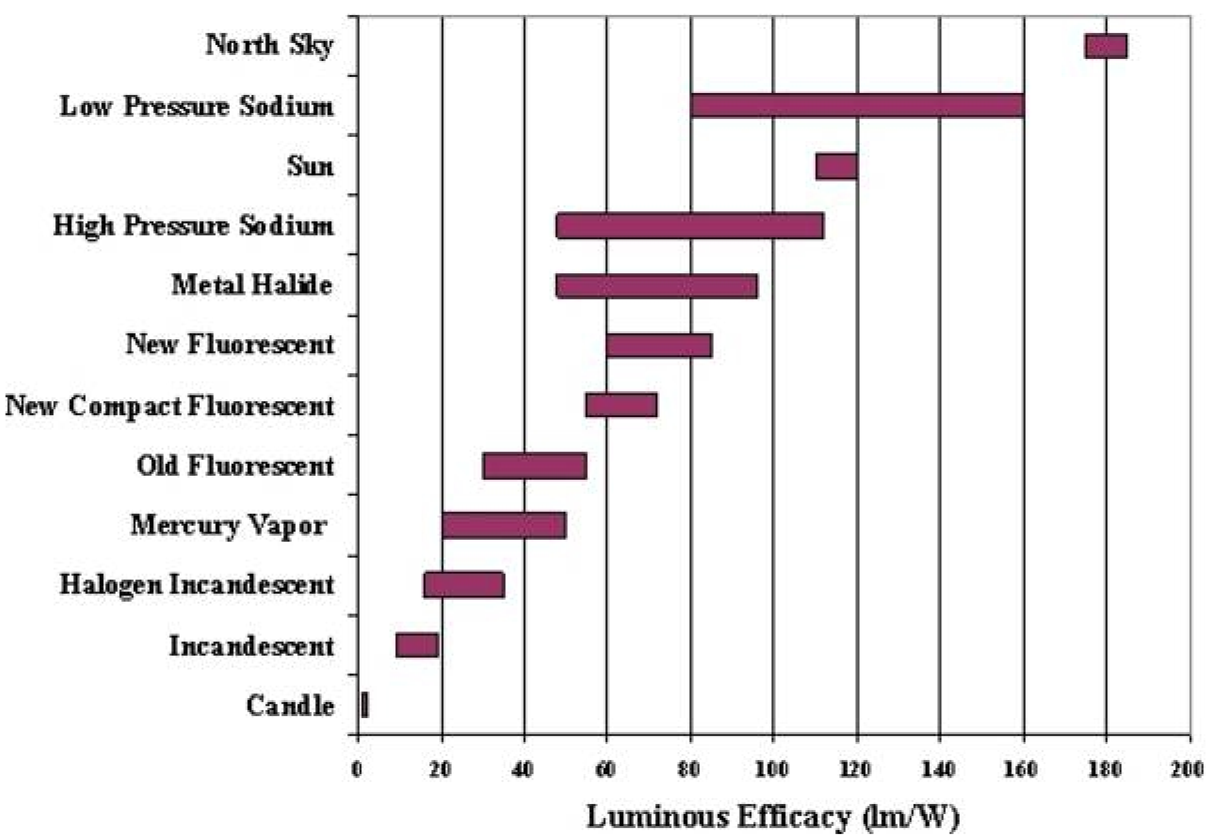
Natural Lighting

by Larry Kinney, Boulder Colorado

Using the sun's lumens directly to supply interior light began before recorded history. However, Edison's invention made it easy to ignore the usefulness of natural light, with the consequence that these days many buildings are built which use much more electric energy than they should, both for lighting and for cooling. Electric lighting has at least three disadvantages vis-à-vis well-designed daylighting systems:

***Its color properties can't match those of natural sunlight;**
***It makes the electric meter run to supply light; and**
***It makes it run even more to remove the extra heat associated with electric lights which tend to produce much more heat than light.**

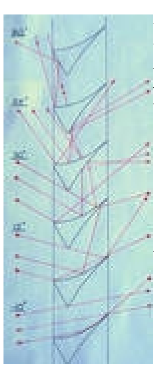
Lumens are units of light, while watts are units power that are experienced as heat in lighting. The luminous efficacy (lumens per watt, lm/W) of Edison's incandescent lights run about 15 lm/W, good compact fluorescents about 70 lm/W, and the best metal halide lights about 85 lm/W. By contrast, direct beam sunshine is about 113 lm/W and a light from a north sky about 180 lm/W. So during the cooling season, daylighting can save twice.



