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Determination of Solar Energy Usage Rate, Reliability, and Efficiency for Different Trips of High-Speed Train

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Abstract: In this study, a statistical feasibility analysis was performed using a universally valid equation model to determine how much of the power required by the YHT65000 series high-speed train sets can be supported by solar energy systems. Calculations were made with the necessary parameters obtained from the General Directorate of Meteorology, Turkey. To find the ratio to meet this power requirement, eight different Ankara-Eskişehir / Eskişehir-Ankara trips were used, and these trips were tested by 61 different distribution functions to find the optimum model for the probability density function for each trip. The selection of the best models among these different distribution functions is presented with their error rates. This study reveals the detailed statistical characteristics of the contribution of a solar energy system to be established to support the power requirement of the high-speed train line based on specific trips.

***Keywords**:* Solar energy, Statistical distributions, Railway engineering, Energy efficiency, Probability density function, Power system reliability

Yüksek Hızlı Trenin Farklı Seferlerinde Güneş Enerjisi Kullanım Oranı, Güvenilirliği ve Verimliliğinin Belirlenmesi

Öz: Bu çalışmada, YHT65000 serisi yüksek hızlı tren setlerinin ihtiyaç duyduğu gücün ne kadarının güneş enerjisi sistemleri ile desteklenebileceğini belirlemek için evrensel olarak geçerli bir denklem modeli kullanılarak istatistiksel bir fizibilite analizi yapılmıştır. Hesaplamalar Meteoroloji Genel Müdürlüğü'nden temin edilen gerekli parametreler ile yapılmıştır. Bu güç ihtiyacını karşılayacak oranı bulmak için sekiz farklı Ankara-Eskişehir / Eskişehir-Ankara seferi kullanılmış ve bu seferler 61 farklı dağılım fonksiyonu ile test edilerek her bir sefer için olasılık yoğunluk fonksiyonu için optimum model bulunmuştur. Bu farklı dağılım fonksiyonları arasından en iyi modellerin seçimi hata oranları ile birlikte sunulmuştur. Bu çalışma, yüksek hızlı tren hattının belirli seferlere dayalı güç ihtiyacını desteklemek için kurulacak bir güneş enerjisi sisteminin katkısının detaylı istatistiksel özelliklerini ortaya koymaktadır.

***Anahtar kelimeler**:* Güneş enerjisi, İstatistiksel dağılımlar, Demiryolu mühendisliği, Enerji verimliliği, Olasılık yoğunluk fonksiyonu, Güç sistemi güvenilirliği

1. Introduction

Combining rail systems with solar energy has received much attention in recent years to contribute to energy efficiency by reducing fossil fuel use. In addition, the use of solar energy in rail systems helps prevent environmental pollution. There are many applications around the world where solar panels have been both placed on the rooves of trains and mounted elsewhere. These applications and benefits are mentioned below.

Although it is not a sunny region (900 hours/year), a 3.3 GWh / year solar power plant was established in a railway tunnel near Antwerp, Belgium, and the return on the investment is expected to be realized within 9 years [1]. Vili, the 760mm-gauge vehicle in Hungary, is operated with 9.9 m2 solar panels [2].

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Solar cells are also present at airports in many countries and many projects have been initiated to integrate them into the road surface. If an entire strip of land is covered with PV modules, the railway becomes an addition to such power plants, the return on investment is considered to be less than 10 years for public land PV plants, and several decades for railways [3]. In another study, an optimal design of solar cells is improved by using a social spider algorithm [4].

In the literature, there are important studies on the use of solar power solutions for rail systems, especially on Indian Railways. Indian Railways is one of the world's largest diesel consumers and has an annual consumption of 2.7 billion liters and an annual CO_2 emission of 239.12 tons [5]. Therefore, efforts have been made by Indian Railways to reduce fossil fuel consumption and adopt environmentally friendly technologies [6]. Indian Railways operate a total of 63511 railway cars, including both traditional rail cars and Linke Hofmann Busch rail cars [7]. Most railway cars belonging to Indian Railways are exposed to sunlight throughout the year which provides an opportunity to explore the possibility of using solar energy [8]. A statistical model was developed to estimate the power output per unit roof area of the railway car to evaluate the technical feasibility and economy of Indian Railways before SPV modules on solar-powered cars running on different routes in India were installed [9].

