Risk Factor Analysis of Planning Stage of Lumpsum Hydropower EPC Project Impacted to Quality and Time Performance

Arwan Kahfi[1], Bambang Purwoko Kusumo Bintoro[2], Rosalendro Eddy Nugroho[3]

[1]Civil Engineering Master Program, Mercu Buana University, Jakarta, Indonesia
(Corresponding Author)

[2]Graduate School of Business, Bakrie University, Jakarta, Indonesia

[3]Civil Engineering Master Program, Mercu Buana University, Jakarta, Indonesia

Abstract: *The hydropower EPC project as a large complex project with various types of buildings carries risks that can cause failure or decrease in construction performance, especially quality performance and time schedule performance. EPC contracts with lump sum or fixed costs, where detailed planning is carried out after signing the contract in which one package with construction, then the planning stage has risk factors that affect the quality performance and time performance. A combination of quantitative and qualitative analysis is used as a research approach. Consultation and initial confirmation carried out for determining relevant risk factors to be studied and analyzed in the research model hypothesis using Structural Equation Model (SEM) with Smart-PLS software as a quantitative approach. The research model and risk response input from experts as a qualitative approach. The initial confirmation from the expert, it is known that 6 of the 8 initial variables with 36 out of 45 indicators are considered relevant for carried a hypothetical analysis of risk factors in the planning stage that affect the quality and time performance of the project. It's known that the variables of owner's necessities and requests, the scope of work and the engineering design output have a significant direct effect on quality and time performance. The communication and coordination factors have a significant effect on quality and time performance with the mediation of the engineering design output factors.*

Keywords: EPC of hydropower, risk factors, planning stage, quality performance, time performance.

1. Introduction

Renewable energy has the advantages which not being possessed by non-renewable energy. This energy source can renew as long as the natural cycle is still ongoing, environmentally friendly and can minimize environmental pollution. The hydropower potential in Indonesia according to the Hydro Power Potential Study (APPS) from PT. PLN (Persero) by Nippon Koei Co. Ltd in 1983 was 75 Gigawatt. In 2011 PT. PLN was completed the report for the Master Plant for Hydropower Development in Indonesia through Nippon Koei Co. Ltd. and JICA, it is known that the total potential of hydropower in Indonesia is 26.3 GW including 4.3 GW which was developed and 5.9 GW which is in the process of being developed. From this amount, the potential for hydropower development in Indonesia is still quite large and higher than which has been developed.

From Hardjomuljadi (2014), high uncertainty on the construction of the 9 large hydropower plants that have been built by PLN, it is known that the completion cost compared to the contract has increased is between 50% ~ 300%, and 6 of them spend a cost are 100% higher than the price ceiling of lenders. This increase occurs generally in underground / semi-underground work.

Tangfei, Wang et al. (2015) in a study of several Chinese contractors, it is known that all design management indicator ratings are low (i <4), this clarifies the need for Chinese construction companies to improve design management, such as design schedules, quality, claims management, and design option costs. The risk factor analysis shows that the contractor must systematically increase the design management capacity by focusing on four factors: planning and execution, dispute resolution, design optimization, and engineering promotion.

Based on data obtained from the owner's company of hydropower EPC project in Sumatera, it's known that the amount of delay in the planning stage of the main works which consists of a dam, headrace tunnel waterway, and powerhouse is a delay of more than 1 year or about 20% of total schedule of EPC project.

The design of headrace tunnel work with the largest cost of works or pare to has been delay for completion for more than 1.5 years. This has an impact on delays in commencement of some parts of the work and affects the project completion as a whole, although some commencement work has been agreed to start with some basic design documents.

2. Literature Review

2.1 EPC lumpsum Project

According to Sitorus (2008), EPC is a form of project management concept that delegates responsibility for design and planning activities, procurement of materials and equipment and implementation of construction to EPC contractors. Detailed design is do and in the responsibility of the EPC contractor.

Base on Sudarsono, SA (2001, pg. 98) EPC Project is a project which the EPC contractor works with the scope and responsibility for completion of the works including study and design details, procurement of equipment & bulk materials, construction stages including testing & commissioning and planning of these three activities. Meanwhile, Soeharto (2001) state that the EPC project is a contract system which is generally applied to projects that are complex, complicated and have many problems in their implementation.

2.2 Engineering Stage of EPC Project

Based on Soeharto (2000), engineering is an idea that comes true with the totality of the system, namely by paying attention to the effectiveness of the whole system to operation and maintenance.

Refer to Chiyoda Corp (2017), Front End Engineering Design is basic engineering carried out after a feasibility study and before starting the EPC implementation, which aims to find out technical problems and more actual estimated cost and not more than 5%.

