



**POLITECNICO**  
MILANO 1863

Sustainable Architecture and Landscape Design  
TECHNICAL ENVIRONMENTAL SYSTEMS  
ENERGY PERFORMANCES

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Assignment of Energy Performances of Buildings

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## I.1 Goals&Requirements

Goals: Analysing the energy performance of the same building in different cities with using different insulation.

Requirements:

- 1- Using a software program to calculate the annual heating and cooling consumption of the building.
- 2- Investigate the annual energy consumption of the building by changing location and wall properties.
- 3- Compare the annual consumption figures for three different cities and three different walls with the main event.

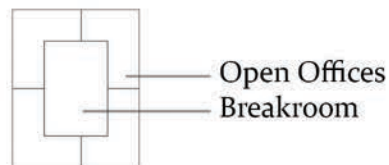
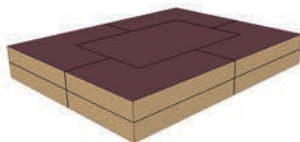
## I.2 General Information

### Locations



### Building

For research, a small, two-storey office building with open offices and break areas was selected.



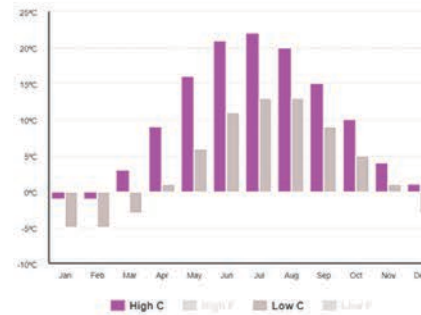
## Wall Types

- Wall without insulation
- Wall with 3.37 cm insulation
- Wall with 9.1 cm insulation

## General Weather Datas of Cities

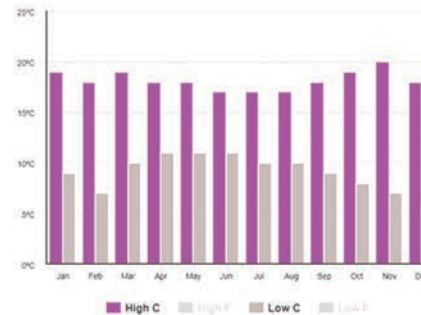
### Average High/Low Temperature

#### Stockholm



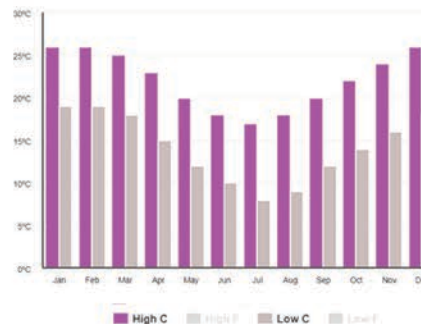
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High °C	-1	-1	3	9	16	21	22	20	15	10	4	1
High °F	30	30	37	48	61	70	72	68	59	50	39	34
Low °C	-5	-5	-3	1	6	11	13	13	9	5	1	-3
Low °F	23	23	27	34	43	52	55	55	48	41	34	27

#### Bogota



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High °C	19	18	19	18	18	17	17	17	18	19	20	18
High °F	66	64	66	64	64	63	63	63	64	66	68	64
Low °C	9	7	10	11	11	11	10	10	9	8	7	6
Low °F	48	45	50	52	52	52	50	50	48	46	45	43

#### Sydney



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High °C	26	26	25	23	20	18	17	18	20	22	24	26
High °F	79	79	77	73	68	64	63	64	68	72	75	79
Low °C	19	19	18	15	12	10	8	9	12	14	16	18
Low °F	66	66	64	59	54	50	46	48	54	57	61	64



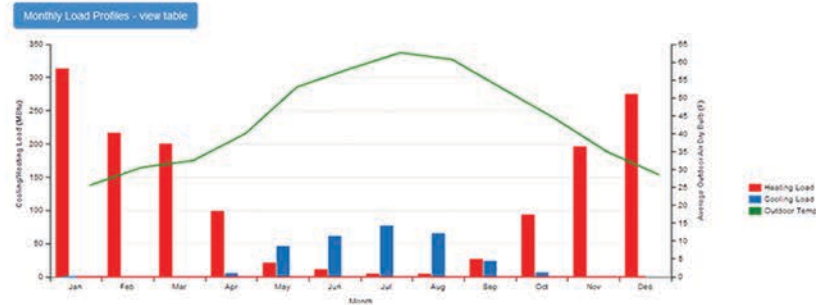
## 2.1 Experiment of one city with three different materials

### Location: Stockholm

Three different types of isolation have been experienced in Stockholm and the results show which is more appropriate for the country conditions.

