Implementation of ANFIS in Forecasting the Development of Renewable Energy in Indonesia in 2030

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ABSTRACT

An important energy fuel for power generation is utilizing petroleum products such as oil and coal. The use of basic fuels is increasing every year and the main fuel reserves are getting depleted/decreasing. In driving a generator, alternative energy is needed whose sources will not run out and can reduce the use of petroleum derivatives. This source is new and renewable energy. To ensure the development of new and renewable energy, it is important to forecast the development of new and renewable energy in Indonesia in 2030 using ANFIS. The results obtained in predicting the development of new and renewable energy in Indonesia in 2030 are 3,369.79 MW.

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1. INTRODUCTION

Energy is needed for human exercise, finance, family, business and transportation. Most of the world's energy supply comes from oil-based commodities, an inexhaustible resource. Energy needs are hung to continue to grow, while oil and coal-saving springs are running low. What's more, the use of oil-based commodities as energy adds to the carbon richness of the climate causing a risky air hazard. Correspondingly, it is very important to supply elective energy other than oil and coal. New and renewable energy (NRE) is one of the preferred sources of energy supply, because apart from being humble in influencing environmental damage, it also ensures energy protection for the future.

Currently, the need for electrical energy has become a basic need for life in carrying out social and financial activities to achieve a normal lifestyle. In accordance with the needs, the level of importance of electrical energy is seen as the level of compensation, economy, and achievement of a nation or region [1].

The availability of clean and healthy energy has become one of the goals of the 2030 financial progress, where limits on energy transport are a common problem and it is the obligation of the central government and neighboring countries to implement this goal. In Indonesia, ways to deal with new and harmless energy for the energy ecosystem are contained in the informal regulation no. 79 of 2014 concerning National Energy Needs (KEN). In the document, new energy and green energy are set to reach 23% in 2025, and by 2050 it will reach no less than 31%. Of course, dependence on oil and coal is assigned to be reduced, by 20% and 25%, separately. To achieve this goal, various efforts and efforts are needed whose elaboration and implementation are contained in the General Energy Plan (RUED) and General Energy Plan (RUED-P).

To meet the wider growth of new and sustainable energy, we must know the use of fossil energy since some time ago. Furthermore, the development of new and wider renewable energy power plants has a vital and essential task as an energy substitute for petroleum products, for example, coal and oil and supports the security of the electricity supply in Indonesia.

2. METHODS

Indonesia has different energy resources, both fossil energy and energy that can be maintained. Fossil energy may consist of coal, gasoline, combustible gas, and coal methane gas (CBM), while energy that is not harmful to ecosystems may consist of geothermal, large-scale water, smaller than normal hydro, biomass, wind, regulation based on sunlight, marine and nuclear energy. As shown by data from the Ministry of Energy and Mineral Resources in 2010, coal resources increased by 105.2 billion tons with deposits of 21.1 billion tons, which were spread over Kalimantan and Sumatra. Oil investment funds are worth 7.76 billion barrels, while gas fuel capacity is worth 157.14 TSCF spread over most of the Natuna Islands,

South Sumatra, East Kalimantan, and Tangguh (West Papua). The gas reserve fund from CBM is considered more significant than conventional gas stockpiling, reaching 453.3 TSCF, especially in the South Sumatra Basin and Kutai Basin. Geothermal storage is valued at 15,867MW spread over different locations with a normal absolute resource of 29,038 MW. The inclusion of very large hydro potentials indicated by the 1983 audit was 75,000 MW, which was repeated in the 1993 survey. In fact, in a Nippon Koei report focused on 2011, the inflow of very large water potentials after going through extra filtration was 26,321 MW, consisting of Exercises that have been carried out plus up to 4,338 MW, projects that have been prepared and those in progress are added. Up to 5,956 MW. Especially the 16,027 MW limit. Other available maintained assets are small-scale hydro, biomass, solar power generation, wind and marine energy. The potential for small-scale hydropower is 500 Mwe, biomass 49,810 Mwe, the solar system 4.80 kWh/m2/day, wind 9,290 Mwe and marine 240 Gwe[2].

