The main entrance of The Alliance Center opens into the community café, which serves beverages and food to go, and the event space, which can accommodate groups of 12 to 200. *Photo by David Lauer, Alliance for Sustainable Colorado*

Alliance for Sustainable Colorado Renovation Raises Its Energy Performance to New Heights

The Alliance for Sustainable Colorado (The Alliance) is a nonprofit organization aiming to transform sustainability from vision to reality. Part of its mission is to change the operating paradigms of commercial building design to make them more sustainable. Toward that end The Alliance uses its headquarters, The Alliance Center at 1536 Wynkoop Street in Denver, as a living laboratory, conducting pilot studies of innovative commercial-building-design solutions for using and generating energy.

As part of the U.S. Department of Energy's (DOE's) Commercial Building Partnerships (CBP) program,[1] The Alliance Center completed extensive renovations in June 2014, aiming to reduce energy consumption by at least 30% compared to ASHRAE/ANSI/IESNA Standard 90.1-2007 or pre-retrofit energy use. The motivations for renovating the already relatively efficient building were a) to explore the nexus between human productivity and building energy use and b) to investigate alternative business models that would make energy efficiency upgrades more attractive to commercial building owners. Another consideration was that The Alliance Center's heating, ventilating, and air conditioning (HVAC) and air distribution systems were in need of replacement.

The Alliance Center is a multi-tenant commercial building that offers shared office space to organizations working in sustainability. It also has a community event space that hosts regular educational and collaborative events and tours. The Alliance Center is a six-story brick structure (five stories above ground) built in 1908 with floor space of about 41,000 ft^2. The building

Project description	Six-story office building
Climate zone information (Denver, CO)	5B (Cool and Dry), ASHRAE 90.1-2007
Ownership model	Owned
Barriers addressed	• Historic building • No access to natural gas at the site
Square footage of project	41,000 ft^2
Expected energy savings compared to ASHRAE 90.1-2007	34% savings (based on energy use) 200,000 kWh/yr saved
Expected energy savings compared to the existing building	20% savings (based on energy use) 100,000 kWh/yr saved
Expected cost savings[2]	$20,000/yr versus ASHRAE 90.1-2007 $9,000/yr versus existing energy use
Project baseline	ASHRAE 90.1-2007 or pre-retrofit energy use
Cost of energy efficiency measures needed to achieve a 5-year payback period	$101,600
Annual avoided carbon dioxide emissions[3]	300,000 lb/yr
Retrofit completion date	June 2014

[1] CBP is a public/private, cost-shared initiative that demonstrates cost-effective, replicable ways to achieve dramatic energy savings in commercial buildings. Companies and organizations, selected through a competitive process, team with DOE and national laboratory staff who provide technical expertise to explore energy-saving ideas and strategies that are applied to specific building projects and that can be replicated across the market.

[2] Energy and power costs used for the calculations were $0.0473/kWh and $15.8/kW (June-September), $12.8/kW (remaining months)

[3] Calculated using the EPA Greenhouse Gas Equivalencies Calculator. Accessed February 20, 2015.

was first renovated for energy efficiency in 2004 when The Alliance bought the building. Interior spaces were reconfigured, telecom and electric systems were updated, and low-flow water fixtures were added. This renovation made The Alliance Center the first historic building in the world to earn two Leadership in Energy & Environmental Design® certifications: Gold for Existing Buildings and Silver for Commercial Interiors. It also earned an ENERGY STAR® rating of 85.

The National Renewable Energy Laboratory (NREL) was the technical lead for the CBP project in collaboration with NORESCO, which provided detailed energy modeling services. Mountain Engineering Partnership designed and implemented a detailed data acquisition system for measuring end uses in the all-electric building to compare pre- and post-retrofit end-use electricity consumption. The Alliance Center teamed with Gensler and 360 Engineering to develop the final architectural and engineering design for the renovation, respectively. Other team members instrumental in the project's lighting, HVAC, and plug load design and installation included EJCM (tenant finishing), Johnson Controls Inc. (controls and data acquisition), Ducts Unlimited Mechanical Systems Inc., Cooper Lighting, Illumination Systems Inc. (lighting design), Crestron (building automation), and ADK Electric Corp.

In addition to improving energy efficiency, The Alliance wanted to enhance occupant comfort and productivity. For example, it replaced interior gypsum board walls with glass, removed dropped ceilings, and lowered high cubicle walls, which created a spacious and light-filled workspace (see before and after photos on page 3). These strategies bring daylight and views deep into the building and reduce energy loads. The remaining electric lighting needs are met with warm, efficient, dimmable light-emitting diode (LED) fixtures. Occupants were also provided with a range of workspaces to meet their varied needs for quiet focus versus active collaboration.

