

# Development of Hesitant Fuzzy-Based Project Selection Method with Consideration of Benefits, Opportunities, Costs and Risks

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**Abstract**—PT X, a power generation company, hasn't been able to meet their target in the business development segment over the past few years. This is due to a problem detected in their Project Portfolio Management, in which PT X's project selection method hasn't considered the ambiguity nature of project's information and risks. This study is going to develop a project selection method for PT X using MCDM (multi criteria decision making) with BOCR (benefit, opportunity, cost, risk) Concept to evaluate many criteria that need to be considered by the company, especially conflicting criteria such as benefit with cost and opportunity with risk. Not only that, hesitant fuzzy will be used because project itself has many uncertain or ambiguous information, so stakeholder will face difficulties in determining the value for the evaluation. From the integration of those things in this study, it is found that for PT X, Benefit has the biggest priority, followed by Opportunity, Risk, and Cost in Project Selection for PT X. It is also found that based on additive-BOCR, Project C gives the optimal value for PT X, followed by Project B, Project A, Project D, dan Project E.

**Keywords**—BOCR, Hesitant Fuzzy, MCDM, Project Selection, Project Portfolio Management.

## I. INTRODUCTION

CURRENTLY, a massive electricity infrastructure development is being carried out by the Government of Indonesia, which was launched under the name of the 35,000 MW Program [1]. This program is listed in the Electricity Supply Business Plan (RUPTL) of PT PLN (Persero), which is annually approved by a Decree of the Minister of Energy and Mineral Resources. In the 2019-2028 RUPTL, which is the last RUPTL which was ratified on 20 February 2019, it is planned that there will be an increase in generating capacity in Indonesia by 56,395 MW. This plan is projected to cause Indonesia to have a power plant capacity of 97,072 MW by the end of 2028.

It can be seen that many new power plants will emerge in Indonesia. This indicates that competition among power plants in Indonesia will increase significantly. One company that was affected by this change is PT X, a company engaged in the field of electricity generation in Indonesia. To face this issue, PT X tried to seize this huge opportunity by participating in the 35,000 MW Program. However, PT X has never achieved the target set by them for the past few years. That is because the company's project selection method has not consider the ambiguity or uncertainty of project information, as well as the risks of the project.

### A. Project Selection Method

In doing business development and increasing its competitive advantage, a company can carry out a set of projects. A group of projects and / or programs and other work that are grouped together to facilitate effective management so that the work can meet the company's strategic objectives is called a portfolio [2]. Project Portfolio Management itself is the management of a portfolio with the aim to maximize the project's contribution to the health and success of the company [3]. One of the steps in this management is the alignment of the project portfolio with the company's strategy, which consists of identification of project until the project authorization [2].

Implementation of project portfolio management can use a variety of techniques to ensure that project investment directly contributes to the achievement of company goals [4]. Some popular methods used by decision makers in portfolio selection activities are AHP, valuation models, and portfolio matrices because these methods can help users in considering the qualitative and quantitative characteristics of the project [5]. The application of one method, namely the scoring model, where the project is assessed based on several criteria as the basis of prioritization or project selection, was found to produce the portfolio with the highest benefits when compared to other methods [6].

### B. Multi Criteria Decision Making dalam Pemilihan Proyek

MCDM is a concept, approach, model, and method to assist decision makers in describing, evaluating, sorting, ranking, choosing or rejecting a thing (candidates, products, projects, etc.) based on evaluation (which can be in the form of scores, scores, preference) for several criteria [7]. In project selection, of course, each project has different advantages and disadvantages. Due to the many different and conflicting criteria that need to be considered in project selection, MCDM is indeed an appropriate method to be used.

Even so, MCDM as a method of project selection has limitations. MCDM will provide the most optimal results when the scores and importance of the criteria are known with certainty [8]. However, in practice, decision making is carried out in an environment where the aims, boundaries, and consequences are not known with certainty. To overcome this, the use of fuzzy was introduced in MCDM [9].

There are many types of fuzzy that have now been applied in MCDM to integrate ambiguity or uncertainty of a decision. One of the uncertainty problems faced is the existence of

Table 1.  
Fuzzy Scale for AHP/ANP based on Saaty's Scale [28]

Rate	Definition	TFN ( $\theta = 1$ )
1	Equal	(1,1,1)
3	Slightly more important	(2, 3, 4)
5	Significantly more important	(4,5,6)
7	Very significantly more important	(6,7,8)
9	Absolutely more important	(8, 9,10)
(2, 4, 6, 8)	In between	$((x - \theta), x, (x + \theta))$
1 / x	Reciprocal	$(1 / (x + \theta), 1/x, 1 / (x - \theta))$

Table 2.  
Fuzzy Scale for DEMATEL [29]

