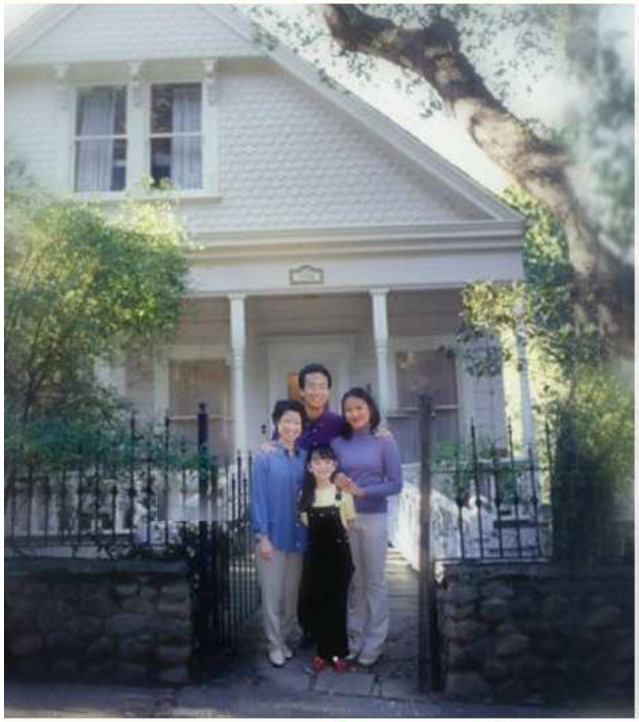


Optimizing HVAC Programming Behavior Remotely to Enhance Energy Efficiency and Demand Response: *A Residential Field Study*

John Steinberg
CEO – EcoFactor

BECC - November 2008

A Big Challenge:

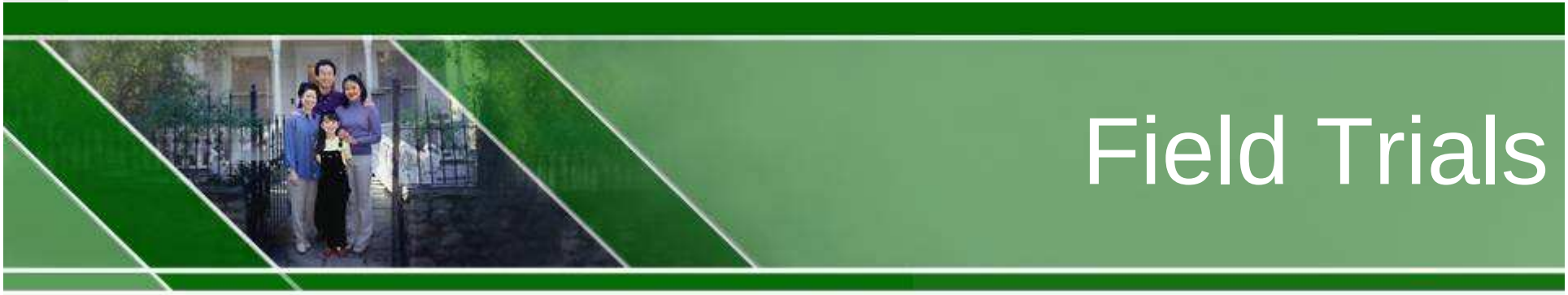
How do you measure the impact of behavior on the heating and cooling of homes?

- Faucet/valve fallacy
- Mapping of fixed numbers to comfort
- Poor programming for when house is unoccupied (“away” strategies)

- 50%+ of programmable thermostats aren’t
- Ad hoc use of “up/down” arrows to manage comfort (even with programming)

A Bigger Challenge:

How do you reduce the impact of these behaviors?



Field Trials

In December of 2007, EcoFactor began trials of a new HVAC management service

The objective:

1. Capture detailed real-world residential HVAC usage data
2. Find and quantify operational inefficiencies
3. Understand how building envelope + HVAC System + behavior (operational efficiency) affect energy consumption (Dynamic Signatures)
4. Determine if automation of HVAC operations results in significant savings

Testing Grounds

- 12 occupied homes: Minneapolis MN
- 10 occupied homes: Adelaide South Australia
- Simultaneous Winter and Summer testing
- Diverse home types
- Cluster of identical homes in a recent development

The Installed Device

- Replaced existing thermostat with off-the-shelf two-way communicating thermostat
- Used homeowner's broadband Internet connection to create bi-directional communication between thermostat and EcoFactor servers in California

QuickTime™ and a
decompressor
are needed to see this picture.

