utility plan and prioritize asset inspection, maintenance, repair, and replacement, ensuring that the most important assets receive the appropriate levels of maintenance in a timely manner.	Customers benefit from service quality, reliability, and managed operating costs.
6. Work Management System (WMS)		
WMS is a highly integrated enterprise software application that improves the tracking and automation of work processes. WMS provides electronic time keeping, work order creation and management, workforce monitoring and planning, streamlined approval authority, project management, cost estimating, and other essential features. RPU's current WMS is only partially implemented and underutilized.	Workflow in a utility environment is very complex. With nearly 600 employees, RPU must rely on automation to support the execution of its work processes. An effective WMS can reduce the time and effort required to generate work orders; increase the accuracy of cost estimates and project budgets; streamline planning and allocation of human and physical resources to better execute work, management, and control of project tasks and costs; and provide several other benefits that improve effectiveness while reducing costs.	An enhanced WMS can reduce the cost and time required to connect new customers, while improving customer service quality. WMS provides increased transparency to project status and schedules to better manage customer expectations. WMS also improves the ability of the Utility to manage water and electric delivery infrastructure in all lifecycle phases, especially inspection and replacement, when service quality can be positively impacted and operating costs effectively managed.
7. Warehouse Inventory System (WIS)		
WIS is an application highly integrated with GIS, WMS, and AMS that manages the supply chain for water and electric infrastructure. WIS is used to plan, order, and stock equipment and parts in quantities and timelines that meet the operational needs of the Utility.	An effective WIS helps the Utility ensure that the right materials and equipment are available, in the right quantities and at the location needed. WIS is integrated with WMS to ensure that material and equipment are available before workers begin the work to install them. WIS is integrated with AMS to maintain adequate inventories to support replacement rates needed for service quality and reliability.	Customers benefit from service quality, reliability, and managed operating costs.
8. Geographic Information System (GIS)		
GIS is an enterprise software application that maintains the locational and physical attributes of water and electric infrastructure overlaid on geographic, political, property and other real-word features. GIS, which combines mapping and AMS, is one of the most important technology applications for utilities. RPU has been an innovator in GIS for more than 20 years and is currently upgrading its GIS to the next generation state-of-the art system.	GIS is used throughout the Utility as the source of infrastructure information. The system keeps track of water and electric delivery networks and all of the elements that comprise those networks. For operating personnel, GIS is the essential source of information about assets—what and where they are and what is around them. Combined with customer information, GIS becomes an essential tool for providing customer service and planning the maintenance and expansion of infrastructure.	With GIS, Utility personnel can respond rapidly to service requests; locate and resolve delivery problems quickly and efficiently; reduce the extent and duration of service interruptions; and provide better customer service overall. GIS is the heart of the "dig alert" programs that improve customer safety. Customers can access Utility GIS information through the CWP to view real-time information about outages and service quality.

Technology Description	Importance to RPU Operations	Importance to RPU Customers
INFORMATION-BASED TECHNOLOGIES (IT REALM) [continued]		
9. Mobile Applications (Mobile Apps)		
Mobile Apps are mobile devices and software applications that provide extensive real-time information (e.g., system status and work requirements) to Utility personnel where and when they need it. Mobile Apps include vehicle-located Internet connectivity, vehicle-mounted and hand-held devices for accessing and using data, and applications for accessing CIS, GIS, WMS, AMS, WIS, and other information useful to field operating personnel. RPU is implementing Mobile Apps as part of the CIS upgrade project.	Mobile Apps increase operational efficiency and safety by providing real-time information to field personnel when and where they need it; ensure system configuration and status is always known by the personnel operating the system; reduce the need for paper-based maps, plans, and work orders; reduce the as-built record keeping effort; and enable field operation personnel to share real time information with system operators and engineers.	Customers will benefit from reduced operating costs and improved service quality and reliability.
10. Operational Data Management System (ODMS)		
The ODMS will expand and enhance the effectiveness of water and electric delivery operating systems. The ODMS will receive data from water and electric delivery and generation system instrumentation and data communication, storage, and analysis systems. The data will support advanced monitoring and control systems to improve the operational efficiency and capability of the water and electric delivery systems.	Current water and electric operating data systems are highly fragmented and require extensive manual manipulation to integrate information into a unified operating environment. The ODMS will provide the needed data collection, integration, storage, and analysis to provide for improved operational decision making and control. The resulting operations improvements will increase operational efficiency and reduce operating costs.	Customers will benefit from reduced operating costs and improved service quality, reliability, and resiliency.
OPERATIONAL TECHNOLOGIES (OT REALM)		
11. Network Communications System (NCS)		
NCS is a comprehensive network of voice, data, and control networks required to operate electric and water delivery systems. NCS includes microwave, fiber optic, wireless communications, wired communications, electric and water SCADA networks, and future digital communications infrastructure.	Voice, data, and control communication systems are essential for effective utility operations. As the number of sensing, monitoring, and control points increases, so does the level of communication, command and control complexity. The Utility requires a high bandwidth, low latency, reliable, secure, and resilient network communications system that uses analog and digital communications across fiber, wireless, and wired networks.	Customers benefit from reduced operating costs, improved reliability, and service quality.
12. Land Mobile Radio (LMR)		
LMR is a wired and wireless communications network used by field operations personnel for voice and data communications. RPU's current LMR system is at the end of its useful economic life.	LMR is the primary authoritative communications network between system operators and field personnel. Switching instructions, system device status and configuration, dispatch instructions, and other essential operating communications are provided on this network.	Customers benefit from reduced operating costs, improved reliability, and service quality.

Technology Description	Importance to RPU Operations	Importance to RPU Customers
OPERATIONAL TECHNOLOGIES (OT REALM) [continued]		
13. Advanced Metering Infrastructure (AMI)		
AMI is a complex system of meters, communication networks, and software to connect customer meters to the Utility. AMI provides remote on-demand meter reading, measurement of voltage and current at customer location, service start/stop, communication with appliances and customer-owned equipment, and outage sensing, thereby reducing the need to send Utility personnel to the customer premise. Water and electric AMI systems are foundational to other beneficial utility technologies. RPU currently uses a one-way communication system for electric metering services and has not implemented advanced metering for water service.	AMI significantly reduces meter reading and meter-related operating costs. Properly enabled AMI can sense outages and service restoration, reducing the duration of outages and the cost to restore outages. AMI can measure electric service voltage and water service pressure that, when used with other technology, can optimize the operation of electric and water delivery systems. Improved metering data helps planners and operators make more informed decisions when planning and operating water and electric delivery systems.	Customers receive better service at a reduced cost through water and electric AMI. Meters can be read on demand, and service can be started and stopped in seconds, reducing RPU response time to address customer needs. Service quality can be measured on-demand, water leaks can be detected remotely, and customers can participate in real time. AMI allows for dynamic rate structures that reward customers who reduce their energy and water consumption during critical periods with lower rates.
14. Meter Data Management System (MDMS)		
MDMS provides automatic processing, transfer, management, and utilization of interval data from digital meters. MDMS is critical to enable advanced rate structures and customer programs.	MDMS provides more timely information about consumption to the utility and adds a deeper level of customer service in the form of outage management, leak detection, and billing accuracy. MDMS enables advanced customer rate programs (e.g., time-of-use, pay-as-you-go).	MDMS provides meaningful and timely consumption data to help energy and water consumers manage their usage.
15. Automatic Vehicle Location (AVL)		
AVL is a system of hardware and software used to track and manage the location of operating fleet, including vehicles, trucks, and major equipment.	AVL improves operational efficiency and enhances workforce safety. Knowing the location of vehicles helps the Utility respond rapidly and assign resources with greater efficiency, which reduces cost and vehicle emissions. AVL improves safety by tracking the location or workers during service restoration, outages, and emergencies.	Customers benefit from reduced operating costs, improved reliability, and service quality. During outages, customers can view the location of Utility operations personnel via the CWP. AVL can also be used to respond to customer concerns regarding fraud by helping to authenticate the identity of operating personnel.
16. Distribution Automation (DA)		
DA is hardware and software, such as widely distributed remote sensing and control devices, that are used by the Utility to enhance the operation of electric and water delivery systems, including outage location and service restoration; leak detection; optimization; and other advanced schemes. Electric DA includes reclosers, capacitor banks, voltage regulators, motor operation switches, circuit breakers, and protective devices. In the water delivery system, automation includes widely distributed pressure, level, and flow sensing; leak detection; remotely operated valves and pumps; and control systems that optimize the energy used to distribute water.	Operational benefits from DA include reduced operating costs, increased reliability, and increased energy efficiency. Outage detection and restoration times are reduced, which lowers costs and improves reliability. Voltage optimization can reduce peak operating demand and system losses, resulting in substantial cost savings. Water delivery automation also reduces costs and increases efficiency. Automation can significantly reduce the amount of energy used to collect, treat, transport, store, and deliver water. Leak detection can save substantial water, reduce costs, and improve service quality.	Customers benefit from increased reliability as a result of reduced outage duration and extent; reduced operating costs as a result of increased efficiency; and improved service quality as a result of delivery system optimization.

Technology Description	Importance to RPU Operations	Importance to RPU Customers
OPERATIONAL TECHNOLOGIES (OT REALM) [continued]		
17. Substation Automation (SA)		
SA is specialized equipment (hardware and software) used to increase the level of automation in electric substations. It includes advanced protection and control devices, enhanced communication and monitoring systems, autonomous equipment operation, and secure remote access and control. RPU is implementing SA throughout its system.	Advanced protective devices provide exceptionally fast and intelligent control of substation circuit breakers, switches, and transformers, thereby reducing the manpower required to operate and maintain substations while improving service quality and reliability. Other SA equipment helps monitor the real-time health of substation equipment to optimize maintenance and avoid catastrophic failures.	Customers benefit from reduced operating costs, improved reliability, and service quality.
18. Outage Management System (OMS)		
OMS is a highly integrated software application used to rapidly detect delivery system service interruptions and then minimize their extent and duration. Effective OMS requires extensive integration with AMI, GIS, CIS, IVR, and AVL systems. RPU does not currently have an OMS.	OMS is an operational technology that significantly reduces the time it takes to detect and restore service interruptions. This results in reduced outage duration, outage extent, and restoration costs. Ancillary benefits include more accurate and informative reliability statistics that allow utility operators to focus and prioritize efforts to maintain and improve reliability. For water delivery, OMS focuses on pressure and flow sensing, leak detection, and valve automation, all of which combine to reduce the time it takes to detect major leaks and stop/reroute/restore water flow to customers.	Customers benefit from reduced operating costs, improved reliability, and service quality.
19. Supervisory Control and Data Acquisition (SCADA) and Advanced/Distribution Management System (ADMS)		
SCADA is a non-integrated foundational system of servers, software, data historians and network architecture (Electric & Water). ADMS is a highly integrated system for monitoring and controlling all aspects of the electric delivery system. This comprehensive monitoring and control system combines OMS, DA, and SA, and adds voltage optimization, transformer load management, networking, modeling, analysis, and state estimation. ADMS is also essential for integrating high levels of distributed generation (e.g., rooftop solar), energy storage, and electric vehicle charging.	An integrated Electric SCADA solution will provide electric automation, Volt/VAR optimization, outage management, and engineering analysis. An integrated Water SCADA system, along with its auxiliary analytical programs, will observe, analyze, and control production and distribution systems to effectively manage water quantity, quality, and reliability, and analyze energy usage and water loss. ADMS allows system operators to ensure a safe, reliable, and efficient distribution system operation, while enabling widespread interconnection of distributed generation, energy storage, and electric vehicle charging. ADMS is seen as the essential system for optimizing distribution system efficiency, reliability, and safety.	Customers benefit from the widespread adoption and integration of customer-owned generation, electric vehicle charging, and energy storage. Additional benefits include improved reliability, safety, and resiliency.

ESTIMATED PROJECT IMPLEMENTATION COSTS

The total estimated cost for implementation of all technology programs is **69.8–103.5 million**, which covers project deployment costs only. **Figure 8** provides a breakdown of implementation costs by phase. **Figure 9** lists implementation costs by project.

Figure 8: Estimated Strategic Technology Plan Implementation Costs by Phase (O&M, Training, and Contingency Costs Not Included)

Phase	Estimated Cost
Phase I (2016–2017)	$27.5–41.1M
Phase II (2018–2020)	$28.0–41.6M
Phase III (2021–2025)	$14.3–20.8M
TOTAL	$69.8–103.5M

Figure 9: Estimated Strategic Technology Plan Costs by Project

Project	Estimated Cost
Project Management and Technology Governance	
• RPU Operational Technology (OT) Office • Technology Governance (Cybersecurity Measures)	$4.4–5.5M
Customer-Focused Technologies (IT Realm)	
1. Customer Information System (CIS) 2. Customer Relationship Management (CRM) 3. Interactive Voice Response (IVR)	$9.2–13.8M
4. Customer Web Portal (CWP)	$3.0–4.5M
Information-Based Technologies (IT Realm)	
5. Asset Management System (AMS) 6. Work Management System (WMS) 7. Warehouse Inventory System (WIS)	$5.6–8.4M
8. Geographic Information System (GIS)	$4.1–6.2M
9. Mobile Applications (Mobile Apps)	$3.0–4.5M
10. Operational Data Management System (ODMS)	$2.3–3.5M
Operational Technologies (OT Realm)	
11. Network Communications System (NCS) 12. Land Mobile Radio (LMR)	$6.9–10.3M
13. Advanced Metering Infrastructure (AMI) 14. Meter Data Management System (MDMS)	$17.7–26.3M
15. Automatic Vehicle Location (AVL)	$0.9–1.4M
16. Distribution Automation (DA)	$5.0–7.6M
17. Substation Automation (SA)	$1.4–2.0M
18. Outage Management System (OMS)	$3.3–5.0M
19. Supervisory Control and Data Acquisition (SCADA) Advanced Distribution Management System (ADMS)	$3.0–4.5M

The costs listed above do not include operations and maintenance (O&M), training, or contingency costs, which should also be considered during implementation of the projects. The following highlights O&M, training, and contingency costs:

- Cumulative O&M cost is $42.9–64.4M at 10% of implementation plan year-over-year technology project costs.
- Training and staff development should be funded at 2–5% of implementation plan technology project costs.
- Contingency funding and management reserve should be funded at 10–15% of implementation plan technology project costs.

The proposed prioritization structure is the mechanism by which the projects initially were allocated based on whether the project was high priority or foundational (Phase I); medium priority (Phase II), or long-term (Phase III). Additional prioritization may be necessary to identify critical path projects and provide a more leveled cash flow for implementation of the projects.

TECHNOLOGY ASSESSMENTS

To form a current-state baseline, RPU evaluated all existing applications and current plans for technology implementation. Once the baseline was established, gaps were determined to establish the steps necessary to reach a desired future-state of technology.

The future-state objectives are assigned a priority for each category of technology to reach the desired future state. Priorities are assigned based upon how the technology addresses business objectives from the previous section. In addition to the applications themselves, the narrative provides guidance for people, processes, and technology and how they are all crucial components for meeting technology objectives.

Assessment of Customer-Focused Technologies (IT Realm)

Customer-focused technologies (**Figure 10**) allow RPU to interact with its customers to help them manage their accounts, start and stop service, request service, report outages and problems, and understand their energy and water consumption and costs. These technologies have to allow interaction when, where, and how the customer desires in order to meet their service expectations. It is imperative that these technologies work well; and while they must meet RPU's operational needs, meeting the customers' needs is more important.

RPU's current efforts are focused on completing the implementation of its new CIS system, including a customer relationship management interface, a customer web portal, and an interactive voice response (IVR) interface. This is a near-term destination on the roadmap and is foundational to other strategic initiatives. Integration of other core systems, including GIS, WMS, AMS, and AMI will be an ongoing initiative as those technologies mature.

Figure 10: Customer-Focused Technologies (IT Realm)

	Current State	Future State
1. Customer Information System (CIS)	Recently completed first phase of CIS replacement project. Legacy system replaced. Additional contracted features in process of being implemented.	Highly integrated CIS capable of complex rates and transactions. Provides real-time information and improves customer experience.
2. Customer Relationship Management (CRM)	Siebel system (311) currently pending upgrade. Salesforce.com is used as key accounts management tool. Neither system is fully implemented or integrated with CIS or GIS.	CRM integrated across systems. Provides real-time and up-to-date information about all aspects of customer/utility relationships to enable customer to maximize the value of their interaction with RPU.
3. Interactive Voice Response (IVR)	IVR is currently not in place. City 311 system provides limited functionality.	Highly integrated IVR system enabling account management, customer support, and outage reporting.
4. Customer Web Portal (CWP)	RPU website allows customers to make account payments online through a third party. Integrated with CIS.	Robust web portal that enables customers to manage all aspects of their service and obtain energy/water consumption analysis and outage information anywhere, anytime.

Assessment of Information-Based Technologies (IT Realm)

RPU uses information-based technologies (**Figure 11**) to improve the effectiveness and efficiency of utility operations. These technologies are used for making operating decisions, performing essential daily work activities, and usually rely on large collections of historical operational data. Even though these technologies are essential to Utility operations, they are governed and maintained by the City's IT department.

Figure 11: Information-Based Technologies (IT Realm)

	Current State	Future State
5. Asset Management System (AMS)	Legacy Synergen system. Used initially to inventory assets and identify maintenance requirements. Records are incomplete and out of date (Electric only). *Water currently tracks assets manually.*	Highly integrated and comprehensive enterprise system for managing all asset data, including description, condition, maintenance history, inspection history, and maintenance requirements with forecasting and data analytics capability.
6. Work Management System (WMS)	Legacy Synergen system primarily for time keeping and work order management. Compatible units module is out of date. System is not integrated. No current mobile solution.	Highly integrated system for planning, forecasting and managing work.
7. Warehouse Inventory System (WIS)	Legacy Synergen system. WIS currently not being used. Currently using IFAS module (Electric only). *Water currently has none.*	Highly integrated system for managing inventory, including up-to-date costs, assemblies, and location. Used with WMS to forecast inventory needs and develop project materials lists.
8. Geographic Information System (GIS)	Enterprise mapping system (CADME) based on ESRI's legacy software/hardware platform. ESRI no longer provides support for existing platform. Working on application to convert RPU data to new ESRI format and deploy ArcGIS Desktop, ArcGIS Server, ArcGIS Professional, and ArcGIS Online functionality.	Highly integrated GIS based on common information model (CIM). Main repository for all asset spatial data. Available to entire workforce. Replaces functional use of paper-based maps with digital maps.
9. Mobile Applications (Mobile Apps)	Streetlight Maintenance App and Mobile WIS App.	Integrated system of field area networks, Mobile Apps, AVL, WMS, AMS, and GIS. Allows field operation personnel to access information without leaving the job site.
10. Operational Data Management System (ODMS)	Non-integrated foundational system of servers, software, data historians, and network architecture (Electric and Water). Water software has been acquired and installed, but is not yet operational.	Highly integrated architecture combining business, planning, engineering, and operational platforms into a logical, secure, and robust enterprise system.

Assessment of Operational Technologies (OT Realm)

Operational technologies are those RPU-specific systems that interact in real-time with the water and electricity delivery systems. These systems, listed in **Figure 12**, are used to monitor, control, and protect delivery systems, while ensuring reliability, safety, and resiliency.

As RPU introduces new operational technologies, the Utility's system architecture must evolve as well, mainly because of physical and logical separations between existing customer-focused, information-based, and real-time operating systems. While the current architecture is serving its purpose, lack of system integration will limit the value new operational technologies can provide.

Figure 12: Operational Technologies (OT Realm)

	Current State	Future State
11. Network Communications System (NCS)	Strong fiber backbone with some capacity constraints and partial wireless network for communicating with remotely located sensing and control equipment. Lacks redundancy.	Resilient networks suitable for high bandwidth data communications across the service area, with access points for all sensing and control devices.
12. Land Mobile Radio (LMR)	Wireless radio communication system used for communication with field and operations personnel. End-of-life system with gaps in coverage and limited or no redundancy.	Resilient wireless voice and data communications network with complete coverage of operational areas.
13. Advanced Metering Infrastructure (AMI)	Limited automatic meter reading and advanced metering requiring manual reads and primarily meter-to-cash process.	Advanced water and electric metering with outage reporting, remote reading, sensing, HAN interface, and remote connect/disconnect.
14. Meter Data Management System (MDMS)	Meter data processing and dissemination are primarily handled manually.	Meter data automatically processed from digital meters and disseminated to systems to enable usage presentment/management, outage management, advanced rate programs, and use of meter interval data in conjunction with control systems.
15. Automatic Vehicle Location (AVL)	Fleet and work management are manually logged and tracked, lacking real-time location and fleet information.	Critical fleet and work management system that tracks the real-time location of vehicles and equipment and integrates with systems like OMS and GIS. Ensures worker and public safety, especially during distress events.
16. Distribution Automation (DA)	Limited testing of network-connected faulted circuit interrupters. Substation feeder breakers have reclosing capability. SCADA monitors feeders at breaker but not downline. Existing SCADA not designed for Distribution Automation, Substation Automation, or OMS. Water SCADA system capable of receiving data and controlling most production and distribution facilities. Limited capability to monitor system pressures and flows or analyze energy management and water loss.	Integrated Volt/VAR management optimizes efficiency and manages demand. Sensing available throughout delivery system. Switching devices isolate faults and restore service. Water SCADA system and auxiliary analytical programs observe, analyze, and control production and distribution systems to effectively manage energy usage and water quantity, quality, reliability, and loss.
17. Substation Automation (SA)	Most substations are equipped with IED relays, communication networks, and digital fault recorders. Remaining substations are scheduled for upgrade.	Real-time monitoring of critical asset condition (transformers and 69kV breakers). Control networks that allow secure remote access and control of substation equipment.
18. Outage Management System (OMS)	Completely manual, paper-based outage management. Outage calls are handled manually. Outage duration and customers impacted based on estimates.	Outages detected automatically via AMI and IVR. Outage cause and location predicted by OMS. Outage maps automatically posted. Precise outage extent and duration data.
19. Supervisory Control and Data Acquisition (SCADA) **Advanced Distribution Management System (ADMS)**	Electric SCADA system is not designed for DA, SA, or OMS. Water SCADA system is capable of receiving data and controlling most production and distribution facilities; however, limited capability to monitor system pressures and flows or analyze energy usage and water loss. No ADMS is currently identified.	ADMS that integrates automation, Volt/VAR optimization, SCADA, outage management, and engineering analysis. Integrated Electric SCADA solution that provides electric automation, Volt/VAR optimization, outage management, and engineering analysis. Water SCADA system, along with its auxiliary analytical programs, that observes, analyzes, and controls production and distribution systems to effectively manage water quantity, quality, and reliability, and analyze energy usage and water loss.

Water and Electric SCADA System Improvements

The strategic technology roadmap does not define specific strategic initiatives for upgrades to the water and electric SCADA systems; however, both systems will receive significant improvements through other roadmap initiatives. As part of the network communications upgrades, the communications system connecting the remote terminal units (RTUs) in substations, generating facilities, and water collection/conveyance/treatment facilities will be upgraded to allow more monitoring and control of endpoints. Bandwidth also will be increased to enable transmission of higher resolution data. As part of the Substation Automation and Distribution Automation initiatives, sensing devices and RTUs will be added or upgraded throughout the system. As part of the water advanced metering initiative, additional pressure and flow sensing devices will be added to the water distribution system to optimize operations, enhance leak detection, reduce water losses, and reduce energy consumed during water collection, treatment, storage, and delivery. As projects become better defined and the technology roadmap is further refined, RPU may decide to budget specifically for water and electric SCADA initiatives that achieve the benefits envisioned by the roadmap.

FUTURE SYSTEM ARCHITECTURE

RPU's Smart Grid architecture must consider RPU's current and future ecosystem. For RPU to realize integration requirements of future Smart Grid technology, RPU should consider the convergence of OT and IT in its system architecture.

Transitioning To a Two-Way Grid

Electric distribution systems are transitioning away from their original purpose of delivering energy from the utility to the customer. The new distribution system is evolving into a complex network that will allow integration of widely distributed energy generation, storage, and management systems owned by customers and third parties. Rooftop and community solar projects are becoming pervasive and, with the advent of effective battery energy storage, are expected to become even more so.

Utilities are already beginning to see reverse power flow on the distribution system during times when load is low and distributed generation is high, creating the need for two-way distribution grid. This new two-way grid differs widely from the one-way grid from which it evolved. Protection schemes must change in order to provide reliable service; work methods must change to ensure worker safety in the presence of new electric generating sources (where none previously existed); and new operational technologies must be deployed to ensure acceptable service quality for all customers, whether or not they have distributed generation or battery energy storage on their premises.

Convergence of Information Technology and Operational Technology

The growth in Smart Grid modernization is driving an important conceptual change in the way RPU will deploy Smart Grid components. This modernization is characterized by the following trends:

- Continuous implementation of IT by the Utility to model, monitor, and manage its distribution system.
- An urgent requirement for RPU to integrate their IT and OT networks.
- Continuous growth in OT deployment.

City IT does not currently include RPU OT systems within its integration vision, nor do individual system vendors consider the needs of all systems integration requirements for RPU. RPU has long-term technology needs that will also add new applications of technology to the OT realm, making the gap wider for having all integration needs met for the entire RPU enterprise.

The Operational Data Management System (ODMS) is a critical technology project that emphasizes future-state system architecture and convergence of IT and OT.

Figure 13 illustrates how convergence of the IT and OT realms is required to realize capabilities of the electric Smart Grid and water utility automation technologies, as well as the benefits of IT/OT convergence to RPU.

Figure 13: IT/OT Convergence

INFORMATION TECHNOLOGIES — Dependent on *information*

- Financial System
- Work Management System (WMS)
- Asset Management System (AMS)
- Warehouse Inventory System (WIS)
- Customer Information System (CIS)
- Geographic Information System (GIS)
- Engineering analysis

OPERATIONAL TECHNOLOGIES — Dependent on *real-time status*

- System Control and Data Acquisition (SCADA)
- Energy Management System (EMS)
- Outage Management System (OMS)
- Automatic Vehicle Location (AVL)
- Meter Data Management System (MDMS)
- Operational Data Management System (ODMS)

IT/OT CONVERGENCE TRENDS

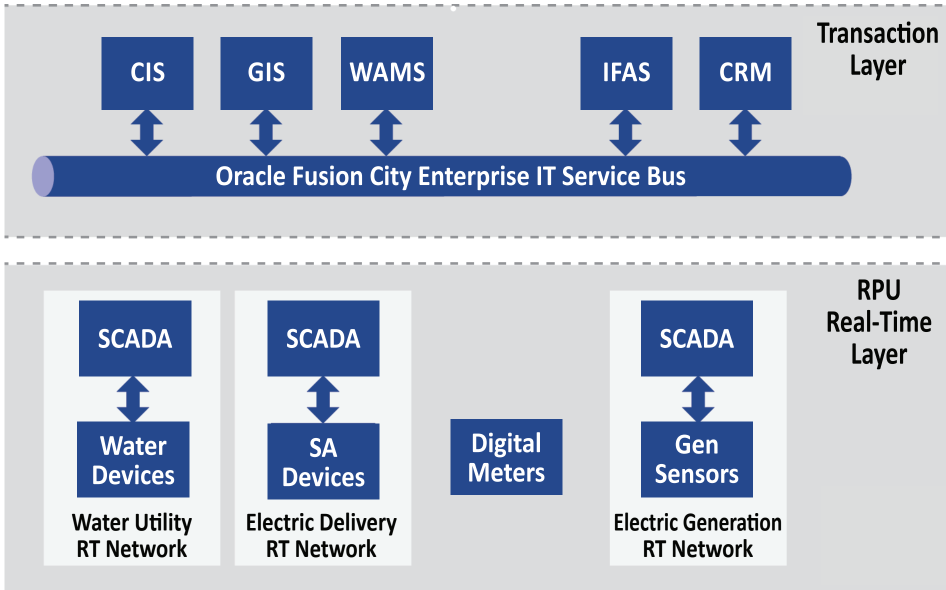
- Real-time status is becoming essential information for CIS, WMS, AMS, WIS, GIS, engineering analysis, and other traditional information-based systems.
- Increasing amount of highly actionable data from mobile field workers, equipment, and operational processes are inputs to information-based systems.
- Operational control systems (EMS, SCADA, and OMS) require real-time information exchange with information-based GIS and engineering analysis systems.

BENEFITS OF IT/OT CONVERGENCE TO RPU

- Effective integration strategies must include common information models (CIMs), service oriented architecture (SOA), and enterprise service bus concepts designed to connect real-time and information-based networks.
- Development, implementation, training, change management, and maintenance of converging technologies (GIS, AVL, MDMS, WMS, AMS, and others) should reside in the Utility domain instead of the City domain.
- Effective use of converging systems requires new business processes, training, education and change management. These issues must be considered when planning staffing and resources to implement and manage systems.

Some architecture and framework for integration is provided by Oracle®[1] Fusion Middleware; however, it does not meet all current or long-term requirements for RPU. **Figure 14** illustrates the current state of RPU's IT system architecture for the transaction layer of systems in the IT realm.

Figure 14: RPU IT System Architecture — Current State



An enterprise integration architecture is required to enable RPU to develop an overarching integration strategy for IT and OT systems. The enterprise architecture will also allow RPU to adopt more specific standards and policies and enforce more comprehensive cybersecurity protocols.

1 Oracle is a registered trademark of Oracle and/or its affiliates.

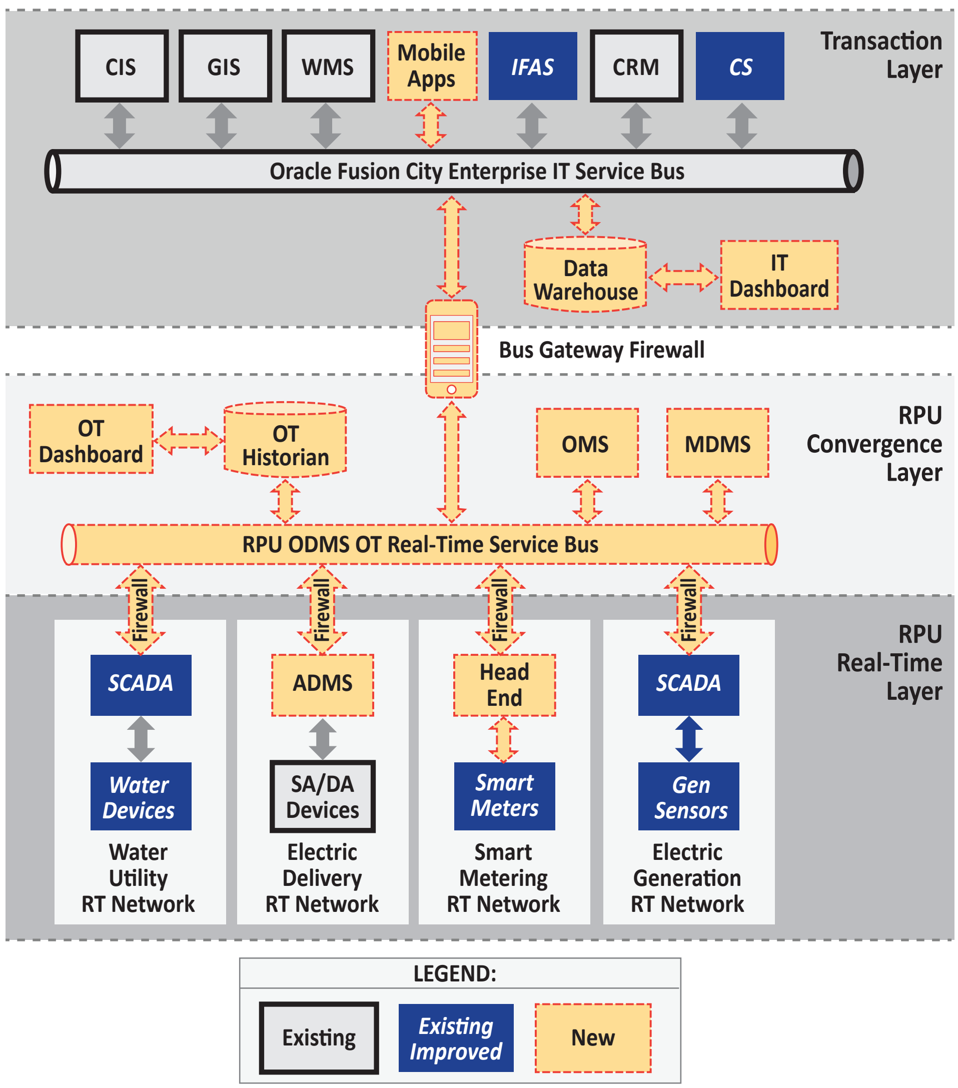
Proposed Enterprise Integration Architecture

RPU should adopt an enterprise integration architecture that will address the areas in which current City IT integration tools do not meet RPU's operational and control systems needs, including sharing data from those systems across the Utility enterprise and coalescing that data with data from IT-realm business systems governed by City IT.

Although the RPU IT-realm systems currently deploy integrations via multiple means, integration can be enabled for all RPU systems and improve existing integrations. The proposed enterprise integration architecture that RPU should consider is illustrated in **Figure 15** and comprises the following layers:

1. **Transaction Layer:** Traditional IT-related functionality and transactions that are passed between functions on a scheduled periodic basis.
2. **Convergence Layer:** New middleware bus structure to tie the Transaction Layer to the Real-Time Layer and provide secure information flows from the islanded SCADA and control systems; also provides ODMS functionality.
3. **Real-Time Layer:** All existing SCADA systems for Energy Delivery and Water departments, and the balance of Plant systems for Generation.

Figure 15: Proposed Enterprise Integration Architecture



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Building a Communications Infrastructure for New Technology Capabilities

RPU should adopt a layered communications architecture to transport traffic from multiple distinct services. This approach simplifies the amount of complexity within each layer, provides flexibility to accommodate new or enhanced services, and allows redundancy and scalability to be adjusted independently and appropriately at each layer. In this architecture, services are delivered via the use of a routed network design.

The layered communications architecture includes three layers: backbone, aggregation, and access. The backbone layer generally has the highest-speed connections and is responsible for transport traffic to the UOC and RERC operations centers from other backbone locations. The aggregation layer serves to collect traffic from regions of the access layer and transmit it to the nearest set of backbone network nodes. The access layer handles last-mile connectivity to devices in the field (such as meters, RTUs, DA equipment, security cameras, and employees' mobile laptops).

The new communications architecture will provide the following benefits:

- Provide for future layered communications enhancements by expanding backbone communications 20% of present capacity using new multiplexing technology.
- Provide a communications backbone infrastructure for future uses.
- Enable the higher throughput that is greatly needed for Water SCADA.
- Enable Electric and Water DA and stronger Electric Delivery SCADA information availability and Smart Grid components.
- Support new remote video requirements for security at critical infrastructure sites.
- Realize new utility programs, such as leasing dark fiber, AMI, customer-side programs, advanced Smart Grid controls, and big data analytics.

STRATEGIC TECHNOLOGY ROADMAP

A phased project schedule and high-level business case provide RPU a strategic roadmap for technology investments. Specific technology project investments are shown in three phases over a ten-year horizon to develop a compelling high-level business case. The high-level business case, in support of the strategic technology roadmap, highlights major technology investments and offers a return on investment (ROI) for technology projects to justify expenditures on technology.

Phased Approach of Strategic Technology Roadmap

The strategic technology roadmap identifies technology project activities in three phases. The three-phase strategic technology roadmap (**Figure 16**) focuses on building an effective OT organization and completing in-flight projects in Phase I, and then implementing operational technologies already proven to provide customer value in Phase II. Investments in more advanced technologies will be scheduled in Phase III to allow time for them to mature.

Immediate efforts in Phase I (2016–2017) focus on completing projects already started, including the CIS replacement, GIS upgrade, and ODMS implementation. During Phase II (2018–2020), RPU will complete the implementation of major improvements to WMS, AMS, Mobile Apps, AMI, and backbone communications systems. By 2025, RPU will implement water and electric ADMS and water and electric AMI, all operating in a highly integrated environment.

Figure 16: Detailed Strategic Technology Roadmap

Project	Est. Cost	Phase I 2016 – 2017	Phase II 2018 – 2019 – 2020	Phase III 2021 – 2022 – 2023 – 2024 – 2025
Project Management and Technology Governance				
OT Office (Operational Technology Office)	$4.4 – 5.5M	• Establish RPU OT office (manager, staff, resources, business processes).	• Manage implementation plan. • Measure and adjust with resources.	• Update Strategic Technology Plan. • Continue implementation plan.
Technology Governance (Cybersecurity measures)		• Cybersecurity, redundancy, and business continuity.	• Strengthen cybersecurity measures.	• Continuous improvements to cybersecurity, redundancy, and business continuity.
Customer-Focused Technologies / IT Realm				
1. CIS (Customer Information System)	$9.2 – 13.8M	• Integrate IVR and CWP enhancements with CIS.	• Potential enhancements/upgrades. 2018–2019: • Document Storage System. • Complete integration with GIS. • Integrate across systems (MDMS, Mobile Apps, permits). 2020: • Integrate with ODMS.	• Assess business needs. • Determine possible future enhancements.
2. CRM (Customer Relationship Management)		• Explore additional functionality of 311 system to expand into key account management.	• Develop KPI Dashboard. • Automate marketing and sales processes.	• Implement advanced CRM big data analytics. • Perform sales and marketing performance analysis.
		• Explore and install rebate software options within 311.	• Enhance online and mobile customer experience (e.g., variable messaging). • Implement automated sales and marketing campaigns and surveys.	• Implement advanced customer choice and programs.
		• Upgrade Siebel system (e-service, email response, MAD, Mobile Apps, web service, etc.).	• Integrate across systems. • Perform data and performance analysis. • Enable social media-driven customer service and communications.	• Further enhance integration across systems.
3. IVR (Interactive Voice Response)		• Requirements development and procurement.	• OMS/IVR implementation.	• Advanced outage analytics.
		• CIS data preparation.	2019–2020: • Integrate across systems (CIS, SCADA, AVL).	• Integrate across systems (ODMS, DA).
4. CWP (Customer Web Portal)	$3.0 – 4.5M	• Enhance customer self-service functions.		• Advanced customer self-service and interaction via multiple channels.
		• Upgrade portal and integrate across systems (GIS, MAD, CRM, IVR). • Integrate mobile devices.	• Develop basic outage app and integrate with OMS.	• Advanced OMS-driven outage communication.
		• Integrate social media and provide basic customer apps. • Automate rebates/conservation.	• Integrate across systems. • Pilot customer programs and usage management.	• Advanced meter data analytics and customer programs.

Project	Est. Cost	Phase I	Phase II	Phase III
		2016 / 2017	2018 / 2019 / 2020	2021 / 2022 / 2023 / 2024 / 2025
Information-Based Technologies / IT Realm				
5. AMS (Asset Management System) **6. WIS** (Warehouse Inventory System) **7. WMS** (Work Management System)	$5.6–8.4M	• Perform needs assessment. • Define business processes. • Complete digital O&M manuals.	• Implementation and integration.	• Control and monitor. • Business intelligence and data analytics and tools.
		• Create Oracle roadmap. • Track asset value and depreciation.	• Oracle upgrade.	• Streamline integration of RPU enterprise data, processes, systems, and people.
8. GIS (Geographic Information System)	$4.1–6.2M	• ETL completion.	• CADME RPU replacement.	• Complete UG ductbank/cable inventory/inspections.
		• CIS premise locations/MAD (master address database) integration.		• Advanced GIS big data analytics and geospatial analysis.
		• Water Field Maintenance application solution.	• Expand/enhance Mobile GIS App.	
		• AutoCAD integration.	• Circuit maps. (2018) • OMS data modeling and input. (2019–2020)	
9. Mobile Apps (Mobile Applications)	$3.0–4.5M	• Mobile device management strategy.	• Improved mobile device access to enterprise system.	• Improved efficiencies (field, office, customers).
		• Implement PragmaCAD.	• Mobile AVL/WMS/AMS/OMS.	• Enhanced customer functions (CWP and Mobile CRM).
		• Address network infrastructure.	• Improved fleet communications.	• Advanced mobile enterprise communications (IPvX).
10. ODMS (Operational Data Management System)	$2.3–3.5M	• Needs assessment (Electric).	• KPI dashboards (Electric).	• Enhance operations efficiency.
		• KPI dashboards (Water).	• Business Intelligence.	
		• Prepare and align enterprise data.	• Align and integrate IT and OT operations and data.	• Advanced big data analytics.
		• Procure and implement.	• Converge IT and OT Enterprise Service Bus.	• Optimize and enhance data and integration.
Operational Technologies / OT Realm				
11. NCS (Network Communication System) **12. LMR** (Land Mobile Radio)	$6.9–10.3M	• Improve and expand fiber backbone. • Expand to include Water.		• Scalable communications infrastructure (vendor- and technology-agnostic).
		• Test/expand aggregation and access layer communications. (2016–2018)		• Transition all communications to latest Internet protocol.
		• Fixed network hybrid AMR/AMI, DA, Video, and enterprise system implementation. (2016–2020)		
		• Commission LMR.		