Rate	Definition	TFN
0	No influence	(0, 0, 0.25)
1	Very low influence	(0, 0.25, 0.25)
2	Low influence	(0.25, 0.5, 0.75)
3	High influence	(0.5, 0.75, 1)
4	Very high influence	(0.75, 1, 1)

Table 3.  
Criteria and Sub-Criteria for BOCR Network

Benefit		Cost	
<b>Economical</b>		<b>Economical</b>	
Tariff		Investment Cost	
Economic Value		Primary Energy Cost	
Influence to Company's Cashflow		O&M Cost	
<b>Technical</b>		<b>Technical</b>	
Feasibility		Distance Between Primary Energy and User	
Efficiency		Project Phase Duration	
		Distance Between Power Plant and Transmission	
Opportunity		Risk	
<b>Technical</b>		<b>Legal</b>	
Opportunity for EBT Development		Legal Risk	
Opportunity for Dispatch		<b>Technical</b>	
Primary Energy Availability		Contractual Risk	
Contract Provisions		Construction Risk	
<b>Economical</b>		<b>Company's Management</b>	
Contribution to Economy		Strategic Risk	
Fund Availability		Failure Risk	
<b>Social and Political</b>			
Government's Support			

Table 4.  
Hesitant Evaluation for Decision Maker 1

Strategic Criteria	Solution & Value Added	High quality, competitive, and environmental friendly	Sustainable
Solution & Value Added	EE	(1/5,1/3)	(1/7,1/5)
High quality, competitive, and environmental friendly		EE	(1/3, 1)
Sustainable			EE

several values or events that may occur, so that decision makers experience doubts in giving their decisions. Fuzzy types such as Type-1 [10] or Type-2 [11] certainly cannot be used to describe this event, because decision makers must still determine one value for their decisions. Therefore, Torra [12] proposes a fuzzy hesitant in which this function will describe the doubts of decision makers in their evaluations.

In making decisions, it is also important to note that the results received by a company are not only positive, but also negative. Benefits and opportunities are the positive effects of a decision, while the costs and risks are the negative impacts. To be able to evaluate decisions carefully by considering these four aspects, Saaty [13] proposes the concept of BOCR (benefit, opportunity, cost, and risk). This method is a concept that illustrates the decision making environment into four networks, namely: benefits, opportunities, costs, and risks. This concept can help decision

makers evaluate the positive and negative impacts of an alternative simultaneously [14]. In each aspect, alternatives will be evaluated, wherein then the four assessments will be combined into one result that illustrates the value of an alternative.

To choose crucial things such as projects to be carried out by a company, it would be better if the method used can provide accurate results and in accordance with company objectives, taking into account the uncertainty of information and the impact given by the project. There has been many paper proposing the implementation of MCDM, such as AHP or ANP, integrated with other concepts, such as fuzzy or BOCR, for project selection [15-20]. Therefore, in this study, another integration method will be developed using the hesitant fuzzy concept and the BOCR Concept in project selection.

Table 5.  
Fuzzy Envelopes Evaluation for Decision Maker 1

Strategic Criteria	Solution & Value Added				High quality, competitive, and environmental friendly				Sustainable			
	L	M1	M2	H	L	M1	M2	H	L	M1	M2	H
Solution & Value Added	1.000	1.000	1.000	1.000	0.167	0.243	0.257	0.500	0.125	0.163	0.170	0.250
High quality, competitive, and environmental friendly					1.000	1.000	1.000	1.000	0.250	0.476	0.524	1.000
Sustainable									1.000	1.000	1.000	1.000

Table 6.  
Aggregate Matrices of Strategic Criteria from All Decision Makers

Strategic Criteria	Solution & Value Added				High quality, competitive, and environmental friendly				Sustainable			
	L	M1	M2	H	L	M1	M2	H	L	M1	M2	H
Solution & Value Added	1.000	1.000	1.000	1.000	0.220	0.263	0.274	0.359	0.304	0.390	0.394	0.574
High quality, competitive, and environmental friendly	2.787	3.656	3.798	4.547	1.000	1.000	1.000	1.000	1.213	1.548	1.620	2.096
Sustainable	1.741	2.541	2.561	3.288	0.477	0.617	0.646	0.824	1.000	1.000	1.000	1.000

Table 7.  
Weights for Strategic Criteria

Strategic Criteria	Fuzzy Weight				Crisp Weight
	L	M1	M2	H	
Solution & Value Added	0.041	0.047	0.048	0.059	13.898%
High quality, competitive, and environmental friendly	0.150	0.178	0.183	0.212	52.270%
Sustainable	0.094	0.116	0.118	0.139	33.833%

