When the Alliance bought a century-old converted warehouse in 2004, the nonprofit had barely moved in before it started tinkering to improve building performance. The organization, which seeks to advance sustainability, renovated the space into a multi-tenant nonprofit center, reducing energy use to 42 kBtu/ft², despite increased occupancy. The project provides examples of ongoing, cost-effective and relatively simple measures to reduce building energy consumption and reduce environmental impact.

The Alliance Center began life in 1908 as a warehouse. Like many of its neighbors in the area near Union Station in Denver’s Lower Downtown historic district, it was strictly utilitarian in character, with post-and-beam construction, plank floors, a brick façade and an elevated loading platform served by a rail spur.

More than a century later, bits of those old rail lines can still be seen peeking through the asphalt of the street out front, but the building has been transformed into an example of cost-effective high performance in existing buildings — and a

**The Building Already Built**

BY PHILLIP SAIEG AND CHRIS WOLDUM

A Google search on “the greenest building is the one already built” yields about 700,000 hits. So, it seems fair to say that architect Carl Elefante’s idea resonates. The owners of the Alliance for Sustainable Colorado took his message to heart when they renovated the six-story 1908 warehouse that is home to nearly three dozen nonprofit organizations.

The original 1908 post-and-beam construction is visible throughout the building and is typical of the Lower Downtown Denver warehouse district.

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The renovation, which took place from 2005–06, encompassed a range of strategies and improvements in several resource areas:

**Energy and Atmosphere**

The Center replaced over 1,000 40 W T-12 fluorescent lamps and magnetic ballasts with 32 W T-8 lamps and high efficiency electronic ballasts, reducing lighting energy use by over 40%. The new lamps contain 50% less mercury and phosphorus, eliminating the need to be disposed of as hazardous waste.

The lamps are dimmable, either manually or, in the case of the lights on the fifth floor, by automatic photosensors that adjust output according to daylight levels. Passive infrared occupancy sensors throughout the building turn lights on or off depending on human presence in the room.

The building's aging HVAC system consists of a 50-ton direct-expansion rooftop air-handling unit, two variable air volume units, diffusers, two exhaust fans, electric radiant heating panels and the associated controls. The control system was changed from pneumatic (air pressure) temperature controls to computerized direct digital controls (DDC) to set heating and cooling levels.

The DDC system allows customization of the temperature and airflow in zones throughout the building, and monitors the internal climate, minimizing energy costs without sacrificing comfort. System managers can change settings online. The DDC system allows customization of the temperature and airflow in zones throughout the building, and monitors the internal climate, minimizing energy costs without sacrificing comfort. System managers can change settings online. The DDC system allows customization of the temperature and airflow in zones throughout the building, and monitors the internal climate, minimizing energy costs without sacrificing comfort. System managers can change settings online. The DDC system allows customization of the temperature and airflow in zones throughout the building, and monitors the internal climate, minimizing energy costs without sacrificing comfort. System managers can change settings online.
Entrance doors were replaced with units featuring 3/16 in. insulating glass with thermal edge spacers, heat mirror films suspended between the two panes, and krypton gas filling the voids. The film and the gas boost the R-value to 9.1, compared with 2.4 for traditional double-pane glass.

The doors allow the lobby to be naturally lit while blocking 99.5% of UV rays, protecting furnishings and carpeting. The lobby’s windows are treated with bronze Mylar film that rejects 99% of incoming ultraviolet radiation and 60% of incoming heat. Windows on the sixth floor feature shade screens made from 100% recycled and recyclable, PVC free materials. The shade screens help control glare and heat gain or loss, while allowing outside views.

The combined savings from all these measures reduced the building’s energy intensity from 56 kbtu/ft² in 2004 prior to the renovation, to 42 kbtu/ft² in 2006. The building’s energy consumption dropped to 55% below the average for office buildings constructed before 1959, as determined in the Energy Information Administration’s 2003 Commercial Buildings Energy Consumption Survey (CBECS).

Calculating a simple payback period is not straightforward due to changing occupancy rates and electricity costs, but if electricity costs had remained at 2004 rates, the payback period would be just under 14 years. (In reality, electricity costs tend to rise over time, which would shorten the payback period.)

The Center is an all-electric building (no fuels are burned on site), and 100% of purchased electricity is carbon offset by means of Green-e certified wind energy credits from Community Energy, Inc. The cost varies from year to year with changing energy market conditions; in 2011 the cost was $5.50 per MWh.

