3.6. How to choose roof for passive solar building?

When choosing a roof for a passive solar building, it's important to consider the following factors:

1. **Orientation**: The roof should be oriented towards the south to maximize solar gain in the winter and minimize it in the summer.
2. **Pitch:** The pitch of the roof should be between 30-45 degrees to maximize solar gain and minimize shading.
3. **Materials:** Dark-colored, highly reflective materials are good at absorbing and retaining heat, while light-colored, highly reflective materials are better at reflecting heat and keeping the building cool.
4. **Insulation:** The roof should have a high R-value (a measure of thermal resistance) to keep the building warm in the winter and cool in the summer.
5. **Overhangs:** Overhangs can be used to shade windows during the summer and allow sunlight in during the winter.
6. **Vents:** Proper ventilation will help keep the building cool in the summer and prevent moisture buildup that can cause mold and mildew.

There are several roof shapes that are commonly used in passive solar buildings:

1. **Gable Roof** (Fig. 3.6.1)**:** A gable roof is a triangular shape that is formed by two sloping planes that meet at a ridge. This roof shape is popular in passive solar buildings because it allows for maximum solar gain during the winter.
2. **Shed Roof** (Fig. 3.6.1)**:** A shed roof is a single sloping plane that is often used to cover an addition to a building. It is a simple and cost-effective way to add a passive solar feature to a building.
3. **Hip Roof** (Fig. 3.6.1)**:** A hip roof has four sloping planes that meet at a ridge. The hip roof is a good option for passive solar buildings because it allows for maximum solar gain during the winter and provides shading during the summer.
4. **Butterfly Roof** (Fig. 3.6.1)**:** A butterfly roof is a V-shaped roof that has two sloping planes that meet at a central point. This roof shape is popular in passive solar buildings because it allows for maximum solar gain during the winter and provides shading during the summer.

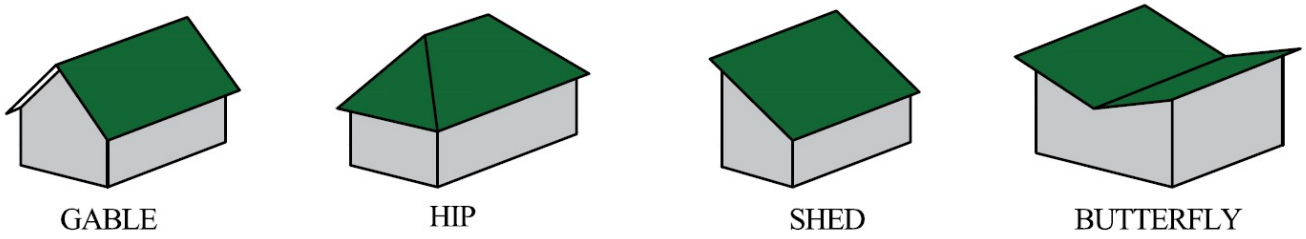

Fig.3.6.1. Roof types. (Source: own elaboration).

5. A **combination** of these shapes, such as a gable-hip or a shed-gable, can also be used in passive solar design to take advantage of the benefits of each shape.

If you are trying to install solar panels on a steep roof, it may not be possible to place panels at the optimal tilt with traditional racking systems. Because the steep angle of your roof might already be higher than the optimal angle for production, the best you can do is lie your panels flat against the roof. Low-angle roofs will also face obstacles when it comes to solar panel installation and may require specialized racking if you're looking to tilt them at the optimal angle. Placing panels flush against these types of roofs will mean less electricity production, which will lead to reduced solar savings over time (Marsh, J., 2022).

In the case of a flat roof, solar installers will usually opt to use racking systems that mount your panels up at an optimal angle. While this allows for your panels to face the sun more directly, you may be limited when it comes to your system size. Tilting panels up on a flat roof will lead to the panels shading one another unless you

space and stagger the rows of panels out on the roof. As a result, you can't install as many panels as you would otherwise be able to if the solar panels were flush against the surface (Marsh, J., 2022).

When choosing materials for a passive solar building roof, it's important to consider the following factors:

1. **Reflectivity:** A highly reflective material will help keep the building cool in the summer by reflecting heat away from the building. Light-colored, reflective materials such as metal, white or light-colored clay or concrete tiles are good options.
2. **Emissivity:** A material with a high emissivity rating will help retain heat inside the building during the winter. Dark-colored, low-emissivity materials such as asphalt shingles, metal or clay tiles are good options.
3. **Insulation:** The roof should have a high R-value (a measure of thermal resistance) to keep the building warm in the winter and cool in the summer. Some popular insulation materials include fiberglass, cellulose, and spray foam.
4. **Durability:** The roofing material should be durable and able to withstand the local climate and weather conditions. For example, if the area is prone to high winds, hail or heavy snowfall, a material that is strong and resistant to those conditions would be a good option.
5. **Environmental Impact:** Some materials may have a greater environmental impact than others, such as the energy required to produce and transport them, the life span of the material and the process of disposing it.

