POLITECNICO
MILANO 1863

Politecnico di Milano
Sustainable Architecture and Landscape Design
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# TECHNICAL ENVIRONMENTAL SYSTEMS

## Open Studio Model


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## THE SIMULATION

The aim of our simulation is to understand and study the relationship between the use of material in buildings and the result in term of use of energy.

In particular we focus on the differences of walls stratigraphy and localization of the bulindigs.

We used the pack of Open Studio Program in order to undersand and analize different situations. Firstly, we built a model of a tyipic office building.

After that, we chose one typology of stratigraphy for external wall and studied the differents results in three different cities characterized by mild, hot and cold climate: Piacenza, Bangkok and Oslo.

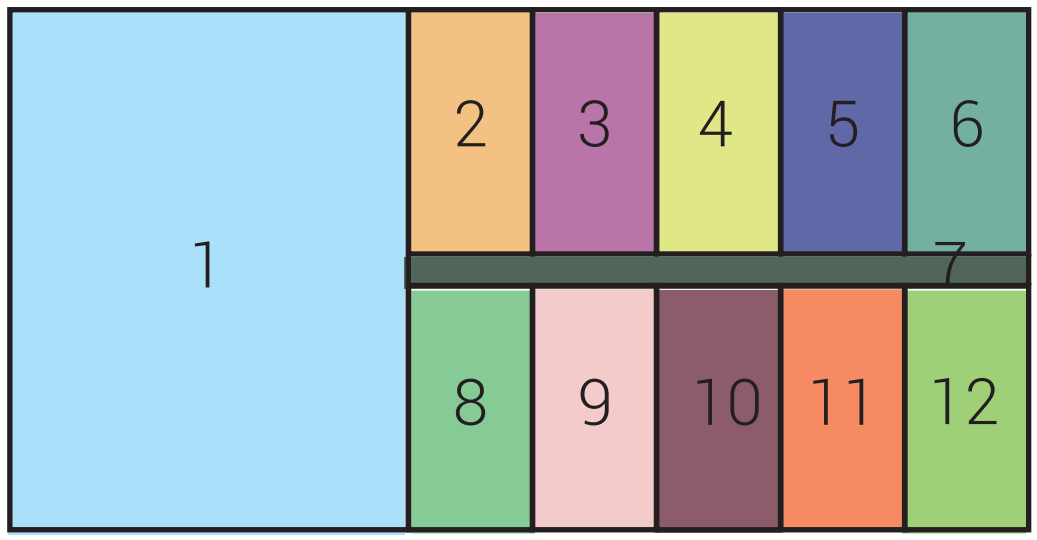
Then we observed the behaviour of three different stratigraphy of external wall in the same city, Piacenza.

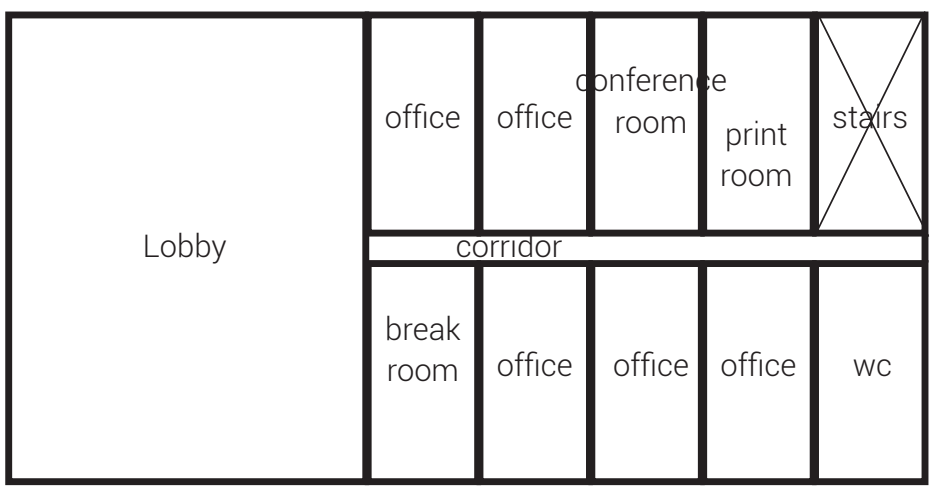
Finally we compared the results of each simulation.

