STATE OF NEW YORK
PUBLIC SERVICE COMMISSION

Proceeding on Motion of the Commission in regard to Reforming the Energy Vision	CASE 14-M-0101

COMMENTS OF ENERGYHUB AND ALARM.COM
ADDRESSING "TRACK 1" POLICY ISSUES

1. INTRODUCTION

EnergyHub[1] respectfully submits these comments in regards to the Commission's April 25, 2014, Order Instituting Rulemaking, *Proceeding on Motion of the Commission in regard to Reforming the Energy Vision* ("OIR"). EnergyHub, a division of Alarm.com, is a longtime leader in enabling rapid deployment of demand response and energy efficiency programs. EnergyHub provides technology solutions that help consumers and utilities understand and control how energy is being used and identify opportunities for savings. EnergyHub intends to continue to innovate and develop service offerings that will provide demand response products in the future. Therefore, EnergyHub is keenly interested in the proposals set forth in this proceeding and looks forward to participating in these important deliberations.

2. GENERAL REMARKS

EnergyHub has been active in markets around the country as a demand response aggregator. These activities include participating in the Texas ERCOT market for

[1] In 2013, Alarm.com (www.alarm.com) completed the acquisition of EnergyHub (www.energyhub.com). Alarm.com provides a suite of connected home services, including substantial solutions for interactive energy management. Today, these combined companies have more than 2 million subscribers nationwide, with a substantial portion that have internet-connected thermostats.

several years and, more recently, as a party to California's "Order Instituting Rulemaking To Enhance the Role of Demand Response in Meeting the State's Resource Planning Needs and Operational Requirements".[2] Additionally, EnergyHub is an active partner in many utility-administered demand response programs. All of these activities afford EnergyHub a breadth of experience that can help inform the discussions in this proceeding and bring benefits to energy customers in the State of New York.

EnergyHub supports the Staff's vision of modernizing the distribution system to create a flexible platform for new energy products and services. We advocate for service providers and demand response aggregators to have greater access to the market. EnergyHub believes that residential load aggregators may be disadvantaged under the traditional system, which is in place in most states. The current system offers utility administered programs and transmission programs as the only channel for aggregator participation. EnergyHub supports the creation of market mechanisms through which aggregators can provide services directly to consumers and participate in new markets to be created under the proposed DSPP model.

As we have stated previously, by participating in this proceeding, EnergyHub will consistently return to this guiding principle:

> *Consumer-deployed technologies are a valuable energy management resource that provide economic benefits, resource adequacy needs and support statewide policy objectives. These technologies should be encouraged to participate in New York energy markets through both regulated programs and open market mechanisms*.

3. <u>TRACK 1 POLICY QUESTIONS</u>

While we recognize that the Commission and Staff have outlined a wide-ranging set of policy and implementation questions, we focus our remarks on the most salient topics raised by those questions where EnergyHub and Alarm.com may provide a unique perspective based on our activities in both utility and consumer market channels.

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[2] Rulemaking 13-09-011

II. Optimal Ownership Structures for Distributed Energy Resources (DER)

Comment: Competitive processes will stimulate innovation and market animation.

With regard to the optimal ownership of DER's, we understand and recognize the desire to stimulate market activity and the development of DER resources as quickly as possible. From that point of view, we acknowledge that there may be opportunities to develop DER resources (including generation, storage demand response or energy efficiency) where utility involvement and ownership create advantages. However, we would highlight an observation contained in the staff report that, "Competitive processes are more likely to stimulate innovation in DER products for consumers." We believe this is true and should not be ignored. As a result *if* utility involvement in the ownership and development of DERs is allowed or encouraged, that involvement should be viewed as a transition strategy only and *in no way* limit the ability of independent non-utility entities to engage in similar activities. Preferably, such involvement should be distinguished from the core responsibilities and operations of the DSPP, perhaps by establishing a separate utility enterprise that is allowed or encouraged to develop these resources, but can be distinguished from the regulated entity of the DSPP. The primary objective of this proceeding is to stimulate market-based activity and any utility involvement should not diminish that goal.

Comment: Consumers can and will continue to purchase DER systems and DER capabilities through consumer channels. These resources should be leveraged to support REV objectives.

As has been noted repeatedly throughout this proceeding by the Commission, staff and parties, the technology landscape is changing rapidly for consumers. During the August 10 Technical Workshop, the Consumer Engagement Committee presentations noted that, "Consumers may not be particularly interested in their energy use *per se* … but they currently are purchasing energy efficiency and load control capabilities embedded within home security, entertainment and connected lifestyle solutions."

There are opportunities to leverage those capabilities to achieve the "market animation" goals within REV. Specifically, we highlight two opportunities to establish near-term transition programs that will serve to both develop a strong energy efficiency and demand response resource and take advantage of consumer-owned technologies.

First, the Commission and staff should consider establishing "bring-your-own-thermostat" mechanisms for residential demand response. Under such programs, internet-enabled thermostats are able to participate in demand response events, facilitated by third-party aggregators, and benefit from existing rates and incentives. These initiatives are active or being considered in California, Texas and Maryland. This is only one example of how consumer technology can be leverage to support REV goals, but as it is a proven, currently active model, we believe that staff should include a provision of this sort in the upcoming Straw Proposal.

Second, thermostats and other home devices can be actively managed by consumers and service providers to offer dynamic energy efficiency savings. These energy savings are in addition to the generally passive savings that accompany programmable thermostats. We have attached a white paper on the "WeatherBug Home Optimization Program Pilot" that describes an approach that generates demand response benefits in addition to energy efficiency. As an immediate transition strategy, we believe that the staff should address in the Straw Proposal a mechanism for these energy savings to be recognized and monetized, perhaps through a "standard offer" for market-based energy efficiency.

We believe that there are tremendous opportunities to leverage consumer-owned technologies to achieve REV objectives. As a result, when considering the question of DER ownership, we encourage the Commission and staff to affirmatively address opportunities to leverage consumer market channels *before* and *in preference to* models that involve utility ownership of DERs. To the extent that utility ownership is promoted, we encourage the Commission to ensure that such ownership or market participation does not create an undue competitive advantage that diminishes the opportunity to foster innovation in consumer markets.

Comment: The DSPP should establish expedited processes for interconnection of preferred DERs on a localized basis.

As we discuss below, specific information that reveals the operational profile of the local grid should be available. Where the operational profiles of DERs can meet operational needs, expedited processes should be established to accelerate the development and deployment of DERs where they can provide the highest value. Expedited processes such as these can significantly increase financing for preferred technologies. For example, California has established a mechanism through their Renewable Auction Mechanism maps that identify criteria for "fast track" eligibility.[3]

III. DSPP Identity

Comment: "Grid operations" should be distinguished from "market operations"

The Staff Report raises the question, "Could the market management function alone be separated for performance by an independent entity?" We believe the answer is yes. Further, we believe that within the specified roles and activities of the proposed DSPP, the functions related to "grid operations" should be clearly distinguished and separated from "market operations." While it is true that these functions are interrelated, there is great value in unbundling the physical operations of the distribution grid from the market activities related to procuring needed resources and services. This is similar to the way that unbundling of these operations underlies the design of Regional Transmission Authorities and Independent System Operators in bulk power markets.

The Staff Report highlighted tariff structure and product innovation as

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[3] For more information about this process, please see the CPUC website at http://www.cpuc.ca.gov/PUC/energy/Renewables/hot/Renewable+Auction+Mechanism.htm

barriers to effective aggregation of consumers, which suggests that if the DSPP is going to be a platform provider, then it must be designed to engage with other platforms in this non-utility channel. Tariffs designed at not only the customer level but also the aggregator level will more effectively allow whole neighborhoods of homes with intelligent thermostats to provide demand response services, for example.

We believe that the procurement of needed resources (whether by tariff, auction or other arrangement) should support, but be distinguished from, the functions of grid operations, load balancing and other system functions. The Staff Report notes that, "In taking on the role of DSPP, the distribution utility expands its function from being a physical conduit for delivery of electricity, to also being a transactional platform for a distribution-level market. The relationship between utilities and regulators has long been shaped by the fact that physical delivery of electricity across a service territory has been a natural monopoly. The introduction of widespread distributed resources can be perceived as challenging the natural monopoly model of utilities. But even if the sources of power are distributed, the need for a single entity to be responsible for reliability of the overall system remains. The REV vision does not eliminate the natural monopoly of the distribution system operator; rather the locus of the natural monopoly is shifted from sheer physical delivery to management of a complex system of inputs and outputs while maintaining reliability."

We believe that these observations support the conclusion *physical* operations of the DSPP (including "identify, plan, design, construct, operate, and maintain the needed modifications to existing distribution facilities to allow wide deployment of distributed energy resources") can be functionally separated from the *market* operations of the DSPP, including procurement of basic services. From this point of view, it is certainly possible and perhaps advantageous to have market management functions performed by an entity that is independent of the DSPP. We propose that the upcoming Straw Proposal include market design wherein grid operations and market operations are distinct and possibly managed by parties that are independent of one another.

V. Transition for Clean Energy Programs

Comment: Established "parallel" consumer market opportunities to enhance and complement regulated programs.

The success of the existing clean energy and energy efficiency programs in New York should be accelerated and complemented with consumer market opportunities. Specifically, we believe that mechanisms in the market can be established in parallel to regulated programs. For example, a "standard offer" for energy efficiency could establish a fixed incentive for verified energy savings that would allow and support product and service innovation *in addition to* the energy savings achieved by regulated programs. We encourage the staff to address this proposed mechanism in the upcoming Straw Proposal.

As an initial market accelerator, utilities can be encouraged to manage incentive programs targeted to increase deployment of DERs with preferred operational characteristics. For example, consumer devices (such as internet-connected thermostats) can be an effective technology to promote both energy efficiency and demand response resources. Incentives funds to deploy and operate consumer devices such as these can quickly advance a preferred resource. California recently approved similar incentives for behind-the-meter generation technologies including wind, fuel cells and energy storage. [4]

VII. Access to Data

Comment: Consumer data access is a foundational element of consumer market innovation.

This proceeding has identified many times that consumer access to their usage, cost and account information is a foundational element of driving energy efficiency, demand response and innovation of other product offerings. We strongly support the comments of other parties (notably the Mission:data coalition) that

[4] See http://www.greentechmedia.com/articles/read/California-Approves-415M-For-Behind-the-Meter-Storage-Fuel-Cells-Wind-an

promote the principle that data access must be established.

Comment: Advanced meter functionality is a foundational element of consumer market innovation.

We recognize that advanced meter functionality is a subject of discussion within this proceeding. It is our observation that nearly every jurisdiction across the country that has considered advanced meter deployment has determined that it is cost-effective and a valuable component of modernizing the electricity grid. We believe the market animation goals outlined in this proceeding support a similar conclusion for New York. We acknowledge that the implementation details may vary from utility to utility, based on existing technologies, the demographics of the customer base and the operating characteristics of the distribution grid. However, there are certain functions, critical to a successful market, that appear to benefit enormously from the wide-scale deployment of advanced meters and supporting communications networks. These functions include monitoring and verification of demand response events, system-wide voltage management, communication with customers, and other system operations. At a minimum, there must be some mechanisms that support private investments in advanced meters for DER applications wherein the system benefits are adequately valued and provided to consumers or third parties making those investments. We propose that the Straw Proposal include analysis of wide-scale deployment of advanced meters to support market animation and as a core element of utility service.

Comment: Basic utility service should include a federated system to provide customer account information.

Multiple parties (including EnergyHub, Alarm.com and retail providers) have noted that establishing systems that facilitate consumer access to their account information will address a major barrier to customer enrollment in programs and market activities. It has been noted repeatedly that drop-put rates of up to 90% are comment at the stage of program enrollment when customers are required to manually retrieve their account information from a printed bill. The impact of this seemingly small barrier is dramatic and suggests that the effectiveness of both regulated programs and consumer market activity could be increased significantly. We proposed that the Straw Proposal include a mechanism by which the DSPP maintains an authorized and federated process to automate the access to consumer account information to facilitate market activity.

VIII. Other Issues

There are several matters of policy that we believe will be vital in order to successfully achieve REV goals of market animation that are worthy of addressing in more detail here. We hope that the upcoming Straw Proposal will include some consideration of how these elements of a successful distribution-level market should be designed.

Specifically, we would call out the need for the Commission to determine:

(1) How to provide appropriate feeder-level profile information about the distribution system; and,

(2) How to ensure platform-to-platform functionality (as distinct from platform-to-consumer).

Comment: Utilities should provide localized information on system operational profiles

It is intuitive and well established in this proceeding that the electric grid has operational characteristics that vary by both location and by time. Feeder-level and circuit-level information must be made available to support market activities, system planning and public policy goals.

This information should be specific enough to ensure targeted and localized development of DERs. A taxonomy of feeder profiles has been established by the Pacific Northwest National Laboratories and may serve as a useful guide for New

York State. A summary that describes this taxonomy is available in the report "Distribution Taxonomy Final Report" (PNNL-18035).[5]

California is deliberately moving forward with distribution system planning requirements that may serve as a useful model. Following the passage of legislation (AB 327), utilities are currently working with commission staff to outline processes that will provide access to operational data for qualified parties and market participants. The California PUC anticipates a forthcoming proceeding that will address the implementation of AB 327 and requirements for utilities to engage in distribution system planning.[6]

This kind of detailed system information is vital to system planning and to advancing public policy goals. Already, in advance of specific commission actions, efforts are underway to develop information tools that can identify system constraints in order to help policy makers and the market support the development of distributed energy resources.[7]

Comment: Both tariff structure and platform functionality should anticipate transactions with aggregators and market-based technology platforms.

At this point, we highlight a vision offered by the Commission in the initiating order:

> "Under this vision, the utility functions as a Distributed System Platform Provider (DSPP), actively managing and coordinating distributed resources and providing a market in which customers are able to optimize their priorities while providing, and being compensated for, system benefits."

With this vision in mind, we would highlight that there are many existing barriers to the vision of a "marketplace" in which customers have access to a variety

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5 This report is available at the following link: http://www.gridlabd.org/models/feeders/taxonomy_of_prototypical_feeders.pdf

6 More information is available on the California PUC website at the following location: http://www.cpuc.ca.gov/PUC/energy/DistGen/NEMWorkShop04232014.htm. Commission Michael Picker is currently leading this process. Recommended advisor and staff contacts include Audrey Lee and Simon Baker.

7 See, for example, the analysis of energy infrastructure, market pricing, and environmental economics using the SPOOL product. More information is available at keva.la.

of energy services from both utility and non-utility providers. This vision is further emphasized in the Staff Report, where the authors observe:

> "The DSPP will create markets, tariffs, and operational systems to enable behind the meter resource providers to monetize products and services that will provide value to the utility system and thus to all customers. Resources provided could include energy efficiency, predictive demand management, demand response, distributed generation, building management systems, microgrids, and more. This framework will provide customers and resource providers with an improved electricity pricing structure and vibrant market to create new value opportunities. The DSPP will enable the adoption of information technology and real-time information flow among market participants, and establish a platform to support demand-side markets and technology innovation. DSPP products and pricing structures will allow for large scale deployment of clean DER, including energy storage that complements renewables, into the electric system."

Therefore, we conclude that barriers preventing open market access for non-utility players should be vigorously examined and addressed. There is a risk, based on some of the comments we have observed, that a utility- or DSPP-centric model may emerge. For example, where the DSPP delivers products and services for consumers, as opposed to consumers engaging directly with energy service providers in an open market.

In the face of this risk, we believe that it is critical that the Commission emphasize affirmatively, and that the Straw Proposal reflect, that the if the DSPP is going to be a platform provider, then it must be designed to engage with other platforms in this non-utility channel. Tariffs designed at not only the customer level but also the aggregator level will more effectively allow whole neighborhoods of homes with intelligent thermostats to provide demand response services, for example.

This is also true for the technical capabilities of the platform as provided by the DSPP. The Commission should establish directives to ensure the platform is able to interoperate with other commercial platforms. EnergyHub and Alarm.com, for example, operate platforms that can communicate with and manage thermostats and other load-control devices at the customer premise. To ensure effective market animation, the platform capabilities must be designed to facilitate "platform-to-aggregator" communications and transactions as well as "platform-to-consumer" interactions.

