An-Najah National University

Faculty of Graduate Studies

Socio-Economic Impacts of Using On-Grid PV Solar Systems in Public Buildings in west Bank, (Schools and Municipalities)

By

Salma 'Muhammed Ali' Yasser Shuqqo

Supervisor

Dr. Imad Ibrik

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This thesis was defended successfully on 5/1/2017 and approved by:

Defense Committee Members	**Signature**
– **Dr. Imad Ibrik / Supervisor**	**.......……………**
– **Dr. Samer Alsadi / External Examiner**	**...……………........**
– **Dr. Waleed Alkokhon / Internal Examiner**	**.......……………**

Dedication

To my father, mother, sister , brothers and grandmothers ……………….

To all friends and colleagues……………………………………………..

To all my teachers……………………………………………………..

To everyone working in this field……………………………………….

To all of them,

I dedicate this work

Acknowledgement

I would like to thank my family for constant love and support that have always given me.

My furthermost appreciation goes to my supervisor, Dr. Imad Ibrik for his exceptional guidance and in rightful comments throughout the duration of this project.

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الإقرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

Socio-Economic Impacts of Using On-Grid PV Solar Systems in Public Buildings in west Bank, (Schools and Municipalities)

أقر بأن ما اشتملت عليه هذه الرسالة إنما هو نتاج جهدي الخاص, باستثناء ما تمت الإشارة إليه حيثما ورد, و أن هذه الرسالة كاملة , أو أي جزء منها لم يقدم من قبل لنيل أي درجة أو لقب علمي أو بحثي لدى أي مؤسسة تعليمية أو بحثية أخرى.

Declaration

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

Student's Name:	اسم الطالب:
Signature:	التوقيع:
Date:	التاريخ:

List of Abbreviations

PV	Photovoltaic
SPBP	Simple Payback Period
EIA	The U.S. Energy Information Administration
IEO2013	The International Energy Outlook 2013
Btu	British Thermal Units
OECD	Organization for Economic Cooperation and Development
SWH	Solar Water Heating
OMSW	The Olive Mill Solid Waste
MSW	Municipal Solid Waste
PR	The Performance Ratio
$\mathbf{P_p}$	Peak Power
P.S.H	Peak Sunshine Hours
$\mathbf{E_{PV}}$	Energy from PV panels
PW	Present Worth
STC	Standard Conditions
AW	Annual Worth

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Socio-Economic Impacts of Using On-Grid PV Solar Systems in Public Buildings in west Bank, (Schools and Municipalities)

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Abstract

We have conducted a study on public buildings that have installed On-Grid PV system. Before installing the system, It's consumption of electricity was 100% from the network provided by the electricity company, but after that, it relied on both the network and the electricity from the solar cells.

In this thesis, I have conducted this study on 2 schools and 3 municipalities- they will be mentioned through the coming sections, and the economical, environmental and social impacts that resulted from the installation of on-grid PV system have been studied.

The main goals of this study are as follows. Firstly to find the performance ratio of each selected building. Secondly, making economical analysis to know the feasibility of these projects through data collection and calculations. Thirdly, studying the environmental impacts of these projects on the environment and its resources. Finally, surveying the opinion of people working in these institutions about the on-grid PV system.

Through this thesis, we were able to touch the real influence behind installing such systems environmentally, economically and socially. We were also able to spread the awareness of the importance of using on-grid PV systems.

This research studies economical environmental and social impacts of using on-grid PV system in public buildings (2 schools and 3 municipalities),

where we found that the performance ratio in these buildings ranges between 81.7% to 96%.

Many economical tools were used to study the economic impact. We found out that the installation's initial costs will be paid back (6-8) years. There were reductions in bills after the installation by range from (22-58)%.

These projects also have positive influences on the environment from different perspectives. The most important one is decreasing the amount of CO_2 emissions, which plays a great factor in saving the environment from climate change.

Related to social impacts, installing on-grid PV system projects on selected buildings , increased people's awareness, not as suspected, towards the importance of renewable energy and its importance in achieving prosperity. We also measured how aware people are of the importance of such systems.

Introduction

Solar energy is a form of renewable energy, there are many advantages that solar energy has to offer over traditional sources of energy like coal and oil. Not only it is completely renewable but is also protects the environment. Photovoltaic (PV) technology converts this energy into electricity without consuming fossil fuels and polluting environment and it is renewable.

The energy situation in Palestine is highly different compared to other countries in the Middle East due to non-availability of natural resource, financial crunch and unstable political condition.

Palestine is heavily dependent on Israel for meeting its energy requirements. Almost all petroleum products are imported through Israeli companies. Israel controls energy imports into Palestine and thus prevents open trade in electricity and petroleum products between Palestine and other countries.

So solar energy is good alternative for energy in Palestine which has a high potential of solar energy falling out during the year compared with other neighboring countries.

In this thesis the economic , environmental and social impacts will be studied for using On-Grid PV system in public buildings.

Methodology of thesis:

we have conducted a study on public buildings that have installed On-Grid PV system. Before installing the system, It's consumption of electricity was 100% from the network provided by the electricity company, but after that, it relied on both the network and the electricity from the solar cells.

In this thesis, I have conducted this study on 2 schools and 3 municipalities- they will be mentioned through the coming sections, and the economical, environmental and social impacts that resulted from the installation of on-grid PV system have been studied.

We started by collecting data about buildings including their consumption of electricity, size of PV systems installed, bills of electricity before and after installing the systems and the opinion of people working in these public buildings. After that we started analyzing the data and get results.

Through this thesis, we were able to touch the real influence behind installing such systems environmentally, economically & socially. We were also able to spread the awareness of the importance of using on-grid P.V systems.

Structure of thesis:

The work carried out in this thesis has been summarized in six chapters

Chapter one: PV systems in public buildings

This chapter talks about the importance of renewable energy in general and solar energy in particular. And it high lights the status of solar energy in Palestine.

Chapter two: Elements of On-Grid PV systems

This chapter talks about the components of On-Grid PV system, how to select buildings for the installation of PV panels, what are the consideration before the installation of On-Grid PV system and then talk about the selected public buildings in this thesis and calculate performance ratio for each selected building.

Chapter three: Economic impacts of using on-grid PV systems in public buildings

In this chapter simple payback period (SPBP) will be calculated, the life cycle cost of on-grid PV systems applied in public buildings including schools and municipalities will be examined to find energy unit price, feasibility study will be made for the systems. In addition to that, a comparison between the consumption of electricity from the network before the installation of the on-grid PV system and after it will be made.

Chapter four: Environmental impacts of using On-Grid PV system in public buildings

The purpose of this chapter is to show the differences in CO_2 emissions and other effects on environment between using solar energy and traditional power plants and using only traditional power plants to cover the consumption in selected public buildings.

Chapter five: Social impacts of using On-Grid PV system in public buildings

In this chapter we will be talking about social impacts of using On-Grid PV system in public buildings and see the awareness about like these projects.

Chapter six: Conclusions and future scope of work

This chapter talks about the main conclusions about using On-Grid PV systems and its social and economic impacts.

Chapter One

Literature Review

1.1 PV systems in public buildings

1.1.1 Importance of renewable energy

Climate change and the need to manage diminishing fossil fuel reserves are, today, two of the biggest challenges facing the planet. In order to secure the future for ourselves and generations to follow, it is widely accepted that we must act now to reduce energy consumption and substantially cut greenhouse gases, such as carbon dioxide. World leaders have resolved to tackle global warming by signing the Kyoto Protocol, an international treaty committing signatory countries to reduce their emissions of carbon dioxide and five other greenhouse gases from 1990 levels. [1]

Renewable energy offers variety of different options to choose from as countries can choose between sun, wind, biomass, geothermal energy, water resources, etc.

Generating electricity from renewable energy rather than fossil fuels offers many benefits in different fields:

- Significant public health benefits. The air and water pollution emitted by coal and natural gas plants is linked to breathing problems, neurological damage, heart attacks, and cancer. Replacing fossil fuels with renewable energy has been found to reduce premature mortality and lost workdays, and it reduces overall healthcare costs

- Environmental benefits, wind, solar, hydroelectric and other renewable systems generate electricity with no associated air pollution emissions. While nonrenewable energy systems emit air pollutants. Fossil fuels when burn create harmful greenhouse gas emissions that have significantly contributed to global warming phenomenon. Using renewable energy instead of fossil fuels we would significantly decrease the total amount of greenhouse gas emissions which would help prevent stronger climate change impact.
- Economic benefits, compared with fossil fuel technologies, which are typically mechanized and capital intensive, the renewable energy industry is more labor-intensive. This means that, on average, more jobs are created for each unit of electricity generated from renewable sources than from fossil fuels. [2]
- The number of people employed within the renewable energy industry continues to grow, and this gives many countries an excellent option to boost their economies in this post-recession period.
- Less foreign oil import. The global oil market has become extremely volatile and our dependence on oil continues to grow. With more emphasis on renewable energy and using domestic renewable energy sources instead of importing foreign oil we would drastically improve our energy security and energy independence. [4]

Whether you believe there are hundreds of years or just a few decades left of fossil fuels, the fact remains that it is a finite resource. At some point, fossil fuels are going to either be gone or they are going to become too expensive to realistically use. [3]

Renewable energy can help in electrification of many rural areas in developing world. In many rural areas renewable energy is cheaper energy option to satisfy energy needs compared to traditional energy solutions.

Renewable energy can also help improve political ties between countries by sharing technological know-how. Some large renewable energy projects could even be joined works of two or more different countries. [4]

In addition, wind and solar energy require essentially no water to operate and thus do not pollute water resources or strain supply by competing with agriculture, drinking water systems, or other important water needs. In contrast, fossil fuels can have a significant impact on water resources.

So, we can see the importance of using renewable energy instead of nonrenewable energy and it's benefits in several sectors.

1.1.2 Renewable energy present and future

Renewable energy nowadays affects many sectors, the transportation sector, the power sector, the environment, energy-water nexus, energy-food-agriculture; waste streams and urban planning. [5]

The U.S. Energy Information Administration (EIA) estimates that about 21% of world marketed energy consumption is from renewable energy sources (biofuels, biomass, geothermal, hydropower, solar, and wind) with a projection for 25% by 2040.[6]

The International Energy Outlook 2013 (IEO2013) projects that world energy consumption will grow by 56 percent between 2010 and 2040. Total world energy use rises from 524 quadrillion British thermal units (Btu) in 2010 to 630 quadrillion Btu in 2020 and to 820 quadrillion Btu in 2040 (Figure 1.1). Much of the growth in energy consumption occurs in countries outside the Organization for Economic Cooperation and Development (OECD), known as non-OECD, where demand is driven by strong, long-term economic growth. Energy use in non-OECD countries increases by 90 percent; in OECD countries, the increase is 17 percent. [7]

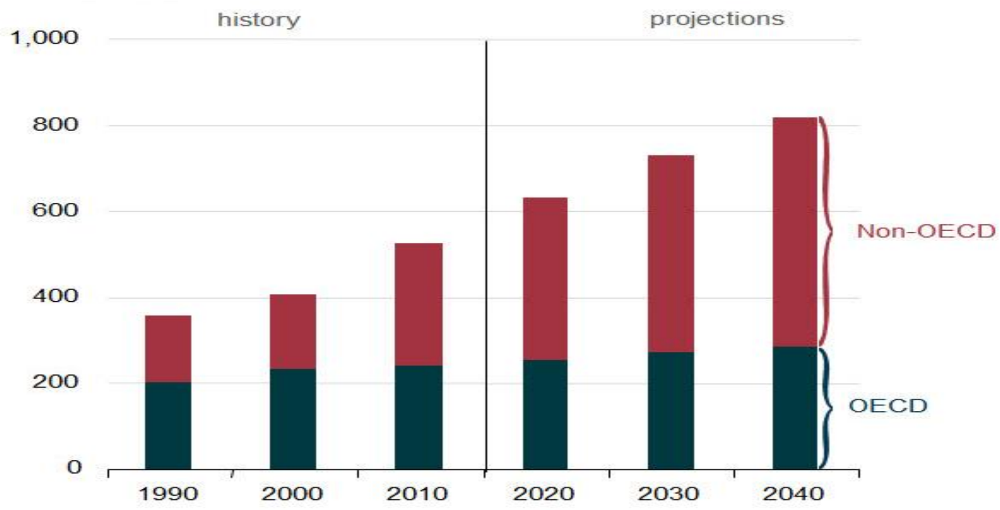

Fig (1.1): World energy consumption

1.1.3 Importance of solar energy

Solar energy is a form of renewable energy, there are many advantages that solar energy has to offer over traditional sources of energy like coal and oil. Not only it is completely renewable but is also protects the environment. Here are some of the advantages of solar energy.

1. Non-polluting: Solar energy is an alternative for fossil fuels as it is non-polluting, clean, reliable and renewable source of energy. It does not pollute the air by releasing harmful gases like carbon dioxide, nitrogen oxide or sulphur oxide. So, the risk of damage to the

environment is reduced. Solar energy also does not require any fuel to produce electricity and thus avoids the problem of transportation of fuel or storage of radioactive waste.

2. Renewable Source: Solar energy is a renewable source of energy as it can be used to produce electricity as long as the sun exists. Sunlight is available everywhere on the Earth. This energy can be harnessed by installing solar panels that can reduce our dependence on other countries for consistent supply of coal to produce electricity. Although solar energy cannot be produced during night and cloudy days but it can be used again and again during day time. Solar energy from sun is consistent and constant power source and can be used to harness power even in remote locations.
3. Low maintenance: Solar cells generally doesn’t require much maintenance and run for a long time. More solar panels can be added from time to time when needed. Although, initial cost of solar panels is steep but there are practically zero recurring costs. Initial cost that is incurred once can be recovered in the long run that range from 10 years – 15 years. Apart from this, solar panels does not create any noise or release any toxic substances.
4. Easy Installation: Solar panels are easy to install and does not require any wires, cords or power sources. Unlike wind and geothermal power stations which require them to be tied with drilling machines, solar panels does not require them and can be installed on the rooftops which means no new space is needed and each home or business user can

generate their own electricity. Moreover, they can be installed in distributed fashion which means no large scale installations are needed. With the advancement in the technology and increase in the production, the cost of solar panels have come down slightly. Areas where cost of electricity is high, payback times can be even lower.

5. Can Be Used in Remote Locations: Solar energy can be of great boon in areas which have no access to power cables. It works great in remote locations where running power lines would be difficult or costly. Solar panels can set up to produce solar energy there as long as it receives the sunlight.
6. Long Lasting Solar Cells: Solar cells make no noise at all and there are no moving parts in solar cells which makes them long lasting and require very little maintenance. Solar energy provides cost effective solutions to energy problems where there is no electricity at all. [8]

Solar energy cells can be used widely, from producing the power for a calculator or a watch to produce enough power to run an entire city. With that kind of versatility, it is a great energy source. Some of the ways solar energy is being used today are:

- Cars
- Cooking
- Coffee Roasters
- Electricity for homes and businesses
- Thermal heating for homes and businesses
- Watches

- Water heaters
- Water treatment plants

There are many other things that are or can be powered by solar energy.

In the future, solar energy may well be the primary form of energy. This could lead to a clean environment, less money spent on utilities, and a healthier world. Solar energy has the potential to allow technology and nature to co-exist peacefully. [9]

1.1.4 Ways to generate solar energy

Humans have been tinkering with solar energy since the dawn of time. Ancient civilizations learned how to use building techniques to store the sun's energy during the day to keep their homes warm at night. They even used glass and mirrors to light fires. It wasn't until the 1950s when technology was developed to convert the sun's energy into electricity using photovoltaic cells, or what we call today, solar panels. One of the first uses of a solar panel was on the Vanguard I space satellite launched in 1958. Since then, innovative uses of solar have been invented to not only generate energy for homes and buildings, but move people in solar cars, boats, and even airplanes.

Types of Current Solar Technology:

- Passive Solar**:** This doesn't involve the use of mechanical and electrical devices. Windows, walls, and floors collect, store, and distribute solar energy in the form of heat in the winter and reject solar heat in the summer. More and more homes are being built to utilize or deflect this type of solar energy.

- Solar Thermal: Technology for harnessing the sun's heat. One use is to heat water on small or large scale.
- Solar Photovoltaic: Technology for producing electricity from the sun using solar cells, typically encased in panels.
- Concentrated Solar**:** Technology for producing electricity from the sun using mirrors (heliostats) to concentrate a large area of solar thermal energy onto a small area. Electrical power is produced when the concentrated light is converted to heat, which drives a heat engine (usually a steam turbine) connected to an electrical power generator. [10]

1.1.5 Ways to generate electrical energy from solar energy

There are many ways to generate electrical energy from solar energy, which are: On- grid PV systems, Off- grid PV systems and Hybrid systems. Every system has its advantages, disadvantages and uses. In this section we will have a look about these ways and the components of every system.

