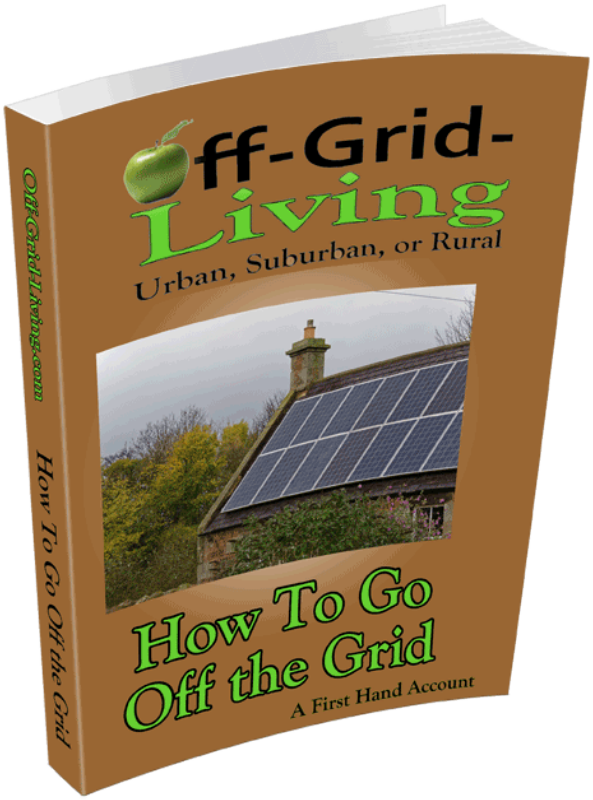
Off-Grid-Living

In An Urban and Suburban World



Lesson #13 …

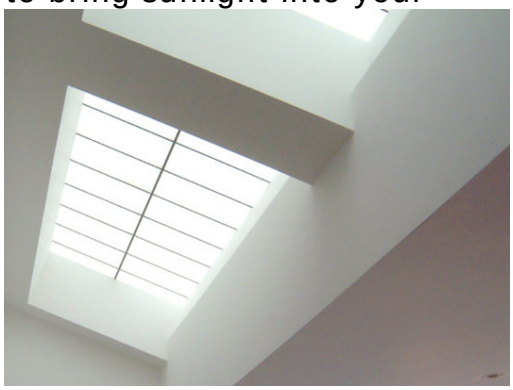
Windows and Skylights

The most important thing to take away from this lesson is…

Maximizing daylight can add needed and necessary light, as well as heat, bringing your overall lighting and heating costs down even more. Windows and skylights are your answer.

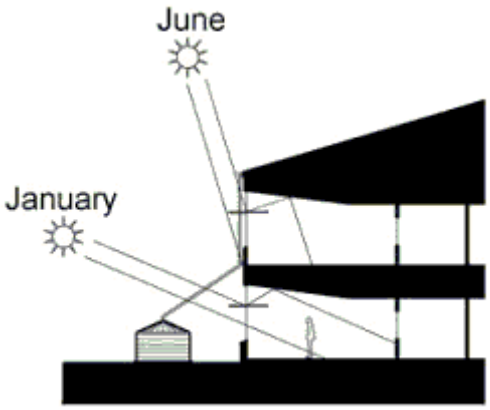
Daylighting

Daylighting is the use of windows and skylights to bring sunlight into your home.



Today's highly energy-efficient windows, as well as advances in lighting design, allow efficient use of windows to reduce the need for artificial lighting during daylight hours without causing heating or cooling problems.

The best way to incorporate daylighting in your home depends on your climate and home's design. The sizes and locations of windows should be based on the cardinal directions rather than their effect on the street-side appearance of the house.



South-facing windows are most advantageous for daylighting and for moderating seasonal temperatures. They allow most winter sunlight into the home but little direct sun during the summer, especially when properly shaded.

North-facing windows are also advantageous for daylighting. They admit relatively even, natural light, producing little glare and almost no unwanted summer heat gain.

Although east- and west-facing windows provide good daylight penetration in the morning and evening, respectively, they should be limited. They may cause glare, admit a lot of heat during the summer when it is usually not wanted, and contribute little to solar heating during the winter.

