POLITECNICO
MILANO 1863

Technical Environmental System
Simulation of Building Energy Performance

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A Report on the Simulation of a Commercial Office Building

2017/2018

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INTRODUCTION

This is a detailed analysis report of a commercial office building. Using SketchUp and OpenStudio software to achieve the building's yearly energy consumption.

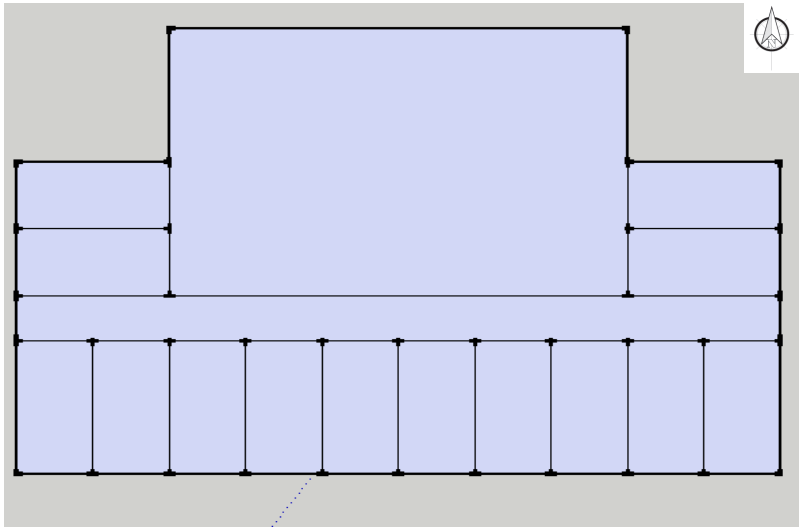
In this project, the geometry of the commercial building was first introduced in SketchUp and the other characteristics of the building was then defined employing OpenStudio. The latter software was used to calculate the yearly heating and cooling consumption of the building for a base case.
Next, a parametric study, was conducted in order to investigate the effect of changing the position and wall characteristics on the building's yearly energy consumption. Accordingly, the simulation was performed for three different cities and three different walls, and the corresponding obtained yearly consumptions was compared with the ones of the base case.

CONTENT

- PLAN:

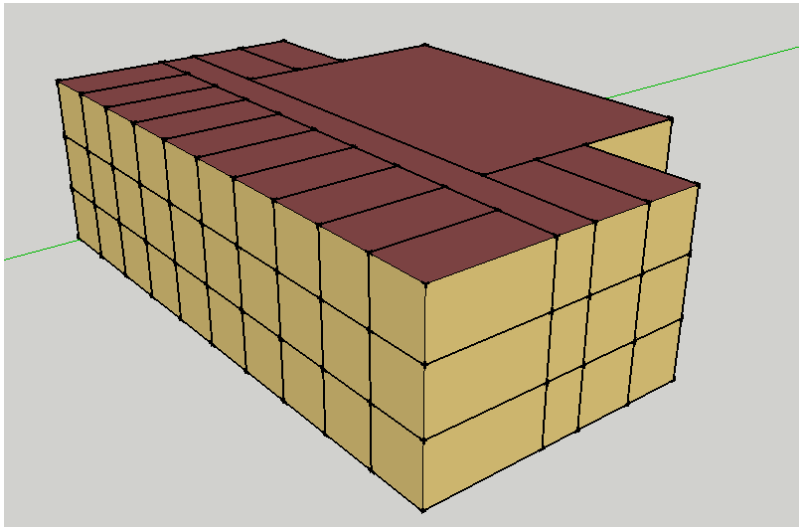
Using SketchUp software, This is the sketch plan of an office building.

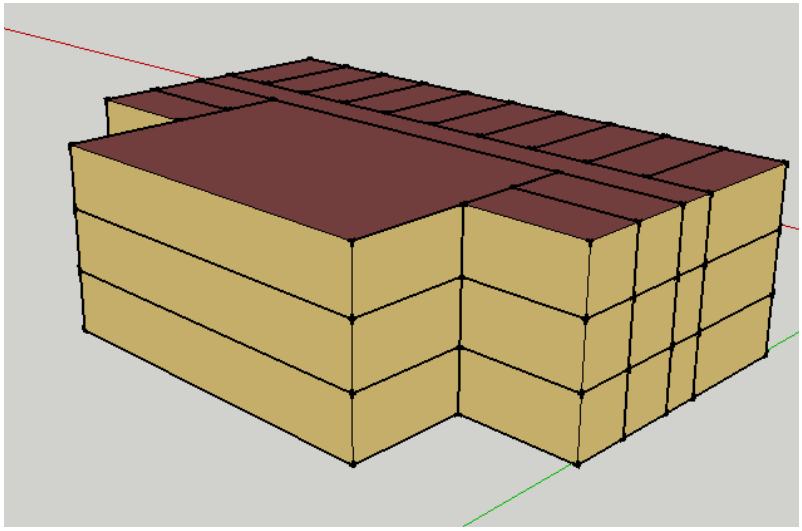
Consist of 10 closed offices, 1open office, corridor, stair hall and restrooms on each floor.



- SPACES:

Using OpenStudio plugin in SketchUp, The builging spaces were created with 3.0 meters space height and 3 building floors.

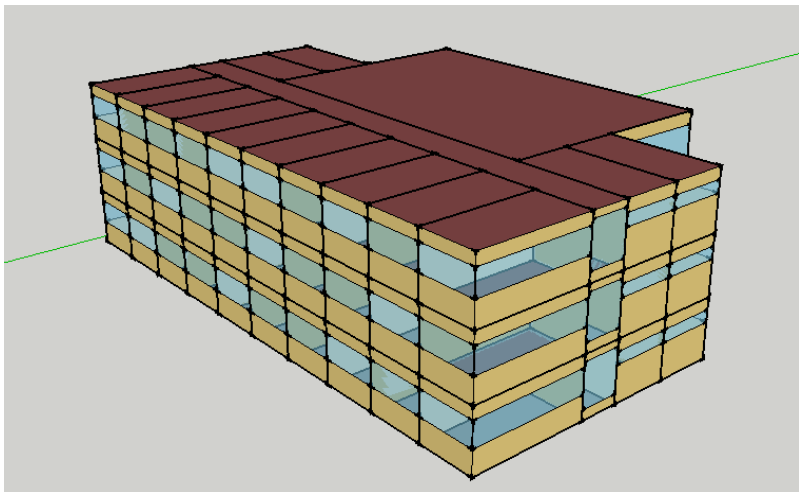


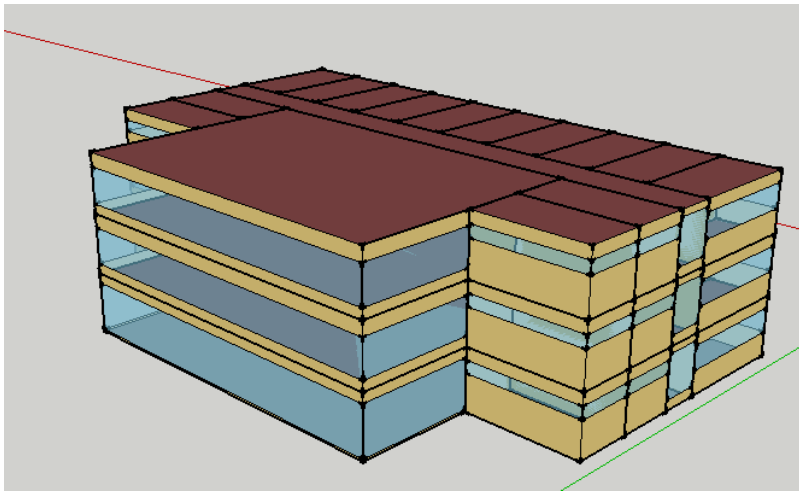


- WINDOWS:

Using OpenStudio plugin in SketchUp, The windows were added with different wall to window ratio depending on the different space functions.

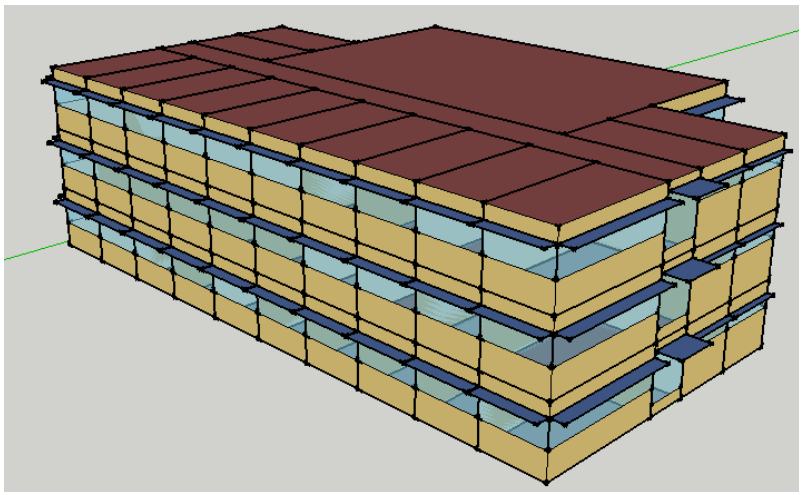
Also to avoid having windows inside the building, the surfaces were matched.

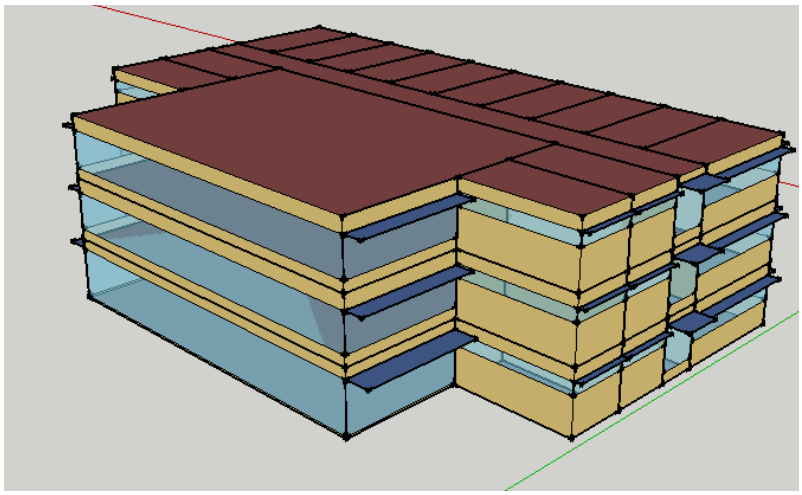




- SHADING:

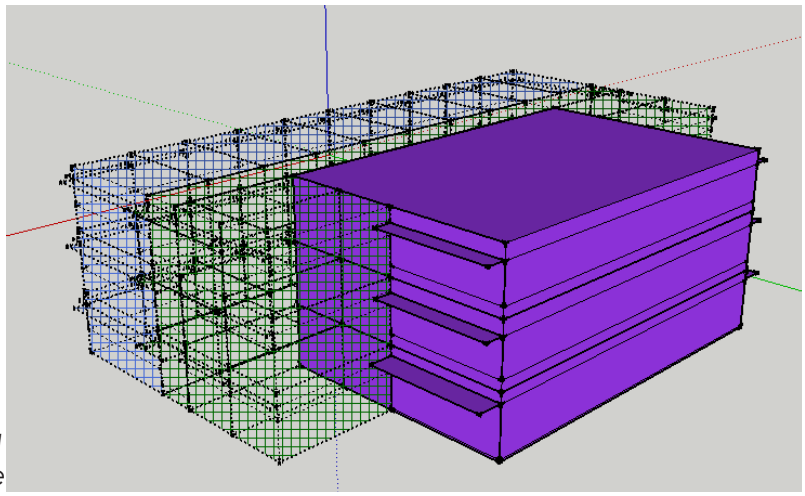
Using OpenStudio plugin in SketchUp, The external shading were added to all surfaces of the building excluding the North.



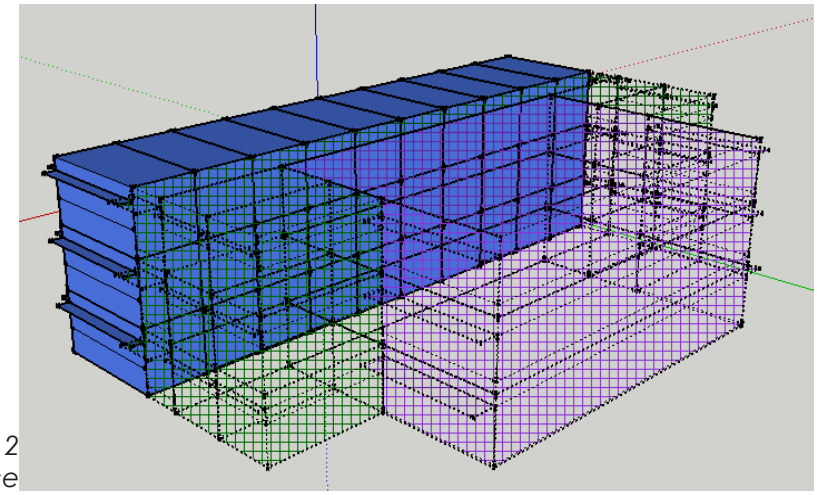


- THERMAL ZONES:

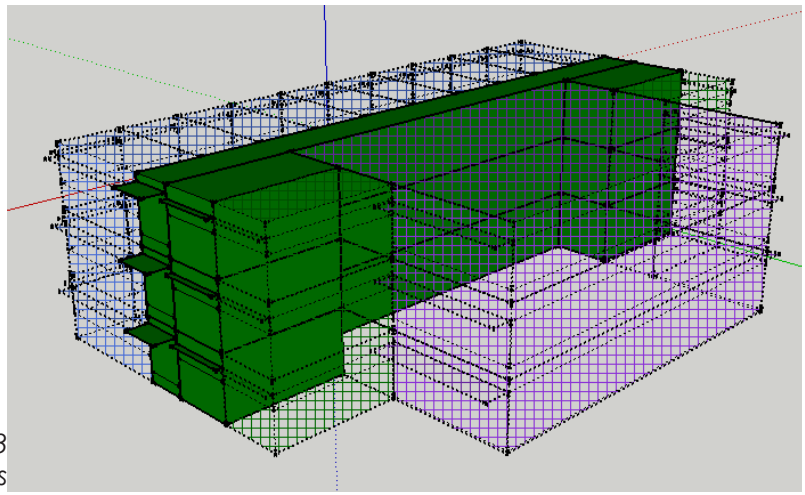
Using OpenStudio plugin in SketchUp, The spaces in the buiding was grouped into different thermal zones. There are 4 termal zones on each floor.



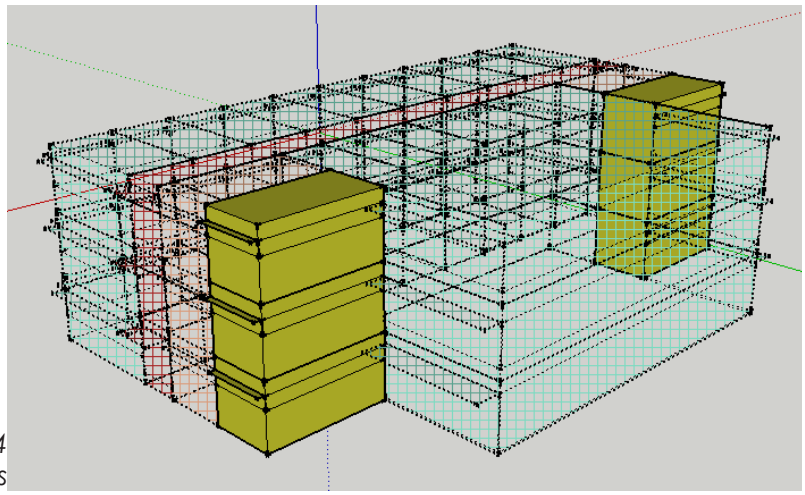
- Thermal Zone 1
open office



- Thermal Zone 2
closed office



- Thermal Zone 3
corridor/stairs



- Thermal Zone 4
restrooms

Using OpenStudio software, the building model of the commercial building was analysed with the weather data of Piacenza, Italy as the base case. Then the yearly heating and cooling consumption of the building was calculated to be compared with the simulation of three other cities .

