BUILDING SIMULATION PROJECT

REPORT
TECHNICAL AND ENVIRONMENTAL SYSTEM

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This report is made based on the results obtained on the simulations run for an office building which was first designed on **SketchUp** and then the characteristics were defined on **OpenStudio**. The weather data was taken from **Energyplus**, and the heating/ cooling footprints were then traced to determine the efficiency of the building systems. Next, a parametric study is conducted to investigate the effects of changing characteristics of the building's yearly energy consumption. Following this, the simulation is performed for three different cities (**Milan, Abu Dhabi and Reykjavik**), and **three different combinations of wall types, window, roof** and the corresponding yearly consumption values obtained are compared with the ones of the base case.

DESCRIPTION OF BUILDING

The building considered for this simulation project is a medium- sized office building which has specified characteristics.

Area of building- 4200 sq.m
Number of floors- 3

Areas allocated in the plans with different thermal zones are

- **Open office-** This is the area where the employees can work in cubicles. This needs to have a separate thermal zone since the exchange of air over a large area needs to be controlled.
- **Conference Room -** These spaces include cabins and meeting rooms.
- **Break room-** This is a designated room on each floor for the employees to use in the lunch break. It will be used relatively lesser by the employees for a couple of hours effectively in a day.
- **Rest rooms-** These are the washroom areas for the employees on each floor.
- **IT Room-** This is room for the central severs, other electrical devices and computer systems.
- **Corridors-** These are the connecting spaces on each floor.

Although it is not physically possible, for ease of the calculation of results we have considered the same thermal zones for all the upper floors as it is in the ground floor.

