Selection of the best public fuel filling stations with analytical hierarchy process in Tangerang Regency

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ABSTRACT

Energy is one of the main factors in supporting mobility in activities. Gas Stations (SPBU) are one way that people can get energy. In its operations, gas stations must be able to provide the best service to consumers so that maintaining consumer loyalty. This study aims to be able to choose the best Gas Stations (SPBU) with Analytical Hierarchy Process (AHP) method. The criteria used are based on previous research and based on the results of expert analysis so that the selected criteria are used as a model in decision making, namely management, sales, services, facilities and variations of fuel products. For alternatives to be evaluated are 5 gas stations located in the Legok area, Tangerang, Banten. Based on the calculation of the pairwise criterion comparison matrix in the AHP method, eigenvalues are obtained to perform consistency tests. after processing and analysis, it is known that the highest criterion is service and the lowest is sales. And alternative calculation results obtained that the gas station 5 is the best alternative chosen.

1. Introduction

Energy is a strategic sector and has an important role in the achievement of social, economic, and environmental goals for Sustainable Development and is a supporter of national economic activity (Konstantinos et al., 2019). Energy is absolutely needed by everyone to support their activities including to be able to move places, delivery of goods and others. Fuel oil (BBM) is one of the energy that is very often used by us. Fuel oil is a very vital commodity, and has strategic value for the life of society and the state. One mechanism to get fuel that can be done is through a fuel distributor. In Article 5 of the EMR Regulation Number 13 of 2018, one of the forms of fuel distribution is the general fuel filling station (SPBU) (Peraturan Menteri Energi Dan Sumber Daya Mineral Republik Indonesia Nomor 13 Tahun 2018 Tentang Kegiatan Penyaluran Bahan Bakar Minyak, Bahan Bakar Gas Dan Liquefled Petroleum Gas, 2018) Gas station is a familiar thing for those of us who daily use private vehicles to travel.

The best gas station selection solution will be completed in this study is to use the method of Multi Criteria Decision Making (MCDM). In this study supplier selection is done by applying Multiple Criteria Decision Making (MCDM) is a decision-making method to determine the best alternative from a number of existing alternatives based on certain criteria (Doaly et al., 2019). The MCDM method used in this research activity serves to determine the selection of the location point of the gas station-Hub so that it requires criteria that support it. In the MCDM method itself must contain three elements, namely attribute elements, objective elements, and the last is the objective element. The multi-Criteria Decision-Making Model (MCDM) as a quantitative approach can consider many relevant qualitative and quantitative objectives (Agung N. Pramudhita et al., 2015). Pramudhita et al. (2015) means that Multi Criteria Decision Making (MCDM) is one of the methods or ways that are most widely used when making decisions (Agung et al., 2015). While in the study Rahardjo et al. (2000), Multi Criteria

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Decision Making (MCDM) explains that it is a decision-making technique by choosing from several available alternatives (Rađenović & Veselinović, 2017) (Rahardjo et al., 2000). Meanwhile, the purpose of MCDM is to select the best alternative from a variety of exclusive alternatives available and interrelated on the basis of general performance in a variety of criteria or attributes determined by the decision-making (Santika et al., 2021).

Analytic Hierarchy Process (AHP) is one of the successful Multi Criteria Decision Making (MCDM) methods in academic research and Application Engineering. Thomas Saaty first introduced a well-known method named Analytic Hierarchy Process (AHP) to help solve complex problems and conflicting criteria in decision making (Chi & Trinh, 2016)(Barrios et al., 2016). AHP (Analitycal Hierarchy Process) is a model in the Management Decision System that is intended to help us and utilize data in making comprehensive and structured decisions (Pelorus & Karahalios, 2017).

In its development, gas stations continue to transform to compete with other gas stations to be able to improve the quality, internal value, quality and provide the best things for the community. This is done in order to create satisfaction for consumers, so that consumers can return to fill up fuel at their gas stations, form loyalty and make the continuity of gas station operations continue to be maintained and increased.

In District Legok, Tangerang, Banten there are 5 gas stations that have been operating. So the need for research that can describe the quality of the 5 gas stations based on criteria that have been established based on previous research. The results of this study are expected to provide benefits to relevant agencies in determining the gas station in the District Legok, Tangerang, Banten to be the best gas station selected. Supported by AHP methods that have been tested in solving decision-making problems, it is expected that the element of objectivity in decision making can be emphasized so that human error can be minimized, accelerate the stages of data processing, decision-making stages, rules and / or policies of a leader in determining the best gas station.

