@ECO FACTOR

Integrated Demand Side Management Using a 2-Way Communicating Thermostat

1. We have leveraged PIER-sponsored research through the Center for the Built Environment at UC Berkeley and Professors David Auslander and Edward Arens to create a system that:

   a) Can reduce A/C compressor and furnace cycle times by 40% without compromising homeowner comfort
   b) Can automate consumer optimization for time-variant pricing
   c) Optimizes consumer control while delivering on utility DR and EE goals

2. These results can be achieved with just a basic 2-way communicating thermostat. Rather than increase the computing power (and thereby cost) of every thermostat, we:

   a) Leverage the growing infrastructure of the Internet
   b) Utilize a centrally located commercial grade software system to provide home-specific energy saving recommendations directly to the thermostat.
   c) Preserve consumer control of all parameters:

      i. Each homeowner decides if they want to manually implement the savings measures or if they want the savings strategies to be automatically implemented
      ii. At any time a simple push of the up or down button on the thermostat can override the recommendation

3. The science behind the system:

   a) The centrally located software analyzes the data provided by the 2-way communicating thermostat and determines the "dynamic signature" of each individual home under varying conditions, which allows us to accurately predict:

      i. How much energy and time it will take for the HVAC system to change the temperature inside the home by one degree
      ii. When the HVAC is turned off, how quickly that temperature change dissipates
      iii. HVAC cycling and inside temperatures 24 hours into the future, which allows us to model multiple programs to find the one that is most efficient for that house on that day, and to predict hourly HVAC energy consumption

b) Consumers are concerned about high utility bills. Energy management software can give homeowners unprecedented insight into WHY their bills are so high. Dynamic signature-based energy management software can distinguish between and quantify problems caused by:

   i. The energy efficiency of the structure (insulation, windows, etc.)
   ii. The size and current working condition of the HVAC system
   iii. The behavior of the homeowner (setback utilization, manual overrides, etc.)

c) The detailed profile of each home can be used to assign a letter grade for each of these contributors to energy consumption to let the homeowner know where improvement is needed and why their bills are high.

4. When managed properly, the same device (the communicating thermostat) that generates large Energy Efficiency/Conservation savings for the consumer can also deliver significant value back to the grid -- benefits that go well beyond simple centrally triggered setpoint changes. An optimized software service can:

   a) Improve AC load forecasting
   b) Drive greater adoption of residential DR because the consumer maintains control and can elect to participate, and if participating can choose to pre-cool or not
   c) Deliver increased yield of DR per AC unit through optimized pre-cooling (load shifting)
   d) Improve visibility and accounting for DR events through real-time reporting

5. These capabilities are not distant pipe dreams; not only can all of these things be done – EcoFactor can do them **right now**.

   a) EcoFactor has two current trial programs, one in the Northern Hemisphere in Minneapolis Minnesota and another in the Southern Hemisphere in Adelaide South Australia, which allows summer and winter testing simultaneously.
   b) EcoFactor has proven substantial energy savings and enhanced user comfort and satisfaction as well as the ability to effectively pre-cool single-family residences so that demand response is significantly enhanced.
   c) For more Information contact:

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Remote Optimization of HVAC for Efficiency and Demand Response:

2007-2008 Global Field Trial Results of
EcoFactor's Integrated Demand Side Management solution

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ABSTRACT

EcoFactor has developed a residential and small commercial energy management service that delivers both double-digit energy savings and significantly enhanced demand response, thereby achieving true integrated demand side management using only a two-way communicating thermostat. Field tests in Minnesota and South Australia have demonstrated that the EcoFactor service can optimize user behavior in ways that significantly reduce energy use; transparently deploy sophisticated control algorithms that decrease consumption without affecting comfort; accurately characterize the thermal behavior of individual houses; and deploy customized pre-cooling strategies that can save consumers money by optimizing for time of use rates and increase the demand response available from many homes by 20%.

