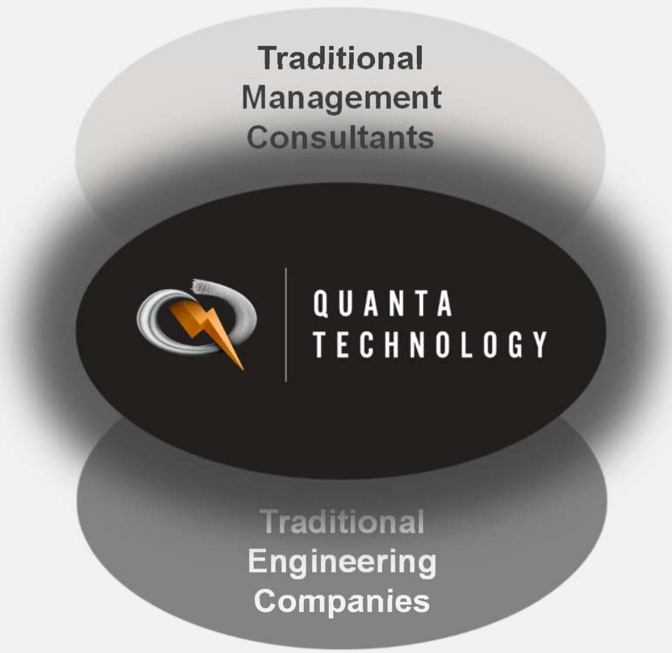
QUANTA TECHNOLOGY
A QUANTA SERVICES COMPANY

AMI 2.0 / Grid Intelligence & Operational Analytics

Agenda

- Introduction – Quanta Technology
- Electric Industry Drivers & Evolution
- Water/Gas Drivers & Evolution
- Data Analytics for Utilities
- Examples
- Questions/Comments

Quanta Technology Speakers



AMI

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Quanta Technology
Our Depth and Breath Value Proposition

An independent technology, consulting, and testing company serving a wide range of electric energy customers

- **Unique business, regulatory, and technical expertise** and best practice know-how
- **Over 400 trusted advisors** with diverse, global experience spanning the entire lifecycle
- Ability to engage in a variety of roles, including **staff augmentation**

A full spectrum of services in the following:

- **Grid modernization**
- **Roadmap development**
- Business case and financing analysis
- **Transmission and distribution planning and operations**
- Grid resilience and reliability
- Lifecycle asset and risk management
- **Protection and control**
- Automation and testing
- **Renewables integration**
- Energy storage
- **Microgrids**
- Electrification
- OT/IT integration
- **Technology integration**
- Digital substations
- **Data management and analytics**
- **Advanced metering infrastructure**
- Workforce training
- Regulatory compliance and support
- **Engineering planning and operations**

Electric
Industry Drivers & Evolution

Industry Trends and Drivers – Electric

Renewable generation and energy storage are being deployed to reduce carbon footprint by replacing carbon-emitting generation— both renewable DERs and the grid are carbon-free and complement each other.

The electric utility industry is preparing for the deployment of electric vehicles and fleet electrification.

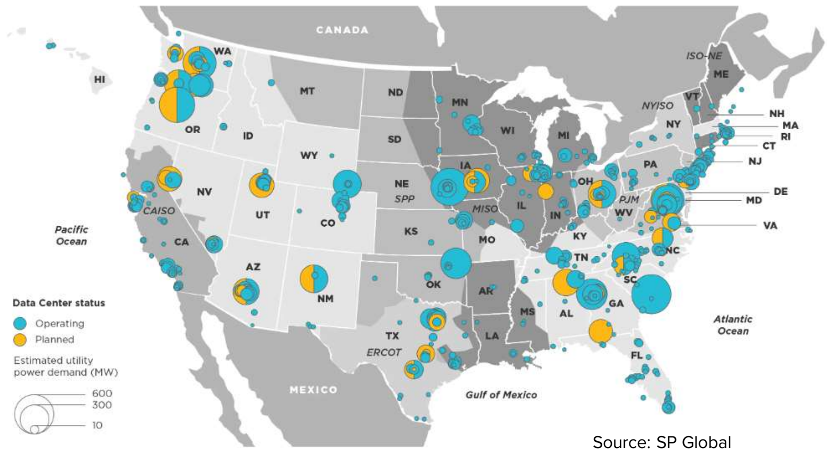
The electric utility industry is leading the way in supporting the communities they serve by adapting to and **mitigating the impacts of severe weather events.**

Expanded and enhanced grids are essential to support beneficial renewables, electrification of transportation, and a resilient grid.

- Optimal integration of DER and energy storage requires expanding and modernizing the grid infrastructure with significant capital investments.
- Shifting load patterns due to electrification require advanced analytics.
- Need for new solutions on the distribution grid to address new issues.
- Demand response and energy efficiency

Proliferation of Data Centers

Operating and Planned Data Centers in the U.S.



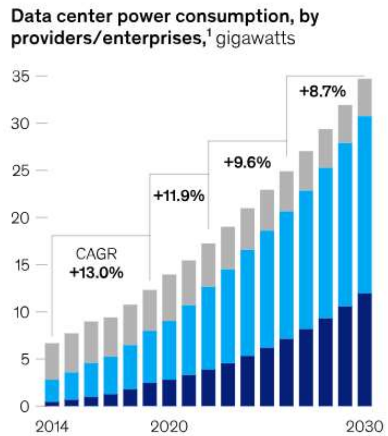
Source: SP Global

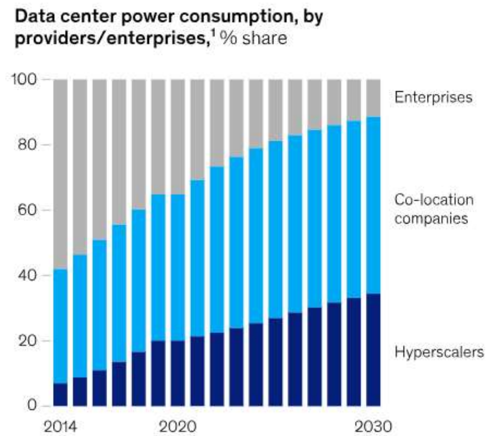
- Top 10 data center locations in the U.S. are Northern Virginia, Phoenix, Dallas, Atlanta, Chicago, Northern California (Silicon Valley), Portland (including Hillsboro, Oregon), New York & New Jersey, Seattle (including Quincy, Washington), and Los Angeles
- There are about 239 data centers in Canada, 73% of them in Toronto (81), Montreal (48), Vancouver (25), Calgary (12) and Edmonton (9)

Target business development efforts to utilities serving areas with data center proliferation

- Industry experienced stagnant, declining, or low/moderate load growth over the last two decades
- **U.S. data center demand is forecast to grow by about 10% annually until 2030**
- **Data centers will use 8% of US power by 2030 (vs. 3% in 2022)**
- US utilities will need to invest around $50B in new generation capacity to support data centers alone
- Significant investments in T&D will also be required

Shortage of utility resources with experience to plan T&D grids with significant load growth



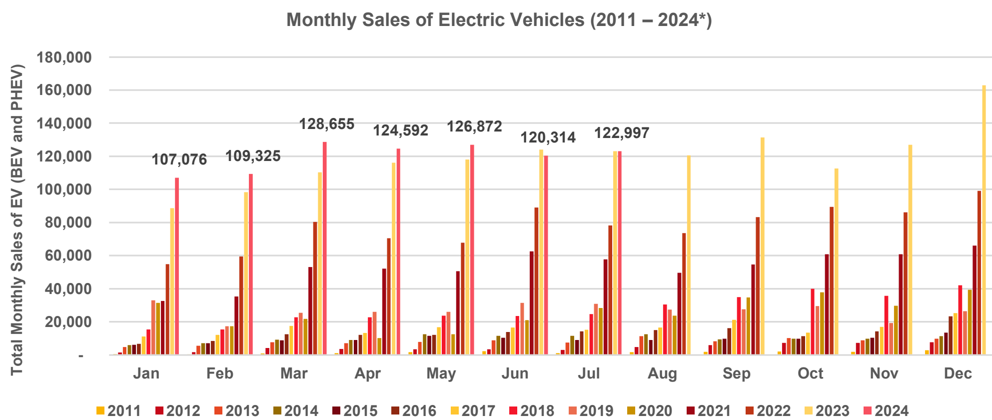


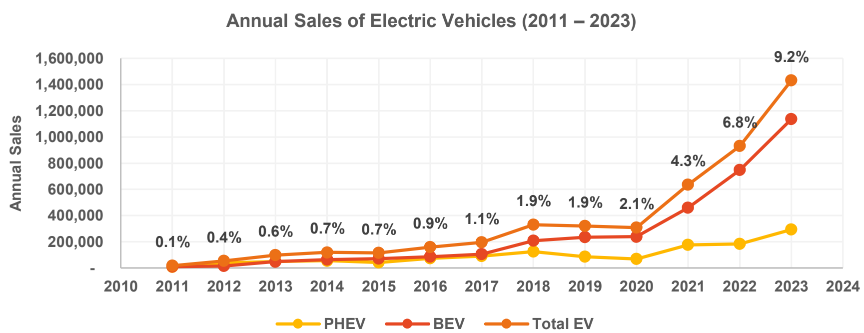
[1]Demand is measured by power consumption to reflect the number of servers a data center can house. Demand includes megawatts for storage, servers, and networks.

