INSTITUTE FOR THE BUILT ENVIRONMENT
Taking Research to Practice

INTEGRATED SUSTAINABILITY MANAGEMENT

A SYSTEMS APPROACH FOR HIGH PERFORMING BUILDINGS

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ABOUT IBE

The Institute for the Built Environment is based at Colorado State University. We form interdisciplinary teams of faculty, students, and off-campus professionals to take research to practice. At our heart, we develop and educate sustainability leaders at CSU. **Our mission is to advance the development of healthy, thriving built environments.** We work with building owners, organizations, and communities to develop strategic programs that increase alignment, build team capacity, and meet sustainability goals.

ABSTRACT

In the past 15 years, the green building movement has made great strides to reduce the impact of the built environment on consumption and carbon emissions. In fact, 20% of new construction projects in the U.S. were estimated to be green buildings in 2015. However, there remain gaps in both knowledge and practice. Many designed-to-be-green buildings fail to live up to their potential for reduced energy consumption, lowered greenhouse gas emissions, and improved occupant well-being. Why do green buildings often fall short of their designed performance? We propose that the root cause is because organizations are not utilizing a systems approach to sustainability. The organization that inhabits a building does not share the values embedded in the building's design. Once a building comes online, it is enveloped in the larger system; the dominant purpose (culture, paradigm, etc.) of that system takes hold and trumps the original design intent.

The integrated sustainability management (ISM) framework provides a model and toolbox to support systems thinking in buildings. The ISM model contains four distinct elements, or quadrants: Organizational Culture, Occupant Behavior, Operations, and Facility Design. The ISM application toolbox provides step-by-step guidance on how to use the ISM model to map, measure, understand, and improve the systems dynamics at play within a green building.

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PREFACE

In 2007, the Poudre School District operations team noticed something odd: one of their schools, Rocky Mountain High School (RMHS), had reduced its electricity consumption by 50%. They noticed that RMHS was actually using about the same amount of electricity as their new LEED Silver High School. Excited but surprised, they asked me to help them answer this question: How did RMHS achieve such a large reduction in electricity use and how can we replicate it in other schools?

As a sociologist, I knew this was an important question and one that I could help them answer. At first, the operations director asked if I could conduct a survey to compare RMHS to another high school, but I explained this would not be the best tool. Instead, I proposed a more extensive study that included focus groups, interviews, site visits, and examining several years of energy data. I am genuinely grateful that they trusted my expertise as a social scientist and agreed to the study I assured them would provide the best answer to their question. Their decision to support social science as a process of discovery was an important one. Without their trust in the value of the sociological research process, we could never have developed this paper.

In exploratory studies such as this, an iterative process is needed of going back and forth between data collection, analysis, and more data collection. This was new territory and demanded integration from other fields. I received help from colleagues in organizational psychology, developmental psychology, and sociology (Dr. Zinta Byrne, Dr. Pat Aloise-Young, and Dr. Michael Lacy, respectively). Each suggested important theoretical literature or methodological tools for analysis.

We discovered that RMHS was unique, not because of one thing, but a whole series of interconnected actions from many actors. After I completed the study, I began presenting what we found to professional and public audiences. In speaking with various audiences, I learned more about how the findings from RMHS could be transferred to other settings like churches or residence halls or commercial office buildings.

It was then that my colleagues at IBE became important partners. I came into this study knowing very little about buildings, operations, or even energy conservation. As I worked to create meaningful models that could be used by others, I needed knowledge from professionals who knew more about buildings than I did. This framework is the product of many white board sessions where my colleagues Stephanie Barr, Brian Dunbar, and Josie Plaut helped me to understand how buildings work. It is also the product of many research projects and the collective wisdom of dozens of building owners, occupants, and operators.

We are grateful to the people who shared their knowledge and passion for great buildings. It is for this collective brain trust that we share this paper. And through this report, we hope that the ISM framework can be a meaningful model to help our clients and the industry at large build and operate better buildings.

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Section 1

THE RESEARCH

INTRODUCTION

Since 1945, the built environment has quadrupled, fragmenting local landscapes and deteriorating ecosystem processes [1]. The built environment is the largest single source of resource consumption, energy use, and greenhouse gas emissions, making it a critical target for conservation efforts. Although the green building movement has brought attention to the impacts of buildings on human and environmental health, LEED Certified, green buildings still only account for about 0.1% of global building stock [1, 2].

