Exciting Urban Spaces with Building Integrated Heliostats

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Building integrated heliostats are a relatively new feature of the city skyline. They offer many potential benefits, and with creativity can make our urban spaces interesting. There is much scope for innovation in design, as well as engineering of heliostat solar lighting solutions that integrate with our daily activities. This presentation discusses some exciting options available for the future of building integrated heliostats.

Form and Function

One of the key attractions of the building integrated heliostat system is its customisability. After the core functional components of the heliostat have been catered for, there is much scope for creativity in their implementation. A heliostat needs a simple mechanism for enabling it to move and follow the sun. It needs some frames and supports, and a reflector. Things like the shape of the reflector, the angle of the post, the colour of the casings etc can be adapted as needed. The heliostat can be placed on virtually any surface that has solar exposure, then redirect that sun to somewhere else where it is needed more.

The most recent building integrated heliostat is Rhodes Central in Sydney [1]. It includes an array of 49 heliostats on the building roof which reflect sunlight into a nearby park, via an array of reflectors (secondary reflectors) elevated on a crown structure above the building. The crown structure that supports the reflectors is a dominant feature of the building architecture, and is visible across much of the city. The heliostats are curved in order to focus their reflected image at the secondary reflectors. The light then diverges again by the time it reaches the park, providing an array of light features (highlights) around the park. This design reduces the secondary reflector mirror area needed to redirect the light into the park. Each heliostat is assigned its own secondary reflector, so the design allows full control over the placement of images in the park (figure 1).

The Rhodes Central heliostat also includes a night-glow feature, here secondary reflector panels may be set to glow in colour. This is possible due to inclusion of a transparent polycarbonate panel in front of the secondary mirror, for the dual purpose of UV light filtering as well as the night-glow display. The polycarbonate panel is edge lit with LEDs. This light is generally captured inside the panel due to total internal reflection, but eventually light scattering effects causes it to exit on one side or the other. Any light that exits on the top side of the panel is reflected back down by the mirror and eventually leaves the panel to produce the effect shown in figure 1.

Figure 1. Rhodes Central heliostat features an array of sun trackers on the building roof, and an array of secondary reflectors on a crown structre above. The heliostat directs light into a nearby park during the day, and has an integrated night-glow feature[1].

Options for future building integrated heliostats

There are many ways that the light from heliostats can be utilised. One way uses optically active particles as part of a secondary reflector device (figure 2). The sunlight from the heliostat first passes through a semi-transparent panel which incorporates fluorescent light absorbers. Part of the spectrum of light reflected from the heliostat is absorbed and re-emitted by the particles [2]. At some angles, the isotropic emission of from the particles will produce an interesting glow visible to the outside observer. Other rays will be totally internally reflected and could be harvested with a photovoltaic (PV) cell at the boundary (ie. a luminescent solar concentrator); or reflected back into the panel to glow in a similar way as demonstrated at Rhodes Central.

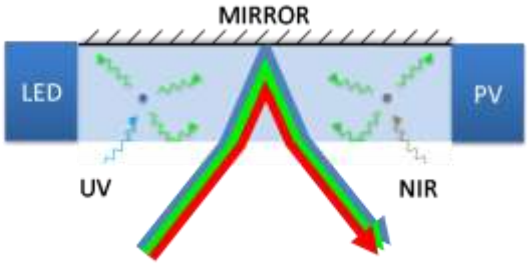

Figure 2. Luminsecent concentrator and light glow system applied as a secondary reflector for a building integrated heliostat system. The device absorbs UV and Infrared light while reflecting visible light.

Alternatively, a band reject (BR) filter could be used in conjunction with a photovoltaic cell to create an interesting effect (figure 3). A PV cell chosen to absorb infrared radiation (say Germanium) would also enable the device to simultaneously reflect visible light to a nearby office or greenspace, while also generating electricity. The cost of the specialised filter and solar panel may be rationalised by using focusing optics from the heliostats. This way, only a small area of PV panel and filter is necessary to transfer a large amount of radiation to target zones of interest. A similar effect is possible in transmission mode without the BR filter, but the geometry of the optics may be a limitation.

