Rhode Island Power Sector Transformation

Grid Connectivity and Meter Functionality Principles and Recommendations

October 13, 1017

Draft for Stakeholder Comment

Power Sector Transformation

Grid Connectivity and Meter Functionality

October 13, 2017

I. Introduction

Information and communications technology (ICT) now shapes every facet of our lives. Increasingly, our homes, schools and offices host many devices that communicate with each other and automatically respond to signals they receive. This transformation that has already changed many aspects of our daily lives is now, finally, shaping the electricity sector. As we modernize the electric grid, we have the opportunity to create greater "intelligence at the grid edge," that may fundamentally transform the capabilities, costs, and control of both the electric utility and the customers they serve. This opens opportunities for Rhode Islanders to transform the way we connect with each other, information, and energy. How we navigate this transformation will play a critical role in the economic vitality and well-being of our state and those who live here.

To take advantage of this opportunity, Rhode Island will need to invest in Advanced Meter Functionality (AMF), which is state-of-the-art digital hardware ("Advanced Meter") and software platforms that measure customer usage and voltage data and communicate them rapidly through the internet. The advantages enabled by AMF for the consumer are: outage prevention, faster outage restoration, access to various pricing options that can save them money, access to energy efficiency and renewable services tailored to their usage, and more efficient use of the distribution system that creates consumer savings. To unlock these consumer advantages, we need to modernize our technology and utility regulations.

AMF is vital to accomplish many of the goals expressed in the Power Sector Transformation (PST) Initiative. The rapid pace of technological development in AMF capabilities means that technological obsolescence is a risk, and this paper offers options for proactively managing that risk. Finally, implementation of the initiatives discussed in this chapter will need to be accomplished with a careful examination of the cybersecurity principles that will protect the system and its customers. All of this can be accomplished in the near future, and will need to be accomplished if Rhode Island is to benefit from the technology changes sweeping electric distribution systems in this country.

This white paper addresses: 1) benefits of advanced meter functionality; 2) context for interconnection of internet and grid; 3) desired network characteristics; 4) public policy considerations for "future-proofing" internet connectivity; 6) need for innovative ownership and access models and 7) policy and regulatory recommendations.

Stakeholder engagement was an integral part of informing this white paper. Three separate meeting were held with stakeholders, to both provide information from experts from around the country, and to take stakeholder comments and questions. In addition, questions were sent out to solicit comments from stakeholders. The responses from stakeholders are summarized in Appendix B.

II. <u>AMF Infrastructure is Evolving and Can Provide Significant Benefit to Customers</u>

An illustrative list of direct and indirect benefits that AMF can provide follows. The State would like to see the deployment of the specific set of capabilities that were identified through docket 4600 and are listed in Appendix A.

a. <u>AMF's Direct Residential Benefits</u>

Historically, advanced meters were utilized primarily by commercial and industrial customers, giving them the ability to shift their time of operations in exchange for more attractive pricing. For residential customers, the savings were more limited with the net benefits being primarily for customers who have solar power net metering. Historically, advanced meters reduced residential costs for meter reading but were not always offset by the upfront capital expense. Going forward, with technology advances to link the advanced meters to grid functionality, there are additional benefits for most residents, such as:

- Provides substantial usage data to tailor pricing and service programs;
- Identifies locations on the grid where renewable distributed energy would be particularly helpful or harmful;
- Provides real-time operational awareness and accurate power status calls, as opposed to the past, where often the utility did not know a customer was without power unless the customer called them;
- Enables efficiencies for the grid system's need to balance power that can result in potential customer savings;
- Reduces costs of manual meter reading, and an increase in the accuracy of the reads, thereby reducing the estimated bills, which can be very inaccurate and can result in unmanageable bills;

- Enables time-based programs such as demand response and time-of-use rates – that can result in shaving peak load, which provides cost savings for all customers and additional cost savings to customers who participate in the program;
- Avoids service calls when the problem is on the customer side of the meter because the utility is better able to pinpoint the source and nature of problems;
- Expedites turn on of service;
- Identifies location of low voltage or other difficulties on the system in real time, enabling proactive maintenance that can avoid outages and verification of voltage complaints;
- Enables tailored energy efficiency programs that show customers how their usage compares to similar residences in their neighborhood, which has demonstrated to be a powerful tool to help customers understand and moderate their power usage;
- Assists with more accurate planning data for the utility by identifying parts of the distribution network that need refurbishment or could benefit from alternative technology, such as microgrids or storage;
- Shares data for status of distributed generation, such as rooftop solar, allowing for better planning of how to support variable energy sources;
- Shortens power outage time by enabling the utility to rapidly identify and limit the scope of the outage area, with limited intrusion to customers.

b. AMF's Indirect Services and Benefits

AMF is a tool that benefits customers and utilities directly and it is also a vehicle that can support additional technology thereby enabling additional indirect benefits for the customer, utility and the environment. The following is not an exhaustive list, but can indicate the important technology that is supported by advanced meter functionality. In many cases, optimization of this technology will require time of use rates, or some other pricing system.

