Modeling of Analytic Hierarchy Process and Simple Additive Weighting for Selection of Regional Development Renewable Energy Center

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Abstract— Based on the law of energy, the government is required to develop potential alternative energy made of palm to overcome the crisis of electricity like in Riau. Considering that Indonesia has a large area that planted by palm and produce palm in high number, Riau is predicted to be able to develop the renewable energy center. Related to this, government policy is needed in determining the in the area based on the potential and predetermined criteria. Simple Additive weighting is a method of decision making based on a weighted sum capable of providing renewable energy-related decisions. The deciding factor is not the decision of ranking the results based on the main criteria such as plantation area and production results, but four other factors have the potential to influence the outcome. Likewise, the weighting using Analytical Hierarchy Process method is more efficient than the ordinary preference weighting because Eigen value does not affect the decision result significantly.

Keywords: *AnalyticHierarchy process, Eigen, Renewable Energy, Simple Additive Weighting*

I. INTRODUCTION (HEADING 1)

Energy development in Indonesia has changed from the exporting country into the importing country. . Both regional and center government have established policies to save the energy, but many parties perceive it does not run maximally. Energy crisis which happened in most of the corner regions in Indonesia gives negative impact to the growth of economy sector. Every year energy crisis always occurs in areas which produce main energy in this country, including Kalimantan and Riau.

Blueprint of national energy management 2006-2025 states that the biggest problems related to energy in Indonesia are the Indonesian Budget (APBN) still depends on oil and gas and subsidized fuel oil (BBM), energy industry doesn't run optimally, infrastructure of energy is still limited, not achieving the economic price and inefficient use of energy [10]. These problems cause the productivity of energy and economy in

Indonesia getting weaker, , especially the one which related to the problem in depending on fuel oil (BBM) where fuel fossil energy will decrease everyday [15].

Apart from the points above, based on the Law No. 30/2007 concerning the energy chapter 20 verse 4 stated that the provision and utilization of new and renewable energy should be increased by the central government and local governments according to their authorities. One of the renewable energy that is defined in the Law is biomass, the main ingredient of biomass is palm[8]. By using palm and palm waste as the main ingredients and using conversion technology of energy, the energy can be used to generate the electrical energy such as a fuel source of Steam Power Palnt (Pembangkit Listrik Tenaga Uap [PLTU]). The electrical energy produced by the energy conversion is highly dependent on the waste generated by the palm oil processing center [8].

Riau Province is a province with an area of 8.91 million Ha, it has the potential to produce the biggest palm oil in Indonesia because it has a plantation area of 2.26 million Ha with an average production of 6.93 million tons per year in the various districts [15]. Each year the productivity of Palm oil in Riau province has increased both in production and plantation area. It became an image of the realization of alternative energy made of palm oil for the foreseeable future with projections of waste produced as a substitute for fossil energy. From sources released by the Central Statistics Agency (Badan Pusat Statistik [BPS]) there is a decrease in the value of some area, it is due to the changes or replanting of palm oil which has reached the age limit.

The relation between energy alternative to palm oil production can not be separated with the condition of the sources which produce raw materials. The government is expected to coordinate and prioritize the policies related to equal distribution of energy in a region [14] . One of the real manifestation of the government's role is to make the selection

and scoring of the renewable energy development center in the form of decision-making.

In the 1980s Thomas Saaty introduced a method with a pattern that is often used in making decisions based on the theory that reflects the way the people think. In the development of this method, it can be use as an alternative in solving various problems such as paiired comparison and weighting, the method is named as the Analytical Hierarchy Process (AHP) [10]. AHP is one of the main series of many methods in Multi-attribute group decision- making (MADM), which is part of the Method of Multi-Criteria Decision Making (MCDM). This method is a method of decision making to establish the best alternative from a number of alternatives based on certain criteria [6], and a simple rangking models that can provide the best solution from a series of given alternatives [7]. To determine a decision from a set of criteria presented can be done by comparing the level of importance between the criteria with the other criteria in the form of paired comparison with hierarchy model [9]. Aside from AHP, SAW is also included in MADM group that presents the concept of seeking a weighted summation of rating the performance of each alternative on all attributes [13].

Dadan Kusdiana in his study stated that the utilization of new and renewable energy from palm oil waste should be increased by the central government and regional governments in accordance with their authorities [8]. Sameer Kumar (2013) pointed out that some MADM method is a simple method to rank the model which is able to provide the best solution from a set of given alternatives. On the other hand, SAW is a decision support method of weighting system which is able to provide the best decision [1].

This research is expected to provide the best solutions in determining the government's policy priorities in scoring areas based on modelling of AHP and SAW by using the time series data of the last 8 years and 6 defined criteria. It is also presented in making the decision based on paired comparison between criteria that are considered more accurate than the MADM models usuallyby giving the preferences of decision makers based on estimation[1].

II. LITERATURE REVIEW

A. Palm

Palm is a tropical plant that come from Nigeria (West Africa) first discovered in the wild. Palm oil entered Indonesia in 1848 by Dutchman, Mauritius Amsterdam.[5].waste of Palm oil consists of solid waste and liquid waste. The solid waste in the form of shield and fiber which are used to fulfill the energy needs in palm factory. Shield, rod, fiber frond, and an empty bunch of palm is used as fuel to survive the steam and electricity need.[2].

