

Energy studies through OpenStudio

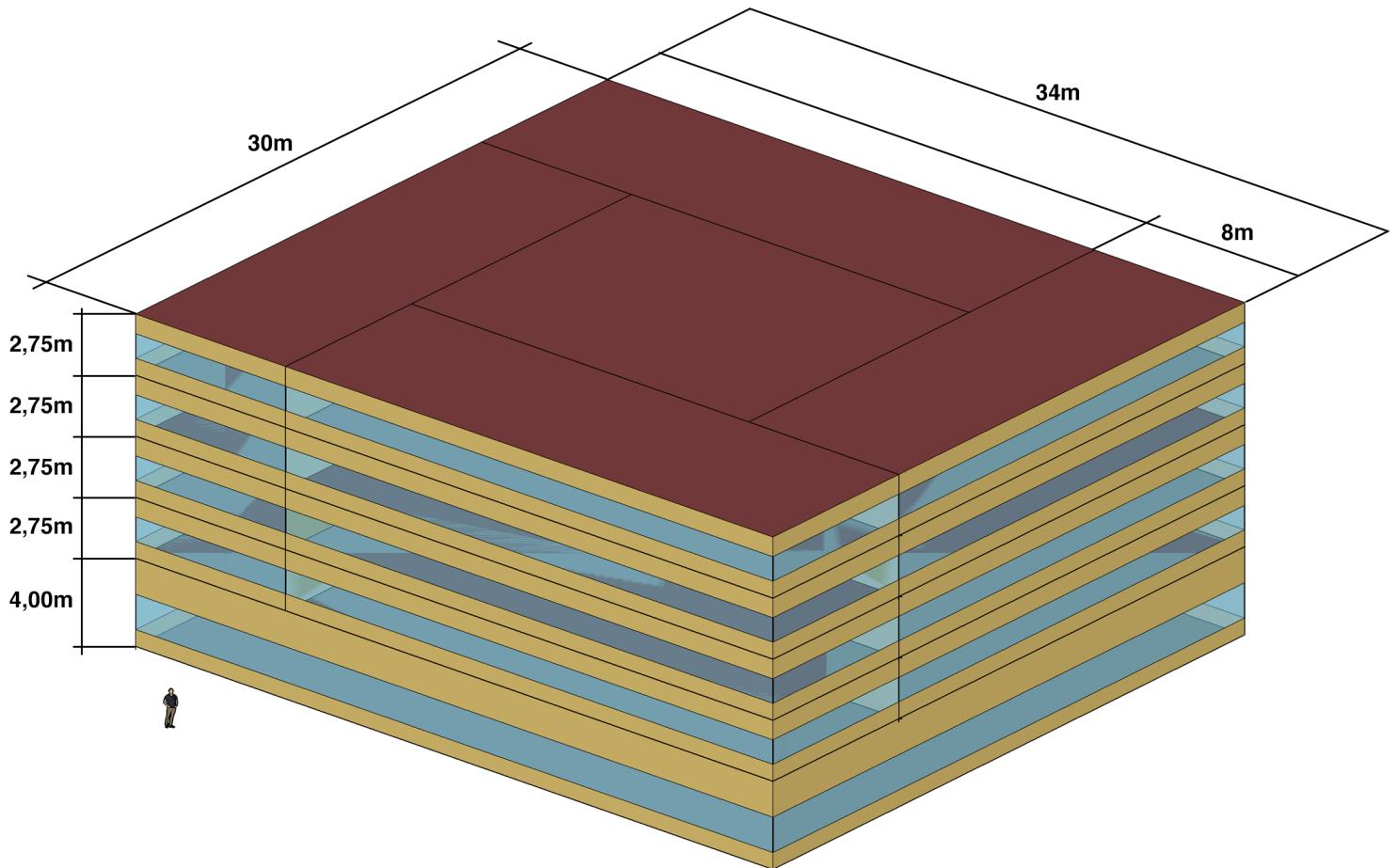
Technical Environmental Systems

Politecnico di Milano, December 2018

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geometry

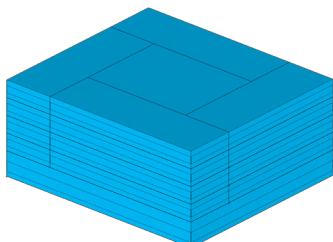
The chosen geometry for the commercial space is based on an urban shopping mall model, with a large, open first floor and additional floors with a central space for escalators/elevator surrounded by commercial space. This results in the building consisting of only one thermal zone as the escalators penetrates the floor boundaries. Also the interior walls are open to the central core.



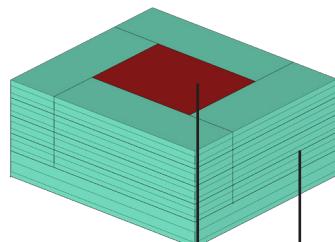
Window to wall ratio: 0.4

Window position: 760mm above floor

Thermal zones



Space types



189.1 - 2009 - Office - Corridor CZ1-3

189.1 - 2009 - Office - OpenOffice CZ1-3

materials

For the materials we have selected three base materials: stucco, concrete and gypsum, appearing in all the wall configurations. These wall configurations are altered with three different insulation thicknesses: 5cm, 10cm and 25cm.

