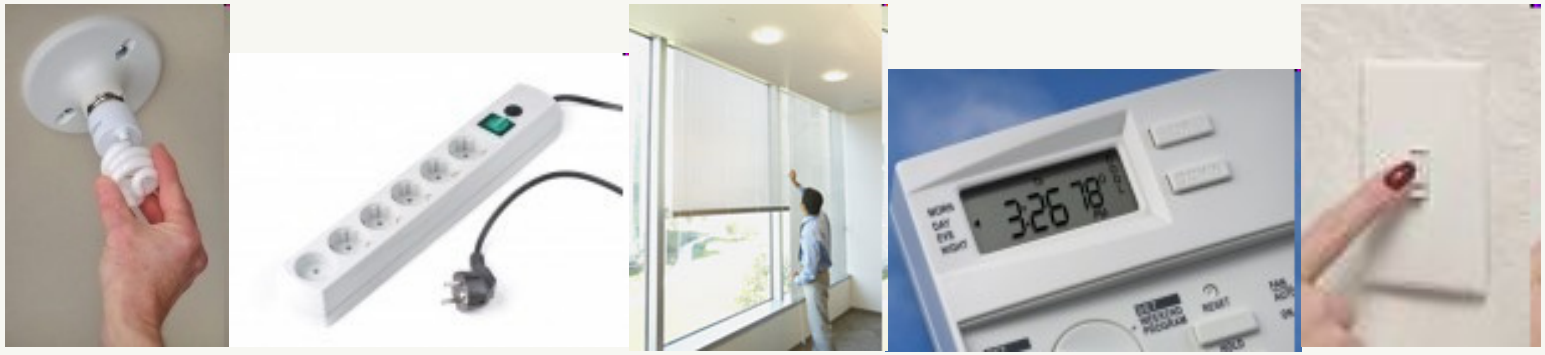
Engaging Households and Saving Energy through Smart Feedback Initiatives



Karen Ehrhardt-Martinez, Ph.D.

Climate, Buildings and Behavior Symposium

May 24, 2012

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Managing an Invisible Resource

- Unlike previous eras – today's energy resources are invisible.
- People no longer cut wood or shovel coal.
- Electricity enters our homes in seamless and silent ways.
- Our only means of assessing our level of consumption is the bill that we pay each month.

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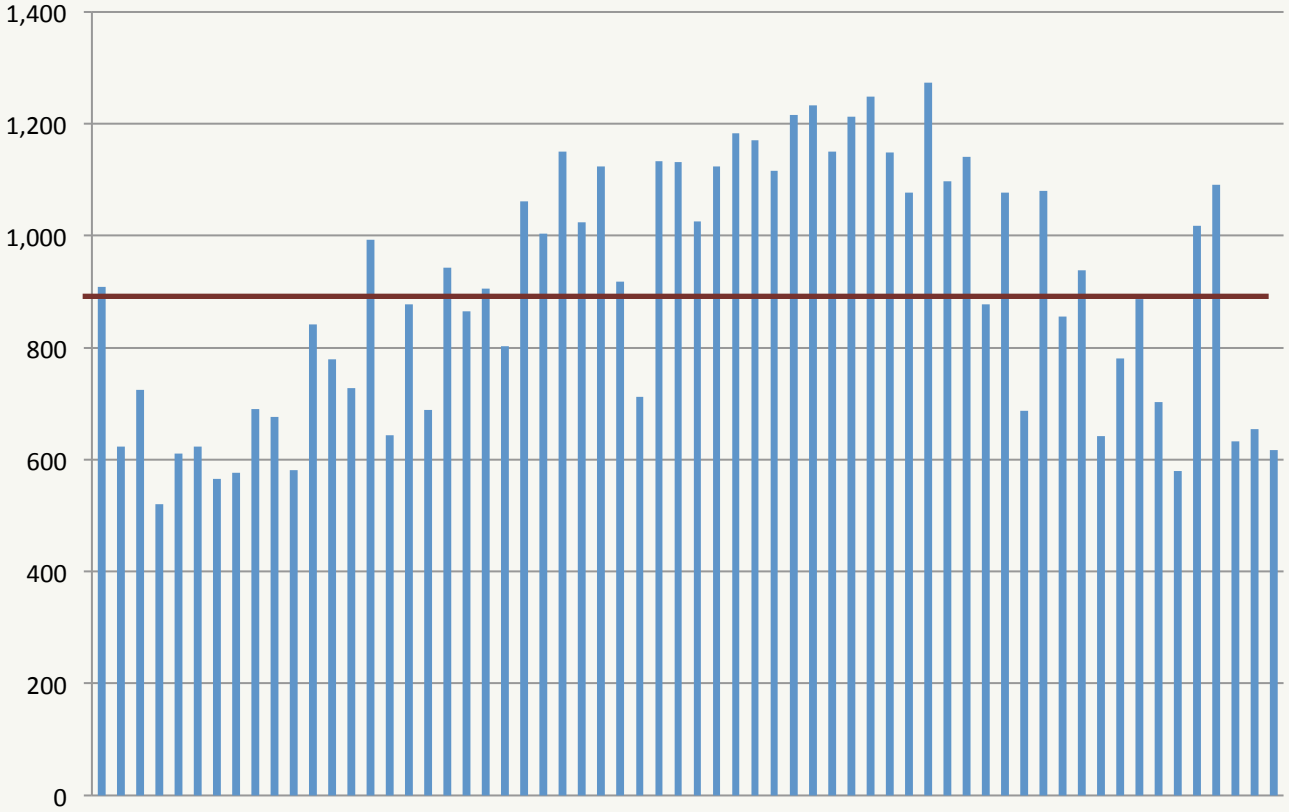
You Aren't Normal and Neither Am I

