An-Najah National University

Faculty of Graduate studies

Technical and Economical Impact of using (on-grid) PV System on the roof top of Civil Defense Centers in West Bank

By

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Supervisor

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This Thesis is Submitted in Partial Fulfillment of the Requirements for the Degree of Master in Clean Energy and Conservation Strategy Engineering, Faculty of Graduate Studies, An-Najah National University, Nablus – Palestine.

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This Thesis was Defended Successfully on 20/2/2019 and approved by:

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2. Dr. Basim Alsyed	**/ External Examiner**	....
3. Dr. Marwan Mahmoud	**/ Internal Examiner**	....

Dedication

To Palestine

To my parents Nabhan & Lubna

To my husband Ihssan

To my sons Yaman and Raha

To my husband's family

To my sisters Tina and Anood

To my brother Ahmad

To my friends

To my colleagues

To my teachers

To everyone who works in this field

To all of them

I dedicate this work

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Acknowledgement

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I would like to express my special thanks and appreciation to my Dr. Imad Ibrik for his continuous support, guidance and encouragement during this work.

I would like to thank also the Energy Research Center and the staff of the Clean Energy and Conservation Strategies Master Program at An-Najah National University.

الإقرار

أنا الموقع أدناه، مقدم الرسالة التي تحمل العنوان:

Technical and Economical Impact of using (on-grid) PV System on the roof top of Civil Defense Centers in West Bank

أقر بأن ما شملت عليه هذه الرسالة إنّما هو نتاج جهدي الخاص، باستثناء ما تمّت الإشارة إليه حيثما ورد، وأنّ هذه الرسالة ككل، أو أيّ جزء منها لم يقدّم من قبل لنيل أيّ درجة أو لقب علميّ لدى أيّ مؤسسة تعليمية أو بحثية أخرى.

Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's Name: **اسم الطالب:**

Signature: **التوقيع:**

Date: **التاريخ:**

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Abbreviations

PV	Photovoltaic
COE	Cost of Energy
Km^2	Kilo Meter Squire
WB	West Bank
m	Meter
km	Kilo Meter
DNI	Direct Normal Irradiation
CST	Concentrated Solar Technologies
CSP	Concentrated Solar Thermal Plant
m^2	Meter squire
GHI	Global Horizontal Irradiation
DIF	Diffused Horizontal Irradiance
Z	Zenith Angle
GTI	Global Tilted Irradiation
CPV	Concentrated Photovoltaic
kWh	Kilo Watt Hour
ERC	Energy Research Center
HOMER	Hybrid Optimization Model for Electric Renewables
mm	Millimeter
P	Power
V	Voltage
I	Current
C	Celsius
V_{oc}	Open Circuit Voltage
I_{sc}	Short Circuit Current
W	Watt
C.D	Civil Defense
C.D.C	Civil Defense Centers

NEPA	National Fire Protection Association
kW	Kilo Watt
Div. F	Diversity Factor
a_w	Surface Azimuth Angle
a_s	Solar Azimuth Angle
a	Solar Altitude Angle
yrs	Years
kW_p	Kilo Watt Peak
PSI	Palestinian Solar Initiatives
PERC	Palestinian Electricity Regulatory Council
NM	Net Metering
RE	Renewable Energy
DISCO	Distribution Company
DC	Direct Current
AC	Alternative Current
W_p	Watt Peak
Ah	Ampere Hour
c-si	Crystalline Silicon
PR	Performance Ratio
STC	Standard Test Conditions
O&M	Operation and Maintenance
GHG	Green House Gaze
DPG	Distributed Power Generation
KVA	Kilo Volt Ampere
MPPT	Maximum Power Point Tracking
PBP	Payback Period
$	Dollar = 3.5 IL
IL	Israeli Shekel
LCC	Life Cycle Cost
P	Present Worth
S	Salvage Value

Aw	Annual Worth
F	Future Worth
PH	Peak Hour
LCOE	Levelized Cost of Energy
CO_2	Carbon Dioxide
Kg	Kilogram

Technical and Economical Impact of using (on-grid) PV System on the roof top of Civil Defense Centers in West Bank.

By

Eng. Tala Nabhan Abdel-Razaq Jallad

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Abstract

Palestine is a region that constantly suffers from political and economic instability, because of the Israeli occupation and the emergence of continuous power cutout problem in all West Bank governorates. Considering the increase of electrical loads on the networks and the important and vital role played by the Civil Defense Service centers in providing services to citizens and high consumption of electricity, that required an alternative energy system to generate electricity, through using solar photovoltaic cells, due to their efficiency and being environmentally friendly projects that reduce pollution.

This thesis aimed at using solar cell systems for the Palestinian Civil Defense Service centers and analyzing the technical and economic impact of using solar energy in the centers and its effect on reducing the electricity bills of the Palestinian Civil Defense Service centers which range between (350-1100) IL monthly through optimal usage of electricity during the day especially at peak time and choosing the best option for electricity supply each scenario, by clarifying the potential of solar energy in Palestine and the intensity of solar radiation and all relevant solar data in Palestine and to

clarify the consumption of Palestinian Civil Defense Service centers and description of the curves of the electric load of most of the Palestinian Civil Defense Service centers, and some special cases which represented as Tubas, Ram and Anabta required for this study, as well as the analysis of the optimal distribution of energy resources in the centers using special programs to improve the energy cost in the West Bank centers.

As a result of the study due to the current high trade tariffs and the quality of solar energy in Palestine, as well as the recent Palestinian laws and directives governing renewable energy projects, we are instructed to think more about using net measurement instructions to cover civil defense centers. Civil defense ranges from (19.2 to 38.4) kWp per year, thus saving between (22,100 - 43,000) IL per year for invoices and for periods of up to 4 years, the cost of projects can be recovered.

In addition to reducing the manifestations of pollution according to civil defense centers. The annual generation of solar cells (28.91 MWh / yr - 57.82 MWh / yr), which will typically save in carbon dioxide amount of (17,346 tons - 57.82 tons) per year.

Introduction

Palestine is totally reliant on importing energy from the neighboring countries so the political situation plays the main factor in development any sector regarding the energy sector, that making the electricity and fuels main problems for Palestinian Authority. Therefore, the need of alternative energy sources is an important issue to meet the growth in the energy demand and avoid building new power plants with a high cost as well as to reduce the sensitivity to political and economic crisis and to reduce the negative effects of non-renewable energy. Using the available renewable energy sources in Palestine, such as solar, wind and biomass, could replace more than 36 % of the current Palestinian electricity demand [1], [2].

Most of the electrical generation and distribution companies in Palestine would benefit from having no electrical overload especially at peak demand during the day, so the electrical distribution companies in Palestine may impose different electrical tariffs during the day such as time of use tariff system in order to maintain the system stable and to reduce the peak demand all times as much as possible by using several conservation strategies and managements , for example we can notice some changes in tariff value also the electrical bills during the day and varies according to the type of the facilities or some small solar power plant to cover good values of loads, so that will lead the consumers to try to conserve their electrical consumption , as well as the distribution of their use of electricity to reduce the peak demand during the day, helping them to reduce their electricity bills[3]. As a result; the electrical distribution companies don't need to purchase a large ratings of power to meet the consumers need and the outages or shortage of power because of the maximum demand and the occurrence of another problems .The lack of knowledge and experiences in the methods of energy conservation cause a problems in the high value bills and multiple problems. [4]

Some studies have resolved these problems through the system would be called “grid-connected PV system.” Recently, grid-connected PV system installation is increasing tremendously in many countries. Around 75% of the total PV systems installed in the world are grid-connected [5] in the future; this penetration rate will become larger because of the economic advantages of these types of renewable energy systems.

This thesis will analyze the technical and economic impacts of using (ON –GRID) PV systems on the roof top of Civil Defense Centers. There are 47 civil defense center distributed in the various governorates in the West Bank ,The emergence of the problem of constant power outages in all governorates of the West Bank, because of the increasing in electrical loads on networks and high consumption of electricity in the centers and high electricity bill , had to be a search for an alternative energy system to generate electricity by using (ON-GRID) PV systems on the roof top of centers due to their efficiency and protection aspects.

Problem Statement

1- Lake of supply, in all cities and villages in West Bank in fact Palestine is one of the areas which suffer from lack of political and economic stability.

2-High cost of energy consumption, leading to a rise in electricity bills in all different countries.

Objectives

The main objectives of this thesis are:

1. Analyzing the Techno-economic impacts of using solar energy in centers.

2. Reducing the electricity bill for the civil defense centers as much as possible through the optimal use of electricity during the day and especially at the peak time and choosing the best option for electrical supply in each scenario.

3. Analyzing the results of optimum distribution of energy resources in the centers by using special software programs.

4. Analyzing different options for optimizing the cost of energy in centers in West Bank.

Thesis Structure

The thesis work has been summarized in five chapters.

Chapter One: Potential of Solar Energy in Palestine.

This chapter illustrates the potential of solar energy in Palestine, the intensity of solar radiation, the number of sunshine hours and all related solar data in our country.

Chapter Two: Introduction of Consumption in Civil Defense Centers.

This chapter illustrates and describes the electrical load curves and the electrical behaviors for most of civil defense centers in Palestine and some of specified centers needed to our study as special cases.

Chapter Three: Elements of PV System and Modeling.

This chapter illustrates and describes how to select the elements of PV systems needed to use for the specified centers.

Chapter Four: Design and Impact of PV System Installations in Civil Defense Centers.

This chapter illustrates the modeling of the PV systems and all economical and technical results, effects and impacts of these systems.

Chapter Five: Economical and Environmental Impact of PV System Installations in Civil Defense Centers.

This chapter illustrates the economic impact of using the PV systems on the COE and the environmental effects and impacts of these systems.

Chapter Five: Results, Conclusion and Recommendation.

This chapter describes the research results, conclusion, recommendations and the future scope of the work.

Chapter One

Potential of Solar Energy in Palestine

1.1 Geographical Context of Palestine

Palestine is a special place located on the Mediterranean basin and it is encircled by Jordan and Syria in the east and Lebanon in the north as shown in figure (1.1), which the country of Palestine full of Muslims, Christians, and Jews as well that make this ideal position a commercial transactions between the country and the neighbouring areas. Because Palestine is occupied land until now; the Palestinian territories are located in the geographical region between Mediterranean Sea and Jordan River, which they comprise the West Bank and Gaza Strip at latitude angle equal to 31 and 33degrees and longitude 34 and 36 degrees[6]. The Palestine geographical maps indicate the climate conditions and the heterogeneous topography of the country. Spread over the total area of 27,000 km^2 [7] and about 6,220km^2 for the Palestinian Territories [6].

Figure (1.1): Palestinian territories in the region. [6]

As shown in figure (1.1); there are two separates Palestinian territories (West Bank and Gaza) which are divided altogether into 16 governorates. Gaza strip is divided into 5 relatively small governorates and the other governorates related to the West Bank equal to 11 governorates [6]. Figure (1.2) shows the administrative division of the Palestinian territories.

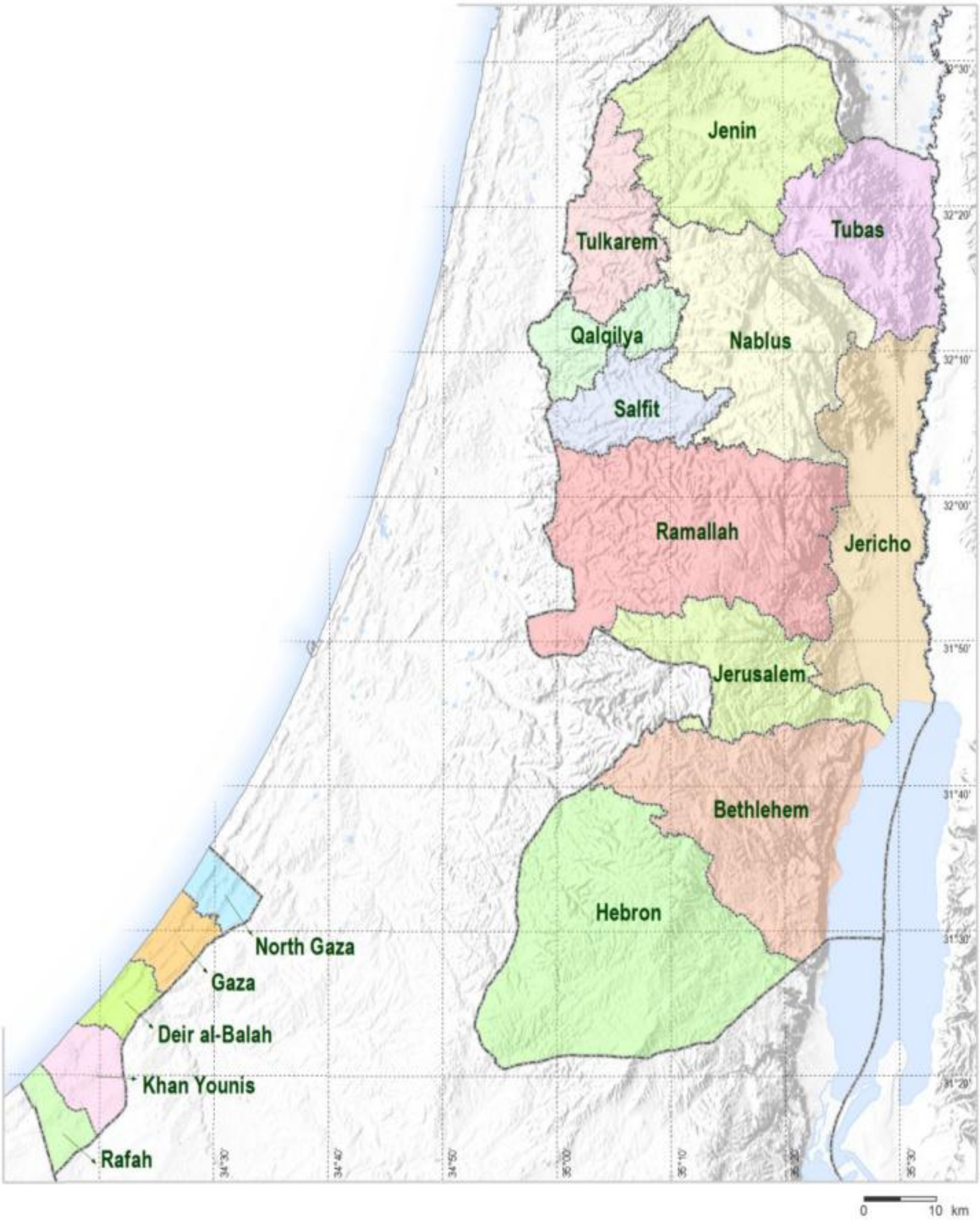

Figure (1.2): Administrative division of the Palestinian territories. [6]

Palestine territories have a Mediterranean climate with hot, long, rainless summers and short, cool, rainy winters. The climate is as such due to the location between the aridity of the Sahara and the Arabian deserts, and the subtropical humidity of the Eastern Mediterranean, in which the climate varies from location to another depending on the altitude and the proximity to the Mediterranean, so the coastal areas such as Gaza Strip has humid and hot weather during summer but mild and moderate winter season. In the hilly areas of the West Bank the weather is cold during winter season but mild at summer season. Figure (1.3) illustrates the terrain of the Palestinian territories. [6]

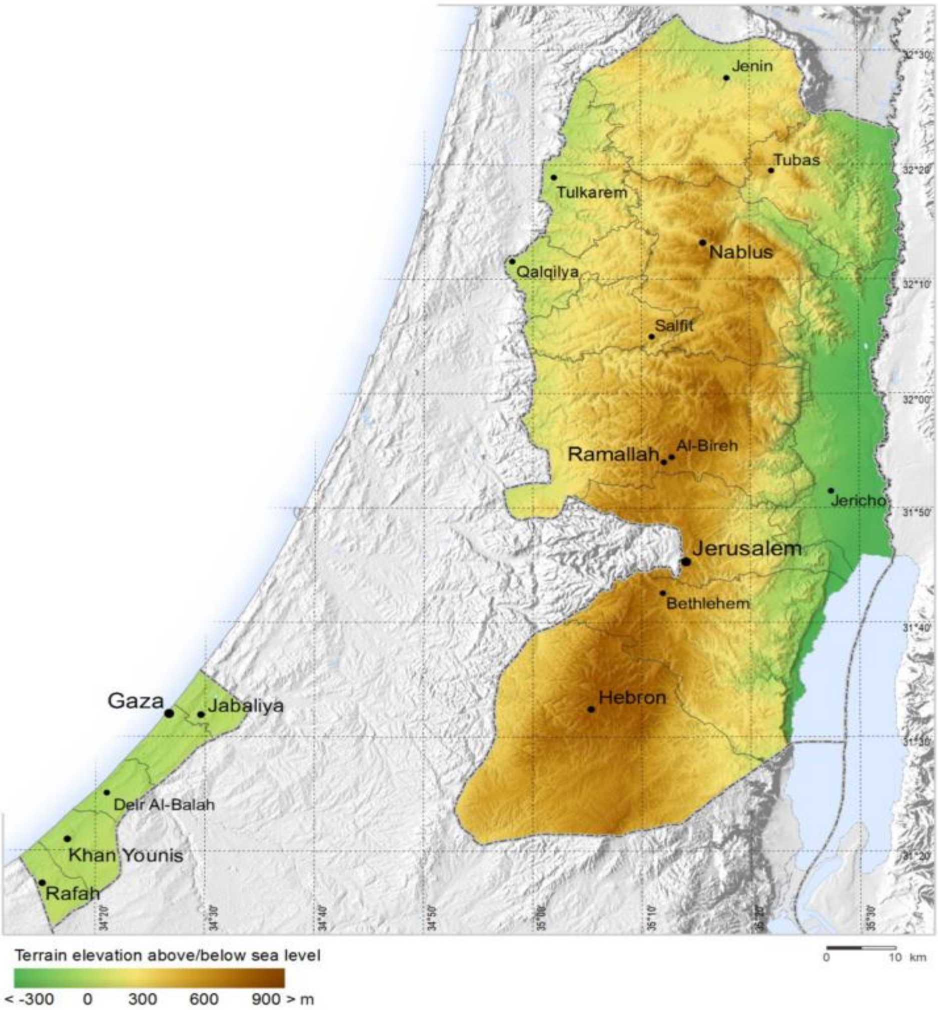

Figure (1.3): Terrain elevation of the Palestinian territories. [6]

According to the figure (1.3); the Palestinian territories can be divided into 5 terrain regions as following: [6]

1. Jordan Valley region, stretching in the south from the WB of the river to the far north of the Dead Sea, which the altitude varies between 200-300 m below the sea level to about 100-200 m above the sea level.

2. Eastern hills, stretching along the eastern part of the WB, which the altitude varies between 200-800 m above the sea level.

3. Central Highlands is the highest area in the WB that stretching over 120 km from Hebron in the South to Tubas in the North.

4. Western West Bank, that covering the other districts if Jenin and Tulkarm. Border region is about 60 km long and 1-3 km wide and the altitude is 100-300 m above the sea level.

5. Gaza Strip is predominantly flat, with dunes near the coast, which the highest point has 105 m above the sea level.

1.2 Solar Resources of Palestine

This section highlights three basic concepts that show the regional differences of basic solar parameters. Firstly, **Direct Normal Irradiation** (DNI) which it is a particular relevance to concentrated solar technologies (CST), including concentrating solar thermal plants (CSP) and concentrated photovoltaic (CPV) that the direct irradiance received on a plane normal to the sun rays also it is the radiant flux collected by a 1-m^2 surface normal to the direction of the Sun, within the extent of the solar disk only [8].

Secondly, **Global Horizontal Irradiation** (GHI) is the climate reference of a site that also known as Global Solar Radiation, which it is the total amount of the direct and diffuse solar radiation as calculated using the following formula:

$$GHI = DNI * \cos(Z) + DIF \quad (1.1)$$

Where:

GHI = Global Horizontal Irradiance (kWh/m^2).

DNI = Direct Normal Irradiance (kWh/m^2).

DIF = Diffuse Horizontal Irradiance (kWh/m^2).

(Z) = Zenith Angle (^{o}).

The GHI is measured by the total of direct and scattered radiation being received on a commonly horizontal surface as seen in figure (1.4) [9].

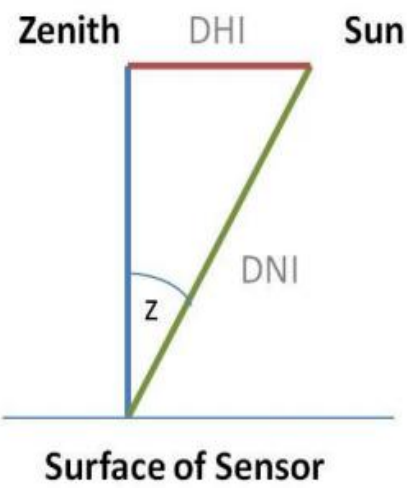

Figure (1.4): Global horizontal irradiation formula.

Thirdly, **Global Tilted Irradiation** (GTI) represents the sum of the diffuse and the direct solar radiation that falling at the surface of the PV modules [6], where **Direct radiation** is also sometimes called "beam radiation" or "direct beam radiation that used to describe solar radiation traveling on a straight line from the sun down to the surface of the earth. On the other hand the **Diffused radiation**, describes the sunlight that has been scattered by molecules and particles in the atmosphere but that has still made it down to the surface of the earth[10]. Notice figure (1.5).

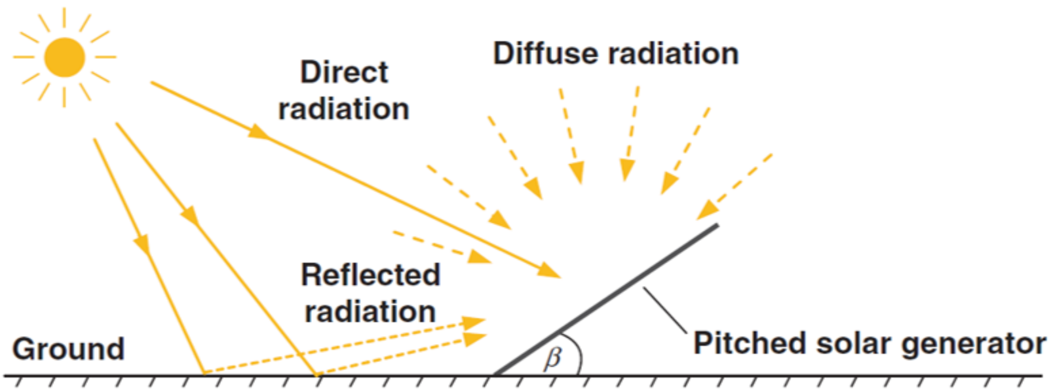

Figure (1.5): Direct and diffused radiation.

1.2.1 Global Horizontal Irradiation

The highest GHI is identified in Gaza region and also in the southern and central hilly parts of the WB, where the annual recorded values reached up to 2100 kWh/m^2, where the sunny season lasts relatively long (from April to September) [6]. Notice figure (1.6).

The less stable weather is from November to May, where the highest variability of GHI between sites, is illustrated from January to April. The international variability of GHI for selected representative sites is calculated from the unbiased standard deviation of GHI over 20 years and considering the long-term, normal distribution of the annual sums, where all locations illustrate similar patterns of GHI changes over recorded period, so the most stable GHI values or the smallest interannual variability are observed and noticed in Jericho [6].

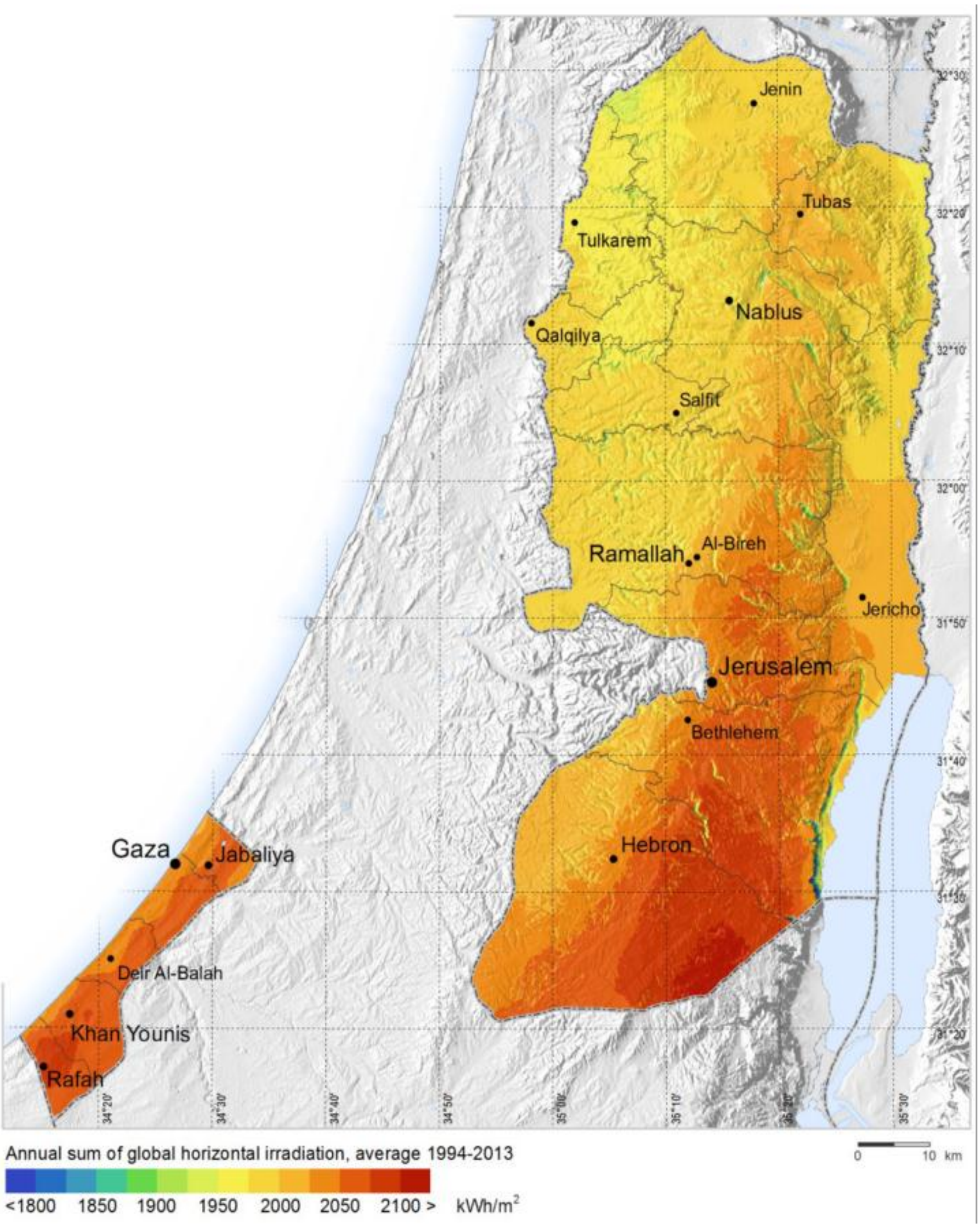

Figure (1.6): Global Horizontal Irradiation – long term yearly average. [6]

The variability in the in the yearly averages of GHI is only1.5%, while the monthly averages have differences ranging from 1.1% in May to 5.2% in February, which the small variability of values caused by similar geographical characteristics [6].

1.2.2 Ratio of Diffuse and Global Irradiation

During winter season from October to April all sites show approximately stable values, while relatively high DIF / GHI ratio, so this illustrates and indicates higher occurrences of clouds, aerosols and water vapour, where the best conditions with clear sky and low aerosols typically occur during summer season from May to September, when the DIF/GHI ratio is reduced approximately to half in this period is shorter and DIF/GHI ratio is not constant also this is not very good potential for installation of the CSP and CPV. Notice table (1.1) [6].

Table (1.1): Monthly Averages Ratio of Diffused to Global Horizontal Irradiation. [6]

Month	Gaza	Hebron	Jericho	Nablus	Ramallah
January	40.2	39.9	42.8	43.0	41.2
February	39.1	39.8	41.6	44.3	42.0
March	36.9	36.9	39.9	41.0	39.0
April	36.1	36.0	40.6	39.5	37.5
May	30.4	27.9	32.8	30.6	28.9
June	24.2	20.1	25.0	23.3	21.4
July	26.0	21.3	26.4	24.9	22.7
August	27.2	22.7	29.1	26.6	24.1
September	29.4	26.5	32.8	30.2	28.3
October	36.8	34.6	41.0	38.7	35.9
November	36.7	34.6	40.8	37.6	35.4
December	37.2	35.8	40.5	39.2	37.1
Year	**31.7**	**29.1**	**34.1**	**32.6**	**30.5**

According to table (1.1); the best conditions can be at the lowest DIF/GHI ratio in Hebron and Ramallah, while the higher ratio is noticed in Jericho. Figure (1.9) illustrates the ratio of the long-term averages of Diffused Horizontal Irradiation (DIF) to Global Horizontal Irradiation (GHI) for each specified location monthly.

According to the last table (1.1); the higher values of DIF/GHI ratio represent the following:

1. Less stable weather.

2. Higher occurrence of clouds or higher atmospheric pollution or weather vapour. Notice figure (1.7).

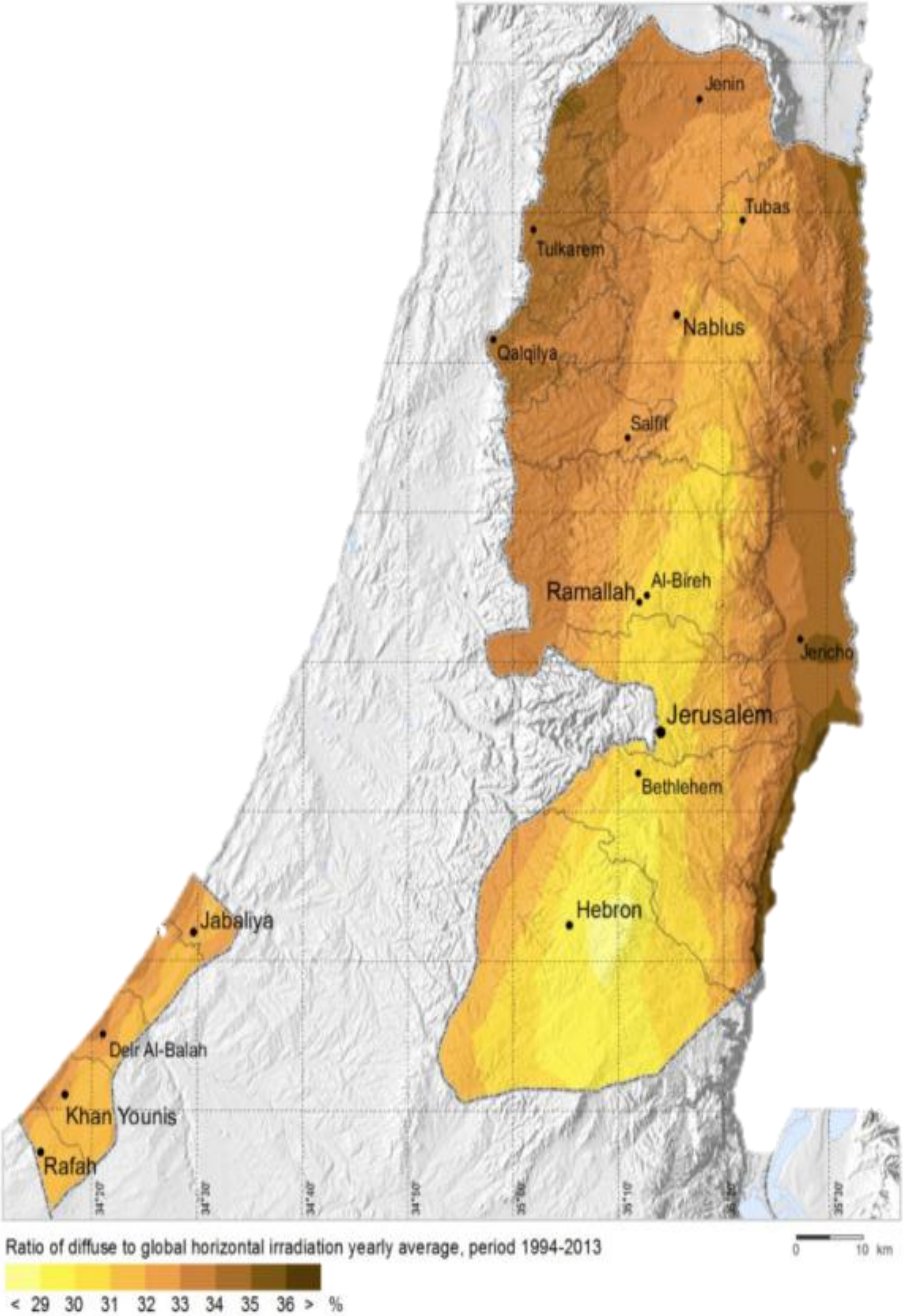

Figure (1.7): Ratio of Diffused to Global Horizontal Irradiation – long-term yearly average. [6]

1.2.3 Global Tilted Irradiation

The Global Tilt Irradiation (GTI) shows the global irradiation that falls on a specified tilted surface in order to maximize the yearly PV production [11], where the highest electricity gains from the tilted PV modules can be noticed when these modules are oriented and fixed at optimum angle by depending on the orientations and the locations of these sites [6]. Figure (1.8) shows the gain of annual GTI relative to GHI.

