

Applying the Analytical Hierarchy Process to Multi-Criteria Analysis for Contractors Selection in Short Contract at Saudi Electricity Company

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Abstract: The Transportation Department at Saudi Electricity Company are responsible for providing the fuel types to the power plants by contractors, the contractors have trucks to transport the fuel from Aramco power plants to the Saudi Electricity power plants. There is a problem in selection contractors at Saudi electricity company depend largely on the least price. This random selection affects the work quality and number of tanks delivered to the various power plants, to solve the problem a model was built by using Analytic Hierarchy Process (AHP). So, the problem which have been addressed and deeply investigated in this study was the bad selection of the contractors in short contracts in the fuel transporting contracts at Saudi Electricity company, particularly in summer season when the consumption of the electricity increase. The methodology is to collect data by asking the expert engineer, and his team, focused questions about the project and take their opinions about some questions in the questionnaire. Applying the Analytic Hierarchy Process (AHP) to decide the best contractors that the transportation department can choose depended on seven criteria. The results obtained from this thesis a proved that contractor No 2, is the best contractor by using the AHP, because he has the highest priority in the priority vector for various alternatives. Also accomplished the aim of this study which was building a model that help in selecting the best contractors with the high level of performance to work with the Saudi electricity company in the transportation department to transport the Fuel oil (diesel, Alc.) by the trucks from Saudi Aramco company to the power plant of the Saudi Electricity Company. After Applied the AHP method to select the best contractor, the result was that Contractor number 2 is considered the best contractor among the four contractors in this study because it has the highest final priority vector.

Keywords: AHP, Saudi Electricity Company, Saudi Aramco Company, Transportation Department, Short Contract

I. INTRODUCTION

The Power Plants of Saudi Electricity Company generate the electricity by using the fuel types like crude, heavy and diesel, so all these types of fuel are significant to generate the electricity in the power plants without troubles. The transportation department at Saudi Electricity Company is responsible to

provide the power plants with required fuel by contractors, the contractors have trucks to transport the fuel from Aramco power plants to the Saudi Electricity power plants.

There are too many power plants that the transportation department, at Saudi Electricity Company, responsible for supplying the fuel to those power plants, including stations of the two holy mosques of Makkah and Madinah. The selection of the contractors, who transported the fuels, depend largely on the least price, after the contractors introduce their offers.

This random selection affects the work quality and hence will affect negatively on the number of tanks delivered to the various power plants. So, the problem which will be addressed and deeply investigated in this study is the bad selection of the contractors in short contracts in the fuel transporting contracts at Saudi Electricity company, particularly in summer season when the consumption of the electricity increase.

The study aims to help Saudi electricity company in selecting the best contractors with the high level of performance to work with the Saudi electricity company in the transportation department to transport the Fuel oil (diesel, Alc) by the trucks from Saudi Aramco company to the power plant of the Saudi Electricity Company.

II. LITERATURE REVIEW

Choosing the most appropriate contractor for project implementation is a fundamental decision for owners and project directors equally [1]. Comparable to other countries, there are great programs introduced via the companies to develop the industry. One of the greatest significant features of these programs is the approach which the clients chose and weigh up their contractors. The strategies and measures for choosing contractors and granting contracts for short projects are dependent on those applied in the private sector. So, without an appropriate and detailed process for picking the principal contractor, the achievement of a project will probably be substantially affected. Selection of the most suitable contractor is an important process in public construction projects. This process is a major decision which may influence the progress and success of a construction project. Improper selection of contractors may lead to problems such as bad quality of work and delay in project duration. Especially in the construction projects of public buildings, the proper choice of contractor is beneficial to the public institution [2].

Choosing the suitable contractor amongst several applicants to a project is directly proportional to the achievement of the project. Contractor selection for the short projects is a complex procedure [3]. Selection of contractor is a procedure of decision-making which comprises the improvement and concern of an extensive variety of necessary and satisfactory criteria of decision in addition to the contribution of several decision makers [4].

In fact, it is a several criteria decision making difficulties in which several decision makers assess the qualities of the contractor consistent with several criteria. In this concern, the analytic Hierarchy Process is considered a competent decision-making procedure dependent on a methodology of multi-criteria decision making (MCDM). This process studies the human assessment, knowledge, awareness and moods in the process of making decision.