Starting with:

Off grid: Also known as (Battery Backup Systems)

Off grid system provides energy independent of the electrical grid. Using this technique allows to provide the utility with 100% of the energy used. Most homes have higher electricity demand in the evening or at night, so off-grid systems usually incorporate either a battery. Off grid systems are used widely in remote areas without utility service. Off-grid solar-electric systems operate independently from the local utility grid to provide electricity to a home, building or boat.

System components:

- PV panels
- battery bank
- charge controller (to protect the battery bank from overcharge)
- inverter
- required electrical safety gear (i.e. fuses, breakers, disconnectors)
- monitoring system to balance energy consumption with production

The other way is: On-grid PV systems

These are the simplest of solar-electric systems, with the fewest components. They can send excess power generated back to the grid when you are overproducing so you credit it for later use.

System components:

PV panels (multiple panels make up an array)

Inverter(s)

Required electrical safety gear (i.e. fuses, breakers, disconnectors)

Monitoring system to monitor energy production (optional)

Finally: Hybrid systems

Which provides power to offset the grid power whenever the sun is shining and will even send excess power to the grid for credit for later use. [11], [12]

1.1.6 Projects around the world applying on-grid solar systems on public buildings

If we have a look around the world, we will see many projects supplying public buildings by solar energy using On-grid PV systems. Many studies were made highlighted different impacts on public buildings from producing energy from solar cells.

As an example, Feasibility Study of Economics and Performance of Solar Photovoltaics at the TechCity East Campus Resource Conservation and Recovery Act Site in Kingston, New York. Also, technical and economic study of a PV system installed on the rooftop of a public building in Goiania and many other studies.

1.2 Renewable energy in Palestine

1.2.1 Available renewable energy in Palestine

Nowadays the world is going forward replacing traditional energy sources by renewable resources to achieve many purposes, also Palestine is progressing in the same way.

With an acknowledged scarcity of conventional energy resources, high population growth and volatile energy prices, many worry that there is a future energy crisis developing in the Palestinian Territory.

To avoid this crisis alternative energy sources must be used. Renewable energy sources available in Palestine are as follows: Solar, geothermal, biomass and wind energy.

Solar Energy

Solar energy can be a major contributor to the future Palestinian energy supply, with its high potential in the area. Palestine receives about 3,000 hours of sunshine per year and has an average solar radiation of 5.4 kWh/m^2. Domestic solar water heating (SWH) is widely used in Palestine where almost 70% of houses and apartments have such systems. In fact, Palestine is one of the leading countries in the field of SWH for domestic purpose. SWH is made locally in the West Bank and Gaza Strip with a production rate of about 24,000 units per year which is considered to be sufficient for the Palestinian market. Solar thermal and photovoltaic systems are yet to take off in Palestinian areas due to high costs associated with such systems.

Geothermal Energy

The heating and cooling requirements of Palestinians can be met by judicious exploitation of geothermal energy. In summer, the temperature below the earth's surface is lower than atmospheric temperatures, and in winter it is higher. MENA Geothermal capitalizes on this by burying pipes below ground. Water pumped through these pipes then capture the temperature to feed the building's heating and cooling system.

A geothermal system utilizes the energy from the sun, which is stored in the earth, to heat and cool homes and buildings. Typically, electric power is used only to operate the unit's fan, compressor and pump. The geothermal system essentially uses the stable temperature of the ground at a specific depth for heating in winter and cooling in summer, providing clean energy and reducing energy costs.

Biomass Energy

Biomass energy is predominantly used for heating purposes and constitutes approximately 15% of Palestinian energy supply. Being an agrarian economy, Palestine has a strong potential for biomass energy. There is good potential for biogas generation from animal manure, poultry litter and crop wastes. In addition, organic fraction of municipal solid wastes is also represents a good biomass resource in Palestine. The Gaza Strip alone produces more than 1300 tons of solid wastes.

Being Palestine one of the many olive oil producing countries in the region, the interest now is directed to utilize the olive mill solid waste (OMSW) to be used as clean source of energy. The olive harvest season is all year round and so the OMSW as a raw material is also constantly available. The annual average amount of OMSW is around 76,000 tons. The municipal solid waste in Palestine could be used as a source of energy, a new developing proposal projects were released by PEC to generate electricity from burning the wastes (WTE). The proposal project is for constructing an 18 MW waste to energy (WTE) power plant in order to get rid of municipal solid waste

(MSW) of the northern provinces of the west bank; this is done by a controlled combustion of the wastes which is exploited generate electricity. Thus, converting MSW to a valuable material rather than being an environmental and economical burden [15]

In addition to these sources there are a few wind energy projects underway, including at the hospital in Hebron.Based on available data and topographical features of Palestine, potential of wind energy seems to be limited to the mountains (elevation of about 1000 m); regions of Nablus, Ramallah and Hebron where the speed surpass 5 m/s and the potential about 600 kwh/m2.Initial studies shows that the wind regime is suitable for operating a wind turbine for wind power generation in city of Hebron in West Bank**.[13],[14],[15]**

1.2.2 Availability of solar energy and its importance

We can see the importance of solar energy by looking at the problems produced from traditional sources. High population growth, increasing living standards and rapid industrial growth has led to tremendous energy demand in the Palestinian Territories in recent years. The energy situation in Palestine is highly different compared to other countries in the Middle East due to non-availability of natural resource, financial crunch and unstable political condition.

Palestine is heavily dependent on Israel for meeting its energy requirements. Almost all petroleum products are imported through Israeli companies. Israel controls energy imports into Palestine and thus prevents open trade in electricity and petroleum products between Palestine and other countries.

The Palestinian power sector is entirely dependent on imported power supply, 88% from the Israel and 3% from Jordan and Egypt.

Egypt supplies merely 17MW of electrical power to the Gaza Strip while 20MW is supplied to Jericho by Jordan’s state-utility firm. Exploitation of renewable energy resources is required at a mass-level so as to ensure a cheap and sustainable source of energy to the Palestinians. The major renewable energy resources in Palestine are solar, geothermal and biomass. At the end of 2012, renewable energy contributed merely 1.4% in the energy mix, though Palestine is targeting 10% clean energy installed capacity by the year 2020.

Palestine has a high potential of solar energy falling out during the year compared with other neighboring countries. The annual daily average of solar radiation in Palestinian Territories is estimated at (5.46 kWh/ m^2.day). The average of solar radiation during winter season is approximately (3.5 kwh/m^2.day), and it exceeds (6.242 Kwh/m^2.day) in the rest of the year. The following table (1.1) shows the values of solar radiation in different locations in Palestine.[16]

Table (1.1): Daily average global solar radiation (kwh/m2.day)

	Allud	Bet Dagan	Jerusalem	Jericho	Bethlehem	Gaza	PT Average
Location	3200N 345E	3200N 344E	3146N 3511E	3151N 352E	3151N 3507E	3131N 3426E	
Jan	3.19	2.85	3.06	2.78	2.93	2.78	**2.97**
Feb	4.36	3.76	3.71	3.28	3.28	3.89	**3.73**
Mar	5.44	4.85	5.03	4.85	4.89	4.86	**5.03**
Apr	6.76	6.01	6.35	6.61	6.61	5.83	**6.24**
May	7.92	7.07	7.55	6.89	6.89	6.94	**7.24**
Jun	8.48	7.69	8.42	8.06	8.06	7.78	**8.13**
Jul	8.31	7.45	8.31	8.12	8.12	7.5	**7.9**
Aug.	7.49	6.91	6.91	7.3	7.3	7.22	**7.30**
Sept.	6.49	5.85	6.66	6.36	6.36	6.25	**6.26**
Oct.	5.06	4.51	4.99	4.93	4.93	4.72	**4.81**
Nov.	3.77	3.34	3.8	3.25	3.25	3.61	**3.51**
Dec.	3.05	2.61	3	2.61	2.61	2.5	**2.74**
Average	**5.86**	**5.24**	**5.70**	**5.45**	**5.45**	**5.33**	**5.46**

Source: PEC, Applications of Solar Thermal Energy in the Mediterranean Basin, Nablus, May 2002

1.2.3 Renewable energy in Palestine by 2020

In 2009, the power consumption in the Palestinian Territory was 4.413 GW/ hour. These power needs are imported from three sources: Israel (86%), Egypt and Jordan (4.5%) and Palestine Electric Company- Gaza (around 10%).

The bill of imported electricity ranges from 400 to 500 million dollars annually. Electricity services (including distribution and maintenance) are carried out by Palestinian providers (3 in the West Bank and one in Gaza). It should be noted that there are no purchase agreements between the PNA and Israel and thus the purchase is done through bilateral contracts between the Israeli Electricity Company and Palestinian providers. The most prominent characteristics of the power sector in the Palestinian Territory are:

Household and services account for 75% of consumption, while 25 percent is consumed by economic and productivity activities. The annual consumption in 2020 is expected to reach 8.400 GW / hour- assuming an annual growth rate of 6%. The wastage of electricity is about 26% of imported energy, while the electricity prices are relatively high as a result of importing most of the needs from Israel. The average per capita consumption of electricity (after deducting wastage) is around 830 KW / hour per year. This average is low compared with neighboring countries (2093 in Jordan, 1549 in Egypt and 6600 In Israel).

The PNA has adopted a national strategy for the energy sector (2011-2013) which aims to increase domestic production of electric power to cover 50% of consumption by 2020. The strategy stipulates that the domestic production of energy should be a combination of both traditional and renewable sources. According to this blueprint, renewable energy will generate 5% of the total target electricity by 2020. [17]

1.3 Importance of On-grid PV system in public buildings

As we mentioned before in section 1.1.5 , we have three ways to generate electricity from solar energy, which are : on-grid, off- grid and hybrid systems. In this section, we will show the importance of on-grid systems over other systems.

On-Grid Systems are solar PV systems that only generate power when the, utility power grid is available. They must connect to the grid to function. They can send excess power generated back to the grid when you are overproducing so you credit it for later use.

These are the simplest systems and the most cost effective to install. These systems will pay for themselves by offsetting utility bills in 3-8 years. [18]

Off-grid systems use batteries to store electricity and provide it for your home, but batteries don’t last forever. In fact, they will need replacement every five to fifteen years (typically less than ten, unless you have deep pockets for high-quality, industrial-type batteries). A minimal bank of batteries will cost at least $1,000, and long-lasting industrial batteries for the same application might cost three to four times that much. And it’s not just the cost in dollars that’s a disadvantage. There’s maintenance and replacement time, aching backs from lifting that heavy metal, and perhaps labor cost—and then there’s the environmental cost of making, moving, recycling, and replacing all that lead.

Batteries have another, less tangible cost, and that’s energy waste. At their best, batteries are 90% efficient. That means if you put in 10 kilowatt-hours (kWh), you will get out less than 9 kWh. As they age, their efficiency drops further, and they are also affected by temperature. All this adds up to more energy waste the larger, older, hotter, or colder your battery bank is.

In comparison to grid-tied systems, stand-alone systems have another serious drawback—wasted surplus energy. When a grid-tied renewable electricity system makes more than the homeowners use, the surplus is fed to the utility, creating an energy credit and allowing the system to always run at full capacity. Nothing is wasted, and the grid is figuratively (not literally) 100% efficient—you get credited for all that you throw their way. When you’re off grid, your surplus must be used or it will be wasted. With most off-grid PV systems, the array simply gets turned off by the controller when the batteries are full, so the energy is never generated. [20]

So, the most proper choice to produce electricity in public buildings is on-grid PV systems; they are more economical than other alternatives. They are also more reliable since any shortage in producing electricity can be compensated from the network. In case of expanding the load, the installed systems must not be replaced and the shortage can be compensated from the network.

Chapter Two

Elements of On-Grid PV system

In this chapter we will be talking about the components of On-Grid PV system, how to select buildings for the installation of PV panels and calculate performance ratio for each selected building.

2.1 Selection of buildings to install On-grid PV system

In this section we will talk about what are the consideration before the installation of On-Grid PV system and then talk about the selected public buildings in this theses and how much do they achieves conditions.

2.1.1 Considerations before installing

Before choosing On-Grid PV system components and starting the installation, many considerations must be taken into account, we have to insure that the roof top is suitable to install the system, we have to take into account that shading can really impact the amount of electricity produced from a solar array if the solar panels are all on the same string, and one of the panels is shaded, all the panels will have the electricity production limited to the one shaded panel.

Therefore, we need to have correctly positioned them (taking on board advice from the installers) and potentially you might wish to put panels on different strings to ensure that you maximize the electricity produced from panels if you know shading is going to be an issue. [21]

So, before installing the panels have a site visit, discuss energy efficient initiatives that could be implemented by the site owner. These could include:

- Replace inefficient electrical appliances with new energy efficient electrical appliances
- Replace tank type electric hot water heaters with a solar water heater either gas or electric boosted.
- Replace incandescent light bulbs with compact fluorescents and/or efficient LED lights
- Assess the occupational safety and health risks when working on that particular site,
- Determine the solar access for the site.
- Determine whether any shading will occur and estimate its effect on the system,
- Determine the orientation and tilt angle of the arrays,
- Determine the available area for the solar array,
- Determine whether the roof is suitable for mounting the array,
- Determine how the modules will be mounted on the roof,
- Determine where the inverter will be located,
- Determine the cabling route and therefore estimate the lengths of the cable runs and determine whether monitoring panels or screens are required. [22] [23]

After taking all these considerations into account, we can then start choosing the components of the on-grid PV systems explained in the next section 2.2

2.1.2 Selection of buildings in this thesis:

A study on public buildings will be made. We chose two public schools and three municipalities. The buildings were chosen on specific criteria. The first criterion, chosen buildings must not be surrounded by other high buildings from the south so that there is no objects that may cause shadow on the system. The second criterion is that there must be enough free space on roof top to install the system. The third criterion is: the possibility of adding the necessary meters on the main board and the availability of necessary data.

The schools are: Al-Razi School and Khawlah Bint Al-Azwar School. The three municipalities are: Hamdi Mango Center, Qabalan Municipality, Baqa alsharqia Municipality. The previous criteria were all found in the selected buildings.

The collected data about schools are as the following:

- **Al-Razi School**

  Is located in Qalqilia at schools street, near Qalqilia Zoo as shown below in figure(2.1).

