An-Najah National University
Faculty of Graduate Studies

Planning for Solar Energy as an Energy Option for Palestine

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الإهداء

إلى الأرض التي رواها احمر جراحنا.....
إلى السماء التي خيمت بظلالها أسرانا.....
إلى كل الذي فيه أرضنا..... وسماؤنا.......فلسطين

إلى الذين يسري المسك في عروقهم........شهداؤنا الأبرار

إلى من بدعائهم تحققت آمالي.....
إلى من لنجاحي سهر الليالي.....
إلى الملائكة التي ترعاني بكل حب وفخر وتفاني.......والدي الأطياب

إلى من اشعر بوجوده بسكينة أيامي.....
والذي طالما كان لي سندي ومصدر اطمئناني......أخي الغالي

إلى اللواتي بوجودهن تزهر أحلامي
واللواتي هن ذخر لي في كل مكاني.......أخواتي الغاليات

إلى من أمدني بيد الدعم .....وإلى من لا تكتمل سعادتي إلا بهم....إليك زوجي العزيز..وإليك ابنتي الحبيبة

إلى كل من علمني....أن علمي سلاح
والذين جعلوا من قلمي رسما ومن فكري مصباح.......أساتذتي الأفاضل

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الإقــرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

Planning for Solar Energy as an Energy Option for Palestine

تخطيط الطاقة الشمسية كمصدر بديل للطاقة في فلسطين

أقر بأن ما اشتملت عليه هذه الرسالة إنما هي نتاج جهدي الخاص، باستثناء مـــا تمــت الإشارة إليه حيثما ورد، وأن هذه الرسالة ككل، أو أي جزء منها لم يقدم من قبل لنيل أية درجة علمية أو بحث علمي أو بحثي لدى أية مؤسسة تعليمية أو بحثية أخرى.

Declaration

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

Student's name:	**اسم الطالب:**
Signature:	**التوقيع:**
Date:	**التاريخ:**

Table of Contents

List of Tables

List of Figures

Planning for Solar Energy as an Energy Option
for Palestine
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Supervisor
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Abstract

The energy sources in the Palestinian territories are very limited and It depends on the imports of different types of fuel from neighboring countries, especially Israel, as the energy consumption in all sectors in the Palestinian territories is relatively small compared with the neighboring Arab countries, as well as the highest percentage of energy consumption is in the household sector, followed by The transportation sector, the third is the industrial sector which has a few percentage of energy consumption.

The researcher in this study studied the energy sector in the Palestinian territories in terms of the quantity of energy consumption in all sectors (domestic, industrial commercial ...), studied all types of available fuels and their prices. The solar energy and its potential in the Palestinian territories were studied in terms of the amount of incident radiation during the year and the various possible applications, and the projects that have been implemented in various regions.

In this study, a hierarchic system was used for planning of the energy sector in Palestine with maximum possible usage of solar energy as an indigenous, clean and cheap source of energy. This hierarch system includes all solar system technologies that can be applied to the in various

sectors. The analysis have shown that solar energy share can reach 11.4% of total energy consumption for the year of 2020 just by implementing solar thermal systems; passive and active. This share may exceed 18% if power generation was implemented using concentrated thermal systems in West Bank and Gaza.

The planning process of expected saving percentage in energy consumption in the Palestinian territories is not easy, for many reasons such as economic, demographic, and political. The researcher adopted on the variables of population and construction in order to forecast the percentage of savings in energy consumption for the coming years in various sectors.

As an expected result, the reduction in consumption of fossil fuels by increasing solar share will have positive environmental impacts as well as economical impact. Gas emission, mainly CO2 will be reduced sharply if this plan is implemented in Palestine.

Chapter 1

Introduction

Chapter 1
Introduction

1.1 Introduction

1.1.1 Background

The West Bank and Gaza Strip who usually called the Palestinian Territories (PT) are located at the geographic latitude of approximately 30 ^{o} N, where the annual incident solar irradiance is about 2000 kWh per m^2. It has, however, no natural energy resources; all of the country's electric power and fuel are imported from Israel where they are derived from imported coal and oil. At present, the electrical peak load of the PT stands at about 650MW, representing approximately 200W per capita; but this value has increased in recent years as the need for electricity, in all walks of life, has risen. In such a situation it is, therefore, not surprising that Palestine has shown a great interest for the use of solar energy.

1.1.2 Map

The map of Palestine clearly defines the geographical position of the country in-between 34.15° and 35.40° east longitude and 29.30° and 33.15° north latitude. The Palestine map further indicates the climatic condition and heterogeneous topography of the country. Spread over total area of 27,000 sq km, Palestine is encircled by Jordan and Syria in the east and Lebanon in the north. The country of Palestine is sacred for Muslims, Christians, and Jews as well. The ideal geographical position of Palestine ensures enhanced commercial transactions between the country and neighboring areas. Situated on the shores of the Mediterranean Sea, Palestine has a natural harbor that easily connects the three continents of Europe, Asia and Africa.

Fig. (1.1): Map of West Bank and Gaza

1.1.3 The Palestinian Energy Sector[1]

The Palestinian Authority (PA) has no economic domestic supplies of primary energy, except for some solar and biomass energy, supplying 9 percent of total energy needs. The lack of available energy contributes to relatively high prices for all forms of energy. As a result, the Palestinian Authority uses relatively small amounts of energy per capita. Despite these

[1] *Progress Report the occupied Palestinian territory, COMMISSION OF THE EUROPEAN COMMUNITIES, Brussels, 23/04/2009, SEC(2009) 519/2*

factors, energy efficiency is low and has grown worse through the 1990s, resulting in unnecessary contributions of greenhouse gases to the atmosphere. The PA established an updated energy policy in the context of the Palestinian energy sector assistance program 2008-2010, the PRDP 2008-2010 and the "Letter of sector" policy. The policy includes objectives such as the improvement and extension of electricity infrastructure and services; capacity-building and institutional reform including the separation of policy and regulatory functions from commercial functions; and increased efficiency. The Cabinet approved an electricity law, which awaits finalization of the legal procedures. The law creates a basis for the establishment of the Palestinian electricity regulatory commission and separates commercial from regulatory functions. The occupied Palestinian territory remained largely dependent on energy imports from Israel. In 2008 the Gaza power station was completely dependent on external aid and had to reduce electricity production due to supply limitations imposed by Israel. This situation continued to impact on the daily life of Gaza inhabitants. Approximately 187 MW.hour are currently available in Gaza against the around 225 MW.hour needed. This results in frequent power outages and the need to use fuel generators for the most essential facilities. Of the available capacity, around 115MW is sold by the Israeli Electrical Company (64%), 17MW (9%) is bought from Egypt and around 50MW (27%) are generated by the Gaza Power Generating Company (GPGC). Since February 2008, electricity flows to Jericho through a new electricity interconnection with Jordan. Reflections started for further links between the West Bank and Jordan. The PA completed a feasibility study regarding a substantial upgrade of the Egypt-Gaza electricity link. Egypt, Jordan and the PA started to explore possibilities for further network interconnections. In October 2008, the Palestinian Authority became a participant in the Arab electricity interconnection project alongside Egypt, Iraq, Jordan, Lebanon, Libya, Syria and Turkey. The PA, Jordan and Israel exchanged views on possible future electricity interconnections. Due to the situation in the Gaza strip, the construction of an electricity line Gaza-Israel remained frozen. The PA worked further on the development of four electricity substations in the West Bank and, with support from the European Commission, started on the upgrading of West Bank electricity networks. It installed pre-paid electricity meters, with a view to improve bill collection. The PA and Egypt studied interconnection possibilities. The economy could benefit from the development of the Gaza offshore gas resources, which in the current circumstances cannot be developed. In 2008, the PA became a partner in the Regional Centre for Renewable Energy and Energy Efficiency for Middle East and North Africa countries. The Cairo-based Centre was inaugurated in June 2008 and is supported by the European Commission, Denmark and Germany. The PA developed plans for a solar power plant in Jericho. The European Commission launched a pilot project on wind energy. At regional level, the Palestinian Authority pursued Euro-Mediterranean energy cooperation, in particular through the multiple projects (see the sectoral report). The July 2008 Summit of the Union for the Mediterranean endorsed the development of a

Mediterranean Solar Plan. In 2008, the PA, Israel and the European Commission re-launched trilateral energy cooperation with the aim of facilitating the joint Palestinian-Israeli "Solar for Peace" initiative and the establishment of a joint energy office. A European Commission financed study was undertaken to support the Solar for Peace project.

A number of barriers exist to improving the energy sector, including, among others:

- The unit price of energy is high,
- Energy resources are either dwindling or non-existent,
- Lack of accurate data needed for any planning program
- Renewable energy has not reached a satisfactory level of utilization,
- Limited information on improving energy efficiency
- Environmental pollution due to conventional energy resources is potentially threatening,
- Low priority of energy end-use efficiency
- Supply of conventional energy (electricity and petroleum products) is monopolized by the Israeli authority. This creates unrealistic price control, energy shortage and future energy crisis.
- Shortage of financing for energy-projects

- Lack of standards governing quality of energy equipment
- Lack of capability to evaluate and prioritize new distribution line projects and to assess the potential to reduce demand or slow its growth through, for example, solar applications in the industrial sector.

1.1.4 Solar Radiation in Palestine

Energy from the sun travels to the earth in the form of electromagnetic radiation similar to radio waves, but in a different frequency range. Available solar energy is often expressed in units of energy per time per unit area, such as watts per square meter (W/m^2). The amount of energy available from the sun outside the Earth's atmosphere is approximately 1367.7 W/m^2; that's nearly the same as a high power hair drier for every square meter of sunlight! Some of the solar energy is absorbed as it passes through the Earth's atmosphere. As a result, on a clear day the amount of solar energy available at the Earth's surface in the direction of the sun is typically 1000 W/m^2. At any particular time, the available solar energy is primarily dependent upon how high the sun is in the sky and current cloud conditions. On a monthly or annual basis, the amount of solar energy available also depends upon the location. Furthermore, useable solar energy is depended upon available solar energy, other weather conditions, the technology used, and the application (Graham, 1990). Table (1.1) and figure (1.2) show the mean monthly and annual daily global radiations ($MJ/m^2/day$) in Jerusalem.

Table (1.1) Mean monthly and annual daily global radiations (MJ/m2/day) in Jerusalem

μ Mean deviation

% Radiation percentages compared to outside the atmosphere

Month	**32°N outside atmosphere**	**Mean Radiation**	**μ**	**%**
January	20.2	12.02	0.8	60
February	25.0	15.25	1.38	61
March	30.8	19.5	1.13	63
April	35.8	24.09	0.63	67
May	39.5	28.02	0.67	71
June	40.8	30.24	0.34	74
July	40.0	29.76	0.34	74
August	37.2	27.35	0.50	74
September	32.6	23.68	0.50	73
October	26.8	18.49	0.71	69
November	21.4	13.99	0.63	65
December	18.7	11.3	0.67	60
Annual	**30.7**	**21.14**	**0.8**	**69**

Source: The climate of Israel: observation, research, and application, By Y. Goldreich, Springer, 2003.

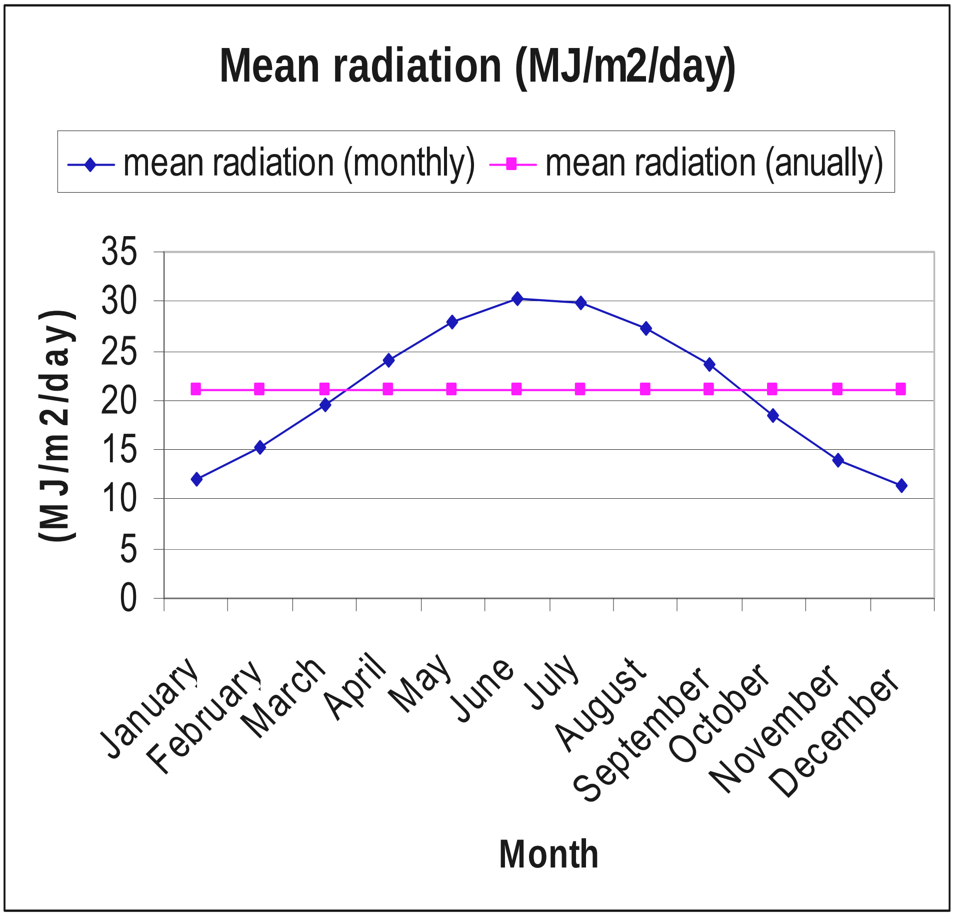

Fig. (1.2) Mean monthly and annual daily global radiations (MJ/m^2/day) in Jerusalem

Palestine lacks any kind of fossil sources of energy. Most of energy needs for industry and other applications is imported from other countries. Fossil sources of energy are considered as very expensive sources from the economic and environmental points of view.

Solar power can be used in both large-scale applications and in smaller systems for the home. Businesses and industry can diversify their energy sources, improve efficiency, and save money by choosing solar technologies for heating and cooling, industrial processes, electricity, and water heating. Homeowners can also use solar technologies for heating and cooling and water heating, and may even be able to produce enough electricity to operate "off-grid" or to sell the extra electricity to the utilities, depending on local programs. The use of passive solar heating and day lighting design strategies can help both homes and commercial buildings operate more efficiently and make them more pleasant and comfortable places in which to live and work (Tabb, 1984).

Palestine receives a relatively high quality of solar energy all over the year. Our goal is to study the extent of which we can plan for solar energy as an economical and reliable source of energy in the future strategic plan for the energy sector (Mohammed, Abed-Esallam "Impact of Energy Management & Conservation on Electrical Energy Planning in the West Bank 2000).

The following two sections will discuss briefly about two applications that are available in the West Bank and Gaza; solar water heaters and photovoltaic cells.

1.1.5 Domestic Solar Water Heaters

Perhaps the most common practical applications of solar energy in Palestine are the solar water heaters that cover roof-tops all over the country. Typical domestic units consist of a 150 liter insulated storage tank and a 2 m^2 flat plate collector. The collector collects solar radiation to heat the water and passes it to storage tank in a pumpless, gravity-driven loop. This system operates at an annual average efficiency of approximately

50%. The use of such as this unit saves its owner some kwh per year in electricity costs, raising the temperature of a tankful of water by approximately 30^{o}C above its starting point on an average day - i.e. heating water to a temperature of about 50^{o}C. This means that most days of the year there is no need to employ the electrical backup heating coil (which all storage tanks contain) in order to ensure that the water is warm enough for washing. Larger systems, usually pump- driven, are to be found in few projects, such as the president residence in Jericho.

1.1.6 Photovoltaic Rural Electrification

At this time, there is no manufacturing industry for photovoltaic (PV) cells in Palestine. This fact, coupled with the still relatively high cost of PV cells, has resulted in a relative dearth of PV demonstration projects despite the ideal climatic conditions the country offers for this technology. However, with the financial support of donating countries such as Germany and Spain, some pilot projects for rural electrification were constructed with technical support of Palestinian research centers.

1.2 Objectives

The main objectives of this thesis are:

1- To study availability of solar energy in all areas of Palestine.

2- To investigate practical applications of solar energy in its thermal and electrical forms.

3- To evaluate economical and environmental impacts of solar energy

4- To plan for solar energy share as an energy source.

5- To recommend new applications and new techniques for replacing traditional energy sources with solar energy as a renewable source.

6- To evaluate the overall impacts on the life of Palestinians and their economy.

7- To recommend new legislations and administrative rules to encourage people for depending more on solar energy.

1.3 Methodology

In this study, we will collect data and information about solar energy availability in Palestine and possible applications for it. This will include:

1- Collecting data regarding solar energy (solar insolation) from various related technical books and references.

2- Collecting measures data about solar radiation in Palestine.

3- Collecting statistical information about actual solar applications such as water heaters.

4- Study of possible applications of solar energy for space heating and electric generation for residential and industrial sectors.

5- Optimizing the maximum level of such applications.

6- Determining the feasible energy share of solar energy in the energy sector.

7- Evaluating the economical impacts (reduction of energy imports)

8- Evaluating environmental impacts (reduction of gas emissions)

1.4 Outline of Study

This thesis is divided into 7 chapters including this introductory chapter.

- ***Chapter 2*** presents the energy sources in Palestine, and Palestinian consumption of energy compared with some neighboring countries. It includes the analysis of energy consumption by sectors from 2001 to 2005 such as residential, industrial, and transportation sector, changes in the energy derivatives prices, factors effects in the energy derivatives prices, and finally Gross Domestic Product or GDP.

- ***Chapter 3*** presents a discussion on solar energy potential, which include solar constant, solar energy potential in PT's, solar energy applications, and photovoltaic projects in Palestinian Territories.

- ***Chapter 4*** discusses solar energy needs in each sector in the Palestinian economy, and the feasible solar technology to be used in each sector.

- ***Chapter 5*** presents the analysis of potential solar energy penetration in each sector and the level of that penetration in order to evaluate the future share of solar energy as an energy option.

- ***Chapter 6*** presents the feasibility of using solar energy for power generation. Two different projects are discussed, one in Jericho for power generation, and the second in Gaza as a cogeneration project for power generation and water desalination.

- Finally ***chapter 7*** presents the results and recommendations of this study that will be presented to the decision-maker, energy planner, researchers.

Chapter 2

Energy Consumption in Palestine

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Energy Consumption in Palestine

Energy sector is considered of a great importance due to its role in reflecting the situation of the infrastructure, economics growth, and prosperity of people. Secure and cheap energy is a major factor for economic development in any country.

Palestine, like other "Developing Countries" has an energy sector, which is suffering the special circumstances due to unique political status of the occupied territories; the West Bank and Gaza Strip. According to economical agreement between Palestinian Authority and Israel, the PA was given little freedom in all aspects of energy sources including electricity and refined petroleum products. Energy imports and energy prices is completely controlled by the Israelis, which resulted in supply interrupts and continuous increase in most of fuels used in the Palestinian territories.

This chapter discusses the energy sources in Palestine, the amounts and forms of energy consumed, also the share of each sector in energy consumption, energy prices (mainly electricity, diesel, gasoline, charcoal and gas), and comparison energy consumption with neighboring countries.

2.1 Energy Sources in Palestine

Palestine is considered as one of the poorest countries compared to other neighboring countries, and there are three respects to be in an unusual position:

- Firstly Palestine is fragmented into two distinct geographical zones with divergent economic characteristics, The West Bank and Gaza Strip. The West Bank, where most of the population and Palestinian economic activity are located, without its own primary energy resources. Gaza's population and economy are smaller but still substantial, but it has some energy supply.

- Secondly there are no developed domestic resources of commercial energy; it is almost dependent on imported energy supplies, specifically oil products and electricity. Because of logistical and political factors nearly all of these supplies at present come from Israel.

- Thirdly Israeli policies and actions imposed on the ability of the Palestinian Authority (PA) to operate and develop its energy systems as unusual challenge.

In general PT's dependent on imported energy from other countries like Israel, Jordan, Egypt, in the following table (2.1) which shows The Total Value of Energy Imports in PT's in Thousand $ between (1996-2005).

Table (2.1) The Total Value of Energy Imports by Year in PT's in thousand $

Year	**1996**	**1997**	**1998**	**1999**	**2000**
Total	384,601	378,080	411,767	391,106	450,286
Year	**2001**	**2002**	**2003**	**2004**	**2005**
Total	377,361	359,690	425,586	659,867	718,135

Source: see Appendix (1)

We can note that the Industrial sector is the third sector that consumed the imported energy from 1996 to 2005 see figure (2.1), in 2005 the percentage of energy imports for industrial sector was 8%, and in same year the transportation storage and telecommunication sector become the second its percentage was 19%.

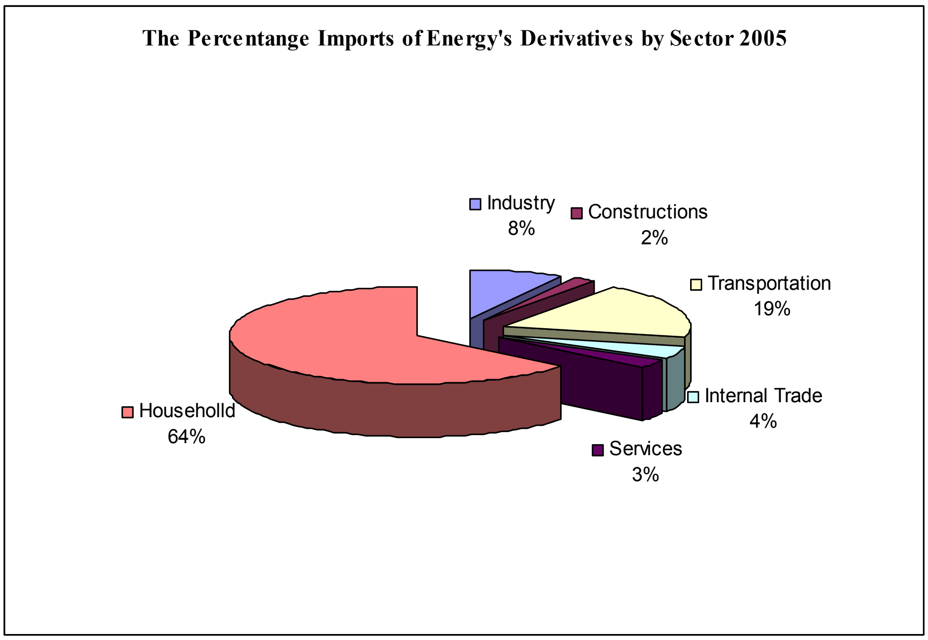


Fig. (2.1) The Percentage Imports of Energy's Derivatives by Sectors in 2005
Source: Palestinian Central Bureau of Statistics (PCBS)

In general there are many deferent sources of energy, but in Palestine they are limited and include the following:

2.1.1 Electrical Energy

The pattern and the characteristics of electricity supply and consumption in the West Bank are different from those in the Gaza region. The difference stems mainly from the lower standard of living in the Gaza area compared to the West Bank.

Almost entirely the West Bank depends for electricity supply on Israel Electric Corporation (IEC). It is mainly supplied by three substations (161/ 33 KV): one in the north in the Ariel settlement (area C) close to Nablus, a second in the south in area C close to Hebron, and a third near Jerusalem in Atarot industrial area (area C). Jerusalem District Electric Company (JDECO) supplies electricity to the center of the West Bank via 11kV and 33kV distribution network at several connection points with the IEC. This includes Ramallah, Bethlehem, Jericho and the eastern part of Jerusalem.

550MVA is the maximum capacity of electricity supply to the West Bank (Ayman Abualkhair, Electricity sector in the Palestinian territories: Which priorities for development and peace, 2006), 70% of electricity indirectly is supplied to East Jerusalem and in bulk to 165 towns and villages in the West Bank by IEC through JDECO, and 30% of electricity is supplied in bulk to 215 towns and villages by IEC directly.

IEC and a diesel (gasoil) based power plant with electric generation capacity of some 140MW is located inside Gaza. This power plant is the only major power generation facility in the occupied Palestinian Territories. Rafah city in the south of Gaza strip has been connected to the Egyptian grid in 2006. This connection provides 17MW supply to southern part of the strip. Electricity is distributed in Gaza via the Electric Distribution Company (GEDCO). The electricity consumption of Gaza Strip was increased by 80% during the period 1999 to 2005, and at about 10% average annual increasing rate.

Gaza is connected from north to south by eleven connection points with Israeli power network, via transmission lines with 22 Kilovolt and total capacity of 115MW.

2.1.2 Petroleum Products

In general, petroleum products (gas, kerosene, gasoline, diesel, oil, and liquefied petroleum gas (LPG)) are imported in Palestine from Israel. Some quantities of these products find their way to Gaza from Egypt.

In 2000, LPG was discovered in the Palestinian Territories at large quantities. Two fields in the Mediterranean Sea were discovered in the cost of Gaza Strip. One of them is entirely within the regional waters while 67% of the second field is located in the Palestinian territory and 33% in areas controlled by Israel.

The first field which is called Gaza Marine; is located 35 kilometers off the coastal range, and the depth of water in the region between 530-680 meters. Marketing of Gas from this field has never been accomplished due to Israeli orders especially after the starting of the second Intifadah in September 2000.

Analysis of the discovered Gas near Gaza was proven to be of good quality without sulfur compounds. The chemical composition includes: methane 99.4%, ethane 0.25%, propane 0.06%, butane 0.03%, carbon dioxide 0.04%, and Nitrogen 0.22%.

2.1.3 Bio energy

Bio energy includes biogas and biomass. The production of biogas is still under investigation in Palestine and it is estimated to be 33 million cubic meters, equivalent to 10M€.

Palestine is an agricultural country and several biomass products are used as energy sources, such as charcoal, wood, wood cake (Jefit) which is the reject of olive oil pressers, and other agricultural wastes. These biomasses are used in households for heating, baking and cooking specially in rural area. 76,000 tons are the annual average of olive mills solid waste (OMSW) which is produced by 265 olive mills in Palestine.

2.1.4 Wind energy

Based on topographical features and available data, Palestine can be considered as a country of moderate wind speed. The annual wind speed is expected to be in the range of (4-6) m/s in hilly regions, such as in Nablus, Ramallah, Jerusalem, and Hebron. In Gaza region (Coastal) the wind speed is very low and it ranges from (2.5-3.5) m/s, also wind speed is very low in Jericho (Jordan valley) with range of (2-3) m/s which is very low and unfeasible. Table (2.2) show the wind speed and potential in some areas of Palestine at different levels based on data from 49 stations distributed throughout the area.

Table (2.2) Wind speed and potential in some areas of Palestine

Location	Wind Speed		Wind Potential (kwh/m²)			
	Elevation (at sea level)	Annual Mean (m/s)	Roughness Class	Elevation		
				10m	20m	40m
Jenin	140	3.65	1	285	431	626
Jericho	-260	3.3	3	146	286	505
Ramallah	874	4.8	2	407	659	1013
Jerusalem	757	4.12	2	334	541	831
Gaza	10	2.9	0	152	201	261

Source: PEC report on renewable energy in Palestine

2.1.5 Solar Energy

Palestine has a high potential of solar energy around the year, with an average solar radiation of 5.46 kWh/ m².day. The most feasible application of solar energy used in the residential sector is the solar water heater (SWH). A survey conducted by PCBS has shown that 67.2% of households are equipped with SWH and a limited percentage in other sectors. More than 90% of SWH's are manufactured locally by Palestinians in the West Bank and Gaza. Other applications of solar energy include Photovoltaic, solar heating and cooling, solar drying, and Greenhouses for agricultural purposes. In the next chapters will discuss in detail about these applications.

2.2 Energy Consumption

According to ESCWA reports, energy consumption in 2005 for countries in south west of Asia and Middle East, Palestine consumes the least amount of energy compared to other countries in the region. Total consumption of all types of energy was equivalent to 840 KTOE. If we compare this consumption to the consumption of other neighboring countries, then it represents around 2%, 7% and 17% compared to Egypt, Syria and Jordan respectively. On the other hand, energy consumption for Israel (with nearly 7 million habitants in 2005) was 12,707 kToe (15 times that the Palestinian Territories), while Lebanon (with 5.47 million habitants in 2005) was 4,057 kToe (5 times superior). As shown in Fig (2.2), this low percentage may be due to several reasons; the weakness of the industrial sector, the deteriorated economy and low income of a large sector of the population. The industrial sector was destroyed by the Israeli occupation during the years of Intifada and its concomitant siege and closures.