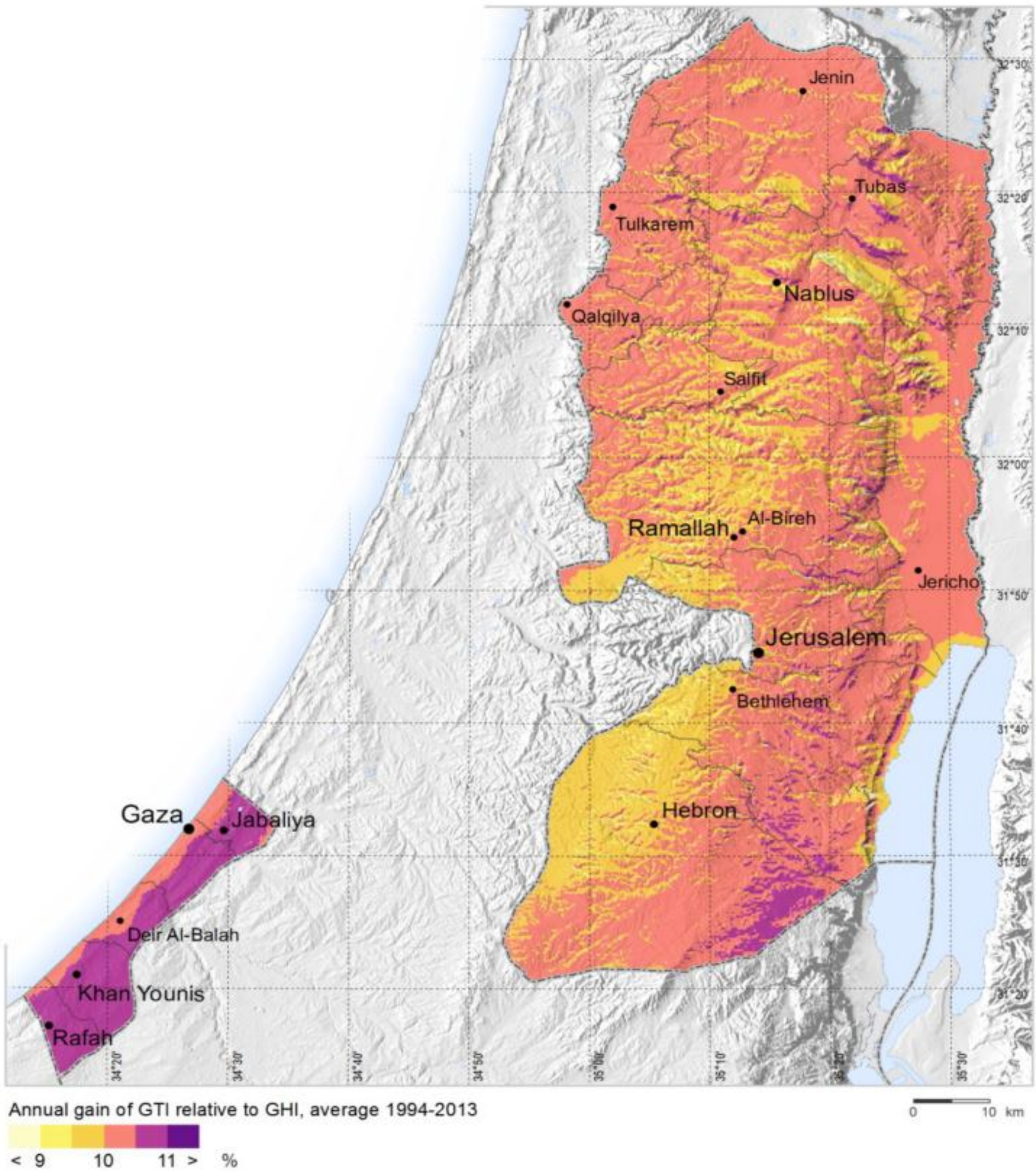

Figure (1.8): The gain of annual GTI relative to GHI. [6]

For the Palestinian territories; the optimum tilt angle is 27^o to 28^o in the WB but for Gaza strip the optimum angle is 26^o to 27^o. The difference by few degrees has usually no effects or impacts on the yearly GTI, so the optimum tilt angle for the Palestinian territories is assumed to be 27^o[6]. Figure (1.9) illustrates the annual sum of global irradiation for a surface tilted at angle equal to 27^o.

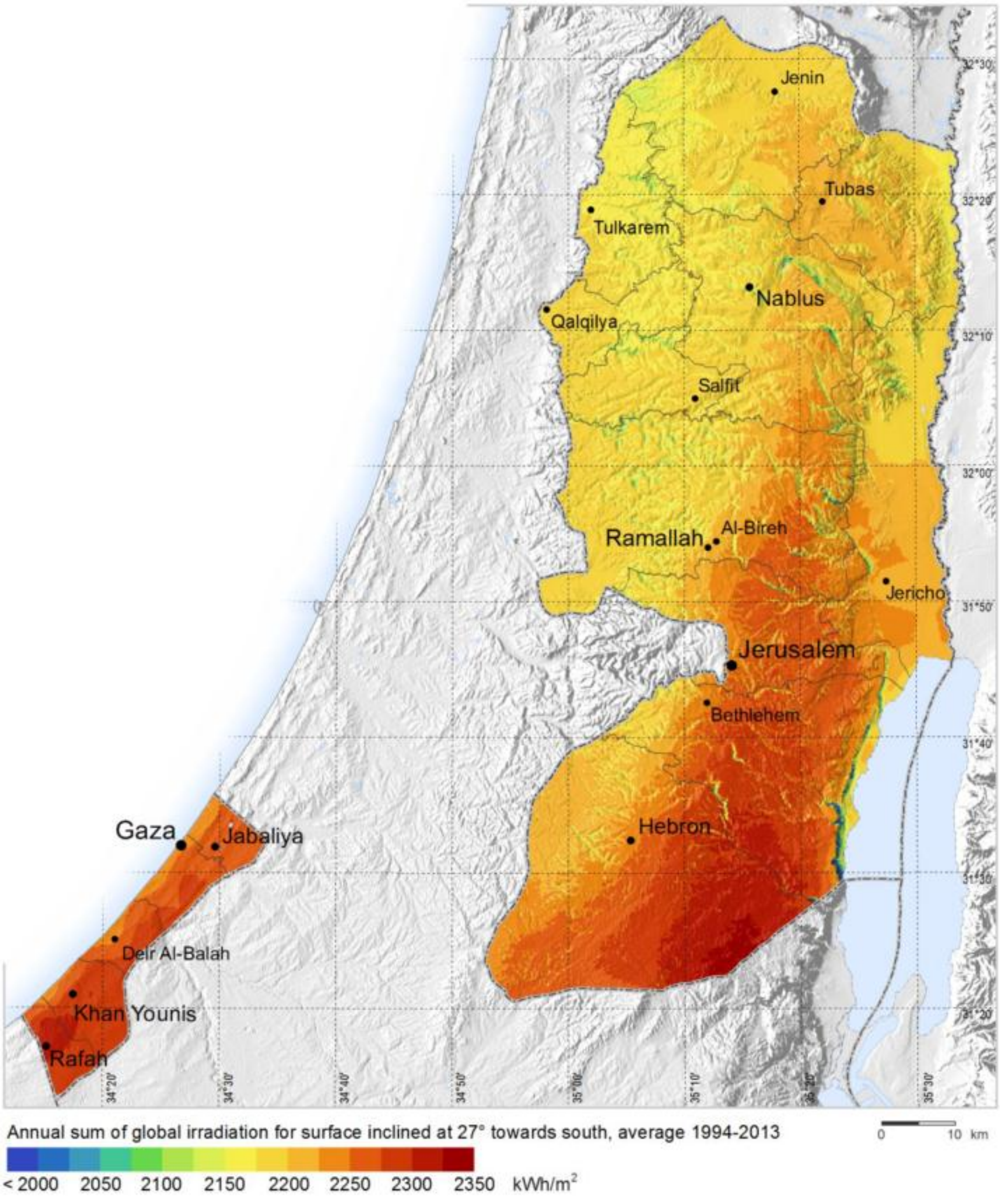

Figure (1.9): Global Tilted Irradiation (GTI) at 27^o. [6]

1.2.4 Direct Normal Irradiation

Direct Normal Irradiation (DNI) parameter is crucial for the concentrated solar technologies, where the highest values are concentrated in the southern parts of the WB and the lowest values are concentrated in Gaza because of the influencing by the presence of the aerosols in the ambient or the atmosphere. The comparison of the monthly values of DNI is shown in figure (1.10). [6]

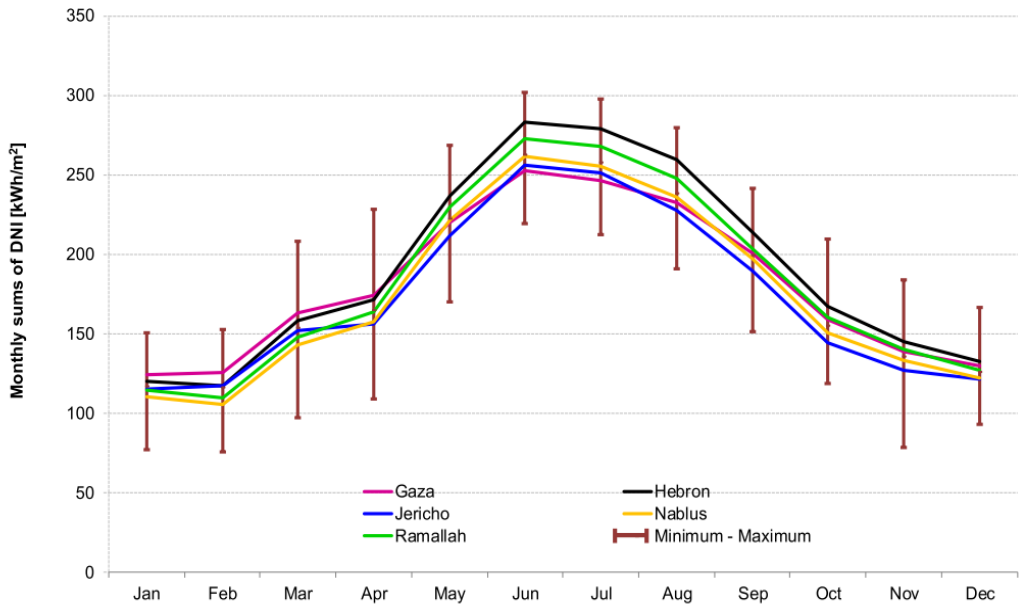

Figure (1.10): Monthly averages of DNI at selected areas. [6]

According to figure (1.10); the less stable DNI conditions are from October to April and as noticed the highest value of DNI is reached in Hebron. Figure (1.11) shows the international variability of DNI for selected representative sites over 20 years and considering the long-term, normal distribution of the annual sums.

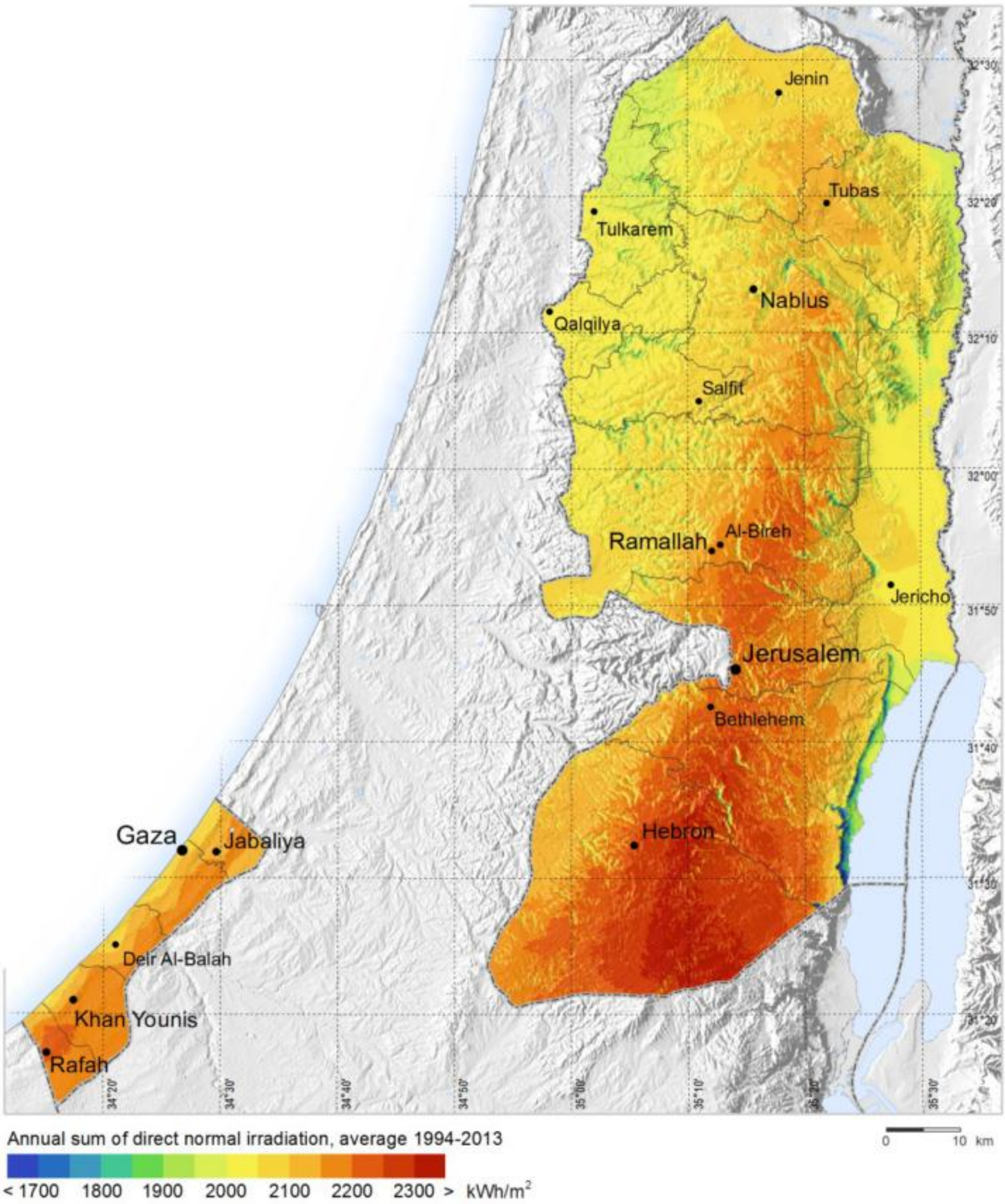

Figure (1.11): DNI- long-term yearly average. [6]

1.2.5 Average Solar Energy

In the Palestinian territories, the lowest solar energy average is in January which amounts to about 2.47kWh/m²-day, while the highest value is in June, with amounts equal to 6.93kWh/m²-day. Table (1.2) and figure (1.12) show the average monthly solar energy on horizontal surface for Salfeet district in 2011, which these data were measured by the ERC of An-Najah University. These measures are very suitable for PV system to generate electricity [12].

Table (1.2): Average Monthly Solar Energy on Horizontal Surface for Salfeet District – 2011. [12]

Month	(kWh/m2-day)
January	2.47
February	2.82
March	4.17
April	4.88
May	5.85
June	6.93
July	6.62
August	6.04
September	5.11
October	4.11
November	3.41
December	3.24

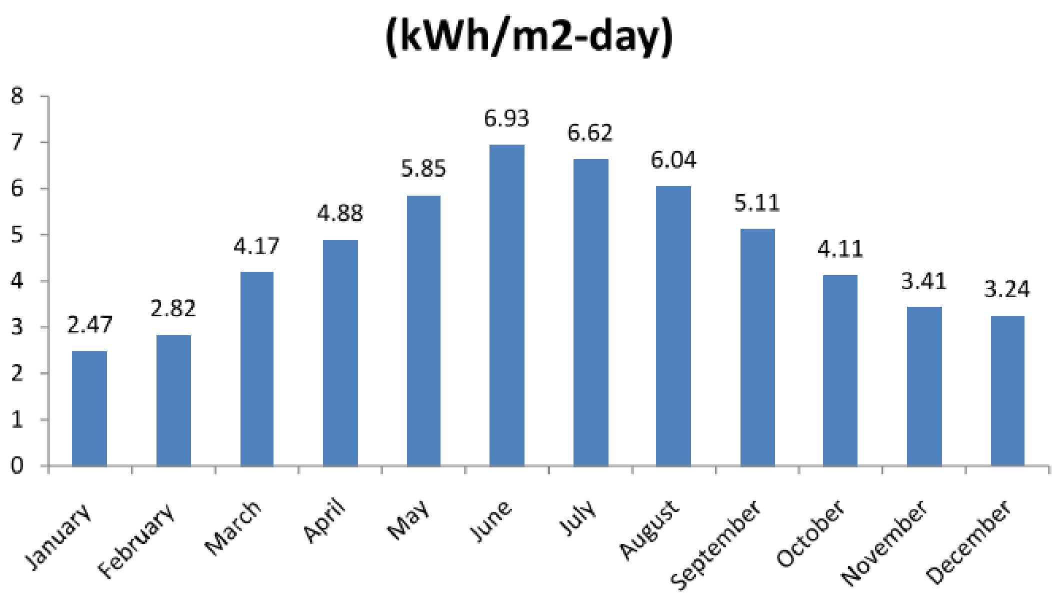

Figure (1.12): Average monthly solar energy on horizontal surface for Salfeet district – 2011. [12]

According to the last table the average is equal to 4.64 kWh/m^2 – day as well as this number can get it with approximate value by using HOMER program, so the scaled annual average of the daily radiation for the Tulkarm city for example with a latitude equal to 32^o and longitude equal to 35^o is 5.45 kWh /m^2 / day. Notice figure (1.13).

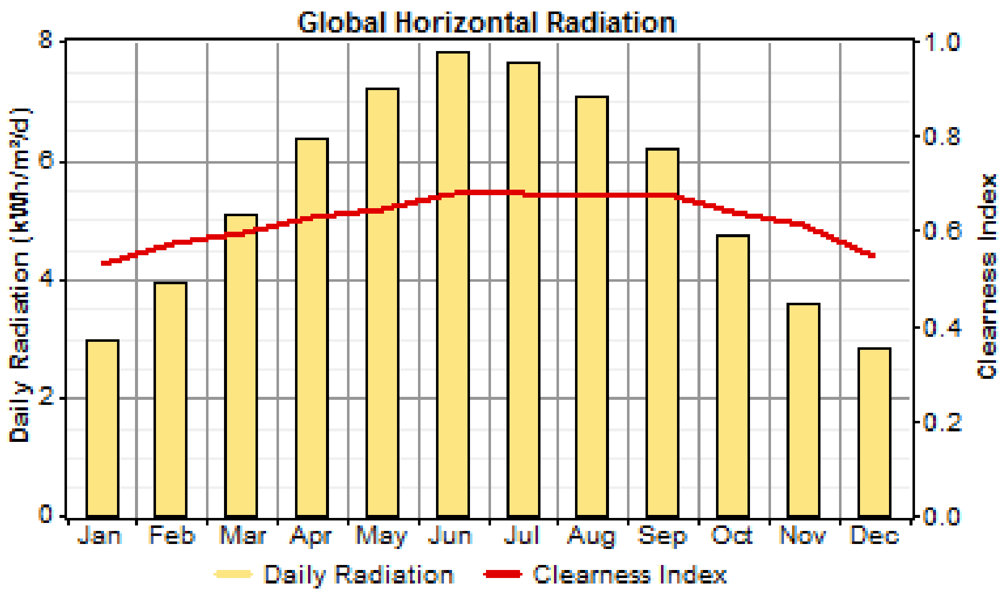

Figure (1.13): Daily radiation curve by HOMER program.

1.3 Climate of Palestine

Palestinian territories have Mediterranean climate, with some variations given by different topography, the whole area is characterized in general with hot, long and dry summer, but with cool, short and rainy winter, where the rainfall season begin from November to February to cover the most of the territories. In Gaza Strip typical the weather pattern is characterized with hot, dry and sunny summers with virtually no rain, so the annual rainfall in Gaza Strip is about 100-400 mm, while for the West Bank; the land having a rainfall less than 500 mm per year [6].

The PV technology works the most effectively at mild and cooler air temperature and stable sunny weather, but the extremely high air temperature and intermittent weather pattern reduces slightly the power output (lower performance ratio) [6].

1.3.1 Air Temperature

In case of PV power plants, air temperature determines energy conversion efficiency in the PV modules, and it also influences the other components and elements such as inverters, transformers, etc., while increasing the air temperature has negative effects and impacts on the performance of PV systems [6]. Figure (1.14) illustrates the air temperature of the Palestinian territories at 2 meters.

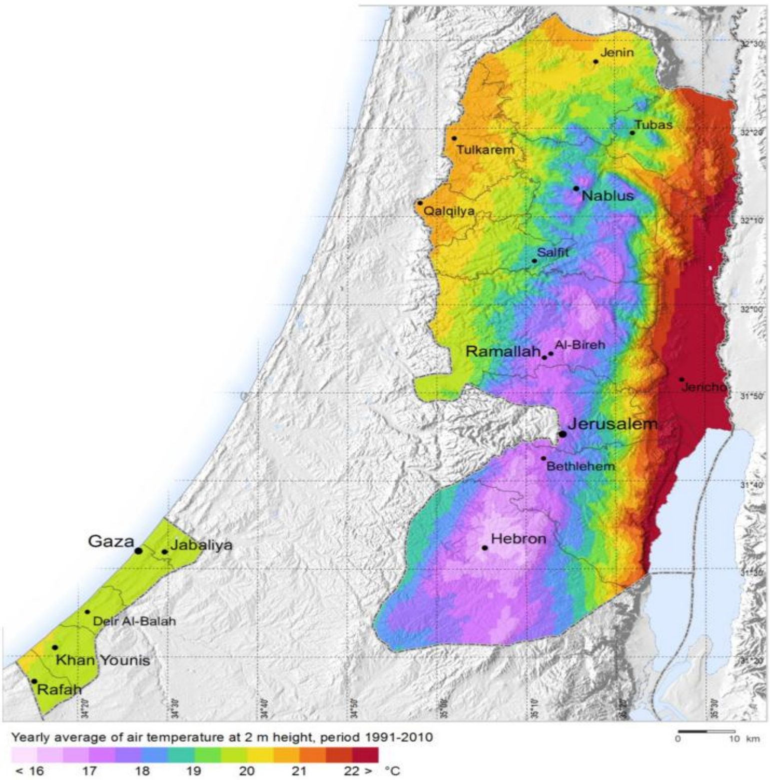

Figure (1.14): Long-term yearly average of air-temperature at 2 m. [6]

As mentioned; solar cells vary under temperature changes, where the change in temperature will affect the output power from the cells, so the voltage is highly dependent on the temperature and an increase in temperature will decrease the voltage. Figure (1.15) and figure (1.16) illustrate the I-V curve and the P-V curve and the effects of temperature on both [13].

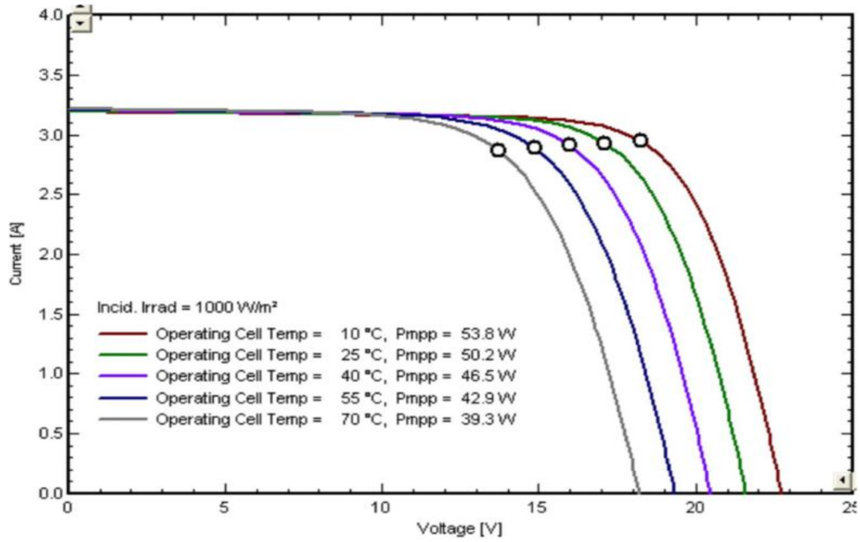

Figure (1.15): Output I-V characteristics of the PV module with different temperature.

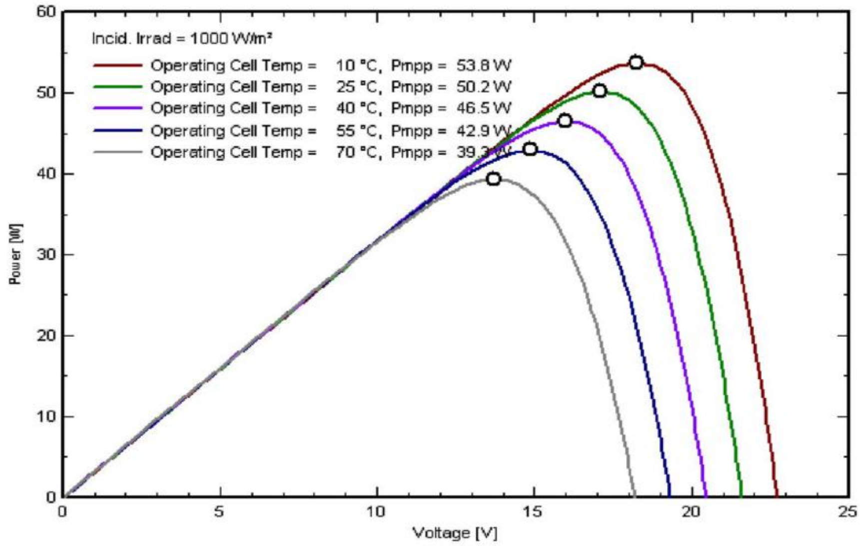

Figure (1.16): Output P-V characteristics of the PV module with different temperature.

For the 1000 W/m^2 I-V curve, figure (1.15) above shows the effect of cell temperature. As the temperature rises above 10 °C, V_{oc} falls while I_{sc} gets slightly higher. However, the graph shows that the current decreases because of the decrease of V_{oc}. Therefore, to get the maximum current output, modules should be mounted so that air can circulate around them freely to keep the cell cool. Figure (1.17) shows the monthly characteristics of temperature at specified sites in Palestine to represent the statistics calculated over 24 hours.

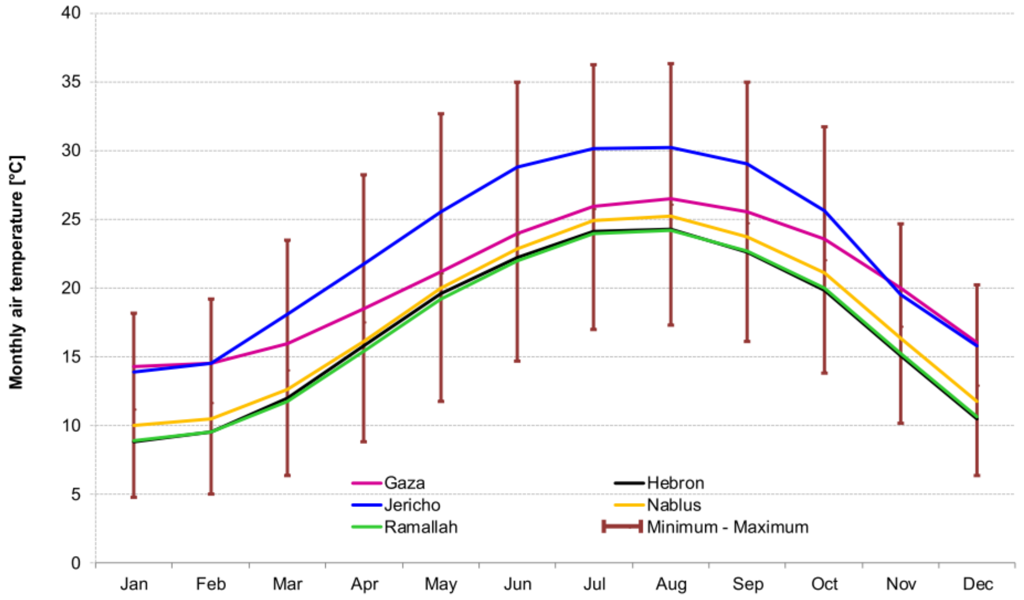

Figure (1.17): Monthly averages, minima and maxima of air-temperature at 2m. [6]

1.3.2 Humidity

Humidity drastically affects the performance of the Solar Panel and proves out to decrease the Power produced from the Solar Panels. According to a study held in Karachi are) the effects of the humidity on the solar panels shown in figure (1.18), figure (1.19) and figure (1.20 [14].

