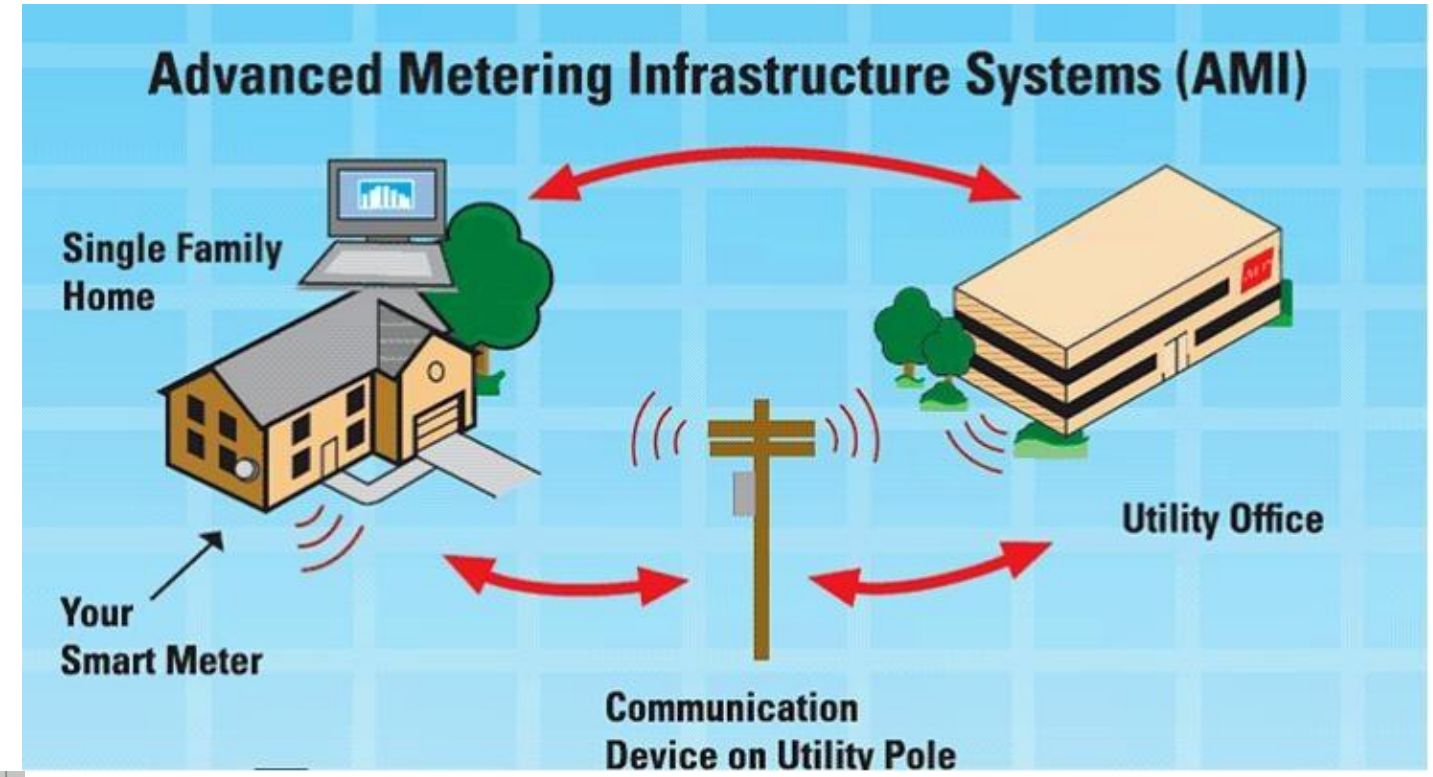
Advanced Metering Infrastructure



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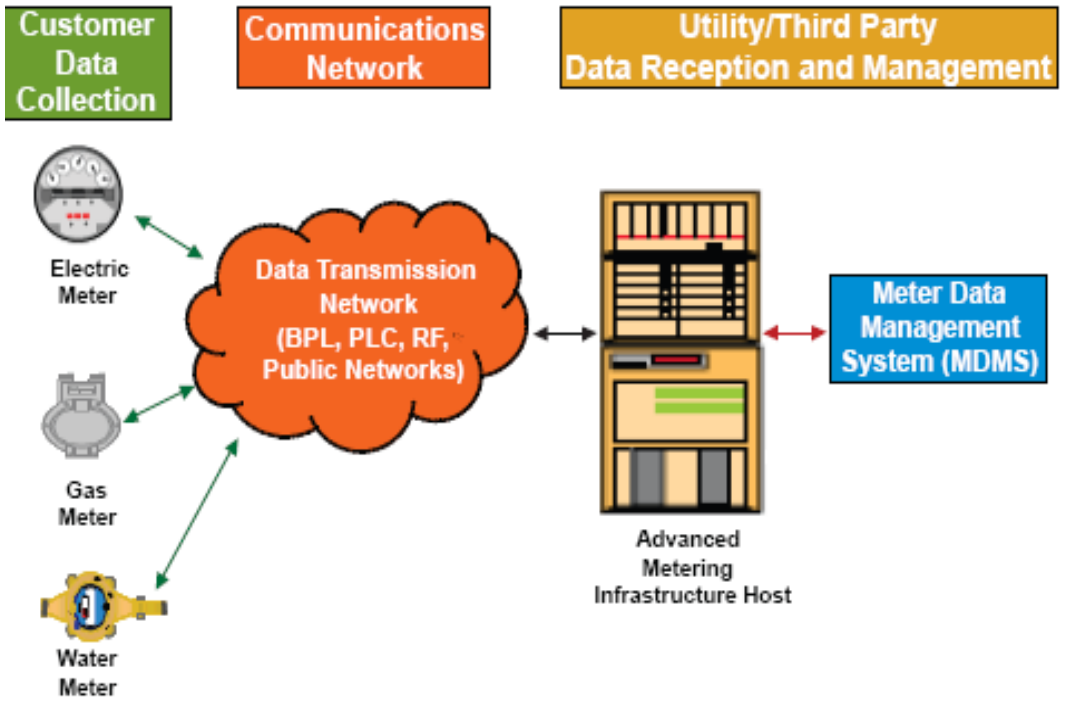
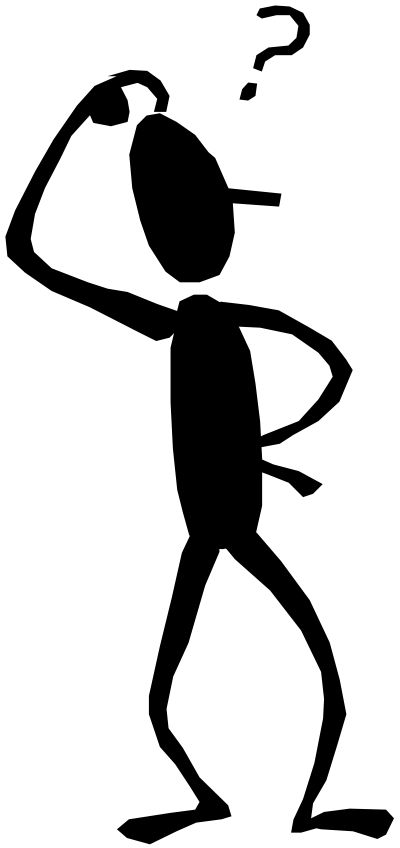
Presentation Overview