Project	Est. Cost	Phase I (2016, 2017)	Phase II (2018, 2019, 2020)	Phase III (2021, 2022, 2023, 2024, 2025)
13. AMI (Advanced Metering Infrastructure) **14. MDMS** (Meter Data Management System)	$17.7 – 26.3M	• Explore options for MDMS.	• AMI Hybrid (selected smart meters at critical locations; Electric only).	• Advanced customer programs with AMI.
		• Address network infrastructure and integrate with SCADA. • Pilot AMI.	• Implement MDMS and integrate across systems.	• Advanced AMI/ big data analytics.
		• Begin rollout of Electric and Water AMR meters. • Begin rollout of Water two-way communication AMR meters.		• Full implementation of AMI metering. • AMI-enabled distribution monitoring with ADMS.
15. AVL (Automatic Vehicle Location)	$0.9 – 1.4M	• Develop fleet guidelines.	• Acquire and integrate AVL.	• Optimize fleet asset lifecycle and work management.
			• Mobile AVL/WMS/OMS.	• Advanced real-time visualization of operations, assets, crews, and work.
		• Address network infrastructure.	• Improve fleet communications.	• Advanced mobile enterprise communications (IPvX).
16. DA (Distribution Automation)	$5.0 – 7.6M	• Pilot DA.	• Expand DA to worst-performing circuits.	• Advanced feeder management, circuit segmentation, FLISR.
		• Address network infrastructure and integrate with SCADA.		• Integrate across systems (ADMS). • Advanced feeder data analytics.
17. SA (Substation Automation)	$1.4 – 2.0M	• Design, test, commission, and implement SA.		
		• Address network infrastructure and integrate with SCADA.	• Integrate across systems.	• Coordinate device management for Volt/VAR and switching FLISR.
			• Formalize protection/coordination and monitoring schemes.	• Integrate across systems.
18. OMS (Outage Management System)	$3.3 – 5.0M	• Requirements development and procurement.	• OMS/IVR and Mobile OMS implementation.	• Advanced outage analytics.
		• GIS and CIS data preparation.	• Integrate across systems (GIS).	• Integrate across systems (ODMS, DA).
			• Integrate across systems (CIS, SCADA, AVL).	
19. SCADA (Supervisory Control and Data Acquisition) **ADMS** (Advanced Distribution Management System)	$3.0 – 4.5M	• SCADA Upgrade (Electric): Design, test, commission, and implement.		
		• SCADA Upgrade (Electric): Address network infrastructure, and integrate with SCADA.		• Integration across systems (ADMS). • Advanced feeder data analytics.
		• SCADA Upgrade (Water): System monitoring Analysis and Energy Management solution selection.	• Implement Energy Management solution and begin installing requisite system monitoring devices.	• Via ODMS, implement OMS and communicate with CIS.
		• Monitor and track SA and DA to identify ADMS requirements and processes.		• Acquire, test, commission ADMS.
			• SME technology & research.	• Develop ADMS network model. • Pilot advanced control functions, FLISR, Volt/VAR. • Integrate with SCADA, SA, DA, OMS, AMI, MDMS.

BUSINESS CASE SUMMARY OF MAJOR TECHNOLOGY INVESTMENTS

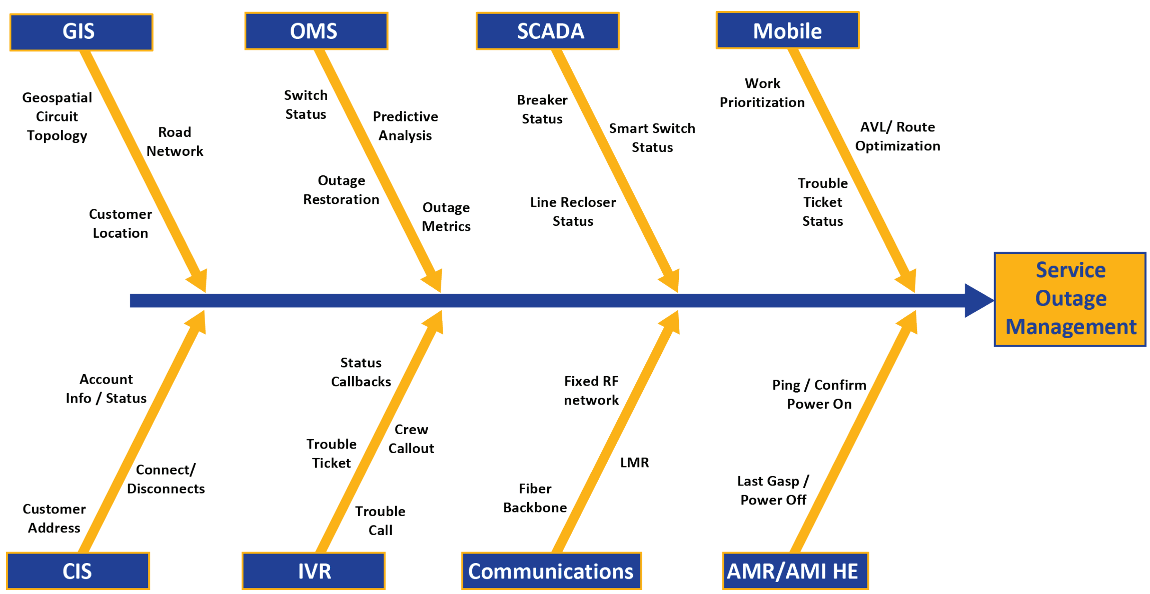
Use cases are required to form a basis of a business case and for some logical technology project activities in order to realize the use case benefits over time. Once the use cases are established, technology projects can be sequenced for costs in specific years and resulting benefit values estimated in order to develop a cost versus benefit business cases analysis.

Enabling Use Cases by Phasing Technology Investments and Resulting Benefits

Use cases are enabled by multiple technologies in the strategic roadmap. To better understand how technology projects should be sequenced and how benefit streams can be phased in the business case, fishbone diagrams represent how each technology component enables a use case and how benefits may be derived from the use case.

Figure 17 presents an example of a fishbone diagram representing the Service Outage Management use case. Each use case enables separate, monetizable benefits in the business case. This example highlights the phasing of foundational technology investments that enable the Service Outage Management use case. Other use cases in the business case are presented in the strategic roadmap section of the Strategic Technology Plan.

Figure 17: Service Outage Management Use Case



The Outage Management System (OMS) is the primary application to enable the service outage management use case, but this use case diagram shows that the service outage management use case is enabled by multiple foundational technologies including GIS, CIS, IVR, OMS, SCADA, AMR/ AMI, Head End (HE) systems, Mobile Apps, and the supporting communications infrastructure.

Business Case ROI Analysis

To develop the business case for the Strategic Technology Plan, a cost-versus-benefit analysis was used to calculate the return on investment (ROI) for major technology investments. To monetize benefits from the technology projects, Leidos used metrics from previous business cases it conducted for various utilities, along with available industry data. The business case employs macroeconomic statistics of benefits stated in a dollar-per-customer-per-year basis, and compares the costs of technology projects with the benefits of implementing those projects.

The business case employs a net present value (NPV) analysis methodology to compare the actual technology costs and monetized benefits and develop an ROI based on present-day dollars of the NPV of costs and benefits.

The NPV approach translates planned annual capital investments, ongoing annual operations and maintenance expenditures, and ongoing annual benefits into today's dollars. The NPV approach adjusts for the time value of money and lists costs and benefits in today's dollars, providing a more meaningful and accurate comparison of alternatives in terms of ROI.

The business case analysis focused on four business cases—two AMR solutions and two AMI solutions—as described below.

- The AMR Low Benefits Case was developed to provide a conservative estimate of ROI and benefits, and represents a business case for technology at the low end of the benefit value spectrum.
- The AMR High Benefits Case illustrates the potential for a relatively high-range ROI, with many benefits from AMR technology at or near median or higher anticipated benefit value. Even though this case reflects optimistic benefits, it uses a more conservative estimate of benefits than the highest benefit estimates available in industry benchmark reports.
- The Full AMI Case involved implementation of AMI throughout the entire meter population.
- The Hybrid AMR/AMI Case applied technology to a focused customer population, to reap AMI benefits at lower costs than the Full AMI Case.

Benefit values in the business cases were determined based on macroeconomic industry benchmarks and Leidos experience conducting business case assessments for other utility clients.

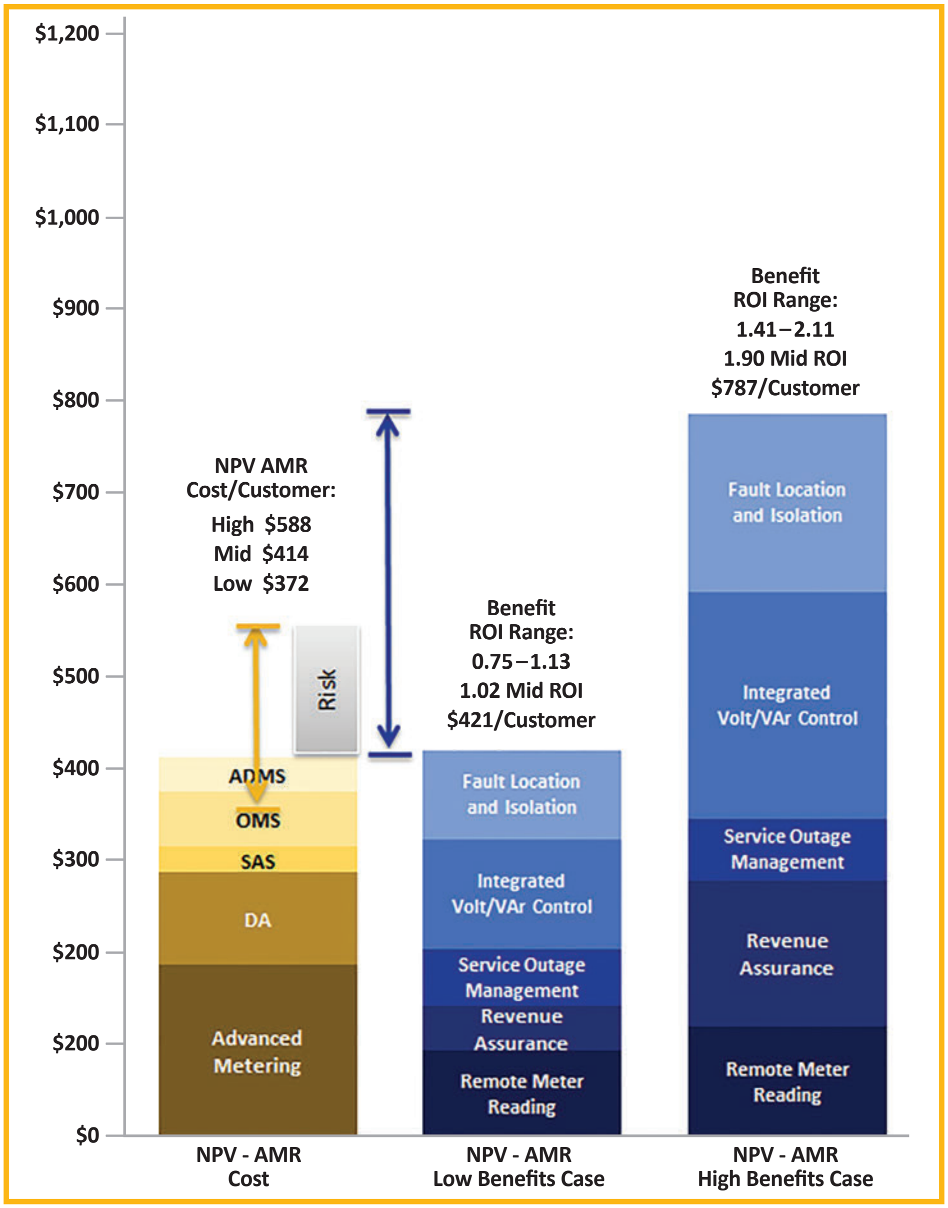
Considering RPU's implementation of AMR technology and its expansion to AMI, Leidos used conservative mid-range benefit estimates for the AMR High Benefits Case, Full AMI Case, and Hybrid AMR/AMI Case.

For some benefits, the same value was used for the AMR High Benefits Case, Full AMI Case, and Hybrid AMR/AMI Case; however, the benefit value was allocated and realized differently over the span of years in the different business case options depending on the technology. For example, additional revenue protection benefits are available to Full AMI versus AMR or Hybrid AMR/AMI. It is the same benefit value per customer but differs throughout the options in that it can be more fully realized with a full population of AMI meters. For more details on the actual benefit values used and how benefits were allocated, see **Appendix A**.

All four business cases considered costs and benefits for technology investments from categories outside of advanced metering in categories of DA, SA, OMS, ADMS, and NCS, to enable desired use cases. The four business case options varied the advanced metering technology used while holding the DA, SA, OMS, ADMS, and NCS technology solutions constant throughout the business case analysis.

Figure 18 (below) summarizes the NPV of costs and benefits for the AMR Low Benefits Case and AMR High Benefits Case. **Figure 19** (next page) summarizes the NPV of costs and benefits for the Full AMI Case and Hybrid AMR/AMI Case.

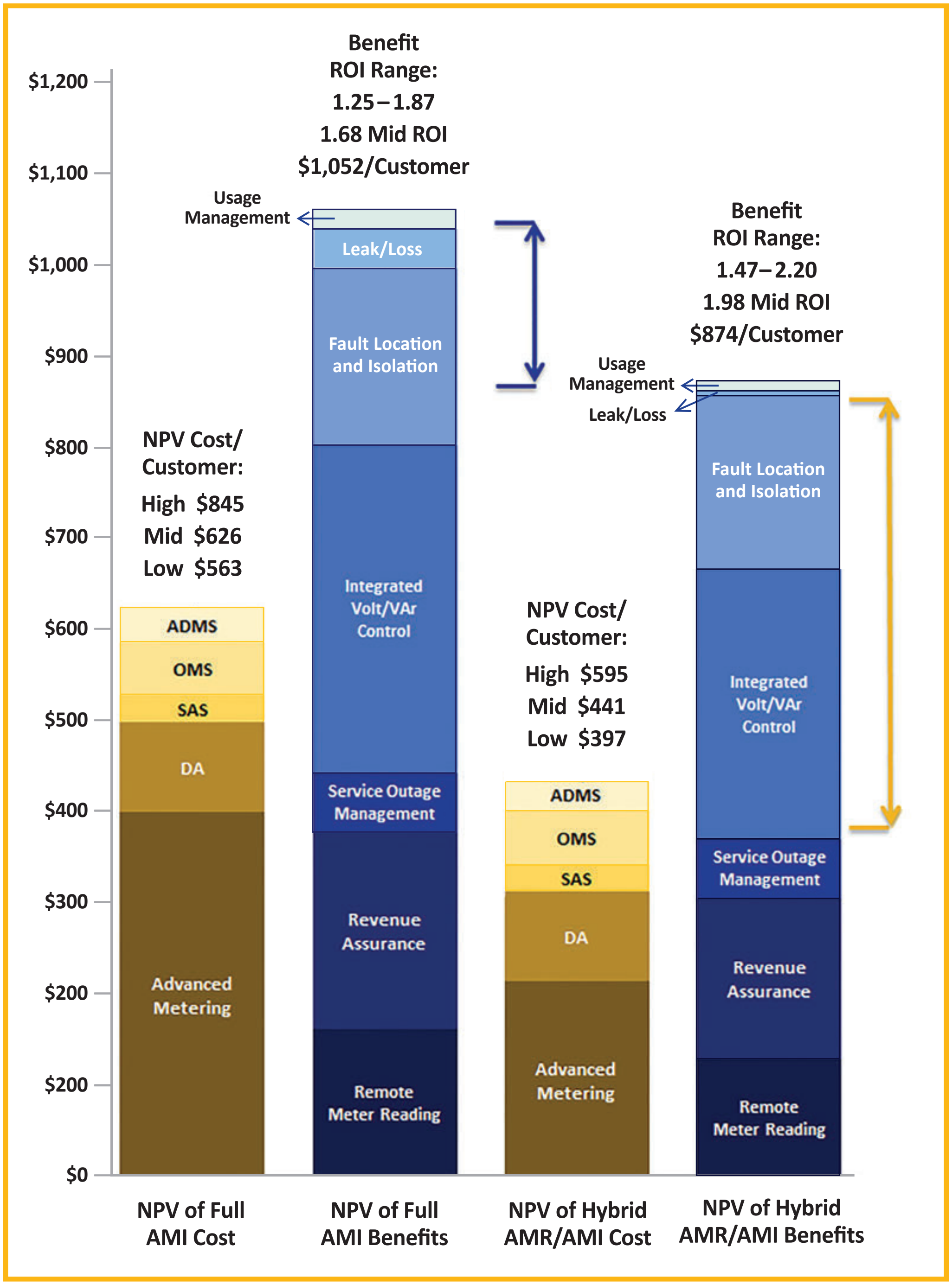
Figure 18: Net Present Value of AMR Cost, AMR Low Benefits Case, and AMR High Benefits Case



LEGEND:

- **Volt/VAR control (**a.k.a. **voltage optimization**; **Volt/VAR optimization**; **conservation voltage regulation):** Ability to manage distribution system voltages and power factor by sensing voltages and currents at customer premises and throughout distribution system, then using advanced control and communication systems to operate substation transformer load-tap changers, capacitor banks, line voltage regulators, and smart inverters to minimize distribution system losses and customer demand.
- **Revenue assurance:** Ability to detect meter tampering, reverse power flow, and energy theft through AMI system.
- **Fault location and isolation:** Also called **fault location/isolation/service restoration** (**FLISR**). Provides automatic fault detection in distribution system (e.g., downed wire; contact with tree or mylar balloon); automatic fault isolation (via circuit breakers, reclosers, and switches); and service restoration to the most customers in the least amount of time. FLISR is a fundamental component of an ADMS.
- **Service outage management system (OMS):** Receives distribution system outage notifications from AMI, SCADA, and IVR systems, to enable Utility personnel to more rapidly locate outages and restore service to customers. An OMS also can manage automated outbound calls (via IVR system) to notify customers of outage areas and estimated service restoration times.

Figure 19: Net Present Value Full AMI and Hybrid AMR/AMI Cost and Benefits



Even though total benefits were higher for the Full AMI Case, ROI was higher for the Hybrid AMR/AMI Case; therefore, Leidos recommends pursuing the Hybrid AMR/AMI solution. A more detailed business case should first be prepared, using actual RPU operating conditions and comparing results to other detailed AMR and AMI business cases.

Because this was a strategic, high-level business case using a macroeconomic approach, and many of RPU's actual operating conditions were not considered, Leidos recommends preparation of additional detailed business case analyses for the highest cost projects in the Strategic Technology Plan. Any future business case analyses should use a microeconomic approach that considers RPU's actual operational statistics and financial realities.

KEY RECOMMENDATIONS

Figure 20 lists the top ten key recommendations from the strategic technology plan. These recommendations are not in any particular order of priority or implementation date.

Figure 20: Top Ten Key Recommendations for Strategic Technology Plan (not in any particular order)

No.	Recommendation	Benefit to RPU
1.	Periodically update the Strategic Technology Plan (annually or biennially), to keep it current and in alignment with business objectives.	• Align technology investments with business objectives. • Position RPU to be more agile and resilient to external market changes and internal drivers.
2.	Establish OT office and develop organizational structure and processes. Hire OT Manager and supporting staff.	• Complete successful technology projects. • Ensure that technology program requirements align with KPIs and SLAs. • Enable standards and cybersecurity.
3.	Use new OT office and organizational structure to foster a culture of project management through SLAs and KPI tracking.	Enable organizational change that positions RPU to be resilient to technology change and market drivers; Ensure maximization of benefit from technology investments through meeting project goals.
4.	Adopt an enterprise integration architecture through new operational data service bus and leveraging the in-place IT service bus.	Reduce data silos. Reduce labor effort to access critical operating data. Enable enterprise integration. Allow access to operational data to provide more real-time decision making.
5.	Improve mobile access to enterprise systems. Layer on new Mobile Apps to enable mobile capabilities with AVL, service orders, OMS, AMS, and WMS. Integrate geographic context for Mobile Apps.	Enhance customer service. Increase crew safety and efficiency. Increase staff efficiency. Improve work scheduling efficiency.
6.	Implement strategic communications backbone, aggregation, and access layers to enable automatic AMR/AMI reading and advanced distribution system monitoring and control capabilities.	Create a communications technology infrastructure to support advanced distribution system monitoring and control. Enable AMR, AMI, and Mobile Apps. Position RPU to take advantage of additional communication business opportunities.
7.	Deploy Hybrid AMR/AMI solution. Develop detailed business case analysis to assign appropriate level of AMI penetration.	Produce remote meter reading benefits in revenue assurance; Enable AMI benefits for less cost for advanced customer and distribution system programs.
8.	Implement improvements to AMS and WMS, including enterprise fleet management with AVL.	Enhance AMS and WMS. Improve fleet utilization, tracking, maintenance, and lifecycle management. Increase crew safety and efficiency.
9.	Provide a customer Mobile App for self-service, rebate, outage, and usage tracking functions. Provide ability for customers to review their energy and water consumption data via the CWP or a Mobile App.	Increase customer convenience; Enhance customer service. Reduce usage and strain of limited resources. Increase customer confidence during outages and disasters. Position RPU to take advantage of distributed energy resources by providing variable rate structures.
10.	Deploy OMS and ADMS.	Provide service outage restoration benefits. Provide benefits from Volt/VAR, FLISR, and advanced distribution monitoring and control capabilities.

STRATEGIC TECHNOLOGIES FOR UTILITY 2.0

The utility industry has enjoyed a profitable, stable business model based on very structured services for more than 100 years. As new technologies and cost-effective alternatives to traditional energy delivery have emerged in the marketplace, the need has been recognized for the industry to move toward a flexible business model. This model would provide services based on customer expectations that are fluid and dependent on technological advances as they unfold. The changes in the industry are expected to multiply across decades, and they will set the stage for how utility companies must adapt to them or risk obsolescence. Much like Eastman/Kodak did when the film industry shifted to a digital environment, the utility industry will need to shift along with the technological advancements that drive customer satisfaction to remain viable.

As a utility owned by the customers it serves, RPU takes pride in the value they provide to the community. Strong reliability, low rates, and the benefits of local control are hallmarks of their 120-year history. Building on their strong infrastructure and economic strength, RPU recognizes the need to engage in the changing landscape of the Utility industry. The need to upgrade current technologies touches all areas of the Utility.

As RPU makes future plans in an environment undergoing rapid change, they will need to modernize their grid from a static delivery system to a more flexible enterprise. The most critically impacted areas are customer experience and smart infrastructure efforts. The Utility has adopted a "fast-follower" strategy to manage technological trends. This approach optimizes cost versus the risk of waiting so long to adopt new technology that costs increase, customer satisfaction becomes stagnant, and RPU falls too far behind to catch up effectively. This is a delicate balance, because adopting technology either too early or too late can have devastating financial impacts. With the aid of this Strategic Technology Plan, RPU reimagines a new technological framework to remain a successful service provider. RPU will update the Plan on an annual basis to reflect changes in business objectives, internal and external market drivers, and utility business models, so it can be proactive, agile, and resilient. The ultimate goal is to incorporate new technologies and prepare for the utility of the future, coupled with balancing prudent financial decisions with capturing opportunities for growth, all while putting the customers' needs first.

·1· STRATEGIC TECHNOLOGY VISION

This section establishes a strategic technology vision for RPU that considers external utility business drivers, industry trends, and RPU's internal business objectives. Included is an outline of the strategic value of major utility technologies and how those technologies align with RPU's business objectives.

TECHNOLOGY DRIVERS

The need for technology within RPU is driven by a number of factors, some external to the Utility and others internal (**Figure 21**). External drivers include Federal and State regulatory and legislative forces, California's energy policy, and the needs and expectations of RPU's customers. Internal drivers include the enterprise vision, RPU's strategic technology vision, operational efficiency, cost management, reliability, aging infrastructure, safety, and workforce development.

Industry trends are another important influence RPU must consider when defining future technology needs. Cross-cutting technology solutions that help address all three drivers are of particular importance, since these solutions can address multiple objectives with the same investment. For example, improved work and asset management can help modernize the grid, increase reliability, and improve operational efficiency, while aligning with utility industry trends. Such cross-cutting solutions are a clear priority for RPU.

Figure 21: Technology Drivers and Industry Trends that Provide Strategic Direction

External Drivers

- Customer expectations for improved customer service, higher reliability, enhanced information and interaction, and Mobile Apps and service.
- GHG emission reduction (AB32).
- Renewable portfolio standards.
- Distributed energy resource targets (SB-1).
- Energy storage targets.
- Energy efficiency, conservation, and demand management.
- Regulations for grid reliability and security, including CPUC GO 165, 170, and 174, and the NERC CIP standards.
- Electric transportation goals.
- Energy Independence and Security Act.
- American Recovery and Reinvestment Act.
- 20% reduction in water consumption by 2020 (SB X7-7).
- Integrated water management, increased water efficiency, reduced energy footprint for water delivery, and use of advanced metering in water delivery systems (CA Water Plan 2013 Update).

Internal Drivers

- Developing and maintaining an effective workforce.
- Enhancing customer experience.
- Improving operational efficiency.
- Improving distribution system efficiency.
- Managing aging infrastructure.
- Maintaining and ensuring system reliability, security, and resiliency.

Industry Trends

- Transition from one-way to two-way power delivery grid, providing integration of widely distributed electric generation, energy storage, and energy management technologies.
- Technology embedded in utility infrastructure and core to the business.
- Legacy customer information and billing systems becoming roadblocks to IT/OT convergence.
- Advanced metering to be the foundation for transforming business models.
- Work management and mobile computing central to an effective workforce.
- Asset management to address aging infrastructure.
- Advanced distribution automation to enable integration of distributed generation and electric transportation.
- GIS as a primary business tool.
- Engaging customers.

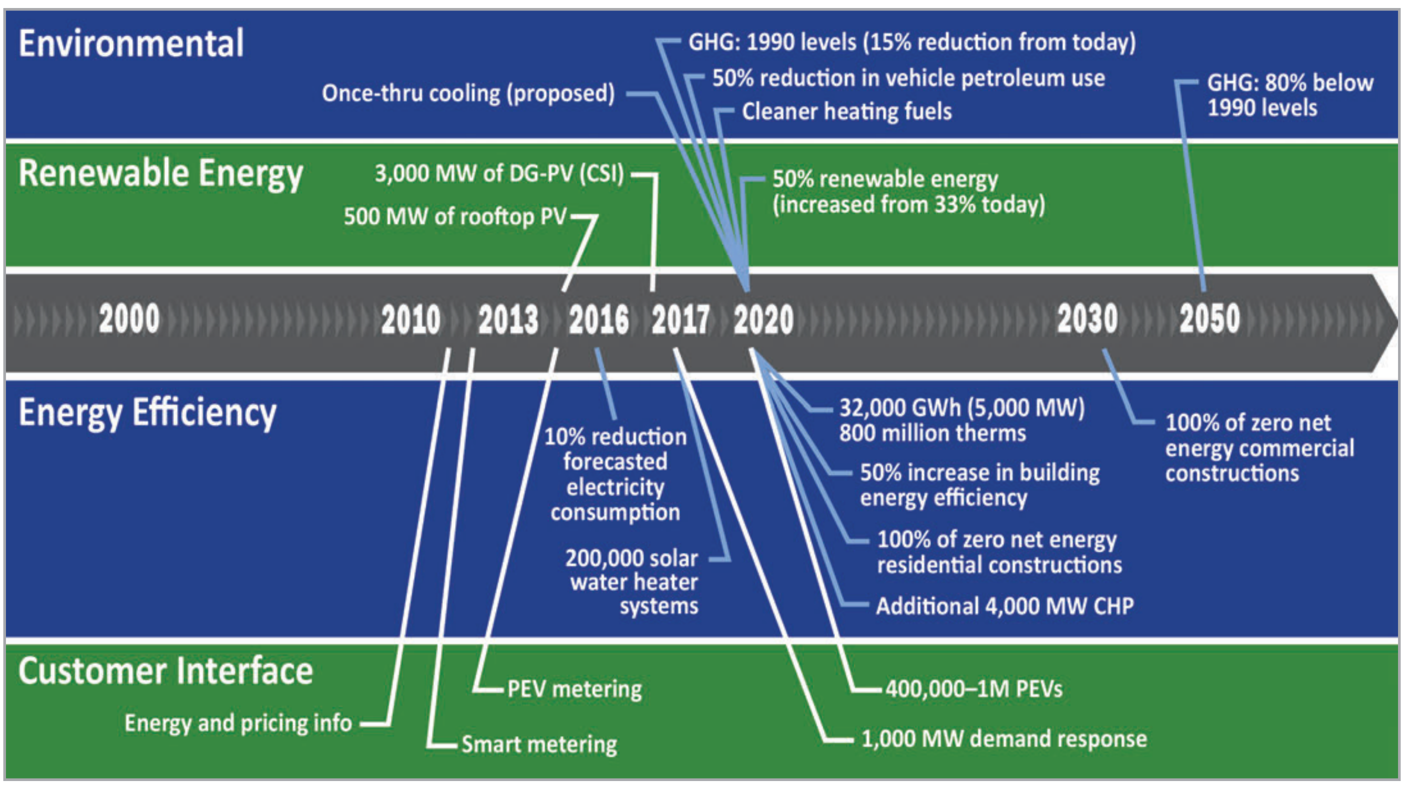
All of the drivers identified in this road-mapping effort have, to some degree, an influence on setting a technology vision and identifying and prioritizing essential technology investments. A discussion of these connections reveals what RPU's technology vision is and explains how technology can help achieve that vision.

EXTERNAL DRIVERS — ENERGY DELIVERY

Environmental and energy policies from federal, state, and local governments are directing utilities to change their business models. Consumer needs are also driving change to policy and the utility business. The myriad of California energy policy objectives and roadmap for implementation is provided in **Figure 22**.

To reduce GHG emissions, utilities are integrating intermittent wind and solar generation to meet policy requirements and the increasingly significant consumer needs. As an added difficulty to the energy policy compliance, a substantial portion of this new generation is highly distributed—many small installations located on the rooftops of homes and businesses. The highly distributed nature and two-way power flow of the new generation complicates operating the existing grid which was designed to primarily work with a one-way power flow.

Figure 22: Regulation, Legislation, and State Energy Policy Compliance Requires Utilities to Implement New Technologies



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EXTERNAL DRIVER/ENERGY: *Greenhouse Gas Emission Reduction*

Assembly Bill 32 (AB 32, the California Global Warming Solutions Act) establishes a comprehensive program of regulatory and market mechanisms to achieve real, quantifiable, cost-effective reductions in GHG emissions and requires a GHG reduction goal of 1990 levels by 2020 (30% reduction from projected levels by 2020, 15% reduction from current levels), with a target of 80% below 1990 emissions levels by 2050.

Utilities are turning to technology in all aspects of water and electricity delivery to contribute to the reduction efforts. Examples where RPU is and will be using technology to reduce GHG emissions include:

- Electric distribution system voltage optimization to reduce electrical losses.
- Advanced electric metering will reduce the use of vehicles for service orders and meter reading.
- Automatic Vehicle Location (AVL) to optimize the routing of vehicles will reduce exhaust emissions.
- Distribution automation and advanced metering will allow the integration of more distributed renewable resources.

Executive Order S-14-08 requires California's retail sellers of electricity to serve 20% of their load with renewable energy by 2010, and 33% of their load with renewable energy by 2020.

EXTERNAL DRIVER/ENERGY: *Renewables Portfolio Standard*

Executive Order S-14-08 requires California's retail sellers of electricity to serve 20% of their load with renewable energy by 2010, and 33% of their load with renewable energy by 2020, including a 20% target for the use of biomass for electricity generation within the established state goals for renewable generation. Governor Brown's latest initiative, the "50-50-50 plan," calls for an increase in the state's renewable energy target from 33% in 2020 to 50% in 2030, a reduction in petroleum use in cars and trucks by up to 50%, and a 50% increase in existing buildings' energy efficiency (including an initiative for cleaner heating fuels). While these goals are not yet regulatory mandates, all expectations are that they will soon be, and many utilities are beginning to plan accordingly. The intermittent nature of predominantly wind and solar resources is creating tremendous operational issues for transmission and distribution grids. A wide range of technology solutions are being developed and deployed to address these integration issues.

EXTERNAL DRIVER/ENERGY: *Distributed Energy Resources and Storage*

California's Million Solar Roofs Program prescribes the installation of 3,000 MW of distributed solar photovoltaic (PV) electricity generation in California by the end of 2016. Furthermore, the California Air Resource Board in its Scoping Plan sets a target of an additional 4,000 MW of installed combined heat and power (CHP) capacity by 2020, enough to displace approximately 30,000 GWh of demand from other power generation sources. Finally, AB 2514 requires consumer-owned utilities to study viable and cost-effective energy storage systems, including the January 1, 2015 target for procurement of an appropriate energy storage system, with a second target to be achieved by January 1, 2020. Highly distributed, intermittent, customer-owned resources require utilities to install advanced sensing, metering, and control systems to allow the safe, secure, and reliable integration of distributed renewable resources.

Distributed generation, solar PV electricity generation in particular, is highly prevalent in Riverside with approximately 1,000 residential and 60 commercial installations having a total capacity of 10 MW. With the current integration strategy, most of these installations are "behind the meter" and appear to RPU as reduced demand for energy. Looking ahead, as the number of installations grows, there is a benefit to interconnecting solar PV electricity generation through smart inverters that allow RPU to monitor and control the output of the generation, providing additional benefit to the customer and the Utility.

Widespread adoption of distributed generation and storage requires transitioning from the traditional one-way grid to a more complex two-way grid. The utility must deploy new sensing and control equipment in the distribution grid to allow power to flow from the customer to the utility while ensuring reliability safety and quality of service. Beyond the technology challenges, utilities must address business process changes in planning, engineering, operations and customer service as a result of this new driver. Among the most significant challenges is the need to restructure electric rates to reflect this new arrangement between the customer and the utility. Today's rate structures usually do not ensure recovery of the utilities' fixed operating costs as revenues decline due to customer generation.

EXTERNAL DRIVER/ENERGY: *Energy Efficiency, Conservation, and Demand Management*

RPU is subject to a myriad of legislation requiring the collection of funds from its customers to be spent on energy efficiency measures to help meet the state's goal of reducing energy demand and consumption. For 2012 through 2020, total energy savings are expected to reach over 4,500 megawatts, the equivalent of nine major power plants. Other state requirements dictate that all new residential construction in California will be zero net energy by 2020, and all new commercial construction in California will be zero net energy by 2030.

Efficiency, conservation, and demand management policies are reducing energy and water consumption and increasing the cost and complexity of operating the Utility, all while reducing revenues needed to pay for the infrastructure required to serve customers. Increasingly complex rates (e.g., feed-in tariffs, electric vehicle charging, net-metering, time-of-use, etc.) and the resulting increasingly complex financial transactions require utilities, including Riverside, to invest millions of dollars replace legacy customer information, billing, and financial systems.

RPU's energy efficiency and conservation programs have reduced peak energy demand by more than 2,000 kW and consumption by nearly 20 million kWh.

RPU's energy efficiency and conservation programs have reduced peak energy demand by more than 2,000 kW and consumption by nearly 20 million kWh. In response to the announced closure of the San Onofre Nuclear Generating Station (SONGS), RPU implemented a voluntary demand response program. This program was developed in partnership with RPU's largest commercial customers. Each customer that participated in the program agreed to voluntarily shed or shift a combined total of 14 MW of electric load during the peak summer months from June to September, if it was deemed necessary by RPU in cooperation with the CAISO to call on this resource.

Technology will help RPU increase its energy efficiency, conservation, and demand management effectiveness.

Advanced metering will:

- Allow RPU to provide detailed and timely information about energy consumption to customers.
- Enable customers to conserve electricity, resulting in direct cost savings.

Advanced distribution sensing and control will enable RPU to:

- Reduce electric losses.
- Reduce customer energy consumption.

Demand response technology will allow RPU to:

- Manage customer demands for energy.
- Reduce operating costs.
- Enhance reliability.

EXTERNAL DRIVER/ENERGY: *Reliability*

California's investor-owned utilities must submit to the CPUC Annual Reliability Reports, demonstrating compliance with reliability guidelines for the duration and frequency of sustained and momentary outages. Consumer-owned utilities often measure their performance against the investor-owned utilities and, therefore, are influenced by these state mandates. Furthermore, the IOUs are subject to General Order (GO) 166, which comprises standards for operation, reliability, and safety during emergencies and disasters; GO 165, which prescribes infrastructure inspection cycles, methods, and requirements for remediating non-compliance; and GO 174, which prescribes uniform requirements for substation inspection programs to enable adequacy of service and promote the safety of workers and the public. Most consumer-owned utilities, including RPU, voluntarily comply with these mandates, even though they are not technically subject to CPUC orders.

Technology will allow RPU to improve the reliability and resiliency of both water and electric delivery. Advanced delivery system sensing and control along with advanced metering and outage management will enable faster detection of outages, reduce outage extents, and improved outage restoration times.

EXTERNAL DRIVER/ENERGY: *Electric Transportation*

State energy policy regarding electric transportation is increasing the number of plug in electric vehicles (PEV) and charging stations. This increases the demand on electric distribution systems and creates the opportunity to use battery energy storage to improve the ability to integrate intermittent renewable resources into the distribution system. Two of the most significant policy objectives are:

- Executive Order B-16-2012 set a goal of reaching 1.5 million zero-emission vehicles on California's roadways by 2025. According to a 2012 projection prepared for SCCG by the UCLA Luskin Center for Innovation, the number of electric vehicles predicted to reside in Riverside by 2022 is estimated to range from 5,600 to 9,900. RPU's role will be to provide electric rates, interconnection policies, and energy management technologies to support the necessary charging infrastructure for electric vehicles.
- AB 1007 caused the development and adoption of a state plan to increase the use of alternative fuels to achieve a goal of 20% non-petroleum fuel use in 2020 and 30% in 2030. The CEC's State Alternative Fuel Plan provides strategies, actions, and recommendations to meet state goals to reduce petroleum consumption in the transportation sector. Funding from the plan added nearly 7,000 charging stations since 2010, totaling 9,400 charging stations statewide.

The PEV market continues to grow in California, with 19 models of full battery-electric vehicles and plug-in hybrid vehicles offered by almost every automobile manufacturer to California consumers.

The PEV market continues to grow in California, with 19 models of full battery-electric vehicles and plug-in hybrid vehicles offered by almost every automobile manufacturer to California consumers. In 2013, PEV sales were triple 2012 levels, and as of September 2014 more than 100,000 PEVs were sold in California, representing about 40% of national PEV sales.

Effective integration of electric vehicles and charging stations requires significant electric system sensing and control to manage the increased demand associated with PEV charging and the grid energy storage potential of PEV batteries. With Riverside's proximity to major transportation corridors, it is likely that significant charging infrastructure will be needed to meet customer needs, and RPU will be required to invest in advanced metering and advanced distribution automation, communication, and controls to manage the impacts to its distribution system resulting from PEV growth.

EXTERNAL DRIVER/ENERGY: *Energy Independence and Security Act of 2007*

In the United States and many other countries, modernization of the electric power grid is central to national efforts to increase reliability, resiliency, sustainability, energy efficiency, security, and efficiency of the electric grid; transition to renewable sources of energy; reduce GHG emissions; implement secure Smart Grid technologies with cybersecurity and privacy issues addressed; support a growing fleet of electric vehicles; and build a sustainable economy that ensures prosperity for future generations.

In the United States and many other countries, modernization of the electric power grid is central to national efforts to increase reliability, resiliency, sustainability, energy efficiency, security, and efficiency of the electric grid.

The Energy Independence and Security Act of 2007 (EISA), which directed the National Institute of Standards and Technology (NIST) to coordinate development of this framework and roadmap, states that national policy supports the creation of a modernized grid. Benefits include:

- Improves capacity, efficiency, reliability, security, and resiliency of water and electricity delivery systems
- Improves resilience to disruption by natural disasters and attacks
- Reduces GHG emissions by enabling electric vehicles and expanded deployment of distributed renewable energy sources and energy storage
- Reduces the energy intensity of water delivery
- Provides consumers with actionable and timely information about their energy and water consumption, provides enhanced consumer choice, and enables new products, services, and markets

EXTERNAL DRIVER/ENERGY: *American Recovery and Reinvestment Act*

The American Recovery and Reinvestment Act of 2009 (Recovery Act or ARRA) provided the U.S. Department of Energy (DOE) with about $4.5 billion to modernize the electric power grid and to implement Title XIII of the EISA, which focused on the smart grid. California's POUs received federal stimulus grants of $321 million toward total program costs of $558 million. These smart grid investments equate to about $240 per each of the 2.4 million customers of the receiving utilities.

In response to the federal direction that states consider in advancing smart grid technologies—particularly those technologies that could advance energy efficiency, demand response, renewable energy, and grid reliability and security—in 2009, California enacted Senate Bill 17 into the Public Utilities Code. The bill establishes as state policy the modernization of the state's electrical grid to maintain reliable and secure electrical service with infrastructure that can meet future growth in demand while achieving several other objectives such as integration of distributed generation resources, demand-side resources, and "smart" technologies.

ARRA-funded investments have had a tremendous impact on the deployment of water and electric delivery system technology. In California alone the cities of Los Angeles, Burbank, Glendale, and Sacramento implemented advanced metering, distribution automation, outage management, and other technologies for more than a million customers. These ARRA-funded projects, totaling nearly $300 million, have produced positive results for customers and utilities. While Riverside applied for an ARRA grant and was not selected, it will benefit from the lessons learned by the other utilities through the information-sharing phase of the ARRA program currently under way.