Source: McKinsey & Co. https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/investing-in-the-rising-data-center-economy

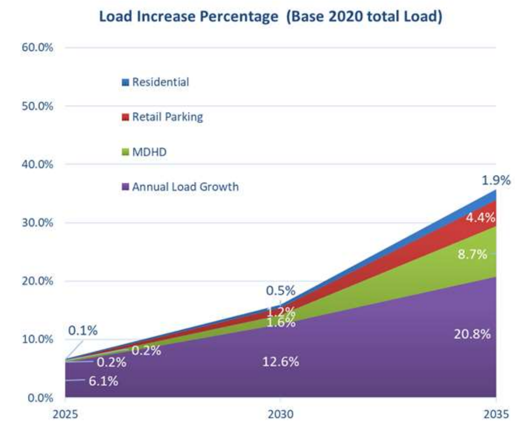
Increasing Adoption of Electric Transportation

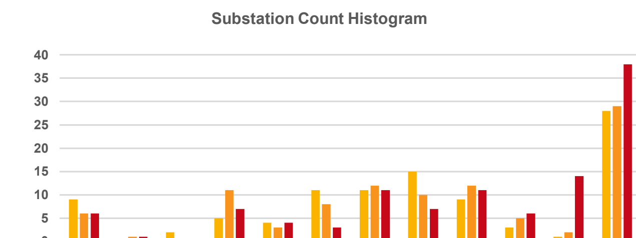
- Increasing adoption of electric vehicles in the U.S. over the last decade for both, month-over-month and annual sales
- Moderate deceleration of electric vehicle adoption in Q2 2024





Source: Light Duty Electric Drive Vehicles Monthly Sales Updates - Historical Data, Argonne National Laboratory



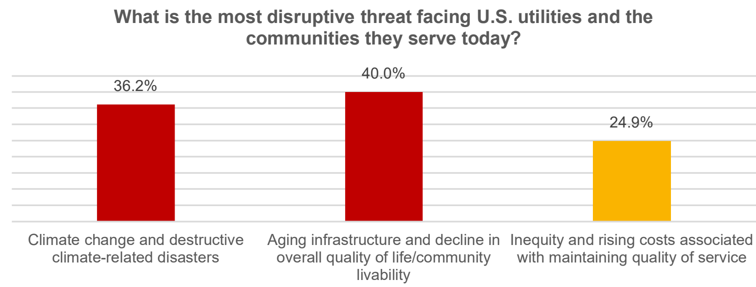


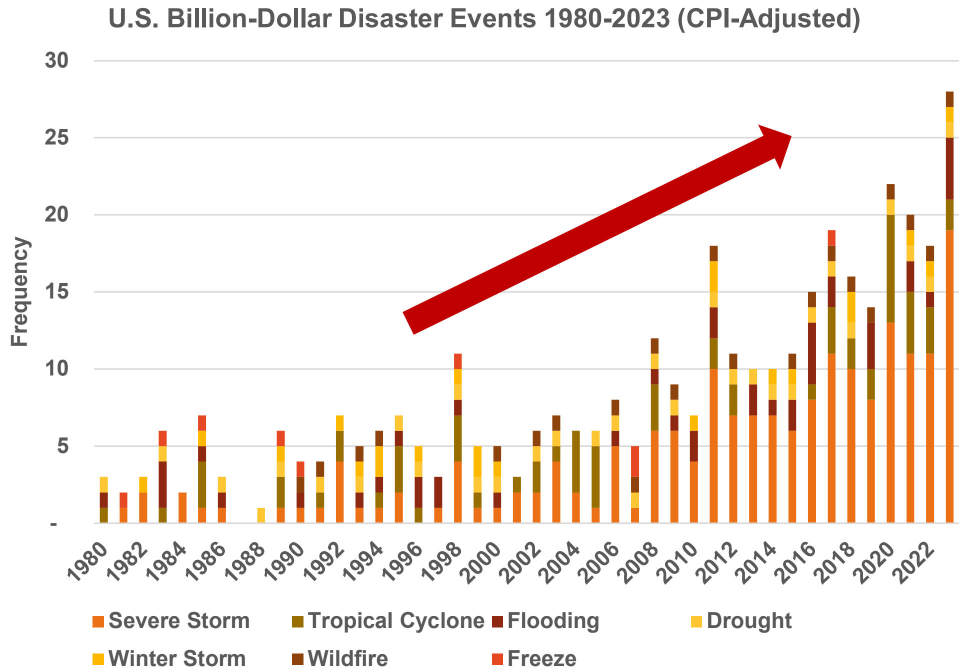
	<10%	10%-20%	20%-30%	30%-40%	40%-50%	50%-60%	60%-70%	70%-80%	80%-90%	90%-100%	Over 100%	70%-or-greater
2025	9	0	2	5	4	11	11	15	9	3	1	28
2030	6	1	0	11	3	8	12	10	12	5	2	29
2035	6	1	0	7	4	3	11	7	11	6	14	38

2025 2030 2035

Increased Impacts of Major Weather Events

- Impact of major weather events to T&D grid has increased steadily over the last four decades
- Severe storms and tropical cyclones are the most frequent and costly events, respectively





Time Period	Billion-Dollar Disasters	Events/Year	Cost ($B)	Percentage of Total Cost (%)	Cost ($B)/Year	Deaths	Deaths/Year
1980s (1980-89)	33	3.3	214.6	8.0	21.5	2,994	299
1990s (1990-99)	57	5.7	327.7	12.3	32.8	3,075	308
2000s (2000-09)	67	6.7	607.2	22.7	60.7	3,102	310
2010s (2010-19)	131	13.1	972.5	36.4	97.3	5,227	523
Last 5 Years (2019-2023)	102	20.4	605.5	22.6	121.1	1,996	399
Last 3 Years (2021-2023)	66	22.0	433.0	16.2	144.3	1,690	563
Last Year (2023)	28	28.0	93.1	3.5	93.1	492	492
All Years (1980-2024)	**377**	**8.4**	**2,674.9**	**100.0**	**59.4**	**16,353**	**363**

Select Time Period Comparisons of **U.S. Billion-Dollar Disasters** (Drought, Flooding, Freeze, Severe Storm, Tropical Cyclone, Wildfire, and Winter Storm) Statistics (CPI-Adjusted)

Source: National Centers for Environmental Information - NOAA

Grid Resiliency

Drivers for utilities:

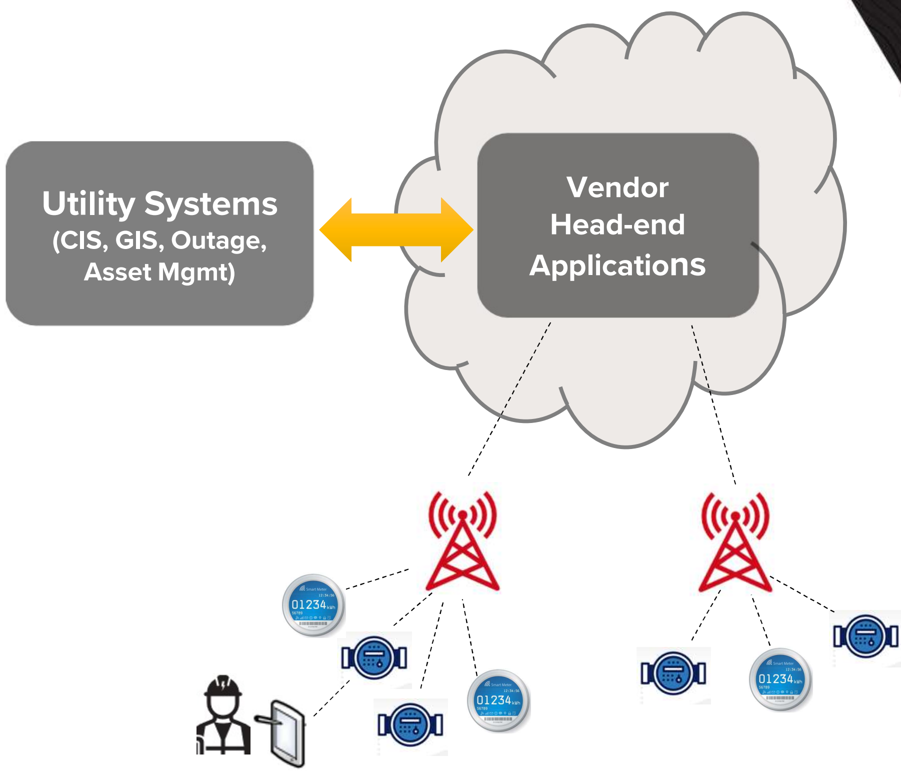
1. Aging infrastructure improvements
2. Operational improvements and efficiencies
3. Distribution Automation and Control
4. Improving capacity for EV loads and DERs

Issues for utilities:

- Undersized conductors
- Damaged poles, insulation and lines
- Vegetation management
- Load growth

