Situated on the high plains at the base of the Rocky Mountains, Denver has a semi-arid climate with sunny days and low humidity — ideal conditions for passive building strategies. The Region 8 EPA Headquarters harnesses nature’s resources, capturing the benefits of free cooling, daylighting and solar energy.

The EPA Region 8 Headquarters serves the mountain states of Colorado, Montana, North Dakota, South Dakota, Utah and Wyoming. The facility, which opened in 2007, consolidated EPA offices that were previously spread out over 23 floors in two towers. Its setting in the revitalized urban district known as LoDo near alternative forms of transportation serves to remind the public of the EPA’s mission of sustainability.

The General Services Administration (GSA) leases the building on behalf of the EPA. Both organizations require LEED Silver for their buildings as a minimum standard. The Region 8 Headquarters achieved LEED-NC Gold using holistic and integrated design, smart site orientation, an efficient underfloor air-distribution system, and a vegetated roof that manages storm water and minimizes the heat island effect.

Minimizing Loads

The building team designed the massing and orientation to capture the maximum climatic benefits (such as daylight and renewable energy) while minimizing thermal loads on the building. The team selected a “double L,” design concept (see diagram, Page 62), which satisfied the desire to create a central atrium and worked well with the building’s position on a street grid that is oriented 45° to the cardinal compass points.

A “sunward L” with legs facing southeast and southwest receives most of the solar radiation while the “windward L” bears the brunt of most of the wind. A series of preliminary studies comparing the merits of different building massing options with resulting thermal loads and daylight availability confirmed the performance benefits of this “double L” atrium approach.

The eastern break between these two wings forms the primary entrance to the building and is adjacent to an urban park, while the western gap orients occupants toward views of the Rocky Mountains.

Curtainwall systems for each “L” are designed as siblings, with the south-facing leg tailored to harvest direct sunlight while minimizing solar gain via a series of horizontal sunshades and lightshelves. The other leg is designed to maximize daylight harvesting from the diffuse north sky while blocking low-angle summer sun with vertical blinds. The nine-story northern leg shelters a roof terrace on the eight-story southern leg from the wind while leaving it exposed to the sun.

The building team evaluated the performance of alternative glazing, external shading devices and reflective versus vegetated roof. The team performed these analyses in an effort to achieve the requisite LEED-NC Gold.
balance of useful versus harmful energy flows that would also meet the challenging aesthetic and development goals of the LoDo District. The district maintains design criteria intended to preserve architectural characteristics of the area. The LoDo requirement for street-front presence, for example, conflicted with government security-related mandates for building setback. Other district requirements influenced material use, cornice heights and architectural expression of central block alleys.

**Passive Strategies**

Passive strategies take advantage of Colorado’s Front Range climate. While security concerns and hardened perimeter requirements prevented an exclusive natural ventilation strategy, the low humidity and large-daily diurnal temperature variation provide an ideal opportunity to flush cool night air through the building. The concrete structure is designed to maximize its exposure to the building interior, reducing cooling requirements through radiant and convective cooling. Iterative energy and daylight simulation helped balance internal daylighting with undesirable glare and winter passive solar heating with summer solar protection. Design in place of the typically required storm water control tanks and filters. However, Colorado water rights law, based on the principal of prior appropriation common to many western states, precludes the capture and reuse of storm water because rights to that use are assumed to be owned by others. The design team worked closely with regulatory agencies to design a vegetated roof system with minimal water retention capability—just enough to irrigate the area. A joint effort by the design team, the EPA and national experts to present documented performance data, together with a commitment by the EPA to monitor and test the effectiveness of the system for a five-year trial period, convinced local authorities to approve the vegetated roof. The team presented studies comparing vegetated roof runoff rate reductions with standard methods for quantifying hydrologic runoff. It also provided studies showing vegetated roofs’ removal rates of phosphates, organic matter and other pollutants. Through a coalition of the EPA, Colorado State University and the Denver Botanical Garden, the vegetated roof continues to serve as a test bed for storm water management, new plant breeds for the Front Range area and urban heat island reduction.

