



RECHARGE  
COLORADO

high performance design workshop  
Beyond the Building: The Occupant Factor 201



Governor's  
Energy Office

## Presenters



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- Principal
- M.E. GROUP



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- Project Manager
- Hutton Architecture Studio



RECHARGE  
COLORADO

# High Performance Building Program



Governor's  
Energy Office

## GEO Mission

Promote sustainable economic development in Colorado through advancing the state's energy market and industry to create jobs, increase energy security, lower long-term consumer costs, and protect our environment.

## GEO High Performance Building Program

Promote the adoption of high performance building practices across Colorado to enhance the built environment, utilize resources wisely, and provide superior spaces for living, working and playing.



Photo courtesy of Julesburg, CO Tourism



Photo by Matt Inden/Weaver Multimedia Group



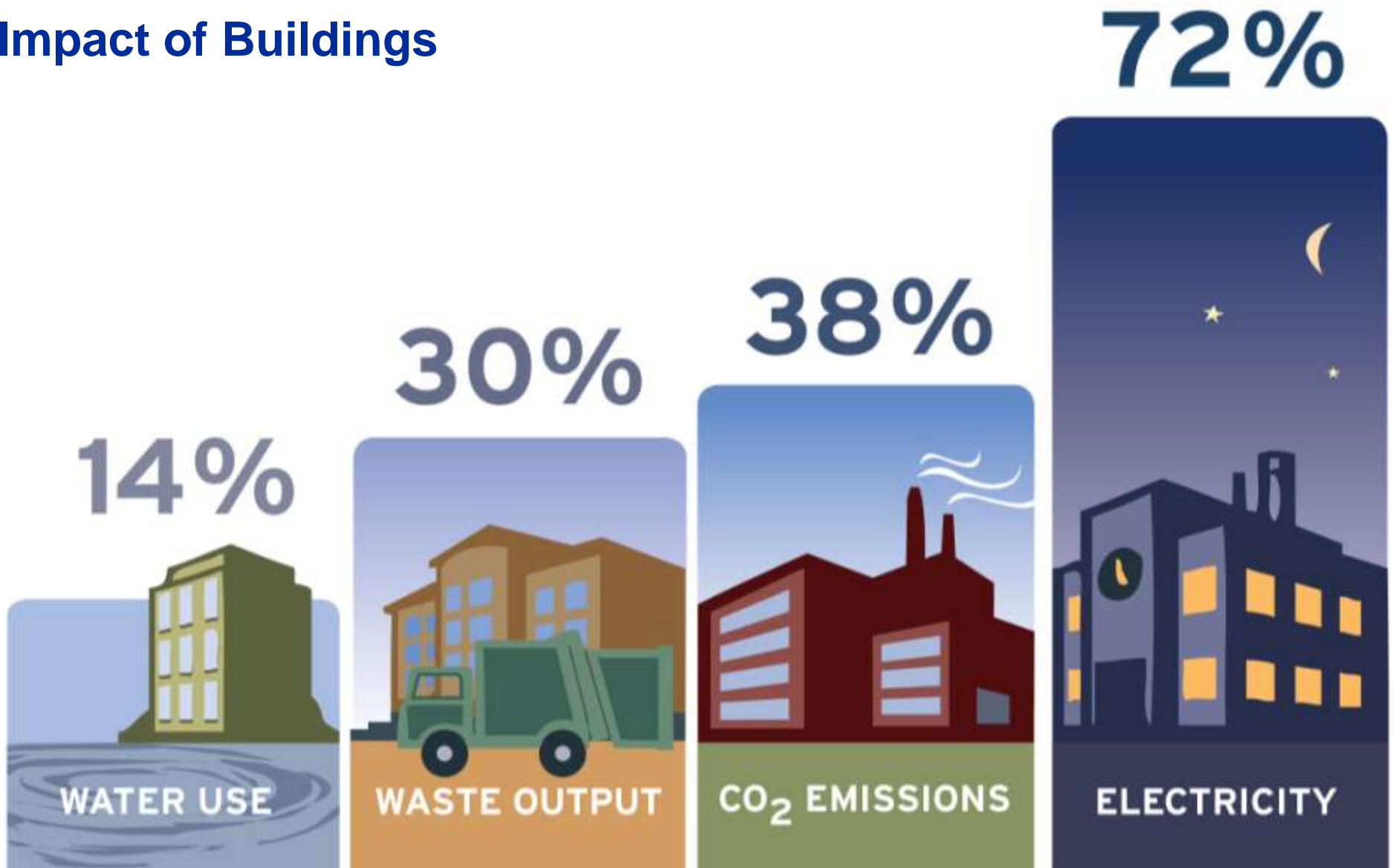
Photo courtesy of Kit Carson Carousel Museum

## Teaching to Fish

- Legislation
- Access to Information
- Advance the New Energy Economy
- Establish Colorado as a leader
- Build a knowledgeable workforce



## Impact of Buildings



## Program Services

### Training & Education

- Webinars
- Workshops
- Tools
- Case Studies

### Partner Program Technical Assistance

- Set high performance design goals
- Identify funding sources
- Champion Energy Efficiency
- Review Plans and Models
- Comply with State Requirements



## GEO Partner Process



**FIND OUT**  
about program



**FILL OUT**  
application



**WORK WITH**  
HPC on scope



**SIGN MOU**  
to get started



**GET GEO**  
assistance

SAVE ENERGY   REDUCE COSTS   ENHANCE PERFORMANCE

*Services are ramping down. Projects only accepted as funding is available.  
Apply now!*

## High Performance Tools and Resources now available:

- Flex Energy: plan for shifts in energy usage and delivery
- Case Studies: 11 High Performance schools, libraries, museums, and more
- Building Owner's Manual: a guide to high performance building
- One pagers, concept overviews, and best practices
- RFP/RFQ Templates: outline for selecting qualified team members
- Contractor's Toolkit: an entire suite of tools for the jobsite
- *Available FREE online at <http://tiny.cc/h7lgc>*



## Presentation Archives

<http://www.rechargecolorado.com/>


- PDFs: <http://tiny.cc/u2n722g0bk>

<http://vimeo.com/channels/geohpbp>

- Recorded webinars:
- LEED CEUs available for viewing past webinars



email [HPBWorkshops@state.co.us](mailto:HPBWorkshops@state.co.us) for more info



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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

# Course Evaluations

- In order to maintain high-quality learning experiences, please access the evaluation for this course by logging into CES Discovery and clicking on the *Course Evaluation* link on the left side of the page



THE AMERICAN INSTITUTE  
OF ARCHITECTS

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- Fill out the GBCI Continuing Education Tracking Form
  - Write legibly (*or we can't send you anything*)
  - Sign the form (*or you get no credit*)
- Return the survey and tracking form
- Certificate will be e-mailed to you



**COLORADO**

**GBCI  
CMP**

*This session is approved for 1.5 GBCI CE Hours*



## Learning Objectives

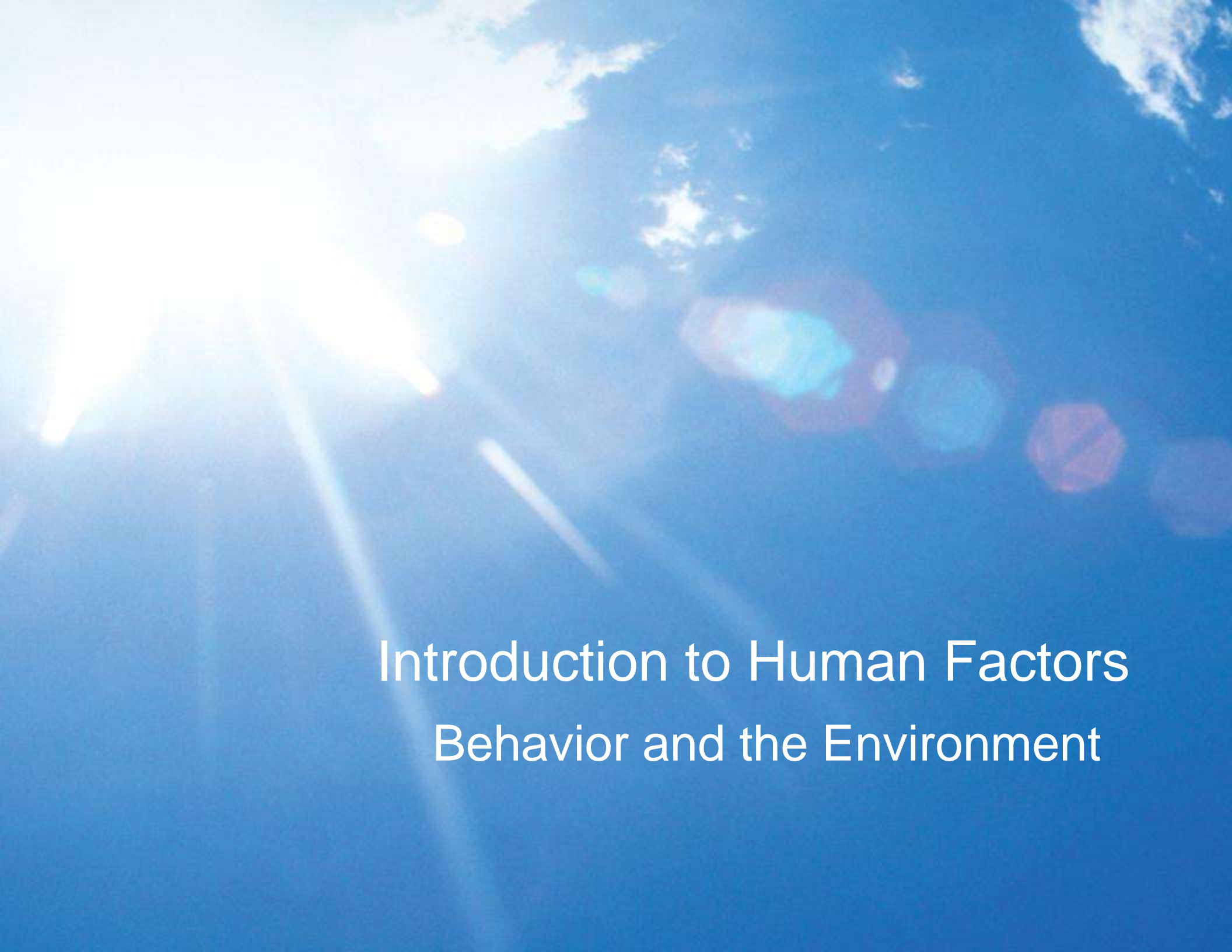
At the end of this program, participants will be able to:

- Propose strategies to increase occupant motivation to enhance energy performance
- Employ integrated design strategies to incorporate user needs into the facility
- Outline the benefits of a Post Occupancy Evaluation
- Identify different methods of gaining occupant information



## Agenda

- Introduction to Human Factors
- Human Factors – Impacts within the Building Process
- Identifying and Aligning Building & Behavior – Pre-Occupancy
- Q and A
- Identifying and Aligning Building & Behavior – Post-Occupancy
- Q and A
- Summary and Wrap up

A bright sun in a blue sky with lens flare effects. The sun is positioned in the upper left quadrant, creating a strong lens flare that extends diagonally across the frame. The sky is a deep blue, and there are some wispy white clouds in the upper right corner. The overall image has a high-contrast, vibrant appearance.