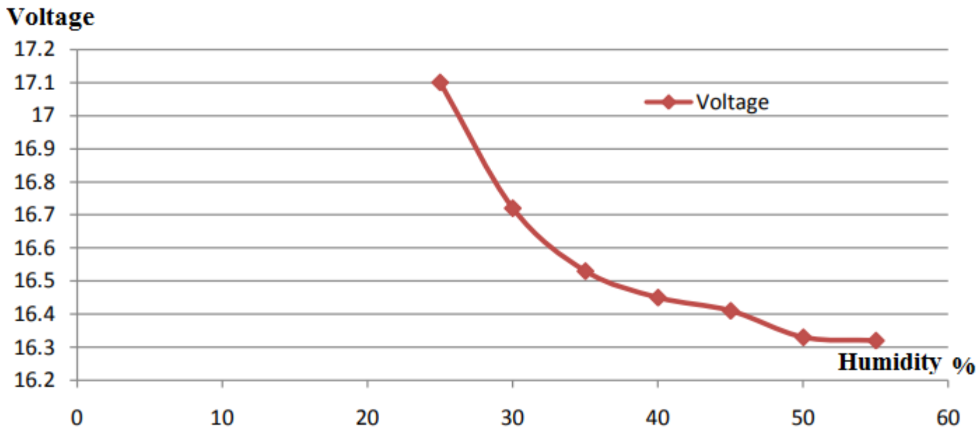

Figure (1.18): Effects of humidity on PV voltage. [14]

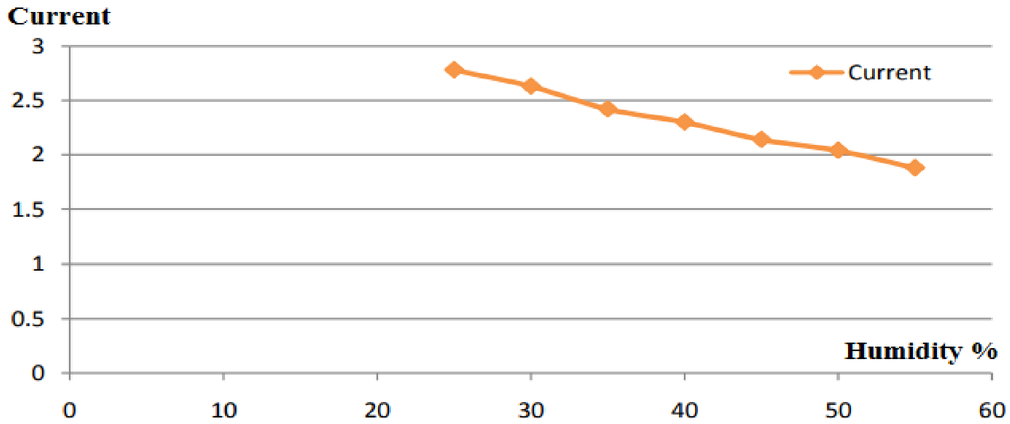

Figure (1.19): Effects of humidity on PV current. [14]

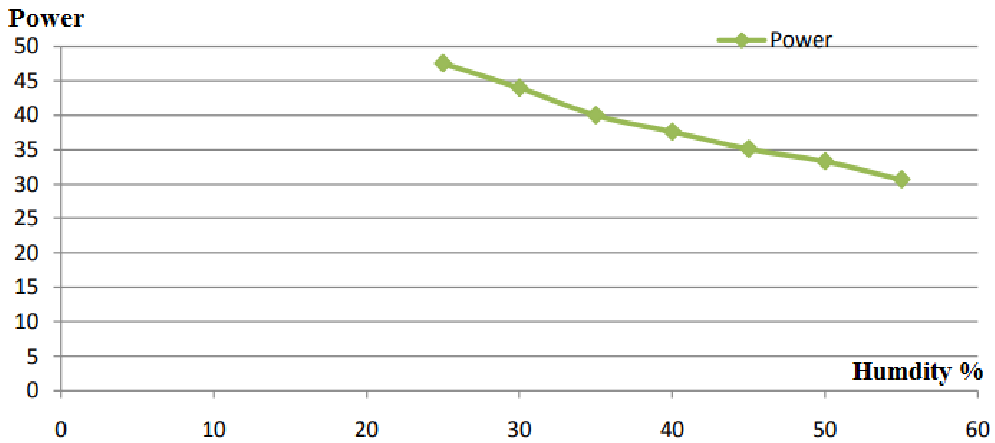

Figure (1.20): Effects of humidity on PV power. [14]

Figure (1.21) shows the long-term yearly average of relative humidity in the Palestinian territories, while figure (1.22) shows the monthly characteristics of humidity foe specified cities.

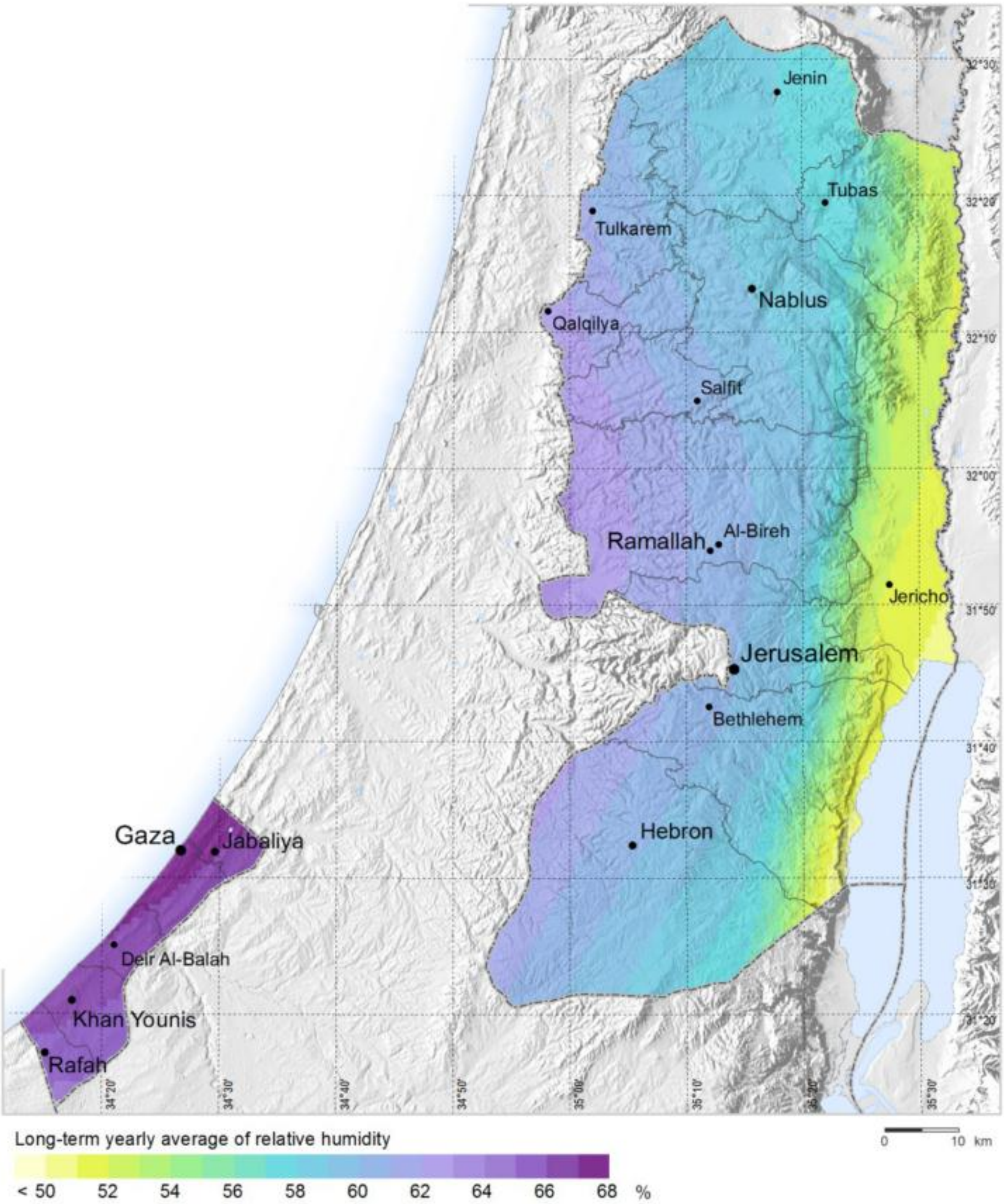

Figure (1.21): Long-term yearly average of relative humidity. [6]

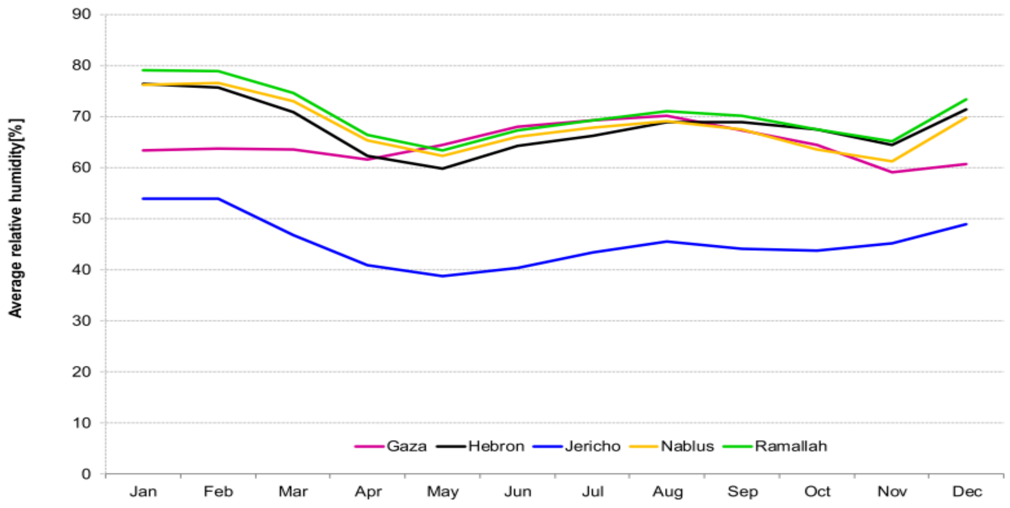

Figure (1.22): Monthly averages, minima and maxima of relative humidity. [6]

1.3.3 Wind Speed

The location of PV systems in not too much windy areas or on the hills can have positive effect on performance of the PV systems, like it has cooling effect on PV modules. However, winds, sometime bringing sand or pollution from urbanised and agricultural areas or from deserts have also negative effect by increasing dirt on surface of PV modules, especially if the region is dry with sparse rainfall. [6]

1.4 Summary

Studying the loads in civil defense centres in Palestine as discussed in chapter 2, requires a deep consideration of the geographical nature of Palestine, its climate ,the intensity of solar radiation and all its characteristics, so that it is easy for us to know the extent of the possibility of employing renewable energy projects in these areas and any of the best sites, which the Palestinian territories have high solar radiation potential in average GHI is higher than 1900kWh/km^2 and DNI is higher than 2000 kWh/km^2, what indicates good conditions for development of solar industry, with a tilt angle 27^o .

Chapter Two

Energy Consumption of Civil Defense Centers in West Bank

2.1 Civil Defense Centers in West Bank

According to Planning center in the C.D; the Palestinian Civil Defense consists of a number of distributed centers based on a number of studied used to distribute these in all governorates of the country as shown in table (2.1),

Table (2.1): Civil Defense Centers in West Bank.

City	Number of centers	locations
Jerusalem	6	3 centers in the territories of Al-Ram, Abu-Dees, Anata and Bir- Nabala.
Ramallah	9	3 centers in the territories of Ramallah & Al-Bireh, Birzeit, Obein, Attaybah, Beit-Lecia and Ni'lin.
Hebron	9	Hebron, Yatta, Dura, Beit Ola, Al Dhahria, Al Samoua, Bani Naim, Yasiriya and Halhoul
Jenin	8	2 centers in the territories of Jenin, Yamun, Yabad, Qabatiyeh, Faqu'a, Barta'a and Jaba.
Salfeet	4	2 centers in the territories of Salfeet, Dierstia, Bedia.
Nablus	5	Nablus, Burin, Northern Asira and Balata.
Tulkarm	3	2 centers in the territories of Tulkarm, Atil "Shaarawia" and Anabta "Wad Al-Shae’er".
Qalqeliyah	4	2 centers in the territories of Qalqeliyah, Azoun and Hajah.
Bethlehem	3	2 centers in the territories of Bethlehem and Obeidiya.
Tubas	2	2 centers in the territories of Tubas.
Jericho	2	2 centers in the territories of Jericho.

According to table (2.1); these centers are geographically distributed as shown in figure (2.1).

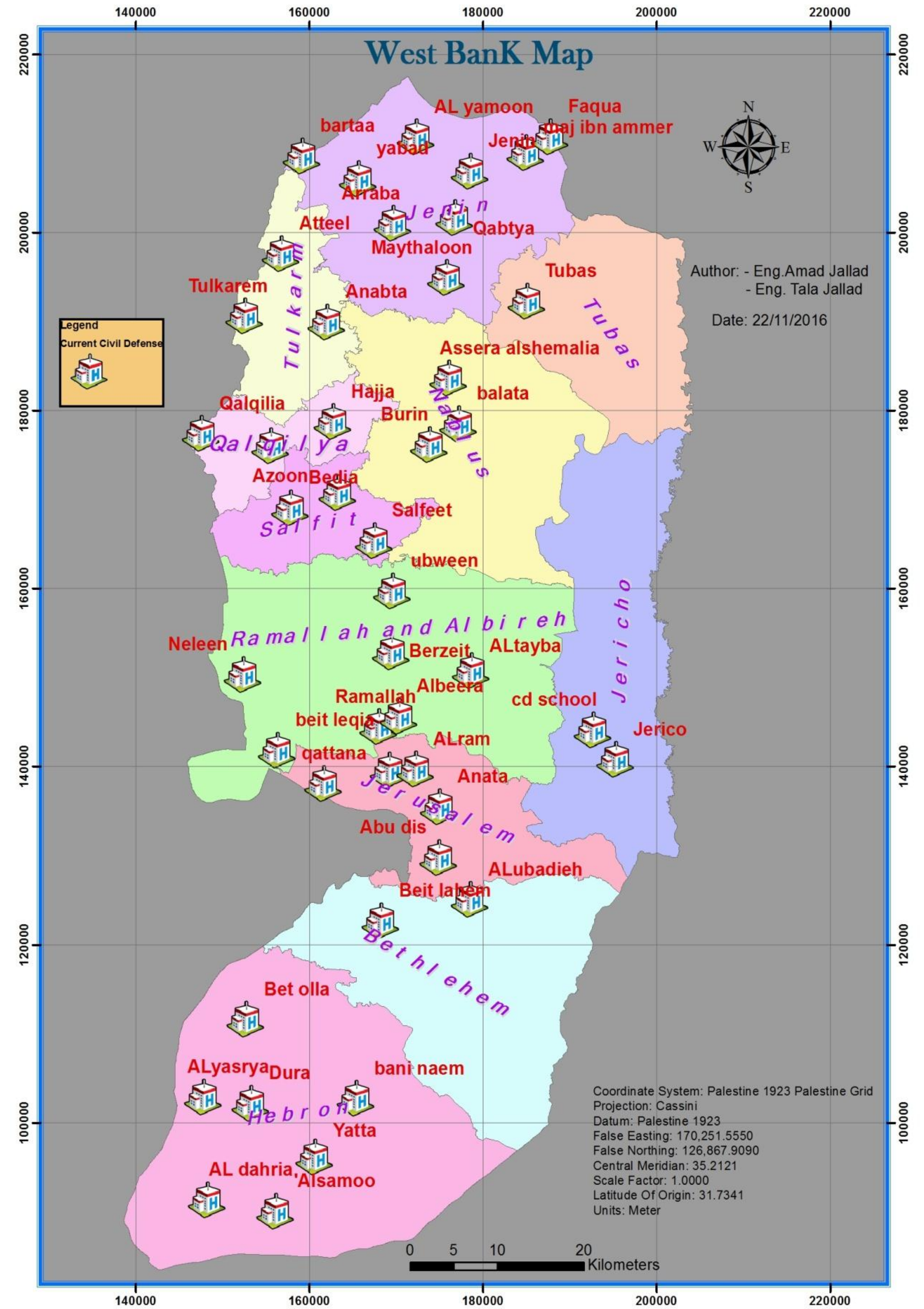

Figure (2.1): Civil Defense centers in WB.

The last mentioned centres in table (2.1), cover different population areas as illustrated in figure (2.2) and table (2.2).

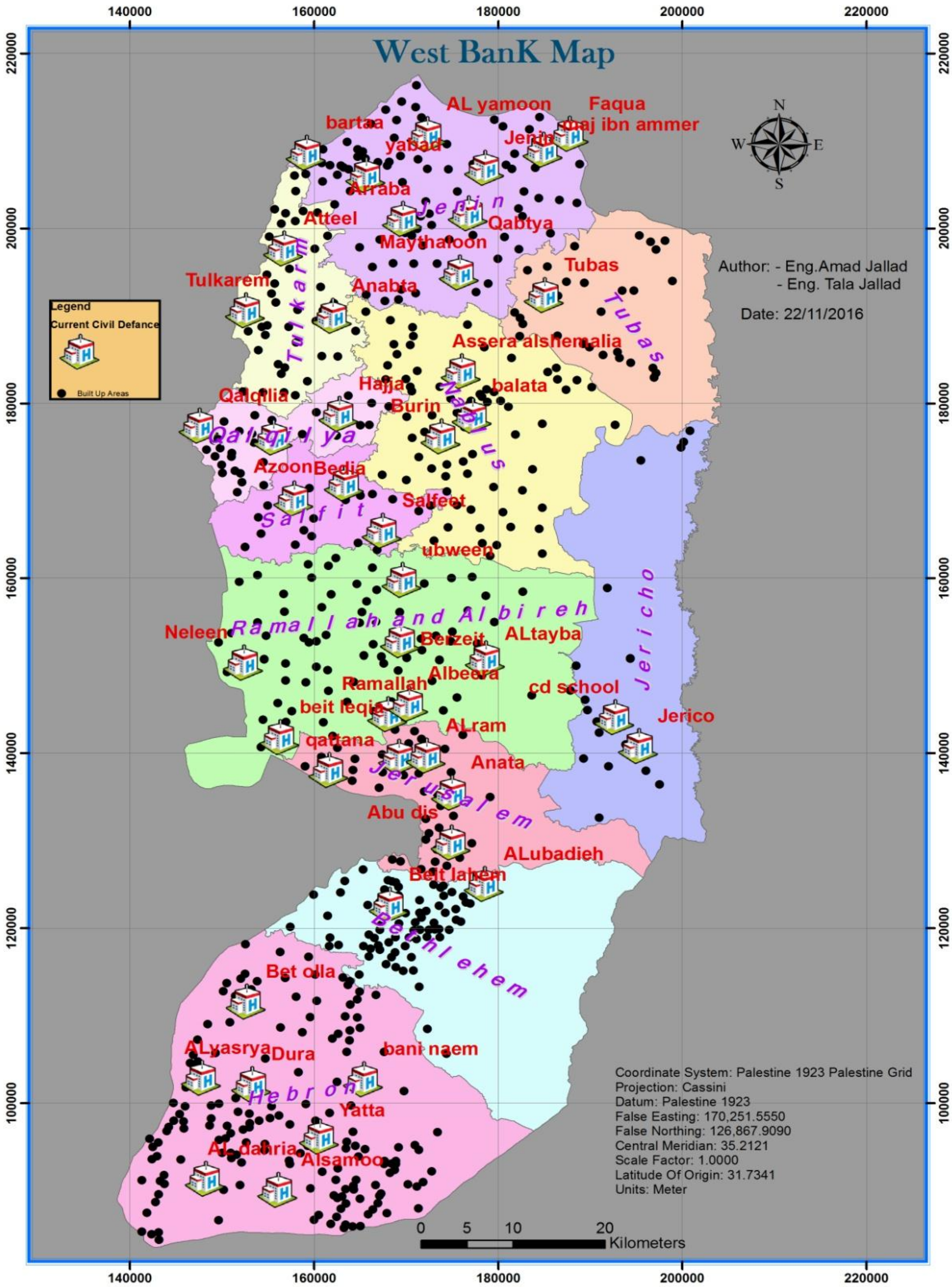

Figure (2.2): Civil Defense coverage of the population areas.

Table (2.2): Civil Defense Coverage of the Population Areas in 2012. [15]

City	Population	Area (km^2)
Jerusalem	396,710	345
Ramallah	319,418	855
Hebron	641,170	997
Jenin	288,511	583
Salfeet	66,119	204
Nablus	356,129	605
Tulkarm	172,224	246
Qalqeliyah	102,649	166
Bethlehem	199,463	659
Tubas	58,586	402
Jericho	48,041	593
Total	**2,649,020**	**5655**

Based on information and data from the planning department of the Civil-Defense Department; the planning criteria or the methodology used for distributing the centres of civil defense is as follows:

2.1.1 Geographical Standard

These standards are based on the distribution of civil defense centres using the spatial dimension basics and referring to the American standards adopted by the National Fire Protection Association (NFPA) to determine the requirements of civil defense centres, so these centres shall cover the area called the service area which shall not exceed 80 km^2 and not less than 40 km^2, which is a global benchmark shows that the maximum response time is 8 min. globally and therefore the physical characteristics and infrastructure are what determines the server.

2.1.2 Demographic Criteria

US standards have relied on a maximum of 100,000 people for the service unit. NFPA relies on civil protection training for civil society, where the highest priority is to integrate volunteer teams with a high percentage. According to NFPA; 69% of fire-fighters in the United States are volunteers in which the residential communities is less than 10,000 people served by volunteer fire-fighters only and this is because the general safety requirements for fire prevention are high in the United States.

There are other requirements must be available in the location of civil defense centres, where the geographical location of the Civil Defense Centre play an important role in determining the efficiency of that centre to carry out the tasks entrusted to him in the required manner.

The efficiency of the site is determined by a number of factors and considerations, including:

A- Reducing the time of arrival to the accident sites: This requires that the locations of the civil defense centres be chosen in a medium area of the supposed service area and on major traffic axes with easy access and exit from that location.

B - Coverage of the service area of the required level and quality of service: the readiness of the centre must be commensurate with the size and nature of uses in the region and human density which are the factors that determine the degree of exposure to fire hazards.

C - Spatial dimension: The spatial dimension is linked to the determination of the planning criteria by determining the maximum distance that vehicles and fire engines can travel to get to the site at a certain time, which the determination of the area according to this criterion is related to a number of factors as following:

1. Area topography.

2. Roads layer used.

3. The urban configuration layer of the area served.

4. Traffic intensity and trends in the region.

2.2 Energy Analysis of Some Civil Defense Centers

According to the Planning Department; all the electrical loads of the civil defense centers are somewhat variable in carrying capacity according to the area of the building and its employees. The average consumption of all loads varies between 350-1150 $/ month. Some Civil Defense centers were taken as samples, which were characterized by high electrical load in order to analyse their load curves, where the load curve is a graphical representation showing the variation in the demand for the energy of consumers on a source of supply with respect to time, as well as these loads are never constant; but they vary from time to time. This load variation during the whole day for example 24 hours is recorded half-hourly or hourly and are plotted against time on the graph. The curve obtained is known as daily load curve as it represents and illustrates the activity of a population quite accurately with respect to electrical power consumption over a given period of time [16]. The full data is attached in the appendix (1).

Three Civil Defense centers were visited and an energy audit was conducted at these facilities: Anabta center, Tubas center and Ram center. The study was to obtain an overview of existing centres energy consumption systems related to different types of loads and using the energy analyser meter in order to get several information and data such as Energy monetization, load curves, frontline troubleshooting, predictive maintenance, long-term analysis and load studies.

2.2.1 Centers Main Data

All centers visited have similarities in the following facilities: offices, receptions, kitchens, toilets and showers, sleeping areas, parking for fire cars, admin manger room, meeting rooms, secretary offices, stair cases and roofs.

2.2.2 Electrical Loads

The three visited centers have electrical loads summarized with: water pumps, diesel generators, lighting systems, office equipment, split unit’s air conditioners and others.

2.2.3 Daily load Curves

We have installed the Energy Analyser device in summer season on the main electrical board for each of the three Civil Defense centres (Anabta, Tubas ,Ram), in order to be able to determine the daily load curve of each one and to study the behaviour of each centre. The results of Anabta, Tubas and Ram were as shown in figure (2.3), figure (2.4) and figure (2.5) respectively.

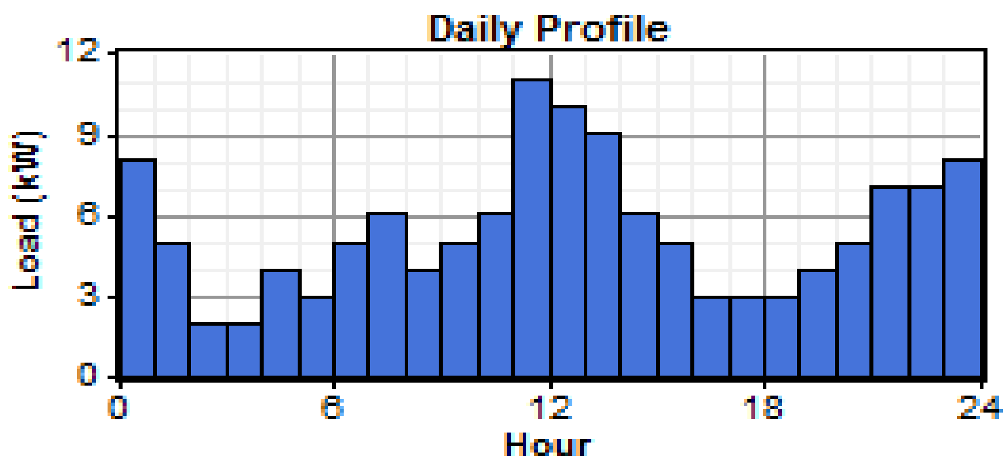

Figure (2.3): The daily load curve of Anabta C.D.C.

Anabta daily load curve shown in figure (2.3) has a great importance in generation and supplying as the curve pesents the following information readily: [17]

1. The daily load curve illustrates the shape of the variation of the load during different hours of the day.

2. The highest point of the curve represents the maximum demand which is equal to 11kW.

3. The area under the curve divided by the total number of hours illustrates the average load.

$$\text{Average Load} = \frac{\text{Area (in kWh) under the daily load curve}}{\text{24 hours}} \quad (2.1)$$

Average Load = 129,6kWh / 24 hr. = 5.4 kW.

4. The daily load curve helps also in selecting the size and the number of generation units.

5. Economical Factors:

A. The demand factor; is the ratio of the maximum demand of a system to the total connected load, in which the connected load is the sum of the continuous ratings of all the equipment connected to supply system. The maximum demand is generally less than the connected load so the values of the demand factor are usually less than 1. [17]

$$\text{Demand Factor} = \frac{\text{Maximum demand}}{\text{Connected load}} < 1 \quad (2.2)$$

The demand factor is constantly changing from time to time or hour to hour of use and it will not be constant and the connected load for large facilities not easily to be measured. [17]

B. The load factor is the ratio of the average demand to the maximum demand in a specified period it may be a day, a month or a year. If the factor measured for a day then it is called a daily load factor and the same for the others. Load factor is always less than 1 because the maximum demand is always more than the average demand, in which it is used for determining the overall cost per unit generated, as well as, load factor is the other terms of efficiency. The higher load factor is GOOD so the power plant may be highly efficient at high load factors. [17]

$$\text{Load Factor} = \frac{\text{Actual load}}{\text{Full load}} < 1 \qquad (2.3)$$

$$\text{Load Factor} = \frac{5.4}{11}$$

$$= 0.491 < 1$$

D. The diversity factor is ratio of the sum of the individual maximum demands of the various sub circuit of a system to the maximum demand of the whole system. Diversity Factor is always more than or equal to 1 because sum of individual maximum demands more or equal to the maximum demand. [17]

$$\text{Div. F} = \frac{\text{Sum of the idividual maximum demand}}{\text{Maximum demand of the system}} \geqslant 1 \qquad (2.4)$$

Div. F = 30 kW/ 11 kW = 2.73 >1

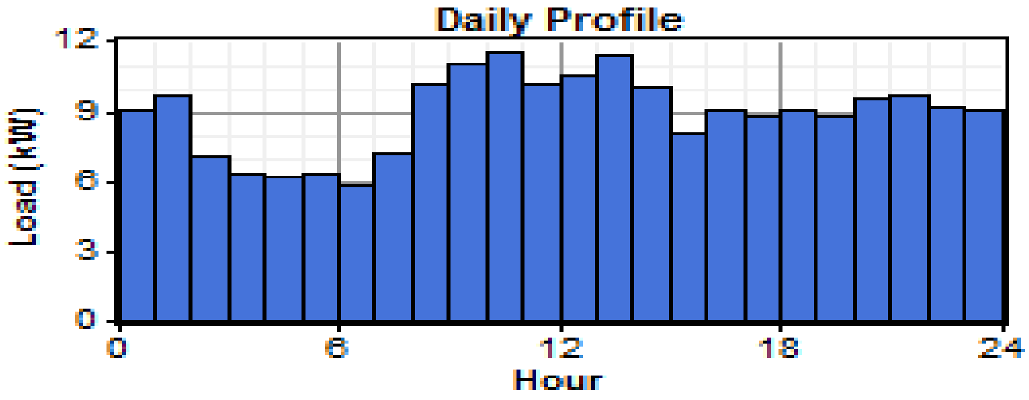

Figure (2.4): The daily load curve of Tubas C.D.C.

Tubas daily load curve shown in figure (2.4) has a great importance in generation and supplying as the curve presents the following information readily:

1. The highest point of the curve represents the maximum demand which is equal to 11.5kW.

2. According to equation (2.1); the average load is equal to 9 kW.

3. According to equation (2.3); the load factor is equal to 0.783 <1.

4. According to equation (2.4); the Div. factor is equal to 2.956 >1.

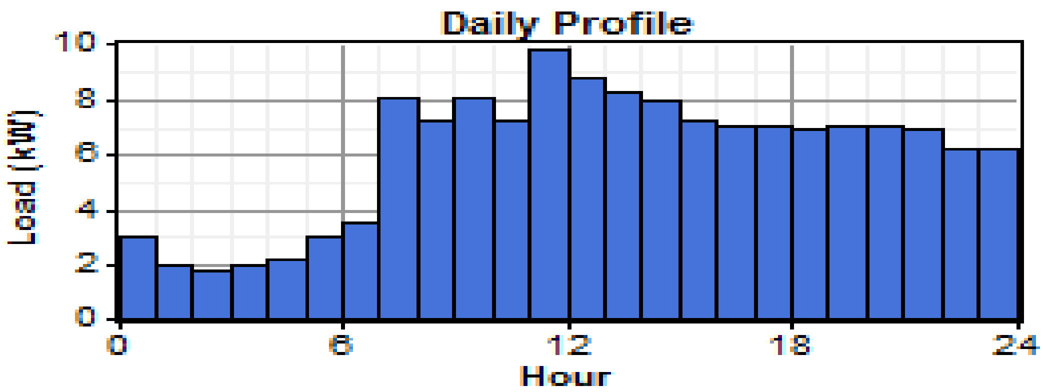

Figure (2.5): The daily load curve of Ram C.D.C.

Ram daily load curve shown in figure (2.5) has a great importance in generation and supplying as the curve presents the following information readily:

1. The highest point of the curve represents the maximum demand which is equal to 9.9kW.

2. According to equation (2.1); the average load is equal to 6 kW.

3. According to equation (2.3); the load factor equal is to 0.55 <1.

4. According to equation (2.4); the Div. factor equal is to 3.52 >1.

2.3 Summary

The geographical area of the Palestinian areas is small and the population is increasing rapidly. Therefore, the number of civil defense centers is increasing to cover these numbers and areas. Therefore, the government expenditure is very cumbersome. It is necessary to look at their electrical loads and know the average consumption of each of them so as to facilitate their analysis and to think more about renewable energy-saving alternatives that need to be studied in detail as in Chapter 3.

Chapter Three

Elements of PVs System and Modeling

3.1 Introduction of Solar Power

Solar power is the energy derived from sunlight, including heating water as well as generating electricity, where solar energy is one of the most important energy resources in the world. Its actual investment has been delayed despite the importance of its advantages as an inexhaustible source. Solar power can be converted from the heat from sunlight into electrical energy to obtain water vapor to be used in power generation turbines. Direct sunlight can also be converted into electricity by using photovoltaic cells, as will be explained extensively in this Chapter. Solar energy is considered to be one of the most sustainable and abundant energies in the Palestinian territories and, more importantly, it is clean, protecting the environment from the emission of harmful gases and affecting the ozone layer. Thus, solar energy can be converted into electrical energy to be used to feed homes, industrial, commercial, agricultural and other facilities.

