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Dear **Wahyudi P Utama**,
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Risk allocation of PPP waste to energy projects in Indonesia: A research framework

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Risk allocation of PPP waste to energy projects in Indonesia: A research framework

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Abstract. Public-Private Partnership (PPP) scheme has been widely adopted in both developed and developing countries to fulfill the need of infrastructure facilities such as toll roads and water supply. In Indonesia, another sector that would be feasible to be developed using the scheme is the energy sector through Waste to Energy (WTE) projects. However, the lack of knowledge and experience of public sectors on the PPP field particularly risk-allocation issues may barrier the project success. This paper presents a research framework to develop a model of risk allocation decision making for PPP WTE projects in Indonesia. A combination of qualitative (literature review and semi-structured interview) and quantitative (Delphi survey) research method is utilized to identify critical risk factors in PPP WTE projects. To develop a risk allocation model, an Adaptive Neuro-Fuzzy Inference System (ANFIS) with two outputs (public and private risk share) is proposed. A set of surveys to collect data for training and checking will be distributed to PPP experts representing government and private sectors in Indonesia, while selected WTE projects are used for data testing. The proposed model is a novel approach in risk allocation PPP research and would be useful for local authorities in Indonesia in proposing the WTE project using the PPP scheme.

1. Introduction

The availability of infrastructure facilities is considered as one of the national economic development pillars. World Economic Forum (WEF) uses the infrastructure as a global competitiveness measure of one country and it empirically correlates to economic growth positively and poverty gap negatively [1]. Electricity as one of the major energy sources plays a vital and strategic role in industrial development. It constitutes a fundamental energy infrastructure which is an essential need for the trade and manufacturing sectors to create high productivity factors [2]. Inadequate supply of electrical energy becomes an obstacle to the growth of investment for driving the economy of a region. Failure to meet such a facility threatens the quality of life and health of the community and impedes economic growth [3].

In reality, the need for electricity in Indonesia has not been fulfilled entirely with around 2,510 villages still unelectrified throughout Indonesia. Based on the Electricity Supply Business Plan (RUPTL) 2018– 2027 of PT. PLN, a State Electrical Company, the demand has been estimated at 56,000 MW with the annual projected growth of 6.86%. However, PT. PLN can only supply approximately 30% of the total need. Meanwhile, Government Regulation No. 79/2014 that sets the national energy

policy also has the objective to reduce the dependence of fuel oil as a source of energy. In line with this policy, PT. PLN plans to increase the use of alternative sources for electrical power generators, including renewable ones such as wind, solar, and waste.

In terms of waste as a source of energy, current technology has afforded to transform garbage into electricity [4]. According to Zhao et al. [5] and Wang and Zhang [6], waste to energy (WTE) incineration constitutes the most effective technique to manage municipal solid waste. Many countries have successfully adopted and implemented the WTE program, such as Denmark [7], Japan [8], and China [6]. In the southeast Asia region, WTE plants have thrived in Thailand, Singapore, Vietnam, Philippine, and Indonesia [9]. WTE is a solution for solving the energy crisis and at the same time may tackle the urban waste problem [10].

By regulation, PT. PLN is not obligated to develop such plants but is mandatory to buy the electrical power from WTE plants. To promote the WTE implementation, the Indonesian government has set a relatively high price for the WTE-generated electricity i.e., USD 13.3 per kWh based on Presidential decree No 35/2018. Local authorities are therefore strongly urged to actively contribute to developing the plants in their regions. Nowadays, the Indonesian government fosters WTE projects development in several cities such as Jakarta, Tangerang, Bandung, Surabaya, and Makassar (see figure 1). Though the provision of infrastructure facilities is fully under government responsibility, the ability to realize them could not be fulfilled solely. Given the importance of public facilities and the limitedness of public sources, the government strongly encourages the involvement of private sectors.

