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ELECTRICIDADE DE MOÇAMBIQUE, E.P.

Energy Efficiency – Building Envelope

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Copenhagen Centre on Energy Efficiency (C2E2)

24 November 2020 | Copenhagen

AGENDA

Objective: share insights on key terms and concepts of energy efficient (EE) building envelopes

#	Minutes	Title	Speaker
1	20 min	EE - Building envelope	Clara Camarasa
2	10 min	Q&A Session	Clara Camarasa

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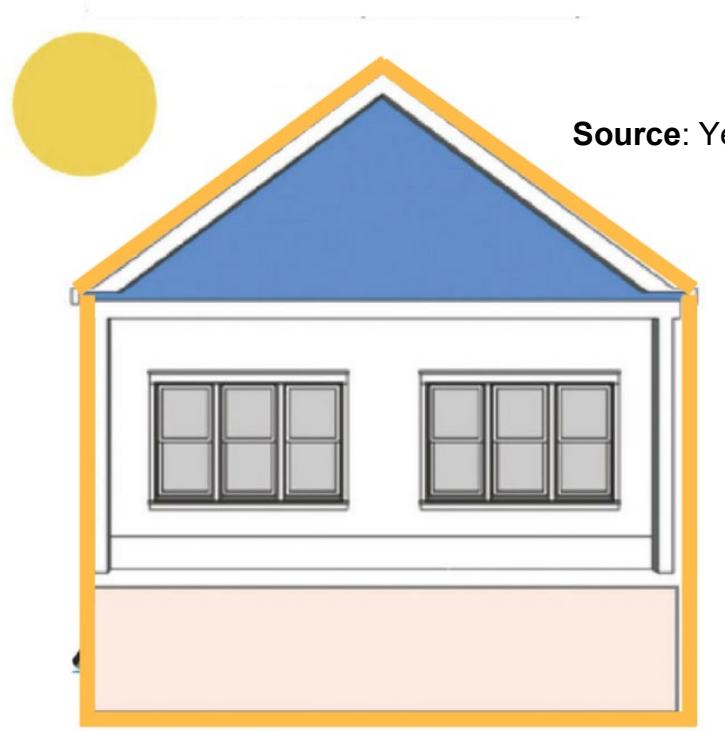
DEFINITION OF BUILDING ENVELOPE

- 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.

