Estimation of Solar Radiation Value using Artificial Intelligence Networks

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Abstract

Energy need in our country and in the world is increasing day by day. Due to the limited use of fossil fuels to meet this need, the trend towards renewable energy sources has gradually increased. Solar energy, which is considered as an inexhaustible energy source among renewable energy sources, is the most widely used and studied energy source. In this study, solar radiation value has been modeled by using the data obtained from 10 kW small scale solar power plant established in Selçuklu Region of Konya province. While performing this model, the data recorded over a year from the solar power plant and the data obtained from the general directorate of meteorology were used. In this model, the solar radiation value is estimated by using the temperature value in a small scale solar power plant, the voltage and power values obtained from the PV panel. As a result of the modeling, it was seen that the modeling was performed with 86% accuracy.

Keywords: ANN, Renewable energy source, Solar radiation value

Yapay Zekâ Ağları Kullanılarak Güneş Radyasyonu Değerinin Tahmini

Öz

Ülkemizde ve dünyada enerji ihtiyacı her geçen gün artmaktadır. Bu ihtiyacı karşılamak için fosil yakıtların sınırlı kullanımı nedeniyle, yenilenebilir enerji kaynaklarına yönelik eğilim giderek artmıştır. Yenilenebilir enerji kaynakları arasında tükenmez bir enerji kaynağı olarak kabul edilen güneş enerjisi, en çok kullanılan ve üzerinde çalışılan enerji kaynağıdır. Bu çalışmada güneş ışınım değeri, Konya ili Selçuklu Bölgesinde kurulu 10 kW'lık küçük ölçekli güneş enerjisi santralinden elde edilen veriler kullanılarak modellenmiştir. Bu model gerçekleştirilirken güneş santralinden bir yıl boyunca kaydedilen veriler ve meteoroloji genel müdürlüğünden alınan veriler kullanılmıştır. Bu modelde güneş radyasyon değeri, küçük ölçekli bir güneş enerjisi santralindeki sıcaklık değeri, PV panelden elde edilen voltaj ve güç değerleri kullanılarak tahmin edilmektedir. Modelleme sonucunda modellemenin% 86 doğrulukla yapıldığı görülmüştür.

Anahtar Kelimeler: YSA, Yenilenebilir enerji kaynakları, Güneş radyasyon değeri,

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1. Introduction

Energy need is one of the most important problems of today's world and it shows a rapid increase day by day due to many reasons. With the population growth in the world, the demand for new technological developments increases, because of this the energy requirement brought by industrialization increases. The depletion of fossil-based energy resources, which have negative effects on the natural environment such as global warming and toxic gas emissions, today's technological developments have started to reduce the costs of renewable energy resources significantly, increasing the interest in renewable energy resources. The sun, which is among these resources, is the most important energy source of our world. Solar energy is a preferred type of energy due to its advantages such as being environmentally friendly and not requiring maintenance. In addition, the global scale electrical energy potential of the part of the sun rays reaching the earth is 160 times the fossil fuel reserves determined until now. In other words, it is 15000 times more than fossil, nuclear and hydroelectric facilities on earth will produce in a year.(1) The average annual solar radiation value from the horizontal plane on Earth is 170W / m2. [2]. Sunlight hitting the earth in 90 minutes is sufficient to meet the energy need of the whole world for one year [3]. The formation process of oil, coal and natural gas, which we call fossil fuels, was also due to the sun. Renewable energy sources have gained importance as an alternative to fossil fuel-based energy sources that are about to almost extinct today.

In addition to energy sources indirectly connected to the sun such as Hydroelectric, Wind, Biomass; PV (Photovoltaic) power plants that produce electrical energy from direct sunlight are the renewable energy sources used. According to data from the Ministry of energy and Natural Resources, investments in solar energy worldwide increased by about 25% compared to previous years and exceeded $ 150 billion. (4) Solar energy is the radiative energy released as a result of the transformation of hydrogen atoms in the sun into helium atoms [5]. Solar energy is used for different applications in our daily life. These are common usage areas such as wristwatch, calculator, telephone charging units, traffic lights, as well as street lighting, agricultural irrigation, off-grid photovoltaic systems [6]. In addition, water heating systems, solar cookers for cooking purposes and solar coolers are also among the uses of solar energy.