B. Bio Energy

Bioenergy is a renewable alternative fuel that is prospective to be developed, not only because of instability of oil's price, but also because of the limited production of oil in Indonesia.

C. Multi-Attribute Decision Making (MADM)

MADM is one of method in making decision to set the best alternative from a number of alternative based on certain criterion. These criterion usually in the form of measures, rules or standards that are used in decision making. Based on the goal, MCDM can be divided into two models, namely MADM and MODM[11].

The core of MADM are weighting and matrix decision. Weighting decision show the relatives importance from each criterion, $W=(w_1, w_2, w_3, \dots, w_n)$, while decisive matrix is a X matrix that scaled $m \times n$ that consist of elements x_{ij} that represent the rating from alternative A_i ; $i=1,2,3, \dots, m$ toward criterion c_j ; $j=1,2,3, \dots, n$ [11].

D. Simple Additive Weighting (SAW)

SAW method is usually called Weighted Summation Method. The basic concept of SAW is to find out a weighted summation of rating the performance of each alternative on all attributes. [6] The steps to solving by using SAW method as follows[10][11]:

1. Determining the criterion that will be guidance in deciding decision such as C_i .
2. Determining the suitable rating in each of criteria.
3. Making decision matrix based on criterion (C_i), then doing matrix normalization based on the similarities that accommodated with kinds of attributes (benefit or cost), thus get the normalization matrix r .

$$r = \begin{cases} \frac{x_{ij}}{\max_i x_{ij}} & \text{If } j \text{ is benefit attribute} \\ \frac{\min_i x_{ij}}{x_{ij}} & \text{If } j \text{ is cost attribute} \end{cases} \quad (1)$$

4. Result score is obtained from the ranking process such as summation and multiplication normalization matrix R to weight vector in order to obtain highest value that chosen as best alternative (A) as solution.

$$v_i = \sum_{j=1}^n w_j r_{ij} \quad (2)$$

III. RESEARCH METHODOLOGY

This research was based on 6 assessment criterion; The Number of Villages (TNV), The Number of Society (TNS), Population Density (PD), The Wide of Palm Plantation (WPP), The Production of Plantation (TPP), The Total Number of Palm Factories (TPF), and it also consist of 142 alternative district /sub district in Riau Province that will be selected to develop main energy that refers to time series data 2005-2012. This methodology can be shown as this picture below.

Fig. 1 Research Methodology

In choosing the criterion was involved the expert in order to get the information correctly and accurately and it also involved supporting decision committed in renewable energy. Data criterion that used also based on Department Estate Crop and Central Bureau Statistics Riau Province. In weighting the criterion based on the expert determination. This scoring also based on the process toward AHP method by using pairwise comparison until getting Eigen value. Eigen value that got from AHP calculation will be used as the quality of preferences in MADM method.

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The goal of this research was reaching a ranking decision of Area in Riau province that can be built to develop renewable energy that assessed from many aspects and secondary data by using SAW method.

IV. DATA ANALYSIS

There were two analysis steps in this paper; first, it was related to weighting by using AHP method to give the preferences value in making decision. Second, ranking and defining of decision based on SAW method.

A. Weighting Analysis

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

Weighting is a requirement from some models of MADM making decision. This research used paired comparison method in defining weighting. Paired comparison was done by comparing 1 criterion and other which accordance to expertise in order to find out agent value. Paired comparison from 10 experts related to renewable energy that can be seen from the table below.

TABLE 1. CRITERION OF PAIRWISE COMPARISON EIGEN.

Criterion	Q-1	Q-2	Q-3	Q-4	Q-5	Q-6	Q-7	Q-8	Q-9	Q-10
TNV	0.4176	0.0350	0.1093	0.2074	0.2074	0.2077	0.2246	0.1859	0.0590	0.2072
TNS	0.3286	0.1733	0.1093	0.0919	0.0919	0.0900	0.0942	0.0924	0.2685	0.3030
PD	0.1259	0.3615	0.0222	0.0221	0.0221	0.0222	0.0214	0.3205	0.1630	0.0756
WPP	0.0702	0.0445	0.3685	0.3709	0.2856	0.3290	0.3405	0.1796	0.2668	0.1116
TPP	0.0349	0.0365	0.3685	0.2856	0.3709	0.3290	0.2979	0.1865	0.0884	0.2022
TPF	0.0227	0.3492	0.0222	0.0221	0.0221	0.0222	0.0214	0.0350	0.1543	0.1004

From the table above, the average of eigen value as followed 0.1861 0.1643 0.1156 0.2367 0.2200 0.0772. The average of eigen value was used as weighting frequency of SAW method to determine rank decision. All of value Eigen already tested by Consistence Ratio with the result is lower than 10% or lower than 0.1 with simulation in Q-2 as followed:

TABLE 2. MATRIX OF PAIRWISE COMPARISON Q-2

Criterion	TNV	TNS	PD	WPP	TPP	TPF
TNV	1.00	0.14	0.11	1.00	1.00	0.11
TNS	7.00	1.00	0.33	3.00	7.00	0.33
PD	9.00	3.00	1.00	7.00	9.00	1.00

Criterion	TNV	TNS	PD	WPP	TPP	TPF
WPP	1.00	0.33	0.14	1.00	1.00	0.14
TPP	1.00	0.14	0.11	1.00	1.00	0.14
TPF	9.00	3.00	1.00	7.00	7.00	1.00

The result of matrix Consistence Ratio from matrix above as followed: Weighted Sum Vector: 0.2184, 1.0417, 2.1856, 0.2727, 0.2289, 2.1126; Consistence Vector: 6.2452, 6.0114, 6.0461, 6.1237, 6.2725, 6.0493; Lambda (λ): 6.1247; ConsistenceIndex: 0.0249; ConsistenceRatio: 0.0201 or 2.01%

B. Defining Decision Analysis

Making decision analysis comprised SAW method that consisted of some steps, some of them did based on alternative to determining the rating of importance which consists of benefit and cost. Alternative based on benefits consists of TNV, TNS, WPP, TPP, and TPF criterion while alternative based on cost was PD criteria with a score which is given as follows:

TABLE 3. IMPORTANT ALTERNATIVE

Important score		Benefit		Cost	
Bottom	Top	Level	Rating	Level	Rating
0.0000	0.2500	Less importance	1	Very important	1
0.2600	0.5000	Important enough	2	important	2
0.5100	0.7500	important	3	Important enough	3
0.7600	1.0000	Very important	4	Less importance	4

TABLE 4. SELECTED ALTERNATIVE BASED ON SAW METHOD

No	Sub District	2005	2006	2007	2008	2009	2010	2011	2012
1	Bagan Sinembah	0.7293	0.7335	0.7885	0.8489	0.8489	0.8489	0.8489	0.7897
2	Tapung	0.6344	0.6344	0.5753	0.6344	0.7445	0.6895	0.7445	0.7995
3	Mandau	0.6122	0.6714	0.6714	0.6508	0.7100	0.7650	0.7100	0.6634
4	Pinggir	0.5300	0.5892	0.6527	0.6212	0.6212	0.6170	0.5813	0.5813
5	Tapung Hilir	0.4877	0.5468	0.4877	0.5468	0.6569	0.6019	0.6569	0.6695

The average percentage of selected alternative can be seen in diagram below:

Fig. 2: The average percentage of selected alternative

Alternative that will be determined consists of 142 sub districts from 12 districts in Riau Province in 2012, the result of normalization based on similarities 1;

...	...	...	...	...	...	...
50	0.2500	0.2500	1.0000	0.2500	0.2500	0.2500
51	0.2500	0.2500	1.0000	0.2500	0.2500	0.2500
52	0.2500	0.2500	1.0000	0.2500	0.2500	0.2500
53	0.5000	0.5000	1.0000	0.5000	0.7500	0.5000
54	0.7500	0.2500	1.0000	0.2500	0.2500	0.2500
55	1.0000	0.5000	1.0000	0.5000	1.0000	1.0000
56	0.5000	0.2500	1.0000	0.7500	0.7500	1.0000
57	0.5000	0.5000	1.0000	1.0000	0.5000	0.5000
...	...	...	...	...	...	...

Matrix normalized according to equation 2 it will be multiplied by the weighting preferences eigen value AHP method. The results of ranking decisions during the last 8 years is determined by taking the first rank of the top 15 in accordance with the rules Consistence Ratio AHP. The analysis conducted on 15 selected alternatives there are 5 qualified alternatives in each of alternative included in selected criteria annually. This is the selected alternative with the result of SAW methods as follows:

Five selected alternatives are compared with main criteria in development of renewable energy, namely WPP and TPP. From the comparison can be seen how much the influence both main criterion toward the result analysis of ranking by using SAW method. The table below shows the comparison percentage by using SAW method between WPP and TPP.

Fig 3: Comparison Percentage

From the picture above, it can be seen that method result is not always influenced by dominant criteria such as WPP and TPP. It can be seen from diagram above where Tapung Hilir categorized as last ranking but has higher TPP than others and Pinggir also categorized as last ranking but has the secondary highest in WPP. It happens because there are other supporting criterion TNV, TNS, PD and TPF.

V. CONCLUSION

The result of the research can be concluded that determining factors from the result of ranking decision are not based on important ranking in main criterion, namely WPP and TPP, but there are four other factors such as TNV, TNS, PD and TPF which has potential to influence the result. While the preferences weight based on pairwise comparison assessment AHP are more efficiently to compare with regular weight. It can be shown from there was no effect the changing of weight significantly toward the reach goal. While for the calculating of the result of SAW was really influenced by value in important alternative based on benefit and cost. From the result, it obtained 4 important rating will be owned different result with more or less from 4 important rating. The result of calculation in each of alternative or sub district every year has the result that tends did not constant. It caused because the influence of criterion data that usually change.

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