Reducing risks of Power Plants development

LAMPRIDOU ANNA
Researcher
Moschonision 10, Athens
GREECE

KIRYTOPOULOS KONSTANTINOS
Financial & Management Engineering
University of the Aegean
Fostini 32, Chios
GREECE

Abstract: - One of the major sources of air and water pollution is the operation of energy production facilities. On the other hand the prompt production of new or renewed energy facilities may benefit the environment as the new facilities will have a better efficiency rate, lower emissions and higher operation flexibility (dependability), even if the new facilities are not "green" investments like wind farms or biomass plants. This paper aims to present a project risk management method that may aid the contractor of the development of a power plant to deliver the project in time. If such kinds of projects are delivered in time in a large scale, the whole energy production system will replace old (and more polluting) power plants quicker and benefit the most the environment and sustainable growth. The method is presented through a case study of a Combined Cycle Power Plant development project and shows the expected outcome with and without the implementation of the method.

Key-Words: - Risk management, Power Plants, Energy Facilities Construction, Project Management

1 Introduction

During recent years Energy market has developed and sustained a considerable growth mainly due to energy demand increase and market deregulation. At the same time, fossil fuel price increase and the fact that environmental legislation gets stricter every year have persuaded energy providers to begin decommissioning old factories and construct new ones in their place to achieve better cost–efficiency and reduce environmental impact. Although fossil fuel power plants are far from been considered "green energy", modern technological advances assisted into improving highly their efficiency rate, increase their operation flexibility (number of start-ups throughout life-cycle) and reduce dramatically the air, soil and water pollutant residuals. On the other hand "green energy" power plants, such as solar, or wind energy, cannot substitute fossil fuel power plants altogether because they still pose electricity production drawbacks, but more importantly because, they are a much more expensive investment per constructed MW than conventional plants. Therefore, the prompt substitution or renovation of old polluting power plants with new natural gas fired ones with advanced anti-polluting measures may be a preferred investment both in financial and environmental terms

One major problem for the delays in the replacement or renovation of older units is the presence of certain risks that delay power plant development projects. Aim of this paper is to identify such kinds of risks and illustrate how sound risk management methods may reduce the completion time of such a project.

The rest of this paper is organised as follows: In section 2 the basic risk management methodology is presented through a literature review. Section 3 describes the method used to conduct the Case Study. Section 4 is divided into four sub-sections. Sub-section 4.1 describes how the development of a certain power plant is achieved from the contractor's perspective, as well as the specific project context of the case study. Sub-sections 4.2 to 4.4 expose the implementation of the risk management method on the case examined here. Finally, Section 5 reveals the benefits of the method by comparing the potential outcome with and without the implementation of risk management. Moreover it raises a discussion about the conclusions and indicates opportunities for further research in this area.

2 Project Risk Management

The first important consideration in project management is how the cost and the duration of a project can be estimated with the higher possible accuracy [1]. Although several techniques exist for such estimations and there is a lot of "paperwork" in order that enterprises may find efficient ways to cope with the problem [2], planning in minute detail to cover every eventuality reaches quickly the limits of cost, time and effort. As managers cannot predict the future they have eventually to stop planning and take up managing the risks that can jeopardise their cost and time commitments. Successful risk management reduces the exposure of a project to risk [3]. It has been confirmed that too many problems would have been avoided and much more projects would have been delivered on time and within the estimated cost if managers have adopted a risk management policy [4], [5].

Literature review [6] indicates that the first approach of the formal introduction of Risk Management (RM) techniques in the scientific community, was the effort put by Hammer [7] to apply it on technical solutions. The need that urged Hammer to do that was to avoid the technical risks – events that may lead to the failure of complex systems, such as aeroplanes, oil industries, etc. RM has also been included in the theory of investments as financial risk and now it is probably the most advanced sector of RM [8]. Furthermore, RM has been applied to human errors and occupational safety [9]. Recent trends suggest the application of RM during the bidding process and its adoption by the senior management [10].

The steps of Risk Management can be summarised as in **Fig. 1** [3]. The first step of the process is the Development of a Risk Management Plan. This Plan sets the base for Risk Management, including elements such as, the frequency of reporting, the milestones and everything that a project plan would be consisted of. The second step of the process is the identification of risks that might affect the proposal or the project if the provider wins the auction. Identification is an important step of the process since bid managers cannot cope with problems that have not been identified. There are many techniques indicating the way to identify risks, such as checklists, experts' interviews, etc [11].

