

# Building Simulation Project

Technical Environmental Systems  
Politecnico di Milano - Piacenza

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Building Simulation Project

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# intro

## Building Simulation Project

The objective for this project is to see the consumption of a building in different cities around the world.

For this we modelled a 4 storied building of 2000m<sup>2</sup> with 6 different thermal zones.

We use a standard (Base case) study and pick 3 different cities, Bergamo in Italy, Larnaca in Cyprus and Concepcion in Chile.

These cities have different climate during the year between each other.

Using the Köppen climate classification Bergamo is considered temperate with hot summers and humid in every stages. Larnaca is considered Mediterranean close to the desert climate. Concepcion is considered oceanic with Mediterranean influence.

Then we run our simulations using the base case construction set, that consist in a standard wall and roofing system.

After we compare the results between the 3 cities we discovered that the specific system was working for Bergamo and Concepcion, while on Cyprus we had high consumption through the hotter days.

Then we decide to run further simulations for Larnaca to improve the consumption by using 2 different construction sets.

# building

## Building Simulation Project

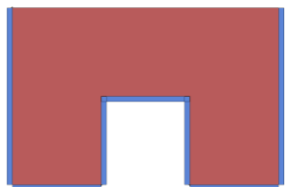
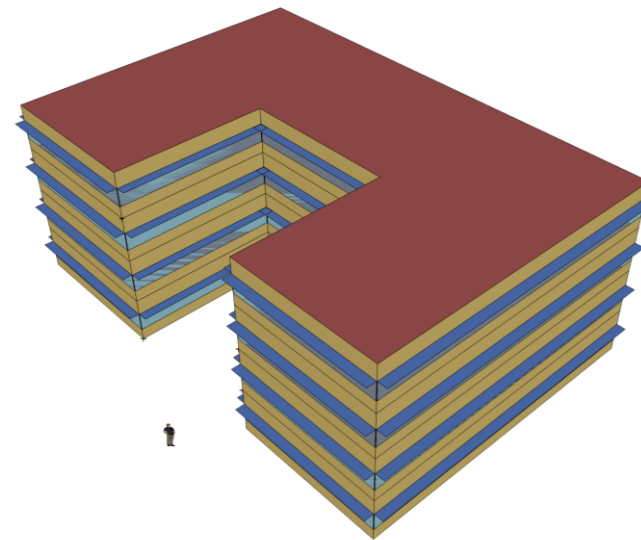
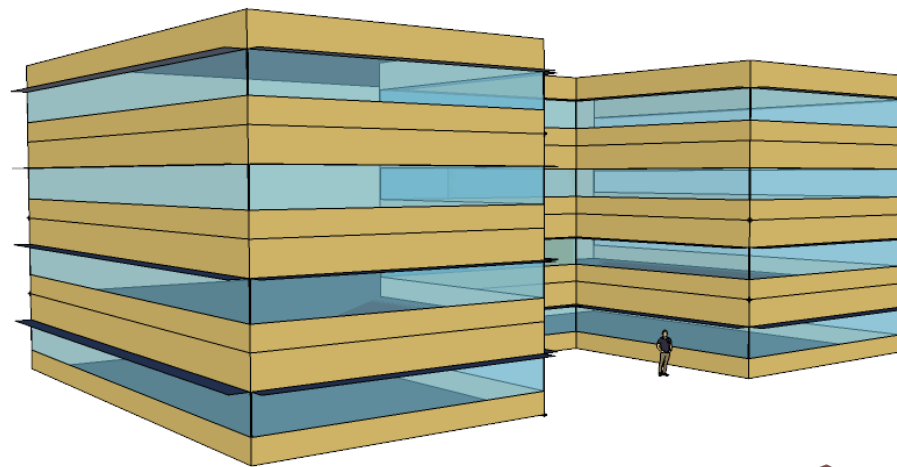
The whole building energy simulation is evaluated for a 4 storied 2000m<sup>2</sup> office building with shading devices.