2.3 Risk Analysis and Risk Response

Refers to PMBOK (2004: 249), quantitative risk analysis is the process of analysing the impact of risk events and giving a rate in the form of a number to the risk list. According to Alam T, (2011), risk identification is a repetitive process because new risks may only become known when the project is ongoing during the project cycle. The frequency of repetition and who are involved in each cycle will vary greatly from case to case.

According to Manullang (2017) risk response is divided into two, namely positive response and negative response. For negative risks, the thing to do is; avoid, transferred, carried out mitigation and accepted.

2.4 Project Performance

In the relationship between project performance which is known as triple constraint with risk, Ahmed (2016) provides an understanding of project risk which means that the risk to one of the project baselines (technical, cost, or schedule) is also considered during the early stages of planning by describing the relationship between time, costs and quality as shown in Figure 1.

Figure 1: Project Triple Constraint

According Wyngaard et.al (2012), Triple Constraint reflects the fact that the three constraints are interrelated and changes on one side of the triangle will affect the other side. The quality of the project is influenced and affected by the balance of these three constraints.

Asiyanto (2004) mention that the definitions of quality are the overall nature and characteristics of a product or service related to its ability to meet a need, and refer to Lavender (1996), quality can be interpreted as conformity to the standards or requirements that have been set for achieved. Quality is a product or service in related to customer desires and requirement. Standards quality can be made into varies levels (high, medium, and low), and the important thing is that the product quality is guaranteed as expected.

Project schedule is a major indicator of project time performance. Kazner (2009) mentions several things that must be considered in scheduling preparation, regardless of the objectives and project complexity. Major indicators can be;
1) Milestone shall be identified and made clear.
2) The sequence of work shall be clearly identified, logic and realistic.
3) Each schedule items must be linked to the work breakdown structure with unique codification.

2.5 EPC Project Risk Factors

Hung and Wang (2016) stated that levels of risk impacts to construction progress finds that the largest risk factor (from high to low impact) is Economy; EPC general contractors; Techniques; The politics & law; Natural conditions and social environment; Management; Contract.

Mai and Wang (2017) analyzed and evaluated carefully the risks of determine causes leading to the poor quality of the project. Quality construction methods for construction are important parts of project quality management which required the contractors to abide by the technical contract to develop the quality management system.

The 6 risk factors researched by Harjomuljadi S. & Sudirman WB (2011), namely 'critical initial risk source factors', as perceived by the client, consultants, and contractors in HEPP projects in PT PLN (Persero) are: subsurface conditions of geology; subsurface conditions of ground water; third party delays; poor site management and supervision; low speed of decision making involving all project teams; and delayed site access.

50 risks are identified in the research by Ayub B. et al. (2016), from 9 group of risk, top 15 severe risks are highlighted in which "construction risks" group is most widely represented with 6 risks, followed by "geological & hydrological risks" group. Responsibility of 23 risks was allocated to EPC contractors and 10 to clients. A total of 14 risks need to be jointly shared between contractors and clients, while responsibility for 3 risks was undecided.

Nobel A. (2018) stated that the risk profile on the underground works from a lender's perspective does change over the life of a hydropower project, from due diligence stage, through construction financing and the operation financing, but it does not diminish altogether.

Gunarso and Kukuh (2018) researched risk factors in the engineering stage, 1 factor during the design concept, 3 factors in basic design with the largest factor, namely resource allocation, 13 factors from detailed design with the biggest factor for economical design products that have an impact on increased costs.

Wei, Li et.al (2012) research 23 risk factors from international HEPP project; obtained 10 high risk factors i.e. Social environmental; State political risk; Owner risk; Market risk; Economic/Financial; Contractual; Risk on project schedule and cost; Risk on / design; Risk on subcontractor; Vendor risk.

3. Research Methodology

3.1 Research Type

This research uses a combined approach between quantitative and qualitative approaches method. Based on the method and data measurement analysis, this research is classified as a survey research, because it uses a questionnaire as its main source as a quantitative research.

According to Istijanto (2008: 21), the word causal comes from the English word, cause means to because or influence. The method used is survey explanatory, which is a way of collecting information from a population, with the aim of explaining and clearing the phenomena that occur by examining the influence between variables.

3.2 Research Variables

Based on the literature study, 8 variables consist of 45 indicators were preliminary proposed. The results of the initial discussion and survey were limited to just few experts, resulting in 6 risk factor variables with 36 indicators that are considered relevant to answer the hypothesis research. Risk factors indicators and project performance indicator shown in table 1.