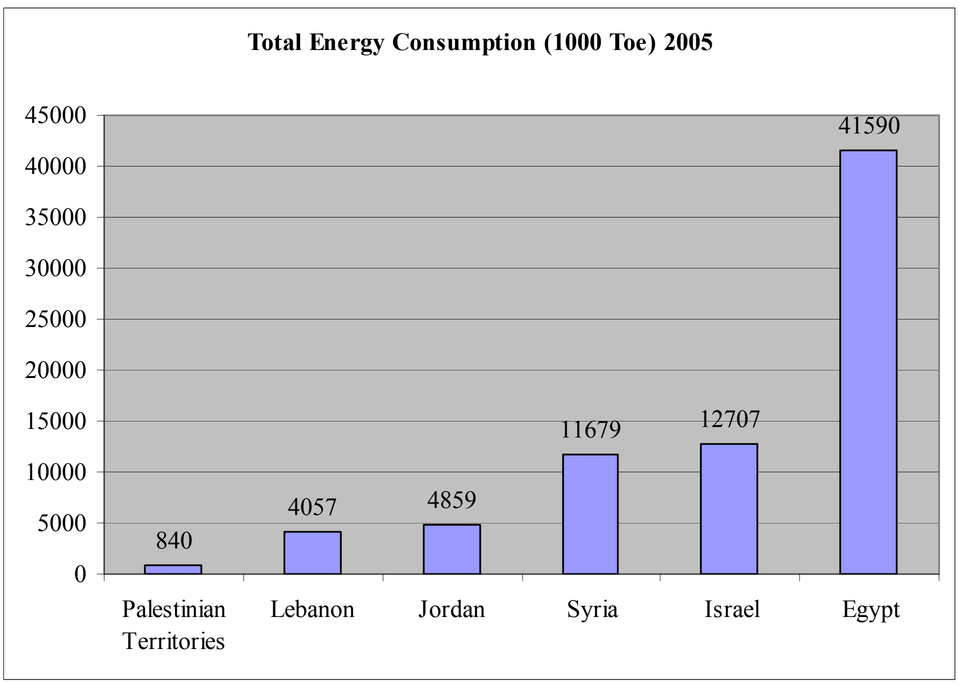


Fig. (2.2): Total energy consumption, 1000Toe in 2005

Source: different sources, appendix (2)

2.3 Energy consumption by sector

Statistics for energy consumption by sector show the role of residential sector as the main energy consumer, with 64% of total consumption in 2005. The transportation sector is the second greatest consumer of energy it consumed about (156 kToe), while the industrial sector comes in the third place with 8%.

For Israel, the transportation sector is the main consumer of energy, with 31% of the total consumption followed by the residential sector with 23%. This result shows the high consumption of energy of transport sector. (International Energy Agency Report for Israel's energy balance 2005).

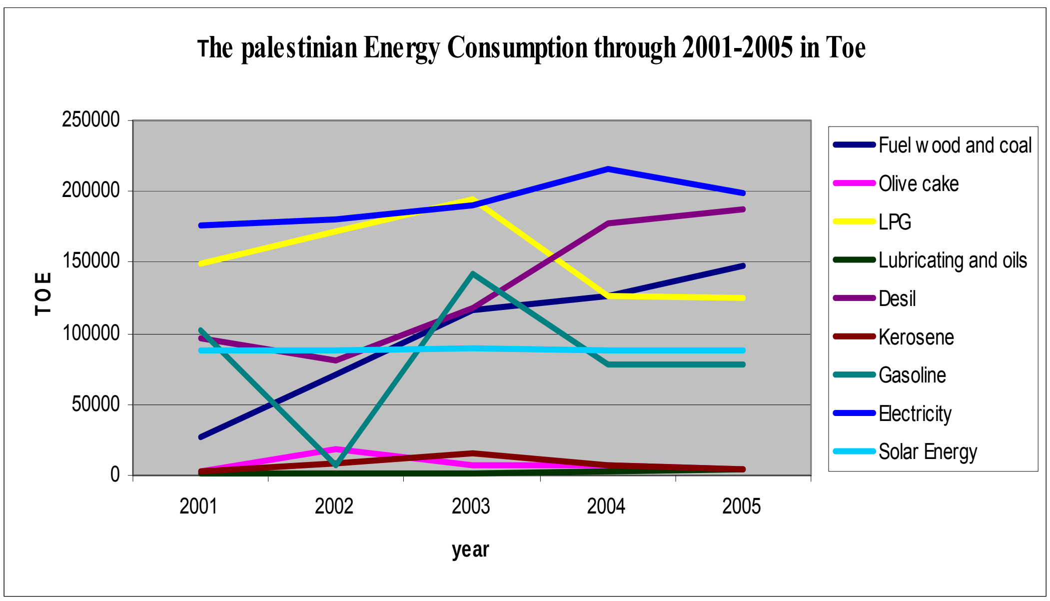


Fig. (2.3): Total Palestinian Energy Consumption by Fuel through (2001_2005) in Toe

Source: Palestinian Central Bureau of Statistics (PCBS)

2.3.1 Residential sector

Given the energy consumption in the residential sector, this represents 64% of the total energy consumed for the years 2001 and 2005. Note that the rate of growth between these two years was equal to 30%, but note that the growth between 2001 and 2003 was higher than the growth between 2005 and 2001, that the rate reached 47% as a result of the apparent increase in energy consumption in this sector in the year 2003 where the highest percentage consumption during the period 2001 - 2005, while the consumption in 2005 declined at a rate of 12% compared with 2003, and this declined may be coming to improve the decline which happened in 2004 by ratio 16% compared to 2003, and we notice that the percentage of increasing in 2002 was 24% compared to 2001, where the gas consumption was represented the highest consumption of fuel in this sector with amounted 163,840 Toe., as we see in the following table(2.3), and figure (2.4).

Table (2.3): The Energy Consumption (in TOE) by Fuel Type in the Residential Sector (2001– 2005)

Year	**2001**	**2002**	**2003**	**2004**	**2005**	**Total**
Wood and Charcoal	26,252	71,035	115,511	125,701	146,780	**485,278**
Jift(Wood Cake)	3,259	18,943	6,629	6,741	4,367	**39,938**
LPG	142,019	163,840	186,514	111,698	108,549	**712,619**
Diesel	5,415	9,764	37,192	8,307	23,614	**84,291**
Kerosene	1,508	7,538	13,622	4,498	3,172	**30,338**
Electricity	144,940	150,773	156,606	162,356	159,555	**774,230**
Solar Energy	88,231	88,644	89,058	87,896	87,456	**441,285**
Total	411,623	510,538	605,130	507,195	533,492	**2,567,979**
%	64%	81%	69%	61%	64%	**67%**
change		24%	19%	-16%	5%	**32%**
growth	**2001**	**2003**	**2005**	**2003/2001**	**2005/2001**	**2005/2003**
	411,623	605,130	533,492	+47%	+30%	**-12%**

Source: Palestinian Central Bureau of Statistics (PCBS)

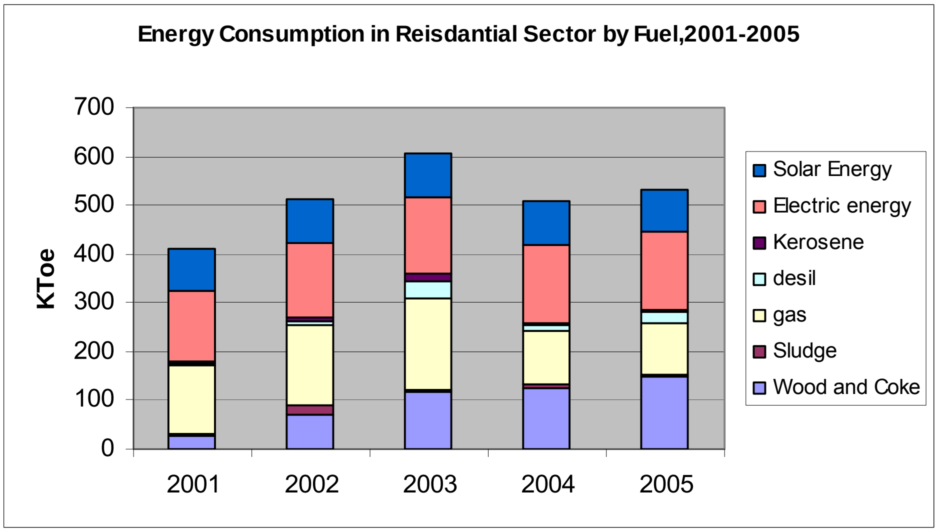


Fig. (2.4): Energy Consumption in Residential Sector by Fuel (2001-2005)

Source: PCB

2.3.2 Transportation Sector

The data indicates that the transportation sector became second sector in the order of the energy consumption in 2005 hitting 19% of the total energy consumed in all sectors for this year.

The data showed consistency in the use of energy in the transportation sector in terms of convergence rate of consumption for the period situated between 2001 and 2005 except 2002, which thrust a sharp decrease in the amount of energy consumed in 2001 by an estimated 79%, as shown in table(2.4) and figure (2.5) respectively, and this decrease in the energy consumption was referred to several factors specific to the Political events, the siege of economic and frequent blockades homeland, which significantly limited the movement of Transportation and thus negatively impact on the amount of energy consumed per formed as 4%.

Table (2.4): The Energy Consumption in Toe by Fuel Types in the Transportation Sector (2001 – 2005)

Fuel / Year	2001	2002	2003	2004	2005	Total
Wood and Coke	11	0	0	**0**	**1**	**12**
LPG	40	28	40	83	72	**264**
Lubricating and oils	126	66	113	770	1,833	**2,908**
Diesel	35,437	26,571	26,772	70,123	83,219	**242,123**
Kerosene	38	0	161	80	24	**302**
petroleum oils	92,338	0	136,199	65,005	69,521	**363,063**
Electricity	1,230	0	1,719	2,769	1,265	**6,984**
Total	129,220	26,666	165,004	138,830	155,935	**615,654**
%	20%	4%	19%	17%	19%	**16%**
change		-79%	519%	-16%	12%	**436%**
growth	**2001**	**2003**	**2005**	**2003/2001**	**2005/2001**	**2005/2003**
	129,220	165,004	155,935	+28%	+21%	**- 5%**

Source: Palestinian Central Bureau of Statistics

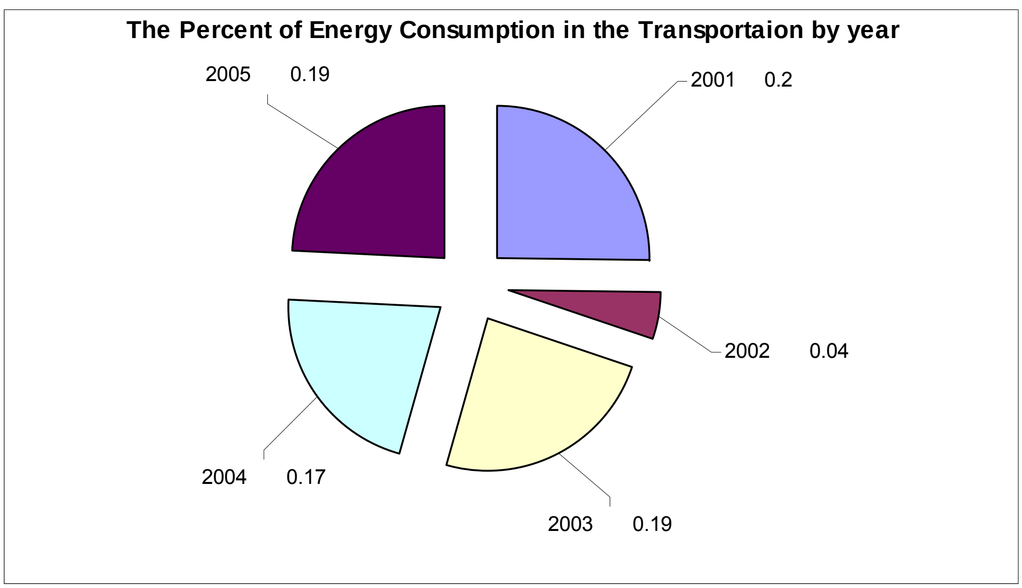


Fig. (2.5): The Percent of Energy Consumption in the Transportation by year

2.3.3 Industrial Sector

What distinguishes the Palestinian industrial sector is the relatively steadfastness in terms of economic size, although it contains a lot of industrial activities such as manufacturing metal products, which its establishments reached in 2006 about 2795 plant , as well as upholstery industry , food and beverages industry , and other industries which characterized by its small size. Around 50000 laborers work in this sector, where the output reached in nearly one and half billion dollars and this represents almost a quarter of GDP.

However we note that the consumption of energy of industry sector depends on consuming diesel as a basic source. A percentage of diesel consumption in this sector for the years 2001 and 2005 represents 64% of the total consumption of energy derivatives for each year. As the proportion of consumption ranged during the period between (2002-2004) from 54% to 57% of the total consumption of energy derivatives. We also note the decline that occurred in 2002 when the decrease reached 8% compared with 2001, while increased by 13% in 2003 as in 2002 but the data show a clear rise considerably during the year 2004 amounted to 67% compared with 2003, where the consumption of diesel fuel represented more than half of the total derivative fuel consumption for this year, then the energy consumption returned back in this sector to decline again in 2005 by 15% over in 2004. But the data indicated that the consumption of energy has changed in 2001 to in 2005 with ratio 48%, but when we remark the following table (2.5) and fig (2.6) we can say that there are no official statistics on the amount of solar energy consumed in this sector, especially for the purpose of heating.

Table (2.5): The Energy Consumption by Fuel Types in the Industrial sector (2001 – 2005) in Toe

Year	Wood and Coke	LPG	Lubricating and oils	Diesel	Kerosene	Petroleum oils	Electric energy	Total	%	change	growth	
2001	200	3,781	820	30,642	220	3,644	7,836	47,143	7%	–	2001	47,143
2002	265	3,858	702	25,157	171	2,328	11,032	43,512	7%	-8%	2003	48,964
2003	102	2,910	847	26,541	988	2,131	15,445	48,964	6%	13%	2005	69,627
2004	255	5,933	1,222	47,314	564	2,993	23,413	81,694	10%	67%	**Ch 03/01**	4%
2005	187	5,703	1,315	44,255	459	2,348	15,360	69,627	8%	-15%	**Ch 05/01**	48%
Total	**1,009**	**22,186**	**4,906**	**173,910**	**2,401**	**13,444**	**73,085**	**290,940**	**8%**	**57%**	**Ch 05/03**	**42%**

Data Source: Palestinian Central Bureau of Statistics

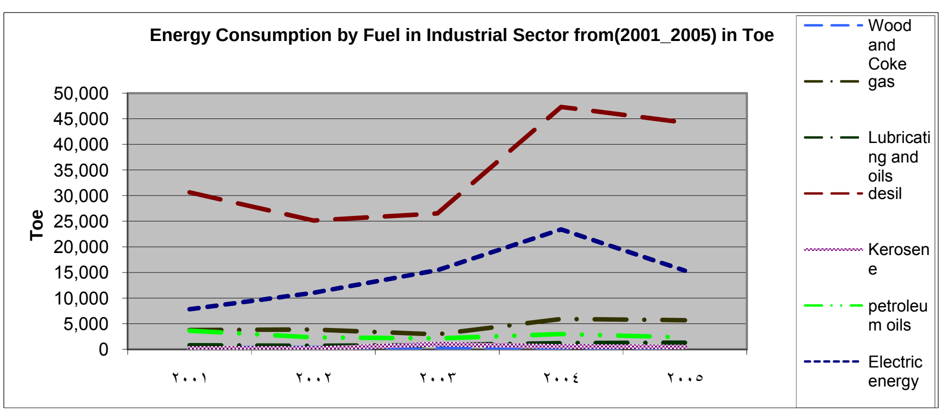


Fig. (2.6): Energy Consumption by Fuel in Industrial Sector from (2001_2005) in Toe

2.3.4 Trade and Services Sector

With regard to the consumption of energy products in the sectors of trade and services, they have faced several circumstances since the Israeli occupation of the West Bank and Gaza Strip in 1967, and since that period the Palestinian economy linked to the Israeli economy and Israel has adopted all the ways to make the Palestinian economy is an economy subsequent to the Israeli economy, as considering the last one is the only monopoly to the energy derivatives.

The volume of trade's exchange to the rest of the West Bank and Gaza Strip represented 72% of GDP in 2003 according to the data unpublished for the Palestinian Central Bureau of Statistics, this shows the importance of trade and services sector in the Palestinian economy and the role which they played in development, but we note from the following table (2.6) the low-level of consumption of derivatives Energy used in these sectors which reached 69,365 TOE in 2004, and the energy consumption rising in trade and services sector by 40% in 2003, but returned to the decline in 2005 by 11% .

We also note that more use of energy derivatives in these sectors is the diesel fuel which had more than one third from the total of consumption in all years (35% - 45%), and this shows the using of diesel in service's and trade's business which based on transportation as I indicated earlier in the transportation sector. The use of electricity is also accounted for about one third of consumption in the trade and service sectors of the total energy used and the percentage of the energy consumption reached between (33% - 42%) from 2001 - 2005.

Table (2.6): The Energy Consumption by Fuel Types in the Trade and Service sector (2001 – 2005) in TOE

Year	Wood and Coke	LPG	Lubricating and oils	Diesel	Kerosene	Petroleum oils	Electric energy	Total	%	change	growth	
2001	110	3,768	344	22,333	412	5,801	21,936	**54,705**	20%	–	2001	**54,705**
2002	160	4,188	400	16,091	516	4,741	18,958	**45,053**	16%	-18%	2003	**49,417**
2003	189	4,899	715	22,725	779	3,870	16,240	**49,417**	18%	10%	2005	**61,474**
2004	146	8,643	1,017	26,411	1,782	7,370	23,995	**69,365**	25%	40%	**Δ 03/01**	-10%
2005	282	9,769	1,131	22,512	885	5,308	21,588	**61,474**	22%	-11%	**Δ 05/01**	12%
Total	**886**	**31,267**	**3,607**	**110,072**	**4,375**	**27,090**	**102,717**	**280,013**	**100%**	**21%**	**Δ 05/03**	24%

Source: Palestinian Central Bureau of Statistics

2.4 Energy Prices in Palestine

Prices of energy are relatively high since almost all energy consumed is imported and it is heavily taxed.

The energy derivatives price have been moving in simple rang during the mentioned period. While this has not caused a significant mix-up unlike the energy derivatives crisis in the followed periods that came after 2006. The energy derivatives prices in the above period are considered to be too high compared to the other countries particularly the produced countries due to saving the maximum marginal profitability for the clients or the distributors, but in the Palestinian market we are noticed some equilibrium between supply and demand despite of the monopoly in this market, may be because this market considered as strategic market and it's controlled by the agreements by the Palestinian Authority and the Israel.

2.4.1 Changes in Energy Derivatives Prices

During the second Intifada the high prices originated around 2003-2004, the energy derivatives prices have stayed at high levels for all energy categories, it rose by different ratios like the electrical av. kw. limit down has changed in it's prices by the highest change 17% in 2002 to 0% in 2005 but the electrical av. kw. additional has changed by 10% in 2002, 17% in 2003 and 3% in 2004 to 0% in 2005, but the energy derivatives prices change for the main fuel categories were more consistently increased, where the lubricant like Motor, Gear and Break energy derivatives was changed by -4% - 10% between 2001 and 2005. The data in table (2.7) shows the highest frequency in the diesel prices, because the growth in its prices was decline from 24% in 2001 to -3% in 2003 and it does refer to increase in 2004 from 15% to 25% in 2005. But the growth prices for Kerosene moved between 19% in 2001 to 15% in 2005 and the Benzene # 96 prices was changed more smoothly between 7% and 6% in 2001 - 2005, and the Benzene # 98 prices were moved backward from 12% in 2001 to 5% in 2005. We can note that there is sharply dropped in 2003 as not normal year where it reached to -3% as result to the sage and the closed by Israel.

Table (2.7) Average consumer prices for some types of fuels and energy in Palestinian Territories during 2001 – 2005 in NIS

Energy Category/ Year	Trade Mark	Origin	Pay Unit	2001	2002	2003	2004	2005
Electricity average Kw./ minimum limit		Local	Kw	0.47	0.55	0.56	0.54	0.54
Electricity average Kw./ additional		Local	Kw	0.48	0.53	0.62	0.64	0.64
Gas Cylinder		Local	Cylinder 12 Kg	36.51	37.06	36.39	38.91	44.53
Charcoal		Local	1 Kg	3.47	3.75	3.69	4.29	5.02
Motor Energy derivatives	Bin Dix	Israel	Bag 1/2 Liter	11.42	13.22	13.89	11.74	12.67
Motor Energy derivatives 40	Baz	Israel	1 Liter	14.62	14.19	14.91	14.34	15.4
Gear Energy derivatives	Sonol	Israel	1 Liter	14.48	14.35	14.56	15.78	15.51
Break Energy derivatives	S.T.P	British	Bag 350 Ml	8.24	8.42	8.72	9.33	10.22
Diesel	Badisco	Israel	1 Liter	1.95	2.41	2.34	2.69	3.37
Gasoline		Israel	1 Liter	2.27	2.69	2.61	3.01	3.45
Benzene 96	Badisco	Israel	1 Liter	3.99	4.27	4.54	4.81	5.16
Benzene 98	Badisco	Israel	1 Liter	4.39	4.92	5.32	5.31	5.58

Source: Palestinian Central Bureau of Statistics. See appendix (4)

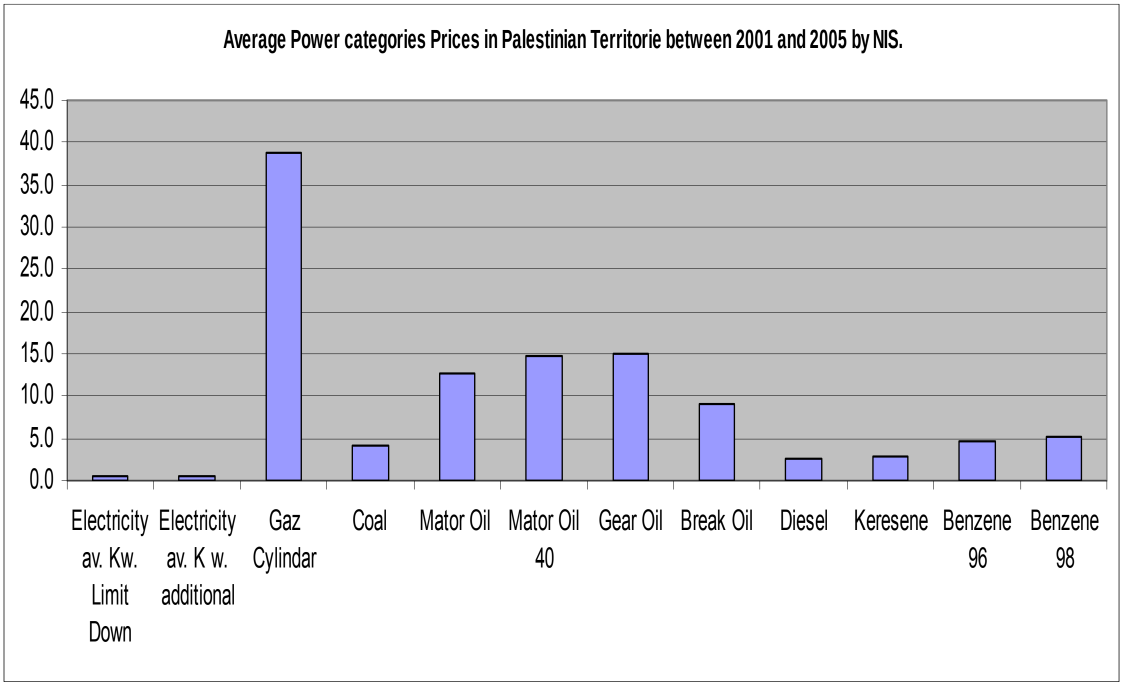


Fig. (2.7): Average Energy Categories Prices in Palestinian Territories between 2001 and 2005 by NIS.

2.4.2 Factors Effects in the Energy Derivatives prices:

The main factors that stand up behind the high levels are the uncontrolled player of exogenous factors in the Palestinian court and market like the limited permits of imports for these energy derivatives which it come with more obliged by Israeli traders (insecure supply and geopolitical risks), the mechanism of market (demand and supply) and the futures market in relation to the changes in the energy derivatives prices.

- Demand: the demand for energy derivatives during 2001 – 2005 was steady growing by normal expanding demand of regional economy, where the imports of energy derivatives data during that period in Palestinian territories which indicate that to the Palestinian energy consumption by 720,140 thousand dollar in 2005, and the demand of electricity was represented the most of the energy derivatives price where recorded by 191,955 thousand dollar in the same year.

- Supply and geopolitical risks: the supply of energy derivatives has been increasing in correspondence with the increasing demand with creating a critical situation where the demand can not be satisfied in 2003 for many reasons through the deeply reactions by Israeli forces in intifadah events.

2.5 Gross Domestic Product or GDP:

The Palestinian economy had witnessed a significant development since the advent of the PNA in 1994 up to the year 2000, when the second Intifada erupted. Historically, the value of GDP in Palestine increased from 440 million dollars in 1968 to 2238 million in 1992, and then jumped to 4562 million dollars in 1999. With the commencement of the second Intifada in 2000, the level of GNP(Gross National Production) has decreased significantly by approximately 20% during the subsequent years, and continued to do so until 2004 when GNP level returned to its 1999 level. While GNI (Gross National Income) lost about 38% for the same period. The 2001 - 2002 period was the most critical period in Palestine as expressed in both economic and political aspects. However, since 2004, there is a signal of weak recovery, thus GDP may have a positive rate of growth in 2005.

The definition of the Gross Domestic Product or GDP is the summary measure of the output or production during a certain period in time. Estimate of GDP, like the output and the value added, can vary according to taxes and subsidies taken into consideration. GDP is usually estimated at market prices, producers' prices, or basic prices.

Table (2.8) Gross Domestic Product by Expenditure for the Years 2000-2005 at Current Prices Value in US$ Million

Final use	**Remaining West Bank* and Gaza Strip**							
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
GDP	3,944.30	4,178.50	4,194.70	3,897.20	3,432.60	3,840.90	4,198.40	4,634.40

Data Source: Palestinian Central Bureau of Statistics

The Palestinian Economy is still suffering from economic crises, caused by the Israeli measures in the Palestinian Territory since the beginning of the second Intifada in September 2000. There was a substantial decline in the performance of different socioeconomic areas, which had reached its core in 2002. In 2003, the Palestinian economy had accomplished a slight improvement in most economic activities.

The findings of the National Accounts at constant prices of the Remaining West Bank and Gaza Strip for the year 2003, showed that the value of the Gross domestic product had reached 4010.8 million US$ at constant prices (1997 is the base year), with a growth rate of 4.5% compared to the year 2002, and a decline by 11.1% compared to 1999. Although the value of GDP per capita was 1184.8 US$, with a decline of 0.5% compared to 2002, and 25.5% with the 1999. The Gross national Income amounted to 4372.5 million US$, by 7.0% growth rate compared to

2002 and a decline by 17.3% compared to 1999. GNI per capita was 1291.6 US$ through 2003, to set down an increase by 1.9% compared to 2002 and a declined by 31.6% compared to 1999. The Gross disposable income amounted to 5869.1 million US$ in 2003, increased by 12.7%, 3.2% compared to 2002, 1999 respectively. GDI per capita accomplished a growth rate by 7.3% compared to 2002, and declined by 14.7% compared to 1999. The 2003 findings showed also an increase by 8.3% in final consumption which reached 5371.7 million US$. The household final consumption formed 4128.1 million US$, with a 12.4% growth rate compared to 2002, and declined by 1.2% compared to 1999. The value of gross capital formation was 1126.3 million US$ during the year 2003 accomplishing a growth rate by 66.1% compared to 2002 and a decline by 45.9% compared to 1999. The deficit in trade balance for net exports of goods and services amounted to 2487.1 million US$. Performance of Main Economic Activities indicates the following:

- The gross value added for Agriculture activity increased by 11.0% during 2003 in relation to 2002, while declined by 10.4% compared with 1999
- The gross value added for Manufacturing (Mining, Manufacturing, Electricity and Water Supply) in Remaining West Bank and Gaza Strip declined by 27.8%, and 35.6% during 2003 compared to 2002 and respectively 1999.

- The gross value added for Construction activity grew by 65.5% during 2003 compared to 2002, while declined by 76.5% compared to 1999.

- The gross value added for Wholesale and Retail Trade and Financial Intermediation activities declined by 9.6%, 3.8% compared to 2002 respectively, and declined by 23.6%, 17.0% compared to 1999 respectively.

