TECHNICAL ENVIRONMENTAL SYSTEMS

0. STUDENTI

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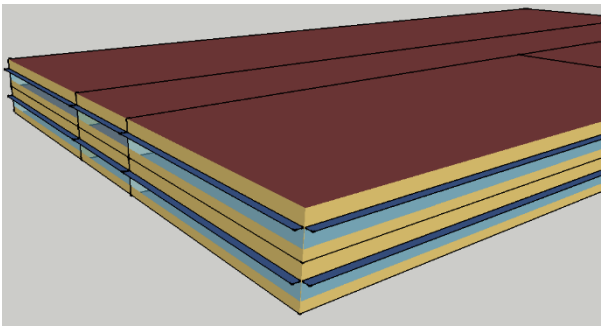
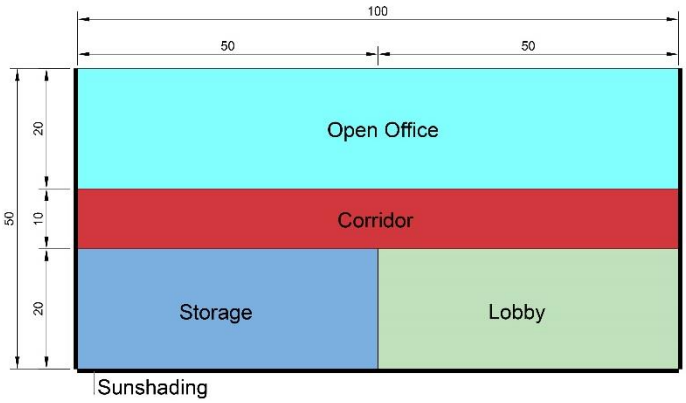
1. INTRODUCTION

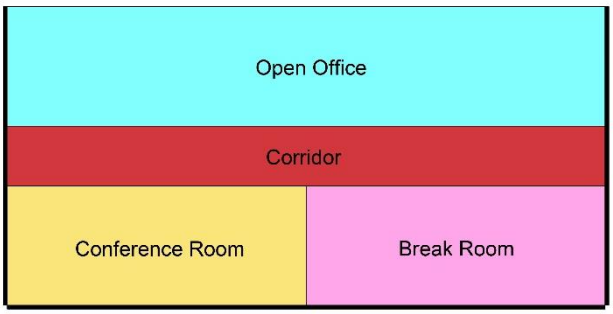
In this esercitation with Open Studio we considered the energy consuption of an office building composed by open offices (two floors), break room, lobby, corridor, conference room and storage.
We took Piacenza as first case study, we considered the weather conditions of this city and we proposed a setting for the wall stratification.
After that, we applied the same wall stratification of elements in the same building located in Oslo, a city with a really different weather compared with Piacenza and then we changed the package (stratification) of the building's elements to make it more insulating.

2. BUILDING

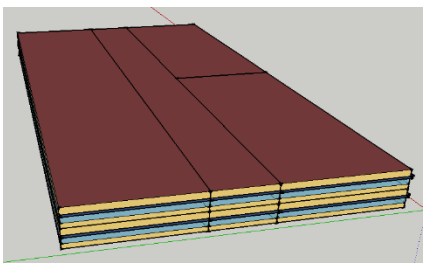
Building Type: Office
Area: 10000 m^2
Height: 6.10 m
Floors: 2
Location 1: Piacenza
Location 2: Oslo