EXTERNAL DRIVERS — WATER DELIVERY

The California Water Plan is the state's long-term strategic plan for guiding the management and development of water resources. The plan is the primary tool for achieving the 20x2020 Water Conservation Plan, the state's vision of a 20% reduction in water consumption by 2020. Updated every 5 years, the third volume, released in October 2013, identifies 30 Resource Management Strategies (RMSs) that can be used to help meet the water resource needs of the different regions in the state. An RMS is a technique, program, or policy that helps local agencies and governments manage water and other related resources. Strategies identified in the California Water Plan include actions such as agricultural and urban water use efficiency, conjunctive management, and groundwater desalination, watershed management, forest management, and urban stormwater management. The strategy identified as having the greatest potential water supply benefit was urban water use efficiency, with up to 3.1 MAF by 2030.

EXTERNAL DRIVER/WATER: *Water/Energy Nexus and Greenhouse Gas Reduction*

Innovations in both water and energy systems present interesting and important synergistic opportunities. In addition to saving water, improving water use efficiency provides significant energy savings. The California Energy Commission (CEC) reports the following:

1. The transportation and treatment of water, the treatment and disposal of wastewater, and the energy used to heat and consume water account for nearly 20% of the total electricity and 30% of the total non-power plant related natural gas consumed in California.
2. Increased water use efficiency is a significant new water supply available to meet this expected growth in water demand over the next 25 years.

Instrumentation, communication, and control technologies allow water managers to optimize pressures and flows in water distribution systems to minimize the amount of energy used to collect, treat, and deliver water to customers. Innovations in water management can significantly reduce energy use, and innovations in energy systems can significantly reduce water use. The potential multiple benefits of the integrated management of water and energy are important aspects of the water/energy nexus.

EXTERNAL DRIVER/WATER: *Efficiency, Conservation, and Demand Management*

Examples where RPU will continue to use technology for efficiency, conservation, and GHG reduction are listed below.

Advanced Water Delivery Control

- Reduces the amount of energy required to produce, store, and deliver water. The new water Operational Distribution Management System (ODMS) is one example.

Advanced Water Metering

- Reduces water leaks.
- Reduces the use of vehicles for service orders and meter reading.
- Allow RPU to provide detailed and timely information about water consumption to customers.
- Enable customers to conserve water, resulting in direct cost savings.

Automatic Vehicle Location (AVL)

- Optimizes the routing of vehicles, which reduces exhaust emissions.

Demand Response Technology

- Reduces RPU's operating costs.
- Enhances reliability.
- Allows water conservation through usage management measures during drought conditions.

INTERNAL DRIVERS — ENERGY DELIVERY

INTERNAL DRIVER/ENERGY: *Workforce Development*

Workforce development challenges are driving utilities to operate differently. Most utilities, including Riverside, face tremendous challenges with their workforce ranging from retirements and loss of expertise, to recruiting and retaining employees, to keeping up with requirements for training and education. Exacerbating the problem is that as the effectiveness of its workforce is declining due to these challenges, the need for infrastructure replacement and maintenance is increasing.

Perhaps the most significant workforce challenges are in field operations, engineering, and data analytics. Through advanced work and asset management technologies, utilities can better plan and prioritize workforce activities, forecast workforce needs, and increase the efficiency of the workforce.

Another role that technology plays is attracting potential employees. When choosing between employers, younger tech-savvy workers will gravitate to employers who value and employ technology over an employer who uses out-of-date technology and work methods. So, technology can also attract desirable employees to the Utility.

INTERNAL DRIVER/ENERGY: *Enhancing Customer Service*

Enhancing customer service, and the overall customer experience of the Utility, is another significant technology driver. A typical RPU customer has the ability to manage their cable television, cellular communications, and natural gas services with greater ease, flexibility, and timeliness than it can with RPU. And just across the street from many of RPU's customers, where electric service is provided by Southern California Edison (SCE), albeit for a higher price; customers can go to a website and look at their energy use in near real time, move, add, change and cancel service, review rate options, get advice on how to save energy and money, and other services.

The ongoing CIS replacement project includes significant improvements to customer interaction, including a new customer care web portal through which a customer can have complete access to its utility accounts.

RPU's customers want interaction with the Utility anytime, from anyplace and using their preferred method of communication, whether by telephone or by smartphone. The ongoing CIS replacement project includes significant improvements to customer interaction, including a new customer care web portal through which a customer can have complete access to its utility accounts. Eventually, as the meter data management system is implemented and more detailed water and electric metering data is collected, RPU customers will have access to very detailed information about how and when they use water and electricity, which will allow them to take action to reduce consumption and cost.

New technologies will also allow RPU to provide a wider range of services and options, including advanced rates for distributed generation, electric vehicle charging, and pre-pay services. With a pre-pay program, RPU customers pay in advance for their water and electric use instead of paying deposits. Through advanced metering, meter data management, and the CIS, customers can track their daily balance and receive alerts by text, phone, or email when they are reaching their consumption limit. This improves the customers' ability to budget for their utility costs and make their payments to RPU when it is most convenient for the customers. The result for RPU is improved customer satisfaction, reduced write-offs of bad debt, and improved operational efficiency.

INTERNAL DRIVER/ENERGY: *Improving Operational Efficiency*

Improving the efficiency of operations, that is the amount of labor and time that it takes to complete our work, remains a priority for RPU. Technology plays an important role in achieving this objective by allowing more widespread use of automation and better management of operating information. This becomes increasingly important as the complexity of operations is increasing at the same time as RPU is facing challenges with developing an effective workforce and managing an aging infrastructure. Examples of how technology helps improve operating efficiency include:

- Improved work management, service order management, asset management, and inventory management systems will allow RPU to better plan and forecast labor needs, optimize the use of resources, and reduce the level of effort to execute work
- Water and electric delivery system automation reduce the amount of labor and time required to operate the delivery systems
- Water and electric outage management systems will reduce the time to locate and restore service interruptions.

RPU's current work, asset, service order, and inventory management systems require additional investment to reach the level of performance needed. As part of the new customer information system upgrade, RPU implemented a new mobile service order management system and plans to reinvest in the work and asset management systems.

Complicating the challenges of implementing and maintaining technology at RPU is its organizational structure, its relationship with the City, and the skills and availability of its workforce. When RPU is in complete control of its investments in technology, it has demonstrated some great success stories.

According to RPU staff and management, the challenges are attributed to having control of the project and having adequate staff with the required skills to implement and then maintain the systems. Especially the latter. One of the most important recommendations in this strategic technology roadmap is that RPU needs to establish its own IT governance structure—not to work in isolation from the rest of the enterprise, rather to provide technology leadership and implementation capabilities that put RPU's priorities first.

Of their own accord, GIS, AMI, OMS, AVL, Mobile Apps, MDMS, and CIS are technologies that bring tremendous benefit to utilities, but not if they are operated independently in institutional silos. These core systems and their related applications require significant integration to realize their full potential and benefit.

INTERNAL DRIVER/ENERGY: *Improving Distribution System Efficiency*

RPU's water and electric delivery system infrastructure is not perfectly efficient. Electrical losses, low power factor, voltage and pressure regulation, water leaks, and the energy used in storing and delivering water all contribute to inefficiencies. RPU spends millions of dollars helping customers improve efficiency in the use of water and electricity so that they can save money and help the environment, and invests in infrastructure and technologies to improve delivery system efficiency. Three examples of where technology can help include:

- Distribution automation and advanced metering are the key elements to optimizing the voltage at which the electric system operates and the pressure at which the water system operates—improving both increases operating efficiency.
- Advanced water and electric metering provide the sensing necessary to detect diversion, theft, and leaks that all contribute to inefficient operations.
- The ODMS will reduce the amount of energy used to store and deliver water to customers.

RPU has used automation for water and electric system operations at a level limited by the capability of SCADA systems for many years. In recent years, RPU has begun to explore the costs and benefits of increasing the use of automation to improve efficiency. Getting to real improvements in water and electric delivery system efficiency requires implementation of the proposed advanced metering and distribution and delivery automation projects.

One of the most important recommendations in this strategic technology roadmap is that RPU needs to establish its own IT governance structure—not to work in isolation from the rest of the City enterprise, rather to provide technology leadership and implementation capabilities that put RPU's priorities first.

INTERNAL DRIVER/ENERGY: *Managing Aging Infrastructure*

RPU has been delivering water and electricity to the Riverside community for more than a hundred years, and some of the infrastructure is that old. While most is not, RPU is constantly challenged by the need to optimize the limited resources needed to operate, maintain, and replace infrastructure. To perform this responsibility, the Utility must track and analyze an enormous amount of information about the age, condition, maintenance history and requirements, location, reliability, and other characteristics of tens of thousands of pieces of equipment, and thousands of miles of electric lines and water lines. Technology helps manage aging infrastructure in several ways, including:

- An AMS that tracks the characteristics, age, condition, and essential asset data and provide convenient access to accurate data when and where it is needed, whether in an engineer's office or a worker's vehicle
- A GIS that provides accurate information about the location and connectivity of water and electric assets and makes that information available wherever and whenever users need it.

RPU already uses both GIS and AMS in operations. However, the 20 year-old GIS system is at the end of its useful life and is being replaced, and the partially implemented AMS requires additional effort and investment to be as useful as it needs to be.

INTERNAL DRIVER/ENERGY: *Maintaining System Reliability, Security, and Resiliency*

RPU operates a very secure, safe, and reliable water and electricity delivery system, but it is a constant challenge. The security of the systems is constantly under attack, whether thieves and vandals, hackers, or other bad actors, the threats change and so the security vigil is never ending. RPU systems have performed very reliably for many years and have achieved award-winning reliability levels, but the demand for higher reliability from our customers requires evolving both reliability standards and the means of maintaining those standards.

Safety is a core value in the organization and drives RPU to find solutions for operating safely as the use of the distribution system changes to include generating sources located on customers' premises, which can create an unsafe condition for workers. The role that technology plays in addressing these drivers includes:

- Delivery system automation, advanced metering, and outage management will allow RPU to detect outages as soon as they happen, automatically locate and isolate the cause of the outage, and restore service faster.
- Advanced metering will enable safe integration of increased levels of customer-owned generation, especially solar PV electricity generation, by providing the sensing and control needed for system operators to better predict the levels of generation and controls and automation to create safe working environments when necessary.
- Advanced automation in the electric and water delivery system along with improvements in the communications systems will improve situational awareness to detect and respond to security threats.

RPU has invested significantly and wisely in security systems for its physical and cyber assets; however, as the threats evolve, more action is required to ensure adequate protection, including increased video surveillance, access control, and tamper detection. Increasing the backbone fiber optic communications network, SCADA and data communications networks are essential for collecting and transmitting the increased data needed to meet security expectations.

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Paper-based outage management methods have been largely effective, but they are inefficient and not suitable for accomplishing long-term reliability needs. Maintaining excellent safety performance in an environment where the distribution system includes potentially dangerous voltage sources requires new sensing and automation.

INTERNAL DRIVERS — WATER DELIVERY

INTERNAL DRIVER/WATER: *Improving Water Delivery System Performance*

Improving water delivery system performance depends on various technologies, including:

- advanced control of highly efficient electric motors for water pumping and treatment processes;
- widely distributed instrumentation and control devices throughout the water delivery system to optimize pressure, flows, and storage levels;
- wide-area communication systems capable of transmitting data, sensing, and control signals to widely distributed instrumentation; and
- advanced customer premise metering that provides near real-time consumption data to customers, to help them understand and alter their water consumption habits.

Because these technologies provide water managers and consumers near real-time data and control, the treatment, delivery, consumption, and retreatment of water can be optimized to minimize energy use, energy costs, and GHG emissions, while simultaneously maximizing water efficiency and conservation.

INTERNAL DRIVER/WATER: *Leak Identification and Mitigation*

A primary benefit of technology applied to water delivery is its potential to reduce non-revenue water (NRW), which is water lost through leaks and other unmetered activity. As RPU's water distribution system infrastructure ages, it becomes more prone to leaks. Technology allows system operators to detect leaks sooner and then remotely operate the water distribution system to limit the extent and duration of leaks. Essential to effective leak detection is near real-time widespread monitoring of system pressures and flows. Ideally, every customer meter or service point would be instrumented and connected to a communication system; service points, laterals, and mains would be equipped with remotely operable shut-off valves, pressure control devices, and acoustic leak detection sensors; and all points of supply would be remotely monitored and controlled all to provide the ability to monitor and optimize the operation of the distribution system.

A traditional water metering system requires meter readers to physically visit each meter to record water usage. Because this activity is time-intensive, meters are often read only monthly or bi-monthly, increasing the potential for leaks to go unnoticed for significant time periods, wasting water and driving up customer bills. Advanced technologies are available to provide increased accuracy in measuring and monitoring water usage, including advanced metering systems that can provide remote meter readings multiple times per day making the identification of leaks via abnormalities such as 24-hour usage or spikes in withdrawals much quicker and more accurate. Utilities have expressed interest in reading all of the meters in a pumping district or pressure zone simultaneously at the beginning and end of a time period (say, one day), and comparing this to the water delivered to that district to help pinpoint non-revenue water.

The amount of NRW in a system can be significant, with some estimates as high as 30% of system water pumped but not paid for. Distribution-management systems are available to water utilities that can measure water flows and water pressure over time to detect abnormalities that may signal a leak within the system. Leak-mitigation systems with advanced sensors and metering technology automatically shut off water if leaks are detected, and can send texts, emails, and other automated notifications to water managers.

INTERNAL DRIVER/WATER: *Advanced Metering and Real-Time Information*

An essential technology for maximizing urban water use efficiency is advanced metering that more accurately monitors and measures urban water usage. While there are a variety of different service providers and system setups, AMI generally consists of a system of "smart" meters capable of sending and receiving usage and other data to a centralized meter management software platform. Water managers are benefiting from advanced metering technology that provides real-time or near-real-time information about their water infrastructure systems. This data helps managers optimize their systems and improve leak detection and repair, and it highlights large water users within their system for conservation efforts. Benefits from water AMI include the following:

- Providing highly accurate data collection, which decreases the possibility of incorrect meter readings.
- Allowing staff to provide customers with timely information on water usage and cost.
- Identifying water leaks in a timely manner, reducing wasted water and helping to prevent water bill increases due to leaks.
- Reading meters multiple times a day, instead of once every other month
- Allowing customer service representatives to initiate new accounts, close existing accounts, and address billing questions far more quickly and efficiently.
- Transmitting information from water meters using low-power radio signals without staff having to open meter boxes or step onto a customer's property.
- Providing an online portal that will assist customers in managing and monitoring their water consumption once the entire system is up and running.

> **An essential technology for maximizing urban water use efficiency is advanced metering that more accurately monitors and measures urban water usage.**

The city of San Francisco is the first large municipality in California to implement AMI throughout its distribution network, installing the Aclara STAR network starting in 2010. When fully deployed to the approximately 170,000 municipal meters, the city will receive readings four times per day, allowing SFPUC to better monitor systemwide usage, and to make the data available online to its customers. In southern California, the Cities of San Diego, Burbank, and Glendale have or are deploying water AMI systems. Most water utilities in southern California are using and earlier generation of advanced metering termed automatic meter reading (AMR). While AMR systems have reduced meter reading costs, improved meter accuracy and provided more useful consumption data, the technology is becoming obsolete in favor of the more capable and beneficial AMI systems.

INTERNAL DRIVER/WATER: *Information Sharing Influences Customer Behavior*

Water is one of the largest electricity uses in California, accounting for approximately 19% of total electricity use and about 33% of the non-power plant natural gas use in the state. The CEC and the California Public Utilities Commission (CPUC) have both concluded that energy used for water presents large untapped opportunities for cost-effective energy-efficiency improvements and greenhouse gas (GHG) emissions reductions. The CEC commented that: "The Energy Commission, the Department of Water Resources, the CPUC, local water agencies, and other stakeholders should explore and pursue cost-effective water-efficiency opportunities that would save energy and decrease the energy intensity in the water sector." This aligns well with the objectives of the state's Water Plan. To understand innovation opportunities in science, technology, and management of the water/energy nexus, both sides of the equation must be considered: energy inputs to the water systems, and water inputs to the energy system.

There is an innovation in "behavioral change," as many water utilities are beginning to offer ratepayers increasing access to information about their individual water use and how it relates to their neighbors and average utility users.

There is an innovation in "behavioral change," as many water utilities are beginning to offer ratepayers increasing access to information about their individual water use and how it relates to their neighbors and average utility users. The simple sharing of information has led to increased conservation efforts, and utilities have developed comparison contests to recognize large water-conservation improvements within the ratepayer base.

As water use becomes increasingly restricted it becomes increasingly valuable to have more knowledge of customer water use in near real time. In tiered pricing programs, customer meters can be read frequently and customers notified of their usage to allow them to avoid consuming higher cost water resulting in high water bills.

The enforcement of water use restrictions becomes more effective as well. Rather than depending on monthly meter reads, observations from enforcement patrols or tips from the public, utilities can automatically detect water use outside of approved schedules allowing them to take action to stop unauthorized use much sooner.

INTERNAL DRIVER/WATER: *Pricing Flexibility*

While residential use accounts for the largest percentage of urban water use, for commercial and industrial customers, the top few water users often account for the vast majority of the remaining water use. The time-specific meter readings offered by AMI can help utilities design time-of-use structures for these large users to incentivize water withdrawals when water supply is most robust, reducing stress on the infrastructure. The increased information provided by AMI can have additional benefits for all customers, and more accurate metering can promote piloting and/or adoption of innovative system-wide pricing strategies.

INTERNAL DRIVER/WATER: *Backflow Detection*

An AMI system can provide information about backflow at the meter. Backflow might be due to a pressure drop in the distribution system (e.g., from a main break or heavy use of a fire hydrant) or an increase in pressure on the customer side. For instance, the customer might have a secondary source of water such as a well. The result is water in the customer service plumbing flows back into the public water system, a concern for water system security.

Another potential source of reverse flow is tampering with the meter by turning the meter backwards. This is of concern, since with AMI physical inspection of the meter would be infrequent.

Advanced metering systems have the ability to detect backflow to varying degrees of precision, using some combination of the water meter, the transmitter and software tools. A simple AMR system can detect when a meter read is lower than a prior reading, which might represent backflow or tampering. The more frequently the meter is read, the greater the ability of the system to detect small backflow events (for example, a backflow of several gallons, which is likely to be "erased" by subsequent consumption). The resolution of the data coming from the meter and the frequency at which this data is collected are also important.

Some meters can provide backflow information with high sensitivity, and multiple levels (low or high) of alert. Backflow flags can be set and stored. Some AMI systems can provide an almost immediate alarm to the utility or designated recipient, allowing the user to know about when the event occurred and for how long before it stopped.

Backflow monitoring may indicate a compromise in the integrity of the system, which might require disinfection and boil water orders. In light of security concerns for water systems, the ability to detect an event where large and extended flows of unknown quality are obvious. Backflow detection could be a big help in monitoring for tampering and theft of service.

INTERNAL DRIVER/WATER: *Remote-Controlled Service Line Valves*

Several firms have introduced or are developing service line shut-off valves controlled through the AMI system. This innovative technology has significant potential for isolating customers during main repair or replacement, emergency shutoffs in lieu of accessing other valves in the customer's premises, seasonal customers, sub-metering situations (e.g., apartment units), customer turnover and vacancies, and delinquency enforcement.

In the case of property sale or seasonal use, some utilities require taking a meter reading and shutting off the service. Ideally, an AMI system could do both from the office. Shut-off valves are especially attractive to utility enforcement staff, reducing employee risk, and providing quicker response to delinquency situations and restoration when the customer pays. Some valves feature a partial flow setting, to allow a minimum amount of water for essential purposes only.

Shut-off valves present many considerations, including installation cost, since they may have to be cut in to the service line. They might also be subject to tampering or replacement with straight pipe. Lack of inspection for open valves or faulty plumbing in the customer's premises might create liability for the water utility. Installation on the customer's plumbing inside might require regulatory or ordinance changes, although utilities sometimes own the valves on either side of the meter. The valve must be connected securely to the AMI transmitter/receiver, unless it has its own internal transmitter/receiver.

> **The most advanced utilities rely on their GIS systems as the 'single-point-of-truth' for all asset information, including location, condition, physical, electrical and hydraulic characteristics, inspection history, and more.**

INDUSTRY TRENDS

In 2005 RPU participated in the California Energy Commission research project, "Defining the Pathway to California's 2020 Smart Grid for Publicly Owned Utilities." In that effort, 13 of California's consumer-owned utilities examined the current and future states of their use of information and operational technologies using the Smart Grid Maturity Model (SGMM). In this analysis, RPU, as compared to other utilities, is not on the leading edge of technology implementation and innovation.

Understanding the construct of the model, how the comparisons were made, and interpreting the results explains that, while not an innovator, RPU is not alone in its approach to learning from the industry before making investments in new technologies. The construct of the SGMM includes eight operating domains and six maturity levels, as outlined in **Figure 23**.

Figure 23: Smart Grid Maturity Model

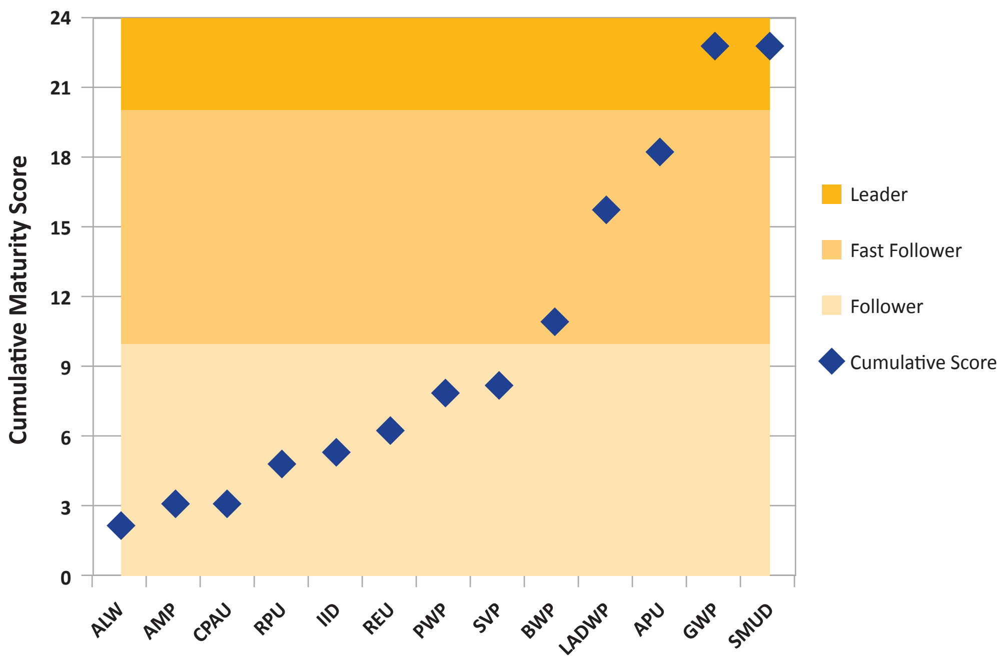
Operating Domains	Maturity Levels
• Strategy, Management, and Regulatory (SMR) • Organization and Structure (OS) • Grid Operations (GO) • Work and Asset Management (WAM) • Technology (TECH) • Customer (CUST) • Value Chain Integration (VCI) • Societal and Environmental (SE)	• 0 - Default: Default level for the model. • 1 - Initiating: Organization is taking the first implementation steps within a domain. • 2 - Enabling: Organization is implementing features within a domain that will enable it to achieve and sustain grid modernization. • 3 - Integrating: Organization's Smart Grid deployment within a given domain is being integrated across the organization. • 4 - Optimizing: Organization's Smart Grid implementation within a given domain is being tuned and used to further increase organizational performance. • 5 - Pioneering: Organization is breaking new ground and advancing the state of practice within a domain.

To determine maturity levels for each domain, utilities participated in a survey of more than 100 expected characteristics. Each utility evaluated its maturity level for their current situation (2005) and for their expected situation in 2020. A key result of the analysis was the classification of utility maturity levels into three categories:

- **Leaders:** Utilities exhibiting the highest current and future maturity levels.
- **Fast Followers:** Utilities that were somewhat less mature than the leaders.
- **Followers:** Utilities that were clearly behind the Leaders and Fast Followers.

Based on RPU's current and future maturity levels, RPU is identified as a "Follower" (**Figure 24**). In examining the results for RPU and the other utilities, it was apparent that this classification reflected RPU's technology strategy, which, like most consumer-owned utilities in the nation, is designed intentionally to follow trends in the industry at a pace that minimizes the risk of obsolescence and stranded investment. Instead, Riverside looks for the appropriate balance between cost, risk, and customer value in determining when and how to invest in technology.

Figure 24: RPU is a Technology Follower



LEGEND:

Azusa Light and Water; Alameda Municipal Power; City of Palo Alto Utilities; Riverside Public Utilities; Imperial Irrigation District; Redding Electric Utility; Pasadena Water and Power; Silicon Valley Power; Burbank Water and Power; Los Angeles Department of Water and Power; Anaheim Public Utilities; Glendale Water and Power; Sacramento Municipal Utility District

In 2005, RPU was facing difficult decisions about advanced metering, distribution automation, customer information, and billing and other technology issues. RPU elected the proven approach to automatic meter reading, began planning the replacement of its CIS, and began significant substation modernization and transmission interconnection projects – a reflection of its priorities on reliability, safety, and cost control.

A key strategy in this roadmap is to not deviate from what has apparently worked well in the past. RPU will continue to invest in technology, but only after its value is understood and its uncertainties mitigated. The challenge RPU faces today is not falling so far behind the industry that the cost of catching up exceeds the value to the customer. Accordingly, it is important to consider the utility industry technology trends that contribute to RPU's technology strategy.

INDUSTRY TREND: *Technology is infrastructure.*

In most utilities, technology has become a pervasive component of the work environment. From desktop and notebook computers, to engineering and planning models, to work and asset management, to energy management systems, to SCADA, to electronic protection and control systems, to the smart phone in practically every employee's pocket—technology is everywhere and indispensable. Because it touches every part of the organization and is necessary to operate and manage water and electricity supply systems, technology has become every bit as important as the infrastructure utilities are required to operate and maintain. Technology has become infrastructure, and utilities need to address the planning, operations, and maintenance of technology with the same level of attention as any other infrastructure element.

Throughout the industry, utilities are changing the way they plan, operate, and maintain their technology systems. These changes range from how technology is planned (e.g., this roadmap), to how technology is managed. RPU should develop its own Operations Technology Management division to support the technology needs of Power Delivery, Water Delivery, Finance, Customer Service, and Resources. Working closely with the City's IT department, RPU's OT department would focus on the real-time and information-based technologies essential to the operations of the water and electric delivery systems, providing the primary support for technologies including AMI, OMS, AMS, WMS, ADMS, SCADA, and NCS. The real-time operational nature of these core systems requires specific expertise and capabilities that rarely exist outside the utility environment and are often seen as being beyond the realm of the City IT department. This is because City IT has their own challenges managing all of the other IT infrastructure required for desktop applications and support, enterprise resource management, public safety, public works, and other functions.

INDUSTRY TREND: *GIS is a primary utility business tool.*

Second to the essential role that customer information systems provide, geographic information systems are a foundational resource needed to operate water and electric distribution systems. GIS is a necessary tool for tracking assets, tracking asset locations in the real-world so they can be safely located by workers, maintaining essential operating information, and a myriad of other uses. Knowing exactly where electric and water infrastructure is located and identifying physical characteristics is the simplest role of GIS.

Electric and water utilities are by nature linear-asset intensive and highly dependent on tracking and maintain the location of assets. GIS has become the most important tool for utilities to manage the geospatial information related to infrastructure. While GIS has not completely replaced the need for physical maps and drawings, the trend is indisputably in that direction.

The trend in the utility industry is for GIS to become the central tool for physical operations. Some utilities use GIS as the operating interface to SCADA, AMS, system modeling and state estimation, AVL, equipment tracking, OMS, EMS, and more.

Very advanced utilities have practically accomplished that objective using vehicle mounted, GPS-enabled computer displays and handheld devices to provide real-time situational awareness to utility operating personnel. The most advanced utilities rely on their GIS systems as the 'single-point-of-truth' for all asset information, including location, condition, physical, electrical and hydraulic characteristics, inspection history, and more. From the location of electric and water meters, to pipelines and power lines, to substations and pumping stations, every asset 'lives' in the GIS system.

The remote sensing of water and electric service quality allows utilities to optimize their delivery systems, increasing efficiency and reducing delivery costs.

Reinforcing the central role GIS plays in utility operations is the increasing level of integration to other core technology platforms, including customer information and billing, SCADA, WMS, and AMS. Each of these other platforms perform best when there exists high levels of integration.

RPU's GIS system has been an essential part of operations for over 20 years. Now at the end of its useful life, the next generation of GIS will be highly integrated with advanced features keeping it at the top of the list of critical operational technology.

RPU was once a leader in GIS with the early development of its CADME GIS system. Over time, for a variety of reasons explained later, RPU is now facing a significant and very challenging GIS upgrade. Getting through that upgrade quickly and focusing on integration with other core platforms is an important aspect of this roadmap.

INDUSTRY TREND: *Legacy CIS and billing systems are roadblocks to service expansion.*

Most, if not all, utilities struggle with the vision of providing expanded services and more options to their customers and the reality of the limitations of their information systems to allow those new services and options to be delivered. In the municipal environment, the problem is exacerbated by the need to deliver other services, like solid waste collection, waste water collection and treatment, storm water collection, and in some cases natural gas, and telecommunications services. It is very difficult to implement and manage a customer information and billing system that can track, bill, collect, and manage accounts for all of these services, especially on one bill. So when the state energy policy mandates that utilities allow customers to install their own generation and sell the excess back to the Utility, these legacy CIS systems are not up to the task.

RPU has already faced these challenges and is currently replacing its CIS. The new system will include a new meter data management system, a new service order management system, a customer web portal, and other features. The project is now nearly complete, but significant work remains to integrate with other essential systems such as City 311, GIS, and WMS; and implement the CWP, new cashiering system, and service order systems, which is considered Phase 2 of the CIS project. This integration and implementation work is captured in the strategic roadmap.

INDUSTRY TREND: *Advanced metering transforms utility business models.*

Advanced metering has become a keystone of utility operational technologies. With the ability to collect highly granular information about water and electric consumption, utilities and their partners are transforming the way customers use information to change their behavior. By showing customers exactly how and when they use water and electricity, they become empowered to make changes that save money and help the environment.

The remote sensing of water and electric service quality allows utilities to optimize their delivery systems, increasing efficiency and reducing delivery costs. By providing the ability to remotely connect and disconnect service, utilities are able to be more responsive to customer requests for service, while reducing the added costs of uncollectable accounts and the service order labor costs associated with turning services on and off. With these new metering technologies, utilities are able to offer more services, such as pre-pay for service; more rate options, including real-time and dynamic pricing; and increase the reliability, security, and safety of the system through tamper and theft detection, voltage/pressure sensing, and outage detection.

Most Californians receive electricity, natural gas, and water service through an advanced meter as the state's three investor-owned utilities and largest consumer-owned utilities have or are implementing these new metering technologies. The trend is worldwide and nationwide, especially for larger utilities where the scale of metering is greater than at RPU. However, the value to the customer and the Utility provided by advanced metering is well understood and is a compelling driver for RPU to implement advanced water and electric metering.

RPU's current advanced metering implementation is somewhat contrary to the trend in the industry. In the utility industry, many perceive Mobile AMR to be an inferior choice compared to AMI in anticipation of the future value of opportunities offered by AMI and its ability to reap customer service and operational efficiency benefits.

Of RPU's 105,000 electric customers, approximately 83,000 are metered with a digital meter that can be read remotely from a vehicle or hand-held device. With further modification the meters could be read from a wireless network. However, the meters being installed use one-way communicating technology that is more than 20 years old. In fact, many utilities are replacing similar systems because of the limitations in the capability. For water, RPU is replacing water meters, but has not yet started the installation of the technology needed to read the water meter remotely.

This roadmap provides an advanced metering solution that provides advanced water and electric metering where it provides the best value to customers while using as much of the existing AMR system technology as is reasonable. A system-wide wireless communications network will allow remote reading and communication with all type of meters in-use and planned to be used.

The roadmap outlines a preferred plan for advanced metering to replace about 2,000 AMR meters with new AMI meters to provide system-wide sensing for outage management and voltage optimization. The plan further outlines installing about 10,000 new AMI meters with remote disconnect capability where having that remote disconnect capability provides attractive operating benefits for implementation of advanced metering in the distribution system.

This AMI-hybrid preferred plan is a compromise, driven by the need to maximize the value of the recent AMR investments and the cost of installing the new AMI and NCS technology that ultimately will provide the greatest benefit to RPU and its customers.

INDUSTRY TREND: *Work management and mobile computing are central to an effective workforce.*

Electric and water utilities are extremely complex businesses that are asset- and labor-intensive. Finding the right balance between providing reliable service and doing so at an affordable price depends heavily on the amount of work put into operations. Utilities must look to a wide range of solutions for managing the cost of operations, especially labor costs. One of the most important strategies is centered on work management—the process of planning and forecasting work, doing the work, and then finding ways to do the work better. A WMS is used in almost every utility for this purpose. All work is created and managed within the WMS. An advanced WMS is highly integrated with GIS, AMS, WIS, and other systems to enable the exchange of all information needed to get work done in the least amount of time, at the least cost, but without compromise for safety or quality.

Many, if not most, utilities have implemented some form of mobile computing for their workforce. In these utilities, service vehicles and equipment are outfitted with some form of computer terminal that provides access to essential operating information; including the work and service orders to be completed, inventory information about the location and availability of the materials and equipment needed to do the work, the order in which the work needs to be completed, where the work is located, and so on. In this operating environment, the mobile workforce has all the information they need wherever and whenever they need it. This workforce does not have to start its day in an office lining up the work, materials, and equipment needed—all the information they need is right where they are doing the work.

RPU has a WMS that was installed more than 10 years ago, but due to insufficient support and maintenance, it is used for only a fraction of its capabilities. Data is incomplete, work processes and workflows are not modeled correctly, and integration with other systems is incomplete. RPU currently has no mobile computing environment or mobile work management capability. Looking forward, this roadmap envisions a future where workers have real-time access to all the information they need for their work, wherever they are located and whenever they need it.

Many, if not most, utilities have implemented some form of mobile computing for their workforce.

INDUSTRY TREND: *Asset management is needed to address aging infrastructure.*

Asset management is another significant challenge utilities are addressing through technology and is often the area that requires the most attention. An AMS is used by utilities to track and manage the lifecycle of infrastructure assets. The systems are very mature for power plants, water treatment facilities, and substations, but less mature for water and electric distributions systems.

Utilities are turning their attention to asset management as a way to improve system reliability and reduce operating costs. Sophisticated asset management applications can forecast future maintenance costs and use real-time asset condition monitoring to determine maintenance requirements. Real-time monitoring of power transformer dissolved gases is an example of this advanced asset management.

RPU has an AMS for its water and electric delivery systems, but it is not fully implemented and the data has not been adequately maintained. Instead, standalone spreadsheets and custom applications are being used for managing some assets. Lack of planning and inadequate staffing are contributing factors to the current state of asset management.

INDUSTRY TREND: *Distribution automation enables distributed generation and electric transportation.*

Faced with the need to integrate distributed generation into electric distribution systems, utilities are turning to distribution automation to provide enhanced sensing and control to ensure that increasing levels of distributed generation can be safely integrated into a system that was never intended for that purpose. RPU's distribution system was designed with idea that electricity would flow from the substation to the customer premise and it is protected and controlled for that purpose.

With generation sources, electric vehicle batteries, and battery energy storage connected to the distribution system; there is the potential for unsafe working and operating conditions to occur, including unexpected voltage sources during an outage, voltage regulation problems due to over-generation, and power quality issues resulting from inverter induced harmonics.

Solving these challenges requires new types of meters, protective devices, and increasing sensing and measurement of operating conditions. Distribution automation and advanced metering are two technologies that provide the additional situational awareness needed to ensure safe and reliable operations.

Distribution automation and advanced metering are two technologies that provide the additional situational awareness needed to ensure safe and reliable operation of a two-way grid.

STRATEGIC TECHNOLOGY ISSUES

Analysis of the impact of external and internal technology drivers and industry trends on the current state of technology implementation at RPU revealed several strategic technology issues requiring focus in RPU's strategic technology vision and roadmap (**Figure 25**).

Figure 25: Strategic Technology Issues

The strategic technology vision and roadmap focused on these technology issues:

- Technology in the utility environment is becoming infrastructure and should be planned, developed and maintained with the same level of priority as energy and water delivery infrastructure.
- The water and electric utility industries are becoming increasingly dependent on technology to manage change, meet customer expectations, improve operations, address workforce challenges and manage aging infrastructure.
- As a second-mover, RPU must see where customer value is developing in other utilities and follow-suit before it becomes too difficult to catch-up.
- RPU's investments in technology must balance customer value, operational necessity, and capability.
- Prior experience has proven that executive support, careful planning and fully supported implementation and maintenance are all required to achieve the expected outcome of a technology implementation.
- Engaging customers to consume energy and water differently requires extensive effort and non-traditional information including more detail, in-near time with compelling presentation and analytics all of which require new technologies.
- Achieving higher levels of operational efficiency, reliability, security and safety requires widely distributed sensing, control and communications technology.
- Integrating higher levels of distributed, intermittent resources; energy storage; electric vehicle charging requires two-way grid technology.
- Meeting new customer-service expectations, requires full-time access to information from a wide variety of devices in real-time. Responding to customer speed-of-service expectations requires advanced metering, remote connect/disconnect and Internet-based transacting.

STRATEGIC TECHNOLOGY ISSUE: *Planning for technology as infrastructure.*

Technology is no longer just a tool used to operate RPU's utilities. With hundreds of computers, applications, servers, networks, routers, sensors, and miles of fiber optic cables and a myriad of other devices, technology has become infrastructure. It is infrastructure that must be planned, implemented, operated, and maintained much like the water and electric distribution systems. It is the primary mechanism by which RPU manages the delivery of its services and collects revenue from its customers. It is integrated in every facet of the operation and the utilities cannot be operated without the technologies that RPU uses.

In the current situation at RPU, technology is not yet seen as infrastructure, but that is changing as is evident by this strategic roadmap. The most important strategy that RPU needs to implement is to develop a management and organization structure to maintain this infrastructure component just as it does for power and water delivery and water and power resources. Many of the technology implementation challenges that RPU is currently dealing with can be attributed to the lack of technology leadership and management; the lack of staffing and resources to manage technology investments; and the resulting view that technology is a tool rather than a critical infrastructure component.

STRATEGIC TECHNOLOGY ISSUE: *Increased dependence on technology.*

The dependence on technology in the electric and water utility industry is readily apparent, as all core utility functions are already or soon will be technology-based. Interaction with customers and meter-to-cash process is already highly dependent on the CIS. It will become more technology dependent as the metering element becomes more automated and customers become increasingly dependent on the Internet and the myriad of phones, tablets, and computers that they use for practically every other service they require.

Providing field forces with the ability to access and use the information they need to operate and maintain the water and electric distribution systems from wherever and whenever they need it is an obvious operating advantage, but requires significant investment to implement. GIS, EMS, SCADA, and other core functions, while mature, are evolving in their capability and usefulness at an amazing pace.

Providing field forces with the ability to access and use the information they need to operate and maintain the water and electric distribution systems from wherever and whenever they need it is an obvious operating advantage, but requires significant investment to implement.

While RPU's dependency on technology for fulfilling its mission of safe, reliable, and low-cost electricity and water is constantly increasing, its investments have been somewhat behind the rest of the industry and its allocation of resources to extract the value from existing technology investments has been inadequate. Faced with an increasing dependency on technology and driven by the need to capture the value that technology provides, RPU needs to make significant changes to its business processes and technology management approach to be successful.

STRATEGIC TECHNOLOGY ISSUE: *Catching up with industry trends.*

As previously discussed, RPU is not a leader or innovator in the application of technology in the water and electric utility space. While there is great advantage to following the lessons learned from technology failures and the growing pains that first-movers endure, there is also a disadvantage to getting left too far behind.

Riverside is practically surrounded by electric and water utilities that are more advanced in their use of technologies to enhance customer value. These differentiators could become competitive advantages for the other utilities when attracting new businesses, jobs, and economic development to their communities.

STRATEGIC TECHNOLOGY ISSUE: *Balancing cost and customer value.*

Technology investment comes at a cost—sometimes a very high cost—both in terms of the capital and operating costs, but just as importantly, in terms of the disruption it can cause if change is not managed properly. Looking at the opportunities RPU is facing, it must develop a business case approach to prioritizing its investments and efforts. It is impractical to take on all the technologies that would be of value to its customers and its operations at one time. Focusing on providing value to its customers, meeting customer expectations, and addressing the operational mandates of safety and reliability will ensure that it invests its limited resources in the right technologies at the right time.

STRATEGIC TECHNOLOGY ISSUE: *Engaging customers with technology.*

Informing and educating customers about the costs and environmental impacts of water and electric utilities is an increasingly important objective for utilities. For RPU, current efforts include newsletters, the RPU website, bill stuffers, workshops, and other traditional communication channels. The industry trend is toward providing more detailed information to customers, more frequently, and through the communication channels that individual customers most prefer.

Advanced metering systems allow for collection of consumption information every few minutes, which is presented to the customer not more than a day later.

Advanced metering systems allow for collection of consumption information every few minutes, which is presented to the customer not more than a day later. This detailed information, properly presented, can help customers relate consumption to specific activities like the amount of electricity they use to cool their home and the amount of water they consume in watering their lawns. Technology-enabled analysis of detailed data can also reveal water leaks, energy and water diversion, and delivery system inefficiencies.