In Italy, amorphous silicon modules were installed on five passenger cars, two locomotives, and three freight cars [10]. In 2010, France's state-owned railway tested a Diesel Multi-Unit (DMU) equipped with thin-film Copper Indium Gallium Selenite SPV modules and the 990 Wp ceiling-mounted SPV system to partially power the electrical lighting system inside the DMU [11].

According to a study conducted in Iran in 2013, an SPV system can meet 74% of a passenger car's power requirement in hot months and 25% in cold months, 63.7 kWh of energy can be saved, and annual CO_2 emissions can be reduced by 37 tons [12].

In a study proposing to utilize solar energy for the development of a solar-powered railway transportation system in Pakistan, Pakistan's solar energy potential was evaluated and a case study for solar-powered vehicles was presented [13].

In another study, the effectiveness of the circuit configuration change, taking into account partial shadows in the rooftop PV system at Tokyo Station, was verified. It was concluded that it could improve the power output to the level that would be expected in a solar radiation field, and unlike complex switching techniques on a large scale, the real effects of a circuit configuration change can be implemented with minimal cost [14].

In a recent study, a photovoltaic power generation system was designed using the roof of Gwangmyeong Station, the largest railway station building in Korea, and the estimated power generation volume was calculated using the PV system. The contribution of the photovoltaic power generation system to carbon emission reduction in electric railway systems was also analyzed [15]. A more recent study provides a detailed analysis of roadside PV power integration into the direct current (DC) traction power supply system of the urban rail transit (URT) based on the data of Shanghai URT Line 11 [16]. In addition, Jia et al. have examined the perspective of solar-powered road and rail transport in China in their current work [17].

The problem of providing the power demand of any system with solar energy should be analyzed statistically in terms of instant energy need and instantaneous solar energy production. In one of the current studies on this subject, solar energy system integration into smart cities has been discussed statistically [18]. In another study, Blaga et al. analyzed the effectiveness of solar forecasting models statistically in detail [19]. In addition, in another study, the energy production performance of all renewable energy sources for Romania was statistically demonstrated based on years [20]. In a more recent study, a detailed statistical analysis of renewable energy sources in terms of sustainability and forecasting has been made comparatively for Europe and Romania [21]. Another recent study presents the statistical indicators of renewable energy resources in the railway transportation structure of European countries [22].

When the studies examining solar radiation in terms of the probability distribution function are searched in the literature, one of the outstanding studies is the study of solar energy production by Afzaal et al. using Weibull distribution on a power grid [23]. In addition, Ayodele used different probability distribution functions to model the global solar radiation of the city of Ibadan, the capital of Nigeria, and compared their performances over model errors in his article published in 2015 [24]. In one of the most recent studies, Wahbah et al. propose a hybrid Beta-Kernel density estimation (KDE) model for solar radiation probability intensity estimation [25].

The structure of this article is as follows: Section 2 presents the technical information about the route used for this study and the details of the high-speed train for which the power requirement is to be determined. The case study and the power calculations required for this case study are discussed in Section 3. The distributions of the solar energy system's contribution to eight different train trips, which are modeled with the best distribution model using the Kolmogorov-Smirnov Goodness-of-Fit test, are discussed. In Section 5, the contribution of the solar energy system for each trip is analyzed comparatively with each other in terms of efficiency and reliability based on basic statistics and those obtained from the distribution models. Finally, the conclusion for the obtained results is presented in Section 6. The motivation of this study is demostration of possibility to use the sun, which is a type of renewable energy, in rail systems. In addition aim of this study can be indicated the rate of utilization of solar energy and which trips were both the most reliable and the most efficient.

2. Technical Information

Studies are performed according to a specific route and train in Turkey. The main reason for the energy consumption of trains is train resistance, which is the sum of the forces that negatively affect the train movement [26]. The reason for choosing the route selected for this study is that the ramp level is close to 0% and the curve is almost 0 m. diameter. As can be expected, solar energy will be insufficient to meet the full power needs of a high-speed train. For this reason, as ramp and curve values increase power consumption, a route with low consumption has been chosen so that the percentage of solar energy usage is high. Thus, the investment in this solar-based train-designed facility will be logical. The technical information on the high-speed train used in this study is given in Table 1.

