Residential Energy Savings through Data Analytics

A Parks Associates Whitepaper

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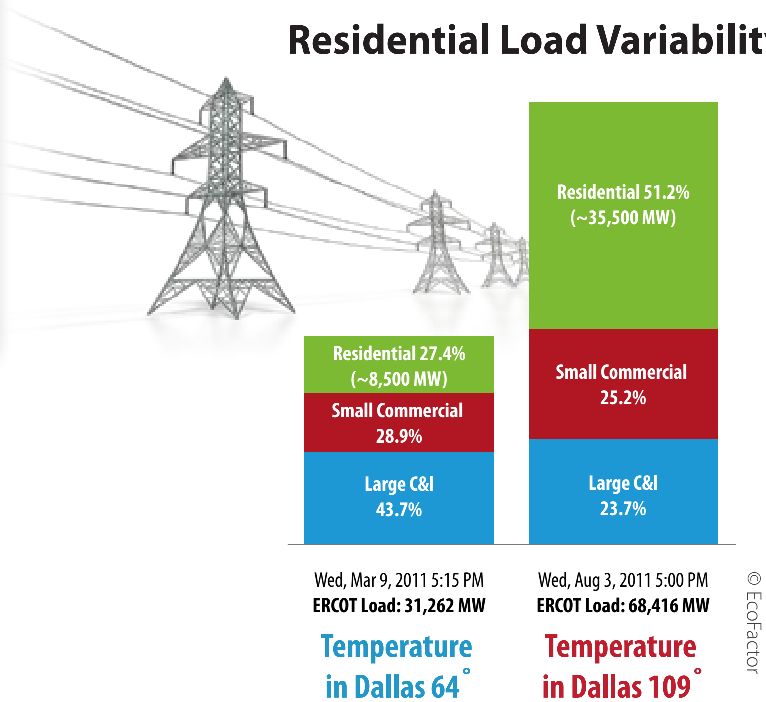
RESIDENTIAL ENERGY CONSUMPTION

The U.S. Department of Energy estimates that ***43% of the Energy*** CONSUMED BY RESIDENTIAL HOUSEHOLDS **goes to heating and cooling the home.**

In some regions in the U.S, the percentage **EXCEEDS 50%**.

Residential Load Variability

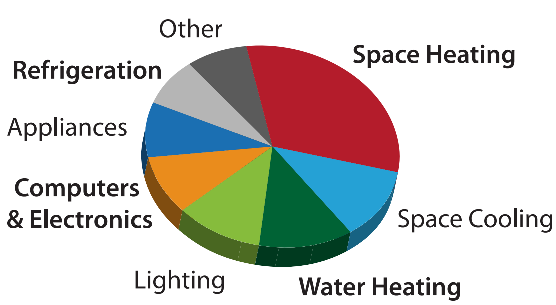


Not only is the cost of heating or cooling a home the largest component of the overall energy bill, heating and cooling equipment have considerable daily and seasonal variation in consumption patterns. Utilities must have adequate power generation to cover the most extreme days of the year. Some power plants are constructed to meet this demand and operate only a few hours a year, when the demand for electricity is at its peak.

Heating and cooling to maintain temperature during weather changes are **the primary cause for both daily and seasonal peaks** in energy consumption.

How Residential Energy is Used

U.S. Households



Source: U.S. Department of Energy | © Parks Associates

During peak summer temperatures, air conditioners run 90-100% of the time to keep pace with the peak heat load condition.[1]

Because heating and cooling are the largest component of the overall energy bill and contribute the most to the variability in demand at different times of day and days of the year, **there is a huge opportunity** for heating and cooling controls that would reduce both the base cost and the variability.

[1] http://www.fsec.ucf.edu/en/publications/html/FSEC-PF-328-97/

EVOLUTION OF HEATING & COOLING CONTROL SOLUTIONS

While the HVAC industry has expended considerable time and effort into improving equipment performance and the building industry improved building efficiency, the operation and control of equipment remain in the hands of the consumer.

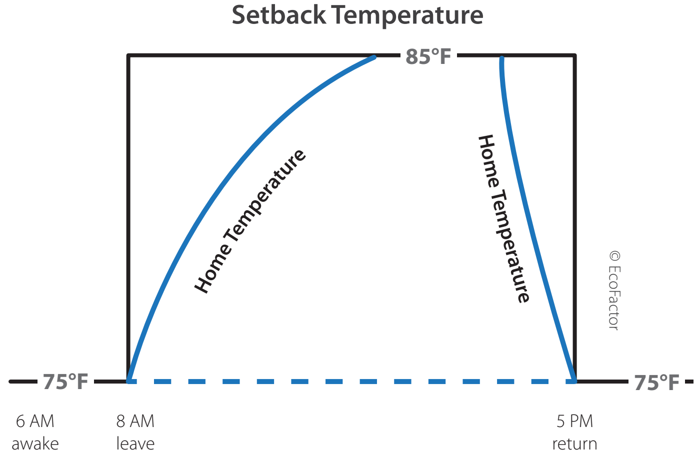
Unfortunately, the average consumer does not understand the operation of heating and cooling equipment; one example is the consumer tendency to believe, erroneously, that if the temperature set point is increased by several degrees, then the home temperature will change faster than if the temperature was changed by a single degree. This misunderstanding leads to significant waste.

