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Session 3: Global Lessons on Smart Metering
Smart Metering Experience in the USA

Presented By

Glenn Pritchard, Sr. Manager, Advanced Grid, PECO

Confidentiality and Privacy

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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-two 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.

Exelon – Service Territories

- Atlantic City Electric (PHI)
- Delmarva Power (PHI)
- Baltimore Gas and Electric (BGE)
- ComEd
- PECO
- Pepco (PHI)

Agenda

- Advanced Metering Infrastructure Systems
- PECO's AMI Deployment
- System Integration and Benefit Delivery
- Change Management
- Lessons Learned
- Summary and Conclusions

Goals of AMI

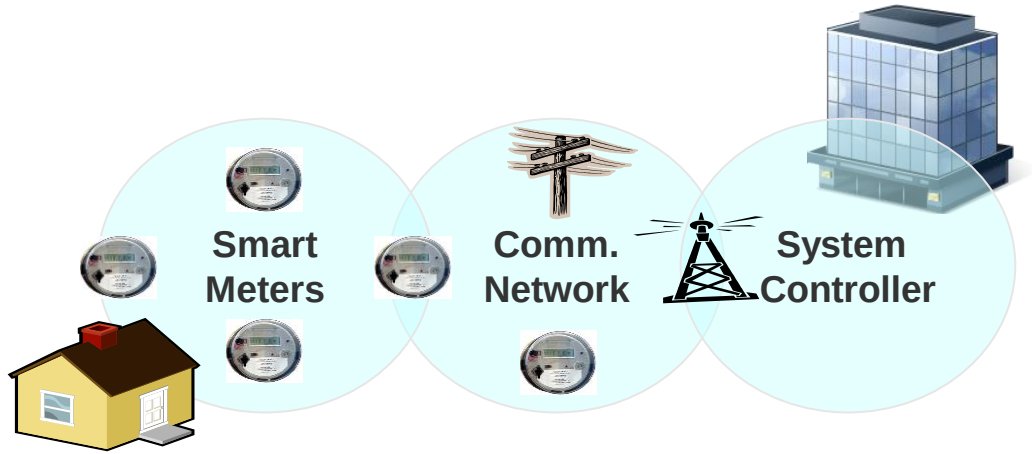
Smart meters provide a way of measuring energy consumption at specific intervals, allowing utility companies to create rates that more closely reflect the true cost of energy according to the time of day and the season.

Benefits to consumers include:

- **Remotely reading meter consumption**, eliminating the need to visit each meter monthly and environmental impact of such activities.
- **Ending estimated bills**, which are a major source of complaints for many customers
- Tools to help consumers better **manage their energy** purchases by providing up-to-date information on energy consumption and in doing so help people to manage their energy use and reduce their energy bills
- **Remotely connect/disconnect services** on-demand as needed, thereby saving service calls and truck rolls to manually do so.
- **Proactively receive alarms** related to site conditions, outages and tampering.

Key System Components

- **System Controller**, **Head-End System** – Responsible for managing the overall system. It ensures that communications to all devices are reliable. It acts as an interface to the external systems.
- **Communications Network** – Responsible for two-way communication of moving data and commands from the end-points and the head-end system
- **End-Points**, including **Smart Meters** – Responsible for measuring and collecting data, including energy consumption data, and preparing to be sent to the head-end. Additional functions and monitoring is often included.



System Architecture Considerations

- Centralized vs. Decentralized Processing
- FAN vs. Backhaul Communications
- Bandwidth Requirements
- Private vs. Public Solutions
- Radio Frequency Availability
- Owned, Outsourced vs. Managed Service
- Scalability

System Design Considerations

Ease of Deployment

- Speed to deploy
- Support for Ad Hoc requirements
- Support for Gas

Manageability

- Tools to support
- Cost to support and maintain

Outage Management Performance

- Ability to process outage notifications
- Ability to ping during events
- Time to re-establish communications after an outage

Automation

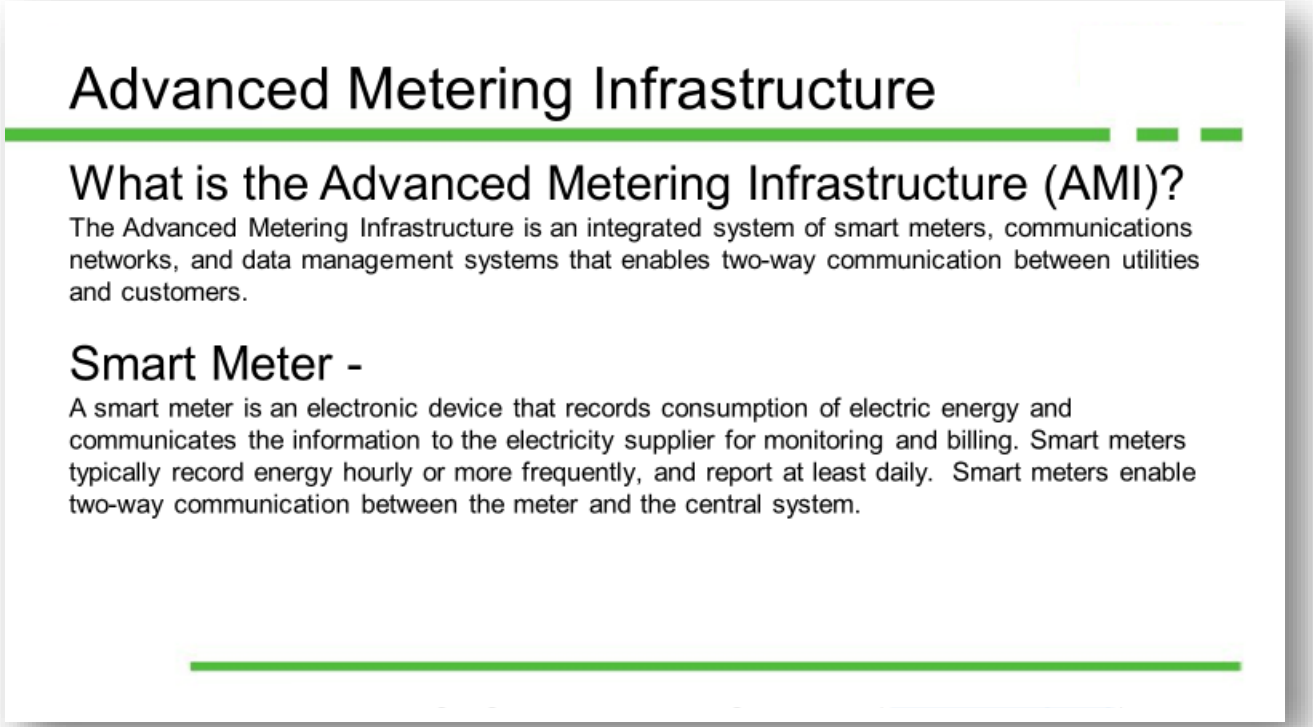
- Available bandwidth
- Low latency
- Security