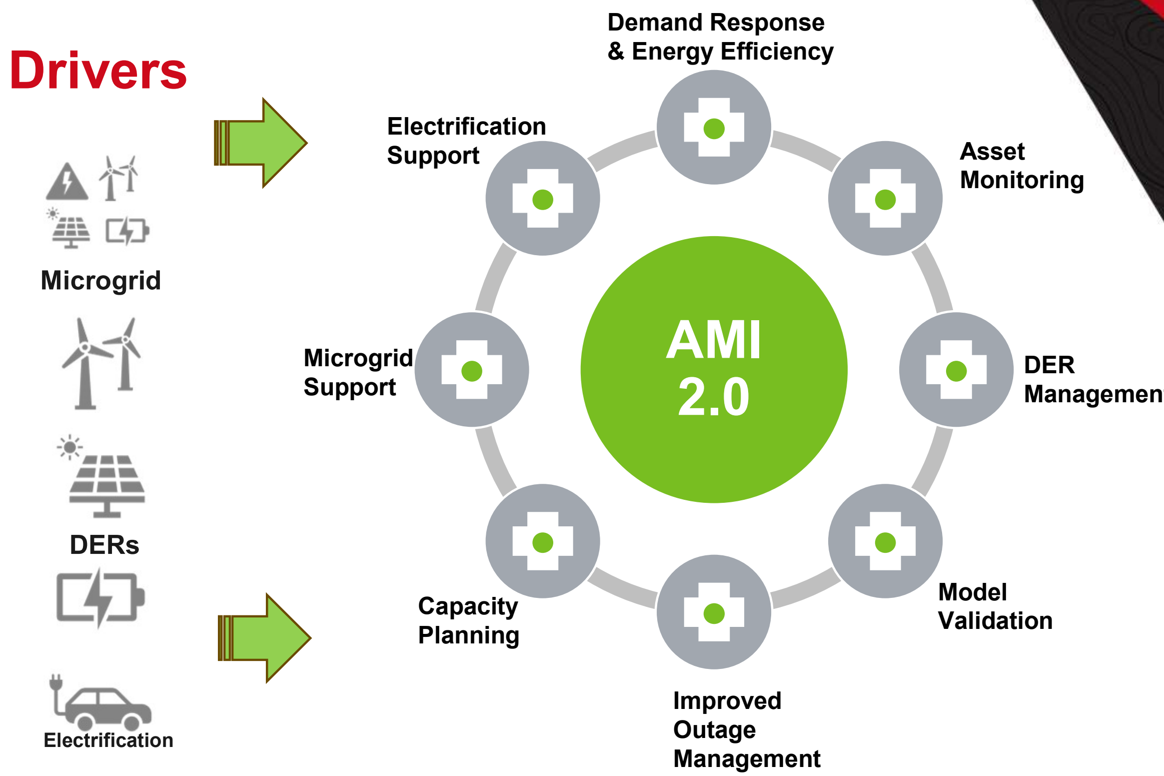
AMI 1.0

- Two-way communication & control
- Automated reading and interval data
- Alarms/event reporting
- Advanced measures (power quality, volt/var, etc.)
- Outage / Restoration reporting
- On-demand reads, connect/disconnect, automated firmware updates
- Transitions Utility from once monthly to near real-time information
- **Foundational technology to enable Smart Utility evolution**
- **Must be fully integrated to Utility Systems**

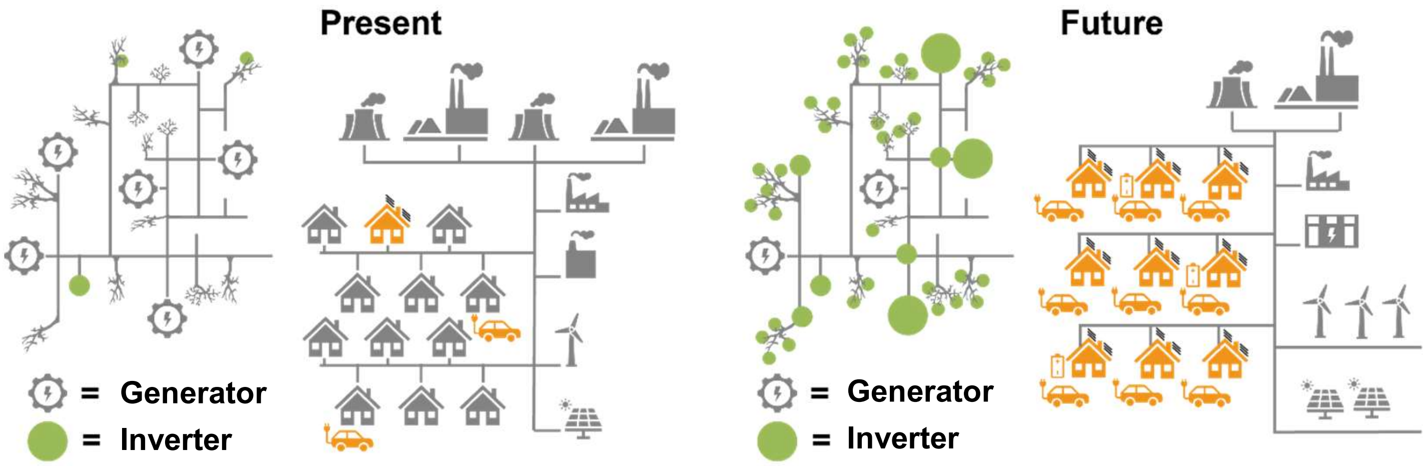


AMI 2.0 – Key Improvements

- Distributed grid edge intelligence
  - Meter Operating System (OS) & Applications
- Improved meter sampling
  - Sub-second sampling at meter
  - Enables load disaggregation
- Meters can coordinate to:
  - Identify phase to allow balancing
  - Identify meters on same transformer (dynamic model verification)
  - Meter mapping to transformer allows load analysis, predictive transformer failure analysis improving asset management
- Integration of edge sensors and grid devices
  - Enhanced distribution automation (monitoring & control)
  - DER management & integration with DERMS
  - Street lighting, smart city
- Improved data accuracy and resolution
  - Leveraging multiple data sources to increase information value