Building Summary

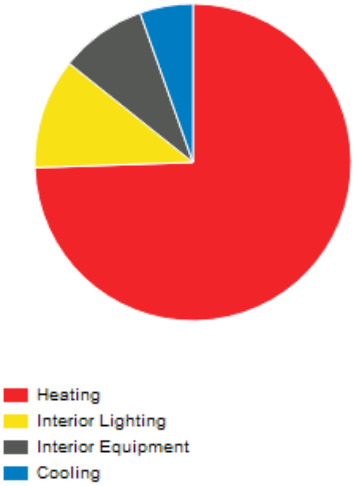
Information	Value	Units
Building Name	Building 1	building_name
Net Site Energy	589,713	kBtu
Total Building Area	5,683	ft^2
EUI (Based on Net Site Energy and Total Building Area)	103.76	kBtu/ft^2
OpenStudio Standards Building Type		

Weather Summary

	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	

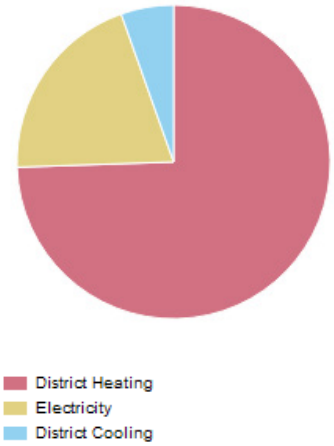
Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 1	5,683	16	19.96
ASHRAE 189.1-2009 ExtWall Mass ClimateZone 1	5,386	69	5.76



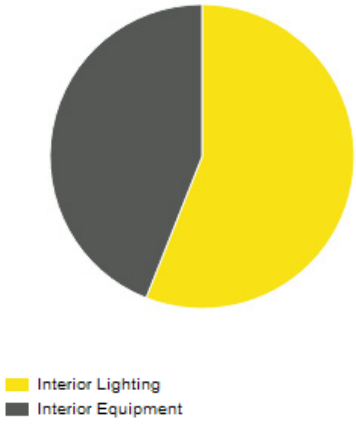
End Use - view table

End Use	Consumption (kBtu)
Heating	439,124
Cooling	32,027
Interior Lighting	66,395
Exterior Lighting	0
Interior Equipment	52,168
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

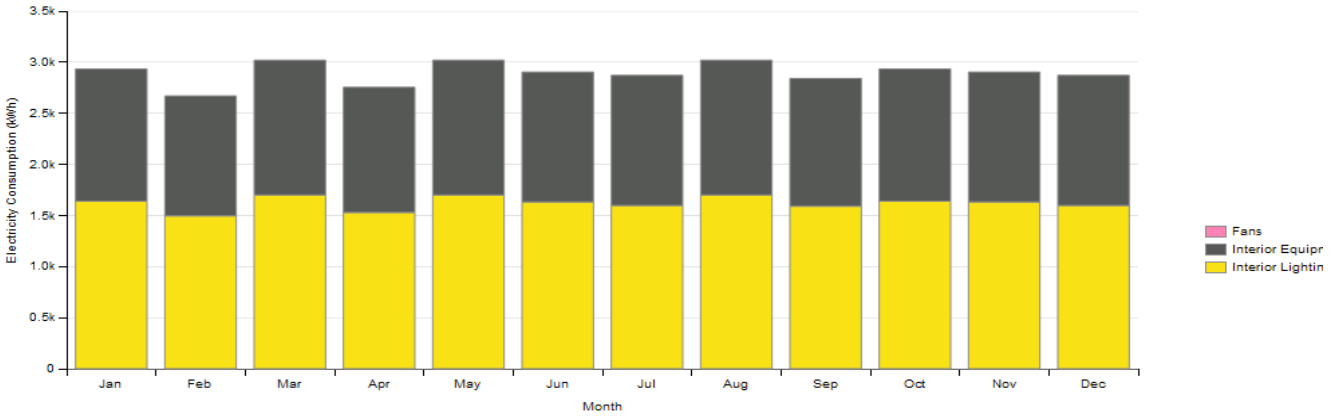
Fuel	Consumption (kBtu)
Electricity	118,562
Natural Gas	0
Additional Fuel	0
District Cooling	32,027
District Heating	439,124



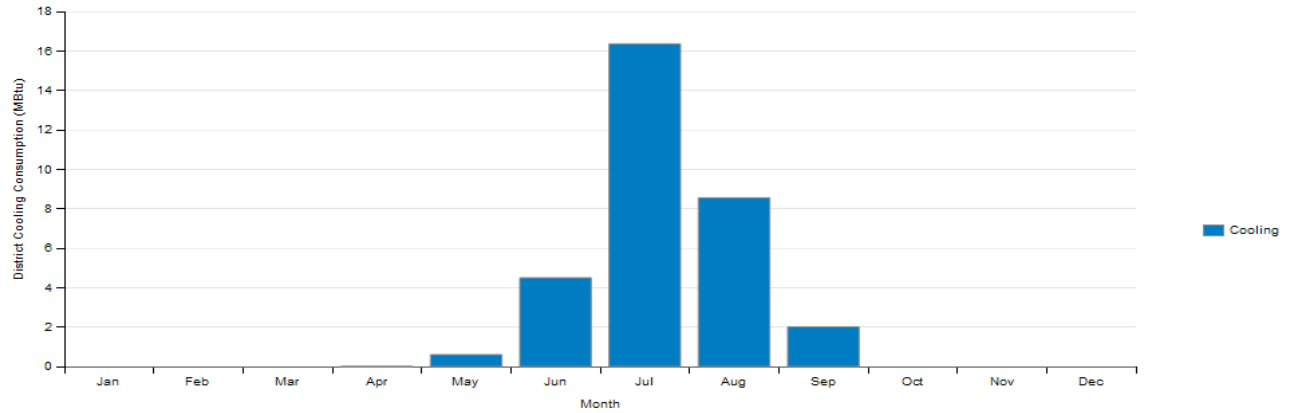
EUI - Electricity - view table

End Use	Consumption (kWh)
Heating	0
Cooling	0
Interior Lighting	19,458
Exterior Lighting	0
Interior Equipment	15,289
Exterior Equipment	0
Fans	0
Pumps	0
Heat Rejection	0
Humidification	0
Heat Recovery	0
Water Systems	0
Refrigeration	0
Generators	0

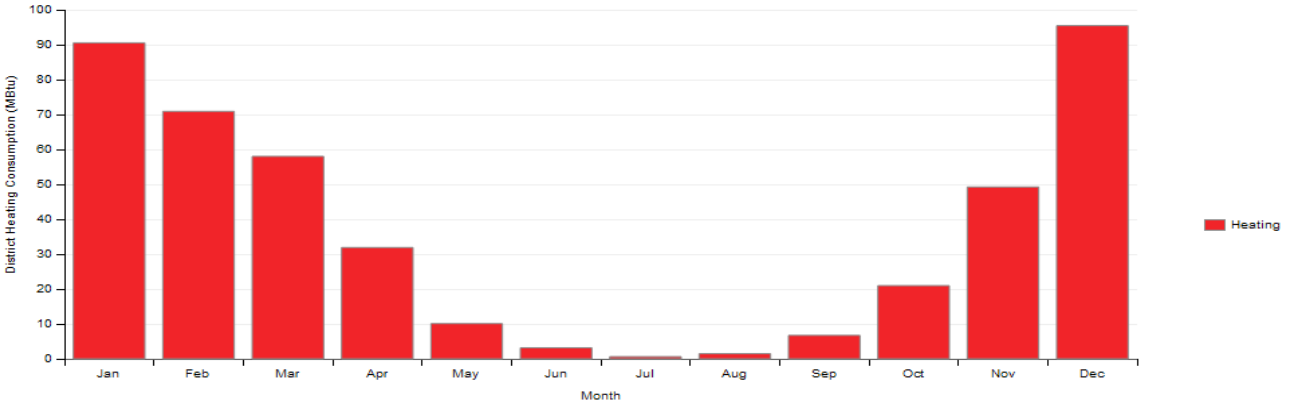
Electricity Consumption (kWh) - view table



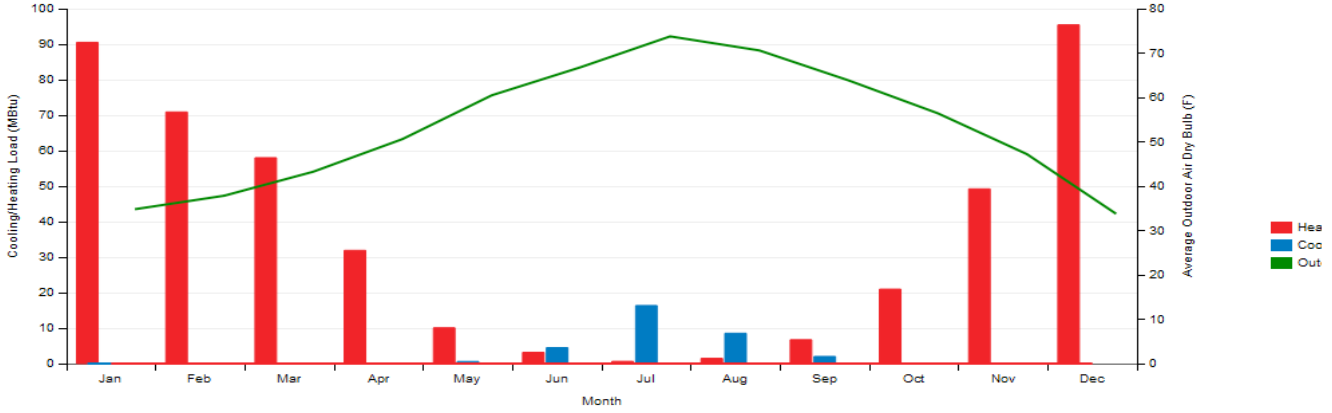
District Cooling Consumption (MBtu) - view table



District Heating Consumption (MBtu) - view table



Monthly Load Profiles - view table



_CITY 1: MODIFIED WALL 1

HAMBURG, GERMANY

For this city, three different walls (**Modified wall 1 / 2 / 3**) with different characteristics are used for the simulation, The differnce in characteristics is the thickness of wall insulation. The results are then compared with the base case.

MODIFIED WALL 1 Characteristics: Stucco (0.025 m) | Concrete (0.203 m) | Wall Insulation (0.068m) | Gypsum (0.012 m)

Building Summary

Information	Value	Units
Building Name	Building 1	building_name
Net Site Energy	740,387	kBtu
Total Building Area	5,683	ft^2
EUI (Based on Net Site Energy and Total Building Area)	130.27	kBtu/ft^2
OpenStudio Standards Building Type		

Weather Summary

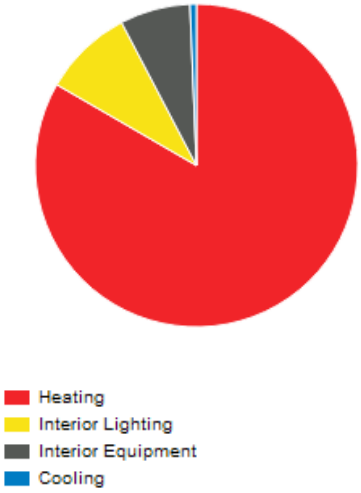
	Value
Weather File	HAMBURG - DEU IWEC Data WMO#=101470
Latitude	53.63
Longitude	10.00
Elevation	52 (ft)
Time Zone	1.00
North Axis Angle	0.00
ASHRAE Climate Zone	

Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 1	5,683	16	19.96
modified wall 1	5,386	69	7.27

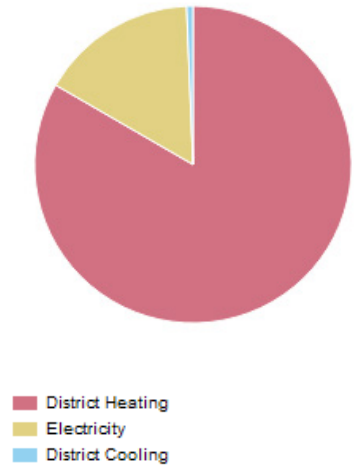
_CITY 1: MODIFIED WALL 1

HAMBURG, GERMANY



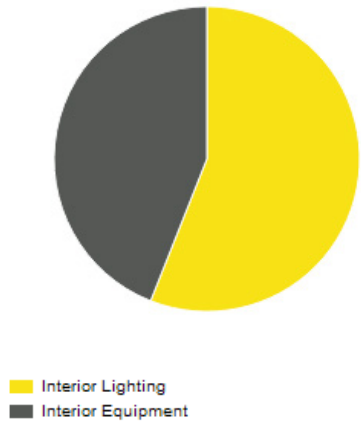
End Use - view table

End Use	Consumption (kBtu)
Heating	617,048
Cooling	4,777
Interior Lighting	66,395
Exterior Lighting	0
Interior Equipment	52,168
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	118,562
Natural Gas	0
Additional Fuel	0
District Cooling	4,777
District Heating	617,048



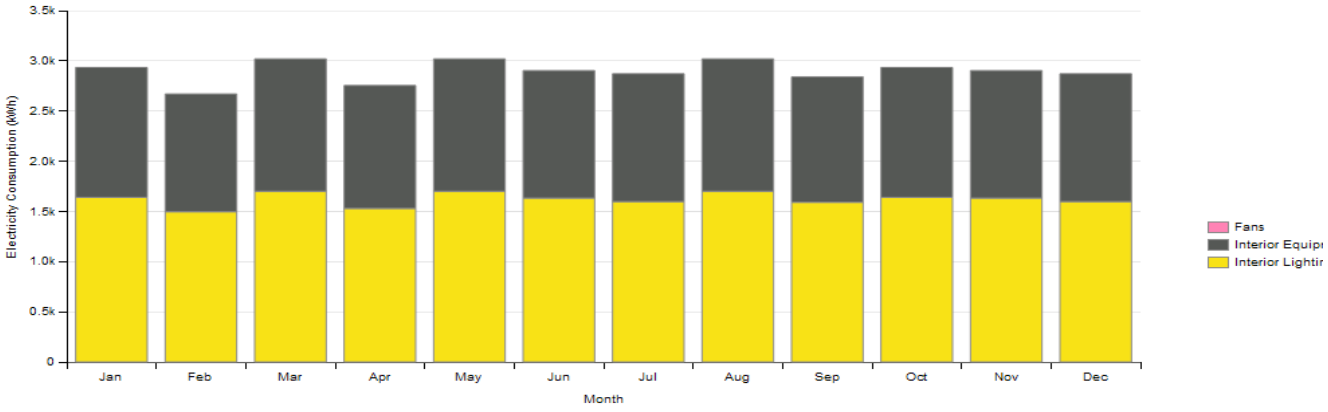
EUI - Electricity - view table

End Use	Consumption (kWh)
Heating	0
Cooling	0
Interior Lighting	19,458
Exterior Lighting	0
Interior Equipment	15,289
Exterior Equipment	0
Fans	0
Pumps	0
Heat Rejection	0
Humidification	0
Heat Recovery	0
Water Systems	0
Refrigeration	0
Generators	0