AMI 2.0

AMI 2.0 is a system upgrade that results in increased network reliability and more reliable exchanges of data

The functions build upon 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 Functions

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

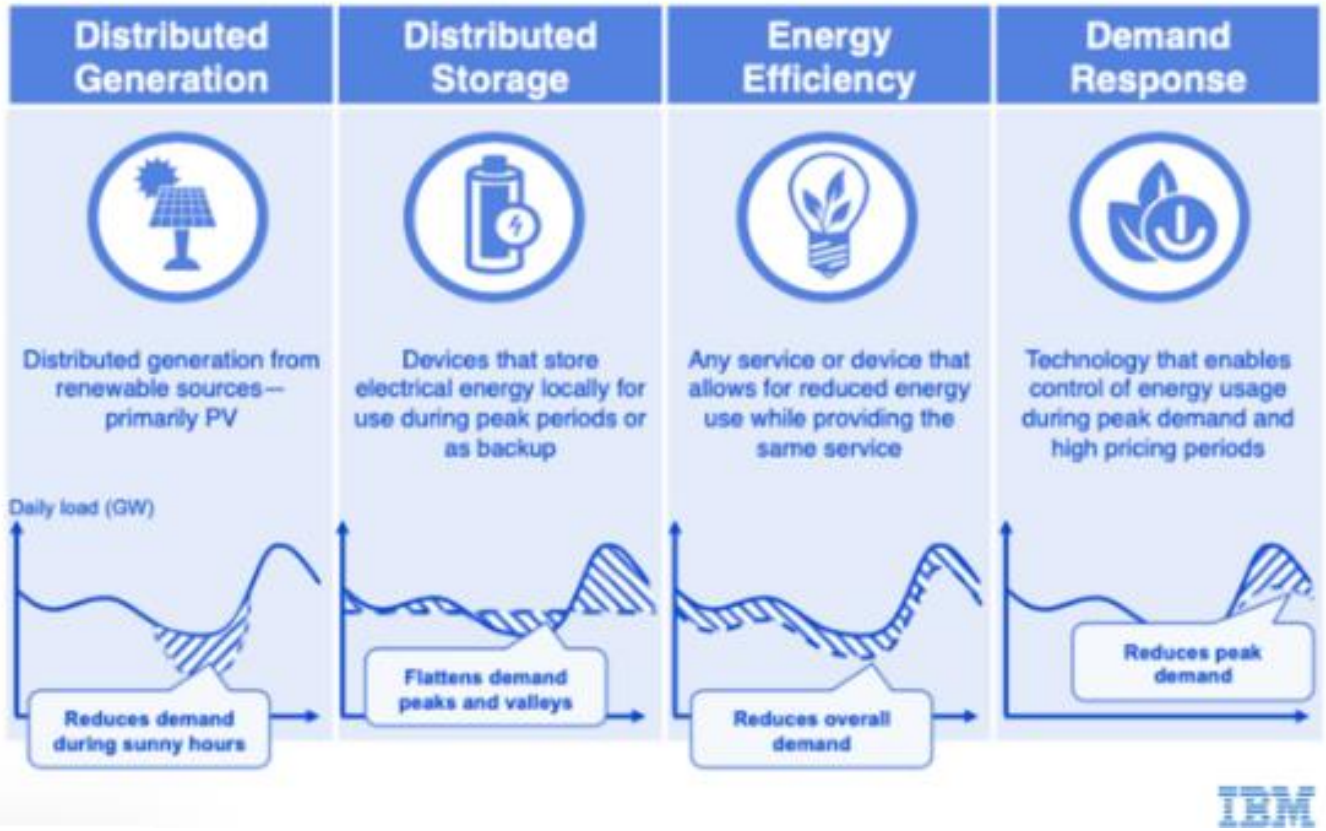
AMI 2.0 Use Cases

Grid optimization use cases

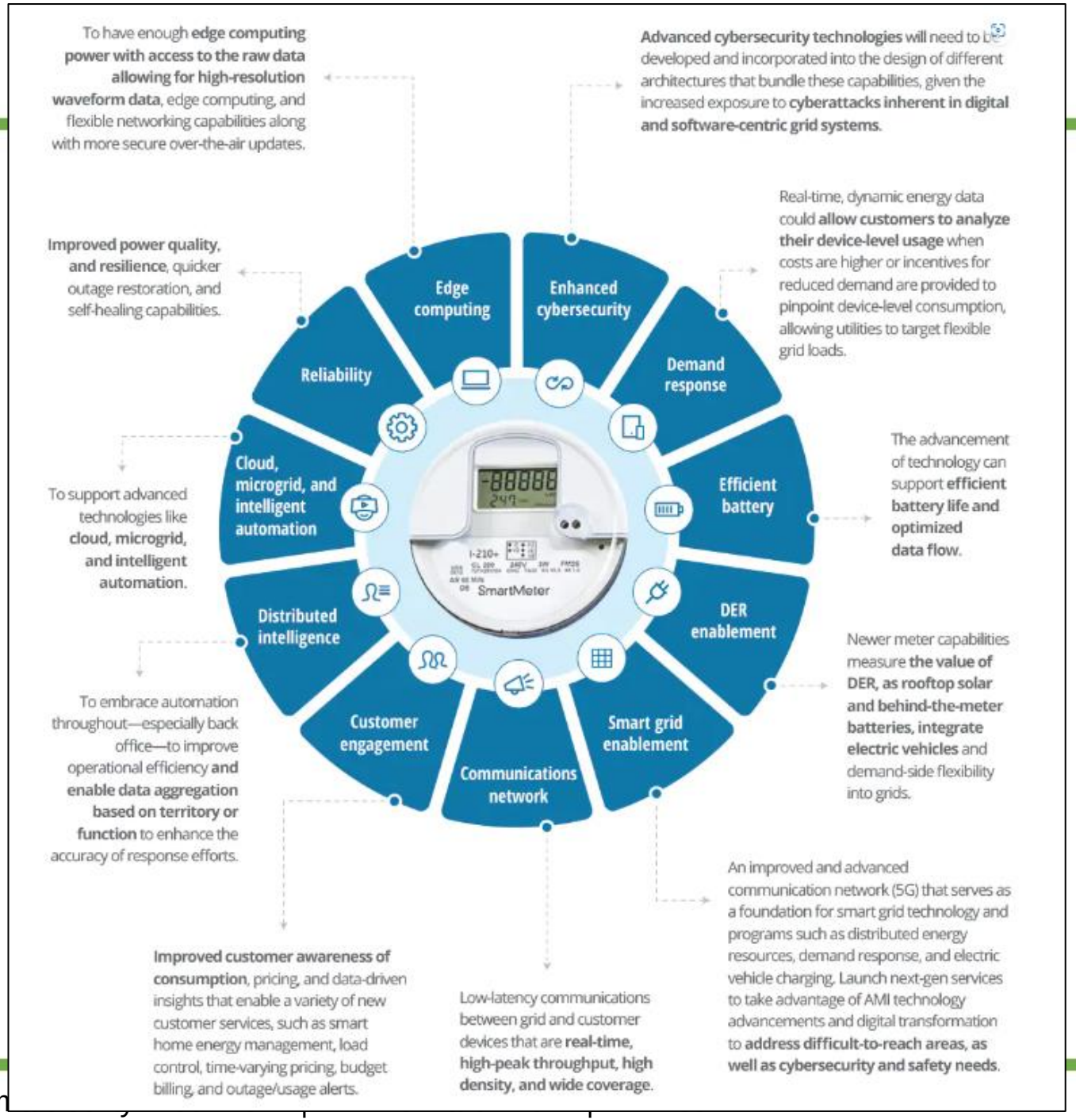
- Supply/Demand security on all voltage levels
- Manage Congestion management (dispatching)
- Keep Grid stable (frequency, voltage) despite renewable
- Optimize utilization of grid capacity

