Risk Management of the Equipment Supply Process in the Power Plant Projects in Iran

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Given the importance of the power plant projects in the development and economic growth in developing countries, it's necessary to explore challenges and risks that are obstacle against achieving the desired objectives including time, cost and quality of these projects. In this paper, the risks of the equipment supply process in the combined cycle power plant projects are identified and then appropriate solutions for key risks are presented. During the study, the following are used in this process: the risk breakdown structure, interviews and field studies to find out all types of risks in the equipment supply process, also preparing a questionnaire including the probabilities and impacts of risks in order to assess and rank these risks, and finally using a two-round Delphi survey to find out appropriate solutions to respond to key risks.

Key Words: Risk Management, Power Plant Projects, Supply Equipment, Risk Identification, Risk Assessment

Introduction

Power plants are an infrastructure that plays a significant role in the development and economic growth in developing countries (Likhitruangslip & Praphansiri 2010). The successive of electricity demand contributes to the increasing number of new power plant projects worldwide, so it's necessary to explore challenges and risks of these projects that are obstacle against achieving the desired objectives including time, cost and quality.
There are several definitions of risk which are similar to each other from two aspects of uncertainty of events, and probable damages. According to the PMBOK (2004) standard, risk is a phenomenon or situation which if happens, it will positively or negatively affects a project objectives. Also, risk management has been accepted as an important part of decision- making process (Han et al. 2008) and now accepted as an important tool in the management of projects (wood & Ellis 2003). In recent years, many efforts have been made in this field and many researchers have studied the risk management. Some of the previous studies on risk management practice are regarding: report of findings of an empirical Chinese industry survey on the importance of project risks, application of risk management techniques, status of the risk management systems, and the barriers to risk management that were perceived by the main project participants (Tang et al. 2007); application of risk management techniques and barriers to risk management in the Queensland engineering construction industry (Lyons and Skitmore 2003); important risks associated with China's build-operate-transfer (BOT) projects and the effectiveness of mitigation measures(Wang et al. 1999); explore risk prevention mechanisms and measures in construction projects due to asymmetric information (Xiang et al. 2012); examining how risk is reflected in infrastructure regulatory contracts by identifying risks that must be addressed in infrastructure contracts, and then their classification, allocation, and impact are presented along with the measures to minimize risks (Marques and Berg 2011); identifying the preferred risk allocation in PPP projects of mainland China and the Hong Kong Special Administrative Region and then comparing these preferences to those in the U.K. and Greece (Ke et al. 2010). Project Management Institute (2004) published Project Management Body of Knowledge (PMBOK) that introduces risk management as a set of processes with six steps: risk management planning, risk identification, qualitative risk analysis, quantitative risk analysis, risk response planning, risk monitoring and control.

Given that the equipment supply of the power plant projects includes about 30% of the total project cost, and delay in the construction or delivery of this equipment as well as their poor performance can lead to failure to achieve the desired objectives of the project, the aim of this study is to examine and identify risks of this area, and to find appropriate ways to respond to them. In this paper, considering the exceptional condition of economics and politics in Iran, the attribute of "Supplier Selection and Ordering" is presented.

Procurement Management

Procurement management is considered as a major part in the project which is also associated with other pillars and parts. Any disruption in this process leads to problems in the project implementation, and delays in its delivery. In this research, the different phase of equipment supply in Jahrom Power Plant is grouped as Fig.1, and the activities of equipment supply in each phase are determined. This chart is studied as the project's RBS (Risk Breakdown Structure), and the risks associated with each of these activities are identified in the risk identification section.

Considering the exceptional conditions of politics and economics in Iran which are mostly caused by the international sanctions, the “Supplier Selection and Ordering” attribute is chosen to be presented in this paper. It should be noted that results of our original research show that most of the top risks of equipment supply phase are related to this very attribute.