For this engagement strategy to work, RPU must rethink its approach to customer engagement and prepare itself for managing the unavoidable technology and social challenges. While most customers have and use smart phones, RPU is not yet ready to engage in operational communications with its customers via these channels and in the multitude of languages that its customers speak. RPU must also ramp up its social media presence to best reach that subset of its customers that prefer that particular channel for learning, informing, and communicating.

STRATEGIC TECHNOLOGY ISSUE: *Improving operational efficiency.*

Technology has significant positive and negative implications for operational efficiency, the amount of time and effort RPU exerts in completing its work. Properly implemented, technology can reduce the time and effort to serve customers. Advanced metering and meter data management allows meters to be read remotely, on demand, and services to be started and stopped in an instant rather than dispatching meter readers and services personnel. Advanced distribution sensing and control along with outage management can reduce the time and effort for operating personnel to locate the cause of outages and restore service to customers. Work and asset management systems can reduce the time and effort needed to plan, manage, and execute nearly every business process in the Utility. The list of beneficial attributes of well executed technology investments is more extensive than these few examples.

On the other hand, improperly implemented, these same technology investments can actually have the completely opposite effect—increasing the time and effort to execute the work of the Utility. This can happen when insufficient financial and human resources are allocated to support technology throughout its lifecycle, especially the operational phase during which integration with other systems, revision updates, data maintenance and business process redesign are all necessary. It is imperative that as RPU's technologies becomes increasingly inseparable from its operating infrastructure, proper governance, support, and maintenance of technology-based solutions must become core business functions within the Utility.

RPU STRATEGIC TECHNOLOGY VISION

RPU identified a strategic technology vision and a set of business objectives that prioritized its technology implementations. The technology vision is consistent with the enterprise vision (**Figure 26**) and state and federal energy policies.

Figure 26: Enterprise Vision and Strategic Technology Vision Statements

ENTERPRISE VISION
Our customers will recognize Riverside Public Utilities as a unique community asset with a global reputation for **innovation**, **sustainability**, and an enhanced **quality of life**.

RPU STRATEGIC TECHNOLOGY VISION
Integration of advanced technology, people, and processes will improve utility operational efficiency, reliability, and customer satisfaction. Advanced technology will enable RPU to deliver a customer experience that enhances quality of life and promotes economic development.

Enterprise Vision

Management and staff conducted rigorous needs assessment, vision development, and gap analysis exercises, culminating in an enterprise vision to provide a future destination for RPU's strategic technology roadmap.

Technology can help RPU meet each element of the enterprise vision in the following ways:

- Technology is at the core of innovation and can energize employees, customers, and the community.
- Technology is an essential instrument for enabling economic, social, and environmental sustainability.
- Technology can enhance the quality of life by improving the resiliency and reliability of electric and water delivery.

RPU Strategic Technology Vision

At the core of the strategic technology vision is the fundamental philosophy that technology can improve the way RPU conducts its business but will be implemented based on a balance of business needs, operational needs, and customer value. Technology can help RPU meet each element of the strategic technology vision in the following ways:

- Integration of advanced technology, people, and processes will improve utility operational efficiency, reliability, and customer satisfaction.
- Advanced technology will enable RPU to deliver a customer experience that enhances quality of life and promotes economic development.

STRATEGIC BUSINESS OBJECTIVES

RPU identified the five primary strategic business objectives described on the following pages. Properly implemented operational technologies can help RPU achieve each objective.

1. **Customer Service:** *Enhance the customer service experience and boost customer satisfaction.*
2. **Reliability:** *Improve reliability, safety, and resiliency.*
3. **Operational Efficiency:** *Increase operational efficiency.*
4. **Community Service:** *Increase community service and enhance the quality of life for RPU customers.*
5. **Economic Development:** *Promote economic development in RPU's service area.*

Customer Service: *Enhance the customer service experience and boost customer satisfaction.*

The customer experience is influenced by their ability to interact with other service providers, such as cable TV, Internet, banking, and appliance repair—all industries with a high level of technology-based customer engagement. Customers increasingly assimilate technology as part of their lives—whether it is social media, online shopping and banking, reading a book, or paying bills—and they expect their utility service providers to offer similar customer interaction and engagement. Customers with access to timely and accurate energy and water usage data are empowered to use these resources according to their own needs and priorities, including managing their budget, reducing GHG emissions, and improving their comfort level.

CURRENT STATE

- Customers can manage most services from the web, telephone and in person.
- New customer information and billing system is being implemented.
- Customers cannot access detailed water and energy consumption information; limited to monthly aggregate data at least 45 days after consumption.
- Social media is used in a limited manner with Facebook and Twitter.
- Proactive notification is limited to public appeal via radio and television, door hangers and bill stuffers.

DESIRED FUTURE STATE

- Customers can manage all of their services from any place at any time
- Customers have complete access to energy and water consumption data anyplace, anytime.
- Customers receive information from and communicate with utility via social media.
- Utility offers a wide variety of rates and service options to match customer needs including pre-pay.
- Utility proactively informs customers about severe weather, and planned and unplanned outages using a wide range of communications media.

PEOPLE, PROCESS, AND TECHNOLOGY GAPS

- Electric AMR system cannot collect detailed electric consumption information.
- Customer web portal is limited to payment transactions.
- CIS is not integrated with GIS.
- RPU does not have outage management system.
- RPU does not have IVR or reverse 911.

Current State

RPU is currently implementing a new advanced customer information and billing system. The new system will allow for more complex rate design; provide for multiple payment methods through a third party; and provide a web-portal for customer interaction. RPU is considering, but has not yet developed a strategy for engaging customers through social media. RPU currently does not provide a customer web-portal through which customers can review their detailed energy and water consumption.

The new CIS integrations with other existing and proposed systems will allow accurate representation of customer connections with the Utility to improve outage management; map the relationship between customers and the delivery systems; notify customers of system activities, automate the exchange of customer billing and accounting with the financial system, and provide accurate information about customers when they contact RPU through the IVR.

RPU is currently deploying an automatic meter reading system (Itron OpenWay) for its electric meters that will reduce meter reading expenses. The current system does not support two-way functionality such as remote connect/disconnect, cannot be reprogrammed remotely, does not have a HAN interface, does not report interval data, does not provide 'last-gasp' reporting for outage management, and does not provide remote sensing of voltage, currents, power factor. RPU has not deployed meter data management. The smart metering initiative will expand existing water and electric automatic meter reading (AMR) and initiate an advanced metering infrastructure (AMI) and MDMS.

Desired Future State

RPU can enhance the customer service experience and increase customer satisfaction with technologies that allow customers to interact with the Utility 24x7 by telephone, computer, or smart device. This will reduce the time it takes for the Utility to respond to customer needs and requests, engage customers through social media, and provide customers with detailed information about their energy and water usage. These technologies will empower customers to make choices that sustain and improve their quality of life, address the customer's desire for 24x7 interaction, near real-time delivery of accurate information about outages, and detailed information about how and when they consume water and electricity; and will allow them to review and pay bills using technology-based methods.

RPU's electric and water meter-to-cash process, as currently envisioned, will have limited impact on the customer experience.

People, Process, and Technology Gaps

RPU's electric and water meter-to-cash process, as currently envisioned, will have limited impact on the customer experience. The AMR-based systems will not readily provide detailed interval data necessary for informing customers about how to change their consumption behavior. Without remote disconnect capabilities, RPU cannot be as responsive to customer request for service restoration. Without voltage sensing, RPU cannot implement a robust outage management system to better inform customers about outages.

Reliability: *Improve reliability, safety, and resiliency.*

Reliability, safety, and resiliency are an essential triad for operating water and electric utilities. Customers' increasing dependence on and use of technology at home and work necessitate ever increasing levels of operational reliability. The use of the electric distribution system as a collection system for distributed generating resources adds a dangerous new element to system operations that requires advanced sensing and control to protect workers. The ability to recover from severe storms, earthquakes, and other disasters requires a level of resiliency that cannot be achieved without the technologies that provide remote sensing and control of water and electric systems.

CURRENT STATE

- Physical security is improving.
- Delivery systems are reliable but seldom tested by distress events.
- The condition of aging infrastructure is an operational concern.
- Cybersecurity is a growing concern. The only RPU system with cybersecurity protocols directly controlled by RPU is SCADA.
- Core systems should be examined for redundancy. For example, the voice communication system lacks redundancy.
- Asset management processes are highly manual, not well defined, and focused primarily on annual inspections.

DESIRED FUTURE STATE

- Water and electric distribution systems are highly reliable and efficient, secure from physical and cyber threats, and resilient to storms, flooding, wildfire, drought, and seismic events.
- Networks, systems, and intelligent devices are secure from physical and cyber threats.
- Sufficient redundancy exists in applications, voice and data communications systems to ensure effective operations during times of distress.
- Asset management is used to monitor the health of assets, as well as forecast and prioritize capital and O&M expenditures.

PEOPLE, PROCESS, AND TECHNOLOGY GAPS

- Need to define future asset management business needs and processes, and fully implement an asset management program.
- Sufficient resources should be allocated to implement, operate, and maintain asset management data and systems.
- Voice and data communications systems should be updated and secured, and redundancy provided.
- Cybersecurity standards and business processes should be adopted, maintained, and administered within RPU.

Current State

Reliability and safety are core values for RPU, and it has achieved award-winning levels of electric service reliability. RPU currently has limited distribution automation, outage management is a completely manual process, and some essential systems, such as land mobile radio, have no redundancy.

Desired Future State

Widely distributed real-time monitoring and control of operating conditions allows system operators increased operating flexibility and capability. Automation of water and electric system operations reduces the frequency, extent, and duration of service outages, improves distribution system efficiency, and increases situational awareness.

Advanced WMS and AMS increase workforce effectiveness, enhances worker and public safety, and reduces operating costs. Asset management systems address many challenges of aging infrastructure. Accurate, geo-referenced asset inventories reduce outage response times, improve effectiveness of inspection programs, improve inventory management, provide for the planning of infrastructure maintenance and replacement, maintain correct accounting, and provide a single version of the truth for asset location, age, and condition.

Using AMS to conduct condition-based maintenance maximizes the effectiveness of maintenance expenditures, reduces outages, and improves the planning and scheduling of maintenance activities. Using asset management systems to estimate and track costs improves the accuracy of project cost estimates, improves management of capital and operating budgets, and helps to control project costs.

WMS addresses many challenges of workforce effectiveness. Using work management systems to create and track operating and capital projects identifies resource constraints, helps prioritize expenditures and improves workforce efficiency. Planning, scheduling, and dispatching workforce through work management systems reduces non-productive labor expenses.

OMS improves system reliability, enhance the customer relationship, and improve safety. Outage management, especially when coupled with distribution automation, reduces outage response time and reduces outage duration.

Accurate outage restoration times provided by OMS increase customer awareness and satisfaction. Combined with automatic vehicle location (AVL) technology, OMS increases situational awareness and improves safety for restoration crews

AMI and MDMS positively transform utility operations. AMI/MDMS provide near-real-time meter (consumption and demand) reads (water and electric) at 15-minute intervals; which allows for high-visibility of consumption behavior, implementation of real-time pricing, detection of theft and diversion, and monitoring of service quality at the customer premise. Equipped with switches, AMI allows dispatchers to disconnect and restore service nearly instantaneously, thereby improving cash flow, reducing operating costs, and improving customer relationships. Equipped with home area network interfaces, AMI provides a platform for customer communication and direct load control.

People, Process, and Technology Gaps

As opportunities and positive business cases arise, RPU should increase distribution automation, implement automation for outage management and implement some essential systems, such as land mobile radio with adequate redundancy in order to increase business continuity in these areas.

Operational Efficiency: *Increase operational efficiency.*

Managing the cost of water and electric distribution system operations is a very high priority for RPU. It is also a challenging balance between maintaining high reliability, operating safely, and enhancing the customer experience, all of which tend to drive operating costs upward. Technology allows RPU to look for new operational savings from streamlining work processes by putting mobile computing to work for field personnel; using an effective work management system to improve its ability to plan, prioritize, and execute work; employing remote disconnect and reconnect for meters instead of rolling out a truck and service person; and using automation to reduce the amount of labor it takes to operate the delivery systems. Technology can also be used to increase the physical efficiency of the delivery systems—using voltage optimization and transformer load management to reduce electrical losses and advanced water system operations to reduce the amount of energy needed to collect, store, and deliver water.

CURRENT STATE

- Work and business processes are based on tradition, are not documented and have not been reviewed for technology-driven improvement.
- Workload forecasting is done at the budgetary level but not in the operational and planning domain.
- Intellectual capital is not formally assessed, maintained or distributed.
- Advanced sensing and delivery system automation is based on SCADA, has limited distribution beyond the substation, and is limited but expanding in the water domain.
- Distribution automation has been deployed at multiple locations beyond the substations.
- Delivery system optimization is a planning consideration but not an operational priority.

DESIRED FUTURE STATE

- Work and business processes are optimized.
- Workload forecasting defines resource needs, identifies constraints and optimizes allocation of resources.
- Intellectual capital is retained in the organization and widely distributed to promote workforce development and retention.
- Advanced sensing and automation reduce level of effort to manage and operate delivery systems.
- Efficiency of water and electric delivery systems are optimized through loss reduction.
- Advanced sensing and automation create a safe work environment.

PEOPLE, PROCESS, AND TECHNOLOGY GAPS

- Defining future business needs, use cases and defining business processes is needed before implementing new core technologies.
- Work management system exists but is partially implemented, out-of-date and lacks sufficient resources to fully implement and manage.
- Widely distributed sensing and automation in both water and electric delivery systems will improve efficiency, reduce operating costs and improve safety.
- IT governance, resource needs and project implementation support is needed before attempting new technology implementations.

Current State

RPU can improve system operations through upgrades to the existing GIS, WMS, and AMS. These technologies address enterprise drivers, such as developing a technology-rich work environment, that attract technology-motivated employees into an industry that historically has not been seen as desirable by many young people.

In addition, integrating information and operational technologies across various divisions through technology (especially GIS, CIS, WMS, AMS, and accounting) improves overall effectiveness, enhances the customer experience, and reduces operating costs. Current state challenges include the following.

- Work and business processes are based on tradition, are not widely and uniformly documented, have not been reviewed for technology-driven improvement, and are not regularly examined and redesigned to address improvements in system integration and implementation of new technologies.
- Operating and capital planning do not include workload forecasts that are based on operating objectives; therefore, budgets tend to be based on what can be done with the resources that exist rather than determining the resources that would be needed to accomplish higher level objectives.
- Some databases and information collections (e.g., asset management, engineering models, and GIS data) are not maintained and information is not readily accessible or distributed to operating personnel when and where they most need it.
- Advanced sensing and delivery system automation is based on SCADA, has limited distribution beyond the substation, and is limited but expanding in the water domain.
- Distribution automation has been deployed at multiple locations beyond the substations and includes:
  - three (3) field reclosers;
  - three (3) overhead gang operated switches;
  - two (2) automatic transfer switches; and
  - one (1) pad-mounted switch.
- Delivery system optimization is a planning consideration, but not an operational priority due to the absence of sensing, control, and communications technologies needed to optimize system operations.

RPU can improve system operations through upgrades to the existing GIS, WMS, and AMS. These technologies address enterprise drivers that attract technology-motivated employees into an industry that historically has not been seen as desirable by young people.

Desired Future State

RPU's future operations will be highly dependent on technology to ensure operational efficiency. Future success will depend on foundational changes that must start now, especially increased attention to the design and implementation of business processes that can benefit from automation. This is particularly important for WMS, AMS, OMS, CIS, and meter-to-cash processes. Future objectives include: work and business processes are optimized to take advantage of data analytics, automation, and integration of key IT and OT systems.

The planning, forecasting, tracking, and completion of all work will be coordinated with an effective WMS that is highly integrated with AMS, WIS, GIS, CIS, and other core systems. Institutional knowledge is embedded and widely distributed in the enterprise with information available to those who need it, whenever and wherever they need it. This knowledge retention and management reduces the time it takes to locate and use knowledge of the delivery system, and ensures that intellectual capital remains with the enterprise as human capital comes and goes.

Widely distributed sensing and controls automation enables water and electric delivery systems to be operated with minimal loss, maximum reliability, and complete safety.

People, Process, and Technology Gaps

In order to achieve the desired future state of operating efficiency, significant gaps to the existing state must be overcome. Future business needs must be mapped out and resources to implement WMS and AMS should be addressed. Advanced and widely distributed sensing and increased automation in both water and electric delivery systems will improve efficiency, reduce operating costs, and improve safety.

Community Service: *Increase community service and enhance the quality of life for RPU customers.*

RPU's role in increasing community service and enhancing the quality of life for its customers includes tangible impacts such as improved air quality and reduced GHG emissions, reliable and affordable water and electricity, and the jobs and revenues that result from economic development. More difficult to quantify but not hard to observe are the impacts RPU can have as a good corporate citizen by supporting community programs, educating the community on the value of public power, and providing a revenue stream to support other services.

Technology can help RPU achieve its expectations in this objective in a number of ways. Technology is needed to allow increased penetration of clean, renewable distributed generation such as solar PV electricity generation. Technology allows for the integration of electric vehicle charging. Technology streamlines work and reduces emissions from operating vehicles and equipment, all of which reduce GHG emissions and improves local air quality.

CURRENT STATE

- Traditional service models are evolving to address customer needs and community objectives.
- The lack of certainty about the impact to the electric delivery system of increased saturation of distributed resources is a limiting factor.
- Current rate and business models are threatened by the revenue erosion resulting from conservation, efficiency and distributed generation.
- Customers receive only monthly information about water and energy consumption.

DESIRED FUTURE STATE

- Customers continue to receive excellent service at competitive rates.
- Integration of distributed renewable resources that contribute to clean air and water.
- Utility services are financially, socially and environmentally sustainable.
- Customers have all the information they need, when and where they need it to empower them to use energy and water wisely.
- The security and resiliency of water and electric delivery systems are essential for ensuring safe and healthy communities.

PEOPLE, PROCESS, AND TECHNOLOGY GAPS

- Current rate structures are not sustainable with increasing distributed generation, sustained drought, and aging infrastructure replacement.
- RPU cannot collect, analyze or distribute detailed energy and water consumption information to its customers.
- RPU lacks the advanced sensing, control and communications systems that would provide additional reliability, safety and resiliency.

Current State

Today, RPU works hard to be a valuable asset to the community. It widely supports community programs, it strives to raise awareness about the value of water and electricity conservation and efficiency, and strives to maintain costs through efficient and effective operations.

Desired Future State

RPU's future role in enhancing community service and quality of life will be centered around its ability to offer innovative and creative services that are cost effective and provide value to customers and the community.

People, Process, and Technology Gaps

Rate structures and business models that become difficult or impossible to sustain from market and regulatory pressures will need to be addressed. Customers will require more detailed information about their energy and water consumption. Issues that may arise from distributed generation, sustained drought and aging infrastructure may facilitate a need to change RPU's current business model and modes of operation.

Economic Development: *Promote economic development in RPU's service area.*

Attracting residents to RPU's service territory usually means taking them from SCE's service territory, and SCE's electric service is much more technology based than RPU's today. Implementing technologies that allow businesses to manage energy and water costs, to use renewable sources of energy, and to innovate the use of water and energy in their processes will attract healthcare, education, research, and high-technology manufacturing employers to the community.

As a consumer-owned utility, RPU is uniquely positioned to provide energy, water, and services that reflect the values and priorities of the community because the strategic direction and key decisions about how to operate and grow the Utility are made by community members.

CURRENT STATE

- RPU provides reliable and cost effective utility services but technology is not a factor
- Electric transportation is an emerging issue but not yet a business driver
- Distributed generation is growing but is customer-owned and behind-the-meter so provides little value to the community as a whole
- Energy and water efficiency programs rely on traditional methods and incentives
- Energy storage concepts are surfacing but not an active element in the community
- Fiber communication services are being explored

DESIRED FUTURE STATE

- Technology, education and healthcare industries choose Riverside for their businesses and jobs because of the reliability, cost and innovation in water and electric service and customer care
- Electric transportation is supported with reliable infrastructure, convenient access and affordable costs
- Distributed renewable resources and energy storage are encouraged and supported

PEOPLE, PROCESS, AND TECHNOLOGY GAPS

- Advanced metering, data analytics and customer communications are needed to have more impact on customer behavior
- Innovative utility services are not an economic development message
- Advanced distribution sensing and control are needed to integrate increasing levels of distributed generation, electric vehicles and energy storage
- Increased fiber optic network capacity is needed to provide fiber communication services

Current State

RPU has played a key role in revitalizing the local economy. The Utility has bolstered Riverside's economic development by stabilizing utility rates through the City Council adopted rate freeze. Originally adopted in 2010, this rate freeze has provided business customers with stable and predictable rates during this economic recovery. The Utility also offers attractive economic development and business retention electric rates to new and existing customers. As a result of the rate freeze and economic development efforts, RPU experienced an expanded customer base and a healthy 3.7% increase in load growth. Utility load growth has also led to a 4% increase in retail sales.

Desired Future State

RPU envisions an increasing role in economic development. In addition to providing cost-effective, reliable, and environmentally friendly water and electricity, RPU could drive economic growth using innovative technologies and creative solutions, including high capacity data communications for businesses, creative rates, and payment choices.

People, Process, and Technology Gaps

Keeping utility costs low helps customers to stretch their budgets, thus providing more money to spend on other products and services in the community. In addition to competitive rates, RPU can help their customers understand how to better use water and electricity to reduce their utility costs. Advanced metering, consumption-data analytics, and enhanced customer communications are needed to better engage customers and have more impact on their consumption behavior.

RPU's existing metering technology is very limited for both water and electric in that its manual collection processes limit the amount of detailed information that can be collected and creates a delay of at least 30 days from when a customer uses water and electricity to when the customer can see how much was used. Further, customers cannot know when during a billing cycle energy and water were used. Overcoming this gap will require new metering technology, new meter to cash business processes, and new staff with the skills to understand how best to analyze and present data to customers.

Providing innovative utility services is not an economic development message. RPU's current economic development message relies on a slight rate advantage over SCE, an increasingly green resource portfolio, and good service reliability, all of which help attract new businesses and create new jobs in the community. RPU could do more to encourage economic growth, especially job growth, by attracting health care, education, and technology companies into the community. These progressive industries are attracted by innovation, creativity, and sustainability.

RPU should use new technology and new business processes to further embrace distributed generation, especially solar PV electricity generation, electric transportation, and advanced communications in addition to its traditional value proposition. Technologies required to accomplish this include advanced water and electric distribution sensing and control, advanced metering, and enhanced data communications networks.

ALIGNMENT OF TECHNOLOGY PRIORITIES WITH RPU BUSINESS OBJECTIVES

Understanding utility industry trends and having a clear set of business objectives frames the overall strategic technology roadmap. Industry trends define the currently available technologies, and RPU's business objectives provide a basis for determining the degree to which each technology can help RPU achieve its vision.

What remains is establishing the priority in which each new technology will be implemented. For the Strategic Technology Plan, priorities were established based on the following factors:

- Technology investments that meet multiple business objectives were given higher priority.
- Technology investments that are already started must be quickly reevaluated, adjusted (if necessary), and successfully completed.
- Technology investments that have a higher risk of obsolescence, higher operational complexity, and value that is difficult to measure were given lower priority.

RPU examined 19 technologies to determine the degree to which each technology meets each of RPU's five primary business objectives, based on the following ratings:

1. **Essential** — The technology is required for meeting the business objective.
2. **Important:** The technology contributes to meeting the business objective.
3. **Related:** *The technology is closely related to another technology that is rated as either "essential" or "important" for meeting the business objective.*

Each of the 19 proposed technology projects achieved a rating of "essential" for at least two of the five business objectives. Of particular interest are the technologies that achieved the most "essential" ratings (see **Figure 27**).

The alignment of RPU's technology objectives and business objectives indicates the importance of investing in operating technologies to support operations.

Figure 27: Alignment of Technology Priorities with RPU Business Objectives

Technology	Business Objective: Customer Service	Business Objective: Reliability	Business Objective: Operational Efficiency	Business Objective: Community Service	Business Objective: Economic Development
Customer-Focused Technologies / IT Realm					
1. Customer Information System (CIS)	●	■	■	■	●
2. Customer Relationship Management (CRM)	●	▲	■	■	●
3. Interactive Voice Response (IVR)	●	●	●	■	●
4. Customer Web Portal (CWP)	●	▲	▲	■	●
Information-Based Technologies / IT Realm					
5. Asset Management System (AMS)	▲	●	●	■	■
6. Work Management System (WMS)	■	●	●	■	■
7. Warehouse Inventory System (WIS)	▲	●	●	▲	■
8. Geographic Information System (GIS)	■	●	●	■	●
9. Mobile Applications (Mobile Apps)	■	●	●	●	●
10. Operational Data Management System (ODMS)	▲	●	●	■	■
Operational Technologies / OT Realm					
11. Network Communications System (NCS)	■	●	●	●	●
12. Land Mobile Radio (LMR)	▲	●	●	●	●
13. Advanced Metering Infrastructure (AMI)	●	●	●	■	●
14. Meter Data Management System (MDMS)	●	●	●	■	■
15. Automatic Vehicle Location (AVL)	■	●	●	■	■
16. Distribution Automation (DA)	■	●	●	●	●
17. Substation Automation (SA)	■	●	●	●	●
18. Outage Management System (OMS)	●	●	●	●	●
19. Supervisory Control and Data Acquisition (SCADA) and Advanced/Distribution Management System (ADMS)	■	●	●	●	●

● Essential ■ Important ▲ Related

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PHASE III TECHNOLOGY OBJECTIVES

To form a current-state baseline, this section evaluates existing applications and current plans for technology implementation. It also establishes objectives for a desired future-state of technology. The future-state objectives are assigned a priority for each technology to reach the desired future state. Priorities are assigned based upon how the technology addresses business objectives from the previous section. In addition to the applications themselves, the narrative provides guidance for people, process and technology and how they are all crucial components for meeting technology objectives.

CUSTOMER-FOCUSED TECHNOLOGIES IN THE IT REALM

Customer-focused technologies allow RPU to interact with its customers to help them manage their accounts, start and stop service, request service, report outages and problems, and understand their energy and water consumption and costs. These technologies (outlined in **Figure 28**) have to allow interaction when, where, and how the customer desires in order meet their service expectations. It is imperative that these technologies work well; and while they must meet RPU's operational needs, meeting the customers' needs is more important.

RPU's current efforts are focused on completing the implementation of its new CIS system, including a customer web portal, customer relationship management interface, and interactive voice response (IVR) interface. This is a near-term destination on the roadmap and is foundational to other strategic initiatives. Integration of other core systems, including GIS, WMS, AMS, and AMI, will be an ongoing initiative as those technologies mature.

Figure 28: Customer-Focused Technologies (IT Realm)

	Current State	Future State
1. Customer Information System (CIS)	Recently completed first phase of CIS replacement project	Highly integrated CIS capable of complex rates and transactions
2. Customer Relationship Management (CRM)	Siebel system (311) pending upgrade. Salesforce.com used as key accounts management tool. Neither system is fully implemented nor integrated with CIS or GIS	CRM across systems. Provides real-time and up-to-date information about all aspects of customer/utility relationship
3. Interactive Voice Response (IVR)	Not in place. City 311 system provides very limited functionality	Highly integrated IVR system enabling account management, customer support, and outage reporting
4. Customer Web Portal (CWP)	RPU website with ability to make account payments on-line through third party	Robust online access enables customers to manage all aspects of their service, obtain energy/water consumption analysis and outage information. Available anywhere, anytime

1. Customer Information System (CIS)

CIS is a core-enabling technology for a large portion of utility businesses and the technology on the frontline for managing customer account information as well as interactions with customers in conjunction with CRM. CIS has the most integrations and data sharing across enterprise applications, which adds to the complexity and criticality to have a successful replacement project for driving additional value from integrations to the CIS. Any system requiring customer-related information needs CIS, and metering and billing are at the center of systems impacted by CIS.

RPU is currently implementing a new advanced customer information and billing system. The new system will allow for more complex rate design, provide for multiple payment methods through a third party, and provide a web-portal for customer interaction. Beyond the scope of the enQuesta CIS implementation project, RPU will have workflow improvement projects, additional system integrations, mobile-enabled processes, and additional customer programs such as prepay that will be required from the Utility enterprise CIS.

The new CIS will improve the customer experience through enhancing and integrating the customer portal, giving more choice and availability for the customer to self-serve; improving both requester and RPU staff satisfaction by creating or enhancing the integration with systems involved in providing service request and payment status; and enhancing customer communications during outages with CIS to OMS integration. Additionally, this technology program will enhance operational efficiency through tighter integration to IFAS and Billing, providing greater, more timely, and more accurate access to accounting and billing records; enabling more integration to CRM, making all customer contacts accessible to CSRs and sharing data with CRM and CIS; and enhancing RPU's ability to better plan for the investments that they will need to make in service and infrastructure areas by using procured or developed tools to analyze data from the CRM, CIS, WMS, and AMS.

CIS is a core-enabling technology for a large portion of utility businesses and the technology on the frontline for managing customer account information, as well as interactions with customers in conjunction with CRM.

2. Customer Relationship Management (CRM)

Oracle Siebel CRM functionality handles marketing campaigns, sales prospecting, and market information tracking, but these functions are not being fully utilized. RPU has also purchased the Salesforce CRM application, which has desired yet overlapping marketing functionality, plus the ability to support rebate processing automation.

Rebate processing automation from Salesforce has not been implemented, so processing is still manual. Lack of standardization and consistency of customer-related information creates concerns between the City-administered and RPU-administered CRMs. Since customer account and address location records are not always consistent across systems integrated with the Oracle Siebel CRM, RPU experiences customer identification and service routing challenges. Feedback on status and resolution of service requests and payments is also a challenge since CRM is not fully integrated with the systems that track the status.

RPU is considering but has not yet developed a strategy for engaging customers through social media for feedback, trend information, and other service functions. Also, since RPU creates and distributes customer surveys manually, timely review and reporting of survey results is a challenge.

The standardization of data must be a priority. With the development of the supporting business processes to maintain the standardization, this standardization will improve customer satisfaction by enhancing the integration with systems involved in providing service request and payment status.

RPU should create KPI metrics using Siebel's social media integration, automated survey processing in both the service and marketing areas, and consolidation of data from CRM, CIS, GIS, AMS, and WMS systems. These metrics will not only gauge performance and social sentiment, but also will foster service improvements.

The rebate tracking and processing functionality can be partially addressed with Salesforce and a customer-facing, front-end rebate application processing system. This will enhance operational efficiency through reducing the time and effort to report on, track, accept, and turn around rebate applications by automating the rebate process.

3. Interactive Voice Response (IVR)

The primary initiative for the IVR technology program is to acquire, implement, and integrate an IVR into the process for service orders, handling customer calls, and interaction with customers in a more automated fashion when system trouble is encountered. The IVR will prevent loss of customer contacts during high-call volumes, and enable customer calls to be turned into useful and actionable data for use within other RPU data systems.

Currently during normal business hours, outage information from customers is manually logged by the customer service center using the CRM system to keep track of calls. The CRM call taker must check the CIS tickets to determine if the customer was disconnected for non-payment. If not, it is entered into the CIS as a service order, which also prints out at the Dispatch center and ultimately SPL if a work order is issued against the service order trouble ticket. Dispatchers monitor the Banner service orders or SPL work tickets. Dispatchers then relay trouble information via radio or telephone to the mobile field staff over the radio or cell phones.

After hours, the dispatch center fields customer trouble calls directly. This process is manual and dispatchers do not have access to the CRM system. Call backs to customers are manual and may or may not be captured by the CRM system.

The benefits of IVR are all related to RPU's goal of improving the customer experience. Customer call data sharing between all RPU systems and better capture of every customer contact made during and after business hours will improve the handling of customer concerns. IVR will also eliminate customer call wait times during periods of high call volume and provide the customer with the choice of one of multiple means for RPU to contact them.

4. Customer Web Portal (CWP)

The technology program for the customer portal consists of further development of RPU's "front-door" customer portal website and development of a customer Mobile App, made available through the Google Android Marketplace and Apple App Store. Many customers want to enhance their experience by having more convenient access to RPU's programs through their mobile devices of choice.

The new avenues for customer self-service and the increased automation will reduce internal labor processing hours and enhance the efficiency of RPU's customer programs.

Additional functionality should be developed to have additional customer account self-service, and access to and automation of programs, useful links, and outage reporting. Rebates and other program forms processing can be automated and managed through the additional customer portal and advanced Mobile App functionality. The new avenues for customer self-service and the increased automation will reduce internal labor processing hours and enhance the efficiency of RPU's customer programs.

INFORMATION-BASED TECHNOLOGIES IN THE IT REALM

Information-based technologies are used by RPU to improve the effectiveness and efficiency of utility operations. These technologies (**Figure 29**) are generally used to make real-time operating decisions but they are used all-day, every day to perform essential work activities and usually rely on large collections of historical operating data or information. The information-based technologies are so essential to operations as to be considered operational technology as opposed to information technology which is governed and maintained by the City's IT department.

Figure 29: Information-Based Technologies (IT Realm)

	Current State	Future State
5. Asset Management System (AMS)	Legacy Synergen system. Used initially to inventory assets and identify maintenance requirements. Records are incomplete and out-of-date. Water currently tracks assets manually.	Highly integrated and comprehensive enterprise system that manages all asset data including description, condition, maintenance history, inspection history and maintenance requirements.
6. Work Management System (WMS)	Legacy Synergen system primarily for time-keeping and work-order management. Compatible units module is out of date. System is not integrated. No mobile solution currently in place.	Highly integrated system for planning, forecasting and managing work. Integrated with GIS, AMS, WIS, CIS and ERP. Compatible units system is core engine for creating work.
7. Warehouse Inventory System (WIS)	Legacy Synergen system. WIS not being used. Electric division is currently using IFAS module. Water currently has none.	Highly integrated system for managing inventory, including up-to-date costs, assemblies, location. Used with WMS to forecast inventory needs and develop project materials lists.
8. Geographic Information System (GIS)	Enterprise mapping system (CADME) based on ESRI's legacy software/hardware platform. Esri no longer provides support for existing platform. Working on application to convert RPU data to new ESRI format and deploy ArcGIS Desktop, ArcGIS Server, ArcGIS Professional, and ArcGIS Online functionality.	Highly integrated GIS based on CIM. Main repository for all asset data. Available to entire workforce. Replaces paper-based maps and asset records.
9. Mobile Applications (Mobile Apps)	Streetlight Maintenance Application Mobile WMS App.	Integrated system of field area networks, Mobile Apps, AVL, WMS, AMS, and GIS. Allows field personnel to access information without leaving the job site.
10. Operational Data Management System (ODMS)	Non-integrated foundational system of servers, software, data historians and network architecture (Electric & Water). Software has been acquired & installed but not yet operational (Water only).	Highly integrated architecture combining, business, planning, engineering and operational platforms into a logical, secure and robust enterprise system

5. Asset Management System (AMS)

Many utilities rely on an AMS to better manage the immense water and electric infrastructure challenges associated with utility operations. AMS functionality includes maintaining accurate and complete asset information to forecast, plan, and manage asset lifecycle costs. An AMS is typically highly integrated with other core systems, such as GIS, WMS, IMS, and ERP.

RPU's AMS is only partially implemented and does not have complete asset inventories for all utilities. RPU lacks a comprehensive asset management strategy and asset management business processes. Standards and guidelines for asset management lack a fixed asset register that is based on compatible units and coordinates from an enterprise perspective. Existing work processes do not facilitate the use of the WMS and AMS as intended. Additionally, not all departments are using the Oracle system to capture job-specific work and assets. Work orders originating from the Oracle system lack the integration and association needed to appropriately capture assets for accounting purposes in IFAS. This creates a gap in understanding the Utility's individual and mass assets with respect to costing/valuation and retirement.

The upgraded AMS will create a framework for proactive asset management, thereby improving asset reliability and operational performance, and allowing for the ability to budget and estimate construction costs.

6. Work Management System (WMS)

A well implemented and functioning WMS will positively impact the handling of timesheets, work approvals, and work management, as well as fixed assets and the WIS. Currently, appropriate user-level access, ownership, and administration for the WMS are not clearly defined. Although all departments use the timecards module, the are transferred from paper. This duplication process is inefficient and error-prone. The evolutions and customizations to the vendor's base product make the systems difficult to upgrade. Service and work orders lack geographic content and GIS integration, which hampers crew and work scheduling. Project approvals in the Oracle system are cumbersome and require additional external research for information lost as a result of missing or broken reference links. Customer service representatives have a difficult time confirming the status of work orders generated from service orders in the CIS. Job costing and estimating are hindered by the lack of compatible units and work management and material standards.

The WMS must be upgraded to appropriately define business processes within the Oracle system and integrate with all departments and other systems. The required WMS module refresh needs to be completed in conjunction with the AMS module implementation. Once business process mapping is complete, user profiles and administration duties need to be outlined. Particular emphasis should be placed on improvements to timecard, approvals, and construction cycle business processes. Also required is improved integration of the WMS with enQuesta CIS, IFAS, GIS, and the Oracle AMS and WIS modules.

An upgrade is necessary to WMS to appropriately define business processes within the Oracle system, and to integrate with all departments and other systems as necessary.

Implementation of the WMS program will increase operational efficiency through improved work management workflows and less manual data handling; enhance customer service by allowing more direct access to work progress for a job associated with a customer's service request; improve operational efficiency by streamlining the approvals process so work can commence quicker; and increase the understanding of customers' contributions to construction costs, which can improve the bottom line and decrease overhead from uncollected capital construction costs. In addition, the WMS will improve accountability for construction work through and improved timecard process. WMS improvements in conjunction with AMS improvements will provide for improved planning, job costing, asset and labor cost accounting, and material costs tracking.

7. Warehouse Inventory System (WIS)

The warehouse inventory system (WIS) is important not only for controlling and minimizing stock materials on hand, but it is important for its hand-off of materials through the work management system and assigning the cost of materials to assets in the asset management system. The WIS is an integral part of the workflows and information needed by the WMS and AMS.

Since not all RPU organizations are using the functionality of the WMS and AMS to associate assets to work and requested parts from the warehouse, the overall effectiveness of the warehousing and inventory system suffers. The key areas of concern are use of parts on compatible units, fulfillment and accounting accuracy, carrying cost, material cost reconciliation to assets, ad-hoc purchases, and proactive inventory control.

WMS and AMS functionality should be implemented RPU-wide with tight integration to the WIS functions to automate the reconciliation of material costs to work orders and ultimately to assets. Properly defined asset records with priorities and standardized part catalogs are required to address the concerns listed above. In addition, requesting parts by utilizing the work management functionality with assets and associated charge codes listed on work orders will further contribute to addressing the concerns. The program needs to be run in parallel to work management and asset management programs. Standardizing parts to be used for compatible units, supply chain management and material accounting procedures, and material planning and workflows need to be documented and procedures built within the Oracle framework as a part of this program.

Some of the benefits of the WIS technology program include a reduction in inventory carrying costs, stock-out costs, ordering costs, and material lead times. Additionally, WIS will improve inventory accuracy; picking accuracy and picking time; and operational efficiency of the warehouse through better warehouse resource planning and scheduling, and labor and equipment utilization.

8. Geographic Information System (GIS)

The technology program for GIS consists of modernizing and leveraging the existing RPU GIS technology by upgrading and integrating the GIS with other enterprise systems. Projects within the GIS program include: replacement of CADME functionality in the new ArcFM Esri platform for the water and electric utilities, GIS workflow improvement projects, additional integrations, and mobile-enabled GIS processes that will be required from the Utility enterprise. Since GIS is a City enterprise system, projects in the GIS program are multifaceted, requiring a harmonized effort with City IT and other City departments.

> **Because GIS is a core-enabling technology for a large portion of utility operations, it is a critical element in the context of the Strategic Technology Plan.**

The 20-year-old CADME is long past its prime, and is causing upgrading issues for other areas of technology since it runs on outdated hardware and operating system technology and is no longer supported by the enterprise GIS platform vendor, Esri. Because GIS is a core-enabling technology for a large portion of utility operations, it is a critical element in the context of the Strategic Technology Plan.

Anything requiring the element of location needs GIS, and GIS is a critical component of asset management, especially for fixed assets of the utilities' distribution systems. Furthermore, GIS is an essential component of mobile computing as nearly every utility Mobile App is map-based. Primary business areas benefiting from the location-based information from GIS are: asset management, engineering, customer service, and operations. RPU envisions enhanced benefits from GIS and from mobile computing in the areas of operational efficiency and customer service.

9. Mobile Applications (Mobile Apps)

Although some mobile technology is currently deployed on a limited basis with the AMS and WMS, new Mobile Apps can be enabled to work with many systems and enhance other aspects of daily work for RPU employees. RPU's Mobile Apps program includes acquisition, design, development, integration, testing, and deployment of new business practices; increasing mobility of core enabling enterprise systems; additional communications infrastructure with AVL; and Mobile Apps for CRM, design, staking, inventory collection, inspection, and OMS.

Implementation of the Mobile Apps program will increase the efficiency and accuracy of data capture through mobile-enabled core business systems, as well as reduce internal labor hours by eliminating paperwork and manual data processing and streamlining information sharing between the Utility central offices and the field. Additionally, Mobile Apps will reduce restoration times by providing real-time information and optimal routing capabilities to dispatchers and field workers, and increase field worker safety through a heightened awareness of the status of systems and crews while working an outage.

