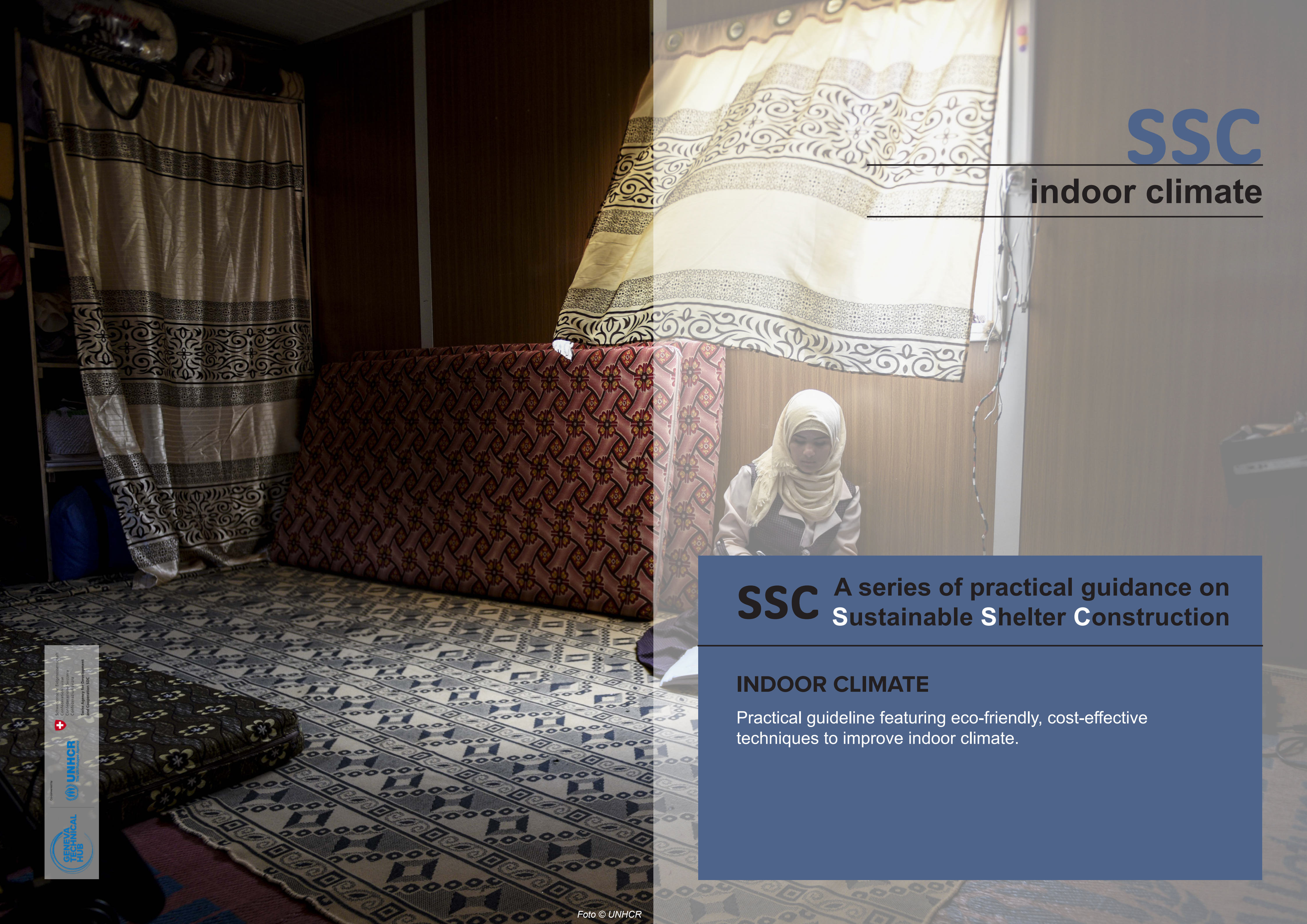

SSC

indoor climate

SSC A series of practical guidance on **S**ustainable **S**helter **C**onstruction

INDOOR CLIMATE

Practical guideline featuring eco-friendly, cost-effective techniques to improve indoor climate.

