

Technical and Economical Evaluation of Solar Plant for Electricity Supply Anar City Residential Customers

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Abstract: The greatest source of energy is solar energy that energy emitted from the different forms is used in order to provide the required energy fossil fuels. This becomes more important in time energy conversion systems who Knows unenergy using photo voltaic systems directly without due processis converted into electrical energy. Since the Electricity production is One of the bases of the economic power of a country Because of the Has been Attention Increase in electricity production and value added in recent decades. Mean while, with the collection and access to advanced technology, Implementation and use of clean energy and renewable energy systems for human needs has been a significant growth. This paper introduces a new system of photovoltaic systems as an energy we will evaluate technical and economic assessment of photovoltaic cells for the study case.

Key words: Solar panels • Photovoltaic power plants • Payback period (Life-Cycle Cost)

INTRODUCTION

Iran is a country in terms of geographical area is hot and dry and getting more sun light during different months of the year. In Iran Except for the Caspian Sea coast Across the country Percent of Sunny daysare63 to98% in year. The energy content of the different parts of the country show in Figure 1 [1]. Solar energy as a clean energy source that can Provide most of the energy consumption is Used in the form of heat or electricity. Due to the increasing cost of energy from fossil fuels Cost of power generation using renewable energy and new developments in science and technology reduced and the economy is closely. Due to the fact that the lifetime ofPVsystems20 years. Technology as one of the most important and effective tools The use of new energy and According to international experience can respond appropriately to supply electrical energy is In areas outside of power network. While our country almost 20years experience there is as a source of energy using photovoltaic systems in telecommunication stations in remote areas. In this paper further more PV systems are introduced we is investigated Economic evaluation of photovoltaic systems for electricity supply in rural areas and Comparison with electrification through hens work electricity.

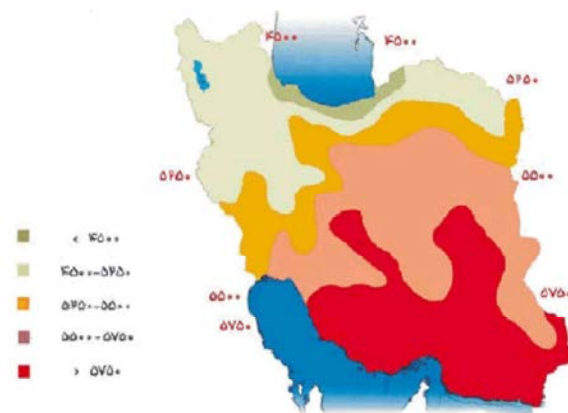


Fig 1: Map of average Daily received energy in Iran

Introduction of Photovoltaic Systems: To phenomenon in its effect And without the use of mechanical mechanisms that Radiant energy is converted into electrical energy This phenomenon is called photovoltaic. This phenomena on is based on the hypothesis of an atom of radiant energy. The system also uses these properties is called a photovoltaic system. PV systems are composed of three main:

- Solar panels: Solar radiation energy is converted into electrical energy.

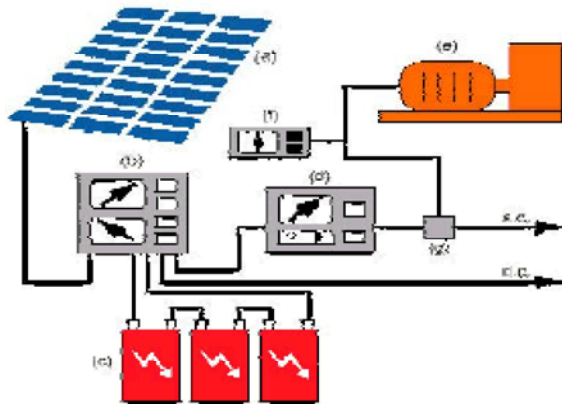


Fig. 2: General View of a photovoltaic system

Table 1: Common types of solar cells

Solar cell materials	Thickness (mm)	(%) Efficiency
Single-crystal silicon	0.3	15-18
Multi-crystalline silicon	0.3	13-15
Hybridsilicon	0.02	18

- Intermediate part or Desirable power part: Electrical energy from photovoltaic systems based on the was done, design Management this suggested. In Proportion with Consumer needs.
- Consumer or electrica load: All electrical consumers such as a cand dc in volved is Proportion a amount of Power consumption.

