T.C.
ISTANBUL AYDIN UNIVERSITY
INSTITUTE OF SCIENCE AND TECHNOLOGY

STUDY OF THE ECONOMIC INVESTMENT OF SOLAR POWER PLANTS CONNECTED TO THE LOCAL ELECTRICITY GRID IN GAZA STRIP

THESIS

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Department of Electrical & Electronic Engineering

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June, 2019

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STUDY THE EFFECT OF ECONOMIC TECHNOLOGY FOR USING ON-GRID PHOTOVOLTAIC SOLAR SYSTEMS IN THE GAZA STRIP AND USING MATLAB FOR MODELING AND SIMULATION SOLAR CELLS

THESIS

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DECLARATION

I hereby declare that all information in this thesis document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results, which are not original to this thesis.

Ahmed M.M. SHAHEEN

I extend my deepest gratitude to family, whose has been a constant source of support and encouragement during all the challenges in my life.

FOREWORD

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May 2019 **Ahmed M.M. Shaheen**

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ABBREVIATIONS

AC	: Current
DC	: Current
ENRA	: Energy and Natural Resources Authority
G	: Irradiation
HOMER	: Optimization Model for Electric Renewables
Iph	: Photo - Current
Isc	: Circuit Current
PV	: Photovoltaic
STC	: Standard Test Conditions
T	: Temperature
UPS	: Uninterrupted Power Supply
Voc	: Open Circuit Voltage

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STUDY OF THE ECONOMIC INVESTMENT OF SOLAR POWER PLANTS CONNECTED TO THE LOCAL ELECTRICITY GRID IN GAZA STRIP

ABSTRACT

The Gaza Strip suffers from a severe crisis in the shortage of electric power supplies, especially since 2006. This has negatively affected the type, quality and quantity of services provided in all fields. In this sense, the study aims to complete the shortage of electricity by using solar system. In this regard, the solar systems associated with the electrical grid, with storage batteries, have emerged. Also, the technical implications of the applicability of these systems to the local reality have been assessed. In addition, the study dealt with the feasibility study of the solar systems under study by addressing the period of recovery.
HOMER's simulation and analysis program (Hybrid optimization model for electric renewable), where it works on modeling all types of solar systems and then selects the best technical operating point for studying the feasibility of using grid-related solar systems has been implemented in the field of modeling renewable energy systems and evaluating them technically and economically at Al-Shifa Hospital in Gaza through the design and construction of a solar system connected to the network with the use of batteries as a storage system. The results, which were based on a set of real inputs such as the amounts of solar radiation and electrical loads, showed the feasibility of this economic electrical system by measuring the high financial returns and the period of recovery of the amounts invested.
On the other hand, the study presented a technical evaluation of the actual solar system in the same place by using homer simulation technics .The results of the evaluation showed the economic feasibility of the project (the recovery period is about 1.43 years), albeit to a lesser degree than that obtained from the simulation and analysis program HOMER (the recovery period is about 2.10 years) due to the high cost of adding batteries in the existing solar system.
Also, we applied the same experience with adding batteries for Al-Salam neighborhood in Gaza and the results of the evaluation showed by HOMER simulation technices that the economic feasibility of the project (the recovery period is about 2.51 years).
In addition, modeling and simulations of the solar cell were carried out using MATLAB to determine the effect of radiation and temperature change on both the I-V curve and the P-V curve.
Also, the study presented a number of recommendations, including the adoption of the application of solar systems connected to the network in the presence of batteries as a storage system in government institutions and service places for many economic reasons and technical determinants. In addition, it is necessary to develop strategies and develop a package of incentives such as good loans and unconditional benefits, together with the development of a set of regulatory and organized laws to work in the field of solar systems.

Keywords : *Pv system, On-grid ,Off-grid, Recovery Period , HOMER, MATLAB.*

GAZZE ŞERİDİ'NDEKİ YEREL ELEKTRİK ŞEBEKESİNE BAĞLI GÜNEŞ ENERJİSİ SANTRALİNİN EKONOMİK YATIRIMININ İNCELENMESİ

ÖZET

Gazze Şeridi, özellikle 2006 yılından bu yana, ciddi anlamda bir elektrik güç kaynağı kıtlığı krizinden muzdarip. Bu, her alanda verilen hizmetlerin türünü, kalitesini ve miktarını olumsuz yönde etkiledi. Bu anlamda, çalışma güneş sistemi kullanarak elektrik kıtlığını tamamlamayı amaçlamaktadır. Bu bağlamda, elektrik şebekesiyle ilişkili güneş enerjisi sistemleri, akülerle birlikte ortaya çıkmıştır. Ayrıca, bu sistemlerin yerel gerçekliğe uygulanabilirliğinin teknik etkileri değerlendirilmiştir. Ek olarak, çalışma toparlanma dönemine değinerek çalışmakta olan güneş sistemlerinin fizibilite çalışmasını ele almıştır.

HOMER'in her türlü güneş enerjisi sisteminin (elektrik yenilenebilir hibrit optimizasyon modeli) modellenmesi üzerine çalışan ve daha sonra şebeke ile ilgili güneş enerjisi sistemlerinin kullanım fizibilitesinin incelenmesi için en iyi teknik çalışma noktasını seçen simülasyon ve analiz programı, yenilenebilir enerji sistemlerinin modellenmesi ve teknik ve ekonomik olarak değerlendirilmesi alanında uygulanmıştır. Gazze'deki Al-Shifa Hastanesinde, ağa bağlı bir güneş enerjisi sisteminin tasarlanması ve inşası ile akülerin depolama sistemi olarak kullanılması. Güneş radyasyonu ve elektrik yükü miktarları gibi bir dizi gerçek girdiyi temel alan sonuçlar, yüksek finansal getirileri ve yatırılan tutarların geri kazanım süresini ölçerek bu ekonomik elektrik sisteminin uygulanabilirliğini göstermiştir.

Diğer taraftan, çalışma homer simülasyon teknikleri kullanılarak aynı yerde gerçek güneş sisteminin teknik bir değerlendirmesini sunmuştur. Değerlendirme sonuçları, HOMER simülasyon ve analiz programından (geri kazanım süresi yaklaşık 2.10 yıl) yüksek olması nedeniyle projenin ekonomik geri kazanılabilirliğinin (geri kazanım süresi yaklaşık 1.43 yıl olduğunu) göstermiştir. mevcut güneş sistemine akü ekleme maliyeti.

Ayrıca Gazze'deki Al-Salam mahallesine pil ekleyerek de aynı deneyimi uyguladık ve HOMER simülasyon tekniklerinin projenin ekonomik fizibilitesinin (iyileşme süresi yaklaşık 2.51 yıl olduğunu) gösterdiği değerlendirme sonuçlarının sonucunu gördük.

Ek olarak, radyasyon ve sıcaklık değişiminin hem I-V eğrisi hem de P-V eğrisi üzerindeki etkisini belirlemek için MATLAB kullanılarak güneş hücresinin modellenmesi ve simülasyonları yapılmıştır.

Ayrıca, araştırma, devlet kurumlarında akülerin bulunduğu bir depolama sistemi olarak şebekeye bağlı güneş sistemlerinin uygulanmasının ve birçok ekonomik neden ve teknik belirleyicilerin hizmet yerlerinin kabul edilmesini de içeren bir takım öneriler sunmuştur. Ek olarak, güneş sistemleri alanında çalışacak bir dizi düzenleyici ve organize kanunun geliştirilmesiyle birlikte iyi krediler ve koşulsuz faydalar gibi stratejiler geliştirmek ve bir teşvik paketi geliştirmek gerekir.

Anahtar Kelimeler : *Gunes paneli , Devre ici , Devre disi , HOMER , MATLAB*

1. INTRODUCTION

Renewable energy has become the ideal alternative that humanity seeks to address the problem of the depletion of fossil fuels and cool and its negative effects. Especially environmental pollution . With the steady growth of the world’s population and the consequent increase in electricity consumption worldwide, the international demands have been raised for the promotion of the optimal utilization of renewable energies, especially solar energy.

As a result of that , some developed countries have made significant break through and progress in this area to reach the stage of self-sufficiency and reduce dependence on renewable energy , which is under threat, where Germany recorded about 95% of its consumption of electricity generated from renewable sources in May 2016, Denmark also recorded about 140 % of its wind powered electricity needs in the winter of 2017[1].

Therefore, third world countries have a tendency to exploit renewable energy such as solar energy and wind energy. In order to find some effective solutions to the suffering of successive crises and suffocating at all levels related to the energy sector, whether on the public sector or even the private sector, and this should mobilize most of the developing world to promote investment in the same field.

Whereas Palestine and the Gaza Strip in particular are suffering greatly from an escalating crisis in the electricity supply process, whether by the Israeli occupation or by the Egyptian side, which directly control either the supply of electricity to the areas or even supply the fuel needed to operate the only power plant in the Gaza Strip. On the other hand, political conditions, or even technical reasons, sometimes lead to a constant flow of electricity, which is limited and even diminishing available resources. In addition, one of the most important obstacles facing the energy sector in Gaza is the increase in population and the accompanying urban expansion, which necessitates the establishment of many residential cities with the facilities needed for electricity.

On the other hand, the weakness of the process of collecting funds owed by consumers in the Gaza Strip, due to the difficult economic conditions experienced by the population as a result of the unjust siege that followed the events of the abhorrent division in 2007, has had impact on the inability of the Energy and Natural Resources Authority of Gaza to purchase fuel for the operation of the Gaza power station, which has often caused considerable confusion in the generation and distribution of electricity to consumers. The high tax rate imposed on the quantities of fuel supplied to the power plan has played a negative role in reducing the amount of fuel purchased from the Israeli side, which has also contributed to the recent exacerbation of the power supply crisis.

Accordingly, all of the above obstacles made the supervisors and workers in the field of electric power put forward many initiatives and proposals that can help in providing effective solutions, even if they are expensive, contribute to solving the crisis of our outages continue.

The abundance of solar radiation that God has provided to this regions a blessing that Gaza’s stakeholder must use in an efficient way to generate electricity and fill deficit resulting from weak power supply. And experience has shown that the optimal utilization of solar energy in the generation of electric power is one of the important solutions to the escalating crisis in the electricity sector and to stop depletion of resources available from capital and efforts and energies waste in inefficient alternatives, which in turn adversely affect all indicators of sustainable development.

As a result, many governmental and non-governmental institutions as wall as individuals, have started using solar systems of various types.This work began about a decade ago with the installation of many independent solar systems on the roofs of buildings, communities and the headquarters of various institutions, which proves its efficiency as suitable alternative to the power failure crisis in addition to the complete elimination of diesel generators.

With the growing need for such alternatives, another set of large solar systems has emerged on the surface, especially for enterprises. Solar systems associated with the electrical grid with batteries as a back up storage system are one of the solutions currently under way and represent the focus of research in the study presented.

1.1 The Study Problem:

The problem of electricity power in the Gaza strip has become the concern of all citizens, and they agree with all their work and interests according to the availability of electricity, This crisis surfaced in 2006 when the transfer station adjacent to the only power plant in the Gaza Strip was bombed by Israeli war planes.