In most cases the occupant-centered approaches also improved energy efficiency. Energy modeling predicted that The Alliance Center will surpass the DOE goal of 30% by achieving a 34% reduction in annual energy use per square foot; it is too early to draw conclusions based on the utility or submeter measurements because construction was completed so recently. During the renovation The Alliance Center increased occupant capacity from 120 workstations to 260. Per-capita energy consumption is expected to decrease by more than half.

Expected Energy Performance Results

An energy model for the pre-retrofit building was created with eQUEST and calibrated using a year's worth of submetered data and monthly utility bills to create a pre-retrofit baseline model. A minimally code-compliant baseline was also generated. Potential energy efficiency measures (EEMs) for The Alliance Center, including replacement of the HVAC system, were evaluated based on modeled energy performance and cost. The building's annual energy use intensity (EUI) after the renovation is predicted to be 34.7 kBtu/ft^2—a 20% improvement over the building's EUI before the CBP renovation and 34% better than ASHRAE 90.1-2007 requirements (see Table 1).

Table 1. Expected Energy Savings Versus ASHRAE 90.1-2007

End Use	Electricity Savings, $/yr	Electricity savings, kWh/yr
Heating	$4,900	22,400
Cooling	$1,500	12,200
Interior Lighting	$3,200	44,500
Exterior Lighting	$130	2,400
Equipment	$4,800	76,600
Fans	$2,200	12,600
Cooling Tower	$370	2,000
Pumps	$3,100	25,300
Service Hot Water	$110	1,400
Total	**$20,310**	**199,400**

Decision Criteria

This renovation project supports The Alliance's core values by identifying promising EEMs and business models for similar commercial buildings and demonstrates innovative approaches to energy and space use. This demonstration promotes the most promising strategies by sharing monitoring and verification data. The upgrades will help The Alliance Center reduce its carbon footprint—another of the organization's key goals. The decision-making process was also influenced by the fact that The Alliance Center is in a historic district, which prevented changes to the building's appearance. Finally, the building has no access to natural gas, which constrained HVAC design decision making.

Economic Goals

The goal of the economic analysis was to identify investments that would achieve a 5-year simple payback. Other considerations tracked in this project—but more difficult to quantify—included the effects of the upgrades on occupant productivity, real estate values, occupancy rates, and building income. One feature of The Alliance's new business model is the practice of licensing desks or spaces to occupants and providing shared resources such as computer networks, conference rooms, and technical services. The Alliance expects this practice will double the income from the building, which appeals to commercial building owners and increases the value of the property. In addition, the building's amenities, such as a bike parking area, welcoming ground-floor café, and access to public transportation, help ensure a positive experience for building occupants, which may help retain tenants.

Branding

Creating sustainable communities is a core value of The Alliance. The group walks its talk by creating a community of sustainability enthusiasts in The Alliance Center. When users commit to sharing the building space they agree to support The Alliance's mission of transforming sustainability from vision to reality through collaboration and demonstration. Tenants agree

to minimize their environmental impact in the building. This includes minimizing energy use through measures such as purchasing efficient office equipment that meets ENERGY STAR requirements. At the same time, The Alliance aims to pioneer solutions that are broadly applicable and financially appealing to the general office real estate sector, which accounts for about 17% of total commercial floor area in the United States.

