Advanced Metering Infrastructure (AMI)

Overview of System Features and Capabilities

Chris King
Chief Strategy Officer
eMeter Corporation

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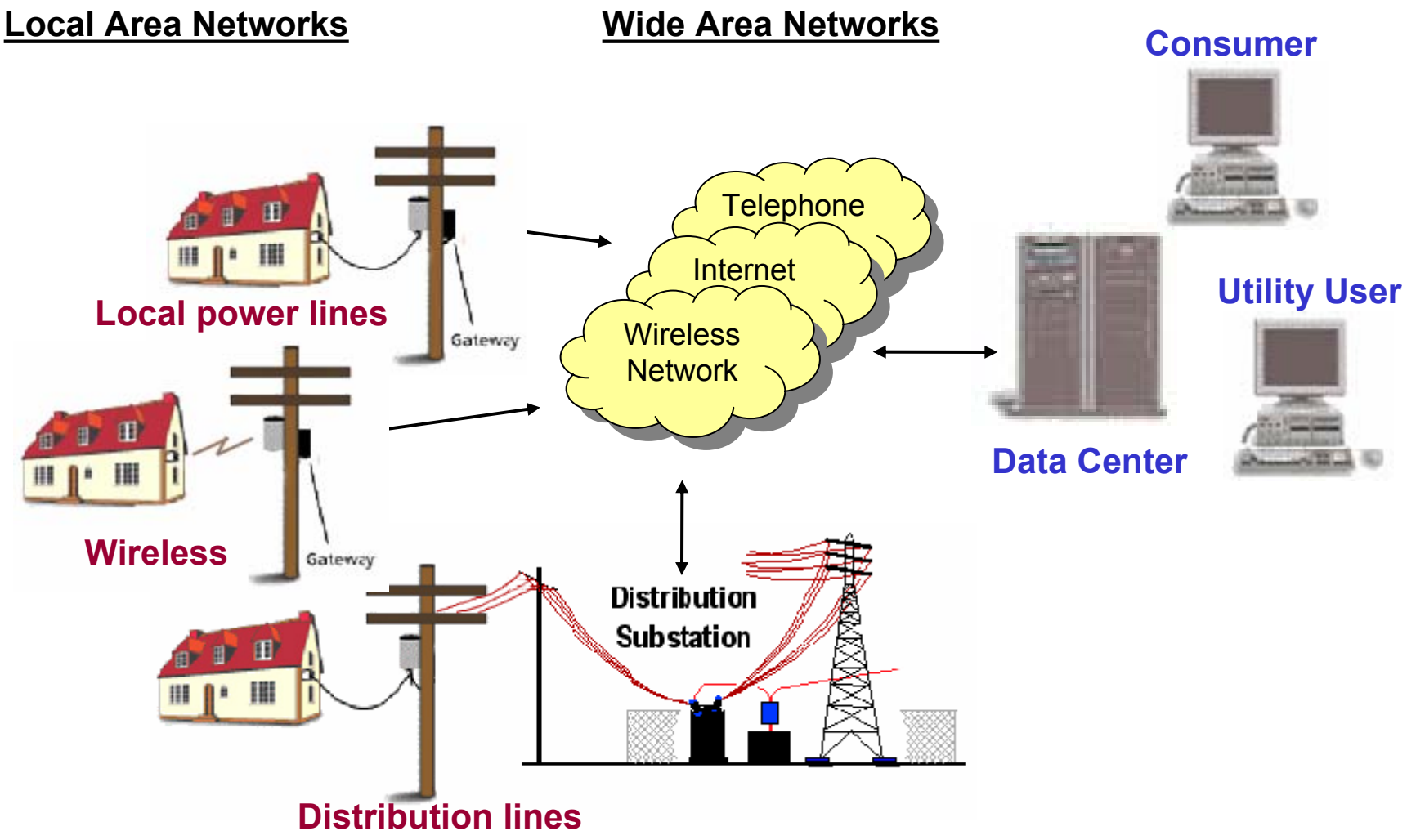
Today's Presentation