PROGRAMMABLE THERMOSTATS

Most programmable thermostats allow the user to change the temperature setting for four different periods during the day. Users can program an awake time, a leave time, a return time, and a sleep time for each day. The savings from using a programmable thermostat are based on the setback temperature settings. Since the amount of heat flow between the inside and outside of a home is proportional to the temperature difference between inside and outside, increasing or decreasing the unoccupied temperature set point affects energy usage.

This figure shows how a typical programmable thermostat changes temperature set points to reduce energy consumption in the summer.

Temperature Settings for a Programmable Thermostat



Even though most thermostats sold today are programmable, ***not everyone takes advantage*** of the programmable features.

According to a Q4 2011 U.S. survey from Parks Associates, **54% of broadband households own a programmable thermostat.**

However, only 44% are highly confident that it is optimally programmed.

The user interface for most LCD screens is not easily understood. Confused users do not want to take the chance to program their system and come home to a cold house in the middle of winter.

Efforts to give consumers tools to conserve by programming their thermostat have not been effective. *Complexity associated with programming and variability in personal schedules prevents many from capturing the potential savings* from changing the set point temperature during periods when the home is not occupied.

AWAY FEATURE

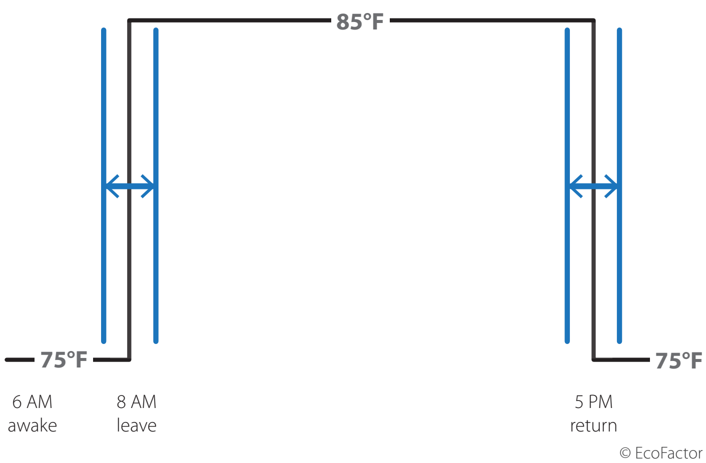
Since much of the savings from the use of a programmable thermostat comes from programming a setback temperature during unoccupied periods, *if a household does not have a period when everyone is away from the home consistently,* the homeowner **cannot take advantage** of that feature and the resulting savings.

Some new thermostats have a single button that works just like turning off the lights on the way out the door, allowing the consumer to set back the temperature by 2 to 4 degrees while they are out. When they return home, the homeowner can simply return the temperature to the normal set point. Because the temperature was set back by only a few degrees, the system is generally able to restore the home to the comfortable temperature quickly.

While this feature can help homeowners save money, *it requires them to remember to use it* and to make the effort to walk to the thermostat and press the button before leaving. Since thermostats are installed in central locations in the home that reflect the overall temperature, they are generally not located near the main entry door. There may be one on the first floor and another on the second floor, *requiring users to make a special trip to set back the thermostat when they leave*.

Therefore, only a small percentage of users actually use the away feature.

Variability in Actual Timing vs. Programmed Timing



ADAPTIVE HOME/AWAY ALGORITHM

Another issue with programming a specific time that everyone leaves the home and everyone returns is that *people do not always leave and return at the same time* every day. So on the days that they return home early during the winter, their house is too cold. On the days that they work late, the home is heated unnecessarily early, wasting money. If the thermostat understands the precise time when someone leaves and returns to the home, it can eliminate these problems.

There are several approaches that use manual inputs or separate devices or sensors to measure the time of departure and return.

THE FIRST METHOD requires the owner to notify the system when they leave and plan to return. New systems use smartphone applications to simplify this task.

ANOTHER METHOD involves using the GPS position of a mobile phone to know when someone has left the home and to estimate the return time based on mobile phone movement. The GPS in a car could be used in the same way.

A THIRD METHOD uses sensors, either within the thermostat or as part of a security system, to detect when someone is home. Electric meters can also be used in conjunction with other sensors to determine occupancy.

Understanding the precise departure and return times allows the system to adapt to the variability in an individual's schedule. As with the away feature in the thermostat, systems that require human interaction are less likely to be utilized.

Systems that automatically adapt to occupant behavior **would allow** for a more effective approach to eliminating waste.