4. CONCLUSION

In conclusion, we believe that achieving many of the goals related to "market animation" requires that the Commission address certain fundamental components of the consumer market channel. These include:

(1) *Access to Data*: Consumers must be empowered with access to their own usage, pricing and customer information in order to engage the marketplace;

(2) *System Information*: Feeder-level profile information must be established in order to guide market activities and ensure that DERs are appropriately located and utilized to address system needs and constraints;

(3) *Platform Capabilities*: The DSPP capabilities and functions must be designed to encourage aggregators and consumer product companies to effectively address system needs.

We recognize that the immediate concern of the Commission and staff is to determine effective transition policies and programs that ensure that the environmental and clean energy benefits achieved to date are preserved and enhanced. These transition strategies must also ensure that the existing market continues to provide consumers with affordable, reliable service in the near term. Recognizing these needs, we have proposed at least two strategies that we think can be included within the Commission's plans. These include:

(1) Bring-your-own-thermostat programs that allow consumer-owned technologies to be leveraged for demand response purposes; and,

(2) Standard offer energy efficiency incentives that provide mechanisms that support consumer market innovations which deliver additional energy efficiency and clean energy benefits.

Advanced meter functionality is a fundamental component of operating and delivering services in the animated market proposed by this proceeding. In particular, the effective management of the market transactions proposed and the metrics related to system efficiency proposed would seem to rely on a common technology network of metering and communications. We hope that the Commission will affirmatively pursue advanced metering.

We appreciate the opportunity to provide these comments and look forward to further activities within this proceeding.

Respectfully submitted,

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White Paper

WeatherBug Home Optimization Program Pilot

Energy Efficient Achievement and Calculated Savings

Prepared for CenterPoint Energy and Earth Networks

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1 Executive Summary

Earth Networks, the owner of the WeatherBug weather network, conducted a pilot program in the CenterPoint Energy (CNP) service territory during May-September 2013 to implement the WeatherBug Home Program.[1] The goal of the Pilot was to evaluate and analyze the patent pending WeatherBug Home Thermostat Optimization service on residential customers with two-way communicating thermostats. This report calculates some measure of summer average "deemed energy savings" per ft^2, identifies lessons learned, and provides recommendations to improve future performance.

For the pilot, customers were recruited from a population of consumers who had the thermostat already installed in their homes. From this group there were 217 consumers in the group whose thermostats were optimized, and 142 consumers in the group whose thermostats were not optimized. The goal of the WeatherBug Home Optimization in the Pilot was to minimize the amount of energy used to maintain occupant comfort. The participants in this Pilot participated in the program in a passive manner with few opt-outs or inquiries to Earth Networks about the Program. To solicit enrollment, one email offer was sent to the target group. No financial incentive was given for participation in the Pilot.

The pilot was conducted during May-September 2013, and data was collected to assess the Pilot's impacts. It was found that optimized houses saved 5.24% of whole house electricity per ft over the Control Group. Of this, 3.85% was directly attributable to the WeatherBug Home Optimization. These energy efficiency (EE) savings were achieved without sacrificing comfort for participants. Figure 1.1 summarizes these results. In particular, using Earth Networks personalized house optimization based on their proprietary weather data; the Pilot demonstrated significantly higher savings over competing solutions that use general behavioral approaches to achieve EE savings.

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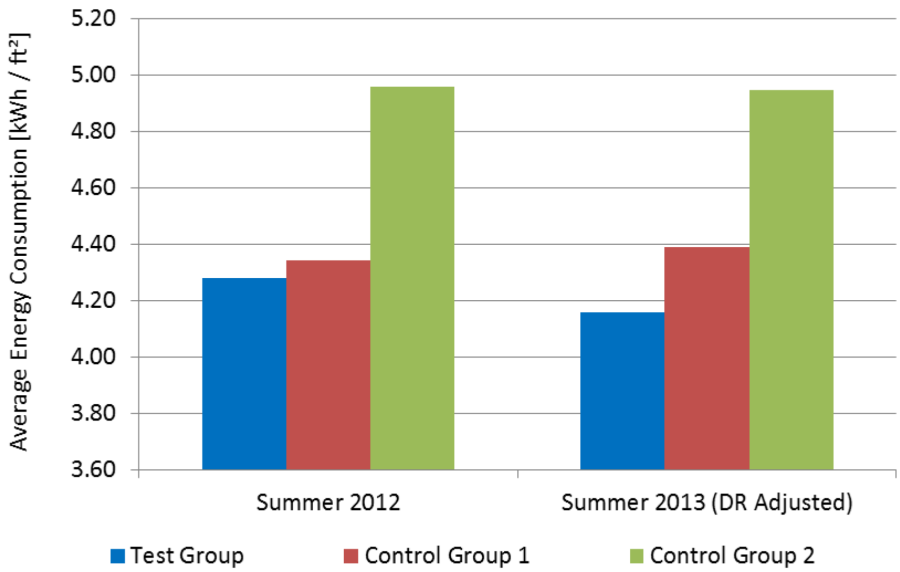
[1] WeatherBug Home was formerly branded as e5. The marketing for the Program began in the last week of March 2012. http://earthnetworks.com/Products/WeatherBugHome.aspx.

Figure 1.1: WeatherBug Home Pilot Program Results Summary



In estimating the above mentioned electricity savings the actual electricity consumption per ft^2 between the WeatherBug Home Optimization Program participants (Test Group) and a Control Group whose members were not engaged in WeatherBug Home Optimization technology. However, to ensure that the calculated electricity savings are not overestimated, a methodology was established to isolate the portion of electricity savings that could come purely from participation in the Program. This methodology allowed us to estimate the minimum impact that could reasonably be attributable to the impact of the Optimization technology.[2]

In addition to energy efficiency, Demand Response (DR) was also part of this Pilot, with the DR capacity obtained through this Pilot participating in the Electric Reliability Council of Texas (ERCOT) Weather Sensitive Load (WSL) pilot. The WSL pilot included many houses outside the CNP territory and used a rotating control group[3]. Due to grid conditions in Texas, the WSL pilot did not call any actual DR events in 2013, but called eight tests events in the summer of 2013. The DR features of WeatherBug Home were fully tested and reported on in a 2012 white paper[4] and further details of the DR aspects of this program can be found in the ERCOT WSL pilot report, when published.

The Pilot provides a valuable set of data for calculating the average energy efficiency savings for a larger scale program. It demonstrates that our method to calculate average energy saving per square foot is appropriate and results in reasonable outcomes. Therefore, it is recommend the estimated hourly average energy savings be considered standard "deemed savings" for the WeatherBug Home Optimization technology.

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[2] See discussion in subsection 5.2, *Estimated Deemed Average Electricity Savings*, for more details on the methodology.

[3] ERCOT WSL DR Pilot: http://www.ercot.com/mktrules/pilots/wsers/. The WSL Pilot report is expected to be published in December 2013.

[4] Pionergy Consulting (2012). *e5 Demand-Response Program Pilot: DR Results and Calculated Peak Demand Savings*, Prepared for Earth Networks, September, Austin, Texas.

Finally, the WeatherBug Home Program Pilot provided a unique opportunity to explore the value and acceptance of this new technology. In fact, the Pilot showed customers willingness to participate in the Optimization Program.

Several key observations were identified and lessons learned including:

1. While occupant comfort temperatures and schedules are generally consistent, the optimum thermostat schedule to achieve the optimum balance between comfort and efficiency varies daily and the primary source of this variability is the weather.
2. Detailed interval data - from thermostats, smart meters, and weather stations –are needed to refine thermostat control for energy efficiency and load management with little impact on the consumer.
3. Solar insolence is a critical parameter to include when modeling the HVAC energy consumption, and internal temperatures of a house.
4. WeatherBug Home Optimization lowered the peak load of participating houses on average, a particularly important point for service areas in need of more capacity during peak hours when the most expensive generation units are in operation.
5. WeatherBug Home Optimization was used to minimize the amount of energy used to maintain occupant comfort. Alternatively, WeatherBug Home Optimization could be implemented to minimize cost in a variable energy price or Peak Time Rebate (PTR) without compromising comfort.
6. While one brand of thermostat was used in this Pilot, WeatherBug Home Optimization techniques can work on any two-way communicating thermostat currently on the market.
7. Optimization allows participants to save energy without actively controlling their thermostat or responding to generic behavioral messages to save energy by raising thermostat setpoints or adjusting thermostat schedules.
8. There is potential to achieve more EE savings by sending additional customized recommendations to participants using the results from WeatherBug Home's detailed analytics. The WeatherBug Home ScoreCard (Appendix 1) is one mechanism to graphically demonstrate techniques to the consumers for their individual house that result in further EE savings.

2 Introduction

The demand for electricity is growing in the Electric Reliability Council of Texas (ERCOT) region and in every regulated utility service area in Texas, at a much faster rate than most of states in the United States. Given a high growth in demand for electricity, ERCOT is facing significant capacity shortage projected in the near future. Texas Legislators and the Public Utility Commission of Texas (PUCT) have recognized the importance of strategies that result in reduction in residential energy consumption. Specifically, in 2010 the PUCT approved Substantive Rule § 25.181 calling for 25% of load growth in 2012 in the state to be offset through energy efficiency programs. The law further requires the utilities to offset more than 30% of load growth in the coming years.[5]

In response to legislative mandates and regulatory rules, Texas Investor Owned Utilities, including CenterPoint Energy, have been pursuing energy efficiency strategies for many years. To test the effectiveness of the WeatherBug Home technology in obtaining energy efficiency savings, Earth Networks conducted the WeatherBug Home Program Pilot during summer 2013 where a limited number of customers were selected and offered thermostat optimization tools. Digital (email) marketing was used to attract participants, and after the fact analysis and evaluation were performed to measure the impacts. The Pilot was used as a unique opportunity to evaluate this new technology and determine the savings potential, as well as design a program that can be implemented by various utilities statewide.

2.1 *WeatherBug Home Program Pilot*

The WeatherBug Home Energy Efficiency Program (EE Program) offers energy efficiency tools to residential electricity customers through a thermostat setpoint optimization feature. This feature, Test Group Optimization, intelligently adjusts the customer's thermostat setpoint schedule to minimize daily heating, ventilation, and air conditioning (HVAC) energy consumption without sacrificing comfort. This technology uses real-time data from smart meters, connected thermostats, and hyper-local weather stations to perform advanced analytics on a residential structure. Optimization enabled customer thermostat setpoint adjustment using three mechanisms: Smart Setback, Setpoint Smoothing, and Precooling (or preheating).[6]

- **Smart Setback** gives customers the ability to set what temperature they want it to be at a particular time, as opposed to just the setpoint. For example, customers can indicate that they are arriving at home around 6:00 p.m. and desire to have 76 °F temperature at home.
- **Setpoint Smoothing** shaves off HVAC cycling before a setback period, based on the individual house and HVAC equipment. Using this technique, Earth Networks starts a more efficient setback period earlier if it will not result in more than 2 °F higher temperatures.
- **Precooling** takes advantage of higher efficiency operating conditions. For example, Earth Networks decreases home temperature by a few degrees in the early afternoon to cool the air, allowing the need for less electricity to manage peak load time in the late afternoon when electricity is produced at the highest costs.[7] This technique was not used in this pilot due to thermostat limitations; specifically this technique requires

[5] Texas Senate Bill 7 and PUCT Subst. Rule 25.181: http://www.texasefficiency.com/index.php/about/energy-efficiency-rule.

[6] More details on these optimization mechanisms are provided under Subsection 3.2.

[7] Further explanation of the optimization mechanisms can be found in section 4.3 of Siemann, M. (2013), "Performance and application of residential building energy grey-box models", Ph.D. Dissertation, University of Maryland, http://drum.lib.umd.edu/handle/1903/14299.

the use of more than four setpoints, which was not available in the thermostats used in the Pilot.

The application of these particular mechanisms towards determining the optimized schedule each day depends on the house's thermodynamic model and local weather forecast. Each mechanism is only implemented if the model determines that it will be effective in lowering the energy consumption for that day. Therefore, the analysis is not necessarily a reflection of the mechanism themselves, but rather the WeatherBug Home intelligence of when to apply them.

These three mechanisms are selected due to their effectiveness to save energy under different circumstances. For example, Smart Setback is the best when the weather is inconsistent. In contrast, Setpoint Smoothing is selected when enough of the load is completely removed and not shifted to the least efficient afternoon on hot days. However, WeatherBug Home intelligence recommends Precooling when weather has consistently remained hot and is expected to peak up during normal peak hours. It is important to note that applying the correct mechanism during the correct conditions is critical to achieving EE savings. Simply applying these mechanisms everyday does not yield consistent EE savings because each of these techniques can result in negative EE savings in certain weather conditions on certain houses.

To initiate the WeatherBug Home Program Pilot, Earth Networks engaged with CenterPoint Energy in the spring of 2012 for a WeatherBug Home DR Pilot, then again in 2013 to enter into a Research and Development (R&D) Pilot of the WeatherBug Home EE technology. Residential customers within the CNP service territory, who met certain requirements on building type and size, were qualified to participate.

2.2 *Customer Communication and Selection*

Customers within the CNP service territory, who are living in single family (residential households) premises of any size and condos/townhouses with a minimum of 1,880 ft^2, were qualified to participate in the Pilot. As a result, any single-family, residential customer who signed-up for the WeatherBug Home service, and had installed the appropriate thermostat equipment was included in the Pilot.[8]

In general, participants in the 2013 Pilot were people who participated in the 2012 CenterPoint DR pilot, and who continued to have the necessary equipment (two-way communicating thermostats) active in their home. A few new participants were added by promoting the Program via digital channels to customers who had the participating thermostat and who lived in competitive areas of the ERCOT footprint, including the CenterPoint service territory. Earth Networks and its partner, EnergyHub, used various methods to inform potential participants about the Pilot, including the following:

[8] These thermostats were originally made available to participants during the 2012 DR pilot from the Earth Networks online WeatherBug Home store, other online retailers, or could be bought in local retail stores and installed by the customer.

- Email marketing to consumers in the CenterPoint Energy service territory, who had the necessary thermostat equipment installed in their house and connected to the interactive thermostat control web portal hosted by EnergyHub.
- Consumers were offered the ability to Optimize their 2-way thermostat in addition to getting an energy use ScoreCard report

Excluded from the Pilot were people who lived in multi-tenant properties smaller than 1,880 ft^2, and commercial structures. In the future the Earth Networks' models will be modified to include these customers.

2.3 *Pilot Objectives*

The electric industry, operating within the Electric Reliability Council of Texas region, has gone through significant restructuring in the last twelve years. In particular, the customer side has seen drastic changes through the introduction of retail choice and recent implementation of advanced metering infrastructure (smart meters), which are now installed at all residential properties. Smart meters enhance the potential for customer participation in energy efficiency programs. Access to detailed interval electric use data available from advanced meters allow utilities to test new technologies, such as the WeatherBug Home technology.

The goal of the Pilot is to evaluate and analyze WeatherBug Home's Optimization service on residential customers with two-way thermostats. The Pilot includes evaluation of the WeatherBug Home technology and business model. In particular, an attempt is made to identify lessons learned, provide recommendations to improve future performance, and calculate some measure of summer average "deemed energy savings" per ft^2. Such deemed savings will be requested from the PUCT, to be applied for each new participant who will engage in this program when it is offered to all qualified customers.

3 Pilot Participation

3.1 *Participants*

Customers have access to their communicating thermostat through either web portal or mobile application. Participating customers were provided assurance that their energy use data would be used for this program through secure methods, and agreed upon through the Terms of Use and Privacy Policy for the WeatherBug Home Program.[9] In addition, to be optimized, customers had to activate the Optimization feature in either their Radio Thermostat web portal or mobile application.[10] Figure 3.1 is a screen shot of the web portal with Optimization enabled and Figure 3.2 is taken from the mobile app.