1. What is AMI?
2. Why should AMI be implemented?
3. What issues face AMI?



Background: What is the Smart Grid?

- Monitors supply and demand of electricity for users
- Permits users to use more energy when it costs less and to use less energy when it costs more



Smart Grid Background Continued

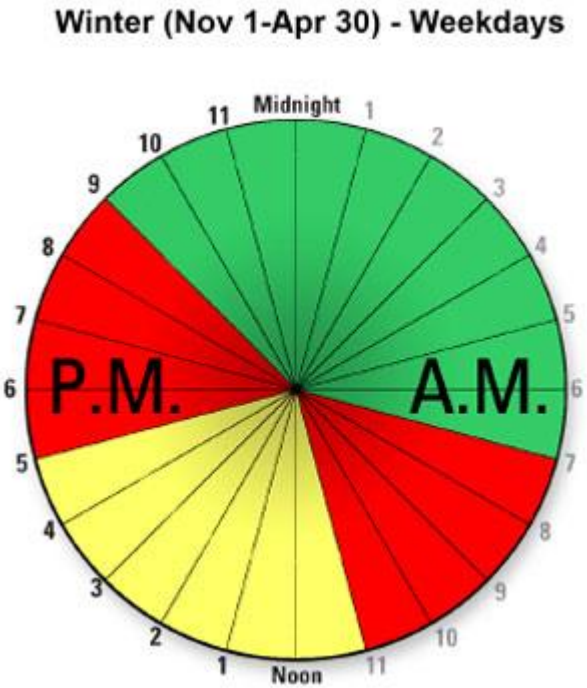
- Two different concepts
  - Transmission level grid that allows utilities to operate more efficiently
  - The interface between the utility and the customer

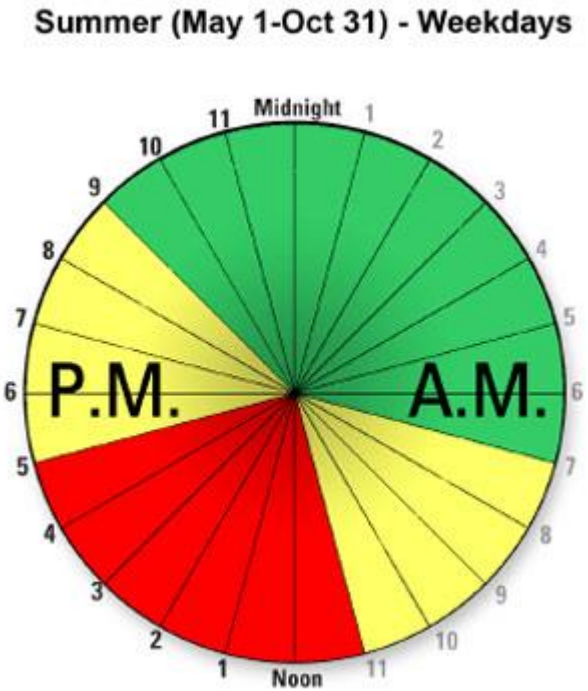
Technologies to Implement the Smart Grid

- There are many
  - Visualizing Energy Resources Dynamically on Earth ("VERDE")
  - Distributed generation
- Most important two here:
  1. Smart Metering
  2. Advanced Metering Infrastructure ("AMI")

1. Smart Metering

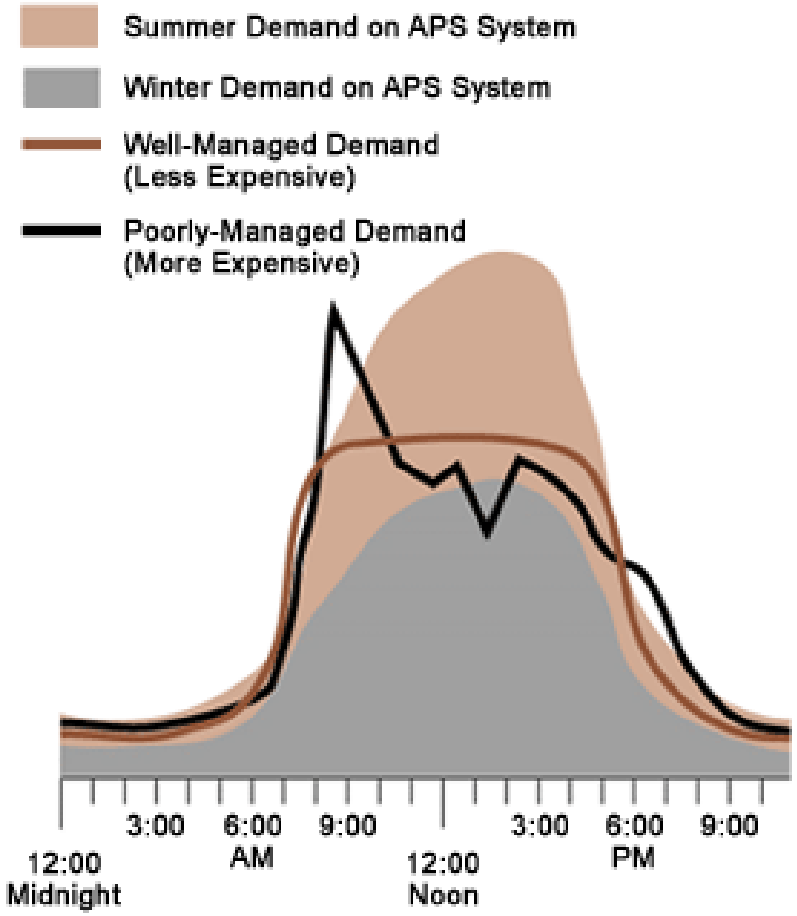
- A very broad concept
  - Combo of metering-related technologies systematically configured to support complex rates
- What are complex rates?
  - Any rate that goes beyond a simple total monthly billing for total electricity consumption