OPTIMUM AWAY TEMPERATURE SETTING

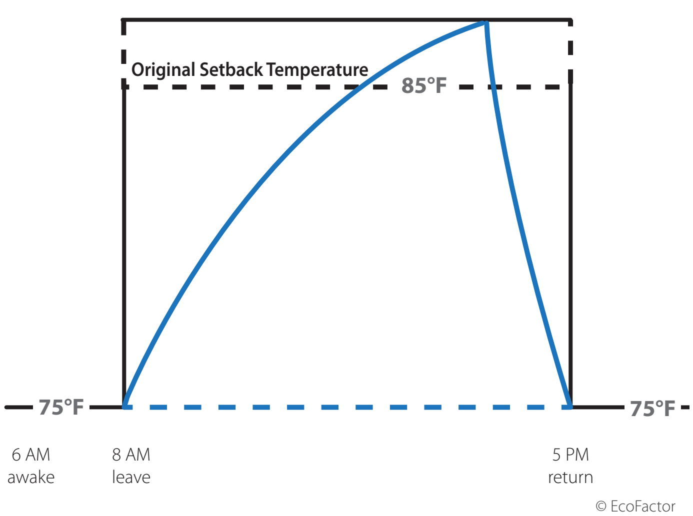
In previous examples, the setback temperature is set to 85°F. **The ideal setback temperature for each house depends on the weather, the building, and equipment performance**. Therefore, the best setback temperature varies for each day of the year.

For many homes, **the best setback temperature is simply the highest temperature that allows the system to recover** to the comfort setting by the return time.

From an energy perspective, the best temperature would eliminate all cycling at the setback temperature.

The home temperature would drift up until the air conditioner must turn on in order to recover the home temperature to the occupied set point.

Optimal Setback Temperature



In this example, the temperature set point was set to 85°F. But the ideal setting for this day was 86°F.

Because there is no good method for consumers to know what the best setback temperature is for their home on a given day, they are left to guess and, as a result, may waste energy by keeping their home too cool during unoccupied periods or cause discomfort by allowing their home to get too hot for the system to recover.

OPTIMIZING HUMAN COMFORT

Human comfort is dependent on many factors in addition to temperature. Humidity plays a big factor. In summer, 98% of people are satisfied with a temperature setting of 80°F at 20% humidity, 75° at 60% humidity, and 72° at 90% humidity.

Setting a thermostat to a **constant temperature** setting, *regardless of the humidity,* **will result in discomfort, wasted energy, or both.**

One day 75°F will feel fine. The next day it will feel too hot or too cold, causing the occupant to manually change the temperature setting.

Because most thermostats do not sense humidity, they do not control based on the combination of temperature and humidity. They control using temperature, and therefore owners must make manual adjustments to maintain comfort. Since humidity changes throughout the day, temperature set points must also change to maintain comfort.

Humidity is not the only factor that impacts comfort. *Radiant temperature, the temperature of the floors, ceilings, and walls in a room, also has a large impact*. The amount of air flow in a room is another key factor. At higher radiant levels, people feel comfortable at lower temperatures. Similarly, at higher air flows, people feel comfortable at higher temperatures.

Human comfort is not only dependent on environmental factors. *Activity level impacts comfort as well*. Comfort is determined by how easy it is for the body to maintain a constant temperature. When active, the body generates more heat and needs a cooler climate to maintain comfort. When inactive, the body generates less heat and can maintain comfort at a higher temperature.

Given the multiple environmental and personal factors that determine an individual's comfort level, *no thermostat control algorithm is able to make changes automatically* to account for all of these factors.

As a result, **energy is wasted** overcooling homes. **A new approach is needed**.

NEW SOLUTIONS

The cost to heat and cool a home is a function of equipment efficiency, building efficiency, and operation.

EQUIPMENT EFFICIENCY	Is a measure of the performance of the furnace and air-conditioning equipment and ducting.
BUILDING EFFICIENCY	The efficiency of the building is a measure of the insulation from outdoor temperatures and radiant energy as well as how airtight the building is.
OPERATION	The third factor, operation, is a measure of how the consumer uses and controls the system by turning it on or off and setting temperatures.

New solutions use weather information and the operating history of the thermostat to build a mathematical model of equipment performance and building performance. Those models, together with programming and user inputs such as manual adjustments, are then used to determine the best set point for each time period in the day, automatically making small changes to minimize energy consumption without sacrificing comfort.

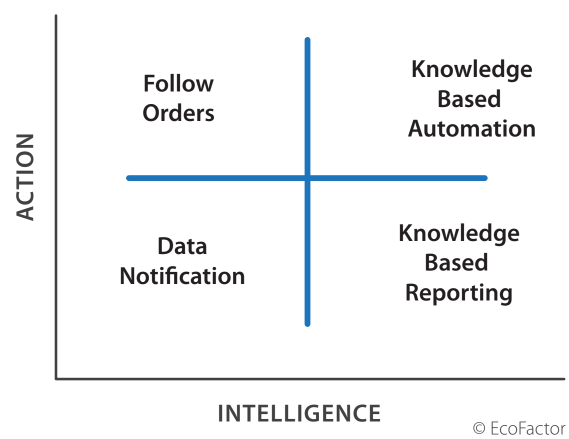
Models are also used to inform load shifting during demand response events.

