Anatomy of a Demonstration Pilot: Smart Grid Appliances Case Study

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The Project

- Reducing residential load through bundled small “background” actions
  - 2-year comparative field test in Glasgow, KY
  - “intelligent” appliances - GE Profile® line ENERGY STAR® Appliances enabled with Brillion® technology
  - 20 Test sites, 10 Control sites

- Objectives
  - Quantify baseline of residential appliances
  - Quantify energy & demand impact of bundled high-efficiency appliance retrofit
  - Measure demand response and load shifting capability
  - Observe ability & willingness of homeowners to allow 3rd party control
  - Assess customer behavior change and acceptance relative to the perceived benefits

- Challenges
  - Small participant pool
  - Selection bias
  - Lots of experiment possibilities – hard to narrow down to satisfy all partners
The Project Team
GE Energy Management & Demand Response Appliances

Utility companies that have implemented time-of-use pricing communicate their daily rate schedules to the home.

GE’s Demand Response Appliances react, saving money while lowering peak demand and the need for more power generation.

 Optionally, the GE Home Energy Manager correlates rates with user-preferences to balance cost, comfort, and convenience.

Home Energy Manager
This energy brain works in conjunction with you and your home to help understand and optimize energy use.

Refrigerator
This Profile refrigerator can reduce energy use on demand and delay defrosts to inexpensive rate periods.

Range & Microwave
Cooking energy is reduced and with dual cavities, the range can preference the smaller upper oven.

Dishwasher
The dishwasher is aware of expensive rate periods and can wait to run when energy costs are lower.

Laundry Pair
When high rates arise, this laundry pair will save you money while getting your clothes clean and dry.

Hybrid Water Heater
The water heater can switch to heat-pump mode and modify temperature settings during high rates.
The Brains of the Operation

Nucleus energy manager plugs into any standard electrical outlet, and is designed to wirelessly gather power usage information from the smart meter, thermostat, and from “Brillion” enabled appliances.
Human Interaction
Engaging Participants through Social Media
Project Facebook Page

- Includes utility, GE, consumers, researchers
- Communication alerts from project sponsors
…for troubleshooting with participants
Just a quick update on the Thanksgiving feast. I did not cook a Turkey, I was told to cook each person a mini turkey. So I got 18 Turkey's and ran them through the shrink cycle in the new dryer and that worked great. Next I brined the mini turkey's in the briner drawer of the new fridge, I used 1 cup of salt 1 cup of brown sugar and a couple of handfuls of rosemary out of the garden to a gallon of water, let the mini turkeys brine in this for 12 hours. Took them out and ran them through the rinse cycle of the dishwasher. A little Lowery's salt and pepper mix. Into the oven with the probe set for 180 degrees, when the internal temp. was 180 I turned the oven to broil for 5 min., just to brown. Do not attempt this at home, I am a professional and was using special modified GE appliances.
…for confessions

Glasgow EPB TVA/GE
Project
October 1 via mobile
near Glasgow, KY

Well... We had a good run going, but I finally had to override today... We were down to 1 diaper!!
Thanks to everyone in the project (and a lot of other customers in Glasgow), just look at how we were able to manage our peak this morning! Though the 20 homes in the project were not the whole story, this does give you all a realistic example of why we think it so important for appliance manufacturers to work with utilities to enable us to actively manage our load. The ability to flatten peaks and fill in valleys of a community's electrical demand is one of the most promising technologies that we hope will allow us to reduce the amount of new generation capacity needed. If successful, the understanding of this capacity may yield lower electric rates for all. Thanks for being a part of this research!
The Study – One Year In
<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3a</th>
<th>Phase 3b</th>
<th>Phase 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installed metering devices</td>
<td>Installed GE smart appliance bundle</td>
<td>Initiated test parameters</td>
<td>Altered test parameters</td>
<td>In process - will alter test</td>
</tr>
<tr>
<td>Monitored energy use of existing appliances</td>
<td>Monitored baseline energy use of appliance bundle</td>
<td>Pricing signals for 4 hours during peak event period of 2 p.m. to 6 p.m. on weekdays</td>
<td>Pricing signals shifted to 6 hours during peak event of 6 a.m. and 12 p.m. on weekdays</td>
<td>parameters over 11 month period</td>
</tr>
<tr>
<td>Established baseline profile of each home</td>
<td>Quantified efficiency gains</td>
<td>Remotely applied low-energy mode during event periods</td>
<td>Remotely applied low-energy mode during event periods</td>
<td>Seasonal pricing signals from phases 3 and 3.5</td>
</tr>
<tr>
<td>3 month duration</td>
<td>3 month duration</td>
<td>$1 per day incentive provided for not overriding low-energy settings during event</td>
<td>$1 per day incentive provided for not overriding low-energy settings during event</td>
<td>Enact Critical Peak Pricing events</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 month duration</td>
<td>Conducted in-home evaluations</td>
<td>Enact HVAC control</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4 month duration</td>
<td>Remotely apply low-energy mode during peak event periods</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Incentive adjustments</td>
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Phase One – Establish the Baseline

