Controlling natural lighting in educational spaces and saving energy

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Abstract

Natural lighting is a very important element in educational spaces. It gives students and teachers a feeling of Visual comfort, which will help Raise the efficiency of education. Also, it improves the quality of education because it facilitates communication between students and teachers. Additionally, using natural lighting help save the consumption of energy in the building. So, it is necessary to study the amount of lighting indoor educational spaces and its effect. Therefore, the study will include controlling natural lighting in educational spaces and its ability to save energy in El Arish; North Sinai; Egypt. So, the study contains four phases the first phase Analyzed the effect of different ratios of windows in the four external walls and their ability to save energy. Then, the second phase analyzed the effect of different ratios of windows in the external east wall and their ability to save energy. Additionally, the third phase studied the amount of lighting in the plan and section at different locations at the same time. Finally, the fourth phase studied the amount of lighting in the plan and section at the same location at different times. The finding will explain the effect of windows ratio at zone sensible heating, Comfort Temperature, Glazing Gains, and Wall Gains. Also, the effect of the location of the windowon the amount of natural lighting and the location of lighting inside the apace.

Keywords: Natural lighting; Energy saving; Educational spaces; visual comfort.

1. Introduction

Light is a very important environmental factor after water and food because it affects different bodily functions such as blood pressure, pulse, and brain activity[1, 2]. Natural lighting when compared with other forms of light, it had the richest spectral content which provides more usable light to the eye. the best lighting source for buildings is Natural lighting, including school buildings. The main requirement related to the health and comfort of a building is natural lighting [3, 4].

According to that natural lighting help student through reading by decreasing the amount of stress on the students' eyes[5].In many buildings' interior decoration, elevations, planning, and color selection are dependent on the availability of natural light.

The natural lighting in spaces depends on the shape of the opening, window size, the type of climate in the region, the method of construction of the light opening, and the main purpose of the building.[6] One of the main components spatial between the outside and inside is windows. Additionally, it is the main source of natural lighting [7]. The amount of daylight received on the ground varies with the location of the windows[8].

the main determinant of lighting requirements is Visual comfort [8]. The natural lighting benefits improved student attendance, reduced utility costs for school districts, academic performance, and a less stressful environment for students [9]. Also, it increased teacher and student attendance, reduced fatigue factors, improved student health, increased achievement rates, and enhancement of general development[10]. Additionally, natural lighting made students think better because it made them feel comfortable.

the primary light source in buildings Before the 1940s is natural lighting. The sun's rays increase the brightness or fade depending on the accompanying weather condition and the degree of sunlight throughout the day[11]. A space design should be taking natural light as a structural element [12], Because it creates dynamic spaces that reduce the energy needs of buildings and support human health and actions [5, 13]. The lighting sector consumes 20% of world electricity production, contributes 6% of global CO_2 emissions, and as much as 3% of world oil demand for the same purpose[14].

For the sake of energy savings, an architectural statement should integrate natural lighting into a building [5].Saving energy helped at reducing carbon dioxide emissions, leading to a decrease in greenhouse gases and ultimately a reduction in global warming. "The reduction in the use of energy in buildings has been identified as a major objective, of which electrical lighting energy is a significant factor [15]. Natural lighting when done correctly helps to raise the overall energy performance of buildings [16, 17]. Reducing pollution by three-time needs saving one unit of electricity because it means saving three units of fossil fuel consumption [18].

All previous studies had explained the main element that affectedstudentsin educational spaces. Also, it explained the effect of natural lighting in saving energy consumption. So, it included studies of the effect of controlling natural lighting in educational spaces and saving energy. This study will explain the role of the windows in controlling natural lighting in El Arish; North Sinai; Egypt. Also, the effect of the windows ratio at zone sensible heating, Comfort Temperature, Glazing Gains, and Wall Gains. Additionally, study its effect on saving energy consumption. Besides that, it will study the different locations of the windows at external elevations and their effect on the amount of natural lighting indoor educational spaces. Also, the location of natural lighting in the inside space. To improve the natural lighting indoor spaces and controlling at saving energy.

2. Methodology:

This paper will Analyze the natural lighting inside educational spaces and its effect onsaving energy consumption. the place of the case study is innorth Sinai, especially in El-Arish city. It has been determined the dimension of the space to study with 4m width x 4m length x 4m highest. This model had been simulated with a design-builder program to study the effect of different ratios of windows at zone sensible heating, Comfort Temperature, Glazing Gains, and Wall Gains. Also, study its effect on saving energy consumption. Additionally, it has been studied the amount of lighting in the plan and section at different locations and different times on the date of 21 June. It had been chosenthe east elevation for this study because it's the elevation exposed to six different times in the morning from six o'clock to eleven o'clock according to figure1. This timein the morning had a lot of times when students speeded it at the educational spacing.

Day21 June	**Time o'clock**					
Angel	6	7	8	9	10	11
Vertical	12	24	37	50	62	75
Horizontal	70	76	83	89	98	116

Figure1explains Vertical and Horizontal angle 21 June

This paper included three phases. The first phase Analyzed the effect of different ratios of windows in the four external walls and their ability to save energy.Then, the second phase analyzed the effect of different ratios of windows in the external east wall and their ability to save energy. Additionally, the third phase studied the amount of lighting in the plan and section at different locations at the same time. Finally, the fourth phase studied the amount of lighting in the plan and section at the same location at different times.

For, study the third phase and fourthphasesit has been determined the dimension of the case study with 4m width x 4m length x 4m highest. According to that, the dimension of elevation is width 4mand height 4 m. So, the elevation has been Split into three-zone at different levels as explained in figure2 and every zone was split into three windows on the same level. Also, the shape of the windows is Square, and the area of the window is 1m^2 with dimension (1m length x 1m highest established for all examples in all zones. Zone 1 contains example1, example2, and example3. Zone 2 contains example4, example5, and example6. Zone 3 contains example7, example8, and example9.

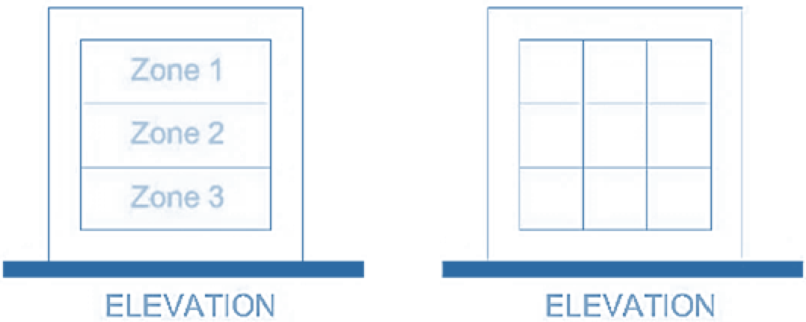


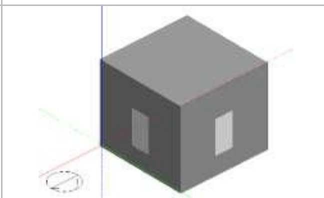
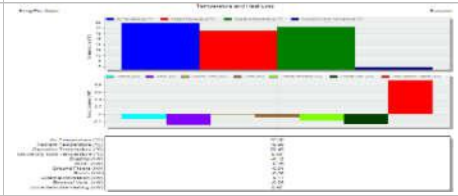
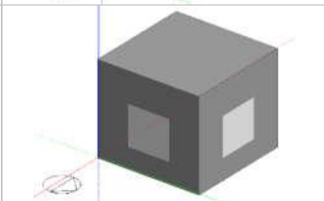
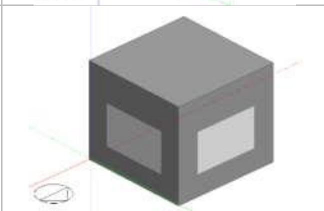
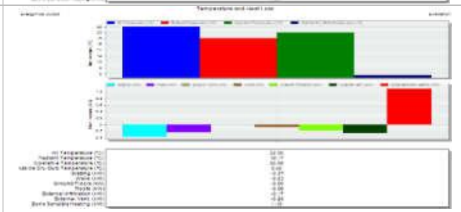
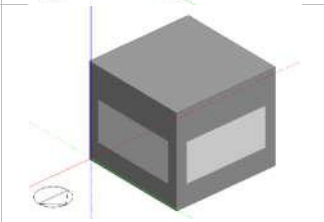
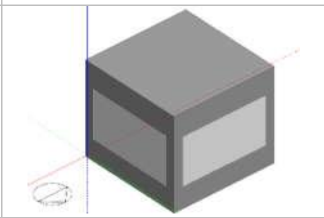
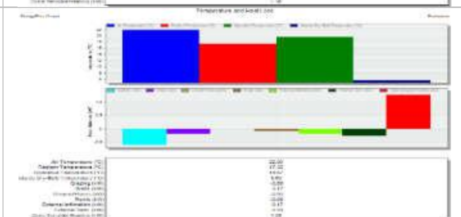
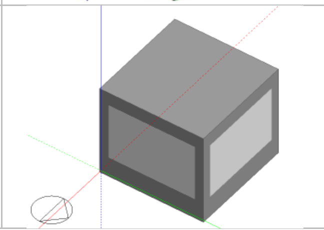
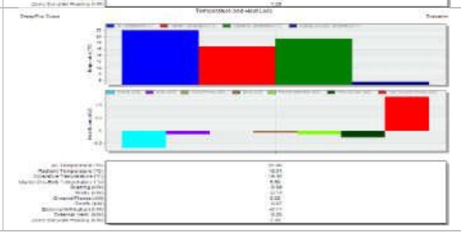
Figure2 explains the split of the elevation

2.1. The first phase Analysis the effect of different ratios of windows in the four external walls and their ability to save energy.

This phase has contained two parts. The first part had been discussed the different ratios of the windows at the four external walls with ratios (10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, and 90%) from the wall. Also, it had been studied the effect of this ratio at zone sensible heating, Comfort Temperature, Glazing Gains, and Wall Gains. The second part had been studied the ability to change the ratio of the window at saving energy consumption which uses in District Heating and District Cooling.

