# TECHNICAL ENVIRONMENTAL SYSTEMS

## OPEN STUDIO _ BUILDING SIMULATION PROJECT


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## INTRODUCTION

The architect has many things to consider when designing or choosing materials for their buildings. One criteria to take into consideration is the energy consumption, and how material choice can effect the outcome. In this assignment, we will analyze the energy performance of a building in relation with its condition system (heating and cooling), interior equipment and interior lighting. Our methodology of completing this analysis will include the use of SkethUp, Openstudio, and Energy plus.

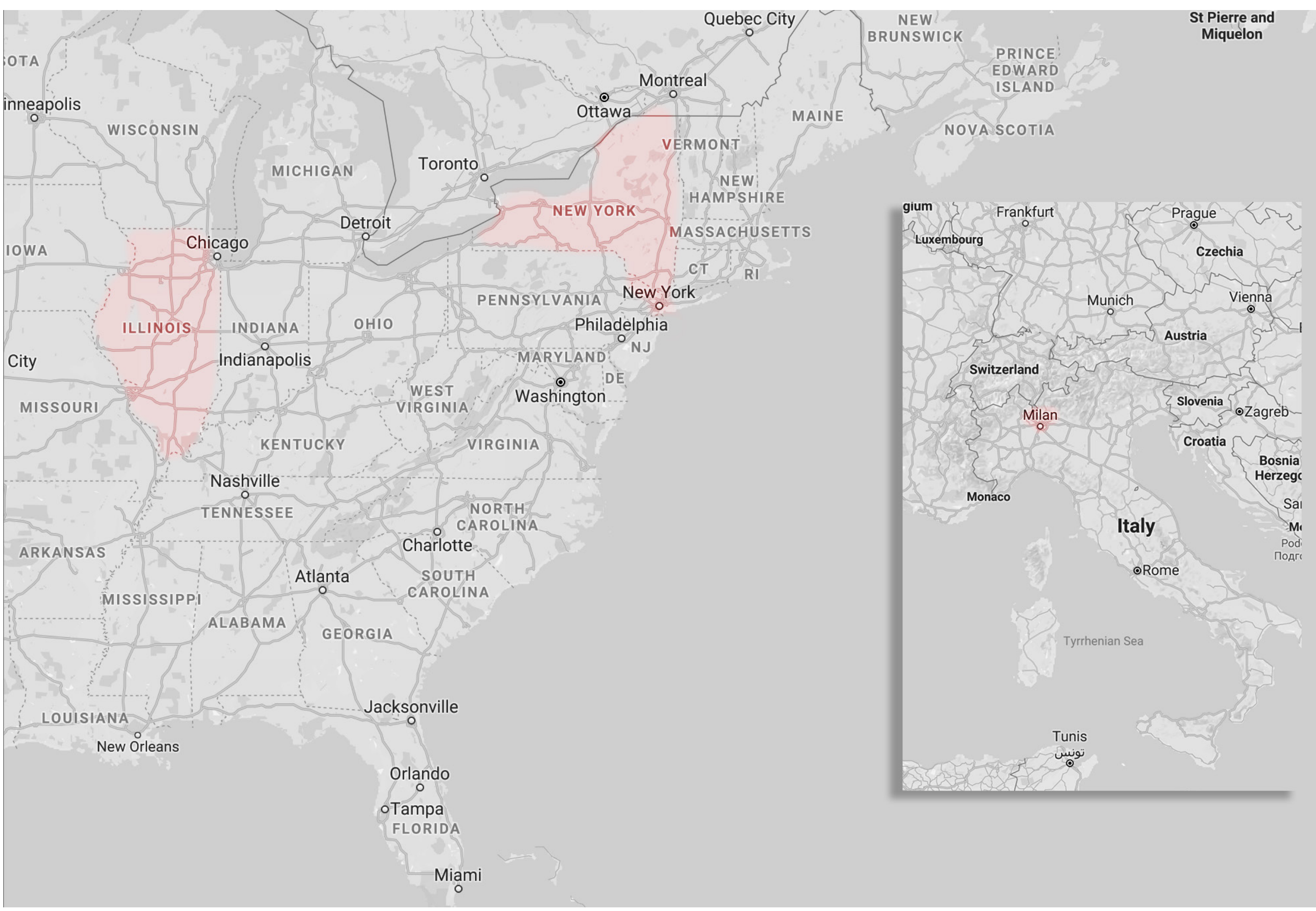
## PROCESS

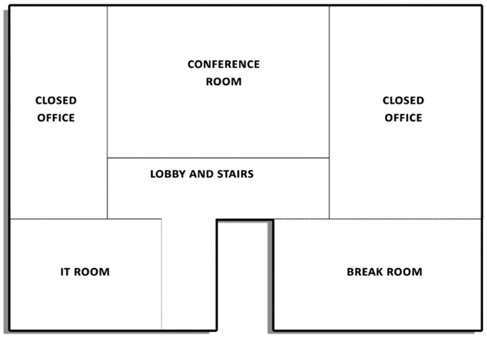
First we designed a simple building with a wide lobby and large conference room space. With Openstudio, we determined 5 thermal zones and applied it to our building in the following locations: New York, Chicago, and Milano. Next, we determined the settings for the external walls, roofs, and for the windows. The wall components are one layer of stucco, 20 cm of concrete wall, a 25 cm wall insulation and a 1/2 inch gypsum panel. For the windows, a 05 mm glass is used. Lastly, the roof is conformed by a membrane of metal decking and roof insulation at 30 cm.

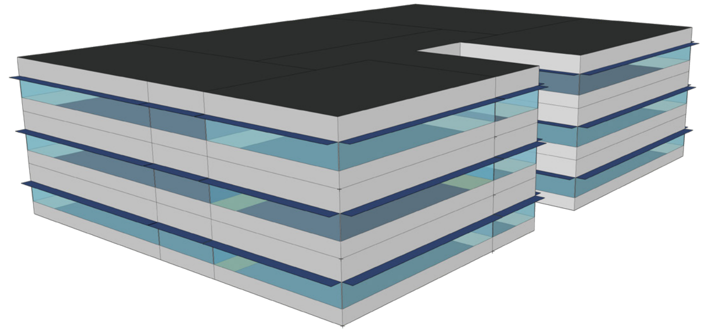
## RESULTS

We will be comparing the wall, stucco, concrete, wall insulation and the gypsum panel in each of the cities decided. Then, we will take New York City as a case study and change one wall component to see how it reacts in order to improve energy performance of the building.

