Building Simulation Project

Project by

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ENERGY AND ENVIRONMENTAL TECHNOLOGIES FOR BUILDING SYSTEM
Prof. Behzad Najafi

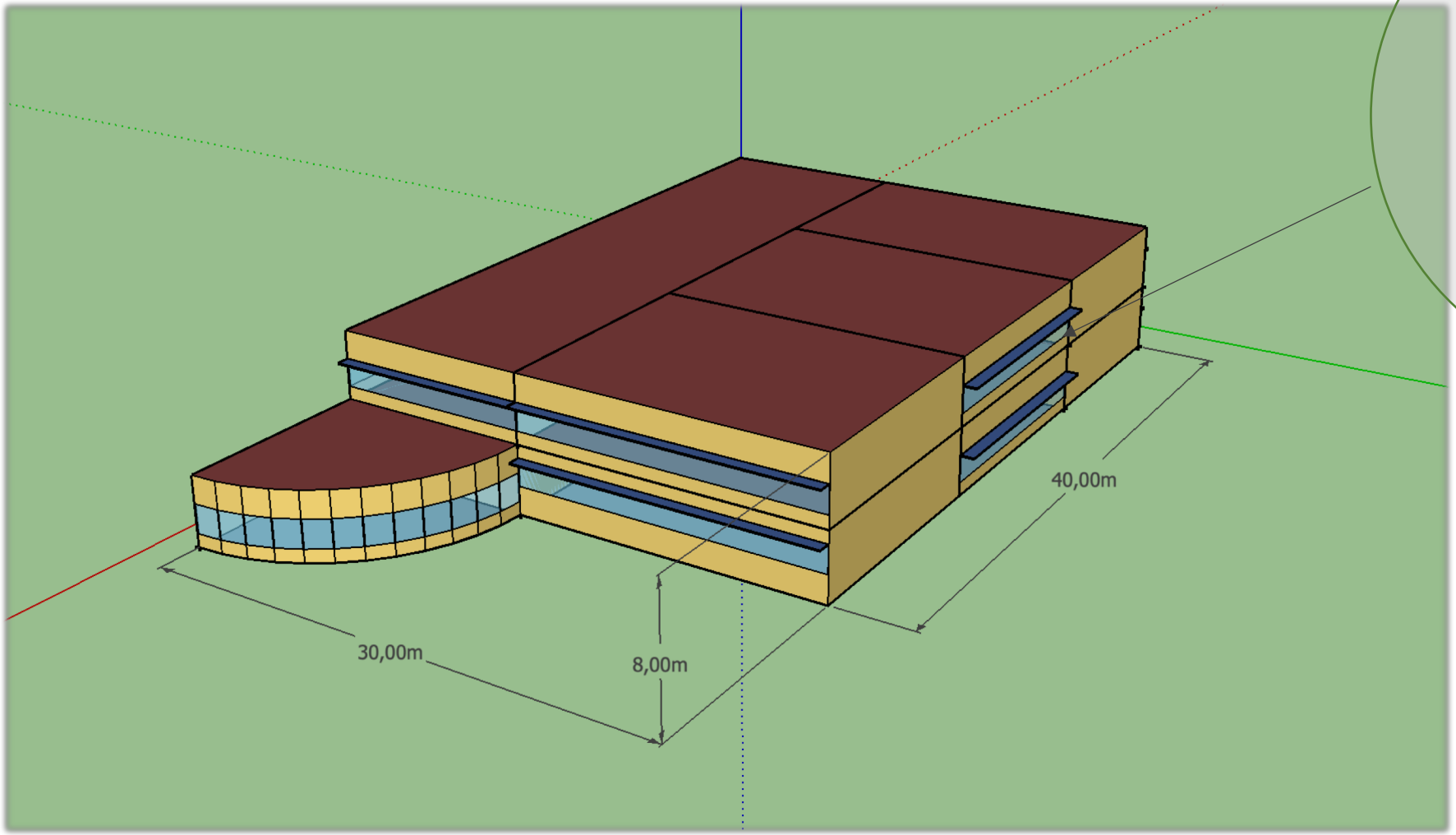
In this project we calculate the **yearly heating and cooling consumption** of Zara store for a base case.