# Introduction to Human Factors Behavior and the Environment

# The Science Behind Behavior

$$B = f(I + E)$$



I



E

## Behavior

is a function of the

Individual and the Environment

Kurt Lewin, 1936

*Principles of Topological Psychology*

## The Individual



# The Individual

## Occupant Needs

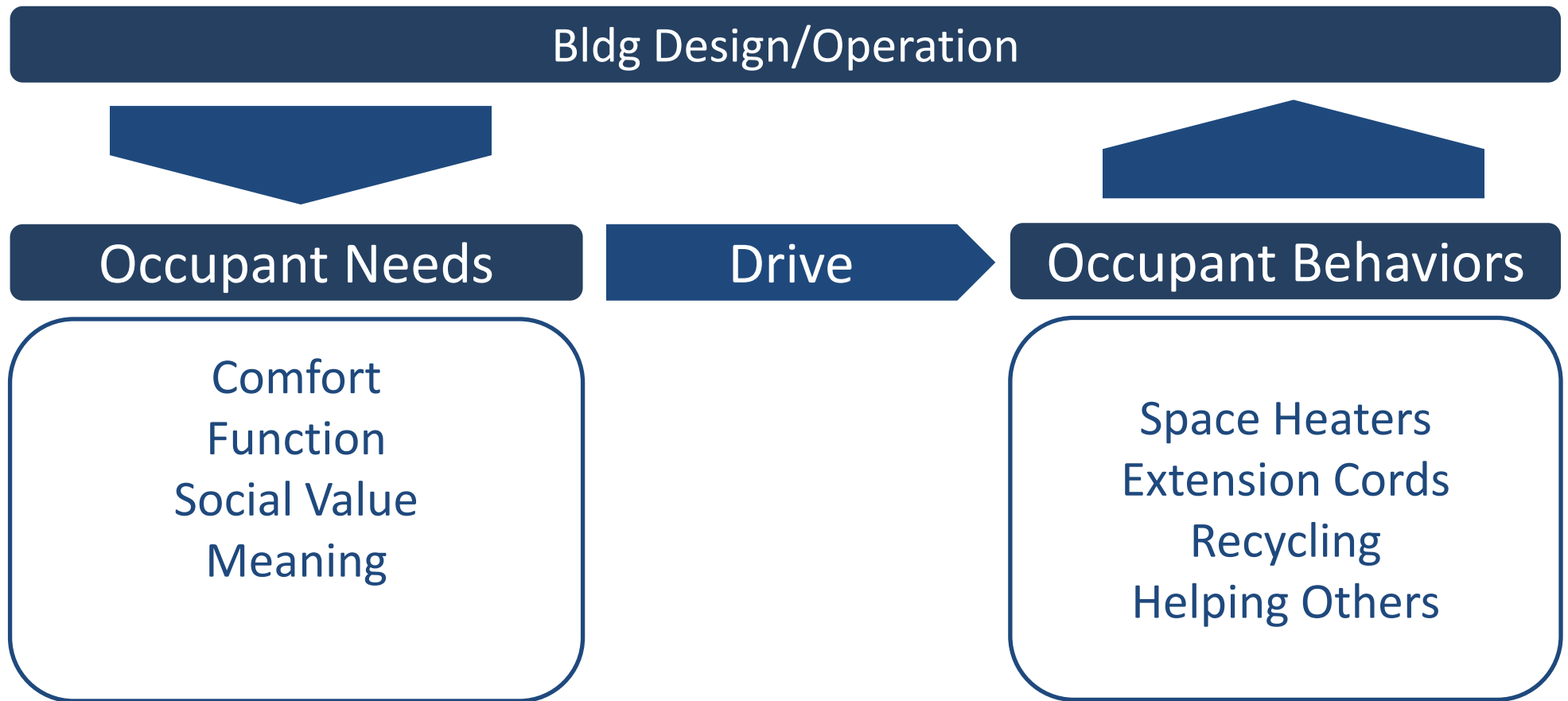
Comfort  
Function  
Social Value  
Meaning  
Etc.

## Drive

## Occupant Behaviors

Space Heaters  
Extension Cords  
Recycling  
Helping Others  
Etc.

# The Individual and Environment

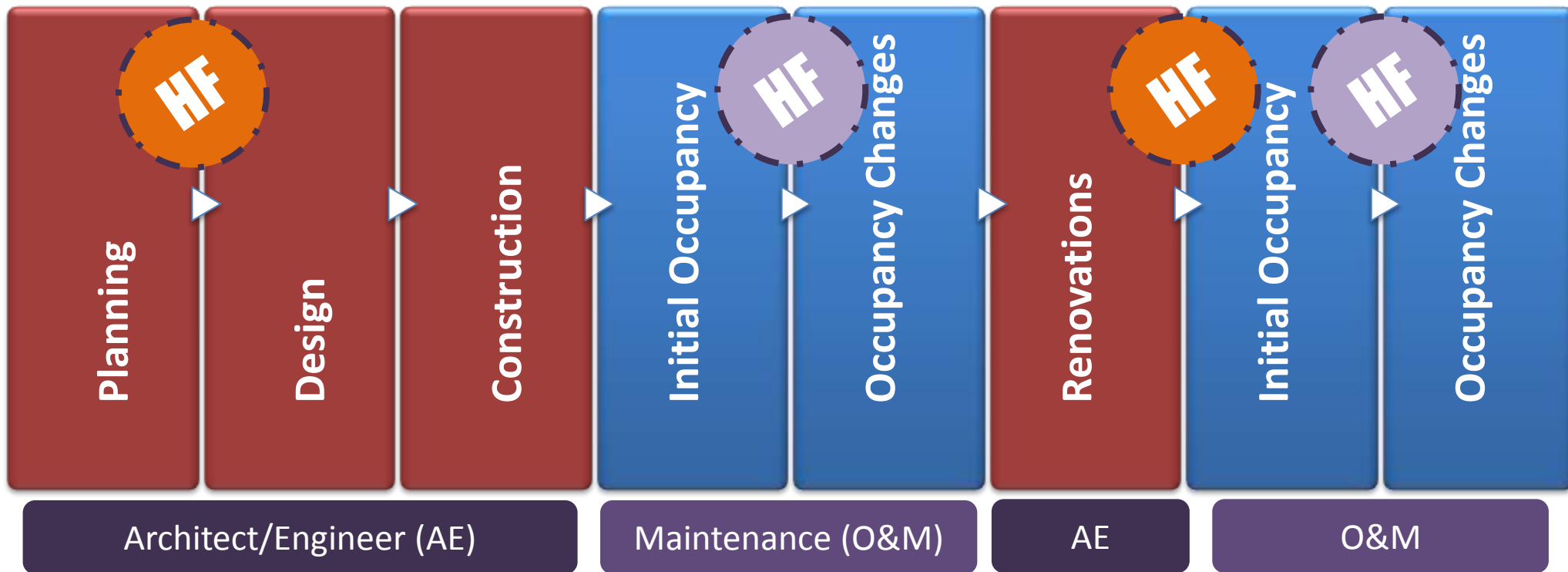


A bright sun in a blue sky with lens flare effects. The sun is positioned in the upper left quadrant, creating a strong glare and several diagonal light streaks across the frame. The sky is a deep blue, and there are some wispy white clouds in the upper right corner. The overall image has a high-contrast, vibrant appearance.

# Human Factors

Impacts within the Building Process

## Current Building Process



What's the big deal?