GENEVA TECHNICAL HUB
Co-convened by
UNHCR The UN Refugee Agency
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Swiss Agency for Development and Cooperation SDC

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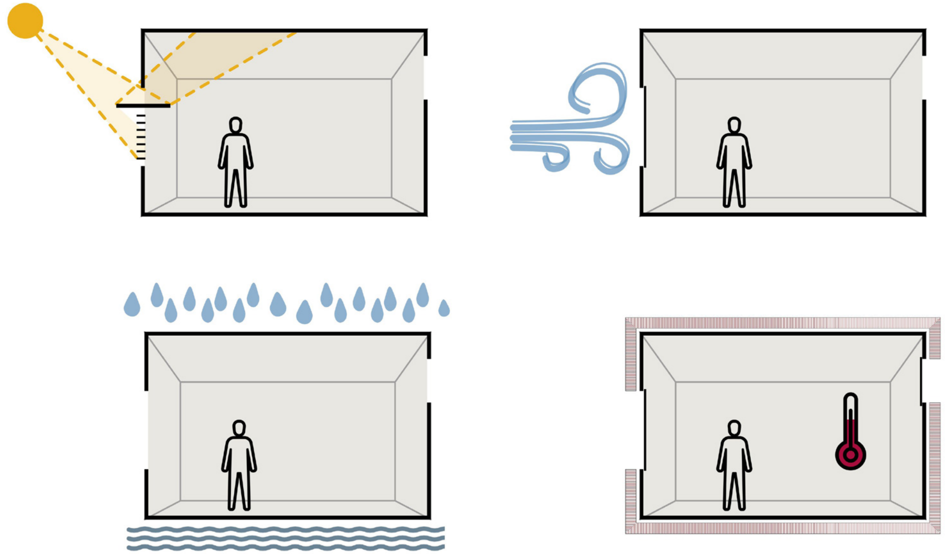
01 | Introduction

A well-considered indoor climate is fundamental for ensuring that shelter occupants experience a comfortable and healthy living environment. The design of a building should account for a range of elements that collectively determine the indoor climate, including:

- **the air temperature**
- **the humidity of the air**
- **the composition of the air**
- **air circulation**
- **the surface temperature of the walls and furnishings and the**
- **lighting of the room.**

These factors interact in ways that directly influence occupant comfort, health, and the overall performance of a shelter. Designers and builders must acknowledge that while outdoor conditions are beyond control, a well-planned shelter can mediate these effects to maintain a stable and safe indoor environment. By managing these key factors, it is possible to reduce stress on residents and prevent potential health issues. This document provides clear, practical guidance on integrating these essential elements into shelter design, ensuring that indoor spaces are not only comfortable and efficient but also sustainable over the long term. The objective is to support well-informed decisions in the construction process and contribute to an improved quality of life for shelter inhabitants. Practical design choices lead to measurable benefits.

02 Outdoor Climate



Elements that influences indoor climate

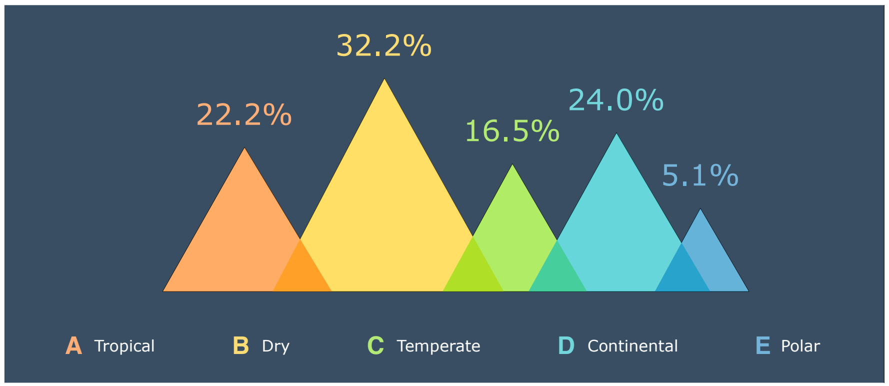
Climat Classification

A shelter in a **tropical** climate must be able to deal primarily with high temperature, humidity and withstand heavy rains.