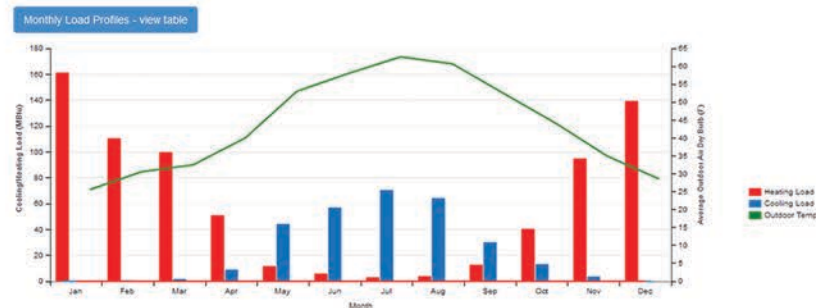
#### Wall without insulation

HVAC Load Profiles



#### Wall with insulation (3.37 cm)

HVAC Load Profiles



#### Wall with insulation (9.14 cm)

HVAC Load Profiles

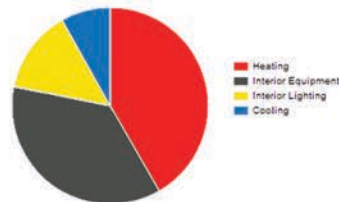


## Annual Overview

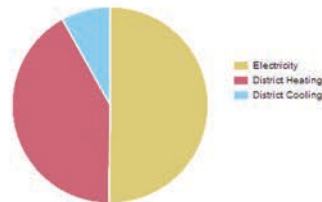
The program is giving an opportunity of receiving the diagrams of energy attribute. It has been experienced how the energy outputs change in the same weather condition for different kind of insulation thickness.

#### Wall without insulation

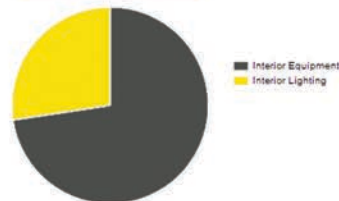
End Use - view table



Energy Use - view table



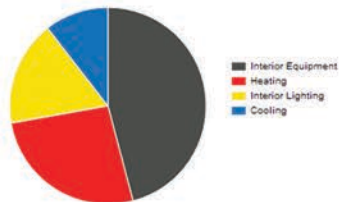
EUI - Electricity - view table



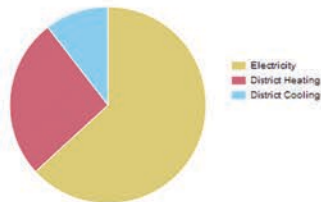
EUI - Gas - view table

#### Wall with insulation 3.37 cm

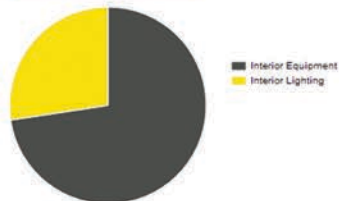
End Use - view table



Energy Use - view table



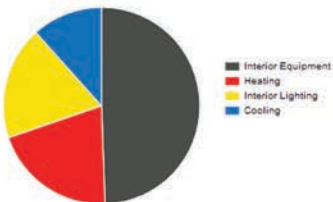
EUI - Electricity - view table



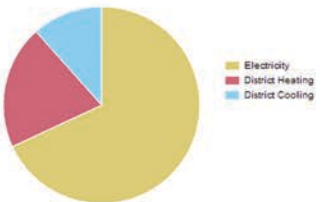
EUI - Gas - view table

#### Wall with insulation 9.14 cm

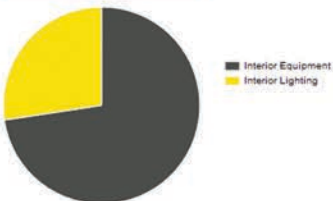
End Use - view table



Energy Use - view table



EUI - Electricity - view table



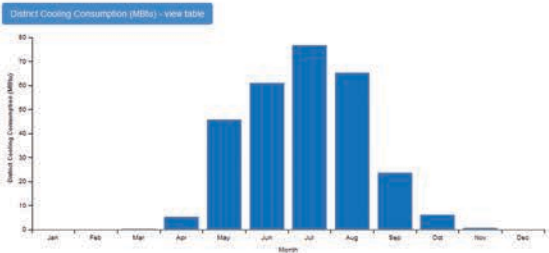
EUI - Gas - view table

# Cooling-Heating Consumptions

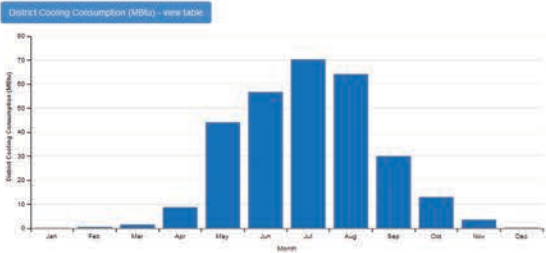
Three different types of isolation have been experienced in Stockholm and the results show which is more appropriate for the country conditions.

