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Smart Meter-Enabled Demand Response:

Impact, Process, and Technology Assessment

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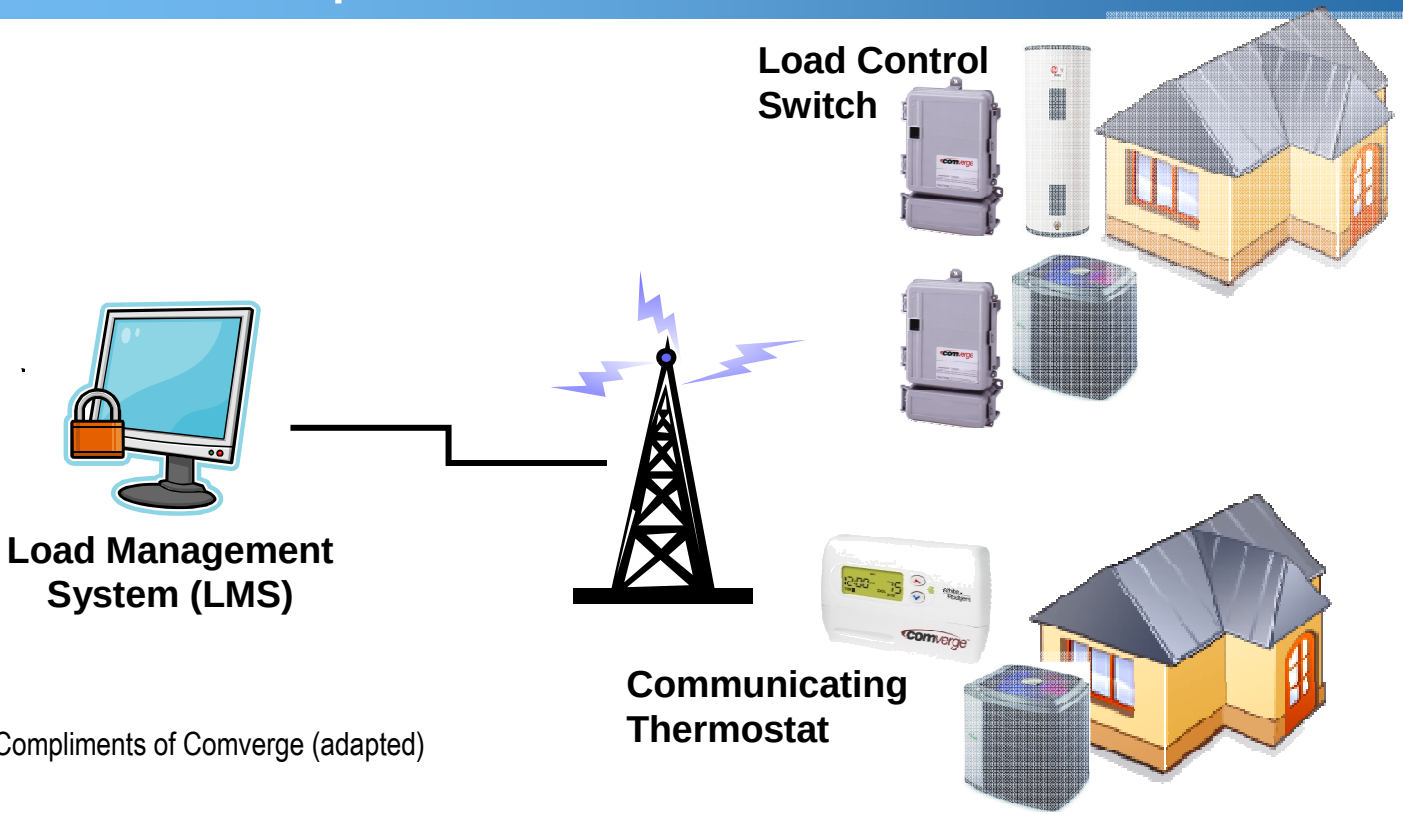
Evaluation of "Un-smart" Residential Demand Response is Well-Established



Compliments of Comverge (adapted)

- Technology and communication is simple
- Evaluation focuses on load reduction from DR events
  - Sample of homes with data loggers to measure loads
  - Regression analysis of event impacts