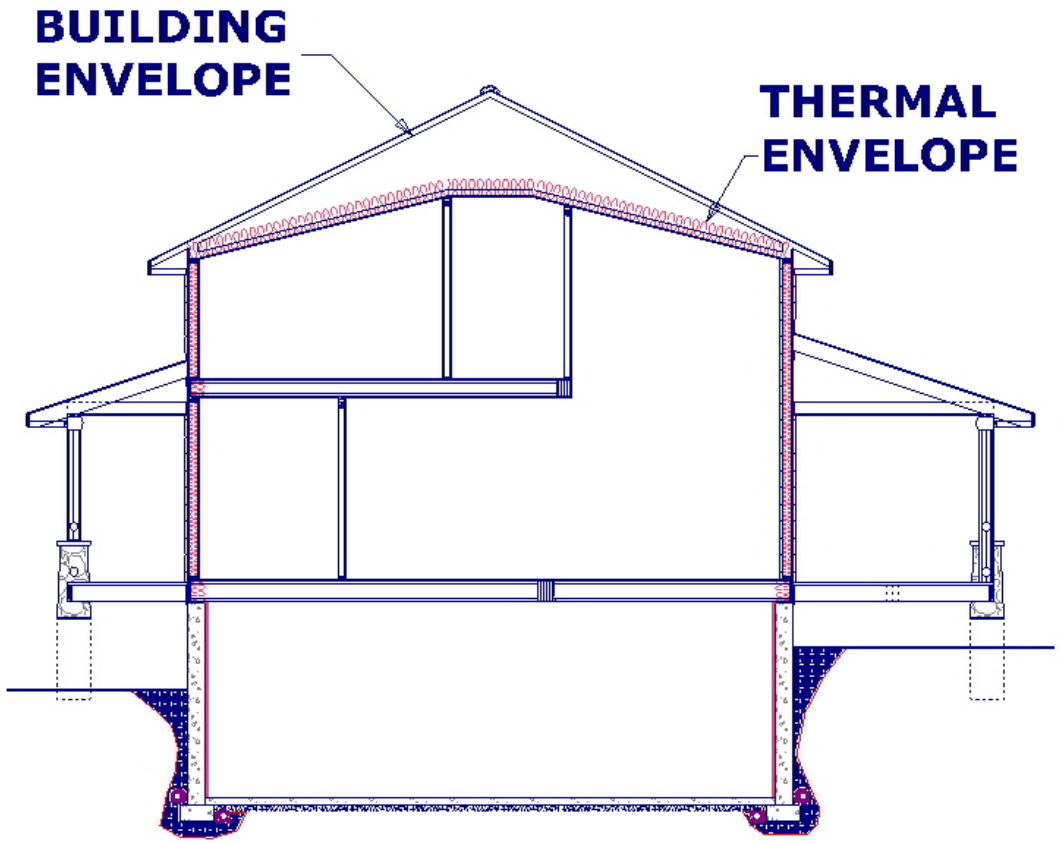
- A building envelope functions can be divided into 3 categories:
  - Support: to ensure strength and rigidity; providing structural support against internal and external loads and forces.
  - Control: to control the exchange of water, air, condensation and heat between the interior and exterior of the building.
  - Finish: this is for aesthetic purposes. To make the building look attractive while still performing support and control functions.



Source: Yellow blue

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.



Source: The Energy Efficient House

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.

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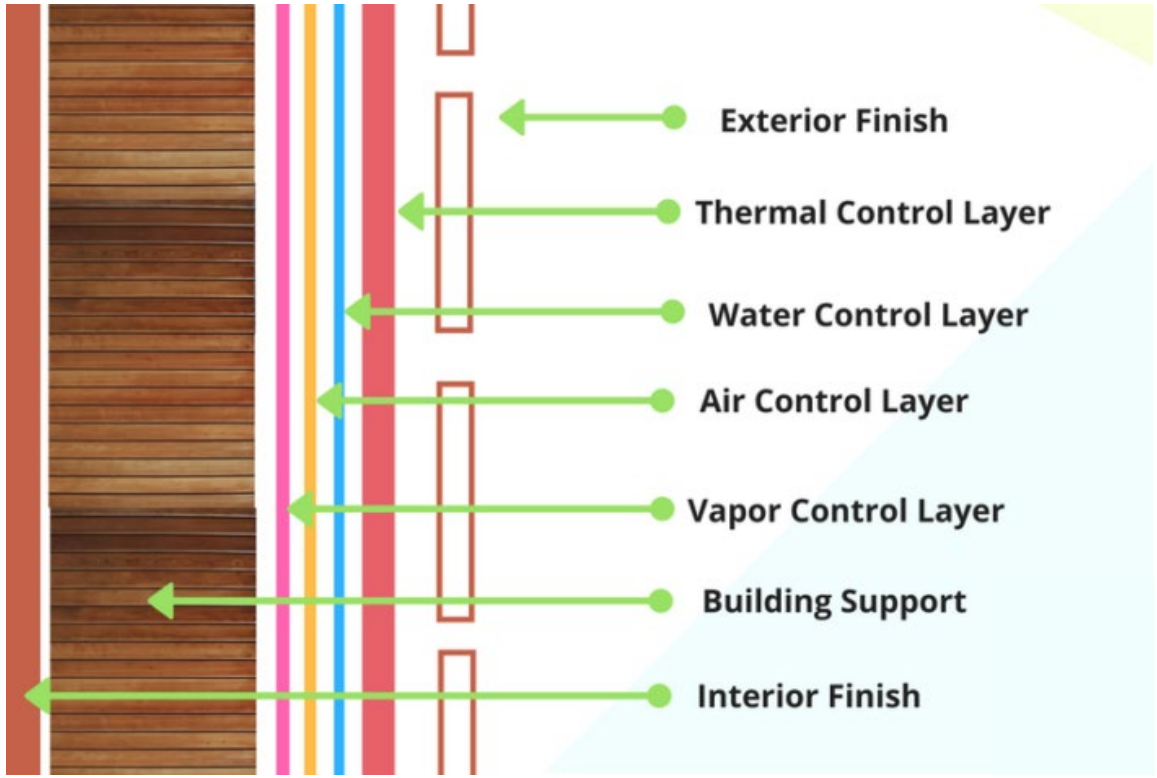
BUILDING ENVELOPE LAYERS