2.1.1. Part 1:

In this part has been used the design-builder program has to analyze the ratio of the window at the external walls in space 4m length x 4m width x 4m height. Figure3 explains the Simulation of the temperature and heat loss for the nine different ratios of windows at the external wall. Also, explain the zone sensible heating (KW) in every different ratio. The program has simulated Comfort Temperature (°C), Glazing Gains (kW), and Wall Gains (kW) for these nine different ratios of windows at the external wall as explained in figure4.

w.ratio%	The perspective	Simulation of the temperature and heat loss	analyzes
Windows ratio 10%			The zone sensible heating (KW) = 0.92
Windows ratio 20%			The zone sensible heating (KW) = 1.01
Windows ratio 30%			The zone sensible heating (KW) = 1.10
Windows ratio 40%			The zone sensible heating (KW) = 1.18
Windows ratio 50%			The zone sensible heating (KW) = 1.26
Windows ratio 60%			The zone sensible heating (KW) = 1.33

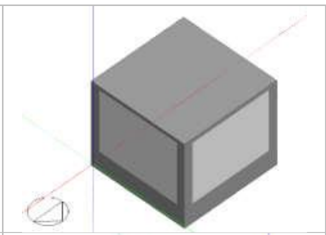
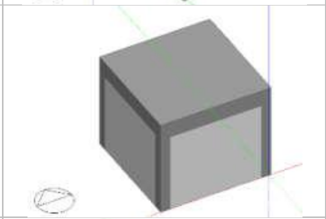
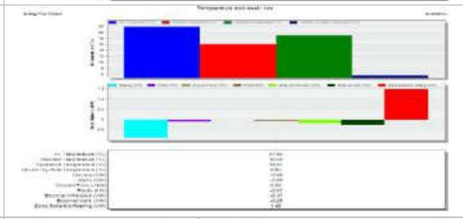
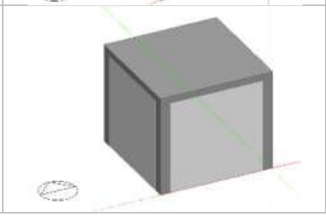
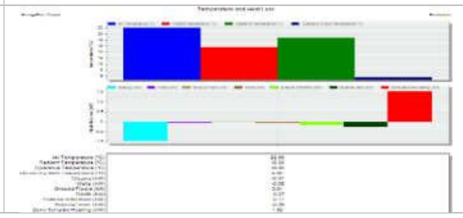
Windows ratio 70%			The zone sensible heating (KW) = 1.40
Windows ratio 80%			The zone sensible heating (KW) = 1.46
Windows ratio 90%			The zone sensible heating (KW) = 1.52

Figure3 explains the zone sensible heating (KW) for nine different ratios of windows at the external wall

analysis	Windows ratio 10%	Windows ratio 20%	Windows ratio 30%	Windows ratio 40%	Windows ratio 50%	Windows ratio 60%	Windows ratio 70%	Windows ratio 80%	Windows ratio 90%
Comfort Temperature (°C)	20.49	20.28	20.08	19.89	19.67	19.45	19.23	19.02	18.8
Glazing Gains (kW)	-0.122	-0.245	-0.366	-0.483	-0.591	-0.695	-0.793	-0.883	-0.971
Wall Gains (kW)	-0.288	-0.257	-0.227	-0.198	-0.169	-0.141	-0.115	-0.089	-0.064

Figure4 explains Comfort Temperature (°C), Glazing Gains (kW), and Wall Gains (kW)for nine different ratios of windows at the external wall.

2.1.2. Part 2

This part explained the energy uses forDistrict Heating and District Cooling in the space from the analysis of the building with the design-builder program. This energy consumption had been calculated at nine different ratios of the windows at the four external walls as explained in figure5.

Windows ratio %	In four elevations	
	District Heating (KWH)	District Cooling (KWH)
10%	34.68	2494.28
20%	23.51	3559.97
30%	24.18	4505
40%	30.2	5334.06
50%	39.45	6069.18
60%	35.37	6706.97
70%	72.95	7261.87
80%	96.9	7758.81
90%	128.66	8198.39

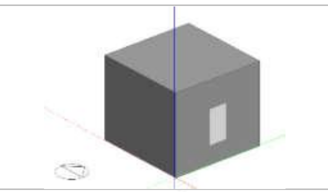
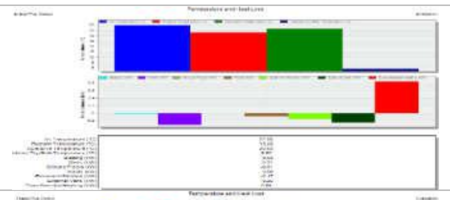
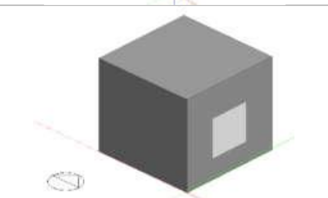
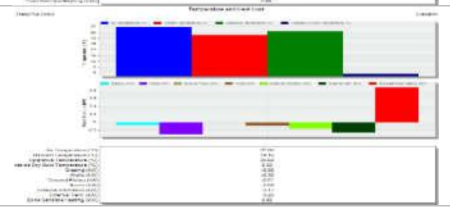
Figure5explained the energy uses at District Heating and District Cooling at nine different ratios of the windows at the four external walls.

2.2. The second phase Analysis the effect of different ratios of windows in the external east wall and their ability to save energy.

This phase has contained two parts. The first part had been discussed the different ratios of the windows at the external east wall with ratios (10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, and 90%) from the wall. Also, it had been studied the effect of this ratio at zone sensible heating, Comfort Temperature, Glazing Gains, and Wall Gains. The second part had been studied the ability to change the ratio of the window at saving energy consumption which uses in District Heating and District Cooling.

2.2.1. Part 1

In this part has been used the design-builder program has to analyze the different ratios of the window at the external east wall in space 4m length x 4m width x 4m height. Figure6 explains the Simulation of the temperature and heat loss for the nine different ratios of windows at the external east wall. Also, explain the zone sensible heating (KW) in every different ratio. The program has simulated Comfort Temperature (°C), Glazing Gains (kW), and Wall Gains (kW) for these nine different ratios of windows at the external wall as explained in figure7.

w.ratio%	The perspective	Simulation of the temperature and heat loss	analyzes
Windows ratio 10%			The zone sensible heating (KW) = 0.85
Windows ratio 20%			The zone sensible heating (KW) = .88

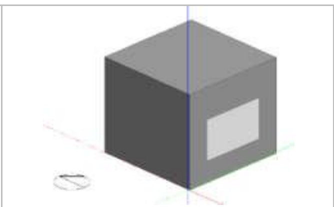
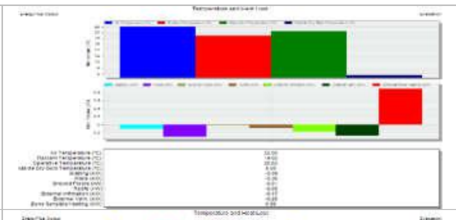
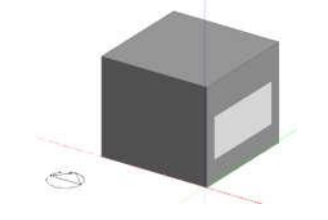
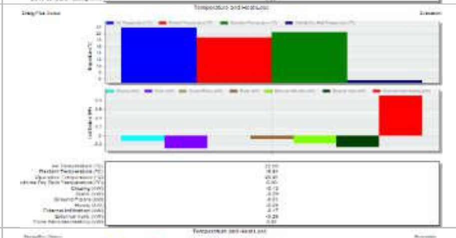
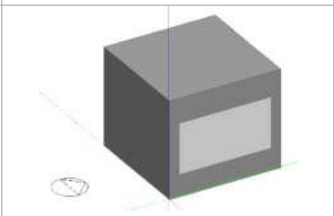
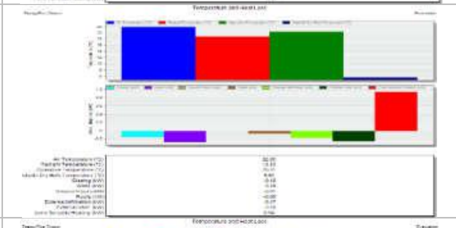
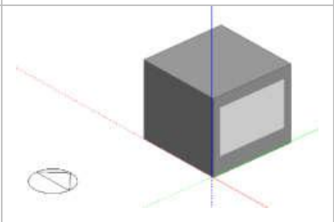
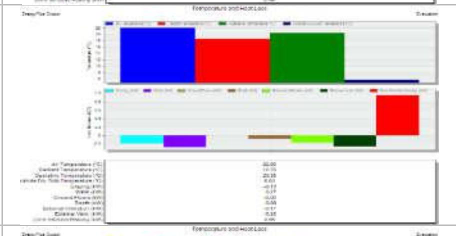
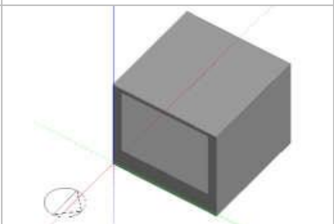
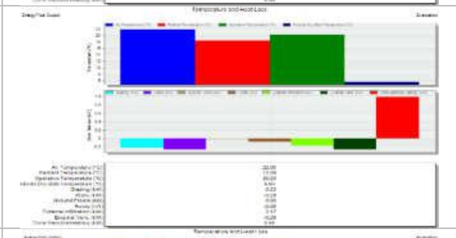
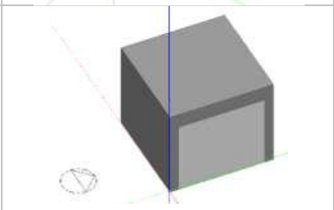
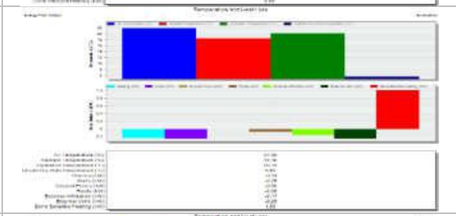
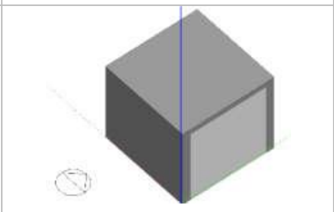
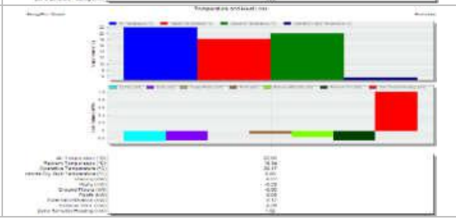
Windows ratio 30%			The zone sensible heating (KW) = .90
Windows ratio 40%			The zone sensible heating (KW) = .92
Windows ratio 50%			The zone sensible heating (KW) = .94
Windows ratio 60%			The zone sensible heating (KW) = .96
Windows ratio 70%			The zone sensible heating (KW) = .98
Windows ratio 80%			The zone sensible heating (KW) = 1.00
Windows ratio 90%			The zone sensible heating (KW) = 1.02

Figure6 explains the zone sensible heating (KW) for nine different ratios of windows at the external wall

analysis	Windows ratio 10%	Windows ratio 20%	Windows ratio 30%	Windows ratio 40%	Windows ratio 50%	Windows ratio 60%	Windows ratio 70%	Windows ratio 80%	Windows ratio 90%
Comfort Temperature (°C)	20.63	20.58	20.52	20.47	20.41	20.35	20.29	20.23	20.17
Glazing Gains (kW)	-0.031	-0.063	-0.094	-0.126	-0.156	-0.186	-0.216	-0.244	-0.274
Wall Gains (kW)	-0.311	-0.303	-0.295	-0.287	-0.279	-0.271	-0.263	-0.255	-0.247

Figure7 explains Comfort Temperature (°C), Glazing Gains (kW), and Wall Gains (kW)for nine different ratios of windows at the external wall.