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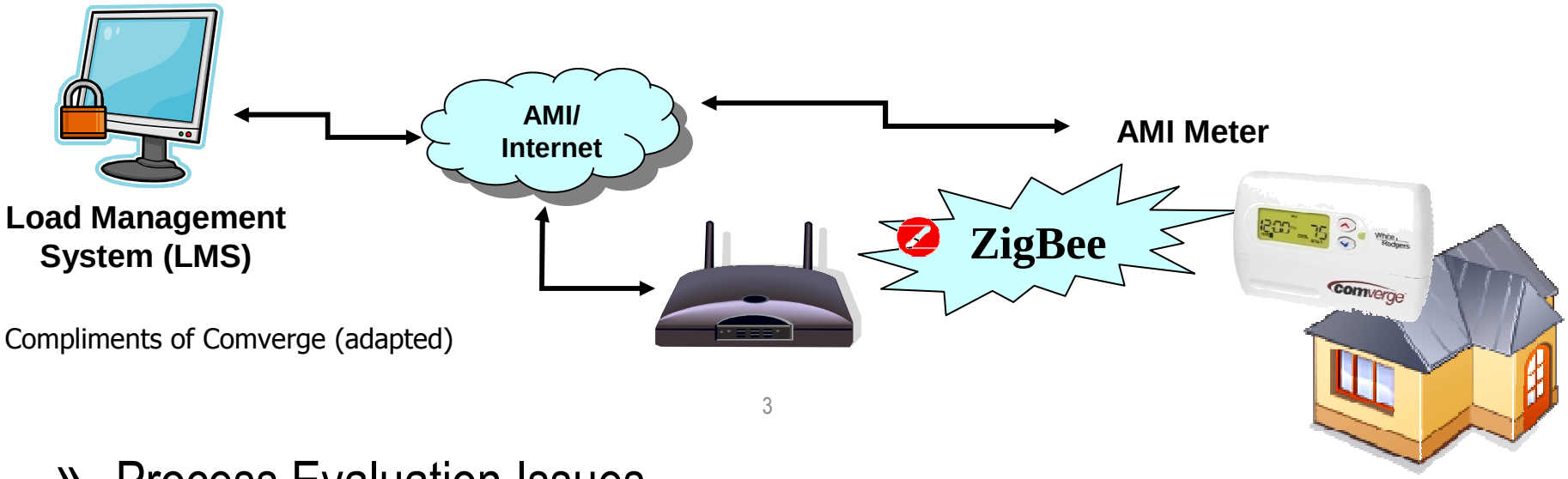
Smart Grid Adds Capability But Also Challenges for Evaluation

AMI/Broadband Combined with HAN (2-way)



Compliments of Comverge (adapted)

- Process Evaluation Issues
  - Customer use of new information and capabilities
  - Customer interaction with technology
- New Technology Issues
  - Accuracy and speed of customer information
  - Reliability of communications

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NSTAR'S Smart Grid Pilot: AMR-Based Dynamic Pricing

- Functionality:
  - AC load control
  - Dynamic pricing
  - Usage/cost information via internet and in-home display
- Communications:
  - Zigbee HAN between meter, thermostat, & in-home display
  - Customers' broadband connections customer ←→utility
- "Soft Launch" in August 2010 with 300 customers
- Full enrollment of ~3,000 participants in 2012

U.S. DOE Smart Grid Demonstration Project – Goal:

Prove viability of using AMR, HAN, and broadband —instead of full AMI— to enable dynamic pricing and other "smart" functionality

