jOiNEd For sUsTainability - bUilding climate REsilient communities in WB and EU

Passive house design for sustainable structures

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Energy efficiency

Why is introduced ?

- Environmental pollution
- Climate changes
- Depletion of fossil reserves
- Huge energy demand and consumption

What is achieved ?

- Reduced energy consumption
- Reduced emission of greenhouse gases
- Increased participation in renewable energy sources
- Contribution to the set of goals for sustainable development

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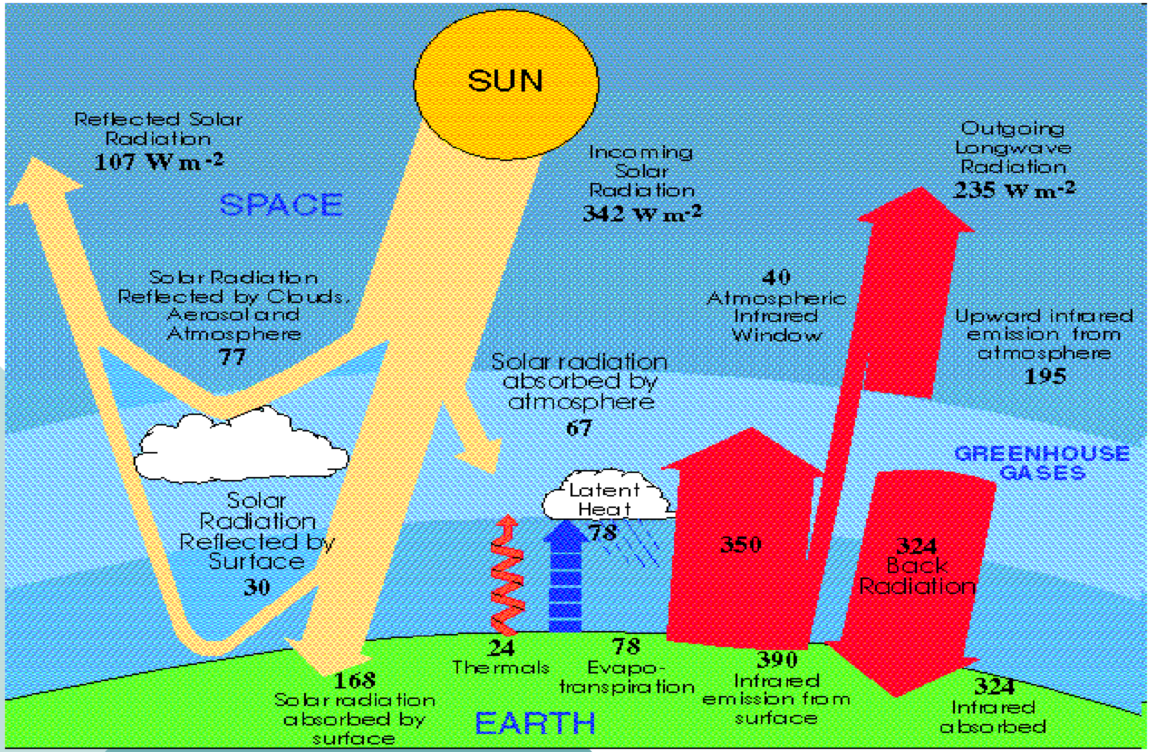
Energy efficiency

Reason: Environmental pollution (CO_2 emission)

Human activities contribute to increased concentration of **CO_2 in the atmosphere**



Effect: Climate changes (the greenhouse effect)

(melting of the polar ice)

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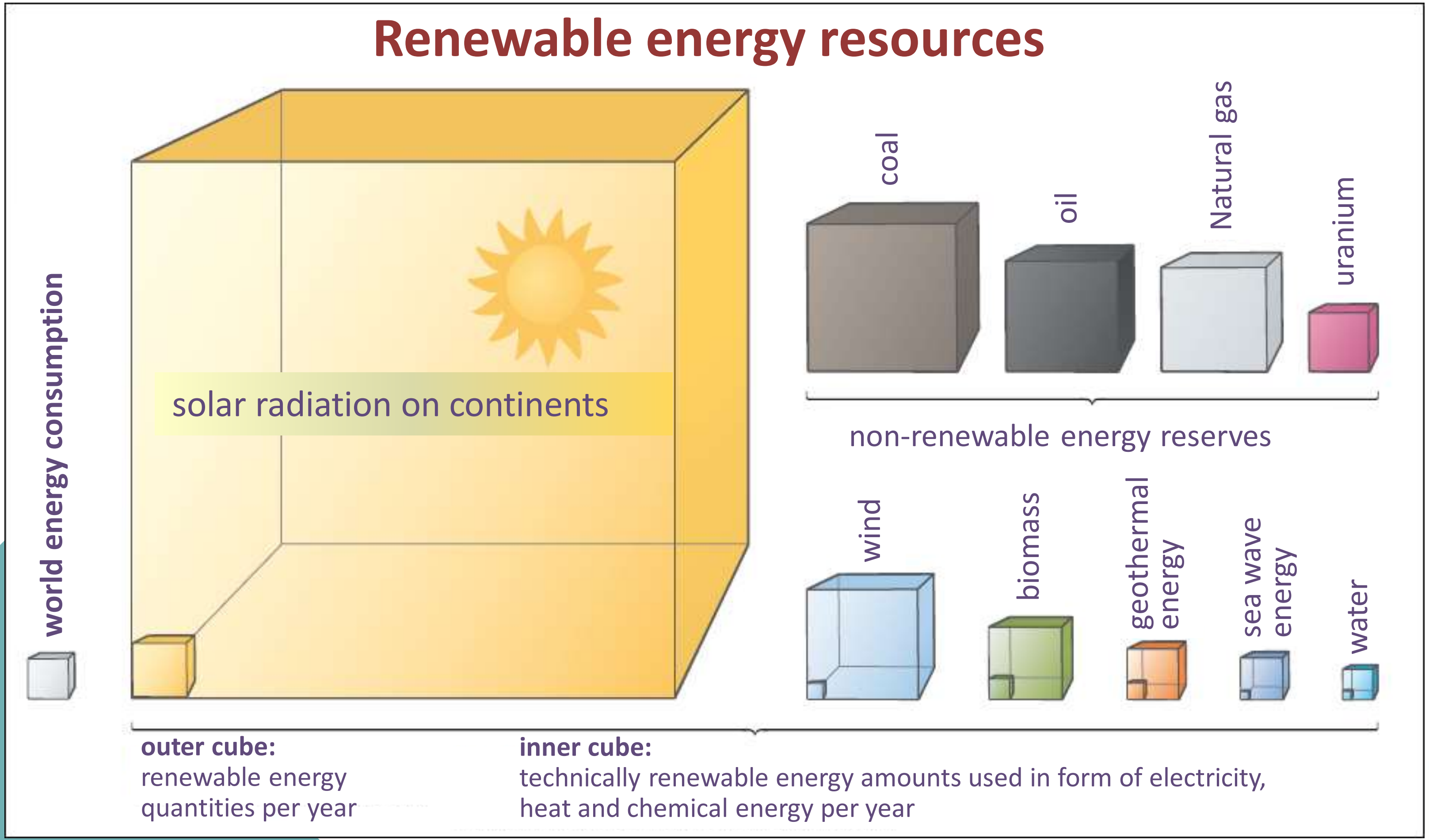
Energy efficiency

- **Depletion of fossil reserves**
- **Huge energy demand and consumption**



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IFUTURE

What is achieved ?

Contribution to set goals for sustainable development

What is sustainable development?

„ Sustainable development means meeting today's needs without compromising the ability of future generations to meet their own needs "

SUSTAINABILITY, should be the dominant philosophy which must be respected by every individual in the global society.

One of the steps – sustainable buildings!

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How to design sustainable buildings?

Integrated building design is a comprehensive approach which brings together all profiles of designers that have to be involved in the design process:

- ✓ architects,
- ✓ structural engineers,
- ✓ passive solar building designers,
- ✓ HVAC system **engineers.**

⬇

Energy optimization of the building

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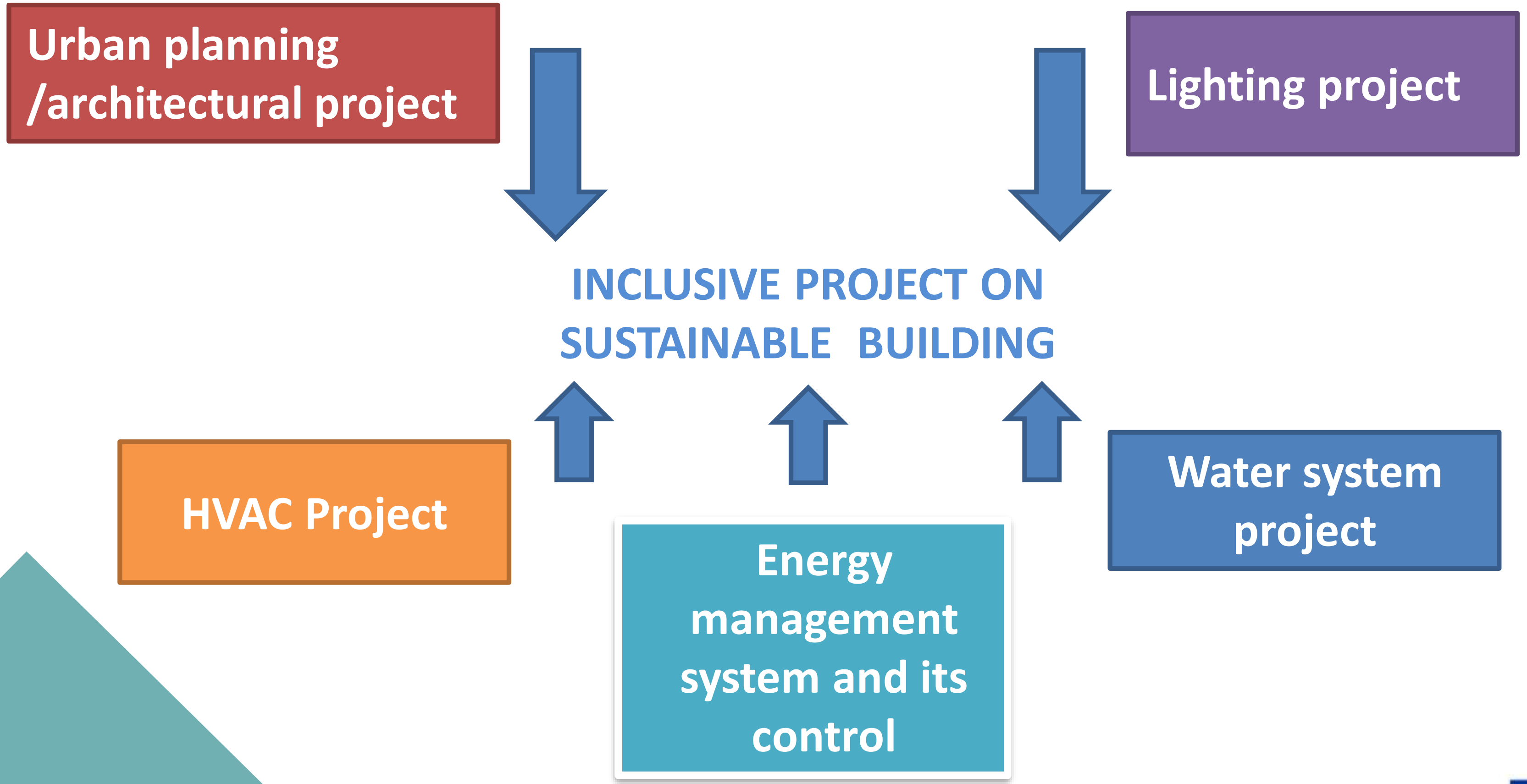
Energy optimization of the building



