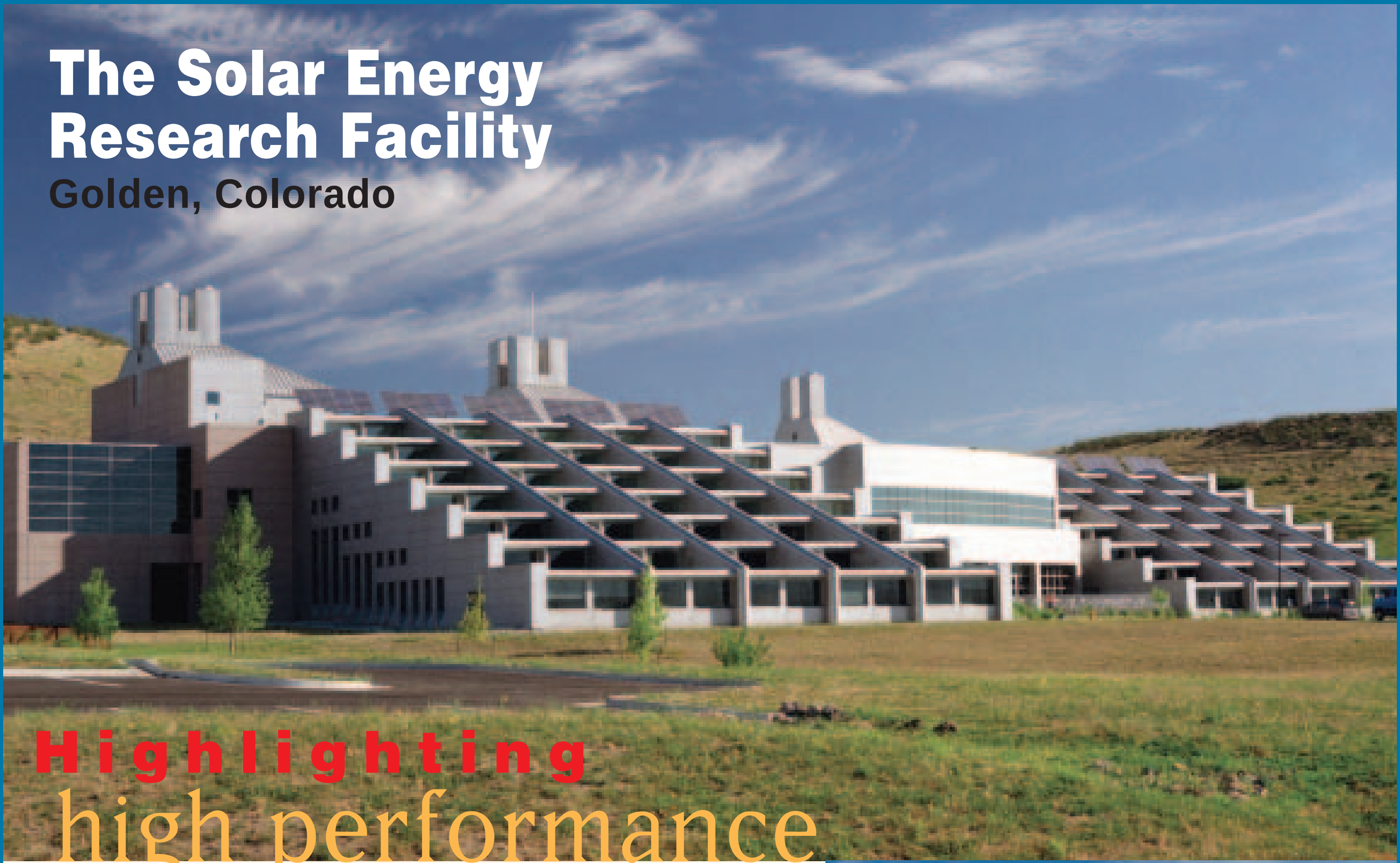
The Solar Energy Research Facility

Golden, Colorado



Highlighting high performance

Laboratory facilities, like the National Renewable Energy Laboratory's Solar Energy Research Facility, are energy intensive. So the main challenge for the design team was to find efficient ways to heat, cool, light, and ventilate to meet the exacting requirements of the laboratory settings while still maintaining comfort and pleasant conditions in the office spaces.