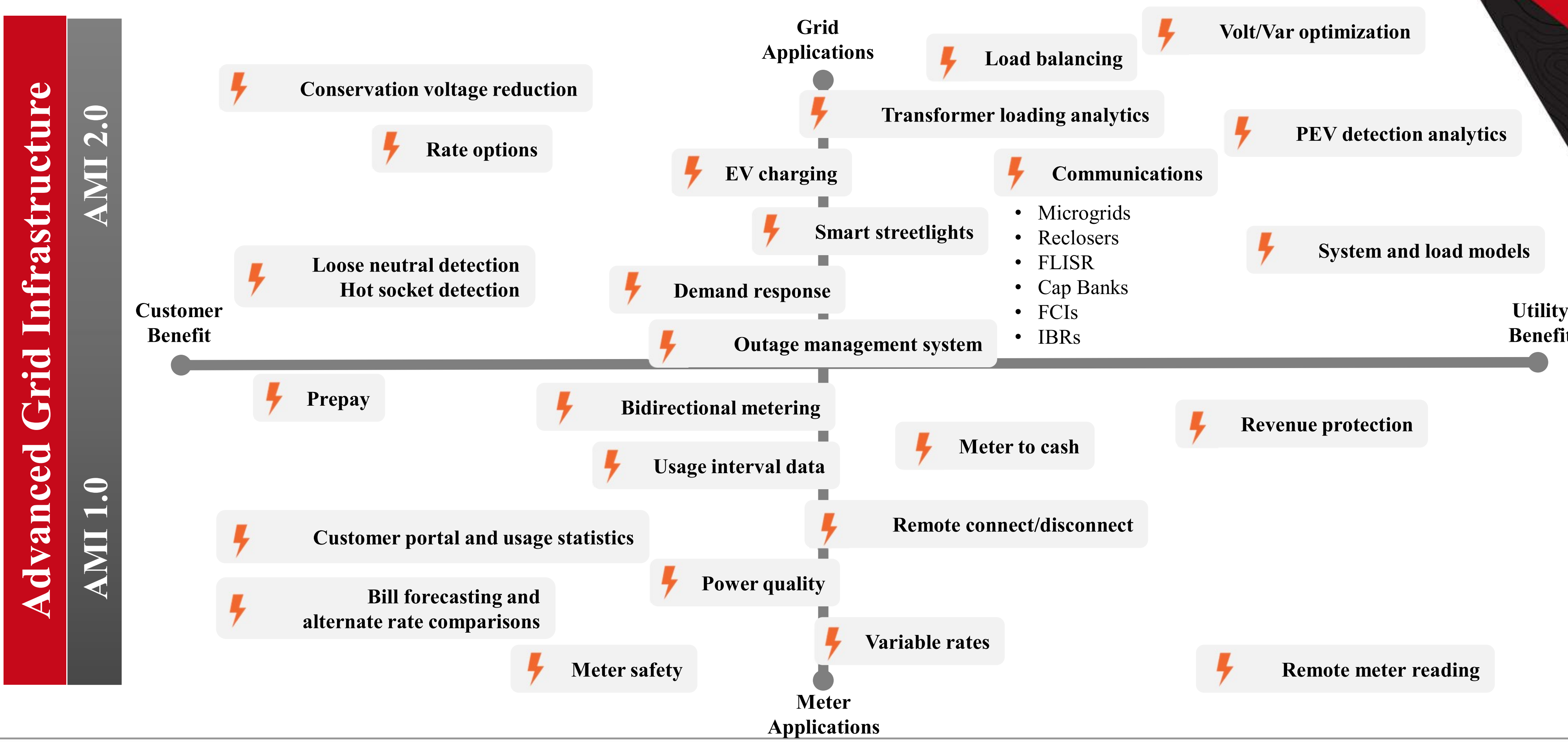


Advanced Grid Infrastructure (AGI) Vision



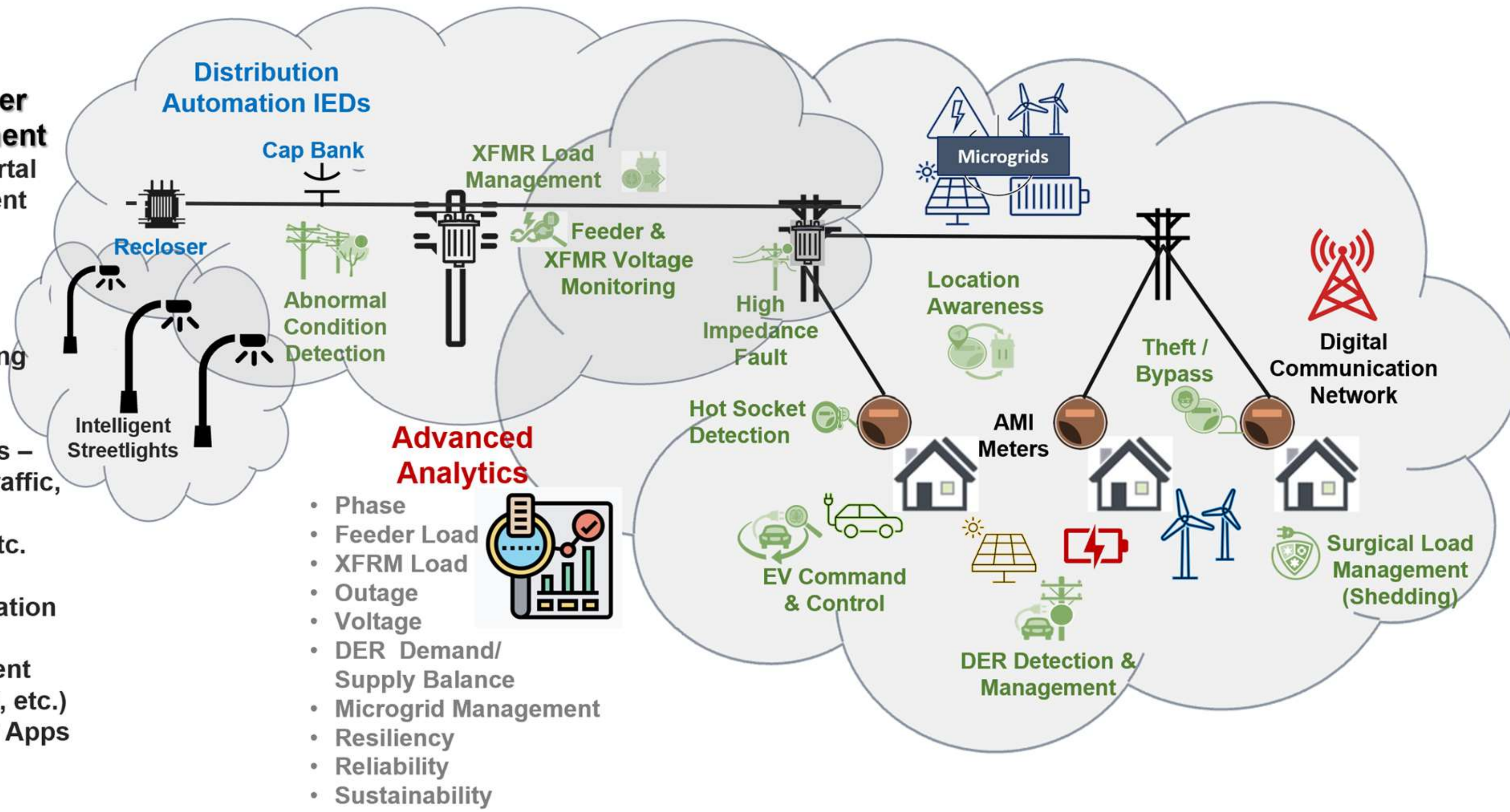
AGI is leveraging the full capabilities of AMI 2.0 systems to realize distribution grid modernization. AMI 2.0 provides grid edge intelligence, system-wide distribution, digital communications network, and advanced capabilities such as grid modeling, reliability analysis, ADMS interface for DA devices and improved outage capabilities, improved customer options for demand response and energy efficiency and other capabilities.

AMI Grid Modernization (Electric Use Cases)



AMI 2.0 Edge Computing / Distributed Intelligence Apps

Customer Engagement
- Energy Portal
- Pre-Payment
- Demand Response
- Energy Efficiency
- DER Hosting Capacity
- Intelligent Streetlights – Apps for traffic, flooding, security, etc.
- Load Disaggregation
- Rates Development (TOU, CPP, etc.)
- Smart City Apps



Water/Gas
Industry Drivers & Evolution

Industry Trends and Drivers – Water

Non-revenue water loss averages about 20% across utilities representing millions of dollars of losses and operational expenditures

Three primary drivers for utilities:

1. Non-revenue water loss reduction
2. Operational improvements and efficiencies
3. Aging infrastructure improvements

Water losses:

- Real losses – real water leaks
- Apparent losses – under/inaccurate metering due to aging meters
- Utilities seeking to improve operational efficiencies through deployment of AMI systems

Industry Trends and Drivers – Gas

Primary drivers for utilities:

1. Safety
   - Excess flow or Un-regulated flow
   - Integrated shut-off valves – triggers for high pressure, high temperature, tamper and high flow rate.
2. Increased Data Capabilities
   - Increased historical usage profiles with resolution down to 15 minutes
3. Real-time data & advanced analytics

AMI Water Evolution

Manual / AMR

- Walk-by, Touch, Drive-by
- Once / month readings
- Limited indications

AMI

- Automated reading
- Interval data
- Alerts, Alarms
- Theft detection
- Near-real time data
- MDM-lite

Advanced Features & Sensors

- Pressure
- Acoustic Leak Detection
- Water Temperature
- Water Quality
- Remote connect/ disconnect (tri-state)
- Level sensors
- Smart gateways
- IoT Devices

Data Analytics & Intelligence

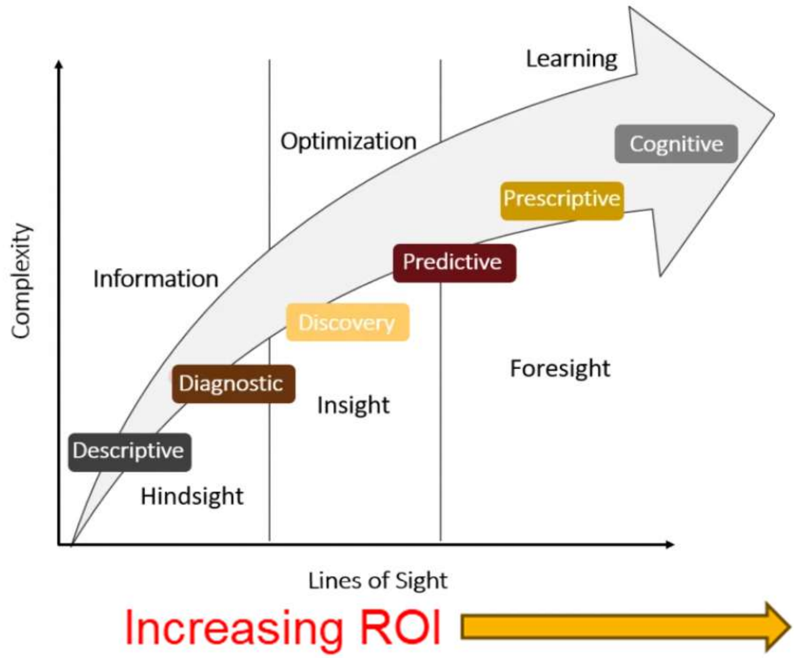
- Centralized dashboards & reporting
- Data lakes, repository
- System Water Balance
- Non-revenue water loss reduction
- District metering
- Pressure monitoring