1. Overview of metering technologies
2. System costs and benefits
3. Case studies
   - U.S.
   - International

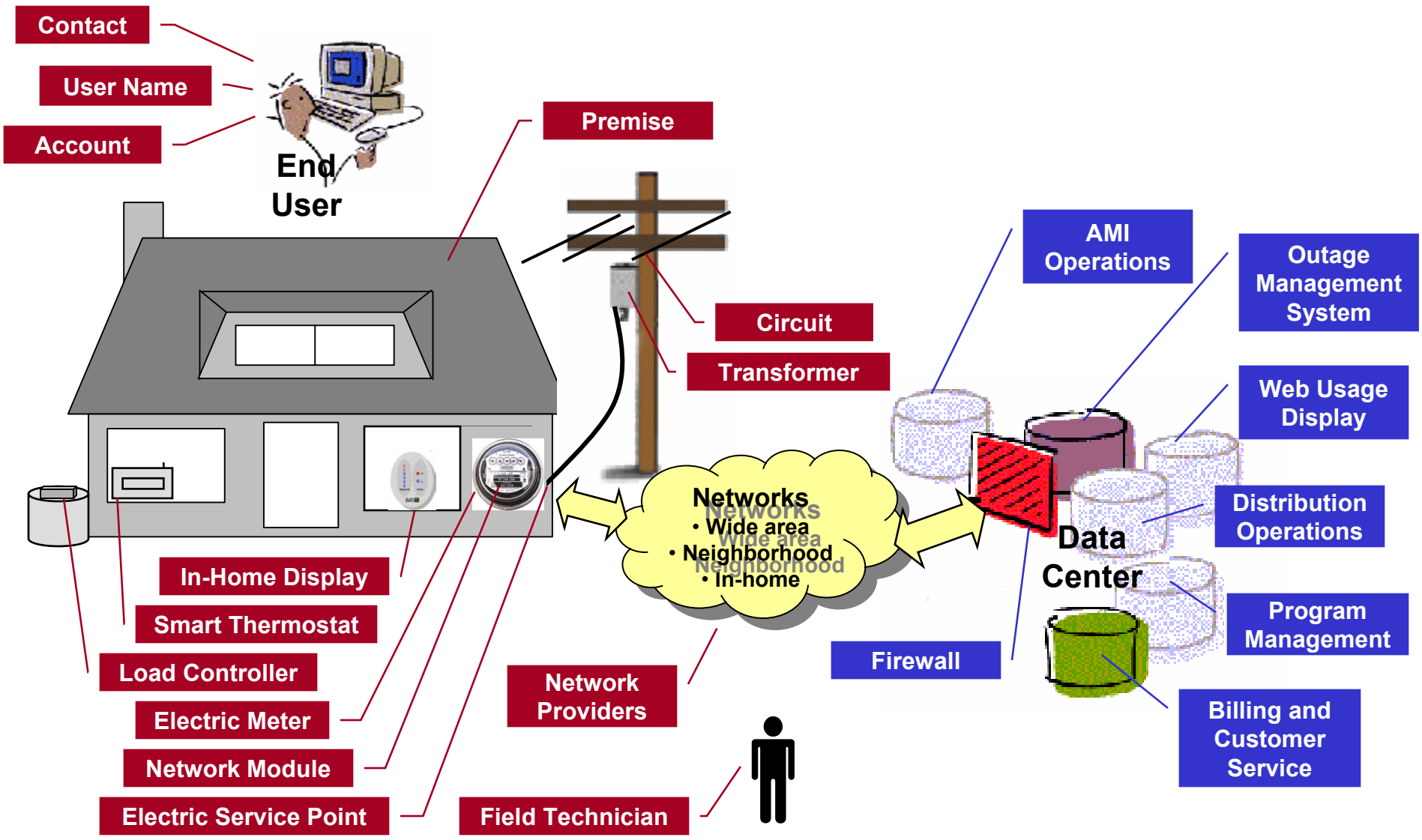
Metering Technologies

System Element/Feature	Manual	Automatic Meter Reading (AMR)	Advanced Metering Infrastructure
Meters	Electromechanical	Hybrid 	Hybrid or solid-state
Data collection	Manual, monthly	Drive-by, monthly	Remote via communications network, daily or more often
Data recording	Total consumption	Total consumption	Time-based (usage each hour or more often)
Primary applications	Total consumption billing	Total consumption billing	Pricing options Customer options Utility operations Emergency demand response
Key software interfaces	Billing and customer information system	Billing and customer information system	Billing and customer information system Customer data display Outage management Emergency demand response
Additional devices enabled (but not included in base infrastructure)	None	None	Smart thermostats In-home displays Appliance controllers
Current penetration in California (residential and small commercial)	>95%	<5%	None (pilot only)

AMI Communication Networks

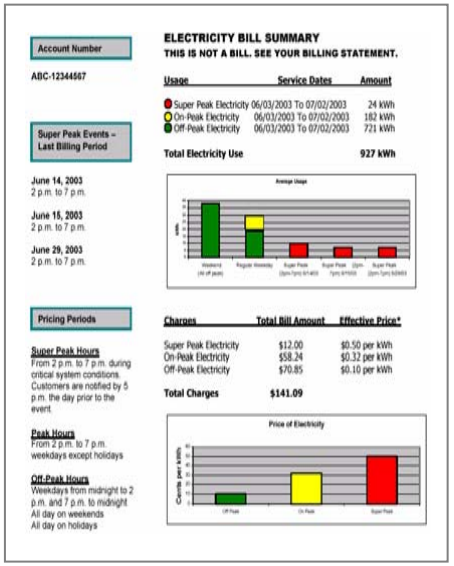


AMI Data and Software Relationships



Metering System Applications

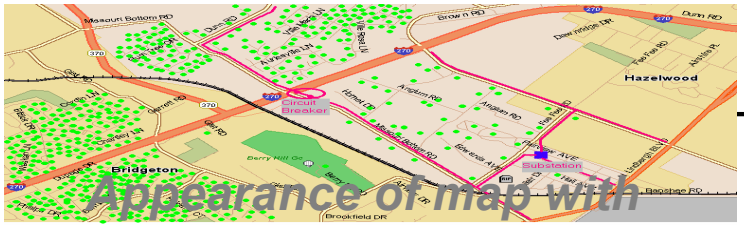
	Manual/AMR	AMI
Pricing	Total consumption only	Total consumption Time-of-use Critical peak pricing Real-time pricing
Other demand response	None	Load control Demand bidding Demand reserves Critical peak rebates
Customer feedback	Monthly bill	Monthly bill Monthly detailed report Web display In-home display
Customer bill savings	Turn off appliances manually	Turn off appliances Shift appliances off peak Manual or automatic control
Outages	Customer phone calls	Automatic detection Verification of restoration at individual home level
Distribution operations	Use engineering models	Dynamic, real-time operations