1 story: Lobby

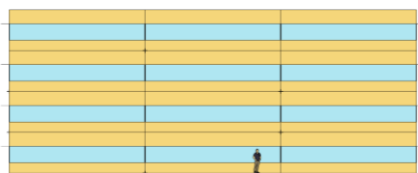
2 story: Office and computer room

3 story: Office and print room

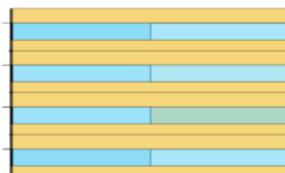
4 story: Conference room



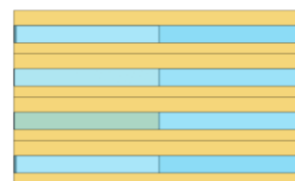
top



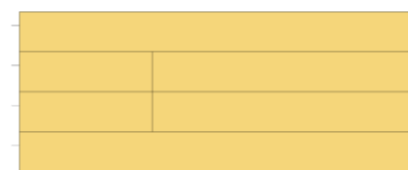
front



left



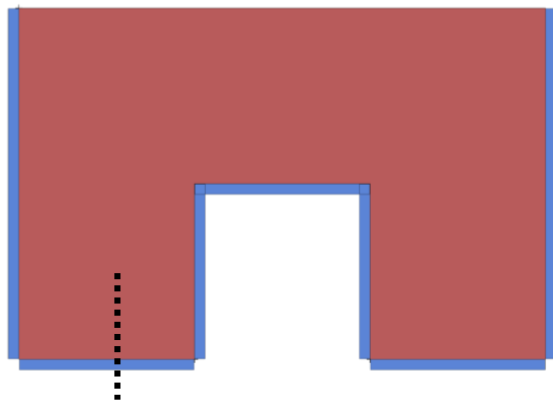
right



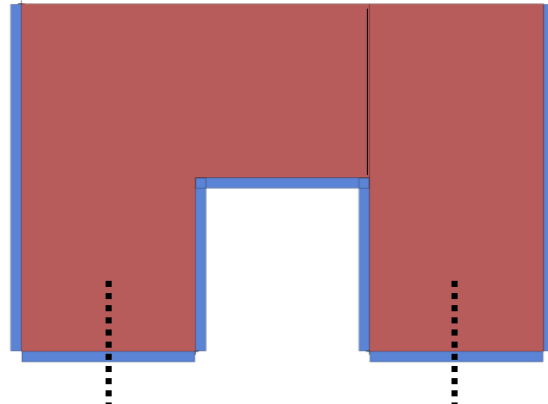
back

# building

Building Simulation Project

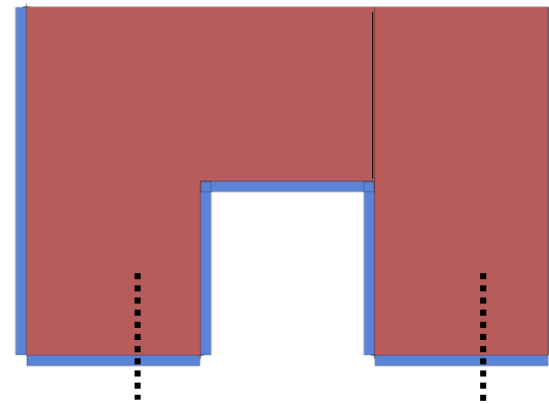


1 story:  
Lobby  
1 thermal zone



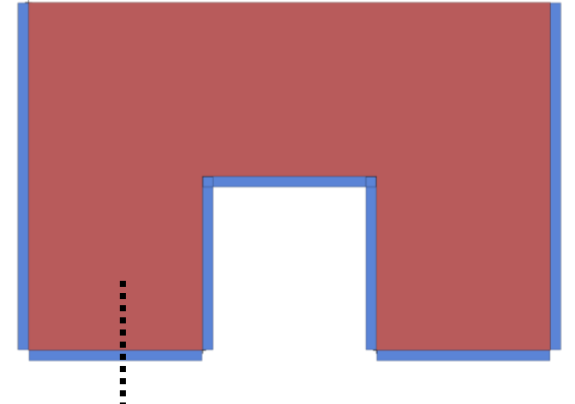
2 story:  
office  
2 thermal zone

2 story:  
I.T room  
3 thermal zone



3 story:  
office  
4 thermal zone

3 story:  
Print room  
5 thermal zone



4 story:  
Conference room  
6 thermal zone

**cities**

Building Simulation Project



**Concepción, Chile**

36°50' 00"S

73°03' 00"O

**Bergamo, Italy**

45°41'45" N

9°40'01" E

**Larnaca, Cyprus**

34°55' 00"N

33°38' 00"E

# Base case study

## Building Simulation Project

The base case study consists in a standard construction set.  
The standard construction set:

### Wall N° 1

- Stucco (0.00253m)
- Concrete (0.2033m)
- Wall insulation (0.0337m)
- Gypsum (0.0127m)

### Floor N° 1

- Concrete (0.1016m)
- Carpet

### Roof N°1

- Roof membrane (0.0095m)
- Roof insulation (0.1693m)
- Metal decking (0.0015m)

We use this set in the 3 cities and compare the results in terms of energy consumption. The shell of the building is the same for the three cases and the only change is the orientation of the building in Chile because it is in the southern hemisphere.