The basic need in hot and **dry** climates is protection from the sun and heat and the removal of hot air from the shelter.

A shelter in the **continental** climate must prevent heat loss as efficiently as possible in winter, but also guarantee good ventilation in warm or hot temperatures.

In the **polar** climate, it is almost exclusively about preventing heat loss.



Climate classification according Köppen

Elements that collectively determine the indoor climate

The main factors affecting shelter are sun and heat, wind, precipitation and heat loss in cold temperatures.

Sun and heat: Direct sunlight increases indoor temperatures and causes overheating. Shading, ventilation and appropriate materials help to balance the indoor environment in warm conditions.

Wind: High winds cause structural damage and increase heat loss. Wind-resistant materials, strategic orientation and barriers such as vegetation reduce wind exposure and improve stability.

Precipitation – Rain and snow can damage shelters. Waterproof materials, sloped roofs and drainage systems prevent water and mold ingress and ensure durability and comfort.

Heat loss – In cold climates, insulation, airtight construction and efficient heating are essential. Well-insulated doors, windows and walls minimize energy consumption and ensure comfort.

03 Natural Lighting

Some recommendations for natural lighting:

- **Window Size and Quantity:** Adapt the size and number of windows to the outdoor climate and the specific needs of the occupants.
- **Window-to-Floor Ratio:** Ensure window areas are approximately 10% of the total floor area for balanced natural lighting.
- **Daylight Control:** Utilize blinds and shutters in hot climates to manage light and reduce heat gain.
- **Traditional Design Insights:** Learn from traditional building practices to address challenges related to window placement and exposure.
- **Reflective Surfaces:** Using light-colored walls, ceilings, and floors can help bounce daylight deeper into the interior space, reducing reliance on artificial lighting.
- **Windows Orientation:** The orientation of windows affects the intensity and duration of daylight, with south-facing windows receiving more consistent sunlight in many climates.
- **Use of Translucent Materials:** Translucent materials for curtains or partitions can allow light to spread while maintaining privacy.

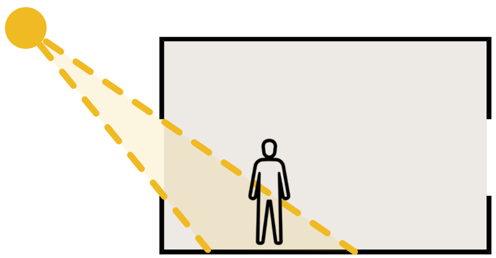
Natural Lighting: A Key to Health and Learning

Adequate lighting, including access to daylight, are among the basic elements required to ensure the health and well-being of shelter inhabitants. Daylight is inseparably linked to the energy demand and the indoor climate of a shelter. The size and placement of window openings should be determined based on adequacy needs and security concerns.

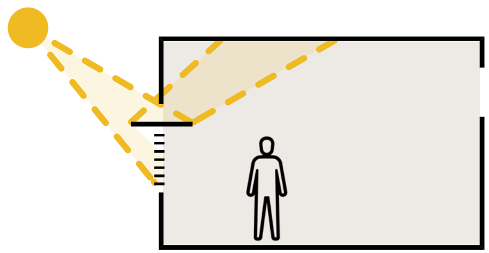
Adequate lighting conditions indoors do not only contribute to the health and well being of the habitants, they also ensure a living space that can enhance the learning potential of school-age children and provide a space adequate to perform specific livelihood activities.

