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Smart Metering Part A – International Experiences
AMI Update – What's New?

Presented By

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Glenn Pritchard

Glenn Pritchard is currently the Manager of Advanced Grid Operations and Technology for PECO's Smart Grid/Smart Meter system. PECO's Smart Grid consists of 2.3M electric and gas meters and over 4,000 Distribution Automation devices. Pritchard graduated from Clemson University in 1990 with a B.S. Degree in Electrical Engineering. He is a registered professional engineer in Pennsylvania. He has been with Exelon/PECO in Philadelphia for over thirty-three years where he is responsible for developing new applications that leverage the Smart Grid, AMI Systems and metering data.

Other areas of experience include distribution & transmission engineering, substation automation and communications. Pritchard specializes in finding new applications of existing and emerging technologies.

Beyond his work at PECO, Pritchard has taught numerous classes and frequently presents at the key industry venues, including DistribuTECH, EEI and IEEE. He has authored numerous papers on Smart Grids, AMI systems and the use of the data generated by such platforms.

Pritchard has been recently recognized as PECO's Innovation Champion of the Year for 2021. Other notable awards include EPRI's Technology Transfer Award in 2017 and 2014, the 2010 IEC Grid Vision and the 2008 Utilimetrics' Utility Best Practices Awards for his work in the Smart Grid and AMI fields.

AMI Update – What's New?

Key Trends

- Utilities are embarking on their second round of AMI deployments.
- Often seen as a system refresh. Meters have a defined book and a service life.
- Must be accounted for in the initial deployment
- Recurring full system deployments are not realistic
- Must have a plan for continuous refresh, update and growth
- Meter technology continues to evolve, some may call this AMI 2.0 others label this "Next Generation"
- Latest functionality trend is Grid Edge and Distributed Intelligence
- Intriguing, but is this necessary, can we already accomplish the intended functionality?

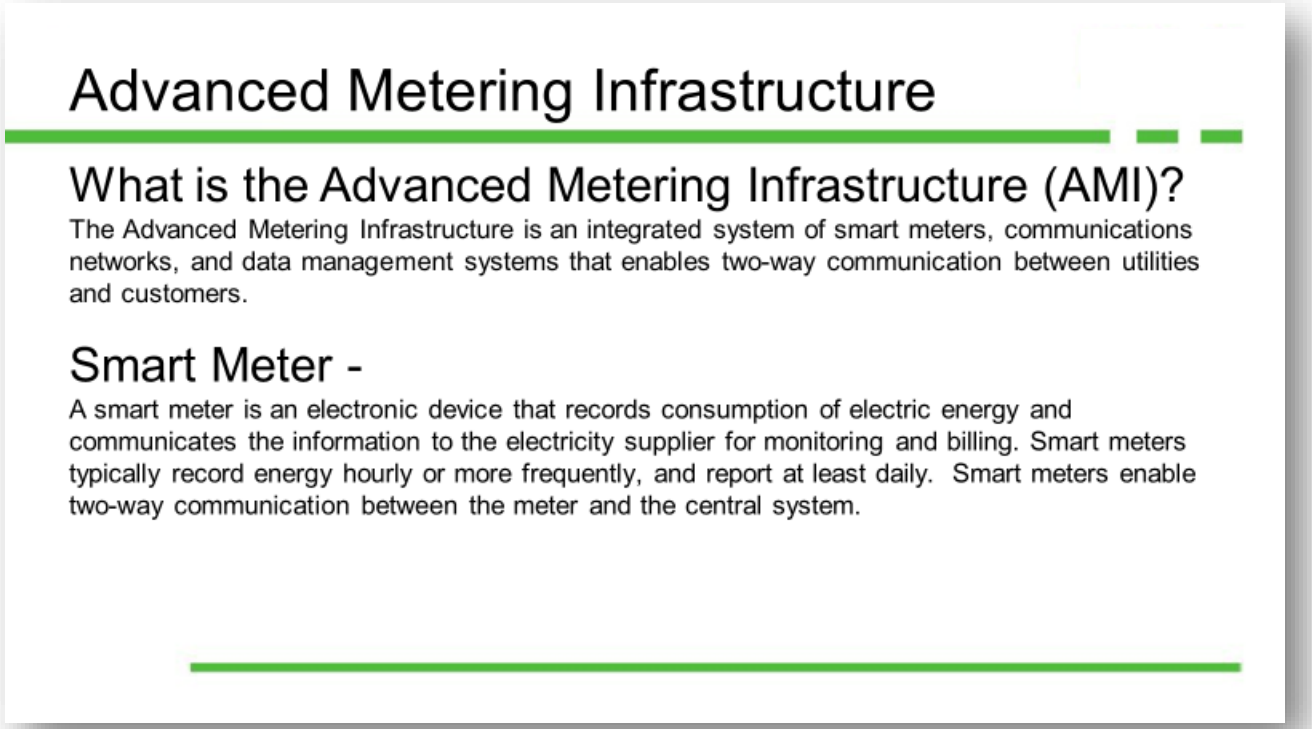
AMI Update – Agenda

- AMI 2.0
- Meter Architecture Evolution
- Distributed Intelligence & Grid Edge Solutions
- System Obsolescence Challenges
- PECO Update

AMI 2.0

- AMI 2.0 is positioned as a system upgrade that results in increased network reliability and more reliable exchanges of data
- The functions build upon initial AMI deployments (aka AMI 1.0), which set the foundation for the future

"Many of the end user/customer advantages promised by AMI 1.0 did not materialize."