- The gross value added for Transport, Storage and communication activities declined by 0.4% during 2003 compared to 2002, and declined by 63.7% compared to 1999. The Gross Value added for Services activities grew by 11.1% compared with 2002 and by 11.0% compared 1999.

Chapter 3

Solar Energy Potential and Applications

Chapter 3
Solar Energy Potential and Applications

Energy from the sun travels to the earth in the form of electromagnetic radiation similar to radio waves, but in a different frequency range. This sunlight is a clean, renewable source of energy. It is a sustainable resource meaning it doesn't run out, but can be maintained.

There are many ways that solar energy can be used effectively. In this chapter, many topics will be discussed: solar constant, solar energy potential in PT's, solar energy systems: solar thermal applications, photovoltaic (solar cell).

3.1 Solar Constant

The solar constant is defined as the quantity of solar energy (W/m^2) at normal incidence outside the atmosphere (extraterrestrial) at the mean sun-earth distance. Its mean value is 1367.7 W/m^2.

Solar constant acquires special importance in the applications of solar energy so that it can not in fact access to the amount of energy from the sun is higher than the value of solar constant, for the amount of energy reaching the Earth is less than the value of solar constant because of the inversion of solar radiation absorbed or while transiting Atmosphere.

It's possible to calculate the value of solar constant and sun as a black body temperature 6 thousand degrees Kelvin, as a result of these accounts produces the value of the solar constant equal (1600 w/m^2) , but the measurement process conducted by the spacecraft gives value less than that value as computational practical value amounting to (1353 w/m^2). The solar constant has had many different numerical expressions throughout the years, some of the more familiar ones have been:

1353 W/m^2, 1366.1, 1363, 1367, 1367.5, 1367.7, 1368, 1370, 1371, and 1395.

From the previous data, one may see that the concept of a "constant" is actually rather variable. Supposedly, the concept of a "constant" means that the particular event being observed or analyzed remains constant throughout the Universe. In this specific case, we are talking about the Sun's radiation that reaches the surface of the Earth, and therefore, we may comprehend a certain variance in the nature of the events, depending upon variables in the numerous conditions of existence. For example, at what position on the surface of the Earth one takes the measurement, and whether the measurement is made below or above the Earth's atmosphere, and so on.

3.2 Solar Energy Potential in PT's

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 (6.2

Kwh/m².day) in the rest of the year. The following table (3.1) shows the values of solar radiation in different locations in Palestine.

Table (3.1) Daily Average Global Solar Radiation (kWh/m².day) in PT's

	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

3.3 Solar Energy Applications

Sun gives energy in two forms: heat and light. , so human seek with the passage of time to use solar energy ideally in numerous applications, and in the following some applications that can be used in the Palestinian Territories.

3.3.1 Solar Thermal Applications

Today, we are able to harness solar energy in many ways, including using it for water heating, solar heating and cooling of buildings, crop and vegetable drying, and greenhouse agriculture.

3.3.1.1 Solar Water Heater (SWH)

Solar water heaters come in a variety of configurations. Each differs in design, cost, performance, and level of complexity. There are two main types of systems: passive and active solar heating.

* ***Passive Solar Heating.*** It can be inferred by its name, where the sun acting in everything without any mechanical help in any ways.

When referring to space heating, passive solar design takes advantage of the sun's warmth through such design features as large, south-facing windows and materials in the floors or walls that will absorb warmth during the day and release that warmth at night, when the heat is most needed because the south side of a building always receives the most sunlight. Passive solar water heating refers to a hot water system that is not aided by heat pumps. These systems will include a solar collector to heat the water and a storage tank to store the hot water.

* ***Active Solar Heating.*** Active solar heating uses the same concepts in terms of passive solar heating, absorbs sunlight and compounded by using a special mechanical designs. Active solar heating generates more heat for hot water and space heating more than passive solar heating, there are two essential active solar heating system based on whether liquid or air is heated in the solar collector. An air-based system heats air in an "air" collector, and a liquid-based system heats water or an antifreeze solution in a "hydronic" collector. Both of these systems absorb and collect solar

radiation, then transfer the solar heat directly to the interior space or to a storage system; an auxiliary or backup system provides the additional heat.

The technical potential for residential applications of solar heating systems is 0.5 to 1.0 m^2 of solar collector/inhabitant. “Solar countries” such as Israel, Greece, and Cyprus already have high “solar water heating penetration” (Israel has about 0.95 m^2 per inhabitant), whereas some of the best IEA (International Energy Agency) countries, such as Greece and Austria, have a penetration of between 0.2 and 0.25 m^2 per inhabitant.

Most solar water-heating systems have two main parts: (1) solar collector and (2) a storage tank. The most common collector used in solar hot water systems is the flat-plate collector, and the most common water heating methods is thermosyphon system, and Collective systems.

3.3.1.1.1 Flat-Plate Collector.

The most solar collectors which are sold in many countries are of flat-plate collector which is composed of insulated metal box covered with transparent front cover plastic or glass, called the glazing, and dark-colored absorber. The absorber, inside the flat-plate collector, converts sunlight to heat and transfers it to water in the absorber tubes. The absorber is usually made of materials such as copper, galvanized steel, aluminum or fiberglass-reinforced plastic. The collector housing can be made of plastic, metal or wood and the glass front cover prevent wind and breezes from carrying the collected heat away. However, the glass also reflects a small part of the sunlight, which does not then reach the absorber at all. The first accurate model of flat-plate solar collectors was developed by Hottel and Whillier in the 1950's. Figure (3.1) shows the processes occurring at a flat-plate.

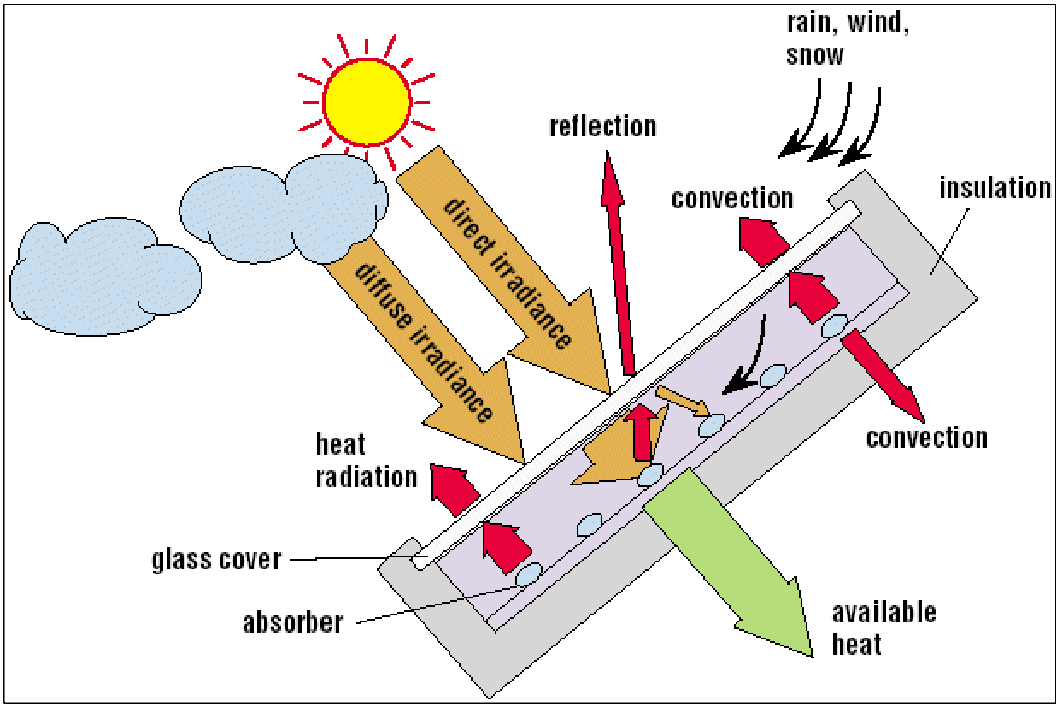


Fig (3.1) Processes at a flat-plate collector

Source: http://www.volker-quaschning.de/articles/fundamentals4/index_e.html

3.3.1.1.2 Thermosyphon systems

There are several systems for storing water in cloudy days or at night through the use of tanks based on the principle of gravity is the most important of these systems the thermosyphon system is shown in figure (3.2) This system relies on that cold water has a higher specific density than warm water, making them heavier and thus moves down to the bottom. Therefore, the water storage tank is always mounted above the collector, so that cold water reaches the collector from via a descending water pipe. After the collector heats up the water, the hot water rises again and reaches the tank through an ascending water pipe at the upper end of the collector. The cycle of tank–water pipe–collector ensures the water is heated up until it achieves an equilibrium temperature. The consumer can use hot water at the top of the storage tank, and any quantity of hot water used is replaced by cold water at the bottom. Then the collector heats up the cold water again.

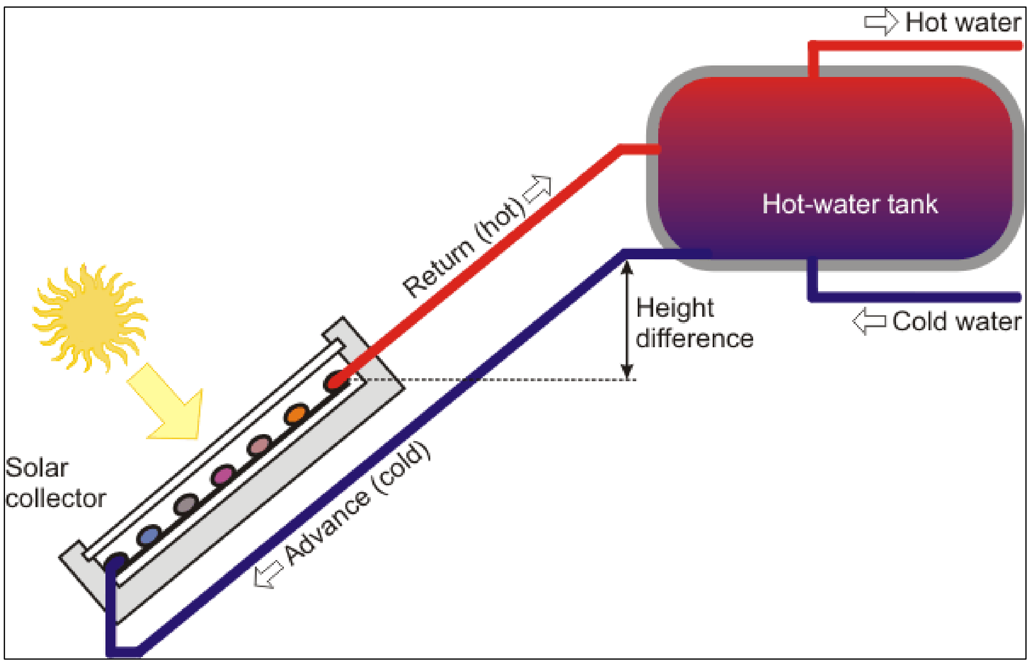


Fig. (3.2) A thermosyphon system

Source: http://www.volker-quaschning.de/articles/fundamentals4/index_e.html

3.3.1.1.3 Direct Pump Solar Water Heaters

In this system of heating systems depends on using pumps devices to move water between storage tanks and collectors, the site for storage tank is not important as can be level or low level of the collector see figure (3.3), the goal of using pumps is to raise the efficiency of water heating system compared with systems that rely on thermosyphon system.

But this system of course has a disadvantage that is using of the electricity for the operation of the pump. This system often used in commercial applications, and in hospitals in developing countries.

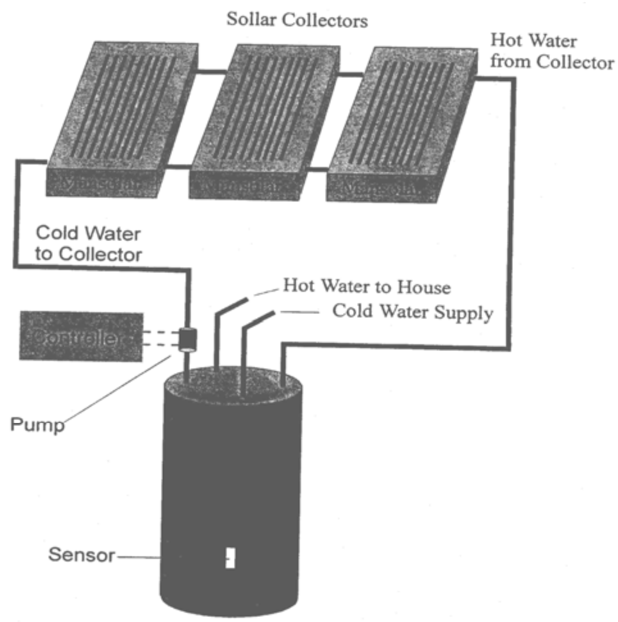


Fig. (3.3) Direct pump solar water heater

3.3.1.1.4 Applications of Solar water Heaters in PT's

The sectors which consume the hot water show significantly in residential and there are other sectors such as services sector (hospitals, medical clinics, educations), commercial (hotels, restaurants) and industrial sector, but as noted in the previous chapter that their is no statistical information about quantity of hot water consumed in each sector except residential sector.

Households: have the fundamental role in the market of solar water heating. About 67.2% of houses are actually using solar family system of water heating in 2005(PCBS survey of house energy 2005).

* One of the most common solar water heating systems is thermosyphonic open circuit system which allows using hot water directly by consumer. This system consists of 2 or 3 flat-plate collectors, each measuring 1.7 m^2, a rating of 2750 kcal/ day (iron collector) as a yearly average output, and it directed to the south with angle 42º.

For climate conditions, three collectors are generally used in hilly areas, while two collectors are utilized in the Jordan Valley, Jenin, Tulkarm and Gaza Strip. The hot water storage tank has a capacity of 150-200 litres. The cold water supply tank is located generally above the hot water storage tank. The area of a system with three collectors is 5 m^2 which can produce 12 kWh daily, particularly in summer time or 200 litre of hot water (50-60 ^oC).

In 1999, in Palestine their was a 15 manufacturing workshop for local solar water heating system and about 26,000 units were manufactured locally.

Industry of solar water heaters is strongly affected by the Israeli market due to the occupation and Israeli monopolizing practices on the trade movements throughout the borders and obstacles on import/ export of material and products. However, the raw material is usually imported from Israel, Europe and Turkey such as the shell for the hot water storage tank and the inner painted lining of the storage tank, pipes, insulation materials, sheet metals and pumps.

- Collective systems: Many of the apartments in residential buildings in the Gaza Strip and Nablus have been using this system as it more than

20 systems are available in 1999, in addition to its use in hospitals see figure (3.4), hotels and universities, fitness clubs, and security residencies. The perspective of collective systems seems large if real efforts are directed towards the efficient utilization of solar energy by imposition of standards to improve the quality.

Fig. (3.4) Collective Solar system at Jericho hospital

Source; www.perc.ps

* Direct pump system: This system is used in the roofs of villas where storage tank is kept indoor, sited at the same level as the collector and the pump circulate hot water between storage tank and the collector see figure (3.5).

Fig. (3.5) Direct pump system on the roof of villas

The system is considered direct because no heat exchangers are involved during the heating of water. The liquid that runs in the collector is the water used by the consumer.

* Central (SWH) for apartment buildings: this system successfully used and adopted for apartment buildings in Palestine, Solar collectors are shared for all apartments. Collectors are connected in arrays and parallel and then in series, as shown in figure (3.6).

Each three collectors are connected in series to form one group and then connected in parallel to the similar groups that is in some designs and within the array itself. Each apartment uses the domestic hot water separately. The hot water is a double jacket storage tank and acts as heat exchanger, inside each apartment one storage tank is installed.

A mixture of water and antifreeze is the liquid heat carrier that runs through the solar collector, to circulate the heat carrier liquid from the solar collectors to the heat water exchangers and back a pump is used. The temperatures are sensed by the differential controller at the coldest point in the storage tank and the hot end of the solar collector. If the temperature difference is higher than a predetermined value, it will activate the pump. An electric back up system is installed in each storage tank. The cost of this type of systems is around that of individual ones.

In 1999 more than 20 systems of this type have been installed in Gaza and West Bank. They have been working perfectly for the last few years. This system has observed many advantages such as:

- No needing for stands or cold water on the roof.
- The number of collectors is less than that in traditional system, Almost 20% of collectors could be saved.
- Comparing with thermosyphone system about two third of the space on the roof is needed.
- Neither freeze nor calcification problems observed.
- Saving of one to two cubic meter of water each month for each apartment, in addition to minimum heat losses from the hot water storage tank, due to placing the storage tank indoor and close to a place of use.
- Better view of the roof and eventually of the city.

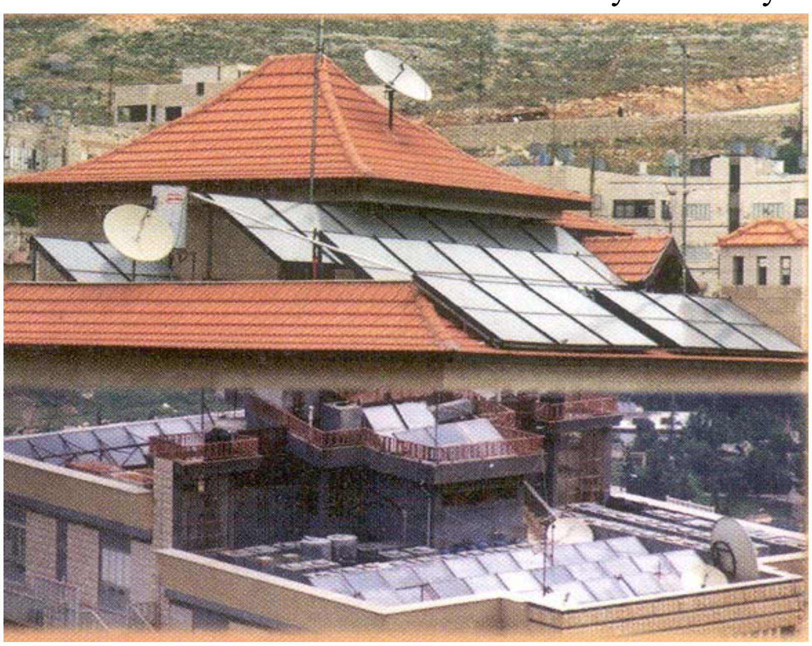


Fig. (3.6): Central solar water heater for apartment buildings

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

3.3.1.2 Solar Heating and Cooling of Buildings

Passive solar space heating is used in traditional and wide form in Palestine, particularly when the buildings were constructed and windows were oriented to the direction of the sun to benefit from the direct rays in heating the indoor air but it is an ineffective way, because the duration of the sun is a few hours especially in winter and also there is no way to keep heat inside for moor hours.

Passive solar heating is the absorption of solar energy in a building to reduce the energy required to warm the habitable areas (i.e. to contribute to space heating).

Air is normally used to circulate and distribute the collected energy, generally without the use of pumps or fans. The collector may be an integral part of the building, perhaps designed as part of an architectural feature that provides light and heat.

Indeed, the air flow generated can be used as a means of ventilating the building, or even cooling it by drawing in cooler air to replace upwardly moving solar heated air.

Different types of passive solar heating and cooling for buildings will be discussed in detail in chapter 4, which summarizes solar applications in residential and public buildings. **These systems include: Solar Window, Solar Wall, Solar Roof, Solar Chimney and Greenhouse (Solarium).**

3.3.1.3 Solar Thermal Electricity Generation

Solar thermal energy can be collected at large scale and used to heat a transfer fluid that can then power a steam turbine to generate electricity. Sunlight may be collected using huge mirror arrays focused on to a receiver at the top of a tower or, at the other extreme, may be based on the temperature gradient produced when sunlight impinges on a "solar pond" (a large salty lake) and heats the water at its base.

Most commercially attractive is the solar thermal electricity generation system originally developed by Luz, which uses parabolic reflectors to warm heat-transfer oil running through a pipe at the focus of the reflector. This heated oil is used to raise steam to power a turbine.

3.3.1.4 Solar Drying

Using the sun to dry crops, grains, vegetables and to make yogurt is one of the oldest and most widely used applications of solar energy. The simplest and least expensive technique is to allow crops to dry naturally in the field, or to spread grain and fruit out in the sun after harvesting, but this industry is small and limited in some villages and charitable institutions and voluntary

3.3.1.5 Greenhouse Agriculture

Another agricultural application of solar energy is greenhouse heating. Solar greenhouse is designed to utilize solar energy for both heating and lighting see figure (3.7). Greenhouse is used to plant many flowers and vegetables, medicinal herbs, and it has many benefits such as increase production and reduces the amount of water lost in irrigation in addition to a temperature appropriate for the growth of some plants, but it is still using traditional.

Fig. (3.7) Greenhouse heating in one of The Palestinian Village

3.3.1.6 Solar cooking

Solar cookers are great educational tools; they fall into two main categories –direct solar concentrators and solar ovens. The basic design for a solar oven is that a glass cover of a box . the insulation lined The box and a reflective surface is applied to concentrate the heat onto the pots. The other approach is to reflect the suns rays onto a put, often with a parabolic dish. The pots to absorb heat it can be painted black. It is a real oven, it typically cooks at temperatures between 225 - 275 F. and will cook most anything you would put in your oven at home. They are considered a slow cooker, usually taking about twice as long as your conventional oven.

The cookers have limitations in terms of only being effective during hours of strong sunlight on a domestic scale. For the periods when there is cloud or during the morning and evening hours there is another cooking oven. However, the main advantage to solar cookers is that wood does not need to be purchased or collected, which is often a very time consuming activity for women. There are many forms of solar cookers the following figure(3.8) shows one of them.

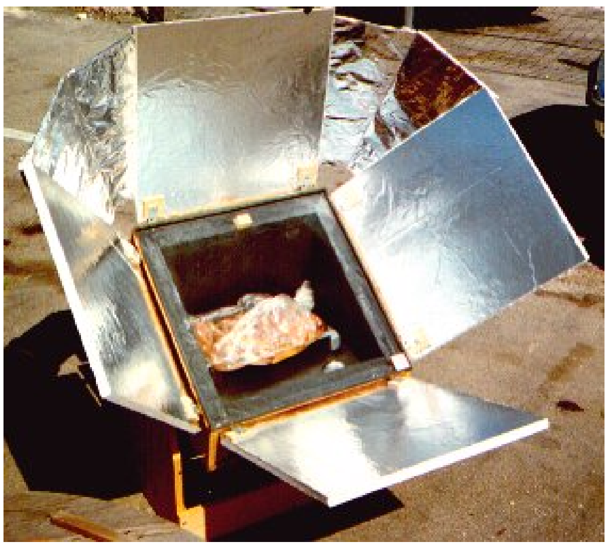


Fig. (3.8) Solar Cooker
Source: http://www.cookwiththesun.com

3.3.2 Photovoltaic (Solar cell)

Photovoltaic (PV) or Solar cell is an energy conversion system which converts the light comes from the sun into electricity. PV's have played an important role in our life, such as feeding satellites with needed electricity and they have many applications and benefits, as will be discussed later.

The amount of solar radiation varies with the passage of time during the day, solar cells can work between the hours of 6 a.m. to 6 p.m. and the value of energy generated almost remain within the normal distribution curve compared with the axis of time as shown in the following figure (3.9).

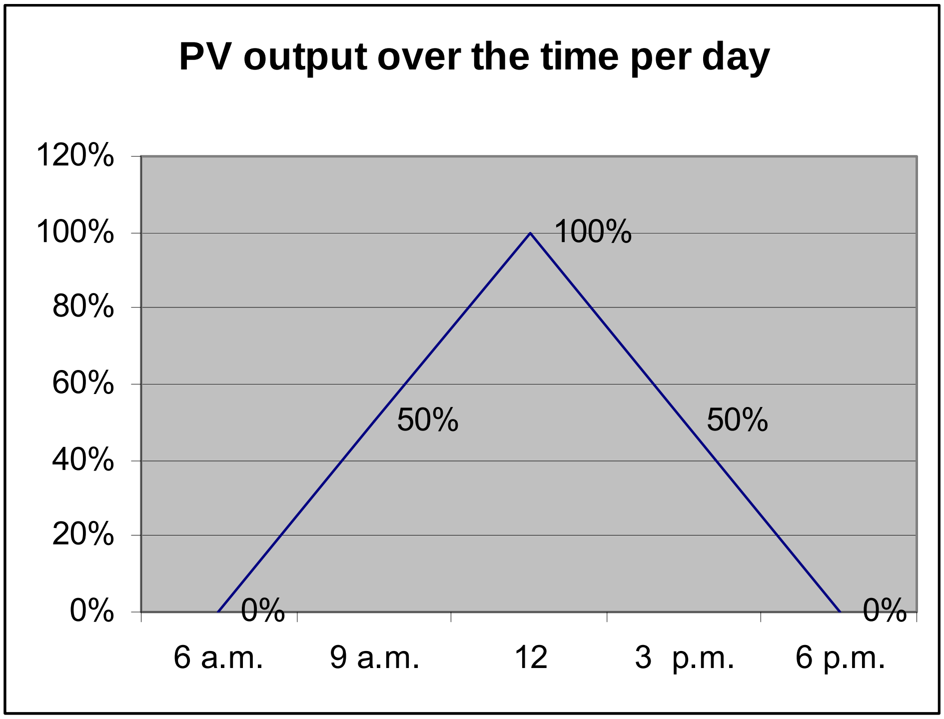


Fig. (3.9) PV output over daytime per day

3.3.2.1 How photovoltaic work?

The solar cells (PV) convert sunlight directly into electricity without the need to heat the air or water.

Photovoltaic cell made from at least two layers of the semiconductor material is usually silicon. A positive layer which called p-type, the other layer negative which called n-type, and between them area that called p/n junction, see figure (3.10).

When light falls on the cell surface and then enter the photons will be absorbed by atoms semiconductor article, which lead to liberation of electrons from the negative layer flowing across the electric circuit and then return to class with which constitutes a positive flow of electrons electricity.

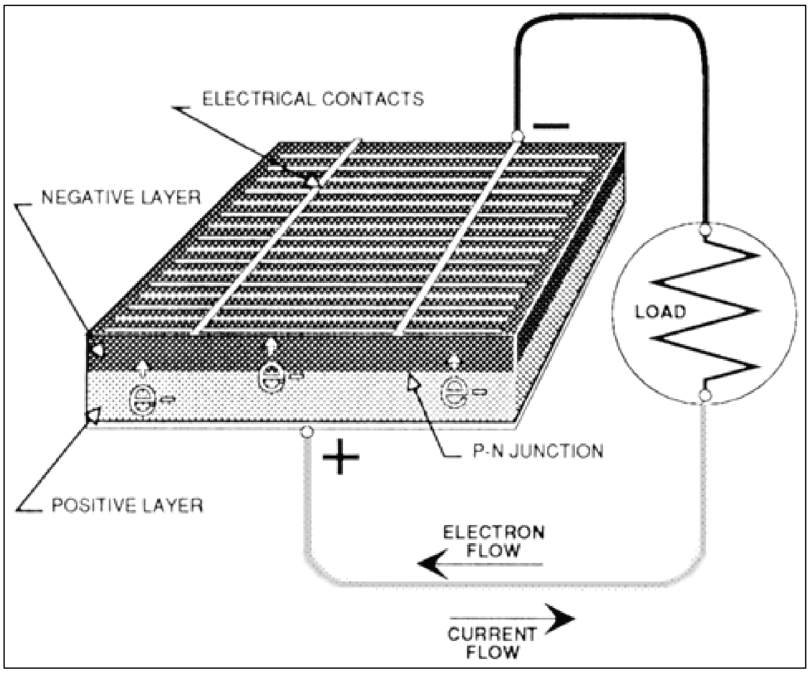


Fig. (3.10) Components of PV Cell

Source: http://polarpowerinc.com/info/operation20/operation23.htm

These cells are linked with each other in a sealed so-called module. When two modules are linked with each other in series the voltage will be doubled, while the current remains constant, but when two modules are linked in parallel the current will be doubled and the voltage remains constant.

For the current and the voltage that be required many number of modules are linked to each other in a series and parallel form which called array. The following figure (3.11) shows photovoltaic cell, module, and array.