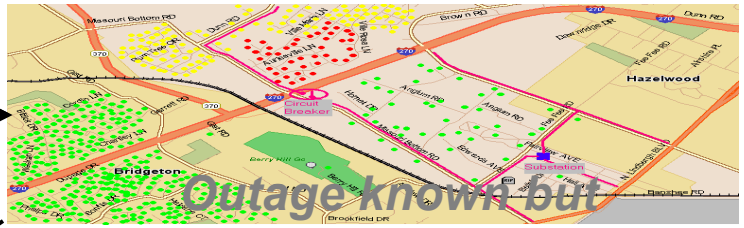
New Utility Capabilities Enabled by AMI

Service	New Capabilities Enabled
Power Quality	Meter-level voltage monitoring
Distribution Automation	Load balancing Capacitor bank switching* Regulator and tap changer monitoring* Transformer load management Automated outage management

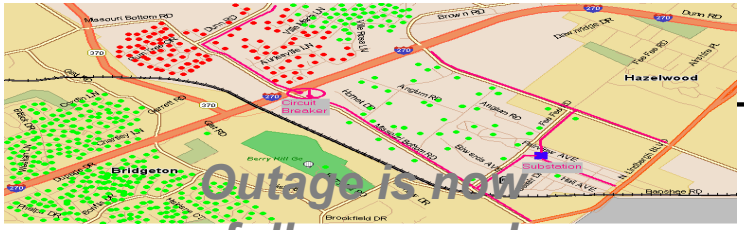
* - requires additional devices



Appearance of map with normal power status



Outage known but not yet fully mapped



Outage is now fully mapped

Individual customers still out

Monitor restoration to be sure power is fully restored

Major AMI Installations

Utility	Type	Technology	Quantity	Install Completed
U.S.				
Kansas City Power & Light (MO)	Electric	Wireless	400,000	1996
Duquesne Light (PA)	Electric	Wireless	580,000	1998
Ameren (MO)	Electric & Gas	Wireless	1,400,000	1999
Xcel Energy (MN)	Electric & Gas	Wireless	1,400,000	1999
Puget Sound Energy (WA)	Electric & Gas	Wireless	1,500,000	2000
United Illuminating (CT)	Electric	Wireless	320,000	2000
Indianapolis Power & Light (IN)	Electric	Wireless	470,000	2000
Exelon (PA)	Electric & Gas	Wireless	2,100,000	2002
Wisconsin Public Service (WI)	Gas	Wireless	200,000	2003
Wisconsin Public Service (WI)	Electric	Distribution line carrier	650,000	2004
PPL (PA)	Electric	Distribution line carrier	1,300,000	2004
JEA (FL)	Electric & Water	Wireless	600,000	2005
WE Energies (WI)	Electric & Gas	Wireless	1,000,000	2005
Hundreds of Small Utilities	Electric & Gas	Various	5,000,000	2004
International				
ENEL (Italy)	Electric	Power line carrier	30,000,000	2005
PREPA (Puerto Rico)	Electric	Distribution line carrier	1,400,000	2006
Sweden	Electric	Wireless & power line carrier	5,200,000	2009
Ontario (Canada)	Electric	To be determined	[5,000,000]	2010
Victoria (Australia)	Electric	To be determined	[2,500,000]	2013

Customer Service Benefits of AMI (Basic)

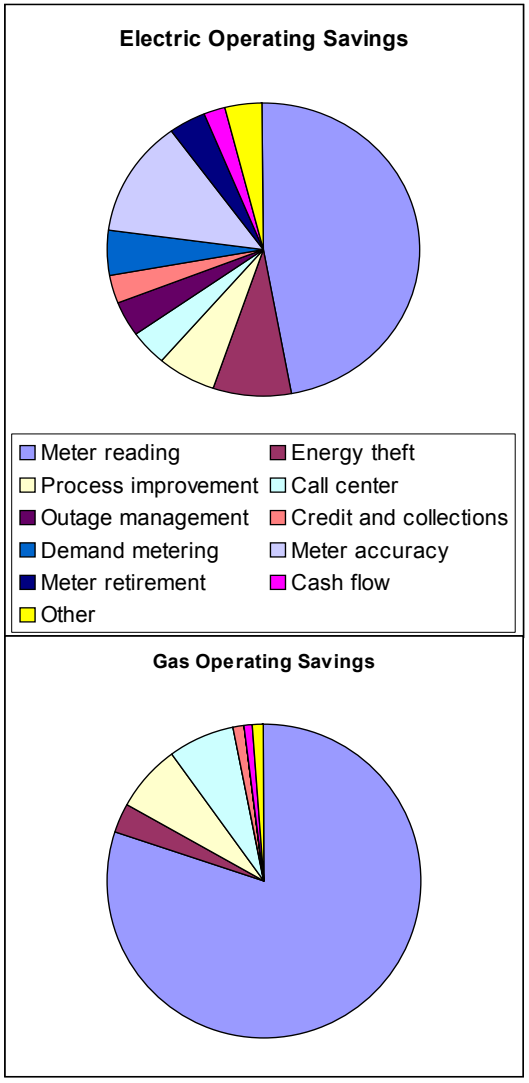
Service	New Options Supported
Billing	❑ Choice of billing date ❑ No estimated bills ❑ Month-to-date bill ❑ Projected month-end bill
Pricing	Choice of flat rates or dynamic pricing
Outage handling	Automatic response and restoration verification by utilities
Usage information	❑ Real-time meter read ❑ First call problem resolution ❑ Web data access ❑ Monthly detailed usage reports ❑ Baseline threshold alarms ❑ Month-to-date usage ❑ Daily or hourly data for customer education

Benefits – Utility Operations

Puget Sound Energy Example

Source	Share of benefits	
	Electric	Gas
Meter reading	47%	80%
Energy theft	8%	3%
Process improvement	6%	7%
Call center	4%	7%
Outage management	4%	0%
Credit and collections	3%	1%
Demand metering	5%	0%
Meter accuracy	13%	0%
Meter retirement	4%	0%
Cash flow	2%	1%
Other	4%	1%
TOTAL	100%	100%

