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Identification, Assessment and Ranking Risks of Overhead Power Lines Projects using TOPSIS Method

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Abstract: In the electric power industry, electric energy generated in power plants transmitted to overhead power lines through power substations and finally it is delivered to consumers. Currently overhead power lines projects are under the regional electric companies of the country. The overhead power lines projects aim to provide energy power for various provinces and keep the customers satisfied. These projects consisting of several main phases, including Initial phase, Design and Engineering phase, Procurement phase, Implementation phase, and the Final phase. Any phase may face specific risks. If one of risks occurs, the project objectives may be affected. Therefore, the effective risk management should be emphasized and implemented in these projects to assure the achievement of the project objective. In this study, risks are identified through the literature review, semi-interviews with experts, and WBS. Ranking, as a part of the complex process of risk management, is an essential step in order to assess and respond to risks timely and appropriately. In this paper, after identifying of the key overhead power lines risks and necessary attribute for analyzing, Multiple Attribute Decision-Making (MADM) approach for assessing and ranking of the key risks were used**.**

Keywords: Risk ،Project Risk Management ،Ranking ،Multiple-Attribute Decision Making (MADM), overhead power lines

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1. Introduction

Risks are involved in every business, and the most project management issues arise from uncertainties associated with them [1]. Recently, risks in projects have become larger in terms of number and impact, requiring stakeholders of a firm to have well-developed risk management to protect themselves against financial or legal consequences [2]. Risk management is the systematic process for identifying, and responding to project risk. It includes maximizing the probability and consequences of positive events and minimizing the probability and consequences of adverse events to project objectives [3]. Several studies on risk management in projects [1]- [5]- [4]- [2] indicate that the risk management process is the systematic process of identifying, analyzing and responding to the project risk in order to maximize the results of the positive events and decrease the probability and consequences of unpleasant events on the project objectives [6].

In the electric power industry as one of the key energy industries, electric power transmission network is an intermediate level in the electric power supply chain. Therefore, the electric energy generated in power plants is transmitted to power substations via electric power transmission lines and finally delivered to consumers. The purpose of construction of the transmission lines and substations is to meet the needs of customers, increase stability, reliability of the system, and exchange electric energy with neighboring countries [7]. Overhead power lines projects (transmission and sub-distribution) with the aim of supplying electricity to different provinces in order to meet energy requirements and customer satisfaction, consisting of several main phases. These main phases are Initial phase, Design and Engineering phase, Procurement phase, Implementation phase, and Final phase. Any phase may face specific risks. If one of risks occurs, impacts at least one project objective (e.g. quality, cost, time, etc.). Delays and increasing cost in implementation of these projects can lead

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to more thinking. If the risk management is implemented effectively in the overhead power lines projects, these project performance through assuring the achievement of the project objectives improves. However, with project managers that act only on the basis of their taste and knowledge, the risk management or the project management will not have the proper outputs.

Therefore, considering all of the above, establishing a scientific and standard system for managing risk of the overhead power lines projects in order to achieve their objectives, which is to delivering the projects on schedule, in accordance with the budget and in line with qualitative standards, is essential. Therefore, in this study, at the first stage, risks that effect on cost, time and quality of the overhead power lines projects are identified. Then assessment and ranking as key parts of the risk management process was performed. Ranking and prioritize the project risks can be done with qualitative and quantitative methods. One of the efficient methods for doing this is multiple attribute decision-making methods (MADM) that lead to more accurate decisions for managers. Although researchers have already used multiple attribute decision making methods separately or in combination with other methods of decision-making in risk management process of many projects, But studies shows that these methods has not been used in overhead power lines projects. In this paper, we identify risks of Zarinshahr–Shahrakfulad overhead power line project and the technique for order preference by similarity to ideal solution (TOPSIS) as one of the most popular and widely applied MADM methods is used for ranking risks of the project.

2. Literature Review

A project is a temporary endeavor designed to produce a unique product, service or result with a defined beginning and end undertaken to meet unique goals and objectives. The temporary nature of projects stands in contrast with business as usual (or operations), which are repetitive, permanent, or semi-permanent functional activities to produce products or services [8].

Project management is the application of knowledge, skills, tools, and techniques to project activities in order to meet or exceed stakeholder needs and expectations from a project [8].

The term "risk" is derived from the Italian verb "riscare" which means: "to have the cheek to do something." Risk is a permanent element of each decision-making process, including design and planning decisions [9].

Traditional view to risk is a negative view which is agent of damages, dangers and negative effects. Undoubtedly, usual concept and application of risk is lonely concerned of negative concept. This interpretation of risk has brought in the most of dictionaries and even technical texts and classic standards in project management [10].

Project Management Body of knowledge (PMBOK Guide) is published from Project Management Institute (PMI) defined that project risk is an uncertain event or condition that, if it occurs, has a positive or a negative effort on a project objective. A risk has a cause and, if occurs, a consequence [3].