In the past 15 years, the green building movement has made great strides from the construction of thousands of green buildings to the adoption of green building codes to the creation of guides for green building operations. In fact, 20% of new construction projects in the U.S. were estimated to be green building in 2015 [3]. However, there remains a gap in both knowledge and practice. Many designed-to-be-green buildings fail to live up to their potential for reduced energy consumption, lowered greenhouse gas emissions, and improved occupant well-being [4, 5].

Why do green buildings often fall short of their designed performance?

It is essential that we answer this question to reduce the impact of the built environment and meet our climate goals. Much time and effort have been spent to justify these practices and push the market forward; therefore, we are honor bound to ensure that every green building is living up to its designed intent.

This question prompted us to create a new model for evaluating building performance. We call it Integrated Sustainability Management (ISM). This framework is the result of dozens of case studies and applied projects in which we sought to document, develop programs, or improve the performance of commercial and residential buildings. We have used the ISM model in our work at IBE since 2013.

Based on our research and practice, we propose that to construct and operate green buildings that live up to their vision for improving human and environmental health and reducing resource consumption, a systems thinking approach to building operations is required.

A systems perspective on buildings recognizes that there are countless, unique elements at play within a building that influence performance. This is broader than just engineering or design—once a building is operational, a whole new set of authorities enters the space and can quickly sabotage the design intent.

SUSTAINABILITY AND SYSTEMS THINKING

In the past decade, we've witnessed environmental crises that span national boundaries. We've begun questioning our own role within the larger environmental system and identifying problematic behaviors in industry, design, and even our own lifestyles. The role we play within the system is complex, multi-faceted, and difficult to define and understand. The problems we face cannot be approached in a piece by piece manner, we must begin by unravelling them to see how they are connected, to even begin tackling environmental crises. Such system level challenges require systems thinking.

As defined by Donella Meadows [6]: ***A system is an interconnected set of elements that is coherently organized in a way that achieves something.***

Through systems thinking, we seek to understand the elements and the organization of a system. Where traditional analysis focuses on fixing the individual pieces, systems thinking raises the level of examination to the whole in order to better understand the root cause of the problem. Systems thinking is incredibly effective in helping solve complex issues. It enables us to design interventions that can not only solve problems but even enhance a system.

In a systems thinking approach to solving a problem, we begin by investigating the structures, patterns, and cycles that contribute to the system, rather than only specific events. By focusing on the entire system, we can identify solutions that address as many problems as possible in the system. This being said, systems thinking is not a quick fix. It takes time and effort to overcome the inertia of a system's predisposed behavior. But it will identify, with more precision, where some of the true blockages and challenges lie. As Albert Einstein famously once said, "We cannot solve problems by using the same kind of thinking we used when we created them." So to solve complex, global environmental issues, we need a new way of thinking.

Another key idea within the systems thinking literature is leverage points, the places in a system where a small change can make a big impact. There are many types of leverage points and each has a different level of effectiveness. Donella Meadows has summarized the known leverage points and ranked them in order of effectiveness and effort. We have adapted this list in the figure below.

In addition to evaluating an intervention based on where it falls on the leverage scale, there are also other indicators of a good intervention, such as how it impacts other parts of the system. It is helpful to consider the following questions:

- Does it amplify?
- Is it synergistic?
- Does it solve several issues at once?
- Is it self-sustaining?
- Does the intervention require continuous inputs, or is the stock naturally replenishing? Can it evolve?

LEVERAGE POINTS

Adapted from Donella Meadows, Leverage Points: Places to Intervene in a System [9]

DIFFICULTY & EFFECTIVENESS

1. PARADIGM
The beliefs driving the system

2. GOALS
What the system is trying to achieve

3. GOVERNANCE & POWER
Organizational structure, ability to evolve, the rules of behavior

4. INFORMATION FLOWS
Communication, how quickly people get the info to make decisions

5. POSITIVE FEEDBACK LOOPS
Rewards for good behavior

6. NEGATIVE FEEDBACK LOOPS
Punishment for bad behavior

7. STRUCTURAL ELEMENTS
The physical building, tools, & numbers you can measure

THE INTEGRATED SUSTAINABILITY MANAGEMENT FRAMEWORK

The intent of the Integrated Sustainability Management (ISM) framework is to serve as a tool to support systems thinking in buildings. The ISM framework was founded on the idea that to meet performance goals, sustainability must be integrated across the whole system of a building.

