Why don't buildings behave the way we want them to?
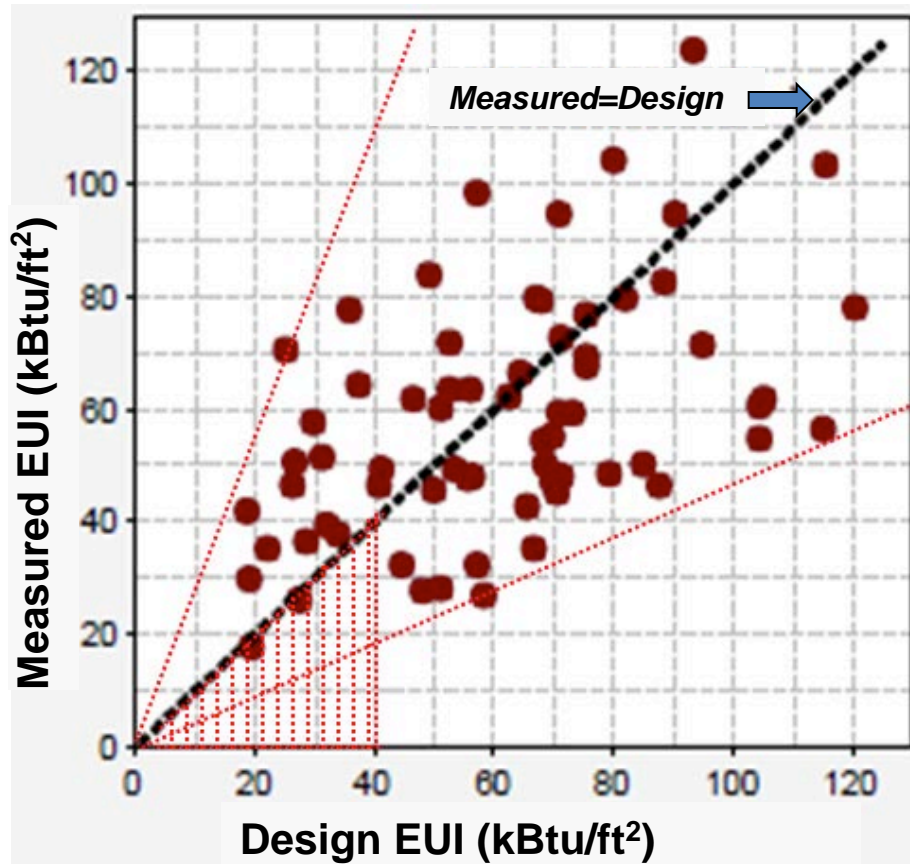
Rick Diamond, LBNL

NSF BEST Center

National Workshop

January 8, 2015

Low-Energy Buildings Do Not Perform as We Expected

Measured=Design

Measured EUI (kBtu/ft^2)

Design EUI (kBtu/ft^2)

Source: Energy performance of LEED-NC buildings, NBI, 2008

Observations:

1. Various building types, ages, locations

2. Average over all projects is not bad

3. Max over-predict by **120%**

4. Max under-predict by **65%**

5. **Almost all under-predicted for low energy designs**

   (red triangle: EUI <= 40)

Why don't buildings behave the way we want them to?

Definitions:

1. Behavior
2. Buildings
3. We

What do we mean by "Behavior"?

A) Everyone knows what it means

B) No one knows what it means

C) Some people know what it means

D) Other:

E) All of the above

Why should we care about behavior, energy, & buildings?