Enables Demand Side Management - When the utility or third party provider provides an incentive for customers not to use power at expensive high peak times. In the commercial and industrial sectors, the savings to the customer and the utility can be significant. It can also integrate with household systems to lower peak times by controlling thermostats and certain appliances remotely. For instance, a dishwasher can be programed to turn on outside of peak hours, thereby saving money.

Increases Distributed Generation Capacity – Smart meters can enable different sources of energy, from residential rooftop solar, to larger photovoltaic solar arrays, including community solar programs, wind farms, combined heat and power, renewable biomass, or other sources of energy that are not large centralized power plants. The more modern grid can support these different sources of energy, which can provide more choices for customers.

Supports Deployment of Energy Storage - Storage systems help shave peak load, provide ancillary services to the grid such as voltage control, and enable more variable renewable energy to the system by backing them up when the sun and wind are not available. They can be thermal or mechanical, as found in dedicated batteries, electric vehicles, and other beneficial electrification units such as heating.

Upgrades Legacy Infrastructure - As the internet of things (IoT) and enterprise big data emerge and as Rhode Islanders demand more bandwidth, the existing network infrastructure will not be able to meet the connectivity needs of businesses and residents. By investing and leading in the development of next generation networks, the State can attract, retain, and grow businesses by providing the internet bandwidth they need.

Development of Civic Internet of Things and the Smart Grid - The emergence of the civic internet of things will have a host of applications for improving the lives of Rhode Islanders, including enabling a smart grid that can maximize the efficiency of energy in the state to save ratepayers money, increase energy efficiency, and decrease outages. To take advantage of this, the State will need next generation networks that can handle significantly more data, with lower latency, and lower costs per bit.

Ubiquitous Access to High Speed Connectivity - Investment in next generation networks will provide a critical opportunity to both close the adoption gap among low-income Rhode Islanders and the remaining last mile access gaps in areas such as Block Island. Currently, 26% of Rhode Island households are still disconnected from high speed internet and as a result face a digital equity gap limiting their educational and economic opportunities. Ubiquitous connectivity will improve the quality of life and economic opportunities available to Rhode Islanders.

Residential Technologies that Communicate with Grid-edge Devices - There are a number of devices that can communicate with grid-edge devices and control platforms to provide greater customer choice and value. These may be owned by parties other than the utility or the customer. Among these devices are: programmable thermostats, irrigation and lighting controllers, pool filter pump controllers, entertainment systems, routers, cable boxes, smart TVs, security systems, intrusion detection systems, fire alarms, washers and dryers, dishwashers, refrigerators and freezers, and home energy management systems that can reside on security and entertainment system platforms.

III. Context on the interconnectivity of residential internet and grid connectivity

Grid modernization and connectivity: The 20th century distribution grid was designed for one-directional power flow from large central power plants to distant loads. As a result, it required little situational awareness and could be designed with analog self-correcting controls. There were no digital controls until the end of the 20th century. In the 21st century, distributed energy resources, such as rooftop photovoltaics, are leading to multidirectional power flows on the distribution grid. The emerging complexity of distribution grid power flows now needs real-time situational awareness to keep the lights on, increase renewable energy usage, and minimize procurement and distribution costs for ratepayers. Technologies are required that can (1) exchange information between all generating and consuming energy resources; (2) perform system-management using programmable controls; (3) integrate data from ubiquitous sensors and computer-based analytics; and (4) interface with increasingly intelligent devices within the home to help system operators manage peaks. The underlying foundation beneath all of these capabilities is network connectivity.

Consumer demand and connectivity: The U.S. economy is increasingly shifting from producing goods to producing knowledge and services. For a knowledge economy, broadband is the commons of collaboration and it is critical that the cost and availability of bandwidth in Rhode Island never constrains economic or social progress. To assure that our residents enjoy the benefits of affordable, abundant bandwidth, the State, as well as its municipalities, wish to work with all stakeholders to accelerate, and lower the cost of deployment and operation of next generation broadband networks.

Equity and access: One of the greatest challenges for our existing communications infrastructure is ensuring equal access to all communities urban and rural, rich and poor. Any future network buildout must address these issues proactively to be viable.