A 2.4 kW solar photovoltaic array on the roof supplies a small portion of the building’s electricity. Its primary role is to demonstrate solar PV technology to visitors touring the building.

Water Efficiency

In early 2006 all water fixtures were replaced with more efficient models, which reduced water consumption by 20% and saved more than $4,500 per year—enough though the number of workers in the building doubled and the number of visitors rose by a factor of 10. The new fixtures cost about $22,000, yielding a payback time of less than five years.
Infrared Self-Generating Faucets. These faucets save water and energy by generating hydroelectric power each time water under pressure flows through internal turbines. The electrical energy is stored in a rechargeable battery inside the faucet assembly. Water flows and turns off automatically. Combined with an aerator, each cycle uses less than 0.1 gallon of water.

Low-Flow Showerheads. Low-flow showerheads deliver less than 1.5 gallons per minute. A lever on the showerhead can regulate the flow, allowing even more water to be saved while soaping up and shaving.

Kitchenette Faucet Aerators. Faucet aerators mix air with water to increase the shower-like spray, while reducing the amount of water used to 0.8 gallons per minute. A lever on the flow restrictor quickly and easily cuts the flow to a trickle to save water while washing dishes, hands, etc.

High-Efficiency Toilets. Toilets are dual flush (0.9 gallons or 1.6 gallons) or 1 gallon units with air pressure-assisted flushing.

Waterless Urinals. All six urinals are waterless models with slick porcelain surfaces and cartridges containing a biodegradable sealing liquid; the urine passes through the cartridges and the liquid traps odors and sediments. The urinals save about 60,000 gallons of water per year.

Materials and Resources
The renovation used recycled, reclaimed and/or sustainably sourced materials wherever possible throughout the building.

Acoustics Materials. Many offices use open floor plans to increase interaction, natural light penetration and airflow. Sound-absorbing and sound-masking materials, such as ceiling tiles, reduce noise in these environments.

Office partitions with 80% recycled fabric over soft cores (as opposed to fabric over metal), were chosen for their sound absorptive quality. Sound deadening board (structural fiberboard) is made of 97% organic materials, including recovered wood or sugar cane fibers, and has a sound transmission class rating of at least 45. Tiled carpeting mutes footsteps.

Carpeting. Where carpeting is installed, the building uses bio-based polymers made from poly-lactic acid (PLA), a starch from corn and other plant material. It is

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The Alliance Center encourages tenants to bike to work by providing convenient bike racks and showers for bikers. The building’s location provides easy access to bus and light rail routes, while an on-site car sharing option provides transportation for those needing to commute to meetings.

Over 100 plug load monitors have been installed in the Alliance Center to track energy use at an individual level. A study being led by a group of graduate students from Virginia Tech University involves using this data and evaluating how social networks can be used to reduce energy consumption.

The tenants have been divided into a variety of test groups, each with varying access to a software platform that compares their energy use data to others, and allows them to track and suggest specific actions to reduce energy use. The researchers will then evaluate whether access to this energy use information and the various social network interactions changed behavior and reduced energy consumption.

The initial study took place from May through mid-July. A detailed report is expected later this year with a second study likely next spring.

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from samples of reclaimed materials. Every board, hinge and latch has been used before or has been diverted from the waste stream.

**Countertops and Flooring.** Countertops and linoleum floors are made of a natural product, composed of linseed oil, wood flour, resin binders and dry pigments. These ingredients are mixed and pressed onto a natural jute backing. The product lasts 25 to 40 years, is biodegradable, gives off no volatile organic compounds (VOCs), and is easily cared for.

**Wheatboard.** Several places in the Center feature use of wheatboard, a replacement for particleboard, plywood or medium density fiberboard. Wheatboard is made from waste wheat straw fiber-bonded with a formaldehyde-free agent.

**Furnishings.** Most of the furnishings are reused or are made from recycled materials. The lobby features a beautiful custom-built cabinet made of reclaimed materials, and are recyclable. The modular tile design reduces waste and cost, while the non-directional patterns reduce installation waste; together, these features allow for undetectable replacement of damaged carpet squares.

**Indoor Environmental Quality**

The Center minimizes VOCs through its choices of low- and no-VOC paint, wood sealers, adhesives, flooring, furniture, wall board and doors. Paper and cleaning products are acquired from environmentally friendly sources. Commercial quality doormats at the entrances catch dirt and keep it from entering the building. The mats help keep the carpets and flooring cleaner, reduce the amount of maintenance and cleaning required, and lengthen the life of the flooring materials.