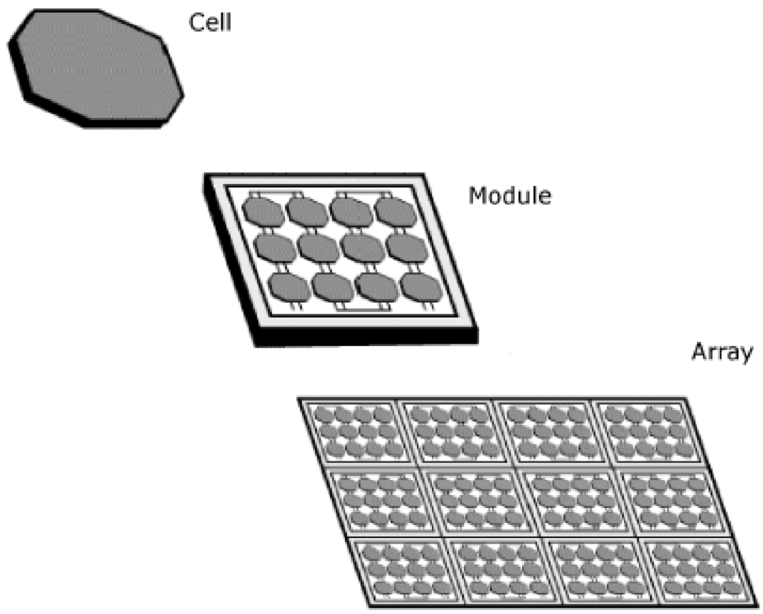


Fig. (3.11) Photovoltaic Cell, Module, and Array
Source: http://www.blueplanet-energy.com/images/solar/

*** The Four General Types of Silicon Photovoltaic Cells are:**

- Single-crystal silicon.

  15% efficient, typically expensive to make (grown as big crystal)

- Poly-crystalline silicon (also known as multicrystal silicon).

  10–12% efficient, cheaper to make (cast in ingots)

- Amorphous silicon (also known as thin film silicon).

  4–6% efficient, cheapest per Watt, easily deposited on a wide range of surface type

- Ribbon silicon.

They are made by growing a ribbon from the molten silicon instead of an ingot. These cells operate the same as single and poly-crystal cells. The anti-reflective coating used on most ribbon silicon cells gives them a prismatic rainbow appearance.

3.3.2.2 Advantages of Photovoltaic

Photovoltaic (PV) systems are an important energy technology for many reasons such as:

- **PV costs little to build and operate**

Once installation of PV systems can produce electricity continuously with minimal operating costs, installation and maintenance, these cells are usually installed near the scene, which uses electricity and usually require much shorter lines used in the power distribution network, which means less consumption of wire, low cost of the time required for installation, and reduced permitting paperwork, particularly in urban areas.

Low-maintenance, cost-effective PV systems are ideal for supplying power to remote communications stations, navigational buoys at sea, and homes more than a quarter mile from utility power lines.

- **No fuel use**

One of the main features of the photovoltaic system that do not need fuels such as diesel or kerosene to produce electricity but the reliance on the Sun as the main fuel and it does not cost money it is free in the extraction or reprocessing, or Depletion.

- **PV is modular and thus flexible in terms of size and applications**

Fortunately in the use of photovoltaic cells that are not one size fits all applications but a photovoltaic system can be built in any size response to the needs required in the various applications, For instance, homeowners can add modules every few years as their energy usage and financial resources grow. And ranchers can use mobile trailer-mounted pumping systems for watering cattle that are rotated around different field.

- **PV is highly reliable and needs little maintenance**.

What is the value of the electricity when it is not available?

To consider this question once thought of the last lost of electricity on your house and what you are doing at that time such as studying examinations, watching television, using of the Internet, the cleaning of the house or preparing food and other things that relying on electric equipment in their work.

However, many companies lose a lot of money when their work disrupted for a few minutes due to the outage of the electricity, that from here we can see the importance of reliability key to these things.

Also the photovoltaic system was developed for use in space to provide the majority of Satellite orbiting the Earth for energy operations, where repairs are expensive and impossible in addition to the reliability of it is working for a long time, it does not need for maintenance, and work on the production of energy in all forms of weather with various efficiency.

photovoltaic is easy maintenance system contains no moving parts and the battery which associated with the system sufficient to maintain the effectiveness and operation of the system so that when the manufacturing cells be built, it will be tested for the weather conditions as impact of the hail, high winds, freezing and melting, and the different weather does not affect the productivity of photovoltaic as is the case in other types of media Energy production.

- **Long life**

Photovoltaic system has a long life there is not a decline in the level of its performance before 15 year.

- **PV has virtually no environmental impact**

Photovoltaic system does not have environmental effects, making it one of the cleanest techniques used in energy production.

It does not burn fuel to produce electricity, which means that there is no gas is emitted to pollute the air or the lifting of global warming, but when we compared it with electricity generated from fossil fuels which result in the emission of large quantities of toxic gases such as carbon dioxide, nitrogen oxide, sulfur dioxide Which means air pollution and the environment and an increase in global warming.

PV system also has no moving parts, if it does not affect the output of the environment in disturbing voices, and don't made noise.

Since that PV system is manufactured from small quantities of chemicals, it reduces the risk and the resulting of its long life is few of the process of disposal or destruction that can be controlled.

From all these things we can deduce that the PV system is friend to the environment.

- **PV is strengthening the economy and reducing trade deficit.**

Despite tireless efforts and substantial steps to reduce the cost of electricity production by photovoltaic but it is not yet competitive in terms of electricity use with the fixed network, but however is the fact that the sources of energy used in the production of electricity on a continuous rise in the cost and reduced production and undoubtedly the cost of electricity produced by the photovoltaic system become few and economic.

Also not rely on using fuel in photovoltaic means no need to import it; we will have saved large amounts of money in addition not rely on any other country in the refueling, also can be said because PV has a long life that their using is economically.

The latter case, if (PV) was manufactured locally, it will save many of the import expenses of the State as well as provide jobs for many unemployed and thus contribute to reducing the budget deficit in the State.

- **Development human life**

When using photovoltaic especially in remote areas which not reached by electricity network, that help to improve the life in those areas where lighting can be provided, and there are an opportunities to become a communications network also using essential and luxury homes needs, such as washing machines and refrigerators as well as many others.

3.3.2.3 Common Photovoltaic Applications

Photovoltaic system generates clean electric power, as I said earlier from its advantages it is modular that could be connected a number of modules in parallel or serial, this operation made PV system access to different Voltage easy and this means that can be used in several applications for different voltages.

The most important areas where the use photovoltaic system is remote and rural areas and where there is no electricity or generally network access to electricity is expensive.

This increase dramatically the quality of life for local population and encourage them to stay in their villages without the need to reflect on migration to big cities in order to improve the standard of living.

The following figure (3.12) summarizes the applications of PV systems as a function of installed peak power. As shown, the range of possible applications extends from very small devices such as solar calculators or watches to the grid-connected multi-megawatt power plants.

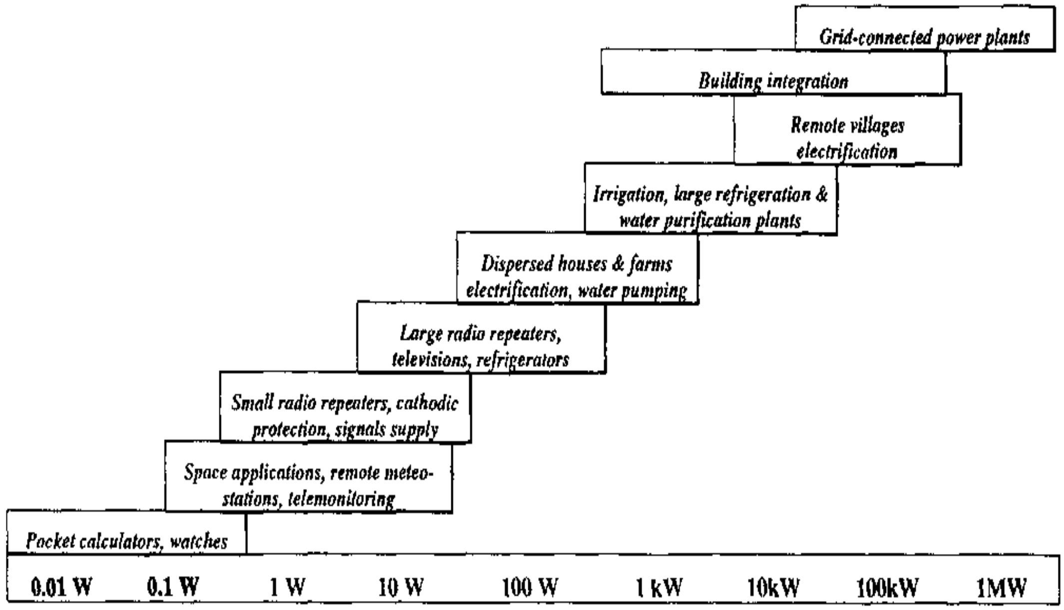


Fig. (3.12) Photovoltaic Applications

upbooks/uu24ee/uu24ee0i.htm

In the following some common application for PV:

- **Remote village electrification**

In many villages and remote areas there is no electricity network, but is often rely on private generators to provide the simple requirements of the population who are in these areas because of many reasons:

* The electricity network is far away from these areas.

* The distance between the houses is large.

* The number of population is few.

* And on the other hand that connecting these areas with electricity network is costly, difficult and economically not feasible

But because the life in constant evolution must find a way easier and cheaper to secure the needs of these areas with electricity, many studies and research projects proof that the PV system is the least expensive and easier option connectivity to meet the requirements of energy.

The PV system supplies energy effectively for the operation of refrigerators, televisions, lightings, radios, etc. and the following figure (3.13) shows PV arrays in one of the villages that used the PV system.

In social terms their are many benefits of the PV system such as it is economic prosperity and improve the standard of living in the village in general and women in particular, by reducing the time required for the basic tasks, such as access to water and light up the house, and the health situation in these areas is through establishment of health clinics and provides electricity and therefore be able to provide treatment and preservation of medicines, vaccines and the refrigerators at home can be preserved food, thus preventing food poisoning caused by corruption.

It is also the development of social education, where it could provide schools with lighting and sophisticated learning facilities such as computer and the provision of clean water, which would have a positive impact on the village or the region as whole different age groups.

Fig. (3.13) PV array in one of the village

Source: www.perc.ps

For example, in Palestine, many residential communities lacking electricity and the possibility of connecting power are very poor in the near future due to the political and financial.

The total number of Palestinians villages that are not electrified in 2005 was more than 40 villages.

The daily demands of these villages from electricity is low, some people of these villages depend on private diesel generators which mostly are used unprofessional, making it dangerous use, these small generators pollute strongly the environment, and are not reliable due to their frequent faults. In addition a high diesel prices in Palestine estimated 3.45 Shekels per liter.

- **Water pumping**

Photovoltaic system is ideal often used for water pumping for irrigation, drinking, and small industrial purposes.

PV-powered water pumping is especially popular in rural areas because, although the electricity is used as it is generated, the water can be stored in tanks and reservoirs during daylight hours and then using water by gravity when it was needed especially at night. And storing water is much cheaper than storing electricity.

For most of the agricultural irrigation water is needed during daylight hours in summer especially when the plants need water, here is the effectiveness of solar cells and highly significant because the sun is strong.

Pumping system through PV is excellent in the small and medium-scales of pumping needs.

PV water pump lock like other water pumps but what distinguishes it that it does not depend on any type of fuel, but the source of energy is the sun. PV pumping system consists of simple parts in the form of solar cells (PV array), motor, pump and tank to store water, sometimes PV array placed or fixed on passive trackers in order to increase pumping volume or time. There are two types of motors AC or DC can be connected to the system.

When the sun shines and its rays fall on the surface of the PV array, it converted sunlight directly into electricity and the electricity gathered in the array and then goes to the pump's controller and motor after that pump push up water from the well to the tanks for use, the following Figure (3.14) shows parts of the PV pumping system.

The use of this system has many advantages as well as it is not expensive, economically, does not effect on the environment because it does not use any kind of fuel and also contribute in raising the standard of living and health of the population especially in rural and remote areas.

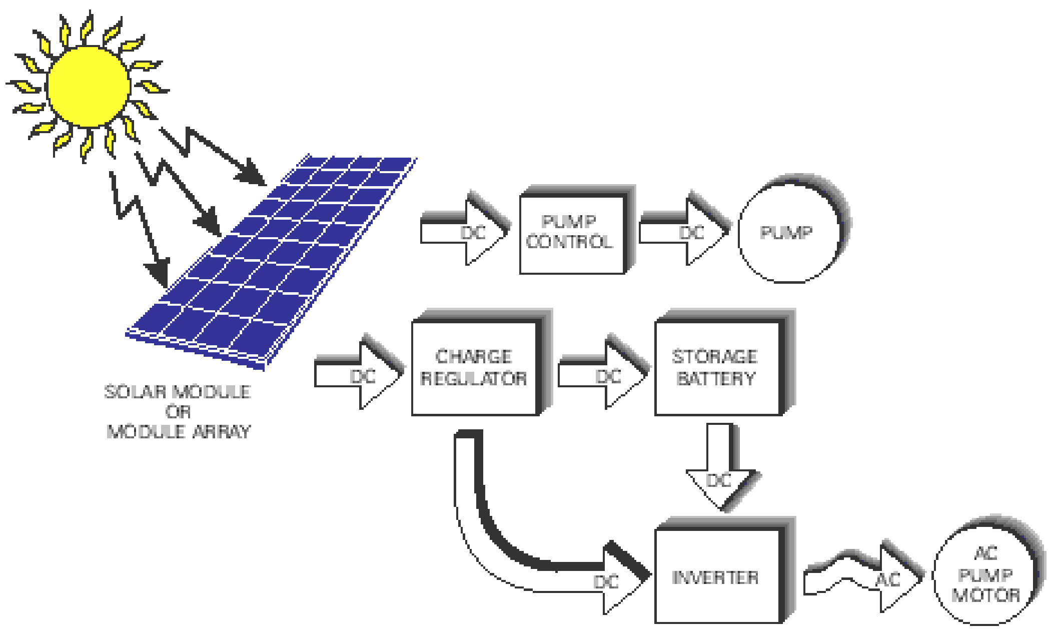


Fig. (3.14) Parts of the PV Pumping System
Source: http://www.kyocerasolar.com/solar/pumping.html

- **PV electrification of clinic in rural village**

There are many villages where clinics are not connected to the electricity grid and thus services may be limited and insufficient to the needs of the population.

The average load in these clinics is estimated at about 2.4 kwh/day, which is to run refrigerators medicines and vaccines, lighting, and some simple medical equipment, so easy to deliver electricity to these clinics by using PV system with low cost less than the cost of using fuel generators or Linked it to the public network and this helps in raising the standard of health in these villages.

- **Lighting**

PV lighting is lighting that operate by the electricity which produced from PV cells these kind of lighting systems are reliable and cheap cost, they used in many parts of the world and the most common applications of PV lighting are: In remote locations such as nature preserves, mountain areas, national and state parks, or rural towns and villages, street lighting, security, gardens, billboard, highway signs ,vacation cabins, and car's parking.

These PV lighting systems are usually off-grid, or "stand-alone" system and a source of energy is the sun only.

PV powered lighting system collects solar energy using one or more PV panels, energy is stored in a battery or a series of batteries and then releases the energy to operate light sources (lamps) at night.

PV lighting system consists of PV panels, batteries, electronics (including battery charge controller, inverter, and timer or switch), light sources (lamps), and luminaries, the following figure (3.15) shows PV lighting system components and energy flow diagram.

The most lamps which are recommended in these systems of lighting are fluorescent or sodium lamps with low voltage (12 or 24 volt DC) because of there high efficiency of lumens per watt. The batteries which are used in these PV lighting systems are designed specially for this purpose the best type of battery is deep discharge (deep-cycle) battery that can be repeatedly drained its energy and recharged, these batteries must be replaced when their rated capacity are reduced less of 80%, batteries must be put in protected place in order to resist the changes in weather, during the time work maintenance must be done to these batteries and keep these batteries a clean to ensure maximum performance, batteries must be regulated by charge controllers which protect them from over-discharge by loads and overcharge by PV panels. The cost of these PV-powered lighting systems varies as the size.

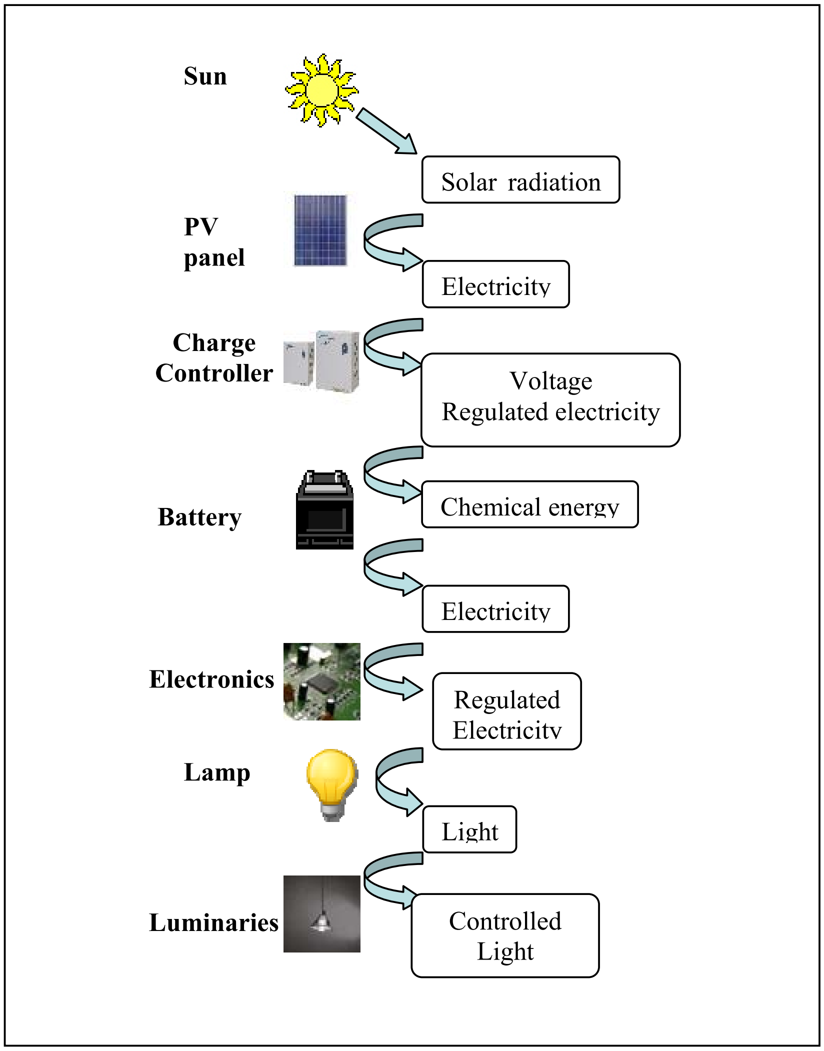


Fig (3.15) PV lighting system components and energy flow diagram

- **PV communication**

The use of PV arrays to power mobile, radio system, radio communication, telephones, remote control system, emergency call boxes, microwave links, TV translators and receivers in areas remote from electric network utilities is considered.

The range of power that is used in these systems various from few watts for emergency call system to several kilowatts for large radio repeaters.

- **Gate Openers**

Gate Openers powered by electricity produced from PV module by using wireless remote controls that releases gate latch, opens the gate, and closes behind the vehicle. Gates are designed to stop if resistance is met as a safety mechanism. Small PV module is charging the batteries gates of only a few watts. Digital keypads are available to allow access with an entry code for persons without a transmitter.

- **Consumer Electronics**

One of the uses of PV technologies is consumer electronics that require low energy, which we see all around us, such as watches, calculators, cameras, which are working well, even in artificial light environments such as classrooms and offices.

- **Battery Charging**

Photovoltaic system provides constant and small current to the batteries to prevent discharge problem which happened when these batteries are not used from time to time because their capacity gradually diminishes. These PV cells are very reliable and a cheap solution in these cases.

- **Warning signal**

Photovoltaic system is used to power warning signal in several areas such as the transportation, oil industries, utility and military. This warning signal that could be transmission tower, highway warning signs, navigational beacons, railroad signals, and audible emergency signals.

- **Remote switching**

One of the ideal applications for photovoltaic power is remotely switches because these switches require very little power throughout the year. Transmission line can not power the switch because it is expensive to connect the switch to the grid by transformer and the switch must operate when the line is out of service.

- **Remote monitoring**

In these days the applications of photovoltaic has become very large and monitoring is one of these largest applications. PV systems are used to monitor the water, temperature, weather, pipe lines, flow rates, and factory emissions.

3.3.2.4 Photovoltaic Projects in Palestinian Territories

The max kilowatt PV system installed in Palestine is about 50kwp (The Palestinian Energy and Environment Research Center PEC), there are numbers of PV system projects are implemented in Palestine's villages such as the following:

***** PEC had implemented three electrification projects, in those projects about 50 households, 20 clinics, 25 schools, and 5 mosques were electrified using stand alone PV system. (Note: some of these systems are currently not working).

Fig. (3.16) PV system, rural clinic- Kufor Thulth village in the north of West Bank. Source: www.perc.ps

* Supplying of medical center and isolated clinics with required electricity for lighting, refrigeration, and operating small medical equipments such as, "rural clinic in- Kufor Thulth village", see figure (3.16).

* Installation PV system for Bedouin tents, and police stations.

* Supplying animal zoo with PV system such as Qalqelia zoo.

* Water pumping system were electrified using stand alone PV system, see figure (3.17) PV water pump in one of the Palestinian village.

Fig. (3.17) PV water pump in one of the Palestinian villages

Source: www.perc.ps

* Installation PV system for hospital and school, see figure (3.18)

* Gaza municipality lights some main streets using PV electricity, see figure (3.19).

* Another Project for street lighting and electrification of public sites at **Jib Al aldeeb** community is going to be implemented by Arij [1]. This project is financed by UNDP/PAPP, GEF and SGP.

* The energy research center at An Najah National University electrified a Palestinian village (Atouf) by PV centralized power system. The village includes 25 houses, school, and clinic with power capacity about 24 kWp. The project is considered a successful renewable energy application in Palestine. The project was financed by EU.

Fig. (3.18) School PV system in one of Palestinian's villages

Source: www.perc.ps

Fig. (3.19) Solar Street Lighting in Gaza

[1] Palestinian research and development institution, www.arij.org

- Installing Solar Chargers for Video and Mobile Phone in South Hebron see figure (3.20): The systems are based on 10W solar panel a charge controller and a small deep cycle battery. The systems will allow for day and night charging of both video and mobile phones.

Fig. (3.20) Solar Panel Charger for Video and Mobile in South Hebron

Source: http://villagesgroup.files.wordpress.com

Chapter 4

Energy Needs by Sector and Potential Solar Energy Applications

Chapter 4

Energy Needs by Sector and Potential Solar Energy Applications

After the identification of solar energy and their different uses we want to achieve optimal use. Therefore, this chapter will discuss potential applications of solar energy in Palestinian Territories between the reality and what can be reached to give a higher percentage of use in various sectors: residential, industrial, public building.

4.1 Residential and Public building Sector

After having considered the previous chapters, especially the statistics of using different kinds of energy fuel in different sectors as in chapter two, we note that the statistics of the use of solar energy in Palestinian Territories only appear in the residential sector see table (4.1), however, it does not mean that there is no use in other sectors, but we can say that the highest use of solar energy system in Palestine is in the household sectors.

Table (4.1) Types & values in Toe of energy Consumption in Residential sector in 2005.

Years	Wood and Charcoal	Wood Cake(Jift)	gas	diesel	Kerosene	Electric energy	Solar Energy	Total
2005	146,780	4,367	108,549	23,614	3,172	159,555	87,456	533,492
	% 27.5	% 0.8	% 20.3	% 4.4	% 0.6	% 29.9	% 16.4	

Source: PCB

4.1.1 Types of energy consumption

In residential and public building there are many forms of energy consumption such as hot water, space heating and cooling, lighting, cooking**,**

4.1.1.1 Hot water

There is no quantitative information about quantity of hot water consumed in private (homes) and public building (education, hospitals, clinics, hotels, restaurants.), and about energy sources used in each sector. In general, electricity, petroleum products, firewood and solar energy are the available sources used for hot water production.

Households

Hot water is conceder from the necessities of all families that is needed in their daily lives for bathing, cleaning, cooking and other purposes, which can be obtained using different types of fuel as shown in the following table (4.2) which shows the percentage of households using different types of fuel to produce hot water

Table (4.2) the percentage of households using different types of fuel to produce hot water

Index	
The percentage of households using LPG	% 35.0
The percentage of households using solar energy	% 27.8
The percentage of households using electricity	% 25.2
The percentage of households using firewood	% 9.8
The percentage of households using kerosene	% 1.0

Source: PCB, household energy survey 2005

From the above table, it is clear that the Liquefied Petroleum Gas (LPG) is the most fuel used in water heating, followed by solar energy, electricity, firewood and kerosene. It could be argued that there are families who use two different systems to heat water, for example solar water heaters and gas or electricity boilers. This is done because solar energy may not be available throughout the year, especially in cloudy days.

The amount of hot water needed by each family ranging from 150 to 200 liters per day during summer, and less than 200 liters in winter. Temperature of hot water may range between (50-60 °C). The amount of hot water consumption increases as family size increases.

According to statistics of the Palestinian Bureau of Statistics in 2005 (survey of house energy), about 67.2% of households equipped with solar heater system (SWH) or the equivalent of 428486 heater system. These SWH's have two or three collectors in each solar heater system. Each collector has an area of 1.7 m^2 (with Ave. 3.4 m^2), and the average annual requirement of hot water for each family is 54,750 liters. Every solar water heater can provide around 70% of total needed hot water. It is estimated that all solar water heaters produce around 17 million cubic meters (17 million m^3/year) each year.

The quantity of thermal energy gained by solar water heaters is approximately 620 KWh/year for each square meter of the area of the collector, which is almost equivalent to (940 GWh/year). All previous data based on statistics of the year 2005.

While the percentage of households which were equipped with solar water heaters was 63.8% in 1999 that nearly equal 263000 systems their area are 1025000 m^2 and the quantity of hot water produced through out these (SWH) approximately 11 million meters cubic per year(11 million m^3/year) that equal (630 GWh / year). As shown in the following table (4.3).

The increase of installing solar water heater from 1999 to 2005 is not large, and we can observe that the consumption of solar energy in general during the years from 2001 to 2005 is almost stable, as shown in the table (4.4) and figure (4.1).

Table (4.3) No. of Household Equipped with SWH

Region	**Litres / day** 150 – 200 L/day per household (during summer)	**No. of households equipped with SWH**
West bank & Gaza Strip	11 million m^3/ year (allover the year)	263,000 (1999)
West bank & Gaza Strip	17 million m^3/ year (allover the year)	428,486 (2005)

Source: PCB, PEC

Table (4.4) Percentage of Solar Energy Consumed by The Year

Year	**%**	**Solar Energy Total in Toe**	**Grand Total in Toe**
2001	13,6%	88.231,3	648.588,1
2002	14,0%	88.644,4	631.802,3
2003	10,2%	89.057,5	875.636,0
2004	10,6%	87.895,7	831.359,7
2005	10,4%	87.456,1	839.671,1
Total	**11,5%**	**441.285,0**	**3.827.057,2**

Source: PCB

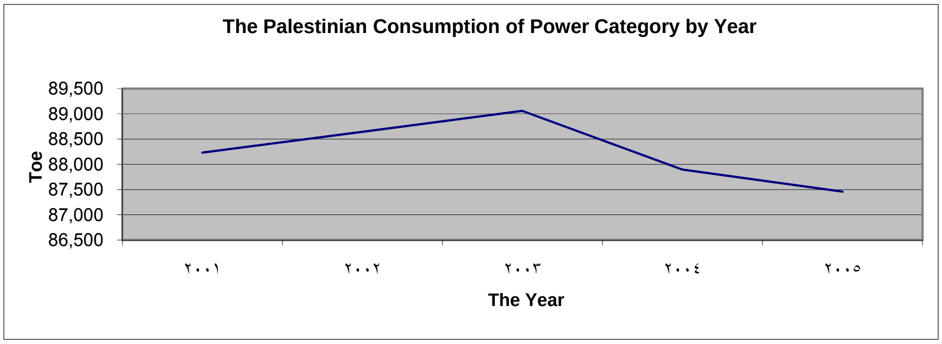


Fig. (4.1) The Palestinian Consumption of Solar Energy by Year.

Source: PCB

While the solar collectors produced only 27.8% of the consumed hot water, there are many reasons that obvious why solar energy has not been efficiently utilized:

- The quality of the systems is low,
- The areas of panels are not sufficient to fulfil the demand,
- The dependence on other energy source as electricity and Inefficient use of the system with its full capacity.

Hotels

In1999 the total number of hotels in PT's is 92 with 3682 rooms & 7986 beds (Table 4.5), with a room occupancy rate 27% (prevalently in summer time occupancy rate 41%, which is extremely important because of the possibility to use SWH). The average yearly demand of hot water is 64,686 m^3 (2.5 m^3 monthly demand per bed).

It is found that about 50% of hotels are using SWH covering 25% of the total needs of hot water. This is equivalent to 8086 m^3/year produced by solar collectors of total area 2635 m^2. This information does not change so we can say that the in the year 2005 it is still the number of hotels equipped with SWH is 50% from all hotels.

