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Design And Analysis A Solar System For A Villa

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Abstract

There are numerous energy sources available, but their proportional utilization in the globe and in Palestine is not equal. We rely largely on electricity supplied by Qatari electricity businesses operating within the occupied country, which is delivered throughout Palestine via multiple connecting points. Installing solar cells and relying on them, (at least in part), for daily use to minimize network pressure and deliver long-term economic savings

Solar cells are designed in two examples for a villa in the Tulkarm area, one connected to the grid and the other disconnected from it.

From shadow analysis to estimating the vacant spaces and loads in the house, we examined all of the design criteria.

Also, based on studies and values taken over 20 years, including changing temperatures, the region was analyzed in terms of the sun's path throughout the year and the amount of radiation emitted by it, and finally, the used categories of inverters, batteries, solar cells, and everything else the system requires were chosen.

Chapter 1
Introduction

1.1 Introduction

Photovoltaics offer consumers the ability to generate electricity in a clean, quiet and reliable way. Photovoltaic systems are comprised of photovoltaic cells, devices that convert light energy directly into electricity. Because the source of light is usually the sun, they are often called solar cells. The word photovoltaic comes from "photo," meaning light, and "voltaic," which refers to producing electricity. Therefore, the photovoltaic process is "producing electricity directly from sunlight." Photovoltaics are often referred to as PV.

PV systems are being installed by Texans who already have grid-supplied electricity but want to begin to live more independently or who are concerned about the environment. For some applications where small amounts of electricity are required, like emergency call boxes, PV systems are often cost justified even when grid electricity is not very far away. When applications require larger amounts of electricity and are located away from existing power lines, photovoltaic systems can in many cases offer the least expensive, most viable option.

In use today on street lights, gate openers and other low power tasks, photovoltaics are gaining popularity in Texas and around the world as their price declines and efficiency increases.

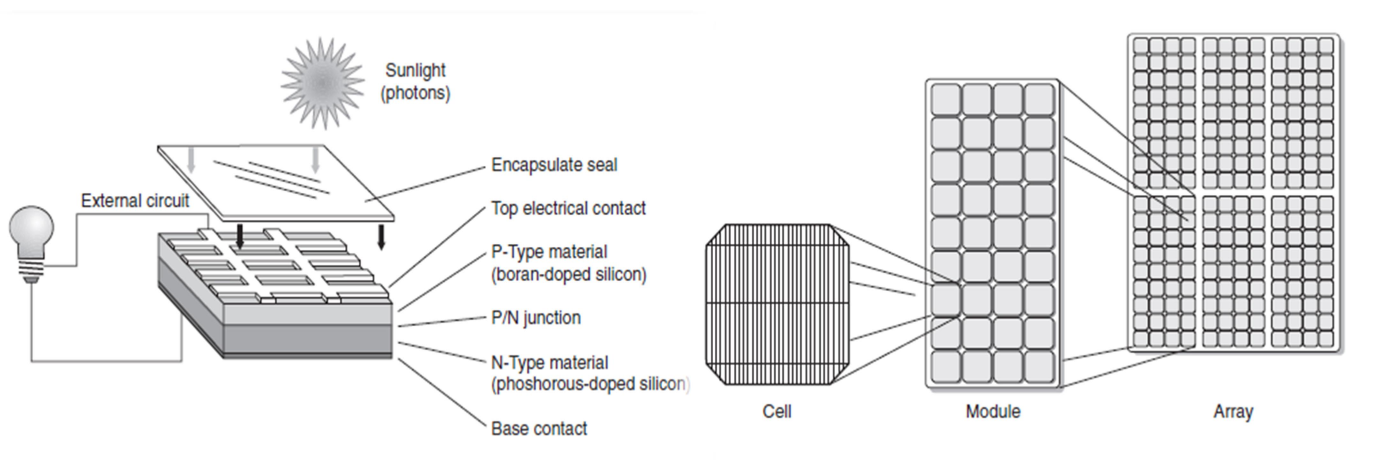


Fig.1

1.2 Photovoltaic System Definition

photovoltaic system, also PV system or solar power system, is an electric power system designed to supply usable solar power by means of photovoltaics. It consists of an arrangement of several components, including solar panels to absorb and convert sunlight into electricity, a solar inverter to convert the output from direct to alternating current, as well as mounting, cabling, and other electrical accessories to set up a working system. It may also use a solar tracking system to improve the system's overall performance and include an integrated battery.

PV systems convert light directly into electricity, they are not to be confused with other solar technologies, such as concentrated solar power or solar thermal, used for heating and cooling. A solar array only encompasses the ensemble of solar panels, the visible part of the PV system, and does not include all the other hardware, often summarized as balance of system (BOS).

PV systems range from small, rooftop-mounted or building-integrated systems with capacities from a few to several tens of kilowatts, to large utility-scale power stations of hundreds of megawatts. Nowadays, most PV systems are grid-connected, while off-grid or stand-alone systems account for a small portion of the market.

Operating silently and without any moving parts or environmental emissions, PV systems have developed from being niche market applications into a mature technology used for mainstream electricity generation. A rooftop system recoups the invested energy for its manufacturing and installation within 0.7 to 2 years and produces about 95 percent of net clean renewable energy over a 30-year service lifetime

1.3 Overview

In this day, renewable resource is one of the major concerns because of increasing more power demand but the quality and availability of conventional energy sources are not enough.Energy is essential factor for the development of any nations of all over the world. Most of the energy production depends on fossil fuel. The resources of the fossil fuels are limited, so that there are growing demand for energy from renewable resources like solar, geothermal and ocean tidal wave. Among all renewable systems, photovoltaic "PV" system is the one which has great chance to replace the conventional energy resources. To enhance the performance of solar panel the only way is to increase the intensity of light falling on it. Solar tracker is the best technology to increase the efficiency of solar panel by keeping panel aligned with the suns position. A solar tracker is a system that follows the sun as it moves across the sky. When paired with solar panels, the panels can follow the path of the sun and produce more renewable energy for you to use

1.3.1Type of PV Modules

There are three types of PV cell technologies that dominate the world market: monocrystalline silicon, polycrystalline silicon, and thin film. Higher efficiency PV technologies, including gallium arsenide and multi-junction cells, are less common due to their high cost, but are ideal for use in concentrated photovoltaic systems and space applications.

1.Monocrystalline Silicon Cell

The first commercially available solar cells were made from monocrystalline silicon, which is an extremely pure form of silicon. To produce these, a seed crystal is pulled out of a mass of molten silicon creating a cylindrical ingot with a single, continuous, crystal lattice structure. This crystal is then mechanically sawn into thin wafers, polished and doped to create the required p-n junction. After an anti-reflective coating and the front and rear metal contacts are added, the cell is finally wired and packaged alongside many other cells into a full solar panel Monocrystalline silicon cells are highly efficient, but their manufacturing process is slow and labour intensive, making them more expensive than their polycrystalline or thin film counterparts.

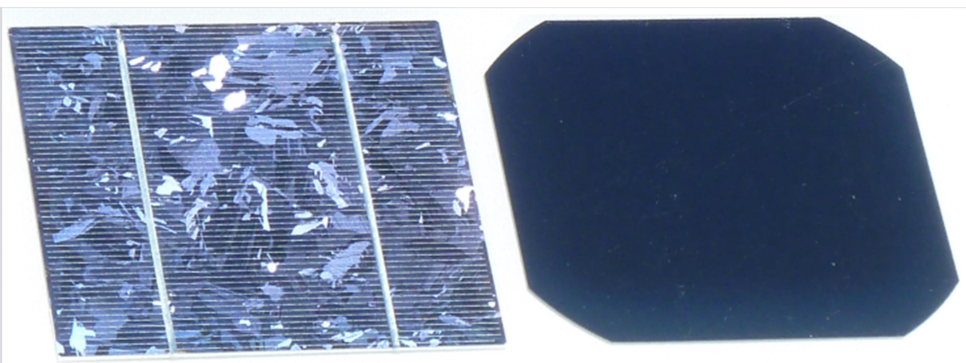


Figure 2. An image comparing a polycrystalline silicon cell (left) and a monocrystalline silicon cell (right).[4]

Fig.2

2.Polycrystalline Silicon Cell

Instead of a single uniform crystal structure, polycrystalline (or multicrystalline) cells contain many small grains of crystals (see figure 2). They can be made by simply casting a cube-shaped ingot from molten silicon, then sawn and packaged similar to monocrystalline cells. Another method known as edge-defined film-fed growth (EFG) involves drawing a thin ribbon of polycrystalline silicon from a mass of molten silicon. A cheaper but less efficient alternative, polycrystalline silicon PV cells dominate the world market, representing about 70% of global PV production in 2015

