Risk analysis of river type hydroelectric power plants: An analysis by using fuzzy logic

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(1) Overview

With the liberalization of the energy market, market participants are faced to take the necessary measures to manage the risks. In particular, risk analysis becomes more important for hydroelectric power plants, such as river type small-scale hydro-electric projects. In this context, an accurate risk analysis of investment projects is very important for successful execution of the projects. Otherwise, the risk factors should jeopardize the economic viability of the small scale projects. Therefore, the main purpose of this paper is to study the risk factors faced by river type hydraulic power plants using the fuzzy logic. The reason for the use of fuzzy logic is that it facilitates to convert verbal expressions to the numerical values. We can say that the information used in risk analysis is in nature verbal. This information is used in everyday life expressed in words and sentences, which are called as fuzzy information. In this paper, the numerical fuzzy logic method is chosen as a convenient method for digitizing the verbal expressions. The risk analysis by using fuzzy logic is conducted for 15 river type hydroelectric power plants located in Turkey.

(2) Methods

In this paper, to be used in the analysis of river type hydroelectric power plant projects, 9 risk factors were identified after review of the relevant literature. In order to determine the relative importance levels of the risk factors, a survey was sent to project managers with experience in hydroelectric power projects and work for companies that obtained generation license from Turkish energy regulator - EMRA. 16 different project managers participated in the survey, 1 questionnaire was eliminated due to lack of consistent data. As a result, a total of 15 questionnaires were accepted and used in the analysis. Risk factors were scaled from 1 to 5, meaning that 1 refers to "*very low risk*" and 5 refer to "*very high risk*". The experts were requested to rate risk factors according to the criteria scores from 1 to 5. In addition, they were asked to share their planned and actual costs for 8 main items such as project design, civil works, electromechanical equipment, hydro mechanical equipment, network connectivity, land use and permits, financial expenses and additional expenses.

(3) Results

The results are given below in figure 1. As seen from Fig.1, grid connection, land rent, access to infrastructure, geology, and law changes are the major risk factors. Fig.2 shows the unit investment cost according to the risk index.

The analysis of the questionnaires completed by the project managers determined that the most important risk factors for river type power plant projects are the "*network connection*" and "*land use and land acquisition*".

Fig. 1: The major risk factors.

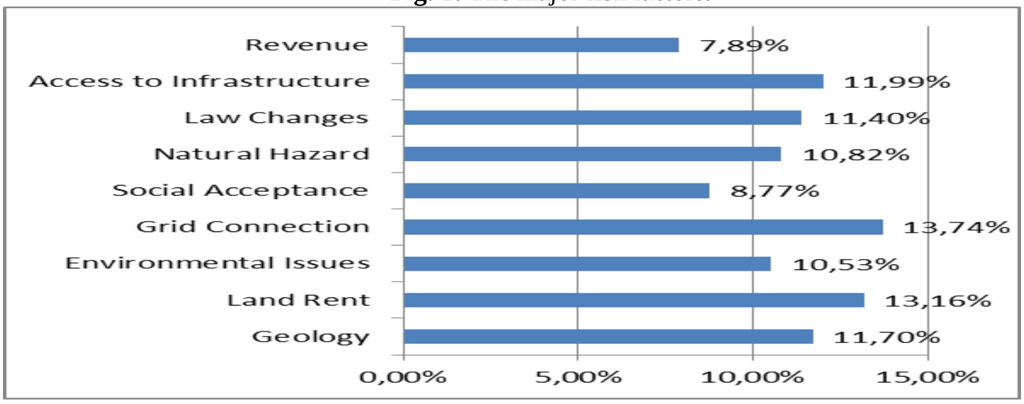

Fig. 2: Risk index and the corresponding unit investment cost (US$/kW)

Risk Index	Unit Investment Cost (US$/kW)
Very Low Risk: 0 - 0.2	500 - 1000
Low Risk: 0.2 - 0.4	1000 - 1500
Medium Risk: 0.4 - 0.6	1500 - 2000
High Risk:0.6 - 0.8	2000 - 2500
Very High Risk: 0.8 - 1.0	2500 - 3500

Hydroelectric power plant projects located in the same basin affect each other in terms of connection to the network. This makes network connection a critical issue for project owners. Changes in the connection point to the network would increase the cost of construction and expropriation.

The reason for the high risk factor of expropriation is that expropriation costs cannot be forecast during the feasibility period. Legislative changes and court cases due to environmental and other concerns by domestic people in the project location cause delays in the completion of the project.

(4) Conclusions

A study by Hall et al. about cost analysis on 2155 hydroelectric power plants in the United States found that the investment cost for hydroelectric cost changes between 500 US$/kW and US$ 6000/kW. The average investment cost is US$ 1650/kW, and 90% of the projects' investment cost is US$ 3350/kW. A similar study was conducted for 250 projects with a total capacity of 202 GW of hydroelectric power plants and the cost of the investment completed in 2003 and found that the investment cost for hydroelectric power plants are between US$ 450/kW and US$ 4500/kW.

As seen in Figure 2, we concluded that the amount of investment risk according to the index unit of US$ 500/kW to US$ 3500/kW for river hydroelectric power plant projects in Turkey is consistent with previous studies.

As a conclusion, this paper shows that each project is unique and the investor is required to determine the main risk factors for the success of the project. The uncertain environment makes impossible the use of deterministic models. But the fuzzy logic is a powerful tool to identify risk factors and evaluate the success of the project.

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