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"Developing Practical PV-Energy Storage Solutions For Tulkarm City”

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Abstract

In this report, the problem of the electricity sector in Tulkarm city and the ways to solve it in a new and effective way was presented, as Tulkarm city suffers from the problem of power outages for two main reasons:

1) Existence of an over load on the transformers as the transformers are loaded with very large loads (loads up to 115% of the transformer)

2) The decrease in the amount of electricity coming from the Israeli occupation, which does not cover the needs of citizens, especially during peak times.

Therefore, a new solution was presented to summarize these two problems by studying the case of transformers in Tulkarm city. The loads on the transformers were divided into six types (large morning loads, normal morning loads, medical morning loads, evening large loads, normal evening loads and evening medical loads),where each type was studied separately and appropriate solutions were proposed using solar panels to contribute to solving the two main problems that the city suffers from. A new structure was designed to put solar panels on it so that it has an economical, attractive and cheaper price compared to the normal chassis.

Al-Murabba transformer was taken as a case and an example for the rest of the city transformers, where the transformer was checked and the loads were known, divided and a load profile was made for them.

Where it was found that the maximum value of the loads are as follows:

High morning loads (20%) equal 142 kW.

Normal morning loads (70%) equal 496 kW.

Medical morning loads (10%) equal to 70 kW.

High evening loads (35%) equal to 244 kW.

Normal evening loads (50%) equal 349 kW.

Medical evening loads (15%) equal to 104 kW.

In this report, solutions have been developed for each problem that may exist in any of the loads depending on the type in which they are placed. A solar energy system with net metering system was proposed to solve the problem of high and normal morning loads, and a hybrid system (solar panels and municipal electricity) was also proposed. The municipality and batteries will be the solution in case there is a problem with the transformer due to the morning medical loads. For high evening loads, solar batteries have been proposed as a solution by designing an off-grid system, storing solar energy in the batteries during the day and supplying it to the evening loads in two ways:

1) Converting all night loads (for example, a commercial store) to solar electricity by (converting the electric energy in the batteries into alternating electricity by the inverter) and this solution is expensive.

2) Converting the lighting in the shops to direct dependence on the batteries, as the percentage of lighting consumption in most residential buildings is about 30% of the total energy consumed and reaches more than 30% in the shops, which is the least expensive solution.

For evening medical loads, a hybrid system (diesel generator, municipal electricity, batteries) was proposed.

In this report, the cost of the new structure was calculated, then a comparison was made between the new structure and the traditional structure, and the result was that the cost of designing a complete system using the new structure equals 47,000 NIS, while the cost of designing the complete traditional system with the same capacity is 142,000 NIS, which means that the system which is designed with the new structure is less expensive, better and greatly saves space, which helps people who do not have enough space to install solar panels on their rooftops.

An electronic survey was conducted for the people of Tulkarm and their opinions about solar energy, the extent of their knowledge and belief in it, and the problems that prevent them from installing it. The following was found: that a small percentage of people have solar energy systems (about 10%), about 95% of people believe in solar energy as a solution to the problem of the current shortage in the city, about 100% of people support the use of solar energy in the residential area in which they live, the population's knowledge of solar energy is almost average and one of the most important problems that prevent them from installing it is its high price and the lack of sufficient space.

In the end, the overload on the transformer was eliminated, the transformer was returned to its normal state, and the electricity coming from the Israeli occupation was reduced through the use of solar panels. The streets were used to install solar panels, thus saving a lot of land. Thus, the problem of the electricity sector in Tulkarm city is solved.

The following software was used in the design process: pvsyst, Sketchup, AutoCAD, ETABS. The following sites were also used: mstkshf dot com, Global Solar Atlas, meteoblue.

contents

List of Figures

List of Tables :

Acknowledgments:

To everyone who helped us reach this stage, to everyone who gave us so much and so much, to our families, our fathers, our mothers, our generous family, our teachers, our friends, our colleagues and our loved ones. ..... Thank you, we thank you very much.

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We cannot mention many names, but we would like to mention the project supervisor, Dr. Mohammad Al-Sayed, and the municipality of Tulkarm for their effective follow-up and communication to accomplish this work..

1.Chapter one : Introduction

1.1 Overview

Tulkarm city is located in the northwest of the West Bank at longitude and latitude (32.31325°,035.033966°) and is considered an area with high humidity due to its proximity to the Mediterranean Sea, and as for the radiation intensity in the city, it is equal to about 2090 kWh / m^2 , and for the best tilt angle of inclination for solar panels, angle 28 is the ideal tilt angle for the solar panels. For information on humidity, wind, temperature, rain, and number of cloudy days, the diagrams are found in the appendices.

The lands of Tulkarm form a divider between the Palestinian National Authority and the Palestinian territories occupied by Israel since 1948. It is 15 kilometers from the Mediterranean coast and at an altitude of 65-125 meters above sea level. Tulkarm includes several neighborhoods within its plan, such as Al-Shweika neighborhood, Ektba neighborhood, Al-Thanbeh neighborhood, Rashid neighborhood, Azab neighborhood, Al-Kafa neighborhood, Ertah neighborhood, New Mohandessin neighborhood, Staff housing neighborhood, and others in addition to camps such as Tulkarm camp and Nour Shams camp. The population of the city is estimated at 44 thousand people, and the capacity of the electric power needed by the city is 45 MVA, while the electrical capacity of the occupying authority is 32 MVA distributed over two lines distributed on 134 transformers.

Tulkarm city suffers from the problem of electricity shortage, which has become the leading news of all the newspapers and local media, so that the city suffers greatly from a large interruption, especially in the summer months (the month of 7, 8 and 9) in most days and over large hours.

1.2Objectives

- Studying the situation of electrical energy in Tulkarm city and identifying the electricity problem that the city suffers from, its causes and ways to solve it.

- Develop a plan to help solve the electricity problem through the (hybrid system), which contributes to alleviating electrical loads during the peak period.

- Studying the design of a new type of structures for solar panels and using the streets to place panels on them instead of land (which may not be available, especially in city centers) or rooftops (which may not be sufficient to design a cell system to meet all the needs of residential apartments in the building) with Pay attention to cost and aesthetics.

1.3Statement of the problem

- There is an overload on the transformer, which makes it difficult to choose solutions.
- Designing a new shape to put panels on it, which needs to take into account the height of buildings and trees in the streets to avoid the shadows.

1.4 Methodology

- ❖ The official authority responsible for Tulkarm city (Tulkarm municipality) was approached and the necessary information was collected, such as the load profile, electrical transformers, etc.

- ❖ The information and plans were studied and the reports related to the problem were reviewed. The files related to the electricity sector in Tulkarm city were studied. Radiation intensity, number of rainy and cloudy days for the city and average temperature are studied to help in the solar panel design process, as solar panels are affected by all the combined factors.

- ❖ New ways have been found to solve the problem, as reliance on traditional methods has become an old and expensive solution, and the trend to solve new problems must be based on new ideas and methods to solve the problem, as the idea of designing a solar energy system in a new way has been directed to solve the problem of energy shortage.

- ❖ Contacts have been made with the relevant responsible authorities to obtain information and inquiries when all developments occur. Several times have been contacted with the engineers of Tulkarm Municipality to verify several important matters.

- ❖ Contacts have been made with companies, institutions and people related to the Palestinian market (Local Market) to get the real prices of all materials, tools and devices needed to get the final price and compare the new solution with the traditional solution.

2.Chapter two: Literature Review

Various studies have been completed, which discussed different subjects that are to be merged in this project, Developing Practical PV-Energy Storage Solutions For Tulkarm City. This section discusses the reviews and researches based on and builds up this project.

Salah, W.A. and Abuhelwa, M discussed the main energy problem in Tulkarm city due to its rapid population growth and the problem of interruptions in electricity, especially in the summer. They presented the reality of energy consumption, climate and weather in Palestine and the reasons that make Tulkarm a large area for energy resources. They have suggested several solutions to address this problem. The first solution, i.e. scheduling the delivery of energy to neighborhoods on the basis of relevance, has already been adopted. As a second solution, they suggested the use of diesel generators. The last solution was the use of renewable energy, especially solar energy, which is the most effective one. They have done a survey to study people's awareness of the daily use of electricity. It turns out that people's awareness of the use of electricity may be the best possible way to overcome frequent blackouts.[1]

Nassar, Y. and Alsadi, S demonstrated the importance of achieving energy security in light of the electricity crisis in Gaza. Energy security includes maintaining energy supply and reliability to meet demand at all times and at good prices, while avoiding impacts on human health and the environment. They analyzed the current energy situation in the Gaza Stripand suggested four scenarios to get out of this impasse. They carried out an economic and environmental assessment in order to find out which scenario would generate higher revenues. This competition was won by renewable energy plants. The study set a timetable for the complete transition of the electricity industry from conventional energy to renewable energy. Unfortunately, however, providing a sustainable and renewable energy source to the Gaza Strip has not been a priority for any of the donors or successive Palestinian governments. The duty of international communities and national bodies remains to defend the property of the Palestinian people, especially at the level of infrastructure, against the repeated attacks of the Israeli army on the Gaza Strip, otherwise there is no value for any attempt to advance the Palestinian people.[2]

González, P et al implemented the measures on the grid, which showed the effect of the photovoltaic system on the power quality of the distribution network, the insertion of the photovoltaic power plant causes changes in the measured quality parameters and operational characteristics that do not seriously affect the operation of the grid due to the power limit of twenty of the power grid short-circuit For the generating stations specified in the report. They summarized measurements of power quality (PQ) parameters made in a radial distribution network at two time periods, before and after the PV power plant was connected to the grid.It also presents the same parameters measured at the PCC (point of common coupling) of the grid and the PV plant to discuss how the grid impedance and the ratio between the injected power and the power required by the load affect changes in the power quality of the distribution system. They evaluates the impact of photovoltaic power generation on the distribution system and important issues such as reverse power flow and harmonic distortion are analyzed. [3]

Canova, A et al presented the problem of energy penetration for PV systems in urban networks. After describing the qualitative problem, two different environments for PV systems were analyzed: rural and urban networks. For the rural grid, a single line was simulated in order to evaluate the relationship between the number of PV systems installed along the line and the maximum installable PV capacity.In the second part of the paper, potential problems due to energy penetration were examined regarding the cluster PV system to be installed in Turin (Italy) during the EU project.[4]

DEMIDOV, I et al studied and designed an off-grid solar system connected to batteries in Namibia in Africa, and the focus was on the technical and economic analysis of the configuration of a low voltage (LV) distribution network based on off-grid solutions based on photovoltaic energy and energy storage in rural African areas.The components of off-grid solar energy have been studied and costs compared with the system connected to the grid, and the advantages of the off-grid system and the disadvantages of the system connected to the grid have been shown.[5]

El-houar, H et al studied the energy situation in the village of Tazota in Morocco, where a rural house was targeted to design an off-grid solar energy system and real monthly electrical requirements and hourly climatic conditions were used. In addition to making the economic feasibility of the system and studying the prices in real terms.[6]

Said , Z et al explained the vision of solar systems in the United Arab Emirates , as the UAE seeks to reach 44% of its energy by solar energy by 2050, and here in this paper a comprehensive technical, economic and environmental assessment of the solar photovoltaic system is presented. So that 6 different locations were selected in the Emirates and the installation of solar systems in them and a comparison between the six regions. In addition, different cell technologies (single-crystal, polycrystalline and thin-film) were analyzed to conclude the optimal selection, in addition to studying the atmospheric factors affecting the solar system. The effect of reducing the battery bank size from 24 hours to 12 hours standby has also been demonstrated.[7]

The existing literature gives a very broad overview of modeling approaches, technologies, and feasibility for Developing Practical PV-Energy Storage Solutions For Tulkarm City. 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 Electricity problems in Tulkarm city:

3.1.1) Over load on transformers

Many transformers in the city of Tulkarm suffer from overloads, as the percentage in the summer reaches about 115%, which causes many problems in the transformers, but in normal months the loads on the transformers are approximately 95%[8], which is also considered a large load on the transformer. The suitable load for the transformer is approximately 70%.[9]

Electricity is cut off for several hours in Tulkarm city, due to the overloading on the transformer rating value , and the figures below show this.

Figure(1) below shows the hourly load and the percentage of loads on Al-Murabba transformer during only one day in 03/08/2021. And figure(2) below shows the hourly load on Murabba transformer in five different days in August(8) with respect to the transformer rating, which is 630 kVA.

المحول : المربعة		date	time	Power(p)		reactive (Q	(p)^2	(Q)^2	S (kVA)	rated pow	situation	s	percent
المحول: 630 KVA		8/3/2021	0	704.32	117.44kvar	117.44	496067	13792.2	714.044	630	not_Ok	84.044	113.34
			0.5	692.8	114.88kvar	114.88	479972	13197.4	702.26	630	not_Ok	72.2601	111.47
			1	683.52	113.28kvar	113.28	467200	12832.4	692.843	630	not_Ok	62.8434	109.975
			1.5	672	112.00kvar	112.00	451584	12544	681.269	630	not_Ok	51.2694	108.138
			2	645.44	111.68kvar	111.68	416593	12472.4	655.031	630	not_Ok	25.0307	103.973
			2.5	641.28	113.60kvar	113.60	411240	12905	651.264	630	not_Ok	21.2642	103.375
			3	624.64	113.60kvar	113.60	390175	12905	634.886	630	not_Ok	4.88589	100.776
			3.5	611.84	111.04kvar	111.04	374348	12329.9	621.834	630	Ok	-8.1656	98.7039
			4	606.72	113.92kvar	113.92	368109	12977.8	617.322	630	Ok	-12.678	97.9877
			4.5	607.68	116.48kvar	116.48	369275	13567.6	618.743	630	Ok	-11.257	98.2131
			5	602.88	119.36kvar	119.36	363464	14246.8	614.582	630	Ok	-15.418	97.5527
			5.5	580.8	118.40kvar	118.40	337329	14018.6	592.745	630	Ok	-37.255	94.0866
			6	563.84	118.72kvar	118.72	317916	14094.4	576.203	630	Ok	-53.797	91.4608
			6.5	557.76	122.88kvar	122.88	311096	15099.5	571.135	630	Ok	-58.865	90.6564
			7	553.6	121.28kvar	121.28	306473	14708.8	566.729	630	Ok	-63.271	89.957
			7.5	566.72	119.68kvar	119.68	321172	14323.3	579.219	630	Ok	-50.781	91.9396
			8	566.4	116.48kvar	116.48	320809	13567.6	578.253	630	Ok	-51.747	91.7862
			8.5	576.32	117.12kvar	117.12	332145	13717.1	588.1	630	Ok	-41.9	93.3492
			9	586.56	121.60kvar	121.60	344053	14786.6	599.032	630	Ok	-30.968	95.0844
			9.5	591.68	120.64kvar	120.64	350085	14554	603.854	630	Ok	-26.146	95.8498
			10	607.04	121.92kvar	121.92	368498	14864.5	619.162	630	Ok	-10.838	98.2797
			10.5	614.08	122.24kvar	122.24	377094	14942.6	626.128	630	Ok	-3.8715	99.3855
			11	630.08	125.12kvar	125.12	397001	15655	642.383	630	not_Ok	12.3829	101.966
			11.5	627.2	127.36kvar	127.36	393380	16220.6	640	630	not_Ok	10.0003	101.587
			12	635.52	127.04kvar	127.04	403886	16139.2	648.093	630	not_Ok	18.0932	102.872
			12.5	652.16	126.40kvar	126.40	425313	15977	664.296	630	not_Ok	34.2963	105.444
			13	658.88	127.04kvar	127.04	434123	16139.2	671.016	630	not_Ok	41.0157	106.51
			13.5	658.88	125.44kvar	125.44	434123	15735.2	670.715	630	not_Ok	40.7146	106.463
			14	662.72	122.24kvar	122.24	439198	14942.6	673.899	630	not_Ok	43.8994	106.968
			14.5	676.48	125.12kvar	125.12	457625	15655	687.954	630	not_Ok	57.9536	109.199
			15	698.88	126.40kvar	126.40	488433	15977	710.218	630	not_Ok	80.2184	112.733
			15.5	717.12	124.80kvar	124.80	514261	15575	727.898	630	not_Ok	97.8984	115.539
			16	704	123.20kvar	123.20	495616	15178.2	714.699	630	not_Ok	84.6987	113.444
			16.5	728.96	127.04kvar	127.04	531383	16139.2	739.947	630	not_Ok	109.947	117.452
			17	722.56	126.72kvar	126.72	522093	16058	733.588	630	not_Ok	103.588	116.442
			17.5	703.36	124.80kvar	124.80	494715	15575	714.346	630	not_Ok	84.3461	113.388
			18	704.96	127.36kvar	127.36	496969	16220.6	716.372	630	not_Ok	86.3722	113.71
			18.5	692.48	128.64kvar	128.64	479529	16548.2	704.327	630	not_Ok	74.3272	111.798
			19	673.6	126.40kvar	126.40	453737	15977	685.357	630	not_Ok	55.3568	108.787
			19.5	697.92	131.52kvar	131.52	487092	17297.5	710.204	630	not_Ok	80.2041	112.731
			20	695.36	126.08kvar	126.08	483526	15896.2	706.698	630	not_Ok	76.6977	112.174
			20.5	710.72	126.08kvar	126.08	505123	15896.2	721.817	630	not_Ok	91.8165	114.574
			21	706.56	124.16kvar	124.16	499227	15415.7	717.386	630	not_Ok	87.386	113.871
			21.5	699.2	122.56kvar	122.56	488881	15021	709.86	630	not_Ok	79.8603	112.676
			22	716.48	125.12kvar	125.12	513344	15655	727.323	630	not_Ok	97.3229	115.448
			22.5	704	122.24kvar	122.24	495616	14942.6	714.534	630	not_Ok	84.5338	113.418
			23	710.72	117.76kvar	117.76	505123	13867.4	720.41	630	not_Ok	90.4098	114.351
			23.5	711.36	116.80kvar	116.80	506033	13642.2	720.885	630	not_Ok	90.8851	114.426

Figure 1:The hourly load on Murabba transformer in 03/08/2021

3.1.2:) Electricity coming from the occupation side:

Tulkarm city obtains its own electricity from the Israeli occupation, which supplies the city with a limited amount of electricity with a capacity of (32 MVA), divided into two lines and distributed among 134 transformers in the city, while the amount of electricity that Tulkarm needs is currently estimated at (45 MVA), which causes a power outage in many areas, especially in the summer.

Figure(2) below shows the single lines of electricity coming from the occupation side and their distribution to the city's transformers.

