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The Contribution of Solar Energy to Reduce Electricity Shortage in the Gaza Strip through Using Photovoltaic Panels as a Replacement to Roofing Tiles

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ABSTRACT: *The The Gaza Strip is suffering from a variety of problems due to the Israeli siege. Electricity shortage is one of the most profound problems causing regular power cuts with drastic effects on people's daily lives. The current electricity shortage reaches 48% of the required 400 MW demand. This study proposes a solution to this problem based on exploiting solar energy, which is highly available in the Gaza Strip, to overcome electricity shortage. Such solution would be suitable for an average household of five persons. From an economic perspective, there is a financial feasibility for replacing roofing tiles with photovoltaic panels. The savings of not using roofing tiles can be used to mount photovoltaic panels which in turn will have huge savings in cutting electricity bills. The overall aesthetic view of the house can also be improved.*

Keywords: *Electricity Shortage, Solar Energy, Energy consumption per Housing Unit, Photovoltaic Panels, Roofing Tile,*

I. Introduction

In the uppermost position the variable floor becomes not only powerful security system for your pool, but also a part of the original courtyard that surrounds it. This is owed to the region of pool becoming entirely covered and inaccessible.

Renewable energy is the focus of attention of governments and researchers in the world due to many reasons, the most important one is the environmental damage resulting from the emission of harmful gases and global warming and the rising in temperature of the earth to have a negative impact on both humans and the environment.

For Palestine in general and Gaza in particular, the government and institutions must be thinking in the exploitation of these resources and the support of all related projects. Gaza Strip especially has two main sources available, they are the sun and the wind, that can be utilized in the production of electrical energy, which Gaza Strip is suffering from the shortages of it due to the siege imposed on it for a number of years.
Because the production of large amounts of alternative energy, whether from the sun require large tracts of land and this is what is not available within the eligible populated regions, and there is an urgent need to supply the buildings with energy produced from renewable sources. All eyes of the world are directed toward benefiting from the rooftops either tiled or flat in energy production because of the many benefits it has, the most important of them the getting rid of the large electrical losses in the supply of housing units.

1.1 Research Objectives

The objectives of this research paper are to show that:

- alternative energy sources available in the Gaza Strip.
- how contribution of alternative energy can help in covering the deficit of energy in Gaza Strip
- how exploiting space rooftops in putting together alternative energy systems
- how the feasibility of replacing tiled roofs with Photovoltaic Panels

1.2 Total energy consumption in the Gaza Strip and the existing deficit

According to the statistics of the United Nations technical office for coordination of humanitarian affairs for the month of March 2012, as described in the figure 1, the total electric power fed to Gaza Strip is 217MW, while the energy consumption required for it is 359MW, a total deficit of 36.6% [1].

Adding to the crisis, the blockade imposed on the Gaza Strip since 2006, made it impossible to provide this much energy at the moment, so it imposes the deficit on the company of distributing electricity in the Gaza Strip and for years the company re-distribute the electrical loads available according to a specific timetable to all districts and provinces of Gaza Strip.

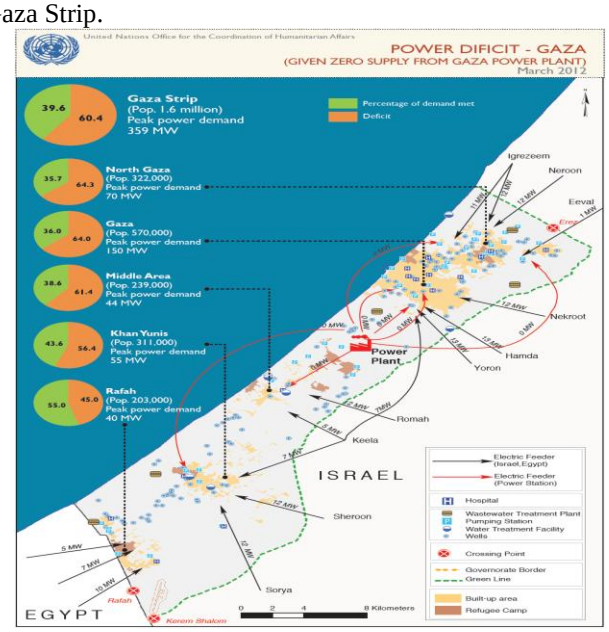

Figure 1: The distribution of available energy to the provinces in Gaza Strip. [2]

II. The Most Important Alternative Energy Sources Are Available In The Gaza Strip

Palestine in general and Gaza Strip in particular is not considered rich area of natural energy resources such as oil or natural gas only in very limited quantities barely cover the costs of extraction it, so moving attention to alternative energy or renewable sources, and there are many sources in Gaza Strip, including:

- **Solar energy**

Can be used in two ways:

a. Photovoltaic: The generation of electricity through solar PV cells which are the cleanest types of energy and the most important.
b. Solarthermie: The water heating by the sun is one of the oldest methods for the production of thermal energy and the most widespread in the world.