Since then, Gaza have been suffering from a near constant interruption of electricity. This is in addition to the lack or availability of industrial fuel needed to operate the plant. All these reasons have been an engine for the search for viable alternatives to their potential for electricity production.

It should be noted that this study is recent and rare studies at the local level, which dealt with the subject of the research. So it is not possible through the amount of previous knowledge to test the validity or negation of any hypotheses expected, Therefore, in this study, it is enough to ask a series of questions as a result of using the analytical descriptive approach to the reality of the problem, without exceeding this description to build relationships between them and test these relations. The problem of the study is represented of the following main question :

What are the technical and economic effects of the use of solar systems connected to the grid to produce electricity in the Gaza Strip?

The main question arise from a series of sub-questions :

Are there possibilities for building grid-connected solar system that reduce power outages?

Do the proposed system reduce operational costs compared to other diesel and inverter systems for individuals or institutions?

Is there a possibility of building an investment structure in solar energy connected to the network?

1.2 Objectives Of The Study:

Identify the reality of the crisis of power outages in the Gaza Strip by addressing the causes of this crisis.

A vision of how to address this problem by addressing the range of initiatives put forward, including the use of solar energy to generate electricity.

Identify the components of different solar systems, including the on-grid as an alternative.

Discussing and analyzing the feasibility of using solar grid systems and their economic efficiency through reviewing the indicators of sustainable development.

One of the models that can be applied is the case study of a hospital in Gaza. And the other model was applying solar system for Al-Salam neighborhood.

To come up with recommendations and results that enable the researcher to disseminate them on a wider scale over the long form perspective.

1.3 Methodology Of The Study

In this study, the analytical descriptive will be used to address all types of electrical solar systems used in the Gaza Strip and the most important characteristic of each type of the other types. In addition, the study will address in same detail the case study of solar system connected to the network of a hospital in Gaza. Then applying the same system to Al-Salam neighborhood and apply one of the systems of analysis and simulation to know the feasibility of economic calculation of the recovery period of the proposed solar system taking into account both the cost of the maintenance of some components such as storage system; Batteries and inverters.

To enrich this study , many interviews will also be conducted with specialists in this field (the energy and natural Resources Authority in Gaza, solar energy consultants and exports in Gaza Strip besides the engineers responsible for some of the existing solar systems), while a number of secondary sources will be used in the use of books, magazines published statistics and websites.

1.4 The Importance of Studying:

1. The study sheds light on the daily problem experienced by the residents of the Gaza Strip, which is the almost continuous interruption of the electricity supply, which negatively affects all the details of their daily lives both at the level of institutions or individuals.

2. The importance of this study at the local level in the mechanism of selecting the best configurations of the solar systems in terms of economic and technical commensurate with the reality of the crisis of power supply shortage in the Gaza Strip.

3. On the other hand, the importance of this study at the local level stems from the modern idea and the scarcity of sources, references and studies that talked about the idea under consideration.

1.5 What Distinguishes The Current Study From Previous Studies:

Perhaps the most important thing that distinguishes this study from other previous studies is that the majority of the studies and researches that have been conducted in the Gaza Strip have touched on the solar systems that are not connected to the grid, known as the ‘off-grid’ system, while this research well highlight the ‘on-grid’ system, which is less material cost and longer life cycle.

The star city of research on this subject in economic terms,while the majority of the research dealt more engineering than economic.

This study will follow more than one methodology in a serious attempt to solve the problem, where it consists of the following :

Through the case study ‘Al-Shifa Hospital’ aims to reduce the monthly operating expenses by using the on-grid system to generate electricity from solar energy and then prove the feasibility of this system and demonstrate its efficiency in filling the deficit resulting from the lack of power supply in an attempt to encourage interested investors and stoke holders to exploit solar energy and thus the possibility of generalizing this experience and recommendation on the various sectors concerned and try to reach stage of sustainable development.

The serious attempt to transfer the experience and knowledge of specialists and stoke holders through conducting interviews and reaching then with the best and most effective way to implement this system.

This study is one of the few studies that used simulation and analysis HOMER (Hybrid optimization model for electric renewable), where it works on modeling all types of solar systems and then selects the best technical operating point for studying the feasibility of using grid-related solar systems. Perhaps the most important outputs of this program is providing renewable energy entrepreneurs with the economic feasibility of the proposed system as well as some indicators of sustainable development at the environmental level by calculating the amount of toxic gases that can be reduced if renewable systems are applied.

2. ENERGY IN PALESTINE: SOURCES AND TYPES

2.1 Introduction:

This chapter provides a detailed description of the electrical power sector in Palestine, indicating the most important sectors and the most consuming electric power, which is the domestic and service sector.

The second part of this chapter will discuss in some detail the most important components of the solar systems. Then, the most common types of solar electrical systems in Palestine and the world with an explanation of the most important features of each type, in addition to the disadvantages that face.

In the same context, the process of listing different types of photovoltaic systems will include a detailed explanation of the mechanism of work of each system and what are the technical determinants necessary for each system to generate electricity using solar radiation.

2.2 Characteristic of the energy sector in Palestine:

In light of the current situation of the electricity sector in Palestine, and given the size and impact of obstacles to the development of this vital sector and its adverse results in various field and at all levels of society, there are promising efforts and initiatives, in order to organize this sector and improve the performance and productivity of its actors. Perhaps the most promising future initiatives and plans are related to the use of renewable energy.

In light of the large population expansion, the dependence on external sources of electricity supply is mainly concentrated in one side, which is Israeli occupation despite the height cost and the environmental damage associated with the use of traditional energy in generating electricity. Accordingly, it was necessary to search for alternative options that meet the principle of energy security to meet the need and provide them from a variety of energy sources that ensure sufficient and sustainable energy availability, taking into account the cost and environmental factors as well as the strategic and economic dimensions.

On the official level, the Palestinian cabinet recently approved the Palestinian Solar Energy Initiative, which aims at generating solar power capacity of about 5 Megawatts by 2015, by supplying 1000 solar homes with solar cells to generate electricity[21].

On the other hand, these efforts face a series of obstacles that limit the possibility of expanding the use of alternative energy, in addition to the scarcity of expertise and human resources required to develop this field, also the high cost of investment and the limited land available for the establishment of alternative energy projects that require large areas.

2.3 Energy Sources in Gaza Strip

Gaza Strip suffers from scarcity of natural resources and mineral resources, especially the scarcity of traditional sources of energy such as oil and natural gas, perhaps the most worst thing for consumers in Gaza Strip is the Israeli authorities control of fuel entering to Gaza,which causes huge rises in the prices of fuel and energy sources. The following section illustrates the most important sources of conventional energy and renewable energy in the Gaza Strip.

Firstly:Traditional energy natural gas

British gas company discovered a group of natural gas fields off the shores of the Gaza Strip in 2000, which represents one of the essential stations that rely on the Palestinian economy in the Gaza Strip although not yet to extract gas from it.

Some estimates indicate the discovery of more than 30 billion cubic meters of natural gas in two fields,the Gaza sea field and the border field. Gaza sea field is the largest field and is located entirely within Palestinian territorial waters. The volume of natural gas in Gaza offshore field is estimated at 28 billion cubic meters, on the other hand, the border field the smaller field, is equivalent to 3 billion cubic meters of natural gas, but is located in the border area with the Israeli side. In a related context, experts expect the economy to reach billions of dollars, thus enhancing their positive impact on the Palestinian economy in general and the energy sector in Gaza in particular.

According to the Palestinian Investment fund (2015), the extraction of natural gas off the shores of Gaza will achieve a range of revenues to the Palestinian economy, the most important of these are;

1. Providing the expenses related to the import of electric power and fuel by replacing it with natural gas available from local sources. Some preliminary studies indicate that the Palestinian Authority can provide approximately 560 million dollar per year of Palestinian expenditures on the energy sector as a result of this replacement.
2. Gas extraction is expected to generate about 2.5 billion dollar (50%) of profits over the life of the project.
3. Creating huge investment opportunities in the energy sector by allowing private producers to participate in the construction of the Palestinian power grid.

Secondly: Renewable Energy-Solar Energy

Perhaps Gaza Strip is part of solar belt, which is located between latitudes.40 degrees north of the equator and 40 degrees south, represents areal addition to one of the most important sources of renewable energy (solar energy). The arrival of sunny days in this belt to approximately 300 days a year(82% of the days of the year) in addition to the small difference between the length of the day and night hours not more than 4 hours allows the use of sunlight in the production of energy better than is available in areas that are outside the scope of this belt. It should be noted that some statistics recorded that the average annual rate of solar energy falling per square meter is reached throughout Palestine to about 4.5 KW.Hour/ day. According to these estimates, the radiation energy received by Palestine throughout the year allows direct access to electricity directly through solar panels or indirectly through turbines.

2.4 The Energy Crisis in Gaza Strip

In the last two decades, the Palestinian people in the Gaza Strip suffer from the growing problem of power cuts for long periods of time during one day, sometimes even according to the latest statistics (16-20) hours per day. This problem was exacerbated and surfaced in 2006 when the Israeli authorities targeted the only power plant in Gaza Strip, which caused a major disruption in the supply of electricity to the residents of Gaza Strip.

Perhaps this problem has cast a shadow over all sectors of life in the Palestinian society such as health, economy, education and others in the Gaza Strip as well as most factories have closed and large groups of workers have been laid off in various industrial fields, which represented a heavy burden on the Palestinian component, especially the economic and in industrial sector.

All these thing shave been aggravated and exacerbated by the un just siege imposed by the Israeli occupation and the Egyptian authorities, which have so far insisted on closing all crossings and ports that could ease the siege, including the supply of electricity or even the fuel needed to operate power plant in Gaza.

According to the Palestinian Energy Authority, there are three main actors working to supply Gaza Strip with electricity:

Firstly, the Israeli side, which usually provides electricity from ten main lines, with a capacity of 12 megawatts per line, which is recycled to120 MW.

Secondly, the Egyptian side is supplying Gaza Strip with 28 MW from El Arish power station.

Thirdly, Gaza power plant , which is the only station in Gaza Strip.This plant was operating with all its electrical capacity, which is estimated at 140 MW distributed over four main turbines. It should be noted that the Israeli Side targeted the power plant in Gaza in July of 2006. The power plant has only produced 50% of its original capacity of a maximum of approximately 65 megawatts when the amount of industrial fuel required for its operation is available.

On the other hand, the Egyptian lines are working to provide the southern region of Gaza Strip with the necessary electric power, specifically Rafah. Despite the limitations of these lines coming from Egypt, but these lines suffer from the near-permanent cut by the Egyptian side under the pretext of breakdowns and maintenance operations that are almost not over.

Furthermore, the report of the united nations issued in 2017 entitled ‘Humanitarian Impact of the Gaza Electricity Crisis’ that the year2016 recorded what was obtained by 150 megawatts of electricity at the rate of 120 MW of the Israeli side and 30 MW of the Egyptian side as the station electricity generation in Gaza did not work most of the year.

Therefore, all the available electrical quantities do not meet the needs of the basic sector by 34%, forcing the electricity distribution company in Gaza Strip to create distribution tables for the electric quotas available to cover all areas of the sector.

