

Solar Technologies Program

Melissa Lapsa, Program Manager
ORNL Office of Energy Efficiency and
Renewable Energy

*DOE Industrial Assessment Centers (IAC)
Student Meeting — Oak Ridge, Tennessee*

February 1, 2007

ORNL's Solar Technologies Program continues to provide science and technology innovations

While making positive contributions to communities



Hybrid solar lighting:

- ✓ Optical fibers, controls, and system integration
- ✓ GPS tracking and real-time monitoring
- ✓ Technology can be used for concentrating solar power to enhance PV efficiency



Photovoltaics:

- ✓ Increasing energy efficiency of PV materials
- ✓ Unique laser & materials processing facility
- ✓ Collaborating with Georgia Tech (DOE Center of Excellence)

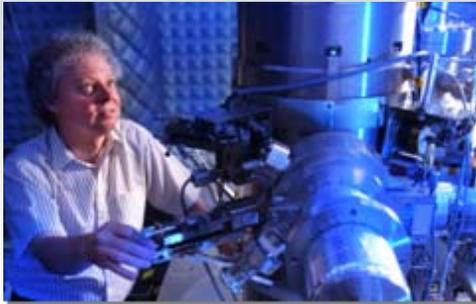


Power electronics:

- ✓ Advanced R&D on integrated electronics
- ✓ PV application for integrating electronics
- ✓ Increases modularity, decreases cost and system shut-downs