Name: Stucco 25mm	Name: Gypsum 13mm	Name: Concrete 25cm
Measure Tags (Optional):	Measure Tags (Optional):	Measure Tags (Optional):
Standard: <input type="button" value="▼"/> Standard Source: <input type="button" value="▼"/>	Standard: <input type="button" value="▼"/> Standard Source: <input type="button" value="▼"/>	Standard: <input type="button" value="▼"/> Standard Source: <input type="button" value="▼"/>
Standards Category: <input type="button" value="▼"/> Standards Identifier: <input type="button" value="▼"/>	Standards Category: <input type="button" value="▼"/> Standards Identifier: <input type="button" value="▼"/>	Standards Category: <input type="button" value="▼"/> Standards Identifier: <input type="button" value="▼"/>
Composite Framing Material: <input type="button" value="▼"/> Composite Framing Configuration: <input type="button" value="▼"/>	Composite Framing Material: <input type="button" value="▼"/> Composite Framing Configuration: <input type="button" value="▼"/>	Composite Framing Material: <input type="button" value="▼"/> Composite Framing Configuration: <input type="button" value="▼"/>
Composite Framing Depth: <input type="button" value="▼"/> Composite Framing Size: <input type="button" value="▼"/>	Composite Framing Depth: <input type="button" value="▼"/> Composite Framing Size: <input type="button" value="▼"/>	Composite Framing Depth: <input type="button" value="▼"/> Composite Framing Size: <input type="button" value="▼"/>
Composite Cavity Insulation: <input type="button" value="▼"/>	Composite Cavity Insulation: <input type="button" value="▼"/>	Composite Cavity Insulation: <input type="button" value="▼"/>
Roughness: <input type="button" value="▼"/> Thickness: <input type="button" value="▼"/> Smooth <input type="button" value="▼"/> 0.025000 m	Roughness: <input type="button" value="▼"/> Thickness: <input type="button" value="▼"/> Smooth <input type="button" value="▼"/> 0.013000 m	Roughness: <input type="button" value="▼"/> Thickness: <input type="button" value="▼"/> MediumRough <input type="button" value="▼"/> 0.250000 m
Conductivity: <input type="button" value="▼"/> Density: <input type="button" value="▼"/> 0.691800 W/m·K 1858.000000 kg/m ³	Conductivity: <input type="button" value="▼"/> Density: <input type="button" value="▼"/> 0.160000 W/m·K 784.900000 kg/m ³	Conductivity: <input type="button" value="▼"/> Density: <input type="button" value="▼"/> 1.729600 W/m·K 2243.000000 kg/m ³
Specific Heat: <input type="button" value="▼"/> Thermal Absorptance: <input type="button" value="▼"/> 837.000000 J/kg·K 0.900000	Specific Heat: <input type="button" value="▼"/> Thermal Absorptance: <input type="button" value="▼"/> 830.000000 J/kg·K 0.900000	Specific Heat: <input type="button" value="▼"/> Thermal Absorptance: <input type="button" value="▼"/> 837.000000 J/kg·K 0.900000
Solar Absorptance: <input type="button" value="▼"/> Visible Absorptance: <input type="button" value="▼"/> 0.920000	Solar Absorptance: <input type="button" value="▼"/> Visible Absorptance: <input type="button" value="▼"/> 0.400000	Solar Absorptance: <input type="button" value="▼"/> Visible Absorptance: <input type="button" value="▼"/> 0.650000
Composite Cavity Insulation: <input type="button" value="▼"/>	Composite Cavity Insulation: <input type="button" value="▼"/>	Composite Cavity Insulation: <input type="button" value="▼"/>