Designers used a whole-building approach — looking at the way the building's site, windows, walls, floors, and electrical and mechanical systems could work together most efficiently. Blending architecture and energy efficiency, designers took advantage of the south-sloping site by situating the offices to the south and partly earth-sheltering the labs to the north. A stair-step configuration for the building allows daylight and heat into the office areas, while the laboratories in the back of the building are in a more controlled environment where tight levels of ventilation, humidity, temperature, and light are critical. A unique mechanical system makes the most of the natural environment and the building's design to efficiently heat and cool the building at an annual utility bill savings of almost $200,000 per year.

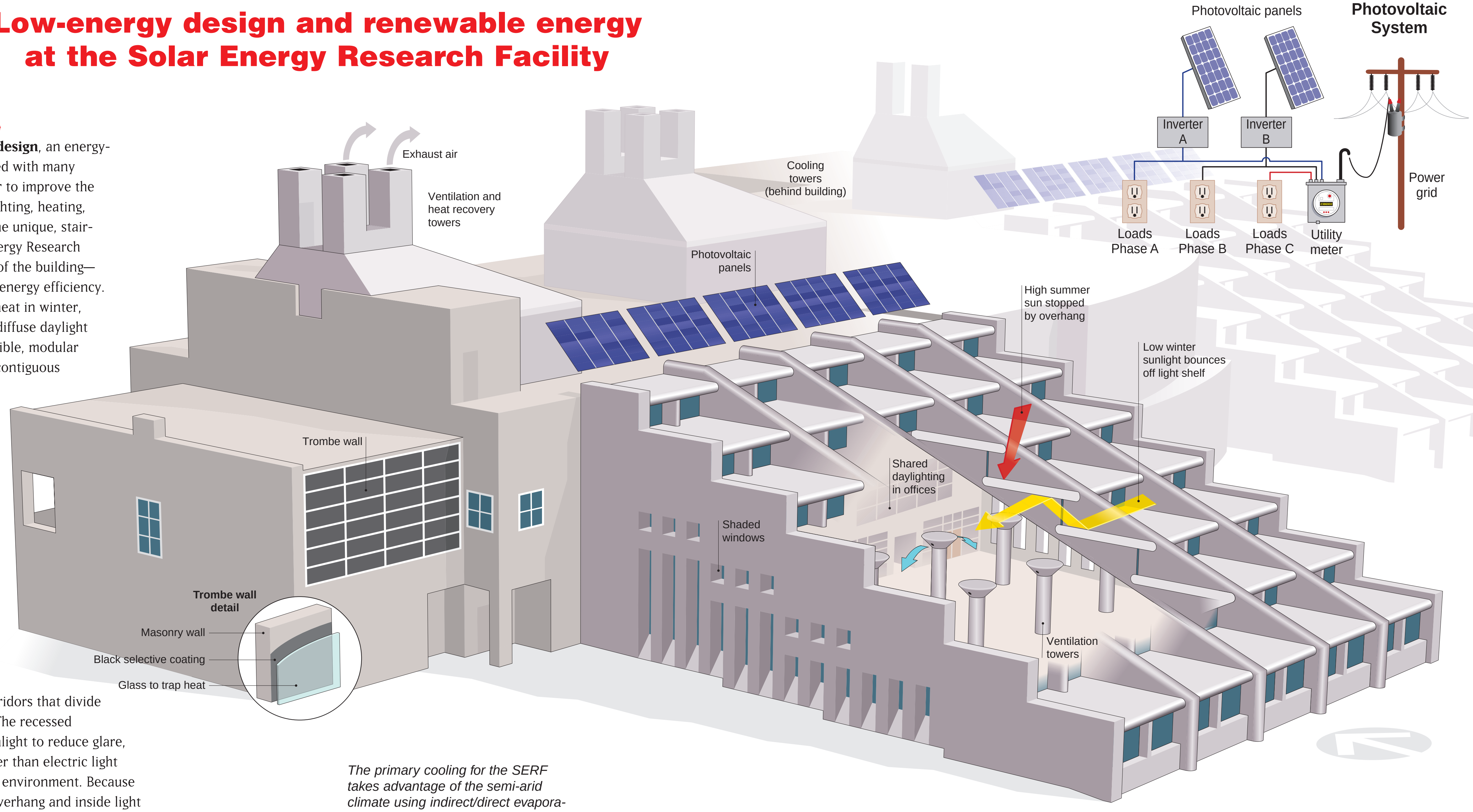
With innovation and dedication to the tenets of renewable energy and energy efficiency, the Solar Energy Research Facility has become not only a laboratory to explore ways to turn the sun's light into electricity and power, but also a building that puts the laboratory's research into action.