Our country is extremely rich in solar energy potential. It is thought to have an annual energy potential of 380 billion kWh. The average annual solar radiation in Turkey is 1.527 kWh/ m2 per year, and the average annual sunbathing time is 2.741 hours. These values are equivalent to a daily average global radiation value of 4.18 kWh/ m2 and a daily average sunbathing time of 7.5 hours. As of the end of June 2018, the total installed power of the PV solar power plant in our country is 4,726 MW, of which 4,703 MW unlicensed and 23 MW licensed. [7]. While the installed power of electrical energy (all power plants) in our country was 78 thousand 599 MW in 2016, it reached 82 thousand 312 MW as of October 31, 2017. In 2018 agenda focuses on domestic energy moves in Turkey. [8]. Our country is among the countries with the highest solar potential in Europe. According to the 2017 Renewable Energy Statistics Report of the International Renewable Energy Agency (IRENA), it ranked 25th among the world countries with 844 MW in 2016 in terms of photovoltaic installed power, and ranked 13th with a capacity of 3,422 MW at the end of 2017. In the European countries ranking, it was 15th in 2016, and 7th in 2017. Its installed capacity in this area in 2017, has been proportionally highest increase in the country Turkey [9].

In the literature, there are various studies such as radio estimation for different geographies and locations, examination of different PV technologies, solar radiation estimation with artificial intelligence methods, efficiency analysis and monitoring of PV systems connected to the grid.

Literature of YSA

Solar radiation data plays an important role in solar energy research. Due to the lack of Metorology stations in the desired locations, there is no solar data here. Thus solar radiation is estimated precisely for these locations using various models.

Artificial Neural Networks (ANN) methodology is applied to the data obtained from a 750 W solar panel. It is seen that the time frame of 5 minutes provides the best solar energy forecast in the short term and can be used 35 minutes in the medium term in April. It also increased to 3 and 40 minutes for very short and medium time estimates, respectively, in August. The difference between Root Mean Square Errors (RMSEs) measured and test values varied between 33–55 W and 37–63 W, respectively, in April and August. Specifically, for solar irradiation during August, stable conditions are observed and these conditions allow the ANN to easily predict the electricity generated 30 - 300 minutes ahead [10].

The aim of this study is to review the Artificial Neural Network (ANN) based techniques to identify appropriate methods for solar radiation prediction in the literature and to define research gaps. The study shows that artificial neural network techniques predict solar radiation more precisely than traditional methods [11].

The aim of this study is to estimate the optimum tilt angle for PV panels in order to collect the maximum solar irradiance for the city of Dharan in Saudi Arabia. A newly developed optimization algorithm called the vortex search algorithm is used to predict solar radiation on the inclined surface. Moreover, in the proposed approach, a year can be divided into different periods and the optimal angle can be obtained separately for each of these periods. Horizontal tilt data (ie direct, scattered and global solar radiation) are used to estimate the optimum tilt angle. The results show that the solar radiation estimated using the optimum tilt angle is maximized compared to that predicted on a horizontal surface [12].

An artificial network network (ANN) model was used to estimate the solar radiation parameters of seven provinces from the Mediterranean region of Anatolia. Data from the Turkish state and Meteorological Services were used to estimate solar radiation. Data

for 2006 was used for testing, and data for 2005, 2007 and 2008 were estimated. The effects of the input parameter count were tested on the solar radiation, which is the output layer. The results showed that the method could be used by researchers or scientists to design high-efficiency solar devices. In addition, input parameters were found to be the most effective parameter in predicting future solar radiation data [13].

The aim of this study is to estimate the efficiency of the photovoltaic cell using artificial neural network technology, taking into account environmental impacts. For this estimate, environmental factors such as wind speed, temperature, humidity and angle of the cell were taken into account in response to the voltage value of the photovoltaic cell. In this study, an Artificial Neural Network has been modeled for a 4.2V-100mA photovoltaic cell that makes predictions about the efficiency of the cell depending on environmental factors such as wind speed, temperature, humidity and the angle of the cell with horizontal. The data required for modeling was recorded in the Keşan District of Edirne in a certain period of time. The data of the study were obtained by taking into account 5 different factors in total. These factors were determined as four input parameters called air temperature, humidity, wind speed and angle of the photovoltaic cell, and one output parameter formed by the corresponding voltage values. This model estimates the efficiency value of the photovoltaic cell well in percentage terms. In addition, it seems that the performance criteria of the network in training and testing operations are quite good. This shows that the network modeled for efficiency estimation has high prediction ability [14].