3.2 Types of PV Projects

The energy produced by solar panels depends on several factors, including the tendency and direction of the board, so two methods are adopted when installing solar panels such as fixed systems and rotated systems (single axis and dual axis rotated systems). These types are used in order to obtain the highest proportion of solar radiation to produce energy which is protected by several important factors, the most important is the location of the sun for the solar cells, which can be identified through three elements and explained more in figure (3.1):

1.**Surface azimuth angle (a_w)**; which means the deviation of the projection on a horizontal plane of the normal to the surface from the local meridian, with zero due south. East negative, and west positive. [18]

2**. Solar azimuth angle (a_s)**; which means the angular displacement from south of the projection of beam radiation on the horizontal plane, where displacement east of south are negative and west of south are positive. [18]

3. **Solar altitude angle (a)**; which means the angle between the horizontal and the line to the sun. [19]

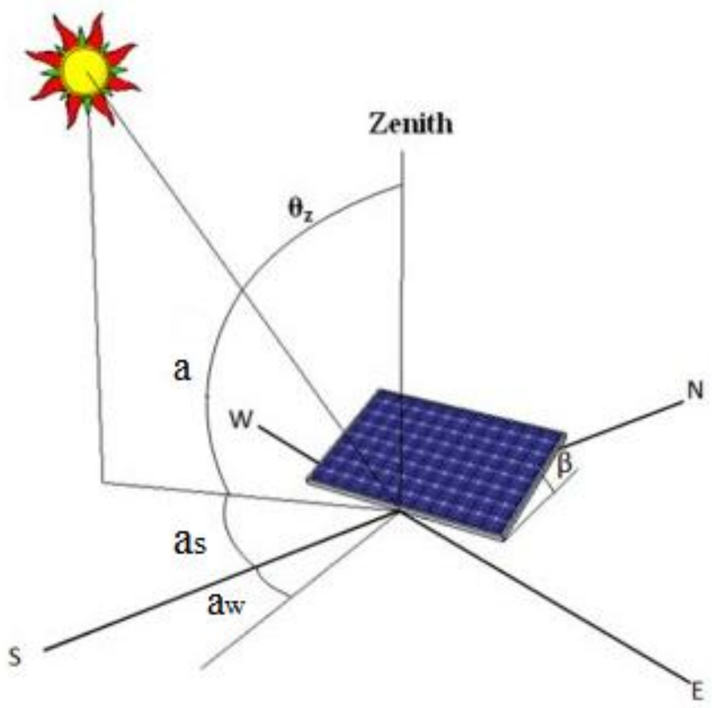

Figure (3.1): Solar angles for PV plane. [20]

As mentioned; a number of technical options are available, so in general, PV power systems can be distinguished based on the type of mounting the PV modules that can be classified as following:

1. Open Space Free Standing PV Systems

a. Fixed-mounted PV modules; are the major type of the large utility scale PV systems that mounted at fixed position with optimum tilt angle (a), that make these projects simplest and lowest cost choice for implementation of PV power plants. Particularly financial convenience and ease of installation caused that fixed systems are currently mainstream on PV market. Notice figure (3.2). [6]

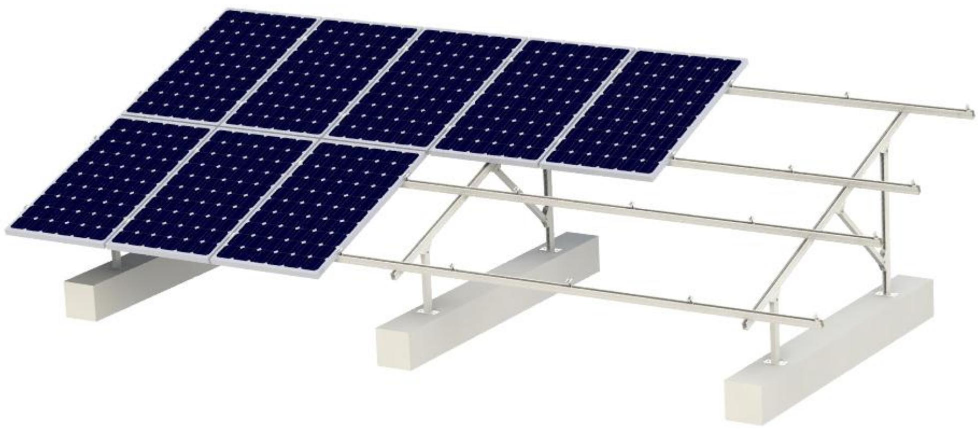

Figure (3.2): Fixed mounted PV system.

b. Sun-tracking systems; are the other alternative, where these solar trackers adjust the orientation of the PV modules during a day to a more favorable position in relation with the sun, so the PV modules will collect the radiation as much as possible for longer period during the day. These systems can be classified to two types as following: [21]

* One axis trackers; with North- South orientation of rotating axis, which the positive featured is elongated power generation profile stretching from early morning to the late afternoon and this will prevent the lower part of the modules to be shaded from the others, while the downside is the limited output power at the peak periods in winter.

* Two axis trackers; where modules are positioned to rotate left- right and up-down, so this is makes the system complex for monitoring the structure and with higher price.

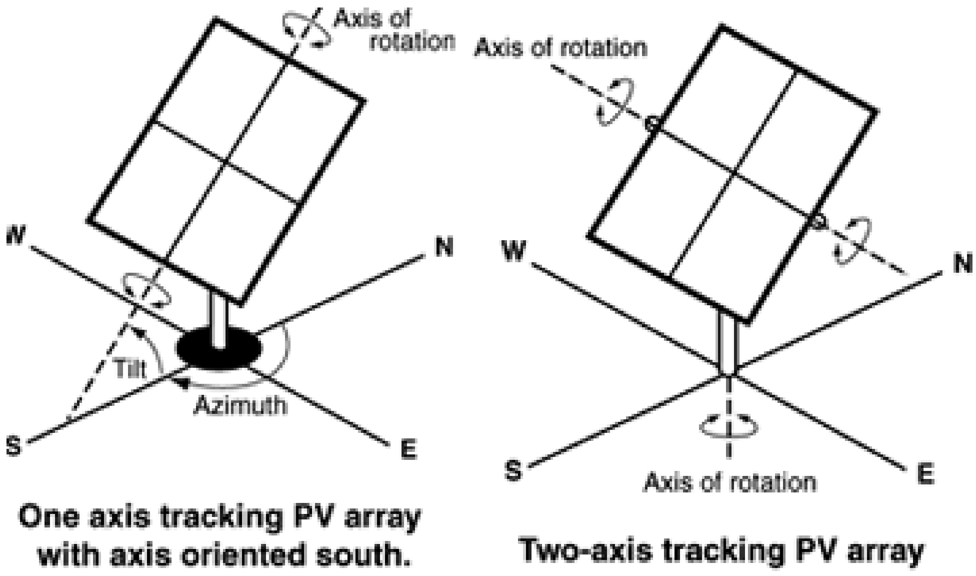

Figure (3.3): Tracking PV systems.

2. Roof Mounted Space Systems

Roof mounted PV systems are typically small to medium size, such as ranging from hundreds of watts to hundreds of kilowatts, where these modules can be mounted on flat or tilted roofs as well as can be used as shade structure, or can be directly integrated as a part of building cover. The main characteristics of these systems is the high dispersion and connection into low voltage distribution grid , so the direct connection into the grid means that the inverter must provide all protections required by regulations such as voltage, frequency, isolation check, etc. Notice figure (3.4). [22]

Figure (3.4): Roof mounted PV system.

3.3 Types of Installed PV Systems

Solar projects differ in terms of installation in two respects, where the first section are Off-Grid projects that separated from the network itself and the other are On-grid projects that connected to the network, which vary somewhat in some things inherently the first of several aspects as well as the laws in force in Palestine to organize these projects, Which will be detailed as follows:

1. Off-Grid Systems [23]

These systems allow storing the solar power in batteries for use when the power grid goes down or if you are not on the grid. The positive side of these systems that they provide power for the critical loads when the power grid is down. Notice figure (3.5).

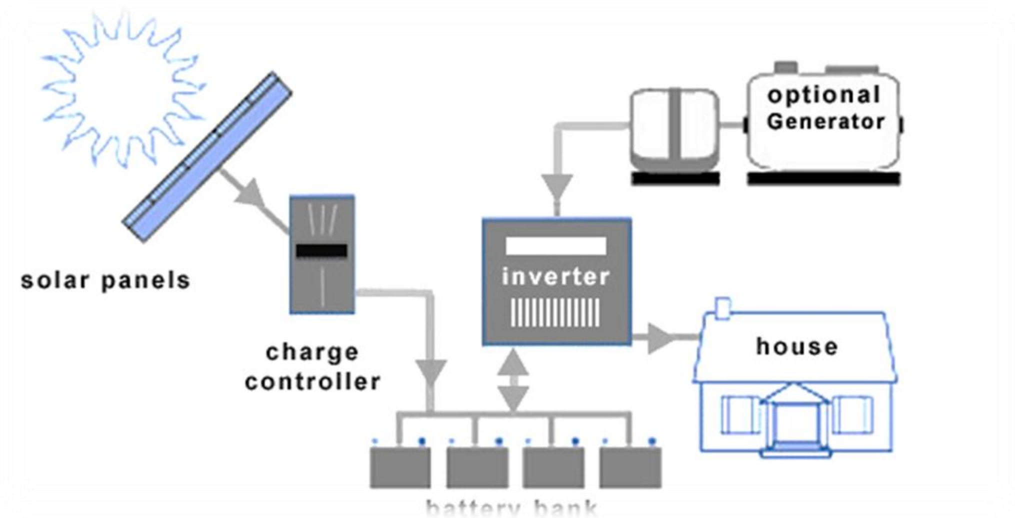

Figure (3.5): Off-grid PV system.

2. On-grid Systems [23]

These systems generate power when the utility power grid is available. They must connect to the grid to function, in which they can send excess power generated back to the grid when you are overproducing so you credit it for later use. The positive side of these are simplest systems and the most cost effective to install and these systems will pay for themselves by offsetting utility bills in 3-8 yrs., while the downside of these that they do not provide power during a grid outage. Notice figure (3.6).

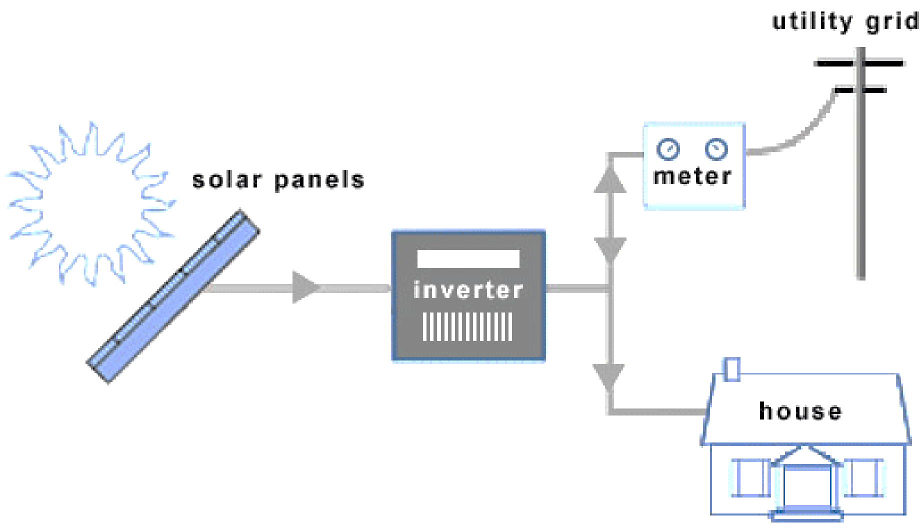

Figure (3.6): On-grid PV system.

In order to reduce consumption, especially in the civil defense centres and according to the regulations governing the projects of solar energy in Palestine, it is all oriented towards On-grid projects because of its advantages, where these laws are divided as following:

A. Feed in Tariff [24]

In this case, any citizen can install a system of solar cells and sell the electricity generated at a preferential price (i.e, a price higher than the normal electricity price of the grid), which guarantees the owner of the solar system to recover the capital in a specified time period (approximately 8 years). After the capital is recovered, this project represents a fixed monthly income for the owner. One of the systems implemented in Palestine is the Palestinian National Solar Initiative (PSI) for the domestic sector up to $5kw_{p,}$ as a catalytic step by the government to encourage citizens to install these systems in their homes and obtain a special electrical tariff for productive energy. The Palestinian Electricity Regulatory Council (PERC); is the organizer during the implementation of this initiative. As well as, the 2015 Renewable Energy and Natural Resources Law came to promote the exploitation and development of renewable sources, and to increase the proportion of its contribution to total energy mix, and regulates the power purchase agreements with carriers; recently the Palestinian Council of Ministers approved a unique renewable energy incentive package that leap Palestine towards Green Energy or Sustainable Energies within the Palestinian Investment Encouragement law over regional legislations, and gives a competitive advantage form investors to invest in Palestine, as this contract can be granted to support strategic projects, geographic location or named sector to generate jobs, technology transfer or implement international standards to protect the environment or generate energy from alternative resources. [25]These incentives are follows:

Utility scale projects, more than (1) Megawatt/h power generation:

Stage 1: 0% income tax for seven years starts from operations

Stage 2: 5% income tax following stage one for five years

Stage 3: 10% income tax following stage 2 for three years

Feed in projects with less than (1) Megawatt/h power generation:

A. Current projects that enjoys incentives receive additional extinction if they generates power as follows

i. 20 KW power generation receives extension for one

ii. 40 KW power generation receives extension for two years

iii. 60 KW power generation receives extension for three years

B. **Projects never received incentives or their incentives period expired** and generates 40 KW subject to 5% income tax for two years.

B. Net Metering [26]

This system differs from the previous system in that not all electrical energy produced is purchased, but exchanged with the network. During the day, the system feeds the network, and at night the consumer feeded from the network. As a result of using this type of system, it is possible to get a monthly electricity bill of zero shekels, so there are general notes about Net-Metering (NM) regulation summarized as follows:

- NM policy:

- The Customer can cover only their consumption from the production from RE project.
- The distribution company will install bidirectional meters (or two meters as available) that measure: consumed energy from network and exported energy from RE to the network.
- In the end of each month the distribution company make clearance between these two measures (consumption & exported);
- If consumed energy less than exported energy, the DISCO will carry over the exceeded kWh of exported energy to the next month with deduction fees 25%”
- In the end of production year the credits must be reset.
- In this policy we also make a permit to build RE project away from consumption location (for example the consumption location in Ramallah and production in Jericho; the fees will be 10% of total production). For full data notice appendix (2).

- The limitations of NM regulation are as follows:

- Annual Consumption ≥ annual production of RE
- Production ratio = 1 kW solar PV ➔ 1500 kWh/year
- Year of production from 1st of April to end of March

3.4 Selecting of PV Elements [27]

Solar photovoltaic system is one of renewable energy system that uses PV modules to convert sunlight into electricity, in which the electricity generated can be used directly or stored, fed back into grid line or combined with one or more other electricity generators or more renewable energy source.

The major components for solar PV system are the PV module, solar charge controller, inverter, battery bank, auxiliary energy sources and loads (appliances).

1. **PV module** – converts sunlight into DC electricity.

2. **Solar charge controller** – regulates the voltage and current coming from the PV panels going to battery and prevents battery overcharging and prolongs the battery life.

3. **Inverter** – converts DC output of PV panels into AC current for AC appliances or fed back into grid line.

4. **Battery** – stores energy for supplying to electrical appliances when there is a demand.

5. **Load** – is electrical appliances that connected to solar PV system such as lights, radio, TV, computer, refrigerator, etc.

6. **Auxiliary energy sources** - is diesel generator or other renewable energy sources.

The most important steps should be considered to make a PV designing for are as following:

Firstly, is to find out the total power and energy consumption of all loads in the facilities that need to be supplied by the solar PV system by calculating the total Watt-hours per day for each appliance used, and calculating total Watt-hours per day needed from the PV modules.

Secondly, select PV module, where different size of PV modules will produce different amount of power, so the peak watt (Wp) produced depends on the size of the PV module, facility orientation and climate of site location, then Calculating the number of PV modules for the system **by** dividing the answer obtained in equation (3.1) by the rated output Watt-peak of the available PV modules.

$$PV_{Wp} = \frac{\text{Desired demand (kWh)}}{0.9 \text{ x } 5.45 \text{ kWh/m}^2\text{/day}} \quad (3.1)$$

$$\textbf{No. PV} = \frac{\textbf{PV}_{Wp}}{\textbf{P}_{mpp}} \quad (3.2)$$

The number 5.45 kWh /m^2 / day, is the approximate scaled annual average of the daily radiation of Palestine with a latitude equal to 32^o and longitude equal to 35^o.HOMER program can give us the daily radiation curve for these specified orientations as shown in figure (3.7).

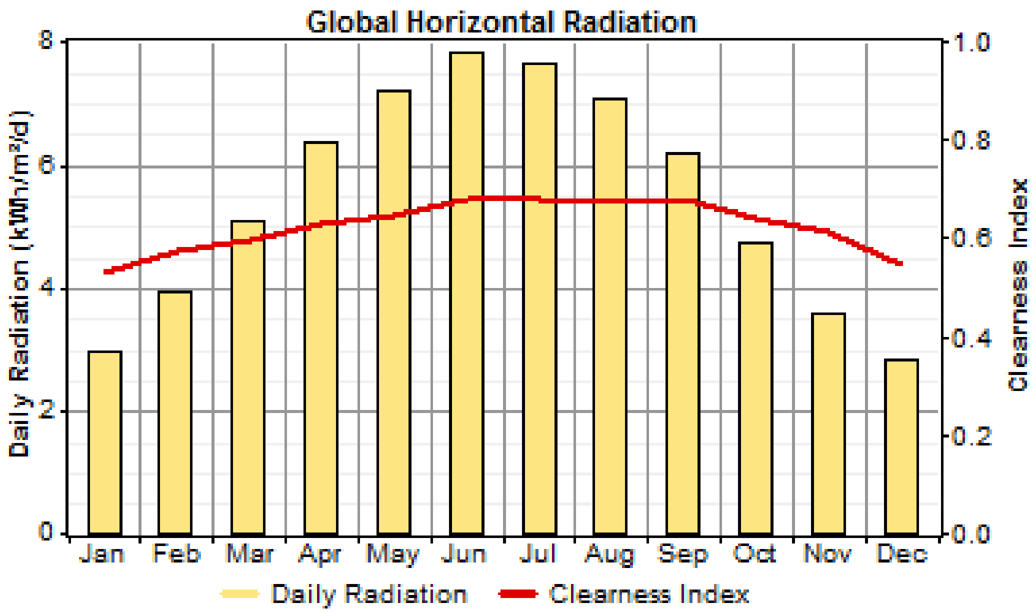

Figure (3.7): Daily radiation curve by HOMER program.

Thirdly, inverter is used in the system where AC power output is needed. The input rating of the inverter should never be lower than the total watt of loads. The inverter must have the same input nominal voltage as the battery.

For stand-alone systems, the inverter must be large enough to cover the total amount of watts you will be using at one time. The inverter size should be 25-30% bigger than total Watts of appliances.

Finally, is to size the batteries needed for the system, in which batteries used are specifically designed to be discharged to low energy level and rapid recharged or cycle charged and discharged day after day for years. The batteries size should be large enough to store sufficient energy to operate the Loads at night and cloudy days. The size of battery can be calculated as following:

$$\text{Battery Capacity (Ah)} = \frac{\text{Total (Wh) per day used x Days of autonomy}}{\text{(0.85 x 0.6 x nominal battery voltage)}} \tag{3.3}$$

Where, 0.85 is the ampere hour efficiency of battery and 0.6 is the depth of discharge.

3.5 Solar Energy Losses [6]

PV modules are often installed in suboptimal positions, it may sometimes as a different deviation from the optimum altitude angle or another causes in different aspects concluded in the following steps:

1. Losses due to terrain shading; An intensive analysis should be undertaken to consider all data about the surface of the model and the surrounded area such as sometimes there is a shading because of the local features, buildings, structures, vegetation nearby the system that not considered .

2. Losses due to the angular reflectivity; the losses depends on the surface type and cleanness where the cleaner surfaces give the lower reflectance losses.

3. Losses due to dirt and soiling; these losses depend on the environmental factors and the cleaning of PV modules surface during the lifetime of the project.

4. Losses due to the performance of PV modules outside of STC conditions; these losses depend on the module technology and mounting type, where these losses are higher for crystalline silicon modules mounted at tracker than fixed position ones.

5. Losses by inter-row shading; these losses depend on the row spacing, so these losses can be avoided by optimizing the distance between rows of the module table.

6. Power tolerance of modules; from the module power tolerance result bigger or smaller mismatch losses of the modules connected in strings.

7. Mismatch and DC cabling losses.

8. Inverter losses from conversion of DC to AC.

9. AC and transformer losses; the inverter output is connected to the grid through the transformer. The additional AC losses reduce the final system output by a combination of cabling and transformer losses.

3.6 Solar PV Systems Descriptions

1. Solar PV systems advantages:

- There is no harmful greenhouse gas (GHG) emission thus solar PV is environmentally friendly.
- Solar energy is supplied by nature, so it is free and abundant.
- Solar energy can be made available almost anywhere there is sunlight.
- Solar energy is especially appropriate for smart energy networks with distributed power generation (DPG).
- Solar Panels cost is currently on a fast reducing track and is expected to continue reducing for the next years.
- Operating and maintenance costs for PV panels are considered to be low, almost negligible, compared to costs of other renewable energy systems.
- PV panels have no mechanically moving parts, except in cases of –sun-tracking mechanical bases.
- PV panels are totally silent, producing no noise at all; consequently, they are a perfect solution for urban areas and for residential applications.
- Residential solar panels are easy to install on rooftops or on the ground without any interference to residential lifestyle.

1. Solar PV systems disadvantages:

- Solar energy has intermittency issues; not shining at night but also during daytime there may be cloudy or rainy weather. Consequently, intermittency and unpredictability of solar energy makes solar energy panels less reliable a solution.

- Solar energy panels require additional equipment (inverters) to convert direct electricity (DC) to alternating electricity (AC) in order to be used on the power network.

- For a continuous supply of electric power, especially for on-grid connections, Photovoltaic panels require not only inverters but also storage batteries; thus increasing the investment cost for PV panels considerably

- In case of land-mounted PV panel installations, they require relatively large areas for deployment; usually the land space is committed for this purpose for a period of 15-20 years – or even longer.

- Solar panels efficiency levels are relatively low compared to the efficiency levels of other renewable energy systems.

- Though PV panels have no considerable maintenance or operating costs, they are fragile and can be damaged relatively easily; additional insurance costs are therefore of ultimate importance to safeguard a PV investment.

3.7 Summary

Palestine oriented towards On-grid PV projects because of its advantages, which the organizing laws are divided to feed in tariff or Net metering instructions, so it is necessary to know the methodologies of connecting PVs to grid and the needed apparatus for designing as shown on chapter 4.

Chapter Four

Design and Impact of PV System Installations in Civil Defense Centers

4.1 Introduction

The quality of solar energy in Palestine, as well as the recent Palestinian laws and instructions governing the renewable energy projects have helped to open a competitive market among the competitors and investors in the Palestinian market, prompting consumers to turn to such projects such as net metering instructions, which was explained previously as On-grid projects linked to the network. In this chapter, emphasis was placed on the three centers mentioned previously, entitled with the Anabta, Tubas and Al Ram centers, and carried out field visits to these centers and taking all the AutoCAD plans for these centers. This is accomplished by several important issues: how to distribute these systems to these establishments, the financial impact of such projects and the period of recovery of the invested amounts and then the work of several scenarios to ensure the best systems and the appropriate size to achieve this.

4.2 Technical Analysis of installation PV systems in Civil Defense Centers

After studying the chosen centers in terms of economic feasibility, it is necessary to think seriously and study these projects and how much these projects can be applied to these centers, so all the engineering plans were collected for these centers to define where these centers are located and their location in terms of directions and to study the possible or available space to implement these net-metering systems. Based on what is available in the Palestinian market; has been taken into account the polycrystalline modules with capacity up to 320wp with dimensions about 2m X 1m for the technical design, where the distance among the modules selected to be approximately about 2.54m. Notice figure (4.1).

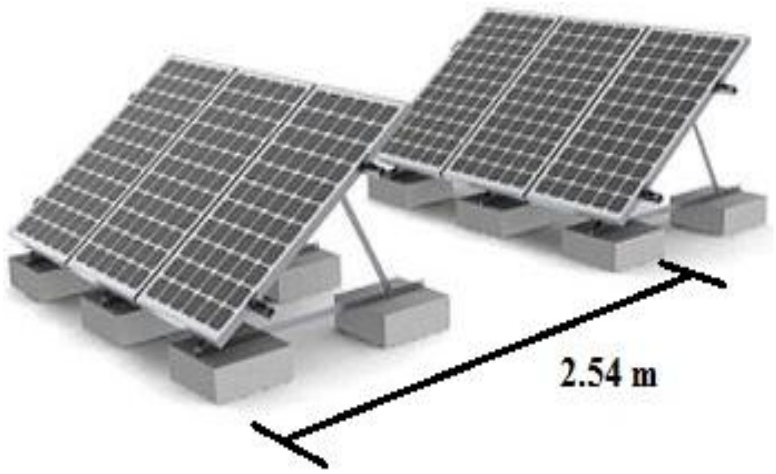

Figure (4.1): The distance between modules.

4.2.1 Technical Analysis of installation PV systems in the desired Centers

According to the average consumption of Anabta center in figure (2.3); it was about 5.4kW, so through using the equation (3.1); the peak power needed it will be about 26 kWp, so that need two inverters with capacity equal to 10 kVA to cover and give a power equal to 19.2 kWp, Thus the design is assumed to be as shown in figures (4.2), and (4.4), also as discussed in table (4.1).

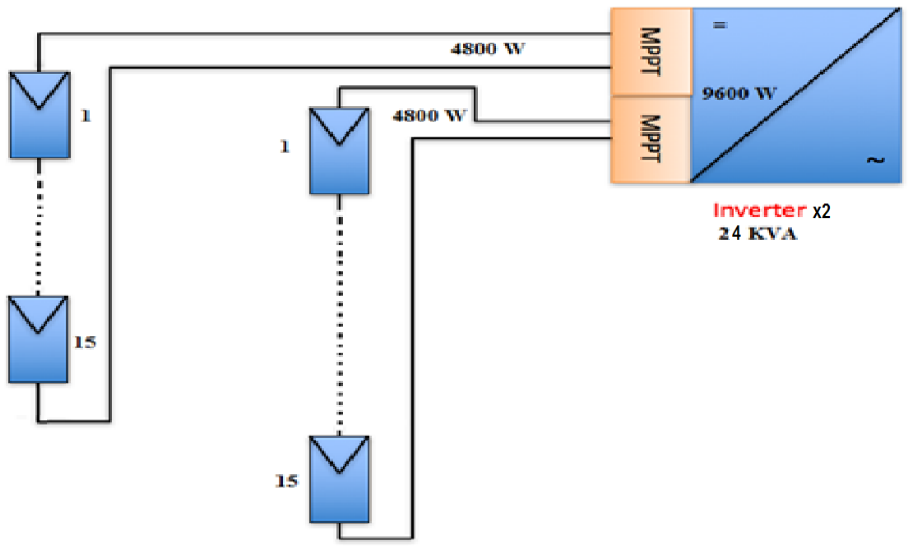

Figure (4.2): The technical connection diagram for Anabta center.

Table (4.1): The Technical Analysis for Anabta Center.

No. of strings	4
No. of modules in series	15
Total number of modules	60
Peak Power	19200 Wp
Power of each string	4800
Number of strings per single inverter input	1
Number of inverter inputs	2 MPPT
Number of strings per inverter	2 string
Power input for every single input	4800 Wp
Total module area	155 m² including spacing
Pnom each group	9600 kWp
Inverter nominal power	12kVA
Total inverters power	24 kVA
Pnom Ratio	0.96 = (19.2kW/ 20 kVA)
PV module type	Q- Cell / Hanwha (320 w_p) .Full data in appendix (3)
Protection devices in the box to inverters	4 surge arrestors 4 DC circuit breakers
Cables cross sectional are between PV modules	6 mm^2
Inverter type	ABB .Full data in appendix(4)

According to the average consumption of Ram center in figure (2.5); it was about 6 kW, so through using the equation (3.1); the peak power needed it will be about 19.2 kWp thus the design is assumed will be as Anabta center, but according to the average consumption of Tubas center in figure (2.4); it was about 9 kW, so through using the equation (3.1); the peak power needed it will be about 43 kWp, so that need two inverters with capacity equal to 20 kVA to cover and give a power equal to 38.4 kWp, thus the design is assumed to be as shown in figure (4.3)), and (4.4), also as discussed in table (4.2).

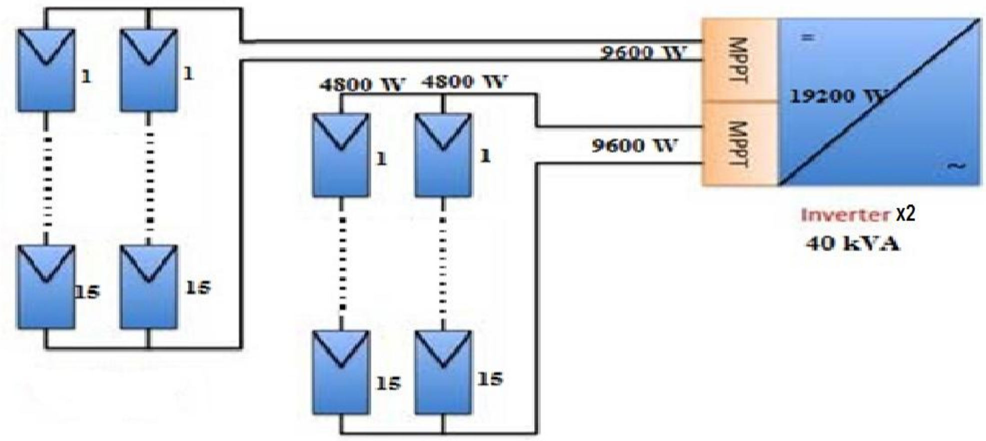

Figure (4.3): The technical connection diagram for Tubas center.

Table (4.2): The Technical Analysis for Tubas Center.

Strings	8
modules in series	15
Total number of modules	120
Peak Power	38400 Wp
Power of each string	9600 = (4800*2)
Number of strings per single inverter input	1
Number of inverter inputs	2 MPPT
Number of strings per inverter	2 string
Power input for every single input	9600 Wp
Total module area	407 m^2 = (120*2.54m^2 / 0.75)
Pnom each group	19200 kWp
Inverter nominal power	10kVA
Total inverters power	40 kVA
Pnom Ratio	0.96
PV module type	Q- Cell / Hanwha (320 w_p)
Protection devices in the box to inverters	8 surge arrestors 8 DC circuit breakers
Cables cross sectional are between PV modules	6 mm^2
Inverter type	ABB .Full data in appendix(5)

According to figures (4.2) and (4.3) and tables (4.1) and (4.2); the connecting process for the net metering system will be as in figure (4.4).

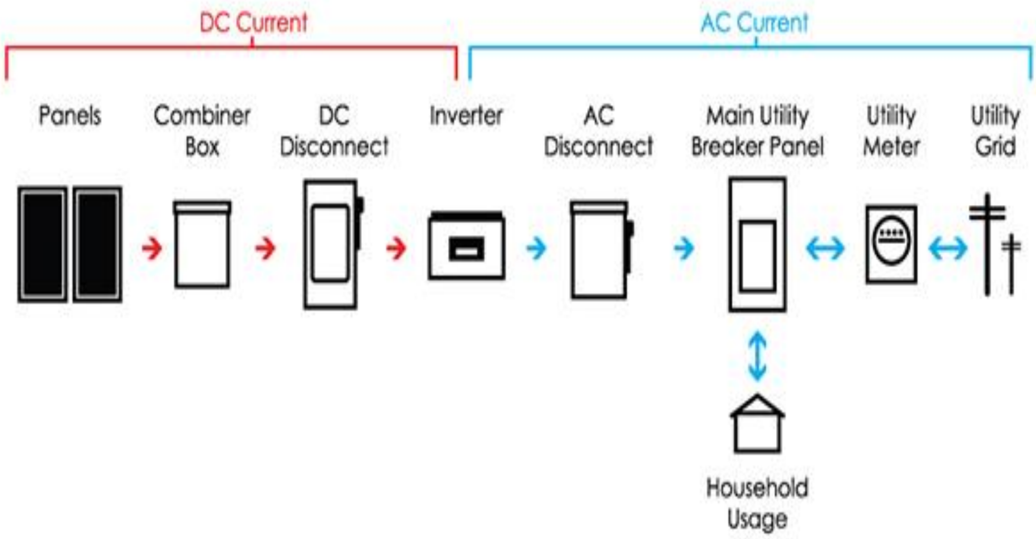

Figure (4.4): Net-metering system connection.

After these technical analysis and after the knowledge of the possible solar modules needed to cover the average consumption of these centers, it is necessary to think carefully how to distribute these systems to these centers and whether there is sufficient space for the distribution of the solar modules, so that these schemes were obtained from the Planning Department in the Civil Defense and beyond it was studied by the AutoCAD program, taking into account the coefficient of surface works, space, ventilation, spaces among these modules and the distance of the shadow among the modules, the location of the centers and the direction of the south for them. Through these schemes was applied to the center of Ram and Anabta so that the center of Tubas has the same scheme for the building of Anabta. Notice figure (4.5) and figure (4.6).