3.Thin Film Cells

One type of thin film PV cell is amorphous silicon (a-Si) which is produced by depositing thin layers of silicon on to a glass substrate. The result is a very thin and flexible cell which uses less than 1% of the silicon needed for a crystalline cell. Due to this reduction in raw material and a less energy intensive manufacturing process, amorphous silicon cells are much cheaper to produce. Their efficiency, however, is greatly reduced because the silicon atoms are much less ordered than in their crystalline forms leaving 'dangling bonds' that combine with other elements making them electrically inactive. These cells also suffer from a 20% drop in efficiency within the first few months of operation before stabilizing, and are therefore sold with power ratings based on their degraded output

Fig.3

Thin Film Cells

1.4 Problem Statement

Palestine faces major problems in electricity supply is unstable due to the increase in population density, the weather conditions, and also the increase in electrical loads on transformers within cities, whether they are from factories, homes, or any human interests. and in the Tulkarm area in particular the problem is very hard Citizens use techniques to solve their problems, such as the current solar energy system to increase electrical energy, , so the owner of a residential villa in the city wanted to search for a solution to this problem in his home especially for him

1.5 Project Objectives

The electricity problem in the city is increasing and there is no general solution to this problem, so we wanted to solve the villa owner effectively and with the best design to solve the problem in his home, at least, and the objectives are arranged as follows

1.Solve the problem with the best design with the available resources

2.Save as much as possible on costs

3.Not affecting the public electrical network after this solution

4. Basically not to cut off the power to the house after implementing the solution

1.6 Scope of the work

The system works on making use of solar energy to operate the house in the event of a power outage through the energy stored in the batteries or supplementing the missing capacity from the network in the event of a power shortage .

Fig.4 sample diagram for systems

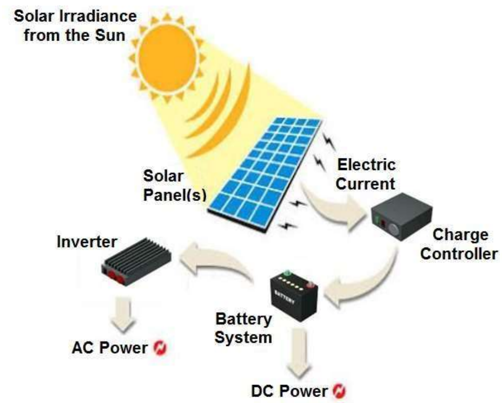


Fig.4

1.7 How does it work

When the sun's rays begin to appear, as show in fig.5 the cells begin the process of storing and transferring electrical energy through the charge controller and also with a closed switch in the normal position of the batteries .

(The switch opens when the batteries are full, it prevents the current from flowing to the batteries)

And after that, if the main switch of the system is open towards the batteries, the power goes out to the load after converting it from the direct current to the alternating current to the load to be fed.

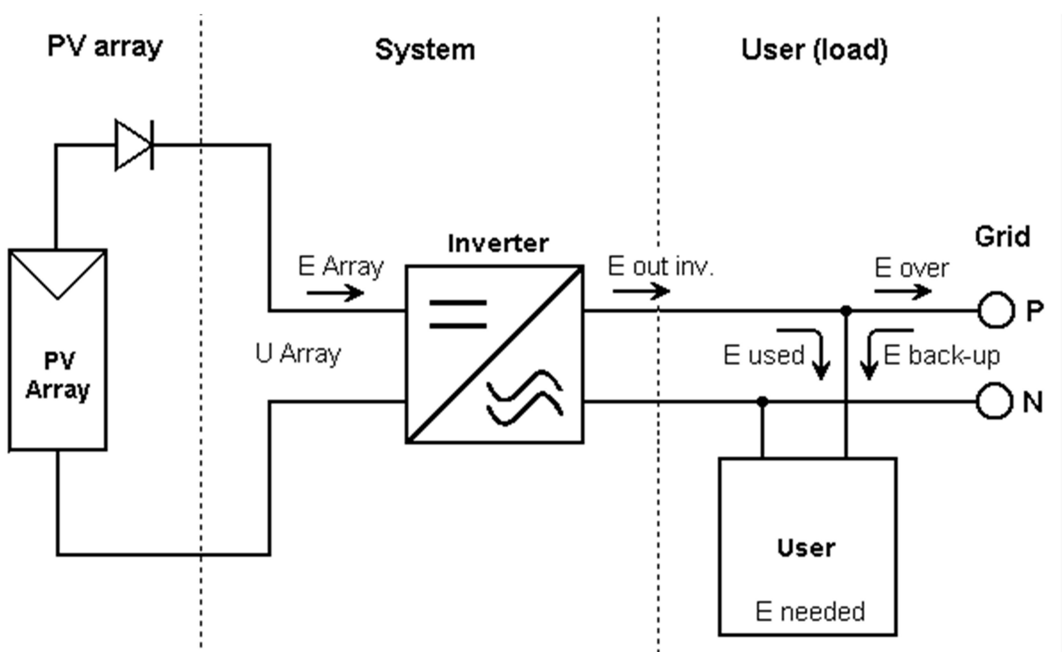


Fig.5

1.8Advantages and Disadvantages of solar PV

1.8.1 Advantages

1.PV panels provide clean – green energy. During electricity generation with PV panels there is no harmful greenhouse gas emissions thus solar PV is environmentally friendly.

2.Solar energy is energy supplied by nature – it is thus free and abundant!

3.Solar energy can be made available almost anywhere there is sunlight

4.Operating and maintenance costs for PV panels are considered to be low, almost negligible, compared to costs of other renewable energy systems

5.PV panels are totally silent, producing no noise at all; consequently, they are a perfect solution for urban areas and for residential applications (see solar panels for home)

1.8.2 Disadvantages

1.Solar PV panels are more expensive than panels designed for solar thermal energy. However, they do a lot more for your home or business than solar thermal panels do, and there are some incentives and grants to help pay for them.

2.You need an adequate roof space to display your solar PV panels. The larger the panel covering the more electricity generated

3.These systems may not be a viable green energy option for you if your home or business if you have a predominantly north or east facing roof or if tall buildings and/or trees place your roof in the shade during the day.

4. Some toxic chemicals, like cadmium and arsenic, are used in the PV production process. These environmental impacts are minor and can be easily controlled through recycling and proper disposal.

1.9 Important of the work

The solar system is of great importance, as it has been used in many applications over tens of years and solves many problems such as the lack of an electrical network in some remote areas and also the lack of electrical capacity from the company and saving mainly in the long run as we benefit from the sun's rays that we do not pay for

1.10 The Effect of Weather on the System

Cloudy Environment

Since the PV cells depend on solar radiation for functioning, solar panels in overcast weather tend to be slightly less productive as compared to sunny days. A solar panel's output during a cloudy day also depends on how dense the cloud cover is. For instance, cirrocumulus or thin sheet-like clouds may not have much impact on the performance of solar panels. Meanwhile, on partly overcast days the performance of even the most effective solar panels for cloudy days can fall by 10 per cent to 25 per cent. However, rainy days are not as terrible as they may seem. The panels getting dusty over time can also impact their output negatively. Rainwater can wash away the dirt, thereby, saving some of the maintenance efforts.

Snowy Environment

While a large layer of snow can obstruct the PV cells' ability to produce energy, a thin layer of snow isn't as problematic because some sunlight can still flow through. Furthermore, most rooftop systems are designed so that snow falls off naturally. Surprisingly, because the snow works as a mirror, the dusting of snow around the house can actually improve solar energy generation. As a result, the rate of heat transfer hitting the solar panels increases in the winter.

Lightning

The way lightning strikes solar panels and inverters can have an impact on them. A direct lightning strike, for example, can potentially melt the panels. Indirect lightning hits, which are more common than direct lightning strikes, can cause voltage surges that harm several system components. Users of solar panels who live in areas prone to lightning strikes might seek out organizations who provide lightning insurance. Meanwhile, Genus protects the solar power plant by using a LA (lightning arrestor).

Extreme Temperatures

High temperatures can boost the effectiveness of solar panels, according to one of the numerous myths about the weather effect on solar panels. Solar panels are more productive when temperatures are low, as paradoxical as it may sound. Due to voltage drop, high temperatures diminish the power output of PV cells. As a result, a chilly sunny day is far better for the solar panels' optimal performance.

CHAPTER 2
Constraints, Standards and Earlier Coursework

2.1Constraints

In every project an entry must appear during each stage of the project From choosing the address to delivering the report.

In this The project, the first obstacle was choosing the topic and where the project will be implemented and what is the goal behind it, and choosing the type of cells used, but all this was determined after several discussions between us and the supervisor.

The second is that the cost of the items is about 1500 shekels in Nablus.

2.2Standards

1.PV modules LG 400 N2T-A5

2.Inverters STT-10KTL_P

3.Charg Controller

4.Battary Banks

5.DC Isolator

6.AC Circuit Breaker

2.3Earlier coursework

Through the five years too many courses had been taken, some of them have been used in this project in direct way or not directly either in hardware design, software design, writing the report or even in preparing the presentation. The following paragraphs mention the courses that used in this project.

