Formulating Risk Mitigation Strategies on the Engineering, Procurement and Construction (EPC) Project in Mini Hydro Power Plant Development

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Abstract: The demand for electricity in Indonesia has been escalating rapidly for the past years. One of the priorities to fulfill the demand is by developing mini hydro power. However, the potential risk of implementation can arise at any stages of EPC process. XYZ is a EPC contractor company facing problems in managing risk. The objectives of this study are to identify risks and measuring the magnitude of the risk and develop effective risk mitigation strategies. Data analysis was conducted by determining the relative importance index (RII). There are 12 factors (22.64%) were categorized as very significant risks ($80 \leq \text{RII} \leq 100$). The respondent considers that the level grade in reliability and availability plant are the highest risk factor. The twelfth rank was taken by inaccuracy of engineers’ estimations during the preparation of material take over (MTO)/bill of quantity (BQ). Improvement in the company’s human resources is a major concern of the respondents, because the main weight of the respondent’s assessment of the strategy group was the dominant risk factor based on analitical hyrarchy process (AHP).

Keywords: mitigation strategy, Risk identification, mini hydro EPC project, AHP, RII
Projected electricity demand in Indonesia is arising rapidly every year. These conditions have forced the government through Owned-State Electricity Company (PT PLN Persero) to seek the provision of renewable energy that is also in line with efforts to reduce carbon emissions produced. Data from the National Action Plan for Greenhouse Gas, Emissions Reduction (RAN – GRK) 2014, states that the target for the development and management of renewable energy and energy conversion is expected to reduce greenhouse gas emissions by 4.4 million tonnes CO2e. One of these efforts is the development of mini hydro power. The price of the energy produced by the Minister of Energy and Mineral Resources Regulation refers mini hydro powerplant No. 12/2014 is Rp. 1075 to Rp. 1720/KWh.

According Dewayana, et al. (2010)⁴, mini hydro power operating cost is the lowest among the models of other types of plants. The advantage of mini hydro power operation is started and stopped is easy, secure load changed, the distortion rate is low, easy maintenance and automatic starting without an outside power (black start). The efficiency of the turbine and generator on mini hydro power units could reach about 95%. However, the implementation of mini hydro power plant also sometimes have a lot of obstacles.

Alencar and Aquiar (2006)⁵ explains that the project EPC hydropower plants have different risk character and divide into two stages. The first phase is the implementation, takes place within a period of 3-5 years. At this stage, the company works in capital-intensive conditions and is characterized by the concentrated investment flows without income.

Sudirman and Hardjomuljadi (2011)⁶ explains that hydro electric power plant has complex structures and involves large amounts of capital with a long-running construction period. This situation imposes uncertainty factors with considerably high risks. Nelson (2005)⁷ explains that according to the model of project EPC, contractors take full responsibility for the design phase, procurement of equipment, management and administration of subcontractors, project completion schedule, permitting and approvals required in completion of projects and guarantee the performance of the plant. However, in practice, the potential risk can arise at any stage of the process of EPC. Potential risks can be studied from various aspects, usually appear on the financial aspect, aspect of administrative/legal contracts, technical aspect of the project in which there are a lot of issues ranging from the engineering phase, procurement phase, construction phase, testing and commissioning phase. In addition, potential problem arises from the environmental and government regulations.

**Problem and Objectives of the Study**

XYZ is a EPC contracting company that has been working 13 mini hydro power plant projects in Indonesia, and it is been getting cooperation contract for ten similar projects to be undertaken in the next five years. XYZ was facing some problems during the project earlier mini hydro powerplants. This research needs to be done in relation to the needs of company to analyze risk based on mini hydro power project with EPC contract, and prioritize mitigation strategies to reduce risk, which is important to be considered for the next project.