[And Neither are the People that We'reWorking With]

Average Monthly Electricity Consumption per HH by State, 2009



US Avg. = 908 kwh

Maine Avg. = 521 kwh

Louisiana Avg. = 1273 kwh

High = 2.4 times

Source: EIA at http://205.254.135.24/tools/faqs/

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Residential Electricity Consumption

Census Division State	Average Monthly Consumption (kWh)	Average Monthly Bill (Dollar and cents)
New England	657	$106.66
Maine	521	$81.83
Connecticut	750	$144.40
Middle Atlantic	727	$114.91
New York	610	$114.39
New Jersey	731	$121.13
Pennsylvania	878	$111.50
East North Central	832	$94.96
Indiana	1,065	$101.79
Wisconsin	716	$90.59
West North Central	994	$95.87
Minnesota	814	$86.19
Missouri	1,153	$104.66
South Atlantic	1,212	$132.94
District of Columbia	778	$108.93
North Carolina	1,238	$125.20
South Carolina	1,310	$137.59
Mountain	872	$91.49
Colorado	709	$78.22
Arizona	1,059	$116.09
Pacific Contiguous	675	$83.09
California	562	$82.85
Oregon	964	$85.52
Washington	1,030	$82.75
U.S. Total	958	$110.55

610 kWh

709 kWh

Source:EIA 2009

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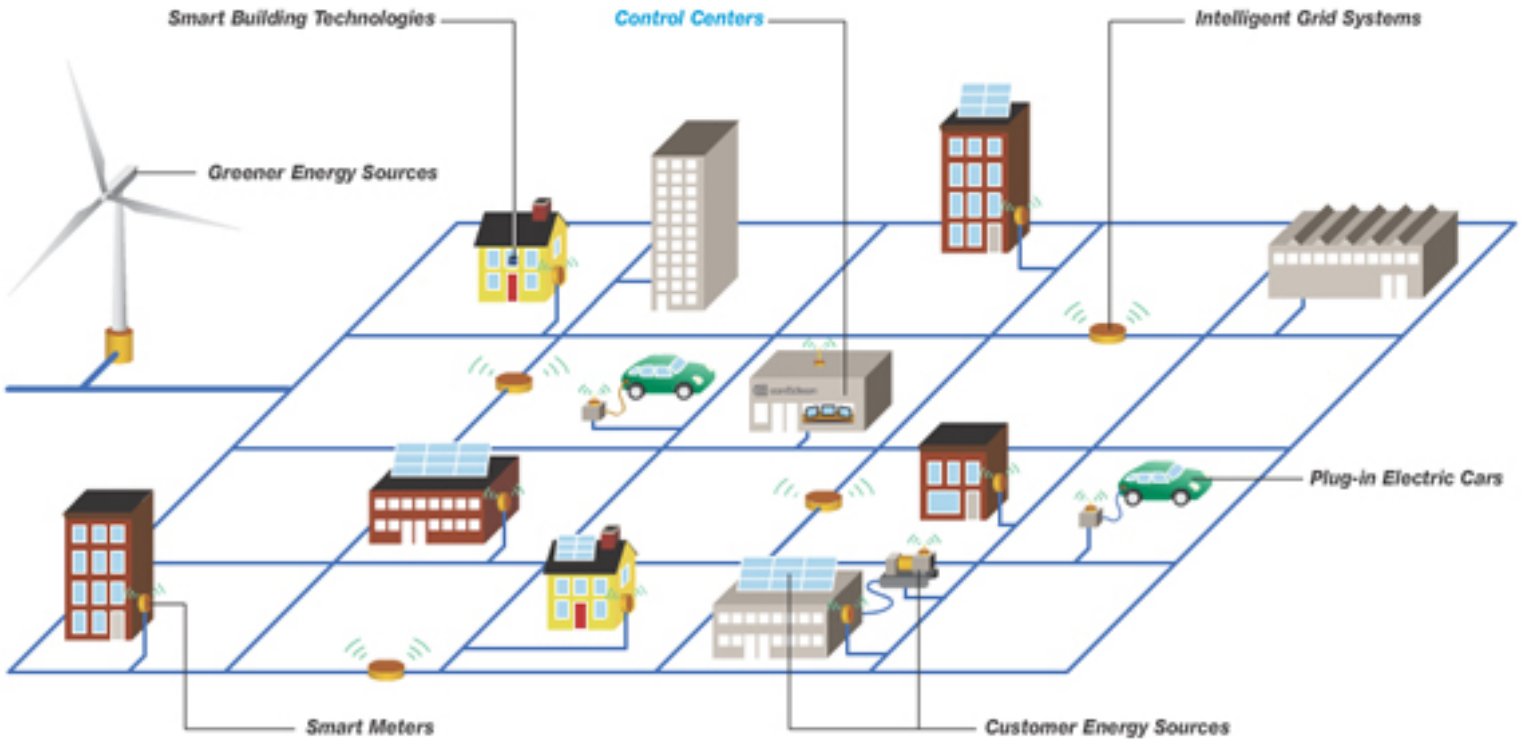
Smart Grid

