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"Design a PV grid connected Car Parking system for Eastern Car Complex of Nablus Municipality"

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Abstract

Cities in Palestine in general and Nablus in particular suffer from a shortage of electric power due to several reasons, the most important of which is the occupation, as the occupation prevents us from exploiting resources and disconnecting from it and places strict restrictions to keep the occupation not only limited to the land, but includes all aspects of life, including energy.

This project was designated to help meet part of the needs of the Nablus city for electric power by exploiting the Eastern car Complex to design solar energy systems and exploit all available places within it. As three design cases were assumed to take into account all options and capabilities available to us, where the best and latest global programs Specialized in this field were used, such as HelioScope, sketch up and AutoCAD to get the most accurate results that are: 35.4 kilowatts were obtained, which is equivalent to the consumption of 11 Palestinian homes in the first case, 44.8 kilowatts were obtained, which is equivalent to the consumption of 15 Palestinian homes in the second case and 108 kilowatts which is equivalent to the consumption of 36 Palestinian homes in the third case were obtained.

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Acknowledgments:

To all those who helped us reach this stage, to everyone who gave us a lot and a lot, to our families, to our parents, to our mothers, to our generous family, to our teachers, our friends, colleagues, and loved ones, to all the hands that helped us during this educational process, to everyone who transplanted We have a love of ambition and reaching this crucial stage ..... Thank you, and we thank you very much and grateful.

We will not forget those unknown soldiers who went through the various stages and stations of study and helped us with a word in the words to redress fractures and go beyond the most difficult and most difficult stages that affect our future, to everyone who met us with a smile every morning of every university day, to those distant people near ... you have all the love. And affection.

We cannot mention the names of many, but we singly mention the project supervisor, Dr. Aysar Yasin, the municipality of Nablus, and the engineer, Maysam Melhem, for their effective follow-up and communication to accomplish this work.

1.Chapter one : Introduction

1.1 Overview

Today we all hear about renewable energy and see it everywhere around us with its various types and applications, and with the passage of time increases research in this area and increases attempts to search for other sources of energy and also increases experiments in developing renewable energy means that currently exist, and because of the large and increasing consumption of oil and fear of depleting The world's reserves of oil in the future, as it constitutes 90% of our energy consumption through fossil fuels [1].

With the great advancement in technology and with the development of mankind, the whole world has become more aware of the problems of fossil fuels currently used and their damages to humans, animals and the surrounding environment, so that the transformation has become To renewable energy and moving away from fossil fuels is a matter of time, and in light of global policies calling for a shift to renewable energy as an alternative and a solution to energy problems in the future and competition between world countries in this field, we conclude that the coming years will witness a significant and remarkable development in this field[2].

Among the types of renewable energy used in energy production around the world are solar energy, wind energy, geothermal energy, hydropower and bioenergy[3] .

In Palestine, the renewable energy situation differs from the rest of the Middle East countries due to the political, economic and demographic conditions that the country suffers from. Palestine relies on obtaining fossil fuels 100% and 87% of its electricity from foreign countries. On the other hand, Palestine has a high capacity of solar energy, about 3000 hours of brightness per year, with solar radiation ranging between 6 to 8.5 (kilowatt hours / square meters / day), and these values confirm that investing in solar energy in Palestine is feasible[4].

The consumption of electrical energy in Nablus is from 75 to 85 MWh daily, and the largest consumption of electrical energy is 105 MWh daily. The amount of energy supplied to Nablus by the Israeli occupation is equal to 110 MWh daily[5].

Therefore, our project will focus on the exploitation of solar energy in Palestine by presenting a design that we have designed during this course to produce electrical energy through solar panels that depend on solar energy.

1.2Objectives

- ❖ Designing a solar cell system for the eastern car complex in Nablus and making it the first car complex producing electric energy using solar energy in Palestine.
- ❖ Producing electrical energy using solar cells and filling part of the shortage that Nablus suffers from.
- ❖ Exploiting the solar panels system and using them as umbrellas for cars, drivers and passengers.

1.3 Statement of the problem

- The difficulty of obtaining aerial photos of the site using international design programs.
- The tall trees in the complex are one of the important problems that greatly limit the design and negatively affect the solar cells.

1.4 Methodology

Gather all necessary data about the compound such as charts, aerial photos, and weather information.

Three cases (three visions) were developed for the complex and were designed according to them :

- ❖ The first case: the current state of the complex
- ❖ The second case: an amendment to the existing facilities (increasing the height) and reducing the height of trees
- ❖ The third case: modification to existing facilities (increasing the height) and reducing the height of trees and designing solar cell systems for car parks that do not have shades.

1.5 Information about the car complex

The eastern car complex of Nablus is located on the eastern side of it, where it is bordered on the east (residential buildings) and from the west (Al-Jahez Street with a width of 10 meters and the eastern market of Nablus) and from the north (Al-Hurriya Street with a width of 20 meters) and from the south (residential buildings) and its area is estimated at about 7 dunams = 7000 square meters[6].

The complex is considered a stopover for the villages and cities east of Nablus, such as Tubas, Tamoun and .... etc., as it is thus the only connection point between Nablus and the villages and cities in the east.

The eastern complex has one entrance on the north side (the northern entrance) and two exits, a taxi exit on the northwestern side and a bus exit on the southwestern side. The complex contains 300 taxis and 70 buses (19 passengers) distributed over 36 transport lines. The number of citizens who pass through it is estimated (6,900 passengers, according to the figures of Nablus municipality for the year 2019), including students, employees and tourists, and the number of employees in the complex is only 5 employees[6].

Here, in this project, we will design a station to generate electric energy through solar cells in the complex, to be the first complex in Palestine to produce electrical energy through solar cells.

1.6 Weather data for Nablus city

Nablus is located at latitude 32.21^0 and longitude 35.256^0.

Table(1) in bottom shows the weather conditions in Nablus (maximum and minimum temperature, relative humidity, solar radiation and wind speed) throughout the year.

Table 1:Climate zones average annual weather parameters in Palestine [7]**.**

City	Tulkarem	Jericho	Hebron	Jerusalem	Bethlehem	Jenin	Gaza	Nablus
Humidity (%)	69.4	52	61.8	57.0	54.7	68.9	70.8	60.5
Cooling design temperature (°C)	36.9	46.4	38.0	38.0	42.1	40.4	43.5	38.8
Heating design temperature (°C)	4.2	−0.4	−3.0	−4.1	−0.9	1.0	2.0	−2.8
Temperature (°C)	18.9	25.2	23.1	18.4	17.2	21.7	20.7	18.4
Wind speed (km/h)	6.8	2.0	3.9	3.9	3.6	2.6	-	4.98
Solar radiation (kWh/m^2 day)	5.6	6.1	6.2	5.35	6.0	5.28	6.2	5.8

There are several figures showing the weather in Nablus city in more detail.(see Appendices).

2.Chapter two: Literature Review

Various studies have been completed, which discussed different subjects that are to be merged in this project, Sizing of a Solar Parking System Connected to the Grid. This section discusses the reviews and researches based on and builds up this project.

Dahbi A et al installed the solar car park in Adrar region , south west of Algeria. They used it in order to benefit from the roof area by installing photovoltaic panels, moreover for obtaining shadow and electrical energy. This latter can be used for different applications such as charging electrical cars and grid connection which is the used application in that paper. In that work, the solar car park is studied to be installed in Adrar with a power equals to 31.5 kWc. They compared between the simulation using PVSYST and the analytical results, And by matching the numbers with each other, it is obvious that a very good accuracy is noticed from this comparison [8].

Umer F et al presented a solution to the problem of increasing dependence on fossil fuels to generate electricity, which leads to many environmental problems, By implementing solar car parking lots at Bahawalpur. Using HelioScope online software, the detailed work was done to select the location of solar parking lots, maximum generation of solar electric power and capacity effects with shading of trees and nearby buildings. They made improvements to various parking canopies with standard tilt angles, and it was analyzed that a south-facing monopitch canopy with a 10-degree tilt angle had the highest efficiency for installing new solar-powered parking lots. The total investment cost of the parking structure and the photovoltaic (PV) system can be paid back in 6-7 years [9].

Charney et al installed a solar PV ”carport” at the University of Southern California football stadium, the Los Angeles Memorial Coliseum. They used System Advisor Model (SAM) in their analysis and design modeling, when they studied simulations of two different modules, the Yingli Energy YL260P-35B module and the Sunpower SPR-305E-WHT-D module. Then, they compared the energy and financial results. then, as a result, the solar energy system is financially viable when using both modules. They considered their project as feasible one because the payback period is shorter than the estimated life of the project which it is around 12 years, the value for the net savings with system is positive and the net present value is positive [10].

Krishnan R et al provided a method for determining the technical and economic potential for converting a national scale retail company’s parking lot area to a solar farm with PV canopies, enabling sustainable electricity generation while preserving their function to park automobiles. To demonstrate this method, analysis of Walmart Supercenters, USA is presented as a case study. They performed a sensitivity analysis on the price per unit power installed, solar energy production as a proxy for conversion efficiency, electricity rates and revenue earned per unit area. This study reveals that even at modest rates of electricity and installation rates, PV profits from solar canopies are high, particularly in locations with high solar irradiation. The results show solar canopies for parking lot areas are a profitable as well a responsible step in most locations and there is significant potential for sustainable energy deployment in cities by other similar retailers using solar PV canopies [11].

Neumann, H et al analyzed the PV potential of different 48 parking lots in Frauenfeld, a capital of Switzerland. They concluded that solar carports could be feasible and favorable option for generate electricity from renewable energy which serve the transport purposes, so that these parking lots can cover approximately between 15% and 40% from energy demand for private car use. These 48 parking lots are distributed in a certain areas of the city specially in commercial and industrial areas [12].

Alghamdi, A et al conducted a case study in King Abdulaziz University, Saudi Arabia, which has 8% of campus parking area. ArcGIS, a geographical information system tool, and TRNSYS software were used as models to simulate solar radiation and generate power from a photovoltaic system. Car parks consist of already shaded spaces and open spaces for cars, and both spaces have been analyzed to obtain the PV energy from the aforementioned modeling techniques which can generate 36.4 MWp of maximum electrical power and 66.2 GWh of electrical energy. An economic analysis was performed that represents a cost of US $ 44.5 million with a repayment period(payback period) ranging from 8 to 16 year [13].

Ingersoll, J and Perkins, C designed the 2.1 kW PV vehicle charging station in Santa Monica, California as an experimental scale, a pioneering unit for installing photovoltaic (PV) systems in parking shades to enhance the solar parking mechanism [3, 14]. It was designed for seven car parks, and has a capacity of 2.1 kW. System simulation analysis was performed at "Sandia National Laboratories Albuquerque, NM" at 40° degree west of south and 22.5° tilt [14].

The existing literature gives a very broad overview of modeling approaches, technologies, and feasibility for solar parking lots canopies . The detailed discussion is highly dependent on theses researches and builds this project upon it, and its results have to be discussed and taken into consideration for optimum outputs of this project.

3. Chapter three : Results and Data Analysis

3.1 Solar system information:

The panels were taken from [Trina solar, TSM-DE20-590 (590W)] and kaco type inverters in different sizes[15].

The tilt angle of the panels in Nablus was considered 32^0.

The azimuth angle is taken as 180^0.

The design was based on two types of orientation, and it was linked according to the available space for the panels, commensurate with the attractive design and shape.

3.2 Design cases:

Three cases (three scenarios) were taken for the complex to study all possible opportunities to design the system and obtain the most energy possible, taking into account the aesthetics of the design.

And we did this using sketch up, AutoCAD and HelioScope software.

- Case1: Current Situation.
- Case2: Modification of the status of the existing facilities (Good Option).
- Case3: The Advanced Option (The Best).

3.2.1 Case 1: Current Situation

The current situation of the complex was studied and the necessary measurements and heights were taken for that, as the complex currently consists of a two-storey administrative building (a cafeteria on the ground floor and an administrative office on the first floor) with a height From 5 m to 6 m sloping with an angle and one iron canopy for cars with a height of 3 m to 4 m sloping at an angle from the middle and public bathrooms inside the complex with a height of 4 meters and trees are distributed within the complex and their lengths range from 3 meters to 11 meters, and Details are shown in figure (1).