Table 8.  
Weights for BOCR

Merits	Solution & Value Added				High quality, competitive, and environmental friendly				Sustainable				Fuzzy Weight				Crisp Weight
	L	M1	M2	H	L	M1	M2	H	L	M1	M2	H	L	M1	M2	H	
	0.04	0.04	0.04	0.05	0.15	0.17	0.18	0.21	0.09	0.11	0.11	0.13					
	1	7	8	9	0	8	3	2	4	6	8	9					
B	0.13	0.16	0.16	0.19	0.11	0.14	0.14	0.17	0.08	0.11	0.10	0.13	0.0	0.04	0.04	0.06	33.127
	1	2	6	6	3	8	7	4	5	0	8	7	30	7	8	8	%
O	0.08	0.09	0.10	0.12	0.08	0.10	0.10	0.12	0.07	0.09	0.09	0.11	0.0	0.03	0.03	0.04	23.930
	0	8	1	6	8	0	0	0	3	2	2	9	23	3	4	9	%
C	0.06	0.07	0.07	0.08	0.07	0.08	0.08	0.10	0.07	0.09	0.09	0.11	0.0	0.02	0.03	0.04	20.889
	2	2	4	8	5	5	5	2	3	1	1	0	21	9	0	2	%
R	0.07	0.08	0.08	0.09	0.06	0.07	0.08	0.09	0.09	0.10	0.11	0.13	0.0	0.03	0.03	0.04	22.054
	3	3	4	9	8	9	0	4	1	9	1	4	22	1	2	4	%

II. METHODOLOGY

A. BOCR Concept

Every decision not only has a positive impact, but also a negative which needs to be considered by decision makers [21]. Benefits and opportunities are the positive effects of a decision, while the costs and risks are the negative impacts. The benefit itself is a positive impact that is certain to be obtained by a company, while the cost is a negative impact that must be received. Positive impacts that are uncertain are opportunities, while negative impacts that are uncertain are

risks [13]. These four aspects can reduce or increase the value of a choice.

To be able to evaluate decisions carefully by considering these four aspects, Saaty [13] proposes the concept of BOCR (benefit, opportunity, cost, and risk). This method is a concept that describes the decision making environment into four networks, namely: benefits, opportunities, costs, and risks. In each aspect, alternatives will be evaluated, wherein then the four assessments will be combined into one result that illustrates the value of an alternative. Benefits, opportunities, costs and risks must also be prioritized based on strategic criteria [13]. Then, the evaluation results from each aspect

Table 9.  
Dispatcher and Receiver Value for Each Sub-Criteria

Benefit	D	R	D-R	D+R	Cost	D	R	D-R	D+R
<b>Economical</b>					<b>Economical</b>				
Tariff	9.048	9.209	18.257	-0.161	Investment Cost	3.501	3.906	7.407	-0.405
Economic Value	8.652	9.383	18.035	-0.731	Primary Energy Cost	3.333	3.297	6.629	0.036
Influence to Company's Cashflow	8.659	8.789	17.448	-0.130	O&M Cost	2.945	3.231	6.176	-0.286
<b>Technical</b>					<b>Technical</b>				
Feasibility	9.172	9.147	18.319	0.025	Distance Between Primary Energy and User Project Phase	3.509	3.237	6.746	0.272
Efficiency	9.049	8.051	17.099	0.998	Duration Distance Between Power Plant and Transmission	3.286	3.537	6.824	-0.251
						3.663	3.029	6.692	0.633
<b>Opportunity</b>	<b>D</b>	<b>R</b>	<b>D-R</b>	<b>D+R</b>	<b>Risk</b>	<b>D</b>	<b>R</b>	<b>D-R</b>	<b>D+R</b>
<b>Technical</b>					<b>Legal</b>				
Opportunity for EBT Development	4.057	4.359	8.416	-0.302	Legal Risk	9.109	9.203	18.311	-0.094
Opportunity for Dispatch Primary Energy Sources Availability	4.017	3.898	7.915	0.119	<b>Technical</b>				
Contract Provisions	4.133	3.807	7.941	0.326	Contractual Risk	9.050	8.942	17.991	0.108
<b>Economical</b>	3.917	3.926	7.843	-0.009	Construction Risk	9.149	9.065	18.215	0.084
Contribution to Economy	3.714	3.797	7.511	-0.083	<b>Company's Management</b>				
Fund Availability	3.865	3.907	7.771	-0.042	Strategic Risk	8.715	8.907	17.622	-0.192
<b>Social and Political</b>					Failure Risk	9.096	9.002	18.097	0.094
Government's Support	3.952	3.961	7.913	-0.009					

Table 10.  
Weighted Supermatrix for Benefit Network

Cluster	Node	Best Benefit	Economic Value	Influence to Company's Cashflow	Tariff	Efficiency	Feasibility
<b>Goal</b>	Best Benefit	0.000	0.000	0.000	0.000	0.000	0.000
	Economy Value	0.502	0.000	0.614	0.487	0.215	0.474
<b>Economical</b>	Influence to Company's Cashflow	0.159	0.000	0.000	0.351	0.092	0.334
	Tariff	0.170	0.838	0.224	0.000	0.108	0.192
<b>Technical</b>	Efficiency	0.059	0.000	0.000	0.000	0.000	0.000
	Feasibility	0.110	0.162	0.162	0.162	0.586	0.000