Risk of duplicative infrastructure: As the demand for communications capabilities on all types of infrastructure increases, there is a risk of overlapping and duplicating communications infrastructure, which could increase costs for consumers and ratepayers alike. As the steward and architect of the electric distribution system, the electric utility occupies a central place in the changing power sector. At the same time the ubiquity of electricity infrastructure, and its growing need to support two way information flow, make it an excellent candidate to lead the rollout of **shared** next generation wireless infrastructure for the current and future needs of infrastructure operators and consumers.

Utility Business Model. The traditional regulatory model for electric utilities, in which the electric utility earns a return based largely on the cumulative value of the prudent infrastructure it has deployed, may exert an "infrastructure bias" to deploy capital-intensive solutions. As distributed energy resources and grid control technologies offer new opportunities to provide reliable service at low cost, the impact of this infrastructure bias on ratepayers will grow. Topical incentives may correct this infrastructure bias. As corrective incentives become more widespread a broader evaluation may be needed. This issue is discussed at length in the affiliated Utility Business Model white paper.

Risk of Technology Obsolescence. The electric system of the twenty-first century will be asked to deploy a range of new technology systems and to manage the risk of technology obsolescence, creating new challenges for the current business model in which operational costs are usually recovered directly based on a prudency test.

Cybersecurity. Grid modernization provides an opportunity to address existing cyber security issues and also raises new issues. The utility is increasingly in need of detecting, responding and recovering from cyber threats as well as addressing customer data protection with new generations of distributed cryptography. With respect to detection, response and recovery, having redundancy of systems to narrow the surface of potential attack is important. As discussed in the Utility Business Model white paper, the key is outcome-based, not technology-based.

AMI Firewall Location Defines the Grid Edge - Equipment and firewalls need to have the following characteristics:

- Firewalls need to clearly limit physical and informational access;
- Future solutions will need to be layered, as applications will need to be replaceable without adversely affecting other applications;
- Layers will need to have well-defined interface with neighboring layers;
- Equipment controls need to be software-based, remotely fixable, and able to be upgraded without the need to go into the meter to change them;
- Communications protocols need to be secure at every layer, from the physical to the application, in order not to fall victim to the capital bias found in the traditional business model.

IV. Desired Network Characteristics

Stakeholders across industry generally agree that the key network characteristics of next generation networks in Rhode Island include the following:

Leverage Existing Infrastructure - The next generation networks should leverage existing network infrastructure rather than build redundant infrastructure side by side. Rhode Island is already one of the most broadband-ready states in the nation with an extensive fiber backbone and high speed broadband available to 98% of Rhode Islanders. This fiber has the capacity to and will provide the backhaul for Next Generation networks. By leveraging this infrastructure, next generation networks can be constructed in Rhode Island in a more cost-effective and timely manner.

Small Cells and Network Densification - Network densification is the process of adding more cell sites to increase the amount of available capacity. It will be a major component of next generation networks in Rhode Island. This includes the construction of a heavy concentrations of small cells and the continued development of macro-cell sites. This will create the ultra-dense network configurations, particularly in metro areas that will be foundational to technologies such as 5G.

Last Mile Connectivity - Investment in next generation connectivity should be used to provide last mile connections in Rhode Island so that every Rhode Islander has access to high speed connectivity.

V. Public Policy Considerations for "Future-Proofing" Internet Connectivity

In order to effectively plan for the rapidly approaching future of connectivity and avoid shortsighted investment, this section explains public policy considerations relevant to the existing broadband and communication technologies coming down the pipeline.

Legacy Systems Are a Cybersecurity Problem - Legacy systems are inherently insecure because they were not built to be secure against the serious cyber security threats that we face today. As a result, cybersecurity solutions for connectivity and the grid are an afterthought rather than a critical function of our grid and networks. In the construction of next generation networks, cyber security must be baked into the design and incentives must be put into the marketplace to prevent consumers from compromising network security.

Sharing Electric, Water, Transportation and Internet Connectivity - The opportunity exists to leverage the connectivity needs of the public sector and utility providers to bring additional value to broadband investments without compromising the safety and security of sensitive data. This could allow us to efficiently and cost effectively reach rural and sparsely populated areas. Similarly, the opportunity exists to develop a single set of connectivity assets to serve a range of infrastructure sectors, such as water, electricity, and transportation. Realizing the opportunity of new information and communication technologies will require electric utilities to leverage data communications systems, potentially through some form of partnership with firms in the data communications industry.