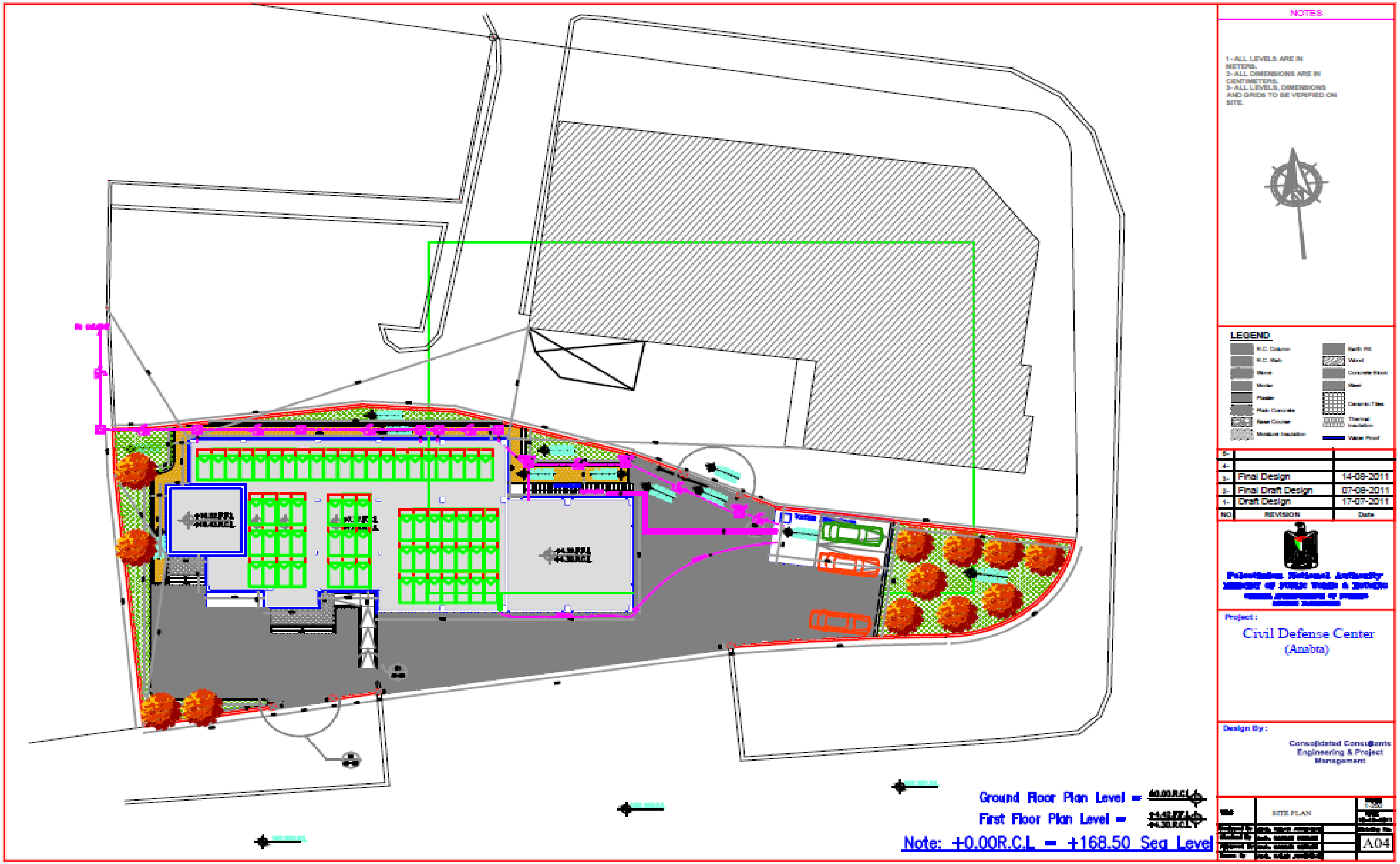

Figure (4.5): Solar modules distribution for Anabta C.D.C.

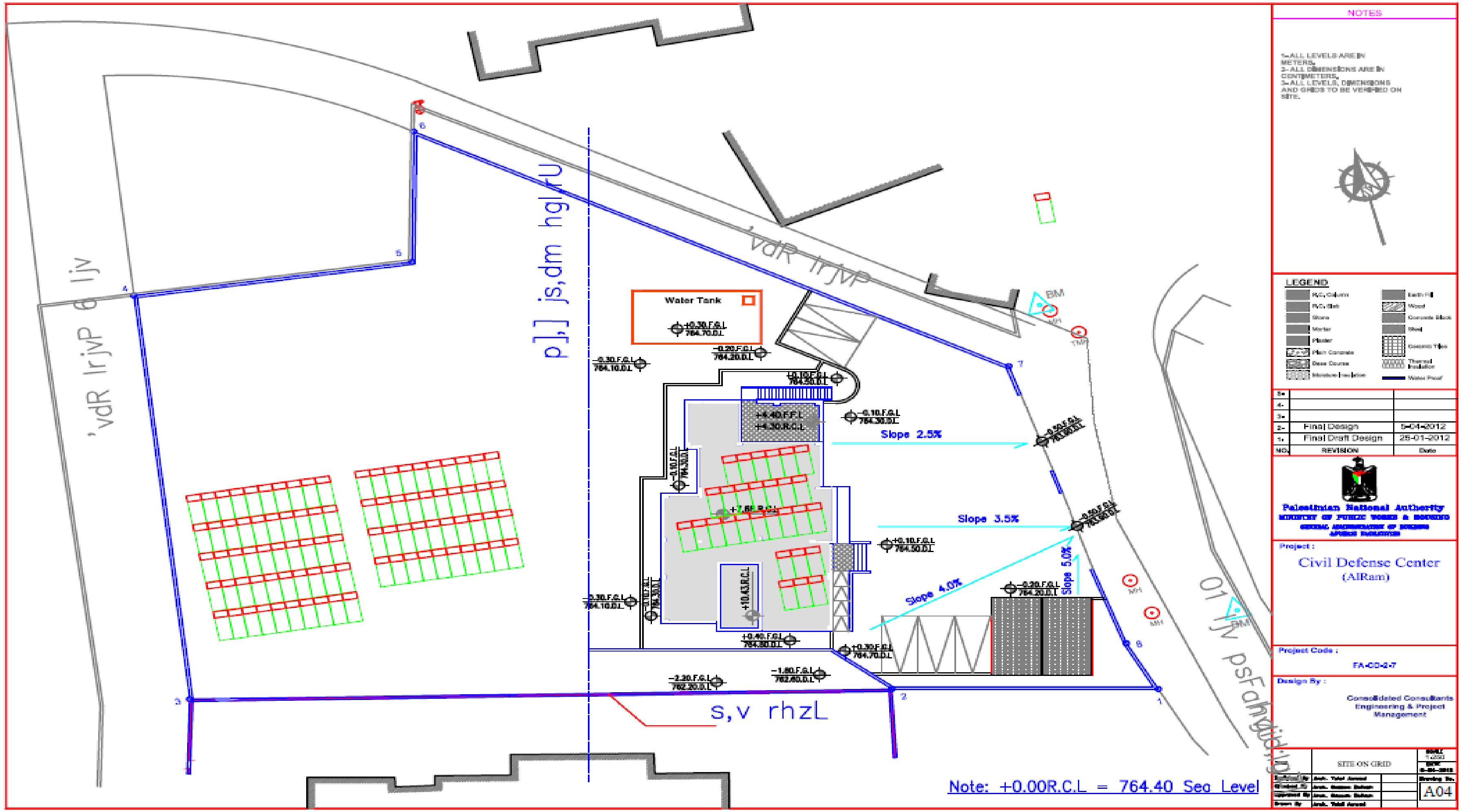

Figure (4.6): Solar modules distribution for Ram C.D.C.

According to figure (4.5) and figure (4.6); the design of these centers are almost similar and there is an enough space to distribute the solar modules freely whether were on the rooftops or outside.

4.3 Impacts of PV systems installation in Civil Defense Centers

After studying the previous centers in terms of the nature of the load and space available for the implementation of solar energy, and after the positive results found ; it is necessary to examine the feasibility of these projects financially as well as the savings and the payback period (PBP) for these projects. The instructions in the manual for net metering instructions as mentioned previously were implemented and an Excel file was used to help in the feasibility study and the payback period for any wanted project.

In the table (4.3), the following data were taken into account for studying the financial feasibility and calculating the project payback period as fixed values for all projects.

Table (4.3): The Essential Values for Calculating the PBP by using the Net Metering Instructions.

Term	Value
Commercial Tariff	0.6248
VAT (%)	16%
1$= (IL)	3.5
% Transfer of energy	75%
Cost of 1kWp ($)	1100$
O&M (IL)	308$

According to these data in table (4.3), the results were as following in tables (4.4), (4.5) and (4.6) for Anabta, Ram and Tubas centers respectively:

Table (4.4): Payback Period Study for Anabta Center.

	Consumption (kWh)	Cost (IL)	Practical (kWh/kWp)	Production (kWh)	Surplus (kWh)
Apr	3,100	2,246.78	143	2,850	-250
May	4,480	3,246.96	180	3,600	-880
Jun	3,280	2,377.24	186	3,720	+440
Jul	3,200	2,319.26	189	3,780	+580
Aug	2,920	2,116.32	189	3,780	+860
Sep	3,580	2,594.67	143	2,850	-730
Oct	4,900	3,551.36	109	2,175	-2,725
Nov	3,400	2,464.21	79	1,575	-1,825
Dec	4,900	3,551.36	68	1,350	-3,550
Jan	4,900	3,551.36	68	1,350	-3,550
Feb	4,600	3,333.93	68	1,350	-3,250
Mar	3,400	2,464.21	105	2,100	-1,300
Total	**46,660**	**33,817.67**	**1,524**	**30,480**	**-16,200**

According to these results the PBP is the time at which the initial cash outflow of an investment is expected to be recovered from the cash inflows generated by the investment, so the formula needed to calculate PBP of a project really depends on whether the cash flow per period from the project is even or uneven. In case they are even, the formula to calculate payback period is: [28]

$$\text{Payback Period} = \frac{\text{Initial Investment}}{\text{Cash Inflow per Period}} \tag{4.1}$$

When cash inflows are uneven, we need to calculate the cumulative net cash flow for each period and then use the following formula for payback period:

$$\text{Payback Period} = A + \frac{B}{C} \tag{4.2}$$

the constants in the above formula represents:

A is the last period with a negative cumulative cash flow; **B** is the absolute value of cumulative cash flow at the end of the period A; **C** is the total cash flow during the period after A.

So the PBP for Anabta centre equal to **3.68** years. For full data notice appendix (6).

Table (4.5): Payback Period Study for Ram Center.

	Consumption (kWh)	Cost (IL)	Practical (kWh/kWp)	Production (kWh)	Surplus (kWh)
Apr	4,100	2,971.55	143	2,850	-1,250
May	4,200	3,044.03	180	3,600	-600
Jun	4,000	2,899.07	186	3,720	-280
Jul	2,500	1,811.92	189	3,780	+1,280
Aug	2,700	1,956.87	189	3,780	+1,080
Sep	3,700	2,681.64	143	2,850	-850
Oct	3,500	2,536.69	109	2,175	-1,325
Nov	6,600	4,783.47	79	1,575	-5,025
Dec	6,000	4,348.61	68	1,350	-4,650
Jan	5,400	3,913.75	68	1,350	-4,050
Feb	5,200	3,768.79	68	1,350	-3,850
Mar	4, 800	3,478.89	105	2,100	-2,700
Total	**52,700**	**38,195.27**	**1,524**	**30,480**	**-22,220**

The PBP for Ram centre also equal to **2.03** years. For full data notice appendix (6).

Table (4.6): Payback period study for Tubas Center.

	Consumption (kWh)	Cost (IL)	Practical (kWh/kWp)	Production (kWh)	Surplus (kWh)
Apr	6,964	5,034.24	143	5,415	-1,531
May	5,403	3,915.92	180	6,840	+1,437
Jun	6,523	4,727.66	186	7,068	+545
Jul	5,723	4,147.85	189	7,182	+1,459
Aug	7,003	5,075.55	189	7,182	+179
Sep	8,124	5,888.02	143	5,415	-2,709
Oct	7,964	5,772.05	109	4,132	-3,381.5
Nov	8,404	6,090.95	79	2,992	-5,411.5
Dec	7,964	5,772.05	68	2,565	-5,399
Jan	7,804	5,656.09	68	2,565	-5,239
Feb	8,203	5,945.27	68	2,565	-5,638
Mar	6,203	4,495.74	105	3,990	-2,213
Total	**86,264**	**62,521.39**	**1,524**	**57,912**	**-28,352**

The PBP for Tubas centre also equal to **3.57** years. For full data notice appendix (6).

4.4 Summery

The high commercial tariff nowadays and the quality of solar energy in Palestine, as well as the recent Palestinian laws and instructions that governing the renewable energy projects, oriented us to think more about using the net-metering instructions to cover civil defense centers, which the values of peak power needed from the photovoltaic systems for civil defense centres in ranges from 19.2 – 38.4 kW_p, so these achieve a saving approximately between 22,100 – 43,000 IL per year for invoices, with a payback periods not exceeding 4 years, but the COE of these projects and the economic and environmental impact are very important issue to discuss as in chapter 5.

Chapter Five

Economical and Environmental Impact of PV System Installations in Civil Defense Centers

5.1 Economical Analysis of installation of PV systems in Civil Defense Centers

The economic analysis of any solar energy projects requires consideration of the concept of the life cycle cost (LCC) of the project, which is defined as the sum of present worth (*P*) for all components that the project required including the initial costs, operational and maintenance costs and the salvage values.

5.1.1 PV Systems Initial Costs

The initial costs of the on-grid PV system depends on the capacity of the project and consist of the price of PV-modules, inverters, transformers, wires, labors, technician’s wages and any other components needed.

The PV- modules are available in different capacities and types, in which the capacity of these determined by the Peak watt at STC. The price of mono-crystalline and for the poly-crystalline modules are the same, but the installation costs for these are different depending on establishing these projects.

The grid-tie inverters are also the same, which available with different capacities, where the price of these depends on their capacities, efficiency, protection, MPPT controller and others.

Other initial costs can be considered in our calculation for any project, such as shipping costs, wires costs, room's costs, protection components costs, accessories costs, land use costs and others, which also varies according to the size of the project.

5.1.2 PV Systems Operation and Maintenance Costs

The operation and maintenance costs come after establishing the project in order to let the system run for a specified number of years called the life cycle of the project where these costs can be fixed or variable.

5.1.3 PV Systems Salvage Value

Salvage value (S) is the estimated resale value of an asset at the end of its useful life. Salvage value is subtracted from the cost of a fixed asset to determine the amount of the asset cost that will be depreciated. Thus, salvage value is used as a component of the depreciation calculation. Notice formula (5.1) that shows how to calculate this value.

$$S = P\,(1-i)^{y} \qquad (5.1)$$

Where; P = the original price

i = Depreciation rate

y = age of project

Figure (5.1), represents and illustrates the cash flow for all costs where will be during the life cycle of the PV project.

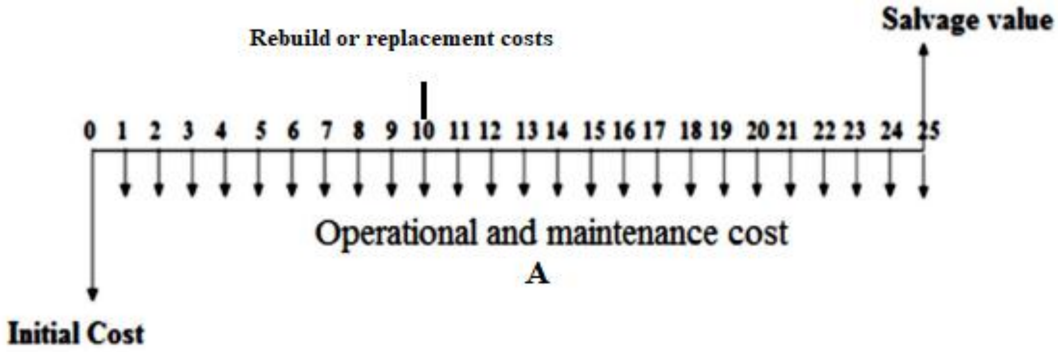

Figure (5.1): The cash flow of PV project represents the initial, O&M and salvage revenue.

To calculate the energy unit price generated from the PV system projects, it is necessary to calculate the annual worth (Aw) value, which to do it, it is important to change all values to the present value which these can be calculated according to the following formulas:

$$P = F\,(1/\ 1+i)^{n} \qquad (5.2)$$

$$Aw = P\,(i\,(1+i)^{n} / (1+i)^{n} - 1) \qquad (5.3)$$

$$(\$/kWh) = Aw / \text{Total kWh produced annually} \qquad (5.4)$$

Where; P = Present worth, value or amount.

Aw = Annual worth or uniform amount per specified period.

F = Future worth, value or amount.

i = Discount rate.

n = no. of the expected life of the project.

All projects according to the net –metering instructions are viable projects and the recovery period is good even if the tariff for the net-metering or the tariff from the supplier increased. Figures (5.2), (5.3) and (5.4) show the cash flow for the last three centers respectively.

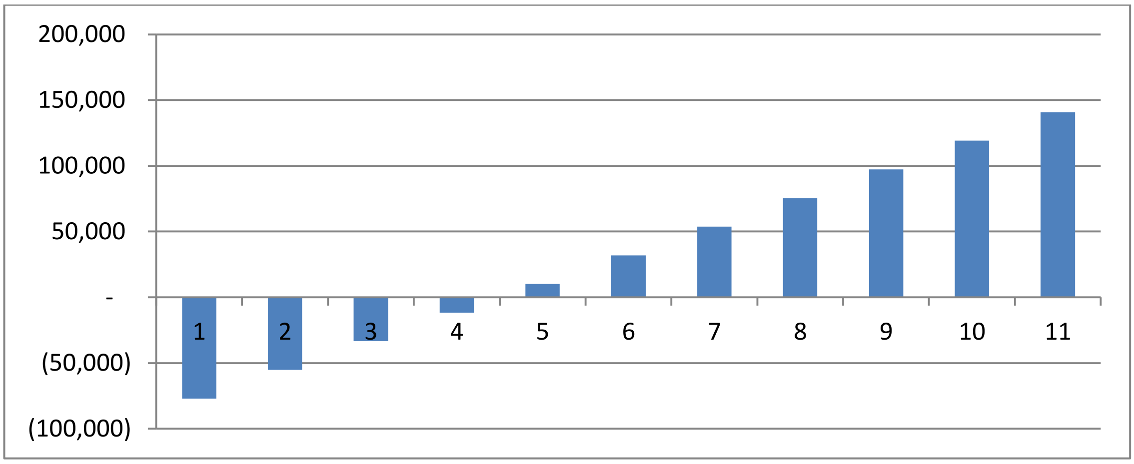

Figure (5.2): Cash flow diagram for Anabta Center.

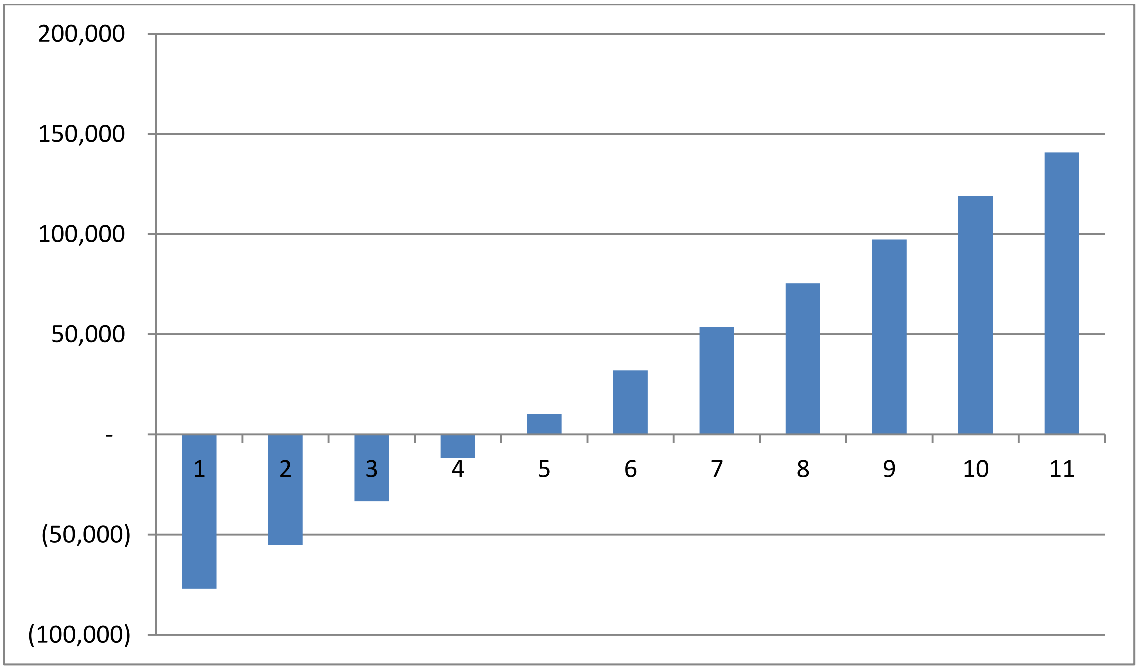

Figure (5.3): Cash flow diagram for Ram Center.

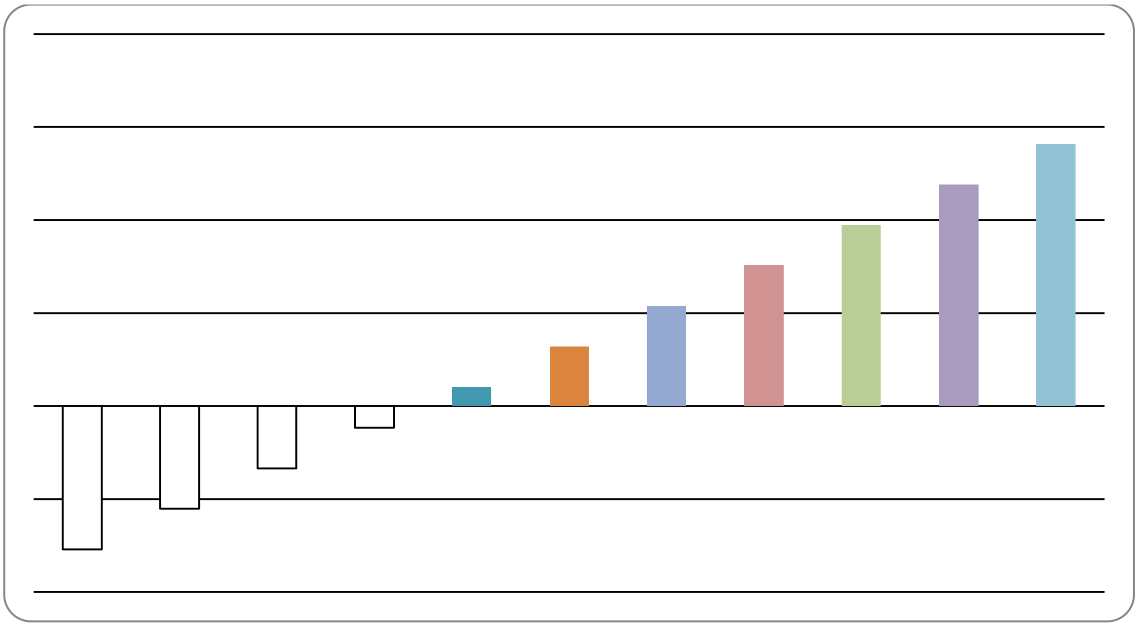

Figure (5.4): Cash flow diagram for Tubas Center.

As a result of this analysis and referring to appendix (5); Applying Net-metering instructions on the civil defense centres will achieves a saving approximately between 22,100 – 42,000 IL per year for invoices.

According to these formulas it is necessary to use the tables of the discount rate so to make the simulation more easy it is better to think about using the HOMER program as used in this following section (5.2).

5.2 Economic Impact of PV installations in Civil Defense Centers

It is known that the electrical tariff of government institutions is the commercial tariff, which is characterized by being the highest electrical tariff among all categories applied, which amounts to 0.1785 $ / kWh for the post-paid electrical meters, as well as 0.1704 $ / kWh of pre-paid electrical meters without the value added tax of 16%, that according to the system issued by the Council of Ministers for the tariff of electricity in

2017 [29], which causes fatigue to government institutions and high financial burdens, so therefore it was worth thinking about other solutions and exploitation of renewable energy projects, this is due to its availability and the existence of laws and regulations regulating the work mechanisms to support the exploitation of such projects in order to reduce consumption and dependence on others in electric power and reduce their operating costs and to obtain competitive electricity tariffs.

The energy produced from the PV systems for whole life cycle can be calculated as the following formula considering the irradiation characteristics in Palestine as mentioned in chapter 1:

$$(kWh / year) = Peak\ Power\ (kW_p) \times Peak\ hour\ (PH/day) \times 356 \times PR\ (\%). \quad (5.5)$$

Where, the performance ratio (PR): 75% (for whole system), and peak irradiation hour per day equal to 5.5hr, as well as the Global Horizontal Irradiation (GHI) approximately between 5.2- 5.5 peak hour per day.

To get the lowest COE for the last three civil defense centers that have been taken in consideration as a case study of a commercial loads, according to the daily load curves in figures (2.3), (2.4) and (2.5), and the previous laws in the previous chapter by using HOMER program, all of the available options should be considered and then making a comparison among them, where the COE can be defined as the average cost per kWh of useful electrical energy produced by the proposed system. In other words, there is a term called the Levelized Cost of Energy (LCOE), which is known as the price at which electricity must be generated from a specific source to break even over the lifetime of the project. It can be calculated in a single formula as: [30]

$$LCOE = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}} \tag{5.6}$$

Where, It = Investment expenditures in year t.

Mt = operations and maintenance expenditures in year t.

Ft= fuel expenditures in year t, which is zero for photovoltaic electricity.

Et = electricity generation in the year t.

r= discount rate.

n = investment period considered in years.

5.2.1 Centers Load Feeding by Grid and PV system

In this case, it has been proposed to feed the center loads from the electrical networks and solar cell systems with 20%, 40%, 80% and 100% from the PV system to show the impact of net metering projects that allow the installing of projects with capacities up to 100% of the average consumption rate. Tables (5.1), (5.2) and (5.3) show the results of these assumptions.

Table (5.1): Comparison Table of Load Feeding by Grid and PV System for Anabta Center.

Case No.	Option	COE ($/kWh)
1	20% PV	0.157
2	40% PV	0.122
3	80% PV	0.0693
4	100% PV	0.015

Table (5.2): Comparison Table of Load Feeding by Grid and PV System for Tubas Center.

Case No.	Option	COE ($/kWh)
1	20% PV	0.150
2	40% PV	0.122
3	80% PV	0.066
4	100% PV	0.039

Table (5.3): Comparison Table of Load Feeding by Grid and PV System for Al-Ram Center.

Case No.	Option	COE ($/kWh)
1	20% PV	0.154
2	40% PV	0.128
3	80% PV	0.0651
4	100% PV	0.0366

According to the last tables; all COE came less than the commercial tariffs applied to these centers regardless of the percentage of contribution by the solar cell projects. This gives a good impression on the use of renewable energy projects connected to the grid and the application of net metering instructions. Notice figure (5.5).

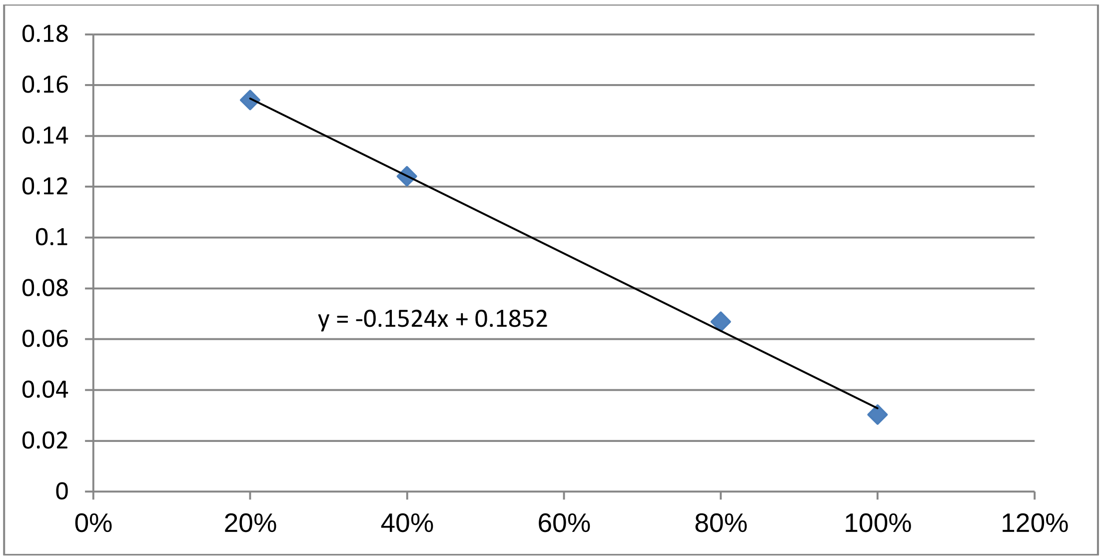

Figure (5.5): COE vs. percent of PV system used to cover the load.

As a result of the variation of COE because of the variation of PV system installed can be represented by the following formula:

$$Y = -0.1524x+0.1852 \tag{5.7}$$

Where; Y = COE.

X = the percent between the load and the PV system installed.

5.3 Environmental Impact of PV installations in Civil Defense Centers

Every energy generation and transmission method affects the environment, which it is obvious conventional generating options can damage air, climate, water, land and wildlife, landscape, as well as raise the levels of harmful radiation, while the sustainable technologies are substantially safer offering a solution to many environmental and social problems.

Generally; solar energy technologies provide obvious advantages in comparison with conventional technologies, thus contributing to the sustainable development of human activities, which it is not continuing the depletion of the exhausted natural resources, so their main positive side is related to reduced CO_2 emissions, because these kinds of technologies don't have any emissions or waste product during the life cycle of the project, as well as there is no noise during the generating procedure or no chemical pollutant during use. It is one of the most viable renewable energy technologies for use in an urban environment, replacing existing building cladding materials.

The amount of CO_2 emission savings from the photovoltaic power generation approximately is between 0.6 – 1.0 kg/kWh, as it is for the distributed photovoltaic power generation. According to appendix (1); Table (5.4) illustrates important information as a result for this thesis for the most important C.D.C that varies with their loads. [31]

Table (5.4): The most Important C.D.C. that varies with their Loads and their Results.

C.D.C	PV Capacity kWp	Cost of project (IL)	Expected output (E/yr)	Expected Saving (IL)	Saving (Co_2) ton /year
Anabta	19.2	73,920	28,908	21,258	17.346
Tubas	38.4	146,300	57,214	43,161	57.82
Ram	19.2	73,920	28,908	21,258	17.346
Jenin	19.2	73,920	28,908	21,258	17.346
Tulkarm	35	134,750	52,697	38,700	31.62
Dura	10	38,500	15,056	11,358	9.06

According to the civil defense centers; the energy generated yearly from the PV systems is between (28.91 MWh/yr. – 57.82 MWh/yr.) which the savings in CO_2 will be usually between (17.346 tons - 57.82 tons).

5.4 Summary

This chapter discussed the economic impact of using PV systems according to determining the capital costs of these projects during the life cycle and how they affects the COE, as well as discussed the environmental impacts of using these projects on the emissions such as CO_2.

Chapter Six

Results, Conclusion and Recommendation

6.1 Results and conclusion

1. The Palestinian territories have high solar radiation potential in average GHI is higher than 1900kWh/km^2 and DNI is higher than 2000 kWh/km^2, what indicates good conditions for development of solar industry.

2. The most stable GHI values in the Palestinian territories are observed in Jericho.

3. The best solar potential conditions can be at the lowest DIF/GHI ratio in Hebron and Ramallah, while the higher ratio noticed in Jericho.

4. The optimum tilt angle for the Palestinian territories is assumed to be 27^o.

5. The less stable DNI conditions are from October to April and the highest value of DNI is reached in Hebron.

6. In the Palestinian territories, the lowest solar energy average is in January with amounts about 2.47kWh/m^2-day, while the highest value is in June, with amounts equal to 6.93kWh/m^2-day.

7. Every civil defense centre in the Palestinian territories covers a population between 48,041 to 641,170 as minimum and maximum values respectively and covers areas also between 166 to 997 km^2 for everyone.