## CITIES MAP





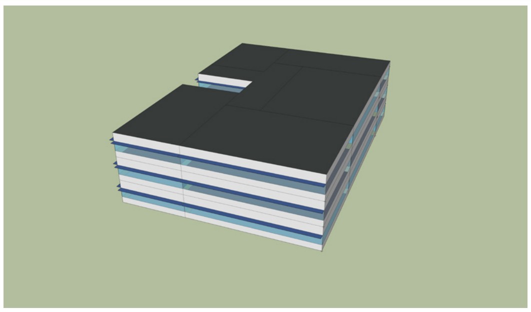



Space Type Breakdown - view table

| Space Type Name | Floor Area (ft^2) | Standards Building Type | Standards Space Type |
|---|---|---|---|
| 189.1-2009 - Office - BreakRoom - CZ1-3 | 4,045 | Office | BreakRoom |
| 189.1-2009 - Office - ClosedOffice - CZ1-3 | 9,301 | Office | ClosedOffice |
| 189.1-2009 - Office - Conference - CZ1-3 | 5,956 | Office | Conference |
| 189.1-2009 - Office - IT_Room - CZ1-3 | 2,959 | Office | IT_Room |
| 189.1-2009 - Office - Lobby - CZ1-3 | 3,436 | Office | Lobby |

Building Summary

| Data | Value |
|---|---|
| Building Name | Building 1 |
| Total Site Energy | 2,058,564 kBtu |
| Total Building Area | 25,697 ft^2 |
| Total Site EUI | 80.11 kBtu/ft^2 |
| OpenStudio Standards Building Type | n/a |

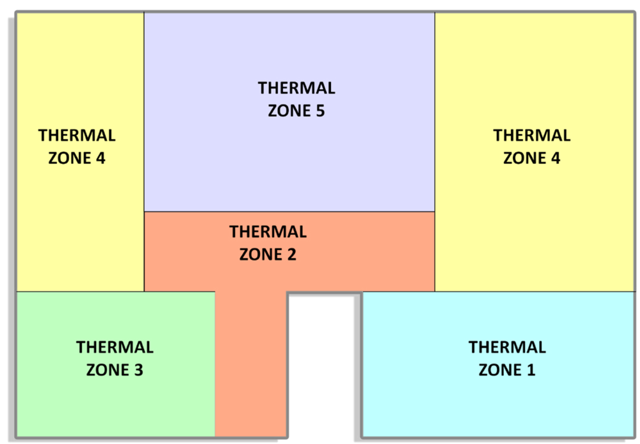


Window-to-Wall and Skylight-to-Roof area Ratios

| Description | Total (%) | North (%) | East (%) | South (%) | West (%) |
|---|---|---|---|---|---|
| Gross Window-Wall Ratio | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 |
| Gross Window-Wall Ratio (Conditioned) | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 |
| Skylight-Roof Ratio | 0.0 | | | | |

Site and Source Energy

| | Total Energy (kBtu) | Energy Per Total Building Area (kBtu/ft^2) | Energy Per Conditioned Building Area (kBtu/ft^2) |
|---|---|---|---|
| Total Site Energy | 2058563.9 | 80.1 | 80.1 |
| Net Site Energy | 2058563.9 | 80.1 | 80.1 |
| Total Source Energy | 6203311.3 | 241.4 | 241.4 |
| Net Source Energy | 6203311.3 | 241.4 | 241.4 |




Electric Plug Load Consumption

| | Electricity Annual Value (kWh) |
|---|---|
| InteriorEquipment:Electricity:Zone:THERMAL ZONE 1 | 85447.22 |
| InteriorEquipment:Electricity:Zone:THERMAL ZONE 4 | 28194.44 |
| InteriorEquipment:Electricity:Zone:THERMAL ZONE 5 | 10438.89 |
| InteriorEquipment:Electricity:Zone:THERMAL ZONE 3 | 21861.11 |
| InteriorEquipment:Electricity:Zone:THERMAL ZONE 2 | 1138.89 |

Zone Lighting

| Lights | Zone | Lighting Power Density (W/ft^2) | Total Power (W) | Schedule Name | Scheduled Hours/Week (hr) | Actual Load Hours/Week (hr) | Return Air Fraction | Annual Consumption (kWh) |
|---|---|---|---|---|---|---|---|---|
| THERMAL ZONE 1 189.1-2009 - OFFICE - BREAKROOM - CZ1-3 LIGHTS | THERMAL ZONE 1 | 1.08 | 4368.39 | OFFICE BLDG LIGHT | 61.85 | 61.85 | 0.0000 | 14088.89 |
| THERMAL ZONE 4 189.1-2009 - OFFICE - CLOSEDOFFICE - CZ1-3 LIGHTS | THERMAL ZONE 4 | 0.99 | 9208.07 | OFFICE BLDG LIGHT | 61.85 | 61.85 | 0.0000 | 29697.22 |
| THERMAL ZONE 5 189.1-2009 - OFFICE - CONFERENCE - CZ1-3 LIGHTS | THERMAL ZONE 5 | 1.17 | 6968.45 | OFFICE BLDG LIGHT | 61.85 | 61.85 | 0.0000 | 22475.0 |
| THERMAL ZONE 3 189.1-2009 - OFFICE - IT_ROOM - CZ1-3 LIGHTS | THERMAL ZONE 3 | 0.99 | 2928.94 | OFFICE BLDG LIGHT | 61.85 | 61.85 | 0.0000 | 9447.22 |
| THERMAL ZONE 2 189.1-2009 - OFFICE - LOBBY - CZ1-3 LIGHTS | THERMAL ZONE 2 | 1.17 | 4020.49 | OFFICE BLDG LIGHT | 61.85 | 61.85 | 0.0000 | 12966.67 |

## SIMULATION OF BUILDING IN *MILANO, ITALY*

The city of Milano is located in northern Italy. It has a latitude of 45.62 N and a longitude of 9.19 E with an elevation of 120 m.

**Weather Summary**

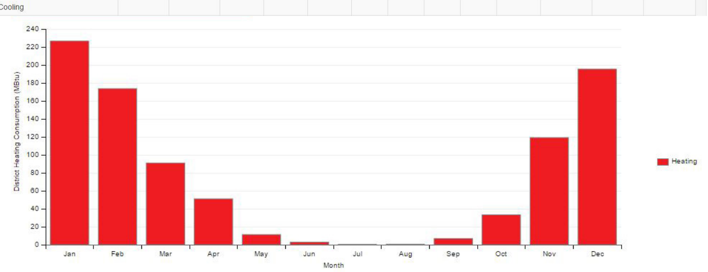
| | Value |
|---|---|
| Weather File | MILAN - ITA IWEC Data WMO#=160660 |
| Latitude | 45.62 |
| Longitude | 8.73 |
| Elevation | 692 (ft) |
| Time Zone | 1.00 |
| North Axis Angle | 0.00 |
| ASHRAE Climate Zone | |