2.2.2. Part 2

This part explained the energy uses for District Heating and District Cooling in the space from the analysis of the building with the design-builder program. This energy consumption had been calculated at nine different ratios of the windows at the external east wall as explained in figure8.

Windows ratio %	In east elevation	
	District Heating (KWH)	District Cooling (KWH)
10%	68.33	1826.69
20%	55.24	2162.46
30%	47.23	2498.42
40%	42.15	2832.21
50%	38.6	3168.44
60%	36.05	3501.54
70%	34.34	3828.21
80%	33.21	4142.35
90%	32.72	4453.42

Figure8explained the energy uses at District Heating and District Cooling at nine different ratios of the windows at the external east walls.

2.3. The third phase is the amount of lighting in the plan and section at the location of the different windows at the same time for all zones at every time.

This phase has studied the effect of different window locations at the sametime. According to that, it has been studied the three zones which differ at the level and the three examples of windows location in every zone. So, it had been division this phase to six cases every case studied all examples at zones with a specific time.

2.3.1. Case 1: studies the effects of solar radiation on the windows at the east elevation and explains the amount of natural lighting inside space on 21 June at Six o'clock in the morning with a Vertical angle of 12 ^{O} and a Horizontal angle70 ^{O} as explained at figure9.

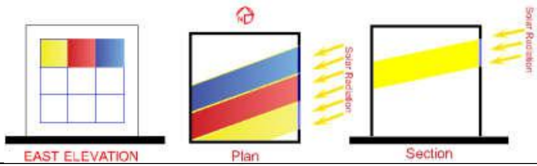
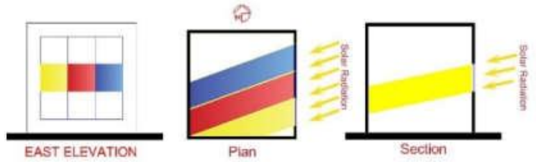
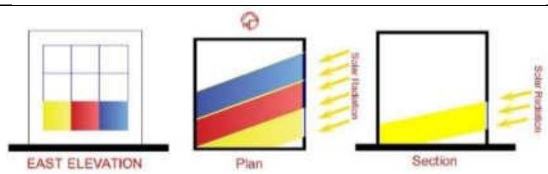
	Elevation, plan, section	Natural lighting area m²		
			plan	section
Zone 1		Example 1	2.2548	3.6641
		Example 2	3.5958	3.6641
		Example 3	3.5958	3.6641
Zone 2		Example 4	2.2548	3.6641
		Example 5	3.5958	3.6641
		Example 6	3.5958	3.6641
Zone 3		Example 7	2.2548	3.4535
		Example 8	3.5958	3.4535
		Example 9	3.5958	3.4535

Figure9 explains the amount of direct natural lighting inside the space according to the different locations of windows in the three zones at Six o'clock in the morning.

2.3.2. Case 2 studies the effects of solar radiation on the windows at the east elevation and explains the amount of natural lighting inside space on 21 June at Seven o'clock in the morning with a Vertical angle of 24 ^{O} and a Horizontal angle76 ^{O} as explained at figure10.

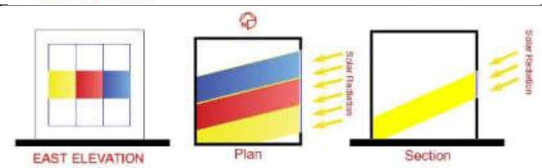
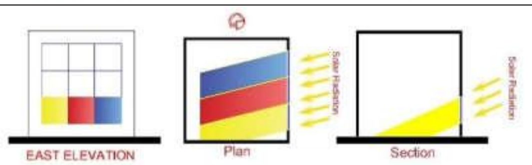
	Elevation, plan, section	Natural lighting area m²		
			plan	section
Zone 1		Example 1	3.0243	3.5958
		Example 2	3.6475	3.5958
		Example 3	3.6475	3.5958
Zone 2		Example 4	3.0243	3.5251
		Example 5	3.6475	3.5251
		Example 6	3.6475	3.5251
Zone 3		Example 7	2.7809	2.0692
		Example 8	3.1518	2.0692
		Example 9	3.1518	2.0692

Figure10 explains the amount of direct natural lighting inside the space according to the different locations of windows in the three zones at Seven o'clock in the morning.

2.3.3. Case 3: studies the effects of solar radiation on the windows at the east elevation and explains the amount of natural lighting inside space on 21 June at Eight o'clock in the morning with a Vertical angle of 37 ^{O} and a Horizontal angle83 ^{O}. The figures11 explain the location of the windowand the area of natural ventilation in the plan and the section for indoor space for three zones.

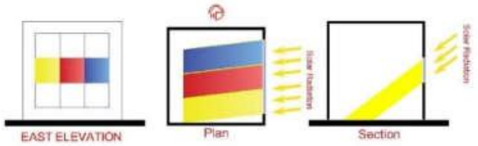
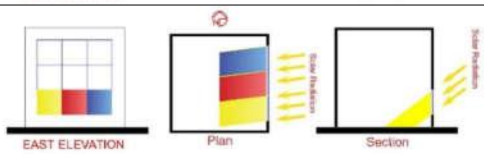
	Elevation, plan, section	Natural lighting area m^2		
			plan	section
Zone 1		Example 1	3.6774	3.3463
		Example 2	3.7046	3.3463
		Example 3	3.7046	3.3463
Zone 2		Example 4	3.1498	2.3595
		Example 5	3.1505	2.3595
		Example 6	3.1505	2.3595
Zone 3		Example 7	1.8430	1.1525
		Example 8	1.8430	1.1525
		Example 9	1.8430	1.1525

Figure11 explains the amount of direct natural lighting inside the space according to the different locations of windows in the three zones at Eight o'clock in the morning.

2.3.4. Case 4: studies the effects of solar radiation on the windows at the east elevation and explains the amount of natural lighting inside space on 21 June at Nine o'clock in the morning with a Vertical angle of 50 ^{O} and a Horizontal angle89 ^{O}. The figures12 explain the location of the window and the area of natural ventilation in the plan and the section for indoor space for three zones.

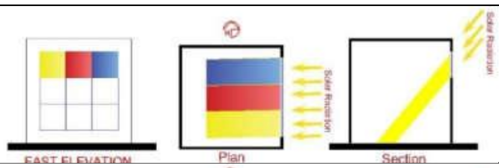
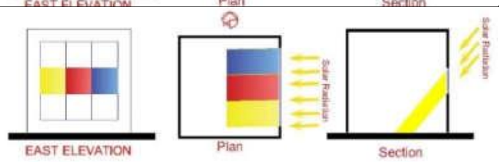
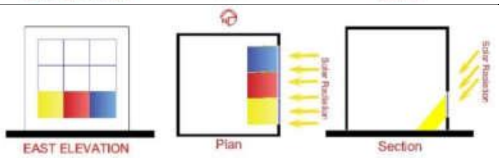
	Elevation, plan, section	Natural lighting area m^2		
			plan	section
Zone 1		Example 1	2.8109	2.1059
		Example 2	2.8109	2.1059
		Example 3	2.8109	2.1059
Zone 2		Example 4	1.9736	1.3868
		Example 5	1.9736	1.3868
		Example 6	1.9736	1.3868
Zone 3		Example 7	1.1363	0.6677
		Example 8	1.1363	0.6677
		Example 9	1.1363	0.6677

Figure12 explains the amount of direct natural lighting inside the space according to the different locations of windows in the three zones at Nine o'clock in the morning.

2.3.5. Case 5: studies the effects of solar radiation on the windows at the east elevation and explains the amount of natural lighting inside the space on 21 June at Ten o'clock in the morning with a Vertical angle of 62 ^{O} and a Horizontal angle of 98 ^{O}. The figures13 explain the location of the window and the area of natural ventilation in the plan and the section for indoor space for three zones.

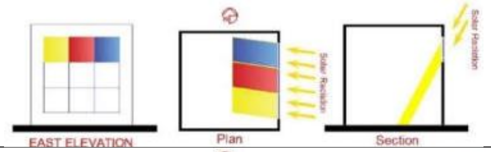
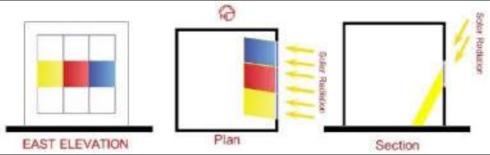
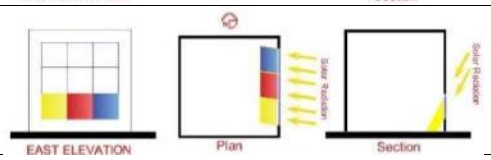
	Elevation, plan, section	Natural lighting area m^2		
			plan	section
Zone 1		Example 1	1.7284	1.1887
		Example 2	1.7284	1.1887
		Example 3	1.7284	1.1887
Zone 2		Example 4	1.1863	0.777
		Example 5	1.1863	0.777
		Example 6	1.1863	0.777
Zone 3		Example 7	0.6647	0.3653
		Example 8	0.6647	0.3653
		Example 9	0.6647	0.3653

Figure13 explains the amount of direct natural lighting inside the space according to the different locations of windows in the three zones at Ten o'clock in the morning.

2.3.6. Case 6: studies the effects of solar radiation on the windows at the east elevation and explains the amount of natural lighting inside the space on 21 June at Eleven o'clock in the morning with a Vertical angle of 75 ^{O} and a Horizontal angle of 116 ^{O}. The figures14 explain the location of the window and the area of natural ventilation in the plan and the section for indoor space for three zones.

