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The U.S. Department of Energy’s (DOE) Federal Energy Management Program (FEMP) facilitates the Federal Government’s implementation of sound, cost-effective energy management and investment practices to enhance the nation’s energy security and environmental stewardship.

The transpired solar collector on the National Renewable Energy Laboratory’s Waste Handling Facility in Golden, Colorado.

TRANSPIRED SOLAR COLLECTOR AT NREL’S WASTE HANDLING FACILITY USES SOLAR ENERGY TO HEAT VENTILATION AIR

The transpired solar collector (TSC) installed on the National Renewable Energy Laboratory’s (NREL) Waste Handling Facility (WHF) in Golden, Colorado, is one of the earliest applications of this technology and the first use of the technology at a Federal facility. Since its installation in 1990, the system has provided solar pre-heated ventilation air to contribute to meeting the high heat ventilation air requirements of this facility. The TSC is an efficient alternative for pre-heating ventilation air and can improve indoor air quality in facilities with large ventilation air needs.

The NREL WHF was an ideal candidate for the TSC technology. The facility is a 1,300 square foot (ft²) chemical waste storage building that requires a ventilation rate of 3,000 cubic feet per meter (CFM) to maintain safe indoor conditions. Because open flames are prohibited in the building due to the

danger of combustion, ventilation air is heated with electricity instead of gas. The WHF has a large, south-facing wall area with only one penetration. Finally, the addition of the TSC was an acceptable architectural change to the building.

The 300 ft² transpired collector saves about 14,310 kilowatt hours (kWh) annually (25.7% of the energy required to heat the facility’s ventilation air). In addition, the system annually avoids 14.9 tons of carbon dioxide (CO₂) and 52 pounds of nitrogen oxide (NO_x) emissions. With a 2005 installation cost of \$20/ft² and a utility cost of \$0.054/kWh, NREL saves \$726 a year in electric bills. This investment results in a nine-year simple payback. Over the 25-year study period, the life-cycle savings are expected to equal 356,527 kWh. Over its life cycle, the system will provide energy to the site at an equivalent energy rate of \$0.02/kWh of heat.

How the Technology Works

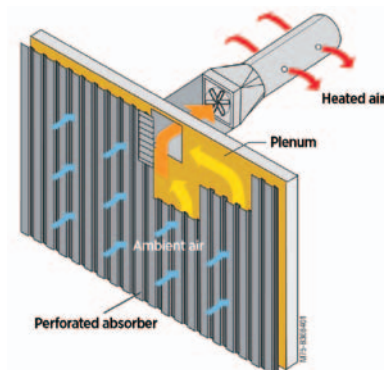
The transpired collector is a dark-colored, perforated metal wall installed on a south-facing side of a building, creating an approximately 6 in.

Highlights

System Size	300 ft ² transpired solar collector
Energy Production	About 125 Btu/hr/ft ² (400 W/m ²) of heat delivery under ideal conditions (full sun)
Installation Date	1990
Motivation	Provide solar-heated ventilation air to offset some of the heating with conventional electric resistance heaters
Annual Savings	14,310 kWh (49 million Btu/yr) or about 26% of the energy required to heat the facility’s ventilation air

System Details

Components	Black, 300 ft ² corrugated aluminum transpired solar collector with a porosity of 2%; bypass damper; two-speed 3000 CFM vane axial supply fan; electric duct heater; thermostat controller
Storage	None
Loads	188 million Btu/year (55,038 kWh/year) winter average to heat 1,300 ft ² Waste Handling Facility
Parameter Measured	Air temperature leaving the collector, ambient air temperature, incident solar energy, wind speed, and air mass flow rate delivered to the building
Expected Life	25 years was the original life expectancy; however, NREL anticipates a much longer life
Supplier	ATAS International; product name: Inspire www.atas.com



Transpired Solar Collector

A fan draws air through perforations in the transpired solar collector absorber surface then delivers the air to the building interior.