SUMMARY

Problem Addressed

Electric utilities face significant and growing problems related to the imbalance between the demand for and supply of electricity, which varies dramatically between January and July, and between 4AM and 4PM. Historically, the only way utilities could meet peak demands was to buy or generate additional supply. Recently utilities have begun to resolve that imbalance more efficiently by paying customers to deliver "demand response" – to reduce electricity consumption on request during a handful of peak periods each season. The largest component of peak load is generally residential air conditioning, but first-generation demand response solutions have met with limited success as applied to the residential market.

At the same time, rising energy prices are motivating consumers to find ways to reduce overall consumption. Because space heating and cooling are the largest components of most energy bills, increasing the efficiency of the HVAC system can yield significantly greater savings than most other efficiency plays, such as compact fluorescent light bulbs.[i] Utilities are facing growing pressure from regulators to drive more efficient energy consumption, and to offer programs that integrate energy efficiency with demand response.

The EcoFactor Solution

EcoFactor addresses both of these critical needs. It provides more flexible, intelligent and efficient demand response during peak days, but also about provides consumers the tools to automate and refine their energy consumption year round. By combining these two benefits, it delivers a true Integrated Demand Side Management solution for electric utilities.

Our SaaS platform will work with any manufacturer's two-way communicating thermostat and has proven to increase the effectiveness of a utility-triggered DR event (that is, increases the effective DR yield per A/C system) by more than 20% by utilizing a pre-cooling/storage strategy customized for each participating home. And on non DR days, the EcoFactor service offers energy savings of as much as 40% (an average of $400/year) – *without* decreasing comfort and *without* requiring active energy management by the homeowner– through individualized and weather-specific optimization of HVAC usage.

The keys to EcoFactor's patent-pending service are the data we collect and what we are able to do with it. Traditional programmable thermostats may be thought of as glorified switches. EcoFactor gains access to a wealth of data by using the thermostat as a networked sensor. Like conventional unconnected devices, EcoFactor-enabled thermostats measure temperature. But EcoFactor combines that data with information from other sources to create a highly accurate window into the performance of the building and its HVAC system, as well as into the behavior and preferences of the occupants. By logging temperature and HVAC cycling behavior as reported by the thermostat every 60 seconds, EcoFactor is able to determine the "dynamic signature" of the home – its ability to store and reject heat under changing conditions. By logging all of the inputs to the system – including the changing preferences of the occupants as expressed each time the "up" and "down" buttons are pressed – we are able to learn about the preferences and schedules of the occupants, which will allow us to decrease energy consumption without decreasing comfort.

The Field Study

EcoFactor began field trials in December 2007. Ecofactor tested winter and summer algorithms simultaneously by deploying the service to twelve homes in Minnesota and ten in South Australia. These deployments have already confirmed EcoFactor's fundamental value proposition: that an optimized two-way communicating thermostat service can both deliver significant savings to consumers and provide an automated and verifiable means to increase the yield of DR per home while improving consumer acceptance.

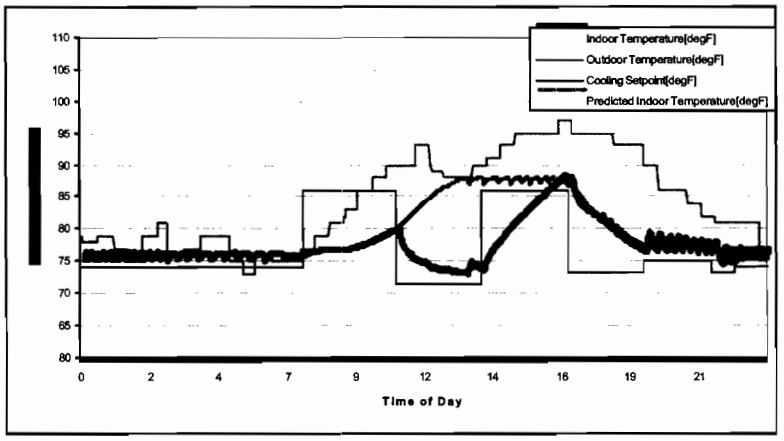
Significant findings include the following:

User acceptance: In Minnesota, 376 of 552 consumers surveyed volunteered to participate in the field trial, compared to the 1-2% opt-in rates typical of utility programs. As of May 10, 2008 all 12 Minnesota homes continue to use the service. 9 of 10 Adelaide users continue to use the service; the 10th sold his house, but asked to keep the system and plans to install the hardware in his new home. In traditional DR programs, large numbers of customers tend to seek to withdraw after each DR event.