Figure 2 shows a general view of a photovoltaic system [2].

Solar Panels: Photovoltaic panels are exposed to the sun are composed of photovoltaic cells. Main constituent of most commercially available solar cells are from thin layers of semi conductor materials such as silicon. The main reason for this subject is rapid development and industrial production of bulk silicon Low cost and high efficiency in comparison with other semi conductors. Common types of solar cells are described in Table (1).

When the sun's photons to collide electrons leave these mi conductor atoms and holes that occur. If both cells are electrical conductors, Causes Creates a current that is called the current photon (I_{ph}). In the darkness, the solar cell is not active and acts like a PN junction diode that diode current is called the dark current (I_D). Equivalent circuit of a PV cell is shown in Figure (3). I_{ph} is current Photons from the sun, I_D diode current, R_s is Connect the series resistor who Losses are shown in cells [3,4].

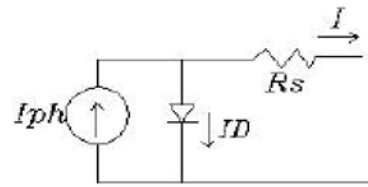


Fig. 3: The equivalent circuit of a cell

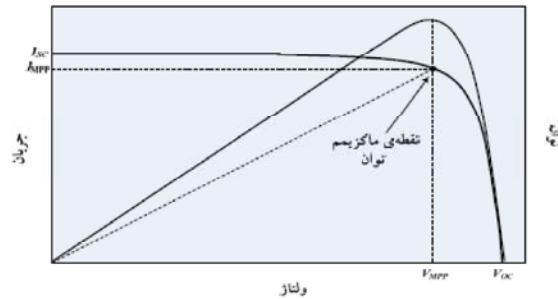


Fig. 4: Current-voltage characteristics of solar cell

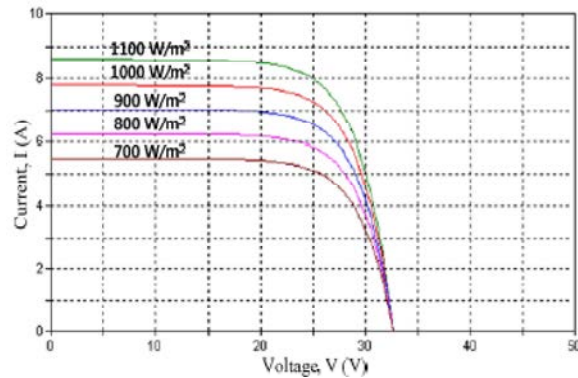


Fig. 5: The effect of solar radiation on the curve of the voltage-current

The relationship between the voltage and current of cell For different loads is shown in Figure 4. As is clear from this figure, current-voltage characteristics-the solar cells is highly nonlinear. The point at which the product of voltage and current is it highest point is called maximum power cells [5].

Current-Voltage characteristic curve-changes with two factors of solar radiation and ambient temperature. Solar cell current-voltage curves in Figures 5 and 6 show the variation of temperature and radiation. Usually produced by each cell voltage is about 5 volts. Current occurring in the cells follower are Cell area and intensity of solar radiation and temperature. To increase the voltage and current installed a group of cells connected in series and parallel to make a larger unit. That the larger units called modules. By installing some solar modules Is created on the retentive plate. Figure 7 shows the electrical connection of several panels to gether.