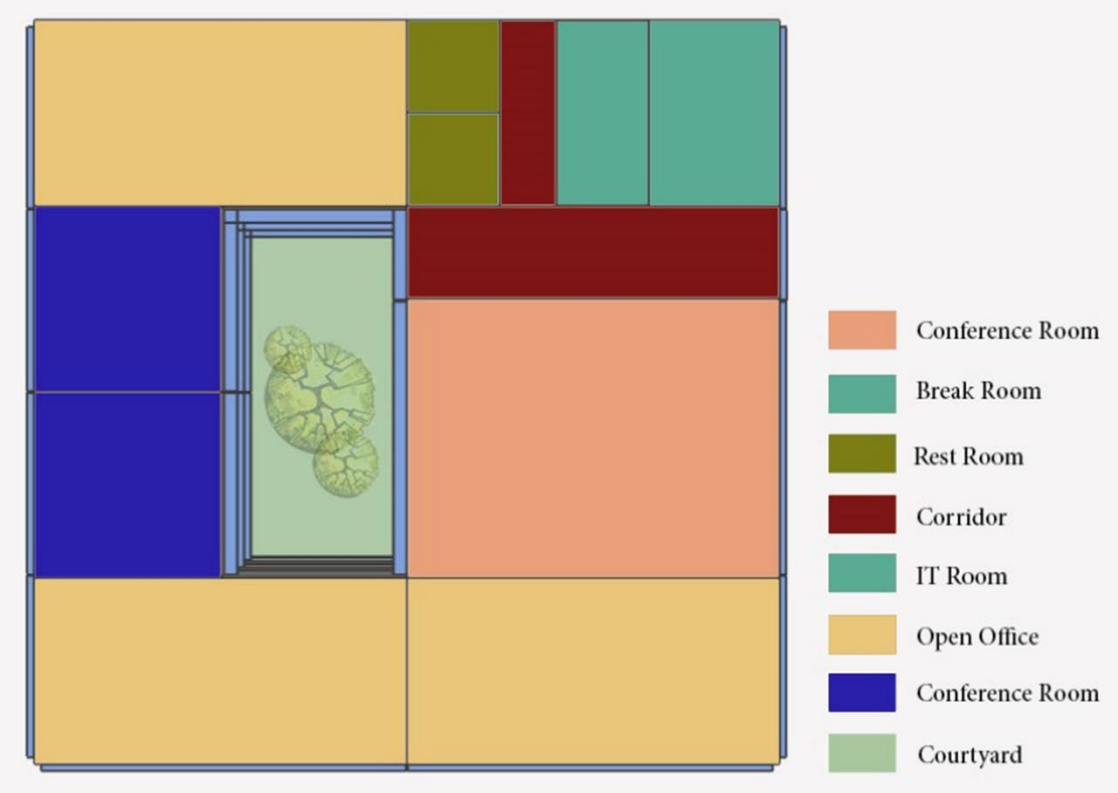


Figure 1: Typical Floor Plan

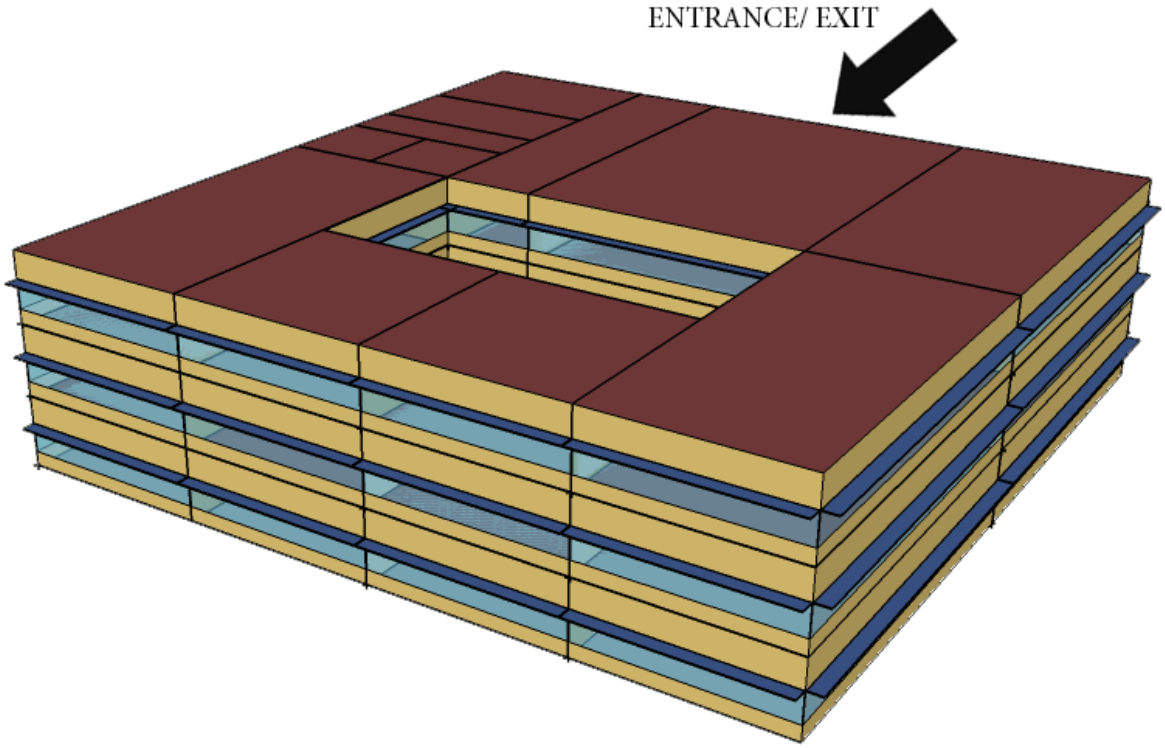


Figure 2: View of base Model of building

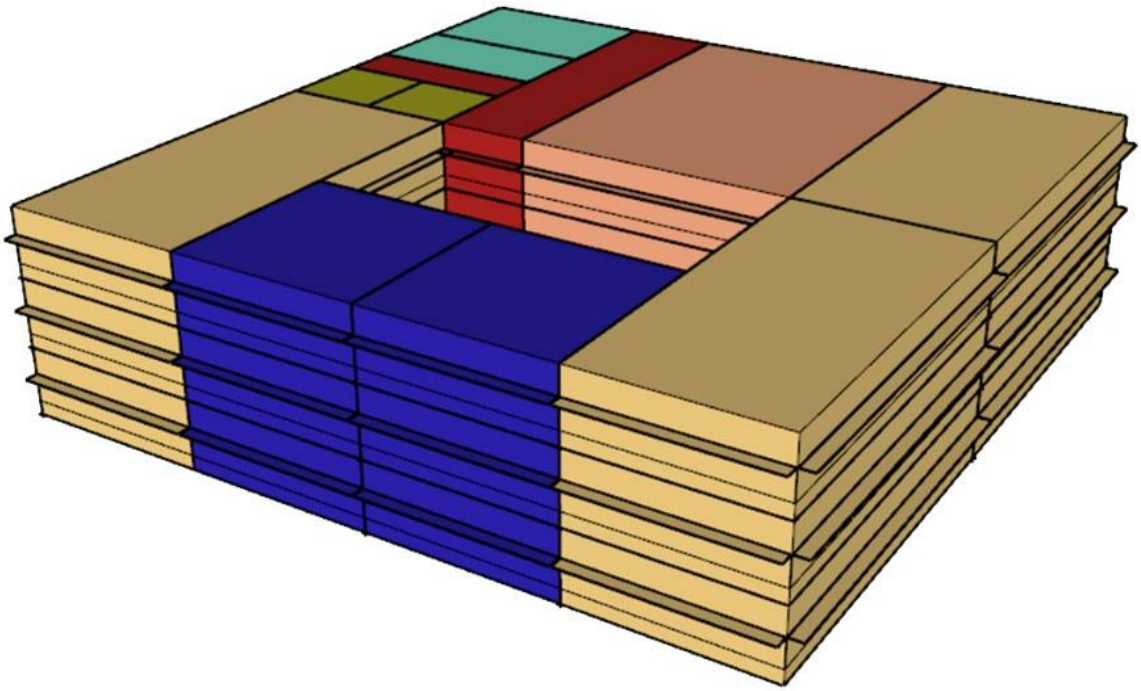


Figure 3: Different Thermal Zones

Location 1: MILAN

Milan has a **humid subtropical climate**, according to the Köppen climate classification, or a temperate oceanic climate, according to the Trewartha climate classification. Milan's climate is like much of Northern Italy's inland plains, with hot, sultry summers and cold, foggy winters.

According to the international Climate Zone Definitions, Milan comes under Zone 4.

Climate Data for Milan

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature (°C)	1.9	4.3	8.7	13	17.6	21.1	23.8	22.8	19.3	13.4	7.7	3.3
Min. Temperature (°C)	-0.8	0.9	4.3	7.9	12.1	15.8	18.3	17.8	14.7	9.5	4.6	0.6
Max. Temperature (°C)	4.7	7.8	13.1	18.2	23.1	26.5	29.3	27.8	24	17.4	10.8	6
Precipitation / Rainfall (mm)	55	62	79	92	94	97	67	90	78	118	110	71

SITE AND SOURCE ENERGY

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	2287.8	544.71	544.71
Net Site Energy	2287.8	544.71	544.71
Total Source Energy	6663.15	1586.47	1586.47
Net Source Energy	6663.15	1586.47	1586.47

END USES

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]
Heating	0	0	0	0	904.25
Cooling	0	0	0	466.96	0
Interior Lighting	550.7	0	0	0	0
Interior Equipment	365.89	0	0	0	0

Location 2: ABU DHABI