8. The efficiency of the civil defense site is determined by reducing the time of arrival, coverage of the service area and spatial dimension.

9. The current consumption of the civil defense centres varies between 350-1150 $/ month, where the average load varies between 5.4 to 11.5 kW, so the centers are increasing rapidly that will make expenditure is very cumbersome.

10. The projects of solar energy in Palestine oriented towards On-grid projects because of its advantages, where the organizing laws are divided to feed in tariff or Net metering instructions

11. In feed in tariff any citizen can install a system of solar cells and sell the electricity generated at a preferential price, while for net-metering instructions not all electrical energy produced is purchased, but exchanged with the network.

12. The values of peak power needed from the photovoltaic systems for civil defense centres range from 19.2 – 38.4 kW_p, which most these centres have the same shape and space, as well as there is an enough spaces for establishing PV systems in these centres.

13. Applying Net- metering instructions on the civil defense centres will achieves a saving approximately between 22,100 – 42,000 IL per year for invoices.

14. Depending on the electrical behaviour of the civil defence centres, and the applying of the net-metering instructions, we found that all payback periods were in a suitable period not exceeding 4 years.

15. The COE at using PV system that covering 100% of the average consumption is the best case, which the COE was between 0.015 – 0.039 $/KWh less than the commercial tariff.

16. The energy generated yearly from the PV systems for civil defense centers was between (28.91 MWh/yr. – 57.82 MWh/yr.), which the savings in CO_2 will be between (17.346 tons - 57.82 tons).

6.2 Recommendations

1. Taking in our consideration the provision of sufficient space on the surfaces or near the centers to be able to install the PV system on almost the area.

2. Working on the conservation strategies in the centers and in the newest ones before starting to design the PV systems.

3. Designing the staircase in new centers to be in the northern side to avoid the shadows on of this and the effects of PV systems.

4. Designing the roofs of the new centers to be able to establish the PV systems and equipped with all installations needed and grounding system.

5. Selecting small standalone generators, so that helps to reduce the amount of diesel consumed and the GHG.

6. The responsible ministries should strengthen the relations with the national and international donors to support these kinds of projects.

7. It is important to expedite the process of drafting legislation that governing the renewable energy projects and finding new mechanisms to encourage the investors.

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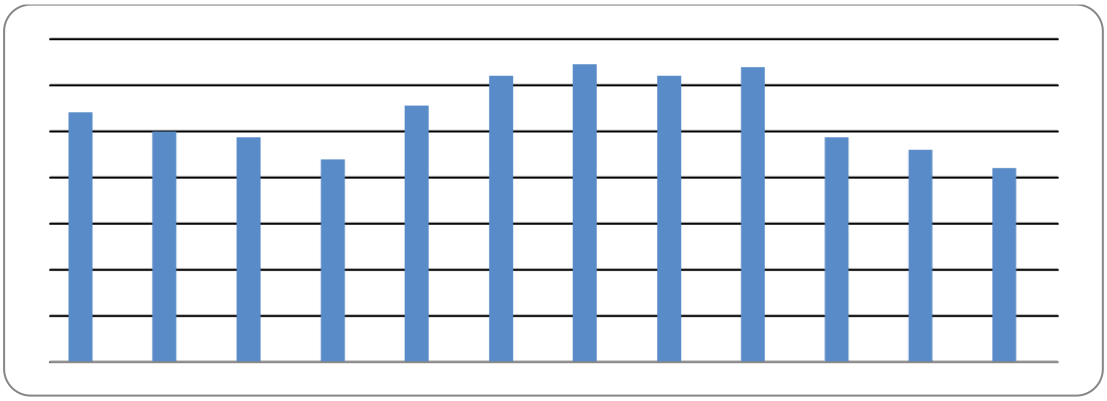
Appendix (1)

Load Curves for most of Civil Defense Centers

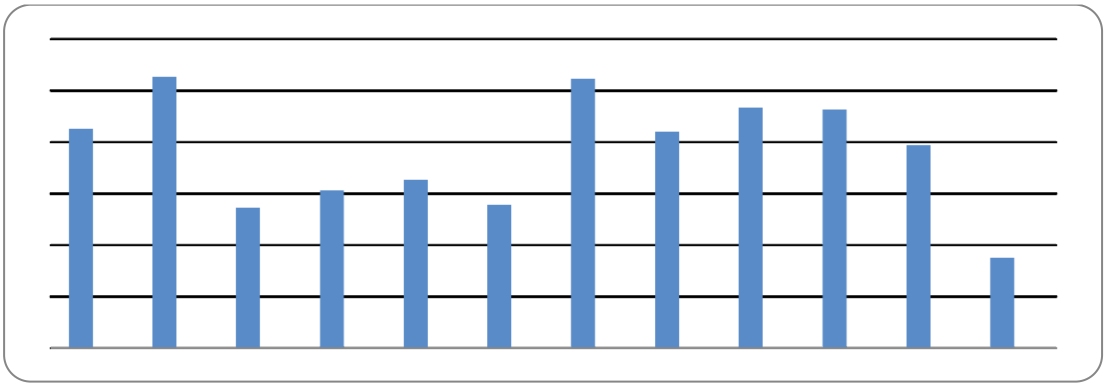
Average of electrical consumption for Civil Defense Centers

Hint : the valuse in the X-axis represents the number of month and the Y-axis represents the cost of cosumption in NIS.

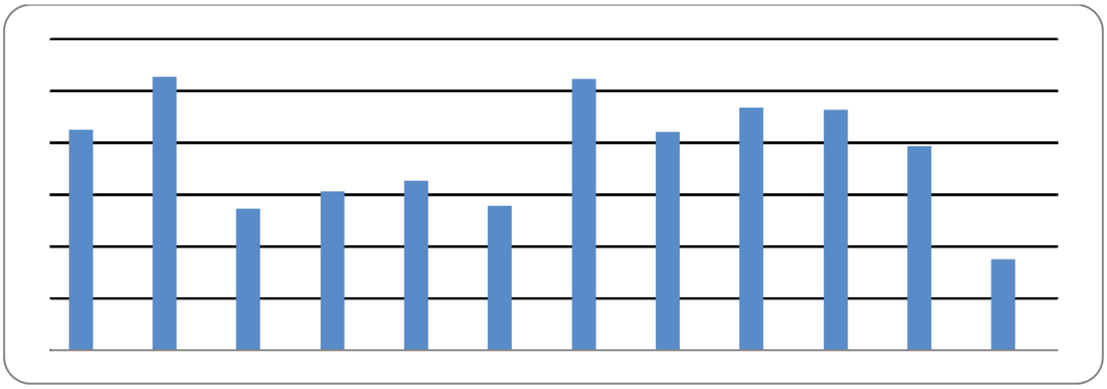
- The center of Marj Ben Amer / Jenin



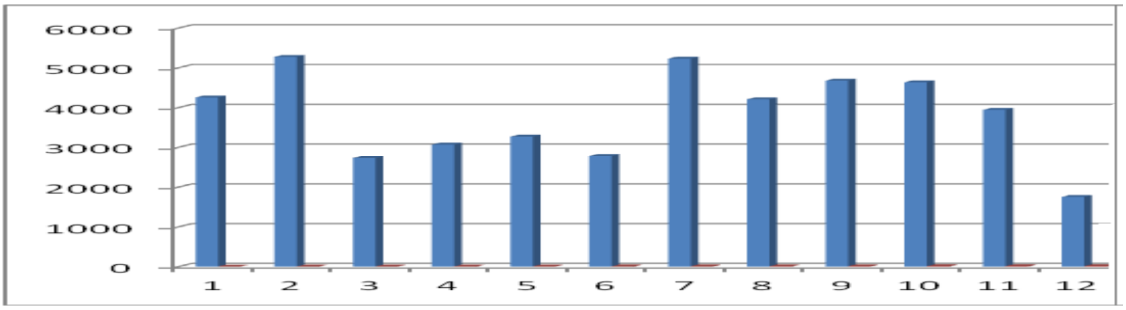
- Tulkarm Civil Defense Center



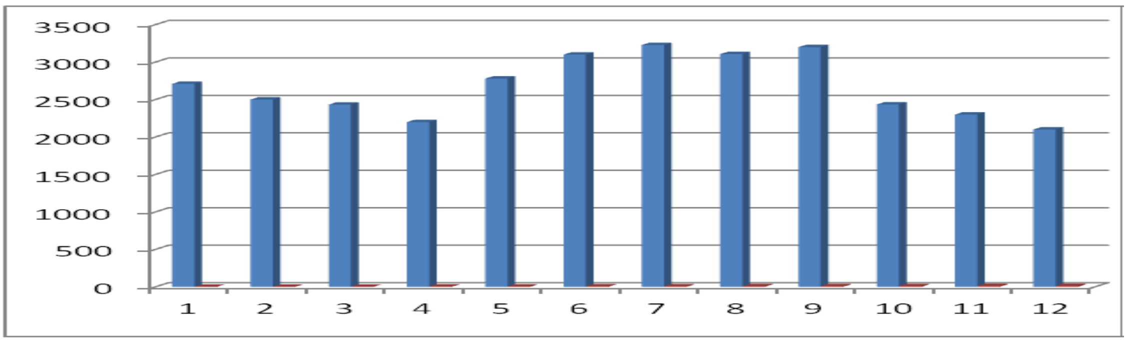
- Al-Taybah Center / Ramallah



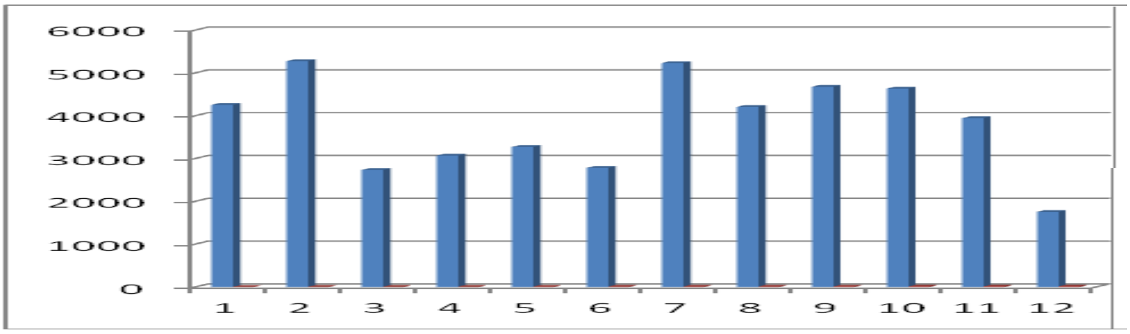
-Bethlehem Center



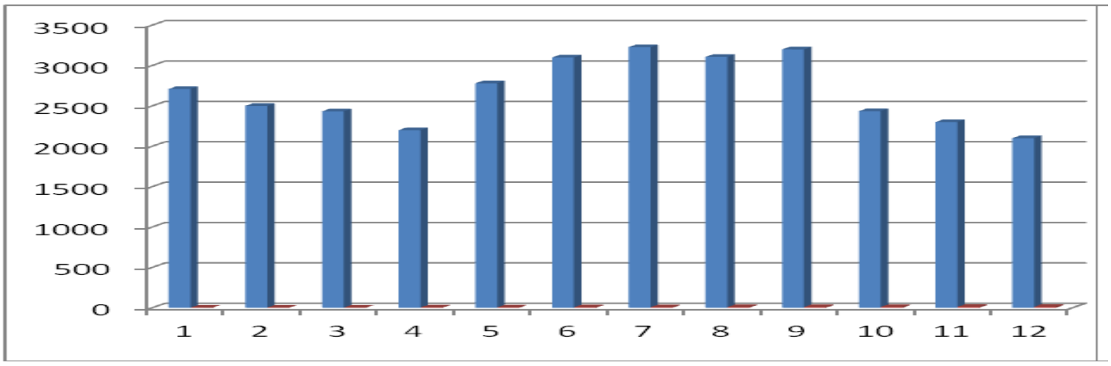
-Qalqiliya Civil Defense Center



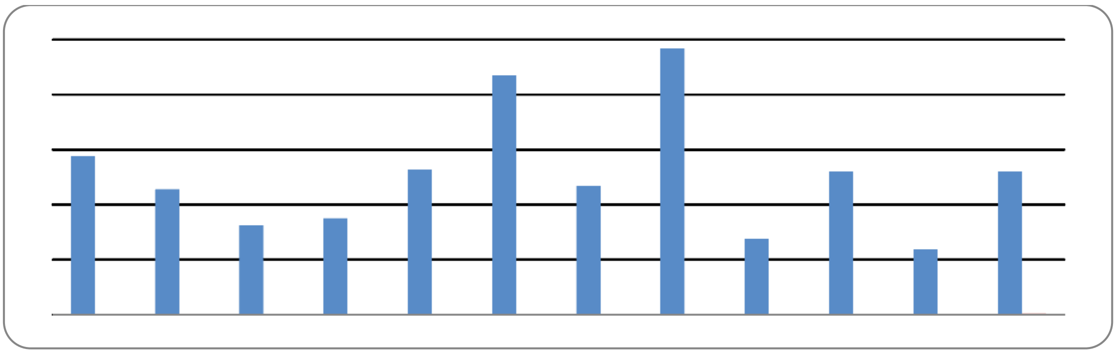
-Bedia center/ Salfit



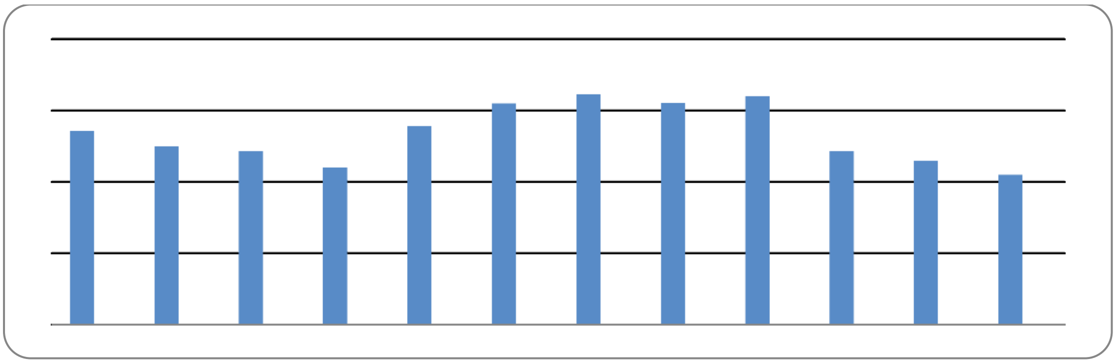
-Al-Daheriah center/ Hebron



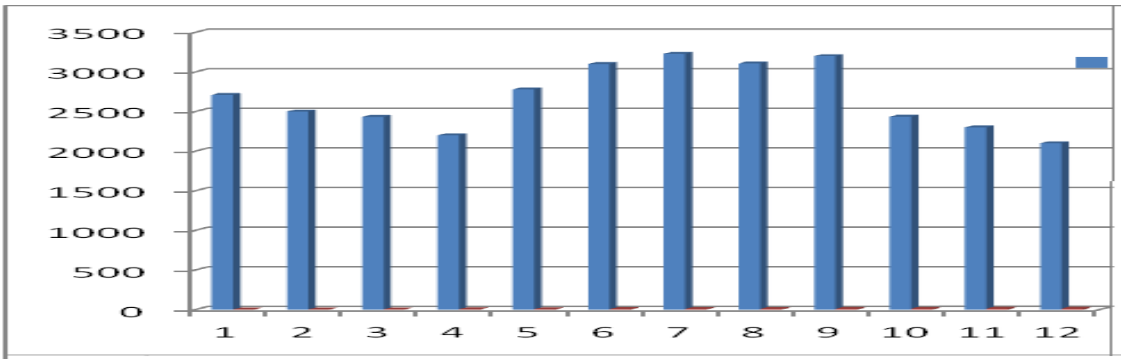
-Dura center/ Hebron



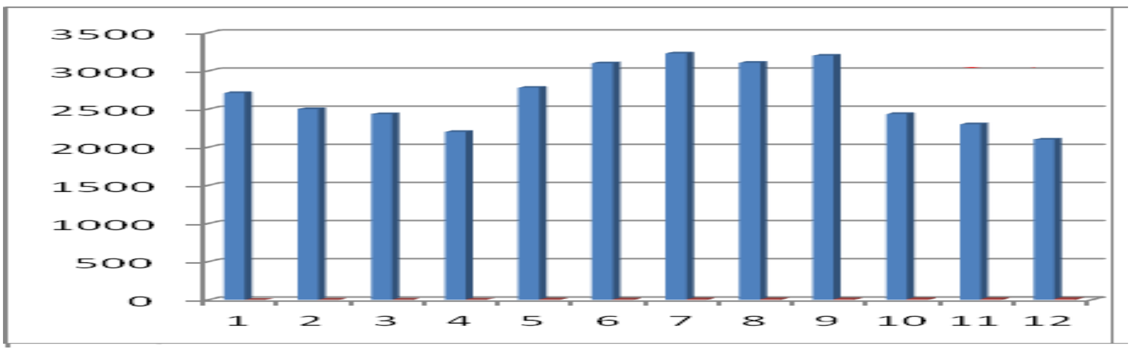
-Yatta center/ Hebron



-Balatah center/ Nablus



-Northern Asira Center/ Nablus



Appendix (2)

Net Metering Instructions

الدليل الارشادي

<u>تعليمات منظمة لمشاريع الطاقة المتجددة</u>

<u>المربوطة على شبكة الكهرباء بنظام صافي</u>

<u>القياس</u>

مقدمة

بناء على المادة الخامسة من التعليمات المنظمة لمشاريع الطاقة المتجددة المربوطة على شبكة الكهرباء بنظام صافي القياس الصادرة بقرار من مجلس الوزراء رقم (17/77/04/م.و/ر.ح) لعام 2015، تم اصدار هذا الدليل الارشادي للتعليمات بعد موافقة مجلس تنظيم قطاع الكهرباء الفلسطيني.

التعريفات

الطاقة المتجددة: الطاقة البديلة الناتجة من مصادر طبيعية لها طابع الديمومة والاستمرارية.

سلطة الطاقة: سلطة الطاقة والموارد الطبيعية الفلسطينية.

المجلس: مجلس تنظيم قطاع الكهرباء الفلسطيني.

المشترك: أي شخص طبيعي أو اعتباري يتم تزويده بالطاقة الكهربائية بشكل دائم.

المشروع: نظام الطاقة المتجددة الخاضع لتعليمات صافي القياس والذي يقوم المشترك بتركيبه.

نظم مصادر الطاقة المتجددة: النظم والمعدات التي تستخدم لاستغلال مصادر الطاقة المتجددة لإنتاج الطاقة.

منشأة الطاقة المتجددة: المنشأة التي تستخدم نظم مصادر الطاقة المتجددة لإنتاج الطاقة وفقاً للاشتراطات والمعايير التي تحددها سلطة الطاقة لهذا الخصوص وخاصة بالمشترك.

الموزع: أي شركة تقوم بتوزيع الطاقة الكهربائية على المشتركين ومرخص لها.

التعليمات: تعليمات صافي القياس المقرة من مجلس الوزراء

كود التوزيع: نظام تضعه سلطة الطاقة يحدد الشروط والأنظمة الخاصة بتصميم وإنشاء وتعديل وتشغيل وصيانة أصول شبكات التوزيع والعلاقة بين شركات التوزيع وكافة مستخدمي شبكة التوزيع لضمان استقرار وكفاءة واقتصادية شبكة التوزيع.

الدليل الارشادي: القواعد التي يضعها الموزع وفقا للمرجعيات التنظيمية وتتضمن اجراءات وشروط الربط وتحديد متطلباته على شبكة الكهرباء لنظام صافي القياس وتتم الموافقة عليه من قبل المجلس.

نقطة الربط: نقطة توصيل المشروع او ادواته مع الشبكة وفيها نقطة قياس الطاقة الكهربائية للمنشأة .

قدرة المشروع: هي القدرة الفعلية للمشروع على التيار المتردد (AC power)

المادة (1): احكام وشروط عامة

أ. ان يكون المشترك مسددا لجميع الذمم المستحقة عليه للموزع أو متفق مع الموزع على جدولتها.

ب. ان يكون المشترك لديه اشتراك دائم لدى الموزع.

ت. الالتزام بتركيب مواد ذات مواصفات فنية مطابقة للمواصفات الفلسطينية حسب الملحق رقم (1).

ث. الالتزام بشروط الموزع الفنية بخصوص المشروع ونقطة الربط وفقا للملحق (1).

المادة (2): المعايير الفنية

أ. تطبق هذه المواد الواردة في هذا الدليل على المشاريع التي لا تزيد قدرتها عن 1000 كيلوواط ضمن فئة المشاريع المتعلقة بالاستهلاك الذاتي.

ب. بما لا يتعارض مع التعليمات، يجب ان لا تزيد كمية الطاقة الكهربائية السنوية المنتجة من المشروع عن 100% من متوسط كمية الطاقة الكهربائية السنوية المستهلكة من قبل المشترك.

ت. في حال كان المشترك لم يكمل سنة في اشتراكه بحيث لم يعلم الاستهلاك السنوي الحقيقي؛ يجب أن لا تزيد كمية الطاقة الكهربائية السنوية المنتجة من المشروع عن 50% من متوسط كمية الطاقة الكهربائية السنوية المقدرة للاستهلاك والمعتمدة من الموزع. على أن يكون بمقدور المشترك زيادة قدرة المشروع بعد مرور سنة على بدء تسجيل الاستهلاك السنوي بناء على النقطة ب من هذه المادة.

ث. بما لا يتعارض مع النقطة (أ) والنقطة (ب)، فان قدرة المشروع يجب ان لا تزيد عن قدرة اشتراك المنشأة المقدرة من الموزع او قدرة المحول المغذي اذا كان خاصا.

ج. يتم تقدير قدرة المشروع بناء على الملحق رقم (2).

ح. على الموزع دراسة وضع الشبكة من الناحية الفنية بالنسبة لقدرات مشاريع الطاقة المتجددة المربوطة عليها ويكون للموزع قرار تحديد امكانية قبول ربط مشاريع اضافية على شبكته من الناحية الفنية.

المادة (3): العدادات

أ. يستبدل عداد المشترك القائم بعداد ذو اتجاهين (Bidirectional meter) لقياس الطاقة الكهربائية المستهلكة من الموزع، والطاقة المصدرة من المشروع الى شبكة الموزع وفقا للملحق (3)، ويتحمل المشرك سعر العداد الجديد.

ب. في حال عدم توفر العداد المذكور في النقطة السابقة (أ)؛ يتم اضافة عداد لقياس الطاقة الكهربائية المصدرة من المشروع الى شبكة الموزع وفقا للملحق (3) مع استمرار وجود عداد لقياس الطاقة الكهربائية المستهلكة من الموزع، ويتحمل المشترك سعر العداد الجديد.

في حال كان عداد استهلاك المشترك هو عداد مسبق الدفع فعلى الموزع استبداله بعداد استهلاك عادي وذلك لصعوبة إجراء التسوية المالية وعلى حساب المشترك.

المادة (4): الاحتساب والتعرفة

أ. يقوم الموزع باصدار تقرير شهري يبين كمية الطاقة المصدرة من المشروع الى شبكة الموزع والطاقة المستهلكة من الموزع.

ب. في حال كانت كمية الطاقة المستهلكة أكبر من كمية الطاقة المصدرة يقوم المشترك شهرياً بتسديد قيمة صافي كمية الطاقة الكهربائية المترتبة عليه.

ت. في حال كانت كمية الطاقة المستهلكة اقل من المصدرة يقوم الموزع بتدوير فائض الطاقة الكهربائية الى حساب الشهر الذي يليه مخصوماً منها النسبة المقرة في النقطة (ب) من المادة الأولى حسب ملحق قرار التعرفة الصادر من مجلس الوزراء رقم (17/77/03/م.و/ر.ح) لعام 2015.

ث. يتم عمل تسوية مالية في نهاية السنة الانتاجية للمشروع (1 نيسان – 31 اذار) بحيث يتم تدوير رصيد الطاقة المصدرة لصالح المشترك خلال سنة انتاجية واحدة فقط وفقا للملحق (4).

المادة (5) : اختلاف مكان المشروع والاستهلاك

أ. بما لا يتعارض مع شروط التعليمات، يحق لأي مشترك ضمن منطقة امتياز الموزع ان يقوم بإنشاء مشروع لإنتاج الطاقة المتجددة وربطه على شبكة الموزع واستهلاك الطاقة المنتجة من ذلك المشروع في مكان مختلف عن مكان المشروع بحيث يكون مكان الاستهلاك ضمن امتياز الموزع فقط، وفي هذه الحالة يقوم الموزع بخصم نسبة نقل الطاقة إلى مكان الاستهلاك المقرة حسب النقطة (ت) من المادة الأولى من ملحق قرار التعرفة الصادر من مجلس الوزراء رقم (17/77/03/م.و/ر.ح) لعام 2015.

ب. تطبق على المستفيدين من هذه المادة كافة الاجراءات والتعليمات المنظمة لمشاريع الطاقة المتجددة المربوطة على شبكة الكهرباء بنظام صافي القياس.

المادة (6): الاجراءات

أ. تقديم الطلب

1. على من يرغب بالاشتراك التقدم الى الموزع وتعبئة نموذج الطلب، حسب الملحق رقم (5).
2. يترتب على المشترك دفع رسم طلب اشتراك جديد مقداره (70) شيكل غير مستردة حسب رسوم الربط المقرة.
3. على المشترك تزويد الموزع بالدراسة الاولية لمشروعه تشمل: تصاميم المشروع وتفاصيل نقطة الربط وذلك بعد الموافقة الأولية.

ب. دراسة الطلب

1. يقوم الموزع بدراسة طلب المشترك خلال 30 يوم من تاريخ التقديم.
2. يتم دراسة اثر ربط المشروع على شبكة التوزيع ومدى مطابقة المشروع للشروط الفنية.
3. في حال وجود ملاحظات على المشروع، يتم اخبار المشترك خلال 10 ايام من تاريخ الانتهاء من الدراسة.

ت. اتفاقية الربط

1. بعد تعديل المشترك لطلبه بناء على ملاحظات الموزع، او ان الطلب كان متطابقا مع شروط الموزع فبإمكانه توقيع الاتفاقية حسب الملحق رقم (6).

2. يبدا المشترك بتنفيذ المشروع، وعليه الانتهاء منه خلال 6 شهور من تاريخ توقيع الاتفاقية، واذا لم يلتزم بهذه المدة تعتبر الاتفاقية لاغية.
3. للموزع الحق في التمديد لفترة التنفيذ بناء على طلب المشترك ولمدة 3 شهور اضافية فقط.

ث. الفحص والربط والتشغيل

1. على المشترك ان يطلب ربط مشروعه بعد تعبئته طلب فحص وربط من الموزع حسب الملحق رقم (7).
2. يقوم الموزع بفحص المشروع وموافقته للشروط المطبقة خلال 20 يوم مقابل رسوم فحص غير مستردة: (50، 150) شيكل لعداد واحد فاز وعداد ثلاثة فاز على التوالي حسب رسوم الربط المقرة.
3. في حال عدم موافقة المشروع مع الشروط الفنية فان على المشترك ان يعدل مشروعه بما يتوافق مع ملاحظات الموزع خلال شهر واحد فقط ويقدم طلب فحص وربط جديد حسب النقطة (2) من هذه المادة.
4. في حال موافقة المشروع للشروط الفنية للموزع، فان على الموزع ربط النظام مع شبكة التوزيع وتشغيله مقابل رسوم ربط غير مستردة: (150، 450) شيكل لعداد واحد فاز وعداد ثلاثة فاز على التوالي حسب رسوم الربط المقرة.

المادة (7): علاقة الموزع والمشترك

أ. تكاليف الربط: يتحمل المشترك كافة التكاليف لربط مشروعه بنقطة الربط المقرة من الموزع.

ب. حدود المسؤولية: يعتبر المشترك مسؤولا مسؤولية مباشرة عن تشغيل وصيانة المشروع وحتى نقطة الربط، وعليه فان الموزع لا يتحمل اية مسؤولية قانونية او مالية عما يقع من اضرار نتيجة حدوث اي خلل او خطا او تغيير او سوء استخدام للمشروع.

ت. فصل المشروع:

يجوز للموزع القيام بالفصل المؤقت لنظم مصادر الطاقة المتجددة وفقاً للشروط التالية دون اية التزامات مالية:

1. في حالة الانقطاع المبرمج لنظام التوزيع وبعد إشعار المستخدم بذلك.
2. في حالة الانقطاع غير المبرمج أو الظروف الطارئة على نظام التوزيع.

ث. يجوز للموزع القيام بالفحص الدوري للمشروع لمراقبة موافقته مع الشروط الفنية، وفي حال ان المشروع غير متطابق مع هذه المعايير فعلى المشترك ان يعدل اوضاعه بما يتوافق مع الملاحظات المقدمة.

ج. في حال عدم التزام المشترك بالملاحظات الفنية، فان للموزع ان يفصل المشروع عن شبكة التوزيع دون اية التزامات مالية، وفي حال عدل المشترك المشروع بناء على الملاحظات فان الموزع يقوم بربط المشروع بناء على المادة السادسة (ث 4) من هذا الدليل.

ح. في حال التزام المشترك بالملاحظات الفنية فان على الموزع اعادة ربط المشروع.

خ. في حال رغب المشترك في الفصل المؤقت لمشروعه عليه باشعار الموزع قبل 5 ايام من يوم بدء الفصل المؤقت.

د. في حال رغب المشترك في الفصل الدائم للمشروع، عليه باشعار الموزع قبل شهر من تاريخ بدء الفصل الدائم، ويكون الاشعار مبررا.

ذ. في حال تم فصل الاشتراك يتم فصل المشروع تلقائيا وبشكل فوري.

المادة (8): أحكام نهائية

أ. يقوم المجلس بمراجعة الاحكام الواردة في قانون الطاقة المتجددة وكفاءة الطاقة وقانون الكهرباء العام لاصدار تعليمات حل الخلافات واصدار التفسيرات الخاصة بها.

ب. للمجلس أن يبت في الحالات التي لم يرد فيها نص ضمن هذا الدليل الارشادي.

ت. للمجلس ان يعيد النظر في هذه التعليمات بشكل سنوي او كلما دعت الحاجة بما لا يتعارض مع قانون الطاقة المتجددة وكفاءة الطاقة وقانون الكهرباء العام

الملحق رقم (1): نموذج الشروط الفنية

أ. من جهة التيار الثابت يجب تركيب قاطع كهربائي للصواعق (surge arrestors C.B.).

ب. في حال وجود مولد ديزل احتياطي لدى المشترك؛ يجب تركيب حساس يمنع تشغيل مشروع الطاقة المتجددة في حال تشغيل مولد الديزل.

ت. يتم تركيب العداد في لوحة العدادات الرئيسية وحال عدم وجود حيز كاف فيها يتم اضافة لوحة عداد بنفس المواصفات المقرة من الموزع للوحات.

ث. يشترط في المشاريع ذات القدرات الاكبر من (10 ك و) تركيب نظام مراقبة عن طريق الانترنت، بما يمكن الموزع من مراقبة المشروع، وتكون تكلفته على حساب صاحب المشروع.

ج. يشترط تركيب ELCB وفقا لمتطلبات المنشأة.

ح. التأكد من ان محول المشروع لا يستمر في العمل حال انقطاع مصدر الكهرباء من الشبكة.

خ. الهيكل الحامل للالواح اما ان يكون المنيوم خاص بنظم الطاقة المتجددة او حديد مجلفن

د. يشترط في المشاريع ذات القدرات الاكبر من (10 ك و) مراجعة الجهات ذات العلاقة بخصوص سلامة المشروع العامة وعدم وجود ما يضر بسلامة المنشأة او السلامة العامة للمحيط.