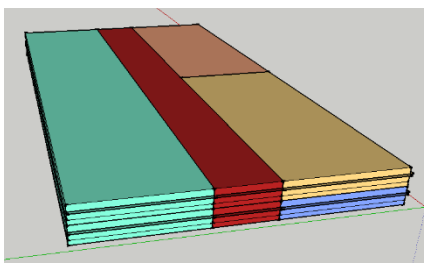




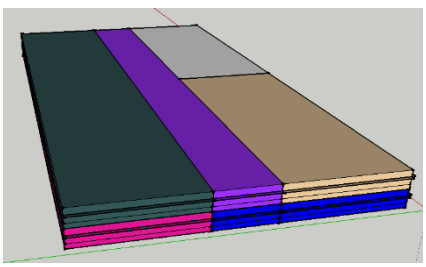
RENDER BY SURFACE TYPE



RENDER BY SPACE TYPE



RENDER BY THERMAL ZONE



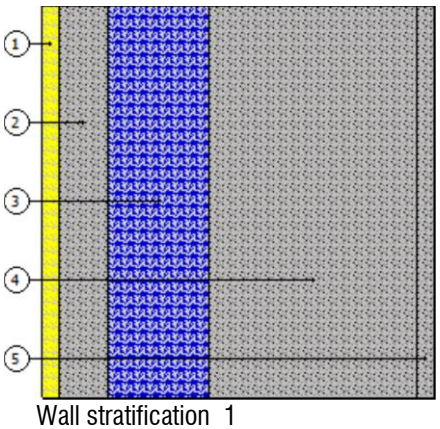
BUILDING SUMMARY

Information	Value	Units
Building Name	Building 1	building_name
Net Site Energy	3,851,872	kBtu
Total Building Area	107,639	ft^2
EUI (Based on Net Site Energy and Total Building Area)	35.79	kBtu/ft^2
OpenStudio Standards Building Type		

WEATHER SUMMARY (Piacenza)

	Value
Weather File	Piacenza - ITA IGDG WMO#=160840
Latitude	44.92
Longitude	9.73
Elevation	440 (ft)
Time Zone	1.00
North Axis Angle	0.00
ASHRAE Climate Zone	

Superficial mass: 164.000 kg/m²



Wall stratification_1

THERMOIGROMETRIC CHARACTERISTICS

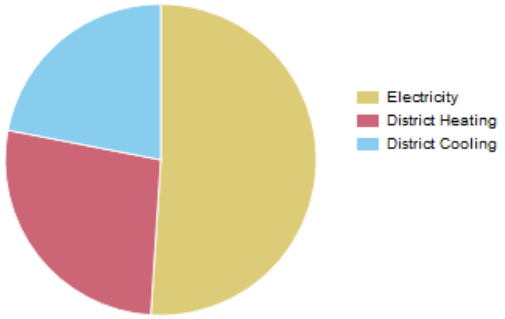
Perimeter wall

N	Description from internal to external	Tickness [cm]	λ [W/mK]	C [W/m²K]	δ [kg/m³]	δ_p x 10^{12} [kg/msPa]	R [m²K/W]
1	Interior finish	2,0	1,470		1.700	9,65	0,014
2	Autoclave cellular concrete for external walls with humidity from 6% to 10% (400 kg / m³)	6,0	0,170		400	27,571	0,353
3	Extruded expanded polystyrene, without skin (50 k)	12,0	0,034		50	1,379	3,529
4	Autoclave cellular concrete for external walls with humidity from 6% to 10% (400 kg / m³)	25,0	0,170		400	27,571	1,471
5	Plaster	2,0	0,700		1.400	19,3	0,029
Total thickness		47,0					

Thermal transmittance [W/m²K]	0,180
Periodic thermal transmittance [W/m²K]	0,030
Phase displacement [h]	13,82
Damping	0,167
Internal thermal capacity [kJ/m²K]	46,717
Internal surface resistance	0,130
Externalal surface resistance	0,040
Total thermal resistance	5,565

ANNUAL OVERVIEW

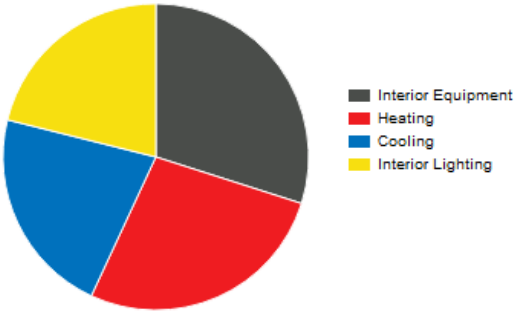
Energy Use



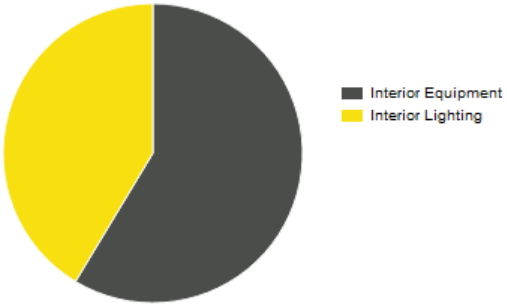
Fuel	Consumption (kBtu)
Electricity	1,965,147
Natural Gas	0
Additional Fuel	0
District Cooling	845,860
District Heating	1,040,864

In this situation the annual energy use is about 3851871 KBtu= 1128.87 KWh. The 51% is used by electricity, 22% by cooling and 27% by heating consumption.