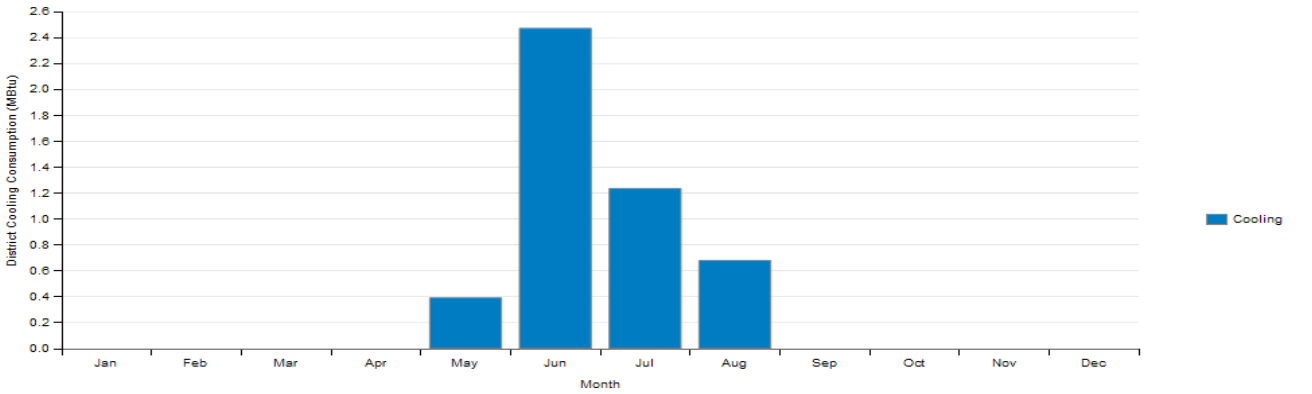
_CITY 1: MODIFIED WALL 1

HAMBURG, GERMANY

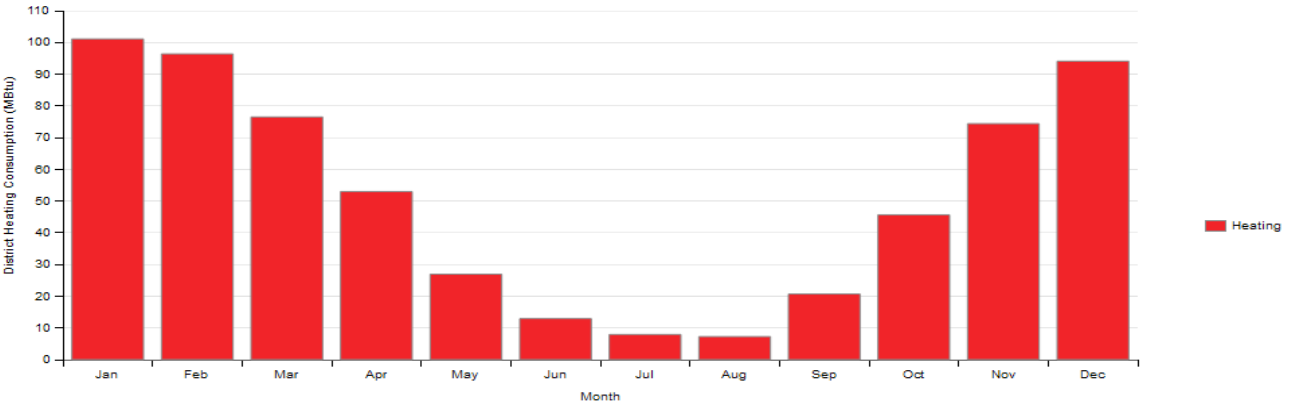
Electricity Consumption (kWh) - view table



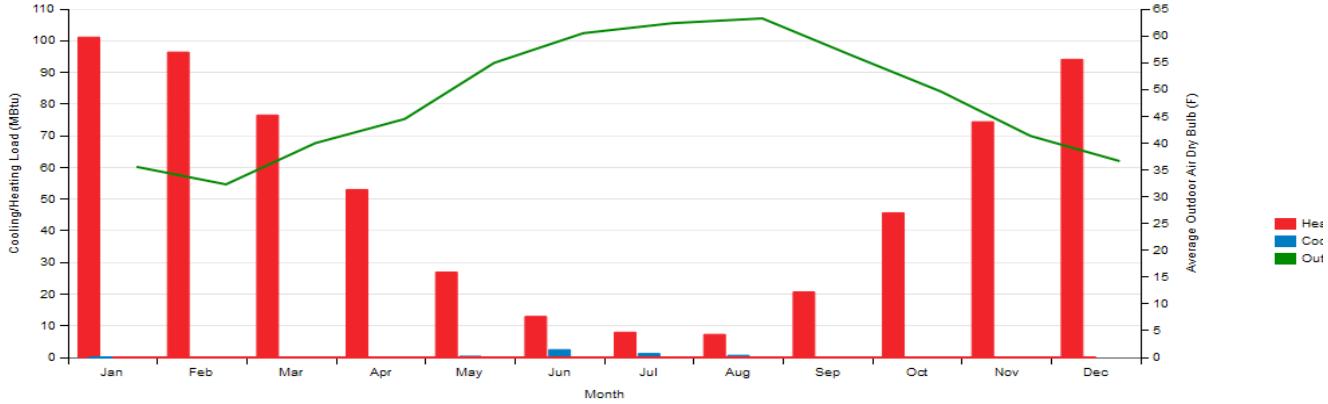
District Cooling Consumption (MBtu) - view table



District Heating Consumption (MBtu) - view table



Monthly Load Profiles - view table



_CITY 1: MODIFIED WALL 2

HAMBURG, GERMANY

MODIFIED WALL 2 Characteristics: Stucco (0.025 m) | Concrete (0.203 m) | Wall Insulation (0.079 m) | Gypsum (0.012 m)

Building Summary

Information	Value	Units
Building Name	Building 1	building_name
Net Site Energy	721,914	kBtu
Total Building Area	5,683	ft^2
EUI (Based on Net Site Energy and Total Building Area)	127.02	kBtu/ft^2
OpenStudio Standards Building Type		

Weather Summary

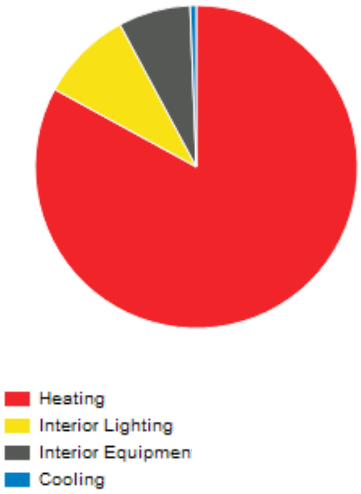
	Value
Weather File	HAMBURG - DEU IWEC Data WMO#=101470
Latitude	53.63
Longitude	10.00
Elevation	52 (ft)
Time Zone	1.00
North Axis Angle	0.00
ASHRAE Climate Zone	

Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 1	5,683	16	19.96
modified wall 2	5,386	69	11.76

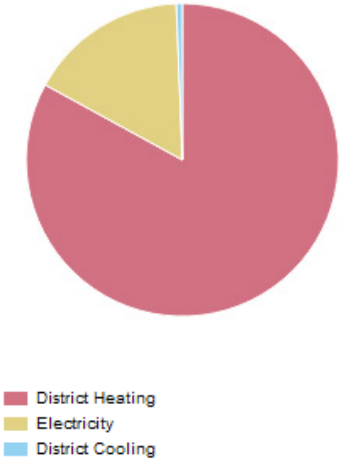
_CITY 1: MODIFIED WALL 2

HAMBURG, GERMANY



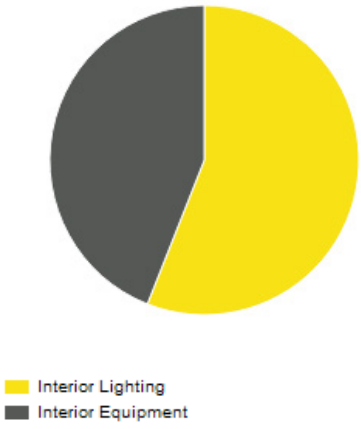
End Use - view table

End Use	Consumption (kBtu)
Heating	598,926
Cooling	4,426
Interior Lighting	66,395
Exterior Lighting	0
Interior Equipment	52,168
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	118,562
Natural Gas	0
Additional Fuel	0
District Cooling	4,426
District Heating	598,926



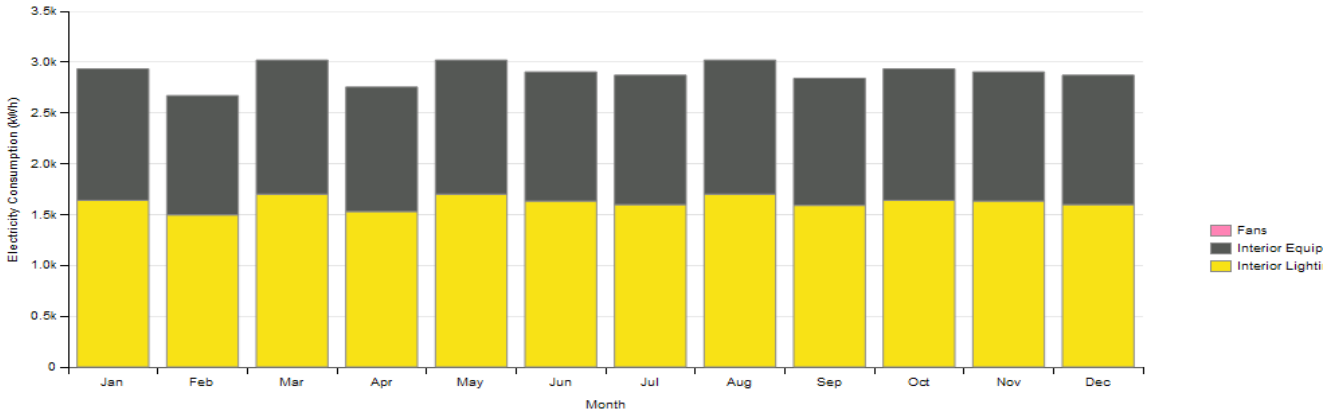
EUI - Electricity - view table

End Use	Consumption (kWh)
Heating	0
Cooling	0
Interior Lighting	19,458
Exterior Lighting	0
Interior Equipment	15,289
Exterior Equipment	0
Fans	0
Pumps	0
Heat Rejection	0
Humidification	0
Heat Recovery	0
Water Systems	0
Refrigeration	0
Generators	0

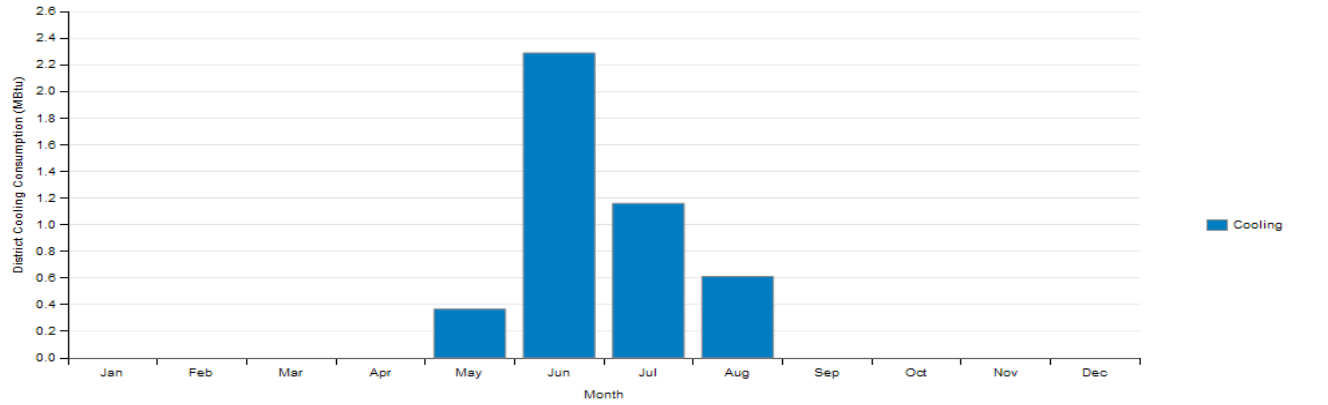
_CITY 1: MODIFIED WALL 2

HAMBURG, GERMANY

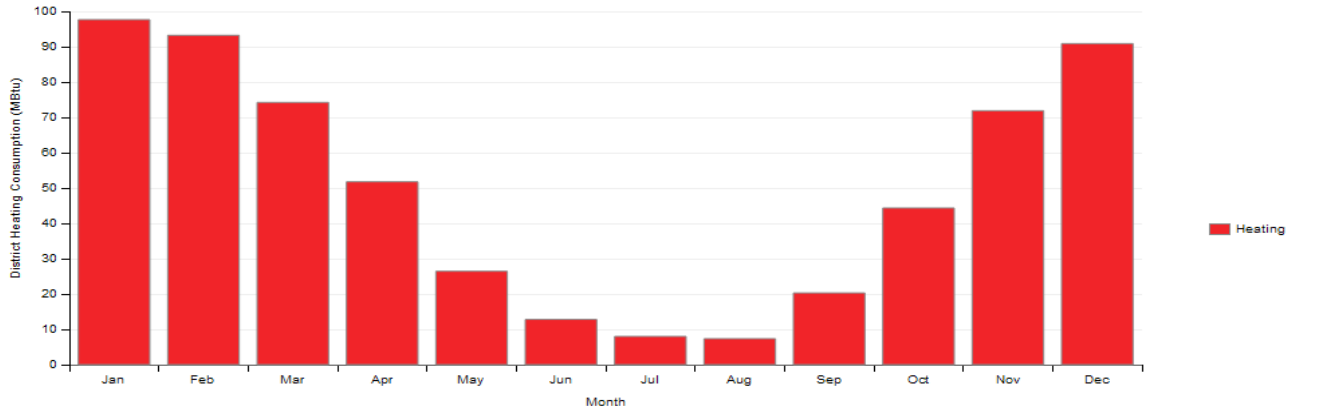
Electricity Consumption (kWh) - view table



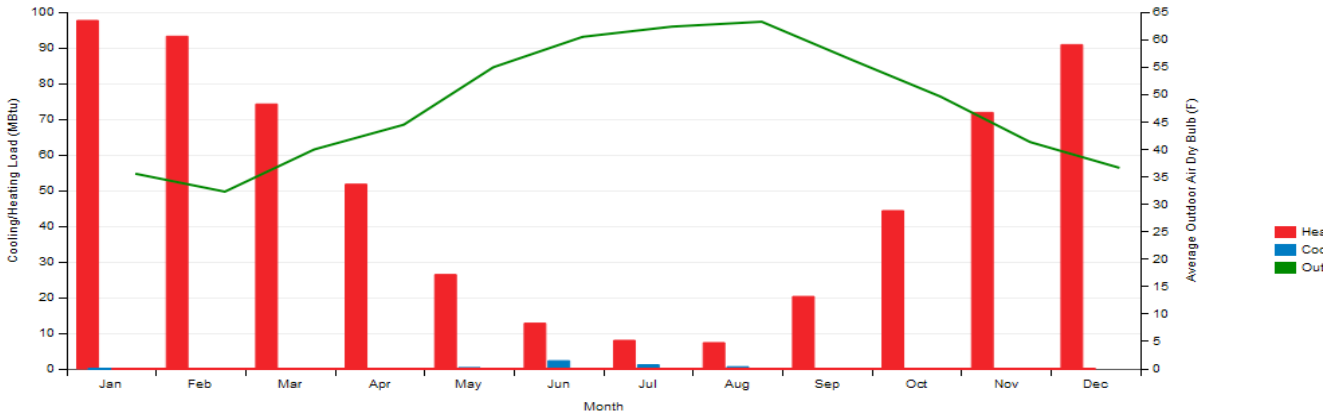
District Cooling Consumption (MBtu) - view table



District Heating Consumption (MBtu) - view table



Monthly Load Profiles - view table



_CITY 1: MODIFIED WALL 3

HAMBURG, GERMANY

MODIFIED WALL 3 Characteristics: Stucco (0.025 m) | Concrete (0.203 m) | Wall Insulation (0.110 m) | Gypsum (0.012 m)

Building Summary

Information	Value	Units
Building Name	Building 1	building_name
Net Site Energy	713,574	kBtu
Total Building Area	5,683	ft^2
EUI (Based on Net Site Energy and Total Building Area)	125.56	kBtu/ft^2
OpenStudio Standards Building Type		