GSI estimates allow to determine the amount of photovoltaic (FV) power generated and help power grid operators estimate problems related to the nature of FV power and planning for appropriate solutions and decisions. In this study, a new methodology for local estimation of daily global horizontal radiation (GHI) is proposed, which is a combination of spatial modeling and artificial neural networks (ANN) techniques. An ANN-based model has been developed to predict local GHI based on daily weather forecasts provided by the US National Oceanic and Atmospheric Administration (NOAA) for four neighboring regions. The methodology was tested for two locations; Le Bourget du Lac (450 38 N, 50 51E), located in the French Alps and Kadarache, located in the south of France. The model's estimates were compared with measured data for the two locations, and the validation results showed that the ANN method presented in this study could predict daily Global Horizontal Irradiance (GHI) with satisfactory accuracy. In this study, a new ANN-based model has been developed to predict global horizontal sunlight on the surface. The main specificity of this model is that the meteorological forecasts are used as input to fill the lack of the measured database, which is often indispensable for this type of task [15].

Artificial neural networks were used by the author in the field of solar energy; for modeling and design of a solar steam generating facility, for estimating the parabolic trough collector crossover factor and local concentration ratio, and for modeling and performance prediction of solar water heating systems. It has also been used to predict the heating loads of buildings, to predict air flow in a naturally ventilated test room and to estimate the energy consumption of a passive solar building. The errors reported in these models are within acceptable limits, clearly showing that artificial neural networks can be used for modeling in other renewable energy generation and utilization areas [16].

This article presents a solar radiation prediction technique based on fuzzy and neural networks aimed at achieving good accuracy in different weather conditions. By using fuzzy logic and neural network together, the forecast results can very well follow the actual values in different sky and temperature conditions. The effectiveness of the approach is confirmed by a case study where four different scenarios are tested. Mean Absolute Percent Error (MAPE) is much smaller than other solar radiation method. The proposed method can be used for both hourly and daily solar radiation estimation. After obtaining sky and temperature information for the next period from NEA, solar radiation can be predicted with the proposed method and with reasonably good accuracy [17].

All studies in the literature have proven that AI algorithms play an important role in improving the performance of PV systems. This article shows that AI algorithms are expected to play a critical role in all aspects of FV research. The conclusion of the research articles on the recent achievements of AI algorithms in photovoltaic systems is that AI is concerned with all aspects of PV systems design such as control and monitoring, and the research is moving towards intelligent photovoltaic systems [18].

As the power output of PV systems is critically dependent on weather conditions, unexpected changes in power outputs can increase the operating costs of the power system. Developing a reliable algorithm that can minimize errors associated with predicting near future PV power generation is extremely useful to efficiently integrate VER into the grid. FV power prediction can play a key role in overcoming these challenges. This article presents a one-hour forward prediction of power output of a PV system using a combination of wavelet transform (WT) and artificial intelligence (AI) techniques by combining the interactions of the PV system with solar radiation and temperature data. In the proposed method, WT is applied to have a significant impact on the malicious PV power time series data, and AI techniques better capture the nonlinear PV fluctuation [19].

Solar energy caused by sunlight has a structure that cannot be broken down due to the stochastic environment of meteorological conditions. Therefore, power system control and energy work require an estimate of solar energy (radiation) from a few seconds to a week in advance. A variety of solar radiation prediction methods have been used to deal with prediction shortcomings. Predictive data mining offers various methods for solar radiation prediction, of which the artificial neural network is one of the reliable and accurate methods. Artificial neural network techniques have been used in the design of solar energy systems and to predict solar radiation to evaluate the available literature on the basis of predictive accuracy tend inadequacies. From the results of this study, it was seen that the artificial neural network provides good accuracy in terms of less than 20% prediction error. It has been found that the accuracy of solar radiation prediction models depends on the input parameters and the architecture type algorithms used. Therefore, when compared to other empirical models, the artificial neural network is able to cope with many input meteorological parameters, making it more accurate and reliable [20].