PSE Payback: **Operations Only = 9 years**
Operations w/TOU = 5 years



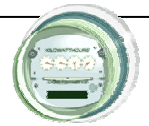
Utility AMI Deployment Drivers

Operational Efficiency	Ameren	KCPL	NSP	PSE	IPL	Exelon	UI	JEA	IPC	PPL	WE Energies
Operating Costs	●	●	●	●	●	●	●	●	●	●	●
Improved Accuracy		●	●	●		●		●	●	●	●
Theft Detection	●	●		●	●	●	●	●	●	●	
Distribution Service	●	●	●			●				●	●
Demand Response							●				
Customer Service											
Rate Options				●			●				
Billing Options		●		●	●		●	●			●
Internet Access		●		●							
Outage Response	●		●	●	●		●	●			
Service Quality	●	●	●	●	●	●	●	●		●	●

AMI Costs in Volume

1. **Meter with Communications Module: $50-400**
   - New vs. retrofit
   - Residential/small commercial vs. large commercial
2. **Meter installation: $10-200**
   - Residential/small commercial vs. large commercial
   - Primary variable is “drive time” (universal vs. scattered deployment)
3. **Local Area Network Node: $2-50 per meter**
   - At premise vs. pole top vs. substation
   - Primary variables are network type and number of meters connected
4. **Wide Area Network: $10 per LAN node per month**
   - Public vs. private network
5. **Data Center: $0.25 to $5 per meter per month**
   - Staffing, facilities, servers, and other operations & maintenance
   - Startup and base monthly cost
6. **Field Equipment Operations & Maintenance: $1 per meter-mo**
   - Meters
   - Local Area Network nodes
7. **Overheads: 10-20%**
   - Administrative & general
   - Financing costs for capital investments

Meter with Communications Module



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Meter Installation

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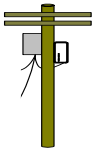
Local Area Network Node



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Wide Area Network Communications Services

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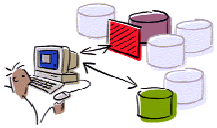
Data Center



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Field Equipment Operations & Maintenance

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Overheads & Administrative Costs