For example, **the model can calculate the best temperature to pre-cool a home during summer, allowing the system to remain off during peak times**. Other uses include notifying the home dweller when there is a change in building or equipment performance. Notifications can be something simple such as informing users to close a window when the air conditioner is on or to replace an air filter. They can also be notifications such as alerts about degraded equipment performance. These analytics are valuable to both the homeowner and service contractors.

Data analytics presents a new approach to address this problem.

New data analytic systems add control capabilities to information gathering. With both superior intelligence and control, data analytics-based control provides a knowledge-based automation approach to the problem.

Data Analytics System Types



Physical Models

The behavior of a given home can be modeled in several ways. There are physical models that describe the thermal properties of the home and behavioral models that describe the occupancy and comfort of the inhabitants. The physical models of the home are created using a mountain of data collected each minute of the day from the thermostat and weather data sources. The thermostat provides the current set point and actual temperature in increments as fine as 0.2°F, the system operating mode, and the operating state (running, 1st, 2nd stage, etc.).

Weather data includes outside temperature, radiant load, humidity, and wind speed and direction. This data feeds a thermodynamic model of the home that can be used to predict the rate of temperature change when the system is running and when it is off. The input data and the thermodynamic model are then used to model system runtime.

The models understand the impact of different runtimes. Short run times, when the furnace cycles on for only a few minutes and then off, are sufficient to raise the air temperature only. Longer run times not only heat the air but can begin to store energy in the thermal mass of the home. Conversely, longer off times allow the air temperature to draw from the stored energy in the thermal mass and shorter off times reflect air temperature decreases due to higher loads.

> EcoFactor, *a leader in data analytics for residential energy management,* uses a combination of thermodynamic modeling and data mining to develop a unique model for each individual thermostat.

A combination of inverse modeling techniques is used to create the physical model. The intellectual property that enables EcoFactor to develop a model based on only thermostat data and external data sources such as weather differentiates it well in the market.

Prior to the EcoFactor approach, a home would have to be outfitted with 30-40 sensors costing thousands of dollars to accomplish similar results.

EcoFactor's proprietary modeling is effective with a single sensor in the home, the thermostat. EcoFactor's intellectual property includes nine patents with broad coverage across connected devices and cloud computing, giving them a dominant position in this space.

Comfort Model

While data analysis and the resulting building and equipment performance models have many advantages over basic thermostat controls, EcoFactor has also developed a novel approach to tackling the waste associated with over cooling or heating a space. Behavior or comfort models are developed by modeling occupancy patterns and recording all factors that impact human comfort including temperature, humidity, and radiant energy.

In addition the models extract every speck of information possible from manual adjustments to the thermostat. The EcoFactor behavior models are continuously updated with a learning layer that evaluates new data and updates all of the individual models for the home. While the physical models have a plethora of data from which to develop the model, the behavior model has less information and therefore uses artificial intelligence to create the model. The EcoFactor algorithm acknowledges the uncertainty that comes from insufficient data and continually incorporates new data to refine and reinforce the model. The learning layer provides updates as more data is gathered. When the model encounters a new situation, where the original model was extrapolated, the machine learning system replaces the extrapolated portion of the model with the updated factors at the new conditions.

For example, a model may be extrapolated to define the impact of an outside temperature of 105 degrees, but the precise changes in behavior and the thermal changes are updated on the one day of the summer when temperatures reach 105 degrees. Similarly, initial behavior models may have to be extrapolated for demand response events, but those models are refined after the system learns from each event.

EcoFactor's Knowledge-Based Automation

1. Equipment Performance Anomaly Detection

After the equipment performance model is defined, any variation in actual performance as compared to the model can be identified and that information passed to the homeowner and used to adjust operation. The analytics engine can detect minor degradation of equipment performance due to conditions such as a clogged air filter or a small leak in refrigerant as well as more severe system performance issues due to damaged duct work, a damaged blower motor, etc.

2. Building Performance Anomaly Detection

Building performance anomalies can also be identified. The system can measure the impact of adding new insulation or replacing windows on the overall building performance. Changes to the building performance over time can also be detected.

3. Optimum Unoccupied Setback Temperature

With models for building and equipment performance in hand, the knowledge based automation system is able to make smart decisions, calculating the ideal setback temperature for unoccupied periods. The calculations use weather forecasts to predict temperature rise. It also uses the building performance model that includes the impact of thermal mass of the home to understand when the system must start for the temperature of the home to be at a comfortable level by the time people return home.

4. Modeling for Weather Impacts on Comfort

EcoFactor collects weather data for a home's specific zip code from a weather service that is fed into the comfort model to understand what adjustments should be made to temperature to maintain comfort at the lowest possible cost. The system automatically adjusts the thermostat throughout the day to maintain comfort and eliminate waste due to over heating or cooling a space.