Risk management is defined as a set of methods and activities designed to reduce the disturbances occurring during the realization of the project [3].The fundamental aim of a risk management process is to ensure that all steps needed to achieve the project objectives will be taken. Those objectives normally include the delivery of a project on schedule, in accordance with the budget and in line with all quantitative and qualitative standards. In other words, a risk management system is aimed at identifying and analyzing all risk events which may occur during the realization of the project and subsequently allow undertaking of appropriate mitigating actions [11-13].

3. Statistical population

In this study, the statistical population of experts consisted of the senior managers, the overhead power lines projects managers, experts with different classes in different agents including employers, advisors, supervisors, and contractors. These people have worked on the overhead power lines projects, are familiar to the risk management, have high experiences in their expertise and have a significant role in achieving project objectives.

4. Risk Identification

A risk can't be managed unless it is identified at the first. Similarly, after completion of the risk management plan, the first process in the replication process of the project risk management is identification of all risks about the objectives of the project [14].

At this stage, the literature review conducted aided in having a better understanding of overhead power lines projects and risk management in them. Risks of the projects are identified based on librarian studies, semi-structured interviews with experts, and work breakdown structure (WBS) of the projects was developed with consideration of experts opinions. The list of the identified risks according to research scope, the degree of importance and the subject is reviewed and then risks with the same content merged together.

3. Risk Assessment and Ranking

Risk assessment is a systematic process for identifying and evaluating events (i.e., possible risks and opportunities) that could affect the achievement of objectives, positively or negatively.

The purpose of the risk assessment is the measurement of risks by various factors such as the level of impact and likelihood of occurrence. Risks ranking is the key part of this process because with ranking determined priorities of risks [15].

Most organizations have limited resources to manage all risks equally. To overcome this problem, they can assess and priorities the risk level of each project, so that an appropriate level of effort can be applied to the management of those risks. In particular, resources will be directed to manage projects with the higher risk ranking. A ranking of risks should be seen as one input to decision making, not as a final recommendation for management priorities [16].

In most of the risk assessment, the criteria "impact" and "probability" of risk is used. In this paper, the technique for order preference by similarity to ideal solution (TOPSIS) as one of the most popular and widely applied MADM methods is used for ranking risks of Zarinshahr – Shahrakfulad overhead power line project and in addition to "impact" and "probability" criteria, "manageability" and "imminent" criteria are also considered.

4. TOPSIS Method

TOPSIS (Technique for order preference by similarity to an ideal solution) method is presented in Chen and Hwang [17], with reference to Hwang and Yoon [18]. TOPSIS is a multiple criteria method to identify solutions from a finite set of alternatives. The basic principle is that the chosen alternative should have the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution. The procedure of TOPSIS can be expressed in a series of steps:

(1) Calculate the normalized decision matrix. The normalized value n_{ij} is calculated as:

$$n_{ij}=[n_{ij}] \quad n_{ij}= x_{ij}/(\sqrt{\sum_{i=1}^{m} x_{ij}^2} \quad i=1, \ldots, m \;\; j=1, \ldots, m$$

(2) Calculate the weighted normalized decision matrix. The weighted normalized value V_{ij} is calculated as:

$$V_{ij} = N_{ij}\times W_j \quad i=1, \ldots,m, j=1, \ldots, m$$

Where W_i is the weight of the *i*th attribute or criterion, and $\sum_{j=1}^{n} w_j = 1$

(3) Determine the positive ideal and negative ideal solution

$$A^+ = \{v_1^+, \ldots, v_n\} \text{ where } v_j^+ = \{ \max (v_{ij}) \text{ if } j \in J; \min (v_{ij}) \text{ if } j \in J'$$

$$A^- = \{ v_1^-, \ldots, v_n^- \}, \text{ where } v_j^- = \{ \min (v_{ij}) \text{ if } j \in J; \max (v_{ij}) \text{ if } j \in J'\}$$

Where I is associated with benefit criteria, and J is associated with cost criteria.

(4)Calculate the separation measures, using the n-dimensional Euclidean distance. The separation of each alternative from the ideal solution is given as:

$$d_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2} \;, \quad i = 1,2,\ldots,m$$

Similarly, the separation from the negative ideal solution is given as:

$$d_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2} \;, \quad i = 1,2,\ldots,m$$

(5) Calculate the relative closeness to the ideal solution. The relative closeness of the alternative A_i respect to A^+ is defined as

$$CL_i^+ = \frac{d_i^-}{d_i^- + d_i^+}$$

Since $d^-_i \geq 0$ and $d^+_i \geq 0$, then, clearly, Ri ∈ [0, 1]

(6)Rank the preference order. For ranking alternatives using this index, we can rank alternatives in decreasing order.