Weather Summary

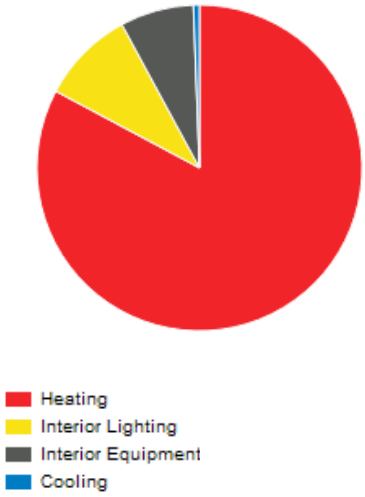
	Value
Weather File	HAMBURG - DEU IWEC Data WMO#=101470
Latitude	53.63
Longitude	10.00
Elevation	52 (ft)
Time Zone	1.00
North Axis Angle	0.00
ASHRAE Climate Zone	

Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 1	5,683	16	19.96
modified wall 3	5,386	69	15.84

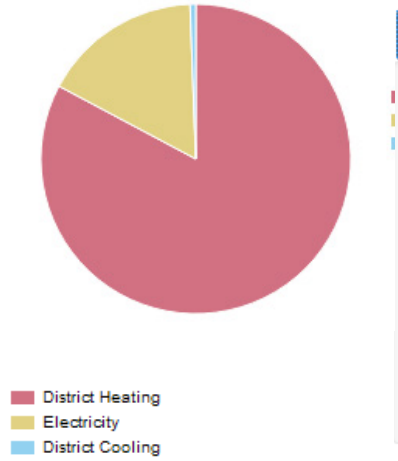
_CITY 1: MODIFIED WALL 3

HAMBURG, GERMANY



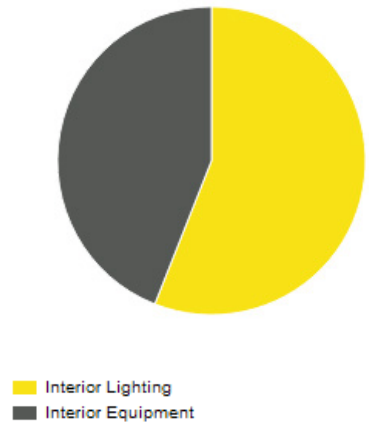
End Use - view table

End Use	Consumption (kBtu)
Heating	590,746
Cooling	4,256
Interior Lighting	66,395
Exterior Lighting	0
Interior Equipment	52,168
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	118,562
Natural Gas	0
Additional Fuel	0
District Cooling	4,256
District Heating	590,746



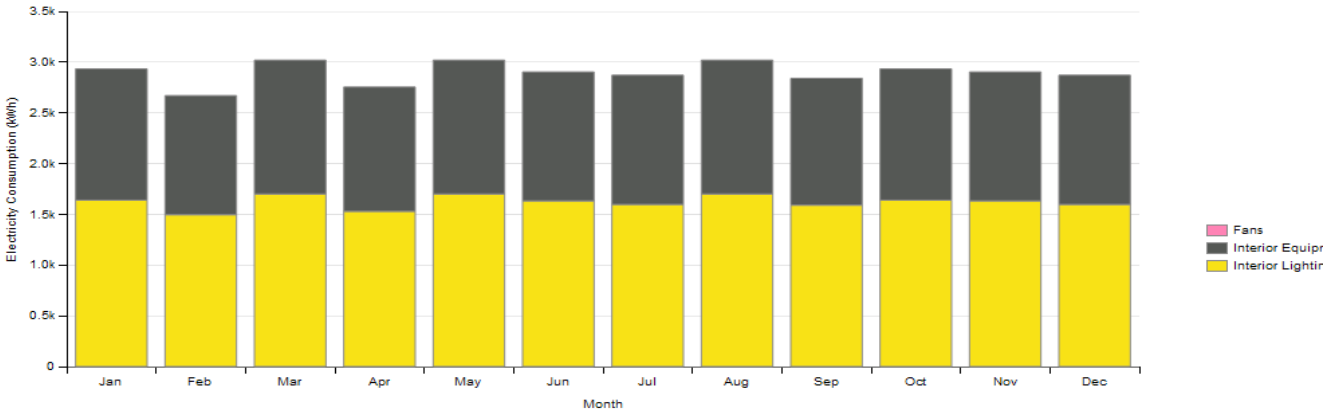
EUI - Electricity - view table

End Use	Consumption (kWh)
Heating	0
Cooling	0
Interior Lighting	19,458
Exterior Lighting	0
Interior Equipment	15,289
Exterior Equipment	0
Fans	0
Pumps	0
Heat Rejection	0
Humidification	0
Heat Recovery	0
Water Systems	0
Refrigeration	0
Generators	0

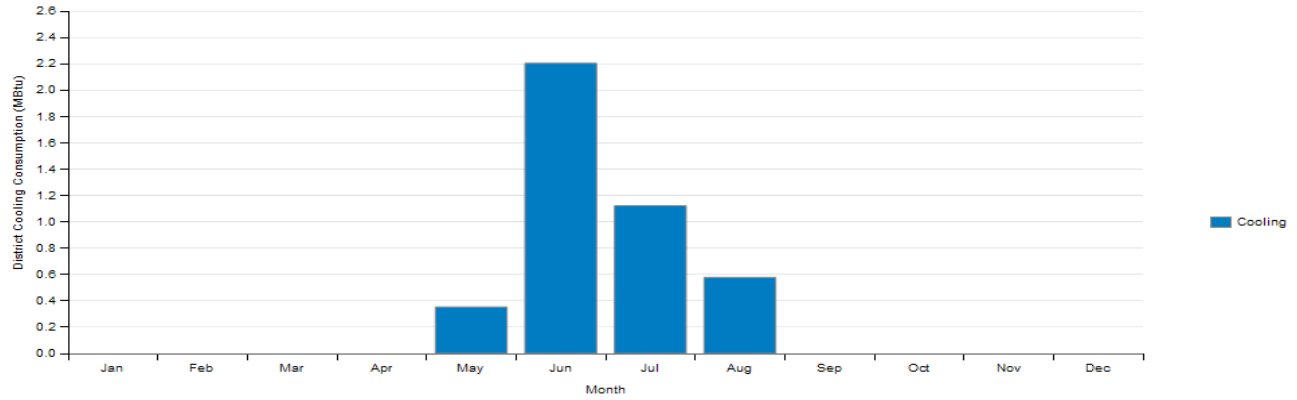
_CITY 1: MODIFIED WALL 3

HAMBURG, GERMANY

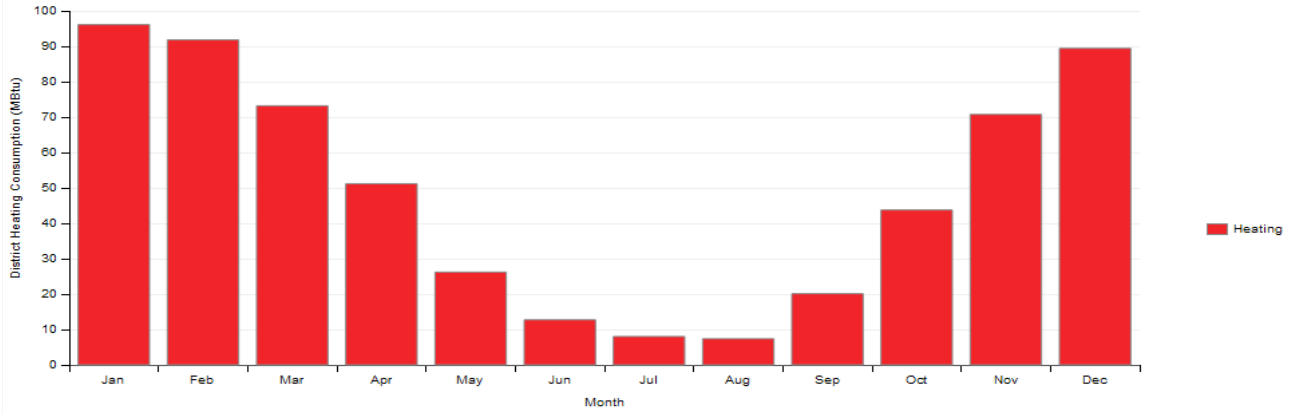
Electricity Consumption (kWh) - view table



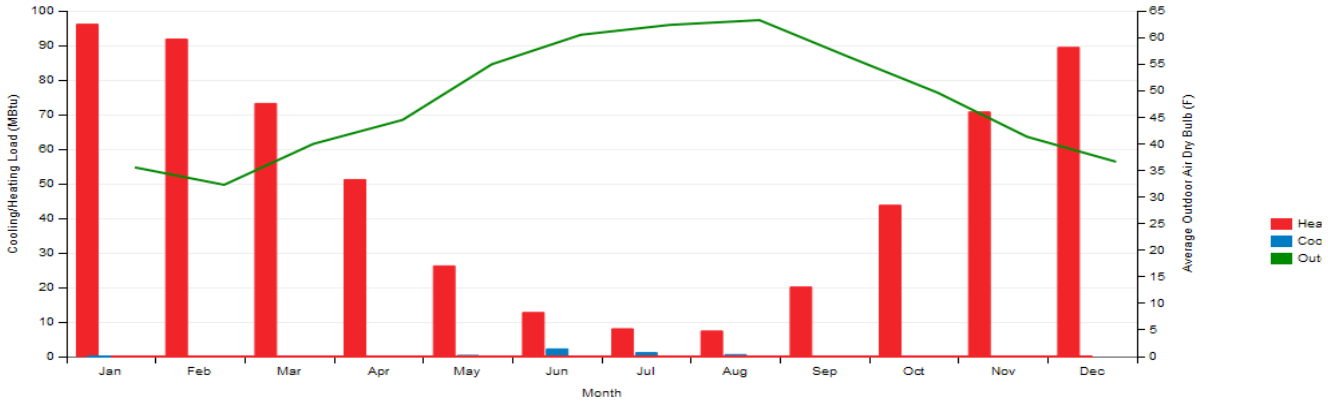
District Cooling Consumption (MBtu) - view table



District Heating Consumption (MBtu) - view table



Monthly Load Profiles - view table



_CITY 1: COMPARISM WITH BASE CASE

HAMBURG, GERMANY

The report show that the Net site energy consumption for city 1 is higher than the base case.

By using the weather data of Piacenza for base case, and the weather data of Hamburg with different wall characteristics, the results below reflect that each case has a different effect on the yearly energy consumption of the building. The thicker the wall insulation, the lower the energy consumed.

	Base Case	M.Wall 1	M.Wall 2	M.Wall 3	Unit
Net Site Energy	589,713	740,387	721,914	713,574	KBtu
Total Building Area	5, 683	5, 683	5, 683	5, 683	ft^2
EUI *(Based on Net Site Energy and Total Building Area)*	103	130	127	125	KBtu/ ft^2
Electricity	118,562	118,562	118,562	118,562	KBtu
District Cooling	32,027	4,777	4,426	4,256	KBtu
District Heating	439,124	617,048	598, 926	590,746	KBtu

M. WALL 1 Characteristics: Stucco (0.025 m) | Concrete (0.203 m) | **Wall Insulation (0.068 m)** | Gypsum (0.012 m)
M. WALL 2 Characteristics: Stucco (0.025 m) | Concrete (0.203 m) | **Wall Insulation (0.079 m)** | Gypsum (0.012 m)
M. WALL 3 Characteristics: Stucco (0.025 m) | Concrete (0.203 m) | **Wall Insulation (0.110 m)** | Gypsum (0.012 m)

Units of measurement
kBtu = kilo-British thermal unit
ft^2 = square feet
m = meter

To convert kilo-British thermal unit (kBtu) to kilo-Watt-hour (kWh)
1 kBtu = 0.293 kWh
Example; for base case Net Site Energy of 589,713 kBtu X 0.293 = **172,785 kWh**

_CITY 2: MODIFIED WALL 1

GENEVA, SWITZERLAND

For this city, three different walls (**Modified wall 1 / 2 / 3**) with different characteristics are used for the simulation, The differnce in characteristics is the thickness of wall insulation. The results are then compared with the base case.

MODIFIED WALL 1 Characteristics: Stucco (0.025 m) | Concrete (0.203 m) | Wall Insulation (0.068 m) | Gypsum (0.012 m)

Building Summary

Information	Value	Units
Building Name	Building 1	building_name
Net Site Energy	622,337	kBtu
Total Building Area	5,683	ft^2
EUI (Based on Net Site Energy and Total Building Area)	109.50	kBtu/ft^2
OpenStudio Standards Building Type		

Weather Summary

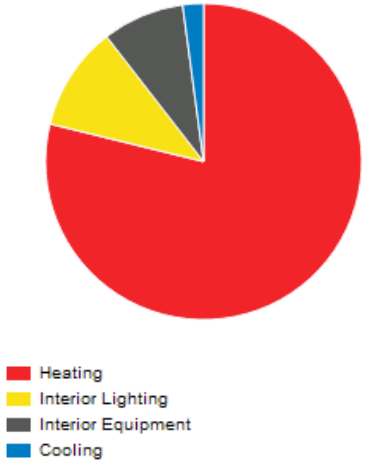
	Value
Weather File	GENEVA - CHE IWEC Data WMO#=067000
Latitude	46.25
Longitude	6.13
Elevation	1365 (ft)
Time Zone	1.00
North Axis Angle	0.00
ASHRAE Climate Zone	

Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 1	5,683	16	19.96
Modified wall 1	5,386	69	7.27

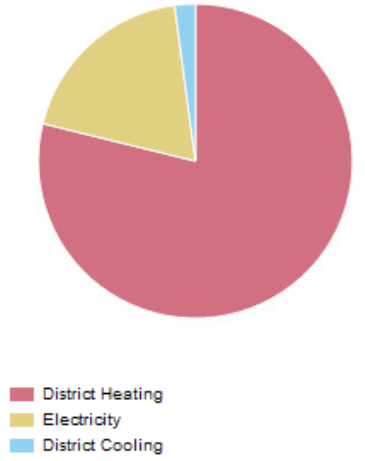
_CITY 2: MODIFIED WALL 1

GENEVA, SWITZERLAND



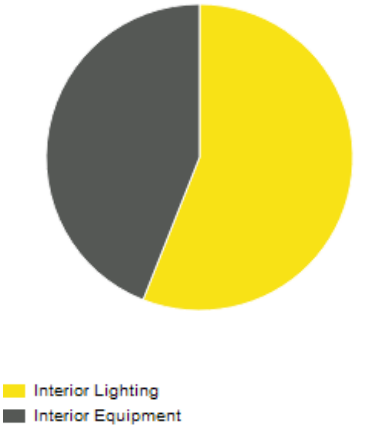
End Use - view table

End Use	Consumption (kBtu)
Heating	490,571
Cooling	13,203
Interior Lighting	66,395
Exterior Lighting	0
Interior Equipment	52,168
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	118,562
Natural Gas	0
Additional Fuel	0
District Cooling	13,203
District Heating	490,571