[9] See information provided at: http://www.earthnetworks.com/e5/e5termsandconditions.aspx .
[10] Thermostat portal access is only available to consumers with participating thermostats. In the portals the Optimization feature was branded as SmartShift.

Figure 3.1: Radio Thermostat Web Portal Thermostat View Highlighting the Optimization Feature Enabled

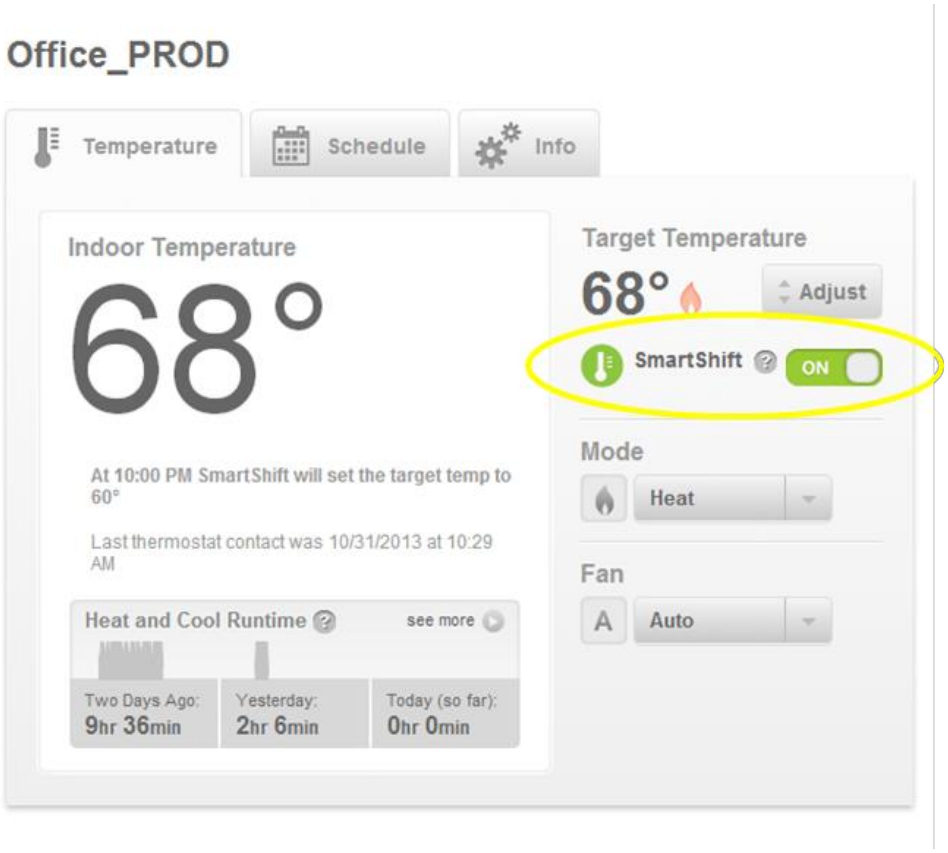
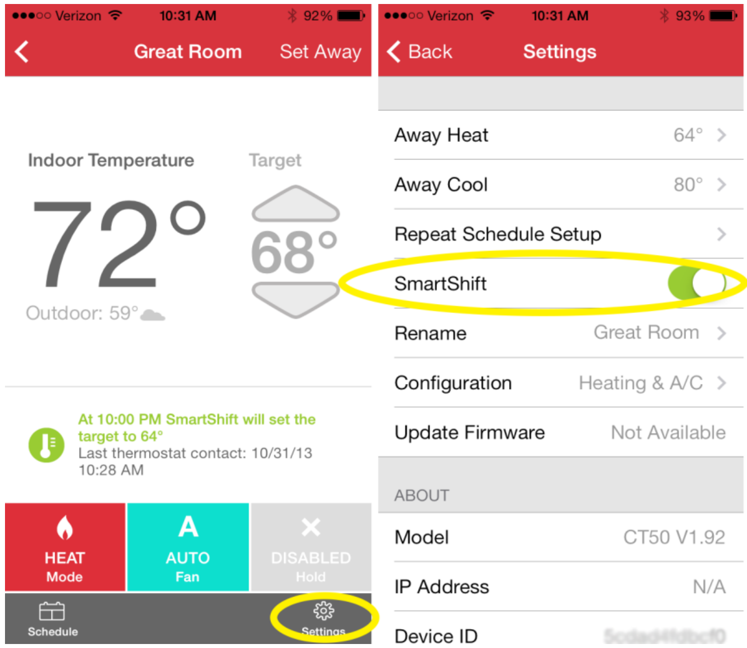


Figure 3.2: Radio Thermostat Mobile Application Thermostat View Highlighting the Optimization Feature Enabled



To enable or disable Optimization service, the customer has to click (or touch) the green button to the right of the word "Optimization" to toggle the functionality on/off. In addition, placing the thermostat on hold turned off the Optimization service, and Pilot participants had to toggle the Optimization service back on to re-engage the Optimization service. Customers could enable/disable this feature at any time, but their thermostat setpoints would not be optimized unless the feature was enabled the previous day. There was no ramification for toggling the functionality off, other than the cessation of Optimization service.

Throughout the Pilot period, participants were not required to take any other action to receive the thermostat setpoint Optimization. If at some point during the Pilot they over-rode their thermostat schedule by putting the thermostat on hold, they were required to re-enable Optimization via the thermostat portal or mobile app to continue to receive optimized schedules.

If Optimization was not turned on at 2:00am Central Time, the participant's thermostat would not receive an optimized schedule for the following day.

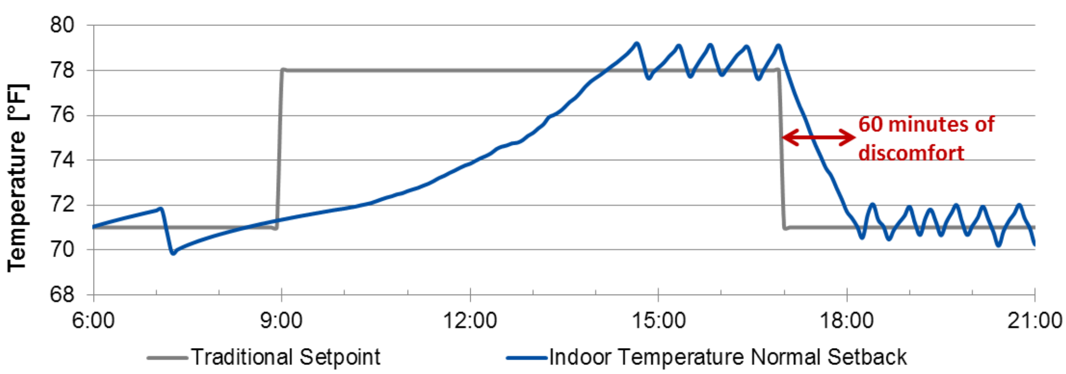
The marketing approach taken by Earth Networks resulted in about 359 participants with about 217 activating the Optimization feature for some period of time for the Pilot in the CenterPoint Energy service area. The Earth Networks' Pilot information reflects the impact of Optimization on early adopters of 2-way thermostats, eager to explore new opportunities, and therefore serve as a representative sample of potential participants for the WeatherBug Home Program in the next few years. Therefore, the Pilot provides valuable set of data for calculating the average summer energy reduction savings for potential participants in the near future.

3.2 *Optimization Mechanisms*

The WeatherBug Home Optimization system improves the energy efficiency of thermostat setpoint schedules through three mechanisms: Smart Setback, Setpoint Smoothing, and Precooling. These three optimization mechanisms, which were among various techniques used by thermostat vendors dealing with cooling and heating activities, were selected due to their EE potential and scalability. Another technique used in the market is actively raising the thermostat setpoints for particular day-part intervals or the entire day. This was not implemented because of Earth Networks commitment to minimize discomfort. A decision was also made not to use techniques that ran the air conditioner fan for a period of time after the air conditioner condenser had shut off because this technique does not result in significant savings in most instances, and the Application Programming Interface (API) interface with the participating thermostats did not offer an ability to execute such commands.

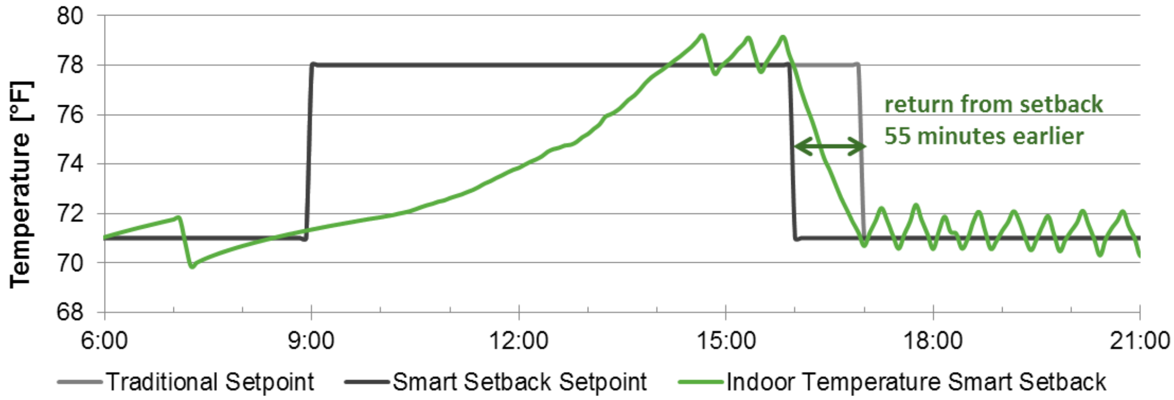
Smart Setback: This mechanism works by calculating the time required to shorten a setback setpoint in order to bring the actual indoor air temperature to the desired temperature. The algorithm simulates the indoor air temperature with the building model and iteratively shortens the setback period until the desired temperature is forecasted to be met. This method with the building model is demonstrated to be superior to using a statistical "cooling time" average from past data or just the outdoor temperature. In the following example (Figure 3.3) a user sets back to 78 °F while away at work then has it programmed to change to 71 °F when they return at 17:00. A traditional thermostat will wait until that programmed time (17:00) to actually turn ON, and the user may come home to an uncomfortable house, discouraging use of the setback.

Figure 3.3: Simulation of Traditional Setback Resulting in 60 Minutes of Discomfort



If 17:00 is programmed with Smart Setback the algorithm will determine how far in advance that 71 °F setpoint needs to be implemented so it will be 71 °F at 17:00 (Figure 3.4). Earth Networks simulations show that this technique works on 100% of houses on 100% of days.

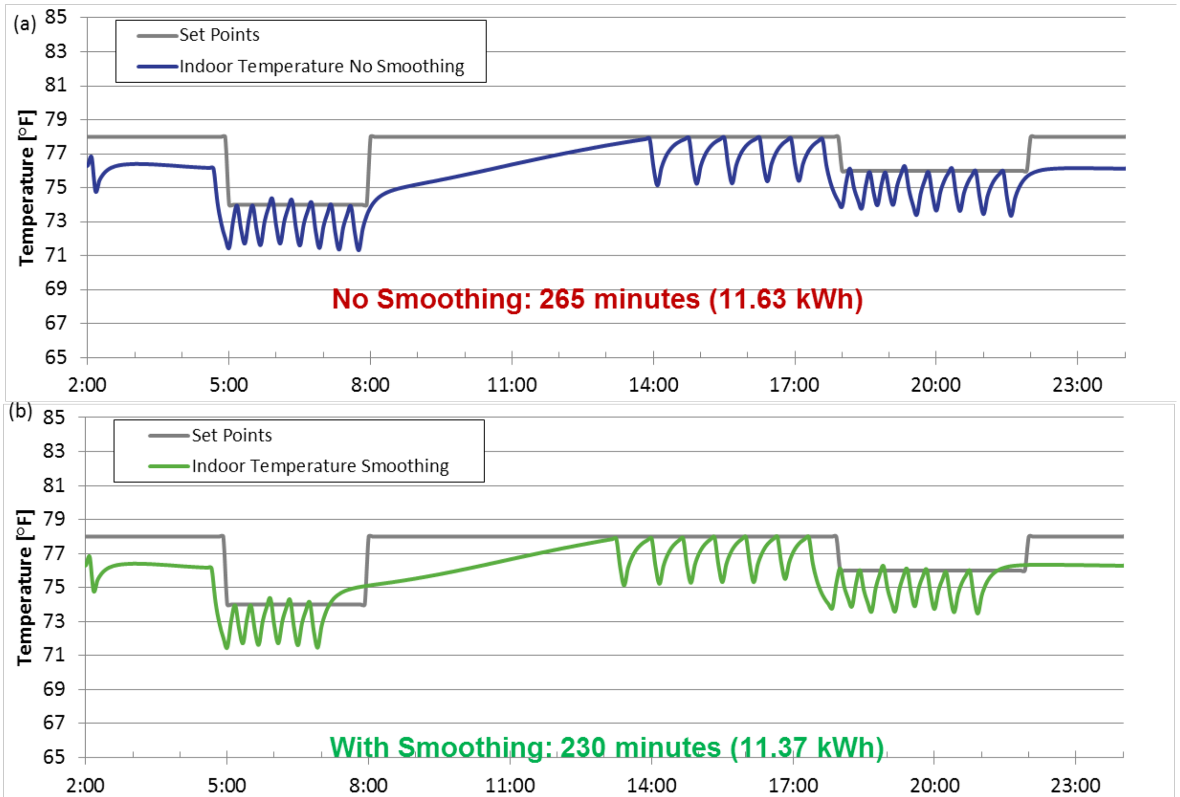
Figure 3.4: Smart Setback Begins the Comfortable Setpoint 55 Minutes Earlier



In this particular example the Smart Setback schedule actually would consume more energy than the traditional setback schedule because less time is spent at the higher temperature. Overall, this technique saves energy because it allows the user to be more aggressive with their setbacks. It converts users who originally held constant temperatures because of fear of being uncomfortable into ones wanting to utilize the full energy saving potential of setback.

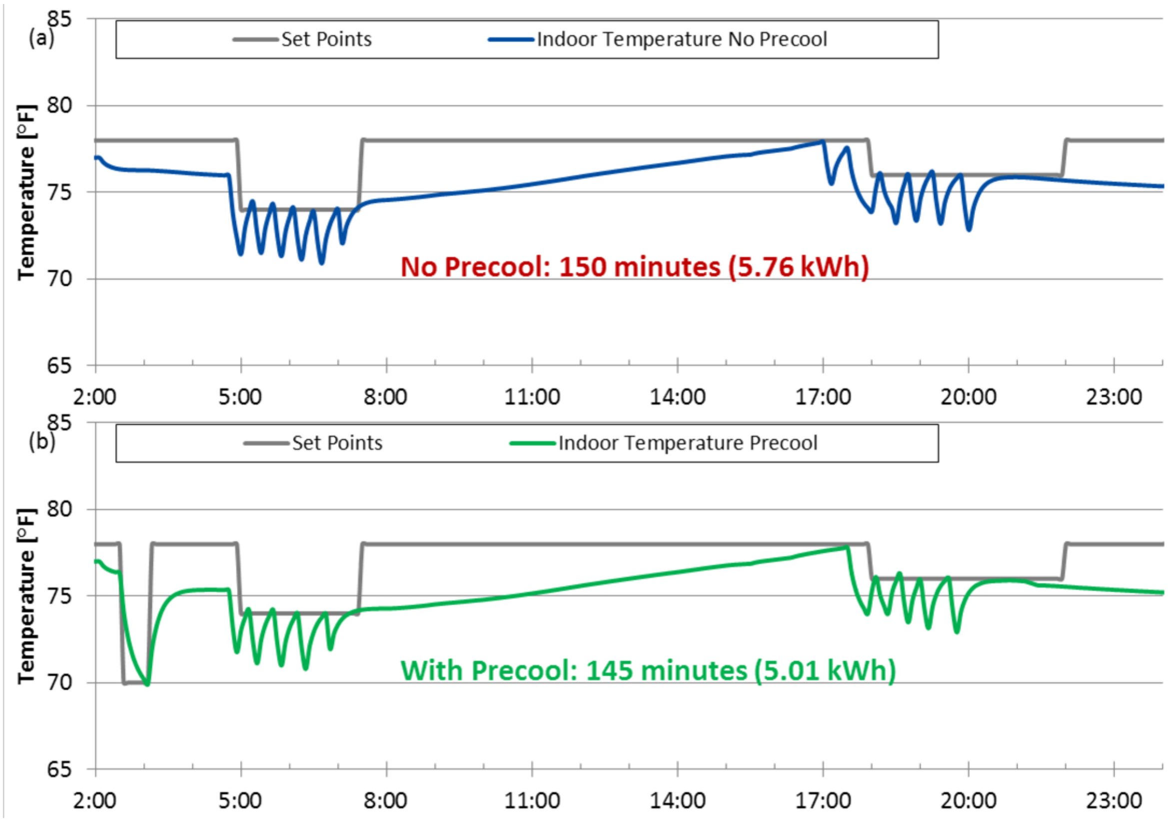
Setpoint Smoothing: This mechanism occurs in the hour before a schedule is nearing a jump up to a high setback temperature. The setback temperature is started earlier if the temperature will not rise more than 1 °C (or 1.8 °F) by the end of the current period. This usually shaves off one or two duty cycles from the lower, less efficient setpoint temperature. Figure 3.5 shows how Setpoint Smoothing removes cycles before the 8:00 and 22:00 setbacks. Earth Networks simulations show that this technique works on 85% of houses on 40% of days.

