Bringing a little sunshine into our lives

Hybrid Solar Lighting

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Solution

The ability to affordably collect and concentrate sunlight is a fundamental requirement of today's emerging solar energy solutions. Whether the collected sunlight is being used to generate distributed power from new high-efficiency concentrated photovoltaic (CPV) cells, grow microorganisms for biofuel production or CO_2sequestration, or used directly to deliver the highest-quality interior building lighting, a need for cost-effective and reliable collection of sunlight remains. Sunlight Direct has developed a concentrator platform that:

- Can accurately track the Sun with minimal maintenance,
- Concentrates sunlight with durable, low-cost optics,
- Can be used with a variety of solar technologies, and
- Is scalable for installation on commercial rooftops and in wide-ranging environments.

What is Hybrid Sola Lighting?

Hybrid Solar Lighting (HSL) systems combine the use of solar with artificial light for interior illumination by channeling sunlight through fiber optic cable bundles to provide solar light into rooms without windows or skylights, and by supplementing this natural light with artificial typically LED light as required.

The bundles are led from exterior/rooftop optical light collectors through small openings or cable ducts and carry the light to where it is needed. The optical fibers end in hybrid luminaires where the sunlight is joined with electric light, either on demand or to automatically maintain a constant light level even as the available sunlight decreases.

Introduction

Hybrid solar lighting provides an exciting new means of reducing energy consumption while also delivering significant benefits associated with natural lighting in commercial buildings.

The hybrid lighting technology was originally developed for fluorescent lighting applications but recently has been enhanced to work with incandescent accent-lighting sources, such as the parabolic aluminized reflector (PAR) lamps commonly used in retail spaces. Commercial building owners (specifically retailers) use the lowefficiency PAR lamps because of their desirable optical properties and positive impact on sales. Yet the use of this inefficient lighting results in some retailers' spending 55–70% of their energy budgets on lighting and lighting-related energy costs.

Hybrid lighting has the potential to significantly reduce energy consumption while also maintaining or exceeding lighting quality requirements. Implementation of the hybrid solar lighting technology across the United States would represent significant energy savings to the country and would provide building managers with a near-term, energy-efficient, higher quality, economically viable alternative to incandescent lamps.

Artificial lighting accounts for almost a quarter of the energy consumed in commercial buildings and 10–20% of energy consumed by industry. Solar lighting cans significantly reduce artificial lighting requirements and energy costs in many commercial and industrial buildings and in institutional facilities such as schools, libraries, and hospitals.

Benefits

- Improved lighting quality (Fig.1)
- Reduced energy usage
- Reduced building cooling load
- Reduced CO_2 emissions
- Non-energy benefits to building owner/ manager such as improved employee

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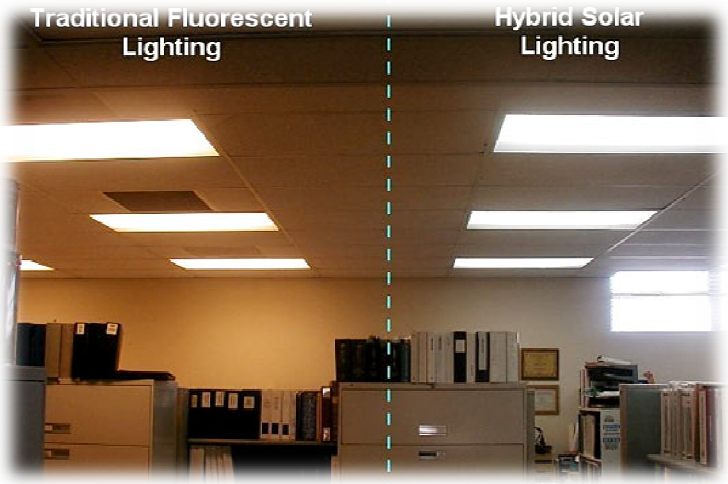


Fig. 1

Principles of Operation

The hybrid solar lighting system uses a roof-mounted solar collector (Fig. 2) to concentrate visible sunlight into a bundle of plastic optical fibers. The optical fibers penetrate the roof and distribute the sunlight to multiple “hybrid” luminaires within the building (Fig. 3). The hybrid luminaires blend the natural light with artificial lightto maintain a constant level of room lighting. One collector powers about eight fluorescent hybrid light fixtures, which can illuminate about 1000 square feet.

