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Prediction of Solar Irradiation Potential in Island Area of Indonesia Using Artificial Neural Network (ANN) Method

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Abstract

Utilize solar energy system requires having knowledge about solar irradiation potential in different locations. There is no report about prediction of solar irradiation potential for Indonesia by using Artificial Neural Network (ANN) method. This paper explores the use of neural network method for predicting monthly average global solar irradiation in the horizontal surface by meteorological data in Indonesia. The database consists of 5 years data (2005 to 2009), that collected in Manado (altitude 1.3 N, longitude 124.9 E), a city in Sulawesi island, Indonesia. Average sunshine duration, average wind speed, average temperature, average relative humidity, and average precipitation are used as inputs, and the monthly average global solar irradiation is used as output, which is a target of prediction in the ANN model. To evaluate the performance of ANN models, statistical error analysis in terms of mean absolute percentage error (MAPE), mean absolute bias error (MABE) and root mean square error (RMSE) are conducted for testing data. The proposed ANN model is predicted the monthly average global solar irradiation with an accuracy of 95% and MAPE of 4.8%, MABE of 0.59 MJ/m², RMSE of 0.22 MJ/m² for testing data. This study can demonstrate the concept of ANN method with Multi Layer Perception (MLP) type to predict monthly global solar irradiation potential in this location. It can open wide analyze to other location in island area of Indonesia.

Keywords: *Solar Irradiation; Artificial Neural Network, Island Area, Renewable Energy, Multi Layer Perception.*

1. Introduction

Indonesia consists of many small islands surround mainland which is facing electricity power shortage problem. Renewable energy such as solar energy system can be an alternative energy supply to the islands where are not connected to the grid. PV system can be used for electrification and it most suitable for remote and island area such as Indonesia in the term of resource availability and economic feasibility [1]. At the present, island communities rely on fossil fuel to supply energy needs. Consequently, energy supply to such communalities is on considerable concern. These islands have adequate amount of locally available resources of renewable energy potential, such as solar energy.

Global solar irradiation data provide information on how much of the sun's energy strikes a surface at a location on earth during particular time period. The amount of solar irradiation potential in the particular location is important for solar energy system design, such as stand alone PV and hybrid system. Solar irradiation potential is also required for crop models (in agriculture engineering field) as well as building thermal performance (in agriculture field).

Due to the geographical condition, the measurement of solar irradiation for all location of interest in island community of Indonesia that spread out widely in many location become difficult and expensive. Prediction of solar radiation data using appropriate model can be an

alternative solution to develop for developing country, such as Indonesia. This paper study about the development and usage of the ANN models in such location.

The purposes of this study are defined as follow:

- To explore the ability of the ANN method to predict monthly average global solar irradiation value in the island area of Indonesia
- To select the best ANN model for predicting monthly average global solar radiation in the horizontal surface by meteorological data in Indonesia.

This paper is organized as follows: literature review about ANN theory and previous works predicting solar irradiance is described in section 2. The database used in this study and the method of ANN application for predicting solar irradiations are presented in section 3. The result of simulation ANN model and evaluations are shown in section 4. Conclusion is given in section 5.

2. Literature Review and Previous Work

This section describes about literature review and previous works on predicting solar radiation by using ANN method.

Artificial Neural Networks are computational systems that their model and functionality is inherited from the recently acquired knowledge of the biological computational units, namely, the brain's neurons. An ANN consists of many interconnected identical neurons. A typical neural network usually has 3 layers of neurons, each of which is connected to the neurons in the next layer. These connections are weights which are applied to values passed from one neuron to the next. Input values in the first layer are weighted and passed to the second (hidden layer). Neuron in the hidden layer produce outputs that are based upon the sum of weighted values passed to them. The hidden layer passes values to the output layer in the same fashion and the output layer produces the desired result. The network learns by adjusting the interconnection weights. The answers the network is producing are repeatedly compared with the correct answers, and each time the connection weights are adjusted in the direction of the correct answers [2].

There are many ANN types, one of the typical one is Back Propagation (BP). The Back Propagation (BP) algorithm is a supervised iterative training method for multilayer feed forward nets with a differential nonlinear function. The BP algorithm minimizes the mean square difference between the network output and the desired output.