- **Wind energy**

This energy can be utilized in a positive way in the current era in electric power generation, based on wind speed.

- **Bio energy**

It can be produced from agricultural and animal waste.

2.1 How to take advantage of alternative energy sources to cover the deficit in the electric power in Gaza Strip

In recent years, high-raised buildings in the Gaza Strip had spread in line with the sharp increase in population; the consumption of electrical energy in these buildings is huge due to the high content of residential units, each consisting of an average of five members. What distinguishes these buildings in Gaza Strip that large tracts surfaces and most owners of these buildings prefer the tiled work surfaces in the last floor.

The following is a detailed study of the needs of residential units consisting of five members and the amount of consumption of energy and the necessary calculations for the solar photovoltage able to cover the needs of the housing unit.

2.2. Average daily requirement for the housing unit that consists of five members:

Based on the above, high-raised buildings in Gaza Strip consist of multiple residential units; each housing unit is composed of an average of five members [3].

The following table shows an example of a realistic amount of electric power consumed by such residential units per day, also illustrates the types of devices most commonly used in Gaza Strip, as well as the average number of working hours of each device and its consumption.

Table 1: Average daily consumption of energy for a housing unit that consists of five members

S.	Devices	Number of devices	Working hours	Consumption [W]	Total consumption [Wh]
1	Refrigerator	1	24	65	1560
2	PC	1	4	100	400
3	Fan	2	4	85	680
4	Television	1	5	120	600
5	Lighting PL	5	6	20	600
6	Water pump	1	1	1000	1000
7	Washer	1	2	1000	2000
8	Water Heater	1	2	1200	2400
9	Microwave	1	0.5	1000	500
Total daily consumption [Wh / day]					9740

The above table shows that the average daily consumption of a residential unit consisting of five members up to about 10KWh/day within 24 hours.

III. Utilization Of Solar Energy

To cover the consumption of a housing unit which is composed of five members, as shown in the table above is 10KW. In this research, a study of the possibility of making use of solar energy that can be provided in appropriate cost with local efforts in Gaza Strip.

The number of hours of solar radiation is linked directly to that of solar energy can be produced throughout the day or throughout the year. Figure 2 shows that the hours of solar radiation in Gaza Strip up to 8 hours per day [4] as an annual rate. This is the number of hours among the highest in the world, which confirms the feasibility of the use of solar photovoltage in the production of alternative electrical energy in Gaza Strip.

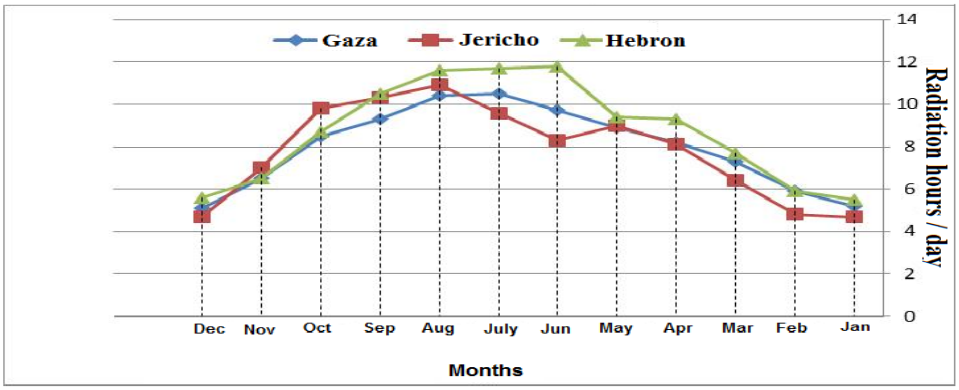

Figure 2: Average hours of solar radiation of Gaza city compared with Hebron and Jericho by months of the year 2007

From the above data, the average number of hours of solar radiation to Gaza City is clear that the rate is 8 hours per day throughout the year , after taking into account the peak hours of sunlight as the higher efficiency of solar cells and the gradual decrease in the efficiency with changing the angle of sunshine from hour to another, and the consequent weakness of the productive capacity of solar cells must take into account the angle of orientation of solar cells by sun preference in the four seasons of the year , while in the case of cells

moving on one axis is considered to change the orientation of cells depending on the movement of the sun is definitely better in terms of productivity about 30 % [6] .

