ENERGY AND ARCHITECTURE: THE SUSTAINABLE FUTURE

THE RESEARCH SUPPORT FACILITY PROJECT

At the U.S. Department of Energy's National Renewable Energy Laboratory in Golden, Colorado

OWNER:

U.S. DEPARTMENT OF ENERGY

www.energy.gov

National Renewable Energy Laboratory

www.nrel.gov

Alliance for Sustainable Energy, LLC

allianceforsustainableenergy.org

PROJECT TEAM:

General Contractor:
HASELDEN
haselden.com

Architect, Interior Design, Landscape Architecture:
RNL
rnldesign.com

Mechanical, Electrical Engineer and Sustainability Consultant:
STANTEC
stantec.com

A NEW BENCHMARK IN SUSTAINABILITY

The Challenge: To design and build a national showcase building demonstrating the integration of high-performance design features, passive energy strategies and renewable energy as a prototype for the future of large-scale net-zero energy buildings.

The Result: The U.S. Department of Energy's (DOE) Research Support Facility (RSF) at the National Renewable Energy Laboratory, a new 222,000 square foot office building. The project achieves the U.S. Green Building Council's Leadership in Energy and Environmental Design New Construction (LEED-NC) Platinum certification, and is expected to become the largest net-zero energy office building in the nation.

The new DOE/NREL RSF will consolidate more than 800 NREL and DOE Golden Field Office staff into one location.

"The contract with NREL means our team collectively guarantees the performance of the facility. The LEED Platinum and zero-energy design will still allow for the RSF to be built using conventional techniques and products."

— RICH VON LUHRTE, FAIA, LEED AP, PRESIDENT, RNL

UNIQUE REQUIREMENTS

The RSF lobby includes many sustainable materials, including reclaimed beetle-kill pine.

"This building will demonstrate that the energy performance of commercial buildings can be substantially improved using an integrated design process. Through this innovative approach, combined with a relentless focus on the energy model, our team is creating a new national standard for large-scale sustainable commercial buildings that is achievable and marketable now."

— JEFF BAKER, DIRECTOR,
OFFICE OF LABORATORY
OPERATIONS
U.S. DEPARTMENT OF ENERGY

Delivered as a design-build project, the team met numerous requirements including:

1) At a minimum, design a building to meet a U.S. Green Building Council LEED-Platinum rating. The team is reaching beyond this contract requirement to deliver a net-zero energy building.

2) Develop an integrated design approach and net-zero energy solution that may be commercially replicated by others in the future, allowing the innovative design and construction to be in line with conventional processes while meeting the total project cost of $64 million. DOE set the baseline for these efforts, establishing a goal "to create the technology and knowledge base for cost-effective zero-energy commercial buildings (ZEBs) by 2025." This building is expected to be delivered 15 years ahead of this goal.

3) Design a building with a target energy use intensity of 35.1 kBtu/sf/year including the full campus data center, which is 50% better than current ASHRAE standards.

4) A three-pronged approach to safety: safety of maintenance activities, safe deconstruction at the end of the building's life cycle, and safety of construction.

5) Deliver a high performance workplace that is flexible, allows secure collaboration with outsiders, supports future technologies and honors future staff needs.

UNPARALLELED SOLUTION

Library spaces allow for effective research and problem-solving.

Through an intensely integrated and collaborative approach with the client and the design/build team, the design was developed with the idea to "Keep It Simple." This overarching concept involved designing an elegant solution reflecting the honest expression of the scientific, environmental and aesthetic. The result will be an energy efficient and inspiring workplace for NREL and DOE staff.

"The solution is simple, honest and elegant. There is tremendous beauty in reaching zero."

— CRAIG RANDOCK, AIA, LEED AP, DESIGN PRINCIPAL AT RNL

The Research Support Facility will be an industry changing project as an early North American prototype for large scale net-zero energy office buildings. The project incorporates a combination of timeless design concepts and new energy solutions. These strategies include:

Low Energy Consumption – Achieving a net-zero energy building requires creating a building with very low energy consumption that is offset with on-site renewable energy generation.

