Clean energy from renewable energy sources, Solar energy for a clean environment and A Case Study: Kars Harakani Airport Solar Power Plant for Kars province

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Research Article

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Clean energy from renewable energy sources, Solar energy for a clean environment and A Case Study: Kars Harakani Airport Solar Power Plant for Kars province

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Abstract: In this study, the total installation cost was calculated with the selection of solar panels (PV) to be used, Control Monitoring System, number of inverters when applying solar energy from renewable energy sources to Kars Airport in order to obtain a clean environment and clean energy. According to the latest two-year data obtained with the permission of the institution from Kars Harakani Airport Electricity Distribution, the total electricity consumption was calculated by the amount of electricity produced by the SPP project. In the continuation, the cost analysis tables are given when there is an overdraft and non-credit installation with the amortization time required for installation. For installation, statistical data on annual hours of sunshine and rainy days were taken from the General Directorate of Meteorology of Kars province. As a result of calculations; since the service life of a SPP project is 25 years; when the entire project is made without credit,the installation cost of TL 19,917,859.75 ($2.706.157,41) pays off in 4.5 years and the remaining amount of electricity sales earned in 20.5 years is 547,535,115. 02 TL ($74,391,336. 52) . It was found that when the entire loan was established, it paid off in 8 years. From these calculations, if the airport uses an overdraft system, it will pay off in about 8 years and the system will generate and sell its own electricity for 17 years . It was calculated that it would have a profit of 495.177.856,89 TL ($67,277,771. 92). For the non-credit SPP project,it was found that it will provide an added value of 547.535.115, 02 TL ($74,391,336. 52) to the institution, where it can pay off in 4.5 years and produce and sell its own electricity for 20.5 years.

Keywords: Renewable Energy, Solar Energy, Solar Power Plant Project, Cost Analysis, Installation and PV Panel Selection, Inverters, Eastern Anatolia Region of TURKEY Solar Energy Potential.

HIGHLIGHTS:

- Solar energy potential in Turkey and the use of renewable energy sources in Eastern provinces
- Examination of SPP samples in different geographical conditions and places and numerical calculations for airport installation
- Evaluating numerical results with annual electricity consumption data and conducting optimal cost analysis

1 INTRODUCTION

Solar energy is used in agriculture, industry, electrical plants, buildings, factories. The raw material of solar energy is cheap and is a clean source of renewable energy. Because of the damage caused to people and the environment by fossil fuels, more demand for solar energy from renewable energy sources has increased. Considering the application areas of solar energy, buildings heated by the sun can be listed as generating electricity from solar energy, meeting the energy needs of buildings and factories from solar energy [1]. A study conducted in Konya mentioned the potential of solar energy in Konya and mentioned a sample project aimed at increasing the use of solar energy in buildings [2]. Among renewable energy sources, one of the cleanest and most economical is undoubtedly solar energy. Photovoltaic batteries are used to obtain electricity from solar energy. Photovoltaic means converting solar energy into electrical energy as a word. Photo; means light, voltaic; voltage means electrical volt. It was formed from the fusion of the two words. Photovoltaic semi-conductor batteries (PV) convert solar panels directly into electrical energy [3]. Currently, solar energy systems are used in many developing countries and Turkey. Solar cell systems are used to supply of electricity needs, especially in rural areas [4]. In terms of solar energy in Van province, taking into account global radiation values, clean environment-sensitive SPP were tried to be tested [5-7]. A medium-sized Marina was selected in the Mediterranean region and an analysis was made of the electricity consumption of this place by using solar energy. In this study, it is observed that the estimated electricity generation (kwh) with a slope of 31.7° from the total solar energy for 12 months meets the Marina consumption by taking monthly averages. In addition, a marina was selected in the Fethiye district of Muğla province, where a significant 8.7% of Turkey's yachts are located, so solar energy systems at the Marina have not previously been used in electricity production, which they use for water heating purposes [8]. Electricity generation based on solar energy has become quite popular in recent years. Germany has 44% of solar photovoltaic installed power worldwide. (17,336 W), Germany is followed by Spain (3.86 W), Japan (3.66 W) and Italy (3.56 W) [9].

In a study conducted in Uşak, Aegean Region, the SPP sample was given with detailed SWOT analysis and investment, cost and economic results. In the example of Uşak, which is a real estate development study, 3

different regions were selected as alternative places for the SPP project. As a result of the feasibility studies, 24100 m2 solar power plant installation was designed in the Central Village of Derbent, located 36 km from Uşak province, and it was calculated that it would pay off itself in about 10 years and that this system, which has a life of 25 years, would profit for 15 years [10].