## THE BUILDING

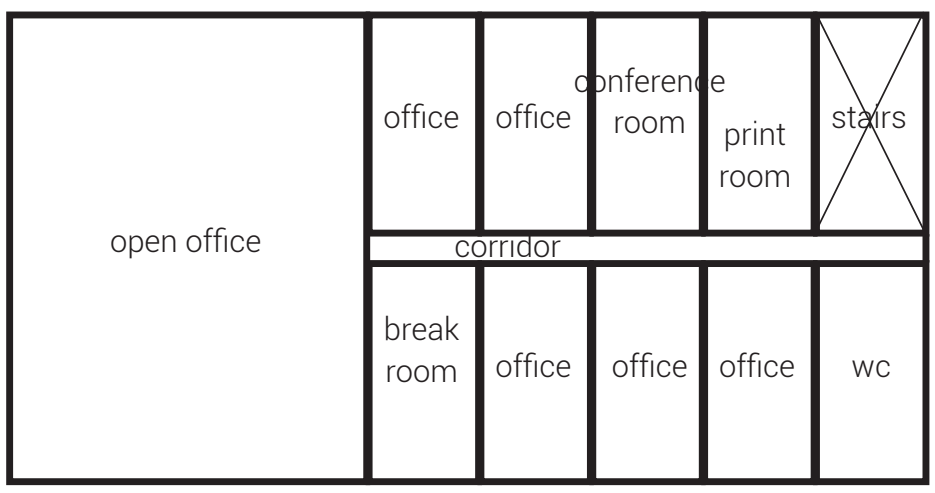
The building that we considered is an office structure of 40 x 20 and 7 metres high. It is composed by two floors of 3,5 m with a similar suddivision: one big room of 300 m2, one corridor of 30 m2 and ten rooms of 47 m2, for a total of 1600 m2.

To create the 3D model we have used Sketcup. All the four facades of the building are with continous glass but we have added solar shading only on the south,east and west facedes. We immagine all the room with an autonomous heating and cooling system, that's why we set them as different climate zone.