Then we compare data of the building sited in three different cities and with different walls and windows compositions.

To do this we need two software:

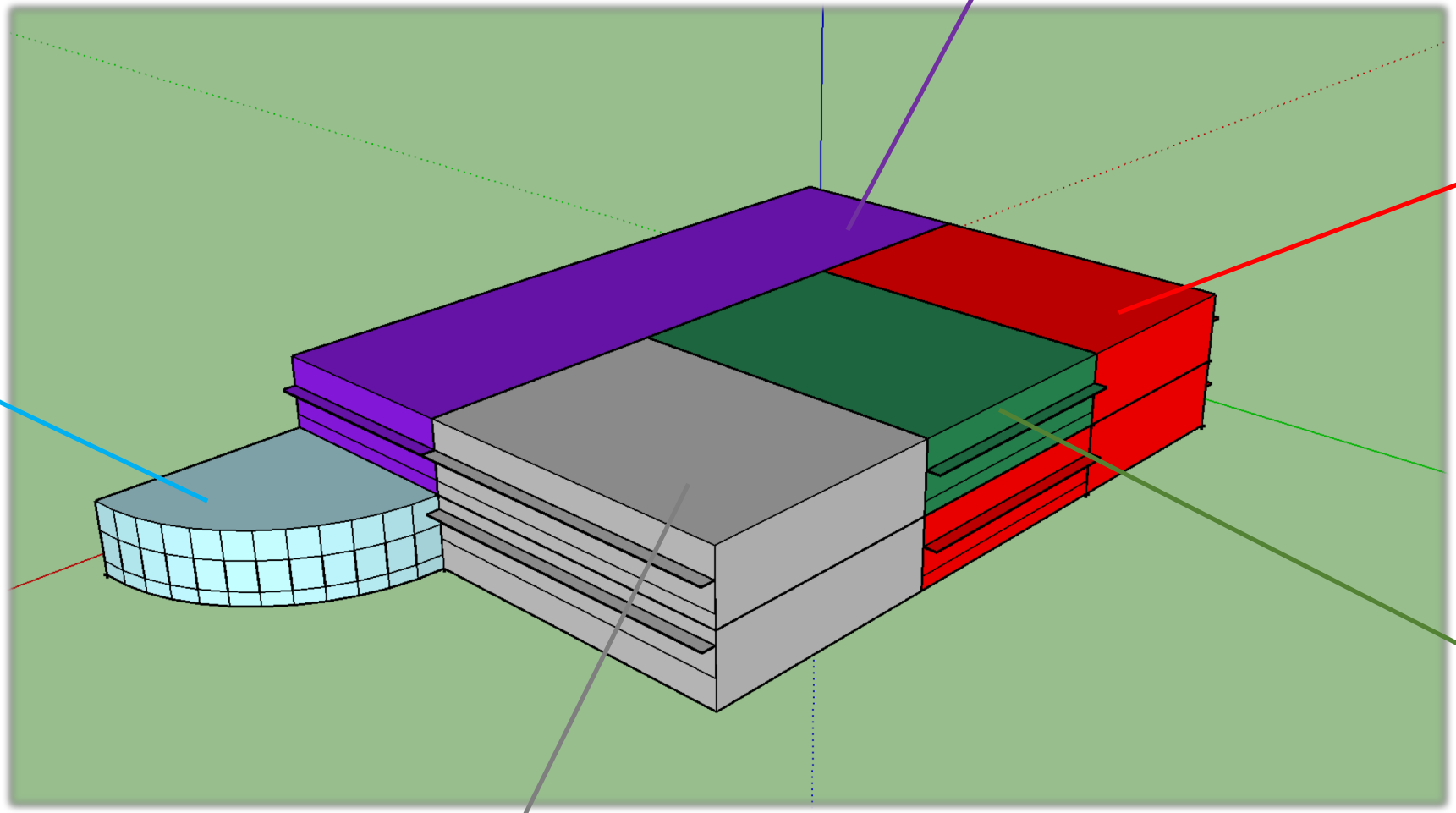
Sketchup to design the building and **Openstudio** to calculate the loads.