Solar energy power systems are the most powerful source among renewable energy systems. The most important reason for this is that solar energy is unlimited and clean energy. In his study, Dinçer compared fossil fuels such as coal, gas, electricity between 1999 and 2006 in kwh/ euro and examined pv module production quantities between 1990 and 2006 [11]. One of the most commonly used energies today is electricity. Electricity is an indispensable requirement of our lives. It is used to obtain light to warm up. Heat and light are not a form of energy, but are essential for the sustainability of human life. But day by day, electricity sales prices are increasing. This scope also makes sense and is necessary in the coming years to obtain electricity from renewable energy sources. Electricity generation from solar energy is achieved with the help of photovoltaic panels. China is the leader in PV panel production [12-14]. Buyukzeren et al., SPP Konya Meram Medical Faculty identified the potential of the building, photovoltaic system design, whether in regard to the amount of monthly and annual energy production and financial cost analysis for greenhouse gas emissions for 40 years to pay back the equity aided the PV system, PV system have found that greenhouse gas emissions unassisted approximately 42 years. They also reported that, unlike European countries, Turkey does not support greenhouse gas emissions [15]. In another feasibility report, a report was prepared on R & D activities in the Eastern Anatolia region for potential power generation and aimed to use these potential promised energy sources in Igdir effectively. Structural suitability of Igdir province for FV solar energy, electrical infrastructure, land suitability, environmental impacts, incentives, support and financial analysis were conducted [6]. Kars Harakani Airport is a civil airport located in Kars. Opened in 1988, the airport has a runway and a 35,946 m2 terminal building and VIP lounge for passengers. The airport was closed to flights during the spring and summer seasons due to renovations in 2007 and opened to flights again in October. As the airport's passenger capacity increased, a new and larger airport was needed. The current airport, which started in 2012, was opened in 2013. The capacity of the new terminal is between 2.5 - 3 million and is the largest terminal building in the Eastern Anatolia region. Kars Airport is of great importance for cities in northeast Turkey. Passengers arriving at the airport not only travel from Kars and its districts, but also to the cities of Ağrı, Ardahan and Artvin. Its runway is 3500x45 meters. There is a 35,946 m2 terminal for passengers (Kars Harakani Airport). Jed et al. looked at performance analyses for an SPP (Solar Power Plant) project in Mauritania with an installed power of 954,809 kWp. They looked at monthly and annual panel and System yields. December, August, 0.61% of the monthly performance rate, and December, 0.71% of the average monthly 0.66% of The showed that the study showed. January and October (20.54%) and January (11.66%) reached the maximum and minimum, respectively, the average monthly capacity factor [16]. The social life and technology that people build for themselves depends heavily on energy consumption. However, the world's energy resources have been depleted for a long time, and if we want to develop a sustainable human society, we have to face energy resource problems and find solutions. If we continue to use fossil fuels at the current rate, 21. It will be completely exhausted in a century. Because of the first law of thermodynamics (energy conversion) and the second law (entropy increase), the activity of our civilization will be disrupted as a result of massive energy consumption in a closed system. The use of solar energy as an alternative to traditional fossil fuel-based resources has increased tremendously over the years due to its environmentally harmless nature. However, PV technology still shows rapid development in an effort to achieve high efficiency and reduce cost [17]. Renewable energy sources are more preferable than fossil sources, because they are usually free and have no environmental impact, such as environmental pollution, pollution, a study conducted in Kuwait in 2020 tested SPP projects for different regions. They have reported the importance of clean energy in the Gulf countries, especially for the Gulf regions, to develop their domestic economies and to provide an energy portfolio. Their study identified potential areas for solar power plants in Kuwait [18].

Solar energy systems are installed in many airports such as Cochin airport (India), Chicago Rockford Airport (USA), Fresno Yosemite Airport (USA), Indianapolis Airport (USA), Adelaide airport (Australia), Kuala Lumpur Airport (Malaysia), Mumbai airport (India), Moi airport (Kenya) etc [19-21]. An optimization model was also created for the Macedonian airport, for heating, cooling and optimal conditions of use were investigated [22].

In their work in 2016 - 2017, Sukumaran et al investigated the energy needs of Raja Bohar airport from solar energy.They calculated that 2733.122 MWh of electrical energy was sufficient [23]. Kichou et al. (2019) aimed to save energy for a combined system together with solar energy and heat power batteries. between May April 2016 and April 2017, energy design was achieved by reducing the energy from 140 kw to 120 kw for energy management. Self-generating buildings have been designed and have achieved an energy saving of 30% and a saving of 4000 euros each year [24].

SW TECH Energy has completed the installation and pre-acceptance of Solar Power Plant with a power of 2,530 kWp in Selim District of Kars province [25].