Table 1: Research Variables & Indicators

Variables and Indicators (Risk Factors)		
Engineering Design Output (EDO)	EDO.1	The quality of design
	EDO.2	The quality of construction drawing
	EDO.3	The detailedness and accurateness of material specification
	EDO.4	Design product from contractors tend to be economical
	EDO.5	The parameters and standards that will be used as references for construction works
Data Availability (DA)	DA.1	The completeness of geological data
	DA.2	The completeness of tender drawing
	DA.3	Existing condition mismatch to existing data
	DA.4	Unavailability of data required for design
Variable and Indicator (Risk Factor)		
Scope of Engineering Works (SEW)	SEW.1	The clearness of definition and scope of basic design and detailed design
	SEW.2	The failure of the contractor in converting the basic design to a detailed design
	SEW.3	The in-depth geological survey was carried out by contractor
	SEW.4	The completeness of technical description of the planning by the contractor
Owner Necessities & Requests (O-N&R)	O-N&R.1	The completeness of explanation by owner regarding their requirement
	O-N&R.2	The lateness of change requirement by contractor
	O-N&R.3	A change order by employer's during engineering stage
	O-N&R.4	The differences in the material standards by the employer
	O-N&R.5	There are indications of a project to be postponed by the employer
Communication & Coordination (C&C)	C&C.1	The effectiveness of communication for logic of the design was chosen
	C&C.2	The smoothness of design review and approval process
	C&C.3	The comprehensiveness of design review and approval process
	K&K.4	The effectiveness of communication between owners and contractors
	C&C.5	Coordination among contractor engineering team members
Project Performances Indicators		
Quality & Time Performance (Q&T-P)	Q&T-P.1	The intensity of the inspection was carried out for the contractor's work
	Q&T-P.2	The amount of non-compliance records of the contractor works
	Q&T-P.3	The amount of contractor works was rejected
	Q&T-P.4	Employers satisfaction to the contractor works
	Q&T-P.5	The latens of start of construction works
	Q&T-P.6	Additional time for civil construction works
	Q&T-P.7	Delay of start of sub-contractor works
	Q&T-P.8	Additional time for E&M manufacturing

Two variables were excluded in the preliminary stage is variable of Duration of engineering stage and Utilization of technology with consideration already represented by other's variables.

3.3 Research Design & Samples

The purpose of this research is to assess the risk factors that occur during planning stage of the EPC project that have a significant effect on the quality and time performance of the hydropower EPC project. The first survey was conducted on 7 respondents which is leaders of the parties involved in the project.

The next stage is a survey for 52 respondents who are involved in the hydropower EPC project with a lumpsum contract in Indonesia which consists of owner, designer contractors and owner engineers. Based on respondent background data obtained, it's known that 60% of respondents have experience of more than 20 years and more than 65% have at least a magister education and above.

From quantitative analysis obtained risk factors variable through the indicators it represents have significance effect. Then, the expert will provide confirmation and explanation of the implications of risk factors in the EPC PLTA lump sum contract project and provide input in the form of responses to risk factors as research output.

3.4   Data Analysis Technique

This research use Partial Least Square (PLS) as an approach tool and the Software applied is Smart-PLS 3.2. According to Ghozali (2014), PLS approach is distribution free were not mandatory to assume certain distributing data, it can be in the form of nominal, category, ordinal, interval and ratio. PLS accept all standards of variance can be assumed as variance which is useful to explain.
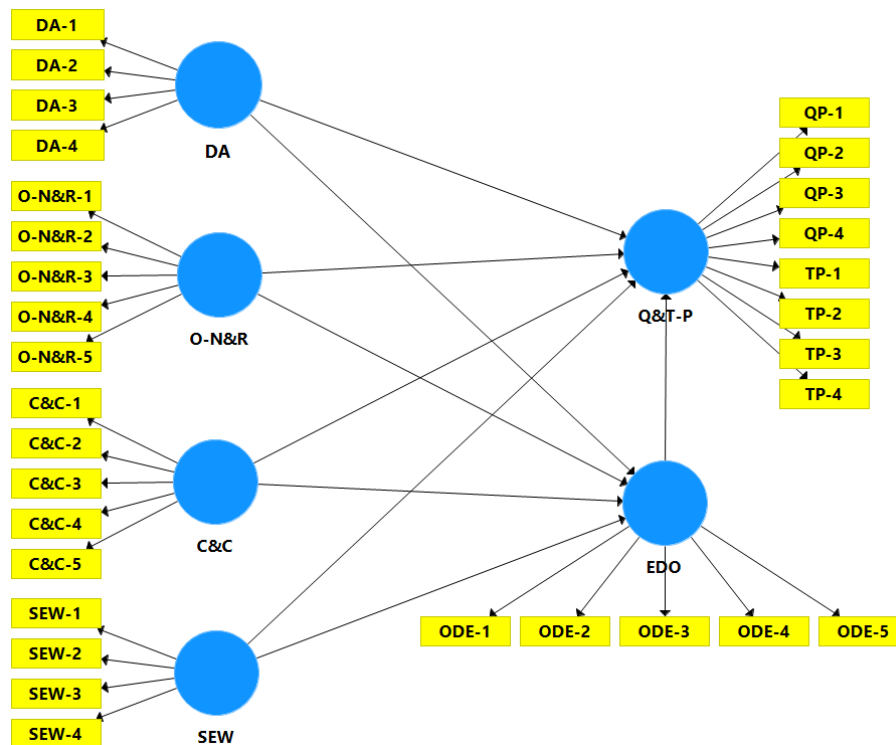