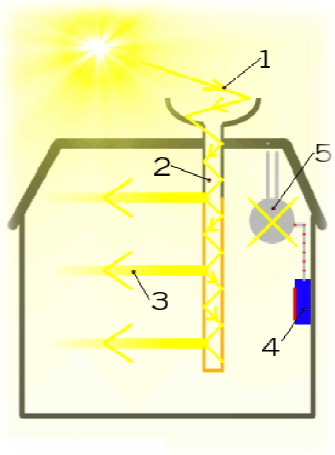
Fig. 2

Fig. 3

When sunlight is plentiful, the fiber optics in the luminaires provides all or most of the light needed in an area. During times of little or no sunlight, a sensor controls the intensity of the artificial lamps to maintain a desired illumination level. Unlike conventional electric lamps, the natural light produces little to no waste heat, having an efficacy of 200 lumens/Watt (l/W), and is cool to the touch. This is becausethe system’s solar collector removes the infrared (IR) light from the sunlight—the part of the spectrum that generates much of the heat in conventional bulbs. Because the optical fibers lose light as their length increases, it makes sense right now to use hybrid solar lighting in top-story or single-story spaces.The current optimal optical fiber length is 50 feet or less.

The hybrid solar lighting technology can separate and use different portions of sunlight for various applications. Thus, visible light can be used directly for lighting applications while IR light can be used to produce electricity or generate heat for hot water or space heating. The optimal use of these wavelengths is the focus of continued studies and development efforts.

How it work:



1) A parabolic dish on the roof collects sunlight and feeds it into a fiber-optic cable.
2) The light bounces down the fiber-optic cable, reflecting off the walls inside.
3) A light fitting inside your home allows the light to escape and illuminate your room.
4) A photoelectric light sensor monitors the light level.
5) If it gets too dark, the photoelectric sensor switches on an ordinary electric light (and switches off again automatically when daylight levels increase again).

Future approaches

- Multifunctional—compatible with various electric lamps, light fixtures, hot water heaters, photovoltaicand usable for various applications.
- Reconfigurable—easily modified as space needs change
- Seamlessly integrated—connected to standard power sources to ensure that disruptions in service do not occur on cloudy days or at night
- Architecturally compatible— designed to eliminate architectural design hassles and maintenance problems limiting the use of solar power
- Affordable

The new hybrid solar lighting strategy is the logical pathway for achieving these goals because the technology uses small, flexible optical fibers to deliver the sunlight directly to where it is needed. Hybrid solar lighting is applicable to many building types and can be used for a variety of lighting and heating applications. As a result, the potential near-term energy savings of hybrid solar lighting could be significant.

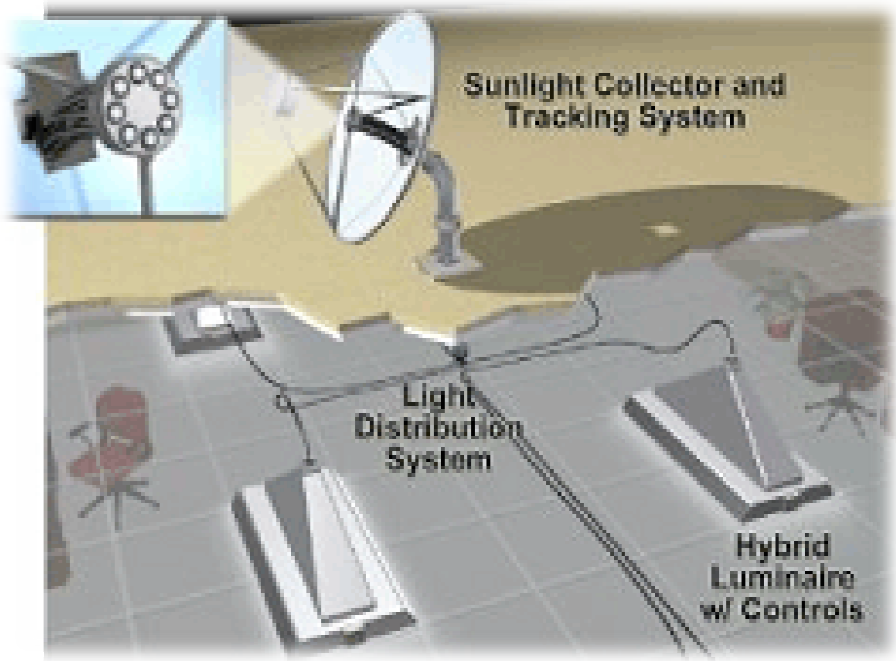


Fig. 4. In a solar lighting and power system, the roof-mounted concentrators collect sunlight and distribute it through the optical fibers to hybrid lighting fixtures in the building's interior.