Fig 1. Solar Power Plant with a power of 2,530 kWp in Selim District of Kars province (access link: https://cw-enerji.com/kars-selim-ilcesine-2-530-kwp-arazi-uzeri-ges/ 09.03.2021).

In this study, cost and economic depreciation analysis were performed for the SPP project selected PV module installation for Kars Harakani Airport. Kars Harakani Airport is 6 km from Kars center and 11 minutes from Kars Center. Although the Eastern Anatolia Region is a cold climate region, especially compared to many regions of Turkey, it has more sunny days and therefore more sunshining time when Meterology data is examined. As a location, there is a favorable rural area for implementing the SPP project.

Fig 2. Google Maps distance between Kars city center and airport (Google maps Maps access link: https://www.google.com/maps/d/u/0/viewer?msa=0&hl=tr&ie=UTF8&t=m&ll=40.582022344857876%2C43.11250392263456&spn=0.00896%2C0.016072&z=12&iwloc=0004bcd5cd4f0f35a83b1&source=embed&mid=1RcoV11PKi-cQGhvqqqEKrvoJ-Ok 09.03.2021).

Fig 3. Kars Harakani Airport (TC Ministry of Transport and Infrastructure General Directorate of State Airports Authority, Kars Harakani Airport, access link: https://www.dhmi.gov.tr/Sayfalar/EN/DefaultEN.aspx 09.03.2021).

There are quite a lot of rural areas around Kars airport. In addition,looking at sun shining times, Kars province receives more sun than many western cities with an average sunshining time of 77.1 per year, which allows the panels to work longer and be used in electricity generation. From the General Directorate of Meterology, installation calculations were started according to the calculations by looking at the annual and monthly amount and duration of sunshining.

Nomenclature

$E_{COC,\,2019}$	Average cost of 1 kwh in 2019
$E_{COC,\,2020}$	Average cost of 1 kwh in 2020
$A_{A,T,C}$	Average annual total consumption kwh
$T_{T,O,C,2019}$	Total consumption based on tl in 2019
$T_{T,O,C,2020}$	Total consumption based on tl in 2020
$P_{T,C,2019}$	Total energy consumption based on kwh in 2019
$P_{T,C,2020}$	Total energy consumption based on kwh in 2020
P_p	Power of a PV panel (kW)
η_P	PV panel efficiency
$t_{shining}$	Time of daily sunshining PV (h)
$t_{m,shining}$	Monthly time of sunshining PV (h)
$\eta_{p,m}$	Monthly PV panel efficiency
N_{pv}	Number of PV panel
$P_{g,f,PV}$	Generated energy from PV panels (kW)
N_M	Number of days per month
A_R	Required panel area (m^2)
PV_D	PV module dimensions (mxm)

2 MATHEMATICAL AND FINANCIAL MODEL

Kars airport electricity consumption was discussed with Kars airport Directorate and electricity consumption and bills were taken for the last two years by obtaining the necessary permits.

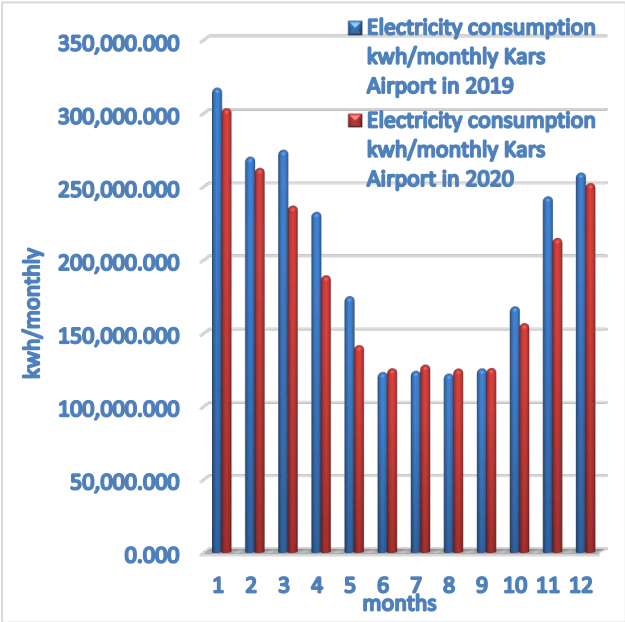

Fig 4. Kars airport monthly electricity consumption in kwh between 2019 and 2020.

Considering that Kars and the surrounding provinces are favorable for winter tourism, we can say why consumption increases in winter. Most consumption was observed in January in 2019 and 2020. It has been decided that the SPP project to be designed for this will be designed to meet these months. June July August between 2019 and 2020 were the least consumed, and winter months were the most consumed.