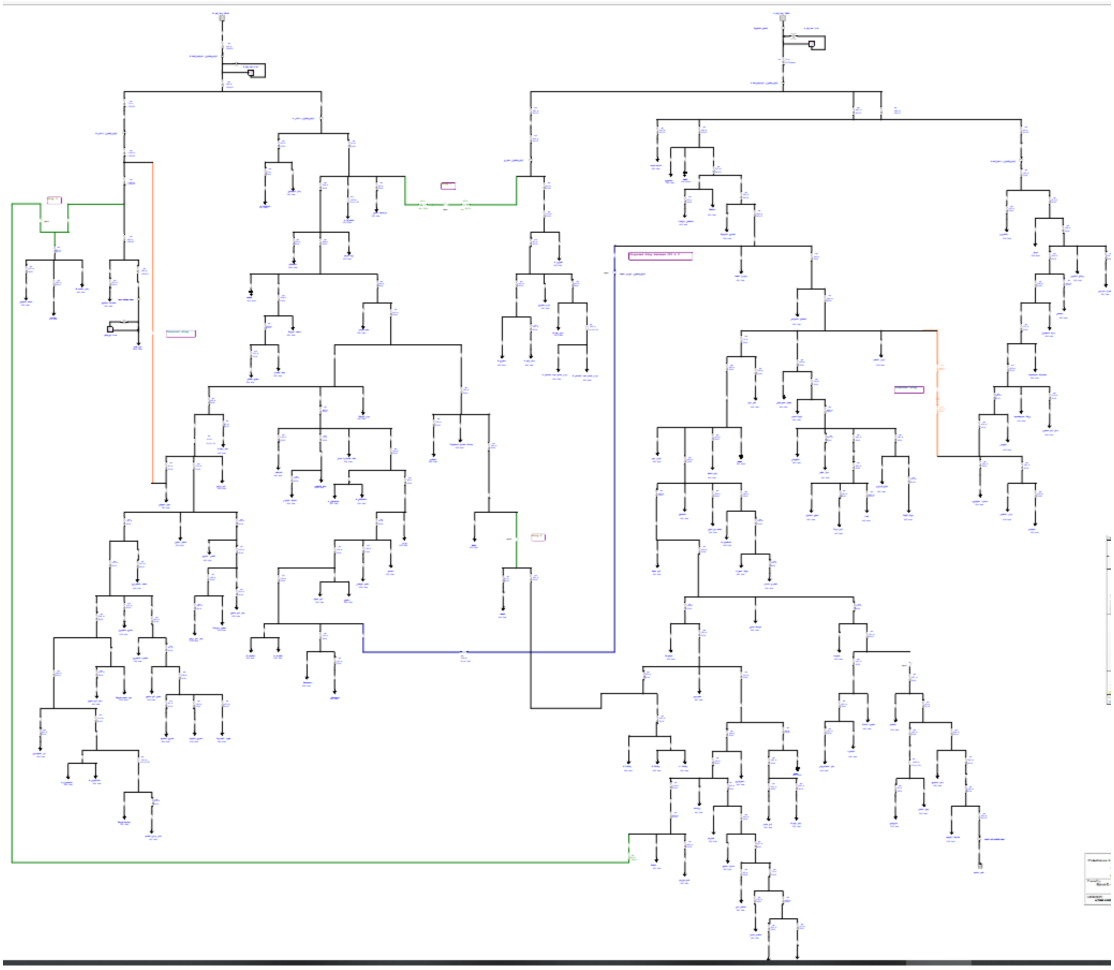


Figure 2:SLD of the electricity coming from Israeli side

3.2 The loads on the transformers

In this report, only one transformer load (Murabba transformer) was taken, which will be considered as a general case and an example for the rest of the transformers in the city.

The loads on the transformer were classified into two types (day loads and night loads).

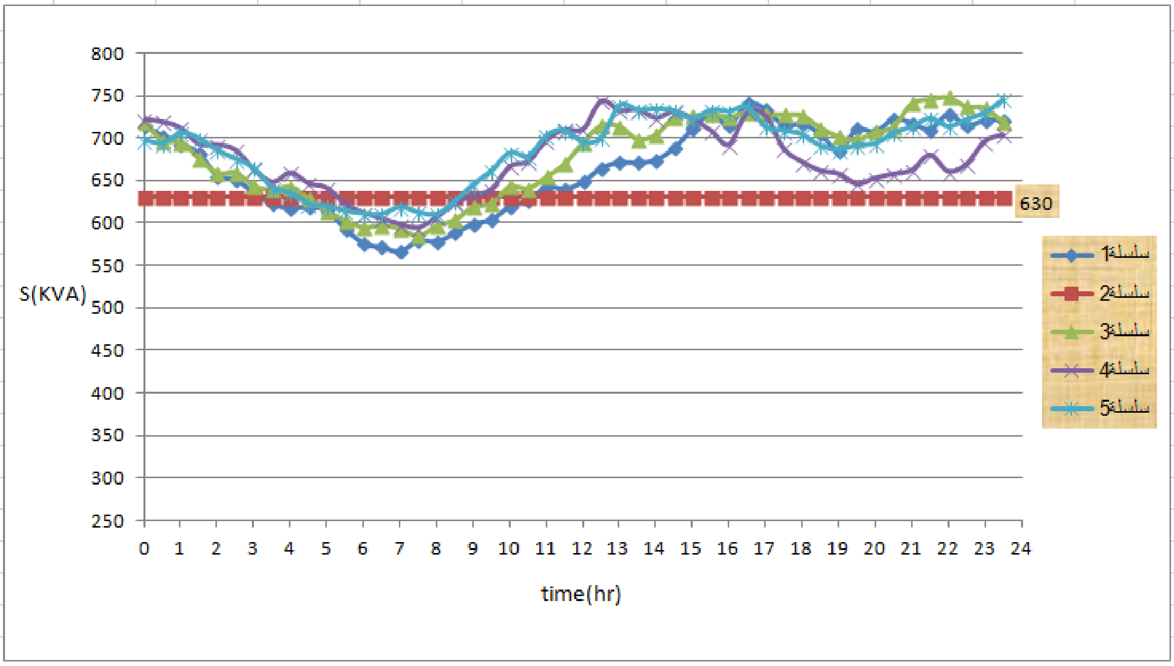


Figure 3:The load profile on Murabba transformer in five different days in August(8) With respect to the transformer rating

3.2.1) Daytime loads: These loads are divided into three types:

- High daytime loads: such as schools, government institutions and factories (20% of the transformer).

- Normal daytime loads: homes and shops with normal consumption (70% of the transformer).

- Medical day loads: such as hospitals, health centers and clinics (10% of the transformer).

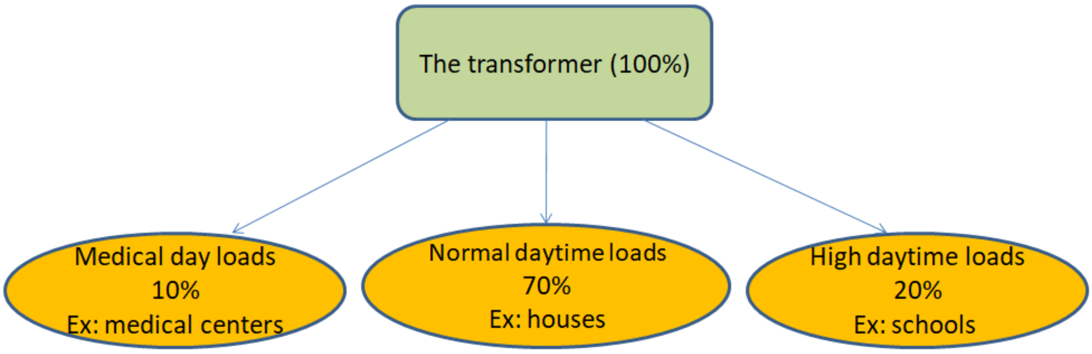


Figure 4:Imposed daily electrical loads in Tulkarm city

3.2.2) Night loads: These loads are divided into three types:

- High night loads: such as street lighting, commercial malls, large cafes and wedding halls (35% of the transformer)

- Normal night loads: homes and shops with normal consumption (50% of the transformer)

- Medical night loads: such as hospitals, health centers and clinics (15% of the transformer)

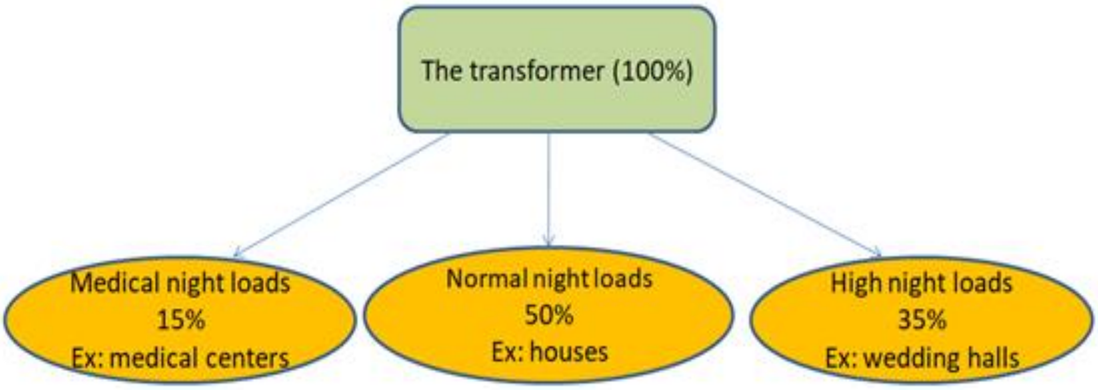


Figure 5:: Imposed night electrical loads in Tulkarm city

As these ratios were assumed because there are no real ratios and detailed readings clarify this by the municipality

3.3) The Solutions to the electricity problem of Tulkarm city

Appropriate solutions to the problem are arrived at in terms of understanding the problem and finding solutions by thinking outside the box.

The problem of over loads on the transformer and the shortage of electricity in the city has been solved as follows, as the solution was adopted based on the classifications that were set in the previous part (3.2), where:

3.3.1) Daytime load problem:

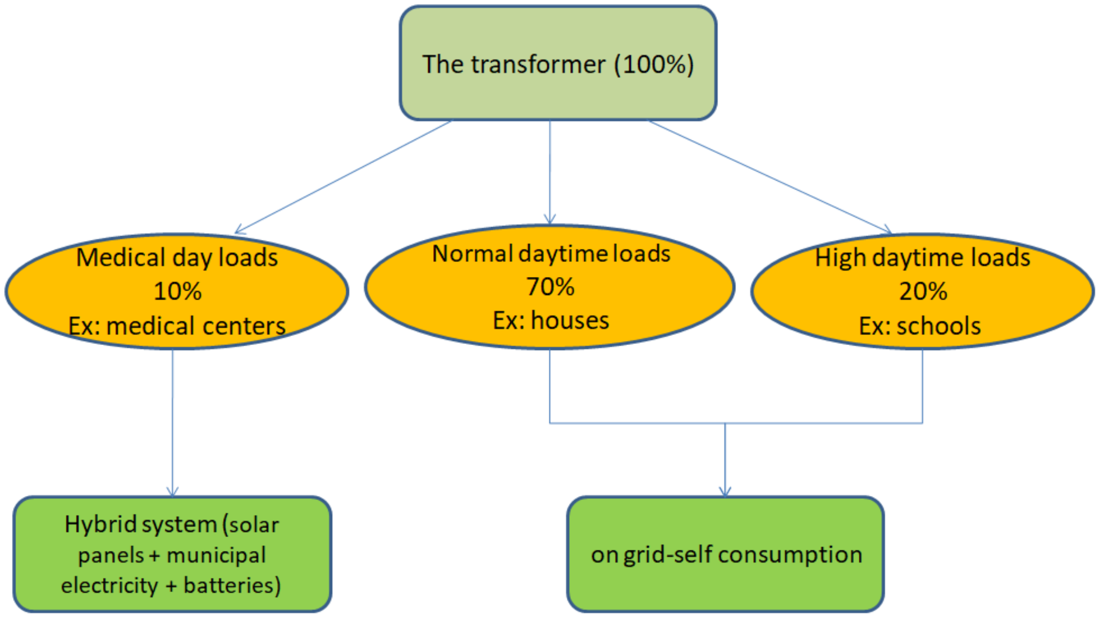


Figure 6:Suggested solution for daytime electrical loads

-Normal and High daytime loads: the work of a solar cell system connected to the network, but with a net-measuring system (self consumption), whereby this solution will be supplied to the loads by electricity coming from the solar panels directly. In the event of excess energy, it is pumped to the network, and thus these loads are disposed of and removed from the transformer, thus returning the transformer to its normal ratio. While in the event of a shortage, this shortage is taken from the municipality (the design is based on the absence of a shortage of electricity) .

- Medical day loads: in the event that the ratio of these loads is large and the solution stops there, a hybrid system is made (solar panels + municipal electricity + batteries), but in most cases this part is not important because the largest percentage in most transformers is on the previous two types.

3.3.2) Night load problem:

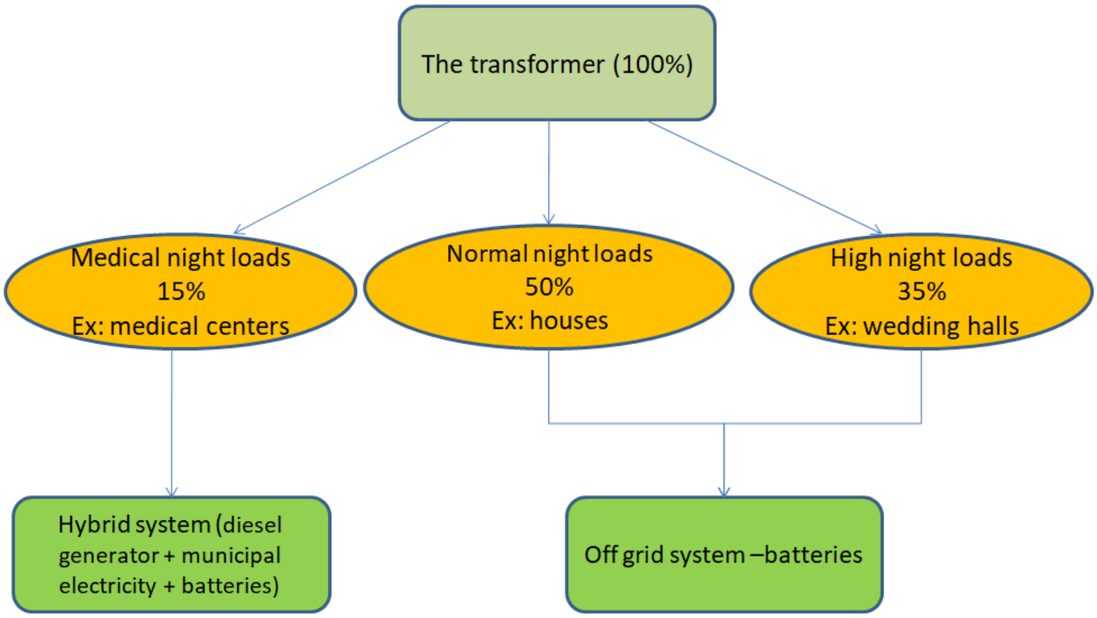


Figure 7:Suggested solution for night electrical loads

- Normal and high night loads: This problem is solved by designing an (off-grid) system so that the necessary energy is stored in batteries and supplied to the night loads.

Here, two plans of action have been developed, which are as follows:

1) Converting all night loads (e.g. commercial store) to solar electricity by converting the electrical energy in the batteries into alternating electricity by an inverter, which is an expensive solution.

2) Converting lighting in shops to direct dependence on batteries, where the percentage of lighting consumption in most residential buildings is approximately 30% of the total energy consumed and reaches more than 30% in shops, which is the least expensive solution.[9]

- Medical night loads: In the event that the percentage of these loads is large and the solution stops there, a hybrid system is made (diesel generator + municipal electricity + batteries), but often this part is not important because the largest percentage in most transformers is on the previous two types.

3.4) The structure design :

Several software have been used in designing the structure of the solar cells, which are the SketchUp and ETABS software.

SketchUp Software :

Here in this report, a structure has been designed in a new way, figure(8) below shows the structure, which will be presented for the first time, and it is considered a major and essential part of solving this problem, not just an ordinary structure on which solar panels are placed.

Figure 8:The shape of the structure

❖ Installation and details:

The new structure consists of 3 poles with a diameter of 0.5 m for each pole and a distance of 10 m (20 m in total distance) between each pole. The street solar system is designed with a height of 12 meters (the height of each column) to avoid shading.

As described in the ETABS design, in the next section, an approved engineering study plan for winds with a wind speed of 120 km/h has been developed. The chassis is also designed to withstand the weight produced by 40 units of approximately 1 ton (1,000 kg).