Finding the optimum angle of inclination of PV panels is an optimization problem. Therefore, in this paper model, the drive optimization approach such as particle swarm optimization (PSO) estimator is proposed to find the optimal slope angle and its results are compared with the analytical results. When three statistical approaches such as descriptive method, direct method and Altman-Bland methods were adopted, the PSO estimator results were found to be sufficient for the ANA results at 95% confidence interval within the scope of the statistical study. In this study, an evolutionary optimization approach is proposed, such as the PSO estimator that maximizes the total sunlight on the surface of the PV panel to Egsmax. Since the PSO estimator is a model-based approach, the selection of the appropriate model entry is extremely important. Therefore, the cost function to be optimized using the PSO and its constraints is also presented in this study. The PSO forecaster predicts product deactivation, and these results can be used to improve the energy collection of solar collectors. From the analysis it can be concluded that the PSO estimator is a model-based approach to estimate the optimum angle of inclination [21].

This study also estimated the value of solar radiation using artificial intelligence. In this study, data obtained in 2018 was used in a 10 kW solar panel system located in Konya and Seljuk campus. Solar radiation value was accepted as output in the modeling, temperature, voltage and power values obtained from the PV panel were used as input values of the modeling. From 2920 data recorded for modeling to 2336 data for training, 584 data were used for testing. As a result, a success of 86% was achieved.

1.2. Solar Energy and Power Plant

Energy, expressed in the simplest terms as the ability of an object or system to do work; light, heat, mechanical and chemical forms are the most important and basic requirements in all aspects of human life. In order to meet the energy needs, fossil fuels such as oil, coal and natural gas, as well as renewable energy sources such as wind, solar and biomass are used. The insufficiency of fossil fuels has increased the demand for renewable energy sources today, where the annual energy consumption per person is increasing day by day. Solar energy is a preferred type of energy due to its advantages such as being environmentally friendly and not requiring maintenance. Today, solar energy is generally used in heating systems and electricity generation systems.

1.2.1. Solar Energy

The Sun, which is the source of life on Earth, is also the source of the energy that human beings need to survive. The sun is about 150 million km from the earth. Except for nuclear fuels, it is the main source of all fuels used in the world. In it, fusion reactions take place, in which hydrogen is transformed into Helium, and the resulting mass difference is converted into heat energy and propagates into space. Solar energy; It is the radiative energy released by the fusion process in the core of the sun [22]. The total energy that the world gets from the sun is 1,5 quadrillion ($1,5 \times 1015$) MW / h in a year. This amount of energy is equivalent to 28,000 times the energy consumed by humans in 1 year in the world. If only 0.1% of this energy reaching the earth's surface can be converted into electrical energy with 10% efficiency, a power 4 times the global electrical capacity of 3,000 GW can be obtained [23].

1.2.2. Solar Power Plant

There are basically two methods to obtain electrical energy from solar energy, indirect (solar concentrator systems) and direct (photovoltaic). In the indirect method, the motion energy from water vapor obtained as a result of focusing the energy using solar energy condensing systems is converted into electrical energy by magnetic means. In the direct method, solar energy is converted into electrical energy by chemical means by photovoltaic method. Photovoltaic systems are structures that convert sunlight falling on it directly into electricity. Nowadays, solar energy is transformed into electrical energy with an efficiency of around 25-43% depending on the structure of the photovoltaic cell [24].

Figure 1. Concentrated solar energy systems (CSP) are based on reflecting the sun rays falling over a large area to a relatively small area by means of mirrors and sun tracking systems connected to these mirrors. CSP technology is based on the principle of collecting the sun rays collected in the parabolic trough-shaped collectors in the water transmitted through the tube passing through the focus point of the mirrors and directly producing steam. Water and steam passing through the units that are connected to each other by heating and when the desired temperature and pressure values are reached from the last unit, the steam produced is sent directly to the steam turbine and electrical energy is produced without creating carbon emissions [25].
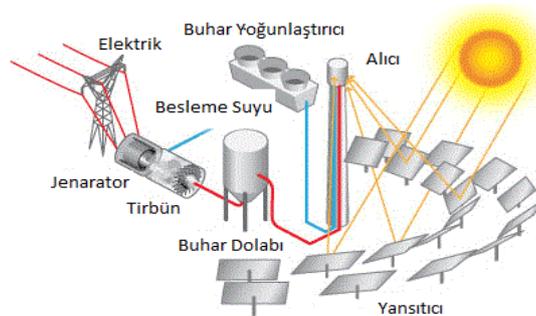

Figure 1. Concentrated solar energy systems (CSP)

Photovoltaic cells are semiconductor substances that convert sunlight directly into electrical energy. Photon particles, which are the carriers and emitters of solar energy, generate electrical energy when they fall on the photovoltaic cell. When sunlight falls on the semiconductor material, the radiation energy moves the free electrons belonging to the atom of the matter, and the current on the conductor is created by the movement of free electrons. Silicon and silicon alloys are the most commonly used materials in FV cell construction [26]. A large number of solar cells are connected in Series or parallel to each other to increase power output. This structure is called a solar cell module or FV module. Depending on the power demand, modules can be connected to each other in Series or parallel, creating FV panels or FV arrays. In this way, systems up to MW levels can be created. Currently, almost only silicon semiconductor material is used in the production of FV cells. The basic component of an FV plant is the FV cell. The cell produces approximately 4-5 Watts of power under standard conditions (temperature of 25°C, radiation power of 1000 W/m2) [27].