**Sizing Period Design Days**

| | Maximum Dry Bulb (F) | Daily Temperature Range (R) | Humidity Value | Humidity Type | Wind Speed (mph) | Wind Direction |
|---|---|---|---|---|---|---|
| MILANO-LINATE ANN CLG .4% CONDNS DB=>MWB | 91.4 | 18.36 | 75.38 | Wetbulb [F] | 5.14 | 220.0 |
| MILANO-LINATE ANN CLG .4% CONDNS DP=>MDB | 83.3 | 18.36 | 74.3 | Dewpoint [F] | 5.14 | 220.0 |
| MILANO-LINATE ANN CLG .4% CONDNS ENTH=>MDB | 87.8 | 18.36 | 33.32 | Enthalpy [Btu/lb] | 5.14 | 220.0 |
| MILANO-LINATE ANN CLG .4% CONDNS WB=>MDB | 87.8 | 18.36 | 77.36 | Wetbulb [F] | 5.14 | 220.0 |
| MILANO-LINATE ANN HTG 99.6% CONDNS DB | 22.82 | 0.0 | 22.82 | Wetbulb [F] | 0.89 | 240.0 |
| MILANO-LINATE ANN HTG WIND 99.6% CONDNS WS=>MCDB | 47.84 | 0.0 | 47.84 | Wetbulb [F] | 23.04 | 240.0 |
| MILANO-LINATE ANN HUM_N 99.6% CONDNS DP=>MCDB | 36.14 | 0.0 | 11.3 | Dewpoint [F] | 0.89 | 240.0 |

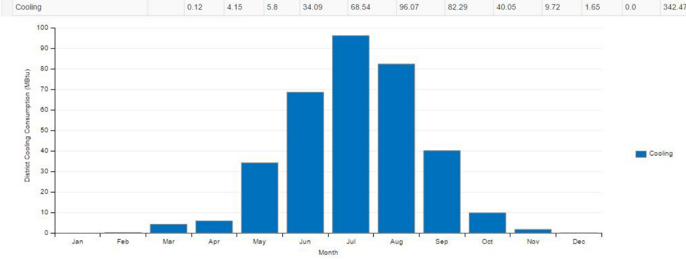
**District Heating Consumption (MBtu) - view table**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heating | 226.56 | 173.61 | 90.94 | 51.07 | 11.22 | 2.84 | 0.28 | 0.5 | 6.87 | 33.26 | 119.14 | 195.37 | 911.66 |
| Cooling | | | | | | | | | | | | | |




**District Cooling Consumption (MBtu) - view table**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heating | | | | | | | | | | | | | |
| Cooling | | 0.12 | 4.15 | 5.8 | 34.09 | 68.54 | 96.07 | 82.29 | 40.05 | 9.72 | 1.65 | 0.0 | 342.47 |

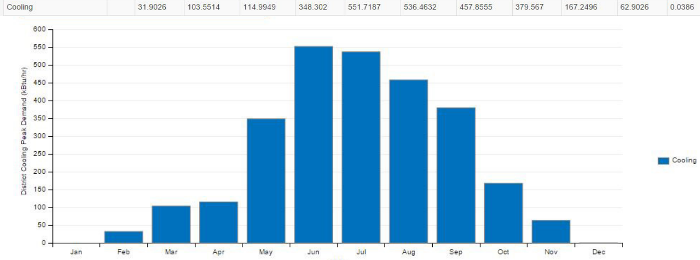



**District Heating Peak Demand (kBtu/hr) - view table**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heating | 994.5193 | 892.7594 | 817.7695 | 764.0387 | 572.2032 | 499.9884 | 213.3073 | 242.3888 | 540.2982 | 704.729 | 787.6992 | 931.9952 |
| Cooling | | | | | | | | | | | | |

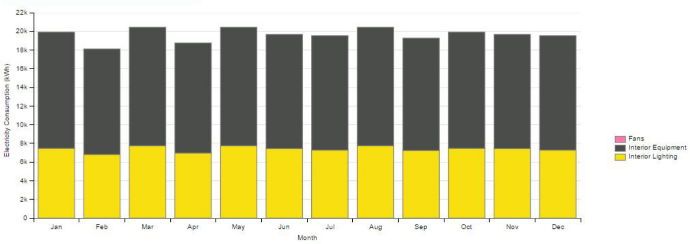

**District Cooling Peak Demand (kBtu/hr) - view table**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heating | | | | | | | | | | | | |
| Cooling | | 31.9026 | 103.5514 | 114.9949 | 348.302 | 551.7187 | 536.4632 | 457.8555 | 379.567 | 167.2496 | 62.9026 | 0.0386 |



## SIMULATION OF BUILDING IN *MILANO, ITALY*

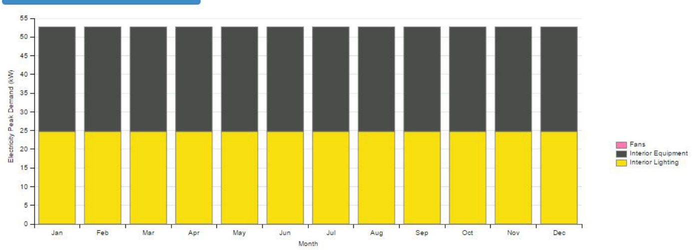
Electricity Consumption (kWh) - view table




Electricity Consumption (kWh) - view table

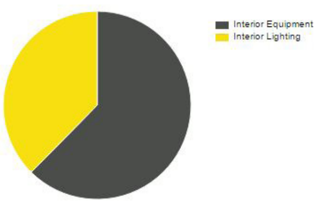
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heating | | | | | | | | | | | | | |
| Cooling | | | | | | | | | | | | | |
| Interior Lighting | 7472.97 | 6818.58 | 7750.67 | 6969.81 | 7750.67 | 7439.97 | 7280.5 | 7750.67 | 7247.5 | 7472.97 | 7439.97 | 7280.5 | 88674.78 |
| Exterior Lighting | | | | | | | | | | | | | |
| Interior Equipment | 12451.86 | 11296.75 | 12694.08 | 11792.03 | 12694.08 | 12228.31 | 12257.81 | 12694.08 | 12034.22 | 12451.86 | 12228.31 | 12257.81 | 147081.19 |
| Exterior Equipment | | | | | | | | | | | | | |
| Fans | | | | | | | | | | | | | |
| Pumps | | | | | | | | | | | | | |
| Heat Rejection | | | | | | | | | | | | | |
| Humidification | | | | | | | | | | | | | |
| Heat Recovery | | | | | | | | | | | | | |
| Water Systems | | | | | | | | | | | | | |
| Refrigeration | | | | | | | | | | | | | |
| Generators | | | | | | | | | | | | | |
| Total | 19924.83 | 18115.33 | 20444.75 | 18761.83 | 20444.75 | 19668.28 | 19538.31 | 20444.75 | 19281.72 | 19924.83 | 19668.28 | 19538.31 | 235755.97 |