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
  - More Memory
  - Modern Interfaces
  - Expansion Slots
  - Improved Security

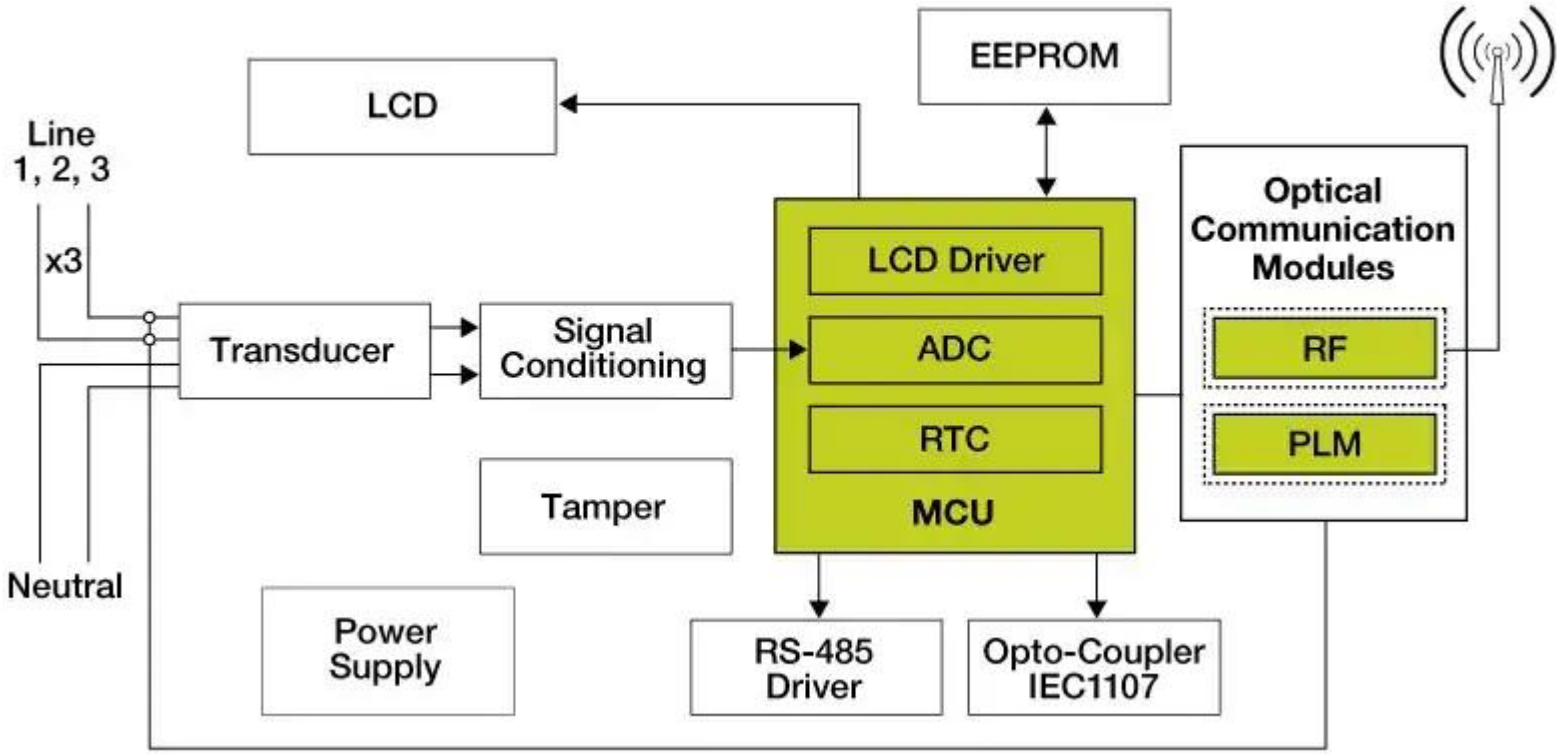
Meter Architecture Evolution

- Core Functionality
  - Energy Measurement
    - Register Reads
    - Interval Reads
  - Real & Reactive Power
  - 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
  - High Speed Sampling
  - 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

New Data Opportunities

Going Beyond Energy Consumption and Usage

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

Analytics Use Cases

Grid

Distribution Operations

- Outage Management
- TLM/Overload Prevention
- CVR
- Phase Balancing
- Non-tech Loss Localization
- Event Correlations
- Deployment Health

System Planning

- Device Capacity Planning
- Device lifecycle management
- EV Planning
- Connectivity Model Audit
- Stressed Asset ID
- Data Quality

Energy Procurement

- Demand Forecasting
- Inventory Monitoring

Meter

Meter Services

- Defective Meter ID
- Defective Socket ID
- New Meter Health
- Contract Validation
- Data Quality Assurance
- Geospatial Outlier Monitoring
- Net Meter
- Geospatial Reporting
- Meter Inventory Tracking

AMI Deployment

- New meter health
- Deployment Tracking
- Network Tracking
- Customer Refusal Tracking
- Deployment Data Quality
- Geospatial Reporting

Customer

Billing

- High Bill Prioritization
- Low Bill Prioritization
- Stopped Meter
- Slow Consumption
- Diagnostic Prioritization
- Account Billing Prioritization
- Rates Analysis
- Bill Cycle Monitoring
- Consumption reporting
- Settlements Reporting