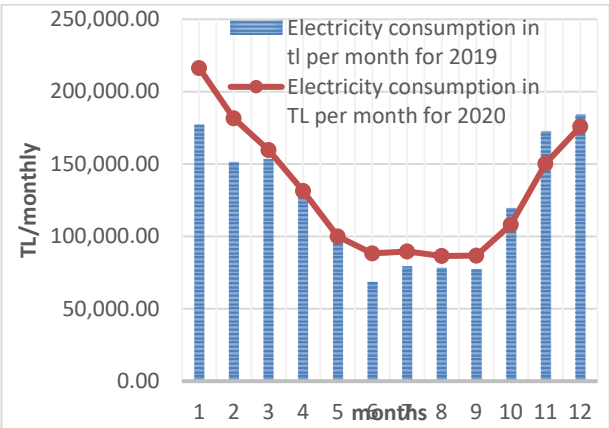

Fig 5. Kars airport monthly electricity consumption in TL (Turkish Liras) between 2019 and 2020.

FINANCIAL MODEL

By calculating the average annual total consumption and electricity increase rates, the rate of increase coming to electricity on a year-by-year basis was also calculated and the average consumption was calculated.

$$E_{COC,2019} = \frac{T_{To.c.2019}}{P_{T,C\ 2019}} \quad (1)$$

$$E_{COC,2019} = \frac{1.488.205,32}{2.430.108,840} = 0,6124 \text{ TL/kwh } (0,0832^{1}\ \$/kwh)(Excluding\ VAT)$$

$$E_{COC,2020} = \frac{T_{To.c.2020}}{P_{T,C\ 2020}} \quad (2)$$

$$E_{COC,2020} = \frac{1.574.260,95}{2.257.274,880} = 0,6974 \frac{TL}{kwh}\ (0,0947\$ /kwh)(Excluding\ VAT)(Excluding\ VAT)$$

Average annual total consumption calculated based on last 2 years;

$$A_{A,T,C,} = \frac{P_{T.c.2019} + P_{T.c.2020}}{2} \quad (3)$$

$$A_{A,T,C,} = 2.343.691,860 \text{ kwh}$$

Annual electricity increase rate calculated based on last 2 years;

$$A_{E,I,O} = \frac{(E_{coc,2020} - E_{coc,2019})}{E_{coc,2019}} \quad (4)$$

$A_{E,I,O}$= (0,6974 - 0,6124) / 0,6124 = %13,88

Considering the life of the solar power plant energy system as 25 years, the 25-year consumption cost table, which was prepared by taking into account the electricity consumption and increase rate during this time; the cost of 1 kwh in the last consumption year in 2020; 0.6974 TL (0,0947 $),[1] 04.01.2021 exchange rate day based; 1$=7,3602 TL (selected 4th January for exchange rate day based; because 1-2-3 January: New Year Holiday in 2021 in Turkey). The amount of electricity consumed for 25 years, was calculated. The goal here is how much money is spent on electrical energy at the end of 25 years. The aim of the project is to provide the cost consumed and spent here from solar energy and to sell the excess energy gained to the state. In total, when looking at the amount of electricity consumption made by the end of 2021 to 2045 ; 1kWh unit of electricity consumption is projected to be 17,975 TL under Turkish conditions when looking at the rate of increase made at the end of 25 years.

Tablo 1. Analysis of The Consumption Cost of Kars Airport For The Next 25 Years

	$A_{A,T,C,}$	Cost of 1kwh	Total Cost
1. Year	2.343.691,860	0,7942Tl	1.861.358,01TL
2. Year	2.343.691,860	0,9044TL	2.119.714,50 TL
3. Year	2.343.691,860	1,0300TL	2.413.930,88 TL
4. Year	2.343.691,860	1,1729TL	2.748.984,48 TL
5. Year	2.343.691,860	1,3357TL	3.130.543,53 TL
6. Year	2.343.691,860	1,5211TL	3.565.062,97 TL
7. Year	2.343.691,860	1,7323 TL	4.059.893,71 TL
8. Year	2.343.691,860	1,9727 TL	4.623.406,96 TL
9. Year	2.343.691,860	2,2465 TL	5.265.135,85 TL