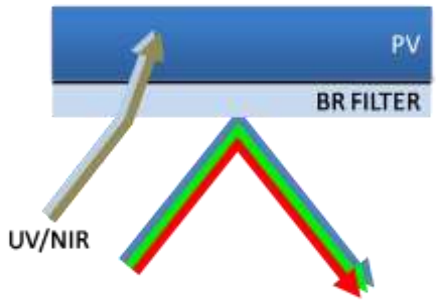

Figure 3. Band reject filter designed to reflect visible radiation (looks like a mirror), while also generating electricity with a PV cell.

Energy extraction and spectrum splitting can also be achieved with fluids (figure 4). Water has relatively high absorptivity in the infrared, so fluid depths in the 10s of millimetres would be sufficient to extract heat from the infrared and UV portion of the spectrum while allowing visible light to pass on to a target of interest. The fluid would also extract energy that otherwise would account as a mirror reflectivity loss.

Introduction of nanoparticles into the fluid would enable the device to switch from 'reflection mode' to 'dispersion mode', creating a bright screen, rather than reflecting light elsewhere[3]. An application of this would be to exhibit different behaviour for different times of day; in the morning, the system reflects light to a shaded area to the east; then in the afternoon when that space is naturally lit, the system acts as a diffuser, enhancing lighting to the west.

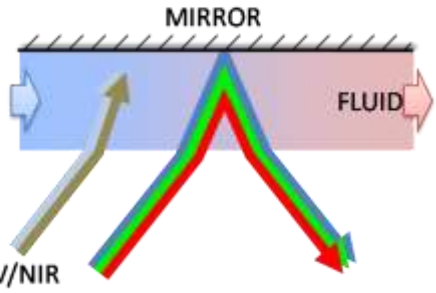

Figure 4. A fluid contained within a cavity on the front side of a mirror is used for thermal energy extraction. Addition of particles to the fluid can make the devie act as a switchable diffuser.

Active and responsive lighting systems

Heliostats are usually designed to respond to their local environment, adjusting their operation accordingly. In rain, they orient to enhance reflector cleaning, and in wind they move to a brace position. There is scope to further develop this, with changed behaviour responding to inputs like soundscapes, people movements or directly interactive interfaces. Solar reflection locations can be adjusted according to a range of inputs. Note that heliostat movements are generally slow due to the need for precision in following the sun.

A system with thermally triggered events could be driven by energy from a heliostat. Imagine a large lava lamp (Mathmos), where the heliostat is the source of heat that makes the blobs rise and fall? Or perhaps a bimetallic sculpture that bends and warps with variable heat distributions arriving from the heliostat? Natural variations in the solar conditions create variability in the thermal output of the heliostat and in doing so 'give life' to the thermally active parts of the system. Highly concentrated sunlight from heliostats can also be used for dramatic effects, such as vaporising water jets in mid air.

Figure 4. 'Lava lamp' by Mathmos

The building integrated heliostat concept is an invitation for creative thinking, and prompts a range of interesting scientific and engineering innovations. Solar lighting offers many opportunities for cross-disciplinary collaboration, with scope to make a visible and meaningful impact on our living spaces.

References

[1] Rhodes Central is a Billbergia development. Photos provided by Heliosystems Pty Ltd (2021)
[2] C. Yang, W. Sheng, M. Moemeni, M. Bates, C.K. Herrera, B. Borhan, R.R. Lunt, "Ultraviolet and Near-Infrared Dual-Band Selective-Harvesting Transparent Luminescent Solar Concentrators", Advanced Energy Materials, Volume 11, Issue 12, Artiicle 2003581.
[3] Dengwei Jing, Dongxing Song, "Optical properties of nanofluids considering particle size distribution: Experimental and theoretical investigations", Renewable and Sustainable Energy Reviews, Volume 78, 2017, Pages 452-465,