Table 1. Technical information of YHT 65000 high-speed train (obtained from Turkish State Railways)

Main Characteristics of YHT6500	
Catenary Type	AC 25 kV, 50 Hz
Traction Motor Power	AC 4800 kW
Power	38400 kW
Maximum Speed	275 km/h
Line Gap	1435 mm

The route information of the Ankara-Eskişehir YHT line is given in Figure 1.a and general structure of the PV system is summarized in Figure 1.b.

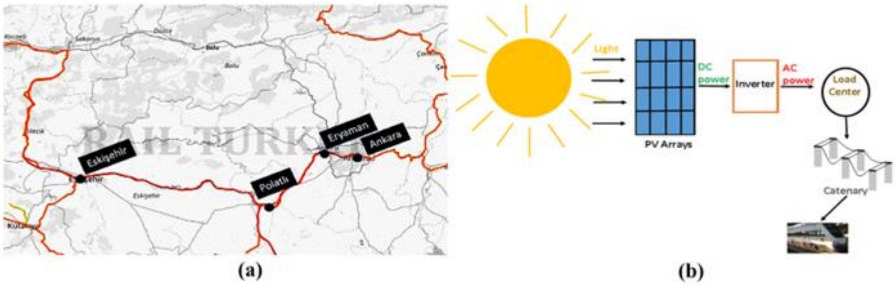


Figure 1. Grid-connected PV system and departures

(a)Route information of Ankara-Eskişehir YHT line (obtained from Turkish State Railways)
(b)General structure of the PV system

The route given in Figure 1 presents the 245 km route traveled by the YHT 65000 trains, which perform five departures and five return trips per day. A trip takes about 1 hour 30 minutes. The departure times are: 06:20, 08:15, 13:10, 18:00 and 20:25. However, on the last trip, there is no sunlight. The arrival times are: 06:40, 10:30, 15:00, 17:30 and 20:20. In this study 8 trips are considered for distribution functions.

3. Case Study

It was found that the amount of power required for the eight daily trips can be supported by a grid connected to the PV system. The maximum that can be obtained from solar panels is as in (1), and the total energy during a trip can be calculated by (2) [15, 27, 28].

$$P(t) = \eta \cdot A \cdot G(t) \cdot [1 - 0.005 \cdot (T(t) - 25)] \tag{1}$$

$$W_{PV} = \int_{t0}^{t1} P(t)dt \tag{2}$$

η is system efficiency. A is total panel area (m^2). H is the photoelectric conversion efficiency of the PV array (%). G (t) is the global solar radiation value changing with time t (Watt / m^2); T (t), ambient temperature value at time t (◦C).

In this study, the power supplied from solar energy was directly given to the grid and it is possible to find out how much of the power requirement of the different departures can be met in this way. While making these calculations, some assumptions were made. These are:

Cable efficiencies are 100%. There is no efficiency decrease in panels caused by temperature. The panel efficiency is 19% (polycrystalline panel). The inverter efficiency is 98%. The temperature and global solar radiation values used were obtained from the Turkish Meteorological General Directorate.

Since the system is for connection to the network (network or load dependent), it is assumed that a central inverter was used instead of a battery. The area on which the solar panels are to be placed is 1000 m^2, which is part of the s roof size of Polatlı YHT Station (TCDD).

The train makes ten trips between Eskişehir-Ankara and Ankara-Eskişehir. Its actual demanded energy per single trip is 6 MWh [29]. Eight of these trips take place during the hours of sunlight (radiation information from meteorology is available for these eight trips). The total energy demand is 48 MWh (for the 8 trips) in a day, which is 17.52 GWh a year. The calculation was made using equation (1).

4. Methods

The contribution of the solar energy system to a single departure or arrival trip is defined in terms of percentage and a time series of 365 contribution percentiles was constructed for each trip to observe the change in the solar energy system's contribution to the respective trip over a year. These time series were modeled with 61 different distribution functions for the eight different trip times. The Kolmogorov-Smirnov-based Goodness-of-Fit test was applied by using Easy-Fit software to choose the best distribution function for each trip. The Kolmogorov-Smirnov test is a nonparametric test based on the empirical cumulative distribution function (ECDF) [30].