Name: Inner Insulation 5cm	Name: Wall Insulation 10cm	Name: Wall Insulation 20cm
Measure Tags (Optional):	Measure Tags (Optional):	Measure Tags (Optional):
Standard: <input type="button" value="▼"/> Standard Source: <input type="button" value="▼"/>	Standard: <input type="button" value="▼"/> Standard Source: <input type="button" value="▼"/>	Standard: <input type="button" value="▼"/> Standard Source: <input type="button" value="▼"/>
Standards Category: <input type="button" value="▼"/> Standards Identifier: <input type="button" value="▼"/>	Standards Category: <input type="button" value="▼"/> Standards Identifier: <input type="button" value="▼"/>	Standards Category: <input type="button" value="▼"/> Standards Identifier: <input type="button" value="▼"/>
Composite Framing Material: <input type="button" value="▼"/> Composite Framing Configuration: <input type="button" value="▼"/>	Composite Framing Material: <input type="button" value="▼"/> Composite Framing Configuration: <input type="button" value="▼"/>	Composite Framing Material: <input type="button" value="▼"/> Composite Framing Configuration: <input type="button" value="▼"/>
Composite Framing Depth: <input type="button" value="▼"/> Composite Framing Size: <input type="button" value="▼"/>	Composite Framing Depth: <input type="button" value="▼"/> Composite Framing Size: <input type="button" value="▼"/>	Composite Framing Depth: <input type="button" value="▼"/> Composite Framing Size: <input type="button" value="▼"/>
Composite Cavity Insulation: <input type="button" value="▼"/>	Composite Cavity Insulation: <input type="button" value="▼"/>	Composite Cavity Insulation: <input type="button" value="▼"/>
Roughness: <input type="button" value="▼"/> Thickness: <input type="button" value="▼"/> MediumRough <input type="button" value="▼"/> 0.050000 m	Roughness: <input type="button" value="▼"/> Thickness: <input type="button" value="▼"/> MediumRough <input type="button" value="▼"/> 0.100000 m	Roughness: <input type="button" value="▼"/> Thickness: <input type="button" value="▼"/> MediumRough <input type="button" value="▼"/> 0.200000 m
Conductivity: <input type="button" value="▼"/> Density: <input type="button" value="▼"/> 0.043200 W/m·K 91.000000 kg/m ³	Conductivity: <input type="button" value="▼"/> Density: <input type="button" value="▼"/> 0.043200 W/m·K 91.000000 kg/m ³	Conductivity: <input type="button" value="▼"/> Density: <input type="button" value="▼"/> 0.043200 W/m·K 91.000000 kg/m ³
Specific Heat: <input type="button" value="▼"/> Thermal Absorptance: <input type="button" value="▼"/> 837.000000 J/kg·K 0.900000	Specific Heat: <input type="button" value="▼"/> Thermal Absorptance: <input type="button" value="▼"/> 837.000000 J/kg·K 0.900000	Specific Heat: <input type="button" value="▼"/> Thermal Absorptance: <input type="button" value="▼"/> 837.000000 J/kg·K 0.900000
Solar Absorptance: <input type="button" value="▼"/> Visible Absorptance: <input type="button" value="▼"/> 0.500000	Solar Absorptance: <input type="button" value="▼"/> Visible Absorptance: <input type="button" value="▼"/> 0.500000	Solar Absorptance: <input type="button" value="▼"/> Visible Absorptance: <input type="button" value="▼"/> 0.500000
Composite Cavity Insulation: <input type="button" value="▼"/>	Composite Cavity Insulation: <input type="button" value="▼"/>	Composite Cavity Insulation: <input type="button" value="▼"/>

walls

Our three different walls are composed by the materials seen on the previous page, to achieve walls with low, medium and high thermal resistance.

1. Low thermal resistance external wall

This wall is simply composed by stucco, concrete and gypsum and has no insulation layer.

2. Medium thermal resistance external wall

Additional to the stucco, concrete and gypsum we have added a 10cm layer of insulation between the concrete and the gypsum.

3. High thermal resistance external wall

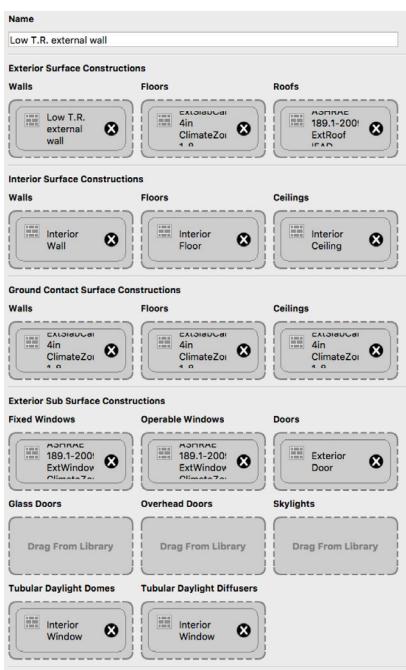
In this high thermal resistance wall, we have thickened the insulation layer to 20cm, and also adding an inner insulation layer of 5cm.

1	2	3
<p>Name: Low T.R. external wall</p> <p>Measure Tags (Optional): Standard: SHRAE 189.1-2009 Standard Source:</p> <p>Intended Surface Type: ExteriorWall Standards Construction Type: Mass</p> <p>Fenestration Type: Fenestration Assembly Context:</p> <p>Fenestration Number of Panes: Fenestration Frame Type:</p> <p>Fenestration Divider Type: Fenestration Tint:</p> <p>Fenestration Gas Fill: Fenestration Low Emissivity Coating: off</p> <p>Layer: Outside</p> <p>Stucco 25mm Concrete 25cm Gypsum 13mm</p>	<p>Name: Medium T.R. external wall</p> <p>Measure Tags (Optional): Standard: SHRAE 189.1-2009 Standard Source:</p> <p>Intended Surface Type: ExteriorWall Standards Construction Type: Mass</p> <p>Fenestration Type: Fenestration Assembly Context:</p> <p>Fenestration Number of Panes: Fenestration Frame Type:</p> <p>Fenestration Divider Type: Fenestration Tint:</p> <p>Fenestration Gas Fill: Fenestration Low Emissivity Coating: off</p> <p>Layer: Outside</p> <p>Stucco 25mm Concrete 25cm Wall Insulation 10cm Gypsum 13mm</p>	<p>Name: High T.R. external wall</p> <p>Measure Tags (Optional): Standard: SHRAE 189.1-2009 Standard Source:</p> <p>Intended Surface Type: ExteriorWall Standards Construction Type: Mass</p> <p>Fenestration Type: Fenestration Assembly Context:</p> <p>Fenestration Number of Panes: Fenestration Frame Type:</p> <p>Fenestration Divider Type: Fenestration Tint:</p> <p>Fenestration Gas Fill: Fenestration Low Emissivity Coating: off</p> <p>Layer: Outside</p> <p>Stucco 25mm Concrete 25cm Wall Insulation 20cm Inner Insulation 5cm Gypsum 13mm</p>

