Clean and Green Technology

'Hybrid Solar Lighting'

***Abstract*— We demonstrate an innovative application and investigative results of fiber optic day lighting systems as a means of bringing direct sunlight into a building while maintaining the controllability and ease of application usually reserved for electric lighting by collecting natural light and channeling it through optical fibers to luminaries within the space. In contrast to conventional methods of lighting as well as solar energy, this project focuses on reducing losses due to radiation, transmission and conversion to achieve increased efficiency and provide a profitable solution to the energy crisis the world is facing today.**

This project manifests the system performance which is accurately described by employing and analysis based on fiber and lens optics and interior illumination. Excellent efficiency is achieved which is only slightly reduced due to either transmission losses, although negligible, or a cloudy day, by employing the concept of hybridizing solar source along with electrical source for optimum interior lighting. This is implemented by using high quality Fresnel lenses (for concentrating and collecting sunlight), optical fibers (for transmission) and luminaries (for lighting).

Large scale commercial buildings such as textile showrooms, malls, hospitals, museums, schools, colleges are the major nerve centers of applicability of this project. For employing simple yet innovative principle, elementary mechanical concepts were executed with the sole purpose of curbing pollution, to dwindle green house effect and tackle energy crises. The high efficiency ingenious applicability achieved in this project brings it one step closer to commercialization.

***Keywords*— luminaries; transmission; lens optics; Fresnel lenses; green house effect**

I. INTRODUCTION (*HEADING 1*)

In the current climate of increasing energy prices and rising environmental awareness, energy conservation and resource preservation issues are the topics of governmental policy discussions for every nation on the planet.

The aim of the project was to introduce Hybrid Solar Lighting (HSL) technology to significantly reduce energy consumption associated with artificial lighting in commercial buildings.

II. PRINCIPLE

In the schematic sketch shown in Figure 1, the simple principle of the system is displayed. First, sunlight is collected by solar panels outdoors. The sunlight is then brought into the building through the optical cables. Indoors, the sunlight flows out through luminaries. This technology is also called fiber optic solar lighting. This allows for the electric lights to be turned off during the day, which results in lower electricity bills and less energy demand.

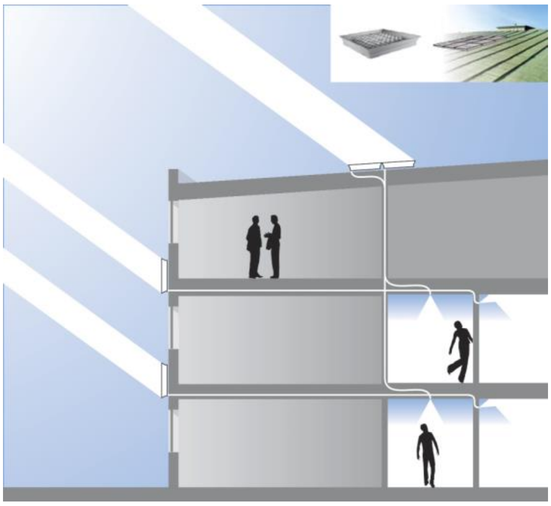

Figure 1: Principle of HSL

III. MATERIALS REQUIRED

A. Solar Collector

The solar collectors are 1sq.m modules as shown in figure 2. In the collector, 64 Fresnel lenses move uniformly around their axis, tracking and concentrating sunlight. This movement is achieved with three motors (consuming under 2 watts). The tracking is controlled by photo sensors that feeds the internal micro computer with light level data. The configuration ensures that sunlight is efficiently concentrated on optical fibers placed at focal point of each lens.

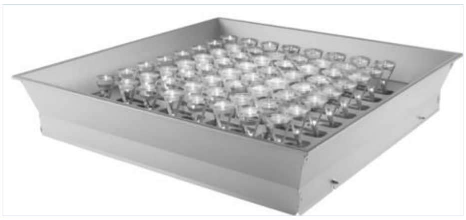

Figure 2: Solar Collector

B. Fresnel Lens

As shown in Figure 3, each lens is held in place by the V- shaped metal frame which is secured to a pivot point at its base. This mounting allows each lens to pivot in a cone around the frame's base. The circular lenses are mounted in a grid across the collector's face each surrounded by enough space to accommodate its conical movement in response to change in position of sun. the supports are interconnected with a grid of struts linked to actuator motors controlled by a photo sensitive tracking system which continuously points the array of lenses in the direction of maximum solar intensity. Articulation of each lens allows for tilt angles of 60 degrees in any direction, forming a 120 degrees active cone capable of capturing direct sunlight for a period of eight hours. Each lens is mounted above an optical fiber with the exposed end at the focal point.