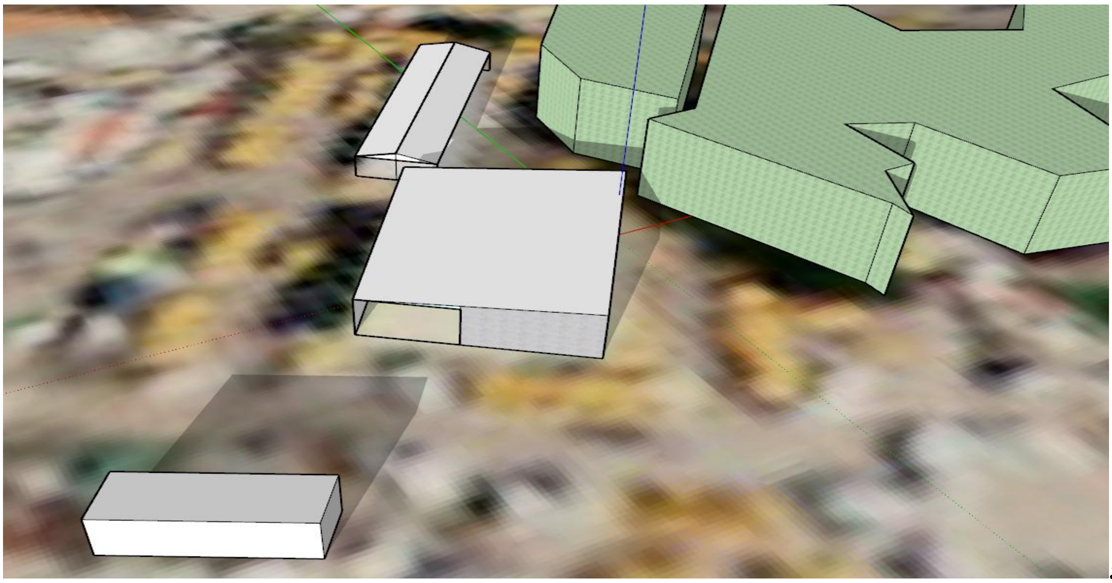 :

Figure 1: Sketch Up image of the car complex (case 1)

Designs:

-Design of the solar energy system for the administration building with a capacity of ($30kw_p$).

Height = 5 m to 6 m

Surface area = 467 m^2

Number of modules = 51 modules [Trina solar , TSM-DE20-590 (590W)]

Orientation of modules : landscape (horizontal)

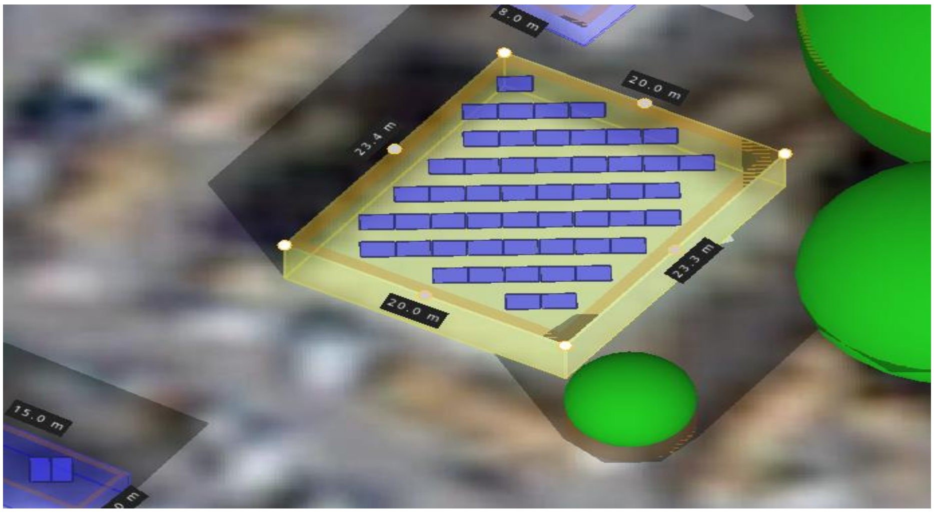

Figure 2: Design of the solar energy system for the administration building using HelioScope (case1)

-Design a solar system for the car park covered with an iron canopy with a capacity of (3 kw_p)

Height = 3 m to 4 m

Surface area = 226 m^2

Number of modules = 5 modules [Trina solar , TSM-DE20-590 (590W)]

Orientation of modules : landscape (horizontal)

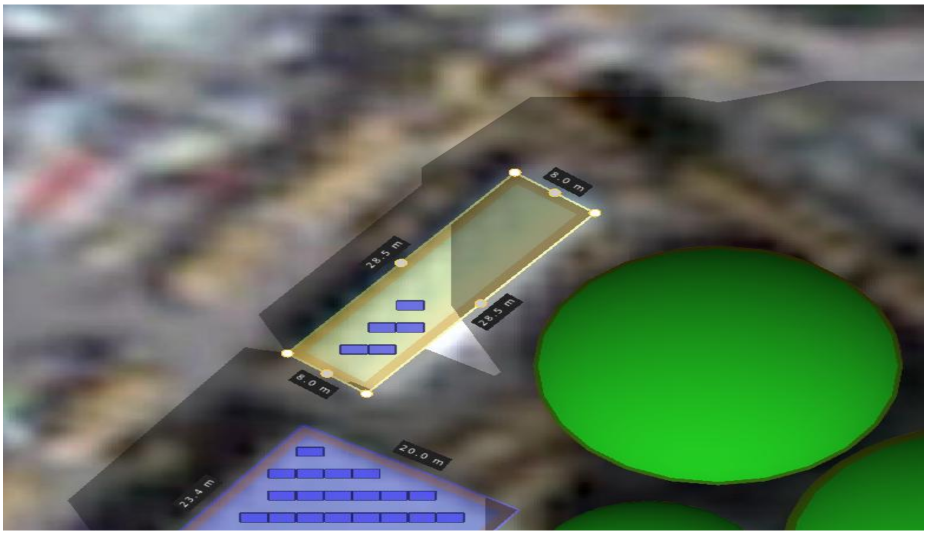

Figure 3: Design of the solar energy system for the car park covered with an iron canopy using HelioScope (case1)

-Design a Solar system for public bathrooms in the complex with a capacity of (2.4 kw_p)

Height = 4 m

Surface area = 75 m^2

Number of modules = 4 modules [Trina solar , TSM-DE20-590 (590W)]

Orientation of modules : portrait (vertical)

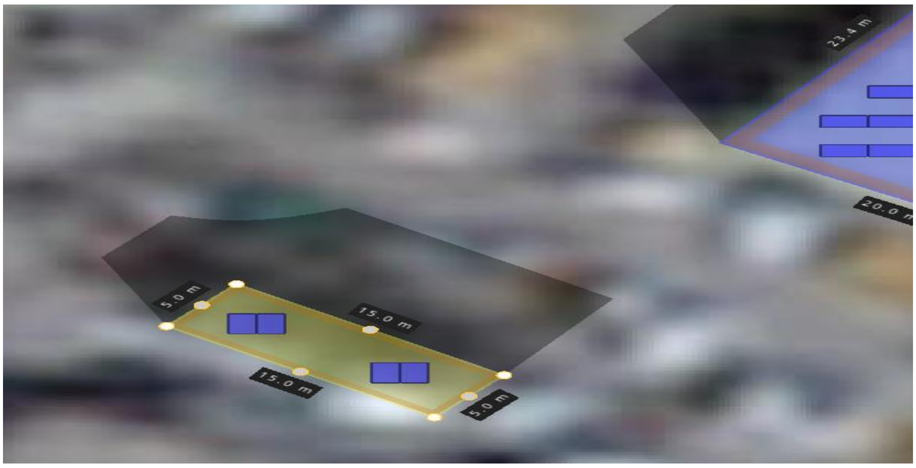

Figure 4: Design a Solar system for public bathrooms using HelioScope(case1)

the total number of modules = 60 modules [Trina solar , TSM-DE20-590 (590W)]

the total power of modules = 35.4 kw_p

Number of inverters = 1 inverter [KACO, Powador 36.0 TL3 (30 kw)]

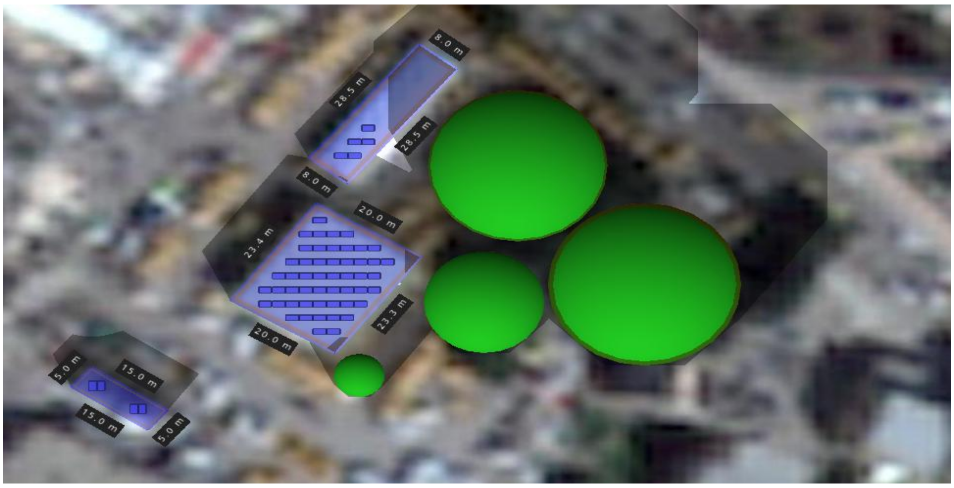

Figure 5: Design of the solar energy system for the current situation(case1) of complex

Protection system and distribution of solar panels:

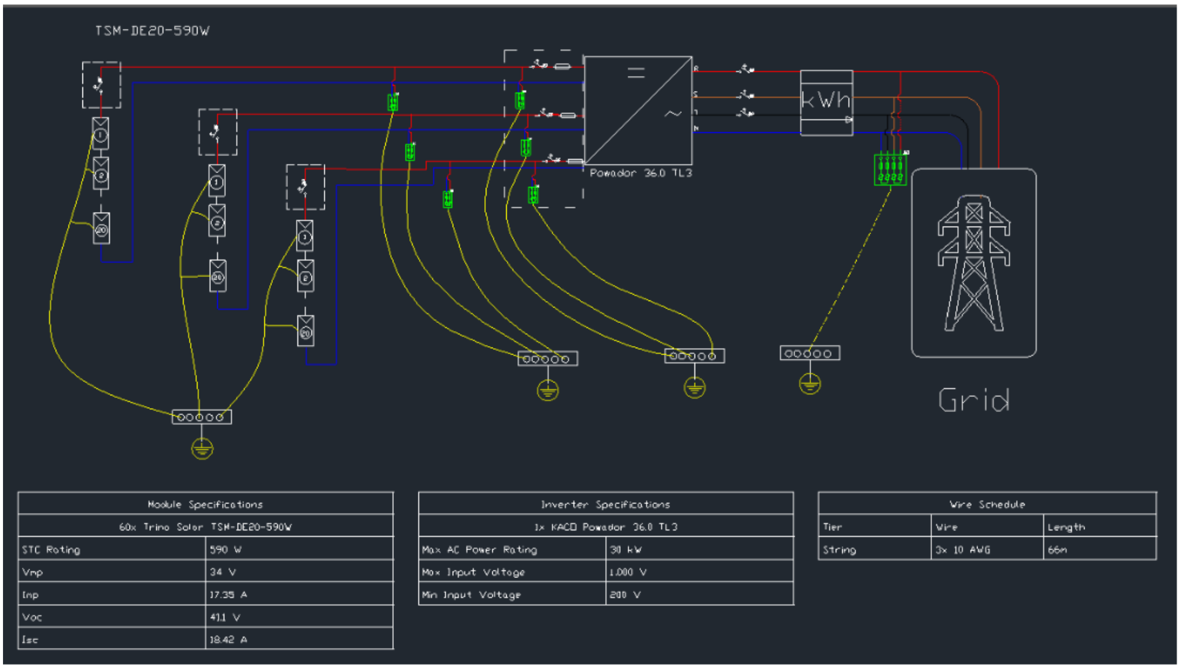

Figure 6: Plan of the solar energy system for the current situation(case1) of complex using AutoCAD

Table 2 : quantities and prices (case 1)

	quantities	Unit Price (NIS)	Total cost(NIS)
Solar Modules	60	770 (220$)	46200
Inverters	1	13000	13000
Circuit Breakers(DC) (25A)	6	280	1680
Circuit Breakers(AC) (100A)	3	200	600
Fuses	3	15	45
Surge Arrestors(DC)	6	170	1020
Surge Arrestors(AC)	1	140	140
Dc Cables 5*6 mm^2	32 m	4	128
Ac Cables 5*16 mm^2	40 m	32	1280
Cable shoes	10	0.8	8
Earth leakage	4	115	460
Earth cable	10	5	50
Junction Box	1	160	160
Structures	60	200	12000
Electrode + busbar	4	210	840

Where the size of the solar system is estimated at (35.4 kw_p).

Thus, the system cost is estimated at (77600 NIS).

3.2.2 Case 2: Modification of the status of existing facilities (good option)

For the administrative building :

Here a study was made to control the height of the administrative building by designing a structure with a height of 1 m from the western side of the administrative building (with a height of 5 meters) and making the cells at a height of 6 m so that the shape becomes horizontal and attractive and to facilitate the installation of panels on it

For the iron canopy :

Also, a structure was designed with a height of 1 m from the east and west side of the iron canopy (which have a height of 3 meters) and made the cells at a height of 4 meters so that the shape became horizontal and attractive and to facilitate the installation of panels on it

For public toilets :

The structure is designed with a height of 1 m from the surface of the bathrooms and the cells are made at a height of 5 meters so that the shape becomes horizontal and attractive and makes it easy to install the panels on it

For trees :

Reducing the height of trees to 5 meters (maximum tree height) was studied to avoid the effect of their shade, which negatively affects solar panels and their production.

The goal here in this case is to increase the size of the system and to have an attractive, easy-to-install shape for the panels.