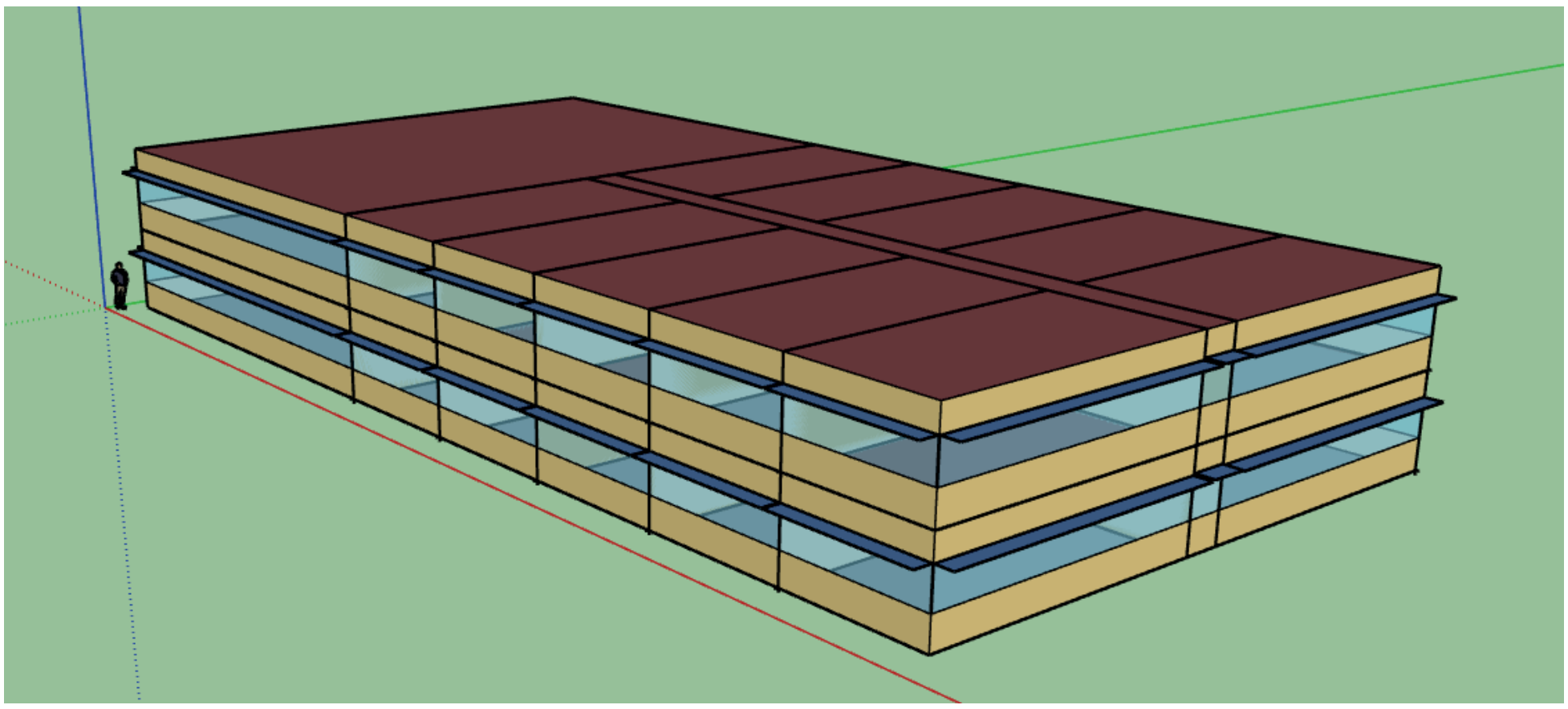



GROUND FLOOR




FIRST FLOOR



## SIMULATION 1

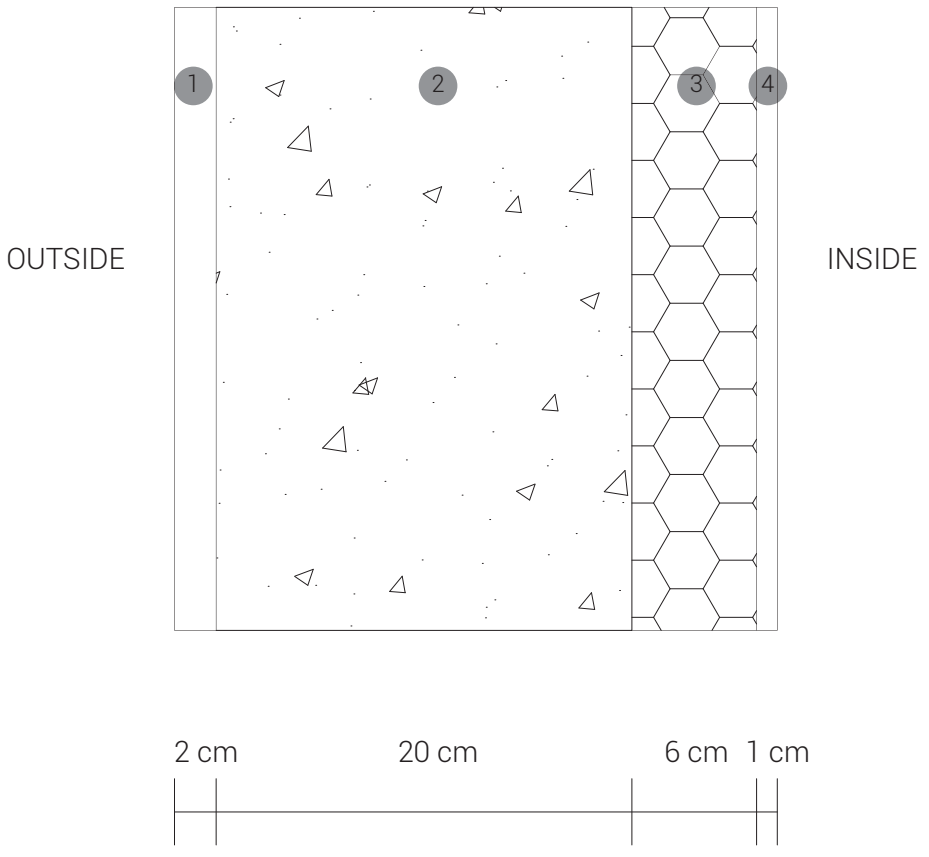
### Piacenza-Wall type 1

In the first simulation we chose the localization in the city of Piacenza, in the North of Italy.

Latitudine: 45° 2' 31 N

Longitudine: 9° 42' 16 E

We chose a wall stratigraphy following the sandars of this climate zone.




WALL TYPE 1

Layers

1. STUCCO Conductivity: 0,0432 W/mK - Densitivity: 91 kg/m3 - Specific Heat: 837 J/kgK - Thermal Absorptance: 0,9 - Solar Absorptance: 0,5 - Visible Absorptance: 0,5
2. CONCRETE Conductivity: 1,7296 W/mK - Densitivity: 2243 kg/m3 - Specific Heat: 837 J/kgK - Thermal Absorptance: 0,9 - Solar Absorptance: 0,65 - Visible Absorptance: 0,65
3. WALL INSULATION Conductivity: 0,0432 W/mK - Densitivity: 91 kg/m3 Specific Heat: 837 J/kgK - Thermal Absorptance: 0,9 - Solar Absorptance: 0,5 - Visible Absorptance: 0,5
4. GYPSUM Conductivity: 0,16 W/mK - Densitivity: 784,9 kg/m3 - Specific Heat: 830 J/kgK - Thermal Absorptance: 0,9 - Solar Absorptance: 0,4 - Visible Absorptance: 0,4