Call Center

- High Bill Customer Benchmarking
- High Bill Account Reporting

Safety

- Gas Leaks
- Water Leaks
- Meter Overheating

Demand Response & Energy Efficiency

- Program Customer Targeting
- Load Disaggregation
- Behavioral Program Analytics
- Geospatial Reporting
- Customer Usage Reporting
- Program Efficacy
- Auditing Support
- Regulatory Compliance/M&V
- Whole Building Reporting
- Predictive load

Operations

- Resource Planning Prioritization
- Account Transition Monitoring

Finance

Revenue Protection

- Identifying bypass
- Diversions
- Identifying meter swaps
- Identifying meter tampering
- Smart meter deployment theft
- Identifying Behavioral Trends

Operations

- Unbilled Sales Reporting
- Forecasting
- Rate Development

Evolution of Analytics

- Centralized
  - Analytics developed on a centralized platform and data lake
  - Easy to integrate data from multiple sources to gain insight
  - Analytics take place at many locations throughout the meter to cash process flow
- Decentralized
  - Computing power is now available deep into the grid and specifically at the meter
- Hybrid
  - Maximizing the benefits of both Centralize and Decentralized applications and analysis

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

PECO – About Us

- Subsidiary of Exelon Corporation
- The Largest Electric and Natural Gas Utility in Pennsylvania
- Serving the greater Philadelphia area for more than 100 years
- 2,100 square miles (5,400 km^2) service territory
- Pennsylvania's largest electric and natural gas utility
  - More than 1.6M electric customers, 8,983 megawatt peak load
  - More than 525K natural gas customers

Counties:

Bucks
Chester
Delaware
Lancaster
Montgomery
Philadelphia
York

PECO's Infrastructure - Electric

- Transmission System
  - 500, 220, 138 & 69kv Transmission Lines
  - 1,067 miles (1,720 km) of high voltage lines
- Substations
  - 449 Primary and Unit Substations
  - SCADA coverage for all primary stations
- Distribution System
  - 2,242 Distribution Circuits covering 21,362 miles (34,378 km)
  - 34, 13.2, 4 & 2.4kv Distribution Lines
- Automation
  - >1,800 Distribution Automation Reclosers
    - Communicating via Telco Circuits or Private Wireless Solutions
    - Supporting 34 & 13kv Systems
  - Fully Automated Meter Reading
    - Sensus FlexNet Smart Grid and AMI Platform serving 2.3M electric and natural gas meters
  - Fully integrated AMI and Outage Management Systems

Advanced Grid/Meter Background

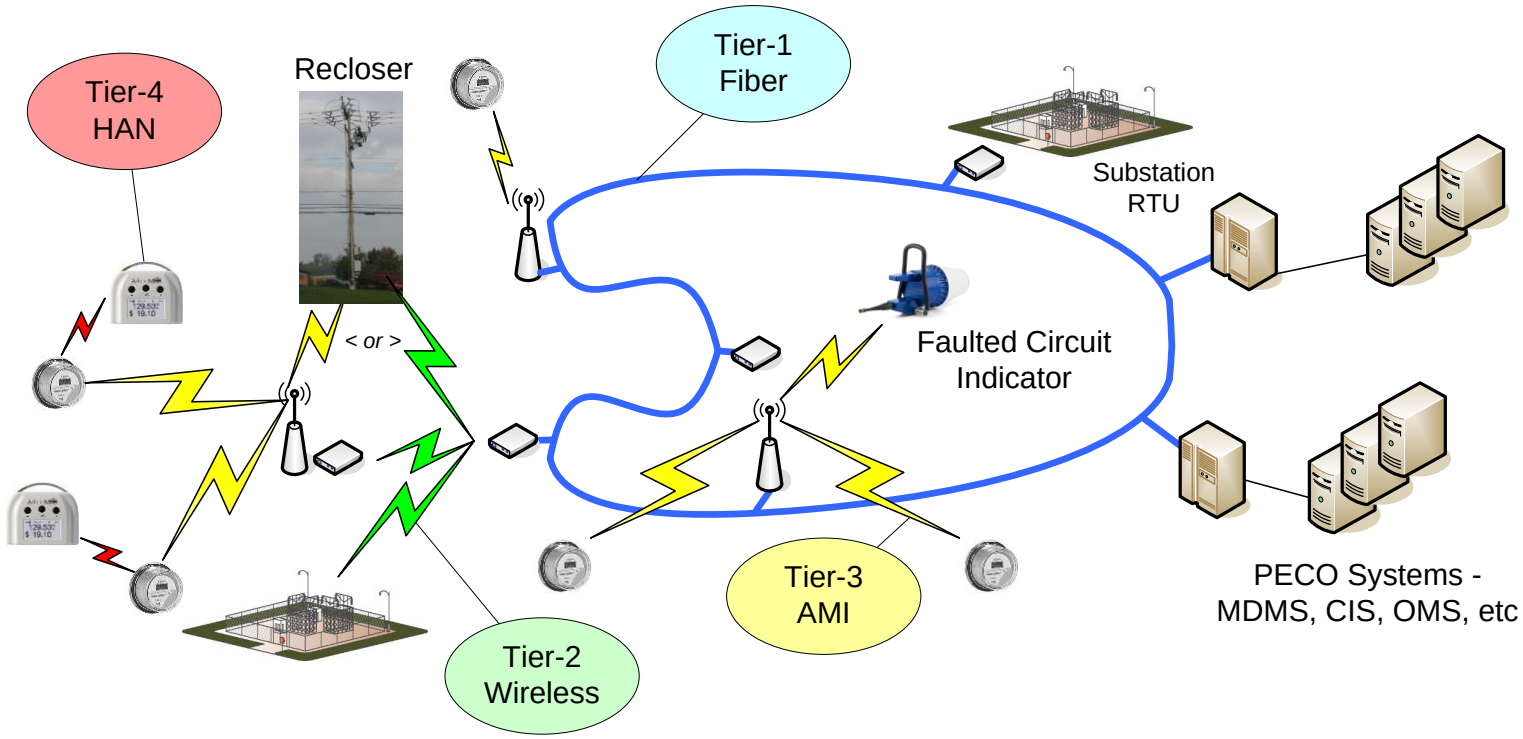
- PA Act 129 (Oct. 2008) required electric distribution companies to provide all customers with new metering technology within 15 years
- In October 2009, PECO was awarded a $200M U.S. DOE Smart Grid Investment Grant – one of 6 companies out of 400 applicants to receive the maximum grant under the program - to support a comprehensive advanced grid project and reduce costs to customers
- In 2012, PECO initiated the AMI Gas installation program to fully realize the benefits of moving from an AMR third party meter reading system to an AMI private meter read system, in conjunction with the SG/SM Electric program.
- In August 2013, the PA PUC approved PECO's plan to accelerate its meter deployment and complete this project by 2015, maximizing benefits to customers
- PECO has completed the AMI electric meter and gas module installation programs.
  - 1.725 million AMI electric meter installs
  - 550K AMI Gas module installs