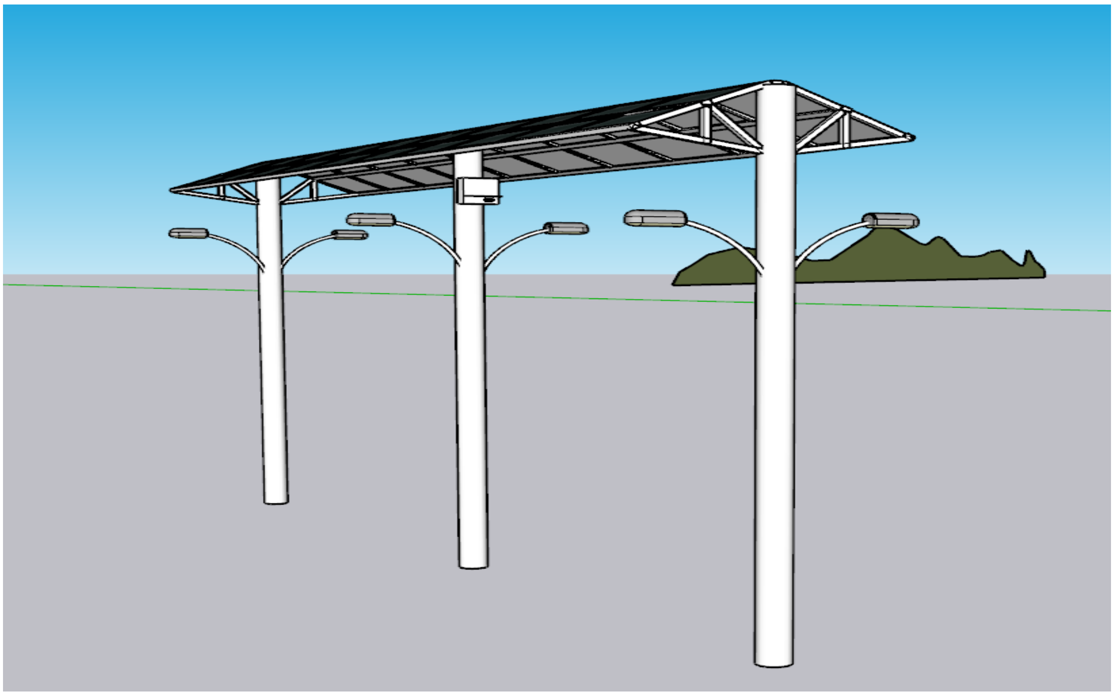


Figure 9:Aesthetic illustration shape of the structure

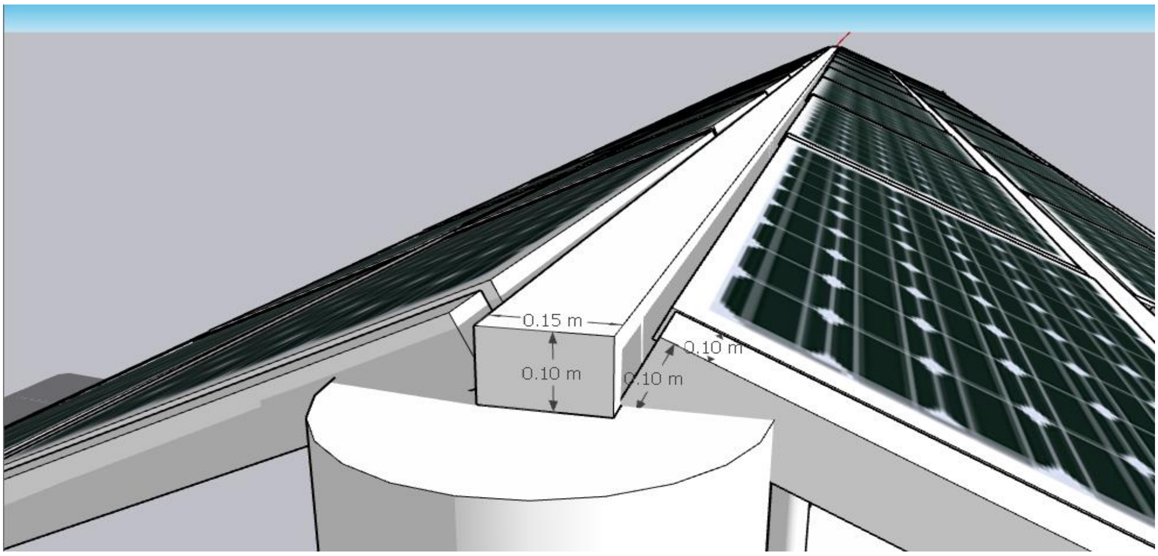


Figure 10:Dimensions of the structure

- ❖ The Components:

Table 1 : the components of structure with economic value

	Dimensions	Quantity	Unit price(NIS)	The cost	Total cost (NIS)
Pole	12 m*0.5m	3	1200	3600	3 600
Main parts of galvanized iron (Profila)	20m*(150*100*3 mm)	5	1 m = 30 NIS	3000	6 600
Galvanized iron straight pieces (Profila)	1m* (100*100*3 mm)	44	1m = 25 NIS	1100	7 700
Straight metal parts (stents)	1m* (100*100*3 mm)	16	1m = 25 NIS	400	8 100

- ❖ Features (Pros) of the new structure:

1) This new structure has been designed to exploit the islands located in the streets or in the middle of the streets in the absence of an island.

2) Through this structure, the problem of using agricultural lands to put solar panels on them can be eliminated (especially in the case of large stations).

3) An aesthetic view that indicates the progress of the city.

4) It can be used as rain umbrellas that people passing in the streets can hide under.

5) In residential buildings, the roof of the building is not enough to install a solar system on it that covers all the apartments inside, so the new structure will solve this problem by installing solar panels on the new structure in the same street or area that contains the residential architecture.

6) Savings in the price of land, as one structure is designed to produce a capacity of 20 kilowatts, which is equivalent to an area of 200 square meters of land.[10]

7) The possibility of placing the new structure within the cities (Areas A) saves the citizens, investors, municipalities and Palestinian electricity companies from building high-capacity stations in the outskirts of the city or in the villages, thus reducing the amount of loss during the period of the energy transfer process.

8) The possibility of designing the structure at different heights according to the heights of the influential buildings located on that street to avoid shadows.

9) The possibility of using the new structure in the place of the existing lighting poles, where the structure can be designed with the possibility of placing street lighting on it.

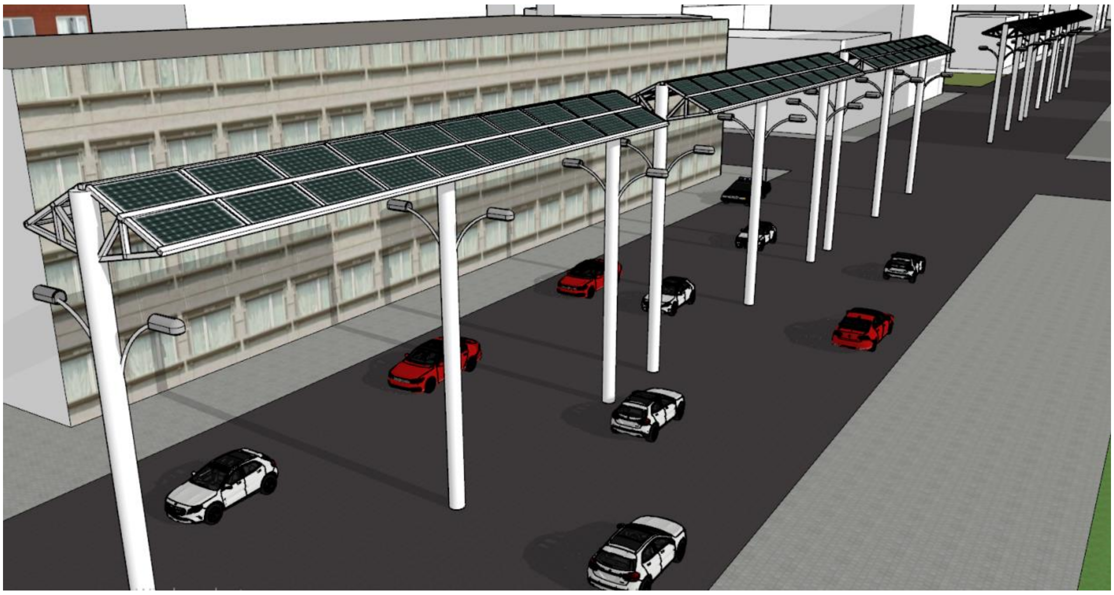


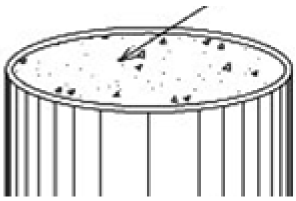
Figure 11:The final shape of the street after placing the structure

ETABS software :

This program was used to determine the dimensions of length, width, height and thickness necessary for the structure to bear the weight produced by the 40 modules, which is approximately 1 ton (1000 kilograms) .

After examining on the ETABS program, it was found that three Poles were needed, and their characteristics were monitored in table (1) below :

Table 2:The Characteristics of Poles hold the modules

Characteristics of Poles	
Type	Cylindrical Steel filled with concrete (p300) 
Outside diameter	0.5 m
Thickness	20mm (2cm)

The two figures below show the 3D view of the structure from two sides: the first side is the southeast side shown in figure(12), and the second is the southwest side shown in figure (13).

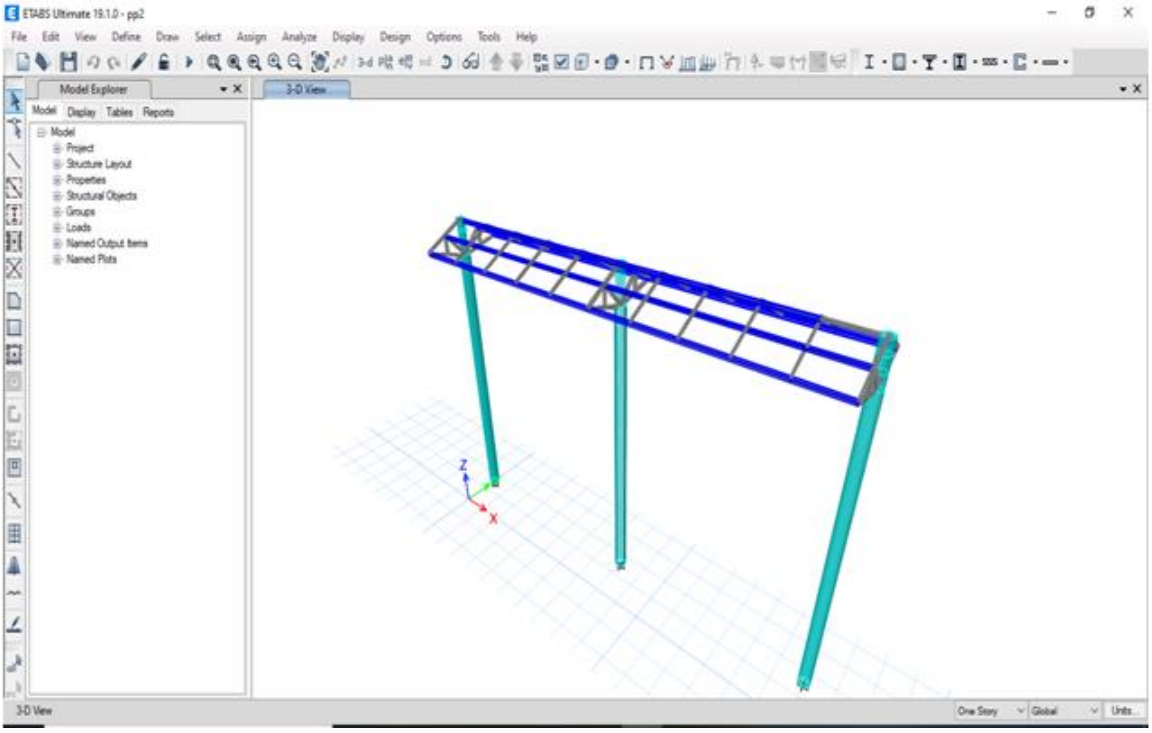


Figure 12: South East (SE) 3D view of the structure

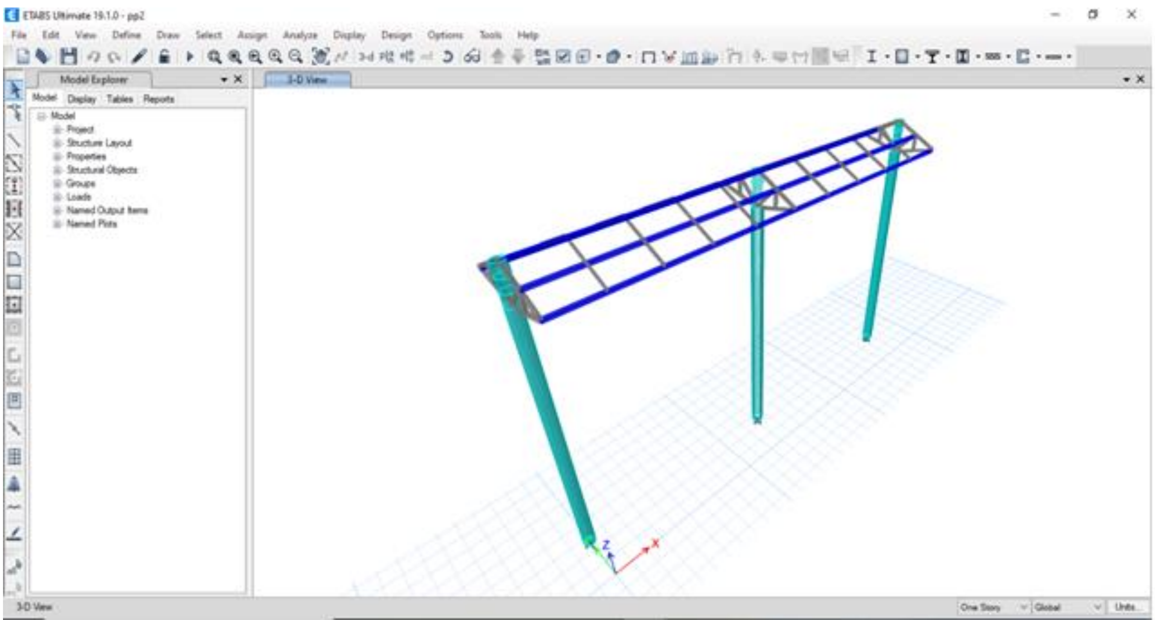


Figure 13:South West (SW) 3D view of the structure

The figure(14) below shows the elevation view from the front side and the necessary struts of the structure.

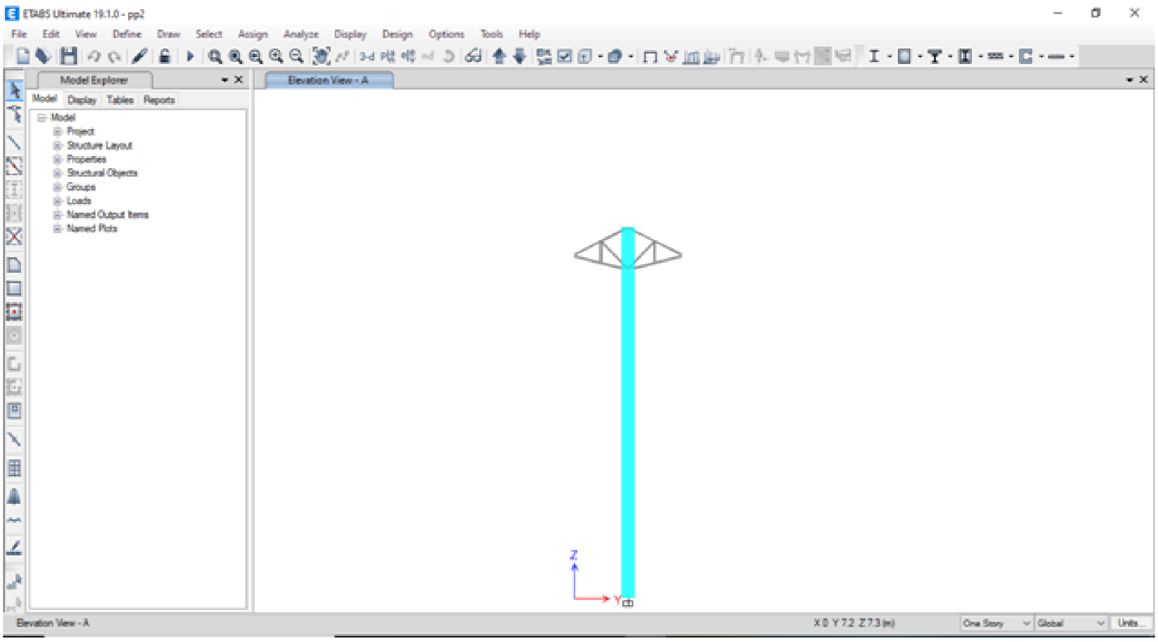


Figure 14:the Elevation view with struts of the structure

The number of cells on the structure listed in the pictures below is 40 cells distributed on two sides, each side contains 20 cells as shown in figure (15) and figure (16) .

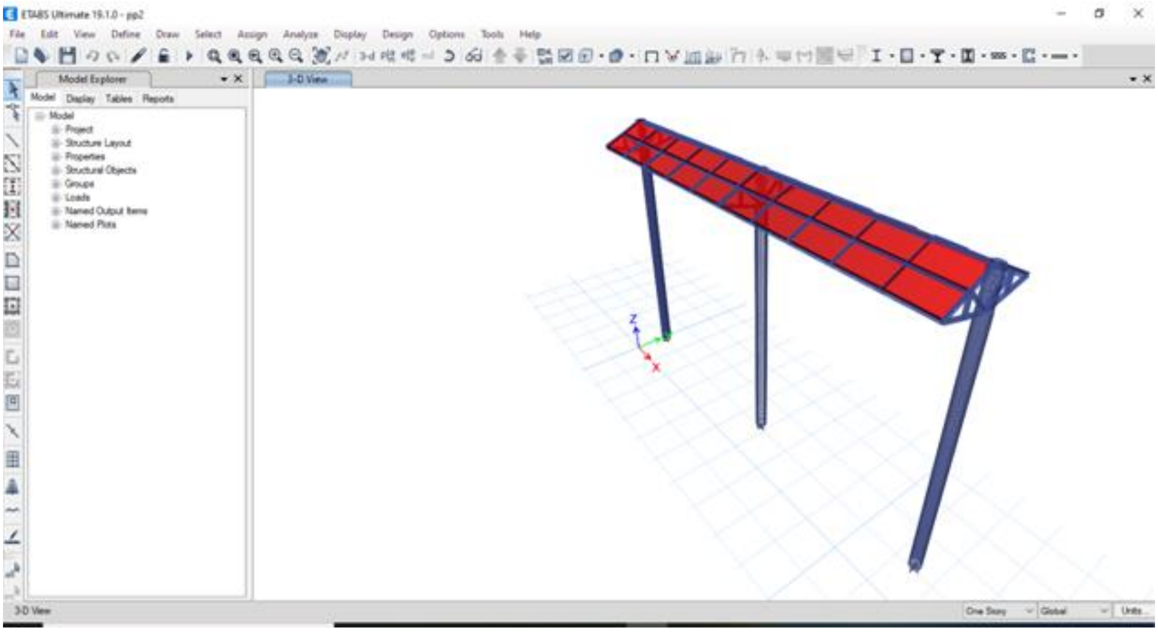


Figure 15:3D view of the modules on the structure

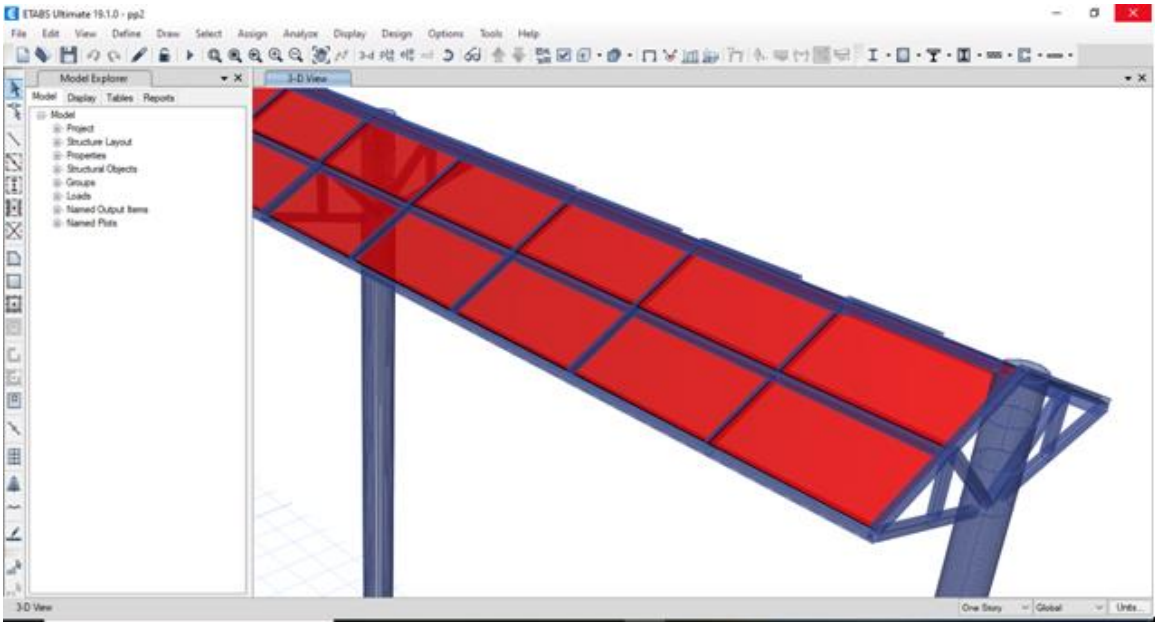


Figure 16:3D close-up view of the modules on the structure

The following figure (17) shows the acceptable deflection resulting from the dead load (Dead loads are structural loads of a constant magnitude over time. They include the self-weight of structural members. Dead loads also include the loads of fixtures that are permanently attached to the structure).