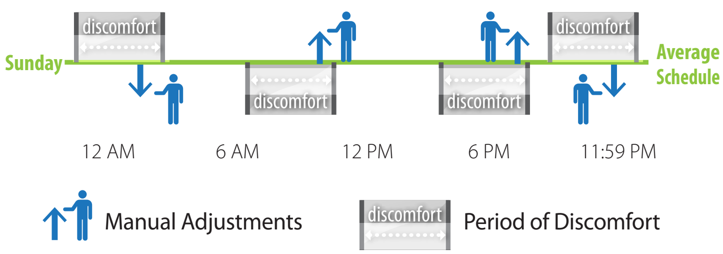
5. Modeling for Variations in Occupancy

EcoFactor uses data points from the thermostat to create the behavior model, which includes the occupancy status of the home. Understanding current occupancy status allows the EcoFactor analytics platform to adjust set points to maximize savings automatically.

6. Modeling for Variations in Activity, Human Comfort

EcoFactor also uses manual adjustments made by the homeowner to refine the comfort model for the home. Each manual adjustment is tracked and recorded to understand changes in homeowner behavior and adjust automated system controls to maximize both comfort and savings. The comfort model learns the homeowner preferences and makes automatic adjustments to maintain comfort at the lowest possible cost.

Using Manual Adjustments to Model Comfort



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7. Micro Adjustments

Once the comfort model is established, the thermostat moves to autopilot, automatically making small adjustments to the temperature set point to maximize comfort and eliminate all of the waste associated with over heating or cooling a space. The comfort model is also used to make adjustments automatically based on prior history of manual adjustments and eliminate waste due to mis-operation. Micro adjustments can be made during all operating periods of the day. Micro adjustments are also made to different control parameters within the thermostat to maximize equipment efficiency.

For example, during some periods of the day, the air conditioner may cycle on for only a few minutes. This short cycling of the system is less efficient and also reduces the lifetime of the HVAC equipment. EcoFactor's models can accurately predict runtime and eliminate short cycling by automatically detecting it and then adjusting the temperature dead band, eliminating short-cycling conditions and reducing overall runtime of the system.

QUANTIFYING ENERGY SAVINGS

Many different approaches are used to quantify savings for energy-efficiency programs. Energy audit companies often make claims based on past experience or national studies. Rarely are those savings estimates validated after the work is complete.

Utilities use a more disciplined methodical approach when evaluating energy efficiency.

A pilot program is designed, and participants are recruited to evaluate a specific product or technology. The study participants are usually then divided into groups. One group is a control group that receives no treatment, and a second group is provided with the new product or service. Each pilot participant is closely monitored, and measurements compare the two groups.

While this approach is thorough, it has several flaws. The first source of error comes from sampling. Sampling error occurs when the participants in the study do not accurately represent the overall population. Consumer attitudes and motivations toward energy savings can be broken into many different segments. Individual attitudes regarding comfort, control, and savings vary dramatically. Some people prioritize control over savings and comfort; others favor savings over comfort and control. Over or under sampling these different segments will have a significant impact on the results.

Given that participation in energy pilots is voluntary, it is likely that utilities oversample the segment interested in energy savings and under sample the majority of the population that are not actively engaged in energy-saving programs.

Once the pilot is completed, the results are used to estimate the impact on the overall population. Unfortunately, in most cases, there is no good method to determine the effectiveness of the program on the overall population after deployment.

Many behavior-based programs fall into this category. Participants are given feedback in the form of real-time energy information, comparative data on energy consumption, and recommendations on how to change their behavior to reduce energy consumption.

Studies indicate that these behavior-based programs result in an average of 2-3% savings for an individual consumer.

In most of these programs, consumers are advised to make investments in better insulation, new windows, CFL or LED bulbs, or new appliances based on typical savings. If the program collects more detailed information on the home, the savings estimates can be refined; however, the actual savings remain dependent on many factors. While gamification and other approaches to consumer engagement may improve the engagement of some customers, most consumers spend only minutes each year thinking about energy. Solutions that automate savings rather than depend upon individual initiative are more likely to succeed with a broad customer base.

Before connected devices and smart meters, *validation of actual savings was not feasible*.

With the advent of connected devices, savings can be quantified with much greater precision than ever before. EcoFactor uses a groundbreaking approach, using data analytics to create physical models of the home to model equipment runtime. The runtime model can be combined with fuel type and cost of fuel to calculate savings in dollars as well as return on investment. Using the runtime model, EcoFactor can estimate what the runtime ***would have been***, if no micro adjustments were made, and compare that to the actual runtime. The difference is the savings.

Instead of estimating the savings, or applying a static sample to a dynamic population, EcoFactor calculates the actual savings for each thermostat in each home. This approach is far superior to using results from a study or a statistical sample.

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BASELINE COMPARISONS

The industry has a significant problem when it comes to comparing results of savings from different HVAC energy-efficiency programs. The root of the problem is that there is no consistent baseline from which comparisons can be made.

The industry needs to define a baseline case from which vendors can estimate the equipment runtime and resulting energy cost.

