



Energy Efficiency Guidelines for Office Buildings in Tropical Climate

Designing for a Low Energy Demand: Parametric Study

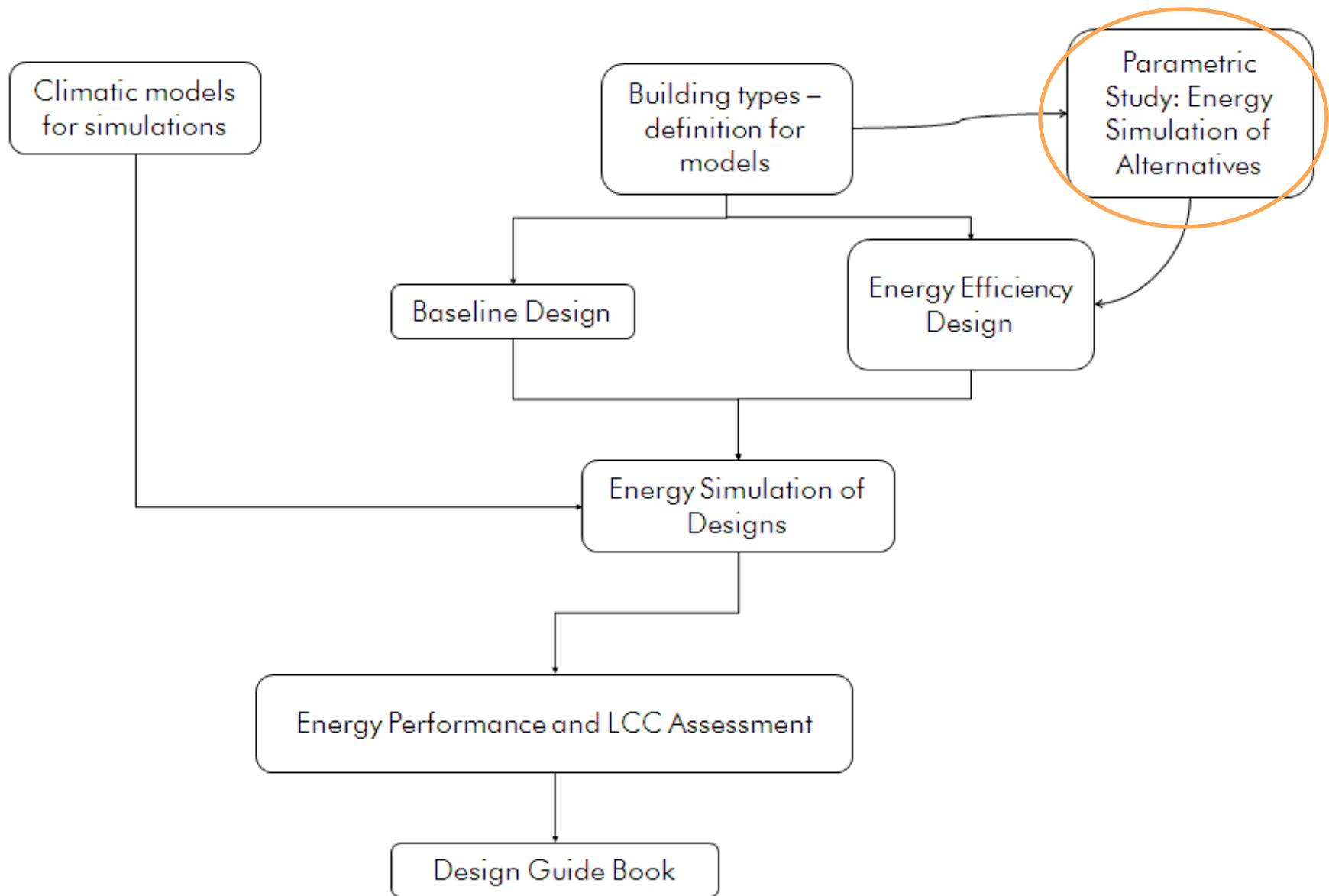


Organization of
American States

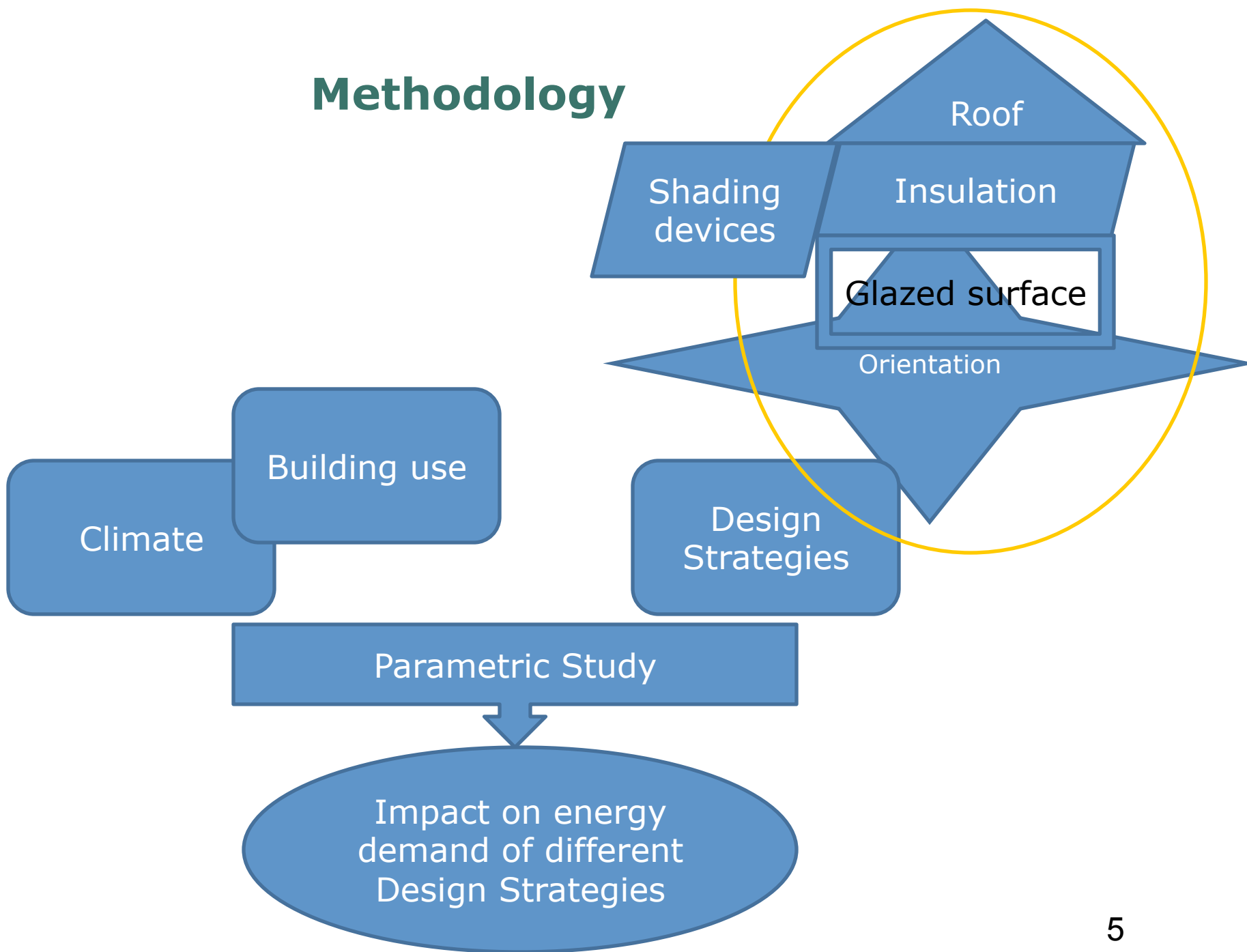
OUTLINE OF THE PRESENTATION

- Designing for a low Energy Demand
 - Parametric study
 - Software:
 - Energy Performance simulation
 - Renewable Energy
 - Lighting
- Design methodology

- Parametric study
 1. Shape of the building
 2. Insulation and thermal mass
 3. Glazing type and amount of glazing
 4. Building Orientation
 5. Solar protection – window glazing elements
 6. Contact between building and ground
 7. Night natural ventilation
 8. Heat recovery device in ventilation system

