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Research Article

Economic Study of Solar Power for an Office Building in Jask Port

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Abstract: In this research, the plan for providing required electricity of a small office building with an area of 120 m^2, in Jask port in south of Iran, by using photovoltaic system was reviewed. At first, the amount of energy required for this building was calculated by studying the electrical facilities' plans of the building. Then, according to the estimated required energy, the design and financial estimation of solar electrical system was performed. Then, costs required for providing the energy of this building through electricity network has been calculated and in the end, economic analysis of the plan has been done by comparing these costs. The results of this research show that: if the distance between this building and the electricity network (A.C power) is equal or more than 500 m, setup of solar electrical system has less cost than providing the energy by the electricity network and photovoltaic system has 100% economic justification. If the distance between the office building and the electricity network is less than 250 m, the solar power system does not have economic justification.

Keywords: Economic analysis, Jask port, photovoltai.c system, power generation, solar energy

INTRODUCTION

Solar energy is the largest energy source in the world and it's considered as a renewable source. Batool *et al*. (2005) showed light energy which shines every hour from sun to earth, is more than the whole energy that all residents of the earth spend during a year.

By comparing the advantages and disadvantages of solar power, David (2010) showed that solar has many advantages and few disadvantages. The advantages of solar power are obvious:

• Stable• Reliable• Abundant• Free for everyone (after the costs of the equipment and setup)• Available everywhere• The most cost-efficient form of energy, if used correctly• Clean power (zero emissions, zero health risks)• Preserves our natural environment, air quality and limited water supplies• No delivery costs• No pollution• Almost maintenance free• Generates local jobs

Iran is one of the most susceptible countries in the word for using the solar energy. The sunlight received in Iran in a year, is about 1000 times the annual energy consumption and export of this country (Mahdi and Seyed Abbas, 2003).

One method for producing electricity from solar energy is using photovoltaic system. Photovoltaic system is a system which produces electrical energy from solar radiation to solar cells and then by controlling and transforming that energy into arbitrary form and proper power, it's usable for various purposes.

The results of Mahdi and Seyed Abbas (2003) research showed: On average, a 3-kw photovoltaic system may prevent diffusion of 800 Kg Carbon dioxide annually.
A photovoltaic system consists of 4 parts:

Solar panel: Solar panel or photovoltaic cell is a device which directly transforms the solar energy to electrical energy.

Charge controller: The main purpose of charge controller is to protect the battery from excessive charge or discharge by the solar panel or the consumer. The charge controller adjusts the input current and voltage of the battery.

Battery bank: The duty of battery bank is to save electrical energy for times that this energy is not available. (such as nights or cloudy weather)

Inverter: Inverter is an electronics transformer which transforms DC current to AC current.

Nowadays, photovoltaic system have been installed on roofs and exterior view of many buildings, sky crashers and public and research halls in different parts of the world, for example 4 Times Square , the highest sky crasher in New York in 1990s (http://www. californiasolarcenter.org).

The results of Mohammad and Batool (2011) research showed that firstly, most regions in Iran has

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high capacity for using solar renewable energy, secondly, most sunny days in April and May are in Jask and Minab cities which are located in Hormozgan province. since the scope of our research is also Jask port, the results of this research indicates the high ability of this port in applying solar energy.The purpose of performing this research is to design and financially estimate the plan for supplying the power of an office building in Jask port, in Hormozgan Province, by using photovoltaic system. Next, the initial costs and current costs for supplying the power of this building by the city's electricity network have been calculated and in the end, economic analysis of the plan has been done by comparing these costs.

MATERIALS AND METHODS

Case study: The case study for supplying the solar energy in this research is a small office building with an area of 120 m^2 in Jask port. In Fig. 1, the architectural plan of this building is shown.

Research geographical range: Jask port with an area of 16000 km^2 is located in south of Iran in the coast of Oman Sea and in the east of Hormoz Strait. This port is one of the environs of Hormozgan province and its altitude is 4.8 m. This port has a hot and humid weather such that the maximum temperature in summer is 41 to 52°C, but in winter, the weather is mild and about 17°C.

The results of Mohammad and Batool (2011) research showed that Hormozgan province and Jask port are among the high-radiation areas which have the minimum number of cloudy days. In Fig. 2, you can see the zoning of Iran's high-radiation areas based on the average of minimum cloudy days in autumn, in which the Hormozgan province has a high capability of radiation.