Figure 3.5: Setpoint Smoothing Simulation: (a) without Setpoint Smoothing and (b) with Setpoint Smoothing



Precooling: The third mechanism involves Precooling in the early morning (when an air conditioner gets the most cooling per input kW of power) and/or prior to a price increase projected due to the expected tight supply and demand condition in the electricity market. The algorithm iteratively finds the balancing point between utilizing efficiency and Precooling too much by abandoning the testing of additional Precooling when the overall consumption begins to increase. Figure 3.6 simulates how Precooling at the more efficient 2:15am reduces the amount of cooling required at the less efficient 18:00 despite having similar runtime totals. Earth Networks simulations show that this technique works on 30% of houses on 15% of days.

Figure 3.6: Precooling Simulation: (a) No Precooling and (b) 25 Minutes of Precooling at 2:15am to Reduce the Electricity Consumption in the Late Afternoon



Note that Precooling was not available for schedules that had setbacks. The thermostat used was limited to only four daily setpoint periods (5 counting the starting point) and adding in a Precooling period would require too many setpoints. This mechanism will be utilized more in the future, especially when more variable prices are introduced in retail electricity market.

3.3 *Description of the Scheduling Process*

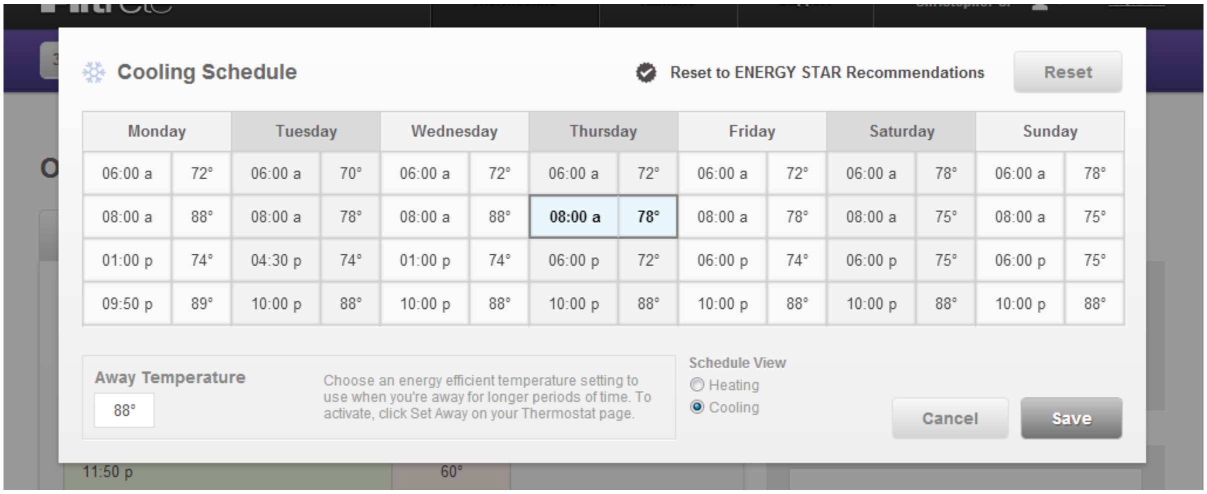
The WeatherBug Home Optimization technology is implemented each night in the 2:00am hour. If the customer had the Optimization feature enabled in the web portal or mobile app, an optimized thermostat setpoint schedule is produced using their house's thermodynamic energy model, desired temperature schedule, and local weather forecasts. These thermodynamic models are derived monthly from past data for all WeatherBug Home customers, and serve as a simulation tool to test the effectiveness of the previously mentioned energy saving mechanisms for a given day.[11]

Customers are asked to identify the time of the day and its corresponding temperature setpoint desired to be achieved at that time. As mentioned previously, customers have up to four timing points per day to set and must provide their preferences for all seven days in each

[11] Further explanation of the thermodynamic building energy model can be found in section 3.2 of Siemann, M. (2013), "Performance and application of residential building energy grey-box models", Ph.D Dissertation, University of Maryland, http://drum.lib.umd.edu/handle/1903/14299.

week. Figure 3.7 shows customers interface with the Radio Thermostat Web Portal Thermostat Cooling Scheduling.

Figure 3.7: Radio Thermostat Web Portal Thermostat Cooling Scheduling Interface



The localized weather forecasts are produced by Earth Networks for each zip code, and contain predicted outdoor air temperature, wind speed, and quite significantly, solar power.

Each morning when the Optimization feature is enabled, Earth Networks cloud-based software system generates an optimized setpoint schedule and sends it to the target thermostat using the Radio Thermostat / EnergyHub Application Programming Interface. These optimized setpoints will "overwrite" the default schedule on the thermostat for that entire day. If the customer disabled Optimization, or instituted any temperature change such as a hold period, the change overwrites any Optimization scheduling during that and any additional period of the day. To change the thermostat schedule to a permanent hold, the consumer needed to first disable Optimization, and then set the hold. In this case Optimization was disabled until the customer enabled Optimization manually. A temporary hold (where the customer simply changes the temperature for the current period) would change the thermostat setpoint, but would revert to the Optimization schedule once the next schedule period was reached. This gives customers full control of their comfort and does not force them to a particular schedule.

4 Pilot Results

To better understand the results of the Pilot, it is helpful to explain a few terminologies used in this section:

- **Setpoint:** Desired temperature that the thermostat controls the HVAC to. This is originally set by the customer and can be modified with the Optimization.
- **Test Group (With Optimization)**: Earth Networks customers who participated in the Pilot by enabling the Optimization feature and received at least 1 optimized schedule to their thermostat. These customers also received 3 home EE ScoreCards.

- **Control Group 1**: Earth Networks customers who participated in the Pilot without ever enabling the Optimization feature during the Pilot implementation; they had the option to enable Optimization but never did. These customers also received 3 home EE ScoreCards. They serve as the baseline to measure the savings of actively utilizing the optimized setpoint schedules. Note that these customers were only involved in the Earth Networks Demand Response program. Program analysis and evaluation removes and accounts for any differences due to DR participation.
- **Control Group 2:** This Control Group was comprised of customers from another company that was partnered with Earth Networks in their Demand Response program. They performed their program independent of Earth Networks and had no contact with Earth Networks or the WeatherBug Home Program. It is known that these customers also control their HVAC with an internet connected thermostat. They will serve as a second baseline.
- **Optimization Threshold:** The threshold is the number of days in the analysis period when the customer enabled Optimization for that house to be classified as being a full Test Group participant. This is used to determine with analysis grouping that a customer falls into, based on the number of received optimized setpoint schedules. In addition, by revising this threshold, we can assess whether the WeatherBug Home Optimization technology has different outcomes when duration (in days) of participation in the Program increases.
- **House Size Thresholds:** The lower and upper bounds of a typical house's square footage that are included in the study. These are used to remove any outliers that could skew the analysis. In addition, by revising this threshold, we can assess whether the WeatherBug Home Optimization technology has different outcomes when house size increases.
- **Residual:** The difference between two points on a plot at the same x-axis value.

4.1 *Explanation of Data Involved in the Analysis*

- **Weather Data**: Weather observation data from the Earth Networks WeatherBug network was used to build the thermodynamic building models associated with WeatherBug Home. Outdoor temperature, wind speed, solar insolence, and relative humidity were recorded in 5-minute intervals and used in the model training phase. This data was averaged from 20 WeatherBug stations in the Houston, Texas area in 15-minute intervals to characterize the general weather of each summer (2013 and 2012) for the analysis.
- **Smart Meter Interval Data:** Electrical energy consumption data from customer smart meters was provided by CenterPoint Energy for the participating houses. The data was measured and delivered in 15-minute intervals, in units of kilowatt hours (kWh). Data was requested from January 2012 to September 2013, but only processed for May 1 – September 30 of 2012 and 2013. Houses were left out of the analysis if data was missing for more than one day in the analysis period. It should be noted that this was only observed in less than 5% of the initial population. Aside

from these, this data was very reliable and the primary measurement of electricity consumption used in this analysis.

- **Thermostat Setpoint Data**: The internet connected thermostats record the temperature setpoint driving the thermostat in 5-minute intervals. This data is the desired temperature the thermostat is controlling the HVAC system to deliver at that particular time. The units for this analysis are in degrees Fahrenheit. Due to periodic internet connection issues, this data is not always continuous; however, averaging across the entire analysis period remedied any missing data. This information is not as reliable as the Smart Meter Interval Data; however, this is the best data available in both Pilot years for a subset of the WeatherBug Home customers.[12] If a house had multiple thermostats enrolled in the WeatherBug Home program the setpoints between these thermostats were averaged to result in one value at every time step.

- **Thermostat Runtime Data**: The internet connected thermostat records when the HVAC system was ON or OFF to provide cooling or heating. This data is recorded continuously but was scaled up to reflect 5-minute intervals in units of ON time in minutes during that interval. Like the Thermostat Setpoint Data this dataset can suffer from intermittent connection issues and is not as reliable as the Smart Meter Interval Data. However, this information is the best data available in both years for a subset of the WeatherBug Home customers.[13] If a house had multiple thermostats enrolled in the WeatherBug Home Program the runtime between these thermostats were averaged to result in one value at every time step.

- **HVAC Power Data**: This approximation of the electrical power load of the HVAC system is derived from the Thermostat Runtime Data and the power curve of the house's HVAC system.[14] The units are in average kW over a 15-minute interval. Like the other thermostat data this is not as reliable as the Smart Meter Interval Data. However, this is the only useful available data in both years for a subset of the WeatherBug Home customers.[15] If a house had multiple thermostats enrolled in the WeatherBug Home program the HVAC load between these thermostats were averaged to result in one value at every time step.

- **House Size**: The approximate furnished floor space of each house was collected using the website www.Zillow.com.[16] Zillow uses public tax records to assess the approximate size of each house. At the time of the analysis, a small population of the houses (~5%) did not return a value for the house size from this service and are excluded from the analysis via the House Size Thresholds.

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[12] The primary analysis is based solely on smart meter data. Any analysis using thermostat data (setpoints, runtime, HVAC power) is only supplementary and intended to further assist us to better understand the results.
[13] The primary analysis is based solely on smart meter data. Any analysis using thermostat data (setpoints, runtime, HVAC power) is only supplementary and intended to further assist us to better understand the results.
[14] Further explanation of the Energy Consumption Modeling with Thermostats can be found in section 3.2.6 of Siemann, M. (2013), "Performance and application of residential building energy grey-box models", Ph.D. Dissertation, University of Maryland, http://drum.lib.umd.edu/handle/1903/14299.
[15] The primary analysis is based solely on smart meter data. Any analysis using thermostat data (setpoints, runtime, HVAC power) is only supplementary and intended to further assist us to better understand the results.
[16] Zillow API information: http://www.zillow.com/howto/api/APIOverview.htm

4.2 *Scope of the Analysis*

The analysis performed as part of the Program Pilot investigates data from May 1, 2012 – September 30, 2012 and May 1, 2013 – September 30, 2013. During the summer of 2012 all the WeatherBug Home customers (those who were part of either the Test Group Optimization or Control Group 1) did not have access to the WeatherBug Home Optimization feature. In the summer of 2013 Earth Networks added the new Optimization feature, but only the customers comprising the Test Group enabled it. The majority of the houses participated in eight Demand Response tests throughout the summer 2013 as part of the ERCOT Emergency Response Service for WSL Pilot. Tests were performed on June 13, 26; July 11, 30; August 7, 30; and September 11, 19. However, no emergency DR Event Day was announced by ERCOT during the Pilot period. Therefore, the DR tests days, which only had impact on energy consumption during the actual test event, were removed from the analysis.

Data was collected from 364 Earth Networks customers (359 with complete data and within size thresholds) and from 712 houses that were not direct customers (635 with complete data and within size thresholds).[17] The house size was identified for 1,065 of these houses[18]. Houses classified as Control Group 2 were not involved in WeatherBug Home Optimization activities and were excluded in the following analyses. Several different analyses were conducted to measure the amount of energy savings for Day-By-Day, Average Summer Day, Average Thermostat Setpoint, Average HVAC Load, and Potential (Worst and Best) results.

Some examples are provided to demonstrate the results for Optimization Program. In conducting these analyses, the following assumptions were used: the Optimization Threshold of at least one-day active participation, House Size Lower Threshold of 700 ft^2, and House Size Upper Threshold of 5,500 ft^2.

4.3 *Day-By-Day Analysis*

The daily average energy consumption figures for the Test Group and Control Group 1 are compared to identify when Optimization was saving the most energy. Figure 4.1 plots these groups for the summer of 2013 with the 8 DR days removed and Figure 4.2 further organizes this data by summer months.

[17] These were the houses that were controlled by another company that was partnered with Earth Networks in their Demand Response program.
[18] These 1,065 houses also include houses with incomplete data and/or outside the size thresholds.