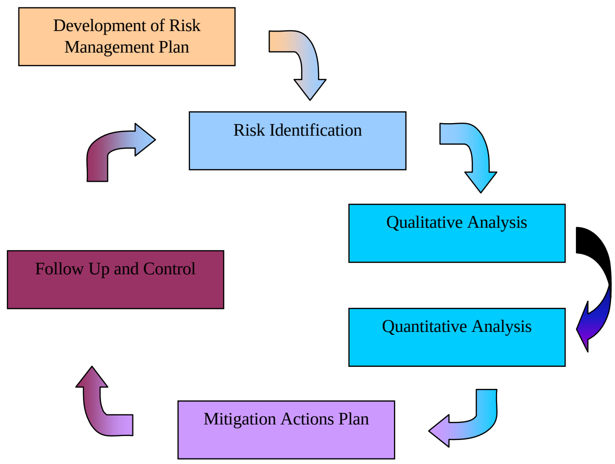

Fig. 1: Risk Management Cycle [3]

The third and fourth steps of the process address the analysis issue. Depending on the amount of information available or desirable, analysis could be either qualitative or quantitative. Several techniques are available for risk analysis. Some of them are three point estimate, decision trees, Monte Carlo simulation, etc [12]. Next step for RM is the Mitigation Action Plan, i.e. the definition of specific and effective response, in order to smooth or completely eliminate the risk that may put the project (or the bid) into jeopardy. Preventive or corrective actions maybe used in order to obtain the minimisation of risk [3, 13].

The last step, which is the Follow Up and Control of risks, aims to assure that the outcome from the previous steps is still valid as the time passes by, the mitigation actions defined are really efficient and that every new risk is registered.

3 Methodology

The methodology followed in this paper is depicted in **Fig. 2**. The first step of the method is the development of the project schedule. The project is scheduled in detail and appropriate software is used in order to efficiently provide the Gantt chart.

The next step of the process is the conduct of structured interviews to power plant development project experts. Through these interviews all the potential risks are identified and linked to specific project activities.

The quantification of risk takes place during the next step of the methodology. Overall project quantitative risk analysis is conducted with the aid of the Monte Carlo Simulation (MCS). MCS is used for finding the cumulative distribution function of project network completion times. In MCS, the random selection process is repeated several times so as to create multiple scenarios [14]. Each time a value is randomly selected for every variable of the objective function, a possible scenario is formed that leads to a certain outcome. This process is called iteration. The synthesis of all the iterations gives a range of possible outcomes (project completion times), thus the statistical distribution describing the project completion time. In its implementation, MCS can use the three-point duration estimation approach to establish a statistical distribution of the duration of each activity.

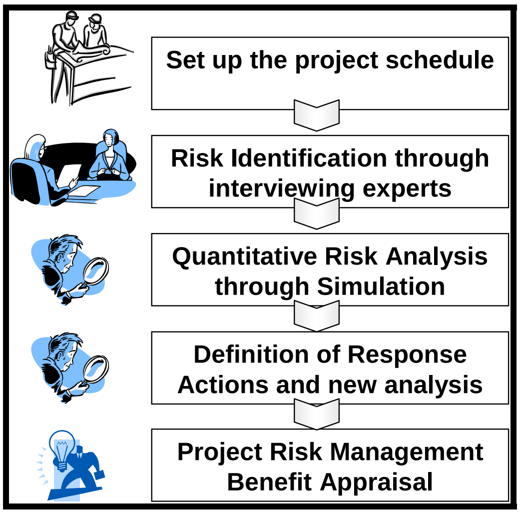

Fig. 2: Methodology

During the following step of the method, mitigation actions are defined and the risk is reduced to an acceptable level. A new MCS will reveal a new statistical distribution describing the project completion time with the risk management plan.

Finally, the two statistical distributions (with and without the implementation of the risk management plan) are compared in order that the project management may appraise the benefits provided.

4 Case Study

4.1 Combined Cycle Power Plant (CCPP) development

The aforementioned methodology was implemented on a Combined Cycle Power Plant (CCPP) development project.