Therefore, this section will address and attempt to provide deep background and valued information regarding the literature review considered about most of the key words and basic terminologies that have a direct link with the title of this study such as the Analytical Hierarchy Process, Multi-Criteria

Analysis, Contractors Selection, Short Contracts, Saudi Electricity Company and other relevant topics of concern.

Contractor selection is one of the furthestmost significant phases in construction contracts. So, one of the fundamental activities of any customer is contractor selection. Devoid of an appropriate and accurate method for selecting the top contractor, the accomplishment of a project will probably be affected. Several contractor selection methods presently in existence are evaluated as imperfect and biased, and lacking concerns relating to the contractor's capability to accomplish concurrently, time, cost, quality and safety criteria.

The Analytic Hierarchy Process (AHP) is a multi-objective, multi-criterion decision-making methodology, which was initially established by Prof. Thomas L. Saaty, which utilizes a pairwise comparison process to get to a scale of preferences amongst groups of alternatives. The AHP includes three measures: hierarchic structure, prioritization procedure, and calculation of results. To employ this technique, it is essential to break down a multifaceted unstructured problem into its constituent parts; organizing these parts, or variables, into a hierarchic ranking; allocating numerical values to particular assessments on the comparative significance of each variable and synthesizing the assessment to decide which variables have the highest priority and should be acted accordingly to impact the outcome of the situation [5]

Decision-making, on the other hand, is the study of ascertaining and selecting alternatives to discover the best solution dependent on different factors and considering the decision-makers' expectations. Each decision is taken within a decision environment, which is defined as the gathering of information, alternatives, values and favorites existing at the time when the decision should be taken. The challenging point in decision-making is the array of the criteria established for assessing the alternatives. The intentions are commonly conflicting, and, in the majority of the cases, different individuals of decision-makers are included in the process. To simplify this sort of analysis, a group of tools referred to as Multi-criteria decision-making methods acquired ground attributable to the necessity to have a prescribed method to support decision-making in circumstances including multiple criteria.

Multi-criteria decision-making methods is a branch of a general class of Operations Research models that is suitable for addressing complex problems featuring high uncertainty, conflicting objectives, different forms of data and information, multi interests and perspectives, and the accounting for complex and evolving biophysical and socio-economic systems. This major class of methods is further divided into Multi-objective decision-making and Multi-attribute decision-making.

Literature survey has been undertaken in this area and presented. Concerning to this problem, the contractor pre- qualification, and assessment and selection procedure requires to be studied to realize the project objectives dependent on multi criteria decision making process. A hierarchy model has been created using the collected data for contractor selection that represented through the Analytic Hierarchy Process (AHP). Through using this model and with the assistance of AHP technique one can develop contractor selection approach which can be most useful for the company.

III. METHODOLOGY

The study methodology relevant to a study theme has been referred to as the channelized in addition to systematic methodology relevant to problem solving [6] and it has been considered as the discipline behind the reviewing that shapes the inclusive route of the research. It offers each research an effective explanation, rationalization, forecast and clarification relevant to a selected research theme [7].

This section involved the methodology utilized to accomplish the goals of this study comprising the necessary data and the approach to gather them and the concept of Analytical Hierarchy Process (AHP). To accomplish the goals of this research, the study plan involves and goes through various stages which include:

- Identifying the essential data, then gathering of these data.
- Preparing a questionnaire survey, then analyzing of the data obtained
- Creating an AHP model, and validation of the model.
- Formulation and Design of Questionnaire

The intended respondent relevant to the questionnaire was restricted to one expert who is specialized in the area of multi-criteria analysis for contractor's selection in short contracts. The prepared questionnaire included of sixty-three questions (42 questions of Alternative survey & 21 questions of Criteria survey) with general inquiry relevant to application of multi-criteria analysis and the use of Analytical Hierarchy Process.

- Data Analysis

The data analysis should be undertaken since the collected data via the participant will be incapable to offer a brief, comprehensible and perfect finding if the data collected is not understood appropriately. The data analysis is relevant for guaranteeing effective understanding of data for accomplishing short, recognizable and logical finding from the collected data by the participant. The data acquired should be analyzed via the statistical package for the Social Science (SPSS) for data analysis and manipulation and other statistical tools such as Pairwise Comparison Matrix and measuring Consistency relevant to each question.