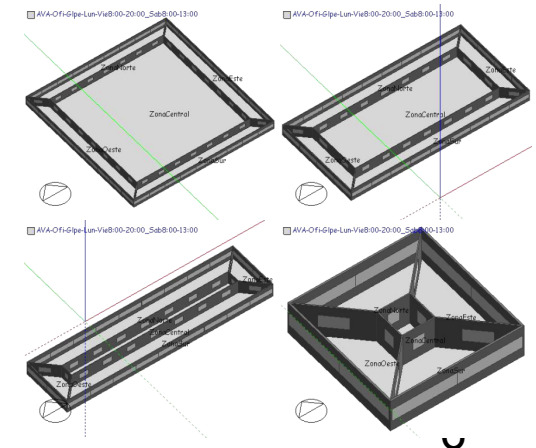
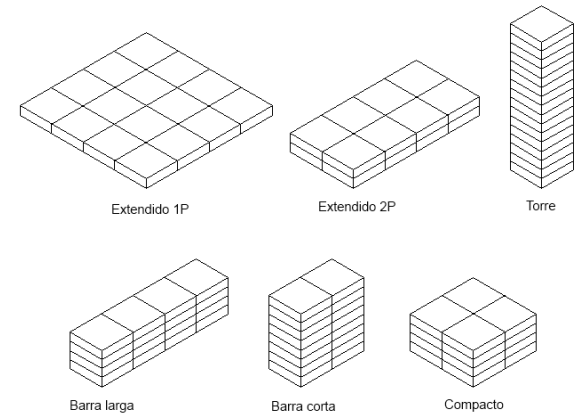
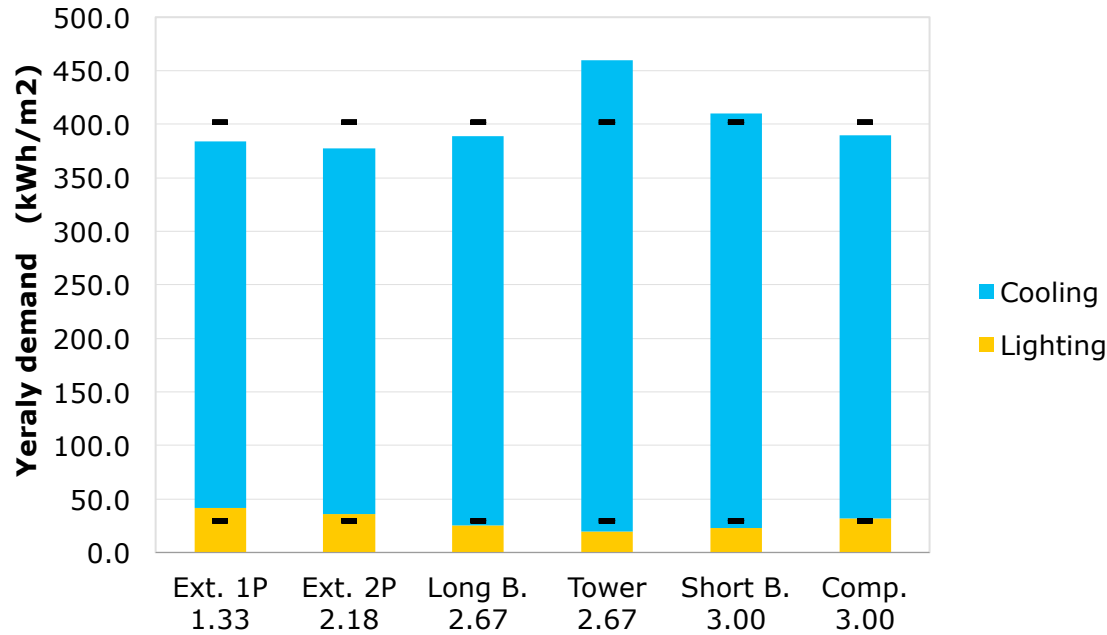


Methodology



Shape of the building

Building shapes sorted by compactness

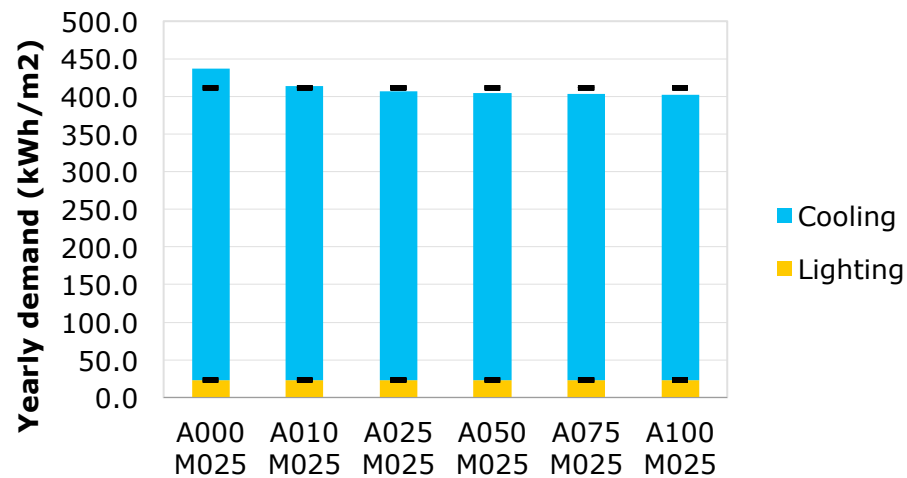


Shape	% Gl. Glazed	Lighting	Cooling	Total	Improvement
Ext. 1P 4.4%	0,04	41,6	342,1	383,7	16,6%
Ext. 2P 10.9%	0,11	36,1	341,5	377,6	17,9%
Comp. 20.0%	0,20	31,8	358,0	389,8	15,2%
Long B. 22.2%	0,22	24,9	363,9	388,8	15,5%
Short B. 30.0%	0,30	23,2	386,6	409,8	10,9%
Tower 35.6%	0,36	19,6	440,2	459,9	Ref.