A) Behavior is the "fastest & cheapest" strategy to address major carbon reduction

B) Behavior impacts the design, delivery and performance of buildings

C) Behavior determines the amount and rate of energy use in buildings, transportation, etc.
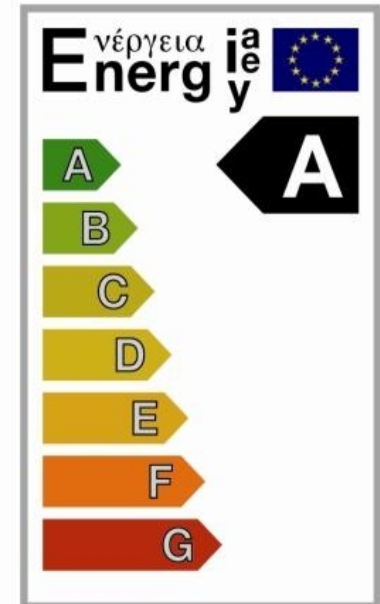
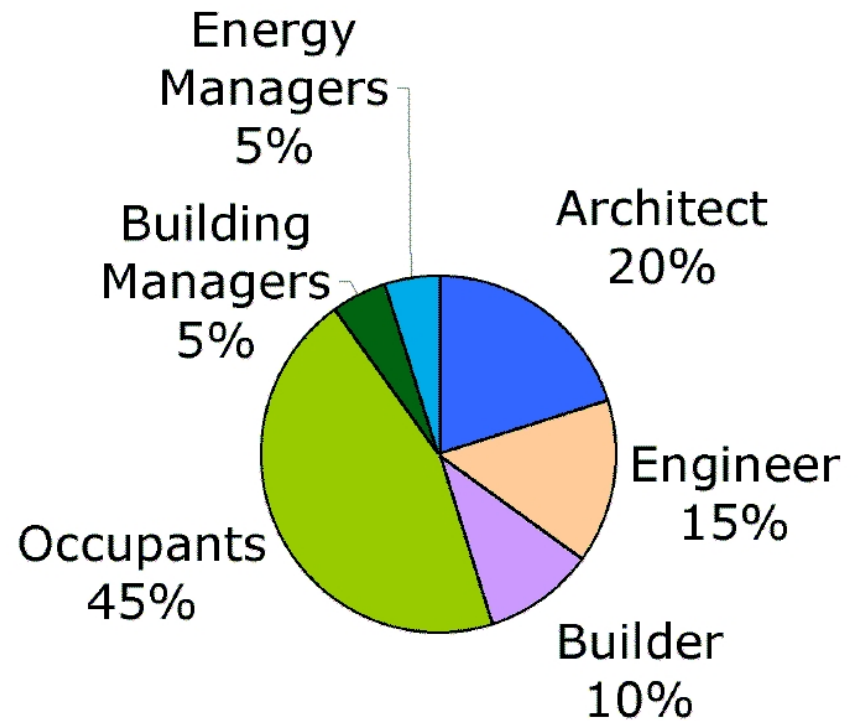# Behavior is a major determinant of energy use in buildings.

How much do identical buildings vary in energy use?

A) 1:1

B) 1:2

C) 1:5

D) 1:20

E) All of the above

Whose Behavior is an Important Determinant of Energy Use?

A) Architects

B) Builders

C) Building Operators

D) Occupants

E) Owner

Energy Managers 5%

Building Managers 5%

Architect 20%

Engineer 15%

Builder 10%

Occupants 45%

What are the
Drivers of Behavior?

A) Deities

B) Economics

C) Sociology, Psychology, Anthropology, etc.

D) Biology

E) All of the above

Do people need more information to change behavior?

A) People lack information on what to do

B) People may know what to do--but there may be other reasons why they choose not to act

C) People need to be engaged before they can act

D) People can change behavior without knowing why.

Is real-time feedback important?

When does feedback work?