CCP Plants combine the operation of a gas turbine along with a steam turbine. Light oil fuel or natural gas is burned to propel the gas turbine. The exhaust gases are forwarded to a boiler where water is heated up into steam which is pressed into the steam turbine in separated pressure stages. The combination exploits efficiently both fuel and exhaust gases thermal power to achieve efficiency rates up to 57%-58%.

The unit examined here is natural gas fired with an electricity output of 400MW. It comprises of the following main components, 230MW gas turbine (GT), a 170MW steam turbine (ST) and a generator running on a single axle with clutch. The selected boiler is once through type with natural draft and its cooling is performed with sea water.

The unit will be constructed on Evia island (one of the biggest Greek islands nearby Athens) in an existing coastal power facility and its purpose is to substitute two of the existing units which run on heavy fuel. The main reason for the replacement is the lower environmental impact of the new unit.

The project initial schedule is presented in an abstract level in the Gantt Chart in **Fig. 3**. In fact only the basic phases are included for reasons of brevity in this paper, while in the study the Gantt chart used was much more detailed.

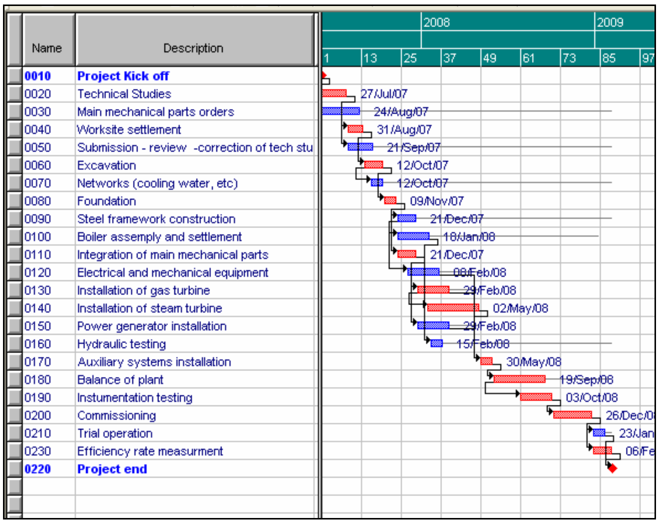

Fig. 3: Gantt Chart for the CCPP development

4.2 Risk identification in CCPP development

The structured interviews with the project experts revealed the risks that may impact the project. **Table 1** illustrates the most important of the identified risks. The ID is the identification number of the risk. Column "Risk" includes the risk name and column "Activity ID" includes the ID of the activities (same as in the Gantt chart) that are going to be impacted by the risk.

Although risks ID1 and ID7 have a straightforward cost impact they usually do cause delays. For instance, for ID7, the materials cost increase will lead to the increase of time of vendor selection as the project management team will need to find the cheapest source.

ID	Risk	Activity ID
1	*Construction company will invest significant amount of money at project initiation whereas it gets paid when succeeding project milestones, therefore cash inflow will be negative for the first few months*	All
2	Delays for obtaining the buildings construction permit and for local authorities evaluation of environmental limits on solid and liquid residuals	0020
3	Failing to follow specialised project specification details during engineering study of main plant components and thus order wrongful systems to the manufacturers.	0110 0120
4	Failing to convince main equipment manufacturers to construct parts and systems outside of standardised design when specialised or different specification are required	0030
5	Due to increased demand for energy production facilities, timely procurement of Power Train equipment (GT, ST & generator) maybe jeopardised	0130 0140
6	Plant systems and components or specialised personnel failing to arrive at construction site on estimated time schedule	All
7	*Materials price increase (especially for stainless steel and copper) throughout project execution*	0030
8	Defective manufacturing of main parts and components i.e. flawed casting of turbine casing or shaft	0180 0190 0210
9	Damaging existing facility infrastructure (i.e. old water, fuel pipelines) when excavating during construction due to lack of information on subterranean networks	0060
10	Faults and accidents during power train, boiler tubes and secondary systems assembly and commissioning	0100 0200
11	Soil subsidence especially at coastal installation (i.e. circulating sea water channel inlet, construction of unloading docks)	0080
12	Circulating sea water system infection with algae or mussels	0210

Table 1: Methodology

4.3 Risk analysis in CCPP development

Each one of the identified risks was assigned a probability of occurrence and a potential time impact in case of occurrence.