Advanced Meter Functionality

Act 129 Summary Requirements List
Bi-directional data communications
Remote disconnection and reconnection
15-minute or shorter interval data to customers, EGSs, 3rd parties and RTOs on daily basis
Record minimum hourly reads and deliver at least once per day
On-board meter storage of meter compliant with national, non-proprietary standards
Open standards and protocols compliant with national, non-proprietary standards
Ability to upgrade minimum capabilities as technology advances and becomes economically feasible
Ability to monitor voltage at each meter and report data
Remote programming
Communicate outages and restorations
Ability to support net metering of customer-generators
Support automatic load control by EDC, customer and 3rd parties with customer consent
Support time-of-use and real-time pricing programs
Provide customer direct access to consumption and pricing information (hourly consumption information)

PECO's Smart Grid

- End-Points
- Network/Transport
  - Backhaul - Tier 1 & 2
  - Field Area Network – Tier 3
  - Home Area Network – Tier 4
- Head-End/Master Controller
- Down Stream Applications



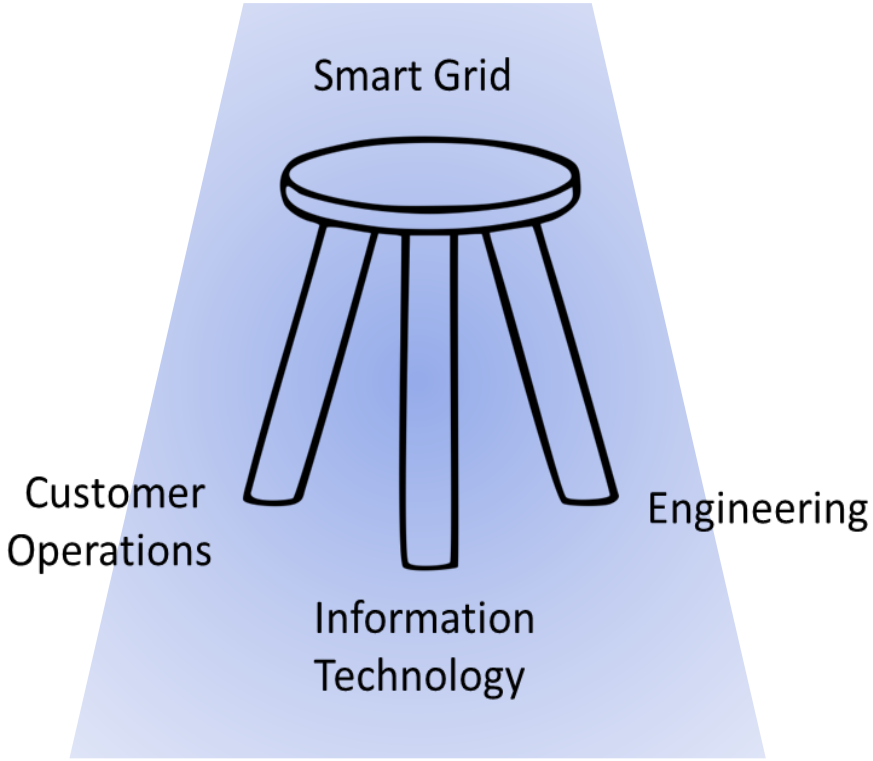
PECO's Smart Grid Architecture

System Design Principles

- **Security**
  - Robust end-to-end, aligned with industry best practices (FIPS 140-2 compliant or certified)
- **Converged Communications**
  - Advanced Grid applications will share a converged shared communications infrastructure but will be logically isolated (tunneled)
- **Interoperable**
  - Industry standard open protocols will be utilized preferentially end-to-end
  - Avoid use of proprietary protocols
- **Privately owned communications**
  - Privately owned communications enables the Utility to maintain governance and control over all aspects of the technology
- **No Unanalyzed Single Points of Failure** (*Self Healing*)
  - The comm. architecture will be designed with no unanalyzed single points of failure
  - Consistent with the deterministic philosophy, failure modes and backup schemes shall be incorporated to form a “self healing” architecture
- **Maintenance Management & Monitoring**
  - Inherent to the communications Architecture will be Comm. Maintenance Management & Monitoring, i.e. the ability to maintain, monitor and control network devices
- **Defined Standards**
  - Architectural Design Standards will exist to embody & enumerate the details of the Fundamental Design Principles

Program Structure

- Governance Models
  - Who are the stakeholders and the sponsors?
- The Power of Sponsorship
  - True sponsorship will empower adoption and success
- Setting Real Expectations
  - Acknowledge what can be done and when
- Don’t Underestimate Change Management
  - Acceptance and Trust will make or break your project
- Training
  - Don’t underestimate the needs



Key System Stakeholders

- IT
- Billing
- Engineering
- Communications
- Operations
- Data & Analytics

Common Interfaces

- **ADM** – Asset Data Management – A system to keep inventory of all assets and their configurations
- **MDM** – Meter Data Management – Used to store and process all meter reading data
- **CIS** – Customer Information System – Essentially the billing system
- **DMS/ADMS** – (Advanced) Distribution Management System – The SCADA host for the distribution system
- **OMS** - Outage Management System – The system that manages outage and system restorations
- **Analytics Platform** – Is responsible for all advanced calculations and analysis, may include a **Data Lake**
- **DERMS** – Distributed Energy Resource Management – Manages the Distributed Energy resources such as Demand Response, solar and batteries.