- Required Data

This section clarifies the necessary data that will support in accomplishing the objectives of the research. This data comprises the followings:

1. The most important criteria implemented for the contractor's selection in short contract at Saudi electricity company.
 2. The Analytical Hierarchy Process (AHP) concepts.
 3. Information on available projects or previous transportation projects.
- The questionnaire used in this study

A questionnaire is one of the most important techniques for gathering the data from the study sample. It is formulated of a list of questions to gather the basic data from respondents who help by their responses in accomplishing the study objectives. The questionnaire should be prepared to be clear for the reader. This study, depending entirely on preparation of a questionnaire of reasonable questions that cover all the topic. The questions should be classified into Alternative survey and Criteria survey questions. Then each class should further be grouped into two axes, that is, the alternative survey should be separated into two axes whereas the Criteria survey should be separated, also, into two axes. Each axis should be formulated, using the affinity process, to represent a number of 3 to 4 questions

out of the total sum of the questions for each class. The following are the four major axes of the questionnaire:

a. Alternative survey:

This class involved two axes, as follows:

Axis 1: This axis comprised a group of four questions to which the Expert responded and provided his opinion regarding four variables, that is, the No. of years of experience, No. of drivers per year, the No. of engineers and technicians, and the No. of trucks.

Axis 2: This axis involved of a group of three questions to which the Expert responded and provided his opinion regarding three variables, that is, No. of maintenance places, No. of certificates of excellence, and the No of delegates.

b. Criteria survey:

This class, also, involved two axes, as follows:

Axis 1: This axis included a group of three questions to which the Expert responded and provided his opinion regarding three variables, that is, the No of years of experience, the No. of drivers per year, and the No. of engineers and technicians.

Axis 2: This axis included of a group of three questions to which the Expert responded and provided his opinion regarding three variables, that is, the No. of trucks, the No. of maintenance places, and the No. of certificates of excellence.

- Data Collection

To collect the data, a 20 years experienced expert engineer, and his team, in supervising contractors to deliver fuel trucks to power plants was met. An overview about contractors and their effect on the work and power plants in general, the forecast for 5 years to the quantity, the criteria that influence the choice of contractors' selection was given. The most commonly method used in contractor's selection in short contract at Saudi Electricity Company was determined. The expert man is one of fuel transportation expert in Saudi Electricity Company. Rough consensus* (RC) has been reached as the expert man, and his team, indicated that 85% of the fuel transportation group agrees such as a percentage represents the dominant view of a group.

- Process of data Collection

Data necessary to realize study objectives is gathered by following a quantitative research methodology which dependent on a questionnaire survey. After that, the data attained can be utilized in building a model dependent on an Analytical Hierarchy Process (AHP). The steps necessary to carry out this research could be summarized in the following:

- Finding the key objective, that is, select the best contractors with high level of performance.
- Pinpointing the criteria that effects on choice of choosing contractors and will be assessed through an expert engineer.
- Ascertaining the alternatives, namely, the contractors' names.
- Creating a model of decision-making applying the Analytic Hierarchy Process (AHP).

- Formulating a questionnaire which interprets the model of AHP into set of questions.
- Determining “the expert” who will be included in data collection process thru requesting him to response the questionnaire.
- Converting the collected data (Responses) into mathematical matrixes to complete the construction procedure of the AHP model.
- Creating weights for every criterion, regarding the fundamental objective.
- Creating weights for every contractor, regarding every criterion.
- Creating total weights for every contractor.
- Contractors prioritization consistent with the created weights.
- Choosing the furthestmost proper contractor for fuel transportation from both Aramco to Saudi Electricity power plants.
- The Procedure

Every procedure applied in this research will be clarified comprehensively in the following divisions. The procedure will be brief in the subsequent steps:

- Pairwise Comparison Matrix

To identify the priorities for the criteria, it is required to build a matrix of the pairwise comparison. The finding of the pairwise matrix is based on the included extent of the experience of the experts (specialists) and their consistency. The expected calculations undertaken for this study are as follows;

- 1) Values in every column of the pairwise comparison matrix should be summed up.
- 2) Divide every element in the pairwise comparison matrix by its column total value in the column/total
- 3) The resulting matrix is called the normalized pairwise comparison matrix.
- 4) Calculate the average of the elements in every row of the normalized pairwise comparison by the following equation:

$$\text{Average} = \text{First value in the row} + \text{second value in the row} + \dots \text{ etc.}$$

- 5) The calculated averages offer the priorities for the criteria.

