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APPLICATION AND ECONOMIC CONTRIBUTION OF THE SOLAR ENERGY SYSTEM IN AGRICULTURAL PLANTS: USING PVSYST SOFTWARE

ABSTRACT

In the developing world, the importance of energy is increasing every year. In the developing world, we will see that, our need for electrical energy will not only increase in industrial enlightenment and heating, but also will increase in the transportation sector. Developed countries give importance to renewable energy sources, which are environmentally friendly, in their energy production and consumption. Electricity production from solar energy, one of the renewable energy sources, has been a very important topic for engineers, architects and scientists. Turkey is located in a great geography in terms of sun ray. In this article, a feasibility study has been done about using the solar energy potential on a breeding farm with an empty roof by using PV simulation software. With this work, the efficiency of an agricultural production that even produces energy from its roof will increase. It will also help other users.

Keywords: Energy, Renewable Energy, Solar Energy, Agricultural Plants, PVSYST Software

1. INTRODUCTION

The population growth in our developing country causes the development of the industry. Since oil and natural gas resources are limited in our country, we supply our energy needs from other countries. With the introduction of electric vehicles into our lives, our energy need will increase even more. Fossil-based energy productions such as oil and coal damage the global climate. Because of this reason, developed countries prefer renewable energy sources. Our country is taking steps to increase the amount of renewable energy resources in total energy production. Photovoltaic (PV) panels are used to generate electrical energy from solar energy. They convert the sun ray waves that come on the panels into electrical energy. The main source of the solar energy system is the panels [1].

Photovoltaic systems are made in two types, dependent and independent to the grid. Grid-connected systems are directly connected to the electricity grid. This system generates electricity without need for transmission, distribution losses and batteries. In an independent system, the produced power is directly connected to the load. If the is no direct load the PV array, is connected to a storage device, ie a battery [2 and 3]. When the power supplied by the PV modules exceeds the load demand, the battery stores energy and releases it if PV supply is insufficient. This independent PV power production is used for electricity production at home [4]. Software's are used to calculate the efficiency of energy production with PV panels. Researchers have generally studied the energy that can be

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produced with the PVsyst software. Irwan et al. presented the independent photovoltaic (SAPV) system evaluation using PVsyst software for solar power generation. They calculated the estimated energy produced for the whole year with the PVsyst software [5].

For small houses in India, the performance and cost analysis of the system were evaluated by using PVsyst software. The effect of global radiation on solar energy production has been studied. It's said that, in May global irradiation was low due to the temperature on the PV module. In March, horizontal global irradiation was low, but using solar energy was found to be maximum compared to the other month [6]. Operating temperature decreases the performance of PV cell modules. Operating the solar photovoltaic at a lower temperature will prolong its life. Therefore, it can be increased by using coolers that prevent them from overheating. One of the best ways to cool the PV module is to use water as the cooling fluid [7].

This study was carried out to evaluate the scope of electricity demand and the economic feasibility of photovoltaic systems. Using the PVsyst software program, it is aimed to simulate the amount of energy produced by the system, amortization period and carbon release, which will be designed to meet the energy needs of an agricultural plants located in Elazığ with rooftop photovoltaic systems. The geographical location of the building was specified in the PVsyst software program and calculations were made.

2. RESEARCH SIGNIFICANCE

Due to their increasing dependence on imported fossil fuels in energy consumption, renewable energy sources have become a very important issue for the whole world. Demand for solar energy systems is increasing with the need for environmentally friendly energy. There is a general consensus in the international literature on the environmental impacts and cost of energy production. Although Turkey is among the richest regions in the world in terms of solar energy, investments in PV power plants are quite small and have been observed as a result of extensive literature studies. For this reason, how to design a roof type PV system using PV software, its contribution to the economy and depreciation period were investigated in this study. With this research, it aims to evaluate the investment cost for energy to be obtained from the roof of an agricultural enterprise and to offer the benefits that will occur with the implementation of a solar energy facility. At the same time, a lot of energy has been consumed in farms recently. Energy consumption is increasing rapidly in air conditioning, ventilation, lighting and supply systems in indoor areas. In this way, electricity generation of agricultural power plants will be provided, excess production will create material income and carbon emissions will be reduced. At the same time, as around the world, land use will be reduced by switching to an individual electricity generation system and using roofs in solar power plants that take up a lot of space. This study is intended to be useful for investors in the application of solar energy systems in both industrial areas and agricultural enterprises.

