Advanced Metering Infrastructure and Energy Feedback Options

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KEMA Inc.
AESP Brown Bag Presentation
May 7, 2009

"Smart Grid" Concept – In the News

- Obama asked the Congress "to act without delay" to pass legislation on Smart Grid
  - Goals: doubling alternative energy production in the next three years, building a new electricity Smart Grid
- ARRA contains major investments related to smart grid
  - More than $3.3 billion in smart grid technology development grants, additional $615 million for smart grid storage
    - DOE Smart Grid Investment Package: grants ranging from $500,000 to $20 million for smart grid projects
  - U.S. Commerce Department's National Institute of Standards and Technology (NIST) is developing a three-phase plan to expedite development of key standards for a nationwide Smart Grid

Smart Grid Defined

- **"Smart grid":** delivers electricity from suppliers to consumers using digital technology to save energy, reduce cost and increase reliability
  - Increases connectivity, automation and coordination between grid suppliers and facilitates competition
  - Enables greater use of alternative energy sources
  - Automation and monitoring capabilities for bulk transmission
  - Enables use of market forces to drive energy conservation

Smart Grid and customer participation

- **"Traditional" electric grid** - utilities ensure constant availability of electricity at a constant price, 24/7, in the face of any and all hazards and changing conditions.
- **Smart grid** - incorporates consumer equipment and behavior in grid design, operation, and communication.
  - real-time electricity pricing
  - incentive-based load reduction signals
  - emergency load reduction signals.

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How are Smart Grids related to AMI?

- **AMI ≠ Smart Grid**
- **Advanced Metering Infrastructure (AMI) -** systems that measure, collect and analyze energy usage from advanced meters through communication media
  - Infrastructure includes hardware, software, communications, customer associated systems and meter data management (MDM) software.
  - AMI enables two-way communications with the meter.
- AMI is an important *part* of the the development of smart grids – can be a stepping stone
- Feedback devices used with AMI will become more popular as utilities spend money on smart grid technology

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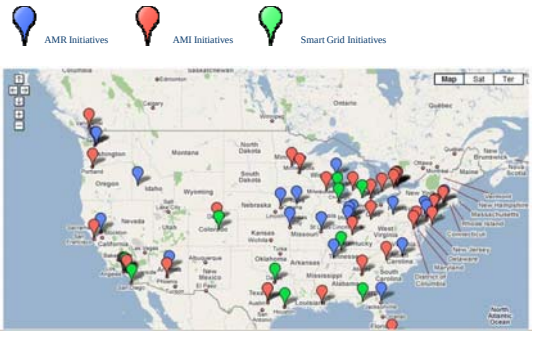

Source: Enernex Smart Meter Data for the California Energy Commission

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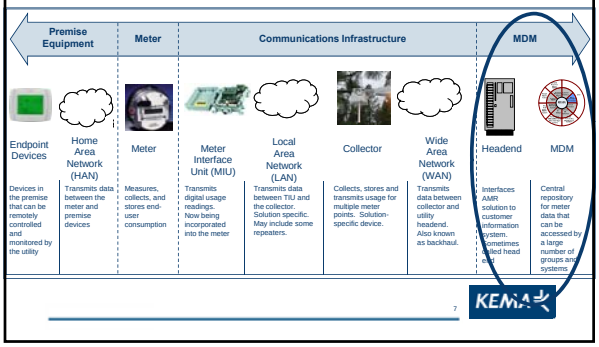
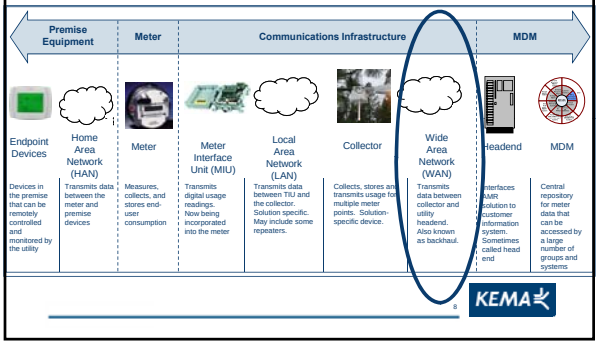
AMI System Overview: Meter Data Management