Basically there are many parameters in the ANN, which the designer of the ANN should assign, such as learning rate, momentum rate, weight and so forth. Here, we only explain about three important parameters in MLP type of ANN model. Learning rate term, L, indicates how much the weight change to effect on each pass. This is typically a number between 0 and 1. Momentum term, M, indicates how much a previous weight change should influence the current weight change. As neuron pass values from one layer of the network to the next layer, the values are modified by a weight value in the link that represents connection strengths between the neuron. The weights of connection between neurons are adjusted during the training process to achieve the desired input and output relation of the network. ANNs perform in many different forms, some require model with total interconnection among neurons and others require arrangement in layers [3].

The advantage of neural networks is their learning ability to perform specific tasks. Learning is accomplished by adjusting the weights of the connections between neurons. Weights are adjusted so that the network can be producing the outputs as close as possible to the known correct answers of training data. During the training stage, the network is learning the rule for associating the inputs with the target outputs. Due to the generalization capabilities of the neural networks, it performs similarly on data for testing that have not used for training [4].

There are several studies to predict monthly average global solar irradiation potential based on ANN method. Since ANN are highly nonlinear and require no prior assumption concerning the data relationship, they have become useful tool for predicting solar irradiation. Particularly, in the meteorological and solar energy resources fields, ANN based models have been successfully developed to model different solar radiation variable in many location. Jiang [5] developed estimation of monthly mean daily global solar irradiation using ANN method in China. The data period used are from 1995 to 2004 and the inputs for the networks are latitude, altitude and mean sunshine duration. The result indicated that MAPE of 3.75%, 5.43%, 0.16%, 4.96% and 0.16% for Kashi, Geermu, Shenyang, Chengdu and Zhengshou respectively.

Mubiru and Banda [6] explored the possibility of developing a prediction model using ANN to estimate monthly average daily global solar irradiation for locations in Uganda based on weather station data: sunshine duration, maximum temperature, cloud cover and location parameters: latitude, longitude, altitude. A correlation coefficient of 0.974 was obtained with mean bias error of 0.59 MJ/m² and RMSE of 0.385 MJ/m².

Mohandez *et al* (1998) used neural network technique for modeling monthly mean daily values of global solar radiation for locations in Saudi Arabia based on data: latitude, longitude, altitude and the sunshine duration as inputs. The result obtained MAPE for 10 locations used for testing, such as 10.7% for Tabuk station, 6.5% for Al-Ula station, 14.6% for Unayzah station, 10.5% for Shaqra station, 13.4% for Dawdami station, 10.1% for Yabrin station, 16.4% for Turabah station, 11.3% for Heifa station, 19.1% for Kwash station, 13.5% for Najran station [4].

Alawi and Hinai (1998) have developed ANN to predict solar radiation in Seeb location, a city in Oman. The input data to the network included: location parameters, month, averages of pressure, temperature, vapor pressure, relative humidity, wind speed and sunshine duration. The ANN model proposed performed an accuracy of 7.3% as the mean absolute percentage error [7].

From the above reviewed, ANN models have been successfully demonstrated to have potential in estimating monthly average global solar irradiation by many researchers in many countries. However, these ANN models are location dependent and specific to each location. So far, there is no report about prediction of solar radiation potential for Indonesia by using ANN method. We aim to develop neural network based models for predicting monthly average global solar irradiation potential in Manado, a city in Indonesia based on meteorological data available.

3. Data and Developed model of ANN

This section is described about database used in this study and the method of ANN application for predicting global solar irradiation in island area of Indonesia.

As case study in Manado, a city situated in the Sulawesi island (*Figure 1*) was chosen to represent meteorological data measurement for training in the ANN based. The data is taken from meteorological station in Manado, which is situated at altitude 1.3 N, longitude 124.9 E and altitude 85 m. Manado lies in equator where has solar radiation through all the year with average solar radiation 5.73 kWh/m² and average sunshine duration 5.8 hours a day [8].

Figure 1. Location of study in island country of Indonesia.

The database consists of 5 years data meteorological data, which is collected from 2005 until 2009 by meteorological station in Manado city. The data were split into two, as 48 months (January 2005 to December 2008) were used for training a neural network and the rest data for testing. The model was tested to predict solar irradiation values for Manado location over a 12 month period. In this study, the training of the models uses a feed-forward neural network with Back Propagation training algorithm. The inputs were monthly average sunshine duration (hours), monthly average maximum wind speed (m/s), monthly average relative humidity, monthly average rainfall (mm), monthly average temperature (°C). The output was monthly average global solar irradiation potential. Training the model was done using a neural net simulator known as "NeuroShell."