3. METHODOLOGY

Turkey is in a great location geographically in terms of solar radiation. As can also be seen on the figure 1, the amount of global radiation changes between 1400 and 2000kWh/m^2. This shows that every region of our country can take advantage from sun rays. Many projects that encourage solar energy systems in both agricultural and industrial fields are supported by our government. Thus, the electricity production system with solar energy, which is an

economical and environmentally friendly system, both meets the energy needs of the institution it is located and sells the surplus electricity generated to the distribution plant. With these supports, while the productivity of the agricultural production farm or industry increases, also environmentally friendly energy source is produced. The PVsyst program is a simulation program developed by the University of Geneva, Switzerland, used to design and study the results of photovoltaic systems, such as grid-connected or grid-independent PV systems, PV irrigation systems and DC networks. The PVsyst program provides more detailed calculations than other programs and evaluations using different parameters [9]. In solar energy system; the location of the PV panel, inclination, orientation, geographical coordinates, modules, parameters such as the quality of the inverter is influenced by the energy production. Panels were chosen as 400Wp monocrystalline. Monocrystalline Solar energy panel provides great energy in a small area and is the most efficient panel type. It can also work more efficiently in hot climates. Energy conversion is targeted with 3 units of 50kW inverters. It used PVsyst software (Perez Model) to estimate the solar radiation coming to the surface plane [10].

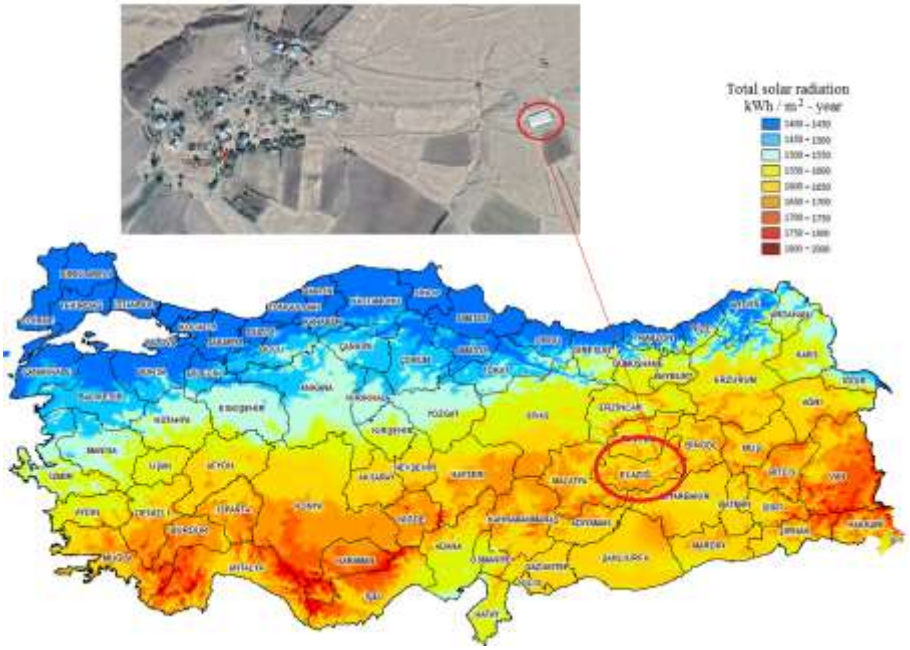

Figure 1. Turkey global horizontal irradiance [8]