A Daunting Task

- Collect > 25,000 points of data for each house every day
- Analyze the data in near real-time to identify inefficiencies
- Take action that results in energy savings, improved occupant comfort and convenience

Folklore Example: Summer “Away” Cooling

- Two identical homes (structure, location, HVAC)
- Similar family composition
- Neither family was home during the day– both parents worked and child was at school
- Same intent to maximize energy efficiency, but two very different cooling strategies

The Two Strategies

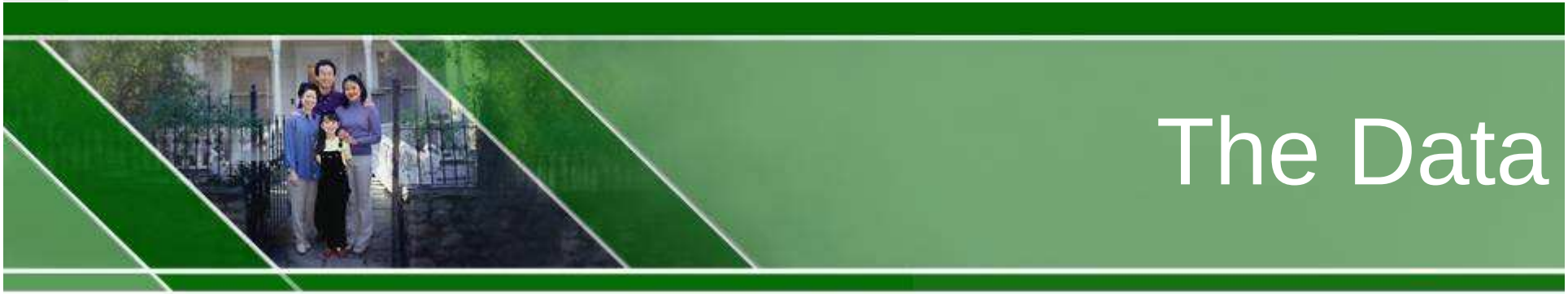
Home #1

- Never lets the home get above 80 degrees.
- Reasoning: because the AC system will use too much energy to get the temperature down to a comfortable level by the time they get home if they let it go any higher.