2. Methods

In conducting this research on the selection of the best gas station by using the method of Multi Criteria Decision Making (MCDM). The MCDM method used in this research activity serves to determine the selection of the location point of the gas station-Hub so that it requires criteria that support it both in terms of aspects of benefits, opportunities, costs and risks (Astuti & Amran, 2011). One of the methods of MCDM is AHP (Analytical Hierarchy Process). Analytical Hierarchy Process (AHP) is a decision support model that outlines multi-factor or multi-criterion problems (Moengin & Adisuwiryo, 2017). The advantage of the AHP model compared to other decision-making models lies in its ability to solve multiobjective problems with multicriteria. Most existing models use single objectives with multicriteria. Linear Programming models, for example, use a goal with many constraints (criteria). The advantages of this AHP model are more due to its high flexibility, especially in making hierarchies. This flexibility allows AHP models to capture multiple objectives and multiple criteria at once in a model or hierarchy (Sri Ipnuwati et al., 2018).

The first stage in this study with the study of literature, namely by collecting references related previous research along with information from experts to be able to determine the selected criteria that will be used in determining the purpose of the study, namely the selection of the best gas station. The second stage is to identify the associated gas stations within the research area which is then used as an alternative to the best gas stations. Based on the first and second steps, the team conducted field observations and licensing reviews to the relevant parties, namely by visiting directly to the gas stations that were the object of research. The next step is to define the objectives, criteria, alternatives and research objectives into the AHP hierarchy tree. The fourth step is to design paired comparison questionnaires using criteria and alternatives that have been determined. The next step is to collect data, by filling out questionnaires by experts so that data is obtained as needed for making Analytical Hierarchy Process (AHP). The sixth step is by processing the data obtained and then carried out consistency test analysis to obtain the weight of the criteria, alternative weights and conclusions of the best gas stations selected.

In collecting data, conducted direct observation in the field and conduct direct interviews with managers of business entities responsible for all matters concerning the performance of the dealer in the region or area of work, namely Tangerang, Banten and representatives of the government in charge of the distribution of fuel in Indonesia. Then given some questions related to fuel distributors located in the District Legok which is still actively operating up to the time of data collection is done.

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Input	Activities	Method	Output
References bibliography	Determination of criteria	Literature Studies	Selection criteria for the best gas stations
Expert experience		Focus Group Discussion	
SPBU in the study area	Determination Of Alternatives	Analysis and evaluation of SPBU data	Alternatives SPBU
Goals	Making AHP hierarchical structure	AHP	AHP structure
Criteria			
Alternatives			
Criteria	Questionnaire Design pair wise comparisons	Method pair wise comparisons	Questionnaire
Alternatives			
Respondent	Dissemination Of Questionnaires	Expert Assessment	Value of pair wise comparisons to criteria and Alternatives
Questionnaire			
Questionnaire Filling	Questionnaire data processing	Consistency Test	Weight criteria
			Weight alternatives
			Selected alternatives

Fig. 1 Research methods.

The Analytical Hierarchy Process (AHP) is a theory of measurement. According to Saaty, to make decisions in a good and appropriate way, several priorities are needed, and decision – making should be broken down into steps as follows:

a. First, define a problem and determine the type of criteria to be sought
b. Develop a hierarchy of decisions from the top with the purpose of decision-making and then see the clear objectives from a broad perspective, through the criteria from top to bottom, as shown in Fig. 1.

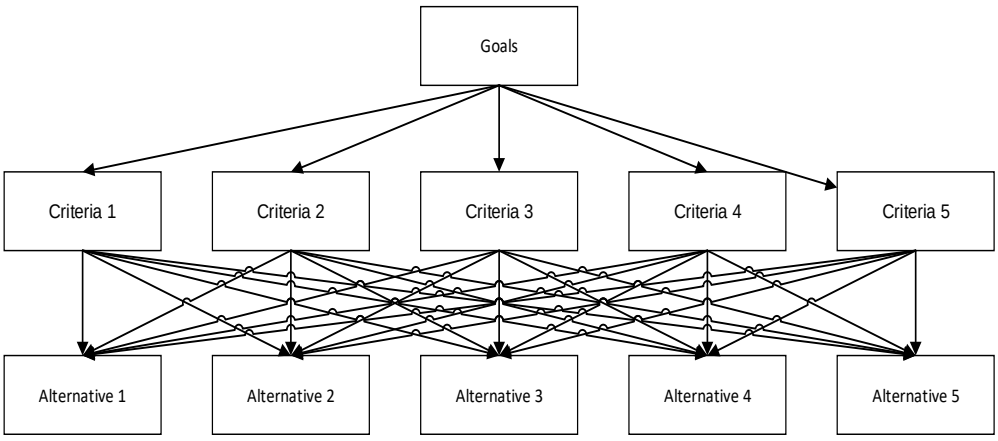

Fig. 2 AHP hierarchical structure.