Solar User Centers at ORNL

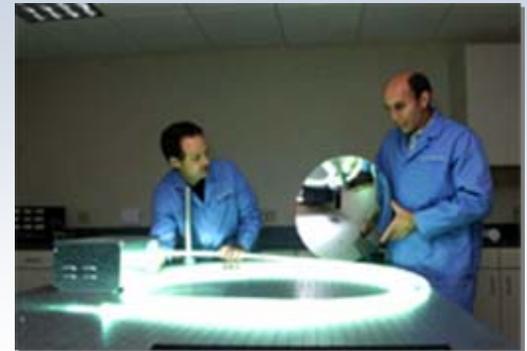
High Temperature
Materials Laboratory



Material Processing
Group



Photonics Laboratory



Nanoscale Science &
Technology Lab



Solar Technologies
Laboratory



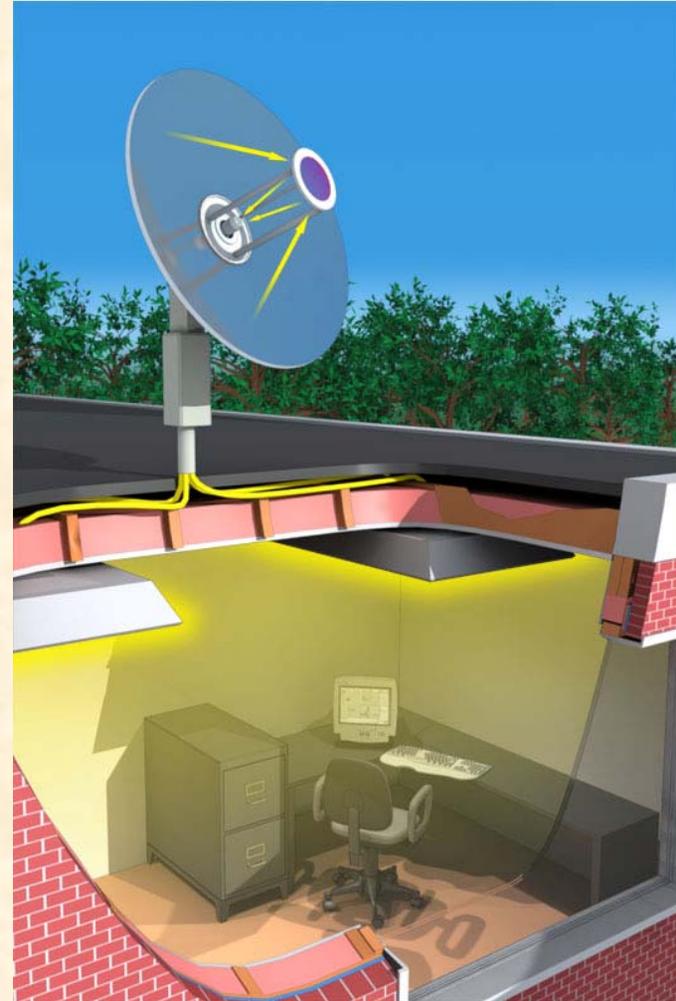
Photovoltaic
Characterization Center



COMING SOON!!

Hybrid Solar Lighting (HSL) is an Important Alternative Energy Source

- **Artificial lighting is the largest component of electricity use in commercial U.S. buildings**
- **Most commercial lighting occurs during peak daylight hours**
- **HSL collects sunlight and distributes it, via plastic optical fibers, to “hybrid” luminaires which mix solar and electric light**
- **Photo-sensors adjust the electric lamps to compensate for changes in sunlight intensity**



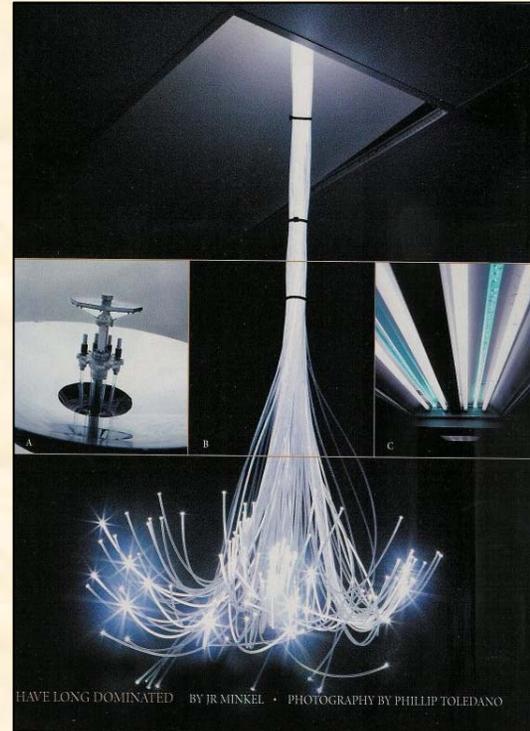
Kris Holland, Mafic Studios, Inc., www.maficstudios.com

Components of the HSL System

1. **Solar Collector – Concentrates and collects the sunlight into an optical fiber bundle.**
2. **Plastic Fiber Optic Bundle – Transmits lighting into building interior.**
3. **Hybrid Luminaires – Disperse light into rooms.**



1. Solar Collector



2. Optical Fibers



3. Hybrid Luminaire

Solar Collector

- The solar collector concentrates sunlight and distributes it via plastic optical fibers, to “hybrid” luminaires containing both solar and electric lamps



Figure. Solar Collector

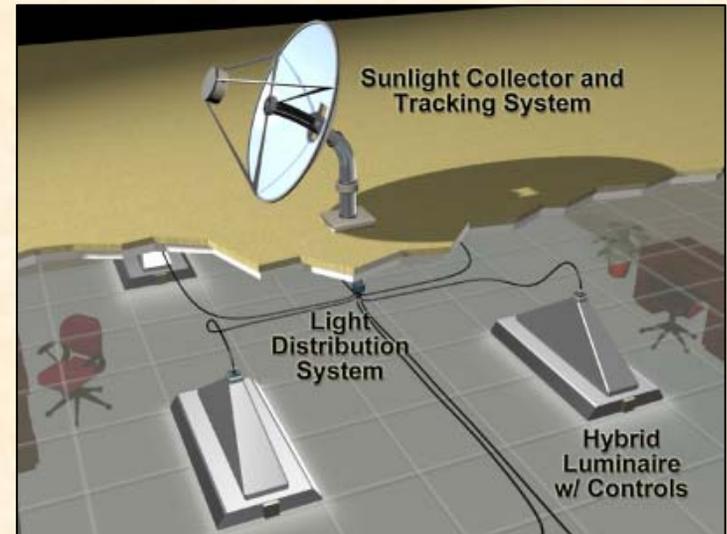


Figure. Graphical Representation of HSL3000

- Photosensors maintain a constant illumination level by controlling the intensity of electric lamps
- Developed with the help of the HSL partnership