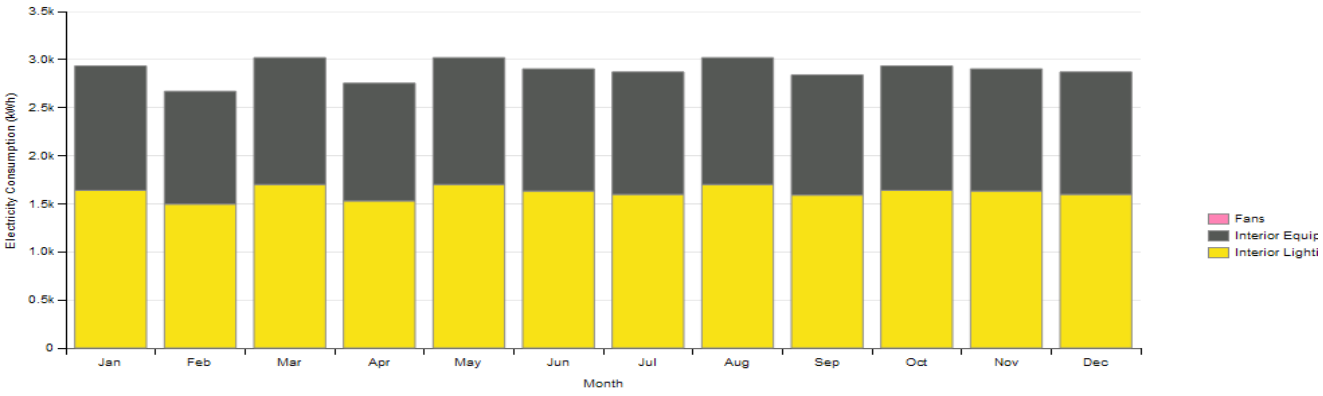
EUI - Electricity - view table

End Use	Consumption (kWh)
Heating	0
Cooling	0
Interior Lighting	19,458
Exterior Lighting	0
Interior Equipment	15,289
Exterior Equipment	0
Fans	0
Pumps	0
Heat Rejection	0
Humidification	0
Heat Recovery	0
Water Systems	0
Refrigeration	0
Generators	0

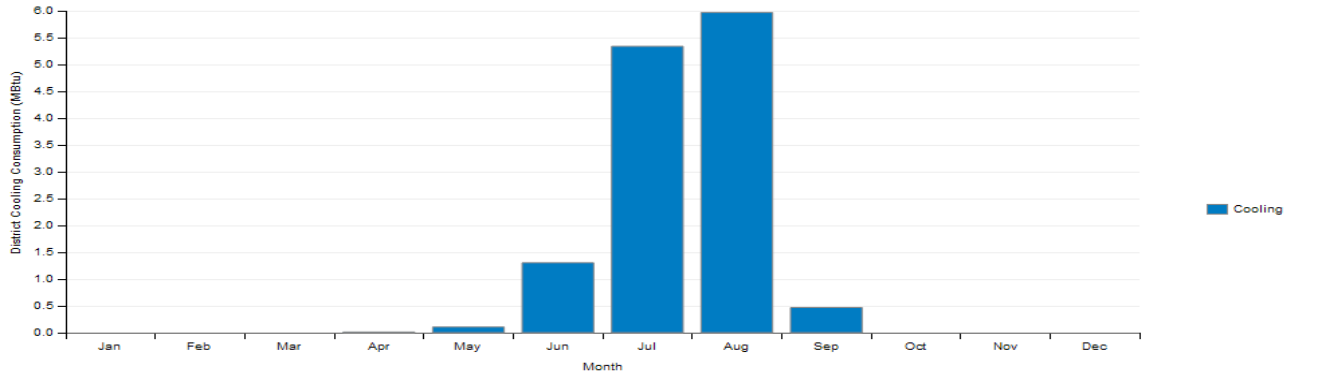
_CITY 2: MODIFIED WALL 1

GENEVA, SWITZERLAND

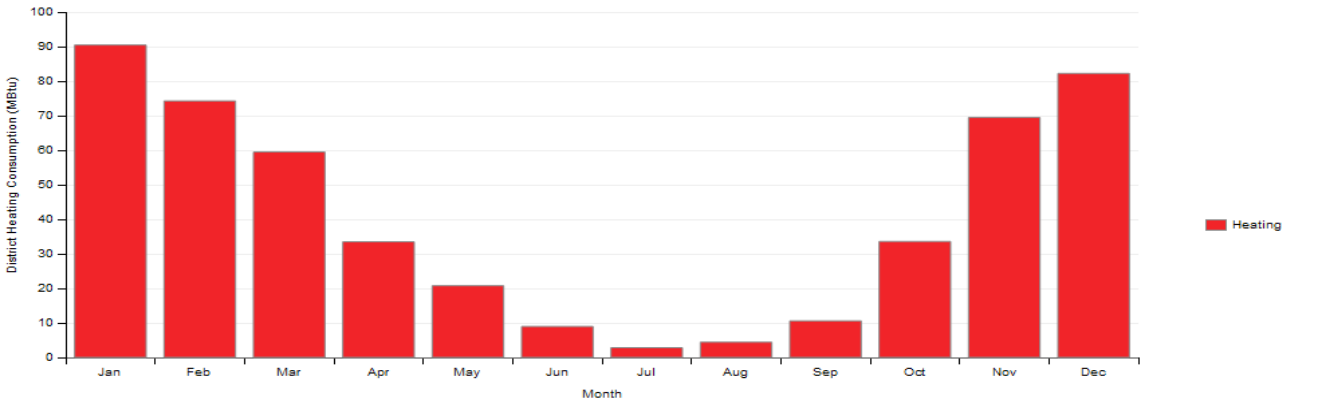
Electricity Consumption (kWh) - view table



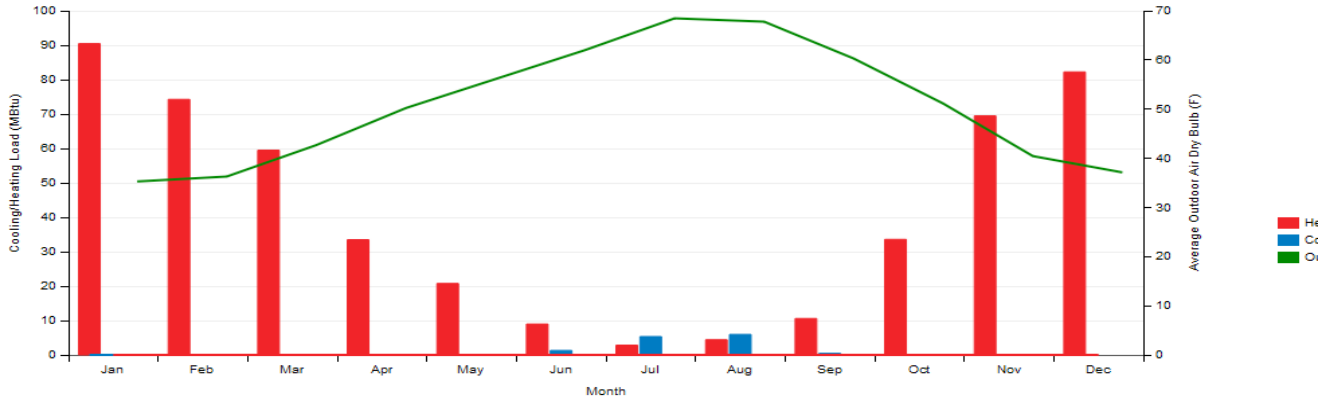
District Cooling Consumption (MBtu) - view table



District Heating Consumption (MBtu) - view table



Monthly Load Profiles - view table



_CITY 2: MODIFIED WALL 2

GENEVA, SWITZERLAND

MODIFIED WALL 2 Characteristics: Stucco (0.025 m) | Concrete (0.203 m) | Wall Insulation (0.079 m) | Gypsum (0.012 m)

Building Summary

Information	Value	Units
Building Name	Building 1	building_name
Net Site Energy	607,399	kBtu
Total Building Area	5,683	ft^2
EUI (Based on Net Site Energy and Total Building Area)	106.87	kBtu/ft^2
OpenStudio Standards Building Type		

Weather Summary

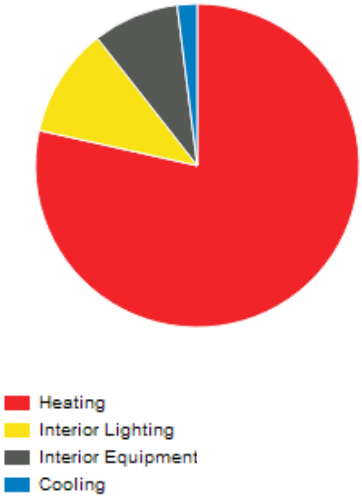
	Value
Weather File	GENEVA - CHE IWEC Data WMO#=067000
Latitude	46.25
Longitude	6.13
Elevation	1365 (ft)
Time Zone	1.00
North Axis Angle	0.00
ASHRAE Climate Zone	

Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 1	5,683	16	19.96
Modified wall 2	5,386	69	11.76

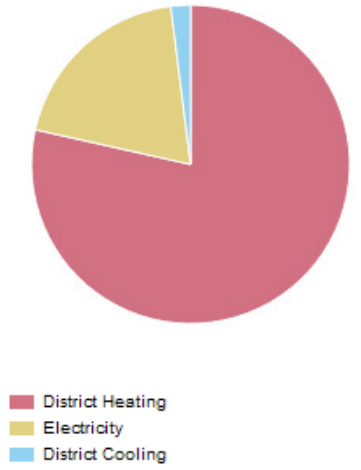
_CITY 2: MODIFIED WALL 2

GENEVA, SWITZERLAND



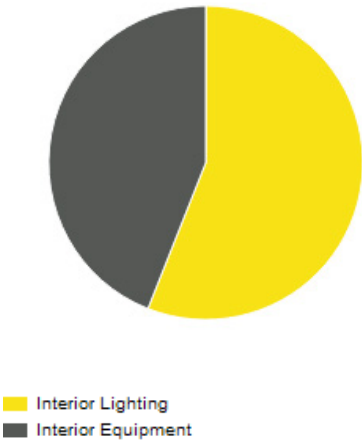
End Use - view table

End Use	Consumption (kBtu)
Heating	476,743
Cooling	12,094
Interior Lighting	66,395
Exterior Lighting	0
Interior Equipment	52,168
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	118,562
Natural Gas	0
Additional Fuel	0
District Cooling	12,094
District Heating	476,743



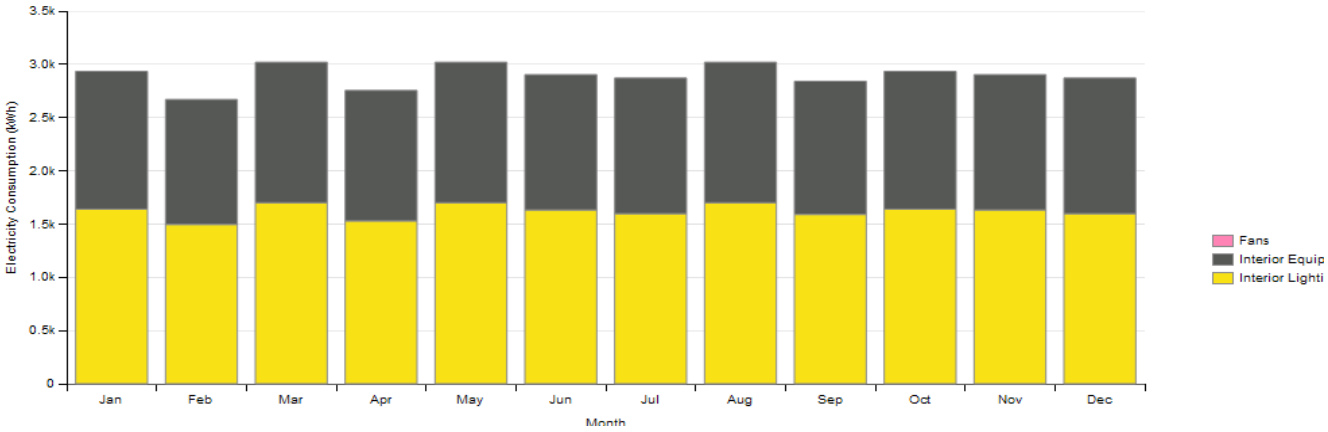
EUI - Electricity - view table

End Use	Consumption (kWh)
Heating	0
Cooling	0
Interior Lighting	19,458
Exterior Lighting	0
Interior Equipment	15,289
Exterior Equipment	0
Fans	0
Pumps	0
Heat Rejection	0
Humidification	0
Heat Recovery	0
Water Systems	0
Refrigeration	0
Generators	0

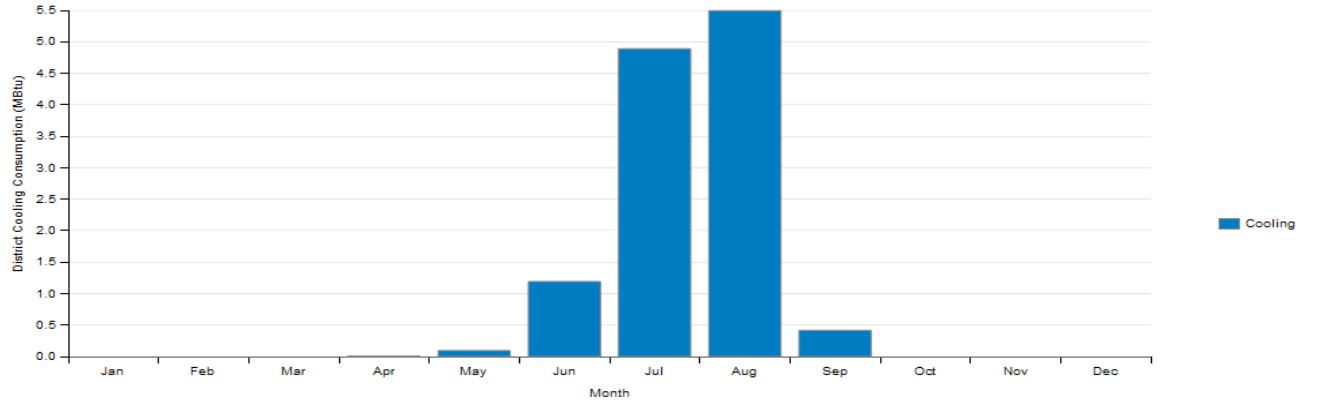
_CITY 2: MODIFIED WALL 2

GENEVA, SWITZERLAND

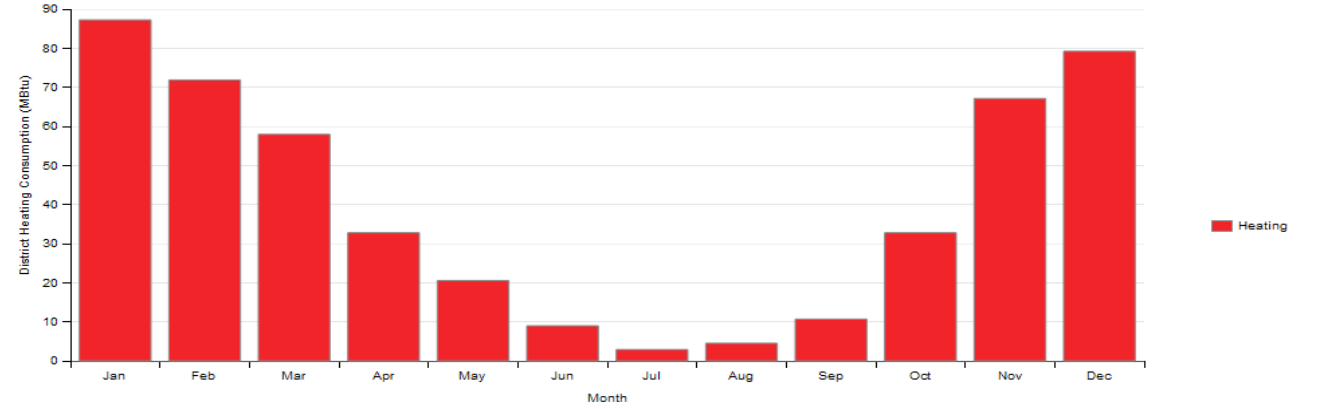
Electricity Consumption (kWh) - view table