Smart Water Utility

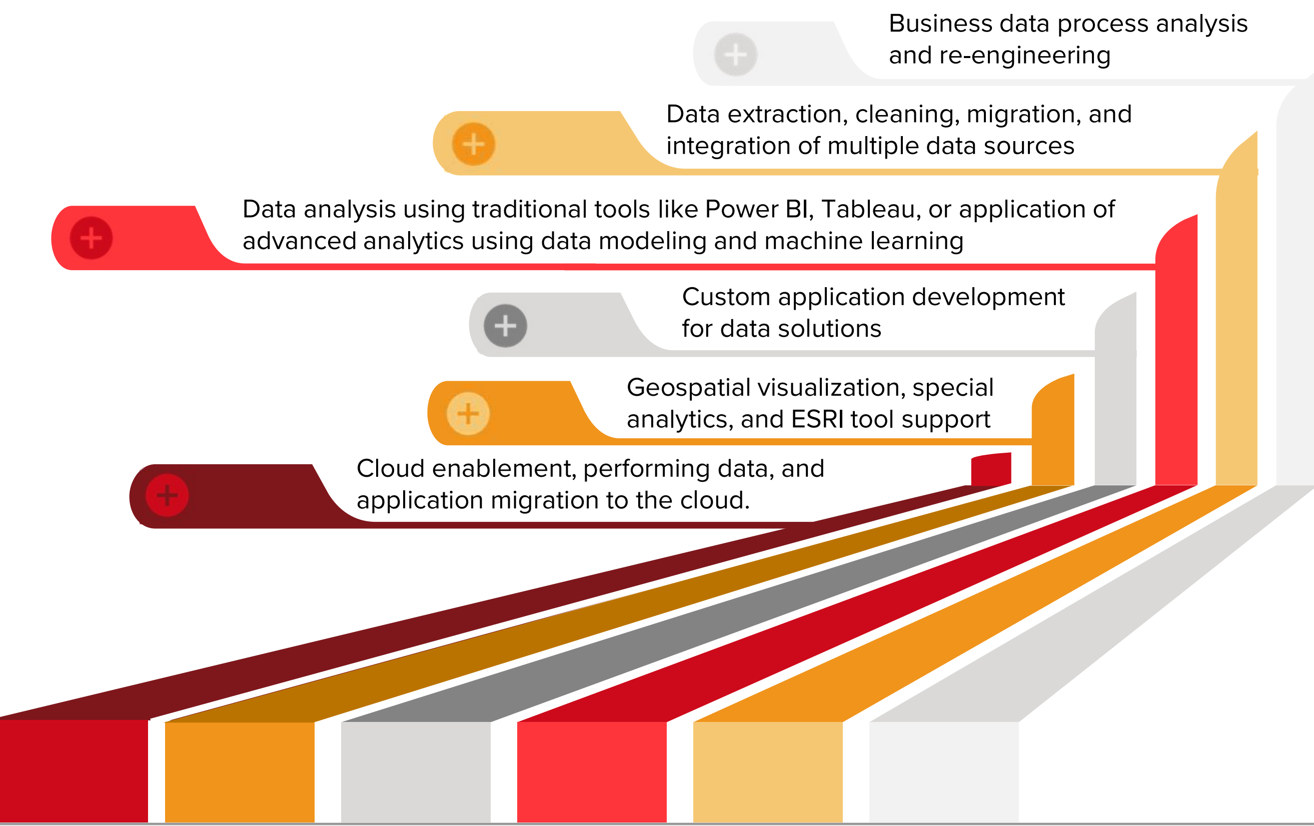
- Integrated operations (treatment, metering, wastewater)
- Advanced metering
- Wellfield monitoring
- Distribution pressure monitoring
- Water quality monitoring
- I&I / Sanitary Sewer overflow monitoring
- SCADA integration

Data Analytics for Utilities

Data Analytics for Utilities



Advanced Analytics Services with Quanta Technology:
Utility SMEs working with Data Analytics SMEs



The Advanced Applications Analytics team is multidisciplinary.

The broad range of skills allow us to assist Utilities with all types of data analysis, predictive analytics using machine learning, geospatial data, relational database queries and integrations, as well as back-office software integrations.

Our expertise in cloud-based solutions allows us to both advise or migrate customer applications from on-premise to hybrid or fully to the cloud.

Data Analytics for Utilities: Grid Insights *(Video)*

Examples

Example #1:
Transformer Utilization & Overloading

Data Analytics for Utilities: Customer Successes
AMI analytics for voltage issue resolution

Project Title: Cluster Analytics for Identification and Resolution of Transformer Exceedances

Client: San Diego Gas & Electric

Project features:

- Customer voltage exceedances may be caused by primary issues (wide area) or secondary issues (local)
- Quanta Technology developed a system that uses AMI data to determine the cause of the voltage exceedances
- The system provide clues for permanent resolution of the exceedances

Data Sources for Service Transformer Monitoring

Table 1: Data Sources and Needed Inputs

DESCRIPTION	DATA SOURCE	INPUT VALUE DESCRIPTION
Transformer Location	GIS/Asset Catalog	Service Transformer ID
		Service Transformer Latitude
		Service Transformer Longitude
Transformer Type and Rating	Asset Catalog	Service Transformer ID
		Service Transformer Rating
Meter Type	Asset Catalog/MDM	S2, other (if other will meter report primary or stepped down information?)
Meter Location	GIS/AMI	Meter Latitude
		Meter Longitude
AMI 2.0 Data	MDM	kWh delivered per phase
		kVAh delivered per phase
		kWh received per phase
		kVAh received per phase
		Avg voltage per phase
		Avg current per phase
		Avg power factor(PF) per phase
		Event data from momentary and sustained outages if available (AMI 2.0)
		Grouped meters and associated transformer (AMI 2.0)
		Transformer to meter hierarchy (AMI 2.0)
		Voltage profile
		Meter Longitude
		Meter Latitude
Grid Model	Grid Model Application	Distribution substation to line, to transformer, to meter model.

Example #2: Electrification

Electrification: Challenges and Opportunities

Why the interest in heavy-duty fleets?
Chargers can be 150X the size of light-duty vehicle chargers and diesel engines account for most harmful emissions impacting society.

EV transportation, whether heavy or light-duty vehicles, requires unique solutions and approach

- **How to achieve collaboration** among fleet owners, charging developers, utilities, regulators, city officials, vehicle manufacturers?
- **Locating where, when, and how big loads will be (roadmaps).**
- **How to allocate load data** to specific feeders and substations?
- **What are the best solutions to mitigating this new load?**
- **How to incorporate Energy Justice Metrics** into Prioritization and Decision Processes

Comprehensive approach to address challenges and opportunities:

- **Electrification forecasting** based on regulatory and industry trends and advanced driving pattern analysis to assist with short to long-term planning
- **Assessment** of charging technologies, vehicle adoption, and locations
- **EV load-impact analysis** of residential and commercial fleets on electricity grids
- **Deployment and implementation** of mitigation technologies, including grid upgrades and reconfiguration, charging and demand-side management, photovoltaic, and storage.
- **Our team** listens to their customers and ensures our knowledge and approaches are transferred to our clients

Electrification: Opportunities and Impacts - Five-step Process

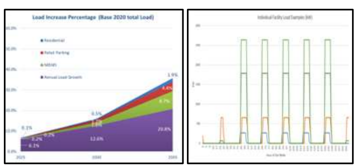
1

Address Level Bottom-up analysis to identify site locations

2

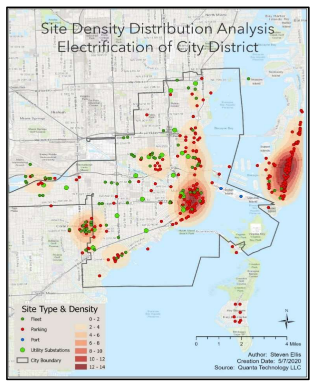
Forecasting adoption and estimating loads

- Adoption Curves
  - Regulations
  - Economics
- Scenario Analysis
- 8760 Load Profiles



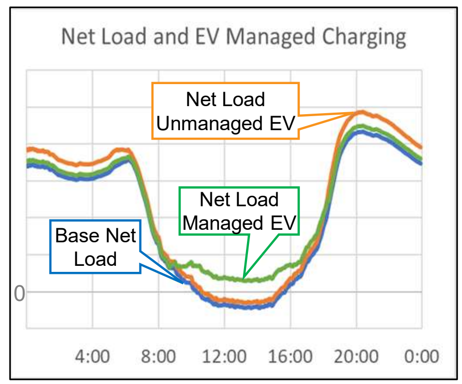
3

Map and aggregate facility loads curves to desired level



4

Evaluating mitigation options: managed charging, DERs, and infrastructure upgrades



5

Regulatory support to gain acceptance of optimal solution approach

- Expert Witnesses
- Creating and Supporting defensible data for Utility solutions
- All Electrification – EV, Building and Industrial Electrification
- Ensure utilities are viewed as enablers of electrification

Study is fully customizable: Number of steps, Areas, HD/MD/LD

Electrification: Address Level - Bottom-up Analysis to Identify MHD Fleet Impact

Example Case Study

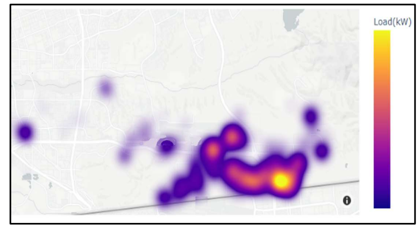
Problem

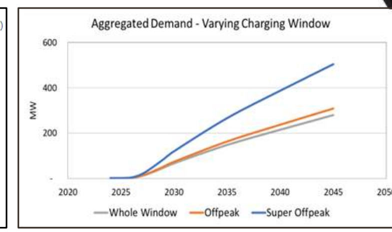
- Utility would like to have a better understanding of MHD Fleet Loads
- Engaged with QTech team to utilize the "address-level" approach
- **Selected pilot area due to unusually large number of heavy-duty vehicles in area**

Approach

- **Starts with finding facilities and vehicles using accurate data sources**
- **Once identified, customized adoption curves can be made across facility/vehicle types**
- **Load estimates can be made, aggregated up into individual facility and territory load curves – in LoadSEER format if requested**
- GPS coordinates of sites allow loads to be linked to specific feeders/substation to determine the impact – solves the disaggregation problem from top-down approaches
- In most cases, QTech evaluates impact, mitigation, and supports regulatory efforts to justify actions