VI. Need for Innovation in Ownership & Access Models

The interrelated public policy considerations listed above highlight the reason there is a need to consider new models of cost-sharing for the risks and benefits of the underlying enabling technology. The pace of regulatory change is generally slower than changes in technology. As such, we must ensure that customers are not paying for quickly-obsolescent technologies, while also encouraging prudent and value-adding technologies. Technologies are becoming available and adopted by electric utilities at an increasingly rapid pace and yet sometimes system needs are changing more quickly than solutions are becoming available. For rapidly changing technology, there is never a right time to buy, as the next iteration will include features that are desirable. However, customers cannot be expected to pay for every new functionality. This is especially true of technology such as meters, which generally take some period of time to bring to every customer. Often, the earliest advanced meters to be installed are obsolete before the last of the customers are receiving the technology. In some states, the period of time that customers pay for advanced meter assets, through the regulated depreciation rate, has often been much longer than the actual rate of meters' usefulness. Furthermore, in many states, utilities deployed smart meters but did not deploy the energy services that are enabled by them, leaving customers with net losses.

Therefore, it is critical that policy proposals regarding technology, including AMF, need to describe the plan for avoiding this obsolescence, to give the consumer the benefit of technology as it evolves. The utility also needs to plan so that they are not stranding their assets.

While there broad agreement on both the network characteristics of next generation connectivity in Rhode Island there are strongly diverging opinions on how this network should be built and who should own it. As a result, there are multiple models for ownership and access for regulators to consider when investing in next generation networks. Three primary models often discussed are:

- ***Broadband as the Commons:*** This model imagines broadband infrastructure as a public utility that should be owned by the state and accessible to anyone. This would require public private partnership between the State and a private sector firm. The state would own the infrastructure while the private sector would build and maintain this network. Proponents of this model believe that the government will serve as a neutral owner of infrastructure and will drive greater competition for service providers and more ubiquitous and equitable access.

- ***Private Market Solution:*** This model sees the private market as continuing to be able to deliver the connectivity that Rhode Island needs with non-profits like OSHEAN filling in the gaps of service where it is not cost-effective for the private sector. In this model, existing telecom firms would build and operate the next generation networks.

- ***Infrastructure/Utility Led Partnership:*** The connectivity needs of the electric grid, and other major types of infrastructure, would drive the utility to partner with a wireless service provider to expand and upgrade the existing wireless infrastructure. A cost-sharing agreement will be negotiated to support the benefits and risks to both the internet provider and utility.

VII. Policy & Regulatory Recommendations

The State's grid connectivity and functionality goals will guide the communications network and control technology investment for the coming decade. As such, the Power Sector Transformation Initiative proposes to implement the following policy goals for the electric grid's advanced functionality and connectivity: 1) greater connectivity; 2) Two-way information flow; and 3) enhanced cybersecurity.

To accomplish these three policy goals, it is important that the utility provide the following through the regulatory process:

1. Advanced meter business case and time varying rates roll out plan. This must include a business case describing potential scenarios for advanced meter roll out and include the meter infrastructure, time-varying rates, and data management components. Any advanced meter rollout plan must include protections for low income ratepayers as well as a platform upgrade model to protect all ratepayers from a growing obsolescence risk.

2. Advanced meter capabilities and third party access. This will include a list of known capabilities (i.e., load shifting, peak shaving) along with an aggressive implementation schedule driven by advanced meter penetration. It will also include a plan to provide third party access to the advanced meter platform to deploy new grid facing and consumer facing applications.

3. Advanced network deployment savings using shared infrastructure. This will include potential innovative partnership opportunities to use a shared communications network to supply connectivity to meters and other components of the automated grid to provide greater customer value. Piggybacking, expanding and accelerating the already planned deployment of advanced wireless networks by major carriers should significantly reduce capital costs for ratepayers. Such cost savings should be spelled out. Any such plans should also include an accounting of the efforts necessary to ensure the security of the connections against possible cyber incursions.

4. Advanced meter functionality benefit cost analysis. Based on the business case, this analysis will engage in an in-depth assessment of benefits and costs based on the categories established in Docket 4600. These functions are summarized in the table found in Appendix A.

5. Cybersecurity. - The utility should meet with the Commission on at least an annual basis, and provide to the Commission a classified report, which explains their efforts to detect, respond and recover from cyber threats, as well as an explanation of the layering of technology designed to accomplish the goal of preventing threats. This recommendation is discussed further in the Utility Business Model white paper.