Figure 2.9 shows the maps of Gaza Strip, showing all electricity supply lines from all parties, where ever Egyptian Side, the Israeli occupation or even the Gaza power plant. The proportion and quantity of actual electrical power consumption versus the quantity of what is available on the ground is also illustrated the figure.

It is should be noted that the month of April 2017 witnessed the reduction of the quantities of electricity supplied by the Israeli Side, where the proportion of the supply of electric power to about 70 MW out of 120 MW. On the other hand, the Egyptian side occasionally separates its supply of electric power from Gaza Strip to reach at times to zero MW of the 30 MW.It should be noted that Gaza power plant is almost half capacity, with a capacity of about 70 megawatts to halve by about 35 MW, due to the lack of industrial fuel supplies needed to operate them, until at times it stopped completely from producing any quantities The power power of electricity in case of preventing the supply of industrial fuel needed to operate both from the Israeli side and even Egyptian.

Perhaps one of the most disastrous results of the reduction of electricity supply and quantities of fuel required to operate the power plant was to reduce electricity supply to all life facilities in the Gaza Strip very significantly. It has reached its peak by providing the beneficiaries with a maximum of four hours of access to electricity for twelve hours according to the evidence on the ground.

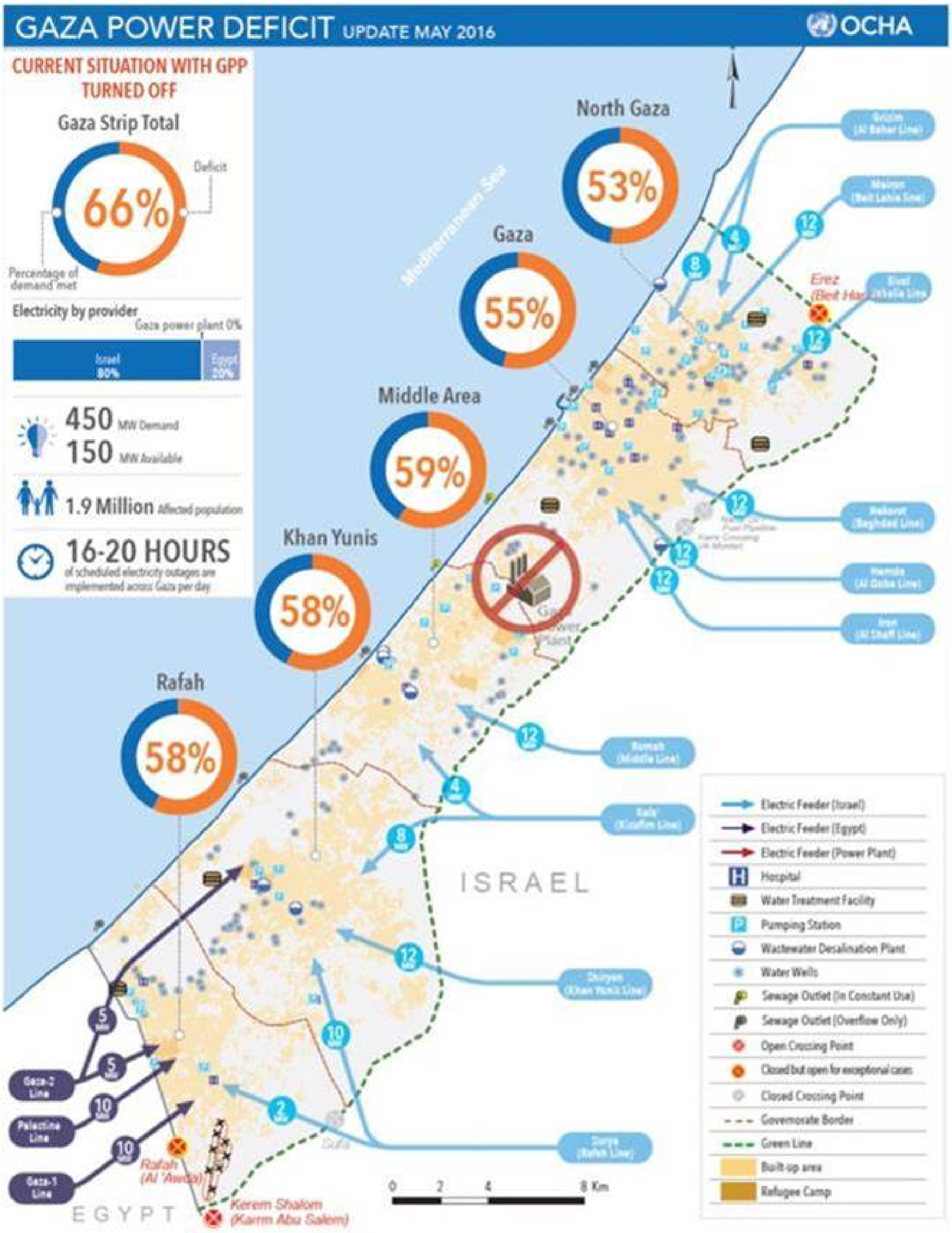

Figure 2.1: Gaza Strip Electricity Map of 2016 - Available and Unavailable[20]

2.5 Development of Renewable Energy in Palestine:

Palestine is geographically located within the area of the region rich in solar radiation, located 30 degrees north of the equator, which means that the solar energy that is located on every square meter is estimated at three thousand kilowatt hours, so add Palestine has about 300 sunny days a year.

The 2009 Hafeetha-Abu study indicates that the annual rate of solar energy reaches 5.64 kWh per square meter per day, a high percentage compared to some other countries, indicating a good environment for renewable energy use. Therefore, this has seriously created promising opportunities for the optimal utilization of solar energy through the generation of electricity by solar cell technology.

With regard to the above, Palestinian efforts - individual and institutional - have continued towards the use of renewable energy in an attempt to keep pace with this technological development. Therefore, some research institutes and Palestinian bodies such as the Palestinian Center for Energy and Environment Research at the Energy Authority, the Energy Research Center at Al-Najah University, the Palestinian Center for Renewable Energy at the University College of Applied Sciences in Gaza and the Palestinian Society for Solar and Sustainable Energy have made small efforts in small pilot projects. Electricity generation. In addition, NGO's contributed international funding to a number of promising projects such as feeding outpatient clinics, schools and parts of hospitals, such as at Al-Shifa Hospital in Gaza, Nasser Hospital in Khan Younis.

Officially, within one of the previous efforts, the Palestinian Energy Authority approved a national strategy for the energy sector between 2011 and 2013 to regulate the issue of alternative energy and promote the diffusion of its uses in the Palestinian areas , This strategy envisages increasing the local production of electricity to cover the equivalent of 20% of the Palestinian consumption by the year 2020. The remaining percentage will be covered through the Eight Link Project with the neighboring countries. On the other hand, on the other hand, on the other hand, on the other hand, in order to promote the deployment of solar energy in Palestine, the Palestinian Authority signed an agreement with the

Japanese government to implement an electric power project with the use of 300-500 kW solar cells to cover the needs of the agricultural and industrial area in Jericho[21], Table 3.1 shows the extent to which Palestine and neighboring countries have relied on renewable sources for electricity generation.

Table 2.1: Ratio of the dependence of Palestine and neighboring countries on renewable energy until 2017[22]

country	Reliance on renewable energy
Palestine	0.02%
Jordan	2%
Egypt	3%
lsrael	5%

The following section shows the main components of the electrical solar systems used in Palestine in addition to their types and mechanisms of operation in detail.

2.6 Basic components of solar systems:

2.6.1 Solar cells:

Solar cells are the backbone of solar systems of all kinds and mechanisms of action, which are dark-colored panels absorb photons falling from the sun and then converted into continuous electrical energy (DC). Solar cells are also called photovoltaic cells. It can also benefit from electric power generated in the operation of equipment and lighting of homes or postpone their use for later times by storing them in batteries recharged and used more than once. Physically, solar cells are generally manufactured from silicon (Si), which is a semiconductor. The capacity of solar cells is measured in watts.

2.6.1.1 Mechanism of the action of solar cells:

The idea of working solar cells and generating electricity is that when solar radiation falls on the cell surface, solar radiation passes through its surface after which a small fraction is absorbed through the first layer of the phosphorus cell. The second layer, made up of a mixture of silicon and boron, absorbs the remaining portion of the sun's rays, which represents the bulk of it.

Meanwhile, during the absorption of solar radiation a group of free electrons that can flow through the ends of the electrical conductor in the cell, causing the current. Increased free electron movement can be observed as the intensity of light falling on the cell increases. Consequently, the electric current generated on the ends of the cell can be used to connect any of the electrical loads and to benefit from the movement of the electrons resulting from the shedding of sunlight on the cell in the processes of lighting, cooling, heating.

Figure 3.1 shows the layers of the electrical cell and the mechanism of the fall and absorption of solar radiation producing an electric current

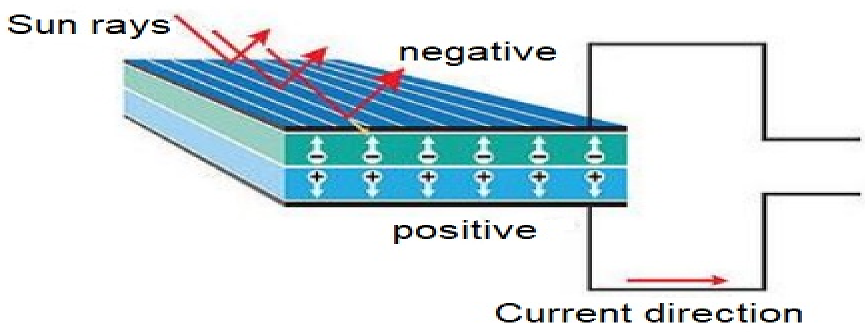

Figure 2.2: Installation and operation of the solar cell[23]

2.6.1.2 Solar cell types:

There are three main types of photovoltaic solar cells, which vary according to the structure of the silicon material, such as:

Mono crystalline

This type of cell consists of single crystalline silicone and a high degree of purity of impurities. The process of manufacturing these silicon chips is relatively complex, and this is considered to be much higher than in other species.

One of the most important characteristics of this type of cell that have a large capacity to withstand temperatures, and the efficiency of production is higher than other types, ranging from 15% - 20%. One color and ranging from blue to black[24]. Figure 3.2 shows the general appearance of a mono crystalline solar cell.

Figure 2.3: Mono crystalline solar cell[25]

Poly crystalline

This type of crystalline silicone is less effective and efficient than its mono crystalline counterparts. Physically, the process of making this type of cell is easier, where it is done without slicing of the silicon slices, but the melting and integration and therefore have a crystal blue color and may also be available in lead color. Their efficiency ranges from 10% to 14%[26]. Figure 3.3 shows the shape of a crystalline cell of a polymorphic type.