Some of the risks were point estimated (single value probability of occurrence and single value time impact) while others used stochastic distributions for modelling both probability of occurrence and time impact.

For example risk ID2 was estimated to have a significant impact on Activity ID0020. Initially Activity ID0020 was estimated to last 40 days. However the imposing of this risk on the activity led to the conclusion that the activity may last from 40 to 90 days with a most probable value of 60 days. This was modeled through a triangular distribution and added in the MCS model. The same analysis was made for each identified risk that had an impact on project's schedule. **Fig. 4** gives the output of the MCS (with all the risks taken into consideration) for the final duration of the project. It can be concluded from **Fig. 4** that there is an 18% probability that the project will finish before the 1st of July 2009 (deadline asked by the customer).

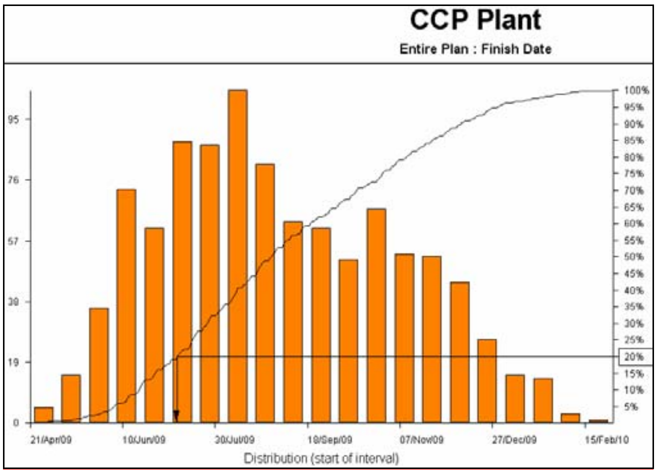

Fig. 4: Risk analysis results – without responses

4.4 Risk response in CCPP development

For each identified risk a risk response was decided and its effect on the probability of occurrence or/and impact on the project has been recorder.

Table 2, shows the response action for most of the important risks. The project team had to passively accept some of the risks. The definition of certain response actions alleviated the risks as one can see in the simulation results after the response actions. **Fig. 5** gives the output of the MCS (with all the mitigated and remaining risks taken into consideration) for the final duration of the project.

ID	Risk ID	Response action
1	2	Prepare any technical studies in time and try to keep close contact with authorities for spotting any reason for delay early.
2	3	Perform a very precise and detailed engineering study during project qualification and detailed analysis of project specifications.
3	4	Negotiate with customer at contract signature stage when requested specification are outside manufacturer standard design
4	4	Try to form permanent commercial collaboration with manufacturers of main components and minimise the number of potential equipment vendors
5	5	Sign a back-to-back contract with the Power Train equipment manufacturer before project qualification stage for their procurement
6	6	Arrange the schedule quite earlier than needed and impose strict penalties to any subcontractors for such delays.
7	7	Set up a dedicated procurement department in order to be well informed on materials price fluctuations, form a complete materials list immediately after contract signature and try to agree on fixed prices for the materials procurement.
8	8	Use an on-vendor-site quality control in order to minimise the potential delay and (as contingency) put pressure on the manufacturer for urgent delivery of the correct component
9	9	Request detailed network drawings from the customer.
10	12	Use filters even if it is not specifically asked in the contract.

Table 2: Risk response actions

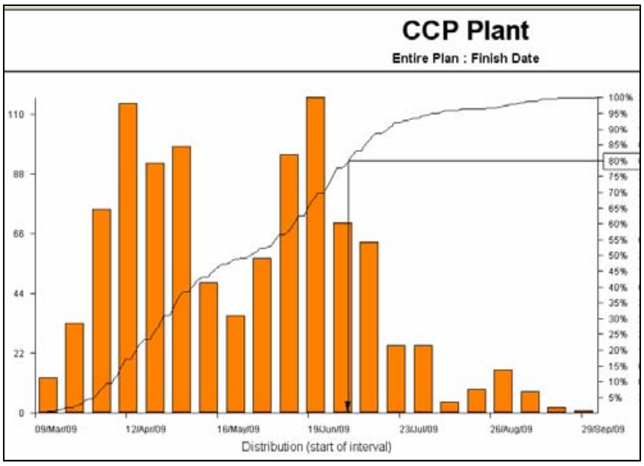

Fig. 5: Risk analysis results – with responses

5 Conclusion – Further research

Fig. 5 reveals that the implementation of project risk management activities will lead to an 80% confidence level for delivering the project in time (before 1st of July 2009). Thus, comparison between **Fig. 4** and **Fig. 5** indicates that the implementation of risk management will increase the probability of achieving the project objective (deadline) by 62%.

