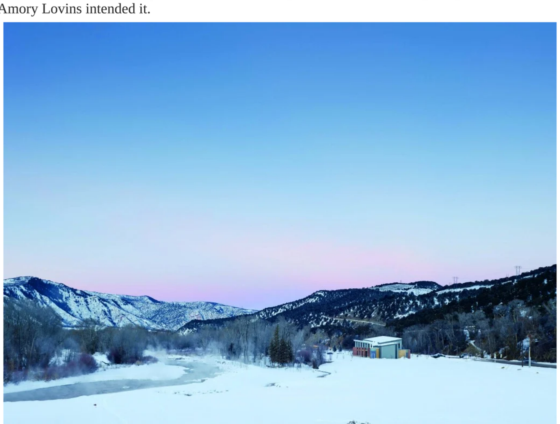
Rocky Mountain Institute Innovation Center, Basalt, Colo.

March 20, 2017 by Chris McClurg

Tim Griffith
The Innovation Center is truly a shining example of the office building of the future, "creating delight when entered, and regret when departed," as Amory Lovins intended it.



Tim Griffith
The Rocky Mountain Institute's beyond net zero energy Innovation Center, located on the banks of the Roaring Fork River just outside Aspen, Colo., is the highest performing building in the coldest climate zone in the U.S.

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Rocky Mountain Institute (RMI) is a nonprofit dedicated to transforming global energy use to create a clean, prosperous, and secure low-carbon future. Therefore, when RMI needed a new office and convening center for 50 employees in the mountain community of Basalt, Colo., they seized the opportunity to practice what they preached with a state-of-the-art building that achieved an unprecedented level of integration, automation, and performance. The resulting Innovation Center (IC) is the highest performing building in the coldest climate zone in the U.S., generating more energy on site than it uses in a year. It serves as a replicable model—with its team dedicated to transparently sharing details on process, performance, and key lessons learned—showcasing how net-zero buildings are better for owners, occupants, and the environment.

That's because the IC sits right in the sweet spot to move the market. At 15,610 square feet, it's similar in size to 90% of all commercial buildings, half of which are also owner occupied. The industry has taken notice. Since the building opened in December 2015, several thousand visitors from six countries have attended tours. The building has earned honors such as the PHIUS Best Overall Project of 2016 award, and received LEED Platinum certification, among other accolades.

What makes the IC so cutting edge is not a single technology—rather it's the thoughtful combination of passive design features with best-on-the-market technologies, plus a careful balance of automated and manual controls. Four specific categories underlie performance optimization: passive design, redefining thermal comfort, managing system control complexity, and renewable energy production and management.

The south view's 52% window-to-wall ratio enables the building to capture ample winter sunlight and heat gain.

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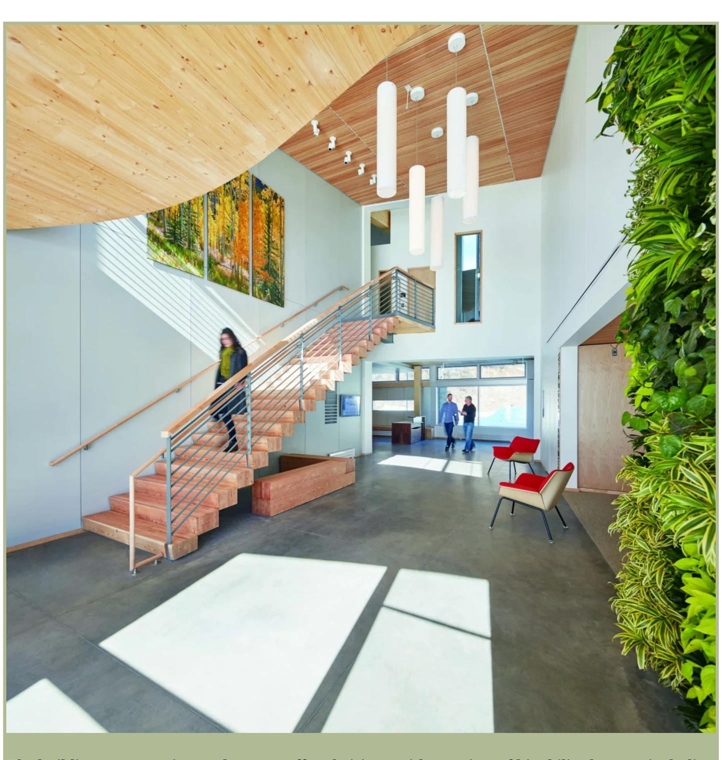
Starting with Passive Design
When RMI began working with the design team, they first considered what occupants would need from a building—a comfortable, pleasing, and productive space—then maximized all passive approaches to meet these needs before considering any mechanical means.