Figure 2: Risk Factor effect on Quality and Time Performance Model

4. Result & Finding

4.1 Validity and Reliability Test

The initial stage of this research was to test the validity and reliability of the results of the questionnaire that was given by the respondents using the SPSS version 23.0 program.

1) Validity Test
Initial testing carried out the SPSS computer program for 50 accepted respondents. By these number, determinates r-critical value table by degree of freedom df = N-2 = 48 and significancy (5%) is = 0.279. All indicators fulfil the criteria, except O-N&R.3 and O-N&R.4 was obtained Cronbach Alpha < 0.279 i.e. 0.238. Then all the respondent answer can be concluded valid.

2) Reliability Test
Testing reliability with this SPSS, will compare the Cronbach's Alpha value of each variable from the results of the SPSS data processing with its critical point value, which required the Cronbach's Alpha value must have a value greater than 0.7.

3.5   Research Framework Model

Refer to Hussein, SA (2015), the mediating or intervening variables are between the independent and dependent variables where this variable mediates the effects of the independent variable on the dependent variable. The initial model was built to present a mediating variable which

according to the expert's view was taken from the variables studied.

The multi-dimensionality of each construct tested was checking at the convergent validity of each construct indicator. Manifest variables for good model requirement with external loading 0.7 or higher are considered acceptable, and will use in this research, then loading factor < 0.7 excluded from the model. Thus, all constructs have met the validity requirements as shown in Fig. 2.

Table 2: Reliability Test

Variable	Cronbach's Alpha	Conclusion
Engineering Design Output (EDO)	0.835	Reliable
Scope of Engineering Works (SEW)	0.889	Reliable
Owner Necessities & Requests (O-N&R)	0.449	Not Reliable
Communication & Coordination (C&C)	0.908	Reliable
Quality & Time Performance (Q&T-P)	0.781	Reliable

O-N&R Owner Necessities & Requests variables are not reliable in testing with SPSS, however, invalid indicators will be evaluated in the next stage or excluded in Smart-PLS.

4.2 Evaluate the Outer Model

1) Loading Factor
The convergent validity test used for check the outer loading or loading factor value whether declared to meet the convergent validity in the good category if the outer loading value is > 0.7. The indicator with loading factor below 0.7 was excluded from model, then the outer loading value of each indicator shown in table-3. Variable Contractor

performance obtained loading factor lower than 0.7 then was excluded in convergent validity test.

2) Discriminant Validity

Beside the Fornell-Larcker test which compares the AVE value and R^2 value, the following discriminant test uses cross loading to see whether the indicator has its own latent variable that is higher than the other latent variables. The loading factor can be seen in a cross-loading table below.