Passive Solar Window Design

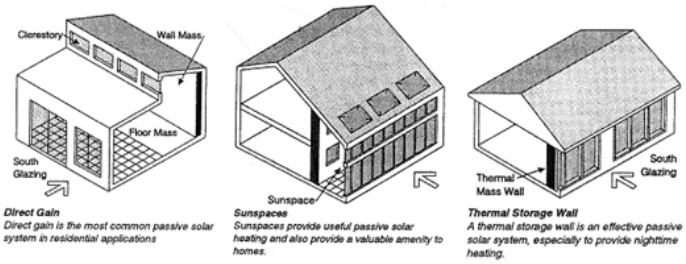
Properly designed, energy efficient windows represent a cost-effective way to use solar energy for heating. Photo credit: Dwight Stone.

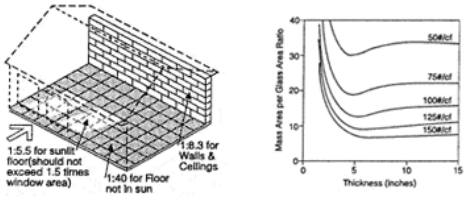
Windows are an important element in passive solar home designs, which can reduce heating, cooling, and lighting needs in a house.

Passive solar design strategies vary by building location and regional climate. The basic techniques involving windows remain the same—select, orient, and size glass to control solar heat gain along with different glazings usually selected for different sides of the house (exposures or orientations). For most U.S. climates, you want to maximize solar heat gain in winter and minimize it in summer.

Heating-Dominated Climates

In heating-dominated climates, major glazing areas should generally face south to collect solar heat during the winter when the sun is low in the sky. In the summer, when the sun is high overhead, overhangs or other shading devices (e.g., awnings) prevent excessive heat gain.





To be effective, south-facing windows usually must have a solar heat gain coefficient (SHGC) of greater than 0.6 to maximize solar heat gain during the winter, a U-factor of 0.35 or less to reduce conductive heat transfer, and a high visible transmittance (VT) for good visible light transfer.

Windows on east-, west-, and north-facing walls are reduced in heating climates, while still allowing for adequate daylight. East- and west-facing windows are limited because it is difficult to effectively control the heat and penetrating rays of the sun when it is low in the sky. These windows should have a low SHGC and/or be shaded. North-facing windows collect little solar heat, so they are used just to provide useful lighting.

Low-emissivity window glazing can help control solar heat gain and loss in heating climates.

Cooling-Dominated Climates

In cooling climates, particularly effective strategies include preferential use of north-facing windows and generously shaded south-facing windows. Windows with low SHGCs are more effective at reducing cooling loads. The following types of glazing help reduce solar heat gain, lowering a window's SHGC:

Improving the Energy Efficiency of Existing Windows

You can improve the energy efficiency of existing windows by doing the following:

- **Adding storm windows**
  Reduce air leakage and some heat transfer

- **Caulking and weather stripping**
  Reduce air leakage around windows

- **Using window treatments or coverings**
  Reduce heat loss and/or gain

However, if your home has very old and/or inefficient windows, it might be more cost effective to replace them than to make these improvements. New, energy-efficient windows eventually pay for themselves through lower heating and cooling costs, and sometimes even lighting costs.

Adding Storm Windows

If you have old windows in your home, the best way to improve your home's energy efficiency is to replace them with new, energy-efficient windows. However, if you're on a tight budget, a less expensive option is to use storm windows. Some types of storm windows are also a good option for those living in apartments.

Even though storm windows add little to the insulating performance of single-glazed windows (that are in good condition,) field studies have found

that they can help to reduce air movement into and out of existing windows. Therefore, they help reduce heating and cooling costs.

Types of Storm Windows

Storm windows are available for most types of windows. They can be installed on the interior or exterior of the primary window. They range from the inexpensive plastic sheets or films designed for one heating season, to triple-track glass units with low-emissivity coatings that offer many years of use. Mid-priced storm windows may use glass, plastic panels, or special plastic sheets that have specific optical qualities. Those made of polycarbonate plastic or laminated glass also offer a high degree of resistance to breaking during storms and/or from intruders.

