BUILDING SIMULATION PROJECT

TECHNICAL ENVIRONMENT SYSTEMS- SEMESTER 1

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INTRODUCTION

This report is made based on the results obtained on the simulations run for an office building which was first introduced on SketchUp and then the characteristics were defined on OpenStudio. 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 Linate, Piacenza and New York), and three different wall types, and the corresponding obtained yearly consumptions 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- 5376 sqm
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.
- **Closed office**- These spaces include cabins of senior employees and small conference 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.
- **Stair**- This is the vertical circulation lobby which involves the staircases and elevators.
- **Corridors**- These are the connecting spaces on each floor.

FLOOR PLANS

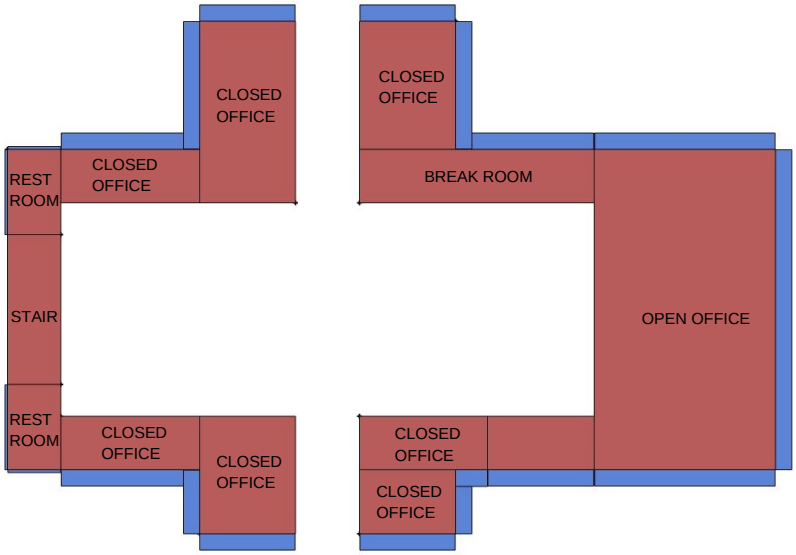


Figure 1: Ground floor plan

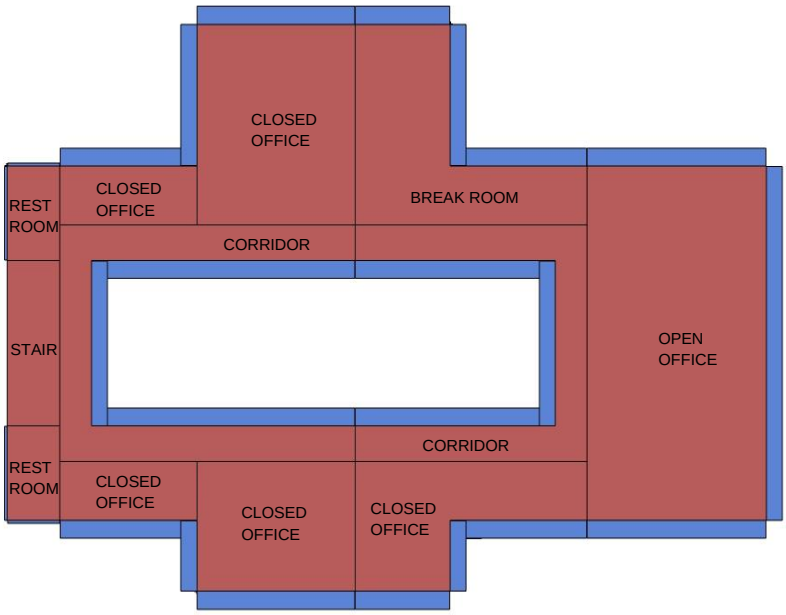


Figure 2: Typical floor plan

BASE MODEL COMPARISONS AT DIFFERENT LOCATIONS

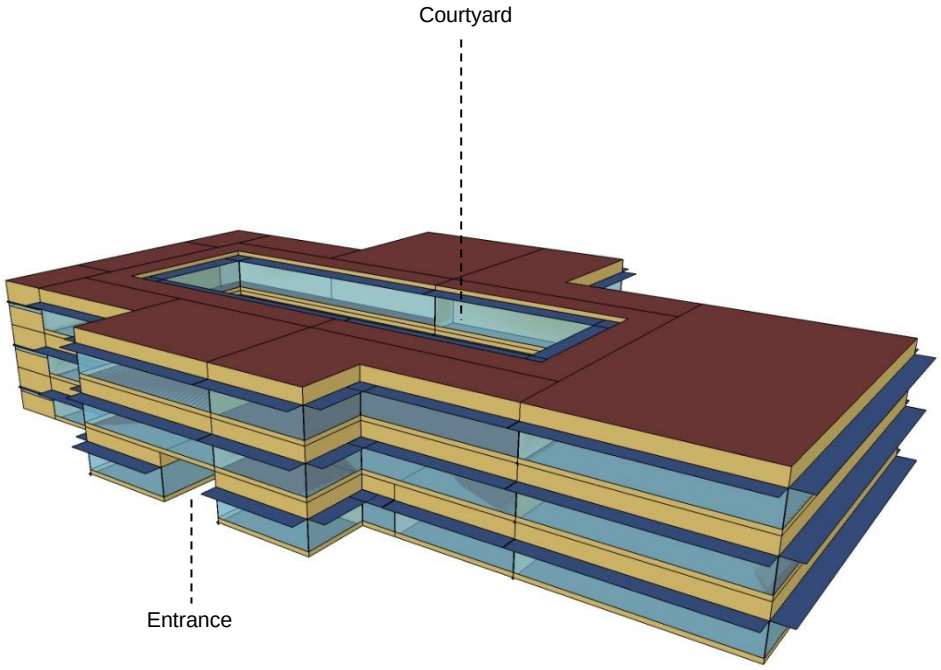


Figure 3: View of base model of building

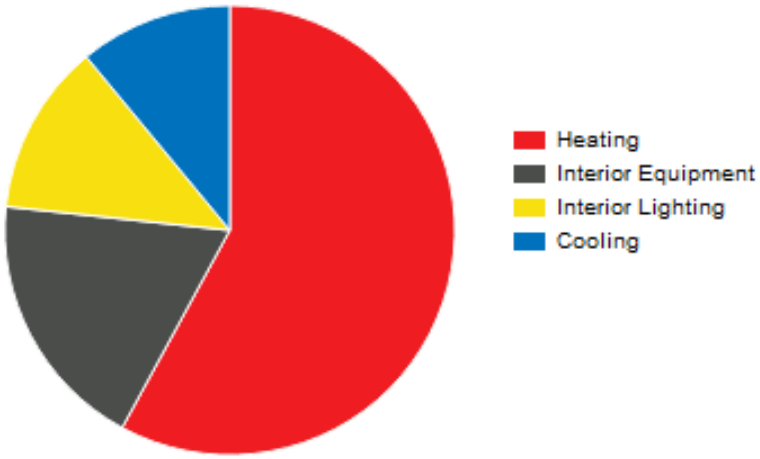
1. LOCATION: MILANO- LINATE

Climate- 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.

Climate data for Milan (Linate Airport, 1971–2000, Extremes 1946–present) [hide]

