

# Enhancing Energy Efficiency in East African Municipalities

## MODULE 3

# AGENDA

**Objective:** share insights on the importance energy efficiency (EE) in buildings, potential actions for commercial buildings, building envelope, as well as energy management and audits for buildings

#	Minutes	Title	Speaker
3.1	20 min	The status quo and energy efficiency potential actions for commercial buildings	Clara Camarasa
3.2	20 min	Energy Efficiency - Building Envelope	Clara Camarasa
3.3	20 min	Energy Management and Audit for buildings	Rahul Raju
3.4	10 min	Q&A Session	Clara Camarasa, Rahul Raju

## Session 3.2. Energy Efficiency - Building Envelope

**Clara Camarasa, PhD**

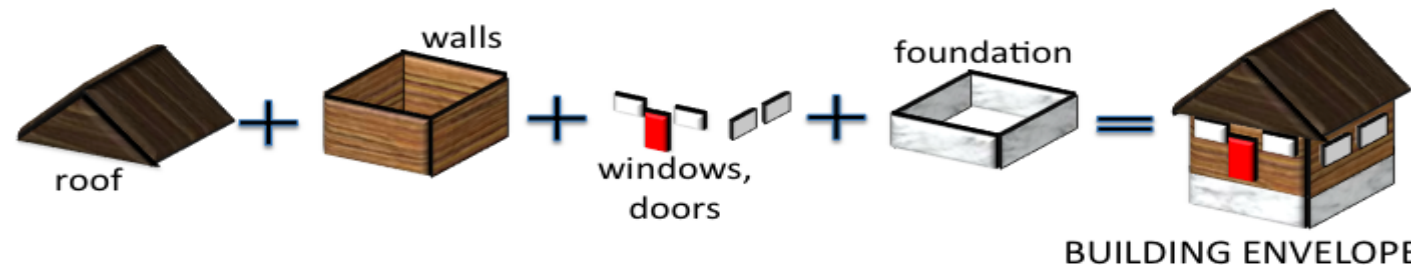
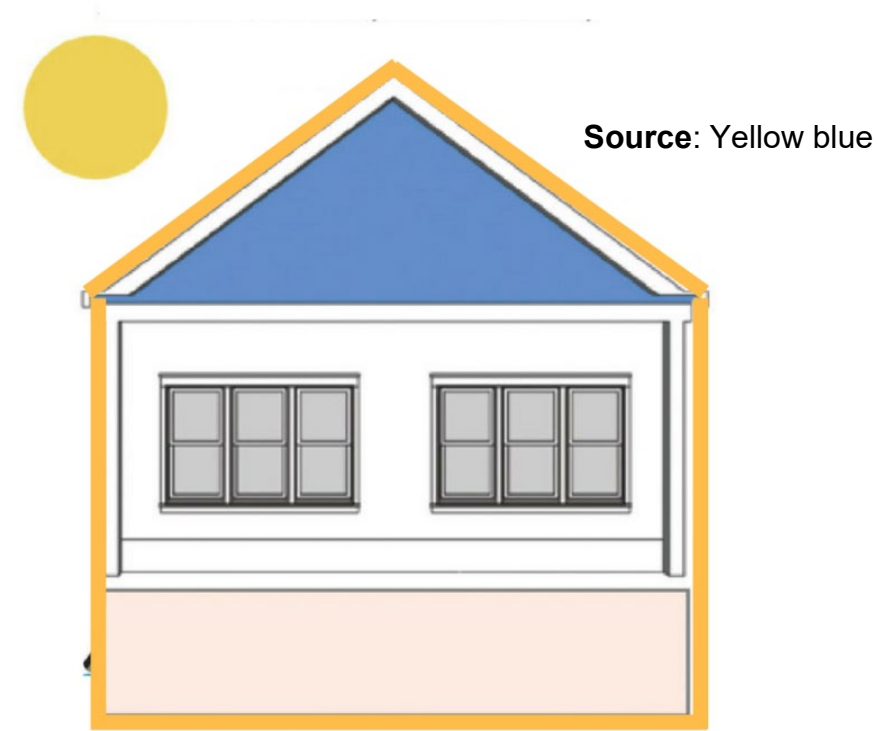
18 March 2021 | Copenhagen