More Data & New Functions

- Increased Sample Rates
  - 60-, 15-, 5- & 1-minute samples are possible
- Multiple Recording Channels
  - Some vendors are claiming up to 32 independent channels are available
- Distributed Intelligence and Decision Making local to the meter

Question – *Has the network and head-end kept pace with the new meter capabilities?*

New Data Opportunities

Going Beyond Energy Consumption and Usage

Voltage

- True RMS data to give accurate profiles throughout a feeder
- Key for managing the distribution grid that is rich with DER inputs
- Creates the foundation for voltage management programs

Power Quality & Harmonics

- Ability to track and manage power factor and flow across a feeder
- Helps ensure low noise is maintained
- Helps identify sources/locations of emerging trouble on the grid

New Functions

- On-Board Decision Making
  - EV Charging Management
  - Voltage Regulation
- Analytics
  - Non-intrusive load monitoring & Load Disaggregation
- New Communications Methods for FAN and HAN
  - WiFi Enabled Meters

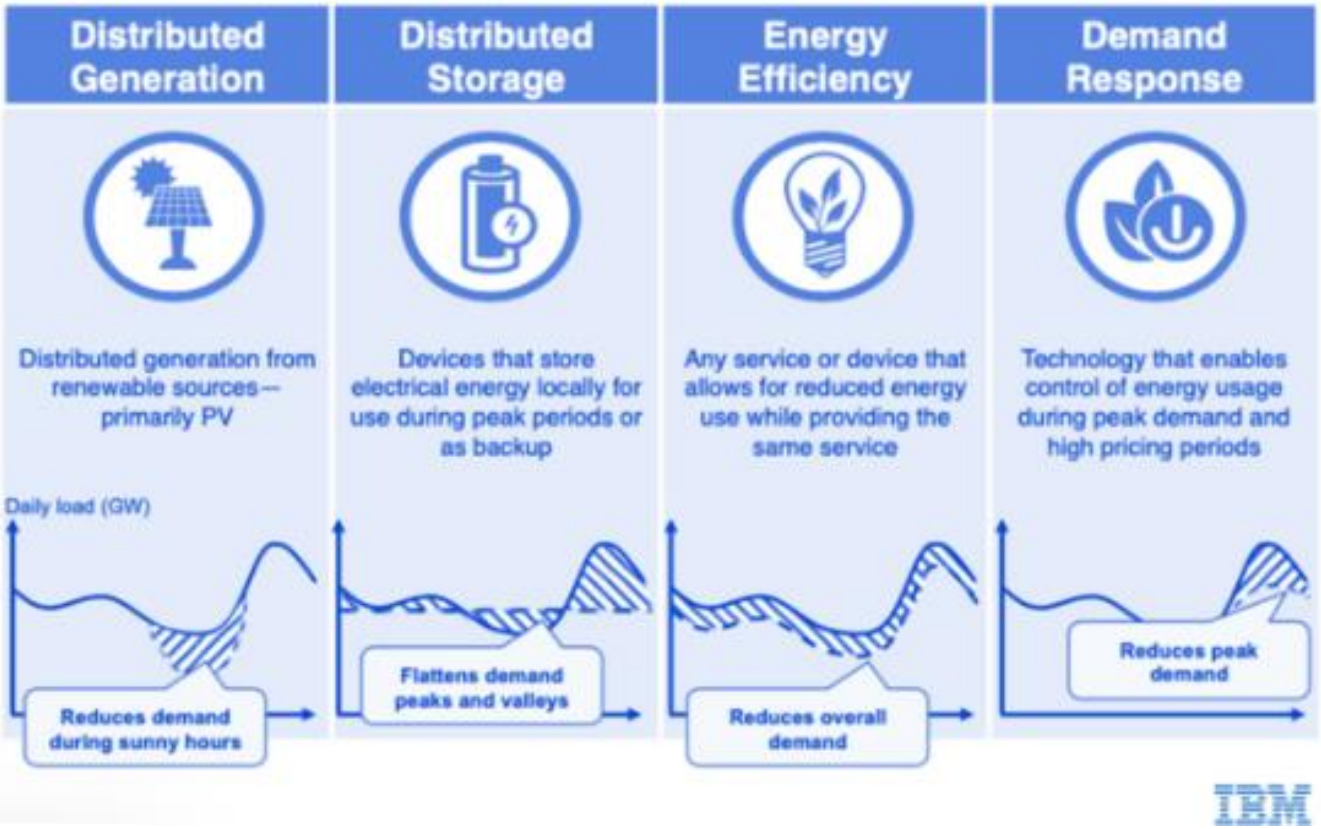
AMI 2.0 Use Cases

Grid optimization use cases

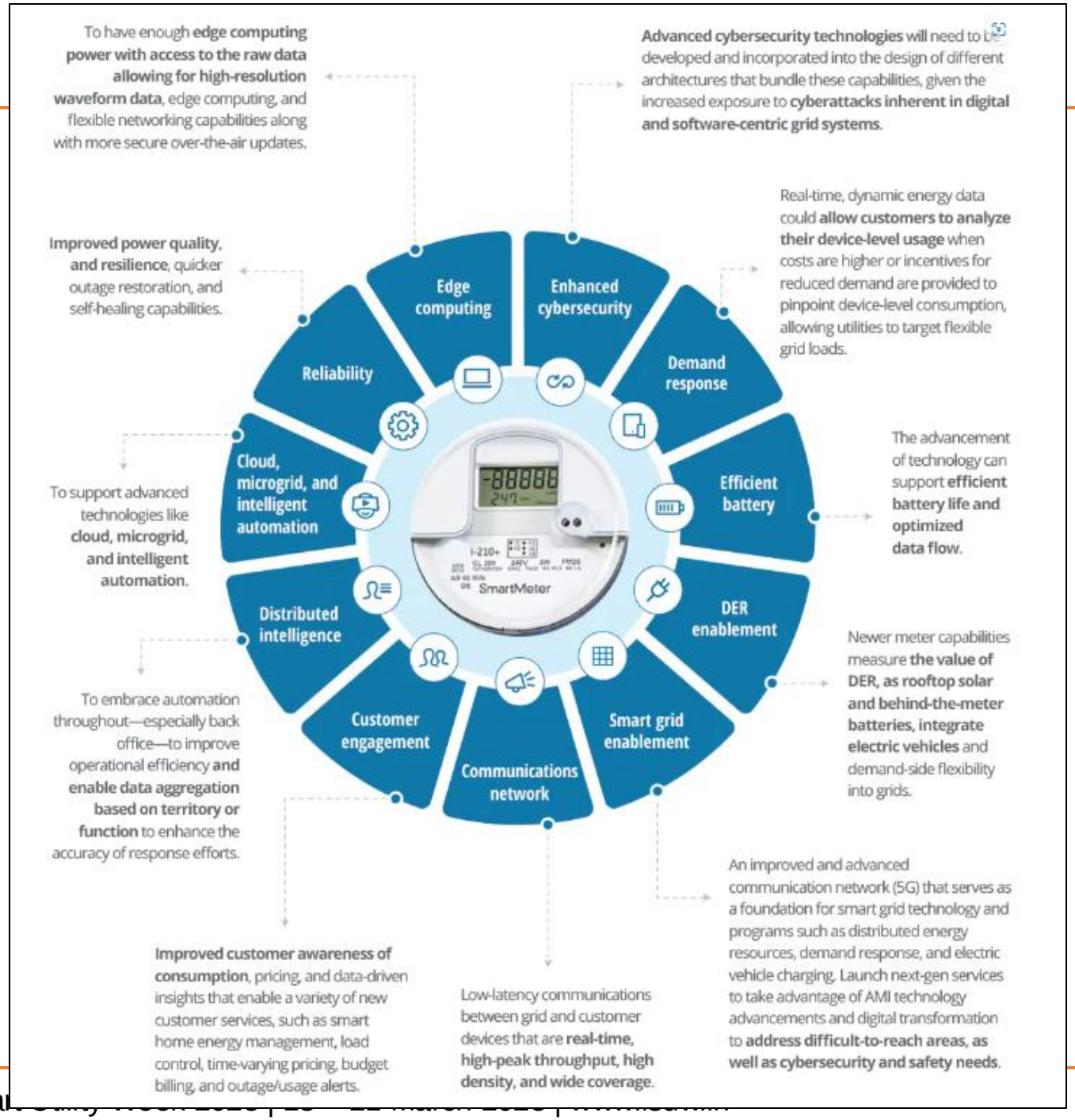
- Supply/Demand security on all voltage levels
- Manage Congestion management (dispatching)
- Keep Grid stable (frequency, voltage) despite renewable
- Optimize utilization of grid capacity

Distributed Energy Resources use cases

- Distributed generation
- Distributed storage
- Energy Efficiency
- Demand Response
- Load and Feed-in Management
- Microgrids & VPP (Virtual Power Plant) Mgmt.
- Ripple Control (heating, heat pumps)



[AMI – Advanced Analytics Opportunities - Utility Analytics Institute]



