Portable Solar Water Pump Design And Forecasting Very Short-Term Sun Light Radiation Using Feed Forward Neural Network Method

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Abstract
Portable Solar Water Pump is an alternative to renewable energy that can convert solar radiation into the form of electrical energy used to pump rice field irrigation water. Solar radiation promotes increased photovoltaic absorption, leading to improved battery life time performance. Solar cells have a high efficiency value if photons from sunlight can be absorbed as much as possible. This research aims to design a Portable Solar Water Pump. After that analyze the forecasting of solar radiation Watt/m^2 in the next hour starting from 08.00-13.00 then predicted at 14.00 using the Feed-Forward Neural Network (FFNN) method. And get an error value of 2.6. With the highest radiation value of 1285,6 Watt/m^2.

Keywords: *Photovoltaic, Portable Solar Water Pump, Solar Radiation, Feed Forward Neural Network*

I. INTRODUCTION

The most useful and effective renewable energy source is solar energy using photovoltaic panels in a wide range to meet their energy needs. The most effective application of Photovoltaic Panels is for the extraction of the most important and most basic necessity of human life i.e. water. Water pumping is one of the simplest and most widely appropriate uses for Photovoltaic. From crop irrigation to watering stocks for domestic use, solar-powered pumping systems meet a wide range of water needs. [1]. Agriculture is not only the world's largest sector that consumes a volume of water, but also relatively low efficiency and high users of subsidized water. More than two-thirds of the water drawn from the earth's water sources is used for irrigation [2]. Due to the high increase in renewable energy, the importance of these predictions of meteorological magnitudes, such as wind speed and solar radiation, is increasing. Today, prediction systems have proven their strong economic impact and improved integration into the power grid [3]. Many researchers are working on this topic, ie. Intelligent irrigation system, which includes autonomous monitoring and control of water pumps using photovoltaic energy. The power supply for the entire system is drawn from renewable energy i.e. photovoltaic cell energy; [4-5]. for a better understanding of its structure. Finally, a mathematical model was developed with MATLAB/SIMULINK, to determine the effect of temperature and solar radiation on the performance of PV panels [6]. More recently, researchers have focused their experience and learning in developing advanced Artificial Intelligence (AI) solutions and tools to help power system operators, to better maintain and understand their grids predictive maintenance solutions. Load forecasting is an important application of AI methods. Electrical load forecasting is essential for an efficient and safe power supply. Also, in the spot electricity market, the result of short-term electrical power forecasting is the daily clearing limit of the market as well as the basis for the price formation of intra-day markets and real-time markets. Therefore, it is necessary for the short-term electrical precision of load forecasting technology to be higher and higher. Load forecasting methods can be classified into three categories: a. methods based on classical mathematical statistical models, such as time series analysis, regression analysis, methods based on machine learning [7-12].

However, intense solar radiation can cause the PV module to overheat resulting in a decrease in output voltage and conversion efficiency. In this work, we will try to estimate Radiation using artificial neural networks that take measurements in place of parameters as input [13]. Location is very important in the installation of solar power systems because it is related to the availability of sunlight, light intensity [14].

Based on solar radiation data collected from 18 locations in Indonesia, the distribution of solar radiation in Indonesia can be classified in the western part of Indonesia is approximately of 4,5 kWh/m^2/day with a monthly variation of about 10% [15].

II. LITERATURE

Off Grid Solar Power Plant

This Off-Grid Type Solar Power Plant is a type of solar generation wherever there is no source of supply available or it is a remote area. Solar power plants. The resulting solar energy is stored in the available batteries, which are further converted into AC using inverters. The main advantage of this type of plant is that consumers are free from any kind of possible blackout or blackout. But the battery is a major disadvantage due to its high cost. Also, the battery needs regular maintenance and replacement after some time, which is financially disruptive for consumers. [16].

Feed Forward Neural Network

Forecasting Sunlight Radiation using Matlab Neural Network Software techniques. The historical input data i.e. temperature, humidity, wind speed, theoretical radiation and real power are first normalized and then applied to the input layer of the Elman network. Solar power radiation determines the overall trend of photovoltaic power: Weather, Radiation Type, Temperature, Humidity, Wind. The input data is divided into training data and test data. Training date [17].