Outcome





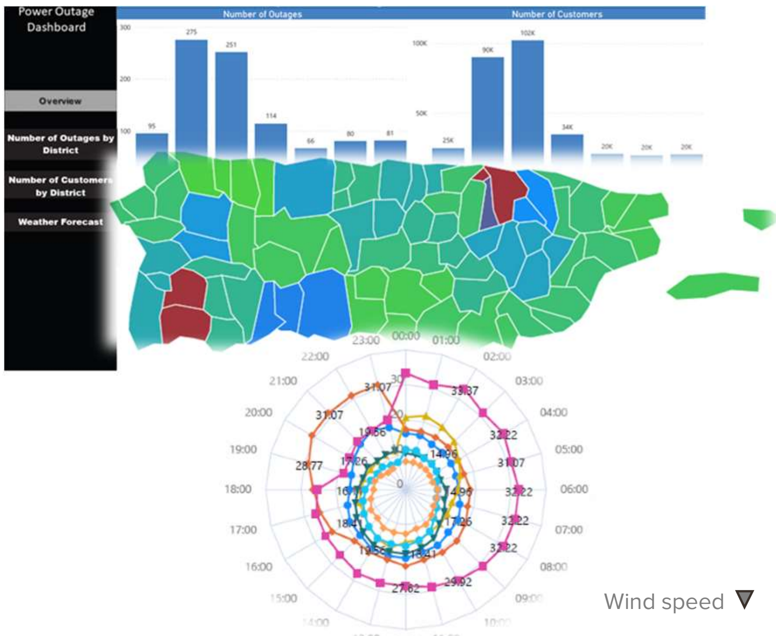
- Key take-aways: size of load (>300 MW), at night, overwhelms current infrastructure
- Key take-away: Load is not uniformly distributed: Address level approach needed
- Key take-away: Graph on right shows the difference in "managed" charging – 200 MW difference. Leading the utility to examine their tariffs, education on charging
- 8760 profiles created for each facility in LoadSEER format
- Result is being used to compare with current load estimation

Example #3:
Responding to Weather Events

Data Analytics for Utilities: Customer Successes

Operational intelligence that supports preparation efforts to respond to weather events

MACHINE LEARNING ANALYTICS



Weather forecast based, 7-day ahead hourly forecast of number of outages and affected customers across the distribution system

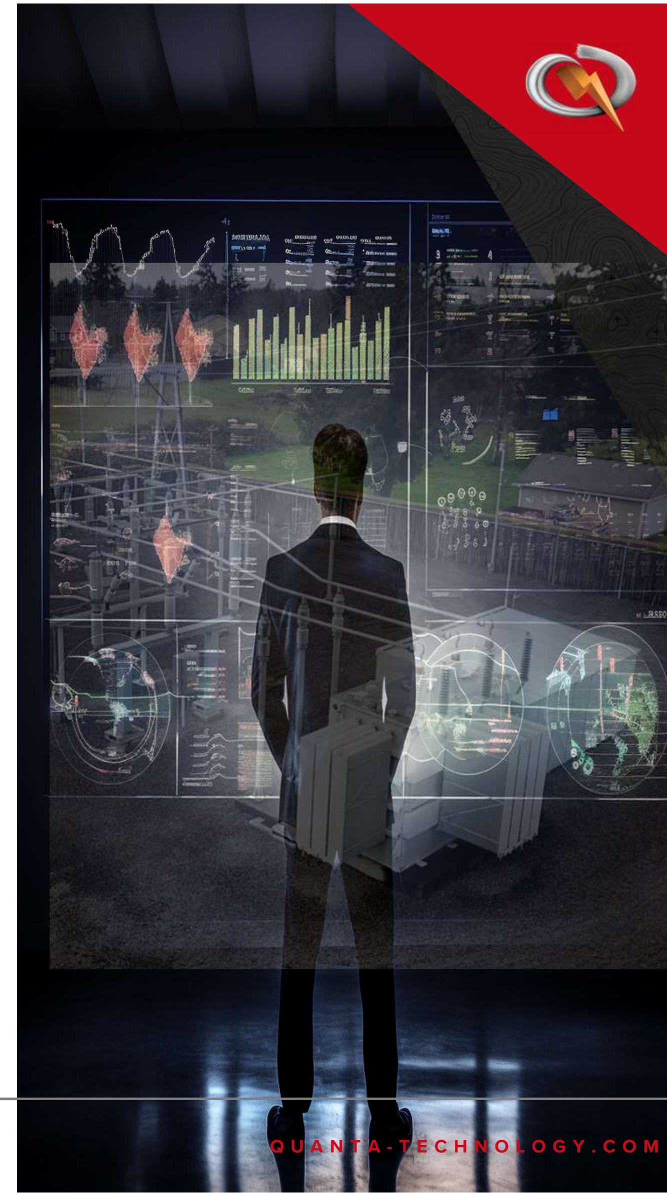
Luma (Puerto Rico) has been using this outage prediction tool to enhance preparations for upcoming weather events. The outage prediction tool is autonomous and automated to hourly update the forecast of expected number of outages and affected customers – entire system and by region - based on weather forecast, which is contextualized and visualized for system operations' planning activities. Due to dynamic weather forecast conditions, the tool features email and text notifications once outage forecasts change significantly. Available in the cloud and on-premise environment.

Example #4:
Asset Management

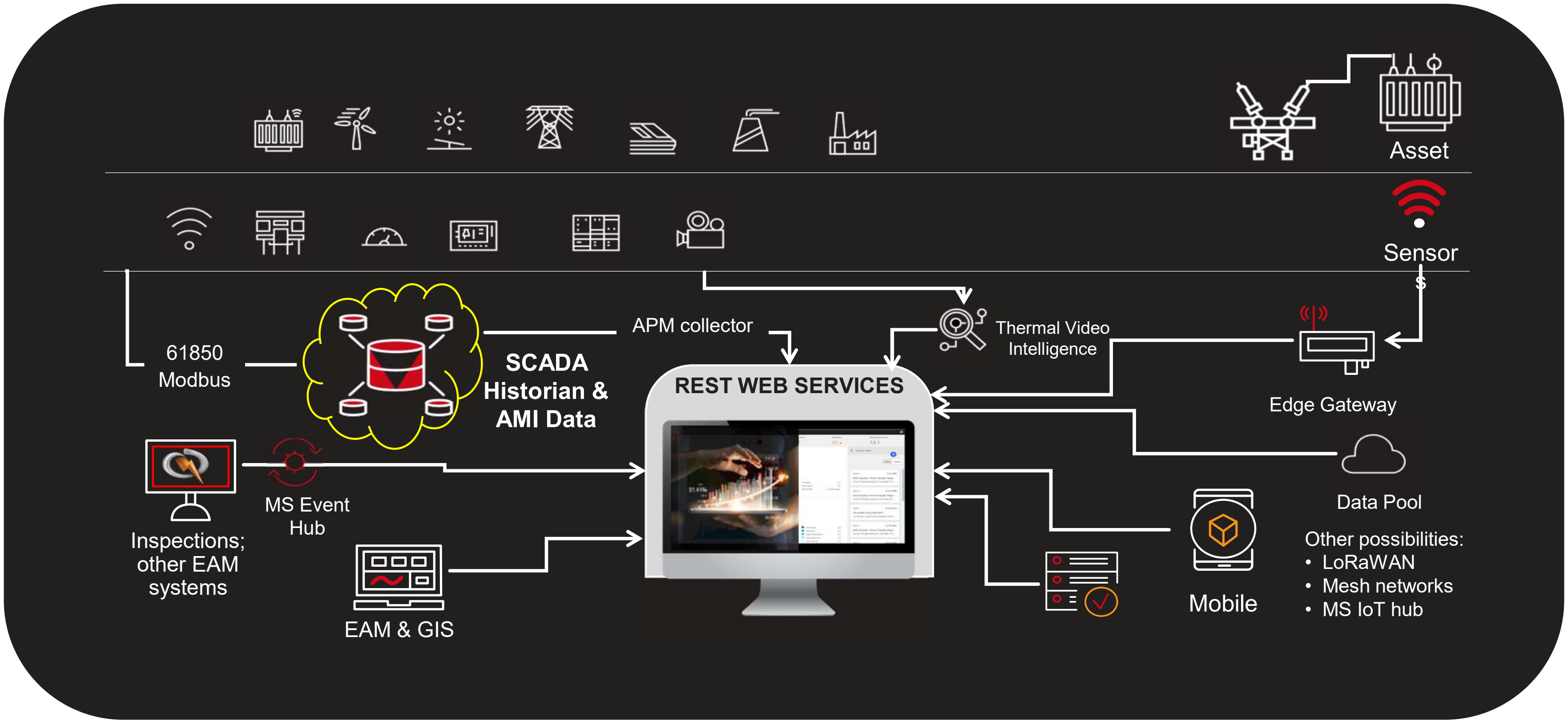
Technology Integration for Substations Asset Performance Management (APM)

Advanced Metering Infrastructure (AMI) provides numerous benefits to substations, enhancing their performance, reliability, and efficiency. Leveraging AMI data with SCADA (Supervisory Control and Data Acquisition) and PI Historian systems can significantly enhance substation asset management.

