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Technical and Economic Assessment of Photovoltaic for Electricity Supply - A Case Study on the Electrical Distribution Network of IRAN

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Abstract: 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 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. 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.

Keyword: Solar panels, photovoltaic power plants, payback period (Life-Cycle Cost)

1. 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 ofPVsystemsis20 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.

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.

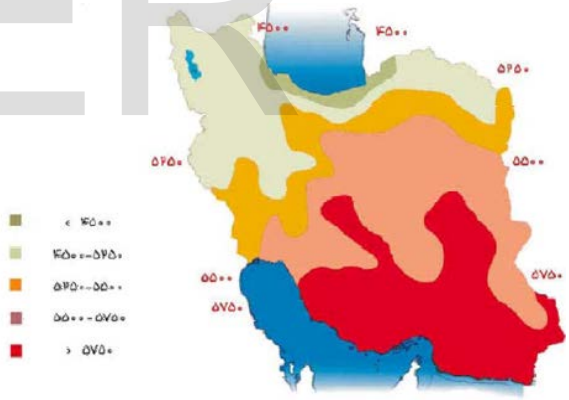

Fig 1: Map of average Daily received energy in Iran

2. 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:

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

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2- 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.
3- Consumer or electrical load: All electrical consumers such as a cand dc in volved are Proportion a amount of Power consumption.

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

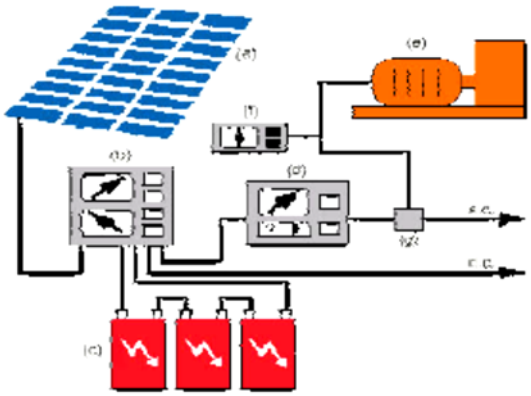

Fig 2- General View of a photovoltaic system

3. 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).

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
Hybrid silicon	0.02	18

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].

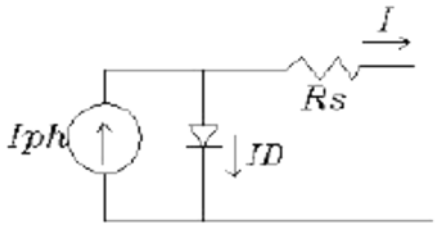

Fig 3- The equivalent circuit of a cell

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]

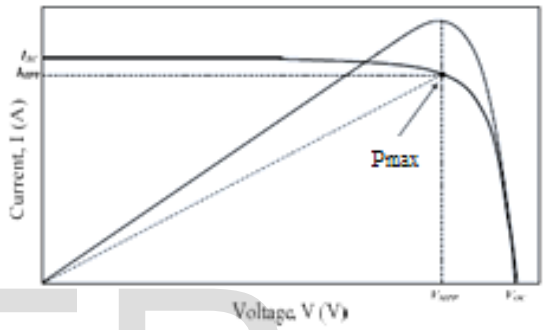

Fig 4- current-voltage characteristics of solar cell

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 7shows the electrical connection of several panels to get her.

a. 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.

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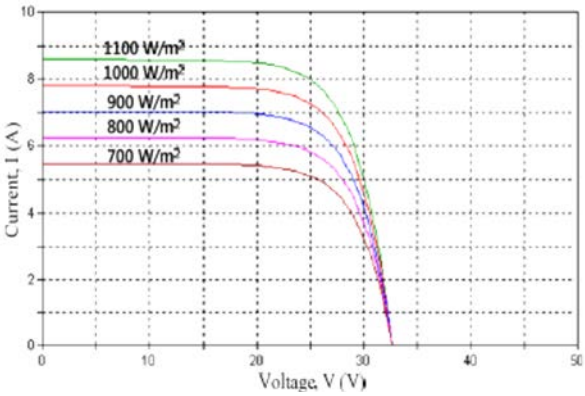