The Optical Fibers

- **Commercially available plastic optical fibers**
- **Optical bundle consists of 127 smaller optical fibers**



Figure. Testing on Optical Fiber Bundle



- **Only solar concentrating technology to use plastic optical fibers**

The Hybrid Luminaires

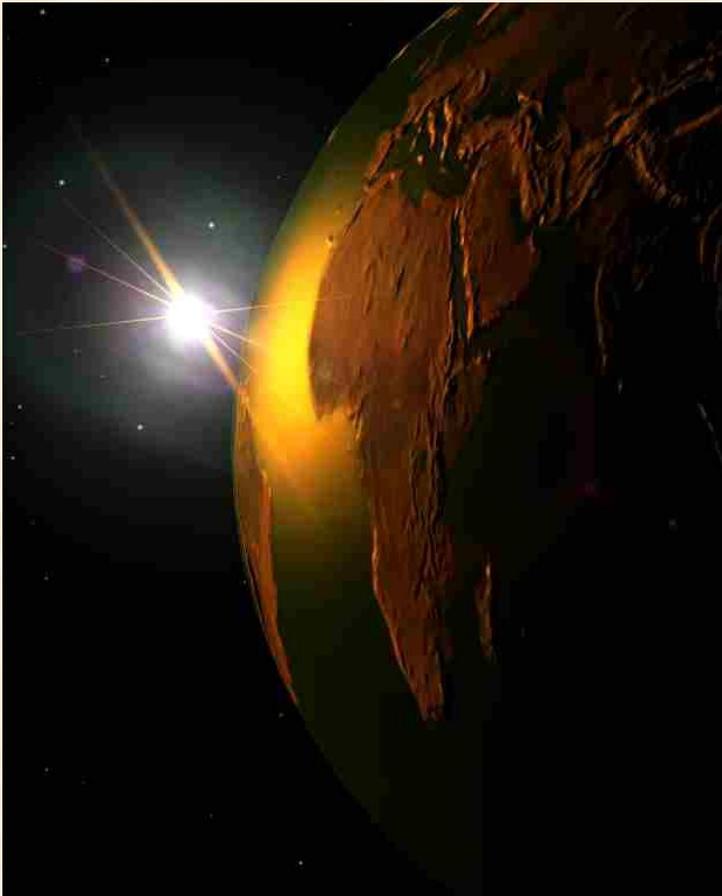


Fluorescent Bulb

Sunlight Diffusing Rod



ORNL Built on the Best Available Sun Tracking Technology

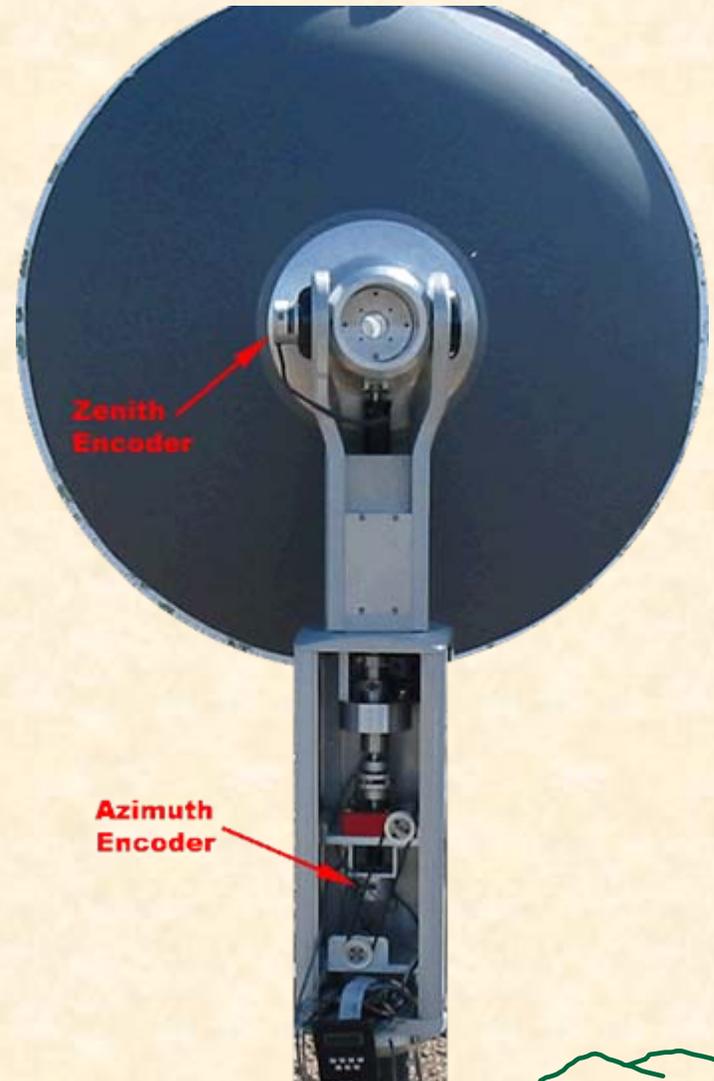


- **Building on Sandia's research, ORNL developed an enhanced controller for HSL**