The Solar Energy Research Facility's stair-step design provides shade in summer, solar heat in winter, and diffuse daylight throughout the year.

Low-energy design and renewable energy at the Solar Energy Research Facility

Building Envelope

Using **whole-building design**, an energy-efficient building is designed with many features that work together to improve the quality and efficiency of lighting, heating, cooling, and ventilation. The unique, stair-step design of the Solar Energy Research Facility (SERF) is a feature of the building—blending architecture with energy efficiency. The design provides solar heat in winter, shade in the summer, and diffuse daylight throughout the year. A flexible, modular design incorporates three contiguous segments to make good use of sunlight for heating and daylighting while minimizing cooling.



Lighting

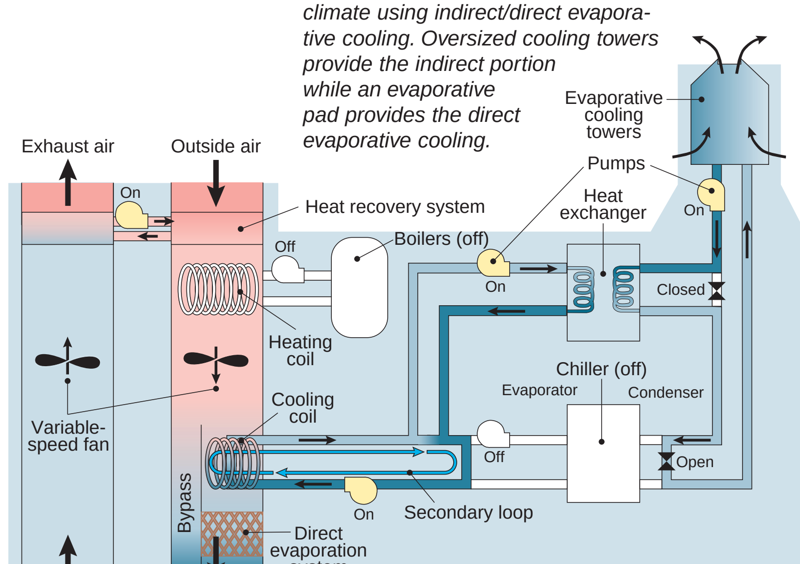
Stepped clerestory windows bring daylight inside to illuminate office areas and brighten the corridors that divide offices from laboratories. The recessed clerestories scatter the sunlight to reduce glare, creating a light that is softer than electric light and resulting in a pleasant environment. Because of the windows' exterior overhang and inside light "shelves," indirect sunlight enters the building to provide quality light year-round.

Sunlight is shared with interior hallways and offices through strategically placed windows and curved alcoves that let light into the space. **Daylighting** minimizes the need for electric lighting, decreases the amount of power used, and reduces cooling costs that would be incurred to manage the heat produced by electric lights.

Very **efficient lights** including T-8, compact fluorescents, and metal halide save an additional $10,000 a year.

Designers saved even more electricity by using **on-demand lighting**, where motion sensors automatically turn lights off when nobody is using them. Lights turn on automatically when someone walks into a laboratory and turn off when the last person leaves.

