Assessing Risk on The Engineering Procurement Construction (EPC) Project from The Perspective of The Owner: A Case Study

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Abstract. Risk is part of infrastructure projects, and EPC projects are no exception. Risk is a consequence of uncertainty conditions. In construction projects, the risk cannot be predicted because there are a lot of uncertainties in predicting problems [1]. The risks in different types of contract projects would also be different, because of the different characteristics of each contract. In this study, the risk of construction projects was reviewed based on the project life cycle of the E.P.C (Engineering Procurement Contract) contract. The aim of this study is to analyze the risk from the perception of the owner of the project with the Engineering, Procurement, and Construction contract type. Primary data collected were in the form of identification and assessment of the impact and risk probability obtained by interviews and questionnaires. Data analysis was done with the Risk Breakdown Structure method to determine the risk ranking. The risk analysis of the Engineering Procurement Construction project from the owner's perception showed that the majority risk was risk in the low category (46%), then moderate risk (27%), and high risk (27%).

1. Introduction

The risks in a construction project are different with different types of contract. This is due to the different types of projects life cycle in each contract type.

One of the ways to achieve sustainable development in a country is by creating a strong construction industry towards global competition [2]. One of the work contract systems used in infrastructure projects is Engineering, Procurement, and Construction (EPC) [3].

The EPC contract model is widely used by the private sector to carry out construction work on large-scale infrastructure projects [4]. The EPC method can improve a contractor’s efficiency in terms of design, procurement, and construction simultaneously in achieving initial builder involvement, cost savings, and the effectiveness of a project duration [5].

Engineering, Procurement, and Construction (EPC) is a construction model that integrates work between engineering, procurement, and construction in one contract. In an EPC project, the general contractor appointed by the owner has duties ranging from planning, procurement of materials, to construction [6]. An Engineering, Procurement, and Construction (EPC) / Turnkey contract covers design, procurement and construction that refer to the contracting company in accordance with the contract, then the quality, safety, schedule and cost are the full responsibility of the Contractor for the entire project [7].

Madureira and Carvalho [8] stated five factors that presented a strong correlation with EPC project: cooperation, trust, exchange of information, synergy, degree of integration. One problem in the
construction industry is the flow effect resulting from low efficiency and productivity. EPC is one of the solutions to face dilemmas in construction processes which cause poor performance [9].

Applications in engineering, procurement, and construction (EPC) projects cannot be avoided, due to the demands of developments in construction projects. In the EPC model, the contractor is responsible for procurement and construction risks arising from immature technical and social aspects during the "initiation" phase of the project [10].

Risk is a consequence of uncertain conditions that often cannot be predicted precisely. It is therefore necessary to assess risk and perform risk management from the start of a construction project, to reduce the impact and probability of risks that might occur [11].

Risk management is a systematic control procedure for estimating risks that might be encountered in a project. This is a phased procedure consisting of risk identification, risk classification, risk analysis, and risk response [12]. The risk management process helps the owner and the project team to make informed decisions about alternative approaches to the risks involved, to increase the likelihood of project success in terms of cost, time, and quality.

Most of the risk studies on the EPC project were viewed from the contractor's perspective. While the owner, the other stakeholder in the EPC project, also has risks. Many of the studies reviewing risks in EPC projects from a contractor's perspective focused on two things, schedule-related variations and time-cost analysis [10; 13]. The aim of this study is to analyze the risk from the perception of the owner of the project with the Engineering Procurement Construction contract type.

2. State of The Art

2.1. State of The Art of Engineering, Procurement, and Construction

Some researchers have provided definitions of EPC, and it can be concluded that EPC is a project management concept that designs, procures materials and equipment, and constructs [3]. The basic contractual structure of an EPC contract is illustrated in Figure 1, taking an example of a project-financed power project, while in reality, detailed structures can differ from one project to another [4].

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**Figure 1.** Basic Structure in an EPC Contract
The EPC Performance Related Indicators were poor design, poor project planning, bad estimation, incomplete design, stakeholder involvement that does not accommodate disputes, loss of reputation, old delivery of goods, poor site supervision, poor project control, changes in project implementation, delay in delivery of building materials on site, inappropriate quality of building materials, redo of inadequate tasks, inadequate or inefficient equipment or machinery sub-contractors, unskilled labor, labor changes, accidents or incidents, excessive bureaucratic inclusion [14]. In analyzing the productivity of this EPC contract, it is necessary to know in advance what risks might occur in the application of the contract.

2.2. State of The Art of Risk in Engineering Procurement Construction
EPC project risks have been associated with construction, design, payment, client, and sub-contractor (procurement) risks [15]. Yoo et al. [16] studied the importance of 52 risk elements through expert surveys and weighing of risks for EPC nuclear power projects, and it was concluded that procurement and delivery schedules were the most critical risk factors for a project’s success.

EPC contracts tend to handle problems with greater sophistication than other types of construction contracts. The prerequisites needed for the successful functioning of the EPC approach include that the contractor understands, manages and influences the allocation of risk and ready to assume the level of risks [4].