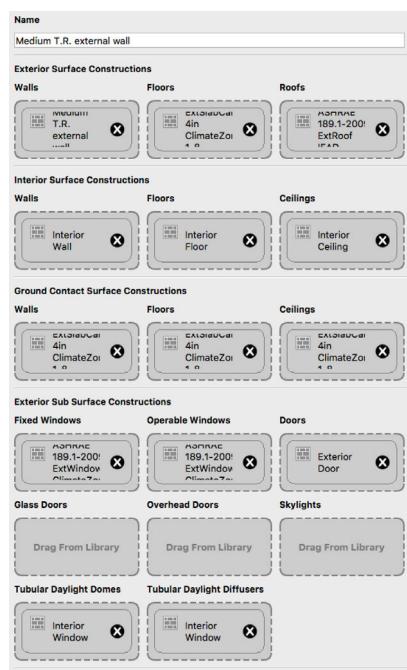
construction sets

For the construction sets, we have used the '189.1 - 2009 - CZ1 Office' as the default foundation. Three new construction sets have been created by replacing the default external walls with the three different walls we have presented on the previous page, creating construction sets with three different thermal resistances.

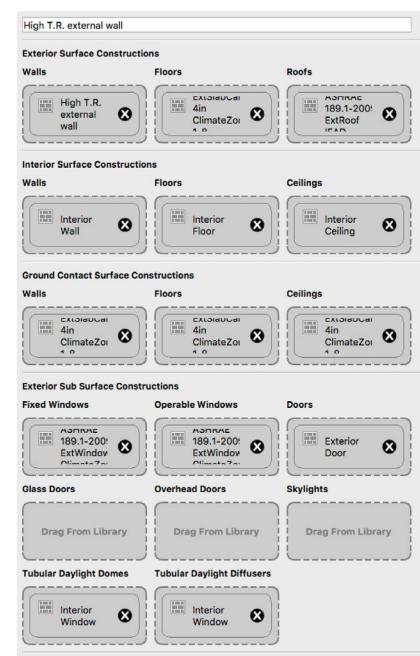
Low T.R.



Medium T.R.



High T.R.



space configurations

Further, we have applied the different construction sets to create three buildings with different thermal qualities. There is one open ground floor, and four commercial spaces in each of the additional floors. For these, we have used the default space type '189.1 - 2009 - Office - OpenOffice CZ1-3'. For the escalator area in floors 1-4 we have used the default space type "189.1 - 2009 - Office - Corridor CZ1 - 3'. The different spaces all belong to the same thermal zones, as mentioned.

Low T.R.

Space Name	All	Story	Thermal Zone	Space Type	Default Construction Set	Default Schedule Set	Part of Total Floor Area
1-1	<input type="checkbox"/>	Building Story 2	Thermal Zone 1	189.1-2009 - Office - C	Low T.R. external wall	<input type="checkbox"/>	<input checked="" type="checkbox"/>
1-2	<input type="checkbox"/>	Building Story 2	Thermal Zone 1	189.1-2009 - Office - C	Low T.R. external wall	<input type="checkbox"/>	<input checked="" type="checkbox"/>
1-3	<input type="checkbox"/>	Building Story 2	Thermal Zone 1	189.1-2009 - Office - C	Low T.R. external wall	<input type="checkbox"/>	<input checked="" type="checkbox"/>
1-4	<input type="checkbox"/>	Building Story 2	Thermal Zone 1	189.1-2009 - Office - C	Low T.R. external wall	<input type="checkbox"/>	<input checked="" type="checkbox"/>
1-C	<input type="checkbox"/>	Building Story 2	Thermal Zone 1	189.1-2009 - Office - C	Low T.R. external wall	<input type="checkbox"/>	<input checked="" type="checkbox"/>
2-1	<input type="checkbox"/>	Building Story 3	Thermal Zone 1	189.1-2009 - Office - C	Low T.R. external wall	<input type="checkbox"/>	<input checked="" type="checkbox"/>
2-2	<input type="checkbox"/>	Building Story 3	Thermal Zone 1	189.1-2009 - Office - C	Low T.R. external wall	<input type="checkbox"/>	<input checked="" type="checkbox"/>
2-3	<input type="checkbox"/>	Building Story 3	Thermal Zone 1	189.1-2009 - Office - C	Low T.R. external wall	<input type="checkbox"/>	<input checked="" type="checkbox"/>
2-4	<input type="checkbox"/>	Building Story 3	Thermal Zone 1	189.1-2009 - Office - C	Low T.R. external wall	<input type="checkbox"/>	<input checked="" type="checkbox"/>
2-C	<input type="checkbox"/>	Building Story 3	Thermal Zone 1	189.1-2009 - Office - C	Low T.R. external wall	<input type="checkbox"/>	<input checked="" type="checkbox"/>
3-1	<input type="checkbox"/>	Building Story 4	Thermal Zone 1	189.1-2009 - Office - C	Low T.R. external wall	<input type="checkbox"/>	<input checked="" type="checkbox"/>
3-2	<input type="checkbox"/>	Building Story 4	Thermal Zone 1	189.1-2009 - Office - C	Low T.R. external wall	<input type="checkbox"/>	<input checked="" type="checkbox"/>
3-3	<input type="checkbox"/>	Building Story 4	Thermal Zone 1	189.1-2009 - Office - C	Low T.R. external wall	<input type="checkbox"/>	<input checked="" type="checkbox"/>
3-4	<input type="checkbox"/>	Building Story 4	Thermal Zone 1	189.1-2009 - Office - C	Low T.R. external wall	<input type="checkbox"/>	<input checked="" type="checkbox"/>
3-C	<input type="checkbox"/>	Building Story 4	Thermal Zone 1	189.1-2009 - Office - C	Low T.R. external wall	<input type="checkbox"/>	<input checked="" type="checkbox"/>
4-1	<input type="checkbox"/>	Building Story 5	Thermal Zone 1	189.1-2009 - Office - C	Low T.R. external wall	<input type="checkbox"/>	<input checked="" type="checkbox"/>
4-2	<input type="checkbox"/>	Building Story 5	Thermal Zone 1	189.1-2009 - Office - C	Low T.R. external wall	<input type="checkbox"/>	<input checked="" type="checkbox"/>
4-3	<input type="checkbox"/>	Building Story 5	Thermal Zone 1	189.1-2009 - Office - C	Low T.R. external wall	<input type="checkbox"/>	<input checked="" type="checkbox"/>
4-4	<input type="checkbox"/>	Building Story 5	Thermal Zone 1	189.1-2009 - Office - C	Low T.R. external wall	<input type="checkbox"/>	<input checked="" type="checkbox"/>
4-C	<input type="checkbox"/>	Building Story 5	Thermal Zone 1	189.1-2009 - Office - C	Low T.R. external wall	<input type="checkbox"/>	<input checked="" type="checkbox"/>
GF	<input type="checkbox"/>	Building Story 1	Thermal Zone 1	189.1-2009 - Office - C	Low T.R. external wall	<input type="checkbox"/>	<input checked="" type="checkbox"/>