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

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ENVELOPE DESIGN FOR 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

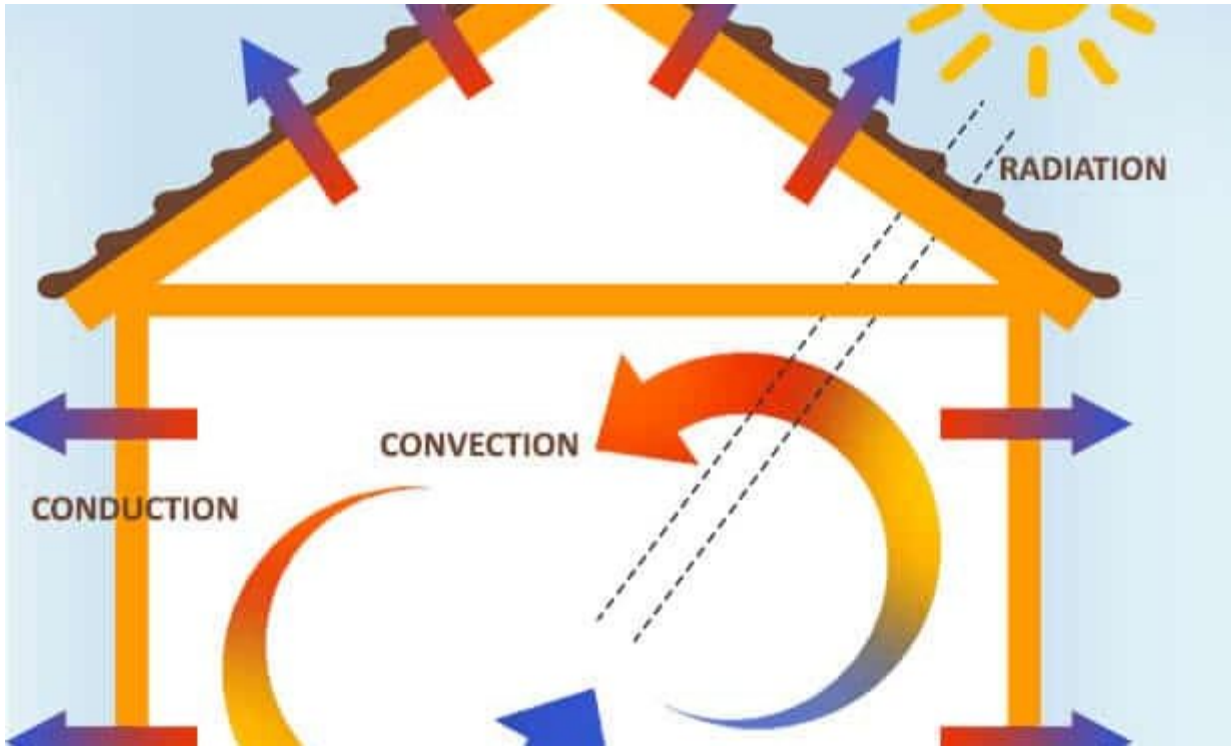
- Avoid solar radiation (e.g. overhangs)
- Maximize ventilation
- Light coloured
- Low mass materials to avoid condensation

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.