In the case of thermostats, since according to a Q4 2011 Parks Associates survey, 54% of people do not program their thermostats to automatically change temperature set points throughout the day, the baseline case for thermostat control should be when the thermostat is held at a constant temperature. If the baseline case is set to 72 degrees, the savings are more substantial (in the air-conditioning context) than if the baseline is set to 75 degrees or the EPA's recommended 78 degrees for the summer.

Without a standard baseline, there is no way to compare savings between different approaches. One vendor may claim up to 20% savings, but without knowing the basis for that claim, consumers have no means to make a valid comparison. Because this is the case, vendors are encouraged to use a low number such as 72 degrees as the baseline for comparison. EcoFactor uses a baseline of 75 degrees, which represents the most realistic summertime temperature set point.

CALCULATION OF SAVINGS

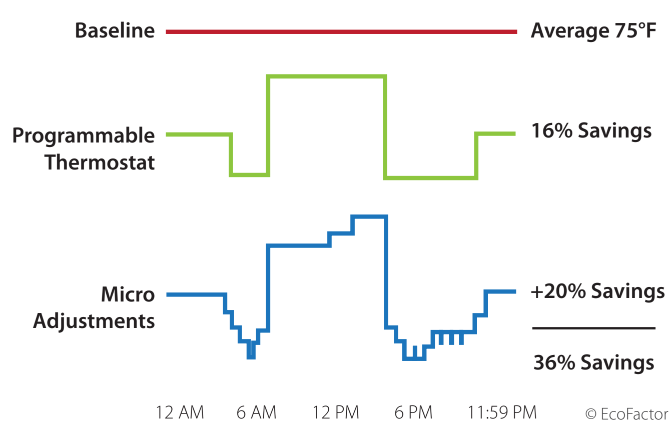
EcoFactor uses a two-step approach to calculating savings. When new customers begin using the EcoFactor service, they use an online tool to help guide them through the process of programming their thermostat. The savings from this first step are calculated to be up to 16% as compared to the baseline condition, a constant 75°F temperature set point. That means that the AC unit runs 16% less time after consumers use the programming wizard than it would have if the temperature remained at a constant 75°F. Although the savings from properly programming a thermostat are real, this portion of the savings are not counted when EcoFactor reports savings to customers.

The second step, the modeling process, usually takes approximately two weeks to complete. During that time, the system is operating like a programmable thermostat and collecting data to create the model. After the two-week data collection period, the models are developed, and the system begins to make micro adjustments, automatically making changes in the background and continuing to learn and refine models.

MICROADJUSTMENTS

Micro adjustments, *the 20 to 30 small changes to the temperature and other thermostat parameters each day,* provide up to an **incremental 20% savings**, so that overall, the systems runs up to **36% less time** than it would have at the baseline condition.

Average Temperature Baseline, Programmable Thermostat, and Micro Adjustments
based on Data Mining and Analytics



USING DATA ANALYTICS TO IMPROVE DEMAND RESPONSE

From a utility perspective, the objective of demand response programs is to maximize the load that is reduced during the DR event. Traditional thermostat-based demand response programs have override rates as high as 10%.[2] People sign up for the program, but when the time comes, they manually override the thermostat set point changes. In many cases, the manual adjustments actually result in longer equipment runtimes during the demand response events.

When people become uncomfortable and discover that their thermostat set points have been changed, ***a common reaction is to not merely undo the DR-related set point increase but to push back*** *by choosing a set point that is lower than the normal set point*.

The AC system must run longer to reach this new set point, thus consuming more energy than it would have without the DR event.

Instead of inflicting pain during a DR event that reduces participation and long-term effectiveness of a program, a data analytics-based approach seeks to eliminate the pain and expand participation, thereby maximizing effectiveness of the DR program. The EcoFactor load-shifting solution uses a combination of both physical and behavioral models to define the pre-cooling strategy and event strategy. Pre-cooling uses the thermal mass within the home as a thermal battery, storing energy before the event that will be used to cool the home during the DR event. EcoFactor has developed a proprietary solution that models the thermal mass in the home and controls the temperature set point to maintain comfort and store energy prior to DR event.

The simplest context for optimizing a DR event is when the home is unoccupied.

During this condition, the model only needs to calculate the setback temperature that will keep the AC unit off during the event. For example, many programs use a 4-degree set point change at the start of a demand event to allow the system to remain off for the majority of the event. A typical day-ahead demand response event will last anywhere from 1 hour to 3 hours. The objective is to keep the home cool and comfortable before and during the event and, at the same time, shift load away from the event. Using the physical models for the home, EcoFactor calculates how much thermal energy it must store in the home to allow the AC to remain off during the event.

The solution gets more complicated when the home is occupied. A behavioral model is then layered on top of the thermal model to adjust the pre-cooling and event strategies to assure that the individual homeowner will remain comfortable. The behavioral model takes into account the previously expressed preferences of occupants in order to minimize "angry" overrides and thus runtime.

The combination of the physical models and behavioral models radically improves all metrics. The number of people that opt out of an individual event is small; the number of people who cancel their subscription to the program is small; and the total load shed during the event is maximized.