English 102 and control system help us were employed in writing professional report and preparing a perfect presentation.

special topics in powers and (stability and protection of electrical power system) to understand the connection of solar system with grid

Electrical circuits 1, 2 and Electronics Circuits 1, 2, 3 will help us to understand the usage of different electrical components and guided us to install these components correctly in project 2.

Sensors and Measurements helped us to deal with different sensors, such and got us the basic knowledge to use each sensor correctly.

Chapter 3
Literature Review

*Review of the performance of residential PV systems in France

This is done analyzing the operational data of 6868 installations. Three main questions are posed. How much energy do they produce? What level of performance is associated to their production? Which are thekey parameters that most influence their quality? During the year 2010, the PV systems in France have produced a mean annual energy of 1163 kWh/kWp. As a whole, the orientation of PV generators causes energy productions to be some 7% inferior to optimally oriented PV systems. The mean Performance Ratio is 76% and the mean Performance Index is 85%. That is to say, the energy produced by a typical PV system in France is 15% inferior to the energy produced by a very high quality PV system. On average, the real power of the PV modules falls 4.9% below its corresponding nominal power announced on the manufacturer’s datasheet. A brief analysis by PV modules technology has led to relevant observationsو about two technologies in particular. On the one hand, the PV systems equipped with heterojunction with intrinsic thin layer (HIT) modules show performances higher than average. On the other hand, the systems equipped with the copper indium (di)selenide (CIS) modules show a real power thatis 16% lower than their nominal value.

**A Critical Appraisal of PV-Systems’ Performance

Despite its popularity, its adoption is still facing enormous challenges, especially in developing countries. Experience from research and practice has revealed that installed PV systems significantly underperform. This has been one of the major barriers to PV-system adoption, yet it has received very little attention. The poor performance of installed PV-systems means they do not generate the required electric energy output they have been designed to produce. Performance assessment parameters such as performance yields and performance ratio (PR) help to provide mathematical accounts of the expected energy output of PV-systems. Many reasons have been advanced for the disparity in the performance of PV-systems. This study aims to analyze the factors that affect the performance of installed PV-systems, such as geographical location, solar irradiance, dust, and shading. Other factors such as multiplicity of PV-system components in the market and the complexity of the permutations of these components, their types, efficiencies, and their different performance indicators are poorly understood, thus making it difficult to optimize the efficiency of the system as a whole.

***A comprehensive review on protection challenges and fault diagnosis in PV systems

According to the National Electric Code (NEC) article 690 [11], the DC side of all PV systems must be protected against over-current faults, ground faults and arcing faults using Over Current Protection Devices (OCPDs), Ground Fault Detection and Interruption (GFDI) fuses/ Ground Fault Protection Devices (GFPDs) and Arc Fault Circuit Interrupters (AFCIs) respectively. In addition, arcing faults can also be detected using string level Arc Fault Detectors (AFDs). However, it has been reported in literature [12–19] that on several instances, these protection devices have failed to detect their corresponding faults in the PV array due to: 1) Lower fault current magnitudes, 2) Presence of Maximum Power Point Trackers (MPPTs) and 3) Non-linear PV characteristics and its colossal dependency on the insolation levels]. Further, any electrical fault occurrence in the DC side of a PV system is bound to have a catastrophic effect on the output characteristics; which is usually unpredictable and sometimes even burns out the complete system even though the system is equipped with protection devices [16,17]. At the same time, it is to be noted that, faults occurring in low irradiation levels may remain undetected in the PV system and lead to significant energy losses and degradation of PV panels [18,19]. According to energy audit reports, the annual energy losses due to fault occurrences are estimated to be as high as 18.9% for the domestic PV systems in UK [20].

****Renewable energy in the Palestinian Territories: Opportunities and challenges

The vast majority of fossil fuels consumed in the Palestinian Territories are imported, with the majority originating in Israel and with marginal percentages from Egypt and Jordan. Fossil fuels are principally consumed by the transportation sector. Fig. 1 shows the primary energy sources in the Palestinian Territories. The majority, 78%, are liquid fossil fuels, such as gasoline, diesel and liquefied petroleum gas, while the remaining 22% is renewable energy sources. Fig. 2 illustrates that diesel and gasoline account for 79% of the fossil fuels consumed in the Palestinian Territories. There is no consumption of solid fossil fuels in the Palestinian Territories.

Fig. 3 demonstrates that 56% of renewable energy produced in the Palestinian Territories is solar energy from solar water heaters and 43% is biomass from wood, olive cake and charcoal. The biomass is mainly used for heating purposes. The only domestic production of traditional power takes place at the Gaza Power Plant, which has struggled to operate atmore than half capacity since 2006 and especially since 2009 when the Israeli Air Force attacked it and when European Union funding of fuel shipments ceased.

Chapter 4
Methodology

4.1 Network General Analysis

Most of electrical energy in the West Bank is generated and supplied by IEC. The Palestinian areas are supplied from connection points of 33 kV and 22 kV. Recently, new connection points of 161 kV are constructed to make the electric power grid able to withstand the growing demand of electrical energy in the West Bank, also to improve the performance and reliability of the overall transmission and distribution systems. Four new connection points of 161 /33 kV are located in northern (Nablus and Jenin), central (Ramallah), and southern (Hebron) areas of the West Bank . The electrical distribution companies buy electrical energy from IEC and sell it to consumers at higher price to recover the services and maintenance of electrical power networks. The peak demand in the northern districts of West Bank has been forecasted as shown in Table 1. It can be seen that the growth in total electrical power demand has increased from 243 MW in 2012 to 318 MW in 2016

City/ Year	**2012**	**2014**	**2016**	**2018**	**2020**
Jenin	60	68	78	90	103
Tubas	10	11.5	13	15	17
Tulkarm	45	51.5	59	67.5	77
Qalqilia	20	23	26	30	34
Nablus	90	103	118	135	154
Salfeet	18	21	23.5	27	30.5
Total North	243	278	317.5	364.5	415.5

Table 1. The electric power demands in (MW) in the northern districts of the West Bank

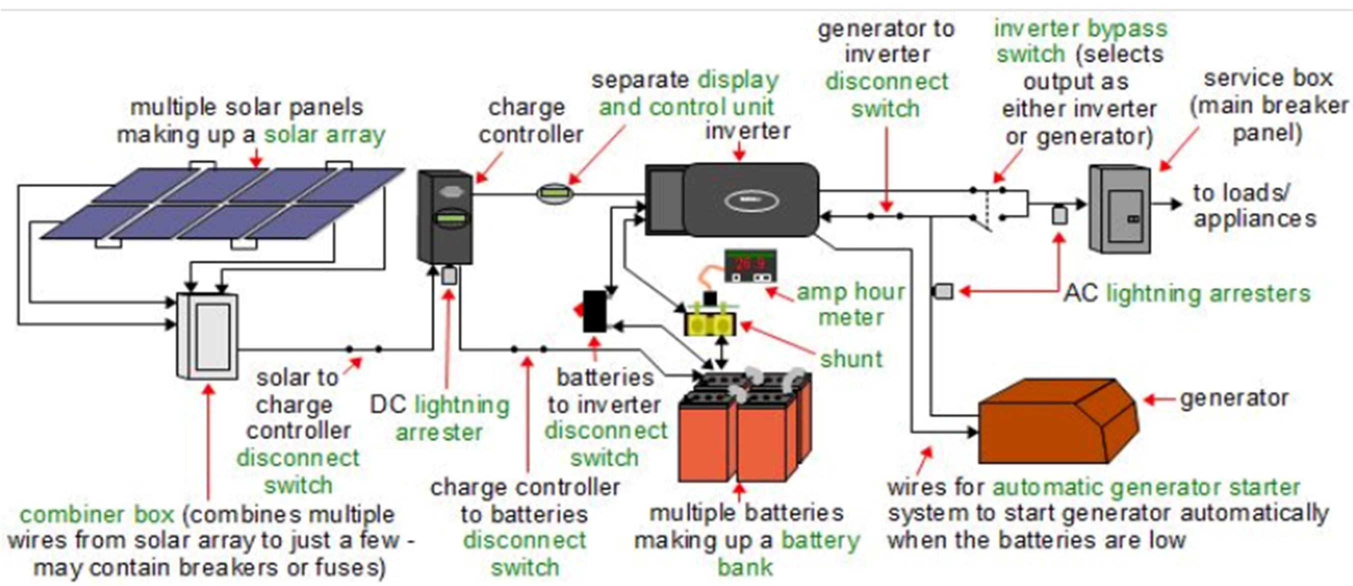
As mentioned above, the electrical network in the West Bank suffers from a lack of capacity and needs to be developed, and because we are governed by resources (due to the Israeli occupation), we need to cover the missing capacity in several ways, such as solar cells

We have previously defined solar cells and explained the principle of their work and their types, as well as the advantages and disadvantages. We will start with ways to connect them with the electrical network and the method of work

4.2Type Of Connection with Grid

4.2.1 Off-Grid

The off-grid system term states the system not relating to the gird facility. Primarily, the system which is not connected to the main electrical grid is term as off-grid PV system Off-grid system also called standalone system or mini grid which can generate the power and run the appliances by itself. Off-grid systems are suitable for the electrification of small community. Off-grid electrification system is viable for the remote areas in the countries where they do have little or no access to the electricity because of the distinct living and spread population in the vast area. The off-grid system refers to the support that would be adequate for a living without depending on the grid or other system. Electrical energy in the off-gird system produced through the Solar photovoltaic panels needs to be stored or saved because mrequirement from the load can be different from the solar panel output, battery bank is also used for the purpose generally



More complete off-grid system diagram.