Some examples of roofing materials that are commonly used in passive solar buildings include:

1. Metal roofing, such as aluminum, steel, and copper, which are highly reflective and durable.
2. Clay or concrete tiles, which are also highly reflective and durable, and can be made in different colors.
3. Asphalt shingles, which are widely available and affordable, but have lower reflectivity and durability.
4. Green roofs and living roofs are also a good option for passive solar buildings as they provide insulation, reflectivity and also improve the air quality and biodiversity.

3.6.1. Cool roofs

A cool roof is a roofing system that reflects more sunlight and absorbs less heat than a standard roof (Fig. 3.6.2). These types of roofs are designed to stay cooler in the sun and help reduce the amount of heat absorbed by the building, which can help lower energy costs and improve indoor comfort.

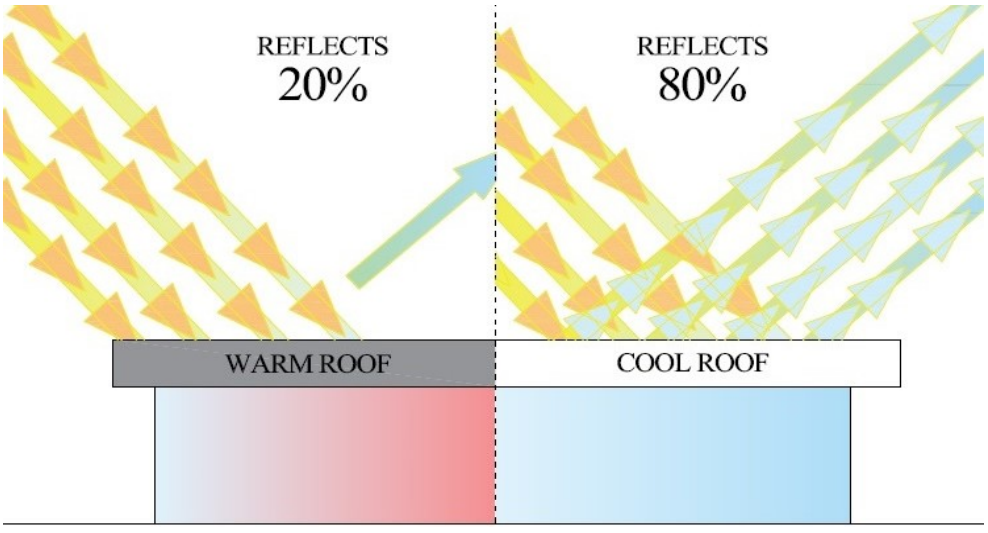

Fig.3.6.2. Absorption of solar energy of warm or cool roof. (Source: own elaboration).

Cool roofs are typically made with reflective materials, such as white or light-colored reflective paint, reflective shingles, metal roofing, or reflective tiles. These materials have a higher solar reflectance (the ability

to reflect sunlight) and a lower thermal emittance (the ability to emit absorbed heat) than traditional roofing materials.

There are two main types of cool roofing:

1. **Built-up roofing systems:** This type of roofing is made up of several layers of materials, such as asphalt, gravel, and insulation. Cool roofs use reflective materials such as white gravel or reflective paint to reduce heat absorption.
2. **Single-ply roofing systems:** These roofs are made of a single layer of materials, such as PVC, TPO, or EPDM. They are often reflective and energy-efficient.

The installation of a cool roofing system is similar to that of a traditional roofing system, but with the use of reflective material. It also requires proper ventilation, insulation, and regular maintenance to ensure its longevity and efficiency.

It is important to note that cool roofing materials may not be suitable for all climates and building types.

Scientists have developed an all-season smart-roof coating that keeps homes warm during the winter and cool during the summer without consuming natural gas or electricity. Research findings reported in the journal Science point to a groundbreaking technology that outperforms commercial cool-roof systems in energy savings (Duque, T., 2021).

"Our new material – called a temperature-adaptive radiative coating or TARC – can enable energy savings by automatically turning off the radiative cooling in the winter, overcoming the problem of overcooling", said Junqiao Wu, a faculty scientist in Berkeley Lab's Materials Sciences Division and a UC Berkeley professor of materials science and engineering who led the study (Duque, T., 2021).