Table 3: Cross Loading

| Indicator	C&C	O-N&R	SEW	EDO	Q&T-P
C&C-1	**0.891**	0.176	-0.035	-0.350	-0.285
C&C -2	**0.800**	0.258	-0.055	-0.270	0.014
C&C -3	**0.781**	-0.038	-0.060	-0.218	-0.068
C&C -4	**0.892**	0.321	-0.153	-0.405	-0.068
C&C -5	**0.900**	0.016	-0.088	-0.287	-0.126
O-N&R.1	0.171	**0.956**	0.487	0.400	0.470
O-N&R.2	0.170	**0.914**	0.315	0.234	0.319
SEW.1	-0.116	0.360	**0.903**	0.609	0.303
SEW.2	-0.089	0.359	**0.891**	0.551	0.274
SEW.3	-0.100	0.388	**0.912**	0.690	0.285
SEW.4	0.034	0.476	**0.749**	0.333	0.259
EDO.1	-0.318	0.241	0.387	**0.787**	0.572
EDO.3	-0.279	0.257	0.624	**0.865**	0.418
EDO.4	-0.310	0.390	0.626	**0.877**	0.553
EDO.5	-0.339	0.284	0.568	**0.855**	0.627
QP.2	-0.103	0.428	0.264	0.577	**0.789**
QP.3	-0.185	0.410	0.310	0.599	**0.812**
QP.4	-0.106	0.288	0.276	0.523	**0.843**
TP.2	-0.190	0.405	0.226	0.479	**0.857**
TP.3	-0.210	0.454	0.262	0.592	**0.900**
TP.4	-0.182	0.337	0.306	0.578	**0.822**
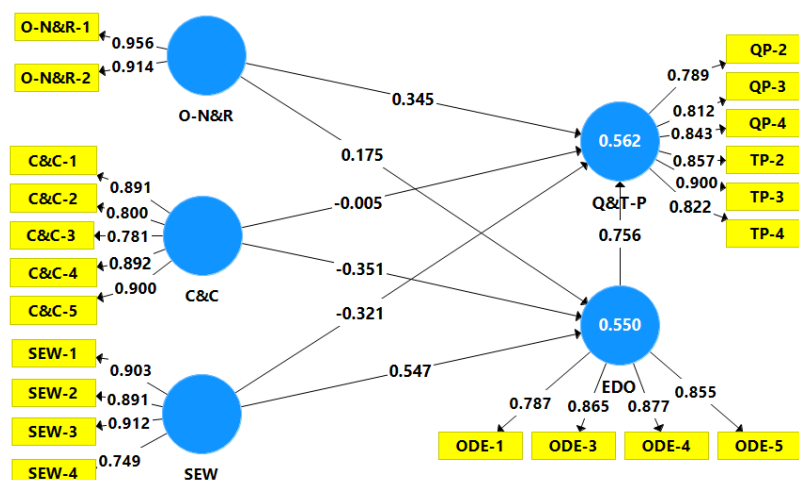
Figure 3: Risk Factor on Quality and Time Performance Model

The table above shown the value of the loading factor value > 0.7 and this value is higher than the value of cross loading. Discriminant test has been conducted with Fernel Larcker criteria; it is found that all variables meet the discriminant validity test.

3) Reliability Test

The reliability of research instruments in this study was tested using composite reliability and Cronbach's Alpha coefficient. All variables are concluded to be consistent and stable, where the lowest composite reliability and Cronbach's Alpha values are in the variable of EDO Engineering Design Output respectively 0.910 and 0.717, and the highest is in the variable of O-N&R Owner Necessities & Requests respectively 0.933 and 0.875.

4.3 Evaluate the Inner Model

This research will explain the results of the path coefficient test and the goodness of fit test. The results of the R-square test display a value between 0.33 and 0.67, so it is said that the effect of the 3 exogenous variables is moderate. For the Goodness of Fit value above 0.36, then the research model has a good performance criterion and a great ability to clarify the factors being researched.

4.4 Path Coefficient Test

Path coefficient evaluation is used to show how strong the effect or influence of the independent variable on the dependent variable. From the figure of the measurement model above, the model was evaluated by excluding the Data Availability variable in final model because it has low path coefficient and GoF values, and neither the partial hypothesis nor the mediation hypothesis can be accepted. The final research measurement model with each coefficient value is as shown in Figure 3 below.

From the figure of the measurement model above, the equation obtained from this measurement model is as follows:

EDO = 0.178 * O-N&R – 0.307 * C&C + 0.598 * SEW, $R^2 = 0.591$

Q&T-P = 0.340 * O-N&R – 0.032 * C&C – 0.382 * SEW + 0.790 * EDO, $R^2 = 0.563$

Based on these equations, it can be concluded that Owner Necessities and Requests, Communication and Coordination, Scope of Engineering Works and Engineering Design Output have an effect of 56.3% to Quality and Time Performance, while the remaining 43.7%

is influenced by other risk factors which not covered in this research.

4.5 Hypothesis Test

1) Partial Hypothesis Test

The hypothesis to be answered in this study is what kind of risk factors have a significant effect on quality performance and time performance. Hypothesis can be accepted by comparison between t-statistics and t-table, when t-statistic is higher than t-table and significancy value lower than 0.005. Use degree of freedom (df) = 50-2 = 48 for two-tailed test and significancy level (α) determined 5%, find the t–table is 1,680. The following is table for partial hypothesis of the research.

