EMpowering Consumers to Save with Feedback Devices:

Technologies to Motivate, Enable, and Engage Consumers to Reduce Energy Usage

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for

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EMpower Devices:

EM = Energy Management

EMpower = consumer ownership and control

Devices (Noun) = Technology

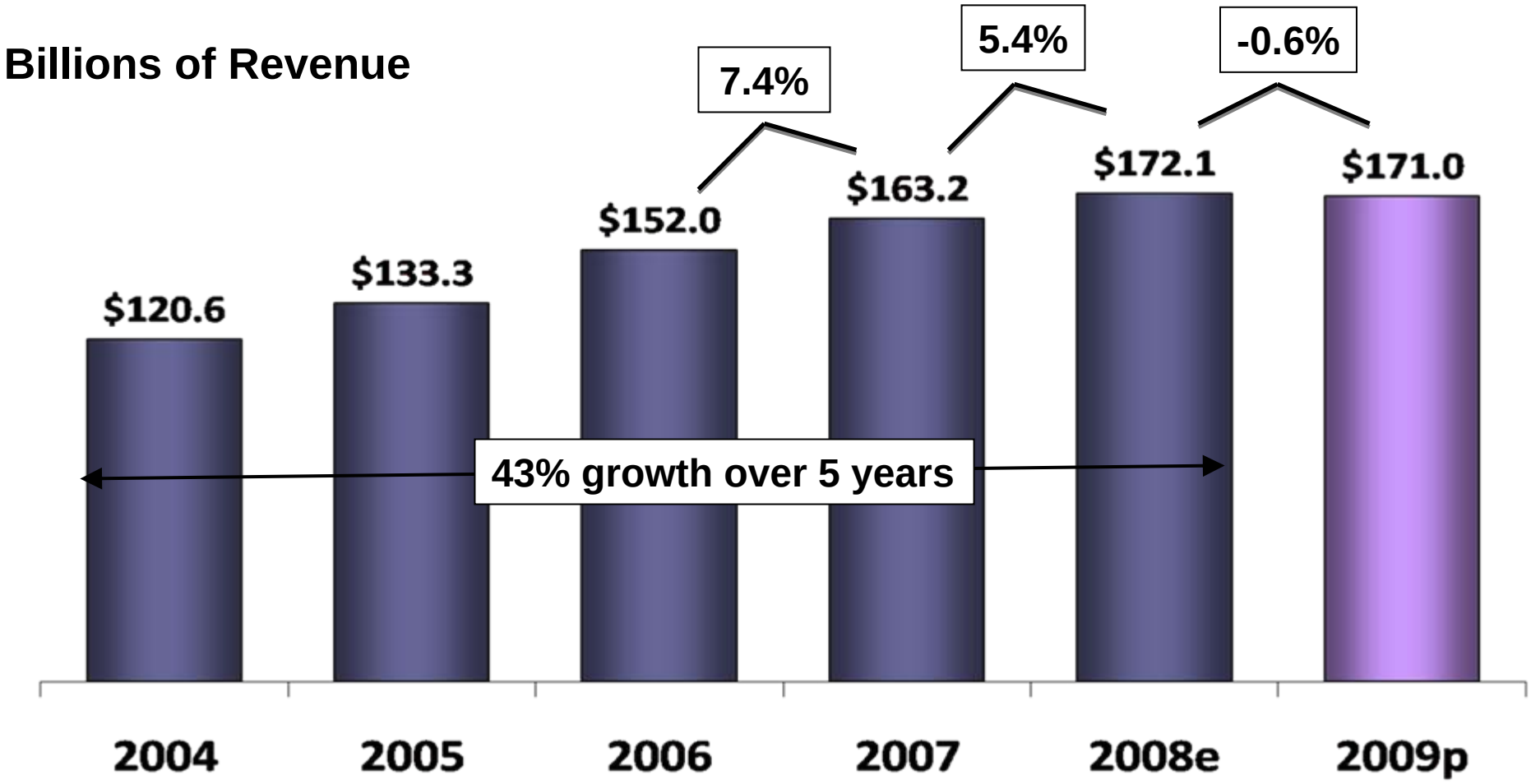
Devices (Verb) = Methods

Presentation Outline

- **Feedback Technologies**
- Consumer Behavior Primer
- Behavioral Approaches to Feedback and Technology