## Monthly Overview

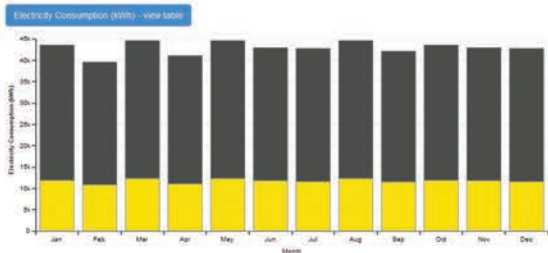
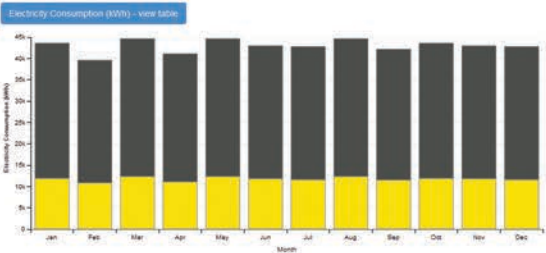
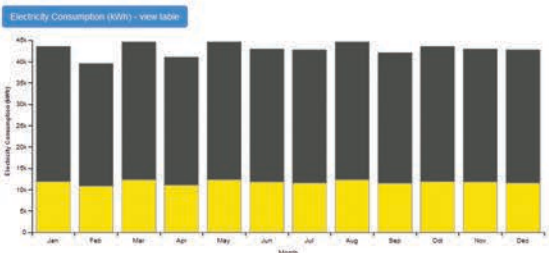
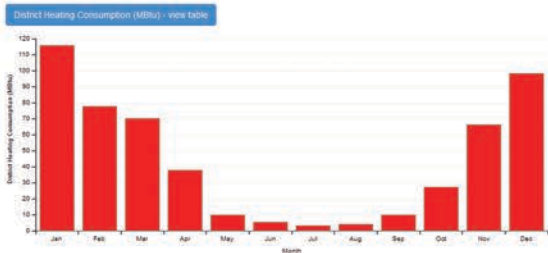
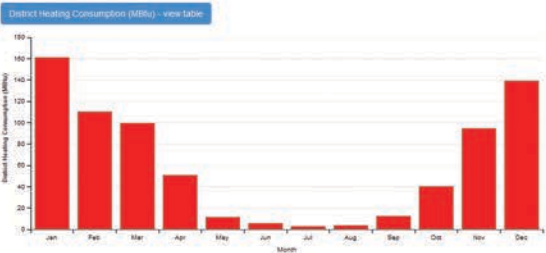
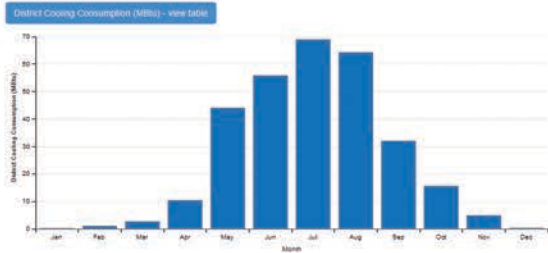
Wall without insulation



Wall with insulation 3.37 cm



Wall with insulation 9.14 cm

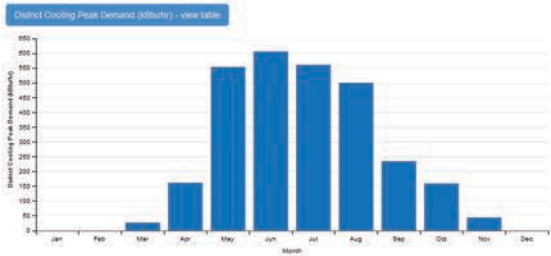


# Cooling-Heating Peak Demands

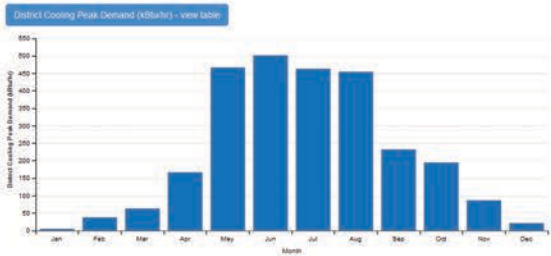
Three different types of isolation have been experienced in Stockholm and the results show which is more appropriate for the country conditions.

