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Human-Dedicated Sustainable Product and Process Design: Materials, Resources, and Energy

Proceedings of the 4th International Conference on Engineering, Technology, and Industrial Application (ICETIA) 2017

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13–14 December 2017

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Hari Prasetyo, Nurul Hidayati, Eko Setiawan and Tri Widayatno

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Preface: Human-Dedicated Sustainable Product and Process Design: Materials, Resources, and Energy

Proceedings of the 4th International Conference on Engineering, Technology, and Industrial Application (ICETIA) 2017

International Conference on Engineering, Technology and Industrial Application (ICETIA) is an international conference organized annually by the Engineering Faculty of Universitas Muhammadiyah Surakarta (UMS), known as the biggest private university in Central Java, Indonesia. The 4th ICETIA has been successfully held on 13-14 December 2017 at Alila Hotel, Surakarta, Central Java, Indonesia, attracting more than 300 participants.

This year's conference brought a theme of Human-Dedicated Sustainable Product and Process Design: Materials, Resources, and Energy. It provided an excellent atmosphere for academicians, researchers, industrial professionals and government bodies to share ideas and any breakthrough in terms of materials, resources and energy aiming at establishing sustainable industrial development.

The committee received more than 200 papers, 174 of which were selected and presented in the conference. In these proceedings, the papers are then organized by grouping them into five sub-themes namely: (i) Sustainable Industrial Process and System Optimization, (ii) Product Design, Material and Building Engineering, (iii) Sustainable Infrastructure and Built Environment, (iv) Preservation, Conservation and Water Management, (v) Green Energy and Computing. It is expected that materials presented in these proceedings contribute constructively to create sustainable products and processes beneficial to humans.

Surakarta, Indonesia

7 March 2018

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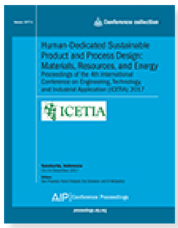

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Alternative Selection Scenarios of Oil and Gas Using Fuzzy Analytical Hierarchy Process (FAHP)

Dea Dana Lestari[1, a)], Djoko Budiyanto Setyohadi[1, b)] and Suyoto[1, c)]

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Abstract. In the petroleum world, oil and gas resources exploitation activities will be carried out continuously until the production reach the limit of economic boundaries, where the quality of production is not good anymore. Before it happens, the experts will arrange reserve activities to anticipate any losses if the contract period of the company is still long. This research proposes the development of oil and gas field scenarios in the use of Fuzzy AHP to assist petroleum experts in designing efficient and effective scenarios. In this way, it will assist the petroleum expert in dealing with the problem of loss and proper decision making.

INTRODUCTION

There are three things that are important for the company regarding with the quality, the yield, and current oil prices [1]. The production of oil and gas that continuosly produces large volume will be inversely proportional to the declining resources [2]. It will have adverse impact for the company if the oil and gas production reaches the economic limit [3]. Economic limit is the unfavorable condition of oil and gas production in which the supply cannot be traded or processed into basic needs. If the company's exploitation contract is still long and production goes down to the ecomonic limit, the oil experts should undertake particular oil field development scenario [4]. The development scenario is the addition of activities to the exploitation of oil wells due to the declining yields and conditions such as oil trapped in stone basins [5].

Scenario activities require data production of at least the last five years, and it is necessary to observe the graph of the oil well production curve. This study used a fuzzy logic analytical hierarchy process (FAHP) to address the ambigous data from the past production results, and to forecast the future production results and to assist petroleum experts in designing decision-making scenarios.

LITERATURE REVIEW

Decision Support System (DSS)

Decision support systems are the theories used for multi-criteria evaluation and decision-making [6]. DSS will be interconnected with information systems by analyzing and summarizing data to assist users in decision making [7]. There are seven sub-fields of DSS that can be used [8], namely: personal decision support system (PDSS) for the manager or small manager group, Group Support System (GSS) for communication in a group work; Negotiation Support System (NSS) for negotiations between businesses; Intelligent Decision Support System (IDSS) using artificial intelligence for decision support; Knowledge Management based DSS (KMDSS) for individuals and organizations in storing data; Data Warehousing (DW) for large-scale data to support the decision; and the Corporate Reporting and Analysis System focuses on executive information systems (EIS), business intelligence (BI), corporate performance management system (CPM) to analyze information and reporting and analysis tools.