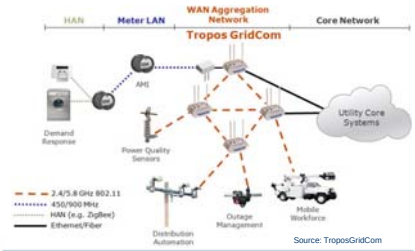


AMI System Overview: Wide Area Network



WAN (Wide Area Network)

- Network covering a broad area – transmits data between LAN/collector and MDM
- Options: Wired, Wireless – Public Carriers



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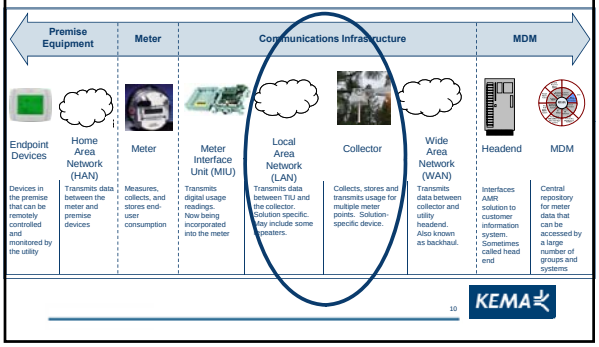
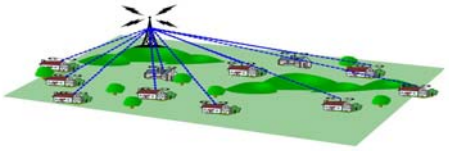
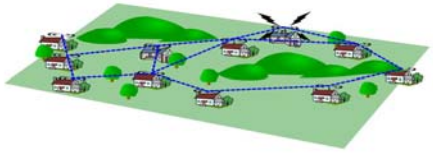
AMI System Overview: Local Area Network, Collectors



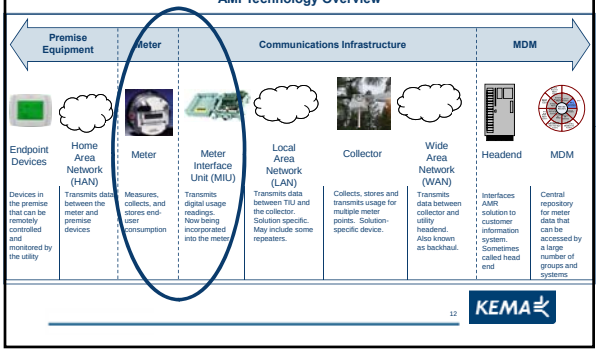
Typical P2P Network



Mesh Network



AMI System Overview: Meter and MIU



Smart Meters

- Electro-mechanical meters have limited functionality
  - Demand, Consumption
- Newer residential solid state meters contain robust monitoring and reporting capabilities:
  - Demand, Consumption by time
  - Bi-directional communications
  - Downloadable configurations
  - Ability be reprogrammed over the air
  - Voltage measurement, Tamper detection
  - Automatic reporting of power outage and restoration
  - Service relay (whole home disconnect), Event record

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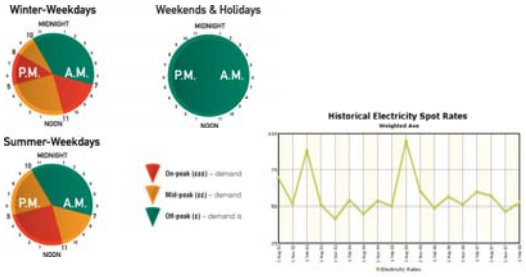
Possible Applications: Time of Use pricing, more detailed utility bills