# Base case study

## Building Simulation Project

### Wall N°1

	Roughness	Thickness m	Conductivity w/mK	Density k/m3	Specific heat J/kgK	Thermal absorptance	Solar absorptance	Visible absorptance
Stucco	smooth	0.00253	0.6918	1858	837	0.9	0.92	0.92
Concrete	Medium rough	0.2033	1.7296	2243	837	0.9	0.65	0.65
Wall insulation	Medium rough	0.0337	0.0432	91	837	0.9	0.5	0.5
Gypsum	smooth	0.0127	0.16	784.9	830	0.9	0.4	0.4
Total thickness		0.25223						



# Base case study

## Building Simulation Project

### Floor N°1

	Thickness m	Conductivity w/mK	Density k/m3	Thermal absorptance	Solar absorptance	Visible absorptance	roughness	Specific heat J/kgK	Thermal resistance M2K/W
Concrete	0.1016	1.311	2240	0.9	0.85	0.85	rough	836.8	
Carpet				0.9	0.8	0.8			0.1
Total thickness	0.1016								

# Base case study

## Building Simulation Project

### Roof N°1

	Thickness m	Roughness	Conduc- tivity w/mK	Density k/m3	Thermal absorptanc e	Solar absorptanc e	Visible absorpta nce	Specific heat J/kgK	Thermal resistance M2K/W
Roof membrane	0.0095	Very rough	0.16	1121.29	0.9	0.7	0.7	14660	
Roof insulation	0.1693	Medium rough	0.049	265	0.9	0.7	0.7	836.8	
Metal decking	0.0015	Medium smooth	45.006	7680	0.9	0.6	0.6	418.4	

# Base case study. Results

## Building Simulation Project

Base case study in 3 different cities.

### Bergamo, Italy

	Electricity GJ	District Cooling GJ	District Heating GJ
Heating	0.0	0.0	423.34
Cooling	0.0	177.24	0.0
Interior Lighting	269.95	0.0	0.0
Interior equipment	268.25	0.0	0.0
Total End Uses	548.2	177.24	423.34

### Larnaca, Cyprus

	Electricity GJ	District Cooling GJ	District Heating GJ
Heating	0.0	0.0	70.01
Cooling	0.0	493.82	0.0
Interior Lighting	269.95	0.0	0.0
Interior equipment	268.25	0.0	0.0
Total End Uses	548.2	493.82	70.01

### Concepcion, Chile

	Electricity GJ	District Cooling GJ	District Heating GJ
Heating	0.0	0.0	201.13
Cooling	0.0	96.7	0.0
Interior Lighting	269.95	0.0	0.0
Interior equipment	268.25	0.0	0.0
Total End Uses	548.2	96.7	201.13

# Base case study. Results

## Building Simulation Project

city		Bergamo	Italy	Larnaca	Cyprus	Concepcion	Chile
	Electricity GJ	District Cooling GJ	District Heating GJ	District Cooling GJ	District Heating GJ	District Cooling GJ	District Heating GJ
Heating	0.0	0.0	423.34	0.0	70.01	0.0	201.13
Cooling	0.0	177.24	0.0	493.82	0.0	96.7	0.0
Interior Lighting	269.95	0.0	0.0	0.0	0.0	0.0	0.0
Interior equipment	278.25	0.0	0.0	0.0	0.0	0.0	0.0
Total End Uses	548.2	177.24	423.34	493.82	70.01	96.7	201.13

# Base case study. Analysis

Building Simulation Project

## Observations

Comparison between the 3 cities. We observe that Larnaca has the highest consumption results in terms of consumption. So we will take this case and run the sensitive study in the case of Larnaca, Cyprus.

Considering the results we change the construction sets in Larnac, Cyprus. In order to have better results and consumption.