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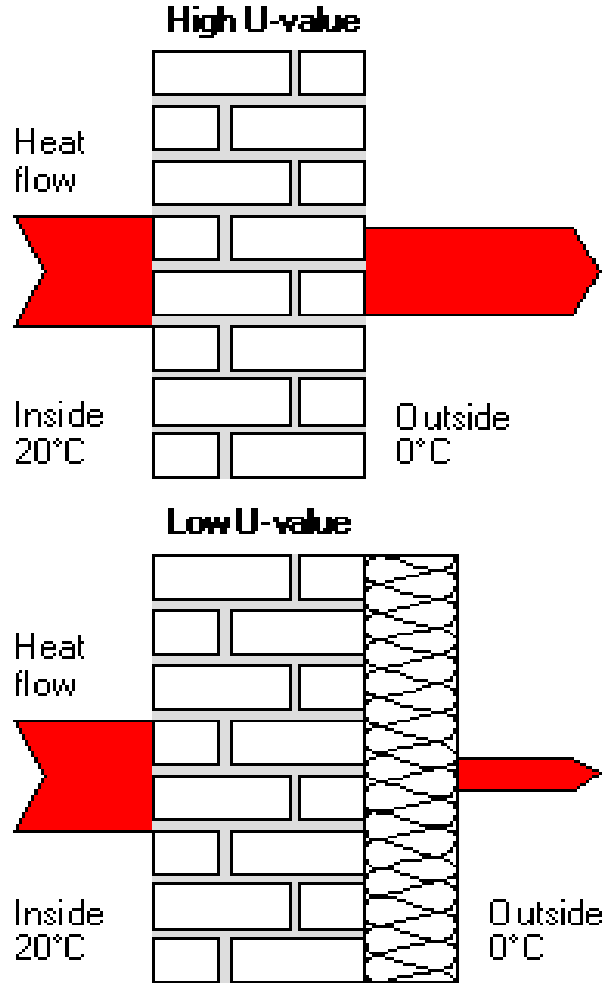
WALLS, INSULATION AND R-VALUES