10. Year	2.343.691,860	2,5583 TL	5.995.936,70 TL
11. Year	2.343.691,860	2,9134 TL	6.828.172,72 TL
12. Year	2.343.691,860	3,3178 TL	7.775.923,09 TL
13. Year	2.343.691,860	3,7783 TL	8.855.221,21 TL
14. Year	2.343.691,860	4,3028 TL	10.084.325,92 TL
15. Year	2.343.691,860	4,9000 TL	11.484.030,36 TL
16. Year	2.343.691,860	5,5801 TL	13.078.013,77 TL
17. Year	2.343.691,860	6,3546 TL	14.893.242,08 TL
18. Year	2.343.691,860	7,2366 TL	16.960.424,08 TL
19. Year	2.343.691,860	8,2411 TL	19.314.530,94 TL
20. Year	2.343.691,860	9,3849 TL	21.995.387,84 TL
21. Year	2.343.691,860	10,6876 TL	25.048.347,67 TL
22. Year	2.343.691,860	12,1710 TL	28.525.058,33 TL
23. Year	2.343.691,860	13,8603 TL	32.484.336,42 TL
24. Year	2.343.691,860	15,7841 TL	36.993.162,32 TL
25. Year	2.343.691,860	17,9750 TL	42.127.813,25 TL

For The Next 25-Years Total Electricity Consumption Cost of Kars Airport : 332.231.957,61TL
45.138.985,03 $

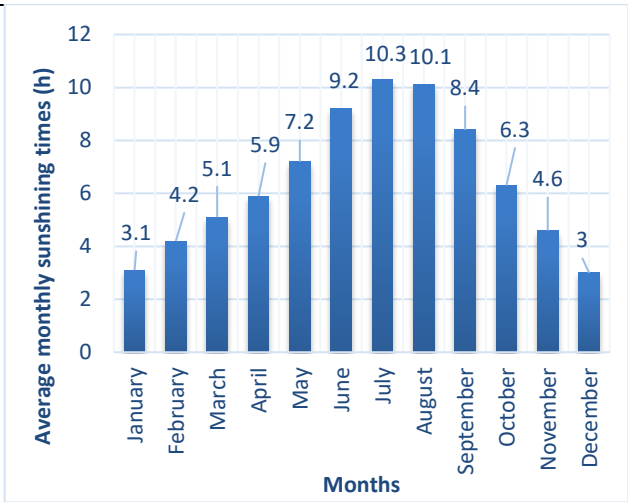

Fig 7. Average monthly sunshining times values in Kars province

After finding these for the next 25-year electricity consumption amounts, project feasibility calculations were calculated by selecting equipment such as photovoltaic panels (PV), inverters, other power storage elements, wiring and electrical panels for the solar power plant by taking sunbathing times according to the data obtained from Meteorology for Kars province.

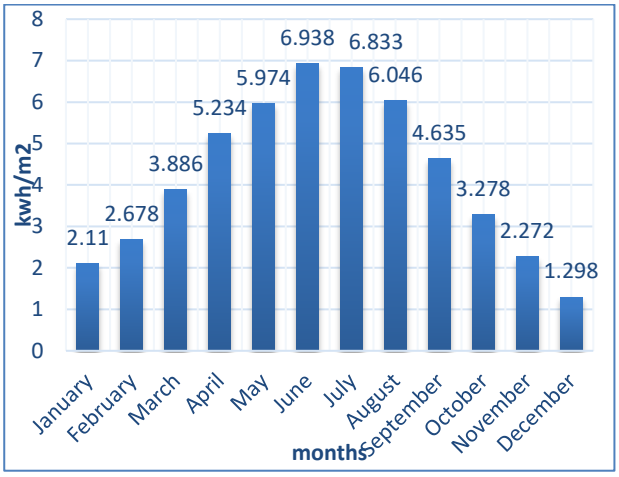

Fig 6. Average monthly global radiation values in Kars province (Turkey global solar radiation average for many years (2004-2018) Heliosat Model products, MGM (2021) access link: https://www.mgm.gov.tr/eng/forecast-cities.aspx. 09.03.2021)

MATHEMATICAL MODEL

Based on the total two-year electricity consumption for Kars Airport,it is calculated that an SPP project with a power of 340,000, 000 kwh will cover the electricity of this place, as well as much more in the summer and in other months, a large amount of electricity produced by solar photovoltaic panels will be sold to the Electricity Distribution Company. For this reason, it was concluded that there should be conversion from renewable energy sources to solar energy, as well as studies to reduce the installation costs of photovoltaic panels and other electrical equipment used. According to calculations made by taking the average of the winter months with the highest consumption of total energy consumption 340,000,000 kwh, we can provide this energy required for the airport by using 9327 units of mono PERC Crystal PV panels with 400 watts of energy production. In addition, an on grid system was designed to sell more of the energy obtained to the state. It has been calculated that 170 of the 20 kw converters to electric energy by inverters be used for this on grid system should be used. In Table 2, the technical characteristics of the equipment used in the SPP system are given. Solar Power Plant on grid PV system consists of several solar panels, one or several inverters, power control system and monitiring system and grid connection equipments (AC-DC wirings and profiles).