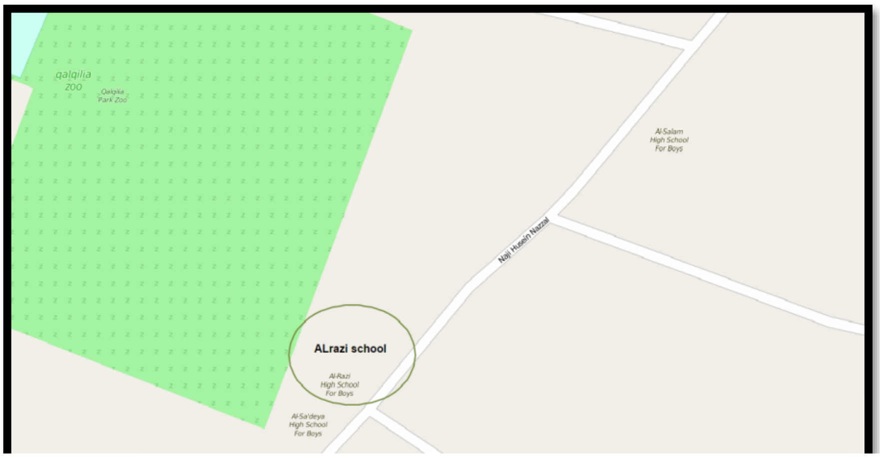

Fig (2.1): Location of Al Razi School

The coordination: Lat: 32°11'41.23"N, Long: 34°58'19.48"E

The school is not surrounded by high buildings from the south, so there is no object may cause shadow on system as shown below in figure (2.2):

Fig (2.2): Roof top of Al Razi School

Global Irradiation for site for inclination of 32 degrees is shown in table (2.1):

Table (2.1): Global Irradiation for Al Razi school site for inclination of 32 degree

Month	H(32)
Jan	4290
Feb	4820
Mar	6280
Apr	6530
May	6970
Jun	7250
Jul	7220
Aug	7280
Sep	6990
Oct	6300
Nov	5250
Dec	4380

H (32): Irradiation on plane at angle (32 degree) - Wh/m2/day

Energy consumption = 35497 kwh/year

- **Khawlah Bint Al-Azwar School**

Is located in Albireh at Alkhan street, as shown below in figure (2.3):

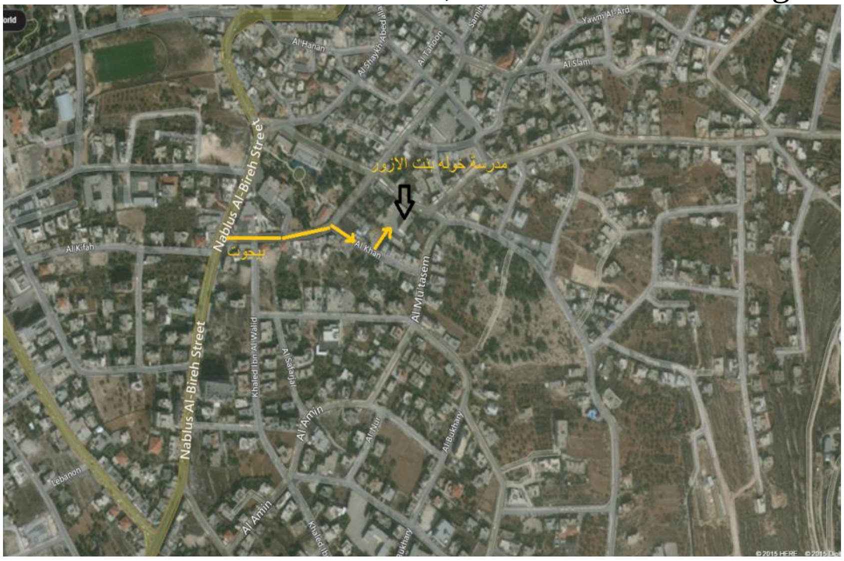

Fig (2.3): Location of Khawlah Bint Al-Azwar school

The coordination: Lat: 31°54'14.63"N, Long: 35°12'52.05"E

The school is not surrounded by high buildings from the south, so there is no object may cause shadow on system as shown below in figure (2.4):

Fig (2.4): Roof top of Khawlah Bint Al-Azwar school

Global irradiation for site for inclination of 32 degrees as shown in table (2.2):

Table (2.2): Global Irradiation for Khawlah Bint Al-Azwar school site for inclination of 32 degree:

Month	H(32)
Jan	4240
Feb	4710
Mar	6040
Apr	6460
May	6940
Jun	7310
Jul	7320
Aug	7400
Sep	7140
Oct	6330
Nov	5320
Dec	4340

H (32): Irradiation on plane at angle (32 degree) - Wh/m2/day

- **Qabalan Municipality**

Qabalan Municipality is located in Qabalan town with coordination 32° 6'11.04"N, 35°17'18.69"E, as shown below in figure (2.5):

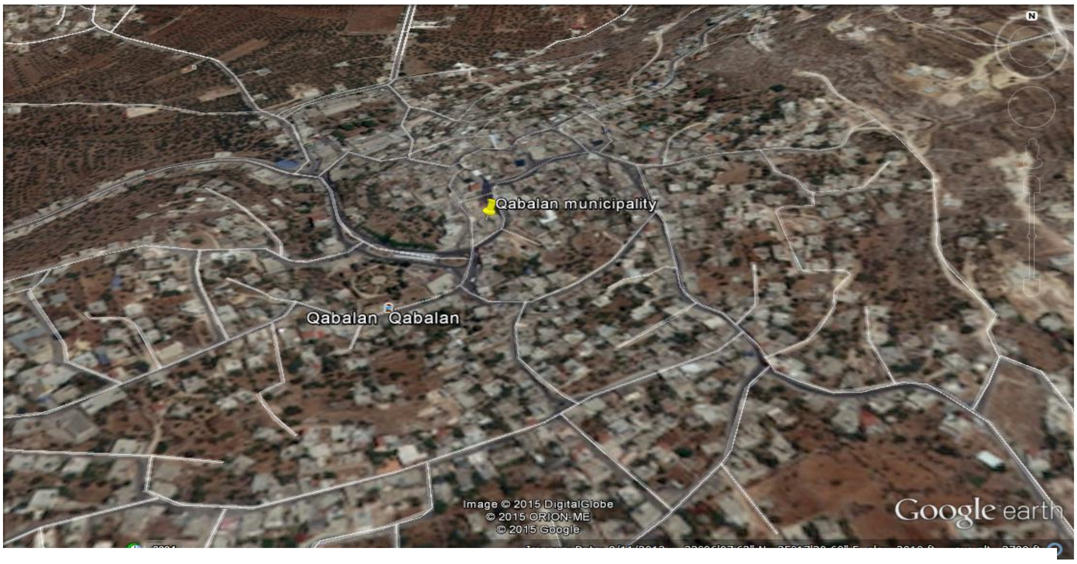

Fig (2.5): Location of Qabalan Municipality

Energy consumption = 14 MWh/year

The plant is 5KWp PV system

Global irradiation for site for inclination of 32 degrees as shown in table (2.3):

Table (2.3): Global Irradiation for Qabalan Municipality site for inclination of 32 degrees:

Month	H(32)
Jan	4070
Feb	4540
Mar	5890
Apr	6320
May	6880
Jun	7240
Jul	7250
Aug	7290
Sep	6950
Oct	6160
Nov	5100
Dec	4230

H(32): Irradiation on plane at angle (32 degree) - Wh/m2/day

- **Hamdi Mango Center**

Hamdi Mango Center is a municipal building located in western part of Nablus with coordination 32°13'33.00"N, 35°15'7.27"E, as shown in figure (2.6)

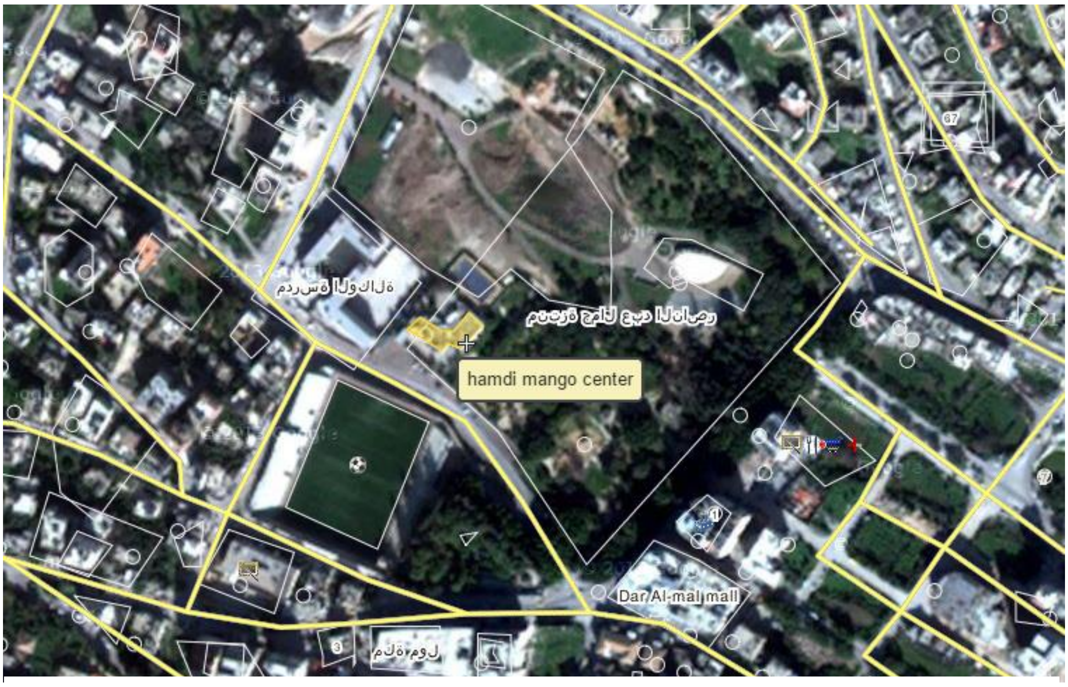

Fig (2.6): Location of Hamdi Mango Center

Energy consumption = 131 MWh/year

The plant is 20KWp PV system

Global irradiation for site for inclination of 32 degrees as shown in table (2.4):

Table (2.4): Global Irradiation for Hamdi Mango Center site for inclination of 32 degree:

Month	H(32)
Jan	4030
Feb	4500
Mar	5940
Apr	6310
May	6870
Jun	7250
Jul	7250
Aug	7290
Sep	6910
Oct	6120
Nov	5040
Dec	4160

H(32): Irradiation on plane at angle (32 degree) - Wh/m2/day

- **Baqa alsharqia Municipality**

Baqa alsharqia Municipality is located in Baqa Alsharqia with coordination 32°24'35.33"N, 35° 4'27.41"E, as shown in figure (2.7):

Fig (2.7): Location of Baqa alsharqia Municipality

Energy consumption = 17 MWh/year

The plant is 5KWp PV system

Global irradiation for site for inclination of 32 degree as shown in table(2.5) :

Table (2.5): Global Irradiation for Baqa alsharqia site for inclination of 32 degree:

Month	H(32)
Jan	4200
Feb	4680
Mar	6190
Apr	6460
May	6940
Jun	7240
Jul	7240
Aug	7280
Sep	7010
Oct	6240
Nov	5160
Dec	4330

H(32): Irradiation on plane at angle (32 degree) - Wh/m2/day

2.2 On-Grid PV system components

In this section we will talk about the components of On-grid PV system and then the components of On-grid PV systems in selected public buildings.

On-grid PV system components are: PV array, balance of system equipment, DC to AC inverter and metering, as shown in figure (2.8)

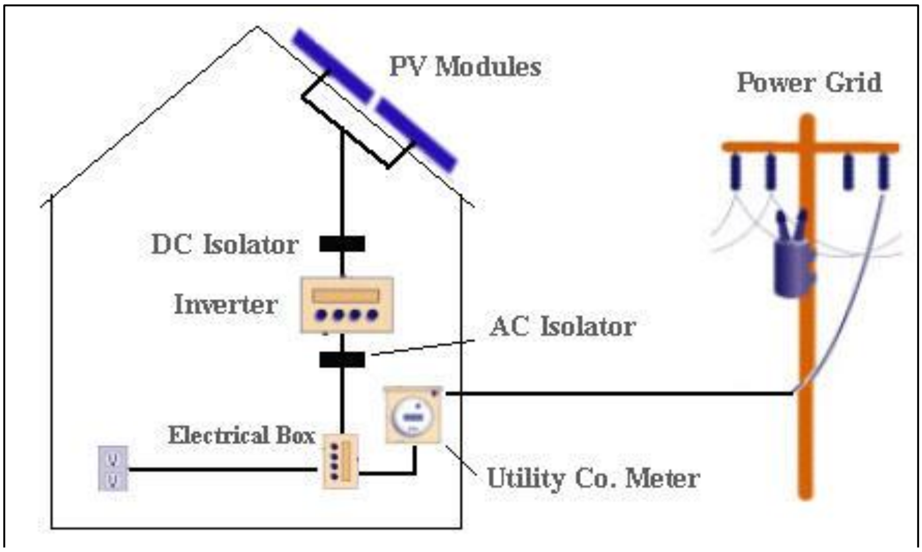

Fig (2.8): On-grid PV system components

1- PV Array: A PV Array is made up of PV modules, which are environmentally-sealed collections of PV Cells— the devices that convert sunlight to electricity.. Often sets of four or more smaller modules are framed or attached together by struts in what is called a panel. The module is made up from solar cells and there is three common types of solar cells, which are:

- Mono crystalline solar cells
- Poly crystalline solar cells
- Thin film solar cells

2- (BOS): BOS includes mounting systems and wiring systems used to integrate the solar modules into the structural and electrical systems of the home. The wiring systems include disconnects for the dc and ac sides of the inverter, ground-fault protection, and over current protection for the solar modules. Most systems include a combiner board of some kind since most modules require fusing for each module source circuit. Some inverters include this fusing and combining function within the inverter enclosure.

3- DC-AC inverter: This is the device that takes the DC power from the PV array and

converts it into standard AC power used by the house appliances.

4- Metering: This includes meters to provide indication of system performance. Some meters can indicate home energy usage.

5- Other components: utility switch (depending on local utility) [21]

2.2.1 Components of selected public buildings

Starting with public schools:

The components of On-grid PV system in public schools are as in table (2.6):

Table (2.6): The components of On-grid PV system in public schools

Item #	Category	Description of item(as offer)	QTY
1	PV	PV modules 320Wp - 24V	24
2	Inverter	grid Interactive Inverter, single phase "three single phase"	3
3	Monitoring	real time monitoring system (data logger) with on-line screen unit	1
4	Meter	Bi-directional three phase meter with time discrimination and indirect measure using current transformers.	1
5		three phase electronic meter 400V	1
6	Fire extinguisher	fire extinguisher system	1
7	Surge Protection	surge protection device I max = 15KA, 400V, including circuit breaker	1

The components of On-grid PV system in public municipalities (Qabalan and Baqa al sharqiya) are as in table (2.7)

Table (2.7): The components of On-grid PV system in public municipalities (Qabalan and Baqa al sharqiya)

Item #	Category	Description of item(as offer)	QTY
1	PV	PV modules 320Wp - 24V	16
2	Inverter	grid Interactive Inverter, "three phase"	1
3	Monitoring	real time monitoring system (data logger) with on-line screen unit, to measure and monitoring real time data from the solar system	1
4	Meter	Bi-directional three phase meter with time discrimination and indirect measure using current transformers.	1
5		three phase electronic meter 400V	1

The components of On-grid PV system in public municipalities (Hamdi Mango) are as in table (2.8)

Table (2.8): The components of On-grid PV system in public municipalities (Hamdi Mango)

Item #	Category	Description of item(as offer)	QTY
1	PV	PV modules 320Wp - 24V	64
2	Inverter	grid Interactive Inverter, "three phase"	2
3	Monitoring	Real time monitoring system (data logger) with on-line screen unit, to measure and monitoring real time data from the solar system	1
4	Meter	Bi-directional three phase meter with time discrimination and indirect measure using current transformers.	1
5		three phase electronic meter 400V	2

2.3 Performance Ratio calculations

In this section we will talk about what is performance ratio, why is it's important and calculate the P.R for the On-Grid PV systems in public buildings.

2.3.1 Performance Ratio

In this section we will talk about what is performance ratio and why is it's important.

The performance ratio is one of the most important variables for evaluating the efficiency of a PV plant. The performance ratio is a measure of the quality of a PV plant that is independent of location and it therefore often described as a quality factor. The performance ratio (PR) is stated as percent describes the relationship between the actual and theoretical energy outputs of the PV plant. It thus shows the proportion of the energy that is actually available for export to the grid after deduction of energy loss (e.g. due to thermal losses and conduction losses) and of energy consumption for operation. The closer the PR value determined for a PV plant approaches 100 %, the more efficiently the respective PV plant is operating. In real life, a value of 100 % cannot be achieved, as unavoidable losses always arise with the operation of the PV plant (e.g. thermal loss due to heating of the PV modules). High-performance PV plants can however reach a performance ratio of up to 80 %. [24]

The following equation 2.1 explains how to calculate the performance ratio:

P.R = Actual reading of plant output in kWh p.a. \ nominal plant output in kWh p.a. (2.1)

The performance ratio can be used to compare PV plants supplying the grid at different locations all over the world.

The nominal system output = P_p x P.S.H x η (2.2)

Where:

P_p: peak power

P.S.H: peak sunshine hours, average P.S.H in Palestine =5.4 wh /day

η: Overall efficiency, equals 0.9

2.3.2 Performance ratio of selected public buildings

In this section we will find out the performance ratio for the selected public buildings. To calculate performance ratio, we will use equation (2.1) which requires to know the actual and theoretical output from PV systems.

Actual output from PV systems for one year is shown in table (2.9)

Table (2.9): Actual output from PV systems in selected public buildings

Public building	Actual output from PV system (kwh/year)
AL- Razi school	11,243.6
Khawlah Bint Al-Azwar school	11,563.00
Baqa alsharqia Municipality	8,521.9
Qabalan Municipality	8,131.6
Hamdi mango municipality	29,292.8

Theoretical output can be calculated using equation (2.2)

Table (2.10) shows peak power of every chosen public building

Table (2.10): Peak power of chosen public buildings

Building	Peak power (kw)
AL- Razi school	7.76
Khawlah Bint Al-Azwar school	7.76
Baqa alsharqia Municipality	5
Qabalan Municipality	5
Hamdi mango municipality	20

As an example, in AL- Razi school:

Actual output from PV system /year = 11,243.6 kwh

Theoretical output = 7.76kw x5.4 h/day x365 days x0.9

= 7.76kw x 5.4 h/day x365 days x0.9

= 13,765.5 kwh/year

Now,

P.R in Al Razi school = 11,243.6 kwh / 13,765.5 kwh/year

= 81.7%

We can see that P.R in Al Razi school is high and as we said before the closer the PR value determined for a PV plant approaches 100 %, the more efficiently the respective PV plant is operating.