Energy and Environment Drive the Design – The design of the RSF is based on simple timeless concepts of respecting the natural environment and configuring the building to respond to the movement of the sun. Mastered by our ancestors long before air conditioning was invented, these passive, energy-free design solutions work well with the site's dry Colorado climate.

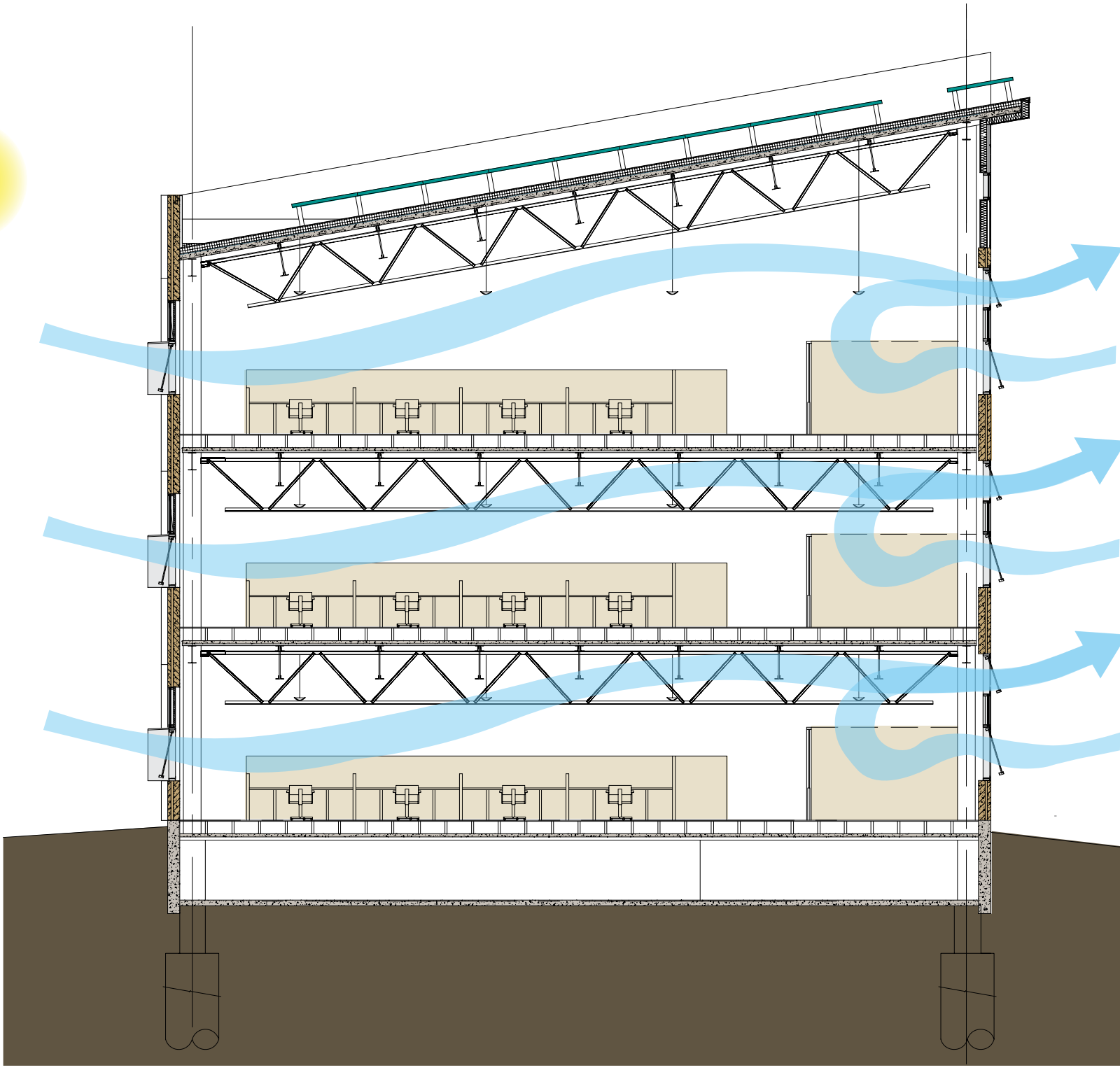
Reclaimed natural gas pipelines, which are repurposed as vertical structural columns are put in place at the construction site.