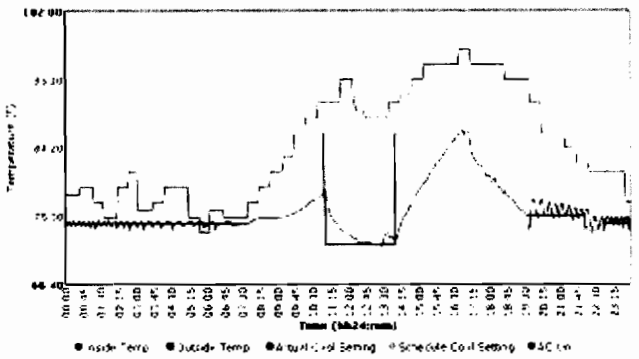
Behavior: EcoFactor demonstrated that consumer preferences as manifested in HVAC usage vary dramatically, and that those differences directly resulted in differences of as much as 25% in energy consumption between otherwise identical homes. EcoFactor also showed that its analytics can influence consumers to significantly alter their behavior. Those changes included adoption of recommended setback schedules that reduced manual thermostat over-rides by more than 90% and by adopting significantly more energy efficient setback schedules.

Dynamic Signature and Temperature Prediction: EcoFactor demonstrated the ability to determine the dynamic signatures (thermal mass as manifested under varying conditions) of individual structures, with a high degree of accuracy, using only a single sensor: a 2-way communicating thermostat. After only 3 days of monitoring a home, EcoFactor's dynamic signature algorithms can predict temperature several hours in advance with a margin of error of less than 2%.

"What if" modeling: EcoFactor demonstrated the ability to leverage its real data and algorithms by comparing results from each home to alternative heating/cooling strategies as they would affect each individual house. This ability to model future events and HVAC behavior also translates into the ability to forecast loads.



Pre-cooling: EcoFactor has show that, in a time-variant pricing environment, its intelligent pre-conditioning can save consumers significant energy costs and shift demand from higher to lower-priced periods. It was also shown the differences in dynamic signatures between homes make one-size-fits-all pre-cooling programs impractical. Load shifting works on many homes, but efficacy is highly dependent on weather conditions and occupant behavior. Using time-of-use price tiers from actual Pacific Gas & Electric tariffs, EcoFactor would have saved 5.5% of air conditioning costs on the days tested while shifting 100% of the air conditioning load out of the peak period. Applying TOU rates more conducive to pre-cooling (by eliminating the "part peak" shoulder immediately preceding the peak period) would increase the savings from pre-cooling to 16%.



Demand Response: EcoFactor proved that individualized pre-cooling strategies can improve the yield of kilowatts of DR per residential air conditioner by more than 20%.

Just-in-time Preconditioning: EcoFactor has demonstrated that it can predict with a high degree of accuracy what the temperature inside a home will be several hours into the future. EcoFactor leveraged that ability by pre-conditioning homes to a desired temperature at a desired time over a broad range of conditions to an accuracy of roughly one-half degree Fahrenheit, well below the generally accepted threshold of detectabilty.

Sawtooth algorithm: EcoFactor developed and deployed a "sawtooth" waveform algorithm that saved an average of 5.5% of heating costs in 9 Minnesota homes over a two-month period. The tests also demonstrated that the algorithm was well-tolerated and in fact apparently unnoticed by occupants under almost all circumstances.

Anomaly Detection: EcoFactor has demonstrated that its dynamic signature modeling is sufficiently precise that it can reliably detect anomalies such as open windows. By calculating the differential between "what should have been" and reality (open window) behavior can now be directly mapped into energy savings/loss.