c. Construct a set of pairwise comparison matrices. Each element at the top level is used to compare the elements of the level below it that relate to these criteria, as shown in Table 1

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Table 1 Pairwise comparison matrix

	Criteria-1	Criteria -2	Criteria -3	Criteria -N
Criteria -1	K1 / K1	K1 / K2	K1 / K3	K1 / K4
Criteria -2	K2 / K1	K2 / K2	K2 / K3	K2 / K4
Criteria -3	K3 / K1	K3 / K2	K3 / K3	K3 / K4
Criteria -N	KN / K1	KN / K2	KN / K3	KN / K4

Based on its development Thomas L Saaty, divides the weighting criteria or fundamental scale into the following according to Table 2.

Table 2 Fundamental scale

Scale	Description	Explanation
1	Equally Important	Elements one and two have an equally large influence on the purpose
3	A higher element has less influence	Experience and judgment higher than others
5	Which element is higher in influence	Experience and judgment higher than others
7	One element is stronger than the other	Favorite and donated experiences and ratings
9	The single most important / absolute element	Evidence that one element is more powerful than another
2,4,6,8	A value between two adjacent values	Compromised values

d. Calculate eigenvalues and perform consistency tests. Using the priority level obtained from the pairwise comparison matrix which then produces eigenvalues. Next, a consistency test is performed. If the results obtained are not consistent, then the data collection must be repeated
e. Repeat steps c and d for the entire hierarchy level
f. Calculates the eigenvectors of each pairwise comparison matrix. This is the weight of each element as the determination of the priority of the elements at the lowest level of the hierarchy to the goal. The calculation is done by adding the values of each column of the matrix, then dividing each value of the column by the total of the corresponding column to obtain the normalization of the Matrix and then adding each value of each row and dividing by the number of elements to get the average value.
g. Calculate hierarchical consistency. The AHP method must be equipped with a Consistency Index (CI) calculation to determine the consistency of the data or filling from the source. Where λmax is the result of the calculation of each matrix order by summing the results of multiplication between the sum of the weights of all the criteria in each column of the matrix with the value of the main eigenvector of the Matrix.

Table 3 Random index

1	2	3	4	5	6
0,00	0,00	0,58	0,90	1,12	1,24

In several previous studies relevant to the current conditions as well as expert opinions, several factors were found to be very influential regarding the assessment of gas stations by consumers, including:

a. Management
The stability of an organization or company depends on well-organized management. Job desk of each PIC and good supervision from top management can support gas stations to be able to transform in facing future challenges and good business governance (Widjaja Djohan, Suryadi Winata, 2018).
b. Sales
This is an important aspect for the sustainability of gas stations. With sufficient or high sales or turnover can make gas stations to be able to operate and develop themselves better. Evan

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Rosiska, 2018 revealed that sales are the main criteria in the selection of business partners (Rosiska, 2018)

c. Services
Service is one of the most important things to determine the quality of a gas station. Because this is something that can be directly felt by consumers. This is also what some researchers see in assessing suppliers (Marlina, 2021) (Maulana et al., 2022).

d. Facilities
Facilities to support the completeness of gas stations and equipment for visitors include minimarkets, ATMs, toilets, charging, etc. In a study also conducted by Dias Aziz Pramudita, 2020 in hospitals, facilities were also one of the criteria observed (Dias Aziz Pramudita, 2020).

e. BBM variations
According to Eka Martyani, 2019, a diverse menu is one of the attraction factors. In this case, the availability of various types of fuel can make consumers able to choose which products are in accordance with what is needed (Eka Martyani, 2019).

The above criteria were chosen because they were obtained from previous research and were in accordance with expert opinions and relevant to current conditions.

3. Results and Discussion

The next step is to collect, process and analyze data that refers to research on the first research to find the best gas station in Legok, Tangerang district, Banten province by using the Analytical Hierarchy Process (AHP), some of the criteria used to decide, among others, management, sales, service; facilities; and variations of fuel products as previous research above and supported by expert opinion. The tracing process carried out in AHP is as follows:

1. Creation of a hierarchy of criteria based on the objectives to be achieved, the criteria obtained and the available alternatives, it can be seen in Fig. 2 hierarchy system.
2.