**COPENHAGEN CENTRE  
ON ENERGY EFFICIENCY**  
SEforALL EE HUB

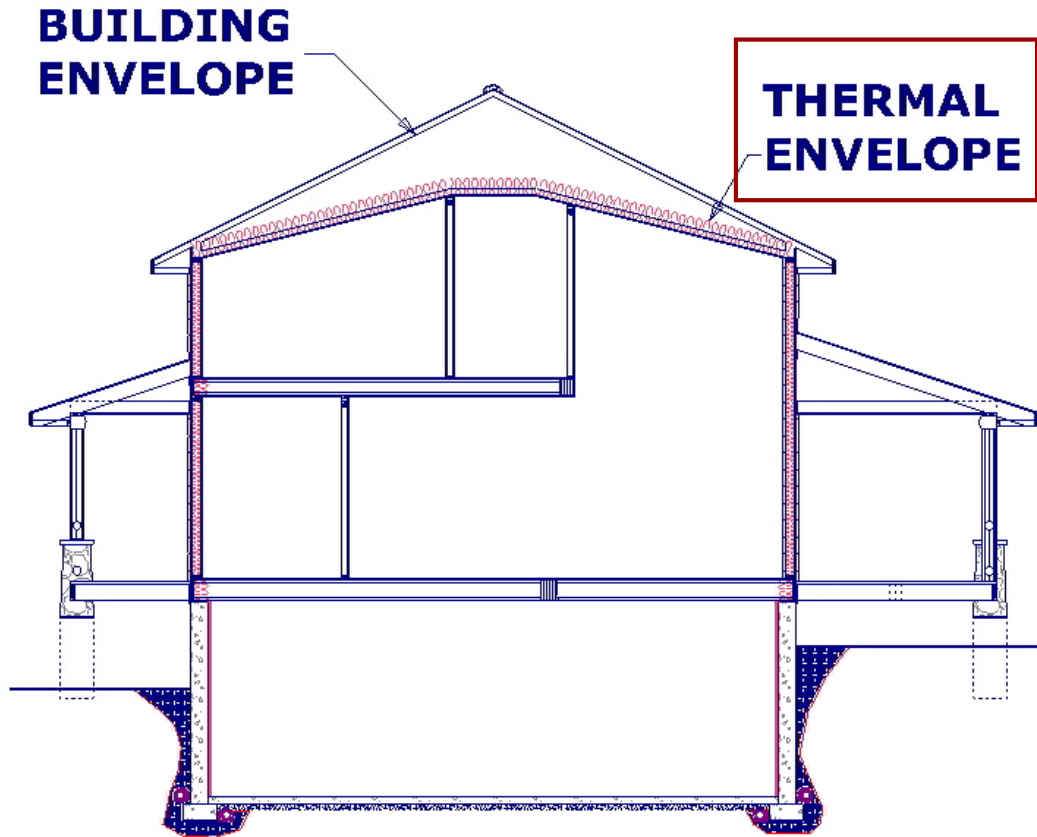
# DEFINITION OF BUILDING ENVELOPE

- The building envelope is the physical separator between the interior and exterior of a building.
- Components of the envelope are typically: walls, foundation floors, roofs, fenestrations and doors.
- Fenestrations are any opening in the structure: windows, skylights, etc.
- A building envelope functions can be divided into 3 categories:
  - Support: to ensure strength and rigidity; providing structural support against internal and external loads and forces.
  - Control: to control the exchange of water, air, condensation and heat between the interior and exterior of the building.
  - Finish: this is for aesthetic purposes. To make the building look attractive while still performing support and control functions.