1.1. **ANFIS**

The structure of ANFIS (Adaptive Neuro Fuzzy Inference System or commonly called Adaptive Network Based Fuzzy Inference System) is associated with the organization of the false brain but remembers its ability with a subtle induction framework. In the structure of Neuro-Fuzzy, the learning framework is in the brain associated with various valuable data mixtures to revive the limits of the Fuzzy Inference System [3].

The data used for the learning framework (planning) consists of data, ANFIS cut points, and test data that are in the ANFIS readiness period which is then equipped with learning collaboration on the data so that the results obtained later are by normal results. The setup with ANFIS uses crossbreed learning calculations, which incorporates the Least-Squares Error (LSE) system to find forward-generated values and uses Backpropagation Error (EBP) and slant plummeting retrogressively to address errors that occur in each layer[4]. ANFIS consists of five layers. The principle layer consists of fuzzified associations in which objective data and data are organized, all things considered. In the second and third layers, the inference cycle is completed which is used to conclude the fine rules using the Sugeno allowance where the results will be considered in the accompanying assessment. At layer 4, the following value request process is completed using LSE. At layer 5, the once-over pattern of the two results at layer 4. In ANFIS, the deduction framework Smooth (FIS) is located in layers 1, 2, 3 and 4 where FIS is the central determinant stored in brain organization[5]. After working on the forward flow, the backward flow estimation was completed to study the error values of each layer and change the data boundary values using the slope of the slope. The above computational cooperation will be repeated continuously until the error value meets the most outrageous error value not shown. The connection flow in the ANFIS system consists of five layers and is depicted in Figure 1.

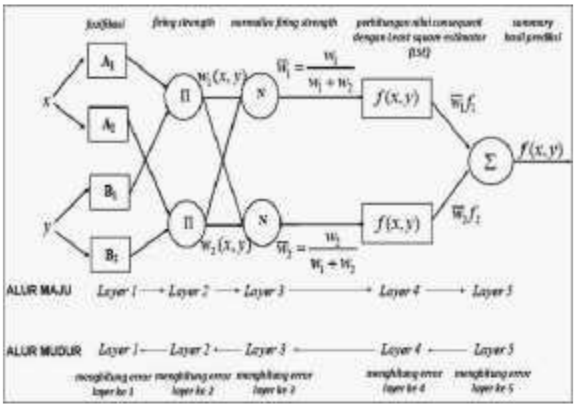

Figure 1. Structure of ANFIS

The process of this research will be explained in the flow chart in Figure 2.

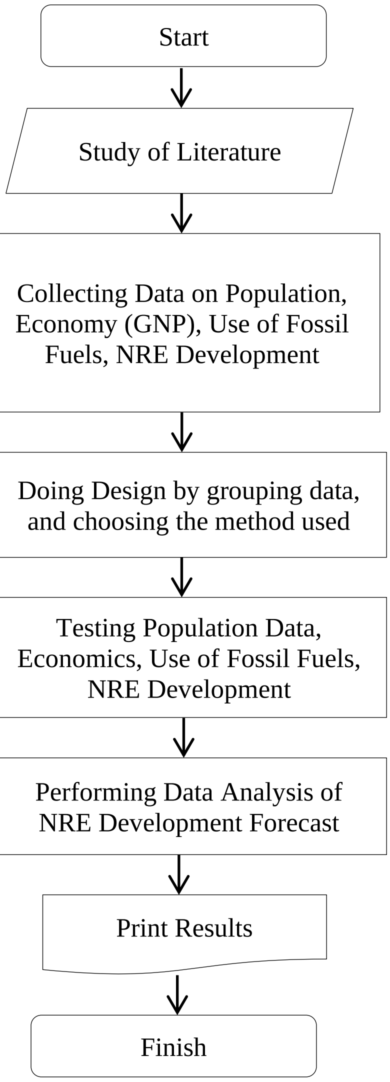

Figure 2. Research Flowchart

3. RESULTS AND DISCUSSION

The research data were obtained from the Indonesian Central Statistics Agency and the Ministry of Energy and Mineral Resources and RUPTL PT. PLN (Persero) can be seen in tables 1,2,3 and 4.