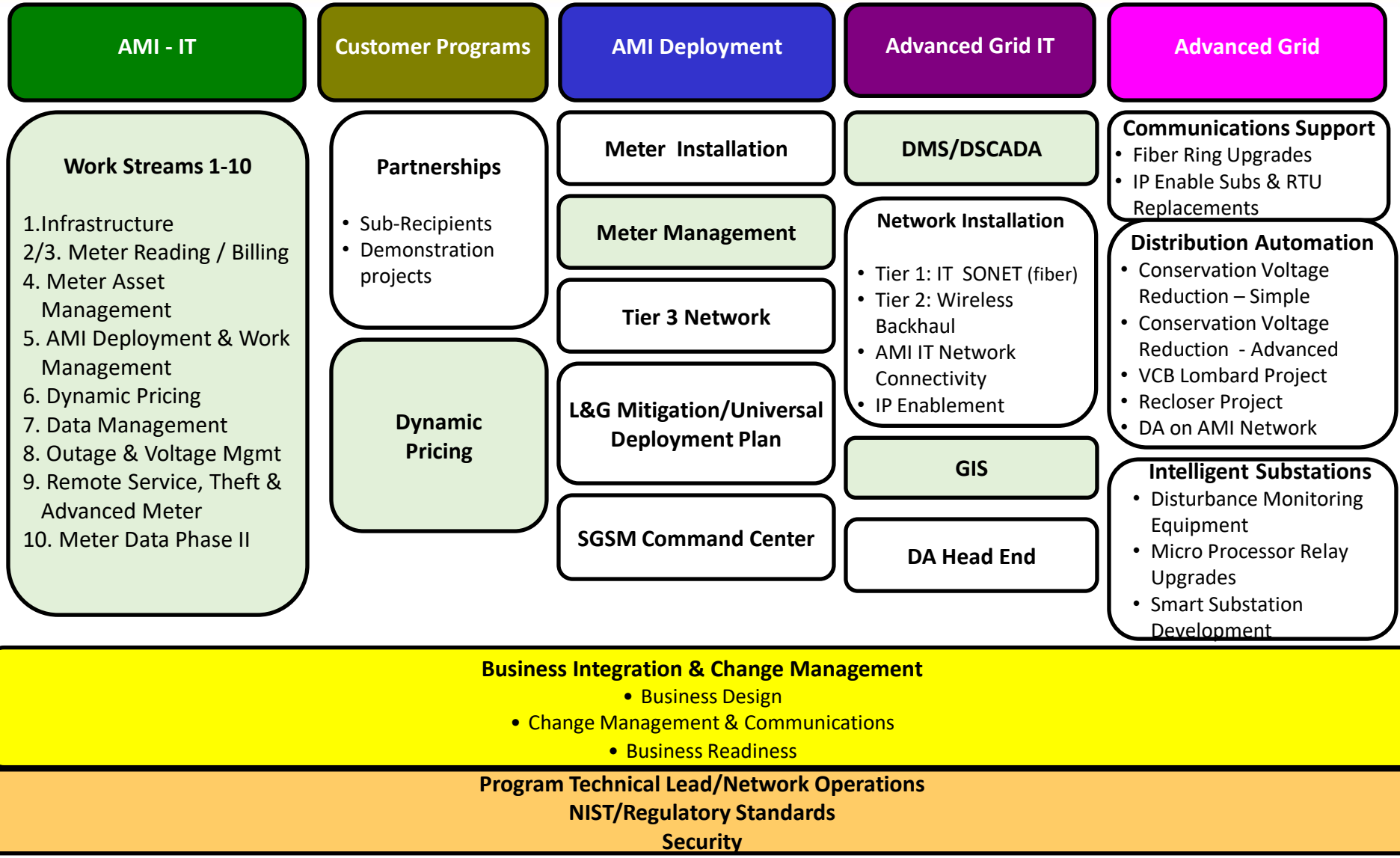
Organization Design

- Success requires alignment with the Vision Statement
  - Balance across organizations and functions is needed
- Four Key Functions are needed to deploy, operate and maintain an AMI system
  - Operations – Includes exception management and deployment
  - Engineering – System Design, Subject Matter Expertise, Innovation
  - IT – Application Operations, Support and New Solution Development
  - Field Teams – All Physical work and investigations
- Will these be under one leader or embedded in their respective organizations?

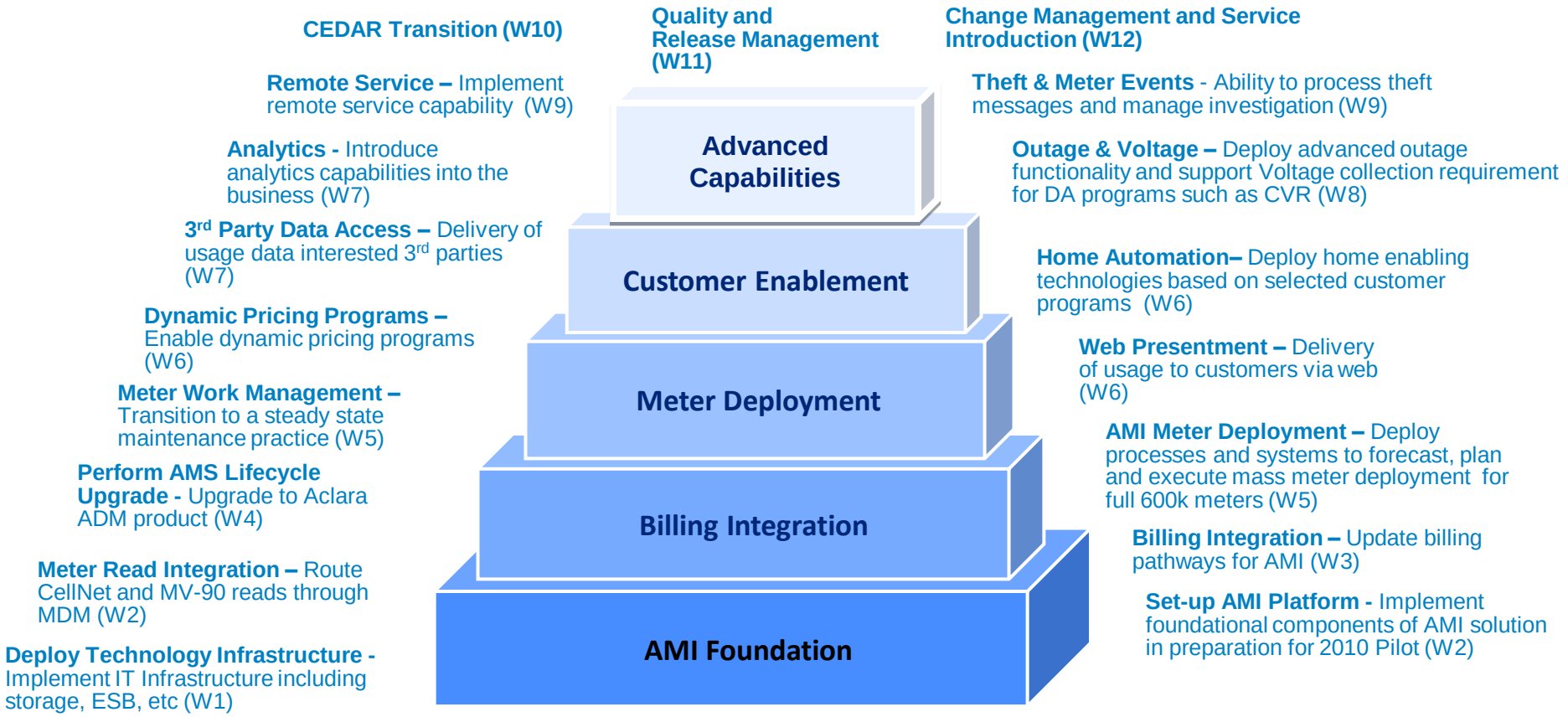
Resources & Roles

- RACI Matrix –
  - Responsible
  - Actor
  - Consulted
  - Informed
- Project Manager
- System Architect
- Consultant / External Advisor