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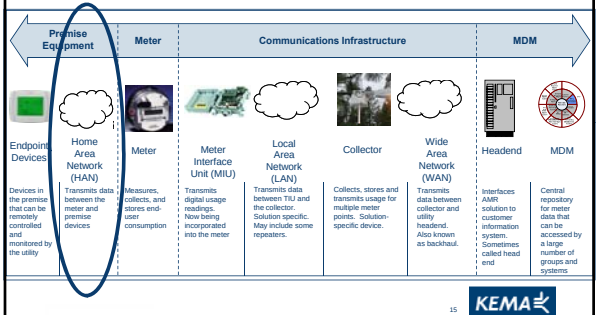
AMI System Overview: HAN



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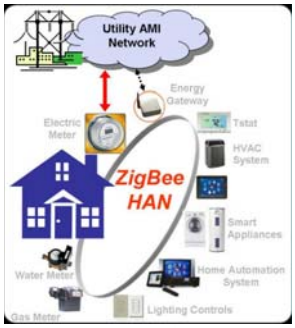
Home Area Networks

- Network within a home, connecting digital devices
  - Wireless:
    - Zigbee
    - Z-Wave
    - Bluetooth
    - All of the above
  - Wired
    - Power-line
      - Broadband
      - Narrowband
- Hybrid systems



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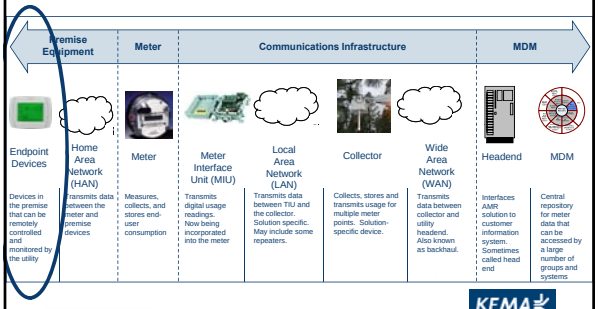
AMI System Overview: Endpoint Devices



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Some common HAN peripheral devices

- Programmable Communicating Thermostats
- Water and Gas Meters
- White Goods
- In home display unit
- Pool Pump
- Water heaters
- Space heaters
- Automation systems

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Leading vendors of PCT's

Comverge
(White Rodgers)

HAI-Omnistat

Carrier

AprilAir

Honeywell

Lightstat

Hunter

Control 4

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White Goods

- Appliances receive a signal from their local utility, will react based on the internal programming.
- Some operation may be delayed from occurring during peak energy usage hours enabling the utility to easily manage peak load conditions.
- User interaction:
  - Consumers benefit from the dynamic pricing by being notified of critical peak pricing on appliance display
  - Appliances will be programmed to avoid peak usage but consumers may choose to override

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In home display Vendors

Vendor	One-way	Two-way	Utility-centric	Customer-centric
Aclara	X	*	X	
Ambient	X			X
Aztech		X	X	
BlueLine	X	*	X	X
Cent.a.meter	X		X	
Comverge		X	X	
Control4	X			X
Echelon		X	X	
Energate		X	X	
Energy Control Systems	X		X	
Honeywell	X		X	
KLG Systel		X		X
Landis+Gyr		X	X	
Sen Vision Energy Technology	X			X
Secure Meters	X		X	
Tendril Networks		X	X	X
The Energy Detective	X		X	

Source: Energy Insights

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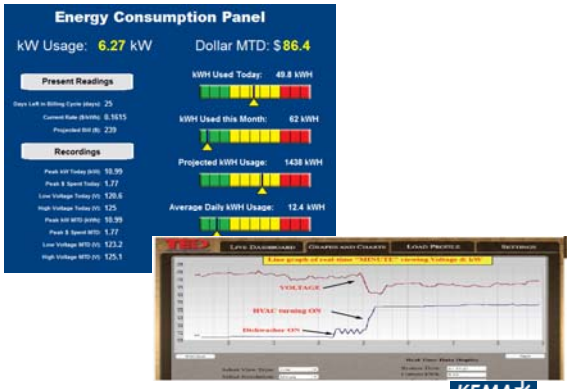

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Whole home automation systems

- Interfacing with the system controller
- Interacting with customer configuration
- System level knowledge and management
- Strategies not under control

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Summary: Feedback Options with AMI and Smart Grid

