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The Feasibility of Installing Photovoltaic Panels in Passive Educational Building Located at Tehran

Shima Sadaf Saz[1], Maria Kord Jamshidi[2]

[1]Architecture Master Student at the University of Pardisan, Mazandaran,Iran- shsadaf1360@yahoo.com
[2]PhD Assistant Professor, Faculty of Art and Architecture, the University of Mazandaran, Babolsar, Iran

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ABSTRACT

More than 95 percent of energy in Iran is provided by fossil fuels and it is the cause of emitting one present of greenhouse gas in the word. Also, generating environmental pollutants in Iran is 2.8 times higher than world standard. Therefore, using renewable energies especially solar energy is a necessity and appears to be important issue in an increasing rate in country budget. In this research which is designing passive educational building, by using inactive systems we reduce fossil fuels and minimize energy consumption, alongside using solar panels for saving energy. In doing this, we consider the economical aspect of using photovoltaic panels in educational building. The research methodology applied in this study is analytical-descriptive. The consumption cost per square meter of educational spaces is calculated by analyzing the costs of energy consumed by 15 schools in different areas in Tehran. Comparing that cost with the cost of installing photovoltaic panels enabled us to analyze economic aspects of utilizing the technology. The results show capital return of utilizing the technology in Tehran is around 8 years. Considering payback period, utilizing solar panels alongside inactive systems and protection policies of the government, leads to reduction in energy consumption in educational buildings and will be economical.

KEYWORDS: Photovoltaic panels, energy consumption, cost, solar systems.

1. INTRODUCTION

Sun is the main source of energies on earth. Humankind has been using those energies for a long time. However, today´s view to those energy sources is not a primitive and simple perspective. Scientists rather try to satisfy the present need of societies. Therefore, they continuously are looking ways to convert the solar energy into the demanded energy. In other words, technology must be modified in a way that could help it directly utilize the solar energies [1]. With respect to the importance of environmental issues, saving in fossil resources, the problems of energy supply, limited recourses, and large costs spent for the utilization and production, demand to utilizing renewable energies becomes tangible every day. Rapid growth of energy consumption has caused serious damages to human living environment. The growing consumption of fossil fuels increases global warming by producing polluting gases and has destructive effects on ozone layer [2]; which lead to intensifying natural disasters such as storms, hurricanes, fire in wood, irregular tied and ebbs, flood, famine, drought, insects invasions etc., which are among many consequences of increase in temperature [3].

Utilizing solar energy is affected by several factors such as solar radiation time in different seasons of year and various hours of day, geographic regions and climate conditions [4]. Iran is one of the countries that because of its situation in 25 to 40 degrees longitude and its location in solar belt receive on average 280 days of sunshine per year [2]. For this reason, the country has a great potential for using solar energy by facilitating buildings and using suitable materials and modern solar facilities. It is possible to provide large portion of energy consumption of buildings through receiving and converting solar energy. One of these methods is to employ inactive solar systems. This type of utilizing solar energy is considered in design stages of the buildings in a way that building could provide thermal, heating and cooling facilities in natural form by using solar radiation energy, which in turn minimize the need to mechanical facilities [5]. Due to limitation of fossil fuels resources and environmental pollutions causes by it, along with stepwise increase in the price of energy carries in the country (caused by eliminating subsidies in the course of time), using solar energy will be changed into demand in near future [6]. Regarding this project, using photovoltaic panels which are a part of active solar systems, alongside inactive solar system, could considerably reduce the energy consumption of educational buildings.

* **Corresponding Author:** Shima Sadaf Saz, Architecture Master Student at the University of Pardisan, Mazandaran, Iran- shsadaf1360@yahoo.com

2. MATERIALS AND METHODS

Passive buildings are structures that consume little amount of energy while provide comfortable internal conditions both in winter and in summer with no need to conventional central heating and cooling systems[7]. In this study, via inactive systems which minimize energy consumption, we utilize solar panels for saving energy. In doing so, we consider the economical aspect of using photovoltaic panels in educational building.

The applied methodology in this study is analytical-descriptive. In designing the educational building we used Design Builder software. Also, the panels which are used in this building are designed as semi-transparent panels that provide both the electricity for the building and illumination for classrooms [8].

The consumption cost per square meter of educational spaces is calculated by analyzing the costs of energy consumed by 15 schools with different spaces located at Tehran. Comparing calculated cost with the cost of installing photovoltaic panels enabled to check whether utilizing the panels is economical or not.