Figure 1. The development plan of Waste to Energy plants in Indonesia [11]

As with other greenfield infrastructure projects, WTE projects are typically capital intensive investments. Examples include the Surakarta 10 MW WTE project, which is worth USD 57.82 million, the Denpasar 15-20 MW of USD 120 million, the Jakarta 35 MW of USD 345.8 million, and Palembang 20 MW of USD 120 million [12]. However, attracting local government participation in WTE plant development features a common problem arising from the fact that the ability to finance the huge investments differs from authority to authority. Local authorities such as Jakarta, Surabaya, and Makassar appear not to have significant obstacles in realizing the WTE plant. On the contrary, cities with a limited budget have to seek private investors to support financing the plants. In connection with the private sector participation in the public sectors, the Indonesian government has regulated the public-private partnership (PPP) infrastructure provision under Presidential Regulation No. 38/2015.

2. Problem statement

The success of PPP projects heavily relies on the advisability of management and risk-sharing. Poor risk management can cause serious problems [6]. There exist many important risk events and project failures in WTE projects implemented under the PPP scheme [13-15]. Therefore, the government and private sectors should understand PPP specific risks regarding the country and type of project, which is WTE in this case.

The basic principle of the PPP scheme is risk-sharing. Risk allocation has a pivotal role in PPP contracts and is the key to the success of the PPP scheme [16]. Distribution of risk means determining which party bears negative consequences if the risk occurs in the future [17]. Furthermore, structuring risk allocation between the government and the private sector in the PPP scheme is often not easy. Chung et al. [18] opine that the intrinsic risk in the PPP scheme is the process of decision making for risk

allocation itself. Ameyaw and Chan [19] argue that "The difficulty of a risk-allocation decision becomes the differences in perceptions regarding risk criticality and risk-management capability of each of the parties involved". Thus, an effective decision on risk allocation does not depend on preferred options and mainstream opinions. To tackle this issue, several studies propose decision frameworks to support risk allocation decision-making for PPP projects.

Despite the significance of the risk allocation-related issue in WTE projects, research in this area in particular within the Indonesian context is not well established in the existing body of literature. This research is therefore focused on the model development of risk allocation decision-making for PPP-WTE projects. The results of this research are expected to facilitate decision-makers, especially local governments, in designing policies and specific strategies in managing project risks and at the same time to attract the interest of the private sector.

3. Research and objectives

The research aims at developing a dependable and practical model of risk allocation decision making in PPP waste to energy projects in Indonesia. The specific objectives to achieve the research aim are:

- To identify the characteristic and risk environment in WTE projects;
- To identify and evaluate risk factors of PPP WTE projects;
- To determine the most important risk allocation criteria in PPP WTE projects;
- To develop a risk assessment model for PPP WTE projects;
- To develop a decision-making model of risk allocation for PPP WTE projects.

The present paper is dedicated to describing the research framework that will be adopted to meet this research's aim and objectives.

4. Research framework of the study

This research adopts a sequential combination of research methods encompassing both qualitative and quantitative techniques to enhance data validity and reliability [20]. This research begins with a comprehensive literature review of WTE projects and its risk environment, the PPP applications for WTE projects, and risk management procedure riveted on risk factors and risk allocation. This stage is directed to achieve the research objective 1 and objective 2.

The next stage is the collection of primary data that involves a two-round Delphi survey and personal interviews with industrial practitioners in the WTE projects in Indonesia. This stage is designed to attain research objective 3 and objective 4. The collected data will be statistically analyzed using mean score ranking and factor analysis. The ultimate objective of this research agenda, which is to develop a decision-making model of risk allocation will be achieved by employing the Adaptive Neuro-Fuzzy Inference System (ANFIS). The design of the research framework for this study is illustrated in figure 2.

4.1. Literature review

This research systematically reviews academic publications from scientific journals, proceedings, dissertations, textbooks, institutional reports, and internet sources. This review aims to explore the research transformation in the area of interest. It is firstly directed to investigate the development of incineration WTE projects in Indonesia. The primary objective of the review is to identify relevant risk factors concerning WTE projects and the decision-making approaches applied for risk allocation strategy. This review also assists to define the gaps in the research.