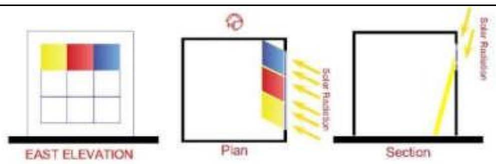
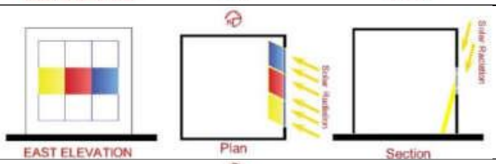
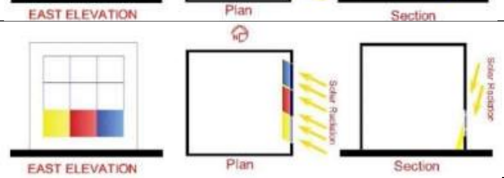
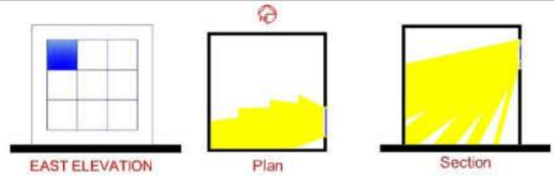
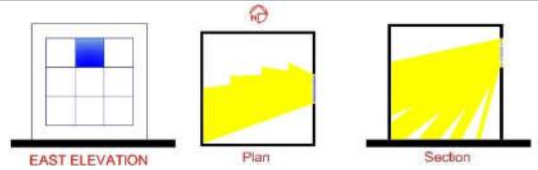
	Elevation, plan, section	Natural lighting area m^2		
			plan	section
Zone 1		Example 1	0.7696	0.4107
		Example 2	0.7696	0.4107
		Example 3	0.7696	0.4107
Zone 2		Example 4	0.5177	0.2628
		Example 5	0.5177	0.2628
		Example 6	0.5177	0.2628
Zone 3		Example 7	0.2654	0.1148
		Example 8	0.2654	0.1148
		Example 9	0.2654	0.1148

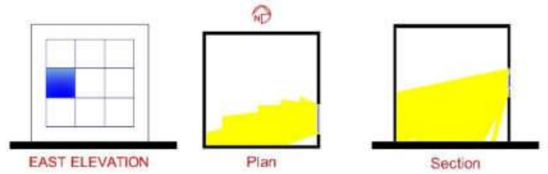
Figure14 explains the amount of direct natural lighting inside the space according to the different locations of windows in the three zones at Eleven o'clock in the morning.

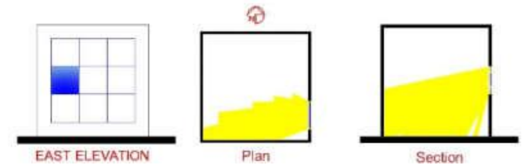
2.4. The fourth phase is the amount of lighting in the plan and section at the same location at different times.

This phase studies the amount of lighting in the plan and the section of space at different times for every location of windows. This phase is the division into nine locations for windows as explained in figure15. On21 June from six o'clock to eleveno'clock.

<table>
<tr><td>Location 1</td><td>

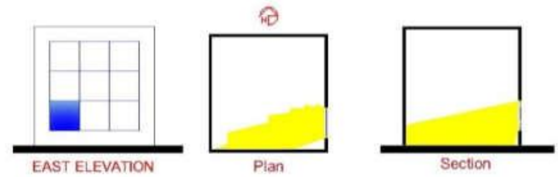
Natural lighting area in plan = 4.8835m^2
Natural lighting area in section = 9.6632m^2</td><td>Location 2</td><td>

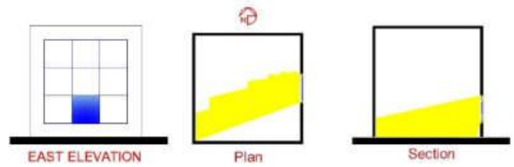
Natural lighting area in plan = 6.2259 m^2
Natural lighting area in section =9.6632 m^2</td></tr>
<tr><td>Location 3</td><td>

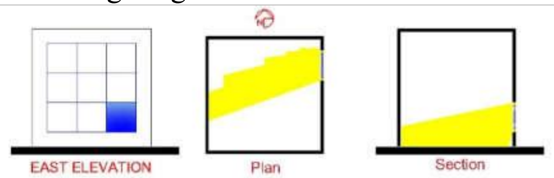
Natural lighting area in plan = 6.2256 m^2
Natural lighting area in section = 9.6632m^2</td><td>Location 4</td><td>

Natural lighting area in plan = 4.2129 m^2
Natural lighting area in section = 7.3637m^2</td></tr>
<tr><td>Location 5</td><td>

Natural lighting area in plan = 5.5553 m^2
Natural lighting area in section = 7.3637m^2</td><td>Location 6</td><td>

Natural lighting area in plan = 5.5553 m^2
Natural lighting area in section = 7.3637m^2</td></tr>
<tr><td>Location 7</td><td>

Natural lighting area in plan = 3.2888m^2
Natural lighting area in section = 4.0081m^2</td><td>Location 8</td><td>

Natural lighting area in plan = 4.6266m^2
Natural lighting area in section = 4.0081m^2</td></tr>
<tr><td>Location 98</td><td>

Natural lighting area in plan = 4.6266m^2
Natural lighting area in section = 4.0081m^2</td><td colspan="2">The total area of the plan for space is 14.5888m^2
The total area of the section for space is 14.5888m^2</td></tr>
</table>

Figure15explains the amount of Natural lighting area in the plan and section at nine different locations.

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3. Discus and result:

3.1. The first phase Analysis the effect of different ratios of windows in the four external walls and their ability to save energy.

3.1.1. Part 1 Compare The program simulation for Comfort Temperature (°C), Glazing Gains (kW), and Wall Gains (kW) for the nine different ratios of windows at the four external walls (North – East – South – West)as explained figure16.

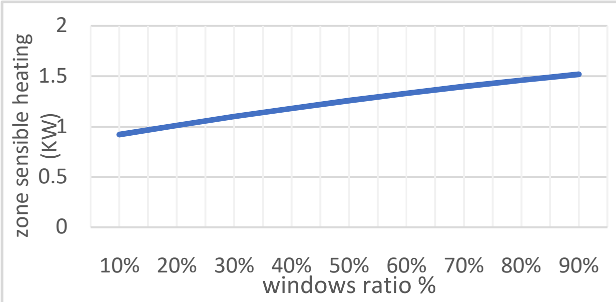
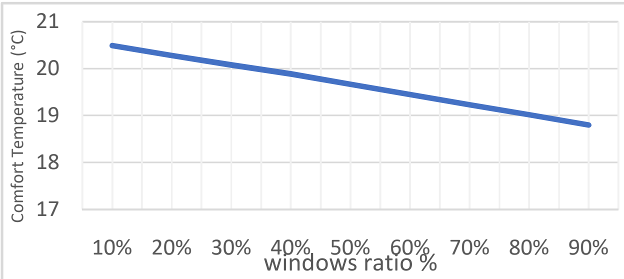
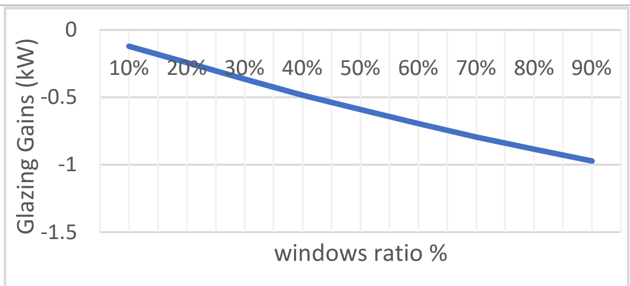
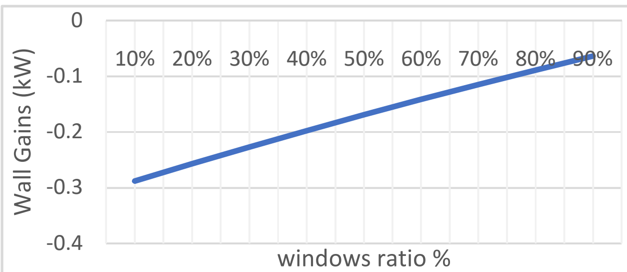
Title	Figure	**Analysis**
comparison zone sensible heating		the zone sensible heating increases from windows ratio10% to windows ratio90% with a ratio of 39.4%. this increases no more than 10% between each window ratio and the next. According to that, the zone sensible heating increases with an increase in the ratio of the window at the external wall.
comparison Comfort Temperature		the Comfort Temperature decreases from windows ratio10% to windows ratio90% with a ratio of 8.2%. this increases no more than 2% between each window ratio and the next. According to that, the Comfort Temperature decreases with an increase in the ratio of the window at the external wall.
comparison Glazing Gains		The Glazing Gains decrease from windows ratio10% to windows ratio90% with a ratio of 87.4%. According to that, the Glazing Gains decrease with an increase in the ratio of the window at the external wall.
comparison Wall Gains		The Wall Gains increase from windows ratio10% to windows ratio90% with a ratio of 77.7%. According to that, the Wall Gains increase with an increase in the ratio of the window at the external wall.

Figure16 explains the comparison of the zone sensible heating, zone sensible heating, Comfort Temperature, Glazing Gains, and Wall Gains between nine different ratios of windows at the four external walls.

3.1.2. Part 2 The energy needed for District Heating was increasing with increasing the ratio of the windows on every wall. It didn't go in a straight line, but it increased and decreased according to the ratio of the window as explained figure17.

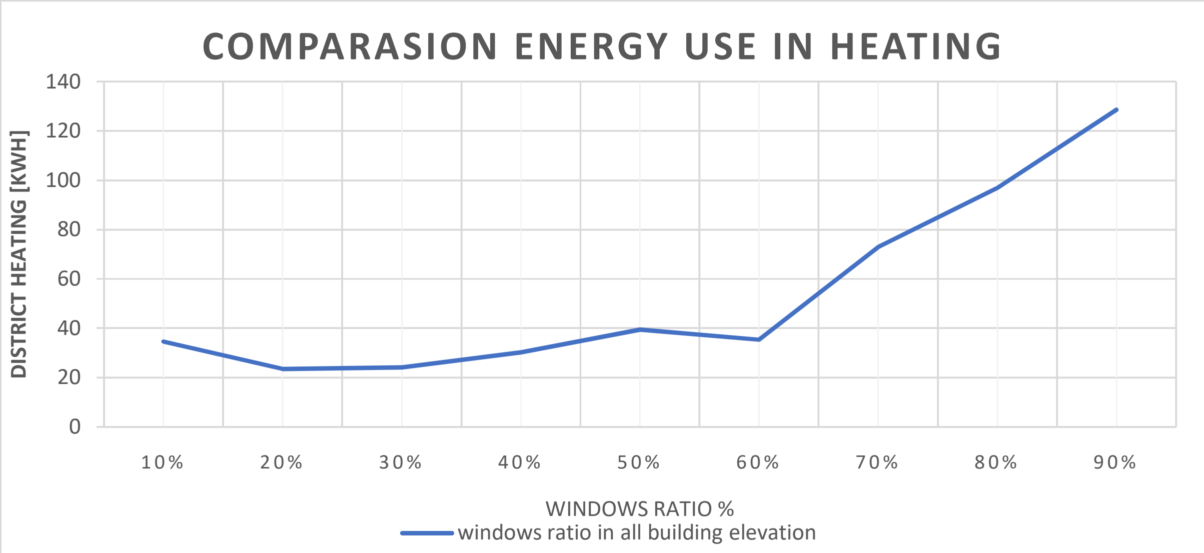


Figure17 explains the comparison of the District Heating (KWH) between nine different ratios of windows at four external walls.