10. Operational Data Management System (ODMS)

The Department's Water and Electric Divisions collect thousands of data points daily from field testing, online analyzers, production meters, and other instruments. This data comes into the office via handwritten log sheets, electronic files, and Supervisory Control and Data Acquisition (SCADA) Systems. The data is stored in various formats such as spreadsheets, Microsoft Access database records, SCADA historian records, and other electronic formats. These formats are not interchangeable, which makes generating reports and analyzing data cumbersome. The lack of central data management delays the decision-making process related to water operation.

The ODMS will serve as the "Convergence Layer" between the Operations and Information Technology systems at RPU and will also be the backbone of the new Operations Technology systems such as DA, ADMS, OMS, MDMS, and Smart Metering. The ODMS will be an autonomous dynamic repository of enterprise information that exposes formerly siloed information and supports the historical archival and retrieval of all information for a specified period of time. As a non-intrusive platform for all enterprise information, it will not impose any restructuring or modification of the interface systems databases or other data structures, but will provide the ability to automatically consolidate the contents of distributed databases into a single, centrally located database over a wide area network.

Additionally, ODMS will provide client and management tools that have the ability to view distributed databases as one consolidated database, maintain the integrity of data sources, provide data capture services for real-time data sources such as SCADA, and provide the tools required to seamlessly exchange data with business systems on the corporate network.

Some of the benefits of the ODMS technology program include improved performance and production via increased visibility, better decision making enterprise wide with real time KPI information, better alignment of operational areas with overall business goals, increased regulatory and environmental reporting and compliance, and risk reduction with joint IT/OT security solutions. ODMS will also reduce costs from efficiency gains in knowing information in real time, by optimization of operational processes, and improved asset maintenance and field workforce management.

OPERATIONAL TECHNOLOGIES

Operational technologies refer to those systems that interact in real-time with the water and electricity delivery systems (**Figure 30**). These systems are used to monitor, control, and protect the delivery systems while ensuring reliability, safety, and resiliency.

Figure 30: Operational Technologies (OT Realm)

	Current State	Future State
11. Network Communications System (NCS)	Strong fiber backbone with some capacity constraints and partial wireless network for communicating with remotely located sensing and control equipment. Lacks redundancy.	Resilient networks suitable for high bandwidth data communications across the service area with access points for all sensing and control devices.
12. Land Mobile Radio (LMR)	Wireless radio communication system used for communication with field and operations personnel. End-of-life system with gaps in coverage and limited or no redundancy.	Resilient wireless voice and data communications network with complete coverage.
13. Advanced Metering Infrastructure (AMI)	Limited automatic meter reading and advanced metering requiring manual reads and primarily meter-to-cash process.	Advanced water and electric metering with outage reporting, remote reading, sensing, HAN interface and remote connect/disconnect.
14. Meter Data Management System (MDMS)	Meter data processing and dissemination are primarily handled manually.	Meter data automatically processed from digital meters and disseminated to systems to enable usage presentment/management , outage management, advanced rate programs, and ability to use meter interval data in conjunction with control systems.
15. Automatic Vehicle Location (AVL)	Fleet and work management are manually logged and tracked, lacking real-time location and fleet information.	Critical fleet and work management system that tracks the real-time location of vehicles and equipment. Ensures worker and public safety, especially during distress events.
16. Distribution Automation (DA)	Limited testing of network connected faulted circuit interrupters. Substation feeder breakers have reclosing capability. SCADA monitors feeders at breaker but not down-line. Existing SCADA not designed for Distribution Automation, Substation Automation and OMS. Water SCADA system is capable of receiving data and controlling most production and distribution facilities. Limited capability to monitor system pressures and flows, and to analyze energy management and water loss.	Integrated Volt/VAR management optimizes efficiency and manages demand. Sensing is available throughout delivery system. Switching devices isolate faults and restore service. Water SCADA system along with its auxiliary analytical programs will be able to observe, analyze and control the production and distribution systems to effectively manage water quantity, quality, reliability, and energy usage and water loss.
17. Substation Automation (SA)	Most substations equipped with IED relays, communication networks and digital fault recorders. Remaining substations are scheduled for upgrading.	Provides real-time monitoring of critical asset condition (transformers and 69kV breakers). Control networks allow secure remote access and control of substation equipment.
18. Outage Management System (OMS)	Completely manual, paper-based management. Outage calls handled manually. Outage durations and customers impact based on estimates.	Outages detected automatically through AMI and IVR. Outage cause and location predicted by OMS. Outage maps automatically posted. Duration and extent very accurately known.
19. Supervisory Control and Data Acquisition (SCADA) **Advanced/Distribution Management System (ADMS)**	Existing Electric SCADA system is not designed for DA, SA, or OMS. Existing Water SCADA system is capable of receiving data and controlling most production and distribution facilities. Limited capability to monitor system pressures and flows, and to analyze energy usage and water loss.	ADMS integrates automation, Volt/VAR optimization, SCADA, outage management, and engineering analysis. Integrated Electric SCADA solution will provide electric automation, Volt/VAR optimization, outage management, and engineering analysis. Water SCADA system, along with its auxiliary analytical programs, will observe, analyze, and control production and distribution systems to effectively manage water quantity, quality, and reliability, and analyze energy usage and water loss.

11. Network Communications System (NCS) — Backbone and Aggregation Layers

The scope of the Communications project is to design, procure, install, test, and integrate equipment, systems, and software in a two-phased, incremental approach over a period of less than three years that allows end-to-end rollout and capability realization.

RPU currently operates, maintains, and relies heavily upon a communications infrastructure based on radio frequency, fiber optics, and commercially provided telecommunications systems. These systems need to be upgraded to provide improved performance, throughput, bandwidth, and reliability in order to support current operations (in the case of Water SCADA) and future capabilities (including electric and water AMR, DA, video, enterprise mobility, and voice communications).

In particular, studies have discovered that certain sites are significantly overloaded to the point that more than 70% of transmissions have errors resulting in dropped data and excessive latency in real-time communications to field instrumentation and controls. Also of note, certain portions of the fiber optic system have no further spare capacity.

The scope of the Communications project is to design, procure, install, test, and integrate equipment, systems, and software in a two-phased, incremental approach over a period of less than three years that allows end-to-end rollout and capability realization.

Backbone and Aggregation layers are the primary integrations to achieve communications infrastructure functionality. The Aggregation Layer is covered as a part of the Smart Metering, Distribution Automation, and Enterprise Mobility programs. It is recommended that the integrations be in two phases over time, to achieve an incremental, scalable rollout of capability in a controlled manner. This will allow RPU to manage both resource allocations while meeting the expanding needs of systems requiring communications.

The Communications rollout is one of the highest priority projects as the improvements will provide the required infrastructure to realize all new functionality, such as fixed network AMR for water and electric, DA, video, and enterprise mobility.

12. Land Mobile Radio (LMR)

LMR is a wireless communications system intended for use by terrestrial users in vehicles (mobiles) or on foot (portables). The new system should capitalize on digital technology known as frequency division multiple access (FDMA). The new Land Mobile Radio system will supply new antennas to provide citywide coverage, provide a new dispatcher console, coexist with the current analog LMR system, be based on FDMA technology, support narrow channels, enable trunked modes of operation for both analog and digital modulations, have multiple talk groups, and support private calling. It will also be AES and DES encrypted and be capable of Over the Air Programming (OTAP).

Some of the benefits of the LMR technology program include reliable system service in the event of a natural disaster in which cellular service is disabled; improved crew safety, voice quality, and channel sharing; a larger coverage area compared to analog at low radio frequency; a higher level of security with encryption capabilities; and reduced reaction time to outage events in case of a disaster backing up the phone system.

13. Advanced Metering Infrastructure (AMI)

RPU is currently deploying an automatic meter reading system for its electric meters that will reduce meter reading expenses. The current system does not support two-way functionality such as remote connect/disconnect, cannot be reprogrammed remotely, does not have a HAN interface, does not report interval data, does not provide 'last-gasp' reporting for outage management, and does not provide remote sensing of voltage, currents, and power factor.

Initial deployments of smart meters were driven primarily by the desire to improve the meter-to-cash process and were focused on decreasing operating expenses via reducing manual meter reads, decreasing truck rolls, and eliminating estimated bills with minimal integration of other utility IT systems and/or analytics platforms. Smart meters not only provide automated billing information (serving as virtual electric "cash registers"), but they also provide instrumentation of the premises in the form of meter ID, voltage, power, status, and time tags. This instrumentation data is valuable for outage detection, demand management, voltage/VAR optimization, and system balancing if it is read often (once every 5 minutes or less).

Some of the benefits of automatic meter reading (AMR) include fewer truck rolls for manual reads, increase in operational efficiencies in field and meter services, reduction in unaccounted for energy or water (loss or theft), increase in operational efficiencies in billing and customer management, improvement in outage management efficiency, enhanced customer service, billing accuracy and timeliness improvement, reduced consumption on inactive meters, and informed decisions on water or energy consumption.

AMI It will also increase reliability through early identification of outages and leaks, increase safety for meter readers, and improve environmental preservation through reduced peak-time usage.

AMI It will also increase reliability through early identification of outages and leaks, as well as increase safety for meter readers, improve environmental preservation through reduced peak-time usage, and enable programs such as Conservation Voltage Reduction, Volt/VAR Optimization, Demand Response, and Direct Load Control.

In addition, electric AMI provides the potential to enable plug-in electric vehicles, enables net metering and reduces costs, enables new services (e.g., smart appliances, load reduction programs like Demand Response), allows fewer truck rolls for remote connect- and disconnect-enabled meters, and acts as a deterrent to late or no-pay customer behavior.

14. Meter Data Management System (MDMS)

A meter data management system (MDMS) is an application used to collect and analyze large amounts of water and electric meter reads in conjunction with advanced metering systems. The MDM resides logically between the meter data collection head-end and the operating network. The MDM should be highly integrated with outage management, customer information and GIS system to maximize the value of the information stored in the MDM.

An effective MDM system is essential for outage management, complex rate structures, meter data analytics for forecasting and planning and other operating functions. RPU does not yet have a MDM system but envisions its implementation as it advanced water and electric metering programs evolve. RPU investigated a MDM system with the procurement an implementation of the CIS replacement project but is not going to initiate an MDM until other higher priority projects are addressed and in conjunction with the second phase of the CIS project.

The Head End project is a combination of the acquisition, integration, and test of a commercially available, off-the-shelf package. In order to make the best use of the smart meter capabilities, the following functions must also be integrated: smart meters, head end, MDM, OMS, and ADMS.

15. Automatic Vehicle Location (AVL) and Fleet Management

AVL hardware and software solution enables utility personnel to automatically be located within a geographic and distribution system context and is to be paired with an enterprise Fleet Management application in order to derive maximum benefits from both.

Currently, dispatchers and field crews do not have map-based visibility of where crews are located in the field, nor where all other crews may already be working throughout the distribution system. There is some loss of direct accountability to the customers by loss of association of the crews to specific service orders, and lack of the ability to continually monitor work progress of a customer request. Furthermore, fleet assets (including vehicle condition, maintenance, status, and location) are tracked manually, creating operational inefficiencies and lack of visibility of crew work and work status.

AVL and Fleet Management will enhance customer service through fleet-specific service order management capabilities, reduce fleet fuel costs and increase crew productivity by proactive and geospatially assigned and optimized field work, and improve safety and restoration work agility during outages, as well as create efficiencies for routine field servicing of day-to-day operations.

16. Distribution Automation (DA)

RPU currently has limited visibility of the electric distribution system downline of the breaker; therefore, in an effort to improve its reliability, RPU is implementing a Distribution Reliability Improvement Program (the Program) to identify the worst-performing circuits and to initiate projects to mitigate outages. The goal of the Program is to reduce the frequency and number of customers affected by outages and the associated operations and maintenance costs.

The Program will identify system risks that may result in future outages, identify the root causes of past outages, identify solutions, and initiate projects to implement appropriate system enhancements to further reduce outages. The initial project under the Program will be the Substation Improvement Project (the Project), which will focus solely on the feeders from the pilot area substation. The Project identifies system risks that could result in future outages, identifies the root causes of past outages, identifies solutions, and implements appropriate system enhancements to further reduce outages.

Once the pilot projects have been successfully undertaken and positive metrics show how other portions of the system can have DA applied in a manner that will constitute a positive business case, the DA program should be expanded and coordinated with replacement of aging infrastructure. In the future, DA technology will become cheaper and more of an inherent infrastructure cost rather than as an added cost of emerging technology.

17. Substation Automation (SA)

As part of RPU's infrastructure replacement and modernization, RPU has begun replacing electromechanical devices with IEDs, including replacing electromechanical relays with digital relays, adding transformer temperature controllers, adding digital fault recorders (DFR), and additional automation. The SA system is pivotal to the success of IED implementation and integration of data from the IEDs. SA consolidates and processes data from IEDs that enable operations and engineering staff to collect and analyze data regarding the operation of the electrical system.

RPU developed SA standards by 2006, and started the process of adding SA in the substations in 2006. RPU's philosophy is to install SA in the substation's control buildings to manage the sub-transmission level IEDs (equipment in the switchyard – 66 kV) and install SA in switchgears to manage the IEDs in the distribution level IEDs. The data from SA will help the Utility reducing operational and maintenance expenses. In addition, it will assist in meeting the new regulatory requirements, such as NERC-CIP.

Some of the benefits of the SA technology program include local autonomous control at IEDs with the loss of SCADA or communications, reduced time to locate and to fix problems, reduced primary equipment maintenance costs, and reduced secondary equipment operation and maintenance (O&M) costs. SA will also limit the impact on customers from outages, enable operational decisions to be made more quickly with more timely data, improve access to substation data, and improve power system flexibility and reliability.

18. Outage Management System (OMS)

Currently RPU does not have a technology-based outage management system. Outage information is currently only passed through radio or telephone from customers to dispatchers and then from dispatchers on to the mobile field staff over the radio or cell phones. Except for dispatcher instructions, paper maps, and their own working operational knowledge; RPU fieldworkers have no visibility of what is happening with the distribution system.

RPU will deploy an outage management system that will notify system operators of an outage within seconds. Relying on an integrated network of sensors located at every customer service point, sensors distributed throughout the electric distribution system, and sensors located in the substations, the future OMS will notify system operators of every customer affected by the outage; will identify on an electronic map the most likely location of the outage cause; and will recommend, and in some cases will automatically execute, switching operations to reduce the extent of the outage and restore service to as many customers as possible. Additionally, OMS empowers dispatch personnel to schedule, prioritize, and assign outage tickets in real time to the field and have real-time status updates sent from the field.

RPU will deploy an outage management system that will notify system operators of an outage within seconds.

Some of the benefits of the OMS technology program include decreased restoration times by providing real-time information and optimal routing capabilities to dispatchers and field workers, increased customer satisfaction through more timely completion of planned and unplanned outages, and increased field worker safety through a heightened awareness of everything happening on the distribution system and with other crews in the course of working outages.

19. Water and Electric SCADA System Improvements and Advanced Distribution Management System (ADMS)

The water and electric SCADA systems will receive significant improvements. The existing Electric SCADA system is not designed for DA, SA, or OMS. The existing Water SCADA system is capable of receiving data and controlling most production and distribution facilities, but has limited capability to monitor system pressures and flows or analyze energy usage and water loss.

As part of the NCS upgrades, the capabilities of the communications system that connects remote terminal units in substations, generating facilities, and water collection/conveyance/treatment facilities will be upgraded to allow more monitoring and control of endpoints and increased bandwidth for transmission of higher resolution data.

ADMS is a system of systems used to optimize the capability, efficiency, reliability and security of water and electric delivery systems. For electric delivery systems, ADMS features include voltage optimization (i.e., volt-var optimization and conservation voltage regulation/reduction), fault location, isolation, and restoration (FLISR), outage management and state estimation. On the water system, advance management systems are used to detect leaks, optimize operating pressures and reduce the amount of energy needed to collect, treat, store and deliver water. For RPU, ADMS is a long-term vision.

SYSTEM ARCHITECTURE CONSIDERATIONS

As RPU introduces new operational technologies, the architecture of its technology systems must evolve. In the current environment, there is significant physical and logical separation between customer focused, information based, and real time operating systems. While the current architecture is serving its purpose, it limits the value the new operational technology can provide.

Convergence of Information Technology and Operational Technology

RPU's Smart Grid architecture must consider RPU's current and future ecosystem. For RPU to realize integration requirements of future Smart Grid and technology, RPU should consider the convergence of OT and IT in its architecture. The following graphic illustrates a view of how the convergence of IT and OT realms is required to realize capabilities of Smart Grid technologies.

The growth in Smart Grid modernization is driving an important conceptual change in the way RPU will deploy Smart Grid components. This modernization is characterized by the following trends:

- Continuous implementation of IT to model, monitor, and manage its distribution system.
- An urgent requirement for RPU to integrate their IT and OT networks.
- Continuous growth in OT deployment.

City IT does not currently include RPU OT systems within its integration vision, nor do individual system vendors consider the needs of all systems integration requirements for RPU. RPU has long-term technology needs that will also add new applications of technology to the OT realm, making the gap wider for having all integration needs met for the entire RPU enterprise. **Figure 31** illustrates how convergence of the IT and OT realms is required to realize capabilities of the electric Smart Grid and water utility automation technologies, as well as the benefits of IT/OT convergence to RPU.

Figure 31: IT/OT Convergence

INFORMATION TECHNOLOGIES — Dependent on *information*

- Financial System
- Work Management System (WMS)
- Asset Management System (AMS)
- Warehouse Inventory System (WIS)
- Customer Information System (CIS)
- Geographic Information System (GIS)
- Engineering analysis

OPERATIONAL TECHNOLOGIES — Dependent on *real-time status*

- System Control and Data Acquisition (SCADA)
- Energy Management System (EMS)
- Outage Management System (OMS)
- Automatic Vehicle Location (AVL)
- Meter Data Management System (MDMS)
- Operational Data Management System (ODMS)

IT/OT CONVERGENCE TRENDS

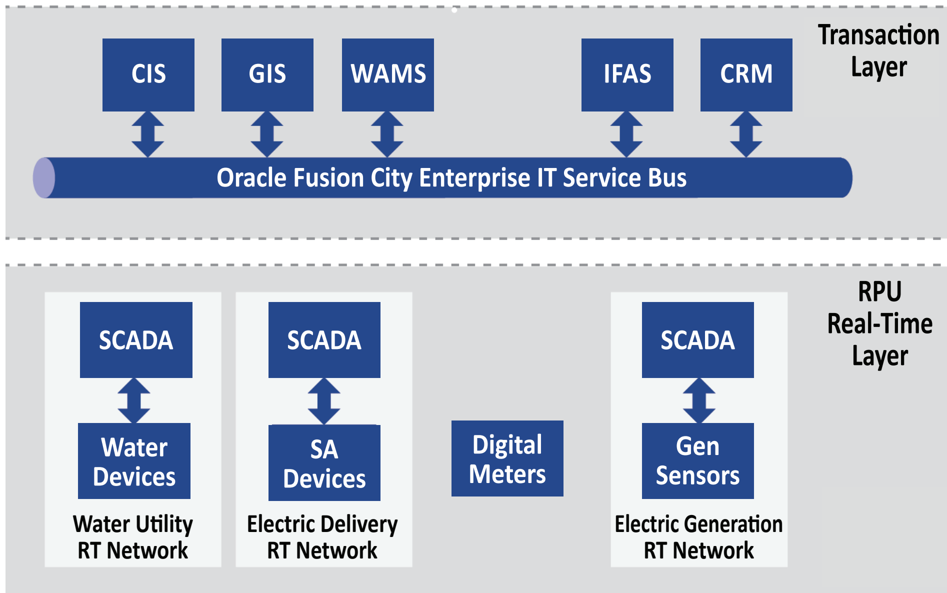
- Real-time status is becoming essential information for CIS, WMS, AMS, WIS, GIS, engineering analysis, and other traditional information-based systems.
- Increasing amount of highly actionable data from mobile field workers, equipment, and operational processes are inputs to information-based systems.
- Operational control systems (EMS, SCADA, and OMS) require real-time information exchange with information-based GIS and engineering analysis systems.

BENEFITS OF IT/OT CONVERGENCE TO RPU

- Effective integration strategies must include common information models (CIMs), service oriented architecture (SOA), and enterprise service bus concepts designed to connect real-time and information-based networks.
- Development, implementation, training, change management, and maintenance of converging technologies (GIS, AVL, MDMS, WMS, AMS, and others) should reside in the Utility domain instead of the City domain.
- Effective use of converging systems requires new business processes, training, education and change management. These issues must be considered when planning staffing and resources to implement and manage systems.

Oracle® Fusion Middleware provides some architecture and framework for integration, but it does not meet all current or long-term requirements for RPU. **Figure 32** illustrates the current state of RPU's IT system architecture for the transaction layer of systems in the IT realm.

Figure 32: RPU IT System Architecture — Current State



An enterprise integration architecture is required for RPU to develop an overarching integration strategy for IT and OT systems. The enterprise architecture also will enable RPU to adopt more specific standards and policies and enforce comprehensive cybersecurity protocols.

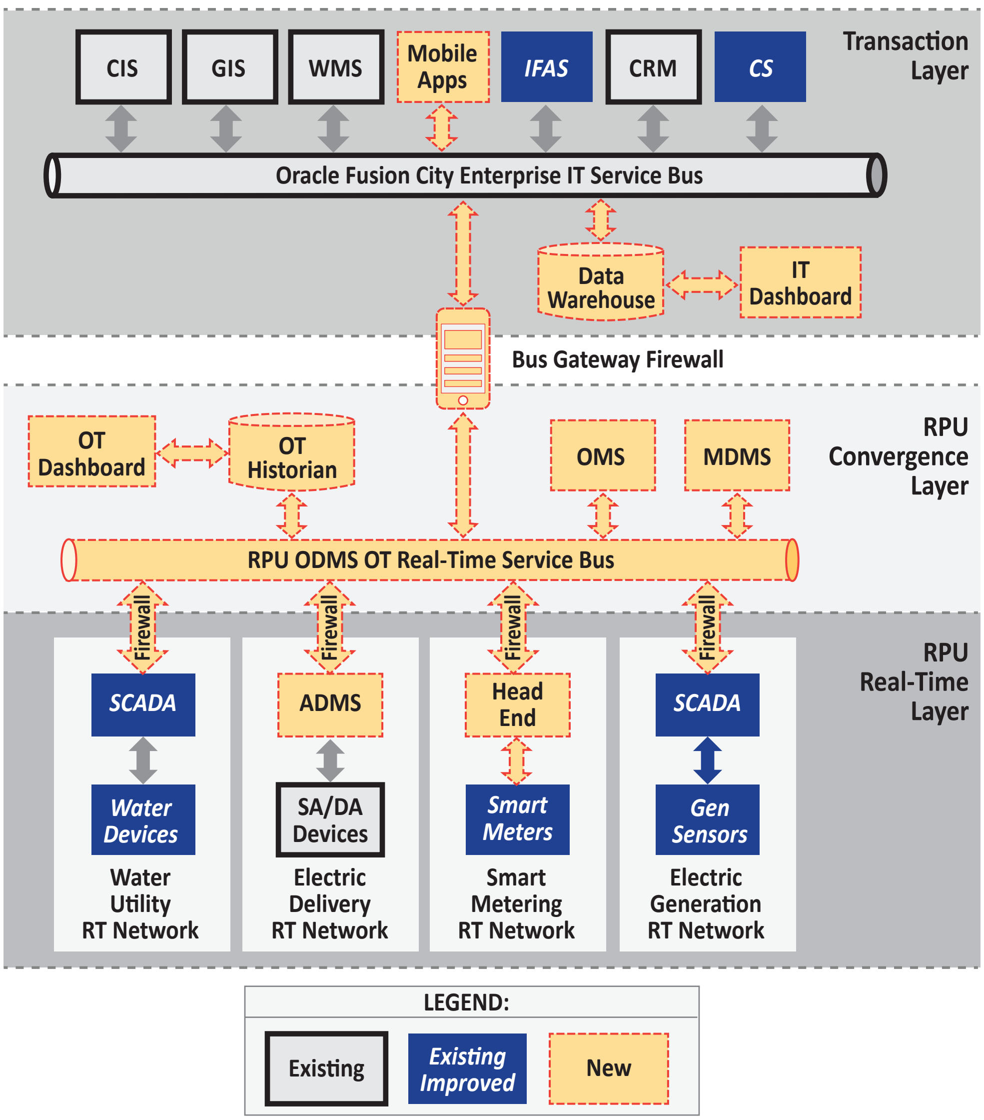
Proposed Enterprise Integration Architecture

RPU should adopt an enterprise integration architecture that will address the areas in which current City IT integration tools do not meet RPU's operational and control systems needs, including sharing data from those systems across the Utility enterprise and coalescing that data with data from IT-realm business systems governed by City IT.

Although the RPU IT-realm systems currently deploy integrations via multiple means, integration can be enabled for all RPU systems and improve existing integrations. The proposed architecture RPU should consider (illustrated in **Figure 33**) comprises the following layers:

1. **Transaction Layer:** Traditional IT-related functionality and transactions that are passed between functions on a scheduled periodic basis.
2. **Convergence Layer:** New middleware bus structure to tie the Transaction Layer to the Real-Time Layer and provide secure information flows from the islanded SCADA and control systems; also provides ODMS functionality.
3. **Real-Time Layer:** All existing SCADA systems for Energy Delivery and Water departments, and the balance of Plant systems for Generation.

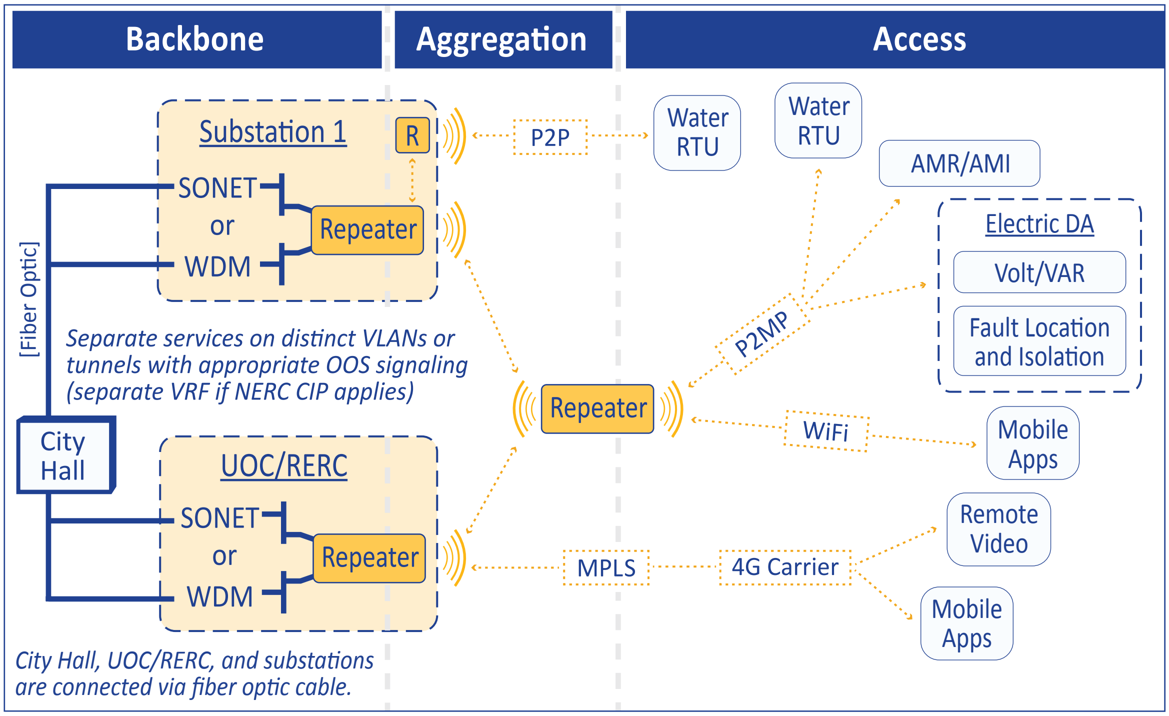
Figure 33: Proposed Enterprise Integration Architecture



Building For New Technology Capabilities

RPU should adopt a layered communications network architecture to transport traffic from multiple distinct services. This approach simplifies the amount of complexity within each layer, provides flexibility to accommodate new or enhanced services, and allows redundancy and scalability to be adjusted independently and appropriately at each layer. In this architecture, services are delivered via the use of a routed network design. **Figure 34** illustrates the three-layered communications architecture to support new technologies initiatives.

Figure 34: Proposed Communications Architecture to Support Technology Initiatives



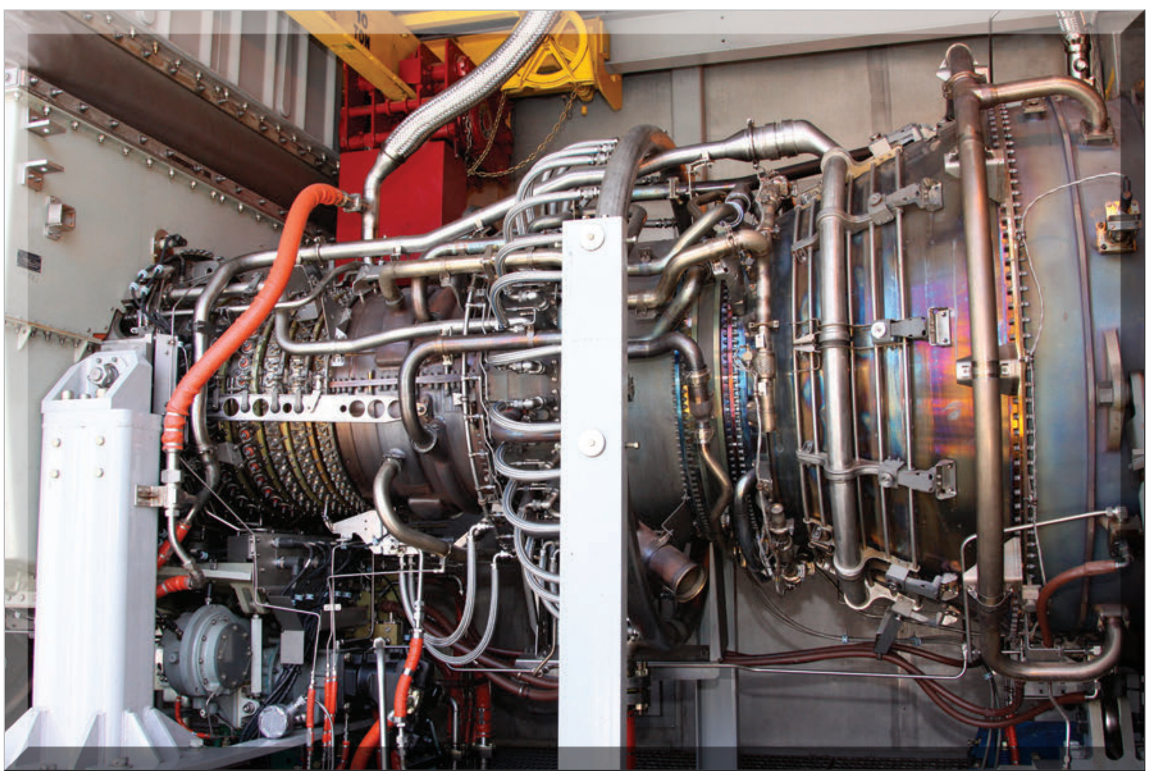
4G	4th generation (mobile telecommunications technology)	P2P	point to point (one-to-one connection on secure closed data network)
AMR	automated meter reading	RTU	remote terminal unit
NERC CIP	North American Electric Reliability Corporation Critical Infrastructure Protection	SONET	synchronous optical network
		UOC/RERC	Utility Operation Center/Riverside Energy Resource Center
DA	distribution automation	VLAN	virtual local area network
MPLS	multiprotocol label switching	VRF	virtual routing and forwarding
OOS	out of service (signaling message)	WDM	wavelength division multiplexing
P2MP	point to multi-point (one-to-many connection on secure closed data network)	WiFi	wireless fidelity

RPU should adopt a network design with three layers: backbone, aggregation, and access. The backbone layer generally has the highest speed connections and is responsible for transport traffic to the UOC and RERC operations centers from other backbone locations. The aggregation layer serves to collect traffic from regions of the access layer and bring it toward a nearest set of backbone network nodes. The access layer, by contrast, handles "last mile" connectivity to devices in the field. The devices, for example, may be meters, RTUs, DA equipment, security cameras, or employees with mobile laptops.

The use of routing allows the network design to be reasonably simple, scalable, and resilient. In addition, moving the resilience strategy from particular link technologies to a routed layer allows for many different types of underlying links to be used, providing opportunities to reduce cost, reclaim bandwidth, or harness new technologies as they mature.

New communications infrastructure will provide RPU the following capabilities:

- Provide for future layered communications enhancements by expanding the backbone communications by at least 20 fold of the present capacity by using new multiplexing technology
- Enable higher throughput that is greatly needed for Water SCADA.
- Enable Electric and Water DA and stronger Electric Delivery SCADA information availability and Smart Grid components.
- Support the new remote video requirements for security at critical infrastructure sites.
- Realize new utility programs, such as leasing dark fiber, AMI, customer side programs, advanced Smart Grid controls, and big data analytics.



Water and Electric SCADA System Improvements and ADMS

The water and electric SCADA systems will receive significant improvements. The existing Electric SCADA system is not designed for DA, SA, or OMS. The existing Water SCADA system is capable of receiving data and controlling most production and distribution facilities, but has limited capability to monitor system pressures and flows or analyze energy usage and water loss.

As part of the NCS upgrades, the capabilities of the communications system that connects remote terminal units in substations, generating facilities, and water collection/conveyance/treatment facilities will be upgraded to allow more monitoring and control of endpoints and increased bandwidth for transmission of higher resolution data.

As part of the SCADA initiative, sensing devices and RTUs will be added or upgraded throughout the system. As part of the water advanced metering initiative, additional pressure and flow sensing devices will be added to the water distribution system to optimize operations, enhance leak detection, reduce water losses, and reduce the amount of energy consumed in the collection, treatment, storage, and delivery of water.

The ADMS program involves deployment of systems used to optimize the capability, efficiency, reliability, and security of water and electric delivery systems. For RPU, ADMS is a long-term vision.

There is no proposed technology investment activity in Phase I for ADMS. Phase II and Phase III activities for ADMS focus mainly on conducting research in coordination with monitoring and tracking the SA and DA program results, to identify the requirements and processes that will be affected to achieve ADMS. RPU will also need to identify Subject Matter Experts (SMEs) to spearhead the deployment of ADMS.

The ADMS will be an extension of the SCADA systems, and the vendors providing the ADMS application functionality will likely be the same vendor as the SCADA systems currently in place. SCADA upgrades were recently put in place at RPU, and the ADMS-related activities are envisioned as the future major upgrades necessary to the SCADA systems that complement DA and bring in the new ADMS functionality necessary.

In Phase III, RPU will focus on acquisition and deployment of an ADMS solution, developing the ADMS network model and the integrations with other technologies to enable voltage optimization (i.e., Volt/VAR optimization and conservation voltage regulation/reduction); fault location, isolation, and restoration (FLISR); outage management; and state estimation for electric delivery system.

Because the water and electric delivery have different SCADA systems, it is likely that separate ADMS systems to support water and electric delivery purposes may evolve independently, but both will need to provide data to the OT service bus for enterprise data sharing.

Implications for People, Processes, and Systems

As new operational technologies are introduced into RPU's water and electric operations, it will be increasingly important to consider the impact of implementation on people, including employees and customers; business process and integrated systems (**Figure 35**). Failure to consider these three dynamics can limit the value that new operational technology can bring to the enterprise. Key concerns will include:

- Adding new IT/OT management and staff within RPU is critical to ensuring successful technology implementation, integration, and lifecycle value.

- Building a business process centric organization will ensure that technology addresses business needs and that technology value and benefits are realized.
- Focus on completing in-flight technology projects; new projects that address safety (AVL and LMR); WMS, AMS, and piloting of advanced technologies like smart metering, distribution automation and voltage optimization.

Figure 35: Implications for People, Processes, and Systems

PEOPLE

- Increased management, staffing and out-sourcing/partnering are required to plan, implement and manage technology projects, and develop, optimize and support effective business processes.
- Increased, sustained training is required to ensure that staff maximize the value of existing and new systems.
- Organization structure should be adjusted to reflect need for RPU-centric IT governance and to reflect the convergence of information-based and real-time responsibilities (like engineering and operations)

PROCESSES

- Business process development, implementation, and optimization should be an ongoing function, appropriately staffed and supported throughout the organization.
- Business processes should address the full life-cycle of technologies, not just procurement and initial implementation.
- Immediate need is to focus on work and asset management business needs and processes.
- Business processes should be designed to mitigate organization silos, especially between information-based and real-time domains (like engineering and operations, GIS and SCADA, and eventually CIS/CRM and OMS/ADMS).
- Early process activities should include the development and tracking of metrics required to evaluate the value of technology implementation for business case consideration (like truck-rolls, outage identification time, and outage isolation time).

SYSTEMS

- Completing the implementation and integration of in-flight major projects (CIS, GIS and ODMS) must be the immediate priority. Especially important is ensuring effective management and allocation of sufficient resources.
- Safety-driven projects including replacement of the land mobile radio system and implementation of an AVL system should begin as soon as possible.
- WMS and AMS system improvements will have the greatest positive impact on operating efficiency. Identifying future WMS and AMS business needs and processes should start as soon as possible.
- Planning and piloting of advanced technologies including outage management, distribution automation, voltage optimization and smart metering should be accelerated and expanded.

BENEFITS TO RPU

- Adding new IT/OT management and staff within RPU is critical to ensuring successful technology implementation, integration, and lifecycle value.
- Building a business process-centric organization will ensure that technology addresses business needs and technology value and benefits are realized.
- Focus on completing in-flight technology projects, new projects that address safety (AVL and LMR), WMS, AMS, and piloting of advanced technologies like smart metering, distribution automation and voltage optimization.

People

Next to its customers, RPU's greatest asset is its people. RPU employs over 600 individuals and each of them will be impacted by technology. For technology deployments to be successful, the Utility's employees must be involved in identifying the business and customer needs that technology support; must be involved in the selection and deployment of the technology and must receive training and support throughout the useful life of the technology.

Providing sufficient and qualified personnel to lead, manage, deliver, and maintain technologies is an essential factor for successful implementations. There is currently no centralized leadership from a strategic perspective that promotes a common approach to technology projects, embraces a future-state vision, or is held accountable for successful execution of a given project. There is a clear lack of ownership for each of the existing projects, and as such, there is no one person with the authority or responsibility for delivery.

This Plan strongly recommends development of a technology management team within the Utility to lead the deployment of technology initiatives. RPU should establish an Operational Technology (OT) office with a manager and staff to support existing and future technology projects. OT office staff would comprise a systems architect, a database designer, a communications specialist, and a project controller.

Each current project would be assigned a dedicated project manager that will report to the Manager of the OT office, who also would serve as the direct liaison to the City IT Chief Innovation Officer.

This organization will streamline daily operations within RPU by defining who is responsible for solving technology problems and by providing City IT a single point of contact with whom to coordinate technology issues. The OT office will give RPU direct control of projects being executed, and the enhanced coordination with City IT will promote a better working relationship for both the Utility and the City.

The OT office also will act as a liaison to the City of Riverside Department of Innovation and Technology. The immediate benefits of the OT office include a raised level of visibility for all current projects; a one-stop shop for anything related to current or future technology projects; the identification, management, and elevation of risks as appropriate; and the significantly increased chance of successful project implementation realizing full functionality of applications, on time and under budget.

This Plan strongly recommends development of a technology management team within the Utility to lead the deployment of technology initiatives. RPU should establish an Operational Technology (OT) office with a manager and staff to support existing and future technology projects.

Processes

Successfully implementing and integrating new technologies requires a thorough understanding of the impact to existing business processes and a clear understanding of future business process needs. Business processes should be well-defined, documented, and adhered to for all operating practices. Business processes should be designed to mitigate organization silos, especially between information-based and real-time domains (like engineering and operations, GIS and SCADA, and, eventually CIS and CRM, and OMS and ADMS).

RPU should undertake business process and application data mapping in order to make core applications themselves more effective and to also allow data from those core applications to be able to be integrated across the IT and OT realms.

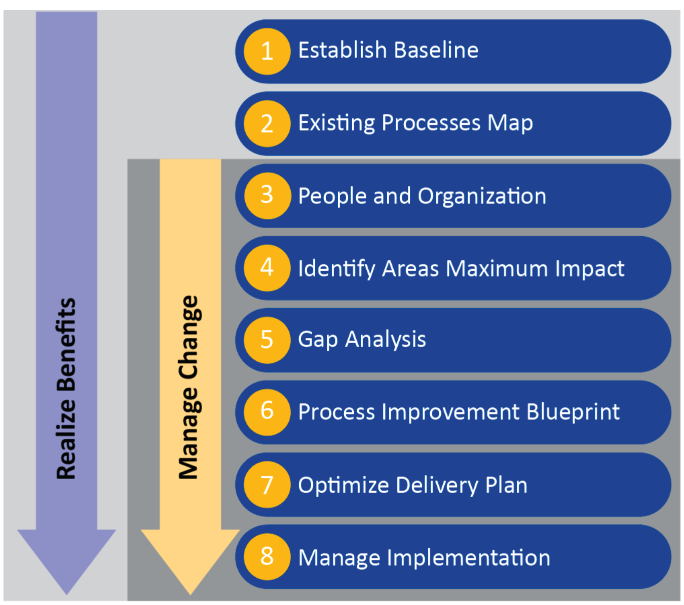
Early process activities should include the development and tracking of metrics required to evaluate the value of technology implementation for business case consideration (like truck-rolls, outage identification time, and outage isolation time).