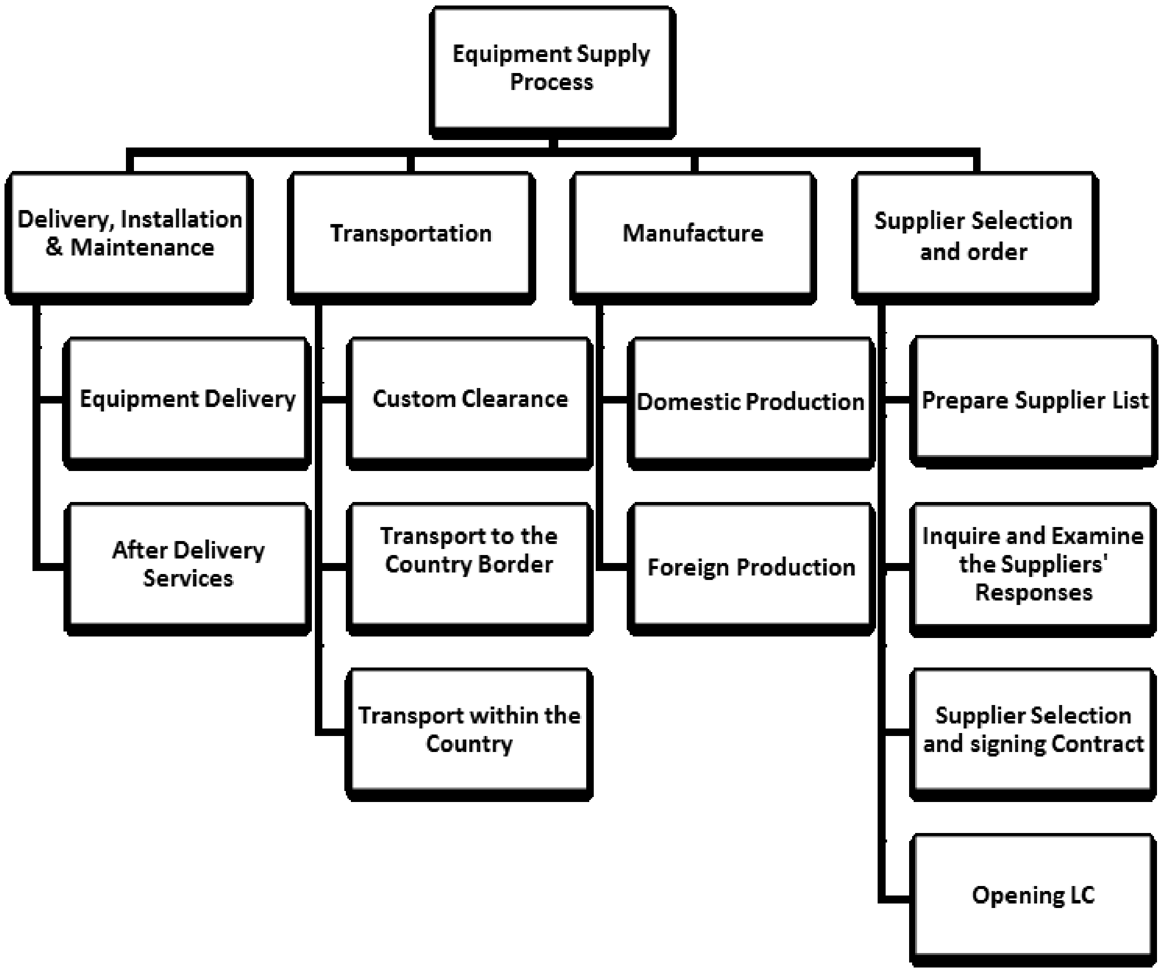

Figure 1: Risk breakdown structure for the equipment supply process in Jahrom Power Plant

Introduction of Main Equipment

Every power plant consist of a variety of integrated systems that each of them encompasses numerous types of equipment (Likhitruangslip & Praphansiri 2010). Given that most of these equipment spend a very small portion of the project costs and the risks related to them do not have much impact on the project objectives, the equipment with the highest cost are selected for the risk management process. To this end, according to the power plant projects WBS, the equipment which have the highest cost percentage and include 20% of the project total cost are specified. These Equipments are Turbine, Heat Recovery Steam Generator (HRSG), Generator, Transformer, Main Voltage (MV) & Low Voltage (LV) Panels, Boiler Feed Pump (BFP), and Cooling Water Pump (CWP).

Methodology

This research is done in three parts:

Risk identification. Risk identification is conducted using the project RBS and field studies including reviewing documents of the power plant projects on which risk management operations have been performed, as well as interviews with experts in this field. In this research, 101 risks in the equipment supply phase of the power plant project are originally determined. Forty two of them were related to the “Supplier Selection and Ordering” attribute. A list of these risks is presented in Table 1.

