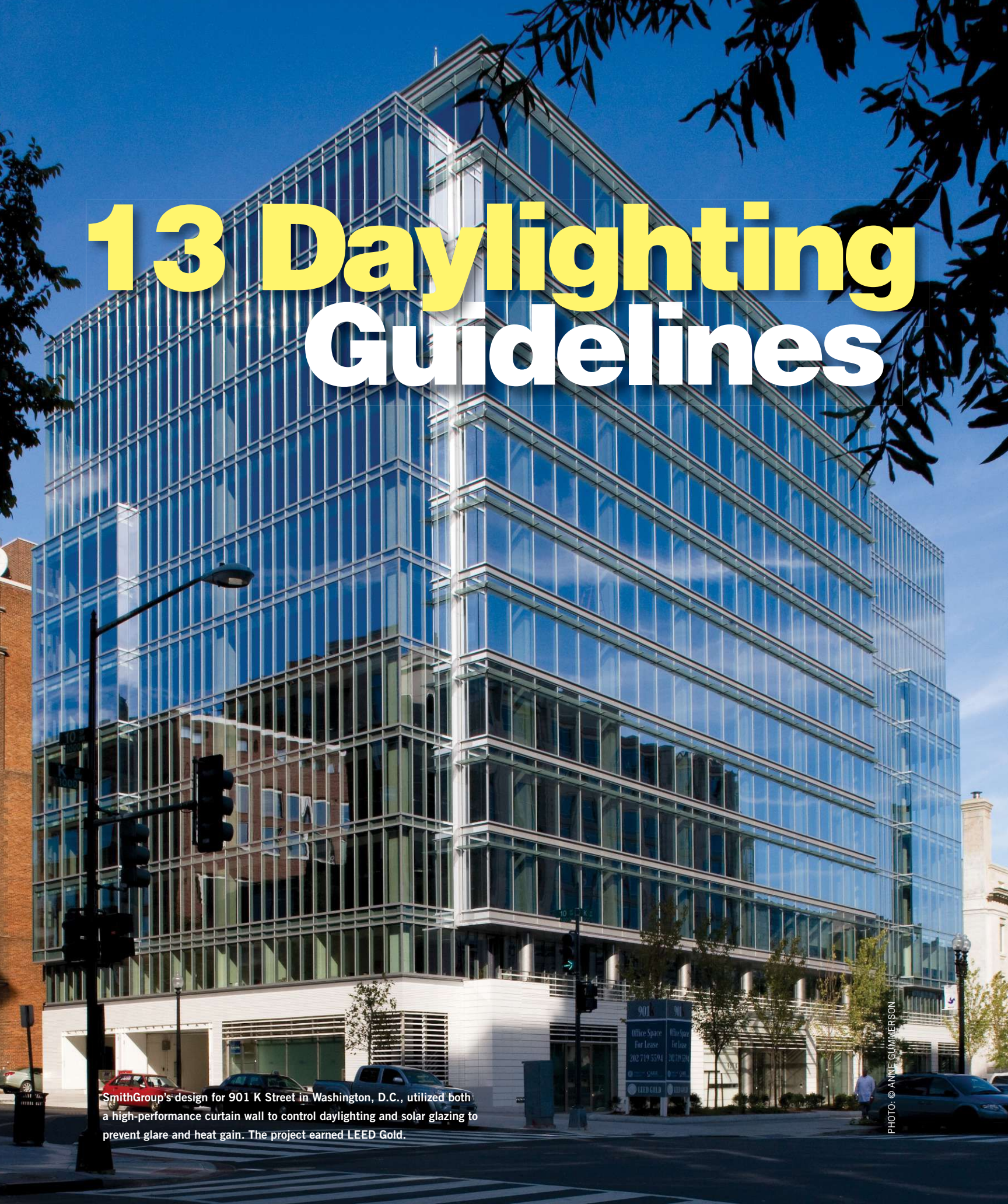
13 Daylighting Guidelines



SmithGroup's design for 901 K Street in Washington, D.C., utilized both a high-performance curtain wall to control daylighting and solar glazing to prevent glare and heat gain. The project earned LEED Gold.

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To get your project's daylighting right, you need to go well beyond window design and take into account the building as a whole.

By Jay W. Schneider, Editor

"Daylighting is not a window thing," says Steve Fronek, PE. "It's an integrated design concept that involves the whole building and factors in climate, the building's orientation, how the floor plan is laid out, and interior lighting design and controls."

"Daylighting has to be integrated at the beginning of design," says Fronek, VP of Technical Services at Wausau Window and Wall Systems. "Windows are just a small part of it."

The following guidelines are based on input from Fronek and the National Renewable Energy Laboratory's technical report *Lessons Learned from Case Studies of Six High-Performance Buildings*.

