National Renewable Energy Laboratory's Thermal Test Facility

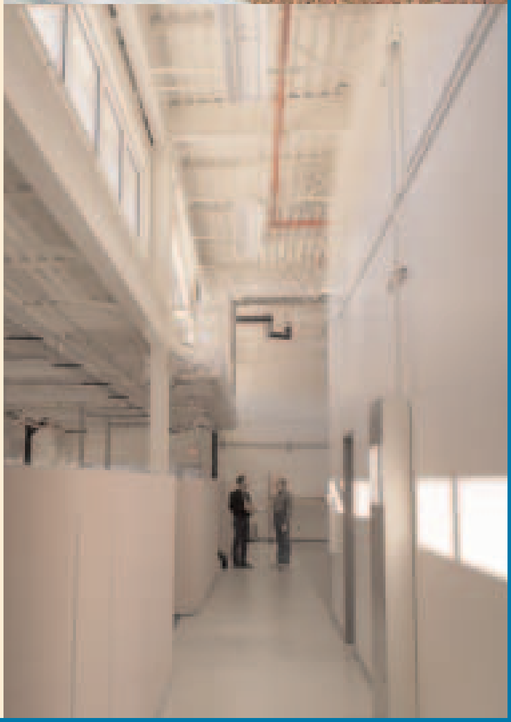
Golden, Colorado

Highlighting high performance

The hot summers and cold winters in Golden, Colorado, make energy-efficient building design a challenge. But when outlining plans for its Thermal Test Facility, built in 1996, the National Renewable Energy Laboratory used a simple design to create a high performance building. An integrated approach—considering how all the building technologies work together most efficiently—was at the heart of the design process.

The cost-effective, energy-efficient building incorporates features, such as daylighting and an evaporative cooler, that take advantage of Golden's abundant sunshine and arid climate. Researchers monitor the performance of the 11,000-square-foot building, which boasts an energy cost savings of 63% for heating, cooling, and lighting.

The basic plan of the building can be adapted to many needs, including retail and warehouse space; the Thermal Test Facility contains office and laboratory space. Appropriately, research in the facility centers on the development of energy-efficient and renewable energy technologies that are cost effective and environmentally friendly.



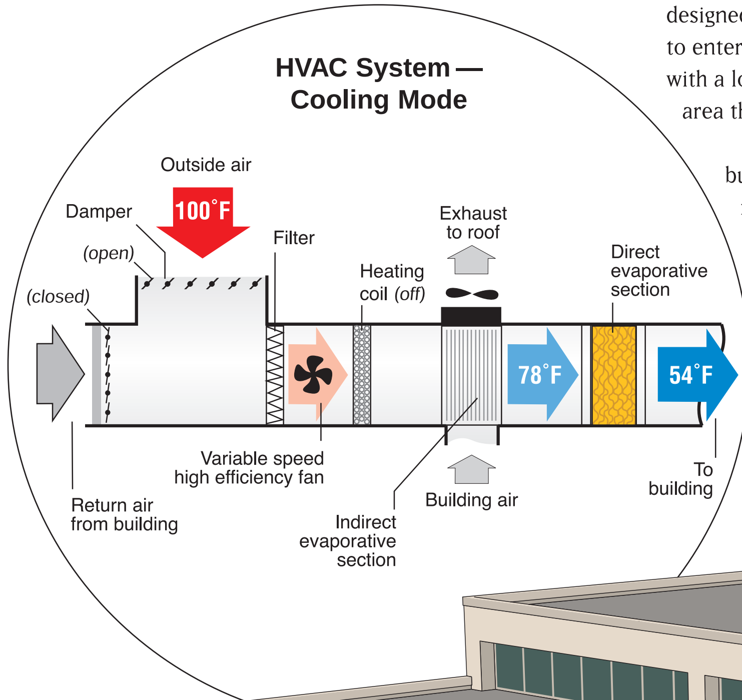
Daylight from clerestory windows is the primary source of light in the Thermal Test Facility. Daylighting and energy-efficient lighting reduce energy use for lights by 75%.