End Use

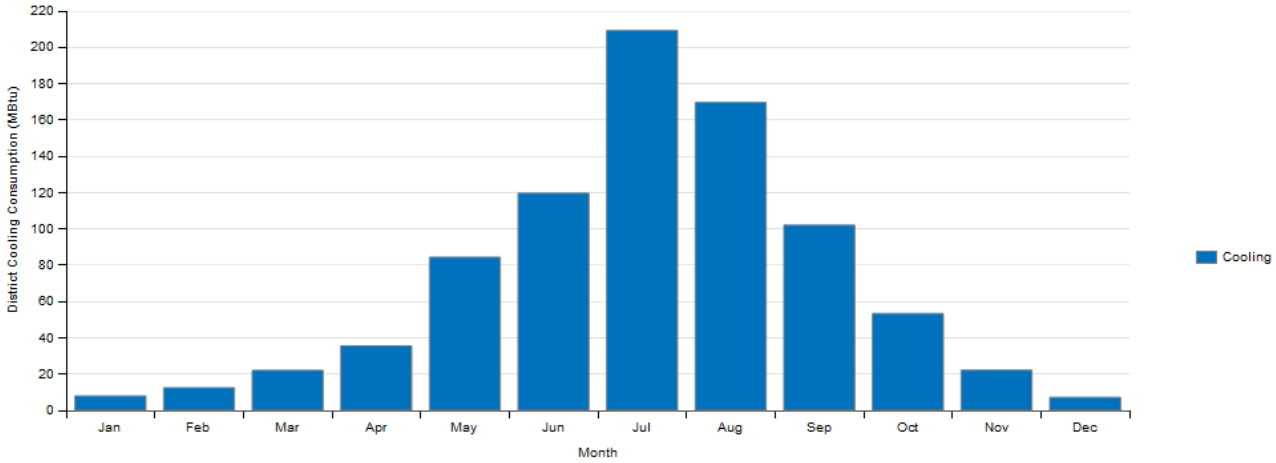


EUI-Electricuty



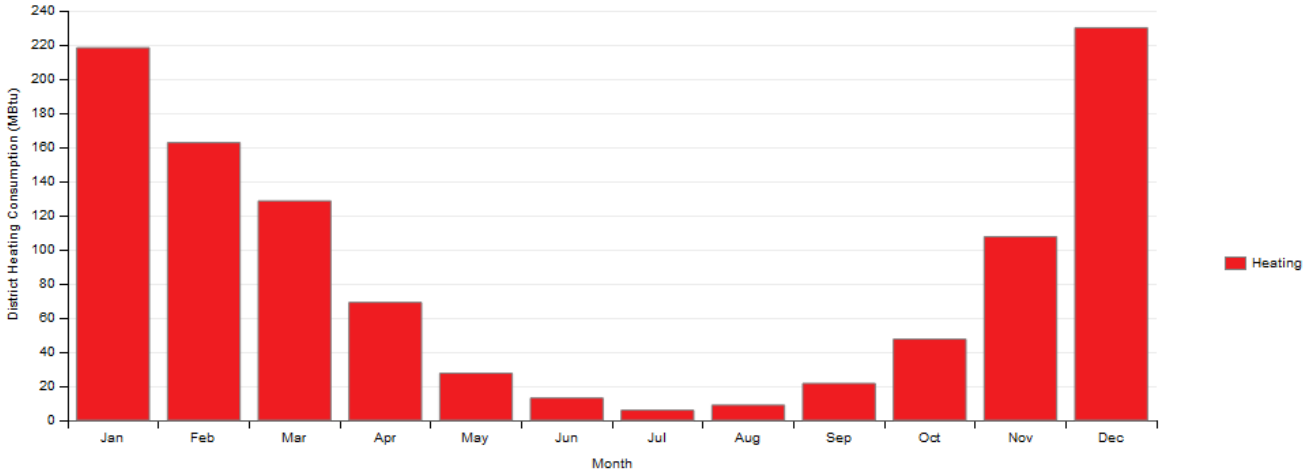
DISTRICT COOLING CONSUMPTION

The following graphics are expressed in MBtu



We can noticed that the energy consumption in cooling is higher during the summer, in particular, during July the energy consumption is equal to 209 MBtu = 61.25 KWh

DISTRICT HEATING CONSUMPTION



We can noticed that the energy consumption in heating is higher during the winter, in particular, during December, the energy consumption is equal to 218 MBtu = 63.88 KWh.