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The decision support system (DSS) method is superior in solving the problem with the final result by using the ranking, but the DSS can cause different assessment of each assessor in the standard of agree or disagree [8].

Fuzzy Analytical Hierarchy Process (FAHP)

Fuzzy Analytical Hierarchy Process (FAHP) is a theory that uses priority scale and criteria according to expert consideration and compares the criteria with comparison scale [9]. Static data of exploitation activities conducted by petroleum companies in the future can be estimate by using FAHP [10]. Initially, it needs an analysis of an object for the purpose of reducing the cryptic data before performing the calculations [11]. The process performed is illustrated in Figure 1.

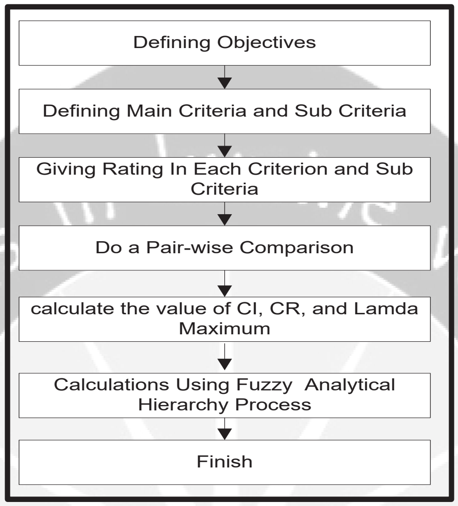

FIGURE 1. The Process Flow of FAHP Method

Decline Curve Analysis (DCA)

Despite of its simplicity, DCA is a theory with promising advantages. It a production curve data of at least the last 5 {five} years to be used as a reference in the next production level [12]. DCA can also be used in estimating reserves and predicting long-term production rates [13]. The data used is analysis of the previous curve of oil well production, which shows a decline trend [14]. Petroleum experts have to consider several risks before making scenarios for further action if oil production has eventually decreased. By using the FAHP method, petroleum experts can use the DCA data to determine the proper and suitable injection in the scenario [15]. Figure 2 shows the production vs time graph that could explain the Decline Curve Analysis or the downward trend in oil well yield pattern. This pattern will be used to forecast the future production yield.

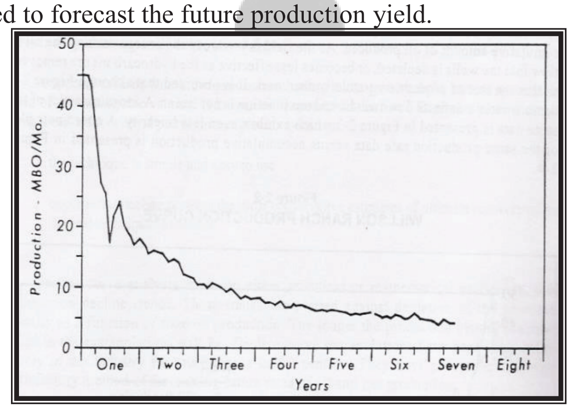

FIGURE 2. Production Rate Chart vs Time

Enhanced Oil Recovery (EOR)

In fact oil and gas prices is increasing from year to year, in which the need for oil and gas in a country increases by 1.5%. To continuously obtain oil and gas results, petroleum engineers will need to conduct a second drilling stage using enhanced oil recovery (EOR) injection technique on oil wells [16]. The enhanced oil recovery method (EOR) is a method of taking crude oil trapped within the porous rock [17]. Moreover, there are a variety of additional technique that can be used, such as the injection process, secondary process, and tertiary process.

RESEARCH METHODOLOGY

In this study, the FAHP was to overcome the cryptic data on previous oil production data and to get the best ranking as an alternative in deciding the oil and gas development scenario to be done.

Schematic Design of Research Methods

The steps used in this study are described in Figure 3, in which the blue line indicates the initial stage of data collection and the red line indicates the FAHP process used to obtain an alternative ranking for oil field development scenarios. The main purpose of this research was to get the ranking of scenarios as continued oil field development.