Figure 7: Sketch Up image of the car complex (case2)

Designs:

-Design of the solar energy system for the administration building with a capacity of (30.7 kw_p)

Height = 6 m

Surface area = 467 m^2

Number of modules = 52 modules [Trina solar , TSM-DE20-590 (590W)]

Orientation of modules : landscape (horizontal)

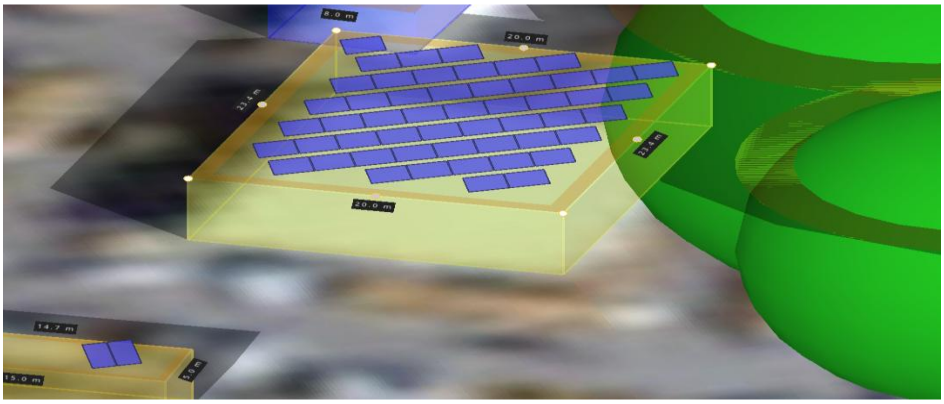

Figure 8: Design of the solar energy system for the administration using HelioScope (case2)

- Designing a solar parking system covered by an iron canopy with a capacity of (11.2 kw_p)

Height = 4 m

Surface area = 226 m^2

Number of modules = 19 modules [Trina solar , TSM-DE20-590 (590W)]

Orientation of modules : portrait (vertical)

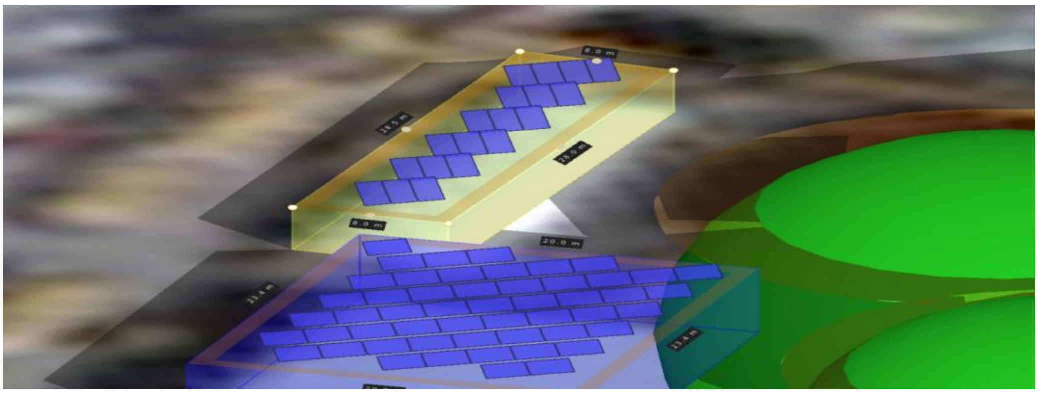

Figure 9: Designing a solar parking system covered by an iron canopy using HelioScope(case2)

- Design a solar system for a public bath with a capacity of (3 kw_p)

Height = 5 m

Surface area = 75 m^2

Number of modules = 5 modules [Trina solar , TSM-DE20-590 (590W)]

Orientation of modules : portrait (vertical)

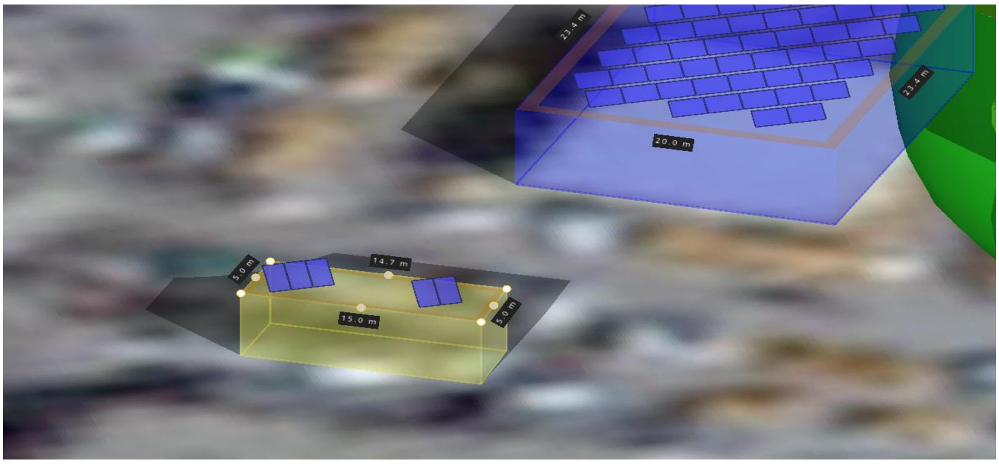

Figure 10: Design a solar system for a public bath using HelioScope (case2)

the total number of modules =76 modules [Trina solar , TSM-DE20-590 (590W)]

the total power of modules = 44.8 kw_p

Number of inverters = 2 inverter [KACO, Blue planet 20.0 TL3 (20kw)]

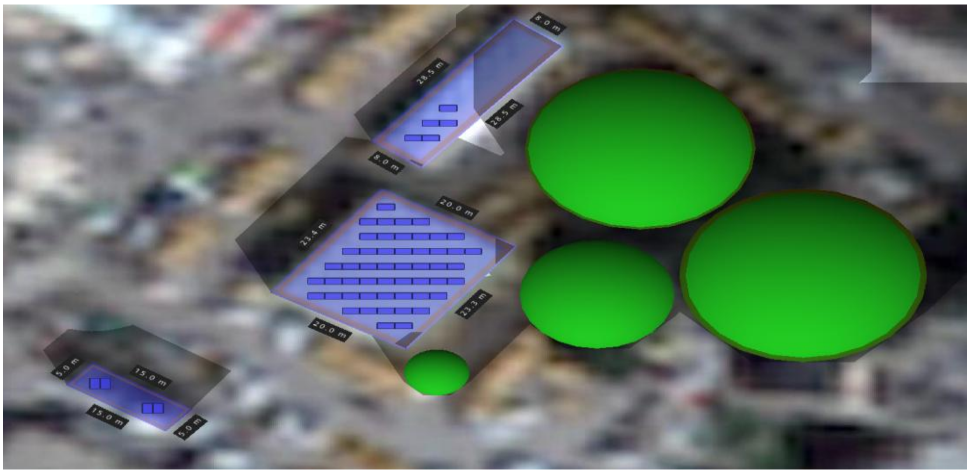

Figure 11: Design of the solar energy system for the Modification of the status of existing facilities (case2)

Protection system and distribution of solar panels :

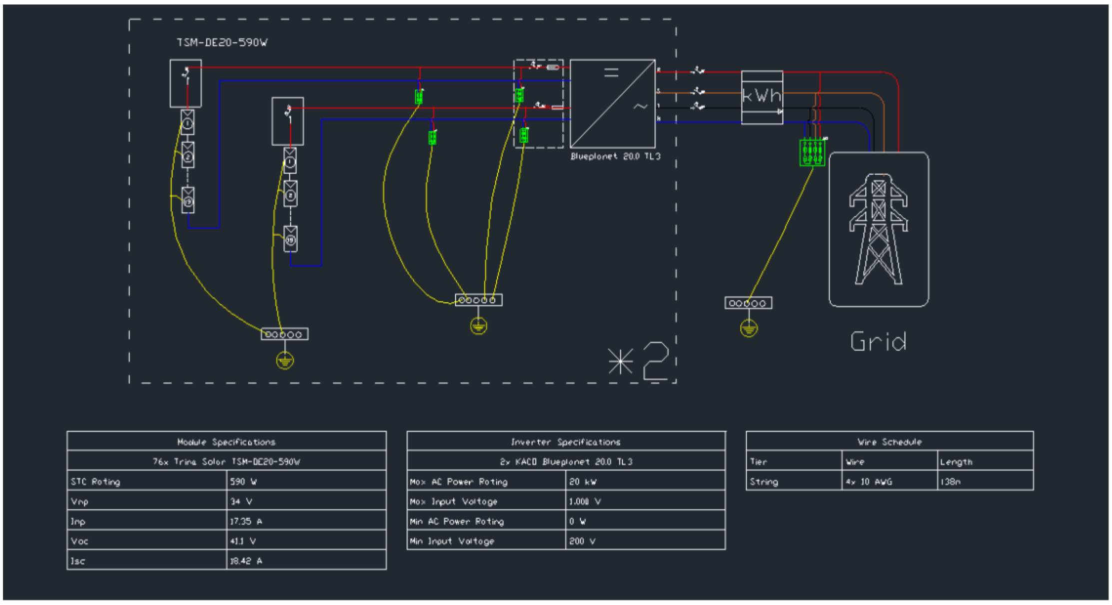

Figure 12: Plan of the solar energy system for the Modification of the status of existing facilities (case2) using AutoCAD

Table 3: quantities and prices (case2)

	quantities	Unit Price (NIS)	Total cost(NIS)
Solar Modules	76	770 (220$)	58520
Inverters	2	10000	20000
Circuit Breakers(DC) (25A)	8	280	2240
Circuit Breakers(AC) (63A)	3	200	600
Fuses	4	15	60
Surge Arrestors(DC)	8	170	1360
Surge Arrestors(AC)	1	140	140
Dc Cables 5*6 mm^2	40 m* 2inverter	4	320
Ac Cables 5*10 mm^2	32 m	20	640
Cable shoes	12	0.8	9.6
Earth leakage	5	115	575
Earth cable	13	5	65
Junction Box	1	160	160
Structures	76	200	15200
Electrode + busbar	5	210	1050

Where the size of the solar system is estimated at (44.8kw).

Thus, the system cost is estimated at (101000 NIS).

3.2.3 Case 3: Advanced Option (Best)

In this case, solar energy systems were designed for all car parks in the complex, in addition to adjusting the height of the administrative building by designing a structure with a height of 1 m from the western side of the administrative building (with a height of 5 meters) and making the cells at a height of 6 m

For the iron canopy :

Also, a structure was designed with a height of 3 m from the east and west side of the iron canopy (which have a height of 3 meters) and the cells were made at a height of 6 meters so that the shape became horizontal and attractive and to facilitate the installation of panels on it

For public toilets :

The structure is designed with a height of 1 m from the surface of the bathrooms and the cells are made at a height of 5 meters so that the shape becomes horizontal and attractive and makes it easy to install the panels on it.

For trees :

Reducing tree height to 6 m (maximum tree height) was studied to avoid the resulting shade adversely affecting solar panels and production.

For car parks (that do not contain shades)

Structures are designed in different heights depending on the location of each site

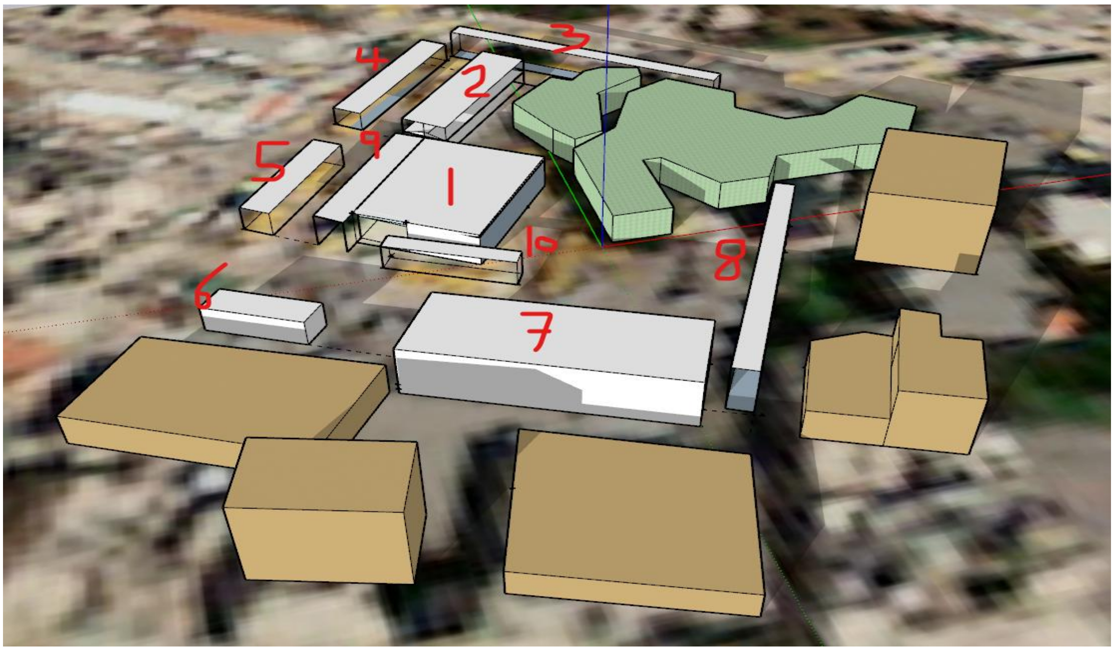

Figure 13: Sketch Up image of the complex distributed by numbers (case3)