- Consistency

A fundamental step in AHP is generating of several pairwise comparisons, as described earlier. A significant consideration in this procedure is the consistency of the pairwise assessments given by the decision maker. The steps are as follows:

1. Each value in the first column of the pairwise comparison matrix should be multiplied by the priority of the first item.
2. The elements of the weighted sum vector acquired in step 1 should be divided by the corresponding priority for each criterion.
3. The average of the values found in step 2 should be calculated.

4. The consistency index (CI) should be calculated.
5. The consistency ratio (CR) should be calculated.

IV. RESULTS AND DISCUSSION

- Research model

After clarifying the problem, now the process of developing the model to reach the best contractor among several contractors for short-term contracts with the Saudi Electricity Company is going to be elaborated (Figure1). First the model built depending on asking the expert engineer, and his team, one question, that is, What are the most criteria that effect on the performance of any contractor who are responsible about transport the fuel from Aramco power plants to Saudi electricity power plants?. Their answer was there are seven important criteria that effect on the performance of the contractor. Accordingly, the model of this study should basically be built depending on the seven criteria. As I build my hierarchy, I am going to consider the values or measurements of the different elements that build the model up as presented in the following points.

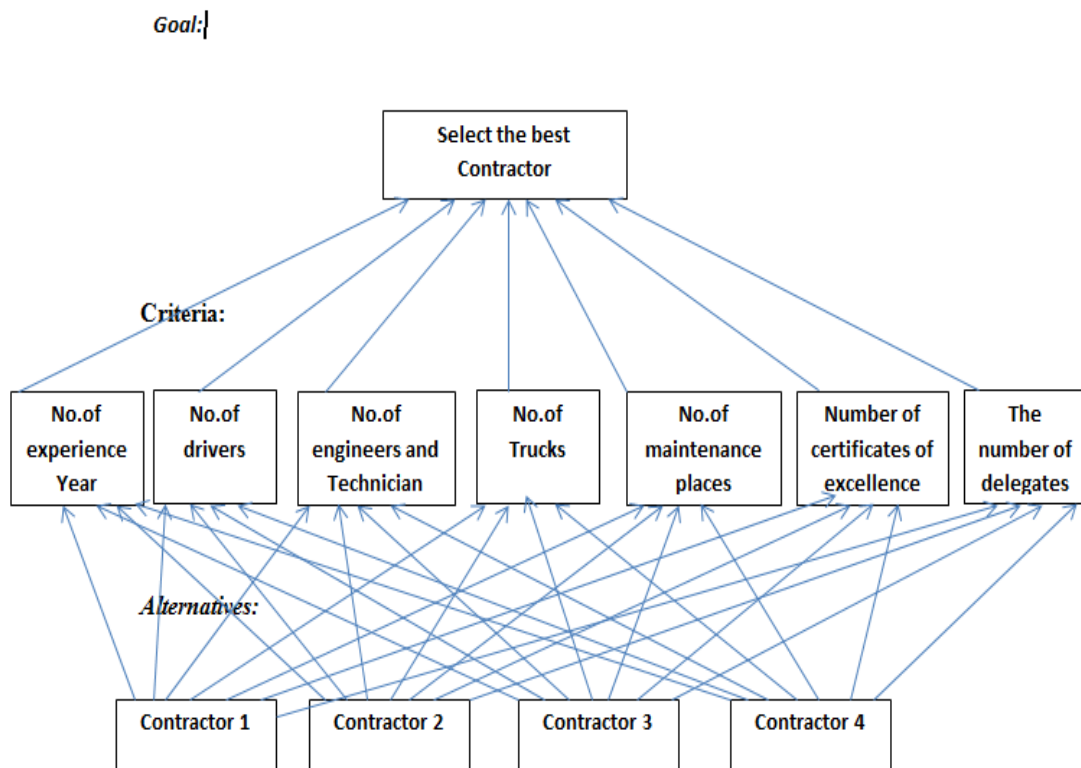


Figure 1.1 Illustration of the AHP methodology for outlining the model

- Discussion

The results obtained from this thesis a proved that contractor No 2, is the best contractor by using the AHP, because he has the highest priority in the priority vector for various alternatives. Contractor no 1, Contractor no 3, Contractor no 4 are rejected because they have small priority vector compared to contractor no 2. That is, Contractor no 1 got the priority vector of (0.26651), Contractor no 3 got the priority vector (0.264666) and contractor no 4 got the priority vector (0.098457). So, the contractors