One risk from the owner's perception is the contractor's claim [11]. Causes of contractor claims in EPC projects are external risks, client's organizational behavior, and project definitions in contracts [17]. Causes of contractor claims are analyzed among others as external risks (sociopolitical risk, economic risk and natural hazards), client organization behavior (premature payments, order changes, and inefficient processing), and project definitions in contracts (unclear scope of work and technical specifications).

There are several potential risks in EPC projects such as potential delays in schedules, quality problems, hostile relations, and information interruptions [18,19]. This is because an EPC project typically has a long, large-scale, and multi-participatory process [6].

3. Materials and Methods
The primary data collection was done by interview and questionnaire survey. Primary data collected were identification risks and the risks of impacts and probabilities. Secondary data were obtained from other studies, for example, reference books, magazine articles, journals related to research topics, and project data. Other secondary data were EPC project technical documents and other project documents. The authors reviewed the EPC scheme in a case project of a steam power plant (PLTU) in Indonesia. Respondents were the decision makers on related projects. Data analysis was done using the Risk Breakdown Structure method to determine the risk ranking.

4. Results and Discussion
4.1. Identification of Risk
The identification of risks in the Engineering Procurement Construction projects was divided according to the project life cycle: the Phase of Engineering, the Phase of Procurement, and the Phase of Construction (Figure 2). There were 12 identified risks and they were then divided into the three aforementioned phases.

![Figure 2. The Life Cycle of an Engineering, Procurement, and Construction project](image-url)
4.2. Risk Analysis
Risk analysis was carried out using the Risk Breakdown Structure method. The data needed were probability weight and the impact of each risk. These data were obtained using a questionnaire and interviews with respondents. After the probability and risk impacts were obtained, the level of risk was calculated by multiplying probability and impact values. The risk analysis is presented in Table 1.

Table 1. Risk Analysis in an Engineering, Procurement, and Construction Project from the Owner’s Perception

| Phase of Engineering | Code | Identification of Risk                                                                 | Probability | Impact | Risk Level | Risk Category | Risk Rank |
|----------------------|------|----------------------------------------------------------------------------------------|-------------|--------|------------|---------------|-----------|
|                      | F1   | The results of the initial study (engineering and environment) were less accurate       | 3           | 4      | 12         | High          | 2         |
|                      | F2   | The quality of the contractor was not as expected                                       | 1           | 3      | 3          | Low           | 9         |
|                      | F3   | Delay in design produced                                                                | 2           | 2      | 4          | Low           | 8         |
|                      | F4   | Personnel and equipment of mobilized contractors were not in accordance with the offer  | 1           | 3      | 3          | Low           | 10        |
|                      | F5   | Land status and the environment issues around the project                                | 2           | 5      | 10         | High          | 3         |

| Phase of Procurement |
|----------------------|
|                      |
|                      | Code | Identification of Risk                                                                 | Probability | Impact | Risk Level | Risk Category | Risk Rank |
|                      | G1   | The timing of the procurement was not appropriate                                      | 2           | 5      | 10         | High          | 4         |
|                      | G2   | Selected vendors were less competent                                                    | 3           | 3      | 9          | Moderate      | 5         |

| Phase of Construction |
|-----------------------|
|                      |
|                      | Code | Identification of Risk                                                                 | Probability | Impact | Risk Level | Risk Category | Risk Rank |
|                      | H2   | Inaccurate quantity estimation                                                          | 2           | 3      | 6          | Moderate      | 6         |
|                      | H3   | Contractor’s performance was not in accordance with planning                            | 1           | 2      | 2          | Low           | 11        |
|                      | H4   | Project start time was late                                                             | 2           | 3      | 6          | Moderate      | 7         |
|                      | H5   | Project cost escalation                                                                | 1           | 1      | 1          | Low           | 12        |
|                      | H6   | Contract Change Order by contractor                                                     | 3           | 4      | 12         | High          | 1         |

Furthermore, the risk level were then categorized into three groups i.e. the low risk, moderate risk, or high risk. The results of this risk analysis can be seen in figure 3. Most risks were in the low category.

![Figure 3. Risk Level on the EPC Project from the Owner's Perspective](image)
4.3. Risk Responses
Risk responses were obtained by interviewing respondents to find action plans that need to be prepared to reduce the probability and impact of risk. Risks were also grouped into risk received, mitigation, or avoided. The results of risk response grouping are presented in Figure 4. Most risk responses were received risks.

![Figure 4](image_url)

**Figure 4.** Risk Responses on the EPC Project from the Owner's Perspective

5. Conclusions
From this study it can be seen that from the perspective of the owner, the highest risk in the EPC project were Contract Change Order by contractor and results of the initial study (engineering and environment) that were less accurate than expected. 12 risks were identified, and most were in the low risk level. Further research can assess risk from the perspective of other stakeholders involved in an EPC project.

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