Wind speed is taken by anemometer, sunshine duration was measured with a Campbel-Stokes heliograph, temperature is measured by thermometer, rainfall is taken by rain gauge measurement and solar radiation was recorded manned by Gun Bellani pyranometer. No information is available regarding instrument calibration and other possible error during measurement. However, based on previous work that has been studied by Rumbayan (the author) [8] to verify data, found the measured data in meteorological station appears to be satisfactory as the values compare well with those at nearby location, such

as Kuching at the latitude 1.5 N and longitude 110.3 E and Senai, Malaysia at latitude 1.6 N and longitude 103.7 E.

Since there is no method to predetermine the best combination of neuron/layers, as this depend on the specific model, the physical process and the training data that the network will simulate. From references, there are some empirical relationships to solve this problem but the best method is up to the researcher to build several models and choose the best suited for the particular application [9].

Based on this, the training in this study starts with defining the parameters with minimum error by trial and error using fixed and change parameter one by one, then use the selected parameter in neural network for several case of the number of neurons in the hidden layer. Then the model of ANN was used for training and testing. By several attempts from 3 to 5 neurons in the hidden layer, the least error was found. This configuration is used to present the network model to be reported in this study.

In this study, the process of neural networks for predicting the monthly global solar irradiation potential is divided into two sections, i.e training and testing.

a. Training section

The process of the research is done by two thresholds in the training section. First, varying the parameter (by trial and error attempt) in order to determine the appropriate parameters with the optimum value. Second, varying the number of neurons in hidden layer in order to get minimum error value. The number of hidden layer is set to vary from 2 to 4 in single hidden layer. To train the network, 48 monthly data from historical meteorological data is used by defining input and output.

b. Testing section

In the testing section, data of monthly average for one year were used as an evaluation. By using ANN model, the result of monthly solar irradiation has been identified, then it has been compared with the actual measured of meteorological data. Predicted values of global solar irradiation were compared with measured values taken from meteorological data through analysis of error, in terms of Mean Absolute Percentage Error (MAPE), Mean Absolute Bias Error (MABE) and Root Means Square Error (RMSE).

Models are evaluated in terms of errors that are given by equation 1, 2 and 3 where Hmi is measured values and Hpi is predicted values for monthly average global solar irradiation, n is the number of testing examples.

The mean absolute percentage error (MAPE) is defined by equation 1.

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{H_{mi} - H_{pi}}{H_{mi}}\right| \quad (1)$$

In MAPE, sign of errors are neglected and percentage errors are added up to obtain the average. MAPE is commonly used in quantitative forecasting methods because it produces a measure of relative overall fit. It usually expresses accuracy as a percentage. The mean absolute bias error (MABE) is defined by equation 2.

$$MABE = 1/n\ \Sigma_i (i=1)^n \equiv [\ |H_i mi\ ]\ - H_i pi\ |\ \ (2)$$

The MABE represents the absolute value of the bias error and is a measure of the goodness of correlation.

The mean absolute bias error (MABE) is defined by equation 3.

$$\mathrm{RMSE} = \frac{1}{n}\sqrt{\sum_{i=1}^{n}(H_{pi} - H_{mi})^2} \quad (3)$$

The RMSE gives information on short-term performance by allowing a term by term comparison of actual deviations between estimated and measured values. The RMSE is the fundamental measure of accuracy, as the lower the RMSE, the more accurate the estimate.

4. Simulation Result and Evaluation

This section presents the results of ANN model simulation and evaluation by comparing between measured and predicted neural network values based on statistical error. The neural networks with multilayer perception (MLP) type were trained to predict global solar irradiation potential for 12 monthly data as testing.

There was no significant difference in the use of one, two and three hidden layers architectures. One hidden layer was used in order to minimize the complexity of the proposed ANN model. One hidden layer is chosen to simplify the network architecture proposed. Tymvios [10] found that increasing the number of hidden layers from one to two do not necessary lead to improve the performance of neural network. Also increasing the number of hidden layer to three could lead to performance deterioration.

The parameters of learning rate, momentum, initial weight were selected from trial and error attempts, by setting 2 parameters fixed and vary 1 parameter in software simulation. The parameter selection of learning rate, momentum, initial weight of 0.3, 0.5, 0.7 respectively were used as optimum parameter for ANN model for reporting the result of prediction. The above parameter has been used for training the ANN model with varying neurons in single hidden layer by MLP type.