RPU should undertake business process and application data mapping in order to make core applications themselves more effective and to also allow data from those core applications to be able to be integrated across the IT and OT realms. RPU should undertake business process mapping leading to development of meaningful KPIs for measurement of performance, which may also include SLAs.

RPU should also reduce system silos as an ongoing effort to create more fully functional integration between systems. Mapping business processes and data can help in understanding this issue. Systems have redundant information scattered throughout the enterprise, and ad-hoc databases and spreadsheets are used to close the gap left by the distrust of duplicated data stored in one place or another.

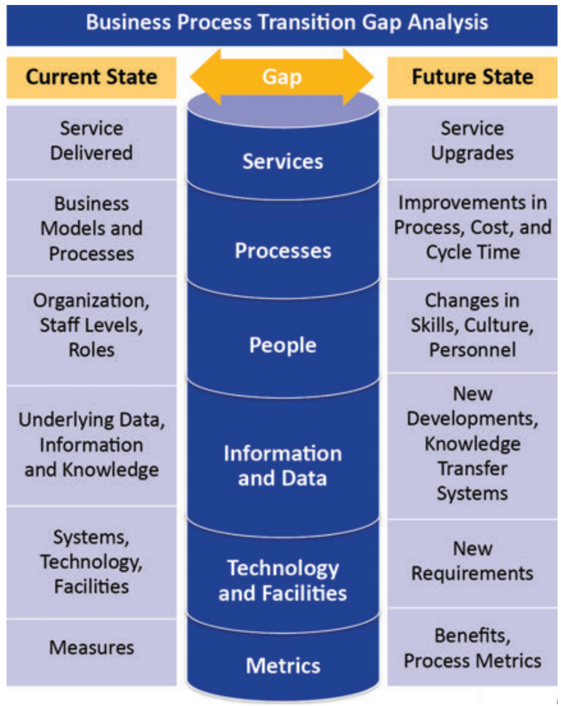
In using business process mapping to begin the process to expose data from their existing silos, some applications at RPU will require a true-up and new business process mapping in order to take advantage of technology and more readily allow for integration (**Figure 36**).

Figure 36: Technology Implementation Business Process



Some projects are already in progress and some are in the planning stages. Some of the core foundational technology projects in-flight and requiring new business process mapping are: CIS, GIS, AMS/WMS, SA, and smart metering (**Figure 37**).

Figure 37: Business Process Transition Gap Analysis



RPU needs to create process diagrams for many major business processes. Where problems become apparent from developing the process flows, consider new data modeling to take corrective measures that address problems in underlying core systems. Define data ownership and create clear definitions of the "system of record" for any particular piece of information.

Systems

Completing the implementation and integration of in-flight major projects (CIS, GIS communications and ODMS) must be the immediate priority – especially important is ensuring effective management and allocation of sufficient resources.

Safety-driven projects, including replacement of the LMR system and implementation of an AVL system, and should begin as soon as possible.

WMS and AMS improvements will have the greatest positive impact on operating efficiency. Identifying future WMS business needs and processes should start as soon as possible.

Planning and piloting of advanced technologies, including outage management, distribution automation, voltage optimization, and smart metering should be accelerated and expanded.

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STRATEGIC TECHNOLOGY ROADMAP

This section outlines a strategic roadmap and business case for technology investments, building upon the previous section's technology objectives. Specific technology project investments are shown in three phases, over a ten-year horizon, in order to develop a compelling business case. The high-level business case, in support of the strategic technology roadmap, highlights major technology investments and offers a return on investment (ROI) for technology projects to justify the expenditure on technology.

PHASED APPROACH OF STRATEGIC TECHNOLOGY ROADMAP

Electric and water utilities have had to become more flexible and agile due to constantly changing regulatory requirements, state and federal energy policies, and economic conditions, and RPU is no exception. The strategic technology roadmap is structured to provide a flexible approach to achieving RPU's technology vision.

Rather than making wholesale system changes that have very long-term implications, RPU will implement a series of technology improvement projects in three manageable phases over a 10-year period. This phased implementation will allow RPU to complete projects and assess their impact on other systems more quickly and efficiently, and then adjust tactics as needed to achieve the next near-term objective. RPU must remain flexible ini its outlook and, based on business drivers, be able to change the projects being considered in each phase and the speed of implementation.

Figure 38 outlines the three phases of the strategic technology roadmap. Other options to phase these projects may also be beneficial and should be evaluated as needed. Phase I includes building an effective OT organization and completing in-flight projects. Phase II focuses on implementing operational technologies already proven to provide customer value. Implementation of advanced technologies is planned for Phase III, to allow time for those technologies to mature.

Figure 38: Three Phases of Strategic Technology Roadmap

Phase I 2016–2017	Phase II 2018–2020	Phase III 2021–2025
• Complete in-flight projects. • Develop future business needs. • Establish OT office. • Develop technology governance (cybersecurity) measures.	• Improve operational effectiveness. • Improve work/asset/inventory management, outage management, and communications infrastructure. • Complete advanced technology pilots.	• Implement advanced technologies that provide customer value. • Implement AMI, ADMS, and other technologies, based on customer value.

A detailed roadmap is provided in **Figure 39** on the following pages.

Figure 39: Detailed Strategic Technology Roadmap

Project	Est. Cost	Phase I	Phase II	Phase III
		2016 · 2017	2018 · 2019 · 2020	2021 · 2022 · 2023 · 2024 · 2025
Project Management and Technology Governance				
OT Office (Operational Technology Office)	$4.4 – 5.5M	• Establish RPU OT office (manager, staff, resources, business processes).	• Manage implementation plan. • Measure and adjust with resources.	• Update Strategic Technology Plan. • Continue implementation plan.
Technology Governance (Cybersecurity measures)		• Cybersecurity, redundancy, and business continuity.	• Strengthen cybersecurity measures.	• Continuous improvements to cybersecurity, redundancy, and business continuity.
Customer-Focused Technologies / IT Realm				
1. CIS (Customer Information System)	$9.2 – 13.8M	• Integrate IVR and CWP enhancements with CIS.	• Potential enhancements/upgrades. 2018–2019: • Document Storage System. • Complete integration with GIS. • Integrate across systems (MDMS, Mobile Apps, permits). 2020: • Integrate with ODMS.	• Assess business needs. • Determine possible future enhancements.
2. CRM (Customer Relationship Management)		• Explore additional functionality of 311 system to expand into key account management.	• Develop KPI Dashboard. • Automate marketing and sales processes.	• Implement advanced CRM big data analytics. • Perform sales and marketing performance analysis.
		• Explore and install rebate software options within 311.	• Enhance online and mobile customer experience (e.g., variable messaging). • Implement automated sales and marketing campaigns and surveys.	• Implement advanced customer choice and programs.
		• Upgrade Siebel system (e-service, email response, MAD, Mobile App web service, etc.).	• Integrate across systems. • Perform data and performance analysis. • Enable social media-driven customer service and communications.	• Further enhance integration across systems.
3. IVR (Interactive Voice Recognition)		• Requirements development and procurement.	• OMS/IVR implementation.	• Advanced outage analytics.
		• CIS data preparation.	2019–2020: • Integrate across systems (CIS, SCADA, AVL).	• Integrate across systems (ODMS, DA).
4. CWP (Customer Web Portal)	$3.0 – 4.5M	• Enhance customer self-service functions.		• Advanced customer self-service and interaction via multiple channels.
		• Upgrade portal and integrate across systems (GIS, MAD, CRM, IVR). • Integrate mobile devices.	• Develop basic outage app and integrate with OMS.	• Advanced OMS-driven outage communication.
		• Integrate social media and provide basic customer apps. • Automate rebates/conservation.	• Integrate across systems. • Pilot customer programs and usage management.	• Advanced meter data analytics and customer programs.

<table>
<tr><th rowspan="2">Project</th><th rowspan="2">Est. Cost</th><th>Phase I</th><th colspan="2">Phase II</th><th>Phase III</th></tr>
<tr><th>2016 / 2017</th><th>2018</th><th>2019 / 2020</th><th>2021 / 2022 / 2023 / 2024 / 2025</th></tr>
<tr><td colspan="6">Information-Based Technologies / IT Realm</td></tr>
<tr><td rowspan="2">5. AMS (Asset Management System)
6. WIS (Warehouse Inventory System)
7. WMS (Work Management System)</td><td rowspan="2">$5.6–8.4M</td><td>• Perform needs assessment.
• Define business processes.
• Complete digital O&M manuals.</td><td colspan="2">• Implementation and integration.</td><td>• Control and monitor.
• Business intelligence and data analytics and tools.</td></tr>
<tr><td>• Create Oracle roadmap.
• Track asset value and depreciation.</td><td colspan="2">• Oracle upgrade.</td><td>• Streamline integration of RPU enterprise data, processes, systems, and people.</td></tr>
<tr><td rowspan="4">8. GIS (Geographic Information System)</td><td rowspan="4">$4.1–6.2M</td><td>• ETL completion.</td><td colspan="2">• CADME RPU replacement.</td><td>• Complete UG ductbank/cable inventory/inspections.</td></tr>
<tr><td>• CIS premise locations/MAD (master address database) integration.</td><td colspan="2"></td><td>• Advanced GIS big data analytics and geospatial analysis.</td></tr>
<tr><td>• Water Field Maintenance application solution.</td><td colspan="2">• Expand/enhance Mobile GIS App.</td><td></td></tr>
<tr><td>• AutoCAD integration.</td><td>• Circuit maps.</td><td>• OMS data modeling and input.</td><td></td></tr>
<tr><td rowspan="3">9. Mobile Apps (Mobile Applications)</td><td rowspan="3">$3.0–4.5M</td><td>• Mobile device management strategy.</td><td colspan="2">• Improved mobile device access to enterprise system.</td><td>• Improved efficiencies (field, office, customers).</td></tr>
<tr><td>• Implement PragmaCAD.</td><td colspan="2">• Mobile AVL/WMS/AMS/OMS Apps.</td><td>• Enhanced customer functions (CWP and Mobile CRM).</td></tr>
<tr><td>• Address network infrastructure.</td><td colspan="2">• Improved fleet communications.</td><td>• Advanced mobile enterprise communications (IPvX).</td></tr>
<tr><td rowspan="4">10. ODMS (Operational Data Management System)</td><td rowspan="4">$2.3–3.5M</td><td>• Needs assessment (Electric).</td><td colspan="2">• KPI dashboards (Electric).</td><td>• Enhance operations efficiency.</td></tr>
<tr><td>• KPI dashboards (Water).</td><td colspan="2">• Business Intelligence.</td><td></td></tr>
<tr><td>• Prepare and align enterprise data.</td><td colspan="2">• Align and integrate IT and OT operations and data.</td><td>• Advanced big data analytics.</td></tr>
<tr><td>• Procure and implement.</td><td colspan="2">• Converge IT and OT Enterprise Service Bus.</td><td>• Optimize and enhance data and integration.</td></tr>
<tr><td colspan="6">Operational Technologies / OT Realm</td></tr>
<tr><td rowspan="4">11. NCS (Network Communication System)
12. LMR (Land Mobile Radio)</td><td rowspan="4">$6.9–10.3M</td><td>• Improve and expand fiber backbone.
• Expand to include Water.</td><td colspan="2"></td><td>• Scalable communications infrastructure (vendor- and technology-agnostic).</td></tr>
<tr><td colspan="2">• Test/expand aggregation and access layer communications.</td><td></td><td rowspan="3">• Transition all communications to latest Internet protocol.</td></tr>
<tr><td colspan="3">• Fixed network hybrid AMR/AMI, DA, Video, and enterprise system implementation.</td></tr>
<tr><td>• Commission LMR.</td><td colspan="2"></td></tr>
<tr><td rowspan="4">13. AMI (Advanced Metering Infrastructure)
14. MDMS (Meter Data Management System)</td><td rowspan="4">$17.7–26.3M</td><td>• Explore options for MDMS.</td><td colspan="2">• AMI Hybrid (selected smart meters at critical locations; Electric only).</td><td>• Advanced customer programs with AMI.</td></tr>
<tr><td>• Address network infrastructure and integrate with SCADA.</td><td colspan="2" rowspan="2">• Implement MDMS and integrate across systems.</td><td rowspan="2">• Advanced AMI/ big data analytics.</td></tr>
<tr><td>• Pilot AMI.</td></tr>
<tr><td colspan="3">• Begin rollout of Electric and Water AMR meters.
• Begin rollout of Water two-way communication AMR meters.</td><td>• Full implementation of AMI metering.
• AMI-enabled distribution monitoring with ADMS.</td></tr>
</table>

Project	Est. Cost	Phase I 2016	Phase I 2017	Phase II 2018	Phase II 2019	Phase II 2020	Phase III 2021	Phase III 2022	Phase III 2023	Phase III 2024	Phase III 2025
15. AVL (Automatic Vehicle Location)	$0.9 – 1.4M	• Develop fleet guidelines.		• Acquire and integrate AVL.			• Optimize fleet asset lifecycle and work management.				
				• Mobile AVL/WMS/OMS Apps.			• Advanced real-time visualization of operations, assets, crews, and work.				
		• Address network infrastructure.		• Improve fleet communications.			• Advanced mobile enterprise communications (IPvX).				
16. DA (Distribution Automation)	$5.0 – 7.6M	• Pilot DA.		• Expand DA to worst-performing circuits.			• Advanced feeder management, circuit segmentation, FLISR.				
		• Address network infrastructure and integrate with SCADA.					• Integrate across systems (ADMS).				
							• Advanced feeder data analytics.				
17. SA (Substation Automation)	$1.4 – 2.0M	• Design, test, commission, and implement SA.									
		• Address network infrastructure and integrate with SCADA.				• Integrate across systems.	• Coordinate device management for Volt/VAR and switching FLISR.				
				• Formalize protection/coordination and monitoring schemes.			• Integrate across systems.				
18. OMS (Outage Management System)	$3.3 – 5.0M	• Requirements development and procurement.		• OMS/IVR and Mobile OMS implementation.			• Advanced outage analytics.				
		• GIS and CIS data preparation.		• Integrate across systems (GIS).			• Integrate across systems (ODMS, DA).				
					• Integrate across systems (CIS, SCADA, AVL).						
19. SCADA (Supervisory Control and Data Acquisition) **ADMS** (Advanced Distribution Management System)	$3.0 – 4.5M	• SCADA Upgrade (Electric): Design, test, commission, and implement.									
		• SCADA Upgrade (Electric): Address network infrastructure, and integrate with SCADA.					• Integration across systems (ADMS).				
							• Advanced feeder data analytics.				
		• SCADA Upgrade (Water): System monitoring Analysis and Energy Management solution selection.		• Implement Energy Management solution and begin installing requisite system monitoring devices.			• Via ODMS, implement OMS and communicate with CIS.				
		• Monitor and track SA and DA to identify ADMS requirements and processes.					• Acquire, test, commission ADMS.				
				• SME technology & research.				• Develop ADMS network model.			
									• Pilot advanced control functions, FLISR, Volt/VAR.		
									• Integrate with SCADA, SA, DA, OMS, AMI, MDMS.		

Phase I and Phase II Technology Activities

Phase I and Phase II technology investments include technology projects over a five year period with a finite level of definition that are readily quantifiable in cost. Most defined technology projects happen or begin within Phase I and Phase II.

Phase I and Phase II consist of technology projects that are the most important for RPU to meet Phase III technology objectives and directly respond to RPU's established business objectives. Immediate Phase I (2015–2017) efforts are focused on completing projects already started, including the CIS replacement, GIS upgrade, and ODMS implementation. During Phase II (2017–2020), RPU will complete the implementation of major improvements to WMS, AMS, Mobile Apps, ADMS, and backbone communications systems.

Phases I and II are mostly foundational to provide a level of technology infrastructure that will enable advanced analytic capabilities for the Utility in the future. Technology investments during these phases will also position RPU to be agile enough to respond to currently forecasted and unforeseen changes to the Utility business model.

Phase III Technology Activities

For Phase III, by 2025 RPU will implement an ADMS and advanced metering for the electric and water systems, operating in a highly integrated environment. This will position RPU for resiliency and the ability to take advantage of big data and advanced analytics.

Costs for Phase I and Phase II technology investments are more well-defined than those in Phase III. The ADMS system is one of the few technology initiatives in Phase III with a finite definition and detailed costs outlined in the strategic technology roadmap. Costs are included to make the business case for benefits from ADMS capabilities.

It is envisioned that activities in Phase III will likely be focused upon utilizing advanced analytic capabilities enabled by RPU technologies after systems are put in place and become integrated with people and processes. Major investments may be warranted in Phase III, but are envisioned to be mostly for staff training and development, developing metrics and KPIs based upon advanced analytics, and for building upon technology infrastructure already in place from Phase I and Phase II.

These investments in advanced analytics and staff development lack definition at this time, and innovations may happen within the first five years of the roadmap that may drive unforeseeable change within Phase III. Other investments in Phase III will likely include capital investment in the physical plant as opposed to technology. This physical plant investment driven by technology will be based on successful pilot programs completed in Phase I and Phase II with technologies such as DA and SA.

Therefore, the only defined costs for Phase III are for the ADMS system.

It is envisioned that activities in Phase III will likely be focused upon utilizing advanced analytic capabilities enabled by RPU technologies after systems are put in place and become integrated with people and processes.

BUSINESS CASE FOR MAJOR TECHNOLOGY INVESTMENTS

To develop the business case for major technology investments, Leidos used statistics from detailed business cases conducted for similar clients as well as utility industry reports in order to understand and monetize benefits of technology project use cases.

To develop a high-level business case for the strategic roadmap, Leidos developed macro-economic benefit statistics, stated in dollars per customer per year. Using annual costs of planned RPU technology projects and monetized benefits, Leidos then developed a net present value (NPV) analysis of the actual technology costs and benefits for a 20-year investment return period.

An NPV approach was used in order to develop a return on investment (ROI) to state costs versus benefits in present-day dollars. The NPV approach translates planned annual capital investments, ongoing annual operations and maintenance expenditures, and ongoing annual benefits into today's dollars. The NPV approach adjusts for the time value of money and states costs and benefits in today's dollars, providing a more meaningful and accurate comparison of alternatives in terms of ROI.

> **An NPV approach was used in order to develop a return on investment (ROI) to state costs versus benefits in present-day dollars.**

The business case analysis focused on four business cases. Two of the business cases focused on AMR solutions. One AMR solution, the "AMR Low Case" was developed to have a conservative estimate of ROI from relatively lower customer-experienced benefits. A second AMR solution, the "AMR High Case" shows the potential for a relatively high ranging ROIwith many benefits from AMR technology at or near median and higher anticipated benefit values.

The two other business cases focused on AMI technology. One of the AMI solutions, "Full AMI" was for an implementation of AMI with AMI throughout the entire meter population at full AMI penetration. The "Full AMI" case has a higher cost than the second AMI case, which used an AMR/AMI hybrid solution, shown as the "AMR/I Hybrid" case. In the AMR/I Hybrid case, AMI technology is applied to a focused customer population in order to reap AMI benefits for less cost.

Benefit values in the business case were determined based on macroeconomic industry benchmarks and Leidos experience from conducting business case assessments for other utility clients. The "AMR Low Case" was developed to have a conservative estimate of benefits and represents a business case for technology at the low end of the benefit value spectrum.

Benefits used in the "AMR High Case" option are in the high-range of benefit values for AMR technology, yet are still somewhat conservative, based on the highest industry benchmarks. The AMR High case reflects optimistic benefits, but uses a more conservative estimate of benefits than seen in some of the highest benefit estimates available in industry reports.

Considering RPU's implementation of AMR technology and its expansion to AMI, Leidos used conservative, mid-range benefit estimates for the AMR High Case, the Full AMI case and the AMR/I Hybrid, based on its experience and industry benchmarks.

For some benefits, the same value for the benefit is used for the AMR High case, the AMI Full case and the AMR/I Hybrid, but is the benefit value is allocated and realized differently over the years in the different business case options, depending upon the technology. For instance, additional revenue protection benefits are available to full AMI versus the AMR and AMR/I hybrid. It is the same benefit value per customer but differs throughout the options in that it can be more fully realized with a full population of AMI meters. For more details on the actual benefit values used and how benefits are allocated, refer to **Appendix A**.

All four business cases considered costs and benefits for technology investments from categories outside of advanced metering in categories of DA, SA, OMS, ADMS, and NCS, to enable desired use cases. The four business case options varied the advanced metering technology used while holding the DA, SA, OMS, ADMS, and NCS technology solutions constant throughout the business case analysis.

Major Technology Project Investments

For the high-level business case, costs were taken from major technology projects of the strategic roadmap and benefits were derived from use cases primarily enabled by the major technology projects investments. The following RPU major technology project investments are considered for the purpose of the business case analysis:

- Automatic Meter Reading (AMR), including Meters, Head End (HE), and Mobile Apps
- Full penetration AMR low and high cases
- AMR with strategic penetration of AMI (Hybrid AMR/AMI)
- Full penetration AMI case
- Distribution Automation (DA) and Advanced Distribution Management System (ADMS)
- Substation Automation (SA) System
- Outage Management System (OMS) and Interactive Voice Response (IVR) system for outage communications
- Communications Access Layer for enabling the specific technologies with costs allocated to the specific technology investments listed above

Some technology project investment costs are considered as sunk costs or do not contribute to the monetized benefits claimed and these costs are not factored into the high-level business case NPV calculations. Sunk costs were not considered in the high-level business case from projects in-flight or already completed.

Technology investments identified in the strategic roadmap for GIS, CIS, customer portal, and Mobile Apps are either considered sunk or having separate use-case benefits, not identified within the high-level business case. These technology investments are, however, foundational and may be considered as enablers to reap additional benefits of the use cases identified below.

Technology should be implemented in a phased approach that builds a strong foundation to enable reaping the maximum benefits from technology investments.

Benefits of Technology Investments

This subsection of the high-level business case of the strategic roadmap highlights how major technology project investments create use case capabilities and what benefits may be gained from the capabilities. How to enable use cases by phasing investments to build foundational technology infrastructure is illustrated next. Once use case benefits are defined they can be monetized, where a dollar value is assigned to the benefit. The phased technology investments can then be applied in a tactical implementation plan for technology projects in the following section.

Leidos conducted research of industry benchmarks and business cases in order to ascertain the monetized benefit values of smart grid projects. "Smart Grid Economic and Environmental Benefits,"[1] a Smart Grid Consumer Collaborative (SGCC) report; Smart Grid Investment Grant Program progress reports[2] published by the U.S. Department of Energy; and various publicly available business cases served as resources for the input parameters used in the business cases.

Benefit monetization for the identified use cases come from industry reference reports or Leidos studies and are adjusted for RPU, using RPU specific data and assumptions. Using benefit monetization metrics coupled with the RPU customer and reliability statistics, Leidos developed estimates of the potential benefits to RPU on a per customer per year basis from investing in the technology projects. The ranges for the potential benefits, for low- and high-level cases, are derived from various industry benchmarks such as SGIG progress reports and Leidos utility market intelligence gained by conducting assessments of similar technology deployments.

Figure 40 summarizes the benefits organized by technology use case that were used in the business case. Other benefits certainly exist to bolster the business case for the proposed technology investments. These benefits are not listed below and are not used in the high-level business case NPV calculations. These unlisted benefits are either too difficult to be monetized because insufficient industry metrics exist to monetize them or the benefits are societal, environmental, or otherwise intangible for assigning a dollar value of the benefit.

Figure 40: RPU Use Case Benefit Categories and Monetized Benefits Used in the Business Case

Use Case Benefit Category	Monetized Benefit Applied to the Business Case
Remote meter reading and disconnect	• Average reduction in routine and special meter reading • Average reduction in connect/disconnect services
Revenue Assurance	• Improved metering accuracy and meter-to-cash processes • Average reduction in theft and unbilled/uncollectable account handling
Service Outage Management	• Average reduction in outage identification and restoration time • Average reduction in customer interruption duration (CAIDI)
Integrated Volt/VAR Control	• Average reduction in peak demand • Average reduction in energy use • Average reduction in line losses
Fault Location and Isolation	• Average reduction in system average interruption duration (SAIDI)
Water Leak & Loss Detection	• Average reduction in water leak and losses
Customer Usage Management	• Average reduction in customer energy and water use

Some projects are foundational to form a technology infrastructure for enabling use cases. Technology should be implemented in a phased approach that builds a strong foundation to enable reaping the maximum benefits from technology investments.

1 Smart Grid Consumer Collaborative, "Smart Grid Economic and Environmental Benefits: A Review and Synthesis of Research on Smart Grid Benefits and Costs," 8 October 2013, (hereinafter referred to as SGCC).
2 Smart Grid Resource Center, https://www.smartgrid.gov/library

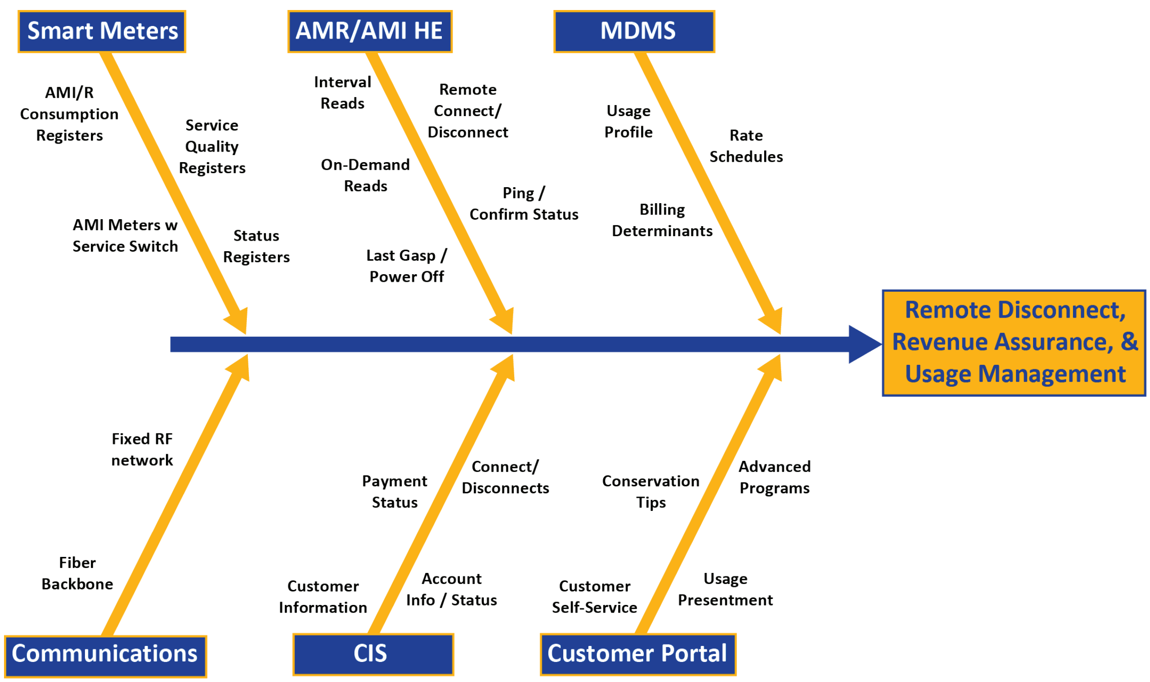
Enabling Use Cases by Phasing Technology Investments and Resulting Benefits

Use cases are enabled by multiple technology types in the strategic roadmap. In order to better understand how technology projects should be phased and implemented, and to understand how benefit streams can be phased in the business case, fishbone diagrams represent how technology components enable each use case.

Remote Disconnect, Revenue Assurance, and Customer Usage Management

Figure 41 presents the phasing of the technology investments to enable remote meter reading and disconnects, revenue assurance, and usage management use cases. These use cases are enabled by the AMR/AMI head-end, meter data management system (MDMS), CIS, customer portal, and deployment of hybrid AMI and AMR meters with supporting communications infrastructure.

Figure 41: Remote Disconnect, Revenue Assurance, and Usage Management Use Case



AMR and AMI meters deployed with a head end system and a fixed RF network is the foundation for ensuring billing information accuracy, remote connect/disconnect, and usage management. The AMR/AMI Head End system will manage, monitor, and control smart meter communications for scheduled and on-demand reads, status confirmations, last gasp messages and pings, and remote connects/disconnects with the AMI meters that are equipped with service switches. It will require integration with CIS to tie customer with the meter for customer / account information and status and payment status.

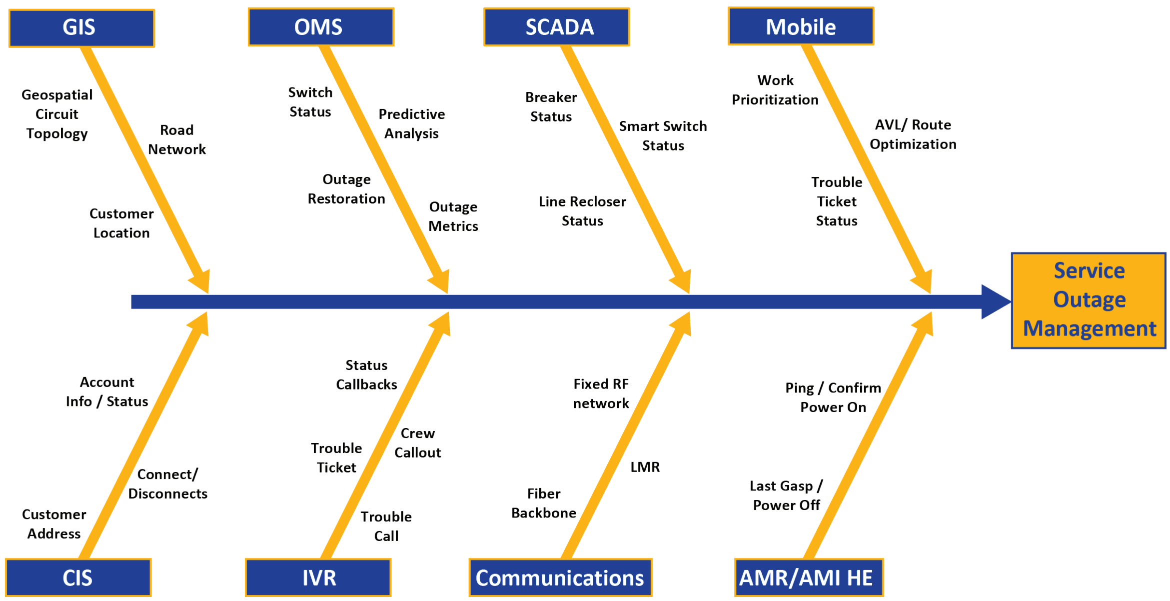
The meter data management system (MDMS) serves as repository for water and electric meter reads. It is capable of presenting customer usage profiles and calculating billing determinants based on RPU rate schedules.

At basic integration levels with CIS, the Customer Portal enables basic customer self service functions such as customer/account information updates, online bill presentment and payments. Customer Portal also integrated with AMR/AMI Head End and MDMS enables customers to view their usage profiles (recent or historical), and manage their consumption through available programs, conservation tips, and online customer analytics capabilities.

Service Outage Management

Figure 42 presents the phasing of the technology investments to enable service outage management use case. This use case is enabled by GIS, CIS, OMS/IVR, SCADA, AMR/AMI Head End system and Mobile Apps and the supporting communications infrastructure.

Figure 42: Service Outage Management Use Case



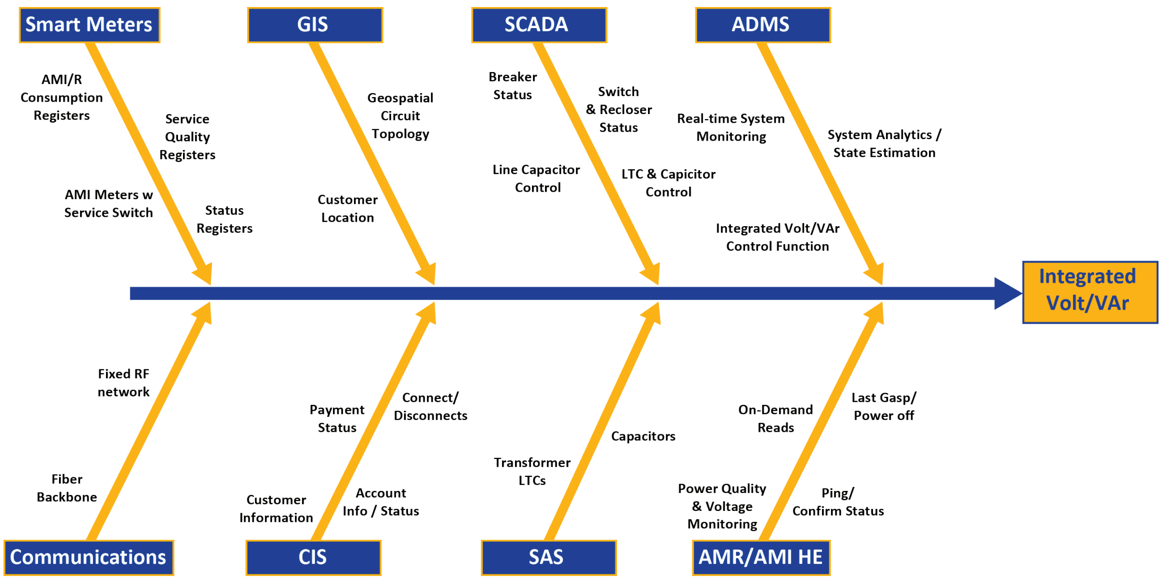
OMS is the primary application for service outage management. OMS requires geospatial circuit connectivity and customer location information from integration of GIS and CIS applications to predict and work outages. IVR and AMR/AMI Head End system provides the trouble indications at customer location, while SCADA will provide power off and on indications at reclosers and substation breaker and higher levels based on real-time status of breakers, switches, or reclosers.

Dispatchers manage and prioritize restoration efforts in the field using the OMS connectivity model tracing capabilities for real-time presentation of trouble indications and outages in relation to crew locations and utility assets. Field crews use the Mobile OMS App to view the current state of the connectivity model, and to receive and update status of the trouble tickets in the field. SCADA, AMR/AMI Head End system, Mobile OMS, and AVL applications will all leverage the communications infrastructure.

Integrated Volt/VAR Management and Control

Figure 43 presents the phasing of the technology investments to enable the integrated Volt/VAR management use case. This use case is enabled by GIS, CIS, SCADA, AMR/AMI Head End system, and ADMS applications and deployment of smart meters and substation automation devices with supporting communications infrastructure.

Figure 43: Integrated Volt/VAR Management Use Case



SCADA and ADMS applications are the primary technologies for the integrated Volt/VAR management and control use case. SCADA will enable dispatchers to monitor and control substation and distribution automation devices (LTCs, capacitors) to manage Volt/VAR profiles in the circuits.

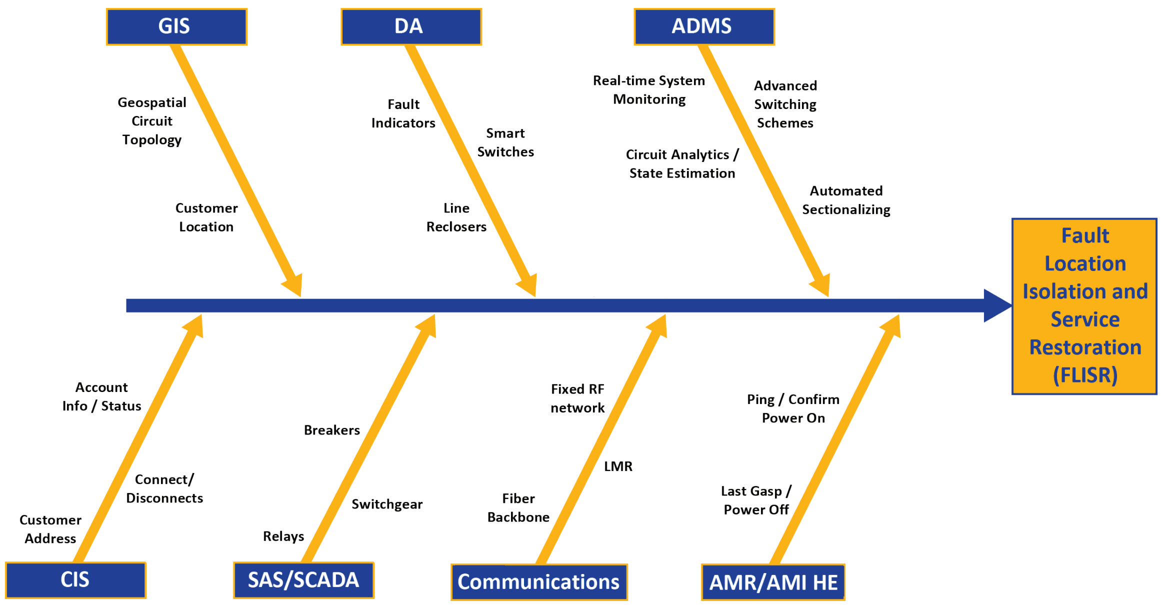
However, Volt/VAR management via SCADA will be somewhat limited without real-time monitoring and control of Volt/VAR levels end of the line. ADMS will provide this capability in a more integrated fashion by enabling real-time monitoring of substation- and circuit-level input from SCADA and customer-level input from the AMR/AMI Head End system.

ADMS will require geospatial circuit connectivity and customer location information from integration of GIS and CIS applications. It will use real-time analytics to manage and control substation and field device settings to keep Volt/VAR readings within acceptable thresholds. SCADA, AMR/AMI Head End system, and ADMS applications will all leverage the communications infrastructure to communicate with devices in the field.

Fault Location, Isolation, and Service Restoration (FLISR)

Figure 44 presents the phasing of the technology investments to enable the fault location, isolation, and service restoration (FLISR) use case. This use case is enabled by GIS, CIS, SCADA, AMR/AMI Head End system, and ADMS applications and deployment of distribution and substation automation devices with supporting communications infrastructure.

Figure 44: Fault Location, Isolation, and Service Restoration Use Case



ADMS applications are the primary application for FLISR. SCADA enables dispatchers to monitor and control substation and distribution automation devices (breakers, switches, fault current indicators, and line reclosers) to predict and isolate fault locations. However, the fault location isolation via SCADA will be less efficient and somewhat limited without the connectivity model, state estimation and real-time confirmation, and last gasp information from the AMR/AMI Head End system.

The ADMS enables a more advanced and integrated FLISR application by real-time monitoring of substation- and circuit-level input from SCADA and customer-level input from the AMR/AMI Head End system. The ADMS requires geospatial circuit connectivity and customer location information from integration of GIS and CIS applications. It can use real-time analytics to predict fault locations and control substation and field devices to restore service to as many customers as possible using advanced switching schemes. The SCADA, AMR/AMI Head End system, and ADMS applications leverage the communications infrastructure to communicate with devices in the field.

Some of the electric-delivery specific use cases have similar applications and parallels for water leak and loss detection, which are enabled by a geospatial water connectivity and flow model with customer location information and deployment of smart valves, pumps, and other intelligent devices in the water delivery system. Water SCADA can monitor and control the status of these devices and obtain water flow, quality, or pressure readings at different locations in the system. Together with the customer usage information from AMI/AMR Head End System, water analytics can be conducted for detection and containment or water leaks and losses.

Monetizing Benefits from Use Cases

The major technology project investments of the strategic technology roadmap enable use case capabilities. Benefits are derived from use case categories that are enabled by the major technology projects and are evaluated in the high-level business case.

Benefits shown below are those that can be monetized by assigning a dollar value on a per customer, per year basis. The following are benefits derived for the high-level business case and are listed by use case categories:

- **Remote Meter Reading:** Reducing operating costs from capabilities such as remote meter reading and remote service disconnect/reconnect
- **Revenue Assurance:** Improving revenue capture through improved Smart Meter accuracy and theft detection capabilities
- **Service Outage Management:** Reducing operational costs by improving outage detection efforts
- **Integrated Volt/VAR Control:** Reducing peak demand, energy use, and line losses through increasing electric distribution efficiency
- **Fault Location and Isolation:** Reducing operational costs by improving outage identification and restoration efforts
- **Water Leak and Loss Detection:** Reducing operational costs by improving water leak and loss identification efforts
- **Customer Usage Management:** Enabling conservation and reducing customer energy and water use by providing energy/water usage data to customers

Appendix A details the dollar amounts of benefit assumptions used in the NPV calculations of the high-level business case and describes the approach for application of benefits in each of the four business case options.

ESTIMATED NET PRESENT VALUE OF TECHNOLOGY COSTS AND BENEFITS

The project costs for up-front capital investments are phased in based on the proposed technology roadmap. Ongoing annual operations, maintenance and upgrade expenditures are realized over time at 10% of the deployment costs following each project's deployment. These costs are then translated to a per-customer basis to form a mutual basis for comparison between the costs and estimated benefits. **Figure 45** summarizes the costs as negative values for the Full AMR, Full AMI, and Hybrid ARM/AMI project options.