- Smart electricity meters
  - TOU pricing, advanced billing
- Programmable thermostats
- Water and Gas Meters
- White Goods
- End-use feedback devices
- In home display units
- Automation systems

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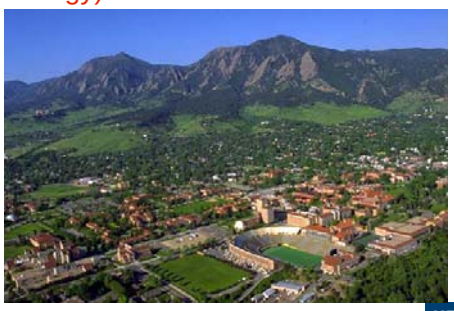
Smart Grid City – Boulder, CO (Xcel Energy)



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Xcel Energy

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Envision Center (Duke Energy, KEMA)

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Thank you for your attention.

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EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Residential Electricity Use Feedback: The Value of Information

AESP Brown Bag Session Presentation

Thursday May 7, 2009

Jennifer Robinson
Sr. Project Engineer/Scientist

Today's Presentation

- Definitions and context
- Feedback delivery mechanisms
- Past research:
  - What makes effective feedback
  - Results and gaps
- Ongoing research:
  - Addressing the gaps, preliminary results
- Going forward

Feedback Defined

- What is feedback:
  - "A process whereby the results of action serve continually to modify further action."

    -- Webster's Pocket Dictionary, 1997

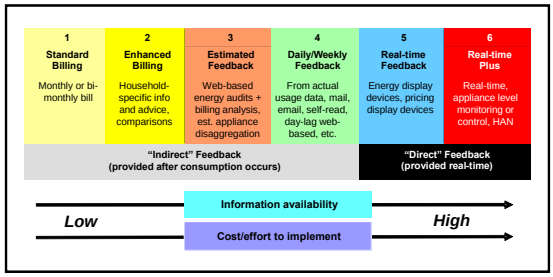
  

  - Household-specific electricity consumption information
- For this presentation: the focus is the information, not the technology

Context

- Why consider feedback, why now?
  - Pressing issues support the need for conservation and efficiency
    - Climate change
    - New power generation requirements
    - Transmission constraints
  - New technologies allow for ease of provision
  - Conservation results

Feedback Delivery Mechanisms



Feedback Body of Research – Past

- Several critical summary analyses:
  - Darby 2001, 2006
  - Fischer, 2007
  - Abrahamse, *et al.*, 2005
- EPRI review, 31 studies

Feedback Body of Research – Past

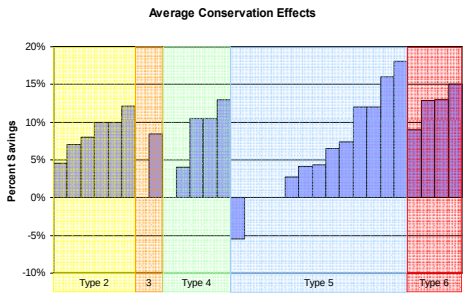
From summary analyses, most effective feedback:

- Provided frequently, as soon after consumption as possible
- Presented clearly and simply
- Customized to the household's specific circumstances
- Provided relative to a meaningful standard of comparison
- Provided over an extended period of time
- Includes appliance-specific consumption breakdown (some studies)
- Interactive (some studies)

Feedback Body of Research - Past

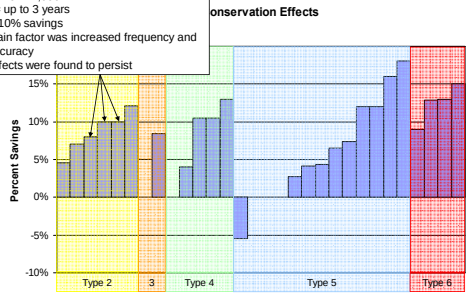
- Summary analyses, average conservation effects wide-ranging:
  - Direct feedback: 5-15% range
  - Indirect feedback: up to 10%
- EPRI review, also wide-ranging:
  - -5.5% to 18%