Abu Dhabi has a **hot desert climate** (Köppen climate classification BWh). Sunny blue skies can be expected throughout the year. The months of June through September are generally extremely hot and humid. During this time, sandstorms occur intermittently, in some cases reducing visibility to a few meters.

According to the international Climate Zone Definitions, Abu Dhabi comes under Zone 1.

Climate Data for Abu Dhabi

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature (°C)	18.2	19.1	22.2	26	30.6	32	34.1	34.2	32	28.7	24.5	20.2
Min. Temperature (°C)	12.7	13.8	16.5	19.7	23.9	25.5	28.2	28.5	25.7	22.2	18.2	14.6
Max. Temperature (°C)	23.8	24.5	27.9	32.4	37.4	38.6	40	40	38.4	35.3	30.9	25.9
Precipitation / Rainfall (mm)	8	29	18	7	0	0	1	0	0	0	0	12

SITE AND SOURCE ENERGY

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	2805.91	668.07	668.07
Net Site Energy	2805.91	668.07	668.07
Total Source Energy	5044.63	1201.10	1201.10
Net Source Energy	5044.63	1201.10	1201.10

END USES

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]
Heating	0.00	0.00	0.00	0.00	57.59
Cooling	0.00	0.00	0.00	1831.73	0.00
Interior Lighting	550.70	0.00	0.00	0.00	0.00
Interior Equipment	365.89	0.00	0.00	0.00	0.00

Location 3: REYKJAVIC

The climate of Iceland is subarctic (Köppen climate classification: CFC) near the southern coastal area and tundra inland in the highlands. In Reykjavík, the summers are short, cool, and mostly cloudy and the winters are long, very cold, wet, windy, and overcast. Over the course of the year, the temperature typically varies from *28°F*to *57°F* and is rarely below *17°F* or above *62°F*.