Examining the coefficient of variation (CV), skewness (SK), and excess kurtosis (κ) statistics of each trip's data before choosing the best fitting distribution model for the data of each trip also provides important information about the shape of the distribution. These statistics are presented in Table 2 for departure and arrival trips.

The smaller variation coefficients mean more stable data. Based on this relationship, it can be inferred that the most stable and reliable data belongs to the 10:30 return trip and the most unstable and unreliable data belongs to the 18:00 departure trip. The daylight hours between 08:05-15:00 show more stable behavior compared to the early and late hours of the day.

Skewness measures the asymmetry of the probability distribution. The tail is on the left side of the distribution when negative skewness is seen and on the right side when positive skewness is observed. According to Table 2, the 08:05, 10:30, and 13:10 trips have tails on the left side of their distributions, whereas the others have tails on the right side. The tail appearing on the right side indicates that smaller ratios are more probable.

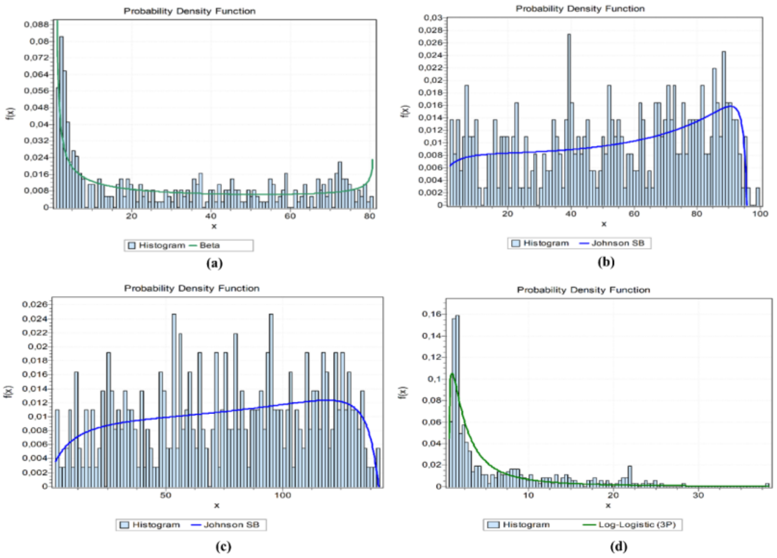
Table 2. Statistical characteristics of daily data for solar energy system's contribution to the power supply of each YHT departure and arrival trip over a year.

Trip	Mean	SD	CV	SK	κ
06:20	32.033%	26.499%	0.8595	0.4148	-1.3234
08:05	53.284%	27.950%	0.5246	-0.2714	-1.1582
13:10	76.087%	37.700%	0.4955	-0.1647	-1.1164
18:00	6.2885%	6.8277%	1.0858	1.5153	1.6794
06:40	35.148%	30.903%	0.8792	0.4831	-1.2574
10:30	164.63%	73.369%	0.4457	-0.548	-0.8081
15:00	87.302%	56.035%	0.6418	0.1512	-1.3468
17:30	16.087%	16.681%	1.0369	0.9658	-0.2847

The distribution of the data can be classified as platykurtic, mesokurtic, and leptokurtic in terms of excess kurtosis. The negative excess kurtosis means platykurtic distribution, which has a thinner tail than a normal distribution. The positive excess kurtosis denotes leptokurtic distribution, which has a thicker tail than the normal distribution. Mesokurtic distributions have excess kurtosis close to zero, which means that they have normal-like tails. According to Table 2, only the data of the 18:00 trip has leptokurtic distribution, and all the other trips have platykurtic distribution.

The data belonging to the departure and arrival trips are modeled as presented below.

As can be seen in Figure 2.a, the data for the 06:20 departure trip and similarly 06:40 arrival trip are modeled with the best Beta distribution.



(a) (b) (c) (d)

Figure 2. Best probability density functions for departure trips

(a)Beta for 06:20 (b)Johnson SB for 08:05 (c)Johnson SB for 13:10 (d) 3P log-log for 18:00.