Feedback Body of Research - Past



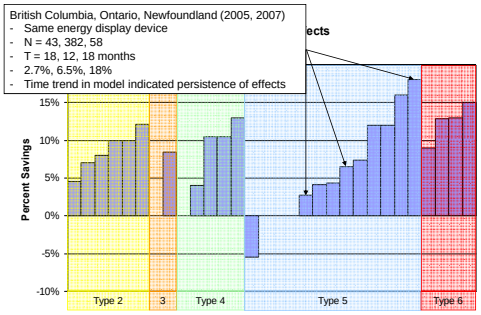
Feedback Body of Research - Past

Scandinavian studies (late 80s to early 90s)
- Enhanced billing
- N = 611-2,000
- t = up to 3 years
- 8-10% savings
- Main factor was increased frequency and accuracy
- Effects were found to persist



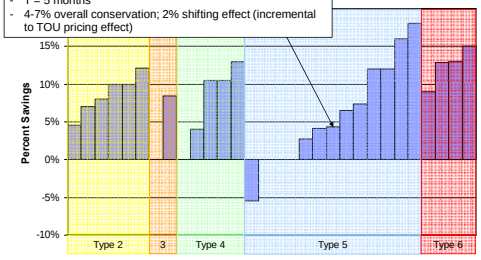
Feedback Body of Research - Past

British Columbia, Ontario, Newfoundland (2005, 2007)
- Same energy display device
- N = 43, 382, 58
- T = 18, 12, 18 months
- 2.7%, 6.5%, 18%
- Time trend in model indicated persistence of effects



Feedback Body of Research - Past

Ontario (2008)
- Same energy display device, in TOU pricing environment
- N = 234 with displays (411 total in treatment groups)
- T = 5 months
- 4-7% overall conservation; 2% shifting effect (incremental to TOU pricing effect)



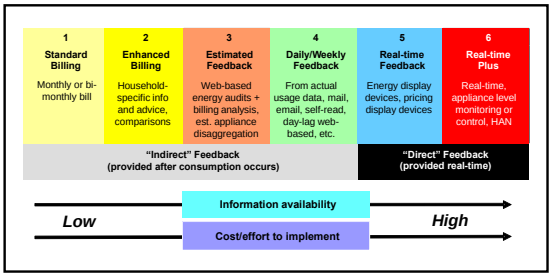
Feedback Body of Research - Past

- Research gaps:
  - Feedback delivery mechanism/type
  - Participation levels
  - Persistence
  - Pricing interactions
  - Demographic distributions



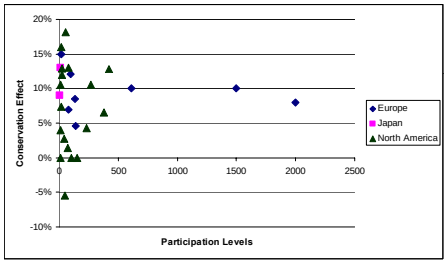


Area 1: Feedback Delivery Mechanism/Type



Area 2: Participation Levels

- Treatment group participation levels vary substantially
- Most were less than 200



Area 3: Persistence of Effects

- Some evidence of persistence
- Mainly involving enhanced billing (type 2) and display devices (type 5)
- Generalizability of the findings to the NA situation?
- Appropriate study length?

Area 4: Feedback and Pricing

- How do the two interact, if at all?
- Relatively new area

	Reference	Feedback Type	Sample Size	Duration (months)	Feedback Effect (Overall Conservation)	Feedback Effect (On-Peak Reduction)
		2				
CA SPP	Elliott, *et al.*, 2006	3	152	4	0%	0%
	Robinson 2007	4	106	3	0%	0%
	Hydro One 2008	5	411	5	4%	Incremental effect of 1.8% over TOU rates
CA SPP	Martinez and Geltz 2005	5	61	2	NA	0%
	Sexton, *et al.*, 1987	5	51	10	-5.5% (increase)	Incremental effect of 1.2% over TOU rates
		6				

Area 5: Demographic Effects

Trait	Evidence From Studies
Age	Greater effect with younger households?
Income	Variation in findings
Education	Greater effect with more highly educated households?
Electricity consumption	Greater effect with higher consumers?