Table (4.5): Number of hotels & number of rooms

Region	No' hotels	No' rooms	Demand Hot Water(DHW) m^3 / day
W.B & G.S (1999)	92	3682	665
W.B & G.S (2002)	72	3098	539
W.B & G.S (2005)	77	3691	660

Source: PCB, PEC

Hospitals:

The total number of hospitals in PT's is 64 hospitals with 4,545 beds (Table 4.6). The total annual demand of hot water is 109,080 m^3 (2 m^3 monthly demand per bed). About 50% of the hospitals are equipped with SWH systems, producing 40% of their needs of hot water. Assuming 60% occupancy rate of beds, about 13,089 m^3 of hot water is yearly produced by solar collectors of total area 4,295 m^2.

Table (4.6) Number of hospitals & number of beds in PT's

Region	No. of hospitals	No. of beds	DHW m^3 / day
W.B & G.S (1999)	64	4545	294
W.B & G.S (2005)	76	5007	334

Source: PCB, PEC

Universities, security and sports residencies

The information about these sectors is not available, but we sure that some solar systems are installed in security residencies, fitness club and universities like that ones used in BirZiet University, President Office in Jericho and fitness club in Ramallah

4.1.1.2 Space Heating and cooling

Heating and cooling is one of forms of energy consumption in homes and public buildings, and it can be noted that use different means to achieve the purpose, for example, central air conditioner, fans, heater which rely on it's work of different types of fuel such as electricity, gas, kerosene, firewood. From the following table (4.7), we can observe the families ratio that used different types of heating facilities.

Table (4.7) Percentage of households using heating facilities in PT's

Index	%
Percentage of households using Electrical Heater	**39.4%**
Percentage of households using Gas Heater	**34.7%**
Percentage of households using Kerosene Heater	**11.2%**
Percentage of households using Wood heater	**35.4%**
Percentage of households using Central Heater	**1.6%**
Percentage of households using other	**9.4%**
Percentage of households don't use any thing	**13.3%**

Source: PSBC_Survey 2005 Q1

4.1.1.3 Lighting

Lighting is one of the most important forms of energy consumption in all sectors, especially domestic, hospitals, hotels and other public buildings based on the facility of using electricity as a main source of fuel as indicated in the following table(4.8), which show the percentage distribution of households in PT's by the main fuel used for lighting and region, it can be said that the reasons for the high reliance on the electricity as a main source has been used in the lighting and the large quantities consumption of energy due to:

- Poor design of houses and public buildings so that there is no good for the design of windows and therefore not to rely on natural lighting.

- Poor distribution of electric light bulbs when the plans were designed, as well as in execution

- The use of low-efficient lighting system and therefore the largest consumption of energy and wastage in the consumption.

In public buildings, the percentage of energy consumption for lighting ranges between 35%-40% from all energy consumption in this sector.

Table (4.8) Percentage Distribution of Households in the Palestinian Territory by the Main Fuel Used for Lighting and Region 2005

Region	Kerosene	LPG	Electricity	Others	Not Exist
Palestinian Territory	0.5	0.0	99.1	0.1	0.3
West Bank	0.4	0.1	99.1	0.0	0.4
North of West Bank	0.4	0.1	99.5	0.0	0.0
Middle of West Bank	0.5	0.0	98.8	0.1	0.6
South of West Bank	0.1	0.1	98.9	0.2	0.7
Gaza Strip	0.7	0.0	99.1	0.2	0.0

Source: PCB, household energy survey 2005

4.1.1.4 Cooking

The main fuel adopted in the process of cooking is LPG with different consumption sectors, for example the percentage of households using gas as a main fuel in cooking in the Palestinian Territory is 97.7% in 2005 ,the percentage of households that used gas burner is 99.3% for the same year and we can say that there is a small percentage of households used other types of burner and thus other types of fuel such as wood as a second class , few families that used burner based on diesel or electricity, as shown in the tables (4.9),(4.10).

As for public buildings, hospitals, and hotels in particular, the process of cooking is in a larger quantities at specified times, which means that the quantity of consumption fuel is large to carry out this work.

Table (4.9) Percentage of Households in the Palestinian Territory Using Cooking Facilities by Cooking Facility and Region 2005

Region	Wood Burner	Kerosene Burner	Gas Burner	Electrical Oven
Palestinian Territory	**10.0**	**0.8**	**99.3**	**7.4**
West Bank	**6.8**	**1.1**	**99.0**	**4.6**
North of West Bank	3.9	0.6	99.7	7.0
Middle of West Bank	1.2	0.7	99.7	3.2
South of West Bank	17.6	2.3	97.2	2.7
Gaza Strip	**16.3**	**0.2**	**99.9**	**13.0**

Source: PCB, household energy survey 2005

Table (4.10) Percentage Distribution of Households in the Palestinian Territory by the Main Fuel Used for Cooking and Region 2005

Region	Electricity	Not Exist	Wood	Kerosene	LPG
Palestinian Territory	0.0	0.0	2.0	0.3	97.7
West Bank	0.0	0.1	2.4	0.4	97.1
North of West Bank	0.1	0.0	0.6	0.0	99.3
Middle of West Bank	0.0	0.0	0.4	0.6	99.0
South of West Bank	0.0	0.3	7.5	0.6	91.6
Gaza Strip	0.0	0.0	1.0	0.1	98.9

Source: PCB, household energy survey 2005

4.1.1.5 Other Uses

Consumption of energy have other forms that are not mentioned previously in the operation of machinery such as refrigerators, washing machines and other measurements, we can observe that the greater reliance in the operation of these measurements on electricity regardless of the consumer sector for example, the percentage of electricity consumption in the household sector for 2005 is 19% of the total energy consumption for the same year, while the percentage of electricity consumption from the total energy consumption in the household sector was 29.9% and the average household consumption of electricity is 256 kwh, as shown in Table (4.11).

The rate of consumption of electricity in the services sector is 38% of the total energy consumption in this sector for the year 2005.

This confirms that the marks of these sectors are heavily dependent on electricity as a main fuel that used in the operation of different machines.

Table (4.11) General Indicator

Indicator	1999	2003	2004	2005
Percentage of Households Connected to the Electricity Public Network	96.8	99.3	99.4	99.4
Percentage of Households Using Solar Heater	63.8	70.3	68.7	67.2
Percentage of Households Using Space Heating Facilities	75.2	86.0	86.4	86.7
Percentage of Households Using Gas Burner for Cooking	98.0	99.6	99.7	99.3
Average Household Consumption of Electricity (kw.h)	264.6	268.0	264.7	256.0
Average Household Consumption of Gasoline (liter)	21.7	12.0	10.7	10.0
Average Household Consumption of LPG (kg)	32.0	31.0	32.1	30.0
Average Household Consumption of Kerosene (liter)	11.9	17.0	23.2	22.0
Average Household Consumption of Wood (kg)	86.5	259.0	207.2	236.0

Source: PCB

4.2 Industrial sector

The industry in PT's is very small , also the consumption of energy in this sector is small, but when we look at the commodity produced in this industry we note the high energy costs compared to that total cost of the commodity.

Some studies which were held in the Palestinian territories by the United Nations Development Program (UNDP) show the cost of energy constitutes 25% of the total cost of industrial production, or the equivalent of 25 million dollars annually.

The reasons for the high cost of energy in the Palestinian industry is the high price of electricity compared with neighboring countries such as Jordan, and lack of attention given to energy efficiency in industry. Table (4.12) shows types & values in Toe of energy consumption for industrial sector by year 2005.

Table (4.12) Types & values in Toe of energy Consumption for Industrial sector by year 2005.

Year	Wood and Coke	LPG	Lubricating and oils	Diesel	Kerosene	petroleum oils	Electric energy	Total
2005	187.4	5,703.1	1,314.6	44,255.4	458.5	2,348.4	15,359.7	71,632.1
	0%	8%	2%	62%	1%	3%	21%	

Source: PCB

4.2.1 Types of energy consumption

Industry is based on secondary sources of energy which was imported directly from Israel, from these sources:

- Electric power.
- Fuel specially diesel and heavy fuel; gasoline is used significantly in the transportation sector, food and ceramics industries.
- Oil-fired cars.
- The charcoal used in the food industry and other.

4.2.1.1 Steam and Hot Water

There is no information about the quantity of hot water consumed in industrial sector but we can say there are many factories use hot water for many purposes such as production process, sterilization, cleaning and washing machines and grand floors, in milks and yogurts factories, and in metallic water factories etc., we can note from table (4.13) the percentage of using different types of fuel in various industries, but sum times steam could be used in factories and the following table (4.14) shows the percentage of factories which needs to produce steam in their works.

Table (4.13) Percentage of using different types of fuel in various industries

Product Type	Benzene	Diesel	Fuel (%)	Gas (%)	Others (%)
Food	0	60	15	20	5
Textile and Clothes	0	75	0	0	25
Leather	0	100	0	0	0
Wood and Furniture	0	50	0	0	50
Plastics	0	60	0	0	40
Chemicals	0	75	13	0	12
Construction	0	43	0	14	43
Metals	16	67	0	17	0
Paper and Carton	20.0	60	20	0	0
Glass	18	27	37	18	0

Source: Energy in Palestinian Industrial Sector, Baba M.F., UNDP report 1995

Table (4.14) Percentages of factories which needs to produce steam in their works.

Product Type	%
Food	65
Textile and Clothes	50
Leather	20
Wood and Furniture	14
Plastics	10
Chemicals	22
Construction	0
Metals	14
Paper and Carton	20
Glass	100

Source: Energy in Palestinian Industrial Sector, Baba M.F., UNDP report 1995

4.2.1.2 Space heating and cooling

Many factories using space heating system and air conditioning in working space or in the offices so a lot of energy was consumed in this type of energy consumption see table (4.15), but there is no solar space heating or cooling system in these factories, and there is no solar techniques in the industrial sector.

Table (4.15) Number of Factories and their percentages with Air Conditioning & space heating system.

Product Type	No. Factories with air conditioning in working space	No. Factories with air conditioning in main offices	Factories with heating systems in the offices (%)
Food	20	35	47
Textile and Clothes	50	50	56
Leather	60	40	20
Wood and Furniture	14	29	43
Plastics	30	20	20
Chemicals	11	33	67
Construction	0	17	42
Metals	14	43	86
Paper and Carton	20	40	60
Glass	100	25	50

Source: Energy in Palestinian Industrial Sector, Baba M.F., UNDP report 1995

4.2.1.3 Other Uses

Electricity has large using in industrial sector in many forms like in lighting, switching machines and motors, its percentage 21% form the total energy consumption in the year 2005. It becomes after diesel fuel.

4.3 Application of solar energy that can be used

Solar technology was used to reduce the dependent on energy consumption from fuel in different sectors. In this section we summarized some solar application that can be used.

4.3.1 Solar Thermal Water heating systems

Households, public building (hotels, hospitals, universities, school), and factories are the main users of solar water heating systems.

In chapter three we discussed the types of solar water heating system that is used in houses, some hotels, hospitals in PT's such as thermosyphon system, direct pump system, central (SWH) for apartment buildings and collective system, but installing these system is not sufficient.

The hot water which was used in these sectors has 100 °C as maximum temperature that means the conventional types of solar water heating are sufficient to give the required hot water, but the problem is that the number of installed systems isn't preparation to give the demand of hot water and the efficiency is not high so we can use other system such as:

- **Solar District Heating**

District heating is one of heating systems that transfers and distributes heat that used in the residential industrial and commercial sectors for hot water heating, space heating, and industrial processes, it is very reliable, see figure (4.2). The temperature of district heating supply water varies depending on the country weather, being for example 65-115° C. The temperature is at its lowest in summer and highest in winter, when heat is only needed for hot water.

It consists of heat production units, which could be a combination of heating-only plants, combined heat and power production plants, waste heat recovery plants, peaking and standby heat plants, primary heat distribution network, substations at the consumer connection points, end-users secondary networks and installations for space heating and domestic hot water.

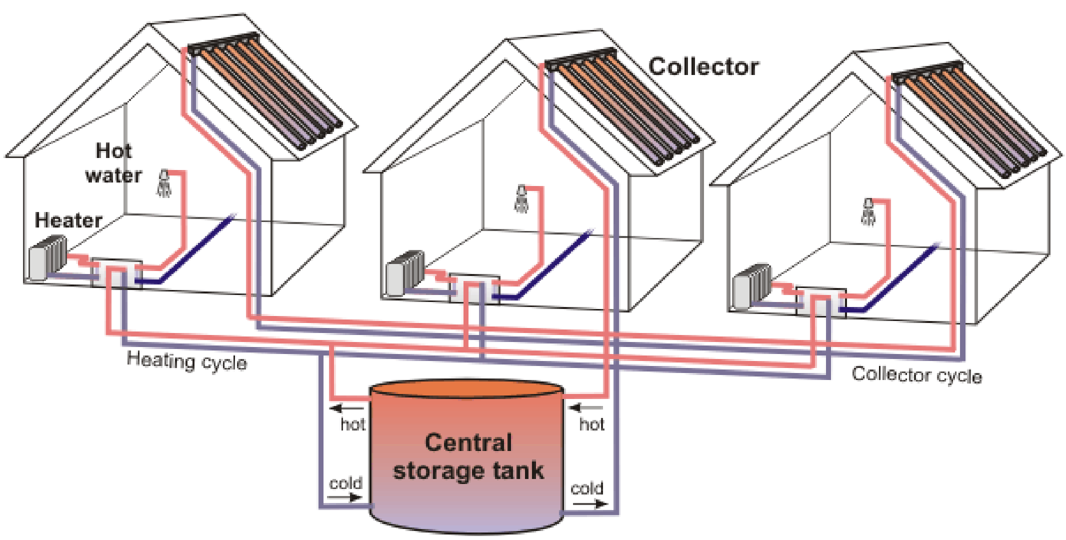


Fig. (4.2) Solar District Heating System

Source: http://www.volker-quaschning.de/articles/fundamentals4/figure6.gif.

- **Integrated Collector Storage (ICS) System**

ICS also called batch water heater, see figure (4.3) the water is heated and stored inside the collector. These systems are suitable only for warm climates where there is no risk of freezing.

ICS are made of one or more black tanks or tubes in an insulated glazed box. Cold water first passes through the solar collector, which preheats the water, and then continues to the conventional backup water heater.

ICS systems are simple, reliable solar water heaters. However, they should be installed only in climates with mild freezing because the collector itself or the outdoor pipes could freeze in severely cold weather. Some recent work indicates that the problem with freezing pipes can be overcome in some cases by using freeze-tolerant piping in conjunction with a freeze-protection method.

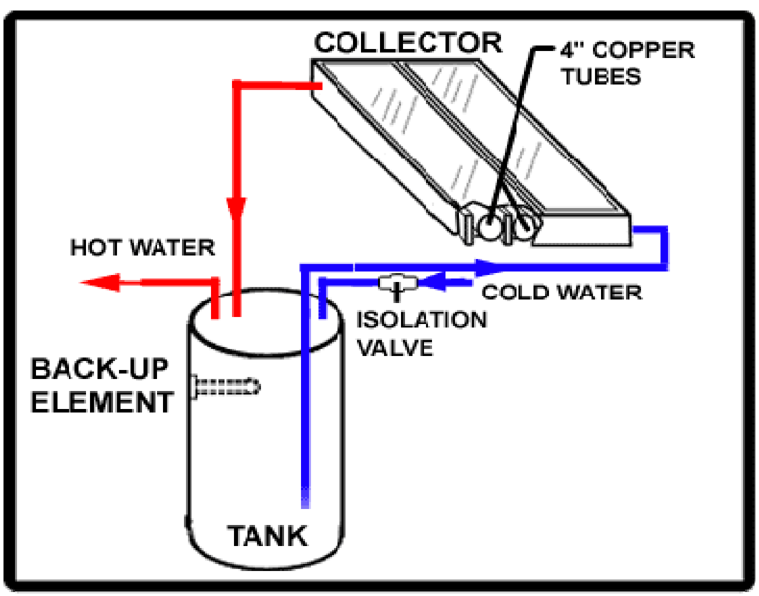


Fig. (4.3): Integral-collector storage system

Source: http://www.energysolutionsfl.com/images/passivesys.gif

- **The Vacuum Tube Collector**

A vacuum tube collector is composed of a series of evacuated glass tubes. Inside the tube, an absorber plate, in contact with a pipe in which the heat transfer fluid flows, collects the solar energy. Heat losses are low, owing to the insulating properties of the vacuum. Therefore, the temperature can rise to over 100°C. This type of collector is particularly well adapted to applications that need high temperatures, see figure (4.4).

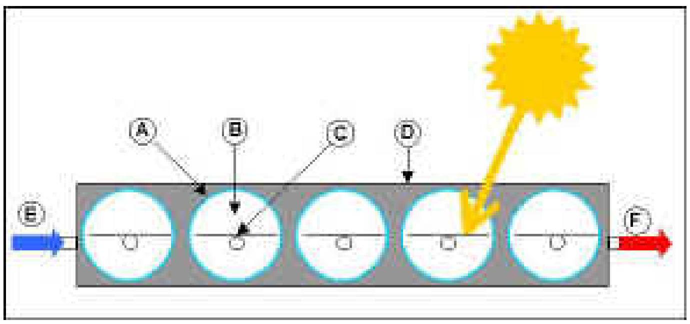


Fig (4.4) Vacuum Tube Collector

- **Concentrating Collectors**

Concentrating collectors use mirrored surfaces to concentrate the sun's energy on an absorber called a receiver, see figure (4.5). Concentrating collectors also achieve high temperatures, but unlike evacuated-tube collectors, they can do so only when direct sunlight is available. The mirrored surface focuses sunlight collected over a large area onto a smaller absorber area to achieve high temperatures. Some designs concentrate solar energy onto a focal point, while others concentrate the sun's rays along a thin line called the focal line. The receiver is located at the focal point or along the focal line. A heat-transfer fluid flows through the receiver and absorbs heat. These collectors reach much higher temperatures than flat-plate collectors. However, concentrators can only focus direct solar radiation, with the result being that their performance is poor on hazy or cloudy days.

Concentrators perform best when pointed directly at the sun. To do this, these systems use tracking mechanisms to move the collectors during the day to keep them focused on the sun. Single-axis trackers move east to west; dual-axis trackers move east and west and north and south (to follow the sun throughout the year). In addition to these mechanical trackers, there are passive trackers that use Freon to supply the movement. While not widely used, they do provide a low-maintenance alternative to mechanical systems.

Concentrators are used mostly in commercial and industrial applications because they are expensive and because the trackers need frequent maintenance. Some residential solar energy systems use parabolic-trough concentrating systems. These installations can provide hot water, space heating, and water purification. Most residential systems use single-axis trackers, which are less expensive and simpler than dual-axis trackers.

There are four basic types of concentrating collectors: Parabolic trough, parabolic dish, Power tower, Stationary concentrating collectors.

Fig (4.5) Solar Concentrating Collectors

Source: http://www.esru.strath.ac.uk/Courseware/Solar_energy/Images/solar6.gif

4.3.2 Space Heating and Cooling Systems

Heating a home with solar energy is not difficult in Palestine. If done correctly the building will use 50 to 70 percent less energy during the heating season, have good day lighting and remain cool during the hottest summer months. Two approaches can be used to heat a home with solar energy: an active system or a passive system. Active systems use mechanical equipment such as a pump or fan to move energy from collectors into the house. Passive systems are much more common, simply relying on south facing windows to allow solar heat and light into the building, figure (4.6) shows the sun chart for space heating using passive solar systems

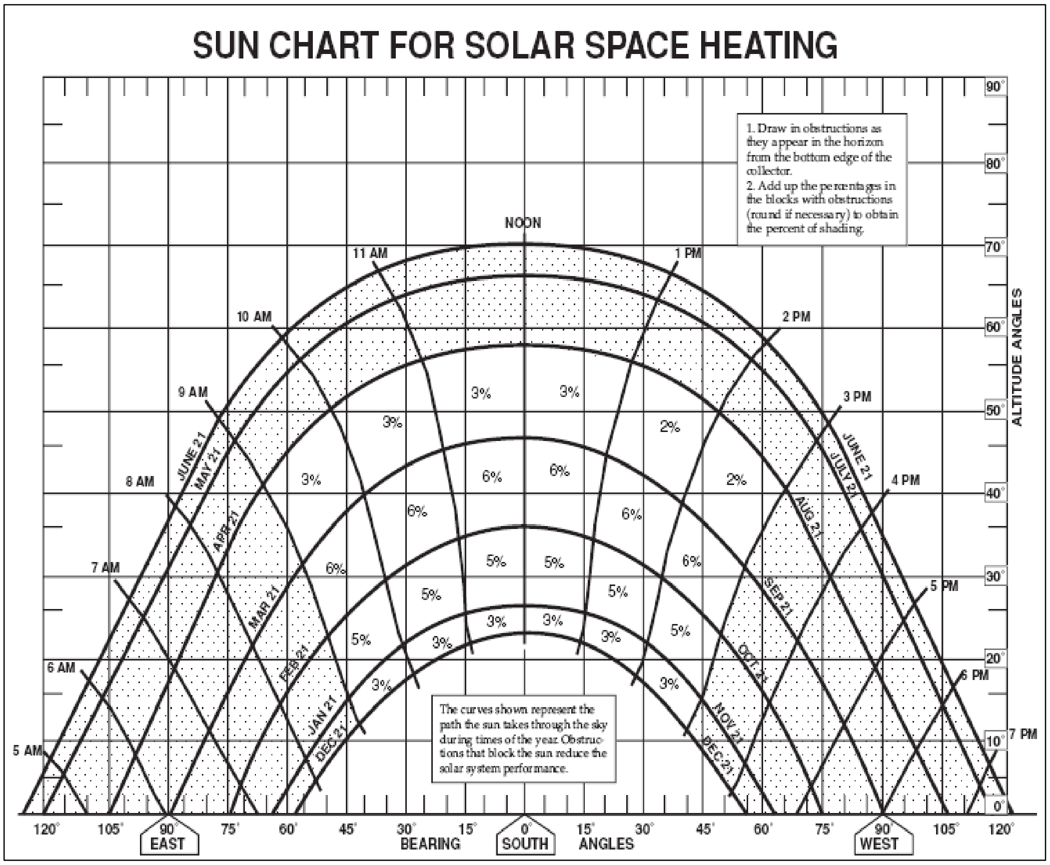


Fig. (4.6) Sun chart for space heating using passive solar systems.

Space heating and cooling consume a huge amount of energy in all sectors in the PA. In order to reduce these quantities we can design our new building to include one of the following systems:

• Solar Window

Windows are one of the important elements in designing buildings because of their role in reducing the energy consumed in heating, cooling and lighting, also they are considered as a good and inexpensive solar collector. The size of the windows, the types of glass used and the orientation are the basic techniques to derive the maximum benefit from solar windows. Therefore, the best design is to make the windows facing the south to obtain the largest amount of solar energy especially in the winter when the sun is low in the sky while in the summer when the sun is high and its temperature is high. Also, a several techniques can be used to reduce the excessive heat from entering through these windows, such as shading or the use of umbrellas. The shading helps to reduce heat gain in summer and heat loss at night, see figure (4.7).

North windows that have a role in the provision of lighting, in particular, while the East and West windows should be limited as it is difficult to control the quantity of heat entering through the sky, especially when they are low.

New technologies are used in designing the windows that include selective coatings, and increasing window insulation properties lessened such concerns to help keep heat where it is needed.

A high Solar Heat Gain Coefficient (SHGC)—usually 0.60 or higher—to maximize heat gain is required in south-facing windows to be effective, to reduce conductive heat transfer the U-factor must be low (0.35 or less), and for good visible light transfer it is used a high visible transmittance (VT). SHGC refers to the portion of incident sunlight admitted through a window, and U-factor indicates the heat loss rate for the window assembly.

For north-facing window particularly effective strategies include preferential are used along with generously shaded south-facing windows.

Shading from landscaping, overhangs, shutters, and solar window screens helps lower heat gain on windows that receive full sun.

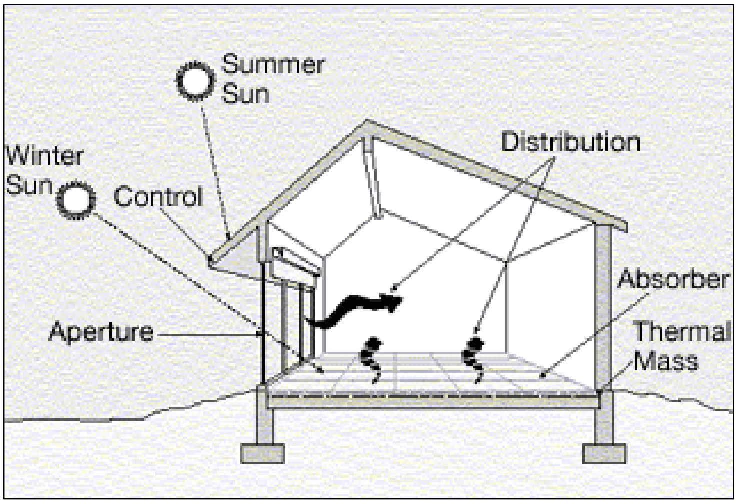


Fig.(4.7) Solar Window

Source: http://warmair.net/html/passive_solar_heating.html

- **Solar Wall (or Trombe Wall)**

Solar walls are simple systems used for space heating. These walls are also known as Trombe walls. The diagram in figure (4.8) shows how the collector operates. The solar radiation heats the outside of the solar wall. The heat slowly passes through the massive wall, and arrives at the inside surface of the wall several hours later to provide heat in the evening. The glazed covering on the outside of the wall reduces heat loss, and allows more heat transfer to the inside space. The vents shown at the top and bottom of the wall in this diagram are optional -- they allow heat to be transferred to the living space earlier in the day than occurs with an unvented solar wall.

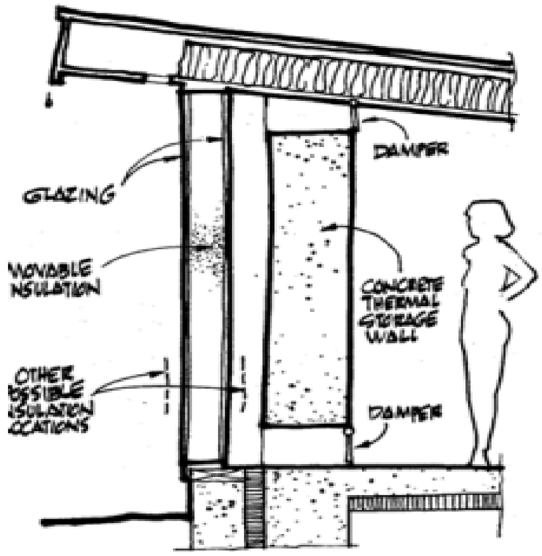


Fig (4.8): Solar wall

Source: "Passive Solar Energy ", Bruce Anderson and Malcolm Wells.

These walls can be used in new construction or as a retrofit. Some existing homes have wall construction that can be converted to a solar wall easily.

The characteristics of a solar wall as compared to a solar window:

1- Its efficiency in collecting solar heat is not as high as a direct gain window of the same size.

2- Night heat losses are less than for direct gain windows.

3- Very simple -- no fans, no ducts, no controllers.

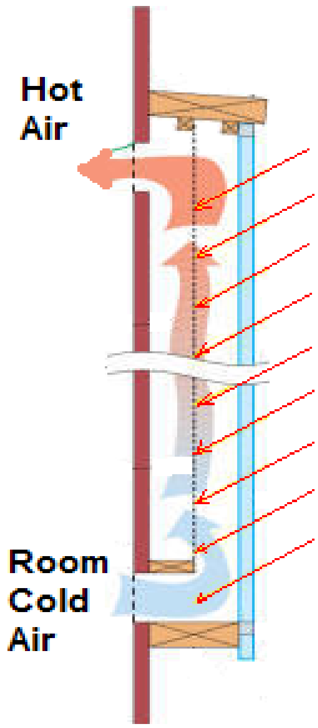
4- Does not provide daylighting or views as a direct gain window would -- this can be an advantage or disadvantage.

5- The inside surface of the wall can be used to some extent, but should not be covered with anything that reduces heat transfer from the wall to the living space.

6- Depending on the current wall construction, it may be easier to retrofit a solar wall than to retrofit a direct gain window, since no wall structural members are cut. The collectors can be used in new construction, or as a retrofit.

- **Solar Chimneys**

This retrofit passive space heating device, called a thermosiphoning air panel (TAP), uses the existing house wall as the major structural element. The exterior finish is removed, new glass box structural sheathing added over the existing wall, and wood framing added to support the ribbed aluminum absorber plate (industrial siding material) and to support the field-installed insulated glass units. The system shown uses three patio door replacement units as the aperture, creating three areas of absorber plate, each of which requires a high and a low vent through the house wall to allow the thermosiphoning action to occur. The weight of the added glazing is carried by brackets at the base of the panel to a continuous ledger strip bolted to the house wall. After flashing is added, the exterior siding materials are patched around the unit to complete the installation.