**THERMAL RESISTANCE:** 0,46 + 0,11 + 1,38 + 0,06 = 2,01 m2K/W

| TOTAL ENERGY [GJ] | HEATING [GJ] | COOLING [GJ] |
|---|---|---|
| 989.25 | 388.39 | 171.83 |

## SIMULATION 2

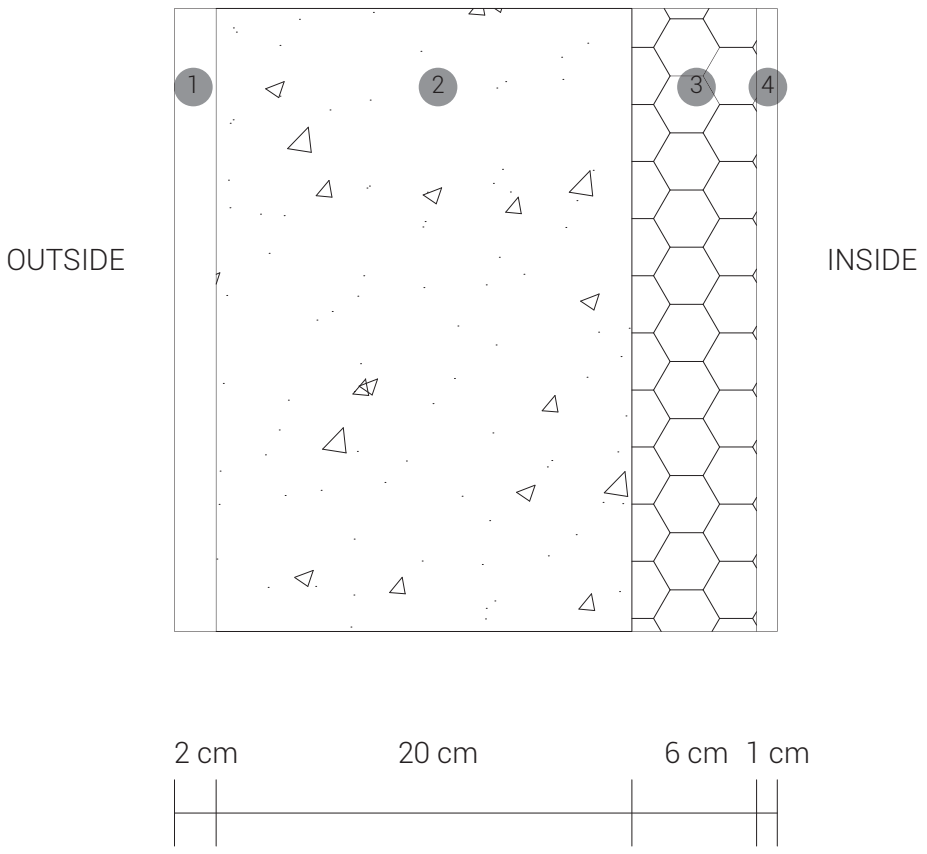
### Bangkok-Wall type 1

In the second simulation we chose the localization in the city of Bangkok, the main city of Thailand.

Latitudine: 13°45'14" N

Longitudine: 100°30'05" E

We chose the Wall Type 1, used before.




WALL TYPE 1

Layers

1. STUCCO Conductivity: 0,0432 W/mK - Densitivity: 91 kg/m3 - Specific Heat: 837 J/kgK - Thermal Absorptance: 0,9 - Solar Absorptance: 0,5 - Visible Absorptance: 0,5
2. CONCRETE Conductivity: 1,7296 W/mK - Densitivity: 2243 kg/m3 - Specific Heat: 837 J/kgK - Thermal Absorptance: 0,9 - Solar Absorptance: 0,65 - Visible Absorptance: 0,65
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4. GYPSUM Conductivity: 0,16 W/mK - Densitivity: 784,9 kg/m3 - Specific Heat: 830 J/kgK - Thermal Absorptance: 0,9 - Solar Absorptance: 0,4 - Visible Absorptance: 0,4