## Monthly Overview

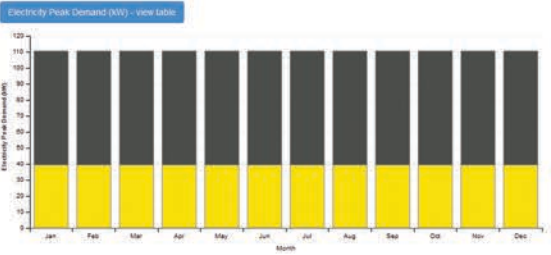
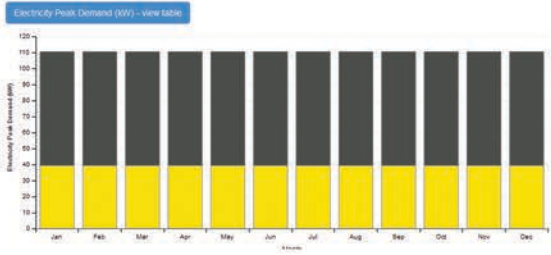
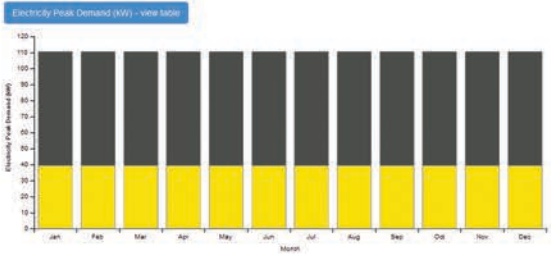
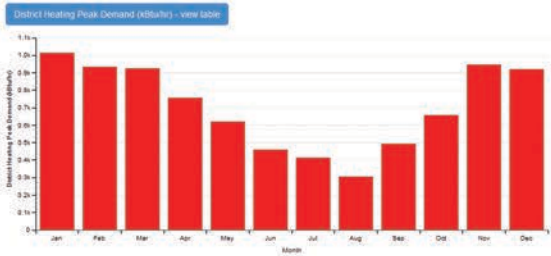
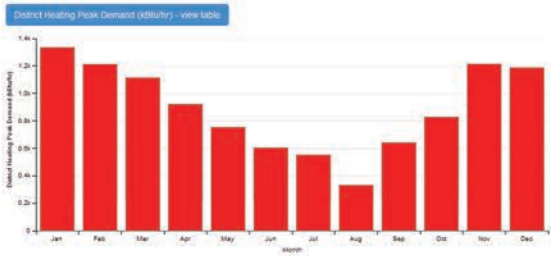
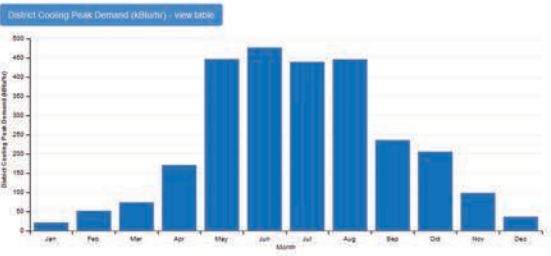
Wall without insulation



Wall with insulation 3.37 cm



Wall with insulation 9.14 cm





# Site and Source Summary

## Wall without insulation

### Site and Source Energy

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft <sup>2</sup> )	Energy Per Conditioned Building Area (kBtu/ft <sup>2</sup> )
Total Site Energy	3503046.7	81.4	81.4
Net Site Energy	3503046.7	81.4	81.4
Total Source Energy	11145571.3	258.9	258.9
Net Source Energy	11145571.3	258.9	258.9

### Site to Source Energy Conversion Factors

	Site→Source Conversion Factor
Electricity	3.167
Natural Gas	1.084
District Cooling	1.056
District Heating	3.613

## Wall with insulation 3.37 cm

### Site and Source Energy

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft <sup>2</sup> )	Energy Per Conditioned Building Area (kBtu/ft <sup>2</sup> )
Total Site Energy	2763274.5	64.6	64.6
Net Site Energy	2763274.5	64.6	64.6
Total Source Energy	8524184.0	198.0	198.0
Net Source Energy	8524184.0	198.0	198.0

### Site to Source Energy Conversion Factors

	Site→Source Conversion Factor
Electricity	3.167
Natural Gas	1.084
District Cooling	1.056
District Heating	3.613

## Wall with insulation 9.14 cm

### Site and Source Energy

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft <sup>2</sup> )	Energy Per Conditioned Building Area (kBtu/ft <sup>2</sup> )
Total Site Energy	2563683.1	60.0	60.0
Net Site Energy	2563683.1	60.0	60.0
Total Source Energy	7783029.0	188.8	188.8
Net Source Energy	7783029.0	188.8	188.8

### Site to Source Energy Conversion Factors

	Site→Source Conversion Factor
Electricity	3.167
Natural Gas	1.084
District Cooling	1.056
District Heating	3.613

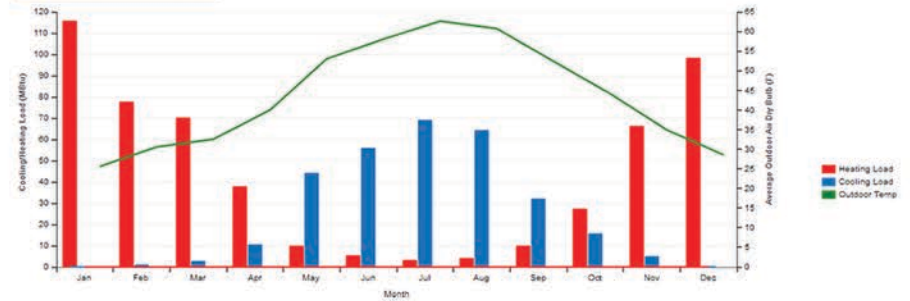
## 2.2 Comparison of one type wall between three cities