Table 11.  
Limiting Supermatrix for Benefit Network

Cluster	Node	Best Benefit	Economic Value	Influence to Company's Cashflow	Tariff	Efficiency	Feasibility
<b>Goal</b>	Best Benefit	0.000	0.000	0.000	0.000	0.000	0.000
	Economy Value	<b>0.341</b>	<b>0.341</b>	<b>0.341</b>	<b>0.341</b>	<b>0.341</b>	<b>0.341</b>
<b>Economical</b>	Influence to Company's Cashflow	<b>0.169</b>	<b>0.169</b>	<b>0.169</b>	<b>0.169</b>	<b>0.169</b>	<b>0.169</b>
	Tariff	<b>0.350</b>	<b>0.350</b>	<b>0.350</b>	<b>0.350</b>	<b>0.350</b>	<b>0.350</b>
<b>Technical</b>	Efficiency	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>
	Feasibility	<b>0.139</b>	<b>0.139</b>	<b>0.139</b>	<b>0.139</b>	<b>0.139</b>	<b>0.139</b>

can be synthesized and combined into one value using several formulas. The following are some formulas that can be used [13]: (i) multiplicative which is a marginal formula (1) and

(ii) additive that describes the final result in total or global (2).

Table 12.  
Weights for BOCR Network

Benefit	Local Weight	Global Weight	Cost	Local Weight	Global Weight
<b>Economical</b>			<b>Economical</b>		
Tariff	40.709%	35.038%	Investment Cost	52.827%	42.691%
Economic Value	39.602%	34.085%	Primary Energy Cost	37.325%	30.163%
Influence to Company's Cashflow	19.689%	16.946%	O&M Cost	9.848%	7.958%
<b>Technical</b>			<b>Technical</b>		
Feasibility	100.000%	13.932%	Distance Between Primary Energy and User	48.378%	9.282%
Efficiency	0.000%	0.000%	Project Phase Duration	51.622%	9.905%
			Distance Between Power Plant and Transmission	0.000%	0.000%
Opportunity	Local Weight	Global Weight	Risk	Local Weight	Global Weight
<b>Technical</b>			<b>Legal</b>		
Opportunity for EBT Development	38.993%	24.318%	Legal Risk	100.000%	32.144%
Opportunity for Dispatch Primary Energy Sources Availability	24.703%	15.406%	<b>Technical</b>		
Contract Provisions	21.537%	13.431%	Contractual Risk	41.899%	11.162%
<b>Economical</b>			Construction Risk	58.101%	15.477%
Contribution to Economy	39.132%	9.842%	<b>Company's Management</b>		
Fund Availability	60.868%	15.309%	Strategic Risk	38.506%	15.871%
<b>Social and Political</b>			Failure Risk	61.494%	25.346%
Government's Support	12.485%	12.485%			

Table 13.  
Synthesis BOCR Value for Projects

Project	Benefit	Opportunity	Cost	Risk	Synthesis	
	33.127%	23.930%	20.889%	22.054%	Additive	Multiplicative
Project A	0.204	0.194	0.196	0.211	0.026	0.956
Project B	0.215	0.191	0.199	0.198	0.032	1.044
Project C	0.217	0.248	0.226	0.202	0.039	1.175
Project D	0.191	0.191	0.193	0.208	0.023	0.911
Project E	0.173	0.176	0.186	0.181	0.021	0.905

Table 14.  
Project Selection and Prioritization Based on Synthesis BOCR

Project	Rank	Decision
Project C	1	Selected
Project B	2	Selected
Project A	3	Selected with Mitigation Plan
Project D	4	Selected with Mitigation Plan
Project E	5	Selected with Mitigation Plan

$$B_i O_i / C_i R_i \tag{1}$$

$$b B_i + o O_i - c C_i - r R_i \tag{2}$$

*B. Analytic Hierarchy Process and Analytic Network Process*

AHP was introduced by Saaty [22], which is a complex decision analysis method that qualitatively compares each criteria in pairs. In AHP, the analysis process is carried out in two phases, namely (i) structuring the problem, (ii) determining priorities based on pairwise comparisons [23]. Then, a comparison is made between each variable to get priority weighting. Lower level priorities will follow from upper level priorities.

Saaty [22] states that AHP does not pay attention to the relationship and interaction between criteria that can affect the performance of these criteria. This is a weakness of AHP, where many decision problems cannot be arranged based on a hierarchical structure due to interactions and dependencies

between elements at the top level and elements at the bottom level. Analytical Network Process (ANP) emerged as a method developed from AHP, where problems have a network structure (network) and comparisons are made by taking into account the relationship between these criteria.

