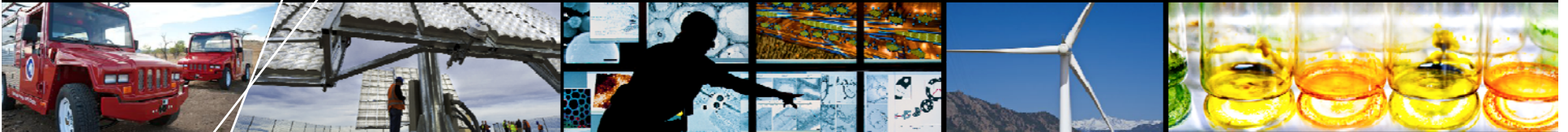




U.S. DEPARTMENT OF
ENERGY | Energy Efficiency &
Renewable Energy



Human Factors and Post-Occupancy Evaluation



NASA Net Zero Workshop

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Sustainable NREL

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“Modern technology (is) the defining force of a new social order in which efficiency is no longer an option but a necessity imposed on all human activity”.

Jacques Ellul



Measures of Success

- **Technologies deployed met energy goal expectations**
- **Real-time performance meets or exceeds modeled targets**
- **Providing a quality indoor environment**

Considerations for Success

Even with high-performance, innovative building features, we have found that a substantial portion of building performance is related to occupant behavior.



The feedback loop will help answer the important building questions of why do occupants accept or reject a building system such as operable windows or daylighting technologies and what motivates occupants to engage with building systems in an energy-efficient manner.

Critical Interface: Human and Building

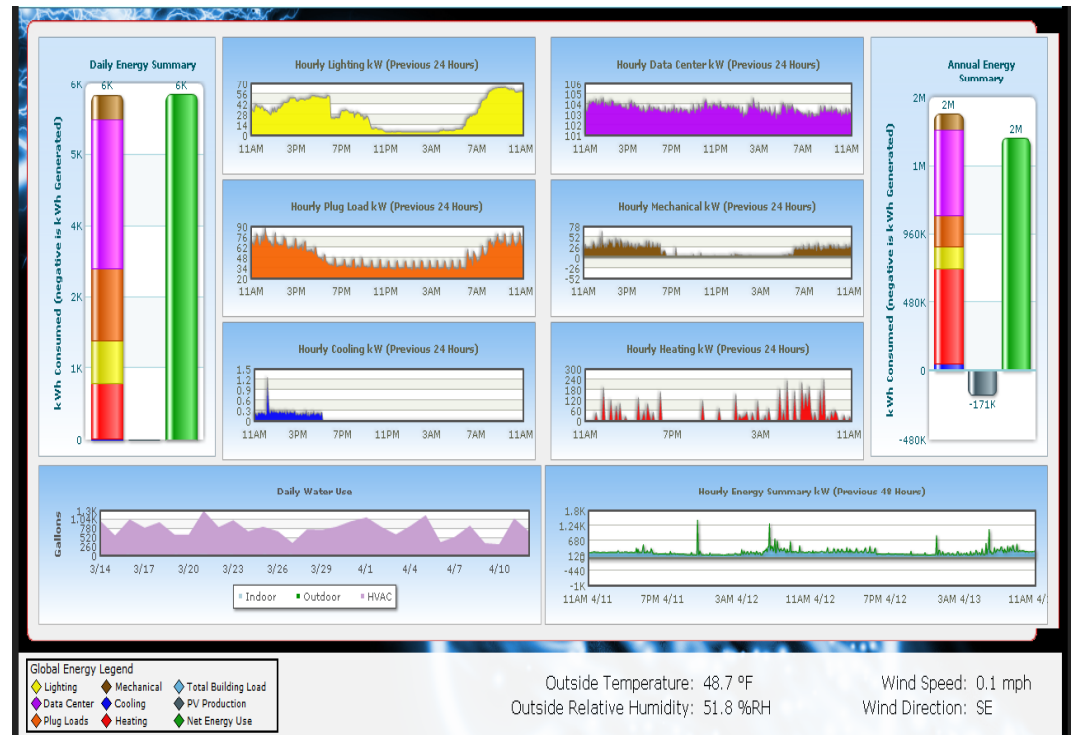
- **Plug Load Management Effectiveness**
 - Specified equipment use
 - Operational controls
 - Occupant education
- **Human Capital Productivity and Wellness**
 - Anecdotal feedback
 - Reportable absenteeism and complaints
 - Space utilization

Devising a tool to benchmark post-occupancy feedback

The opening of NREL's Research Support Facility (RSF) creates a unique opportunity for NREL to:

- Better understand building occupants' real-time comfort in comparison to environmental conditions
- Determine what type of information displays best motivate occupants to engage in energy-saving behavior at work

