Integrating House of Risk Method with PESTLE and CIMOSA for Risk Assessment of Java-Bali I Power Plant Construction Project

A Muntoha¹ and A Sudiarno²
¹Department of Technology Management, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia
²Department of Industrial Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia
aminmuntoha@gmail.com

Abstract. Java-Bali I Combined Cycle Power Plant Project is part of 35,000 MW electrical generating development program. To fulfill the project construction objectives, a risk assessment is needed. It is started with risk identification using PESTLE analysis and CIMOSA approach. It can be identified that there are 18 risk events for external factor, 22 risk events for internal factor and 54 risk agents that will be analysed using House of Risk (HOR) stage 1 method. Focus Group Discussion (FGD) is held for assessing severity of each risk events and occurrence of risk agents, also the correlation between them. Using HOR stage 1 is obtained Aggregate Risk Potential (ARP) value for each risk agents. Using pareto analysis, 11 risk agents is chosen as priority and will be evaluated using HOR stage 2. Using HOR stage 2 method, 7 preventive actions (PA) are identified to prevent risk agents occur. As final result, using Cost Benefit Analysis (CBA), 7 recommendations is suggested in order to make project successful according to the target specified.

1. Introduction
One of the government's strategic programs in improving economic growth and the welfare of the Indonesian people is by develop 35,000 MW power plant project. The main obstacles in implementing the 35,000 MW program is related to the provision of land. To solve that, PLN (national electric company) utilize the land on existing power plant areas, especially for Java region where the land is very limited. The benefit obtained by utilizing existing land is it can accelerate the project started. For economical reason, without land acquisition process especially in Java island, it is considered can reduce project cost. The availability of several supporting facilities for a plant such as primary energy supply infrastructure, interconnected transmission network systems and other supporting facilities, give more positive values of development on existing land. On the other hand, there are some difficulties that must be faced, for example the design of the new plant must be adjusted to the existing location which is usually also very limited. In addition, during project construction, executors must be extra careful to the existence of existing plants, especially if the plant is operating. One of the 35,000 MW project that utilize existing land is Java-Bali I Combined Cycle Power Plant (CCPP) with a capacity of 779 MW where is located in Semarang City, side by side with existing power plants with a capacity of 1,000 MW.

Infrastructure project usually put time as main target that has to be fulfilled[1]. The same thing applies for this project. At each of the milestone, it is necessary to consider the timelines of its
completion due to it is related with other projects, fuel supply and transmission network project. Assignment from PLN to its subsidiary to carry out the project are a new challenge due to all this time, the core business of the subsidiary is as the operational and maintenance (O & M) of the plant, not as the project development. The new assignment was followed up by restructuring the company's organization and forming a new unit, the Project Unit. The lack of experience in carrying out a power plant development project will increase the potential risks of the project itself.

One of main characteristic of a project is doing something that has never been done before, or can be said that each project is unique [1]. Included in this project, potential risks will arise in related to the conditions of the construction site, environmental conditions and certain other conditions which may be different from the risks in other projects. For the reasons above, a risk assessment process is needed which according to ISO 31010 (2009) includes risk identification, risk analysis and risk evaluation so that projects can meet the required targets. The scope in this risk assessment is seen from the perspective of the project owner (owner) not the contractor or project executor.

2. Risk Assessment Process

ISO 31000:2009 stated that the risk management process is a systematic application of management policies, procedures and applications regarding communication activities, mentoring, setting the context, identifying, analysing and evaluating, handling, monitoring and reviewing risks. In practical applications, it is supported by ISO 31010: 2009 which explain in more detail about the stages of risk assessment and the method used. ISO 31010: 2009 contains guidelines for selecting and applying methods systematically in carrying out risk assessment. Figure 1 explains risk assessment process that is starting from risk identification, risk analysis and risk evaluation. The purpose of the risk assessment itself is to provide information and analysis to determine decisions about how to manage risk and how to choose between several risk management options.

Many tools or methods can be used for risk identification. Sigmund & Radujkovic [3] and Samantra, et al [4] in previous research using RBS (Risk Breakdown Structure) for risk identification. In addition, another method commonly used is identification through literature studies as done by Klober-Koch, et al[5], Baghdadi & Kishk [6], and many more. Furthermore, field survey methods and questionnaires were also conducted by other researchers such as Kraidi et al[7], Holmen et al [8], etc.