- A class of technology people are using to bring utility electricity delivery systems into the 21st century,
- Uses computer-based remote control and automation,
- Made possible by two-way communication technology and computer processing that has been used for decades in other industries,
- Better integrate all of the grid components from power plants and wind farms to consumers of electricity in homes and businesses,
- Many benefits to utilities and consumers -- mostly seen in big improvements in energy efficiency on the electricity grid and in the energy users' homes and offices.

conEdison

Smart Grid

Smart grid puts information and communication technology into electricity generation, delivery, and consumption, making systems cleaner, safer, and more reliable and efficient.



Advanced Meters

- Advance metering systems record customer consumption and other information on an hourly or more frequent basis and provide for daily or more frequent transmittal of measurements over a communication network to a central collection point. (FERC 2008)
- When combined with other technologies and programs, the data collected by advanced meters **provide the opportunity** to empower households to become better energy managers and reduce consumption.
- Advanced meters alone **are not sufficient** to change household energy consumption practices.
- To empower consumers, utilities must either directly or indirectly provide this information to consumers in a useful format that contextualizes the information, motivates action, and breaks down barriers.

Feedback Meta-Analysis and Report

The complete research report is entitled:

Advanced Metering Initiatives and Residential Feedback Programs

June 2010

Karen Ehrhardt-Martinez – RASEI

John A. "Skip" Laitner – ACEEE

Kat A. Donnelly – Empower Devices

Available at: www.aceee.org/research-report/e105

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Research Questions

1. How much electricity have households saved through the use of feedback?
2. How do savings vary by the type of feedback?
3. Are direct or indirect forms of feedback better?
4. Is feedback more effective when combined with social science insights?
5. Does feedback work differently in demand response programs?
6. How persistent are feedback-induced savings over time?
7. How effective *could* feedback be in achieving energy savings?
8. What are the potential national-level savings of feedback-induced energy savings?