Table 4: Partial Hypothesis

Relation Hypothesis	t-statistic	Significancy	Conclusion
C&C → Q&T-P	0.036	0.486	Not Accepted
O-N&R → Q&T-P	2.703	0.004	Accepted
SEW → Q&T-P	2.385	0.009	Accepted
EDO → Q&T-P	5.146	0.000	Accepted
C&C → EDO	2.664	0.004	Accepted
O-N&R → EDO	1.545	0.061	Not Accepted
SEW → EDO	4.796	0.000	Accepted

2) Mediation Hypothesis Test

The variable of engineering design output has been selected as a mediating variable through discussion with expert and result of the correlation asses between exogenous variable from other risk factors to endogenous variable from another risk variable that is being considered as the mediating variable with the criteria for the highest number of accepted hypothesis variables and the highest R^2 value. In addition, the selection of the mediating variable is also based on input from experts by looking at the correlation of the indicators that represent the variables.

Table 5: Mediation Hypothesis

Relation Hypothesis	t-statistic	Significancy	Conclusion
C&C → EDO → O-N&R	2.222	0.013	Accepted
O-N&R → EDO → Q&T-P	1.472	0.071	Not Accepted
SEW → EDO → Q&T-P	3.735	0.000	Accepted

4.6 Finding & Discussion

Obtained the hypothesis result as follows;
1) Communication and coordination during engineering stage have no significance impact directly to quality and time performance. However, with the output design engineering factor as a mediator, then the communication and coordination have an inversely significant effect.
2) Owner necessities & requests in engineering stage have inline significance effect to quality and time performance.
3) Scope of engineering works during engineering stage have significance effect to quality and time performance both directly and mediated by engineering design output.
4) Engineering design output have inline significance effect to quality and time performance.
5) Availability data in engineering have no significance effect to quality and time performance neither directly nor mediated by engineering design output.
6) Almost all of experts gave a relatively similar related to the research result hypothesis, that is the hypothesis the significance of the correlation of the risk factor as an independent variable to quality and time performance can be accepted.

Discussions as a part of the research were conducted with the experts who have more than 30 years of experience in the hydropower project. Risk factor implication to the project case researched for each dominant indicator which shown by loading factor value can be explained below;

1) Communication and Coordination

The communication system in the EPC contract prepared by the owner shown that the communication mechanism in the project and the design approval process involving contractor engineers is aimed for ensuring the fulfillment of project quality, where communication and coordination of technical issue can only be carried out by employer engineers with the contractor engineer as the door for communication on the two parties between owner and contractor.

The ongoing communication process has a negative relationship with -0.005, so these confirms that the communication process both on the indicators of C&C.4 and C&C.5 have risks impact on slowing down the project completion where poor communication between the contractor and the owner greatly affects the design completion time.

Related to the C&C.4 Ineffective communication between the owner and the contractor, beside the communication for technical issue between the employer engineer and the contractor engineer, discussion of non-technical issues such as administrative problems i.e. payment of progress to the contractor, fulfillment of permits, and land acquisition also affects the design planning process.

2) Owner Necessities & Requests

This variable is represented by 2 valid indicators, i.e. O-N&R.1 The project owner does not fully describe his needs and O-N&R.2 Changes desired by the project owner are late. Experts say that these 2 indicators coloring the planning implementation process of the project, where changes from the owner are related to ensuring the achievement of the QA/AC in project planning, however these has a significant impact on the delay in the completion of the design work. On the other hand, the fail of fulfillment of the QA/QC in planning process risk to quality performance specifically the quality of design output. This is closely related to the indication of design changes initiated by contractor as intended the factor of EDO.4 without referring to contracting procedure.

Indicators which invalid and was excluded are O-N&R.5 There is an indication of project delay from the owner. However, the expert confirmed that in the project researched case, there were indications of delays being caused by late payments to contractors, so this indicator has an influence both directly and indirectly on the quality of work and the time completion of the project.

3) Scope of Engineering Works

The dominant indicators in this variable are respectively; SEW.3 No in-depth geological survey was carried out, SEW.1 Definition of the scope of basic and detailed design stages, SEW.2 Failure to convert basic design to detailed design and SEW.4 The completeness of technical description of the planning by the contractor. Regarding indicators SEW.2 and SEW.1, concerning the conversion process from design concept to basic design have a big risk to the lateness completion of the hydropower project due to the repetitive and long approval process.

Regarding these above, it is indicated that the contractor intends to changes and optimize the design but did not follow contractual procedures such as value engineering, this is one of the risk factors that were not raised in this research. The delay design engineering process occurs more frequently in the works that involve site conditions data, especially sub-surface geology. The loading factor value for indicator of SEW.3 shows the highest level of dominance among several indicators representing this variable.

4) Engineering Design Output

This variable constructed by 4 valid indicators and the highest dominance that is ODE.4 Design product is tend to be economical with an outer loading value of 0.877.