The amounts of the neurons within hidden layers are optimized during learning step of the ANN, with criteria of statistical error. This study explores three models of MLP structures i.e two, three and four neuron at hidden layer. The MLP structure of 5-2-1 indicated the number of neurons in input layer is 5, the number of neuron in hidden layer is 2 and the number of neuron in output layer is 1. The MLP structure of 5-3-1 indicated the number of neurons in input layer is 5, the number of neuron in hidden layer is 3 and the number of neuron in output layer is 1. The MLP structure of 5-4-1 indicated the number of neurons in input layer is 5, the number of neuron in hidden layer is 4 and the number of neuron in output layer is 1.

Statistically error for 3 models of ANN was evaluated based on MAPE, MABE and RMSE criteria from test data. Data testing were not included as part of ANN training data. Hence, these results demonstrate the generalization capability of this method over unseen data.

The evaluations of predicted and measured values for 3 models were presented in the ***Table 1***.

TABLE 1. Statistically error (MAPE, MABE and RMSE) for 3 models of ANN proposed with different structures

MLP structure	MAPE (%)	MABE (MJ/m²)	RMSE (MJ/m²)
5-2-1	4.8	0.59	0.22
5-3-1	6.1	0.76	0.26
5-4-1	6.5	0.81	0.29

After several trials in varying the number of hidden neuron, it was found two amounts of neuron to be least error for the testing process in the neural network. Performance of predicted values of ANN model 1, 2, and 3 as compared to measured values of monthly average daily values of global solar irradiation on horizontal surface for 3 configuration models were presented in ***Figure 2a***, ***2b*** and ***2c***.

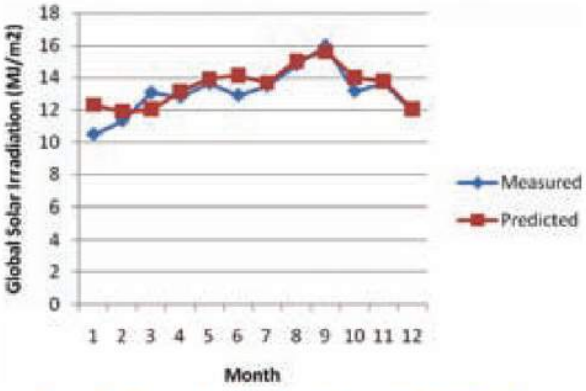

Figure 2a. Measured and predicted values with 5-2-1 MLP structure

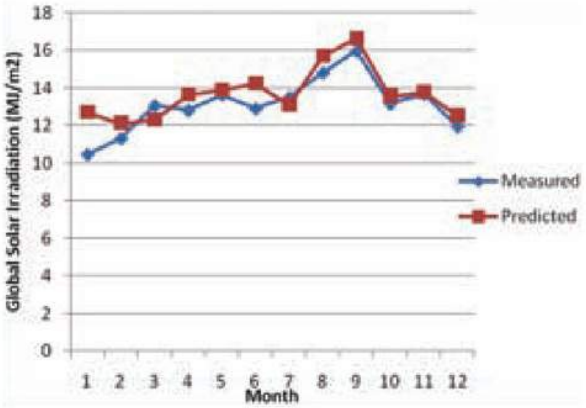

Figure 2b. Measured and predicted values with 5-3-1 MLP structure

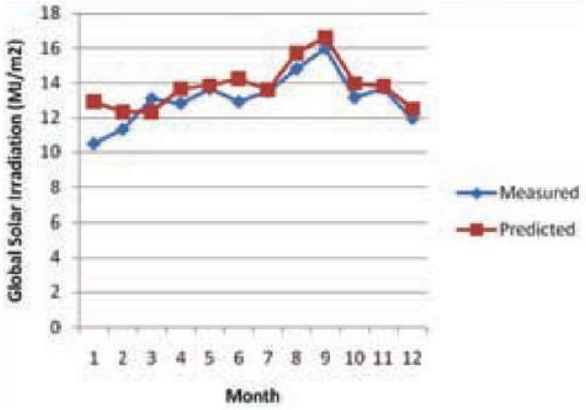

Figure 2c. Measured and predicted values with 5-4-1 MLP structure

The best estimator with the minimum error with two neurons at hidden layer was chosen to be presented in this paper (*Figure 3*). The result of measured and predicted values of monthly global solar irradiation for testing stage in ANN model with 5-2-1 configuration were shown in *Table 2*.