Appendix A— Applications Desired From an Advanced Grid

Rhode Island Power Sector Transformation

Advanced Grid Capabilities

August 20th, 2017

Goal	Capability	Description
Security and Resiliency	Automated islanding and reconnection (microgrid) control	Automated islanding and reconnection is achieved by automated separation and subsequent reconnection (autonomous synchronization) of an independently operated portion of the T&D system (i.e., microgrid) from the interconnected electric grid. A microgrid is an integrated energy system consisting of interconnected loads and distributed energy resources which, as
	Fault Location, Isolation, Service Restoration (FLISR)	FDIR is a collective term for the process of identifying the location of a fault condition on the system through the use of current and voltage monitoring devices; isolating the fault between two devices adjacent to the fault (e.g., opening two switches on either side of the fault); and, restoring service to the customers in the unaffected areas (i.e., not in the isolated section where the fault occurred). Next generation systems may use pre-programmed restoration scenarios that rapidly respond to equipment load ratings and real-time system load measurements. Such advanced applications require a robust, scalable two-
	Automated Feeder Reconfiguation	Automated feeder reconfiguration refers to the constant monitoring of the status of the distribution system (e.g. voltage and load conditions) and the ability of the system to respond by using alternate sources of supply to avoid an overload situation. Some FDIR systems also support automated feeder reconfiguration capability that enables restoration of service to the
	Remote Monitoring & Diagnostics (equipment and system conditions)	Remote monitoring and diagnostics for system conditions consists of data collected via SCADA systems, to include voltage, loading, current, power factor and frequency. A Distribution Company may use these data to feed planning models, support advanced load forecasting and enable analytics that can improve and optimize system planning and operations. Remote monitoring and diagnostics enable Distribution Companies to collect more frequent data on the status of system equipment
	Adaptive protection	Adaptive protection uses adjustable protective relay settings (e.g., current, voltage, feeders, and equipment) in real time based on signals from local sensors or a central control system. This is particularly useful for feeder transfers and two-way power flow
	Outage and restoration notification	Provides power status information down to the customer service point. Upon loss of power or restoration of power, status sensors will send a notification message to a central monitoring system that can analyze and deliver the message to a reliability operator or system. Sensors should be capable of measuring load side power status and sending a notification message upon
	Dynamic event notification	Automatic notification by the DSPP to market participants of events including, but not limited to: price changes, incentives, penalities, or special circumstances; events or conditions that may effect market operations; events or conditions that may effect electrical network performance or availability such as equipment failure, weather or other hazards; achieving or exceeding various production or consumption targets or thresholds. Such notification would be intended to provide market participants the ability to respond to important situations or conditions in a timely manner (NY)
Facilitate Consumer Choice	Time Varying / Dynamic Pricing	Time varying rates (TVR) changes the price customers pay based on time of day such that the rate is higher during periods of peak demand. At the most extreme, customers can pay a different price every hour based on wholesale market prices. In more traditional pricing structures, customers pay a different rate for a given number of hours every weekday, coincident with the time of system peak demand. Another form of time varying rates is a critical peak price or peak-time rebate that is typically implemented for a limited number of critical peak events when the system is constrained due to very high demand. A critical
	Home Area Network Communications Capability	A home area network (HAN) is a network of energy management devices, digital consumer electronics, signal-controlled or enabled appliances, and applications within a home environment that is on the customer side of the electric meter13. A HAN provides customers with access to usage data in more frequent time increments than once-monthly billing information. Retail pricing information may also be communicated to customers through a HAN. For example, a customer may program controls in the home to increase the set-point on the air conditioner in response to a critical peak signal sent from the Distribution
	Energy Usage Visibility	Allow customers to view, and to assign others to view, their energy usage data
	Demand Side Management Options	Support systems and software to manage a range of customer-side energy resources
Integrate Renewables	Remote Distributed Generation Disconnect	Remote disconnect is technology that enables a Distribution Company to use automation to remotely disconnect a distributed generation facility from the distribution system to protect safety or maintain service to other customers. (MA)
	Energy storage	Storage of electricity for later use. An electricity storage device can convert electricity into another form of energy in its charging state, and then produce electricity through a reverse conversion process. The electricity storage device can be stationary or mobile depending on its application. Most electricity storage devices include an inverter or converter so as to
	DER power control	Adjustment of status and power output or consumption for electricity producing/storing distributed energy resources. The purpose is to control the real power production or consumption by these devices. Control could be achieved by delivering an