المواصفات المطلوب احضار مطابقة لها من مؤسسة المواصفات والمقاييس:

1. PS 2676: 2012 IEC 61215 CRYSTALLINE SILICON TERRESTRIAL PHOTOVOLTAIC PV) MODULES–DESIGN QUALIFICATION AND TYPE) APPROVEL.
2. PS 2678: 2012 IEC 61646 THIN_FILM TERRESTRIAL PV MODULES – DESIGN QUALIFICATION AND TYPE) APPROVEL.
3. PS 2707-1: AS 4777-1 GRID CONNECTION OF ENERGY SYSTEMS VIA INVERTERS INSTALLATION REQUIREMENTS.
4. PS 2707-2: AS 4777-2 GRID CONNECTION OF ENERGY SYSTEMS VIA INVERTERS INVERTER REQUIREMENTS.
5. PS 2707-3: AS 4777-3 GRID CONNECTION OF ENERGY SYSTEMS VIA INVERTERS GRID PROTECTION REQUIREMENTS.
6. PS 2684: 2012 IEC 61730-1 Photovoltaic (PV) module safety qualification: Requirements for construction.
7. PS 2685: 2012 IEC 61730-2 Photovoltaic (PV) module safety qualification: Requirements for testing.
8. PS 2679: 2012 IEC 61683 Photovoltaic systems – Power conditioners – Procedure for measuring efficiency.

الملحق رقم (2): نموذج تحديد قدرة المشروع القصوى

لغايات احتساب قدرة المشروع؛ يتم اعتماد متوسط انتاج مشروع الطاقة الشمسية السنوي: 1500 ك و س / ك و

أ. مشترك لديه استهلاك لمدة عام فأكثر:

كمية الطاقة الكهربائية السنوية المستهلكة من قبل المشترك: .... ك و س.

قدرة اشتراك المنشأة المقدرة من الموزع (قدرة المحول المغذي الخاص): .... ك و

$$\text{قدرة مشروع الطاقة الشمسية} = \frac{\text{كمية الطاقة الكهربائية السنوية المستهلكة من قبل المشترك}}{1500}$$

ملاحظة:

قدرة مشروع الطاقة الشمسية $\leq$ قدرة الاشتراك المقدر من الموزع (قدرة المحول المغذي الخاص) $<$ 1000 ك و

ب. مشترك ليس لديه استهلاك لمدة عام:

كمية الطاقة الكهربائية السنوية المقدرة للاستهلاك من قبل المشترك: .... ك و س.

قدرة اشتراك المنشأة المقدرة من الموزع (قدرة المحول المغذي الخاص): .... ك و

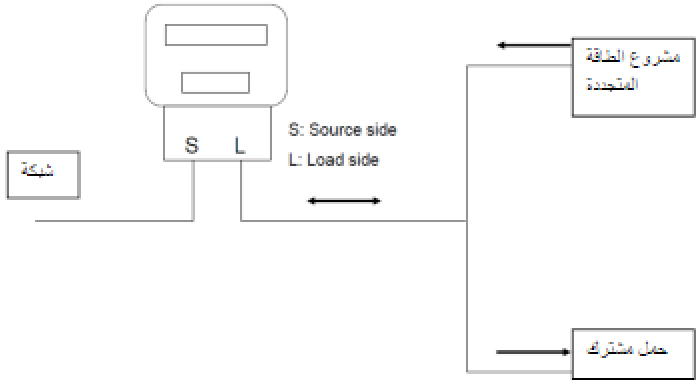
$$\text{قدرة مشروع الطاقة الشمسية} = \frac{\text{كمية الطاقة الكهربائية السنوية المقدرة للاستهلاك} \times 50\%}{1500}$$

ملاحظة:

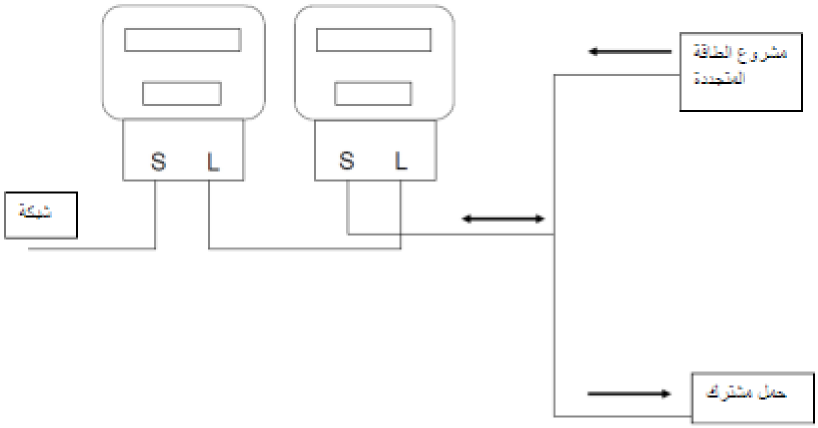
قدرة مشروع الطاقة الشمسية $\leq$ قدرة الاشتراك المقدر من الموزع (قدرة المحول المغذي الخاص) $<$ 1000 ك و

الملحق رقم (3): نموذج مخطط العدادات

أ. استبدال عداد المشترك بعداد ذو اتجاهين:



ب. اضافة عداد تصدير منفصل عن عداد الاستهلاك



الملحق رقم (4): نموذج الاحتساب

أ. تسوية مالية شهرية خاصة بانظمة صافي القياس – المشروع في نفس المنشأة

التاريخ:

اسم المشترك: العنوان:

رقم الاشتراك: التعرفة:

العداد	القراءة السابقة (ك و س)	القراءة الحالية (ك و س)	الشهري (ك و س)
التصدير			
الاستهلاك			

فرق الطاقة = الاستهلاك – التصدير

ملاحظة:

- اذا كان فرق الطاقة موجبا؛ يسدد المشترك قيمة الفرق حسب تعرفته (مستحقات الموزع = فرق الطاقة – رصيد المشترك للشهر السابق ان وجد(*))
- اذا كان فرق الطاقة سالبا؛ يتم اضافة رصيد طاقة الى المشترك كما يلي:
  (رصيد المشترك للطاقة الفائضة = فرق الطاقة للشهر الحالي X 75%(**) + رصيد المشترك للشهر السابق ان وجد)
- في حال استخدام عداد TOU فيتم احتساب تسوية مالية لكل فترة تعرفة بشكل منفصل ولا يتم تدوير رصيد الطاقة من فترة الى اخرى

(*) يستمر ترحيل رصيد فائض الطاقة للمشترك خلال السنة الانتاجية فقط (1 نيسان وحتى 31 آذار)

(**) النسبة المقرة في النقطة (ب) من المادة الأولى حسب ملحق قرار التعرفة الصادر من مجلس الوزراء رقم (17/77/03/م.و/ر.ح) لعام 2015 =25%

الملحق رقم (4): نموذج الاحتساب

ب. تسوية مالية شهرية خاصة بانظمة صافي القياس – مثال تعرفة مستوية – المشروع في نفس المنشأة

الشهر	الاستهلاك (ك و س)	التصدير (ك و س)	فرق الطاقة (ك و س)	الطاقة الفائضة (ك و س)	رصيد المشترك (ك و س)	مستحقات الموزع (ك و س)
4	500	650	(150)	113	113	–
5	1000	850	150	–	–	38
6	500	850	(350)	263	263	–
7	1000	900	100	–	163	–
8	800	900	(100)	75	238	–
9	700	650	50	–	188	–
10	600	500	100	–	88	–
11	300	350	(50)	38	125	–
12	650	300	350	–	–	225
1	650	300	350	–	–	350
2	500	300	200	–	–	200
3	500	500	–	–	–	–

ملاحظة: في حال كانت تعرفة المشترك TOU فان الجدول اعلاه يطبق لكل فترة تعرفة (A, B, C) بشكل منفصل ولا يتم تدوير الطاقة الفائضة من فئة لأخرى.

الملحق رقم (4): نموذج الاحتساب

ت. تسوية مالية شهرية خاصة بأنظمة صافي القياس – مشروع عبور طاقة

التاريخ:

اسم المشترك: العنوان:

رقم الاشتراك: التعرفة:

العداد	القراءة السابقة (ك و س)	القراءة الحالية (ك و س)	الشهري (ك و س)
الانتاج			
الاستهلاك			

طاقة العبور = الانتاج X 90%(*)

فرق الطاقة = الاستهلاك – العبور

ملاحظة:

- اذا كان فرق الطاقة موجبا؛ يسدد المشترك قيمة الفرق حسب تعرفته
(مستحقات الموزع = فرق الطاقة – رصيد المشترك للشهر السابق ان وجد(**))
- اذا كان فرق الطاقة سالبا؛ يتم اضافة رصيد طاقة الى المشترك كما يلي:
(رصيد المشترك للطاقة الفائضة = فرق الطاقة X 75%(***) + رصيد المشترك للشهر السابق ان وجد)
- في حال استخدام عداد TOU فيتم احتساب تسوية مالية لكل فترة تعرفة بشكل منفصل ولا يتم تدوير الطاقة الفائضة من فترة الى اخرى

(*) نسبة خصم نقل الطاقة إلى مكان الاستهلاك المقرة حسب النقطة ت من المادة الأولى من ملحق قرار التعرفة الصادر من مجلس الوزراء رقم (17/77/03/م.و/ر.ح) لعام 2015. = 10%

(**) يستمر ترحيل فائض الطاقة خلال السنة الانتاجية فقط (1 نيسان وحتى 31 آذار)

(**) النسبة المقرة في النقطة (ب) من المادة الأولى حسب ملحق قرار التعرفة الصادر من مجلس الوزراء رقم (17/77/03/م.و/ر.ح) لعام 2015= 25%

الملحق رقم (4): نموذج الاحتساب

ث. تسوية مالية شهرية خاصة بانظمة صافي القياس – مشروع عبور طاقة – مثال تعرفة مستوية

الشهر	الاستهلاك (ك و س)	الانتاج (ك و س)	طاقة العبور (ك و س)	فرق الطاقة (ك و س)	الطاقة الفائضة (ك و س)	رصيد المشترك (ك و س)	مستحقات الموزع (ك و س)
4	3000	5200	4680	(1,680)	1,260	1,260	–
5	8000	6800	6120	1,880	–	–	620
6	4000	6800	6120	(2,120)	1,590	1,590	–
7	7000	7200	6480	520	–	1,070	–
8	6400	7200	6480	(80)	60	1,130	–
9	5600	5200	4680	920	–	210	–
10	5000	4000	3600	1,400	–	–	1,190
11	3000	2800	2520	480	–	–	480
12	5200	2400	2160	3,040	–	–	3,040
1	3000	2400	2160	840	–	–	840
2	4000	2400	2160	1,840	–	–	1,840
3	5000	4000	3600	1,400	–	–	1,400

ملاحظة: في حال كانت تعرفة المشترك TOU فان الجدول اعلاه يطبق لكل فترة تعرفة (A, B, C) بشكل منفصل ولا يتم تدوير الطاقة الفائضة من فئة لأخرى.

الملحق رقم (5): نموذج طلب الاشتراك

طلب الاشتراك في مشاريع الطاقة المتجددة المربوطة على شبكة الكهرباء بنظام صافي القياس

رقم الطلب :.........................

تاريخ الطلب: ....

---

1. **معلومات مقدم الطلب**

اسم مقدم الطلب : .... رقم الهوية : ....

تلفون : .... محمول : .... ايميل :..................

---

2. **معلومات المفوض (ان وجد)**

اسم المفوض في حالة حدوث طارئ : ....رقم الهوية : ....

تلفون : .... محمول : .... ايميل : ....

---

3. **معلومات العقار**

المحافظة : .... المدينة / القرية : .... الشارع : ....

ملكية العقار : ☐ ملك ☐ مستأجر

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4. **معلومات اشتراك الكهرباء**

اسم المشترك :................................. رقم الاشتراك : ....

معدل الاستهلاك السنوي : ....(KWh)

نوعية الخدمة: ☐ فاز ☐ 3 فاز

نوع العداد : ☐ فاتورة ☐ دفع مسبق

تصنيف فئة التعرفة: ....

ديون سابقة للموزع: .... هل هي مجدولة: ☐ نعم ☐ لا

5. **معلومات مشروع الطاقة المتجددة**

قدرة المشروع التصميمية (تيار متردد): .... كيلو واط

نوع تقنية الطاقة المتجددة المستخدمة : ....

المكان المقترح : ☐ سطح البناء ☐ الارض ☐ غير ذلك

اذا كانت اجابتك غير ذلك الرجاء توضيح المكان المقترح:.................................

6. **اقرار مقدم الطلب**

يقر مقدم الطلب بان المعلومات الواردة في هذا الطلب صحيحة وانه على علم تام بتعليمات صافي القياس والدليل الارشادي الخاص بها وملحقاته وعليه يوافق على الالتزام ببنود وشروط اتفاقية الربط بنظام صافي القياس.

يقوم مقدم الطلب باستكمال تزويد الموزع باي اوراق او تفاصيل لاستكمال الطلب.

الاسم/الشركة:.. التوقيع/ الختم:.......................................

المرفقات :

1. نسخة عن تصميم ودراسة المشروع (تقدم بعد الحصول على الموافقة الأولية)
2. قائمة بالمواد المقترحة والجهات التي اعتمدت مواصفاتها الفنية.
3. صورة عن الهوية
4. تفويض رسمي ان وجد
5. تقديم إذن إشغال
6. وصل دفع رسوم طلب الاشتراك
7. موافقة مالك العقار في حالة المستأجر
8. اثبات جدولة الديون
9. تقديم موافقة السلامة العامة من الجهة ذات العلاقة

<u>الملحق رقم (6): نموذج اتفاقية الربط</u>

<u>اتفاقية ربط مشاريع الطاقة المتجددة على شبكة الكهرباء بنظام صافي القياس</u>

الطرف الاول (الموزع) .... العنوان: ....

الطروف الثاني (المشترك): .... العنوان: ....

<u>مقدمة:</u>

بما ان الطرف الثاني يرغب في تركيب وربط وتشغيل مشروع طاقة متجددة مع الطرف الاول بنظام صافي القياس، وبناء على رقم طلب الاشتراك المقدم رقم ()، وقد تم الموافقة على الطلب ومتوافق مع الدليل الارشادي وملحقاته، فقد اتفق الطرفان على ما يلي:

<u>المادة (1)</u>

تتألف هذه الاتفاقية من (11) مادة وتعتبر المقدمة جزء لا يتجزأ منها وتقرأ معها كوحدة واحدة.

<u>المادة (2): التعريفات</u>

الطاقة المتجددة: الطاقة البديلة الناتجة من مصادر طبيعية لها طابع الديمومة والاستمرارية.
سلطة الطاقة: سلطة الطاقة والموارد الطبيعية الفلسطينية.
المجلس: مجلس تنظيم قطاع الكهرباء الفلسطيني.
المشترك: أي شخص طبيعي أو اعتباري يتم تزويده بالطاقة الكهربائية بشكل دائم.
المشروع: نظام الطاقة المتجددة الخاضع لهذه التعليمات.
نظم مصادر الطاقة المتجددة: النظم والمعدات التي تستخدم لاستغلال مصادر الطاقة المتجددة لإنتاج الطاقة.
منشأة الطاقة المتجددة: المنشأة التي تستخدم نظم مصادر الطاقة المتجددة لإنتاج الطاقة وفقاً للاشتراطات والمعايير التي تحددها سلطة الطاقة لهذا الخصوص وخاصة بالمشترك.
الموزع: أي شركة تقوم بتوزيع الطاقة الكهربائية على المشتركين ومرخص لها.
كود التوزيع: نظام تضعه سلطة الطاقة يحدد الشروط والأنظمة الخاصة بتصميم وإنشاء وتعديل وتشغيل وصيانة أصول شبكات التوزيع والعلاقة بين شركات التوزيع وكافة مستخدمي شبكة التوزيع لضمان استقرار وكفاءة واقتصادية شبكة التوزيع.

الدليل الإرشادي: القواعد التي يضعها الموزع وفقا للمرجعيات التنظيمية وتتضمن اجراءات وشروط الربط وتحديد متطلباته على شبكة الكهرباء لنظام صافي القياس وتتم الموافقة عليه من قبل المجلس.

<u>المادة (3):</u>

يقوم الطرف الثاني وعلى حسابه الخاص بتصميم وانشاء وربط مشروع الطاقة المتجددة بناء على تعليمات نظام صافي القياس والدليل الارشادي الخاص بها.

<u>المادة (4)</u>

يكون المشروع متوافقا مع الشروط والمواصفات الفنية المقرة وبناء على الدليل الارشادي وملحقاته، وتعتبر مواد المشروع ملكا خاصا للطرف الثاني ويلتزم بتشغيلها وصيانتها على حسابه الخاص.

<u>المادة (5)</u>

يتحمل الطرف الثاني كافة التكاليف لربط مشروعه بنقطة الربط المقرة من الطرف الاول.

<u>المادة (6)</u>

أ. يلتزم الطرف الثاني قيمة فرق الطاقة المترتبة عليه شهريا للطرف الاول وحسب التعرفة الخاصة به.

ب. يلتزم الطرف الاول بتدوير صافي فائض الطاقة شهريا وخلال السنة الانتاجية (1 نيسان – 31 آذار)

ت. في حالة وجود رسوم اضافية على استهلاك المشترك يتم تحصيلها من قبل الموزع كما هي (مثل رسوم إنارة الشوارع).

ث. في حال تخلف الطرف الثاني عن دفع المستحقات المترتبة عليه، تطبق عليه تعليمات فصل التيار الكهربائي المقرة.

ج. يكون الطرف الثاني مسؤولا مسؤولية مباشرة عن تشغيل وصيانة المشروع وحتى نقطة الربط، وعليه فان الموزع لا يتحمل اية مسؤولية قانونية او مالية عما يقع من اضرار نتيجة حدوث اي خلل او خطا او تغيير او سوء استخدام للمشروع.

<u>المادة (7)</u>

يجوز للموزع القيام بالفصل المؤقت لنظم مصادر الطاقة المتجددة وفقاً للشروط التالية دون اية التزامات مالية:

أ. في حالة الانقطاع المبرمج لنظام التوزيع وبعد إشعار المستخدم بذلك.

ب. في حالة الانقطاع غير المبرمج أو الظروف الطارئة على نظام التوزيع.

ت. في حال عدم التزام المشترك بالملاحظات الفنية

المادة (8)

أ. في حال رغب الطرف الثاني في الفصل المؤقت لمشروعه عليه باشعار الموزع قبل 5 ايام من يوم بدء الفصل المؤقت.

ب. في حال رغب الطرف الثاني في الفصل الدائم للمشروع، عليه باشعار الموزع قبل شهر من تاريخ بدء الفصل الدائم، ويكون الاشعار مبررا.

المادة (9)

يلزم الطرف الثاني بشروط التشغيل والصيانة للمشروع لضمان تطابقه المستمر مع الشروط الفنية للتشغيل وكود التوزيع.

المادة (10)

يجوز للموزع القيام بالفحص الدوري للمشروع لمراقبة موافقته مع الشروط الفنية.

المادة (11)

تخضع هذه الاتفاقية للقوانين الفلسطينية.

التاريخ:.................................

الطرف الاول: الطرف الثاني:

الملحق رقم (7): نموذج طلب فحص وربط

معلومات المشروع			
اسم المشترك ورقمه		اسم المخول بالمتابعة (ان وجد)	
العنوان			

موقع المشروع	

معلومات الجهة المنفذة			
اسم فني الربط		رقم رخصة تأهيله	
اسم الشركة			
العنوان			
تاريخ طلب الفحص والربط			
ملاحظات الجهة المنفذة:			

السادة (الموزع) ....

استنادا لهذا الطلب بفحص وربط نظام صافي القياس للمشترك المذكور اعلاه، فانني اعلمكم بجاهزية فحص وربط المشروع، وبهذا أقر انه تم الانتهاء من تركيب وفحص المشروع وفقا لتعليمات صافي القياس والدليل الارشادي وملحقاته المقرة، وهو مستوف لكافة شروط الربط والتشغيل الواردة.

وعليه ارجو اتخاذ الاجراءات اللازمة من طرفكم لتحديد موعد ربط النظام للمشترك وتشغيله.

مرفق نسخة عن العقد بين المشترك والجهة التمويلية او المنفذة للتأكد من جهوزية المشروع للربط

اسم فني الربط:.. التوقيع/ الختم:......................................

لاستخدام الموزع الداخلي:

قائمة التدقيق والمراجعة:

- مخططات المشروع كما تم تنفيذه (As Built): يشمل مخطط المشروع في الموقع ومخطط SLD

- وصل دفع رسوم طلب الفحص والربط
- نسخة عن شهادة تأهيل فني الربط
- قائمة بالمواد المستخدمة في المشروع والجهة المعتمدة لمواصفاتها (مثل: الواح، كوابل DC، محول، عاكس، لوحات)
- موافقة قائمة الشروط الفنية كاملة

	Vac RMS		5% Percentage	Iac RMS		5% Percentage
	Clamp	Inverter		Clamp	Inverter	
Inverter out						

جهد الدخل للانفيرتر : ....

	With inverter	Without inverter
PF		
THD%		

	Pass	Fail
Earthing test		
Voc test		
Isc test		
Polarity test		
Operational test		

1.1. تقديم المخططات الفنية اللازمة من الشركة المنفذة للمشروع وتشمل المخططات التالية (بعد الموافقة الاولية):

1.1.1. مخطط كهربائي تفصيلي لكامل النظام المنوي تركيبه يشمل ويوضح مكونات المشروع والتوصيلات بين أجزاء النظام والحمايات...الخ

1.1.2. مخطط لأنظمة التأريض يوضح فيها طريقة التأريض والتوصيلات وجسور التأريض. وأن يكون نظام التأريض معزول عن أي نظام تأريض آخر .

1.1.3. نسخة عن الدليل الفني للمواد المستخدمة في المشروع.

1.1.4. مخطط جغرافي (مساحة) يوضح مواقع أجزاء المشروع لجميع مكوناته.

1.1.5. مخطط كهربائي أحادي يوضح طريقة الربط ومقاطع الأسلاك ، والقواطع الكهربائية لكل أجزاء النظام.

1.2. كوابل التيار المستمر DC

1.2.1. تكون الكوابل المستفيدة للتيار المستمر (DC) من الموصلات النحاسية المرنة (FLEXIBLE MULTISTRANDED COPPER CONDUCTOR).

1.2.2. تكون جميع الكوابل الكهربائيه ملائمه للجهد والتيار في الدائره الخاصه بالجهد الثابت.

1.2.3. توضع الكوابل بين علب التجميع والمحول العاكس (INVERTER) في ترنشات مثبته ومحميه من الصدمات الميكانيكيه وتتحمل الظروف الجويه الخارجيه وتكون مساحه مقطع الكوابل ملائمه لحجم الربط بحيث يكون التيار الذي يمكن تحمله اعلى من 130% من تيار دائرة القصر وهبوط في الجهد لا يتعدى 1.5%، كما يتم استخدام الكوابل بنفس المواصفات الخاصه بالالواح الشمسيه.

1.3. كوابل التيار المتناوب AC

1.3.1. تكون الكوابل الخاصة بدائرة التيار المتردد من نوع (STRANDED COPPER) وملائمه للجهد والتيار

1.3.2. عدم تمديد كوابل الدوائر المترددة والمستمرة في نفس المجرى بحيث تكون خطوط (AC) في مواسير أو ترنشات و خطوط (DC) في مواسير أو ترنشات أخرى.

1.3.3. توضع الكوابل بين علب التجميع و المحول في ترنشات مثبته ومحمية من الصدمات الميكانيكية وتتحمل الظروف الجوية الخارجية.

1.4. القواطع

1.4.1. مجموعة القواطع الكهربائية DC

- يتم تزويد المشروع بقواطع الحماية المناسبة وحسب متطلبات الموزع.
- يجب تركيب قاطع حمايه (DC) لكل سلسله من الالواح الشمسيه ويتم تجميعها بعلبه تجميع خارجيه مضاده للحريق.ذات عزل IP65على الاقل. حسب الموضح في المخطط.
- اذا تم تركيب الالواح الشمسيه بعيداً عن مجال الرؤية بالنسبه للمحول الكهربائي فيتم تركيب مفتاح اخر بعد الالواح الشمسيه(من جهه المحول)
- يكون التيار الاسمي لقاطع حماية التيار المستمر رقم (2) يساوي اعلى قيمه من التيار الذي من الممكن الحصول عليه من الخلايا الشمسيه بعزل 1000 فولت.

1.4.2. المحولات

- يجب ملائمة المحول المراد تركيبه للظروف البيئية المحيطة.
- لا يتم قبول ربط محول مع شبكة او اجزاء من الشبكة تقل فيها الفولتية عن 200 فولت.
- يجب تركيب المحول في مكان يسهل الوصول اليه للصيانة
- يجب تأريض الغلاف الخارجي للمحول بواسطة موصل خاص الى جسر التأريض الرئيسي.

1.4.3. الاشارات التحذيرية

يجب وضع اشارات تحذيرية وتوضيحية على جميع اجزاء النظام وحيثما لزم

الملاحظات الفنية للجنة :

....

....

....

....

....

لقد تم تجهيز وتوصيل المشروع بعد الفحص والكشف عليه من قبلنا، حيث تبين ان المشروع متوافق مع تعليمات صافي القياس والدليل الارشادي وملحقاته، وملتزم بقائمة الالتدقيق والمراجعة كاملة كما هو موضح اعلاه..

وعلى هذا تم اصدار هذا الامر بالربط.

التاريخ: التوقيع: الاسم:

Appendix (3)

Q- Cell / Hanwha (320 w_p) datasheet

powered by Q.ANTUM DUO

Q.PEAK DUO BLK-G5 305-320

Q.ANTUM SOLAR MODULE

The new Q.PEAK DUO BLK-G5 solar module from Q CELLS impresses with its outstanding visual appearance and particularly high performance on a small surface thanks to the innovative Q.ANTUM DUO Technology. Q.ANTUM's world-record-holding cell concept has now been combined with state-of-the-art circuitry half cells and a six-busbar design, thus achieving outstanding performance under real conditions — both with low-intensity solar radiation as well as on hot, clear summer days.

Q.ANTUM TECHNOLOGY: LOW LEVELISED COST OF ELECTRICITY
Higher yield per surface area, lower BOS costs, higher power classes, and an efficiency rate of up to 19.3%.

INNOVATIVE ALL-WEATHER TECHNOLOGY
Optimal yields, whatever the weather with excellent low-light and temperature behaviour.

ENDURING HIGH PERFORMANCE
Long-term yield security with Anti LID Technology, Anti PID Technology[1], Hot-Spot Protect and Traceable Quality Tra.Q™.

EXTREME WEATHER RATING
High-tech aluminium alloy frame, certified for high snow (5400 Pa) and wind loads (4000 Pa).

A RELIABLE INVESTMENT
Inclusive 12-year product warranty and 25-year linear performance warranty[2].

STATE OF THE ART MODULE TECHNOLOGY
Q.ANTUM DUO combines cutting edge cell separation and innovative wiring with Q.ANTUM Technology.

EUPD RESEARCH TOP BRAND PV MODULES 2017

VDE Quality Tested

Q CELLS

[1] APT test conditions according to IEC/TS 62804-1:2015, method B (−1500V, 168h)
[2] See data sheet on rear for further information.

THE IDEAL SOLUTION FOR:

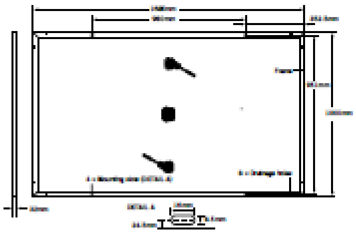
Rooftop arrays on residential buildings

Engineered in Germany

Q CELLS

MECHANICAL SPECIFICATION

Format	1685 mm × 1000 mm × 32 mm (including frame)
Weight	18.7 kg
Front Cover	3.2 mm thermally pre-stressed glass with anti-reflection technology
Back Cover	Composite film
Frame	Black anodised aluminium
Cell	6 × 20 monocrystalline Q.ANTUM solar half cells
Junction box	70-85 mm × 50-70 mm × 13-21 mm Protection class IP67, with bypass diodes
Cable	4 mm² Solar cable; (+) 1100 mm, (–) 1100 mm
Connector	Multi-Contact MC4, IP65 and IP68

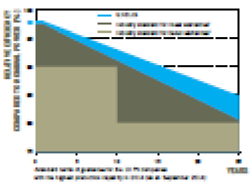


ELECTRICAL CHARACTERISTICS

POWER CLASS			305	310	315	320
MINIMUM PERFORMANCE AT STANDARD TEST CONDITIONS, STC[1] (POWER TOLERANCE +5W / –0W)						
Minimum: Power at MPP[2]	P_{MPP}	[W]	305	310	315	320
Minimum: Short Circuit Current[*]	I_{SC}	[A]	9.78	9.83	9.89	9.94
Minimum: Open Circuit Voltage[*]	V_{OC}	[V]	39.75	40.02	40.29	40.56
Minimum: Current at MPP[*]	I_{MPP}	[A]	9.31	9.36	9.41	9.47
Minimum: Voltage at MPP[*]	V_{MPP}	[V]	32.78	33.12	33.46	33.80
Minimum: Efficiency[2]	η	[%]	≥ 18.1	≥ 18.4	≥ 18.7	≥ 19.0
MINIMUM PERFORMANCE AT NORMAL OPERATING CONDITIONS, NOC[3]						
Minimum: Power at MPP[2]	P_{MPP}	[W]	226.0	229.7	233.5	237.2
Minimum: Short Circuit Current[*]	I_{SC}	[A]	7.88	7.93	7.97	8.02
Minimum: Open Circuit Voltage[*]	V_{OC}	[V]	37.18	37.43	37.69	37.94
Minimum: Current at MPP[*]	I_{MPP}	[A]	7.32	7.36	7.41	7.45
Minimum: Voltage at MPP[*]	V_{MPP}	[V]	30.88	31.20	31.52	31.84

[1] 1000 W/m², 25 °C, spectrum AM 1.5G [2] Measurement tolerances STC ±3%; NOC ±5% [3] 800 W/m², NOCT, spectrum AM 1.5G [*] typical values, actual values may differ

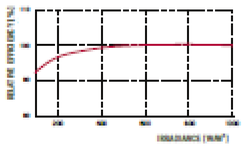
Q CELLS PERFORMANCE WARRANTY



At least 98 % of nominal power during first year. Thereafter max. 0.54 % degradation per year. At least 93.1 % of nominal power up to 10 years. At least 85 % of nominal power up to 25 years.

All data within measurement tolerances. Full warranties in accordance with the warranty terms of the Q CELLS sales organisation of your respective country.

PERFORMANCE AT LOW IRRADIANCE



Typical module performance under low irradiance conditions in comparison to STC conditions (25 °C, 1000 W/m²).

TEMPERATURE COEFFICIENTS

Temperature Coefficient of I_{SC}	α	[% / K]	+0.04	Temperature Coefficient of V_{OC}	β	[% / K]	–0.28
Temperature Coefficient of P_{MPP}	γ	[% / K]	–0.37	Normal Operating Cell Temperature	NOCT	[°C]	45

PROPERTIES FOR SYSTEM DESIGN

Maximum System Voltage	V_{SYS}	[V]	1000	Safety Class	II
Maximum Reverse Current	I_R	[A]	20	Fire Rating	C
Push/Pull Load (Test-load in accordance with IEC 61215)		[Pa]	5400/4000	Permitted Module Temperature On Continuous Duty	-40 °C up to +85 °C

QUALIFICATIONS AND CERTIFICATES

VDE Quality Tested, IEC 61215 (Ed. 2), IEC 61730 (Ed. 1), Application class A
This data sheet complies with DIN EN 50380.

PARTNER

NOTE: Installation instructions must be followed. See the installation and operating manual or contact our technical service department for further information on approved installation and use of this product.

Hanwha Q CELLS GmbH
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Engineered in Germany

Appendix (4)

10 kVA – ABB inverters datasheet

Solar inverters

ABB string inverters
PVI-10.0/12.0-I-OUTD
10 to 12 kW

Designed for commercial usage, this three-phase inverter is highly unique in its ability to control the performance of the PV panels, especially during periods of variable weather conditions.

The high speed, precise Multiple Power Point Tracker (MPPT) algorithm enables real-time power tracking and improved energy harvesting.

This device has two independent MPPTs and efficiency ratings of up to 97.3%.

Flat efficiency curves ensure high efficiency at all output levels delivering consistent and stable performance across the entire input voltage and output power range.

The input voltage range makes the inverter suitable for installations with reduced string size

Dual input section with independent MPP tracking, allows for optimal energy harvesting from two sub-arrays oriented in different directions.

Each inverter is set on specific grid codes which can be selected in the field.

The outdoor enclosure provides unrestricted usage under any environmental condition.