Fig.6

Simple Diagram for off grid

4.2.2 ON-Grid

Grid connected photovoltaic power system is an electricity generating system which is linked to the utility gird . This photovoltaic system contains solar panel, inverter and the equipment to provide connection to the grid. Grid connected nsystems are feasible for various setup such as residential. Commercial and larger scale grid tied system different than the off grid solar power systems. Usually grid connected system does not need battery backup, because when system generate the energy more than the load it will automatically transfer to the linked utility gird.

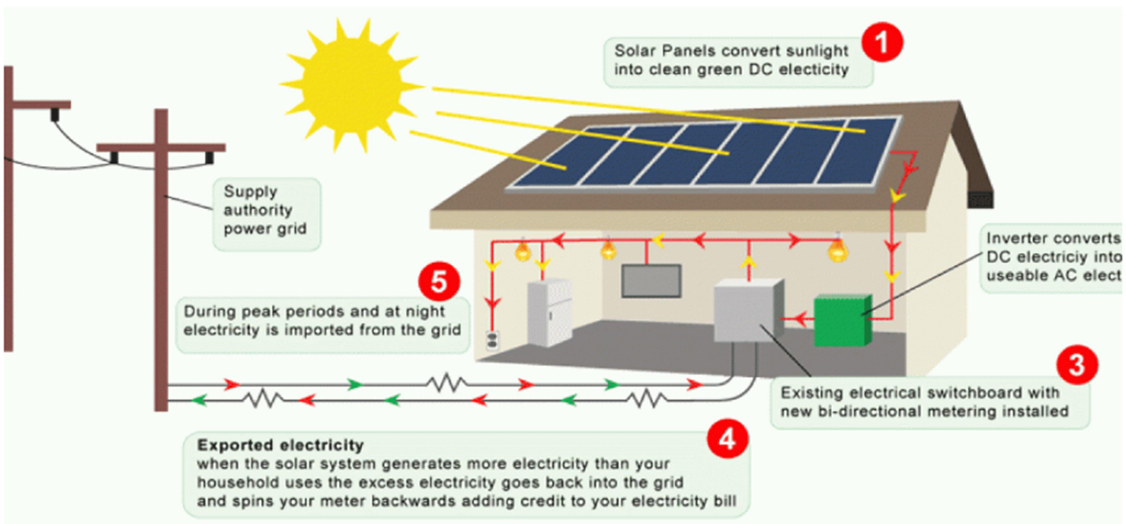


Fig.7

Simple Diagram for on grid

In the residential setups grid connected rooftop systems usually having the capability of 10 kilowatts which could be enough to meet the house requirements, and the excess would feed the grid which can be used by other consumers connected to the grid. The feedback or excess power transfer system works through a meter to track the transferred power. In some instances, PV system wattage could be less than the normal consumption due to several different factors and in this scenario, consumer will utilize the grid energy

4.3 Hardware system

Off Grid

1.solar panels	2.charge controllers
3.battery bank(s)	4.inverters

ON Grid

1.solar panels	2.Grid
3. inverters	4.DC Isolator
5. AC Circuit Breakers	6.Solar power Meter

4.3.1 Solar Panels

In this project we will use solar panels from LG company with model number LG 400 N2W-A5 and here are some details about it :

Mechanical Properties

Cells	6 x 12
Cell Vendor	LG
Cell Type	Monocrystalline / N-type
Cell Dimensions	161.7 x 161.7 mm / 6 inches
# of Busbar	12 (Multi Wire Busbar)
Dimensions (L x W x H)	2024 x 1024 x 40 mm 79.69 x 40.31 x 1.57 inch
Front Load	5400Pa
Rear Load	4300Pa
Weight	21.7 kg
Connector Type	MC4
Junction Box	IP68 with 3 Bypass Diodes
Cables	1200 mm x 2 ea
Glass	High Transmission Tempered Glass
Frame	Anodized Aluminium

Certifications and Warranty

Certifications	IEC 61215, IEC 61730-1/-2 UL 1703 IEC 61701 (Salt mist corrosion test) IEC 62716 (Ammonia corrosion test) ISO 9001
Module Fire Performance (USA)	Type 1
Fire Rating (CANADA)	Class C (ULC / ORD C1703)
Product Warranty	15 years
Output Warranty of Pmax	Linear warranty**

** 1) 1st year : 98%, 2) After 1st year : 0.5% annual degradation, 3) 25 years : 86%

Temperature Characteristics

NOCT	45 ± 3 °C
Pmpp	-0.36%/°C
Voc	-0.26%/°C
Isc	0.02 %/°C

Fig.8

Electrical Properties (STC *)

Module	400W
Maximum Power (Pmax)	400
MPP Voltage (Vmpp)	40.6
MPP Current (Impp)	9.86
Open Circuit Voltage (Voc)	49.3
Short Circuit Current (Isc)	10.47
Module Efficiency	19.3
Operating Temperature	-40 ~ +90
Maximum System Voltage	1500 (UL)
Maximum Series Fuse Rating	20
Power Tolerance (%)	0 ~ +3

* STC (Standard Test Condition): Irradiance 1,000 W/m², Ambient Temperature 25 °C, AM 1.5
* The nameplate power output is measured and determined by LG Electronics at its sole and absolute discretion.
* The Typical change in module efficiency at 200W/m² in relation to 1000W/m² is -2.0%.

Electrical Properties (NOCT*)

Module	400W
Maximum Power (Pmax)	296
MPP Voltage (Vmpp)	37.6
MPP Current (Impp)	7.88
Open Circuit Voltage (Voc)	46.1
Short Circuit Current (Isc)	8.41

* NOCT (Nominal Operating Cell Temperature): Irradiance 800W/m², ambient temperature 20 °C, wind speed 1m/s

Fig.8

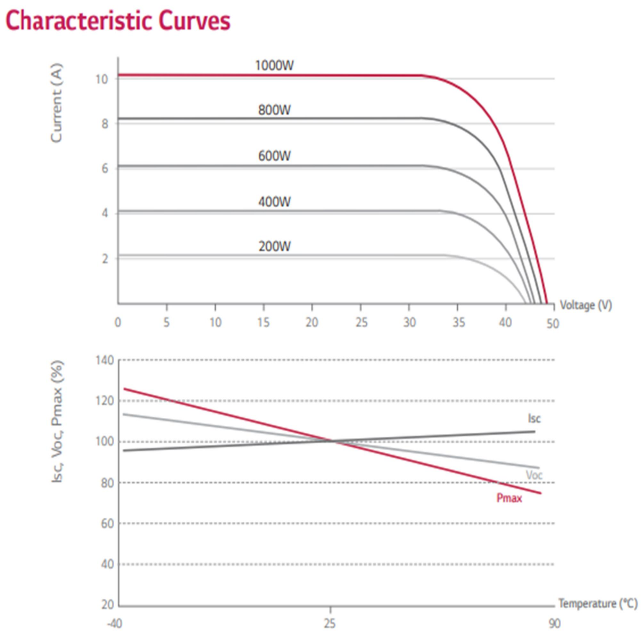


Fig.8

Fig.8

4.3.2 Inverters

is the battery inverter for high-voltage manufacturers. With a charge and discharge power of 2.5 kW, it is ideally suited to handle electricity demand of a private household.

Fig.9

4.3.3DC Isolator

A DC isolator is a manual disconnection switch that stops electricity generated by a PV system flowing through the system to make it safe in emergency situations or to allow for servicing and maintenance

Technical data	Sunny Boy Storage 2.5
AC connection	
Rated power (at 230 V, 50 Hz)	2500 W
Max. apparent AC power	2500 VA
Nominal AC voltage / range	220 V, 230 V, 240 V / 180 V to 280 V
AC power frequency / range	50 Hz, 60 Hz / −5 Hz to +5 Hz
Rated power frequency / rated grid voltage	50 Hz / 230 V
Max. AC current	11 A
Power factor at rated power	1
Adjustable displacement power factor	0.8 overexcited to 0.8 underexcited
Feed-in phases / connection phases	1 / 1
Battery DC input	
Max. DC power (at cos φ = 1)	2650 W
Max. DC voltage	500 V
DC voltage range / DC rated voltage	100 V to 500 V / 360 V
Min. DC voltage / start DC voltage	100 V / 100 V
Max. DC current	10 A
Max. DC short-circuit current	18 A
Battery type	Li-ion*
Efficiency	
Max. efficiency / European weighted efficiency	~97.0% / ~96.5%
Self-consumption with no load / standby	≤ 10 W / ≤ 2 W
Protective devices	

Fig.10

While DC isolators provide additional safety protection, they also introduce additional points of potential failure within a PV system and, in some cases, failure of DC isolators have resulted in fires.