In the same way we can calculate performance ratio for other public buildings. Table (2.11) shows the performance ratio for PV systems in selected public buildings.

Table (2.11): Performance ratio for PV systems in selected public buildings.

Building	Performance Ratio (P.R)
AL- Razi school	81.7%
Khawlah Bint Al-Azwar school	84%
Baqa alsharqia Municipality	96%
Qabalan Municipality	91.7%
Hamdi mango municipality	82.6%

The results in previous table (Table 2.11) shows that P.R in all selected public buildings is high, that informs how energy efficient and reliable PV plant is.

Chapter Three
Economic impacts of using On-Grid PV systems in public buildings

Economic impacts of using on-grid PV systems in public buildings

In this chapter simple payback period (SPBP) will be calculated, the life cycle cost of on-grid PV systems applied in public buildings including schools and municipalities will be examined to find energy unit price, feasibility study will be made for the systems. In addition to that, a comparison between the consumption of electricity from the network before the installation of the on-grid PV system and after it will be made.

3.1 Simple payback period

In this section payback period will be defined and calculated for the On-Grid PV systems in selected public buildings.

The payback period is the length of time required to recover the cost of an investment. The payback period of a given investment or project is an important determinant of whether to undertake the position or project, as longer payback periods are typically not desirable for investment positions. The payback period ignores the time value of money, unlike other methods of capital budgeting, such as net present value, internal rate of return or discounted cash flow.[25]

In this thesis we calculated SPBP to have a look if similar projects will be made is it advantageous. Simple payback period (SPBP) evaluates the economic impact of the projects, it can be found using equation (3.1):

$$\text{SPBP} = \frac{investmant}{saving} \qquad (3.1)$$

Where:

Investment: Is initial cost of the system, equals the sum of installation cost and components costs.

Saving: The cost of energy produced from On-Grid PV system.

Starting with calculating the investment cost of the systems:

$$\text{Investment cost} = \text{Components cost} + \text{Installation cost} \quad (3.2)$$

The cost of PV system components is shown in table 3.1 and installation cost is shown in table 3.2:

Table (3.1): cost of PV system components in public schools

Item number	Component	Quantity	Unit price	Total price ($)
1	PV modules	24	235	5,640
2	Single phase Inverter	3	950	2,850
3	Monitoring system	1	750	750
4	Meters	1	572	572
5	Other components		288	288
Total components costs			10,100 $	

Table (3.2): Installation cost of On-Grid PV system in public schools

Item number	Installation of	Total price ($)
1	PV panels	2394
2	Protection elements	1186
3	Inverters	280
4	Distribution board and meters	361
5	Monitoring system	712
6	Wires and other elements	697.5
Total cost		5,630.5 $

So investment cost of on-grid PV system in both public schools is calculated using equation (3.2)

$$\text{Investment cost} = \text{installation cost} + \text{components costs} \quad (3.2)$$

$$= 5,630.5 + 10,100$$

$$= 15,730.5 \ \$$$

The cost of On-Grid PV system components and installation in each of Baqa alsharqia and Qabalan municipalities can be calculated using equation (3.3):

System components and installation cost= 2$ *P_p (3.3)

Where P_p is taken from table (2.10) in previous chapter.

System components and installation cost in Baqa alsharqia and Qabalan municipalities = 2$ * 5,000 wp

= 10,000 $

The cost of PV system components and installation in Hamdi mango municipality can be calculated using the same way explained before, so

System components and installation cost= 40,000 $

Table (3.3): Investment cost of On-Grid PV system in each selected public building

Building	Investment cost $
AL- Razi school	15,730.5
Khawlah Bint Al-Azwar school	15,730.5
Baqa alsharqia municipality	10,000
Qabalan municipality	10,000
Hamdi mango municipality	40,000

Now, we will calculate saving in each of the selected public buildings

Saving = output energy from PV per year × feed in tariff /KWh (3.4)

Saving = $E_{PV} \times Z_{tarrif}$

Where:

E_{PV}: Energy from PV panels, E_{PV} is taken from table (2.9) in previous chapter.

Z_{tarrif}: cost of kwh in NIS.

As an example:

Saving in Al-Razi school = $E_{PV} \times Z_{tarrif}$

= 11,243.6 kwh/year ×0.65 NIS/kwh

= 7308.34 NIS/year

So, saving in the buildings is shown in table 3.4:

Table (3.4): saving in public buildings

Building	E_{PV} kwh/year	Z_{tarrif} NIS/kwh	Saving NIS/year
AL- Razi school	11,243.6	0.65	7308.34
Khawlah Bint Al-Azwar school	11,563	0.65	7515.95
Baqa alsharqia municipality	8,521.9	0.65	5539.235
Qabalan municipality	8,131.6	0.65	5285.54
Hamdi mango municipality	29,292.8	0.65	19040.32

Now, the S.P.B.P in each building will be calculated using equation (3.1) as shown in table 3.5:

Table (3.5): SPBP in each selected public buildings

Public building	Investment $	Investment NIS (1$=3.77 NIS)	Saving (NIS/year)	SPBP (year)
AL- Razi school	15,730.5 $	59,304	7,308.34	8.1
Khawlah Bint Al-Azwar school	15,730.5 $	59,304	7515.95	7.89
Baqa alsharqia municipality	10,000$	37,700	5,539.235	6.8
Qabalan municipality	10,000$	37,700	5,285.54	7.1
Hamdi mango municipality	40,000$	150,800	19,040.32	7.92

From previous results in table 3.5 we can see that S.P.B.P ranges from six to Eight years which are suitable periods to recover the investment cost.

3.2 The life cycle cost

In this section life cycle cost will be defined and calculated to the systems in the selected buildings.

Life cycle cost is the sum of all present worth (PW) of all components that consists of initial costs, running (maintenance and operating costs) and salvage costs.

1- Initial cost of on-grid PV system

   This cost includes the costs of the components (which include PV panels, inverter, wires, meters and other components) and the installation of the system. These costs depend on the size and the kind of the system.

   So, the initial cost is the overall sum of all previous costs, which can be calculated using equation (3.2) as explained before in section 3.1:

   $$\text{Initial cost} = \sum \text{components costs} + \text{installation} \qquad (3.2)$$

   - Initial cost of PV panels:

     This cost depends on the size and kind of the panel, the size of the panels is chosen according to the peak watt at STC (standard conditions).

   - Initial cost of on-grid PV inverter

It is available in different sizes, types and costs. The size of the inverter is depending on many parameters including efficiency, capacity, protection and other parameters.

- Other initial costs

  There are many other initial costs which are different from system to another depending on the needs of the project, the size of the system and if the project is for public or private use. These costs may include shipping, accessories, wires and other costs.

2- Operation and maintenance costs of on-grid PV system

   Which are called running cost. These costs are calculated after the installation of the system to run the project for certain number of years. They are often found by multiplying initial cost by 2%.

3- Salvage cost of on-grid PV system

   This cost is considered as the value of the project at the end of its life cycle- Life cycle of the PV system is approximately 25 years- Which is around 15% of initial cost of on-grid PV system. [26]

After determining all previous costs, we can draw cash flow for the project. Figure (3.1) shows the cash flow of the project, which represents initial, running and salvage costs of the project:

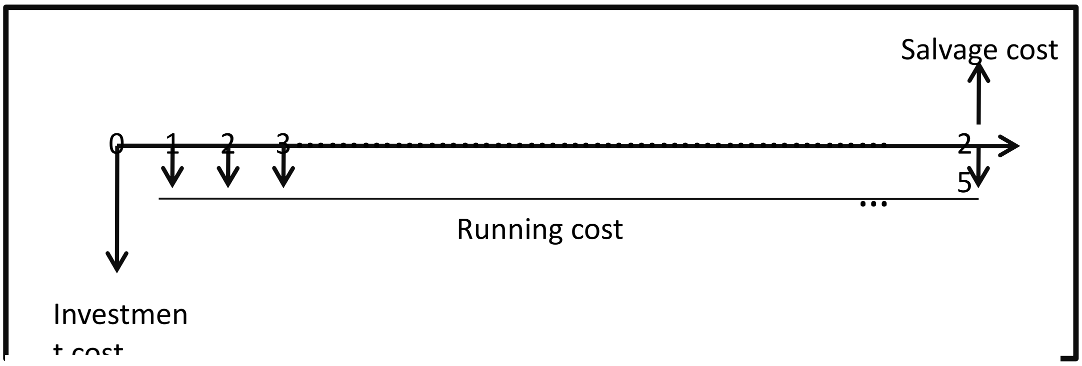

Fig (3.1): Cash flow of the project

To be able to calculate the annual series (AW) of cash flow in figure (3.1) we start with converting all costs to present worth (PW) using equation (3.5):

The life cycle cost of on-grid PV system= initial cost + present worth of running cost - present worth of salvage value. (3.5)

The life cycle cost of on-grid PV system= initial cost + running cost × (P/A, i, n) - salvage value× (P/F, i, n)

- A (P/A, i, n): uniform series present worth factor.
- A : starts at the end of the first year and continues n years.
- (P/A) can be found using the equation (3.6):

  $P= A[((1+i)^n-1)/i(1+i)^n]$, $i\neq0$ (3.6)
- i= 10%
- n= 25 years
- F (P/F, i, n):the single- payment present- worth factor.
- (F/A) can be found using the equation (3.7):

  $P= F [1/(1+i)^n]$ (3.7)

  Then we will find the annual worth of the cash flow using equation (3.8):

  AW = PW (A/P, i, n) (3.8)

We can use tables of factors in order to simplify the calculations- appendix A.

Then the energy unit price calculated from equation (3.9):

$$(NIS/KWh) = \frac{AW}{Total yearly KWh produced} \quad (3.9)$$

As a case study, this economical study will be applied on the previously chosen public buildings- 2 schools and 3 municipalities.

Starting with the public schools, both Al-Razi and Khawlah Bint Al-Azwar have the same PV system size, and approximately the same conditions, so the same calculations will be applied on both.

1- Initial cost

Initial cost was calculated in previous section 3.1 in table (3.3)

2- Operation and maintenance costs

As we mentioned before it equals 2% of initial cost.

Operation and maintenance costs= 2% ×15,730.5 $=

314.61 $

3- Salvage cost

It equals approximately 15% of initial cost.

So,

Salvage cost = 15% × 15,730.5$=

2,359.575 $

So the cash flow of this system can be drawn as seen in figure (3.2):

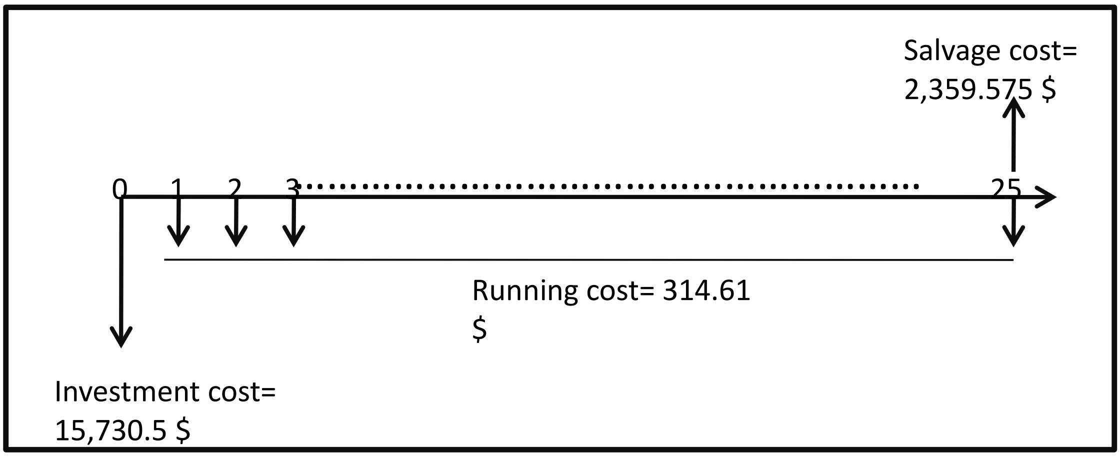

Fig (3.2): Cash flow of public schools

Calculation of present worth:

PW = initial cost + present worth of running cost - present worth of salvage value

PW = initial cost + running cost × (P/A, i, n) - salvage value× (P/F, i, n)

PW = 15,730.5 + 314.61 × (P/A, 10%, 25) - 2,359.575 × (P/F, 10%, 25)

The factors in the above equation is taken from appendix A:

PW = 15,730.5 + 314.61 × 9.0770 - 2,359.575 × 0.0923

PW = 18,368.43 $

AW = PW (A/P, i, n) = PW (A/P, 10%, 25)

From appendix D, the term (A/P, 10%, 25) equals to 0.11017, then:

AW = 18,368.43 × 0.11017= 2,023.65 $

Total energy yield from public chosen schools for the first year is as follows:

Table (3.6): Total energy yield from public chosen schools for the first year

School	Energy yield from PV system E_{PV} (kwh)
AL- Razi school	11,243.60
Khawlah Bint Al-Azwar school	11,563.00

Finally the cost of 1 KWh from the on-grid PV system in public schools calculated by equation (3.9) is as follows in table (3.7):

Table (3.7): Cost of 1 KWh from the on-grid PV system in public schools

School	Cost of 1 KWh ($)
AL- Razi school	0.179982
Khawlah Bint Al-Azwar school	0.175011

Since 1$= 3.77 NIS, so:

Table (3. 8): The cost(in NIS) of 1 KWh from the on-grid PV system in public schools

School	Cost of 1 KWh (NIS)
AL- Razi school	0.678532
Khawlah Bint Al-Azwar school	0.659791

Now, the same calculations will be made on the selected municipalities: Qabalan municipality, Hamdi Mango municipality and Baqa alsharqia municipality. Both Baqa alsharqia and Qabalan municipalities have the same size which is 5KWp system and Hamdi Mango municipal size is 20 KWp.

1- Initial cost

Initial cost was calculated in previous section 3.1 in table (3.3)

2- Operation and maintenance costs calculated as mentioned before Shown in table 3.9

Table (3.9): Operation and maintenance cost in each selected municipality

Municipality	Initial cost $	Operation and maintenance costs $
Baqa alsharqia and Qabalan municipalities	10,000	2% × 10,000=200
Hamdi mango municipality	40,000	2% × 40,000=800

3- Salvage cost

It equals approximately 15% of initial cost.