Control4 home Energy Management System (EMS) EC-100

Consumer Electronics Industry Growth

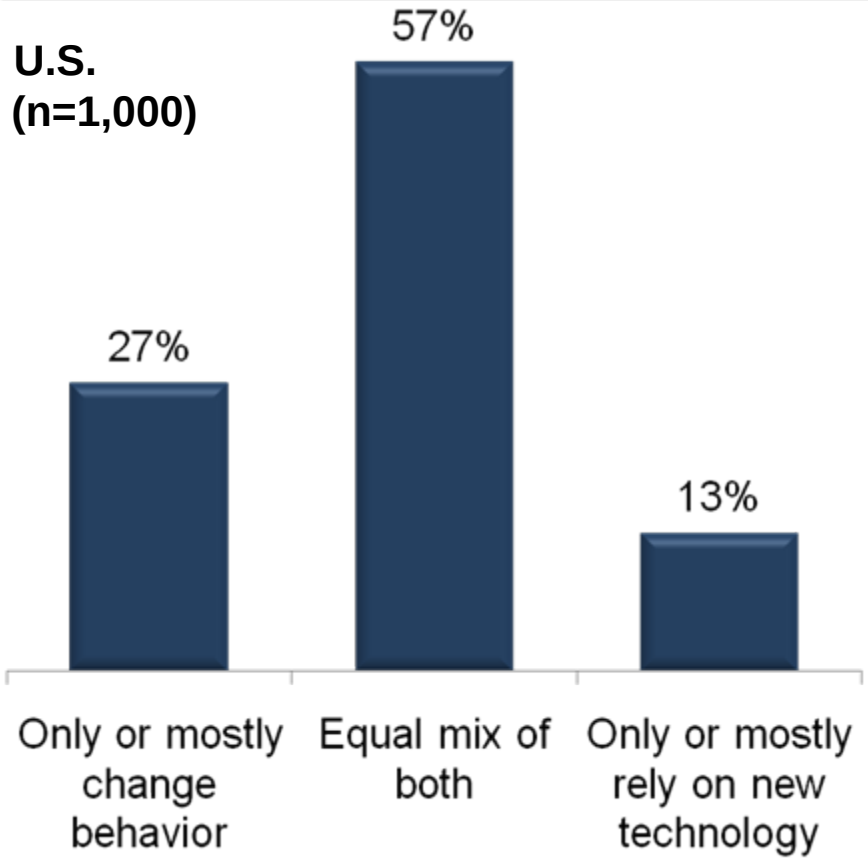


Source: CEA 2009.
CEA Sales and Forecasts, Jan 2009

Consumers Prefer Multifaceted Approach

Consumers see a role for both technology and behavioral changes to conserve household energy

Base: U.S. adults (n=1,000)

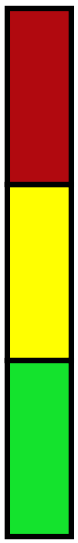


- **Men are more likely to rely only/mostly on a technology solution (16% vs. 10% for women)**
- **Those living in older homes (pre 1970) are more likely to only/mostly rely on behavioral changes (33% vs. 27% overall)**

Source: CEA 2009

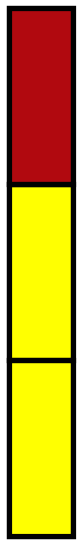
Today's Feedback Technologies: Feedback Levels and Effectiveness

Consumer Effectiveness



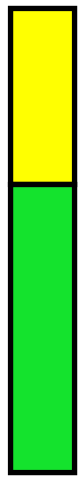
- -Little to No Effect
- -Some Response
- -Most Effective

Frequency



- -Monthly (Utility Bill)
- -Next Day (CA Smart meters)
- -Real-Time Display, Website, or HAN*

Level of Detail



- -Household
- -Circuit Level
- -Appliance Level
- -Completely disambiguated (disaggregated)

***HAN-Home Area (Automation) Network**

Feedback Technologies

Feature	Utility Bill	Smart Meters	Simple Stand Alones/Web Feedback	Home Area Networks	Disambiguation Algorithms
Frequency	Monthly				
Level of Detail: Whole House or Appliance-Specific	Whole home				
Additional Capabilities	Some tips, rebates				
Cost to Consumer	N/A				

