Economic Evaluation of Residential Grid Connected PV Systems Based on Net- Metering and Feed-in-Tariff Schemes in Palestine

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Abstract- Net-Metering and Feed-in Tariff schemes used for accounting the energy of PV grid connected systems in Palestine are discussed and evaluated in this paper. Net- Metering scheme includes two main items that have a negative effect on the economics of the PV system. The first item is represented in monthly subtraction of 25% of the excess PV energy, as compensation for utilizing the electric grid and the second one is striking off the excess PV energy at the end of each year instead of carrying it forward to following year. Economic analysis of PV grid connected system certifies that Net-Metering reduces the income of the PV system and therefore does not encourage expanding the use of PV systems. Considering Net-Metering, a PV system of 5 kWp with an annual yield of 8686 kWh installed on a house with an annual consumption of 6984 kWh, 19% of total annual PV energy generated will not be credited which results in a net present value of 5126 $, an internal rate of return of 17.3% and a payback period of 7.6 years. On the other hand, the same analysis were used to evaluate the same system with Feed-in Tariff, where the total annual PV energy will be credited, the results were 7991 $, 22% and 5.7 year respectively. Moreover, the performed analyses show that the Net- Metering is sensitive to load profile variation even at constant annual energy load. For this case, different economic parameters were obtained for different two load scenarios.

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Keywords: Grid connected PV systems, Net-Metering, Feed-in Tariff, Net present value, Dynamic payback.

1. Introduction

Energy demand is growing rapidly due to increasing the population and looking for more comfort ability and luxury in life. The dominant energy source is fossil fuels which are still available but environmental concerns and reduction in cost of renewable energy equipments lead the world to start installing and utilizing renewable energy resources to generate electricity. Renewable energy sources include photovoltaic PV systems, wind power systems, hydropower and other systems. Among these PV systems are used extensively in residential and commercial sectors especially in countries with high solar energy potential. Due to the continuous decrease of PV modules cost and the increase in solar cell efficiency, solar photovoltaic (PV) power became the most widely owned electricity source in the world [1]. The European Photovoltaic Industry Association (EPIA) reported that the total cumulative installed PV capacity in the world exceeded 138.8 GW in 2013 [2] and at the end of 2016 amounted to at least 303 GW [3]. The global PV market grew from 40 GW in 2014 to 50 GW in 2015 [3]. The rooftop PV systems, which are installed commonly on the roofs of residential houses and interconnected in distribution voltage level or low voltage network, have several advantages like efficiency increasing because the losses are decreased as the source is near the load, also the voltage profile is improved and the voltage drop is decreased for the same reason.

Several countries in southern Europe, Middle East and North Africa (MENA- Countries) as Cyprus, Jordan, Israel, Tunis, Palestine, Italy, Spain ,Portugal and France which exhibit high solar energy potential have extensively installed PV rooftop systems and large grid connected PV systems during the last ten years. In some of these MENA countries, PV system become a competitive alternative for electricity generation due to high solar radiation ,decreasing of PV system cost and high fuel prices. The incentives in these countries represented in the adopted energy accounting schemes as Feed-in Tariff and Net-Metering were an effective tool for driving the PV market in these countries [4]. However it should be emphasized that the rules constituting these schemes are not the same in all mentioned countries. For instance the Net-Metering scheme in Israel allows the PV system owner to credit the surplus produced PV energy at the end of the billing year for the following 24 months while in Palestine, Cyprus and Jordan for 12 months only. In addition, the Net-metering consumer in Cyprus is obliged to pay a fixed charge based on the installed PV system capacity while in Palestine 25% of the monthly produced PV energy will be deducted as compensation for utilizing the electric grid.

Based on the trends observed , it is evident that PV technology is on the way to become a major source of power generation for covering the power supply needs of millions of households. The main challenges that must be overcome to achieve this are further reduction of PV cost ,the improvement of system efficiency and energy yield of the PV systems as well as developing soft accounting schemes [4].