In this time of global transition, organizations are recognizing the role they will play in a more sustainable future, and preparing for the opportunities and risks that lie ahead. This has led many to build green buildings, but (as we've now realized) simply having a LEED-certified building is not enough. A building is just one element of the organizational system that inhabits it; once it comes online, the larger system envelopes it. Then, the dominant purpose (culture, paradigm, etc.) of the organizational system takes hold and trumps the original design intent of the building.

This is why green buildings often fail to meet their performance standards. It is because there is a disconnect. Somewhere—either in operation practices, occupant behavior, and/or the organizational leadership—purpose isn't aligned. For an organization to truly position itself for the future, systematic organizational change—holistic change, not just changing the building—is required.

The ISM framework is a method to identify and resolve organizational sustainability challenges. Research indicates that change is fostered through integrated efforts at multiple organizational levels, including institutional and structural changes, organizational culture and leadership, and individual attitudes and behaviors [7, 8]. Positive change becomes possible when people interact and transcend organizational barriers.

THE FOUR QUADRANTS

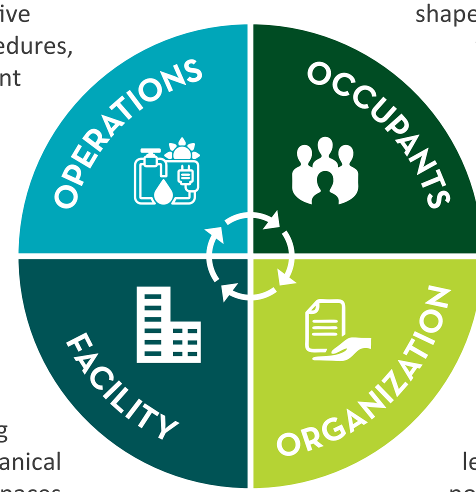
The ISM framework is elegant in its simplicity. It contains only four distinct elements, or quadrants. These four—Organizational Culture, Occupant Behavior, Operations, and Facility Design—encompass the primary elements that drive the system and dictate building performance. Understanding the dynamic behavior of the system requires considering each quadrant separately and as it interacts with the others.

OPERATIONS

Includes all of the activities and routines of the operations staff, building engineers, custodians, and maintenance techs. Activities include system control settings, preventative maintenance procedures, energy management practices, cleaning and custodial practices, and repairs.

OCCUPANTS

Includes all human interactions in the building among long-term residents, tenants, and transitory populations. The influence of these groups is shaped by the amount of their control on the space, frequency of visits, length of time spent in the building, and sense of ownership for the space.



FACILITIES

Includes all of the system's physical elements, including the building, mechanical systems, exterior spaces, etc. This quadrant does not include human interface with the facility.

ORG.CULTURE

Includes all the shared values, social norms, leadership structure, policies, and practices within an organization. It also contains the organization's spoken or unspoken vision.

THE ROSE: A SUSTAINABLE, AFFORDABLE HOUSING DEVELOPMENT

The Rose is a 90-unit, mixed-income apartment project in Minneapolis, Minnesota that was designed using the Living Building Challenge [12] framework. With locally sourced building materials, non-toxic paints and finishes, recycled flooring, renewable energy systems, and a large community garden, it's one of the healthiest, greenest places to live in the U.S. The apartment buildings were designed with superior building envelopes, lighting, and HVAC systems.

PROBLEM

While the Rose is designed to be one of the most sustainable, energy-efficient buildings in the United States, it had to first overcome occupant behavior challenges to meet its goals.

PROCESS

The owner of the Rose, Aeon, quickly learned when they opened The Rose that residents needed to be engaged in order for the building to meet its sustainability goals. To investigate barriers, the team conducted focus groups and interviews with leadership, operations, and residents. They found that the majority of residents are Somali refugees and the temperature set point in the units was too low for their comfort. Residents tried to raise the temperature using space heaters, which caused the system to switch to cooling, which exacerbated the problem and caused more energy use. The misalignment between operational controls and occupant behaviors was at the root of the problem.

SOLUTION

First, the broken relationship between residents and on-site management needed to be fixed. Residents felt like management didn't care about their comfort, and management didn't understand how to keep residents from using space heaters. So to mend this relationship they created a bridge: peer ambassadors. These resident representatives share concerns directly with management, collaborate to come to mutually beneficial solutions, and communicate back to their neighbors. They also inform future communications materials and resident events to ensure cultural relevancy.

Next, operation practices and system set points needed to be changed. Changing the controls on the HVAC system to shut off at a certain temperature, rather than switching to cooling, reduced resident complaints of feeling cold. This required training for on-site staff to manage seasonal settings. In addition, the team created better reports for on-site staff so that they can detect and correct problems quickly.