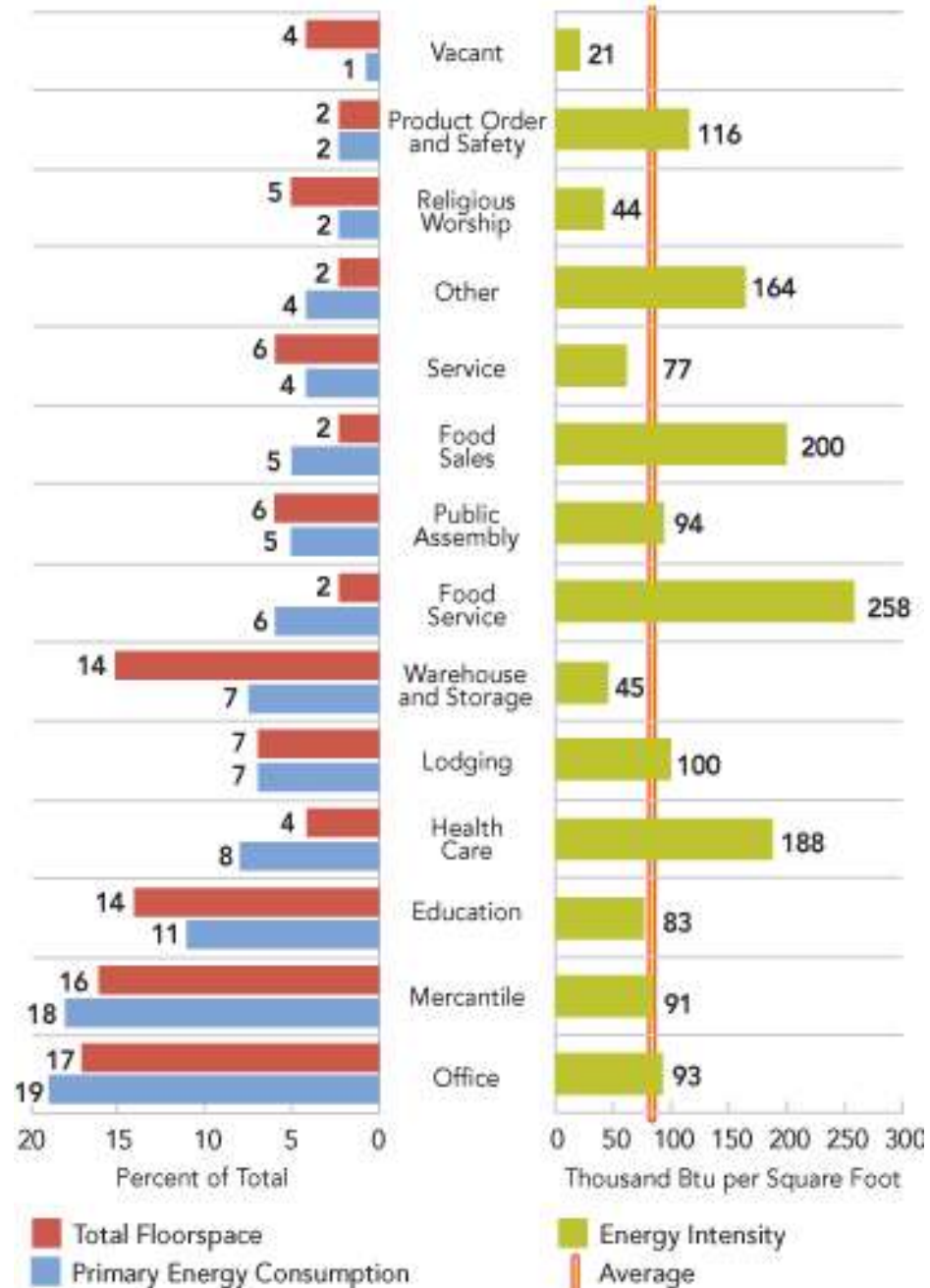
Why should we  
care?



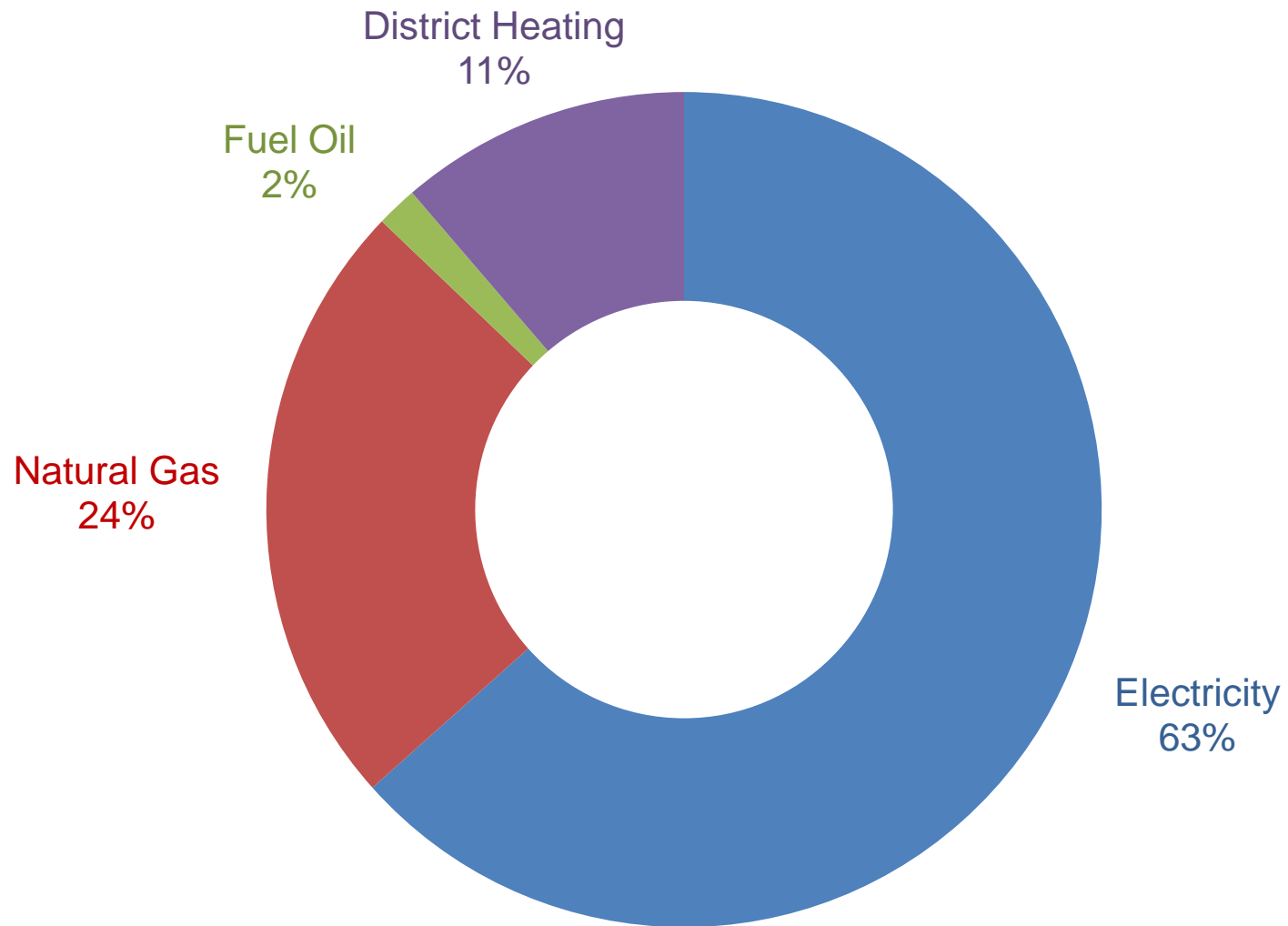
# WHY?

We're the experts.

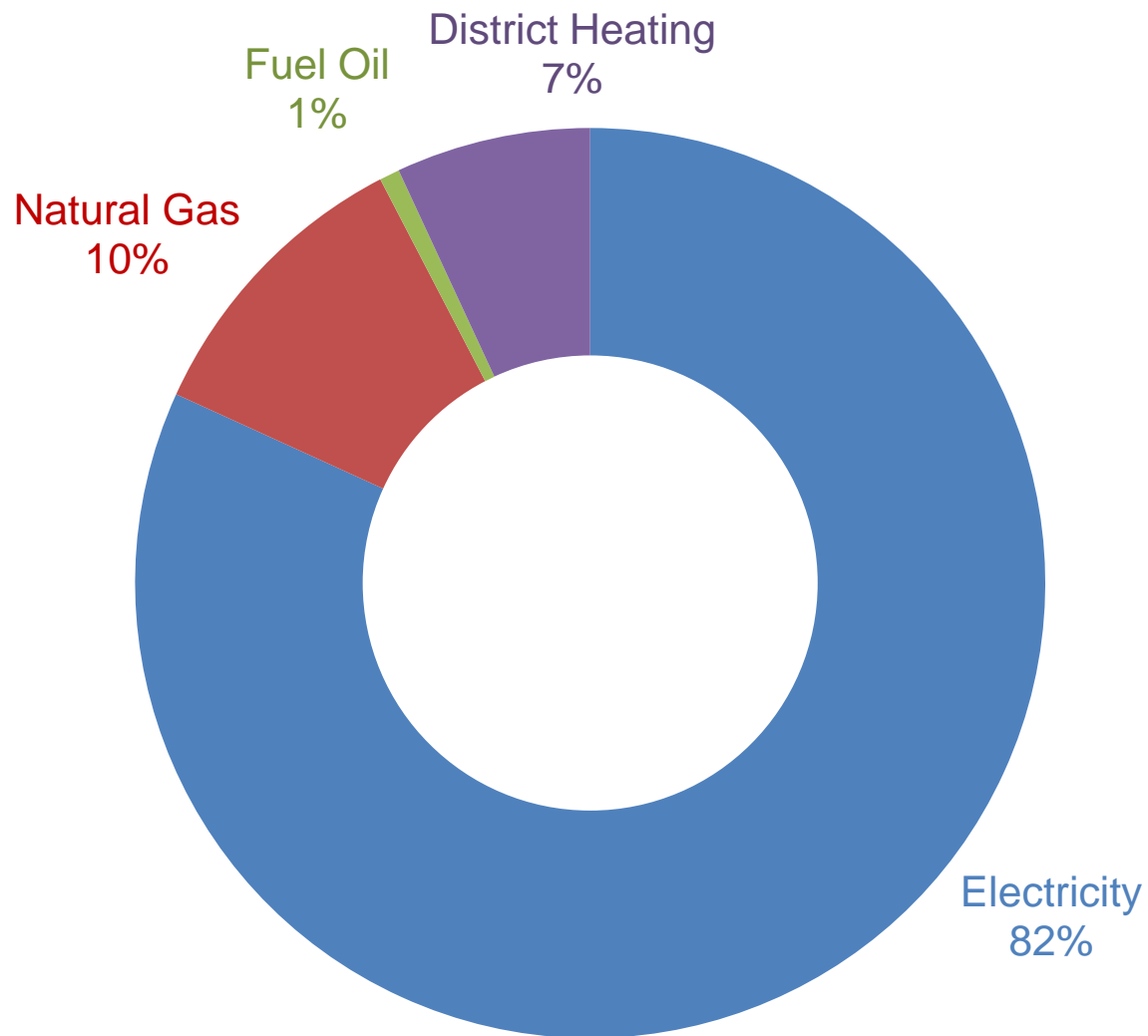
Just use the building as we  
intended.