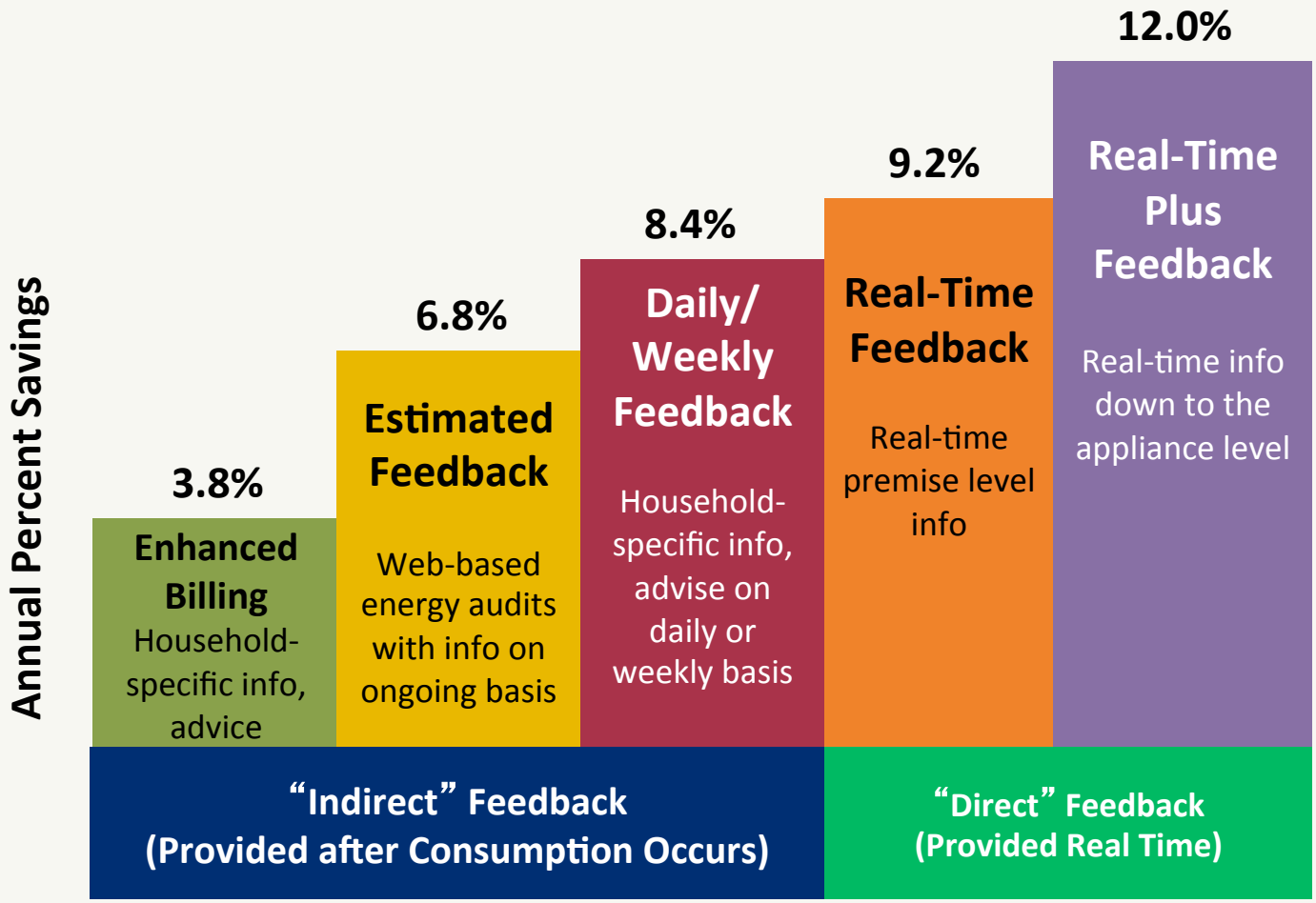
Scope of Feedback Programs

An assessment of 61 primary research studies of 57 feedback initiatives:

- Several continents and 9 countries
- 21 studies 1974-1994 – What we call the "Energy Crisis Era"
- 36 studies 1995-2010 – What we call the "Climate Era"

Region	Number of Studies	Percent
United States	33	57%
Europe	13	22%
Canada	9	16%
Other	3	5%

Average Household Electricity Savings (4-12%) Of Historical Programs by Feedback Type



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Indirect versus Direct Forms of Feedback