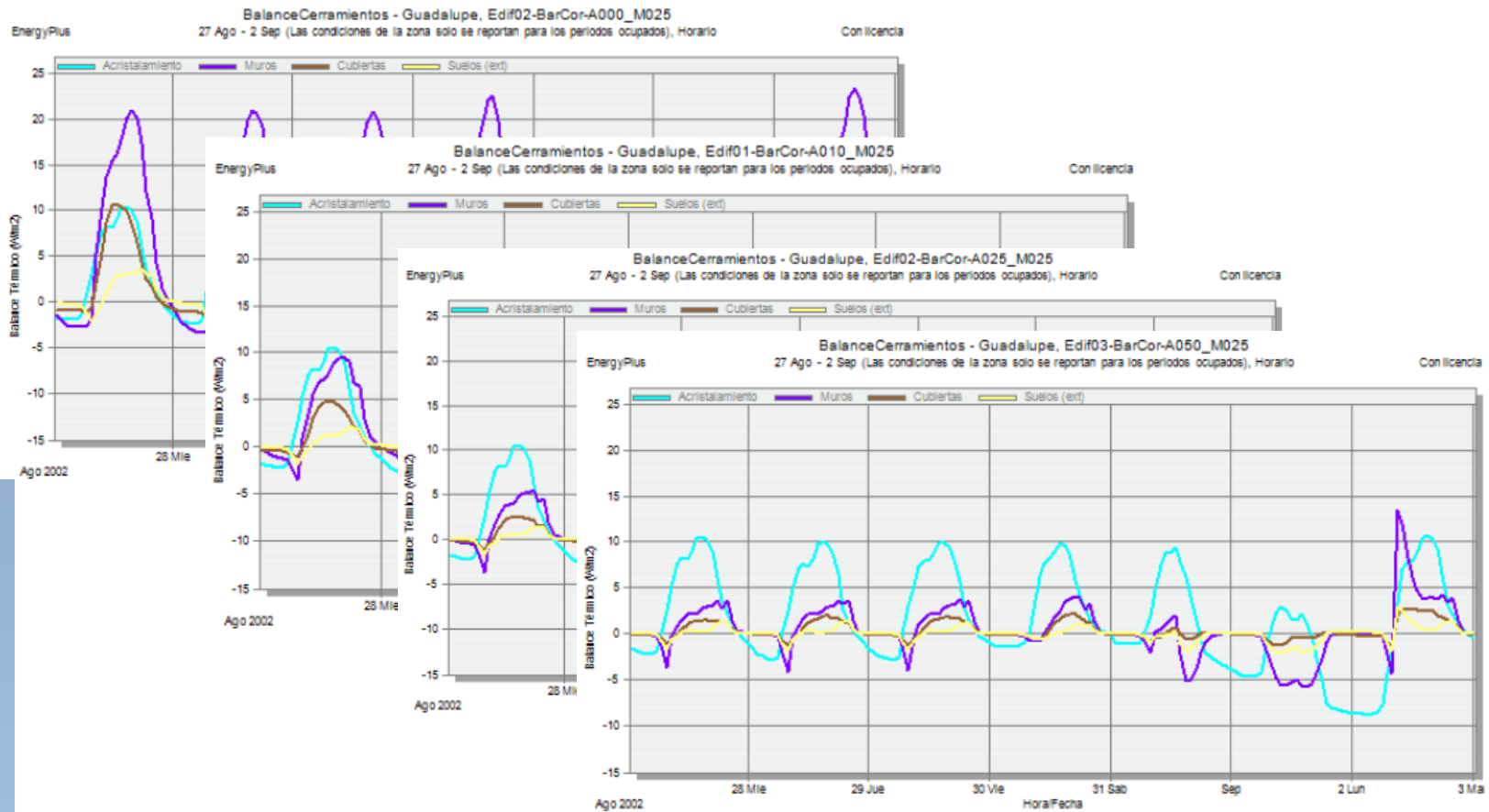
Insulation and thermal mass

Enclosure	Lighting	Cooling	Total	Improvement
A000 M025	23,2	413,8	437,0	Ref.
A010 M025	23,2	390,8	414,0	5,2%
A025 M025	23,2	384,0	407,2	6,8%
A050 M025	23,2	380,8	404,0	7,5%
A075 M025	23,2	379,6	402,8	7,8%
A100 M025	23,2	379,0	402,2	7,9%

Varying insulation thickness

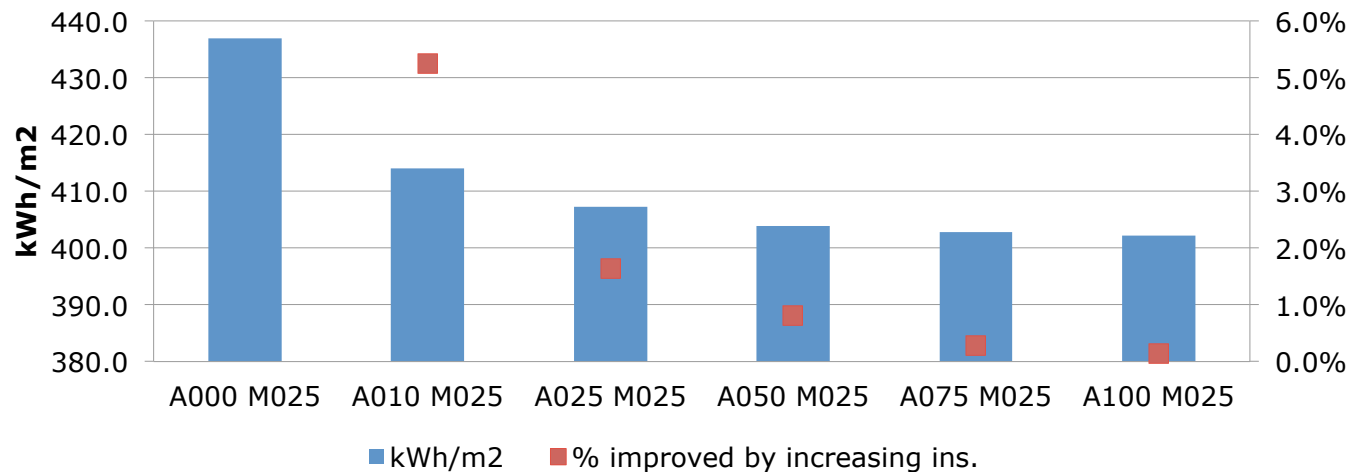


Insulation and thermal mass



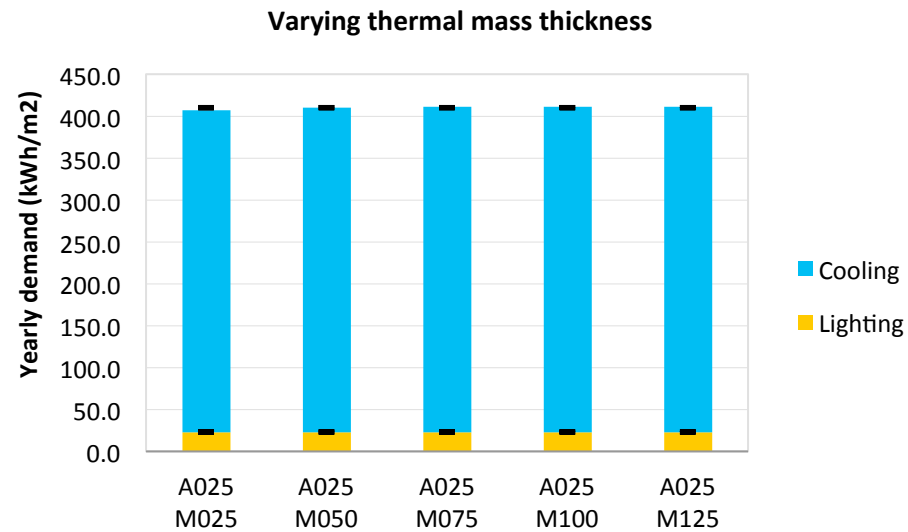
Insulation and thermal mass

Specific Energy Demand for diff. Thermal Insulation



Insulation and thermal mass

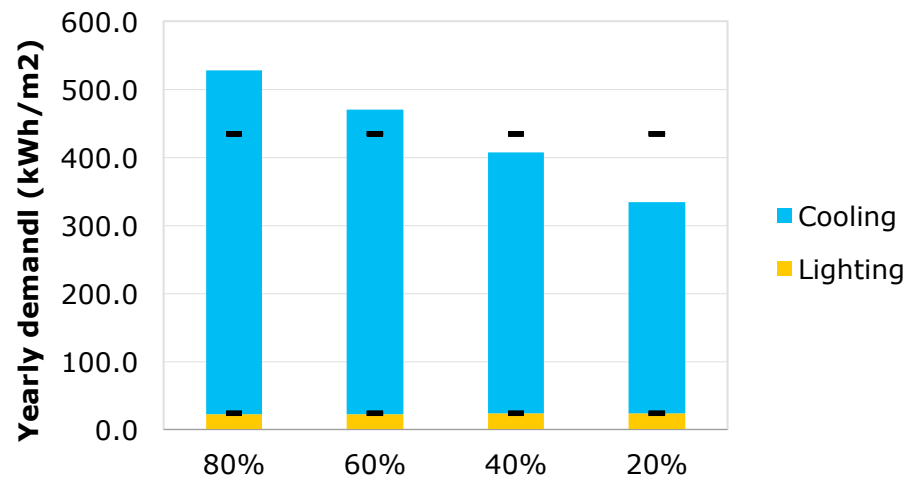
Enclosure	Lighting	Cooling	Total	Improvement
A025 M025	23,2	384,0	407,2	Ref.
A025 M050	23,2	386,6	409,8	-0,6%
A025 M075	23,2	387,4	410,6	-0,8%
A025 M100	23,2	388,0	411,2	-1,0%
A025 M125	23,2	388,4	411,6	-1,1%



Glazing type and amount of glazing

Glazing to wall ratio	Lighting	Cooling	Total	Improvement
80%	22,8	504,7	527,6	Ref.
60%	23,0	446,6	469,7	11,0%
40%	23,2	384,0	407,2	22,8%
20%	23,9	309,6	333,5	36,8%

Glazing to wall ratio. Double clear glazing



Glazing type and amount of glazing

Single pane glazing, clear.

Double glazing, clear.

Double glazing with low emissive layer (LoE).

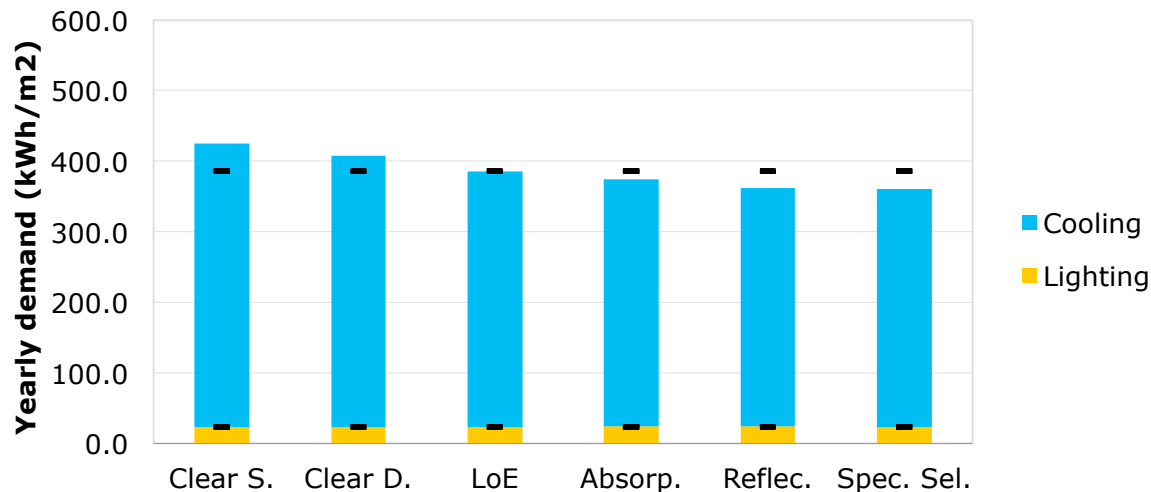
Double glazing with absorptive external pane.