The primary cooling for the SERF takes advantage of the semi-arid climate using indirect/direct evaporative cooling. Oversized cooling towers provide the indirect portion while an evaporative pad provides the direct evaporative cooling.



Cooling System: Using Evaporative Cooling

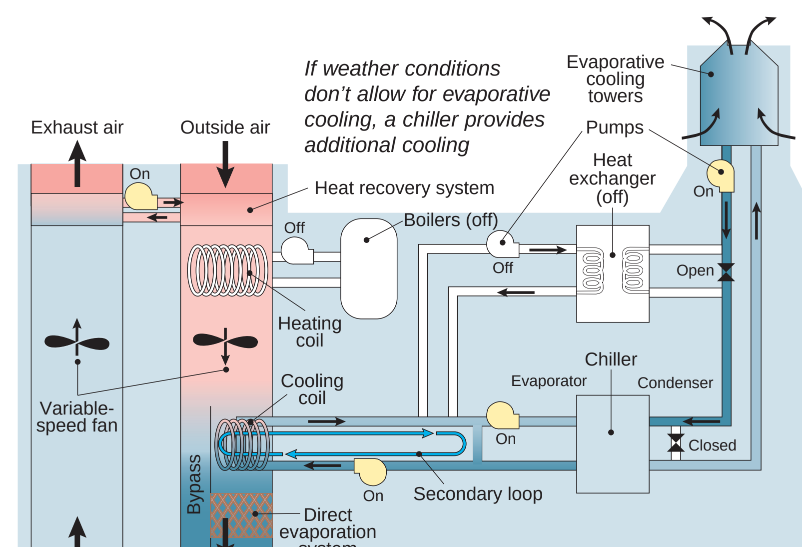
Cooling

In a conventional building, mechanical chillers cool the water that is used to cool the air and equipment. But the SERF uses **indirect evaporative cooling** to help the water-cooling process and save energy.

In addition, the SERF uses **direct evaporative cooling** to lower air temperature and increase humidity. The cool air is distributed throughout the building, limiting the need for conventional cooling systems that consume more energy.

Automatic window shades and overhangs help keep offices cool by shading light and heat during the hottest parts of the day.

If weather conditions don't allow for evaporative cooling, a chiller provides additional cooling



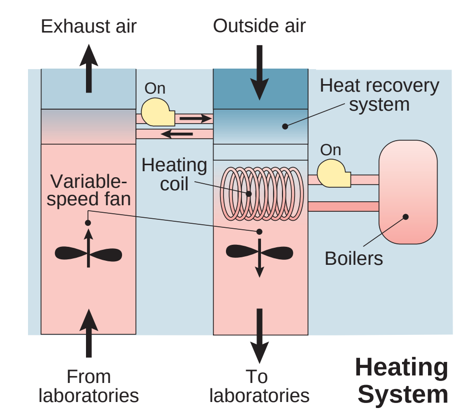
Cooling System: Using Chiller

Photovoltaics

Two 6-kilowatt arrays of photovoltaic panels are installed on south-facing roof areas on the SERF. The photovoltaic system is tied directly to the building's electrical supply. The solar panels are integrated with the building design.

Ventilation

As a safety precaution, the SERF's ventilation system completely exchanges the air in the laboratories as many as 12 times an hour. This requirement causes large heating and cooling loads to condition outside air. Rather than just exhaust the warm air from the building, the SERF's exhaust **heat recovery system** uses a heat exchanger to capture the energy exhausted from the laboratories. This captured energy is used to condition fresh, incoming air. The system displaces about 50% of the energy that would have to be used to heat and cool the incoming air. **Variable-speed fans** carefully maintain building pressure and temperature while saving energy.



Heating System

Heating

To help heat part of the building, the SERF's design includes a **Trombe wall** along the south face of the building. This 16-inch-thick, concrete wall is coated with a dark, heat-absorbing material, and is covered with glass. The coating absorbs heat from the sun. When the massive wall heats up, its radiant energy is transmitted to the inside of the building in winter. The radiative effect provides comfort without heating the environment. A hot water boiler provides heat for the offices and laboratories.