### Wall with insulation (9.14 cm)

#### - Stockholm

#### HVAC Load Profiles

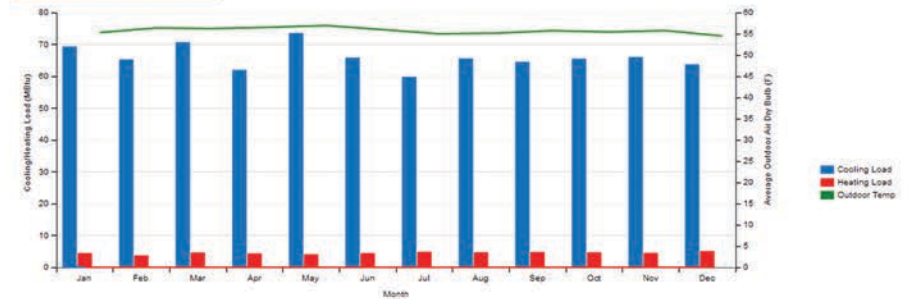
##### Monthly Load Profiles - view table



#### - Bogota

#### HVAC Load Profiles

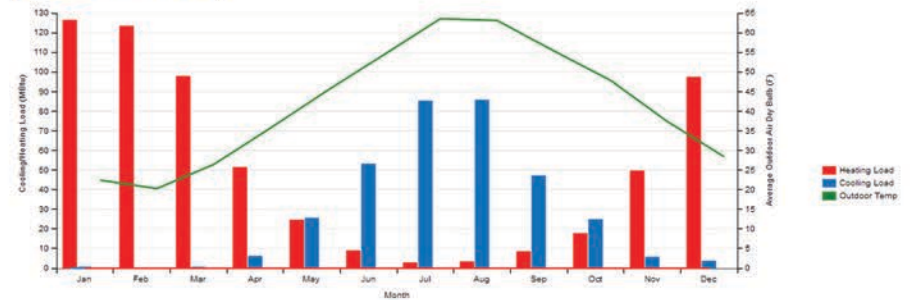
##### Monthly Load Profiles - view table



#### - Sydney

#### HVAC Load Profiles

##### Monthly Load Profiles - view table

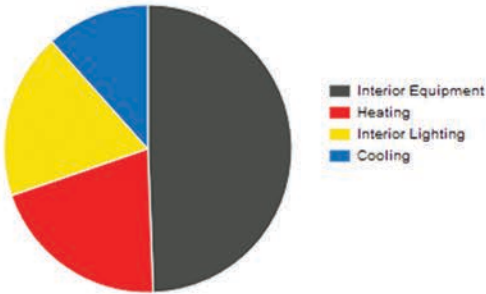


# Annual Overview

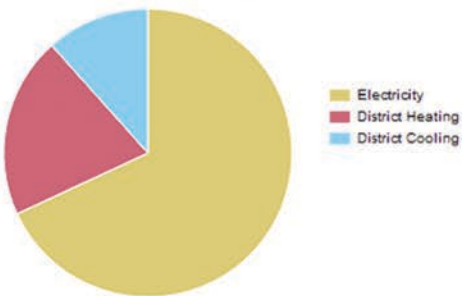
The program is giving an opportunity of receiving the diagrams of energy attribute. It has been experienced how the energy outputs change in the same weather condition for different cities.