Controlling Daylight

Effective daylight control is essential for maintaining comfort, energy efficiency, and security in living spaces. By using various shading strategies and tools, natural light can be optimized while minimizing heat, glare, and other environmental challenges.



Daylight **admission** desired



Daylight **control** desired

04 Shading

Foto © UNHCR

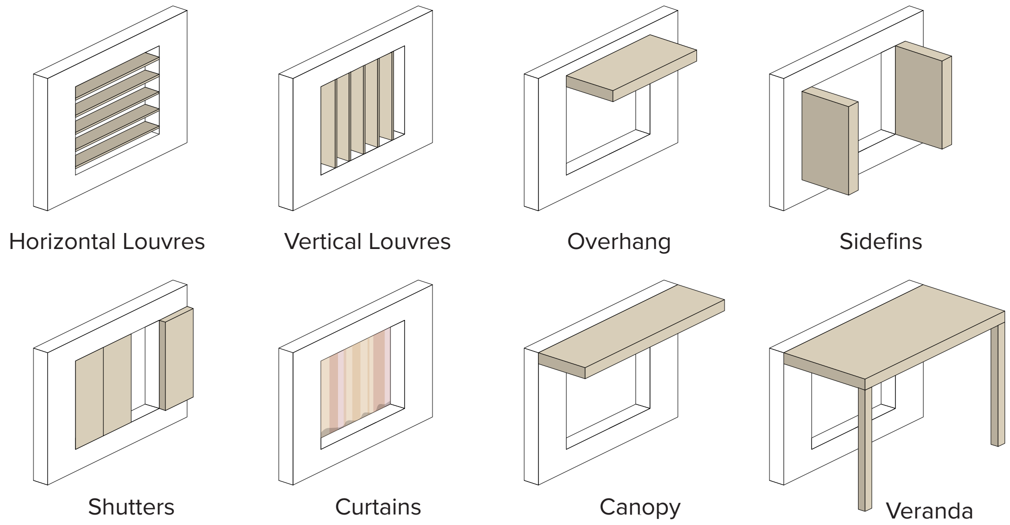
Effective Shading Strategies

Regulating sunlight through adequate shading is essential for maintaining a comfortable and healthy indoor environment, particularly in shelters. Direct sunlight can cause overheating, glare, and excessive brightness, leading to discomfort and reduced productivity. Shading devices such as horizontal or vertical louvres, overhangs, and side fins can help control the amount and angle of sunlight entering a space, thereby improving indoor climate conditions.

These shading solutions not only enhance thermal comfort by reducing heat gain but also create a balanced daylight distribution, reducing the need for artificial lighting during the day. Additionally, features like shutters and curtains provide flexibility to adjust lighting and privacy based on varying needs. Implementing canopies or verandas can offer outdoor shaded areas for social activities, extending usable living space.

Effective shading strategies contribute significantly to the overall well-being and energy efficiency of shelters, creating environments conducive to rest, learning, and livelihood activities.

Some recommendations for natural lighting:



Horizontal and Vertical Louvres

Louvres reduce solar radiation and help control internal temperatures by limiting direct sunlight. Depending on their design, they can also serve as protection against break-ins. Adjustable louvres offer flexibility in controlling light and ventilation, thus improving comfort and energy efficiency.

Overhangs and Sidefins

Overhangs and sidefins provide permanent shading from above or to the side, reducing heat and glare. They help control the amount of sunlight coming in, keeping spaces cooler while still allowing in daylight, making them ideal for hot climates.

Shutters

Shutters provide shade and excellent protection against break-ins. They can also insulate against heat or cold, improving energy efficiency. They can be adjusted to control privacy and light, and are practical in a range of climates.