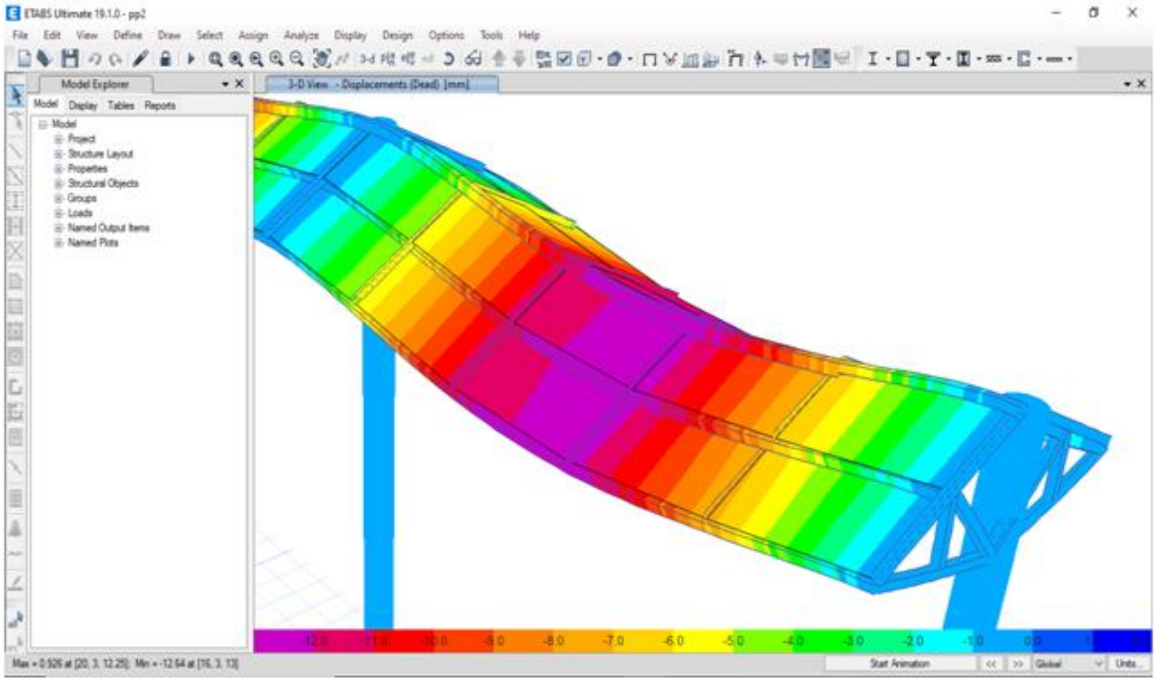


Figure 17:: 3D view of the deflection resulting from the dead load

The following figure (18) shows the acceptable deflection resulting from the wind load after applying a speed of 120 km/h, which is equivalent to a force of 0.77 kN.

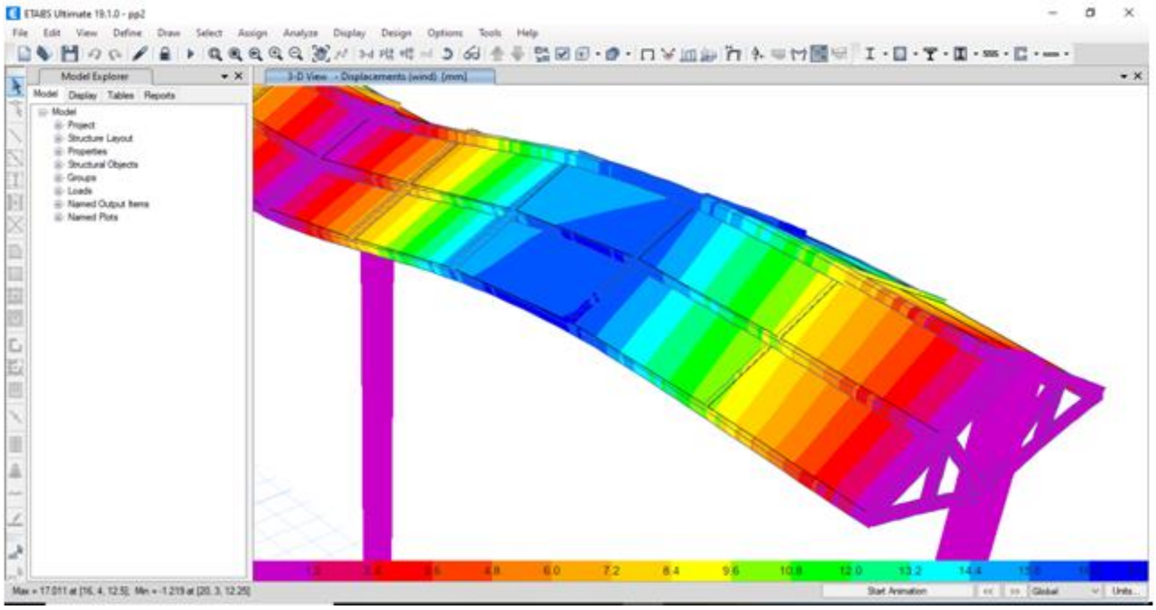


Figure18:3D view of the deflection resulting from the wind load

The steel dimensions needed to be placed under the modules was determined in numbers shown in the figures (19), (20), (21) below.

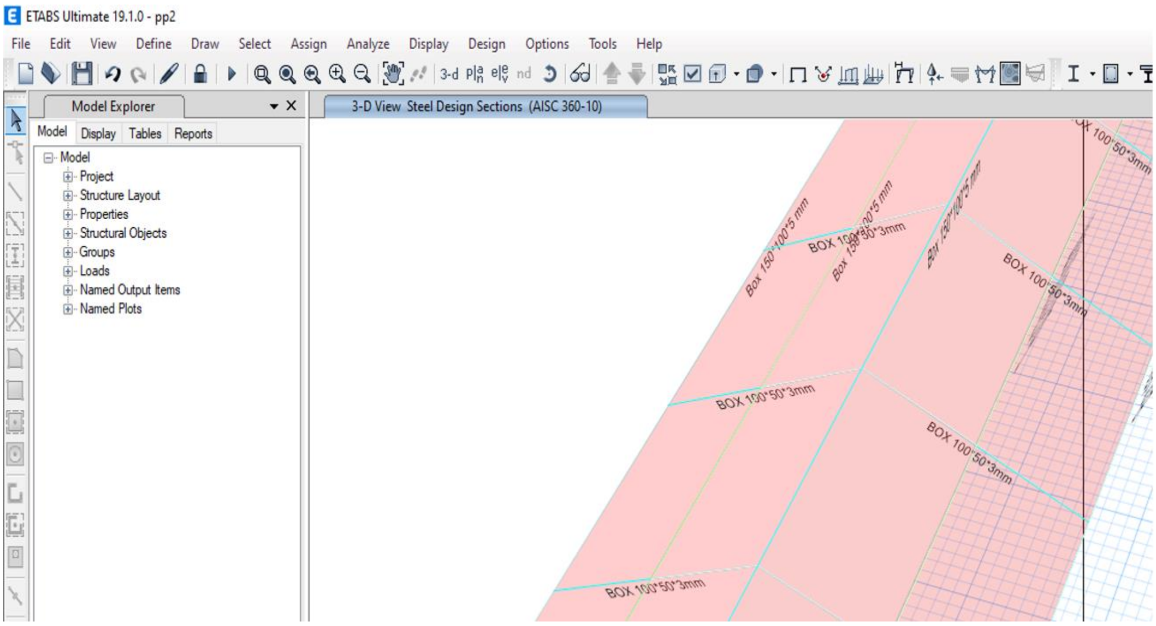


Figure 19:3D view of the steel dimensions needed in the structure

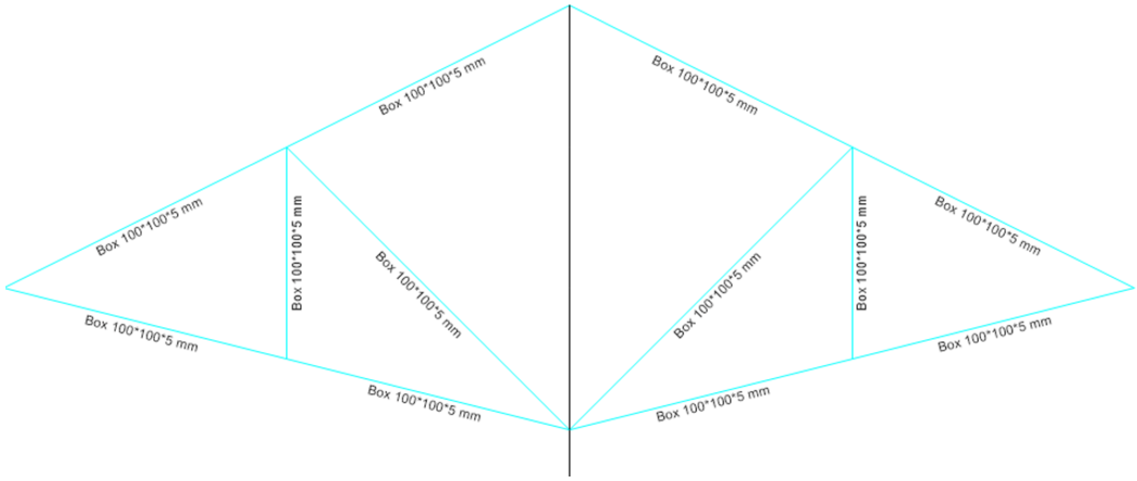


Figure 20:: 3D front view of the steel dimensions needed in the structure (struts)

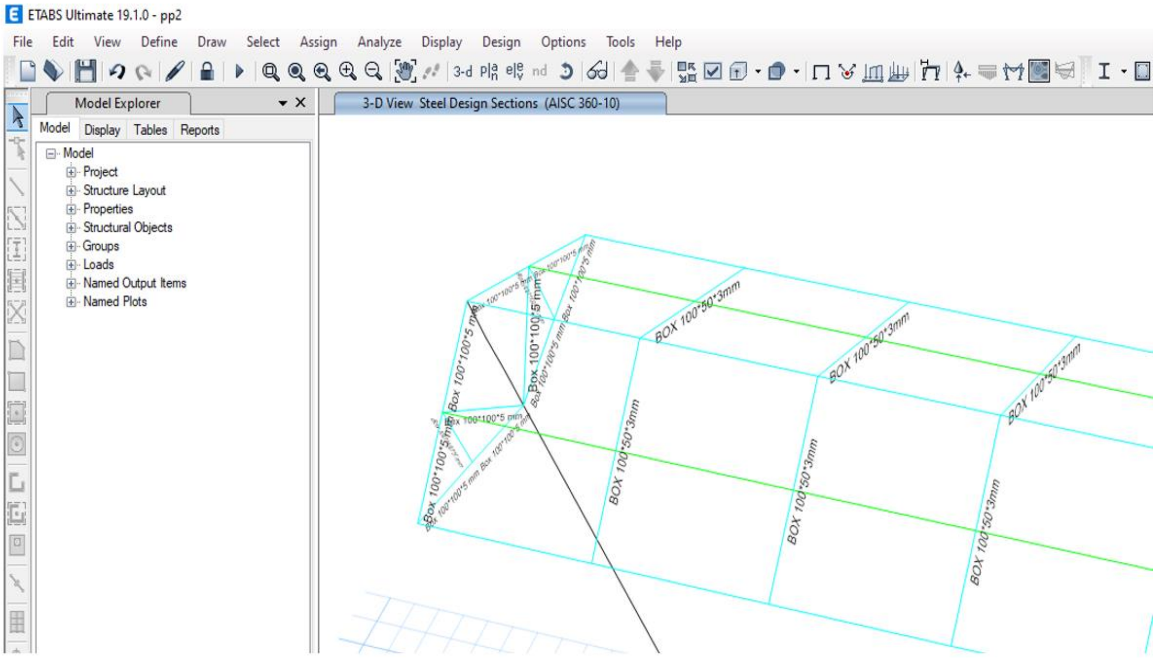


Figure 21:another 3D view of the steel dimensions needed in the structure

3.5) Calculations:

The structure is designed to produce 20 kW, and when calculating the maximum power that must be supplied to Al-Murabba transformer, it is 91.4 kW AC during the day and 80 kW AC at night.

It equates to 164.52 kW DC during the day and 239.37 kW DC for batteries to supply high night loads. This means we need 403.89 kW DC, which means we need about 20 new chassis to cover this load.

But if we assume that the construction will be designed on a plot of land using the traditional structure, it will require 4000 square meters (where one kilo needs 10 square meters).

As for the wires, we need 6mm^2 DC DC wires and 6 mm^2 AC wires.

3.6 Questionnaire:

The result was good, I made a copy of the performance of the business, and to see what people think of that activity and the results were as follows:

- 95.2% support the use of solar cells in their homes.

- 9.5% have solar energy in their homes.

- 95.2% believe in solar energy as a solution to the problem of lack of current in the city.

- 100% support the use of solar energy in the residential area in which they live.

- 95.2% prefer solar cells over diesel generators.

- 100% prefer to use solar energy in their shops.

- 90.5% support using batteries in their stores at night.

- As for the reasons that prevent citizens from installing solar energy, most of the answers centered around the high price of solar systems, the lack of adequate money to install solar systems, the absence of a law regulating the relationship between citizens and municipalities, in addition to the high costs, lack of experience in the market, Lack of knowledge about costs, <u>the location of the shop and the lack of a good space for installing solar cells.</u>

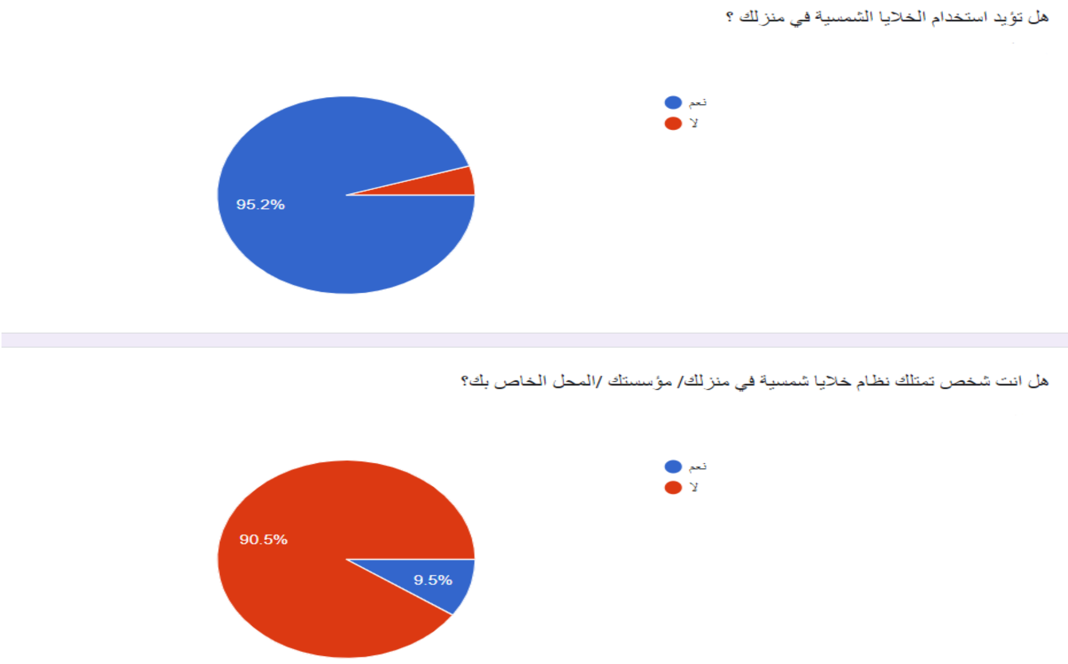


Figure 22 :Questionnaire 1

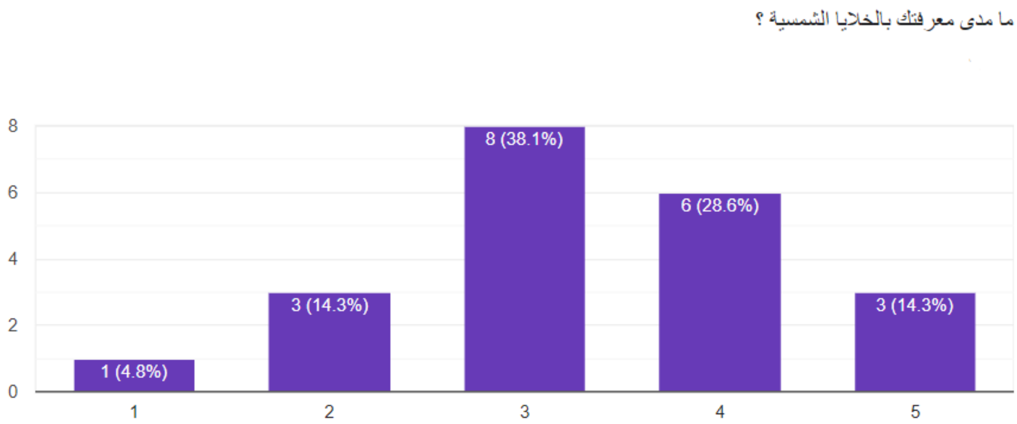
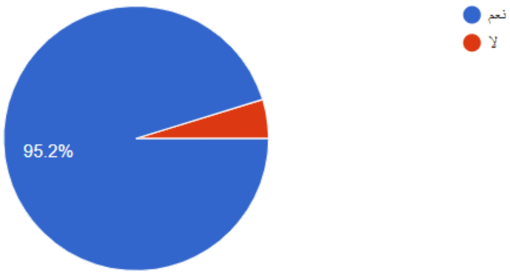