From Deloitte's AMI 2.0 Study

https://www2.deloitte.com/us/en/pages/energy-and-resources/articles/next-gen-advanced-metering-infrastructure.html

Meter Hardware Evolution

- Key Changes
  - New Microprocessors
    - Faster
    - Greater Functionality
  - Access to more internal Memory
  - Modern Interfaces
  - Expansion Slots
  - Improved Security

Meter Architecture Evolution

Core Functionality

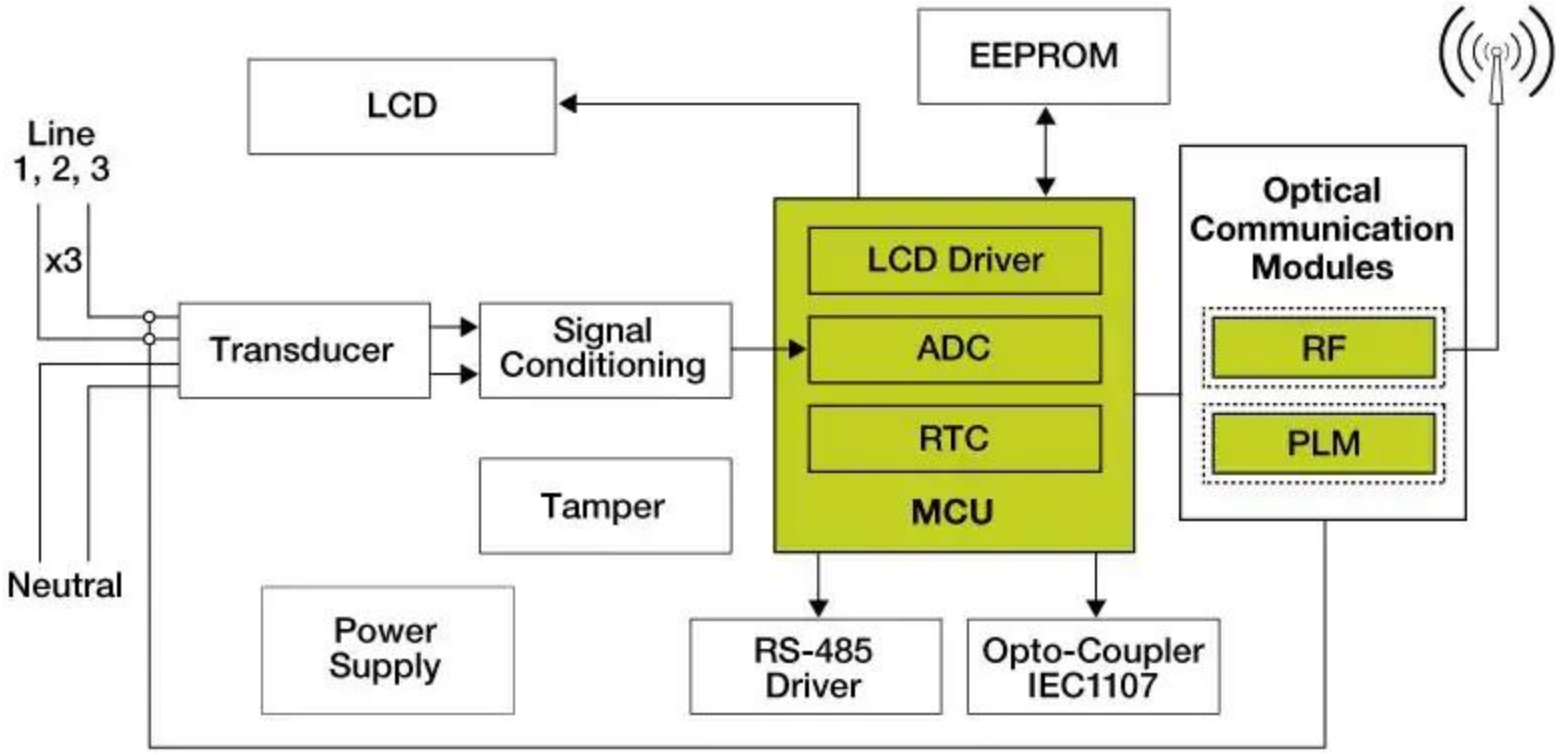
- Energy Measurement
  - Register Reads
  - Interval Reads
- Real & Reactive Power
- Net Metering
- Alarms
  - Tamper/Non-Technical Losses
  - Outage
  - Meter Health

New Functionality

- Independent channels (up to 32) that have unique sample rates and transmit frequencies
  - DER, Electric Vehicles, Storage
- Advanced Alarms
  - Sag/Swell
  - Power Quality
- Distributed Intelligence

Meters are now able to record multiple data streams independently to delivery new benefit. Each channel may be configured to deliver data at unique intervals as require