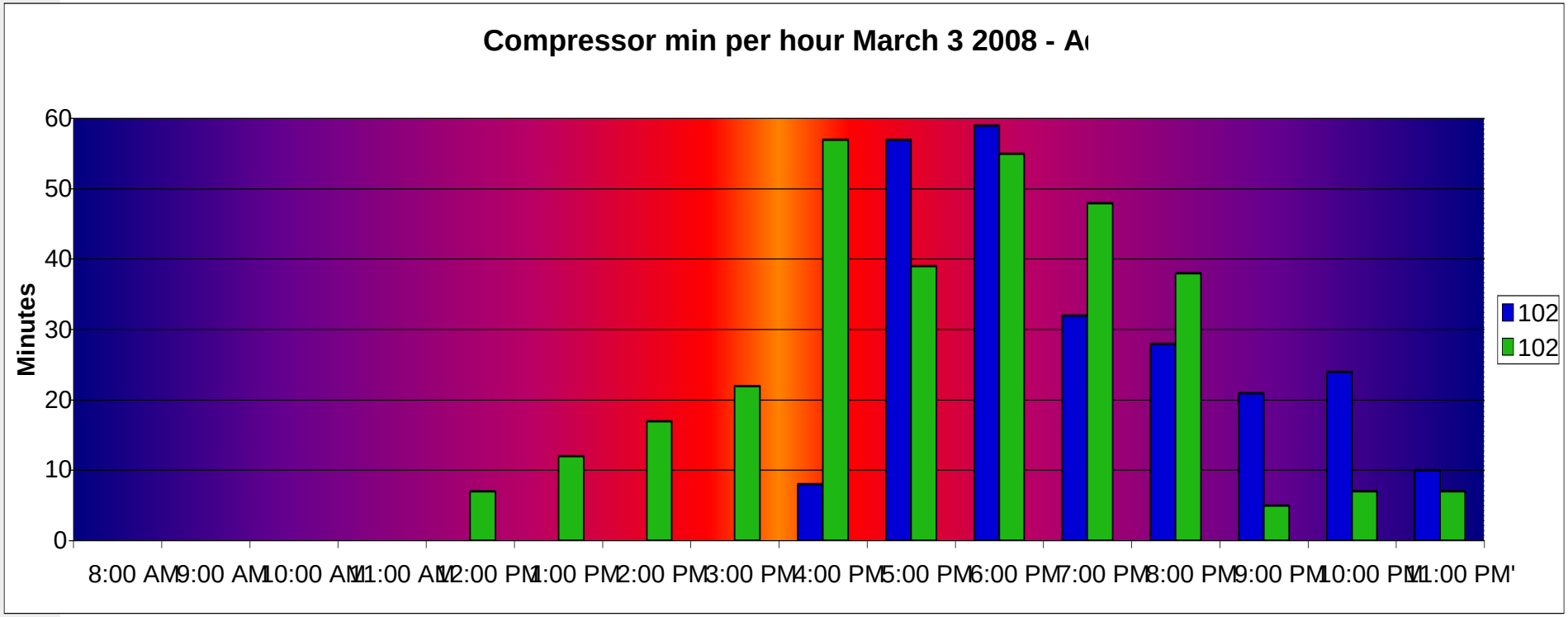
Home #2

- Turns off the AC completely during the day. Programs it to turn on one hour before they return.

ECO FACTOR



The Data



Who used more energy?

- Home #1 used 31% more energy for the same level of comfort as Home #2.
- Does this mean EVERYONE should shut off their AC system when they are not home?
- Is there a strategy that should be universally promoted to optimize comfort and Energy Efficiency?

One size does not fit all

- Home #2 strategy was tested in other homes…
- Outcome was sometimes unacceptable: some AC units ran open-loop for hours into the night trying to overcome daytime heat soak
- Dynamic signatures allow matching of strategy to circumstance

More behavioral issues found and fixed

Constant Setpoint changes

- Faucet/valve fallacy; mapping issues
  - Adelaide house (pre-optimization): 8 changes/day, 28°F/day

- The Fix
  - Analysis of manual inputs; reprogramming to fit expressed preferences of the occupants
  - Post-optimization: 0.6 changes/day, 3°F/day (92% reduction)

Takeaway #1

Major effects of specific behaviors on operational efficiency can be identified and quantified

Takeaway #2:

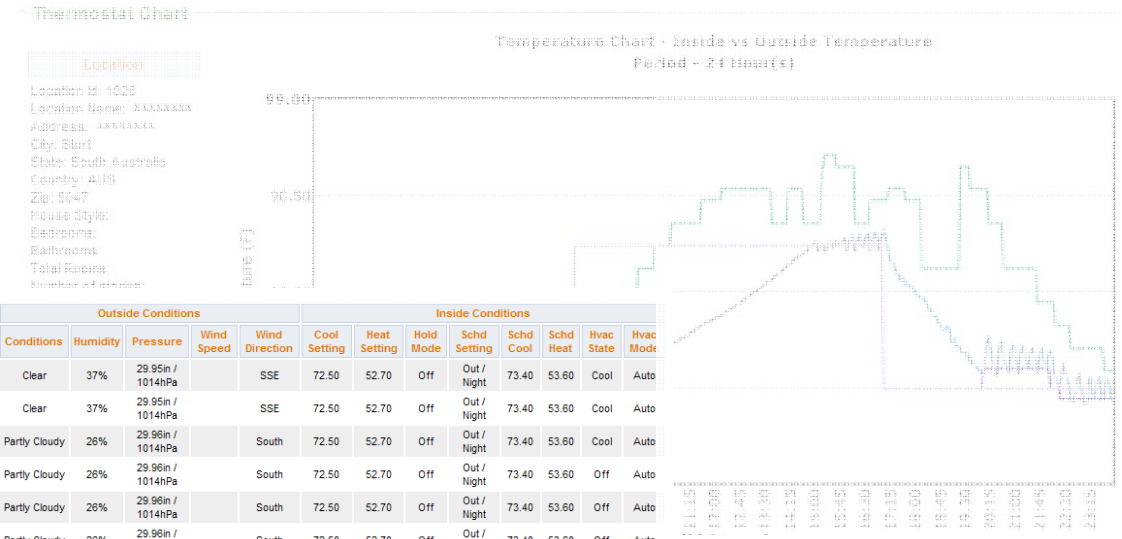
A system that understands the dynamic signature of a home and the desires of its occupants can dramatically reduce energy usage

Takeaway 3:

Large real-world reductions in energy usage are possible *without loss of comfort* through conversion of behavior into **automated operational efficiency**

What does it take to make this work?