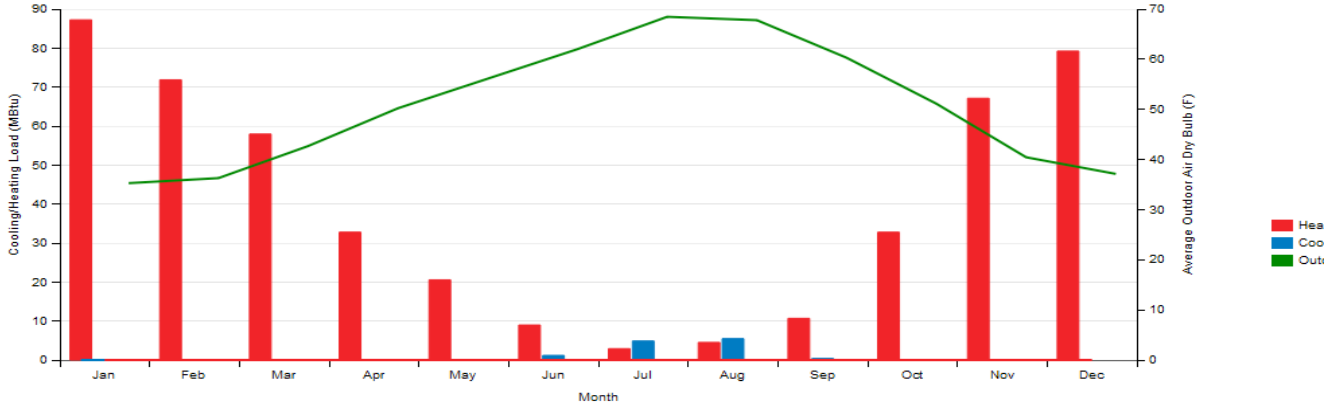
District Cooling Consumption (MBtu) - view table



District Heating Consumption (MBtu) - view table



Monthly Load Profiles - view table



_CITY 2: MODIFIED WALL 3

GENEVA, SWITZERLAND

MODIFIED WALL 3 Characteristics: Stucco (0.025 m) | Concrete (0.203 m) | Wall Insulation (0.110 m) | Gypsum (0.012 m)

Building Summary

Information	Value	Units
Building Name	Building 1	building_name
Net Site Energy	600,632	kBtu
Total Building Area	5,683	ft^2
EUI (Based on Net Site Energy and Total Building Area)	105.68	kBtu/ft^2
OpenStudio Standards Building Type		

Weather Summary

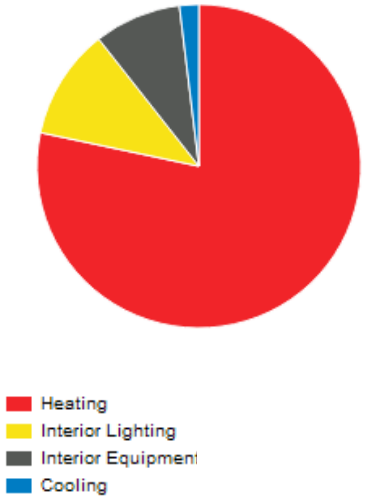
	Value
Weather File	GENEVA - CHE IWEC Data WMO#=067000
Latitude	46.25
Longitude	6.13
Elevation	1365 (ft)
Time Zone	1.00
North Axis Angle	0.00
ASHRAE Climate Zone	

Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 1	5,683	16	19.96
Modified wall 3	5,386	69	15.84

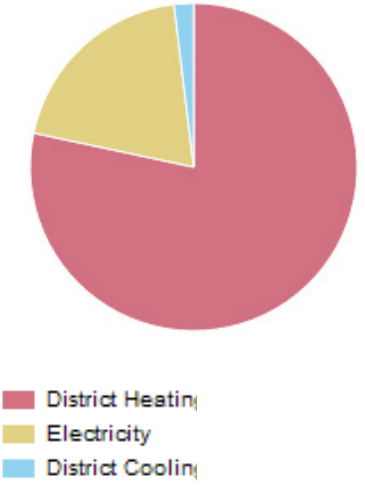
_CITY 2: MODIFIED WALL 3

GENEVA, SWITZERLAND



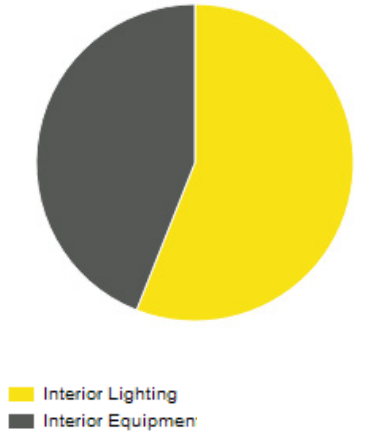
End Use - view table

End Use	Consumption (kBtu)
Heating	470,477
Cooling	11,582
Interior Lighting	66,395
Exterior Lighting	0
Interior Equipment	52,168
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	118,562
Natural Gas	0
Additional Fuel	0
District Cooling	11,582
District Heating	470,477



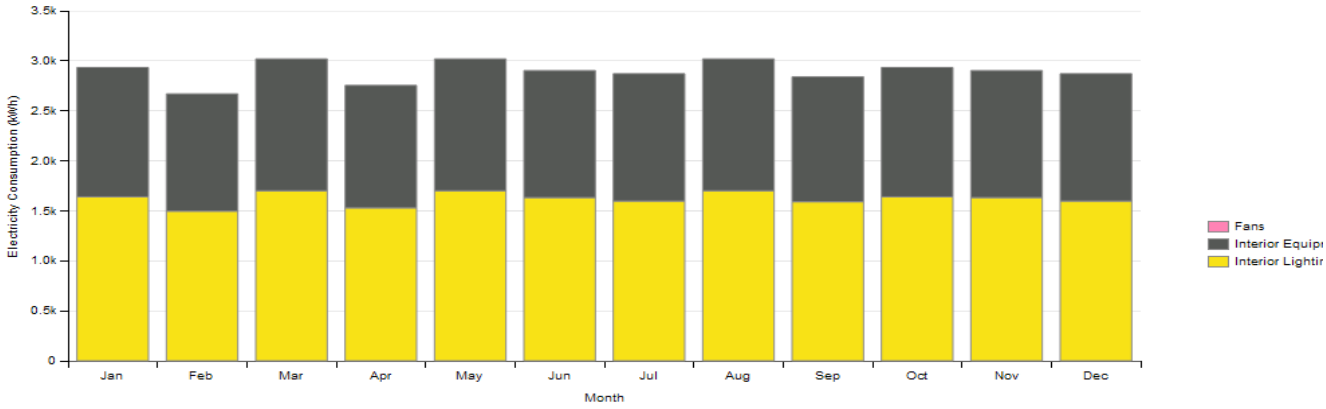
EUI - Electricity - view table

End Use	Consumption (kWh)
Heating	0
Cooling	0
Interior Lighting	19,458
Exterior Lighting	0
Interior Equipment	15,289
Exterior Equipment	0
Fans	0
Pumps	0
Heat Rejection	0
Humidification	0
Heat Recovery	0
Water Systems	0
Refrigeration	0
Generators	0

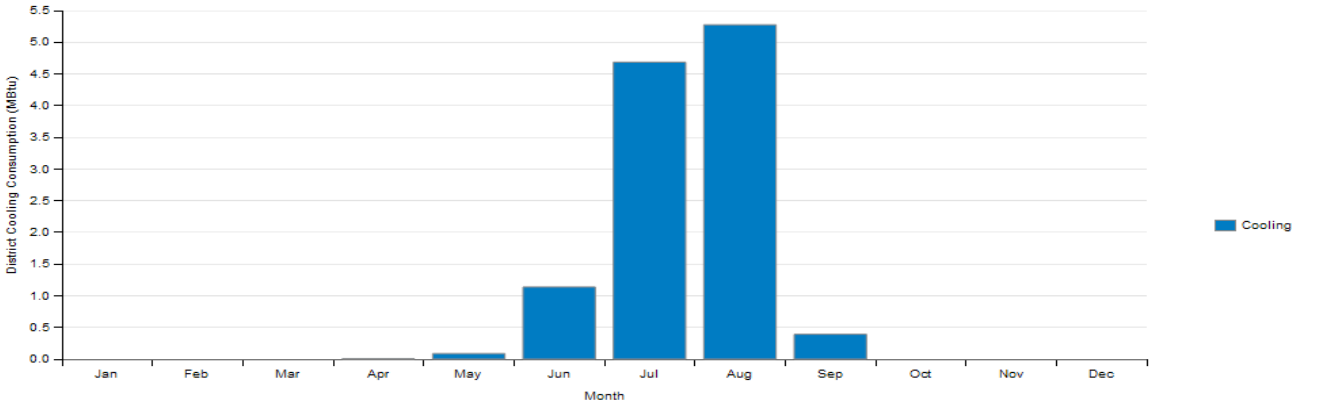
_CITY 2: MODIFIED WALL 3

GENEVA, SWITZERLAND

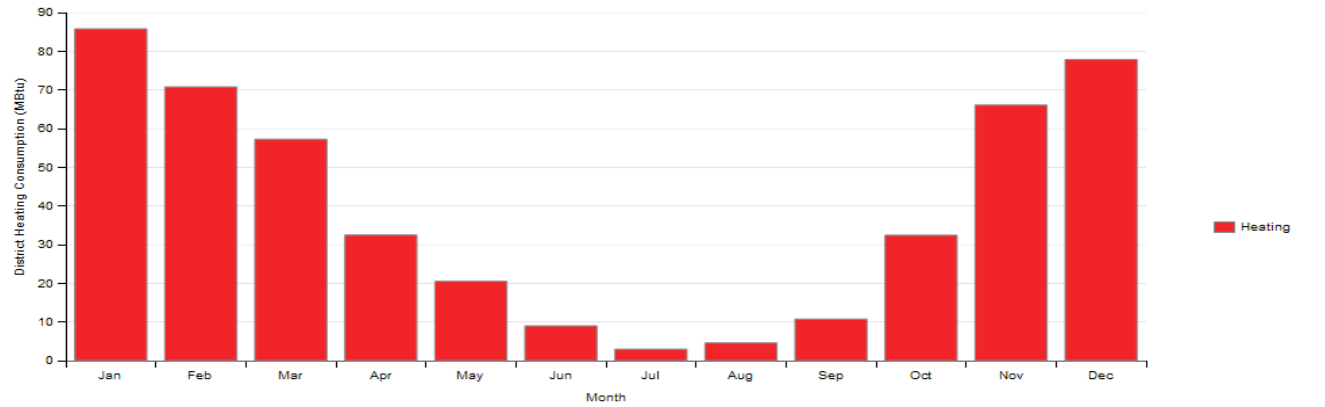
Electricity Consumption (kWh) - view table



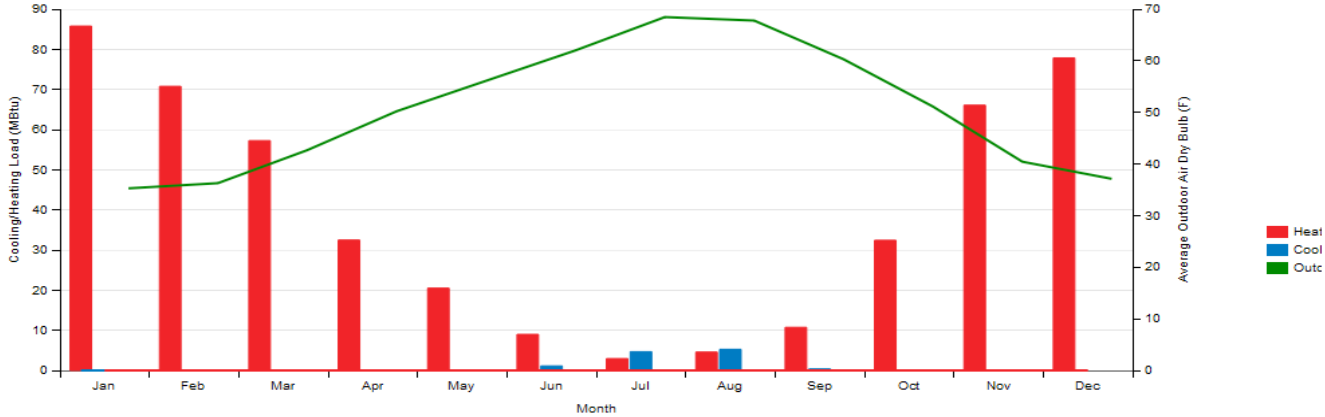
District Cooling Consumption (MBtu) - view table



District Heating Consumption (MBtu) - view table



Monthly Load Profiles - view table



_CITY 2: COMPARISM WITH BASE CASE

GENEVA, SWITZERLAND

The report show that the Net site energy consumption for city 2 is higher than the base case.

By using the weather data of Piacenza for base case, and the weather data of Geneva with different wall characteristics, the results below reflect that each case has a different effect on the yearly energy consumption of the building. The thicker the wall insulation, the lower the energy consumed.

	Base Case	M.Wall 1	M.Wall 2	M.Wall 3	Unit
Net Site Energy	589,713	622,337	607,399	600,632	KBtu
Total Building Area	5, 683	5, 683	5, 683	5, 683	ft^2
EUI *(Based on Net Site Energy and Total Building Area)*	103	109	106	105	KBtu/ ft^2
Electricity	118,562	118,562	118,562	118,562	KBtu
District Cooling	32,027	13,203	12,094	11,582	KBtu
District Heating	439,124	490,571	476,743	470,477	KBtu

M. WALL 1 Characteristics: Stucco (0.025 m) | Concrete (0.203 m) | **Wall Insulation (0.068 m)** | Gypsum (0.012 m)
M. WALL 2 Characteristics: Stucco (0.025 m) | Concrete (0.203 m) | **Wall Insulation (0.079 m)** | Gypsum (0.012 m)
M. WALL 3 Characteristics: Stucco (0.025 m) | Concrete (0.203 m) | **Wall Insulation (0.110 m)** | Gypsum (0.012 m)

Units of measurement
kBtu = kilo-British thermal unit
ft^2 = square feet
m = meter

To convert kilo-British thermal unit (kBtu) to kilo-Watt-hour (kWh)
1 kBtu = 0.293 kWh
Example; for base case Net Site Energy of 589,713 kBtu X 0.293 = **172,785 kWh**

_CITY 3: MODIFIED WALL 1

NAPLES, ITALY

For this city, three different walls (**Modified wall 1 / 2 / 3**) with different characteristics are used for the simulation, The differnce in characteristics is the thickness of wall insulation. The results are then compared with the base case.