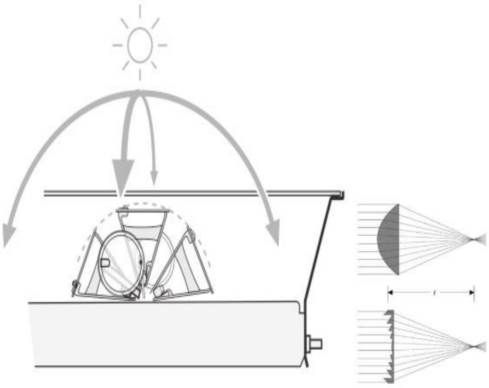

Figure 3: Fresnel Lens

C. Optical Cables

Four optical cables are required for a panel. These are 6 mm in diameter, a density of 30 gm/m and can be up to 20m long. The bending radius can be as small as 50 mm, making it possible to transmit light at tight corners. As shown in Figure 4, the optical cables are sheathed with a fire resistant material called Megolon. Within the cable, the light is transmitted through High Performance Plastic Optical fiber made of PMMA (polymethylmethacrylate).

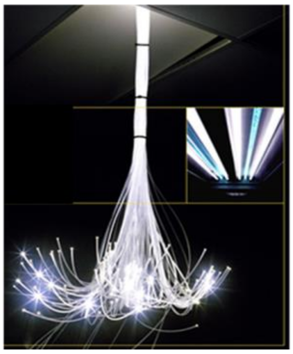

Figure 4: Optical Cables

IV. ENERGY AUDIT IN VARIOUS COMMERCIAL BUILDINGS

A survey was conducted to find out the energy savings in various commercial buildings associated with lighting and also air conditioning such as , schools, textile showrooms, malls, hospitals etc.

Data on electrical energy consumption was collected from the above mentioned buildings with the help of State Electricity Board. The findings given in Figure 5.