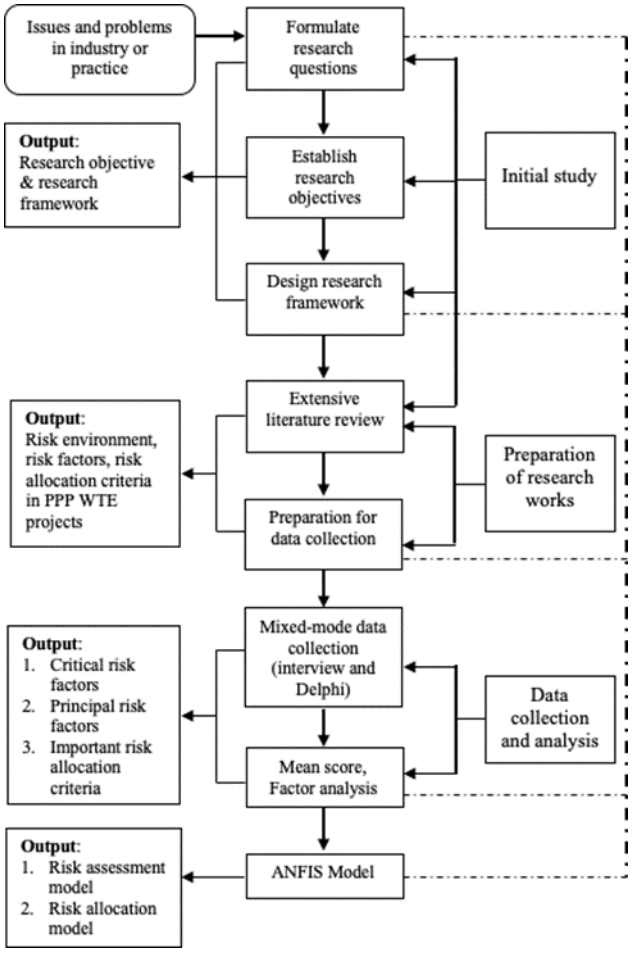

Figure 2. Research framework of the study

4.2. Inteviews

The purpose of the interview is to solicit clarification and elaboration [21, 22], which apprehend the issues from the respondents' perspectives. The qualitative information seized during the interviews enriches the data by extending the insights [23]. After the literature review is done, the research will proceed with interviews with industrial practitioners e.g., WTE operators or investors and concerned governmental bodies e.g., BAPPENAS, PT. PLN, and local authorities. This stage is performed to obtain their viewpoints on WTE projects and their risk milieu. Along with the literature review outcomes, the information gathered from the interviews will be used to prepare for the Delphi questionnaire survey.

4.3. Delphi survey

Delphi is a technique for arranging a process of group communication to deal with a complex problem that needs building up consensus or convergence of thought [24]. The Delphi technique employs a series of questionnaires iterations to collect data from selected experts. This technique has been more appropriate than a simple questionnaire for item prioritization [25] and can minimize the biases resulting from the dominant panelist, unrelated conversation, and group insistence [24].

Among the benefits of the Delphi technique are panelists' agreement achieved through repeated surveys and suitable for studies in which past data are shortcoming for application of other approaches [26]. Given that the information on WTE projects and the number of WTE plants in Indonesia are scanty, the use of the Delphi as a compatible data collection technique for the current study is very reasonable. Thus, this method will be used to evaluate and assess risk factors in PPP WTE projects in Indonesia.

Regarding the number of repetitions, this research will administer the Delphi survey in two rounds. A two-round exercise lessens Delphi panelists' exhaustion and attrition biases than the reiteration rounds [27].

Regardless of the panelist's criteria, determining the suitable size of experts involved is still in disagreement or debatable. Because PPP is new and emerging in Indonesia, identifying panelists having adequate expertise and knowledge also poses another challenge. Two strategies namely purposive sampling and a semi snowballing method will be used to solve this problem, as advised by Ameyaw [26]. The collected data in this stage will then be analyzed using three tests, including Kendall's coefficient of concordance (W), Spearman's rho correlation, and the Kruskal-Wallis test. The expected results from this analysis are the identified critical risk factors and important risk allocation criteria (RAC) in PPP WTE incineration projects. RAC is used to assess each risk factor, which is required for the ANFIS-based model development.