Figure 23 :Questionnaire2

في رأيك ، هل ترى انه من الممكن ان تساهم الخلايا الشمسية في سد النقص في الطاقة الكهربائية الواصل للمدينة من قبل الاحتلال



هل تؤيد استعمال الخلايا الشمسية في منطقتك ؟

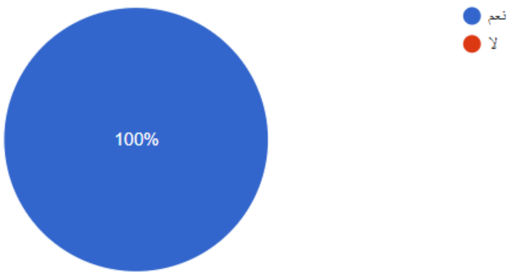


Figure 24:Questionnaire3

Figure 25 :Questionnaire4

Figure 26 :Questionnaire5

اذا كنت تفضل استخدام الخلايا الشمسية ، ما هي الاسباب التي تمنعك من استعمالها في منزلك /المحل الخاص بك/مؤسستك؟

لانها بدون بطاريات تخزين والبطاريات سعرها باهض

عدم توفر المال

لا اعرف

عدم وجود قانون منظم للعلاقة بين المواطنين والبلديات بالإضافة إلى التكاليف الباهضة

التكلفة العالية و عدم الاستفاده منها في فصل الشتاء

افضل استخدامها بدون اي مانع

نظام مكلف

السعر

عدم توفر الوقت لاستشارة المختصين ومباشرة العمل

Figure 27 :Questionnaire6

اذا كنت تفضل استخدام الخلايا الشمسية ، ما هي الاسباب التي تمنعك من استعمالها في منزلك /المحل الخاص بك/مؤسستك؟

أسعارها الباهضة

تكلفه عاليه،ويمكن تخرب

الوضع المادي لا يسمح

عدم الالمام بالتكاليف

موقع المحل

التكلفة العالية

عدم توفر مساحة جيده لتركيب الخلايا الشمسية

تكلفتها العالية

عدم وجود مساحة كافية

Figure 28 :Questionnaire7

3.7) Single line diagram(SLD) of the systems after design :

The figures (22), (23) below show SLD for each of the two systems, connected to the grid and off-grid, respectively.

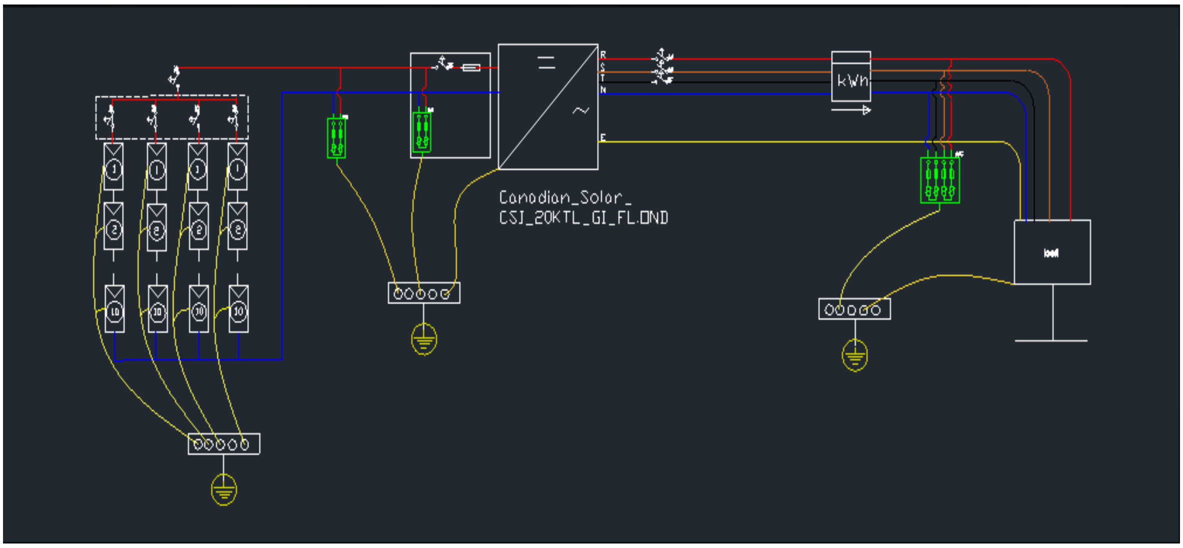


Figure 29: SLD od on -grid system

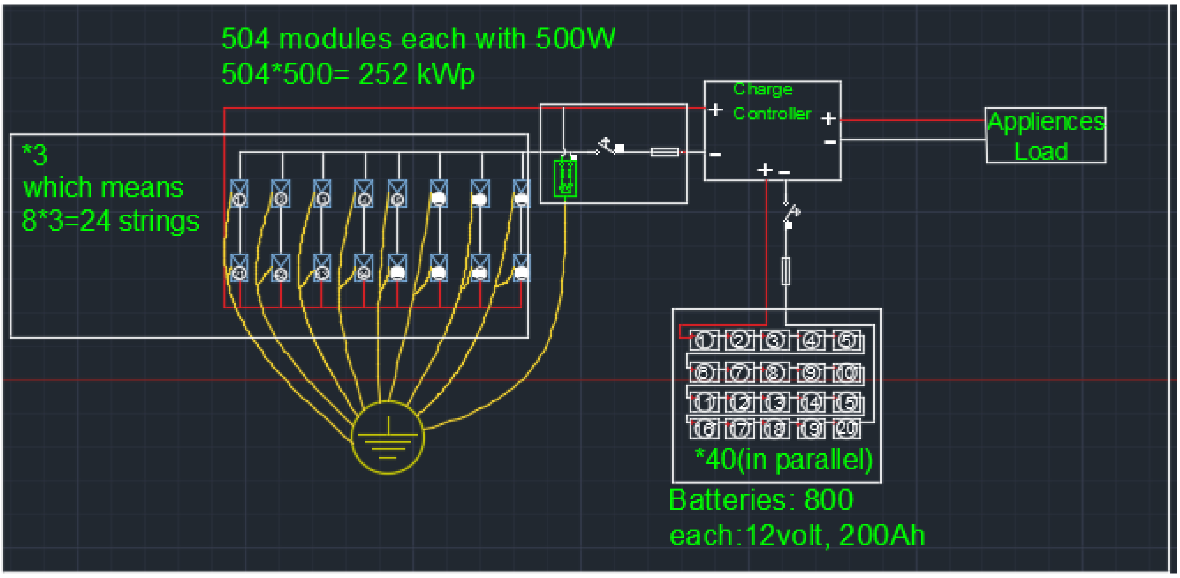


Figure 30: SLD of off-grid system

4.Chapter four : Discussion

In this project, the electrical situation of the city of Tulkarm was studied, and according to the results that appeared in the previous chapter, it was concluded that there is a shortage of electric current in the city, in addition to the presence of excessive loads on the transformers.

Accordingly, a plan was developed to solve the problem, taking into account the square transformer as a case and example for the rest of the city's transformers, and the loads on the transformers were divided and classified into daytime loads (high, normal, medical) and night loads (high, normal, medical). The condition of the transformer was then studied and the amount of overloads per hour throughout the year, as well as the amount of electrical current needed by the transformer.

The morning period (9 hours) was considered from 8 am to 5 pm, and the evening period (15 hours) from 5 pm to 8 am.

Accordingly, a plan was developed as follows:

Converting high and normal morning loads to a solar energy system that depends on the net metering system (self-consumption), and proposing the work of a hybrid system (solar cells, batteries and municipal electricity) for morning medical loads, Thus, the loads on the transformer were reduced, in addition to self-reliance in producing electricity from the sun, and not resorting to Israeli electricity.

In the case of high night loads, a storage system consisting of solar panels feeding the batteries and supplying high and normal night loads was undertaken, and a hybrid system (generator, municipal electricity and batteries) was proposed to supply medical loads.

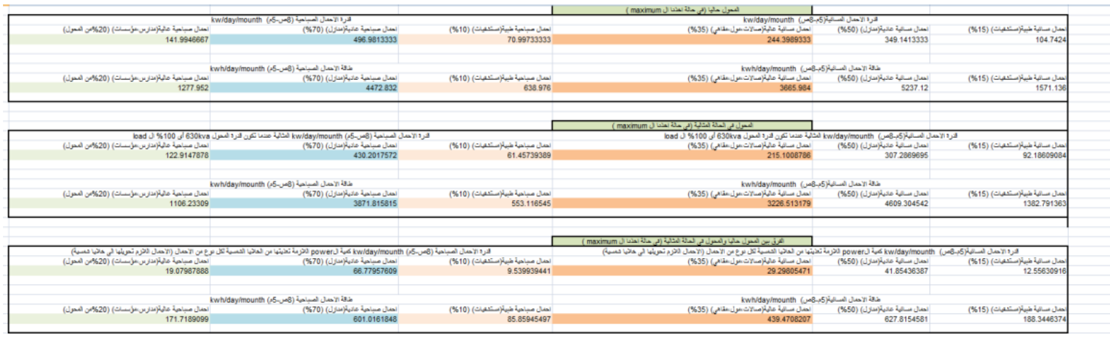


Figure 31: Detailed solution of the problem

In addition, the case of the solar panels and their installation method was studied, as a new structure was proposed to install the solar panels in a way that takes advantage of the islands in the streets and undeveloped areas to install the panels on them, to generate electric power and save large areas. Where the new structure takes into account all the heights of the buildings, which can cause and avoid shadows on the panels, in addition to the fact that the system in its new form is less expensive than the existing system in the traditional form, where the price of the new system is estimated at (47000NIS) and the price of the traditional system (142000 NIS). Table (3),(4) below show the comparison between the two systems.

A Canadian solar inverter with a capacity of 20 kilowatts and a Trina solar panel with a capacity of 500 watts has been selected, where the panels can be used with a greater capacity to compensate the shortage that results from directing the panels to the east, west or north according to the direction of the structure, which depends on the direction of the street. In addition to the use of 12-volt and 200 Ah batteries.

Weather maps and global locations were used to determine the amount of solar radiation, the number of sunny, rainy and cloudy days, and wind speed, which affects the design, it is included in the appendix.

Table 3: Calculation of the cost of the new structure

	Quantity	Unit price(NIS)	The cost(NIS)	Total cost (NIS)
The new structure	1	8 100	8 100	8 100
Modules(500w)	40	640	25 600	33 700
Inverter (20 kw)	1	10 000	10 000	43 700
Circuit Breakers(DC)	6	200	1200	44 900
Circuit Breakers(AC)	3	50	150	45 050
Fuses	1	15	15	45 065
Surge Arrestors(DC)	2	170	340	45 405
Surge Arrestors(AC)	1	140	140	45 545
Dc Cables	10 m	4	40	45 585
Ac Cables	15 m	3	45	45 630
Earth cable	15 m	5	75	45 705
Earth leakage	1	115	115	45 820
Junction Box	2	160	320	46 140
Electrode + busbar	3	210	630	46 770
Anchors and connections	1	50	50	46 820

Table 4: Calculation of the cost of the traditional structure

	Quantity	Unit price(NIS)	The cost(NIS)	Total cost (NIS)
traditional structure	1	3 000	3 000	3 000
Modules(500w)	40	640	25 600	28 600
Inverter (20 kw)	1	10 000	10 000	38 600
Circuit Breakers(DC)	6	200	1200	39 800
Circuit Breakers(AC)	3	50	150	39 950
Fuses	1	15	15	39 965
Surge Arrestors(DC)	2	170	340	40 305
Surge Arrestors(AC)	1	140	140	40 445
Dc Cables	10 m	4	40	40 485
Ac Cables	15 m	3	45	40 530
Earth cable	15 m	5	75	40 605
Earth leakage	1	115	115	40 720
Junction Box	3	160	480	41 200
Electrode + busbar	3	210	630	41 830
Anchors and connections	1	50	50	41 880
Theland	200 m^2	500	100 000	141 880

The total cost of the system by the new structure = 46 820 nis = 47 000 nis

The total cost of the system by the traditional structure = 141 880 nis = 142 000 nis

Here, the price difference between the two systems (the new and the traditional) was noticed, as the price of the new system (20 kilowatts) is only 47,000 NIS, while the traditional system costs 142,000 NIS. This means that designing a solar energy system using the new structure is better in terms of price than designing a solar energy system Solar energy using the traditional structure.

In addition, a questionnaire (opinion poll) was conducted to determine the extent to which the residents of Tulkarm are aware of solar energy and their opinion of solar energy and whether they consider it a solution and believe in it or not. They were asked to mention the reasons that prevent them from installing it, as the results showed that the majority support solar energy, but a large percentage did not install these systems because of their high cost, but with that it was concluded that many believe that it is the solution to get rid of the electricity problems that the city suffers from.

5. Chapter five: Conclusions

- The problem of Tulkarm city in the electricity sector has been explained, which suffers from two main problems, namely the lack of current reaching the city and the overload of transformers.

- The climatic conditions in Tulkarm city and the conditions related to the climate in the city have been established.

- One transformer (the square transformer) was taken as a case and example for the rest of the city transformers, where the transformer needs a DC 165 kW system to cover the shortfall in the morning loads and a 240 kW DC system to supply the batteries to cover the shortfall in the night loads.

- The loads on the transformer were divided and a solution was proposed for each load problem that might fall within the existing loads.

- A new structure has been proposed in a new shape and style that takes advantage of the islands and the middle of the streets to install solar panels.

- A questionnaire was conducted to find out the opinion of people in Tulkarm city with solar energy and how much they believe in it as a solution to save them from the electricity problem that Tulkarm city suffers from.

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Appendices:

1)PV Panels Selection:

Mono Multi Solutions

THE

Vertex

BACKSHEET MONOCRYSTALLINE MODULE

PRODUCTS: TSM-DE18M(II) | POWER RANGE: 480-505W

500W+
MAXIMUM POWER OUTPUT

21.1%
MAXIMUM EFFICIENCY

0~+5W
POSITIVE POWER TOLERANCE

Founded in 1997, Trina Solar is the world's leading total solution provider for solar energy. With local presence around the globe, Trina Solar is able to provide exceptional service to each customer in each market and deliver our innovative, reliable products with the backing of Trina as a strong, bankable brand. Trina Solar now distributes its PV products to over 100 countries all over the world. We are committed to building strategic, mutually beneficial collaborations with installers, developers, distributors and other partners in driving smart energy together.

Comprehensive Products and System Certificates

IEC61215/IEC61730/IEC61701/IEC62716
ISO 9001: Quality Management System
ISO 14001: Environmental Management System
ISO14064: Greenhouse Gases Emissions Verification
ISO45001: Occupational Health and Safety Management System

Trinasolar

High customer value

- Lower LCOE (Levelized Cost Of Energy), reduced BOS (Balance Of System) cost, shorter payback time
- Lower guaranteed first year and annual degradation
- Designed for compatibility with existing mainstream system components
- Higher return on Investment

High power up to 505W

- Large area cells based on 210mm silicon wafers and 1/3-cut cell technology
- Up to 21.1% module efficiency with high density interconnect technology
- Multi-busbar technology for better light trapping effect, lower series resistance and improved current collection

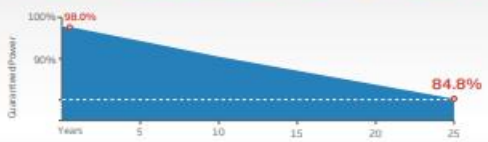
High reliability

- Minimized micro-cracks with innovative non-destructive cutting technology
- Ensured PID resistance through cell process and module material control
- Resistant to harsh environments such as salt, ammonia, sand, high temperature and high humidity areas
- Mechanical performance up to 5400 Pa positive load and 2400 Pa negative load

High energy yield

- Excellent IAM (Incident Angle Modifier) and low irradiation performance, validated by 3rd party certifications
- The unique design provides optimized energy production under inter-row shading conditions
- Lower temperature coefficient (-0.36%) and operating temperature

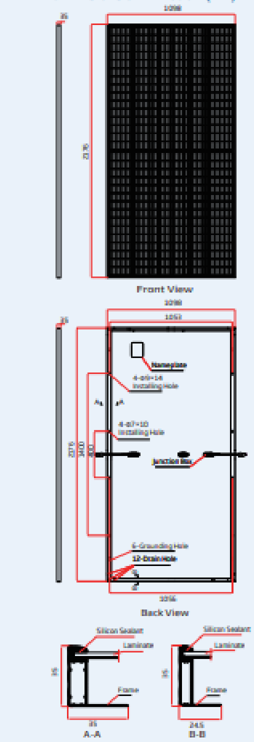
Trina Solar's VERTEX Backsheet Performance Warranty



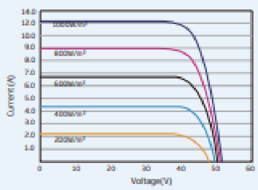
Vertex

BACKSHEET MONOCRYSTALLINE MODULE

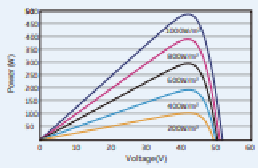
DIMENSIONS OF PV MODULE(mm)



I-V CURVES OF PV MODULE(490 W)



P-V CURVES OF PV MODULE(490W)



ELECTRICAL DATA (STC)

Peak Power Watts-P_{MAX} (Wp)*	480	485	490	495	500	505
Power Tolerance-P_{MAX} (W)	0 ~ +5					
Maximum Power Voltage-V_{MPP} (V)	42.0	42.2	42.4	42.6	42.8	43.0
Maximum Power Current-I_{MPP} (A)	11.42	11.49	11.56	11.63	11.69	11.75
Open Circuit Voltage-V_{OC} (V)	50.8	51.1	51.3	51.5	51.7	51.9
Short Circuit Current-I_{SC} (A)	11.99	12.07	12.14	12.21	12.28	12.35
Module Efficiency η_m (%)	20.1	20.3	20.5	20.7	20.9	21.1

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

ELECTRICAL DATA (NMOT)

Maximum Power-P_{MAX} (Wp)	363	367	371	375	379	382
Maximum Power Voltage-V_{MPP} (V)	39.6	39.8	40.0	40.2	40.4	40.6
Maximum Power Current-I_{MPP} (A)	9.15	9.20	9.26	9.32	9.37	9.43
Open Circuit Voltage-V_{OC} (V)	48.0	48.2	48.4	48.6	48.8	49.0
Short Circuit Current-I_{SC} (A)	9.65	9.72	9.77	9.83	9.89	9.94

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

MECHANICAL DATA

Solar Cells	Monocrystalline
Cell Orientation	150 cells
Module Dimensions	2176 ×1098× 35 mm (85.67 × 43.23 × 1.38 inches)
Weight	26.3 kg (58.0 lb)
Glass	3.2 mm (0.13 inches), High Transmission, AR Coated Heat Strengthened Glass
Encapsulant Material	EVA
Backsheet	White
Frame	35 mm (1.38 inches) Anodized Aluminium Alloy
J-Box	IP 68 rated
Cables	Photovoltaic Technology Cable 4.0mm² (0.006 inches²), Portrait: N 280mm/P 280mm(11.02/11.02inches) Landscape: N 1400 mm /P 1400 mm (55.12/55.12 inches)
Connector	MC4 EVO2 / TS4*

*Please refer to regional datasheet for specified connector.