The RSF is a living laboratory



Building Agent Program Purpose

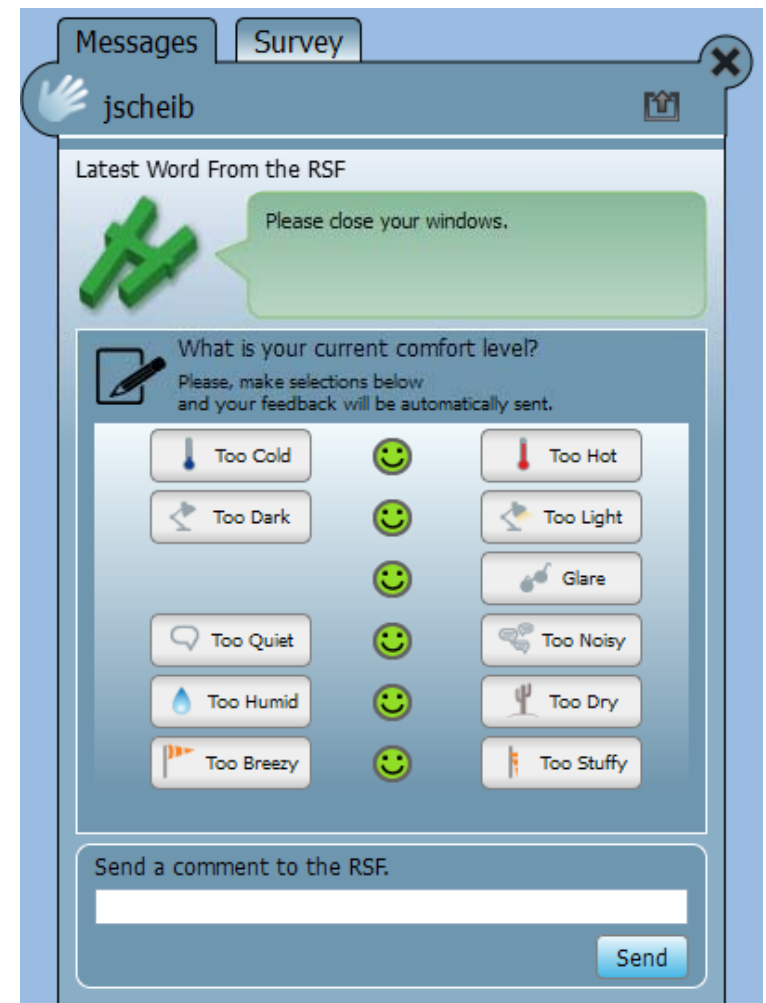


- Evaluate occupant comfort and satisfaction
- Encourage occupant interaction with building systems to save energy
- Implement a thermal comfort survey as a requirement for LEED Platinum certification
- Evaluate the need for building improvements

Building Agent Program

This project proposes to create “agents” that act as an interface between occupants and building-automation systems. The program takes the form of a computer application with the following tabs:

- First tab, Ongoing occupant comfort survey and building messages
- Second tab, LEED occupant comfort survey
- Future tabs, RSF energy-use displays shown in analytical, emotional, and competitive forms



First tab, ongoing survey and messages

Occupant Comfort Survey

- First-year, one-time occupant survey creates baseline information
- Survey is comprised of 65 questions in
 - background information
 - thermal comfort
 - Lighting
 - air quality
 - acoustics
 - building features
 - office layout
 - office furniture
 - energy efficiency
- 49.5% response return
317 occupants responded
(640 in residence)

The screenshot shows a web-based survey interface titled "Building Occupant Agent". It has two tabs: "Messages" and "Survey". The "Survey" tab is active, showing a progress bar for "LEED Survey" and a question: "13. How satisfied are you with the indoor temperature during the winter season?". Below the question is a Likert scale with seven points, ranging from "Very Unsatisfied" (represented by a sad face emoji) to "Very Satisfied" (represented by a happy face emoji). The second point is selected. Below this is question 14: "14. If dissatisfied with winter temperatures, what is the reason?". It has six radio button options: "N/A", "Hot", "Too warm", "Too cool", "Cold", and "Temperature swings". A "Save and Continue" button is at the bottom right.