According to the international Climate Zone Definitions, Reykjavic comes under Zone 7.

Climate data for Reykjavik

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature (°C)	-0.2	0.5	0.8	3.1	6.6	9.2	11	10.6	7.9	4.7	1.6	0.1
Min. Temperature (°C)	-2.5	-1.9	-1.6	0.5	3.8	6.7	8.5	8.2	5.5	2.5	-0.6	-2.2
Max. Temperature (°C)	2.2	2.9	3.3	5.8	9.5	11.8	13.6	13.1	10.4	6.9	3.8	2.5
Precipitation / Rainfall (mm)	83	80	79	59	54	50	54	68	75	96	87	84

SITE AND SOURCE ENERGY

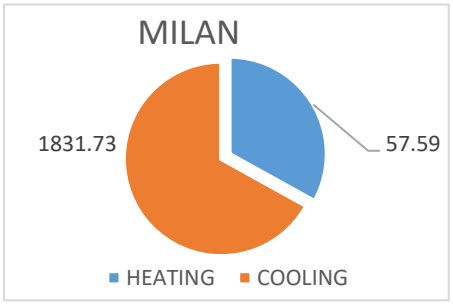
	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	2670.92	635.93	635.93
Net Site Energy	2670.92	635.93	635.93
Total Source Energy	9202.10	2190.98	2190.98
Net Source Energy	9202.10	2190.98	2190.98

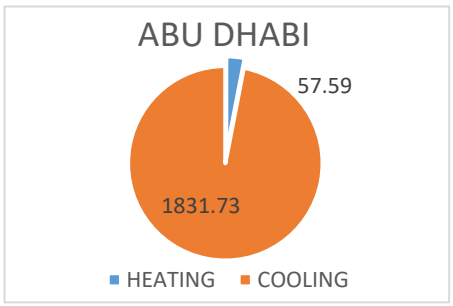
END USES

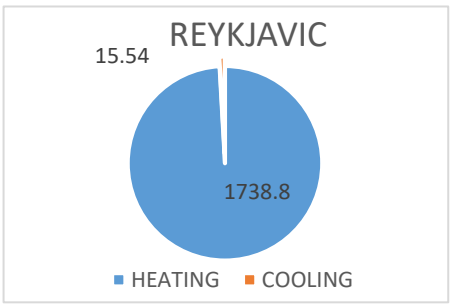
	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]
Heating	0.00	0.00	0.00	0.00	1738.80
Cooling	0.00	0.00	0.00	15.54	0.00
Interior Lighting	550.70	0.00	0.00	0.00	0.00
Interior Equipment	365.89	0.00	0.00	0.00	0.00

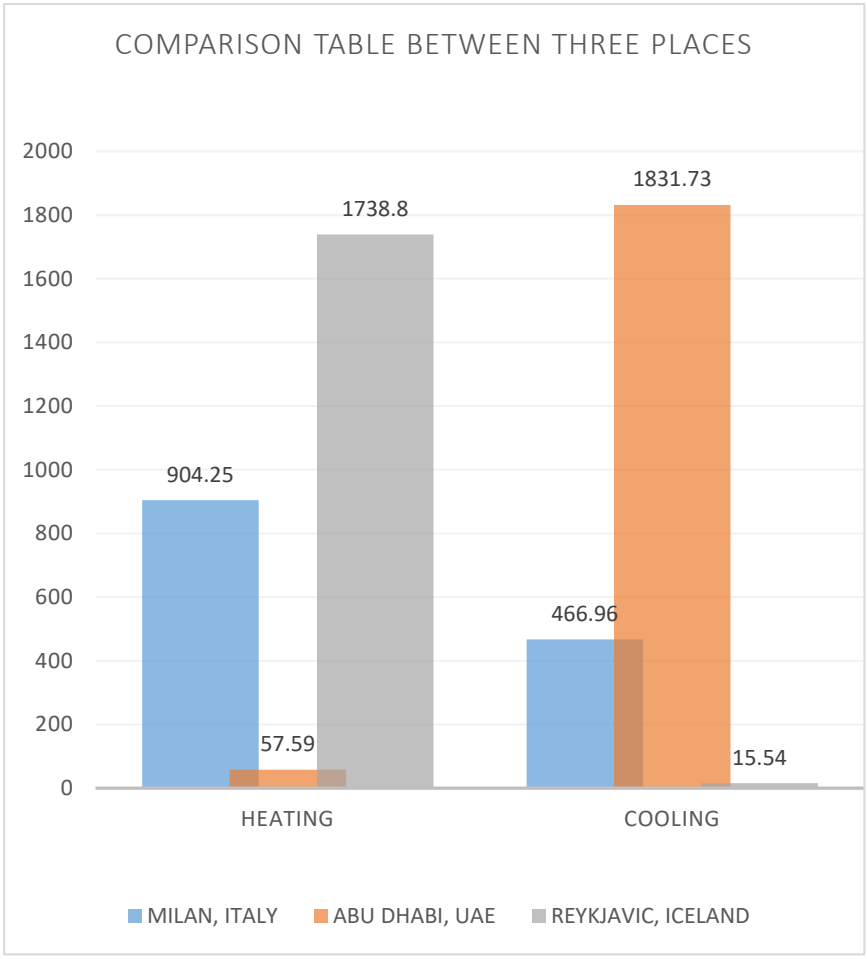
COMPARISON TABLE FOR DIFFERENT LOCATIONS