Figure 2. Photovoltaic System

1.3. Artificial Neural Networks

Neural Networks (ANN) is a data processing technique that was inspired by the working principle of the human brain, artificially imitating nerve cells in the brain and applying it to computer systems to solve complex problems. ANN learns from examples as in the human brain and is generally used in situations where the relationships between data are not very complex and linear. The simplest ANN structure consists of 3 different layers as input layer, hidden layer and output layer as shown in Fig 3, and one or more simple artificial neural cells called neuron or processing element in each layer.

The most important point in modeling any problem with the ANN method is to determine the most appropriate network architecture that will provide the best solution to the problem, namely the number of hidden layers and the number of processing elements in the hidden layer (s). The number of process elements in the input and output layer is equal to the number of parameters to be used in modeling, while the number of hidden layers and the number of process elements in each hidden layer vary depending on the difficulty of the problem to be modeled. As the relationship between the data in the problem to be modeled becomes complex, the number of hidden layers in the network architecture to be created and the number of processing elements in each layer generally increase.
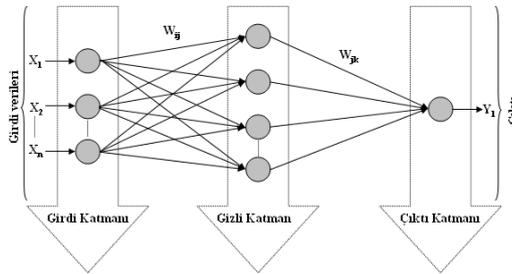

Figure 3. Basic three layer ANN

1.4. Accuracy of Modeling

Accuracy is a value that shows how close the calculated value is to the measured value. Equation x is used to determine the error value between the measured value and the calculated or predicted value for each data value.

$$\delta_i = \frac{\left| R_a - R_a{}^0 \right|}{R_a} * 100 \tag{1}$$

Here

δi: Error of each data,

Ra: Estimation results,

Ra0: Experimental results,

i: Data means value.

Equation xx is used to determine the total error of all the model.

$$\Delta \;=\; \frac{1}{n}\sum_{i}^{n}\delta_i \tag{2}$$

Here: Estimated accuracy of the model, n = Number of data.

2. Material and Method

2.1. Solar Power Plant

A 10 KWp solar power plant with solar panels has been established in Selcuk University Technical Sciences vocational school garden. The installed power plant is connected to the energy system of Myo. All technical specifications determined by the Energy Market Supervisory Board were carefully fulfilled in the system installation.
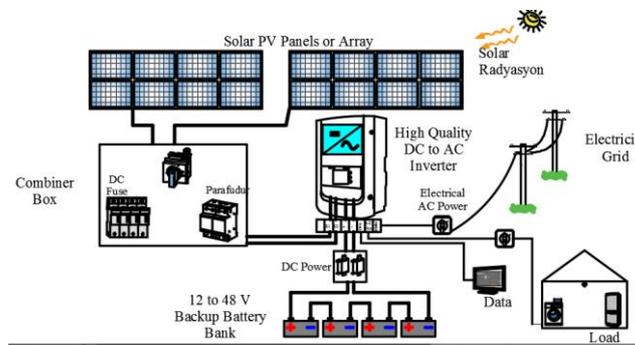

Figure 4. On-Off Grid Network

Photovoltaic systems to generate electricity from the sun; Depending on the applications, PV panels consist of accumulators, inverters, battery chargers and various protection elements. PV modules are used as power source in the system. If the systems are Off-Grid (without network connection), the electrical energy obtained from the sun is stored in accumulators by means of battery chargers. Inverters are needed for On-Grid (network connected) and situations where alternating current is needed. Especially in grid-connected systems, the surplus of electricity generated can be sold to the grid without the need to store it. The application works as both On-Grid and Off-Grid. The batteries used are controlled by the inverter without the need for a separate charge control unit.