The characteristics of the Solar Chimney see figure (4.9) as compared to a solar window:

- It has roughly the same collection efficiency as a direct gain window.
- Night heat losses are less than for direct gain windows.
- Very simple -- no fans, no ducts, no controllers -- uses natural convection.
- Does not provide day lighting or views as a direct gain window would -- this can be an advantage or disadvantage.
- The inside surface of the wall can be used for shelves etc. -- unlike a direct gain window.

- No structural changes to the wall framing are required, since no structural members are cut -- this can make it an easier retrofit than a direct gain window.

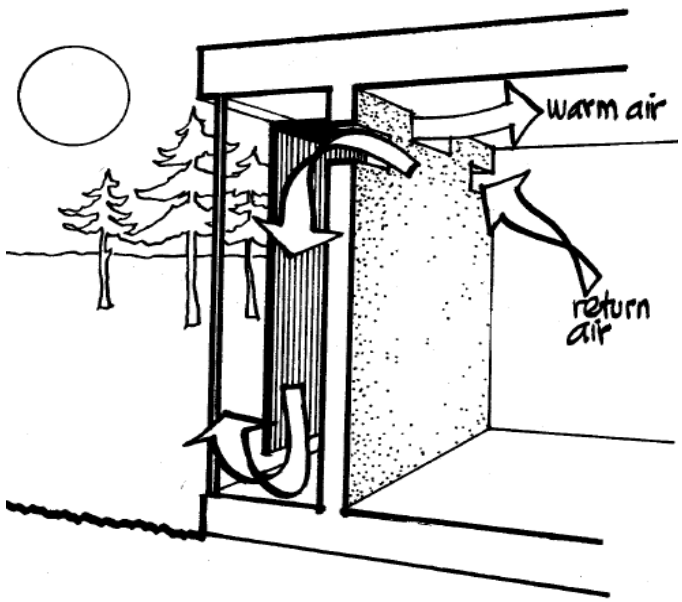


Fig. (4.9) Solar Chimney

Source: "Passive Solar Energy ", Bruce Anderson and Malcolm Wells.

These are very cost effective energy collectors. For example, a PV panel of the same size would cost 5 to 10 times more, and produce about one fifth as much energy! Depending on the materials used, and how good a scrounger you are, the payback period will usually be a year or two at 2006 fuel prices.

- **Solar Roofs**

Solar roofs, often called thermal storage roofs, see figure (4.10) is similar to storage walls. Waterbed-like bags of water, exposed to sunlight, collect, store and distribute heat. This heat passes freely down through the supporting ceiling to the house, gently warming it. In the summer, heat rises through the ceiling into the water, cooling the house. Then at night, the water is cooled by the radiation of its heat to the sky. Movable insulation covers the ponds at night in winter, to trap heat inside, and during the day in summer, to shade the ponds while the sun is shining.

Generally, solar roof ponds are 8 to 12 inches deep. Roof ponds are always flat, but in northern buildings the glazing is often sloped to the south to capture the sun's low rays as well as to shed snow. Under the sloped glass, the walls are well insulated and faced with materials that reflect the sunlight into the ponds.

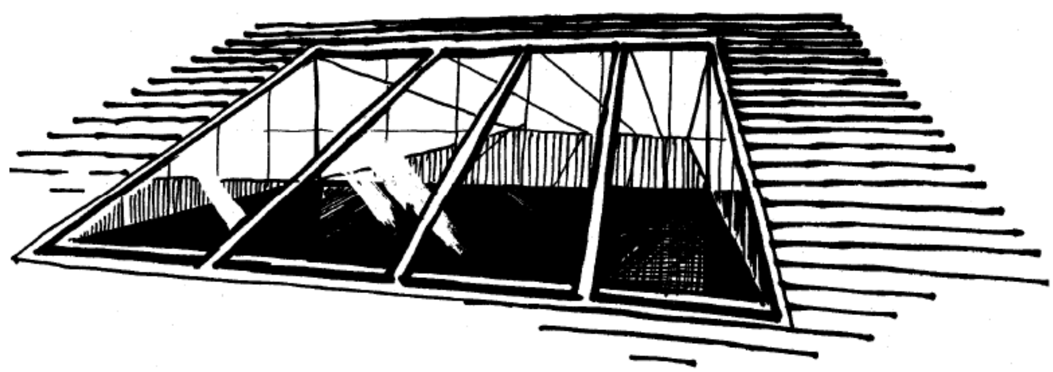


Fig. (4.10) Solar Roof
Source: "Passive Solar Energy ", Bruce Anderson and Malcolm Wells.

- **Greenhouse (Solarium)**

Greenhouses are the most common solar rooms, see figure (4.11) Conventional greenhouses, however, are not designed to take maximum advantage of the sun's energy. The problem is that most are built with a single layer of glass, and so they lose more heat at night than they gain from the sun during the day. Consequently, they need expensive auxiliary heat to keep the plants warm.

A solar greenhouse is designed both to maximize solar gain and to minimize heat loss. Usually, only the south facing walls and roof of the solar greenhouses are glazed, while the east and west walls are well-insulated. (Southeast and southwest portions, if any, are also glazed, partly because plants need that low-angle early sunlight.) If at least two layers of glass or plastic are used instead of one, this type of greenhouse will remain above freezing most of the winter in all but the coldest climates of this country. However, for maximum heat savings while growing plants year round, three and even four layers of glass and plastic should be used where winters have more than 5000 degree days. Keep in mind that each additional layer of glazing blocks additional sunlight.

For maximum sunshine, and for minimum heat loss at night, movable insulation is used in combination with double glazing. This can be tough to do, however. Some of the tricky design and construction problems include storing the insulation out of the way during the day, interfering with plants while moving the insulation, and obtaining tight seals against the glazing when the insulation is closed. Additional considerations include the need for insulation to resist mold, other plant and insect life, and moisture damage.

Fig. (4.11) Solar Room

- **Under floor heating using solar water heating**

Under floor heating and cooling is a form of central heating and cooling which uses heat conduction and radiant heat or cold for indoor climate control, rather than forced air heating which relies on convection, see figure (4.12). Heat can be provided by circulating heated water or by electric cable, mesh, or film heaters. This technique does not require hot water at high temperatures as the case for central heaters with radiators. Warm water at temperature around 30°C is good enough to make the room warm enough for residents. This fact makes solar water heaters a good source of energy for this system as it is difficult to get higher temperatures in winter.

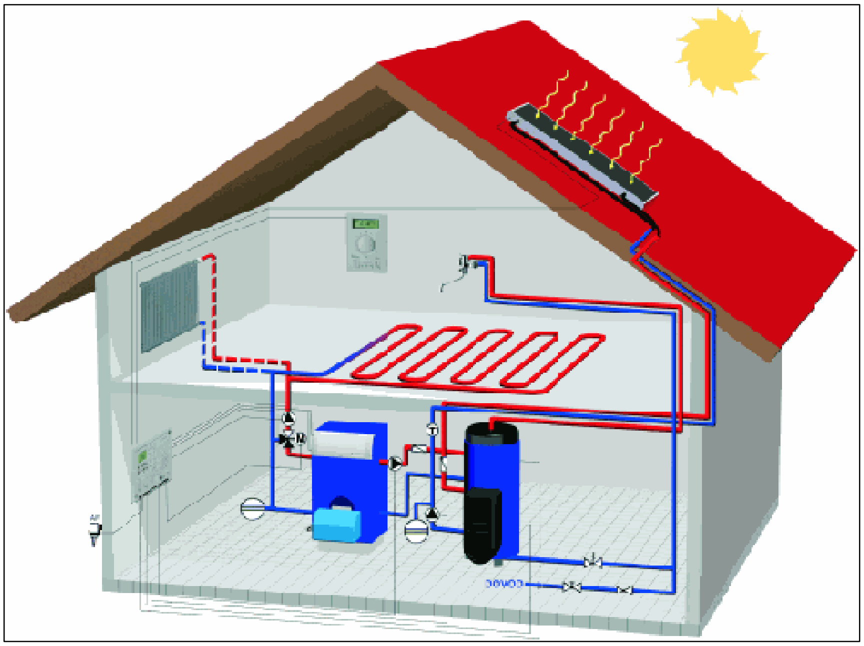


Fig.(4.12) Under_Floor Hot Water System

Chapter 5

Solar Energy as a Clean and Cheap Energy Option

Chapter 5
Solar Energy as a Clean and Cheap Energy Option

From previous chapters it can be concluded that there are many applications of solar energy with high potential in Palestine. It is very important for decision makers and planners to make a target for the extent of solar energy share as an economical and indigenous source of energy.

In this chapter, the percentage of energy share of solar energy in each sector and sub-sector will be estimated. Lately, the overall share of solar energy will be estimated for future planning.

5.1 Solar Energy as an Energy Option for Sectors and Sub-sectors

In order to estimate the potential share of solar energy for each sector, it is very important to specify and identify the main types of energy used for these sectors and their quantities and share. Solar energy will replace some of these fuels when solar technologies are adopted for certain applications in these sectors. Table (5.1) indicates the main tapes of energy sources used in year 1999 in the Palestinian Territories, and the quantities used in each sector, and the percentage of this fuel for the sector and in total consumption.

It is important to note that these quantities has changed dramatically after September 2000 when the second uprising (Intifada) started. The transportation and industrial sectors were affected badly in the following five years. The total energy consumption consumed by the industrial sector dropped bellow 4% in 2002 and 2003. The energy consumed by the residential sector increased sharply and represented a higher percentage of total consumption. The residential sector consumption exceeded 60% of total energy consumption in the period 2001-2004. However, without considering the Intfada and its impact, it is clear the industrial sector consumes a very low percentage (less than 20%) of total energy consumed in Palestine compared to more than 35% in all neighboring countries. This is a direct result of the political situation, where Palestine is still under occupation and there are many obstacles for industrial development.

Table (5.1) Energy Use in the Palestinian Authority in 1999.

Sector	**Energy Usage By Type**							
	Electricity		**Oil/Gas**		**Charcoal & Biomass**		**Energy Use**	
	KTOE	**% of Total**	**KTOE**	**% of Total**	**KTOE**	**% of Total**	**KTOE**	**% of Total**
Transportation	0	0	241	42	0	0	241	28
Residential	128	61	137	24	83	96	348	40
Commercial	38	18	68	12	0	0	106	12
Industrial	29	14	120	21	3	4	152	18
Government	13	6	6	1	0	0	19	2
Other	2	1	1	0	0	0	2	0
TOTAL	210	100	573	100	86	0	872	100
% of Fuel Total	**24%**		**66%**		**10%**		**100%**	

Source: Administrative reports of the Central Bureau of Statistics Feb. 2000.

From the previous chapter, it was clear that solar energy applications for residential sector are very potential and feasible. This fact combined with the fact that the residential sector still represents the highest percentage of total energy consumption, will make solar energy share among all future fuels relatively high. This share is expected to be much higher than that planned for other countries for the reason mentioned before. In Table (5.2), the potential applications of solar energy for each sector are identified. From this table, it is clear that the thermal applications of solar energy are mostly used. Electrical applications such as photovoltaic technology are still expensive with limited applications at the moment. This doesn't mean that these applications are eliminated from the future planning, but rather it indicates that the overall percentage of these applications will be restively small compared to the thermal applications.

Table (5.2) Potential solar energy applications for sectors

Sector	Potential Solar Applications
Transportation	Not applicable now, future applications may be possible if electric cars are widely used. PV's can be used for charging batteries of cars.
Residential	Solar water heating, space heating, space cooling, space lighting (day lighting), cooking.
Commercial	Space heating and cooling.
Industrial	Space heating and cooling, solar water heating, steam generation and other thermal applications.
Government	Space heating and cooling, PV's for some remote applications.
Electricity Generation	Photovoltaic, Solar Bonds, Solar Thermal Stations
Other	Greenhouses for Agricultural applications.

5.1.1 Applications of Solar Energy in the Transportation Sector

Even if cars powered entirely by the sun's rays never become viable, solar power could still become a key component in the transportation industry. One groundbreaking new technology, hydrogen power, could receive a huge boost from solar power. One of the barriers to use of hydrogen is the lack of free hydrogen atoms in the lower reaches of earth's atmosphere. Very soon solar power could be the best option for the clean and low-cost production of hydrogen, but it is not expected to expand this on commercial scale in the nearest future. For planning for the next two decades, it is very difficult to predict any valuable share for solar energy in the transportation sector.

5.1.2 Public buildings

Most of the energy used in public buildings is consumed for three main purposes:

- Lighting
- Heating, ventilation and air conditioning
- Office appliances and other machines

5.1.2.1 Heating and cooling

The energy consumed in heating and cooling account between (50 - 60%) of the total energy consumed in public buildings (when central HVAC systems are available. Recently, ministry of local Governments (MOLG) has adopted the new code for "Energy Efficient Building Design". This code will be mandated starting 2009 for all public buildings and for all buildings two years later. Implementing this code will result in a huge reduction in heating and cooling loads and as a result in energy consumed for heating and cooling of buildings.

Implementing the code for energy efficiency in building will yield much higher improvement and energy saving if combined with Passive Solar Design for these buildings. For public buildings, different solar systems can be considered taking into account that these buildings usually used during daytime only. These passive systems include:

- Solar window.
- Solar wall.
- Solar Chimney.
- Solar water heating for space heating, usually used with under floor heating techniques.

Our survey has shown that none of these systems has been applied for any public building. Recently, with the assistance of Building Engineering Department at An-Najah University, some engineering firms started to implement some of the solar systems in newly designed public buildings. It is our expectation that the number of such new buildings will increase dramatically in the coming decade. Also, we hope that the awareness of architects and engineers will be combined with incorporate these techniques into the new building as well as the Palestinian Ministry of Local Government issued the legislation should be used for energy-saving buildings, such as the mandatory starting from the year 2010 for public buildings and buildings over an area of 250 meters square. So the application of this law in addition to the exploitation of solar energy will contribute to reduce the consumption of electric power and fuel increasingly with time.

Based on estimates of the growing public buildings until 2020, as in the Table (5.3), on the assumption that all new buildings will apply the building code that specialized of energy-saving buildings and a steady increase in the percentage of buildings used for solar energy in heating and cooling the result will be as follows tables (5.4) & (5.5):

Table (5.3) Forecasted Growth in number of public buildings in Palestine 2007- 2020

Year	No of building	houses	Public Building	Others*
2007	466,707	343,030	88,208	354,70
2010	648,441	476,605	122,556	492,82
2012	769,600	565,656	145,454	561,81
2015	951,336	699,232	179,802	723,02
2018	113,307,1	832,807	214,151	861,13
2020	125,422,8	921,858	237,049	915,59

***Other: .... Free, Abandoned, Locked, Unknown**
Source: PCBS

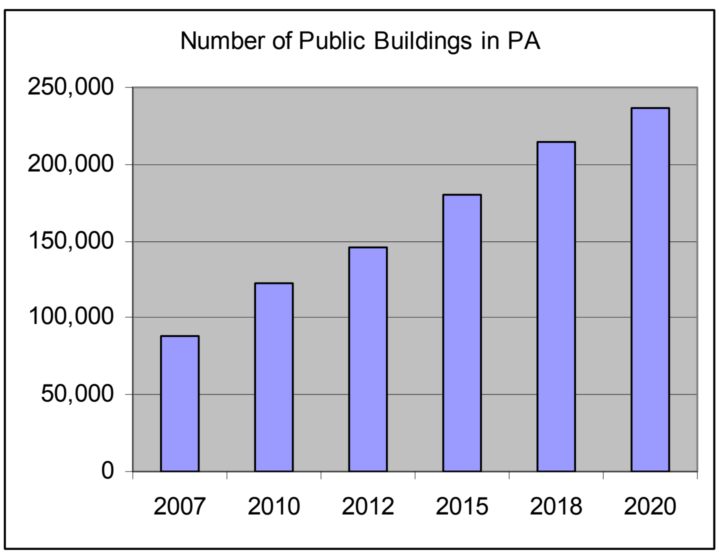


Fig (5.1) Expected numbers of public buildings in West Bank and Gaza (2007-2020)

Source: Palestine in numbers 2007

Table (5.4) Planned Public Buildings with solar system & energy code

Year	Number of new buildings (after 2007)	Percentage of New Buildings with energy saving Code	Planned % of buildings with solar system
2010	34,348	100% new Buildings only	5 %
2012	57,246	100% new Buildings only	10%
2015	91594	100% new Buildings only	20%
2018	125,943	100% new Buildings only	25%
2020	148,841	100% new Buildings only	30%

Table (5.4) was constructed based on the assumption that the code for energy efficient buildings will be implemented for all public buildings starting 2009. As a matter of fact, it is extremely difficult to estimate the actual savings in heating and cooling loads by implementing the code for different reasons. This includes the fact that the code includes the minimum requirements without upper limit. Also it is highly difficult to predict the performance of the insulation of the building when using different materials and techniques. In any case, according to experts in this subject, the expected reduction in heating and cooling loads is predicted to be between 30-50% of total load. For simplicity of calculations and for diversity, this number was averaged at 40%.

If we assume that only 5% of new buildings will be designed with one of the passive solar systems in 2010, and this percentage increases to 25% by 2020, then an annual increase of 2% in expected. In general, if the passive system was designed correctly, then it is expected that the heating and cooling loads will be reduced by 60% (50-70%). This will result in reduction in total energy consumed for heating and cooling in new public buildings a follows:

Energy savings (%) =

(% of new buildings with solar design) X (Expected savings in each building)

As we considered that average savings in energy demand is around 60%, then the total expected savings in new buildings will be as shown in table (5.5).

Since the "Energy Efficient Building Code" will be mandatory for all public buildings in Palestine by 2009, then it is expected savings in energy used for heating, ventilation and air conditioning to range between 30 and 50%. For purposes of simplicity we will consider that average savings by implementing this code will be around 40% of energy consumed for this purpose. The combined savings in energy in new public buildings by using solar design and implementing the code are summarized in table (5.6) and figure (5.2) bellow.

Table (5.5) Forecasted savings in energy by using passive solar systems in new public buildings (2010 – 2020)

Year	Expected % of energy savings in public buildings by using solar design	Expected % of new buildings with solar system**	Total
2010	60%	5%	3 %
2012	60%	9%	5.4 %
2015	60%	15%	9 %
2018	60%	21%	12.6 %
2020	60%	25%	15 %

**** Increment of 2% per year assumed**

Table (5.6) Expected energy savings in new public buildings (HVAC systems only) by implementing solar design and the code for energy efficiency.

Year	Expected % of energy savings in new public buildings by using Energy Code	Expected % Of savings by using solar system in new Public Buildings	Total
2010	30-50% (Average ≈ 40%)	3 %	43 %
2012	30-50% (Average ≈ 40%	5.4 %	45.4 %
2015	30-50% (Average ≈ 40%	9 %	49 %
2018	30-50% (Average ≈ 40%	12.6 %	52 %
2020	30-50% (Average ≈ 40%	15 %	55 %

Since we considered that heating, ventilation and air conditioning systems consumes around 55% of total energy consumed in public buildings, then, we can forecast the savings percentages of total energy demand in these buildings. Also, all of the savings we considered in this study are made for new buildings only, and then we have to find out the relative percentage of new buildings to the total number of buildings. This is summarized in table (5.7) bellow.

Table (5.7) Expected energy savings in total energy consumption by all public buildings by implementing solar design and the code for energy efficiency.

Year	Total number of Public Buildings	Number of new buildings	% of new buildings to total number of buildings	Expected % Of savings in HVAC	Expected % Of savings in Total energy consumption
	B	N	P=(N/B)x100%	S	PxS
2007	88,208	-	-	-	-
2010	122,556	34,348	28%	43 %	12%
2012	145,454	57,246	39%	45.4 %	21%
2015	179,802	91594	50%	49 %	25%
2018	214,151	125,943	59%	52 %	31%
2020	237,049	148,841	63%	55 %	35%

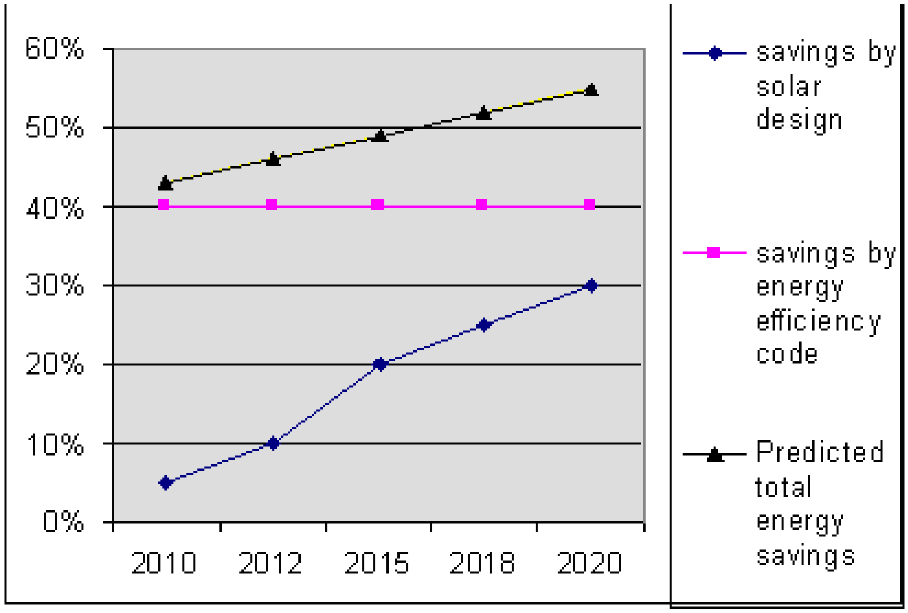


Fig (5.2) Expected energy savings (%) in HVAC systems in new public buildings by implementing solar design and the code for energy efficiency.

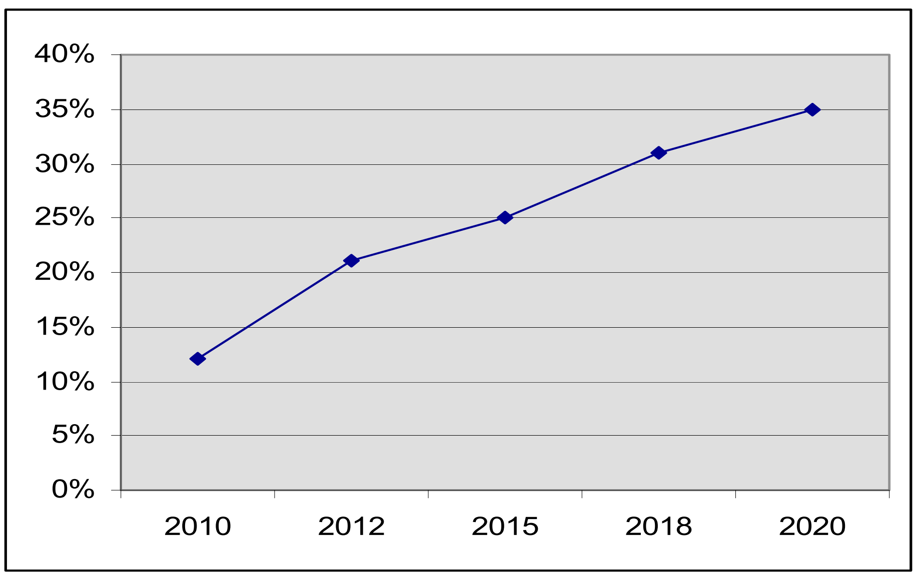


Fig. (5.3) Expected energy savings in total energy consumption by all public buildings by implementing solar design and the code for energy efficiency

5.1.2.2 Investment

The investment needed in public buildings for implementing passive solar energy systems and the energy efficiency code is minimal and it is part of the construction cost. The energy code requires high insulation of exterior walls, roofs and floors in addition to proper ventilation of the building. The main investment will be in the cost of the insulating materials which are not very expensive. In worst cases, this cost will not exceed 5% of the total cost of the building. However, the payback period is usually less than two years.

The investment in passive solar systems is very small. This is usually goes to the architectural design and the cost of glassing areas. In most cases, adding a passive system such as solar window, solar wall or solar chimney will not increase the cost of the building more than 2%, this makes the payback period of the investment less than one year which is extremely feasible.

5.1.2.3 Lighting

Lighting consumes around (35-35%) of total energy consumed in public buildings. Natural lighting can be used to reduce this amount of energy which is consumed for lighting. According to the Illumination Engineering Society (IES), proper lighting design can save up to 25% of energy used for lighting. However, it is very difficult to assume any value for energy saving in lighting in Palestine due to difficulty in comparison between buildings which are different in size, orientation, and color and surrounding. It is the duty of the Ministry of Local Governments, Engineers Association and other concerned parties to increase the awareness of architects, engineers, contractors and public about increasing dependence on natural lighting.

5.1.3 Residential sector

The residential sector can be considered the major consumer of energy in the Palestinian Territories due to the weakness of the industrial sector. This sector consumes between 40-60% of the total energy consumed in the territories. Most of this energy is used for lighting, heating and air conditioning. It is a matter of fact that a high percentage of this energy is wasted in different methods in this sector. Unfortunately, our local buildings and homes are far from being considered friends of the environment. These buildings have very high thermal conductivity, poor solar design, low dependence on energy efficient lamps, and appliances with low energy efficiency.

Since this sector is the major consumer of energy, then introducing solar energy to this sector will result in relatively high savings in energy, and reduction in energy imports. The solar share will be much higher in Palestine than other countries in the region because of the wide range of applications of solar energy in the residential sector. These applications include:

- Solar Water heating
- Solar Space Heating
- Solar Ventilation
- Solar cockers
- Solar water pumping

- Solar electrification for small houses in rural areas.

From the data available form the Central Bureau of Statistics, it is clear that many types of energy are consumed by the residential sector. This includes electricity, oil fuels, biomass and LPG. These fuels are used for lighting, space heating, cooling, water heating, cooking and other types. All sources of information don't provide exact quantities of fuel consumed for each activity. So, we tried to approximate these values using data available from neighboring countries with similar economic and social situations. The results of our estimations are shown in table (5.8).

Table (5.8) Fuel Types and their share in the Residential Sector

Types of energy consumption	**Lighting**	**Heating / AC**	**Laundry / Ref.**	**Water Heating**	**TV / Ironing & others**	**Cooking**
Fuel Type	Electric	Electric, Kerosene, LPG, Wood, Biomass, Diesel	Electric	LPG, solar, Electric, Wood, Kerosene	Electric	LPG, Wood, Kerosene, Electric
Sub-sector consumption	25%	30%	15%	12%	11%	7%

5.1.3.1 Heating and Air condition

It is estimated that 30% of total energy consumed in residential sector is used for space heating and cooling. In the last few years the number of air conditioning units used in private houses and apartments has increased sharply. This fact can be attributed to the following reasons:

- Changes in weather conditions and global warming

- Low prices of air conditioning units
- Concentration of buildings in small areas due to restrictions on building zones imposed by the Israeli occupation authorities.

The intensive usage of air conditioning units increased the demand for electric power in the last five years. In addition to that, electricity can be considered a competitive energy source because of the sharp increase in oil and gas prices in the last three years. Also, electric ovens are replacing LPG ovens in a high percentage of new homes in Palestine.

Fortunately, "Passive Solar Energy" has many feasible applications in the residential sector. Currently, around 69% of the homes in West Bank and Gaza are equipped with Solar Water Heaters (SWH). This is relatively high percentage if we take into account that there is no mandatory law for using SWH's in the residential sector, as the case in Israel. This proves that the people themselves are aware of the feasibility of solar energy for this purpose. However, this is not the case for other applications such as space heating and cooling.

A recent study by ESCWA has shown that using SWH's can save at least 70% of total energy consumed for domestic water heating. It is our goal that at least 95% of residential buildings be equipped with SWH's by the year 2020. This can be accomplished by a mandatory law, increasing public awareness and developing better systems suitable for all kinds of buildings.

Solar water heating is used for domestic purposes only. Modern technologies showed that it can be used effectively for space heating in certain systems such as under floor heating, where warm water is sufficient. Introducing this technology will provide additional savings in energy used for space heating.

Space heating and cooling consumes around 30% of total energy consumption in the residential sector. As discussed before for public buildings, this amount can be reduced by implementing the code for energy efficient buildings and adding passive solar designs to new buildings. While implementing the code of energy efficient buildings was mandatory for all public buildings starting 2009, it is clear that implementing the code in residential sector will take sometime beyond 2011 as proposed. In this regard, we will consider that the code will be implemented gradually in this sector until 2020 when all new building will adopt the code, see table (5.9).