4.3.4 AC Circuit Breakers

A circuit breaker protection system can consist of up to three parts. A sensing system that detects an overload situation, a relay that conveys the information to the switching arrangement, and the combination of contacts and the contact actuator. This arrangement is typically found in power transmission and distribution networks dealing with very high voltages, currents, and powers. Lower power circuit breakers have the sensing and actuation mechanisms collocated, or even built into a single unit

Fig.11

4.3.5 Battery Bank

Battery Bank Systems integrate with a Photovoltaic (PV) system to store excess solar energy generated during daylight hours. This stored power is then utilized on demand when required, reducing your overall consumption of grid electricity.

How many batteries should my solar power system have?

Fig.12

It depends on the amount of AC loads, which are often household electric appliances, and the length of time they will be powered by batteries. For example, suppose you have 1500W AC loads that must be powered for 3 hours by batteries. This is the formula:

1500W x 3 hours = 4500Wh, which means you need 4500Wh battery capacity If we use 12V 150Ah gel deep cycle battery, (Gel link) The single battery capacity is 12V x 150Ah = 1800Wh 450 0Wh / 1800Wh = 2.5, so we need at least 3 pcs battery to support AC loads.

4.3.6 Solar Power Meter

is a device that measures solar power or sunshine in W/m2 and can be used to check the effectiveness of windows or to install solar power equipment.

To monitor and assess PV plant performance, solar meters collect PV yield generation and local energy usage.

It frequently includes a monitoring function that alerts plant owners to concerns with PV plant performance, allowing them to promptly rectify issues and maximize return on investment.

Fig.13

Note : **In this project, the [PVSyst] program was used to design solar cells**

To assist the design and accuracy of work and performance, the first stage in the design of the solar system is to know the location and extent of the sun's rays. To create a correct and efficient system, data must be collected over a period of time.

4.4Weather Data

Solar Radiation

The electromagnetic radiation emitted by the sun is known as solar radiation, sometimes known as the solar resource or just sunshine. A multitude of devices can be used to catch solar radiation and convert it into useful forms of energy such as heat and electricity. However, the technical viability and cost-effectiveness of these systems at a given area are determined by the solar resource available.

Temperature Effect

Temperature increases reduce the effectiveness of solar panels, which may seem counterintuitive. Photovoltaic modules are tested at a temperature of 25 degrees Celsius (STC) – about 77 degrees Fahrenheit – and heat can lower output efficiency by 10% to 25% depending on where they are installed. The output current of the solar panel increases exponentially as the temperature of the panel rises, whereas the voltage output decreases linearly. In fact, the voltage drop is so consistent that it may be used to precisely monitor temperature.

The sun radiation and temperature data for Tulkarm are organized as follows, based on research and data collected over a 20-year period.

Site **Ţūlkarm (Palestine, State Of)**

Data source Meteonorm 8.0 (1991-2010), Sat=100%

	Global horizontal irradiation	Horizontal diffuse irradiation	Temperature	Wind Velocity	Linke turbidity	Relative humidity
	kWh/m²/mth	kWh/m²/mth	°C	m/s	[-]	%
January	89.9	33.9	12.8	3.00	3.510	69.1
February	99.3	48.0	14.0	3.00	4.020	67.3
March	147.5	65.3	16.7	3.01	4.806	63.0
April	174.6	77.1	19.4	3.00	5.658	59.7
May	211.8	85.5	22.9	3.00	5.472	58.2
June	233.3	70.5	25.5	3.00	4.115	63.4
July	221.7	78.8	28.1	3.00	4.156	64.6
August	200.9	79.4	28.6	2.90	4.194	64.9
September	167.0	61.4	26.6	2.80	4.184	64.4
October	127.9	60.0	24.0	2.59	4.488	61.9
November	92.8	39.8	19.1	2.49	3.748	59.0
December	79.5	40.2	14.9	2.79	3.517	65.1
Year	**1846.2**	**739.8**	**21.1**	**2.9**	**4.322**	**63.4**

Global horizontal irradiation year-to-year variability 6.5%

Fig.14

4.4.1 Partial Shading Effects In Photo voltaic Arrays

Shading plays a very important role on the performance of a solar PV system and many of the system designers unfortunately do not take shading in to consideration while analyzing there system performance. Some of the software such as PVsyst is quite capable of simulating shading and estimating energy losses due to shading of the PV array. Below figures shows typical sunpath of New delhi.

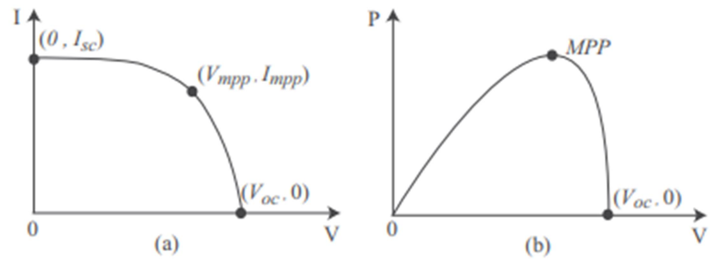


Fig.15 Characteristic curves of a PV array. (a) Current–voltage curve and (b) power–voltage curve.

Fig.14 illustrates typical current–voltage and power–voltage curves for a homogeneous PV array under uniform insolation of all the PV modules. Conventional MPPT techniques find the voltage Vmpp and current Impp at which the PV array operates at the MP P.

Fig.16

However, these techniques may malfunction for nonuniform insolation of the PV array. Various factors such as aging, dust, and partial shading result in mismatching and, hence, nonuniform operation conditions. Partial shading is a frequent phenomenon that occurs when some mcells within a module or array are shaded by buildings, birds, mpassing clouds, or some other object, as illustrated in Fig. 15.

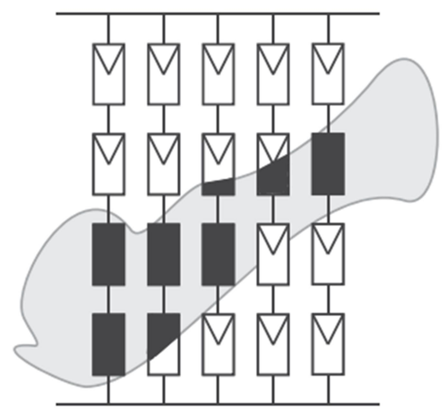


Fig.16 PV modules under the partial shading condition.

Since the short-circuit current of a PV cell is proportional to the insolation level, the partial shading effect is a reduction of the photocurrent for the shaded PV cells while the unshaded cells continue to operate at a higher photocurrent. Since the string current must be equal through all the series-connected cells, the result is that the shaded cells operate in the reverse bias region to conduct the larger current of the unshaded cells Fig. 3 illustrates how the string current flows through all the series-connected cells including shaded and unshaded. The bias voltage Vbias is the reverse voltage at which the shaded cells must operate to support the common string current.

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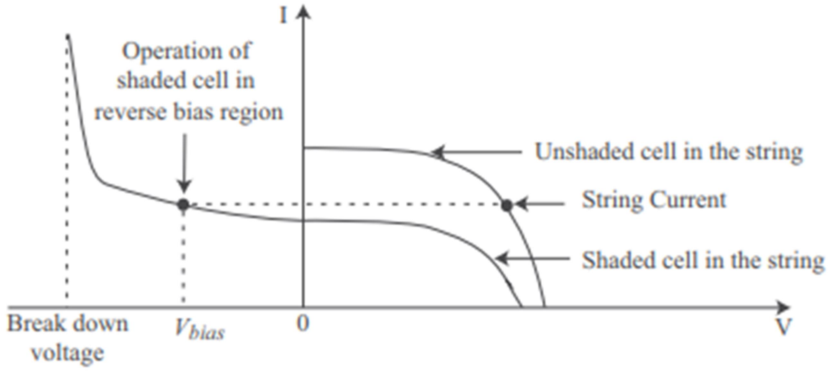


Fig.17 **Current–voltage curve of a PV cell operating in a reverse bias region.**

The shaded cells consume power due to the reverse voltage polarity. Therefore, the maximum extractable power from the shaded PV array decreases. The high bias voltage may also lead to an avalanche break down. This, in turn, may cause the thermal break down of the cell, creating a so-called hot spot. If untreated, excessive heating can result in cell burn out and create an open circuit in the shaded string

4.4.2Sun Paths

in fact the first requirement is to understand sun path diagram of a given location which shows the path of the sun across sky from the summer to winter solstice. PVsyst is capable of generating sun path diagram for a given location and energy production can be simulated for each hour during winter and summer seasons and accordingly the system design can be optimized for annual yield basis, summer yield basis or winter yield basis depending on the design criteria . It is possible to estimate the reduction of energy generation of a solar plant due to shading from a individual object for example following figure shows simulation of a Tree and inverter room in PVsyst through which the energy reduction due to shading of these objects on array output can be analyzed while shading simulation a percent loss due to shading for each hour is calculated and accordingly the annual losses can be derived for the shadings through these objects . A typical analysis conducted by our team ,the output of a 5MW system can have shading losses as high as 2-3% due to shading from the near objects .the below figures highlights the shading effect due to inverter rooms and a tree beside a roof top PV

The sun's course in the Tulkarm region is depicted in the diagram below, according to the program employed.