- **With the advancement of technology over the last 15 years we were able to improve performance:**
 - Improved precision due to faster calculation of equations
 - Variable-speed, solid-state motor control
 - Reduce 4 circuit boards into 1
 - GPS inputs for position and Coordinated Universal Time (UTC)
 - Windows user interface
 - Low cost

HSL Requires Following the Changing Path of the Sun

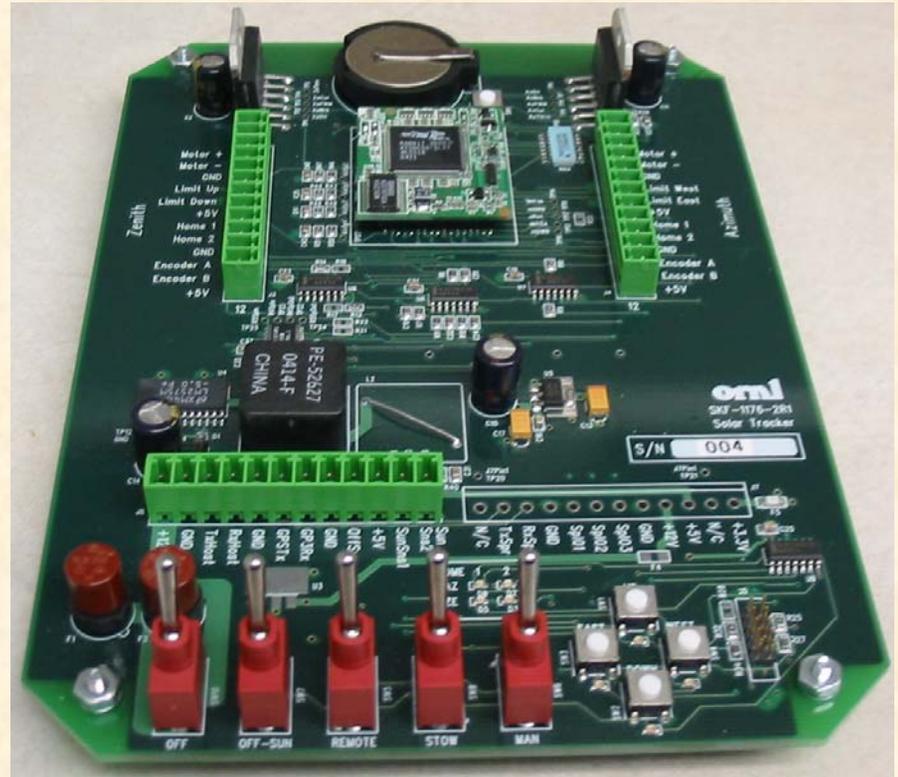
The control system must be capable of the following:

- 0.1° tracking accuracy required by the two-mirror geometry to keep the focused beam on the 1.5” fiber bundle
- Calculate the sun’s path based on latitude, longitude and time of day
- Track accurately throughout the year
- Compact hardware
- Low cost



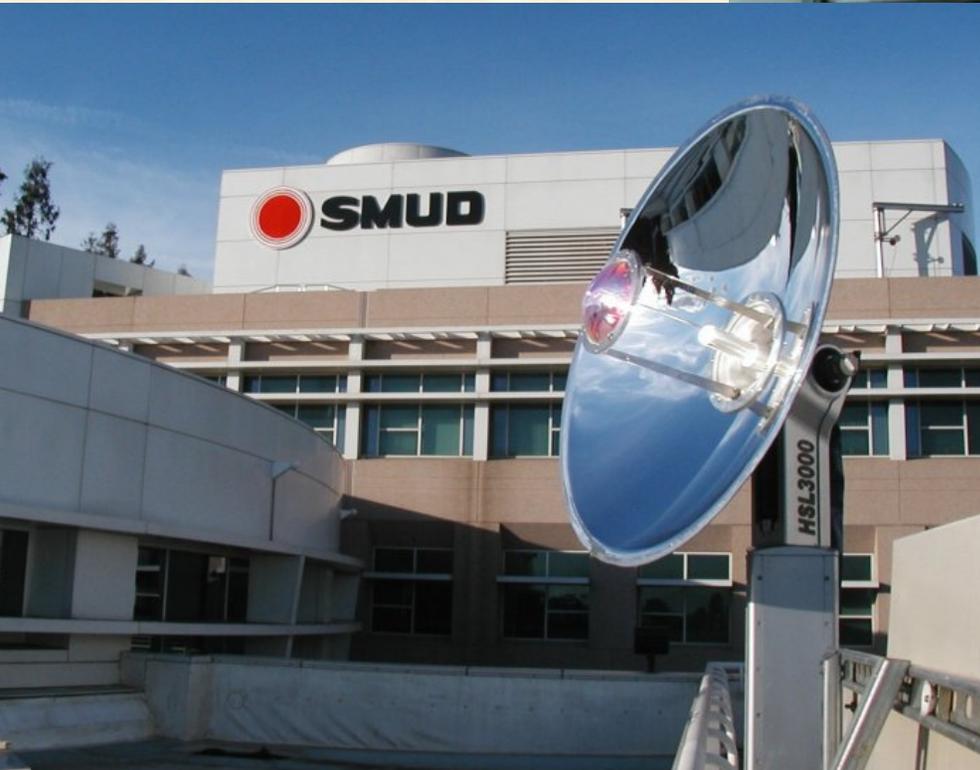
The Sun Tracker has been Successfully Tested with the HSL Collector

- **Calculates Sun position every second**
- **Field upgradeable**
- **Compact 7.25" x 5.25" package**
 - Power Supply
 - Jog controls to manually move the collector
 - GPS interface
 - Motor Drives
 - Indicator LEDs



Full Spectrum Lighting Is Superior in Quality

Occupants can compare the difference between direct sunlight and electric light in the same fixture and the same room.