Feedback Technologies

Feature	Utility Bill	Smart Meters	Simple Stand Alones/Web Feedback	Home Area Networks	Disambiguation Algorithms
Frequency	Monthly	10 s, 15 min, 1x/day			
Level of Detail: Whole House or Appliance-Specific	Whole home	Whole home (some large appliance recognition is possible with analysis)			
Additional Capabilities	Some tips, rebates	Control or automation w/ additional technology			
Cost to Consumer	N/A	Recovered in rates			

Feedback Technologies

Feature	Utility Bill	Smart Meters	Simple Stand Alones/Web Feedback	Home Area Networks	Disambiguation Algorithms
Frequency	Monthly	10 s, 15 min, 1x/day	Real-time (~2s)		
Level of Detail: Whole House or Appliance-Specific	Whole home	Whole home (some large appliance recognition is possible with analysis)	Whole home, OR appliance-specific, or a little of both (using statistics)		
Additional Capabilities	Some tips, rebates	Control or automation w/ additional technology	Stand-alones provide mainly usage, some have cumulative data & future projections. Web displays vary.		
Cost to Consumer	N/A	Recovered in rates	$20 - 250 per unit		

Feedback Technologies

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Frequency	Monthly	10 s, 15 min, 1x/day	Real-time (~2s)	Real-time (~2s)	
Level of Detail: Whole House or Appliance-Specific	Whole home	Whole home (some large appliance recognition is possible with analysis)	Whole home, OR appliance-specific, or a little of both (using statistics)	Appliance-specific and/or whole-home shown at a common display	
Additional Capabilities	Some tips, rebates	Control or automation w/ additional technology	Stand-alones provide mainly usage, some have cumulative data & future projections. Web displays vary.	Control and automation is possible, including on entertainment & security systems	
Cost to Consumer	N/A	Recovered in rates	$20 - 250 per unit	$20-300 per sensor/transmitter → $1,500-10,000 for whole house	

Carrie Armel (Stanford University Precourt Institute for Energy Efficiency) and Kat A. Donnelly (EMpower Devices & Assoc.)

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Level of Detail: Whole House or Appliance-Specific	Whole home	Whole home (some large appliance recognition is possible with analysis)	Whole home, OR appliance-specific, or a little of both (using statistics)	Appliance-specific and/or whole-home shown at a common display	Appliance-specific & overall home shown at a common display
Additional Capabilities	Some tips, rebates	Control or automation w/ additional technology	Stand-alones provide mainly usage, some have cumulative data & future projections. Web displays vary.	Control and automation is possible, including on entertainment & security systems	- Limitation is 75-85% accuracy - Control and automation is probably not possible
Cost to Consumer	N/A	Recovered in rates	$20 - 250 per unit	$20-300 per sensor/transmitter → $1,500-10,000 for whole house	• Little cost to add to existing technology • $100-$200 as stand-alone device

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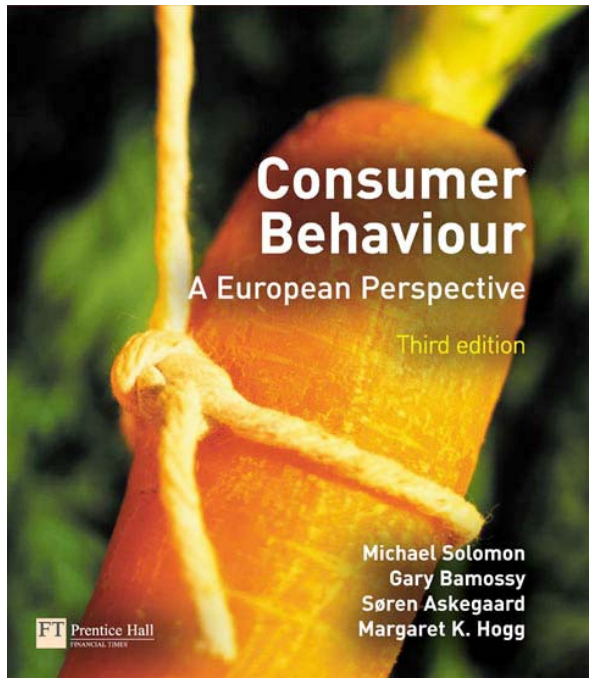

