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Original Research Article

A Research On the Meet of Energy Needs in Broiler Plant with Solar Panels

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ABSTRACT

One of the biggest problems of today's enterprises is the high-value electricity costs. In order to solve this problem, solutions should be developed based on solar energy projects. Moreover, by selling after the self-consumption to the grid can be obtained more profit. This study includes the investigation of the rooftop of broiler plant with solar energy system. As a result, the total energy consumption of the plant was calculated as 46782 kWhyear^{-1}. To cover the consumption, 508 pieces (250 Watt) polycrystalline solar panels were used. The panels can be generate a total energy of 161536 kWhyear^{-1}. It is foreseen that a total energy of 114754 kWhyear^{-1} can be supply to the grid and 15264 \$year^{-1} income can be obtain. The payback period of the system was found 5.9 years.

Keywords: Solar energy, Poultry plant, Energy requirement, Energy cost

INTRODUCTION

The demand for energy is increasing rapidlyin developing countries. After the adverse effects on the environment of non-renewable energy, a change towards cleaner energy is begun.The most efficient energy providing method from renewable energy sources is the sun. (Husain et al., 2018). Photovoltaic technology is a solar energy application to producethe current and voltage (Hasan and Parida, 2016). Ithasstarted to show development in the 1950's and became more common by increasing efficiency (Ghaith et al., 2017). It is stated that solar energy system will be 345 GW in 2020 and 1081 GW in 2030 (Tyagi et al., 2013). With the decreasing of panel prices, it becomes low-cost to generate electricity and revives the energy market (Pillai and McLaughlin 2013).

The widely area of solar energy in Turkey is to provide hot water with solar collectors (Varınca and Gönüllü, 2006). In addition, to heating or cooling in greenhouses with active and passive systems (Kendirli and Çakmak, 2010), photovoltaic powered micro (drip) irrigation system (Atay et al., 2013), to dry the wet foods under the sun (Bayrakçı and Koçar, 2012) and water pumping systems for small-scale agricultural irrigation (Atmaca et al., 2014) were used as well.

Chicken coops are the most intensive use of energy in animal shelters. The applications for lighting, ventilation, heating, cooling, egg collection, fertilizer cleaning are needed (Bayraktar et al., 2015). In an evaluation made by considering the direct and indirect use of energy used in production, the efficiency was determined as 15% (MacKay, 2009). In order to increase this efficiency and to save electricity at every stage of production, solar energy usage in broiler plant is an effective alternative.

Within the scope of this study, the electricity consumption of the cooling system in the summer months, heating system in the summer and winter and the sale to the grid were considered and the broiler plant with the capacity of 35000 were investigated.

MATERIALS AND METHODS

In this study, a plant located in the Akçaova VillageofManyas - Balıkesir 40°7'21", 27°51'58" were choosen (Figure 2). The length andwidth of the plantare 126 and 8.25 m, respectively. The area is 1039.5 m^2 (Figure 1).

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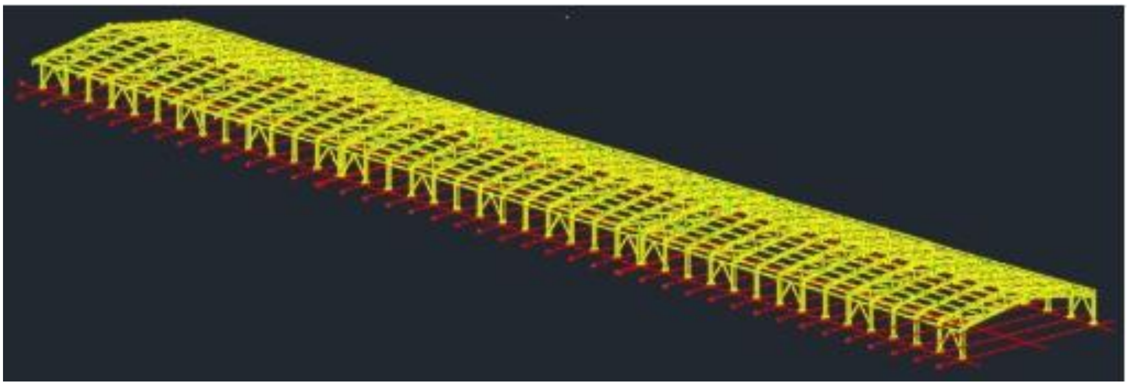

Figure 1. Roof Area of Plant.

Figure 2. Top View of the Plant.

To know the electrical information of the plant and the amount of energy consumption during daily activities (Table 1 and 2) are necessary to design solar energy systems. According to the roof area, the theoretical power and panel installation are determine (Table 3 and 4). Also, the global radiation values and sunshine duration in the region needs be taken into consideration (Jamil and Bellos, 2019).