So,

Salvage cost = 15% × initial cost,

Shown in table 3.10

Table (3.10): Salvage cost in each municipality

Municipality	Initial cost $	Salvage cost $
Baqa alsharqia and Qabalan municipalities	10,000	1,500
Hamdi mango municipality	40,000	6,000

So the cash flow of these systems can be drawn as seen in figure (3.3) and figure (3.4)

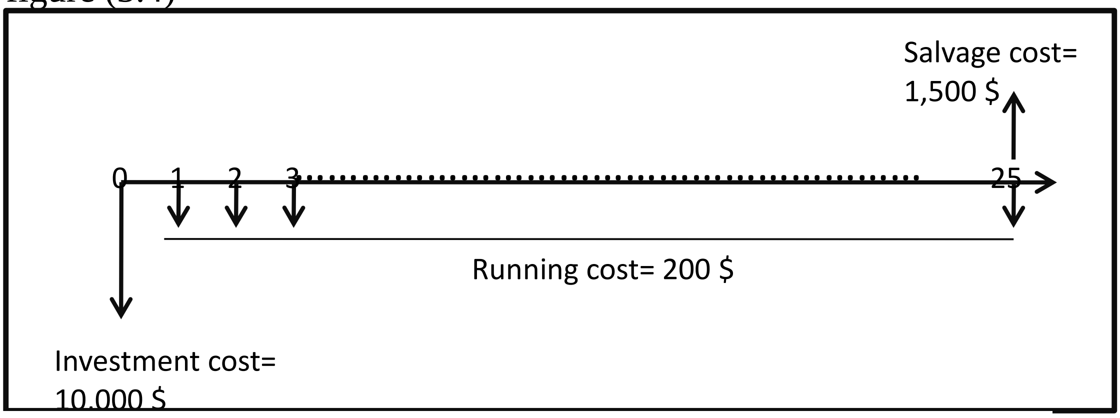

Fig (3.3): Cash flow of Baqa alsharqia and Qabalan Municipality

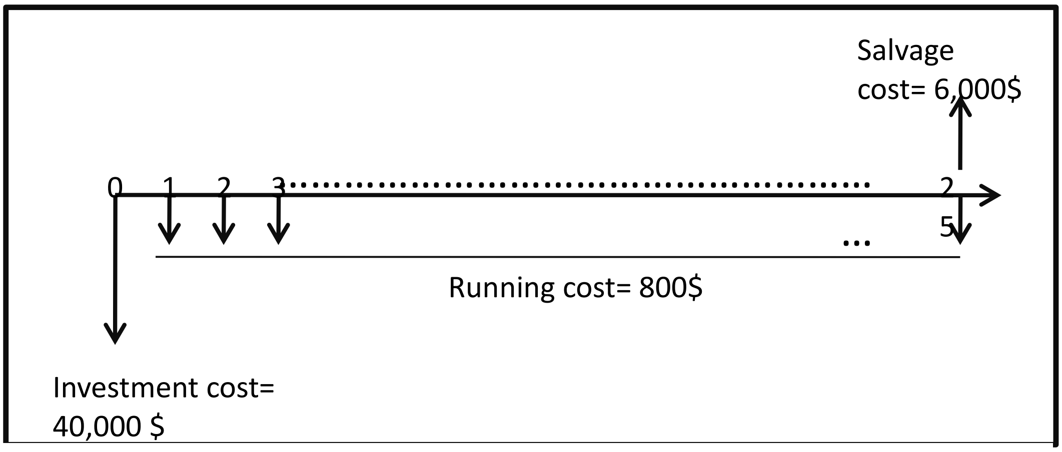

Fig (3.4): Cash flow of Hamdi Mango Municipality

Calculation of present worth, using above equations:

The results are shown in table (3.11)

Table (3.11): Present worth of PV systems in selected public municipalities

Municipality	PW ($)
Baqa alsharqia and Qabalan municipalities	11,676.95 $
Hamdi mango municipality	46,707.8 $

The annual worth will be calculated:

AW (Baqa alsharqia and Qabalan municipalities) = 1,286.4$

AW (Hamdi mango municipality) = 5,145.8$

Total energy yield from public chosen municipalities for the first year are as in table 3.12:

Table (3.12): Total energy yield from public chosen municipalities for the first year

Municipality	Energy yield from PV system E_{PV} (kwh)
Baqa alsharqia	8,521.90
Qabalan	8,131.60
Hamdi mango	29,292.80

Finally the cost of 1 KWh from the on-grid PV system in public municipalities is as in table 3.13:

Table (3.13): The cost($) of 1 KWh from the on-grid PV system in public municipalities

Municipality	Cost of 1 KWh ($/Kwh)
Baqa alsharqia	0.150952
Qabalan	0.158198
Hamdi mango	0.175668

Since 1$= 3.77 NIS, so:

Table (3.14): The cost(NIS) of 1 KWh from the on-grid PV system in public municipalities

Municipality	Cost of 1 KWh (NIS/Kwh)
Baqa alsharqia	0.56909
Qabalan	0.596405
Hamdi mango	0.662267

We can see that cost of kwh in both schools and Hamdi Mango is more than 0.65, which refers to high investment cost, since the elements were chosen with best criteria . So if the same study is made on the same buildings with different elements the cost will be lower.

And we have to take into account that the investment cost wasn't paid by the schools or municipalities , it was paid from external donor.

3.3 Comparison between the consumption of electricity from the network before and after the installation of PV system

In this section, we will make a comparison between the consumption from the network in public buildings before the installation of on-grid PV system and after it. This comparison will be presented through the bills before and after operating the systems.

The total bill of consumption from network= E × Z (3.10)

Where :

E: Energy consumed from network

Z: The cost of kwh in NIS

And after installing the PV system " using net metering policy" :

The total bill of consumption from network= (E × Z) - (EPV ×Z) (3.11)

Where :

E: Energy consumed from network (taken from bills)

E_{PV}: Energy from PV

Z: The cost of kwh in NIS

As an example, we will calculate the bill of Al-Razi school before and after installing On-Grid PV system and compare between the results.

Before installing the PV system:

The total bill of consumption from network = 35,497 kwh/year × 0.65 NIS/kwh

= 23,073.05 NIS / year

After installing the PV system =23,073.05 NIS / year - 7,308.34 NIS/ year

=15,764.7 NIS/ year

Then we will calculate the percentage of reduction

percentage of reduction= (Bill before- Bill after) / Bill before x100% (3.12)

As an example, in Al-Razi school:

percentage of reduction = (23073.05 - 15764.71) / 23073.05 x100%

= 31.7 %

Figure (3.5) shows the difference in bills before and after using On-Grid PV cells

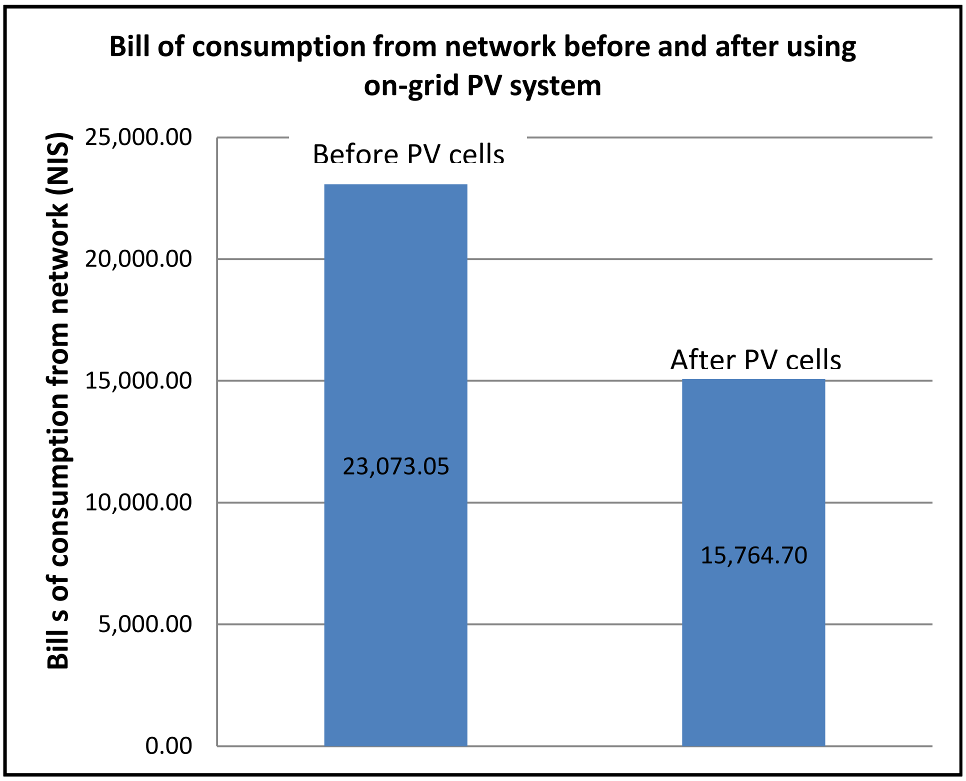

Fig (3.5): Comparison between bills before and after using On-Grid PV cells in Al Razi
Al Razi school

In the same way the other bills were calculated as shown in table (3.15)

Table (3.15): Bills in selected public buildings before and after installing On-Grid PV systems and the percentage of reduction in the bills.

	Public building	Bill before the installation (NIS)	Bill after the installation (NIS)	Percentage of reduction %
1	AL-Razi school	23,073.05	15,764.71	31.7
2	Khawlah Bint Al-Azwar school	23,728.49	16,212.54	31.7
3	Baqa alsharqia municipality	11,050	5,510.77	50.1
4	Qabalan municipality	9,100	3,814.46	58.1

5	Hamdi mango municipality	85,150	66,109.68	22.4

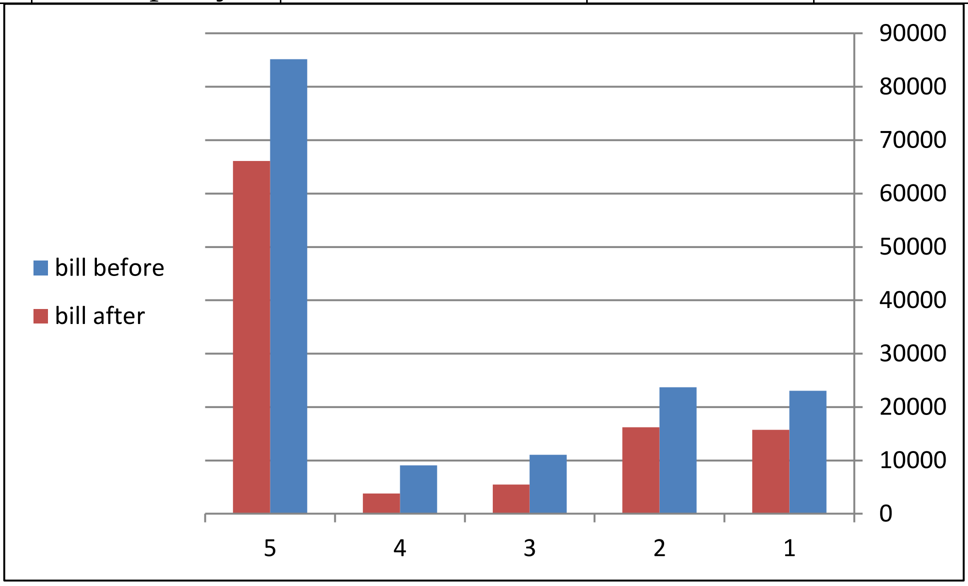

Fig (3.6): Difference in consumption in public buildings before and after installing PV systems

From figure 3.6 we can see that the consumption from network after installing On-Grid PV systems is reduced in all the public buildings. Also we can see that the percentage of reduction in consumption from network ranges from 22 to 58 %, of course it depends on the capacity of PV system installation.

3.4 Feasibility study of using On-Grid PV systems in public buildings by using net present value

In this section a visibility study will be made on the selected public schools and municipalities by calculating the net present value - present worth (PW) for each On-Grid PV system in these buildings. If PW > 0 then the project is feasible, but if PW<0 the project is not feasible. This study will be made to give a vision for future similar projects.

To calculate the net present value PW we have to find all the costs in present time, these costs are:

1- Initial cost of on-grid PV system
2- Operation and maintenance costs of on-grid PV system
3- Saving
4- Salvage cost of on-grid PV system

Cash flow can be drawn as seen in figure 3.7

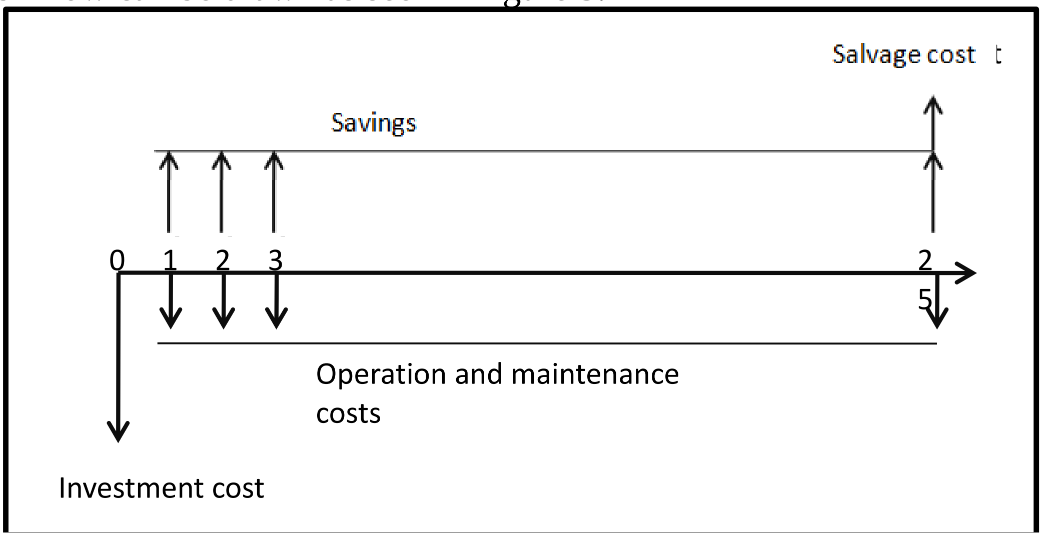

Fig (3.7): Cash flow of On-Grid PV system in public building

Initial, operation and maintenance, saving and salvage costs were calculated in sections 3.1 and 3.2.

The next table 3.16 shows all these costs and savings.

Table 3.16): The Costs and Savings of ON-Grid PV systems in selected public buildings

Public building	Initial cost ($)	Running cost ($)	Saving ($)	Salvage cost ($)
AL- Razi school	15,730.5	314.61	1938.552	2,359.575
Khawlah Bint Al-Azwar school	15,730.5	314.61	1993.621	2,359.575
Baqa alsharqia municipality	10,000	200	1469.293	1,500
Qabalan municipality	10,000	200	1402	1,500
Hamdi mango municipality	40.000	800	5050.483	6,000

The net metering "PW" for each system in chosen public building will be calculated using the following equation :

PW= - initial cost –present worth of running cost + present worth of saving + present worth of salvage cost (3.13)

PW = -initial cost - running cost × (P/A, i, n) + saving × (P/A, i, n) + salvage value × (P/F, i, n)

As an example PW will be calculate for Al-Razi school

PW = - 15,730.5 - 314.61 × (P/A, 10%, 25) +1,938.552× (P/A, 10%, 25) + 2,359.575 × (P/F, 10%, 25)

PW = - 15,730.5 - 314.61 × 9.0770 + 1,938.552× 9.0770 + 2,359.575 × 0.0923

PW= -772.19 $

The same calculations were made on the other systems and we had the results shown in table (3.17):

Table (3.17): Net present value "PW" of systems in selected public buildings

Building	PW ($)
AL- Razi school	-772.19
Khawlah Bint Al-Azwar school	-272.328
Baqa alsharqia municipality	1659.823
Qabalan municipality	1049.004
Hamdi mango municipality	39095.43

Since PW in each of the public municipalities is >0, then ON-Grid PV system in each of the public municipalities is feasible.

But we can see that PW in each of the public schools is < 0, this is due to additional cost of PV components in these systems.

Chapter Four

Environmental impacts of using On-Grid PV system in public buildings

The purpose of this chapter is to show the differences in CO_2 emissions and other effects on environment between using solar energy and coal power plant and using only coal power plant to cover the consumption in selected public buildings.

In Palestine, most of the consumption of electricity is covered by Israeli's electrical generation stations most of them runs by coal and natural gas [27], whereas few consumptions amounts are covered by Jordanian's and Egyptian's electrical generation stations.

4.1 Impacts of conventional power plants

Laws have restricted the usage of power plants to protect environment and humans. There are many environmental impacts on burning fossil fuels and coal. We will be explaining each as follows:

1- Air emissions

Carbon dioxide, sulfur dioxide, nitrogen oxides, and mercury compounds are released when burning coal. So, for the huge amount of emissions released we need control devices to reduce these emissions. additional emissions are cause while mining, cleaning, and transporting coal to the power plant generate

2- Water resource use

to remove impurities from coal at the mine and burning process in power plants, we use large quantities of water. We also use water for producing steam and for cooling. When water is withdrawn from a lake or river, fish and other aquatic life can be affected, as well as animals and people who depend on these sources.

3- Water discharge

Water used in the power plant boiler and cooling system becomes polluted. If the water used in the power plant is discharged to a lake or river, the pollutants in the water can harm fish and plants. Further, if the coal stored in piles outside the power plant is exposed to rain, the water that runs off these piles can flush heavy metals from the coal, such as arsenic and lead, into nearby bodies of water. Coal mining can contribute in contaminating bodies of water with heavy metals when the water used to clean the coal is discharged back into the environment. This discharge usually requires a permit and is monitored.

4- Solid waste generation

Coal combustion residues account for 90% of all fossil fuel combustion wastes produced, only about 20% of these wastes are utilized! The major potential impacts of ash disposal on terrestrial ecosystems include: leaching of potentially toxic substances into soils and groundwater; reductions in plant establishment and growth due primarily to adverse chemical characteristics of the ash; changes in the elemental composition of vegetation growing on the ash; and increased mobility and accumulation of potentially toxic elements throughout the food chain. Ash disposal in landfills and settling ponds can influence adjacent aquatic ecosystems directly, through inputs of ash basin effluent and surface runoff, and indirectly, through seepage and groundwater contamination.