According to Saaty [24], hierarchy is a structure that is straight from top to bottom, while the network is a structure that is spread in various directions and includes cycles between clusters and within the same cluster. Decisions made based on network structure will produce different results from decisions based on hierarchical structure.

*C. DEMATEL*

DEMATEL is used to estimate the direct and indirect causal relations between several factors developed by Fontela and Gabus [25]. This method is a comprehensive technique in compiling and analyzing cause-effect relationships between factors. The final result of DEMATEL is a map that represents the relationship between factors or impact-relation map (IRM).

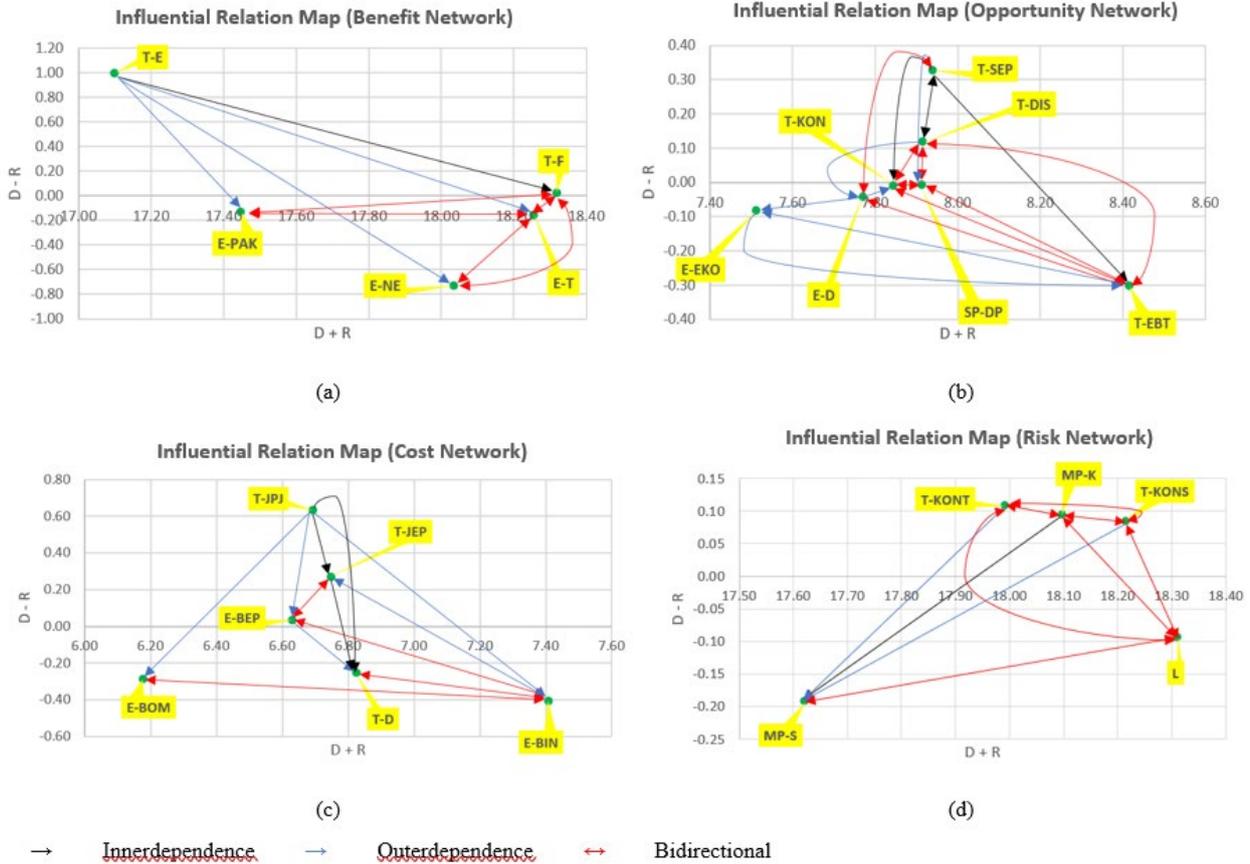


Figure 1. Influential Relation Map for BOCR Network: (a) Benefit, (b) Opportunity, (c) Cost, (d) Risk.

D. Fuzzy

The use of fuzzy in MCDM is implemented when the achievement of objectives cannot be defined with crisp or definite data [26]. Fuzzy integration in MCDM has led to the emergence of methods that can solve problems that previously could not be solved by conventional MCDM [8].

There are four types of fuzzy that have been widely applied in MCDM: (a) Type-1 Fuzzy [10], which is the simplest fuzzy function, (b) Type-2 Fuzzy [11], which is a function developed from Type-1 Fuzzy, where the function can describe uncertainties related to the membership function, (c) Intuitionistic Fuzzy [27], which describes consideration of possible errors (errors) of the decision-making judgment, and (d) Hesitant Fuzzy [12], which describes the function in which decision makers experience doubts regarding their preferences in valuation.