Highlights

- True three-phase bridge topology for DC/AC output converter
- The HF isolation allows positive or negative ground configuration
- The unit is free of electrolytic capacitors, leading to a longer product lifetime
- Night wake up button to access energy harvesting data and error log

Power and productivity for a better world™ ABB

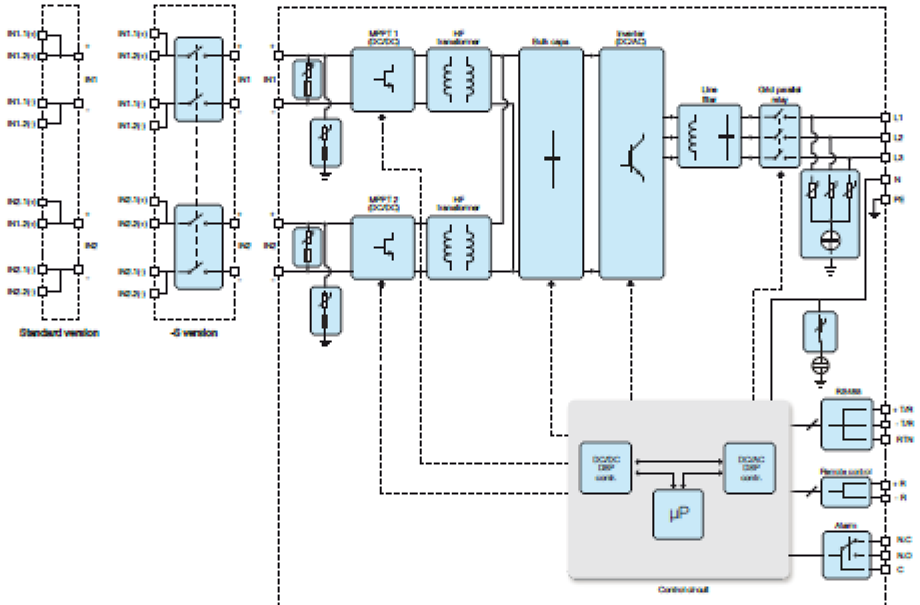
Additional highlights

- Integrated DC disconnect switch in compliance with international Standards (-S version)
- Natural convection cooling for maximum reliability
- Outdoor enclosure for unrestricted use under any environmental conditions (IP65)
- RS-485 communication interface (for connection to laptop or data logger)

Technical data and types

Type code	PVI-10.0-I-OUTD-400	PVI-12.0-I-OUTD-400
Input side		
Absolute maximum DC input voltage ($V_{max,abs}$)	520 V	
Start-up DC input voltage (V_{start})	200 V (adj. 120...350 V)	
Operating DC input voltage range (V_{dcmin}...V_{dcmax})	0.7 x V_{start}...520 V	
Rated DC input voltage (V_{dcr})	345 V	
Rated DC input power (P_{dcr})	10500 W	12300 W
Number of independent MPPT	2[1]	
Maximum DC input power for each MPPT ($P_{MPPTmax}$)	6800 W	
DC input voltage range with parallel configuration of MPPT at P_{acr}	220...470 V	250...470 V
DC power limitation with parallel configuration of MPPT	Linear derating from max to null [470V≤V_{MPPT}≤520V]	
DC power limitation for each MPPT with independent configuration of MPPT at P_{acr}, max unbalance example	6800 W [285V≤V_{MPPT}≤470V] the other channel: P_{dcr}-6800W [155V≤V_{MPPT}≤470V]	6800 W [275V≤V_{MPPT}≤470V] the other channel: P_{dcr}-6800W [220V≤V_{MPPT}≤470V]
Maximum DC input current (I_{dcmax}) / for each MPPT ($I_{MPPTmax}$)	48.0 A / 24.0 A	50.0 A / 25.0 A
Maximum input short circuit current for each MPPT	29.0 A	
Number of DC inputs pairs for each MPPT	2	
DC connection type	Tool Free PV connector WM / MC4	
Input protection		
Reverse polarity protection	Yes, from limited current source	
Input over voltage protection for each MPPT - varistor	2	
Photovoltaic array isolation control	According to local standard	
DC switch rating for each MPPT (version with DC switch)	32 A / 600 V	
Output side		
AC grid connection type	Three phase 3W or 4W+PE	
Rated AC power (P_{acr} @cosϕ=1)	10000 W	12000 W
Maximum AC output power (P_{acmax} @cosϕ=1)	11000 W [2]	12500 W [3]
Maximum apparent power (S_{max})	11100 VA	13300 VA
Rated AC grid voltage ($V_{ac,r}$)	400 V	
AC voltage range	320...480 V [1]	
Maximum AC output current ($I_{ac,max}$)	16.0 A	18.0 A
Contributory fault current	25.0 A	
Rated output frequency (f_r)	50 Hz / 60 Hz	
Output frequency range (f_{min}...f_{max})	47...53 Hz / 57...63 Hz[2]	
Nominal power factor and adjustable range	> 0.995, adj. ± 0.9 with P_{acr}=10.0 kW	> 0.995, adj. ± 0.9 with P_{acr}=12.0 kW
Total current harmonic distortion	< 2%	
AC connection type	Screw terminal block, cable gland M40	
Output protection		
Anti-islanding protection	According to local standard	
Maximum AC overcurrent protection	20.0 A	
Output overvoltage protection - varistor	3 plus gas arrester	

Block diagram of PVI-10.0/12.0-I-OUTD



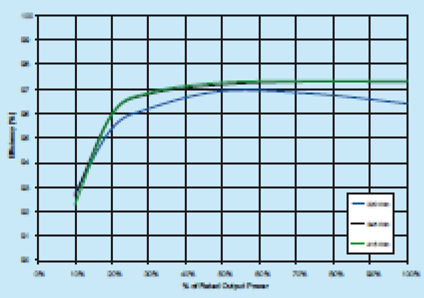
Technical data and types

Type code	PVI-10.0-I-OUTD-400	PVI-12.0-I-OUTD-400
Operating performance		
Maximum efficiency (η_{max})	97.3%	
Weighted efficiency (EURO/CEC)	97.0% / -	
Feed in power threshold	30 W	
Stand-by consumption	< 8 W	
Communication		
Wired local monitoring	PVI-USB-RS232_485 (opt.)	
Remote monitoring	VSN300 Wifi Logger Card® (opt.), PVI-AEC-EVO (opt.), VSN700 Data Logger (opt.)	
Wireless local monitoring	VSN300 Wifi Logger Card® (opt.)	
User interface	16 characters x 2 lines LCD display	
Environmental		
Ambient temperature range	-25...+60°C /-13...140°F with derating above 50°C/122°F	-25...+60°C /-13...140°F with derating above 45°C/113°F
Relative humidity	0...100% condensing	
Noise emission	< 50 dB(A) @ 1 m	
Maximum operating altitude without derating	2000 m / 6560 ft	
Physical		
Environmental protection rating	IP 65	
Cooling	Natural	
Dimension (H x W x D)	716mm x 645mm x 222mm / 28.2" x 25.4" x 8.7"	
Weight	< 45.8 kg / 99.0 lb	
Mounting system	Wall bracket	
Safety		
Isolation level	HF transformer	
Marking	CE (50 Hz only)	
Safety and EMC standard	EN 50178, EN62109-1, EN62109-2, AS/NZS3100, AS/NZS 60950, EN61000-3-2, EN61000-3-3, EN61000-6-2, EN61000-6-3	EN 50178, EN62109-1, EN62109-2, AS/NZS3100, AS/NZS 60950, EN61000-6-2, EN61000-6-3, EN61000-3-11, EN61000-3-12
Grid standard (check your sales channel for availability)	CEI 0-21, CEI 0-16, VDE 0126-1-1, VDE-AR-N 4105, G83/2, G59/3, C10/11, EN 50438 (not for all national appendices), RD1699, RD 1565, AS 4777, ABNT NBR 16149, CLC/FprTS 50549	CEI 0-21, CEI 0-16, VDE 0126-1-1, VDE-AR-N 4105, G59/3, C10/11, EN 50438 (not for all national appendices), RD1699, RD 1565, AS 4777, ABNT NBR 16149, CLC/FprTS 50549
Available products variants		
Standard	PVI-10.0-I-OUTD-400	PVI-12.0-I-OUTD-400
With DC switch	PVI-10.0-I-OUTD-S-400	PVI-12.0-I-OUTD-S-400

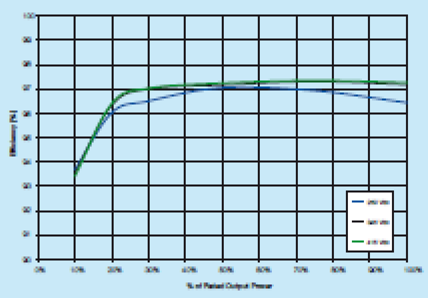
1. The AC voltage range may vary depending on specific country grid standard
2. The Frequency range may vary depending on specific country grid standard
3. Limited to 10000 W for Belgium and Germany
4. Limited to 12000 W for Germany
5. Independent MPPT just with negative ground
6. Check availability before to order

Remark. Features not specifically listed in the present data sheet are not included in the product

Efficiency curves of PVI-10.0-I-OUTD



Efficiency curves of PVI-12.0-I-OUTD



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Solar inverters

ABB string inverters TRIO-20.0/27.6-TL-OUTD 20kW to 27.6kW

A commercial photovoltaic (PV) system using a TRIO-based modular architecture can reduce BOS costs by as much as 40 percent.

The TRIO is a modular option using models at 20.0kW and 27.6kW.
It can be used alone for a 20kW system or combined as building blocks for large commercial and utility scale systems. With two independent Multiple Power Point Trackers (MPPT) and peak efficiency ratings of 98.2 percent, these inverters offer superior energy harvest. The flat efficiency curves offer high efficiency at all output levels ensuring consistent and stable performance across the entire input voltage and output power range.
Employing fan-less convection cooling and no electrolytic capacitors, TRIO is designed for long service life.

The TRIO offers flexible power factor control to comply with utility grid requirements where required.
As the first 1000Vdc string inverter certified to UL1741, the TRIO leads the way for efficient, cost-saving, decentralized system design.
The TRIO is equipped with integrated Modbus and utility interactive controls including adjustable power factor and curtailment. Additional AC and DC protections as well as arc-fault circuit interruption are all available in the TRIO. These inverters provide the monitoring, control features, and protection required in today's commercial solar installations.

Highlights:

- This flexible and dependable three-phase string inverter has innovative features to lower system Levelized Cost Of Energy (LCOE) and improve Return on Investment (ROI) on commercial solar installations.
- Fully utilize available roof space and maximize harvest with dual independent MPPT.
- Wall-mountable design and 1000Vdc input voltage lower installation and material costs.

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Additional highlights:

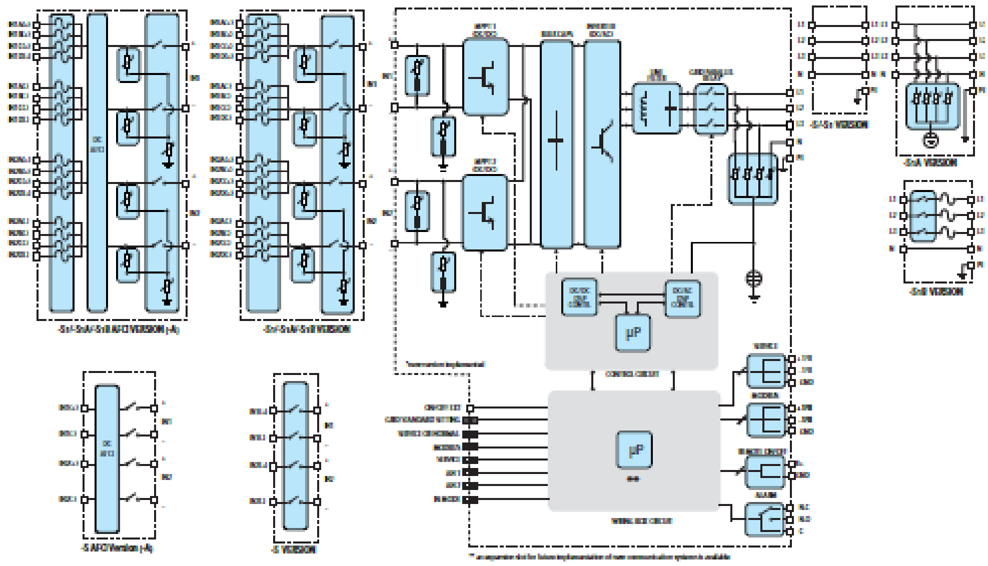
- Multiple AC and DC level protection options available including arc-fault circuit interruption (AFCI).
- Wide DC input voltage and operating temperature range enable greater PV array design flexibility.
- Modular design capability improves system availability and eliminates single point of failure.
- Utility interactive control features and Modbus protocol integrates with monitoring and control systems.
- Design uses natural convection cooling and no electrolytic capacitors for increased reliability.
- This inverter comes with a standard 10 year warranty. Extended warranty offered at 15 and 20 years.

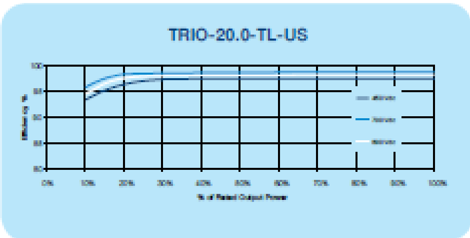
Technical data and types

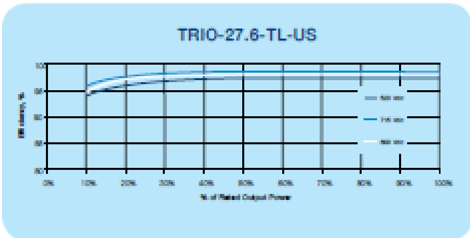
Type code	TRIO-20.0-TL-OUTD	TRIO-27.6-TL-OUTD
Nominal output power	20000W	27600W
Maximum output power	22000W[1]	30000W[1]
Rated grid AC voltage	480V	
Input side (DC)		
Number of independent MPPT channels	2; Programmable for 1 MPPT	
Maximum usable power for each MPPT channel	12000W	16000W
Absolute maximum voltage (V_{max})	1000V	
Start-up voltage (V_{start})	360V (adj. 250-500V)	
Full power MPPT voltage range	450-800V	520-800V
Operating MPPT voltage range	200-950V	
Maximum usable current (Idc max) per MPPT channel	25.0A	30.9A
Maximum short circuit current (Isc max) per MPPT channel	30.0A	36.0A
Number of inputs (strings) per MPPT channel	-S version: 1; -S1, -S1A, -S1B versions: 4	
Array wiring termination type	Terminal block, screw terminal, copper only, -S: 12AWG-2AWG; -S1, -S1A, -S1B: 12AWG-6AWG	
Output side (AC)		
Grid connection type	3Ø/3W or 4W + Ground	
Default voltage range	422-528V	
Adjustable voltage range	240-552V	
Nominal grid frequency	60Hz	
Adjustable grid frequency range	57-63Hz	
Maximum current (Iac max/phase)	27.0 A_{rms}	36.0 A_{rms}
Power factor	> 0.995 (adj. ±0.8, or ±0.9 for active power >20KW)	>0.995 (adj. ± 0.8, or ±0.9 for active power >27.6KW)
Total harmonic distortion at rated power	<3	
Grid wiring termination type	Pass-through terminal. Tension clamp. Copper 8AWG-4AWG	Pass-through terminal. Tension clamp. Copper 6AWG-4AWG
Input protection devices		
Reverse polarity protection	Yes, passive inverter protection only.[2]	
Supplementary over-voltage protection type for each MPPT	-S1, -S1A, -S1B version: plug-in class II modular surge arrestor	
PV array ground fault detection	Meets UL1741/NEC requirements	
Output protection devices		
Anti-islanding protection	Meets UL1741/IEEE 1547 requirements	
Supplementary over-voltage protection type	-S1A version: plug-in class II modular surge arrestor	
Optional AC fused disconnect current rating (per contact)	35A	45A
Operating performance		
Maximum efficiency	98.2%	
CEC efficiency	97.5%	
Feed-in power threshold	65W_{out}	70W_{out}
Communication		
User-interface display	5.5" x 1.25" graphic display	
Standard communication interfaces	(1) RS485 connection, can be configured for Aurora protocol or Modbus RTU. Support for optional monitoring expansion cards.	
Optional remote monitoring logger	Aurora Logger Commercial (optional)	
Environmental		
Ambient operating temperature range	-22°F to +140°F (-30°C to +60°C) Derating above +113°F (45°C)	
Ambient storage temperature range	-40°F to +185°F (-40°C to +85°C)	
Relative humidity	0-100% condensing	
Acoustic noise emission level	<50 db (A) @1m	
Maximum operating altitude without derating	6560ft (2000m)	
Mechanical specifications		
Enclosure rating	NEMA 4X	
Cooling	Natural Convection	
Dimensions (H x W x D)	41.7 x 27.6 x 11.5 in. / 1061 x 702 x 292 mm.	
Unit weight	157lbs (71kg)	168lbs (76kg)
Conduit connections	Bottom: (2) concentric DC KOs 1", 1 1/2" on removable plate, (2) 1/2" plugged comm. openings, (1) 1" plugged AC opening	
Mounting system	Wall bracket	

1. Capability enabled within maximum input current, maximum input power, maximum output current, and ambient operating temperature limits
2. In -S1, -S1A and -S1B models, the string polarity must be verified before connection. Please refer to installation manual for the correct installation procedure.

Block diagram of TRIO-20.0/27.6-TL-OUTD







Technical data and types

Type code	TRIO-2.0-TL-OUTD	TRIO-27.6-TL-OUTD
Safety		
Isolation level	Transformerless, Floating Array Required.	
Safety and EMC standard	UL1741, IEEE1547, IEEE1547.1, CSA C22.2 107.1-01-2001, FCC Part 15 Sub-part B Class B Limits	
Safety approval	cCSAus	
Warranty		
Standard warranty	10 years	
Extended warranty	15 & 20 years	
Available models		
Standard with DC disconnect	TRIO-20.0-TL-OUTD-S-US-480	TRIO-27.6-TL-OUTD-S-US-480
With DC disconnect, DC fuses and DC surge protection	TRIO-20.0-TL-OUTD-S1-US-480	TRIO-27.6-TL-OUTD-S1-US-480
With DC disconnect, DC fuses, DC surge protection and AC surge protection	TRIO-20.0-TL-OUTD-S1A-US-480	TRIO-27.6-TL-OUTD-S1A-US-480
With DC disconnect, DC fuses, DC surge protection and AC fused disconnect	TRIO-20.0-TL-OUTD-S1B-US-480	TRIO-27.6-TL-OUTD-S1B-US-480
Standard with DC disconnect and Arc-Fault circuit Interruption	TRIO-20.0-TL-OUTD-S-US-480-A	TRIO-27.6-TL-OUTD-S-US-480-A
With DC disconnect, DC fuses, DC surge protection and Arc-Fault circuit Interruption	TRIO-20.0-TL-OUTD-S1-US-480-A	TRIO-27.6-TL-OUTD-S1-US-480-A
With DC Disconnect, DC fuses, DC surge protection, AC surge protection and Arc-Fault circuit Interruption	TRIO-20.0-TL-OUTD-S1A-US-480-A	TRIO-27.6-TL-OUTD-S1A-US-480-A
With DC disconnect, DC fuses, DC surge protection, AC fused disconnect and Arc-fault circuit Interruption	TRIO-20.0-TL-OUTD-S1B-US-480-A	TRIO-27.6-TL-OUTD-S1B-US-480-A

All data is subject to change without notice

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Appendix (5)

Net Metering & PBP for C.D.C

Net-metering & PBP for Anabta C.D.C

Commercial	0.6248	capacity project (kWp)	20.00
VAT	16%		
$1 = (ILS)	3.5	cost of project ILS	77,000.00
% of transfe	75%	O&M ILS	308.00
cost of 1 kW	1,100.00	Annual Cash Flow ILS	20,949.45

Net-metering & PBP for Anabta C.D.C.

IRR	
0	(77,000.00)
1	20,949.45
2	20,949.45
3	20,949.45
4	20,949.45
5	20,949.45
6	20,949.45
7	20,949.45
8	20,949.45
9	20,949.45
10	20,949.45
	24%
2	
PBP	3.68

	Commercial			Solar PV							
	Consumption	Cost (ILS)	Tariff	Theoritical kW	Practical kWh/kWp	Production (kW	Surplus kWh	credit kWh	kwh cons		ILS
Apr	3,100	2,246.78	0.7248	190	143	2,850.00	(250.00)		250.00	250	181.19
May	4,480	3,246.96	0.72	240	180	3,600.00	(880.00)		880.00	880	637.80
Jun	3,280	2,377.24	0.72	248	186	3,720.00	440.00		(440.00)	0	-
Jul	3,200	2,319.26	0.72	252	189	3,780.00	580.00		(580.00)	0	-
Aug	2,920	2,116.32	0.72	252	189	3,780.00	860.00		(860.00)	1410	-
Sep	3,580	2,594.67	0.72	190	143	2,850.00	(730.00)		730.00	680	-
Oct	4,900	3,551.36	0.72	145	109	2,175.00	(2,725.00)		2,725.00	2,045.00	1,974.99
Nov	3,400	2,464.21	0.72	105	79	1,575.00	(1,825.00)		1,825.00	1,825.00	1,322.70
Dec	4,900	3,551.36	0.72	90	68	1,350.00	(3,550.00)		3,550.00	3,550.00	2,572.93
Jan	4,900	3,551.36	0.72	90	68	1,350.00	(3,550.00)		3,550.00	3,550.00	2,572.93
Feb	4,600	3,333.93	0.72	90	68	1,350.00	(3,250.00)		3,250.00	3,250.00	2,355.50
Mar	3,400	2,464.21	0.72	140	105	2,100.00	(1,300.00)		1,300.00	1,300.00	942.20
Total	46,660	33,817.67		2,032	1,524	30,480.00	(16,180.00)	-	16,200.00	18740	12,560.23

		1	2	3	4	5	6	7	8	9	10	PBP
1 Initial inves	77,000											
Cash flows	(77,000)	20,949.45	20,949.45	20,949.45	20,949.45	20,949.45	20,949.45	20,949.45	20,949.45	20,949.45	20,949.45	
Cumulative (	(77,000)	(56,051)	(35,101)	(14,152)	6,798	27,747	48,697	69,646	90,596	111,545	132,494	
Fraction calculations		n/m	n/m	n/m	0.68	0.32	1.32	2.32	3.32	4.32	5.32	

Net-metering & PBP for Ram C.D.C

Commercia	0.6248
VAT	16%
$1 = (ILS)	3.5
% of transfe	75%
cost of 1 kW	1,100.00

capacity project (kWp)	20.00
cost of project ILS	77,000.00
O&M ILS	308.00
Annual Cash Flow ILS	37,887.27

Net-metering & PBP for Ram C.D.C.

IRR	
0	(77,000.00)
1	37,887.27
2	37,887.27
3	37,887.27
4	37,887.27
5	37,887.27
6	37,887.27
7	37,887.27
8	37,887.27
9	37,887.27
10	37,887.27
	48%
2	
PBP	2.03

	Commercial			Solar PV							
	Consumption	Cost (ILS)	Tariff	Theoritical kW	Practical kWh/kWp	Production (kW	Surplus kWh	credit kWh	kwh cons		ILS
Apr	4,100	2,971.55	0.7248	190	143	2,850.00	(1,250.00)		1,250.00	1250	905.96
May	4,200	3,044.03	0.72	240	180	3,600.00	(600.00)		600.00	600	434.86
Jun	4,000	2,899.07	0.72	248	186	3,720.00	(280.00)		280.00	280	202.94
Jul	2,500	1,811.92	0.72	252	189	3,780.00	1,280.00		(1,280.00)	0	-
Aug	2,700	1,956.87	0.72	252	189	3,780.00	1,080.00		(1,080.00)	1770	-
Sep	3,700	2,681.64	0.72	190	143	2,850.00	(850.00)		850.00	920	-
Oct	3,500	2,536.69	0.72	145	109	2,175.00	(1,325.00)		1,325.00	405.00	293.53
Nov	6,600	4,783.47	0.72	105	79	1,575.00	(5,025.00)		5,025.00	5,025.00	3,641.96
Dec	6,000	4,348.61	0.72	90	68	1,350.00	(4,650.00)		4,650.00	4,650.00	3,370.17
Jan	5,400	3,913.75	0.72	90	68	1,350.00	(4,050.00)		4,050.00	4,050.00	2,935.31
Feb	5,200	3,768.79	0.72	90	68	1,350.00	(3,850.00)		3,850.00	3,850.00	2,790.36
Mar	4,800	3,478.89	0.72	140	105	2,100.00	(2,700.00)		2,700.00	2,700.00	1,956.87
Total	52,700	38,195.27		2,032	1,524	30,480.00	(22,220.00)	-	21,600.00	25500	-

		1	2	3	4	5	6	7	8	9	10	PBP
1 Initial inve	77,000											
Cash flows	(77,000)	37,887.27	37,887.27	37,887.27	37,887.27	37,887.27	37,887.27	37,887.27	37,887.27	37,887.27	37,887.27	
Cumulative (	(77,000)	(39,113)	(1,225)	36,662	74,549	112,436	150,324	188,211	226,098	263,985	301,873	
Fraction calculations		n/m	n/m	0.03	0.97	1.97	2.97	3.97	4.97	5.97	6.97	

Net-metering & PBP for Tubas C.D.C

Commercia	0.6248
VAT	16%
$1 = (ILS)	3.5
% of transfe	75%
cost of 1 kW	1,100.00

capacity project (kWp)	38.00
cost of project ILS	146,300.00
O&M ILS	585.20
Annual Cash Flow ILS	40,961.40

Net-metering & PBP for Tubas C.D.C.

IRR	
0	(146,300.00)
1	40,961.40
2	40,961.40
3	40,961.40
4	40,961.40
5	40,961.40
6	40,961.40
7	40,961.40
8	40,961.40
9	40,961.40
10	40,961.40
	25%
2	
PBP	3.57

	Commercial			Solar PV							
	Consumptior	Cost (ILS)	Tariff	Theoritical kW	Practical kWh/kWp	Production (kW	Surplus kWh	credit kWh	kwh cons		ILS
Apr	6,946	5,034.24	0.7248	190	143	5,415.00	(1,531.00)		1,531.00	250	181.19
May	5,403	3,915.92	0.72	240	180	6,840.00	1,437.00		(1,437.00)	0	-
Jun	6,523	4,727.66	0.72	248	186	7,068.00	545.00		(545.00)	0	-
Jul	5,723	4,147.85	0.72	252	189	7,182.00	1,459.00		(1,459.00)	0	-
Aug	7,003	5,075.55	0.72	252	189	7,182.00	179.00		(179.00)	2715	-
Sep	8,124	5,888.02	0.72	190	143	5,415.00	(2,709.00)		2,709.00	6	-
Oct	7,964	5,772.05	0.72	145	109	4,132.50	(3,831.50)		3,831.50	3,825.50	2,772.60
Nov	8,404	6,090.95	0.72	105	79	2,992.50	(5,411.50)		5,411.50	5,411.50	3,922.08
Dec	7,964	5,772.05	0.72	90	68	2,565.00	(5,399.00)		5,399.00	5,399.00	3,913.02
Jan	7,804	5,656.09	0.72	90	68	2,565.00	(5,239.00)		5,239.00	5,239.00	3,797.06
Feb	8,203	5,945.27	0.72	90	68	2,565.00	(5,638.00)		5,638.00	5,638.00	4,086.24
Mar	6,203	5,411.50	0.72	140	105	3,990.00	(2,213.00)		2,213.00	2,213.00	1,603.91
Total	86,264	63,437.15		2,032	1,524	57,912.00	(28,352.00)	-	27,732.00	30697	20,276.11

		1	2	3	4	5	6	7	8	9	10	PBP
1 Initial inves	146,300											
Cash flows	(146,300)	40,961.40	40,961.40	40,961.40	40,961.40	40,961.40	40,961.40	40,961.40	40,961.40	40,961.40	40,961.40	
Cumulative c	(146,300)	(105,339)	(64,377)	(23,416)	17,546	58,507	99,468	140,430	181,391	222,353	263,314	
Fraction calculations		n/m	n/m	n/m	0.57	0.43	1.43	2.43	3.43	4.43	5.43	

جامعة النجاح الوطنية

كلية الدراسات العليا

التأثير الفني والاقتصادي من استخدام أنظمة الخلايا الشمسية المربوطة على الشبكات الكهربائية في مراكز جهاز الدفاع المدني

إعداد

تالة نبهان عبد الرزاق جلاد

إشراف

د. عماد بريك

قدمت هذه الاطروحة استكمالا لمتطلبات الحصول على درجة الماجستير في هندسة الطاقة النظيفة وترشيد الاستهلاك، بكلية الدراسات العليا، في جامعة النجاح الوطنية، نابلس– فلسطين.

2019

التأثير الفني والاقتصادي من استخدام أنظمة الخلايا الشمسية المربوطة على الشبكات الكهربائية في مراكز جهاز الدفاع المدني

إعداد

تالة نبهان عبد الرزاق جلاد

إشراف

د. عماد بريك

الملخص

فلسطين هي إحدى المناطق التي تعاني من عدم الاستقرار السياسي والاقتصادي واستمرار الاحتلال، وبسبب ظهور مشكلة الانقطاع المستمر للكهرباء في كافة محافظات الضفة ونظراً لزيادة الاحمال الكهربائية على الشبكات ونظراً للدور المهم والحيوي الذي تقوم به مراكز جهاز الدفاع المدني في تقديم الخدمات للمواطنين والاستهلاك العالي للتيار الكهربائي في المراكز كان لابد من البحث عن نظام طاقة بديل في توليد الكهرباء وهو استخدام الخلايا الشمسية الكهروضوئية نظرا لكفاءتها وباعتبارها مشاريع صديقة للبيئة وتحافظ عليها من التلوث.

جاءت هذه الرسالة لتتناول موضوع استخدام انظمة الخلايا الشمسية في مراكز الدفاع المدني الفلسطيني وتحليل الاثر التقني والاقتصادي من استخدام الطاقة الشمسية في المراكز ومدى تأثيرها على خفض فواتير الكهرباء لمراكز الدفاع المدني الفلسطيني التي تتراوح قيمة فواتيرها ما بين IL (350-1100) شهرياً وتوضيح استهلاك مراكز الدفاع المدني الفلسطيني ووصف لمنحنيات الحمل الكهربائي لمعظم مراكز الدفاع المدني الفلسطيني.

واختيار أفضل خيار للإمداد الكهربائي في كل من السيناريوهات وذلك من خلال توضيح إمكانات الطاقة الشمسية في فلسطين وشدة الاشعاع الشمسي وجميع البيانات الشمسية ذات الصلة في فلسطين وبعض المراكز المحددة اللازمة لدراستنا كحالات خاصة والتي تمثلت بمركز طوباس والرام وعنبتا وتحليل نتائج التوزيع الأمثل لموارد الطاقة في المراكز باستخدام برامج خاصة لتحسين تكلفة الطاقة في مراكز الضفة الغربية.

كنتيجة للدارسة نظرا للتعريفة التجارية المرتفعة في الوقت الحاضر ونوعية الطاقة الشمسية في فلسطين، كذلك القوانين والتوجيهات الفلسطينية الأخيرة التي تحكم مشاريع الطاقة المتجددة، ترشدنا إلى التفكير أكثر في استخدام تعليمات صافي القياس لتغطية مراكز الدفاع المدني، حيث ان قيم القدرة القصوى المطلوبة من الأنظمة الكهروضوئية لمراكز الدفاع المدني في مدى يتراوح بين kW_p (19.2 – 38.4) وبالتالي تحقق هذه الوفورات ما بين IL (22,100 – 43,000) في السنة للفواتير وخلال فترات زمنية لا تتجاوز 4 سنوات يمكن استرداد تكلفة المشاريع.

اضافة الى الحد من مظاهر التلوث وفقا لمراكز الدفاع المدني الطاقة المولدة سنوياً من أنظمة الخلايا الشمسية (28.91 MWh/yr. – 57.82 MWh/yr.) والتي ستكون عادةً وفورات في ثاني أكسيد الكربون بما يتراوح (17.346 tons - 57.82 tons) سنوياً.