The Behavioral Approach

- Research findings suggest that technology adoption and price are not sufficient to drive efficiency[1]
  - Behavior and technology are closely interwoven throughout life, yet the role of psychology receives surprisingly modest attention in technology design and in policymaking
  - Energy-related technologies and policies need to bridge the gap between economical, technological, and psychological approaches

- Residential sector behavior-related energy savings about 25% of current residential sector energy consumption[2]

(1) Midden et al 2007, Ehrhardt-Martinez and Laitner 2009

(2) Gardner and Stern 2008, Laitner et al. 2009

Behavioral Aspects of Successful Feedback:

- **Motivate**:
  - Set challenging, but achievable goals
  - Social context (e.g. comparisons among like groups)

- **Enable** (example: feedback technologies):
  - Computerized, interactive, custom presentation
  - Clear and Appealing interface (Keep it SIMPLE!)
  - Supplemental Automation
  - Data
    - Both whole house and appliance specific
    - Real-time (<2 s)
    - Given over a long period of time (historical)

- **Engage**:
  - Wide variety of approaches: "Not one size fits all"
  - Social Communities and Competitions
  - Personalized feedback loop with actionable steps

Technology and Behavior Feedback Issues

Mostly Behavioral:

- **Resolution:** Frequency and Level of Detail about usage
- **Presentation/Visualization:** Incorporate consumer behavior
- **Mode of display:** Targeted display, internet, mobile, others?
- **Target population:** Segment customers
- **Target behaviors:** Purchase, one-time, and habits

Mostly Technological:

- **Data Management:** Large-scale, complex systems
- **Networking and Automation:** Partnerships, collaborations.
- **Security and Privacy:** Standards, data ownership
- **Whole-home interoperability:** HAN, renewables,

Proposed Framework for Energy Efficiency Behavioral Approaches

Influence Dimension Co-Benefit	**Motivation** Apply Behavior and Policy Solutions	**Ability** Apply Technology Solutions
Personal: Simplicity, Convenience, Comfort, Health, Core Values, Personalized	**Make the Undesirable Desirable:** Goal-setting, Feedback: immediate historical, and projected feedback loops, Understand core values and needs.	**Much of Willpower is Skill:** Provide simple technology solutions, Provide education, installation, and training

(Adapted from the Six Dimensions of Personal, Social, and Structural Motivation (Patterson, 2008))

Proposed Framework for Energy Efficiency Behavioral Approaches

Influence Dimension Co-Benefit	**Motivation** Apply Behavior and Policy Solutions	**Ability** Apply Technology Solutions
Social: Norms, Prevalent Perceptions, Attitudes, Social Approval	**Harness Peer Pressure:** Modeling, Comparisons, Networks, Communities	**Find Strength in Numbers:** Involve the consumer in technology solutions (where users co-develop and co-create solutions), Use Networks, Communities

(Adapted from the Six Dimensions of Personal, Social, and Structural Motivation (Patterson, 2008))

Proposed Framework for Energy Efficiency Behavioral Approaches

Influence Dimension Co-Benefit	**Motivation** Apply Behavior and Policy Solutions	**Ability** Apply Technology Solutions
Structural: Ownership, Enablement, Automation	**Design Rewards and Demand Accountability**: Goal Setting, Feedback, Actionable Steps, Incentives/Disincentives, Financing, Pricing Policies	**Change the Environment:** Physical location, Feedback technology, Automation levels targeted to consumer needs and desires (including automation levels)

(Adapted from the Six Dimensions of Personal, Social, and Structural Motivation (Patterson, 2008))