The energy needed for District cooling was increasing from windows ratio10% to windows ratio90% with a ratio of 69.5% as explained figure18. According to that, the energy needed for District cooling was increasing with increasing the ratio of the windows on every wall. So, the correct design for natural lighting helps to save energy[16].

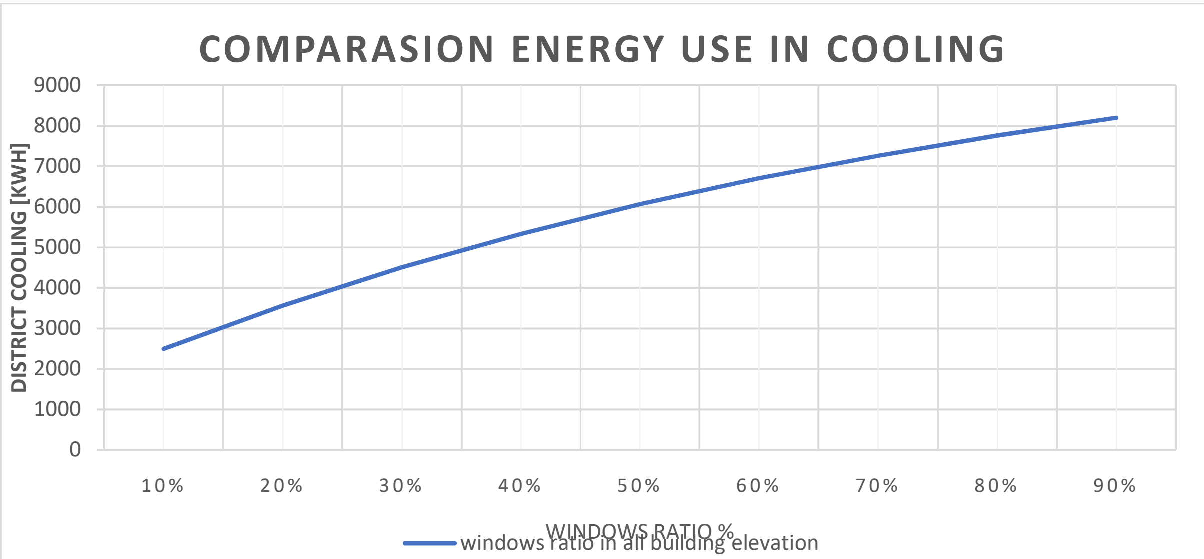


Figure18 explains the comparison of the district cooling (KWH) between nine different ratios of windows at four external walls.

3.2. The second phase Analysis the effect of different ratios of windows in the external east wall and their ability to save energy.

3.2.1. Part1: Compare The program simulation for Comfort Temperature (°C), Glazing Gains (kW), and Wall Gains (kW) for the nine different ratios of windows at the external east wall asexplainedin figure19.

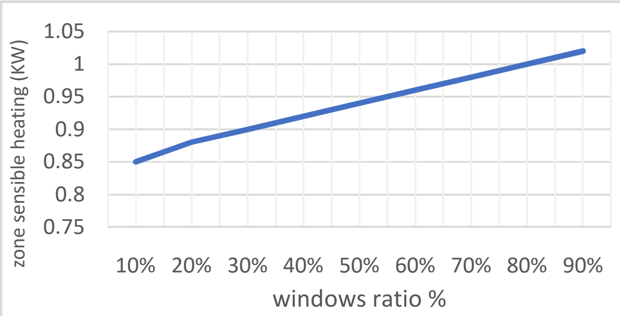
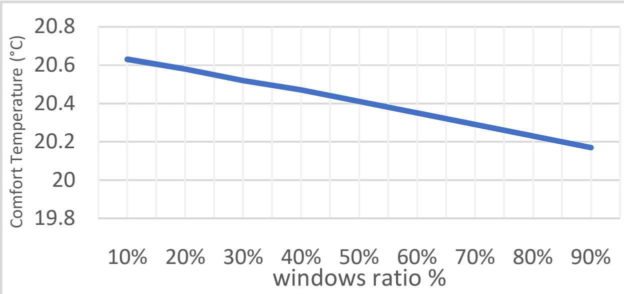
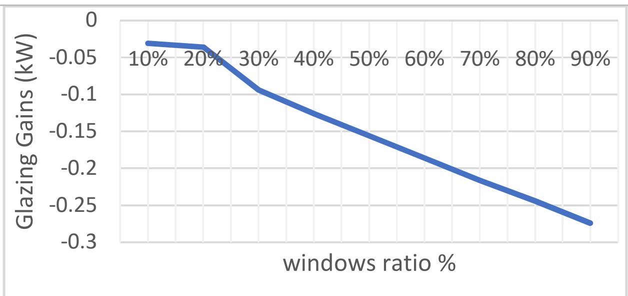
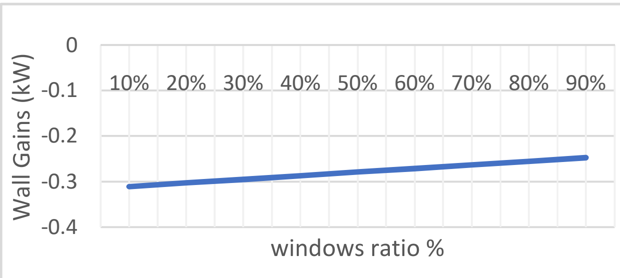
Title	Figure	**Analysis**
comparison zone sensible heating		the zone sensible heating increases from windows ratio10% to windows ratio90% with a ratio of 16.6%. this increases no more than 5% between each window ratio and the next. According to that the zone sensible heating increases with an increase in the ratio of the window at the external wall.
comparison Comfort Temperature		the Comfort Temperature decreases from windows ratio10% to windows ratio90% with a ratio of 2.2%. this increases no more than .5% between each window ratio and the next. According to that, the Comfort Temperature decreases with an increase in the ratio of the window at the external wall.
comparison Glazing Gains		The Glazing Gains decrease from windows ratio10% to windows ratio90% with a ratio of 88.6%. According to that, the Glazing Gains decrease with an increase in the ratio of the window at the external wall.
comparison Wall Gains		The Wall Gains increase from windows ratio10% to windows ratio90% with a ratio of 20.5%. According to that, the Wall Gains increase with an increase in the ratio of the window at the external wall.

Figure19 explains the comparison of the zone sensible heating, zone sensible heating, Comfort Temperature, Glazing Gains, and Wall Gains between nine different ratios of windows at the external east walls.

3.2.2. Part 2 The energy needed for District Heating was decreased with increasing the ratio of the windows on the east wall as explained figure20.

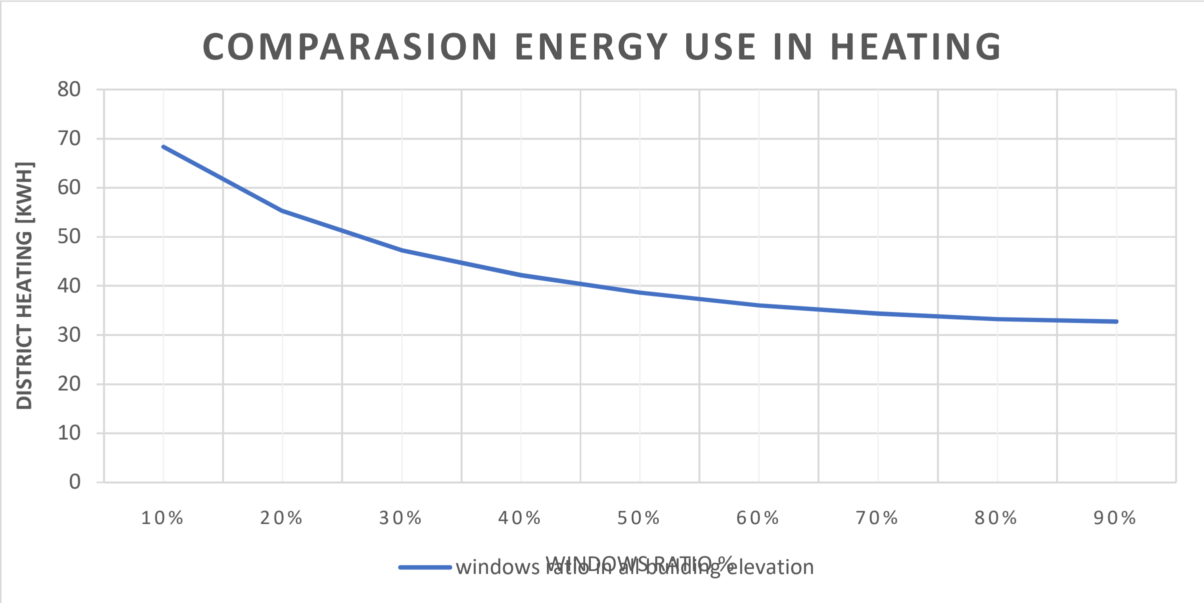


Figure20 explains the comparison of the District Heating (KWH) between nine different ratios of windows at four external walls.

The energy needed for District cooling was increasing from windows ratio10% to windows ratio90% with a ratio of 58.9%. It goes in a straight line as explained figure21. According to that, the energy needed for District cooling was increasing with increasing the ratio of the windows on every wall.So, the correct design for natural lighting helps to save energy[16].

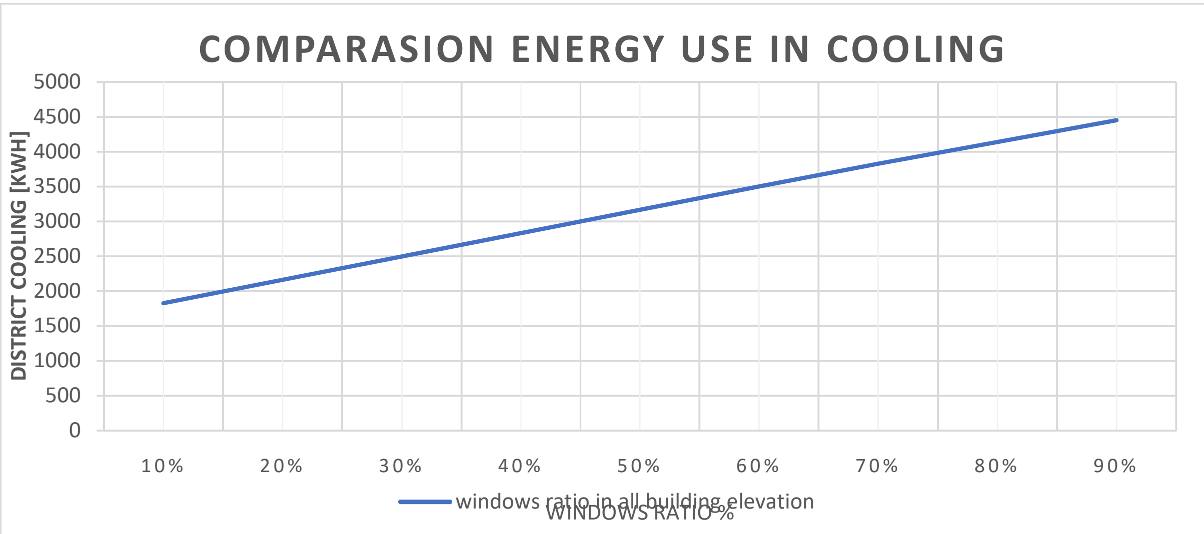


Figure21 explains the comparison of the district cooling (KWH) between nine different ratios of windows at four external walls.