During engineering design stage, it was confirmed that there was no design that tended to be economical can be counted and verified, apart from the type of lump sum contract where the volume of work stated in the contract could not be re-measured as stated by Asiyanto (2005), although there were value engineering and variation order mechanisms covered in contract. However, the trend of economical design is considered as a large potential risk that affects the quality and time performance of the project as evidenced by the repeated review and approval processes related to design, and the results of this research reveal that the engineering design output can mediate the effect of the scope of work which is dominated by indicator of design conversion at engineering stage.

Refer to the general opinion about the relationship and pattern of change in the triple constraint model, one of which is expressed by Wyngaard et.al (2012), in case one corner considered fixed or locked as an implication of the lump sum contract, then there is the possibility of movement of change on the other two corners i.e. the time and scope of work. In the model from Ahmed (2016) in fig. 1, it's explained that quality is between the two corner of time and the scope of work, then this condition seen as a large potential risk to project performance.

Soeharto (1997) states that the level of economical tendency is carried out by contractors to reduce implementation costs while Andi & Minato (2003) states that economical design is influenced by limited costs and time in the design planning process, which according to him that this is influenced by the owner's request for construction costs optimizing without thinking of long-term project costs, especially during operation or project life cycle time.

The risk response is one part of the results of this study. The following table is the risk response for dominant risk factors which was recommend for the hydropower EPC project to reduce the scale of impact and the probability of occurrence of risk being caused by determined factors.

Table 6: Risk Factor Response

Risk Factor	Risk Response
C&C.4.	- Retrospect the basic communication chart between the employer engineer and the contractor engineer, especially scope of object to be communicate. - Accelerate discussion of non-technical issues at higher management levels hence does not affect the design engineering stage. - Preparing the owner engineering team to be familiar for contractual aspect apart from engineering itself
C&C.5 and C&C.3	- Intensifying use of the Integrated Database (IDB) and Electronic Data Interchange (EDI) in planning stage. - Synchronize the understanding of management policies towards the direction of engineering needs as a whole i.e. design stage, difficulty level implementation, ease of maintenance, etc.
O-N&R.1 and. O-N&R.2	- Clarify the scope of comments and design review from contractor engineers to contractor designers and from employer engineers to contractor engineers - Tighten the evaluation of the contractor design submission schedule - Sharping the contract terms relating to contract price, change of scope of works, provisional sum, and others
SEW.1 and SEW.2	- Clarify the EPC contract clauses related to the scope of design planning work. - Amend the EPC contract regarding clauses of works scope that have a bad risk affect to the quality. - Clarify the consequences and conditions that obliges the execution of the contract in accordance with the specified time. - Clear up the stages and schedule of the design work by the contractor in the contract.
SEW.3	- Prioritizing contractors for undertake geological surveys immediately after commencement of EPC contracts. - Clear up the geological surveys that has and what has not been done during the technical explanation of the EPC contract according to the agreed standard technical specifications.
EDO.4	- Describe in detail in the EPC contract the procedure for changes initiated by both the owner and the contractor. - Strengthen the QA/QC team of owner engineers in the application of QA/QC to maintain design quality.
EDO.3	- Clarify the technical specification clauses in the contract related to the selection process and material quality test methods, in-situ test methods during work implementation, hydraulic structure model tests, structural application tests and quality improvement methods. - Clear up the clauses of the payment system related to measurement method, material or structure units, and penalties for project design implementation errors.

5. Conclusion & Suggestion

5.1 Conclusion

Owner necessities and requests, scope of engineering works and engineering design output have a significant effect on the quality and time performance of the hydropower EPC project with a lump sum contract. By mediating the Engineering design output factor, then the communication and coordination have a significant effect on the quality and time performance of the project.

Risk in failure to achieve the project performance is one of an implication of the triple constraint theory where the movement of one side of project performance can be trigger another side to move achieve the balancing of the project performance.

Obtained 10 indicators that represent risk factor variables with high dominance have clear implications in the design engineering stages of hydropower EPC project with lumpsum contract researched.

Generally, the risk responses presented are the actions that need to be taken during preparing of EPC contract documents, in addition to actions that can be taken during the implementation of the EPC contract. Managerial response that can be taken in risk mitigation are; selection of contract types and references, selection of EPC contractors, and preparation of crucial EPC contract clauses to minimize the possibility of the aforementioned risk factors.

2.2 Suggestion

The risk factor for delay of payment by the owner which comes from internal can be studied in more detail in subsequent studies. Besides, research with more samples and a larger project area distribution.

The risk management study, in particular measures the level of risk impact and risk occurrence probabilities are necessary to carried out for lumpsum hydropower EPC project which is being researched.

