POLITECNICO DI MILANO

Piacenza

School of Architecture, Urban Planning and Construction Engineering

Master of Science in Sustainable Architecture and Landscape Design

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Technical Assignment - TECHNICAL ENVIRONMENTAL SYSTEMS

Academic Year 2017/2018

Simulation of Building Energy Performance

The objective of this assignment is to analyze the energy performance of a building in relation with its conditioning system (heating and cooling), interior equipment and interior lighting. In order to do so we approach the assignment with a comparative analysis working with the following softwares: Energy plus, Sketch Up, and Openstudio.

First, for the comparative analysis three different cities of Europe were chosen. The first one is **Milan**, for being a big city with the most similar climate to Piacenza; **Munich**, for being another important European city located in the middle part of the continent; and finally **Copenhagen**, because of its extreme temperatures.

Secondly, a building prototype is modeled in order to compare it in the three different scenarios. This building has a rectangular shape of 50 m x 25 m with four stories high. The building main use is office type and has a small portion of break room that is use for relaxing time. The space for the offices in each plan has a “U” shape surrounding the break room space.

Finally, some settings are configured for the external walls and for the roofs and windows as well. The wall components are one layer of stucco, 20 cm of concrete wall, a 03 cm wall insulation and a ½ inch gypsum panel. For the windows a 05 mm glass is used. At last, the roof is conformed by a roof membrane, a metal decking and roof insulation of 30 cm. In addition to this, the building is configured with two other options to compare in the city of Munich.

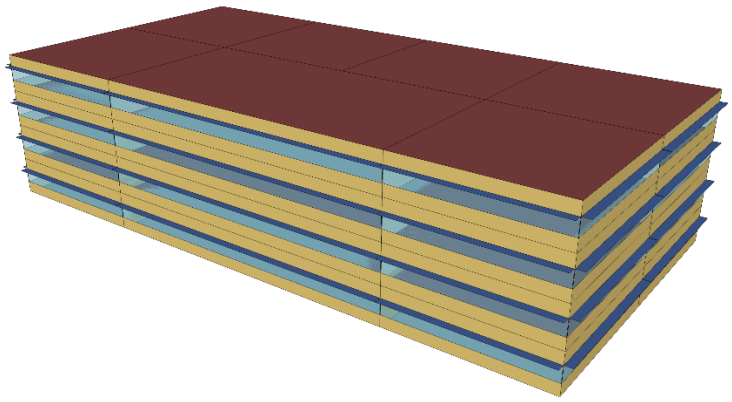

Image 1: Model of the building to analyze.

1. Simulation of Building in Milano

The city of Milan is located in the north part of Italy, in the latitude 45.62 and longitude 8.73 with an elevation of 210.92 meters. According to the analysis the Total Site Energy required is 3,743.51 GJ for the 5000 m^2 of the building. This means 748.70 MJ/m^2.

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	3743.51	748.70	748.70
Net Site Energy	3743.51	748.70	748.70
Total Source Energy	9400.84	1880.17	1880.17
Net Source Energy	9400.84	1880.17	1880.17

Image 2: Energy consumption chart for Milan.

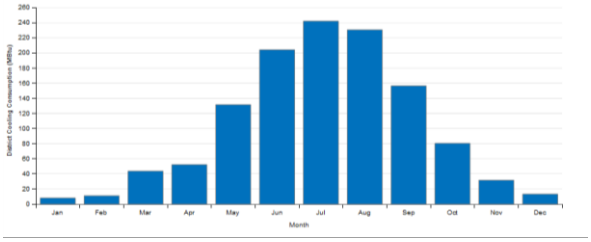

Image 3: Energy consumption by cooling per month.

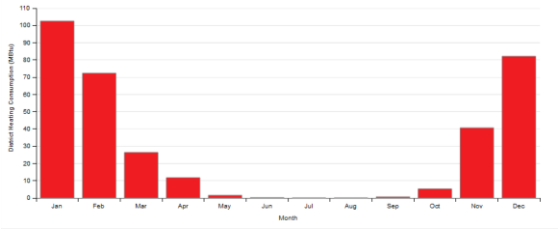

Image 4: Energy consumption by heating per month.