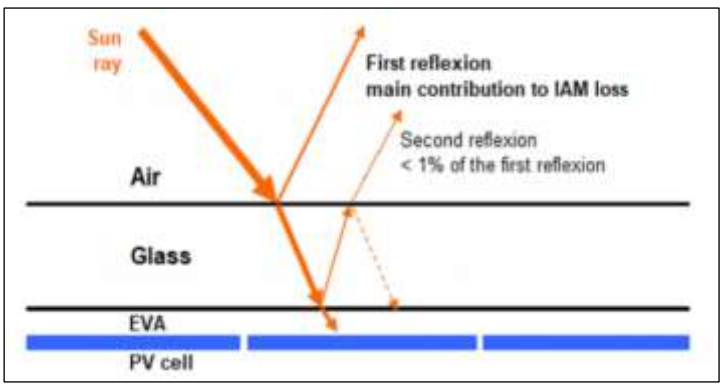

Figure 2. Array incidence loss

PVsyst uses an IAM function, which describes the deficit of transmission as a function of the incidence angle. It allows the calculation of the light effectively reaching the cell surface under the protective layer (usually glass) as a function of the angle of incidence of the sun's ray.

- **Study Area:** In this study, the town of Elazig in Turkey, which has been selected. Its location is at the coordinates of 38.79270°N longitude and 39.931186°E latitude. In this town, an assessment was made by applying solar energy to an existing breeding farm. The farm has a capacity of 50 cattle. The roof area where the Solar Energy System will be applied is 850m^2, the panel angle is taken as 100 due to the roof slope. The optimized inclination angle is 10° and the azimuth angle is 165°. The carrying capacity of the existing roof has been calculated. Static calculations were examined and it was found that the bearing capacity was suitable. After the aluminum laths are placed on the existing roof, the panels will be mounted on the laths. Power transmission line distance is 600 meters. Transmission line cost has also been calculated within the costs.
- **Structural design procedure for solar panel installation on the roof:** Solar panel roof static controls are started with on-site inspection and data collected in the existing building static project. In addition to the design loads of the building such as coating, snow, ice and wind loads defined in the regulations, the weights of the solar panel and mounting elements are also applied to the existing roof structure. The solar panel mounting structure type has been selected in accordance with the roof covering. This choice depends on the roof type and solar panel placement. As a result of the calculations, if the current capacity of the roof is sufficient for the mounting of the solar panel roof, a static compliance report is prepared. If there is a lack of capacity due to the addition of solar panels or any other reason, a preliminary project is prepared with retrofit proposals. Then, the retrofit details are prepared and added to the TEDAS Solar Roof Installation Static project. Strengthening works are examined at least once on site. The prepared project and static calculations are completed by first submitting to the authority authorized for the building license, then to the General Directorate of TEDAS or the provincial organization of the relevant distribution plant. The existing roof is examined by technical personnel and the drawings of the roof elements are produced. The areas where the solar panel will be installed are determined. Load carrying capacity is examined. Architectural and static projects of the existing building are provided.
- **Carbon emission:** Carbon emission refers to the release of carbon formed in nature into the atmosphere. Carbon emissions are mostly a result of human activities. The main reason for climate change is that the greenhouse gases (such as carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride) that accumulate in the atmosphere increase the temperature level of the earth. These gases released into the atmosphere cause the average temperature of the earth to increase. Today, the world is in serious danger due to climate change. We can summarize the main reasons for the increase in carbon emissions in recent years with the following items:
  - Uncontrolled industrialization
  - Constantly increasing energy demand

- Urbanization on the rise
- Declining forest areas
- Intensive livestock activities
- Uncontrolled greenhouse gas emissions

If we don't reduce carbon emissions, we could lose almost everything from our diet to the air we breathe. The severe drought in the central belt which Turkey is no show would be effective. Providing the energy of farms with panels is a very important investment to reduce carbon emissions. The amount of CO_2 can be determined with the Carbon Neutral Charitable Fund (CNCF) online calculation program. According to this program, 0.94kg of CO_2 gas is released into the atmosphere in order to obtain 1 kWh of electrical energy Considering this value, the annual prevented CO_2 amount with panels to be made on the farm is:

$$CO_{2(blocked)} = \left[\text{The total electricity generated annually } \left(kWh/year\right)\right] * \left[0{,}94\ \left(kg/kWh\right)\right] \quad (1)$$

Using Equation 1, the total amount of CO_2 blocked is calculated as 164.547kg [11].