The best predicted versus measured irradiation values for ANN model was presented in *Figure 2a* and the values were presented in *Table 2*. The maximum difference occurred for January, follow by June and March. Other 9 months (for February, April, May, July, August, September, October and December) were shown good agreement between measured and predicted values with acceptable difference value between 0.09 to 0.85 MJ/m^2.

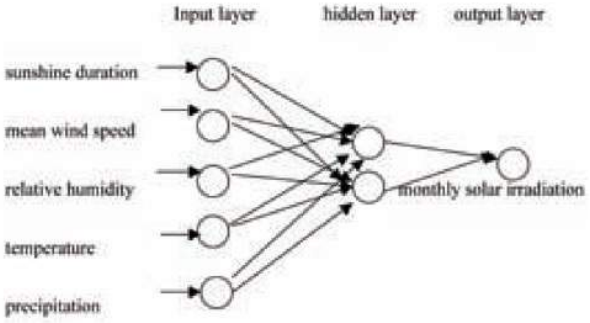

Figure 3. ANN model developed for predicting monthly global solar irradiation potential for Manado, Indonesia.

TABLE 2. The result for testing stage in ANN model with configuration 5-2-1

Month	Predicted (MJ/m^2)	Measured (MJ/m^2)	Difference
January	10.48	12.31	-1.83
February	11.33	11.9	-0.57
March	13.08	12.04	1.04
April	12.82	13.15	-0.33
May	13.65	13.95	-0.3
June	12.92	14.15	-1.23
July	13.51	13.69	-0.18
August	14.82	15.06	-0.24
September	15.99	15.61	0.38
October	13.17	14.02	-0.85
November	13.69	13.78	-0.09
December	11.96	12.05	-0.09

It was found that the prediction of global solar irradiation obtained for the 12 months testing data well compared with the actual measured value, giving a correlation coefficient of 0.86 and MABE is 0.59 MJ/m^2. It can be seen that in general, there it was good agreement between measurements and predictions value of monthly global solar irradiation potential in Manado, Indonesia. This shows the potential of ANN method to predict monthly global solar irradiation in island area of Indonesia in reasonable accuracy.

Comparison between the MAPE of the proposed ANN model in this study and the MAPE of other selected references has been showed in *Table 3*.

TABLE 3. Comparison between the MAPE of the proposed ANN model in this study and the MAPE of four selected references

References	Location of study	MAPE (%)
Mohandes et al,1998 [11]	Al Ulah, Saudi Arabia	6.5
Alawi and Hinai, 1998 [7]	Majees, Oman	7.3
Sozen et al 2005 [11]	Siirt, Turkey	6.7
Jiang, 2008 [5]	Germu, China	5.4
Present study by author, 2010	Manado, Indonesia	4.8

Similar studies have been reached by many studies in the other area dealing with meteorological data with reasonable accuracy. The proposed ANN model for this study performs a smaller MAPE.

Conclusions

This study has been proposed the model of ANN to predict monthly average daily global solar irradiation in horizontal surface in Manado, Indonesia as area of study. This study proves that ANN can be used predicting of global solar irradiation potential in Manado, Indonesia by using meteorological data.

In this research, an accuracy of 95% and a mean absolute percentage error of 4.8% can be achieved by the best estimator with MLP structure that consists of 5, 2, 1 neurons in input layer, hidden layer and output layer respectively. Result has shown good agreement between the estimated and measured values of monthly average global solar irradiation. A correlation coefficient of 0.86 was obtained with mean absolute bias error of 0.59 MJ/m² and RMSE of 0.2 MJ/m². The feed-forward back propagation algorithm with single hidden layer was used in this analysis.

For further study, it is considered to develop prediction model for many location of Indonesia, where spread out from eastern to western part of Indonesia in order to represent the whole solar irradiation potential for this country. This study plan can be introduced neural network technique for modeling the spatial variation of global solar irradiation in Indonesia.