Sample Program Structure



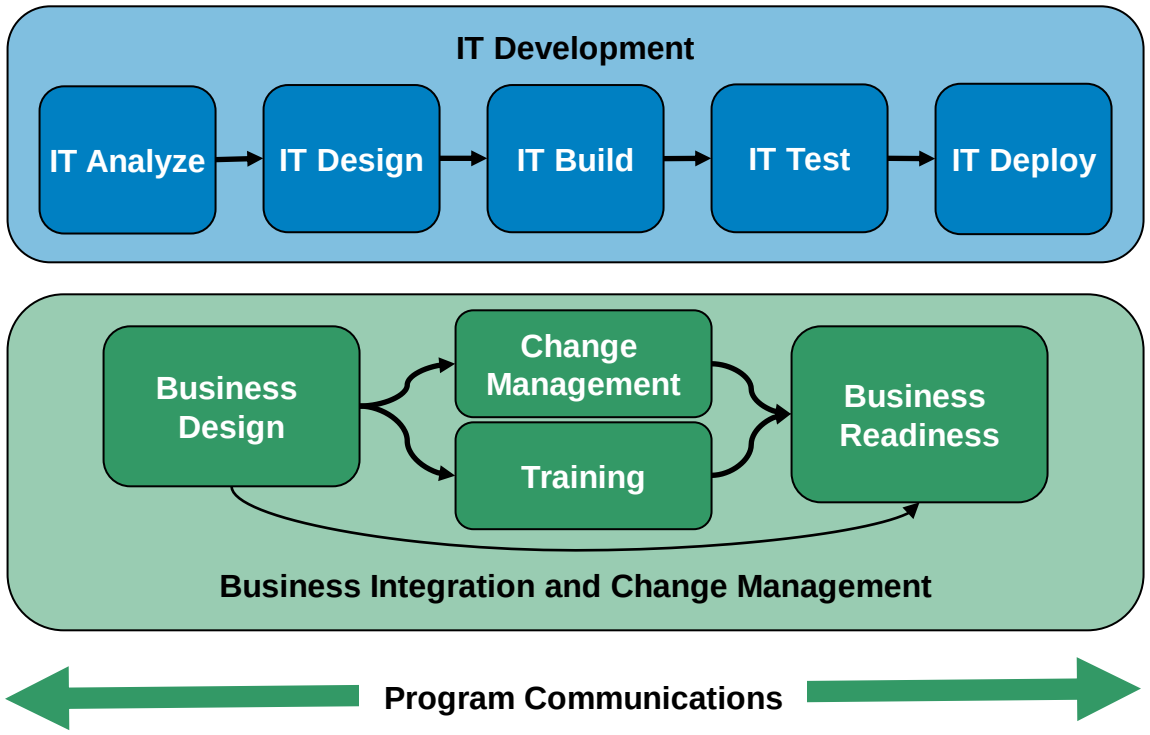
Sample IT Work Streams



The Project Team has defined the following project work streams:

W1 – AMI Infrastructure
W2 – AMI Platform
W3 – Billing
W4 – Meter Asset Management
W5 – AMI Deployment & Meter Work Management
W6 – Customer Programs
W7 – Data Management
W8 – Outage & Voltage Management
W9 – Remote Service, Theft, Advanced Meter Events
W10 – CEDAR Transition
W11 – Quality and Release Management
W12 – Change Management and Service Introduction

Business Integration



Key Activities

- Capture Business Requirements from AMI Analyze Phase
- Conduct Business Impact Assessment
- Develop detailed process inventory for affected operational areas
- Modify current business processes or create new business processes to meet new business requirements

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- Assess workforce skills and needs
- Conduct Organization Design
- Engage and align leadership
- Manage Stakeholder Expectations
- Implement Change Agent Network
- Talent Management
- Develop messaging and communicate changes throughout the organization
- Develop training content
- Conduct training

- Support systems testing
- Operational Readiness Test Lead
- Execute Business Readiness Procedures
- Coordinate ‘work down’ plans
- Provide input to key strategic and tactical decisions
- Status and Metrics
- Transition to Postproduction Support
- Transition to Operations