# BUILDING ENVELOPE vs THERMAL ENVELOPE

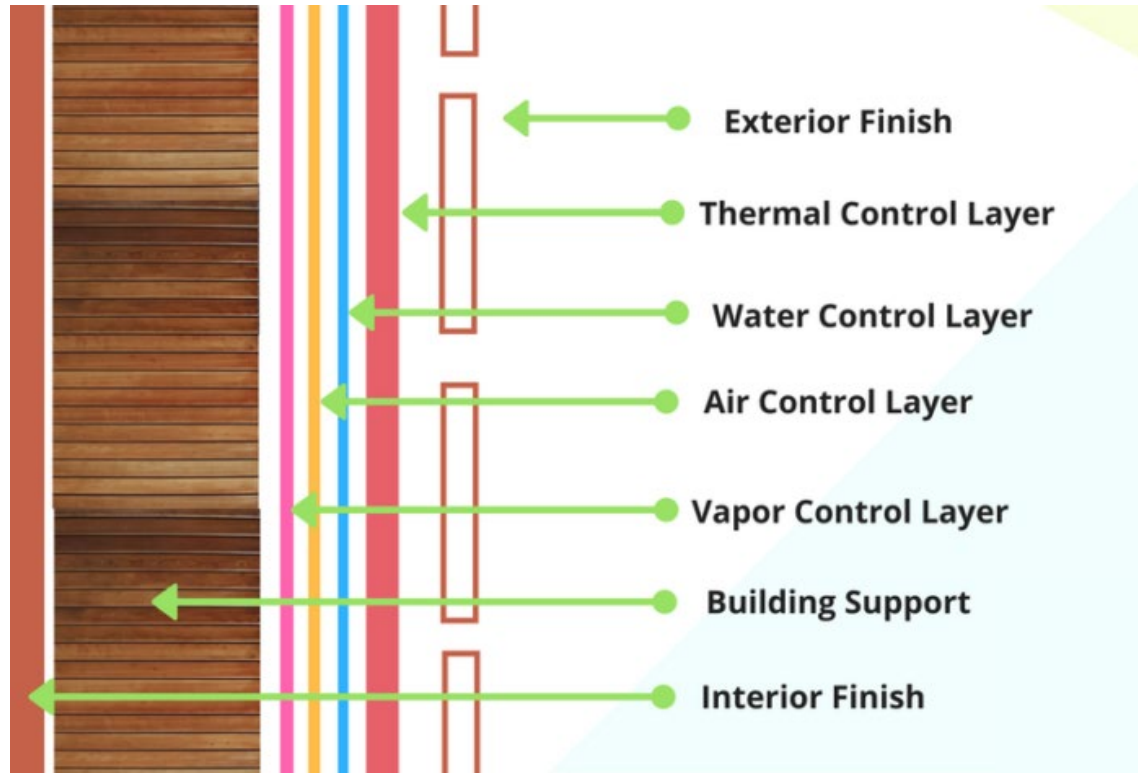
The “**building envelope**” is the **physical separator between the interior and exterior environment** of a buildings including air, water and heat, light and noise transfer.



The ‘**thermal envelope**’ of a building is **the union of those structures that separate the conditioned part** of the building (space heated and/or cooled) **from the outside** or from other parts of the building that are not conditioned.

**Source:** The Energy Efficient House

# BUILDING ENVELOPE LAYERS



Source: Yellow blue

- The envelope is a composition of layers with varying thermal and permeability properties.
- The choice of envelope is governed by the climate, culture, and available materials.
- In harsh climates, it is conceived as a closed shell and proceeds to selectively punch holes in it to make limited and special contact with the outdoors (also unwanted external influences such as noise or visual clutter).
- When external conditions are very close to the desired internal ones, the envelope often begins as an open structural frame



# ENVELOPES AND CLIMATE

A well-designed envelope responds to the local climate.