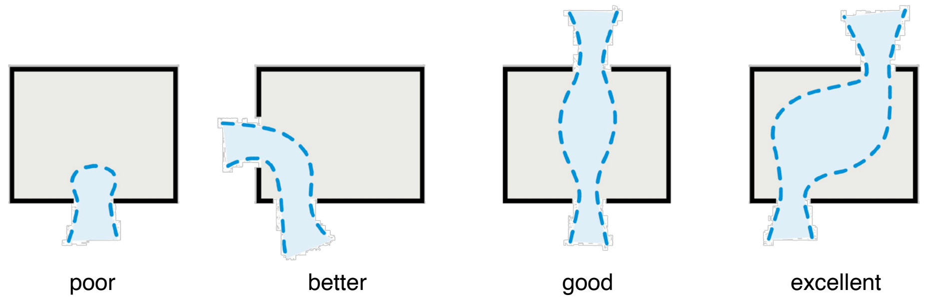
Curtains

Inexpensive, practical and versatile. Curtains block sunlight, provide privacy and allow air circulation, making them a simple yet effective way to control light and maintain comfort.

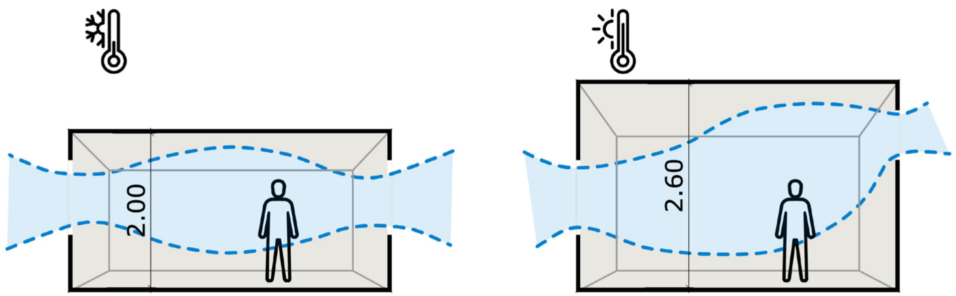
Canopy and Veranda

Canopies and verandas provide constant shade and protect the building from weather conditions such as humidity. They also help to reduce solar radiation, keeping the interior cool while expanding the living space outdoors.

05 Natural Ventilation



- If the space has only one facade exposed to the exterior, it is preferred to provide at least 2 windows on the facade.
- Two windows in two adjacent facades, resulting in a better but still low air exchange rate.
- Windows in opposite facades give a good cross ventilation.
- The windows should rather be staggered than aligned to change the air in the entire shelter.



Effective Natural Ventilation

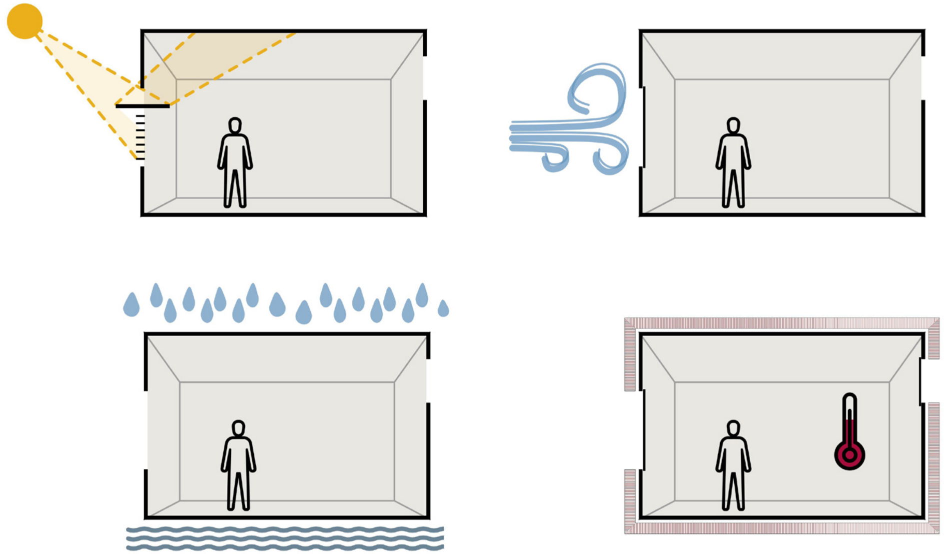
Natural ventilation is essential for maintaining a healthy indoor environment as it promotes air circulation and ensures a constant supply of fresh oxygen. Effective ventilation helps prevent condensation, which can damage structures and foster mold growth, posing serious health risks. It also mitigates the spread of airborne diseases and reduces the buildup of harmful smoke and gases, which can lead to respiratory problems.