A) Prius riders are a captive audience, with immediate feedback on their actions

B) Homeowners may be captive, but may not be motivated to act on information

C) Office workers may be neither captive nor motivated

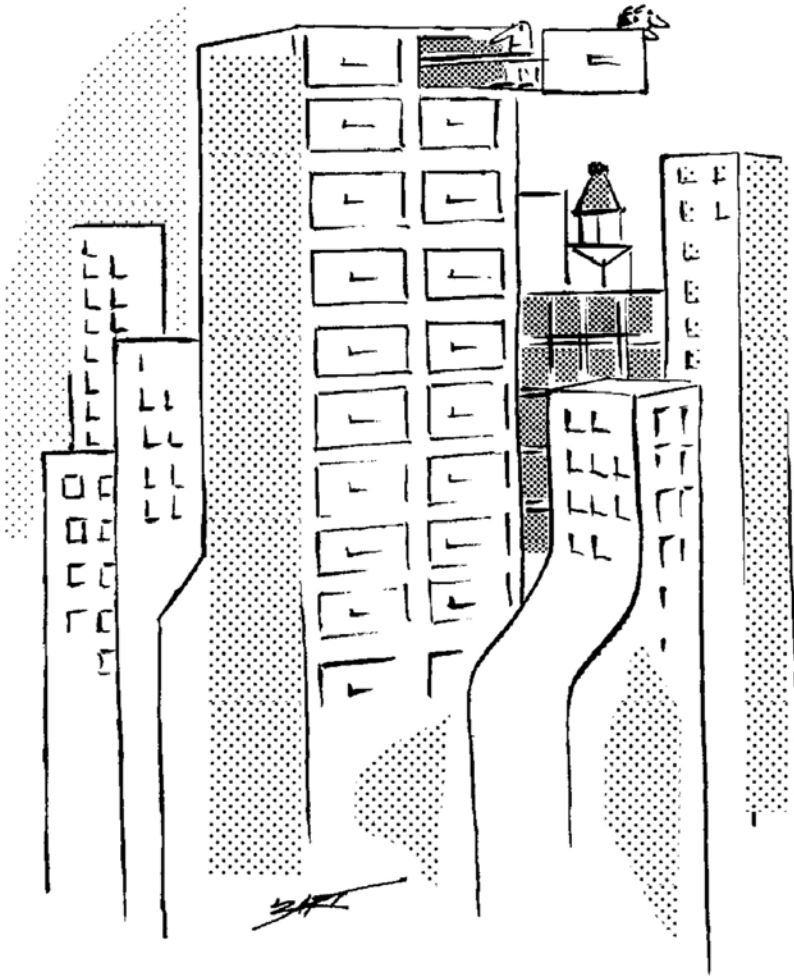D) Individuals may choose to ignore information if it is not perceived as having value to them

Is it Easy to Change Behavior?

People will change if:

A) They are motivated to change

B) They have the ability to change

C) The context or culture supports the change

D) If a trigger is present

E) All of the above

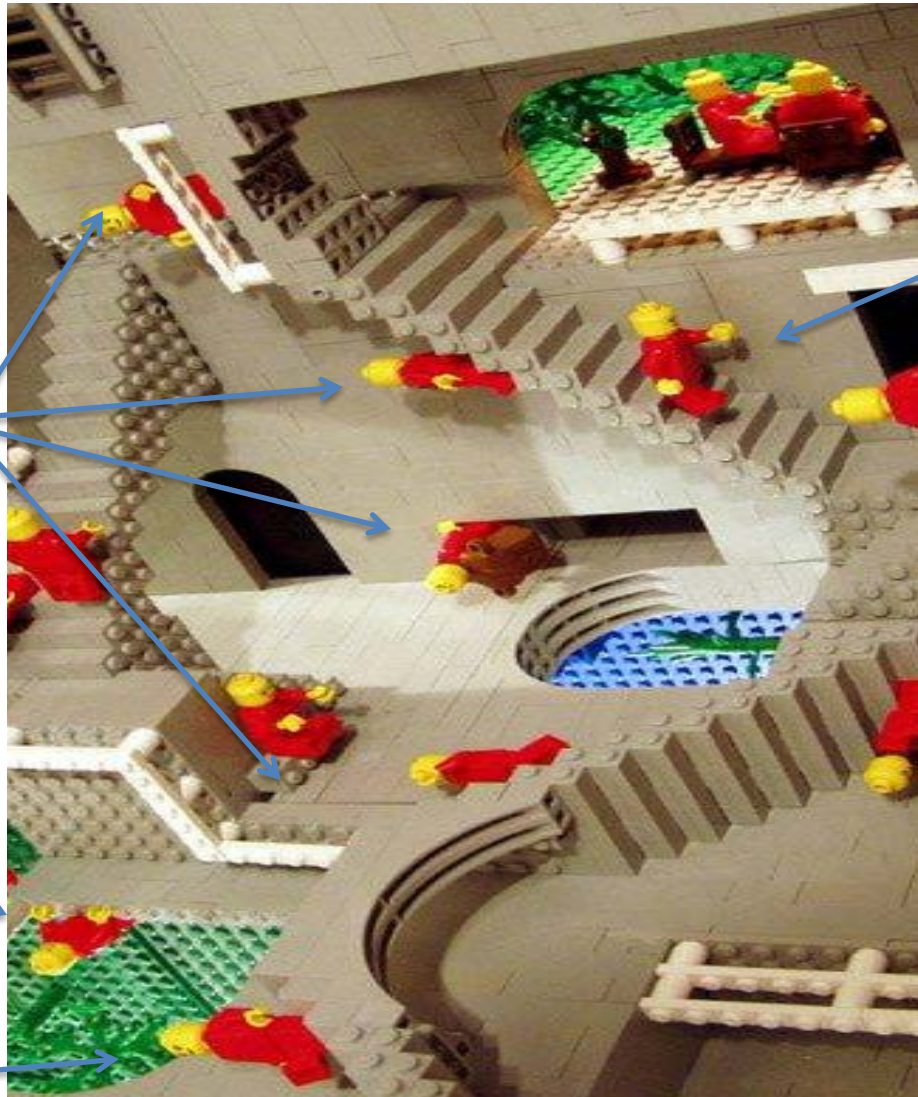TURN DOWN THE HEAT, THE BILLS AND CARBON POLLUTION

WHAT CAN YOU DO IN YOUR WORLD?

savepower.nsw.gov.au

What goes on in Buildings?

Open the door and
see all the people .....

(*material from Judith Heerwagen, GSA*)

Many people, many roles, perspectives & needs..

Decision makers set the agenda

Workers Have different comfort preferences and work styles.

IT person - keeps the energy consuming computers & devices up and running.

Building Operator – Tracks, adjusts conditions

Office manager – Makes purchasing decisions

Facility mgr – deals with complaints.