Stockholm

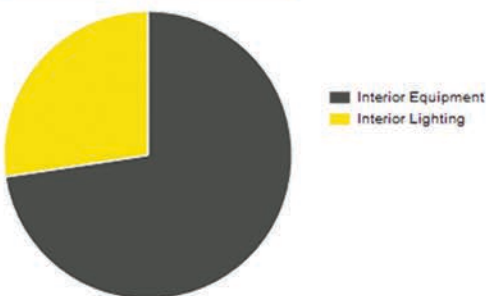
End Use - view table



Energy Use - view table

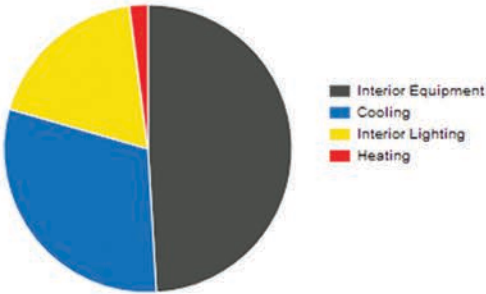


EUI - Electricity - view table

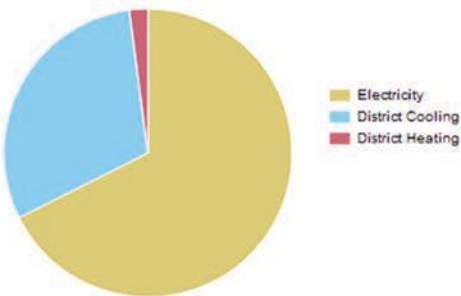


Bogota

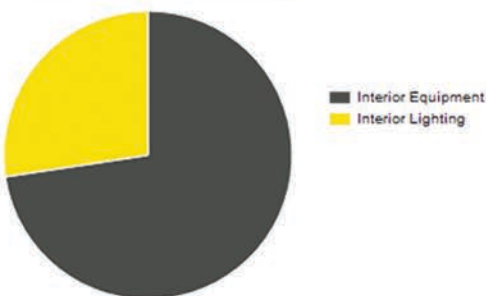
End Use - view table



Energy Use - view table

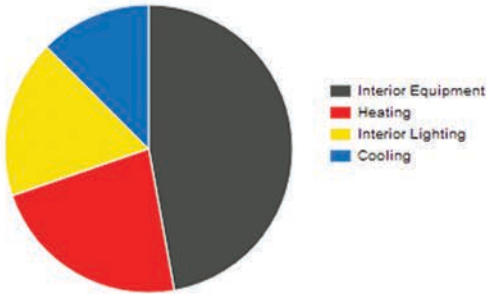


EUI - Electricity - view table

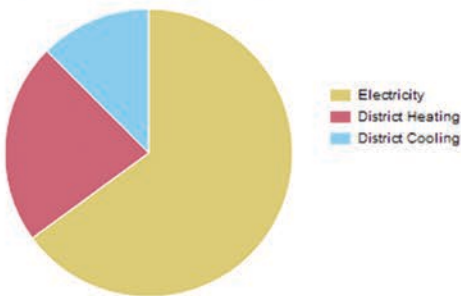


Sydney

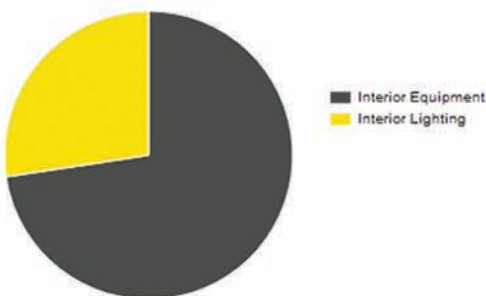
End Use - view table



Energy Use - view table



EUI - Electricity - view table

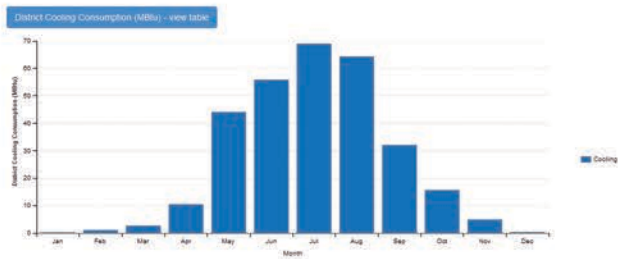


# Cooling-Heating Consumptions

The same wall type was experienced in 3 different cities and compared according to consumptions of cooling and heating.