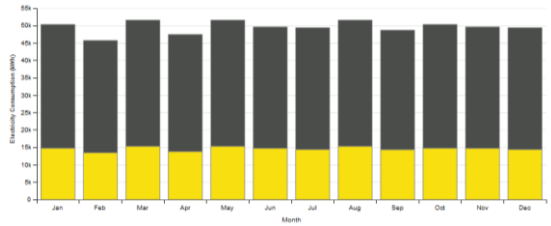

Image 5: Equipment and interior lightning per month.

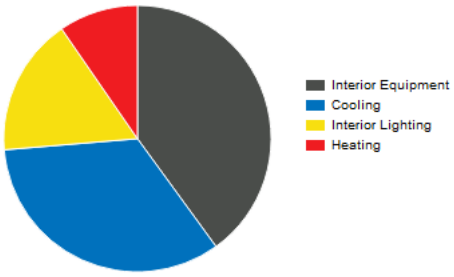

Image 6: Pie chart of energy consumption elements.

The analysis shows us that the critical month for energy consumption in cooling is July with 72,681 kWh and for the heating system January is the critical month with 30,186 kWh. Nevertheless, July is by far the most demanding month for the cooling system where temperatures can rise to more than 30° C. The energy consumption for the interior equipment is also high because of the building use.

2. Simulation of Building in Copenhagen

The city of Copenhagen is located in the north eastern part of Denmark near Sweden, in the latitude 55.63 and longitude 12.67 with an elevation of 4.88 meters. According to the analysis the Total Site Energy required is 3,345.29 GJ for the 5000 m^2 of the building. This means 669.06 MJ/m^2.

Site and Source Energy

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	3345.29	669.06	669.06
Net Site Energy	3345.29	669.06	669.06
Total Source Energy	9702.94	1940.59	1940.59
Net Source Energy	9702.94	1940.59	1940.59

Image 7: Energy consumption chart for Milan.

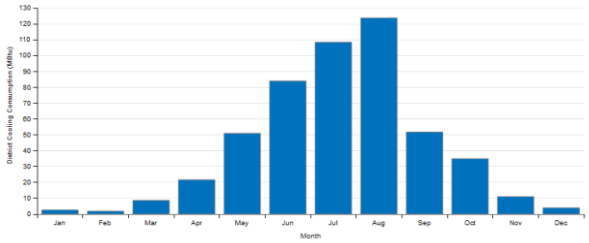

Image 8: Energy consumption by cooling per month.

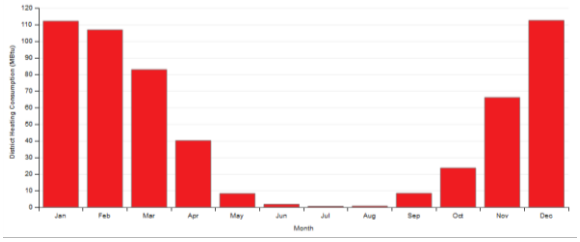

Image 9: Energy consumption by heating per month.

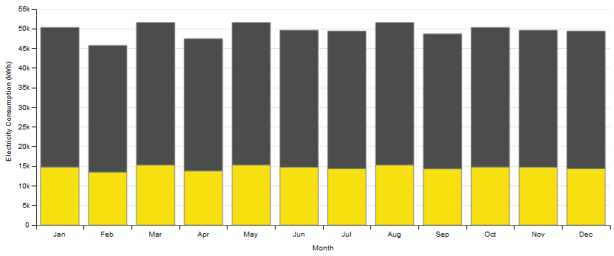

Image 10: Equipment and interior lightning per month.