Figüre 5. Control and recording system

2.2. Photovoltaic panels

FV batteries, first discovered by French physicist Edmond Becquerel in 1839, are semiconductor materials that convert sunlight on their surface into direct current electrical energy without any intermediate elements. The first solar cell was discovered by Charles Fritts in 1884 [28].

Figure 6. Photovoltaic panels

In this study, 270 W monocrystalline panels were used. Panels are products tested and approved according to IEC 61215 (for crystal modules) and IEC 61730 (Photovoltaic module safety qualification) standards, which are defined by international standards, and bear the CE mark. For the standard test conditions specified on each panel label; At least 270Wp power, 37V open circuit voltage and 9A short circuit current are predicted. The maximum system voltage of the panels is 1000 V. Panels have IP67 (female-male connector connected) protection class integrated connectors. The cables of these connectors are of different lengths to provide visual separation of the positive (+) and negative (-) poles. The panels have connection boxes with IP65 protection class. There are at least three bypass diodes in these junction boxes.

Table 1: Electrical values of panels under Standard Test Conditions

Standard Test Conditions (STC) Electrical parameters			
Module type			M60-270A
Power output	Pmaks	W	270
Module efficiency	η	%	19
Voltage = Pmax	Vmpp	V	32,14
Current = P max	Impp	A	8,4
Open circuit voltage	Voc	V	36,84
Short circuit current	Isc	A	8,99

2.3. Accumulators

Batteries that are used to store electrical energy generated in Off-Grid systems can be grouped as Water Type Batteries, VLRA type, AGM and GEL, Nickel based, NiCd and NiMH, Li-Ion type batteries. Batteries store electrical energy chemically. It is used to meet the energy needed at the end of the sunshine period in solar energy systems. Its filling and usage are controlled by special circuits. Capacities are given in Ah hour. Batteries with deep discharge (Depth Of Discharge) are used. The measure of how much the DOD battery will be discharged is the ratio of charge current and discharge current to the capacity of the C battery. Example 100Ah battery C / 10 charge → max. 10A charging current. More AGM and GEL batteries are used in photovoltaic systems. Batteries can be connected in series / parallel according to the energy desired to be stored. In series connection Voltage is collected, in parallel connection current is added. Batteries of the same type and capacity must be used in serial / parallel connection. Voltage equalization of batteries used at certain times should be made. 200A / h Gel batteries were used in this application.

Figure 7. Batteries connected in series with 200 Ah 12 V

2.4. Inverter

They are electronic devices that convert the direct current electrical energy produced by the panels into alternating current. The solar inverter is the most important component of every PV plant. Inverters are intelligent system managers. It not only converts the direct current generated by the PV modules into alternating current suitable for the grid, it also supervises the gains and controls the local electricity grid. The electricity consumed in Off-Grid (Independent solar photovoltaic system, a system not connected to the grid) comes only from the energy produced by the PVs. Such systems store the excess energy generated in batteries. On-Grid solar photovoltaic system is a grid connected (parallel) system. When solar energy is available, the system supplies the generated energy to the grid. Hybride (hybrid) solar photovoltaic system is a system where solar and grid power technology are used together to provide more advantages.

If the energy generated by the PVs is sufficient for consumption, the inverter will use the PV energy and charge the battery. Likewise, if consumption exceeds PV energy, the inverter will take extra energy from the grid. When there is no sun, the inverter uses only the energy from the batteries or takes the energy it will use from the grid, depending on its energy consumption. Since this application includes a hybrid system, a 10kW Hybrid inverter was used to suit this situation.

*Figure 8. 3 Phase Hybrid Inverter*

2.5. Cables and Protection Elements

In photovoltaic systems, the choice of cable should not be neglected. In particular, it is one of the main factors that should be considered when calculating DC (direct current) systems, and the cost of damage caused when not paying attention is high. FV solar cables will be made by using FV1-F type solar cables that are type approved with TÜV certificate, resistant to high temperature and heat, UV resistant, double insulated, halogen-free, lead-free, with "class 5" bendable conductors in accordance with IEC 60228 and IEC 60287 standards. Solar cables to be used in the system must be produced according to 1800V rated voltage.