Examples of Complex Rates

- Time of use (TOU) rates
- Demand rates
- Dynamic or peak-sensitive rates



More on Smart Metering

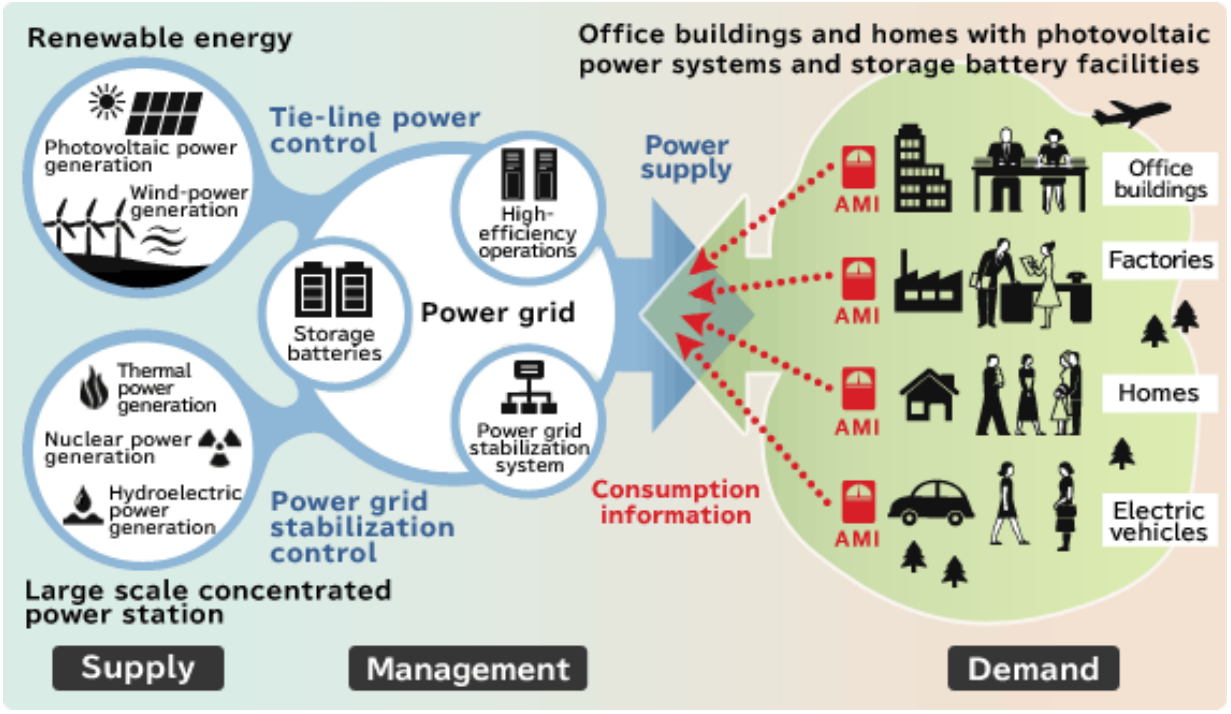
- Traditional meters are manually read on a monthly basis; smart meters are interval meters
  - Allow measurement of usage over much shorter intervals
  - More precise measurement provides greater flexibility and efficiency
- Proliferation almost tripled from 2006 to 2008, to 19M smart meters