Second tab, LEED comfort survey

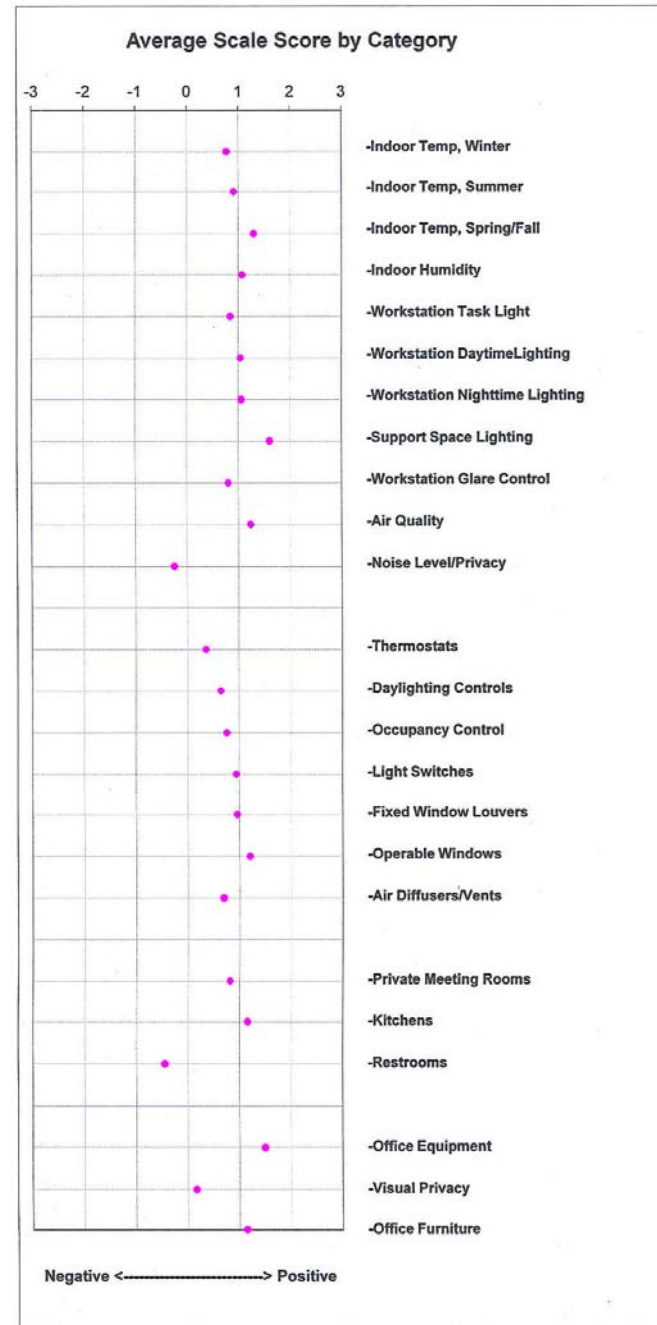
Survey Findings

Negative

- Restrooms
- Noise Level / Privacy
- Visual Privacy

Positive

- Office Equipment
- Support Space Lighting
- Air Quality
- Operable Windows
- Kitchens



Mitigation Actions

Restrooms

“C” Wing odors were addressed through installation of new vent stacks

Noise Level / Privacy

On-going education effort for staff to modify personal conduct in open space forum and increase the utilization of huddle and telephone rooms

Visual Privacy

Interact with staff to devise actions to address fishbowl effect

Occupant Follow-up Survey

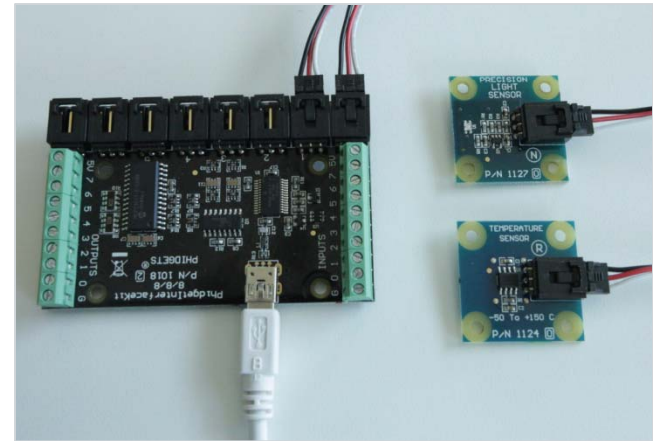
Short 10 sensory question survey to illuminate ‘experiential’ response

- Productivity
- Creativity
- Collaboration
- Community
- Emotional Wellbeing
- Knowledge Sharing
- Perception
- Satisfaction
- Enhanced Communication