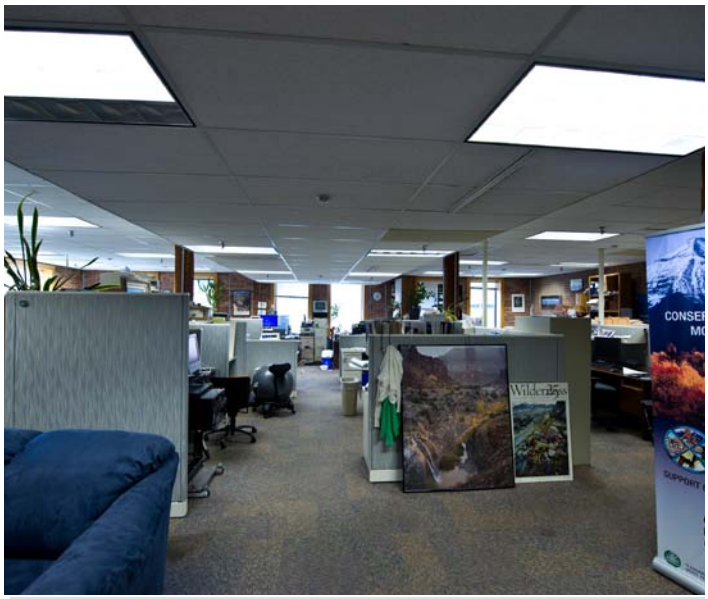
Operation

Energy efficiency is very important to The Alliance, and occupant behavior impacts energy use in even the most energy-efficient building. In an effort to shape occupant behavior, The Alliance drafted a space usage agreement and license that includes an appendix of environmental performance regulations. Potential occupants agree to follow these regulations and take direction from Alliance staff about the efficient use of energy through measures such as sharing multifunction office equipment. Electricity consumption is monitored by floor now, but The Alliance intends to measure by individual seats in the future. These data are integrated with the building's data collection system to identify savings opportunities. Space use is also tracked to make the most efficient use of the building's flexible space configuration.

Energy Efficiency Measures

The Alliance implemented the EEMs shown in Table 2 (page 4) based on the energy and economic analysis results, cost effectiveness, and potential impacts on occupant comfort and productivity. The cost premiums for individual EEMs to meet a 5-year simple payback based on each EEM's estimated annual energy cost savings versus minimal compliance with ASHRAE 90.1-2007 are included in the table; they may not accurately reflect the real cost, which took into account other sources of value besides energy savings. The cool roof annual savings is slightly negative, because in Denver the increased heating required in the winter will likely outweigh cooling savings in the summer.

The totals for the EEMs in this table differ slightly from the results from the whole-building model because of interactions between EEMs and rounding. Although common industry practice is to screen EEMs individually, NREL recommends that the entire package of EEMs be considered as an integrated whole to account for interactions. This approach allows mechanical systems to be downsized because of reduced internal gains, and because effective low-cost EEMs can help pay for measures that save significant energy but have higher capital costs. Accounting for interactions is straightforward once an energy model has been created for the building.



Workspace at The Alliance Center in September 2010, before the latest renovation. *Photo by Dennis Schroeder, NREL*

A typical suite layout after the renovation features an open floor plan, glass interior walls, and low cubicle walls, all of which allow daylight and views deep into the building. *Photo by Kim Hughes, Alliance for Sustainable Colorado*

Table 2. Energy Efficiency Measures

	Climate Dependent	Expected Annual Savings, $/yr	Expected Annual Savings, kWh/yr	Improvement Cost for a 5-yr Payback, $
Roof				
EEM1: Improved roof insulation (R-10 to R-32)	Yes	$1,400	8,000	$7,000
EEM2: Cool roof (abs 0.7 to 0.55)	Yes	$30	(90)	$140
Lighting: 6.4% Expected Energy Savings				
EEM3: Energy-efficient (LED) interior lighting fixtures with occupancy sensors	No; however, heating costs will increase slightly in heating-dominated climates	$2,800	35,000	$14,200
EEM4: Reduced exterior lighting load (2 kW to 1.25 kW)	No	$130	2,400	$660
Process/Plug Load: 10.7% Expected Energy Savings				
Reduced equipment power density (1.0 to 0.8 W/ft^2)	No	$1,700	25,900	$8,500
EEM6: Plug load management	No	$1,700	37,400	$8,400
Service Water Heating: 0.2% Expected Energy Savings				
EEM7: Low-flow fixtures	No	$100	1,400	$520
HVAC: 14.5% Expected Energy Savings				
EEM8: DX cooling with good part-load efficiency, supply air temperature reset, and dual temperature economizer	Yes	$3,700	31,200	$18,400
EEM9: New variable air volume (VAV) boxes and demand controlled ventilation	No	$8,600	54,500	$42,800
Total	**N/A**	**$20,200**	**195,700**	**$100,600**

Color accents and natural elements are scattered throughout the building. The flooring in this hallway is cork.

Photo by Kim Hughes, Alliance for Sustainable Colorado

Energy Use Intensities by End Use

To understand and benchmark the expected performance of the newly renovated building, three energy models were created with eQUEST:

- A minimally code-compliant baseline model based on ASHRAE 90.1-2007 and ASHRAE 62.1-2007
- A model that captured the performance of The Alliance Center before the latest CBP renovation.
- A model representating the expected performance of The Alliance Center with all EEMs implemented.

The first two models were used to benchmark the expected performance of the newly renovated Center.

Code-Compliant Baseline Model

The code-compliant baseline model is representative of a building that meets the owner's program needs and is built according to the prescriptive specifications of Standards 90.1-2007 and 62.1-2007. The baseline HVAC system for the size and type of building is variable air volume air handling units with fan-powered boxes served by chilled water. The Standard 90.1-2007 model has an expected annual EUI of 52.5 kBtu/ft^2.