Figure 4.1: Summer 2013 Day-By-Day Average Electricity Consumption

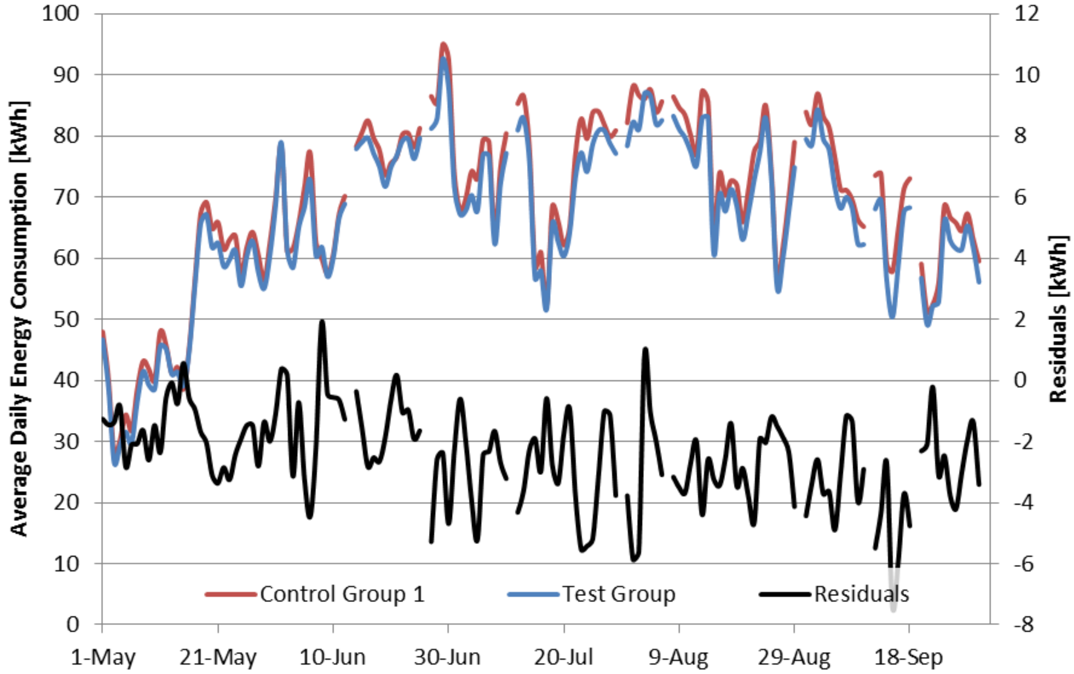
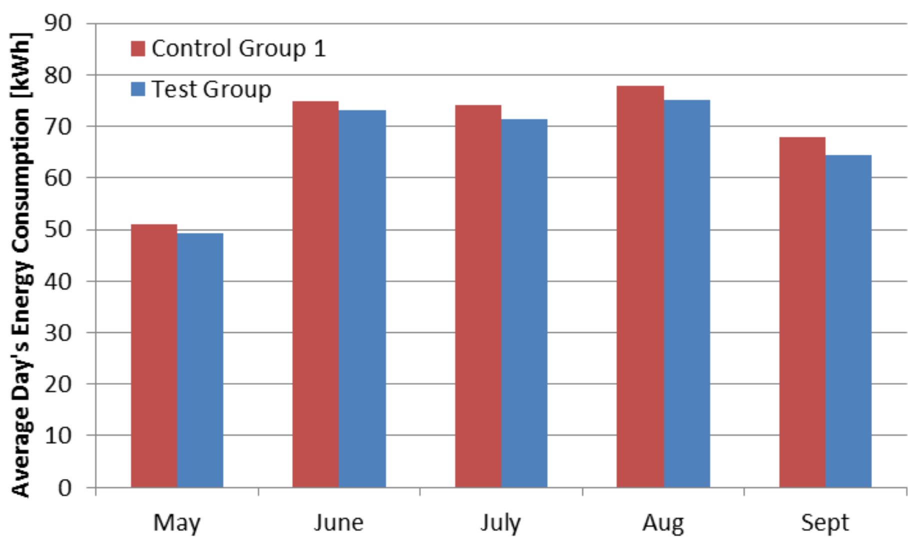


Figure 4.2: Average Summer 2013 Monthly Electricity Consumption Aggregated by Groups

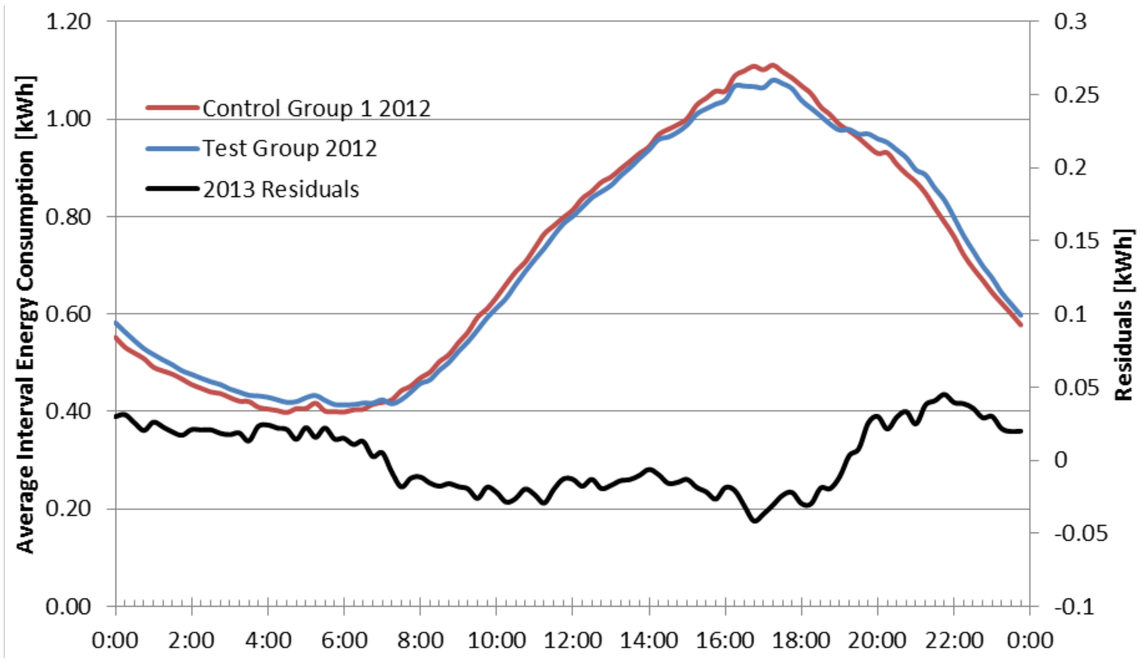


The Test Group Optimization group consumed a lower amount of energy than Control Group 1 on the majority of the days in the summer of 2013. A larger savings was seen in the later months of the summer when the weather was warmer. The Optimization improves the efficiency of running the air conditioning (AC) to maintain comfort in a house, so higher savings results from the warmer periods are expected.

4.4 *Average Summer Day Analysis*

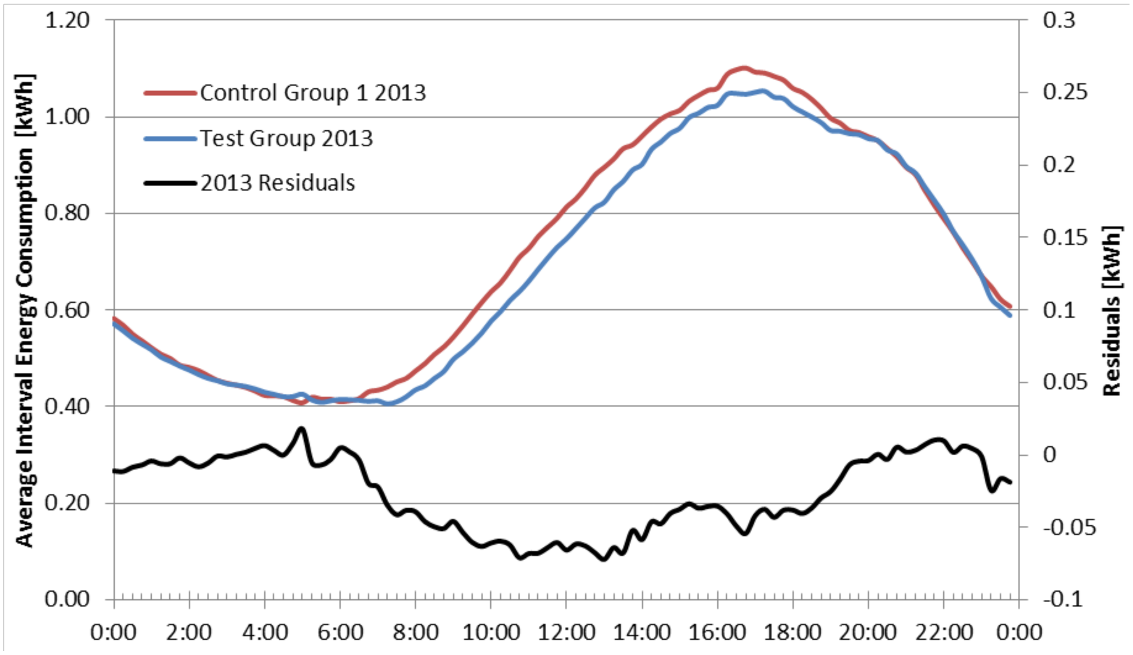
The average electricity consumption of each daily 15-minute interval of the Test Group Optimization and Control Group 1 are compared to identify at what time during the day the WeatherBug Home Optimization was reducing the electricity consumption. Figure 4.3 shows the average day's 15-minute electricity consumption for the two groups for the summer of 2012 before Optimization was available, and Figure 4.4 shows the results for the summer of 2013.[19]

Figure 4.3: Summer 2012 Average Day's 15-Minute Electricity Consumption



[19] Figures 4.3 and 4.4 are reflecting average electricity consumption for each 15-minute Interval during the five months of Pilot implementation that is May 1 – September 30.

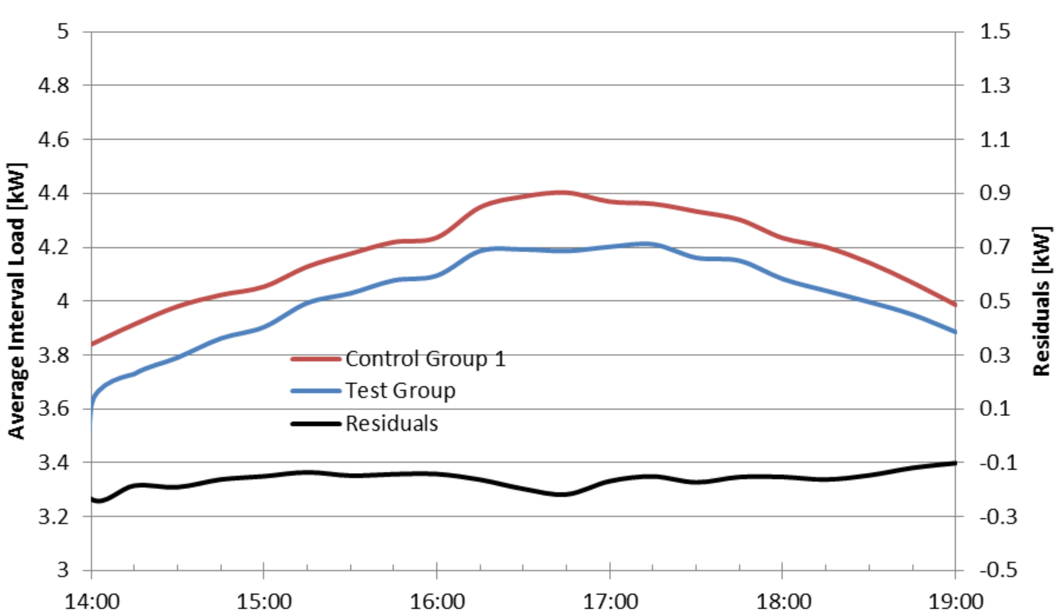
Figure 4.4: Summer 2013 Average Day's 15-Minute Electricity Consumption



The data from the summer of 2012 plot shows that these two groups were quite similar on the average daily electricity consumption. Houses in Control Group 1 used a bit more energy during the peak, but the houses in Test Group used more in early morning and the evening. The plot from 2013 shows the Optimization is further driving lower energy consumption from 7:00am to 7:15pm. The morning hours show savings due to Setpoint Smoothing and the rest of the afternoon and evening come from higher setbacks.

Particularly important to the utility is the performance during the peak hours. Figure 4.5 further zooms in on the peak hours between 2:00pm and 7:00pm.

Figure 4.5: Summer 2013 Average Day's 15-Minute Electricity Consumption during Peak Hours

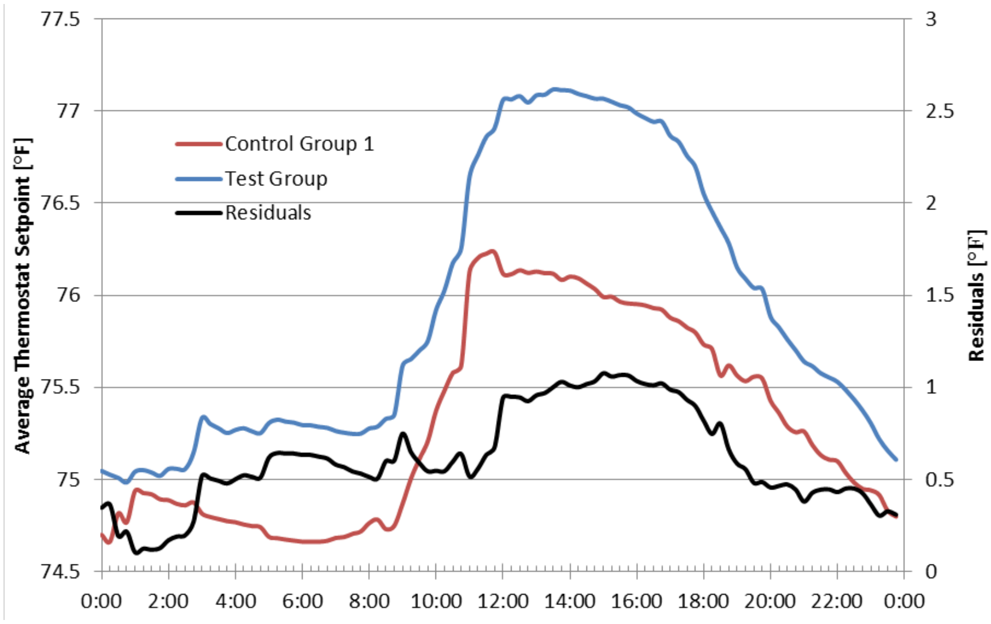


The Test Group houses used on average about 150-200 Watts less electricity than the Control Group 1 houses during these hours. While not that significant compared to the entire load, the value comes from this reduction without peak reduction being a goal of the Optimization feature. This can significantly reduce demand required by the utility if adopted on a broad scale, reducing the need for the most expensive generation, and keeping overall pricing down. If customers were subscribed to a peak or variable pricing plan, these periods would be more expensive, and Optimization would also actively shift load away from the peak to minimize cost.

4.5 *Average Thermostat Setpoint*

The average day's thermostat setpoints of the Test Group and Control Group 1 are compared to identify why the Test Group houses are using less energy. Figure 4.6 plots the average setpoints for the average day during the summer of 2013 (including weekends).

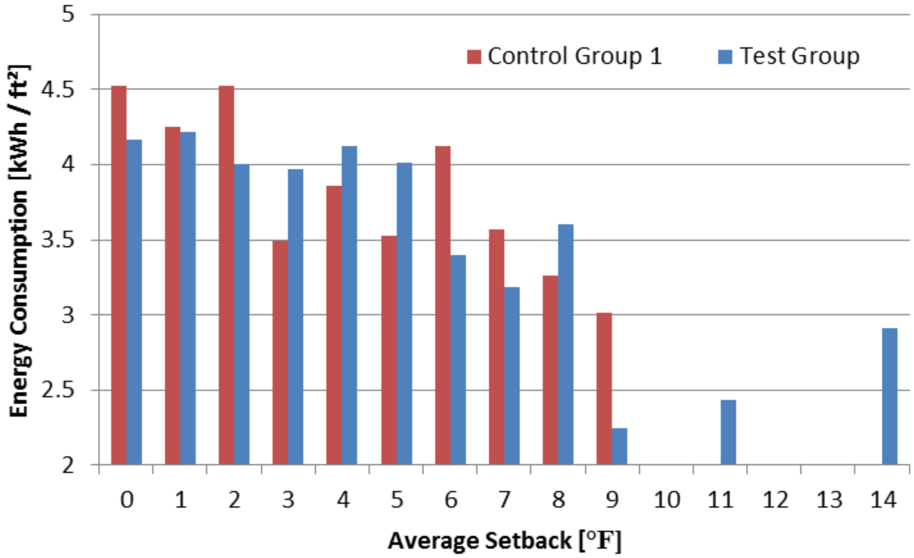
Figure 4.6: Summer 2013 Average Day's 15-Minute Thermostat Setpoints



The average thermostat setpoint for the Test Group in 2013 was 75.9 °F while Control Group 1's average setpoint was 75.3 °F, a difference of 0.6 °F. The largest difference was in the afternoon at over 1 °F. This difference during the hottest period of the day is the largest contributor to the lower energy consumption for the Test Group. It is hypothesized that the Smart Setback aspect of the Optimization is responsible for this higher setpoint. The higher setpoints in the mid-morning compared to the early morning are also signs of Setpoint Smoothing. Customers in the Test Group are not sacrificing comfort with these higher setpoints because they are indicating that these periods are not as important to maintain their comfort. Further savings can be achieved if the setpoints are automatically adjusted to higher values when comfort is not a priority for customers. This intelligence is planned to be incorporated into future versions of the Optimization feature.