Major impacts are generally associated with changes in water chemistry, including changes in pH and concentrations of potentially toxic elements. Using ash as a soil amendment can improve soil texture and water-holding capacity, increase soil pH, and enhance soil fertility. [28]

5- Land resource use

various pollutants from the coal may cause the soil at coal power plant sites to become contaminated and take a long time to recover, even after the power plant closes down. Coal mining and processing also have environmental impacts on land. Surface mining disturbs larger areas than underground mining.[29]

4.2 Environmental impacts of using PV solar cells

Producing electricity using solar cells have environmental impacts. We will explain them thoroughly in the following points:

1-Water use

water is not used in generating electricity, but it's important in all manufacturing processes of PV cells and in cleaning. the amount of water used is very small compared with the amount used for producing electricity from coal power plant, so we can neglect it. But what we must take into consideration is that the water used by some solar thermal systems can be reused.

2-Hazardous materials

The PV cell manufacturing process includes a number of hazardous materials, most of which are used to clean and purify the semiconductor surface. These chemicals, similar to those used in the general semiconductor industry, include hydrochloric acid, sulfuric acid, nitric acid, hydrogen fluoride, 1,1,1-trichloroethane, and acetone. the type of cell, the amount of cleaning that is needed, and the size of silicon wafer are what determines the amount and type of chemicals used. Health risks may face workers associated with inhaling silicon dust. Thus, PV manufactures must follow U.S. laws to ensure that workers are not harmed by exposure to these chemicals and that manufacturing waste products are disposed of properly.

Thin-film PV cells contain a number of more toxic materials than those used in traditional silicon photovoltaic cells, including gallium arsenide, copper-indium-gallium-dieseline, and cadmium-telluride. If not handled and disposed of properly, these materials could pose serious environmental or public health threats. However, manufacturers have a strong financial incentive to ensure that these highly valuable and often rare materials are recycled rather than thrown away.[30]

Since Photovoltaic panels contains hazardous materials there is the probability for environmental contamination if they were damaged or improperly disposed upon decommissioning. Concentrating solar power systems may employ materials such as oils or molten salts, hydraulic fluids, coolants, and lubricants, that may be hazardous and present spill risks. So we need proper planning and good maintenance practices to minimize impacts from hazardous materials. [31]

3-life cycle global warming emissions

Generating electricity from solar energy doesn't have global warming emissions, but there are other emissions associated with other stages of the solar life-cycle, including manufacturing, materials transportation, installation, maintenance, decommissioning and dismantlement.

there are many estimates for the average of co2 emissions, but the average is (0.6- 2lbs of CO_2 E/kwh) and coal(1.4-3. 6lbs of CO_2E/Kwh).[30]

4-Climate change

Climate change has been considered as a natural threat to human development exceeds a natural problem into a crisis. so, there has been a growing international awareness towards it.

Solar power is described as a zero emissions form of energy, and green house gases from it are negligible. However, as has been mentioned before, we have gases emitted at other stages.

5-Land use

On-grid PV system size ranges from a small distributed rooftop PV arrays to large utility-scale PV and CSP projects,which plays a great role in the level of environmental impacts

Depending on their location, larger utility-scale solar facilities can raise concerns about land degradation and habitat loss. The total land used when installing the on-grid PV system depends on the technology, the topography of the site and the intensity of the solar resource

Unlike wind facilities, there is less opportunity for sharing land with agricultural uses along with solar projects, but we should take into account that land impacts from utility-scale solar systems can be minimized through sitting them at lower-quality locations such as brown fields, abandoned mining land, or existing transportation and transmission corridors. Smaller scale solar PV arrays, which can be put on roof top takes negligible area, so we don't need special land to produce electricity as power plants. [30][31]

6-Visual

There are different perspectives towards solar panels. some are positive. others are negative. it’s a largely a matter of opinion..[31]

4.3 Environmental impacts of using PV solar cells in selected public buildings

The production of CO_2 emissions will be calculated before and after installing On-Grid PV systems in public buildings. Production of CO_2 emissions before installing On-Grid PV systems in public buildings are from burning coal and natural gas in power plants, since electricity in west bank consumes electricity from Israeli coal and gas power plants. Production of CO_2 emissions after installing On-Grid PV systems in public buildings are from both power plants and solar cells. [27]

Starting with calculations of the expected amounts of CO_2 emissions reduction. As an example,

For Al-Razi school reduction of CO_2 emissions expected is calculated as shown in equation (4.1):

$$\text{Reduction in } CO_2 \text{ emissions (Kg)} = 0.7 \text{ kg/kwh} \times E_{PV} \text{ kwh} \quad (4.1)$$

$$\text{Reduction in } CO_2 \text{ emissions (Kg)} = 0.7 \text{ kg/kwh} \times 11{,}243.60 \text{ kwh}$$

Reduction in CO_2 emissions (Kg) = 7,870.52 kg

The same calculations was made for the other buildings and the results were as shown in table 4.1:

Table (4.1): Expected reduction in CO_2 emissions in selected buildings

Public building	E_{PV} kwh	Reduction in CO_2 emissions kg
AL- Razi school	11,243.60	7,870.52
Khawlah Bint Al-Azwar school	11,563.00	8,094.10
Baqa alsharqia municipality	8,521.90	5,965.33
Qabalan municipality	8,131.60	5,692.12
Hamdi mango municipality	29,292.80	20,504.96

The total amount of reduction in CO_2 emissions will be 48,127.03 kg.

Other environmental impacts of PV power systems on environment are:

1) Water use, we can neglect this amount since we don't manufacture and the need for water is only for maintenance and cleaning.

2) Hazardous materials, no manufacturing so no hazardous material released, but if they were damaged or improperly disposed upon decommissioning.

3) Land use, no land use because it's installed on roof top.

4) Climate change, emissions form of energy, and green house gases from it are negligible, so it has no negative effect on climate change.

The results can be summarized as seen in table 4.2:

Table (4.2): The environmental impacts of using coal power plant vs PV system

	Coal Power Plant	Solar Cells
Emissions	More	Less
Water	Higher	Lower
Solid waste	Higher and more toxic	Lower
Land use	Wider	No use
Climate change	High effect	No effect

Chapter Five

Social impacts of using On-Grid PV system in public buildings

In this chapter we will be talking about social impacts of using On-Grid PV system in public buildings and see the awareness about like these projects.

Solar energy plays big role in different sectors in the society. One of the important sectors is the social one, since it affects it in several ways, which are:

1- Job Creation

When cities or companies decide to build and operate solar energy facilities, the projects often help to create numerous jobs. For instance, workers are needed to plan the project, develop and implement the project, build the solar energy plant, manage the equipment and operate the facility. Thus, many new jobs can be fulfilled by workers as a result of a city or state using solar energy facilities to generate electricity for the area, and this would in turn help decrease the unemployment rate of the given area.

2- Economics

With more people able to find employment as a result of the increased number of jobs created by the development and operation of solar energy panels, more people would have money to contribute the the nation's economy.

3- Health

Generating energy from solar panels emits very little pollution into the air, and thus solar energy is a much cleaner source of energy than the burning of fossil fuels. Cities or areas that decide to use solar energy to power the buildings would thus enjoy a cleaner quality of air in the region, which in turn can make the citizens and workers in the area more healthy. [32]

This technology will be affected by the culture of the population and their awareness for like these projects. Since culture and awareness of people plays big role in the spread and use of solar cells.

To study the public opinion and the interests of people towards projects concerned with saving energy, we have carried out a quick survey on buildings where On-Grid PV system is implemented through asking employees different questions. Through the given questions, we wanted to know whether these buildings benefited from On-Grid PV systems, and we also wanted to measure people's awareness of renewable energy importance.

Our first question was concerned with how much did the solar cells affected public and governmental buildings, whether there were benefits behind implementing such systems on these buildings and whether there were differences on the electricity bills before and after installing such systems.

the results were as figure 5.1 shows:

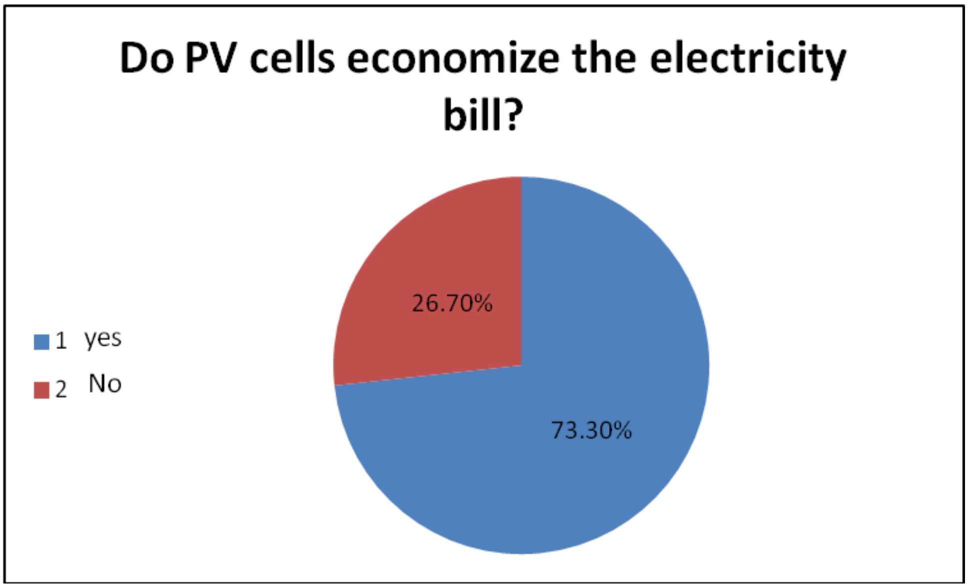

Fig (5.1): The percentage of people agreeing on the economization of on-grid PV system.

We found out that the general opinion of these employees in those buildings is that On-Grid PV cells do affect the bills effectively. the percentage of those employees was 73.7% whereas 26.7% see that there is no difference on the bills. As we can see, 73.7% is such a great percentage that shows how well-aware they are of their economic feasibility.

Since the project has been implemented on schools and since students play a major role in saving energy we see that it's a must to get the students involved and to spread the awareness among them. So, our next question was about whether these schools teach their students about renewable energy. The results were as figure 5.2 shows:

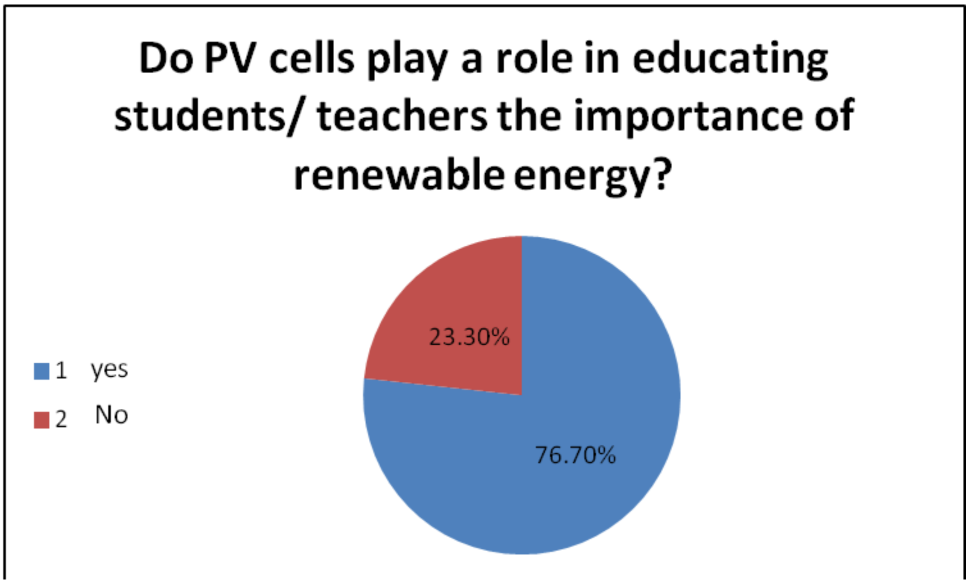

Fig (5.2): The percentage of people agreeing on the role of on-grid PV system in educating students and teachers the importance of renewable energy

With 63.3% yes responses and 36.7% no responses, we conclude that we need to raise our students' awareness of the renewable energy importance. More efforts should be invested in our students so that they could see the benefits of saving energy.

After installing these systems, We wanted to see whether the employees think that implementing such systems plays a factor in achieving property and development. The results were as figure 5.3 shows:

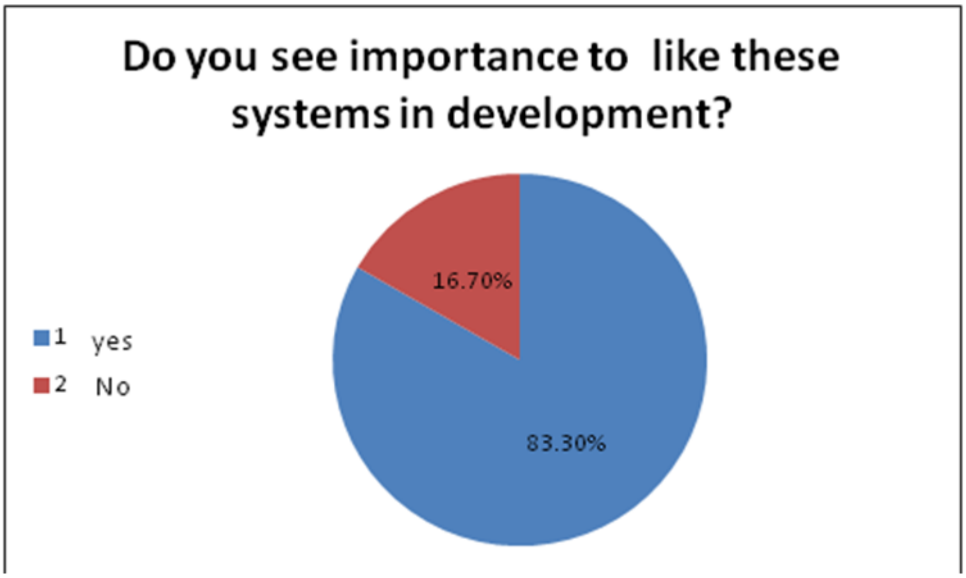

Fig (5.3): The percentage of people seeing that installing on-grid PV system plays a role in the development.