- Instrumentation and monitoring Test and Control sites
- Installation of the End-Use Meters on select appliances as well as collection of inside and outside temperatures. The purpose is to create baseline results for comparison against performance in subsequent phases.
Anatomy

Smart Appliance System

Measurement and Validation System

- Grid Operator Interface
- Automated Energy Web Client
- Wireless Router
- AcquSuite Data Server
- Breaker Box
- WattNodes
- GE Nucleus
- Refrigerator
- Range
- Dishwasher
- Washer/Dryer
- Water Heater

MODEBUS Network Devices and Software
- Current Transformers

KEMA

16
This customer tends to use his appliances late at night, along with other plug loads, leading us to believe this family tend to be “night owls”.
This customer tends to be much more similar to a typical residential customer where the appliances tend to be used in the morning and evening hours.
Phase Two – Quantity Efficiency Gains

Phase 1 Usage by Appliance

Phase 2 Usage by Appliance

48% reduction in usage
**Individual Appliance Efficiency Gains**

- Heat pump water heater 70%
- Refrigeration 33%
- Dryer 9%
- Range 8%
- Clothes Washer 5%
- Dishwasher -5%
Electric Water Heater Performance

Dramatic drop & stabilizing daily use

Significant reduction in peak demand
**Refrigerators**

![Graphs showing demand for refrigerators across different phases.](image)
Phase 3 – Response to Pricing Signals

- Nucleus reacts to utility high-price-period signal by signaling all appliances to shift into a low-energy mode

- Event parameters
  - 10¢/kWh base rate, 20¢/kWh peak period rate
  - Call period for phase 3a: 2p.m. – 6p.m.; phase 3b: 6a.m. to Noon

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Low Energy Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dishwasher</td>
<td>Dry cycle disabled</td>
</tr>
<tr>
<td>Clothes Washer</td>
<td>Cold water only</td>
</tr>
<tr>
<td>Dryer</td>
<td>Cycle runs in reduced heat mode – one of two heating elements de-activated</td>
</tr>
<tr>
<td>Heat Pump Water Heater</td>
<td>Set point lowered to 110° F; HP-only mode activated, upper resistance element de-activated</td>
</tr>
<tr>
<td>Refrigerator</td>
<td>Freezer set point raised, features disabled include: TurboCool/Quick Chill/Quick Defrost/Quick Freeze/Quick Ice</td>
</tr>
<tr>
<td>Range</td>
<td>Lower oven prevented from starting, outer broil elements disabled on upper oven, preheating slowed, burners reduced to ~80% power, self-clean mode disabled</td>
</tr>
</tbody>
</table>
Phase 2 versus Phase 3: Full Appliance Bundle

Average Hourly Weekday Comparison: Phase 2 vs Phase 3
Appliance: Total Appliance Bundle    Analysis Type: Demand

Average Hourly Weekday Comparison: Phase 2 vs Phase 3.5
Appliance: Total Appliance Bundle    Analysis Type: Demand
Energy Footprint

- We see the impact in the energy footprint → participants allowed 3rd party control 97% of the time over 30 week period
- 3% opt-out: #1 appliance overridden? #2?
Phase 4 – Activating Thermostats

- In process now, continues for 11-months
- Builds on Phase 3 by adding thermostat control
- Will they be as willing to allow temperature fluctuations?
- Looking at persistence
  - Maintain 3% opt-out rate?
  - Participant fatigue?
GE & other appliance manufacturers are moving away from utility control for grid stabilization and energy optimization and toward consumers for convinces enabled through smartphone apps.
Thank-You!

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