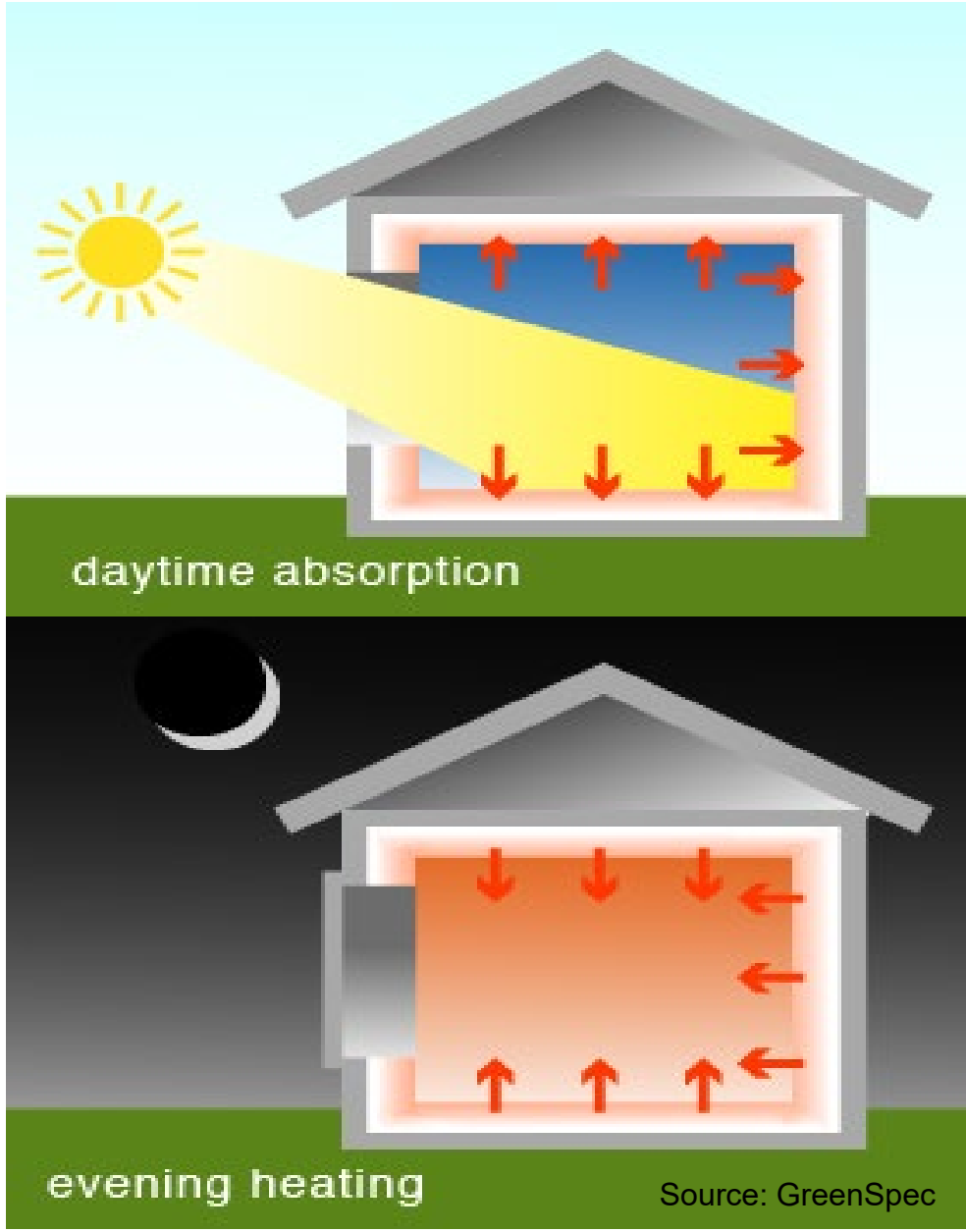
- Optimizing the heat transfer through the walls is important in high performance building design.
- Both thermal mass and insulation with passive design strategies can reduce the amount of energy that active systems (e.g. HVAC) need to use.
- Resistance to conduction is measured by R-value (thermal 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-value = 1 ÷ U-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

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INSULATION MATERIALS

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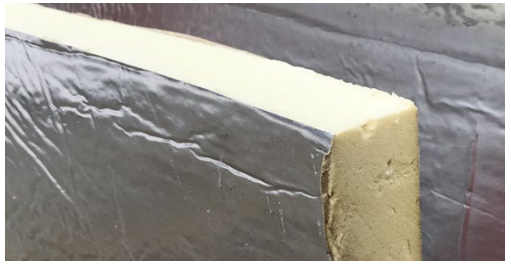

Insulations Source: EcoHome

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).