4. RESULT AND DISCUSSION

Table 1 depicts the balances and main results of grid connected PV systems. Yearly global horizontal irradiation is 1542.8kWh/m^2. The yearly global incident energy on the collector plane is 1500.5kWh/m^2. The energy available at the output of the PV array is 178012 kWh. The energy injected into the grid is 175046kWh. The yearly average efficiency of the system is 11.46%. The average ambient temperature is 11.93°C.

Table 1. Simulation of the energy production plant

	GlobHor kWh/m^2	DiffHor kWh/m^2	T_Amb °C	GlobInc kWh/m^2	GlobEff kWh/m^2	EArray kWh	E_Grid kWh	PR
January	63.4	30.71	-3.31	59.5	57.9	7733	7619	0.99
February	78.2	35.57	-1.59	74.5	73.1	9640	9499	0.986
Marc	117.6	52.73	4.97	113.5	111.7	14173	13964	0.952
April	134.9	62.45	10.41	132	130.2	15987	15737	0.923
May	177.8	78.74	16.08	175.2	172.9	20579	20240	0.894
June	198.9	75.15	22.14	197.1	194.7	22540	22134	0.869
July	201.9	77.39	26.8	199.4	197.1	22455	22037	0.855
August	185	67.44	26.69	181.8	179.4	20544	20169	0.859
September	152.4	48.99	20.72	147.5	145.4	17122	16830	0.883
October	108.5	45.25	14.32	103.5	101.6	12535	12341	0.923
November	68.6	29.36	6.24	64.5	62.7	8045	7919	0.951
December	55.6	28.24	-0.3	52	50.3	6660	6557	0.976
Year	1542.8	632.02	11.93083	1500.5	1477	178012	175046	0.92175

The highest PR was recorded at 86.9% June and the lowest PR of 97.6% in December. The annual average PR is 90.3%. Figure 3 shows the production of vitality with month-to-month losses. Figure 3 graphically represents the performance ratio of event energy for the entire month of the year. The average performance ratio is 0.903.

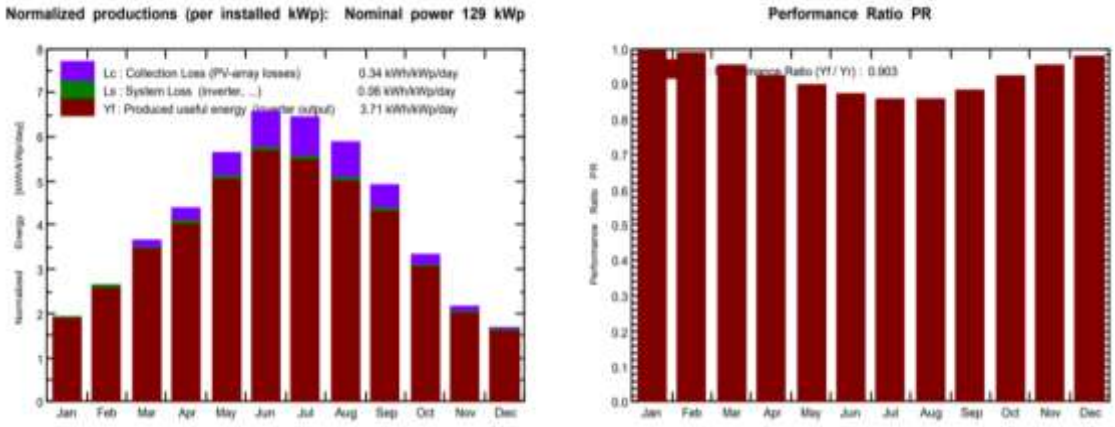

Figure 3. Simulation of the energy generation plant

Energy Transmission Line, solar power plants material labor and operating cost is calculated as 83675$. The annual return of the solar energy system is calculated as 18292.73$ in Table 1. A total of 175050kWh of energy is produced annually. Panel factories provide 25-year product warranty. It also predicts that there will be one percent energy loss each year. When the annual return of the facility is divided by the cost, it provides a financial return of the solar power plant in 4.6 years. From here, it seems that there is a type of investment that returns very quickly. Currently, Turkey also supports state agricultural plants by 50 percent and guarantees to buy the energy they produce. Thus, the plant's amortization period is reduced by half. By supporting agricultural plants, energy costs are reduced and they also have the chance to increase their production capacity.