III. PROPOSED MODEL

The proposed model for a company to select projects to become their portfolio is composed of the following steps:

1. Identify the decision makers.
2. Identify the strategic criteria and control hierarchy.
3. Identify the criteria and sub-criteria for BOCR networks.
4. Identify the weights of strategic criteria and weights of BOCR based on strategic criteria using hesitant fuzzy AHP [30]. The scale in Table 1 is used for this calculation.
5. Identify the significant dependencies among criteria and sub-criteria in the BOCR networks using fuzzy DEMATEL [31]. The scale in Table 2 is used for this calculation.

6. Identify the weights of BOCR criteria and sub-criteria using hesitant fuzzy ANP. SuperDecision software and scale in Table 1 are used for this calculation.
7. Evaluate and select power plant projects using additive-BOCR and multiplicative-BOCR. The ranked will be determined based on additive-BOCR, ranked from the highest value (the most prioritized project) to the lowest value (the least prioritized project).

IV. CASE STUDY

This proposed model will be implemented in PT X, an electricity company based on Indonesia, to select from five projects based on RUPTL 2019-2028. Below are the explanations.

*Step 1. Identify the decision makers:* For this paper, five decision makers are chosen who are head of divisions and experts in power plant development of PT X. The decision makers then will be questioned using questionnaires to identify criteria, their dependencies with each other, and their weight based on their importance.

*Step 2. Identify the strategic criteria and control hierarchy:* Based on interview with decision makers, it is decided that PT X's missions will be the strategic criteria for the project selections. This is because when making a decision, especially investment decisions such as the implementation of a project, it is necessary to ensure that the project is aligned with the company's goals, as outlined in the vision. Missions, as derivatives and steps to achieve vision, is suitable as a strategic criterion. Mission as a strategic criterion can ensure that the results of this method are in line with the company's

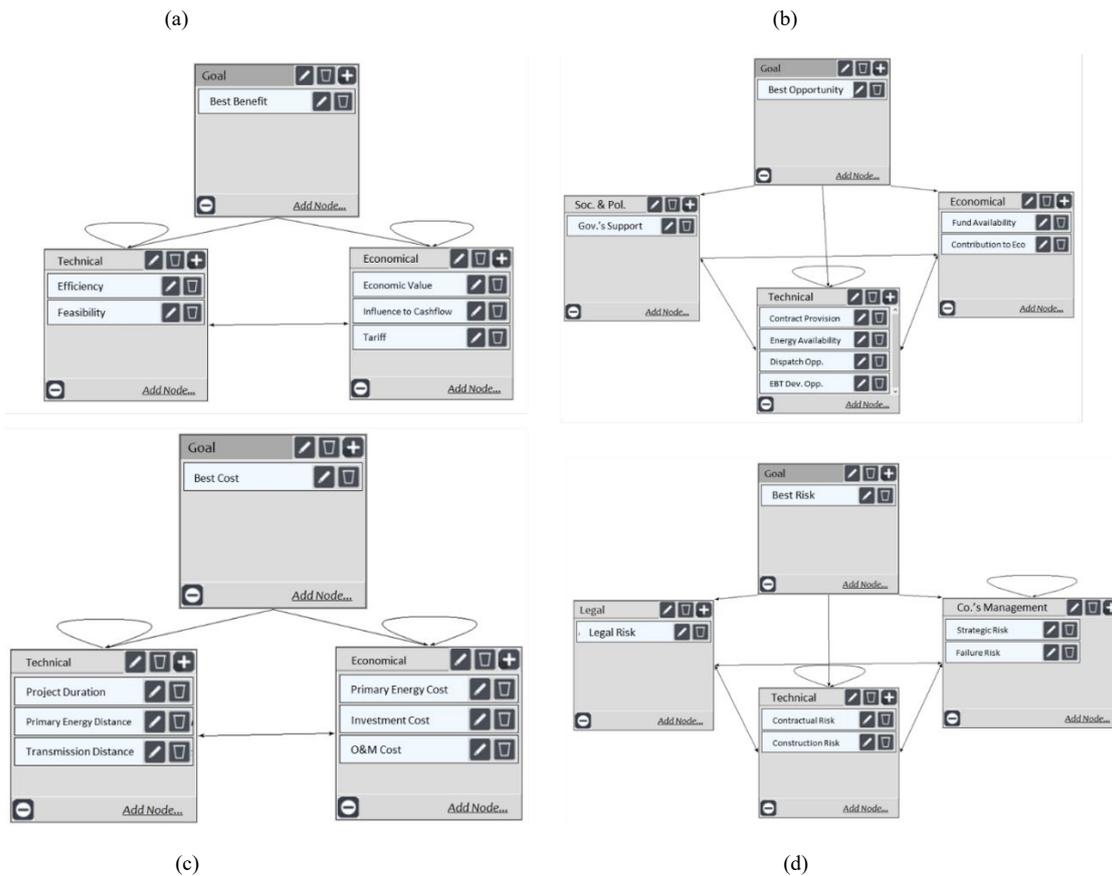


Figure 2. BOCR Network Structures: (a) Benefit, (b) Opportunity, (c) Cost, (d) Risk.

vision. Thus, the strategic criteria for this model are: (1) Solution and Value Added, (2) High quality, competitive, and environmental friendly, and (3) Sustainable.