According to the different climate condition between winter and summer, this two graphics are inversely proportional; during the summer I need more energy to cooling my building from June to August and during the winter I need more energy to heat my building from December to February.

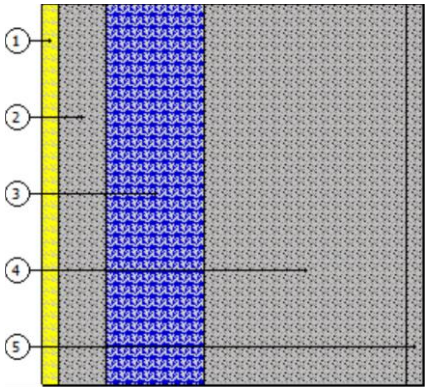
BUILDING SUMMARY

Information	Value	Units
Building Name	Building 1	building_name
Net Site Energy	4,126,360	kBtu
Total Building Area	107,639	ft^2
EUI (Based on Net Site Energy and Total Building Area)	38.34	kBtu/ft^2
OpenStudio Standards Building Type		

WEATHER SUMMARY (Oslo)

	Value
Weather File	OSLO/FORNEBU - NOR IWEC Data WMO#=014880
Latitude	59.90
Longitude	10.62
Elevation	56 (ft)
Time Zone	1.00
North Axis Angle	0.00
ASHRAE Climate Zone	

Superficial mass: 164,000 kg/m²



Wall stratification_1

THERMOIGROMETRIC CHARACTERISTICS

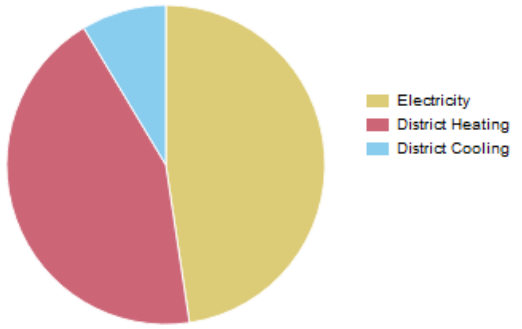
Perimeter wall

N	Description from internal to external	Tickness [cm]	λ [W/mK]	C [W/m²K]	δ [kg/m³]	δ_p x 10^{12} [kg/msPa]	R [m²K/W]
1	Interior finish	2,0	1,470		1.700	9,65	0,014
2	Autoclave cellular concrete for external walls with humidity from 6% to 10% (400 kg / m³)	6,0	0,170		400	27,571	0,353
3	Extruded expanded polystyrene, without skin (50 k)	12,0	0,034		50	1,379	3,529
4	Autoclave cellular concrete for external walls with humidity from 6% to 10% (400 kg / m³)	25,0	0,170		400	27,571	1,471
5	Plaster	2,0	0,700		1.400	19,3	0,029
Total thickness		47,0					

Thermal transmittance [W/m²K]	0,180
Periodic thermal transmittance [W/m²K]	0,030
Phase displacement [h]	13,82
Damping	0,167
Internal thermal capacity [kJ/m²K]	46,717
Internal surface resistance	0,130
Externalal surface resistance	0,040
Total thermal resistance	5,565

ANNUAL OVERVIEW

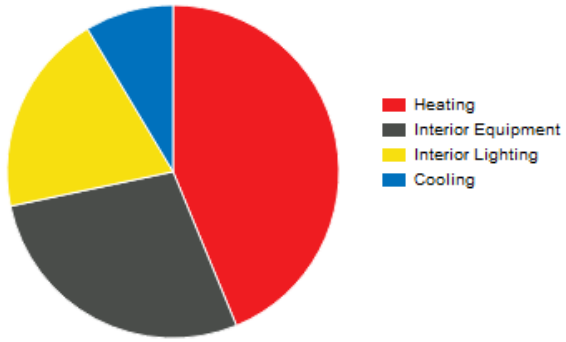
Energy Use



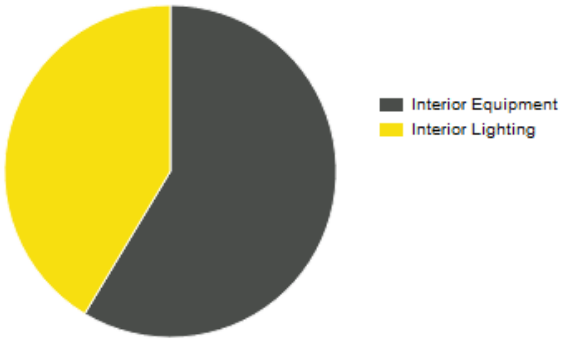
Fuel	Consumption (kBtu)
Electricity	1,965,147
Natural Gas	0
Additional Fuel	0
District Cooling	355,488
District Heating	1,805,724