Low-energy design and renewable energy at the Thermal Test Facility

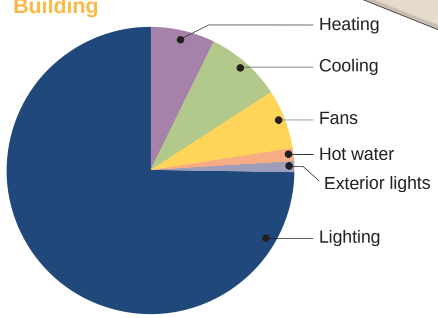
Cooling

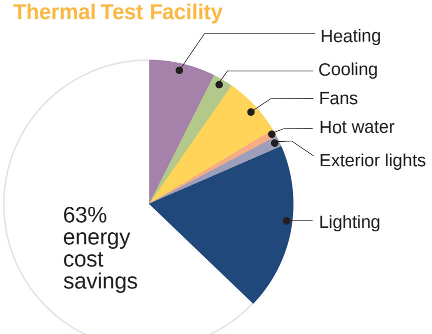
The building's shell, or envelope, was designed to minimize cooling needs. **Window overhangs** shade the windows from the high summer sun, reducing the amount of heat absorbed by the building. Daylighting minimizes the use of electrical lights, further reducing cooling loads.

When necessary, the building is cooled with an indirect/direct **evaporative cooling system**. Outdoor air is drawn first through the indirect section, which is a heat exchanger. The air moves through one side of the exchanger, while on the other side warm indoor air is exhausted through a water-soaked evaporative media to the roof. The exhausted air is cooled as it moves through the evaporative media. Because the incoming and exhausted air streams are divided by just a thin membrane, the process removes heat from the incoming air without adding humidity. The pre-cooled air is then pulled through the direct section. It moves through a honeycomb material through which water is seeping. The water evaporates, takes heat with it, and further cools the air.



Actual Energy Comparison*



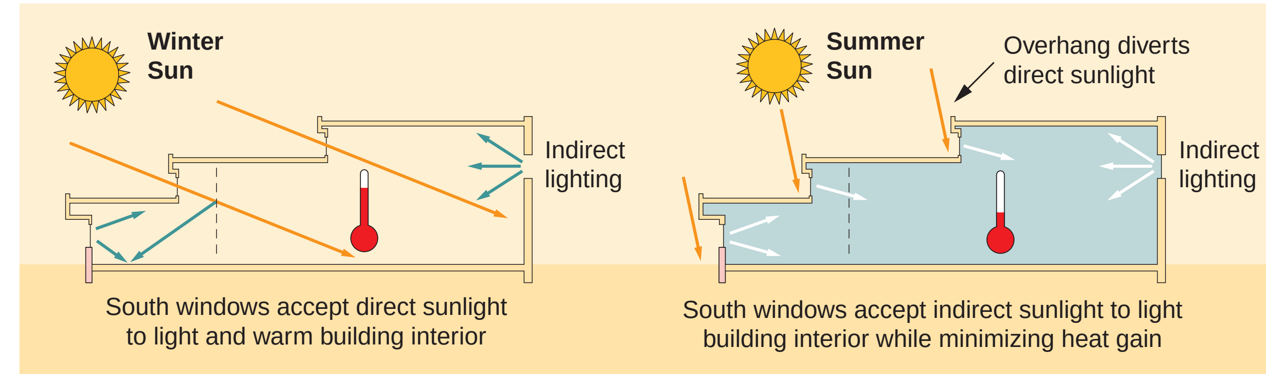


* This comparison does not include plug loads, which are not affected.

Windows

Designers used computer simulations to select window sizes and glass types that would minimize heat transfer and maximize daylighting potential. The **clerestory windows** are clear double-pane glass with a **low-emissivity coating** designed to reduce heat flow while allowing the visible light to enter. The glass near office space has a slight gray tint with a low-emissivity coating to reduce solar gains in an area that needs minimal heating.

Most windows are located on the south side of the building, with few on the east and west. Windows were included on the north side to increase daylighting.



Thermal Envelope

A rigid exterior **insulation** and finish system (EIFS) covers the exterior surface of the outside walls in the building. This insulation helps to maintain building temperature. Some exterior walls are constructed of concrete, which increases their ability to store heat.