For the most part, interior storm windows offer greater convenience than exterior storm windows. They're easier to install and remove; they require less maintenance because they're not exposed to the elements; and, because they seal tightly to the primary window, they're more effective at reducing air infiltration. Interior storm windows also are often the best choice for apartments and houses with more than one floor. If you can afford exterior storm windows, you can probably afford some newer, more energy-efficient windows, which will be a better investment.

Glass pane types offer better visibility and longer life than plastic pane types, but glass is heavy and fragile. In general, plastics are most economical for people with small budgets or who live in apartments. However, while inexpensive and relatively easy to install, they are easy to damage. Plastic panels, such as Plexiglas and acrylics are tougher and lighter than glass, but may scratch easily. Some may turn yellow over time as well. Some plastic films may significantly reduce visibility and degrade over time when exposed to sunlight.

Wood, aluminum, and vinyl are the most common storm window frame materials. There are advantages and disadvantages to all types of frame materials. Although very strong, light, and almost maintenance free, aluminum frames conduct heat very rapidly. Because of this, aluminum makes a very poor insulating material.

Wood frames insulate well, but they weather with age. They also expand and contract according to weather conditions. Wood-frame storm windows installed during the winter may not close easily during the summer, and those installed during the summer may fit loosely in the winter. They can

also be quite heavy and thicker than metal frames. This can make storage difficult, reduce the view out the window, and reduce the amount of natural light in the room. Wood frames also require the most maintenance. There are, however, aluminum- or vinyl-clad wood frames that reduce maintenance requirements.

Vinyl frames are usually made of polyvinyl chloride (PVC) with ultraviolet light (UV) stabilizers to keep sunlight from breaking down the material. They, however, may expand and warp at high temperatures, and crack in extremely low temperatures. Also, if sunlight hits the material for many hours a day, colors other than white will tend to fade over time.

Installation

No matter what type you choose, the storm window frame must be hung square with the primary window and sealed to the opening. You should also consider the fact that they should be easy to move to allow for cleaning and ventilation.

Exterior-mounted storm windows must have "weep holes" at the bottom of the frame to allow any moisture that collects between the primary window and the storm window to drain out. Even though these drainage holes subtract from energy savings, not having them will eventually cause the primary window frame to rot, and possibly make them impossible to operate.

Window Treatments and Coverings

You can choose window treatments or coverings not only for decoration but also for saving energy. Some carefully selected window treatments can reduce heat loss in the winter and heat gain in the summer. They include the following:

- Awnings
- Blinds
- Draperies
- High-reflectivity films
- Insulated panels
- Mesh window screens
- Overhangs
- Shades
- Shutters
- Storm panels.

Window treatments, however, aren't effective at reducing air leakage or infiltration. You need to caulk and weather strip around windows to reduce air leakage.

Skylight Design Considerations

Before selecting a skylight for your home, you need to determine what type of skylight will work best and where to improve your home's energy efficiency.

Energy Performance

First, it's a good idea to understand the energy performance ratings of skylights if you don't already. You can then determine what energy performance ratings you need for your skylight based on your climate and home's design.

For labeling energy-efficient skylights, ENERGY STAR® has established minimum energy performance rating criteria by climate. However, this criteria doesn't account for a home's design. Therefore, if you're constructing a new home or doing some major remodeling, you should also take advantage of the opportunity to incorporate your skylight design and selection as an integral part of your whole-house design—an approach for building an energy-efficient home.

Size and Position

The physical size of the skylight greatly affects the illumination level and temperature of the space below. As a rule of thumb, the skylight size should never be more than 5% of the floor area in rooms with many windows and no more than 15% of the room's total floor area for spaces with few windows.

You should also consider a skylight's position if you want to maximize daylighting and/or passive solar heating potential. Skylights on roofs that face north provide fairly constant but cool illumination. Those on east-facing roofs provide maximum light and solar heat gain in the morning. West-facing skylights provide afternoon sunlight and heat gain. South-facing skylights provide the greatest potential for desirable winter passive solar heat gain than any other location, but often allow unwanted heat gain in the summer. You can prevent unwanted solar heat gain by installing the skylight in the shade of deciduous (leaf-shedding) trees or adding a movable window

covering on the inside or outside of the skylight. Some units have special glazing that can help control solar heat gain.

Skylight Selection

You'll find that you have several options to consider when selecting the type of skylight to use in your home.