## Office Building: Fuel Usage



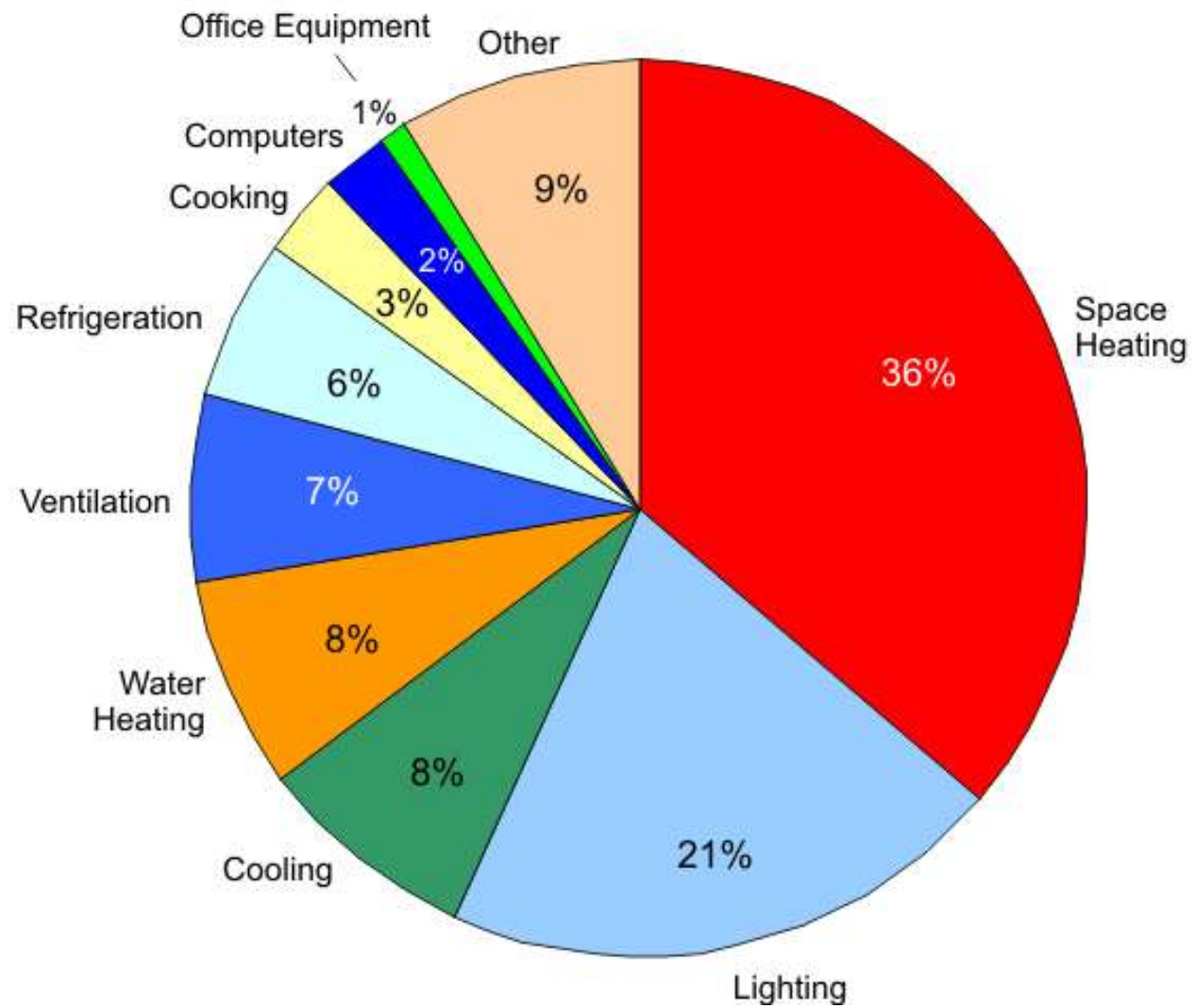
## Office Building: Fuel Expenditure (\$)



=\$1.71/sf

2003

Percent of Total Consumption in Commercial Buildings by End Use



## Examples of Problems

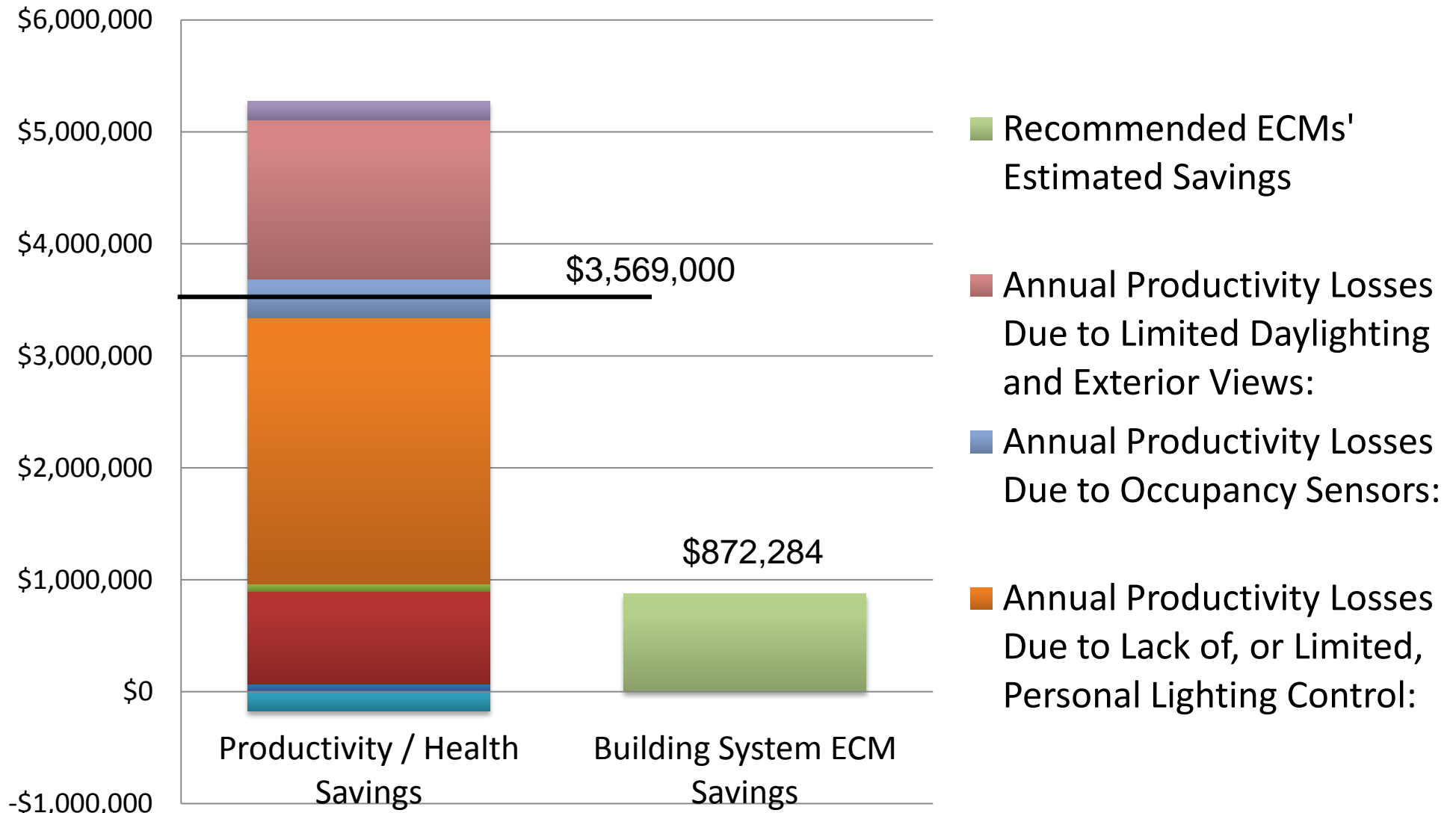
### Owners Problems

- Higher Energy/Water Cost
- Higher Maintenance Cost
- Lower Occupant Satisfaction and Productivity/Performance
- Absenteeism Above Expectations
- Sick Building Syndrome Symptoms Above Expectations
- Greater Environmental Footprint

### Occupants Problems

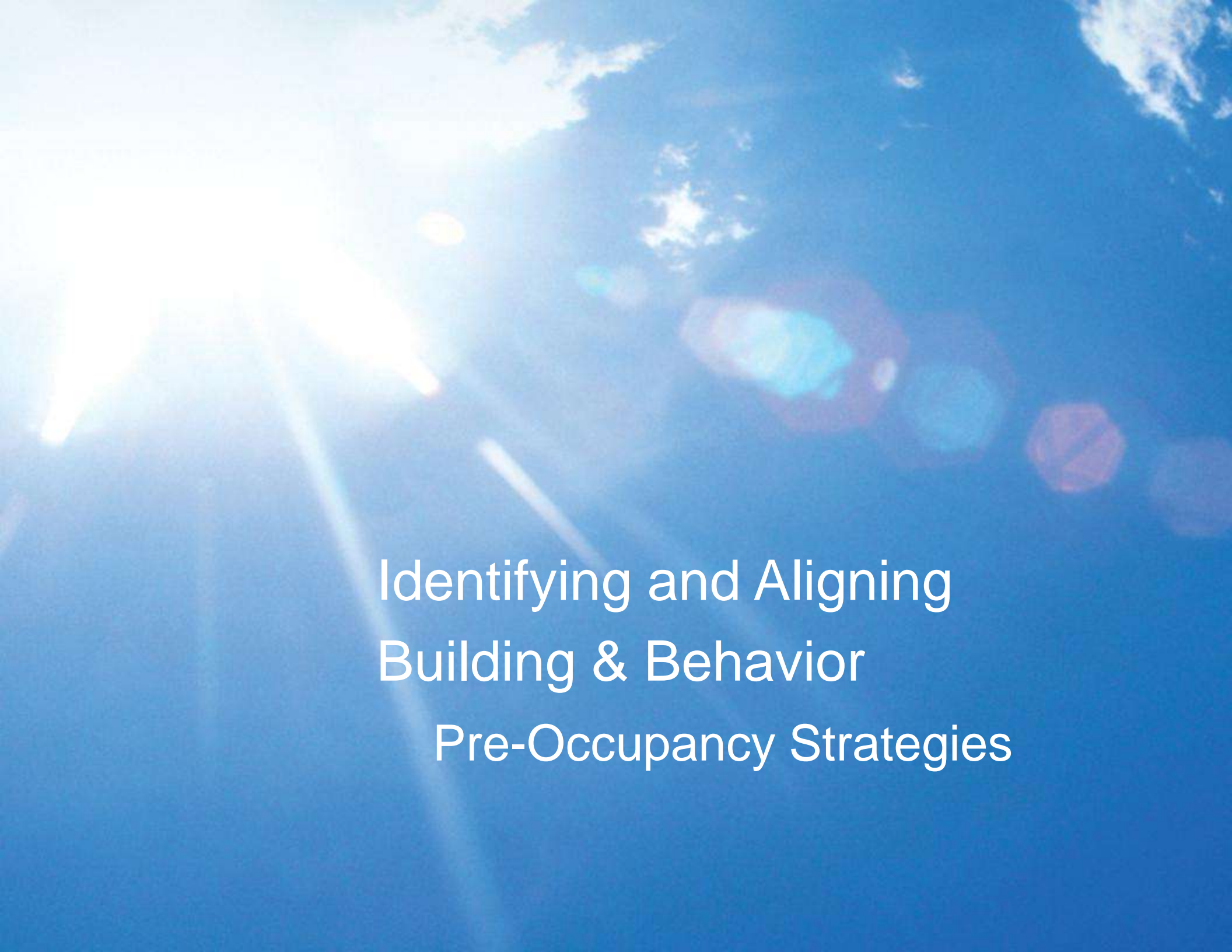
- Uncomfortable
- Not able to work efficiently
- Feeling tired
- Feeling frustrated
- Feeling unimportant
- Lower loyalty to owner