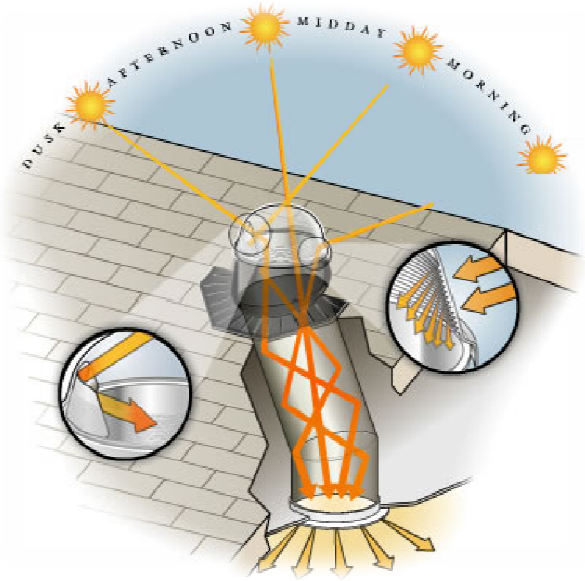


Fig. 5

Advantages of Hybrid Solar Lighting

Electric lighting is the greatest consumer of electricity in buildings (Fig. 6), and the generation of this electricity by conventional power plants is the building sector's most significant cause of air pollution. Hybrid lighting can help conserve electricity in proportion to the amount of sunlight available.

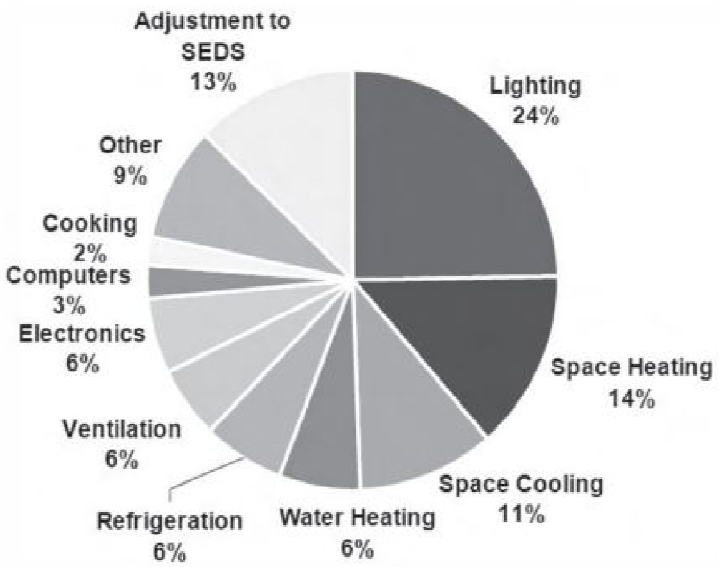


Fig. 6

Full-spectrum solar energy systems provide a new and realistic opportunity for wide-ranging energy, environmental, and economic benefits. Because hybrid solar lighting has no infrared component, it can be considered a high-efficiency light source. Other advantages of hybrid solar lighting are:

- Roof penetrations are small and minimal, reducing the potential for leaks.
- IR and UV energy in sunlight is separated from the visible light, rather than being transmitted into buildings. Heating, ventilation, and air-conditioning (HVAC) loads are thus reduced by 5 to 10%, compared to buildings having conventional electric lighting systems.
- Hybrid solar lighting systems are readily adaptable to large buildings with multiple floors, relatively low ceiling heights, and interior walls, though currently fiberoptic output is optimized on the top two floors. A single system can distribute enough sunlight to co-illuminate several rooms in a typical office building.
- Large portions of valuable plenum space (the area between the roof and drop ceiling) are not needed.

- Hybrid solar lighting can be used both for direct ambient lighting (as in skylights) and for indirect lighting, task lighting, and accent lighting.
- In retrofit applications, hybrid solar lighting is easily incorporated into existing building designs, and the optical fibers can be rerouted to different locations as lighting needs change. By intentionally misaligning the solar collector from the sun, occupants can even dim distributed sunlight.

Cost Consideration

Timeline for price reductions in hybrid solar lighting (in US)

Cost element	2006	2007 (Product launch)	2012
System Cost	$20,000	$16,000	$3,000
Installation cost	$4,000	$3,000	$1,000

Efficiency

Hybrid solar lighting technology could replace less efficiency conventional electric lamps.

Type of Lighting	Typical energy efficiency (approx. lm/W)
Incandescent	15
Fluorescent	75
Hybrid Solar	200