Residential Water Heater Load Controller

EPRI Smart Grid Advisory Meeting
Red Bank, New Jersey

June 24, 2009

Residential Two-way Water Heater Load Control Pilot

Purpose

- Demonstrate a two-way water heater load control system
- Shift peak load minimizing customer impact
- Capture operational data and usage profiles to support Measurement & Verification

Project participants

- Bristol Essential Services (BTES) including BTES selected water heater program customers
- Carina Technology, Inc. (Communications, AMI, and controls development)
- EPRI (Project analysis and evaluation)
- TVA (Project development and management)

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PROJECT BACKGROUND

- Residential electric water heating in TVA service area
  - Represents significant percentage of TVA's load
  - Approximately a 70% market share
- Typical electric water heaters
  - Incorporates an insulated storage tank
  - Relatively small (4.5 kW) heating element
- BTES has a very successful water heater program
  - Customer friendly…install, warranty, service calls, financing
  - More than 14,000 load managed water heaters
  - Existing utility load control is unidirectional
  - No confirmation signal is received at water heater
  - Water heater may or may not be energized when controlled
  - Utility experiences "rebound" at end of control period

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PROJECT DESCRIPTION

- Communications
  - Utilize BTES infrastructure (FTTH)
  - Gateway device communicates with water heater switch (currently using Zigbee protocols)
- Intelligent 2-way water heater interface/control switch
  - Validates control signal is received at the water heater
  - Monitors water heater operational status…is the customer running out of hot water?
  - Normal operation allows "override of load control function" to prevent hot water "run-out"
  - Delayed return to service at end of the control period
- Evaluation of benefits and value
  - Verify more recent newer water heater usage profiles
  - Identify load reduction for various demographic groups

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Project Objectives

1. Validate statistically valid levels of peak shedding that can occur reliably
2. Determine predictable data patterns
3. Provide measurements of actual water heater tank operating temperatures
4. Identify optimum load control algorithms to achieve the maximum possible load shift
5. Shift water heating load off-peak

Residential Water Heater Controller Development – Project Phases

- Phase I - Alpha version controller – 25 units
- Phase II - Beta 1.0 units – 250 units
  - gather demographic and baseline "comfort" data, develop a plan to test Load Control Schemes, analyzing preliminary data
- Phase III – Beta 2.0 units - testing of 5000 units
  - develop seasonal data and baseline data
  - validate actual peak shifting,
  - fine tune Load Control Schemes for various demographic user groups
  - obtain third-party analysis and validation,

Residential Water Heater Controller Development – Communications System

WISE – Water heater Information Solution for Energy

Key Requirements

- Capture data in 15 minute intervals
- Characterize usage patterns by water heater type, usage, temperature drop, etc
- Utilize dynamic algorithms to enable self-awareness and sustainability of system
- Categorize common usage groups (weekday, weekend, holiday).
- Two-way communication with inside customer display unit.
- Future applications easily add-on.
- Capacity to deliver additional applications and services through a common portal.

EPRI Analysis Background

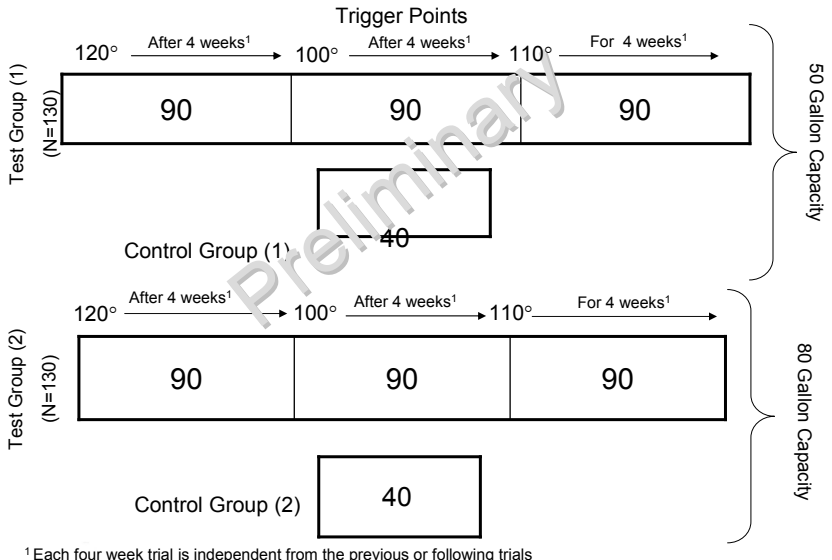
- BTES is implementing an ongoing water heater load control program whereby they will provide the water heater for a nominal charge to electric customers that allow BTES to control the usage during periods of high cost.
- BTES installs the water heaters available in either 50 or 80 gallon sizes and are high efficiency models. Customer is responsible for maintenance although maintenance packages are available.
- Carina Technologies has developed a control board that will allow BTES to curtail load for a set duration until the water temperature drops to a trigger point at which time the heating elements would come ON. The curtailment signals and all data collection functions travel through BTES' broadband system. All households will have this connection.
- The intent of this study is to determine what types of control strategies could be developed that would allow BTES to reduce their peak demands without sacrificing comfort for their customers
- Specifically this study is intended to test changes in hot water consumption (energy use) and whether participants notice any inconvenience