Meter Block Diagram



Key Components

- Metrology
- CTs/Coils
- CPU/Memory
- Battery
- Display
- Interfaces
- Communications
- RCD Switch
- Surge Suppression

Grid Edge Applications and Functionality

- Downloadable Applications
  - Meter and Socket Health
  - Location Awareness
  - Tamper & Non-Technical Losses
  - Load Disaggregation
  - Transformer Load Analysis
  - DER Management
  - Load Shedding
  - IoT/Smart Device Management
- Concerns
  - Validating Applications
  - Managing Application functions
  - Version Control
  - Meter Maintenance actions
    - Meter changes
    - Functional Changes
    - Updates in firmware

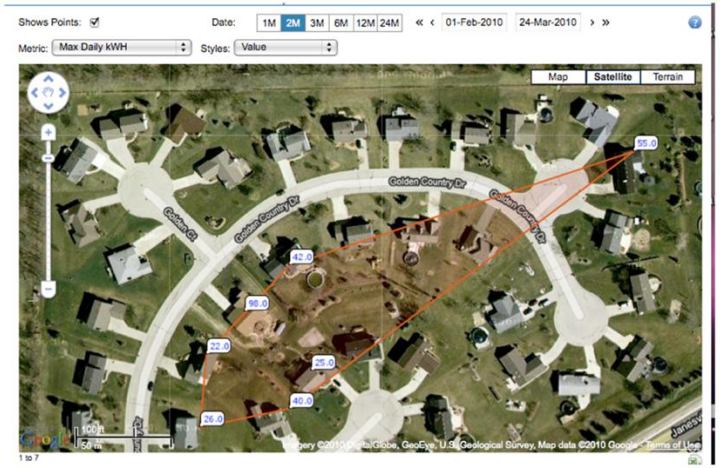
Use Case : Meter and Socket Health

- Remotely identifying meter irregularities and emerging problems
- Excess temperature detection and alarming
  - Auto Make Safe by disconnecting load
- Battery monitoring, if equipped

Use Case: Location Awareness

- Identifying neighbouring meters to connectivity model accuracy
- Reduces unnecessary dispatch and truck rolls

Outlier Analysis

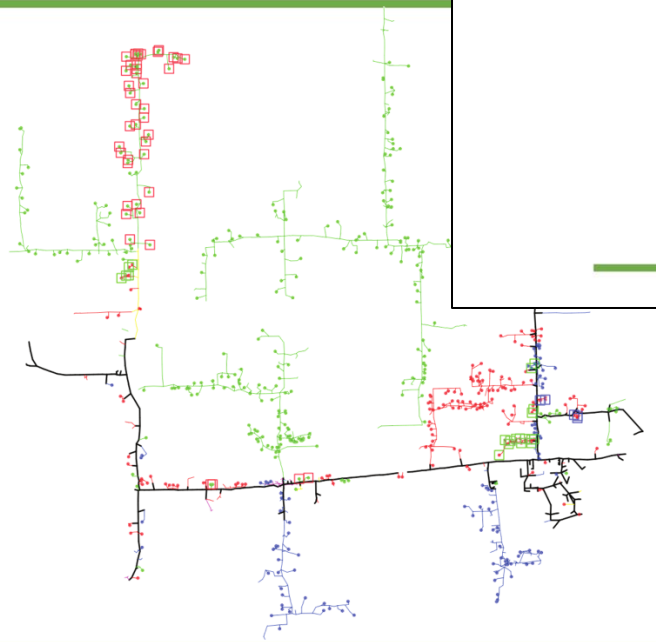


During a routine transformer outage, outlier customers are identified and corrections to the connectivity models are made

AMI Data : Identify Meter Phasing

Problem: Phasing errors are common in GIS data.

Solution: Use voltage and current from substation SCADA and customer AMI to estimate phasing.



Source: EPRI DMD Project

Use Case: Tamper & Non-Technical Losses

- Alarming on expected conditions
- Identifying changes in service impedance, sending alarms for further investigation

Use Case: Load Disaggregation

- Ability to sense various types of loads
  - Electric Vehicles
  - Heat Pumps/Air Conditioning
  - Machinery
- Potentially able to coordinate and schedule loads according to current grid conditions

Use Case: Transformer Load Analysis

- Using metering data to construct actual models of transformer performance
- Monitoring transformer loading and alarming when overloads are identified

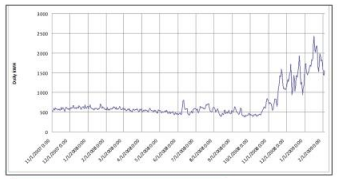
Transformer Performance, Loading etc.,

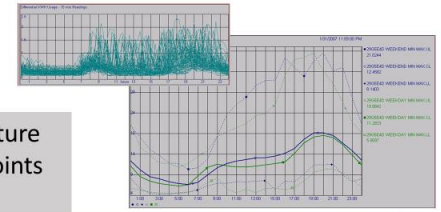
Compare transformer vs meters
Identify transformer loading (for planning and operational purposes)
Load profile at transformer level
Identify transformer to premise mapping in accuracies
Distribution transformer loading
Transformer Asset Monitoring