Existing Building Model

The second baseline model is representative of the building before the latest renovation. All areas in the building are served by VAV rooftop units with direct expansion cooling and electric resistance heating (the site has no natural gas service). The existing building model has an expected energy use of 43.8 kBtu/ft^2, which is 17% less than the Standard 90.1-2007-based model.

Proposed Design Model

The proposed design model is representative of the building after the renovation is complete. This model has an expected annual EUI of 34.9 kBtu/ ft^2 and an energy savings of 34% compared to the ASHRAE 90.1-2007 baseline.

Table 3 shows the annual EUIs and percent savings for all three models.

Table 3. Estimated EUIs

End Use Category	ASHRAE 90.1-2007 Model Annual EUI (kBtu/ft^2)	Existing Building		Proposed Design	
		Annual EUI (kBtu/ft^2)	Percent Savings Over 90.1-2007	Annual EUI (kBtu/ft^2)	Percent Savings Over 90.1-2007
Cooling	3.3	4.8	-42%	2.3	32%
Heating	15.8	14.6	7%	13.8	13%
Interior Lighting	9.8	7.5	24%	5.9	40%
Exterior Lighting	0.6	0.4	25%	0.4	38%
Equipment	15.9	13.4	16%	9.1	43%
Fans	4.2	2.7	36%	3.1	27%
Cooling Tower	0.2	0.0	100%	0.0	100%
Pumps	2.3	0.1	96%	0.04	98%
Service Hot Water	0.4	0.3	29%	0.3	29%
Total	**52.5**	**43.8**	**17%**	**34.9**	**34%**

The view from the roof of The Alliance Center which is located in the heart of downtown Denver. *Photo by Dennis Schroeder, NREL*

Lessons Learned

The Alliance Center renovation project combines measurable energy efficiency goals with practical commercial building market considerations. The updated space is intended to be beautiful, quiet, and comfortable. It is designed to allow occupants to work productively alone and in groups. To achieve the DOE goal of improving commercial building energy efficiency on a large scale, commercial building owners must realize benefits beyond energy savings, considering that they typically pass energy costs on to tenants. If the Alliance's assumptions are validated, other commercial building owners may be interested in replicating the business model.

Good Buildings Can Become Better

The Alliance Center project proves that an already relatively efficient building can be a good candidate for further energy efficiency improvements, especially at the end of the life of major systems. The newest upgrades for the building include naturally lighted and quieter workspaces; improved collaboration spaces; a larger event space; eco-friendly and recycled materials and products; a new efficient HVAC system; energy-efficient office equipment with occupancy-based controls; and a better insulated roof. The Alliance is also working to improve and quantify occupant productivity in this project, which can be boosted by upgrades that enhance comfort and aesthetics through new HVAC, upgraded controls, increased daylighting and expanded views, a diversity of workspaces, and enhanced lighting design.

Monitoring Matters

Measuring and monitoring plug loads and other energy uses allow building operators to identify and correct problems in energy-using systems. For example, the first HVAC system installed during the renovation did not work properly; however, the energy monitoring system detected the excess energy use and the unit was replaced quickly.

Monitoring and verifying energy use also help educate and engage occupants. When users can easily track their energy use, they can modify their behavior to save energy. As the saying goes, what gets measured gets managed. The Alliance is developing a dashboard that will allow user-friendly remote monitoring of energy use.

Lighting Lessons

LED fixtures are used predominantly throughout this building. Occupants enjoy high-quality lighting, and the energy consumption for interior lighting is expected to decrease by roughly 20% compared with pre-renovation use and by 40% versus 90.1-2007 requirements.

Energy Efficiency and Real Estate Values

In addition to reaching its energy efficiency goals, The Alliance is working on innovative strategies to make energy efficiency attractive to commercial building owners. For example, it is testing ways to increase space efficiency while also improving comfort and productivity. Rather than using a traditional lease arrangement, The Alliance's approach is to license a desk or space to users and to offer shared amenities through an innovative agreement. The benefit of higher occupant density to the building owner is a higher income than traditional leased office space, which results in a higher real estate value for the property. If it is successful, it will be a business model that other building owners can replicate.

For more information about this project worth watching, visit the Alliance for Sustainable Colorado website.

The Alliance Center, headquarters of the Alliance for Sustainable Colorado in downtown Denver, Colorado, is surrounded by bike paths, pedestrian walkways, light rail, and bus stops. *Photo by David Lauer, Alliance for Sustainable Colorado*

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DOE/GO-102015-4635 • March 2015

Prepared by the National Renewable Energy Laboratory (NREL), a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. NREL is operated by the Alliance for Sustainable Energy, LLC.