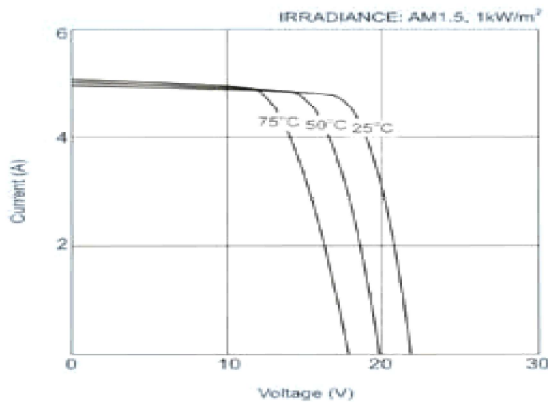


Fig. 6: The effect of temperature on the voltage-curve

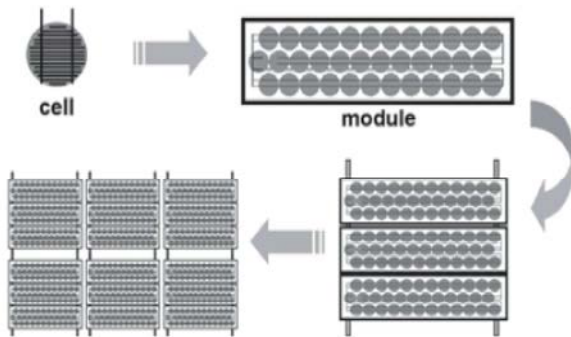


Fig. 7: Cells, solar modules and arrays

Appropriate Power Distribution: In the inter face panel Electrical energy from photovoltaic systems based on have been designed Proportional with Consumer needs and suggested management. This equipment mainly contain storage and backup systems, charge controllers, inverters and Based on the need soft he consumer.

Charge Control: Devices in the solar system which regulation and control the battery charge and discharge current and voltage. Prevent possible damage inflicted on the operating lifespan of a battery and maintain it. One of characters of Solar Panels is when changes output voltage panel's with Cloudy weather or Change to the Sun. So charge and discharge control and Stabilize the output voltage at Solar power is one of the most important points It is set up with charge control. Monitor the level of charge and discharge current and voltage in the selection of this system, the benefits of existing systems in the market.

Solar Battery: Battery bank numberis included usually 12 to 24volt battery that Connected in series to provide system Required voltage. System swchich Are isolated from the network Energy stored in the batteries, is done

when the night or Orate emergency times. Support systems are used in the battery during network outages. Network-connected systems do not require batteries. In gredients of battery can Be Lead-acid, nickel-cadmium and.

Inverter: If the output of the ac adapter is required for example, if they must Production energy of photovoltaic conversion its produced dc output voltage of converter by an electronic circuit convert to alternating voltage. Depending on the application, can be single phase or three phase. Electronic circuit used is called an inverter. Dc voltage input to the inverter in photovoltaic system Can be output from the output of solar arrays or batteries to be used in this system. Output phase voltage inverter with dc input voltage is in accordance with the following equation:

$$V_{Ph} = \frac{2\sqrt{2}}{\pi} \cos\left(\frac{\pi}{6}\right) V_d$$

V_d : Dc voltage input to the inverter
 V_{ph} : Ac output voltage of the inverter

Consumer or Electrical Load: All electrical consumers such as acanddc is proportional to the rate of consumption.

Uses Photovoltaic Panels: Such cases used in photovoltaic cells can be pointed to Remote are alighting, remote communications systems, water pumps, water filtration systems, electricity supply in rural areas Calculators, watches and toys, emergency systems [8].

In general, applications of photovoltaic cells can be classified into three categories:

- Network connected applications
- Disconnected from the network applications
- Applications Support Systems

Applications of Network Connected Photovoltaic Systems: Design of network connected photovoltaic systems Is such that, operation simultaneously and are connected to the national power network. One of the main components of photovoltaic systems connected to the network are Transducers which Dc power generated by the solar cells are converted according to the ac voltage and the power network and automatic power will off when not needed. Over all bilateral relationship are between PV cells and networks So that the dc power produced by photovoltaic systems may require more than the surplus