	DER power factor control	Adjustment of status and power output or consumption for electricity producing/storing distributed energy resources. The purpose is to control the real power production or consumption by these devices. Control could be achieved by delivering an
	DER optimization	Determine the values for the controllable factors of one or more DERs to maximize, minimize or balance system performance on either side of the DSPP service point. Optimization goals could include, but are not limited to, energy efficiency, reliability,
	Algorithms and analytics for Customer/DER/Microgrid control and optimization	Software that can utilize operational and non-operational data from network sensors, equipment health sensors, weather instruments, and other operational technology or models to analyze system performance, identify abnormal conditions and determine optimum set points or topologies for network elements. (NY)
Control Energy Costs	Integrated and Automated Volt/VAR Control, Conservation Voltage Reduction	Volt/VAR management is the term for technology that measures voltage and power factor on the distribution system and corrects imbalances to minimize power quality disturbances and limit line losses of the system. Next generation systems may include centralized processing with the ability to perform feeder-specific, substation-specific and area/region optimization. Future applications may also incorporate distributed solar photovoltaic (PV) cells and other resources through the use of controllable inverters for VAR support. Conservation voltage reduction refers to the active management of distribution voltage
	Utility/3rd party Load Control	A load control demand response program is one where a signal is sent to a customer device (e.g., programmable controllable thermostats, water heaters, air conditioners, Electric Vehicle Supply Equipment (EVSE)) instructing that device to reduce electricity consumption. A two-way signal allows the sender of the signal to confirm whether the device has responded or the
	Remote Monitoring & Diagnostics (system conditions)	
	Load leveling and shifting	Load leveling and shifting alters the pattern of demand to more closely match output from non-dispatchable, intermittent distributed resources such as solar PV. This technology may help mitigate reverse power flows and localized disturbances typically associated with high levels of intermittent distributed generation. Advanced applications may enable Distribution Companies to use distributed resources for system balancing operations. Such applications may include: on-site battery storage
	Advanced Load Forecasting	Advanced load forecasting is the process of making more accurate and discrete predictions about future system loads based on customer usage data. Improved forecasts enable operators to better schedule and dispatch generation. Such forecasting may
	Real-time load monitoring	Provides real-time measurement of energy consumption at the customer premise or device level. This could be accomplished using voltage and current sensors housed within a smart meter or other similarly capable sensor. The sensors would be connected to a communications network capable of delivering load measurements to a central monitoring system in intervals
	Real-time network monitoring	Provides real-time measurement of voltage and current within the transmission and distribution network, including primary distribution feeders, laterals and line transformers. This monitoring can provide a high resolution view of voltage and load profiles throughout the network suitable for use in operations and real-time optimization algorithms. Sensors could be housed in T&D power equipment such as circuit breakers, reclosers, voltage regulators, capacitor banks, transformers, or other
	Real-time load transfer	Real-time load transfer is achieved through real-time feeder reconfiguration and optimization to relieve load on equipment, improve asset utilization, improve distribution system efficiency, and enhance system performance. (NY)
	Algorithms and analytics for Grid control and optimization	Software that can utilize operational and non-operational data from network sensors, equipment health sensors, weather instruments, and other operational technology or models to analyze system performance, identify abnormal conditions and
	Power flow control	Flow control requires techniques that are applied at transmission and distribution levels to influence the path that power (real & reactive) travels. This uses such tools as flexible AC transmission systems (FACTS), phase angle regulating transformers
	Dynamic capability rating	Dynamic capability rating can be achieved through real-time determination of an element's (e.g., line, transformer, DER, etc.) ability to carry load based on electrical and environmental conditions. (NY)
Workforce Management	Mobile Workforce Management Systems	The capability to communicate the status of assigned work projects between workers and a dispatch office and to
	Mobile GIS Platforms	The capability to allow employees to locate themselves and distribution assets through a mobile application.
	Market-based demand response	Demand response that can be targeted at certain market participants to optimize system performance. Response incentives and penalties would be calculated based on real-time network conditions including supply, demand, congestion, energy
	Dynamic electricity production forecasting	Calculation and forecasting of electricity production from DER based on geography, forecasted fuel supply, solar insolation, wind speed, electrical network conditions, or other factors that would affect the quantity and quality of electricity. Production forecasts would change with changes in input data. The purpose of the forecasts would be to provide supply information to
	Dynamic electricity consumption forecasting	Calculation and forecasting of electricity consumption based on ambient temperature, weather, day of week, time of day, electrical network conditions, or other factors that would affect the quantity and quality of electricity. Consumption forecasts