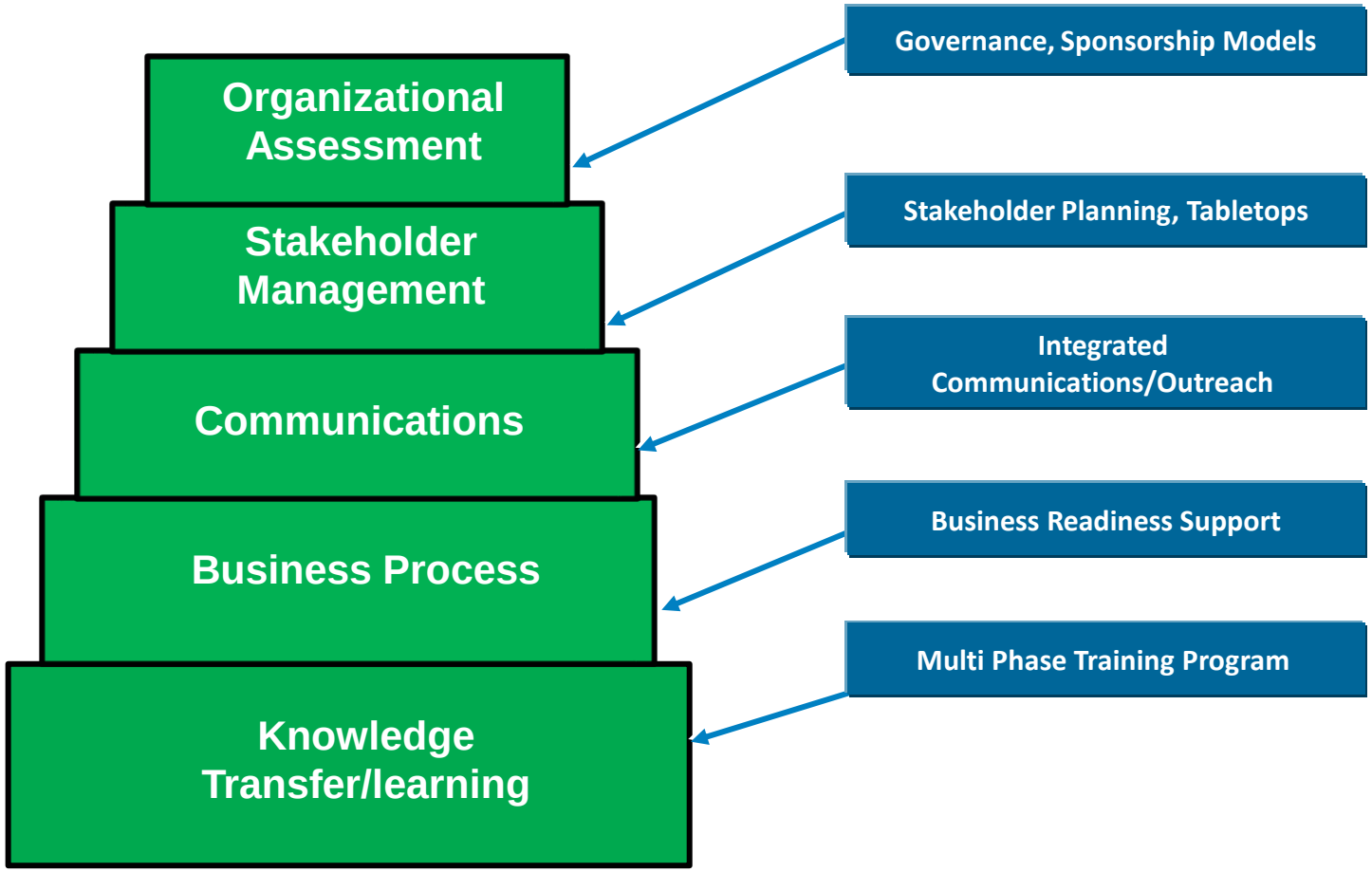
Defining Change Management

Change Management is……the process, tools, techniques to manage the people side of organizational change which support:

- Identifying and analyzing the changes which will take place within an organization
- Helping the stakeholders understand the effect of these changes on their roles/responsibilities/work
- Facilitating and documenting the changes within the organization, driving to a new business model
- Creating the plans and actions to drive the successful implementation of the change such as communications, sponsorship, coaching, training, stakeholder management and reinforcement mechanisms such as rewards and recognitions
- Aligning the change within the organization to ensure ongoing integration of the change

Change Management is a process focused on reducing business risk by increasing acceptance and successful integration of a change by all levels of stakeholders and business areas

The Building Blocks of Change Management



Configuration Management

- It is important to set plans and structure to manage the configuration of your platform
- Focus areas include:
  - Network Elements
  - Meters
  - Communication Modules
- Need to consider: OS Kernel, Firmware, Applications

Meter and System Obsolescence

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

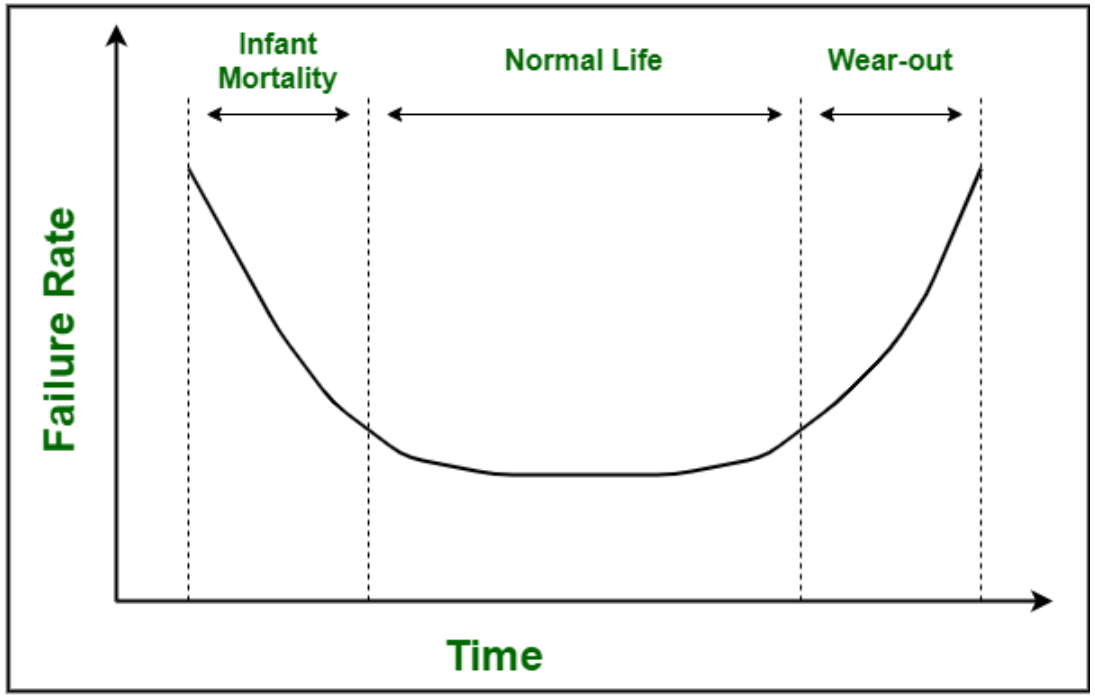
- Bathtub Curve
- Impact from the COVID Pandemic
- Obsolescence Planning
- Financial Concerns

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.

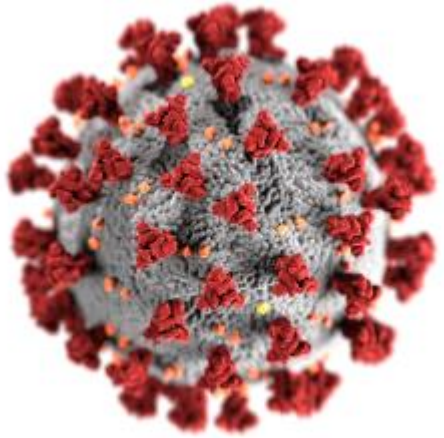


Bathtub Curve

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*

Meter and System Obsolescence

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

Lessons Learned

- Vendor & Consultant Selection
- System and Network Design
- Hardware Selection
- Business Process Design
- Deployment Phases
- Configuration Management
- Change Management
- Celebrate Success

Summary and Conclusion

- Advanced Metering Infrastructure Systems
- PECO's AMI Deployment
- System Integration and Benefit Delivery
- Change Management
- Lessons Learned
- Summary and Conclusions

Questions?

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“THANK YOU”

47

THANK YOU

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Links/References (If any)