The First Market for HSL Has Been Identified

Buildings:

- located in the sunbelt and Hawaii
- in geographic areas with time-of-day electricity prices and summertime peak shaving needs
- lit all day, everyday
- in applications where lighting quality is important
- where less-efficient electric lamps are used



Energy Savings Benefits

- The HSL technology targets commercial buildings in the sunbelt regions of the U.S. where cooling is a significant source of energy use.
- HSL lighting can be considered a high efficiency light source

	Incandescent	Fluorescent	HSL
Typical Energy Eff. (lumens/watt)	≈15	≈ 75	≈ 200

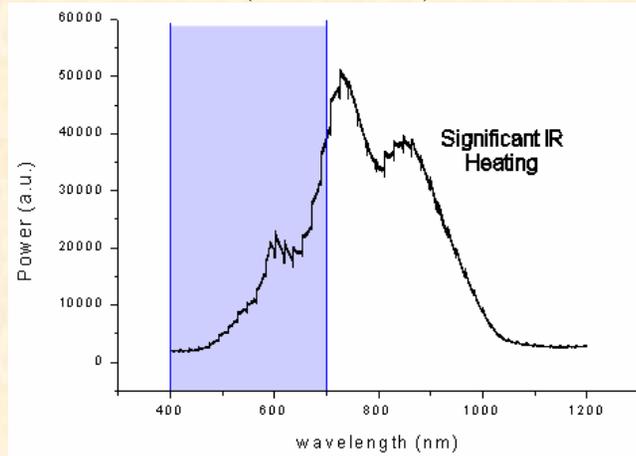
For incandescent applications, one HSL unit will typically save 6,000 kWh in energy savings (associated with lighting) and 2,000 kWh of air cooling per year.

For incandescent applications, one HSL unit displaces 8,000 kWh per year.

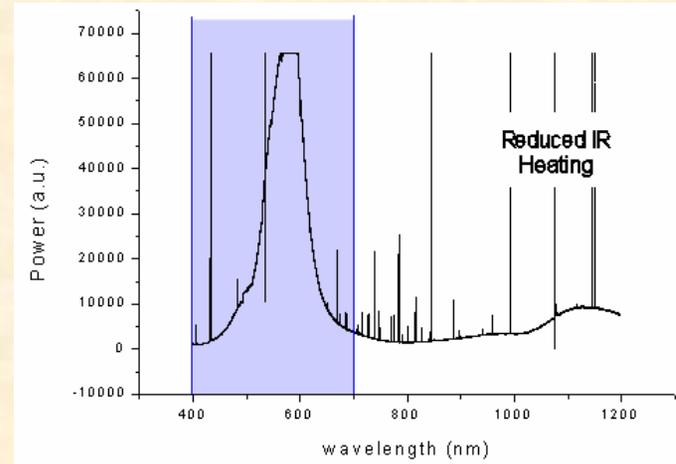
- At \$0.10 per kWh, can save \$8,000 over 10 years
- Operation and maintenance savings could add another \$2,500
- For floor-spaces of 100,000 to 200,000 sq. ft., this translates into \$1.1M to \$2.1M of energy cost savings

Spectrum of HSL Daylighting

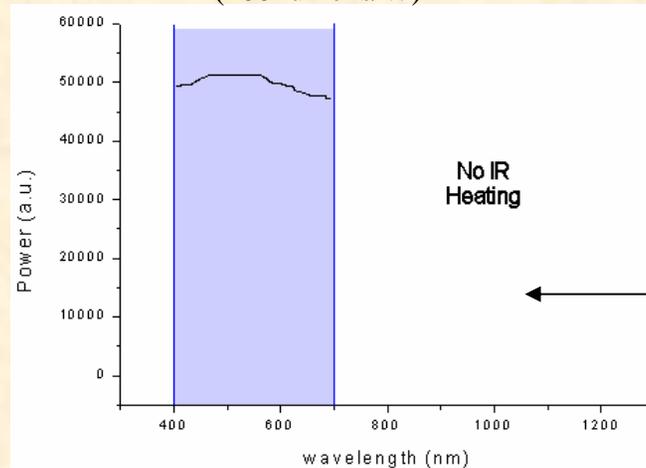
Incandescents
(15 lumens/W)



Fluorescents
(75 lumens/W)