1. Don't overcomplicate the daylighting process. Use your intuition and common sense in conjunction with readily available analysis tools. Fronek recommends Lawrence Berkeley National Laboratory's Radiance tool or any ray-tracing software that's available for download. "You can find out what the daylighting in a room will be like on June 21 at 10:15 in the morning," says Fronek. However, one data point won't tell you much. You need to find daylight characteristics under all conditions any time of the year. And remember that daylighting design *must* include thermal analysis. "Always think about solar heat gain control and daylighting together," says Fronek

2. Don't waste money on daylighting features if you don't control artificial lighting first. Photosensitive controllers should be used to dim or extinguish indoor lights when they're not needed. Building occupants cannot be relied on to dim lights in response to available daylight, cautions the NREL report. Artificial lighting accounts for 40% of the energy used in a typical commercial building and generates at least three watts of heat for each watt of visible light. "Commercial buildings are usually cooling-mode dominated, so waste heat from artificial lights is a tremendous heat source that has to be cooled," says Fronek. "If you look at efficiency, natural daylight is much more energy efficient than having to cool waste heat from your light fixtures."

3. Position lighting for maximum effectiveness. Daylight-corrected fluorescent lamps integrate more seamlessly with natural daylighting strategies. Luminaires should be zoned and positioned parallel to windows.

The case studies in the NREL report showed that the more complex lighting control systems with sensors in each zone were harder to calibrate, and sensors were affected not only by daylight but also by lighting in neighboring zones. The report recommends using central controls instead of distributed controls and limiting zones and the numbers of individual sensors.

Lighting controls also enable designers to use bigger windows, according to Fronek, because the newest energy codes allow natural daylighting to be taken into account using the prescriptive path.

A Baker's Dozen of Daylighting Principles

1. Don't overcomplicate the daylighting process.
2. Don't waste money on daylighting features if you don't control artificial lighting first.
3. Position lighting for maximum effectiveness.
4. Use tall windows to maximize light penetration.
5. Eliminate glazing below sill height.
6. Focus on "effective aperture."
7. Make sure the building program relates to natural daylighting.
8. Calculate daylighting depth.
9. Address light shelf design.
10. Account for climate and geography.
11. Use appropriate materials and colors to finish spaces.
12. Take into account the payback period of daylighting components.
13. Focus on new construction.

4. Use tall windows to maximize light penetration. The best daylighting is top daylighting, and clerestory windows can be used to increase the effective height of transom lites without increasing window-to-wall ratio (WWR). Even relatively low WWR provides more than ample natural daylighting, if properly oriented and directed. "Natural daylighting in architecture was a lost art for many years," says Fronek. "Before we had dependable artificial lighting, offices and classrooms had tall ceilings for tall windows and clerestory glazing. Buildings had light wells and courtyards to get bi-directional lighting. Those buildings maximized daylighting by necessity. We need to get back to those design principles."

5. Eliminate glazing below sill height. Unless a downward view is important—in a condo overlooking Central Park, for example—glazing below the sill height offers little to no useful daylight and contributes to solar heat gain.

PHOTO: © ARMSTRONG

Light shelves, which can increase penetration to 2.0 times head height, are located beneath clerestory windows to help bounce light into the Armstrong World Industries' LEED Platinum HQ in Lancaster, Pa.

6. Focus on "effective aperture." EA is the product of visible light transmittance (VT) and WWR and can be useful in assessing the relationship between visible light and window size. Start with an EA of about 0.30 on the north and south elevations, minimizing glazing on the east and west elevations whenever possible.

A basic EA rule: larger windows should use darker glazing; smaller windows should use clearer glazing. Clearer glazing should also be used on north-facing façades and darker glazing on south, east, and, most importantly, west façades.

Don't worry about views out being distorted by darker glazing because modern spectrally selective glazing has very low solar heat gain and really neutral color rendition in both transmission and reflection, says Fronek. Even large differences in VT are very subtle to the eye.

And remember: Even on a cloudy day, there's almost always enough available daylight for ordinary needs. "If you need 20 footcandles of light on a desk, and an overcast sky is 1,000 footcandles, the daylight factor need is only 2%," says Fronek.