We try 2 new different construction sets. (walls, roof, and floor)

Set 1 and set 2

We try to envelope measures changing the parameters of the roof, wall, glazing system in order to reduce the cooling load so as to reduce the overall energy consumption of the building.

# 2<sup>nd</sup> case study

## Building Simulation Project

The 2 study consist in new walls and roof. Set 1.

### Set 1 Wall 2

- Wood (0.00254m)
- Insulation board (0.0254m)
- Wall air space resistance
- Insulation board (0.0254m)
- Wood (0.00254m)

### Set 1 Roof 2

- Roof membrane (0.0095m)
- Roof insulation (0.2105m)
- Metal decking (0.0015m)



## 2<sup>nd</sup> case study. Larnaca Cyprus

### Building Simulation Project

#### Set 1. Roof

	Thickness m	Conductivity w/mK	Density k/m3	Thermal absorptance	Solar absorptance	Visible absorptance	Roughness	Specific heat J/kgK	Thermal resistance M2K/W
Roof membrane	0.0095	0.16	1121.29	0.9	0.7	0.7	Very rough	14660	
Roof insulation	0.2105	0.049	265	0.9	0.7	0.7	Medium rough	836.8	
Metal decking	0.0015	45.006	7680	0.9	0.6	0.6	Medium smooth	418.4	



## 2<sup>nd</sup> case study. Larnaca Cyprus

Building Simulation Project

### Sensitive Analysis Set 1

	Electricity GJ	District Cooling GJ	District Heating GJ
Heating	0.0	0.0	35.26
Cooling	0.0	464.3	0.0
Interior Lighting	269.95	0.0	0.0
Interior equipment	278.25	0.0	0.0
Total End Uses	548.2	464.3	71.77

## 2<sup>nd</sup> case study. Larnaca Cyprus

### Building Simulation Project

## Comparison

### Base case study

	Electricity GJ	District Cooling GJ	District Heating GJ
Heating	0.0	0.0	70.01
Cooling	0.0	493.82	0.0
Interior Lighting	269.95	0.0	0.0
Interior equipment	278.25	0.0	0.0
Total End Uses	548.2	493.82	70.01

### 2<sup>nd</sup> case study. Set 1

	Electricity GJ	District Cooling GJ	District Heating GJ
Heating	0.0	0.0	35.26
Cooling	0.0	464.3	0.0
Interior Lighting	269.95	0.0	0.0
Interior equipment	278.25	0.0	0.0
Total End Uses	548.2	464.3	71.77

# 3<sup>rd</sup> case study

## Building Simulation Project

The 3 case study.  
The standard construction set:

### Wall N° 1

- Stucco (0.00253m)
- Concrete (0.2033m)
- Wall insulation (0.0681m)
- Gypsum (0.0127m)

### Floor N° 1

- Concrete (0.1016m)
- Carpet

### Roof N°1

- Roof membrane (0.0095m)
- Roof insulation (0.2105m)
- Metal decking (0.0015m)

# 3<sup>rd</sup> case study. Larnaca Cyprus

## Building Simulation Project

### Set 2. Wall

	roughness	Thickness m	Conductivity w/mK	Density k/m3	Specific heat J/kgK	Thermal absorptance	Solar absorptance	Visible absorptan ce
Stucco	smooth	0.00253	0.6918	1858	837	0.9	0.92	0.92
Concrete	Medium rough	0.2033	1.7296	2243	837	0.9	0.65	0.65
Wall insulation	Medium rough	0.0681	0.0432	91	837	0.9	0.5	0.5
Gypsum	smooth	0.0127	0.16	784.9	830	0.9	0.4	0.4
Total thickness								

### 3<sup>rd</sup> case study. Larnaca Cyprus

# Building Simulation Project

## Set 2. Floor

[illegible]

# 3<sup>rd</sup> case study. Larnaca Cyprus

## Building Simulation Project

### Set 2. Roof

	Thickness m	Conductivity w/mK	Density k/m3	Thermal absorptance	Solar absorptance	Visible absorptance	Roughness	Specific heat J/kgK	Thermal resistance M2K/W
Roof membrane	0.0095	0.16	1121.29	0.9	0.7	0.7	Very rough	14660	
Roof insulation	0.2105	0.049	265	0.9	0.7	0.7	Medium rough	836.8	
Metal decking	0.0015	45.006	7680	0.9	0.6	0.6	Medium smooth	418.4	