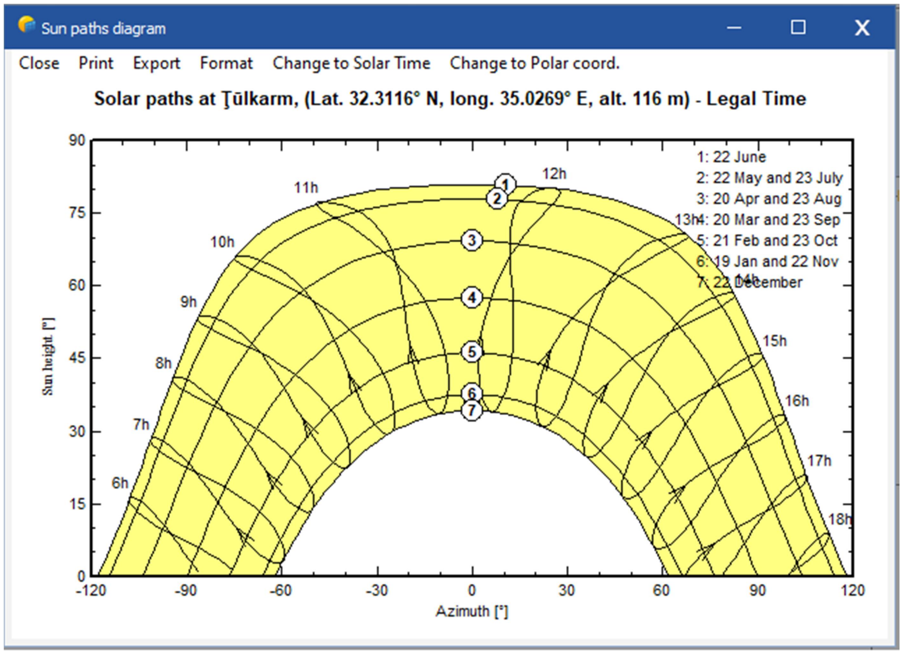


Fig.18

Sun Path Diagram

surface area reaches 100 m^2, 65 m^2 is empty of everything and far from the influence of shadows, as the villa is located in an area far from high residential buildings, meaning that there is no shadow that affects it from the outside, only the shadow of the water tanks and the entrance stairs to the roof of the villa.

4.5 Tilt Angle of PV

Do not overlook the relevance of solar panel orientation and inclination when optimizing solar panel production! However, it is not always about creating the most quantity of energy; you must also consider your consumption requirements.

Why is the tilt of the panels so important?

Because your panels create the most energy when the sun is directly perpendicular to them, the tilt of the panels is crucial. The sun is low in relation to the horizon in the northern hemisphere during the winter. In this scenario, a sharp angle of 60° is ideal for optimal performance of the solar panels. The optimal angle in the spring is 45°, while in the summer, when the sun is high in the sky, a low tilt of 20° is best!

The best solar panel angle for maximizing power generation is determined by the geophysical position of the system and the season. In the summer, deduct 15 degrees from the location latitude, and in the winter, add 15 degrees to the latitude. Annual power production can be increased by up to 15% with seasonal angle adjustment.

Fig.19

Fig. 18 depicts the influence of the angle on benefiting from the sun's rays, with the lower the angle, the greater the advantage, and the angle changes from place to place depending on the location and the sun.

4.6Energy Calculations

The energy consumed by the villa is estimated to be 10 kWh using the gadget for measuring energy consumption in the house,

4.7 losses In pv Systems

The most common causes of mismatch loss are (1) changes in battery voltage due to continual changes in battery State Of Charge (SOC) caused by battery charge and discharge, and (2) changes in ambient temperature, which affects both battery voltage and maximum power voltage. A portion of the energy delivered by the PV array to the battery is lost due to the battery's low efficiency.

The power loss due to array disconnect Pd is the third loss. During the summer, when the battery is completely charged due to excess solar energy, this loss occurs. On a warm summer day, Figure 3 depicts the load and array powers. The array stores the extra energy. The BVR opens switch S (in Fig. 1) when the battery is fully charged, and the array power P is lost. The complete array power is lost during the disconnect interval, and the load is supplied by the battery. All losses in the following study are expressed as percentages of the array maximum daily energy Em,x , which is supplied by :

$$E_{max} = \int P_{max}\, dt.$$

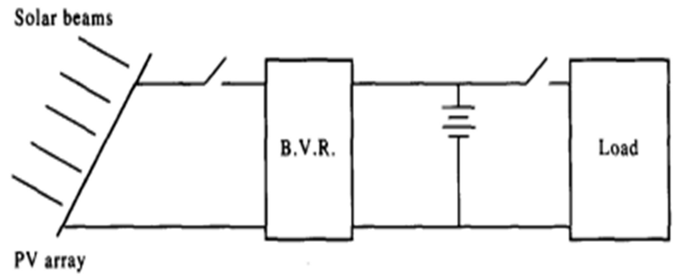


Fig.20 . Block diagram of the conventional PV system.

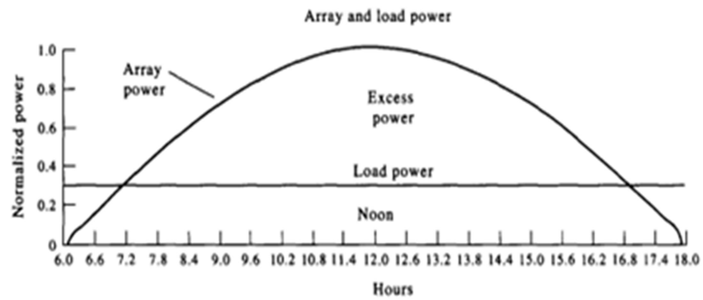


Fig.21 . Array and load power during a typical sunny summer day.

4.8 Overall System Cost

Due to several tax and component price variables, the cost of a solar system in Palestine is a little expensive.

According to the North Electricity Company's analysis, the cost of a solar system is between $1200 and $1400 per kilowatt.

Where the company buys electricity for 0.54 shekels per kilowatt, but due to increased demand for solar cell installation, it is not allowed to connect them to the house, because a meter is installed for the energy coming out of the cells to the network, as well as a meter for the consumed energy, and in the end, it is calculated based on consumption, whether it is less or more than the generated energy.

After nine years of operation, the owner of the solar cells can recoup the cost of the system.

Because the system's life cycle is between 20 and 25 years, we profit from the system for around 11 to 16 years (i.e. after recovering costs).

The following table shows the prices of the components of the system in the West Bank

Item	2 kWp	3 kWp	5 kWp
PV modules	1114	1657	2771
Inverter	857	1086	1286
Accessories	800	1140	1457
Structure	314	371	514
Installation	229	314	600
Total cost ($)	3314	4568	6628
$/Watt	1.65	1.52	1.32

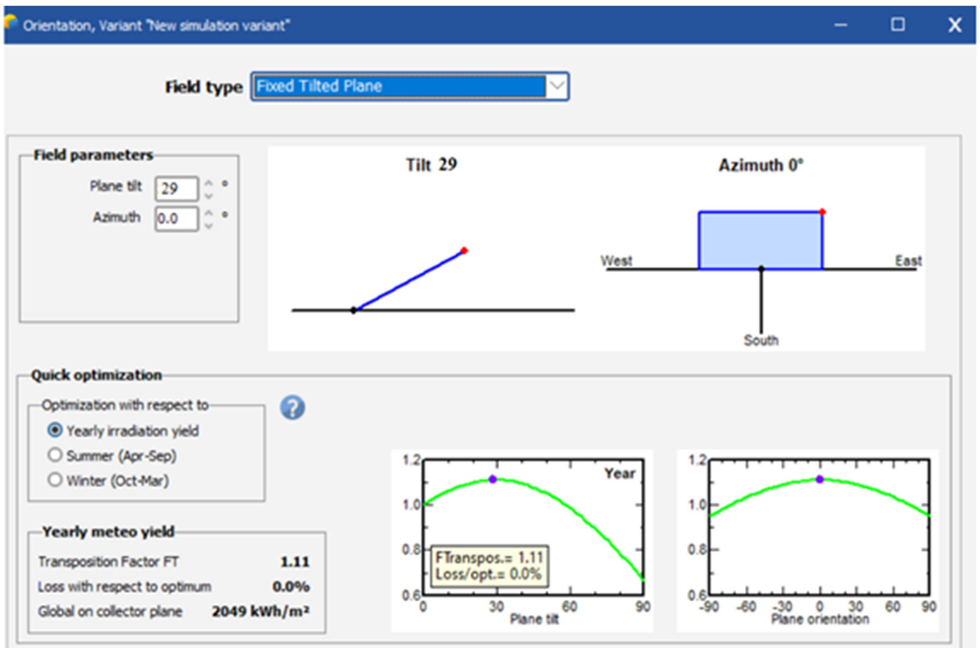
It can be noticed that the PV system cost $/W decreases by increasing the rated power of PV system. The cost of PV modules and inverter in each system represents 60 % of the total system cost.