High penetration of PV systems may impact electricity distribution networks and add negative impacts on the grid such as fluctuations in PV output power due to intermittent nature of renewable energy resources, solar radiation and temperature in case of PV system. Voltage rising is another problem that occurs in case of reverse power direction toward the source which makes the voltage drop negative and sometime may cause inverter disconnecting from the main grid which leads to loss of power generated during interruption periods. Electrical losses also can be increased due to the bidirectional power flow in electrical network. In particular, it has been noted that the increased number of residential PV systems requires new and updated grid equipment [5], and it reduces utility revenues more than it reduces costs. These considerations introduce additional economic and technical challenges for utilities [6]. These issues and others suggest the need for a better understanding of how different tariff schemes affect PV adoption rates, social welfare, and the surplus distribution between households. This paper has three main contributions; First contribution is to indicate the potential of utilizing PV systems for electricity generation based on solar radiation levels in Palestine. The second contribution is to evaluate the Net-Metering scheme used in Palestine and help Palestinian people to understand the applied Net-Metering scheme and its impacts on the considerable economic parameters. The third contribution is to guide the customers to different tariff schemes, PV costs and economical evaluation methods. The paper is organized as follows: Section 2 provides an introduction about energy sector in Palestine and it includes information about electrical network and electrical energy demand. Section 3 shows the potential of solar energy in Palestine and the benefits of using solar PV systems for utilities and customers. Section 4 explains the schemes used for PV systems mainly Feed-in Tariff and Net-Metering schemes; the last is described in detail through an illustrative example. Section 5 presents economic analysis of PV systems considering the two different schemes and it includes determining the economic parameters as net present value (NPV), internal rate of return (IRR) and the dynamic payback period (DPP). Section 6 explains the effect of demand variation on Net-Metering scheme in Palestine. Finally, Section 7 presents the conclusions and recommendations.

2. Electrical energy sector in Palestine

In Palestine most of electricity (about 88%) is imported from the Israeli Electric Corporation (IEC) while a small portion of electrical energy is either generated locally or imported from Jordan and Egypt. Electricity imports from Jordan are estimated at 20 MW of electric power to supply the city of Jericho while imports from Egypt are estimated at 25 MW to supply the city of Rafah in the Gaza Strip. Production of electricity in Palestine is limited to only 70 MW at Gaza power plant [7, 8]. Local power generation represents a strategic Palestinian option to reduce the dependency of the electric sector on Israel and also to reduce prices of electricity which are high compared to prices in the neighboring countries. However, generation of electricity by thermal power plants requires sources of natural gas or petroleum fuel, which are also imported from Israel at high prices. Moreover, thermal power plants require large areas of land far from the population and city centers which are difficult to obtain in the current circumstances. Renewable energy, especially solar energy, is available and economically feasible considering the high solar energy potential and the reduction of solar PV prices in the global market during the last ten years. The aforementioned factors encourage the Palestinians to intensify the use of solar energy for electric power generation. In order to increase and encourage the utilizing of renewable energy sources in Palestine, renewable energy strategy was issued by Palestinian Energy Authority (PEA).The strategy aims to increase utilizing renewable energy sources to reach 10% of total electrical energy demand by the year of 2020 [9, 10]. PEA assign four main requirements to achieve the mentioned target. The first requirement is the endorsement of rules and schemes which are necessary to regulate different issues between renewable energy investors and electrical distribution companies. The second requirement is the provision of adequate financial resources to encourage utilization of renewable energy sources and the adoption of tariffs that can encourage private sector for investment in this new technology. The third requirement is to encourage the specialists, engineers and technicians to build sufficient background of using new technologies and to be familiar with different aspects of renewable energy systems. The fourth is the adoption of renewable energy plan which is required to be finalized by the year of 2020. According to the strategy 130 MW of electrical power will be generated from renewable projects by 2020, and the gross portion of this energy is generated using solar energy [9, 10]. In this context the Palestinian government issued in 2015 a law of Net-Metering to regulate the connection of solar PV generators to public electricity grids [11].

2.1. Electrical power networks

Most of electrical energy in the West Bank is generated and supplied by IEC. The Palestinian areas are supplied from connection points of 33 kV and 22 kV. Recently, new connection points of 161 kV are constructed to make the electric power grid able to withstand the growing demand of electrical energy in the West Bank, also to improve the performance and reliability of the overall transmission and distribution systems. Four new connection points of 161 /33 kV are located in northern (Nablus and Jenin), central (Ramallah), and southern (Hebron) areas of the West Bank [12]. The electrical distribution companies buy electrical energy from IEC and sell it to consumers at higher price to recover the services and maintenance of electrical power networks. The peak demand in the northern districts of West Bank has been forecasted as shown in Table 1. It can be seen that the growth in total electrical power demand has increased from 243 MW in 2012 to 318 MW in 2016 [12].