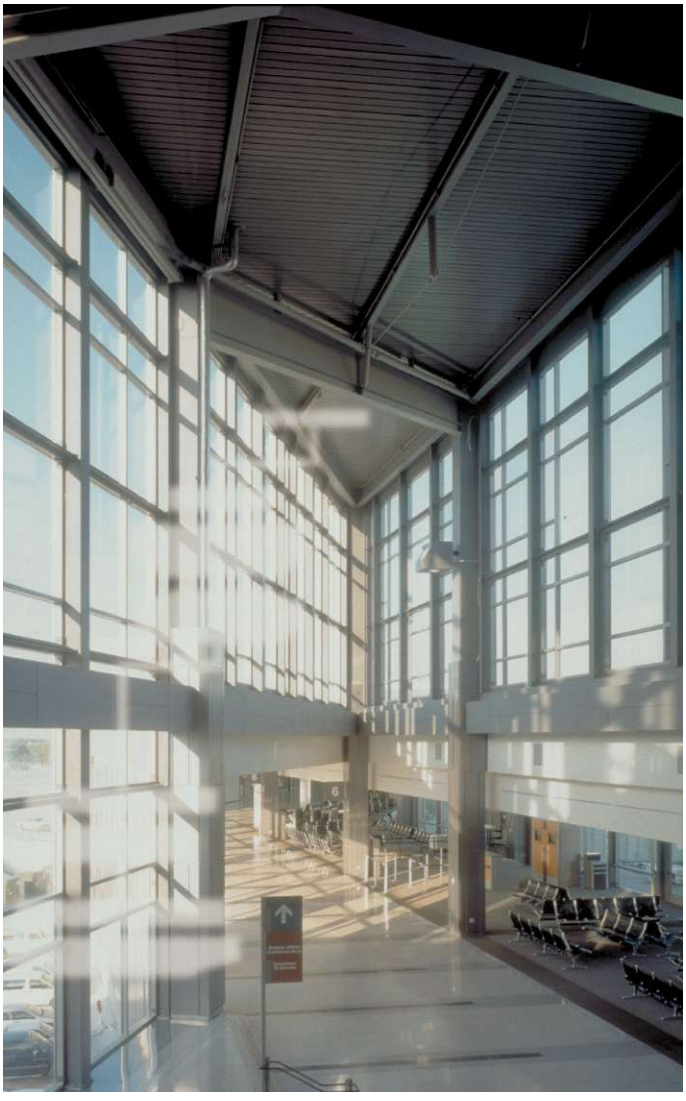
7. Make sure the building program relates to natural daylighting. Make access to daylight a factor when laying out floor plans and designing perimeter spaces. "Everyone loves a window office but open space should be adjacent to windows," says Fronek. If executives won't give up their perimeter offices, use glass demising walls and partitions or punch window openings in private offices to provide even daylight distribution. Locate rooms with little need for daylight (such as copy rooms and server rooms) in non-perimeter spaces. And scale accordingly. While tall conventional windows may work well in providing natural daylight to shallow perimeter offices, more complex strategies (such as light shelves) may be necessary to achieve daylighting in deep south-facing spaces.

8. Calculate daylighting depth. A conventional window can daylight an interior space to a depth of about 1.5 times the window head height. Light shelves and other daylighting systems can increase penetration to 2.0 times head height. While those depths are achievable for a building's north and south façades, doing so on the east and west façades is difficult because of low-angle sun that creates glare. "If you're trying to use low-angle sun for daylighting, you really have to work to bounce it off the ceiling," says Fronek. "Glare just causes people to pull down shades and leave their lights on all day, thereby negating the benefits of daylighting."

Certain building types—hotels, for example—don't need to be

daylit deeply so calculating daylighting depth isn't a concern, says Fronek. Guest floors have short floor slabs because they don't use suspended ceilings so daylight won't penetrate very deeply, which is fine because hotel rooms aren't usually occupied during the day.

9. Address light shelf design. Light redirecting devices like light shelves or profiled louvers are most effective only under "direct beam" clear-sky conditions. Light shelves also have size limits: the depth of light shelf should be equal to the clerestory or transom above it, and no deeper than 30 inches. Also, light shelves should be installed high enough to be out of hanging reach and to avoid a feeling of claustrophobia. There's no minimum requirement, but a height of 7½-8 feet off the floor is recommended.



The best daylighting is top daylighting, which is being harnessed at the Austin Bergstrom International Airport in Texas. Note the reflective surfaces. Smooth surfaces and light-colored interiors aid daylighting distribution.

10. Account for climate and geography. Interior light shelves are most effective for relatively clear climates at mid-latitudes and a southern orientation. "It's unrealistic to control glare with a light shelf, especially at mid-latitudes or higher," says Fronek. "If you're trying to control glare with a light shelf, it's going to have to be 20 feet deep, which isn't realistic." To control low-angle sun, use darker glazing, interior shading other than shelves, or exterior shading devices.

11. Use appropriate materials and colors to finish spaces. Daylighting and indirect lighting fixtures benefit from lightly colored interior surfaces that reflect light. The NREL report recommends eliminating unfinished wood surfaces, rough surfaces, and exposed ductwork. The best daylighting results were reported in spaces with light-colored interiors, smooth surfaces, and finished ceilings. Cubicle walls, furniture, and carpeting should also have light colors and highly reflective surfaces. For light shelf finishes, Fronek recommends standard white paint or clear anodized finishes.

12. Take into account the payback period of daylighting components. Spectrally selective low-e glazing has a very short payback time, so there's no significant cost premium. When you start hanging light shelves inside or sunshades outside on a building's curtain wall, that can up the cost and lengthen the payback period significantly.

13. Focus on new construction. "It's tough to daylight some new construction projects, but it's especially tough to daylight existing buildings," says Fronek.

When is a new construction project a candidate for natural daylighting? When, according to Fronek and the NREL study, it has these characteristics:

- Early enough for integrated design
- An unobstructed site in the mid-latitudes with a clear climate
- Primarily used for daytime occupancy—an office or a school, for example
- Planned using whole-building energy modeling
- Expansive north- and south-facing façades
- Open plan program or glazed interior wall partitions
- Atriums, courtyards, or light wells
- High ceilings
- Dimmable artificial lighting controls available for critical spaces
- Task illumination required
- Blinds, drapes, or shades to be used for glare control **BD+C**