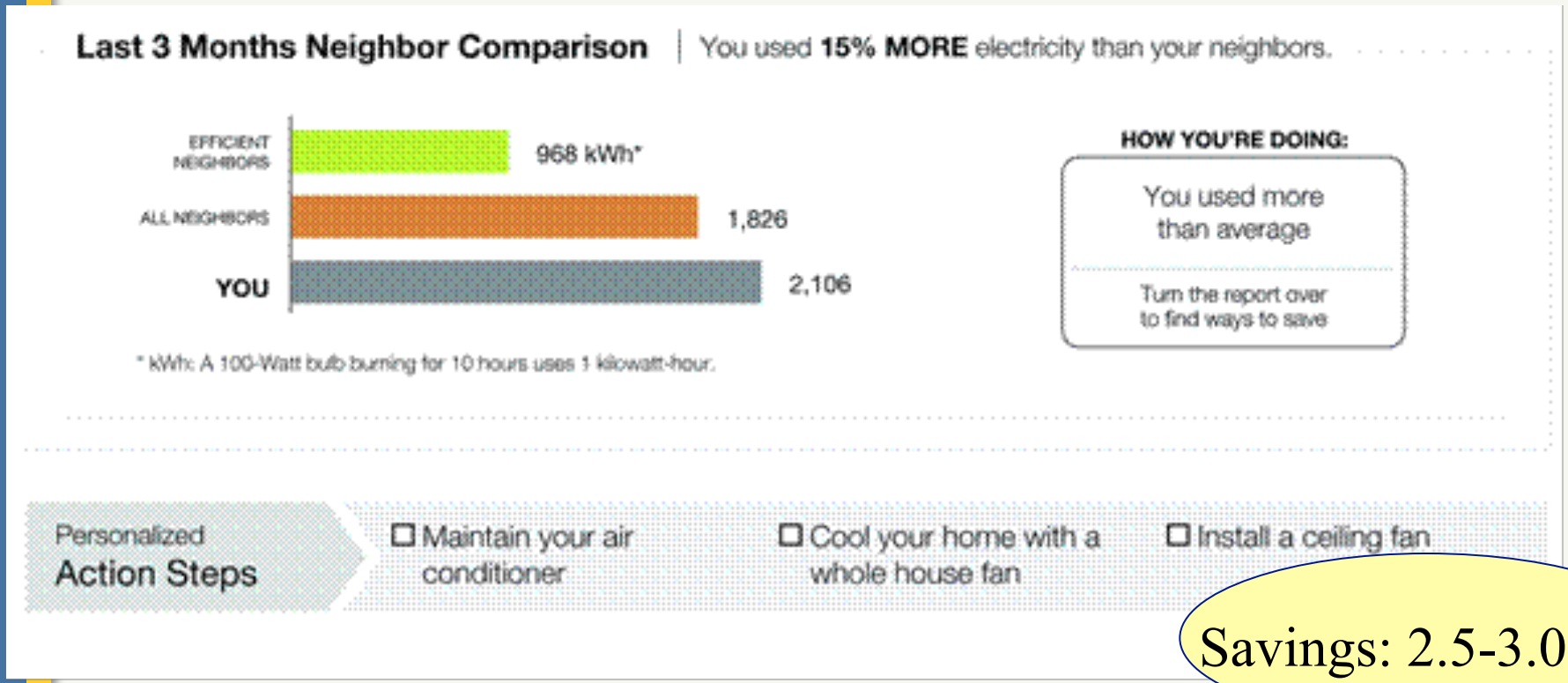
- Indirect and direct forms of feedback tend to influence energy-related behaviors in different ways.
- Indirect feedback helps people to see larger patterns in energy use.
- Direct forms of feedback help people to understand the impact of small behaviors and the implications of specific end uses.
- More and more approaches to feedback are providing both types feedback.

Program Design and Energy Savings

A variety of non-economic motivation strategies could effectively enhance feedback-related energy savings in households.

- **Social norms** – People are motivated to question their behavior if they find out it isn't "normal". Descriptive and injunctive norms help people to evaluate current levels of consumption.
- **Goal setting** – People need to define what they are trying to attain and be able to evaluate their progress.
- **Commitments** – People want to be accountable. Commitments help people to ensure that their actions are consistent with their ideals.
- **Social context** – People generally learn from others and receive encouragement, support and affirmation from others. Receiving and evaluating feedback and developing strategies in a social context increases people's effectiveness.

Using Social Norms: Opower



Savings: 2.5-3.0%

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Program Design and Energy Savings