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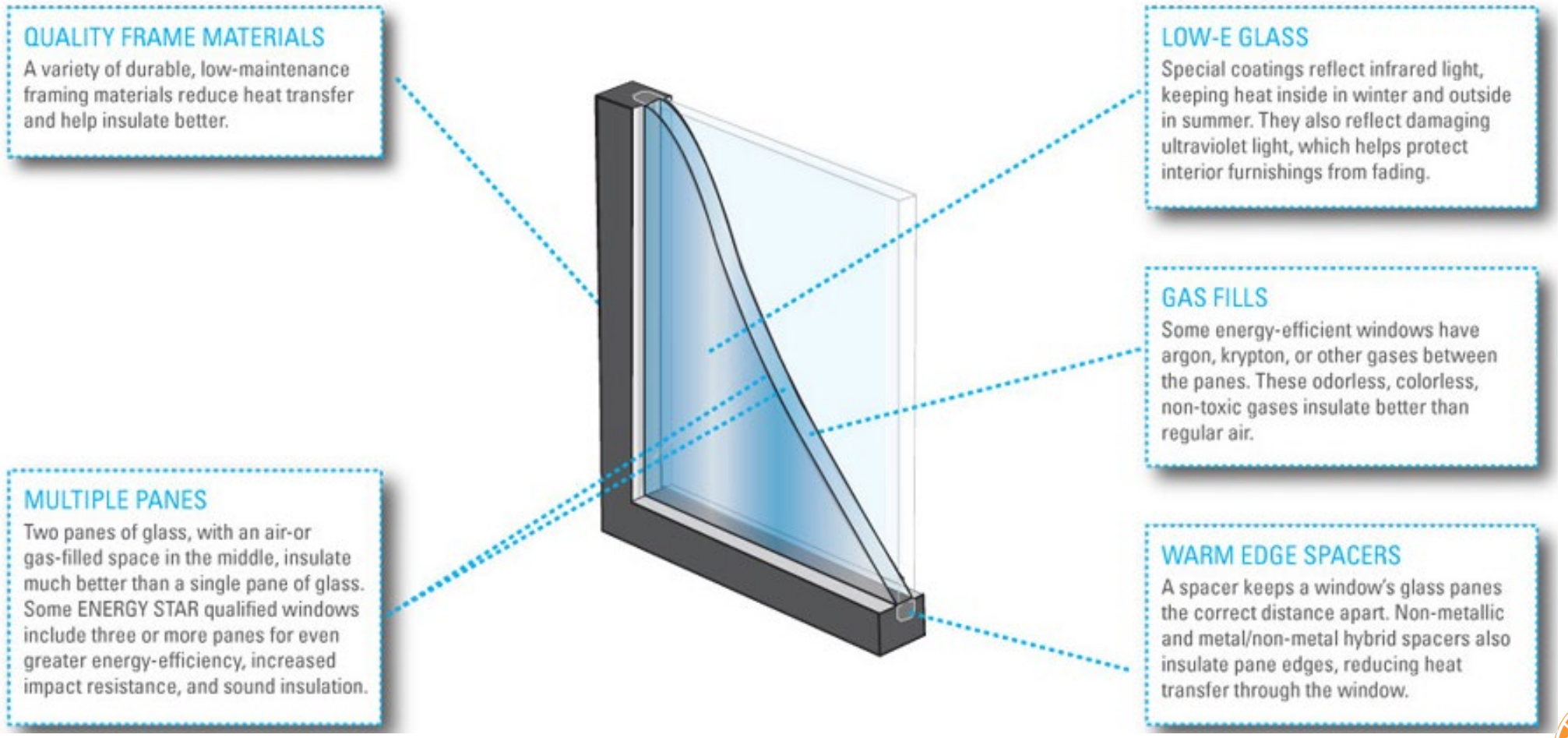
GLAZING PROPERTIES

- 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 (Tvis)
    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 ?