2.2. The nature of load consumption in residential houses

Energy consumption in homes depends mainly on appliances used in the houses including lighting lamps, computers, washing machines, heating, cooling systems, TV and other small appliances. The operating time for using electricity is different from one house to another depending on the nature of inhabitance and the season of the year. Cooling and heating systems make differences in the load curve of houses because in some regions people use fans for cooling instead of using air conditioning units. Also, some residents use fire places for heating while others use electricity for heating. Figure.1 shows the monthly distribution of electrical energy purchased in 2016 from IEC in the West Bank [13]. Figure 1 shows that the consumption during winter is more than summer.

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

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

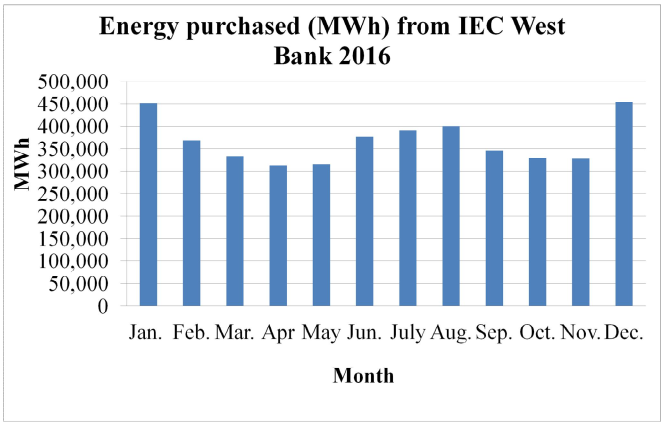

Fig. 1. Electric energy consumption (MWh) in the West Bank in 2016.

3. Solar energy in Palestine

Solar energy is the only secured and viable energy source in Palestine, because it is abundant, has a high potential and it cannot be controlled by IEC.

3.1. Solar energy potential

In Palestine the main two figures that indicate the high potential of solar energy are represented in an annual average of 5.4 kWh/m^2-day and a sunshine duration amounting to about 3000 hours/year [14, 15]. Figure.2 shows the monthly average of daily solar radiation measured on horizontal surface in Nablus area in Palestine [16]. As seen in Fig.2, the average of solar radiation during the eight months: March-October amounts to 6.82 kWh/m^2-day while it amounts to 3.14kWh/m^2-day for the four months of November through February. These figures are very encouraging to use solar energy in thermal and electrical power applications. Different studies have shown that the annual yield of 1 kWp PV system varies in the range of 1600-1800 kWh/year [6].

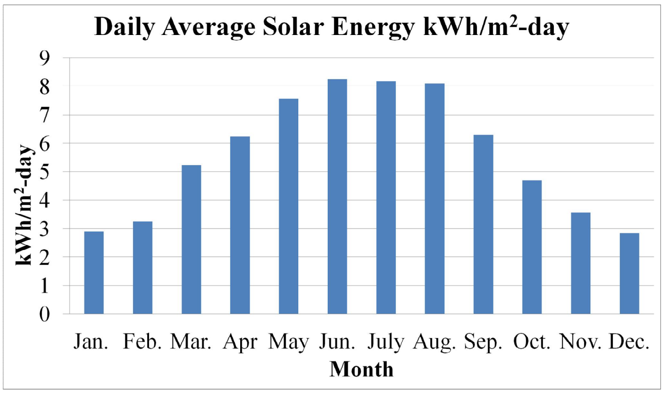

Fig. 2. Monthly average of daily solar radiation measured on horizontal surface in Nablus area (An Najah National University- ERC measurement. for the year 2005).

4. Tariff schemes used in renewable systems

Electrical distribution companies purchase the electrical energy from IEC and sell the kWh units at higher price. The electricity cost is assigned to cover different expenses, such as the cost of energy, customer services and it also includes the maintenance and rehabilitation of electrical power grids. By installing PV systems new modifications related to electrical tariffs have to be assigned by the distribution companies in order to regulate the process of PV system interconnections with the national grid. There are mainly two types of schemes used in Palestine Net-Metering and Feed-in Tariff.

4.1. Feed-in Tariff scheme

In Feed-in Tariff scheme the customer has two separate energy meters as shown in Fig.3, an energy kWh meter measures the electricity produced by the PV system and the second measures the energy consumption by the house.