## Arid climate

- Thermal mass (thick walls)
- High ceilings
- Light colours
- Courtyards with natural ventilation



**Masdar City**  
Source: InHabitat

## Cold climate

- Thick insulation
- Air tightness
- Small windows
- Lifted from ground floor



**Swedish Cabin**  
Source: Sweden.se

## Tropical climate

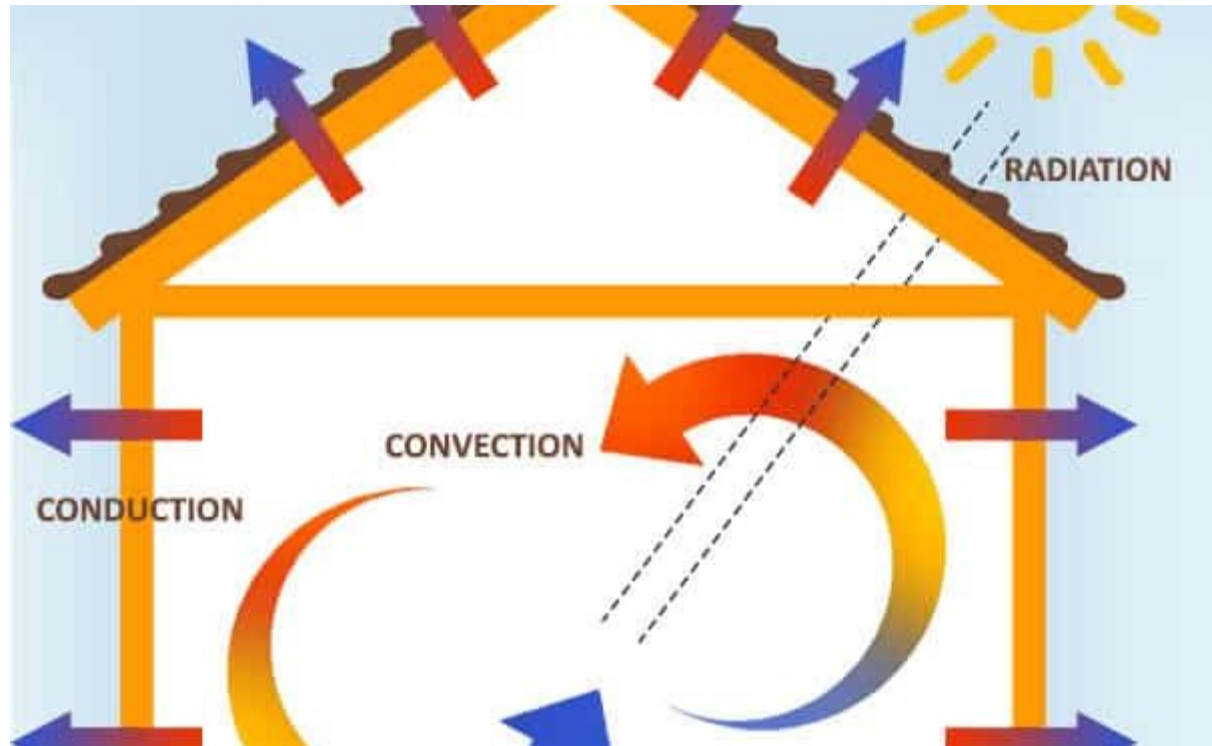
- Avoid solar radiation (e.g. overhangs)
- Maximize ventilation
- Light coloured
- Low mass materials to avoid condensation



**Educational Building in Mozambique**  
Source: ArchDaily

# HEAT TRANSFER: CONVECTION, CONDUCTION AND RADIATION

- **Convection** is the transfer of heat by moving air, like warm air rising to the ceiling.
- **Conduction** is the transfer of heat through a solid material, such as heat being transferred from warmer sections of walls and ceilings to cooler areas.