# 3<sup>rd</sup> case study. Larnaca Cyprus

Building Simulation Project

## Sensitive Analysis Set 2

	Electricity GJ	District Cooling GJ	District Heating GJ
Heating	0.0	0.0	65.22
Cooling	0.0	474.99	0.0
Interior Lighting	269.95	0.0	0.0
Interior equipment	278.25	0.0	0.0
Total End Uses	548.2	474.99	65.22

# 3<sup>rd</sup> case study. Larnaca Cyprus

## Building Simulation Project

### Comparison

#### Base case study

	Electricity GJ	District Cooling GJ	District Heating GJ
Heating	0.0	0.0	70.01
Cooling	0.0	493.82	0.0
Interior Lighting	269.95	0.0	0.0
Interior equipment	278.25	0.0	0.0
Total End Uses	548.2	493.82	70.01

#### 3<sup>rd</sup> case study. Set 2

	Electricity GJ	District Cooling GJ	District Heating GJ
Heating	0.0	0.0	65.22
Cooling	0.0	474.99	0.0
Interior Lighting	269.95	0.0	0.0
Interior equipment	278.25	0.0	0.0
Total End Uses	548.2	474.99	65.22



# Sensitive analysis comparison

## Building Simulation Project

### Base case study

	Electricity GJ	District Cooling GJ	District Heating GJ
Heating	0.0	0.0	70.01
Cooling	0.0	493.82	0.0
Interior Lighting	269.95	0.0	0.0
Interior equipmen t	278.25	0.0	0.0
Total End Uses	548.2	493.82	70.01

### 2<sup>nd</sup> study. Set 1

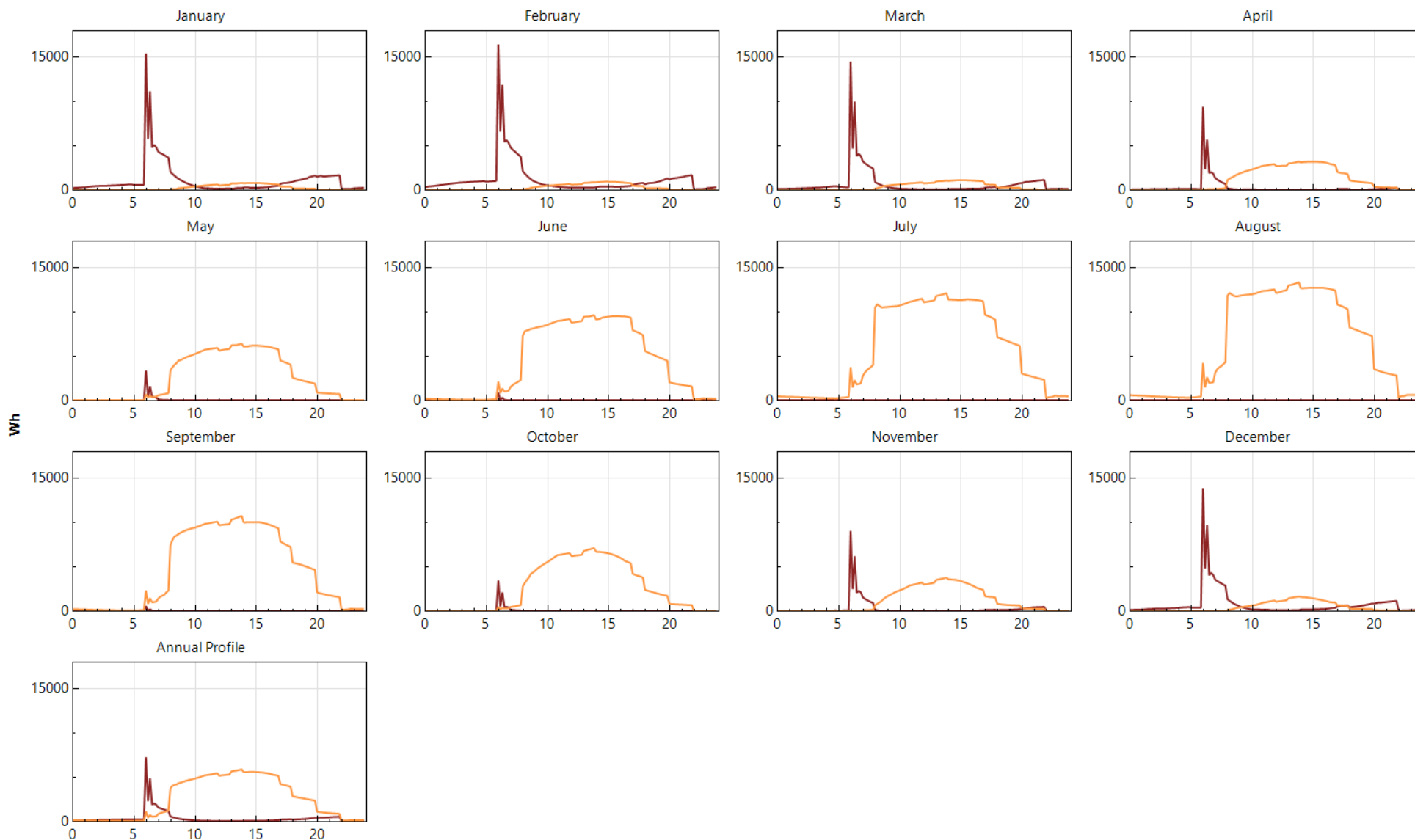
	Electricit y GJ	District Cooling GJ	District Heating GJ
Heating	0.0	0.0	35.26
Cooling	0.0	464.3	0.0
Interior Lighting	269.95	0.0	0.0
Interior equipme nt	278.25	0.0	0.0
Total End Uses	548.2	464.3	71.77