3.3. The third phase is the amount of lighting in the plan and section at the different locations at the same time.

3.3.1. Case 1: The natural lighting for the plan in the first location to every zone is symmetrical and equal to 2.2548m^2 a vertical line. Also, the other location for windows in different zones is symmetrical and equal to 2.2548m^2. Additionally, the natural lighting for the plan in examples 1,4,7 is lower than the lighting in examples2,3,5,6,8,9 with a ratio of 37.2%. The natural lighting for the section in example 1,2,3,4,5,6 is symmetrical and equal to 3.6641m^2. Additionally, examples7,8,9 equal 3.4535 m^2 as explained in a figure22. So, the natural lighting in the section at zone1 and zone2 is symmetrical and higher than in zone3 with a ratio of 5.7%. According to that the location of the window in the same vertical location in the three zones had the same area of natural lighting in the plan. The natural lighting for the section at zone 1 and zone 2 is symmetrical, but zone 3 is different and less than theirs.

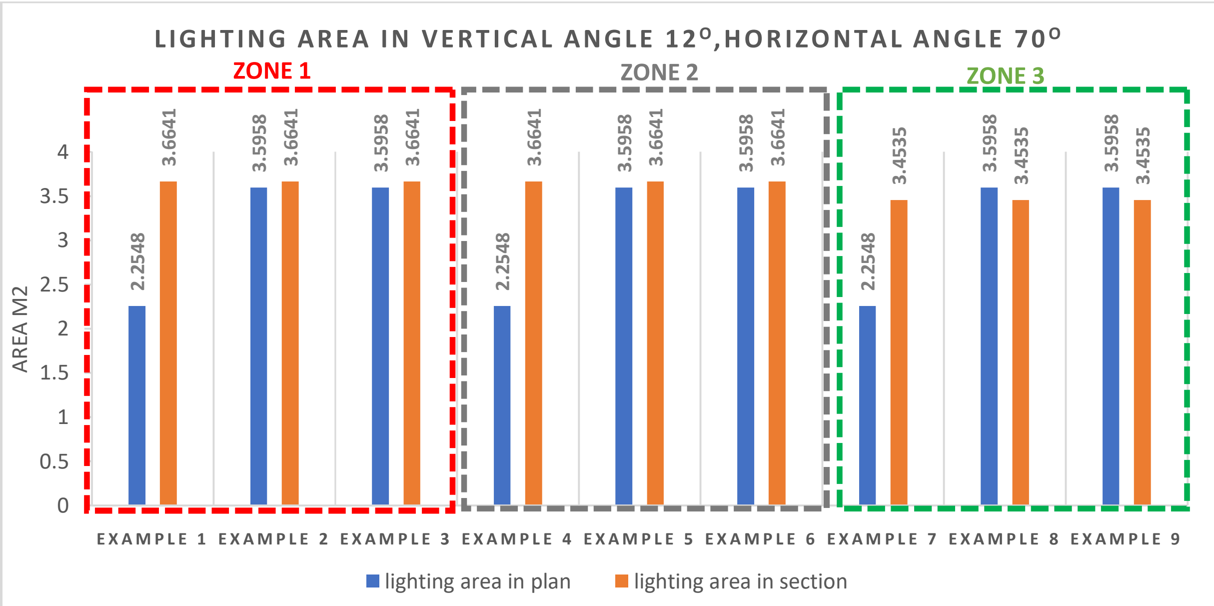


Figure22 explains the comparison of natural lighting area indoor space at plan and section for zones 1,2,3 at six o'clock in the morning in Vertical angle 12^o, Horizontal angle 70^o.

3.3.2. Case 2: The natural lighting for the plan in example 1,4 is symmetrical and equal to 3.024 m^2 at the different zones. But example 7 is lower than theirs with a ratio of 9%. Also, example 2,3,5,6 is symmetrical and equal to 3.6475m^2. But example 8.9 is lower than theirs with a ratio of 13.5%. The natural lighting for the section in example 1,2,3 is highest than in other examples as explained in the figure23. So, example 7,8,9 is lower than example 1,2,3 with a ratio of 42%. Additionally, examples4,5,6 is lower than example 1,2,3 with ratio 2%. According to that, the area of natural lighting has decreased in the section of space in the same vertical windows located in the three zones. The natural lighting for theplan of space at zone 1 and zone 2 is symmetrical, but zone 3 is different and less than theirs.

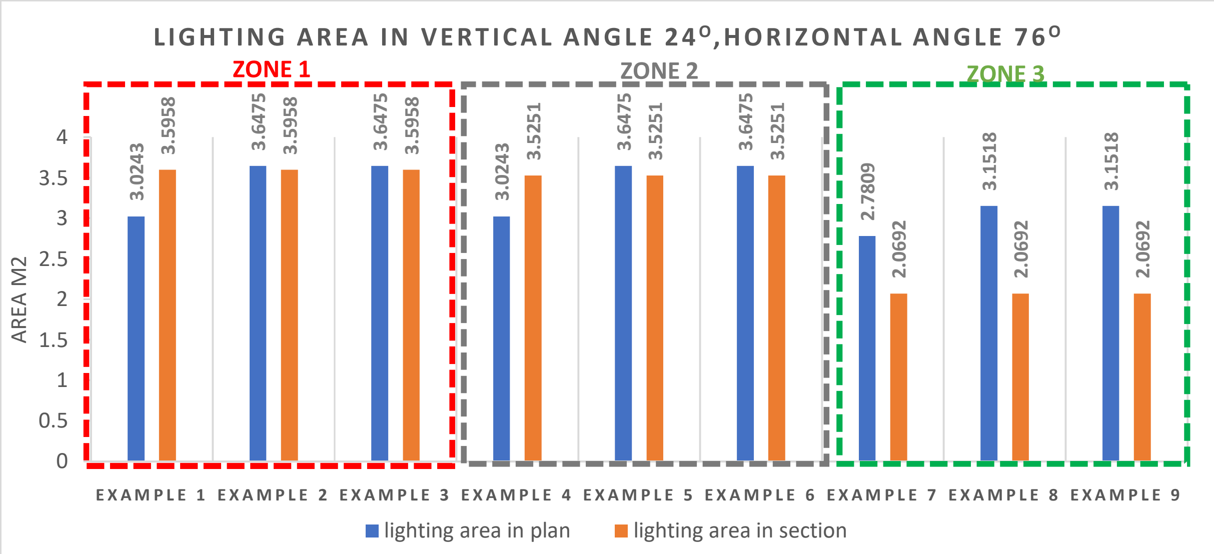


Figure23 explains the comparison of natural lighting area indoor space at plan and section for zones 1,2,3 at seven o'clock in the morning in Vertical angle 24°, Horizontal angle 76°.

3.3.3. Case 3:

The natural lighting for the plan in example 1 is higher than in example 4 with a ratio of 14% and in example 7 with a ratio of 49.8%. Additionally, the natural lighting for the plan in examples 2,3 is higher than in examples 5,6 with a ratio of 14.9%, and in examples 8,9 with a ratio of 50.2%. The natural lighting for the section in zone1 is higher than in zone2 and zone3. Zone 2 is lower than zone1 with a ratio of 29.4%. Also, zone 3 is lower than zone1 with a ratio of 65.5%as explainedin figure24. According to that the natural lighting for the plan and section at the same vertical location is decreased in direction to down.

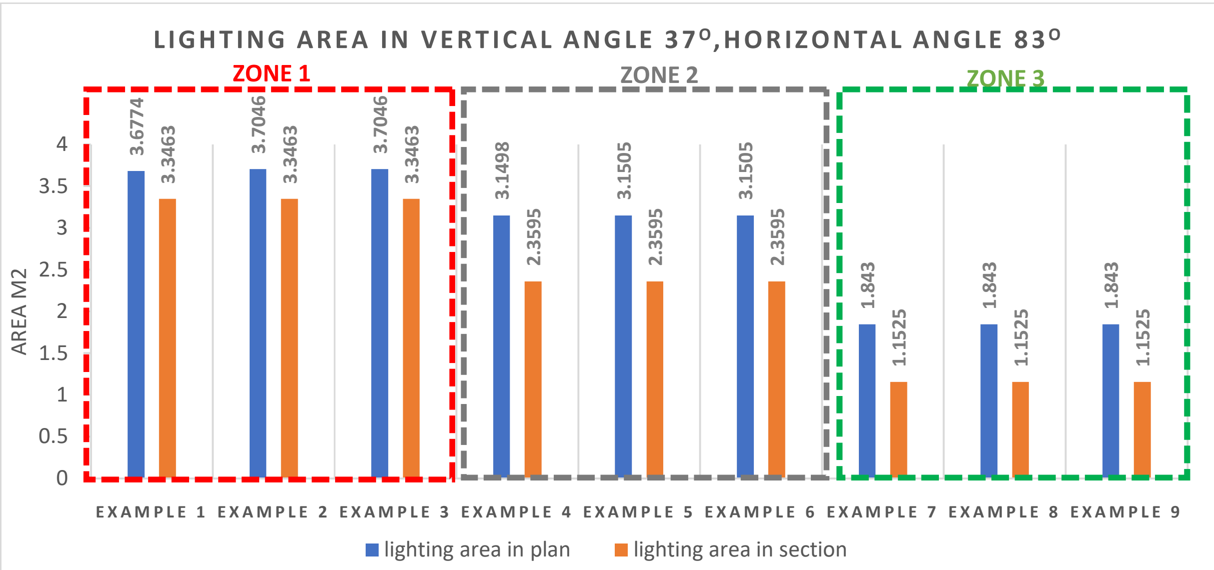


Figure24 explains the comparison of natural lighting area indoor space at plan and section for zones 1,2,3 at eight o'clock in the morning in Vertical angle 37 °, Horizontal angle 83 °.