**THERMAL RESISTANCE:** 0,46 + 0,11 + 1,38 + 0,06 = 2,01 m2K/W

| TOTAL ENERGY [GJ] | HEATING [GJ] | COOLING [GJ] |
|---|---|---|
| 1475.67 | 0.3 | 1046.34 |

## SIMULATION 3

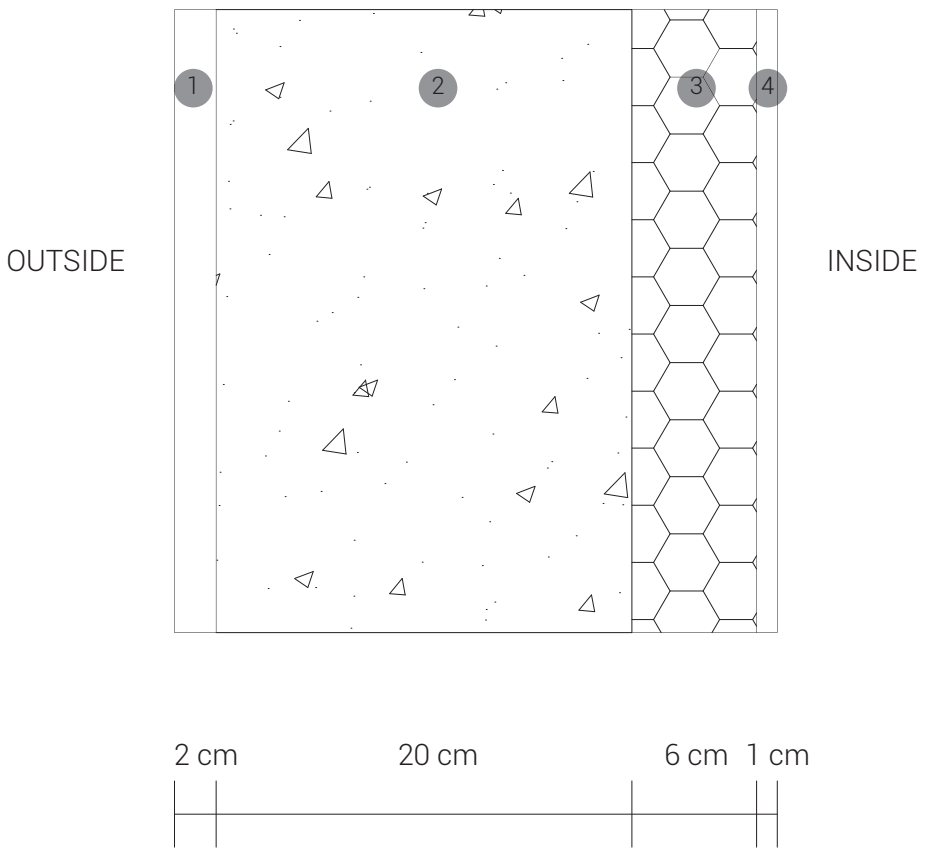
### Oslo-Wall type 1

In the third simulation we chose the localization in the city of Oslo, the main city of Norway.

Latitudine: 59° 54' 45 N

Longitudine: 10° 44' 45 E

We chose the Wall Type 1, used before.




WALL TYPE 1

Layers

1. STUCCO Conductivity: 0,0432 W/mK - Densitivity: 91 kg/m3 - Specific Heat: 837 J/kgK - Thermal Absorptance: 0,9 - Solar Absorptance: 0,5 - Visible Absorptance: 0,5
2. CONCRETE Conductivity: 1,7296 W/mK - Densitivity: 2243 kg/m3 - Specific Heat: 837 J/kgK - Thermal Absorptance: 0,9 - Solar Absorptance: 0,65 - Visible Absorptance: 0,65
3. WALL INSULATION Conductivity: 0,0432 W/mK - Densitivity: 91 kg/m3 Specific Heat: 837 J/kgK - Thermal Absorptance: 0,9 - Solar Absorptance: 0,5 - Visible Absorptance: 0,5
4. GYPSUM Conductivity: 0,16 W/mK - Densitivity: 784,9 kg/m3 - Specific Heat: 830 J/kgK - Thermal Absorptance: 0,9 - Solar Absorptance: 0,4 - Visible Absorptance: 0,4