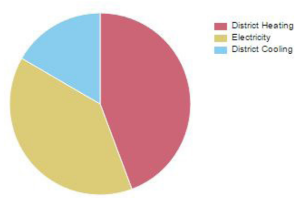
Electricity Peak Demand (kW) - view table

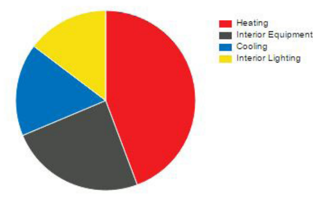



Electricity Peak Demand (kW) - view table

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heating | | | | | | | | | | | | |
| Cooling | | | | | | | | | | | | |
| Interior Lighting | 24.7449 | 24.7449 | 24.7449 | 24.7449 | 24.7449 | 24.7449 | 24.7449 | 24.7449 | 24.7449 | 24.7449 | 24.7449 | 24.7449 |
| Exterior Lighting | | | | | | | | | | | | |
| Interior Equipment | 27.9469 | 27.9469 | 27.9469 | 27.9469 | 27.9469 | 27.9469 | 27.9469 | 27.9469 | 27.9469 | 27.9469 | 27.9469 | 27.9469 |
| Exterior Equipment | | | | | | | | | | | | |
| Fans | | | | | | | | | | | | |
| Pumps | | | | | | | | | | | | |
| Heat Rejection | | | | | | | | | | | | |
| Humidification | | | | | | | | | | | | |
| Heat Recovery | | | | | | | | | | | | |
| Water Systems | | | | | | | | | | | | |
| Refrigeration | | | | | | | | | | | | |
| Generators | | | | | | | | | | | | |
| Total | 52.69 | 52.69 | 52.69 | 52.69 | 52.69 | 52.69 | 52.69 | 52.69 | 52.69 | 52.69 | 52.69 | 52.69 |




EUI - Electricity - view table

| End Use | Consumption (kWh) |
|---|---|
| Heating | 0 |
| Cooling | 0 |
| Interior Lighting | 88,675 |
| Exterior Lighting | 0 |
| Interior Equipment | 147,081 |
| Exterior Equipment | 0 |
| Fans | 0 |
| Pumps | 0 |
| Heat Rejection | 0 |
| Humidification | 0 |
| Heat Recovery | 0 |
| Water Systems | 0 |
| Refrigeration | 0 |
| Generators | 0 |

Energy Use - view table

| Fuel | Consumption (kBtu) |
|---|---|
| Electricity | 804,431 |
| Natural Gas | 0 |
| Additional Fuel | 0 |
| District Cooling | 342,475 |
| District Heating | 911,658 |

End Use - view table

| End Use | Consumption (kBtu) |
|---|---|
| Heating | 911,658 |
| Cooling | 342,475 |
| Interior Lighting | 302,572 |
| Exterior Lighting | 0 |
| Interior Equipment | 501,860 |
| Exterior Equipment | 0 |
| Fans | 0 |
| Pumps | 0 |
| Heat Rejection | 0 |
| Humidification | 0 |
| Heat Recovery | 0 |
| Water Systems | 0 |
| Refrigeration | 0 |
| Generators | 0 |

### RESULTS

In the city of Milano, the building wall composition tested resulted in the total District Heating Consumption being read as 911.66 MBtu, while the District Cooling Consumption was 342.47 MBtu. Regarding the District Heating peak demand, the need is highest in the months of January and December - the demand in January being 994.5193 kBtu/hr and in December the demand is 931.9952 kBtu/hr. Relating to the District Cooling Peak demand periods, the highest demands exist in the months of June at 551.7187 kBtu/hr, July at 536.4631 kBtu/hr, and August at 457.855 kBtu/hr. The electricity consumption, relating to interior lighting was calculated as 88674.78 kWh. The consumption relating to interior equipment was calculated as 147081.19 kWh. The electricity demand in terms of interior lighting and equipment was the same in each month. At the end, it is discovered with the walls of the building containing the material of stucco, concrete, wall insulation at 25 cm, and gypsum, heating consumption exceeds the cooling consumption and interior lighting consumes less electricity than the interior equipment.

## SIMULATION OF BUILDING IN *CHICAGO, US*

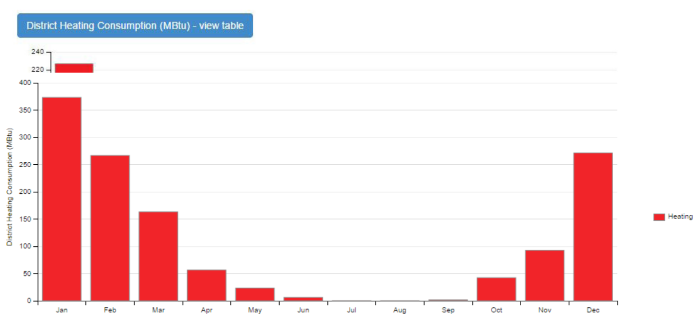
The city of Chicago is located in the northeastern state of Illinois. It has a latitude of 41.878 N and a longitude of 87.63 W with an elevation of 181 m.

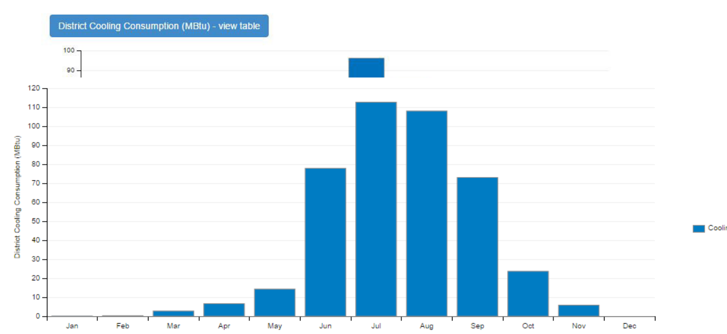
**Weather Summary**

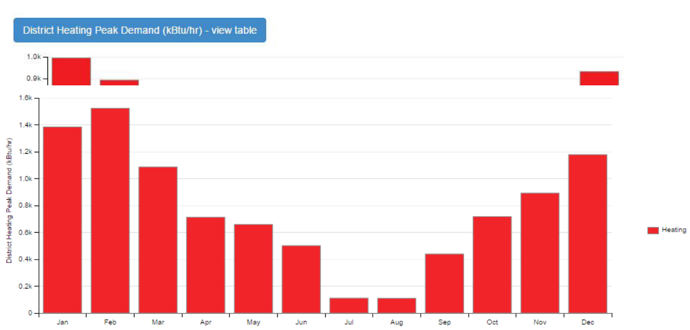
| | Value |
|---|---|
| Weather File | MILAN - ITA IWEC Data WMO#=160660 |
| Latitude | 45.62 |
| Longitude | 8.73 |
| Elevation | 692 (ft) |
| Time Zone | 1.00 |
| North Axis Angle | 0.00 |
| ASHRAE Climate Zone | |