The results show capital return of utilizing the solar panels is around 8 years. Since the useful life of photovoltaic system is around 20 years, there will be high saving in energy consumption and reasonable reduction in costs. Considering this, utilizing solar panels alongside inactive systems and protection policies of the government, leads to reduction in energy consumption in educational building and will be economical.

3. RESULTS AND DISCUSSION

3-1-Recognizing photovoltaic panels and components

One of the first approaches which has employed in using renewable energies is to install photovoltaic cells that could convert the energy received from light photons into electrical energy. By the advancement of the technology, the photovoltaic cells have changed significantly as much as they are presently considered as inseparable part of modern buildings [9].

The most important capability of sunshine energy is its direct conversion into the electricity. One of the systems of direct conversion of radiation energy into electric energy is photovoltaic systems. Photovoltaic is a combination of the word “photo” as light and “volt” as the electrical energy unit. Photovoltaic cell is the sheet that converts sunshine energy without catalyzer or chemical mechanisms [10]. Photovoltaic cells are the major elements that construct photovoltaic systems which are made of silicon and generates the most flexible and valuable forms of energy; that is, electricity. The reliability factor of these cells is very high; they have no depreciations, produce no pollution and have high sunshine energy absorption. By placing the photovoltaic cells a module is developed and a number of modules create photovoltaic sheets and the sheets create arrays [9].

3-2-The use of photovoltaic in building methods, benefits and limitations

Using photovoltaic in buildings takes different ways. The arrangement of photovoltaic sheets on the roof, mounting those sheets on the building, or using them in the building shells are among the methods of using those sheets in the building.

Combination of voltaic sheets with building shell is the newest method of using photovoltaic in the building. Combination of photovoltaic with the building is called “combined photovoltaic”. In the designed model of this project, combined photovoltaic on the roof is used. This method, both replace conventional construction materials and generate electricity. By replacing photovoltaic, the cost of materials is reduced from the whole cost of the building which cover the cost employing photovoltaic cells to some extent. By doing this, the combined photovoltaic systems have lower costs than the systems attached to the building. If the photovoltaic combination by building shell is considered in the preliminary stages of design, its aesthetic aspects and economic advantages will be improved [9].

FIG1.Panels combination in the roof-[9]

Following are reasons that inhabit expansion of photovoltaic technology in Iran [11];

- Unrealistic price of energy in Iran (subsides)
- Absence of participation of specialist and investors
- Lack of knowledge and technical information in this area
- Lack of studies resources in this field
- Little knowledge and insufficient education

3-3-Supportive government policies in utilizing renewable energies

Many countries and recently Iran encourage producers and consumers of renewable energies, for instances;

- For protecting its produces and increase investment in photovoltaic areas, since the year 2000, the German government has been purchasing the power generated by photovoltaic with higher prices.
- Netherlands has considered tax exemption for renewable energies consumer to encourage expansion of this type of energies.
- In Sweden, abundant protective policies are adopted for expanding usage of renewable energies. As an example, for below1.5 MW capacities, each kilowatt power generated from renewable energies, 0.9 Swedish Krona is paid to the electricity producer.
- In England special protective laws have been legislated for expanding the use of renewable energies. In April2001, the Federal Government Organization legislated the Tax Act for climate changes. According to this Act, the industrial and service producers of nonrenewable energies are required to pay huge amount of taxes. On the other hand, green electricity consumers are exempted from this law. In year 2002, the Act of mandating renewable energies use was passed, based on which, electricity power retailers are required to achieve the use of renewable energies to minimum 10% of its electricity generated until 2010[9].
- In Iran, Metropolitan Tehran Electricity power Distribution (MTEPD) in recent years has allocated facilities for installing photovoltaic systems for improving usage of renewable energies for household and non-household consumption from one kilowatt up to 50kilowatt ceiling. The mentioned facilities include maximum 50 % of initial costs related to photovoltaic facilities. The installation and execution costs are around 90,000,000 Rails per kilowatt, which 50% of this amount is free loan. This step is a move towards encouraging and expansion of using solar systems in the country [12]

3-4-Passive educational Complex and energy consumption

Passive buildings are structures that consume little amount of energy while provide comfortable internal conditions both in winter and in summer with no need to conventional central heating and cooling systems[7]. In the Educational Building that is modeled by Design Builder software, the building is designed in an inactive form which enables it to provide its thermal demands with no need to central heating system. In order to lower environmental pollution and preserve the environment from fossil fuels emissions, alongside save energy, in designing Educational Complex active systems including photovoltaic panels are used. The panels which are used in this building are designed as semi-transparent panels that provide both the electricity for the building and illumination for classrooms [8].