3.3.4. Case 4: The natural lighting for the plan in zone1 is the highest one from zone2 and zone3. the natural lighting for the plan in zone1 is higher than in zone2 with a ratio of 29.7% and in zone3 with a ratio of 59.5%. Additionally, the natural lighting for the section in zone1 is the highest one from zone2 and zone3. the natural lighting for the section in zone1 is higher than in zone2 with a ratio of 34.1% and in zone3 with a ratio of 68.2%as explained in figure25. According to that the natural lighting for the plan and section at the same vertical location is decreased in direction to down.

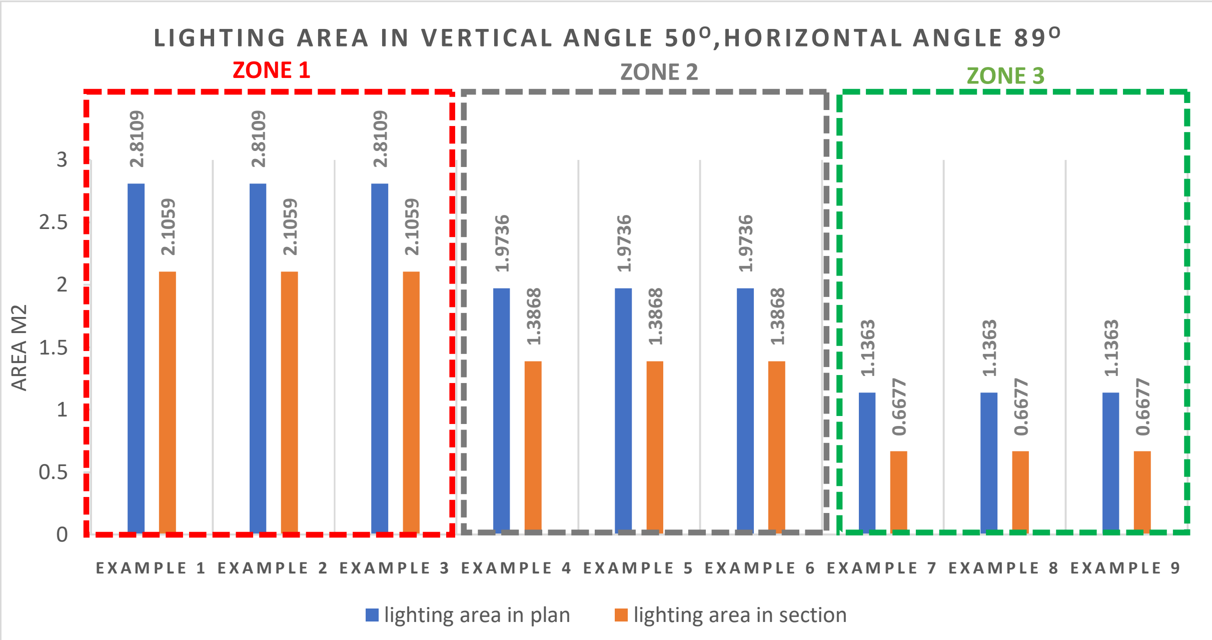


Figure25 explains the comparison of natural lighting area indoor space at plan and section for zones 1,2,3 at nine o'clock in the morning in Vertical angle 50 ^{o}, Horizontal angle 89 ^{o}.

3.3.5. Case 5: the natural lighting for the plan in zone1 is higher than in zone2 with a ratio of 31.3% and in zone3 with a ratio of 61.5%. Additionally, the natural lighting for the section in zone1 is the highest one from zone2 and zone3. the natural lighting for the section in zone1 is higher than in zone2 with a ratio of 34.6% and in zone3 with a ratio of 69.2% as explained in figure26. According to that the natural lighting for the plan and section at the same vertical location is decreased in direction to down.Finally, the natural lighting for the plan in zone1 is the highest one from zone2 and zone3.

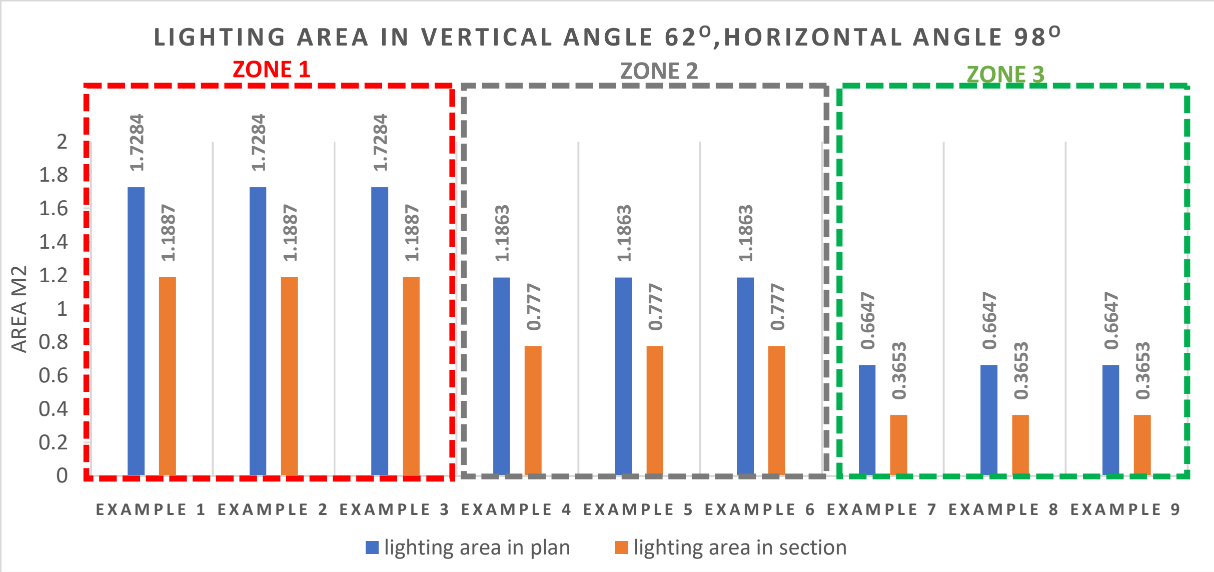


Figure26 explains the comparison of natural lighting area indoor space at plan and section for zones 1,2,3 at ten o'clock in the morning in Vertical angle 62 °, Horizontal angle 98°.

3.3.6. Case 6:

The natural lighting for the plan in zone1 is the highest one from zone2 and zone3. the natural lighting for the plan in zone1 is higher than in zone2 with a ratio of 32.7% and in zone3 with a ratio of 65.5%. Additionally, the natural lighting for the section in zone1 is the highest one from zone2 and zone3. the natural lighting for the section in zone1 is higher than in zone2 with a ratio of 36% and in zone3 with a ratio of 72% as explained in figure27. According to that the natural lighting for the plan and section at the same vertical location is decreased in direction to down.

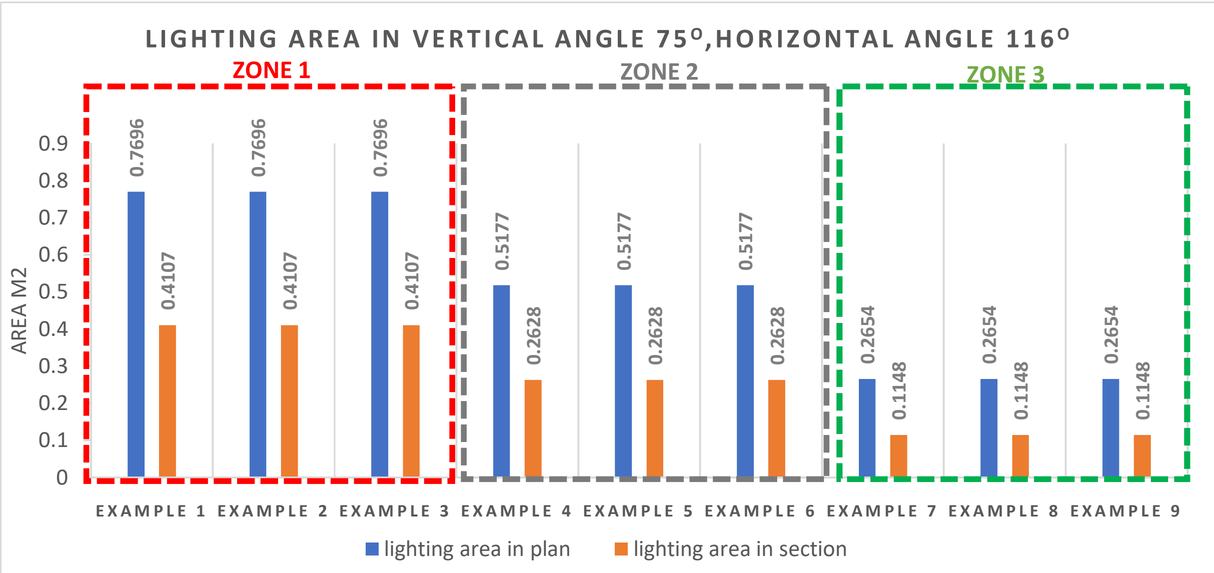
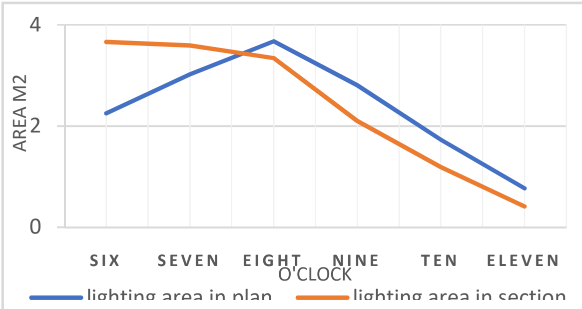
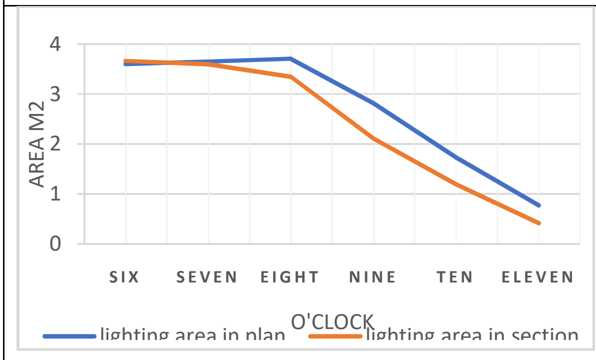
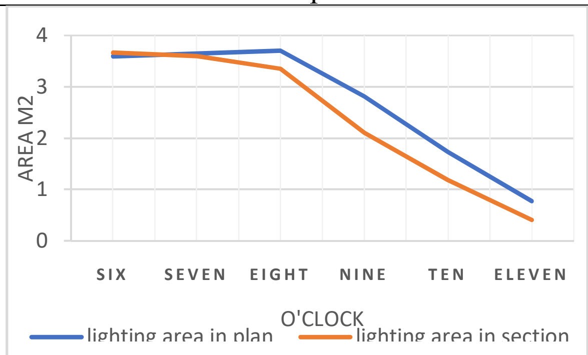
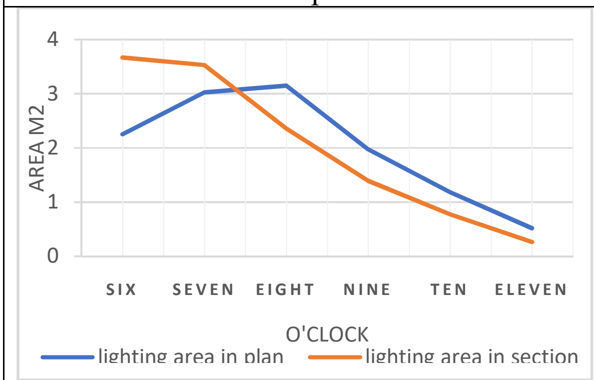
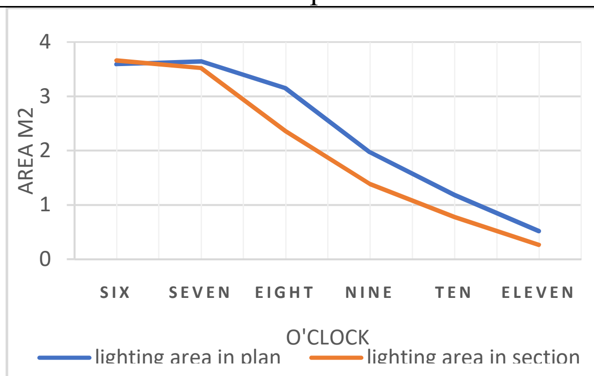