Passive solar systems are getting more and more popular among the people, architects and engineers. We will consider that by 2010 around 5% of new buildings will have one application of solar heating and cooling. By 2020, we plan that at least 30% of all new residential buildings will adopt solar design for heating and cooling. See table (5.10). Recent study by Dr. Mutasim Baba at An-Najah University has shown that passive solar cooling and heating may reduce energy demand by 60% if designed correctly. The results become as in table (5.11) and figure (5.4).

Table (5.9) Expected Numbers of Houses for the next decade

Year	Expected No of houses	No of new houses built after 2010	% of new houses to total houses
2010	476,605	-	-
2012	565,656	89,051	15.7 %
2015	699,232	222,627	31.8 %
2018	832,807	356,202	42.8 %
2020	921,858	445,253	48.3 %

Table (5.10) Expected energy savings in new Houses (HVAC systems only) by implementing solar design and the code for energy efficiency

Year	Expected % of energy savings in new houses by using Energy Code	Expected % of new houses to implement energy code	Expected energy savings by implementing the code in new houses	Expected % Of savings in new houses by using solar system**	Total
2010	30-50% Average ≈40%	10%	4%	3 %	**7 %**
2012	30-50% Average ≈40%	20%	8%	5.4 %	**13.4 %**
2015	30-50% Average ≈40%	40%	16%	9 %	**25 %**
2018	30-50% Average ≈40%	60%	24%	12.6 %	**36.6 %**
2020	30-50% Average ≈40%	80%	32%	15 %	**47 %**

**** Same data used for public buildings – see table 5.6**

Table (5.11) Expected energy savings in total energy consumption by all houses by implementing solar design and the code for energy efficiency

Year	% of new houses to total houses	Expected % Of savings in HVAC	Expected % Of savings in HVAC Total energy consumption	Expected % Of savings in Total energy consumption in residential sector **
2010	-	7%	-	-
2012	15.7 %	13.4%	2.1%	**0.6%**
2015	31.8 %	43 %	13.6%	**4%**
2018	42.8 %	45.4 %	19.4%	**5.8%**
2020	48.3 %	49 %	23.7%	**7.1%**

**** HVAC systems consume 30% of total residential energy consumption**

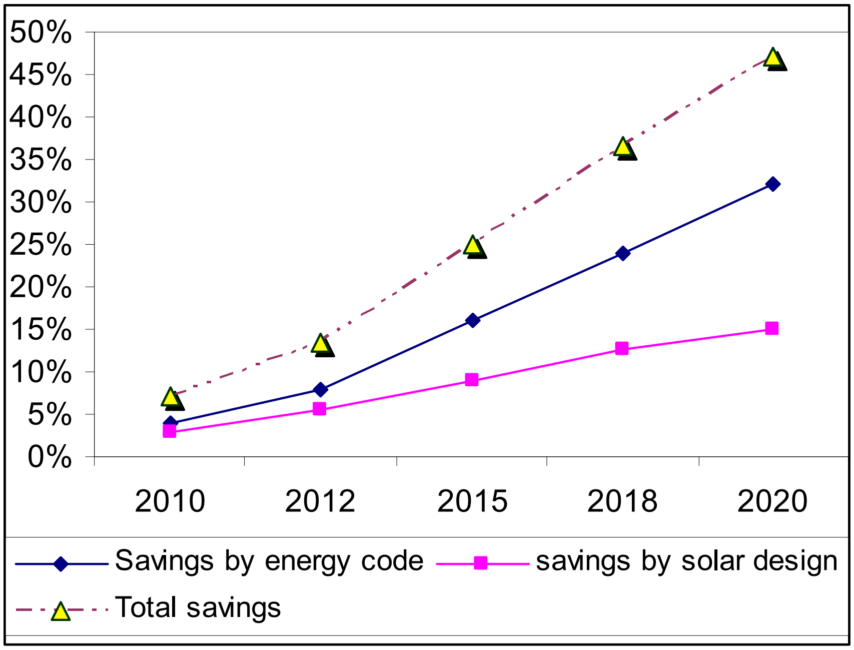


Fig. (5.4) Expected energy savings in residential sector HVAC system

5.1.3.2 Water Heating

Around 12% of energy used in residential sector is consumed for water heating. Electric boilers, kerosene and diesel heaters, LPG boilers and biomass heaters are widely used for water heating in addition to domestic solar water heaters. Central water heating for residential buildings is not common in Palestine. Tankless electric and gas boilers are favored for their cheap price and instant supply of hot water. Dishwashers and cloth automatic washing machines use their built in electric heaters for water heating.

According to statistics of the Palestinian Central Bureau of Statistics in 2005 (survey of house energy), about 67.2% of households were equipped with domestic solar heater system (SWH) or the equivalent of

428,486 heater systems. It's our goal that this percentage will increase to 95% by 2020. This can be accomplished by adopting a mandatory law and by improving efficiency of SWH systems used in the residential sector.

Table (5.12) Percentage of households using different types of fuel to produce hot water

Index	Fuel share in total energy used for water heating
households using LPG	% 35.0
households using solar energy	% 27.8
households using electricity	% 25.2
households using firewood	% 9.8
households using kerosene	% 1.0

ESCWA report ("Improvement of Energy Usage Efficiency in Residential Sector in country members of ESCWA, document # E/ESCWA/ERG/16-2001) estimates that SWH can supply 70-90% (Ave. 80%) of all energy consumption for water heating. This will make the saving's in energy consumed in 2020 to 12% of the total energy consumed in the residential sector.

The above goal can be achieved only by two methods:

1. Encouragement of use of SWH in all sectors by adopting different policies such as mandatory installation of systems in all new houses, tax exemptions, etc.

2. Improvement of overall efficiency of locally produced systems through the imposition of standards, testing for quality assurance, and proper training for technicians who install them.

Figure (5.5) illustrates the Expected savings in energy used for water heating by implementing high efficiency solar water heaters and a mandatory law.

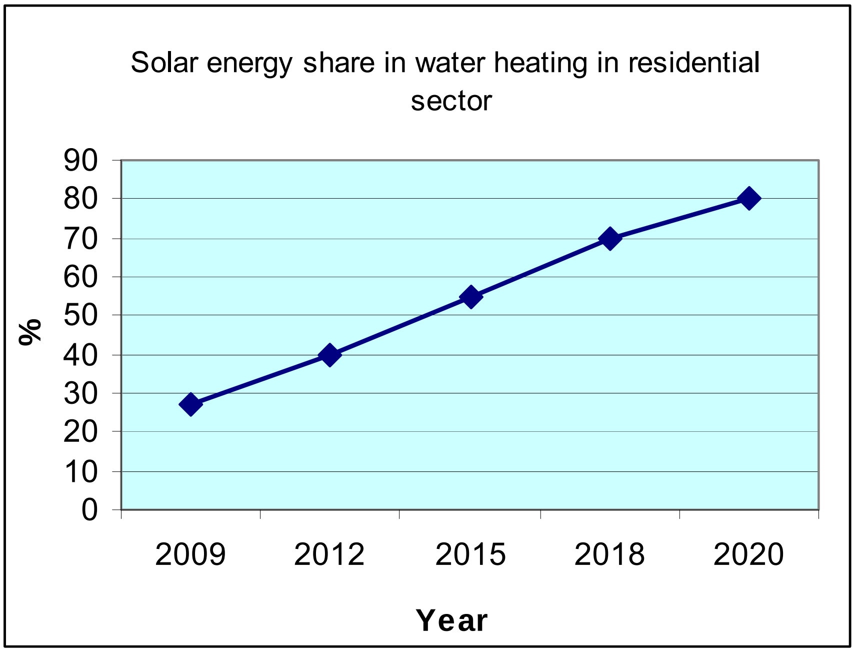


Fig. (5.5) Expected savings in energy used for water heating by implementing solar water heaters

5.1.3.2.1 Solar Water Heaters Industry

Most of solar water heaters are manufactured locally in the West Bank and Gaza. New and old units are imported from Israel and sold in the local market. At this time there are no figures to indicate the percentage of number of systems that are produced locally to the overall number of systems installed annually in the PA, as shown in table (5.13).

The use of SWH in Palestine is market-driven, since the system is competitive with other means of heating (unit price 500 US$). In addition, the system pay-back period is less than 2 years, when compared to that of electric systems. The market for solar thermal energy technologies is estimated at $10 million. Public and private efforts should be done to this industry through the following recommendations:

- Providing financing support for producers from banks and other money lending institutions to help people afford the system.
- Improvement of overall efficiency of locally produced systems through the imposition of standards, testing for quality assurance, and proper training for technicians who install them.
- Extension use of collective SWH systems in the residential, industrial, commercial and service sectors, such as health, education, tourism, sport.
- Governmental policies to encourage the use of SWH, such as mandatory installation of systems in all new houses, tax exemptions, etc.

Table (5.13) Distribution of main SWH producers by Region, 1999

Region	Number of Industry	Employees	Production System/year
W.B- North	6	24	3 480
W.B- Middle	4	40	11 025
W.B- South	2	31	5 670
Gaza Strip	3	30	6 500
Total	15	125	26,675

The industry of solar water heaters is facing strong competition by the Israeli market due to the occupation and Israeli monopolizing practices on the trade movements throughout the borders and obstacles on import/ export of material and products. However, most of the raw material is imported from Israel, Europe and Turkey such as pipes, insulation materials, sheet metals and pumps, the shell for the hot water storage tank and the inner painted lining of the storage tank.

5.1.3.2.2 SWH Systems Prices

The prices of domestic solar system have variation due to quality of materials and labour cost. The final price is in the range 450 – 550 US$ (including installation), an average of 0.31 of GDP. The variation in prices depends on the size of the system 2 or 3 collector panels, type of the system open or closed, and the quality of the components. As an average, prices are in the range 100 – 120 US$/m^2. Table (5.14) represents the price breakdown of the components of a solar family system.

Table (5.14): final price breakdown of solar family system, 1999

Component	Price US$
Flat plate collector panel (90x190 cm)	64 (192 for 3 collectors)
Hot water storage tank (150 litre)	100
Cold water makeup tank (1500 litre)	95
Valves, pipes, etc (on the roof)	40
Fixture	60
Installation	50
Total	**US $ 537 (105 $/m^2)**

For the collective system, the average final price is in the range 120 - 150 US$/m^2.

Closed type systems are not widely used because of their higher prices, but they are preferred over open type systems for their longer life and ability to maintain efficiency over time. Corrosion and blocking of pipes by limestone are the major factors that reduce efficiency overtime especially in open type systems. Table (5.15) represents the price breakdown of a closed type collective system.

Table (5.15) Price breakdown of close-type solar collective system Total area 87 m^2, serves 34 apartments, 1999

Component	**Number of units**	**Unit Price US$**
Flat plate collector panel - 90x190 cm	51	60
Hot water heat exchanger - 150 liter	34	170
Cold water makeup plastic tank - 1000 liter	1	75
Control system with differential thermostat	1	1000
Hot water Circulating pump	1	150
Valves, pipes, etc (on the roof, not to apartments)	lump	1000
Fixtures	lump	500
Installation	lump	1000
Total		**US $ 12,565 (145 $/m2)**

Table (5.16) represents the cost of raw material used in manufacturing the solar water heaters.

Table (5.16): Cost of raw material used, 1999

Material	**manufacturer Cost (US $)**
Sheet metal 2-5 mm	370-450 / ton
Galvanized Sheet metal 0.4-1 mm	600 / ton
Galvanized steel pipes ½”, ¾”, 1”	1 – 2 / m
Insulation (polyurethane) 5 mm thickness	3 / kg
Insulation (rock wool) 5 mm thickness	1.75 / m2
Thermal paint	3 / litre
Single cover glass	3.8 / m2

5.1.3.2.3 Manufacturers

Table (5.17) gives a list of main manufacturers in Palestine.

Table (5.17) List of the main SWH manufacturers in Palestine

No'	Manufacturer	Location
1	Abdul Rahman Tamam	Tulkarem
2	Hamamat Al-Iktissad	Tulkarem
3	Al-Aqsa	Jenin
4	Al-Jalbouni	Jenin
5	Mansour	Nablus
6	Al-Itemad	Ramallah
7	Abu Shushah	Ramallah
8	Original	Al-Ram
9	Niroukh	Hebron
10	Saddik	Al-Aroub
11	Modern National Co.	Gaza
12	Al-Ankar	Gaza
13	Al-Najah	Gaza

5.1.4 Industrial Sector

The uses of solar energy in the industrial sector in the Palestinian territories are still limited, almost non-existent for several reasons. These reasons include the lack of scientific and technical guidance to the owners of factories, and the lack of local expertise necessary for the solar system industry, which slightly differ from those system used in the houses.

While solar energy is needed for space heating and cooling of buildings on the industrial sector, it is more important to use it in the manufacturing process it self. The energy consumed in the industrial sector is used in different forms, such as moving motors and heat. Thermal energy that can be benefit from solar energy includes the following processes:

1. Heating of water, oil, asphalt, etc.

2. Steam generation
3. Heating & cooling (air conditioning)
4. Grain Drying
5. Simple manufacturing (dairy - paper) all these industries need to get the heat, either through air or water. But the most common use of solar energy to heat the water through the surface absorption of solar radiation.

The exploitation of solar energy in the industry gives a clean and a free source of energy, which can be relied upon in the food, chemical, metallurgical, textile, sewing and timber industry in addition to the utilization of solar energy in melting asphalt.

Due to the nature of weather fluctuations in winter and the possibility the sun may not shine for long hours, it is preferable to supplement solar energy systems with other kinds of fuel such as electricity system or gas to cover the deficit if their are a necessary. These auxiliary systems are used only when needed, or when available solar energy not adequate

Solar systems which are needed in the industry may be different from those used for domestic purposes. This difference can be attributed to the following reasons:

- The huge consumption of hot water in industry.

- Most industries need hot water at high temperatures, or as steam.

Therefore, the systems which are used in the industry are characterized by large solar receivers (collectors), concentration solar collectors, and large storage tanks. Concentration collectors are different from flat plate collectors in design, and cost much more. Concentration collectors use some different techniques to achieve the required goal of high temperatures, such as:

1. Concave mirrors to focus heat on water pipeline.
2. Parabolic reflectors to focus heat on water pipeline.
3. Auto tracking system to keep the sun perpendicular at the plates.

The costs of these systems are much higher than those used for domestic purposes. Previous experience from other countries has shown that the payback period of these systems may exceed five years; meanwhile payback period of flat plate collectors for domestic purposes usually doesn't exceed two years.

It is also in the exploitation of solar energy in heating and cooling through the use of special techniques in addition to the application of the law of energy saving in buildings, beginning in 2010, it is expected that the ratio of the contribution of solar energy by the year 2020 approximately 5% of the total energy used in this sector.

Table (5.18) represents the mounts of energy used in the Palestinian industry where solar energy can be used:

Table (5.18) Potential share of solar energy in Palestinian sector

Purpose	% of energy used ♦	% of energy to used from solar ♦	Savings in thermal energy for industry	Total saving in energy for industry **
Water heating	13%	70%	9%	2.7%
Steam Generation	9%	50%	4.5%	1.4%
Hot air for drying	5%	50%	2.5%	0.8%
Total				**4.9%**

**** Around 30% of energy consumed in the industry is used as heat**

♦ Source: M. Baba, "Energy in the industrial sector in Palestine", UNDP report

5.1.4.1 Investment in Solar Systems for Industrial Purposes

It is very important to develop local industry to produce concentration type system which can be used for industrial purposes, such as steam or hot water generation. This may require the followings:

1- financing schemes including very low interest rates and revolving funds

2- special training for personal to work in this new industry

3- Adopting of quality control standards.

5.1.4.2 Quality and specifications:

Majority of manufacturers of SWH systems (flat plate collectors only) have gained their experience from the Israelis, by working jointly with them or as employees. The manufacturers used to fabricate close to the Israeli standards.

The Palestinian Standards Institution has its own code for the SWH manufacturing, testing and installation (PS8p1-4) which is not far from the Israeli's one:

- PS8P1/1997: Solar System for Heating Water, Flat Plate collectors
- PS8P2/1997: Storage tanks for Apartment – Thermo symphonic Water Heater.
- PS8P3/1997: Solar Water Heating System: Thermal Tests for Flat Collectors.
- PS8P4/1997: Solar Water Heater –Installation of Thermo symphonic Apartment Water heater. Instruction for Installation.

The main problem facing the Palestinian Standards Institution in implementation of this code is the difficulties to make the appropriate controls on the products under the absence of specialized labs and clear laws in the specific argument focused on the obligation of standards and certifications. Also, the PSI needs to develop or adopt its own standards for the concentration type collectors needed for industrial application or electricity generation as will be discusses later.

5.1.5 Solar Greenhouses

Solar greenhouses for use in Palestinian Territories are very attractive for farmers because of their high agricultural yield per unit area, and low water consumption. It is very clear that thousands of donums of clear farming were converted into greenhouses. According to PCBS report in 2004, more than 40,000 dunums of greenhouses were operative, mainly of vegetable production. This area represents around 23% of the total agricultural area cultivated for vegetable production. This fact indicates that greenhouses are similar to SWH are economical and feasible.

In Palestine, which is characterized by hotter climates, the conventional greenhouse designs post a problem of high cooling needs in summer. Very little work has been done on improving their designs to suit the hot summer. Also, frost waves which invade the eastern part of the Mediterranean once every few years represent a major problem for greenhouses in winter. The lack of supplementary heating system or heat storage for cold nights is the main reason for damages caused by frost waves.

Solar energy gain in greenhouses can be estimated by 80 terawatt per year.

Chapter 6

Solar Energy for Power Generation

Chapter 6
Solar Energy for Power Generation

The Gaza Power Plant (GPP) is the only significant generation capacity in the West Bank and Gaza with an installed capacity of 140 MW. Also, GPP is the only major privately financed, developed and operated power facility from which power is provided to Gaza under a long term power purchase agreement. It can supply about two-thirds of the current maximum load on the Gaza electricity system, but its overall capacity of this facility doesn't exceed 20% of the combined needs of the West Bank and Gaza. However, it is constrained to using 50% of capacity at present because of the limitations of the transmission network to take power from the plant. The plant generates electricity at high cost because it currently uses costly gasoil which is imported completely from Israel.

The natural gas which was discovered the coast of Gaza has never been extracted. This leaves solar energy as the unique indigenous source of energy for electric generation. There are two different approaches to generate electricity from the sun: photovoltaic (PV) and solar-thermal technologies.

photovoltaic (PV): Initially developed for the space program over 30 years ago, PV like a fuel cell, relies upon chemical reactions to generate electricity. PV cells are small, square shaped semiconductors manufactured in thin film layers from silicon and other conductive materials. When sunlight strikes the PV cell, chemical reactions release electrons, generating electric current. The small current from individual PV cells, which are installed in modules, can power individual homes and businesses or can be plugged into the bulk electricity grid. PV systems operate without producing air, water or solid wastes. Figure (6.1) show the Photovoltaic unit in a village in the West Bank.

Fig. (6.1) Photovoltaic unit in a village in the West Bank

The cost of PV systems includes the price of PV cells, storage batteries, DC to AC inverters, installation and control units. The investment will cost around $5000 per KW peak. This is not competitive to grid power, but it may be more economical in remote areas and small villages in Palestine.

- Solar-thermal technologies are, more or less, a traditional electricity generating technology. They use the sun's heat to create steam to drive an electric generator. Parabolic trough systems, like those operating in southern California, use reflectors to concentrate sunlight to heat oil which in turn creates steam to drive a standard turbine. The biggest concern with solar technologies may be land use.

- Concentrating solar power (CSP) technologies use mirrors to reflect and concentrate sunlight onto receivers that collect the solar energy and convert it to heat, see figure (6.2). This thermal energy can then be used to produce electricity via a steam turbine or heat engine driving a generator. Our goals include increasing the use of CSP in the Palestine, making CSP competitive in the intermediate power market by 2020, and adopting advanced technologies that will reduce systems and storage costs, enabling CSP to be competitive to electricity imported from IEC (Israeli Electric Company) by 2020. The plans to achieve these goals can be achieved through cost-shared contracts with industry, and collaboration with other universities and research centers to remove barriers to deploying the technology, and collaboration with donating countries.

Fig. (6.2) Types of Concentrated Solar Thermal Power Systems

Two other solar-thermal technologies are nearing commercial status. ***Parabolic dish systems*** concentrate sunlight to heat gaseous hydrogen or helium or liquid sodium to create pressurized gas or steam to drive a turbine to generate electricity. ***Central receiver systems*** feature mirrors that reflect sunlight on to a large tower filled with fluid that when heated creates steam to drive a turbine.

6.1 Planned Solar Power Generation Projects in PA

Up to now, “least cost and proven technology” thinking has prevented Middle East and North Africa governments from using a clean, unlimited and very economic source of energy available at their door step solar energy irradiated on the deserts and coasts

Each square kilometer of land in the Middle East receives every year an amount of solar energy that is equivalent to 1.5 million barrels of crude oil. The technology to harvest, store and convert it to useful energy is state of the art: concentrating solar power. A concentrating solar power plant of the size of Lake Nasser in Egypt (Aswan) would harvest an amount of energy equivalent to the present Middle East oil production. Solar energy received on each square kilometer of desert land is sufficient to desalinate an amount of 165,000 cubic meters per day or 60 million cubic meters per year In the last few years there has been a great interest in investing in power generation in the Middle East using solar energy. This interest includes Palestine as two major projects are planned, one in the West Bank and the other in Gaza. These two projects were delayed due to the current political situation and Israeli complete closure of Gaza Strip.

As discussed earlier, generation of electricity from solar energy will reduce dependence on imported energy in the form of electricity or fuel to Gaza power station. In the last few years, two different projects were planned for using solar energy for power generation in Palestine, one in West Bank and the other in Gaza:

1. A pilot project in Jericho with total capacity of 1 MW has been planned by JDECO. This project will be expanded to 100MW by 2020 upon the success of the pilot project. Concentrated thermal solar is the main source of energy for this project. This project will be implemented by Naanovo Energy. Naanovo Energy USA, Inc., is a global clean energy company based in Fort Lauderdale, Florida, United States of America.

The investment of first stage of the pilot project will be US $ 17M and the total investment of the final project will be around US $ 300M. It is expected that this project will provide around 20% of total electric energy consumed in the Palestinian Territories.

2. A pilot project for Water Desalination and Power Generation in Gaza using concentration solar power (CSP). The first phase of the CSP-DSW project comprises of a comprehensive techno-economic feasibility study for the creation of a pilot (demonstration) plant which will utilize solar power technology and tested desalination methods in a more efficient and environmental-friendly combined thermo dynamical cycle for the production of water and simultaneous production of economically competitive, green energy. With the completion of the feasibility study, an implementation design will be proposed for the pilot plant that is best suited to Cyprus' needs and conditions. The second phase of the project is comprised by the actual installation of the plant that will be used to further advance the concept, engineering and optimize the use of this

technology. The third and final phase will see the deployment of the refined technology plants for heavy-load commercial operation.

6.2 Solar Water desalination and Power Generation for Gaza

In the planning effort for constructing a solar water and power source (SW&PS) for Gaza as a multi-national effort. This can be done with existing technologies, human labour and ingenuity, available technology and existing financial resources, and with the over-abundant sources of sunlight and seawater. With energy from concentrating solar collectors figure (6.3) combined power and desalination plants can transform deserts along shore lines into inexhaustible sources of power and water with unlimited capacity. This will give those countries a new horizon for their development.

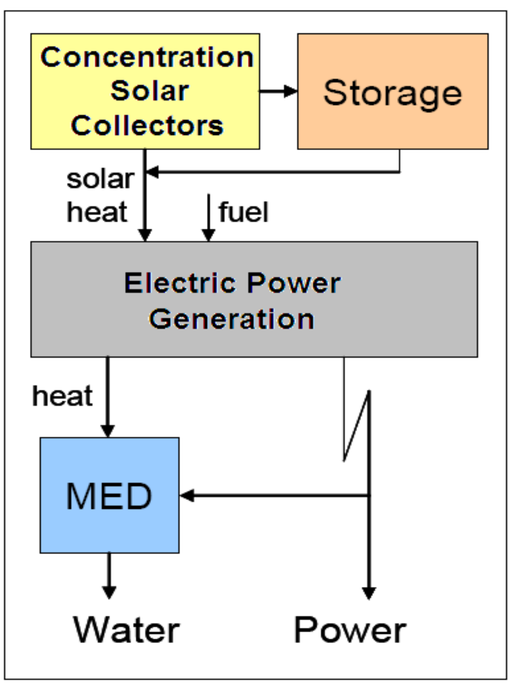


Fig. (6.3) Schematic diagrams of Solar Power and Water Desalination Project

Ref: Solar Water&Power Source for Gaza, project proposal by TREC and cEWE , version as of 2006-09-15

Primarily the Gaza SW&PS will produce power, water and optionally also cooling for buildings for the mounting demand coming up in Gaza for a population expected to reach 3 Million within a few decades. The full project may be accomplished within 10 to 15 years.

That's why the Gaza Solar Water &Power Source effectively would give to humanity an efficient tool to end global warming and to avoid global energy scarcity. It is a global sustainability project.

6.2.1 Basic parameters of the project

For defining the size of the plant we consider the population expected for 2030 and beyond, see the following table (6.1):

Table (6.1) Current and predicted population of Gaza Strip

Population in 2005	**Expected in 2015**	**In 2025**	**In 2035**
1.4 Mio	2.0	2.6	3.3
From Palestinian Central Bureau of Statistics		Assuming 3.0% annual Growth	Assuming 2.0% annual Growth

Since there are virtually no sustainable resources for power and fresh water within Gaza we propose to consider a power and water source with the capacity 3 million people. We adopt the vision that Gaza will not for ever live at the edge of poverty, but rather become a productive and prospering city, like Milan or Dubai for instance, and assume the following per capita demands.

6.2.2 Investment in Water Desalination and Power Generation

Most components, such as steam turbines, power generators and multi effect distillation (MED) units are standard technology. The most appropriate solar steam generator are concentrating solar collectors (like parabolic trough), a proven technology. Their costs however would undergo substantial reduction in the course of the project, due to a beginning mass production and further due to system improve-ments. Very preliminary cost figures have been estimated in deployment scenario, developed by TREC and the German Center for Air and Space Technology (DLR). The cost estimate includes learning curves and cost reduction during progressing deployment. This study yields the following preliminary cost estimate for the Gaza proposal, as shown in table (6.2)

Table (6.2) Investment in SWPS project in Gaza

Components of the Gaza SWPS	**Very preliminary estimate on investment**
Solar Thermal Power Stations, in total with 1200 MW	3 – 5 b$
Multi-Effect Desalination for 360 Mm^3/year	1.5 b$
Infrastructure (roads, pipe lines, power transmission.)	0.5 b$
Total investment	**6 +/- 1 billion $**
Stage 1: 10 MW power capacity on Gaza site	**50 - 70 million $**

Ref: Solar Water&Power Source for Gaza, project proposal by TREC and cEWE , version as of 2006-09-15

6.2.3 A flexible set of stages

The first stage of 10 MW would cost around 60 million $, and require a collector space of 100,000 m^2. The following stages of expansion can be chosen to match the actual demands and the financing opportunities. The project expansion can be terminated or interrupted after completion of any stage, with each stage fully functional. This way the installation of the project can be adjusted to real conditions of Gaza, see figure (6.4) which shows the organizational diagram of the Gaza Project

6.2.4 Estimate of the annual costs

It is assumed that the total investment of 6 billion $ is to be amortized within a period of 15 years with an interest rate of 7% per year. Using a deployment scenario we can give a first preliminary assessment of the costs and of the economy of the Gaza project. Eventually these numbers need to be examined and adjusted to the exact conditions of Gaza, based on a deployment strategy optimized for Gaza.

Costs for capital, operation and maintenance, insurance and supplementary fuels amount to 1.3 b$/y during amortization, and to 0.6 b$/y afterwards. The 1.3 billion $/y can be recovered when power is sold for 0.11$/kWh and water for 1.0 $/m^3, and when carbon credits of 10$ per ton CO_2 are included. After amortization, during the expected remaining physical life time of 15 to 25 years of the plants, the prices can go down, to 0.05 $/kWh and to 0.5 $/m^3 or even lower. We also mention that if the interest rate was 0%, the power and water costs during amortization could go down by 20%, and if the in-vestment would come as a donation by more than 50%.

The cost assessment also shows: when fossil fuel costs will remain constant over the coming 40 years, then oil must be cheaper than 50 $/barrel to be competitive with solar steam produced at day time. If we expect a cost doubling period of 23 years then today's fuel costs need to be below 33$/barrel to be competitive over the full life time. If we consider steam from stored solar heat, then the corresponding numbers would be 72 and 50 $/barrel, respectively. In other words, for day and night time operation

Solar energy is already now the least cost solution, even if oil costs will rise much more slowly than in the recent 5 years, and if a total life time of 30 – 40 years is considered.