The general expression of the Beta probability density function is given in (3) [31].

$$f_{Beta}(x) = \frac{(x-a)^{\alpha_1-1}(b-x)^{\alpha_2-1}}{B(\alpha_1,\alpha_2)(b-a)^{\alpha_1+\alpha_2-1}} \tag{3}$$

In Equations (3), the function $B(\alpha_1, \alpha_2)$ is expressed in terms of Gamma (Γ) function as in Equation (4).

$$B(\alpha_1, \alpha_2) = \frac{\Gamma(\alpha_1)\Gamma(\alpha_2)}{\Gamma(\alpha_1+\alpha_2)} \tag{4}$$

Table 3. Beta pdf coefficients for 06:20 and 06:40 trips

Trip	a	b	α_1	α_2
06:20	1.1442	80.794	0.44405	0.700096
06:40	1.4196	94.672	0.44387	0.729880

Because α_1 is less than 1, a long right-side tail occurred. In addition, because α_2 is also less than 1, this tail rose again, while the random variable continued to its upper limit.

The contribution of the solar energy system for the 06:20 and 06:40 trips is mostly under 10% of the overall energy requirement with approximately 38% probability. However, the long, narrow, and uniform-like tail structure resulting from the obtained Beta distribution coefficients creates an unpredictable region with a 62% probability in total for contribution rates greater than 10%.

When the contribution rate data for the 08:05, 13:10, 10:30, and 15:00 trips were investigated with the K-S test, it was observed that the most suitable distribution model for these trips is the Johnson SB distribution. The Johnson SB distribution is also defined on a limited interval with finite upper and lower boundaries [32]. In the definition of the Johnson SB distribution, there are four parameters to express the probability distribution function. These are listed as follows:

γ: Continuous shape parameter δ: Continuous positive shape parameter

λ: Continuous positive scale parameter ξ: Continuous location parameter
The domain of the continuous random variable x is defined in terms of λ and ξ as in (5).

$$\xi \leq x \leq \xi + \lambda \tag{5}$$

z is the normalized version of the random variable x as expressed in (6).

$$z = \frac{x-\xi}{\lambda} \tag{6}$$

By using these parameters, the Johnson SB probability density function is defined as in (7).

$$f_{Johnson\ SB}(x) = \frac{\delta}{\lambda\sqrt{2\pi}z(1-z)} \cdot e^{-0.5\left(\gamma+\delta ln\left(\frac{z}{1-z}\right)\right)^2} \tag{7}$$

Table 4. Johnson SB pdf coefficients for 08:05, 13:10, 10:30 and 15:00 trips.

Trip	γ	δ	λ	ξ
08:05	-0.25260	0.60136	98.868	-3.0845
13:10	-0.16815	0.69024	142.86	-1.5768
10:30	-0.52931	0.65057	282.58	-15.924
15:00	0.1276	0.49851	178.92	4.7546

Because δ is less than 1 for all these four trips, the skewness of the distribution is negative as shown in Table 2. Moreover, the negative γ causes the left-side tail for 08:05, 13:10 and 10:30 trips. ξ defines the lower bound of the domain and λ defines its width.

The distribution of the contribution rate data for the 18:00 trip is most appropriately modeled by the Three-Parameter Log-Logistic distribution as shown in Figure 2.d. The probability density function for the Three-Parameter Log-Logistic distribution is defined as in (8) [33].

$$f_{log-logistic(3P)}(x) = \frac{\alpha}{\beta}\left(\frac{x-\gamma}{\beta}\right)^{\alpha-1}\left(1+\left(\frac{x-\gamma}{\beta}\right)^{\alpha}\right)^{-2} \tag{8}$$

where $\gamma \leq x \leq +\infty$

In this equation, α, β and γ are the scale, shape, and location parameters, respectively. The third parameter, which is the location parameter, defines the minimum value that the random variable can take.

Table 5. Three-Parameter Log-Logistic pdf coefficients for 18:00 trip.

Trip	α	β	γ
18:00	1.2053	2.41	0.66512

The scale parameter is greater than 1, which causes the pdf to be equal to 0 at the minimum value (location parameter) of the random variable. Because the shape parameter is greater than scale parameter, but less than 8 times the size, a long right-side tail is obtained after the value where the pdf is maximum.