## Monthly Overview

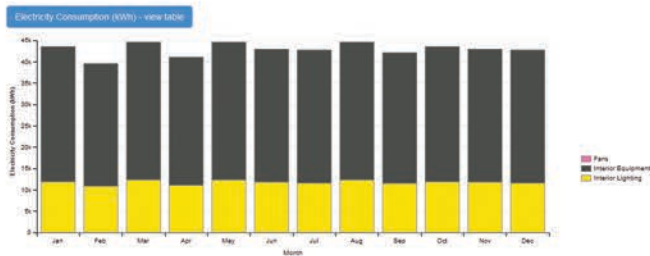
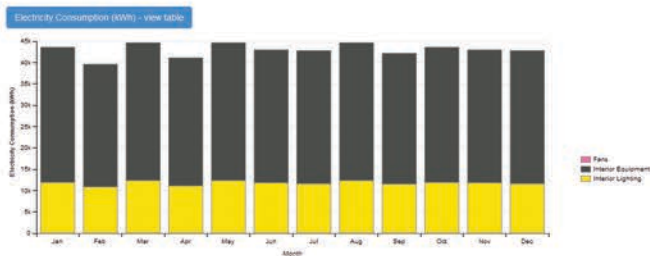
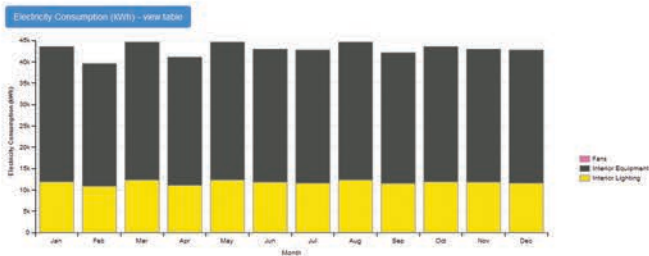
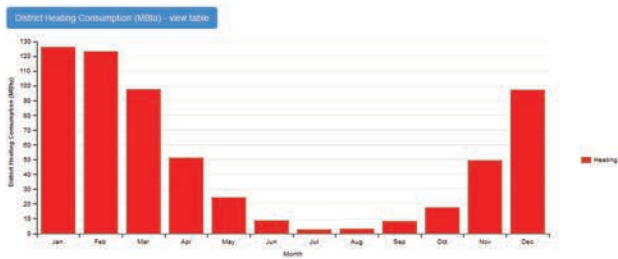
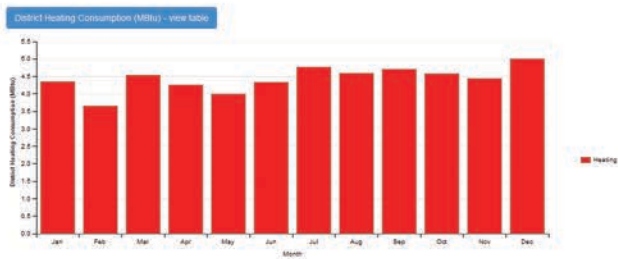
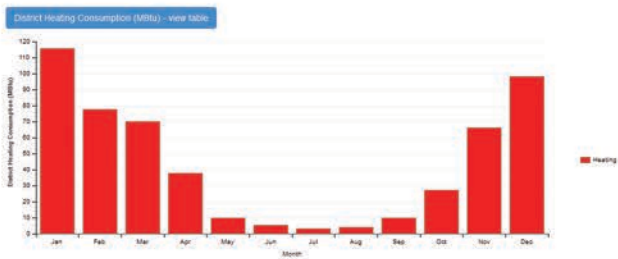
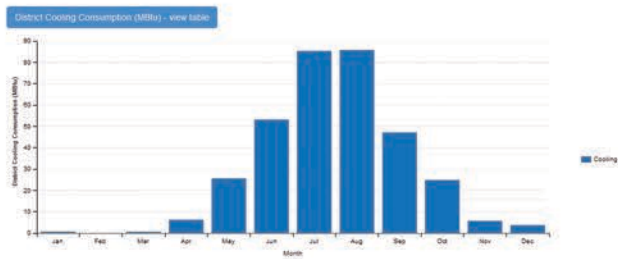
Stockholm



Bogota



Sydney



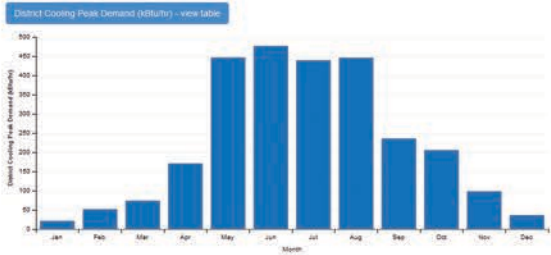


# Cooling-Heating Peak Demands

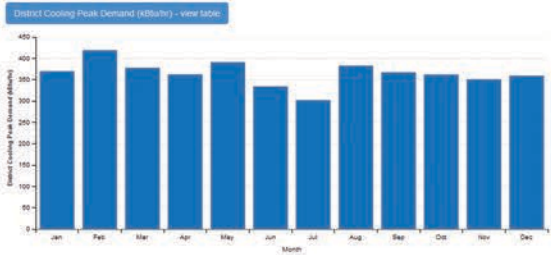
The same wall type was experienced in 3 different cities and compared according to peak demands of cooling and heating.