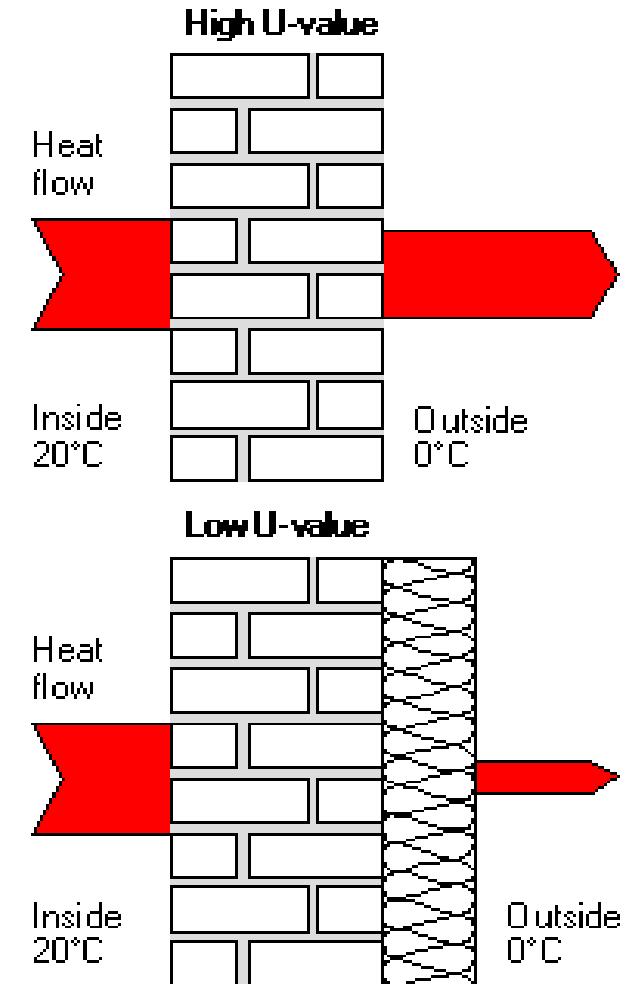


- **Radiation** is the transfer of heat in the form of electromagnetic waves, such as heat being transferred from the roof of a home to the ceiling.



# WALLS, INSULATION AND R-VALUES

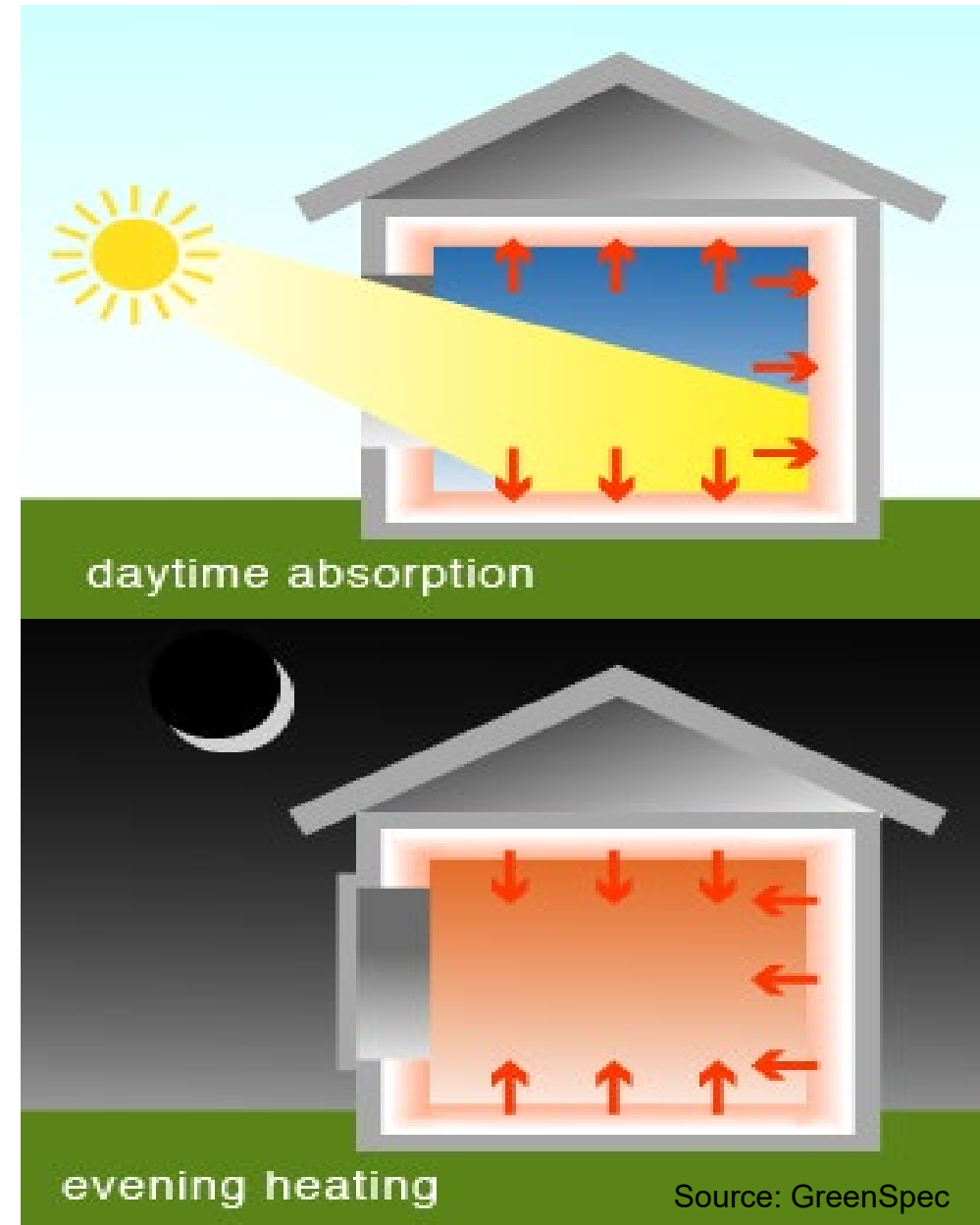
- Optimizing the heat transfer through the walls is important in high performance building design
- Both thermal mass and insulation with passive design strategies can reduce the amount of energy that active systems (e.g. HVAC) need to use.
- Resistance to conduction is measured by R-value (thermal resistance = high R-value)
- The insulating performance is measured by U-Value (Lower number = better insulation performance)
  - R-value and U-value are mathematical reciprocals (i.e.  $R\text{-value} = 1 \div U\text{-value}$ )