In this situation the annual energy use is about 4126359 KBtu= 1209316.44 KWh. The 48 % is used by electricity, 9% by cooling and 44% by heating consumption.

End Use

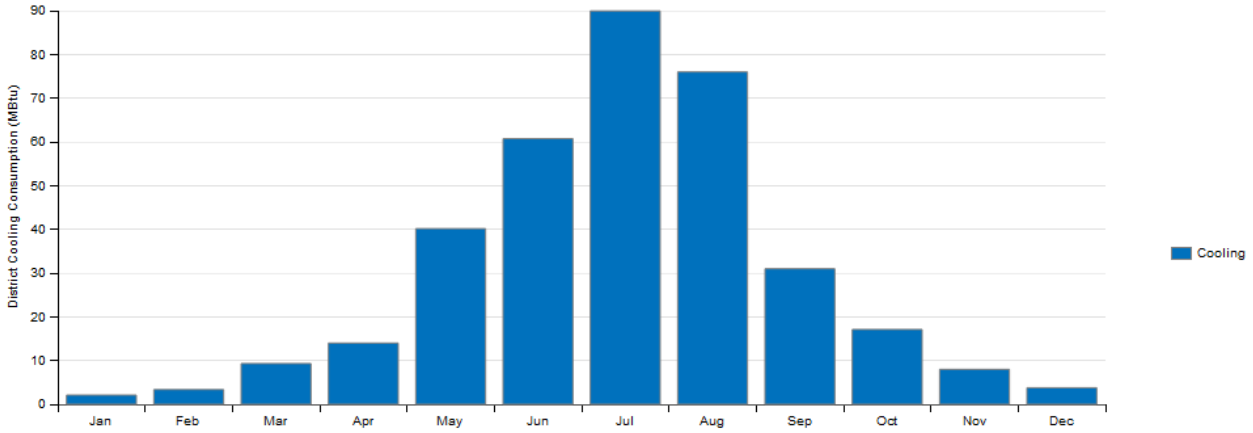


EUI-Electricuty



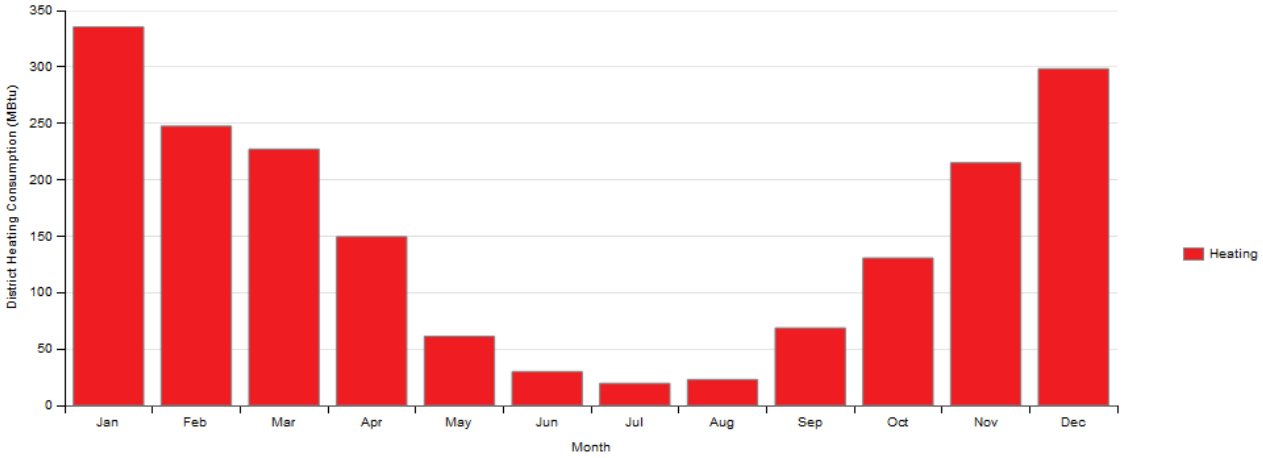
DISTRICT COOLING CONSUMPTION

The following graphics are expressed in MBtu



We can noticed that the energy consumption in cooling is higher during the summer, in particular, during July the energy consumption is equal to 90 MBtu = 26.37 KWh