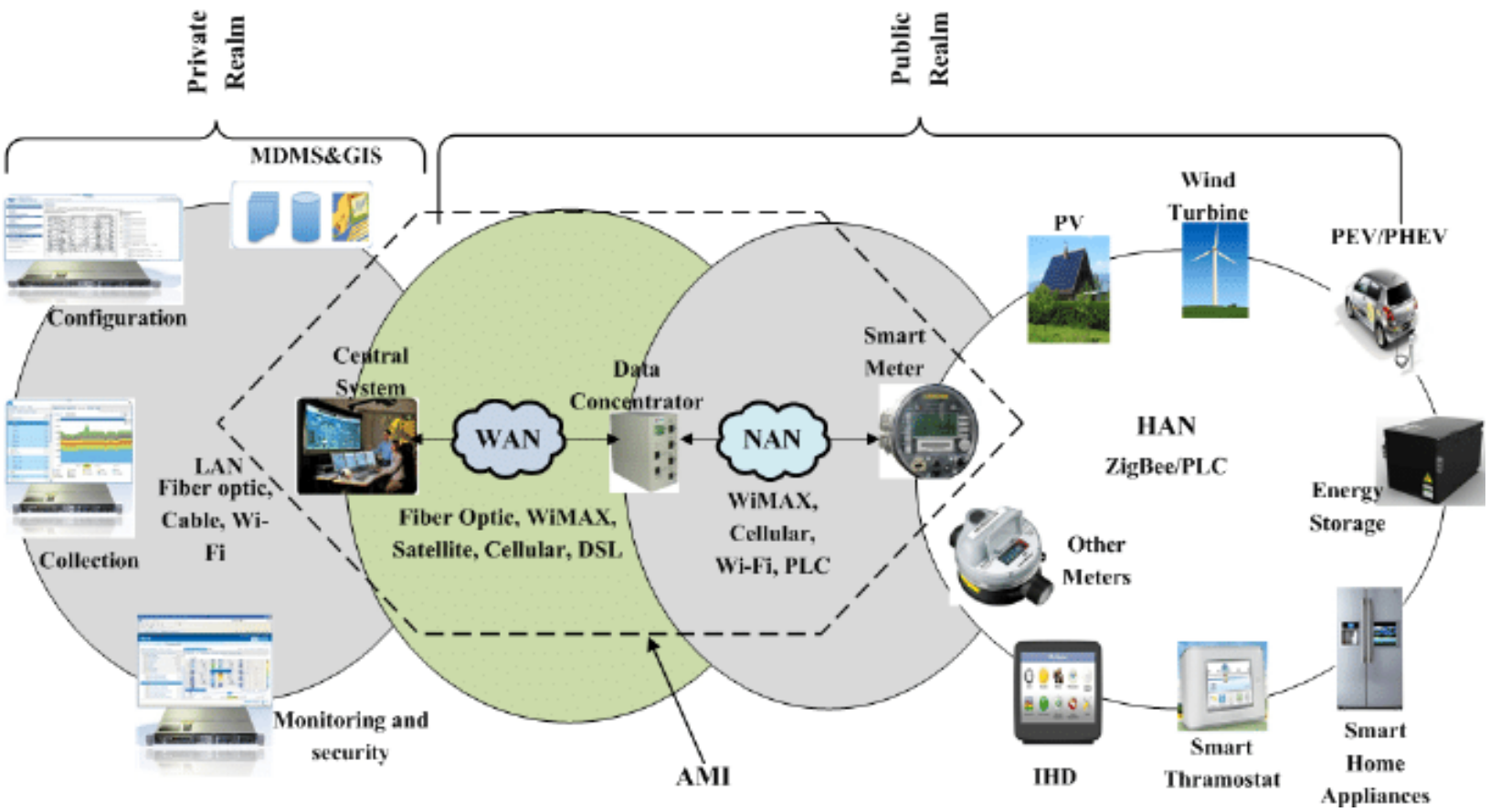
2. Advanced Metering Infrastructure (“AMI”)

- What is it?
  - Smart meters at the consumer’s location
  - Fixed communication networks between consumers and service providers
  - Data reception and management systems that make the info available to the service provider (meter data management system or “MDMS”)
- MDMS: software applications that receive and store meter data and perform other functions

AMI Definition

- Two characteristics
  - Fixed network systems
  - Capable of supporting complex rates