This is especially welcome by electric utilities which have to pay a premium for the electricity they deliver on hot sunny afternoons—circumstances that are ideal for daylighting systems which can lower demand substantially.

Effective daylighting designs do much more than just let in more light through the window. Indeed, direct beam sunlight through windows and skylights (like the case illustrated) can produce very bright areas that can make the lighting environment quite uncomfortable.

By contrast, the ones we have been developing for years direct light onto white ceilings, which in turn reflect diffuse, glare-free light to fall on the work surfaces below. The result can produce both attractive, high-quality lighting environments and substantially reduced electric bills.



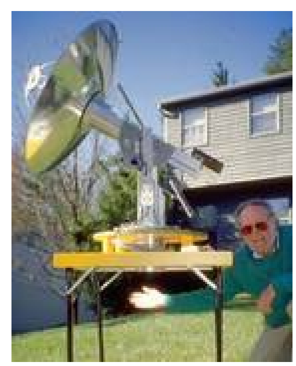
My early work was concentrated on the development of passive daylighting devices that control sunlight using a variety of reflective surfaces oriented to maximize distributing solar light evenly across ceilings while limiting direct beam sunlight on work surfaces. The case illustrated was from a double-reflector design presented at the Second International Daylighting Conference, which was held in 1983.

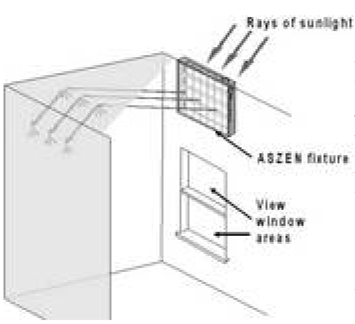
The **Stationary Reflector Reflecting Array (SPRA)** design shown below is a passive system that controls for elevation as well as azimuth while directing sunlight as deep within a structure as possible while minimizing glare year around. Suitable for new buildings or retrofit, the it can be mounted on its own or be encased between glazings, an option which minimizes dust build up on optical surfaces and the need for maintenance.

We still use the best designs from this work, but find that recent technical innovations enable active daylighting systems to be practical and economical. Inexpensive microprocessors, tools from the robotics industry like stepper and gear motors, and inexpensive yet hardy first-surface mirror materials that are highly reflective in the visible portion of the spectrum have opened many doors to the daylighting systems designer.

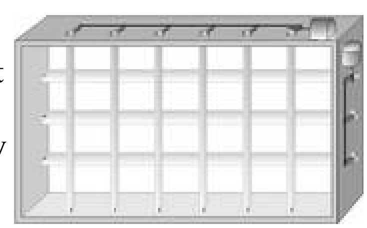
A sample of my daylighting designs, both passive and active, are described in a paper presented at the International Solar Energy Society in 2005. These include:

*The **Daytracker**, a two-axis system that collects direct beam sunlight, concentrates it by a factor or 40, and directs the resulting beam down highly reflective light pipes where it can illuminate spaces via “natural” light fixtures;





*__ASZEN__, a sidewall system that controls light in azimuth and elevation, directing it across ceilings or through rectangular light pipes where it may be used to supply lighting well within a building;



*__Modern Monitors__, toplighting systems which use special fenestration above roofs that gather sunlight and redirect it across ceilings rather than allow it to fall directly on spaces below; and

***Smart Light Shelves**, sidelighting systems which are manipulated to optimize the distribution of light as deeply as possible within a structure while constraining direct beam sunlight from falling on work spaces.

Enhancements of each of these systems is underway, and several other exciting new daylighting systems which include carefully-controlled solar heating may be commercially available in the future.