- Capture time-series kVA data from meter and compare to that at transformer
- Track transformers with loading levels
- Track and trend load profiles at transformer level
- Identify transformer to premise mapping
- Use meter data to determine transformer loading
- Identify risk of failure and corresponding costs (transformer asset monitoring)

Transformer Monitoring

- Utilities use analytics to determine transformer overloads and predict failures based on metering data from the AMR / AMI data
- A program was initiated to investigate daily transformer consumption data (aggregated from meter data) for failures that occurred during winter peak load days
- Transformers with yr-to-yr load increase of more than 25% (3,764 winter, 1,233 summer) were flagged for investigation



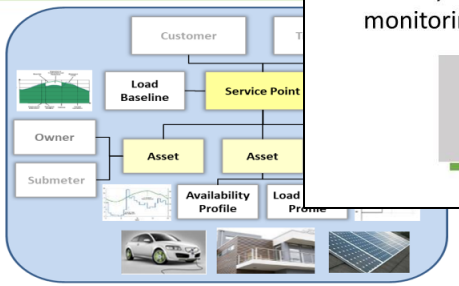


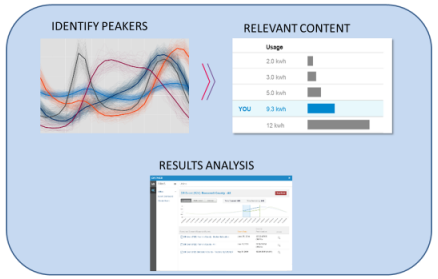
The ultimate goal is incorporating a day-of-week and temperature estimation for all distribution transformer or primary meter points into the outage, and planning systems

Load Monitoring and Analytics

Develop weather normalized capacity peak load contribution
Predict system load by customer class
Correlate usage to weather especially abnormal usage profiles.
Customer Analytics

- Calculate feeder losses to capture meter theft
- Determine voltage profile on feeders
- Determine feeder abnormalities and phase detection
- Provide feeder monitoring
- Trending and Analysis of feeder historical data
- Customer Analytics
  - Usage patters at and correlations with system load
  - Unbilled energy
  - Recoverable revenue
  - Social media value
  - Load profile by customers and groups
  - Abnormal load patters (EV usage for example)
  - Determine optimized aggregation.
  - Load patterns with Net-Metering
  - System enhancements determination
  - Electric/ gas/ water correlation





Use Case: Load Shedding

- Traditionally emergency load sheds are managed at the feeder/circuit level
  - Results in greater impact to customers
- Smart Meters allow you to tactically choose which meters and which load is temporarily turned off and for how long
  - This allows for a safer and more equitable sharing of the impact

Use Case: IoT/Smart Device Management

- The meter continues to be a viable node or gateway into the consumers Smart Home.
- The meter can send load and price information to the house
- It can help make decisions as to which load is modified or turned off
  - Minimal consumer action is needed one the system is set up
  - Different modes can be created for Home, Away, Eco & Comfort

Meter and System Obsolescence

Systems and Hardware get ***OLD*** . . .

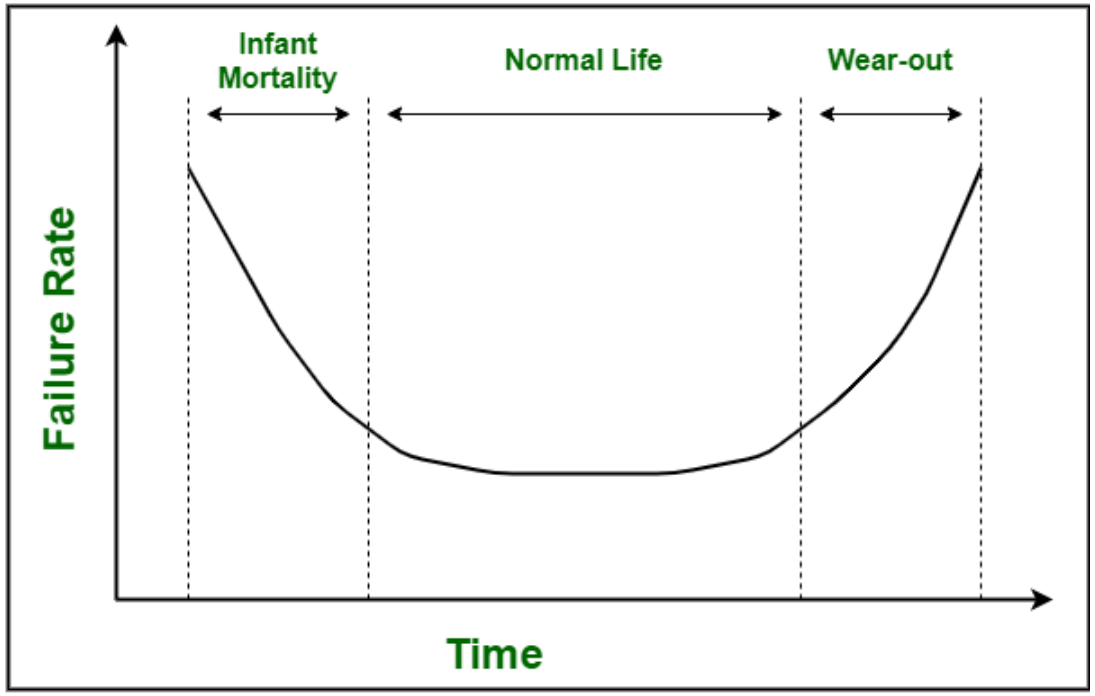
- Bathtub Curve
- Impact from the COVID Pandemic
- Obsolescence Planning
- Financial Concerns