Table 1. Electricity Consuming Equipment in the Enterprise.

Electrical Equipment	Quantity	Unit	Unit Power (kW)
Fan	14	Piece	1.1
Feed Motor	8	Piece	1.1
Pad Cover Motors	1	Piece	1
Buffle Cover Motors	1	Piece	1
Stove Air Fan	1	Piece	7.5
Fluorescent	35	Piece	0.0580
Led Lamp	100	Metre	0.001
Submersible Pump	1	Piece	2.2
Water Pump Pump	1	Piece	4
Stove Fan Motor	2	Piece	0.37
Water Stroke Engine	2	Piece	0.55
Lodgings	1	Piece	5

Table 2. Daily Energy Consumption by Business.

Electrical Equipment	Power (kW)	Piece	Daily Working Time (h)
Fluorescent	0.058	35	20
Feed Motor	1.1	8	2.4
Water Installation Engine	0.55	2	8
Electric Motor of the Fans	1.1	5	24

Table 3. Solar Panel Features.

Type	Polycrystalline
Dimensions	1640 × 992 × 40 mm
Power Output Range	250-275 Watt
Module Efficiency	15.4 – 16.9%
Working Temperature Range	-40 °C – 85 °C

Table 4. Inverter Information.

Max. DC Power	51.000 W
Max. Low Voltage	1.000 V
Rated (Output) Power	50.000 W
Max. Output Current / Rated Output Current	72.5 A / 72.5 A
AC Voltage Range	180 V – 280 V
Max. Yield	98.0%
Dimensions	621 × 733 × 569 mm
Weight	82 kg
Operating Temperature Range	-25 °C – 60 °C

Manyas solar energy potential, global radiation values and sunshine duration are shown in Figure 3, 4 and 5, respectively.

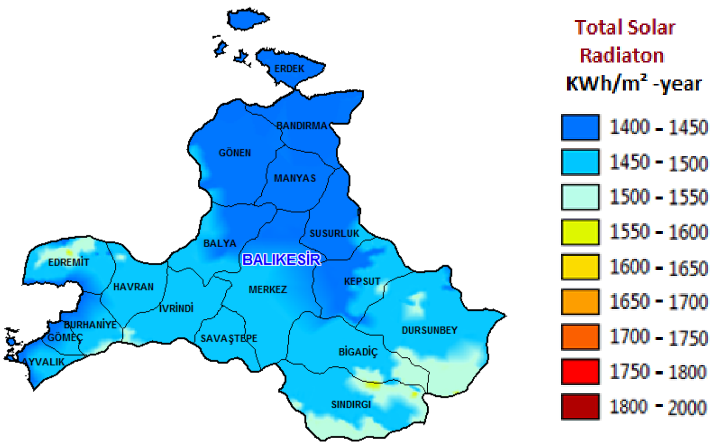

Figure 3. Solar Energy Potential of Balıkesir (YEGM, 2018).

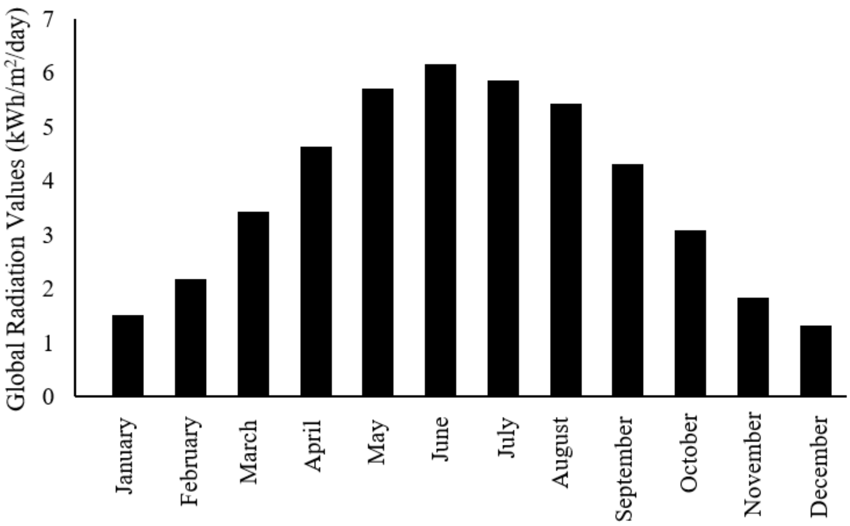

Figure 4. Manyas Global Radiation Values ($kWhm^{-2}day^{-1}$) (YEGM, 2018).