**THERMAL RESISTANCE:** 0,46 + 0,11 + 1,38 + 0,06 = 2,01 m2K/W

| TOTAL ENERGY [GJ] | HEATING [GJ] | COOLING [GJ] |
|---|---|---|
| 1166.04 | 684.03 | 52.98 |

## SIMULATION 4

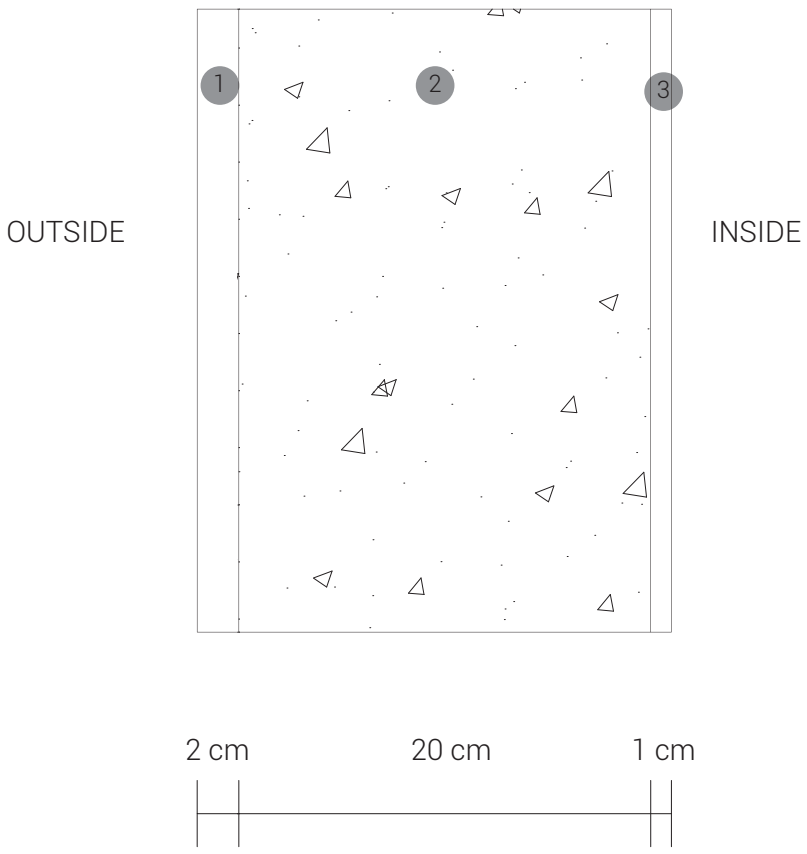
### Piacenza-Wall type 2

In the fourth simulation we chose the localization in the city of Piacenza, in the North of Italy.

Latitudine: 45° 2' 31 N

Longitudine: 9° 42' 16 E

We change the stratigraphy, putting the wall insulation on the external part of the concrete layer.




WALL TYPE 2

Layers

1 STUCCO Conductivity: 0,0432 W/mK - Densitivity: 91 kg/m3 - Specific Heat: 837 J/kgK - Thermal Absorptance: 0,9 - Solar Absorptance: 0,5 - Visible Absorptance: 0,5

2 CONCRETE Conductivity: 1,7296 W/mK - Densitivity: 2243 kg/m3 - Specific Heat: 837 J/kgK - Thermal Absorptance: 0,9 - Solar Absorptance: 0,65 - Visible Absorptance: 0,65

3 GYPSUM Conductivity: 0,16 W/mK - Densitivity: 784,9 kg/m3 - Specific Heat: 830 J/kgK - Thermal Absorptance: 0,9 - Solar Absorptance: 0,4 - Visible Absorptance: 0,4