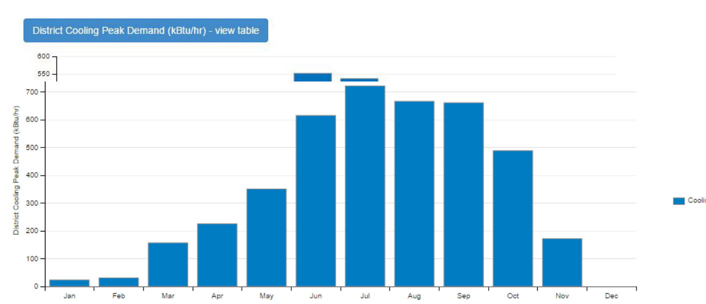
**Sizing Period Design Days**

| | Maximum Dry Bulb (F) | Daily Temperature Range (R) | Humidity Value | Humidity Type | Wind Speed (mph) | Wind Direction |
|---|---|---|---|---|---|---|
| MILANO-LINATE ANN CLG .4% CONDNS DB=>MWB | 91.4 | 18.36 | 75.38 | Wetbulb [F] | 5.14 | 220.0 |
| MILANO-LINATE ANN CLG .4% CONDNS DP=>MDB | 83.3 | 18.36 | 74.3 | Dewpoint [F] | 5.14 | 220.0 |
| MILANO-LINATE ANN CLG .4% CONDNS ENTH=>MDB | 87.8 | 18.36 | 33.32 | Enthalpy [Btu/lb] | 5.14 | 220.0 |
| MILANO-LINATE ANN CLG .4% CONDNS WB=>MDB | 87.8 | 18.36 | 77.36 | Wetbulb [F] | 5.14 | 220.0 |
| MILANO-LINATE ANN HTG 99.6% CONDNS DB | 22.82 | 0.0 | 22.82 | Wetbulb [F] | 0.89 | 240.0 |
| MILANO-LINATE ANN HTG WIND 99.6% CONDNS WS=>MCDB | 47.84 | 0.0 | 47.84 | Wetbulb [F] | 23.04 | 240.0 |
| MILANO-LINATE ANN HUM_N 99.6% CONDNS DP=>MCDB | 36.14 | 0.0 | 11.3 | Dewpoint [F] | 0.89 | 240.0 |

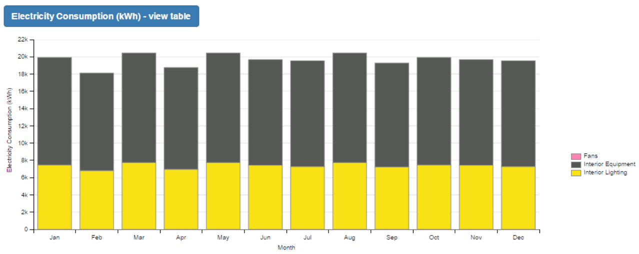


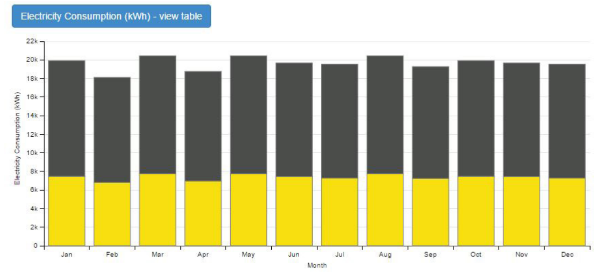



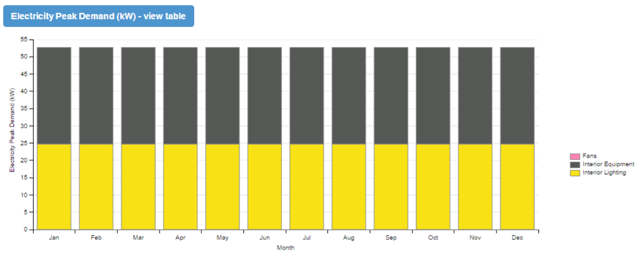



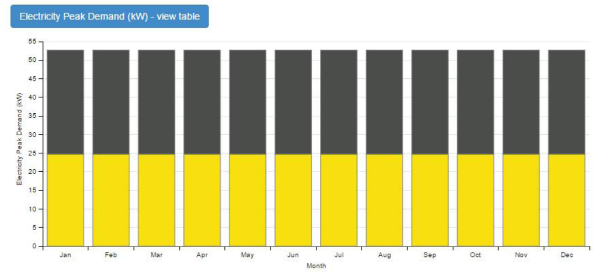
## SIMULATION OF BUILDING IN *CHICAGO, US*

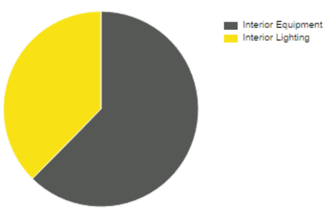


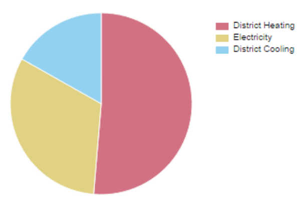

Monthly Overview

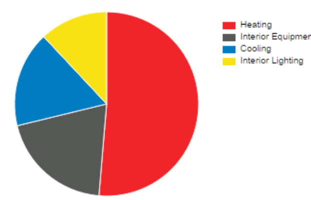



EUI - Gas - view table

| End Use | Consumption (therms) |
|---|---|
| Heating | 0 |
| Cooling | 0 |
| Interior Lighting | 0 |
| Exterior Lighting | 0 |
| Interior Equipment | 0 |
| Exterior Equipment | 0 |
| Fans | 0 |
| Pumps | 0 |
| Heat Rejection | 0 |
| Humidification | 0 |
| Heat Recovery | 0 |
| Water Systems | 0 |
| Refrigeration | 0 |
| Generators | 0 |

EUI - Electricity - view table

| End Use | Consumption (kWh) |
|---|---|
| Heating | 0 |
| Cooling | 0 |
| Interior Lighting | 88,675 |
| Exterior Lighting | 0 |
| Interior Equipment | 147,081 |
| Exterior Equipment | 0 |
| Fans | 0 |

End Use - view table

| End Use | Consumption (kBtu) |
|---|---|
| Heating | 1,296,472 |
| Cooling | 424,859 |
| Interior Lighting | 302,572 |
| Exterior Lighting | 0 |
| Interior Equipment | 501,860 |
| Exterior Equipment | 0 |
| Fans | 0 |
| Pumps | 0 |
| Heat Rejection | 0 |
| Humidification | 0 |
| Heat Recovery | 0 |
| Water Systems | 0 |
| Refrigeration | 0 |
| Generators | 0 |