The equivalent figures for natural gas (NG) can also be inferred. 5.34 MBTU (Million British thermal units) contains the same amount of thermal energy as 1 bbl oil. 5$/MBTU then correspond to 27 $/barrel

The expected solar cost reduction by this project makes the solar solution to an excellent opportunity for large savings in the Sunbelt already now.

In summary we can conclude, that with solar conditions as around Gaza (2300 kWh/m²/y), the solar energy solution will be cheaper than the fossil fuel solution from the beginning, and it is by far the least cost solution for the complete proposed Gaza water and power source.

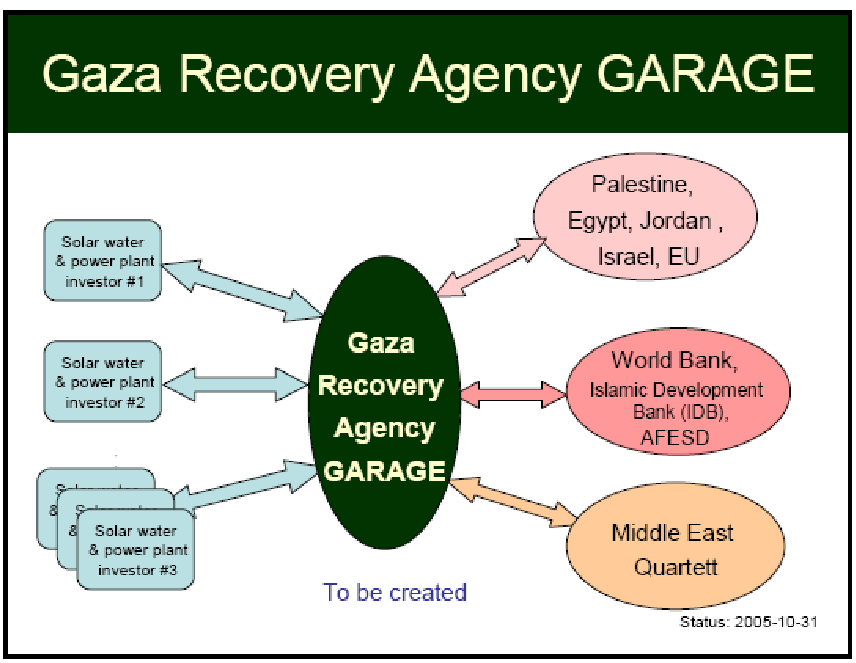


Fig. (6.4) Organizational diagram of the Gaza Project

Ref: Solar Water&Power Source for Gaza, project proposal by TREC and cEWE , version as of 2006-09-15

Chapter 7

Results, Conclusions and Recommendations

Chapter 7

Results, Conclusions and Recommendations

7.1 Structure of Analysis

From the previous chapters, it was clear that there are many sectors in the Palestinian economy where solar energy can be applied in an economical form. However, while energy sector analysis and planning establishes the strategies to be followed in a national energy program, the design, implementation and management of the specific project to implement that strategy. Integrated energy analysis, for example, deals with the amounts of various fuels including solar energy to produce electricity or to be used in any sector.

Like other developing countries, energy planning in Palestine is a hierarchical process, in which several clearly distinct levels of analysis exist. However, the project-by-project practice of solar energy expansion which is followed in Palestine, though an apparent necessity, is not the most desirable approach. There are many uncertainties due to conditions within and outside the country that result in such a practice. Political, economical, geographical, financial, and lack of data are the main uncertainties that affect the planning process in Palestine.

Diverse factors that have to be considered in solar energy planning as an energy option for Palestine were discussed in this thesis. Various attempts were made to deal with the uncertainties, especially in the case of lack of data. In most cases the results could be reached with certain assumptions about uncertainty without thorough justification. For this purpose a Hierarchy Planning Process (HPP) was considered for the energy planning including solar energy planning. HPP structure is shown in Figure 7.1 where all options, objectives, actors were specified in order to achieve the final goal which is higher dependence on solar energy as a clean, renewable and cheap source of energy.

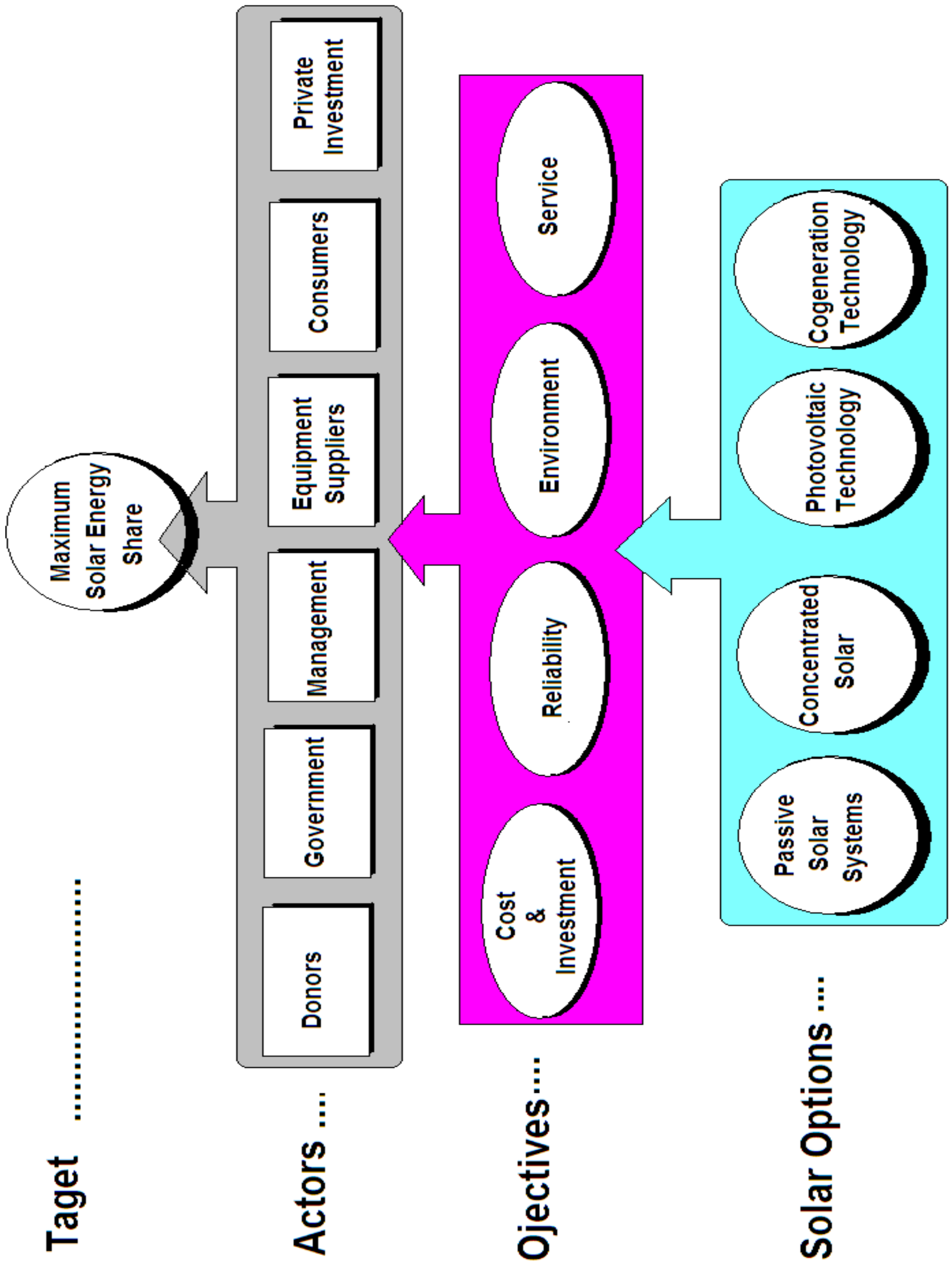


Fig. (7.1) Hierarch structure of solar energy planning

7.1.1 Solar Options

Different solar options were found feasible for implementation in different sectors. These options include:

1. Passive Solar Systems: this includes space heating and cooling and solar water heating for domestic applications in private and public buildings. SWH are locally fabricated and they are used widely in the PT even without mandatory law. Space heating and cooling systems needs special training and education for architects and engineers to integrate them in building designs.

2. Concentrated thermal systems: can be used for generation of high temperature water or steam which is needed for industrial applications and power generation. Industry of such systems is not yet developed in the PA and special training of technical people is needed to enhance such industry.

3. Photovoltaic systems: used for electrification of rural areas or for small projects such as electrification of clinics or schools in remote areas. All PV's are imported from outside, but training of local staff is needed on maintenance of the systems.

4. Cogeneration systems: concentrated thermal systems are used for power generation and water desalination. Such project is needed badly especially in Gaza Strip where is shortage in water and electricity.

The following table (7.1) explains major points of planning factors related to solar options.

Table (7.1) Solar Energy Options Applicable for Palestine

Solar Options in Palestine			
Passive solar and SWH	**Concentrated thermal**	**Photovoltaic**	**Cogeneration**
▪ Applicable in every private or public buildings ▪ Efficiency is relatively high with little technology	▪ Generate steam and very hot water ▪ Needed for industrial applications and power generation ▪ Can be implemented in West Bank and Gaza	▪ Feasible for small villages or projects in remote areas	▪ Produce electric power and desalinated water
▪ Can be completely done locally ▪ Training for architects and engineers is needed	▪ ▪ Need large areas Local industry needed to be developed ▪ Special training is needed for local technicians	▪ Not economical at current prices ▪ Little training needed ▪ Totally imported from outside	- large investment is needed in hundreds of millions of dollars -Needs large areas for concentrated thermal systems dollars
▪ Investment is very small ▪ Payback period is very short usually less than 2 years. ▪ Environmental impacts are great	▪ Investment in industry is moderate ▪ Investment for power generation is very huge (tens of millions of dollars) ▪ Environmental impacts are great	▪ Very little maintenance needed ▪ Investment considered high at private or public scale ▪ Environmental impacts are great	- applicable in Gaza - payback period around ten years - donations from other countries is needed - environmental impacts are great

7.1.2 Objectives

Any project needs to have certain objectives to be achieved. Solar energy projects have many objectives such as

1- Cost and investment: this has to be as small as possible. Passive solar systems and solar water heaters require small investment; however, power generation and cogeneration systems require huge investment. Private investors, banks, NGO's and donating countries are required to invest in such projects for their feedback on peoples life, economy and environment.

2- Reliability: Solar energy systems must have good reliability in order to be accepted by people. People must understand the main positive and negative features of such systems. Need for cheap auxiliary fuel is high in certain applications to ensure high reliability

3- Environment: solar energy projects have positive impacts on local and global environment. Reduction of gas emissions especially CO2 emissions is the direct impact of such systems. Replacing fusel fuels will also enhance the environment in different ways

4- Service: In order to achieve sustainable development in the area of solar energy system, proper service must be provided. Trained people on maintenance and installation of such systems are needed. Large projects for power generation and cogeneration may require special training for engineers and technical staff for providing this service for such advanced projects.

Table (7.2) summarizes all major objectives of solar energy options for Palestine

Table (7.2) Planned Objectives of Solar Projects in Palestine

Objectives of solar energy projects for Palestine			
Cost and Investment	**Reliability**	**Environment**	**Service**
▪ Passive solar and SWH costs very little ▪ Concentrated thermal for industrial applications require moderate investment ▪ Power Generation requires large investments	▪ All systems must work in a reliable way that can be trusted by customers ▪ Pilot projects must be considered before final decisions on large projects	▪ Solar projects have positive impacts on environment ▪ Solar industry must respect the environment	▪ Passive solar systems require little service ▪ Power generation require special service
▪ Donor countries are required to invest in large and moderate projects. ▪ Banks are encourages to finance solar projects ▪ Private investors are encouraged to invest in solar projects. ▪ Solar industry is a feasible area	▪ Backup system or an alternative fuel must be available to ensure system reliability in case of shortage of solar radiation in winter ▪ Alternative fuel must be available, cheap and preferable local if possible	▪ Fusel fuels replaced by clean solar energy ▪ Reduction of gas emissions such CO2 ▪ Little impact on nature and wild life ▪ Noiseless systems	▪ Training of technicians is needed for SWH's and passive systems ▪ Training for engineers is needed for power generation
▪ Government has to give incentives to solar projects ▪ Tax exemptions must be made for solar industries. ▪ Energy authority must encourage such projects over traditional projects if feasible.	▪ For Gaza it is preferable to consider Gas as an alternative fuel. This Gas can be taken from fields discovered offshore Gaza coast. Egyptian Gas is second alternative	▪ Ministry of environment and other agencies must provide the public with information about health and env. Impacts of solar	▪ Universities and technical colleges are main providers for training

7.1.3 Actors and Decision Makers

The planning for any sector requires the integration of efforts of different actors and decision makers. This applies to the planning process for the energy sector in general and for solar energy in specific. Any planning by different actors may lead to results that are far away from the main target. For the solar energy planning the main actors are:

1- Government: The government must adopt a strategic energy policy that considers solar energy as an indigenous fuel that has economical and environmental impacts on the country. This policy must encourage the investment in solar energy projects and solar energy industry by all means. Also, special training and education program must be implemented at different level to ensure quality of people working in this area.

2- Donors: Local and international donors must consider investing in solar project in Palestine as a future energy option. This can be one by financing large thermal projects for power generation, cogeneration, and photovoltaic systems for rural areas. Special funding for developing local industries such as revolving funds can be considered of great important for developing this industry. Funding of training programs also important as a guarantee for success of such projects.

3- Consumers: consumers are a major actor in the planning process. These customers must be encouraged to consider solar energy as a favorable energy option for its economical and environmental impacts. Customers must be aware of all possible setbacks of such projects especially at first stages in order to avoid disappointments. Incentives can be considered to customers who switch from traditional fuels to solar energy.

4- Management: On large scale projects, management plays a great role in the implementation of the project. Managing the project will guarantee the success by all means by recruiting technical staff and providing required equipment.

5- Equipment Suppliers: must be provided with all specifications and quality control guidelines to ensure quality of supplies.

6- Private Investors: must be encouraged to invest in solar energy projects by incentives from governments and other guarantees for them.

Table (7.3) summarizes the main activities and requirement of each actor and decision maker.

Table (7.3) Different Actors and Decision Makers of the Planning Process

Actors and Decision Makers					
Government	**Donors**	**Management**	**Customers**	**Equip. Suppliers**	**Private Investors**
▪ Adopt strategic energy policy with solar energy as an important option	▪ Large projects requires international donations ▪ Donations for local research	▪ Must ensure proper implementation of projects.	▪ Awareness of solar energy importance must be increased	▪ Must be provided with technical specifications and quality	▪ Must be encouraged to invest on small projects
▪ Encourage donors, investors to finance projects ▪ Provide technical education and training for staff.	▪ Donations must be made to develop solar industry of all types and at all levels.	▪ Recruiting of qualified and trained engineers and staff. ▪ Make frequent check on feasibility of the project.	▪ Customers must be encouraged to invest in Passive Solar Projects	▪ Local equipment must be considered if available.	▪ Must be encouraged in investing in solar industries.
▪ Incentives to solar industry and to customers of solar projects.	▪ Local donations for research at local universities must be encouraged.	▪ Prepare progress reports. ▪ Prepare evaluation reports frequently.	▪ Customers must be encouraged to use local systems.	▪ Tax exempt may be considered on certain items to lower	▪ Must be encouraged to buy shares in large solar projects.

7.1.4 Target : Maximize Solar Energy Share as an Energy option

The main target of the planning process is to increase dependence on solar energy which is cheap, renewable and clean, in order to increase its share in total energy consumption in Palestine. All actors, objectives and scenarios must work as planned to achieve this goal.

In our study we tried to estimate the maximum share that we can achieve. The analysis was made based on certain assumptions due to some uncertainties in our country. Also, these results were made on the assumptions that the planning process was done according to the hierarchy structure discussed before.

The next section will discuss the final results we reached for achieving the main target, which is maximizing the solar share in the energy sector in Palestine.

7.2 Results

From Chapters 6 and 7 we can reach quantitative results for our planning process. It is clear that there are different solar energy options that are available for Palestine. This could be divided as follows:

1- Passive and Active Solar Systems: Passive solar systems include solar water heaters, and space heating and cooling of buildings. Active solar systems include concentrated solar thermal, power generation, cogeneration with water desalination and solar cooling

2- Small Projects and Large Projects: Solar water heater, passive solar systems, solar systems for industrial applications, and photovoltaic systems can be considered of small and moderate size. Power generation projects and cogeneration projects are of large size.

3- Investment: Small projects require small investment and can be self financed by customers. Large projects need huge funds and must be financed by the government and donor countries. The size of funds for small projects range between $ 500 and $ 5000, moderate projects require funds between $10,000 and $500,000 such as the case of photovoltaic projects. Large projects may require funds in the range of $ 10M to $ 2B.

4- Time for implementation: small projects can be implemented in few days to few weeks or months. Large projects may require several years for implementation.

7.2.1 Predicted Solar Energy Share

From the results we reached in chapters 6 & 7 we can conclude that solar energy share can be as follows:

Table (7.4) Predicted solar share of energy needed and in total energy consumed in sectors in a year 2020

Sector	Technology	Share of energy needed in sector	Share in total Energy Consumed	Total
Residential	Solar water heating Space Heating and cooling	8.4% 7.1%	6.2 %	11.4%
Public Buildings	Space heating and cooling	35%	4.2 %	
Industrial Sector	Concentrated water heating systems and steam generation	10%	0.4 %	
Rural electrification	Photovoltaic	2%	0.6%	
Power Generation and Cogeneration	Concentrated thermal systems	20%	6.6%	6.6%
Total				18%

7.3 Conclusions

From the results we can conclude the following:

1- Solar energy is available in Palestine at an average daily rate around 21 MJ/m2/day which is relatively high.

2- Solar water heaters are the main solar applications in Palestine, as more than 67% of houses are equipped with domestic solar water heaters. This percentage can be increased to 95% in order to reduce energy used for water heating by 70%.

3- Passive solar heating and cooling systems can be implemented in Palestine by small investment which may not exceed 5% of total building cost including adopting the energy efficiency code. This may result in a reduction of 50-60% of total energy consumed for heating and cooling in buildings.

4- Most of SWH's are manufactured locally by Palestinians. This industry needs more development to be according to the international standards and to minimize imports from Israel.

5- Concentrated heating systems needed to be implemented for Palestine especially for industrial sector. In such case, around 12% of total energy consumed for water heating and steam generation will be replaced.

6- There is a great chance for reducing electricity imports by at least 20% if the concentrated thermal project in Jericho and the Cogeneration (power generation and water desalination) project in Gaza are implemented.

7- Using Passive Solar Design, Solar Water Heaters, and Concentrated Heating Systems according to this plan will make the Solar Share around 11.4 % of total energy consumed in Palestine.

8- With planned power generation in Jericho and Gaza this percentage will increase to 18%.

9- These results make Palestine one of the leading countries in using solar energy. The special situation in Palestine and the weak industrial sector are the main reason for this high percentage.

10- The environmental impact of these projects will be marvelous. The total emissions of gases will be reduced sharply due to replacements of fusil fuels with clean solar energy.

7.4 Recommendations

1. Awareness campaign regarding the crises of energy situation and why we should look for alternatives energy sources

2. Promote the solar industry of all types

3. Adopt legislation for mandating the use of solar water heaters in private and public buildings

4. Increase awareness of architects and engineers about feasibility of passive solar systems and their design.

5. Government must provide incentives to people who implement passive solar systems at their buildings.

6. Increase the solar collector's efficiency and the overall system efficiency through good case insulation, suitable absorber plate material and utilization of solar glass instead of the regular glass for case covering.

7. Training courses for plumbers and technicians for the suitable establishment and orientation of the systems.

8. Regulations and legislations for using the renewable energy sources, especially solar energy.

9. Involve Banks and municipalities in supporting the large scale systems through soft loans.

10. Technology transfer for different types of collectors and systems.

11. Upgrading the present situation in the solar thermal industry and development of new efficient designs for solar water heaters appropriate to local climate conditions and requirements.

12. Extension use of collective SWH systems in the residential, commercial, industrial and service sectors, such as health, education, tourism, sport.

13. Development of governmental policies, regulation rules, provisions and incentives to encourage the use of SWH, such as mandatory installation of systems in all new houses, tax exemptions, etc.

14. Financing schemes by banks and other money lending institutions to help people afford the system.

15. Improvement the quality of locally produced systems through the imposition of standards, as well as supervision and certification by specialized labs and institutions.

16. Application of some kind of guarantee such as GSR.

17. Availability of proper skills, expertise and professional calculation tool through development of training courses and exchange of engineers and technicians with other countries.

18. Getting rid of Israeli monopolizing practices and obstacles on import/ export activities.

19. Improvement of the socio-economic situation that affects the living of standards.

20. Donors must be encouraged to allocate funds for power generation projects in locations where they are found feasible.

21. This study must be followed up for further research and investigation of possible technologies and sectors that are not studied here.

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Appendix

Appendix (1)

The Total Value of Energy Imports by Year & fuel in PT's in Thousand $

The Description	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Motor spirit (gasoline) including aviation spirit.	163,469	135,128	147,193	138.360	140,828	97,880	76,396	77,893	100,875	130,405
Other light petroleum oils and light oils obtained from bituminous minerals (other than crude) light preparations n.e.s. These oils being the basic constituents of the preparations.	1,992	996	1,128	0	3,058	0	1,172	1,765	59,903	7,923
Kerosene (including kerosene- type jet fuel).	3,799	3,671	3,281	6,610	3,436	2,308	1,688	2,130	5,391	3,019
Fuel oil(diesel) n.e.s.	70,626	67,057	89,819	96,324	107,045	95,277	75,222	107,681	224,484	308,619
Lubricating petroleum oils heavy.	5,511	4,922	5,384	3,928	0	14,016	19,215	6,675	9,108	12,175
Oils and other products n.e.s. of the distillation of high temperature coal tar	82	32	96	38	116	2	9	28	1	14
Pitch coke or other mineral tars.	4,222	5,763	4,968	8,439	1,780	158	428	3,952	4,620	3,041
Petroleum bitumen and other residues of petroleum oils or of oils obtained from bituminous minerals.	1,599	220	88	0	837	993	635	37,185	897	1,389
Bituminous mixtures based on natural asphalt on natural bitumen on petroleum bitumen on mineral tar or on mineral tar pitch (e.g. Bituminous mastics cut- backs).	28	113	249	195	1,037	576	356	1,186	1,002	777
Natural gas liquefied.	20,449	18,991	25,271	26,763	48,427	40,000	46,097	40,468	48,482	58,818
Electric energy.	112,823	141,186	134,289	110,448	143,721	126,151	138,471	146,623	205,104	191,955
Grand Total	**384,601**	**378,080**	**411,767**	**391,106**	**450,286**	**377,361**	**359,690**	**425,586**	**659,867**	**718,135**

Source: Palestinian Central Bureau of Statistics (**PCBS**)

Appendix (2)

Some energy indicators of the Palestinian Territories and neighboring Countries (2005)

Indicator	Palestinian Territories	Israel	Jordan	Lebanon	Syria	Egypt
Population (million)	3.76	6.92	5.47	3.58	19.04	74.03
Import (kToe)	187	22458	7082	4958	941	7460
Export (kToe)	19	- 4205	0	0	-12153	-20811
Total energy Consumption (kToe)	840	12707	4859	4057	11679	41590
Industrial sector(kToe)	70	1383	1129	1135	3138	14276
Transport sector (kToe)	156	3976	1934	1537	4029	11304
Residential (kToe)	533	2877	1063	946	1878	8154
Commercial and Public Services (kToe)	61	1092	379	130	0	950

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Israeli Central Bureau of Statistics www.cbs.gov.il

Appendix (3)

The Average of Consumer Price for Some types of fuel and energy in Palestinian Territories during 2001 – 2005

Energy Category Origin/ Year	Electricity av. Kw. Limit Down		Electricity av. Kw. additional		Gas Cylinder		Coal		Motor Oil		Motor Oil 40	
	Local	Change	Local	Change	Local	Change	Local	Change	Israel	Change	Israel	Change
2001	0.47	_	0.48	_	36.51	_	3.47	_	11.42	_	14.62	_
2002	0.55	17%	0.53	10%	37.06	2%	3.75	8%	13.22	16%	14.19	-3%
2003	0.56	2%	0.62	17%	36.39	-2%	3.69	-2%	13.89	5%	14.91	5%
2004	0.54	-4%	0.64	3%	38.91	7%	4.29	16%	11.74	-15%	14.34	-4%
2005	0.54	0%	0.64	0%	44.53	14%	5.02	17%	12.67	8%	15.4	7%

Energy Category Origin/ Year	Gear Oil		Break Oil		Diesel		Kerosene		Benzene 96		Benzene 98	
	Israel	Change	British	Change	Israel	Change	Israel	Change	Israel	Change	Israel	Change
2001	14.48	_	8.24	_	1.95	_	2.27	_	3.99	_	4.39	_
2002	14.35	-1%	8.42	2%	2.41	24%	2.69	19%	4.27	7%	4.92	12%
2003	14.56	1%	8.72	4%	2.34	-3%	2.61	-3%	4.54	6%	5.32	8%
2004	15.78	8%	9.33	7%	2.69	15%	3.01	15%	4.81	6%	5.31	0%
2005	15.51	-2%	10.22	10%	3.37	25%	3.45	15%	5.16	7%	5.58	5%

Source: Palestinian Central Bureau of Statistics (PCBS)

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إشراف
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قدمت هذه الأطروحة استكمالاً لمتطلبات الحصول على درجة الماجستير في التخطيط الحضري والاقليمي من كلية الدراسات العليا في جامعة النجاح الوطنية، نابلس – فلسطين.

2009م

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الملخص

إن مصادر الطاقة في الأراضي الفلسطينية محدودة جدا والاعتماد الأكبر على استيراد أنواع مختلفة من الوقود من الدول المجاورة خاصة إسرائيل, كما إن استهلاك الطاقة في جميع القطاعات في الأراضي الفلسطينية صغير نسبيا مقارنة مع الدول العربية المجاورة, كذلك إن أعلى نسبة لاستهلاك الطاقة يوجد في القطاع المنزلي يليه قطاع المواصلات أما القطاع الصناعي فنسبة الاستهلاك فيه قليلة.

قامت الباحثة في هذه الدراسة بدراسة قطاع الطاقة في الأراضي الفلسطينية من حيث كمية الاستهلاك في كافة القطاعات(المنزلي الصناعي التجاري) ودراسة أسعار الوقود لسنوات مختلفة مع بيان أسباب ارتفاعها. كذلك تم دراسة الطاقة الشمسية ووضعها في الأراضي الفلسطينية من حيث كمية الإشعاع الساقط عليها خلال السنة وتطبيقاتها المختلفة, والمشاريع التي تم تنفيذها في مختلف المناطق.

تم خلال هذه الدراسة التعرف إلى التطبيقات الممكنة للطاقة الشمسية في مختلف القطاعات أهمها الصناعة والذي يفتقر إلى أي تطبيق للأنظمة الشمسية كحالة تخطيطية للمستقبل, وبناء على استخدام هذه التطبيقات فانه تم توقع نسبة الطاقة التي يمكن توفيرها عند استخدام الطاقة الشمسية بالشكل الأمثل من مجموع الطاقة الكلي المستهلكة للعام 2020 والتي تبلغ 11.4%

إن عملية توقع نسبة التوفير في استهلاك الطاقة في الأراضي الفلسطينية ليست سهلة وذلك لأسباب اقتصادية وسكانية وسياسية, ولقد اعتمدت الباحثة على المتغيرات السكانية

والإنشائية وذلك من اجل توقع نسبة التوفير في استهلاك الطاقة للأعوام القادمة في مختلف القطاعات.

بعد مقارنة النتائج المتوقعة عند تطبيق الأنظمة الشمسية في مختلف القطاعات وكمية الطاقة المستهلكة حاليا وبدون تطبيق لهذه الأنظمة تبين أن هناك توفير بنسبة 11.4% من مجمل الطاقة المستهلكة في فلسطين وقد تصل هذه النسبة إلى 18% في غزة وأريحا عند تطبيق مشاريع توليد الطاقة الكهربائية عن طريق الشمس.

وكنتيجة متوقعة في تقليل نسبة استهلاك الطاقة مما يعني تحقيق جدوى اقتصادية ليس هذا وحسب بل ما يترتب على ذلك من فائدة للبيئة حيث إن الأنظمة الشمسية والطاقة الشمسية هي أصدقاء للبيئة لمميزاتها في تقليل نسبة انبعاث غاز CO_2.