Figure 45: Estimated Technology Project Costs and Calculated NPV Cost per Customer

RPU Technology Project	AMR Case	Full AMI	Hybrid AMR/AMI
AMR/AMI, HE, Mobile Apps, CIS	Capital: $17.4M O&M: $28.7M NPV: $188/customer	Capital: $36.7M O&M: $61.4M NPV: $401/customer	Capital: $19.6M O&M: $33.0M NPV: $215/customer
OMS, IVR	Capital: $3.7M • O&M: $5.5M • NPV: $59/customer		
ADMS	Capital: $3.4M • O&M: $3.4M • NPV: $39/customer		
DA	Capital: $5.6M • O&M: $9.5M • NPV: $99/customer		
SA	Capital: $1.5M • O&M: $2.7M • NPV: $29/customer		
Totals	Capital: $31.6M O&M: $49.9M NPV: $414/customer	Capital: $50.9M O&M: $82.5M NPV: $626/customer	Capital: $33.7M O&M: $54.1M NPV: $441/customer

The benefits of the use cases enabled by the technology project investments are also phased in based on the proposed technology roadmap, and after implementation is scheduled in the technology roadmap. These monetized benefits are shown as positive values and are stated on a per-customer basis to form a mutual basis for comparison between costs and benefits.

Figure 46 summarizes the NPV of benefits for technology projects as they relate to use case benefit categories and RPU business objectives. This figure and the figure on the previous page) summarize the cost and benefits of technology projects after adjusting for the time value of money with an NPV analysis. NPV values are stated in present-day dollar totals by customer, so costs and benefits can be compared on the same basis and develop a customer-encountered ROI for the business case.

Figure 46: RPU Use Case Benefits and NPV per Customer of Benefits

RPU Technology Project	Use Case Benefit Category	NPV Benefits / Customer				RPU Business Objectives
		AMR Low Case	AMR High Case	Full AMI Case	AMR/ AMI Hybrid Case	
AMR/AMI, HE, Mobile Apps, CIS	Remote Meter Reading	$94	$120	$163	$131	• Increase operational efficiency. • Enhance customer service experience.
	Revenue Assurance	$49	$160	$215	$175	
OMS, IVR / **AMR/AMI, HE**	Service Outage Management	$62	$67	$67	$67	• Increase operational efficiency. • Enhance customer service experience. • Improve reliability.
ADMS / **DA**	Fault Location and Isolation	$97	$194	$194	$194	• Increase operational efficiency. • Enhance customer service experience. • Improve reliability.
AMR/AMI, HE / **SA** / **ADMS**	Integrated Volt/VAR Control	$119	$246	$358	$295	• Promote economic development. • Enhance community service and quality of life. • Improve reliability.
AMR/AMI, HE, Mobile Apps, CIS	Water Leak and Loss Detection	N/A	N/A	$42	$10	• Increase operational efficiency. • Enhance customer service experience. • Improve reliability.
	Customer Usage Management	N/A	N/A	$13	$3	
NPV of Benefit Totals		**$421**	**$787**	**$1,052**	**$874**	

BUSINESS CASE RETURN ON INVESTMENT ANALYSIS

Figure 47 (below) summarizes the NPV of costs and benefits for the AMR High and Low cases, and **Figure 48** (next page) summarizes the NPV of costs and benefits for the Full AMI and Hybrid AMI and AMR cases. The ratio of the benefits to the costs establish an ROI. Both figures also show the ROI for each business case, along with the NPV of cost and benefits.

Figure 47: NPV AMR Cost, AMR Low Benefits Case, and AMR High Benefits Case

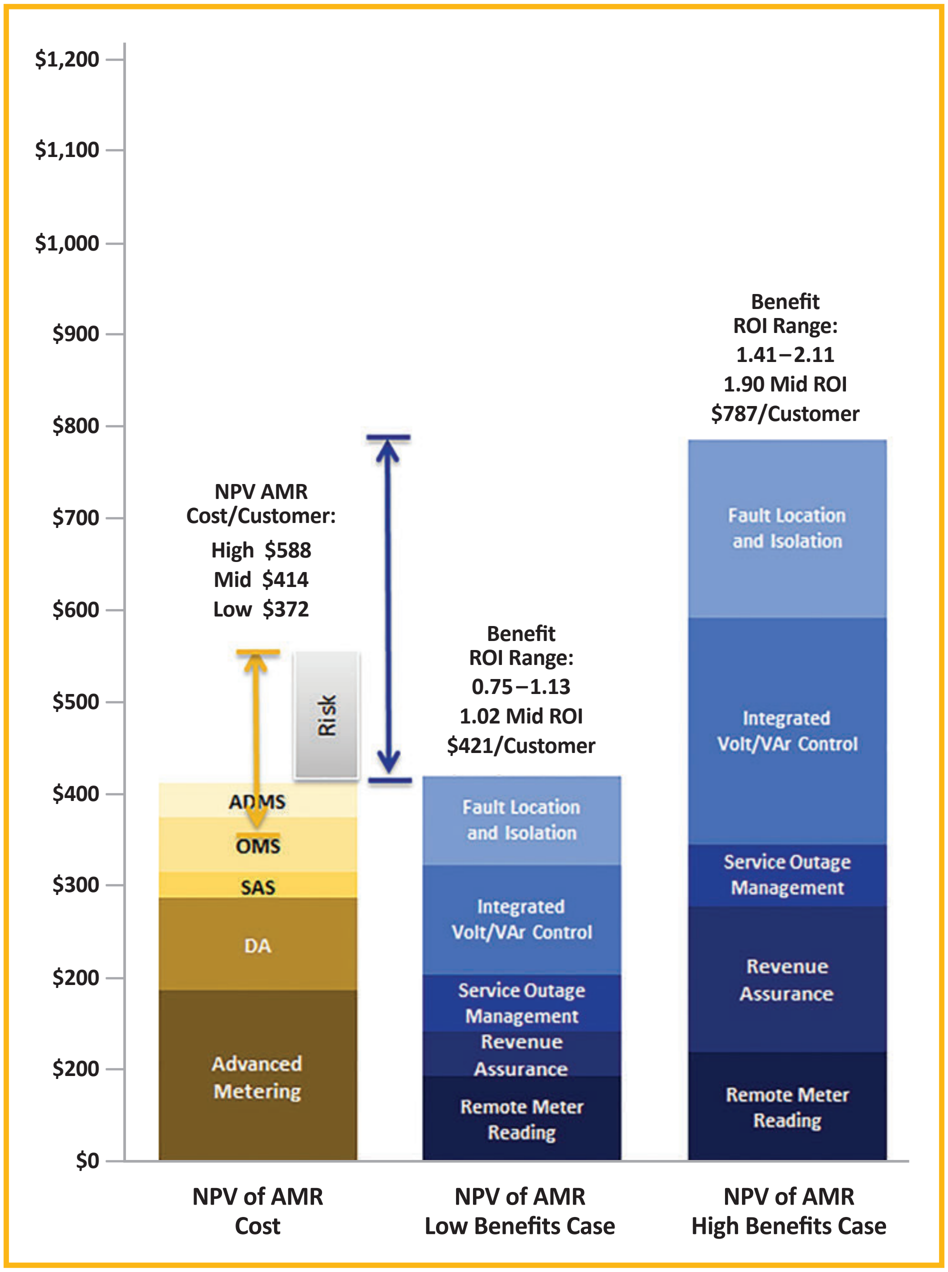
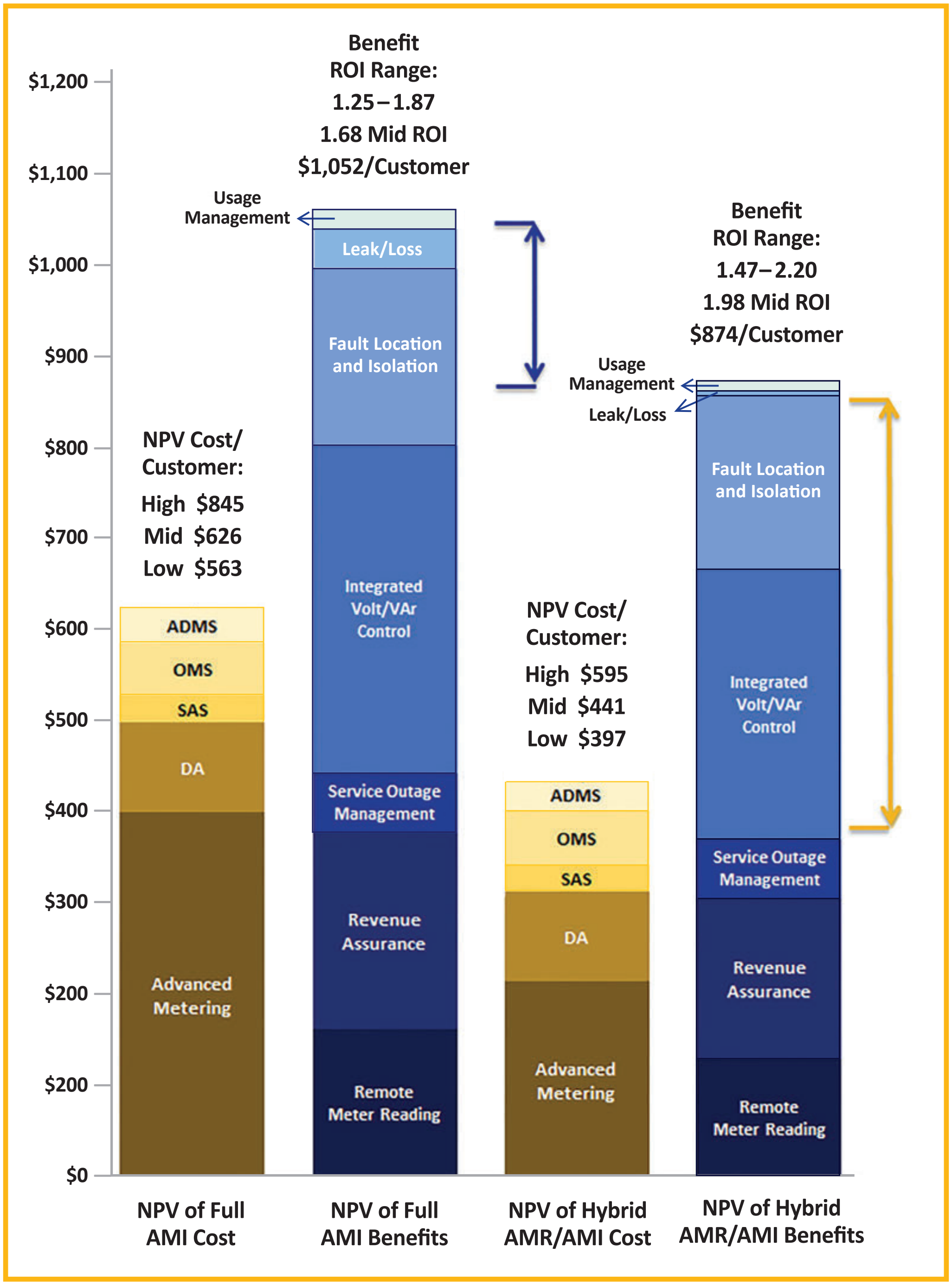


Figure 48: Business Case NPV Cost and Benefits for Full AMI and Hybrid AMR/AMI



Based on the NPV analysis, the ratio of benefits to costs ranges from 1.18–2.20 to 1 in the AMR cases, and 1.91-2.27 to 1 in the full AMI and hybrid AMI/AMR cases, respectively, for a 20-year return period. Subtracting the NPV of total costs from total benefits yields net benefits of approximately $66 per customer in the AMR low benefits case and $509 per customer in the AMR high benefits case.

Although the total benefits are higher for the full AMI business case, the ROI is higher for the AMI/AMR hybrid. Since the ROI is higher for the AMR/AMI hybrid business case option, Leidos recommends pursuing the AMR/AMI hybrid solution as outlined in the strategic roadmap, and recommends doing a more detailed business case, comparing the hybrid AMR/AMI to other full-penetration AMR and AMI detailed business cases.

Since the ROI is higher for the AMR/AMI hybrid business case option, Leidos recommends pursuing the AMR/AMI hybrid solution as outlined in the strategic roadmap.

As this is a strategic, high-level business case using a macroeconomic approach and many of RPU's actual operating conditions were not considered, Leidos recommends producing a detailed business case analysis for the most expensive technology projects. Future detailed business case should be developed using a microeconomic approach, taking into account RPU's actual operating statistics and financial realities.

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TECHNOLOGY IMPLEMENTATION PLANS

This section of the roadmap summarizes the technology implementation plan for each technology program, including project budgets, tasks, and schedule.

The schedule for implementation of all proposed projects covers a 10-year period divided into three phases. The first phase spans Years 1 and 2 (2015–2016); the second phase spans Years 3 through 5 (2017–2019); and the third phase is for Years 6 through 10 (2020–2024).

- **Phase I projects** are mainly driven by "low-hanging fruit" and the desire to complete several inflight projects and initiate foundational projects in the first two years.
- **Phase II projects** are mainly driven by natural evolution of Phase I projects, coupled with continued improvement of RPU operations and practices through deployment of new technology and applications, in alignment with RPU's strategic technology vision.
- **Phase III projects** represent implementation of advanced functionalities and technologies in a more integrated and coordinated utility enterprise environment.

The total estimated cost for implementation of all technology programs is 69.8–103.5 million, which covers project deployment costs only.

The total estimated cost for implementation of all technology programs is **69.8–103.5 million**, which covers project deployment costs only. **Figure 49** provides a breakdown of implementation costs by phase.

Figure 49: Implementation Plan Total Estimated Project Deployment Costs (O&M, Training, and Contingency Costs Not Included)

Phase	Estimated Cost
Phase I (2016–2017)	$27.5–41.1M
Phase II (2018–2020)	$28.0–41.6M
Phase III (2021–2025)	$14.3–20.8M
TOTAL	**$69.8–103.5M**

The costs listed above do not include operations and maintenance (O&M), training, or contingency costs, as outlined below, which should also be considered during project implementation:

- Cumulative O&M costs are $42.9–64.4M at 10% of implementation plan year-over-year technology project costs.
- Training and staff development should be funded at 2–5% of implementation plan technology project costs.
- Contingency funding and management reserve should be funded at 10–15% of implementation plan technology project costs.

The proposed prioritization structure is the mechanism by which the projects have initially been allocated based on if the project was: high priority or foundational (Phase I); medium priority (Phase II), or long-term (Phase III). Additional prioritization may be necessary to identify critical path projects and provide a more leveled cash flow for implementation of the technology projects.

IMPLEMENTATION OF TECHNOLOGY GOVERNANCE, PROJECT MANAGEMENT, AND CYBERSECURITY

There are two overarching programs, as identified below, that enable technology governance and support technology deployments in the technology roadmap. These two programs are both equally important and essential to successful deployment of and realization of benefits from existing and new technology functionality for RPU. The two overarching technology programs relating to technology governance, project management, and cybersecurity are:

- Establish RPU Operation Technology (OT) Office
- Cybersecurity

IMPLEMENTATION PLAN: RPU Operational Technology (OT) Office and Cybersecurity (Technology Governance)

RPU needs to establish an effective OT organization, coordinating efforts with City IT department, to oversee the implementation of the technology projects; completing in-flight projects and implementing technologies already proven to provide customer value before investing in advanced technologies. Part of the OT office's responsibility will be for deploying and administering cybersecurity measures to ensure that sensitive operational data is protected and that sensitive metering and control systems are secured both physically and cyber-digitally.

Figure 50 outlines the implementation plan for establishing an OT organization. The OT office will be specific to RPU's technology needs and provide a focus upon technology specific to RPU's operations. **Figure 50** also illustrates the implementation of a cybersecurity program. Considering the technology projects discussed herein, RPU will need to internally adopt, maintain, and administer cybersecurity standards and business processes.

Figure 50: Implementation Plan —RPU OT Office and Technology Governance (Cybersecurity)

Project	Est. Cost	Phase I (2016, 2017)	Phase II (2018, 2019, 2020)	Phase III (2021, 2022, 2023, 2024, 2025)
OT Office (Operational Technology Office)	$4.4 – 5.5M	• Establish RPU OT office (manager, staff, resources, business processes).	• Manage implementation plan. • Measure and adjust with resources.	• Update Strategic Technology Plan. • Continue implementation plan.
Technology Governance (Cybersecurity measures)		• Cybersecurity, redundancy, and business continuity.	• Strengthen cybersecurity measures.	• Continuous improvements to cybersecurity, redundancy, and business continuity.

Phase I activities for OT mainly focus on development of a City IT and RPU Executive Governance Committee, establishment of the RPU OT office, and hiring an OT manager (reporting to the AGM of Finance) to manage the OT office and future revisions to the Strategic Technology Plan, roadmap, and technology implementation plan. RPU's OT office will foster a culture of project management, business process documentation, and cybersecurity for technology projects.

Phase I will coordinate resources—utility, City IT, or contractors—to ensure successful and timely deployment of the technology projects. Also in Phase I, RPU will assess the existing cybersecurity practices, and identify needs and processes that will be affected with the implementation of the proposed technology projects based on industry best practices applicable to RPU and maturity of these practices.

In Phase II, the OT office will manage, monitor, and track technology implementations, and further identify additional opportunities and lessons learned. In Phase II, RPU will also develop the standards, policies, and procedures for specific systems and processes to establish the cybersecurity guidelines and programs.

In Phase III, the OT office will update the Strategic Technology Plan, roadmap, and technology implementation plan based on progress and newly identified opportunities. Phase III activities will also involve further refinement and hardening of the cybersecurity programs, policies, and procedures to ensure a fully integrated security enterprise.

RPU needs to establish an effective OT organization, coordinating efforts with City IT department, to oversee the implementation of the technology projects.

IMPLEMENTATION OF CUSTOMER-FOCUSED TECHNOLOGIES (IT REALM)

Customer-focused technologies allow RPU to interact with its customers to help them manage their accounts, start and stop service, request service, report outages and problems, and understand their energy and water consumption and costs. These technologies have to allow interaction when, where, and how the customer desires in order meet their service expectations. It is imperative that these technologies work well; and while they must meet RPU's operational needs, meeting the customers' needs is more important.

The technology programs identified in the customer-focused technologies in the IT realm include:

- Customer Information System (CIS) and Customer Relationship Management (CRM)
- Customer Web Portal (CWP)

IMPLEMENTATION PLAN: Customer Information System (CIS), Customer Relationship Management (CRM), and Interactive Voice Response (IVR)

The Customer Information System, Customer Relationship Management, and Interactive Voice Response programs involve a CIS upgrade to enhance utility operations and customer experience with improved workflows and streamlined business processes and operations through enabling technology integrations. **Figure 51** outlines the implementation of the tightly interrelated CIS, CRM, and IVR technology programs. CIS is a core-enabling technology for a large portion of utility businesses and is the technology on the frontline for managing customer account information as well as interactions with customers in conjunction with CRM and IVR.

Figure 51: CIS, CRM, and IVR Implementation

Project	Est. Cost	Phase I 2016 – 2017	Phase II 2018 – 2019 – 2020	Phase III 2021 – 2022 – 2023 – 2024 – 2025
1. CIS (Customer Information System)	$9.2–13.8M	• Integrate IVR and CWP enhancements with CIS.	• Potential enhancements/upgrades. • Document Storage System. • Complete integration with GIS. • Integrate across systems (MDMS, Mobile Apps, permits). • Integrate with ODMS.	• Assess business needs. • Determine possible future enhancements.
2. CRM (Customer Relationship Management)		• Explore additional functionality of 311 system to expand into key account management.	• Develop KPI Dashboard. • Automate marketing and sales processes.	• Implement advanced CRM big data analytics. • Perform sales and marketing performance analysis.
		• Explore and install rebate software options within 311.	• Enhance online and mobile customer experience (e.g., variable messaging). • Implement automated sales and marketing campaigns and surveys.	• Implement advanced customer choice and programs.
		• Upgrade Siebel system (e-service, email response, MAD, mobile application web service, etc.).	• Integrate across systems. • Perform data and performance analysis. • Enable social media-driven customer service and communications.	• Further enhance integration across systems.
3. IVR (Interactive Voice esponse)		• Requirements development and procurement.	• OMS/IVR implementation.	• Advanced outage analytics.
		• CIS data preparation.	• Integrate across systems (CIS, SCADA, AVL).	• Integrate across systems (ODMS, DA).

Phase I CIS and CRM activities involve assessment of needs and business processes, the CIS upgrade, preparation and standardization of customer data, and development of integrations with GIS, MAD, Permits IFAS, and CRM.

Phase II activities mainly focus on deployment of additional functionalities and practices through integrations with CRM, Mobile Apps, MDMS, IVR, and OMS. In this phase, RPU will also develop KPI metrics using data from CRM and social media integration, automated survey processing in both the service and marketing areas, and consolidation of data from CRM, CIS, GIS, AMS, and WMS systems.

In Phase III, RPU will focus on development of advanced and targeted customer choice and programs through advanced data analytics and performance analysis capability of CIS and CRM. RPU will also continue to improve integrations to enable social-media-driven customer service and communications.

IMPLEMENTATION PLAN: Customer Web Portal (CWP)

Figure 52 outlines the implementation of the Customer Web Portal program. The program involves further development of RPU's existing website with additional functionality and improved access to enterprise systems and data, including development of customer Mobile Apps for enabling improved customer self-service.

Figure 52: CWP Implementation

Project	Est. Cost	Phase I	Phase II	Phase III
		2016, 2017	2018, 2019, 2020	2021, 2022, 2023, 2024, 2025
4. CWP (Customer Web Portal)	$3.0–4.5M	• Enhance customer self-service functions.		• Advanced customer self-service and interaction via multiple channels.
		• Upgrade portal and integrate across systems (GIS, MAD, CRM, IVR). • Integrate mobile devices.	• Develop basic outage app and integrate with OMS.	• Advanced OMS-driven outage communication.
		• Integrate social media and provide basic customer apps. • Automate rebates/conservation.	• Integrate across systems. • Pilot customer programs and usage management.	• Advanced meter data analytics and customer programs.

Phase I activities for the CWP mainly focus on upgrading the portal and improving integrations with CIS to enable basic customer self-service functions via the customer portal. RPU will also initiate development of basic Mobile Apps and use of social media.

Phase II activities involve integration of the customer portal with AMI and MDMS to enable customers access to more detailed usage information and pilot customer programs. RPU will also integrate the customer portal with OMS and develop a basic outage app enabling customers to report and access trouble information.

In Phase III, RPU will further refine and advance customer programs through the customer portal, providing enhanced capabilities for meter data analytics and usage management.

IMPLEMENTATION OF INFORMATION-BASED TECHNOLOGIES (IT REALM)

Information-based technologies are used by RPU to improve the effectiveness and efficiency of utility operations. These technologies are generally used every day to perform essential work activities, and usually rely on large collections of historical operating data or information. The information-based technologies are so essential to operations as to be considered operational technolsgy as opposed to information technology, which is governed and maintained by the City's IT department. The technology programs identified in this realm are as follows.

- AMS, WIS, and WMS
- GIS
- Mobile Apps

IMPLEMENTATION PLAN: Asset Management System (AMS), Warehouse Inventory System (WIS), and Work Management System (WMS)

Figure 53 shows the implementation of the Asset Management System, Work Management System, and Warehouse Inventory System—three tightly integrated programs that currently use the enterprise platform from Oracle SPL WorldGroup.

AMS, WMS, and WIS are modules of the same solution for work, asset, and warehouse management. This program involves a reimplementation and expansion of current applications with upgrade to the Oracle platform, as well as a deployment to all utility departments with improved workflows and streamlined business processes and operations through enabling technology integrations.

Figure 53: Implementation Plan — AMS, WIS, and WMS Oracle Improvements

Project	Est. Cost	Phase I		Phase II			Phase III				
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
5. AMS (Asset Management System) 6. WIS (Warehouse Inventory System) 7. WMS (Work Management System)	$5.6 – 8.4M	• Perform needs assessment. • Define business processes. • Complete digital O&M manuals.		• Implementation and integration.			• Control and monitor. • Business intelligence and data analytics and tools.				
		• Create Oracle roadmap. • Track asset value and depreciation.		• Oracle upgrade.			• Streamline integration of RPU enterprise data, processes, systems, and people.				

RPU's current work and asset management solution is on an Oracle platform; however, it needs to be upgraded, which will require considerable adjustments to the WMS, AMS, and WIS module implementations.

Phase I activities mainly focus on assessment of needs and business processes to develop a roadmap for the Oracle upgrade, taking into account the maturity of the existing implementation and prioritization of solution expansion to the other departments.

Phase II activities involve the Oracle upgrade and improvement of integrations to the enQuesta CIS, the Oracle AMS and WIS modules, IFAS, and GIS. In this phase, RPU will also define the key performance indicators (KPIs) and develop dashboards to better monitor and track improvements in operational efficiencies and customer service.

In Phase III, RPU will focus on maximizing the benefits by further refining and tightening enterprise data, process, systems, and people integration to achieve more proactive asset and work management practices supported by advanced data analytics capability. These practices in return will further improve reliability, customer service, operational performance, and the Utility's bottom line.

IMPLEMENTATION PLAN: Geographic Information System (GIS)

Figure 54 outlines the implementation of the Geographic Information System program, which involves modernizing and leveraging the existing RPU GIS technology by upgrading and integrating the GIS with other enterprise systems. This is one of the highest priority projects as GIS, a core-enabling technology, is a critical component of asset management—especially for fixed assets of the utilities' distribution systems—and is an essential component of map-based mobile and operational applications (e.g., OMS, ADMS).

Figure 54: Implementation Plan — GIS CADME Replacement and GIS Improvements

Project	Est. Cost	Phase I		Phase II			Phase III				
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
8. GIS (Geographic Information System)	$4.1–6.2M	• ETL completion.		• CADME RPU replacement.			• Complete UG ductbank/cable inventory/inspections.				
		• CIS premise locations/MAD (master address database) integration.					• Advanced GIS big data analytics and geospatial analysis.				
		• Water Field Maintenance application solution.		• Expand/enhance mobile GIS application.							
		• AutoCAD integration.		• Circuit maps.	• OMS data modeling and input.						

Phase I GIS activities mainly focus on replacement of CADME functionality in the new ArcFM Esri platform for the water and electric utilities, and improvement of GIS workflow, including automated staking and design.

Phase II activities for GIS involve development of electric and water distribution engineering models, additional integrations with MAD, Permits, WMS, AMS, and mobile-enabled GIS processes to enhance operational efficiency and customer service.

In Phase III, RPU will complete and integrate the findings of the complete electric underground ductbank and cable inventory and inspections into the GIS and other platforms for improved capability in GIS data analytics and geospatial analysis.

IMPLEMENTATION PLAN: Mobile Applications (Mobile Apps)

Figure 55 outlines the implementation of the Mobile Applications program. The program involves deployment of Mobile Apps for WMS, CRM, design, staking, inventory collection, inspection, and OMS, with streamlined business processes and operations through enabling technology integrations and communications infrastructure.

Figure 55: Implementation Plan — Mobile Device Enterprise Access and Mobile Applications

Project	Est. Cost	Phase I		Phase II			Phase III				
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
9. Mobile Apps (Mobile Applications)	$3.0–4.5M	• Mobile device management strategy. • Implement PragmaCAD. • Address network infrastructure.		• Improved mobile device access to enterprise system. • Mobile AVL/WMS/AMS/OMS. • Improved fleet communications.			• Improved efficiencies (field, office, customers). • Enhanced customer functions (CWP and mobile CRM). • Advanced mobile enterprise communications (IPvX).				

RPU currently has a limited mobile computing capability with the AMS and WMS. The Mobile Apps program will further enable mobile technology to work with many systems and enhance other aspects of daily work for RPU employees.

Phase I Mobile Apps activities focus mainly on development of a mobile device management strategy for RPU, to enhance access to enterprise systems and data, as well as implementation of PragmaCAD. Mobile Apps will leverage the fixed RF communications network.

Phase II activities involve acquisition, design, development, integration, testing, and deployment of new business practices to enable mobility. Phase II also creates increased mobile access to core enterprise systems as well as Mobile Apps for GIS, WMS, design, staking, inventory collection, inspection, and outage management.

Phase II activities will also involve enhancement of truck communications and integration of AVL with Mobile Apps for GIS, WMS, AMS, and OMS to further streamline operations, enhance customer service, and create operational efficiencies for routine field servicing of day-to-day operations.

Phase III activities mainly focus on maximizing the customer benefits of enterprise mobility through implementation of Mobile CRM and enhancement of customer self service functions via customer portal. In this phase, RPU will further refine mobile processes and integrations, and enable advanced mobile enterprise communications to improve operational efficiencies and streamline real-time information sharing between field, office, and its customers.

IMPLEMENTATION OF OPERATIONAL TECHNOLOGIES (OT REALM)

Operational technologies refer to those systems that interact in real-time with the water and electricity delivery systems and are generally used to make real-time operating decisions. These systems are used to monitor, control, and protect the delivery systems while ensuring reliability, safety, and resiliency.

The technology programs identified in this realm are:

- Operational Data Management System (ODMS)
- Network Communications System (NCS) and Land Mobile Radio (LMR)
- Advanced Metering (AMR, AMI, MDMS)
- Automatic Vehicle Location (AVL)
- Distribution Automation (DA)
- Substation Automation (SA)
- Outage Management System (OMS) and Interactive Voice Response (IVR) for customer outage communications
- Supervisory, Control and Data Acquisition System (SCADA)
- Advanced Distribution Management System (ADMS)

Real-time operational technology systems are used to monitor, control, and protect the delivery systems while ensuring reliability, safety, and resiliency.

IMPLEMENTATION PLAN: Operational Data Management System (ODMS)

The Operation Data Management System program includes creation of a new operational enterprise service bus and implementation of a data gateway that will create the ability to converge the IT and OT service buses. Upon completion, the ODMS will also create a new convergence layer with the data gateway that will allow convergence of the IT and OT realms, Since ODMS will be an RPU-specific technology and primarily managed by RPU, it is categorized in the OT realm.

Figure 56 shows the implementation of the ODMS technology program. The program involves deployment of a non-intrusive platform that will provide the ability to automatically consolidate the contents of distributed databases into a single, centrally located database over a wide area network for all enterprise information. It will serve as an autonomous dynamic repository of enterprise information from a variety of real-time and static sources.

Figure 56: Implementation Plan — ODMS and Related OT Applications

Project	Est. Cost	Phase I (2016–2017)	Phase II (2018–2020)	Phase III (2021–2025)
10. ODMS (Operational Data Management System)	$2.3–3.5M	• Needs assessment (Electric).	• KPI dashboards (Electric).	• Enhance operations efficiency.
		• KPI dashboards (Water).	• Business Intelligence	
		• Prepare and align enterprise data.	• Align and integrate IT and OT operations and data.	• Advanced big data analytics.
		• Procure and implement.	• Converge IT and OT Enterprise Service Bus.	• Optimize and enhance data and integration.

Phase I ODMS activities mainly focus on assessment of needs and business processes, preparation and alignment of enterprise data, and procurement of the ODMS platform.

Phase II activities involve further alignment of IT and OT operations and data, and convergence of IT and OT enterprise service buses (ESBs). In this phase, RPU will also define the key performance indicators (KPIs) and develop dashboards to better monitor and track operational performance and improve decision making by increased enterprise wide visibility.

In Phase III, RPU will focus on maximizing the benefits of ODMS functionality by further enhancing data and integrations and enabling more advanced data analytics.

IMPLEMENTATION PLAN: Network Communications System (NCS) and Land Mobile Radio (LMR)

Figure 57 shows the implementation of the Network Communication System, which includes the Land Mobile Radio program. NCS mainly involves deployment of communication backbone and aggregation layers. This is one of the highest priority projects as the improvements will provide the required infrastructure to realize ALL new functionality such as Fixed Network hybrid AMR/AMI for Water and Electric, DA, Video, and Enterprise Mobility.

Figure 57: NCS and LMR Implementation

Project	Est. Cost	Phase I		Phase II			Phase III				
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
11. NCS (Network Communication System) **12. LMR** (Land Mobile Radio)	$6.9–10.3M	• Improve and expand fiber backbone. • Expand to include Water.					• Scalable communications infrastructure (vendor- and technology-agnostic).				
		• Test/expand aggregation and access layer communications.					• Transition all communications to latest Internet protocol.				
		• Fixed network hybrid AMR/AMI, DA, Video, and enterprise system implementation.									
		• Commission LMR.									

Phase I Communications activities mainly focus on improvement of the fiber backbone through installation of routers and wave divisional multiplexers and commissioning of the LMR, which is a wireless communications system intended for use by terrestrial users in vehicles (mobiles) or on foot (portables). Installation and expansion of the aggregation and access layer communications—routers, point to multi point and point to point repeaters—will be driven by the implementation of the dependent technology projects in Phase I and Phase II.

RPU will further transition all communications needs to IPvX and continue to strengthen the communications infrastructure to ensure a scalable vendor- and technology-agnostic medium in Phase III.

IMPLEMENTATION PLAN: Advanced Metering Infrastructure (AMI) and Meter Data Management System (MDMS)

Figure 58 shows the implementation of the Advanced Metering Infrastructure program, which involves deployment of an hybrid AMR/AMI system with a fixed RF network, and a Meter Data Management System. RPU is currently deploying an AMR system (Itron OpenWay) for its electric meters; however, the current system does not support two-way functionality such as remote connect/disconnect, and does not provide 'last-gasp' reporting for outage management, among other things.

Figure 58: Implementation Plan for Advanced Metering and MDMS

Project	Est. Cost	Phase I	Phase II	Phase III
		2016, 2017	2018, 2019, 2020	2021, 2022, 2023, 2024, 2025
13. AMI (Advanced Metering Infrastructure) **14. MDMS** (Meter Data Management System)	$17.7–26.3M	• Explore options for MDMS.	• AMI Hybrid (selected smart meters at critical locations; Electric only).	• Advanced customer programs with AMI.
		• Address network infrastructure and integrate with SCADA. • Pilot AMI.	• Implement MDMS and integrate across systems.	• Advanced AMI/ big data analytics.
		• Begin rollout of Electric and Water AMR meters. • Begin rollout of Water two-way communication AMR meters.		• Full implementation of AMI metering. • AMI-enabled distribution monitor-ing with ADMS.

Phase I and Phase II advanced metering activities mainly focus on pilot installations of the AMI meters of RPU's electric and water customer population and extending the AMR deployment to the rest of the population (mostly water customers). It also involves deployment and integration of enabling technologies and communication infrastructure. RPU will deploy an MDMS and a AMI head end system with a fixed RF network and develop integrations, including the one with OMS for outage detection.

In Phase III, RPU will mainly focus on further maximizing the benefits of hybrid AMI functionality through design and deployment of advanced customer programs and meter data analytics. With AMI integration, RPU will have AMI-enabled distribution monitoring capability, which is valuable for advanced distribution management applications such as Volt/VAR optimization and system balancing.

IMPLEMENTATION PLAN: Automatic Vehicle Location (AVL)

Figure 59 shows the implementation of the Automatic Vehicle Location program, which mainly involves deployment of an AVL solution with streamlined business processes and operations through enabling technology integrations.

Figure 59: Implementation Plan for Automatic Vehicle Location

Project	Est. Cost	Phase I	Phase II	Phase III
		2016 / 2017	2018 / 2019 / 2020	2021 / 2022 / 2023 / 2024 / 2025
15. AVL (Automatic Vehicle Location)	$0.9–1.4M	• Develop fleet guidelines.	• Acquire and integrate AVL.	• Optimize fleet asset lifecycle and work management.
			• Mobile AVL/WMS/OMS.	• Advanced real-time visualization of operations, assets, crews, and work.
		• Address network infrastructure.	• Improve fleet communications.	• Advanced mobile enterprise communications (IPvX).

Phase I activities for AVL mainly focus on planning for the Phase II acquisition and deployment of the main AVL application and development of fleet management guidelines and business processes. The AVL program requires either a private or public communications network requiring that RPU address its network infrastructure.

Phase II activities involve the acquisition and deployment of an AVL system and the development of fleet management key performance indicators (KPIs), enhancement of truck communications, and integration of AVL with Mobile Apps for GIS, WMS, AMS, and OMS to further streamline operations, enhance customer service, and create operational efficiencies for routine field servicing of day-to-day operations.

Phase III activities mainly focus on maximizing the benefits of AVL and fleet management functionality through further refinement of processes, integrations, and enhancement of mobile communications to increase crew productivity by proactively and geospatially assigned and optimized field work while improving safety and restoration work agility during outages, as well as create efficiencies for routine field servicing of day-to-day operations.

IMPLEMENTATION PLAN: Distribution Automation (DA)

Figure 60 shows the implementation of the Distribution Automation program, which involves a pilot program and a limited expansion of DA devices and enabling communications and technologies to RPU's 20 worst performing circuits. RPU currently has limited visibility of the electric distribution system downline of the breaker.

Figure 60: Implementation Plan for Distribution Automation

Project	Est. Cost	Phase I	Phase II	Phase III
		2016 / 2017	2018 / 2019 / 2020	2021 / 2022 / 2023 / 2024 / 2025
16. DA (Distribution Automation)	$5.0–7.6M	• Pilot DA.	• Expand DA to worst-performing circuits.	• Advanced feeder management, circuit segmentation, FLISR.
		• Address network infrastructure and integrate with SCADA.		• Integrate across systems (ADMS).
				• Advanced feeder data analytics.

Phase I activities mainly focus on a pilot program, which includes deployment of microprocessor-based relays, intelligent electronic devices, faulted circuit indicators, electronic reclosers, and smart switches. As part of the pilot, RPU will integrate all instrumentation with the existing electric SCADA system to monitor and control. RPU will then study the operational benefits and shortcomings of the selected technologies and applications.

In Phase II, RPU will expand the DA rollout to worst performing circuits and integrate with OMS for improved outage management and identification functionality.

With the integration of ADMS in Phase III, RPU will be able to reduce the frequency and number of customers affected by outages and the associated operations and maintenance costs through advanced feeder analytics and management functionality—smart switching, circuit segmentation, and FLISR.

IMPLEMENTATION PLAN: Substation Automation (SA)

Figure 61 shows the implementation of the Substation Automation program. The program involves deployment of SA in the substation control buildings to manage the sub-transmission-level IEDs (equipment in the switchyard – 66 kV) and in switchgears to manage the IEDs in the distribution-level IEDs (switchgear and transformer – 12 kV) and enabling communications and technologies. RPU has already initiated a project and completed deployments in more than 70% of the sub transmission substations and 25% of the distribution switchgear.

Figure 61: Implementation Plan for the Substation Automation System

Project	Est. Cost	Phase I		Phase II			Phase III				
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
17. SA (Substation Automation)	$1.4 – 2.0M	• Design, test, commission, and implement SA.									
		• Address network infrastructure and integrate with SCADA.				• Integrate across systems.	• Coordinate device management for Volt/VAR and switching FLISR.				
				• Formalize protection/coordination and monitoring schemes.			• Integrate across systems.				

This plan captures the SA deployment in RPU's remaining substations and switchgear, excluding customer substations and Clear Water substations (Corona). This program is pivotal to the success of IED implementation and integration of data from the IEDs to enable operations and engineering staff to collect and analyze data regarding the operation of the electrical system.

Phase I activities mainly focus on engineering design, acquisition, testing, and commissioning of SA and related technologies to RPU's remaining substations and switchgear.

In Phase II, RPU will focus on formalizing protection and coordination schemes to further improve power system flexibility and reliability via local autonomous control. With integration to the OMS, SA will limit the impact on customers from outages, enable operational decisions to be made more quickly with more timely data, and improve access to substation data.

With the integration of ADMS in Phase III, RPU will be able to realize more advanced SA system monitoring and coordinated control capabilities that will further enable real-time and automated applications, such as advanced switching schemes, circuit segmentation, FLISR, and Volt/VAR optimization.

IMPLEMENTATION PLAN: Outage Management System (OMS)

Figure 62 shows the implementation of the OMS program, which mainly involves deployment of an OMS and IVR solution with streamlined business processes and operations through enabling technology integrations. Currently RPU does not have a technology-based outage management system. Outage information is currently only passed through radio or telephone from customers to dispatchers and then from dispatchers on to the mobile field staff over the radio or cell phones. Except for dispatcher instructions, paper maps, and their own working operational knowledge, RPU fieldworkers have no visibility of what is happening with the distribution system.

Figure 62: Implementation Plan for Outage Management System and IVR for Outages

Project	Est. Cost	Phase I		Phase II			Phase III				
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
18. OMS (Outage Management System)	$3.3 – 5.0M	• Requirements development and procurement.		• OMS/IVR and mobile OMS implementation.			• Advanced outage analytics.				
		• GIS and CIS data preparation.		• Integrate across systems (GIS).			• Integrate across systems (ODMS, DA).				
					• Integrate across systems (CIS, SCADA, AVL).						

Phase I activities mainly focus on identification of functional and technical requirements for an integrated OMS/IVR solution for automating the outage identification and management processes, preparation of the CIS and GIS data, and the associated procurement activities.

In Phase II, RPU will develop the network connectivity model from GIS, deploy the OMS/IVR solution and integrate it with CIS, SCADA, and AVL solutions to further streamline operations, enhance customer service, and create operational efficiencies for handling planned and unplanned outages. Through its mobile components, OMS will empower dispatch personnel to schedule, prioritize, and assign outage tickets in real time to the field and have real-time status updates sent from the field.

With the ADMS integration in Phase III, the solution will be able to recommend and automatically execute switching operations to reduce the extent of the outage and restore service to as many customers as possible. In addition, as the implementation matures, RPU will be able to conduct advanced outage and root cause analytics to further improve the electric delivery system resilience through more targeted enhancements.