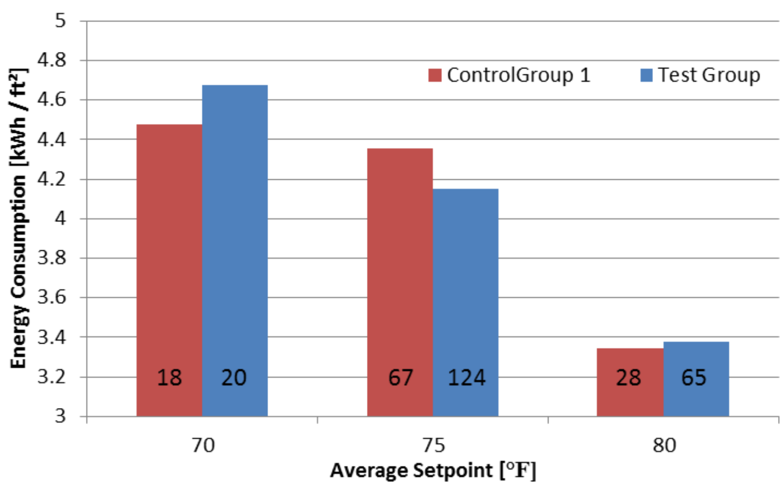
It is also interesting to observe the difference in energy consumption between different average setback amounts. Figure 4.7 plots the average energy consumption for different average setback amounts for both WeatherBug Home and Control Group 1 customers in the Pilot. The average setback per house was calculated as the difference in the minimum and maximum average interval setpoint. Note that an empty bar represents no houses with that average setback.

Figure 4.7: Summer 2013 Energy Consumption per Average Setback



The average setpoint can also be used to explain why houses in the Test Group used less energy. Figure 4.8 the average thermostat setpoint for the houses in both groupings. The average setpoints were rounded into 5 °F bins and the number of houses with each average setpoint is also displayed. Without considering the bin size it would appear that the Test Group houses consume more energy, whereas the energy data reports otherwise.

Figure 4.8: Summer 2013 Energy Consumption per Average Setpoint

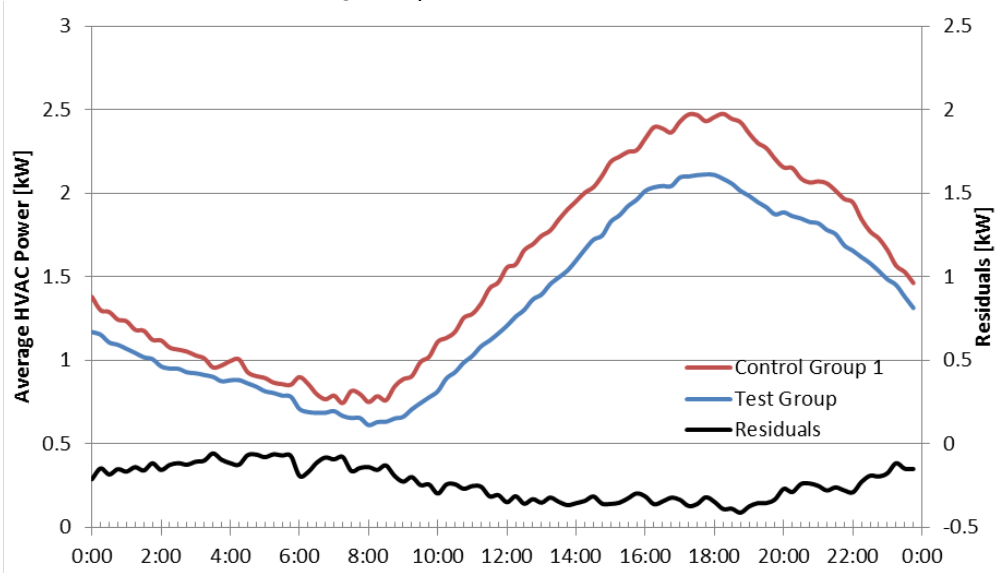


As expected, houses with higher setbacks are shown to consume less energy per square footage than ones with little or no setback. The overall temperature itself is equally important thermodynamically for driving air conditioning use, and also as expected houses with lower average setpoints consumed more energy than ones with higher setpoints. These results do provide evidence that higher setbacks and setpoints are a major contributor to why the Test Group consumed less energy per house area than Control Group 1, especially since this is done in an intelligent way to still maintain similar comfort.

4.6 *Average HVAC Load*

The average day's calculated HVAC power of the Test Group and Control Group 1 are compared to identify whether the Test Group houses are using less electricity due to thermostat control. Figure 4.9 plots the average HVAC load for every 15-minute interval of the average day for both groups.

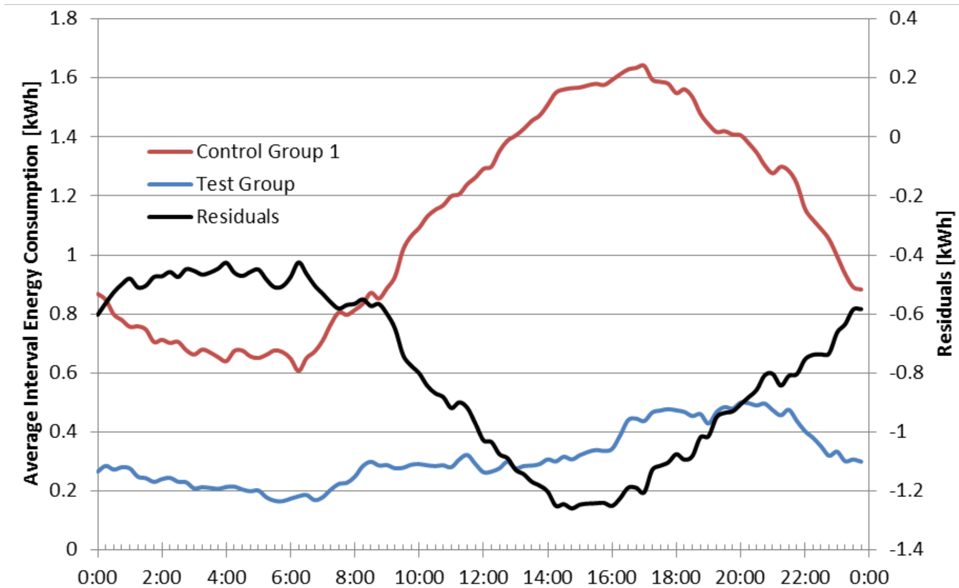
Figure 4.9: Summer 2013 Average Day's 15-Minute HVAC Load



4.7 *Test Group's Potential (Worst and Best)*

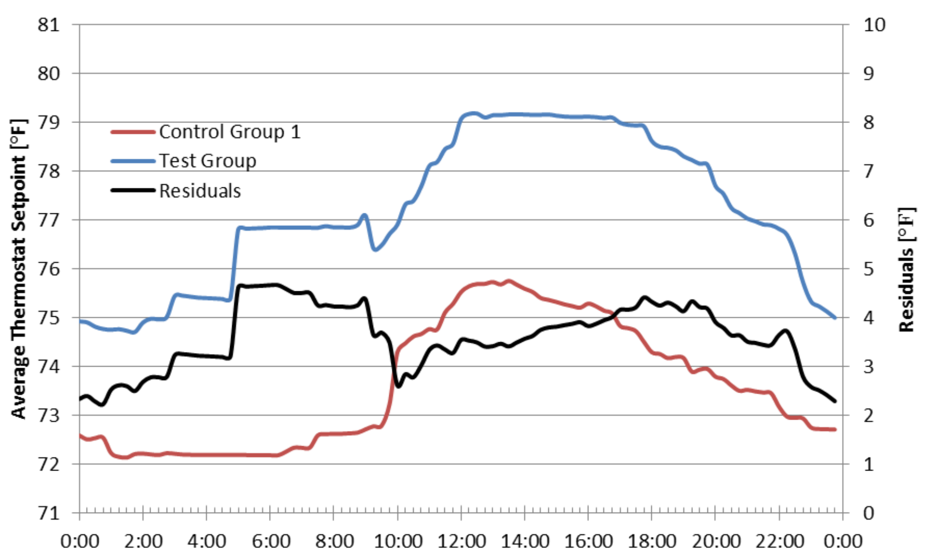
The previous analyses have involved averages of the entire groupings. The potential of the Optimization can also be demonstrated by observing extreme cases. In order to better see and compare the performance of various participants, we selected the worst and the best ten houses among dataset for houses sized between 2,000-3,000 ft^2. In particular, the top ten worst houses were selected from the Control Group 1 whose members were not participating in Optimization and used the most electricity in summer 2013. In contrast, the top ten best houses were selected from Test Group with the least amount of electricity where the Optimization technology was in effect. Figure 4.10 and Figure 4.11 plot the average 15-minute interval electricity and thermostat setpoint of 10 of the worst and best houses.

Figure 4.10: 10 Worst Houses without Optimization and 10 Best with Optimization Average Day's 15-Minute Electricity Consumption



As is evidence, the ten best houses are using less electricity per 15-minute interval throughout every hour with the most noticeable differences during 10am and 9pm. The largest difference concurs with the utility's peak hours of 2pm and 5pm when the difference exceeds 1.2 kWh per each 15-minute interval.

Figure 4.11: 10 Worst Houses without Optimization and 10 Best with Optimization Average Day's 15-Minute Thermostat Setpoints



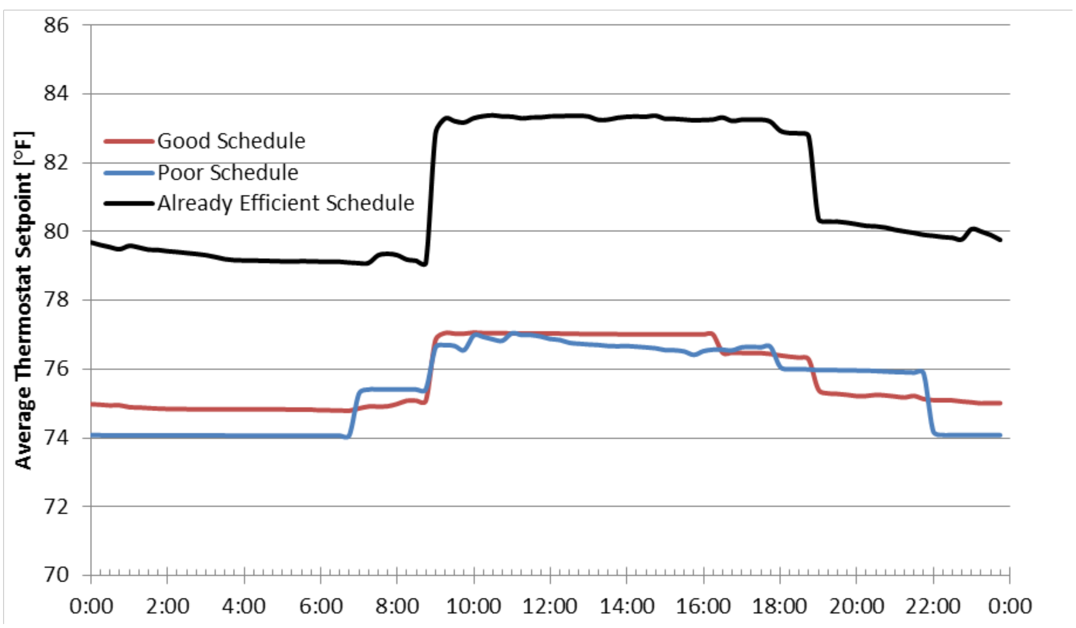
Similarly, a difference in thermostat setpoints can be observed between two groups where the participants in Test Group constantly have setpoints ranging from 2 °F to 4 °F above those in Group 1 voluntarily without sacrificing their level of comfort.

These examples show how extreme a difference there can be between similarly sized houses. The 10 worst houses consume a significantly larger amount of energy throughout the entire day and are maintaining thermostat setpoints that are almost 5 °F lower in certain times than the 10 best houses. The Optimization feature is not responsible for all of this savings difference but it is expected to be a contributor, especially in the morning when Setpoint Smoothing is occurring. Houses with similar inefficient usage to these 10 worst would benefit the most by relying on Optimization technology or other energy management techniques to improve their energy efficiency.

4.8 *Examples of Optimization*

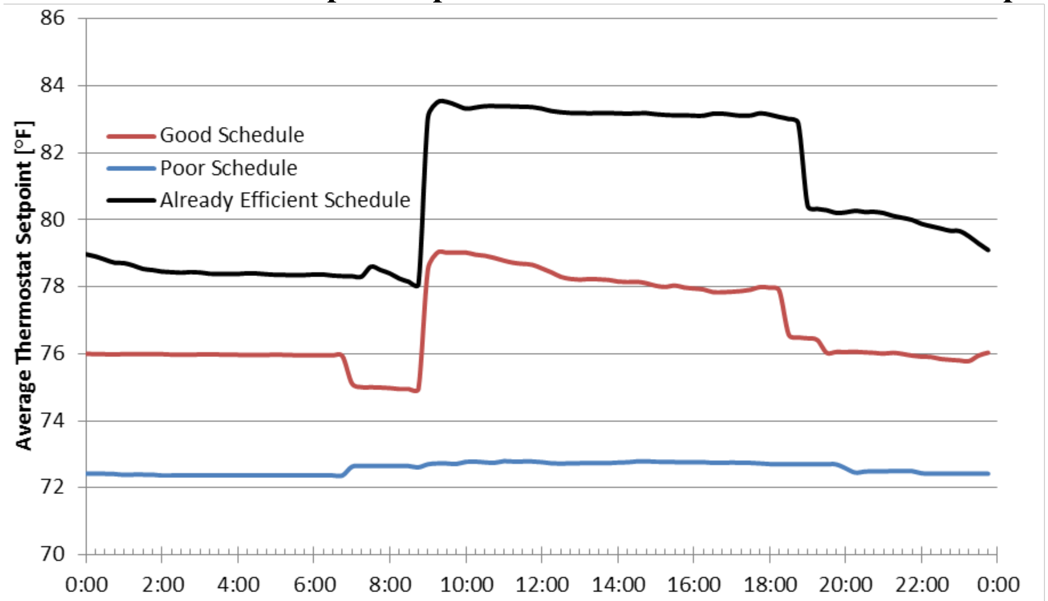
Three examples of houses from the Test Group were chosen to demonstrate the range of customers who enabled the Optimization feature. The first house is classified as having a "good" thermostat setpoint schedule ideal for Optimization. The second has a "poor" schedule that did not take the steps necessary to benefit from the Optimization, and the third has a schedule that is "too efficient" meaning that thermodynamically the Optimization would not be able to add much additional benefit.[20] The average 15-minute interval setpoints for these three houses are plotted on Figure 4.12 for the summer of 2012 without the Optimization and Figure 4.13 for the summer of 2013 with the Optimization feature activated. Table 4.1 contains the seasonal energy consumption for these three examples.

Figure 4.12: Three Test Group Examples from 2012 15-Minute Thermostat Setpoints



[20] This house is represented as "Too Efficient Schedule" in Figures 4.10 and 4.11.

Figure 4.13: Three Test Group Examples from 2013 15-Minute Thermostat Setpoints



The difference in temperatures between "Good" and "Too Efficient" is 4 to 6 degree and may indicate that even the Good one perform less efficiently than the Too Efficient house when it comes to thermostat setpoints. Additional efforts, particularly in customer education and further familiarity with the way thermostats work may provide additional leverage to take full advantage of the new technologies.