RESULTS

In the city of Chicago, the building wall composition tested resulted in the total District Heating Consumption being read as 1296.48 MBtu, while the District Cooling Consumption was 424.86 MBtu. Regarding the District Heating peak demand, the need is highest in the months of February, January, and December - the demand in February being 1523.1378 kBtu/hr, in January the demand is 1384.2182 kBtu/hr, and in December the demand is 1178.3578 kBtu/hr. The District Cooling Peak Demand periods are highest in the months of June, July, August, and September. June was calculated at 616.2411 kBtu/hr, July with 721.4762 kBtu/hr, August at 666.2319 kBtu/hr, and September at 661.0398 kBtu/hr. The electricity consumption, relating to interior lighting and interior equipment was calculated the same as in Milano, because the inside of the building was not effected by location change. Likewise, the electricity demand in terms of interior lighting and equipment was the same in each month. At the end, it can be seen that places the building in Chicago produced a higher heating and cooling consumption of MBtu and a higher heating and cooling demand of kBtu/hr.

## SIMULATION OF BUILDING IN *NEW YORK CITY, US* CASE A

New York City is located in the southeastern part of New York, which located in the northeastern United States of America. It has a latitude of 40.71 N and a longitude of 74.00 W, with an elevation of 10 m.

**Weather Summary**

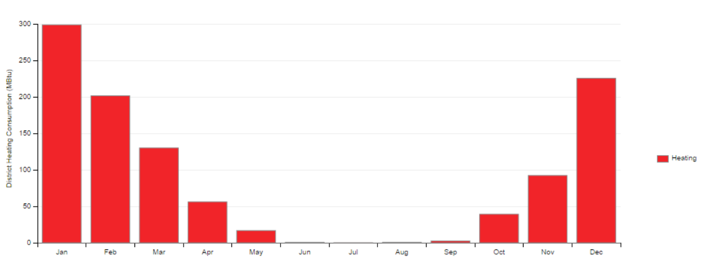
| | Value |
|---|---|
| Weather File | MILAN - ITA IWEC Data WMO#=160660 |
| Latitude | 45.62 |
| Longitude | 8.73 |
| Elevation | 692 (ft) |
| Time Zone | 1.00 |
| North Axis Angle | 0.00 |
| ASHRAE Climate Zone | |

**Sizing Period Design Days**

| | Maximum Dry Bulb (F) | Daily Temperature Range (R) | Humidity Value | Humidity Type | Wind Speed (mph) | Wind Direction |
|---|---|---|---|---|---|---|
| MILANO-LINATE ANN CLG .4% CONDNS DB=>MWB | 91.4 | 18.36 | 75.38 | Wetbulb [F] | 5.14 | 220.0 |
| MILANO-LINATE ANN CLG .4% CONDNS DP=>MDB | 83.3 | 18.36 | 74.3 | Dewpoint [F] | 5.14 | 220.0 |
| MILANO-LINATE ANN CLG .4% CONDNS ENTH=>MDB | 87.8 | 18.36 | 33.32 | Enthalpy [Btu/lb] | 5.14 | 220.0 |
| MILANO-LINATE ANN CLG .4% CONDNS WB=>MDB | 87.8 | 18.36 | 77.36 | Wetbulb [F] | 5.14 | 220.0 |
| MILANO-LINATE ANN HTG 99.6% CONDNS DB | 22.82 | 0.0 | 22.82 | Wetbulb [F] | 0.89 | 240.0 |
| MILANO-LINATE ANN HTG WIND 99.6% CONDNS WS=>MCDB | 47.84 | 0.0 | 47.84 | Wetbulb [F] | 23.04 | 240.0 |
| MILANO-LINATE ANN HUM_N 99.6% CONDNS DP=>MCDB | 36.14 | 0.0 | 11.3 | Dewpoint [F] | 0.89 | 240.0 |

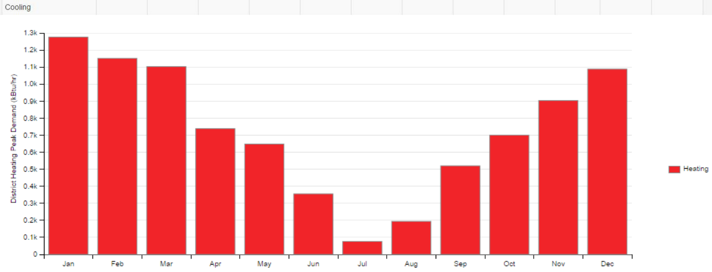
**District Heating Consumption (MBtu) - view table**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heating | 226.56 | 173.61 | 90.94 | 51.07 | 11.22 | 2.84 | 0.28 | 0.5 | 6.87 | 33.26 | 119.14 | 195.37 | 911.66 |
| Cooling | | | | | | | | | | | | | |



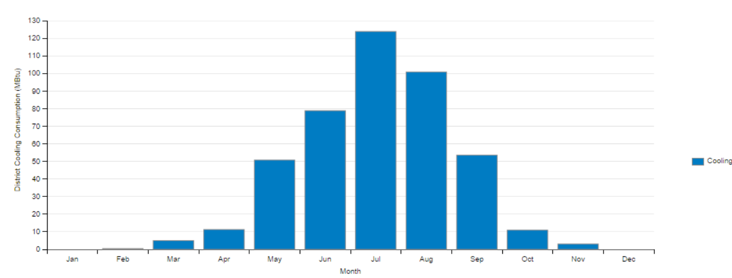

**District Heating Peak Demand (kBtu/hr) - view table**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heating | 994.5193 | 892.7594 | 817.7695 | 764.0387 | 572.2032 | 499.9884 | 213.3073 | 242.3888 | 540.2982 | 704.729 | 787.6992 | 931.9952 |
| Cooling | | | | | | | | | | | | |



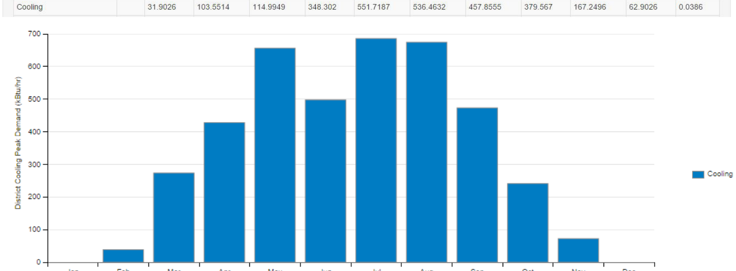

**District Cooling Consumption (MBtu) - view table**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heating | | | | | | | | | | | | | |
| Cooling | | 0.12 | 4.15 | 5.8 | 34.09 | 68.54 | 96.07 | 82.29 | 40.05 | 9.72 | 1.65 | 0.0 | 342.47 |