Estimating the required energy: By using the electrical facilities' plans of this building, the amount of electrical energy consumption of this building according to the type of consumption and daily times are shown in Table 1.
Total power consumption for every day = 47.6 KWh

Design and Financial Estimation of Solar energy system: As it was mentioned earlier, the photovoltaic electricity system is consisted for 4 parts:

Solar Panel: Total power required in a day and night is 47600 w, so the power required in an hour is equal to 1983.4 w. Since this place is located in a lace with high potential for solar radiation, so the efficiency of solar panels maybe considered in the maximum amount, i.e., 35%, which of course is achieved by MPPT-type charge controllers which maximize the efficiency of

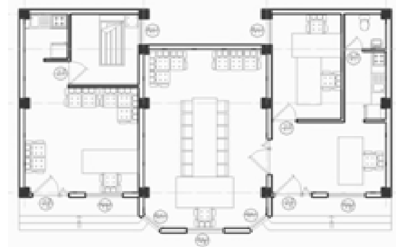

Fig. 1: The architectural plan and furniture of the office building

solar panels. Thus the total nominal power of required solar panels is equal to:

1983.4 w÷35% ≈5667 w

So, totally, we need about 28 number of 200-watt panels for supplying this amount of energy.
Battery Bank
Number of batteries required is calculated as follows:
Total power consumption for every day = 47.6 KWh
Total power consumption for nighttime = 25% × 47.6 KWh = 11.9 KWh

Voltage conversion ratio = 220 V_{AC}÷48 V_{DC}≈ 5

Amount of receive electrical current from the battery bank at nighttime = 11.9 KWh÷220 V×5≈270.45Ah
Capacity of the battery bank required with considering the maximum 80% discharge = 270.45 Ah÷%80 ≈ 338 Ah
Number of batteries (12V, 200Ah) needed to form the battery bank = (338 Ah÷200 Ah) × 4≈ 8

Charge controller: The selected charge controller is MPPT type with input current of 60 Ampere, to which, 12 pairs of panels can be connected in parallel mode and since the number of solar panels is 28, almost a 60-ampere charge controller is required.

Inverter: Since the lighting system of this building is LED lights which work with DC, we don't require inverter for lighting system. Considering the electrical equipment in this office, we need 4 sets of 3-Kw inverters, 2 sets for split units and 1 set for a18000 Btu/h Split unit and the last set is built in for conventional sockets.

According to the daily prices of the required equipment for photovoltaic system, in Table 2, the required equipment for solar power of this office with their costs is provided. (The amount of the initial investment cost of solar power project is 28,578$.)

Calculating the costs of supplying the building's energy by electricity network: The costs for supplying the required energy of this building by the electricity