The basic principle of the TOPSIS method is that the chosen alternative should have the "shortest distance" from the positive ideal solution and the "farthest distance" from the negative ideal solution. The TOPSIS method introduces two ‘‘reference’’ points, but it does not consider the relative importance of the distances from these points.

5. Case Study: Consider Zarrinshahr - Shahrakfulad overhead power line project

Assessment of identified risks is done based on "probability", "impact on cost", "impact on time", "impact on quality", "manageability" and "imminent" criteria. The amount of weight (relative importance), type of criteria, the identified risks and also their quality values for the six criteria are shown in Table 1. To quantify the value, likert scale (VL=1, L=2, M=3, H=4, VH=5 for positive criteria and VL=5, L=4, M=3, H=2, VH=1 for negative criteria) is used.

After obtaining qualitative values with collecting data from the questionnaire, converting them to quantitive ones. To use TOPSIS method for ranking risks, follow the steps below:

Table 1: Risk and qualitative values based on different criteria

Code	**Key Risks**	**Probability**	**Time**	**Cost**	**Quality**	**Manageability**	**Imminent**
	Weight (relative importance)	0.231	0.179	0.128	0.154	0.179	0.129
	Type	**Positive**	**Positive**	**Positive**	**Positive**	**Negative**	**Positive**
1	Less experienced supervisors	VL	VH	VH	H	H	H
2	Regulate the bidding documents without observing all legal issues	VL	VH	VH	VH	H	H
3	Lack of skilled personnel and specialist in advisors team	VL	VH	VH	H	H	H
4	Failure to observe proper schedule for design studies	L	VH	H	M	M	H

	and engineering services						
5	Lack of appropriate insurance in workshop(equipment and personnel)	L	H	VH	L	H	L
6	Failure to submit project progress control reports by contractor	L	H	H	H	VH	L
7	Disproportion in the budget allocation to the project	M	H	H	H	M	H
8	Overlapping functions of employer and supervisor during the project period	M	VH	VH	H	H	L
9	Lack of funding on behalf of employer	M	VH	H	H	M	H
10	Lack of timely presence of legal experts in removal of legal issues on land of the project	M	H	H	L	M	H
11	Changes of the contractor management system after holding tender	M	H	VH	M	H	L
12	Inappropriate evaluation of contractors	M	M	M	VH	H	M
13	Use of unauthorized and foreign personnel in workshop	H	M	M	H	VH	L
14	Lack of coordination between sub-contractors	H	H	H	H	H	L
15	Failure to employ competent supervisors in workshop	H	H	H	H	H	L
16	Lack of accountability of contractor towards the poor performance of the project	H	H	H	H	H	M
17	Frequent replacement of executive members	VH	H	H	H	H	L
18	Lack of adequate employer support of adviser (according to contract)	VH	VH	VH	M	VH	M
19	Lack of permanent presence of responsible person of safety in workshop	VH	H	VH	H	VH	L
20	Inefficiencies schedule and failure to observe order of execution of operations.	VH	VH	H	M	M	M
21	Lack of technical standards at execution phase	VH	H	H	VH	H	L

(1) Calculate the normalized decision matrix (Table 2)

Table 2: normalized the decision matrix

Code	Probability	Time	Cost	Quality	Manageability	Imminent
1	0.036	0.256	0.256	0.227	0.195	0.303
2	0.036	0.256	0.256	0.292	0.195	0.303
3	0.036	0.256	0.256	0.227	0.195	0.303
4	0.107	0.256	0.199	0.162	0.325	0.303
5	0.107	0.199	0.256	0.097	0.195	0.13
6	0.107	0.199	0.199	0.227	0.065	0.13
7	0.179	0.199	0.199	0.227	0.325	0.303
8	0.179	0.256	0.256	0.227	0.195	0.13
9	0.179	0.256	0.199	0.227	0.325	0.303
10	0.179	0.199	0.199	0.097	0.325	0.303

11	0.179	0.199	0.256	0.162	0.195	0.13
12	0.179	0.142	0.142	0.292	0.195	0.217
13	0.25	0.142	0.142	0.227	0.065	0.13
14	0.25	0.199	0.199	0.227	0.195	0.13
15	0.25	0.199	0.199	0.227	0.195	0.13
16	0.25	0.199	0.199	0.227	0.195	0.217
17	0.322	0.199	0.199	0.227	0.195	0.13
18	0.322	0.256	0.256	0.162	0.065	0.217
19	0.322	0.199	0.256	0.227	0.065	0.13
20	0.322	0.256	0.199	0.162	0.325	0.217
21	0.322	0.199	0.199	0.292	0.195	0.13

(2) Calculate the weighted normalized decision matrix (Table 3)