Double glazing with reflective coating.

Double glazing with spectrally selective layer.

Glazing type	Lighting	Cooling	Total	Improvement
Clear S.	23,1	402,3	425,4	Ref.
Clear D.	23,2	384,0	407,2	4,3%
LoE	23,3	362,7	385,9	5,2%
Absorp.	23,8	350,5	374,3	8,1%
Reflec.	24,5	338,2	362,7	10,9%
Spec. Sel.	23,3	337,1	360,4	11,5%

Different glazing type



Building Orientation

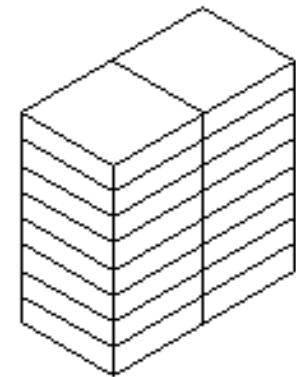
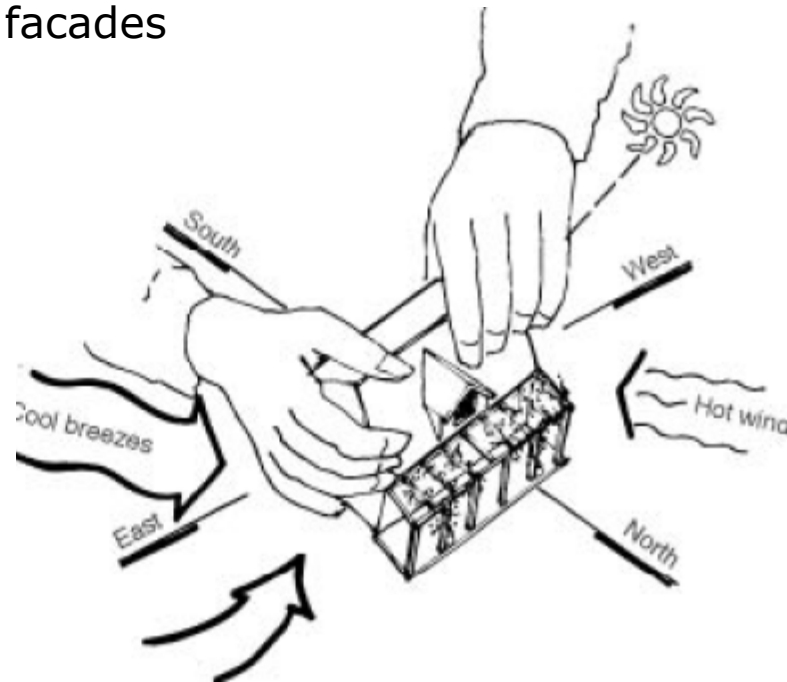
Glazing:

40% on large and small facades

50% on large facades and 20% on small facades

60% on large facades and 0% on small facades

Orientation of large facades

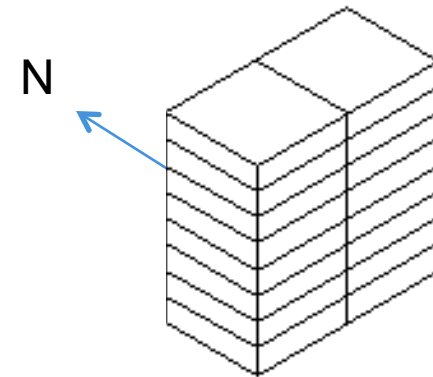


Short bar

Building Orientation

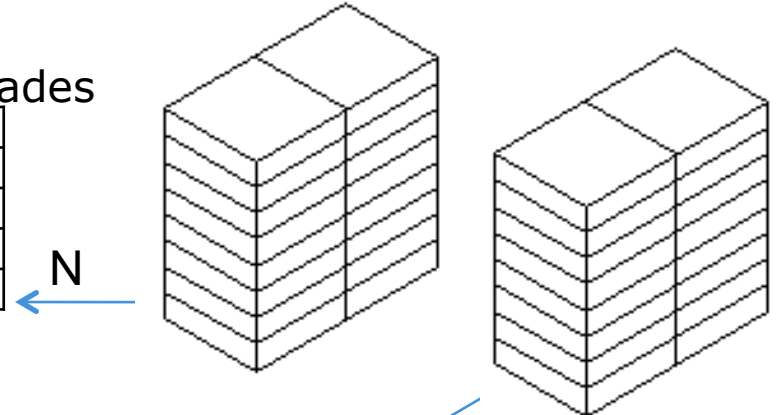
40% on large and small facades

Orientation	Lighting	Cooling	Total	Improvement
S-N	23,2	384,0	407,2	Ref.
SW-NE	23,2	395,5	418,7	-2,8%
W-E	23,3	402,1	425,4	-4,5%
NW-SE	23,3	396,4	419,6	-3,0%



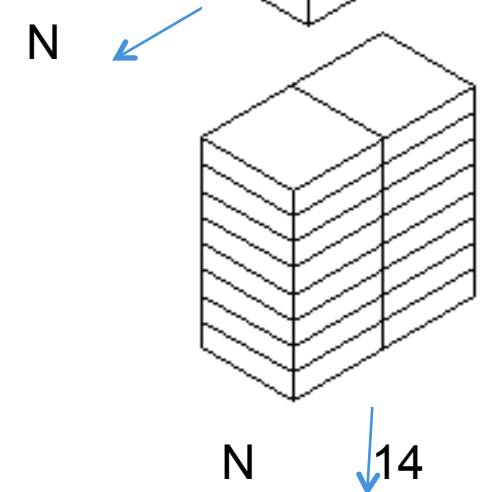
50% on large facades and 20% on small facades

Orientation	Lighting	Cooling	Total	Improvement
S-N	23,3	377,1	400,4	Ref.
SW-NE	23,3	394,2	417,5	-4,3%
W-E	23,4	407,7	431,1	-7,6%
NW-SE	23,4	395,6	419,0	-4,6%



Orientation	Lighting	Cooling	Total	Improvement
S-N	27,0	381,2	408,2	Ref.
SW-NE	26,1	403,9	430,0	-7,4%
W-E	25,6	424,1	449,7	-12,3%
NW-SE	26,1	405,7	431,8	-7,8%