LOCATION	MILAN, ITALY	ABU DHABI, UAE	REYKJAVIC, ICELAND
Heating (GJ)	904.25	57.59	1738.8
Cooling (GJ)	466.96	1831.73	15.54









CONCLUSION

In conclusion, based on our analysis and the simulations run by OpenStudio and EnergyPlus, we observe that our proposed building will be best suited in Milano Linate, Italy because it will consume lesser energy in terms of heating and cooling annually.

In Abu Dhabi, artificial heating is almost unnecessary for most part of the year as the climate is sub desert. Whereas, the cooling load is high due to long and hot summers. The high amount of glass used in the building exterior can be another reason for the same.
In Reykjavik, on the contrary, the heating load is much more than that for Milan or Abu Dhabi due to its severe winters and cold climate.

MODIFIED WALL SIMULATIONS FOR MODEL IN REYKJAVIC

MODIFICATION-1

The exterior walls have been modified in the following way, from the exterior most to the interior most.

- 1" stucco
- 8" concrete HW
- F04 wall air space
- M11 100mm lightweight concrete
- Wall Insulation [31]
- ½ IN Gypsym
- 101 25mm insulation board
- 25mm wood

SITE AND SOURCE ENERGY

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	2643.79	629.47	629.47
Net Site Energy	2643.79	629.47	629.47
Total Source Energy	9105.86	2168.06	2168.06
Net Source Energy	9105.86	2168.06	2168.06

END USES

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]
Heating	0.00	0.00	0.00	0.00	1712.37
Cooling	0.00	0.00	0.00	14.83	0.00
Interior Lighting	550.70	0.00	0.00	0.00	0.00
Interior Equipment	365.89	0.00	0.00	0.00	0.00

MODIFICATION-2

The exterior walls have been modified in the following way, from the exterior most to the interior most. Also added to this, the material of the windows have been altered to obtain maximum results.

Exterior Wall

- 1" stucco
- 8" concrete HW
- F04 wall air space
- M11 100mm lightweight concrete
- Wall Insulation [31]
- ½ IN Gypsum
- 101 25mm insulation board 25mm wood

Glazing Window Materials

ASHRAE 189.1-2009

- Theoretical Glass [221]
- *Modified Glass*
  - Thickness- 0.006m

- Solar Transmittance at Normal Incidence – 0.5
- Front side Solar Reflectance at Normal Incidence – 0.3
- Back side Solar Reflectance at Normal Incidence – 0.45
- Visible Transmittance – 0.45

- Clear glass 3mm

SITE AND SOURCE ENERGY

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	2397.96	570.94	570.94
Net Site Energy	2397.96	570.94	570.94
Total Source Energy	8185.80	1949.00	1949.00
Net Source Energy	8185.80	1949.00	1949.00

END USES

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]
Heating	0.00	0.00	0.00	0.00	1454.11
Cooling	0.00	0.00	0.00	27.26	0.00
Interior Lighting	550.70	0.00	0.00	0.00	0.00
Interior Equipment	365.89	0.00	0.00	0.00	0.00

MODIFICATION-3

The exterior walls have been modified in the following way, from the exterior most to the interior most. Also added to this, the material of the windows have been altered to obtain maximum results. Additionally, the roof material has been modified to obtain the maximum comfortable result in this region.