- **1° Building Story:** Lobby, Vending, Restroom, OpenOffice
- **2° Building Story:** Vending Room, Restroom, OpenOffice, Conference Room



After designing the building we add windows with a defined wall ratio and overhangs on all sides except for the north side.

Finally we define **Thermal zones** numbering from 1 to 5



The three cities we choose are:

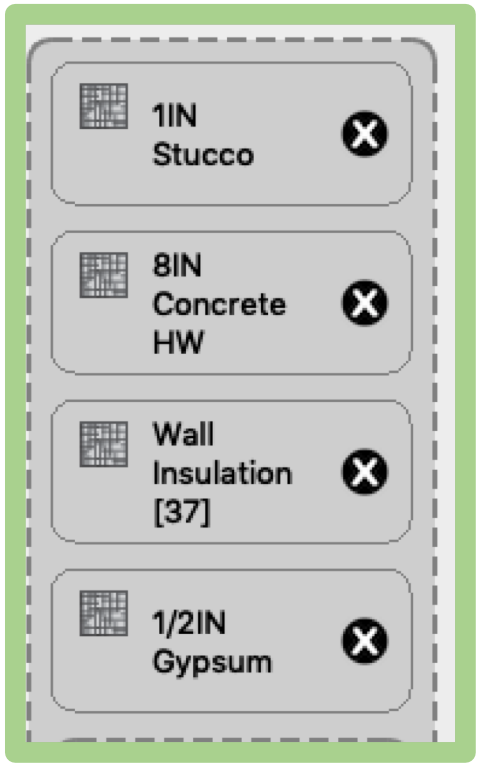
Rome, Mexico City , Oslo.

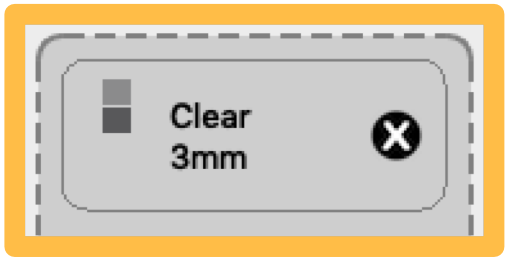
For all of these we consider the base case (default Openstudio sets) comparing the results.

Only for Rome we study the results given by changing wall and windows composition defining two case:

best and worst compared to the base case.

Construction sets for **WALLS** and **WINDOWS** of the **base case** are:

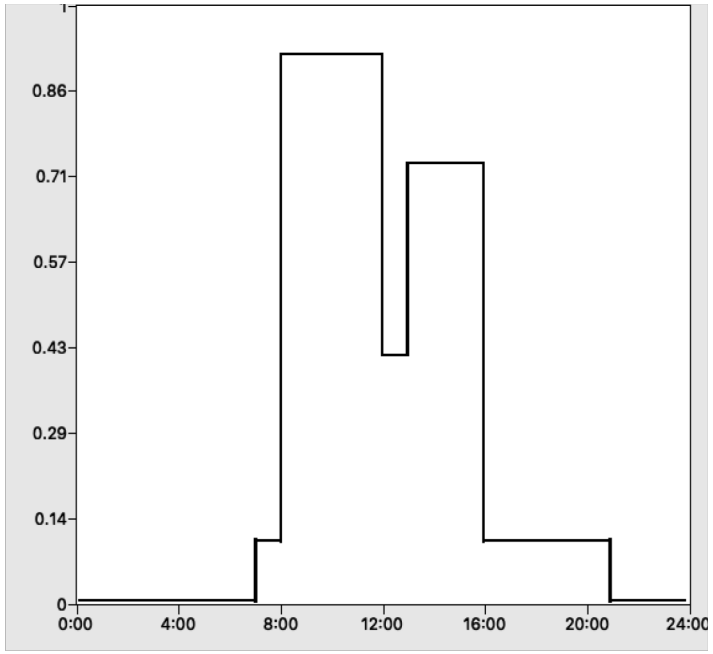




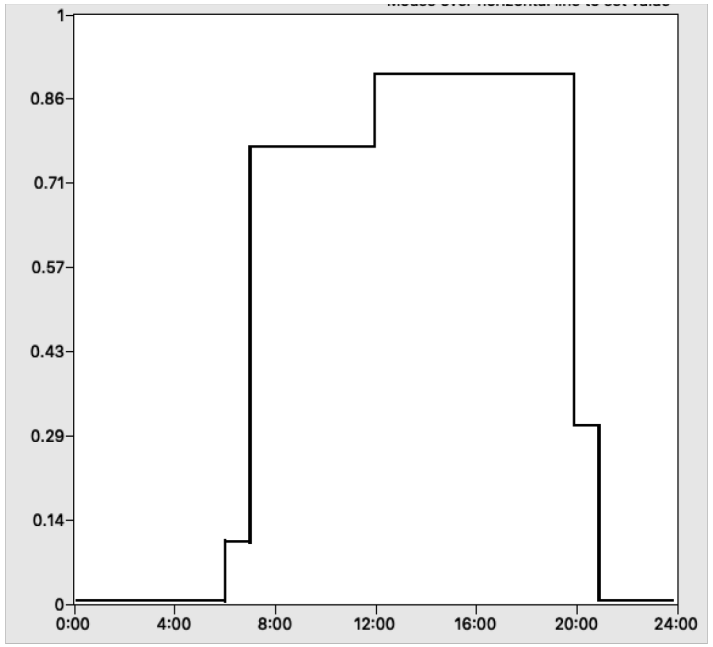
Material	*Conductivity* $[W/mK]$
1IN Stucco	0,69
8IN Concrete HW	1,73
Wall Insulation [37]	0,04
1/2IN Gypsum	0,16
Clear 3mm	0,9

Then we fill in the Schedule Sets defining Occupancy and Light both for weekdays and weekend.

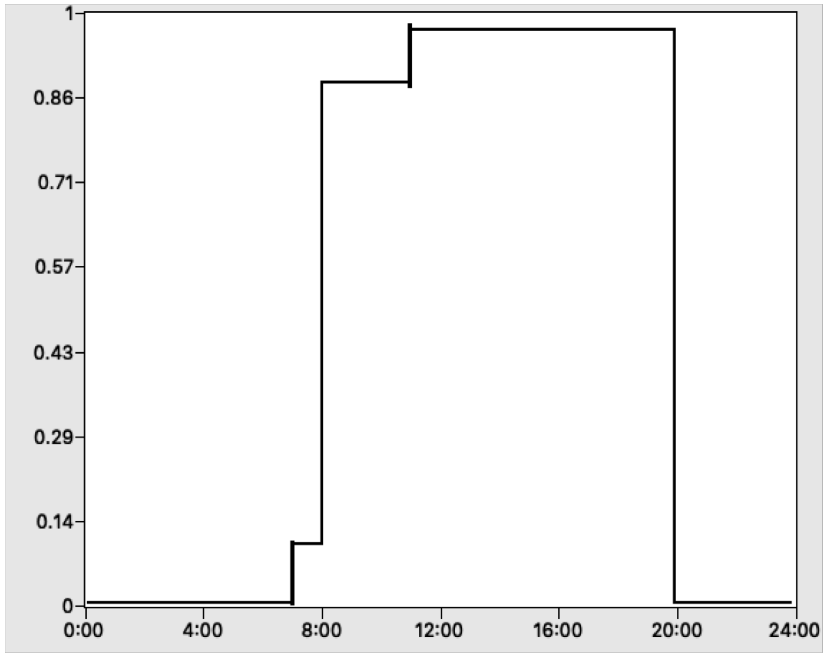
We consider different activity hours based on the space type.