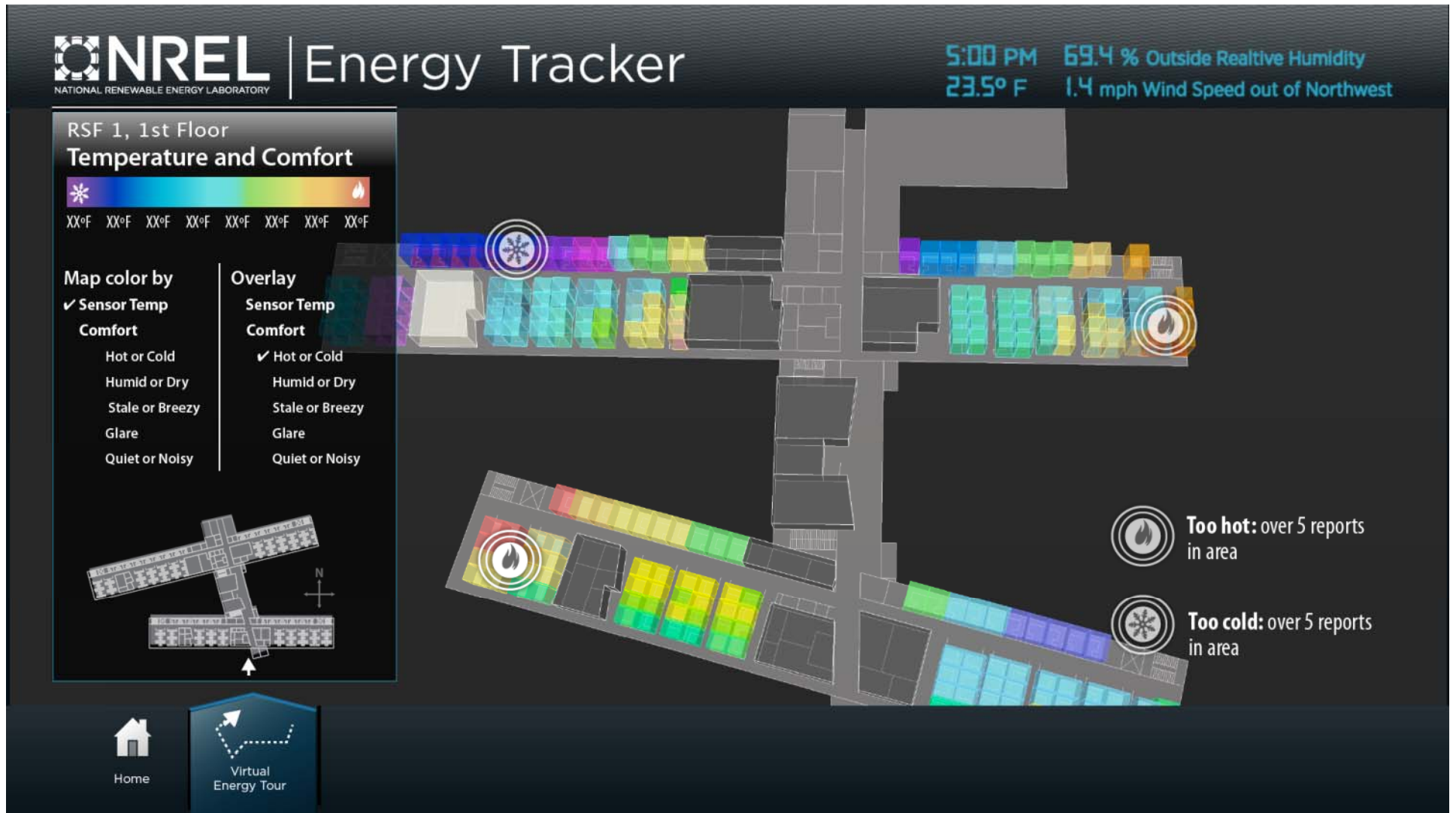
Workstation Sensors

- Environmental conditions to be measured by the building-automation systems and workstation sensors at the same time occupants provide feedback using the ongoing survey
- Target volunteers from reported 'impacted' areas



Workstation sensors in development

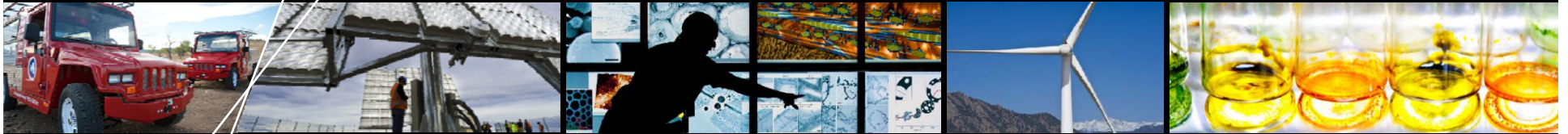
Path Forward



Path Forward

- **Communicate**
- **Monitor expectations**
- **Educate**
- **Behavior Adaptation**
- **Facility Planning Flexibility**





Questions?