Bathtub Curve

- **Infant Mortality Section :** Infant mortality section is simply referred to as early failure period. By seeing curve, one can easily understand that in this section, asset is beginning with its usage for first time. Initially, failure rate i.e. probability of failure occurrence is very high and with increasing time, there is a gradual decrease in failure rate. In this section, failures are usually occurred due to manufacturing defects, installation issues, design issues, material defects, or improper start-up procedures, etc.

- **Normal Life Section :** Normal life section is simply referred to as usual life period or steady-state operation. It can also be said that this section represents normal operating life of assets. By seeing curve, one can easily understand that in this section, asset is still experiencing failure but at normal and low rate. In this section, failures are usually occurred due to overloading, hidden defects, collision with other objects, mistakes of personnel, etc. Failure occurrence generally depends upon function and condition of particular asset. Therefore, for different assets, failure rate can be different. In this period or section, an asset can be remaining unchecked for some time as chances of failure occurrence is low during this period and therefore resources can be used wherever required. Failure rate is almost constant in this phase. One can say that failures generally occur due to random events.

- **Wear-out Section :** Wear-out section is simply referred to as aging period. By seeing curve, one can easily understand that in this section, there is gradual increase in failure rate of assets with increasing time. Number of failures occurrence experienced by assets generally increases with time. In this section, failures are usually occurred due to fatigue, wear, gradual deterioration, corrosion, etc. This period simply represents end of life cycle of assets.

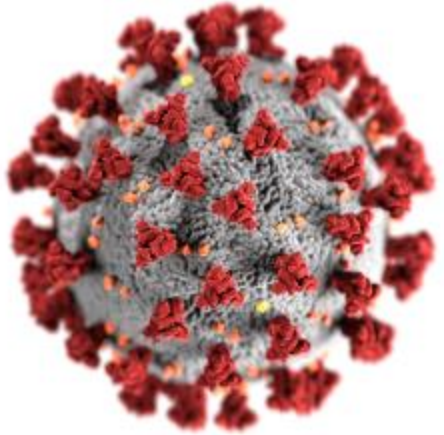


Bathtub Curve

Meter and System Obsolescence

Impact from the COVID Pandemic:

- COVID has changed everything
- Manufacturing plants shut down, some permanently leading to shortages in material supplies
- Manufacturers change their focus on the most profitable product lines, niche lines were closed down
- Meter vendors needed to switch to products that were available and being mass produced
- New meter lines emerged



Obsolescence Planning

- New Smart Meters have a finite useful life (15-20yrs)
- As you prepare to start your initial rollouts, it is important to recognize that there will be a future need to replace both the meters and the networks
- Is a future full redeployment an option?
- Do you have a lifecycle plan?
- What about a future annual replacement plan?

- *It pays to plan for this now, account for it in your Long-Range Financial Plans*
- *It is also advisable to include your regulators and stakeholders*