1, 3 and 4 are rejected to be the best contractors for the Saudi electricity company to work with transportation department in transporting the fuel from Aramco loading point to Saudi electricity power plants. Contractor 2 is the best alternative selected contractor to work with transportation department in transporting the fuel from Aramco loading point to Saudi electricity power plants. Although, Contractor 2 Not got the highest priority vectors (0.129) and (0.25) regarding the No. of Experience Year and No. of drivers respectively, however, he accomplished the highest overall priority vector, i.e. (0.370367), which indicated that, although his years of experience was not vast compared to the other three, but he achieved the required works with limited number of drivers and this was not be considered as a disadvantage.

Table 1. Priority vector for various alternatives

	No. of Experience Year	No. of drivers	No. of engineers and Technicians	No. of Trucks	No. of maintenance places	No. of certificates of excellence	The Number of delegates	Final Priority vector
Contractor 1	0.586	0.6	0.263	0.108	0.0682	0.13	0.109	0.26651
Contractor 2	0.129	0.25	0.558	0.255	0.5219	0.41	0.4674	0.370367
Contractor 3	0.235	0.11	0.122	0.601	0.2121	0.3	0.2715	0.264666
Contractor 4	0.05	0.04	0.057	0.036	0.1978	0.15	0.1521	0.098457

One the other hand, Contractor 2 got the highest score regarding the No. of engineers and technician (0.558); this means that this contractor focused on assigning his works to specialized and professional team who can undertake the assigned tasks effectively as required by Saudi Electricity company using their qualification knowledge efficiently in this field of the work. Furthermore, Contractor 2 got the highest score regarding the priority vector the No. Of maintenance places (0.5219). Dedication of more maintenance places always reflected positively in undertaking of works particularly in the field of transportation. That is, the availability of more maintenance places for the fleet of trucks was considered the most critical aspect of managing truck fleet successfully. This confirmed by study held by the Department of Transport, Abu Dhabi, UAE [8], which showed that scheduled maintenance for trucks and other vehicles aimed at meeting the required standard at all times improved truck operating standards, reduced truck delays due to truck failure, and help to avoid accidents resulting from truck defects and as a result improve the efficiency of undertaking of the required works.

Moreover, Contractor 2, compared to other three contractors (1, 3, and 4), got the highest score regarding the priority vector the No. Of certificates of excellence (0.41). Getting of more certificates of excellence by a person (contractor) is considered an objective indicator [9] of the contractor accomplishment and demonstrated contractor proficiency through confirmation of his services by a third-party professional organization in that field, i.e., experienced checking agency of private or government sectors. Also, the certificates of excellence are issued to confirm that a person (contractor)

is qualified and accredited to accomplish a job, as transporting fuel, or have the documentation to indicate that they are officially carrying out their business.

Contractor 2, compared to other three contractors (1, 3, and 4), also got the highest score regarding the priority vector Number of delegates (0.4674). More number of delegates help in facilitating the smoothness of work carried out by the contractor as they coordinate and organize the process of transporting the fuel from Aramco loading point to Saudi electricity power plants.