Risk identification can be done by classifying risks and their causes based on the analysis of the sources, external and internal risk. To identify external risks, this study will be carried out using the PESTLE analysis (Politic, Economic, Social, Technology, Legal, and Environment). PESTLE is one method or technique in management strategies that can be used effectively to identify risks of external factors in a Risk Management Plan process[9]. Srdjevic et al [6] combined the SWOT / PESTLE analysis to analyze the case studies to reconstruct the water intake structure in Serbia. In this study, internal risk identification is carried out using the CIMOSA (Computer Integrated Manufacture Open System Architecture) approach. CIMOSA modelling can describe all aspects in the structure of business processes so that a system can be optimally integrated. Thus, it is expected that the entire process of implementing the project development can be identified as a risk that can arise in it.

After risk identification is carried out, the next stage is risk analysis and evaluation which in this study will use the House of Risk (HOR) method. The HOR approach, although initially developed by Pujawan & Geraldine [10] for risk management in the supply chain, but it should also can be applied to risk management in a project. The HOR method is used in this study because the advantages of HOR are simple methods (the calculation process uses a simple spreadsheet application), but it is very useful in its application with a focus on handling the main risk sources. On the other hand, in HOR modelling this requires subjective assessment so that the involvement of experienced and directly involved personnel with this project is highly recommended.
3. Identifying Risks Using PESTLE and CIMOSA Analysis

3.1. Identifying External Risks
Using PESTLE analysis, identifying risk related to external factor can be done by looking at the political, economic, social, technology, legal and environment. Political factors are changes in government policies and regulations that can affect the sustainability of the project. The potential for changes in government policies and regulations can be triggered by domestic political conditions as well as global and national economic conditions. Changes in economic conditions that cause a very large difference from the initial assumptions during the feasibility study before starting the project will have an impact on the sustainability of the ongoing project, especially in terms of financing.

Another external factor is social factors that are related to relationship with other parties. The risk that might occur is demonstration from local residents who are disturbed by project activities. Complaints from other companies around the project also need to be considered. In technology factor, risk that might be occurred is growing trend of renewable energy, so this thermal power plant project is no longer a priority for the government. In legal factor, the issue of licensing and lawsuits is a major risk which need to be considered. Last factor is environmental factor which is project activities can cause environmental damage. The result of risk event identification from external factor using PESTLE analysis is shown by Table 1.

3.2. Identifying Internal Risks
For identifying internal risks, CIMOSA approach can be used by classify every activity in the project into CIMOSA business process category. Generally, CIMOSA consists of three process that are operate, support and manage process as shown in Figure 2. Managerial processes focus on how to sustain and improve performance in the future, while operational and support processes focus more on performance in realizing current products/services. In term of an ongoing project that has been started, CIMOSA approach can be used specifically using operational and support processes.

Operational process in CIMOSA is a sequence of business processes starting from get order, develop product, fulfil product, and support product. Get order is preparation process including feasibility study phase until project contract is signed and process of managing permit for construction. Develop product is process for engineering design, procurement, and land preparation for construction. Fulfil product is process for delivering product that consist of construction, test and commissioning until product is handed over to the project owner. Support product is process to support fulfil product activities, for example is how to manage material, tools or equipment that will be used in construction. Support process...
in CIMOSA is various activities to support operational processes. This process focuses on activities that are used to support the main activities of business processes which include financial, human resources, organizational, IT, facilities, etc. Table 2 show the result of risk event identification from internal factor using CIMOSA process business analysis.