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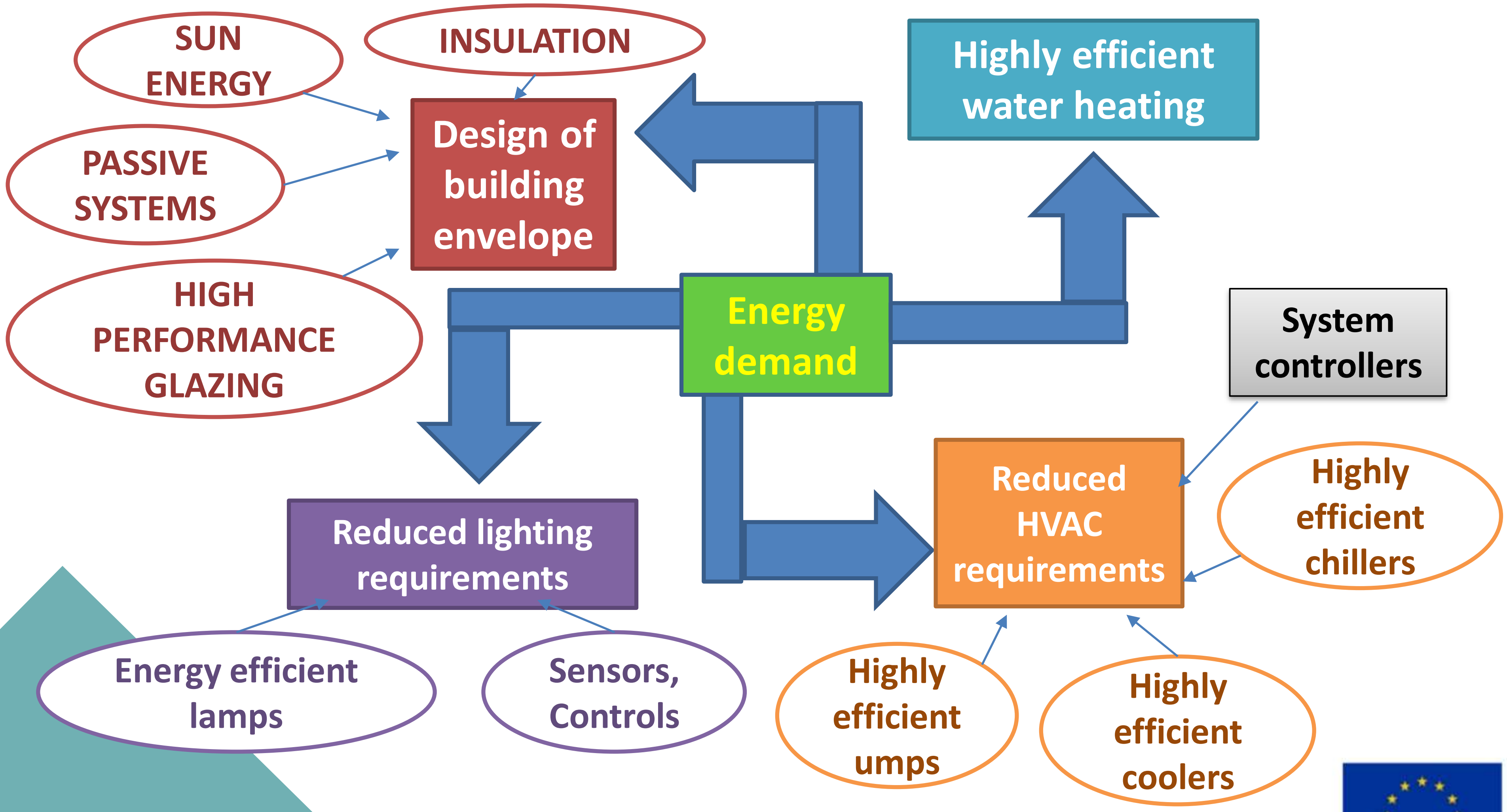
Energy optimization of the building



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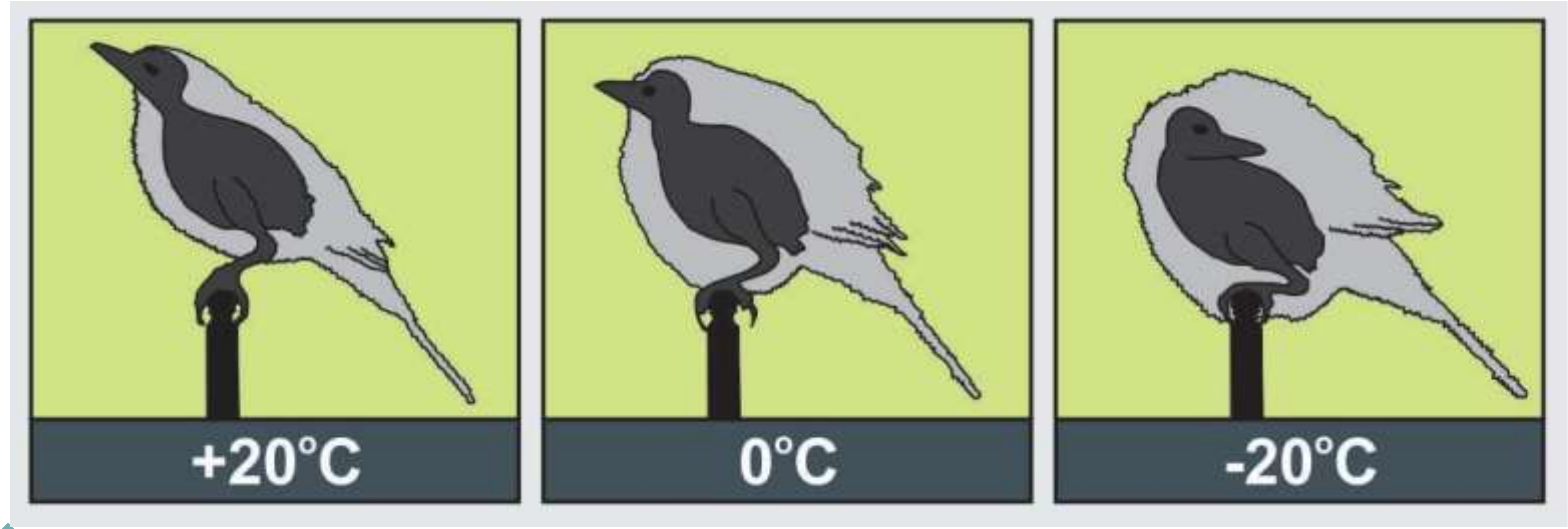
Is the idea for energy efficiency of buildings new and where it comes from?



NATURE TEACHES US HOW TO BUILD

Energy efficiency of buildings is combination of a high level of comfort and low energy consumption

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Is the idea for energy efficiency of buildings new?

Historically, man has always thought about how to build a home that would be warmer in winter and cooler in summer. This problem was also studied by Socrates, a Greek philosopher **2500 years ago**. In the literature, this research is known as **"Socrates House"** and the basis of this research was the influence of the sun movement on the form, appearance and construction of the houses.

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Is the idea new?

Thermal comfort

- Correct orientation;
- Proper dimensioning of the envelope;
- Protection from solar radiation;
- Passive/natural heating /cooling;
- Thermal zoning.

Traditional house in Ohrid

How to achieve ?

Bioclimatic architectural measures:

- Orientation;
- Window positioning, shading;
- Thermal mass;
- Choice of materials for walls, roof, windows, including insulation;
- Surface and volume ratio;
- Landscaping of the space.

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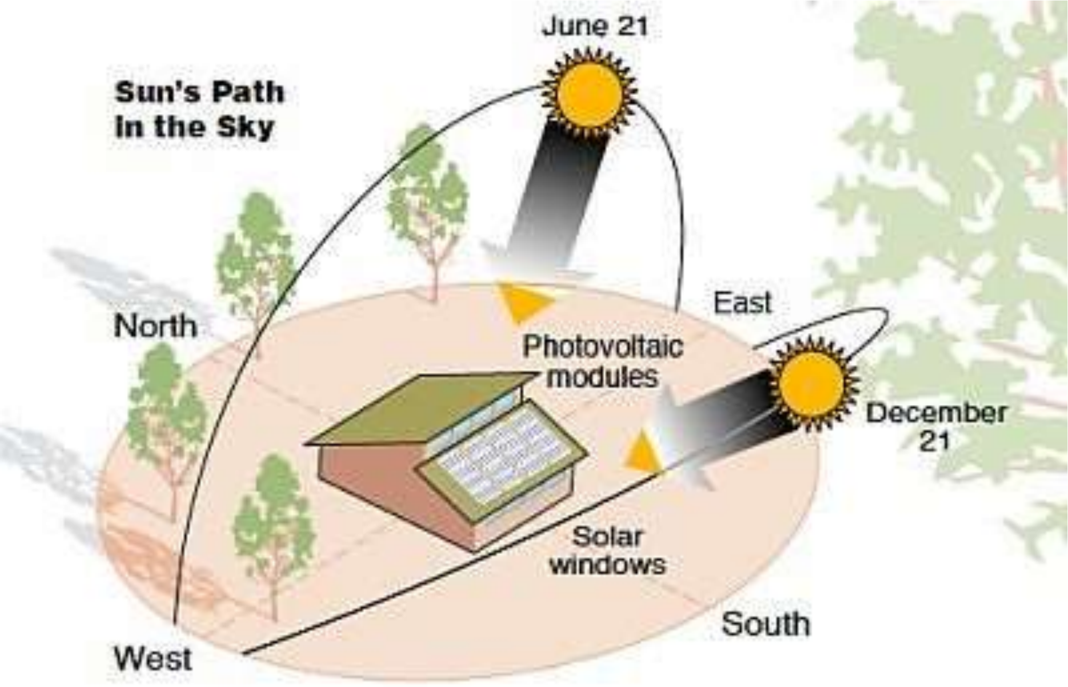
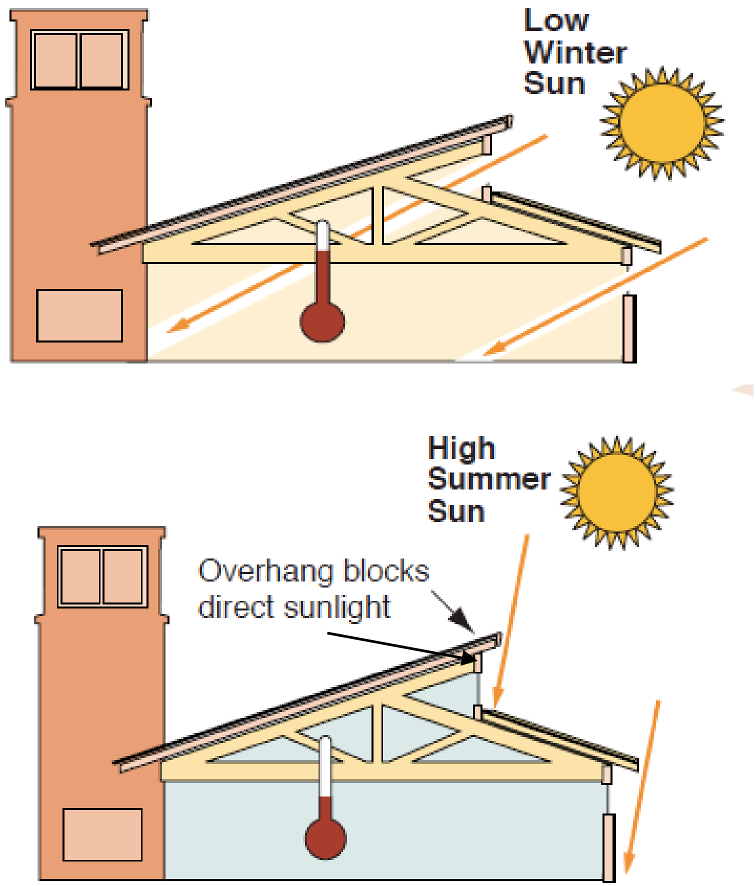
Architectural measures for designing energy efficient buildings

Micro and macro location





Position of the sun and angle at which the sun's rays fall in summer and winter

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Architectural measures for designing energy efficient buildings

Shading of the object with deciduous trees

Shape of the building (O/V=min) and materials used for construction

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Architectural measures for designing energy efficient buildings

Buildings in a warm climate zone:

- Proper orientation of the building to eliminate the influence of the sun on the well insulated walls and windows protected from the sun with blinds and shutters
- Reduced surface area in relation to volume,
- Lighter finishing colors,
- Water, as a landscape element

Buildings in a cold climate zone:

- Large windows to receive solar energy
- Thermal mass for heat storage
- Minimal shading
- Insulated walls and windows
- Dark finishing of the façade
- Well protected north of the building