References

[1] A Guide to the Project Management Body of Knowledge (PMBOK Guide) (2004), 3th edition, Project Management Institute.
[2] Ahmed, Hussnain 2016, Project-Mangement101, https://sites.google.com/a/vt.edu/project-management 101 /in-the-news (accessed on March 2020).
[3] Alam, T 2011. Identifikasi Faktor-Faktor Risiko Proyek Rancang Bangun (Design and Build) pada PT. XYZ yang Berpengaruh terhadap Kinerja Waktu, Tesis. Universitas Indonesia, Depok, Depok.
[4] Andi & Minato, Takayuki 2003, Design documents quality in the Japanese construction industry: factors influencing and impacts on construction process, International Journal of Project Management 21 (2003) 537–546.
[5] Asiyanto. 2004. Manajemen Produksi untuk Jasa Konstruksi, Cetakan Kedua. Jakarta: Pradnya Paramita.
[6] Ayub B. et. al 2016, Risks In EPC Hydropower Projects: A Case Of Pakistan. *8th* International Civil Engineering Congress (ICEC-2016).
[7] Chiyoda Corp 2017. Project Lifecycle Engineering. Accessed on June 2020. https: //www.chiyodacorp. com/en/service/ple/feed/
[8] Ghozali, I., dan Latan, H. 2015, Partial Least Squares : Konsep, Teknik dan Aplikasi Menggunakan SmartPLS 3.0 (Edisi Dua). Semarang: Badan Penerbit Undip.
[9] Gunarso dan Kurniawan K. 2018, Analisis Risiko Tahap Engineering Design pada Pembiayaan Pekerjaan Konstruksi Proyek EPC-SM. Jurnal Teknik Sipil Dan Arsitektur Vol. 22, ISSN: 2301-668X.
[10] Hardjomuljadi, Sarwono and Sudirman, Weddy Bernadi. 2011. Project Risk Management in Hydropower Plant Projects: A Case Study from the State-Owned Electricity Company of Indonesia (January 26, 2011).
[11] Hardjomuljadi, Sarwono 2014, Factor Analysis on Causal of Construction Claims and Disputes in Indonesia (with Reference to the Construction of Hydroelectric Power Project in Indonesia). International Journal of Applied Engineering Research. ISSN 0973-4562 Volume 9. http://dx.doi.org/10.2139/ssrn.1853943
[12] Hussein, Sabil Ananda 2015. Penelitian Bisnis dan Manajemen Menggunakan Partial Least Squares (PLS) dengan smart PLS 3.0. Fakultas Ekonomi – Unibraw, Malang
[13] Istijanto. 2008. Aplikasi Praktis Riset Pemasaran. Jakarta: Gramedia Pustaka Utama.
[14] Mai, S.H. and Wang, J.Q. 2017. Research on Quality Risk of EPC Hydropower Projects in Vietnam. World Journal of Engineering and Technology, 5, 299-308.
[15] Manullang, Shinta T. 2016, Evaluasi Sistem Manajemen Mutu Proyek EPC dalam Fase Engineering Produk Detail ngineering Berbasis Manajemen Risiko pada PT XYZ, Tesis. Universitas Indonesia, Depok.
[16] Nippon Koi Co.Ltd – PT. PLN (Persero) 1983, Hydro Power Potential Study (HPPS). Jakarta.
[17] Nobel, Andrew 2018, Tunnel and Underground Risk in Hydropower – a Lender's Technical Advisor Perspective, ITA Library
[18] Wang, Tangfei. et.al 2015. Enhancing Design Management by Partnering in Delivery of International EPC Projects: Evidence from Chinese Construction Companies, J. Constr. Eng. Manage., 04015099.
[19] Sitorus, Juanto 2008. Risk Factor that influence time performance of EPC gas project in Indonesia. Tesis. Universitas Indonesia, Depok.
[20] Soedarsono, Yudistira SA. 2001, Kamus Istilah Proyek, Elex Media Komputindo, Jakarta, hal. 98.2 Yudhistira Soedarsono, SA., Kamus Istilah Proyek, Elex Media Komputindo, Jakarta, hal.98.2.
[21] Soeharto, Imam Ir. (1999), Manajemen Proyek Dari Konseptual Sampai Operasional, Penerbit Erlangga, Jakarta

[22] Soeharto, Imam Ir. (2000), Manajemen Proyek, Penerbit Erlangga, Jakarta
[23] Wei, Li et.al 2012. A Study on Risk Allocation for International Hydropower General Contracting Projects, Advances in information Sciences and Service Sciences (AISS). Vol.4, Num.5, March 2012
[24] Wyngaard, CJ Van et.al 2012. Theory of the Triple Constraint – a Conceptual Review. Proceedings of the 2012 IEEE.