Designs :

1. Design the solar energy system for the following places (1,6,8,9,10)

-the administration building (30.7 kw_p) : [1]

Height = 6 m

Surface area = 467 m^2

Number of modules = 52 modules [Trina solar , TSM-DE20-590 (590W)]

Orientation of modules : landscape (horizontal)

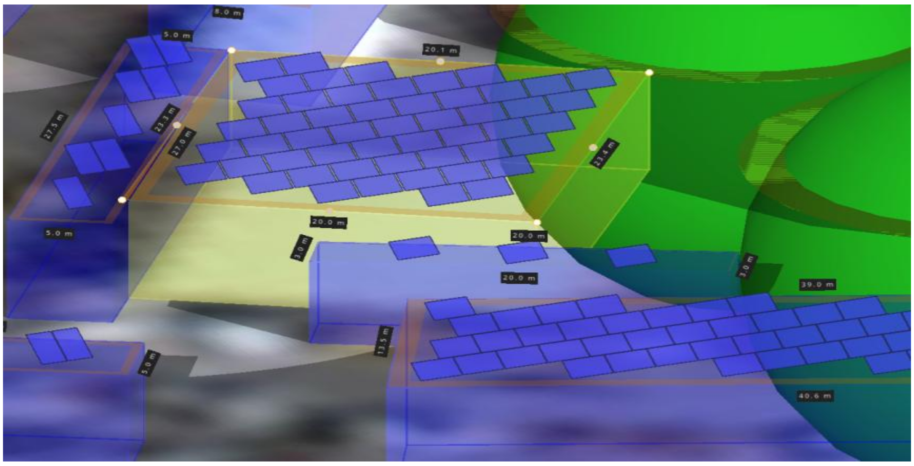

Figure 14: Design of the solar energy system for the administration using HelioScope (case3)

-Designing a solar car parking system for public bathrooms in the south side with a capacity of (3 kw_p). [6]

Height = 6 m

Surface area = 75 m^2

Number of modules = 5 modules [Trina solar , TSM-DE20-590 (590W)]

Orientation of modules : portrait (vertical)

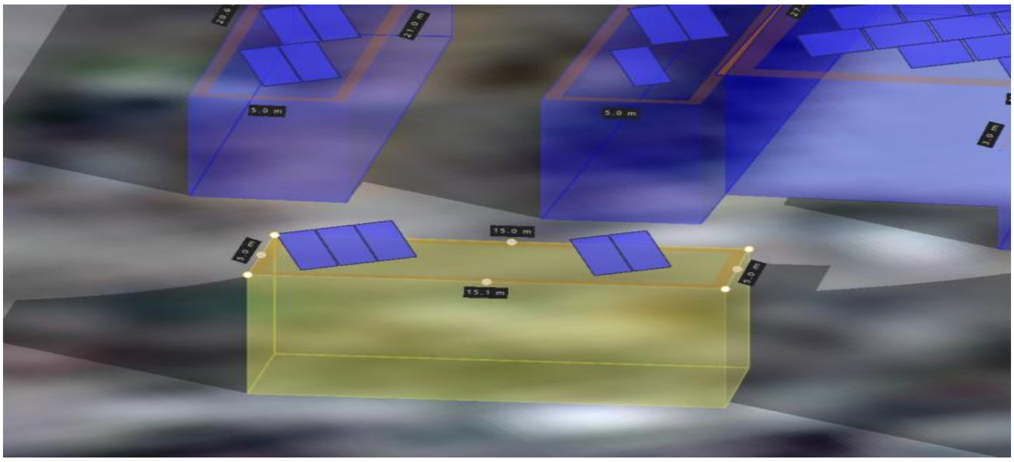

Figure 15: Designing a solar car parking system for public bathrooms using HelioScope(case3)

-the solar parking system on the eastern side of the complex(4.7kw$_p$) [8]

Height = 9 m

Surface area = 143 m^2

Number of modules = 8 modules [Trina solar , TSM-DE20-590 (590W)]

Orientation of modules : portrait (vertical)

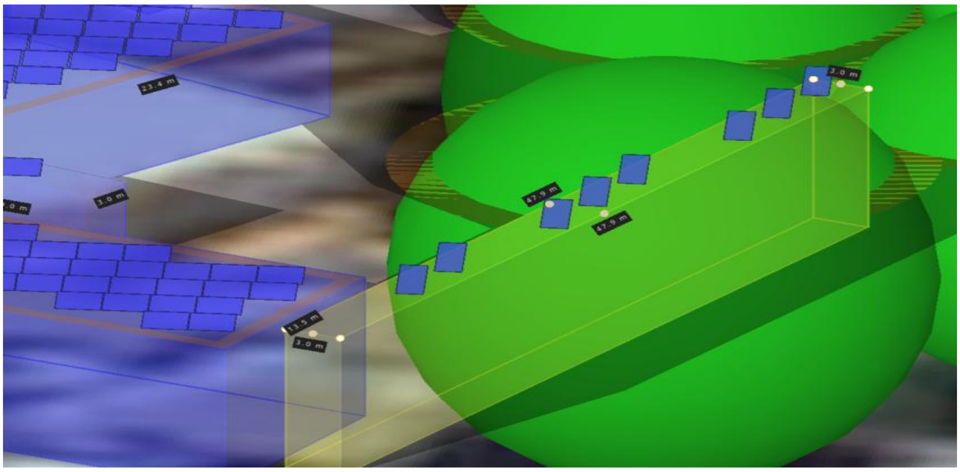

Figure 16: Designing the solar parking system on the eastern side of the complex(case3)

-the parking in the west of the administration building (4.7 kw_p) [9]

Height = 6 m

Surface area = 137 m^2

Number of modules = 8 modules [Trina solar , TSM-DE20-590 (590W)]

Orientation of modules : portrait (vertical)

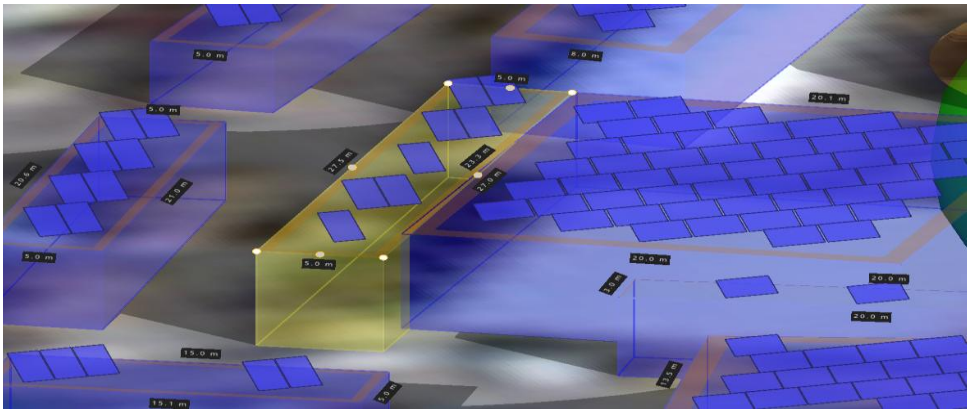

Figure 17:Designing the parking in the west of the administration building(case3)

-the parking in the south of the administration building (1.8 kw_p) [10]

Height = 5 m

Surface area = 60 m^2

Number of modules = 3 modules [Trina solar , TSM-DE20-590 (590W)]

Orientation of modules : landscape (horizontal)

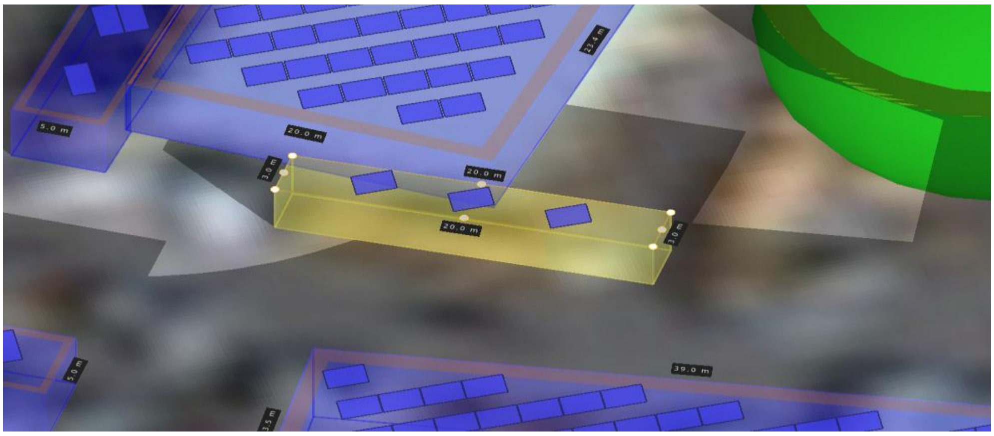

Figure 18: Designing the parking in the south of the administration building using HelioScope (case3)

the total number of modules (for **[(1)+(6)+(8)+(9)+(10)]**) = 76 modules [Trina solar , TSM-DE20-590 (590W)]

the total power of modules = 44.8 kw_p

Number of inverters = 2 inverter [KACO, Blue planet 20.0 TL3 (20kw)]

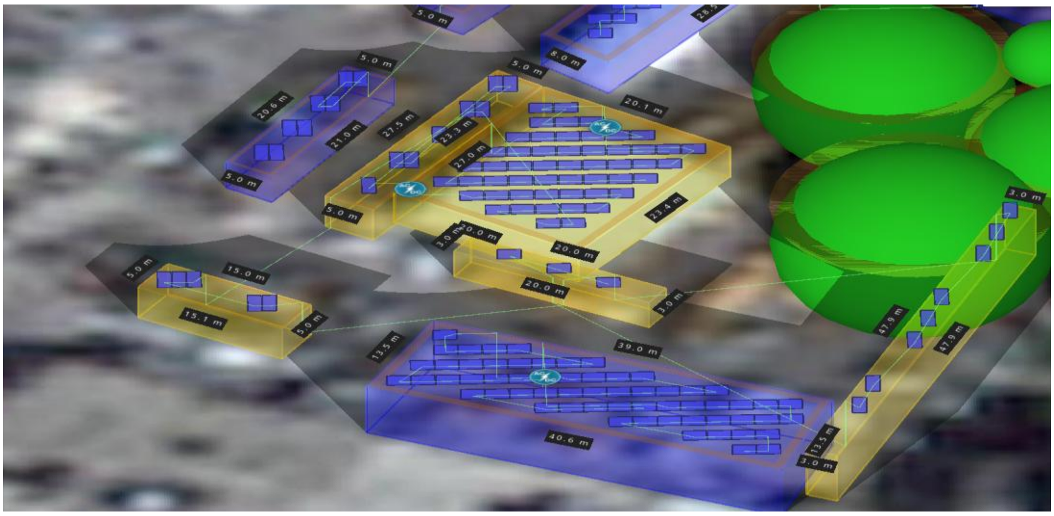

Figure 19: image of the solar energy system for the following places (1,6,8,9,10)using HelioScope(case3)

2. Design the solar energy system for the following places (2,3)

-The design of the solar system for the car park with a capacity iron canopy (8.9 kw_p) [2]

Height = 6 m

Surface area = 226 m^2

Number of modules = 15 modules [Trina solar , TSM-DE20-590 (590W)]

Orientation of modules : landscape (horizontal)

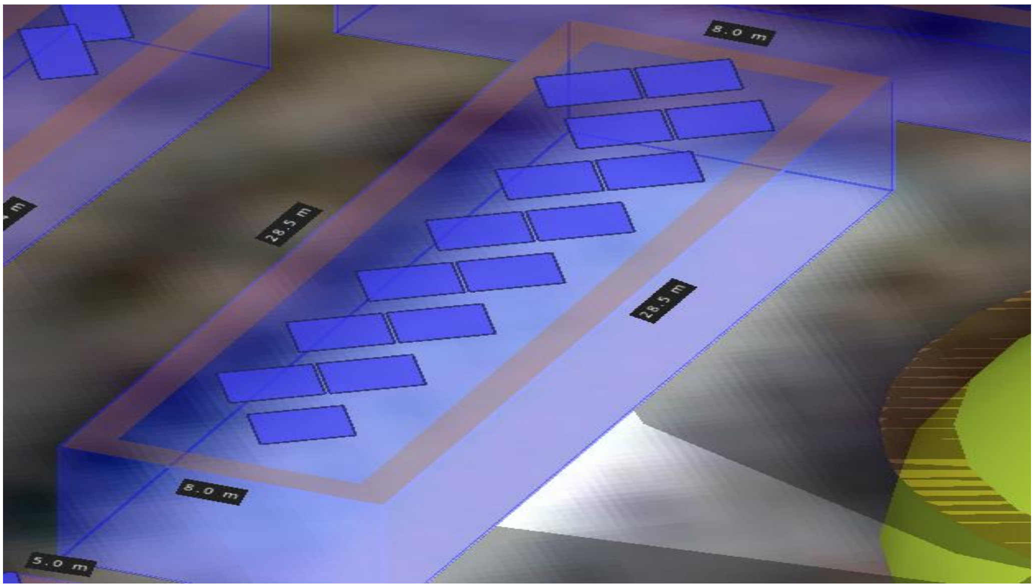

Figure 20: The design of the solar system for the car park with an iron canopy using HelioScope (case3)