1. Real-Time Monitoring and Data Integration
    - **Centralized Data Repository:** Use the PI Historian to collect and store AMI data along with SCADA data in a centralized repository. This allows for comprehensive data analysis and historical trending. Ensure that AMI data is synchronized with SCADA data in real-time to provide a complete picture of substation operations.
2. Predictive Maintenance
    - **Condition-Based Maintenance:** Analyze historical data from the PI Historian to predict when maintenance is needed based on equipment performance trends. This helps in scheduling maintenance activities before failures occur..
3. Enhanced Monitoring and Diagnostics
    - **Real-Time Monitoring:** Combine real-time AMI data with SCADA system monitoring to get a detailed view of substation performance. This includes monitoring voltage levels, load currents, and equipment status.
    - **Anomaly Detection**: Use the integrated data to detect anomalies and potential issues early. The PI Historian can help identify patterns and trends that indicate equipment degradation or impending failures.
4. Improved Decision-Making
    - **Data-Driven Insights:** Leverage the comprehensive data set from AMI, SCADA, and the PI Historian to make informed decisions about substation operations, maintenance, and upgrades.



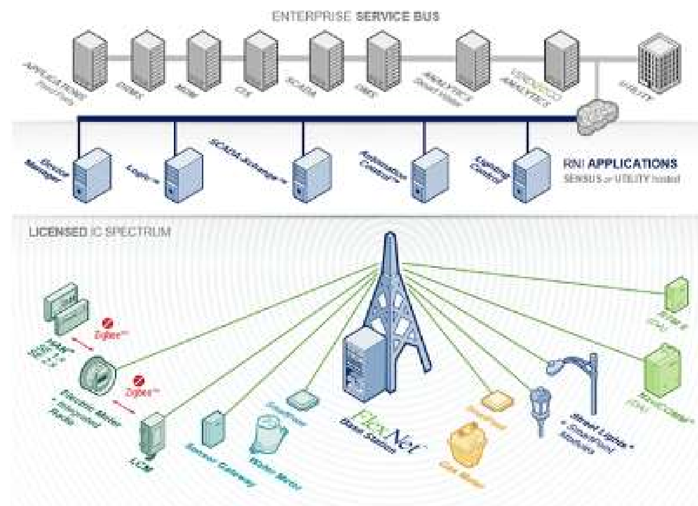
Technology Integration for Substations Asset Performance Management (APM)



Example #5:
NSBU Grid Modernization – Distribution Automation

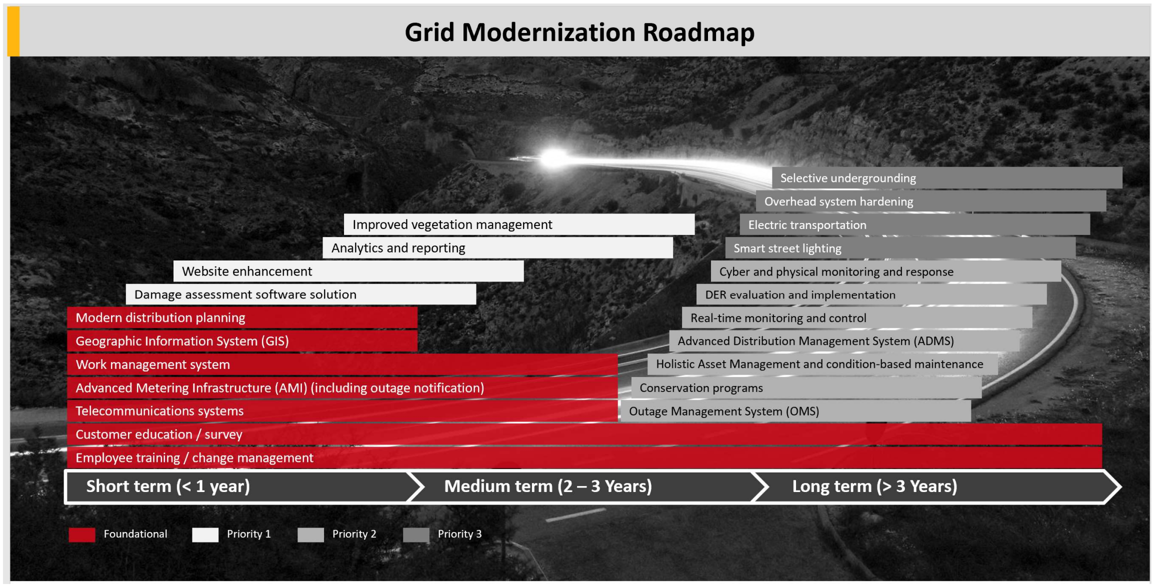
New Smyrna Beach Utilities (NSBU) Overview

- Electric and Water Services
  - 30K Electric
  - 25K Water
- Began Grid Modernization journey in 2019 with development of a strategic roadmap
- Currently deploying Sensus AMI system
  - Full electric deployment
  - Water pilot
  - Grid Evaluation
  - Distribution Automation



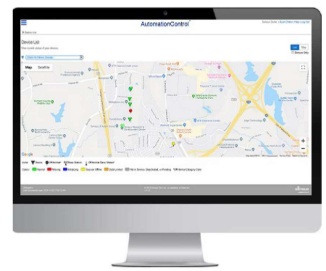
NSBU Grid Modernization Roadmap

- AMI is a foundational technology
- Short Term:
  - AMI Deployment
  - Outage Management
  - Distribution Automation
  - Advanced Analytics



Distribution Automation Solution Components

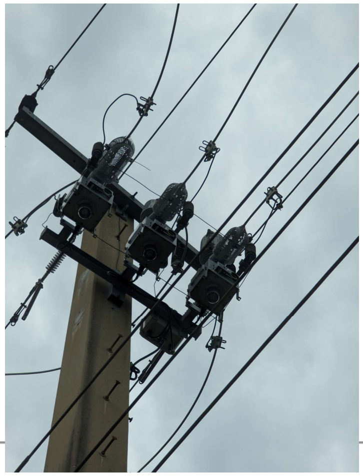
- RTMII - Remote Telemetry Module
  - Modbus, DNP3 support
  - Reclosers, capacitor banks, voltage regulators etc.
- Navicomm - Faulted Circuit Indicator (FCI)
- Automation Control Software Suite
  - Data collection, remote monitoring, analysis
  - Control functions available
  - Integration with Utility SCADA

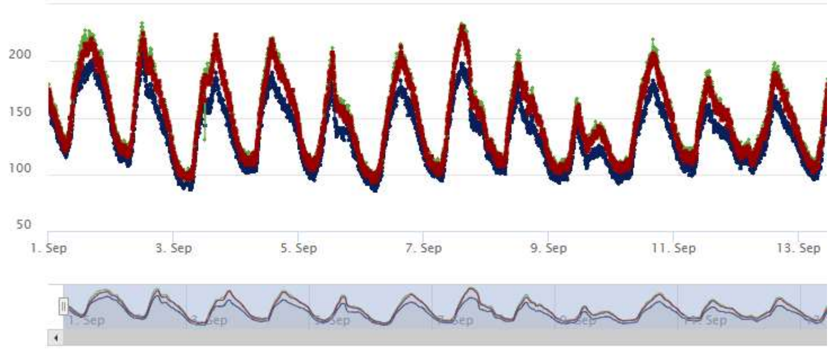


Distribution Automation

Drivers for utilities:

1. Remote monitoring and control
2. Fault Location and Isolation
3. Volt/Var Control
4. Improved customer reliability indices



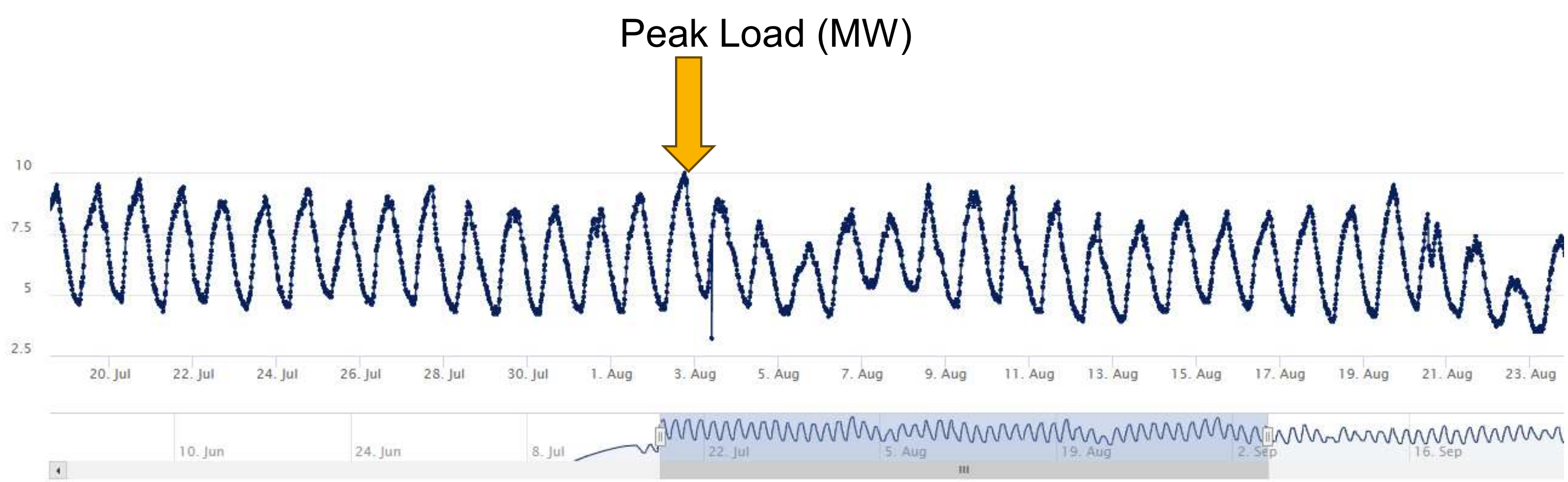


Issues for utilities:

- Unbalanced feeders
- Faults
- Poor voltage
- Customer outage times

Example: Looking at the summer peak loading conditions on a feeder

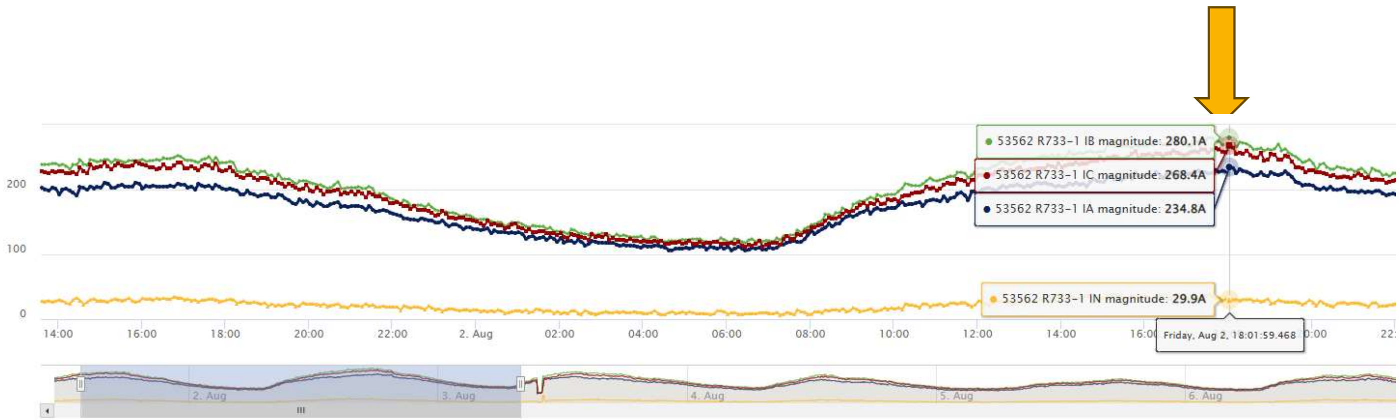
Peak MW reading



Example Data: Looking at the summer peak loading conditions on a feeder

Peak current values at Peak MW

Ia = 280A, Ib = 268A Ic =235A In = 30A



DA Program Benefits

- Remote control of feeder equipment
- Better visibility of feeder operation
- Better coordination between protection and control equipment
- Improved reliability
- Data for planning and forecasting
- Enable SCADA control

Questions or Comments?

Accelerate Successful Outcomes for Your Projects

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Backup Slides

Key Industry Trends – Executive Summary

1 **Load Growth:** significant load growth expected over the next decade due to electrification, data centers, and industrial loads. This will drive investments in new T&D infrastructure

2 **Data Centers and AI:** Data centers are expected to consume 8% of US power by 2030 (vs. 3% in 2022) and impact T&D planning, reliability, resilience and power quality. AI applications (including utilities) are key driver for proliferation

3 **Electrification:** moderate slowdown in adoption of electric transportation. Forecasts show that gas to electric heating conversions, building electrification, etc. will also contribute to expected load growth, magnitude varies by region

4 **Climate Change, Reliability and Resilience:** impacts of severe weather events are increasing steadily, increased focus on utility readiness, concerns about investments not outpacing impacts and ability to justify additional improvements

5 **Digital Transformation:** increased interest in AMI 2.0, data analytics applications, and digital transformation in general to digitize key processes, integrate systems, address data integrity, and improve operational efficiency

6 **Clean Energy:** growing adoption of clean and renewable energy (including off-shore wind) and energy storage, driven by state targets, mandates, and standards

7 **Modern Planning and Operations:** need for new solutions to plan and operate grids with high penetration levels of IBRs, including growing interest in integrated RTD planning

8 **Grid Modernization:** most grid modernization actions increased over the last decade. There was a slow down in the total number of grid modernization activities in 2022 and 2023, due to reduction in policies and deployments

9 **CAPEX:** utility T&D CAPEX has increased significantly over the last decade, steady increase forecasted for 2025, investments targeted to expansion, replacement, and hardening and resilience of T&D infrastructure

10 **IIJA and IRA:** utilities continue exploring IIJA and IRA funding opportunities to offset costs of decarbonization initiatives (e.g., electrification) and emerging technologies (ensure affordability)

Overview of Benefits of AMI 2.0

The real value of AMI data is unlocked through analytics

Benefits for Utilities:

- Being able to capture voltage more frequently than AMI 1.0 meters allows operators **to regulate overall grid voltage with much more control**
    - Can improve theft detection, neutral fault detection, and high impedance detection
- Improve overall DER management
    - **Helps to identify feasible locations** for high-voltage residential EV chargers and whether or not **the existing circuit can handle it**
    - **Improve safety by identifying unregistered DER (PVs, EVs, battery)**
- Utilities can perform phase detection at the meter, the end point of the circuit.
    - Thereby reducing the need to add additional equipment to measure phase load. Improving efficiency and the potential to do phase load balancing in real-time.
- **AMI 2.0 are more like smartphones** allowing for new applications to pushed to them as needed thereby **extending their usefulness**.
    - AMI 1.0 meters were limited to only allow over-the-air updates to firmware and meter configurations

Benefits for Customers:

- **Built-in WiFi** allows customers to use smartphone applications to improve their overall customer experience. For example SRP recently allowed customer to prepay for electricity and set their own thresholds via a smartphone application.
    - This extended capability would **not have been possible using AMI 1.0**
- Non-intrusive load monitoring can be applied by applying **signal processing data analytic/AI algorithms to identify types of appliances** running behind the meter allowing for consumers home energy management solutions integrated into their smart phones.
    - **NOTE:This signal processing can also help utilities identify EV, battery storage, and/or PV usage/adoption which mitigates potential dangerous/safety issues**
- **Consumers who participate in bi-directional metering programs** can have more access to real-time information about the volume of electricity being produced **allowing them to make better decisions** on how much and when to see or store energy.

AGI – Next Generation Grid Modernization

AGI leverages all intelligent grid devices/sensors onto a cohesive network to provide a management system that improves the **customer experience, resiliency, reliability** and **sustainability** of energy delivery.

AGI system includes:

- Advanced metering infrastructure (AMI – smart meters)
- Digital communication network
- Distribution automation (DA) devices – reclosers, fault indicators, capacitor banks, switches, etc.
- Customer interfaces – portal, prepay, etc.
- Data analytics – forecasting, reliability, connectivity model, etc...
- Distributed energy resources (DER)
- Demand response (DR)
- Energy efficiency devices (EE)
- Intelligent LED streetlights

Advanced Grid Infrastructure (AGI) Components

Drivers

Microgrid

DERs

Electrification

\+

AMI

Advanced Meter Infrastructure

\+

DCN

Digital communication network

DCN backbone

Cellular

SCADA, AMI, or other data

\+

AAML

Advanced analytics with machine learning

Near real-time grid connectivity model

=

AGI Outcome

- Preventative outage mitigation actions – vegetation management and degraded infrastructure identification
- Quicker restoration and reduced customer outages (sectionalizing of outages)
- Grid-hardened resiliency
- Increased reliability – improved SAIDI/SAIFI
- Sustainability with reduced carbon footprint
- Energy equity – optimum DER hosting capacity locations

Customer satisfaction and savings (PrePay, CVR, power quality, etc.)

Grid Insights: Proposed Data Analytics Derived AMI Use Cases

Transformer Monitoring

Power Quality Analysis

Anomaly Detection (non-technical losses & safety)

Outage Reliability Metrics

Meter Health Management

Grid Modeling

Consider:

Customer Profiling

- Identify customers via pattern analysis
- Identify EV and/or PV adoption
- Identify potential theft
- Alternate Rate Comparisions

- Utilities have started to embrace cloud computing due to the ever growing and large size of data related to AMI.
  - As such AMI use cases should take advantage of cloud storage, processing, and analytics
- Typical Information/Data available from AMI
  - Cumulative kWh usage
  - Daily kWh usage
  - Peak kW demand
  - Last interval demand
  - Voltage
  - Voltage profile
  - Logs of voltage sag and swell events
  - Voltage event flags
  - Phase information
  - Outage counts
  - Outage logs
  - Tamper notification
  - Power factor
  - Time-of-Use registers (kWh, Peak kW, etc...)

- Data is typically available in real-time and on-demand
- Other data sources to consider combining with AMI data:
  - Meter Data Management Systems(MDMS)
  - Customer Information System (CIS)
    - Billing Systems
  - Outage Management System(OMS)
  - Geographic Information Systems(GIS)
  - Asset Catalog
- **"Enabling more smart meter features and integrating AMI with a larger number of utility systems can raise the total AMI implementation cost, but also increase the value of benefits to support the business case."**
  — Results from the Smart Grid Investment Grant Program Sept 2016, DOE SmartGrid.gov