### 3<sup>rd</sup> study. Set 2

	Electricit y GJ	District Cooling GJ	District Heating GJ
Heating	0.0	0.0	65.22
Cooling	0.0	474.99	0.0
Interior Lighting	269.95	0.0	0.0
Interior equipme nt	278.25	0.0	0.0
Total End Uses	548.2	474.99	65.22

# observations

## Building Simulation Project

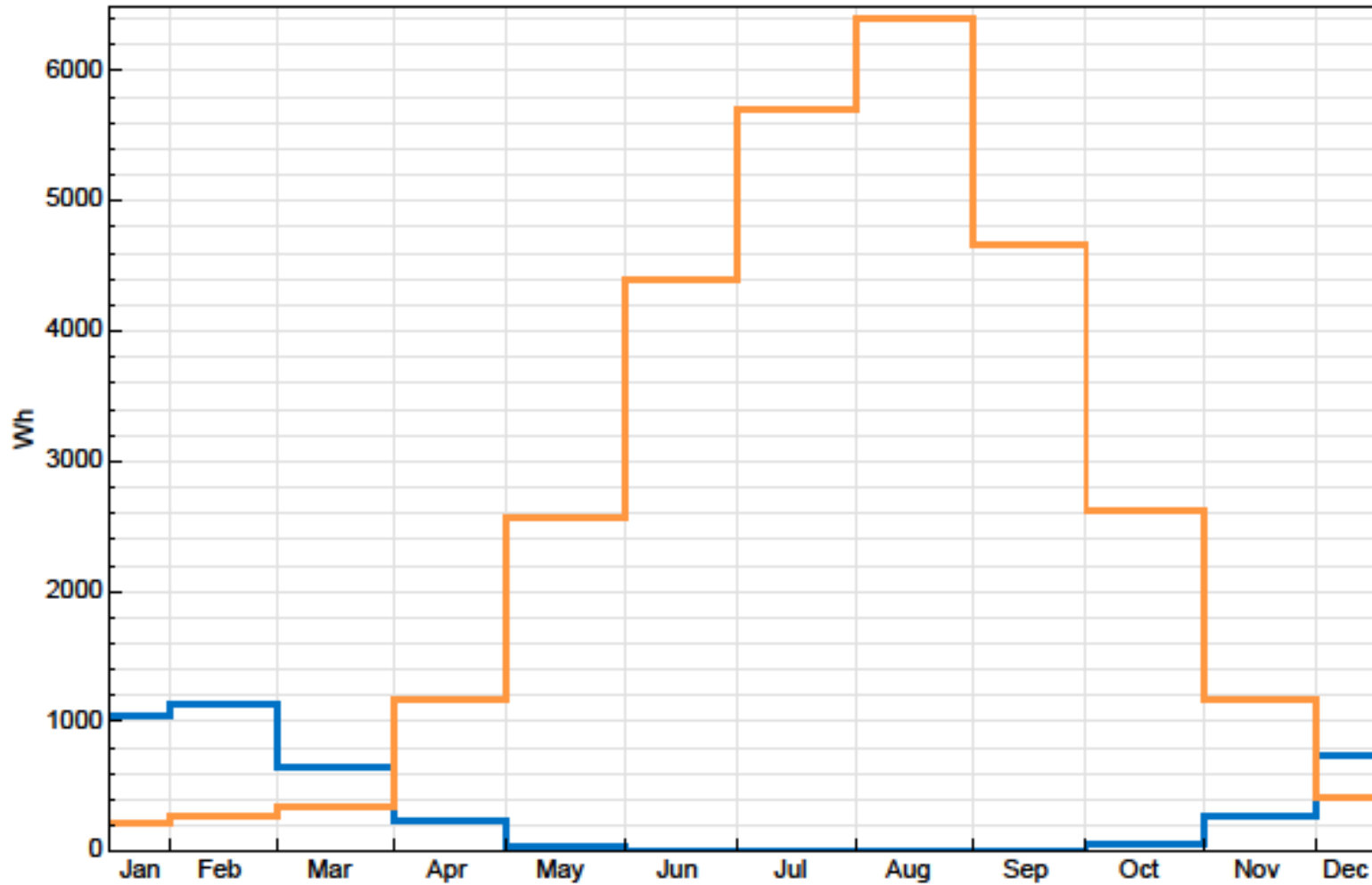


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<input type="checkbox"/>	Environment Run Period Zone Timestep 10 minutes (F)
<input checked="" type="checkbox"/>	<b>Electricity:Facility</b>
<input type="checkbox"/>	Site Run Period Zone Timestep 10 minutes (Wh)
<input type="checkbox"/>	Site Run Period Daily (Wh)
<input checked="" type="checkbox"/>	<b>Zone Air Temperature</b>
<input type="checkbox"/>	THERMAL ZONE 1 Run Period Hourly (F)
<input type="checkbox"/>	THERMAL ZONE 2 Run Period Hourly (F)
<input type="checkbox"/>	THERMAL ZONE 3 Run Period Hourly (F)
<input type="checkbox"/>	THERMAL ZONE 4 Run Period Hourly (F)
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<input type="checkbox"/>	THERMAL ZONE 6 Run Period Hourly (F)
<input checked="" type="checkbox"/>	<b>Zone Air Relative Humidity</b>
<input type="checkbox"/>	THERMAL ZONE 1 Run Period Daily (%)
<input type="checkbox"/>	THERMAL ZONE 2 Run Period Daily (%)
<input type="checkbox"/>	THERMAL ZONE 3 Run Period Daily (%)