| PESTLE | CIMOSA | Code | Risk Events Identification |
|-------|--------|------|---------------------------|
| Politic | Get Order | E19 | Feasibility Study is not accurate |
| | | E20 | Differences between contract and actual condition |
| | | E21 | Project licensing process is not completed |
| Economic | Develop Product | E22 | The delay of land preparation |
| | | E23 | The delay of procurement process |
| | | E24 | Change of local content requirements |
| | | E25 | Design is not according to the standard |
| Social | Fulfil Product | E26 | Interfere with existing power plant operation |
| | | E27 | Quality of project does not meet the standard |
| | | E28 | Result of commissioning does not meet the contract |
| | | E29 | Delay in project completion |
| Technology | Support Product | E30 | Failure of tools/ work equipment |
| | | E31 | Loss of material during project construction |
| | | E32 | Accident during project construction |
| Legal | | E33 | Information of the progress is hampered |
| Environment | | E34 | Communication is hampered |
| | | E35 | Organization structure is not as needed |
| | | E36 | Incompetent worker |
| | | E37 | Procedure of project activities is not completed |
| | | E38 | Increase of project cost significantly |
| | | E39 | Delay of project funding |
| | | E40 | Operational facilities are not appropriate |

3.3. Identifying Risk Agents

After all risk events are identified, next step is to identify risk agents for each of them. Risk agents is a possible factor that cause risk events to occur. One risk event can be caused by several risk agents, on the other hand, one risk agents can cause several risk events. The result of risk agent identification can be shown in Table 3.
| Code | Risk Agents Identification | Code | Risk Agents Identification |
|------|----------------------------|------|----------------------------|
| A1   | Change of regulation       | A28  | Contract is not following standard |
| A2   | Economic condition change  | A29  | Damage of existing equipment |
| A3   | Change if government policy| A30  | Improper relocation of equipment |
| A4   | Traffic jam due to project activities | A31  | Contractor is incompetent |
| A5   | Damage of port facility    | A32  | Improper supervision of work |
| A6   | Local resident activities disturbed | A33  | Improper equipment installation |
| A7   | Lack of project socialization | A34  | Lack of worker/ labor |
| A8   | Information not comes out from one source | A35  | Lack of equipment maintenance |
| A9   | New technology that is more efficient | A36  | Spare part of the equipment is not ready |
| A10  | Increasing awareness of environmental friendliness | A37  | Lack of security personnel |
| A11  | There is no coordination with related party | A38  | There is no actively CCTV |
| A12  | Change of permit regulation| A39  | Improper of HSE supervision |
| A13  | Land lease agreement has not been completed | A40  | Disobey work permit and working method |
| A14  | Violation of regulations    | A41  | There is no HSE procedure |
| A15  | Improper drainage planning  | A42  | Lack of IT/ tools support |
| A16  | Environmental pollution    | A43  | Lack of IT infrastructure |
| A17  | Waste management is not according to regulations | A44  | There is no basic communication procedure |
| A18  | Weather condition           | A45  | Lack of English skill |
| A19  | Survey data is not accurate | A46  | Lack of coordination with contractor |
| A20  | Scope of work additional    | A47  | There is no study of organizational needs |
| A21  | Drawing of existing power plant cannot be found | A48  | The change of new organizational structure |
| A22  | Improper project planning  | A49  | Lack of project experience |
| A23  | Obstacles in the demolition process | A50  | There is no review of procedure |
| A24  | The actual condition of land consolidation is not accordance with calculations | A51  | Contractor’s claim |
| A25  | Design change               | A52  | Cannot fulfill lender requirement |
| A26  | Material and its supplier availability | A53  | Lack of coordination with headquarter |
| A27  | Designer is not competent   | A54  | Existing area is very narrow |

4. Risk Analysis Using HOR Method

To analyze the risk using HOR method, it is necessary to assess severity level of risk events if it occurs and occurrence level of the risk agents that trigger risk events. In addition, it is also necessary to assess whether there is a correlation between risk events and risk agents that have been identified. Weighting criteria for the risk events severity ($S_i$) and risk agents occurrence ($O_j$) are classified into 5 scale levels (point 1 until 5), whereas the correlation level ($R_{ij}$) of risk events and risk agents is classified into 4 scale levels (point 0, 1, 3 and 9). After that, calculation of Aggregate Risk Potential value of each risk agents (ARP_j) can be done by using equation (1).

$$ARP_j = O_j \times \sum_i (S_i \cdot R_{ij}) \quad (1)$$

To get the objectivity of the assessment, weighting is done using the Focus Group Discussion (FGD) stage 1. Personnel who involved in FGD stage 1 were selected with the criteria: experts in project with have experienced more than 5 years and representing each stakeholder (owner, consultant and contractor). Values of risk events severity, risk agents occurrence and their correlated as a result of FGD will be put into HOR 1 matrix as shown in Table 4.