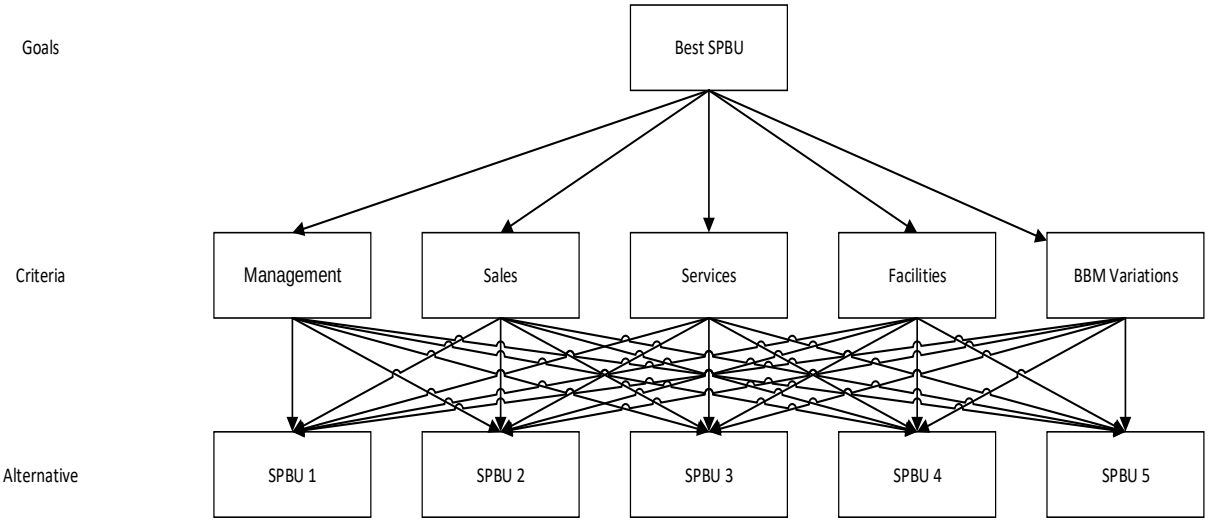

Fig. 3 Hierarchical order of the system.

3. Sorting criteria by pairwise comparison matrices. Calculate the pairwise comparison of criteria whose values are obtained from expert 1 by entering them in Table 4 with the following results:

Table 4 Pairwise Comparison Matrix Criteria

Criteria	Management	Sales	Services	Facilities	BBM Variations
Management	1.00	2.00	0.25	0.50	3.00
Sales	0.50	1.00	0.20	0.33	0.33

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Criteria	Management	Sales	Services	Facilities	BBM Variations
Services	4.00	5.00	1.00	4.00	5.00
Facilities	2.00	3.00	0.25	1.00	3.00
BBM Variations	0.33	3.00	0.20	0.33	1.00
Total	7.83	14.00	1.90	6.17	12.33

In Table 4 above, normalization is then carried out, that is, each column is multiplied by a matrix, each value in the criteria is multiplied by the total criteria or each row is multiplied by the total column. So then obtained the eigenvalue or the value of the Matrix weights normalized criteria such as Table 5 below.

Table 5 Criteria normalization matrix

Criteria	Management	Sales	Services	Facilities	BBM Variations	TOTAL
Management	0.13	0.14	0.13	0.08	0.24	0.15
Sales	0.06	0.07	0.11	0.05	0.03	0.06
Services	0.51	0.36	0.53	0.65	0.41	0.49
Facilities	0.26	0.21	0.13	0.16	0.24	0.20
BBM Variations	0.04	0.21	0.11	0.05	0.08	0.10
Total	1.00	1.00	1.00	1.00	1.00	1.00

The next step is to calculate the priority value of the criteria by dividing each total criteria (n=5), so the priority value of each criterion is obtained with the following results:

Management : 0.15
Sales : 0.06
Services : 0.49
Facilities : 0.20
BBM Variations : 0.10

Next by conducting a consistency test to believe that the priority value on these criteria can be used or not which depends on the results of the consistency test.

4. Consistency Test

a. Counting λ_{maks}

$$= \frac{7.83}{0.15} + \frac{14.00}{0.06} + \frac{1.90}{0.49} + \frac{6.17}{0.20} + \frac{12.33}{0.10}$$

= 5.47 + 5.21+ 5.50 + 5.49+ 5.09

= 5.35

b. Counting consistency index (CI)

$$= \frac{5.35 - 5}{4}$$

= 0.088

c. Counting consistency ratio (CR)

$$= \frac{0.088}{1.12}$$

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= 0.079

By taking into account the CR value above which shows the value of 0.79, the values have been consistent because it has been qualified that the CR value is less than 0.1.