- A Business Intelligence/ Control System for Energy Management
- Making sense of millions points of data
- Automate:
  - Data Collection
  - Analysis
  - Action



Time	Temperature		Outside Conditions					Inside Conditions							
(hh24:mm)	Inside Temp.	Outside Temp.	Conditions	Humidity	Pressure	Wind Speed	Wind Direction	Cool Setting	Heat Setting	Hold Mode	Schd Setting	Schd Cool	Schd Heat	Hvac State	Hvac Mode
2008/03/18 00:00	74.40	81.00	Clear	37%	29.95in / 1014hPa		SSE	72.50	52.70	Off	Out / Night	73.40	53.60	Cool	Auto
2008/03/18 00:03	73.00	81.00	Clear	37%	29.95in / 1014hPa		SSE	72.50	52.70	Off	Out / Night	73.40	53.60	Cool	Auto
2008/03/18 00:06	72.30	80.00	Partly Cloudy	26%	29.96in / 1014hPa		South	72.50	52.70	Off	Out / Night	73.40	53.60	Cool	Auto
2008/03/18 00:09	73.00	80.00	Partly Cloudy	26%	29.96in / 1014hPa		South	72.50	52.70	Off	Out / Night	73.40	53.60	Off	Auto
2008/03/18 00:12	73.90	80.00	Partly Cloudy	26%	29.96in / 1014hPa		South	72.50	52.70	Off	Out / Night	73.40	53.60	Off	Auto
2008/03/18 00:15	74.30	80.00	Partly Cloudy	26%	29.96in / 1014hPa		South	72.50	52.70	Off	Out / Night	73.40	53.60	Off	Auto
2008/03/18 00:18	73.80	80.00	Partly Cloudy	26%	29.96in / 1014hPa		South	72.50	52.70	Off	Out / Night	73.40	53.60	Cool	Auto
2008/03/18 00:21	73.50	80.00	Partly Cloudy	26%	29.96in / 1014hPa		South	72.50	52.70	Off	Out / Night	73.40	53.60	Cool	Auto
2008/03/18 00:24	73.10	80.00	Partly Cloudy	26%	29.96in / 1014hPa		South	72.50	52.70	Off	Out / Night	73.40	53.60	Off	Auto
2008/03/18 00:27	73.90	80.00	Partly Cloudy	26%	29.96in / 1014hPa		South	72.50	52.70	Off	Out / Night	73.40	53.60	Off	Auto
2008/03/18 00:30	74.40	80.00	Partly Cloudy	26%	29.96in / 1014hPa		South	72.50	52.70	Off	Out / Night	73.40	53.60	Cool	Auto
2008/03/18 00:33	73.30	80.00	Partly Cloudy	26%	29.96in / 1014hPa		South	72.50	52.70	Off	Out / Night	73.40	53.60	Cool	Auto
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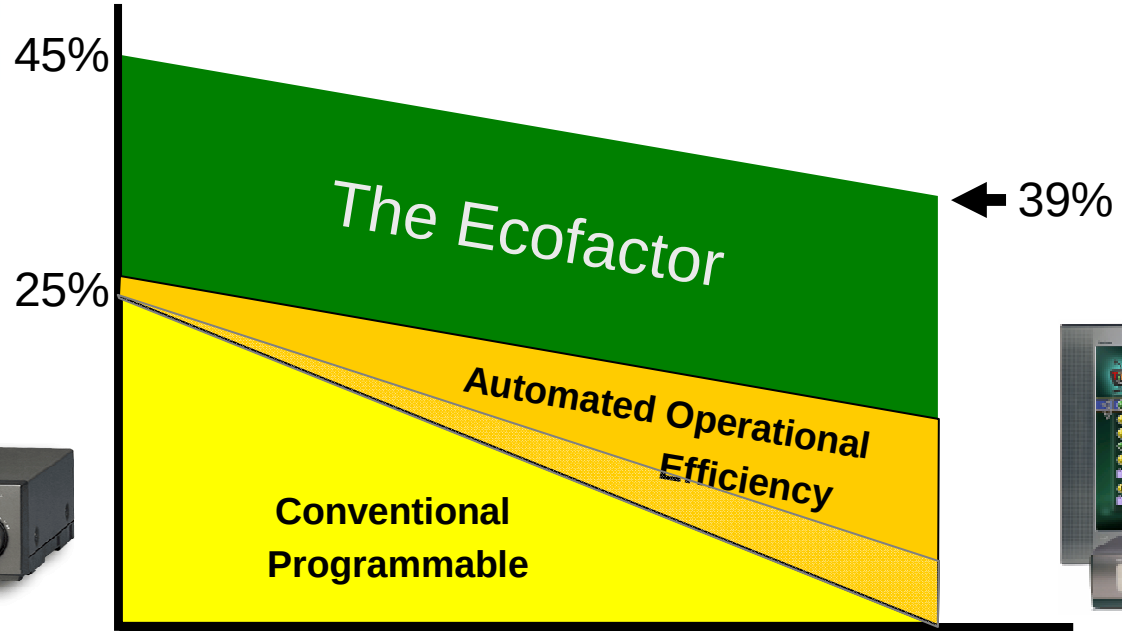
2008/03/18 00:39	72.60	79.00	Clear	39%	29.95in / 1014hPa		SW	72.50	52.70	Off	Out / Night	73.40	53.60	Off	Auto
2008/03/18 00:42	73.30	79.00	Clear	39%	29.95in / 1014hPa		SW	72.50	52.70	Off	Out / Night	73.40	53.60	Off	Auto
2008/03/18 00:45	74.10	79.00	Clear	39%	29.95in / 1014hPa		SW	72.50	52.70	Off	Out / Night	73.40	53.60	Off	Auto
2008/03/18					29.95in /						Out /				