Appendix B – Stakeholder Feedback

The complete set of questions and comments are available on the PUC website and the following is a summary of key points.

NATIONAL GRID

1. AMF and DA Capabilities - National Grid agrees with the DPUC list of capabilities. Rather than a defined list of capabilities, utility proposals for AMF and DA should seek to advance clearly-defined objectives. The capabilities should evolve over time. Initial proposals may focus on foundational investments that enable new or more advanced capabilities in the future.
2. Evaluating qualitative benefits - An AMF proposal should be supported by a strong business case with clear evidence of system and customer benefits. Some important benefits can be described only qualitatively. The primary quantifiable system benefits include avoided wholesale energy and capacity market costs, improved reliability and the potential to defer capital and O&M costs. Qualitative benefits include enabling GHG reductions, ensuring energy security, enabling more accurate system planning, enhanced safety, enhanced data privacy and security, enhanced customer satisfaction, enhanced outage notification, and a simplified move-in/move-out process.
3. Obsolescence - To mitigate obsolescence risk, the Company pursues solutions that use industry-accepted and open integration standards, has a reasonable maintenance and support plan, and provides for cost-effective and efficient upgrade or replacement of components with the shortest useful life. This requires careful consideration, planning, design and classification of assets and components and the ability to remotely connect and update firmware and software. The same hardware can be used by different, isolated, systems for high-accuracy voltage monitoring and outage notification, and can become a node for extension of a complex, hybrid communication system. The Company is committed to seeking out innovative/alternative solutions that are in the best interests of customers.
4. Complementary measures for equity - The Company will build off its experience educating customers on the benefits of energy saving technologies and offering incentives to make these technologies more affordable through its award-winning energy efficiency programs. It will ensure that the benefits of AMF are accessible to all customers, including income-eligible customers.
5. Platform design - The Company expects to apply lessons learned from its Worcester Smart Energy Solutions pilot program in Massachusetts to Rhode Island. With regards to customer privacy, data and cyber security, vendor capabilities, overall cost structures, and product strategies and platforms. AMF, coupled with data management systems and customer engagement portals, will provide a platform to enable an array of future utility and third-party offerings. Customer benefits are likely to be greatest when third parties can innovate and compete to provide

customers with new opportunities, under appropriate terms for security, confidentiality, and customer protection.

6. Shared communications network - Four important challenges must be addressed: (a) finding a model that can be successfully deployed while demonstrating lower communication costs for the end-user, (b) allocating administrative and technical ownership and accountabilities; (c) any restrictions posed by utility regulation or the Telecommunications Act of 1996; and (d) cybersecurity. A shared network must support the Company's obligation to provide for a safe, secure and reliable energy delivery system. There will be mission-critical aspects of distribution and transmission utility operations where it may not be prudent to use a shared network if cyber security issues cannot be clearly and efficiently addressed.

ACADIA CENTER

Obsolescence - It is not necessary for low-income customers to have advanced meters or utilize all their functionalities to benefit from statewide investments and activities of other customers. It may not be useful to include all low-income customers or other low-usage customers in the rollout of AMI if they do not have sufficient load to shift. If these customers are included, they should receive special consideration in rate design (e.g., perhaps being allowed to opt-in even when advanced rate designs are the default for most customers) and access to low-cost energy management technology.

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Overall, the utility should keep electricity delivery as reliable and low cost as possible while providing a platform for independent service providers of all kinds to deliver energy and energy related services. Allowing the regulated monopoly to provide services beyond their natural monopoly functions stifles innovation and is unfair to both ratepayers and to independent service providers. To transition to a competitive meter market place, a significant port of the current utility "customer charge" could be shifted to paying for metering services that customers choose. The PUC could hold a bidding process on some regular interval for providers of default metering services.

1. AMF and DA Capabilities - All of the functions listed on the DPUC-OER spreadsheet of August 20th are important capacities to enable in the 21st century grid. Very few of them should be provided by the distribution company.
3. Obsolescence - Utility ownership and control of advanced metering stifles innovation and emerging energy services and subjects ratepayers to risk of technology obsolescence. Meters should be a tool that distributed energy resource providers of all kinds can provide in ways that optimize their own services and the value that customers choose to purchase from them, without having to double meter.

4. Platform design - Create a secure, trusted and very low-cost digital market place over which all kinds of transactions can be enabled, transacted, recorded, credited and compensated essentially in real time. It is likely too early to implement a blockchain system. As a ratepayer-funded monopoly, any system data, aggregate data and other information collected by the distribution utility should be considered and treated as public information and made easily accessible and easily usable by the public without charge.
5. Shared communications network- The internet should be able to provide appropriate bandwidth and security without creating a specialized standalone network just for utilities.