The shape of the building, a "lazy-h" configuration, is the result of two multi-story office bars oriented along the east-west axis. This allows for optimum daylight access and a perpendicular connector that contains all of the shared public spaces within the building.

This configuration also creates two exterior courtyards that are distinct in purpose and shape. The east entry court will embrace the public visitor entrance with a welcoming civic space, while the employee courtyard to the west forms a more intimate enclosure for relaxation and collaboration.

Exterior Wall Systems – Because of the extensive exterior envelope required to optimize daylighting and natural ventilation, the team devised an exterior wall system that is modular, thermally massive and carried on an efficient structural bay. The column free, structural grid is 30' wide by 60' deep, and integrates the building's kit of parts approach.

Recycling and Reuse – Recycled and repurposed materials are found throughout the design. One ultimate example of irony is that reclaimed natural gas pipelines, a throwback from "old energy" days, are used for the vertical structural columns in a building that is a demonstration of energy efficiency and renewable energy.



Manual and automatic operable windows provide natural ventilation and comfort during the shoulder seasons and mild summer days.

PASSIVE STRATEGIES

"Many of our strategies leverage passive heating and cooling techniques that take maximum advantage of the local climate, and are proven effective with extensive energy modeling and advanced building simulation tools."

— JOHN ANDARY, PE, LEED AP, PRINCIPAL, STANTEC

Natural Ventilation – Single-sided and cross-ventilation strategies to naturally ventilate the building—no employee is more than 30 feet from an operable window and all working spaces are designed for natural, passive cooling.

Night Purging – The building automation system automatically operates specific windows at night to allow the Colorado nighttime air to cool the thermal mass of the building – preparing the building to absorb daytime heat the next day.

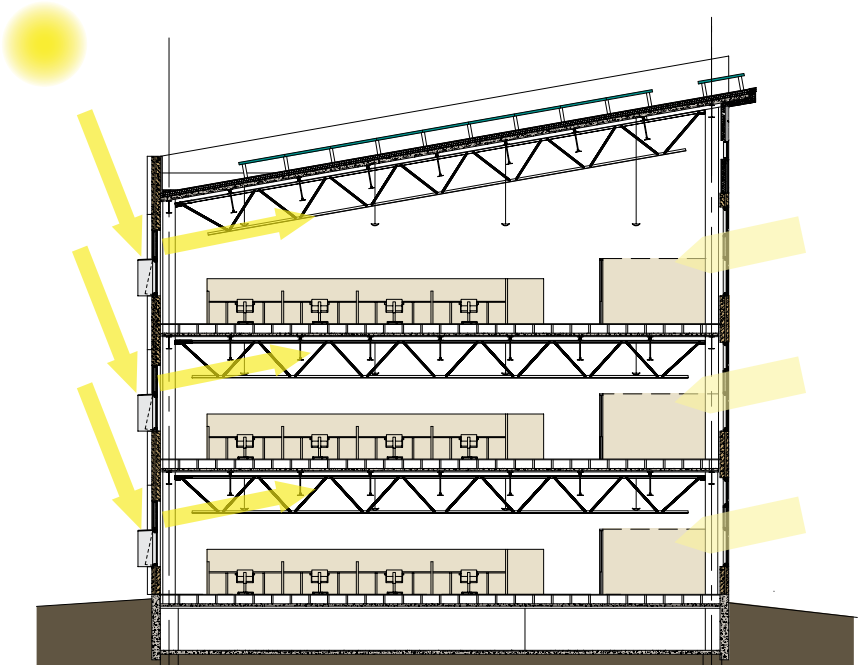
Transpired Solar Collectors – Outside ventilation air is passively preheated via transpired solar collectors on the building's south face before delivery to an underfloor air distribution system. Transpired solar collection is a technology developed by NREL.