Source: Build Desk

# THERMAL MASS

- Thermal mass helps to reduce indoor temperature swings and often leads to reduction in the size of mechanical heating and cooling (HVAC) systems, which is one of the biggest sources of energy use and cost.
- The basic premise is simple: The thermal mass absorbs heat from the surrounding area when it is warm and re-radiates it back out thus cooling afterwards.
- Typically this means that the mass is absorbing heat during the daytime, helping to keep a space from overheating, and radiating at night, helping to keep a space appropriately warm.



Source: GreenSpec

# THERMAL PROPERTIES OF CONSTRUCTION MATERIALS

Building material	Specific heat capacity (J/kgK)	Density (kg/m3)	Effective heat capacity (Wh/m2K)
Water	4200	1000	175
Cast concrete	1000	2000	83.3
Concrete block, heavy (140mm depth)	840	2240	73.1
Calcium silicate block (100mm depth)	1000	1850	51.4
Brick	800	1750	42.4
Timber	1600	650	5.4
Ceramic tiles	800	1900	4.2
Wet plaster	1000	1330	3.7
Plasterboard	840	950	2.7

Source: GreenSpec



Insulations Source: EcoHome

# INSULATION MATERIALS

**1. Batting / Blankets:** In the form of batts or continuous rolls that are hand-cut or trimmed to fit. Stuffed into spaces between studs or joists.

**2. Blown-in/ Loose-Fill:** In the form of batts or continuous rolls that are hand-cut or trimmed to fit. Stuffed into spaces between studs or joists.

**3. Reflective:** Roll of foil, integrated into house wrap, or integrated into rigid insulation board. These "radiant barriers" are typically located between roof rafters, floor joists or wall studs.

**4. Foamed in Place :** Sprayed directly into cavities within the building, where it expands as it sets to fully seal the cavity, filling all nooks and crannies.

**5. Rigid board:** Plastic foams extruded into boards, or fibrous materials pressed into boards. Can also be moulded into pipe-coverings or other 3D shapes (e.g. window frames).