**THERMAL RESISTANCE:** 0,46 + 0,11 + 0,06 = 0,63 m2K/W

| TOTAL ENERGY [GJ] | HEATING [GJ] | COOLING [GJ] |
|---|---|---|
| 1077.39 | 463.04 | 185.31 |

## SIMULATION 5

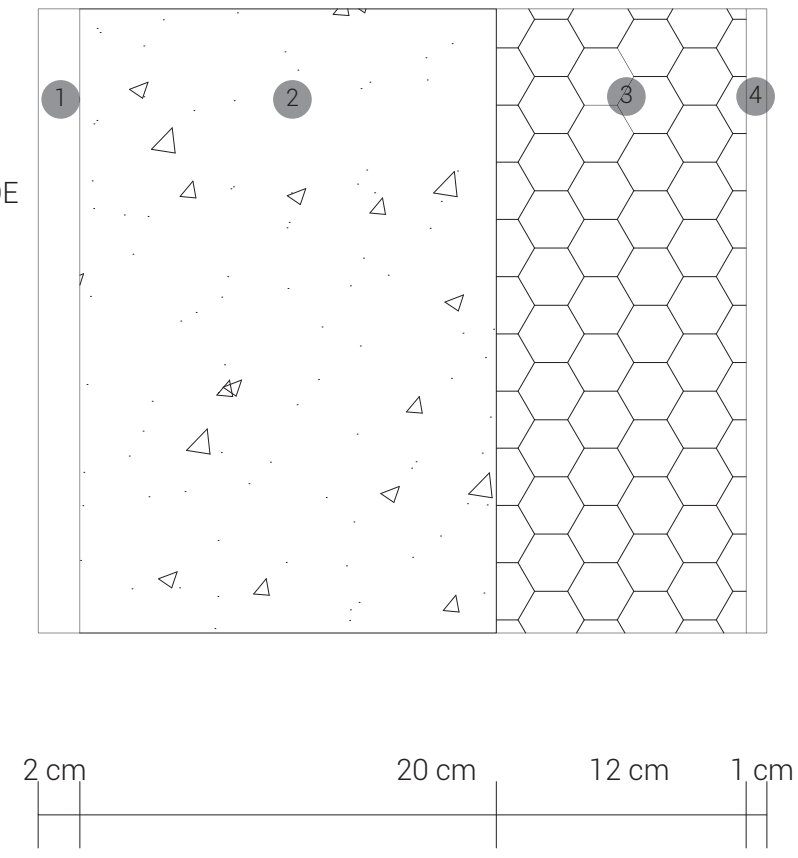
### Piacenza-Wall type 3

In the fifth simulation we chose the localization in the city of Piacenza, in the North of Italy.

Latitudine: 45° 2' 31 N

Longitudine: 9° 42' 16 E

We change the stratigraphy, putting the wall insulation with double thickness, so 12 cm.




WALL TYPE 2

Layers

1. STUCCO Conductivity: 0,0432 W/mK - Densitivity: 91 kg/m3 - Specific Heat: 837 J/kgK - Thermal Absorptance: 0,9 - Solar Absorptance: 0,5 - Visible Absorptance: 0,5
2. WALL INSULATION Conductivity: 0,0432 W/mK - Densitivity: 91 kg/m3 Specific Heat: 837 J/kgK - Thermal Absorptance: 0,9 - Solar Absorptance: 0,5 - Visible Absorptance: 0,5
3. CONCRETE Conductivity: 1,7296 W/mK - Densitivity: 2243 kg/m3 - Specific Heat: 837 J/kgK - Thermal Absorptance: 0,9 - Solar Absorptance: 0,65 - Visible Absorptance: 0,65
4. GYPSUM Conductivity: 0,16 W/mK - Densitivity: 784,9 kg/m3 - Specific Heat: 830 J/kgK - Thermal Absorptance: 0,9 - Solar Absorptance: 0,4 - Visible Absorptance: 0,4

**THERMAL RESISTANCE:** 0,46 + 0,11 + 2,77 + 0,06 = 3,4 m2K/W

| TOTAL ENERGY [GJ] | HEATING [GJ] | COOLING [GJ] |
|---|---|---|
| 974.17 | 375.33 | 169.78 |

CONCLUSION

## Same Wall type - different cities

In the first three simulations we can see how the total energy used by the same building change in order to the localization. We chose a stratigraphy that is usually used in climate zone like Piacenza, in fact in Oslo and Bangkok the amount of energy is higer.

The most critic localization is Bangkok, because the buliding need to use a lot of energy in cooling the internal spaces during the summer, instead it doesn't need almost any energy to heat.

Instead Oslo need more energy during the winter to heat the building than Piacenza. In fact, as we could predict, Piacenza has the more equilibrated results.

## Different Wall types - same city

In the last simulations we can see how the change of the wall insulation change also the condition of the building and its use of energy.

The Wall Type 2, without the layer of insulation use more energy, in particular for heating. In fact the thermal resistance of the wall is considerably less than the other types.

The Wall Type 3, with the double thickness of insulation, as we could predict, need less energy in total but with some differnce between cooling and heating.

| | LOCALIZATION | WALL TYPE | THERMAL RESISTANCE [m2K/W] | TOTAL ENERGY [GJ] | HEATING [GJ] | COOLING [GJ] |
|---|---|---|---|---|---|---|
| SIMULATION 1 | Piacenza | 1 | 2.01 | 989.25 | 388.39 | 171.83 |
| SIMULATION 2 | Bangkok | 1 | 2.01 | 1475.67 | 0.3 | 1046.34 |
| SIMULATION 3 | Oslo | 1 | 2.01 | 1166.04 | 684.03 | 52.98 |
| SIMULATION 4 | Piacenza | 2 | 0.63 | 1077.39 | 463.04 | 185.31 |
| SIMULATION 5 | Piacenza | 3 | 3.4 | 974.17 | 375.33 | 169.78 |