The study aims: (1) Identify the risks faced in dealing with mini hydro power EPC projects (2) Analyze/measure the amount of risk on risk variables that have been identified. (3) Develop risk mitigation strategies that have been measured in the previous

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⁵ Alencar CT, Aquiar FL. 2006. ‘Risk mitigation for the private power project investor in Brazil’. CIB W107 Construction in Developing Country International Symposium. 18-20 January 2006, Santiago. Chile.


process.

**Literature Review**

Cabano (2004) explained that risk can be defined as uncertainties or unknown factors in the project life cycle. Even though the term 'risk' often suggests a threat perspective or negative connotation, risk can also offer positive effects on project objectives. Edward and Bowen (1998) stated the risk in the construction projects can be defined as anything that influences the construction project in the planning phase as well as the execution phase.

Poage (1990) explains that in the management of investment projects of high value and long-term, general corporate developers choose to use the EPC contract scheme. With this EPC contract model, service users more flexibility in preparing the contract. FIDIC (1999), the risk of the development phase of the implementation of micro power projects in nearly all workflow execution of EPC projects, start from client requirements, engineering phases, aspects of project management, procurement phase, the vendor scope, material control, phase fabrication/ construction, commissioning phase and the risks involved in work safety and environmental aspects of the project.

Zhi (1995) introduced a systematic approach to risk management, in four distinct stages: risk classification, risk identification, risk assessment and risk response. Similar risk management steps were also introduced by PMI (2004) which stated there were four fundamental steps of risk management: risk identification, risk analysis (qualitative and quantitative), risk response planning, and risk monitoring and control. Another research Wang et al. (2004) explain that emphasized a systematic approach to risk management in one particular field in construction industry. Which consist of three main steps: risk identification, risk analysis and evaluation, and risk response.

Cohen and Palmer (2004) explain that there are two common techniques to employ in risk identification: experienced-based risk and brainstorming-based risk assessment. The experienced-based technique might be used with interview techniques with project personnel from each discipline within the organization who have experience of similar projects, and/or with an examination of historical data from previous projects to facilitate utilization of corporate knowledge. The brainstorming sessions involve all key stakeholders in identifying and listing the risks. This technique enables the stakeholders to exchange opinions and views on potential risk with the other members of the project team.

The second step entails the risk analysis and evaluation of the risks pertaining to risk management. Wang et al. (2004) suggested that risk analysis response management may only be performed on identified potential risks. Further, risk analysis and evaluation is the intermediate process between risk identification and risk response. PMI (2004) divides risk analysis techniques into qualitative and quantitative approaches. Qualitative risk analysis is the process of assessing the impact and likelihood of identified risk. This process prioritizes risks according

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to their potential affect on project objectives.

**METHODS**

**Time and Place Research**

This study was conducted at the headquarters of XYZ in Bogor, Jakarta and branches of the stakeholders in Sulawesi, Sumatra and West Java. The research was conducted from April to July 2014.

**Types and Sources of Data**

This study used primary data obtained from interviews and questionnaires directly with selected respondents and secondary data from other data obtained either from internal sources or books, journals and previous research.

**Identification Of Risks**

Mitigation strategies require the identification of risk in the early stages. To identify risks that affect the performance of EPC project development mini hydro power conducted a literature review of previous research that has relevance to the business process, plus the variables of the journal, the regulatory aspects and environmental aspects. After the verification of the five respondents who experienced the development of mini hydro power EPC projects completed through interviews. At this stage, the project EPC mini hydro power development is described from beginning to end, and then identified and compiled a list of risks that might occur.

**Measurement Of Variables/Risk Factors**

Measurement of variables in this study using a likert scale to 39 respondents, where respondents rate a statement with 5 criterions on the questionnaire sheet, ie the value of 5 "Very Important", value 4 "Important", value 4 "Somewhat Important", value 2 "not Important" and value 1 "It’s not Important".