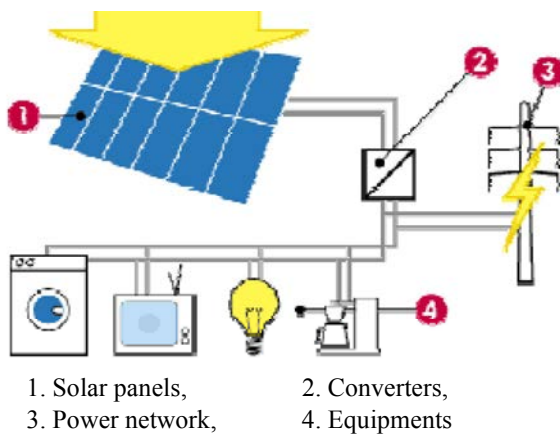


Fig. 8: Components of network connected systems

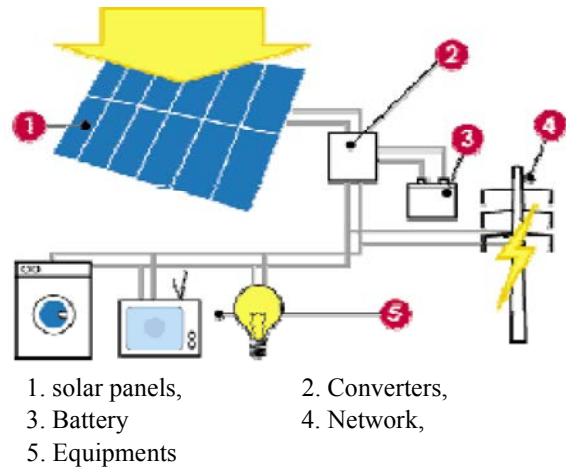


Fig. 10: ComponentSupport System

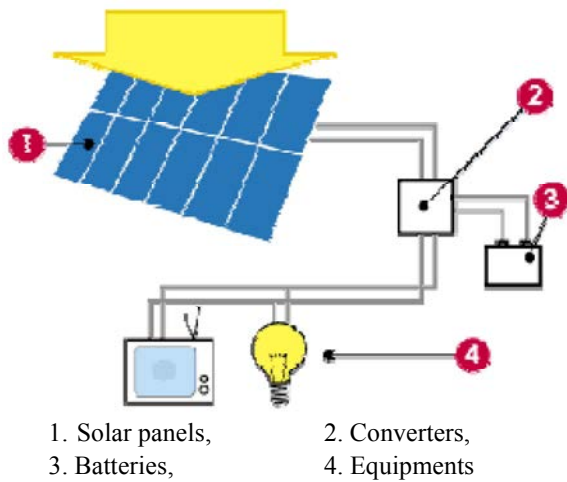


Fig. 9: The components of disconnected from the network

is fed into the Power Network and at night and when climatic reasons, there is no possibility of using sunlight Electrical load requirements are supplied by the power network. Also in applications of network connected, because if there pair is PV system out of the circuit electricity will be provided from the power network [9]. Figure 8 shows the system components connected to the network.

PV Systems Applications Disconnected from the Network: Discontinuous system design is such that the network operate independently from the power network and often are designed to produce Dc or Ac electric load. For Electricity generated by the system to disconnect from the network can be used wind turbines, generators and the nationwide power network as reinforcement. This kind of systems called hybrid photovoltaic. In disconnect systems from network in order to store energy using it to

Table 2: Component and costs of Photovoltaic

Total Price Rails	Number	Unit Price	Description
102400000	32	3200000	Panel
12000000	12	1000000	Battery
5000000	1	5000000	Charge Control
8000000	1	8000000	Inverter
3200000	2	1600000	Structure
130600000	Total		

night Or where there is not enoughsun light, the battery used. [9] Figure 9shows the system components disconnected from the network.

Use Das Support Systems: The application supports most PV systems are network during power outages. A small photovoltaic support system Power supply equipment is like light, Computer, telephone, radio, fax and etc And larger systems can to provide electricity of Equipment needed as a refrigerator when power outage [8]. Figure 10 shows the components of the system.

Economic Evaluation of PV Systems and Power Network: This section compares the cost of electricity from photovoltaic systems and a nationwide network economic evaluation will estimate for a load With 6000 watts of hours per day that is consumption average of residential household.

Estimated Cost of PV Systems: Table 2 shows the components of photovoltaic systems and the costs for the Been said load.

Table 3: Totalcost of photovoltaic systems

Year	Costs Main	Battery replacement costs	Cost Annual Service	Factor productivity	NPV
0	143660000		1306000	1	144966000
1			1306000	909/0	1187154
2			1306000	826/0	1078756
3			1306000	751/0	980806
4			1306000	683/0	891998
5		12000000	1306000	621/0	8263026
6			1306000	564/0	736584
7			1306000	513/0	669978
8			1306000	467/0	609902
9			1306000	424/0	553744
10		12000000	1306000	386/0	5136116
11			1306000	350/0	457100
12			1306000	319/0	416614
13			1306000	290/0	390494
14			1306000	263/0	343478
15		12000000	1306000	239/0	318034
16			1306000	218/0	284708
17			1306000	198/0	258588
18			1306000	180/0	235080
19			1306000	164/0	214184
20			1306000	149/0	194594
NPV Total of		168186938			

Although are unacceptable several methods for calculating the impact of the economic costs In this paper is used method analysis of return on investment (Life-Cycle Cost) [11]. Between the net present value is as follows:

$$NPV = \frac{C}{(1 + d)^y}$$

NPV: Net present value

C: Expenses in the year(y)

d: Interest rate

y: ith appensCostsin the year that.