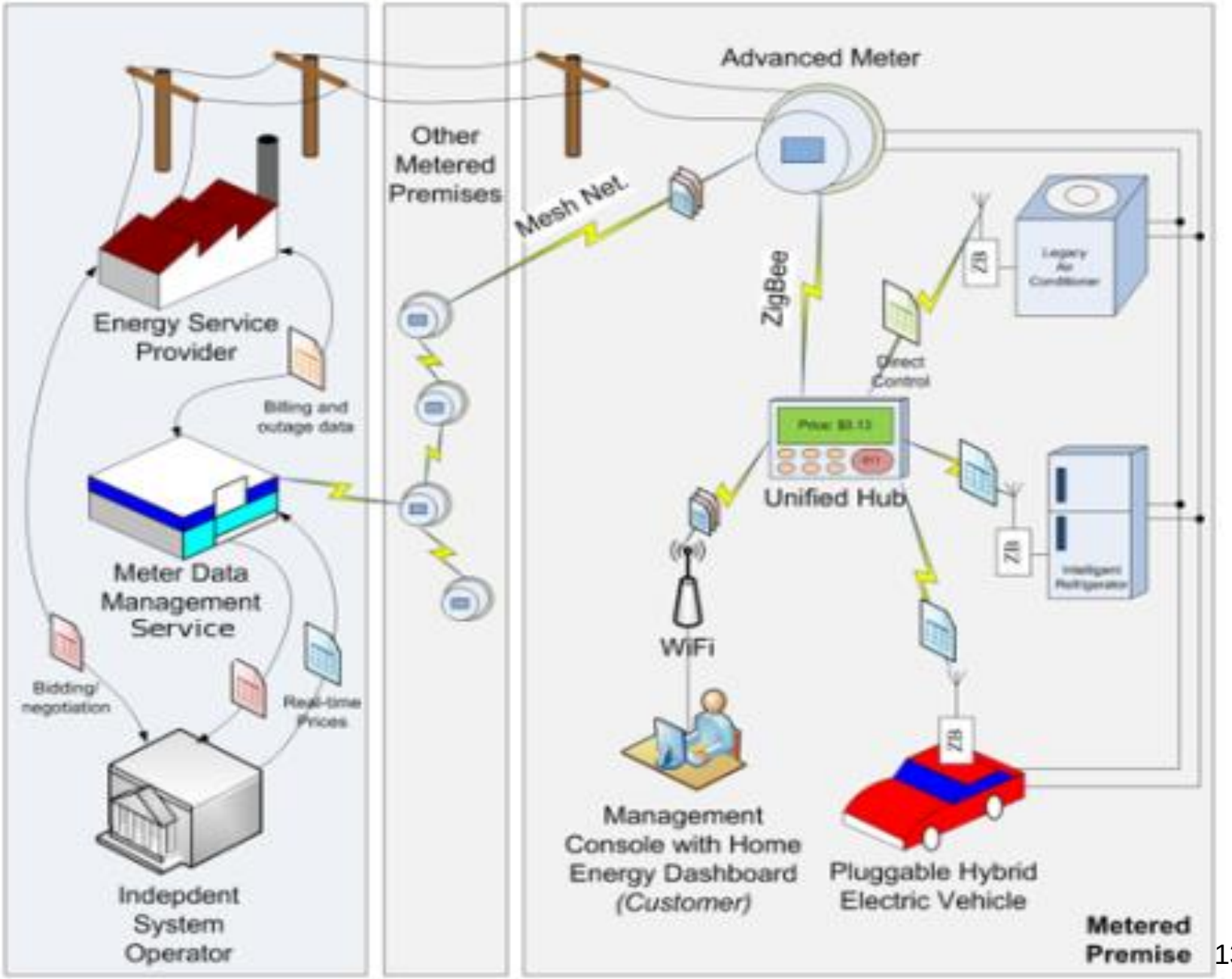




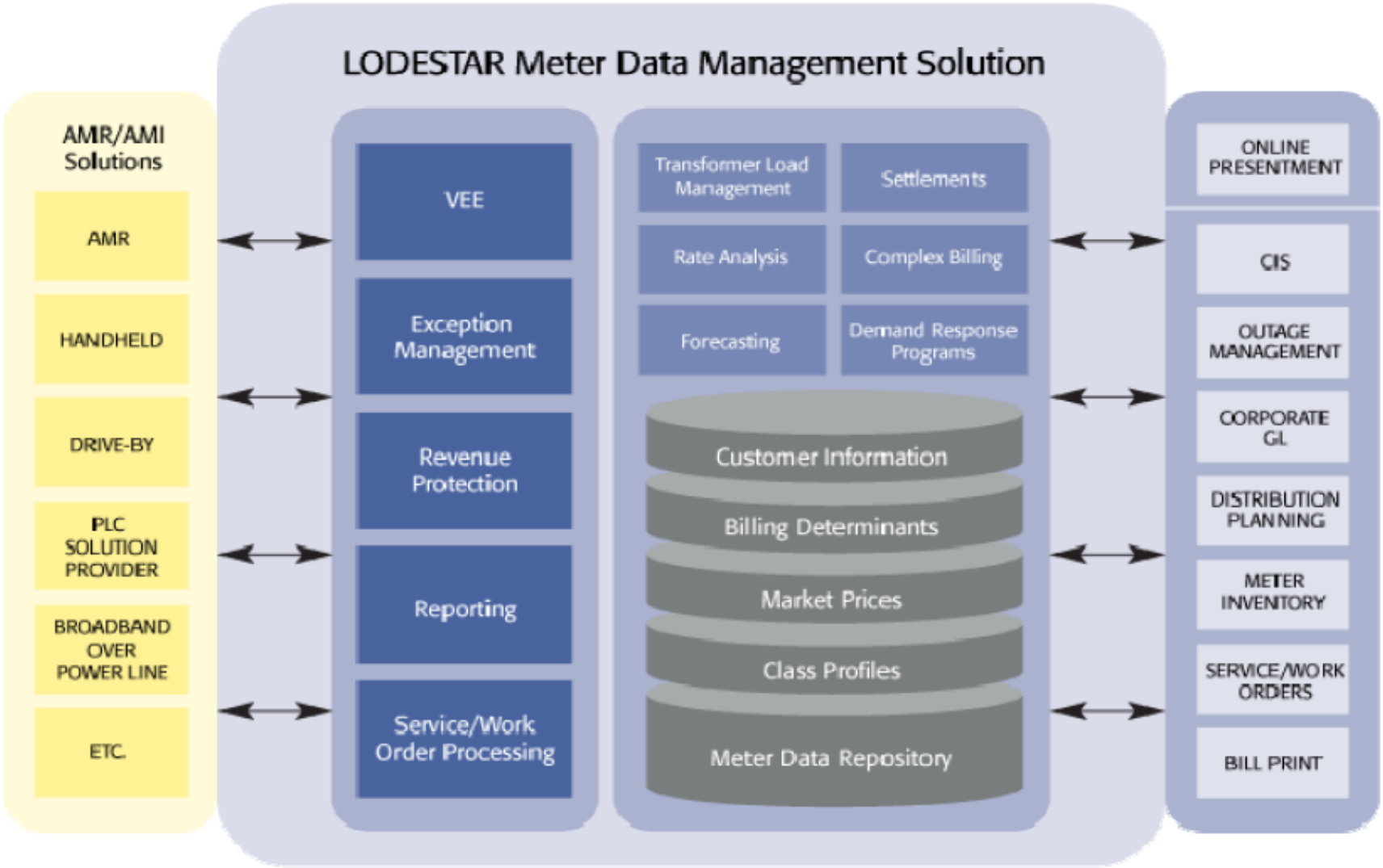
Advanced metering infrastructure (AMI) Architecture.

What does AMI do?

- Enables a two-way flow of information between consumers and utilities
- Enables proliferation of demand response
- Allows service provider to control consumers' electricity usage (load control)
- Facilitates Smart Grid deployment and distributed generation


Advanced Meter
Other Metered Premises
Mesh Net
ZigBee
Energy Service Provider
Billing and outage data
Meter Data Management Service
Bidding/ negotiation
Real-time Prices
Indepdent System Operator
Direct Control
Unified Hub
WiFi
Management Console with Home Energy Dashboard (Customer)
Pluggable Hybrid Electric Vehicle
Metered Premise

MDMS Concept



Gathering Meter Data for Complex Rates

- There are several types of advanced metering, but not all qualify as AMI
  - Standalone meter read locally
  - Standalone meter read remotely over public infrastructure
  - Meter with short-distance communication upgraded to fixed network
  - Private fixed network AMI system

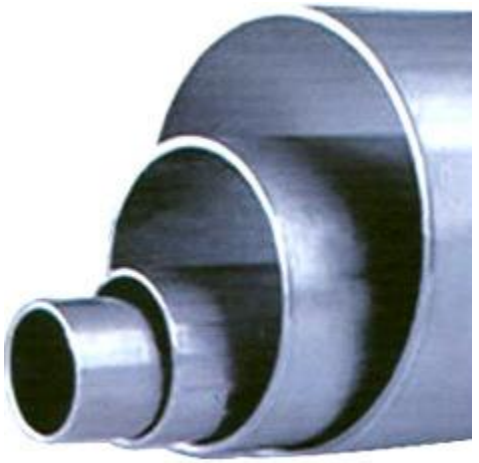
Implementing AMI Fixed Networks

- Options
  - Fixed Radio Frequency (RF)
  - Power Line Communication (PLC)
  - Broadband Over Power Line (BPL)
  - Public Networks
    - E.g., landline, cellular, paging, etc.
- Choice dictated by
  - Benefit to utility
  - Number of customers that will take advantage of dynamic pricing
- First three are the most popular

Data Rate Classes

- Low bandwidth
- Mesh networks
  - Communications from each meter flow through several others on the way to the MDMS
- Full broadband network connections

- More bandwidth equals higher cost
- But also more capability
- Allows for unforeseen value sources



Why implement AMI?