These above findings achieved the aim of this study which is represented in building a model that help in selecting the best contractors with the high level of performance to work with the Saudi electricity company in the transportation department to transport the Fuel oil (diesel, Alc.) by the trucks from Saudi Aramco company to the power plant of the Saudi Electricity Company. Furthermore, the results reached from this study solved the problem that happened each summer seasons, when the consumption of the electricity increase, and the contractors are not able to transport the required fuel from Aramco power plants to Saudi electricity power plants, by indicating that the solution originated from selecting the best contractors with high quality and performance. So the results achieved after applying the model of the analytical hierarchy process will help the Saudi electricity company to achieve their goals in transporting the fuel to the power plants without any problems or difficulties by showing that selecting the best contractor will save time ,effort, money, protect the stock of the fuel in the tanks of the power plant as high percentage, raise the level of the performance for the contractor of fuel department in Saudi electricity company. Also, the results explain to Saudi electricity company that applying this method will help the company in the increasing the quality of the rules of selecting the contractors with high level of performance to work in transporting the fuel from Aramco to Saudi electricity company power plants. This model decreased the disadvantages in the selected contractors, and the benefit from this reflect on level of the work (high, medium, low) and supposed to be high. Contractor no 2, by achieving the highest priority vector (0.370367) is regarded as the best contractor because he has the highest priority vector for various alternatives. This because after calculating the results shown in the previous tables, particularly table no 4.26, the Contractor no 1 has small overall priority vector (0.26651) for various alternatives compared to contractor 2; so, he not selected as the best contractor. Also, Contractor no 3 has small overall priority vector (0.264666) for various alternatives compared to contractor 2; so, he not selected as the best contractor. Finally, Contractor no 4 has small overall priority vector (0.098457) for various alternatives compared to contractor 2; so he not selected as the best contractor.

V. CONCLUSIONS

The results of this project used by decision makers who are involved in the selection of contractors. In conclusion, this project succeeded in developing a mathematical decision-making model that gives priority to all contractors available to choose one for short contracts at the Saudi Electricity Company for seven Criteria. Such interference reveals from various factors (criteria) that the problem can be considered as a multi-standard decision-making problem (MACDM). The AHP tool was used as it represents one of the most common Multi-Criteria Decision Making. The result provides a general rating through which to make the final decision. There is no doubt that the results of this project, facilitate decision making. This is important because it helps the decision maker to resolve the contractor selection issue. This finding of this study was submitted to the top management in the Transportation Department at Saudi Electricity Company who accepted this method that help in selecting the contractors and this study put under discussion to see if it is possible to apply this method in the next short contract to select the best contractors to work with Saudi Electricity Company. Applying this method in the selection of contractors in short contracts at Saudi Electricity Company can reduce the difficulties encounter in this research. According to the positive initial impressions

taken from the top management, the implementation of this method can be soon in the company to choose the best contractors. Finally, after the AHP method application was accomplished the researcher feels very happy and proud to solve this big issue on selecting the contractors at Saudi Electricity Company by using one of the methods learned during studying in Industrial Department at King Abdulaziz University which is affect quality and number of tanks delivered to the various power plants, the aim from this thesis is achieved which is helping the Saudi electricity company in selecting the best contractors with the high level of performance. The goals of this study achieved soon when the top management accept to applying this method to select the contractors at Saudi Electricity Company so, the level of the fuel power plants will be above 80%, especially in the summer season and higher consumption, high Service quality will be provide, for the two holy mosque, especially in AL Hajj season and Umrah season throughout the year, the level of Customer Satisfaction will increase, the quality of work on the Saudi Electricity Company will increase, this is the importance from applying the AHP method in selecting contractors in short contract at Saudi Electricity Company.

VI. RECOMMENDATIONS

The followings are the suggested recommendations by the researcher,

- It is recommended to the Saudi electricity company to use the AHP tool to select the best contractors because it gives the company to select the best contractor without any problems in the performance of the contractors.
- It is recommend to Saudi electricity company to start study the process of selecting the contractors before the season of summer 2019 because the consumption of the electricity increased in each summer, so the need for the short contract increased also, and they are can use the AHP method from this summer to selecting the contractors in short contract for the fuel transportation contract.
- It is recommended to the top management in the Transportation Department to decide quickly to take advantages of the method as soon as possible.
- It is recommended to Saudi electricity company to use the AHP tool to save cost by selecting the best contractors.
- It is recommended to Saudi electricity company to use the AHP tool to save time by selecting the best contractors.
- It is recommended to Saudi electricity company to use the AHP tool to save effort by selecting the best contractors.
- It is recommended to Saudi electricity company to use the AHP tool to avoid the continuous of the same problem.
- It is recommended to Saudi electricity company to update qualified contractors periodically.
- It is recommended to Saudi electricity company, to make agreement with its contractors to not deal with subcontracts.

Conflict of interest: The authors declare that they have no conflict of interest.

Ethical statement: The authors declare that they have followed ethical responsibilities

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