Design strategies for ventilation include the placement of windows on opposite facades to create cross-ventilation. If only one facade is exposed, installing at least two windows improves airflow. The staggered positioning of windows rather than aligning them promotes better air exchange throughout the space. Openings should comprise **at least 5% of the floor area** for adequate air movement, with a recommended air change of 35 m^3 per hour per person. Upper vents facilitate the release of warm air, particularly in tropical climates, ensuring optimal comfort and air quality indoors.

- With regards to natural ventilation, it is recommended that the surface of all window openings should be more than 5% of the surface of the floor area.
- A minimum air change of 35 m3/ hr per person to ensure internal comfort.
- In cold climates, it is important to ensure the gases and fumes caused by heating stoves are properly released from the shelter.
- The Sphere Standards recommend at least 2 meters floor to ceiling height at the hi-ghest point of the shelter (2.6 meters in warm climates).
- Upper vent openings will allow the warm air to escape outside, which isespecially rele-vant in warm/tropical climates.

06 Thermal Comfort

Foto © UNHCR



Thermal comfort simply means being able to protect oneself against the influences of the external climate and to adequately control the natural elements entering the shelter.

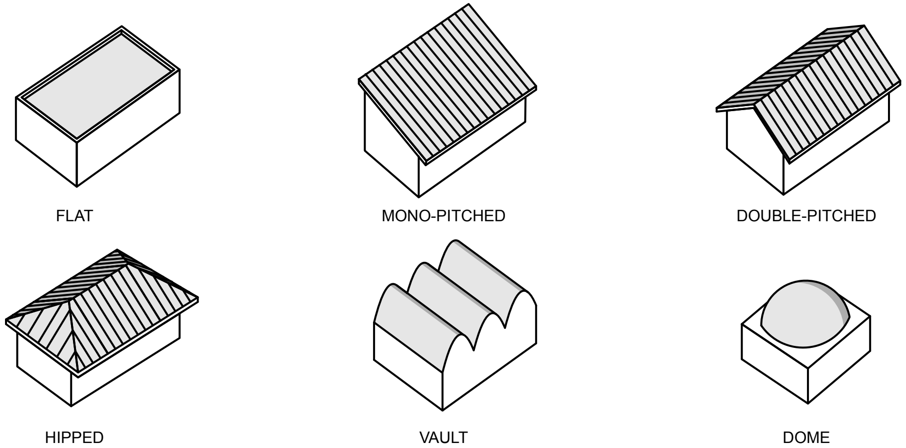
Achieving Optimal Thermal Comfort

When thermal comfort in a shelter is adequate, inhabitants feel physically comfortable as they remain **warm or cool, dry, and well-protected from the elements**. Thermal comfort significantly impacts overall health, safety, and productivity. Several factors influence this balance, including air temperature, humidity, wind, clothing, activity level, and personal characteristics like age and gender.

The ideal indoor temperature in temperate climates is between 20 and 25°C, promoting a livable environment. In warmer regions, higher temperatures may still be acceptable, while in colder climates, shelter temperatures should not fall below 13°C to prevent discomfort and health risks. Adequate insulation reduces heat loss by convection, while controlled ventilation helps regulate humidity and indoor air quality. Wind can either cool or warm the body depending on its temperature and velocity. Proper clothing serves as insulation, minimizing heat exchange with the surroundings. Implementing sustainable solutions for heating, cooling, and ventilation ensures optimal thermal comfort and well-being.