-Designing a solar parking system on the northern side with a capacity of (8.9kw$_p$). [3]

Height = 6 m

Surface area = 237 m^2

Number of modules = 15 modules [Trina solar , TSM-DE20-590 (590W)]

Orientation of modules : landscape (horizontal)

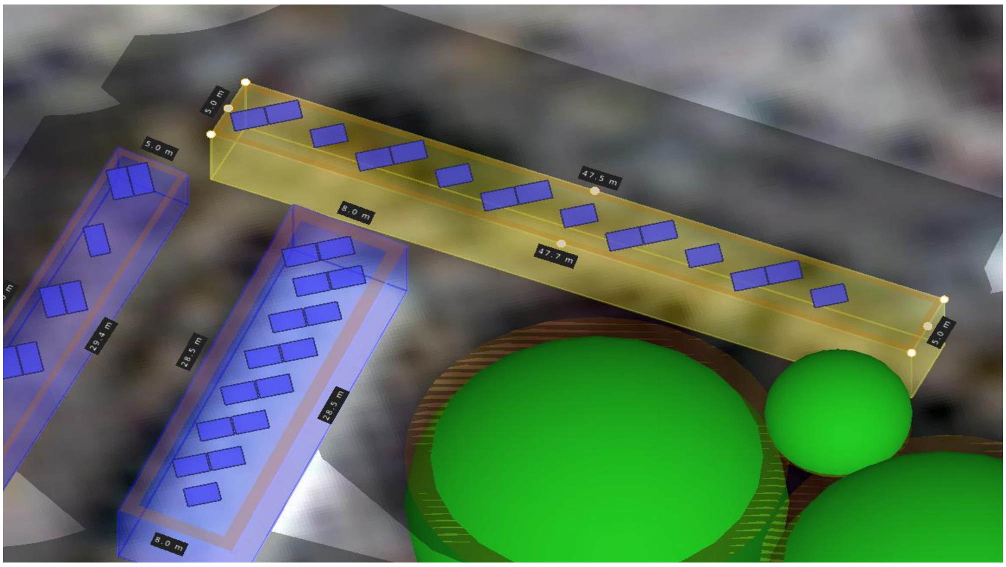

Figure 21: Designing a solar parking system on the northern side using HelioScope (case3)

the total number of modules(for **([(2)+(3)]**) = 30 modules [Trina solar , TSM-DE20-590 (590W)]

the total power of modules = 17.8 kw_p

Number of inverters = 1 inverter [KACO, Blue planet 15.0 TL3(15kw)]

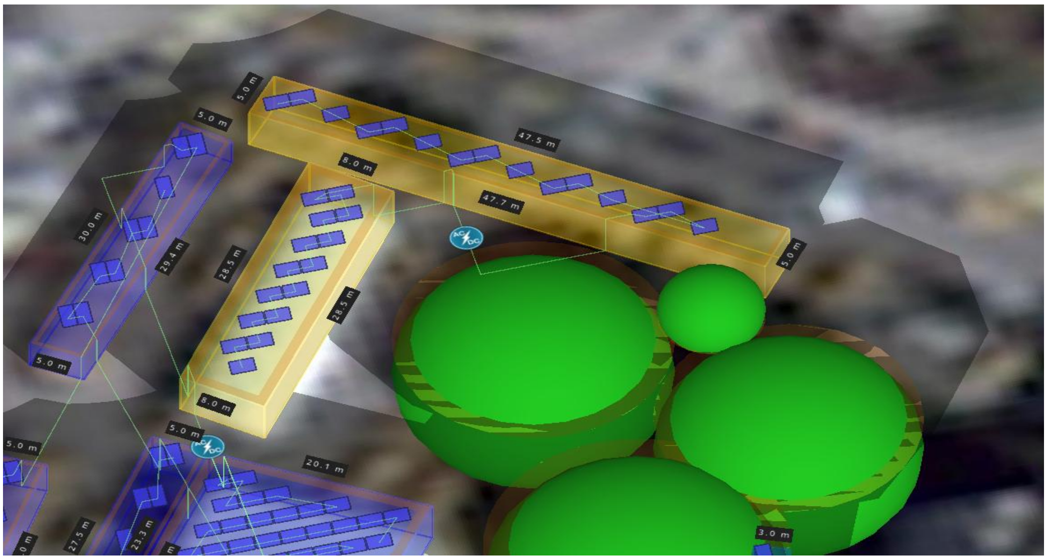

Figure 22: image of the solar energy system for the following places (2,3)using HelioScope (case3)

3. Design the solar energy system for the following place (7)

-Designing the solar parking system on the south side of the complex with a capacity of (35.4 kw_p). [7]

Height = 9 m

Surface area = 537 m^2

Number of modules(**for (7) only**) = 60 modules [Trina solar , TSM-DE20-590 (590W)]

Number of inverters = 1 inverter [KACO, Powador 36.0 TL3 (30 kw)]

Orientation of modules : landscape (horizontal)

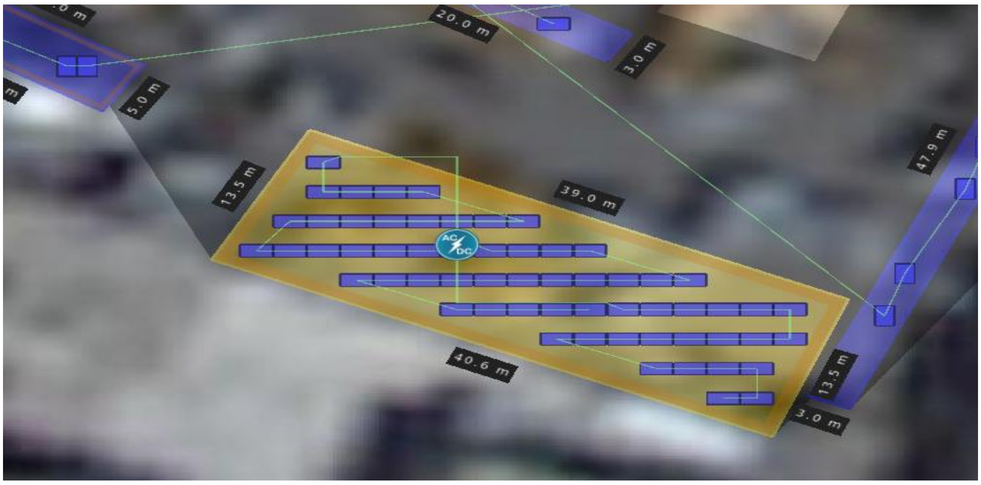

Figure 23: Designing the solar parking system on the south side of the complex(case 3)

4) Design the solar energy system for the following places (4,5)

-Designing a solar powered parking system on the western side with a capacity of (5.3 kw_p). [4]

Height = 4 m

Surface area = 147.5 m^2

Number of modules = 9 modules [Trina solar , TSM-DE20-590 (590W)]

Orientation of modules : portrait (vertical)

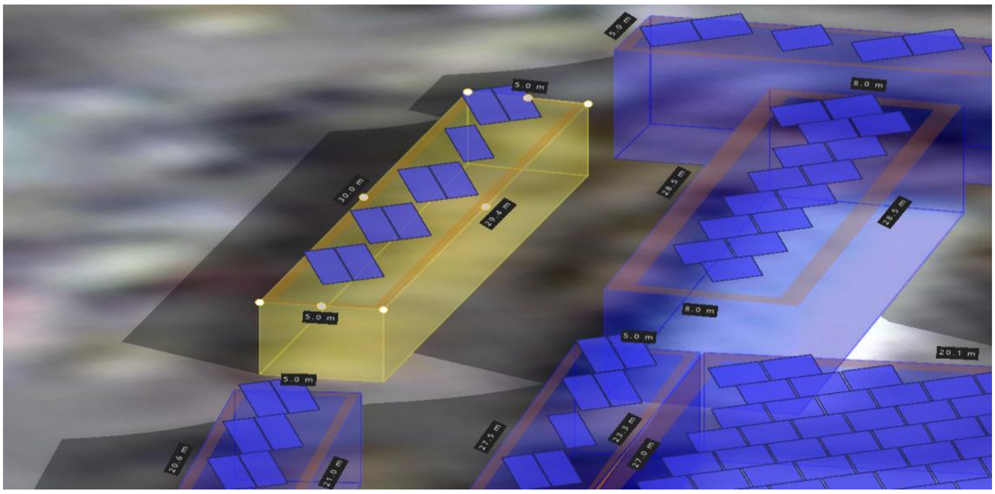

Figure 24: Designing a solar powered parking system on the western side of complex using HelioScope (case3)

-Designing a solar system for parking on the southwestern side, with a capacity of (4.7 kw_p). [5]

Height = 5 m

Surface area = 103 m^2

Number of modules = 8 modules [Trina solar , TSM-DE20-590 (590W)]

Orientation of modules : portrait (vertical)

Image of HelioScope

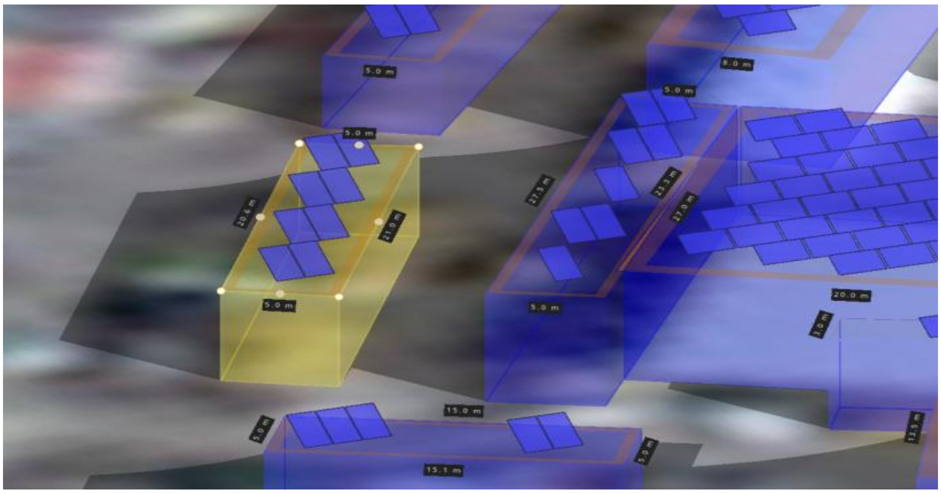

Figure 25: Designing a solar system for parking on the southwestern side of complex using HelioScope (case3)

the total number of modules (for **[(4)+(5)]**) = 17 modules [Trina solar , TSM-DE20-590 (590W)]

the total power of modules = 10 kw_p

Number of inverters = 1 inverter [KACO, Blue planet 10.0 TL3 (10kw)]

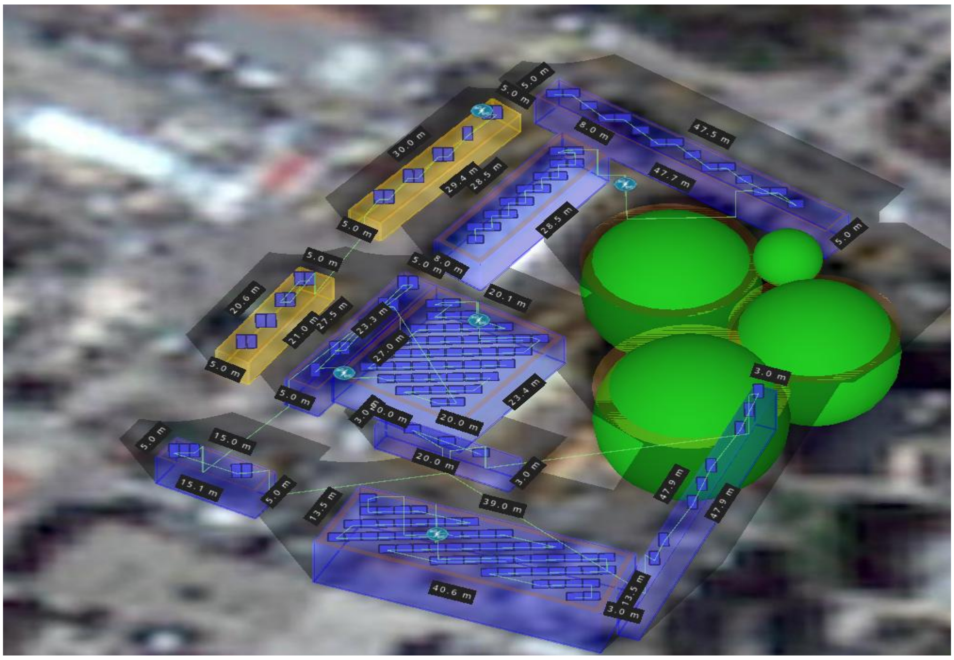

Figure 26: Design the solar energy system for the following places (4,5)using HelioScope (case3)

the total number of modules (**for all [from (1) to (10)]**) = 183 modules [Trina solar , TSM-DE20-590 (590W)]