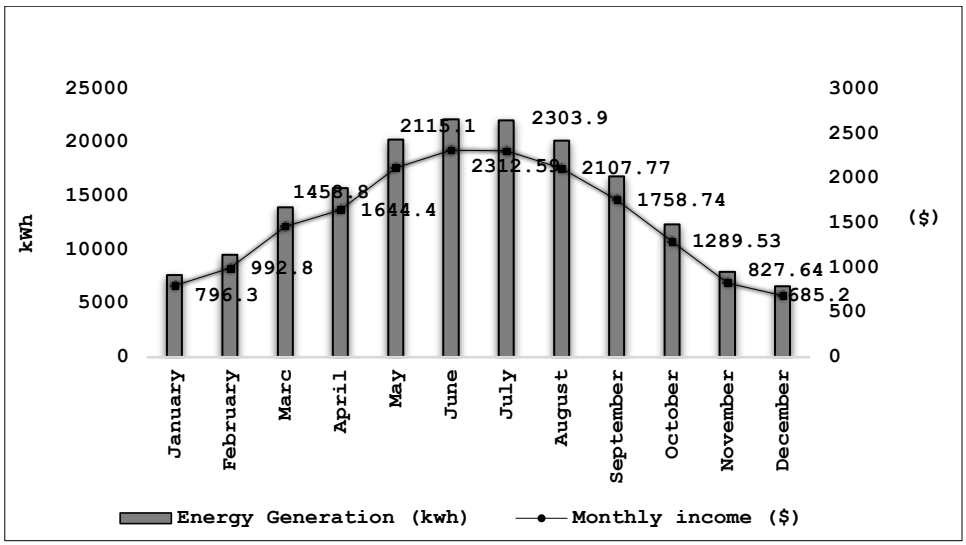

Figure 4. Monthly energy production and monthly income

5. CONCLUSION

In this study, the solar energy potential of the city of Elazig, which is located in the regions of Turkey with high solar energy potential, was investigated. The study investigated how solar energy would affect the city's economy and carbon emissions. Although Turkey is among the richest regions in the world in terms of solar energy, investments in PV power plants are quite small it has been observed as a result of extensive literature studies. For this reason, in this

study, how to design a roof type PV system using PV software, its contribution to the economy and depreciation time were investigated. For this study, an analysis and design study was conducted for the production of electrical energy with a planned PV solar energy system on the roof of an agricultural farm. In this way, electricity generation of the agricultural plants will be provided, surplus production will generate financial income and carbon emissions will be reduced. At the same time, as around the world, land use will be reduced by switching to an individual electricity generation system and using roofs in solar power plants that take up a lot of space. It is intended to be a work that will be useful for different applications based on this work according to different roofing and conditions. As a result of this study;

- By entering data with the PVsyts program, the solar energy system to be applied on the roof is modeled and simulated.
- When the analysis data of the program is examined, the system will produce 1.601.070 kWh of energy for 10 years. Approximately 1.645.470 kg of carbon emissions will be reduced.
- The amortization period of the system has been calculated as 4.6 years.
- When the amortization period is evaluated, the return of the investment is short.
- Feasibility has been made regarding the applicability of the solar energy system on an existing roof. I believe that solar power plants will contribute to roof applications and will be an environmentally friendly investment.

CONFLICT OF INTEREST

The authors declared no conflict of interest.

FINANCIAL DISCLOSURE

The authors declare that this study has received no financial support.

DECLARATION OF ETHICAL STANDARDS

The authors of this article declare that the materials and methods used in this study do not require ethical committee permission and/or legal-special permission.

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