Building Systems

Social System –

The system of people
-Behavior
-Culture
-Mission

← Influence of physical system on human health, comfort and performance

→ Influence of social system on building performance

Physical system–

The system of things
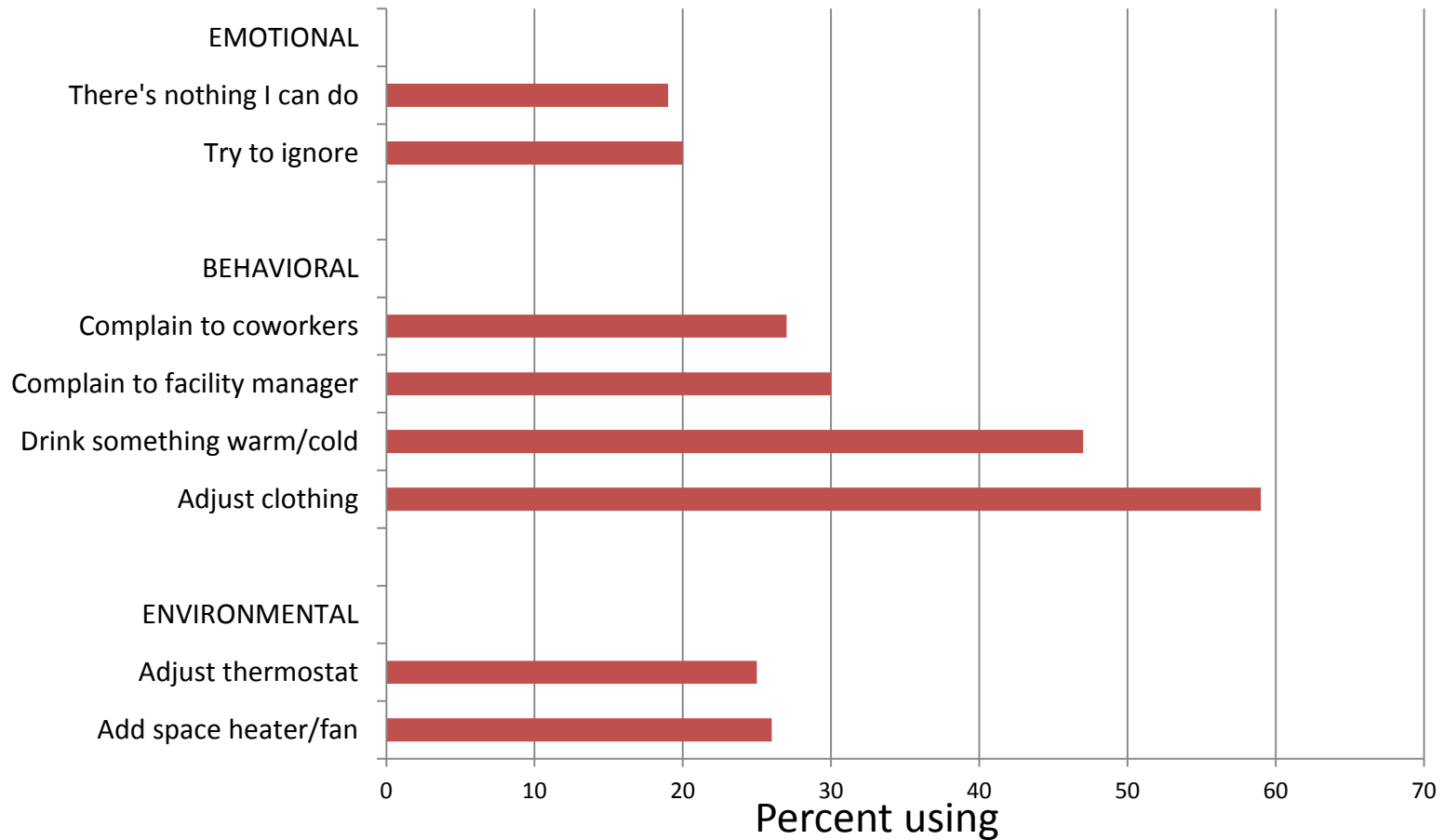-Technologies
-Operations
-Design

What do we know now about
the interaction of the social system
and the physical system?

Specifically, what do we know about
energy and behavior?