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REDUCING ENERGY

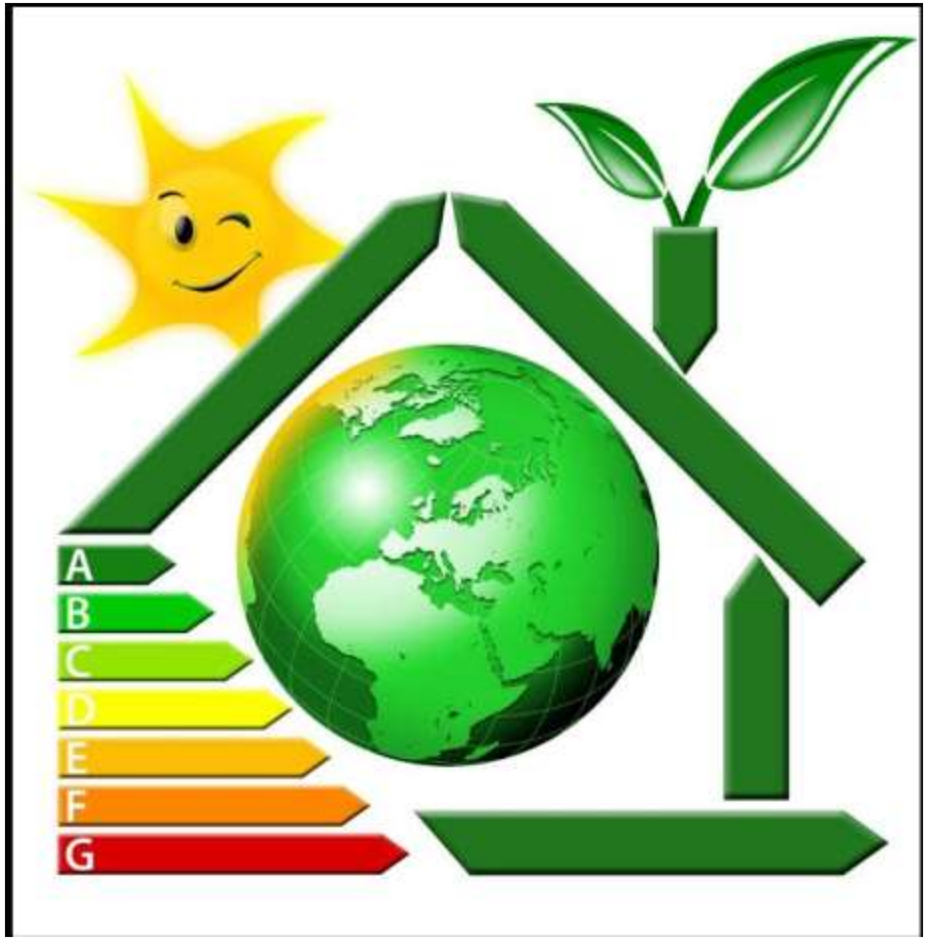
LOSSES IN BUILDINGS

IS THE FIRST STEP

TOWARDS ALL

FURTHER ENERGY

EFFICIENCY MEASURES



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Categories of energy efficient buildings

- Low Energy House
- Passive House (Ultra-low Energy House)
- Zero-energy House
- Autonomous Building
  (house with no bills)
- Energy Plus House

Energy consumption

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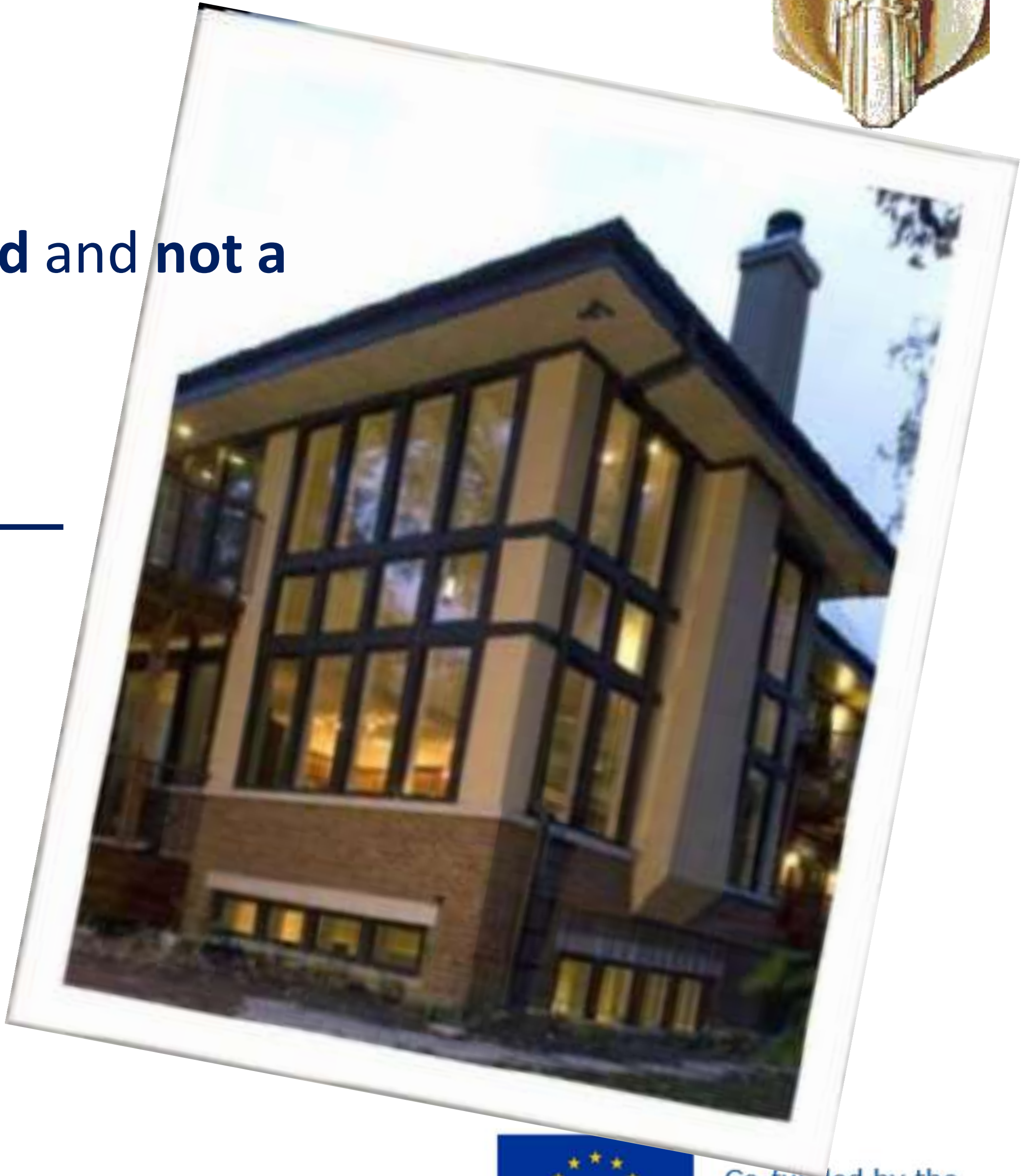
PASSIVE HOUSE

The term **PASSIVE HOUSE** describes a **standard** and **not a specific construction method**



OBJECTIVES:

- Minimum heat losses
- Maximum heat gains from the sun and internal sources
- Rationalization of costs for hot sanitary water
- High comfort

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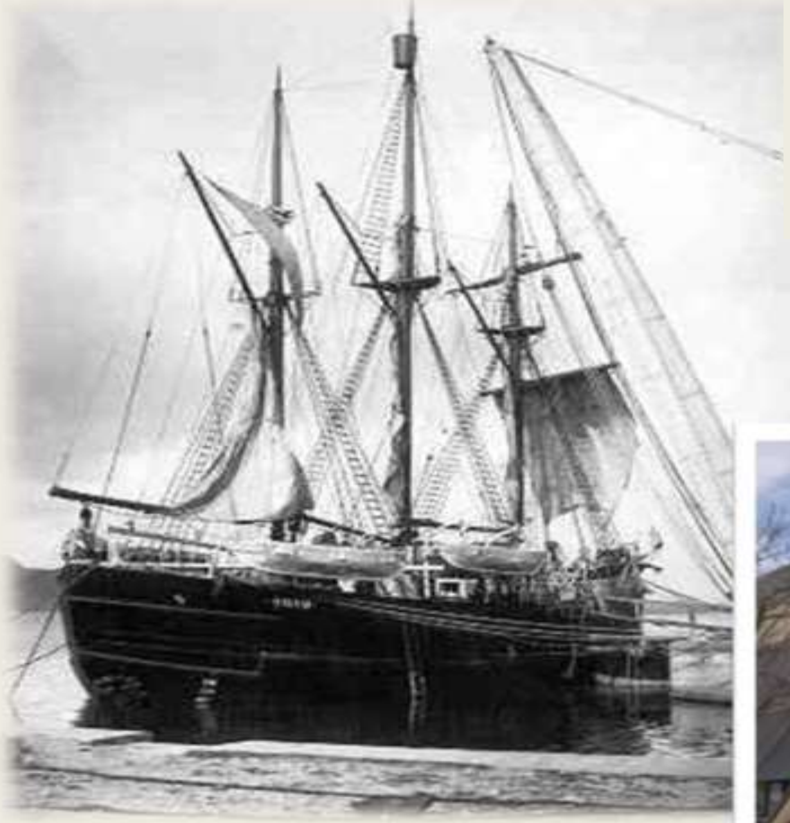
PASSIVE HOUSE

HISTORY:

- FRAM (1893.)
- Expedition to the Arctic
- Constructor: Fridtof Nansen



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PASSIVE HOUSE

HISTORY:

FIRST PASSIVE HOUSE:

Darmstad Kranichstein, in 1991.

- Four private investors form "Passive House Development Society“
- Architects: prof. Bot, Ridder, Westermeyer
- 4 apartments with 156 m2 gross area each
- Built-in precise system for tracking and measuring achievements
- All detailed information is publicly available and subject to analysis

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PASSIVE HOUSE

FACTORS:

Micro and macro location:

- angle of sun rays
- orientation
- shading
- climatic conditions

Design:

- main facade to the south
- utility rooms in the north
- east and west – ineligible
- form factor (=0.7 m^{-1})

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PASSIVE HOUSE

CRITERIUMS:

1

Energy demand for heating

$\leq$ 15 KWh /(m²a)

2

Airtightness

$V_{50} \leq 0.6\ h^{-1}$

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PASSIVE HOUSE

CRITERIUMS:

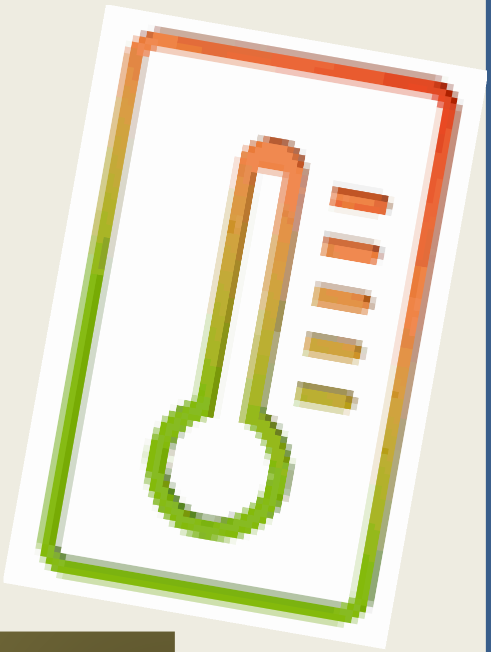
3

Primary energy demand

$\leq$ 120 KWh /(m^2a)

4

Overheating frequency



$\leq$ 10%

Recommended: $\leq$ 4%

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PASSIVE HOUSE

HIGH COMFORT:

ASHRAE Class A Comfort Standard

- ✓ Constant temperature (±0.8 °C)
- ✓ Low risk of draft

  (≤8%, when V_s ≤0.08m/sek)
- ✓ $\Delta T_{FLOOR/CEILING} \leq 4$°C
- ✓ $\Delta T_{FOOT/HEAD} \leq 2$°C (in sitting position)
- ✓ $\Delta T_{GLASS/INSIDE} \leq 4$°C

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PASSIVE HOUSE - CASE STUDY
(Parametric analysis)

REFERENT BUILDING (RB):

- Location: East part of Macedonia
- Elevation: 600 m
- Flat terrain without other building around the RB

- Orientation: **living rooms on south**
- Thermal insulation thickness of walls and roof: **d=20 cm**
- Thermal insulation thickness of floor: **d=25 cm**
- Windows with thermal transmittance:

  U=0.8 W/m²K

  glass: three-layer low-emission
  (4:/14/4/14/:4 Argon 90%)

  frame: W Internorm - passiv Fixverglasung
- Use of renewable energy: **solar panels**
- Building equipement: **A+ class**

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REFERENT BUILDING

Wall structure:

Gypsum board on a metal substructure	12.5 mm
Stone wool with λ= 0.045 W/(mK)	50 mm
Gypsum plaster with λ= 0.510 W/(mK)	17 mm
Masonry from ITONG blocks, λ= 0.160 W/(mK)	250 mm
Gypsum-lime plaster with λ= 0.700 W/(mK)	17 mm
Glue for thermal insulation	5 mm
Thermal insulation with λ= 0.024 W/(mK)	200 mm
Glue and putty	5 mm
Finished abrib	3 mm