When selecting a skylight for energy efficiency, it's important to first consider its energy performance ratings in relation to your climate and home's design. This will help narrow your selection.

A skylight's energy efficiency is dependent upon all of its components:

- Glazing
- Operation and Use
- Shape.

Skylight Glazing

When selecting a skylight for your home, it's important to consider what type of glazing you should use to improve your home's energy efficiency. Based on various skylight design factors—such as its orientation and your climate—you may even want different types of glazing for different skylights throughout your home.

Skylight glazing usually consists of either plastic or glass. Other glazing technologies may also be used for solar heat control.

Plastic Glazing

Plastic glazing is usually inexpensive and less liable to break than most other glazing materials. However, these plastic surfaces scratch easily, and they may become brittle and discolored over time. Many plastics also allow most of the ultraviolet (UV) rays in (unless the glazing is coated with a special film), which increases fading damage to furnishings. Acrylics and polycarbonates are the most commonly used plastic glazing. Acrylics are weaker than polycarbonates, but cost less. Although polycarbonates offer high impact resistance, some yellow with age.

Glass

Glass is usually found on the more expensive skylights. Glass is more durable than plastics and does not discolor. All glass used for skylights must be made of "safety glazing," a generic term for both tempered and laminated glass. Tempered glass is the most impact resistant. Laminated glass is fabricated with a thin layer of plastic embedded near the center of

the glass. Both keep the glass from breaking into large, sharp pieces. Skylights are often made with a tempered glass on the exterior side and a laminated pane on the interior side. This arrangement gives maximum impact resistance while protecting occupants from falling shards of glass.

Solar Heat Control Glazing
Because skylights are located on the roofs, they can result in large amounts of unwanted summer time solar heat gains and winter time heat losses. Manufacturers use various glazing technologies to reduce these impacts. The most common technologies include those also used for window glazing:

- Heat-absorbing tints
- Insulated glazing (double-glazed, triple-glazed)
- Low-emissivity (Low-E) coatings.

Some manufacturers even install a translucent insulation material between several glazing layers to create a more thermally efficient assembly.

Skylight Operation and Use
Some skylights operate to maximize a home's daylighting, and others provide ventilation and moisture control.

Daylighting
Recent "high tech" developments maximize skylights for daylighting. An "element" on the roof becomes an aperture for collecting sunlight. It may be a sun-tracking, open-sided cylinder; a large lens-like element; or merely a conventional skylight with a mirrored reflector mounted adjacent to it. This aperture may then connect to a mirrored pipe, or "light pipe," which has a diffusing lens that mounts on or is recessed into the ceiling of the room below. Most tubular skylights have this feature.

These skylight designs, relative to equivalent traditional skylights, effectively reduce daytime overheating and nighttime heat loss, but they do not provide views or ventilation.

Ventilation
Skylights can provide ventilation as well as light. Ventilating a building through a skylight opening releases the hot air that naturally accumulates near the ceiling. Ventilating skylights usually open outward at the bottom, some more than others. Some units vent through a small, hinged panel. One design uses a swing-down inner sash with a protected vent strip above. This can reduce the potential for rain or snow entering the room if the vents are open. Skylights may be opened manually with a pole, chain, or crank. Automated units with electric motors or pneumatic devices are also

available. Some models incorporate moisture sensors to automatically close the skylight when it rains.

Larger skylights that can be used as doors are sometimes called "roof windows." Roof windows are always located within a few feet of the floor.

Moisture Control
In very cold weather, skylights are often prone to water vapor condensing on the glazing. The accumulation of water may then drip into the room. Better skylights usually have an interior channel to collect the condensate so it can evaporate later. The most thermally efficient skylights are less prone to condensation problems.

Skylight Shapes
Skylights are available in a variety of shapes and sizes. The most common shapes include rectangular, circular, oval, diamond, triangular, multi-sided, and tubular.

Non-rectangular units usually use plastic glazing, but higher quality ones use glass. The glazing can be flat, arched, domed, pyramidal, or "warped plane"—flat on the low side and concave in section on the high side. Of these, the pyramidal, arched, and domed shapes offer flexibility for positioning. Their raised design allows light to enter from more extreme angles than flat or warped plane units. This allows more positioning options.