# GLAZING PROPERTIES

- Good glazing properties control the amount of daylight, quality of light, and amount of solar heat gain into the building.
- They also determine the thermal and visual comfort of a space.
- Some of the most important properties of windows are:
  1. Thermal conductance (U-value)
  2. Solar Heat Gain Coefficient (SHGC)
  3. Visible Light Transmittance ( $T_{vis}$ )
  4. Low shading coefficient (SC)
- Appropriate values for glazing properties vary by climate, size, and placement of the aperture.



Source: UnSplash



# WHAT MAKES AN EE WINDOW ?

## QUALITY FRAME MATERIALS

A variety of durable, low-maintenance framing materials reduce heat transfer and help insulate better.

## LOW-E GLASS

Special coatings reflect infrared light, keeping heat inside in winter and outside in summer. They also reflect damaging ultraviolet light, which helps protect interior furnishings from fading.

## GAS FILLS

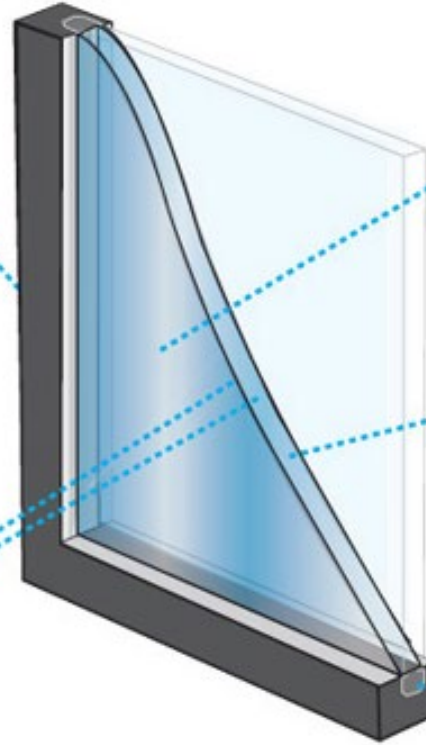
Some energy-efficient windows have argon, krypton, or other gases between the panes. These odorless, colorless, non-toxic gases insulate better than regular air.

## MULTIPLE PANES

Two panes of glass, with an air-or gas-filled space in the middle, insulate much better than a single pane of glass. Some ENERGY STAR qualified windows include three or more panes for even greater energy-efficiency, increased impact resistance, and sound insulation.

## WARM EDGE SPACERS

A spacer keeps a window's glass panes the correct distance apart. Non-metallic and metal/non-metal hybrid spacers also insulate pane edges, reducing heat transfer through the window.