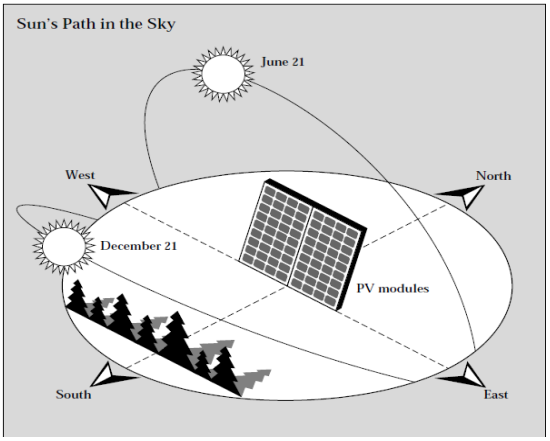

Figure 3. The sun's noontime height above the horizon changes seasonally. This is important to consider when sitting and positioning a PV array [7].

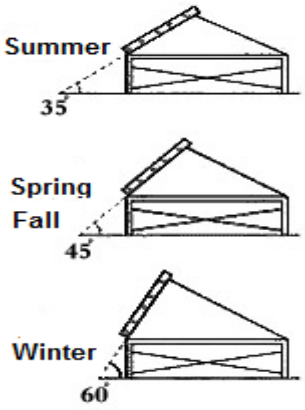

Figure 4. Angles installing solar cells to Gaza City by the four seasons of the year

According to figure 3 and figure 4 above and in order to avoid the high costs associated with movable cells, this study has focused only on fixed angle solar cells of 45o to make the most of solar radiation throughout the year, so to take advantage of daily solar radiation in Gaza. The real rate of the number of hours is about 6.5.

3.1 Installing solar cells on the roofs of building

As for the installation of solar cells on the roofs of buildings, there are two ways, either the traditional way, as shown in the figure 5a over tiled surfaces, or Figure 5b over high-rise buildings 45o angle in the direction of the south.

Figure 5b: Above the high-rise buildings

Figure 5a: Above tiled rooftops

3.2 Replacing tiled surfaces with solar panels

In this research a study of replacing tiled surfaces with solar panels was done in order to preserve the environment on one hand and the other hand to exploit the space available on the roofs of buildings in generating alternative energy from the sun. The aims of the researchers are to study the possibility of really utilizing these tiled surfaces, and to replace them with solar panels to be able to produce alternative energy to cover the deficit of these buildings.

Figure 4: Replacing tiled roofs with solar panels.

In terms of economic, aesthetic and construction, the replacement process is strong and weatherproof leaking water or heat of the sun into the building , except for the obvious exploitation of the surfaces in the production of electrical energy from sunlight.

3.3 The following are the advantages and disadvantages of replacing the tiled surfaces with solar panels
Advantages of surfaces consisting of solar panels compared to tile:

- Taking advantage of the surface area in the production of energy
- More beautiful than the tiled surfaces
- Does not require constant maintenance
- Considered more stable than the tiled, especially in the storm atmosphere
- More weatherproof than tiled

Disadvantages of surfaces consisting of solar panels compared to the tiled

- Increased losses in the production of energy in the case of high temperature under the solar panels
- Cost of tiled surfaces is less expensive than surfaces equipped with solar panels

In the event of replacing tiled surfaces with solar panels, there is a clear saving in term of the cost of the material associated with installing tiles, and a major benefit of solar photovoltage when generating electricity .

IV. Model Of Solar Photo voltage System Needed To Cover Housing Units Consisting Of Five Members

Due to the lack of available space above residential buildings, solar cells of the type (Mono crystalline) were selected because of their high efficiency of energy production with the least possible space compared to other solar cells [5,10]. Engineering calculations for a housing unit that consists of five members in Gaza City has been made on the basis of the following facts:

Table 2: Engineering data model for solar photovoltage system to cover the need of housing units consisting of five members of the electric power

The necessary data	**Units**
The daily energy consumption of the residential unit	10KW
The average daily number of hours of solar radiation	8 according to the source, 6.5 with high efficiency
Type of solar cells used	Mono crystalline, 270Wp
The dimensions of the cell length X width X thickness in centimeters	150X100X8 cm
Searing angle of solar panels	South with an of angle 45^{O}
Voltage needed to run electrical appliances	220V
Used batteries	12V/195Ah
Total electrical losses (by the efficiency of the system)	%20
The surface area of the building available	$150m^2$

The total daily energy = energy needed for residential unit + total loss of the electrical system
= 10KW + 20% * (10kW)
= 12KWh/day

Total daily Amp required per hour
= 12KWh / 12V
= 1000 Ah / day

The number of batteries needed to cover daily energy storage = total daily Amp necessary / Amp per hour battery.
= 1000 Ah / 195 Ah
= 5.12 batteries, taking into account the loss 6 batteries would be required.