After getting ARP values, some risk agents with high ARP values will be chosen using Pareto analysis. FGD stage 2 is held to determine how many risk agents that will be brought into HOR 2 and to identify preventive action for preventing these risk agents occur. From FGD stage 2, it is decided that 20% of risk agents will be selected and these risk agents have 63.76% ARP cumulative as shown in Figure 3. This means that if project owner only focuses on these 20% selected risk agents (11 out of
total 54), then it can overcome 63.76% potential risks that might occur in this project. Preventive Action (PA) need to be addressed for preventing these risk agents appear.

| Table 4. HOR 1 Matrix (FGD Result) |
|------------------------------------|
| Risk Agents | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 | A12 | A13 | A14 | A15 | A16 | A17 | A18 | A19 | A20 | A21 | A22 | A23 | A24 | A25 | A26 | A27 | A28 | A29 | A30 |
| Preventive Action | 45 | 18 | 27 | 54 | 9 | 48 | 30 | 24 | 1 | 45 | 8 | 72 | 54 | 81 | 14 | 225 | 90 | 540 | 540 | 135 | 90 | 36 | 36 | 18 | 27 | 180 | 15 | 5 | 18 | 18 | 45 | 45 | 54 | 3 | 90 | 150 | 54 | 108 | 45 | 18 | 15 |

| Table 5. HOR 2 Matrix (FGD Result) |
|------------------------------------|
| Risk Agents | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 | A12 | A13 | A14 | A15 | A16 | A17 | A18 | A19 | A20 | A21 | A22 | A23 | A24 | A25 | A26 | A27 | A28 | A29 | A30 |
| Preventive Action | 45 | 18 | 27 | 54 | 9 | 48 | 30 | 24 | 1 | 45 | 8 | 72 | 54 | 81 | 14 | 225 | 90 | 540 | 540 | 135 | 90 | 36 | 36 | 18 | 27 | 180 | 15 | 5 | 18 | 18 | 45 | 45 | 54 | 3 | 90 | 150 | 54 | 108 | 45 | 18 | 15 |
Using same FGD, seven PA has been identified. These PA and selected risk agents will be analysed and put into HOR 2 as shown in Table 5. HOR 2 is used to identify the correlation of PA to risk agents ($E_{jk}$) and calculate total effectivity value of each PA ($TE_k$) using equation (2). After that PA can be ranked it priorities based on the difficulty level of implementation ($D_k$) using equation (3).

$$TE_k = \sum_j (ARP_j \cdot E_{jk})$$  \hspace{1cm} (2)  

$$ETD_k = \frac{TE_k}{D_k}$$  \hspace{1cm} (3)  

5. Financially Evaluation of PA Implementation

From HOR 2, it is identified seven PA that has been ranked it priorities. Before it is implemented, this needs to be evaluated using cost benefit analysis (CBA) to ensure that this is financially feasible. Evaluation is done by comparing cost and benefit to be obtained for each PA. Benefit can be calculated as intangible and tangible benefit. Intangible benefit related to company reputation and trust from stakeholders. Tangible benefit for this project can be calculated as avoid production loss opportunity for both, new power plant and existing operated power plant. Cost is calculated by estimated the budget for PA implementation. If benefit will be greater than cost, then PA is financially feasible and can be implemented. Table 6 shows PA that has been ranked and result of CBA.

| Code | Preventive Action                                                                 | Cost (IDR) (a) | Benefit (IDR) (b) | Benefit Cost Ratio (b/a) |
|------|-----------------------------------------------------------------------------------|----------------|-------------------|-------------------------|
| PA2  | Periodically evaluate the performance of supervisory consultants                  | 56,989,405,267 | 65,148,825,474    | 1.14                    |
| PA3  | Proactively coordinate with contractors                                             | 80,000,000     | 1,225,287,005     | 15.32                   |
| PA4  | Coaching, Mentoring, Consulting (CMC) for contractors                              | 0              | 9,169,983,792     | ∞                       |
| PA5  | Project management training and certification                                       | 47,500,000     | 9,131,934,067     | 192.25                  |
| PA6  | Use of appropriate working method                                                  | 0              | 1,225,287,005     | ∞                       |
| PA7  | Fulfilling organizational structure                                                | 2,688,000,000  | 9,131,934,067     | 3.40                    |
| PA8  | Budget adjustments early on (if needed)                                            | 0              | intangible        | -                       |