Air temperature	Increases heat loss by convection High: too warm Low: too cold
Humidity	Reduces heat loss by evaporation High: wet skin and thus uncomfortable Low: dry skin
Wind	Depending on its temperature, it can induce heat gain or loss in the body. Wind velocity and movement, within tolerable limits, can alleviate thermal comfort.
Clothing	Insulation between the human body and environment. Higher the insulation value of clothing, less will the heat exchange with its surroundings.
Activity	The metabolism breaks down the energy from food. Only 20% is used by the body, the rest is released into the environment.
Age and gender	Metabolic rate of older people, children and women are lower than men. People who are ill also have low metabolic rates.

07 Roof and Walls



Resilient Roof and Wall Design

The design of roofs and walls plays a crucial role in creating comfortable and energy-efficient spaces, especially in regions with extreme climatic conditions. Whether it's heat, cold or rain, the choice of roof type, wall structure and materials has a significant impact on a building's thermal performance and longevity. Flat, sloped and domed roofs each offer unique advantages based on environmental factors, while well-ventilated designs provide natural cooling and air circulation. Similarly, walls—through thickness, insulation, and surface treatment—can act as barriers to temperature extremes. By integrating shading, ventilation, and efficient materials, architects can optimize comfort and sustainability, and make buildings resilient to both hot and cold climates. In the following sections, we explore key roof types and wall strategies for various environmental challenges.

Flat Roofs

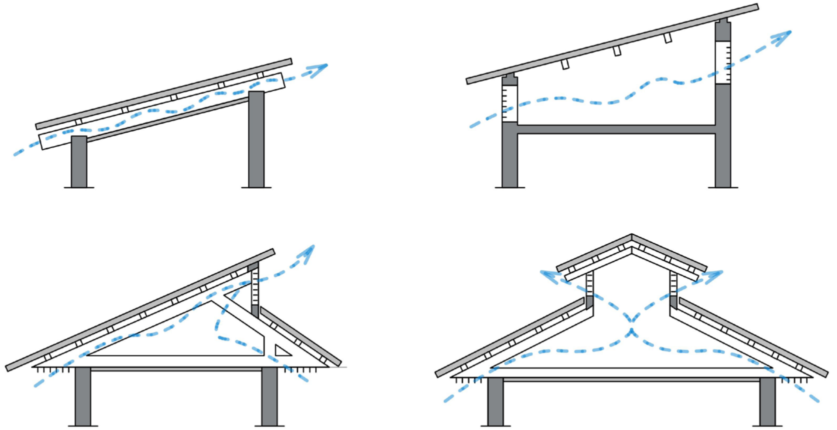
Flat roofs are practical and efficient in regions with limited rainfall. Due to their simple design, they are easier to build and maintain, especially in dry or arid environments. Flat roofs can also serve as versatile surfaces for additional functions, such as rooftop gardens or solar panel installations. Another advantage is that they effectively reflect sunlight, which helps to reduce heat absorption during the day and allows for efficient heat radiation at night, thereby maintaining comfortable indoor temperatures.

Pitched Roofs and Hipped Roofs

Gable roofs and hipped roofs are common in areas that receive a lot of rain or snow. Their sloped shape allows for efficient rainwater drainage, preventing water buildup and reducing the risk of leaks or structural damage. These roofs also provide shade for walls and windows, offering added protection from direct sunlight in hot climates. The additional attic or ceiling space under a gable roof can also be used for insulation, further improving energy efficiency.