DISTRICT HEATING CONSUMPTION



We can noticed that the energy consumption in heating is higher during the winter, in particular, during Genuary, the energy consumption is equal to 335 MBtu = 98.17 KWh

According to the different climate condition between winter and summer, this two graphics are inversely proportional; during the summer I need more energy to cooling my building In july and August and during the winter I need more energy to heat my building from November to February.

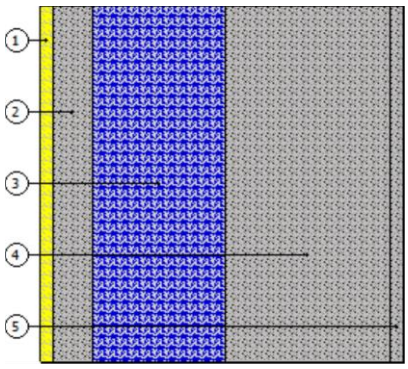
BUILDING SUMMARY

Information	Value	Units
Building Name	Building 1	building_name
Net Site Energy	4,187,864	kBtu
Total Building Area	107,639	ft^2
EUI (Based on Net Site Energy and Total Building Area)	38.91	kBtu/ft^2
OpenStudio Standards Building Type		

WEATHER SUMMARY (Oslo)

	Value
Weather File	OSLO/FORNEBU - NOR IWEC Data WMO#=014880
Latitude	59.90
Longitude	10.62
Elevation	56 (ft)
Time Zone	1.00
North Axis Angle	0.00
ASHRAE Climate Zone	

Superficial mass: 168,000 kg/m²



Wall stratification_2

THERMOIGROMETRIC CHARACTERISTICS

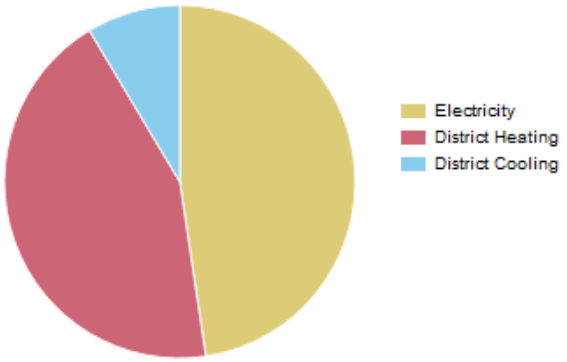
Perimeter wall

N	Description from internal to external	Tickness [cm]	λ [W/mK]	C [W/m²K]	δ [kg/m³]	δ_p x 10^{12} [kg/msPa]	R [m²K/W]
1	Interior finish	2,0	1,470		1.700	9,65	0,014
2	Autoclave cellular concrete for external walls with humidity from 6% to 10% (400 kg / m³)	6,0	0,170		400	27,571	0,353
3	Extruded expanded polystyrene, without skin (50 k)	20,0	0,034		50	1,379	5,882
4	Autoclave cellular concrete for external walls with humidity from 6% to 10% (400 kg / m³)	25,0	0,170		400	27,571	1,471
5	Plaster	2,0	0,700		1.400	19,3	0,029
Total thickness		55,0					

Thermal transmittance [W/m²K]	0,126
Periodic thermal transmittance [W/m²K]	0,016
Phase displacement [h]	16,00
Damping	0,127
Internal thermal capacity [kJ/m²K]	47,011
Internal surface resistance	0,130
Externalal surface resistance	0,040
Total thermal resistance	7,918