**Optimizing Active Systems**

An integrated suite of mechanical, electrical and plumbing (MEP) systems are designed to work in conjunction with the building’s architecture and structure, supplying only the required supplementary conditioning at any given time and allowing the building to take advantage of its passive features.
The South-facing 64 while and nearly $250,000, or $0.80/ft².

cleaning program reduced the building's reducing light pollution. The daytime cleaning crew.

hours every night, instead of continuing the building to be "put to sleep" for 10 well. A daytime cleaning program allows the building's operational efficiency as

The EPA has taken steps to increase Visual transmittance 0.38/0.70

Under slab insulation

Foundation

Glazing percentage: 45%

Overall R-value

R-17.5 (U-value: 0.057)

Overall R-value

V egetated roof

Roof

R-20 (U-value: 0.05)/

Vegetation

External penetration works

V egetated roof

R-20 (U-value: 0.05)/

Roof

Phased air heat distribution (third floor and above) provides

The first and second floors accommodate public functions, including a conference center, and are served by automated and electric ventilation system.

The roof-mounted central cooling plant is comprised of high-efficiency, variable speed electrical centrifugal chillers, variable speed pumps and cooling tower fans with variable speed motors. The adjacency of this plant equipment minimizes piping pressure and thermal losses, further improving energy efficiency.

Plate and frame heat exchangers are provided for waternode free cooling and a separate circuit is provided for after-hour and 24-hour loads. For space and domestic hot water heating, the building connects to a district steam heating system. A cascade approach converts the steam to space heating hot water and then recaptures the waste heat from steam condensate, which is used as the source for the domestic hot water.

An air-side energy recovery system using runaround loops transfers energy from the building relief air to the outdoor air in the air-handling units, further reducing energy demands for mechanical heating and cooling. The air-handling systems include air-side economizers, taking maximum advantage of the Colorado climate for free cooling.

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An underfloor air-distribution (UFAD) system on all office floors (third floor and above) provides added flexibility for office reconfiguration and a healthy, quiet and ultra-low energy ventilation system. The UFAD system also helps expand the free cooling outdoor air economizer zone operation available for the Denver climate, allowing the use of 100% outside air more frequently to cool the space instead of mechanical refrigeration.

The first and second floors accommodate public functions, including a conference center, and are served by a conventional overhead VAV system. A demand-controlled ventilation (DCV) system controls the UFAD system using carbon dioxide sensors throughout the building and monitoring stations in the air handlers. The installation was the subject of subsequent post-occupancy evaluation by the Center for the Built Environment at the University of California, Berkeley (see UFAD System Survey).

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A single daylight model was shared between the architect and engineer. Using this common model, ZGF and Syska Hennessy worked together to efficiently refine the design and assess its performance.

A design session with a physical model on a heliodon (artificial sun) at a local university provided unexpected insights that sent the design in a direction different from the original concept. The elliptical profile of the reflector grid on a standard fluorescent light fixture provided the inspiration for an array of south-facing sail shapes suspended below the atrium glazing.

Designers need post-occupancy feedback on how the building is actually performing so this data can be used to continually tune building performance. For example, higher cooling season energy consumption shown in early electric bills led the design team to discover that the night-flushing regime designed was not being executed properly, and the issue was corrected.

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the yachting industry. A theatrical rigging company in Denver hired a group of rock climbers to install the sails at the top of the atrium.

Due to their elliptical sectional profile, the sail shapes gather daylight from any incident angle and focus it in the desired downward direction. Ultimately, the turnkey solution was completed for a lower cost than the budget allowance. Looking up from the atrium floor, the sails evoke the sun, wind and light. The building's HVAC, lighting and water systems were tuned through a rigorous commissioning process, including a measurement and verification plan. Additional testing and verification began during design development, continued through construction and turnover, and remain part of the culture of the building operation today.

**Renewable Energy Generation**

Building-integrated PV panels were designed for inclusion in the spandrel panels of the “sunward L,” while the cornice of the “northern L” was designed to accommodate a series of vertical axis wind turbines under a concentrating airfoil. Both systems were beyond the project budget and ultimately were not included in the construction.

However, the EPA secured funding from its security division for a 10-kW, 48-panel rooftop photovoltaic system that is mounted above the planted area on the vegetated roof. The installation contributes to the electrical security backup of the building, while also offsetting the base building load. The building’s electrical infrastructure is designed to accommodate the wind turbines in the future, should the organization choose to install them.

During the process of design and construction, the national EPA headquarters in Washington made an agency-wide commitment to purchase 100% renewable energy. Wind-generated power purchased from Excel Energy offsets the energy use of the Region 8 headquarters. The building’s electrical infrastructure is designed to accommodate the wind turbines in the future, should the organization choose to install them.

**Conclusion**

The building was designed, built and is being operated in a way that supports the EPA’s mission of environmental stewardship. Its LEED-NC Gold certification, ENERGY STAR rating of 96 and positive occupant survey results are testament to the integrated building process from design and construction through operation.

**ABOUT THE AUTHORS**

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