Standard cool roofs have high solar reflectance and high thermal emittance (the ability to release heat by emitting thermal-infrared radiation) even in cool weather (Duque, T., 2021).

According to the researchers' measurements, TARC reflects around 75% of sunlight year-round, but its thermal emittance is high (about 90%) when the ambient temperature is warm (above 25 degrees Celsius or 77 degrees Fahrenheit), promoting heat loss to the sky. In cooler weather, TARC's thermal emittance automatically switches to low, helping to retain heat from solar absorption and indoor heating, Levinson said (Duque, T., 2021).

3.6.2. Green roofs

A green roof, also known as a living roof, is a roofing system that incorporates vegetation, such as grasses, flowers, and shrubs, into the design. This type of roof can provide a number of benefits, including insulation, water management, and improved air quality.

When paired with a solar passive house, a green roof can help to further improve the building's energy efficiency by providing additional insulation and shading. Additionally, the plants on a green roof can help to reduce the amount of stormwater runoff, which can be a significant problem in urban areas. It also helps in reducing the heat island effect.

Types of green roofs:

1. **Intensive green roofs:** Intensive green roofs are intended to replicate what can typically be found at ground level in the natural landscape, and in green spaces such as parks or cultivated gardens. Intensive green roofs involve intense landscaping, and are suited to roofs with a highly visible presence or public access, and commonly referred as a "roof garden". Choices include shrubs, native forbs and grasses, larger perennials, tropical, non-native vegetation (WEB-1: *Green Roofers Ltd*).
2. **Semi-intensive green roofs:** Semi-intensive green roof systems include a richer, deeper substrate and drainage solution compared to extensive roofs, enabling use of a wider range of complex plant mixtures. Semi-intensive roofs are generally used within highly visible area's to improve aesthetic design using small shrubs,

forbs, and grasses. They require a higher level of maintenance compared to extensive roofs, due to the vegetation, and substrates used (WEB-1: *Green Roofers Ltd*).

3. **Biodiverse green roofs:** Biodiverse roofs are used primarily for their ecological benefits. They contain a range of recycled materials including rubble, gravel, rubber, or logs to encourage habitation of wildlife such as bees, and small insects. These are sometimes referred to as "brown roofs". They help to support the environment, and can be seen to aid planning applications to help local authorities policies towards building a sustainable environment (WEB-1: *Green Roofers Ltd*).
4. **Extensive green roofs:** Extensive green roofs provide a light-weight, low maintenance, instant 'green effect' roof solution, and are the most common type of green roof we supply. Extensive green roofs are not usually intended for general public access, and are chosen mostly for their ecological benefits. Typically, extensive roofs use a Sedum vegetation due to it's ability to flourish in harsh environments, cost effective, and lightweight system requirements. Extensive green roofs can be designed into new buildings, or 'retro-fitted' onto existing buildings (WEB-1: *Green Roofers Ltd*).

Benefits of green roofs:

There are various reasons why most people want to pursue a green roofing system, both for the home and the community. **Community Benefits Include:**

1. **Creates an Aesthetic Look:** It provides an aesthetic look to urban communities. Urban greening promotes an effective and easy strategy in beautifying the newly-built environment and increases investment opportunities (Jackson, Ch., 2021).
2. **Improves Heat Production:** A green roof improves the overall heat produced by the building structures in urban settings, covering different surfaces that will generate more warmth (Jackson, Ch., 2021).
3. **Prevents Pollution:** The plants in the green roof helps to prevent dust and smog distribution and catch pollutants found in the air (Jackson, Ch., 2021).
4. **Reduces Stormwater:** It minimizes the need to manage stormwater that accumulates and the stress put on local sewer systems (Jackson, Ch., 2021).
5. **Increases Revenue:** The amount of money and work required when constructing a green roof can create or increase revenue and jobs in local businesses (Jackson, Ch., 2021).

A green roof for a solar house and a green roof for a solar building are similar in many ways. Both types of green roofs can provide insulation, water management, and improved air quality. However, there may be some differences in terms of design, maintenance, and overall purpose.

A green roof for a solar house is typically smaller in scale and may be designed to complement the energy-efficient features of the house, such as solar panels. It may be used to provide additional insulation, shading, and aesthetic appeal.

A green roof for a solar building, on the other hand, may be larger in scale and may be used to achieve specific sustainability goals, such as reducing the building's overall energy consumption or improving stormwater management. It may also be used to provide additional space for recreational activities, such as gardening or outdoor seating.

Additionally, a green roof for a solar building may require more maintenance and have different safety considerations due to the size and accessibility.

Overall, the main difference between a green roof for a solar house and a green roof for a solar building is the size, scale and purpose of the building they are installed on.

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