MODIFIED WALL 1 Characteristics: Stucco (0.025 m) | Concrete (0.203 m) | Wall Insulation (0.068 m) | Gypsum (0.012 m)

Building Summary

Information	Value	Units
Building Name	Building 1	building_name
Net Site Energy	395,458	kBtu
Total Building Area	5,683	ft^2
EUI (Based on Net Site Energy and Total Building Area)	69.58	kBtu/ft^2
OpenStudio Standards Building Type		

Weather Summary

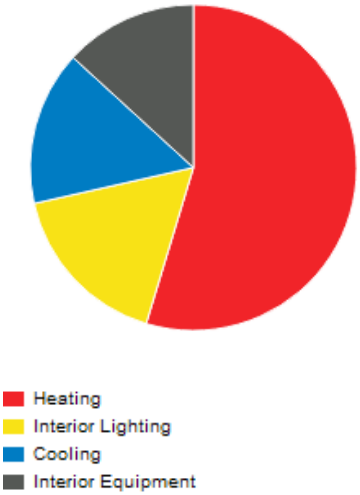
	Value
Weather File	NAPLES - ITA IWEC Data WMO#=162890
Latitude	40.85
Longitude	14.30
Elevation	236 (ft)
Time Zone	1.00
North Axis Angle	0.00
ASHRAE Climate Zone	

Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 1	5,683	16	19.96
modified wall 1	5,386	69	7.27

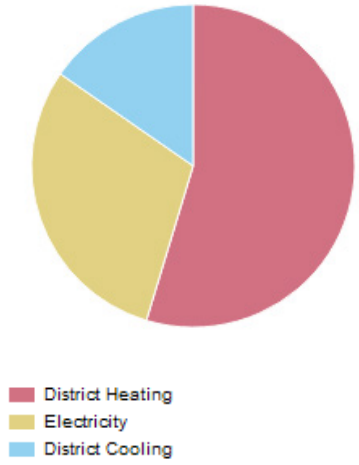
_CITY 3: MODIFIED WALL 1

NAPLES, ITALY



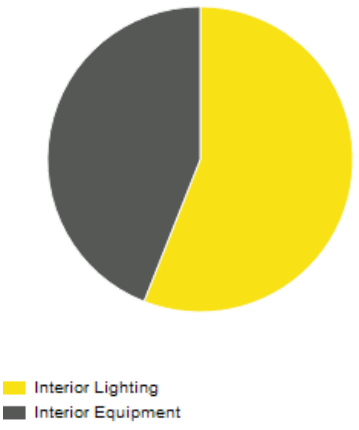
End Use - view table

End Use	Consumption (kBtu)
Heating	216,197
Cooling	60,698
Interior Lighting	66,395
Exterior Lighting	0
Interior Equipment	52,168
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	118,562
Natural Gas	0
Additional Fuel	0
District Cooling	60,698
District Heating	216,197



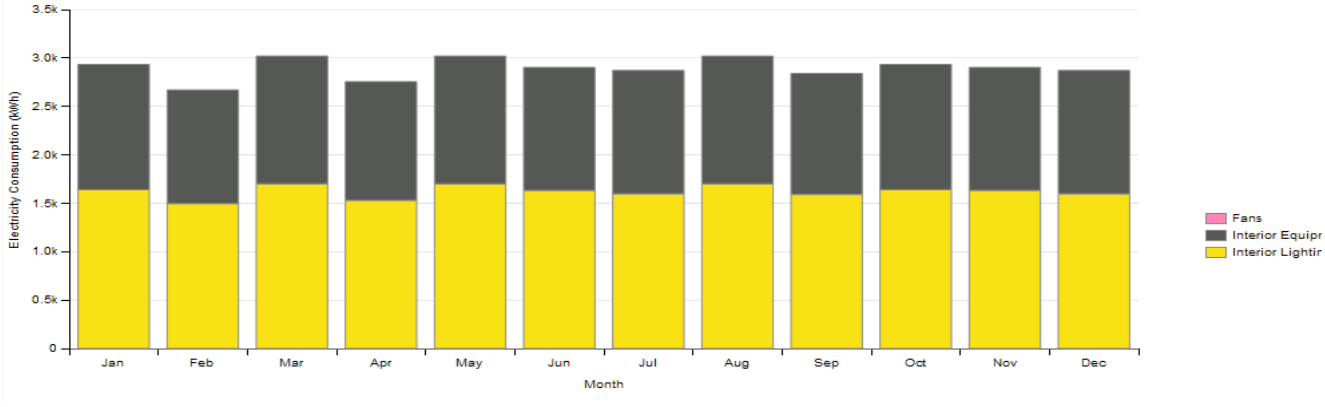
EUI - Electricity - view table

End Use	Consumption (kWh)
Heating	0
Cooling	0
Interior Lighting	19,458
Exterior Lighting	0
Interior Equipment	15,289
Exterior Equipment	0
Fans	0
Pumps	0
Heat Rejection	0
Humidification	0
Heat Recovery	0
Water Systems	0
Refrigeration	0
Generators	0

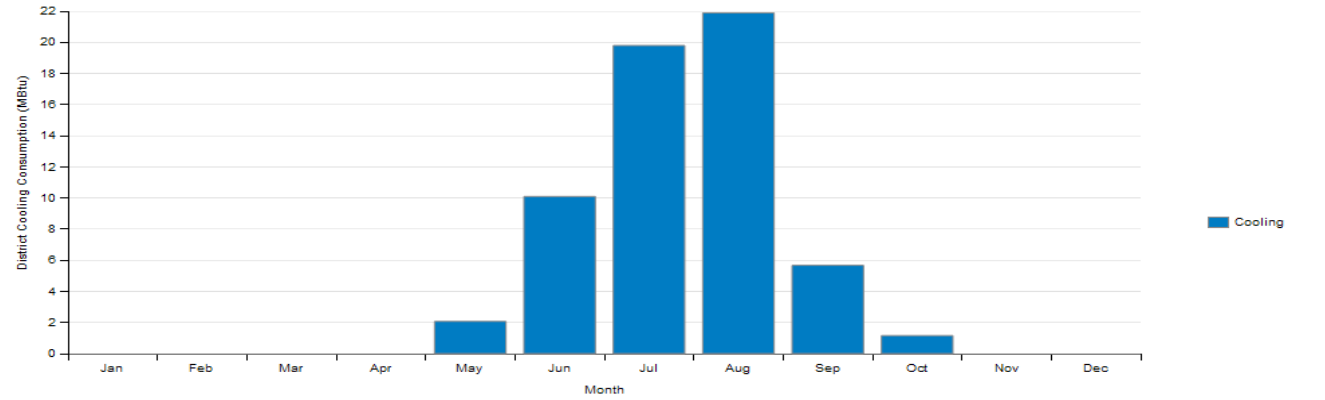
_CITY 3: MODIFIED WALL 1

NAPLES, ITALY

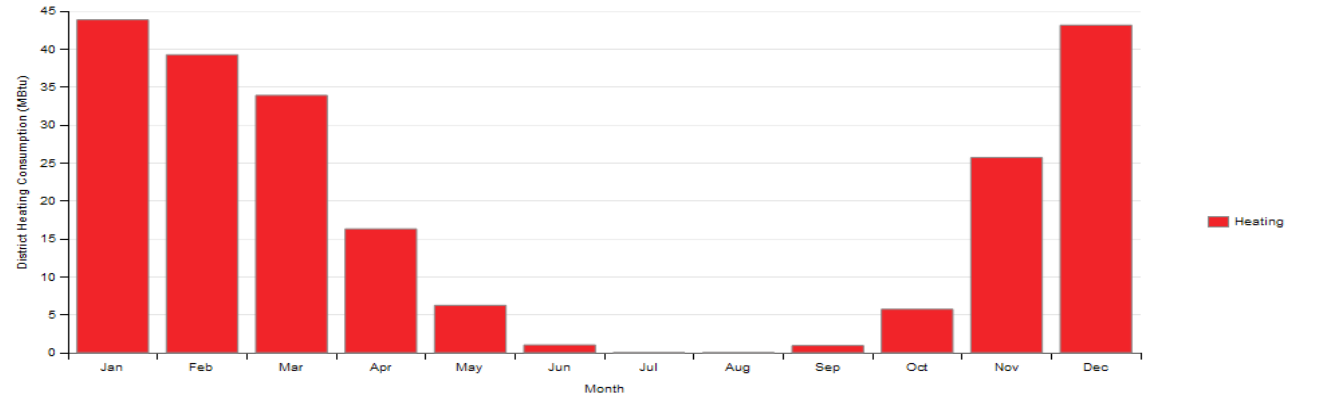
Electricity Consumption (kWh) - view table



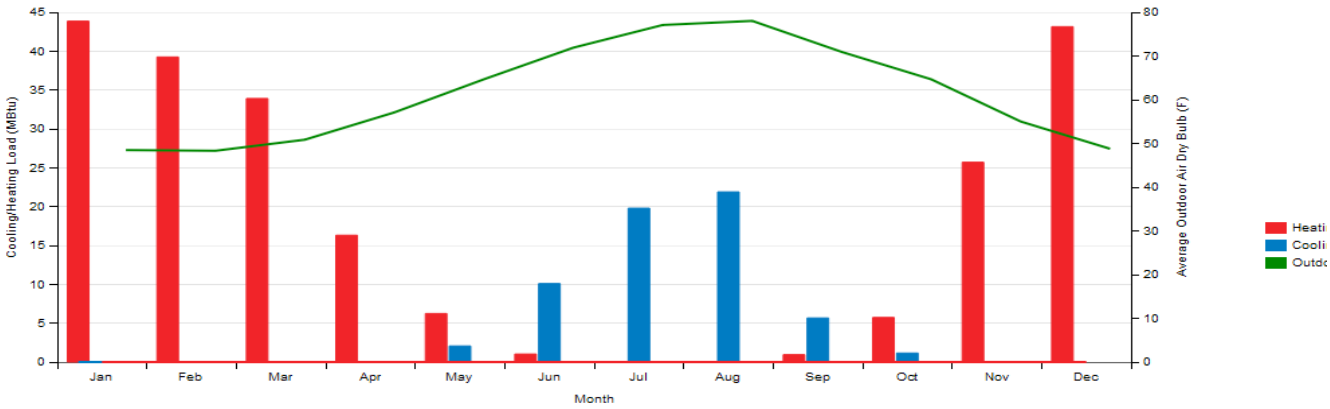
District Cooling Consumption (MBtu) - view table



District Heating Consumption (MBtu) - view table



Monthly Load Profiles - view table



_CITY 3: MODIFIED WALL 2

NAPLES, ITALY

MODIFIED WALL 2 Characteristics: Stucco (0.025 m) | Concrete (0.203 m) | Wall Insulation (0.079 m) | Gypsum (0.012 m)

Building Summary

Information	Value	Units
Building Name	Building 1	building_name
Net Site Energy	387,174	kBtu
Total Building Area	5,683	ft^2
EUI (Based on Net Site Energy and Total Building Area)	68.12	kBtu/ft^2
OpenStudio Standards Building Type		

Weather Summary

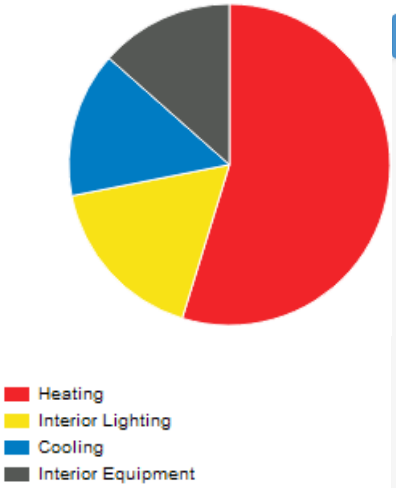
	Value
Weather File	NAPLES - ITA IWEC Data WMO#=162890
Latitude	40.85
Longitude	14.30
Elevation	236 (ft)
Time Zone	1.00
North Axis Angle	0.00
ASHRAE Climate Zone	

Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 1	5,683	16	19.96
modified wall 2	5,386	69	11.76

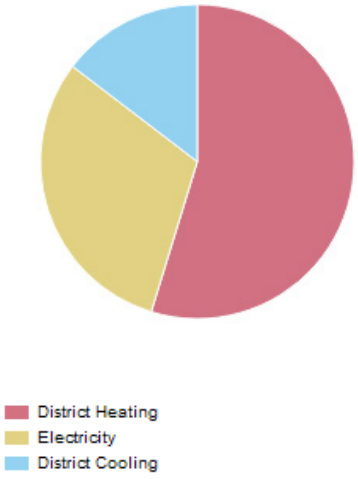
_CITY 3: MODIFIED WALL 2

NAPLES, ITALY



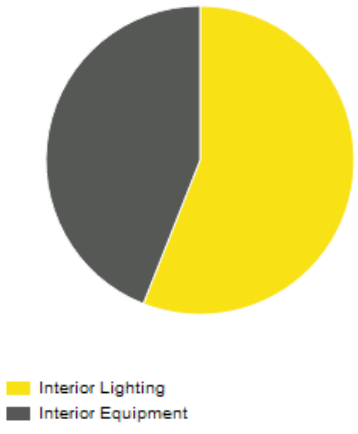
End Use - view table

End Use	Consumption (kBtu)
Heating	211,960
Cooling	56,651
Interior Lighting	66,395
Exterior Lighting	0
Interior Equipment	52,168
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	118,562
Natural Gas	0
Additional Fuel	0
District Cooling	56,651
District Heating	211,960



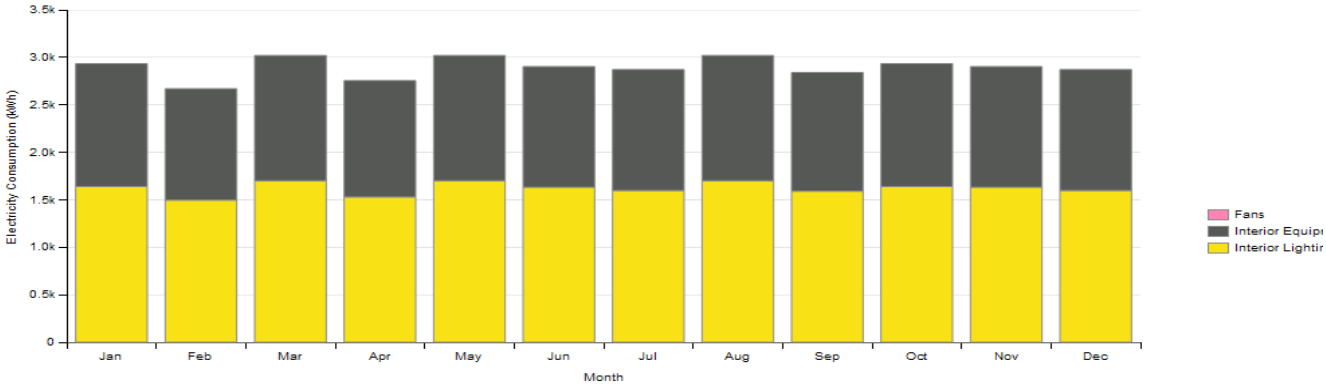
EUI - Electricity - view table

End Use	Consumption (kWh)
Heating	0
Cooling	0
Interior Lighting	19,458
Exterior Lighting	0
Interior Equipment	15,289
Exterior Equipment	0
Fans	0
Pumps	0
Heat Rejection	0
Humidification	0
Heat Recovery	0
Water Systems	0
Refrigeration	0
Generators	0

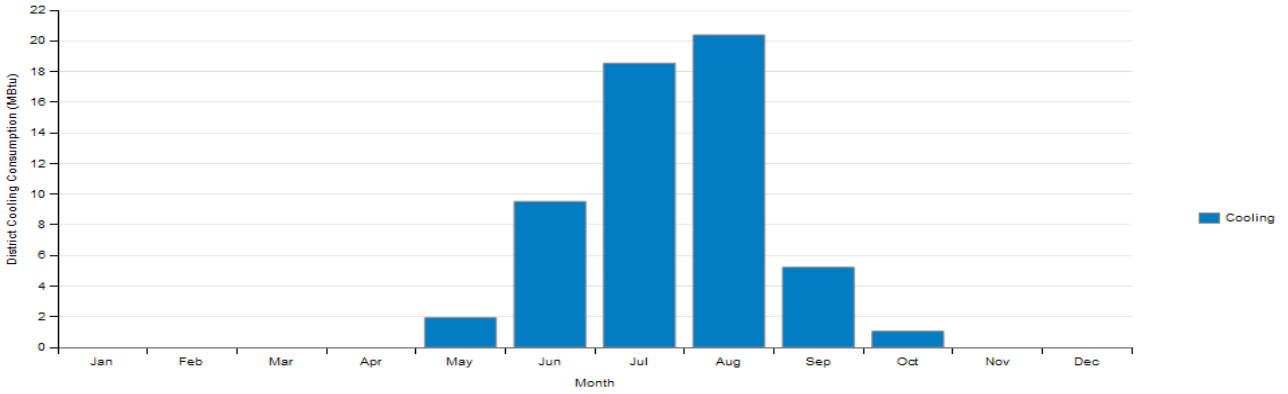
_CITY 3: MODIFIED WALL 2

NAPLES, ITALY

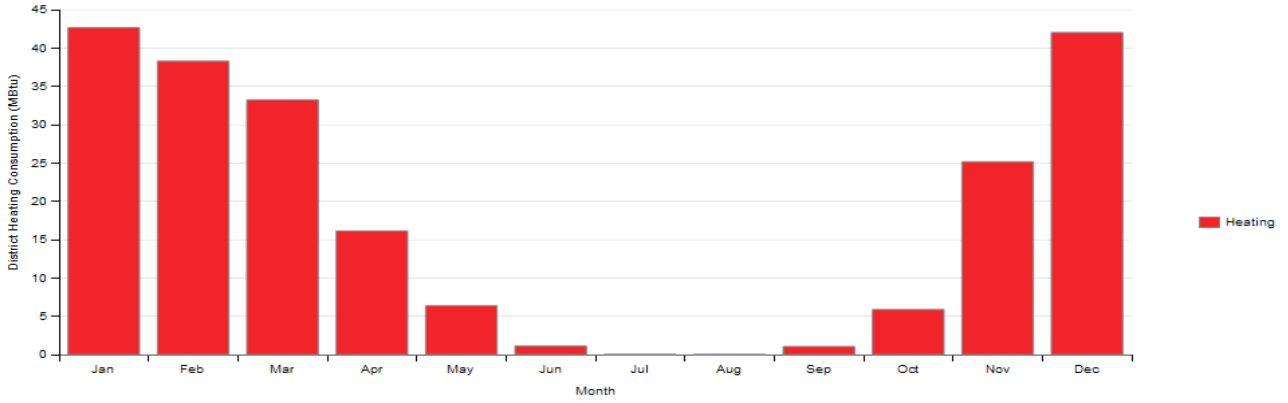
Electricity Consumption (kWh) - view table