6. Conclusion

ISO 31010 provides guidance on selection and application of systematic techniques for risk assessment. Some methods can be used for risk assessment implementation as mentioned in ISO 31010. Despite PESTLE, CIMOSA and HOR methods are not mentioned in ISO 31010, risk assessment process in accordance to ISO 31010 still can carried out by integrating those methods. By integrating House of Risk with PESTLE and CIMOSA methods, risk assessment can be applied for Java-Bali I power plant.
construction project. Others researcher have used another method for project risk assessment but none of them combined PESTLE, CIMOSA and HOR as shown in Table 7.

| Author          | Year | Project                          | Risk Assessment Method          |
|-----------------|------|----------------------------------|---------------------------------|
| Kraidi et al.   | 2018 | Oil and Gas                      | Study of literature, Risk Index |
| Samantra et al. | 2017 | Metropolitan Construction         | RBS, Fuzzy                      |
| Baghdadi & Kishk| 2015 | Aviation Construction            | Study of literature             |
| Sigmund & Radujkovic | 2014 | Construction on Existing Building | RBS                             |
| Srdjevic et al. | 2012 | Water Intake Structure           | SWOT/PESTLE, AHP                |
| Pujawan & Geraldine | 2009 | Fertilizer Company Supply Chain  | SCOR, HOR                       |

For risk identification stage in this study case, using PESTLE and CIMOSA methods resulted 40 risk events and 54 risk agents which will be analysed their severity and occurrence level through HOR 1. From HOR 1 methods and Pareto analysis produces 11 selected risk agents that need to be prevented their occurrence by determining the appropriate preventive action through the HOR 2 method. The results of HOR 2 analysis produces 7 preventive actions that have been prioritized to minimize the occurrence of these risk agents. Final recommendation to be applied in this project as the outcome of risk assessment is 7 preventive actions that have been financially evaluated using cost benefit analysis.

However, after implementing 7 preventive actions in the project, it needs to be reviewed and evaluated periodically for continuous improvement. Integrating HOR methods with PESTLE and CIMOSA need to be applied in other projects not only for power plant construction project to show that these combination methods can be implemented for any general risk assessments. For further study, HOR method can be integrated with other methods to get appropriate and effective combination in risk assessment implementation of a particular activity.

Reference
[1] Kerzner H and Kerzner HR 2009 Project management: a systems approach to planning, scheduling, and controlling (New York: John Wiley & Sons)  
[2] Larson E and Gray C 2010 Project management (New York: McGraw-Hill)  
[3] Sigmund Z and Radujkovic M 2014 Proc. Soc. Behav. 119 894  
[4] Samantra C, Datta S and Mahapatra SS 2017 Eng. Appl. Artif. Intell. 65 449-64.  
[5] Klober-Koch J, Braunreuther S and Reinhart G 2018 Proc. Cirp. 72 683  
[6] Baghdadi A and Kishk M 2015 Procedia Eng. 123 32-40  
[7] Kraidi L, Shah R, Matipa W and Borthwick F 2018 Creative Construction Conf. 2018  
[8] Holmen I, Utnes I and Haugen S 2018 Aquac. Eng. 83 65-75  
[9] Rastogi N and Trivedi M 2016 Int. Res. J. Eng. Tech. 3 384  
[10] Srdjevic Z, Bajcetic R and Srdjevic B 2012 Water Resour. Manag. 26 3379  
[11] Pujawan, N. I. and Geraldin, L. H 2009 Bus. Process Manag. J. 15 953-67  
[12] Bititci US, Ackermann F, Ates A, Davies J, Garengo P, Gibb S et al. 2011 Int. J. Oper. Prod. Manag. 31 851 – 91