HSL Sunlight
(200 lumens/W)

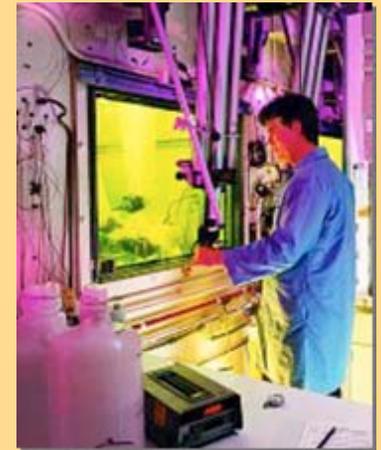
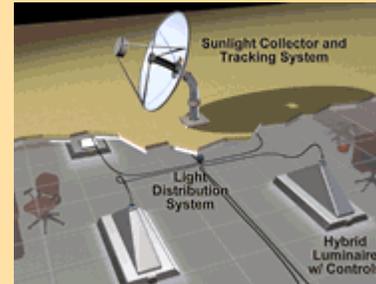
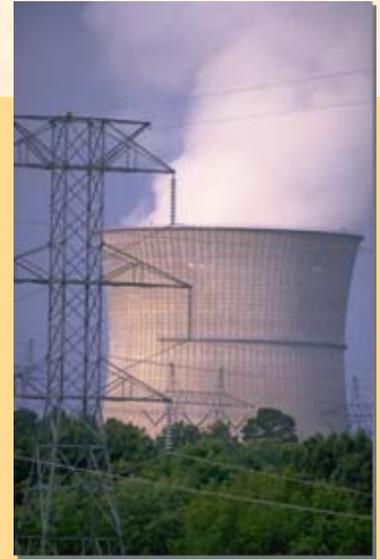


 Visible Portion of Spectrum

No IR Component Means Minimal Heating!

Benefits

- Provides another green option for business customers
- Expends near-zero energy
- Uses direct sunlight
- Easy to install/maintain
- Reduced waste heat





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Bringing a little sunshine into our lives

Hybrid solar lighting may be next big thing

By Michael Schirber
Updated: 8:50 p.m. ET March 24, 2005

With hybrid cars making waves in the auto industry, hybrid solar lighting might be the next big splash - combining the benefits of sunlight with the consistency of traditional electric lighting.

Hybrid solar lighting (HSL) is different than traditional solar power, which converts sunlight into electricity. HSL captures sunlight and channels it directly into a room, using optical fibers.

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Electric lighting



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Gas-powered vehicles

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Century



Hybrid vehicles

Technical Progress and Cost Reductions Have Been Steady

2002 - 2003



Parts Cost – \$50K
Weight – 400 lbs.
Installation – 12 days

2004 - 2005



Parts Cost – \$20K
Weight – 250 lbs.
Installation – 6 days

2006



Parts Cost – \$15K
Weight – 100 lbs.
Installation – 2 days

HSL was the highest rated lab-led project at the 2002 - 2003 SHL Peer Review
"best collaboration.....biggest bang for the programmatic buck"

Awards

Oak Ridge National Laboratory researchers were recognized by ***R&D Magazine* 2006 R&D 100 Awards** for the HSL system. The awards are presented annually by *R&D Magazine* in recognition of the year's most significant technological innovations

HSL received a 2006 "Excellence in Technology Award" from the nine-state Southeast Region of the **Federal Laboratory Consortium for Technology Transfer** and the 2007 National FLC Award.



"I congratulate the researchers who have won these awards, which highlight the power and promise of DOE's investments in science and technology ... through the efforts of dedicated and innovative scientists and engineers at our national laboratories, DOE is helping to enhance our nation's energy, economic and national security."