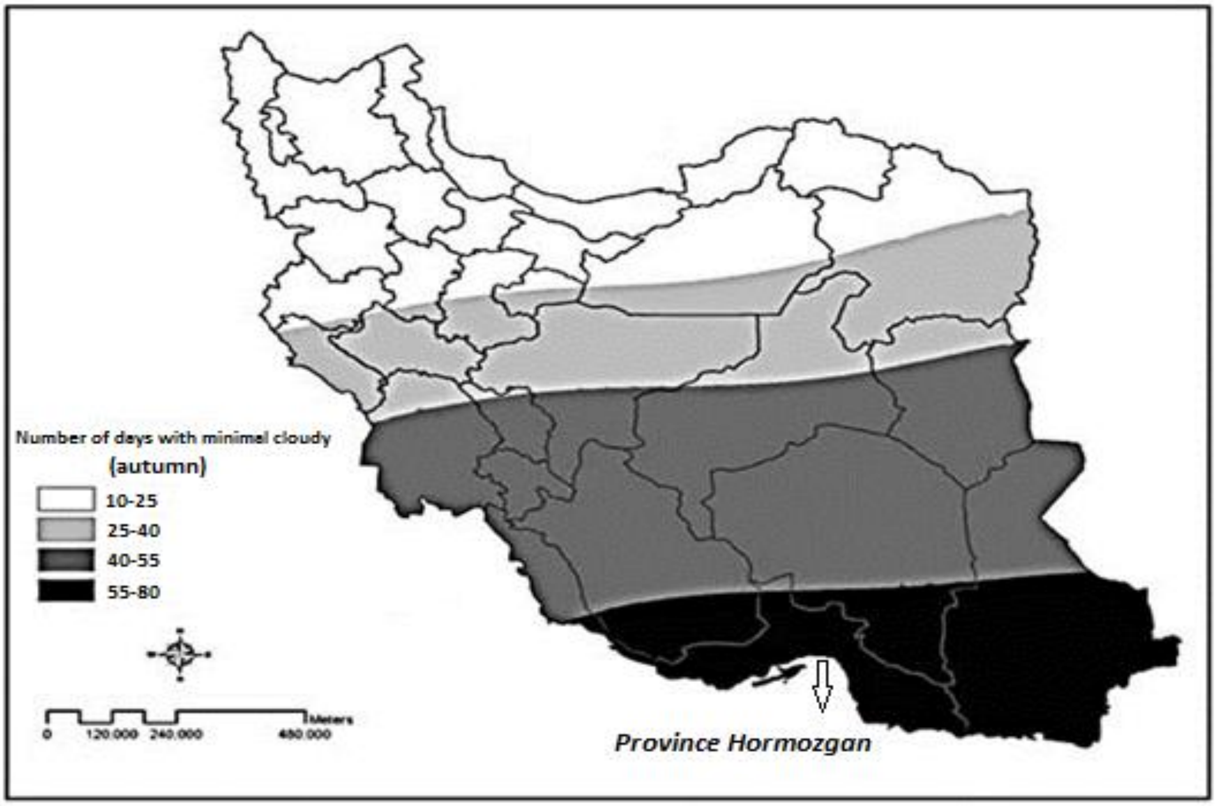

Fig. 2: Zoning high radiation areas of Iran based on the average number of days with minimal cloudy in autumn

Table 1: The required consumption power of case study

	Device name	Average power consumption of the device(W)	Number	Useful time of power consumption per day(h)	Daily power consumption (KWh)
1	Air conditioner (12000 btu/h)	1200	4	6	28.8
2	Air conditioner (10000 btu/h)	2000	1	4	8
3	LED ceiling lights 2*20W	40	11	4	1.76
4	LED ceiling lights 10W	10	1	1	0.02
5	LED Wall lights 10W	10	4	8	0.32
7	Computer	200	5	4	4
13	Copier device	700	1	1	0.7
14	Printer	500	2	1	1
19	Other				3
Total power consumption required (KWh)					47.6

Table 2: Solar power system equipment list with costs

	Equipment	Number	Unit	Unit price($)	Total cost($)	Useful lifetime	Manufacturer	Sales and service representative in Iran
1	Solar panel (200W)	28	piece	652.53	18,270.84	25 years	Aria Solar-Iran	Aria Solar-Iran
2	Deepcycle battery (12V,200Ah)	8	piece	326.26	2,610.08	10 years	Exide - England	Sufco Co.
3	MPPT charge controller 16A	1	piece	1264.27	1,264.27	15 years	Xantrex-USA	Solar sanat parsian Co.
4	Sinus Inverter 3KW	4	piece	1468.19	5,872.76	15 years	HajirSanat-Iran	HajirSanat-Iran
Sum					28,018			
2% of the total cost for miscellaneous equipment					560			
Total					28578$			

Table 3: Initial cost of energy from the A.C power

	Equipment	Unit	Number	Unit price($)	Total cost($)
1	Power post building	m^2	12	500	6000
2	Transformer 25KVA	piece	1	7,341	7341
3	Electrical cable	m	50	10	500
4	Power branching fee (3Ph)	piece	1	1264	1264
5	Power grid constructing	m	0	24.45	0
Sum					15105
2% of the total cost for miscellaneous equipment					308
Total					15413

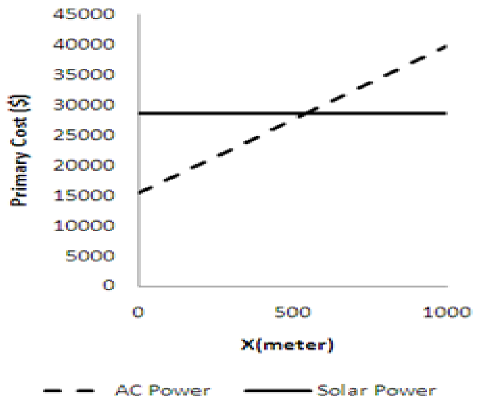

Fig. 3: Comparison between initial costs of solar power and urban power based on the distance between the building and the electricity network

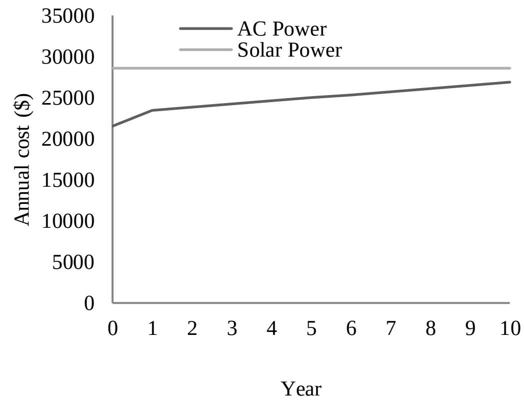

Fig. 4: Comparing the final costs of solar system and electricity network system during the time (the distance between the building and the electricity network is 250 meter)

network are divided in two categories of costs of initial investment and current costs which we will calculate in the following.