Medium T.R.

Space Name	All	Story	Thermal Zone	Space Type	Default Construction Set	Default Schedule Set	Part of Total Floor Area
1-1	<input type="checkbox"/>	Building Story 2	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
1-2	<input type="checkbox"/>	Building Story 2	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
1-3	<input type="checkbox"/>	Building Story 2	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
1-4	<input type="checkbox"/>	Building Story 2	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
1-C	<input type="checkbox"/>	Building Story 2	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
2-1	<input type="checkbox"/>	Building Story 3	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
2-2	<input type="checkbox"/>	Building Story 3	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
2-3	<input type="checkbox"/>	Building Story 3	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
2-4	<input type="checkbox"/>	Building Story 3	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
2-C	<input type="checkbox"/>	Building Story 3	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
3-1	<input type="checkbox"/>	Building Story 4	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
3-2	<input type="checkbox"/>	Building Story 4	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
3-3	<input type="checkbox"/>	Building Story 4	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
3-4	<input type="checkbox"/>	Building Story 4	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
3-C	<input type="checkbox"/>	Building Story 4	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
4-1	<input type="checkbox"/>	Building Story 5	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
4-2	<input type="checkbox"/>	Building Story 5	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
4-3	<input type="checkbox"/>	Building Story 5	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
4-4	<input type="checkbox"/>	Building Story 5	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
4-C	<input type="checkbox"/>	Building Story 5	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
GF	<input type="checkbox"/>	Building Story 1	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>

High T.R.

Space Name	All	Story	Thermal Zone	Space Type	Default Construction Set	Default Schedule Set	Part of Total Floor Area
1-1	<input type="checkbox"/>	Building Story 2	Thermal Zone 1	189.1-2009 - Office - C	High T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
1-2	<input type="checkbox"/>	Building Story 2	Thermal Zone 1	189.1-2009 - Office - C	High T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
1-3	<input type="checkbox"/>	Building Story 2	Thermal Zone 1	189.1-2009 - Office - C	High T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
1-4	<input type="checkbox"/>	Building Story 2	Thermal Zone 1	189.1-2009 - Office - C	High T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
1-C	<input type="checkbox"/>	Building Story 2	Thermal Zone 1	189.1-2009 - Office - C	High T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
2-1	<input type="checkbox"/>	Building Story 3	Thermal Zone 1	189.1-2009 - Office - C	High T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
2-2	<input type="checkbox"/>	Building Story 3	Thermal Zone 1	189.1-2009 - Office - C	High T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
2-3	<input type="checkbox"/>	Building Story 3	Thermal Zone 1	189.1-2009 - Office - C	High T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
2-4	<input type="checkbox"/>	Building Story 3	Thermal Zone 1	189.1-2009 - Office - C	High T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
2-C	<input type="checkbox"/>	Building Story 3	Thermal Zone 1	189.1-2009 - Office - C	High T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
3-1	<input type="checkbox"/>	Building Story 4	Thermal Zone 1	189.1-2009 - Office - C	High T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
3-2	<input type="checkbox"/>	Building Story 4	Thermal Zone 1	189.1-2009 - Office - C	High T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
3-3	<input type="checkbox"/>	Building Story 4	Thermal Zone 1	189.1-2009 - Office - C	High T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
3-4	<input type="checkbox"/>	Building Story 4	Thermal Zone 1	189.1-2009 - Office - C	High T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
3-C	<input type="checkbox"/>	Building Story 4	Thermal Zone 1	189.1-2009 - Office - C	High T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
4-1	<input type="checkbox"/>	Building Story 5	Thermal Zone 1	189.1-2009 - Office - C	High T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
4-2	<input type="checkbox"/>	Building Story 5	Thermal Zone 1	189.1-2009 - Office - C	High T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
4-3	<input type="checkbox"/>	Building Story 5	Thermal Zone 1	189.1-2009 - Office - C	High T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
4-4	<input type="checkbox"/>	Building Story 5	Thermal Zone 1	189.1-2009 - Office - C	High T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
4-C	<input type="checkbox"/>	Building Story 5	Thermal Zone 1	189.1-2009 - Office - C	High T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>
GF	<input type="checkbox"/>	Building Story 1	Thermal Zone 1	189.1-2009 - Office - C	High T.R. external w	<input type="checkbox"/>	<input checked="" type="checkbox"/>