Forecasting has been developed. Today, network artificial nerves are commonly used in signal processing due to their nonlinear capacity and strong performance. In ANN theory, in addition to network structure, the format of training data can also affect network performance directly [18].

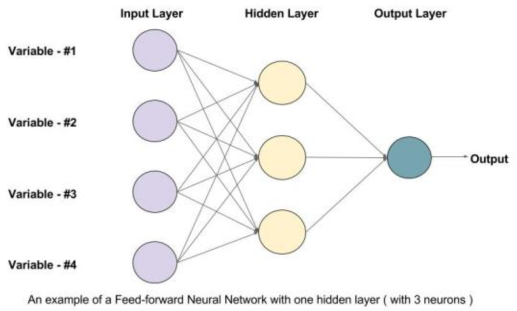

Figure 1.. FFNN Design Example

A typical neural network has two layers, an input layer, a hidden layer and an output layer. The number of neurons corresponds to the size of the input and output layers, while the hidden layer can be manipulated to match its desired output level. The mapping process is achieved by first assigning each individual input a connection weight, which sends the information to the next neuron or junction. The weight vector is first randomly assigned and then fixed by training the network. [19].

Min-Max Normalitation Process:

$$V' = \frac{V(x) - \min(x)}{Range\ (x)} \qquad (1)$$

Explanation:

V' = Normalization results where the value is from 0-1
V(x) = Values to normalize
Min(x) = The lowest value of a data
Max(x) = The highest value of a piece of data
Range(x) = Max(x)-Min(x) values

Summation Function is a function used to find the average weight of all input elements. A simple one is to multiply each input value (Xj) by its weight (Wij) and sum it (called weighted summation, or Si).

$$Si = \sum_{j=i}^{n} Wij * Xj \qquad (2)$$

Explanation:

Wij = Weight Value
Xj = Input Value
Si = Weight Summation

Activation function: A function that describes the relationship between internal activation levels *(summation function)* which may be linear or non-linear. Some of the functions of artificial neural network activation include: hard limit, purelin, and sigmoid. Popularly used is the sigmoid function which has several variants: binary sigmoid, bipolar sigmoid, and tangent. [20].

FFNN Formula

First Weight Input

$$W = Net * I * W\ \{1.1\} \qquad (3)$$

First Input Bias

$$W = Net * b\ \{1.1\} \qquad (4)$$

First Layer

$$W = Net * L * W\ \{1.2\} \qquad (5)$$

Explanation:

Net = Network
I = Input
W = weight
B = Bias

Forecasting Accuracy

The level of accuracy of forecasting in operations management can be seen from the error value. Several methods are more prescribed to summarize errors produced by facts (descriptions) in forecasting techniques. Most of these measurements involve averaging some function of the difference between the actual value and its forecasting value. This difference between the observation value and the forecast value is often referred to as a residual.

1. Mean Squared Eror (MSE)

   Mean Squared Error (MSE) is another method for evaluating forecasting methods. Each error or remainder is squared. Then it is added up and divided by the number of observations. This approach governs large forecasting errors because those errors are squared. A technique that produces moderate errors may be preferable to one that has small errors but sometimes produces something very large. [21].

$$MSE = \frac{1}{n} \sum_{t=1}^{n} \{ Yt - Y't \}^2 \qquad (6)$$

Explanation:

n = Amount of Data
Yt = Actual Data
Y't = Data FFNN

III. RESEARCH METHODS

Research Approach

In this study, the research approach used is development research. The purpose of development research is to develop a system and perfect the system. Research *and Development* is a research method used to produce certain products and test the effectiveness of those products.

This study will develop a design model of portable solar water pump by forecasting very short-term solar radiation.

Research Design

The order of the research design is shown as follows.