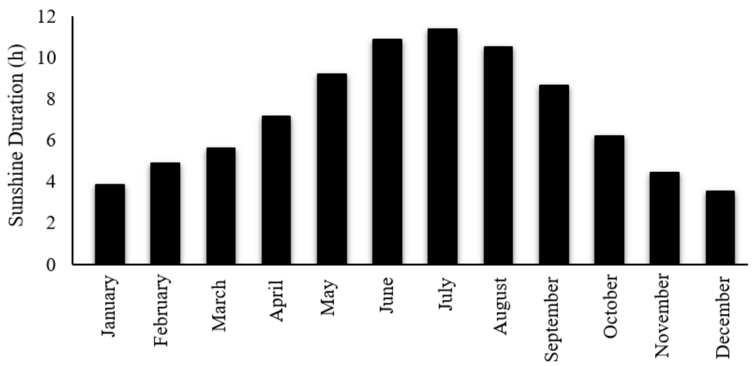

Figure 5. Manyas Sunshine Duration (h) (YEGM, 2018).

The following formulas were used to calculations:

To determine the amount of energy production from solar panels:

$E_{sp} = I \times A \times t \times \eta$ (1)

To determine the energy consumed by the plant:

$T_e = S_{ect} \times 7 \times 4$ (2)

To determine the surplus energy:

$F_e = E_{sp} - T_e$ (3)

To determine the operating energy cost before the panel installation:

$M_p = T_e \times O_t$ (4)

To determine the revenue generated by the sale of surplus energy to the grid:

$G_{fe} = (E_{sp} – T_e) \text{ x } F_{ren}$ (5)

To determine the payback period of investment:

$Y_{gd}= M_{tot} /G_t$ (6)

RESULT AND DISCUSSION

The consumption of the electrical loads running simultaneously in the operation was calculated as 202.5 $kWhday^{-1}$. As a result of the required weekly and monthly calculations, the amount of energy consumed by the enterprise is calculated as 46782 kWhyear^{-1}. As a chick, animals coming to the henhouse go to the slaughterhouse as broiler chick after 6 weeks. It also includes a 3 week period for chickens to go, cleaning of the facility and the arrival of new chicks. In this 3 week period, the consumption of electricity is negligible.

The energy cost of the plant has been as 5080 \$year^{-1} from formulating the monthly energy amounts consumed by the plant with the average of day and night. The final tariff table prepared by the energy market regulation board.

A total of 508 polycrystalline solar panels are placed on the roof and the total capacity was found 127 kW. The theoretical power produced by the solar panels was calculated as 161536 kWhyear^{-1} (Fig. 6). Similarly, Imteaz and Ahsan (2018) were studied on a 2 kW and 5 kW systems. They found the energy demand for 4 people of the family that the energy of the 2 kW system they produce is 19-29%, while it is 49-73% for 5 kW (Fig. 7).

The cost of the polycrystalline panels (508), inverters (10), construction, wires, protection equipment, transformer, other and VAT were $ 127000. In a study conducted by Dagtekin (2012), the cost of a 15 kW PV system was found $ 10316.

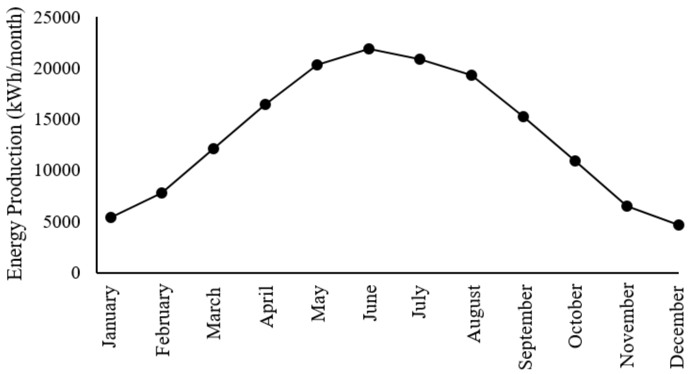

Figure 6. Energy Production (kWhmonth^{-1})

Figure 7. Total energy generated from panels

The surplus energy amount was found as 114754 kWhyear^{-1}. The revenue generated from the PV system is 21484 \$year^{-1}. The revenue from the surplus energy is 1526 \$year^{-1}. Monthly surplus energy amount formulated as a result of the 13.3 ¢kWh^{-1} which will be applied for the production plant based on the solar energy plant. (Büyükzeren, 2015). The electricity production cost is determined as 0.0314 \$kWh^{-1}. In a study conducted by Dagtekin (2012), the cost of energy production is similarly 0.0208 \$kWh^{-1} (Fig. 8 and 9).