= Total Cost

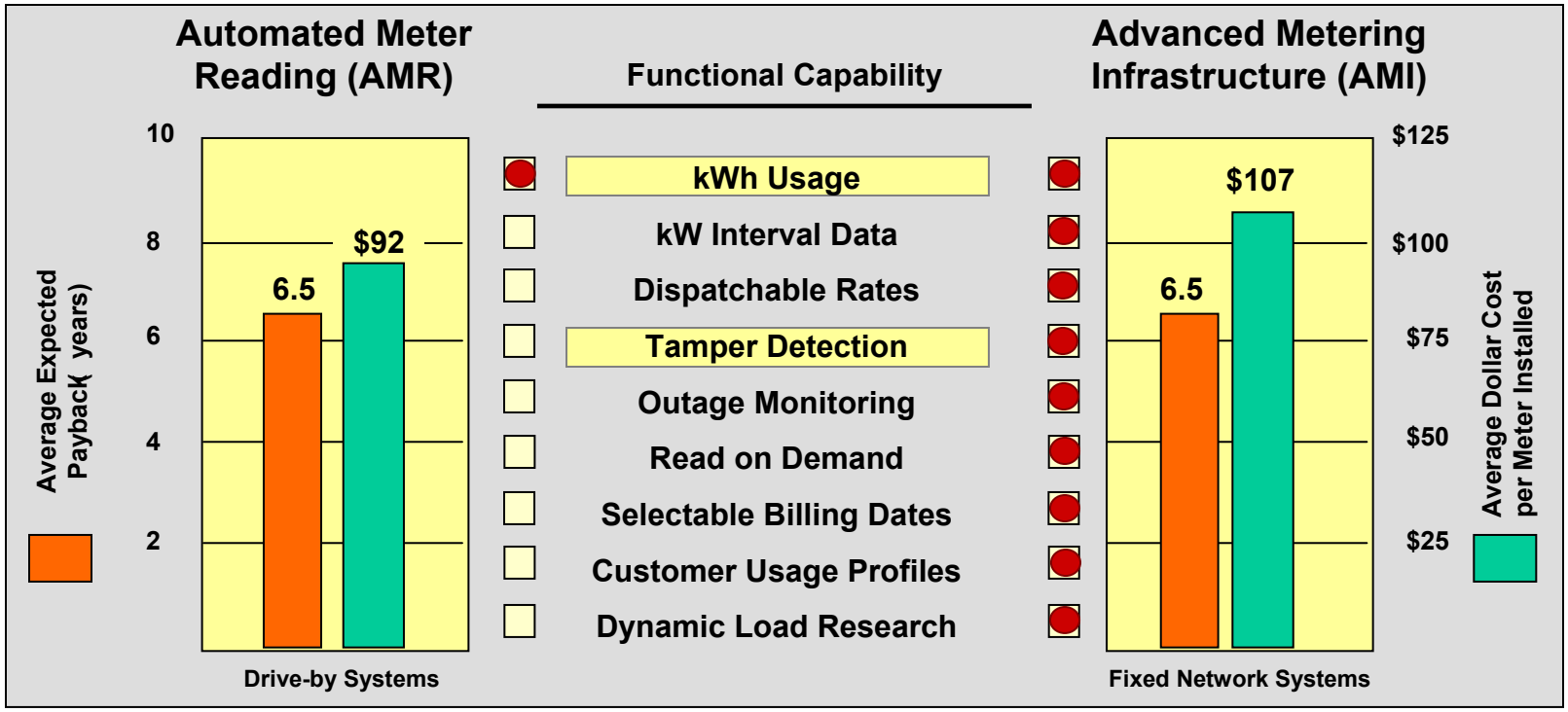
AMI Cost Example: 2 Million Meters

Item	Assumptions	Cost	Average Cost per Meter
Meters and Communications Modules	▪95% residential/5% commercial ▪30% new meters/70% retrofitted meters ▪55% electric/45% gas	▪New residential/small commercial: $60 ▪Retrofit residential/small commercial: $50 ▪New large commercial: $300	**Electric: $70.58** **Gas: $54**
Meter Installation	▪Installation of electric meters with modules ▪Installation of gas modules	▪Electric: $12.50 per meter ▪Gas: $10.00 per meter	**$11.38**
Local Area Network Node	▪Communications node equipment ▪Installation of communications node ▪Node covers 500 meters	▪Equipment: $5,000 ▪Installation: $500	**$11.00**
Wide Area Network	▪Public network	▪Communications: $10 per LAN node per month	**$0.02 per meter-month**
AMI Data Center	▪Software purchase and installation ▪System integration ▪Modification of existing systems ▪Operation of AMI	▪$40 million capital costs ▪$0.30 per meter-month for operations	**$20.00 capital** **$0.30 per meter-month**
Field Equipment Operations and Maintenance	▪Includes hardware and labor cost	▪1% per year of capital cost	**$0.05 per meter-month**
Overheads and Administrative Costs	▪Program management ▪All project overheads	▪20%	**$12.60**
TOTAL COST		▪ **$118.09 capital** ▪ **$0.37 per meter-month**	

AMI Costs Case Study

- Summary of data collected in several eastern U.S. utility procurements
- Independent consultant compared total capital cost and operating benefits of automating meters via AMI vs. AMR
- Technologies
  - Vendors with proven installations
  - Multiple technologies
- Business case
  - Benefits limited to documented utility operating savings
  - No demand response, rate, customer, or system opportunity benefits considered
- Includes meters, communications, training, IT support, and installation

Metering Systems
Average Unit Cost and Functional Comparison



Notes:

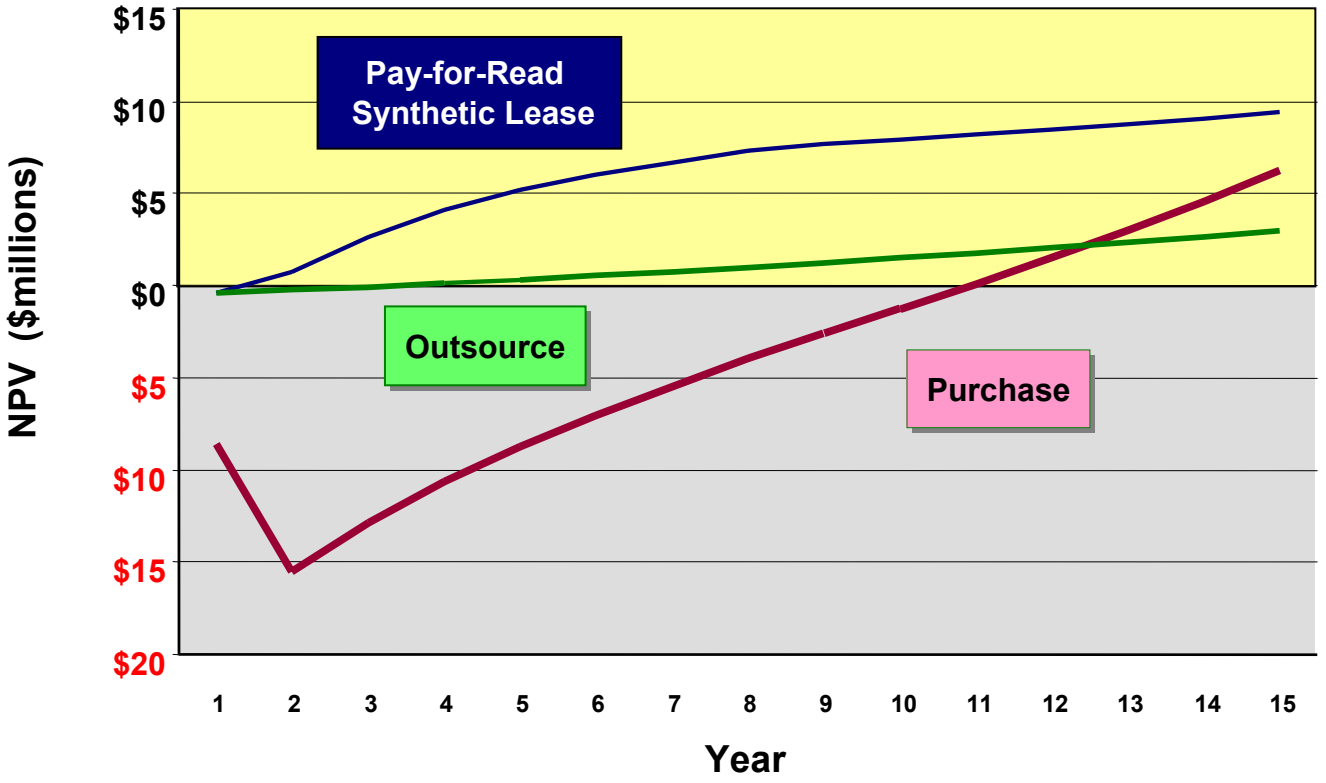
(1) Private communication (9/13/04), established utility consulting firm. Costs represent information drawn from multiple vendors and several utility procurements during summer 2004. Cost data exclude the high-low estimates in each system category.

(2) Costs include meter hardware, installation, communication systems, IT support, training.