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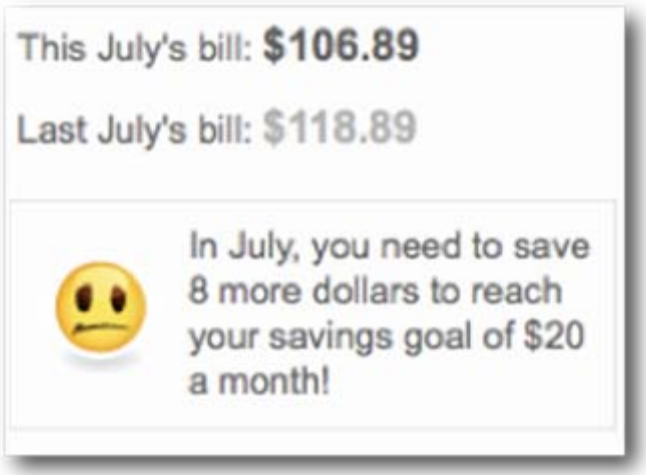
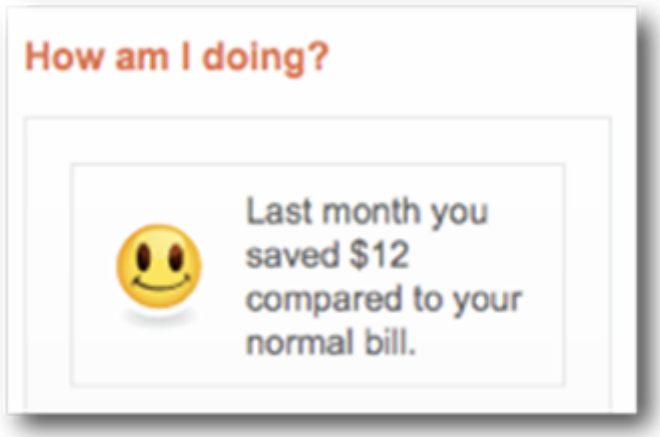
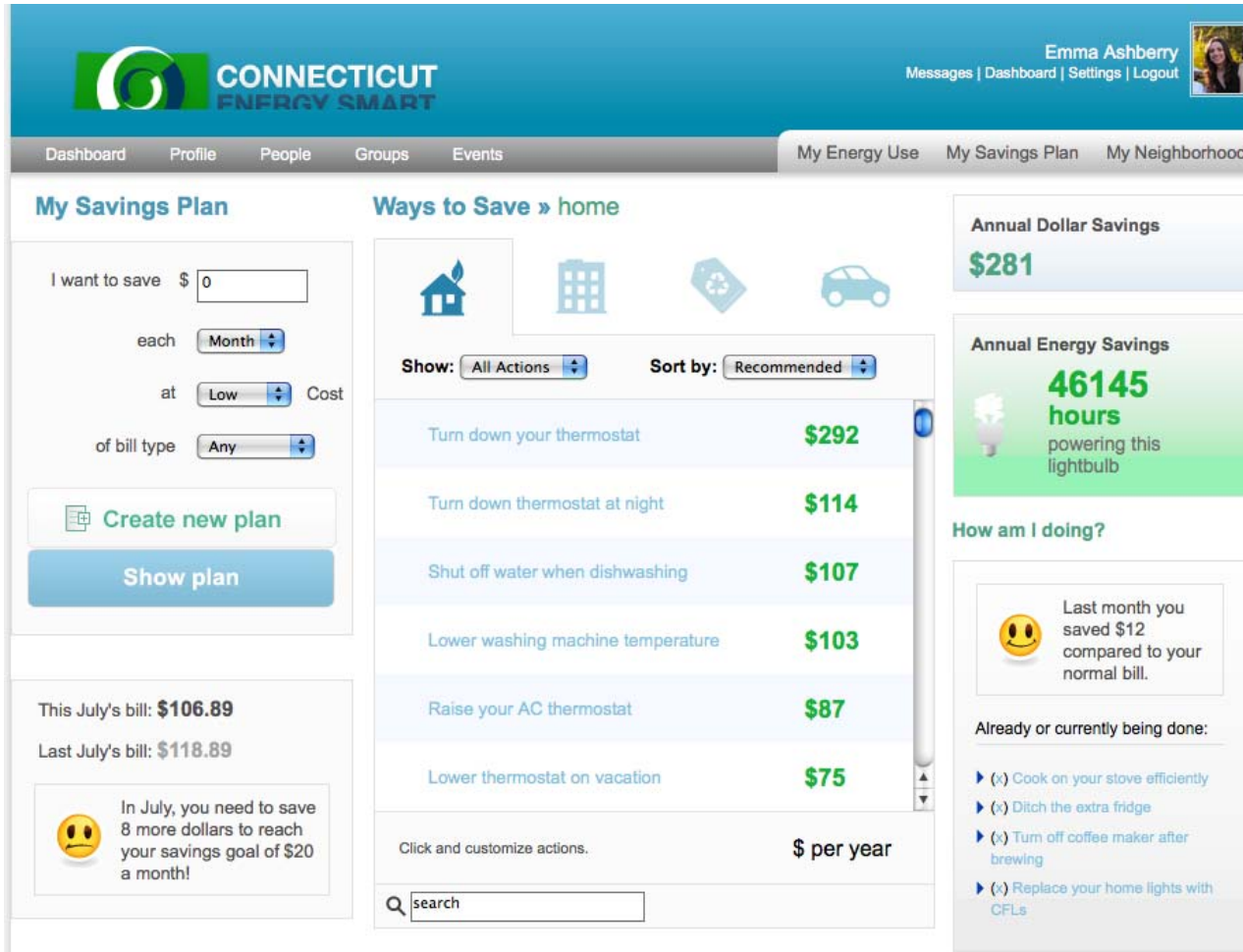