Daylight penetration on the fifth floor is facilitated by use of recycled translucent office partitions made from polycarbonate thermoplastic resin. The panels diffuse the daylight, reducing shadows and glare, while their honeycomb molding provides a sound barrier.

Carbon dioxide levels are monitored by CO2 sensors linked to the HVAC system. If levels rise beyond the limit, the system automatically adds more fresh air to the mix.

**Sustainable Sites**

The Center is located close to bus and light-rail mass transit facilities, and an electronic kiosk in the lobby displays transit routes and schedules. Bike racks and showers in the building encourage commuting by bicycle. The Alliance Center also dedicates one parking spot to a car-sharing option provided by one of its tenants. This car is available for tenants to use for meetings and errands to minimize the number of car commutes.

**Educational Features**

The Alliance’s mission includes using the Center as a tool to introduce various audiences to its sustainable features and to the potential for high performance in existing buildings. Several hundred students, policymakers, building professionals and interested citizens tour the Center each year. A touch screen and extensive digital and passive signage throughout the building enables self-guided tours. The Alliance hosts special events and monthly “dine-a-logues” that bring interested people together for talks and conversations on sustainability-related topics. These events also serve to introduce attendees to the building.

**BENEFITS OF RETROCOMMISSIONING**

Like all complex systems, buildings need periodic assessment and adjustment to function at optimal efficiency. The Alliance hired a commissioning firm in late 2010 to check up on the performance of the Center’s various systems, including the HVAC equipment, the domestic hot water system and the lighting and daylighting controls. A number of things were amiss. For example, the HVAC system’s economizer was not set up properly. Several of the building’s air terminal units were not working because of faulty controls. One of the exhaust fans ran all of the time and the other wasn’t working at all.

The electric water heater leaked. Thermostats were mounted on window frames rather than interior walls, which caused them to misread interior temperatures. On the fifth floor, where the electric light output is modulated by sensors that detect how much daylight is entering the space, several of the sensors were malfunctioning.

The commissioning firm also conducted a survey of the building’s tenants, which exposed further problems. Some areas were too cold, others too warm. (The excessive warmth occurred in winter and summer, pointing to different reasons.) Several tenants found the building to be noisy on occasion, mainly because of sound transmission through walls and floors. Over half complained of unpleasant odors, probably attributable to the inoperative exhaust fan.

A variety of complaints pertained to light levels in specific areas. The Alliance has added sound insulation in problem areas throughout the building and will address temperature control issues through controls and HVAC upgrades in its impending renovation.

Unhappy tenants raise churn rates. The retrocommissioning uncovered several areas that, once addressed, helped saved energy and money by reducing resource waste and tenant turnover.
Collaboration
The Alliance believes in partnerships and collaboration as ways of boosting mission effectiveness, but collaboration also has environmental impacts. Several features of the Center help achieve both goals.

For instance, the Center offers tenants shared services (phones, copiers and printers, Internet) that save money and energy. Shared conference rooms, coordinated via online scheduling software, reduce space waste and help to keep rents down.

The Alliance Center leases space to its nonprofit tenants at below-market rates as part of its mission to promote collaboration among sustainability-focused organizations. Doing so frees up funds for program-related work that tenants would otherwise spend on rent, thereby increasing mission effectiveness. The Center essentially breaks even on rental income versus operating expenses.

Pursuing Higher Performance
With the Center, the Alliance has sought to demonstrate what can be cost-effectively done to raise building performance with relatively simple measures. However, a great deal more potential is waiting to be tapped. Consonant with the idea of a “living building,” the Alliance has not stopped tinkering.

No matter how green a building is constructed, most of the energy it consumes over its lifetime — embodied and consumed energy — is a function of its operations. So the payback of ongoing work and experimentation to improve efficiency increases the longer its life.

Since the original renovation, the Alliance Center has undergone retrocommissioning, LEED re-certification (Gold O&M), upgrades to the building automation systems and deep submetering to allow detailed analysis of electricity consumption by zone and activity. Data collection began in the summer of 2012 and is available at http://tinyurl.com/kt666r2.

Submetering has identified the building’s biggest energy consumers as HVAC, plug loads and lighting. HVAC and lighting will be addressed in the upcoming renovation described below, while the Alliance Center is aiming to reduce energy consumption by engaging tenants in projects to reduce plug loads and other tenant controlled energy uses. (See Tracking and Reducing Individuals’ Energy Use.)