(3) Only vendors with proven gas and electric installations qualified to bid. Evaluation considered only utility operating costs, no DR, rate, customer or other system costs or benefits considered. Multiple communication technologies included in results.

AMI Financing

- Capital costs
  - Around $100 per meter
  - Various financing options

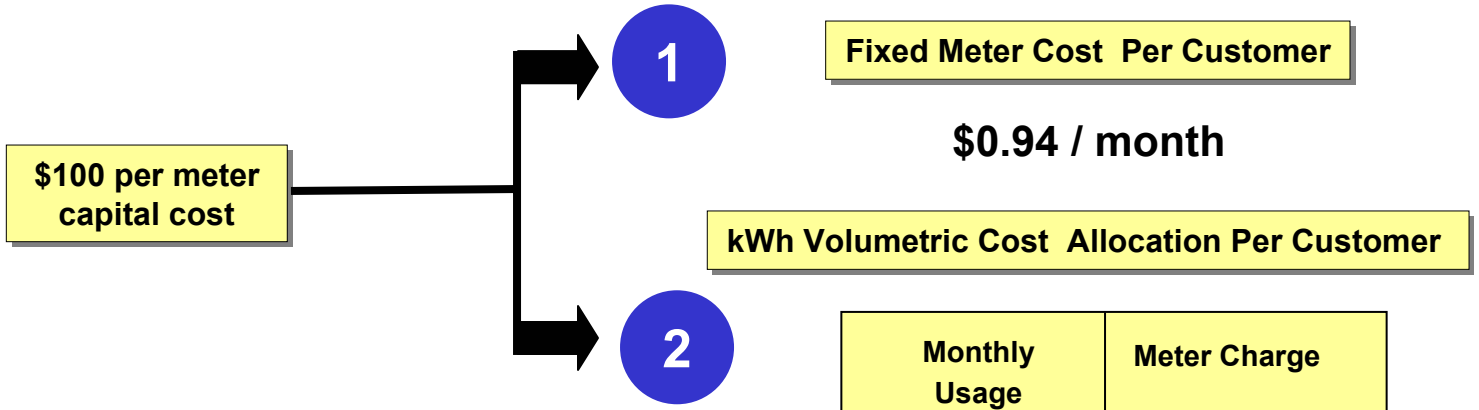


Cost recovery options

PROBLEM Fixed charges disproportionately impact low use customer bills.

SOLUTION Consider a 'volumetric' kWh based cost allocation method.

- Preferred in general as it promotes conservation



Average residential customer

Monthly Usage	Meter Charge
300 kWh	$0.20 per month
500 kWh	$0.33 per month
1,000 kWh	$0.67 per month
1,500 kWh	$1.00 per month

Metering - System Costs versus Cost Allocation

PROBLEM Fixed meter charges disproportionately impact low use customer bills.

SOLUTION Consider a 'volumetric' kWh based cost allocation method.

Total Cost Per Meter / Customer

Residential
$85-$265

1

Fixed Meter Cost Per Customer

$1.05 - $2.25 / month

2

kWh Volumetric Cost Allocation Per Customer

Monthly Usage	Meter Charge
300 kWh	$0.33 per month
500 kWh	$0.56 per month
1,000 kWh	$1.12 per month
1,500 kWh	$1.67 per month