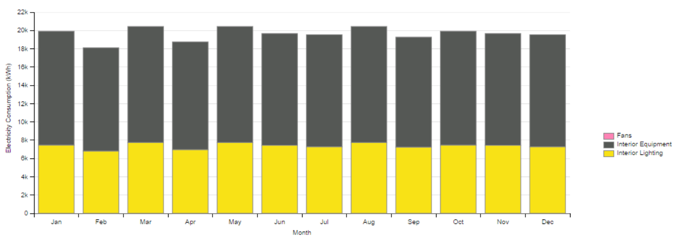

**District Cooling Peak Demand (kBtu/hr) - view table**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heating | | | | | | | | | | | | |
| Cooling | | 31.9026 | 103.5514 | 114.9949 | 348.302 | 551.7187 | 536.4632 | 457.8555 | 379.567 | 167.2496 | 62.9026 | 0.0386 |



## SIMULATION OF BUILDING IN *NEW YORK CITY, US*

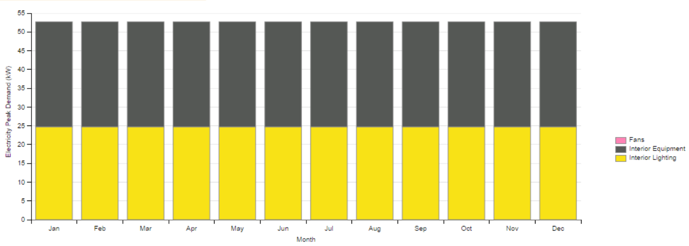
Electricity Consumption (kWh) - view table




Electricity Consumption (kWh) - view table

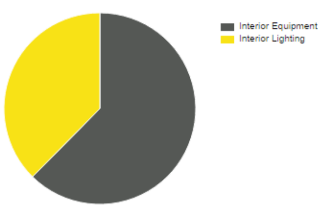
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heating | | | | | | | | | | | | | |
| Cooling | | | | | | | | | | | | | |
| Interior Lighting | 7472.97 | 6818.58 | 7750.67 | 6969.81 | 7750.67 | 7439.97 | 7280.5 | 7750.67 | 7247.5 | 7472.97 | 7439.97 | 7280.5 | 88674.78 |
| Exterior Lighting | | | | | | | | | | | | | |
| Interior Equipment | 12451.86 | 11296.75 | 12694.08 | 11792.03 | 12694.08 | 12228.31 | 12257.81 | 12694.08 | 12034.22 | 12451.86 | 12228.31 | 12257.81 | 147081.19 |
| Exterior Equipment | | | | | | | | | | | | | |
| Fans | | | | | | | | | | | | | |
| Pumps | | | | | | | | | | | | | |
| Heat Rejection | | | | | | | | | | | | | |
| Humidification | | | | | | | | | | | | | |
| Heat Recovery | | | | | | | | | | | | | |
| Water Systems | | | | | | | | | | | | | |
| Refrigeration | | | | | | | | | | | | | |
| Generators | | | | | | | | | | | | | |
| Total | 19924.83 | 18115.33 | 20444.75 | 18761.83 | 20444.75 | 19668.28 | 19538.31 | 20444.75 | 19281.72 | 19924.83 | 19668.28 | 19538.31 | 235755.97 |

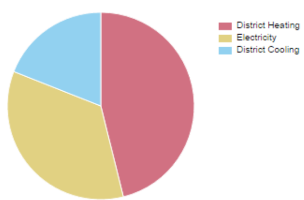
Electricity Peak Demand (kW) - view table

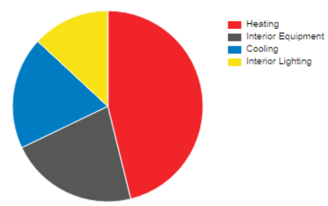



Electricity Peak Demand (kW) - view table

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heating | | | | | | | | | | | | |
| Cooling | | | | | | | | | | | | |
| Interior Lighting | 24.7449 | 24.7449 | 24.7449 | 24.7449 | 24.7449 | 24.7449 | 24.7449 | 24.7449 | 24.7449 | 24.7449 | 24.7449 | 24.7449 |
| Exterior Lighting | | | | | | | | | | | | |
| Interior Equipment | 27.9469 | 27.9469 | 27.9469 | 27.9469 | 27.9469 | 27.9469 | 27.9469 | 27.9469 | 27.9469 | 27.9469 | 27.9469 | 27.9469 |
| Exterior Equipment | | | | | | | | | | | | |
| Fans | | | | | | | | | | | | |
| Pumps | | | | | | | | | | | | |
| Heat Rejection | | | | | | | | | | | | |
| Humidification | | | | | | | | | | | | |
| Heat Recovery | | | | | | | | | | | | |
| Water Systems | | | | | | | | | | | | |
| Refrigeration | | | | | | | | | | | | |
| Generators | | | | | | | | | | | | |
| Total | 52.69 | 52.69 | 52.69 | 52.69 | 52.69 | 52.69 | 52.69 | 52.69 | 52.69 | 52.69 | 52.69 | 52.69 |




EUI - Electricity - view table

| End Use | Consumption (kWh) |
|---|---|
| Heating | 0 |
| Cooling | 0 |
| Interior Lighting | 88,675 |
| Exterior Lighting | 0 |
| Interior Equipment | 147,081 |
| Exterior Equipment | 0 |
| Fans | 0 |
| Pumps | 0 |
| Heat Rejection | 0 |
| Humidification | 0 |
| Heat Recovery | 0 |
| Water Systems | 0 |
| Refrigeration | 0 |
| Generators | 0 |

Energy Use - view table

| Fuel | Consumption (kBtu) |
|---|---|
| Electricity | 804,431 |
| Natural Gas | 0 |
| Additional Fuel | 0 |
| District Cooling | 342,475 |
| District Heating | 911,658 |

End Use - view table

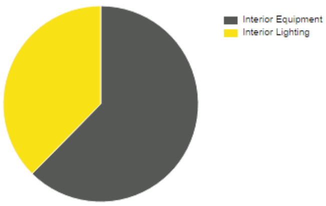
| End Use | Consumption (kBtu) |
|---|---|
| Heating | 911,658 |
| Cooling | 342,475 |
| Interior Lighting | 302,572 |
| Exterior Lighting | 0 |
| Interior Equipment | 501,860 |
| Exterior Equipment | 0 |
| Fans | 0 |
| Pumps | 0 |
| Heat Rejection | 0 |
| Humidification | 0 |
| Heat Recovery | 0 |
| Water Systems | 0 |
| Refrigeration | 0 |
| Generators | 0 |