The slope or curvature of the glazing also helps to shed moisture and leaves. These skylight designs also do not require the additional framing needed to slope a flat skylight for proper drainage on flat or low-slope roofs.

Tubular skylights are smaller than most other skylights. They consist of roof-mounted light or solar collectors, which increase their daylighting potential without the need to increase their size. Because the rooftop solar collector has a small surface area, tubular skylights minimize heat loss in the winter and heat gain in summer. Their small size also minimizes their impact on a home's architecture.

Skylight Installation
Even the most energy-efficient skylight must be properly installed to ensure that its energy performance is achieved. Therefore, it's best to have a professional install your skylight.

In addition to following the manufacturer's guidelines when installing a skylight, it's also important to consider slope and moisture control.

Slope
The slope or tilt of the skylight affects solar heat gain. A low-slope will admit relatively more solar heat in the summer and less in the winter, exactly the opposite of what is desirable.

As a general rule of thumb, you want to achieve a slope equal to your geographical latitude plus 5 to 15 degrees. For example, the optimum slope for a south-facing skylight in Columbus, Ohio, at 40º North latitude, is 45º to 55º. At least one skylight manufacturer makes a prefabricated, tilted base that increases the angle of a skylight above the roof.

Moisture Control
Water leaks are a common problem with skylights. Take the following steps to avoid water leaks:

- Mount the skylight above the roof surface
- Install a curb (a raised, watertight lip that helps to deflect water away from the skylight) and flashing
- Thoroughly seal joints
- Follow the manufacturer's guidelines.

It is also prudent to apply a layer of sheet waterproofing over the flanges/flashing of the skylight. This is generally installed under the finish roofing material as an aid in protecting against ice dams. Avoid water diversion devices such as roof crickets or diverter strips, as they often create more problems than they solve.

What You Can Do Starting Today

Here are some basic methods for achieving energy-efficient windows:

- Install fluorescent light fixtures for all ceiling- and wall-mounted fixtures that will be on for more than 2 hours each day. These often include the fixtures in the kitchen and living room, and sometimes

those in bathrooms, halls, bedrooms, and other higher-demand locations.
- Install dedicated compact fluorescent fixtures, rather than compact fluorescent lamps (CFLs) in incandescent fixtures, so that fluorescent bulbs continue to be used for the life of the house.
- Use CFLs in portable lighting fixtures that are operated for more than 2 hours a day.
- Use ENERGY STAR® labeled lighting fixtures.
- Use occupancy sensors for automatically turning on and off your lights as needed.
- Consider light wall colors to minimize the need for artificial lighting.
- If recessed lights are used in a ceiling with an unconditioned space above it, use only Underwriters Laboratory (UL) approved fixtures that are airtight, are IC (insulation contact) rated, and meet ASTM E283 requirements.

Evaluating your need for skylights and daylighting:

- First consider if the primary purpose is lighting and/or passive heating.
- Remember: Skylights on north-facing roofs provide cool illumination, while east-facing roofs provide maximum light and heat in the morning. West-facing skylights provide afternoon sunlight and heat. South-facing skylights provide more passive solar heat than any other location.
- Carefully study the southerly exposures of both your roof and exterior walls.
- Carefully consider the tilt of the skylight: A low-slope will admit relatively more solar heat in the summer and less in the winter, exactly the opposite of what is desirable.
- **As always, examine your lifestyle**. Inspect your windows. If even after air sealing you're still experiencing air/heat loss, it may be time to replace them. Consider an insulated drapes and/or other window treatments as a low cost way to control heat/cooling loss.
- Carefully look at the orientation of your house. Do you have a lot of southern exposure? Is your roof able to support the use of skylights?
- **Talk to some professionals**: This could possibly be a big expenditure. Get advice and estimates from professionals if you're even considering it. Keep in mind, window treatments such as awnings, movable insulation, windows films, can do a lot of instead replacing windows or installing skylights.

PS…Don't forget you can get personalized coaching at Off-Grid-Living.com/ For some this is the ideal way to get hands on experience as well as personal attention needed to make this work for you.

Coming Up Next ...

Lesson #14: "How To Get Free Glass For Solar Applications."

In the next lesson I'm going to show you a method of getting all the free glass you want for solar and window applications.