Occupancy weekday Office



Light weekday Vending



Light weekend Vending

BASE CASE

Mexico City

	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	166.44	0.00
Cooling	0.00	0.00	0.00	711.15	0.00	0.00

Rome

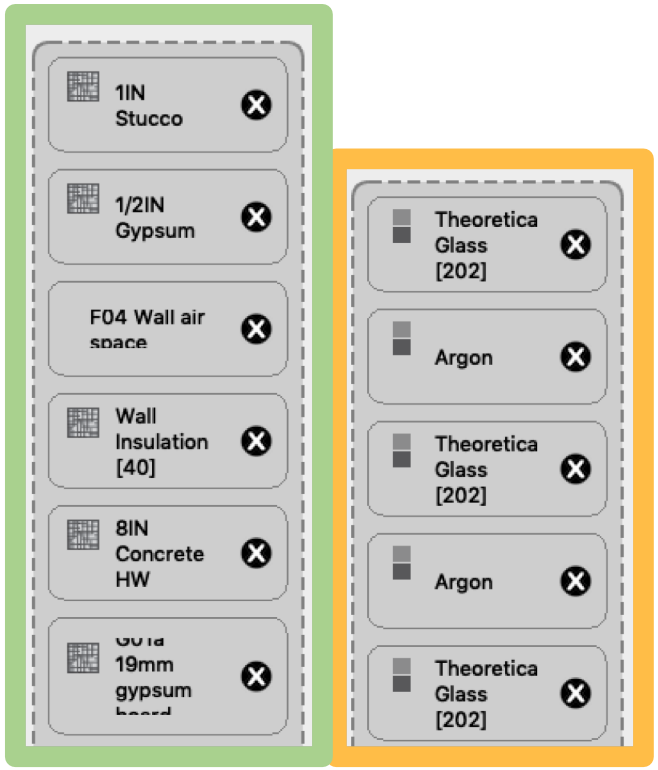
	Subcategory	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	General	0.00	0.00	0.00	0.00	507.14	0.00
Cooling	General	0.00	0.00	0.00	697.22	0.00	0.00

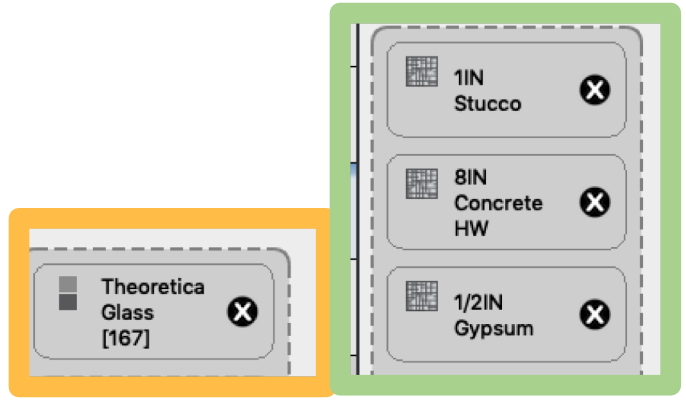
Oslo

	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	1573.56	0.00
Cooling	0.00	0.00	0.00	301.27	0.00	0.00

	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	590.05	0.00
Cooling	0.00	0.00	0.00	558.92	0.00	0.00

WORST CASE ROME





BEST CASE ROME

	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	473.33	0.00
Cooling	0.00	0.00	0.00	545.32	0.00	0.00

At the end of the study we conclude that Heating and Cooling load change according to places.

Mexico city (CZ3) has a high dry bulb temperature. This results in a higher cooling load and a smaller heating load. The reverse happens with **Oslo (CZ6)** which has a lower dry bulb temperature. **Rome (CZ4)** is an intermediate case, then Heating and cooling load are between Mexico and Oslo values.

OSLO/FORNEBU 014880 59.90N 10.62E 17 101.12 1.00 EUW 8298

Annual Heating and Humidification Design Conditions

Coldest month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB	
	99.6%	99%	99.6% DP	99.6% HR	99.6% MCDB	99% DP	99% HR	99% MCDB	0.4% WS	0.4% MCDB	1% WS	1% MCDB	MCWS	PCWD
2	3a	3b	4a	4b	4c	4d	4e	4f	5a	5b	5c	5d	6a	6b
1	-17.2	-14.5	-19.9	0.6	-16.0	-17.0	0.8	-12.9	10.6	5.4	9.4	4.2	0.8	0