Source: EnergyStar

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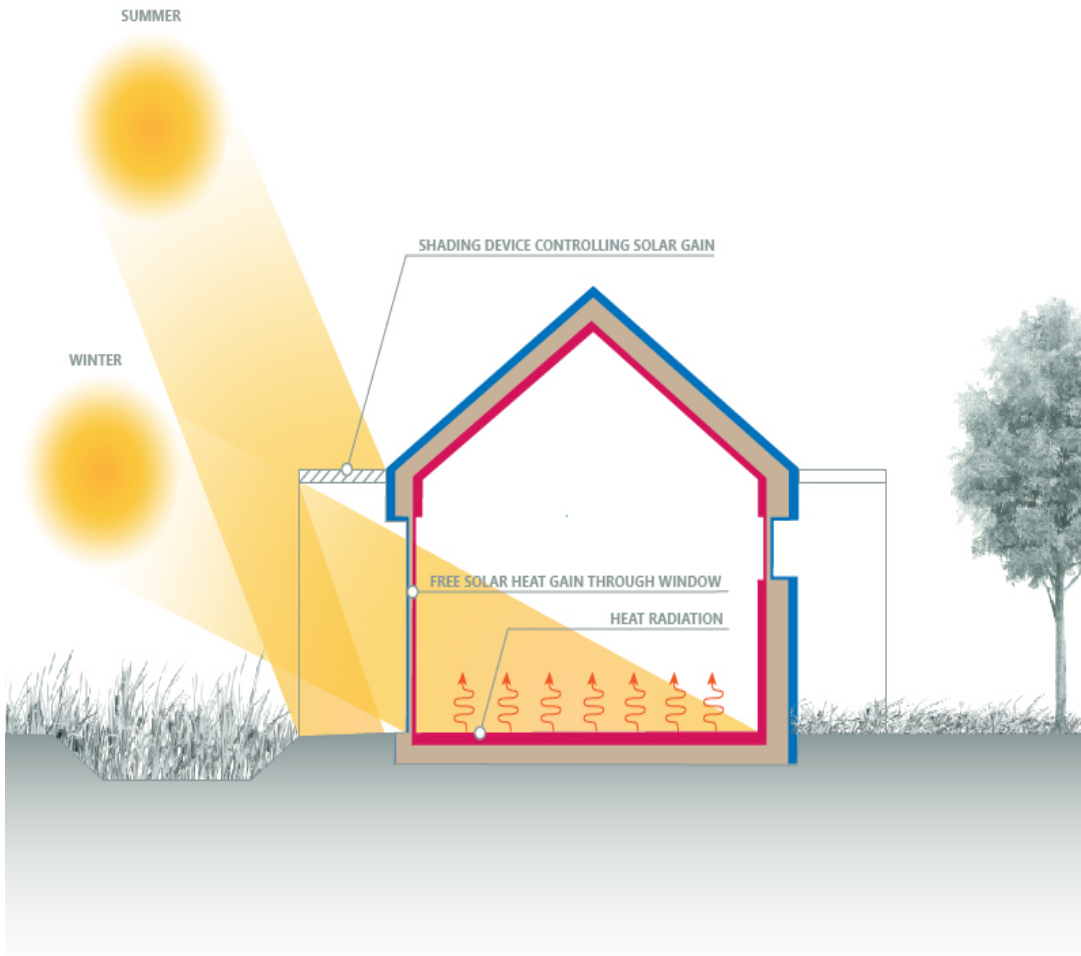
SHADING AND/OR REDIRECTING SUNLIGHT

- 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

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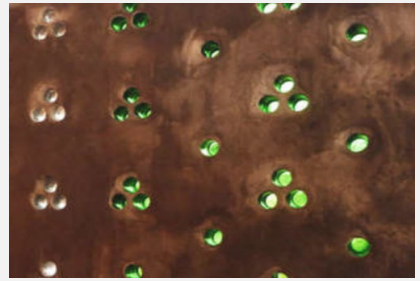
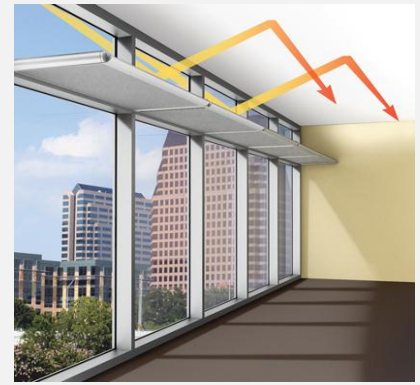
THE BUILDING AS A SYSTEM





Source: Architecture by-nature

Thank you for your attention

https://c2e2.unepdtu.org/

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Q&A Session

Clara Camarasa, C2E2

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