83.3% agreed upon the fact that installing such systems do play a great factor in achieving prosperity. Whereas, 16.7% denied that fact. We can conclude that for a country to accomplish its own development and prosperity, it must take into consideration saving energy and expanding the use of renewable energy resources instead of relying on other traditional resources. We also wanted to know whether these employees see that it’s important to install such systems not only economically, but also environmentally and socially. The results were satisfying. 76.7% affirmed that it is important to implement such systems. only 23.3% disagreed. The results were as figure 5.4 shows:

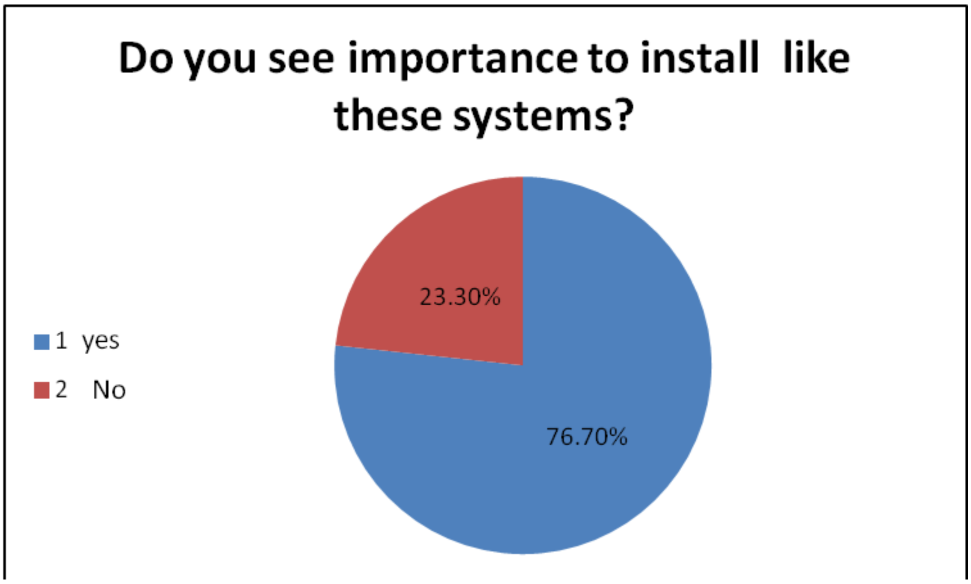

Fig (5.4): Percentage of people agreeing on the importance of on-grid system

Saving the environment and its volatile resources is our aspiration, so we wanted to know if installing such system helped in grabbing the attention towards the environment and its resources. We asked the employees and the results were not as they were supposed to be. only 46.7% answered affirmatively. 53.3% disapproved. As we can see, we need to spread the awareness and do our best to teach people about the importance of such systems in saving environment and its resources. The results were as figure 5.5 shows:

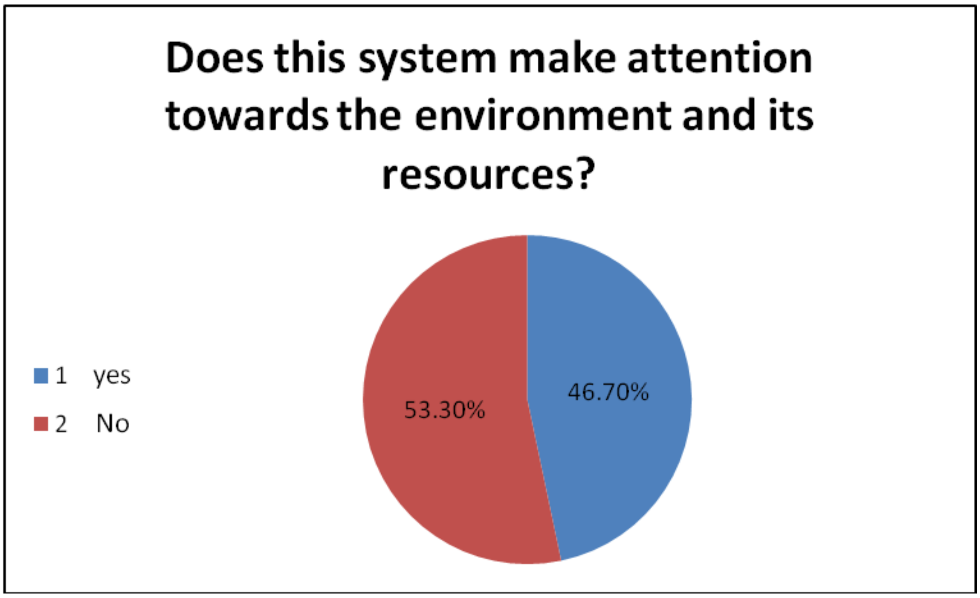

Fig (5.5): The percentage of people agreeing on whether the system grabs attention towards the environment and its resources

The reason behind the dissatisfying result maybe because of the limited number of buildings that installed such systems. therefore, little information about economical feasibility was spread. So we asked whether installing such systems encouraged others to install such systems. The results were as predict. Because of high initial costs- all the costs are compensated after the payback period. 53.3% disapproved .

Students are generally curious about anything they see and they don't know, we wanted to know whether the existence of P.V system has made the students curios enough to learn and search about the renewable energy, so we asked them whether the P.V cells play a role in educating students about the importance of renewable energy. 76.7% expected that the existence of such system affected students and arouse their enthusiasm about learning more how to conserve energy. 23.3% said that it had no effect. The results were as figure 5.6 shows:

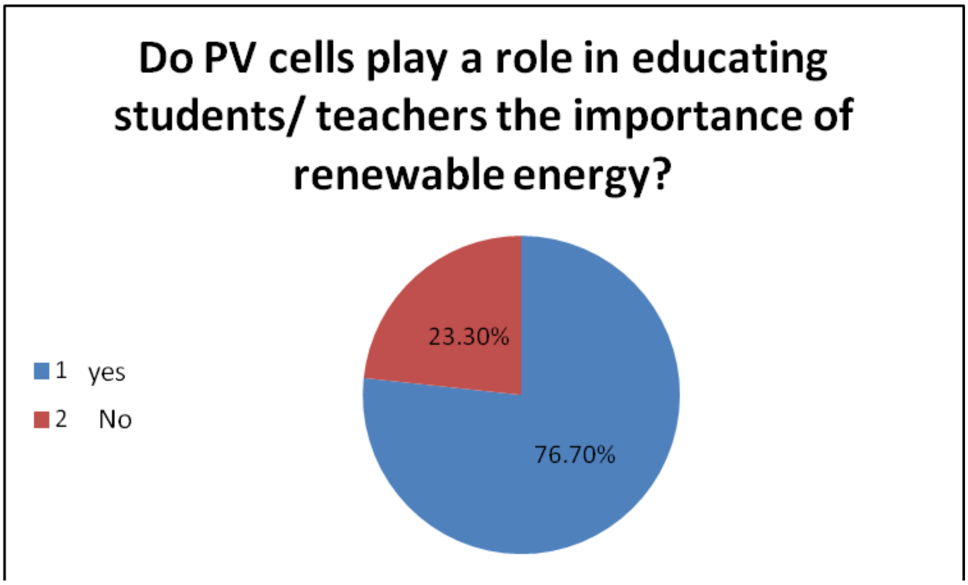

Fig (5.6): The percentage of people seeing that On-grid PV system plays many roles in educating students about energy.

We also wanted to see whether people see the importance of expanding the use of such systems. 80% said it's a necessity for the sake of saving the money, earth and its resources. 20% said there is no need to do so. The results were as figure 5.7 shows:

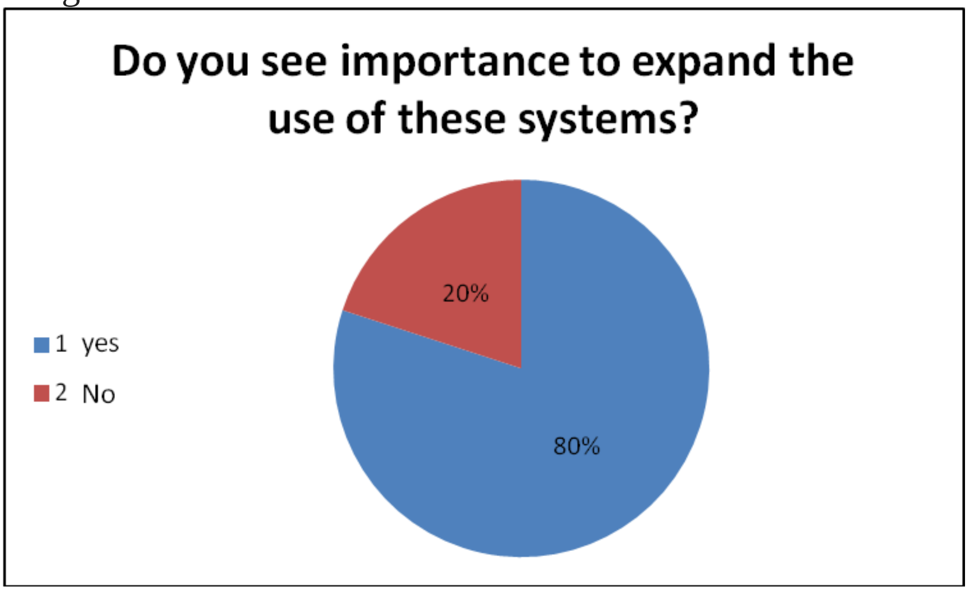

Fig (5.7): The percentage of people seeing the importance of using on-grid PV system

We also asked the employees if you can afford installing such systems and have all the requirements needed, would you install it or not. 63.3% saw that they would definitely do so. 36.7% said they wouldn't because there are many things more important in their point of view. The results were as figure 5.8 shows:

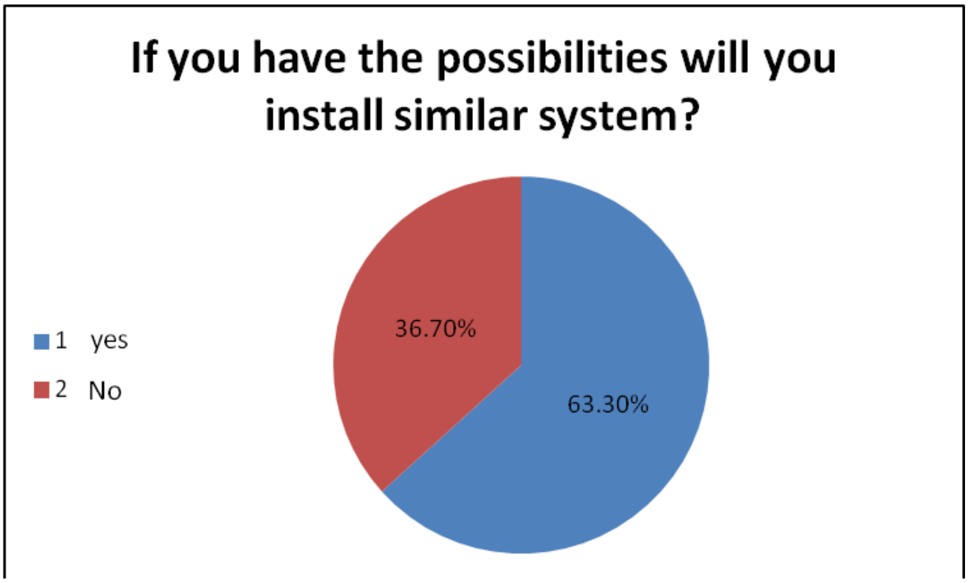

Fig (5.8): The percentage of people that would install such systems if they have the possibilities to do so

Through our public opinion survey we can conclude the advantages and disadvantages of P.V system.

The advantages are as follows:

1. PV system saves money since it reduces the bills of electricity
2. PV system plays role in educating students the importance of it in protecting the environment from pollution
3. PV system reduces the consumption of energy

The disadvantages of these system are

1. The investment cost is very high compared to the financial affordability of people.
2. The need of empty spaces which are not shaded
3. When electricity is off the system also turns off.

Chapter Six
Conclusions and future scope of work

6.1 Conclusion

Our purpose for this thesis was to study the feasibility of installing on-grid PV system on public buildings and its social, environmental and economic influences. Through our work, we have reached to a clear conclusion for how much effective and beneficial these projects are in the above mentioned dimensions.

From this research it's obvious that installing on-grid PV system in public buildings affect social, economic and environmental aspects of life in a society.

Economically, we found out that the investment cost can be paid back between 6-8 years and that refers to the size and the energy production of the system. We studied the feasibility of the projects and found out that they are economically beneficial. the difference on the bills before and after installing the system can be easily observed. We also found out that the percentage of reduction in the bills ranges from (22-58) %.

Concerning the social influences, we figured out that the existence of such systems raised the awareness of students of the importance of renewable energy band its positive impacts on the environment. Moreover, people in the chosen buildings realized the noticeable impacts of such systems in the process of country development. As a result, such systems raises the enthusiasm of saving energy and using more clean energy.

6.1 Future scope of work

After our deep work and calculations, we have reached to many conclusions. We have some recommendations concerning what should be done.

1. Through surveying people's opinion, we found out that the awareness of renewable energy and its importance has to be increased. So, efforts must be put towards working on raising people's awareness.
2. Encouraging the investment in such projects. Not only economic, also environmentally impacts will be gained by increasing the number of such projects in the society.

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Appendices

Appendix A

Table of interest at i=10%

10%	Compound Interest Factors								10%
	Single Payment		Uniform Payment Series				Arithmetic Gradient		
	Compound Amount Factor Find F Given P	Present Worth Factor Find P Given F	Sinking Fund Factor Find A Given F	Capital Recovery Factor Find A Given P	Compound Amount Factor Find F Given A	Present Worth Factor Find P Given A	Gradient Uniform Series Find A Given G	Gradient Present Worth Find P Given G	
n	F/P	P/F	A/F	A/P	F/A	P/A	A/G	P/G	n
1	1.100	.9091	1.0000	1.1000	1.000	0.909	0	0	1
2	1.210	.8264	.4762	.5762	2.100	1.736	0.476	0.826	2
3	1.331	.7513	.3021	.4021	3.310	2.487	0.937	2.329	3
4	1.464	.6830	.2155	.3155	4.641	3.170	1.381	4.378	4
5	1.611	.6209	.1638	.2638	6.105	3.791	1.810	6.862	5
6	1.772	.5645	.1296	.2296	7.716	4.355	2.224	9.684	6
7	1.949	.5132	.1054	.2054	9.487	4.868	2.622	12.763	7
8	2.144	.4665	.0874	.1874	11.436	5.335	3.004	16.029	8
9	2.358	.4241	.0736	.1736	13.579	5.759	3.372	19.421	9
10	2.594	.3855	.0627	.1627	15.937	6.145	3.725	22.891	10
11	2.853	.3505	.0540	.1540	18.531	6.495	4.064	26.396	11
12	3.138	.3186	.0468	.1468	21.384	6.814	4.388	29.901	12
13	3.452	.2897	.0408	.1408	24.523	7.103	4.699	33.377	13
14	3.797	.2633	.0357	.1357	27.975	7.367	4.996	36.801	14
15	4.177	.2394	.0315	.1315	31.772	7.606	5.279	40.152	15
16	4.595	.2176	.0278	.1278	35.950	7.824	5.549	43.416	16
17	5.054	.1978	.0247	.1247	40.545	8.022	5.807	46.582	17
18	5.560	.1799	.0219	.1219	45.599	8.201	6.053	49.640	18
19	6.116	.1635	.0195	.1195	51.159	8.365	6.286	52.583	19
20	6.728	.1486	.0175	.1175	57.275	8.514	6.508	55.407	20
21	7.400	.1351	.0156	.1156	64.003	8.649	6.719	58.110	21
22	8.140	.1228	.0140	.1140	71.403	8.772	6.919	60.689	22
23	8.954	.1117	.0126	.1126	79.543	8.883	7.108	63.146	23
24	9.850	.1015	.0113	.1113	88.497	8.985	7.288	65.481	24
25	10.835	.0923	.0102	.1102	98.347	9.077	7.458	67.696	25
26	11.918	.0839	.00916	.1092	109.182	9.161	7.619	69.794	26
27	13.110	.0763	.00826	.1083	121.100	9.237	7.770	71.777	27
28	14.421	.0693	.00745	.1075	134.210	9.307	7.914	73.650	28
29	15.863	.0630	.00673	.1067	148.631	9.370	8.049	75.415	29
30	17.449	.0573	.00608	.1061	164.494	9.427	8.176	77.077	30
31	19.194	.0521	.00550	.1055	181.944	9.479	8.296	78.640	31
32	21.114	.0474	.00497	.1050	201.138	9.526	8.409	80.108	32
33	23.225	.0431	.00450	.1045	222.252	9.569	8.515	81.486	33
34	25.548	.0391	.00407	.1041	245.477	9.609	8.615	82.777	34
35	28.102	.0356	.00369	.1037	271.025	9.644	8.709	83.987	35
40	45.259	.0221	.00226	.1023	442.593	9.779	9.096	88.953	40
45	72.891	.0137	.00139	.1014	718.905	9.863	9.374	92.454	45
50	117.391	.00852	.00086	.1009	1 163.9	9.915	9.570	94.889	50
55	189.059	.00529	.00053	.1005	1 880.6	9.947	9.708	96.562	55
60	304.482	.00328	.00033	.1003	3 034.8	9.967	9.802	97.701	60
65	490.371	.00204	.00020	.1002	4 893.7	9.980	9.867	98.471	65
70	789.748	.00127	.00013	.1001	7 887.5	9.987	9.911	98.987	70
75	1271.9	.00079	.00008	.1001	12 709.0	9.992	9.941	99.332	75
80	2048.4	.00049	.00005	.1000	20 474.0	9.995	9.961	99.561	80
85	3299.0	.00030	.00003	.1000	32 979.7	9.997	9.974	99.712	85
90	5313.0	.00019	.00002	.1000	53 120.3	9.998	9.983	99.812	90
95	8556.7	.00012	.00001	.1000	85 556.9	9.999	9.989	99.877	95
100	13780.6	.00007	.00001	.1000	137 796.3	9.999	9.993	99.920	100

Appendix B

Some school bills

بلـــــــــــدية قلقيليـــــــــة — قسم الكهرباء

فاتورة كهرباء

تلفون : ٠٩-٢٩٤٠٣١٣ * ٠٩-٢٩٤٠٠١٤ / ٠٩-٢٩٤٦٠٢٦ * ٠٩-٢٩٤٠٣١٤

فاكس : ٠٩-٢٩٤٠٤٣٩

رقم المشترك : ١٠٨٥٩٣ رقم الموقع : ٠١٠١٠٠١٣

اسم المشترك وزارة التربية التعليم العالي/ذكور الرازي الاساسية

العنوان :

تاريخ الفترة من : ٢٠١٢/٠٤/٠٢ لغاية : ٢٠١٢/٠٥/٠٣ رقم الفاتورة : ١٨٥٠٣٢

رقم العداد	قراءة العداد حالية	قراءة العداد سابقة	كمية الاستهلاك	سعر الوحدة اغورة	سعر الوحدة شيقل	قيمة الفاتورة اغورة	قيمة الفاتورة شيقل
٣٩٦٧٢٢٤	٨٦٦٨٤	٨٥٢٣٩	١٤٤٥			١٤	٩١٧

تاريخ الفاتورة : ٢٠١٢/٠٥/٠٣

اخر موعد للدفع : ٢٠١٢/٠٥/٢٠

نوع الاستهلاك: حكومي ٣ فاز

معامل التكبير:

	اغورة	شيقل
الحد الادنى	٠٠	٢٣
متفرقات	٠٠	٠
اثمان سابقة	٧٢	٣٩٣٥٣
دفعات مسبقة	٠٠	٠
خصميات	٠٠	٠
المجموع الكلي	٨٦	٤٠٢٩٣

الاخوة المواطنين الكرام ...
هل تعلم ان عقوبة سرقة التيار الكهربائي دفع غرامة بقيمة (٢٥٠٠) شيقل و نشر الاسم على اللوحات الاعلانية العامة ..