The best-fitting distribution model for the 17:30 return trip is reciprocal distribution. Assuming that the domain of a random variable is given as $a \leq x \leq b$, then the Reciprocal Probability Density Function is expressed as in (9) [34].

$$f_{reciprocal}(x) = \frac{1}{x(lnln\,(b) - lnln\,(a)\,)} \tag{9}$$

Table 6. Reciprocal pdf coefficients for 17:30 trip.

Trip	a	b
17:30	0.78194	62.087

The errors of the pdf models expressed in (4), (9), (12) and (16) for the real contribution data of the 06:20,08:05,13:10 and 18:00 trips are shown in Figure 3.a, 3.b, 3.c and 3.d respectively and the minimum and maximum errors of each pdf is given in Table 7.

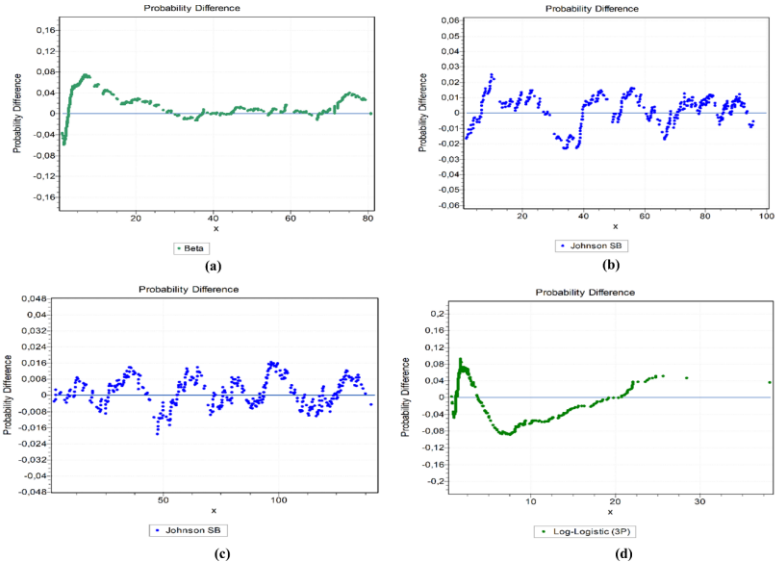


Figure 3. The errors of best probability density functions for departure trips (a)06:20 (b)08:05 (c)13:10 (d)18:00.

Table 7. Minimum and maximum errors of best probability density function for each trip.

Trip	06.20	08:05	13:10	18:00	06:40	10:30	15:00	17:30
min ε	-0.06	-0.025	-0.016	-0.08	-0.06	-0.02	-0.03	-0.08
max ε	0.08	0.025	0.016	0.08	0.08	0.02	0.03	0.04

5. Comparative Results and Discussion

Ratios showing the amount of power that can be supplied by a solar energy system are found for all the days in a year using Equation 1. However, only the minimum, Q1 percentile, median, Q3 percentile and maximum values are presented in Table 8 for departure and arrival trips.

According to Table 8, the solar energy system has the least contribution to the 18:00 departure trip and the largest contribution in departure trips is seen in the 13:10 departure. The Q1 statistic gives an idea of possible scenarios where the conditions are unfavorable, and the Q3 statistic gives an idea of the possible scenarios where the conditions are favorable. According to the Q1 statistics, the worse scenarios for the 08:05 and 13:10 trips are acceptable. On the other hand, the worse scenarios for the 06:20 and 18:00 trips create an inefficient environment for the use of the solar energy system for these two departure trips. According to the Q3 statistics, the better scenarios for the 06:20, 08:05, and 13:10 trips are acceptable. On the other hand, the contribution of the solar energy system is not at a satisfactory level for the 18:00 trip. The solar energy system can generate power more than the train needs at 13:10 trip in the best-case scenario.

Table 8. The Statistics of the Solar Energy System's Contribution to the Power Supply of Each YHT Departure and Arrival Trip.