Financial Concerns

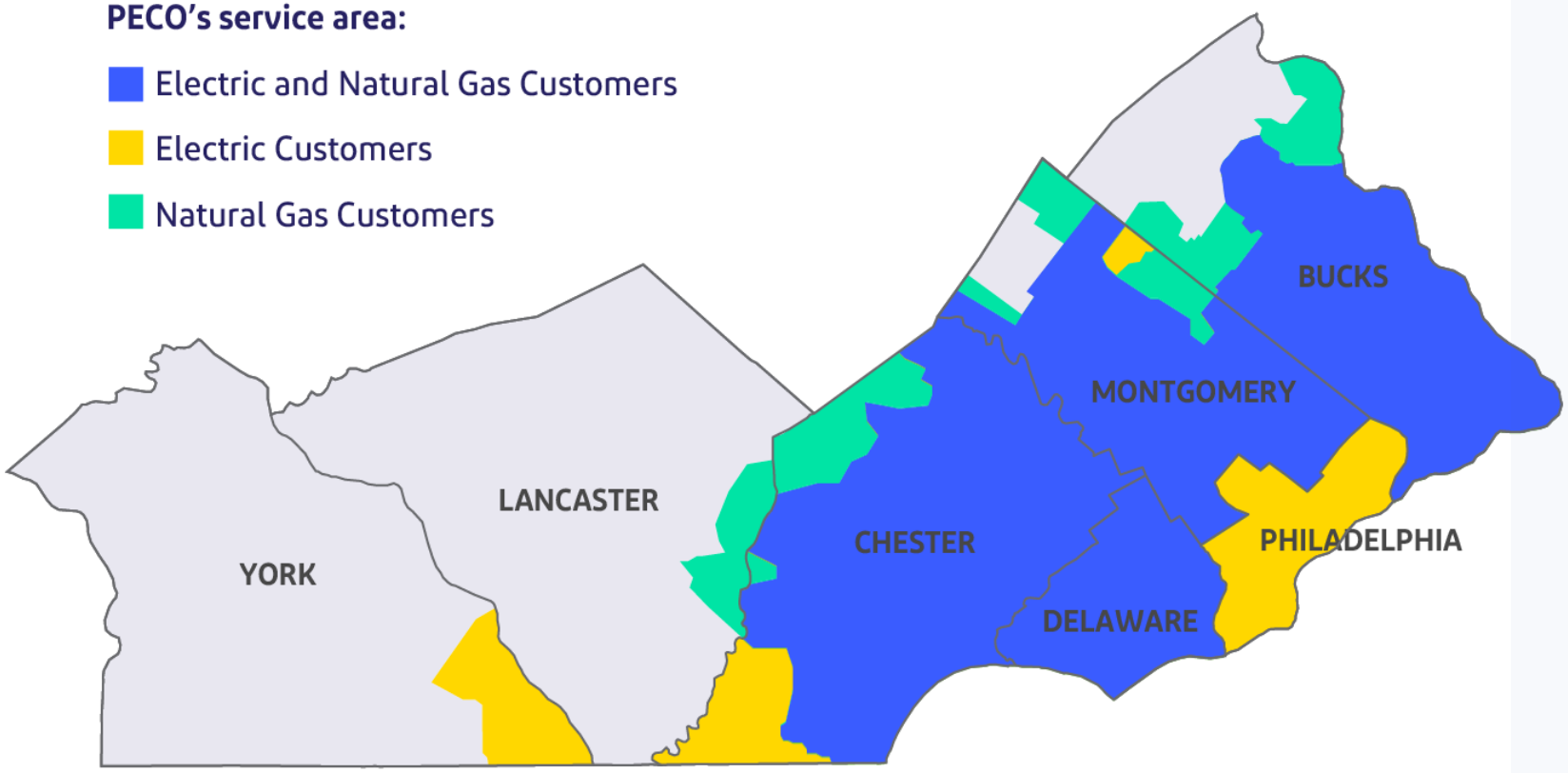
- How will obsolescence impact your initial deployment?
- Will the funding models change?
- When do you begin to prepare for a future redeployment?
  - Will you do a system wide refresh, in one large project?
  - Or, will you consider changing ~10% of your meter population every year to keep the system fresh?

It best to have a plan now for these questions while you still have options

PECO Overview

Headquartered in Philadelphia, PECO is Pennsylvania's largest electric and natural gas energy delivery company, serving 1.7 million electric customers and more than 553,000 natural gas customers in southeastern Pennsylvania. PECO employs approximately 3,000 people and is a subsidiary of Exelon Corporation (NASDAQ: EXC), the largest fully regulated utility company in the nation with more than 10 million customers.

PECO – Who We Are



22,659
distribution miles

1.7 million
electric customers

553,000
natural gas customers

10%
commercial/industrial

90%
residential

PECO Update

- PECO deployed 1.8M AMI electric meters from 2012 to 2016
- PECO follows a 15 financial book life and expects a 20 year service life for the meters
- These meters have served PECO and our customers well
  - Current failure rates are ~0.5%
- PECO is planning for future increases in the failure rates as the 20 year service life approaches
- A Meter Obsolescence Plan has been developed to minimize the impact of future meter failures and customer impact

PECO Update

PECO's Obsolescence Plan

- PECO will exchange:
  - 10% of its meter population from 2027-2031
  - 5% of the population annually from 2032 and beyond
- This plan
  - Avoids the need for a "*big bang*" meter deployment
  - Creates a planful initiative that is financially secure
  - Allows PECO to install the most contemporary meters each year
  - Provides a technology "off ramp" if a new preferred AMI solution is selected

This plan minimizes the impact of future meter failures and customer disruptions

Meter and System Obsolescence

- AMI 2.0
- Meter Architecture Evolution
- Distributed Intelligence & Grid Edge Solutions
- System Obsolescence Challenges

Questions?

Thank You!

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THANK YOU

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Links/References (If any)