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C (°F)	**21.7 (71.1)**	**23.8 (74.8)**									**23.0 (73.4)**	**21.2 (70.2)**	
Average high °C (°F)	5.9 (42.6)	9.0 (48.2)	14.3 (57.7)	17.4 (63.3)	**22.3 (72.1)**	**26.2 (79.2)**			**24.4 (75.9)**	17.8 (64)	10.7 (51.3)	6.4 (43.5)	**17.7 (63.9)**
Daily mean °C (°F)	2.5 (36.5)	4.7 (40.5)	9.0 (48.2)	12.2 (54)	17.0 (62.6)	**20.8 (69.4)**	**23.6 (74.5)**	**23.0 (73.4)**	19.2 (66.6)	13.4 (56.1)	7.2 (45)	3.3 (37.9)	13.0 (55.4)
Average low °C (°F)	−0.9 (30.4)	0.3 (32.5)	3.8 (38.8)	7.0 (44.6)	11.6 (52.9)	15.4 (59.7)	**18.0 (64.4)**	17.6 (63.7)	14.0 (57.2)	9.0 (48.2)	3.7 (38.7)	0.1 (32.2)	8.3 (46.9)
Record low °C (°F)	**−15.0 (5)**	**−15.6 (3.9)**	−7.4 (18.7)	−2.5 (27.5)	−0.8 (30.6)	5.6 (42.1)	8.4 (47.1)	8.0 (46.4)	3.0 (37.4)	−2.3 (27.9)	−6.2 (20.8)	**−13.6 (7.5)**	**−15.6 (3.9)**
Average precipitation mm (inches)	58.7 (2.311)	49.2 (1.937)	65.0 (2.559)	75.5 (2.972)	95.5 (3.76)	66.7 (2.626)	66.8 (2.63)	88.8 (3.496)	93.1 (3.665)	122.4 (4.819)	76.7 (3.02)	61.7 (2.429)	920.1 (36.224)
Average precipitation days (≥ 1.0 mm)	**6.7**	**5.3**	**6.7**	**8.1**	**8.9**	**7.7**	**5.4**	**7.1**	**6.1**	**8.3**	**6.4**	**6.3**	**83.0**
Average relative humidity (%)	**86**	**78**	**71**	**75**	**72**	**71**	**71**	**72**	**74**	**81**	**85**	**86**	**77**
Mean monthly sunshine hours	**58.9**	96.1	151.9	177.0	210.8	243.0	285.2	251.1	186.0	130.2	**66.0**	**58.9**	1,915.1

ANNUAL OVERVIEW



SITE AND SOURCE ENERGY

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	4888.50	909.32	909.32
Net Site Energy	4888.50	909.32	909.32
Total Source Energy	15611.25	2903.88	2903.88
Net Source Energy	15611.25	2903.88	2903.88

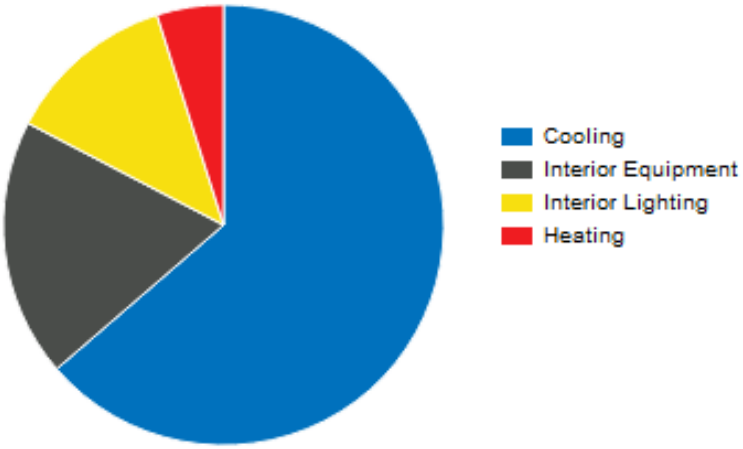
2. LOCATION: NEW DELHI

Climate- The climate of New Delhi is a monsoon-influenced humid subtropical climate (Köppen *Cwa*) bordering a hot semi-arid climate (Köppen *BSh*) with high variation between summer and winter in terms of both temperature and rainfall. The temperature varies from 46 °C (115 °F) in summers to around 0 °C (32 °F) in winters.

Climate data for New Delhi (Safdarjung) 1981–2010 [hide]