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53 Dalal Al-Sirri. "Predicting Lower Fars Heavy Oil Molar Compositions Using Artificial Neural Networks", Proceedings of SPE Heavy Oil Conference and Exhibition HOCE, 12/2011 <1%
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54 ADNAN SOZEN. "A Study for Estimating Solar Resources in Turkey Using Artificial Neural Networks", Energy Sources, 12/1/2004 <1%
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55 Jin, Z.. "General formula for estimation of monthly average daily global solar radiation in China", Energy Conversion and Management, 200501 <1%
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56 Xiaodong Gao, Pute Wu, Xining Zhao, Yinguang Shi, Jiawen Wang. "Estimating <1%

spatial mean soil water contents of sloping jujube orchards using temporal stability", Agricultural Water Management, 2011
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57 Ertekin, C.. "Comparison of some existing models for estimating global solar radiation for Antalya (Turkey)", Energy Conversion and Management, 200003 <1%
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Lampiran 6

LEMBAR
HASIL PENILAIAN SEJAWAT SEBIDANG ATAU *PEER REVIEW*
KARYA ILMIAH : JURNAL ILMIAH

Judul Karya Ilmiah (artikel	:	Prediction of Solar Irradiation Potential in Island Area of Indonesia using Artificial Neural Network Method.
Nama Penulis	:	Meita Rumbayan, Ken Nagasaka
Jumlah Penulis	:	2
Status Pengusul	:	Penulis pertama
Identitas Jurnal Ilmiah	: a. Nama Jurnal	: The Official Journal of Science and Technology
	b. Nomor ISSN	: 2351-8340
	c. Volume, Nomor, Bulan Tahun	: 8, 10, 2010
	d. Penerbit	: ISESCO Science and Technology Vision
	e. DOI artikel (jika ada)	:
	f. Alamat web Jurnal	: https://www.isesco.org.ma/ISESCO_Technology_Vision/NUM10/content.html
	g. Terindeks di Google Scholar	

Kategori Publikasi Jurnal Ilmiah (beri √pada kategori yang tepat)

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- ☐ Jurnal Ilmiah Nasional/Nasional terindeks di DOAJ, CABI, COPERNICUS *

Hasil Penilaian *Peer Review* :

Komponen yang dinilai	Nilai Maksimal Jurnal Ilmiah			Nilai Akhir yang Diperoleh
	International/International Bereputasi*	Nasional Terakreditasi	Nasional	
a. Kelengkapan unsur isi artikel (10%)	40			8
b. Ruang lingkup dan kedalaman pembahasan (30%)	40			24
c. Kecukupan dan kemutakhiran data /informasi dan metodologi (30%)	40			24
d. Kelengkapan unsur dan kualitas terbitan/jurnal (30%)	40			24
Total = 100%				
Nilai Pengusul				80

Catatan penilaian artikel oleh Reviewer :

Tidak Sesuai

Manado, November 2018
Reviewer,

Prof. Dr. Ir. Fabian J. Manoppo, M.Agr
NIP. 196210141992031001
Unit kerja : Fakultas Teknik Universitas Sam Ratulangi

HASIL PENILAIAN SEJAWAT SEBIDANG ATAU *PEER REVIEW*
KARYA ILMIAH : JURNAL ILMIAH

Judul Jurnal Ilmiah (Artikel) : Prediction of Solar Irradiation Potential in Island Area of Indonesia using Artificial Neural Network Method.

Penulis Jurnal Ilmiah : Meita Rumbayan, Ken Nagasaka

Identitas Jurnal Ilmiah :
a. Nama Jurnal : The Official Journal of Science and Technology
b. Volume / Nomor : 8/ 10
c. Edisi (bulan/tahun) : 2010
d. Penerbit : ISESCO Science and Technology Vision
e. Jumlah halaman : 7 Halaman

Kategori Publikasi Jurnal Ilmiah (beri ✓pada kategori yang tepat) :
☑ Jurnal Ilmiah Internasional
☐ Jurnal Ilmiah Nasional Terakreditasi
☑ Jurnal Ilmiah Nasional Tidak Terakreditasi

Hasil Penilaian *Peer Review* :

Komponen Yang Dinilai	Nilai Maksimal Jurnal Ilmiah			Nilai Akhir Yang Diperoleh
	Internasional ☑	Nasional Terakreditasi ☐	Nasional Tidak Terakreditasi ☐	
e. Kelengkapan unsur isi buku (10%)	88			
f. Ruang lingkup dan kedalaman pembahasan (30%)	90			
g. Kecukupan dan kemutahiran data/informasi dan metodologi (30%)	90			
h. Kelengkapan unsur dan kualitas penerbit (30%)	90			
Total = (100%)				