Passive Solar Design
At an elevation of 6,611 feet, Basalt has strong solar gain throughout the year due to high altitude and clear skies. By managing solar gain during the summer and maximizing it during the winter, the design team was able to eliminate mechanical cooling and reduce heating systems to a small, distributed system.

Daylight and heat gain are maximized with a narrow floor plate, southern orientation, and "butterfly" roof design, which together expose as much of the building's thermal mass to the strong winter sun as possible. The size and type of windows for each façade were tuned to optimize southern gain while minimizing heat loss to the north (the window-to-wall ratios are 52% on the south, versus 18% on the north). The window properties on the south were optimized to let in more light and heat than the windows on the north.



The building's open atrium welcomes staff and visitors with a variety of biophilic elements including a living wall, nature-inspired art, curved walls and ceilings, and natural ambient light.

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During the summer and shoulder seasons, external automated sunshades on the south façade control solar gain. The blinds automatically track the sun's angle to balance daylight, glare, and heat gain. By integrating the sunshades with the building's control system, the building is able to deploy them when spaces are getting too hot or retract them when the spaces need more heat.

The building is completely daylit for the majority of the year, thereby significantly reducing its use of energy-intensive interior lighting. The remaining lighting needs are met using efficient LEDs and personal desk lamps.

An Airtight and Superinsulating Envelope
The IC is one of the most airtight office buildings measured in the U.S., with 0.36 air changes per hour, making it 97% more airtight than a conventional U.S. commercial building. Advanced materials combined with precise construction details avoid leakage and make the building's incredible airtightness possible. The building is framed with structural insulating panels (SIPs), providing the dual benefit of continuous insulation and airtightness. Two coats of tape and air barrier material were applied outside the SIPs to ensure tight joints. The design process limited and consolidated essential penetrations, and a scale mockup of key material connections ensured carefully thought-out connections. The construction team continually reviewed details and required high quality from all subconsultants, and two building pressure tests performed before completion ensured execution of the tight construction details.

High-performing windows complete the superinsulating building envelope. Quad-pane windows (two panes of glass, two of film, filled with krypton gas with rigid thermal breaks in the frames) serve the multiple functions of daylighting, passive cooling and heating, insulation, and airtightness—while creating an envelope with triple the code-required levels of insulation.
The building's thermal mass is also important to passive heating and cooling, stabilizing interior temperatures despite significant outdoor temperature swings. Exposed concrete floors provide the majority of the thermal mass. In the winter, the building heats the floors with sunlight, allowing them to radiate heat throughout the space. Phase-change material (PCM) is embedded in the walls and light shelves, providing even more thermal mass.

Maximize Natural Ventilation
Active natural ventilation strategies allow the IC to fully maximize its thermal mass throughout the day. To take advantage of cold evening temperatures, the building automatically opens the windows and cools the internal slab and PCM to keep the building cool throughout the next day. A controls strategy looks up the high temperature for the next day's weather and determines how low the building must precool the slab that night. Due to this automatic temperature reset, the building is, ironically, coldest on the mornings of the hottest days.
During the day, the controls system monitors internal and external temperatures, and in the right conditions will automatically open the windows. Low windows on the south side and high windows on the north side, plus an open office plan, promote efficient air movement through the spaces.
After maximizing passive design and innovative thermal comfort approaches, there remains a very small requirement for heating during the winter, the equivalent of one average home in this climate. RMI used the most efficient heat-recovery ventilation systems (93% efficient) and a small electric radiant heating system under the carpet.

Redefining Thermal Comfort
Most buildings rely on blowing hot or cold air using large HVAC systems to maintain a set temperature, which wastes energy and doesn't address the full thermal comfort of individuals. In contrast, the IC addresses all six thermal comfort indicators—air speed, temperature, humidity, radiative temperature, metabolic rate, and clothing level—identified by ASHRAE and University of California Berkeley Center for the Built Environment (CBE), while requiring dramatically less energy.

Heat gain is controlled and maintained with automated exterior sunshades, shown here on the building's south façade.

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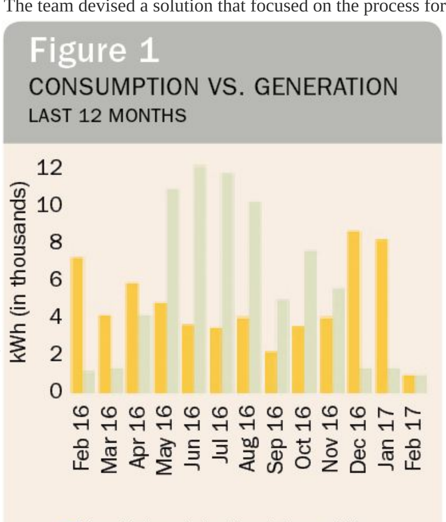
Breaking down thermal comfort into these indicators pushed the team to examine the best way to meet each requirement and resulted in using smaller systems targeted to meet each of those needs. For example, external sunshades were tailored to meet radiant needs while ceiling fans provide airflow. Instead of traditional central systems, which are often oversized to meet every need in all conditions, the Innovation Center uses smaller, more efficient and effective systems sized to address each thermal comfort indicator. Once these passive systems create a stable range of comfortable temperatures, smaller personal comfort approaches fine-tune people's comfort within that range. This approach can accommodate the significant range of perceived comfort due to metabolic, gender, health, or clothing differences.