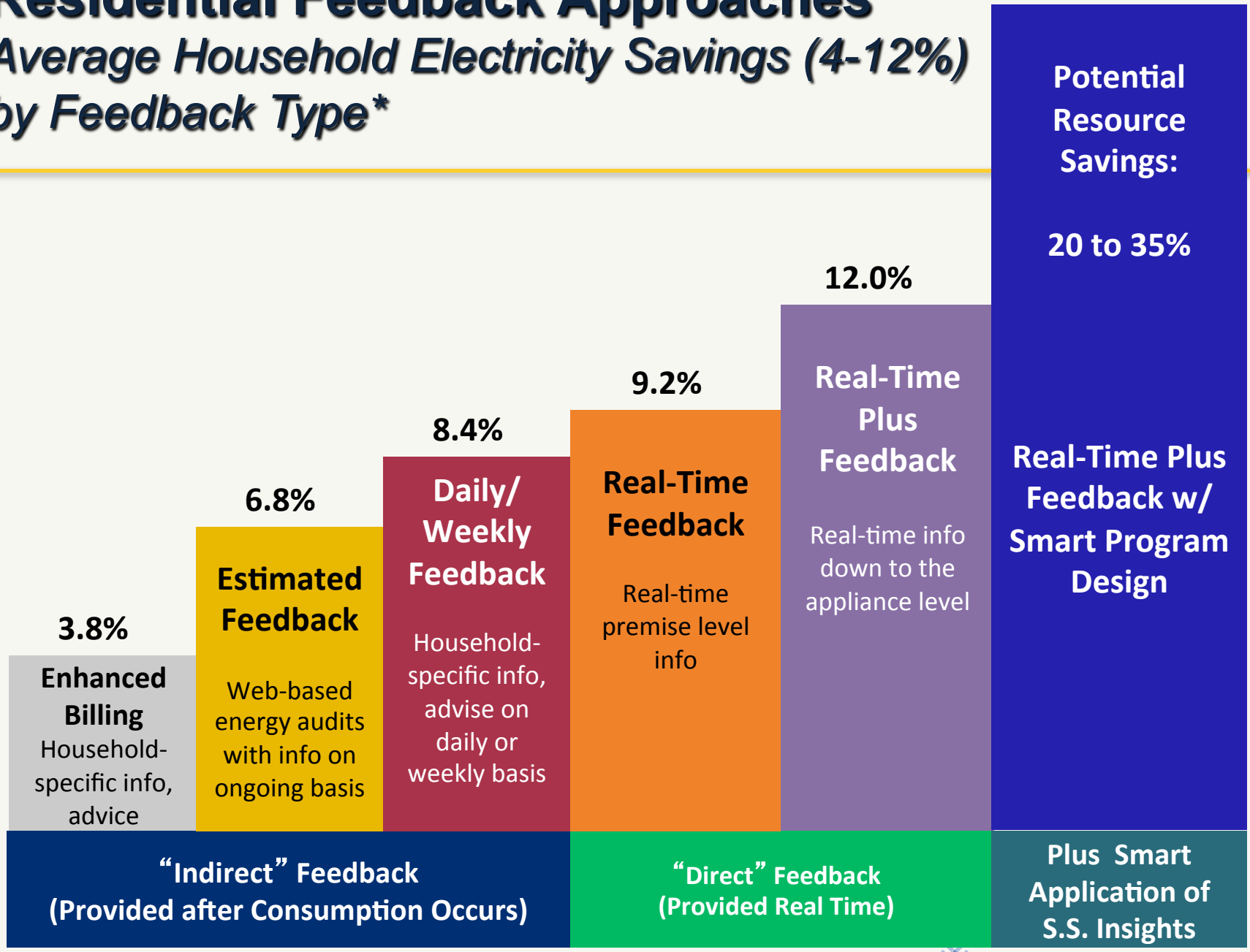
A variety of non-economic motivation strategies can effectively enhance feedback-related energy savings in households.

The Impact of Non-economic Motivational Elements

	Number of Studies	Household Energy Savings	Sources
Social Norms	14	2-10%	Alcott (2009), Ayers et al. (2009), Ehrhardt-Martinez (2009), Nolan et al. (2008), Schultz et al (2007), Wilhite et al. (1999)
Goal Setting	4	5-17%	Seligman (1978), Winett et al. (1982), Van Houwellingen (1989), Abrahamse et al. (2007)
Competitions	1	10-32%	Petersen et al. (2007)
Commitment	1	5-8%	Staats et al. (2004)

Residential Feedback Approaches

*Average Household Electricity Savings (4-12%) by Feedback Type**



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National-level Savings Estimates for the U.S. Residential Sector

National-level savings depend on the type of feedback, the program elements and the level of participation but the economics are generally favorable.

Scenario Impacts by 2030	A	B	C	D
Reference Case Electricity Demand (billion kWh)	1,637	1,637	1,637	1,637
Reference Case Electricity Customers (millions)	146	146	146	146
Participating Feedback Customers (millions)	88	6	72	75
Total Electricity Savings (billion kWh)	40	6	68	103
Savings per Participant (kWh)	458	986	942	1369
Savings per Participant (percent of reference case)	4.10%	8.80%	8.40%	12.20%
Total Electricity Savings (percent of reference case)	2.50%	0.40%	4.20%	6.30%
Total Cost (million constant 2008 dollars, 2010 -2030)	$8,150	$1,909	$21,631	$22,489
Bill Savings (million constant 2008 dollars, 2010 – 2030)	$22,398	$3,510	$37,878	$57,050
Total Resource Cost Test Ratio	2.75	1.84	1.75	2.54

The Flexibility of Feedback

- Eliminates the need for prescriptive programs.
- Maximizes household options.
- Allows for targeted recommendations.
- Engages people in an active learning process.
- Empowers people to become part of the energy solution.

Selected References:

Abrahamse, W., L. Steg, C. Vlek, & T. Rothengatter. 2007. "The effect of tailored information, goal setting, and tailored feedback on household energy use, energy-related behaviors, and behavioral antecedents." *Journal of Environmental Psychology*, 27: 265-276.

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van Houwelingen, J. T. & W. F. van Raaij. 1989. "The effect of goal setting and daily electronic feedback on in-home energy use." *Journal of Consumer Research* 16, 98–105. .