<input type="checkbox"/>	THERMAL ZONE 4 Run Period Daily (%)
<input type="checkbox"/>	THERMAL ZONE 5 Run Period Daily (%)
<input type="checkbox"/>	THERMAL ZONE 6 Run Period Daily (%)
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<input checked="" type="checkbox"/>	Site Run Period Zone Timestep 10 minutes (Wh)
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<input checked="" type="checkbox"/>	Site Run Period Zone Timestep 10 minutes (Wh)

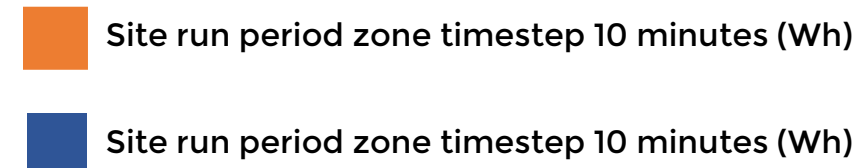
In this graphic we can see the yearly profile for district cooling and district heating facilities.

# observations

## Building Simulation Project



In this graphic we can see the monthly distric heating facility and district cooling facility.



# observations

Building Simulation Project

## conclusion

In this project we observed that Cyprus has a bigger gap between heating and cooling consumption. That is the reason we choose Larnaca, to reduce the difference between the 2 parameters.

Changing the construction sets, allowed us to see that with better insulation we reduce the cooling consumption.

Basically in a hot city as Larnaca the mayor issue for an office building will be in terms of cooling.

We noticed that our construction with a façade covered with 42% windows, is not recommended.