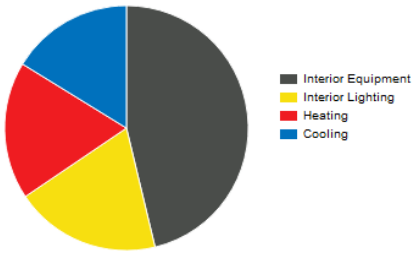

Image 11: Pie chart of energy consumption elements.

The analysis shows us that the critical month for energy consumption for cooling for this city is in August with 36,623 kWh. Meanwhile for the heating system December is the critical month with 33,410 kWh. As we can see, the levels of consumption for cooling and heating are very similar. Nevertheless, the energy consumption for internal equipment and lightning is more than the double and maintains a regular consumption all the year.

3. Simulation of Building in Munich

The city of Munich is located in the south eastern part of Germany, in the latitude 48.13 and longitude 11.10 with an elevation of 529.13 meters. According to the analysis the Total Site Energy required is 3,511.41 GJ for the 5000 m^2 of the building. This means 702.28 MJ/m^2.

Site and Source Energy

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	3511.41	702.28	702.28
Net Site Energy	3511.41	702.28	702.28
Total Source Energy	9922.39	1984.48	1984.48
Net Source Energy	9922.39	1984.48	1984.48

Image 12: Energy consumption chart for Munich.

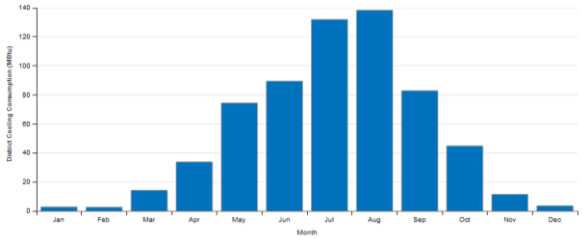

Image 13: Energy consumption by cooling per month.

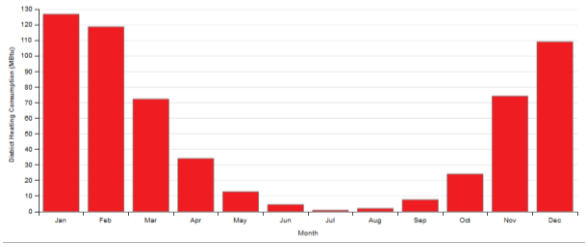

Image 14: Energy consumption by heating per month.

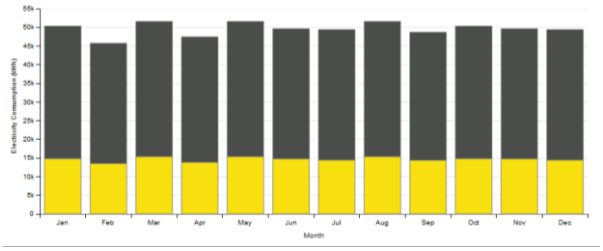

Image 15: Equipment and interior lightning per month.

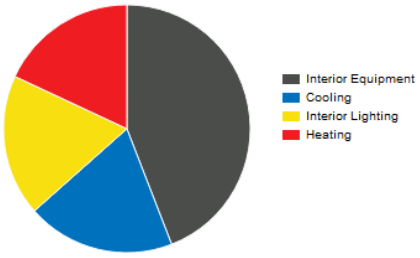

Image 16: Pie chart of energy consumption elements.

The critical month for energy consumption for cooling in Munich is also in the month of August with 40,736 kWh. For the heating system January appears as the critical month with 37,513 kWh. The energy consumption for internal equipment and lightning is nearly the 50,000 kWh making the pie chart for this city the most equally distributed.

For this city, we intend to reduce the energy consumption for heating by introducing isolating elements in the walls, windows and roofs to compare if there is an actual saving by adding those elements to the initial design.

4. Simulation of Building in Munich: Case B

For this case a wider wall insulation of 11 cm is added and instead of a gypsum panel a wooden one of 25 mm is chosen for the interior part.