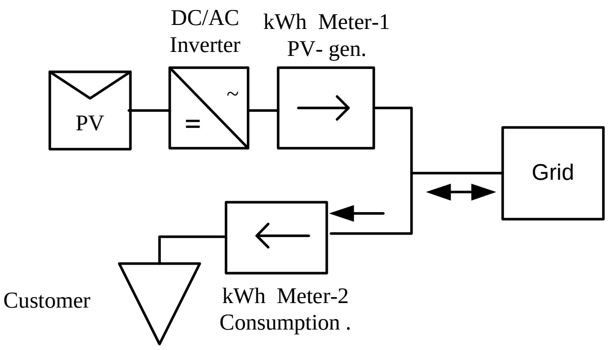

Fig.3. Grid connected PV system with Feed-in Tariff scheme.

In the Feed-in Tariff scheme the energy generated from PV system is sold to grid regardless the house consumption. The entire generations from rooftop PV systems are fed directly to the grid at definite rates set by the electrical distribution company while the consumed electricity is accounted as normal [7,17,18,19].

4.2. Net-Metering scheme

Net-Metering scheme allows small scale renewable energy power producers to store the energy generated in times of over-production, as solar energy during peak production, in the national grid and to balance out their consumption from the grid with stored electricity during other times of low energy production as in cloudy days and during night hours. Palestine Net-Metering scheme obliges the customers having PV systems to have a bidirectional kWh- meter as shown in Fig.4. This meter measures the energy consumed from the grid when the PV generation is less than consumption and also measures the excess energy injected to the grid when the PV generation exceeds the consumption [7,20,21]. With Net-Metering, the customers pay for the net electricity consumed over the billing period at the conventional rate. Providers may benefit from Net-Metering because, when customers are producing electricity during peak periods, the system load factor is increased [22].

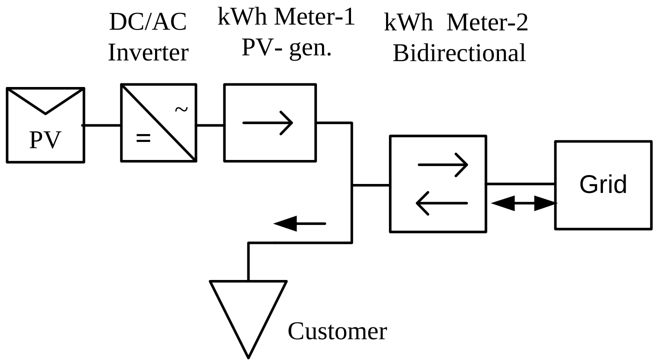

Fig.4. Grid connected PV system with Net-Metering scheme.

The Palestinian Energy Authority (PEA) issued the Net-metering scheme with two main items, first the monthly excess PV energy injected in the grid after covering the load demand will be deducted by 25% for using the national grid which means that only 75% of excess energy will be credited for the following month. The second item, after one year the excess PV energy will not be accounted to the customer [10]. Hence the customers have to manage their consumption in order to avoid losing the excess generated PV energy or to select suitable size of PV system that fits their annual energy consumption.

4.3. Illustrative example for Feed -in Tariff and Net-Metering in Palestine

In this example, the monthly energy consumption for a house is shown in Table 2. The total annual consumption amounts to 6984 kWh with a monthly average of 582 kWh. The load variation depends on the appliances and the behaviour of house inhabitant. A PV system of 5 kWp is used as a rooftop system with an annual yield of 1737 kWh/kWp and different monthly energy generated amounts due to variation of solar radiation and ambient temperature. The useful PV ratio represents the fraction of useful annual PV energy accounted to customer to total annual PV energy generated as in equation (1).

$$Useful\ PV\ ratio = \frac{Annual\ accounted\ PV\ energy\ (kWh)}{Annual\ generated\ PV\ energy\ (kWh)} \times 100\% \quad (1)$$

4.3.1 Net-Metering calculation for PV system

It can be seen in Table 2 that the subtraction of energy consumed from the PV energy generated is illustrated as Net(kWh) where the numbers have two signs. The negative sign indicates the consumption during that month is more than the energy generated from PV, while the positive sign indicates that the generation is more than consumption. The positive amount is multiplied by 0.75 as mentioned before to satisfy the Net-Metering scheme of PEA, while the negative amount remains the same. After doing this for each month and sum all together we obtain 1151 kWh as excess energy that will be striked off because it cannot be carried forward to the following year. Also it can be observed that the annual energy generated from PV is 8686 kWh which is more than the annual home consumption (6984 kWh) by an excess energy of 1702 kWh. The PV energy 8686 kWh can be split into three amounts as shown in Fig.5, 6984 kWh for covering the load , 551 kWh for 25% monthly subtraction and 1151 kWh that will not be counted for the next year. Therefore, the useful energy used for covering the load (6984 kWh) represents the annual income of PV system and accordingly the economical evaluation of PV system will be affected by these figures. The useful PV ratio for this case equals 6984/8686 which is 80.4% and accordingly 19.6% represents the loss of PV generated energy due to Net-Metering scheme.