EPRI Analysis
Sample Design Frame – Key Items

- BTES has 14,000 customers on its water heater control program, of which 5,000 have a meter collar which enabled the home for broadband and the Carina load control
- Phase I which has been completed, tested 25 control units to verify the technology and has proved successful
- Phase II provides for the installation of 250 Carina WISE (water-heater information system for energy) units to modify the usage and to collect load data.
- Phase III upon the successful completion of Phase II will an additional install 5,000 system-wide
- Water heaters are available in either 50 or 80 gallon sizes and the sample is intended to be geographically and demographically diverse
- Sample Design to use cross-sectional control and test group versus "pre/post" method
- Migrating sample site data between control and test groups and between temperature trigger points was considered

The following sample design was proposed:

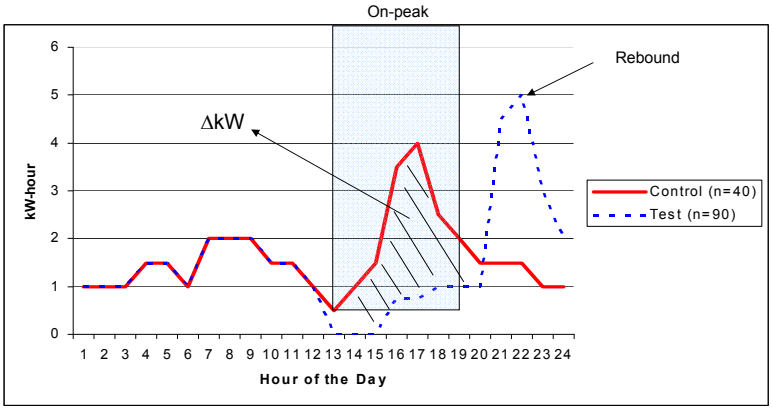
Sample Design Frame :
Specifics Sample Size n=260)
(Active twelve week test)



[1] Each four week trial is independent from the previous or following trials

Sample Design: Water Heater Load Shape Impacts

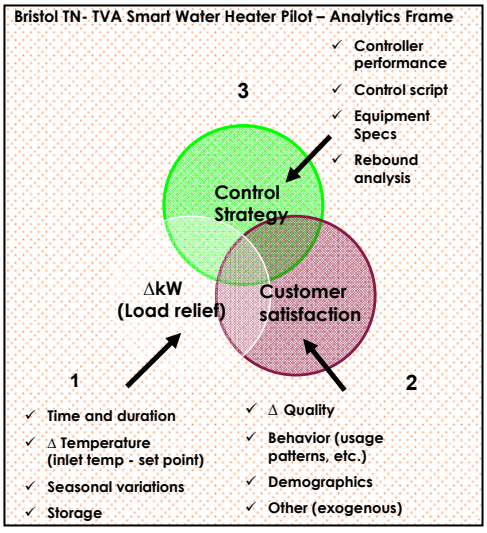
Example BTES Typical Week (50 Gal. @ 110 ° control)



Data collection : Scope

Cross-sectional data -

1. Change in electric consumption (Δ kW)
2. Customer satisfaction and demographics
3. Equipment (water heater) specs



Data Collection and Analysis Tasks

Data Collection

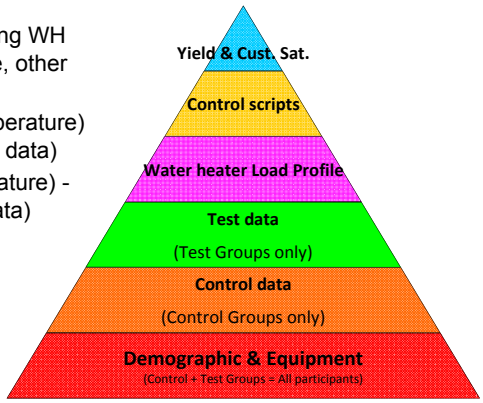
- Demographic and existing WH specs - Behavior, usage, other predictors
- Control data (kWh, temperature) - Uncontrolled (baseline data)
- Test data (kWh, temperature) - Controlled (treatment data)

Modeling

- Aggregate load profile
- Mathematical model
- Scripts

Results

- Yield (Δ kW during peak)
- Customer satisfaction



Project Deliverables

1. Data analysis of load, voltage, and water heater loading patterns
2. Data analysis to determine recovery time in water heater loading and cycling
3. Average water temperature drop per 15 minute intervals and average temperature rise for different customer demographics
4. Customer aggregated patterns into groups with similar usage profiles to analyze and develop optimum control algorithms

Residential Water Heater Control Switch Development

Questions?

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