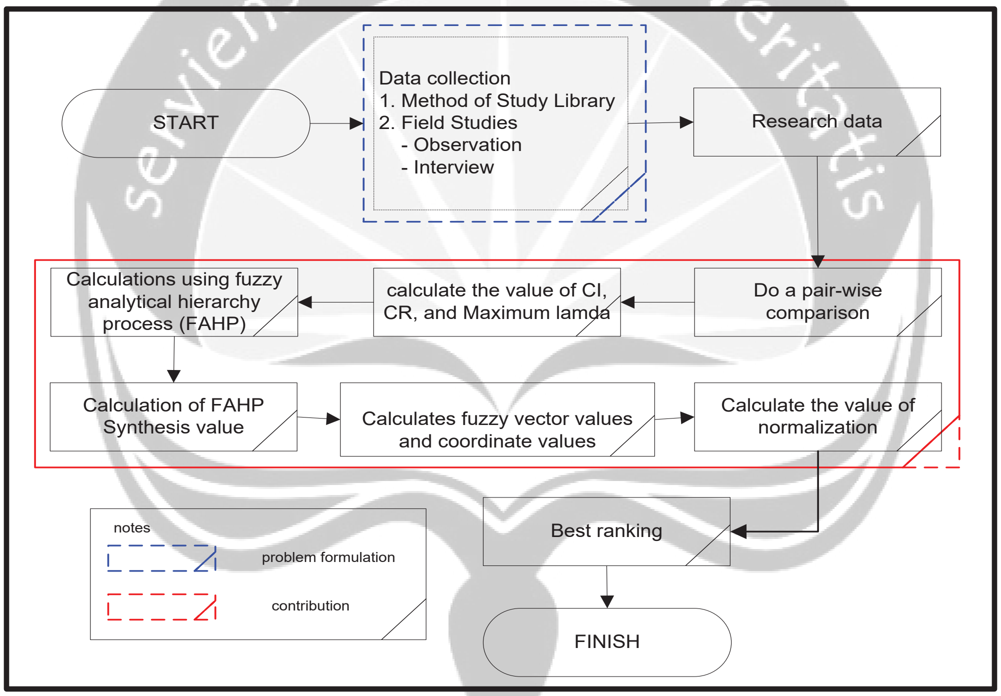

FIGURE 3. Contribution in Research Scheme

Decision Hierarchy Structure

Decision trees are built to gain goals in solving, and weighting problems [18]. The decision tree is described in Figure 4 below.

Preparatory stage

There are three parts in this stage. The first part is technical support, which includes preparation of equipment, transportation, and road construction. The second part is to determine the geographic location, which encompasses geological, geophysical, seismic, and pebble surveys. The last part is the management part, which is to calculating the amount of costs before production.

Analysis Stage

There are five parts in this stage. The first part is oil production results, which is by providing information about field data, wells, number of layers, economic limit, and production time packed into one production result. The data is useful to determine the next stage in the injection part. The second part is contract field, which shows about time period of the area may be exploited in accordance with the agreement. The third part is product price, in which the decline in prices will lead to the increase in demand, and consequently, the decrease in production decreases. Conversely, the rise in production will lead to the rise in, profits, then the value of investment also increases. It can be used as an investment in finding new inventions. The forth part is product quality, or the production-analysis phase, in which the result that reaches the target of the economic limit can be categorized as low yield and vice versa. The last part is management part, which is to calculate the total cost of production obtained.

Injection Stage

This stage is divided into three parts. This stage is also the development of method from the analysis phase packed into several scenarios. The implementation of scenario will be used as a comparison in which the economic value of each scenario will be calculate to get the best ranking. The first part is injection process, which includes infill method (adding new wells), and workover (long well maintenance) that can be moved into production, cleaning well, acidizing, and fracturing. The second part is secondary process, which uses an injection method using water or gas, depending on the location conditions in the production area, either it contains more water or gas. The third part is tertiary process or enhanced oil recovery (EOR) as an injection method using chemical substances, miscible, moisture or oil.