*Step 3. Identify the criteria and sub-criteria for BOCR networks.* After reviewing all of the potential sub-criteria for BOCR network, decision makers chose several sub-criteria that they deemed suitable to be used for company’s project selections (see Table 3).

*Step 4. Identify the weights of strategic criteria and weights of BOCR.* Based on hesitant fuzzy method proposed by Acar et al [24], the weight of strategic criteria and BOCR were composed. The first step is to evaluate the importance of each criteria (see Table 4), then find the envelope from the hesitant evaluation (see Table 5) using fuzzy envelope approach [32].

After finding fuzzy envelopes evaluations from all decision makers, the evaluation were all aggregated using geometric means to become aggregate matrices (see Table 6). The fuzzy weights (see Table 7) are then calculated by calculating each row’s geometric mean, and then normalizing that values by dividing it with the highest score in the scale table, which is 10.

To find the weights for BOCR, then fuzzy weights for Strategic Criteria were multiplied with their respective BOCR fuzzy weights, and then summed to find the fuzzy weights (see Table 8). The fuzzy weights then de-fuzzied.

It was found that the most prioritized strategic criteria in the project selection were “Quality, competitive and environmentally friendly” with a weight of 52.270%, while “Sustainable” occupied the second priority with a weight of

33.833% and “Solution and Value Added” occupied the third priority with 13.898% weight. On the other hand, the most prioritized BOCR in the project selection were “Benefits” with a weight of 33.127%, followed by “Opportunities” with a weight of 23.930%, followed by “Risk” with a weight of 22.054% and a “Cost” with a weight of 20.889%. From the above results, it can be concluded that in choosing the project, PT X prioritizes the positive impacts obtained from the project compared to the negative impacts.

*Step 5. Identify the significant dependencies among criteria and sub-criteria in the BOCR networks.* Based on fuzzy DEMATEL proposed by Tabatabaee et al [25], the dependencies of criteria and sub-criteria among networks are identified. Then, after the Matrix T is composed, then the threshold value for matrix T is calculated for all BOCR networks by averaging all value in the matrix. The value that are higher than the threshold value will then be considered as significant dependencies and will be analyzed further in this paper.

Then, the Dispatcher (D) and Receiver (R) value were calculated for each of the sub-criteria to understand further regarding its dependencies (see Table 9). From those value, some conclusions can be drawn regarding each of sub-criterion dependencies.

For Benefit Network, it can be concluded that Feasibility is the causative factor that most influences other factors. Efficiency is also a causative factor, but does not have a significant effect in this aspect. Tariff and Economic Value are the affected factors that have a big influence with the

factors in this aspect. The Influence to Company's Cashflow is also an impact factor, but it does not have a large influence with other factors.

For Opportunity Network, it can be concluded that the Primary Energy Sources Availability and Opportunities for Dispatch are causal factors, but do not have a large influence on other factors. Opportunities for EBT Development are impacted factors that have a large influence with other factors. Government's Support, Funds Availability, and Contributions to Economy are also affected factors, but do not have a significant influence with other factors.

For Cost Network, it can be concluded that the Distance between Power plants with the Nearest Transmission, Distance of Primary Energy Sources to Users, and Primary Energy Costs are causal factors, but do not have a large influence on other factors. Investment Cost and Project Phase Duration are the affected factors that have a large influence with other factors. O&M Costs are also an impact factor, but do not have a significant effect with other factors.

For Risk Network, it can be concluded that Contractual Risk, Failure Risk, and Construction Risk are causal factors and have a large influence on other factors. Legal Risk is an impact factor that has a big influence with other factors. Strategic Risk is also an impact factor, but does not have a significant influence with other factors.

The dependencies between each of the sub-criteria can be described using Influential Relation Map (see Figure 1). Note that only the significant dependencies were drawn in the map. *Step 6. Identify the weights of BOCR criteria and sub-criteria.* The maps developed from DEMATEL analysis will be the base of the network structure for BOCR (see Figure 2). The beginning for BOCR criteria and sub-criteria weights calculation follows the same steps as strategic criteria and BOCR weight according to the network structure. The weights composed from these steps then were used to composed weighted supermatrix (see Table 10). The weights for each sub-criteria (see Table 12) were then identified from the limiting supermatrix.