It was also clear that residents didn't understand why energy consumption directly related to them. So, the team established better data and communication channels so that residents can understand if their consumption is high compared to their neighbors, give them tips to reduce it, and train on-site staff and peer ambassadors on how to help high users.

Finally, these efforts were successful because Aeon, the developer and management organization, committed to Integrated Sustainability Management. Aeon understood that for the building to be successful, it must have alignment in operations, occupants, and policy. Aeon implemented training to educate staff, began monitoring its goals and reporting annually, and allocated resources and staff to manage this initiative. They also began applying their lessons learned across their housing portfolio.

Section 2

IN PRACTICE

ISM APPLICATION TOOLKIT

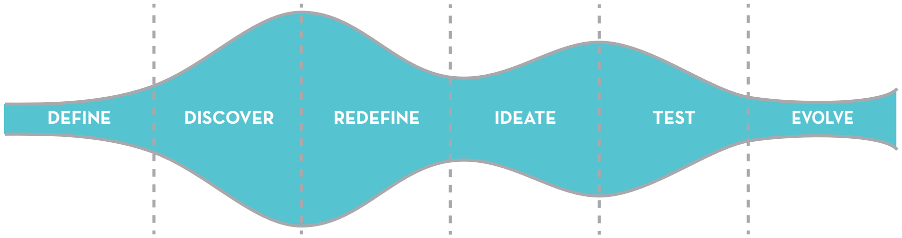
Most often, when a systems approach is not used, a solution to a problem can actually exacerbate the problem. Instead of looking for a quick solution, we must consider that the best solution may reside in another quadrant or in more than one quadrant.

Systems often perform poorly because of how we problem-solve.

APPLYING ISM USING LEVERAGE POINTS & DESIGN-THINKING

When we begin to think holistically about systems it often becomes overwhelming. Where do we even begin? How do we choose the best intervention?

Finally, the application of these ideas is best done in a design-thinking process to help the team understand the problem before testing interventions. We have presented the application of the ISM framework within the design-thinking process and have detailed key questions to consider in each phase.



1. DEFINE

What is the initial definition of the problem?

Consider the problem you are trying to address, what is it? What is your assumed solution to the problem?

What is the urgency?

Why must this problem be solved? What will happen if it is not solved?

2. DISCOVER

How does the problem look from the perspective of each quadrant?

How would operators, occupants, or leadership describe the problem? How might the facility contribute to the problem? Consider conducting focus groups, interviews, and/or performing analysis on operational data and resource consumption to gain insight.

3. REDEFINE

What is the real reason the problem is occurring?

Most often after the process of discovery we realize that the solution we assumed was needed isn't the appropriate intervention. Redefine the problem by explaining the "why."

How can you redefine the problem based on your new understanding of all its parts?

After collecting information, brainstorming, and engaging, you should now see your problem in a new light. Redefine the problem based on insight gathered in the discover stage.

4. IDEATE

What are the possible solutions?

What solutions exist in each quadrant? What is needed to implement these solutions? What are some of the constraints? Consider the list of leverage points.

How might this intervention impact or involve other quadrants? Is it synergistic?

Take a closer look at the overlaps, patterns, and tensions among quadrants. How might a solution in one quadrant solve a problem in another? The best solution is one that solves multiple problems at once.

How will you measure the success of the intervention?

Define a set of criteria for success to help guide and evaluate the development as you scale and build on your solution. Think about how you will collect data and measure the impact of your intervention.

How will you communicate the vision, strategies, and progress of your intervention?

A key component of change efforts is a communication plan defining the vision, behavioral expectations, and ongoing feedback on accomplishments. It is essential to get your organization on board with what you are doing and why.

5. TEST

What was the effect of your intervention?

Gather feedback on the solutions implemented. What was the impact?

Are there any existing issues or barriers?

After gathering feedback, discuss how to improve your next iteration of the intervention. Emphasize what was successful and adjust where there were barriers.

6. EVOLVE

Do your processes allow for continuous improvement?

Continuous feedback cycles allow you to be responsive and flexible.

The success of our Integrated Sustainability Management approach stems from repeated use of the process. Continue to define new challenges and opportunities for change.

ISM APPLICATION EXAMPLES

On the next page we've provided some quick summaries of how the ISM framework has been applied to various problems and building types. These are based on real-world projects our team has worked on and the processes that were used.