4.4. ANFIS model for risk allocation

Most of the models related to risk allocation are however addressed to general PPP infrastructure projects and water sectors. A hybrid of fuzzy evaluation and statistical mean and neural networks is often used to develop risk allocation decision-making models [26]. The unique characteristics of WTE projects compared with other public facilities e.g., road and water supply may curb the effectiveness of general PPP risk allocation design from previous studies.

This research proposes the ANFIS algorithm to make a major and specific contribution to PPP risk allocation in WTE projects in Indonesia. The process of making decisions in a complex environment involving multi-risk factors, the degree of risk and uncertainty, and unrefined information like WTE projects may result in the troublesome problem [28]. Besides, realistically, the relationship among the risk factors is typically non-linear and some factors unidentified. To deal with the limitations, the use of mathematical concepts of Fuzzy Logic (FL) and Neural Network (NN) is adopted by many researchers. Both FL and ANN have merits and demerits, and the amalgamation of the two algorithms bring advantages to existing ones. ANFIS is a kind of integration of FL and NN.

The fundamental concept of ANFIS is to generate the specified input-output pairs through constructing a set of fuzzy if-then rules. In this research, ANFIS is employed to create an input-output network structure. The input (I) consists of risk factor scores obtained from RAC assessment on identified risk factors, while the output (O) is the result of the fuzzy inference system embedded into the structure of adaptive networks. In this context, government and private risk allocation of each identified risk factors are set as outputs. The design of the ANFIS model for risk allocation of PPP WTE projects can be shown in figure 3.

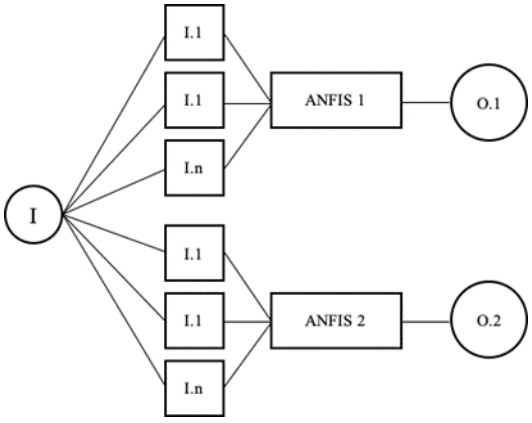

Figure 3. ANFIS network for risk allocation of PPP WTE projects

ANFIS model needs several data for training, checking, and testing. A set of questionnaires will be designed and distributed to PPP experts in Indonesia representing government and private partners.

Selected WTE projects will be used for testing the model. To validate the model network, the common indicators i.e., Root Mean Square Error (RMSE) to measure the performance and the correlation coefficient (R) to view the efficiency will be applied.

5. Conclusions

Development of Waste to Energy (WTE) plants is one of the solutions to solve the municipality solid waste problem and at the same time to increase the electrical power supply. Correspondingly, by Presidential Regulation No. 38/2015, the Indonesian government boosts cooperation between the local authorities and private sector participation to provide public facilities through the PPP mechanism. Due to the WTE projects vary from other public facilities, the PPP implementation such as sharing the risks among partners in such a project would not be synchronized with other public facilities. This paper presents a research framework to develop a model of risk allocation decision making for PPP WTE projects in Indonesia.

The research aim has been established which is to develop a dependable and practical model of risk allocation decision making in PPP WTE projects in Indonesia. Accordingly, specific objectives have been defined to reach the research aim namely A research framework was designed to address the research objectives involving mixed-mode research approaches embracing literature review, semi-structured interviews, and the Delphi survey. The literature review serves the identification of risk environment and risk factors in PPP WTE projects, while semi-structured interviews to gain deep insight into the practice of general PPP and WTE projects in Indonesia. Delphi survey assists to define critical risk factors and the importance of risk allocation criteria. Finally, the research proposes the ANFIS algorithm to develop decision-making model for risk allocation of PPP WTE projects in Indonesia. A better understanding of the mechanism of and the use of reliable risk allocation decision-making techniques may help Indonesian local authorities to attract the participation of private sectors in energy facilities through WTE projects.

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