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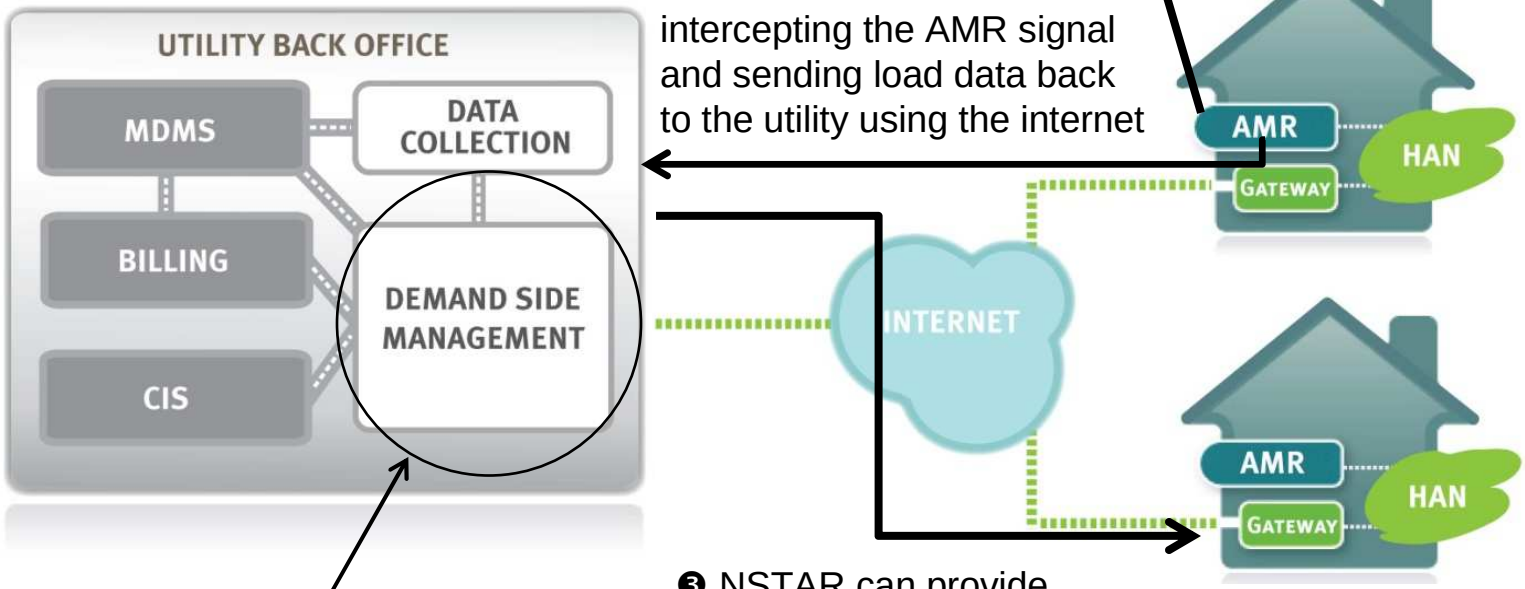
Provision of In-Home Technologies

All Participant Groups			Load Control
Internet Gateway / HAN	**In Home Display**	**Access to Web Portal**	**Programmable Thermostat**
			
•Home Area Network (HAN) to enable two-way communication between the customer and NSTAR	•Zigbee device •Real-time power demand •Billing period electricity consumption & cost •Price of electricity	•View and manage household energy consumption online •Receive messages from NSTAR Electric •Analyze historical usage patterns	•Up to 4 programmable set points per day •Controllable over the Internet via the Web Portal •Critical Event management and control

Smart Grid Communications Architecture

❶ Existing AMR meters allow “drive-by” meter reads

❷ NSTAR is now intercepting the AMR signal and sending load data back to the utility using the internet



❸ NSTAR can provide organized billing information back to the customer

❹ DR events can also be called via broadband; and evaluated with the available customer data

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Customer Access to Usage and Bill Information

Monthly bill

Weekly comparison

Usage to date

Daily Energy Consumption

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Experimental Design

	Group	Smart Thermostat / Direct Load Control	Central Air Conditioning	Group Size
1	TOU Rate plus Critical Peak Pricing (CPP)		~50% with CAC	700
2		☑		700
3	Critical Peak Rebate	☑		700
4	Information-only		~50% with CAC	770
	Total			2,870

Designed to measure impact of:

Information Rates

Thermostats AC ownership

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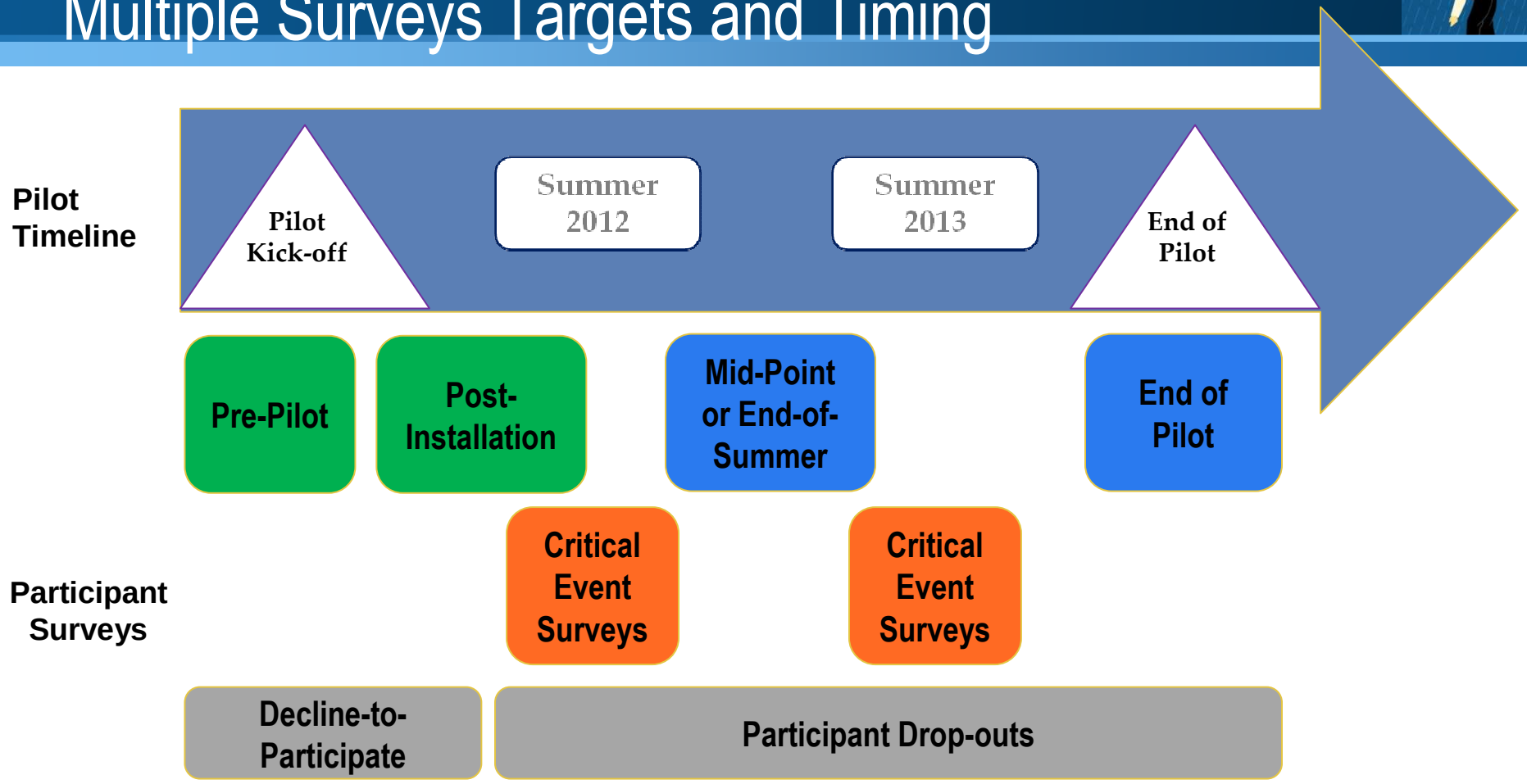
Impact Evaluation – Control Group is the Key

» Use of **regression analysis** to estimate baseline usage
  › Analysis compares measured load to the baseline
  › Baseline estimate depends on what type of impact is being measured

Type of Impacts		Required Control Group
Annual, seasonal, and monthly impacts	➔	Monthly bill customers
Peak load and time-of-day impacts	➔	Existing interval-metered load research sample
Impacts of load control and CPP events	➔	Participants' own interval data

Process Evaluation – Multiple Surveys Targets and Timing



- Pre- and post-pilot
- Why didn't customers want to participate? Or continue participating?
- DR events – get to the customer right away

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Technology Assessment – Key Objectives

Objectives are to assess:

Functionality **Reliability** **Customer Acceptance**

» Assessment addresses
- › HAN message success and failure rates
- › End-to-end communications success
- › Impact on signal success of building characteristics and equip. configurations
- › Need for HAN signal repeaters
- › Issues with broadband configuration or reliability
- › Need for equipment replacement

» Onsite data collection
- › Home characteristics
- › Equipment locations
- › Broadband service provider
- › Air conditioner characteristics

Technology Assessment – Validation of Functionality

System Feature Comparison		
Description	**AMI with HAN**	**Pilot Architecture with HAN**
Interval Data	☑	☑
Customer Information	☑	☑
Direct Load Control	☑	☑
Temperature Setbacks	☑	☑
Remote Upgrades	☑	☑
Revenue Protection	☑	?
Net Metering	☑	☑
Meter Diagnostics	☑	☑
Remote Disconnect	☑	
Automated Outage Reporting	☑	?

Sound Evaluation Approach Is Needed for Assessment of New "Smart" Technologies and Programs

Impacts - Adjust control group for the type of load impacts desired

Process - Multiple customer survey types and timing

Technology – Added dimension

If pilot architecture and program design prove effective…

»Better understanding of impacts from dynamic rates and information access for customers

»Proof-of-concept for leveraging existing AMR meters to provide much of the functionality of expensive AMI infrastructure

Questions?

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