NORTHEAST CLEAN ENERGY COUNCIL (NECEC) and ADVANCED ENERGY ECONOMY INSTITUTE (AEE INSTITUTE)

1. AMF and DA Capabilities - The DPUC chart is a good start, though we did not have sufficient time for detailed review. We look forward to working with others to refine it.
2. Evaluating qualitative benefits - A key function of AMF is the ability to stream information from the customer site in real time. This consumption data, when paired with both tariffs and wholesale market opportunities, enables the provision of signals for and measurement of demand response, creates new price-responsive capabilities, and leads to a more efficient system as a whole. Customer benefits are often what make AMF deployment cost effective. Any AMF business case must include a commitment to achieving well-defined and quantifiable customer benefits, and a detailed strategy for achieving customer benefits.
3. Obsolescence - Third party ownership of meters and/or communications infrastructure is one way to mitigate against technology obsolescence, if the owners are responsible for delivering specific outcomes at an agreed-upon price. Although it must have access to pertinent information supplied by these devices, the utility does not necessarily need to own the meter. The information could be acquired from a third party through a SaaS model.
4. Complementary measures for equity - A customer class may benefit from the deployment of advanced meters even when one's own rate class is not affected by the deployment provided that: (a) the meters deployed lead to increased overall system efficiencies, and that b) some of those efficiency benefits positively affect that given rate class. To ensure these outcomes, investment is needed in (a) advanced distribution system management and software-based analytical capabilities; and (b) significant, personalized customer engagement before, during, and after AMI installations.
5. Platform design- Usage information – properly protected for privacy and cybersecurity – should be made available to consumers and multiple vendors at minimal latencies (one minute or less). The data platform should leverage and enable customer and third-party engagement. A customer-facing portal should

provide customers with their interval data, personalized insights about that data, and tools to better manage their energy use through energy efficiency and demand response. Utility regulators should request annual reporting.

6. Shared communications network -Three potential approaches to the communications infrastructure could be adopted: (a) The use of public next-generation connectivity for the electrical system in which the electric utility purchases a bulk amount of bandwidth and ratepayers act as a kind of anchor tenant; (b) Ownership of a communications infrastructure by the electric utility with sales to other bulk infrastructure customers in which electric ratepayers fund the communications network and have costs reduced; or (c) Participation by the utility in a special purpose vehicle with private vendors supporting multiple infrastructure applications. NECEC and AEEI are agnostic about meter ownership as long as the data and information collected is made available to customers and third parties. National Grid could earn revenue through an emergent data and information portal, whereby the utility and third parties provide access to usage data and information.

ENTRYPOINT NETWORKS

The standards for network communications which enable consumer choice should include at least the following core capabilities: (a) Virtualization; (b) Software Defined Networking (SDN); (c) Orchestration; (d) Scalability; and (e) Separation of Infrastructure and Services. To enable dynamic networks on demand, the infrastructure must be separated from the services running over that infrastructure. Orchestration provides coordination of the Virtualization and SDN components to enable network flexibility, multi-tenant capabilities and to enable a platform which moves software control to the user. EntryPoint Networks' product, FlowOps is an Orchestration tool. FlowOps makes the network into a Software Defined Market Exchange (SDMX) – a marketplace for service providers to establish a presence and deliver meaningful services to whomever wishes to subscribe. It is analogous to the Apple and Android app stores which allow services to be treated as stand-alone applications that leverage the broadband connectivity of the network. Similar to other cloud services, subscribers can allocate what they want, when they want; subscribing to a service requires the click of a button. This marketplace will empower the benefits of competition including lower prices, movement toward abundant bandwidth, compelling new services, and growing innovation activity. With FlowOps, services are provided using private networks with internet-like interfaces and unique privacy, security and reliability advantages.

AGILE FRACTAL GRID

With regards to shared communications network, the Agile Fractal Grid could be used across the entire state of Rhode Island, given the current direction and intensions of the Power Sector Transformation. It addresses three specific needs for the hybrid electric and communications grid: (a) Maintain resilient and secure operations; (b) Incorporate a cloud-based "Digital Marketplace" for supporting the numerous third-party providers of distributed electric controls systems, communications services, and various community services; and (c) Support the emerging Industrial Internet to protect all communications between the elements. Many of RI's goals can be supported by the various third parties that are part of the AFG Community of Practice.

The Agile Fractal Grid has formed a public – private partnership (PPP) called Network as a Service (NaaS), comprised of different groups that own various resources and are making some of them available for the shared communications infrastructure. The owners are compensated for the use of their assets, but the NaaS coordinates the use of these shared resources. Rhode Island's OSHEAN middle mile network could form the backbone of the statewide shared communication infrastructure if arrangements could be made for extending it and supporting the AFG NaaS across the state.