TEMPERATURE RATINGS

NMOT (Nominal Module Operating Temperature)	41°C (±3°C)
Temperature Coefficient of P_{MAX}	- 0.36%/°C
Temperature Coefficient of V_{OC}	- 0.26%/°C
Temperature Coefficient of I_{SC}	0.04%/°C

MAXIMUMRATINGS

Operational Temperature	-40~+85°C
Maximum System Voltage	1500V DC (IEC)
Max Series Fuse Rating	20A

(Do not connect Fuse in Combiner Box with two or more strings in parallel connection)

WARRANTY

12 year Product Workmanship Warranty
25 year Power Warranty
2% first year degradation
0.55% Annual Power Attenuation

(Please refer to product warranty for details)

PACKAGING CONFIGUREATION

Modules per box: 30 pieces
Modules per 40' container: 600 pieces

Trinasolar

CAUTION: READ SAFETY AND INSTALLATION INSTRUCTIONS BEFORE USING THE PRODUCT.

Version number: TSM_EN_2020_A
www.trinasolar.com

Figure 32:Nameplate of PV modules[Trina solar, TSM-DE18M-500W]

2) inverter :

CanadianSolar

THREE PHASE STRING INVERTER 20-30 KW

CSI-20KTL-GI-FL | CSI-25KTL-GI-FL CSI-30KTL-GI-FL

Canadian Solar's grid-tied, transformer-less string inverters help to accelerate the use of three-phase string architecture for commercial rooftop and small ground-mount applications. An NRTL approved, cost-effective alternative to central inverters, these inverters are modular design building blocks that provide high yield and enable significant BoS cost savings. They provide up to 98.6% conversion efficiency, a wide operating range of 200-800 Vdc, and four MPPTs for maximum energy harvest.

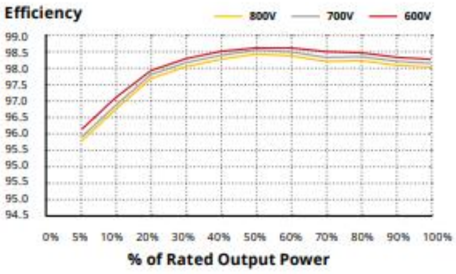
5 years **Standard warranty, extension up to 20 years**

KEY FEATURES

- Maximum efficiency up to 98.6%, Maximum CEC efficiency up to 98.3%
- 4 MPPTs to achieve higher system efficiency
- Transformerless design
- High switching frequency and ultra fast MPPT (<5 sec.) for maximum efficiency over a wide load range

EFFICIENCY CURVE

CSI-30KTL-GI-FL@380 Vac



*For detailed information, please refer to the Installation Manual.

HIGH RELIABILITY

- Advanced thermal design and convection cooling
- Built in over-voltage and over-current protection
- DC reverse polarity and AC short circuit protection

BROAD ADAPTIBILITY

- IP65 rated for outdoor application
- Utility interactive controls: Active power derating, reactive power control and over frequency derating
- Integrated DC load rated disconnect
- Wide MPPT range for flexible string sizing
- 90 degree installation angle
- Supports up to 8 DC string inputs (2 per MPPT)

CANADIAN SOLAR INC. is committed to providing high quality solar products, solar system solutions and services to customers around the world. As a leading PV project developer and manufacturer of solar modules with over 33 GW deployed around the world since 2001, Canadian Solar Inc. is one of the most bankable solar companies worldwide.

CANADIAN SOLAR INC.
545 Speedvale Avenue West, Guelph, Ontario N1K 1E6, Canada | www.canadiansolar.com

SYSTEM/TECHNICAL DATA			
MODEL NAME	**CSI-20KTL-GI-FL**	**CSI-25KTL-GI-FL**	**CSI-30KTL-GI-FL**
DC INPUT			
Max. PV Power	23 kW (13.5 kW/MPPT)	28 kW (13.5 kW/MPPT)	34 kW (13.5 kW/MPPT)
Max. DC Input Voltage	1000 V_{DC}		
Operating DC Input Voltage Range	200-800 V_{DC}		
Start-up DC Input Voltage/Power	350 V		
Number of MPP Trackers	4		
MPPT Full Power Voltage Range	278-800 V_{DC}	347-800 V_{DC}	417-800 V_{DC}
Operating Current (Imp)	72 A (18 A per MPPT)		
Max. Input Current (Isc)	93.6 A (23.4 A per MPPT)		
Number of DC Imputs	8 (2 per MPPT)		
DC Disconnection Type	Load rated DC switch		
AC OUTPUT			
Rated AC Output Power	20 kW	25 kW	30 kW
Max. AC Output Power	22 kW	27.5 kW	33 kW
Rated Output Voltage	380/400 V_{AC}		
Output Voltage Range*	304-460 V_{AC}		
Grid Connection Type	3 Φ/PE		
Nominal AC Output Current @480 Vac	30.3/28.7 A	37.9/36.1 A	45.5/43.3 A
Rated Output Frequency	50/60 Hz		
Output Frequency Range*	47-52/57-62 Hz		
Power Factor	1 default (±0.8 adjustable)		
Current THD	< 3 %		
SYSTEM			
Topology	Transformerless		
Max. Efficiency	98.6 %		
CEC Efficiency	98.3 %		
Night Consumption	< 1 W		
ENVIRONMENT			
Protection Degree	IP65		
Cooling	Natural Convection Cooling		
Operating Temperature Range	-25 ° C to +60 ° C		
Storage Temperature Range	-40 F to + 158 ° F / -40 ° C to +70 ° C		
Operating Humidity	0 - 100 %		
Operating Altitude	4000 m		
Audible Noise	<30 dBA @ 1 m		
DISPLAY AND COMMUNICATION			
Display	LCD + LED		
Communication	Standard: RS485 (Modbus)		
MECHANICAL DATA			
Dimensions (W / H / D)	530 x 700 x 356.5 mm		
Weight	58.2 kg		
Installation Angle	90 degrees from horizontal		
DC Inputs	MC4		
SAFETY			
Safety	IEC62109-1/-2		
Grid Standard	AS4777, NRS097		
Smart-Grid Features	Voltage-Ride Thru, Frequency-Ride Thru, Soft-Start, Volt-Var, Frequency-Watt, Volt-Watt		

*The "Output Voltage Range" and "Output Frequency Range" may differ according to specific grid standard.

* The specifications and key features contained in this datasheet may deviate slightly from our actual products due to the on-going innovation and product enhancement. Canadian Solar Inc. reserves the right to make necessary adjustment to the information described herein at any time without further notice.

Caution: For professional use only. The installation and handling of PV equipment requires professional skills and should only be performed by qualified professionals. Please read the safety and installation instructions before using the product.

CANADIAN SOLAR INC. April 2019 | | Inverter Product Datasheet V3.4_GL

Figure 33: Solar inverter datasheet

3) Map of Palestine :

Figure 34:Map of whole Palestine

4) A map showing the amount of radiation in the city of Tulkarm:

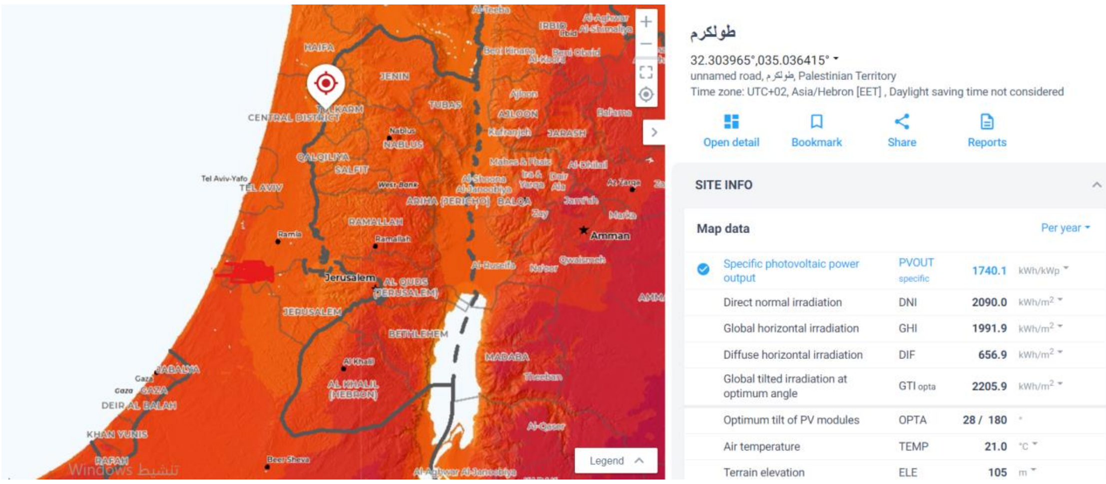


Figure 35: A map showing the amount of radiation in the city of Tulkarm

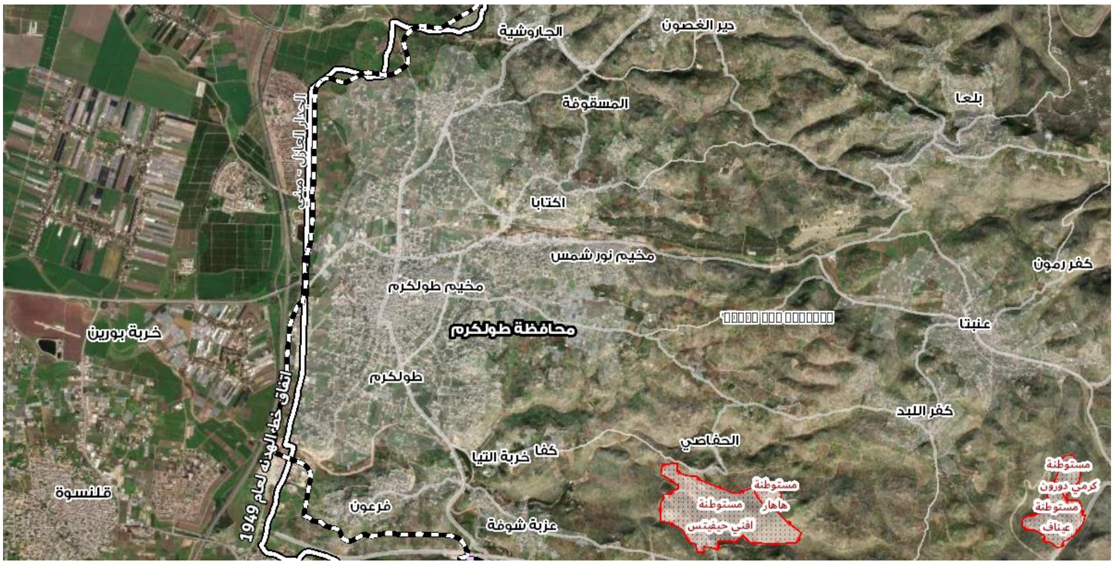


Figure 36:Map of Tulkarm Governorate and it s surrounding villages

5)Tulkarm Monthly Climate Averages

World Weather Online is used to obtain this Figures in the bottom.[11]

A)Monthly Average Temperature and Rainfall in Tulkarm city :

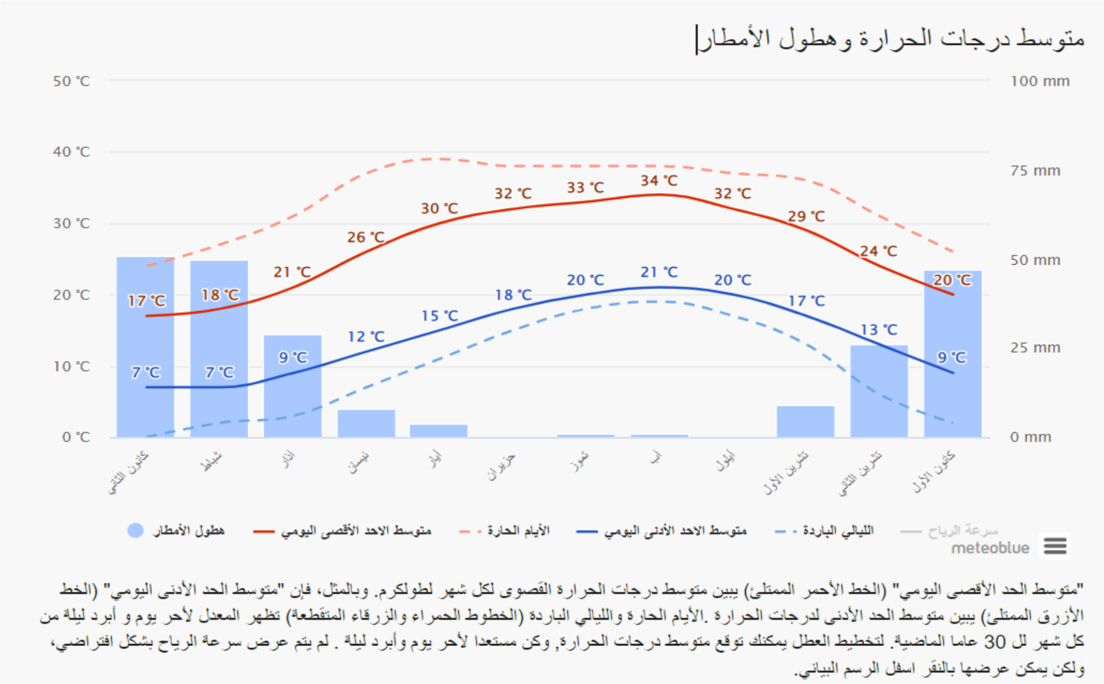


Figure 37:Monthly Average Temperature and Rainfall in Tulkarm city using World Weather Online

B) The number of cloudy and sunny days in the city of Tulkarm:

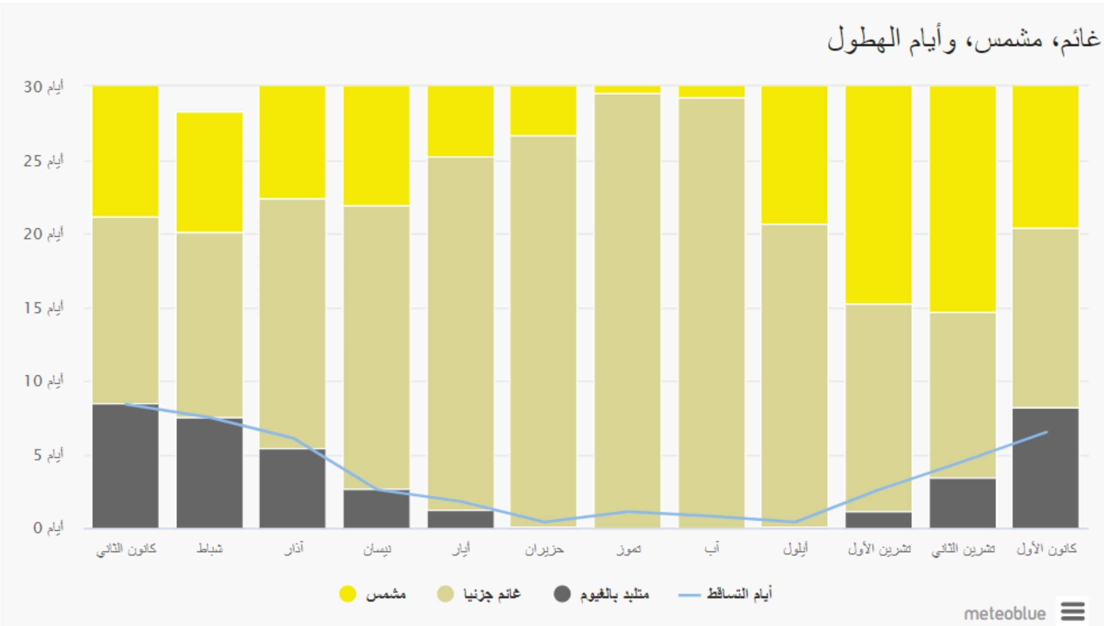


Figure 38: The number of cloudy and sunny days in the city of Tulkarm

c)Monthly Average Maximum temperatures in Tulkarm city:

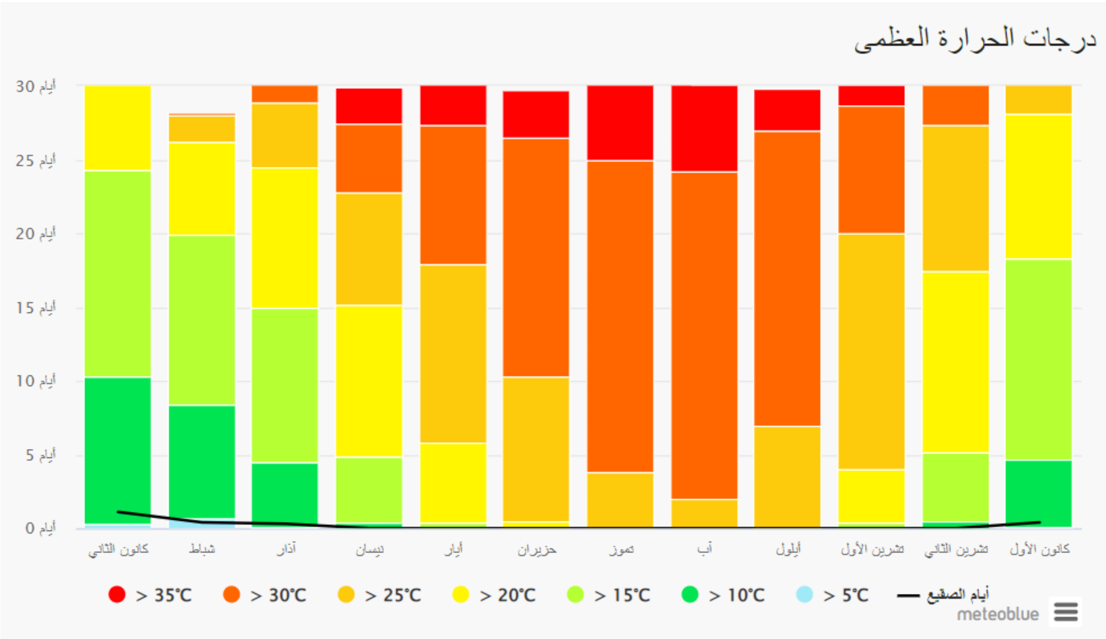


Figure 39:Monthly Average Maximum temperatures in Tulkarm city

d)Max and Average Wind Speed in Tulkarmcity:

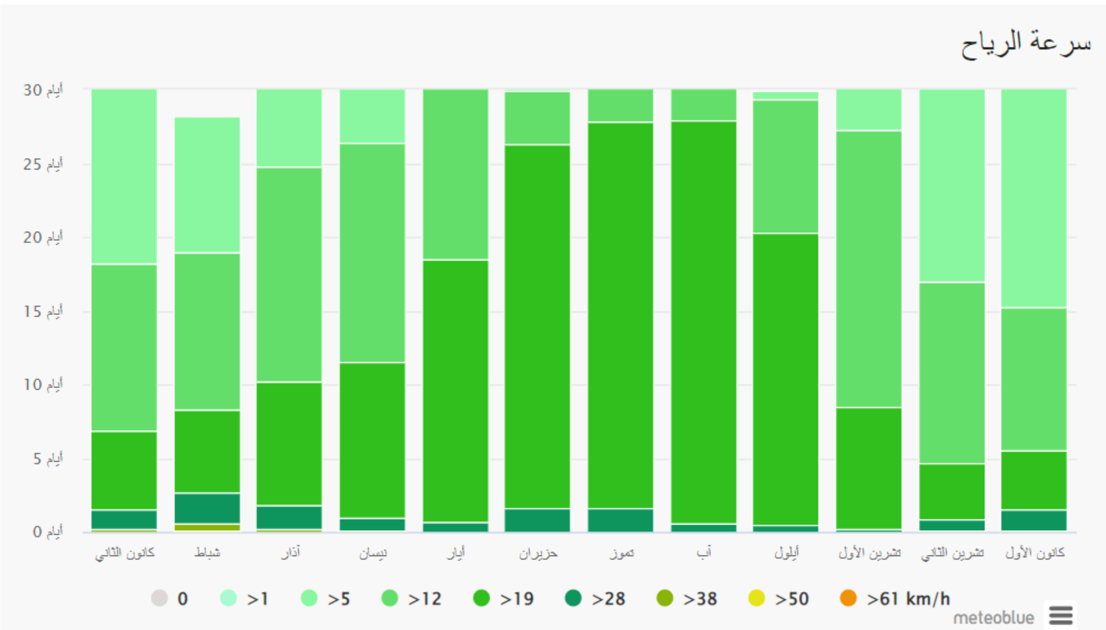


Figure 40:Max and Average Wind Speed in Tulkarm city

6) PVSYST software reports for the two systems (on-grid and off- grid)

A) On-grid report :

Project: graduation project 2 one inverter

Variant: New simulation variant

PVsyst V7.2.8
VC0, Simulation date:
17/12/21 00:18
with v7.2.8

Project summary

Geographical Site		**Situation**		**Project settings**	
Ţūlkarm		Latitude	32.31 °N	Albedo	0.20
Palestine, State Of		Longitude	35.03 °E		
		Altitude	97 m		
		Time zone	UTC+2		

Meteo data
Ţūlkarm
Meteonorm 8.0 (1991-2010), Sat=100% - Synthetic

System summary

Grid-Connected System		**Tables on a building**			
PV Field Orientation		**Near Shadings**		**User's needs**	
Fixed planes	2 orientations	Linear shadings		Unlimited load (grid)	
Tilts/azimuths	26 / 0 °				
	26 / -180 °				

System information

PV Array		**Inverters**	
Nb. of modules	40 units	Nb. of units	1 Unit
Pnom total	20.00 kWp	Pnom total	20.00 kWac
		Pnom ratio	1.000

Results summary

Produced Energy	29.10 MWh/year	Specific production	1455 kWh/kWp/year	Perf. Ratio PR	84.17 %

Table of contents

General parameters

Grid-Connected System — **Tables on a building**

PV Field Orientation

Orientation		Sheds configuration		Models used	
Fixed planes	2 orientations	Nb. of sheds	40 units	Transposition	Perez
Tilts/azimuths	26 / 0 °	**Sizes**		Diffuse	Perez, Meteonorm
	26 / -180 °	Sheds spacing	1.03 m	Circumsolar	separate
		Collector width	1.10 m		
		Ground Cov. Ratio (GCR)	106.4 %		
		Shading limit angle			
		Limit profile angle	84.7 °		

Horizon
Free Horizon

Near Shadings
Linear shadings

User's needs
Unlimited load (grid)

PV Array Characteristics

PV module		Inverter	
Manufacturer	Trina Solar	Manufacturer	Canadian Solar Inc.
Model	TSM-DE18M-(II)-500	Model	CSI-20KTL-GI-FL
(Original PVsyst database)		(Original PVsyst database)	
Unit Nom. Power	500 Wp	Unit Nom. Power	20.0 kWac
Number of PV modules	40 units	Number of inverters	4 * MPPT 25% 1 unit
Nominal (STC)	20.00 kWp	Total power	20.0 kWac
Modules	4 Strings x 10 In series	Operating voltage	200-800 V
At operating cond. (50°C)		Pnom ratio (DC:AC)	1.00
Pmpp	18.21 kWp		
U mpp	390 V		
I mpp	47 A		
Total PV power		**Total inverter power**	
Nominal (STC)	20 kWp	Total power	20 kWac
Total	40 modules	Nb. of inverters	1 Unit
Module area	95.6 m²	Pnom ratio	1.00

Array losses

Thermal Loss factor
Module temperature according to irradiance
Uc (const) 20.0 W/m²K
Uv (wind) 0.0 W/m²K/m/s

DC wiring losses
Global array res. 138 mΩ
Loss Fraction 1.5 % at STC

Module Quality Loss
Loss Fraction -0.8 %

Module mismatch losses
Loss Fraction 2.0 % at MPP

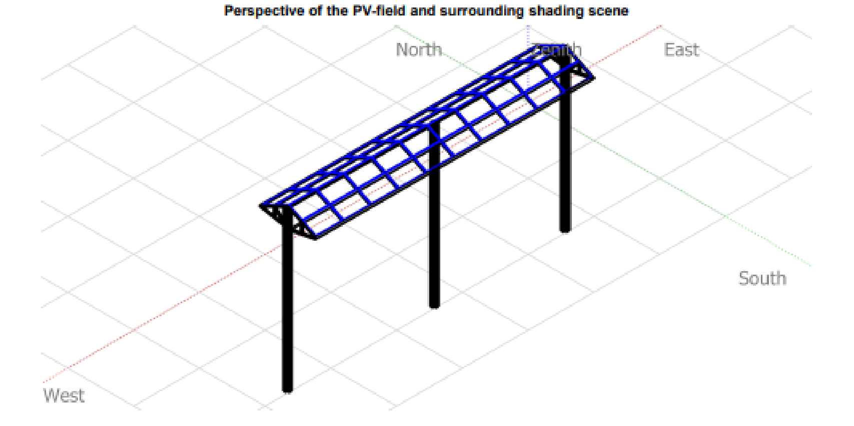
Strings Mismatch loss
Loss Fraction 0.1 %

IAM loss factor
Incidence effect (IAM): Fresnel AR coating, n(glass)=1.526, n(AR)=1.290

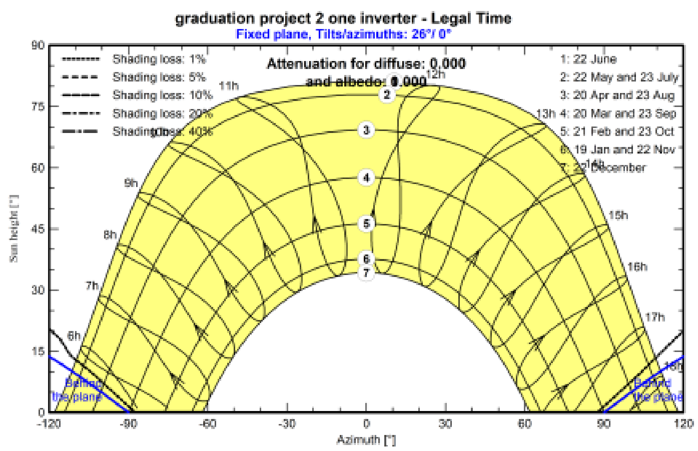
0°	30°	50°	60°	70°	75°	80°	85°	90°
1.000	0.999	0.987	0.962	0.892	0.816	0.681	0.440	0.000

Near shadings parameter

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram



Main results

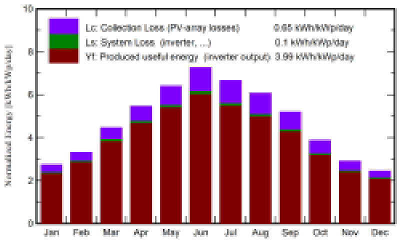
System Production

Produced Energy 29.10 MWh/year

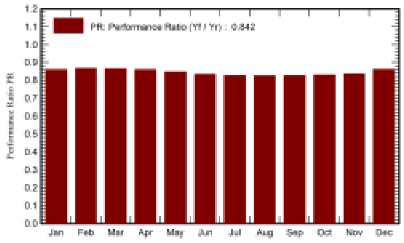
Specific production 1455 kWh/kWp/year

Performance Ratio PR 84.17 %

Normalized productions (per installed kWp)



Performance Ratio PR



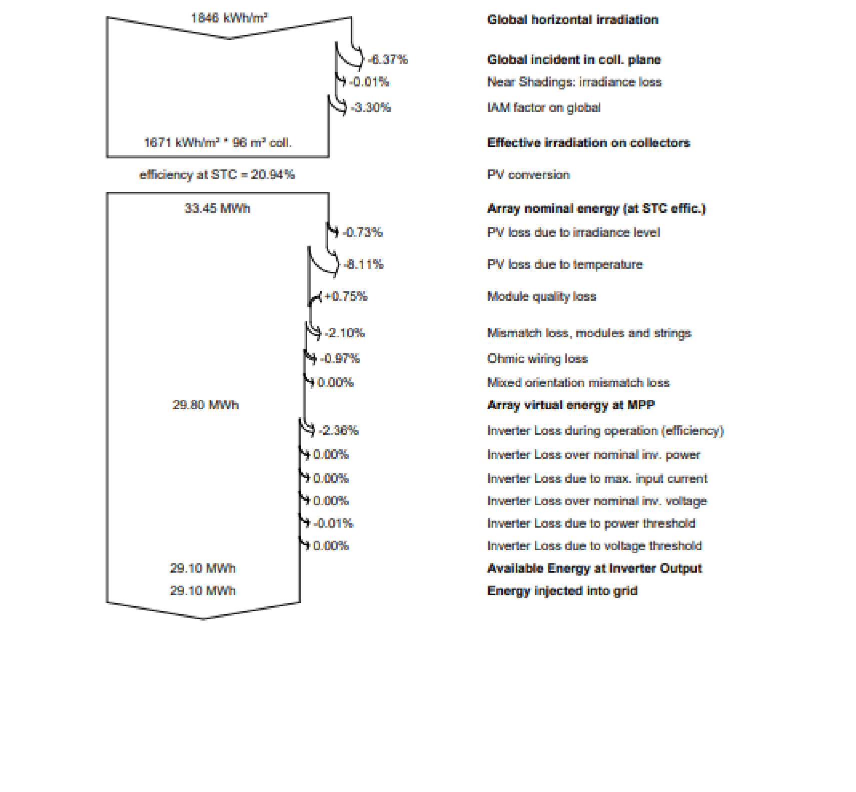
Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR ratio
January	89.9	33.93	12.76	84.8	80.4	1.499	1.458	0.859
February	99.1	47.48	13.97	92.9	88.6	1.650	1.609	0.866
March	147.6	71.05	16.74	138.3	133.2	2.448	2.389	0.864
April	174.7	81.97	19.38	163.7	159.1	2.880	2.814	0.859
May	212.0	90.33	22.95	198.3	193.5	3.439	3.362	0.848
June	233.2	70.59	25.57	217.6	212.7	3.712	3.629	0.834
July	221.6	74.45	28.09	206.6	201.6	3.494	3.414	0.826
August	200.7	77.70	28.58	187.8	182.8	3.172	3.099	0.825
September	167.0	60.47	26.61	156.0	150.5	2.641	2.580	0.827
October	127.8	54.52	23.99	119.9	114.4	2.038	1.988	0.829
November	92.8	36.27	19.10	87.0	82.5	1.496	1.456	0.836
December	79.6	37.05	14.92	75.5	71.8	1.336	1.300	0.860
Year	1846.0	735.82	21.10	1728.5	1671.3	29.804	29.097	0.842

Legends

GlobHor Global horizontal irradiation
DiffHor Horizontal diffuse irradiation
T_Amb Ambient Temperature
GlobInc Global incident in coll. plane
GlobEff Effective Global, corr. for IAM and shadings
EArray Effective energy at the output of the array
E_Grid Energy injected into grid
PR Performance Ratio

Loss diagram



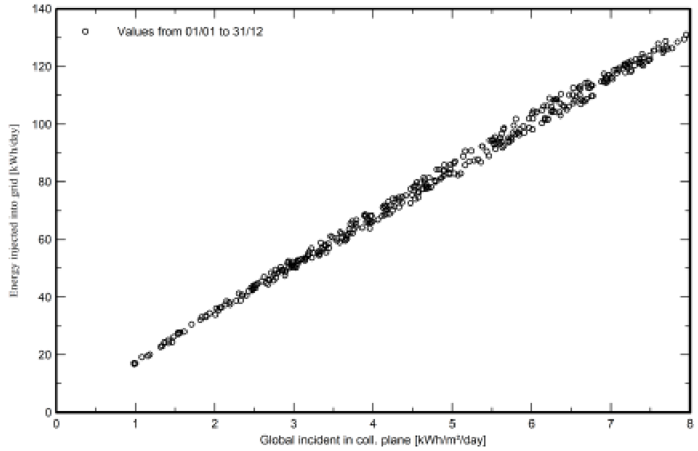
PVsyst V7.2.8
VC0, Simulation date:
17/12/21 00:18
with v7.2.8

Project: graduation project 2 one inverter

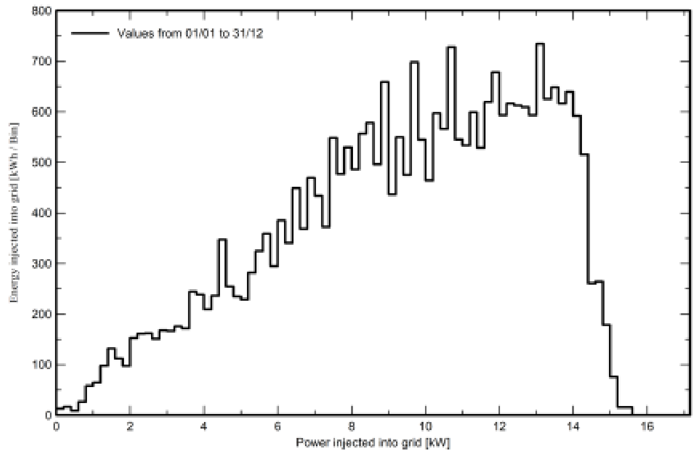
Variant: New simulation variant

Special graphs

Daily Input/Output diagram



System Output Power Distribution



17/12/21 PVsyst Licensed to Page 7/7

Figure 41:On-grid report

B) Off-grid report :

PVSYST V6.81		21/12/21	Page 1/5

Stand alone system: Simulation parameters

Project :	**New Project**				
Geographical Site		**Tulkarm**		Country	**Palestine, State Of**
Situation		Latitude	32.31° N	Longitude	35.03° E
Time defined as		Legal Time	Time zone UT+2	Altitude	125 m
		Albedo	0.20		
Meteo data:		**Tulkarm**	Meteonorm 7.2 (1990-2004), Sat=100% - Synthetic		

Simulation variant :	**varient 1**				
		Simulation date	21/12/21 23h52		

Simulation parameters		System type	**Stand alone system with batteries**		
Collector Plane Orientation		Tilt	26°	Azimuth	0°
Models used		Transposition	Perez	Diffuse	Perez, Meteonorm
User's needs :		Daily household consumers	Constant over the year		
		average	825 kWh/Day		

PV Array Characteristics					
PV module	uCSi-aSi:H	Model	**EST-500**		
Original PVsyst database		Manufacturer	ENN Solar Energy		
Number of PV modules		In series	21 modules	In parallel	24 strings
Total number of PV modules		Nb. modules	504	Unit Nom. Power	500 Wp
Array global power		Nominal (STC)	**252 kWp**	At operating cond.	234 kWp (50°C)
Array operating characteristics (50°C)		U mpp	4173 V	I mpp	56 A
Total area		Module area	**2883 m²**		
System Parameter		System type	**Stand alone system**		
Battery		Model	**AcmeG 12V 200**		
		Manufacturer	Narada		
Battery Pack Characteristics		Nb. of units	20 in series x 40 in parallel		
		Voltage	240 V	Nominal Capacity	8000 Ah
		Discharging min. SOC	20.0 %	Stored energy	1583.2 kWh
		Temperature	Fixed (20°C)		
Controller		Model	Universal controller with MPPT converter		
		Technology	MPPT converter	Temp coeff.	-5.0 mV/°C/elem.
Converter		Maxi and EURO efficiencies	97.0 / 95.0 %		
Battery Management control		Threshold commands as	SOC calculation		
		Charging	SOC = 0.90 / 0.75	i.e. approx.	269.2 / 253.4 V
		Discharging	SOC = 0.20 / 0.45	i.e. approx.	236.2 / 245.7 V