Figure27 explains the comparison of natural lighting area indoor space at plan and section for zones 1,2,3 at eleven o'clock in the morning in Vertical angle 75 °, Horizontal angle 116°.

3.4. The fourth phase is the amount of lighting in the plan and section at the same location at different times.

Compare the amount of lighting in the plan and section at the same location at different times**.** The natural lighting for the plan increases from six o'clock to eight o'clock in all examples 1-8, then it decreases from eight o'clock to eleven o'clock in all these samples with the difference in the number of increases and decreases. But example 9 decreases with time from six o'clock to eleven o'clock. Also, the natural lighting for the section in all examples decreases with time from six o'clock to eleven o'clock as explained in the figure28 below.

<table>
<tr><td>The table explains the comparison of natural lighting area indoor space at plan and section for nine examples at a different time from six o'clock to eleven o'clock on the day 21 June.</td><td>
</td></tr>
<tr><td></td><td>Example 1</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>Example 2</td><td>Example 3</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>Example 4</td><td>Example 5</td></tr>
</table>

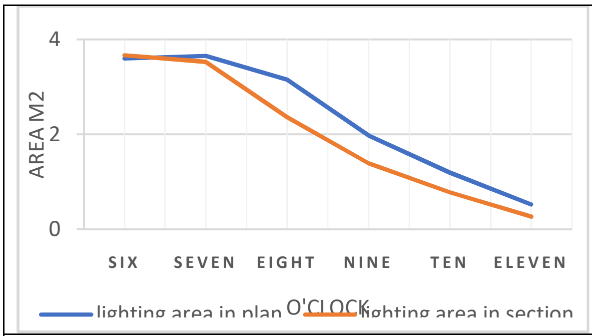
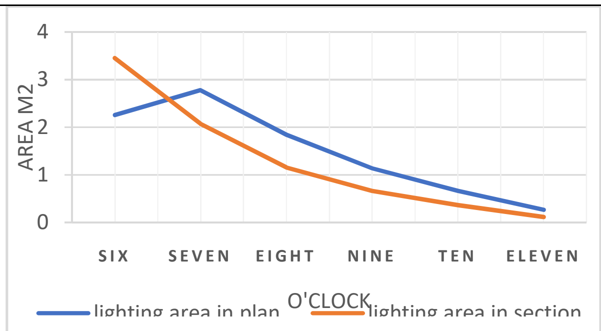
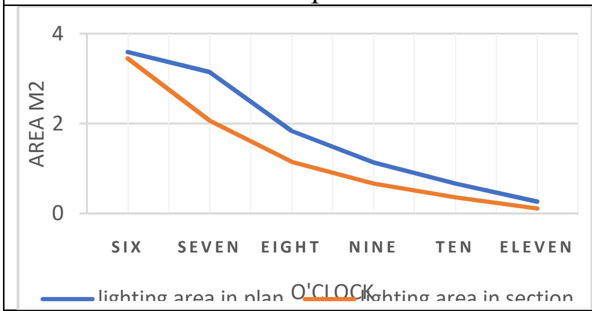
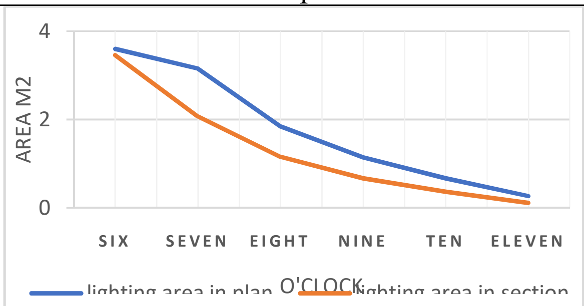
	
Example 6	Example 7
	
Example 8	Example 9

Figure28 explains the natural lighting in the plan and section for nine examplesat a different time

Compare the area of lighting in the educational space at the location of the different windows. The windows location 2,3 is the maxim area of lighting in the section and plan. The ratio of natural lighting area for windows location 2,3 is 42.6% ofthe total area of space in the plan. Also, the ratio of natural lighting area for windows location 2,3 is 66.2% ofthe total area of space in the section. The area of lighting decrease with different level of windows to down as explained figure29.

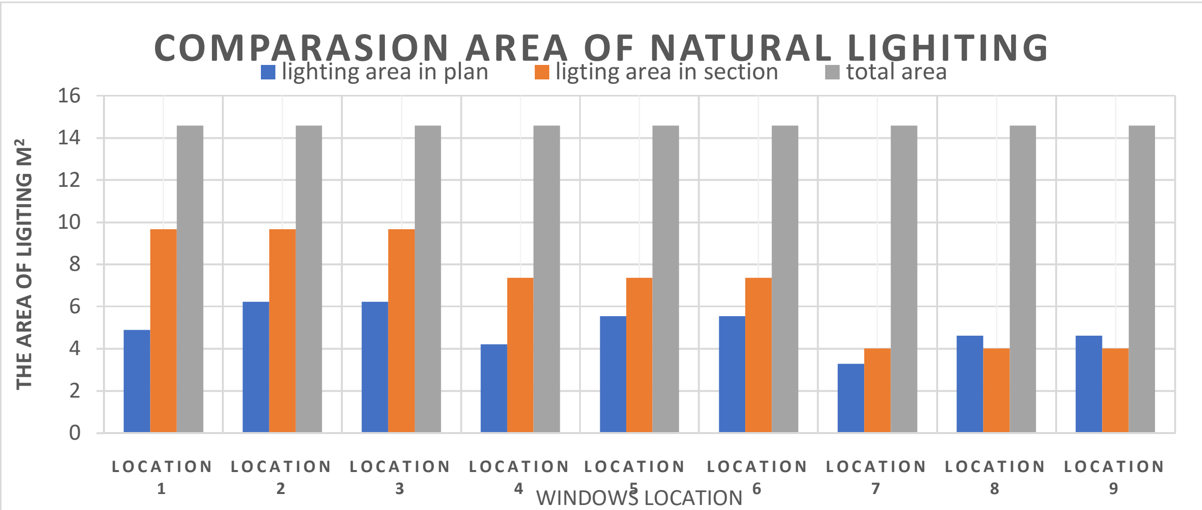


Figure29 explains the natural lighting in the plan and section for nine different windows location.

4. conclusion:

The main goal of this study was to improve the natural lighting of indoor educational spaces and save energy consumption through that. So, it included a comparison of the different effects ofchanging the window ratios at the four external walls. According to that, the zone sensible heating increases with an increase in the ratio of the window at the external wallby no more than 10% between each window ratio and the next.the Comfort Temperature decreases with an increase in the ratio of the window at the external wallby no more than 2% between each window ratio and the next. the Glazing Gains decrease with an increase in the ratio of the window at the four external walls from ratio10% to ratio90% with a ratio of 87.4%.the Wall Gains increase with an increase in the ratio of the window at the external wall windows from ratio10% to ratio90% with a ratio of 77.7%. Additionally, the energy needed for District Heating was increasing with increasing the ratio of the windows on every wall.the energy needed for District cooling was increasing with increasing the ratio of the windows on every wall.

Also, the study included a comparison of the different effects for change the windows ratios at the external east wall. According to that,the zone sensible heating increases with an increase in the ratio of the window at the external wall by no more than 5% between each window ratio and the next.the Comfort Temperature decreases with an increase in the ratio of the window at the external wall by no more than .5% between each window ratio and the next.the Glazing Gains decrease with an increase in the ratio of the window at the external wall windows from ratio10% to ratio90% with a ratio of 88.6%. the Wall Gains increase with an increase in the ratio of the window at the external wall windows from ratio10% to ratio90% with a ratio of 20.5%. Additionally, the energy needed for District Heating was decreased by increasing the ratio of the windows on the east wall**.** the energy needed for District cooling was increased by increasing the ratio of the windows on every wall.

Controlling the ratio of the window at the east elevation effect with a ratio above 65% in the zone sensible heating in space compared with the ratio of the window at the four elevations. Also, controlling the ratio of the window at the east elevation effect with a ratio above 53% in the amount of used energy in District cooling in space compared with the ratio of the window at the four elevations.

Another side of the study included controlling the area of natural lighting indoor spacesby changing the location of the window. The result of this side of the study had given some standers such as the same vertical location of windows having the same area of natural lighting in the plan, but it had differences in the location of lighting in space. The natural lighting for the section in the first level of elevation is symmetrical, but the third level down is different and less than theirs. Also, the area of natural lighting for the plan and section at the same vertical location is decreased in direction to down. According to that, the first level of location windows in elevation is the highest one from the other level.

The natural lighting for the plan increases from six o'clock to eight o'clock, then it decreases from eight o'clock to eleven o'clock in all these samples with the difference in the number of increases and decreases. But one of the window'slocations was different, the location at the down right side in the elevation (example9). Also, the natural lighting for the section in all examples decreases with time from six o'clock to eleven o'clock. Finally, the area of lighting decreased with different levels of windows down.

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