# Productivity/Performance & Health

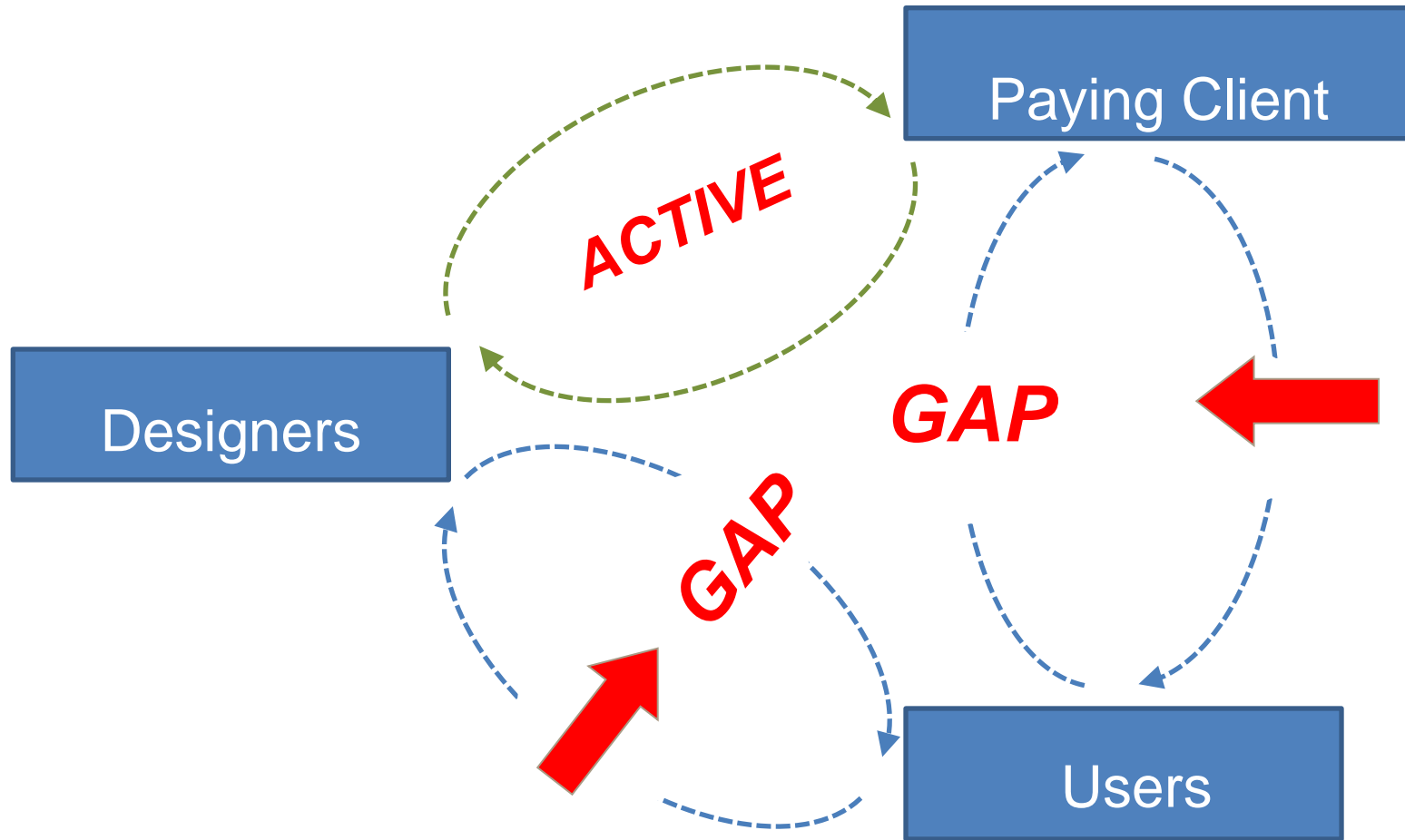


A bright sun in a blue sky with lens flare effects. The sun is positioned in the upper left quadrant, creating a strong glare and several diagonal light streaks across the frame. The sky is a deep blue, and there are some wispy white clouds in the upper right corner. The overall effect is a high-contrast, vibrant blue background with a prominent light source.

# Human Factors Focus Groups

A bright sun in a blue sky with lens flare effects. The sun is positioned in the upper left quadrant, creating a strong lens flare that extends across the sky. The sky is a deep blue with some wispy white clouds. The text is centered in the lower half of the image.

Identifying and Aligning  
Building & Behavior  
Pre-Occupancy Strategies




Typical Programming Diagram

## Incorporating the occupant into the facility:

- Participatory Planning
- Participatory Action Research
- Pre-Occupancy Evaluation
- Observation
- Research





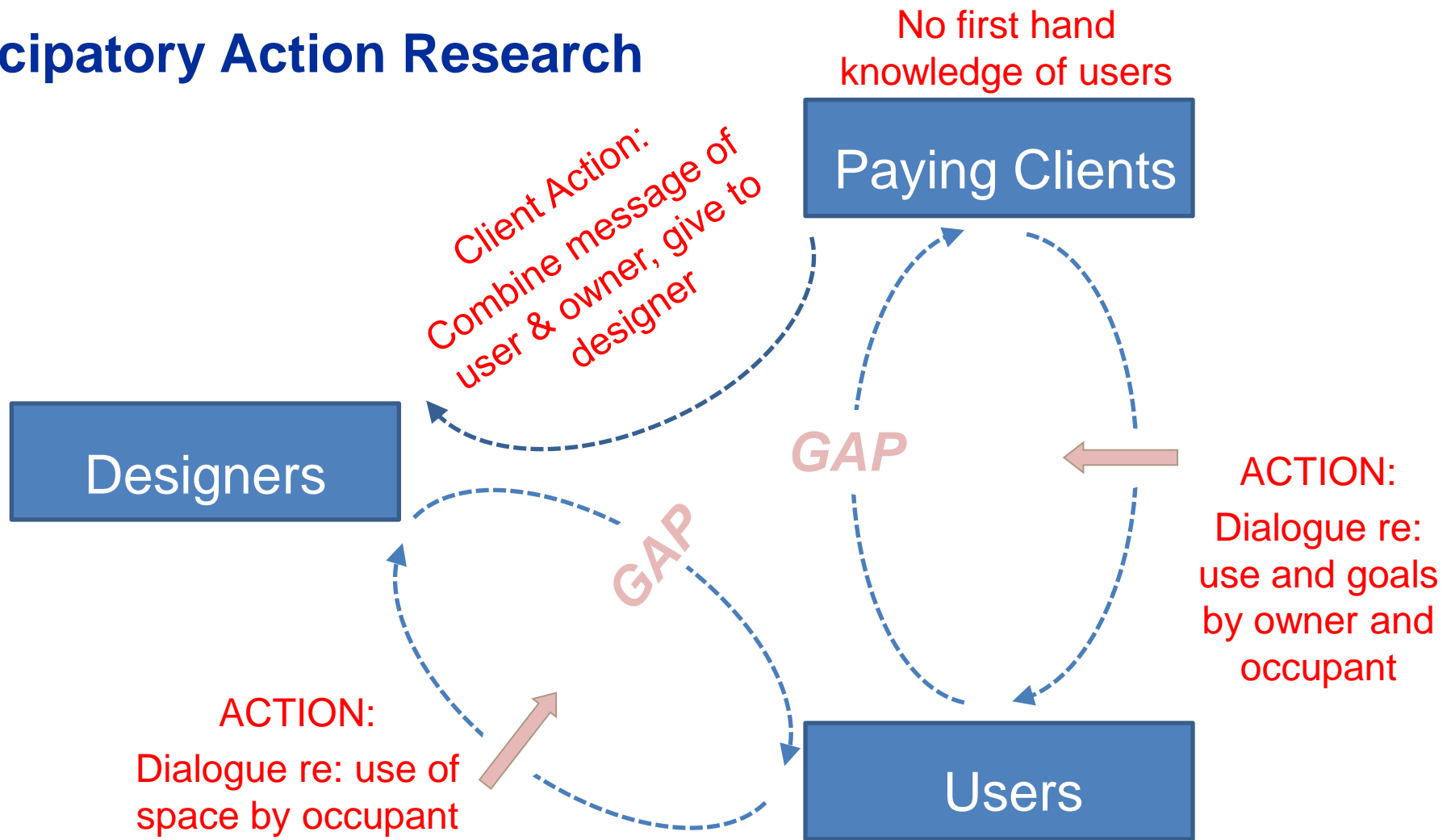
Design, Planning, & Evaluation  
Participatory Action Research