Risk assessment. To perform the risk assessment, a questionnaire is prepared in which the occurrence probability and impact of each risk on the project is determined. Each parameters is evaluated with five options from "very low" to "very high." This questionnaire is given to 25 experts with a bachelor's degree or higher who had at least 5 years experience in main power plant companies in Iran as following: (1) Iran Power Development Company (IPDC) which is in charge of all governmental power plant projects in Iran. People who have been surveyed were Project Executive Managers or employees of the Risk Management Department. (2) Mapna Company which is the only manufacturer of power plants’ main equipment and also the largest power plant EPC contractor in Iran. People who have been surveyed were Project Managers. One of them was the Equipment Supply Manager. (3) Ghods-niroo Engineering Company and Moshanir Company; these two companies handle most of the power plant projects in Iran as consultant. Both companies have matrix structure. People who have been surveyed were Project Managers or Functional Managers.

Table 1:
List of titles for risks of the "Supplier Selection and Ordering" identified in this study

Risk Title	GENERAL	MV & LV PANEL	CWP	BFP	TRANSFORMER	HRSG	GENERATOR	TURBINE
Shortage of client's cash	X							
Restriction on the choice of domestic manufacturers Supplier selection and order								X
Possibility of introducing new vendors				X		X	X	X
Improperness of assessment criteria		X	X	X	X	X	X	X
Flaw and ambiguity in the demand profile		X	X	X	X	X	X	X
Removal of the previously approved foreign suppliers				X		X	X	
Bankruptcy of the selected supplier		X			X			
Error in assessment		X	X	X	X	X	X	X
Delay in responding to price inquiries by suppliers								X
Limitations on opening foreign exchange credits by the Central Bank circulars	X							
Presence of political sanctions and limited suppliers list		X	X	X		X		
Purchase from intermediaries				X				
Opening LC at the intermediary bank	X							
Rejection of Iranian contractors' LC by European countries	X							
Delay in LC extension due to political reasons	X							

After collecting the questionnaires, the average and variance values for the evaluated parameters are determined, and the risk's probability/impact coefficient is calculated which is the multiplication of the average of occurrence probability by the impact of the risk. The result is shown in Table 2.
Reliability of data in this table was verified by "Single-factor ANOVA" method using SPSS software. Software result shows that the survey is valid since P-Value for probability and impact of the risks were nearby zero.

Table 2
Average and standard deviation of probability/impact results for risks

Main Equipment	Risk Type	Probability		Impact		Prob./Imp. Factor
		Ave.	Std. Dev.	Ave.	Std. Dev.	
TURBINE	Restriction on the choice of domestic manufacturers Supplier selection	0.759	0.044	0.784	0.041	0.595
	Possibility of introducing new vendors	0.356	0.068	0.542	0.063	0.193
	Improperness of assessment criteria	0.380	0.037	0.596	0.040	0.226
	Error in assessment	0.380	0.030	0.630	0.035	0.240
	Delay in responding to price inquiries by suppliers	0.447	0.057	0.625	0.034	0.279
	Flaw and ambiguity in the demand profile	0.458	0.073	0.675	0.046	0.309
GENERATOR	Removal of the previously approved foreign suppliers	0.364	0.079	0.752	0.044	0.274
	Possibility of introducing new vendors	0.340	0.053	0.525	0.050	0.179
	Improperness of assessment criteria	0.316	0.030	0.596	0.036	0.188
	Error in evaluation	0.332	0.029	0.592	0.049	0.196
	Flaw and ambiguity in the demand profile	0.340	0.043	0.617	0.052	0.210
HRSG	Removal of the previously approved foreign suppliers	0.450	0.067	0.517	0.065	0.233
	Possibility of introducing new vendors	0.533	0.086	0.457	0.025	0.243
	Presence of political sanctions and limited suppliers	0.500	0.000	0.540	0.028	0.270