It can be concluded that for the decision makers, in the Benefit Network, the most important sub-criteria is Tariff, while the least important is Efficiency. In the Opportunity Network, the most important sub-criteria is Opportunity for EBT Development, while the least important is Contract Provision. In the Cost Network, the most important sub-criteria is Investment Cost, while the least important is Distance between Power Plant and Transmission. In the Risk Network, the most important sub-criteria is Legal Risk, while the least important one is Contractual Risk.

*Step 7. Evaluate and select power plant projects using additive-BOCR and multiplicative-BOCR.* The BOCR values for each project were then composed by multiplying the score assigned by decision makers with the weights calculated from the previous steps. Then, the value were normalized for each BOCR networks. Then, additive-BOCR and multiplicative-BOCR were calculated (see Table 13).

It can be concluded that for the decision makers, in the Benefit Network, the most important sub-criteria is Tariff, while the least important is Efficiency. In the Opportunity Network, the most important sub-criteria is Opportunity for EBT Development, while the least important is Contract

Provision. In the Cost Network, the most important sub-criteria is Investment Cost, while the least important is Distance between Power Plant and Transmission. In the Risk Network, the most important sub-criteria is Legal Risk, while the least important one is Contractual Risk.

*Step 7. Evaluate and select power plant projects using additive-BOCR and multiplicative-BOCR.* The BOCR values for each project were then composed by multiplying the score assigned by decision makers with the weights calculated from the previous steps. Then, the value were normalized for each BOCR networks. Then, additive-BOCR and multiplicative-BOCR were calculated (see Table 13).

Based on the additive value, it can be seen that Project C (0.039) has the highest value and the first priority to be implemented by PT X, followed by Project B (0.032), Project A (0.026), Project D (0.023), and finally Project E (0.021). Project C gets the highest score because this project has the highest value in the aspect that has the highest weight, namely Benefits and Opportunities, even though this project has a high cost due to low priority weighting on that aspect. In contrast to the project, Project D and Project E which have the lowest value in the aspects of Benefits and Opportunities, even though costs and risks are also low, ultimately get low priority as well.

Based on the multiplicative value, it can be seen that Project C (1,175) has the highest value and the first priority to be implemented by PT X, followed by Project B (1,044), Project A (0.956), Project D (0.911), and finally Project E (0.905). It can be seen that Project C and Project B scored above 1, which states that the positive impact of the project is greater than the negative impact, while Project A, Project E, and Project D score below 1, which indicates otherwise.

However, this does not mean that Project A, Project E, and Project D are not suitable to be implemented by PT X. In contrast to the additive approach, the multiplicative approach does not pay attention to the weight of the priority of PT X in its calculations. This approach only looks at the ratio between positive and negative impacts generated by the project. That is why this formula does not reflect the company's attitude in choosing projects, where PT X is willing to bear a large negative impact in order to get a positive impact from the project.

Based on the explanation above, only additive values will be used as a reference to determine whether the project is selected or not (see Table 14). The multiplicative value will be an additional note that the project has a significant negative impact, so that the mitigation that needs to be prepared by PT X must also be sufficient in order to carry out the project well.

## V. CONCLUSION

Based on AHP's hesitant fuzzy analysis for BOCR's control hierarchy and ANP's hesitant fuzzy for the BOCR network, it is found that for BOCR, the first priority is the Benefits, followed by Opportunities, Risks, and Costs. For Benefit Network, the first priority is Tariff, followed by Economic value, Influence to Company's Cashflow, Feasibility, and last Efficiency. For Opportunity Network,

EBT development opportunities is the first priority, followed by Dispatch Opportunity, Fund Availability, Primary Energy Availability, Government's Support, Contribution to Economy, and Contract Provision. For Cost Network, the first priority is Investment Cost, followed by Primary Energy Cost, Project Phase Duration, Distance between Primary Energy Sources and User, O&M Cost and then Distance between Power Plant and Transmission. For Risk Network, the first priority is Legal Risk, followed by Contractual Risk, Construction Risk, Strategic Risk, and Failure Risk.

Based on the synthesis of BOCR, the results of the evaluation, selection and prioritization of projects for the needs of PT X's portfolio are Project C as the first selected project, followed by Project B in the second priority. Project A is in third priority, but with a consideration that the project has a large negative impact and in a great need for mitigation plan, followed by Project D and Project E with the same consideration.

Previously, PT X's project selection method does not consider the ambiguity or uncertainty of project information, as well as the risks of the project. From this paper, it can be seen that the evaluation using the fuzzy hesitant approach provides a greater range of ratings than the usual assessments. This is because decision makers can include element of doubts in their valuations due to the volatile business environment. This proposed method can illustrate the nature of the uncertainty and ambiguity of the information in the project selection. The application of the BOCR approach to the proposed project selection method can also provide a more comprehensive result related to the positive and negative impacts, such as risks, of the project. This will certainly help PT X in selecting their projects more carefully.

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