the total power of modules = 108 kw_p

Number of inverters = 5 inverter of different sizes

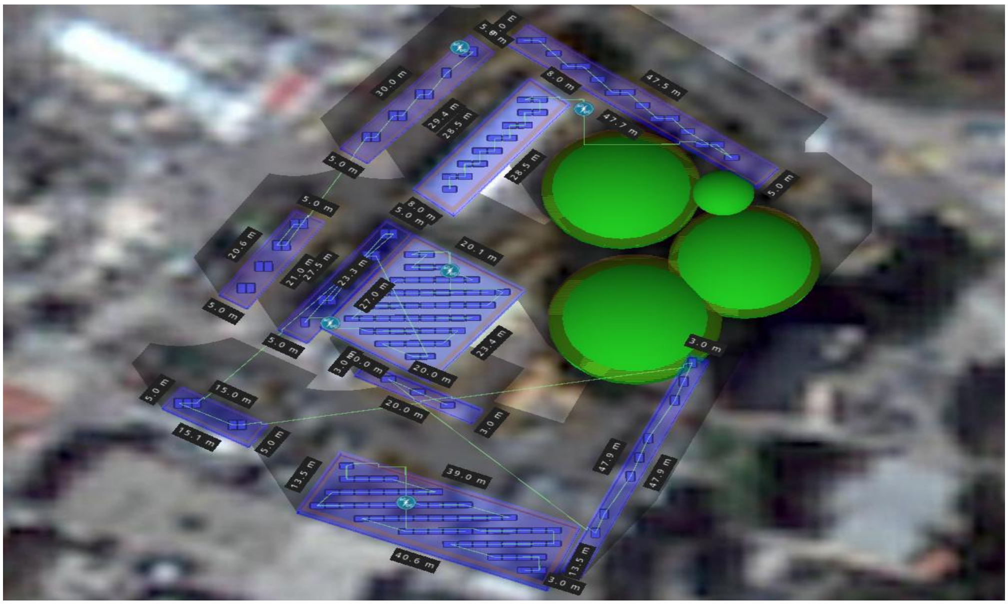

Figure 27: Design the solar energy system for all places (from1 to 10) in case 3

Protection system and distribution of solar panels

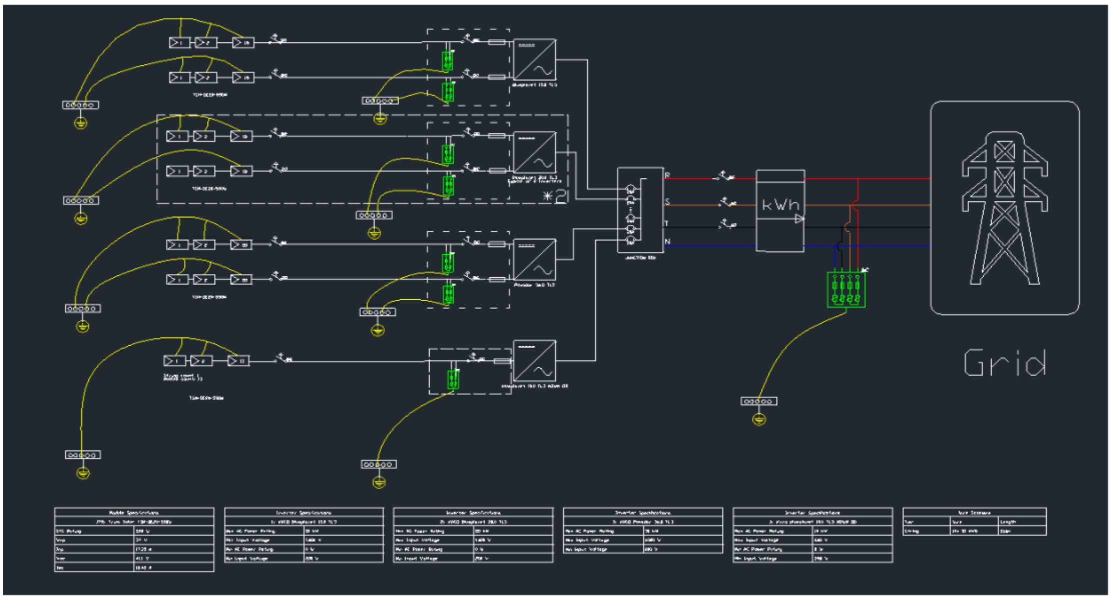

Figure 28: Plan of the solar energy system for the advanced option of complex using AutoCAD (case3)

Table 4:quantities and prices (case3)

	quantities	Unit Price (NIS)	Total cost(NIS)
Solar Modules	183	770 (220$)	140910
Inverters 15 kw 20 kw 30 kw 10 kw	5 1 2 1 1	 8500 10000 13000 5500	47000
Circuit Breakers(DC) (25A)	18	280	5040
Circuit Breakers(AC) (315 A)	3	450	1350
Fuses	9	15	135
Surge Arrestors(DC)	9	170	1530
Surge Arrestors(AC)	1	140	140
Dc Cables 5*6 mm^2	200 m	4	800
Ac Cables 5*50 mm^2	70 m	70	4900
Cable shoes	13	0.8	10.4
Earth leakage	5	115	575
Earth cable	13	5	65
Junction Box	6	160	960
Structures	183+ canopies	200 + canopies	36600 + 50000
Electrode + busbar	11	210	2310

Where the size of the solar system is estimated at (108 kw_p)

Thus, the system cost is estimated at (292000 NIS)

3.3 the structure of modules :

The structure was designed using AutoCAD software to add more clarification to the report, and to obtain the most accurate results

Solar Panel Dimensions (1303mm, 2172mm, 35mm)

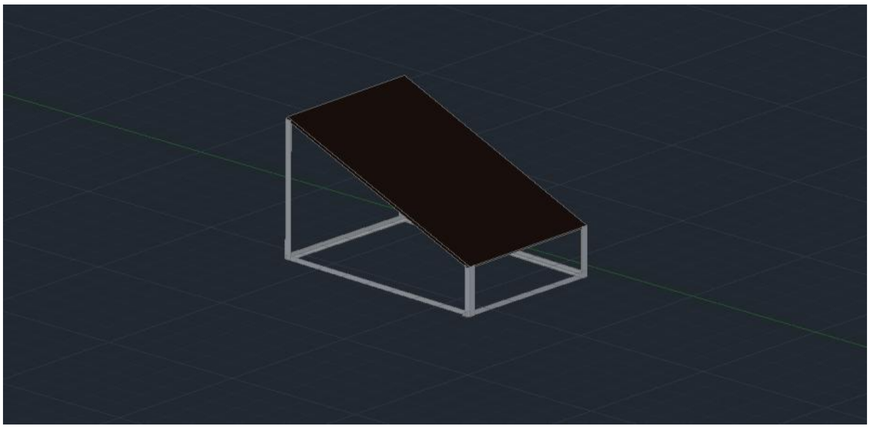

Figure 29: image of structure using AutoCAD software (SW isometric)

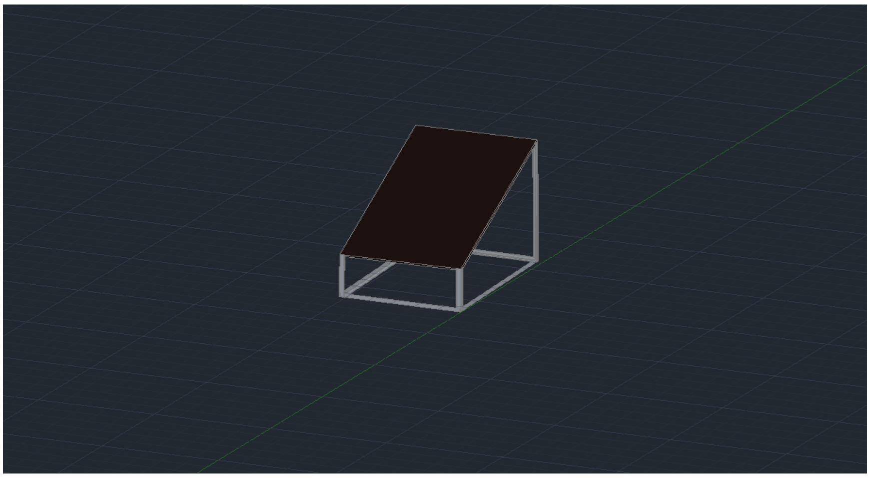

Figure 30: image of structure using AutoCAD software (SE isometric)

4.Chapter four : Discussion

In this project, we have designed a solar energy system connected to the grid in the eastern taxi complex in the city of Nablus, which serves many villages and surrounding cities and forms a link between them and Nablus. We studied the site well after we visited it and took pictures of it. Then we took the plans and all the detailed information from the Nablus municipality, after we visited it as well. and figure(31) show an aerial photograph of the site

Figure 31: aerial photograph of the complex

In this chapter we will discuss the results obtained from the previous chapter. We have studied three different cases of panel installation and compared them to see the best ones with increased energy and the least loss, whether due to shadows or other factors. We will review the design results for the three cases and refer to the best of them:

4.1. Case1: Current Situation

In the first case, we notice that we need 60 solar panels and one inverter with a capacity of 30 kilowatts to obtain a capacity of 35.4 kilowatts , the system cost is estimated at (77600 NIS), so we can use this energy to meet the needs of 11 homes in the city of Nablus or use this electricity to supply factories with it.

We note in this case that the number of panels is small and not all the space that can be exploited has been exploited, but the shade resulting from the existing trees and because of the exploitation of existing buildings only. Thus, the idea of designing a solar system in this case is not desirable because it is possible to obtain a better design and production if the height is reduced Trees and design of systems for unused parking lots, as in the next cases.

4.2. Case2: Modification of the status of the existing facilities (Good Option)

In this case, we notice that we need 76 solar panels and two inverters with a capacity of 20 kilowatts for one inverter to obtain a capacity of 44.8 kilowatts, the system cost is estimated at (101000 NIS) and thus we can use this energy to meet the needs of 15 homes in the city of Nablus or use this electricity to supply Factories out.

In this case, we notice that the number of panels increased from the previous case due to the reduction in the height of the trees and thus the exploitation of the possible area of the existing buildings, but this also is not sufficient because the solar system was designed only for the existing buildings and not to exploit the area of the rest of the complex and the parking spaces in it, which greatly limited the increase Energy output.

4.3. Case3: The Advanced Option (The Best)

Here we need 183 solar panels and 5 inverters of different sizes (10,15,20,30) to obtain a capacity of 108 kilowatts at an estimated, the system cost is estimated at (292000 NIS), so we can use this energy to meet the needs of 36 homes in the city of Nablus or use this electricity to supply Factories out.

Here, in this case, the building area has been fully exploited (due to the reduction in the height of the trees) and the design of solar systems for all car parks in the complex to obtain the largest possible amount of energy, and in this case the side of using solar panels in energy production, the solar panels are used as shades for parking lots. Which has no umbrellas, so this is the best case for using the collector to produce energy.

5. Chapter 5. Conclusions

- In this report, three cases were studied for which a solar system could be designed for the eastern complex of Nablus, so that each case differs from the other in terms of cost, energy produced and the area that was used.
- A study of the energy situation in Palestine in general and in the city of Nablus in particular.
- Using the HelioScope program, which is widely used in Europe and not widely used in the countries of the region (the Middle East), and to show its design capabilities.
- A presentation of similar cases distributed to countries on different continents around the world (in the literature review chapter).
- Detailed information about the complex was shown in terms of the number of transportation lines, the number of passengers, the area, the number of entrances and exits, etc.
- The problem of shadow resulting from trees and focusing on them was presented, which is the main reason for reducing the design area in the complex.

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Appendices:

1)PV Panels Selection:

Table 5: Nameplate of PV modules[Trina solar, TSM-DE20-590 (590W)]

ELECTRICAL DATA (STC)

Peak Power Watts-P_{MAX} (Wp)*	585	590	595	600	605
Power Tolerance-P_{MAX} (W)	0 ~ +5				
Maximum Power Voltage-V_{MPP} (V)	33.8	34.0	34.2	34.4	34.6
Maximum Power Current-I_{MPP} (A)	17.31	17.35	17.40	17.44	17.49
Open Circuit Voltage-V_{OC} (V)	40.9	41.1	41.3	41.5	41.7
Short Circuit Current-I_{SC} (A)	18.37	18.42	18.47	18.52	18.57
Module Efficiency η $_m$ (%)	20.7	20.8	21.0	21.2	21.4

STC: Irradiance 1000W/m², Cell Temperature 25°C, Air Mass AM1.5.
*Measuring tolerance: ±3%.

ELECTRICAL DATA (NOCT)

Maximum Power-P_{MAX} (Wp)	443	447	451	454	458
Maximum Power Voltage-V_{MPP} (V)	31.5	31.7	31.9	32.0	32.2
Maximum Power Current-I_{MPP} (A)	14.05	14.09	14.13	14.18	14.22
Open Circuit Voltage-V_{OC} (V)	38.5	38.7	38.9	39.1	39.3
Short Circuit Current-I_{SC} (A)	14.81	14.85	14.88	14.92	14.96

NOCT: Irradiance at 800W/m², Ambient Temperature 20°C, Wind Speed 1m/s.