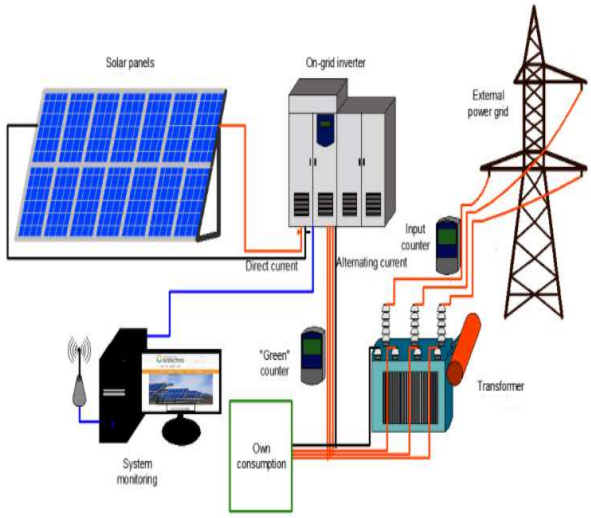

Fig 8. Solar Power Plant Technical Scheme.

Table 2. Technical specifications of solar equipments used for Kars Airport Solar Power Plant System

Photovoltaics Panel Name and Mark	LXR-400M, Lexron
Certifications	CE, IEC
PV Electrical Properties	
Power	400 W
Number of Cells	72
Open Circuit Voltage	47,95 V
Maks. Voltaj	41,70 V
Short Circuit Current	9,99 A
Max Current	9,59 A
Max System Voltage	1000 V
PV Mechanical Properties	
Module dimensions (mm)	990*1960*40
Weight	22 kg
Inverter Name and Mark	On Grid Pv Deye 20 Kw Trifaze (380v) Ongrid Inverter
Inverter Electrical Properties	
Max DC Input power	26 Kw
Max DC Input Current	25+25 A
Number of MPPT / Strings per MPPT	272
Efficiency	
Max. Efficiency	%98,6
Euro Efficiency	%97,8
Inverter Mechanical Properties	
Size (mm)	400W x 520H x 240.5D
Weight (kg)	29
SCADA control and monitoring system	1 piece
Profile	18.000 m^2
AC Wiring	3000 m
DC Wiring	18.000 m
AC Collection Board	20 pieces
Main Collection Board	4 pieces

The lowest-yielding month was found to be the base of the panel.

Total number of panels 9,326.31 for 400 W monocrystalline PV panels exactly 9,327 were calculated.

Annual solar sunshining hours of PV panels:

$$t_{m,shining} = \sum_{i=1}^{N_M} t_{shining} \quad (5)$$

Monthly PV panel efficiency:

$$\eta_{p,m} = P_p \times \eta_P \times t_{m,shining} \quad (6)$$

Monthly total generated energy from PV panels:

$$P_{g,f,PV} = N_{PV} \times \eta_{p,m} \quad (7)$$

The rural area required for installation of a 400 watt perc monocrystalline PV panel has been calculated as follows:

$$A_R = PV_D \times N_{PV} \quad (8)$$

A_R = 0,990 x 1,960 x 9327 =18098.1108 m^2

Table 3. Total monthly generated energy for Kars Airport Solar Power System

MONTHS	P_p(kw)	η_P	$\eta_{p,m}$	$t_{m,shining}$	$\eta_{p,m}$	N_{pv}	$P_{g,f,PV}$ (kwh)
JANUARY	0,4	0,98	0,392	96,1	37,6712	9327	351359,2824
FEBRUARY	0,4	0,98	0,392	117,6	46,099	9327	429967,2384
MARCH	0,4	0,98	0,392	158,1	61,9752	9327	578042,6904
APRİL	0,4	0,98	0,392	177	69,384	9327	647144,568
MAY	0,4	0,98	0,392	223,2	87,4944	9327	816060,2688
JUNE	0,4	0,98	0,392	276	108,192	9327	1009106,784
JULY	0,4	0,98	0,392	319,3	125,1656	9327	1167419,551

AUGUST	0,4	0,98	0,392	313,1	122,7352	9327	1144751,21
SEPTEMBER	0,4	0,98	0,392	252	98,784	9327	921358,368
OCTOBER	0,4	0,98	0,392	195,3	76,5576	9327	714052,7352
NOVEMBER	0,4	0,98	0,392	138	54,096	9327	504553,392
DECEMBER	0,4	0,98	0,392	93	36,456	9327	340025,112

As can be seen from the table above, the solar energy system using 9327 monocrystalline PERC 400 watt PV panels provides the system efficiency even in the coldest months and meets the electrical power required for Kars Airport of 340,000,000 kwh.