Lighting

Daylight from clerestory windows is the building's primary source of light; it is enhanced by white interior surfaces that reflect sunlight. Computer simulations during design helped size and locate the windows to collect the right amount of light.

When daylighting is insufficient, it is supplemented by **T-8 fluorescent lamps** and **compact-fluorescent lamps**. Motion and light sensors help the energy management computer balance electric lighting with daylighting. **Motion detectors** trigger lights in lieu of constant security lighting, further increasing the savings. Daylighting and energy-efficient lighting constitute the most significant energy cost savings in the building.

Heating

In the winter, the sun shines in through clerestory windows, warming the building through **passive solar heating**. If needed, hot water circulates through **heating coils** and transfers heat to the air. Hot water is supplied to these coils from a boiler located in a nearby building.

Landscaping

Water conservation is especially important in this arid climate, so the land surrounding the Thermal Test Facility is landscaped with rocks and drought-resistant shrubs, also called **xeriscaping**.

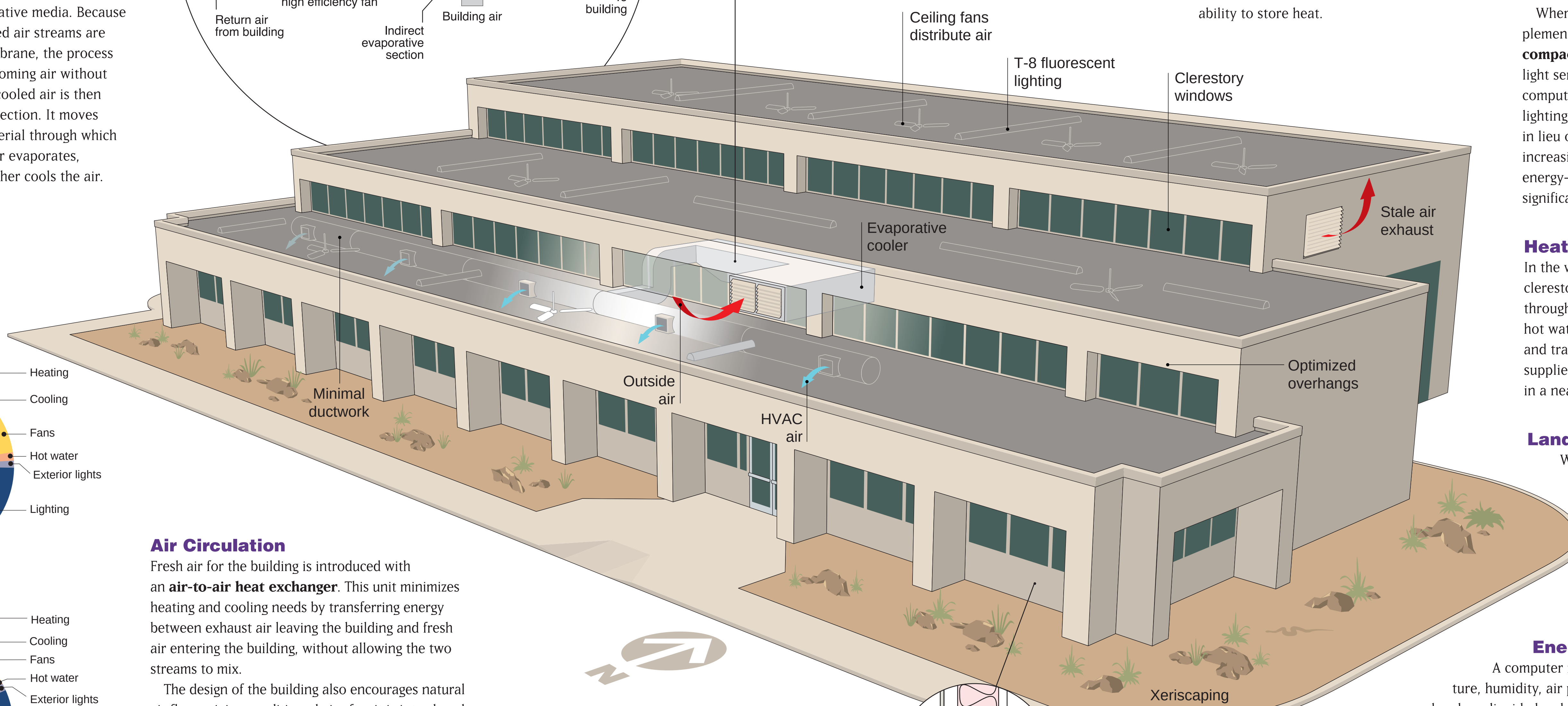
Energy Management System

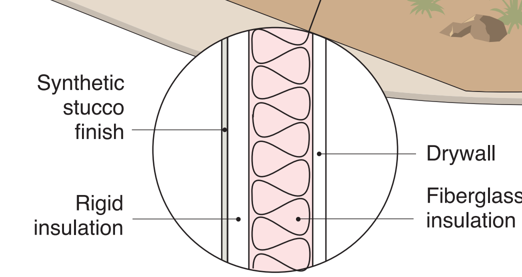
A computer monitors the conditions (temperature, humidity, air pressure, duct pressure, light levels, and carbon dioxide levels) of the building to determine the most efficient method for maintaining a comfortable level in the occupied space. For example, the system may turn on the ceiling fans to circulate cool or warm air through the building instead of operating the more energy-intensive main air handling unit. The system also monitors and records building performance.

Air Circulation

Fresh air for the building is introduced with an **air-to-air heat exchanger**. This unit minimizes heating and cooling needs by transferring energy between exhaust air leaving the building and fresh air entering the building, without allowing the two streams to mix.

The design of the building also encourages natural air flow, mixing conditioned air after it is introduced in the front office area. When stratification occurs, ceiling fans circulate air and distribute it throughout the building, reducing the need for costly duct work or operation of the central fan system.





Buildings for the 21st Century