Table 2
Average and standard deviation of probability/impact results for risks

Main Equipment	Risk Type	Probability Ave.	Probability Std. Dev.	Impact Ave.	Impact Std. Dev.	Prob./Imp. Factor
	list					
	Improperness of assessment criteria	0.325	0.018	0.465	0.056	0.151
	Error in assessment	0.458	0.097	0.596	0.094	0.273
	Flaws and ambiguities in the demand profile	0.258	0.045	0.517	0.054	0.134
TRANSFORMER	Improperness of assessment criteria	0.254	0.008	0.433	0.068	0.110
	Error in assessment	0.300	0.033	0.500	0.061	0.150
	Flaw and ambiguity in the demand profile	0.333	0.044	0.511	0.035	0.170
	Bankruptcy of the selected supplier	0.265	0.033	0.582	0.060	0.154
BFP	Removal of the previously approved foreign suppliers	0.309	0.056	0.709	0.045	0.219
	Possibility of introducing new vendors	0.343	0.043	0.596	0.029	0.205
	Presence of political sanctions and limited suppliers list	0.633	0.017	0.620	0.052	0.393
	Improperness of assessment criteria	0.383	0.031	0.508	0.040	0.195
	Error in assessment	0.283	0.034	0.525	0.060	0.149
	Purchase from intermediaries	0.292	0.047	0.542	0.038	0.158
	Flaws and ambiguities in the demand profile	0.308	0.050	0.600	0.045	0.185
CWP	Presence of political sanctions and limited suppliers list	0.643	0.015	0.685	0.023	0.440
	Improperness of assessment criteria	0.433	0.058	0.517	0.052	0.224
	Error in assessment	0.433	0.058	0.533	0.054	0.231
	Flaw and ambiguity in the demand profile	0.308	0.054	0.575	0.031	0.177
MV & LV PANEL	Presence of political sanctions and limited suppliers list	0.557	0.023	0.667	0.023	0.371
	Improperness of assessment criteria	0.347	0.038	0.441	0.024	0.153
	Error in assessment	0.359	0.029	0.429	0.025	0.154
	Flaw and ambiguity in the demand profile	0.371	0.040	0.394	0.026	0.146
	Bankruptcy of the selected supplier	0.276	0.034	0.418	0.045	0.115
GENERAL	Opening LC at the intermediary bank	0.425	0.069	0.455	0.080	0.193
	Rejection of Iranian contractors' LC by European countries	0.633	0.058	0.733	0.020	0.464
	Delay in LC extension due to political reasons	0.758	0.016	0.775	0.017	0.588
	Restrictions on opening foreign exchange credits by the Central Bank circulars	0.525	0.036	0.642	0.036	0.337
	Shortage of client's cash	0.900	0.000	0.900	0.000	0.810

By sorting the probability/impact coefficient, the project risks can be ordered, and significant risks can be determined. Table 3 lists the most important assessed risks that have the highest probability/impact coefficient.

Table 3
Titles of the most important risks

Rank	Risk Type
1	Shortage of client's cash (General)
2	Restriction on the selection of domestic manufacturers of equipment (Turbine)
3	Delay in the LC extension due to political issues (General)
4	Rejection of Iranian contractors' LC by European countries (General)
5	The existence of political sanctions and limited list of suppliers (CWP)
6	The existence of political sanctions and limited list of suppliers (BFP)
7	The existence of political sanctions and limited list of suppliers (MV&LV Panel)
8	Restrictions on foreign currency credit posed by the Central Bank circulars (General)

Responding to risks. In order to find appropriate solutions to respond to the important determined risks, the Delphi method is used. This way, a list of these risks is prepared as a questionnaire and is sent to 10 experts in this field with at least a bachelor's degree and at least 7 years experience in the field of power plant projects. In the first round of Delphi survey, these people presented their own solutions. After collecting these comments, repetitive and unnecessary items are removed and solutions agreed by all persons are also determined. Then, the presented solutions are posted again for those experts to provide their views on the proposed solutions.

Discussion on Results

The objective of this study is to determine the most important risks in the equipment supply process of the power plant projects especially in Iran, and to provide the best solutions for controlling these risks. These key risks and the solutions for controlling them are shown in Table 4.