des



Solar protection – window glazing elements



Orthographic Projection

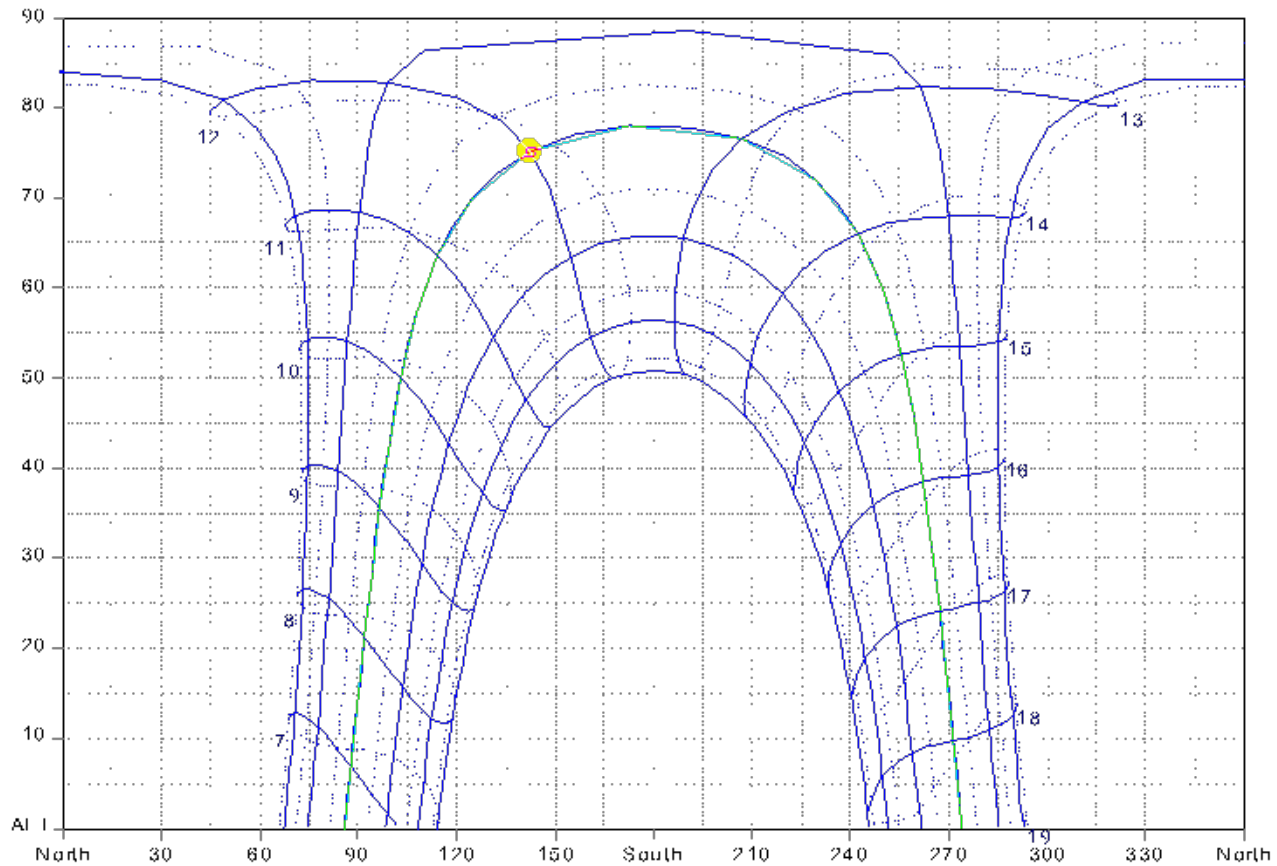
Location: 16.0°, -38.0°

Sun Position: 142.6°, 75.2°

Date/Time: 12:00, 1st Apr

Dotted lines: July-December

HSA: 142.6°, VSA: 101.9°



Solar protection – window glazing elements

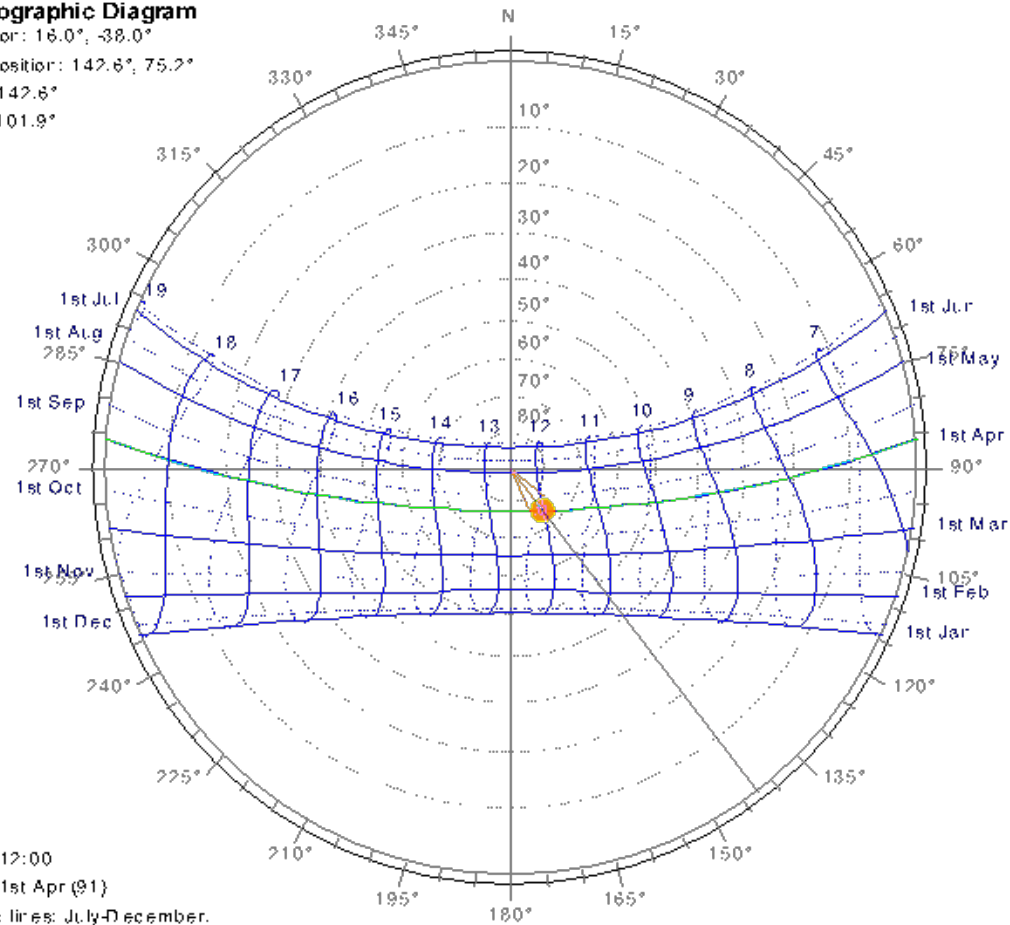
Stereographic Diagram

Location: 16.0° , -38.0°

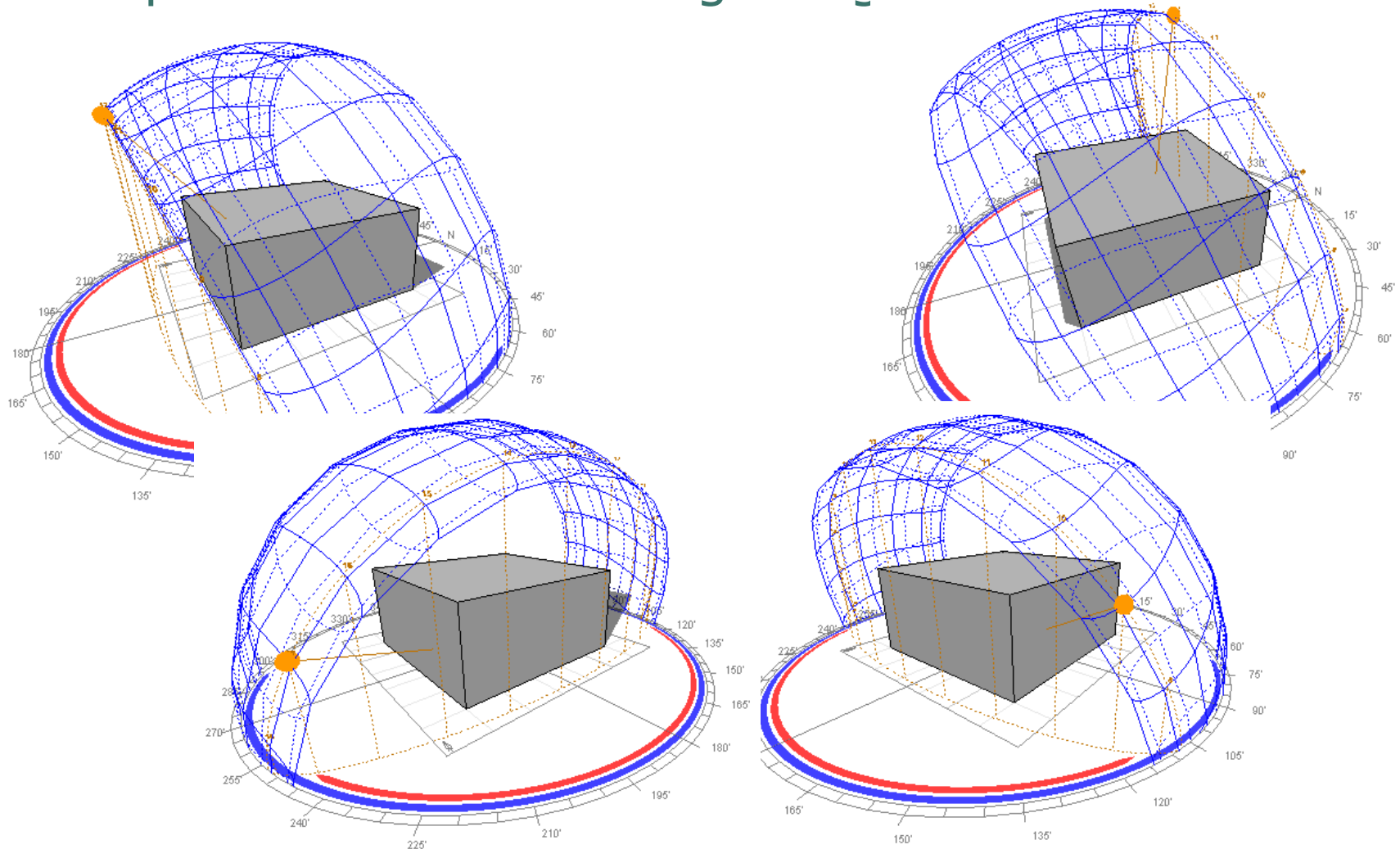