Further Information:

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This presentation is based on recent research by:
Karen Ehrhardt-Martinez, Ph.D.
John A. "Skip" Laitner, ACEEE
Kat A. Donnelly, Empower Devices

The complete research report is entitled:
Advanced Metering Initiatives and Residential Feedback Programs
Available from the American Council for an Energy-Efficient Economy:
http://www.ACEEE.org/pubs/e105.htm

Demand Response and Energy Savings

Feedback can be effective at:

- generating peak-load reductions and
- reducing overall levels of household energy consumption.

However, the focus of feedback programs influences the level of overall savings.

Program Focus	Peak Savings		Overall Energy Savings	
	Range	Average	Range	Average
Peak Demand	1.2% to 33%	12.50%	-5.5% to 8.0%	3%
Overall Conservation & Efficiency	n.a.	n.a.	1.2% to 32%	10%

Overall energy savings are much higher for programs focused on overall efficiency and conservation.

Persistence of Savings Across 28 Studies

Persistent Feedback	Number	Percent
Persistent Savings	12	60%
Increased Savings	2	10%
Diminished Savings	2	10%
Unclear/ Other	4	20%
Total	20	100%

✓ 70% of studies showed persistent or increased savings.

Feedback was Discontinued	Number	Percent
Persistent Savings	3	50%
Increased Savings	2	33%
Diminished Savings	1	17%
Total	6	100%

✓ 83% of studies showed persistent or increased savings.

Persistence Measured in Terms of Device Usage (2 studies)

*use of device was found to decline over time.

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Persistence of Energy Savings

The evidence from 27 of the 57 studies suggests that if the feedback is persistent, then feedback-related savings are persistent over time.

Study	Country	Type of Feedback	Duration of Study (months)	Persistence of Savings
Mountain (2006)	Canada	Real Time Aggregate	13	Persistent conservation effect.
Mountain (2008)	Canada	Real Time Aggregate	24	Persistent conservation effect.
Nielsen (1993)	Denmark	Enhanced Billing	36	Persistent conservation effect.
Staats et al. (2004)	Netherlands	Enhanced Billing	36	Energy savings *increased* from 4.8% (at 8 months) to 7.6% (at 24 months).
Van Houwellingen (1989)	Netherlands	Real Time Aggregate	12	Energy conservation effect did not persist after the energy monitors were removed.
Wilhite and Ling (1995)	Norway	Enhanced Billing	36	Energy savings *increased* from 7.6% at the end of year two to 10% at the end of year three.
Wilhite et al. (1999)	Norway	Enhanced Billing	21	The longer the duration of the intervention and the more information made available to the household, the more persistent the impact.

Persistence of Energy Savings

Are savings persistent when feedback is discontinued?

Study	Country	Type of Feedback	Duration of Study (months)	Energy Savings	Persistence of Savings
Van Houwellingen (1989)	Netherlands	Real-time Aggregate (The Indicator)	24	12.3%	Energy conservation effect did not persist after energy monitors were removed.

"The savings effect was present only when the Indicator or the other feedback systems were present."

Study	Country	Type of Feedback	Duration of Study (months)	Energy Savings	Persistence of Savings
Staats et al. (2004)	Netherlands	Enhanced Billing	36	7.6%	Energy savings *increased* from 4.8% (at 8 mnths) to 7.6% at 2 yrs. Savings persisted long after intervention ended. Persistence came from supportive social environment.

The supportive social environment provided by ecoTeams resulted in persistent energy savings even after feedback was discontinued.

National-level Savings Estimates for the U.S. Residential Sector

National-level savings depend on the type of feedback, the program elements and the level of participation but the economics are generally favorable.