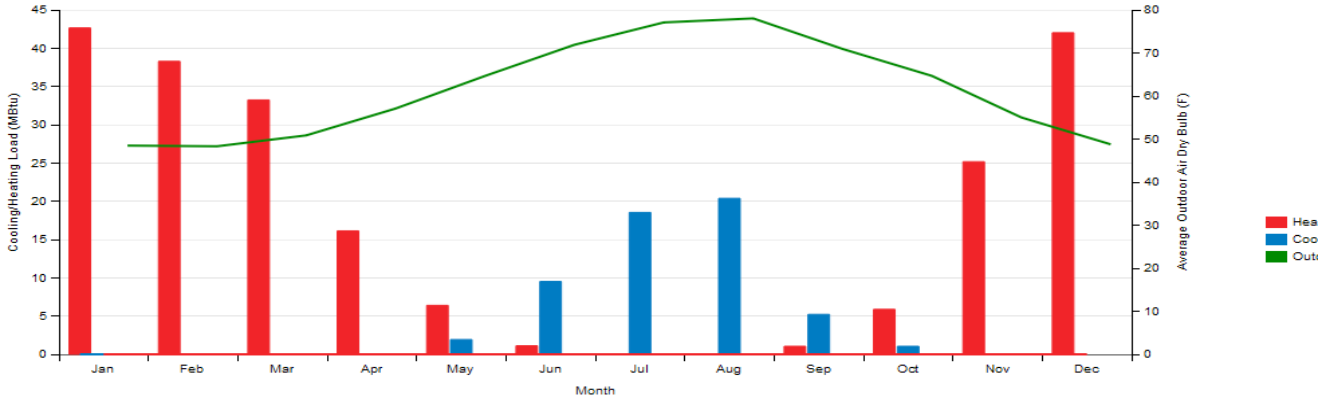
District Cooling Consumption (MBtu) - view table



District Heating Consumption (MBtu) - view table



Monthly Load Profiles - view table



_CITY 3: MODIFIED WALL 3

NAPLES, ITALY

MODIFIED WALL 3 Characteristics: Stucco (0.025 m) | Concrete (0.203 m) | Wall Insulation (0.110 m) | Gypsum (0.012 m)

Building Summary

Information	Value	Units
Building Name	Building 1	building_name
Net Site Energy	383,411	kBtu
Total Building Area	5,683	ft^2
EUI (Based on Net Site Energy and Total Building Area)	67.46	kBtu/ft^2
OpenStudio Standards Building Type		

Weather Summary

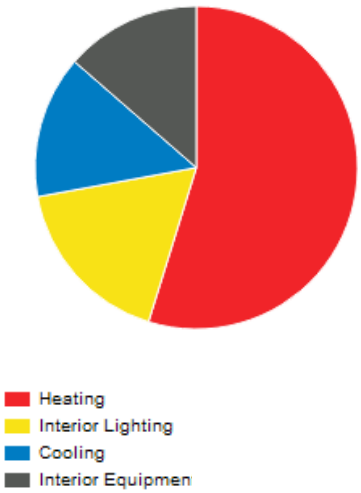
	Value
Weather File	NAPLES - ITA IWEC Data WMO#=162890
Latitude	40.85
Longitude	14.30
Elevation	236 (ft)
Time Zone	1.00
North Axis Angle	0.00
ASHRAE Climate Zone	

Base Surface Constructions

Construction	Net Area (ft^2)	Surface Count	R Value (ft^2*h*R/Btu)
ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 1	5,683	16	19.96
modified wall 3	5,386	69	15.84

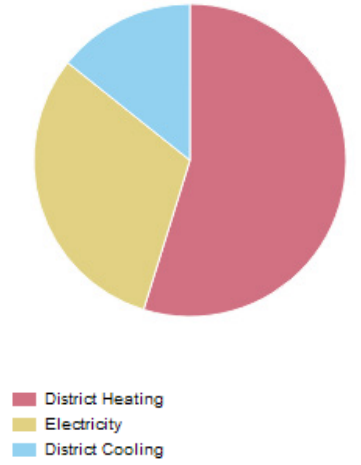
_CITY 3: MODIFIED WALL 3

NAPLES, ITALY



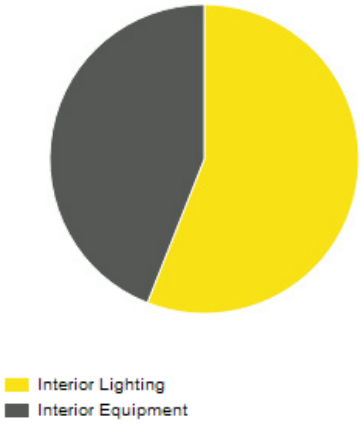
End Use - view table

End Use	Consumption (kBtu)
Heating	210,084
Cooling	54,765
Interior Lighting	66,395
Exterior Lighting	0
Interior Equipment	52,168
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	118,562
Natural Gas	0
Additional Fuel	0
District Cooling	54,765
District Heating	210,084



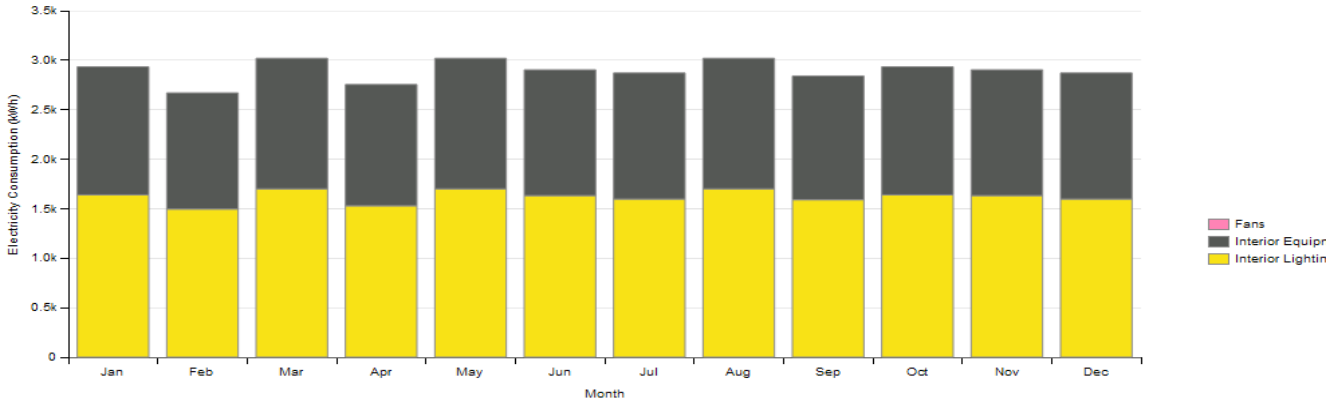
EUI - Electricity - view table

End Use	Consumption (kWh)
Heating	0
Cooling	0
Interior Lighting	19,458
Exterior Lighting	0
Interior Equipment	15,289
Exterior Equipment	0
Fans	0
Pumps	0
Heat Rejection	0
Humidification	0
Heat Recovery	0
Water Systems	0
Refrigeration	0
Generators	0

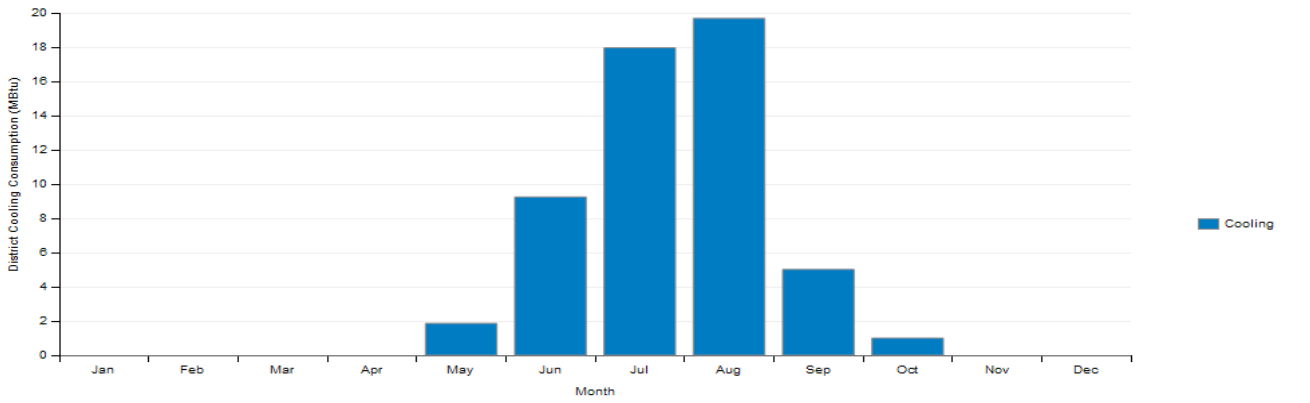
_CITY 3: MODIFIED WALL 3

NAPLES, ITALY

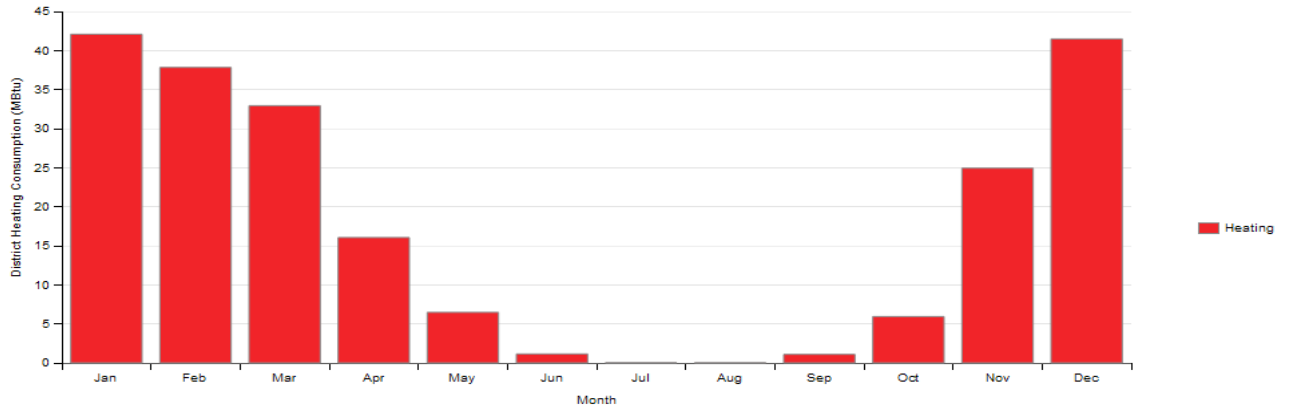
Electricity Consumption (kWh) - view table



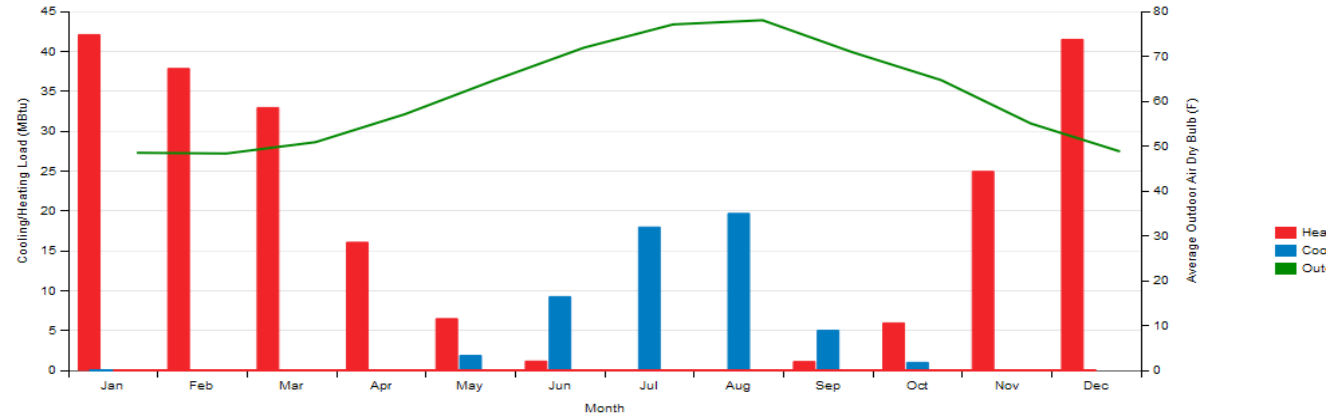
District Cooling Consumption (MBtu) - view table



District Heating Consumption (MBtu) - view table



Monthly Load Profiles - view table



_CITY 3: COMPARISM WITH BASE CASE

NAPLES, ITALY

The report show that the Net site energy consumption for city 3 is lower than the base case.

By using the weather data of Piacenza for base case, and the weather data of Naples with different wall characteristics, the results below reflect that each case has a different effect on the yearly energy consumption of the building. The thicker the wall insulation, the lower the energy consumed.

	Base Case	M.Wall 1	M.Wall 2	M.Wall 3	Unit
Net Site Energy	589,713	395,458	387,174	383,411	KBtu
Total Building Area	5, 683	5, 683	5, 683	5, 683	ft^2
EUI *(Based on Net Site Energy and Total Building Area)*	103	69	68	67	KBtu/ ft^2
Electricity	118,562	118,562	118,562	118,562	KBtu
District Cooling	32,027	60,698	56,651	54,765	KBtu
District Heating	439,124	216,197	211,960	210,084	KBtu

M. WALL 1 Characteristics: Stucco (0.025 m) | Concrete (0.203 m) | **Wall Insulation (0.068 m)** | Gypsum (0.012 m)
M. WALL 2 Characteristics: Stucco (0.025 m) | Concrete (0.203 m) | **Wall Insulation (0.079 m)** | Gypsum (0.012 m)
M. WALL 3 Characteristics: Stucco (0.025 m) | Concrete (0.203 m) | **Wall Insulation (0.110 m)** | Gypsum (0.012 m)

Units of measurement
kBtu = kilo-British thermal unit
ft^2 = square feet
m = meter

To convert kilo-British thermal unit (kBtu) to kilo-Watt-hour (kWh)
1 kBtu = 0.293 kWh
Example; for base case Net Site Energy of 589,713 kBtu X 0.293 = **172,785 kWh**

CONCLUSION

Based on using the weather data of Piacenza for base case, and the weather data of three cities; Hamburg, Geneva and Naples, each with different wall characteristics by changing the wall insulation. The results reflect that each case has a different effect on the yearly energy consumption of the building. Also, the thicker the wall insulation, the lower the energy consumed.

Summary comparism of all three cities with base case (Piacenza);

_City 1 (Hamburg): Net site energy consumption is higher than the base case

_City 2 (Geneva): Net site energy consumption is higher than the base case

_City 3 (Naples): Net site energy consumption is lower than the base case

Therefore, the simulation of a commercial office building, Using SketchUp and OpenStudio software to achieve the building's yearly energy consumption, made it clear that with any change on the position or wall characterictics of a building, there will be an evident effect on the building's energy consumption.