- Public Utilities Regulatory Policies Act section 111(d) mandate
  - As amended by § 1252 of the Energy Policy Act of 2005
- Each utility must offer each class of customers a time-based rate schedule
- And must provide these rates and meter them for those who request

Why implement AMI?

- Public Utilities Regulatory Policies Act section 111(d) mandate
  - Regulators of regulated utilities and unregulated utilities required to “consider and determine” whether smart metering is appropriate
  - If so, these entities must set smart metering standards for the utilities

Determining If Smart Metering Is Appropriate

- Cost-benefit analysis
- Must consider benefits for
  - Customers
  - AND utilities
- Two considerations
  - Metering
  - Programs that allow customers to lessen electricity use

Benefit: Demand Response

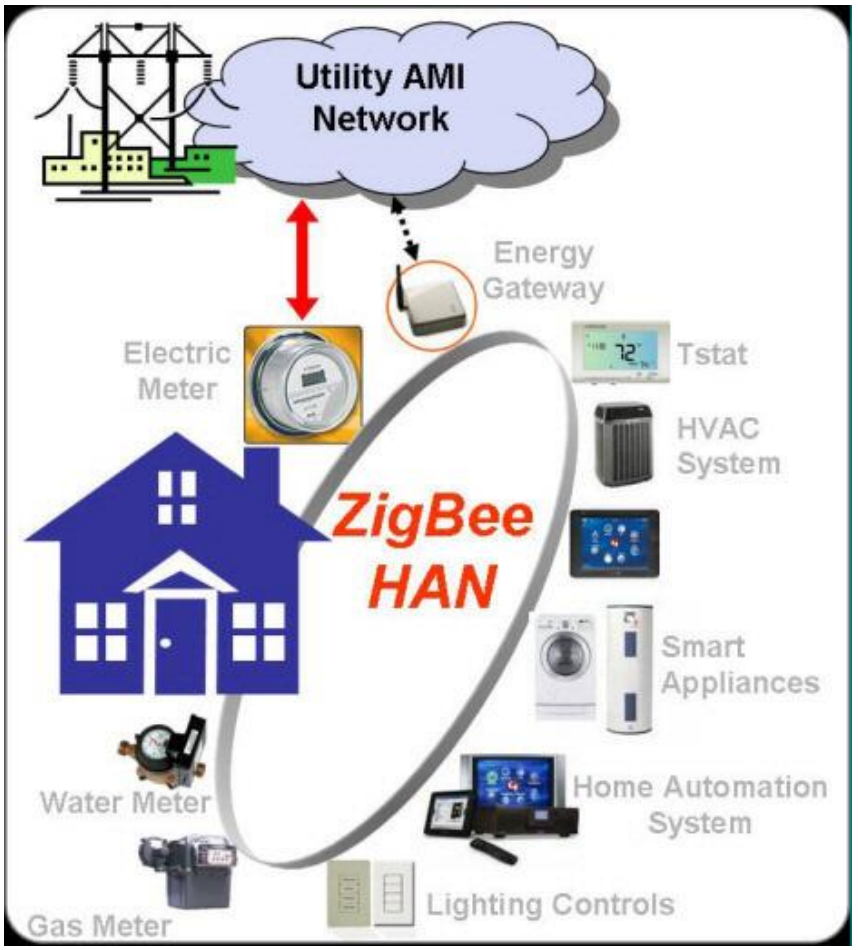
- EPAct of 2005: US's policy is to encourage demand response
- AMI allows consumers to easily take advantage of dynamic pricing programs
- Utility provides info on electricity price changes to consumers so they may modify their usage
- Allows for peak shaving: reducing electrical demand at times when electricity is most costly to produce
- AMI provides info that incentivizes customers to reduce usage and automates that process, requiring minimal consumer effort

Conventional Methods of Providing Price Info

- Examples
  - Newspaper
  - Audio broadcast radio
  - TV
  - Fax
  - Telephone
  - Email
- A fixed network AMI solution would provide this info to many consumers with comparatively less difficulty

Another Benefit: Load Control

- Home Area Networks
- Homes can respond to electricity supply in order to maximize efficiency through user-set profiles
- Utilities can alter supply of electricity to homes when demand is expected to spike



AMI Proliferation

- AMI accounts for 4.7% or 6.7M of all US electricity users
- Number of installed meters projected to grow to 52M by 2012
- Which electricity generating entities have done the most?
  - Electric cooperatives have highest rate at 13%
  - Investor-owned utilities: close to 6%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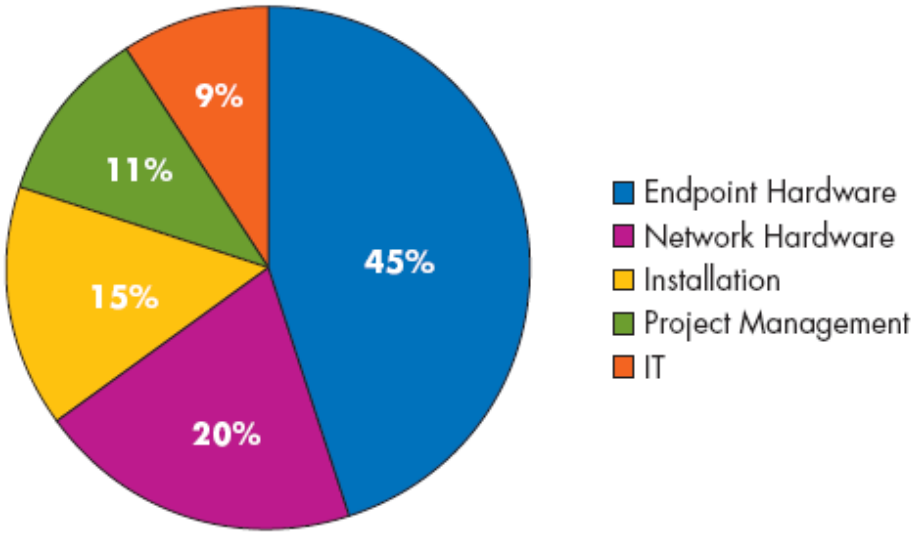
EPRI's Stated AMI Issues