Thermal Labyrinth – A below-grade labyrinth of heavy concrete structures is built in the crawl space of the building. The thermal labyrinth stores thermal energy and provides additional capacity for passive heating and cooling of the building. The heat is expelled to a portion of the labyrinth.

Thermal Mass – A thermally massive exterior wall assembly using an insulated precast concrete panel system provides significant thermal mass that is exposed to the building interior, allowing effective nighttime cooling.

Solar Control – Aggressive window shading is designed to address different orientations and positions of glazed openings. This effectively reduces heat gain during the summer while still providing daylighting.

Daylighting – 100% of all typical work spaces are designed to receive adequate daylight (based on the LEED criteria) by using a narrow floor plate and an advanced light bouncing device (LightLouver) on the south face of the building. Automatic lighting controls turn lights off when they're not needed, saving energy.



Daylight enters the upper portions of the south facing windows and is reflected up to the ceiling and deep into the space with a light reflecting LightLouver. Indirect ambient daylight enters from the north facing windows. 100% of the workspaces are daylit.

Beams are put in place at the construction site. The roof is sloped at 10° and hosts a building integrated photovoltaic system, which provides solar generated electricity to the building.

NEW ENERGY SOLUTIONS

To supplement the many passive design strategies, several new energy solutions are being integrated into the RSF. These technological strategies have two things in common: they are highly energy efficient and simple to operate.

Radiant Slabs – Approximately 42 miles of radiant piping runs through all floors of the building, using water as the primary cooling and heating medium as opposed to forced air. This hydronic radiant slab heating and cooling approach is very energy efficient and thermally comfortable.

Ventilation Air – A dedicated outside air system provides fresh air from a raised floor when building windows are closed on the hottest and coldest days.

Evaporative Cooling – Evaporative cooling for the ventilation system and building data center systems is an efficient and inexpensive system that works well in Colorado's dry climate.

Heat Recovery – Extensive heat recovery from the building data center and other waste heat streams is used to pre-heat air and water for building uses.

Energy Efficient Lighting – Energy efficient lighting fixtures and controls supplement the daylighting system of the building and provide high visual quality at a low power density.

Green Information Technology – Extensive efforts have been made to reduce energy requirements of the information technology systems. A reduction in stand-alone printers and copiers will reduce energy demand without compromising productivity. Stand-alone computers will be phased out for either laptops or "thin client" machines. The energy savings of a laptop over a standard PC is 85%. Using thin client machines brings the energy savings up to 92% per workstation.

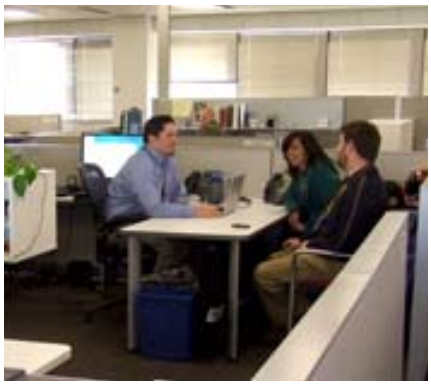
Photovoltaics (PV) – A combination of roof mounted PV and PV integrated into the on-site parking shade canopies provide enough power to operate the facility at an annual net-zero energy basis.

"The simple, but sophisticated energy solutions designed into the NREL RSF facility will move the concept of large scale net-zero energy buildings rapidly forward in our government and commercial building sectors."

JOHN ANDARY PE, LEED AP, PRINCIPAL, STANTEC

WORKPLACE OF THE FUTURE

The open office environment helps achieve many sustainability goals.



"Tearing down walls is an important concept in the RSF, both literally and figuratively."

— GEORGE DOUGLAS,
NREL SPOKESPERSON

The RSF workplace design incorporates innovation not only in sustainability but in how people work. A sustainable open office environment can be a significant culture shift for many organizations, even those whose life's work is based on renewable and efficient use of energy. NREL is addressing this culture shift by building out a full mockup of the workplace in its existing Golden Hill office and touring employees through it before the move to the new permanent office. The goals of the RSF as identified on NREL's web site are to:

- Meet the needs of the workforce — both current and future
- Maximize the efficiency of employee workspaces
- Make best use of the space while using the lowest attainable amount of energy per square foot.

