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# LD+A

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## Sci-fi Gets Real

CONCEPTS COME ALIVE AT BAR BASQUE

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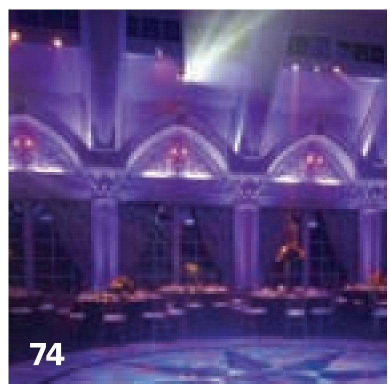


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Sketch: Syd Mead Inc.; Photo: Philip Koether Architects.

# Core Concepts

## Core sunlighting is a practical, natural alternative for interior illumination deep within a building

BY LUÍS FERNANDES AND MICHELE MOSSMAN

A substantial, well-recognized challenge exists in many buildings: how to illuminate central spaces using as little electrical energy as possible. An obvious solution: use available sunlight instead of electric light.

The key is to determine how best to use daylight to illuminate areas deep within a building. A number of architects and building designers advocate eliminating the dark core entirely using narrow floor plates, high ceilings and high fenestration ratios, so that daylight penetrates throughout. With careful design to minimize glare, this solution has the potential to create pleasant spaces. But the idea does not address the massive stock of existing large-floor-plate buildings, or new buildings that require a large floor plate to optimally execute a desired purpose. Narrow floor plates also can be expensive because the construction cost per unit area of floor space is significantly increased.

Here, we discuss a fundamentally different approach to the problem: illuminating a building's core with piped sunlight. This is not a new idea, but thanks to the availability of new optical materials and designs, a theoretical possibility has transformed into a practical and affordable alternative.

Unlike other solar technologies, core sunlighting involves capturing sunlight at the building envelope, concentrating it, transporting it and regulating its release deep within the building at useful indoor lighting levels, typically only 1 percent of outdoor illumination (**Figure 1**). Significant electrical energy savings can be realized if the system incorporates automated electric lighting controls that substantially dim or completely turn off the electric lights.

Core sunlighting systems have the potential to deliver illumination with the benefits of high-quality electric lighting while also providing the advantages of daylight, including excellent color rendering and substantial energy savings. A further benefit is that windows can be optimized to prevent glare and provide a view rather than illumination, with the overhead lighting synchronized with the outdoor lighting, giving

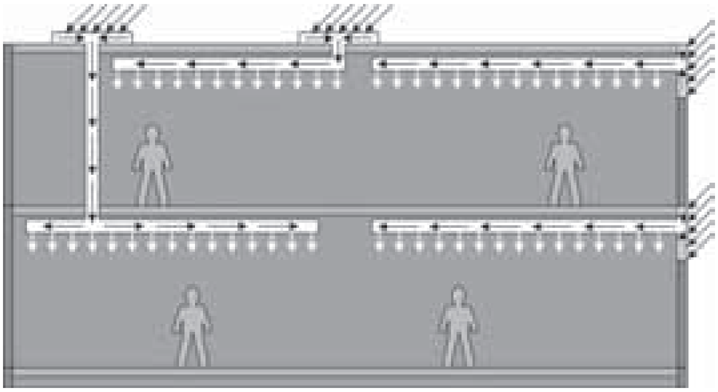

**Figure 1. Sunlight is collected on the rooftop or façade and piped inside for lighting.**

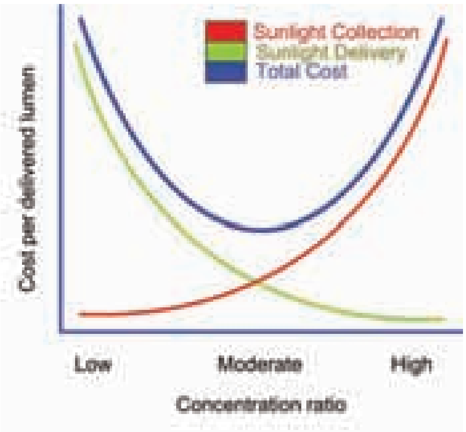


**Figure 2. Optimal system cost depends on choice of sunlight collection and delivery approaches.**

occupants a natural and intuitive sense of connection with the exterior environment.

These benefits, however, will not become widely available until core sunlighting is both cost effective and seamlessly integrated within construction techniques. For this reason, we are part of an ongoing inter-university research collaboration, funded by parties in Canada and California, aimed at achieving mainstream availability by 2030. The core of the partnership is formed by the University of California, Davis; University of California, Merced; University of British Columbia; and Ryerson University in Toronto, and has been complemented with a broad range of participants, including major electrical utilities in Canada and California, national laboratories, and a number of industry professionals and manufacturers.