Sun Position: 142.6° , 75.2°

HSA: 142.6°

VSA: 101.9°



Solar protection – window glazing elements

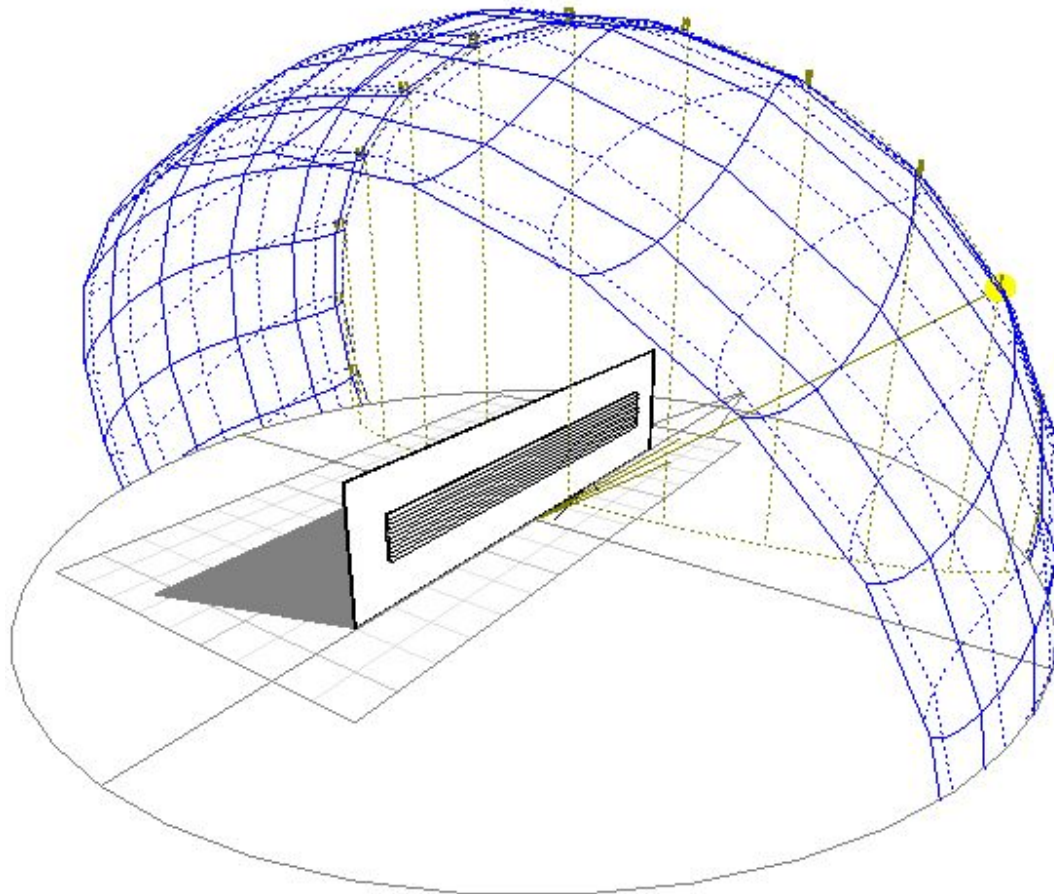


South-oriented glazing: high - first and the last months.

North-oriented glazing: moderate - central months

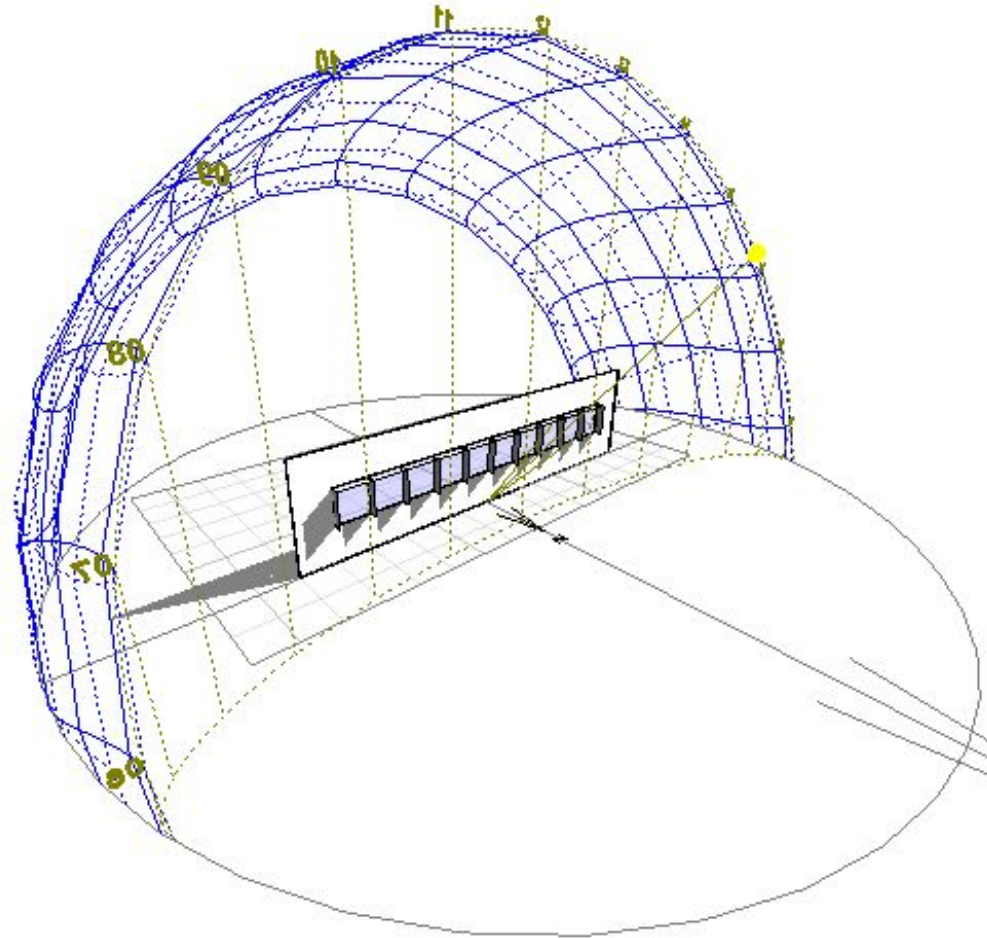
East and West oriented glazing: high all year long, in the morning hours for East and afternoon for West.