Chapter 5
Result and Conclusion

5.1 Result

The Tilt Angle

According to various scientific studies conducted by a number of Palestinian researchers, the best angle of inclination for cells is 29 degrees, which results in a 10% energy gain over a solar panel installed on a horizontal surface

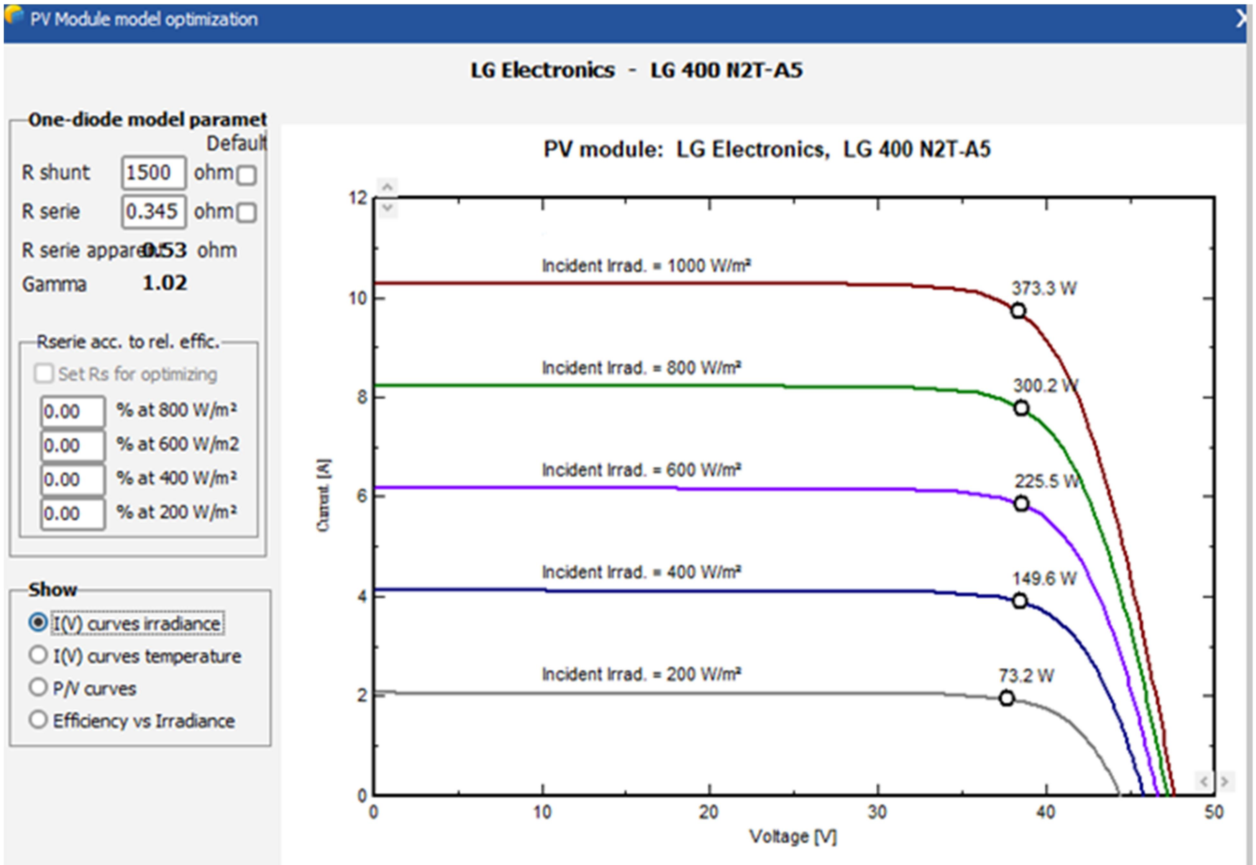


sAfter entering the area and all the information required for the design, the program showed these results As we can see, we need 28 models with a capacity of 400 from LG . Divided into two rows, in each row an equal number of units (14)

PV Array Characteristics

PV module		**Inverter**	
Manufacturer	Generic	Manufacturer	Generic
Model	LG 400 N2T-A5	Model	STT-10KTL-P
(Original PVsyst database)		(Original PVsyst database)	
Unit Nom. Power	400 Wp	Unit Nom. Power	10.00 kWac
Number of PV modules	28 units	Number of inverters	1 unit
Nominal (STC)	11.20 kWp	Total power	10.0 kWac
Modules	2 Strings x 14 In series	Operating voltage	160-1000 V
		Pnom ratio (DC:AC)	1.12

The following graph depicts the behavior of the solar cell over time as a function of the intensity of solar radiation and its impact on the cell's production efficiency.



The production increases dramatically as we approach closer to the optimal radiation of the cell 1000 W/m^2

The system maximum output power, current, and voltage levels are as follows :

Pmpp	10.25 kWp		
U mpp	526 V		
I mpp	19 A		
Total PV power		**Total inverter power**	
Nominal (STC)	11 kWp	Total power	10 kWac
Total	28 modules	Number of inverters	1 unit
Module area	59.2 m²	Pnom ratio	1.12
Cell area	52.1 m²		

one failure in a PV module could affect the energy yield of other PV modules and even could affect the inverter efficiency. Consequently, both failures and the energy losses associated with them are significant and must be clear in order to improve of PV market.

Array losses

PVsyst TRIAL

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

DC wiring losses
Global array res. 445 mΩ
Loss Fraction 1.5 % at STC

Module Quality Loss
Loss Fraction -0.8 %

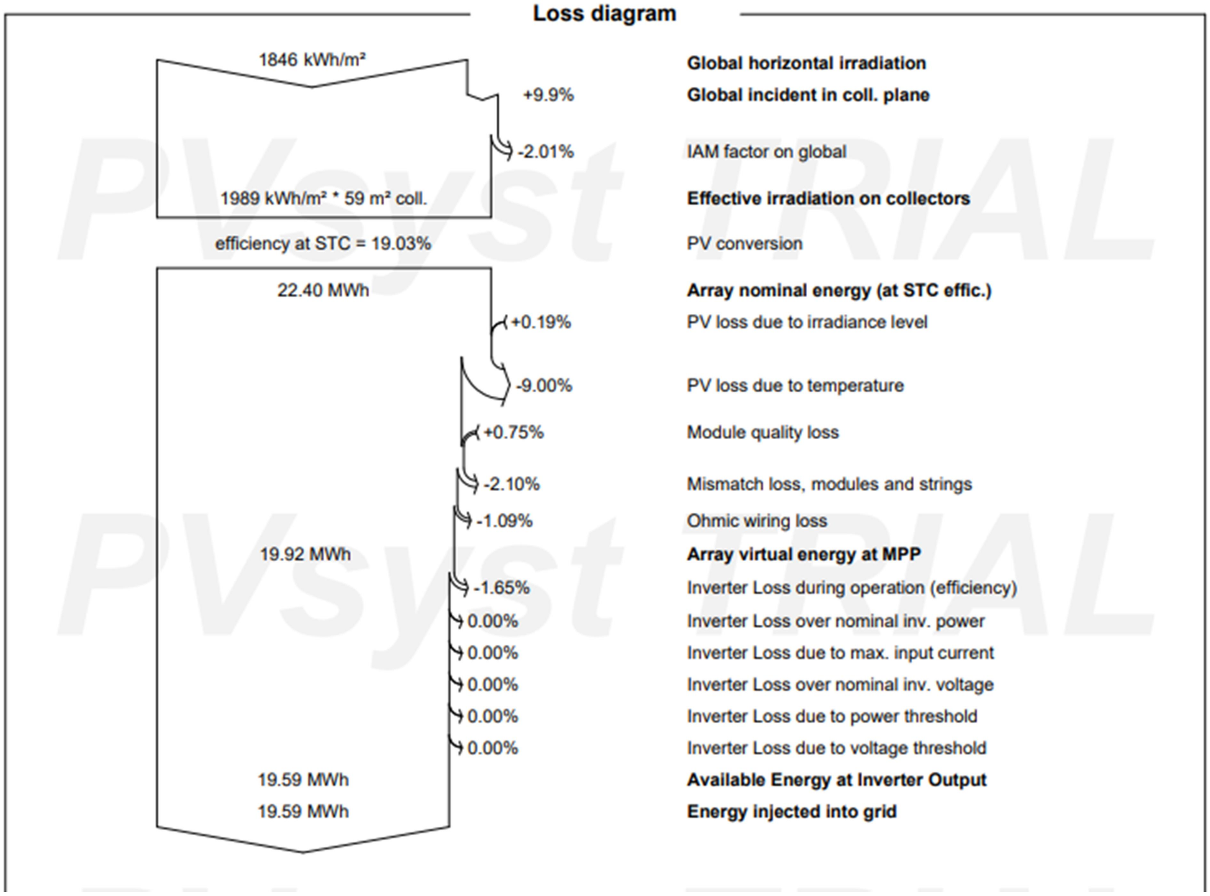
Module mismatch losses
Loss Fraction 2.0 % at MPP