Case Studies

Pennsylvania Power & Light

Idaho Power Company

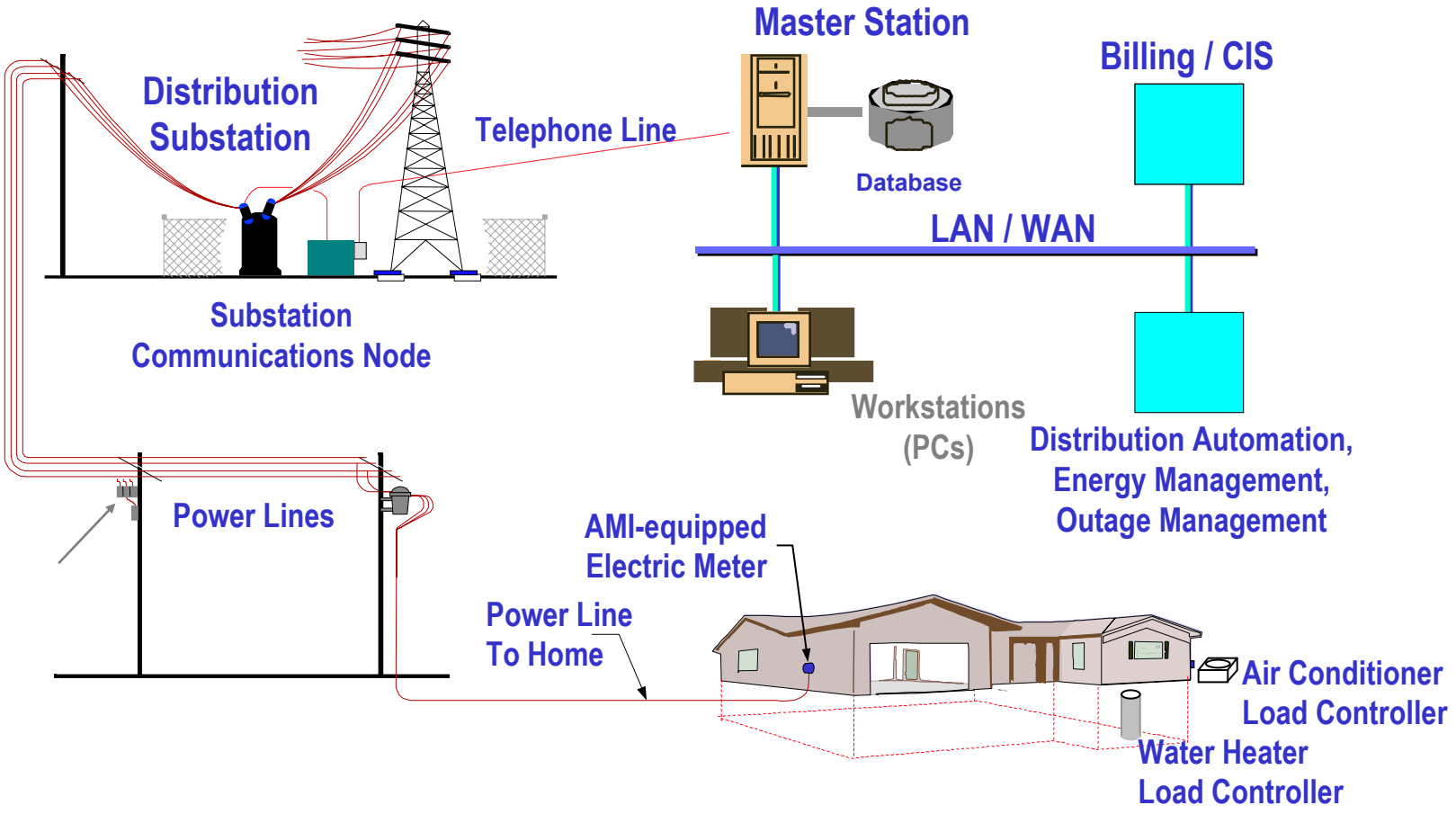
Florida Power & Light

Ward Camp
Vice President
Distribution Control Systems, Inc.

PPL AMI Project

- Goal: reduce utility operating costs and improve customer service
- Scope
  - 1.3 million electric meters
  - Central Pennsylvania
  - Split between urban and rural
- Schedule
  - Began rollout spring 2002
  - Completed installation September 2004 on schedule
- Total capital costs of $160 million
  - $123 per meter
  - More than offset by operating savings

PPL Technology: Distribution Line Carrier



PPL Cost Recovery Filing

- **Justified based on direct operational & maintenance savings**
  - **Remote meter reading**
  - **Fewer customer calls resulting from estimated meter reads**
  - **Shorter phone calls as a result of having better data and having daily data**
  - **Remote collection of move-in/move-out meter reads**
  - **Lower cost to handle high-bill investigations**
  - **Several others**
  - **Other benefits**
    - **Recognized non-economic customer satisfaction benefits (*e.g.* reduced estimated reads, quicker restoration after Hurricane Isabel)**
    - **Believe demand response benefits will occur, but did not attempt to quantify as part of rate case**
- **Utility benefits of $205 million vs. costs of $198 million**
  - **Present-value analysis over 15-year life**
  - **www.pplweb.com/rateinfo/pdf/testimony/Krall/Statement_4.pdf**