Coping with Discomfort

Methods: survey and observations
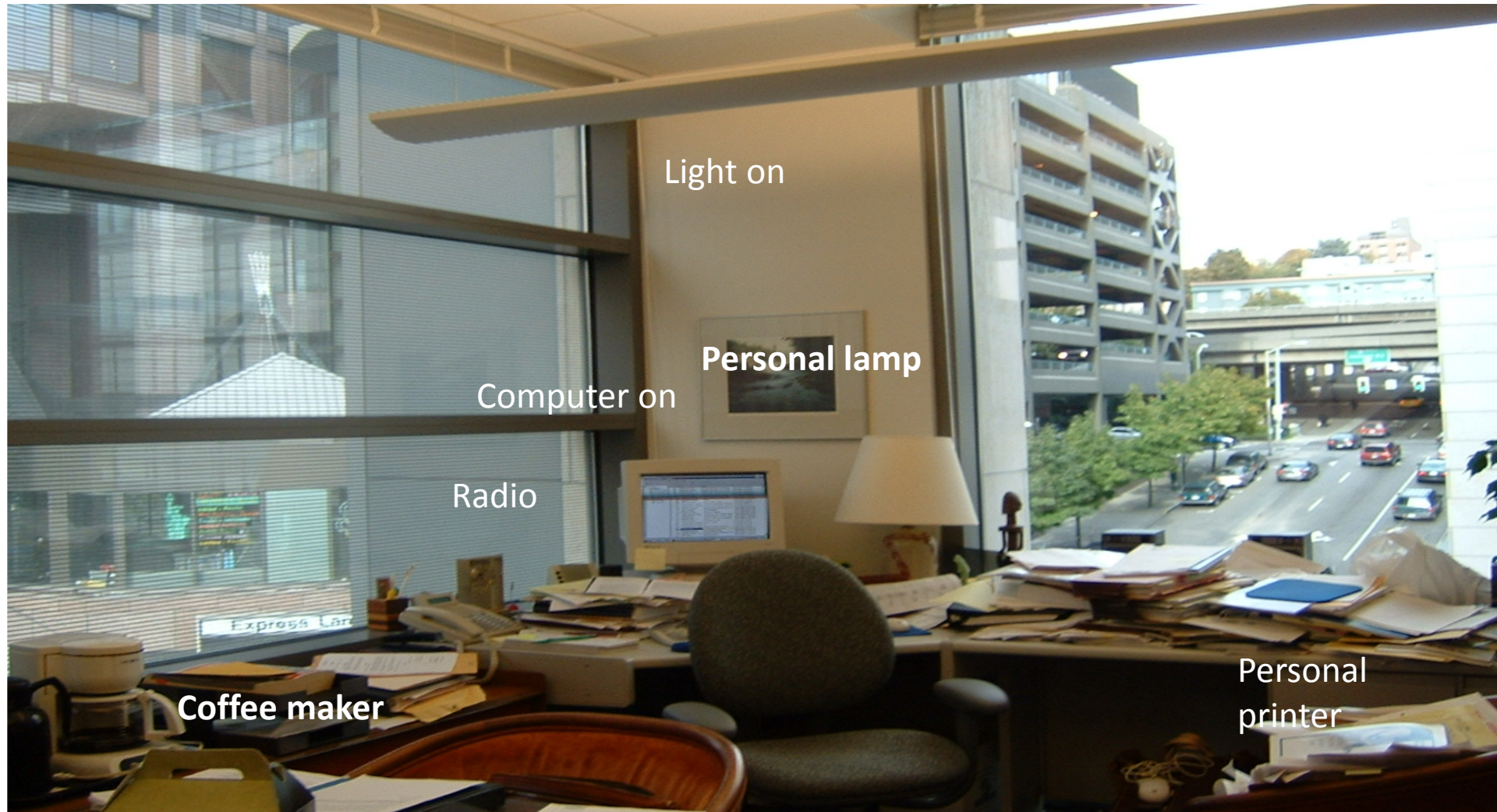
How people cope with discomfort

J. Heerwagen, R. Diamond and J. Loveland 1993. Post occupancy of Seven Energy Edge Buildings, US Department of Energy.

They alter thermal conditions.

Under floor air vent cover

They operate the space and add devices to improve comfort and convenience.

Glare is a frequent problem

They disable daylight sensors, de-lamp fixtures, add task lamps, and turn lights back on when automatic sensors turn them off.

J. Heerwagen, R. Diamond, and J. Loveland, 1993. Post Occupancy Evaluation Of Seven Energy Edge Buildings, US Department of Energy.

People are not passive recipients of design… they actively alter the environment to increase their comfort and reduce distractions.

We want to save energy.
They want to be comfortable and productive.

Implications for energy reduction

Energy reduction goals and technologies are at risk when they are perceived as interfering with personal goals and perceived needs.

How do we counteract this problem?

How do we support and encourage change?