- Some potential variations, but the links are tenuous

Feedback Body of Research – Ongoing

- Ongoing pilot activity
  - Mostly display devices (type 5)

14 Ongoing Utility Pilots	
Baltimore Gas & Electric	NV Energy
Dominion Virginia Power	OFGEM (UK)
Duke Energy	Omaha Public Power District
Energy Trust of Oregon	SaskPower
Focus on Energy Wisconsin	Sacramento Municipal Utility District (SMUD)
Hydro One	TXU
National Grid, NSTAR, W. Mass Electric	We Energies

Ongoing: Baltimore Gas & Electric

- Feedback type: 5
- Pricing display device assessment as part of dynamic pricing and enabling technology pilot
- N = 625 (subset of 1,300 home pilot)
- Duration: Feb '08 – Mar '09
- Results (preliminary, November 2008):
  - 6-7% peak reduction attributable to pricing display device
  - Continuing on this summer, using energy display device as well as pricing display device
  - Commercial

Ongoing: SMUD

- Feedback types: 2, 5
- Monthly/quarterly energy reports (type 2); ongoing display device program (type 5)
- N = 35,000 (type 2); 10,000 (type 5, billing assessment will involve fewer)
- Duration: ~4 years (type 2); 1 year (type 5)
- Results (preliminary, November 2008):
  - Type 2: after ~ 6 months, a 2% savings compared to control

Ongoing: Energy Demand Research Project

- Feedback types: 2, 4, 5
- Wide range of information and feedback provision media
- N = tens of thousands
- Duration: at least two winters and two summers; completed by late 2010/early 2011
- Results (preliminary, for data up to Sept 2008):
  - No statistical sig. effect for billing and display device trials, but still limited winter data
  - Installation issues: battery failure, faulty device problems
  - From various surveys:
    - 66% installed
    - 25% of installed devices still in use after 1 year
    - 50% changed the battery when required
    - 50% use it daily and talk about it to others
    - Customer reaction generally positive

Feedback Body of Research - Ongoing

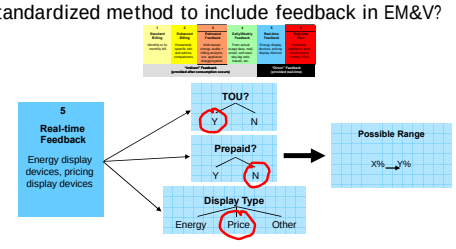
- Feedback type: two large programs (OFGEM and SMUD) are comparing different types of feedback delivery mechanisms
- Participation levels: about half have sample sizes over 500
- Persistence: almost all studies are now at least one year in length to assess persistence
- Fewer pilots are looking at pricing and feedback interaction effects
- Fewer will be able to assess demographic variations of any potential feedback effects

Moving Forward - Research Design

- Research gaps act as barriers to making decisions about what type of feedback and associated delivery systems are cost effective
- Requires research of scope and scale that is beyond the means of any one utility
- A collaborative organized effort:
  - avoid redundancy and focus research on high-value issues
  - use rigorous design principles
  - pool data
  - provide extensible results

Moving Forward - Feedback EM&V

- Behavior-dependent effect: problematic in including feedback in energy efficiency portfolios
- Standardized method to include feedback in EM&V?



Thank You

Together…Shaping the Future of Electricity

We welcome comments and suggestions:
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EPRI (2009). *Residential Electricity Use Feedback: A Research Synthesis and Economic Framework*. EPRI, Palo Alto, CA: 2009. 1016844.
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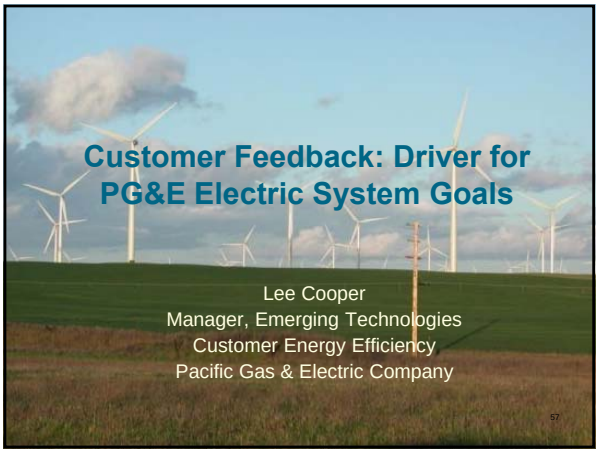