The next stage of paired comparison is also carried out on each criterion with each alternative. So we get 6 CR values for the first expert. then it is then done in turn for the second expert to get 6 CR values. So in total there are 12 CR values that have been calculated. Based on these calculations obtained CR value recapitulation for expert one and expert Two shown in Table 6 as follows:

Table 6 Expert CR value

CR Value	Expert 1	Expert 2
Between Criteria	0.079	0.094
Management	0.083	0.080
Sales	0.050	0.091
Services	0.041	0.047
Facilities	0.087	0.070
BBM Variations	0.094	0.060

After it is obtained that the comparison matrix has been consistent, then the average eigenvalue of its alternatives and between the criteria and alternatives. Thus obtained eigenvalue criteria are as follows:

Table 7 Criterion Eigenvalues

Criteria	Eigen Value	Percent
Management	0.15	15%
Sales	0.06	6%
Services	0.48	48%
Facilities	0.21	21%
BBM Variations	0.10	10%

Based on Table 7 above, it is known that service is the main criterion with an eigenvalue of 0.48 and sales is the lowest criterion with a value of 0.06.

Then for the eigenvalues obtained from the normalized criteria matrix with a combined alternative of 2 experts obtained the numbers seen in Table 8 as follows:

Table 8 Eigenvalues Of Criteria With Alternatives

	Management	Sales	Services	Facilities	BBM Variations
SPBU 1	0.12	0.05	0.07	0.05	0.09
SPBU 2	0.10	0.18	0.06	0.06	0.06
SPBU 3	0.10	0.08	0.14	0.15	0.18
SPBU 4	0.26	0.51	0.29	0.43	0.41
SPBU 5	0.42	0.18	0.43	0.31	0.27
Total	1.00	1.00	1.00	1.00	1.00

After knowing the eigenvalues of each alternative for all defined criteria, then the final result will be sought, namely making a ranking with the highest and lowest values of each alternative by multiplying the eigenvalues of the criteria.

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$$\text{SPBU 1} = \frac{0.15}{0.12} + \frac{0.06}{0.05} + \frac{0.48}{0.07} + \frac{0.21}{0.05} + \frac{0.10}{0.09} = 0.076$$

$$\text{SPBU 2} = \frac{0.15}{0.10} + \frac{0.06}{0.18} + \frac{0.48}{0.06} + \frac{0.21}{0.06} + \frac{0.10}{0.06} = 0.075$$

$$\text{SPBU 3} = \frac{0.15}{0.10} + \frac{0.06}{0.08} + \frac{0.48}{0.14} + \frac{0.21}{0.15} + \frac{0.10}{0.18} = 0.138$$

$$\text{SPBU 4} = \frac{0.15}{0.26} + \frac{0.06}{0.51} + \frac{0.48}{0.29} + \frac{0.21}{0.43} + \frac{0.10}{0.41} = 0.339$$

$$\text{SPBU 5} = \frac{0.15}{0.42} + \frac{0.06}{0.18} + \frac{0.48}{0.43} + \frac{0.21}{0.31} + \frac{0.10}{0.27} = 0.372$$

Based on these calculations can be seen in Table 9 that the order in the selection of the best gas stations in the district legok, Tangerang district, Banten is as follows:

Table 9 Best SPBU final value

Alternatives	Eigen Value	Percent
SPBU 5	0,372	37,2 %
SPBU 4	0,339	33,9 %
SPBU 3	0,138	13,8 %
SPBU 1	0,076	7,6 %
SPBU 2	0,075	7,5 %

4. Conclusion

Based on the results of the discussion and calculations performed in the previous steps can be concluded that Analytical Hierarchy Process (AHP) which is one of the decision support systems can be used as a tool to determine the best gas station (SPBU). Then from the weighting criteria, obtained the highest value is the services (48%) and the other is the Facilities (21%), Management (15%), BBM Variations (10%) and the lowest is the sales (6%). And the final calculation results obtained that the gas station (SPBU) 5 is the best gas station in the District Legok, Tangerang Banten district based on the analysis of calculations with AHP method.

In this study there are some limitations, with the observed gas station area, the scope becomes smaller, and the absence of restrictions on land area and age of the observed gas station makes the assessment of the condition of the gas station to be subjective from the experts. In this research, there are still many things that can be developed, such as the expansion of research areas, the use of other methods or by using criteria that can support similar research fields. The suggestion for entrepreneurs gas station as an object in this study is the need for the development of the company so that consumers can be comfortable so loyal to be consumers at the gas station.

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