**Analysis Of Data**

Data analysis was performed by determining the relative importance index (RII) to measure the level of interest and the preparation of the risk ranking of each variable on the performance-based mini hydro power project with EPC contract. Scores for each risk was obtained by summing each respondent answers were taken from the seven elements of the stakeholders involved in the work of the EPC, namely: project owners, engineering managers, project managers, procurement managers, fabrication and construction managers, managers as well as testing and commissioning, and SHE managers. The results of this study indicate rank calculation of the overall risk variable and will be determined the effect of the strength of each variable risk. The formula used:

\[ RII = \frac{W}{(A \times N)} \]

Keterangan:

RII = Relative Importance Index
\( W \) = Weight given to the risk factor (1, 2, 3, 4 and 5) A = Highest weight is given (in this case 5)
\( N \) = Number of respondents

**Formulation of Mitigation Strategies**

Following the measurement of risk factors that have been identified, researchers use the AHP method to determine the priority actions proposed to management of XYZ in order to reduce the potential risks in the next mini hydro power EPC projects.

The first level is the Goal, which is the goal of research to develop risk mitigation strategies are most useful for XYZ. The second level is variable or risks factor that have been identified based on the weight based on the perception of respondents by RII method. The third level is the policy group or groups of actions to take the company to mitigate risk. The final level is an alternative action that describes corrective actions to address these risks based on the proposed strategy group at level three. Then respondents provide an assessment based on the perception of each components of a 1–9 scale in the form of a questioner.

**RESULT AND DISCUSSION**

**Identification of Risks**

Based on interviews and questionnaires to 39 respondents consisting of EPC projects involved in the development of mini hydro power plants in XYZ, gained as much as 12 score results from a total of 53 risk factors risk factors identified with a rating of "very important" (80 ≤ RII ≤ 100). Table 1 illustrates that the overall value of all elements of stakeholder RII after combined obtained 12 variables/risk factors...
(22.64%) with a rating of risk factors is crucial. Variable/risk factors of low availability and plant reliability ranks highest, next is the change in currency exchange rates and risk factors engineer inaccurate estimates when preparing the material take over (MTO)/Bill of Quantity (BQ) was ranked twelfth as be repaired in the operational phase. While reliability is defined as the probability of an item to be able to carry out the functions that have been assigned, the specific operating conditions and environment for a

Tabel 1. RII Analysis for All Stakeholders with Seven Elements of EPC which Crucial Risk Factors Valued by The Number of Respondents (n = 39)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Risk factor</th>
<th>Weighing Average RII</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>3E3</td>
<td>Level grade in availability and reliability plant</td>
<td>0.87</td>
<td>1</td>
</tr>
<tr>
<td>1B</td>
<td>Changes in currency exchange / depreciation of the rupiah</td>
<td>0.87</td>
<td>2</td>
</tr>
<tr>
<td>3B9</td>
<td>Experience and ability detailers and designers are small</td>
<td>0.86</td>
<td>3</td>
</tr>
<tr>
<td>3A6</td>
<td>Lack of commitment to the project manager of cost budgeting</td>
<td>0.86</td>
<td>4</td>
</tr>
<tr>
<td>3A1</td>
<td>Limited experience of project manager</td>
<td>0.85</td>
<td>5</td>
</tr>
<tr>
<td>3B6</td>
<td>Mismatch between design and implementation of realization</td>
<td>0.85</td>
<td>6</td>
</tr>
<tr>
<td>3D4</td>
<td>Low productivity engineer</td>
<td>0.84</td>
<td>7</td>
</tr>
<tr>
<td>3C4</td>
<td>An increase in the price of raw materials, materials or equipment when the job runs that resulted in cost overrun</td>
<td>0.84</td>
<td>8</td>
</tr>
<tr>
<td>3C6</td>
<td>Delay in arrival of major equipment that are critically affecting subsequent work</td>
<td>0.83</td>
<td>9</td>
</tr>
</tbody>
</table>

a risk factor mitigation strategies that should be found. Level Grade In Availability and Reliability Plant (3E3)

According to experts, level grade in reliability and availability are applied due to first the design of major equipment and plant design concepts provided by the engineering team (in-house) and the third party sub-optimal. Second, quality material/major equipment produced by the company manufacture not meet standards. Third, less maturation of procedures for operation and maintenance. Lastly, lack of availability of spare parts in the maintenance warranty period which should be supplied by the manufacturing company. The result is not achieving system performance as required in the contract clause and may pose a potential LD (liquidated damages) or claims of not achieving the client on system performance. Their opinions are in line with Orbeck (1991)16 explained that there are several factors that affect the availability of a system. These factors that can be corrected at the design stage and the rest can be predetermined.