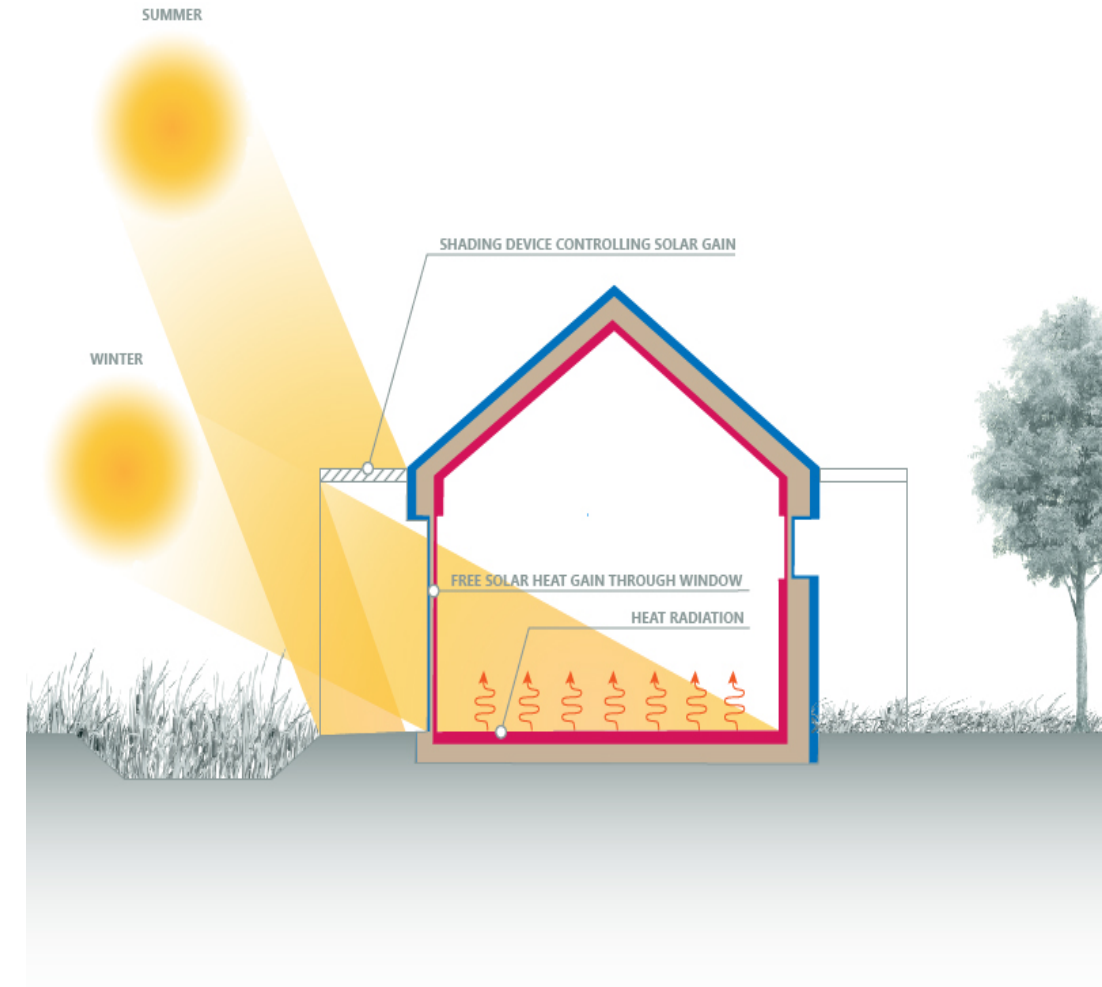


Source: EnergyStar



# SHADING AND/OR REDIRECTING SUNLIGHT

- Shading strategies include overhangs, louvers, and vertical fins.
- Light redirection strategies include light shelves and baffles.
- All of these strategies can be external to the building or internal, fixed position or adjustable.
- Some elements both shade and redirect light at the same time.
- Shades can keep the heat and glare of direct sun from coming through windows, while still allowing diffuse light and views to enter.
- They can also keep direct sunlight off of walls or roofs, to reduce cooling loads.



**Source:** Architecture by-nature

# SUN CONTROL AND SHADING DEVICES

## Tress and Hedge Rows



**Source:** Constructalia

## Exterior elements and overhangs



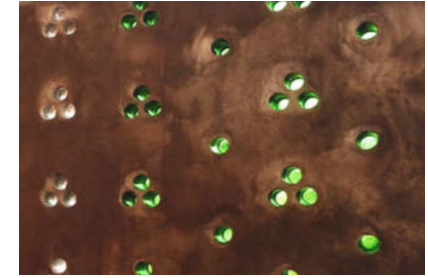
**Source:** WBDG

## Venetian blinds



**Source:** PTAC

# THE BUILDING AS A UNIQUE LONG-LASTING SYSTEM



Source: Architecture by-nature



# LETS RECAP – KEY IDEAS

- ✓ The building envelope is the physical separator between the interior
- ✓ The envelope is a composition of layers with varying thermal and permeability properties.
- ✓ For tropical climates main features are: avoid solar radiation (e.g. overhangs), maximize ventilation, light coloured surfaces and low mass materials to avoid condensation
- ✓ Optimizing the heat transfer through the walls is important in high performance building design
- ✓ EE Windows are; Quality of the frame materials, Multiple Panes, Low e-glass, Gas fills and Warm edge spacers
- ✓ To implement EE measures on the Building envelope:
  - ✓ All building elements of the system need to be taken into consideration – building as a system
  - ✓ There is no one recipe that can suit all buildings – weather conditions, use of the building, available resources (incl. budget) affect its selection



**Thank you for your attention**

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