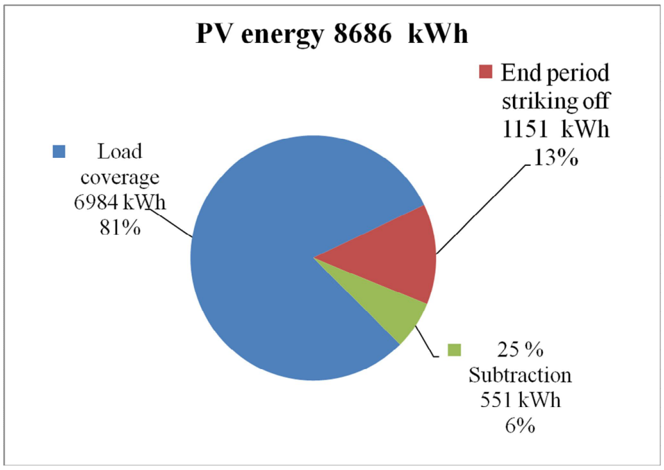

Fig.5. Annual PV energy parts based on Net-Metering

Table 2. PV energy generation and house consumption with balance based on Net- Metering. Net (kWh) with negative sign (-) is the net kWh consumed from the grid, while positive sign (+) is net kWh injected into the grid.

Month	Home cons. (kWh)	PV gen. (kWh)	Net (kWh)	Balance (kWh)
Jan.	750	500	-250	(-250)
Feb.	550	670	+120	120 * 0.75= (90)
Mar.	494	752	+258	258 * 0.75= (193.5)
Apr.	520	878	+358	358 * 0.75= (268.5)
May	540	830	+290	290 * 0.75= (217.5)
June	510	768	+258	258 * 0.75= (193.5)
July	512	820	+308	308 * 0.75= (231)
Aug.	536	803	+267	267 * 0.75= (200.25)
Sep.	542	735	+193	193 * 0.75= (144.75)
Oct.	540	692	+152	152 * 0.75= (114)
Nov.	680	578	-102	(-102)
Dec.	810	660	-150	(-150)
Year	**6984**	**8686**		**1151**

4.3.2 Feed-in Tariff calculation

Feed-in Tariff is used here to account the annual credit for the same example mentioned in previous section. Simply the total annual PV energy is credited to user account and the distribution company pays the corresponding amount of money ($/kWh) to the user. It can be observed in Table 2 that the total amount of PV energy injected into the main grid amounts to 8686 kWh per year. Even the energy generated from PV is more than the annual energy consumption no loss of PV energy and no need for complicated calculation process as in Net-metering scheme. The useful PV ratio for Feed-in Tariff is 100%.

5. Energy and economic analysis of PV systems with different rated power

This section presents a comparative assessment based on economic evaluation between Net-Metering and Feed-in Tariff schemes. PV systems rated at different capacities are considered to show that increasing of PV power generation at constant load results in Net-Metering scheme to increasing financial losses for the PV system owner. On other hand, in Feed-in Tariff , the increasing of rated PV capacity increases the energy sold to the grid and thereby increasing the income which improves the economic parameters to be better than those achieved in Net-Metering scheme.

5.1. energy accounting based on Net-Metering and Feed-in Tariff

Different PV systems rated at 2 kWp, 3 kWp and 5 kWp are chosen to cover a residential load of annual consumption amounting to 6984 kWh/year. Table 3 and Fig.6 show the monthly energy generated from the different PV systems and monthly load consumption.

Table3. Energy consumption and PV energy of different peak power systems.