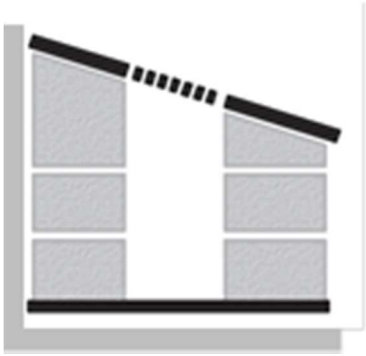

FIG2. Place of photovoltaic panels on the roof of a school [2]

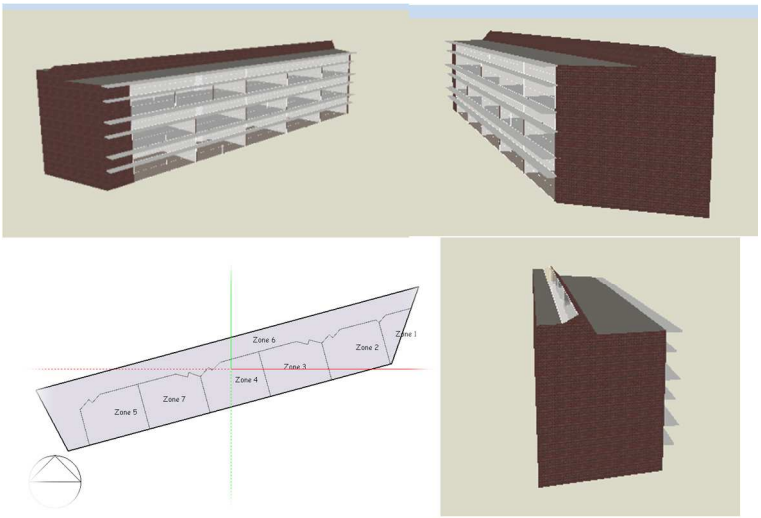

FIG2. Educational Building model [8]

3-5-To evaluate building design in terms of energy consumption

In the present study, the amount of building power consumption is listed in the below table. In measuring it, the space per capita, the physical programs in each block, and the amount of illumination needed in different spaces in kilowatt, has been considered [8].

Table1. Calculate the electricity needed for block B4

Discreation	Area	Intensity (lux)	LM	Type of lighting	LM FOR EACH LAMP	The number of lamps needed	Watt	WATT PER CLASS	NUMBER OF SPACE	TOTAL WATT
CLASSES	50	300	15000	Linear fluorescent	1850	8	24	192	9	1728
LAB	55	500	27500	Linear fluorescent	7000	4	80	320	4	1280
WORKSHOP	110	400	44000	Linear fluorescent	7000	6	80	480	1	480
CORRIDOR	164	100	16400	Linear fluorescent	1850	9	24	216	3	648
STAIRS	14	100	1400	Linear fluorescent	150	9	5	45	6	270
COMPUTER							155		20	3100
Water cooler							188		6	1128
Printer and Fax							154		1	154
SUM										**8788**

Since this building is to be constructed base on the inactive system design, it pays no gas and electricity bills, and the photovoltaic panels provide the electricity in emergency cases. Though, in the first stance, expenditures in solar electrical system the country seems uneconomical; because of the high expenses need for installing and implementing photovoltaic panels, the cheap price of energy carries, and high bank deposit interest rate (as an alternative investment), however in long –term and as the price of energies and fossil fuels will be raised, the designed system will be highly economical. It is logical, in using solar electrical system, the economical aspect should be considered as the second priority, since it has significant effects in reducing air pollutions. With respect to

the explanations provided in this research, the facilities offered by government, as described above, are used in justifying the photovoltaic panels installation and implementation costs. By specifying the amount of electricity consumption for each block introduced above, to calculate the cost of energy consumption, the average consumption costs of one year was calculated for 15 schools in various areas which were selected as samples in Tehran. By calculating the energy consumption per square meters, the energy which was consumed in this building has been specified. By considering the annual 15% inflation rate in ascending form, the annual costs have been calculated. The results of which are shown in the below table.