1. Cost-benefit assessment
2. Security
3. Interoperability and standard interfaces
4. AMI specifications
5. AMI and demand response networks

Cost

- Itemization
  - Hardware and software
  - Installation costs
  - Meter data management
  - Project management
  - IT integration



Cost Estimates

AMI System Type	Cost ($ per meter)
Walk / drive-by (radio)	$50 - $90
Radio fixed network	$100 - $160
Power line fixed network	$110 - $175

Notes

Figures shown include hardware, software, installation, integration with billing only, training, & vendor deployment support.

Costs vary widely; figures shown are approximate, middle-of-range, for estimating purposes only.

Actual values will vary substantially with size of project, geography, customer density, functional requirements, meter inventory, corporate strategy, & many other factors.

Drive-by does not always cost less than fixed network. A power line system may cost less than a radio system.

O&M costs are not shown, vary widely, and appreciably affect annual net benefit.

Product status, risks, performance & other factors vary widely & often have cost & benefit consequences.

Assumptions

Saturation deployment.

Typical mix of single-, network-, & poly-phase meters.

50/50 meter retrofit/replacement.

Cost Estimates

- Hardware and software costs have decreased over time
  - Over the last 10 years, they are 80% of what they were
- 2005-2006: hardware costs were $76/meter on average
- Capital costs for communications infrastructure
  - About $125-$150/meter
- Adding demand response capability increases costs by another $100-$350/site

Security Issues

- Privacy
  - Can determine if someone is home
  - Can determine usage patterns
- Exposure to cyber terrorism

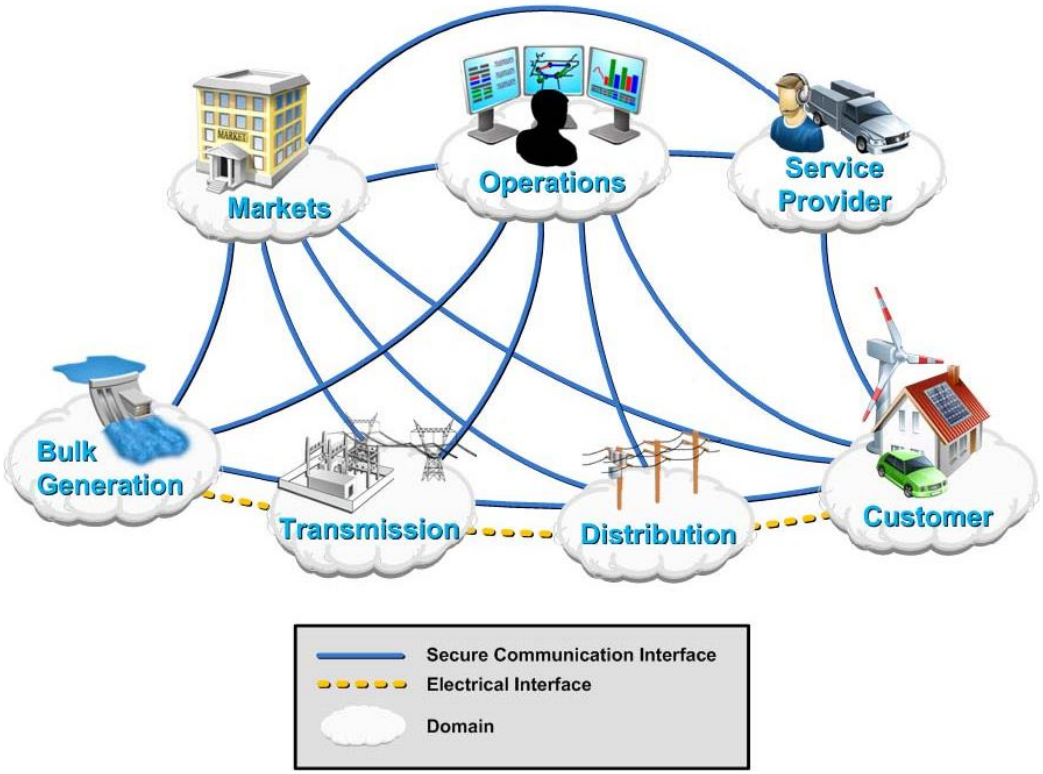
U of I Security Lab Threat Taxonomy

- Curious eavesdroppers
- Motivated eavesdroppers
- Unethical customers
- Overly intrusive meter data management agency
- Active attackers
- Publicity seekers