RMI's Insight Brief detailing this approach can help others replicate the model.

Controls Integration
The multiple targeted systems that made this comfort strategy possible also added significant controls integration complexity, as many of these systems are designed to control independently using their own proprietary systems. The team devised a solution that focused on the process for system integration and commissioning itself.



As each system to be integrated into the central controls was specified, they ensured the system could communicate with the central systems protocol, and the subsystem manufacturer provided support to integrate the system. This support was crucial and, in many systems, lengthened into a long-term relationship through integration and operation to troubleshoot issues.

Moving Beyond Equipment-Based Commissioning
Thorough commissioning is always key to a high-performance building. Traditional commissioning, which looks at each individual piece of equipment and ensures it goes through its own sequence, can be sufficient for a traditional building with central systems. However, the IC's many targeted systems—and particularly the interactions and integration of those systems so critical to the building's performance—made a traditional approach impossible. These interactions are often controlled by many factors and, due to the passive nature of many of the systems, difficult to simulate.

Instead, the commissioning approach evolved to look at how the building performed as a system. It included the usual functional testing of individual pieces of equipment and then shifted to a long-term building-tuning perspective—monitoring every point through a range of conditions over an extended period of time. This required a long-term relationship with the commissioning agent and design team, along with the associated operating budget for this work. This relatively short-term investment quickly paid back in lower energy consumption and reduced occupant complaints.

Occupant Training and Engagement
The IC's occupants play a critical role in achieving ambitious net-zero energy goals and maintaining a high level of performance over time. Before occupying the building, staff received a short but in-depth training on the building's design, performance goals, technologies, and systems to ensure everything was operated as intended to maximize performance.

To further drive engagement, the building utilizes 122 energy meters to monitor the power consumption of every piece of equipment and building circuit. In addition to these primary meters, the power usage for each individual power strip supplying each occupant's desk is monitored through a metering program. Users can view the high-level results from a touch screen dashboard in the building lobby, or dig deeper into more granular data using online platforms. This data has also been instrumental in continued commissioning of building systems and troubleshooting issues.

Meet Energy Needs with Smart Systems
The IC is a true example of a grid asset. Thanks to high levels of efficiency and on-site energy production and storage, it is able to not only generate all the energy it uses over the course of a year but also to control its load profile through the course of the day. By using photovoltaic (PV) and battery systems, the building can manage its loads to minimize peak demand charges, saving RMI money and reducing the local utility's reliance on dirty peaking power plants.

The roof-mounted PV system provides 83 kW of power to the building. Because of the low, 11-degree roof slope and snowy, high country location, the system is expected to have snow coverage up to three months during the winter, which was taken into account in the annual production estimation. Even with this lack of production, the system is designed to meet 1.5 times the IC's building loads. Excess power will power electric vehicle charging stations, to provide carbon-free commuting.
A 30 kW/45 kWh lithium-ion battery system reduces the building's peak energy demand, helping RMI stay below a peak demand of 50 kW and in an economically beneficial utility rate class. RMI chose an energy control system to not only manage the battery charging, but also to integrate all energy systems for the building.

Conclusion
At the Innovation Center, RMI intentionally pushed the edge of design to reach unprecedented levels of passive design and system integration while implementing a novel approach to occupant thermal comfort. By investing in an airtight envelope, three times the code-required levels of insulation, and an active strategy to manage solar gain, RMI was able to eliminate central cooling and reduce heating to a small distributed system, and meet more than 100% of the building's energy needs with onsite PV. The incremental cost for implementing these approaches was 10.8%, but RMI has calculated this investment will pay back in under four years when factoring in energy savings, increased occupant productivity, and decreased maintenance.
As RMI continues to tune the building, they will be constantly searching for better controls integration technologies and personal comfort solutions, and fine-tuning their thermal comfort approach. The IC is an exciting opportunity to continue testing new technologies and approaches, and RMI will continue sharing these lessons with industry to increase adoption of net-zero energy and net-zero carbon buildings, campuses, and communities. •

About the Author
***Chris McClurg** is a senior associate at Rocky Mountain Institute where she managed the design, construction, and operation of the MEP and thermal comfort strategies for the Innovation Center.*

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