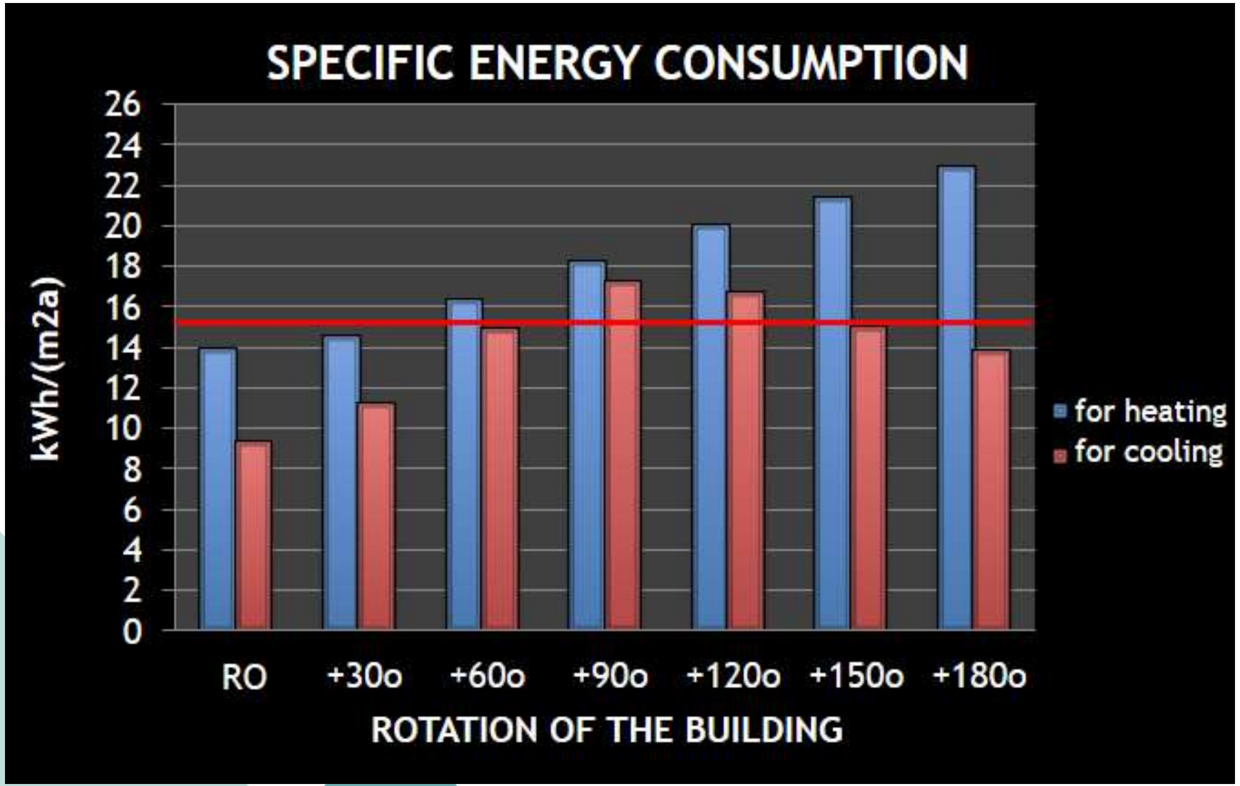
Roof structure:

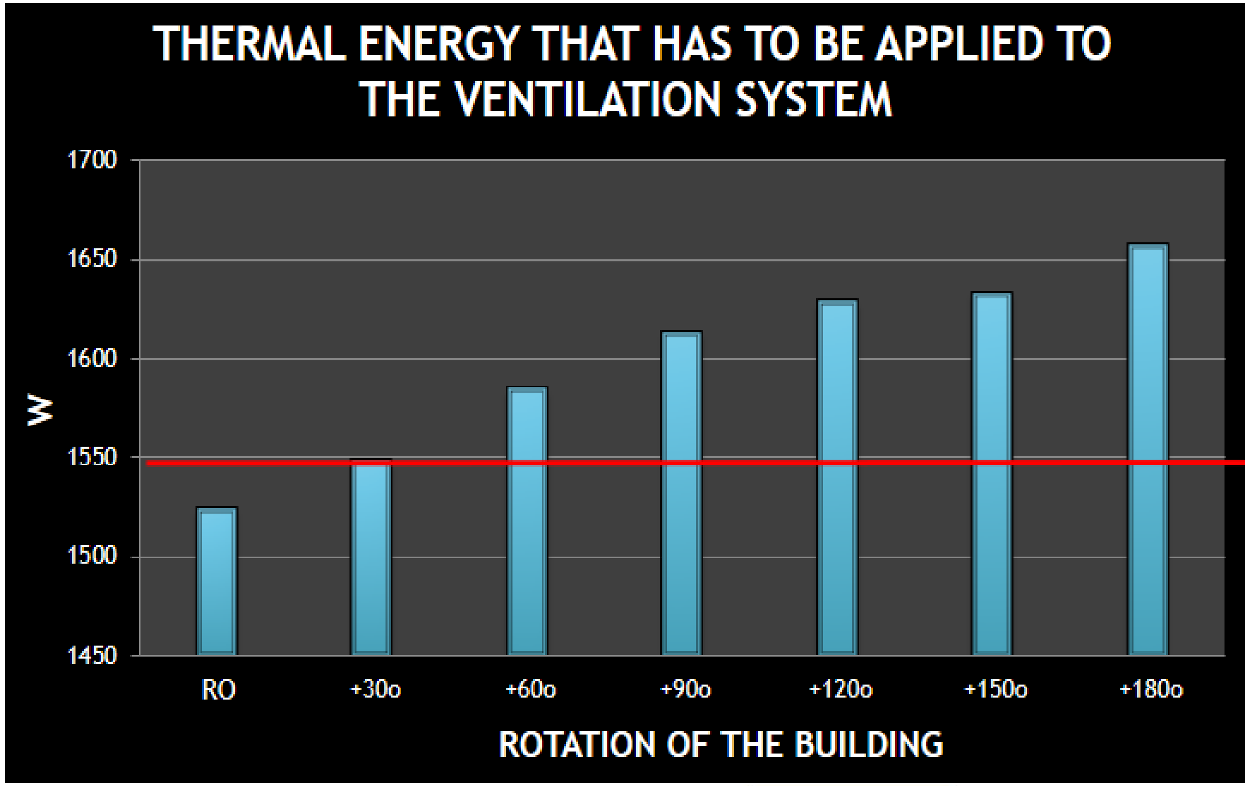
Gypsum board on a metal substructure	12.5 mm
Stone wool with λ= 0.045 W/(mK)	50 mm
RC slab MB30 with λ= 2,300 W/(mK)	100 mm
Thermal insulation with λ= 0.024 W/(mK)	200 mm
Cladding from boards, λ= 0.024 W/(mK)	22 mm
Steam barrier	3 mm
Double wooden framework	
Tiles	

Floor structure:

Floating screed	30 mm
Rock wool with λ= 0.038 W/(mK)	20 mm
RC slab MB30, λ= 2,300 W/(mK)	150 mm
Thermal insulation, λ= 0.038 W/(mK)	250 mm
Hydro insulation λ= 1,200 W/(mK)	8 mm

ORIENTATION INFLUENCE





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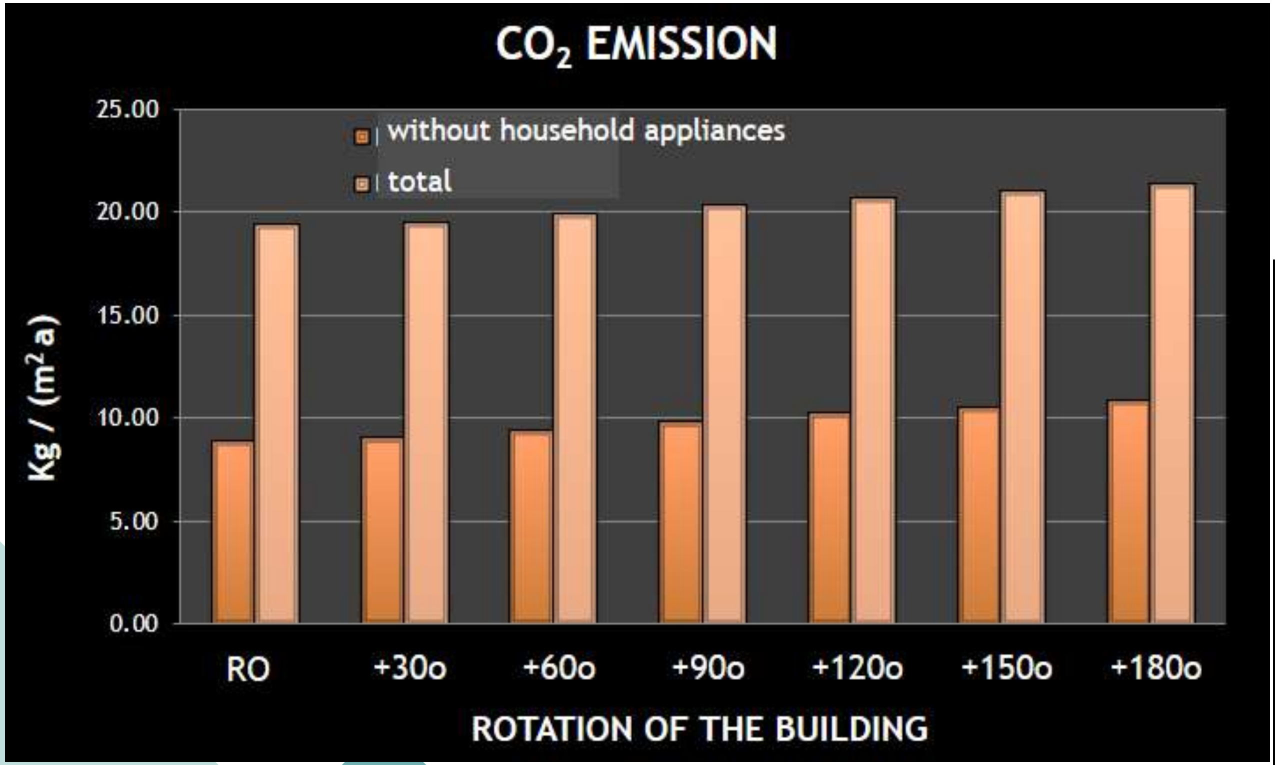