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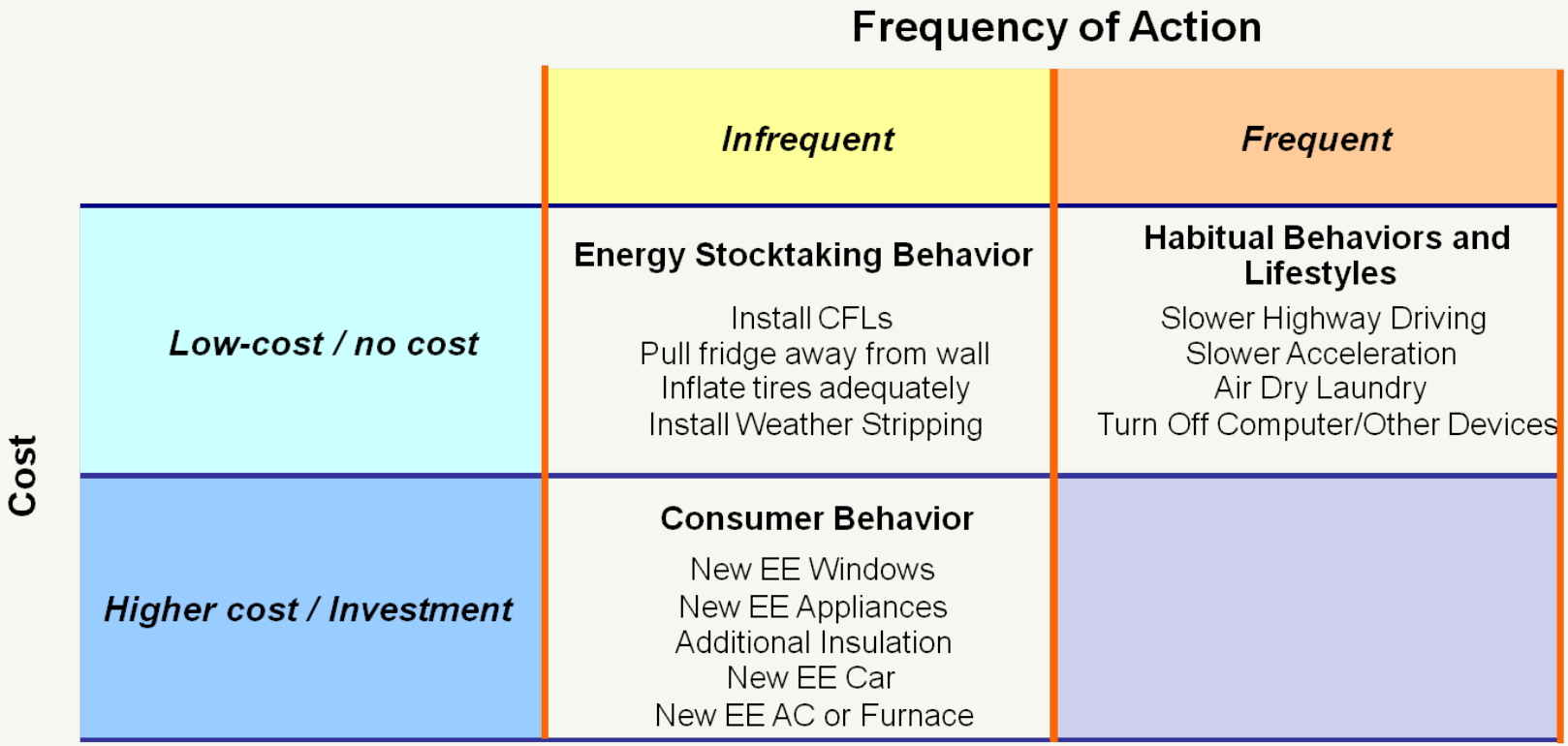
Which Behaviors Change?



Consumer Focus Group Results
1. Participants were engaged, thoughtful, open about Smart Grid topics. With careful communicating and good customer service, positive roll-outs are possible.
2. As with prior research, these results show consumers quickly grasp utility benefits for Smart Grid/Smart Meters but don't grasp the benefits to them. Utility and consumer benefits often don't match. Consumer benefits need to be better articulated and then tailored to each utility customer base.
3. **Consumers are likely to assume Smart Meters provide the user-friendly feedback** that consumer-facing technologies actually provide. This misconception is significant and needs to be overcome to prevent confusion and disappointment.
4. Participants believe that since **utilities and consumers share the benefits** of Smart Grid/Smart Meters, **utilities and consumers should share the costs**. Utilities need to do more to explain how costs are worth it to consumers.
5. Participants voiced some security concerns but didn't dominate thinking.

Consumer Backlash

In Santa Cruz County, south of San Jose, the Board of Supervisors recently extended a yearlong moratorium on installations.

Officials in Marin County, north of San Francisco, approved a ban on meters in unincorporated, largely rural areas, where about a quarter of its population lives.

Closing Thoughts

- AMI technologies provide an important opportunity for significant electricity savings.
- By themselves, however, "Smart Meters" are not smart enough to provide the full opportunity for significant electricity savings.
- Past studies suggest that feedback-related savings during the climate change era (1995-2010) are in the range of 4-12 percent.
- Greater rates of savings can be generated given the right combination of program elements and policy support.

Selected References:

Abrahamse, W., L. Steg, C. Vlek, & T. Rothengatter. 2007. "The effect of tailored information, goal setting, and tailored feedback on household energy use, energy-related behaviors, and behavioral antecedents." *Journal of Environmental Psychology*, 27: 265-276.

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