بلـــــــــــدية قلقيليـــــــــة — قسم الكهرباء

فاتورة كهرباء

تلفون : ٠٩-٢٩٤٠٣١٣ * ٠٩-٢٩٤٠٠١٤ / ٠٩-٢٩٤٦٠٢٦ * ٠٩-٢٩٤٠٣١٤

فاكس : ٠٩-٢٩٤٠٤٣٩

رقم المشترك : ١٠٨٥٩٣ رقم الموقع : ٠١٠١٠٠١٣

اسم المشترك وزارة التربية التعليم العالي/ذكور الرازي الاساسية

العنوان :

تاريخ الفترة من : ٢٠١٢/٠٥/٠٣ لغاية : ٢٠١٢/٠٦/٠٣ رقم الفاتورة : ١٨٩٩٧٢

رقم العداد	قراءة العداد حالية	قراءة العداد سابقة	كمية الاستهلاك	سعر الوحدة اغورة	سعر الوحدة شيقل	قيمة الفاتورة اغورة	قيمة الفاتورة شيقل
٣٩٦٧٢٢٤	٨٨١٩٠	٨٦٦٨٤	١٥٠٦			٨٦	٩٥٥

تاريخ الفاتورة : ٢٠١٢/٠٦/٠٤

اخر موعد للدفع : ٢٠١٢/٠٦/٢١

نوع الاستهلاك: حكومي ٣ فاز

معامل التكبير:

	اغورة	شيقل
الحد الادنى	٠٠	٢٣
متفرقات	٠٠	٠
اثمان سابقة	٨٦	٤٠٢٩٣
دفعات مسبقة	٠٠	٠
خصميات	٠٠	٠
المجموع الكلي	٧٢	٤١٢٧٢

الاخوة المواطنين الكرام ...
هل تعلم ان عقوبة سرقة التيار الكهربائي دفع غرامة بقيمة (٢٥٠٠) شيقل و نشر الاسم على اللوحات الاعلانية العامة ..

بلـــــــــــدية قلقيليـــــــــة — قسم الكهرباء

فاتورة كهرباء

تلفون : [illegible]

فاكس : [illegible]

رقم المشترك : ١٠٨٥٩٣ رقم الموقع : ٠١٠١٠٠١٣

اسم المشترك وزارة التربية والتعليم العالي/مدرسة ذكور الرازي الأساسية

العنوان :

تاريخ الفترة من : [illegible] لغاية : [illegible] رقم الفاتورة : ١٥٤٣١٣

رقم العداد	قراءة العداد حالية	قراءة العداد سابقة	كمية الاستهلاك	سعر الوحدة اغورة	سعر الوحدة شيقل	قيمة الفاتورة اغورة	قيمة الفاتورة شيقل
٣٩٦٧٢٢٤	٧٨٩٠٢	٧٧٢٦٥	١٦٣٧			٠٠	١٠٣٩

تاريخ الفاتورة : ٢٠١١/١١/٠٢

اخر موعد للدفع : ٢٠١١/١١/١٩

نوع الاستهلاك: حكومي ٣ فاز

تاريخ الدفع :

توقيع الجابي :

	اغورة	شيقل
الحد الادنى		٢٣
متفرقات	٠٠	٠
اثمان سابقة	٦١	٣٤١٥٤
دفعات مسبقة		٠
خصميات	٠٠	٠
المجموع الكلي	٦١	٣٥٢١٦

ندعو الاخوة المواطنين الذين لحقهم ضرر زراعي او تجاري او اي نوع من الاضرار جراء بناء الجدار ضرورة مراجعة البلدية

بلـــــــــدية قلقيلـــــــــة　　　　QALQILIA MUNICIPALITY　　　　**قسم الكهرباء**

فاتورة كهرباء

تلفون : ٠٩-٢٩٤٠٠١٤ - ٠٩-٢٩٤٠٣١٣ * ٠٩-٢٩٤٠٣١٤ - ٠٩-٢٩٤٦٠٢٦

فاكس : ٠٩-٢٩٤٠٤٣٩

رقم المشترك : ١٠٨٥٩٣　　　　رقم الموقع : ٠١٠١٠٠١٣

اسم المشترك　وزارة التربية التعليم العالي/ذكور الرازي الاساسية　　　　اصلية

العنوان :

تاريخ الفترة من : ٢٠١٢/٠٨/٠٤　لغاية : ٢٠١٢/٠٩/٠٤　　رقم الفاتورة : ٢٠٤٧٦٥

رقم العداد	قراءة العداد		كمية الاستهلاك	سعر الوحدة		قيمة الفاتورة	
	حالية	سابقة		اغورة	شيقل	اغورة	شيقل
٣٩٦٧٢٢٤	٩٠٠٣٤	٨٩٤٨٢	٥٥٢			٣٥	٣٥٠

تاريخ الفاتورة : ٢٠١٢/٠٩/٠٤

اخر موعد للدفع : ٢٠١٢/٠٩/٢١

نوع الاستهلاك: حكومي ٣ فاز

معامل التكبير : ١

	اغورة	شيقل
الحد الادنى	٠٠	٢٣
متفرقات	٠٠	٠
اثمان سابقة	٧٦	٤٢١٣٨
دفعات مسبقة	٠٠	٠
خصميات	٠٠	٠
المجموع الكلي	١١	٤٢٥١٢

الاخوة المواطنين الكرام ...
هل تعلم ان عقوبة سرقة التيار الكهربائي دفع غرامة بقيمة (٢٥٠٠) شيقل و نشر الاسم على اللوحات الاعلانية العامة ..

C-١

بلـــــــــدية قلقيلـــــــــة　　　　QALQILIA MUNICIPALITY　　　　**قسم الكهرباء**

فاتورة كهرباء

تلفون : ٠٩-٢٩٤٠٠١٤ - ٠٩-٢٩٤٠٣١٣ * ٠٩-٢٩٤٠٣١٤ - ٠٩-٢٩٤٦٠٢٦

فاكس : ٠٩-٢٩٤٠٤٣٩

رقم المشترك : ١٠٨٥٩٣　　　　رقم الموقع : ٠١٠١٠٠١٣

اسم المشترك　مدرسة الرازي الثانوية ٣\فاز

العنوان :

تاريخ الفترة من : ٢٠١١/١٢/٠٤　لغاية : ٢٠١٢/٠١/٠٣　　رقم الفاتوره . ١٦٥١٤٨

رقم العداد	قراءة العداد		كمية الاستهلاك	سعر الوحدة		قيمة الفاتورة	
	حالية	سابقة		اغورة	شيقل	اغورة	شيقل
٣٩٦٧٢٢٤	٨١٥٨٧	٨٠٠٢٠	١٥٦٧			٥٨	٩٩٤

تاريخ الفاتورة : ٢٠١٢/٠١/٠٤

اخر موعد للدفع : ٢٠١٢/٠١/٢١

نوع الاستهلاك: حكومي ٣ فاز

تاريخ الدفع :

توقيع الجابي :

	اغورة	شيقل
الحد الادنى	٠٠	٢٣
متفرقات	٠٠	٠
اثمان سابقة	٢١	٣٥٩٤٩
دفعات مسبقة	٠٠	٠
خصميات	٠٠	٠
المجموع الكلي	٧٩	٣٦٩٦٦

ندعو الاخوة المواطنين الذين لحقهم ضرر مادي من اقامة جدار الفصل العنصري مراجعة مكتب تسجيل اضرار الجدار في البلدية

بلـــــــــدية قلقيلـــــــــة　　　　QALQILIA MUNICIPALITY　　　　**قسم الكهرباء**

فاتورة كهرباء

تلفون : [illegible]

فاكس : [illegible]

رقم المشترك : ١٠٨٥٩٣　　　　رقم الموقع : ٠١٠١٠٠١٣

اسم المشترك　وزراة التربية والتعليم العالي/مدرسة ذكور الرازي الأساسية

العنوان :

تاريخ الفترة من : ٢٠١٢/٠١/٠٣　لغاية : ٢٠١٢/٠٢/٠٥　　رقم الفاتورة : ١٧٠١٥٢

رقم العداد	قراءة العداد		كمية الاستهلاك	سعر الوحدة		قيمة الفاتورة	
	حالية	سابقة		اغورة	شيقل	اغورة	شيقل
٣٩٦٧٢٢٤	٨٢٣٦١	٨١٥٨٧	٧٧٤			٢٦	٤٩١

تاريخ الفاتورة : ٢٠١٢/٠٢/٠٥

اخر موعد للدفع : ٢٠١٢/٠٢/٢٢

نوع الاستهلاك: حكومي ٣ فاز

تاريخ الدفع :

توقيع الجابي :

	اغورة	شيقل
الحد الادنى	٠٠	٢٣
متفرقات	٠٠	٠
اثمان سابقة	٧٩	٣٦٩٦٦
دفعات مسبقة	٠٠	٠
خصميات	٠٠	٠
المجموع الكلي	٠٥	٣٧٤٨١

ندعو الاخوة المواطنين الذين لحقهم ضرر زراعي او تجاري او اي نوع من الاضرار جراء بناء الجدار ضرورة مراجعة البلدية

بلدية قلقيلية - QALQILIA MUNICIPALITY - محاسب البلدية

تفاصيل مراكز التكلفة

من تاريخ	01/06/2015
الى تاريخ	31/12/2016
من مركز تكلفة	مدرسة بنات خولة بنت الأزور الثانوية :E201305640
إلى مركز تكلفة	مدرسة بنات خولة بنت الأزور الثانوية :E201305640
مركز الصرف	نعم
التمويل	نعم
وزارة / مؤسسة	نعم
موقع	نعم
برنامج	نعم
مشروع	نعم
نوع	نعم
دليل	نعم
إشمل الملغي	نعم
حالة	مرحل

مركز المسؤولية		مركز الصرف		التمويل		وزارة / مؤسسة		موقع		برنامج		مشروع		نوع		دليل		حساب		تاريخ	سند	ملاحظة	عملة	مبلغ
الرقم	الاسم	الرقم	الاسم	الرقم	الاسم	الرقم	الاسم	الرقم	الاسم	الرقم	الاسم	الرقم	الاسم	الرقم	الاسم	الرقم	الاسم	الرقم	الاسم				رمز العملة	
E2013...	مدرسة بنات خولة بنت الأزور الثانوية	00	وزارة المالية	11100...	تمويل السلطة (موازنة جارية)	0700000	وزارة التربية والتعليم العالي	110700	محافظة رام الله و البيرة	071101	التعليم الثانوي	000000	بدون مشروع	00	نفقة جارية	562600...	[الشركة كهرباء محافظة القدس المساهمة المحدودة]	222102	كهرباء...	24/05/2...	00/1110...	فواتير كهرباء مديرية رام الله والبيرة والمدارس الحكومية التابعة لها لشهر 4/2016	NIS	771.00
		21	مديرية رام الله							071001	التعليم الاساسي	0000000	بدون مشروع							22/06/2...	21/1110...	فواتير كهرباء شهر 2/2015 لمديرية رام الله والبيرة والمدارس الحكومية التابعة لها ...	NIS	818.61
																				05/08/2...	21/1110...	فواتير كهرباء شهر 3/2015 لمديرية رام الله والبيرة والمدارس الحكومية التابعة لها	NIS	779.71
																				05/08/2...	21/1110...	فواتير كهرباء شهر 4/2015 لمديرية رام الله والبيرة والمدارس الحكومية التابعة لها ...	NIS	206.00

جامعة النجاح الوطنية

كلية الدراسات العليا

التأثير الاقتصادي و الاجتماعي من استخدام أنظمة الخلايا الشمسية الموصولة على الشبكة في المباني العامة في الضفة الغربية (المدارس و البلديات)

إعداد

سلمى "محمد علي" ياسر شقو

إشراف

د.عماد بريك

قدمت هذه الأطروحة استكمالا لمتطلبات الحصول على درجة الماجستير في هندسة الطاقة النظيفة وإستراتيجية الترشيد بكلية الدراسات العليا في جامعة النجاح الوطنية نابلس فلسطين.

2017

التأثير الاقتصادي و الاجتماعي من استخدام أنظمة الخلايا الشمسية الموصولة على الشبكة في المباني العامة في الضفة الغربية (المدارس و البلديات)

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الملخص

لقد أجريت هذه الدراسة على المباني العامة التي تم تثبيت نظام الخلايا الشمسية داخلها. قبل تثبيت النظام، كان استهلاك الكهرباء فيها يعتمد على الكهرباء المزودة من قبل شركة الكهرباء الحكومية بنسبة 100٪ اما بعد اعتماد النظام ،أصبح الاعتماد على كل من الشبكة والكهرباء التي زودت بها من قبل الخلايا الشمسية.

في هذه الأطروحة أجريت هذه الدراسة على مدرستان و ثلاث بلديات –سيتم ذكرهم من خلال الأجزاء القادمة من الاطروحة، وقد تم دراسة الآثار الاقتصادية والبيئية والاجتماعية التي نتجت عن تركيب نظام الخلايا الشمسية الموصولة بالشبكة.

بالنسبة للأهداف الرئيسية لهذه الدراسة فهي على النحو التالي. أولا العثور على نسبة أداء كل مختارا. ثانيا، اجراء دراسة اقتصادية للتعرف على جدوى هذه المشاريع من خلال جمع البيانات والحسابات المتعلقة بها. ثالثا، دراسة الآثار البيئية لهذه المشاريع على البيئة ومواردها. وأخيرا، استطلاع رأي الناس الذين يعملون في هذه المؤسسات عن نظام الطاقة الشمسية على الشبكة.

من خلال هذه الأطروحة، كان ايضا من اهدافنا ان نلمس الأثر الحقيقي لتركيب هذه الأنظمة بيئيا واقتصاديا واجتماعيا. وقياس مدى الوعي بأهمية استخدام نظم الطاقة الشمسية على الشبكة.

تدرس هذه الاطروحة ايضا الآثار الاقتصادية ,البيئية والاجتماعية لاستخدام نظام الطاقة الشمسية على الشبكة في المباني العامة (مدرستان وثلاث بلديات)

وقد استخدمت العديد من الأدوات الاقتصادية لدراسة الأثر الاقتصادي. ووجدت أن التكاليف الأولية لتركيب النظام سيتم استردادها خلال فترة (8-6) سنوات من التركيب. ولوحظ الانخفاض الملموس في فواتير الكهرباء بعد تثبيت النظام من قبل هذه المباني بنسبة(58-22)٪.

لهذه المشاريع أيضا تأثيرات إيجابية على البيئة من منظورات مختلفة. أهمها: التناقص في كمية انبعاثات CO_2، والذي يلعب عاملا مهما في الحفاظ على البيئة من تغير المناخ والاحتباس الحراري.

اما بالنسية للآثار الاجتماعية لتركيب مثل هذه الأنظمة على المباني المختارة، فقد لعبت دورا في زيادة وعي الناس، ولكن ليس بالقدر المتوقع، نحو أهمية الطاقة المتجددة وأهميتها في تحقيق الازدهار. و قد قمنا ايضا بقياس مدى وعي الناس بأهمية هذه النظم.