Month	Load	2 kWp	3 kWp	5 kWp
Jan.	750	210	320	500
Feb.	550	268	402	670
Mar.	494	304	452	752
Apr.	520	352	527	878
May	540	332	498	830
June	510	308	461	768
July	512	328	492	820
Aug.	536	322	482	803
Sep.	542	294	441	735
Oct.	540	280	416	692
Nov.	680	232	347	578
Dec.	810	264	396	660
Total	6984	3494	5234	8686

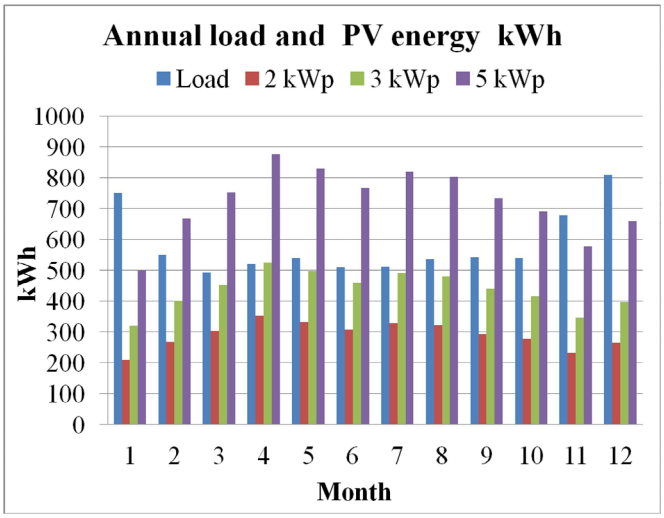

Fig.6. Monthly energy consumption and PV energy generation of different PV systems

Table 4 shows Net-Metering and Feed-in Tariff schemes are applied to account the credited PV energy, loss of PV energy and useful PV ratio.

Table 4.Net-Metering scheme results.

Net metering	2 kWp	3 kWp	5 kWp
PV energy generated (kWh/year)	3484	5214	8686
Credited PV energy (kWh/year)	3484	5212.26	6984
Loss of PV energy (kWh/year)	0	1.74	1702
Useful PV ratio (%)	100%	99.9%	80.4%

Table 5. Feed-in Tariff scheme results.

Feed-in Tariff	2 kWp	3 kWp	5 kWp
PV energy generated (kWh/year)	3484	5214	8686
Credited PV energy (kWh/year)	3484	5214	8686
Loss of PV energy (kWh/year)	0	0	0
Useful PV ratio (%)	100%	100%	100%

The considerable difference between Net-Metering and Feed-in Tariff schemes can be noticed in the case of using 5 kWp PV system. For Net-metering the PV energy which is not credited for the PV owner represents 19% of total annual generated PV energy. In case of using Feed-in Tariff no loss of PV energy will be done.

5.2. Economical evaluation of PV system considering different schemes

Three economic factors are used here to evaluate the PV systems of different rated power (2 kWp, 3 kWp and 5 kWp):

- Net present value (NPV)
- Internal rate of return (IRR)
- Dynamic payback period (DPP)

These factors are used to evaluate the residential PV system of the example illustrated in section 4, for Net-Metering and Feed-in Tariff schemes.

5.2.1 Net present value (NPV)

The NPV of an investment project at time t=0 is the sum of the present values of all cash inflows and outflows linked to the investment:

$$NPV = -I_0 + \sum_{t=0}^{T}(R_t - I_t)q^{-t} + L_T \times q^{-T} \quad (2)$$

$$q^{-t} = \left(1 + \frac{i}{100}\right)^{-t} \quad (3)$$

Where I_0 is the investment cost at the beginning (t=0), T is the life time of the project in years, Rt is the return in time period t, It is the investment in time period t, q^{-t} is discounting factor, i is the discount rate and LT is the salvage value [23,24,25].

A project is profitable when NPV> 0 and the greater the NPV the more profitable. Negative NPV indicates that the fixed interest rate will not be met.

5.2.2 Internal rate of return (IRR)

IRR computes for what interest the NPV will be zero, so it expresses the achievable interest tied-up in the investment [25].

$$0 = -I_0 + \sum_{t=1}^{T} R_t \times \left(1 + \frac{IRR}{100}\right)^{-t} + L_T\left(1 + \frac{IRR}{100}\right)^{-T} \quad (4)$$

5.2.3 Dynamic payback period (DPP)

DPP refers to the period of time in years which is required to recoup the capital investment in a project. The acceptable DPB must be shorter than the service life time of the project [25].

$$DPP = \frac{I_0}{\left(\sum_{t=0}^{T}(R_t - I_t)/T\right)} \quad (5)$$

5.2.4 PV systems costs

A survey was conducted on local companies representing the local market of PV systems in the West Bank-Palestine to obtain an accurate cost of PV systems as summarized in Table 6.