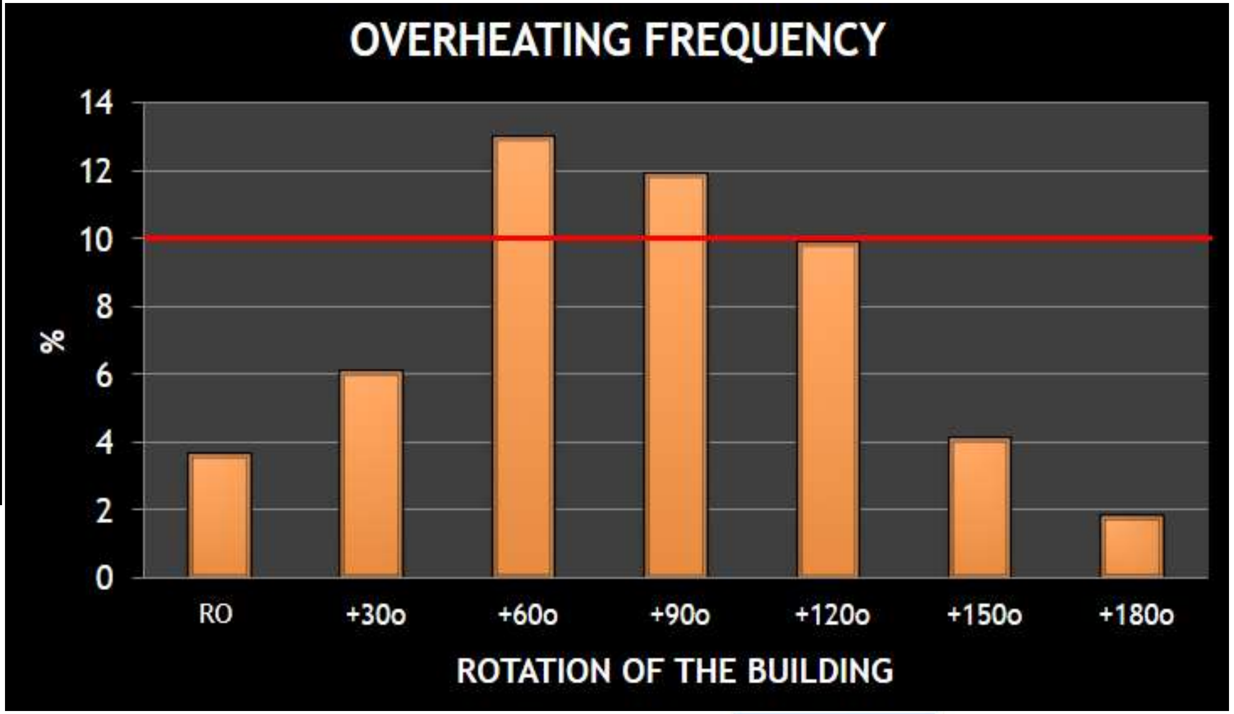

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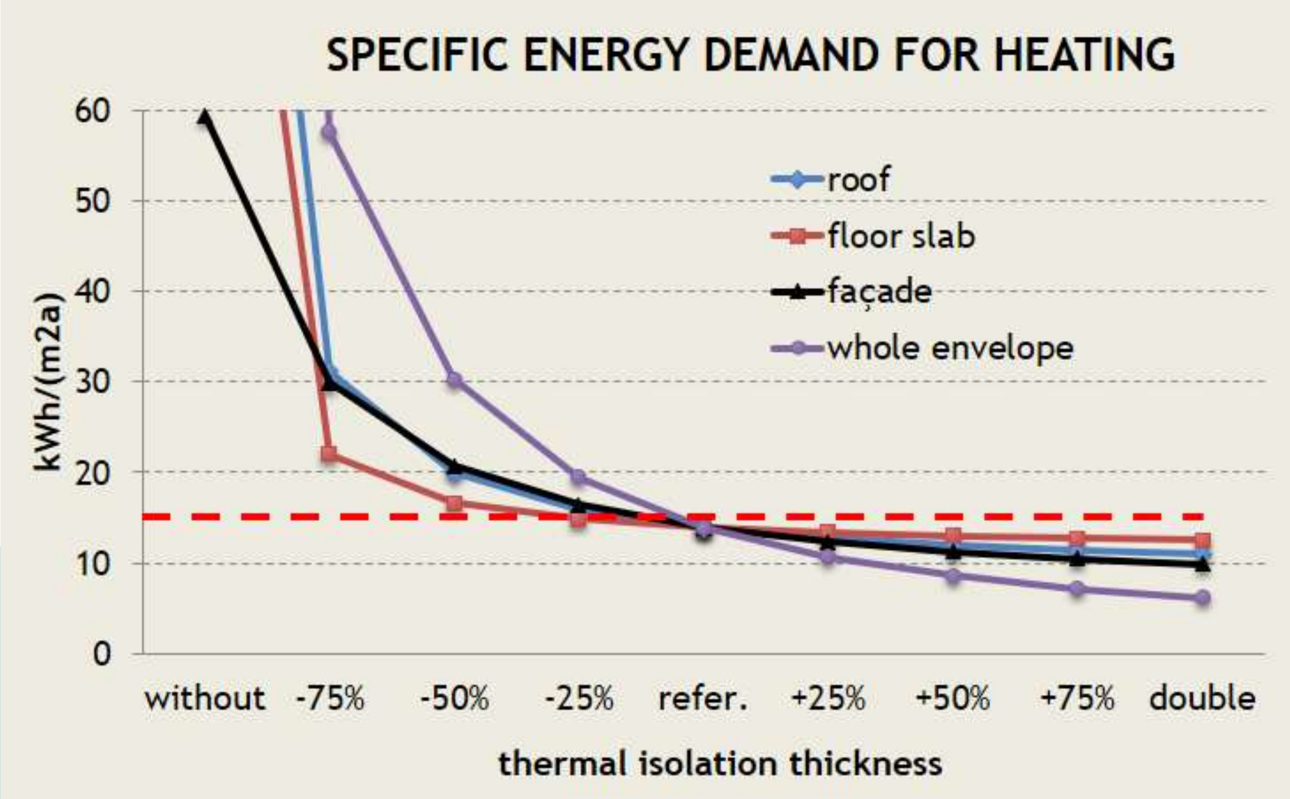
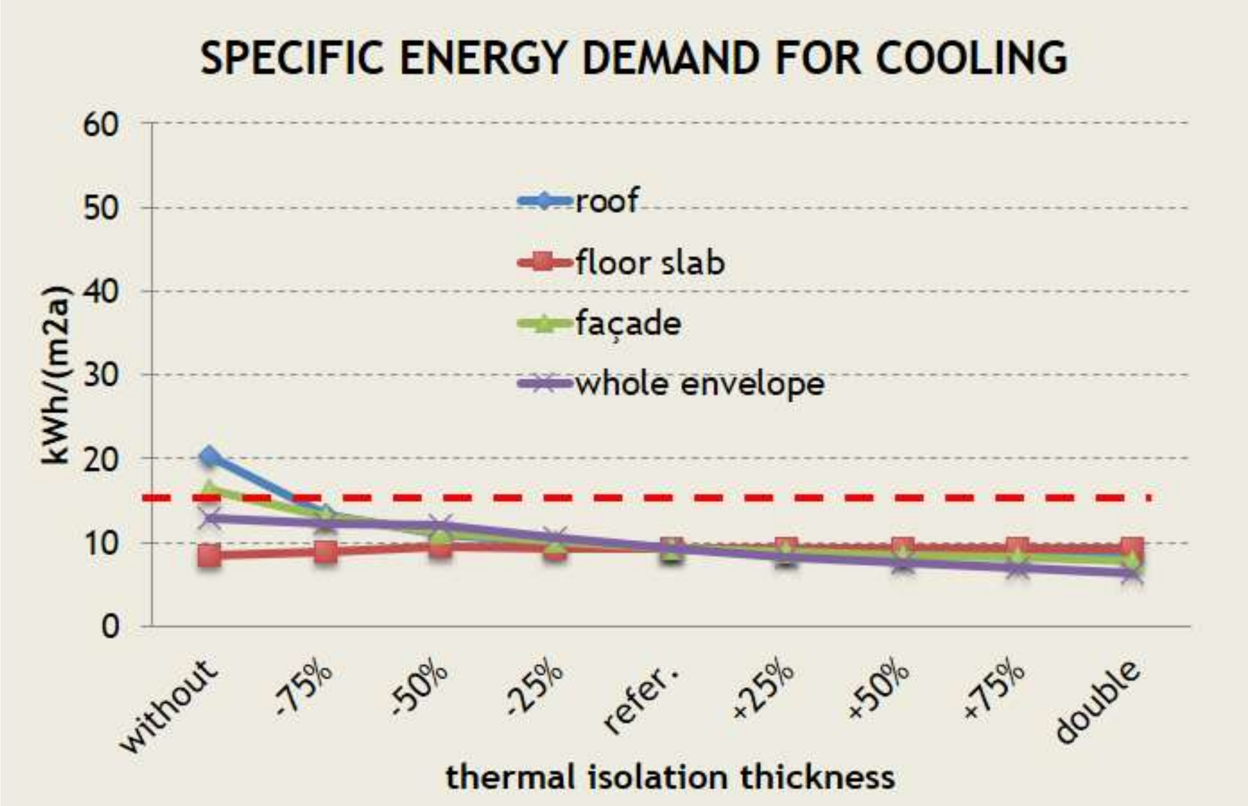
INFLUENCE OF THERMAL INSULATION THICKNESS





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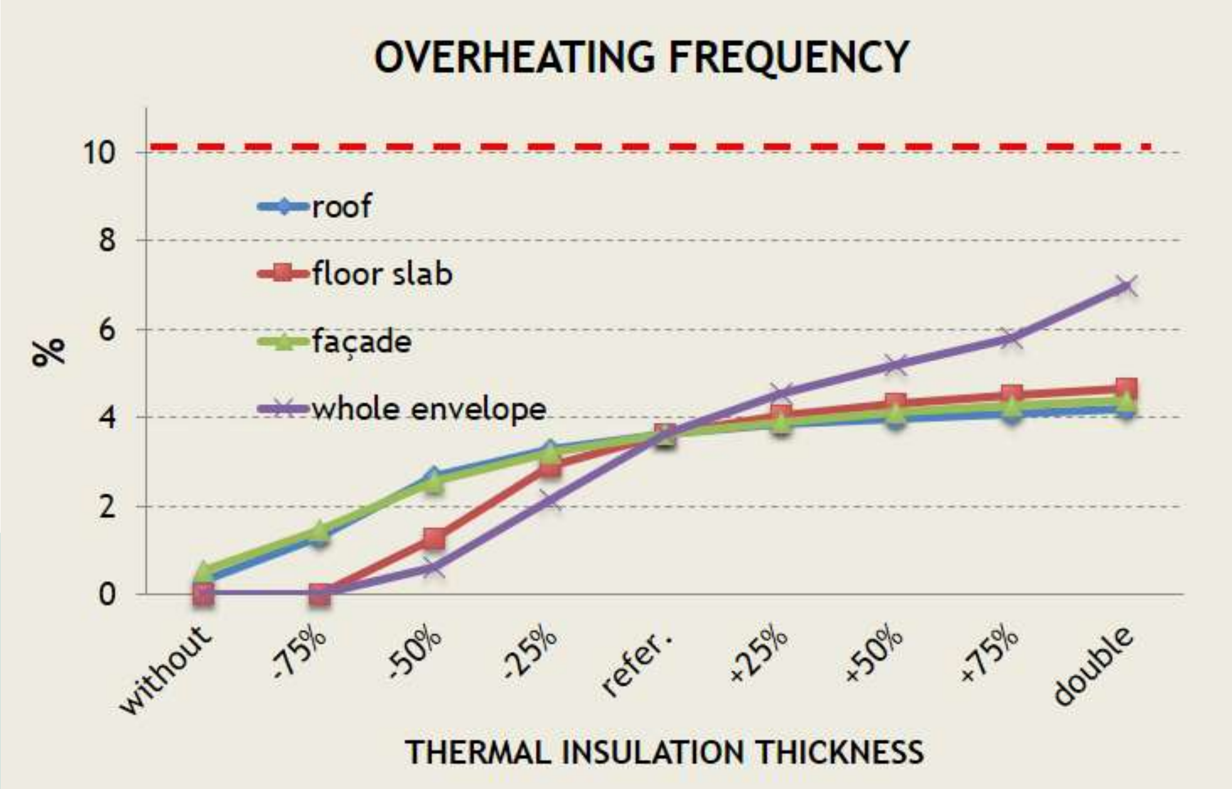