Solar protection – window glazing elements



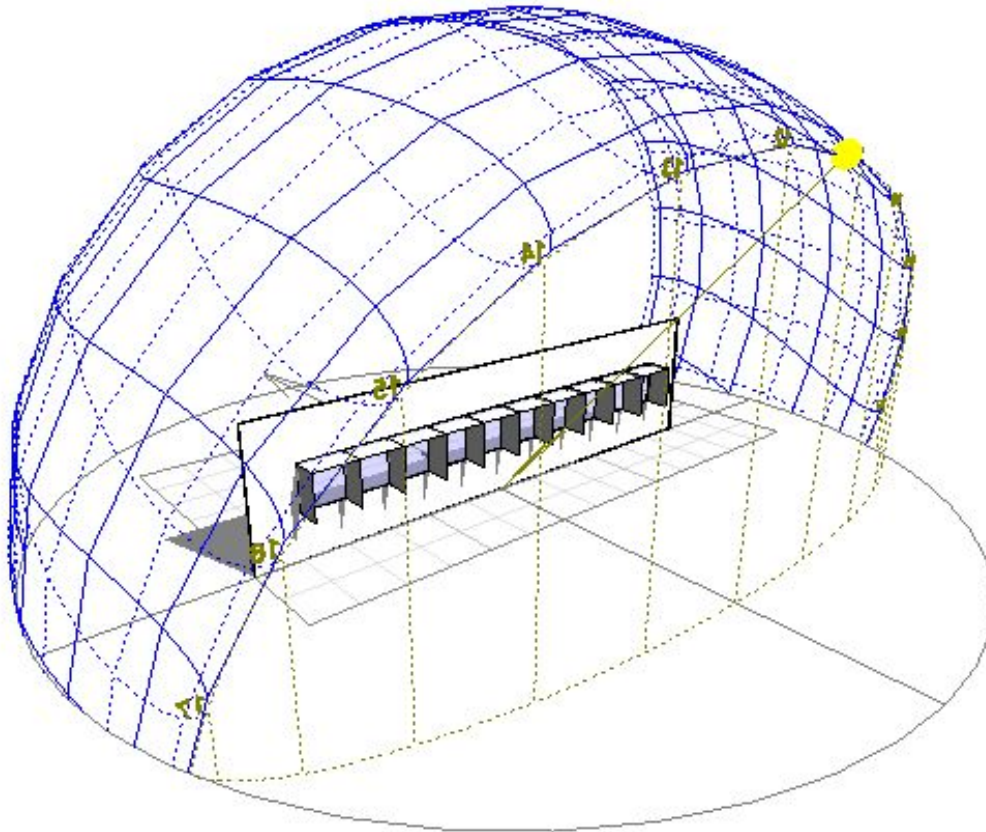
East and West: windows were protected with a 10 cm wide external louvers, separated 10 cm and 45° angle

Solar protection – window glazing elements



North: a 25 cm eave, a 25 cm lateral protection at every 1.20 m

Solar protection – window glazing elements

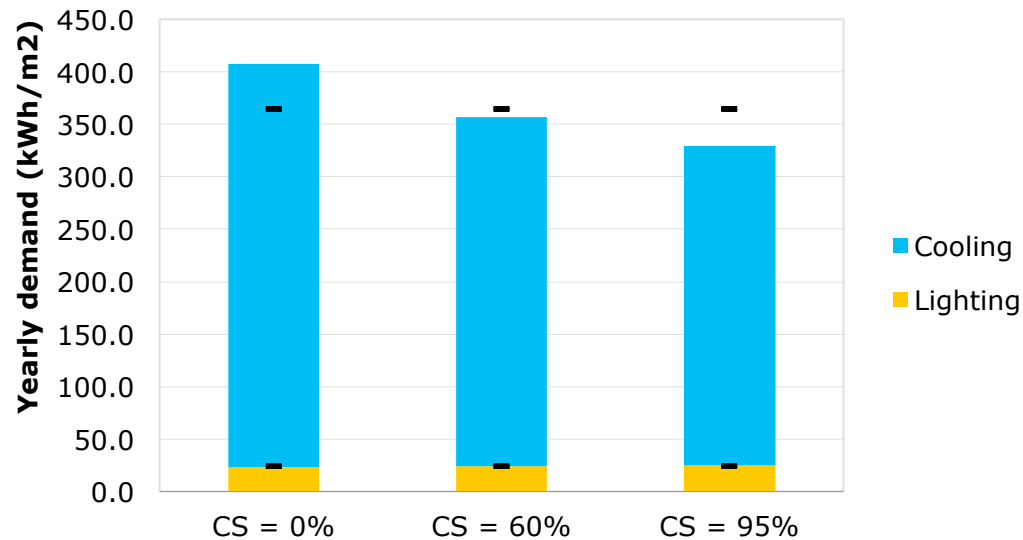


South: a 60 cm wide eave, a 60 cm lateral protection at every 1.20 m

Solar protection – window glazing elements

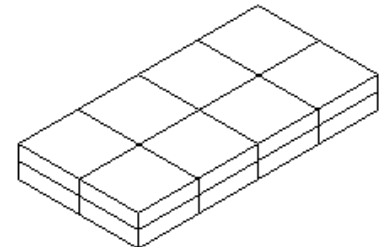
Shading coefficient	Lighting	Cooling	Total	Improvement
CS = 0%	23,2	384,0	407,2	Ref.
CS = 60%	24,0	333,1	357,1	12,3%
CS = 95%	25,0	304,4	329,4	19,1%

**Comparison of different levels of solar protection,
Short Bar**

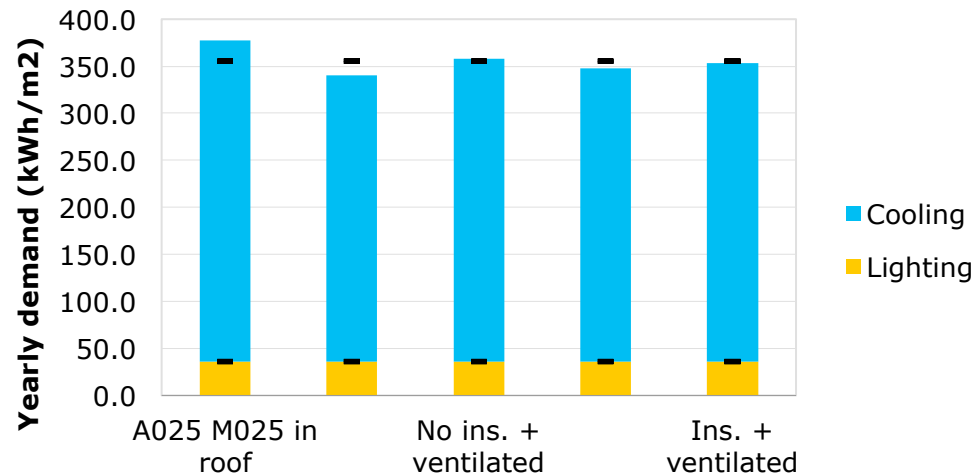


- Roof

Roof	Lighting	Cooling	Total	Improvement
No insulation	36,1	378,5	414,6	Ref.
A025 M025 in roof	36,1	341,5	377,6	8,9%
No ins. + shade	36,1	304,5	340,6	17,8%
No ins. + ventilated	36,0	321,5	357,5	13,8%
Ins. + shade	36,1	311,5	347,6	16,2%
Ins. + ventilated	36,0	317,8	353,8	14,7%



Different roof solutions



Contact between building and ground

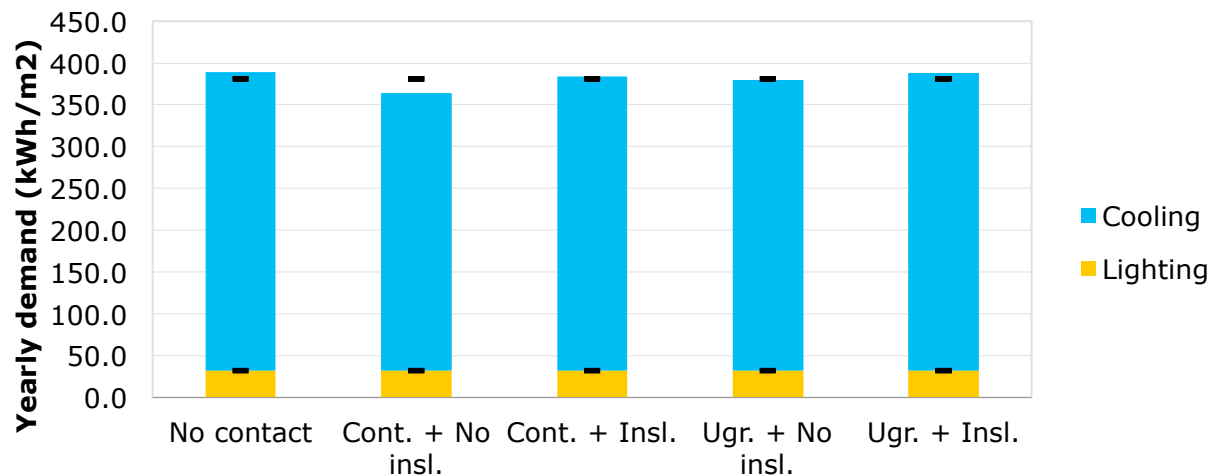
- No contact with ground (pilotis).
- Contact with ground, no insulation on ground floor.
- Contact with ground, 2.5 cm insulation on ground floor.
- Contact, with underground floor, no insulation on floor.
- Contact, with underground floor, 2.5 cm insulation on floor.