2) inverter :

figure 32: Solar inverter

Table 6 :Data sheet of [KACO, Powador 36.0 TL3 (30 kw)]

Electrical data	30.0 TL3	33.0 TL3	36.0 TL3
DC input			
MPP range@Pnom [1]	260 V ... 800 V	280 V ... 800 V	310 V ... 800 V
Operating range	200 V ... 950 V	200 V ... 950 V	200 V ... 950 V
Min. DC voltage/start voltage	200 V / 250 V	200 V / 250 V	200 V / 250 V
No-load voltage	1 000 V	1 000 V	1 000 V
Max. input current	3 x 34.0 A	3 x 34.0 A	3 x 34.0 A
Number of MPP trackers	3	3	3
Max. power/tracker	20 kW	20 kW	20 kW
Number of strings	3 x 1 (version M) / 3 x 4 (version XL)		
AC output			
Rated output (@230 V)	25 000 VA	27 500 VA	30 000 VA
Line voltage	acc. to local requirements	acc. to local requirements	acc. to local requirements
Rated current	3 x 36.2 A	3 x 39.9 A	3 x 43.5 A
Rated frequency	50 Hz / 60 Hz	50 Hz / 60 Hz	50 Hz / 60 Hz
cos phi	0.80 inductive ... 0.80 capacitive	0.80 inductive ... 0.80 capacitive	0.80 inductive ... 0.80 capacitive
Number of grid phases	3	3	3
General electrical data			
Efficiency max. / european	98.0 % / 97.8 %	98.0 % / 97.8 %	98.0 % / 97.8 %
Night consumption	1.5 W	1.5 W	1.5 W
Circuitry topology	transformerless	transformerless	transformerless

Table 7 :Data sheet of [KACO, Blue planet 20.0 TL3 (20kw)]

Electrical data	15.0 TL3	20.0 TL3
Input variables		
Maximum PV generator power	18 000 W	24 000 W
MPP range@Pnom	420 V ... 800 V	515 V ... 800 V
Operating range	200 V - 950 V	200 V - 950 V
Min. DC voltage / starting voltage	200 V / 250 V	200 V / 250 V
No-load voltage	1 000 V	1 000 V
Max. input current	2 x 20.0 A	2 x 20.0 A
Max. short circuit current [$I_{SC\ max}$]	2 x 22.4 A	2 x 22.4 A
Number of MPP trackers	2	2
Max. power/tracker	14.9 kW	15.0 kW
Number of strings	2 x 2	2 x 2
Output variables		
Rated output (@ 230 V)	15 000 VA@230 V	20 000 VA@230 V
Line voltage	400 V / 230 V (3 / N / PE)	400 V / 230 V (3 / N / PE)
Rated current	3 x 21.8 A	3 x 29.0 A
Rated frequency	50 Hz / 60 Hz	50 Hz / 60 Hz
cos phi	0.30 inductive ... 0.30 capacitive	0.30 inductive ... 0.30 capacitive
Number of grid phases	3	3
General electrical data		
Max. efficiency	98,0 %	98.4 %
Europ. efficiency	97.7 %	98.1 %
Night consumption	1.5 W	1.5 W
Switching plan	transformerless	transformerless
Grid monitoring	acc. to local requirements	acc. to local requirements

Table 8:Data sheet of [KACO, Blue planet 15.0 TL3(15kw)]

Electrical data	15.0 TL3	20.0 TL3
Input variables		
Maximum PV generator power	18000 W	24000 W
MPP range@Pnom	420 V ... 800 V	515 V ... 800 V
Operating range	200 V - 950 V	200 V - 950 V
Min. DC voltage / starting voltage	200 V / 250 V	200 V / 250 V
No-load voltage	1000 V	1000 V
Max. input current	2x20.0 A	2x20.0 A
Max. short circuit current [$I_{SC\ max}$]	2x22.4 A	2x22.4 A
Number of MPP trackers	2	2
Max. power/tracker	14.9 kW	15.0 kW
Number of strings	2x2	2x2
Output variables		
Rated output (@ 230 V)	15000 VA@230 V	20000 VA@230 V
Line voltage	400 V / 230 V (3 / N / PE)	400 V / 230 V (3 / N / PE)
Rated current	3x21.8 A	3x29.0 A
Rated frequency	50 Hz / 60 Hz	50 Hz / 60 Hz
cos phi	0.30 inductive ... 0.30 capacitive	0.30 inductive ... 0.30 capacitive
Number of grid phases	3	3
General electrical data		
Max. efficiency	98,0 %	98.4 %
Europ. efficiency	97.7 %	98.1 %
Night consumption	1.5 W	1.5 W
Switching plan	transformerless	transformerless
Grid monitoring	acc. to local requirements	acc. to local requirements

Table 9 : data sheet of [KACO, Blue planet 10.0 TL3 (10kw)]:

Electrical data	5.0 TL3	6.5 TL3	7.5 TL3	8.6 TL3 NEW	9.0 TL3	10.0 TL3 NEW
DC input						
MPP range@Pnom	240 V ... 800 V	310 V ... 800 V	350 V ... 800 V	403 V ... 800 V	420 V ... 800 V	470 V ... 800 V
Operating range	200 V - 950 V	200 V - 950 V	200 V - 950 V	200 V - 950 V	200 V - 950 V	200 V - 950 V
Min. DC voltage/starting voltage	200 V / 250 V	200 V / 250 V	200 V / 250 V	200 V / 250 V	200 V / 250 V	200 V / 250 V
No-load voltage	1000 V	1000 V	1000 V	1000 V	1000 V	1000 V
Max. input current	2x11.0 A	2x11.0 A	2x11.0 A	2 x 11,0 A	2 x 11.0 A	2 x 11.0 A
Number of MPP trackers	2	2	2	2	2	2
Max. power/tracker	5.2 kW	6.7 kW	7.7 kW	8,8 kW	8.8 kW	8.8 kW
Number of strings	2	2	2	2	2	2
AC output						
Rated output	5000 VA	6500 VA	7500 VA	8600 VA	9000 VA	10000 VA
Supply voltage	acc. to local requirements	acc. to local requirements	acc. to local requirements	400 V / 230 V (3/N/PE)	acc. to local requirements	acc. to local requirements
Rated current	3x7.25 A	3x9.5 A	3x10.9 A	3 x 12,5 A	3 x 13.0 A	3 x 14.5 A
Rated frequency	50 Hz / 60 Hz	50 Hz / 60 Hz	50 Hz / 60 Hz	50 Hz	50 Hz / 60 Hz	50 Hz / 60 Hz
cos phi	0.30 inductive ... 0.30 capacitive	0.30 inductive ... 0.30 capacitive	0.30 inductive ... 0.30 capacitive	0.30 inductive ... 0.30 capacitive	0.30 inductive ... 0.30 capacitive	0.30 inductive ... 0.30 capacitive
Number of grid phases	3	3	3	3	3	3
General electrical data						
Max. efficiency	98.3 %	98.3 %	98.3 %	98.5 %	98.5 %	98.5 %
Europ. efficiency	97.4 %	97.6 %	97.7 %	98.1 %	98.1 %	98.3 %
Night consumption	1.5 W	1.5 W	1.5 W	1,5 W	1.5 W	1.5 W
Circuity topology	transformerless	transformerless	transformerless	transformerless	transformerless	transformerless
Mechanical data						

3) Map of Palestine :

figure 33: Map of whole Palestine

4) Map of Nablus Governorate and its villages:

figure 34: Map of Nablus Governorate and it s surrounding villages

5) Map of Nablus city:

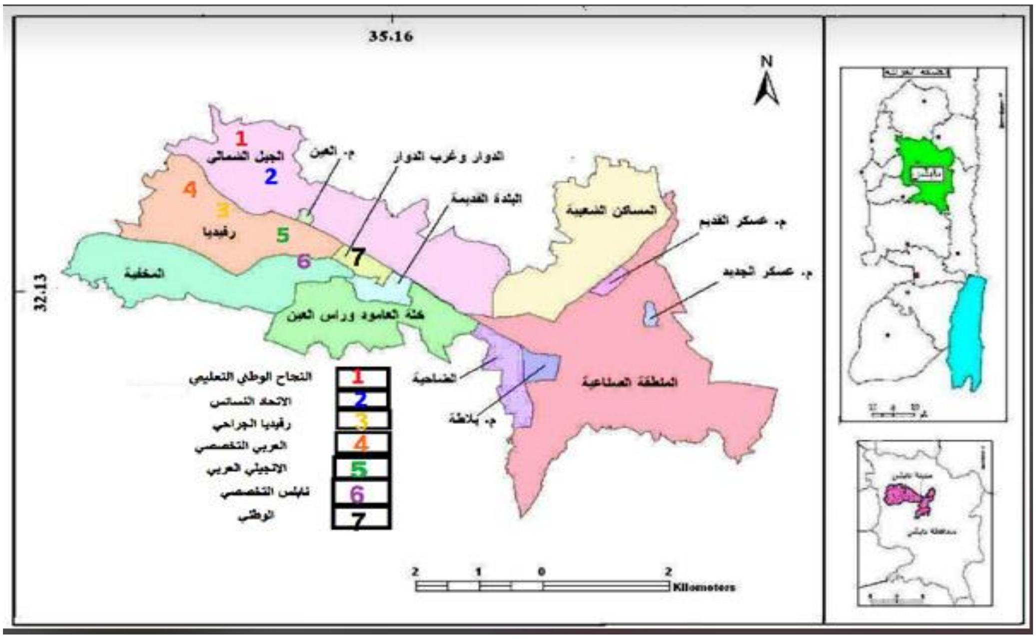

figure 35: Map of Nablus city

6) Nablus Monthly Climate Averages

World Weather Online is used to obtain this Figures in the bottom [16].

A) Monthly Average Temperature in Nablus city :

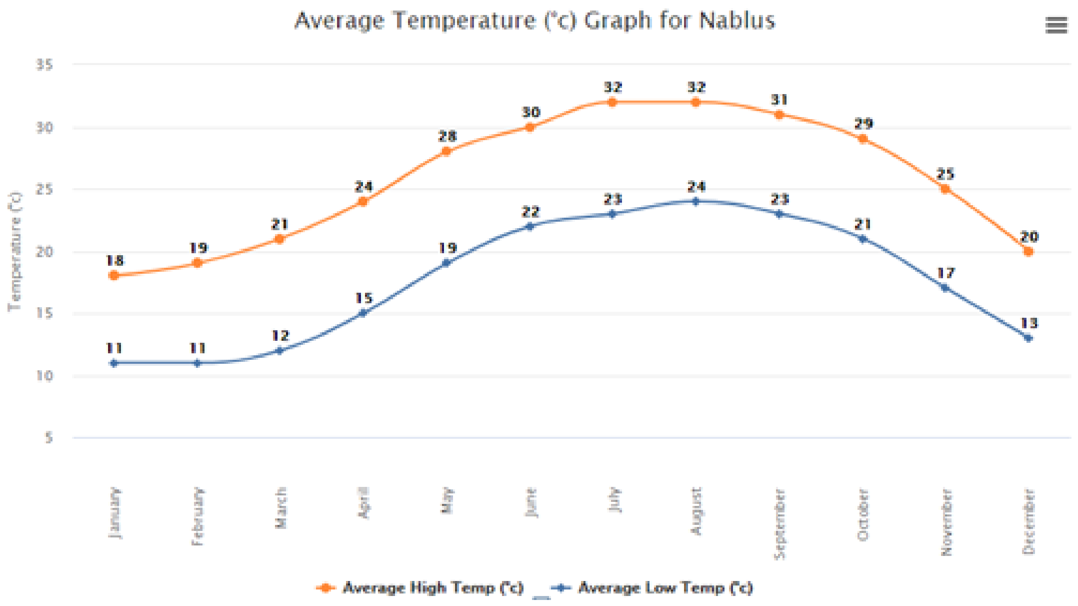

Figure 36 : Monthly Average Temperature in Nablus city using World Weather Online

B) Monthly Average Rainfall in Nablus city:

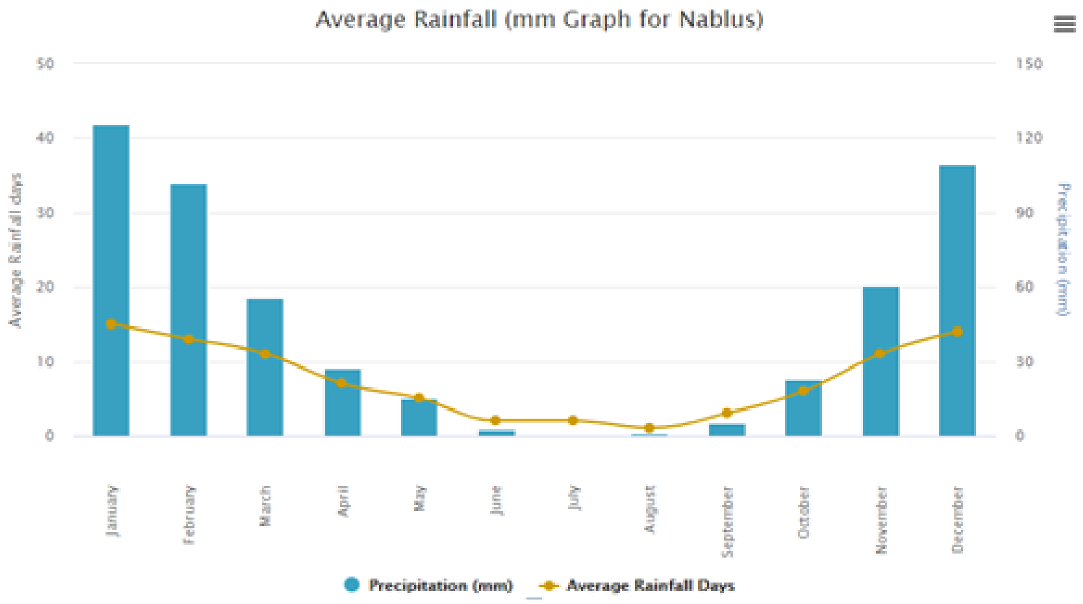

Figure 37: Monthly Average Rainfall in Nablus city using World Weather Online

c) Monthly Average Snowfall in Nablus city :