Strings Mismatch loss
Loss Fraction 0.1 %

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

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

Loss diagram



The following table shows an estimate of the system's production values over the year We note that the highest production was in the month of June (221.7 KWh/m^2), as the average temperature in it reaches “25.54 C “, which is the best temperature to give the highest production efficiency of the system, in contrast to the high temperature.

Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR ratio
January	89.9	33.84	12.76	131.5	129.4	1.356	1.333	0.905
February	99.2	47.42	13.97	126.6	124.4	1.298	1.276	0.900
March	147.6	71.24	16.74	170.4	167.3	1.718	1.690	0.885
April	174.9	82.87	19.38	182.1	178.3	1.806	1.776	0.871
May	211.9	83.08	22.93	202.7	198.2	1.970	1.937	0.853
June	233.3	70.36	25.54	213.7	208.5	2.041	2.006	0.838
July	221.7	76.67	28.03	207.5	202.4	1.967	1.934	0.832
August	200.8	77.10	28.52	203.3	198.8	1.929	1.897	0.833
September	167.0	58.75	26.57	187.4	183.7	1.790	1.760	0.839
October	127.7	58.45	23.87	158.0	155.1	1.548	1.523	0.861
November	92.7	36.14	19.11	129.9	128.0	1.299	1.277	0.878
December	79.6	36.85	14.92	116.3	114.4	1.199	1.180	0.906
Year	1846.3	732.76	21.07	2029.4	1988.6	19.921	19.591	0.862

Legends

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

PVsyst TRIAL

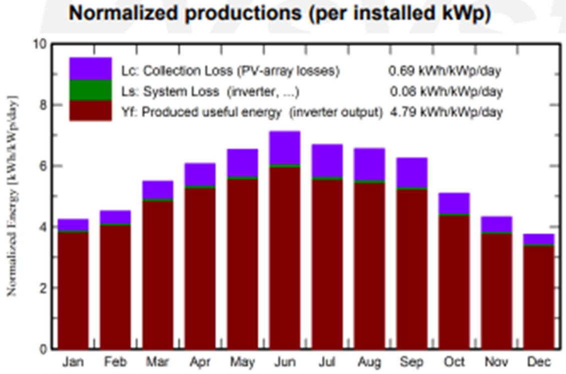
The following graphs show the normal production of the system in kilowatts also the performance ratio of the whole system, where it is on average 86.19 % .

Main results

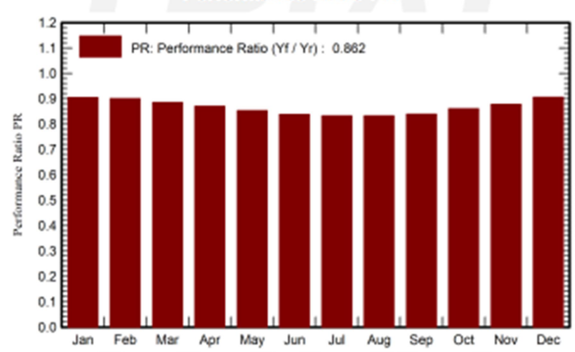
System Production

Produced Energy	19.59 MWh/year	Specific production	1749 kWh/kWp/year
		Performance Ratio PR	86.19 %

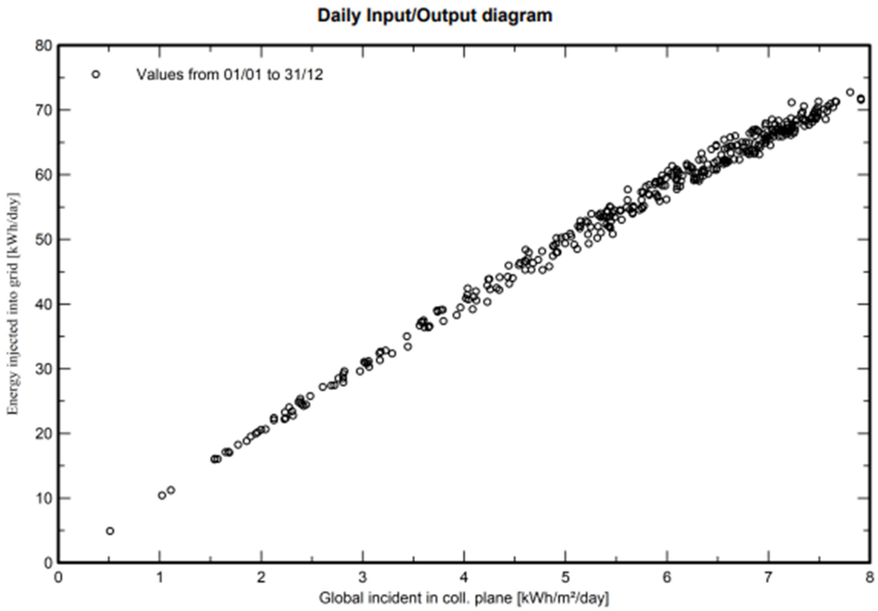
Normalized productions (per installed kWp)



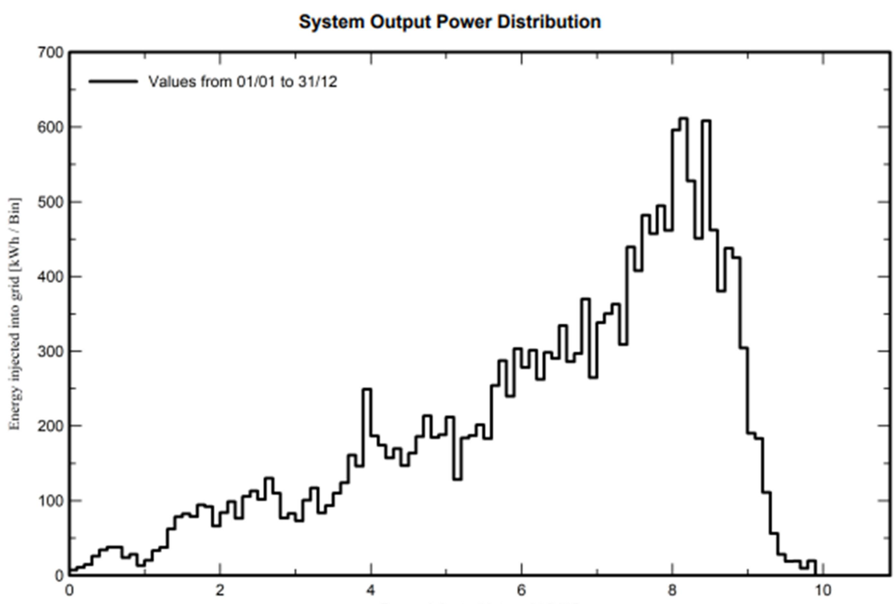
Performance Ratio PR



The following graph shows the daily production of energy and we notice a sharp difference in the values according to the position of the sun in relation to the cells (ie, day and night and the influence of the external atmosphere)



The following diagram shows the amount and distribution of power entering the network from the system



5.2 Conclusion

In this 21st century, as we build our technology, population, and grow, per capita energy consumption increases exponentially

The solar system has many benefits that greatly affect our reality in Palestine, and therefore it is radioactive for installation and at somewhat lower costs than some other installations, especially in the long run.

Where we suffer a lot from power outages and the high price of kilowatts, and some areas are remote and far from the electrical network, and electricity does not reach them in any way.

In such cases where the cost of electricity becomes very high, one can always use an off-grid PV system. Both types of systems.

On-grid and off-grid PV systems have their advantages and disadvantages

Based on the high rate of daily solar radiation on horizontal surfaces (5.4 kWh/m2 per day) and the current price of PV modules, PV systems can be considered as a possible option to support the electricity sector in Palestine.

When predicting power productivity, the Pnom ratio is an important factor to consider. It also reduces the total cost of inverters and related systems for both small and large PV plants.

Chapter 6
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