The proposed method is a framework for the integration of risk management processes in the Power Plants development. It should be denoted that the project end (mean duration) without risk management was estimated at 2 September 2009, while the project end (mean duration) with risk management was estimated at 25 May 2009. This means that risk management will probably save more than 3 months of development time for this specific project.

If such kinds of projects are delivered in time in a large scale, the whole energy production system will replace old (and more polluting) power plants quicker and benefit the most the environment and sustainable growth.

In terms of the environmental impact, risk management will always have a positive effect as it will accelerate the replacement of the old and usually high polluting energy facilities with new ones.

However, there are some considerations for the proposed approach. Apart from the obvious benefit of decreasing project duration, there are certain aspects that should be further investigated such as the cost of risk management. Before deciding that managing time is of great importance one should balance the cost of response actions and then decide whether or not these actions should be implemented.

Further research on the subject has already been undertaken by the authors who are trying to define a CCP plant-specific risk breakdown structure along with the determination of the risks relative importance in these kind of projects. Such an enhancement would aid CCP plant development project managers to quicker identify the relevant risks thus make them able to spent more time searching for appropriate risk response strategies.

References:

[1] Leopoulos, V. and Kirytopoulos, K., 'Methodology for risk management in systems development', *proceedings of the Recent advances in Computers, Computing and Communications Conference*, WSEAS Press, 2002, pp. 13-18.

[2] Gray, C. and Larson, E. *Project Management*, McGraw-Hill, 2000.

[3] Project Management Institute, *A guide to the project management body of knowledge: PMBOK guide. – 3rd ed*., Project Management Institute, USA, 2004.

[4] Chapman, C. and Ward, S., *Project risk management: Processes, Techniques and Insights,* John Wiley & Sons Ltd, 1997.

[5] Chong, Y. and Brown, E., *Managing project risk: Business risk management for project leaders.* Pearson Education Ltd, 2000.

[6] Kirytopoulos, K., Leopoulos, V., Malandrakis, C. and Tatsiopoulos, I., 'Innovative knowledge system for project risk management', *proceedings of the Advances in Systems Science 2001 Conference*, World Scientific and Engineering Society Press, 2001, pp. 505-510.

[7] Hammer, R.W., *Handbook of system and product safety*, Englewood Cliffs, N.J.: Prentice – Hall, 1972.

[8] Alexander, C., *Risk Management and Analysis: Measuring and Modelling Financial Risk*, John Wiley & Son Ltd, 1999.

[9] Kirwan, B., 'Human Error Identification techniques for risk assessment of high risk systems-Part 1: review and evaluation of techniques', *Applied Ergonomics* Vol. 29, No. 3, 1998, pp. 157-177.

[10] Tatsiopoulos, I., Leopoulos, V., Kirytopoulos, K., 'Risk as a strategic decision factor for the competitive bidding process in contract manufacturing', IFIP Conference, Aalborg, Denmark, 2001, pp. 100-107.

[11] Wideman, R., *Project and program risk management: a guide to managing project risks and opportunities*. Project Management Institute, 1992.

[12] Kliem, R and Ludin, I., *Reducing Project Risk*, Gower Publishing Ltd, UK, 1997.

[13] Panayiotou, N., Gayialis, S., Panayiotou, T. and Leopoulos, V., 'Risk Management Issues in the Implementation of an ERP System for a Large Greek Company', *WSEAS Transactions on Computers*, Vol. 3, No.4, 2004, pp.1005-1012.

[14] Kirytopoulos, K., Leopoulos, V. and Diamantas, V., 'PERT versus Monte Carlo Simulation in low risk projects', *e-Proceedings of the CME 25 Conference*, Construction Management and Economics, University of Reading, Reading, UK, 2007.