(15 cm) gap between it and the building's structural wall. The size of the wall varies depending on heating and airflow requirements and climate. Recommended size is 0.25 ft² of TSC per CFM of ventilation air (4 CFM/ft²). In many applications, the TSC will cover the maximum south-facing area available. However, oversizing is not cost effective. The dark-colored wall acts as a large solar collector that converts solar radiation to heat. Fans associated with the building's ventilation system draw outside air through the transpired collector's perforations, and the thermal energy collected by the wall is transferred to the air passing through the holes. The fans then distribute the heated air into the building. A bypass damper activated on warm days and during the summer ensures that solar-heated ventilation air is provided only when heating is needed.

The technology is truly a building-integrated solar system because the system depends on the space between the perforated absorber area and the exterior wall of the building to collect and move heated air. A large, south-facing wall area is required for a TSC installation ($\pm 45^\circ$ of south is often acceptable). This wall must have minimal penetrations and must not be designed to be an explosion blowout wall. The TSC absorber comes in four standard colors (all dark) and many other colors with associated minimum order and lead times, providing architectural flexibility. However, designers should be aware that the overall efficiency of the system decreases for lighter colors. Collectors can be added on to an existing building or designed as part of a new one. These systems can pay for themselves even faster in new construction because they offset part of the costs for the building's façade.

By preheating ventilation air with solar energy, the technology removes a substantial load from a building's conventional heating system, saving energy and money. At night the system can further assist in heating by

recapturing heat lost through the building wall behind the collector. The transpired collector system can also help meet demands for improved indoor air quality, because better ventilation is an integral part of the system.

Performance

NREL's unglazed TSC has been in continuous operation for 15 years. Initial detailed measurements indicated that the average system efficiency was 63%. The collector was installed in front of an existing concrete wall.

In general, each square foot of transpired collector will raise the temperature of 4 CFM of air by as much as 40°F, delivering approximately 240,000 British thermal units (Btu) annually per square foot of installed collector; but as shown in the map, savings are heavily dependent on sunlight and the need for heat. Typical annual efficiency for these systems is between 60% and 65%.

NREL has found many advantages with TSC. These include:

- The system requires minimal maintenance, with no liquids and no moving parts other than the ventilation system fans. The collector system should still be inspected periodically for physical damage and for proper operation of controls.
- The collector system was easily added to the building as a retrofit.
- The system is an effective way to capture renewable energy benefits for this ventilation air preheat application.

Project Partners and Funding Sources

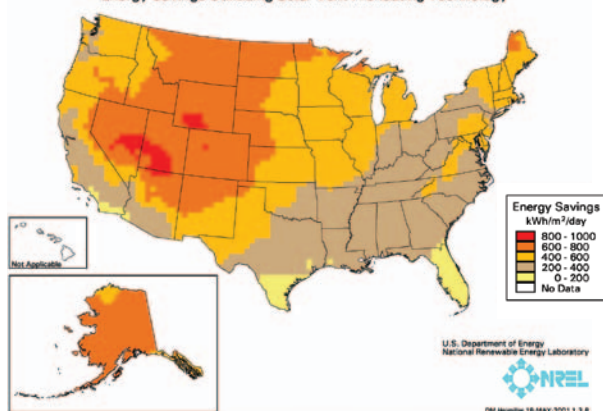
The WHF system was designed and installed by Conserval Systems, Inc. and NREL. NREL researchers instrumented the system and monitored its performance.

Cost Breakdown (2005 US\$)

System cost (includes collector equipment and labor for design and field supervision)	\$6,000
Equivalent energy rate ¹	5.58/million Btu (\$0.02/kWh)
Annual O&M cost	1% of the system costs per year (\$45/year)
Net present value	\$5,163
Savings to investment ratio	1.86
Adjusted internal rate of return	5.59%

¹ The equivalent energy rate is the present value of the initial cost and recurring O&M costs divided by the present value of life-cycle energy savings, calculated using building life-cycle cost version 5.3-05 for a 25-year study period.

Energy Savings Utilizing Solar Vent Preheating Technology



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Printed with a renewable-source ink on
paper containing at least 50% wastepaper,
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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.

DOE/GO-102010-3096 • September 2010

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Federal Energy Management Program