TRADITIONAL DEMAND RESPONSE PROGRAMS **do not account for comfort**; *therefore,* some public utility commissions have **limited the maximum load** shed permitted during an event to **67%**,

—which means—

the AC system **remains off two-thirds** or **67% of the time** during the DR event.

[2] http://www.coned.com/documents/Con%20Edison%20Callable%20Load%20Study_Final%20Report_5-15-08.pdf

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ECOFACTOR CASE STUDY —NEVADA ENERGY

Nevada Energy has implemented EcoFactor's pre-cooling approach and has achieved outstanding results. In the last 2-hour demand response event in Las Vegas and Reno for the 2012 DR season, Nevada Energy was able to achieve 94.5% off in Las Vegas and 99% off in Reno. That means that during the 120 minutes of the event, the average system only ran just over one minute in Reno and less than seven minutes in Las Vegas.

These are actual results measured across all systems in real time, not simulated, estimated, or extrapolated from a limited sample. These results include everyone who opted out of the event by manually adjusting their thermostat.

Overall, Nevada Energy was able to achieve an average load shed of greater than 3.0 KW per home, which is significantly better than the results previously achieved by other residential thermostat load-shed programs used by NV energy.

Since consumer comfort is a priority in the EcoFactor approach, as soon as a consumer makes a manual change to the thermostat either during pre-cool or during the DR period, EcoFactor stops making micro adjustments, using the manual change in temperature set point as an expression of dissatisfaction. That feedback is used to refine the behavioral model for an individual home so that future events will include micro adjustments intended to increase comfort and hopefully reduce the number of manual adjustments. Understanding how an individual reacts to one event allows the model to learn that behavior and prevents opt outs in future events.

QUANTIFY RESULTS OF DR PROGRAMS

Most DR programs are evaluated by placing meters on a small sample of homes and applying the results of that sample to the overall population. This approach has several sources of error.

First there is sample error, meaning that the sample may not accurately represent the population.

The second is that the sample does not account for changes over time. Participation in any program that causes discomfort will reduce over time as people opt out and actively work to disable the equipment installed on the premises.

> Connected devices allow measurement in near real time.

Since the status of every thermostat is reported once per minute, the knowledge-based automation system knows whether the AC unit is running or not running.

Connected devices allow utilities to understand the precise impact of a specific program ***almost immediately*** after the event takes place.

PARTNERSHIP OPPORTUNITIES

CONSUMER VALUE PROPOSITION

From a consumer perspective, the EcoFactor solution is a smart investment. Most investments in energy-saving equipment have a ROI measured in years or even decades. Solar panels and new appliances offer good energy savings but require a significant up-front investment. The EcoFactor solution requires only a nominal investment in hardware and provides an immediate cost savings.

In the near future, as the installed base of Internet-enabled thermostats grows, consumers will be able to connect to the EcoFactor service using their existing connected thermostats, eliminating the need for any up-front investment.

In addition to the energy savings, the EcoFactor solution provides additional functionality and convenience in the form of remote access using a smartphone application and operating feedback that identifies degradation of equipment or building performance.

LOAD-SHIFTING APPLICATIONS

While load shifting is most often deployed as part of a utility-led, incentive-based DR program, the technology can be applied to many use cases.

- Critical peak incentive-based DR programs.
- Using HVAC system load to offset supply variability in areas with high renewable generation capacity, storing energy in thermal mass during periods of excess supply (i.e., high wind generation at night when loads are small), or shedding load for short periods when renewable supply is reduced.
- Programs to minimize the impact on consumers of time-of-use rate structures. Utilities can offer consumers tools that automatically adjustment to dynamic pricing, providing comfort at lower cost.
- Programs to aggregate load and bid into wholesale forward capacity or day-ahead energy markets. Because connected devices have very low latency, the system is not restricted to day-ahead markets. Low latency means that participation in hour-ahead or real-time markets is also possible.

PATHS TO MARKET

Perhaps the most intriguing aspect of the EcoFactor solution is its ability to deliver value to both the consumer and the utility. The energy-savings capability can be bundled with numerous products and services and delivered through multiple channels. Cable and telecom partners, security service providers, thermostat and HVAC OEMs, and dealers are all potential partners that would reap huge benefits by offering the EcoFactor service.

The EcoFactor software as a service business model is suitable for service providers with ongoing billing relationships with consumers. Cable and telecom operators, working to leverage their connection to the home and to the consumer, are adding numerous services to their portfolios, and energy services have a unique potential.

A service that **saves consumers money effectively lowers the cost** of the overall service bundle.

If the service saves a cable subscriber $15 per month, it may be thought of as giving her HBO for free. Security service firms could offer a similar value proposition; the energy savings pays a portion of the fee for a security monitoring service. In addition to the energy savings, service providers can act as aggregators of demand response capacity, providing additional savings to the consumer and/or revenue to the service provider.

HVAC dealers with long-term service contracts to maintain HVAC equipment can also add the EcoFactor service to their contracts and deliver savings to the consumer that nearly pays for the maintenance contract. Bundling EcoFactor with a new system sale provides HVAC dealers with a unique solution that saves consumers money over a competitor's system.