## Participatory Action Research

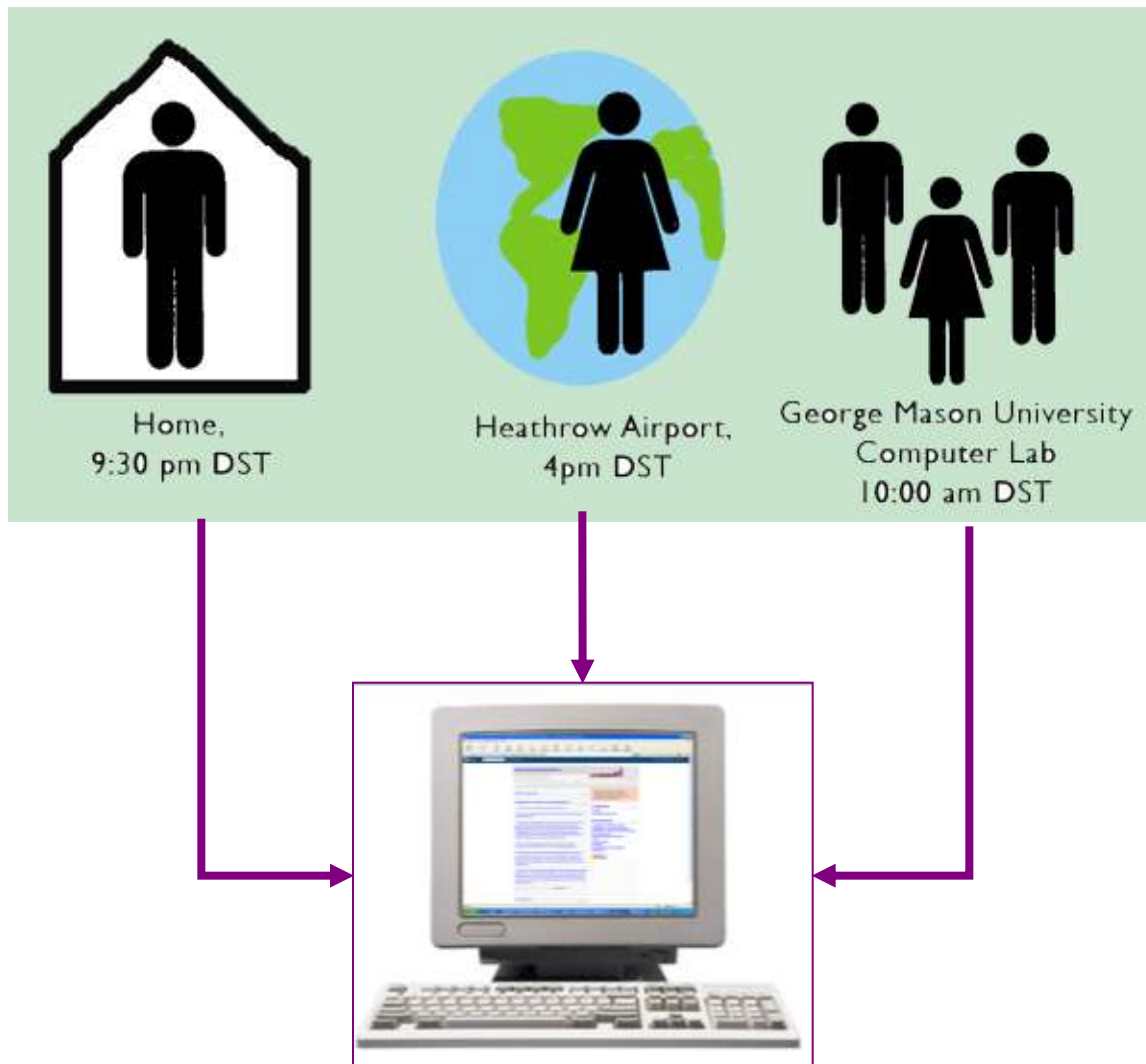
- A democratic approach to study a system, and concurrently to collaborate with members of the system, to change it in what is together regarded as a desirable direction
- To facilitate and stimulate communication across disparate groups

# Participatory Action Research



**ACTION: Reducing the Gap**

# Participatory Action Research



## Asynchronous Communication

The blog provides a collective space which can be conveniently accessed according to an individual's schedule and location.

## Participatory Action Research



“The trees (woodlands) are a source of inspiration in my study because the branching helps me visualize neurons. The window acts as a microscope in the office providing a view of enlarged neurons.” – Giorgio

“Trees are much more inspirational than a brick wall. Everyone who has visited me has commented on the trees. We should do what we can to protect them as we expand.”—Ernie





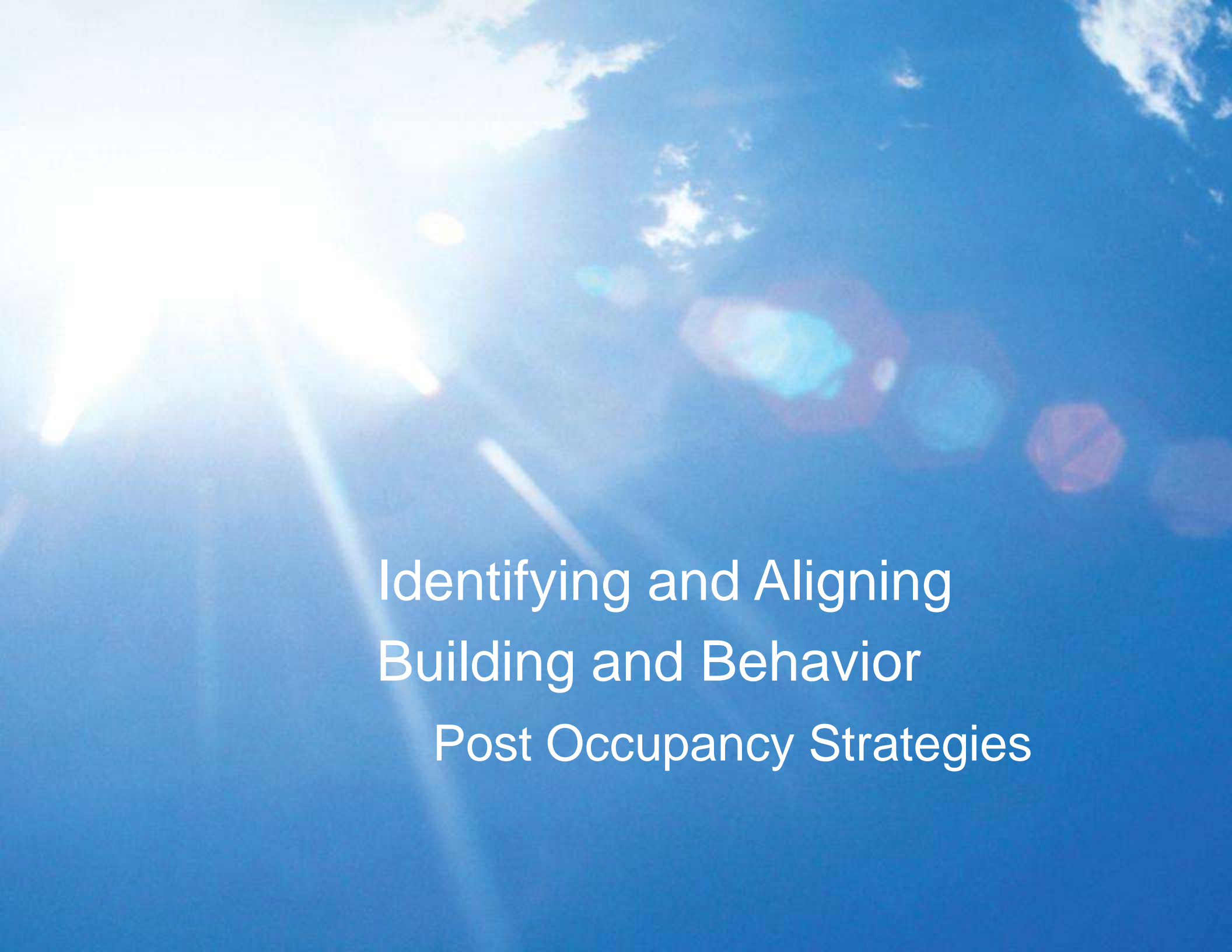
## Participatory Action Research

### Information Sharing

- Among the end-user community
- Between the design teams and the end-users
- Between members of the design and construction team

A bright blue sky with a sun flare in the top left corner and scattered white clouds. The sun flare is a large, bright white area with several rays extending downwards and to the right. There are several smaller, colorful spots (blue, red, yellow) scattered across the sky, possibly due to lens flare or other optical effects. The overall scene is a clear, bright day.

questions?

A bright sun in a blue sky with lens flare effects. The sun is positioned in the upper left quadrant, creating a strong lens flare that extends across the sky. The sky is a deep blue, and there are some wispy white clouds in the upper right corner. The overall scene is bright and clear.

Identifying and Aligning  
Building and Behavior  
Post Occupancy Strategies

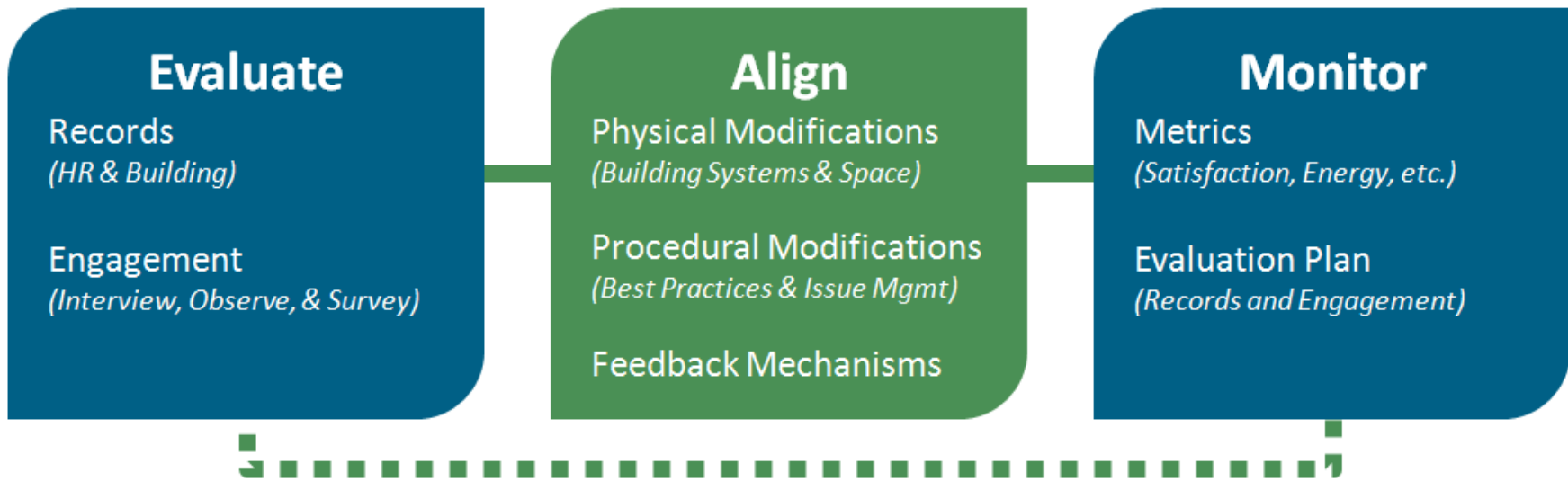
# Post Occupancy Evaluation

POE, POS - Post Occupancy Evaluation, Post Occupancy Study



# Post Occupancy Evaluation

## EAM Model for Building, Occupant Alignment



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# Evaluations



## Evaluations

Partnership between interviewer and interviewee; characterized by close cooperation



# Evaluations

Interpretation: The assignment of meaning to observations – as an investigator, we will always be trying to establish meaning in what we discover.