Figure 2.4: Poly crystalline solar cell[27]

Thin Film Amorphous Silicon

It consists of silicons that have no specific structural or structural classification and are manufactured by passing very thin layers of liquefied silicon in a vacuum with a glass, plastic or metal layer as a supporting layer. This type is flexible and is used when flexible panels are needed. This type of cell is less effective but what distinguishes it is that the cost of the power unit (the electric watt) produced is the cheapest among the three species. There are several types, including multi layer cells, cadmium cells, copper cells and gallium cells.Figure 3.4 shows a silicon film solar cell.

Figure 2.5: Thin Film Amorphous Silicon[28]

2.6.2 Solar energy system batteries:

Which is responsible for the storage of electrical energy in case there is excess of need to be discharged and used when necessary[29]. Electrically, batteries are used to store electrical energy produced from the panels during the presence of solar radiation and are then used during the absence of the sun or even in daylight if the capacity of the electrical loads to operate is greater than the capacity of the energy produced from the solar panels. Solar system batteries are called Deep Cycle batteries, which means long-term charging. In practice, the solar system generally requires a number of batteries, so called the battery bank. Perhaps the most important obstacles to the spread of solar systems locally and even globally are the very high cost of batteries ranging from 200 $ to 230 $ per kilowatt hour. In addition, the battery life varies from 4 to 5 years, so special care should be taken to conserve batteries. Battery charge should not be less than 50% of the total energy stored. The battery life of the battery must be changed and the storage system must be changed to increase the total cost of the solar system. It should be noted that there are two levels of electrical efforts of solar batteries, which are within the range of 12 volts or 24 volts.

Figure 3.5 shows two different types of batteries that can be used to store energy produced from solar cells

Figure 2.6: Solar System Batteries[30]

2.6.3 Solar Power Inverter:

The main function of solar system reflectors / transformers is to convert Current Direct from panels or batteries to Alternating Current, it can be used to feed electrical loads either household or equipment and appliances since most of them operate on AC power. It is important to choose solar power transformers of high efficiency and high quality so as not to waste large amounts of energy during the expected conversion process, and Some of the inverters contain internal chargers that can be connected to the main feed source and charge the battery without waiting to be charged by solar cells.

There are three types of inverters that we have to know :

A. The Stand Alone Solar Inverter

These stand alone solar inverters are called such because they do not need to be hooked up into a solar panel. Instead, it draws its direct current (DC) power from batteries which are charged by photovoltaic (PV) arrays or other resources such as engine generators, hydro turbines and wind turbines. There are a lot of these stand alone inverters which integrate vital battery chargers to refill the battery coming from an alternating current (AC) source whenever possible. Because these inverters are isolated from utility grids, they do not require anti-islanding protection.

B. The Grid Tie Inverters

1. The grid tie inverters match the phase alongside a utility charged sine wave. These grid tie inverters are also programmed to automatically turn itself off during power losses to ensure safety. Hence, these inverters do not provide emergency power during these times. It is recommended for a home which is powered by a utility grid to use a grid tie inverter in their solar system for them to take advantage of net metering. Grid tie inverters require their system to be installed with anti-islanding protection. Islanding is a process where grid tie inverters are fooled that a utility grid is still functioning even if it has been turned off. It takes place due to load circuits that resonate in the electrical system.

C. The Battery Backup Inverters

2.The battery backup inverters are extraordinary inverters which are developed to get energy from batteries and manage the energy charge it got from the battery through the on board charger, and brings the surplus energy to your utility grid. These battery backup inverters are able to supply alternating current (AC) power to selected areas which require energy during a power outage. They are required to be installed with an anti-islanding protection.

2.6.4 Charge Controller:

There are many main functions of the shipping organization, but the most important is the process of regulating and controlling the charging of batteries to protect them, which may result from damage or damage in the storage system if the proportion of freight or the percentage of discharge from certain limits, To be more clear, as the power of solar radiation changes and increases throughout the day, the task of the charging regulator in this case is to purify and stabilize the outside voltage of the solar cell and the receiver to the device. In addition, the voltage regulator works to ensure that the voltage does not return from the battery to the cell may be damaged again[33]. Figure 3.7 illustrates the operation of the charging regulator in solar systems.

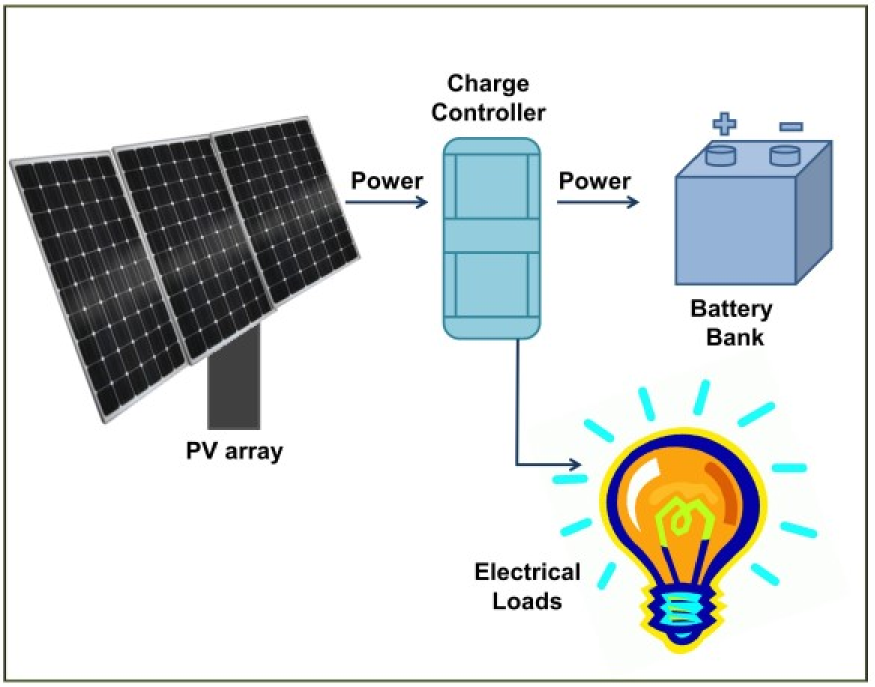

Figure 2.7: Mechanism of operation of the charging regulator in solar systems[34]

Types of Solar Charger Controller:

3.There are three different types of solar charge controllers, they are:

4.Simple 1 or 2 Controls: It has shunt transistors to control the voltage in one or two steps. This controller basically just shorts the solar panel when a certain voltage is arrived at. Their main genuine fuel for keeping such a notorious reputation is their unwavering quality – they have so not many segments, there is very little to break.

5.PWM (Pulse Width Modulated): This is the traditional type charge controller, for instance anthrax, Blue Sky and so on. These are essentially the industry standard now.

6.Maximum power point tracking (MPPT): The MPPT solar charge controller is the sparkling star of today's solar systems. These controllers truly identify the best working voltage and amperage of the solar panel exhibit and match that with the electric cell bank. The outcome is extra 10-30% more power out of your sun oriented cluster versus a PWM controller. It is usually worth the speculation for any solar electric systems over 200 watts.

2.7 Types of photovoltaic systems:

2.7.1 Systems not connected to the network:

This type of solar system is divided into two types:

Direct system that is not connected to the network without direct storage batteries (Direct PV).

Independent system that is not connected to the network with storage batteries (Off-grid Solar System).

Firstly: The Direct System (Direct PV)

A direct system that is not connected to the network without storage batteries is a system that draws its energy directly from the solar panels and is not connected to the grid. Therefore, solar panels are the main and only source for covering the covered loads.

Main Features:

1.No batteries, no transformer or regulator.

2.It needs to connect the panels to the device to be operated.

3.Works only in the daytime at sunrise and stops work when absent.

4.Devices connected to this system must operate on DC.

5.This system is often used to run water pumps during the day to fill reservoirs or to irrigate crops.

6.Its cost is simple and highly economical.

7. In the absence of the sun or on cloudy days, internal combustion engines (generators) can be used as auxiliary systems in emergency periods.

Figure 3.8 shows how to install a direct solar system that is not connected to the network in the absence of batteries for storage.

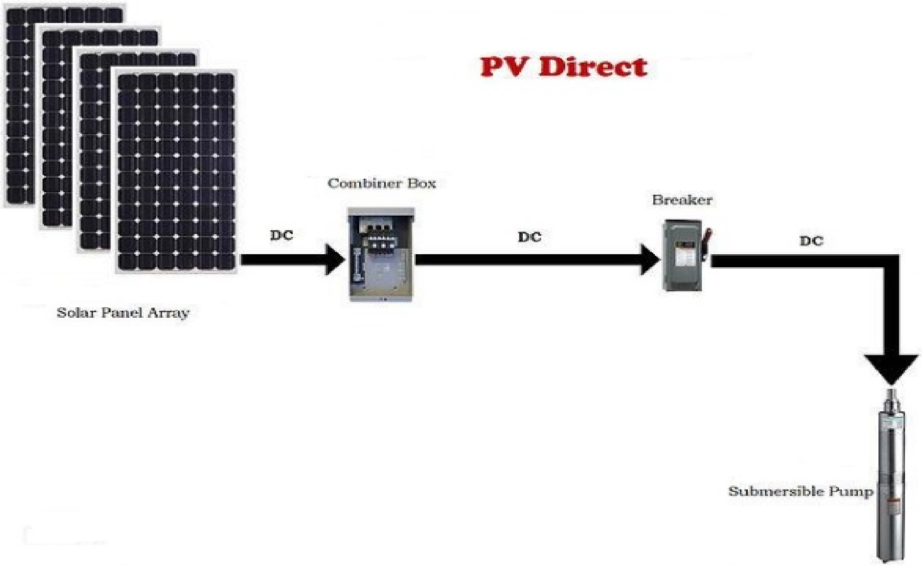

Figure 2.8: Direct solar system not connected to the grid[35]

Secondly: Off-grid Solar System

It is a solar system called the independent system. It is not connected to the electrical grid. It contains a matrix of solar cells that generate electricity from the sun. Inverter, it converts the energy directly to domestic use, Including to storage in batteries through the charging regulator and adapter[36].

Perhaps the most important characteristic of this system from the previous is the existence of batteries that work to store excess electricity in the event of increased production than the need for loads. On the other hand, it works to provide loads of electrical energy or part of it at night or insufficient solar radiation to produce energy to cover loads[37].

On the economic side, the cost of establishing such a solar system for power generation is the major impediment to progress in the promotion and widespread use of electricity because of high-cost storage batteries and limited capacity. In addition, the batteries must be changed every 4-5 years at the maximum age of storage batteries. It is worth mentioning that to calculate the estimated cost of operating a house in the Gaza Strip in full, it requires the equivalent of three to five kilowatts, so the cost of the independent solar system and the network cannot provide the house with electricity around the clock to the equivalent of 10.000-12.000 USD, The amount of batteries available and according to the market price of the components of the system. In addition, the replacement and replacement of the storage system or batteries periodically increases the cost of the solar system greatly, In general, the life of the solar system is about 25 years, which means that we need to replace the batteries about four times and therefore the cost of replacing the batteries can reach the equivalent of 70-80% of the amount of the establishment of the system, so the solar system to about 18.000 - 20.000 USD The cost of the total solar system consists of the initial cost price plus the replacement and replacement price for both the batteries and the inverter if needed. Figure 3.9 shows the composition of the independent and off-grid solar system.