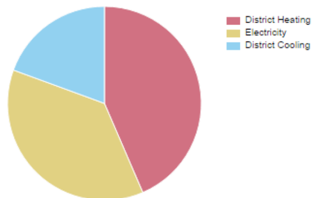
## RESULTS

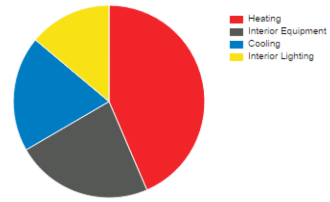
In the New York City, the building wall composition tested resulted _in the total District Heating Consumption being read as 1063.63 MBtu, while the District Cooling Consumption was 438.5 MBtu. Regarding the District Heating peak demand, the need is highest in the months of January, February, and March- the demand in January being 1276.8195 kBtu/hr, in February the demand is 1151.2469 kBtu/hr, and in March the demand is 112.6902 kBtu/hr. The District Cooling Peak Demand periods are highest in the months of May, July, and August. May was calculated at 656.1022 kBtu/hr, July with 685.8459 kBtu/hr, and August at 674.4015 kBtu/hr. The electricity consumption, relating to interior lighting and interior equipment was calculated the same as in Milano, because the inside of the building was not effected by location change. Likewise, the electricity demand in terms of interior lighting and equipment was the same in each month. At the end, it can be seen that places the building in Chicago produced higher heating and cooling consumptions of MBtu and higher heating and cooling demands of kBtu/hr relating to Milano, but can closely be compared to Chicago.

## SIMULATION OF BUILDING IN *NEW YORK CITY, US* CASE B

Change of wall insulation from 25 cm to 31 cm.




EUI - Electricity - view table

| End Use | Consumption (kWh) |
|---|---|
| Heating | 0 |
| Cooling | 0 |
| Interior Lighting | 88,675 |
| Exterior Lighting | 0 |
| Interior Equipment | 147,081 |
| Exterior Equipment | 0 |
| Fans | 0 |
| Pumps | 0 |
| Heat Rejection | 0 |
| Humidification | 0 |
| Heat Recovery | 0 |
| Water Systems | 0 |
| Refrigeration | 0 |
| Generators | 0 |

Energy Use - view table

| Fuel | Consumption (kBtu) |
|---|---|
| Electricity | 804,431 |
| Natural Gas | 0 |
| Additional Fuel | 0 |
| District Cooling | 421,305 |
| District Heating | 944,405 |

End Use - view table

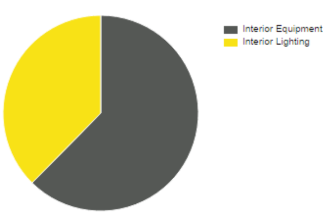
| End Use | Consumption (kBtu) |
|---|---|
| Heating | 944,405 |
| Cooling | 421,305 |
| Interior Lighting | 302,572 |
| Exterior Lighting | 0 |
| Interior Equipment | 501,860 |
| Exterior Equipment | 0 |
| Fans | 0 |
| Pumps | 0 |
| Heat Rejection | 0 |
| Humidification | 0 |
| Heat Recovery | 0 |
| Water Systems | 0 |
| Refrigeration | 0 |
| Generators | 0 |

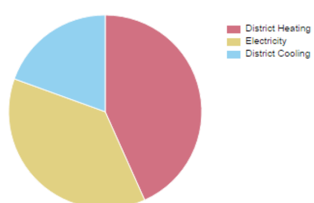
RESULTS

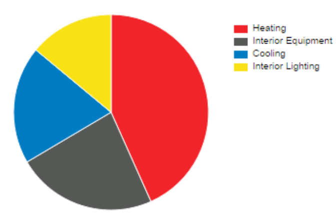
With the change of a thicker wall insulation, the building performance in New York City changed from the District Heating Consumption of 1063.63 MBtu to 944.405 MBtu, while the District Cooling Consumption changed from 438.5 MBtu to 421.305 MBtu. This means that by increasing the thickness of the wall insulation, the energy performance of the building improved considering the heating and cooling consumption lowered in needed months.

## SIMULATION OF BUILDING IN *NEW YORK CITY, US* CASE C

Change of wall insulation from 25 cm to 37 cm.




EUI - Electricity - view table

| End Use | Consumption (kWh) |
|---|---|
| Heating | 0 |
| Cooling | 0 |
| Interior Lighting | 88,675 |
| Exterior Lighting | 0 |
| Interior Equipment | 147,081 |
| Exterior Equipment | 0 |
| Fans | 0 |
| Pumps | 0 |
| Heat Rejection | 0 |
| Humidification | 0 |
| Heat Recovery | 0 |
| Water Systems | 0 |
| Refrigeration | 0 |
| Generators | 0 |

Energy Use - view table

| Fuel | Consumption (kBtu) |
|---|---|
| Electricity | 804,431 |
| Natural Gas | 0 |
| Additional Fuel | 0 |
| District Cooling | 421,077 |
| District Heating | 935,808 |

End Use - view table

| End Use | Consumption (kBtu) |
|---|---|
| Heating | 935,808 |
| Cooling | 421,077 |
| Interior Lighting | 302,572 |
| Exterior Lighting | 0 |
| Interior Equipment | 501,860 |
| Exterior Equipment | 0 |
| Fans | 0 |
| Pumps | 0 |
| Heat Rejection | 0 |
| Humidification | 0 |
| Heat Recovery | 0 |
| Water Systems | 0 |
| Refrigeration | 0 |
| Generators | 0 |

RESULTS

With the change of an even thicker wall insulation, the building performance in New York City changed from the District Heating Consumption of 944.405 MBtu to 935.808 MBtu, while the District Cooling Consumption changed from 438.5 MBtu to 421.305 MBtu to 421.077 MBtu. Although the change was not as drastic as the 25 cm to 31 cm wall insulation, there was still a decrease in both heating and cooling consumption by an increase in thickness to 37 cm of wall insulation.

**CONCLUSION**

In the first calculation of the city of Milano, it can be deduced that energy use for heating is larger than the consumption used for cooling. Next, it can be understood that altitude and proximity to the sea effects the energy consumption of a building. For instance, with the comparison of New York City - a coastal city, and Milano, the total energy consumption is greater. In relation to the change of wall insulation thickness, Cases B and Case C, expose New York City to have a reduction in heat energy consumption because of a wider wall insulation. This means the rise in insulation elements also brings better performance in terms of energy consumption for the cooling systems existing in the warmer months. Based on the comparative analysis made in the models of New York City, it can be understood that energy consumption with relation to insulation materials results in lower energy consumption than those without the necessary insulation elements, even if the cooling system were to require more energy. So it can be assumed that the economic cost will be lower because of this energy consumption reduction.