The Power of Automated Operational Efficiency

Savings



What seeing 24 hours ahead allows

Forecasting:

Predict residential AC loads based on real, continuously updated data

Energy Efficiency:

Optimize individual heating/cooling plans for actual conditions

Demand Response:

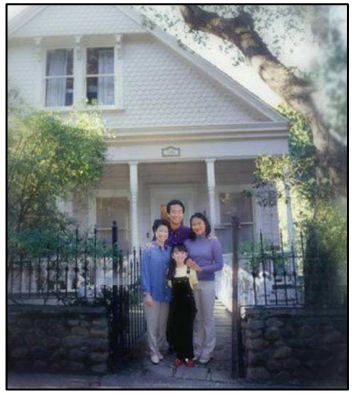
Efficiently prepare homes for DR events through individualized pre-cooling strategies

Variable Pricing:

Automate optimization of price response based upon customer preferences

Understanding why we spend what we do…

- HVAC energy consumption can be attributed to:
  - Building Envelope
  - HVAC system
  - Behavior
- Understanding these variables allows each home to be graded on each factor.
- Let the consumer know why…



Monthly Utility Bill: **$500**

Building Envelope: **B**

State of HVAC: **A-**

Behavior: **D**

Monthly Utility Bill: **$500**

Building Envelope: **A**

State of HVAC: **D-**

Behavior: **B**

Monthly Utility Bill: **$500**

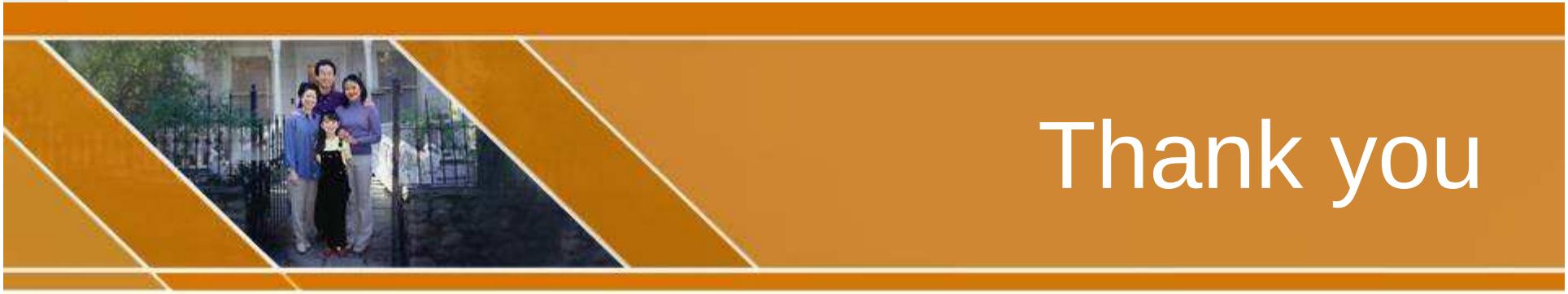
Building Envelope: **D**

State of HVAC: **B**

Behavior: **B+**

We are EcoFactor

Look for us in utility-sponsored energy efficiency trials throughout North America and Europe in the Summer of ‘09



Thank you

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