IMPLEMENTATION PLAN: Water/Electric Supervisory Control and Data Acquisition (SCADA) Upgrade and Advanced Distribution Management System (ADMS)

Figure 63 outlines the implementation of the SCADA and ADMS programs.

Figure 63: Water/Electric SCADA and ADMS Implementation

<table>
<tr><th rowspan="2">Project</th><th rowspan="2">Est. Cost</th><th colspan="2">Phase I</th><th colspan="3">Phase II</th><th colspan="5">Phase III</th></tr>
<tr><th>2016</th><th>2017</th><th>2018</th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th></tr>
<tr><td rowspan="10">19. SCADA (Supervisory Control and Data Acquisition)
ADMS (Advanced Distribution Management System)</td><td rowspan="10">$3.0 – 4.5M</td><td colspan="10">• SCADA Upgrade (Electric): Design, test, commission, and implement.</td></tr>
<tr><td colspan="5" rowspan="2">• SCADA Upgrade (Electric): Address network infrastructure, and integrate with SCADA.</td><td colspan="5">• Integration across systems (ADMS).</td></tr>
<tr><td colspan="5">• Advanced feeder data analytics.</td></tr>
<tr><td colspan="2">• SCADA Upgrade (Water): System monitoring Analysis and Energy Management solution selection.</td><td colspan="3">• Implement Energy Management solution and begin installing requisite system monitoring devices.</td><td colspan="5">• Via ODMS, implement OMS and communicate with CIS.</td></tr>
<tr><td colspan="5">• Monitor and track SA and DA to identify ADMS requirements and processes.</td><td colspan="3">• Acquire, test, commission ADMS.</td><td colspan="2"></td></tr>
<tr><td colspan="2" rowspan="3"></td><td colspan="3" rowspan="3">• SME technology & research.</td><td></td><td colspan="2">• Develop ADMS network model.</td><td colspan="2"></td></tr>
<tr><td colspan="2"></td><td colspan="3">• Pilot advanced control functions, FLISR, Volt/VAR.</td></tr>
<tr><td colspan="2"></td><td colspan="3">• Integrate with SCADA, SA, DA, OMS, AMI, MDMS.</td></tr>
</table>

The water and electric SCADA systems will receive significant improvements. The existing Electric SCADA system is not designed for DA, SA, or OMS. The existing Water SCADA system is capable of receiving data and controlling most production and distribution facilities, but has limited capability to monitor system pressures and flows or analyze energy usage and water loss.

As part of the NCS upgrades, the capabilities of the communications system that connects remote terminal units in substations, generating facilities, and water collection/conveyance/treatment facilities will be upgraded to allow more monitoring and control of endpoints and increased bandwidth for transmission of higher resolution data.

As part of the SCADA initiative, sensing devices and RTUs will be added or upgraded throughout the system. As part of the water advanced metering initiative, additional pressure and flow sensing devices will be added to the water distribution system to optimize operations, enhance leak detection, reduce water losses, and reduce the amount of energy consumed in the collection, treatment, storage, and delivery of water.

The ADMS program involves deployment of systems used to optimize the capability, efficiency, reliability, and security of water and electric delivery systems. For RPU, ADMS is a long-term vision.

There is no proposed technology investment activity in Phase I for ADMS. Phase II and Phase III activities for ADMS focus mainly on conducting research in coordination with monitoring and tracking the SA and DA program results, to identify the requirements and processes that will be affected to achieve ADMS. RPU will also need to identify Subject Matter Experts (SMEs) to spearhead the deployment of ADMS.

The ADMS will be an extension of the SCADA systems, and the vendors providing the ADMS application functionality will likely be the same vendor as the SCADA systems currently in place. SCADA upgrades were recently put in place at RPU, and the ADMS-related activities are envisioned as the future major upgrades necessary to the SCADA systems that complement DA and bring in the new ADMS functionality necessary.

In Phase III, RPU will focus on acquisition and deployment of an ADMS solution, developing the ADMS network model and the integrations with other technologies to enable voltage optimization (i.e., Volt/VAR optimization and conservation voltage regulation/reduction); fault location, isolation, and restoration (FLISR); outage management; and state estimation for electric delivery system.

Because the water and electric delivery have different SCADA systems, it is likely that separate ADMS systems to support water and electric delivery purposes may evolve independently, but both will need to provide data to the OT service bus for enterprise data sharing.

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PLAN TASK SUMMARY AND KEY RECOMMENDATIONS

This section provides a summary of project tasks for the overall Strategic Technology Plan, as well as the key conclusions and recommendations from the technical memos delivered with each task.

STRATEGIC TECHNOLOGY PLAN TASK SUMMARY

The strategic technology plan was devised with an incremental deliverable approach that called for development of technical memos as a deliverable for each project task. Throughout the project duration of the strategic technology plan, evolution of technology projects in flight may have led to discovery that affected the outcome of recommendations in the final report that differ from the previously accepted technical memos, as they were delivered at a given point in time, previous to that discovery. The conclusions shown here are current as of the final report of the strategic technology plan, and may differ slightly from those in previous technical memos of the project. **Figure 64** outlines the strategic technology plan project tasks and objectives and the key conclusions and recommendations from each project task.

Figure 64: Strategic Technology Plan Project Tasks, Objectives, Conclusions, and Recommendations

Strategic Technology Plan Project Tasks and Objectives	Key Conclusions and Recommendations
Visioning for Technology	
• Executive and stakeholder engagement. • Establish vision for technology. • SWOT analysis.	• Define near-term technology goals. • Technology vision statements. • Technology strategies and goals. • Alignment of technology goals with vision. • High-level prioritization of technology goals.
Current State Assessment, Needs Assessment, and Gap Analysis	
• Current state assessment. • Technology needs assessment. • Gap analysis of strategic technology needs.	• Established functional technology areas: OT Realm and need to coordinate IT governance. • Identified need for project management of technology projects, OT Manager, and organizational needs. • Developed current-state architecture diagram, gaps, recommendations, and business benefits of implementing the technology recommendations.
Cybersecurity Assessment	
• Assess maturity of cybersecurity practices. • Establish industry best practices applicable to RPU: – NERC/CIP – NIST 800-53 – ISO 27001/2 • Make recommendations for strategic cybersecurity goals.	• Update and improve patch processes. • Improve account management. • Establish disaster control for critical technologies. Improve existing disaster control for SCADA. • Improve and update policies, procedures, and process documentation. • Improve vendor management. • Implement technology asset management. Develop process to maintain process documentation. • Improve data protection standards and control practices.

Strategic Technology Plan Project Tasks and Objectives	Key Conclusions and Recommendations
Strategic Roadmap	
• Outline technology activities over 10-year horizon. • Provide compelling business case for technology investments.	• Provide phased approach to technology investments. • Build foundational technology infrastructure. • Manage and balance technology project portfolio investments. • Periodically update the Strategic Technology Plan. • The high-level business case provides positive ROI by using a leveraged approach to AMR, and applying AMI strategically with Hybrid AMR/AMI to leverage AMR and communications technology investments. • Develop detailed business case justifications for AMI and most expensive capital investments in technology.
Communications Systems Roadmap and Preliminary Design	
• Establish communication system capabilities and business needs. • Analyze communication systems technology options. • Recommend architecture. • Provide Fiber and LMR recommendations. • Provide Water SCADA specific designs.	• Adopt a layered network architecture with a decoupled network design to provide extensibility while maintaining simplicity. • Use routing techniques to provide resilience. • Use standard techniques such as quality of service management and virtual LANs. • Adopt a network design with three layers—backbone, aggregation, and access. • DWDM or other logical segmentation for fiber in lieu of additional fiber pulls. • NXDN for LMR, implemented with phased approach. • Deploy a suitable firewall to provide boundary between wireless network and SCADA control system. • Provide redundancy to failure of UOC facility for resiliency. • Water SCADA has grown in number of endpoints beyond initial design limits; add routers and bandwidth to help underperforming SCADA communications throughput, responsiveness, reliability, and scalability.
Integration and Mobile App Architecture	
• Establish data and application architecture for integration. • Establish a strategic roadmap specific to Mobile Apps.	• Adopt an enterprise integration architecture through new operational data service bus and leveraging the in-place IT service bus. • Proposed enterprise integration architecture RPU should consider is composed of three layers: Transaction Layer, Real-Time Layer, and Convergence Layer. • Harmonize integration and mobile computing efforts with City IT. • Establish an operational service bus for IT/OT system integration to make critical operational system information available. • Create process flow diagrams. • Implement paperless timecards. • Improve mobile access to enterprise systems. • Implement AVL, WMS, and Mobile Apps for CRM, design, staking, OMS, and inventory and inspection.
Organizational Structure Supporting Technology	
• Establish organizational structure to support elements of RPU-specific technology. • Determine ways to liaison with City IT department.	• Establish Operational Technology (OT) office. • Hire OT Manager (reporting to AGM of Finance) to manage the OT office and future revisions to the Strategic Technology Plan, roadmap, and technology implementation plan. • Foster a culture of project management, business process documentation, and cybersecurity for technology projects. • Organize a City IT/RPU Executive Governance Committee. • Develop service level agreements (SLAs) between City IT and RPU. • Resource needs coordinated through OT office may include many existing resources, but periods of more intense investment may require outsourcing.

Strategic Technology Plan Project Tasks and Objectives	Key Conclusions and Recommendations
Implementation Plan	
• Develop 5-year implementation plan with detailed costs and project tasks, strategic-level planning and budgeting. • Estimate ongoing operation and maintenance technology lifecycle costs.	• Phase I (2016–2017) $27M. • Phase II (2018–2020) $26M. • Phase III (2021–2025) $4+M. • Cumulative O&M cost is $18.4M at 10% of implementation plan year-over-year technology project costs. • Training and staff development should be funded at 2-5% of implementation plan technology project costs. • Contingency funding and management reserve should be funded at 10–15% of implementation plan technology project costs. • Initial project prioritization. • Schedules and budgets by phase for each technology project. • Critical path and technology project predecessor tasks. • Additional prioritization may be necessary to provide a more leveled cash flow for technology projects. • Establishes high-level resource needs at an average 7.5 full time exempt (FTE) over the 10-year horizon.

The conclusions and recommendations listed above are specific to the specific working deliverable in the technical memos of the strategic technology plan project. Some recommendations may have evolved or new recommendations added with organizational changes and factors changing with projects currently in flight.

TOP TEN STRATEGIC TECHNOLOGY RECOMMENDATIONS

The following subsection captures the Top Ten recommendations of the final report of the strategic technology plan, organized by technology area. **Figure 65** provides a summary of the Top Ten recommendations from the strategic technology plan and is intended as a single point from which major recommendations as a part of the overall strategic technology plan may be referenced.

Figure 65: Top Ten Key Recommendations for Strategic Technology Plan (not in any particular order)

No.	Recommendation	Benefit to RPU
1	Provide a periodic update (annually or biennially) to keep the Strategic Technology Plan current and in alignment with business objectives.	Align technology investments with business objectives. Position RPU to be more agile and resilient to external market changes and internal drivers.
2	Hire the Operations Technology Manager and develop the Office of Operations Technology and supporting staff.	Complete successful technology projects. Ensure technology program requirements align with KPIs and SLAs. Enable standards and cybersecurity.
3	Use new OT office and organizational structure to foster a culture of project management through SLAs and KPI tracking.	Enable organizational change that positions RPU to be resilient to technology change and market drivers; Ensure maximization of benefit from technology investments through meeting project goals.
4	Adopt an enterprise integration architecture through new operational data service bus and leveraging the in-place IT service bus.	Reduce data silos and reduce labor effort to access critical operating data. Enable enterprise integration and allow access of operational data to provide more real-time decision making.
5	Improve mobile access to enterprise systems and layer on new Mobile Apps to enable mobile capabilities with AVL, Service orders, OMS, AMS, and WMS. Integrate geographic context for Mobile Apps.	Enhance customer service. Increase crew safety and efficiency. Increase staff efficiency and work scheduling efficiencies.
6	Implement strategic communications backbone, aggregation, and access layers to enable automatic reading for AMR, AMI, and advanced distribution system monitoring and control capabilities.	Create a communications technology infrastructure to support advanced distribution system monitoring and control. Enable AMR, AMI, and Mobile Apps. Position RPU to take advantage of additional communication business opportunities.
7	Deploy Hybrid AMR/AMI and develop a detailed business case analysis to assign the appropriate penetration level of AMI.	Produce remote meter reading benefits in revenue assurance; Enable AMI benefits for less cost for advanced customer and distribution system programs.
8	Implement improvements to AMS and WMS, including enterprise Fleet Management with AVL.	Enhance AMS and WMS. Improve fleet utilization, tracking, maintenance, and lifecycle management. Increase crew safety and efficiency.
9	Provide a customer Mobile App for self-service, rebate, outage, and usage tracking functions. Provide ability for customers to review their energy and water consumption data via the CWP or a Mobile App.	Increase customer convenience. Enhance customer service. Reduce usage and strain on limited resources. Increase customer confidence during outages and disasters. Position RPU to take advantage of distributed energy resources. Variable rate structures.
10	Deploy OMS and ADMS.	Provide service outage restoration benefits. Provide benefits from Volt/VAR, FLISR, and advanced distribution monitoring and control capabilities.

APPENDIX A: BUSINESS CASE BENEFIT ASSUMPTIONS

This appendix provides a summary of the assumed benefits used when developing the four business case options and how the benefits were applied in each option. Each business case option considered benefits for technology investments from categories outside of advanced metering in the categories of DA, SA, OMS, ADMS, and communications investments to enable desired use cases. The four business case options varied the advanced metering technologies (AMR and AMI) used while holding the DA, SA, OMS, ADMS, and communications technology solutions constant.

Benefit values are determined based on the industry benchmarks and Leidos experience from conducting business case assessments for utility clients. The AMR Low Case was developed to have a conservative estimate of benefits and represents a business case for technology at the low end of the benefit value spectrum. Benefits used in the "AMR High Case" option represent higher-end benefit values for AMR technology, yet are still realistic. The AMR High case reflects optimistic benefits, but uses a more conservative estimate of benefits than seen in some of the highest benefit estimates available in industry reports.

Considering RPU's implementation of AMR technology and its expansion to AMI, Leidos used conservative, mid-range benefit estimates for the Full AMI case and the AMR/I Hybrid, based on its experience and industry benchmarks.

For some benefits, the same value for the benefit is used but is allocated and realized differently over the years in the different business case options, depending on the technology. For instance, additional revenue protection benefits are available to full AMI versus the AMR and AMR/I hybrid. It is the same benefit but differs throughout the options in that it can be more fully realized with a full population of AMI meters. **Figure 66** summarizes how benefits are realized by the different underlying technologies in the business case option.

Figure 66: Business Case Benefit Assumptions

<table>
<tr><th>Case</th><th>AMR Low</th><th>AMR High</th><th>Full AMI</th><th>AMR/I Hybrid</th></tr>
<tr><td>Meter Reading

Revenue Assurance</td><td colspan="2">Water or electric AMR meters without RF network receive 50%.

Water or electric AMR meters with RF network receive 75%.

10,000 electric AMI meters receive 100% of the benefit.</td><td>All meters receive 100% of the benefits.</td><td>Water or electric AMR meters with RF network receive 75%.

Water or electric AMI meters (25% of population) receive 100% of benefits.</td></tr>
<tr><td>Service Outage Management</td><td colspan="4">Primarily driven by OMS. CAIDI allocated in the same manner across all cases. Outage I&R time used a lower estimate for AMR low case, but the same average estimate for the high, full, and hybrid cases.</td></tr>
<tr><td>Integrated Volt/VAR Control</td><td>Applies to electric AMR/I meters.

Receive 30% of benefits until ADMS deployment and receive 50% thereafter.</td><td>Applies to electric AMR/I meters.

Receive 50% of benefits until ADMS deployment and receive 70% thereafter.</td><td>Applies to electric AMI meters.

Receive 70% of benefits until ADMS deployment and receive 100% thereafter.</td><td>Applies to electric AMR/I meters.

Receive 60% of benefits until ADMS deployment and receive 80% thereafter.</td></tr>
<tr><td>Fault Location and Isolation</td><td colspan="4">Only applies to the 20 worst performing circuits with DA deployment.

Receive 50% of the benefits until ADMS deployment, and then receive 100% thereafter.</td></tr>
<tr><td>Water Leak, and Loss Detection</td><td></td><td></td><td>Applies to all water AMI meters.</td><td>Applies to water AMI meters (25% of water meter population).</td></tr>
<tr><td>Customer Usage Management</td><td></td><td></td><td>Applies to electric and water AMI meters.</td><td>Applies to water and electric AMI meters (25% of all meter population).</td></tr>
</table>

AMR LOW BENEFITS CASE

Remote meter reading and disconnect

- Average reduction in routine and special meter reading—Electric: $13.68 savings per customer; Water: $10.68 savings per customer.
  - Water or electric AMR meters w/o fixed RF network (2016-2017) receive 50% of the benefits due to elimination of manual reads but still requires walk-by or drive-by meter reading.
    - $6.84 per electric AMR customer.
    - $5.34 per water AMR customer.
  - Water or electric AMR meters with fixed RF network which is phased in over the course of three years, 2018-2020, receive 75% of the benefits due to elimination of drive-by or walk-by meter reading.
    - $10.26 per electric AMR customer with fixed RF network.
    - $8.01 per water AMR customer with fixed RF network.
  - 10,000 electric AMI meters, which are phased in over the course of eight years, 2018-2025, receive 100% of the benefits due to additional capabilities enabled by these meters.
    - $13.68 per electric AMI customer.
    - Water: N/A.
- Average reduction in connect/disconnect services—Electric: $0.07 min savings per customer.
  - Only applies to 10,000 electric AMI meters with service switches which are phased in over the course of eight years, 2018-2025.
  - Water: N/A.

Revenue Assurance

- Average reduction in theft and unbilled/uncollectable account handling—Electric: $3.00 savings per customer; Water: $12.58 savings per customer.
  - Water or electric AMR meters w/o fixed RF network (2016-2017) receive 50% of the benefits.
    - $1.5 per electric AMR customer.
    - $6.29 per water AMR customer.
  - Water or electric AMR meters with fixed RF network which is phased in over the course of three years, 2018-2020, receive 75% of the benefits.
    - $2.25 per electric AMR customer with fixed RF network.
    - $9.44 per water AMR customer with fixed RF network.
- 10,000 electric AMI meters which are phased in over the course of eight years, 2018-2025, receive 100% of the benefits.
    - $3.00 per electric AMI customer.
    - Water: N/A.

Service Outage Management

- Average reduction in outage identification and restoration time—Electric: $1.18 savings per customer.
- Average reduction in customer interruption duration (CAIDI)—4.5%[1] decrease in customer minutes.
- Driven by the implementation of the OMS system in 2020 and realized thereafter.

Integrated Volt/VAR Control

- Average reduction in peak demand—1.8%[2], $6.22 per electric customer.
- Average reduction in energy use—2.2%[3], $22.88 per electric customer.
- Average reduction in line losses—3%[4], $1.20 per electric customer.
- Applies to electric AMR/AMI meters with fixed RF network which are phased in over the course of three years, 2018-2020.
  - Receive 30% of benefits until ADMS deployment (2018-2025) due to limited deployment of AMI meters (9% of population).
    - Average reduction in peak demand: $1.87 (30% of $6.22 per electric customer).
    - Average reduction in energy use: $6.86 (30% of $22.88 per electric customer).
    - Average reduction in line losses: $0.36 (30% of $1.20 per electric customer).
  - Receive 50% of benefits after the ADMS deployment, 2026 and on, due to limited deployment of AMI meters (9% of population).
    - Average reduction in peak demand: $3.11 (50% of $6.22 per electric customer).
    - Average reduction in energy use: $11.44 (50% of $22.88 per electric customer).
  - Average reduction in line losses: $0.60 (50% of $1.20 per electric customer).

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1 Adjusted SGCC estimate, which is based on 4.5% decrease in customer minutes per year for 2013 RPU CAIDI of 72.40 customer minutes.

2 Adjusted SGCC estimate per SGIG projects average demand reduction of 1.8% (1-2.5%).

3 Adjusted SGCC estimate per SGIG projects average energy reduction of 2.2%.

4 Most SGIG projects observed 0-5% reduction in line losses with few feeders over 5%. Industry research stated in SGIG report indicates 5-10% reduction in line losses due to Volt/VAr optimization. Assuming half of RPU's 2013 losses are due to line losses and 3% reduction for low case and 7% reduction for high case in line losses at the average RPU rate for $137.8/MWh.

Fault Location and Isolation

- Average reduction in system average interruption duration (SAIDI)—25%[5] improvement on RPU's top 20 worst performing circuits.
- Only applies to the 20 worst performing circuits with DA deployment.
  - Receive 50% of the benefits until the ADMS deployment, 2018-2025.
  - Receive 100% of benefits after the ADMS deployment, 2026 and beyond.

AMR HIGH BENEFITS CASE

Remote meter reading and disconnect

- Average reduction in routine and special meter reading—Electric: $15.85 savings per customer; Water: $15.74 savings per customer.
  - Water or electric AMR meters w/o fixed RF network (2016-2017) receive 50% of the benefits due to elimination of manual reads but still requires walk-by or drive-by meter reading.
    - $7.93 per electric AMR customer.
    - $7.87 per water AMR customer.
  - Water or electric AMR meters with fixed RF network which is phased in over the course of three years, 2018-2020, receive 75% of the benefits due to elimination of drive-by or walk-by meter reading.
    - $11.89 per electric AMR customer with fixed RF network.
    - $11.80 per water AMR customer with fixed RF network.
  - 10,000 electric AMI meters which are phased in over the course of eight years, 2018-2025, receive 100% of the benefits due to additional capabilities enabled by these meters.
  - $15.85 per electric AMI customer.
  - Water: N/A.
- Average reduction in connect/disconnect services—$3.35 average savings per customer.
  - Only applies to 10,000 electric AMI meters with service switches which are phased in over the course of eight years, 2018-2025.
  - Water: N/A

5 Adjusted SGCC estimate per SGIG projects average reduction of SAIDI (+4% to -56%). Assumed 25% reduction for low case and 50% reduction for high case on RPU's top 20 worst performing circuits.

Revenue Assurance

- Average reduction in theft and unbilled/uncollectable account handling—Electric: $9.00 savings per customer; Water: $42.21 savings per customer.
  - Water or electric AMR meters w/o fixed RF network (2016-2017) receive 50% of the benefits.
    - $4.5 per electric AMR customer.
    - $21.11 per water AMR customer.
  - Water or electric AMR meters with fixed RF network which is phased in over the course of three years, 2018-2020, receive 75% of the benefits.
    - $6.75 per electric AMR customer with fixed RF network.
    - $31.66 per water AMR customer with fixed RF network.
  - 10,000 electric AMI meters which are phased in over the course of eight years, 2018-2025, receive 100% of the benefits.
    - $9.00 per electric AMI customer.
    - Water: N/A.

Service Outage Management

- Average reduction in outage identification and restoration time—Electric: $1.71 saving per customer.
- Average reduction in customer interruption duration (CAIDI)—4.5%[6] decrease in customer minutes.
- Driven by implementation of the OMS system in 2020 and realized thereafter.

6 Adjusted SGCC estimate, which is based on 4.5% decrease in customer minutes per year for 2013 RPU CAIDI of 72.40 customer minutes.

Integrated Volt/VAR Control

- Average reduction in peak demand—3.25%, $11.24 per electric customer.
- Average reduction in energy use—2.7%, $28.08 per electric customer.
- Average reduction in line losses—7%[7], $2.81 per electric customer.
- Applies to electric AMR/AMI meters with fixed RF network which are phased in over the course of three years, 2018-2020.
  - Receive 50% of benefits until ADMS deployment (2018-2025) due to limited deployment of AMI meters (9% of population).
    - Average reduction in peak demand: $5.62 (50% of $11.24 per electric customer).
    - Average reduction in energy use: $14.04 (50% of $28.08 per electric customer).
    - Average reduction in line losses: $1.41 (50% of $2.81 per electric customer).
  - Receive 70% of benefits after the ADMS deployment, 2026 and on, due to limited deployment of AMI meters (9% of population).
    - Average reduction in peak demand: $7.87 (70% of $11.24 per electric customer).
    - Average reduction in energy use: $19.66 (70% of $28.08 per electric customer).
    - Average reduction in line losses: $1.97 (70% of $2.81 per electric customer).

Fault Location and Isolation

- Average reduction in system average interruption duration (SAIDI)—50%8 improvement on RPU's top 20 worst performing circuits.
- Only applies to the 20 worst performing circuits with DA deployment.
  - Receive 50% of the benefits until the ADMS deployment, 2018-2025.
  - Receive 100% of benefits after the ADMS deployment, 2026 and beyond.

7 Most SGIG projects observed 0-5% reduction in line losses with few feeders over 5%. Industry research stated in SGIG report indicates 5-10% reduction in line losses due to Volt/VAr optimization. Assuming half of RPU's 2013 losses are due to line losses and 3% reduction for low case and 7% reduction for high case in line losses at the average RPU rate for $137.8/MWh.

8 Adjusted SGCC estimate per SGIG projects average reduction of SAIDI (+4% to -56%). Assumed 25% reduction for low case and 50% reduction for high case on RPU's top 20 worst performing circuits.

FULL AMI CASE

Remote meter reading and disconnect

- Average reduction in routine and special meter reading—Electric: $15.85 savings per customer; Water: $15.74 savings per customer.
  - Full water and electric AMI meters with fixed RF network deployment which is phased in over the course of five years, 2016-2020.
  - All meters receive 100% of the benefits.
    - $15.85 per electric AMI customer.
    - $15.74 per water AMI customer.
- Average reduction in connect/disconnect services—$6.32 max savings per customer; Water: $4.36 max savings per customer.
  - Applies to 10% of the electric and water meters, phased in over the course of four years, 2017-2020, that have AMI meters and service switches.
    - $6.32 per electric AMI customer.
    - $4.36 per water AMI customer.

Revenue Assurance

- Average reduction in theft and unbilled/uncollectable account handling—Electric: $9.00 savings per customer; Water: $42.219 savings per customer.
- Full water and electric AMI meters with fixed RF network deployment 2016-2020.
- All meters receive 100% of the benefits.
    - $9.00 per electric AMI customer.
    - $42.21 per water AMI customer.

Service Outage Management

- Average reduction in outage identification and restoration time—Electric: $1.71 saving per customer.
- Average reduction in customer interruption duration (CAIDI)—4.5%[10] decrease in customer minutes.
- Driven by the implementation of the OMS system in 2020 and realized thereafter.

9 Adjusted SGCC estimate, which is based on 4.5% decrease in customer minutes per year for 2013 RPU CAIDI of 72.40 customer minutes.

10 Adjusted SGCC estimate, which is based on 4.5% decrease in customer minutes per year for 2013 RPU CAIDI of 72.40 customer minutes.

Integrated Volt/VAR Control

- Average reduction in peak demand—3.25%, $11.24 per electric customer.
- Average reduction in energy use—2.7%, $28.08 per electric customer.
- Average reduction in line losses—7%[11], $2.81 per electric customer.
- Applies to electric AMI meters with fixed RF network which are phased in over the course of five years, 2016-2020
  - Receive 70% of benefits until ADMS deployment (2016-2025).
    - Average reduction in peak demand: $7.87 (70% of $11.24 per electric customer).
    - Average reduction in energy use: $19.66 (70% of $28.08 per electric customer).
    - Average reduction in line losses: $1.97 (70% of $2.81 per electric customer).
  - Receive 100% of benefits after the ADMS deployment, 2026 and beyond.
    - Average reduction in peak demand: $11.24.
    - Average reduction in energy use: $28.08.
    - Average reduction in line losses: $2.81.

Fault Location and Isolation

- Average reduction in system average interruption duration (SAIDI)—50%[12] improvement on RPU's top 20 worst performing circuits.
- Only applies to the 20 worst performing circuits with DA deployment.
  - Receive 50% of the benefits until the ADMS deployment, 2018-2025.
  - Receive 100% of benefits after the ADMS deployment, 2026 and beyond.

Water Leak & Loss Detection

- Average reduction in water leak and losses—$11.0413 savings per customer.
- Applies to all water AMI meters which are phased in over the course of five years, 2016-2020.

11 Most SGIG projects observed 0-5% reduction in line losses with few feeders over 5%. Industry research stated in SGIG report indicates 5-10% reduction in line losses due to Volt/VAr optimization. Assuming half of RPU's 2013 losses are due to line losses and 3% reduction for low case and 7% reduction for high case in line losses at the average RPU rate for $137.8/MWh.

12 Adjusted SGCC estimate per SGIG projects average reduction of SAIDI (+4% to -56%). Assumed 25% reduction for low case and 50% reduction for high case on RPU's top 20 worst performing circuits.

13 Average of water loss and leak prevention impact per customer meter based on Bartlesville and LVMWD AMR/AMI business cases.

Customer Usage Management

- Average reduction in customer energy and water use—$1.35 average savings per customer.
- Applies to all electric and water meters which are phased in over the course of five years, 2016-2020.

HYBRID AMR/AMI CASE

Remote meter reading and disconnect

- Average reduction in routine and special meter reading—Electric: $15.85 savings per customer; Water: $15.74 savings per customer.
  - Water or electric AMR meters with fixed RF network (75% of the meter population) which are phased in over the course of five years, 2016-2020, receive 75% of the benefits.
    - $11.89 per electric AMR customer with fixed RF network.
    - $11.80 per water AMR customer with fixed RF network.
  - Water and electric AMI meters (25% of the meter population) which are phased in over the course of four years, 2017-2020, receive 100% of the benefits.
    - $15.85 per electric AMI customer.
    - $15.74 per water AMI customer.
- Average reduction in connect/disconnect services—$3.35 average savings per customer; Water: $2.18 average savings per customer.
  - Applies to 10% of the electric and water meters, phased in over the course of four years, 2017-2020, that have AMI meters and service switches.
    - $3.35 per electric AMI customer.
    - $2.18 per water AMI customer.

Revenue Assurance

- Average reduction in theft and unbilled/uncollectable account handling—Electric: $9.00 savings per customer; Water: $42.21 savings per customer.
  - Water or electric AMR meters with fixed RF network (75% of the meter population) which are phased in over the course of five years, 2016-2020, receive 75% of the benefits.
    - $6.75 per electric AMR customer with fixed RF network.
    - $31.66 per water AMR customer with fixed RF network.
  - Water and electric AMI meters (25% of the meter population) which are phased in over the course of four years, 2017-2020, receive 100% of the benefits.
    - $9.00 per electric AMI customer.
    - $42.21 per water AMI customer.

Service Outage Management

- Average reduction in outage identification and restoration time—Electric: $1.71 saving per customer.
- Average reduction in customer interruption duration (CAIDI)—4.5%14 decrease in customer minutes.
- Driven by the implementation of the OMS system in 2020 and realized thereafter.

Integrated Volt/VAR Control

- Average reduction in peak demand—3.25%, $11.24 per electric customer.
- Average reduction in energy use—2.7%, $28.08 per electric customer.
- Average reduction in line losses—7%15, $2.81 per electric customer.
- Applies to electric AMI meters with fixed RF network which are phased in over the course of four years, 2017-2020.
    - Receive 60% of benefits until ADMS deployment (2017-2025) due to limited deployment of AMI meters (25% of population).
        - Average reduction in peak demand: $6.74 (60% of $11.24 per electric customer).
        - Average reduction in energy use: $16.85 (60% of $28.08 per electric customer).
        - Average reduction in line losses: $1.68 (60% of $2.81 per electric customer).
    - Receive 80% of benefits after the ADMS deployment, 2026 and on, due to limited deployment of AMI meters (25% of population).
        - Average reduction in peak demand: $8.99 (80% of $11.24 per electric customer).
        - Average reduction in energy use: $22.46 (80% of $28.08 per electric customer).
        - Average reduction in line losses: $2.25 (80% of $2.81 per electric customer).

Fault Location and Isolation

- Average reduction in system average interruption duration (SAIDI)—50%[16] improvement on RPU's top 20 worst performing circuits.
- Only applies to the 20 worst performing circuits with DA deployment.
    - Receive 50% of the benefits until the ADMS deployment, 2018-2025.
    - Receive 100% of benefits after the ADMS deployment, 2026 and beyond.

Water Leak & Loss Detection

- Average reduction in water leak and losses—$11.04[17] savings per customer.
- Only applies to 25% of the water meters with AMI and fixed RF network which are phased in over the course of four years, 2017-2020.

Customer Usage Management

- Average reduction in customer energy and water use—$1.35 average savings per customer.
- Only applies to 25% of the electric and water meters with AMI and fixed RF network which are phased in over the course of four years, 2017-2020.

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14 Adjusted SGCC estimate, which is based on 4.5% decrease in customer minutes per year for 2013 RPU CAIDI of 72.40 customer minutes.

15 Most SGIG projects observed 0-5% reduction in line losses with few feeders over 5%. Industry research stated in SGIG report indicates 5-10% reduction in line losses due to Volt/VAr optimization. Assuming half of RPU's 2013 losses are due to line losses and 3% reduction for low case and 7% reduction for high case in line losses at the average RPU rate for $137.8/MWh.

16 Adjusted SGCC estimate per SGIG projects average reduction of SAIDI (+4% to -56%). Assumed 25% reduction for low case and 50% reduction for high case on RPU's top 20 worst performing circuits.

17 Average of water loss and leak prevention impact per customer meter based on Bartlesville and LVMWD AMR/I business cases.

APPENDIX B: REFERENCE DOCUMENTS

RPU Internal Reference Documents

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APPENDIX C: ACRONYM LIST

RPU Technology Program Acronyms

Program	Definition
ADMS	Advanced Distribution Management System
AMI	Advanced Metering Infrastructure
AMS	Asset Management System
AVL	Automatic Vehicle Location
CIS	Customer Information System
CRM	Customer Relationship Management
IVR	Interactive Voice Response
CWP	Customer Web Portal
DA	Distribution Automation
GIS	Geographic Information System
LMR	Land Mobile Radio
MDMS	Meter Data Management System
Mobile Apps	Mobile Applications
NCS	Network Communications System
ODMS	Operational Data Management System
OMS	Outage Management System
SA	Substation Automation
SCADA	Supervisory Control and Data Acquisition
WIS	Warehouse Inventory System
WMS	Work Management System

Complete Acronym List

Acronym	Definition
ACI	adjacent-channel interference
ACS	affiliated computer services
ADMS	advanced distribution management system
ADS	automated dispatch system
AES	advanced encryption standard
AGM	assistant general manager
AI	analog input
AMI	advanced metering infrastructure
AMR	automatic meter reading
AMS	asset management system
AO	analog output
AP (A/P)	access point
AQMD	Air Quality Management District
ARRA	American Recovery and Reinvestment Act of 2009
AVL	automatic vehicle location
BES	bulk electric system
BNSF	Burlington Northern Santa Fe Railway
BoP	balance of plant
BPEL	business process execution language
C&I	commercial & industrial
C3	command, control, and communications
CADM	core architecture data model
CAISO	California independent system operator
CBWFQ	class-based weighted fair queuing
CCA	critical cyber asset
CEC	California Energy Commission
CEMS	continuous emissions monitoring system
CFR	Code of Federal Regulation
CHP	combined heat and power
CIM	common information model
CIP	Critical Infrastructure Protection
CIO	chief information officer; chief innovation officer
CIP	critical infrastructure protection
CIS	customer information system
CMS	client management system
CMMS	computerized maintenance management system
COBIT	control objectives for information (and related) technology
COM	communications
COTS	commercial off-the-shelf
CPFSK	constant phase frequency shift keying
CPUC	California Public Utilities Commission
CRC	cyclic redundancy check
CRM	customer relationship management

Acronym	Definition
CS	cashiering system
CSMA	carrier sense multiple access
CSR	corporate social responsibility
CTS	clear to send
CWP	customer web portal
DA	distribution automation
DAHS	data acquisition and handling system
dB	decibel
DBA	database administration
dBi	decibel in reference to an isotropic radiator
DCS	distributed control system
DDS	distributed data services
DES	data encryption standard
DER	distributed energy resources
DFR	digital fault recording
DG	distributed generation
DI	discrete input
DL	dedicated licensed
DM	distribution management
DMS	distribution management system
DMZ	Demilitarized Zone
DNP	distributed network protocol
DO	discrete output
DOE	U.S. Department of Energy
DR	disaster recovery
DSL	digital subscriber line
DVR	digital video recorder
DWDM	dense wave division multiplexing
ECN	electronic communication network
EIRP	equivalent isotropically radiated power
EMIS	environmental management information system
EMS	energy management system
ERP	enterprise resource planning
ERT	encoder receiver transmitter
ESB	enterprise service bus
EISA	Energy Independence and Security Act of 2007
ETL	extract, transfer, and load
EV	electric vehicle
FCC	Federal Communications Commission
FDMA	frequency division multiple access
FERC	Federal Energy Regulatory Commission
FLISR	fault location, isolation, and service restoration
FSaaS	full solution-as-a-service
FSU	field service unit
FTE	full-time employee
FTTH	fiber to the home
GE	General Electric
GHG	greenhouse gas
GHz	gigahertz
GIS	geographic information system
GO	General Order
GTG	gas turbine generator
GUI	graphical user interface

Acronym	Definition
HAN	home area network
HE	head end
HMI	human machine interface
HR	human resources
HS	host service
I/O	input/output
IDU	indoor unit
IEC	International Electrotechnical Commission
IED	intelligent electronic device
IEEE	Institute of Electrical and Electronics Engineers
IFAS	integrated financial and administrative system
IMS	information management system
IOU	investor-owned utility
IP	Internet protocol
IR	infrared
IRP	integrated resource plan
ISACA	Information Systems Audit and Control Association
ISM	Industrial, Scientific, and Medical
ISO	International Organization for Standardization
ISP	inside plant
IT	information technology
ITO	information technology officer
IVR	interactive voice response
JE	journal entry
J-Mux	JungleMux
kbps	kilobits per second
kHz	Kilohertz
KPI	key performance indicators
kW	kilowatt
kWh	kilowatt hour
LAN	local area network
LMC	land mobile communication
LMR	land mobile radio
LTC	load tap changer
LTE	long-term evolution
LVMWD	Las Virgenes Municipal Water District
LZO	lempel-ziv-oberhumer (data compression algorithm)
M/W	microwave
MAC	media access control
MAD	master address database
Mbps	megabits per second
MDM	meter data management
MDM	mobile device management
MDMS	meter data management system
MDS	microwave data systems
MHz	megahertz
m-OMS	mobile outage management system
MPLS	multiprotocol label switching
MVPN	mobile virtual private network
MW	megawatt
MPLS	multiprotocol label switching
NAVD	North America Vertical Data

Acronym	Definition
NBCD	National Biomass and Carbon Dataset
NCS	network communications system
NDA	non-disclosure agreement
NED	national elevation dataset
NERC	North American Electric Reliability Corporation
NIST	National Institute of Standards and Testing
NLCD	national land cover database
NMS	network management system
NPV	net present value
NXDN	(common air interface technical protocol for mobile communications)
O&M	operations & maintenance
ODMS	operations data management system
ODU	outdoor unit
OLM	online monitoring
OMAR	operational meter analysis and reporting
OMG	object management group
OMS	outage management system
OS	operating system
OSI	Open Systems International
OSI	Oils Systems Incorporated
OSP	outside plant
OT	operational technology
OTAP	over the air programming
OTM	operation technology manager
P2P	peer-to-peer
PBX	private branch exchange
PCI	payment card industry
PEV	plug-in electric vehicle
PLC	programmable logic controller
PM	project manager
POU	publicly owned utility
PPA	power purchase agreements
PRV	pressure reducing valve
PV	photovoltaic
QA	quality assurance
QoS	quality of service
RERC	Riverside Energy Resource Center
RF	radio frequency
RFP	request for proposal
ROI	return on investment
RPU	Riverside Public Utilities
RTO	recovery time objective
RTS	request to send
RTU	remote terminal unit
RX	reception
SA	substation automation
SAF	store and forward
SAIC	Science Applications International Corporation

Acronym	Definition
SA	substation automation
SCADA	supervisory control and data acquisition
SCCG	Southern California Council of Governments
SCE	Southern California Edison
SDLC	software development life cycle
SGCC	Smart Grid Consumer Collaborative
SGIG	Smart Grid Investment Grant Program
SGMM	smart grid maturity model
SIEM	security information and event management
SLA	service level agreement
SMR	strategy, management, and regulatory
SNR	signal-to-noise ratio
SOA	service-oriented architecture
SOD	segregation of duties
SONET	synchronous optical network
SONGS	San Onofre Nuclear Generating Station
SOP	Standard Operating Procedure
SP	Southern Pacific Transportation Company
SPL	Oracle SPL WorldGroup Software
SQL	structured query language
SWOT	strengths, weaknesses, opportunities, threats
TCO	total cost of ownership
TCP	transmission control protocol
TDM	time division multiplex
TVWB	time varying wide-band
TX	transmission
UHF	ultra high frequency
UNII	Unlicensed National Information Infrastructure
UOC	utility operations center
USGS	United States Geological Survey
VAr	volt-ampere reactive
VHF	very high frequency
VLAN	virtual local area network
VM	virtualized environment
VPN	virtual private network
VRF	virtual routing and forwarding
VVO	voltage and VAr optimization
WAM	work and asset management
WAMS	work and asset management system
WAN	wide area network
WBS	work breakdown structure
WDM	wavelength division multiplexing
WECC	Western Electricity Coordinating Council
WFM	work flow management
WIS	warehouse inventory system
WMS	work management system
WO	work order
WRED	weighted random early drop
WSUS	windows server update services