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.

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BUILDING TECHNOLOGIES PROGRAM

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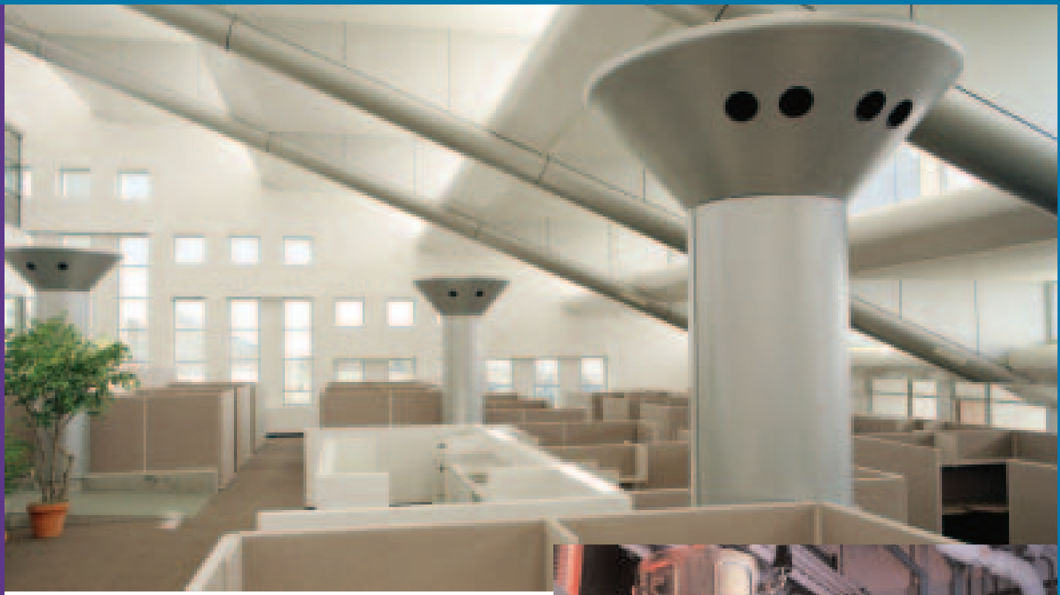

Top: Front office areas are daylit and open for comfort using ventilation towers to circulate heated or cold air. Right: Laboratories in the back of the building have a more controlled environment to meet precise ventilation, temperature, humidity, and lighting needs.

Preparation, talent, and teamwork contribute to high performance. Designing high-performance, energy-saving buildings is no different. Designers use computers to simulate energy use throughout the design process, finding the most energy-efficient design. Whole-building design examines how a building interacts with its systems, activities, and surrounding environment. By optimizing the building's standard components — site, windows, walls, floors, and mechanical/electric systems — building owners can substantially reduce energy use without increasing construction costs.

More Information

The following table shows some of the energy-efficient features of the building.

Key Energy-Efficiency Features

Wall insulation	R-value = 22
Roof insulation	R-value = 35
Windows E&W	U-value 0.31; Solar heat gain coefficient 0.43
Windows other	U-value 0.48; Solar heat gain coefficient 0.57
Daylight	South light shelves, overhangs, photo sensors
Electric lights	T-8, compact fluorescents, and metal halide, occupancy and daylight sensors
Fans and pumps	High efficiency variable frequency drives
Heat recovery for vent air	50% to 60% energy recovered
Cooling	Direct and indirect evaporative, chiller backup
Heating	Direct gain, Trombe wall, gas fired hot water
Photovoltaics	12 kilowatts

Contacts

U.S. Department of Energy

Energy Efficiency and Renewable Energy Clearinghouse (EREC)
1-800-DOE-3732
www.eren.doe.gov

Building Technologies Program
www.highperformancebuildings.gov

National Renewable Energy Laboratory
Center for Buildings and Thermal Systems
www.nrel.gov/buildings/highperformance

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