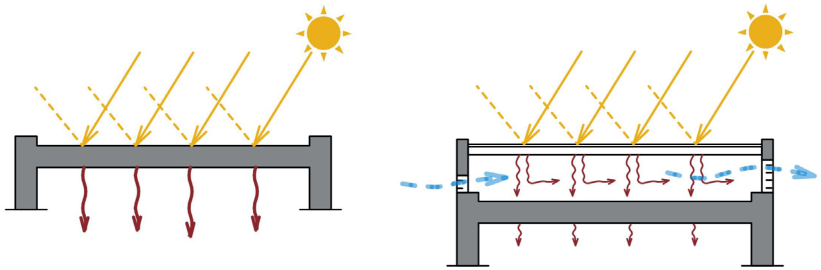
Curved Roofs

Curved roofs are well suited for regions with high direct solar radiation and minimal diffuse radiation, such as hot, dry areas. Their shape allows for better air circulation and ventilation, which helps to naturally cool the interior. Vaulted roofs also provide unique aesthetics while effectively reducing heat buildup inside the shelter. Their ability to reflect and disperse heat makes them an energy-efficient choice in extreme climates.



In **ventilated roofs**, the heat between the two skins is removed by the airflow crossing the roof space through openings facing the prevailing winds. The outlet opening should be larger than the opening for the inlet; they should also be placed at different heights in order to obtain air movement by the stack effect when the wind is not blowing. The heat load is reduced by ventilation in the daytime and rapid cooling is allowed at night.

A sloping roof with wall shading overhangs and a well-ventilated space between roof and ceiling is also an appropriate solution in areas with hot climate.

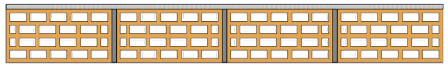


- Flat Roof is a good reflector and re-radiates heat effiiciently especially if it's made of a solid, white painted material.
- The performance of a flat roof can be improved by separating roof and ceiling with a ventilated cavity.
- If this technique is used, the material of the roof should be light in weight and the ceiling material should be massive (heavy).

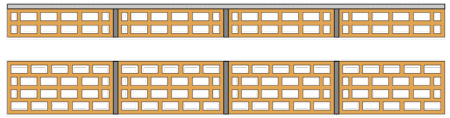
Wall Typologies

In both hot and dry and cold climates, thermal efficiency must be at the forefront of building design to ensure comfort and energy savings. Strategies such as thick walls with closed air spaces, light-colored plaster, cavity walls and solid thermal insulating materials significantly improve a building‘s ability to regulate temperature. These methods not only reduce heat transfer and energy demand, but also improve the stability of the internal temperature, providing effective solutions for extreme climates.

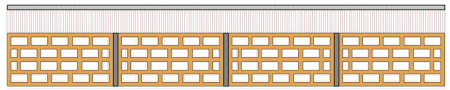
Bright plaster or painting



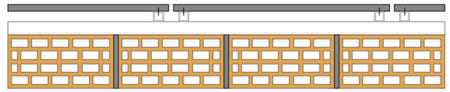
Cavity Wall



Fixed heat-insulating materials



Cavity Wall



For hot & dry and cold climates
The thicker the wall and the more enclosed air space it has, the better it performs in extreme climates. Thick walls act as thermal barriers, absorbing and releasing heat in hot climates, and retaining warmth in cold climates. Enclosed air pockets provide additional insulation, enhancing temperature stability indoors.

Bright plaster or painting
Bright-colored plaster or paint reflects sunlight and heat, reducing the amount absorbed by the building. This simple, cost-effective method keeps interiors cooler in hot climates and minimizes the need for artificial cooling.

Cavity wall
A cavity wall consists of two masonry layers with a gap in between, which acts as an insu-lating barrier. It helps reduce heat transfer, keeping the interior cooler in hot climates and retaining warmth in colder conditions. Insulating the cavity enhances its thermal efficiency.

Fixed heat-insulating materials
Adding insulation to the inside or outside of exposed walls improves thermal performance. External insulation prevents excessive heat or cold absorption, while internal insulation reduces heat loss, ensuring energy efficiency in both hot and cold climates.

Ventilated outer skin
A ventilated outer skin creates an air gap between the outer cladding and structure, allowing heat dissipation. Though more costly, this method efficiently regulates temperature, provi-ding long-term energy savings and improved comfort.

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