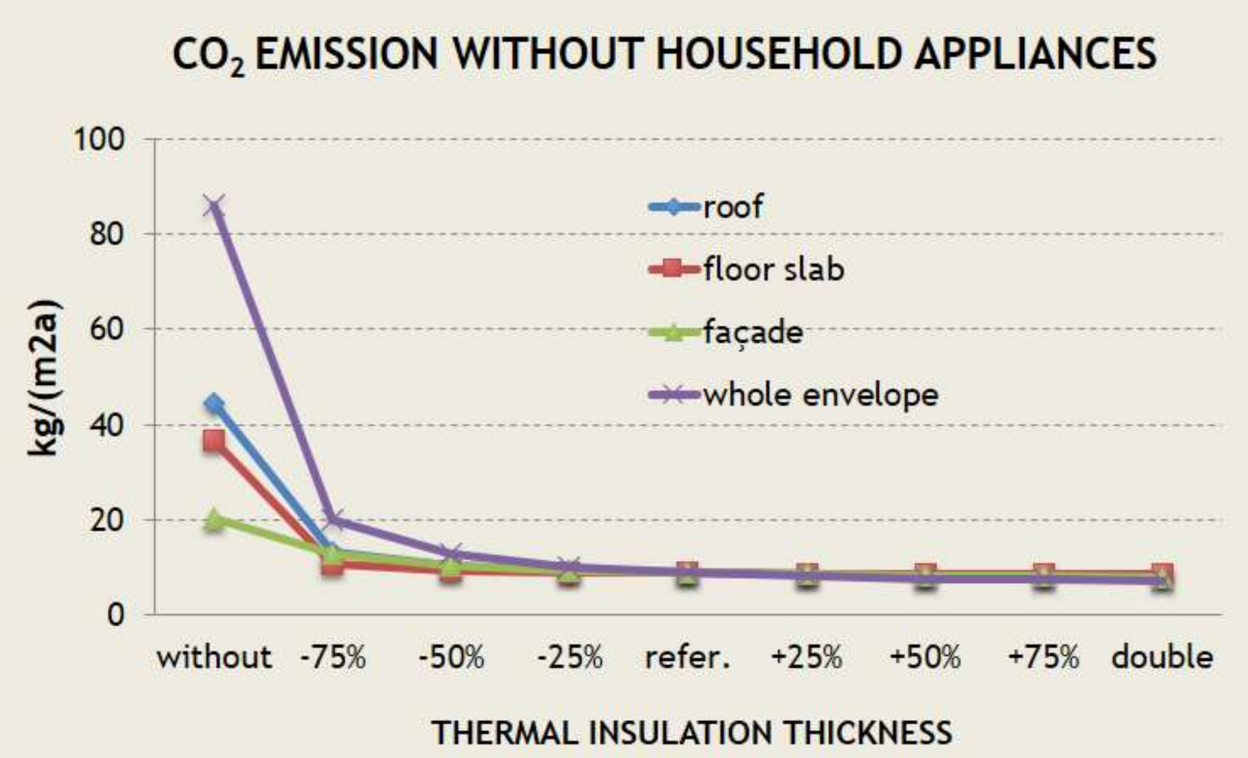

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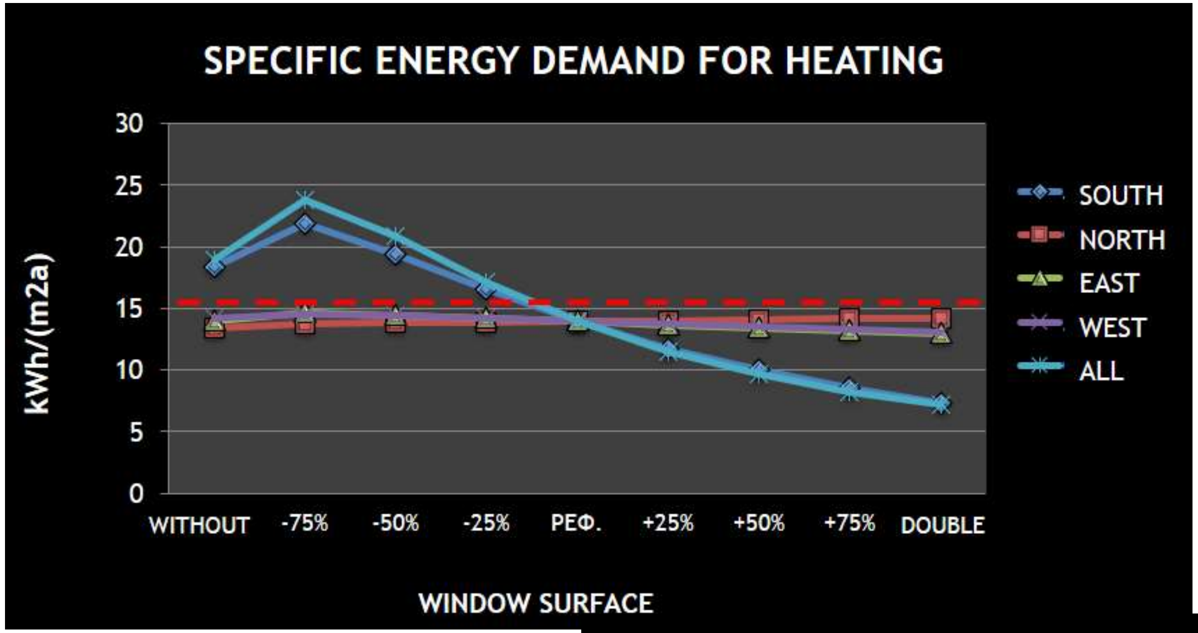
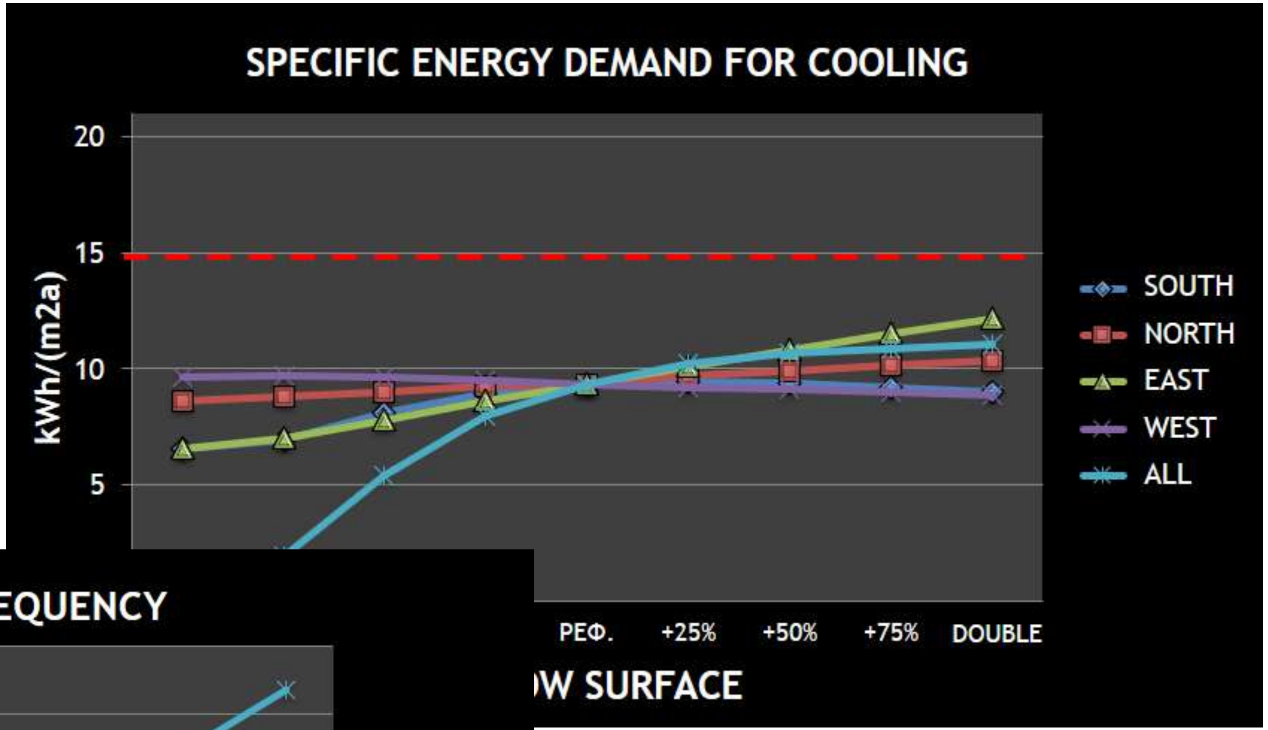
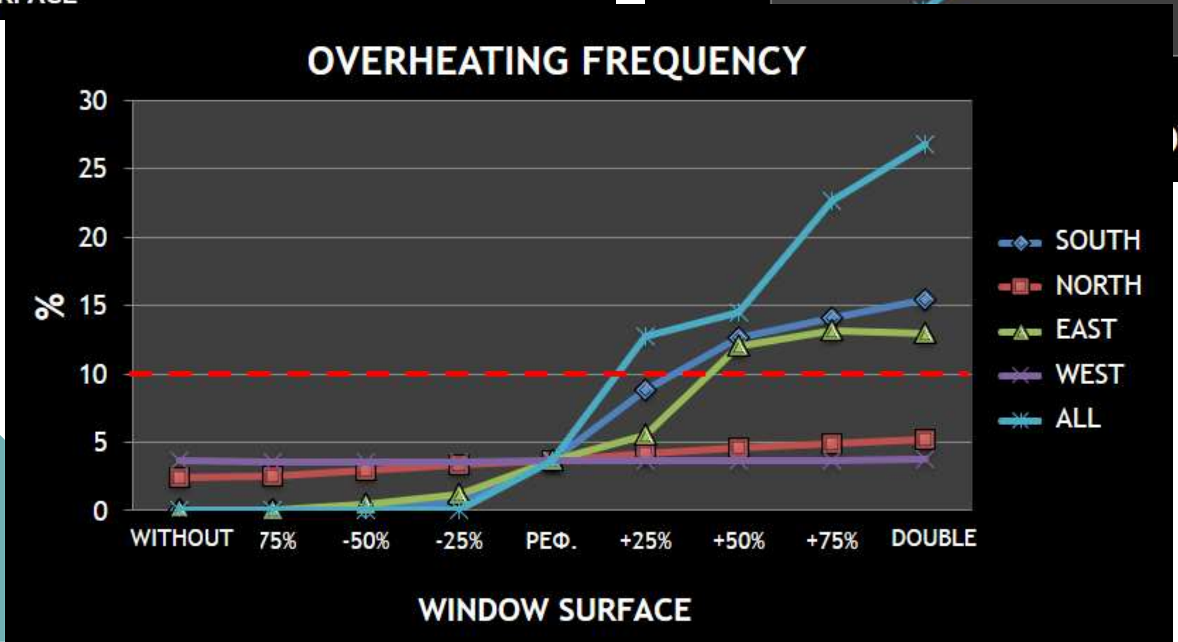
GLAZING INFLUENCE







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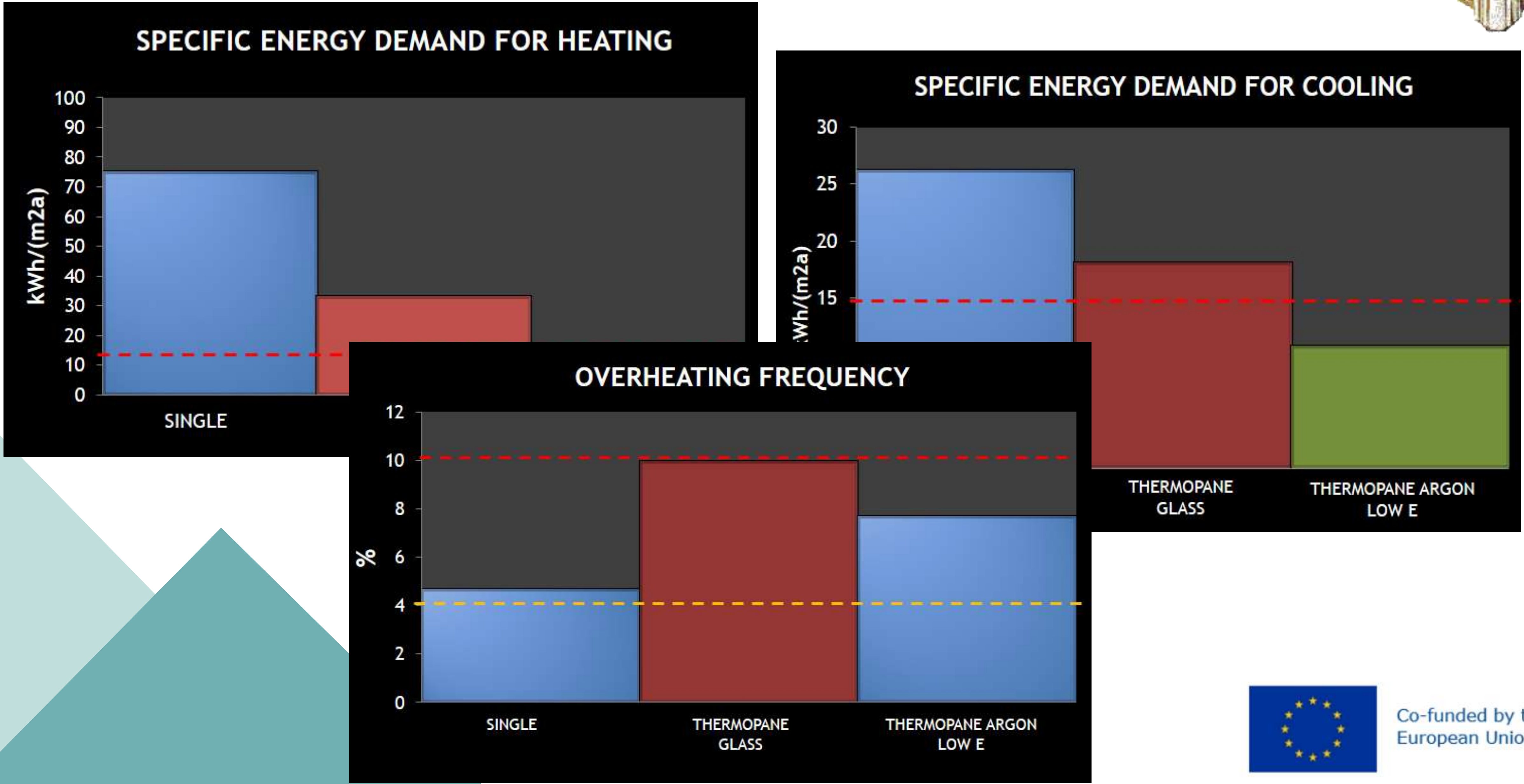
INFLUENCE OF THE TYPE OF GLAZING