Table 1. Population Development Data in Indonesia

Year	Total Population (Millions)
2016	258,49
2017	261,33
2018	264,16
2019	266,91
2020	269,60

Table 2. Data on Economic Development of 2010 Constant Price GNI in Indonesia

Year	Total HK GNP 2010 (Trillion Rupiah)
2016	9433,0
2017	9813,3
2018	10211,5
2019	10615,1
2020	11010,1

Table 3. Data on the Development of Fossil Fuel Use in Indonesia

Year	Total Fossil Fuel Consumption (Million TOE)
2016	67,41
2017	72,13
2018	77,18
2019	82,58
2020	88,36

Table 4. Indonesia's RE Development Data

Year	Renewable Energy (MW)
2016	312
2017	632
2018	512
2019	560
2020	933

3.1. Forecast of New Renewable Energy Development in Indonesia

When entering data into the ANFIS program for testing, it will form an ANFIS block diagram. It can be seen in Figure 3.

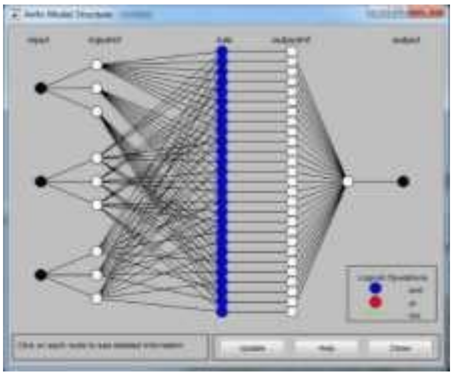

Figure 3. Structure of ANFIS

Figure 3 shows that ANFIS produces the number of nodes: 78, a number of linear parameters: 27, a number of nonlinear parameters: 27, a total number of parameters: 54, the number of training data pairs: 5, the number of checking data pairs: 0, the number of fuzzy rules: 27 The fuzzy rules can be seen in Figure 4.

Figure 4. Fuzzy Rule

In Figure 4, the expanding principles show that there are 27 guidelines formed from testing information on the development of new and renewable energy in Indonesia. Of the 27 principles formed by fuzzy, there is 1 decision that has the right result, which is contained in the fourteenth fuzzy rule. So when testing the information, it has an error of 0.0059934%. The results of these errors can be seen in Figure 5.

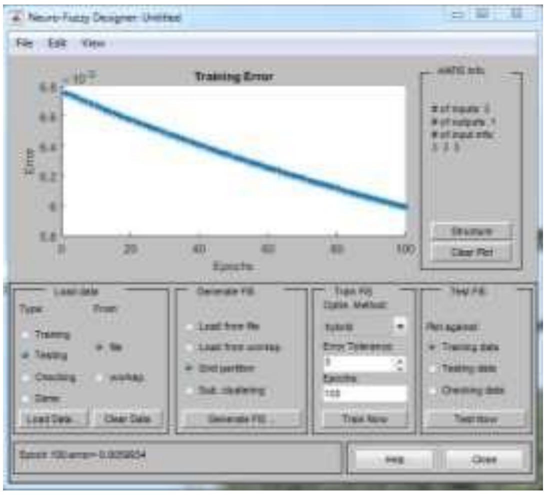

Figure 5. ANFIS Results

Based on Figure 5, it can be seen that the projection results on ANFIS have a very small error value with the actual data. So that the results of the forecast for the development of new and renewable energy in Indonesia in 2020-2030 can be seen in table 5.

Table 5. Results of Forecasting the Development of New Renewable Energy in Indonesia in 2020-2030

Year	Results of the Forecast of NRE Development in Indonesia (MW)
2020	932,94
2021	751,95
2022	647,96
2023	2027,87
2024	1669,89
2025	5543,66
2026	977,94
2027	990,94
2028	2457,85
2029	2483,85
2030	3369,79

4. CONCLUSION

This research produces a forecast of the development of new and renewable energy in Indonesia in 2030 using the ANFIS method of 3369.79 MW. The difference between the ANFIS results and the actual data has an error of 0.0059934%. It is hoped that this research will be able to assist the Ministry of Energy and Mineral Resources in making new and renewable energy forecasts or projections because the ANFIS method has very small errors.

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