results: end uses

We then ran the simulation, calculating annual energy need for heating and cooling the three different external wall configurations. We used the weather data for Piacenza, for this comparison.

Low T.R. End Uses

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	0.00	0.00	0.00	0.00	790.37	0.00
Cooling	0.00	0.00	0.00	416.84	0.00	0.00
Interior Lighting	562.98	0.00	0.00	0.00	0.00	0.00
Exterior Lighting	0.00	0.00	0.00	0.00	0.00	0.00
Interior Equipment	562.85	0.00	0.00	0.00	0.00	0.00
Exterior Equipment	0.00	0.00	0.00	0.00	0.00	0.00
Fans	0.00	0.00	0.00	0.00	0.00	0.00
Pumps	0.00	0.00	0.00	0.00	0.00	0.00
Heat Rejection	0.00	0.00	0.00	0.00	0.00	0.00
Humidification	0.00	0.00	0.00	0.00	0.00	0.00
Heat Recovery	0.00	0.00	0.00	0.00	0.00	0.00
Water Systems	0.00	0.00	0.00	0.00	0.00	0.00
Refrigeration	0.00	0.00	0.00	0.00	0.00	0.00
Generators	0.00	0.00	0.00	0.00	0.00	0.00
Total End Uses	1125.84	0.00	0.00	416.84	790.37	0.00

Note: District heat appears to be the principal heating source based on energy usage.

Medium T.R. End Uses

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	0.00	0.00	0.00	0.00	603.47	0.00
Cooling	0.00	0.00	0.00	385.09	0.00	0.00
Interior Lighting	562.98	0.00	0.00	0.00	0.00	0.00
Exterior Lighting	0.00	0.00	0.00	0.00	0.00	0.00
Interior Equipment	562.85	0.00	0.00	0.00	0.00	0.00
Exterior Equipment	0.00	0.00	0.00	0.00	0.00	0.00
Fans	0.00	0.00	0.00	0.00	0.00	0.00
Pumps	0.00	0.00	0.00	0.00	0.00	0.00
Heat Rejection	0.00	0.00	0.00	0.00	0.00	0.00
Humidification	0.00	0.00	0.00	0.00	0.00	0.00
Heat Recovery	0.00	0.00	0.00	0.00	0.00	0.00
Water Systems	0.00	0.00	0.00	0.00	0.00	0.00
Refrigeration	0.00	0.00	0.00	0.00	0.00	0.00
Generators	0.00	0.00	0.00	0.00	0.00	0.00
Total End Uses	1125.84	0.00	0.00	385.09	603.47	0.00

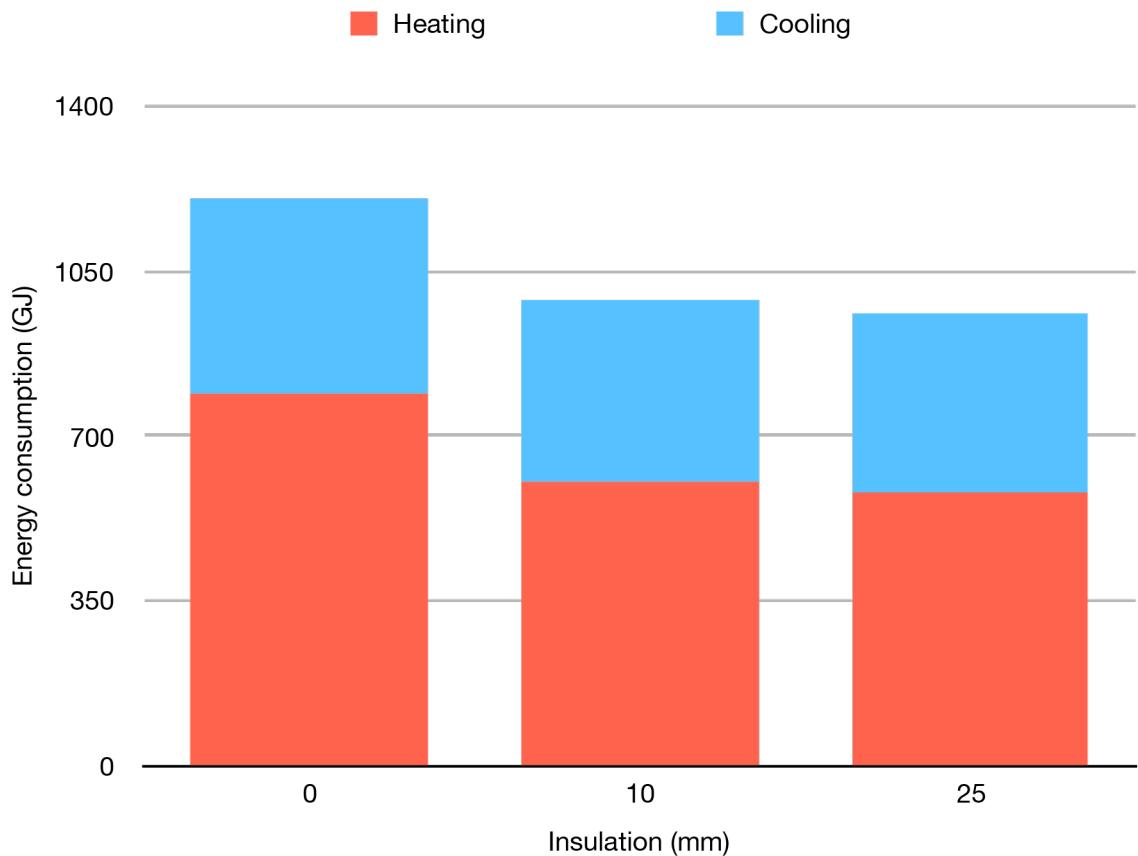
Note: District heat appears to be the principal heating source based on energy usage.