A Key Barrier:

Energy not only supports an organization's mission and work. It also makes our desires possible – comfort, status, convenience. This is why it's hard to change.

Key Questions

- Can deliberate behavioral modifications change current energy habits? And create new, more energy efficient habits?

- What is the impact on energy use compared to existing conditions? (Need pre and post data)

- Which behavioral change strategies are most effective and under what contexts?

- How do we maintain change over time? (tendency to revert to old habits is strong)

Change Model

Behavioral Change

=

M * A * C

Motivation * Ability * Context

And sometimes a T (trigger) is needed

A Model for Creating and Maintaining Behavioral Change

Behavior Change = Motivation + Ability + Context

What behavior?
Whose?

Do you want to change the behavior?

Are you able to? Do you have control?

Does the context aid or inhibit the change?

In order to change a system, you need to change the behaviors of many people in many roles.

Behavior   Core motivators +   Ability +   Context

Who?	Occupants/users	Pleasure/pain	Time	Culture
	Operations	Hope/fear	Effort	Environment
	Procurement	Acceptance/rejection	Control	
	Policy makers		Cost	
		Payoff to self/group	Familiarity	
	Equipment use	(can $ savings be		
	Vehicle use	reinvested?)		
What?	Building conditions			
	Purchasing			
	Alternative work			
	Space sharing			
	Social comparison			
	Social reciprocity			
How?	Eco-feedback			
	Training			
	Context change			
	Policy			

A new environment offers
Opportunity to change
Habits; an existing
Environment acts against
Habit change because
It triggers familiar
behaviors.

High Motivation

People may be willing to try hard to change

Change most likely to occur when ability & motivation are high

Low Motivation

Change is jeopardized

Change may occur If behavior is simple

Low Ability

High Ability

Understanding People in Context

- People don't always do what they say
- People don't always do what they think
- People don't always say how they feel.

A Framework for Change

Roles, Rules and Tools

- What are the **roles** – especially the key roles – and their essential connectedness to system functioning.

- Understanding the formal and informal **rules** – or their absence – that facilitate or impede what practitioners are trying to do in their organizations.

- Describing and evaluating the **tools** — systems, processes, and physical equipment — that practitioners have and don't have to do their work

Using the Framework

The RR&T Framework is a diagnostic tool

To apply it you need to:

- Engage
- Educate
- Enable

Ways to do this are the 8 Principles

Eight Principles of Change

Eight Principles of Institutional Change

1. **Social networking**. Individuals, groups, institutions, and firms change their behaviors when they observe others who have different patterns of behavior or have changed their behaviors.

2. **Multiple motivations**. Behavior changes for multiple reasons, so it is important to provide multiple reasons for the same individual and for other people within organizations or institutions.

3. **Leadership**. Change occurs when formal or informally recognized leader(s) within an organization provide vision, direction, energy, and charisma to support the change effort.

4. **Commitment.** Change occurs when people and groups make public commitments, or when they enact a new or different behavior and that behavior is recognized by others.

8 Principles (cont.)
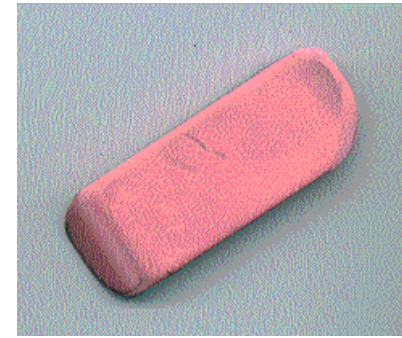
5. **Information and feedback**. Change occurs when there is new information or positive or negative feedback that reinforces an existing or changed behavior.

6. **Infrastructure**. Individual and organizational behavior changes when expectations, rules, or ways of doing things change.

7. **Social empowerment**. Behavior changes when the voices of participants are recognized, and they are encouraged to establish new behaviors.

8. **Continuous change.** Continuous organizational, institutional, and cultural change comes when there is constant assessment and action with respect to goals, feedback, information, leadership, commitment, and multiple motivations.