Secretary of Energy Samuel W. Bodman

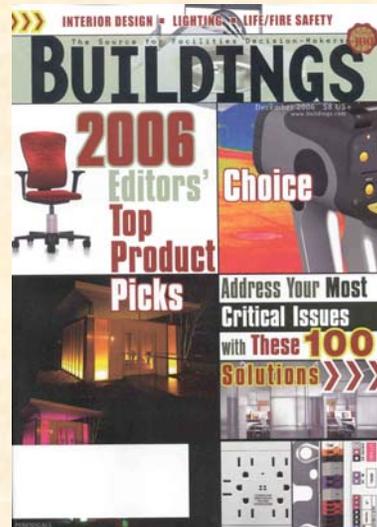


Currently Installed with Nationwide HSL Field Trial Program "Sunlight Inside Initiative"

- ✓ American Museum of Science and Energy (TN)
- ✓ Aveda Corporate Office (MN)
- ✓ Braden's Furniture (TN)
- ✓ Naval Exchange (HI)
- ✓ Oak Ridge National Laboratory (TN)
- ✓ Pacific Northwest National Laboratory (WA)
- ✓ Sacramento Municipal Utility District (CA)
- ✓ San Diego State University (CA)
- ✓ Siskin Children's Center (TN)
- ✓ Staples (NY)
- ✓ Wal-Mart (TX)



Location of 2006/2007 Beta-Sites



National Press
Buildings Magazine
Discovery Channel
Canada
Electrical Line
Magazine
Forbes
MSNBC
Popular Science
Scientific American
Solar Reception

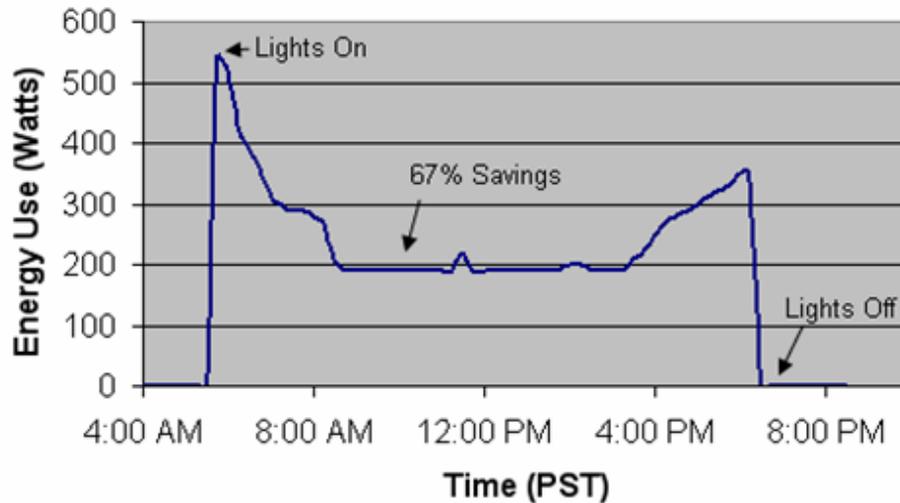
Installation Process

- **Beta-Site Inspection**
- **Phase I**
 - a. Mounting of post
 - b. Installation of luminaires
 - c. Mounting & wiring of solar collector
 - d. Routing/harnessing of fibers
 - e. Polishing of fibers
 - f. Wiring of daylight harvesting system
 - g. Mounting & wiring of remote monitoring components
- **Phase II**
 - a. Configuring of remote monitoring system
 - b. Calibration of solar tracker
 - c. Optimization of optical collection efficiency
 - d. Commissioning of daylight harvesting system



Energy Data

Energy Use at SDSU
(For 06/16/06)



Video: HSL Light Quality Demonstration



Video: System tracking the sun

Application to LEED Projects

HSL can help to secure several key LEED credits including:

- **Innovation in design**
- **Daylighting credits**
- **Controllability of systems**
- **Light pollution reduction**
- **Renewable energy credits**
- **Measurement and verification**



Video. Collector in Motion



Figure. Two small optical fibers produce as much light as a 60 Watt incandescent bulb.

Coming Soon



Southeast Solar Summit at ORNL

October 2007



www.ornl.gov/solar