Collector boxes must have DC IP65 and Class II insulation class in accordance with IEC 61439-2, 61439-3 and UTE C 15-712-1 standards. Collector board must be made of non-conductive material. Panels to be mounted in the open facility area will have 2 DC FV serial (string) inputs and 2 DC MPPT outputs. DC voltage is 1000VDC, series current is 12A / serial. There will be suitable DC fuses at both positive and negative outputs of each series. These surge arresters will be placed in panels. Surge arresters will be at 1000 Vdc rated voltage; the rated discharge currents will not be less than 12.5 kA and the maximum discharge currents will not be less than 25 kA. Operating temperature will be between -40C ° and 85C °. The disconnector switch will be a 0-1 position rail type switch. The switch will be used to turn on and off 1000VDC and 25A DC current. Residual current relay and automatic fuses are used by the network. In addition, the system has a bidirectional counter.

3. Results and Discussion

In this study, an ANN model with 3 inputs and 1 output is created. A total of 2920 data used in the training and testing of the ANN model was obtained in 2018 in a 10 kW Solar Panel system located in Konya and Selçuklu campus. In the modeling realized, the solar radiation value was accepted as the output and the temperature, voltage and power values obtained from the PV panel were selected as the input values of the modeling. From 2920 data recorded for modeling to 2336 data for training, 584 data were used for testing. As a result, a success of 86% was achieved. ANN model was implemented in MATLAB program. Values obtained as a result of modeling are given in Fig. 9-10.
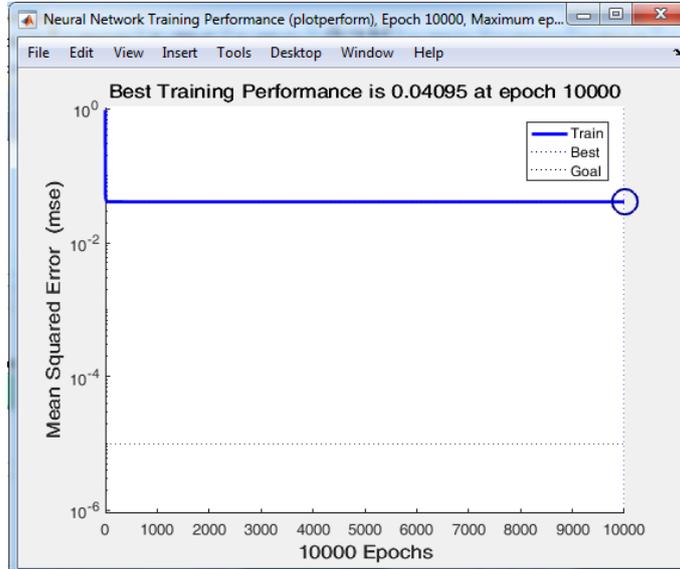
Şekil 9. Best training performance
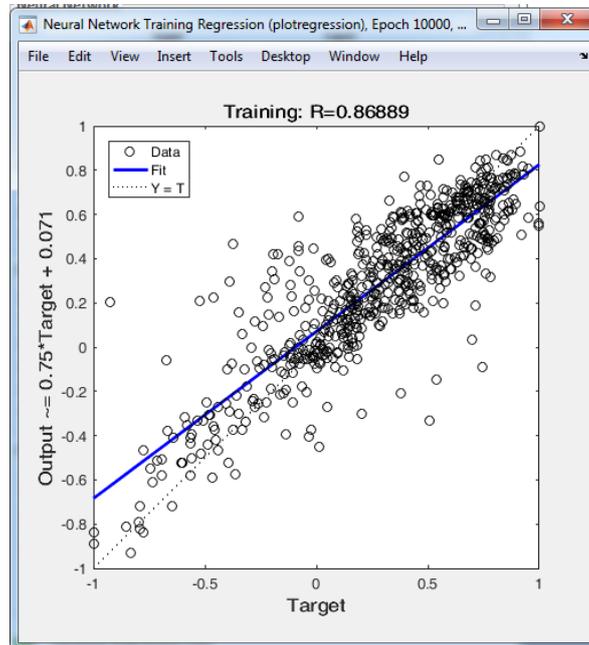
Şekil 10. R value of test data

4. Conclusions and Recommendations

Nowadays, solar energy is being used more and more every day. Studies on this subject are increasing day by day. In this study, the solar radiation value was modeled using ANN. As a result of the created modeling, an accuracy of 86% was obtained. In this study, data for only one year was used. In the next studies, it is thought that the accuracy rate will increase as a result of increasing the number of these data.

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