To meet these goals and the LEED Platinum rating, NREL understands it needs a space that reflects and facilitates a new way of thinking.

The team is providing an interiors solution of modular workstations and demountable walls. This approach works in synergy with the project's energy goals, contributing greatly to daylighting and natural ventilation strategies while providing flexibility. Demountable walls are factory-manufactured with standard construction materials and are 100% moveable and reusable for alternate configurations. This eliminates the need for drywall demolition and reconstruction as workplace needs change, thus reducing time, labor and material waste.

The low profile of the modular workstations allow daylight and views to reach all of the occupants within the space and better flow for natural ventilation via user operated windows.

Lighting typically consumes 30% of the energy use in a standard office building. But the RSF project is no standard run of the mill office. Overall light levels are lower than in a typical office building but don't compromise individual productivity because of the extensive daylighting and individual task lights meet user needs. This eliminates excess energy to light an entire space that may not be at full capacity. The lighting in the RSF is projected to consume only 14.5% of the building's energy.

The open office environment, modular workstations and demountable walls also work hand-in-hand with a raised floor environment, which provides an infrastructure for an under floor air distribution (UFAD) system. UFAD gives individuals the ability to control the temperature in their immediate work areas and provides better indoor air quality. The raised floor system also allows for easy relocation and reconfigurations of workstations, IT systems, cable trays and electrical installations.

Whenever possible, the project team will incorporate materials that meet one of four sustainable criteria: recycled content, regional materials (within a 500 mile radius), rapidly renewable materials, and sustainably certified wood. Their goal, however, is to reach beyond the standard LEED checklist and use materials that meet not just one, but multiple sustainable criteria. For example, the runways at Denver's former Stapleton Airport are the source for recycled aggregate. The material constitutes both regional and recycled content.

METRICS AND RESULTS

NREL's work and research in defining the metrics of net-zero energy building (ZEB) inspired the vision for the RSF. The team was compelled to test the building design against all of the four definitions and metrics of a ZEB – Site Energy, Source Energy, Energy Emissions and Energy Cost. Calculations confirmed that the design would meet all four NREL ZEB definitions.

METRICS

"What we're putting together is more than a building. I firmly believe we're creating the future of our industry with the RSF project. We're not only making history, we're building it."

—BYRON HASELDEN, LEED AP, PRESIDENT, HASELDEN CONSTRUCTION

Energy

- Energy Use Intensity Goal: 35.1 kBTU/sf/year (accounting for full campus data center) to incorporate a higher density of people.
- Energy performance: 50% better than ASHRAE 90.1 standard.

Carbon

- Annual building operation carbon footprint: 0 CO2e/year = carbon neutral

Materials

- Recycled content in building materials: Colorado beetle kill pine for accentuated entry wall; recycled aggregate for foundations and slabs; reclaimed steel gas piping used for structural columns; concrete countertops; gypsum board; fiber cement board; recycled glass and ceramic tiles; carpet tiles; acoustic ceiling panels; cellulose insulation; FSC certified MDF; eco-resin; workstations
- Rapidly renewable materials used: Solid surface countertop; rubber flooring; tackable panels; lounge seating
- Regional materials used: Concrete countertop; gypsum board; fiber cement board; resin panel system; wall tiles
- Low or no volatile organic compound finishes including low-VOC interior paint and carpet.
- Construction waste diverted from landfill: A minimum of 75% of construction waste is being diverted from the landfill.

Water

- Annual building water use: 647,361 gallons/year
- Building water use reduction: 57% over the standard set by U.S. Energy Policy Act of 1992
- Annual irrigation water use: 73,956 gallons/year
- Irrigation water use reduction: 80.4% over the LEED Water Efficient Landscaping Credit

CONSTRUCTION COMPLETION

With the design and construction underway, completion and delivery of this landmark facility of workplace efficiency and environmental responsibility is scheduled for June 2010.

LEFT: Mid-construction photo reveals a below-grade concrete labyrinth that stores thermal energy and provides passive heating and cooling. The "lazy-h" configuration maximizes daylighting in the RSF.