Initial investment cost for supplying the energy by electricity network: The initial costs of supplying the energy required for the office building by the electricity network (A.C Power) includes construction of electrical facilities which are mentioned in Table 3.

It should be noted that according to high amount of humidity in Jask port, all the transformers available in this city must be installed in an electrical building.

The row 5 of Table 3 which is about the cost of developing the electricity network which depends on the distance between this building and the electricity network, which in our calculations we have assumed that the building was constructed next to the electricity network. If the building has distance with the electricity network, with increase in the distance, the cost increases linearly, so we may suggest the following equation for calculation:

$$Y = 24.45 X+15413 \quad (1)$$

In which Y is the final cost of initial investment for supplying energy by electricity network in dollar terms and X is the distance between the building and the electricity network in meter terms.

Current costs of supplying energy by electricity network: If the energy required for the office building is supplied by the electricity network (A.C power), in addition to initial costs, the power consumption costs or current costs must be paid to the utility company. The power consumption tariff for office buildings in 2012, is 0.11$ per Kilowatt.

RESULTS AND DISCUSSION

In previous section, the costs of supplying the power of this office building were calculated by two methods. In this section, we do economic analysis of the plan, by comparing the costs of these 2 methods:

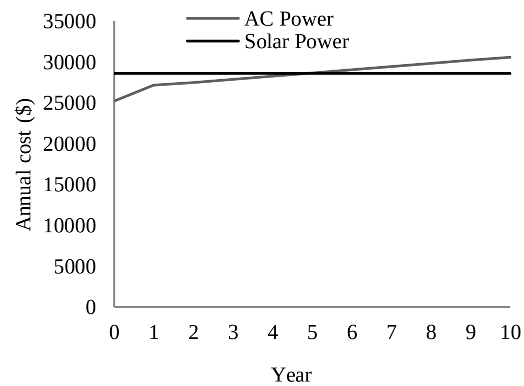

Fig. 5: Comparing the final costs of solar system and electricity network system during the time (the distance between the building and the electricity network is 400 meter)

Economic analysis of the plan according to the distance between the building and the electricity network: Eq. (1) indicates the increase in costs of supplying the energy required for the building by the electricity network in terms of the distance between the building and the electricity network. In Fig. 3 this equation is shown beside the costs of initial investment for supplying the energy by the photovoltaic system.

As it may be seen in Fig. 3, if the distance between the building and electricity network is equal or more than 500 m, the costs of supplying power by photovoltaic system is less than initial costs of supplying energy by electricity network, so it is better to use photovoltaic system for supplying the power of this building.

Economic analysis of the plan according to the time and return of investment: According to estimation of initial and current costs of supplying energy of the building by two methods of photovoltaic system and A.C power in Fig. 4 and 5, a comparison has been made between the costs of these 2 systems during the time. In Fig. 4, it is assumed that the distance between the building and the electricity network is 250 m. In Fig. 5, it is assumed that the distance between the building and the electricity network is 400 m. It must be noted that in calculating the current costs of power supplying by electricity network, the annual inflation rate is assumed to be 20%.
The results of these figures show that:

- If the distance between the office building and the electricity network is less than 250 m (Fig. 4) the investment of solar energy would not be returned during 10 years, so in this condition, the solar power system does not have economic justification.
- If the distance between the office building and the electricity network is equal to 400 meter (Fig.5), after 5 years, the initial investment will be returned, so the solar system will be profitable.

CONCLUSION

Using clean and renewable solar energy for supplying the power of buildings has many advantages and maybe the only disadvantage of this system is its high initial costs. In this research, the plan for supplying the power of an office building with an area of 120 m^2 in Jask port was reviewed by using two methods: 1- photovoltaic system and 2-urban electricity network. At first, the initial and current costs of both power supplying methods were calculated in different conditions and then the economic analysis of the plan was done by comparing these costs. The results of this research showed that: if the distance between the case study building and the electricity network is equal or more than 500 m, the initial costs of solar power is less than the initial costs of power supplying by the electricity network and the photovoltaic system has 100% economic justification. If the distance between the office building and the electricity network is less than 250 m, the investment in solar power will not be returned in 10 years so, in this case, the solar power system does not have economic justification.

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