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C (°F)			40.6 (105.1)	45.6 (114.1)	47.2 (117)	46.7 (116.1)	45.0 (113)	42.0 (107.6)	40.6 (105.1)	39.4 (102.9)			47.2 (117)
Average high °C (°F)	20.5 (68.9)	23.9 (75)			39.5 (103.1)	39.2 (102.6)						23.1 (73.6)	
Average low °C (°F)	7.6 (45.7)	10.4 (50.7)	15.6 (60.1)	21.3 (70.3)	25.8 (78.4)			26.6 (79.9)	25.0 (77)	19.1 (66.4)	12.9 (55.2)	8.3 (46.9)	19.0 (66.2)
Record low °C (°F)	−0.6 (30.9)	1.6 (34.9)	4.4 (39.9)	10.7 (51.3)	15.2 (59.4)	18.9 (66)	20.3 (68.5)	20.7 (69.3)	17.3 (63.1)	9.4 (48.9)	3.9 (39)	1.1 (34)	−0.6 (30.9)
Average rainfall mm (inches)	19.3 (0.76)	22.1 (0.87)	15.9 (0.626)	13.0 (0.512)	31.5 (1.24)	82.2 (3.236)	187.3 (7.374)	232.5 (9.154)	129.8 (5.11)	14.3 (0.563)	4.9 (0.193)	9.4 (0.37)	762.3 (30.012)
Average rainy days	1.3	1.8	1.6	1.2	2.5	4.6	9.4	9.8	5.5	1.0	0.5	0.9	40.1
Average relative humidity (%)	63	55	47	34	33	46	70	73	62	52	55	62	54
Mean monthly sunshine hours	214.6	216.1	239.1	261.0	263.1	196.5	165.9	177.0	219.0	269.3	247.2	215.8	2,684.6

ANNUAL OVERVIEW

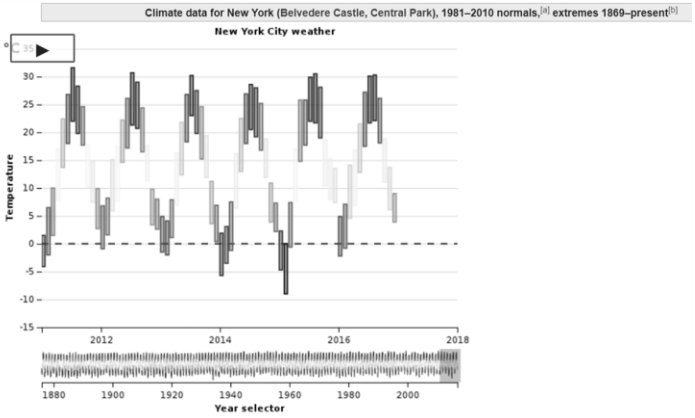


SITE AND SOURCE ENERGY

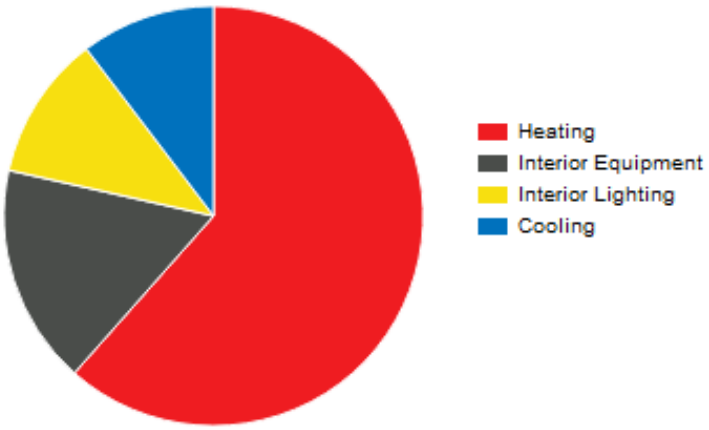
	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	4831.55	898.73	898.73
Net Site Energy	4831.55	898.73	898.73
Total Source Energy	8911.85	1657.71	1657.71
Net Source Energy	8911.85	1657.71	1657.71

3. LOCATION: NEW YORK CITY

Climate- Under the Köppen climate classification, using the 0 °C (32 °F) isotherm, New York City features a humid subtropical climate, and is thus the northernmost major city on the North American continent with this categorization. The suburbs to the immediate north and west lie in the transitional zone between humid subtropical and humid continental climates.