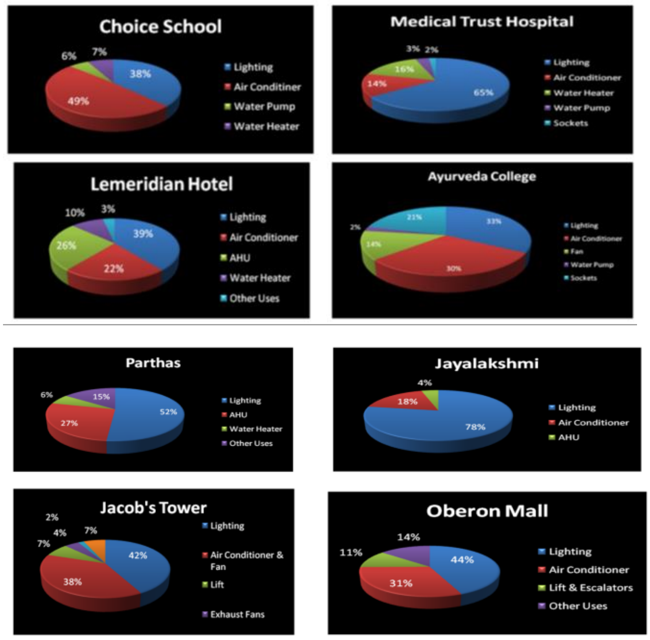

Figure 5: Energy Consumption by Commercial Buildings

V. PAY BACK PERIOD

Calculation for Jayalakshmi Textile Showroom

- Energy consumed for Lighting = 131.44 kW x 330 hrs = 43375.2units
- Energy consumed for Air Conditioner= 30.4 kW x 330 hrs =10032 units
- Total energy for Lighting + Air conditioner = 53107.2 units
- Total cost of energy due to lighting and air-conditioner per month= 38841.6 X Rs 3.7 per unit = Rs 196496.64
- For 1 year, the cost of energy due to lighting and air-conditioner = Rs 2357959.68/-
- The built area of Jayalakshmi Textile show room = 100000 sq ft
- 1 unit of HSL can provide lighting for 1000 sq.ft area
- 1 unit of HSL costs Rs. 3,36,000/-
- Therefore number of HSL units required = 100000 / 1000 = 100 HSL Units
- Total Cost of HSL units = 100 x 336000 = Rs.33600000/-
- Payback Period for Jayalakshmi Textile Showroom = 33600000/ 2357959.68**= 14.2 Years**
- Government of India Subsidy for Solar systems subject to approval of MNRE is 30 %. Then the pay back period will be considerably reduced.
- After subsidy the cost of 100 units will be = 33600000 x 0.7 = Rs.23520000/-

After subsidy the Payback period = 23520000 / 2371279.68 **= 9.97 Years**

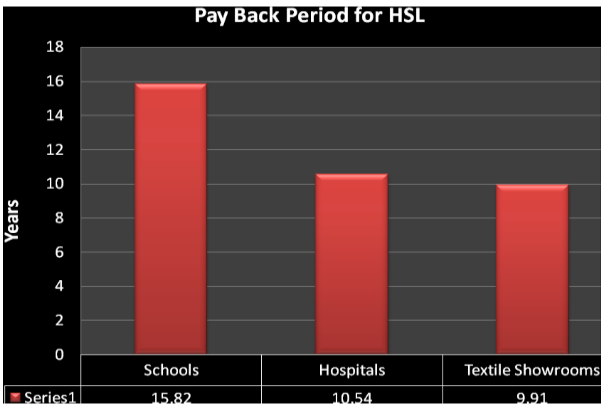

Figure 6: Pay back period for HSL

VI. RESULTS AND DISCUSSION

- It is observed that in commercial buildings, 50 % of electrical energy is used for artificial lighting alone. It produces heat which increases the heat load on the air conditioning system. Air conditioner consumes about 30 % of electrical energy. HSL Luminaires generates no heat and hence energy utilized for air-conditioner can also be saved.
- As electrical energy is mainly produced from the Thermal power plants, it leads to depletion of non-renewable energy sources and increases emission of CO_2. There comes the need for the ultimate requirement for sunlight harvesting. Hence implementing Hybrid Solar Lighting is essential to save electrical energy in a broad scale and also its implementation will have zero Greenhouse gas emission.

From the survey conducted, the consumption of electrical energy units per year for lighting in Schools is 176 MWh, Hospitals is 61.9 MWh, Textile showroom 378.5 MWh. If the HSL technology is implemented, this electrical energy can be saved.

VII. FURTHER SCOPE OF THE PROJECT

A. UV: Air Pollution still a long way off

One of its primary uses is an air purifier, as these wavelengths are able to kill molds and other airborne pathogens. This is a future application, depending on the development of the specific UV-resistant plastic optical fibers able to transmit “deep UV wavelengths” in sufficient strength to have the desired lethal effect on pathogens. At present such fibers are still too expensive for the general market.

B. Agriculture: Direct lighting in Greenhouses

Future pharmaceutical research will involve growing plants that produce specific proteins. Being genetically modified, patented and valued as corporate secrets, they are grown in secure installations that are often windowless. Fiber optic light is the obvious cost saving solution for providing optimum light balance for growth under such conditions. Plants may utilize a wider range of the sun’s energy, depending on species and in each case the grower should be able to decide whether to bring in the UV range and how much of the IR to include or exclude.

C. UV in Animal Husbandry

Another area yet to be developed is natural lighting in factory farms. Most of these high density barns have no windows. As living creatures, domestic mammals and birds also benefit from balanced lighting. The UV light kills bacteria, reducing the risk of infections and loss of valuable livestock.

From the investigation, energy consumption in commercial buildings (mainly in Hospitals) is around 40% for Water heaters. The Infra-red rays from the sunlight can be used for heating water by using a glass surface and an Infra Red

Thermal Photo-Voltaic cell (IR-TPV) by which we can save energy.