PV Array loss factors					
Thermal Loss factor		Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
Wiring Ohmic Loss		Global array res.	1305 mOhm	Loss Fraction	1.5 % at STC
Serie Diode Loss		Voltage Drop	0.7 V	Loss Fraction	0.0 % at STC
Module Quality Loss				Loss Fraction	2.5 %
Module Mismatch Losses				Loss Fraction	0.8 % at MPP
Strings Mismatch loss				Loss Fraction	0.10 %
Incidence effect, ASHRAE parametrization		IAM =	1 - bo (1/cos i - 1)	bo Param.	0.05

PVSYST V6.81		21/12/21	Page 2/5

Stand alone system: Detailed User's needs

Project : **New Project**

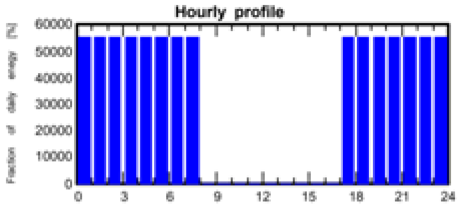
Simulation variant : **varient 1**

Main system parameters	System type	**Stand alone system with batteries**		
PV Field Orientation	tilt	26°	azimuth	0°
PV modules	Model	EST-500	Pnom	500 Wp
PV Array	Nb. of modules	504	Pnom total	**252 kWp**
Battery	Model	AcmeG 12V 200	Technology	Lead-acid, sealed, Gel
Battery Pack	Nb. of units	800	Voltage / Capacity	**240 V / 8000 Ah**
User's needs	Daily household consumers	Constant over the year	Global	301 MWh/year

Daily household consumers, Constant over the year, average = 825 kWh/day

Annual values

	Number	Power	Use	Energy
Shopping mall	1	27000 W/app	15 h/day	405000 Wh/day
market	3	7000 W/app	15 h/day	315000 Wh/day
cafe	1	7000 W tot	15 h/day	105000 Wh/day
Stand-by consumers			24 h/day	24 Wh/day
Total daily energy				825024 Wh/day



Stand alone system: Main results

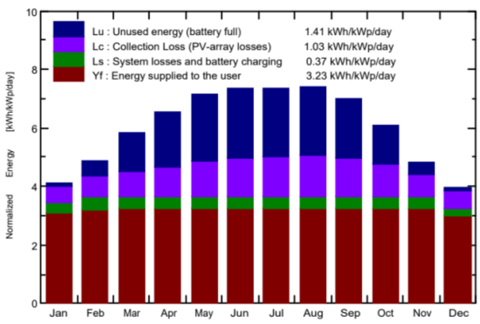
Project : **New Project**

Simulation variant : **varient 1**

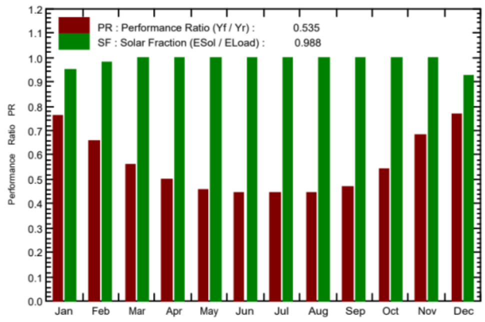
Main system parameters	System type	**Stand alone system with batteries**		
PV Field Orientation	tilt	26°	azimuth	0°
PV modules	Model	EST-500	Pnom	500 Wp
PV Array	Nb. of modules	504	Pnom total	**252 kWp**
Battery	Model	AcmeG 12V 200	Technology	Lead-acid, sealed, Gel
Battery Pack	Nb. of units	800	Voltage / Capacity	**240 V / 8000 Ah**
User's needs	Daily household consumers	Constant over the year	Global	301 MWh/year

Main simulation results				
System Production	**Available Energy**	**440763 kWh/year**	Specific prod.	1749 kWh/kWp/year
	Used Energy	297464 kWh/year	Excess (unused)	129641 kWh/year
	Performance Ratio PR	53.54 %	Solar Fraction SF	98.78 %
Loss of Load	Time Fraction	1.4 %	Missing Energy	3670 kWh/year
Battery ageing (State of Wear)	Cycles SOW	87.1%	Static SOW	91.7%
	Battery lifetime	7.8 years		

Normalized productions (per installed kWp): Nominal power 252 kWp



Performance Ratio PR and Solar Fraction SF



varient 1

Balances and main results

	GlobHor kWh/m²	**GlobEff** kWh/m²	**E_Avail** kWh	**EUnused** kWh	**E_Miss** kWh	**E_User** kWh	**E_Load** kWh	**SolFrac**
January	89.0	123.5	25685	450	1282	24294	25576	0.950
February	106.2	133.3	28116	3802	445	22655	23101	0.981
March	154.9	176.4	37112	10313	0	25576	25576	1.000
April	186.4	191.0	40009	14066	0	24751	24751	1.000
May	229.7	214.6	44512	17719	0	25576	25576	1.000
June	239.3	213.8	43884	17960	0	24751	24751	1.000
July	242.7	221.4	44913	18123	0	25576	25576	1.000
August	224.6	223.0	44951	18146	0	25576	25576	1.000
September	184.5	204.5	41346	15402	0	24751	24751	1.000
October	146.9	183.3	37060	10260	0	25576	25576	1.000
November	102.6	140.6	28663	2821	0	24751	24751	1.000
December	83.4	119.0	24514	578	1943	23633	25576	0.924
Year	1990.3	2144.4	440763	129641	3670	297464	301134	0.988

Legends:	GlobHor	Horizontal global irradiation	E_Miss	Missing energy
	GlobEff	Effective Global, corr. for IAM and shadings	E_User	Energy supplied to the user
	E_Avail	Available Solar Energy	E_Load	Energy need of the user (Load)
	EUnused	Unused energy (battery full)	SolFrac	Solar fraction (EUsed / ELoad)

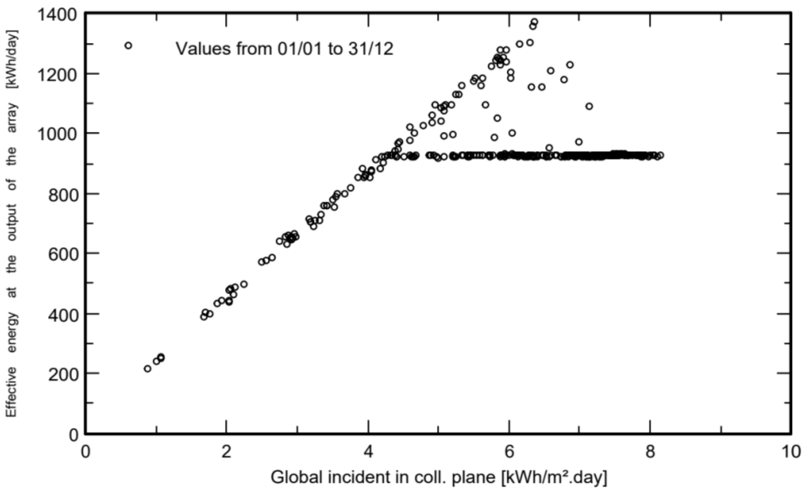
Stand alone system: Special graphs

Project : **New Project**

Simulation variant : **varient 1**

Main system parameters	System type	**Stand alone system with batteries**		
PV Field Orientation	tilt	26°	azimuth	0°
PV modules	Model	EST-500	Pnom	500 Wp
PV Array	Nb. of modules	504	Pnom total	**252 kWp**
Battery	Model	AcmeG 12V 200	Technology	Lead-acid, sealed, Gel
Battery Pack	Nb. of units	800	Voltage / Capacity	**240 V / 8000 Ah**
User's needs	Daily household consumers	Constant over the year	Global	301 MWh/year

Daily Input/Output diagram



PVSYST V6.81		21/12/21	Page 5/5

Stand alone system: Loss diagram

Project : **New Project**

Simulation variant : **varient 1**

Main system parameters	System type	**Stand alone system with batteries**		
PV Field Orientation	tilt	26°	azimuth	0°
PV modules	Model	EST-500	Pnom	500 Wp
PV Array	Nb. of modules	504	Pnom total	**252 kWp**
Battery	Model	AcmeG 12V 200	Technology	Lead-acid, sealed, Gel
Battery Pack	Nb. of units	800	Voltage / Capacity	**240 V / 8000 Ah**
User's needs	Daily household consumers	Constant over the year	Global	301 MWh/year

Loss diagram over the whole year

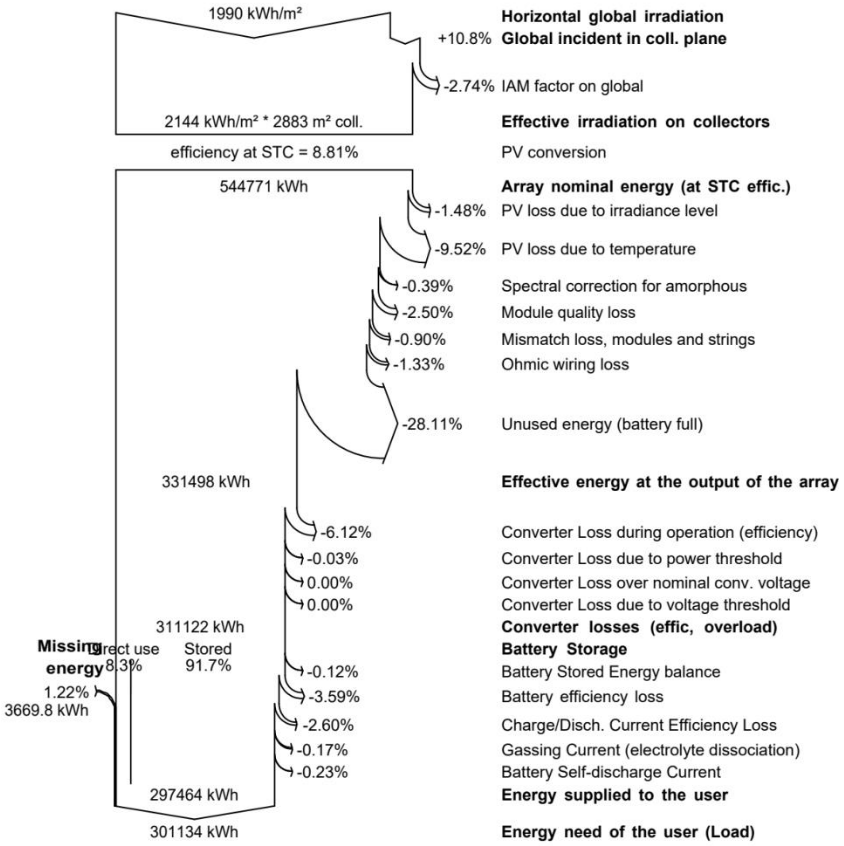


Figure 42:Off-grid report

6) bus line of Tulkarm :

BUS	Transformers number	KV	Terminal Voltage (KV)	Operating Percentage (%)
Bus02	مسجد القبسي	0.4	0.409	102.25
Bus10	اكتابا	0.4	0.406	101.5
Bus14	بئر الحمد لله	0.4	0.414	103.5
Bus17	اكتابا القديمة	0.4	0.410	102.5
Bus29	نور شمس	0.4	0.405	101.25
Bus32	الإسلامية ٢	0.4	0.416	104
Bus36	بئر البجاع	0.4	0.410	102.5
Bus38	مرطبلا النور	0.4	0.420	105
Bus50	الإسلامية ١	0.4	0.409	102.25
Bus65	المحاكم	0.4	0.416	104
Bus66	زيد برهم	0.4	0.414	103.5
Bus69	بئر فزمل	0.4	0.409	102.25
Bus72	الاسكان	0.4	0.411	102.75
Bus73	جامعة القدس المفتوحة	0.4	0.405	101.25
Bus74	KFC 1	0.4	0.407	101.75
Bus75	KFC 2	0.4	0.403	100.75
Bus76	مسجد الروضة	0.4	0.411	102.75
Bus77	بنك القدس	0.4	0.412	103
Bus78	مجمع الأشقر	0.4	0.414	103.5
Bus79	بئر رقم ٣	0.4	0.409	102.25
Bus80	أبو يونس	0.4	0.411	102.75
Bus108	مول اليوجي	0.4	0.412	103
Bus110	مكسي الزين	0.4	0.409	102.25
Bus126	بئر أبو صالح	0.4	0.415	103.75
Bus137	إسكان الرحمة	0.4	0.410	102.5
Bus168	بئر أبو ربحي	0.4	0.411	102.75
Bus174	مخمر الموز	0.4	0.409	102.25
Bus178	مسجد الككروري	0.4	0.412	103
Bus188	مفرق الجعرون	0.4	0.411	102.75
Bus198	منجرة الجعرون	0.4	0.402	100.5
Bus199	دكان أبو صالح	0.4	0.409	102.25
Bus200	بئر ملعب شويكة	0.4	0.412	103
Bus201	بئر أبو منهل	0.4	0.413	103.25
Bus202	ظهرة إكباريه	0.4	0.410	102.5
Bus203	البرق الجديد	0.4	0.414	103.5
Bus204	البرق القديم	0.4	0.410	102.5
Bus205	حي المهداوي	0.4	0.411	102.75
Bus206	المنساوي ١	0.4	0.414	103.5
Bus207	المنساوي ٢	0.4	0.409	102.25
Bus208	جمعية شويكة	0.4	0.406	101.5
Bus209	بئر وادي الشام	0.4	0.408	102
Bus210	المقاطعة	0.4	0.403	100.75
Bus211	المحافظة	0.4	0.409	102.25
Bus212	الشاهد ١	0.4	0.408	102
Bus213	الشاهد ٢	0.4	0.407	101.75
Bus214	أبو حبيب	0.4	0.412	103
Bus215	الناج	0.4	0.413	103.25
Bus216	الامن الوطني	0.4	0.414	103.5
Bus217	دعباس	0.4	0.412	103
Bus218	جوال	0.4	0.412	103
Bus219	المستشفى ٢	0.4	0.408	102
Bus220	المستشفى ١	0.4	0.408	102
Bus221	بنك فلسطين	0.4	0.409	102.25
Bus222	البنك العربي	0.4	0.409	102.25
Bus223	المتحف	0.4	0.399	99.75
Bus224	بنك القاهرة عمان	0.4	0.409	102.25
Bus225	دوار شويكة	0.4	0.413	103.25

BUS	Transformers number	KV	Terminal Voltage (KV)	Operating Percentage (%)
Bus226	خضوري ١	0.4	0.417	104.25
Bus227	دوار خضوري	0.4	0.414	103.5
Bus228	خضوري ٢	0.4	0.414	103.5
Bus229	بئر رقم ١	0.4	0.417	104.25
Bus230	دوار جمال عبد الناصر ٢	0.4	0.414	103.5
Bus231	دوار جمال عبد الناصر ١	0.4	0.414	103.5
Bus232	بئر رقم ٢	0.4	0.413	103.25
Bus233	الصاروخ	0.4	0.415	103.75
Bus234	هواش	0.4	0.418	104.5
Bus235	عمارة الراي	0.4	0.417	104.25
Bus236	ارتاح الغربي	0.4	0.415	103.75
Bus237	العاصي	0.4	0.417	104.25
Bus238	برك المجاري	0.4	0.416	104
Bus239	المدينة الصناعية	0.4	0.417	104.25
Bus240	بئر أبو حنين	0.4	0.414	103.5
Bus241	ورشة الميكانيك	0.4	0.411	102.75
Bus242	اليوجي	0.4	0.410	102.5
Bus243	عمارة السيلاوي	0.4	0.412	103
Bus244	دوار المقبرة	0.4	0.409	102.25
Bus245	الصباح	0.4	0.408	102
Bus246	ثابت ثابت	0.4	0.414	103.5
Bus247	الدلهوم	0.4	0.408	102
Bus248	مستشفى الزكاة	0.4	0.413	103.25
Bus249	المحطة	0.4	0.408	102
Bus250	مفرق الكربية	0.4	0.410	102.5
Bus251	ديوان الجلاد	0.4	0.411	102.75
Bus252	المخبز الفرنسي	0.4	0.403	100.75
Bus253	دوار السلام	0.4	0.407	101.75
Bus254	مصنع العصير	0.4	0.409	102.25
Bus255	أبو درنة	0.4	0.411	102.75
Bus256	كفا	0.4	0.410	102.5
Bus257	عزبة شوفة	0.4	0.404	101
Bus258	مفرق فرعون	0.4	0.406	101.5
Bus259	بئر عطير	0.4	0.410	102.5
Bus260	الشويكي	0.4	0.409	102.25
Bus261	عزبة ناصر	0.4	0.406	101.5
Bus262	مخبز البرغوثي	0.4	0.408	102
Bus263	بئر عرب	0.4	0.408	102
Bus264	بئر سقط	0.4	0.401	100.25
Bus265	فراز مول	0.4	0.408	102
Bus266	المسلخ	0.4	0.406	101.5
Bus267	مصعب بن عمير	0.4	0.403	100.75
Bus268	المغاورات	0.4	0.399	99.75
Bus269	عزبة الجراد	0.4	0.405	101.25
Bus270	انشراح الندو	0.4	0.399	99.75
Bus271	أبو صفية	0.4	0.402	100.5
Bus272	البالونة	0.4	0.398	99.5
Bus273	الفردوس	0.4	0.393	98.25
Bus274	وكالة ١	0.4	0.396	99
Bus275	وكالة ٢	0.4	0.395	98.75
Bus276	وكالة ٣	0.4	0.395	98.75
Bus277	بئر رقم ٥	0.4	0.399	99.75
Bus278	أبو ساهر	0.4	0.398	99.5
Bus279	الحرباوي	0.4	0.401	100.25
Bus280	روكانا	0.4	0.402	100.5
Bus281	الشرعب	0.4	0.401	100.25
Bus282	سان موريس	0.4	0.402	100.5
Bus283	الطنة	0.4	0.402	100.5
Bus284	دائرة السير	0.4	0.399	99.75
Bus285	منشار نور	0.4	0.403	100.75

Figure 43: bus line of Tulkarm