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DEFINE Initial definition of the problem	DISCOVER & REDEFINE Collect input and redefine problem, focusing on why	IDEATE Choose intervention	TEST Test the effectiveness of intervention	EVOLVE Refine the intervention through deeper understanding
Energy use in multi-family housing was out of control because residents were using space heaters. The assumed solution to this problem was to ban all space heaters.	After focus groups with residents and interviews with building engineers, the team found that the residents were comfortable at 78 degrees, but at 78 degrees the AC turned on, so they bought space heaters, which exacerbated the issue.	Change allowable temp ranges, don't allow system to go into cooling mode in heating season.	Measure if energy use was reduced through intervention. Talk to residents and operators.	It was found that residents didn't fully understand the ranges, they were frustrated in a warm October when their AC wouldn't work. So operations created different protocols for shoulder months.
Energy use in commercial office was high. The assumed solution was to create an educational kiosk to display energy use.	After a focus group with staff and interviews with org. leaders, the team found that the cultural norm was that assistants kept lights and technology on from 9 to 5, even when offices were vacant, in order to show their managers they were "here and working hard."	Social marketing campaign to change cultural norm. Visionary communication and a policy from leadership that sets cultural expectations.	Test messages that leadership created with staff. Measuring if behaviors of assistants changed.	It was found that assistants did adopt these new behaviors, but the building engineers had not received the message and needed to be empowered to turn off lights and monitors.
Composting and recycling weren't used correctly in the school cafeteria. The assumed solution was that students needed to be educated on why composting and recycling are important.	After observing the behavior of students during lunch time and conducting a focus group with a sample of students, it was found that students didn't understand what goes where, so they just threw everything in the trash.	Peer ambassadors to stand by containers and show what goes where.	Observe behavior, interview students who still weren't composting.	It was found that many students still didn't understand composting, and though peer ambassadors supported the behavior expectations, illustrative signage was needed to show the actual items that go in each bin.
Water consumption at multi-family property was extremely high. The assumed solution was to retrofit older fixtures with new high-efficiency fixtures.	After interviewing on-site operations staff and performing benchmarking on water consumption trends, it was found that the largest likely cause of high water consumption was from leaks (underground and toilet).	Fix the leaks and establish baseline usage, then retrofit property with high-efficiency fixtures. Integrate leak management into maintenance responsibilities.	Measure water reduction after leak management and fixture retrofit.	Maintenance now had daily leak reports, but these hadn't been integrated into daily routine. So staff were trained to use leak reports to prioritize their daily activities.
Tenants in co-working space were dissatisfied with light levels after office remodel. The assumed solution was to educate tenants on why energy conservation is important.	After focus groups with tenants and building engineers, the team found that the building remodel, which moved toward a more open office design, successfully brought in a lot of natural daylight, but in doing so this reduced individual control for most tenants.	Provide task lighting and more individual control over hotel spaces.	Measure improvement in tenant satisfaction.	Improved relationships between tenants and building engineers opened more conversations so they can address issues sooner.

CASE STUDY: ROCKY MOUNTAIN HIGH SCHOOL

Photo: RB+B Architects

Rocky Mountain High School is one of four high schools in the Poudre School District located in Fort Collins, Colorado, and enrolls about 1,400 students. Rocky was built in 1973 and renovated in 1994. It is the second-oldest high school in Fort Collins.

PROBLEM

Between 2001 and 2007, Rocky Mountain High School reduced its electrical energy consumption by 50%, but the school district had no idea why [10, 11].

PROCESS

The school district had committed to sustainability in 2000 and made some changes in school design and operations practices, but the savings at Rocky were beyond expectations. So the district conducted a formal research project to investigate what factors contributed to Rocky's success in order to implement those practices in its other schools. The research team ran statistical analyses on energy consumption data and conducted interviews and focus groups.