Trip	Min	Q1	Median	Q3	Max
06:20	1.1442%	4.3754%	23.877%	55.314%	80.794%
08:05	1.5305%	31.537%	55.325%	78.264%	99.787%
13:10	2.9422%	47.016%	79.045%	109.87%	141.61%
18:00	0.6673%	1.4742%	2.6004%	8.9889%	38.291%
06:40	1.4196%	4.9410%	25.302%	62.801%	94.672%
10:30	5.3354%	116.84%	180.67%	228.95%	282.58%
15:00	2.9919%	30.223%	85.399%	137.79%	187.19%
17:30	0.7819%	2.1796%	8.2679%	27.83%	62.087%

According to Table 8, the solar energy system has the least contribution to the 17:30 return trip and the largest contribution is seen in the 10:30 trip. For the 10:30, return trip, the solar energy system supplies more than a train set needs in both worse and better scenarios. Moreover, two train sets can be supplied by the solar energy system for the duration of this trip in the better case scenario. According to Q1 statistics, the contribution ratios are not acceptable for the 06:40 and 17:30 trips in the worse scenarios. However, according to Q3 statistics, both contribution ratios are acceptable to support the decision to use a solar energy system as support for both return trips in the better scenarios.

In Table 9, Goodness-of-fit statistics are presented for the best fitting distribution models for departure and arrival trips. The lower KS statistics and The P-Values which are close to 1 imply a better fitting distribution model. Moreover, the Mean Absolute Error (MAE) and Root Mean Square Error (RMSE) of the distribution models should be close to 0.

When Table 9 is examined, it is seen that the Johnson SB model, selected for the 08:05 and 13:10 trips, is more reliable than the Beta model selected for the 06:20 trip and the Three Parameters Log-Logistic model selected for the 18:00 trip. The main reason for this result is the high variation coefficients for the 06:20 and 18:00 trips, as presented in Table 2, which means that the data for these trips are unstable. It is a far more challenging problem to fully fit unstable data with a single distribution model. Data belonging to the 10:30 and 15:00 trips are better fitted with the best fitting distribution because of their fewer variation coefficients, as presented in Table 9.

Table 9. Best Probability Density Function and Its Goodness of Fit Statistics for Each Departure and Arrival Trip.

Trip	Distrib.	KS Stat.	P Val.	MAE	RMSE
06:20	Beta	0.0742	0.0341	0.0246	0.0322
08:05	Johnson SB	0.0261	0.9590	0.0079	0.0096
13:10	Johnson SB	0.0220	0.9929	0.0059	0.0071
18:00	Log-Logistic(3P)	0.0922	0.0038	0.0442	0.0509
06:40	Beta	0.0762	0.0274	0.0272	0.0349
10:30	Johnson SB	0.0368	0.6921	0.0102	0.0130
15:00	Johnson SB	0.0325	0.8288	0.0098	0.0124
17:30	Reciprocal	0.0894	0.0055	0.0357	0.0439

6. Conclusion

In this study, it can be concluded that substantial power support can be provided for the trips between 08:05 and 15:00, to the point where the energy consumption of more than one train set can be met for most of the year for the duration of the 10:30 trip. Conversely, the solar energy system becomes inefficient at hours approaching the evening, such as 17:30 and 18:00.

In the continuation of the study, the most suitable probability models of solar energy contribution rates for each trip and the probability density functions of these probabilistic models were derived. Thanks to these extracted pdfs, the probability that the annual contribution for the relevant trip is lower or higher than a certain value can be calculated. In these extracted models, there is a significant relationship between the tail structure, seen on the right or left, and the average efficiency. The average contribution is higher in daytime trips with distributions where the tail is generally seen on the left, and the average contribution is lower for early morning and late evening trips with distributions where the tail appears on the right.

It should be emphasized that, this study indicated the rate of utilization of solar energy and which trips were both the most reliable and the most efficient. For instance, it has been shown that the most efficient trip for the system is at 10:30, while the most reliable trip is at 13:10. Similarly, it has been revealed that the system is most efficient for the trip 06:40 return trip and most reliable for the 06:20 departure trip. The 18:00 departure trip was found to be the most incompatible with the solar energy system in terms of both efficiency and reliability. The low efficiency in the 18:00 trip is due to the sunset, and the low reliability shows that the annual change of sunset causes serious deviations in this trip.

In future studies, a study is planned to determine which probabilistic methods are best used in which regions. With this study, it will be possible to determine the solar energy utilization rates of the rail systems according to the different trip hours in the most accurate way. This solution will determine whether such an investment is made in this region or not.

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Resume

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