High T.R. End Uses

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	0.00	0.00	0.00	0.00	581.43	0.00
Cooling	0.00	0.00	0.00	379.49	0.00	0.00
Interior Lighting	562.98	0.00	0.00	0.00	0.00	0.00
Exterior Lighting	0.00	0.00	0.00	0.00	0.00	0.00
Interior Equipment	562.85	0.00	0.00	0.00	0.00	0.00
Exterior Equipment	0.00	0.00	0.00	0.00	0.00	0.00
Fans	0.00	0.00	0.00	0.00	0.00	0.00
Pumps	0.00	0.00	0.00	0.00	0.00	0.00
Heat Rejection	0.00	0.00	0.00	0.00	0.00	0.00
Humidification	0.00	0.00	0.00	0.00	0.00	0.00
Heat Recovery	0.00	0.00	0.00	0.00	0.00	0.00
Water Systems	0.00	0.00	0.00	0.00	0.00	0.00
Refrigeration	0.00	0.00	0.00	0.00	0.00	0.00
Generators	0.00	0.00	0.00	0.00	0.00	0.00
Total End Uses	1125.84	0.00	0.00	379.49	581.43	0.00

Note: District heat appears to be the principal heating source based on energy usage.

results: comparison of wall configurations in Piacenza



From the results, we definitely see a difference in the energy consumption. The difference is greater from the configuration with no insulation, to the one with 10 cm insulation. What is interesting to observe in this case, is that, adding 15cm makes little difference, when you already have 10cm of insulation.

Adding 10 cm of insulation to the concrete wall saves a substantial 22% of the energy consumption for heating/cooling.

But, adding an additional 15 cm on top of that saves you less than 3% of the energy consumption.

climate comparisons

After comparing the wall configurations, we used the 'Medium T.R.' configuration as the base to compare annual energy consumption for heating/cooling in three different climates with regards to temperature. We downloaded the data from EnergyPlus, using the .epw- and .ddy-files.

Oslo, Norway (cold)

Weather File [Change Weather File](#)

Name: OSLO/FORNEBU

Latitude: 59.9
Longitude: 10.62
Elevation: 17
Time Zone: 1

NOR_Oslo.Fornebu.014880_IWEC

Piacenza, Italy (mild)

Weather File [Change Weather File](#)

Name: CAIRO

Latitude: 30.13
Longitude: 31.4
Elevation: 74
Time Zone: 2

ITA_Piacenza.160840_IGDG

Cairo, Egypt(hot)

Weather File [Change Weather File](#)

Name: Piacenza

Latitude: 44.92
Longitude: 9.73
Elevation: 134
Time Zone: 1

EGY_Cairo.623660_IWEC

Wall Configuration Base used for climate comparison

The wall configurations of the climate comparison are the 'Medium T.R.' for all three cases.

Wall

Name:
Medium T.R. external wall

Measure Tags (Optional):
Standard: Standard Source:
SHRAE 189.1-2009

Intended Surface Type:
Exterior Wall Mass

Fenestration Type:
Fenestration Assembly Context:

Fenestration Number of Panes:
Fenestration Frame Type:

Fenestration Divider Type:
Fenestration Tint:

Fenestration Gas Fill:
Fenestration Low Emissivity Coating: off

Layer:
Outside

Stucco 25mm
Concrete 25cm
Wall Insulation 10cm
Gypsum 13mm

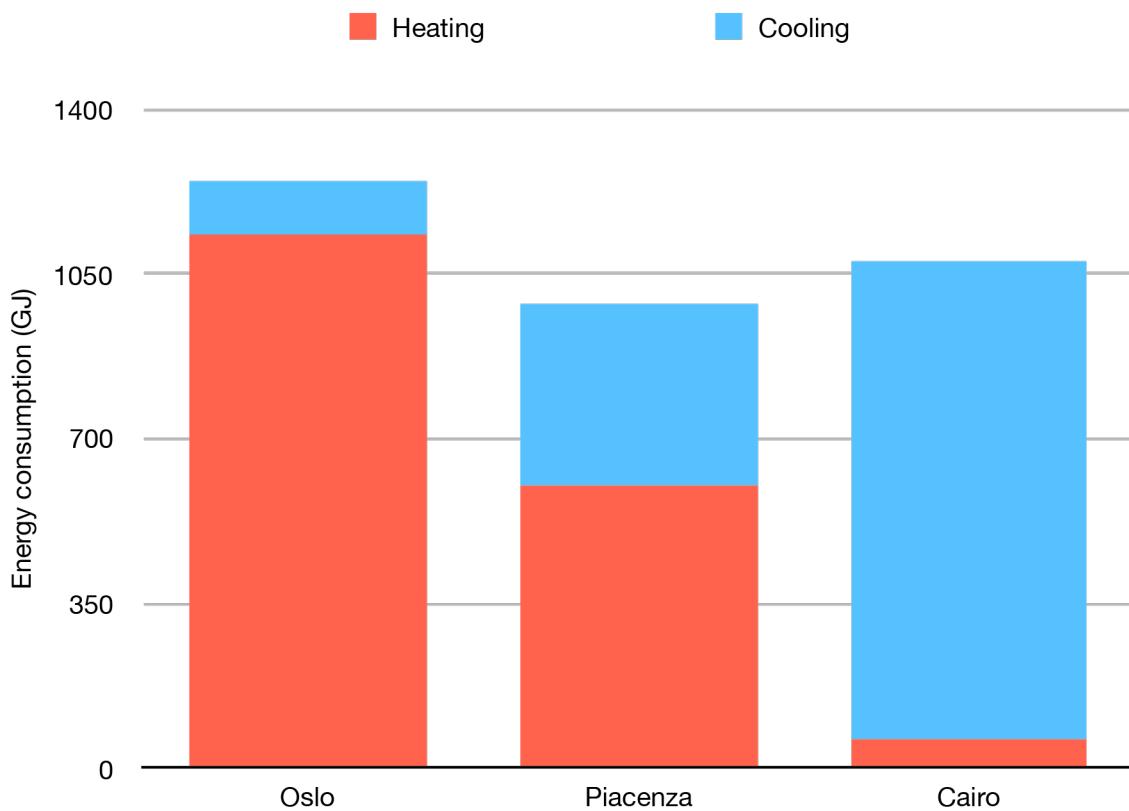
Construction set



Space configurations

Space Name	All	Story	Thermal Zone	Space Type	Default Construction Set	Default Schedule Set	Part of Total Floor Area
1-1	<input type="checkbox"/>	Building Story 2	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
1-2	<input type="checkbox"/>	Building Story 2	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
1-3	<input type="checkbox"/>	Building Story 2	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
1-4	<input type="checkbox"/>	Building Story 2	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
1-C	<input type="checkbox"/>	Building Story 2	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2-1	<input type="checkbox"/>	Building Story 3	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2-2	<input type="checkbox"/>	Building Story 3	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2-3	<input type="checkbox"/>	Building Story 3	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2-4	<input type="checkbox"/>	Building Story 3	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2-C	<input type="checkbox"/>	Building Story 3	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
3-1	<input type="checkbox"/>	Building Story 4	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
3-2	<input type="checkbox"/>	Building Story 4	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
3-3	<input type="checkbox"/>	Building Story 4	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
3-4	<input type="checkbox"/>	Building Story 4	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
3-C	<input type="checkbox"/>	Building Story 4	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
4-1	<input type="checkbox"/>	Building Story 5	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
4-2	<input type="checkbox"/>	Building Story 5	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
4-3	<input type="checkbox"/>	Building Story 5	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
4-4	<input type="checkbox"/>	Building Story 5	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
4-C	<input type="checkbox"/>	Building Story 5	Thermal Zone 1	189.1-2009 - Office - C	Medium T.R. external	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
OF	<input type="checkbox"/>	Building Story 1	Thermal Zone 11	189.1-2009 - Office - C	Medium T.R. external	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

results: comparison of climates



	Heating (GJ)	Cooling (GJ)	Total (GJ)
Oslo	1134	113	1247
Piacenza	603	385	988
Cairo	62	1017	1079

As expected, we see huge differences in how the energy consumption is distributed for heating and cooling, in the different climates. But it is interesting to see how the overall consumption for heating/cooling makes a relatively small difference.

The need for cooling in Cairo, actually produces a energy consumption, almost 9% higher than that of Piacenza. And the energy consumption in Oslo is more than 20% than that of Piacenza.

conclusion

In the wall configurations comparison, we see that the relative effect of the insulation decreases the more insulation you insert. Seeing that the window surface makes 40% of the exterior wall surface, this means that the thermal resistance of the wall will only account for 60% of the exterior boundary's thermal resistance. And, the other way around, even with optimal exterior walls, 40% of window surface will induce a substantial heat loss

Furthermore, we see in the comparison of climates, that Cairo need a substantial amount of energy for cooling and that the total energy consumption regarding heating/cooling is actually lower in colder Piacenza. This, could be due to the large window area.

note:

As mentioned during our conversation with Prof. Najafi, the 20th of December, we would like to remind that the reason we have only one thermal zone, is due to the considerations of the model as an urban mall with continuous escalators (connecting all the rooms). We concluded, during the conversation, that, even though it would be optimal to do the assignment with several thermal zones, we would leave it like this, due to the fact that the assignment was already finished, and that time was an issue regarding the option of doing it again.