# Evaluations

## Interpretation:

Fact > Hypothesis > Implication for Solution >  
Design Idea

Interpretation of occupant or O&M

Follow-up to ensure your interpretation and  
new solution are working as intended



## Evaluations



### Perspective:

Point of view an interviewer and observer takes

Perhaps most important aspect of the Interview and Observation Process

# Evaluations Example

## Blast Curtains

- Fixed ballistic blast curtains installed on interior perimeter windows
- Because they limit natural light, many occupants have removed them down to the second floor
- GSA's official policy is that they should be left up; unofficially has stated they could probably be removed safely from the 4<sup>th</sup> floor on up
- Weighing safety vs. energy savings and daylighting performance/productivity benefits



## Alignment Strategies

- Occupant Focused
  - Behavior Norms
  - Operational Policies
- Building Focused
  - Design Elements
  - Operational Policies



# Occupant Focused Alignment Strategies

## One-Way Messages

- Increase awareness of design elements, operational policies and energy conserving behavior through One-Way Messages



Source: <http://www.yankodesign.com/2009/12/22/always-take-the-stairs/>

**Direct Message**



**Indirect Message**

# Building Focused Alignment Strategies

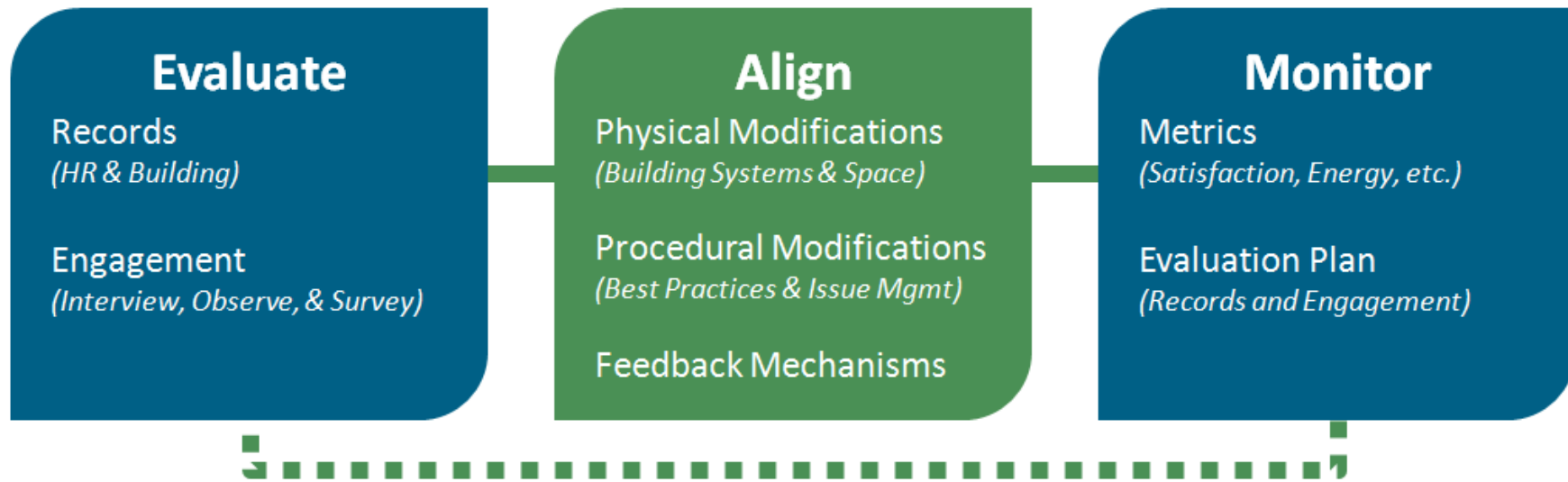
## Decrease Barriers

- Communicate energy information so it has meaning



# Monitoring

## EAM Model for Building, Occupant Alignment



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## Post-Occupancy Daylighting Solutions

- If the space is uncomfortable for its occupants, they will “*fix*” it (*regardless of your design intentions*)



## Post-Occupancy Plug Loads

- Space heaters, lamps, microwaves, and refrigerators



# Phantom Plug Loads

Avoid this...

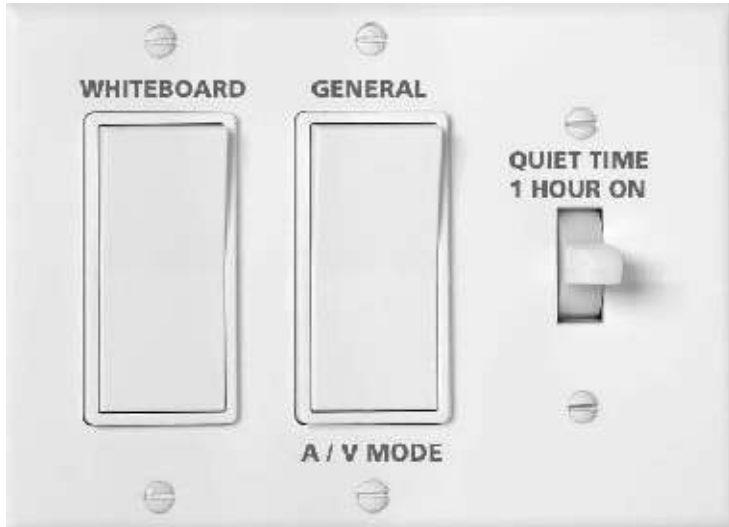


...with this.



Power meters to determine appliance loads, accessible power strips to shut down manually, or personal occupancy sensors for automatic shutoff when spaces are vacant

# Lighting Controls and Sensors



Turn off, dim, or only use the lights which are needed during occupied hours...or, use equipment that does it all for you.



Are you *sure* you need that light turned on?

A bright sun in a blue sky with lens flare effects. The sun is positioned in the upper left quadrant, creating a strong glow and several diagonal light streaks across the frame. The sky is a deep blue with some wispy white clouds near the top edge. The overall image has a high-contrast, vibrant appearance.

Case Study:

Douglas County Schools

Empowering Students


## DCS: Empowering Students

Student project to district program

- Started at Flagstone Elementary
- Reduce energy usage
- Help the environment
- Alert those around them to how much energy could be avoided



# DCS: Empowering Students





























Please Remember!

- Lights/Lamps Off
- Computer in Sleep Mode
- ELMO Off
- Projector Off

## Energy Management Program Audit Tracker

BE GREEN 2

 <p>Great Work! - Thank you for your focus on saving!</p>							
 <p>Getting Good! - Keep practicing your good energy habits!</p>							
 <p>Getting Started - Time to practice energy-saving habits</p>							
	Ms. Smith	Mr. Bell	Ms. Bock	Mr. Rogers	Ms. Woo	Mr. Clute	Mr. Walla

Audit Tracker from Flagstone Elementary

# DCS: Empowering Students

## DCS – plug load results

				Days	Monthly	Monthly	Average	Average	Average
Lighting	Avg Wattage	Quantity	Hours	Per Month	Total kWh	Total KW	kWh Cost	kW Cost	Monthly Cost
<60 (avg 40)	40	975	8	22	6864	39	\$418.70	\$456.30	\$875.00
60	60	998	8	22	10539	59.88	\$642.87	\$700.60	\$1,343.47
75	75	180	8	22	2376	13.5	\$144.94	\$157.95	\$302.89
100	100	342	8	22	6019	34.2	\$367.17	\$400.14	\$767.31
3-Way (avg 150)	150	96	8	22	2534	14.4	\$154.60	\$168.48	\$323.08
Computers	300	16982	8	22	896650	5094.6	\$54,695.63	\$59,606.82	\$114,302.45
Monitors	80	16982	8	22	239107	1358.56	\$14,585.50	\$15,895.15	\$30,480.65
Refrigerators							\$0.00	\$0.00	\$0.00
Dom-Sized (<3.0 cf)	175	727	24	30	91802	127.225	\$5,587.72	\$1,488.53	\$7,076.25
Full-Size	540	39	24	30	5691	88.362	\$88.362	\$88.362	\$10,482.15
Radio/Stereo	150	406	8	22	5406	30.6	\$540.6	\$540.6	\$7,827.92
Space Heaters	1500	208	8	22	54912	312	\$3,349.63	\$3,650.40	\$7,000.03
Microwaves	1450	85	8	22	17202	104.7	\$1,720.2	\$1,720.2	\$13,247.16
Fan	100	8765	8	22	8765	87.65	\$876.5	\$876.5	\$1,117.31
Coffee Maker	850	437	1	22	8172	371.45	\$499.49	\$1,345.97	\$4,844.45
Sharpener	100	1047	0.5	22	1152	104.7	\$70.25	\$1,224.99	\$1,295.24
Air Cleaner	300	172	24	30	37152	51.6	\$2,266.27	\$603.72	\$2,869.99
Toaster/Toaster Oven	1100	121	1	22	2928	133.1	\$178.62	\$1,557.27	\$1,735.89
2-Way	100	732	8	22	12883	73.2	\$785.88	\$856.44	\$1,642.32
CFLs	25	382	8	22	1681	9.55	\$102.53	\$111.74	\$214.26
Televisions	225	1712	8	22	67795	385.2	\$4,135.51	\$4,506.84	\$8,642.35
Projectors	248	1519	8	22	66301	376.712	\$4,044.38	\$4,407.53	\$8,451.91

Computers \$114,302.45  
Monitors \$30,480.65

64% of monthly plug load, by cost, was Computers and Monitors

## DCS: Empowering Students

How were the results achieved?

