Daylighting for Homes

Introduction

By reducing the need for electric light, daylighting can substantially lower home energy use. However, excessive daylighting can increase both heating and cooling loads. A balanced approach to daylighting involves whole building design starting with the location and orientation of a home and continuing with proper room location and design, window sizing and placement, and selection of room finishes.

Green Building Benefits

In addition to reducing the need for electric lighting, daylighting offers many less tangible health and productivity benefits. Studies have shown that high quality light elevates moods, reduces depression, and improves worker productivity and student test scores.

Building Shape and Orientation

Decisions made early in the design process regarding building orientation, form, room depth and height, have a significant impact on the utilization of daylighting. Similar to a passive solar home, a house form that optimizes daylight in temperate climates will be roughly rectangular in shape elongated in the east-west direction. This allows a majority of the rooms and windows to face north and south while reducing the wall and window area facing east and west. East and west facing windows are difficult to shade in summer and can transmit excessive solar heat gain. Major living spaces that are most often used should be located along the home's north and south perimeters adjacent to windows designed to transmit an appropriate amount of natural light.

Room Location and Design

When laying out rooms on a floor plan, establish which spaces will most benefit from daylight and which spaces need little or no daylight. Rooms that require good quality lighting year-round should be placed along the north and south perimeters of a home. Living rooms, family rooms, kitchens, and bedrooms are examples of spaces that can greatly benefit from well-distributed natural light. Rooms that are less often used or have lower lighting requirements can be placed in the home's interior. Laundry rooms, media rooms, and closets are examples of spaces that don't need well-distributed natural light.

A room's orientation makes a big difference in the quality of light it receives. Rooms facing north will receive fairly constant, indirect (or diffuse) daylight all year long. Rooms facing south will receive bright, direct sunlight all year. Ideally, shape and locate each room so that it receives natural light from two different directions. This will allow a room to be illuminated by both direct light and diffuse light at any given time of day.

For good light penetration, the depth of rooms should be kept relatively small adjacent to the wall or window that is the daylight source. A standard window can produce useful illumination to a depth of about 1.5 times the height of the window. For example, given a wall height of 8 feet and a window header height of 7 feet, a room should be no more than 11–12 feet deep for well-distributed daylight. As a general rule-of-thumb, the higher the window is placed in the wall, the deeper the daylight penetration.

To distribute natural light deep inside a home, consider interior glazing that allows light from one space to be shared with another. This can be achieved with transom windows above doors, vision glass, or translucent panels.

Window Location, Design, and Details

The simplest way to provide good quality daylighting for homes is to place windows so that natural light enters every room from more than one direction. This strategy produces much less glare around people and objects than light from a single source does. Furthermore, more even distribution of light results in less contrast in the room as a whole, better illuminating otherwise dark surfaces and corners.

Punched window openings centered in a room, such as small, square windows separated by wall area, result in uneven illumination and harsh contrast between the window and adjacent wall surfaces. A better distribution of light is achieved by locating windows near ceiling and wall surfaces. By reflecting much of the light into a room off the ceiling and walls, the direct light becomes much more diffuse and reduces glare significantly.

Window frame materials should be light-colored to reduce contrast with the view and have a non-glossy (satin or matte) finish to eliminate glare spots. Light-colored window jambs and sills can be beneficial light reflectors. Deep jambs should be splayed (angled toward the interior) to reduce the contrast around the perimeter of the window.

Room Finishes

Once daylight enters a room, the surrounding wall, ceiling, and floor surfaces are important light reflectors. Using reflective finishes will better bounce daylight around the room and reduce extreme brightness contrast.

The most important interior light-reflecting surface is the ceiling. High reflectance paints and ceiling tiles are now available with 0.90 or higher reflectance values. Tilting the ceiling plane toward the daylight source increases the daylight that is reflected from this surface. In small rooms the rear wall is the next important surface since it directly faces the window. This surface should also be highly reflective. The sidewalls and the floor have less impact on how daylight is reflected throughout the space.

Other Strategies

In addition to windows, three other architectural strategies should be considered for effective daylighting in homes. These are skylights, clerestory windows, and roof monitors or cupolas.

Horizontal or sloped skylights can cause overheating in a room because they tend to receive maximum solar gain at the hottest time of the day. The daylight contribution also peaks at midday and falls off severely in the morning and afternoon. High performance skylight designs that incorporate reflectors or glazing options are available. They can reduce the peak daylight and heat gain while increasing early and late afternoon daylight contributions. Another option is a lightpipe or solar tube that uses a high reflectance circular duct to direct daylight from a roof-mounted skylight down to a diffusing lens in the ceiling of a room.

A clerestory window is vertical glazing located high on an exterior wall. South-facing clerestories can be effectively shaded from direct sunlight by a properly designed overhang. In this design, the ceiling can be sloped to better reflect daylight into nearby rooms. Use light-colored overhangs and adjacent roof surfaces to improve the reflected component. If exterior shading is not possible, consider interior vertical baffles to better diffuse the light. A south-facing clerestory will produce higher daylight illumination than a north-facing clerestory. However, a north-facing clerestory receives only diffuse light and will not transmit solar heat gain into a home during the summer. East and west facing clerestories have the same problems as east and west windows: difficult shading and potentially high heat gains.

A roof monitor or cupola consists of a small roof section raised above the adjacent roof with vertical glazing usually located on two opposite sides. The raised roof section should be large enough to provide overhang shading for the vertical glazing. Much of the light transmitted down to the living space below is diffuse light, reflected off the walls and ceiling of the roof monitor.

Figure 1. Roof monitor or cupola[1]

Daylighting Factor

The daylighting factor (DF) is the illuminance at a point indoors, usually on the working plane, expressed as a percentage of the illuminance outdoors.[2] The average daylighting factor is an approximate measure for assessing daylight during the early stages in designing windows, clerestories, and roof monitors. It varies with factors such as the visible sky angle, the width and depth of the room, the net window area, the visible transmittance of the glass, and the reflectance of the surfaces inside the room. The recommended average DF for ordinary visual tasks is 1.5–2.5 percent. For moderately difficult tasks, the average DF ranges from 2.5–4.0 percent. The recommended average DF for difficult, prolonged tasks is 4.0-8.0 percent.

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[1] Photo courtesy Austin Energy Green Building Program.

[2] Illuminance is the total amount of visible light illuminating (incident upon) a point on a surface from all directions above the surface. This "surface" can be a physical surface or an imaginary plane

For more information

- Daylight and Sunlight; Home Energy Magazine http://homeenergy.org/archive/hem.dis.anl.gov/eehem/00/000914.html
- US DOE Building Technologies Program; www.eere.energy.gov/buildings/info/design/integratedbuilding/passivedaylighting.html
- Daylight in Building Design; www.energydesignresources.com/
- PG&E's Pacific Energy Center offers an array of daylighting information and design tools. http://www.pge.com/003_save_energy/003c_edu_train/pec/toolbox/arch/003c1a1_arch_re.shtml
- *Daylighting for Sustainable Design*; Mary Guzowski, McGraw-Hill Co., 2000
- For more information about the Coalition, visit our website at www.greenaffordablehousing.org or call Bruce Mast at 510-271-4785.

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