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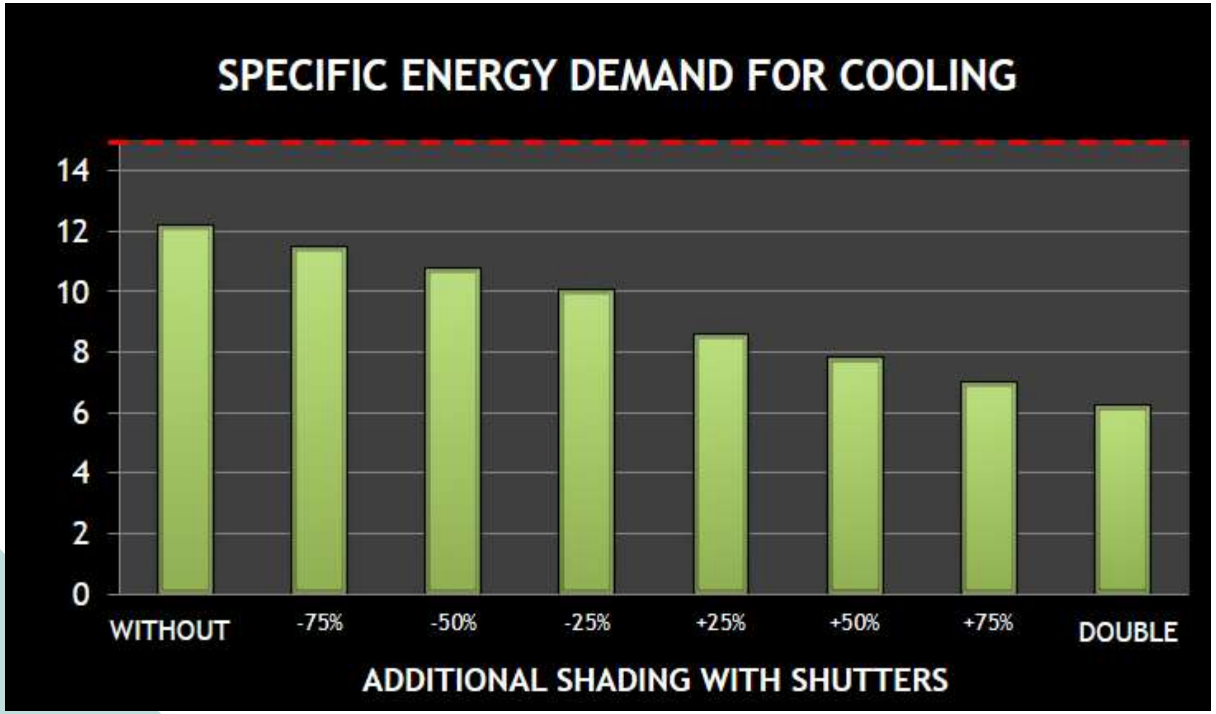
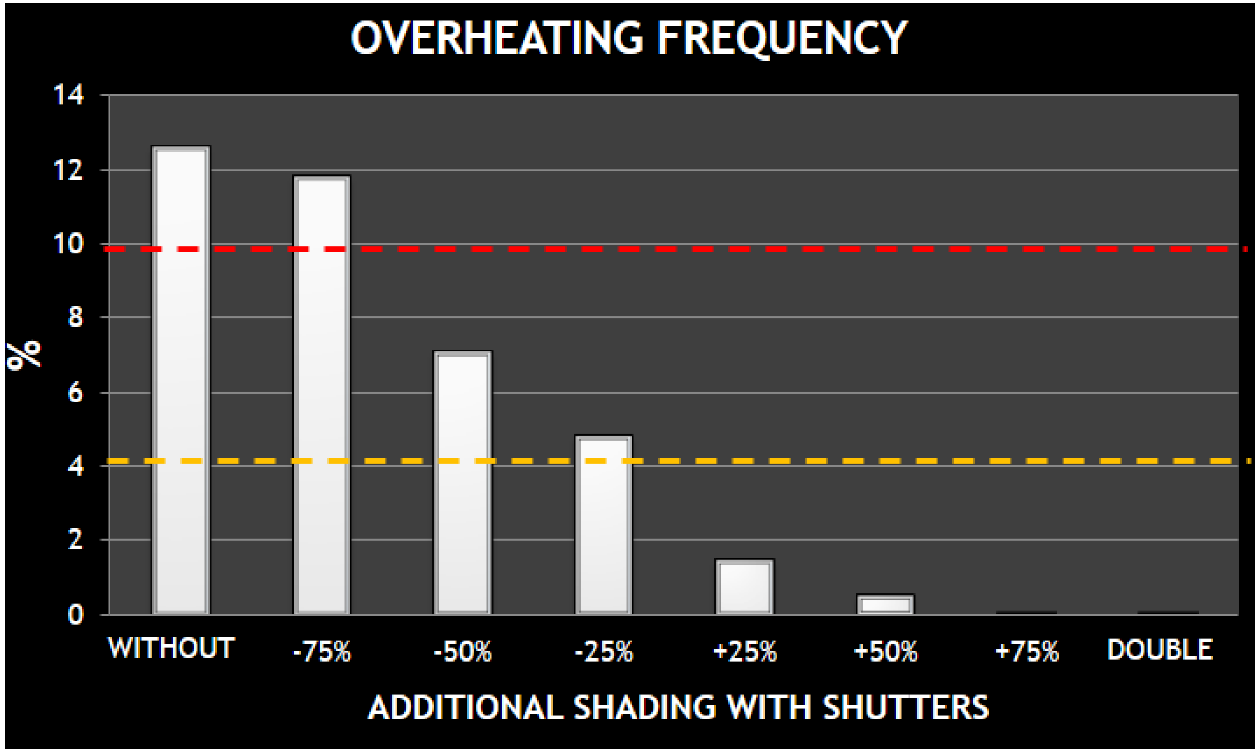
INFLUENCE OF ADDITIONAL SUMMER SHADING





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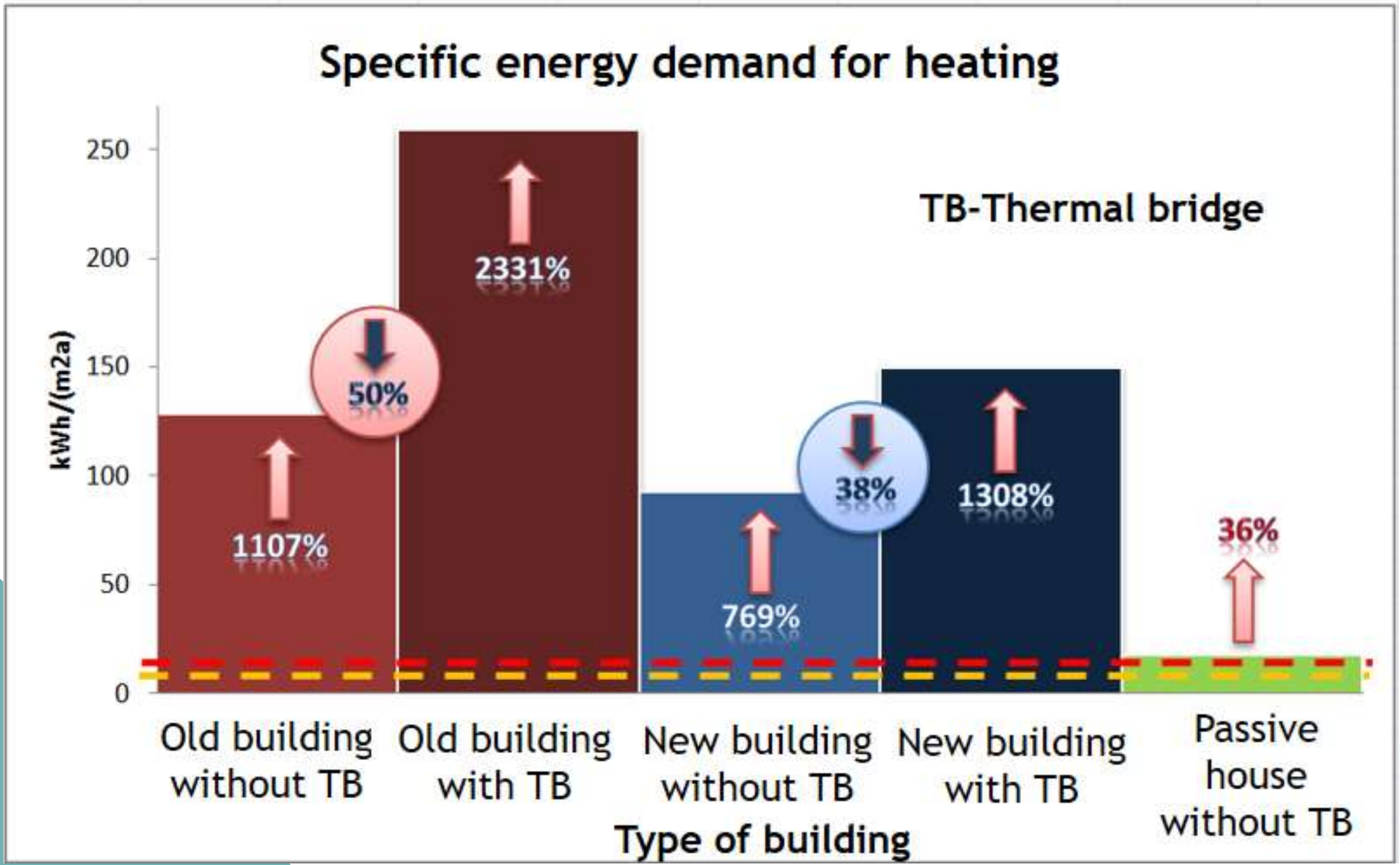
COMPARISON OF DIFFERENT TYPES OF BUILDINGS



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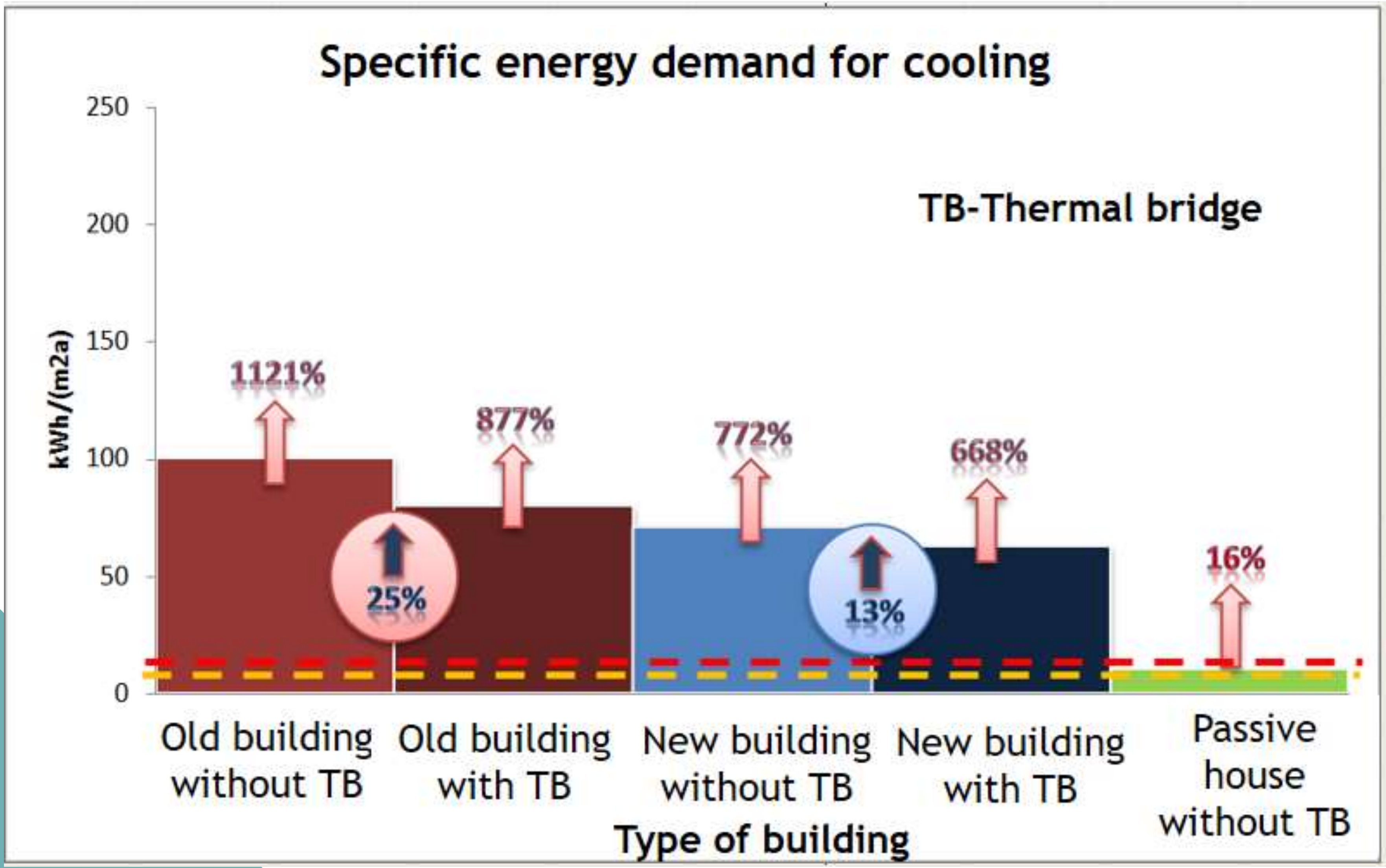