Case Studies

Navy Achieved 50% Savings through integration of Technology and Behavior

Roles, Rules, and Tools
Roles were the newly defined "Building Energy Monitors," who serve as contact points for communication with the core energy management team.

The **tools** included monthly energy reports, that pointed out energy anomalies and increased awareness about energy consumption.

Principles
The Navy applied three social science principles:

1. Social Network & Communications
2. Leadership
3. Information & Feedback

# Lean Green Teams saved the US Postal Service more than $41M in FY 2011

Roles, Rules, and Tools
Roles: USPS created cross-functional teams rather than individuals; the idea is that, in their roles as building inhabitants, drivers, water and consumer product users, and waste disposers, staff can work together to create a conservation culture that results in energy and waste savings.

Principles Applied
The USPS activities applied four social science principles:
1. Leadership
2. Commitment
3. Information & Feedback, and
4. Social Empowerment.
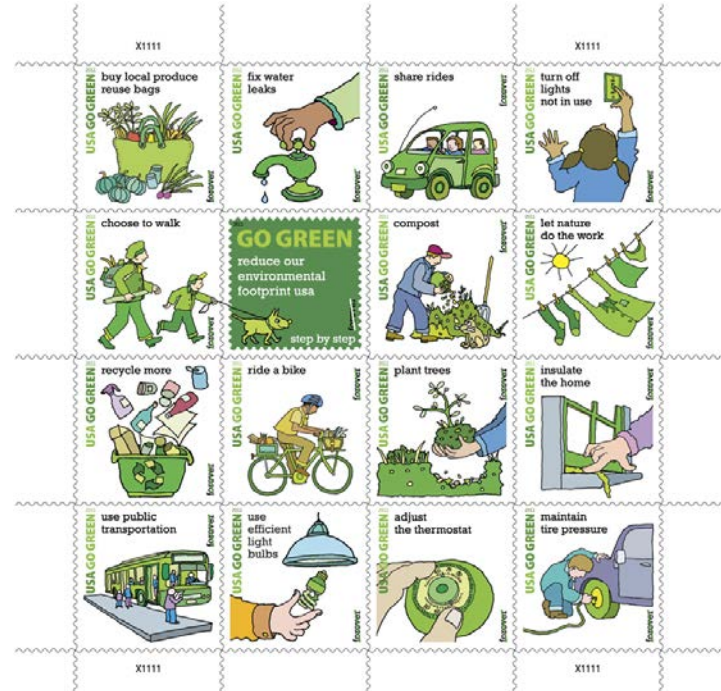
Fish and Wildlife Service achieves savings through "field level up" strategies

Roles, Rules, and Tools

David Guthrie created a network of energy managers that all have clearly defined **roles** and responsibilities.
His **tools** that include training of energy managers, checklists for meeting FWS guidelines, tracking databases for energy and water consumption, and presentations
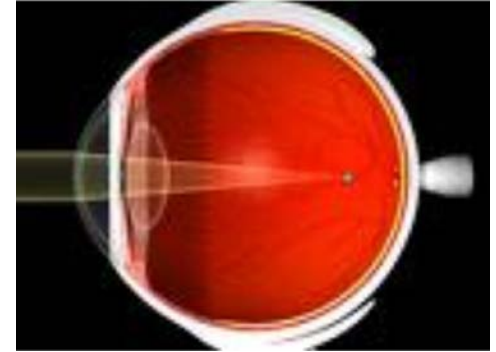
Principles Applied

The FWS applied three social science principles:
1. Social Networking & Communications,
2. Leadership, and
3. Social Empowerment.

Conclusions:
Switch Focus

A) Technology is not independent of behavior, but is part of the cultural and physical context in which it takes place

B) Assumptions about behavior are often limited, and ignore key aspects

C) Behavioral insights can be applied to policies and programs, but need to be subjected to testing and evaluation.