3 SOLAR POWER PLANT FOR KARS HARAKANI AIRPORT SETUP COST ANALYSIS

Solar Power Plant system for Kars Airport 340,000,000 kwh installed power for 170 inverters, AC-DC wiring, control system 9327 PV panels and labor costs together with a total of 19917859.75 TL ($2.706.157,41).
After this cost installation analysis, it was calculated how many years the system paid off itself, given that the excess energy produced was stored by inverters and sold to the state. With this type of renewable energy solar energy, both the institution produces its own electricity and sells the excess energy to the state. Here, the calculations continued; Considering that the Solar Power Plant System for Kars Airport life is 25 years.

Table 4. Solar Power Plant System Installation Equipments and Cost Analysis

Equipments for Kars Harakani Airport SPP System	qty required for installation	unit prices based on TL in Turkey average	total amount based on TL and $
20 KW Inverter	170	12704,27	2159725,9 TL 293.433,05 $
400 W. Pv Panel	9.327	1233,06	11500750,62 TL 1.562.559,53 $
Control And Mon. Sys.	1	101694,91	101694,91 TL 13.816,87 $
Profile	18.000 m^2	67	4824000 TL 655.416,97 $
AC Wiring	3.000 m	6,36	19080 TL 2.592,32 $
DC Wiring	18.000 m	1,86	33480 TL 4.548,79 $
AC Collection Board	20	17380,53	347610,6 TL 47.228,42 $
Main Collection. Board	4	32879,43	131517,72 TL 17.868,77 $
Workmanship and Installation			800000 TL 108.692,70 $
		Total current expenditure	19917859,75 TL **$2.706.157,41**

In total, there are approximately 20,000,000.00 TL ($ 2,717,317.464) initial installation costs of the Solar Power Plant system for Kars Harakani Airport. This cost is only the installation cost, except for the maintenance costs of the system. In addition, approximately 20,000 m^2 of rural installation area is needed, as can be seen from the panel area calculation, wiring and profile installation. After this installation and the necessary rural area calculations, the comparison with the amount of electricity that can be sold annually and currently installed airports is mentioned in the results section. After this installation and the necessary rural area calculations, the amount of electricity that can be sold annually is mentioned in the last part of the study to compare with the currently installed airports.

4 CONCLUSIONS

Since the life of the SPP system is 25 years. There will be 20,000,000.00 tl / 25 years = 800,000. 00 TL ($108.692,70), annual maintenance and repair costs. (increasing by 10% each year). In total,the cost of 8 years of maintenance and repair is 9,148,710.48 TL ($1,242,997. 54). The total cost of the project is 45,887,999.04 TL ($6.234,613. 06) with a term of 8 years, annual cost of 30.43% interest and principal of 208,333. 33tl ($ 28,305. 39). The installation cost of the project is 55,036,709.52 TL ($7,477,610. 60) along with the 8-year maintenance and repair cost. At the end of 8 years, the system fully pays off and will sell its excess electricity to the state for the remaining 17 years, as it produces its own electricity. For 17 years, the SPP system for Kars Airport can make money from selling 495,177,856.89 TL ($67,277,771. 92) of electricity. when SPP system for Kars Airport is made with completely uncredited cash, the repayment period decreases to 4.5 years, 20.5 years it produces its own electricity and sells excess energy to the state. 800,000.00 TL ($108.692. 70) maintenance repair cost and initial installation cost

20.000.000. 00 TL ($2.717.317. 46) 4.5 years of electricity sales, the system pays off on its own, 20.5 years of maintenance repair costs are subtracted 547.535.115. 02 TL ($74,391,336. 52) earning to selling the state.

Table 5. Annual amounts of Energy produced by SPP for Kars Harakani Airport and saleable to the State.

Average annual electricity generation	8.623.841,201 kwh
Average annual electricity consumption	2.343.691,860 kwh
Annual amount of saleable electricity	6.280.149,341 kwh
Estimated sale price	0,3487 TL (0,0473 USD)
Annual amount of saleable electricity	2.189.888,08 TL (297051,0638 USD)

Annual production capacity is produced by solar energy (SPP) system and 25-year calculations have been made based on the year 2020 of the Kars Harakani Airport consumption. It is calculated based on the last two years of 2019-2020, when the annual electricity sales unit price will also increase by 11.5% annually. In Table 6, the amount of electricity that can be sold for one year is calculated in both kwh and tl&usd.. The other 25-year SPP system life calculation was made taking into account this table. Although solar energy is one of the most widely used types of renewable energy, many buildings, campuses, and R & D centers partially benefit from solar energy; solar energy does not have many applications when the airport application is researched around the world. for this reason, the final table examines the comparisons of airports with solar energy systems installed, and if this project is implemented, it will be a worldwide project, but it needs the financial support of the Turkish state for the cost of installation. For financial support, as well as future studies, financial research can be done without engineering PV panel installation calculations.