Energy to be produced by the average daily hours of solar radiation = total power / average daily hours of solar radiation
= 10KW / 6.5 hours
= 1.55KWp

The number of solar panels required to cover the necessary energy = energy to be produced / energy of solar panels.

= 1.55KWp / 270Wp
= 5.75 solar panels, taking into account the losses, 6 solar panels would be required.

The space required for a number of solar panels = number of solar panels * length of panel * width of the panel
= 6 * 1.5m * 1m
= 9 m^2

The engineering calculations above show that the housing unit consisting of five members , which need about 10KW of energy per day requites 6 batteries, 6 solar panels, and a total area of approximately 9 m^2.

V. Economic Feasibility Of Replacing Tile Surfaces With Solar Panels

The following figure (see Figure 6) shows the continued decline in the price of solar panels over the past years [8], with an estimated price of 1 $ / W, this means that the price of solar photovoltage system for residential unit consisting of five members up to $10,000.U.S.

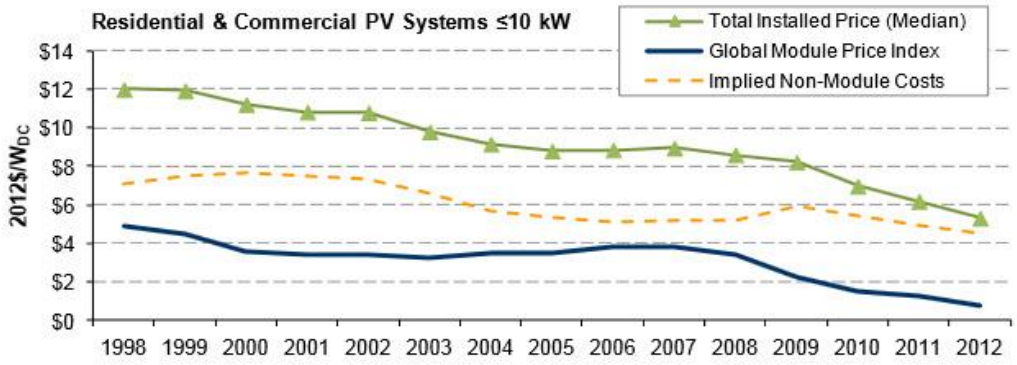

Figure 6: The cost of solar photo voltage systems over the past years

It is known that the life span of the solar photo voltage system is 25 years [9], that is, the total cost of the system must be fully distributed to the life span and in addition to the cost of regular maintenance.

5.1 Solar photovoltage system without tiles (tiles replacement)

The total cost (25 year) = total cost of the solar photovoltage system + the cost of regular maintenance
= $ 10,000 +1000 dollars
= $ 11,000

5.2 TILED ROOFS WITHOUT SOLAR PHOTOVOLTAGE SYSTEM

The total cost (25 years) = consumption of the residential unit energy cost + 9m2 of tiles
= (10KW * 0.5 * NIS 365 Days * 25 years) + (9 m2 * 48 shekels)
= 45,625 shekels + 432 NIS
= 46057 NIS
= 13,159 US dollars

Total difference = 13,159-11,000 = 2,159 dollars
The above comparison shows that the replacement of tiled surfaces with solar photovoltage system for a time frame of 25 years is better economically as a total amount of 2159 dollars, according to current prices for energy systems.

VI. Results And Recommendations

Due to the importance of the topic in general and to Palestine in particular, we recommend the followings:

- Invitation to exploit the roofs of high-rise buildings in the production of electrical energy from solar photo voltage system
- Support projects aimed at replacing the tiled roofs with solar panels.
- The state should contribute in alternative energy projects
- Exempt projects related to alternative energy from tax
- Buy surplus of the needs of citizens by linking it to the electricity network

VII. Conclusion

This study proposed a solution to the problem of electricity shortage in Gaza Strip due to the Israeli siege imposed on Gaza Strip. The solution is based on exploiting solar energy, which is highly available in the Gaza Strip, to overcome electricity shortage. Such solution would be suitable for an average household of five persons. From an economic perspective, there is a financial feasibility for replacing roofing tiles with photovoltaic panels. The savings of not using roofing tiles can be used to mount photovoltaic panels which in turn will have huge savings in cutting electricity bills. The overall aesthetic view of the house can also be improved.

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