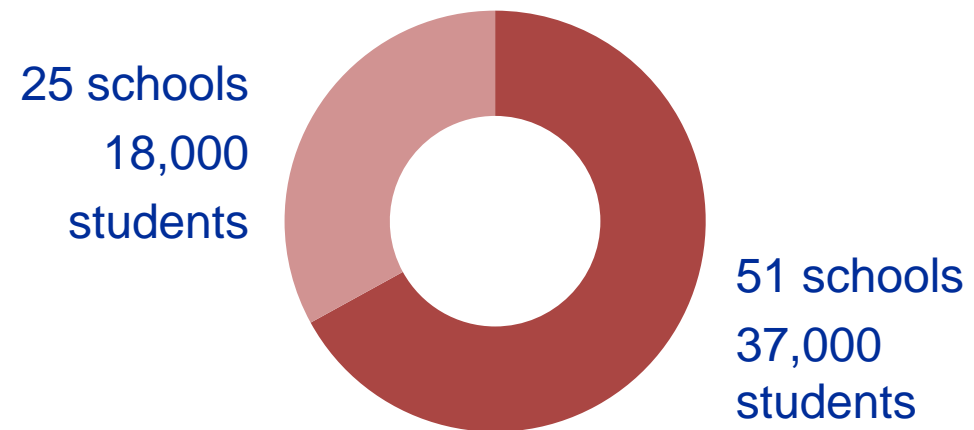
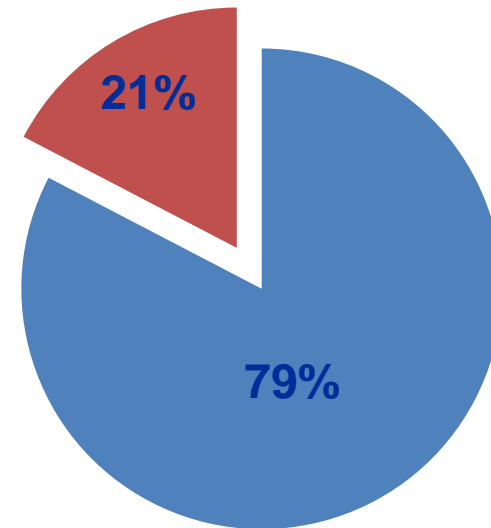
- Groups/Clubs become involved as project
- Implemented as individual student projects
- Competition between classrooms
- Audit & tracking system for public view
- Incentivizing - Stars for students, Starbucks for teachers



## DCS: Empowering Students

### The Results

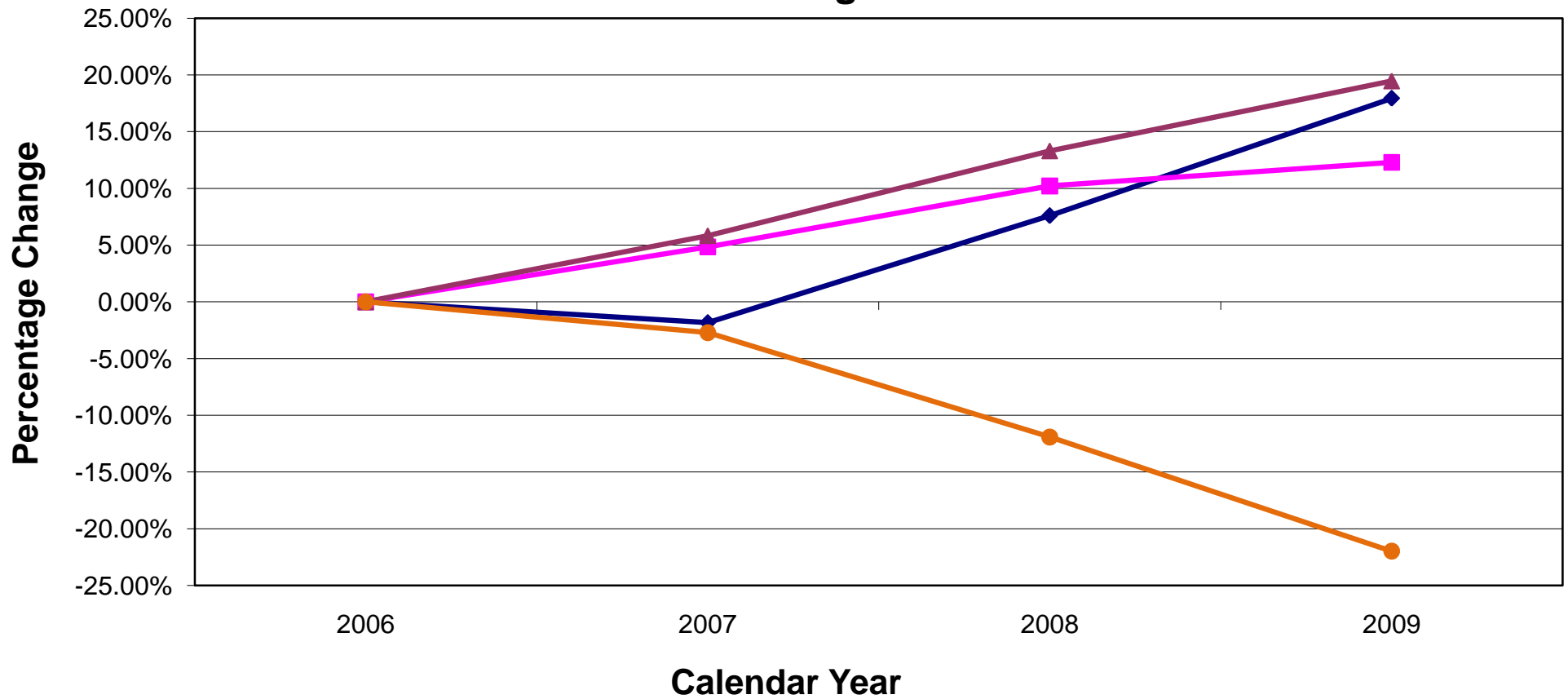
- **21%** reduction of energy use where program instituted
- Program now expanded to **2/3** of the DCSD schools
- **\$2.3 million** total in avoided energy payments



**DCS Program Usage**

# DCS: Empowering Students

## DCSD Electric Usage vs Growth



◆ Average Utility Cost    ■ Student Count    ▲ Square Footage    ● DCSD Usage Per Square Foot

# DCS: Empowering Students

## Program Benefits?

### Tangible Benefits:

- Saved \$
- Saved energy/environment
- Reduce cooling load, lessening mechanical equipment wear

### Intangible Benefits:

- Students as Role Model
- Students learn leadership/responsibility
- Students teach next generation



## DCS: Empowering Students



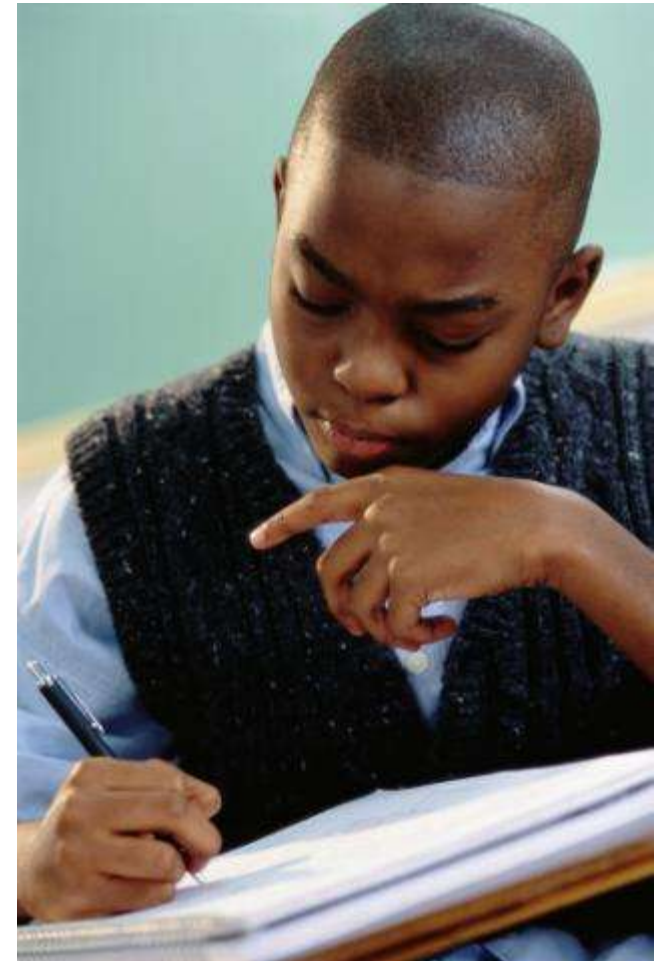
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# Summation

Benefits of Incorporating  
Human Factors

## What if?

- We could reduce our Plug Loads 10%, to where they were in 1990?
- We could only work with 5 other office members to change something in your office. What would it be?
- If you could change something in your office, from a human factors perspective, what would it be?



A bright sun in a blue sky with lens flare and clouds. The sun is positioned in the upper left quadrant, creating a strong lens flare effect that radiates across the frame. The sky is a deep blue, with some white clouds visible in the upper right corner. The overall image has a high-contrast, vibrant appearance.

questions?



## Resources – Energy

- National Renewable Energy Laboratory  
<http://www.nrel.gov>
- Open Energy Info  
[www.openei.org](http://www.openei.org)
- Colorado Governor's Energy Office  
<http://rechargecolorado.com>

## Resources – Human Factors

- Community-Based Social Marketing  
[www.cbsm.com](http://www.cbsm.com)
- InformeDesign  
[www.informedesign.org](http://www.informedesign.org)
- ALA Demographic Data Sources  
<http://www.ala.org/ala/mgrps/rts/magert/publicationsab/demdata.cfm>
- NALP Demographic Collection Tips  
[http://www.nalp.org/collecting\\_demographics](http://www.nalp.org/collecting_demographics)
- California Center for Population Research  
<http://ccpr.ucla.edu:8080/CCPRWebsite/services/data/demographic-data-sources>



## Resources

### How to Obtain Demographic Information

- Human Resource Departments
- Government Departments/Agencies
  - Census Bureau
  - Bureau of Labor Statistics
  - Relevant state departments
  - City Planning/Development Departments
- Internet Sources/Bibliographies
  - ALA Demographic Data Sources
  - NALP Demographic Collection Tips
  - California Center for Population Research