1. Literature
   In the literature study, a search for information about everything related to this research is carried out including:
   a. Learn the characteristics of each equipment and component to be used along with its working principle.
   b. Design and design Portable Solar Water Pump
   c. Get data that is in accordance with the research theme
   Learn and simulate in MATLAB software
2. Planning model Portable Solar Water Pump.
   Design and design some components that will be used in Portable Solar Water Pump
3. Making Portable Solar Water Pump module.
   First make the framework of the Portable Solar Water Pump, then assemble several components that will be used in the Portable Solar Water Pump
4. Working tools
   The tool works by measuring voltage, current, power temperature, irradiation of sunlight in photovoltaic using a multimeter, temperature check, and solar power meter
5. Analysis and forecasting
   After the Portable Solar Water Pump works, analysis and forecasting of solar radiation using the FFNN method is carried out.
6. Finish

Portable Solar Water Pump Design

After reviewing and planning the system, a portable solar water pump design was created. In this study, *photovoltaic modules* were *used with* monocrystalline *silicon cell types* with a maximum output power of 455 WP, 200 AH gell Lithium Battery, 500Watt Inverter, MPPT, Solar charge controller, and 150Watt AC Water Pump. After assembling all the components that will be used for the portable solar water pump system on the *photovoltaic* module, the researcher made a design that can work optimally. The module design is shown in Figure 2 and Figure 3.

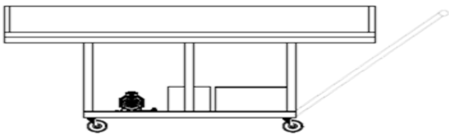

Figure 2. Design of Portable Solar Water Water Pump Left Side View

Figure 3. Design of 3D Portable Solar Water Pump

Caption from figure 3. be:

At the top there is a photovoltaic at the bottom in the form of MPPT Box Inverter, Battery and Water Pump

Feed Forward Neural Network Architecture Design

For the architectural design of the Feed Forward Neural Network can be seen in figure 4.

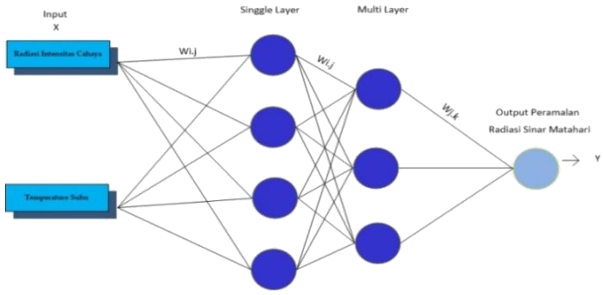

Figure 4. Feed *Forward Neural Network Design*

The architecture design of the Feed forward neural network uses two inputs, namely sunlight radiation and temperature. With Four single layers plus Three multi layers with a frequency of one neuron in the form of sunlight radiation

IV. RESULTS AND DISCUSSION

Result

The results of the implementation of the research entitled "Design of Portable Solar Water Pump and forecasting of very short-term sunlight radiation using the feed forward neural network method succeeded in producing a new PSWP design with added portable frames that can be taken to various places in need.

Figure 5. Portable Solar Water Pump

Figure 6. Portable Solar Water Pump

Figure 5 and Figure 6. above shows the results of a Portable Solar Water Pump with a size of 210 cm x 105 cm with a series of MPPT, Battery Inverter and Water Pump arranged at the bottom.

In this study, medium-scale tools are using a 150Watt AC water pump and using Solar control charge with MPPT type because it is more efficient to see *photovoltaic* power of 455 WP. To store absorbed solar energy, a battery with a size of 200 AH is installed.

Data retrieval process

The measurement was carried out at Jalan Keramat Kelurahan Karangdalam, Sampang District, Sampang Regency on Thursday, June 8, 2023 – June 14, 2023 by taking data on *photovoltaic* in the form of temperature and sunlight radiation using a measuring instrument, solar power meter (measuring radiation), thermometer (measuring temperature), measurement starting at 09.00 to 15.00 WIB with a distance of 30 minutes so that 15 data were obtained for one day and carried out during Seven days. Measurement procedures by placing the Solar power meter parallel to *the photovoltaic* in order to get a suitable radiation value in *photovoltaics*. Then place the thermometer around the *photovoltaic* to measure the ambient temperature *of the photovoltaic*. As shown in figures 7 and 8.