Malang, November 2017

Reviewer

Prof. Dr. Eng. Ir. Abraham Lomi, MSEE, MIET, SMIEEE
NIP.Y. 1018500108
Unit kerja : Jurusan Teknik Elektro
Institut Teknologi Nasional Malang

Lampiran 6

LEMBAR
HASIL PENILAIAN SEJAWAT SEBIDANG ATAU *PEER REVIEW*
KARYA ILMIAH : JURNAL ILMIAH

Judul Karya Ilmiah (artikel : Prediction of Solar Irradiation Potential in Island Area of Indonesia using Artificial Neural Network Method.
Nama Penulis : Meita Rumbayan, Ken Nagasaka
Jumlah Penulis : 2
Status Pengusul : Penulis pertama
Identitas Jurnal Ilmiah : a. Nama Jurnal : The Official Journal of Science and Technology
b. Nomor ISSN : 2351-8340
c. Volume, Nomor, Bulan Tahun : 8, 10, 2010
d. Penerbit : ISESCO Science and Technology Vision
e. DOI artikel (jika ada) :
f. Alamat web Jurnal :
https://www.isesco.org.ma/ISESCO_Technology_Vision/NUM10/content.html
g. Terindeks di Google Scholar ✓

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- ☐ Jurnal Ilmiah Nasional/Nasional terindeks di DOAJ, CABI, COPERNICUS *

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Komponen yang dinilai	Nilai Maksimal Jurnal Ilmiah			Nilai Akhir yang Diperoleh
	International/International Bereputasi* ✓	Nasional Terakreditasi	Nasional	
a. Kelengkapan unsur isi artikel (10%)	80			8
b. Ruang lingkup dan kedalaman pembahasan (30%)	80			24
c. Kecukupan dan kemutakhiran data /informasi dan metodologi (30%)	85			25,5
d. Kelengkapan unsur dan kualitas terbitan/jurnal (30%)	80			24
Total = 100%				
Nilai Pengusul				81,5

Catatan penilaian artikel oleh Reviewer :
Artikel terindeks.

Manado, 30 November 2017

Reviewer 2

Prof. Dr. Ir. Jefrey I. Kindangen, DEA
NIP. 196506031990031003
Unit kerja : Fakultas Teknik
Universitas Sam Ratulangi

Lampiran 6

LEMBAR (*FORM*)
HASIL PENILAIAN SEJAWAT SEBIDANG ATAU *PEER REVIEW*
KARYA ILMIAH : JURNAL ILMIAH (*JOURNAL*)

Judul Karya Ilmiah (artikel (*Title*)	: Prediction of Solar Irradiation Potential in Island Area of Indonesia using Artificial Neural Network Method.	
Nama Penulis	: Meita Rumbayan, Ken Nagasaka	
Jumlah Penulis	: 2	
Status Pengusul	: Penulis pertama	
Identitas Jurnal Ilmiah	: a. Nama Jurnal	: The Official Journal of Science and Technology
	b. Nomor ISSN	: 2351-8340
	c. Volume, Nomor, Bulan Tahun	: 8, 10, 2010
	d. Penerbit	: ISESCO Science and Technology Vision
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	g. Terindeks di Google Scholar	

Kategori Publikasi Jurnal Ilmiah (beri √pada kategori yang tepat)

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Hasil Penilaian *Peer Review* :

Komponen yang dinilai	Nilai Maksimal Jurnal Ilmiah			Nilai Akhir yang Diperoleh
	International/International Bereputasi*	Nasional Terakreditasi	Nasional	
a. Kelengkapan unsur isi artikel (10%)/ *Completeness of the content*	80			8
b. Ruang lingkup dan kedalaman pembahasan (30%)/ *The Scope and the depth of discussion*	80			24
c. Kecukupan dan kemutakhiran data /informasi dan metodologi (30%)/ *Sufficiency and updated data / information and methodology*	80			24
d. Kelengkapan unsur dan kualitas terbitan/jurnal (30%)/ *Completeness of elements and quality of publications / journal*	80			24
Total = 100%				80
Nilai Pengusul				

Catatan penilaian artikel oleh Reviewer /Note by reviewer :
This paper verifies that the prediction method of solar irradiation potential using ANN can overcome the difficulty and high cost for measurement. Those results are expected to apply for any locations in Indonesia

20

Tokyo, March 2018

Y. Nakanishi

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Prof. Dr. Yosuke Nakanishi
Graduate School of Environment and Energy Engineering
Waseda University