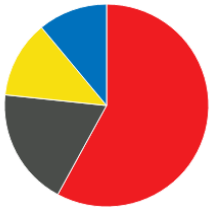
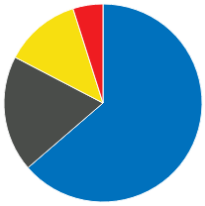
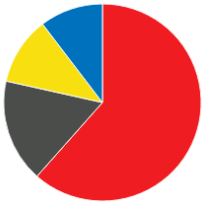
ANNUAL OVERVIEW



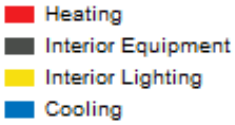
SITE AND SOURCE ENERGY

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	5405.83	1005.55	1005.55
Net Site Energy	5405.83	1005.55	1005.55
Total Source Energy	17422.24	3240.74	3240.74
Net Source Energy	17422.24	3240.74	3240.74

COMPARISON TABLE FOR DIFFERENT LOCATIONS

LOCATION	MILANO LINATE, ITALY	NEW DELHI, INDIA	NEW YORK, USA
ANNUAL OVERVIEW CHART			
HEATING (GJ)	2832.24	236.40	3326.78
COOLING (GJ)	537.46	3076.34	560.25
ELECTRICITY (GJ)	1518.81	1518.81	1518.81

LEGEND



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 New Delhi, artificial heating is almost unnecessary for most part of the year as the climate is tropical. Whereas, the cooling load is high due to long and hot summers. The high amount of glass used in the building exterior is another reason for the same.

In New York, on the contrary, the heating load is much more than that for Milan or New Delhi due to its severe winters.

MODIFIED WALL SIMULATIONS FOR MODEL IN MILANO LINATE

1. MODIFICATION for SIMULATION- 1

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

- 1” stucco
- 8” concrete HW 1
- F04 wall air space
- 8” concrete HW 2

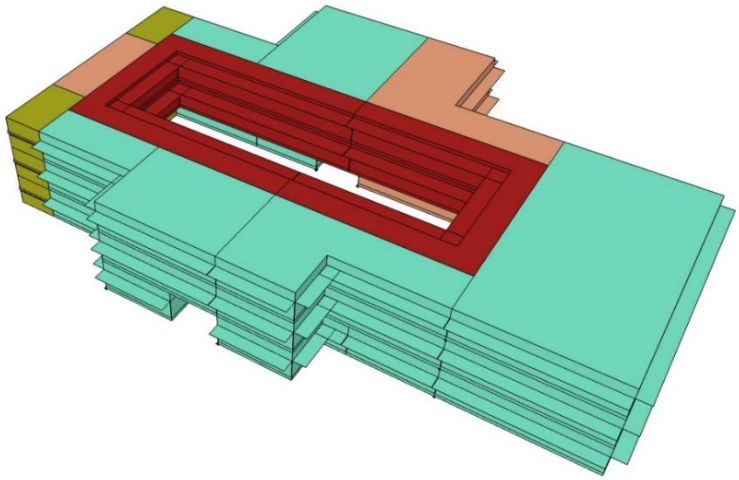
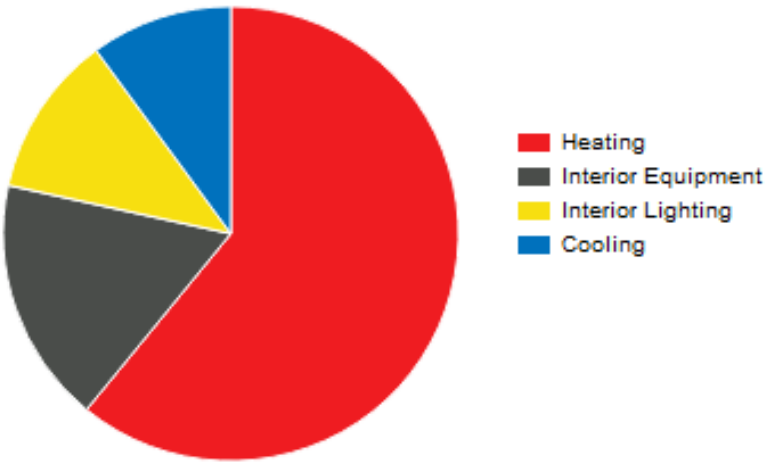


Figure 4: Space types in model for Simulation- 1

ANNUAL OVERVIEW



SITE AND SOURCE ENERGY

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	5235.26	973.82	973.82
Net Site Energy	5235.26	973.82	973.82
Total Source Energy	16889.68	3141.68	3141.68
Net Source Energy	16889.68	3141.68	3141.68

2. MODIFICATION for SIMULATION- 2

MODIFICATION**:** Some of the exterior and interior walls have been modified in the following way, from the **exterior most layer to the interior most layer.** Also, photovoltaic panels have been added to the top floor in an attempt to reduce the energy consumption.