Fig 5- The effect of solar radiation on the curve of the voltage–current

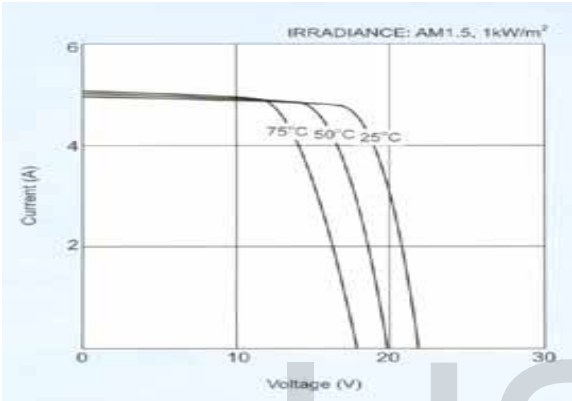


Fig 6- The effect of temperature on the voltage-curve

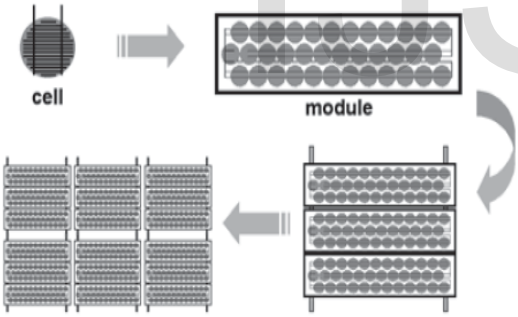


Fig 7- Cells, solar modules and arrays

b. Solar battery

Battery bank numberisincludedusually12 to 24volt battery that Connected in series to provide system Required voltage**.** System switch 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 gradients of battery can be Lead-acid, nickel-cadmium and Whatnot.

c. 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 phases. 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:

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

V_d: Dc voltage input to the inverter

V_{ph}: Ac output voltage of the inverter

4. Consumer or Electrical load:

All electrical consumers such as ac and dc is proportional to the rate of consumption. 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:

a. Network connected applications

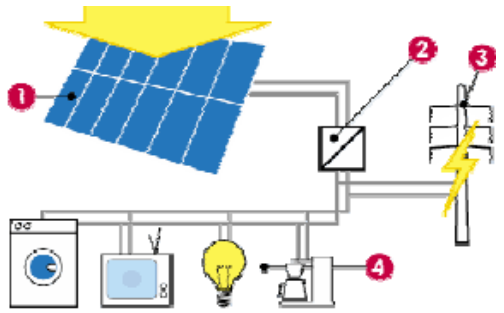
b. Disconnected from the network applications

c. Applications Support Systems

5. 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 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 8shows the system components connected to the network.



1 -solar panels, 2 -Converters, 3 -power network, 4 - equipments
Figure 8-Components of network connected systems

6. 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 With6000 watts of hours per day that is consumption average of residential household.

a. Estimated cost of PV systems

Table 2 shows the components of photovoltaic systems and the costs for the Been said load.

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		

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 appends Costs in 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:

a) Fixed investment costs

Initial investment cost, including the cost of equipment and installation of the system. Usually the cost of installation is equivalent equipment costsis10 percent.

b) 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 batteryisreplaceable3 times the life of the system. The annual cost of servicing photovoltaic systems Is equal to1% of the equipment cost. This amount is equivalent to1306000IRR.Table 3liststhe 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.

b. The estimated cost of the electricity network

Estimates of economic power by the national networkof20kVlineis 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 out one and a half kilometers will be considered. Cost of electrical energy for sale is 846 kWh. Cost of Subscription fee split as well 760,000Rials.

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

$$((CL \times 1.5) + (CM \times L) + CT) / N$$

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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

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

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 transmission increases as accessional.

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

Table4 – Cost per kilowatt-hour, a village of 20 households with different distances from the network

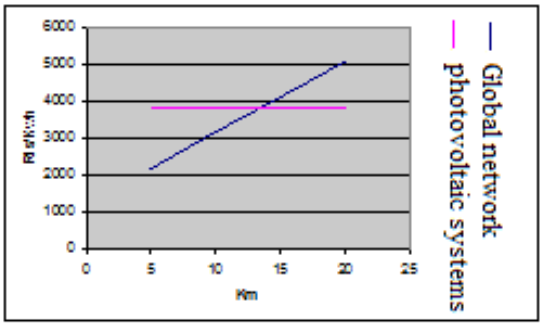

Figure 9-Comparison of cost per kilowatt-hour in a village of 20 households by the Global network and photovoltaic systems

Figure 9 show it is an economical the village consists of 20 households at less than 14km from an atonal network and the distance over which are affordable Photovoltaic systems. So in sparsely populated areas with no access to the national electricity network use of photovoltaic systems not only was technically feasible but also economically also.

7. Result

In this becomes more important in time energy conversion systems who Know sun energy using photovoltaic systems directly without due process 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.

8. Conclusion

Solar power generation has become increasingly attractive worldwide, but several parameters may affect the feasibility of solar PV plants. The paper aims at developing a careful methodology to evaluate the economic feasibility of solar PV systems, regarding to the Italian situation. Three different cities are chosen at Kerman, and one typical plant size is considered. For each case study the energy performance is estimated in terms of productivity per year (kWh/year). All costs and revenues and the cash flows at different timing are converted into equivalent present values, using an appropriate methodology, and the NPV value is considered as the most important parameter for the comparison. In fact, the FITs have been strongly reduced starting from 2011, but at the same time the installation costs have been decreasing. The condition can allow reaching of the grid parity: the cost of generating electricity from alternative energy is equal to or less than the price of purchasing power from the grid. Thanks to a very dynamic solar PV market with a decreasing costs trend and to more and more efficient solar PV technologies, the solar PV systems are a very feasible alternative to the conventional energy sources in Italy.

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