Figure 7. The process of taking solar radiation data

Figure 8. Temperature data retrieval process

In a one-week study, the greatest radiation and temperature were located in the range of 10:30 to 12:30 because at that hour the sunlight shone its best radiation.

By using *a portable solar water pump*, it is more economical to spend on water pumps that originally used fuel oil to be converted into solar thermal energy, thus a useful alternative for the long term.

Discussion

Results of forecasting solar radiance using the *feed forward neural network method.* The results of *FFNN* forecasting as shown 9 following the blue graph are actual data while orange is the result of *FFNN* Y axis graph explaining about sunlight radiation in units of Watt /m^2. While the graph on the X-axis explains about the time period m^2

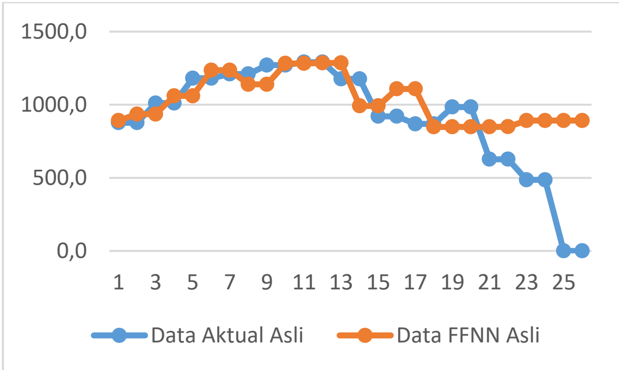

Figure 9. Actual data graph and FFNN on Friday 08.00 – 14.00

In figure 9 it is known that the more data, the better the forecasting results, the graph begins to show a slight / small difference. Figure 10 shows the forecasting results at 14:00

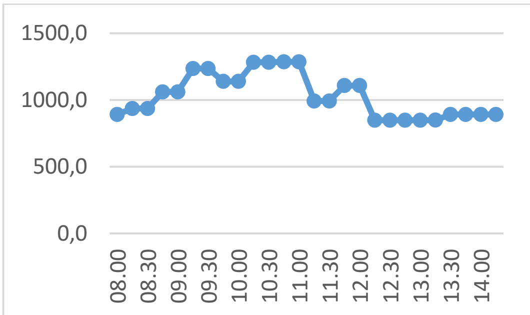

Figure 10. Original FFNN Data Forecasting Chart at 14:00

Mean Squared Error (MSE)

Mean Squared Error (MSE) is another method for evaluating forecasting methods. Each error or remainder is squared. Then it is added up and divided by the number of observations.

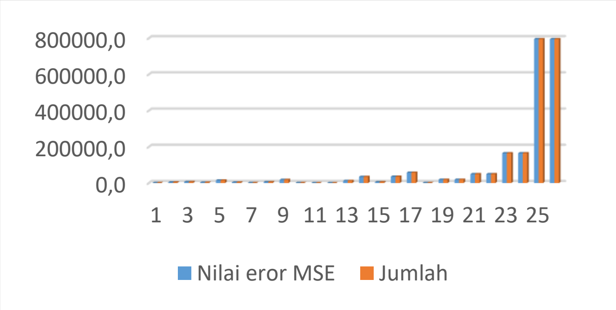

Figure 11. Graph of mean squared error

In figure 11 above shows the MSE graph with the smallest error found a value of 2.6 at 10.30 WIB.

V. CONCLUSION AND SUGGESTION

Conclusion

Designing Portable Solar Water Pump for Irrigation of Farmer Rice Fields. From the research conducted, wind speed also affects the increase in solar radiation.

Get forecasting results for one hour. With an error value using a mean squared error of 2.6. With the highest radiation value of 1285.6 Watts $/.m^2$

Suggestion

In order to achieve better results, the following are recommended:

To design a portable solar water pump is made with a larger size and lighter in order to get efficient results.

For the forecasting process, you should use more data to get more thorough results.

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