Table 4
Key risks and proposed solutions

Risk Title	Solution	Votes	Strategy	Scope of execution	Side Effects
Shortage of client's cash	Selling participating bonds or receiving long-term loans	100%	Avoid	Project	Increase in project cost due to the interest rate of the loans and participating bonds.
	Encouraging the private sector for investment	100%	Avoid	National	Identifying new investors and making the necessary modification in regulations are very time consuming.
	Contractor's guarantees can be freed instead of payment for his invoices	50%	Acceptance	Project	It may decrease the project quality.
Restriction on the selection of domestic manufacturers of equipment.	Construction of new factories	100%	Control	National	It demands plenty of time and cost.
	Increasing capacity of existing factories	60%	Control	National	It demands plenty of time and cost.
	Transfer the work to foreign manufacturers	40%	Avoid	Project	The project has the possibility of facing new risks such as extra cost and delay due to import, transportation and custom works.
Delay in the LC extension due to political issues	Providing credible guarantees for the banks under contract	70%	Control	Project	Providing more guarantees may increase the project cost.
	Using CAD (cash against documents) instead of LC	50%	Avoid	Project	The project has the possibility of facing new risks such as extra cost.
	Re-scheduling the supply plan in order to supply the equipment by the date of LC expiration.	50%	Control	Project	This solution is not executable in every project.
	Holding joint commercial meetings in other countries	40%	Control	National	It demands plenty of time and cost.
Rejection of Iranian contractors' LC by European countries	Improvement of financial and commercial relations with the European countries.	100%	Control	National	It takes a long time to solve the political issues.
	Using countries with good political relations as an intermediary for opening LC	100%	Avoid	Project	It will result in increase in project cost.
	Attracting involvement of above countries for investors	80%	Control	Project	Identifying new investors is very time consuming.

Table 4
Key risks and proposed solutions

Risk Title	Solution	Votes	Strategy	Scope of execution	Side Effects
	Using CAD (cash against documents) instead of LC	60%	Avoid	Project	The project has the possibility of facing new risks such as extra cost.
Political sanctions and limited list of suppliers of CWP, BFP, and MV & LV panels	Transfer the equipment manufacturing technology from well-known manufacturers	100%	Avoid	National	It demands plenty of time and cost. Also, the project can face new un-known risks.
	Using intermediary countries for importing the equipment	80%	Avoid	Project	It will cause an increase in project cost.
	Identify and select new producers from countries with good political relations	70%	Control	National	Identifying new manufacturers is very time consuming.
Restricted foreign currency credits by the Central Bank circulars	Eliminating the restrictions or facilitating the regulations of Central Bank	80%	Avoid	National	This solution demands a national willpower which usually occurs during an along era.
	Consultations of the client's representative with the Central Bank	70%	Control	Project	It results in increase in project duration.
	Not using foreign currency credits	60%	Avoid	Project	This solution is not executable in every project.

As it can be seen, the solutions presented in this paper are reasonable and workable solutions some of which need more time to run specially the national solutions and they will be effective in the long term, while some of these solutions will contain these risks during the project.

Conclusion

In this study, the risks of "Supplier Selection and Ordering" associated with equipment supply of power plant projects have been identified and sorted based on the probability of occurrence and impacts on projects. Therefore, 8 major identified risks are studied that include shortage of client's cash, restriction on the selection of domestic manufacturers, delay in LC extension due to political issues, fail to accept Iranian contractors' LC by European countries, the existence of political sanctions and limited list of suppliers, restrictions on foreign currency credit posed by the circulars of the Central Bank of Iran. Then appropriate solutions for controlling these risks are presented which can be categorized into three major categories:

Development of domestic supplying and manufacturing: This can be done by increasing capacity of existing factories, improve the planning in production line, or construction of new factories,

Extension of the relationship with foreign suppliers: To do this, new foreign suppliers should be identified. The equipment manufacturing technology from well-known manufacturers should be transferred into the country. Also, using countries with good political relations or foreign international banks as an intermediary for opening LC is a proper solution for the identified risks.

Improvement of financial methods. There are some solution is this regard such as selling participating bonds or receiving long-term loans, encouraging the private sector, and facilitating the financial regulations of Central Bank of Iran.

In conclusion, the first stage of risk management plan was to identify, analyze, and find the proper response to the risks which is presented in this paper. These solution can improve time schedule, cost and quality in equipment supply process in the power plant projects. As a recommendation, future studies can provide results for implementation of this plan for several case studies.

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