Standardization

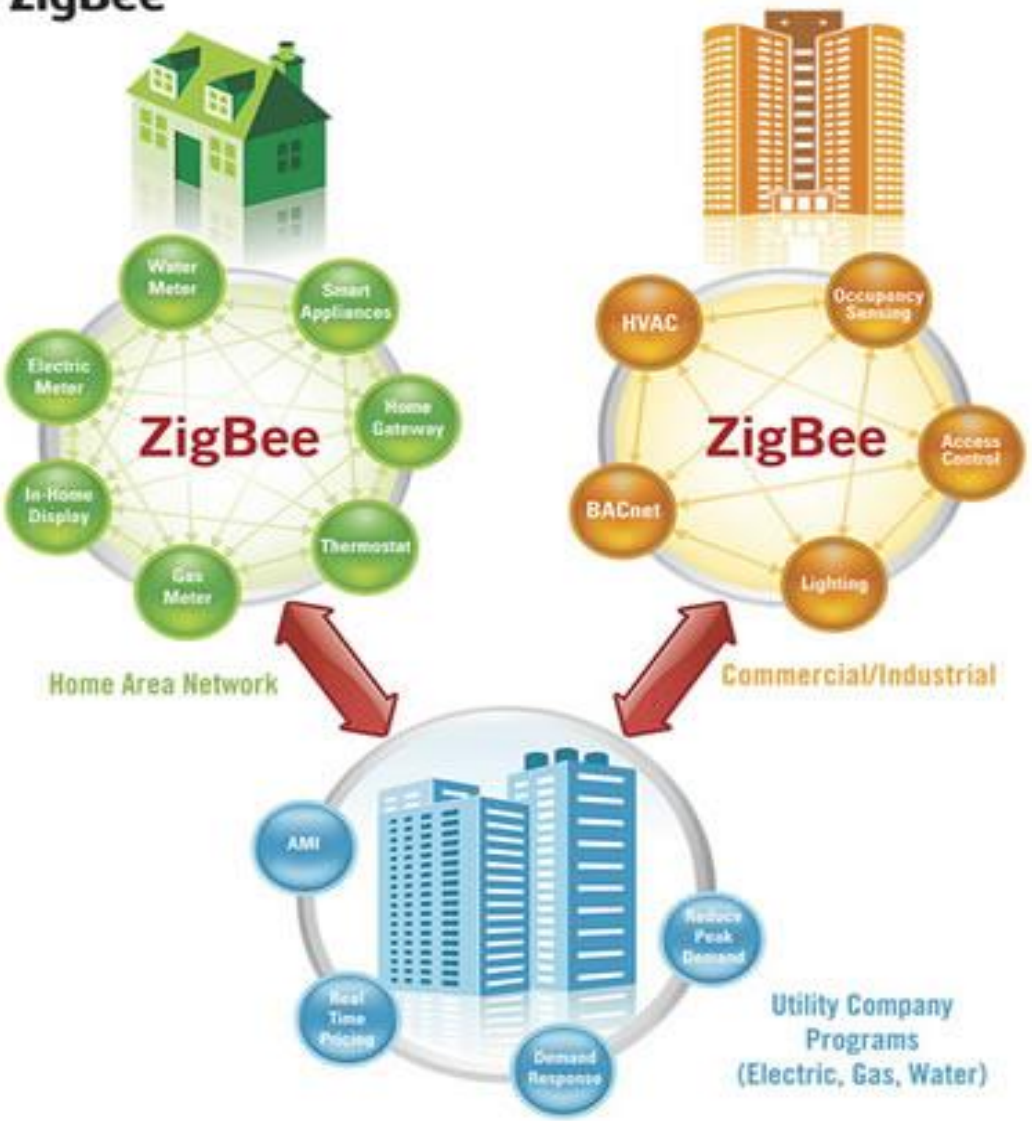
- How do you ensure that everything can communicate in an AMI system?

- Communication protocols amongst
  - Load control devices in HANs
  - Fixed networks



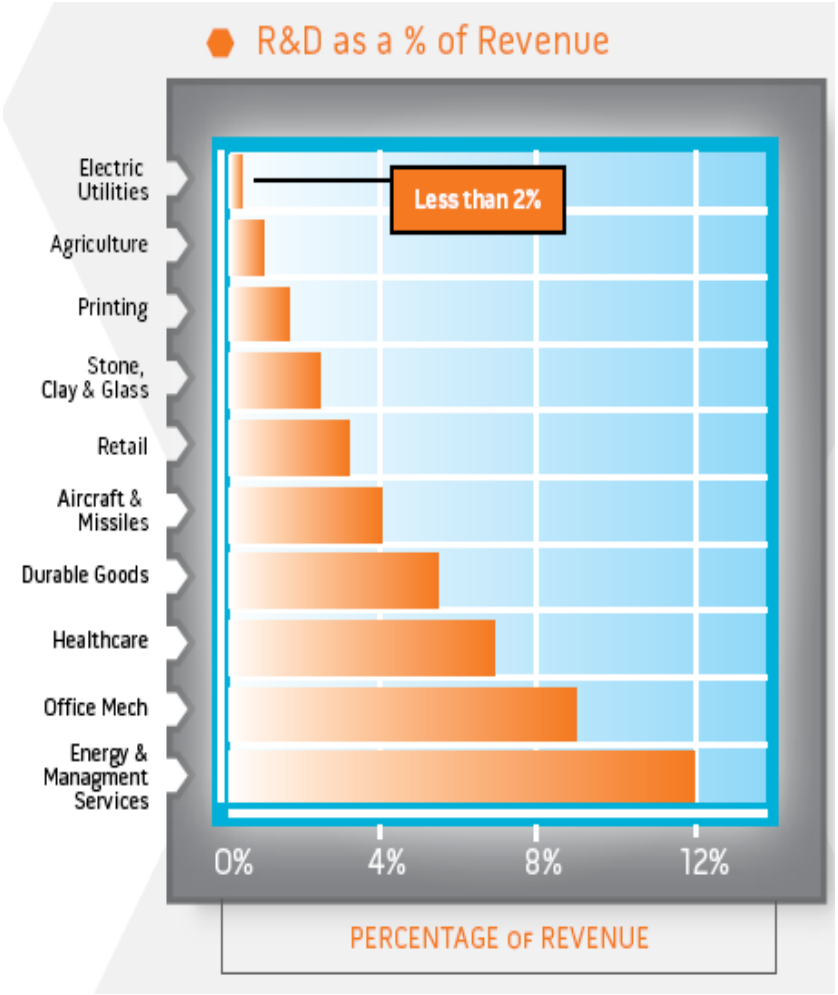
ZigBee Smart Energy

ZigBee®



Conclusion

- AMI faces many challenges but has the potential to greatly increase energy efficiency



UTS Smart Grid

- Tugas Besar dimulai hari ini, (1 1/2 Minggu). Output :
- - File Simulasi
- - Paper : https://jurnal.uns.ac.id/jeeict/about/submissions#authorGuidelines

- Tugas Besar :
- Buat simulasi microgrid di daerah 3T di Indonesia, **dual-mode, (grid connected dan island mode).** Data-data berasal dari sumber misal NASA, Solar/Wind Atlas.
- Data beban bisa dibuat dari penentuan kapasitas, atau dari profil beban.