Changes in Currency Exchange/Depreciation of The Rupiah (1B)

According to experts, changes in currency exchange/depreciation of the rupiah are applied due to decrease/depreciation of the rupiah currency can not be controlled by the company, but by the market. The result is ballooning budget implementation of the completion of construction because most of the major equipment still must be imported.

Experience and Ability Detailers and Designers Are Small (3B9)

According to experts, experience and ability detailers and designers are small are applied due to the lack of competence of detailers/designers should have minimum 5 years work experience as the primary component of plant and is generally purchased from the Chinese state, while the standard

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of design and code standards used in China is different from the standard designs commonly used in Indonesia. Designers and detailers in Indonesia are not familiar with the codes and standards of China. The result is often the re-works that resulted in cost-overruns on the project man hour are used for the re-design works. This is in line with the opinion of Deshpande (2009)17.

**Lack of Commitment to The Project Manager of Cost Budgeting (3A6)**

According to experts, lack of commitment to the project manager of cost budgeting are applied due to the disobedience of the project manager in controlling project costs and irregular work sequences in accordance with the initial plan agreed in the master plan. The result is setting the project cash flow that is not in accordance with the master plan of the project and ultimately will lead to cost-overrun or over budget.

**Limited Experience of Project Manager (3A1)**

According to experts, limited experience of project manager are applied due to the characteristics of EPC project management of internal/own group which tends to facilitate the procedure and limited of experience in terms of the EPC contractor of power plant, as well as handling plant with a similar capacity. The result is not integrated with the project process that will lead to many processes in the EPC phase is not running.

**Mismatch Between Design and Implementation of Realization (3B6)**

Assaf, et al. (1995)18 Explains that in order to adjust the work area with a project environment or discrepancy with the model interpretation of field conditions necessary design changes. Meanwhile, according to experts, it caused by the lack of coordination and communication between the main equipment manufacturer which is ordered from China by the contractor. The result is the re-engineering design that impact on the incremental cost or cost-overrun.

**Low Productivities Engineer (3B4)**

Georgy, et al. (2005)19 Explain that the performance of engineering in the construction industry directly affect the overall performance of the project. According to experts low productivities engineer are applied due to: first, lack synchronize design process between EPC contractor with major components manufacturing plant. Second, lack of power engineering experience designing concept mini hydro power comprehensively. Third, shortage of engineering personnel in accordance with the load borne man hour. Lastly, lack of working equipment engineering to accelerate the design process. The result is the work performance of engineers did not sufficient.

An increase in the price of raw materials, materials or equipment when the job runs that resulted in cost-overrun (3C4)

According to experts, it caused by the decision-making time inaccuracy procurement and purchasing schemes. The impact is the ballooning cost of the project.

**Delay in Arrival of Major Equipment That Are Critically Affecting Subsequent Work (3C6)**

According to experts, it caused by non-compliance with the requirement of planning the arrival of the goods in the field of construction and the less experience of the logistics team manage the planning and delivery of major equipment plants. The result is not the passage of sequence work at a later

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17 Deshpande AS. 2009. ‘Best practices for the management of design in fast track industrial projects’. A dissertations submitted to the division of research and advanced studies of the University of Cincinnati. Proquest LLC (US).


stage, resulting in swelling of the overhead.