ANNUAL OVERVIEW

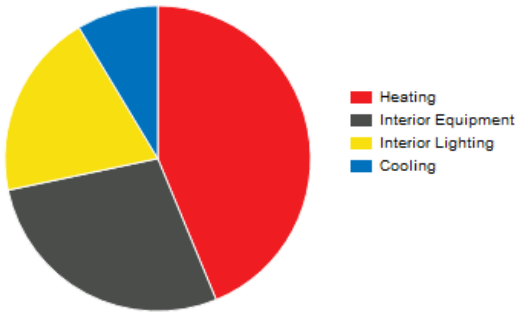
Energy Use



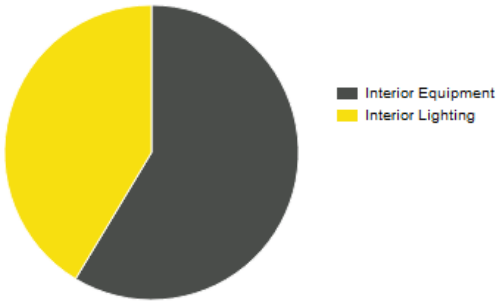
Fuel	Consumption (kBtu)
Electricity	1,965,147
Natural Gas	0
Additional Fuel	0
District Cooling	350,920
District Heating	1,871,797

In this situation the annual energy use is about 4126359 KBtu= 1209316.44 KWh. The 47 % is used by electricity, 8% by cooling and 45% by heating consumption.