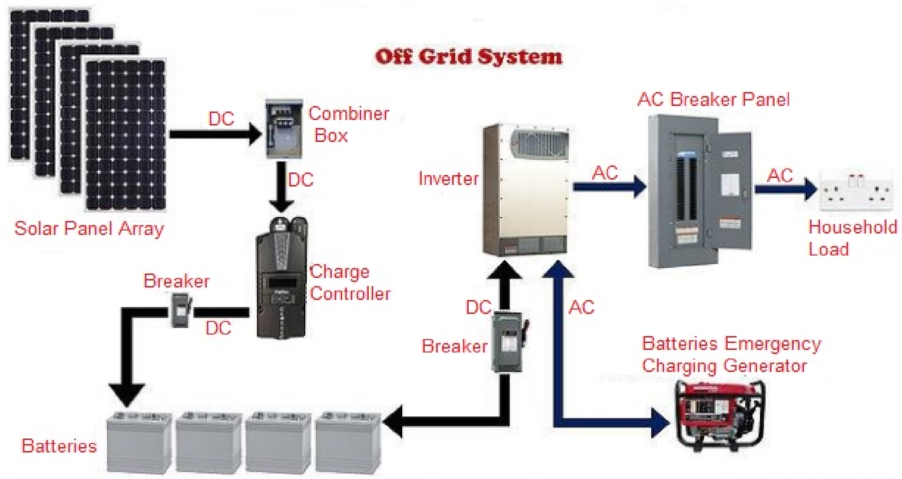

Figure 2.9: Independent solar system that is not connected to the grid[38]

2.7.2 Systems associated with the network:

There are two main types of photovoltaic systems connected to the electrical grid:

System connected with the network without storage batteries (Grid Connected/ On Grid Solar System).

The system associated with the network with storage batteries as an auxiliary system (Grid Connected/ On Grid Solar System).

Firstly: Grid Connected Solar System Without Battery

This grid-connected solar system differs from its independent counterpart in the absence of a storage system (batteries). Therefore, in order for this system to operate around the clock, there must be an electric current on the public electricity network, Works to compensate for the amount of power shortage in the event that the consumption of electricity is greater than the amount of production of the solar system, On the other hand, the network allows the passage of excess electricity to it if the proportion of production of solar energy consumption through an intelligent system called Net Metering[39].

An interview with the specialist in solar energy in the Gaza Strip, where he explained that the idea of the work of Net Metering in general is that the smart meter works to read the amount of electrical energy, whether from the solar system to the public electricity network as well as the amount of electricity supplied from the public electricity network to Solar System, At the end of each period, a system of set-off is applied by calculating the cost of selling the power unit to the public network by double the cost of purchasing it in an attempt to encourage the production of large quantities of electrical energy through the solar systems and selling them to the public network which means that they also help reduce electricity consumption Which is consistent with the philosophy of using solar energy to generate electricity. The tariff rates for the sale of solar power units or the purchase of corresponding units from the public electricity network are included in the policies, strategies and laws governing the operation of the electric power sector in each country.

In return to the components of the solar system connected to the network, this system requires a special inverter grid-on to allow the synchronization of the electric waves coming from both the transformer and the network. According to the economist, the market cost per kilo of the associated solar system is approximately 1,400 $ -1,600 $, equivalent to half of its cost in the independent system due to the lack of a costly storage system (batteries) both when constructing the solar project and even When replacing the storage system with more efficient and efficient. Therefore, the total cost of any solar project connected to the electricity grid without a storage system is the cost of construction plus only the cost of the possibility of replacement of the reflectors after 15-20 years if the solar life of the solar cells is considered about 25 years.

Figure 3.10 shows the composition of the solar system connected to the network in the absence of a storage system.

Figure 2.10: The solar system associated with the grid[40]

Secondly: Grid Connected Solar System With Battery as Backup

This dual system combines the two former systems, the independent solar system connected to the electrical grid in the presence of storage batteries and the solar system connected to the network in the absence of a storage system. Thus, the system combines the characteristics of the two connected and separate solar systems, as it can sometimes act as a networked system when there is an electric current on the public network, and it can also function as an unconnected system when the connection is lost or disconnected. This system is one of the best systems proposed for its ability to be independent from the main electricity network and at the same time can sell the amount of excess electricity to the electricity network or even storage for use at the separation of the network [41].

This system contains all the elements and specifications in the system connected and separated as shown in Figure 3.11

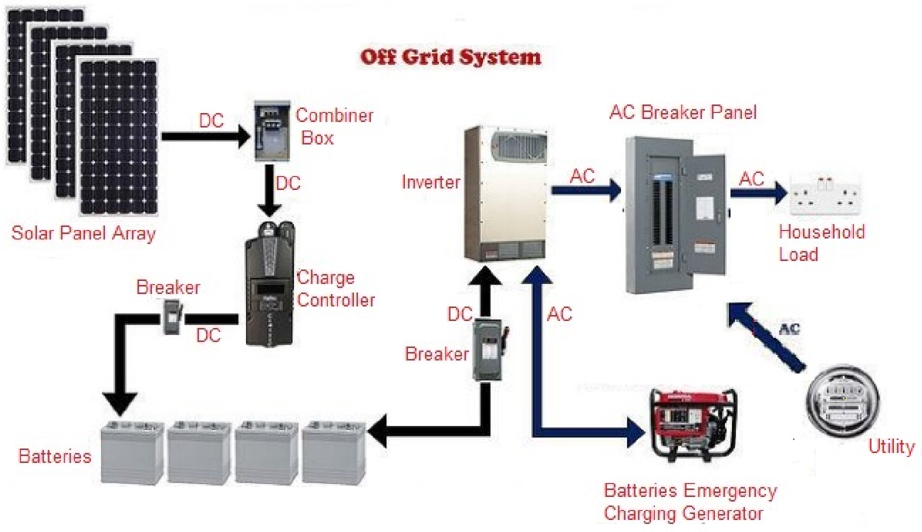

Figure 2.11: The solar system associated with the network in the presence of storage batteries[42]

2.8 Summary:

This chapter sheds light on a number of facts related to the consumption of electricity in Palestine, in addition to introducing some strategies related to the dissemination of the culture of the use of solar energy.

In addition, the different types of PV systems and the main components of each type were presented in addition to its main components. This chapter concluded with the following facts:

Most of the initiatives and efforts that have been applied in the use of solar energy for electric power generation are individual and institutional.

Poor strategies and systems for the use of solar energy at all levels.

The renewable energy sector in Palestine is still suffering from weakness and dispersion and has not achieved any progress on the ground compared to the neighboring countries, which have turned out to be a group of large projects and giants, all because of the absence of proper vision and planning to make a quantum leap in the use of renewable energy.

The relatively high financial cost of solar system components of all kinds.

The PV systems connected to the network cannot be implemented without a storage system on the Palestinian reality in the Gaza Strip, despite its high economic feasibility and material cost.

3. AN APPLIED ON GRID PV SYSTEM FOR AL-SHIFA HOSPITAL AND AL-SALAM NEIGHBORHOOD

3.1 Introduction:

This chapter deals with the feasibility study of a solar system connected to the electrical grid in the presence of a battery system for storage. This system works to meet the basic needs of the electrical energy of Al-Shifa Hospital in Gaza City, taking into account the amount of solar radiation falling on the area under study, in addition to the average daily electrical loads of the hospital. The Homer simulation technics and analysis program will be used for this study.

In the second part of this chapter, the feasibility study will be addressed to application of the solar system to the AL-Salam neighborhood with a population density of 4500 people.

In the same context, we will discuss in some detail the economic feasibility of building a solar system connected to the electrical network of both projects using the Homer simulation and analysis technics. This program will calculate the amount of energy flowing to and from the public electricity grid if the solar system is connected to it, also the cost of establishing the proposed system in US dollars will be presented at local market prices.

In the next part of this chapter we will address the knowledge of the amount of electrical energy produced from the solar system, The redemption period will also be measured for the amounts invested in both projects, in addition to the most important obstacles that led the project officials to prefer to add the storage system (batteries) despite the high cost of its establishment or even replacement after the expiry of its estimated life of t9en to fifteen years.

3.2 Feasibility study of a hospital connected on-grid:

In this part of the chapter, the existed off-grid system in the hospital has acapacity of 42KW with payback period estimated at 6.4 years, therefore we will discuss the feasibility of a solar system connected to the electrical grid in the presence of a storage system. we used the simulation and analysis system (HOMER).

We will start the economic feasibility study by addressing the set of study inputs obtained for the analysis of the solar system through the use of information obtained either from the management of al-Shifa hospital for electric loads or that information on the quantities of solar radiation obtained through the simulation program through National Aeronautics and Space Administration (NASA), Then we will discuss the components of the proposed solar system in their sizes and local market prices before presenting all the results related to the feasibility study in many aspects.

3.2.1 Inputs:

Firstly: Solar Irradiance

The average solar radiation data for one year has been stabilized for the location of al-Shifa Hospital. Table 4.1 shows the geographic location is defined by the latitude and longitude of the hospital site.

Table 3.1: Geographical location of Al-Shifa Hospital in Gaza

Latitude	**53′′**	**21′**	**31°**
Longitude	52′′	23′	34°

Figure 4.1 shows average daily solar radiation data for each month and for a full year.

As a result of analysis of these data by using homer technics, the average daily solar radiation was 5.57 kW. Hour / m2 / day, based on this, the average solar radiation falling on each unit area can be calculated annually by about 2033 kWh. The average solar radiation on each unit area = 5.57 kWh * 365 day.

Which is considered an excellent quantity for building solar systems with great efficiency.

Figure 3.1: Average daily solar radiation

Secondly: Load Profile

In an interview with the hospital's energy officer, he pointed out that the electrical loads that are fed from the solar system at the hospital headquarters are largely fixed. These loads are excluded from cooling, air conditioning and heating operations except in specific places such as the operating room, in other words, the quantities of electrical loads can be divided into two parts :

1.Loads for official working days (Saturday to Thursday).

2.Weekend loads (Friday).