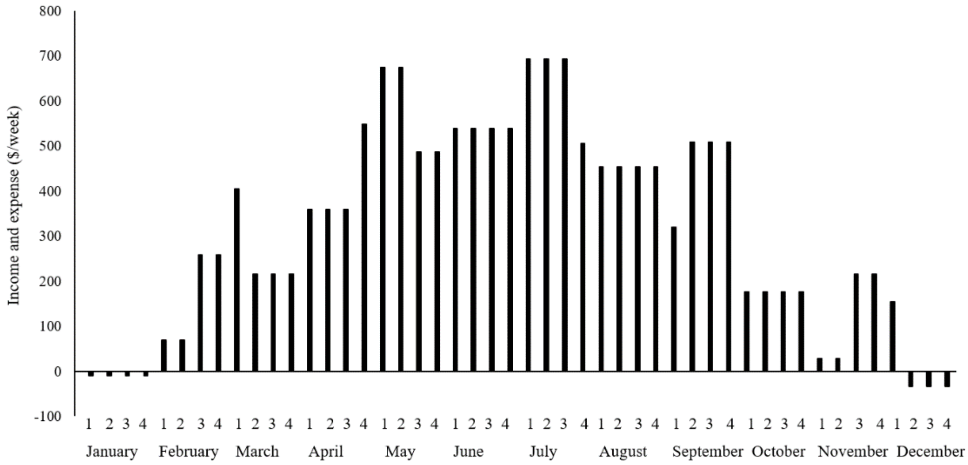

Figure 8. Income and expense of plant ($).

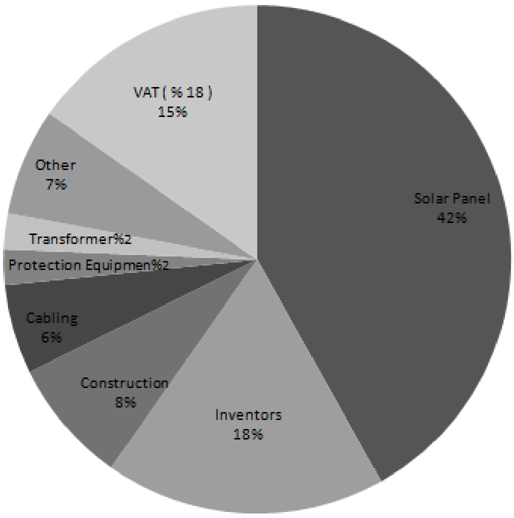

Figure 9. Share of Total Cost of Solar Energy System

The economic life of the PV system is 25 years (Biçen, 2018). The payback period of the investment was calculated as 5.9 years. Dağtekin (2012), the electricity requirement of the evaporative cooling (fan-pad) system of poultry with a capacity of 20000 broilers was met by the electricity produced by photovoltaic method. Electricity generation was found 22935 kWh and the repayment period was 9.2 years. Flannery and Sahajwalla (2013) determined that the total cost of establishing a solar panel system with an average lifespan of 20 years on average in Australia and payback periode was 7 years. However, this payback period is belong to arrangement ofpanels and physical position, etc. Similarly, Singh and Banerjee (2016) have calculated the payback period of 13 years in their study in Mumbai.

CONCLUSIONS

In this study, the electricity consumption of the cooling and heating systems were aimed to be met by PV panels. For this purpose, 161536 kWhyear^{-1} electricity can be produced. The energy obtained from the PV system reaches the highest value in June, while the lowest value in December. The net payback period of the PV electricity generation system is 5.9 years and the electricity production cost is determined as 0.0314 \$kWh^{-1}. Since the economic life of the system is 25 years, the remaining 19.1 years will be net profit.

Abbreviations and Symbols	
E_{sp}	Energy to be collected by a solar panel with flat surface (kWh)
I	Solar radiation intensity to the collector (kW/m^2)
A	Surface area of the collector (m^2)
t	Sunshine duration (h)
η	Electrical efficiency of solar panel
T_e	Energy consumption (kWh)
S_{ect}	Energy consumed according to concurrency (kWh)
F_e	Production surplus energy (kWh)
M_p	Cost of operating energy before panels ($)
O_t	Energy market regulatory board average of day and night tariffs for commercial houses from 1st quarter final tariff table ($)
G_{fe}	Income generated by the sale of surplus energy to the grid ($)
F_{ren}	5346 number of renewable energy resources for the purpose of generating electricity for the purpose of electricity generation 1 number of solar energy based production facility for the price to be applied (13.3 ¢kWh^{-1})
Y_{gd}	Return on investment (year)
M_{tot}	Total cost ($)
G_t	Annual total revenue ($)

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