Table 6.Production from Spp System for Kars Airport by solar panels and airport consumption based on 2020 consumption datas.

2020	airport consumption	production from SPP	surplus saleable	sales amount
JANUARY	302.757,840 kwh	351.359,282 kwh	48.601,442 kwh	16.947,32 TL $2.302,56

FEBRUARY 262.090,080 kwh 429.967,238 kwh 167.877,158 kwh 58.538,77 TL

$7.953,42

MARCH 236.630,880 kwh 578.042,690 kwh 341.681,810 kwh 119.144,45 TL

$16.187,66

APRİL 188.843,760 kwh 647.144,568 kwh 458.300,808 kwh 159.809,49 TL

$21.712,66

MAY 141.150,240 kwh 816.060,260 kwh 674.910,029 kwh 235.341,13 TL

$31.974,83

JUNE 125.375,040 kwh 1.009.106,784 kwh 883.731,744 kwh 308.157,26 TL

$41.868,06

JULY 127.859,760 kwh 1.167.419,551 kwh 1.039.559,791 kwh 362.494,50 TL

$49.250,63

AUGUST 125.133,120 kwh 1.144.751,210 kwh 1.019.618,090 kwh 355.540,83 TL

$48.305,87

SEPTEMBER 125.551,440 kwh 921.358,368 kwh 795.806,928 kwh 277.497,88 TL

$37.702,49

OCTOBER 156.179,520 kwh 714.052,735 kwh 557.873,215 kwh 194.530,39 TL

$26.430,04

NOVEMBER 214.320,240 kwh 504.553,392 kwh 290.233,152 kwh 101.204,30 TL

$13.750,21

DECEMBER 251.742,960 kwh 340.025,112 kwh 88.282,152 kwh 30.783,99 TL

$4.182,49

Total current 2.219.990,29 TL

expenditure $301.620,92

Table 7. Solar Power Plant installed Systems for Airports and comparison of the Solar Power Plant system for Kars Harakani Airport

SOLAR POWER PLANTS FOR AIRPORTS	AREA	ENERGY INSTALLATION AND SAVING	YEARS
Melbourne Airport Australia	150,000 m^2	%15 to %20 energy supply of airport 17GWH	2021
Cochin International Airport, India	45 acres of bufferland	46,000 Panels installation in a six – month 12MW	2015
Kuala Lumpur, Malaysia International Airport	situated 2km around	$27,000 annually system save with provide 19MW annually 26,000 MWH in 2019 winning the Asia Responsible Enterprise Awards 19MW	2014
Minnieapolis-ST. Paul International Airport, US	-	installation of 11,835 solar panels provide 3MW around %20 energy needed two-terminal site and saving in the region of $14 million over 30 years 3MW	2015
Lattanooga Metropolitan Airport, US	-	Phase I- 1MW – 3848 Panels, Phase II- 1,1 MW-3542 Panels Phase III- 641 KW-1886 Panels, 20GWH	2011 2013 2019
Darwin International Airport, Australia	-	I-Stage 4MW PV Solar array II-Stage raise capacity 5,5MW III- Stage 40 MW facility Alice Spring Airport would benefit from 10MW facility, 40MW	2018
Kars Harakani Airport, TURKEY	20.000 m^2	9327 PV Panels with installation cost $ 2.706.157,41; and annually $301.620,92 system with provide annual amount of electricity saleable to the state, 340 MWH	2021

Nomenclature

$A_{A,T,C}$ -average annual total consumption kwh,[-]
AR -required panel area,[m2]
ECOC, 2019 -average cost of 1 kwh in 2019,[-]
ECOC, 2020 -average cost of 1 kwh in 2020,[-]
N M -number of days per month,[-]
Npv -number of PV panel,[-]
Pg,f,PV -generated energy from PV panels,[kW]
Pp -power of a PV panel, [kW]
$P_{T,C,2019}$ -total energy consumption based on kwh in 2019,[-]
$P_{T,C,2020}$ - total energy consumption based on kwh in 2020,[-]
$P_{V\,D}$ -PV module dimensions,[mxm]

SPP -solar power plant,[-]
$T_{T,O,C,2019}$ -total consumption based on tl in 2019,[-]
$T_{T,O,C,2020}$ -total consumption based on tl in 2020,[-]
t shining -time of daily sunshining PV, [h]
$t_{m,shining}$ -monthly time of sunshining PV,[h]
Greek Symbols
η_P - PV panel efficiency,[-]
ηp,m -monthly PV panel efficiency,[-]

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