SOLUTION

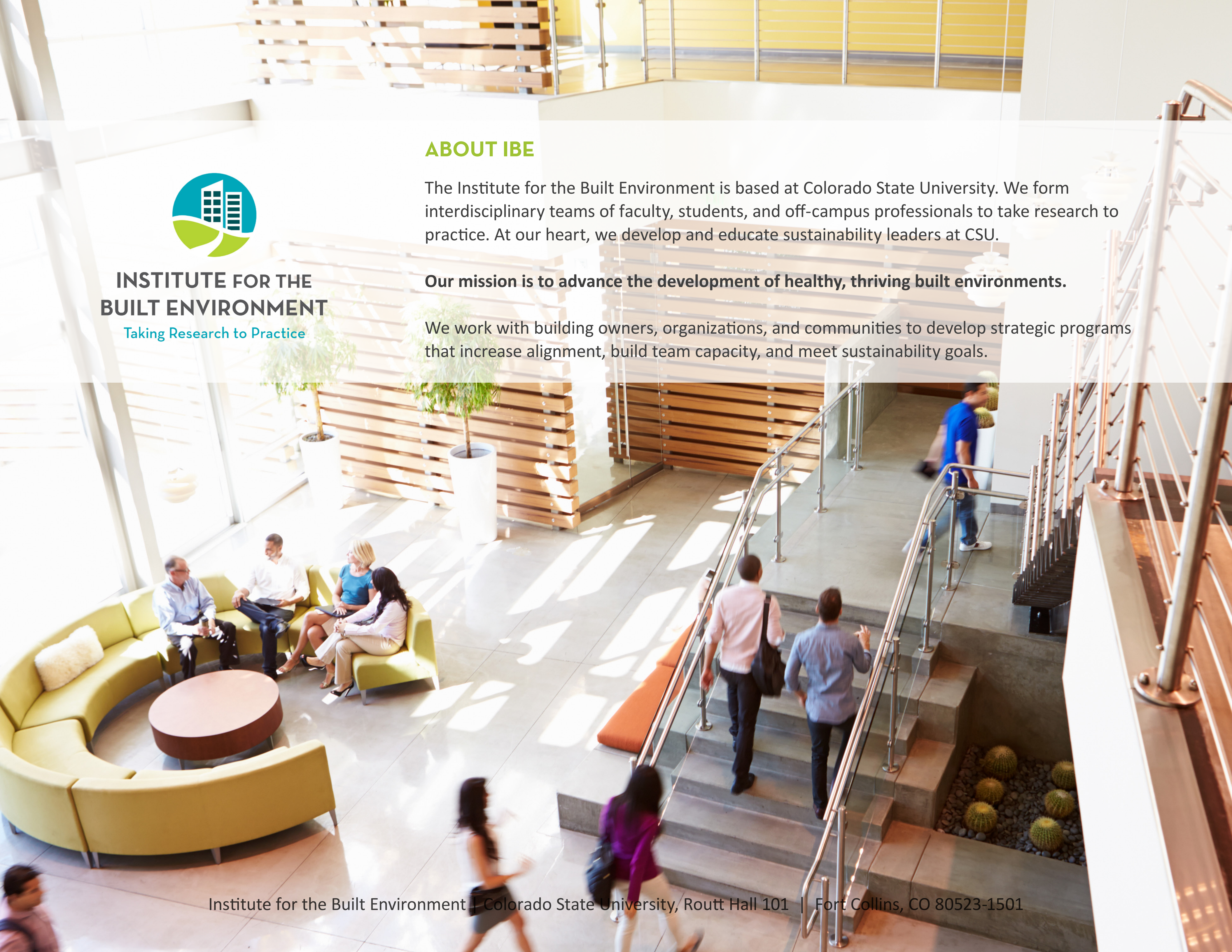
The research revealed that 19% of the reduced energy consumption was from centralizing HVAC control to coordinate with building occupancy. The district also made a written commitment to sustainability and offered financial rebates to encourage its schools to reduce energy.

The additional 31% reduction was the result of small changes to the facility (e.g., de-lamping) and the efforts of three groups of charismatic leaders who changed occupant behavior and operations in the building: custodians and building operators (operations quadrant), teachers and students (occupant quadrant), and the principal (organization quadrant). These charismatic leaders inspired others to make change.

Custodians changed daily routines to turn the lights on immediately before school and turn them off immediately after, instead of leaving the building fully lit and HVAC systems running for one to two hours before and after school.

The principal linked conservation behavior to the school's code of conduct, called the "Lobo Way." Communication aligned with this ethic played a key role in inspiring change. Under the principal's leadership, staff made information transparent through emails, student-written school announcements, newspapers, posters, and parent newsletters.

Finally, students in the environmental group, supported by the science teacher, modeled conservation behavior to fellow students. For example, they organized recycling events and placed small reminders in classrooms to turn off lights. They were also given control of how to spend the district's energy incentive, which they opted to use to purchase wind power, further supporting their efficacy as change agents.



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Our mission is to advance the development of healthy, thriving built environments.

We work with building owners, organizations, and communities to develop strategic programs that increase alignment, build team capacity, and meet sustainability goals.

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