Figure 3.2 shows us the results after applying the data that given from the hospital by Homer program

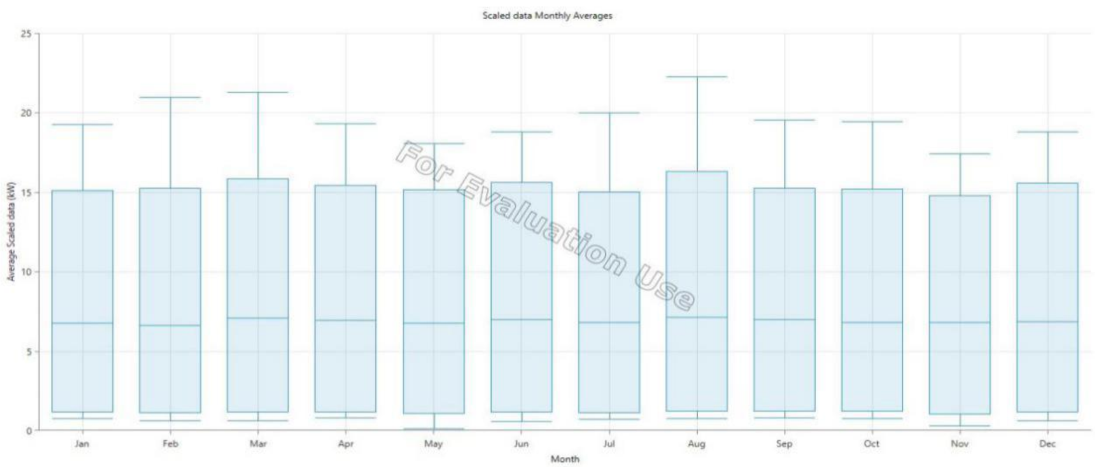

Figure 3.2: The electrical loads of the Al-Shifa Hospital in Gaza City

Figure 3.3: Average daily load readings per month for a full year

Figure 3.3 showed that the average daily electric load was recorded over a year as well as the maximum capacity that electrical loads could reach at some point in the year by using the homer simulation technics instead of the data took by the hospital.

Table 3.2 shows the average daily electric power of different loads estimated in kilowatt hours / day, in addition to the average capacity and maximum capacity in kilowatts.

Table 3.2: Data of the electrical loads of Al-Shifa Hospital [42]

The average daily capacity of the loads	**226.67 KWh/day**
Average capacity	9.44 KW
Maximum capacity	33.86 KW

Thirdly: System Components

The proposed solar system is designed to cover the electrical loads of Al-Shifa Hospital on all components necessary to build the solar system connected to the network in the presence of a storage system. Therefore, the proposed system is generally made up of a group of cells (photovoltaic panels), In addition to Storage batteries and the electric inverter supported by the local electrical grid. Figure 4.4 shows the parts of the existed solar system proposed to cover the loads of Al-Shifa Hospital.

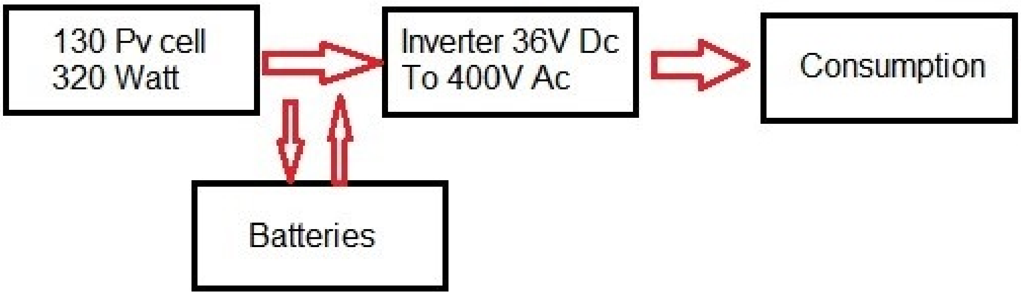

Figure 3.4: Associated solar system components diagram

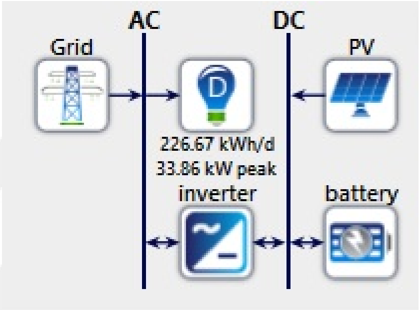

Figure 3.5: Associated solar system components with storage

A. Photovoltatic Array

We used the same solar system that used in hospital with the same capacity of power and number of cells with a combined capacity of 42 kW depending on the existing solar system in the hospital and at a cost of one kilowatt at market prices of about 800 American dollars.The number of cells used in the system is about 130 pv system with a capacity of 320 watt, 36V DC that available in Gaza market. Also, it has been considered that there is no replacement cost for solar cells used since the default life is estimated at about 25 years, which is the same life period of the project fully. Table 4.3 shows the initial cost in addition to the annual maintenance and operation cost of the system's constituent cells:

Table 4.3 show us the costs for solar cells by using homer technics and considered the market price as 800 American dollars per 1 kilowatt.

Table 3.3: Construction and maintenance costs for solar cells

The initial cost	**42KW * 800$** **33.600 USD**
Annual cost of maintenance and operation	400USD per year

Depending on the applicable solar system and at a cost of one kilowatt at market prices in Palestine of about 800 American dollars.

B. Inverter

The proposed solar power of the associated solar system for the hospital under study has been stabilized with a return of 43 kW and an efficiency of 95%, On the other hand, the default lifetime of the reflectors was estimated at about 15 years, In other words, these inverters will be replaced only once during the lifetime of the project. On the other hand, the initial cost of the reflectors was estimated at 7,500 American dollars per 10 kW. In addition, the cost of replacing the reflectors after 15 years was estimated at 50% of the initial cost of the reflectors based on some references to similar feasibility studies. Table 4.4 shows the initial cost, the cost of replacement after 15 years plus the annual operation and maintenance cost of the reflector estimated in US dollars by using homer technics.

Table 3.4: Construction, replacement and maintenance costs of electrical inverters

The initial cost	**30.000 USD**
Replacement cost	15.000 USD
Cost of maintenance	400 USD per year

C. Storage Batteries

A cell or connected group of cells that converts chemical energy into electrical energy by reversible chemical reactions and that may be recharged by passing a current through it in the direction opposite to that of its discharge. In our project

200AH batteries were used with a discharge capacity of up to 50%. On the other hand, the default lifetime of the batteries was estimated at about 15 years. Therefore, the initial cost of the batteries was estimated at 2083 American dollars per 10 kW.Table 4.5 shows the initial cost, the cost of replacement after 15 years plus the annual operation and maintenance cost of the batteries estimated in US dollars by using homer technics.

Table 3.5: Construction, replacement and maintenance costs of electrical batteries

The initial cost	**8.540 USD**
Replacement cost	4.270 USD
Cost of maintenance	400 USD per year

D. Solar Charge Controller

An electronic device that regulates the electrical voltage from the cells before passing through the batteries and from the battery to the electric load in order to preserve the batteries used and ensure that they are shipped and used optimally.In our project MPTT charge controller is used, Which refer to the way these organizations work (follow the point of maximum energy), which is a dc-to-dc, in which the regulator passes the electrical current in the form of pulses from the solar cells to the batteries with the best voltage can be charged batteries through which depend On the principle of extracting the greatest possible energy from solar cells by changing the voltage difference (voltages) so that it gives the greatest output capacity.

Table 3.6: Construction, replacement and maintenance costs of charge controller

The initial cost	**500 USD**
Replacement cost	250 USD

E. Step-up Transformer

7.A transformer in which the output (secondary) voltage is greater than its input (primary) voltage is called a step-up transformer. The step-up transformer decreases the output current for keeping the input and output power of the system equal. In this case, we have to use step up transformer to be able to connect our system with the medium voltage utility grid.

In Palestine the medium voltage is 22 KV, that's why we need step up transformer 400V to 22 KV.

F. Electricity Grid

Through a series of interviews with an expert in the Energy and Natural Resources Authority in Gaza, a general tariff for the purchase of the electricity unit was set in kilowatt hours, taking into consideration that the unit rate of energy is constant throughout the day.

On the other hand, it was suggested that the cost of selling an electric power unit would be in kilowatts. This is equivalent to twice the cost of purchasing it, or about 0.3 American dollar per kilowatt. Hour.

After we studied the applied solar system for Al-Shifa hospital, we will implement the same system to cover a number of loads that provide Al-Salam neighborhood by using homer tecnichs.

After we studied the implementation for Al-Shifa hospital, we will use this study to cover Al-Salam neighborhood in Rafah city with a capacity of 900 homes.

3.3 Implementation of feasibility study on AL-Salam neighborhood:

In this section, Al-Salam neighborhood in Rafah was chosen to study its economic feasibility while solar energy was used to obtain electricity.

In the beginning, we would like to note that the population of Al-Salam neighborhood is about 4500 with an average of 5 members per family. This requires us to establish a solar cell system sufficient to supply 900 homes with electricity to be able to provide the shortage of electricity cut off from Egypt. To know the size of the PV system that will be established, we will study the system for one house.

3.3.1 Inputs:

3.3.1.1 Solar Radiation

The average solar radiation data for one year has been stabilized for the location of Al-Salam neighborhood. Table 4.7 shows the geographic location is defined by the latitude and longitude of the neighborhood site. And figure 4.5 shows the average daily solar radiation data for each month and for a full year by using the homer technics.

Table 3.7: Geographical location of Al-Salam neighborhood

Latitude	**34″**	**52′**	**30°**
longitude	58″	48′	32°

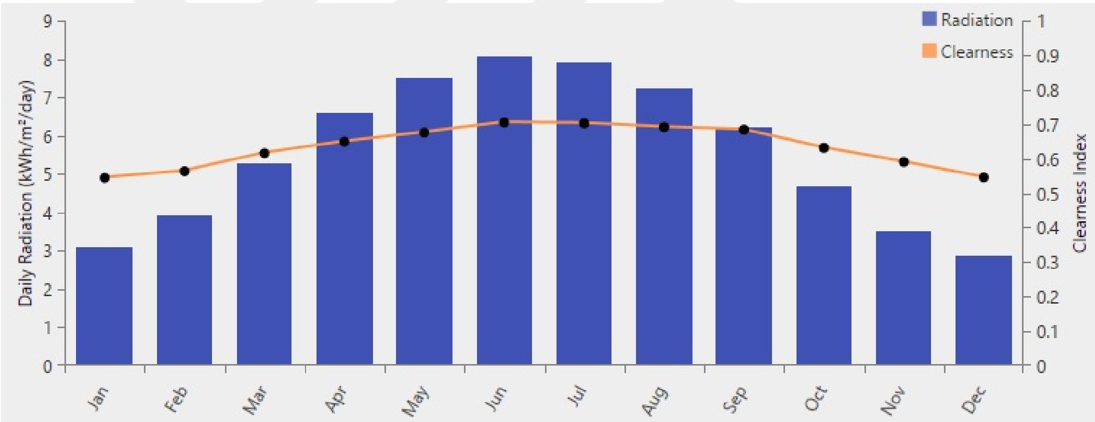

Figure 3.6: Average daily solar radiation

As a result of analysis of these data, the average daily solar radiation was 5.57 kW. Hour / m2 / day, based on this, the average solar radiation falling on each unit area can be calculated annually by about 2033 kW. Which is considered an excellent quantity for building solar systems with great efficiency.

The average solar radiation falling on each unit area = 5.57 * 365 = 2033

3.3.1.2 Load Profile

After a discussion of a number of residents of Al - Salam neighborhood it was found that the average consumption of one household of electricity is 15.845 kWh per year at 43.41 kWh per day. While the average daily solar radiation per square meter is 6 kWh per square meter, and after calculating the total loss in the wiring, the daily requirement of electricity for one home is equal to 34.38 kWh. The data in the table 3.8 took by collecting the electricity bills for the consumption during the year.