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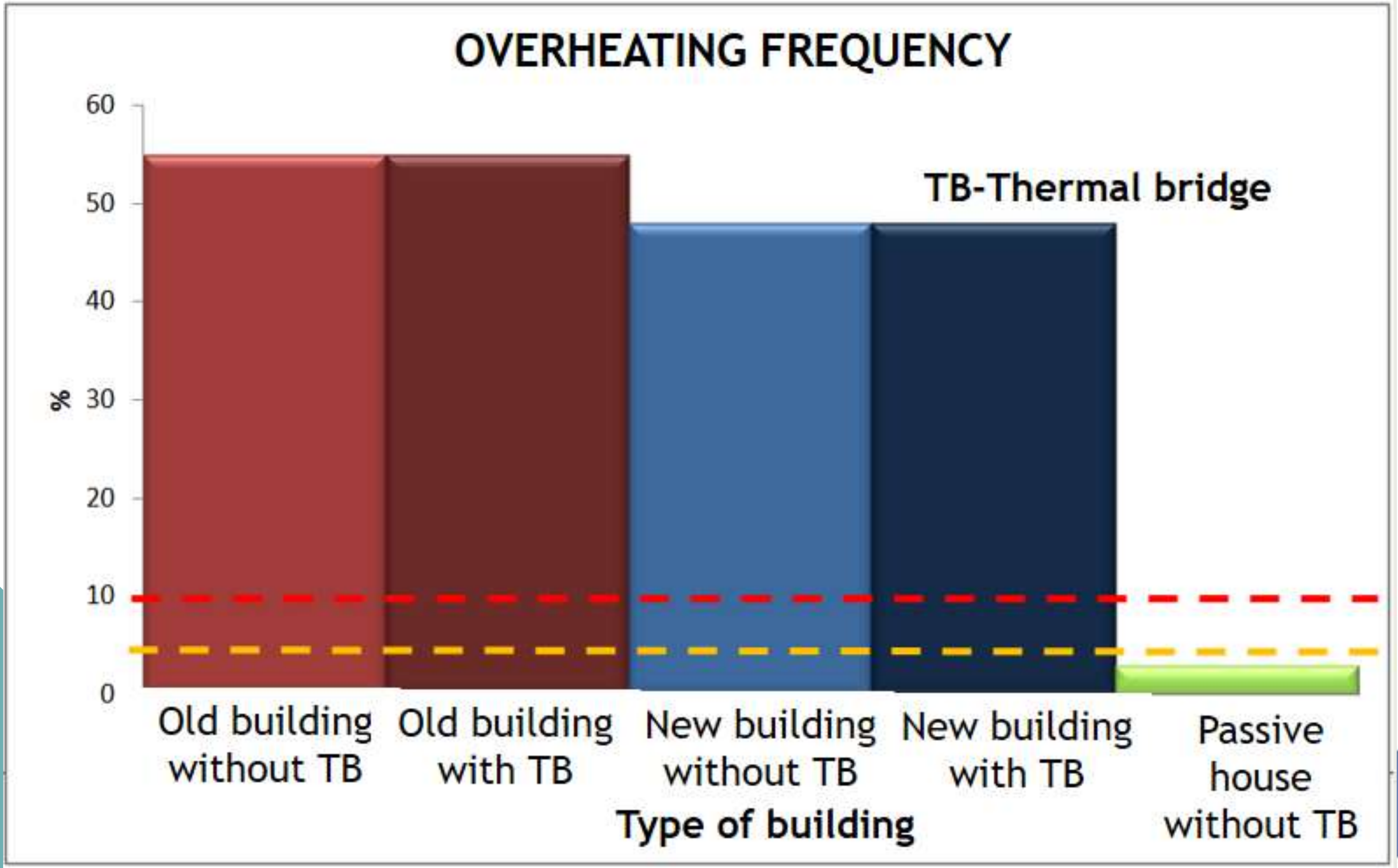

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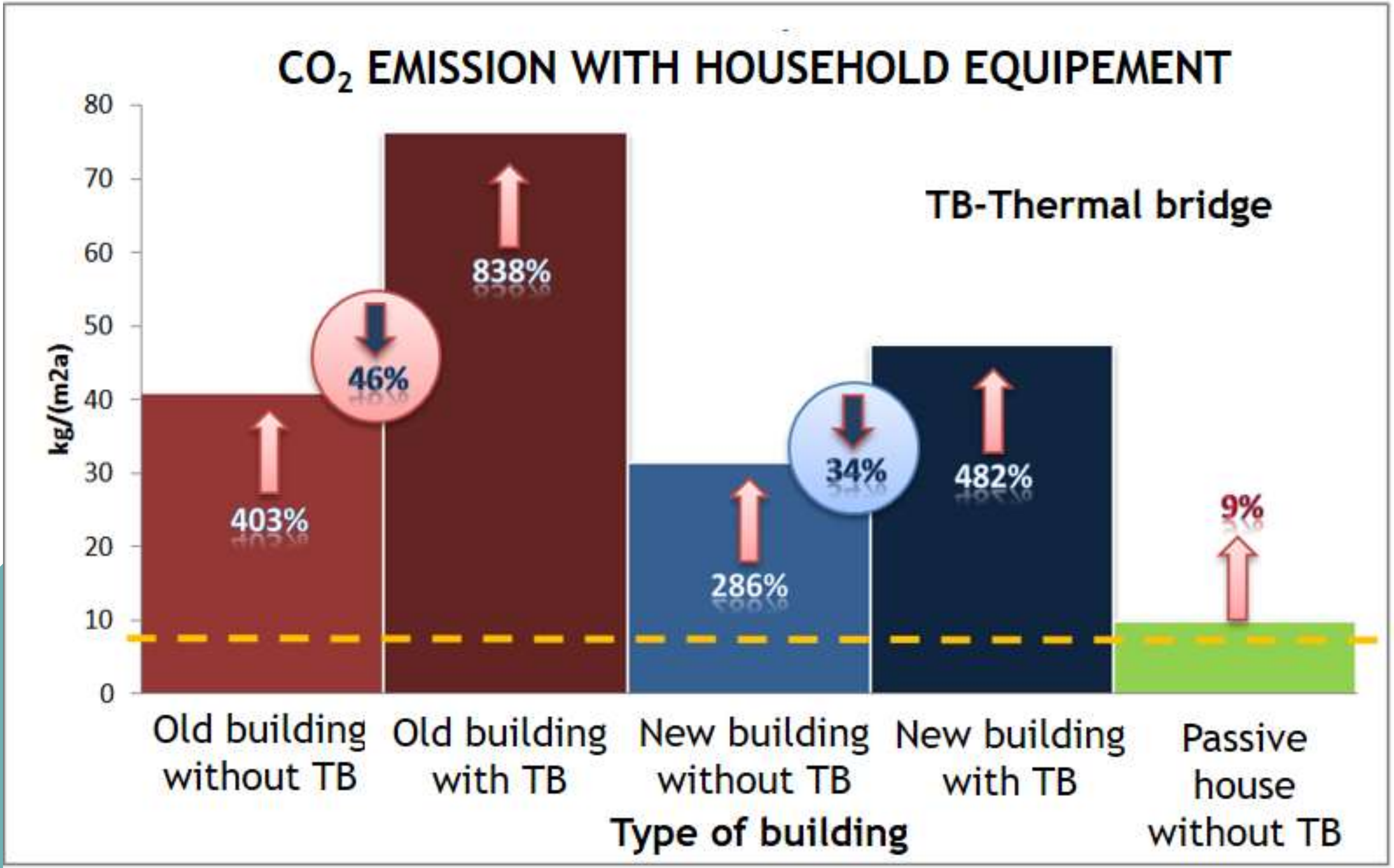

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THERMAL BRIDGES

How to solve thermal bridges ?

THERMAL BRIDGES

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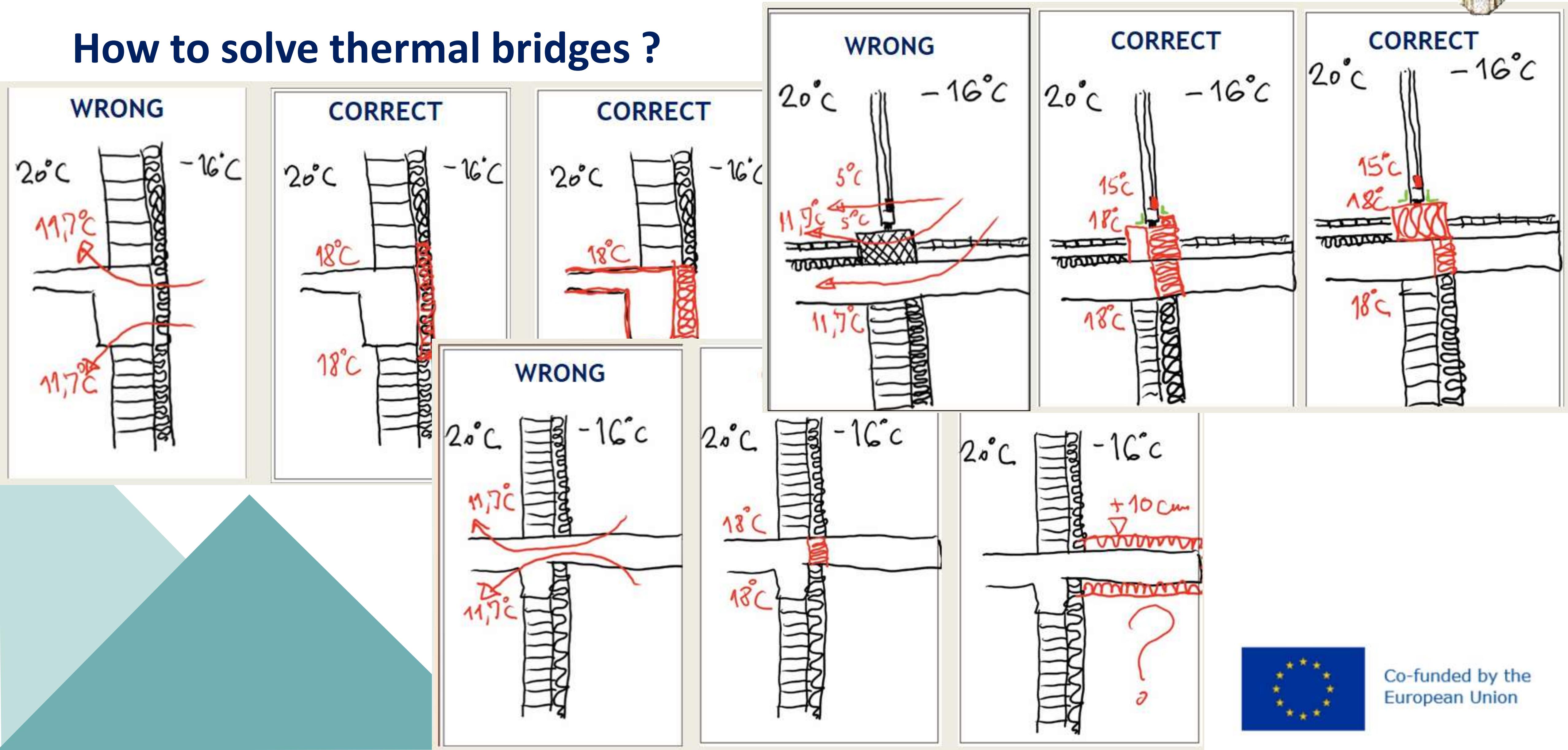

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Thank you for your attention

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