Table 3: weighted normalized decision matrix

Code	Probability	Time	Cost	Quality	Manageability	Imminent
1	0.008	0.046	0.033	0.035	0.035	0.039
2	0.008	0.046	0.033	0.045	0.035	0.039
3	0.008	0.046	0.033	0.035	0.035	0.039
4	0.025	0.046	0.025	0.025	0.058	0.039
5	0.025	0.036	0.033	0.015	0.035	0.017
6	0.025	0.036	0.025	0.035	0.012	0.017
7	0.041	0.036	0.025	0.035	0.058	0.039
8	0.041	0.046	0.033	0.035	0.035	0.017
9	0.041	0.046	0.025	0.035	0.058	0.039
10	0.041	0.036	0.025	0.015	0.058	0.039
11	0.041	0.036	0.033	0.025	0.035	0.017
12	0.041	0.025	0.018	0.045	0.035	0.028
13	0.058	0.025	0.018	0.035	0.012	0.017
14	0.058	0.036	0.025	0.035	0.035	0.017
15	0.058	0.036	0.025	0.035	0.035	0.017
16	0.058	0.036	0.025	0.035	0.035	0.028
17	0.074	0.036	0.025	0.035	0.035	0.017
18	0.074	0.046	0.033	0.025	0.012	0.028
19	0.074	0.036	0.033	0.035	0.012	0.017
20	0.074	0.046	0.025	0.025	0.058	0.028
21	0.074	0.036	0.025	0.045	0.035	0.017

(3), (4), (5) Determine the positive ideal and negative ideal solution, calculate the separation measures and Calculate the relative closeness to the ideal solution (Table 4)

Table 4: Separation from positive and negative ideal solution and relative closeness

Code	Separation from positive ideal solution	Separation from negative ideal solution	Relative closeness
1	0.071	0.046	0.393
2	0.07	0.051	0.421
3	0.071	0.046	0.393
4	0.071	0.037	0.343
5	0.066	0.034	0.34
6	0.056	0.055	0.495
7	0.059	0.046	0.438
8	0.047	0.052	0.525
9	0.058	0.05	0.463
10	0.065	0.042	0.393
11	0.051	0.045	0.469
12	0.049	0.051	0.51
13	0.039	0.071	0.645
14	0.039	0.06	0.606
15	0.039	0.06	0.606
16	0.034	0.061	0.642
17	0.036	0.074	0.673
18	0.023	0.086	0.789
19	0.026	0.085	0.766
20	0.052	0.071	0.577
21	0.034	0.077	0.694

(6) Rank the relative closeness in decreasing order.

Table 4. risk ranking

Code	Rank
18	1
19	2
21	3
17	4
13	5
16	6
14	7
15	7
20	8
8	9
12	10
6	11
11	12
9	13
7	14
2	15
1	16
3	16
10	16
4	17
5	18

The results confirm the superiority of TOPSIS method in ranking the risks due to consideration of several factors simultaneously, consideration different weights for attributes, being scientific and analytical results. According to this ranking, project manager should give high priority to risk with code 18 and respond to it quickly.

5. Conclusion and Recommendation

In the electric power industry as one of the key energy industries, electric power transmission network is an intermediate level in the electric power supply chain. Overhead power lines projects (transmission and sub-distribution) with the aim of supplying electricity to different provinces in order to meet energy requirements and customer satisfaction, consisting of several main phases. These main phases are Initial phase, Design and Engineering phase, Procurement phase, Implementation phase, and Final phase. Any phase may face specific risks. If one of risks occurs, impacts at least one project objective (e.g. quality, cost, time, etc.). Delays and increasing cost in implementation of these projects can lead to more thinking. If the risk management is implemented effectively in the overhead power lines projects, these project performance through assuring the achievement of the project objectives improves.

The risk management process provides a logically consistent framework for identifying and understanding potential risk factors, assessing consequences and their uncertainties, and evaluating and choosing best courses of action necessary to cope with the identified risks in order to achieve the desired

objectives of a given project. Risk assessment is one of the main steps of risk management and risk ranking in turn is an important part of risk assessment. Due to time and financial limitations in response to all risks equally, risk ranking by allowing timely and appropriate responses to them overcome this problem effectively. Since multiple attribute decision making methods (MADM) are useful and known tools for prioritizing many options, in this paper, the technique for order preference by similarity to ideal solution (TOPSIS) as one of the most popular and widely applied MADM methods is used for ranking risks of the Zarinshahr – Shahrakfulad overhead power line project and in addition to "impact" and "probability" criteria, "manageability" and "imminent" criteria are also considered.
Because the overhead power lines projects across the country are similar in nature, the procedure used in this study can be extended to them.

Abbreviations

WBS: Work Breakdown Structure, TOPSIS: Technique for Order Preference by Similarity to an Ideal Solution, MADM: Multiple Attribute Decision-Making.

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