**Damage to or Loss of Materials or Equipment That Have Been Purchased (3C8)**

According to experts, damage to or loss of materials or equipment that have been purchased are applied due to: first, no insurance covering all risks in shipment process. Second, the process of packaging and handling equipment that is not standards-compliant. Lastly warehousing systems and security within the project environment did not support. The outcome was the incremental cost of the damage in lost of material and equipment.

**The Delay in Approval of Drawings by The Consultant/Reviewer (3B3)**

According to experts, it caused by: lack of communication between the parties contracting with the consultant, the absence of an agreement on setting priorities that need to be related to the design of precedence and necessary communication is too long in the process of drawing approval. The result is a delay in the process in the next phase, which is both material and procurement of major equipment and delays in issuing drawings for construction in the field.

**Inaccuracy of Engineers’ Estimations During The Preparation of MTO/BQ (3B8)**

According to experts, it caused by less of careful engineering team in compiling the list of goods needs and the lack of experience of the design team primarily work-related details that have interfaces with other disciplines. The result is a swelling budget/cost of project completion.

**Formulation of Mitigation Strategies**

In this subsection, the researchers conducted an analysis of priority actions in response to the risk factors analyzed in the previous sub-section, through questionnaires to three experts assisted with software Super Decision and Microsoft Excel. AHP analysis model used in this study resulted in four levels, namely the Goal, factors, sub-factors, and alternative strategies such as corrective or preventive action.

Identification for each element in the hierarchy of the AHP is done by experts who represent the five elements involved in the process of EPC. However, by the time the assessment is done only three people expert. Goal of the hierarchical structure is to reduce the risk of development of mini hydro power plants on EPC projects. Level 2 contains risk factors which consists of 12 variables which are the result of the risk assessment method RII. Level 3 is a set of strategies that the company needs to reduce the risks inherent in level 2 Level 4 is variable measures proposed as a risk mitigation strategy. AHP hierarchical structure that is used can be seen in Appendix 1.

**The Relationship of Risk Factors and The Ultimate Goal**

Table 2 shows the relationship between risk factors and UG in the structure of the AHP. The most important factor relations to the risk in the EPC projects is the availability and low plant reliability and weighs

**Tabel 2. Goal and Risk Factor Relationship**

<table>
<thead>
<tr>
<th>GOAL to risk factor</th>
<th>AHP weighing</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level grade in availability and reliability plant</td>
<td>0.1791</td>
<td>1</td>
</tr>
<tr>
<td>Changes in currency exchange / depreciation of the rupee</td>
<td>0.1494</td>
<td>2</td>
</tr>
<tr>
<td>Experience and ability detailers and designers are small</td>
<td>0.1301</td>
<td>3</td>
</tr>
<tr>
<td>Lack of commitment to the project manager of cost budgeting</td>
<td>0.1170</td>
<td>4</td>
</tr>
<tr>
<td>Limited experience of project manager</td>
<td>0.0914</td>
<td>5</td>
</tr>
<tr>
<td>Mismatch between design and implementation of realization</td>
<td>0.0883</td>
<td>6</td>
</tr>
<tr>
<td>Low productivities engineer</td>
<td>0.0740</td>
<td>7</td>
</tr>
<tr>
<td>An increase in the price of raw materials, materials or equipment when the job runs that resulted in cost-overrun</td>
<td>0.0488</td>
<td>8</td>
</tr>
</tbody>
</table>
The Relationship of Risk Factors and Group Strategies

Group priority strategies implemented related to plant availability and reliability are a group of organizational systems improvement strategies and weighs 0.4081. As for the risk factors of experience and ability detailers and designers who are low-risk group HR-related improvement with weight 0.3536. Furthermore, the relationship of risk factors and group strategies can be seen in Table 3.

While Table 4 shows the weight of the group strategy towards the ultimate goal. Where groups of HR-related improvement strategies considered most important to reduce the risks that occur in the development of mini hydro power EPC projects in XYZ with weights 0.3262. Alternative strategies that both groups are in the engineering process improvement strategies with weights 0.2618.