Exterior Wall

- 1" stucco
- 8" concrete HW
- F04 wall air space
- M11 100mm lightweight concrete
- Wall Insulation [31]
- ½ IN Gypsum
- 101 25mm insulation board 25mm wood

Glazing Window Materials

Modified ASHRAE 189.1-2009

- Theoretical Glass [221]
- Modified Glass
  - Thickness- 0.006m
  - Solar Transmittance at Normal Incidence – 0.5
  - Front side Solar Reflectance at Normal Incidence – 0.3
  - Back side Solar Reflectance at Normal Incidence – 0.45
  - Visible Transmittance – 0.45
- Clear 3mm

Roof Materials

Modified ASHRAE 189.1-2009 ExtWindow ClimateZone 7-8

- Roof Membrane
- Roof Insulation[18]
- F05 Ceiling air resistance
- Roof Insulation[25]
- G05 25mm wood

SITE AND SOURCE ENERGY

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	2336.43	556.29	556.29
Net Site Energy	2336.43	556.29	556.29
Total Source Energy	7961.55	1895.61	1895.61
Net Source Energy	7961.55	1895.61	1895.61

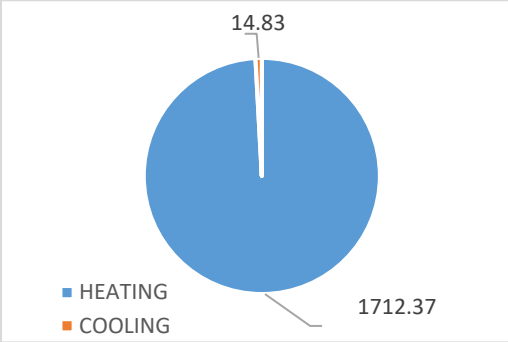
END USES

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]
Heating	0.00	0.00	0.00	0.00	1391.83
Cooling	0.00	0.00	0.00	28.01	0.00
Interior Lighting	550.70	0.00	0.00	0.00	0.00
Interior Equipment	365.89	0.00	0.00	0.00	0.00

COMPARISON BETWEEN THE THREE MODIFICATIONS

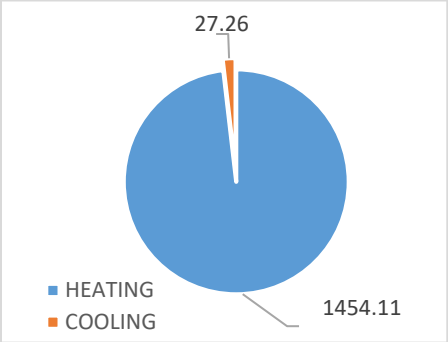
MODIFICATION 01

Only Wall



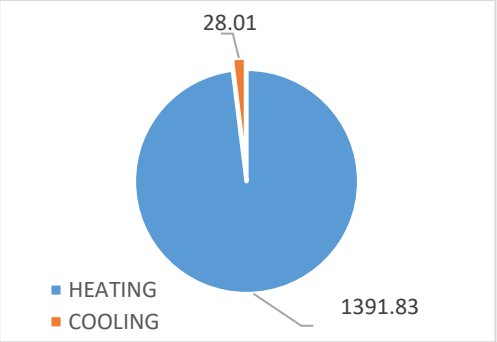
MODIFICATION 02

Wall + Window



MODIFICATION 03

Wall + Window + Roof



	Base Model	Modification 01	Modification 02	Modification 03
Heating	1738.8	1712.37	1454.11	1391.83
Cooling	15.54	14.83	27.26	28.01
Total Site Energy	2670.92	2643.79	2397.96	2336.43
Total Source Energy	9202.1	9105.86	8185.8	7961.55

CONCLUSION

From the comparative tale given above, **MODIFICATION 03** is proved to be the best option since it displays lesser consumption for heating in a region like Reykjvik, and shows less variation for cooling. Thus providing air gaps in external walls and windows; and providing roof insulation would be the best solution for reducing the loads on a building in a cold climate like Reykjvik.