Exterior wall	**Interior wall**
1" stucco	G01 19mm gypsum
8" concrete HW 1	F04 wall air space
I01 125mm insulation	G01 19mm gypsum
½ gypsum	-

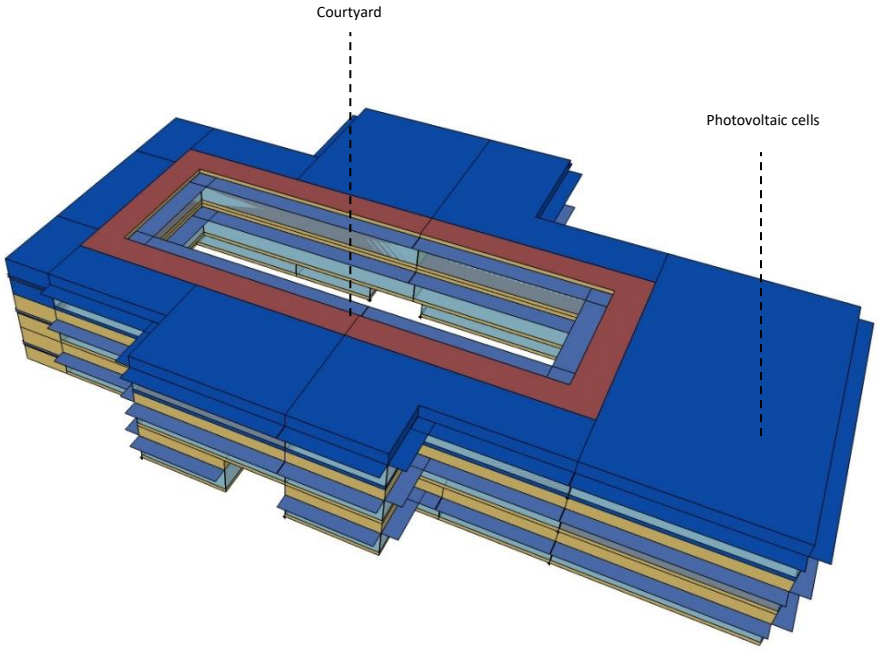
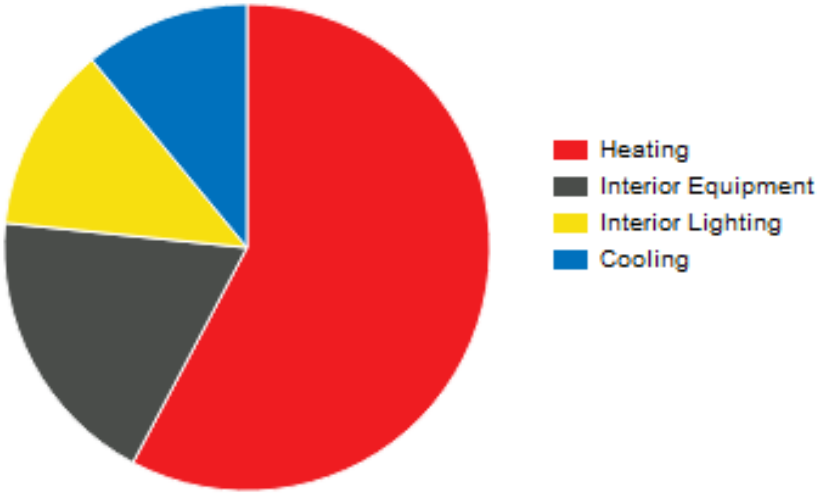


Figure 5: Photovoltaic panels used in model for Simulation 2



SITE AND SOURCE ENERGY

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	4865.43	905.03	905.03
Net Site Energy	3691.52	686.67	686.67
Total Source Energy	15532.51	2889.23	2889.23
Net Source Energy	11814.75	2197.68	2197.68

3. MODIFICATION for SIMULATION- 3

MODIFICATION**:** In this, we have changed the window- to- wall ratio and added photovoltaic panels.