Group Relations Strategy with Action

Furthermore, the relationship of risk factors and group strategies can be seen in Appendix I In a group of HR-related improvement strategies, QC placement representative at the vendor location when major equipment manufacturing process is carried out an important work with weights 0.2839. Furthermore, in the group in the engineering process improvement strategies, conduct a design review of the performance of the system availability is the primary work with weights 0.4309. Doing interfacing between design issued by the manufacturer with a design created by in-house engineer at XYZ company is an important act of weighing 0.5678 in the group communication.

The main work in the policy group improved procurement system is a guarantee of availability of spare parts within the warranty period which is emphasized in the maintenance contract with the manufacturer, with a weight rating 0.4914. Moreover, the last in a group of organizational systems improvement strategy put work preparation time system preventive maintenance and predictive maintenance to achieve the maintainability, control and power efficiency as the main action with weights 0.2963.

Implications

Based on the results of the study, improvement of HR related business is crucial to do, given the respondent’s assessment appears to have a major weight in the group of HR-related improvement strategies. Improvement strategies related to human resources is a major strategy group that gets priority assessment based on risk factors for changes in currency values; experience and ability detailers and designers are small; lack of commitment to the project

Tabel 3. Risk Factor and Cluster Strategy Relationship

<table>
<thead>
<tr>
<th>Cluster Strategy (→)</th>
<th>HR improvement strategy</th>
<th>Engineering process improvement strategy</th>
<th>Communication system improvement strategy</th>
<th>Procurement improvement strategy</th>
<th>Organization improvement strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level grade in availability and reliability plant</td>
<td>0.2701</td>
<td>0.1431</td>
<td>0.3100</td>
<td>0.1485</td>
<td>0.0439</td>
</tr>
<tr>
<td>Changes in currency exchange / depreciation of the rupee</td>
<td>0.3080</td>
<td>0.7997</td>
<td>0.0604</td>
<td>0.0579</td>
<td>0.7336</td>
</tr>
<tr>
<td>Experience and ability detailers and designers are small</td>
<td>0.3536</td>
<td>0.1916</td>
<td>0.0623</td>
<td>0.0607</td>
<td>0.2593</td>
</tr>
<tr>
<td>Lack of commitment to the project manager of cost budgeting</td>
<td>0.4260</td>
<td>0.3141</td>
<td>0.0995</td>
<td>0.0531</td>
<td>0.2209</td>
</tr>
<tr>
<td>Limited experience of project manager</td>
<td>0.3124</td>
<td>0.4071</td>
<td>0.1034</td>
<td>0.0541</td>
<td>0.2549</td>
</tr>
<tr>
<td>Mismatch between design and implementation of realization</td>
<td>0.1806</td>
<td>0.2954</td>
<td>0.0663</td>
<td>0.0665</td>
<td>0.0790</td>
</tr>
<tr>
<td>Low productivities engineer</td>
<td>0.4927</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Formulating Risk Mitigation Strategies on the Engineering, Procurement and Construction (EPC)

Tabel 3. Risk Factor and Cluster Strategy Relationship (continued)

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>HR improvement strategy</th>
<th>Engineering process improvement strategy</th>
<th>Communication system improvement strategy</th>
<th>Procurement improvement strategy</th>
<th>Organization improvement strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do project in a hurry when the job runs than resulted in cost overrun</td>
<td>0.3389</td>
<td>0.3041</td>
<td>0.1099</td>
<td>0.0568</td>
<td>0.1903</td>
</tr>
<tr>
<td>Delay in arrival of major equipment</td>
<td>0.2565</td>
<td>0.2565</td>
<td>0.1175</td>
<td>0.0469</td>
<td>0.3225</td>
</tr>
<tr>
<td>Inaccuracy of engineers' estimations during the preparation of MTO/BQ</td>
<td>0.2425</td>
<td>0.2437</td>
<td>0.1010</td>
<td>0.0495</td>
<td>0.3632</td>
</tr>
</tbody>
</table>