EFFICIENCY2.0 Meets Behavior Best Practices

- Savings goals based on energy end-use, psychographic, and demographic profiles
- Over 400 actionable behavior and purchase recommendations
- Personalized feedback and goal tracking
- Historical, friend, similar



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

- Behavior principles
  - Norms
  - Goals
  - Competitions, networks, comparisons
  - Pricing
  - Actionable steps
  - Preference settings
  - Planned: sophisticated social networking and actionable steps
- Feedback
  - Whole house (7 to 10 secs)
  - Device specific hardware
  - Historical comparisons and estimated budgets
  - In-home display, touch panel, Web, iPhone applications

More than Energy Mgt: Control4

- Similar Behavior principles as Tendril (minus competitions, networks, comparisons)
- Also incorporates entertainment and security
- Similar Feedback plus
  - TV, DVD, and other Web partners

Control4 home Energy Management System (EMS) EC-100

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

Conclusions

- Behavior potential will depend on more informed decision-making and a greater awareness of impacts that follow from the choices.
- Behavior and technology approaches are fundamentally different and should complement each other.
- People are complex and make decisions on much more than economic rationality.
- There are many different way to influence behavior (using software technology, community strategies, feedback devices, etc.)
- The Internet is an important communication medium to influence consumer energy behavior

The bottom line: to achieve the highest residential energy reductions in a cost-effective manner, behavior strategies must play an important role

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Five First Principles for Embracing Customers as Co-Creators of Value

1. Embrace customer-centered design
2. Blend rational and emotional experiences
3. Engage customers in small, observable steps of adoption
4. Segment by observable customer actions
5. Use action research to drive emergence and evolution of solutions

Honebein, PH, Cammarano, RF, and Donnelly, K (2009). *Will Smart Meters Ripen or Rot? Five First Principles for Embracing Customers as Co-creators of Value*. Customer Performance Group LLC White Paper.

Behavior Change Best Practices

Findings from public health suggest that effective behavior change occurs when program administrators:

1. Describe **specific behaviors** to change

2. **Set goals** that people should try to achieve

3. **Identify barriers** to changing behaviors and **ways of overcoming** these barriers

4. Communicate **co-benefits** to the new behaviors

(Source: Dr. Carrie Armel, Stanford Precourt Energy Efficiency Center)

Example Household Behaviors that Impact Energy Use

Target different behaviors and personalities:

purchase behaviors, one time behaviors, and habits.

Consumer Cost	***Frequency of Action***	
	Infrequent	***Frequent***
Low cost / no cost	• Install Compact fluorescents • Pull fridge away from wall • Set up thermostat • Install weather stripping or plasticize windows	• Air dry laundry • Turn off lights, computers, other devices • Change thermostat • Wash clothes in cold water
Higher cost / investment	• New energy-efficient windows, appliances, heating/cooling • Additional insulation	N/A

Table source: Laitner et al. 2009