## TWO DRIVERS: EFFICIENCY AND COST

As with most solar technologies, a key issue is the net capital cost of the system. In this regard, it is important to remember that the dominant capital investment in any building is the structure itself, which means that space inside the building has a very real capital cost per cubic ft. Consequently, any energy-saving system in a building has an effective additional capital cost burden proportional to its volume. This fact makes it economically essential to concentrate sunlight before piping it into the building because the cost of capital of the space required to guide unconcentrated sunlight would be higher than the savings from reduced electrical use. (We should emphasize that this need for concentration does not apply to daylighting at the periphery of a building, using windows, skylights and tubular skylights. Such daylighting methods already are practical and are completely compatible with core sunlighting systems, together forming a natural lighting system for the whole building.)

But just how inexpensive must a core sunlighting system be for the building industry to accept it? Typical electric lighting loads today are an estimated 1 watt per sq ft. If a core sunlighting system turns off this load 40 percent of the average 2,000 workday hours each year, a savings of about 0.8 kWh per sq ft per year results. Typical

**Core sunlighting involves capturing sunlight at the building envelope, concentrating it, transporting it and regulating its release deep within the building at useful indoor lighting levels**

electricity costs currently range roughly between $0.10 and $0.30 per kWh, so the annual savings will be somewhere between $0.08 to $0.24 per sq ft per year. To attain payback within 10 years, core sunlighting must not cost more than $0.80 to $2.40 per sq ft. The exact value will vary, depending on sunlight availability and other factors such as peak load electrical pricing. Despite other potential economic benefits such as protection from energy price escalation, cooling load reduction and increased occupant productivity, this calculation is sobering: It suggests that successful core sunlighting will require optimized, cost-effective materials and volume manufacturing, without significantly adding to the cost of any other building components.

Determining the total system cost by depending on the methods of capturing and distributing the sunlight is a design optimization problem. In one extreme, sunlight is concentrated very little and the collection apparatus is comparatively inexpensive (it could consist of little more than an expanse of glazing), but the subsequent delivery of the light requires high floor-to-floor spacing, which adds considerably to the cost of the building. At the opposite extreme, the sunlight is highly concentrated by more expensive optical components and is directed into comparatively inexpensive small light guides. The optimum design may be a compromise that minimizes total system cost with an intermediate level of concentration (**Figure 2**). Naturally, a variety of design parameters undoubtedly will find optimal application, depending on specific applications.

It may be helpful to loosely classify core sunlighting systems based on the location of sunlight capture and degree of concentration, as depicted in **Figure 3**.

It could be argued that core sunlighting systems in the R2 and F2 categories correspond to the minimum total cost that was shown in Figure 3. However, as mentioned above, systems in the other categories may be no less viable, depending on application and specific system characteristics. Much of what has been learned by studying F2 systems, as described below, is applicable to the other categories.

## TWO CASE STUDIES

Two demonstration projects (academic buildings in British Columbia, Canada) funded largely by the Canadian government, are being conducted to evaluate the performance of some systems of the F2 type (Whitehead, 2010). These systems collect and concentrate sunlight along the façade adjacent the plenum space, below each floor on the wall that has the most sun exposure (**Figure 4**).

Optical components within the enclosure direct sunlight through small windows in the building wall and into dual-function light guides, which distribute the sunlight and provide electric lighting to maintain adequate indoor light levels when enough sunlight is not available. The hollow light guides are inexpensive and highly efficient because of newly developed polymeric reflective films whose absorption is less than 1 percent per reflection. The system provides illumination through the space exceeding the typical standards of ~500 lux for office spaces, using sunlight when available. A preliminary verification undertaken by the electrical utility BC Hydro indicates that performance matches predictions.

## MISSION 2030

New approaches to energy-efficient lighting using core sunlighting mean that almost all areas of a building can be illuminated with sunlight whenever the sun shines, without requiring any increase in floor-to-floor height or large expanses of glazing. As a result, cost-effective, highly efficient core sunlighting systems have the potential to significantly affect how the building industry approaches green building design.

The goal of researchers from Canadian and California universities is to achieve mainstream adoption for the technique by 2030. This will be done in collaboration with other research institutions, as well as utilities, manufacturers, building design practitioners, government and any other relevant stakeholders. ■

| | (1) Low-Concentration Large Hollow Guides | (2) Medium-Concentration Small Hollow Guides | (3) High-Concentration Fiber Optic Guides |
|---|---|---|---|
| Roof Collection (R) | R1 | R2 | R3 |
| Facade Collection (F) | F1 | F2 | F3 |

**Figure 3. Classification of core sunlighting systems.**


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**Figure 4. Two F2 demonstration installations in British Columbia, Canada.**