Table 6. PV system costs in theWest Bank-Palestine ($)

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

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

The calculation of the aforementioned three economic parameters considers the following realistic assumptions:

- Interest rate : 8% (average value in Palestine).
- System life time: 20 years. (mostly considered number).
- Cost of kWh: 0.17 $/kWh (Average price in Palestine).

5.3 Economic analysis results

The economical analysis was performed depending on equations (2 -5) using Excel software. The results obtained are presented in Tables 7 and 8.

Table 7. Results of calculated economic parameters for Net-Metering scheme

PV system	Investment ($)	PV useful income (kWh)	NPV ($)	IRR (%)	DPP (Year)
2 kWp	3314	3484	2550	17.28%	7.626
3 kWp	4568	5212.26	4204	18.95%	6.834
5 kWp	6628	6984	5126	17.32%	7.602

Table 8. Results of calculated economic parameters for Feed-in Tariff scheme

PV system	Investment ($)	PV useful income (kWh)	NPV ($)	IRR (%)	DPP (Year)
2 kWp	3314	3484	2550	17.28%	7.626
3 kWp	4568	5214	4205	18.95%	6.834
5 kWp	6628	8686	7991	22.05%	5.721

The economic parameters obtained in Table 7 and 8 for both accounting schemes are similar for the corresponding 2 kWp and 3 kWp PV systems. This refers to the monthly production of these PV systems which is always less than the load demand as seen in Table 3. This means no energy loss will happen. In the case of 5 kWp the loss of PV energy in Net-Metering scheme makes the economic parameters NPV,IRR and DPP for Feed-in Tariff scheme better than the corresponding Net-Metering economic parameters.

6. Net-Metering scheme analysis considering the load profile variation

As mentioned before the Net-Metering scheme is affected by the load profile. In this analysis a PV system of 2 kWp with an annual yield of 3500 kWh is considered to be a rooftop PV system to supply a house with two different load profiles but with the same annual energy consumption which amounts to 3400 kWh/year.

6.1 Load profile scenarios description

The first scenario represents an annual load profile with high energy consumption during winter where people use electrical heating systems as shown in Table 9 and Fig.7. The second scenario represents an annual load profile with high consumption during summer where people use cooling systems as shown in Table 10 and Fig.8. It can be observed in both scenarios that no excess PV energy over the year is available and the customer has to pay at the end of the year because of the negative sign of the energy sum. The loss of PV energy due to 25% subtraction amounts to 304 kWh/year for first scenario and 172 kWh/year for the second scenario. The useful PV energy for covering the load for first scenario amounts to 3180 kWh while it amounts to 3312 kWh/year for the second scenario.

Table 9. PV energy generation and house consumption with balance based on Net-Metering for first scenario

Month	Home cons. (kWh)	PV gen. (kWh)	Net (kWh)	Balance (kWh)
Jan.	530	200	-330	-330
Feb.	590	268	-322	-322
Mar.	340	304	-36	-36
Apr.	180	352	172	129
May	118	332	214	160.5
June	115	308	193	144.75
July	130	328	198	148.5
Aug.	108	322	214	160.5
Sep.	171	294	123	92.25
Oct.	178	280	102	76.5
Nov.	430	232	-198	-198
Dec.	510	264	-246	-246
Year	**3400**	**3484**		**-220**

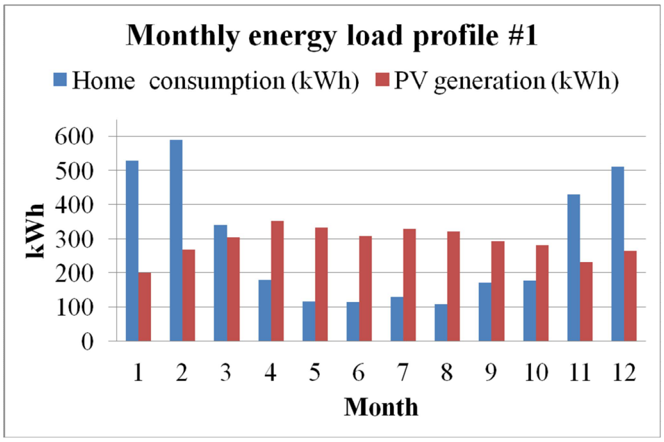

Fig.7.PV energy generation and house consumption of first scenario

Table 10. PV energy generation and house consumption with balance based on Net-Metering for second scenario