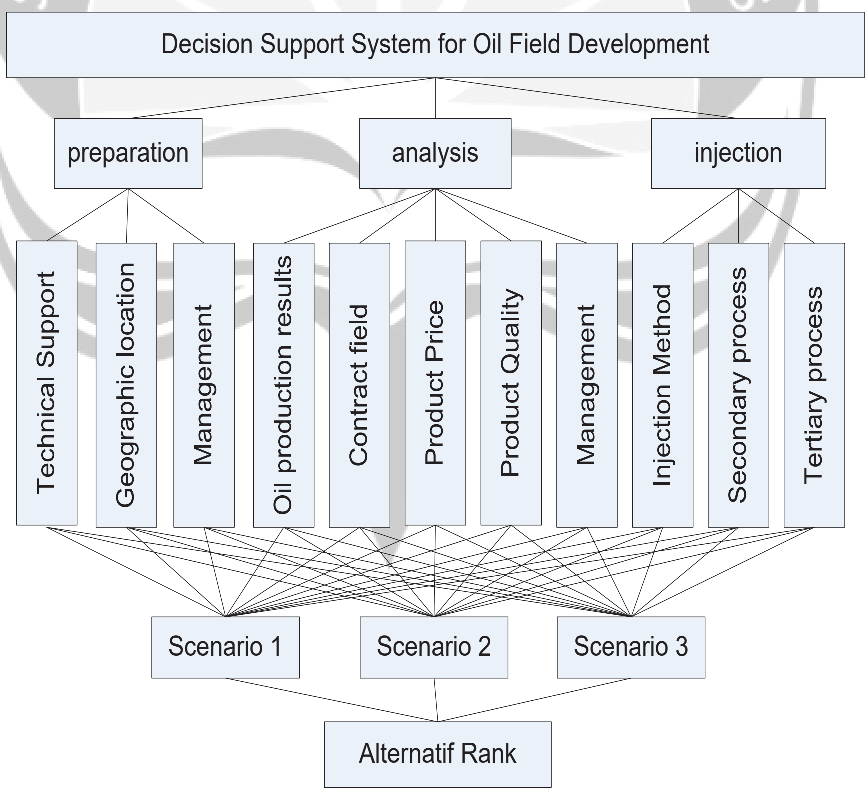

FIGURE 4. Decision Hierarchy Structure

Comparison Scale

The establishment of comparison matrix is done for the initial phase of FAHP calculation. Subsequently, it will give weight and get the normalization value for alternative ranking search. The comparative scale is needed to give the weight of each criterion [9]. Table 1 shows the scale used in this study.

TABLE 1. The Comparison Scale

Level	The definition	Description
1	Equally important	Both elements have the same influence.
3	Slighlty more important	Experience and judgment slightly favors one element compared to another.
5	More important	One element is more preferred and its dominance is practically evident, in compared with another.
7	Very important	One of the elements is proved to be highly preferred and its dominance is practically evident, in compared with another.
9	Absolutely very important	One element is proven to beabsolutely preferred in compared with another, upon conviction
2,4,6,8	Moderate grades	It is indencisive to give of two elements with adjacent importance.

RESULTS AND ANALYSIS

The establishment of the decision tree, and the comparison scale, was followed the performance of the FAHP calculation based on the following meassure:
Step 1 : Create a matrix paired by using the value of the comparison scale and divide the part by the number of rows.
Step 2 : Sum the weights of each row and divide them by the amount of data.
Step 3 : Determine the max value of lambda, CI, and CR with the following formula:

λ max : Sum up the weights and and the number per line (1)

CI : (λ max– number of row) – (number of row -1) (2)

$$CR = \frac{\mathrm{CI}}{0{,}9} \tag{3}$$

Step 4 : Perform normalization calculations from finding fuzzy vector values and coordinate values.
Step 5 : Perform do all the calculations on the criteria and subcriteria, then apply the case study to determine the best ranking.

First, the calculation of the normalization value in the criteria section in Table 2 is as follows:

TABLE 2. The normalization of the main criteria

Criteria	preparation	analysis	injection
preparation	1.00	0.50	0.33
analysis	2.00	1.00	0.50
injection	3.00	2.00	1.00
to tal	6.00	3.50	1.83
		Normalization	
	0.35	0.22	0.43

From Table 2, the normalization value of the criteria section can be determined, in which the preparation stage was 0.35, the analysis stage was 0.22 and the injection stage was 0.43. Subsequently, for normalization value in sub section of each criterion was done, Table 3 as follows:

TABLE 3. The sub-criteria normalization of the preparation section

Sub Criteria	pp1	pp2	pp3
pp1	1.00	2.00	3.00
pp2	0.50	1.00	2.00
pp3	0.33	0.50	1.00
total	1.83	3.50	6.00
Normalization			
	0.37	0.33	0.30

From Table 3, the normalization value of sub-criteria of preparation section can be determined in which technical support was 0.37 geographic location was 0.33, and management was 0.30. Table 4 provides the normalization value in the analysis of sub-criteria as follows:

TABLE 4. The sub-criteria normalization of the analysis part

Sub Criteria	aa1	aa2	aa3	aa4	aa5
aa1	1.00	3.00	2.00	2.00	0.50
aa2	0.33	1.00	0.50	0.50	0.33
aa3	0.50	2.00	1.00	0.50	0.50
aa3	0.50	2.00	2.00	1.00	0.50
aa5	2.00	3.00	2.00	2.00	1.00
total	4.33	11.00	7.50	6.00	2.83
Normalization					
	0.20	0.13	0.25	0.24	0.18

From Table 4, the normalization value of sub-criteria of the analysis was 0.20 for oil production, 0.13 for contract field, 0.25 for product price, 0.24 for product quality, and 0.18 for management. Furthermore, Table 5 the normalization value in sub-section of injection criteria as follows:

TABLE 5. The sub-criteria normalization of the injection part

Sub Criteria	in1	in2	in3
in1	1.00	2.00	3.00
in2	0.50	1.00	2.00
in3	0.33	0.50	1.00
total	1.83	3.50	6.00
Normalization			
	0.43	0.39	0.18

From Table 5 the normalization value of injection part of sub-criteria was 0.43 for injection method, 0.39 for secondary process, and 0.18 for tertiary process.

CASE STUDY

After calculating the normalization value of each criterion and sub-criteria, the calculations in the case study section was done, by using three scenarios in the injection section in order to rank the best scenarios for the development of the oil field. (Table 6)

TABLE 6. The normalization of case study section of injection scenario A

Case Scenario A	A	B	C
A	1.00	0.50	2.00
B	2.00	1.00	3.00
C	0.33	0.50	1.00
Normalization			
	0.33	0.37	0.30

From Table 6, the normalization value of scenario 1 where the value of a was 0.33, B was 0.37, and C was 0.30. Subsequently, Table 7 present the normalization value obtained from scenario 2 as follows.

From Table 7, the normalization value of scenario 2 obtained the value of A was 0.3, B was 0.37, and C was 0.33. Subsequently, Table 8 demonstrates the normalization value obtained from scenario 3 as follows:

TABLE 7. The normalization of case study section of injection scenario B

Case Scenario B	A	B	C
A	1.00	0.33	0.50
B	3.00	1.00	2.00
C	2.00	0.50	1.00
Normalization			
	0.30	0.37	0.33

TABLE 8. The normalization of case study of injection scenario C

Case Scenario C	A	B	C
A	1,00	0,50	0,50
B	2,00	1,00	1,00
C	2,00	1,00	1,00
Normalization			
	0,30	0,38	0,32

From Table 8, the normalization value was obtained from scenario 3, in which the value of a was 0.3, B was 0.38, and C was 0.32. Subsequently, Table 9 shows the overall scenario with the normalization value of the criteria and sub-criteria to obtain the best rank of alternative oil and gas field development.

TABLE 9. The ranking based on the results of normalization

Global	Preparation	Analysis	Injection	Global Weight	Rank
Weight (W)	0.35	0.22	0.43		
Alternative					
A	0.34	0.41	0.30	0.326	3.00
B	0.34	0.41	0.38	0.339	1.00
C	0.34	0.41	0.32	0.335	2.00

CONCLUSION

In the study research for oil field development using Fuzzy AHP method, the results of the three developed scenarios were gained in which the best yield was obtained from scenario B with value 0.339. The second is scenario C with value of 0.335 and the last one is scenario A with value of 0.326. Petroleum experts can use scenario B first, then scenario C scenario A respectively for oil and gas field development. This research can be used for long-term scenario determination and in more than three scenarios. This research is very effective and efficient to assist decision makers in choosing the best scenario at the injection stage that will be done and can provide information for the petroleum companies in decision making in the future.

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