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

Hottest month	Hottest month DB range	Cooling DB/MCWB 0.4% DB	0.4% MCWB	1% DB	1% MCWB	2% DB	2% MCWB	Evaporation WB/MCDB 0.4% WB	0.4% MCDB	1% WB	1% MCDB	2% WB	2% MCDB	MCWS/PCWD to 0.4% DB MCWS	PCWD
7	8	9a	9b	9c	9d	9e	9f	10a	10b	10c	10d	10e	10f	11a	11b
7	8.8	26.8	17.8	25.0	16.9	23.2	15.9	19.2	24.0	18.2	23.1	17.1	21.6	3.2	170

$$\Delta T_{cooling} = 25 - 24 = 1°C$$
$$\Delta T_{heating} = 20 - (-14.5) = 34.5\ °C$$

ROME/FIUMICINO 162420 41.80N 12.23E 3 101.29 1.00 EUW 8201

Annual Heating and Humidification Design Conditions

Coldest month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB	
	99.6%	99%	99.6% DP	99.6% HR	99.6% MCDB	99% DP	99% HR	99% MCDB	0.4% WS	0.4% MCDB	1% WS	1% MCDB	MCWS	PCWD
2	3a	3b	4a	4b	4c	4d	4e	4f	5a	5b	5c	5d	6a	6b
1	-0.4	0.8	-7.8	2.0	3.6	-5.8	2.3	4.5	13.9	10.7	12.2	10.1	3.4	60

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

Hottest month	Hottest month DB range	Cooling DB/MCWB 0.4% DB	0.4% MCWB	1% DB	1% MCWB	2% DB	2% MCWB	Evaporation WB/MCDB 0.4% WB	0.4% MCDB	1% WB	1% MCDB	2% WB	2% MCDB	MCWS/PCWD to 0.4% DB MCWS	PCWD
7	8	9a	9b	9c	9d	9e	9f	10a	10b	10c	10d	10e	10f	11a	11b
8	9.8	30.9	23.2	29.9	23.3	28.9	23.2	26.0	28.5	25.3	27.9	24.5	27.3	5.0	170

$$\Delta T_{cooling} = 29.9 - 24 = 5.9°C$$
$$\Delta T_{heating} = 20 - (-7.8) = 27.8\ °C$$

MEXICO CITY/JUAREZ 766790 19.43N 99.08W 2234 77.21 -6.00 MEX 8294

Annual Heating and Humidification Design Conditions

Coldest month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB	
	99.6%	99%	99.6% DP	99.6% HR	99.6% MCDB	99% DP	99% HR	99% MCDB	0.4% WS	0.4% MCDB	1% WS	1% MCDB	MCWS	PCWD
2	3a	3b	4a	4b	4c	4d	4e	4f	5a	5b	5c	5d	6a	6b
1	4.2	5.8	-4.0	3.5	18.4	-1.8	4.3	17.1	25.8	8.7	23.1	10.7	1.7	60

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

Hottest month	Hottest month DB range	Cooling DB/MCWB 0.4% DB	0.4% MCWB	1% DB	1% MCWB	2% DB	2% MCWB	Evaporation WB/MCDB 0.4% WB	0.4% MCDB	1% WB	1% MCDB	2% WB	2% MCDB	MCWS/PCWD to 0.4% DB MCWS	PCWD
7	8	9a	9b	9c	9d	9e	9f	10a	10b	10c	10d	10e	10f	11a	11b
5	13.8	29.0	13.7	27.9	13.6	26.9	13.5	16.6	23.3	16.1	22.9	15.7	22.4	4.9	0

$$\Delta T_{cooling} = 27.9 - 24 = 3.9°C$$
$$\Delta T_{heating} = 20 - (+5.8) = 14.2\ °C$$

The last step we did is the comparison between best and worst case for Rome changing construction sets for walls and windows.

As we see from results, adding particular layers we improve thermal efficiency of the building reducing loads.

For windows we choose a triple pane window with argon instead of air. For wall we add a layer of insulation and an air gap.

Although adding layers reduces loads and losses, we have to look for the best trade off between costs and efficiency.