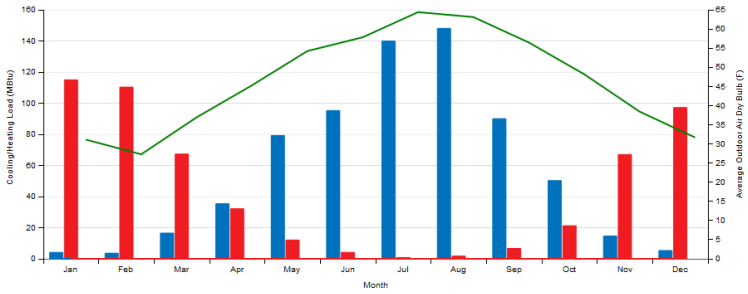

Image 17: Energy consumption by cooling and heating per month.

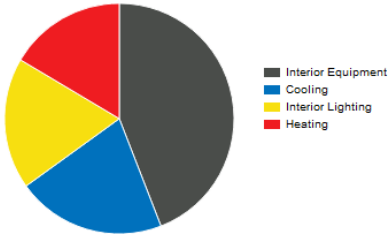

Image 18: Energy consumption elements.

The analysis shows a reduction in the energy consumption in the heating. It is now 33,703 kWh but is still a small reduction taking in account a general projection.

5. Simulation of Building in Munich: Case C

In this last simulation, more insulation is added to the external walls. Besides the stucco and the concrete wall there is a wall insulation of 7 cm, an air gap and another wall insulation of 7 cm. In addition to this there is another concrete wall for the interior part and finally a wood panel of 25 mm.

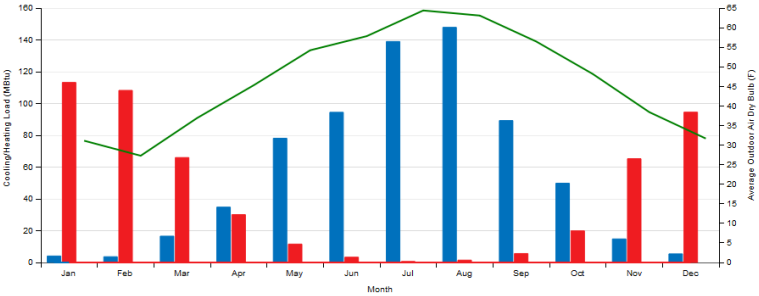

Image 19: Energy consumption by cooling and heating per month.

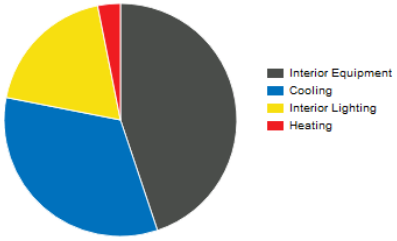

Image 20: Energy consumption elements.

These graphics shows an immense reduction in the energy consumption for heating. It is now 8,206 kWh. In the other hand, the cooling system rise up from 40,736 kWh to 57,149 kWh but this new results are less consuming than the first one by 12,849 kWh making this option more efficient.

6. Conclusions and recommendations

1. In the first analysis, in Milan, we can deduce that the energy use for cooling can be much more consuming than the one for heating.

2. Altitude and proximity to the sea affect the energy consumption in a building. The cooling system seems to rise up when the altitude is higher. For example Milan is almost 200 m higher than Copenhagen and the energy consumption is almost the double than this city.

3. Based in the analysis of the "Case B" in Munich, a reduction in the heat energy consumption can be made by adding a wider insulation and changing the interior material for a warmer one like wood.

4. Based in the analysis of the "Case C" in Munich, a considerable reduction in the heat energy consumption can be made by adding a sandwich of insulation walls and air gap to the external walls in addition to the concrete wall and wood panel in the interior.

5. We can conclude also that this rise in the insulation elements also brings more energy consumption for the cooling systems in the months of hot weather.

6. Based in the comparative analysis made in the models in Munich, we can understand that the energy consumption with the insulation elements is lower than the energy consumption without the insulation elements even if the cooling system requires more energy. In this way, we can assumed that the economic cost is going to be lower, because of the energy consumption reduction.