## Monthly Overview

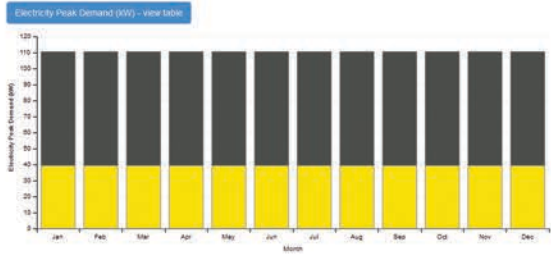
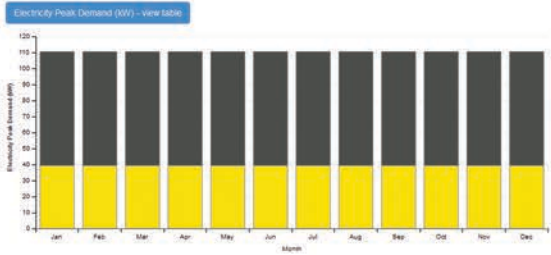
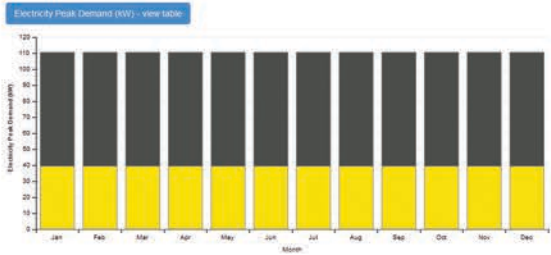
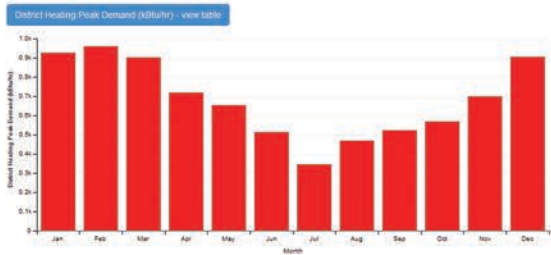
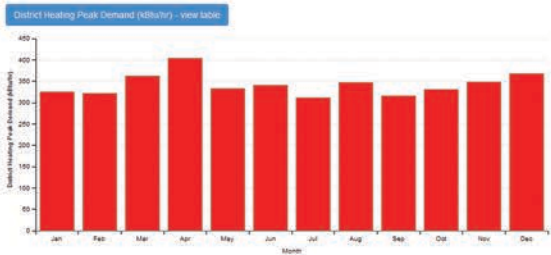
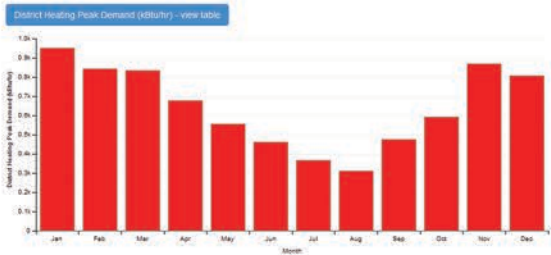
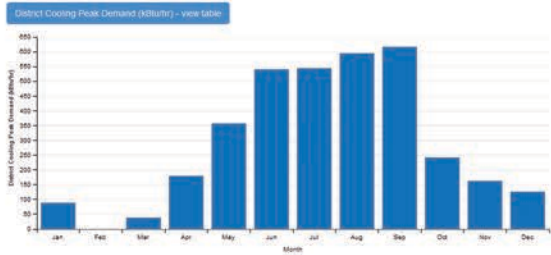
Stockholm



Bogota



Sydney



# Site and Source Summary

## Stockholm

### Site and Source Energy

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft <sup>2</sup> )	Energy Per Conditioned Building Area (kBtu/ft <sup>2</sup> )
Total Site Energy	2563683.1	60.0	60.0
Net Site Energy	2563683.1	60.0	60.0
Total Source Energy	7783029.0	180.8	180.8
Net Source Energy	7783029.0	180.8	180.8

### Site to Source Energy Conversion Factors

	Site to Source Conversion Factor
Electricity	3.167
Natural Gas	1.084
District Cooling	1.056
District Heating	3.613

## Bogota

### Site and Source Energy

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft <sup>2</sup> )	Energy Per Conditioned Building Area (kBtu/ft <sup>2</sup> )
Total Site Energy	2602772.2	60.5	60.5
Net Site Energy	2602772.2	60.5	60.5
Total Source Energy	6597214.9	153.2	153.2
Net Source Energy	6597214.9	153.2	153.2

### Site to Source Energy Conversion Factors

	Site to Source Conversion Factor
Electricity	3.167
Natural Gas	1.084
District Cooling	1.056
District Heating	3.613

## Sydney

### Site and Source Energy

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft <sup>2</sup> )	Energy Per Conditioned Building Area (kBtu/ft <sup>2</sup> )
Total Site Energy	2708046.1	62.9	62.9
Net Site Energy	2708046.1	62.9	62.9
Total Source Energy	8135758.6	189.0	189.0
Net Source Energy	8135758.6	189.0	189.0

### Site to Source Energy Conversion Factors

	Site to Source Conversion Factor
Electricity	3.167
Natural Gas	1.084
District Cooling	1.056
District Heating	3.613

## 2.3 Conclusion

The building which has been hypothetically constructed was kept simple to focus on the calculations and two different types of areas were placed inside (Open offices and a break room). This building was firstly put into Stockholm with three different isolation materials as three different buildings; then one of these materials was selected and tested in three different climatic conditions (Stockholm-Bogota-Sydney). As a result of the experiments made, the heat required for the construction was calculated and all the reactions were observed.

Especially in a city like Stockholm that has a cold clay, it is observed that the insulation material must be thick because the heat requirement is high. Thus, the expenditure of external factors used for heating and cooling has reached the optimum level.

Since they are in different climatic conditions, the insulation material that has appropriate thickness for Stockholm, was tried in Bogota and Sydney and their reactions were observed. As a matter of fact, different results were obtained in these two cities. As observed in the charts, Bogota is not a suitable region for application of this material because it has a hot climate since the city has special geographical location and close to the equator. Additionally in Sydney, it is showed a similar reaction with Stockholm.

In summary, different insulation thicknesses were tested in a city owing to the programs OpenStudio and EnergyPlus. Moreover, One of the tested insulations was applied in two different cities. As a result of these tests, the data we gained showed us how to calculate and optimize the consumed energy.