End Use

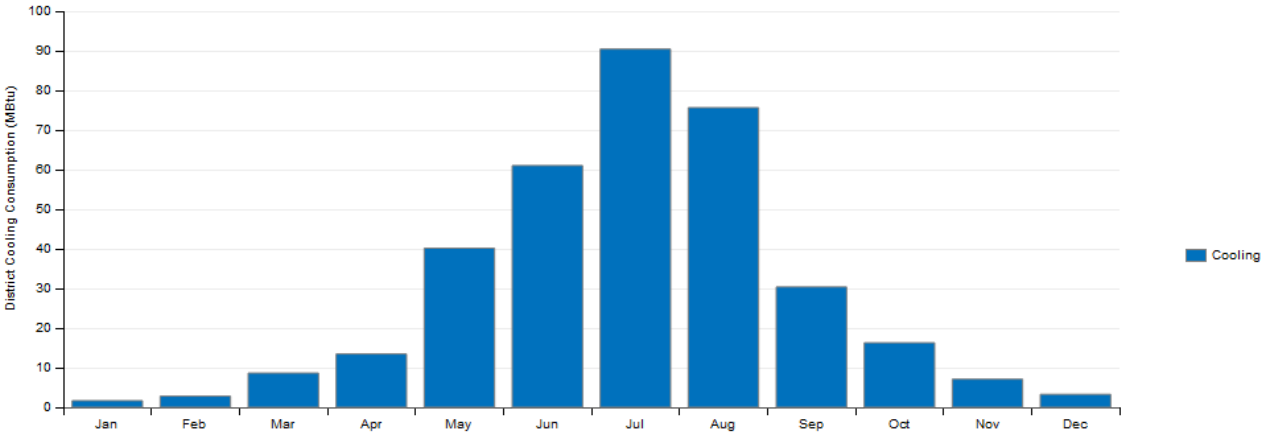


EUI-Electricuty



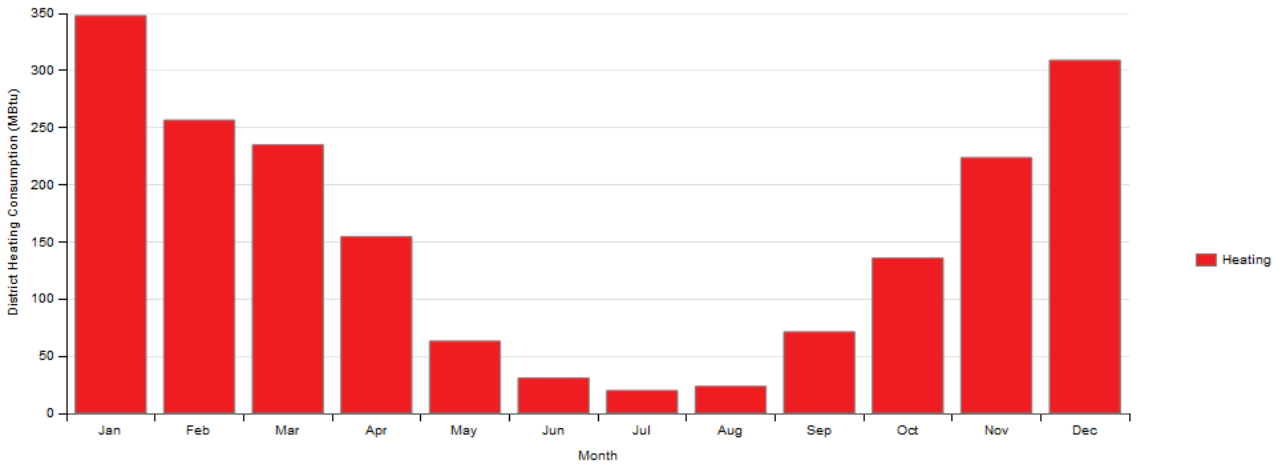
DISTRICT COOLING CONSUMPTION

The following graphics are expressed in MBtu



We can noticed that the energy consumption in cooling is higher during the summer, in particular, during July the energy consumption is equal to 90 MBtu = 26.37 KWh. The cooling consumption is lower than in Piacenza because the of the weather condition that is less hot during the summer.

DISTRICT HEATING CONSUMPTION

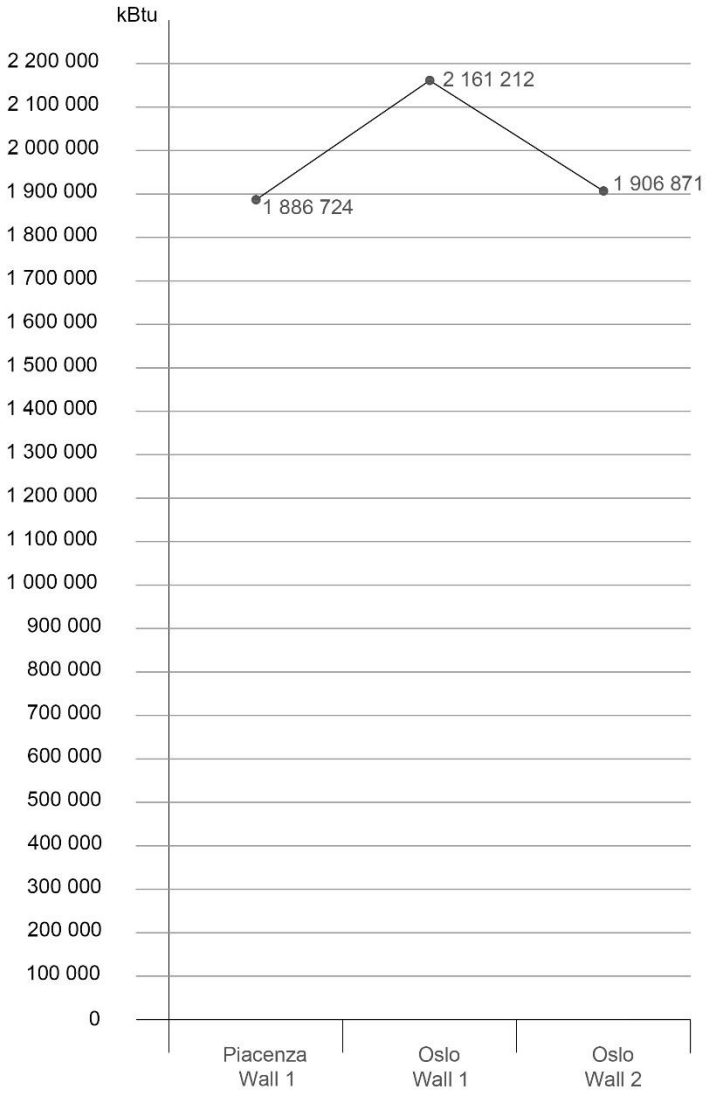


We can noticed that the energy consumption in heating is higher during the winter, in particular, during Genuary, the energy consumption is equal to 348 MBtu = 101.98 KWh. The cooling consumption is higher than in Piacenza because the of the weather condition that is colder during the winter.

According to the different climate condition between winter and summer, this two graphics are inversely proportional; during the summer I need more energy to cooling my building In july and August and during the winter I need more energy to heat my building from November to February.

6. CONCLUSION

From the analysis we can notice that keeping the same wall in two different cities (Piacenza - Oslo) we have different energy consumption because the weather conditions affect the heat transfer. During the winter we have a higher energy consumption in Oslo, the colder city, while during the summer the higher energy consumption is in Piacenza because the weather is warmer.



This graphic shows the sum of the annual cooling and heating energy consumption. After changing the stratification of the wall in Oslo, making it more insulating, we can notice that energy consumption decreased from 2161212 kBtu to 1906871 kBtu.