Table 3.8: average consumption per household of electricity during the year.[40]

Month	Average Load (KWh / day)
1	802
2	1205
3	743
4	695
5	767
6	686
7	1048
8	1313
9	1661
10	2818
11	2205
12	1902
Anuual Average : 15,845 KWh	

According to the above load readings, Figure 3.6 shows the load per household during the year and, Figure 3.7 shows the average daily load readings for each month, by using HOMER technics.

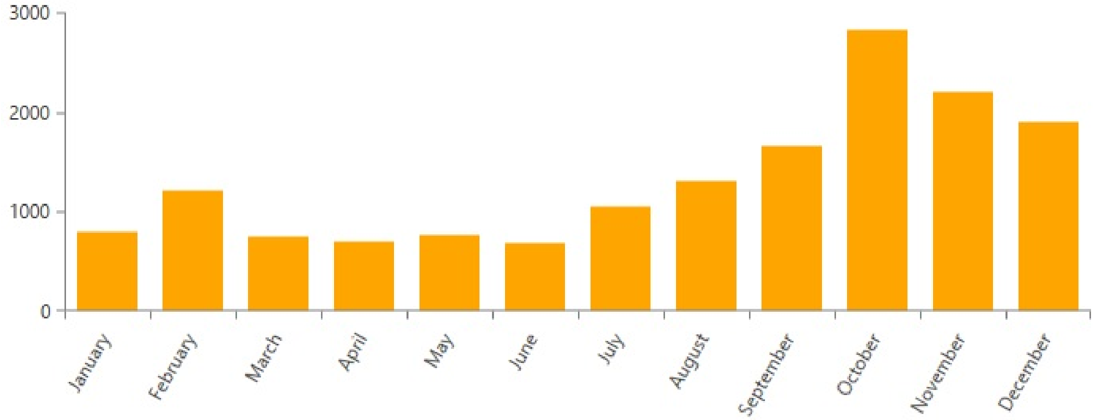

Figure 3.7: The electrical loads per household of the Al-Salam neighborhood during the year.

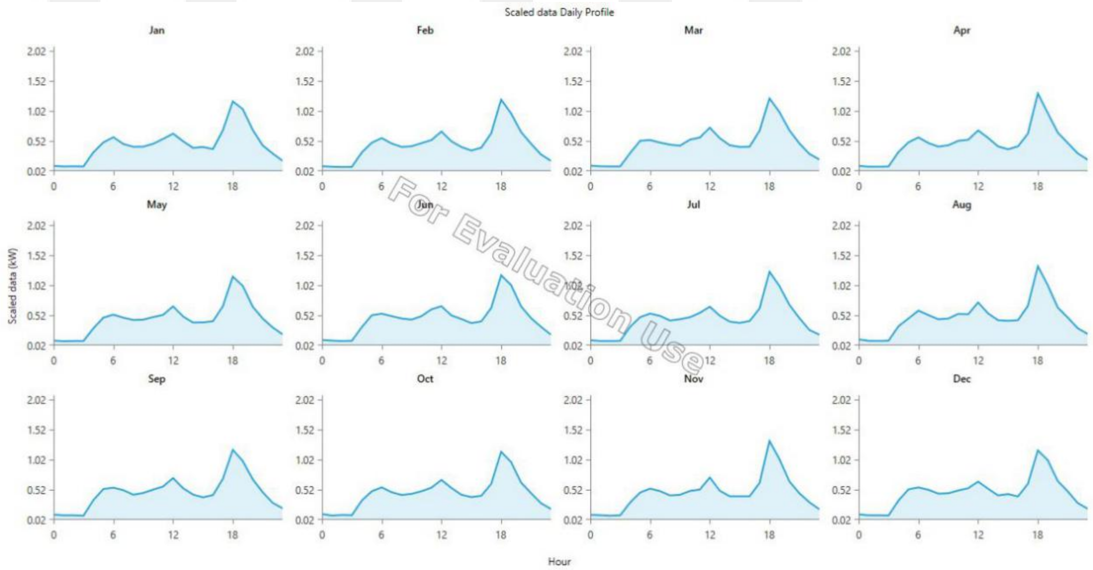

Figure 3.8: Average daily load readings per month for a full year

According to the data that we got by using homer simulation technics:

Total power required for the number of sun hours per day=

(Average household consumption per day / Sun hours)

(43410 / 6 = 7235 watt)

Total power required with loss of efficiency=

(Total power required for the number of sun hours per day * 1.30)

(7235 * 1.30 = 9405 watt)

Total power required for the system =

(Total power required with loss of efficiency * Number of houses)

(9405 watt * 900 = 8.464.950) about 8.5MW

3.3.2 System Components

After we applied the data in table 3.8 , Figure 3.8 shows us the designed system according to the data that collected by the bills per year and the solar system in Palestine.

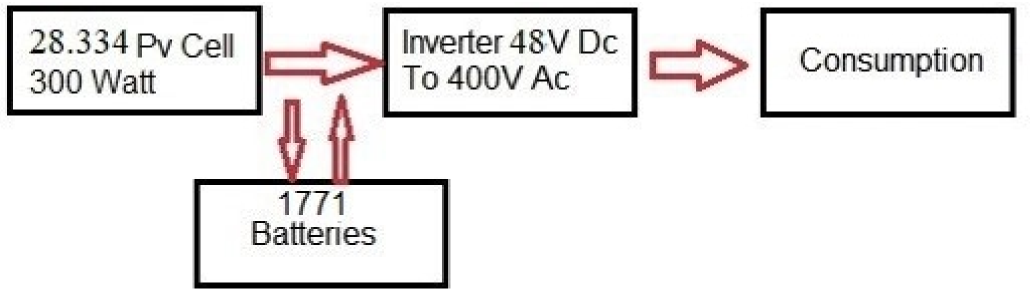

Figure 3.9: Associated solar system components diagram

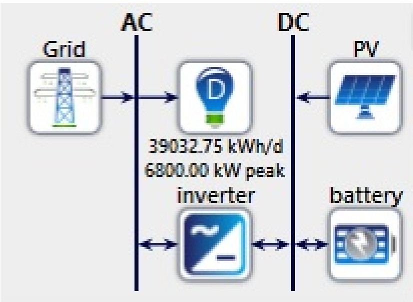

Figure 3.10: Associated solar system components

3.3.2.1 Solar Panels

In our project Poly-crystalline solar cells will be used with capacity of 300 watt,

That's mean instead of getting 8.5 MW we have to use 28.334 cell. Figure 4.9 shows the cell specification that used.

Number of cells =(Total power required with loss of efficiency / The capacity of cell)

Number of cells = 8.5 MW / 300 watt

= 28.334 Pv cell

Figure 3.9 shows us the electrical parameters that used in our project for Al-Salam neighborhood.

Electrical parameters at standard test conditions
(STC:AM=1.5, 1000W/m^2, Cells Temperature 25°C)

Typical type	300W
Max power(Pmax)	300
Max power voltage(Vmp)	37.13
Max power current(Imp)	8.08
Open circuit voltage(Voc)	44.51
Short circuit current(Isc)	8.54
Cell efficiency(%)	17.78
Module Efficiency(%)	15.46
Max system voltage	DC 1000V(TUV)/600V(UL)
Maximum Series Fuse Rating	15A

Figure 3.11: shows the cell specification that used [43]

From the figure above we can calculate the voltage open circuit and the current short circuit to be able to choose the inverter and batteries that will be using in the system.

V_{oc} = 44.51 * 1.14 = 50 V

I_{sc} = 8.54 * 1.14 = 9.7 A

The HOMER simulation program implemented photovoltaic modules with a combined capacity of 8.5 MW depending on the applicable solar system and at a cost of one kilowatt at market prices of about 800 American dollars. Also, it has been considered that there is no replacement cost for solar cells used since the default life is estimated at about 25 years, which is the same life period of the project fully. Table 3.9 shows the initial cost in addition to the annual maintenance and operation cost of the system's constituent cells:

Table 3.9: the initial cost in addition to the annual maintenance

The initial cost	**8500KW * 800$ per 10KW** **6.800.000 USD**
Annual cost of maintenance and operation	72.000 USD per year

3.3.2.2 Inverter

The homer simulation technices preferred to use ABB Inverter with capacity of 50KW instead of getting 8.5MW for this site, these inverters will be replaced only once during the lifetime of the project. On the other hand, the initial cost of the reflectors was estimated at 7,500 American dollars per 10 kW. In addition, the cost of replacing the reflectors after 15 years was estimated at 50% of the initial cost of the reflectors.

Here, the number of inverters need with capacity of 50KW is equal to 240 inverter.

Table 3.10: Construction, replacement and maintenance costs of electrical inverters

The initial cost	**850 * 7500 =** **6.375.000 USD**
Replacement cost	3.187.500 USD
Cost of maintenance	20,000 USD per year

3.3.2.3 Storage batteries

In our project 200AH batteries were used with a discharge capacity of up to 50%. On the other hand, the default lifetime of the batteries was estimated at about 15 years. Therefore, the initial cost of the batteries was estimated at 2083 American dollars per 10 kW.Table 4.11 shows the initial cost, the cost of replacement after 15 years plus the annual operation and maintenance cost of the batteries estimated in US dollars.

Table 3.11: Construction, replacement and maintenance costs of electrical batteries

The initial cost	**1700 * 2083 =** **3.541.100 USD**
Replacement cost	1.770.550 USD
Cost of maintenance	20,000 USD per year

3.3.2.4 Step - up Transformer

The step-up transformer decreases the output current for keeping the input and output power of the system equal. In this case, we have to use step up transformer to be able to connect our system with the medium voltage utility grid.

Table 3.12: Construction and replacement costs of electrical transformer

The initial cost	**22,000 USD**
Replacement cost	11,000 USD

3.3.2.5 High Voltage Switch-gear

Compact substations are used for energy transformation in secondary distribution network from MV to LV or LV to MV. MV fuses up to 40.5 kV, commonly known as high voltage fuses, provide main or back-up protection against overload and over currents. MV switch gear for secondary distribution up to 24 kV.

Table 3.13: Construction costs of switch gear

The initial cost	**10,000 USD**

3.4 Results and Analysis:

3.4.1 Al-Shifa Hospital Implementation

1. The solar system connected to the network in the presence of the system of batteries for storage (On-Grid System with Batteries as Backup System). This hybrid system has been implemented by integrating both the electrical grid and the auxiliary storage system as a result of the continuous interruption of electricity on the public electricity network, which necessitates an alternative to the electrical network, the storage system - batteries.

2. The system consists of 130 solar cells with a capacity of 320 watts per cell, which means that the total capacity of the solar system is 42 kW. With regard to storage batteries, the size of the battery pack in the existing system was estimated at 320 kWh.

3. The payback period of the off-grid existed system was estimated at 6.4 years, whethere on-grid connected system showed us by homer technics that the payback period equal 3.10 years.