Contact between building and ground

Option	Lighting	Cooling	Total	Improvement
No contact	31,8	357,5	389,3	Ref.
Cont. + No insl.	31,8	332,5	364,2	6,4%
Cont. + Insl.	31,8	352,0	383,8	1,4%
Ugr. + No insl.	31,8	348,1	379,8	2,4%
Ugr. + Insl.	31,8	356,5	388,3	0,3%

Contact between building and ground

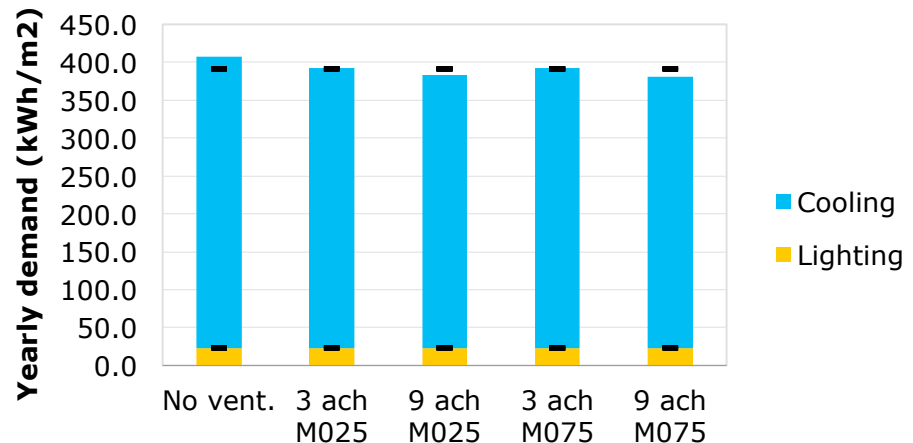


Night natural ventilation

- 3 air changes per hour, low thermal mass (2.5 cm wide)
- 9 air changes per hour, low thermal mass (2.5 cm)
- 3 air changes per hour, higher thermal mass (7.5 cm)
- 9 air changes per hour, higher thermal mass (7.5 cm)

Option	Lighting	Cooling	Total	Improvement
No vent	23,2	384,0	407,2	Ref.
3 ach M025	23,2	368,9	392,1	3,7%
9 ach M025	23,2	360,5	383,7	5,8%
3 ach M075	23,2	369,4	392,6	3,6%
9 ach M075	23,2	357,6	380,8	6,5%

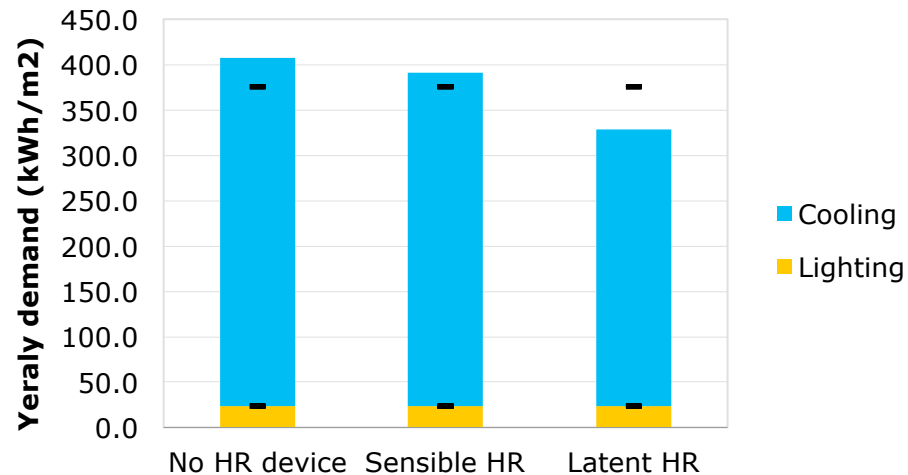
Two levels of nat. Ventilation and two levels of thermal mass



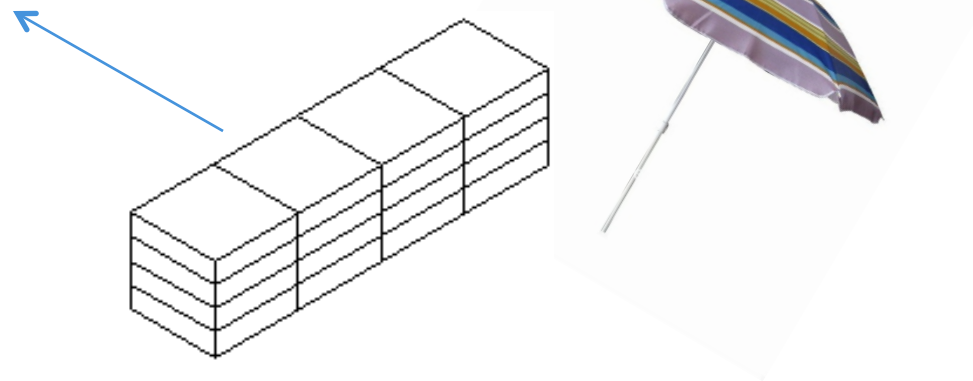
Heat recovery device in ventilation system

Option	Lighting	Cooling	Total	Improvement
No HR device	23,2	384,0	407,2	Ref.
Sensible HR	23,2	367,5	390,7	4,1%
Latent HR	23,2	305,7	328,9	19,2%

Heat recovery unit



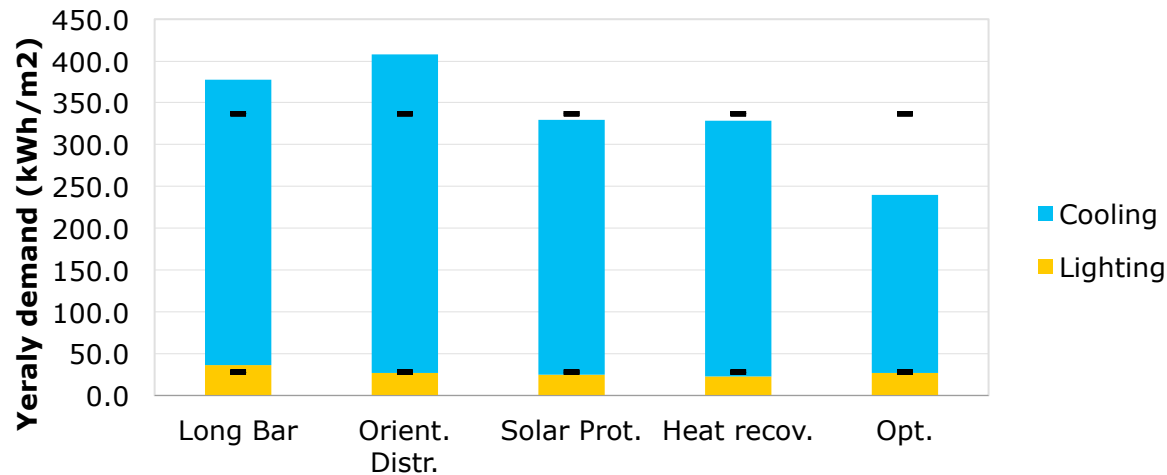
- “Optimized” model:
- **Long Bar shape:** this shape performs better than the average although not the best – solar protection facilitated
- **Large facades north and south-oriented:** Glazing mainly on north and south - optimal one and renders energy savings.
- **40% glazing on large facades, 20% on small facades:** This strategy strengthens the strategies for reduction of solar gains through glazing - facilitates solar protection. Solar protection with shading coefficient close to 95%
- **Heat recovery unit**



- “Optimized” model:

Option	Lighting	Cooling	Total	Improvement
Ext 2p	36,1	341,5	377,6	7,5%
Orient. Distr.	27,0	381,2	408,2	Ref.
Solar Prot.	25,0	304,4	329,4	19,3%
Heat recov.	23,2	305,7	328,9	19,4%
Opt.	26,5	213,3	239,9	41,2%

Optimized model vs. other alternatives



Summary of Parametric Study

- Strong impact



- Weak impact

Summary of Parametric Study

- Strong impact

Amount of glazing

Heat recovery device in
ventilation system

Solar protection – window
glazing elements

Shape of the building
Roof

Building Orientation

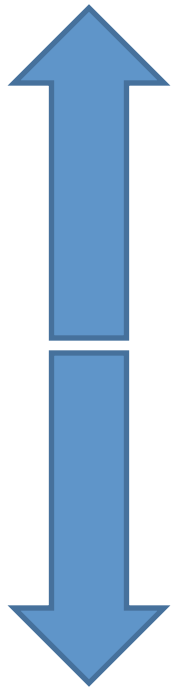
Glazing type

Night natural ventilation

Contact between building and
ground

Insulation and thermal mass

- Weak impact



Thank you

www.tta.com.es

Jaume Serrasolses: jaume.serrasolses@tta.com.es

Unai Arrieta: unai.arrieta@tta.com.es