Pacific Gas and Electric Company

- Energy Services to about 15 M People:
  - 5.2 M Electric Customer Accounts
  - 4.8 M Natural Gas Customer Accounts
- 70,000 square miles with diverse topography
- ~20,000 Employees
- Regulated by the California Public Utilities Commission (CPUC)

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PG&E's demand management offerings

Energy Efficiency

Programs
- Energy codes & standards
- Financial incentives & rebates
- Marketing & outreach
- Training & education
- Energy audits
- Evaluation activities

Channels
- Utility programs
- Partnership programs
- Third-party programs

Demand Response

Programs
- Price-responsive
- Automated load management

Sample Program Elements
- Curtailment requirement
- Contract period
- Eligibility
- Curtailment window
- Event trigger
- Notification time
- Incentive payment
- Non-compliance penalties

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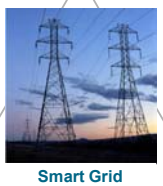
Balancing competing priorities

Reliable Service

Environmental Sustainability

Reasonable Cost



Smart Grid

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Smart Grid will enable a sustainable electric system

Renewable Electric Generation

Efficient Electric Delivery

Managed Electric Demand

The country's largest smart metering program is a foundation

- Automated meter reading for all customers:
  - 10 million meter upgrades
  - Advanced communication networks
  - Robust IT systems
- Frequent meter reads
  - daily for gas
  - hourly or 15 minute intervals for electric
- Enhanced capabilities over time

PG&E SmartMeter

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Provide customers online access to their energy use information

- Displays energy use by billing cycle, month, or week
- Displays hourly electric use by day
- Ability to overlay temperature
- SmartRate customers view usage "framed" by peak periods
- Customer service reps able to view same graphs online

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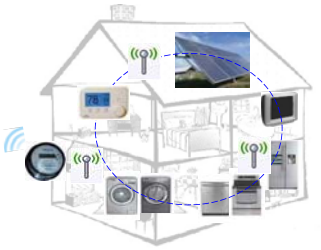
Automated Demand Management



Home Area Network communication

SmartMeter communication

From meter into the home:
- Near real-time electric use
- Time-of-use price
- Appliance / energy management control signals

From meter to utility:
- Customer electric use
- Customer energy generation (e.g. solar)
- Appliance response to energy management control signals

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Home Energy Management

Basic

- Simple high-low indicator

Enhanced

- More comprehensive in-home displays (usage, cost, time)
- Programmable Communicating Thermostat (PCT)

Advanced

- Fully automated intelligent energy management system
- Other automated/ programmable appliances
- Electric vehicle charging / storage
- Distributed generation and storage

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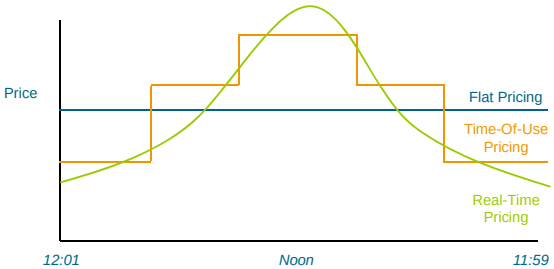
Time-differentiated pricing



Encourage smarter energy use by exposing customers to the real marginal cost of electricity

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Energy Displays – Utility Considerations

- AMI integrated
- Integrated Demand Side Management
- Standards
- Frequency and granularity
- Channel (dedicated, PCT, PC, TV, phone,…)
- Accuracy
- Incentive considerations
  - Cost effectiveness (including installation)
  - Expected useful life

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Energy Displays – Customers

- Segments and profiles
- Residence and business drivers
- Dollars and cents (not kW and kWh)
- Sustainability

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Discussion

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