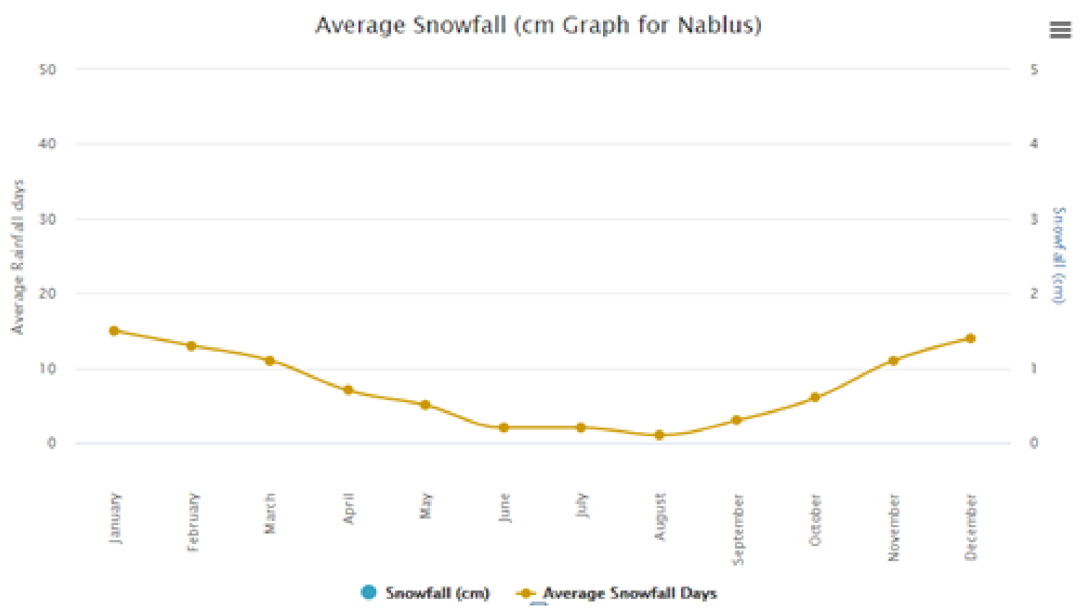

Figure 38 : Monthly Average Snowfall in Nablus city using World Weather Online

d)Max and Average Wind Speed and Wind Gust in Nablus city :

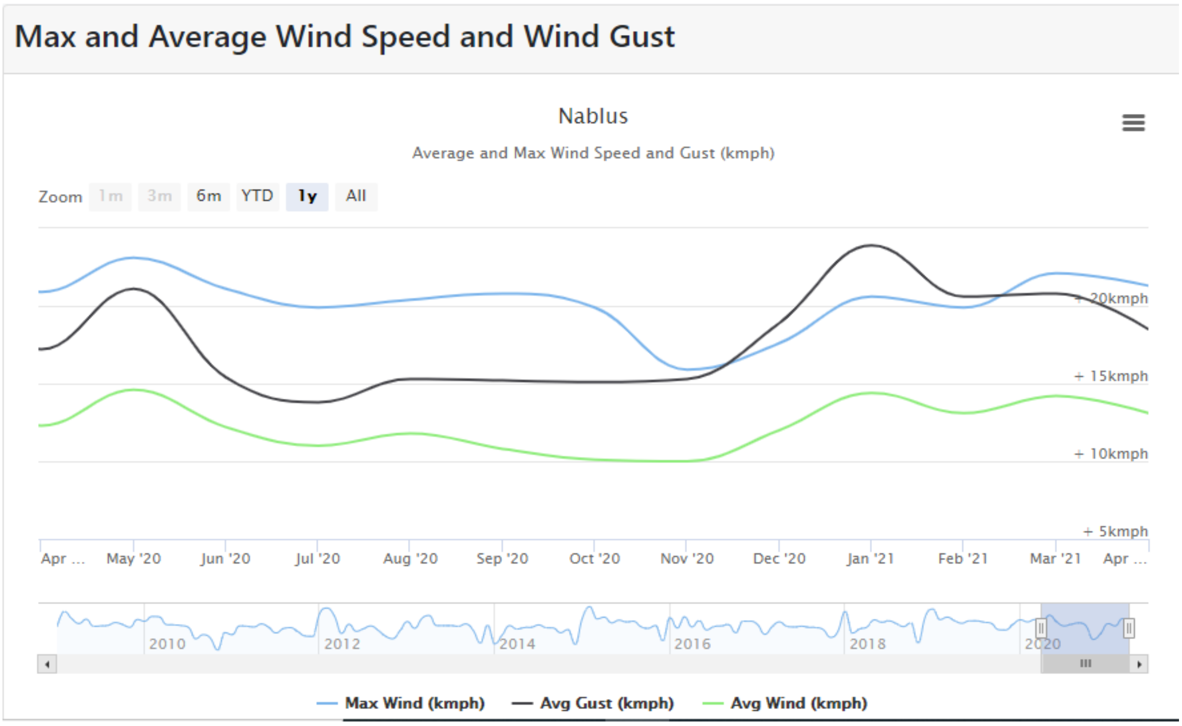

Figure 39 : Max and Average Wind Speed and Wind Gust in Nablus city using World Weather Online

E) Cloud and Humidity in nablus city :

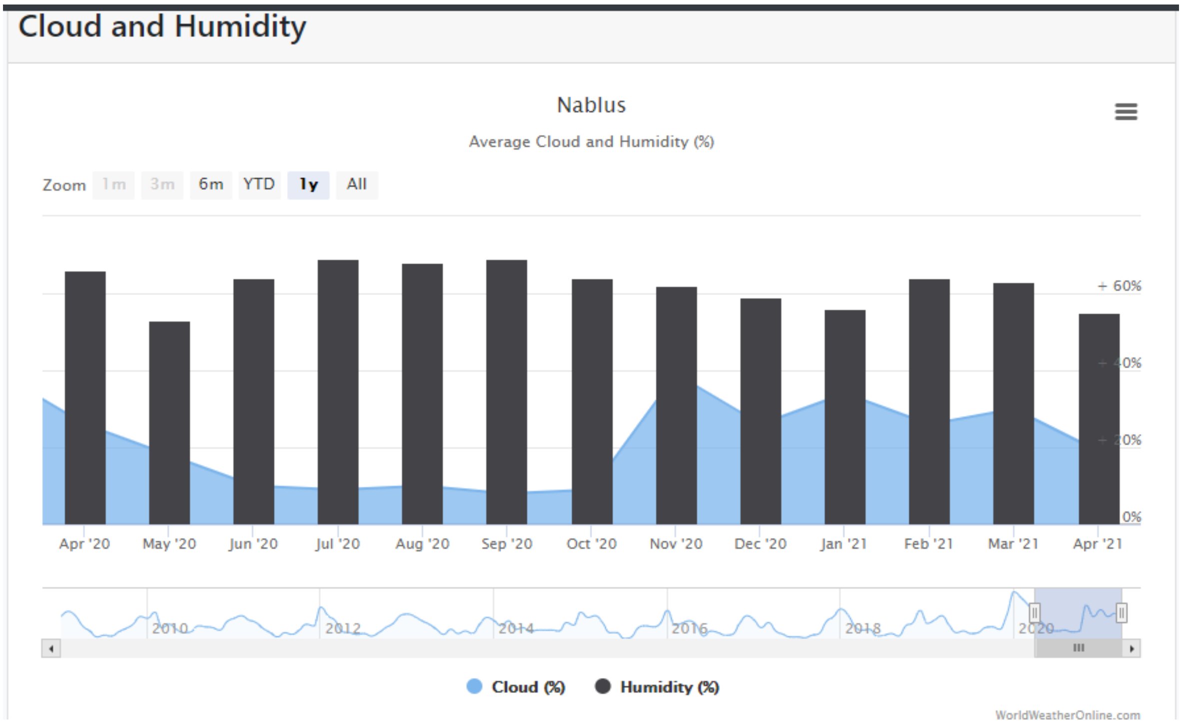

Figure 40 : **Cloud and Humidity in nablus city** ***using World Weather Online***

F) Monthy Average UV for Nablus city :

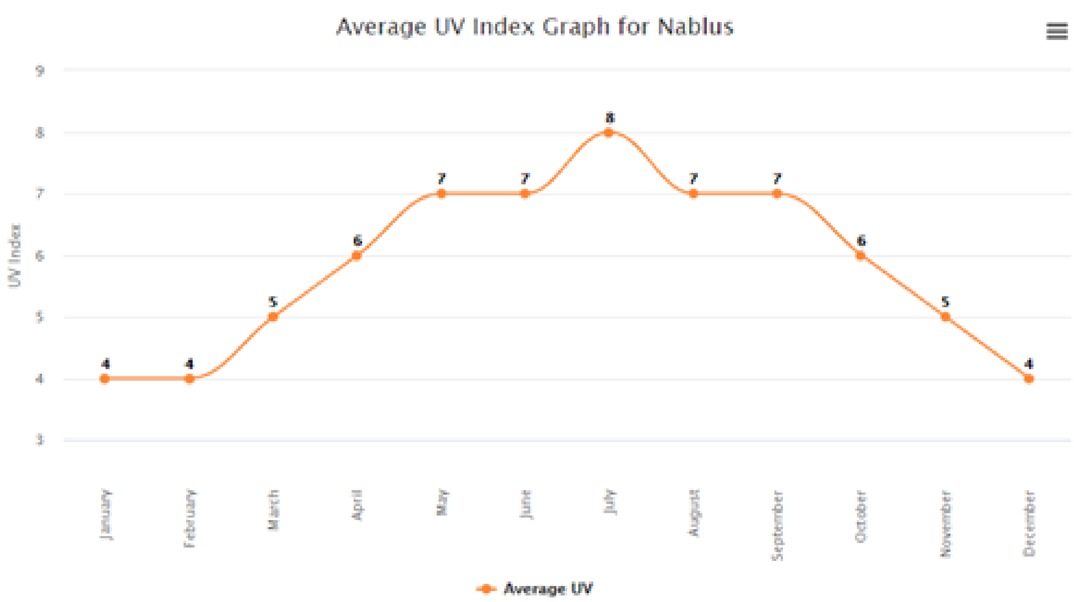

Figure 41 : Monthy Average UV for Nablus city using World Weather Online

G) Monthly Average Sun Hours and Days for Nablus city :

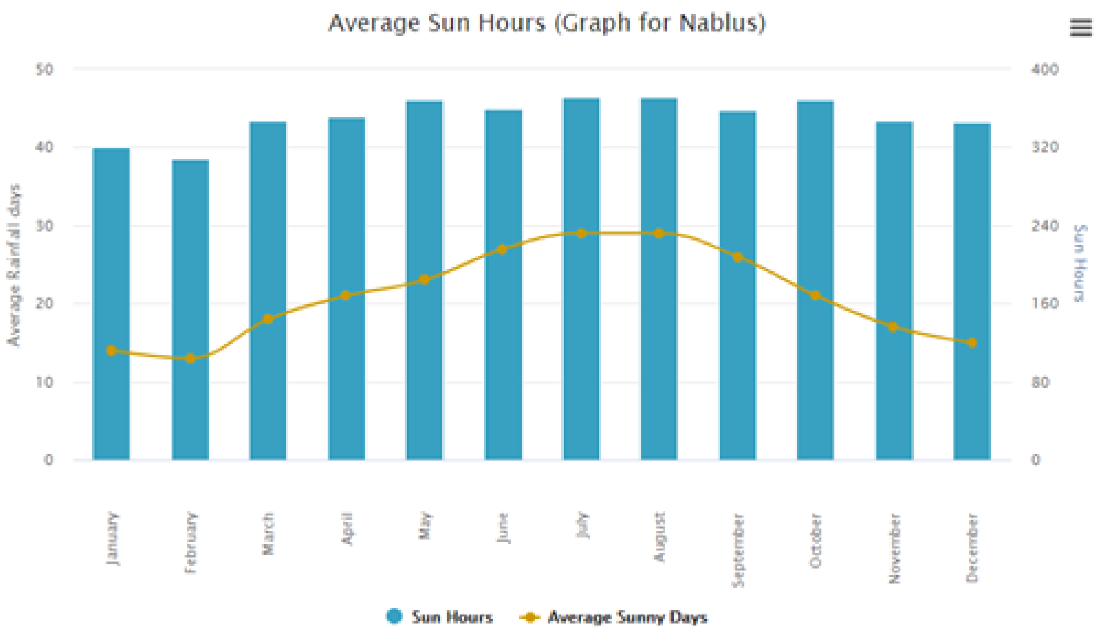

Figure 42 : Monthly Average Sun Hours and Days for Nablus city using World Weather Online