Tabel 4. Weighing for Cluster Strategy to Ultimate Goal

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cluster strategy</th>
<th>Weight</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>HR improvement strategy</td>
<td>0.3262</td>
<td>1</td>
</tr>
<tr>
<td>S2</td>
<td>Engineering process improvement</td>
<td>0.2618</td>
<td>2</td>
</tr>
<tr>
<td>S3</td>
<td>Communication system improvement</td>
<td>0.2574</td>
<td>3</td>
</tr>
<tr>
<td>S4</td>
<td>Procurement improvement strategy</td>
<td>0.0974</td>
<td>4</td>
</tr>
<tr>
<td>S5</td>
<td>Organization improvement strategy</td>
<td>0.0572</td>
<td>5</td>
</tr>
</tbody>
</table>

manager of cost budgeting; engineer productivity is low; rising prices of raw materials during the process of running jobs; damage or loss of material that has been bought and the slow approval of drawings by the consultant/reviewer. Next is revamping the design and process improvement at the organizational system. It can be done in a way stimulant implementing ISO system in the company. As the information, XYZ has not implemented the ISO system in the division that handles mini hydro power EPC projects. Because the ISO system, improvements related systems and processes within the engineering organization itself can be monitored by both the documentation and implementation.

In the group in the engineering process improvement strategy and improvement plan communication system, a design review against performance measures system availability and related modeling interfacing between design issued by the manufacturer with a design created by in-house engineers have a weight rating above 40 percent. It indicates that the availability and reliability of low plant has a tendency due to lack of design reviews conducted by the engineering team. So to reduce these problems, the design team should create a model that comprehensively integrates all components in mini hydro powerboth in modeling software and the actual model (making miniature_mini hydro power models).

Associated with some plan of action that should be a concern of XYZ to reduce the risk in the project management, it is necessary to the implementation of mitigation strategies effectively and efficiently. It
can be done with a pattern of planning, organizing, actuating and controlling (POAC). Preparing the plan formulation with good mitigation strategy as needed in the field and the findings in this study. Followed good organizing, party anyone who will be involved in this strategy, then the strategy has been implemented. In the implementation process should be a controlling activities to keep the implementation of the proposed mitigation strategies in line with the implementation in the field. For future, companies should establish a risk management division, so that in the future the company can identify deeper problems.

**CONCLUSIONS AND SUGGESTION**

**Conclusion**

Assessment of risk factors with ”very important” based on analysis of Sight, obtained as much as 12 variable risk or in other words as much as 22.64 % of the 53 risk variables identified in this study. The order of the risk factors from the highest to the latter is the following: plant availability and reliability is low; changes in currency exchange rates; experience and ability detailers and designers are small; lack of commitment to the project manager of cost budgeting; lack of experience of the project manager; mismatch between design and implementation in the field; engineer productivity is low; rising prices of raw materials, materials or equipment when the job runs that resulted in cost-overruns; delay in the arrival of major equipment that are critically affecting the next job; damage or loss of materials or equipment that have been purchased; slow approval drawings by consultant/reviewer and not accurately estimate when drafting engineer MTO/BQ. It is in line with the assessment of respondents using AHP method.

Improvement in the company’s human resources is a major concern of the respondents, because the main weight of the respondent’s assessment of the strategy group was the dominant risk factor. It seems clear to respondents’ assessment of the relationship repair strategy group HR-related risk factors, which appears 8 of 12 respondents assessment of risk factors with weight above 30%.

**Suggestion**

This study becomes a prefix to conduct further research. It is hoped that future research could conduct a more in-depth analysis. For the next risk variables, related project financing and details of the process in each of these elements need to dig deeper. It should be also studied other external variables, such as the financial institution relationships, relationships macroeconomic variables and variables related to the government’s policy of regional autonomy which in this study was not included as a risk factor variables. In addition, the analysis may be made wider scope, not limited only in the company as a case study.

**REFERENCES**


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