Interest rate of 10percent (in inflation) is usually used in the analysis of the return period. Photovoltaic economy is estimated as follows:

Fixed Investment Costs: Initial investment cost, including the cost of equipment and installation of the system. Usually the cost of installation is equivalent equipment costs is 10 percent.

Variable Costs: Variable costs are including the cost of battery replacement, service and repair, battery life is usually considered to be 5 years. So the battery is replaceable 3 times the life of the system. The annual cost of servicing photovoltaic systems is equal

to 1% of the equipment cost. This amount is equivalent to 1306000IRR. Table 3 lists the costs over the twenty year life of the system has been inserted LCC method also factor is calculated using the following equation:

$$D = \frac{1}{(1.1)^y}$$

Net present value of total capital Replacement and maintenance costs multiplied by the factor obtained for the same year.

$$\frac{NPV - 760000}{20 \times 6 \times 365} = 3822$$

Cost of 760,000 Rials will be considered in this calculation divergence.

The Estimated Cost of the Electricity Network: Estimates of economic power by the national network of 20kV lines as follows:

The average cost per km of 20kV network of 170 million riyals, LV 200 million riyals, 50kVA transformer cost is 50 million. Usually, the Low voltage network for energizing villages about one and a half kilometers will be considered. Cost of electrical energy for sales is 846 kWh. Cost of Subscription fee split as well 760,000Rials.

Distribution and split the cost for a rural household is calculated as follows:

Table 4: Cost per kilowatt-hour, avillage of 20 households with different distances from the network

Distance Network (km)	Cost of photovoltaic systems (Rls/Kwh)	Cost of the Nationwide power network (Rls/Kwh)
5	3822	2198
10	3822	3168
15	3822	4139
20	3822	5109

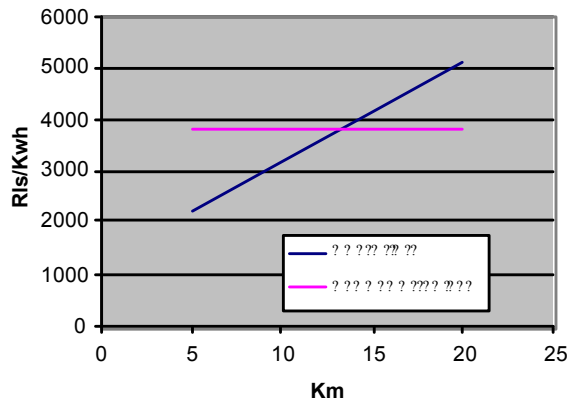


Fig. 11: Comparison of cost per kilowatt-hour in a village of 20 households by the Global network and photovoltaic systems

$$((CL_{1.5})+(CM_L)+CT)/N$$

- CL: Cost of Low Voltage network
- CM: Cost of MV network
- L: Distance from network
- CT: Cost of transformer

The value obtained Is reduced of Cost split.

Unit cost of electrical energy consumed by each house holdover the age of 20 years is:

$$(Distribution\ costs / 20) * 6 * 365$$

Thus, the cost unit of electrical energy consumed by each house hold is equal to the cost of electricity sales In addition, the unit cost of energy distribution.

In Table 4 the results of the calculations based on the proposed method for cost of power transition from Power Network and Photovoltaic systems for rural With 20 households has been estimated distance of the village to network.

Be noted that the cost of installing photovoltaic systems Is in dependent of the access network Obviously, with increasing distance Costs for network transmissionincreasesas ascensional.

Figure 11 shows It is an economical the village consists of 20 households at less than 14km from an atonal network and and the distance over which are affordable Photo voltaicsy stems. Soinsparsely populated areas with no access to the national electricity network use of photovoltaic systems Not only wastechically feasiblebut also economically also.

RESULT

In this becomes more important in time energy conversion systems who Knows unenergy using photo voltaic systems directly without dueprocess is converted into electrical energy. Since the Electricity production is One of the bases of the economic power of a country Because of the has been Attention Increase in electricity production and value added in recent decades. Mean while, with the collection and access to advanced technology, Implementation and use of clean energy and renewable energy systems for human needs has been a significant growth.

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