Table 4.1: Electricity Consumption Comparison among Three Example Houses in the Test Group

	Summer 2012 Energy Consumption [kWh]	Summer 2013 Energy Consumption [kWh]	Savings (%)
Poor House	10,825	11,005	-1.7%
Good House	7,804	6,673	14.5%
Too Efficient House	4,472	3,992	10.7%

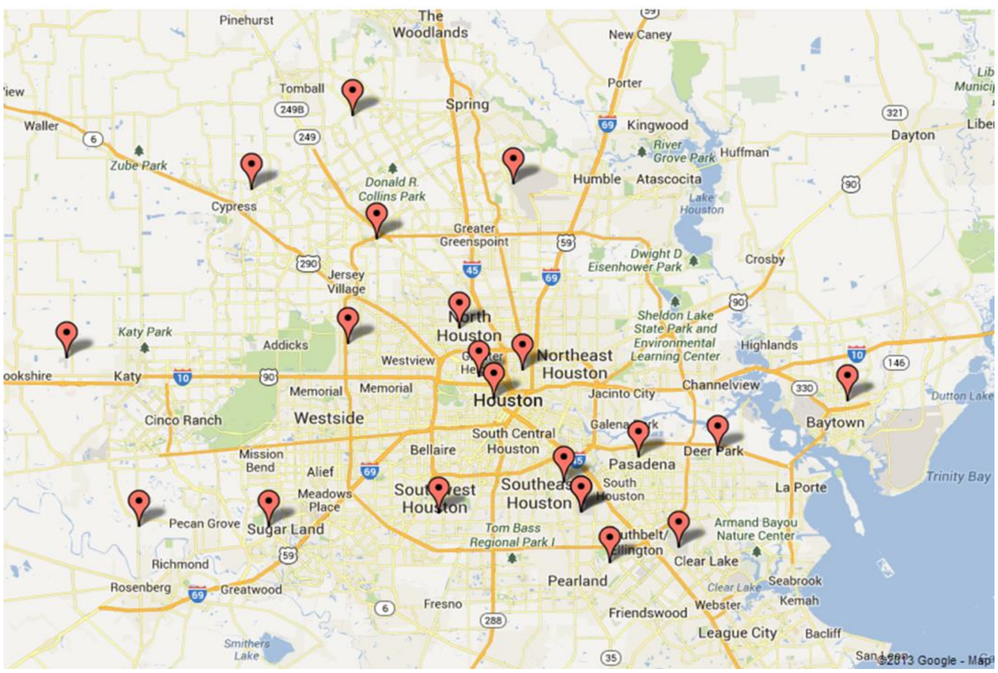
The poor house ended up consuming more electricity in 2013 than 2012. While many factors could be the root of this, the thermostat setpoints for this year were observed to be lowered for the entire day, including elimination of any significant setback. Houses that take this negative turn with Test Group can be identified and homeowner alerts could be provided. The good house was able to improve upon its thermostat setpoint schedule with the Optimization feature. With Optimization the customer raised their setback setpoint by several degrees and Setpoint Smoothing was able to increase the duration of this period. This house saw a 14.5% reduction in their energy use compared to the previous year. The setpoints did not change by enough to account for this entire savings, but it would account for a large portion. The already efficient house had very high thermostat setpoints in 2012. When this customer enabled the Optimization feature in 2013 they did not change their setpoint schedule to invoke a larger savings, especially one as large as 10.7%. This was probably a result of some other behavioral change or equipment upgrade.

All three of these examples are typical of the types of houses that make up the Test Group grouping; not every house is going to reduce their electricity consumption without being targeted using the appropriate mechanism.

4.9 *Houston Weather*

Weather data was averaged from 20 WeatherBug weather stations of the 71 WeatherBug stations in the Houston area to characterize the climate of each summer. These 20 stations represent a significant sample of those used to build the thermodynamic models for the houses in this region. Figure 4.14 plots the locations of all these weather stations on top of a map of the Houston area.

Figure 4.14: Locations of Select 20 WeatherBug Network Weather Stations Used to Characterize the Area's Climate



The weather was fully observed for the summers of 2012 and 2013, and the temperature data was compiled for the summer of 2011 (noted as breaking heat records). The averages and other observations of each summer are presented in Table 4.1.

Table 4.1: Summer Weather Data

	Average Outdoor Temp [°F]	Average High Temp [°F]	Average Low Temp	Days Above 95 °F	Days Above 100 °F	Cooling Degree Days (from 68 °F)[21]	Average Solar Insolence [w/m2]	Average Wind Speed [mph]	Average Relative Humidity [%]
2011	83.31	93.45	75.09	74	8	1383.11	NA	NA	NA
2012	80.84	89.09	73.88	11	1	1146.10	213.53	6. 65	73.44
2013	81.10	89.79	73.81	24	1	1173.04	245.56	7.38	72.46

The summer of 2013 is shown to be hotter than the summer of 2012 using the majority of these metrics. In particular the summer of 2013 experienced 2.4% more cooling degree days than 2012 and more than double the days above 95 °F. However, the summer of 2013 was not as hot as record breaking 2011.

5 Overall Results and Estimated Deemed Savings

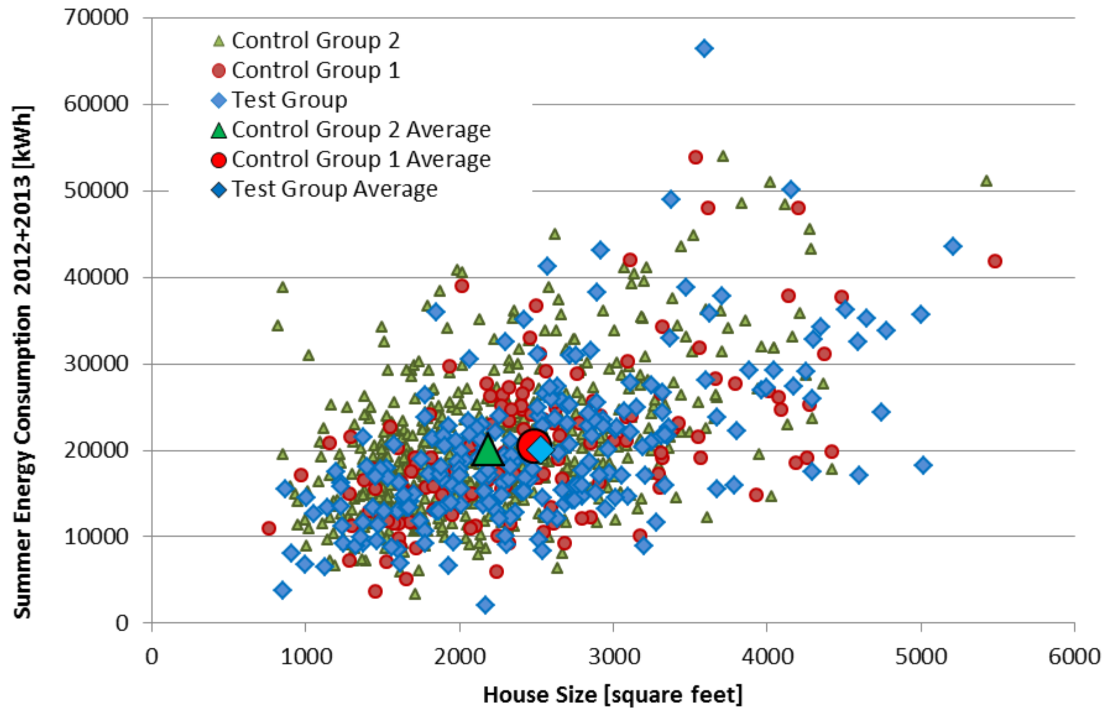
The results of Pilot implementation across CenterPoint Energy service area covering 2013 summer months (May 1 through September 30) is reflected in this section. In particular, the raw data and findings are shared first to demonstrate the actual observation regarding various groups analyzed in this report. The raw data is then used to develop and identify the overall electricity savings that could be contributed to the implementation of the WeatherBug Home Program.

5.1 *Estimated Average Electricity Consumption Savings By Selected Groups*

In performing the analysis, two following thresholds were used: 1) the Optimization Threshold measuring the number of days of participation and 2) House Sizes. Regarding the first one, it was decided to consider customers as active participants as long as they activated their Optimization option for at least one day. House Sizes were analyzed and a decision was made to include houses ranging between 700 ft^2 and 5,500 ft^2 in this analysis. Figure 5.1 shows all houses included in this study by various groups and their two-year electricity consumptions over summers months.

[21] Explanation of Cooling Degree Days is available at:
http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/cdus/degree_days/ddayexp.shtml .

Figure 5.1: House Sizes by Various Groups



While these houses range in size between 750 ft^2 to 5,490 ft^2, their average two-year summer electricity consumption remains close around 20,000 KWh. More detailed information on these houses is provided in Table 5.1.

Table 5.1: Electricity Consumption over Two Summers

		House Size [ft²]	2012 Summer Energy Consumption [kWh]	2013 Summer Energy Consumption (minus DR days) [kWh]	2012 Summer Energy Consumption [kWh / ft²]	2013 Summer Energy Consumption (minus DR days) [kWh / ft²]
Test Group (217 houses)	Average	2522	10448	9603	4.28	3.94
	Median	2432	9516	8638	3.99	3.71
	Minimum	850	959	1153	0.44	0.53
	Maximum	5214	32893	33448	9.14	10.40
	Standard Deviation	894	4623	4286	1.58	1.48
Control Group 1 (142 houses)	Average	2504	10428	9964	4.34	4.16
	Median	2360	10007	9436	4.09	3.95
	Minimum	764	1909	1665	1.31	1.14
	Maximum	5490	27458	26331	10.19	9.10
	Standard Deviation	862	4692	4279	1.72	1.61
Control Group 2 (635 houses)	Average	2186	10307	9811	5.01	4.77
	Median	2065	9619	9117	4.61	4.33
	Minimum	750	1291	1929	0.59	1.13
	Maximum	5433	29986	42491	37.56	56.65
	Standard Deviation	717	4121	4174	2.50	2.86

Various houses reflected different level of electricity savings when engaged in Test Group Program. Figure 5.2 provides percentage savings per ft^2 for various house sizes. A more detailed presentation is provided in Figure 5.3 among various houses when house size is increasing by 500 ft^2. Both plots also display the number of houses in the Test Group and Control Group 1 for that house size range as a ratio, and if either group contains zero houses for that range the percent savings will be zero because of the relativistic calculation.

Figure 5.2: 2013 Percentage Electricity Savings per ft^2 by House Size in Test Group Optimization Program

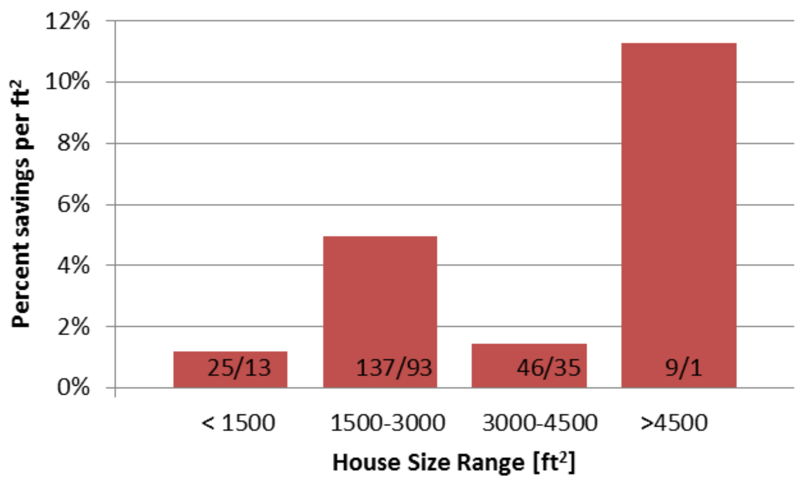
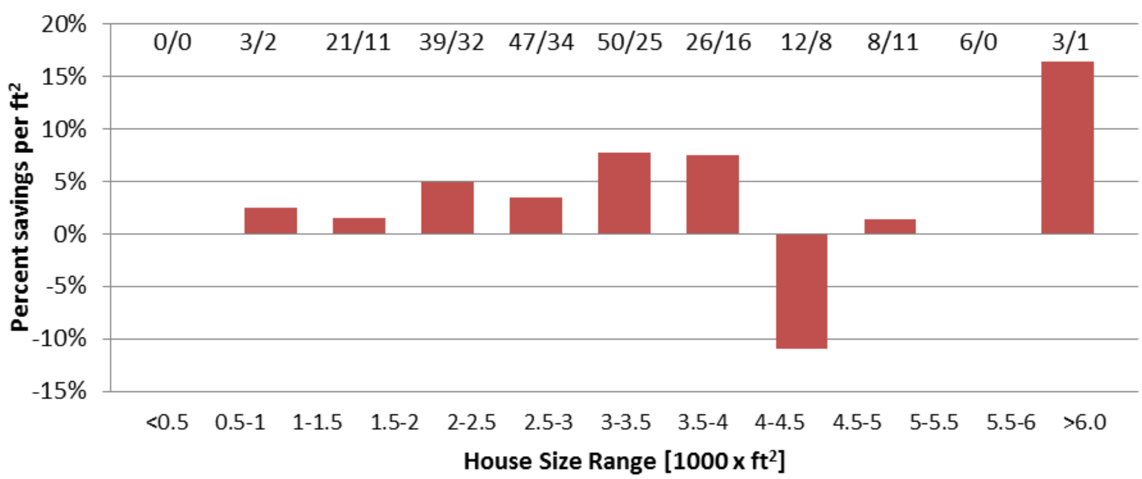


Figure 5.3: Detailed 2013 Percentage Electricity Savings per ft^2 by House Size in Test Group Program

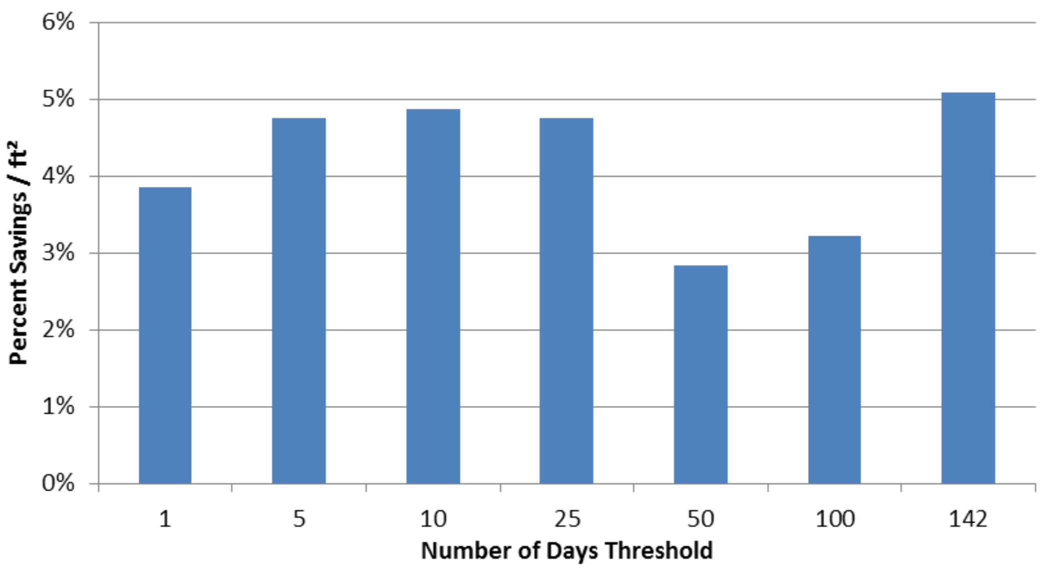


The length of time in the program did not have significant impact. For participants who participated in the Program for a minimum of 25 days, the average energy savings was 4.75% per ft^2 .The amount of savings did not change significantly for those 48 participants who were active in the WeatherBug Home Program for entire programs duration of 142 days, the average energy savings increased to 5.09% per ft^2. Table 5.2 provides the break down in number of participation, the percentage savings, and number of participants. Figure 5.4 reflects a bar chart with similar information.