The Center also rewrote its purchasing policies to comply with LEED EB: O&M’s materials and resources requirements. Affected supplies and materials include consumables such as printing and copier paper, toner cartridges, business cards, batteries and lamps, and durable goods such as copiers and furniture. Many of these purchasing policies have been incorporated into the building’s new “green lease” and rules and regulations.

Above: Well-behaved dogs are welcome and actually play an intentional and crucial role in breaking the ice and developing a sense of community among the 130 people across 30-plus tenant organizations.

Below: Part of the Alliance Center’s mission is to help organizations achieve greater efficiencies by providing stable, healthy, reduced-cost and secure office space. The Alliance also provides a shared phone system, internet service, printing and other services to lower tenant fees and minimize administrative overhead.
The Alliance plans to begin a deep renovation this year that aims to improve the Center’s performance to LEED Platinum levels and qualify for an even higher ENERGY STAR rating. The renovation is designed to address several of the 20 “imperatives” of the Living Building Challenge—while also showing how such improvements can improve tenant well-being and satisfaction, and the building’s financial performance and asset value.

Renovation plans include upgrading the building’s mechanical systems and eliminating the electric radiant heating panels. The renovation also will reconfigure floor plans to provide daylight and views to areas of the building that have lacked such amenities to-date. LED lighting will replace the existing T-8 fixtures. These changes, along with new “green leases” and other tenant engagement initiatives, are projected to reduce energy use by an additional 20%.

The Alliance plans to create an account of its experience and a kind of guide or how-to manual for other building owners and investors. The ultimate goal is to show and explain why society cannot afford not to demand high performance in all buildings.

Conclusion
The Alliance is acutely aware of the challenges and opportunities posed by the built environment with respect to achieving sustainability. Existing buildings account for nearly half of U.S. energy consumption and greenhouse gas emissions, and have long lives. Given the impossibility of razing current building stock and starting from scratch, addressing climate change and other sustainability problems demands upgrading existing buildings.

The Center’s renovation demonstrates that a relatively low cost project can significantly improve a building’s energy performance and sustainability. Strategies such as shared conference rooms and shared office services make efficient use of office space and financial resources. The Center’s ongoing improvements and upcoming deep renovation will pay dividends in energy savings and reduced carbon emissions for decades to come—perhaps even into the next century.

ABOUT THE AUTHORS

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LESIONS LEARNED

Tours Prompt Collaboration. Tours of the building introduce visitors to green building technologies and design, and, more importantly, collaboration in action. This experience often opens opportunities for collaboration with each other and with building tenants.

Seek Tenant Input to Create Buy-In. The Center’s tenants are partners in making the building sustainable. Tenant buy-in for energy-and-resource-saving measures is essential for getting their cooperation and is valuable in helping to create an “operating team” mentality that enhances the building’s efficiency. With a high concentration of environmentally focused organizations, programming buy-in becomes a natural extension of their work.

Actively seeking tenant input into operational or space design changes helps boost tenant employee well-being, morale and productivity, which makes the building more valuable as an asset. Among several exercises conducted in laying the groundwork for the Center’s planned deep retrofit, a tenant design charrette was a tenant design charrette. Tenants gathered with Alliance staff to brainstorm ways to make the building work better for them.

The exercise yielded a number of measures, some of which—such as supplying the elco Car Share option and setting up a building “green team”—have already been implemented. Others are slated for incorporation in the Center’s planned retrofit.

Benefits of Canine Presence. The Alliance believes that dogs are good for morale and encourage interaction. A prominent sign by the Center’s front entrance announces that “well-behaved” dogs are welcome and lays out expectations.

Tenants and visitors are encouraged to bring their canine friends to work, and many do so regularly. This explicit policy no doubt discourages prospective tenants who dislike or are allergic to dogs, but nearly half of all Colorado households have dogs and the Center has had no trouble leasing its spaces. Office dogs often provide an “ice breaker” for new interactions between building occupants and help provide work-life balance.

Hire Experts, Involve Them Early. Building team members with LEED expertise are invaluable, and the project manager should be a LEED AP. A building commissioner should be involved in the project from the start. The Alliance Center renovation might have avoided some corrective actions by taking such precautions. For example, not long after completion of the project, the building owner noticed excessive lighting in the entrance lobby. Many signs explaining the green features of the building hang on the lobby walls, and in addition to the overhead fluorescent fixtures, more than one dozen 250 W incandescent flood lamps illuminated the signs.

Several thousand watts of unnecessary photons were blasting the signs and actually heating the room to the point of requiring air conditioning year-round. Moreover, the lamps were not linked to a switch. These problems were rapidly addressed.