On the other hand, Table 4.9 shows the results for the hospital after running the Homer simulation program, which are summarized as follows:

Table 3.14: Results of applying the solar system of Al-Shifa Hospital

Firstly: Components of the solar system	
Total capacity of solar cells	40 kW
Total energy of storage batteries	320KWh
Allowable discharge rates for batteries	%50
Total construction cost of the project	122.160 USD
Secondly: Electric loads	
Maximum capacity for electric loads	25-27KW
Average daily energy output of cells	235 kWh
Average daily energy consumption of cells	160KWh
Average daily energy consumption of the network	None

3.4.1.1 Payback Period for The Hospital :

In this section, the recovery period will be calculated for the amounts pumped to build the components of the project, such as the replacement of the damaged components, in addition to what was spent during the life of the project on regular maintenance and operation.

Table 3.15: detailing what was invested in the hospital project.

The initial cost	**72.640 USD**
Maintenance cost	30.000 USD
Replacement cost	19.520 USD
TOTAL	122.160 USD

Since this systems do not purchase or sell any electrical power to the public network, it can be said that there is no actual material revenue. If they are not produced from the solar system, the only alternative available for their production is either a power grid or a diesel generator. It was therefore recognized that the amount of savings resulting from non-payment of electricity costs is itself a real resource for the project. On the other hand, the average price of kilowatt was calculated. Hour, if purchased from either the electricity grid or even the diesel generator, is approximately 0.4 USD, since the cost of purchasing it from the public network is estimated at 0.2 USD, as stated previously, while the unit price of diesel generators is about 1 USD.

Accordingly, monthly savings can be calculated when the solar system works.

Monthly savings =

Average daily consumption * Number of days per month * the Cost of the energy unit

= 160KW * 30 * 0.4

The monthly savings amount for hospital is approximately 1.920 USD. And the annual saving money is about 23.040 USD. The redemption period can be calculated as follows:

Payback period = (Initial construction cost / the annual savings amount)

The recovery period for the hospital case was estimated at 3.10 years.

3.4.1.2 Environmental Impacts

One of the most positive aspects of solar energy projects is the environmental effects of reducing the use of fossil fuels to generate electricity, which means low levels of toxic emissions if traditional sources are used alone. Table 4.13 shows the annual reduction in toxic gas emissions for the hospital by using homer technics.

Table 3.16: Low emission of toxic gases for the hospital

Poisonous gas	**Quantity of the decrease in emission (kg / year)**
Carbon dioxide	8100 Kg
Sulfur dioxide	35.1 Kg
Nitrogen oxide	17.2 Kg

3.4.2 Al-Salam neighborhood

The on grid system consists of 28.334 solar cells with a capacity of 300 watts per cell, which I used of my calculations that have total capacity of 8.5 MW solar system. With regard to storage batteries, the size of the battery pack in the existing system was estimated at 17 MW.

To be able to know the payback period of the system that applyied by Homer technics and the system that we calculated for the same loads, we have to use the results that we got from homer technics and the result of what we calculated.

On the other hand, Table 3.17 shows the results for Al-Salam neighborhood in Gaza after running the Homer simulation program, and Table 3.18 shows the system of what I calculated for the same loads which are summarized as follows:

Table 3.17: Results of applying the solar system of Al-Salam neighborhood by homer technics.

Firstly: Components of the solar system	
Total capacity of solar cells	8.5 MW
Total energy of storage batteries	17 MWh
Allowable discharge rates for batteries	%50
Total construction cost of the project	21.825.150 USD
Secondly: Electric loads	
Maximum capacity for electric loads	6.772 KW
Average daily energy output of cells	44.625 kWh
Average daily energy consumption of cells	39.032 KWh

Average daily energy consumption of the network	None

Table 3.18: Results of applying the solar system of Al-Salam neighborhood by my calculations.

Firstly: Components of the solar system	
Total capacity of solar cells	8.5 MW
Total energy of storage batteries	17 MWh
Allowable discharge rates for batteries	%50
Total construction cost of the project	22.675.150 USD
Secondly: Electric loads	
Maximum capacity for electric loads	6.032 KW
Average daily energy output of cells	46.287 kWh
Average daily energy consumption of cells	38.980 KWh
Average daily energy consumption of the network	None

3.4.1.2 Payback Period For Neighborhood

In this section, the recovery period will be calculated for the amounts pumped to build the components of the project, such as the replacement of the damaged components, in addition to what was spent during the life of the project on regular maintenance and operation as shown in Table 3.19.

Table 3.19: detailing what was invested in Al - Salam neighborhood project

The initial cost	16.748.100 USD
Maintenance cost	119.000 USD
Replacement cost	4.958.050 USD
TOTAL	21.825.150 USD

Since this systems do not purchase or sell any electrical power to the public network, it can be said that there is no actual material revenue. If they are not produced from the solar system, the only alternative available for their production is either a power grid or a diesel generator. It was therefore recognized that the amount of savings resulting from non-payment of electricity costs is itself a real resource for the project. On the other hand, the average price of kilowatt was calculated. Hour, if purchased from either the electricity grid or even the diesel generator, is approximately 0.4 USD, since the cost of purchasing it from the public network is estimated at 0.2 USD, as stated previously, while the unit price of diesel generators is about 1 USD.

Accordingly, monthly savings can be calculated when the solar system works.

a) The system that appliyed by homer technics

Accordingly, monthly savings can be calculated when the solar system works.

Monthly savings = Average daily consumption * Number of days per month * the Cost of the energy unit

= 39.032 KW * 30 * 0.4

The monthly savings amount for the neighborhood is approximately 468.828 USD. And the annual saving money is about 5.625.936 USD. The redemption period can be calculated as follows:

Payback period = (Initial construction cost / the annual savings amount)

The recovery period for the neighborhood that appliyed by homer technics was estimated at 2.9 years.

b)The system that calculated by me

Monthly savings = Average daily consumption * Number of days per month * the Cost of the energy unit

= 38.980 KW * 30 * 0.4

The monthly savings amount for the neighborhood is approximately 467.760 USD. And the annual saving money is about 5.613.120 USD. The redemption period can be calculated as follows:

Payback period = (Initial construction cost / the annual savings amount)

The recovery period for the neighborhood that calculated by me was estimated at 3.1 years.

The difference between both systems can show us changing of the construction cost and the payback period because of using different cell capacities or batteries types, which can be acceptable for us.

3.4.1.3 Environmental Impacts

One of the most positive aspects of solar energy projects is the environmental effects of reducing the use of fossil fuels to generate electricity, which means low levels of toxic emissions if traditional sources are used alone. Table 3.20 shows the annual reduction in toxic gas emissions for the neighborhood by using homer technics.

Table 3.20: Low emission of toxic gases for Al-Salam neighborhood in Rafah city

Poisonous gas	Quantity of the decrease in emission / year
Carbon dioxide	54 Ton
Sulfur dioxide	30 Kg
Nitrogen oxide	19 Kg

4. CONCLUSIONS AND RECOMMENDATIONS:

4.1 Results

Through the study, research and analysis in this work has been reached many of the results and outputs, which can be enumerated as follows:

1. The solar system connected to the network in the presence of the system of batteries for storage (On-Grid System with Batteries as Backup System). This hybrid system has been implemented by integrating both the electrical grid and the auxiliary storage system as a result of the continuous interruption of electricity on the public electricity network, which necessitates an alternative to the electrical network, the storage system - batteries.

2. The first system consists of 130 solar cells with a capacity of 320 watts per cell, which means that the total capacity of the solar system is 42 kW. With regard to storage batteries, the size of the battery pack in the existing system was estimated at 320 kWh.

3. The monthly invoice for the purchase of industrial fuel for the operation of diesel generators of the hospital declined significantly after the installation of the solar system and start work, as the hospital consumed about 6000 liters per month.

4. The on grid system connected to the neighborhood consists of 28.334 solar cells with a capacity of 300 watts per cell, which means that the total capacity of the solar system is 8.5 MW. With regard to storage batteries, the size of the battery pack in the existing system was estimated at 17 MW.

5. The high financial cost of building solar systems at all levels, which is a real obstacle for the public to use in its facilities and institutions. The high financial cost of building the solar system of Al-Shifa Hospital in Gaza is a good example whereas, the initial cost of the 42 kW solar system is about 72.640 USD without any cost of maintenance or replacement. And for Al-Salam neighborhood the initial cost of the 8.5 MW solar system is about 16.748.100 USD.

6. Homer technics estimated the pay back period at 2.9 years, while the system that I calculated for the same load estimated the payback period at 3.10 years. The difference between both systems can show us changing of the construction cost and the payback period because of using different cell capacities or batteries types,which can be acceptable for us.

7. The results obtained from the simulation and analysis of a virtual off-grid system connected to Al-Shifa Hospital showed that its economic feasibility and high material returns were measured the recovery period and the costs of construction and replacement, As the recovery period of the proposed system was about 6.4 years. However, there are some technical issues that prevent the real application of this system at this time.

8. In the short term, these projects could lead to a breakthrough in the production of electric power for individuals and institutions. However, in the medium and long term, they concluded the extent of the danger faced by the Palestinian society due to the accumulation of damaged storage batteries and failure to deal with them properly.

4.2 Recommendations:

In this research, the problem of power cuts in the Gaza Strip and the catastrophic effects of this crisis have been scientifically highlighted. It is hoped that this exploratory study of the available alternatives and their usefulness will contribute to reconsideration by officials and decision makers in the electric power sector in the Gaza Strip to promote the dissemination of the culture of solar energy use in the sector. We therefore hope that the following recommendations will be implemented:

1.The adoption by the Palestinian government through the Energy and Natural Resources Authority and the Electricity Distribution Company of clear and ambitious strategies to promote the dissemination of the culture of solar energy use in the Gaza Strip. This is done through the introduction of a set of incentives programs for the use of solar energy, such as tax exemptions for solar systems in addition to providing subsidies to major projects in order to enhance its work and launch. In addition, stimulating banking institutions to provide good, soft and long-term loans is one of the most important initiatives that can promote and encourage the use of solar energy to generate electricity.

2.This study showed us how we can connect on grid system with batteries to provide neighborhood of electricity with capacity of 8.5MW, which can be an example for providing the other neighborhoods in Gaza Strip.

3.Encouraging investment in the field of solar energy, especially in the field of associated solar systems, through activation of the clearing system for the sale or purchase of the amount of electrical energy to and from the electrical grid.

4.Spread the culture of solar energy use and rationalize the consumption of electricity through a series of awareness campaigns directed to the application of solar systems connected to the network in the absence of a storage system in the medium term.

4.3 Future studies:

Based on what has been addressed through this work, it can establish a set of ideas and future studies related to the following:

1. Feasibility study for the implementation of solar system connected to the electrical grid with batteries as a storage system covering large areas to include new neighborhoods and cities such as those being opened in the Gaza Strip in an attempt to reduce reliance on traditional sources of energy such as the local electricity grid.

2. A survey of the regulatory laws of the renewable energy sector in the Gaza Strip and the development of a system of intelligent and effective governance through the development of a set of laws, methods and decisions aimed at achieving quality and control the chaos of the local market in the same field.

3. An analytical study to provide a range of proposals and investment mechanisms and ways to develop and encourage the private sector to invest in the renewable energy sector. This is done by linking it with a package of governmental incentives, both administrative and financial; to work to

strengthen the renewable energy market in the Gaza Strip as one of the possible solutions to the local power crisis.

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