Table2. Spending costs per Square meters of 15 schools in Tehran

SCHOOLS	Area	Annual electricity cost (IRR)	Annual gas consumption cost (IRR)	Total energy costs(IRR)
1	800	12,000,000	54,000,000	66,000,000
2	1,200	13,500,000	61,000,000	74,500,000
3	1,500	14,800,000	88,500,000	103,300,000
4	1,900	16,000,000	114,846,000	130,846,000
5	2,200	19,300,000	126,000,000	145,300,000
6	2,600	21,500,000	151,000,000	172,500,000
7	2,800	23,000,000	165,000,000	188,000,000
8	3,000	3,000,000	165,348,000	168,348,000
9	3,200	24,800,000	178,000,000	202,800,000
10	4,600	31,300,000	225,000,000	256,300,000
11	4,900	31,800,000	249,000,000	280,800,000
12	5,000	33,000,000	262,000,000	295,000,000
13	5,400	40,000,000	278,600,000	318,600,000
14	6,000	43,500,000	322,500,000	366,000,000
15	8,000			
SUM	**53,100**	**327,500,000**	**2,440,794,000**	**2,768,294,000**
The average energy consumption per square meter (£)	**52,134**			
Area of building B4	**1590**			
The cost of electricity in block B4	**82,892,419**			
The cost per kilowatt hour of photovoltaic panels	**(90000000-45000000)=45000000**			
grant50%	**45,000,000**			
Cost of 8 kilowatts of electricity B4	**360,000,000**			

Also, using the statistics given by Synoptic Stations in Tehran, the mean number of sunny days in 10 years is 210 days; hence, the output of photovoltaic system is taken as 60%. Finally, taking into account the annual depreciation costs, the initial capital which was spent for installing photovoltaic panels is returned in around 8 years. Since the useful life of photovoltaic system is around 20 years, there will be high saving in energy consumption and reasonable reduction in costs.

Table 3. Depreciation installation costs of photovoltaic panels-source author

YEAR	The cost of installing PV panels with 60% efficiency+40% of national electricity network costs (dollars)	Schools energy cost+ inflation 15% (IRR)	40% of the cost of electricity	Discount rate(20%)
1	360,000,000	82,892,419	9,806,497	432,000,000
2	358,914,078	95,326,282	11,277,472	430,696,894
3	346,648,083	114,391,538	12,969,092	415,977,700
4	314,555,254	137,269,846	14,914,456	377,466,305
5	255,110,915	164,723,815	17,151,625	306,133,098
6	158,560,908	197,668,578	19,724,368	190,273,089
7	12,328,879	237,202,294	22,683,023	14,794,655
8	-199,724,615	284,642,752	26,085,477	-239,669,538

In the above calculations, by considering the photovoltaic panels' installation costs, assuming that the system was not used, the figure has been calculated by considering this amount is deposited in the local bank with 20% investment interest rate. By taking 60% output of the panels and 40% use of the electricity offered by MTEPD in calculations, 40% of the fixed expenses is added to the amount of the deposit, the sum of which is deducted from fixed annual expenses. The above table has calculated the annual depreciation in this respect.

4- CONCLUSIONS

According to the results of studies on installing photovoltaic panels in passive educational complex, considering cheap price of energy carries rate in the country on one hand, and by using supports shown by the government in recent years on the other hand, since conventional heating and cooling systems are not used in the design school, just by benefitting from the geographic climate and proper designing, full benefit could be realized. Installing photovoltaic panels are highly economical with the possibility of capital return in 8 years and useful life of photovoltaic panels 20 years. Using this system in the schools across the country will be highly economical. Factors prevent the expansion of combined photovoltaic technology in Iran, including; insufficient available information, and lack of awareness of householders from the advantages of reproducible energies. Unfortunately no sufficient education has been provided to introduce these technologies and their advantages; and the intangibility of the importance and necessity to use this kind of energy by people is understandable and lack of enthusiasm seems natural in percent condition.

Overall, by designing and using photovoltaic panels in schools alongside active system which are used in this project, in addition to lowering environmental pollutions and less dependence to fossil fuels consumption, the Educational Complex can be considered as a model in encouraging and popularizing the use of new energies which benefits the society as a whole.

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