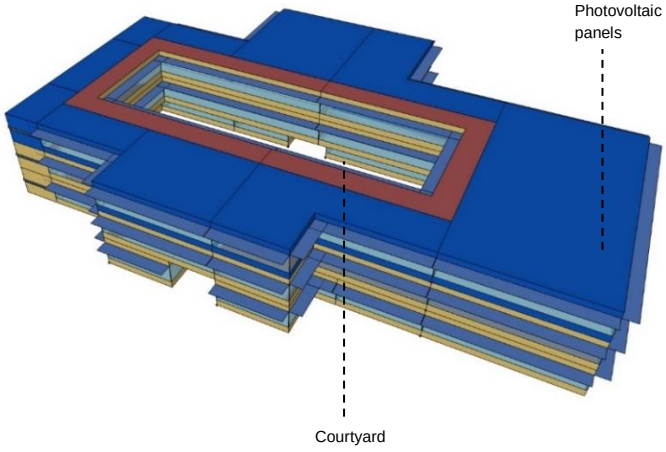
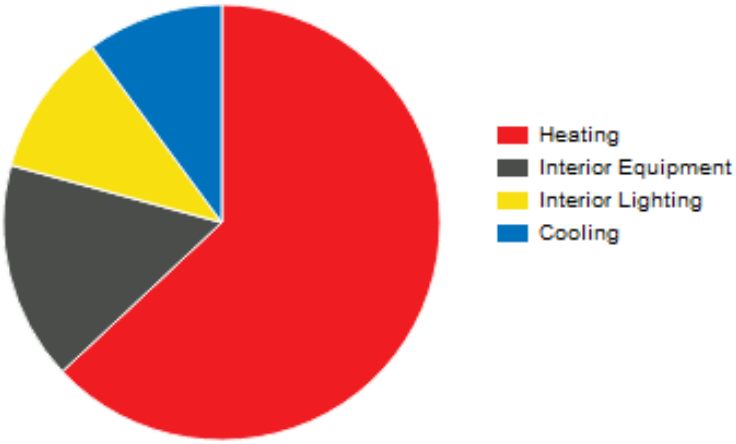


Figure 6: Photovoltaic panels for Simulation- 3

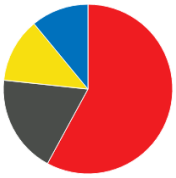
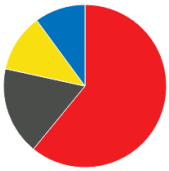
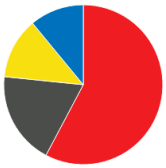
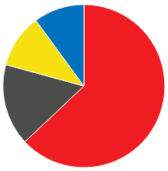
ANNUAL OVERVIEW



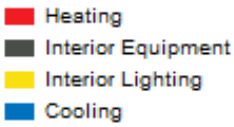
SITE AND SOURCE ENERGY

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	5647.82	1050.56	1050.56
Net Site Energy	4701.79	874.59	874.59
Total Source Energy	18270.34	3398.50	3398.50
Net Source Energy	15274.28	2841.20	2841.20

COMPARISON TABLE FOR DIFFERENT WALL MODIFICATIONS

MODIFICATION	BASE MODEL	MODIFICATION 1	MODIFICATION 2	MODIFICATION 3
ANNUAL OVERVIEW CHART				
HEATING (GJ)	2832.24	3188.96	2810.97	3558.49
COOLING (GJ)	537.46	527.49	535.65	570.53
ELECTRICITY (GJ)	1518.81	1518.81	1518.81	1518.81

LEGEND



CONCLUSION

From the comparison table given above, MODIFICATION-2 is better than modifications 1 and 3 because when compared to the base model, it displays lesser energy consumption for heating and cooling.

It is important to note that the best modification alternative used photovoltaic panels and had insulation gaps/ materials in interior as well as exterior walls.