Month	**Home cons. (kWh)**	**PV gen. (kWh)**	**Net (kWh)**	**Balance (kWh)**
Jan.	120	200	80	60
Feb.	150	268	118	88.5
Mar.	170	304	134	100.5
Apr.	200	352	152	114
May	430	332	-98	-98
June	510	308	-202	-202
July .	478	328	-150	-150
Aug.	420	322	-98	-98
Sep.	350	294	-56	-56
Oct.	210	280	70	52.5
Nov.	192	232	40	30
Dec.	170	264	94	70.5
Year	3400	3484		-88

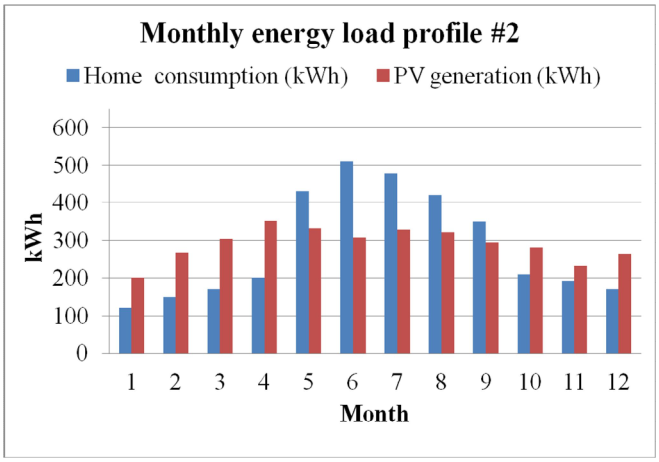

Fig.8. PV energy generation and house consumption of second scenario.

6.2 Economic analysis of scenarios

Economic analysis of the system is performed by using the same equations and same economic parameters mentioned in section 5 with investment cost of PV system amounting to 3314 $.

Table 11. Results of economic parameters of the two scenarios.

Scheme/Scenario	PV income (kWh)	NPV ($)	IRR (%)	DPP (Year)
Net-Metering scenario #1	3180	2038	15.53%	8.657
Net-Metering scenario #2	3312	2260	16.29%	8.176
Feed-in Tariff	3484	2550	17.28%	7.626

The results in Table 11 show that there is a difference of PV economical evaluation due to load profile variation even the annual energy consumption of both scenarios is the same, which is very common in residential sector. This result concludes that it is difficult to perform an accurate evaluation of PV system with Net-Metering scheme, which requires the use of other energy sources or special load management during the worst case periods. In addition the customer has to arrange his energy consumption to be matched with the period where the PV system delivers its maximum energy as outlined in scenario 2.

7. Conclusions and recommendations

Based on the performed analysis and obtained results, the following conclusions and recommendations are made:

- Based on the high average of daily solar radiation on horizontal surface (5.4 kWh/m^2-day) and the current price of PV modules, the PV systems can be considered as a feasible option for supporting the electricity sector in Palestine.

- The Net-Metering scheme applied in Palestine is set in favor of the electric distribution company rather than the PV energy producer. Discounting 25% of PV energy produced as a compensation for utilizing the electric grid is relatively high especially when considering the positive impacts of using PV systems represented in reducing the losses in the grid and increasing its voltage level. Reducing the above percentage would contribute in increasing the number and capacity of PV grid connected systems in Palestine.

- Striking off the excess PV energy delivered to the grid at the end of each year is a loss for the PV system owner. This affects negatively the economics of the PV systems. Such excess energy should be either paid to the system owner or carried forward to the next year.

- The accurate assessment of PV grid connected systems with Net-Metering scheme is difficult due to variation of load profiles in houses. At constant annual energy consumption of a house, with rooftop PV system, one obtains different economic results depending on the load profiles.

- The comparative assessment between Feed-in Tariff and Net-Metering shows that Feed-in Tariff does not depend on the load profile, it depends only on the PV production injected into the grid. On the other hand the Net-Metering scheme depends on load profile and therefore it is recommended for PV owners using Net-Metering to match their consumption to the PV energy production in order to avoid losing 25 % of the PV generation.

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