Table 5.2: Electricity Consumption over Two Summers

Number of Days Threshold	Percent Savings per ft^2	No. of Test Group	No. of Control Group 1
1	3.85%	217	142
5	4.76%	208	151
10	4.87%	200	159
25	4.75%	187	172
50	2.84%	158	201
100	3.22%	111	248
142	5.09%	48	311

Figure 5.4: Percentage of Electricity Savings by Number of Days of Participation in Test Group Program

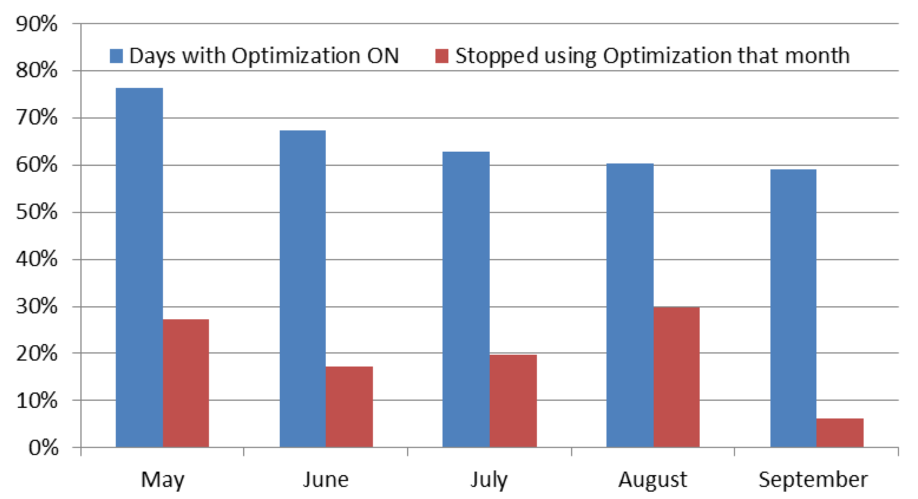


In addition to the number of days of participation that was an indication of willingness to be as part of the Program, we can also look at month to month fluctuations in potential participants to stop using the Program. Such an action would definitely impact the overall electricity savings that could be materialized using Optimization. Table 5.3 provides the break down by summer months in percentage of participants engaging in the Optimization program as well as percentage of participants who completely stopped using the Optimization feature for remainder of the summer. Figure 5.5 reflects a bar chart with similar information.

Table 5.3: 2013 Monthly Percentage of Participants Engaged in Optimization Program

	May	June	July	August	September
Days with Optimization ON	76.26%	67.33%	62.70%	60.20%	59.05%
Stopped using Optimization that month	27.16%	17.28%	19.75%	29.63%	6.17%

Figure 5.5: Percentage of Electricity Savings by Number of Days of Participation in Test Group Program



While it is not known for certain if all these customers actively stopped using the Optimization service because they were not satisfied with its abilities, it is believed that most of these actually come from accidently disabling the service with a hold. Better communication or implementation of the service is recommended to prevent customers from inadvertently operating without Optimization.

Figure 5.6 provides a comparison of average electricity consumption between summers 2012 and 2013 for three groups under study. As could be seen, both Group 1 and Group 2 had higher average electricity consumption in 2013. That is understandable knowing that weather in 2013 was slightly warmer due to the fact that the Cooling Degree Days was about 2% higher than its counterpart in 2012. The same is not true when we compare average electricity consumption in 2013 for participants in Test Group Program, who actually saw reduction in their electricity consumption.

Figure 5.6: Summer Electricity Consumption by Various Groups

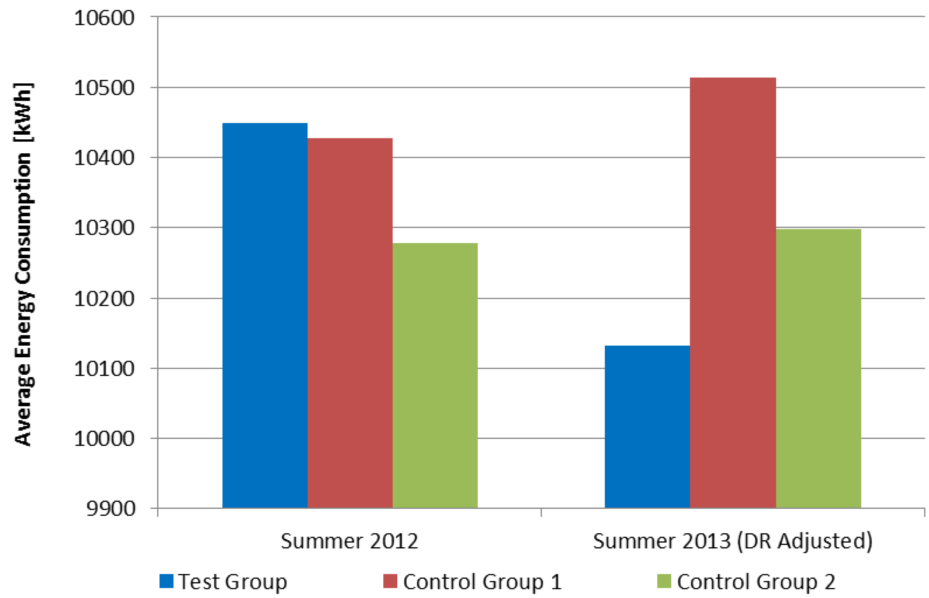
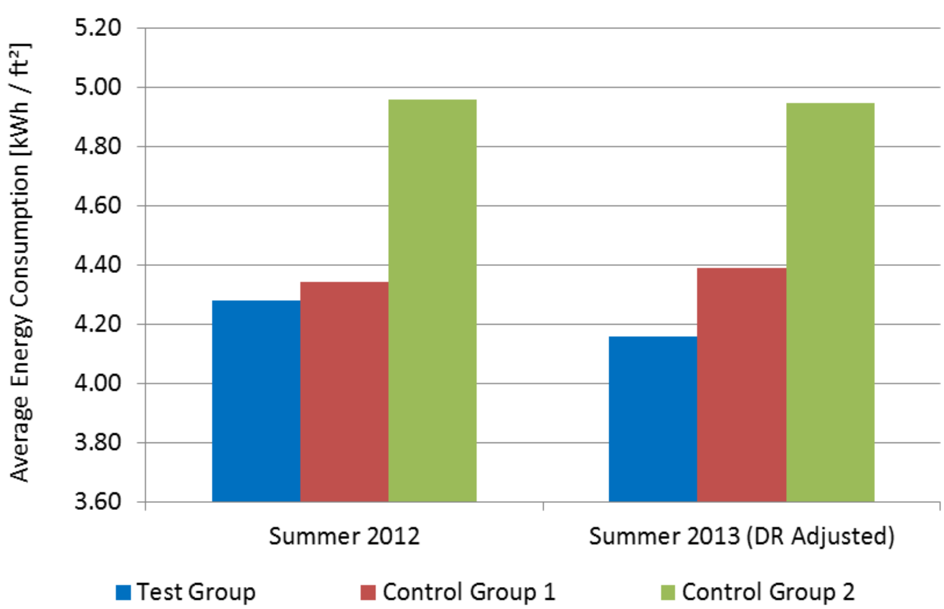


Figure 5.7 is presented to normalize the results by house sizes and present average electricity consumption per ft^2 between summers 2012 and 2013 for three groups under study. Again, similar trends are shown for both Group 1 and Group 2 when figures for 2012 and 2013 are compared. In contrast, the average electricity consumption per ft^2 has decreased in 2013 compared with 2012 for participants in Test Group Optimization Program.

Figure 5.7: Summer Electricity Consumption per ft^2 by Various Groups



The information provided in Figure 5.6 demonstrates that the Test Group participants reduced their 2013 average electricity consumption per ft^2 by an average of 5.24% and 17.33% compared to those included in Group 1 and Group 2, respectively.

5.2 *Estimated Deemed Average Electricity Savings*

Some may conclude that the best way to measure the impacts of Test Group Program is to compare energy savings by participants in this Program with those of Group 1 due to the fact that both groups were offered the option to rely on Optimization technology and participants in Group 1 knowingly opted out of the Program. Therefore, it is safe to conclude that the average electricity savings per ft^2 by participants in Test Group Program is 5.24%.

The 5.24% may be considered as a good proxy for real electricity savings if we could make a strong assumption that the only thing that differentiated among two groups was the issue of participation in Test Group Program. However, we cannot defend such a strong assumption. Rather we agree that it is highly possible that other factors, such as economic and demographic, could have also contributed toward the estimated 5.24% reduction in 2013 average electricity consumption per ft^2 by participants in Test Group Program. Therefore, we need to establish a methodology to isolate the portion of electricity savings that could come purely from participation in the Program.

To achieve that goal, we made a reasonable assumption that if everything, except for participation in Test Group Program, would remain the same, we could expect similar ratio of consumption between two groups when calculated for each of 2012 and 2013.[22] Using this method, we have:

$$(A/B) = (C/D)$$

$$Z = C - X$$

Where:

- A is Average Electricity consumption per ft^2 for Test Group in 2012
- B is Average Electricity consumption per ft^2 for Group 1 in 2012
- C is a proxy for Average Electricity consumption per ft^2 for Test Group in 2013 if there were no implementation of the Program
- D is Average Electricity consumption per ft^2 for Group 1 in 2013
- X is Average Electricity consumption per ft^2 for Test Group in 2013 where the Program was in effect
- Z is a proxy for Average Electricity consumption per ft^2 due to the implementation of Test Group Program in 2013

We can calculate C by replacing the other three values from Figure 5.5 in the above formula resulting in:

$$(4.2825397/4.3425303) = (C/4.1609795)$$

C = 4.1034969, then,

$$Z = 4.1034969 - 3.9431217 = 0.1603753 \text{ kWh}/ft^2$$

[22] The results would be the same if we would equate the percentage difference in electricity consumption between two groups in each year rather than equating their consumption ratios calculated for each year.

Calculating Z as a percentage of D will result in 3.8543% electricity savings per ft^2 for participants in 2013 Test Group Optimization Program.

We believe the 3.85% is a more accurate estimate of the minimum average electricity savings per ft^2 that could result due to the implementation of Test Group Optimization Program.

In summary, we can conclude that our deemed saving assessment indicates that the participants in the WeatherBug Home Pilot experienced a 5.24% whole house electricity savings per ft^2 for optimized houses during summer 2013. In that saving achievement, a 3.85% was directly attributable to the WeatherBug Home Optimization.

5.3 *Estimated Deemed Average Electricity Savings under various Weather Conditions*

Compared to 2011, which was one of the hottest summers in Texas, the 2013 summer should be considered a moderate one. To allow some estimates of the expected electricity savings due to variations in weather, data for Houston area Cooling Degree Days (CDD) is used to scale down or up the savings in 2012 or 2011, respectively. Both estimated savings discussed above, 5.24% and 3.85%, are used to calculate possible outcomes presented in Table 5.4.

Table 5.4: Percentage Average Electricity Savings per ft^2 under various Weather Conditions

	CDD	Optimization Savings	Total Electricity Savings
2013 Pilot	1173.04	3.85%	5.24%
2012 Weather	1146.10	3.76%	5.12%
2011 Weather	1383.11	4.44%	6.18%

In other words, if we had Test Group Program in effect in 2011, we would save electricity by an additional 0.59 % per ft^2 or an additional 15% more saving compared to similar figure for 2013. In contrast, if we had 2012 weather condition, we would see a reduction of 0.09 % per ft^2 or 2.3% in our electricity saving compared to similar figure for 2013.

In summary, the numbers provided in Table 5.4 offer a range of electricity savings that could be achieved in participating houses through the implementation of the Optimization technology given different weather conditions.

6 Observations and Lessons Learned

The Pilot provided a unique opportunity to learn about the implementation of a new technology, list major lessons learned, and identify areas for improvement to enhance various aspects of the WeatherBug Home EE and Demand-Response Program for full implementation throughout CenterPoint Energy service territory.

6.1 *Key Observations Regarding Pilot*

During the Pilot implementation, Earth Networks had several observations including the followings:

Observations included in executive summary:

1. While occupant comfort temperatures and schedules are generally consistent, the optimum thermostat schedule to achieve the optimum balance between comfort and efficiency varies daily and the primary source of this variability is the weather.
2. Detailed interval data - from thermostats, smart meters, and weather stations provide the opportunity to refine thermostat control for energy efficiency and load management with little impact on the consumer.
3. Solar insolence is a critical parameter to include when modeling the HVAC energy consumption, and internal temperatures of a house.
4. The WeatherBug Home Optimization lowered the peak load of participating houses on average, a particularly important point to service areas in need for more capacity during peak hours when the most expensive generation units are in operation
5. WeatherBug Home Optimization was used to minimize the amount of energy used to maintain occupant comfort. The WeatherBug Home Optimization could alternatively be implemented to minimize cost to maintain occupant comfort in a variable energy price or Peak Time Rebate (PTR) without compromising comfort.
6. While one brand of thermostat was used in this Pilot, the WeatherBug Home Optimization techniques can work on any two-way communicating thermostat currently on the market.
7. Optimization allows participants to save energy without actively controlling their thermostat or responding to generic behavioral messages to save energy by raising thermostat setpoints or adjusting thermostat schedules.
8. There is potential to achieve more EE savings by sending additional customized recommendations to participants using the results from WeatherBug Home's detailed analytics. The WeatherBug Home ScoreCard (Appendix 1) is one mechanism to graphically demonstrate techniques to the consumer about techniques for their individual house that result in further EE savings.

Additional Observations:

9. Only two EE techniques were employed in this Pilot. Additional EE techniques are available for piloting and should be tested for effectiveness in the future.
10. Thermostat limitations can limit the ability to employ some techniques – in particular, four setpoints per day limits more advanced control techniques.

11. WeatherBug Home Optimization works on all thermostat schedules. The amount of savings from the Optimization range from 0% for people with flat schedules with no set-back programming to 28% for people with efficient schedules and 8 degree or more set back programming.
12. Larger houses in the Pilot saved a larger percentage of energy than smaller houses. The variation between smaller and larger houses was interesting and should be further explored for additional opportunity in the future.
13. The largest energy savings are available by keeping the occupant comfortable when going into/coming out of setbacks. Control strategies that can consistently ensure occupant comfort can then take advantage of behavioral techniques to encourage larger thermostat setbacks, and larger EE savings.
14. Since WeatherBug Home Optimization achieves EE savings by raising the average temperature in the house through precise timing of thermostat setpoints, greater savings are expected when temperatures trend toward extremes.
15. The Pilot information reflects the impact of Optimization on early adopters of two-way thermostats, eager to explore new opportunities, and therefore serve as a representative sample of potential participants for the WeatherBug Home Program in the next few years. Additional savings may be achieved when these techniques are applied to a general population that is not as attentive to their thermostat settings or energy use as the Pilot participants.
16. DR events did not significantly change the EE savings of the Program. This is mainly due to the limited number hours that DR events were activated relative to the total number of hours in the summer.
17. Control group methodologies are the best way to perform Measurement and Verification (M&V) of EE programs. When using control groups, in addition to the number of thermostats in the control group, it is also important to structure them with house size, house age, and geographic location representative of the optimized population.

6.2 *Actions that Could Increase the EE Savings*

Once a house has been modeled and optimized, additional opportunities to use behavioral techniques that are informed with detailed data analytics present themselves.

1. Informing the consumer on the one action they can take regarding their thermostat setpoint programming that could save energy and money. This can be easily achieved through the details of the WeatherBug Home ScoreCard.
2. Informing the homeowner about their house shell and how efficient it is in various weather conditions (temperature, sun, wind, humidity). By identifying where the house shell is efficient and inefficient, the homeowner can then take action to mitigate the element that is causing the most inefficiency, thereby providing a cost-effective approach to reducing HVAC energy use.

3. Analytics described in this paper can also show the relative efficiency of the controlled HVAC system and identify to the homeowner how much energy and money can be saved by upgrading the system.

Appendix 1: ScoreCard

WeatherBug Home ScoreCard Example

Appendix 2: Excel File

Excel File Model Used to Support Various Tables and Figures Presented in this White Paper

The data collected for all DR Day Events and Test were collected and tabulated in an Excel File supporting various tables and figures presented in this white paper. The Excel File also includes various formulas used to calculate Customer Baseline Consumption and hourly average deemed peak demand reduction savings for various Events and Test.

A copy of the Excel File is provided to CenterPoint Energy. The File can be made available for interested researchers by contacting Dave Oberholzer at Earth Networks at doberholzer@earthnetworks.com .