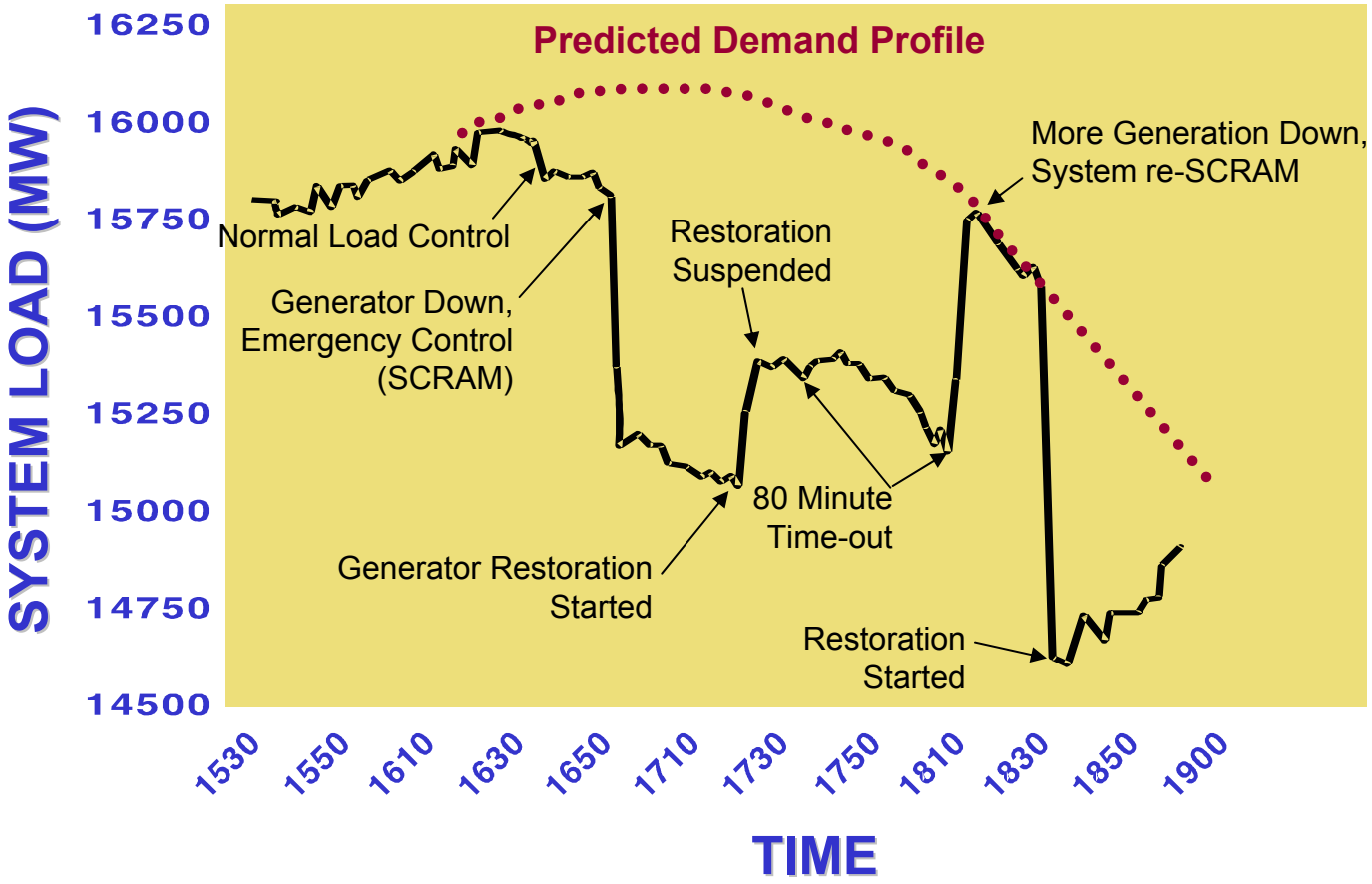
Idaho

- In March 2003, Idaho PUC ruled that dynamic pricing should be made available to all Idaho consumers
- Idaho Power
  - Installing first phase of AMI now
  - Critical peak pricing pilot planned for summer 2005
- Avista
  - Filed a rate case indicating they too, will start implementing AMI

Florida Power & Light (FPL)

- AMI system for both advanced metering and load control
  - Distribution line communications
  - First units installed 1987
  - 710,000 customers
  - 815,000 load control devices
  - Several tens of thousands of AMI meters
- Result is “demand response power plant”
  - 1,000 MW of load reduction in normal operation
  - 2,000 MW in emergency

Emergency Demand Response



Over 975 MW shed in 60 seconds

August 1995

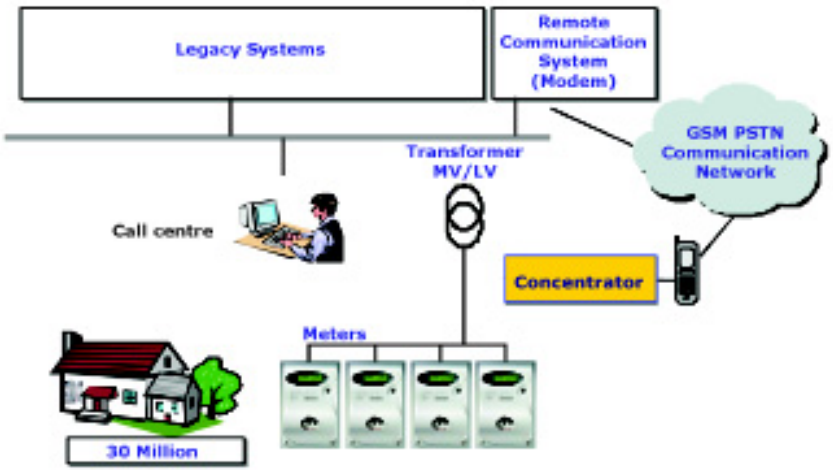
Now over 1,300 MW under control

Demand Response at FPL

- FPL works actively with customer to help them reduce electricity consumption and lower their bills
- Together, FPL's demand response programs total 3,300 MW
  - Over 20% of peak load
- FPL has been able to avoid building ten 400 MW power plants

Italy (ENEL)

- **30 million AMI meters**
  - All customer classes (>90% residential)
  - Approximately 20 million already installed
  - Adding 700,000 per month
- **Key functions**
  - Remote meter reading
  - Pricing and demand response options
  - Remote connect/disconnect for load control
  - Theft detection/anti-tampering functions
  - Customer usage information
  - Prepayment (without card) enabling
  - Conservation voltage reduction
  - Individual customer service quality level monitoring
  - Potential development of value added services for energy market
- **Economics**
  - Four-year payback on utility operating savings



Sweden (Multiple Utilities)

- 2003 legislation mandating AMI deployment to all Swedish power consumers
  - 5.2 million residential, commercial, and industrial customers
  - Installations began 2004
  - Completion by July 1, 2009
- Goals
  - Energy conservation (by providing better, more frequent usage data to consumers)
  - Improved settlement in wholesale power market
- Technologies
  - Combination of wireless and power line carrier communications
  - Typical AMI functionality

Australia (Multiple Utilities)

- July 2004 decision by Victoria Essential Services Commission (Melbourne)
- Conclusions
  - Market forces alone would fail to deliver a timely AMI rollout
  - Regulatory intervention is required to achieve the economic benefits from a more timely and larger scale rollout
  - A net economic benefit would arise to consumers from a timely, mandatory rollout
- Requirements
  - Install AMI on all large businesses by 2008
  - Install AMI on all small businesses and large residential customers (>1,667 kWh/mo) by 2011
  - Install AMI on small residential customers from 2006 to 2013

Canada (Multiple Utilities)

- July 2004 Directive by Ontario Minister of Energy
- Goal: "make more efficient use of the current supply of electricity and to reduce the province's reliance on external sources"
- Requirements
  - Install 800,000 AMI meters by December 2007
  - Install AMI for all Ontario consumers by December 2010
  - Minimum AMI capabilities
    - Record usage during prespecified time periods
    - Support seasonal, time-of-use, critical peak pricing, and other "foreseeable" rate structures
    - Retrieve data from meters remotely at least daily and be capable of providing such data to consumers as feedback
  - Consider additional functions
    - In-home or Web display of usage data
    - Load control
    - Meter reading of gas and water