Parks Associates research indicates that consumers will pay a multiple of the annual energy savings when purchasing new equipment.

Utilities are also a large channel. Although most utility's actions are dictated by regulatory compliance, making them slow-moving, those utilities that have aggressive DR or EE goals for the residential sector are ideal candidates.

As is the case today, different bundling options and packages of services will emerge as energy-efficiency programs are added to the portfolios of service providers. Some companies will discount the hardware and installation cost in return for higher monthly fees or longer contract periods. Others will pass through the hardware and installation costs or bundle them with other equipment sold at higher margins.

On the recurring-revenue side, some businesses will discount the monthly fees for the energy savings and will capture profit as an aggregator. In industries with high churn, they will use the service to minimize churn and reduce customer acquisition costs. Others will simply try to maximize recurring revenue. Utilities are in a unique position by virtue of their business model. They can choose to give away the savings for energy efficiency in return for participation in demand response programs where they will mitigate risk and potentially drive profit from energy markets.

The EcoFactor solution is provided to partners using a software-as-a-service business model. EcoFactor can be used with a variety of communicating thermostats. Since EcoFactor does not sell thermostats, the partner is free to choose any compatible thermostat. EcoFactor has integrated with both ZigBee HA and Z-Wave thermostats and is currently expanding to include WiFi devices. ZigBee and Z-Wave devices require a gateway to convert the ZigBee or Z-Wave signals to Ethernet to the home router. Wi-Fi thermostats do not require this separate bridge. In each case, the on-site provisioning process takes only a few minutes for an installer to complete.

EcoFactor partners with local, regional, and national HVAC service providers for installation services. Some of EcoFactor's partners are also pushing hardware providers to make the devices easy for consumers to self-install.

EcoFactor has numerous partners in the utility space. Utilities are especially interested in delivering a demand response program with minimal negative feedback from consumers. Because the EcoFactor solution models comfort and building performance, it can greatly reduce customer complaints after a demand response event.

Comcast is EcoFactor's most notable MSO partner. As cable and telecom operators add home security and home control services to their array of service offerings, adding an enhanced energy management system including EcoFactor's solution provides another means to create value for consumers.

The data analytics solution applied to thermostat control has many other applications. The existing solution can most easily be ported to water heater control. Water heaters represent the second-largest energy load in the home, and the built-in energy-storage capability make electric water heaters well suited for demand response programs.

CONCLUSIONS

Data analytics is the ideal tool to identify and eliminate all forms of waste in a control system. Creating a model to characterize building performance, equipment performance, and homeowner comfort allows controls to be optimized for both comfort and cost, eliminating waste from:

- Mis-operation, excessive manual adjustments
- Changes in humidity
- Building envelope issues that affects its ability to resist the influence of outside weather conditions
- Changes in upcoming weather
- Changes and variability in repetitive occupancy periods
- Incorrect setback temperature settings for unoccupied periods
- Changes and variability in irregular unoccupied periods

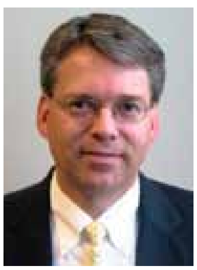
The same technology can be applied to other devices in the home as well, expanding the potential for savings beyond the significant reduction in runtime of HVAC equipment to other large loads in the home.

Sponsored By EcoFactor

EcoFactor is the leading residential energy management company that enables home service providers to offer an energy management service to their customers that does not require them to compromise comfort or change behavior. The EcoFactor platform uses data from communicating thermostats to determine the unique thermal characteristics of each home and automatically optimize energy use to eliminate waste and save money.

Based in Redwood City, Calif., EcoFactor was founded in 2006 to provide an automated alternative to behavior-based residential energy management solutions. EcoFactor is privately held and funded by Claremont Creek Ventures and RockPort Capital Partners. www.**ecofactor**.com

ABOUT THE AUTHOR



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Tom leads Parks Associates research in the areas of home controls, energy management, and home networks. Tom's work includes industry reports, consumer and utility industry survey work, and consulting engagements to leading home systems device and service companies. Tom regularly speaks at industry conferences in the U.S and abroad and is a frequent guest at client planning meetings.

Prior to joining the firm, Tom was a client of Parks Associates' Home Energy Management service (2010) while serving Lennox Industries as Corporate Director, Advanced Engineering and as Director of Product Management. Tom has previously worked in the utilities industry, the consumer goods industry, and for Motorola in the telecom industry. He holds a MS in Software Engineering from the University of Texas and a BS in Systems Engineering from the United States Naval Academy.

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Parks Associates is an internationally recognized market research and consulting company specializing in emerging consumer technology products and services. Founded in 1986, Parks Associates creates research capital for companies ranging from Fortune 500 to small start-ups through market reports, primary studies, consumer research, custom research, workshops, executive conferences, and annual service subscriptions.

The company's expertise includes new media, digital entertainment and gaming, home networks, Internet and television services, digital health, mobile applications and services, consumer electronics, energy management, and home control systems and security.

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