Buildings that are more energy efficient, comfortable, and affordable…that's the goal of the U.S. Department of Energy's Building Technologies Program.

To accelerate development and wide application of energy-efficiency measures, the program:

- Conducts R&D on technologies and concepts for energy-efficiency, working closely with the building industry and with manufacturers of materials, equipment, and appliances
- Promotes energy/money-saving opportunities to both builders and buyers of homes and commercial buildings
- Works with state and local regulatory groups to improve building codes, appliance standards, and guidelines for efficient energy use.

OFFICE OF ENERGY EFFICIENCY
AND RENEWABLE ENERGY

BUILDING TECHNOLOGIES PROGRAM

U.S. DEPARTMENT OF ENERGY

Reducing Energy Use in Buildings

Because 60% of electricity consumption in the United States is used to heat, cool, and operate buildings, potential savings through energy-efficient mechanical systems are enormous. Many advanced energy-saving building technologies are researched and developed at the National Renewable Energy Laboratory in the Thermal Test Facility.

The open-space, high-bay design of the building is flexible and well-suited for state-of-the-art research.

More Information

The following table shows some of the energy-efficient features of the building as designed, compared to a similar, conventional building. R-values and U-values measure how well the insulation or windows transfer heat – the higher the R-value or lower the U-value, the more resistance. Window solar heat gain coefficients (SHGC) measure the amount of solar heat that enters a building through the glass. High SHGCs allow more heat to pass through and are useful for passive solar applications.

Key Energy-Efficiency Features

	Base Case	TTF
Wall insulation	R-value = 11	R-value = 23
Roof insulation	R-value = 19	R-value = 23
Floor insulation		
– Perimeter	R-value = 10	R-value = 10
Windows	Double pane clear	Double pane low-e
– SHGC	0.78	0.68 clerestories
		0.45 view glass
– U-values	0.55	0.45 clerestories
		0.42 view glass

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Top: NREL researcher Paul Torcellini checks the amount of daylight and the accuracy of lighting sensors.

Bottom: In a Thermal Test Facility laboratory, researcher Steve Slayzak inspects a desiccant cooling wheel — an energy-efficient method for conditioning air in humid climates.

Contacts

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