ANALYTIC HIERARCHY PROCESS IN THE EVALUATION OF THIRD PARTY GENERATION

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1.0 INTRODUCTION

The provision of new generating-capacity has, until recently, been an issue internally addressed by utility companies. After deregulation of the industry and the recognition of the potential for savings by accepting third party generation (TPG), Non Utility Generation (NUG) has been adopted as a leading option for future capacity acquisition by an increasing number of electric utility companies. This option became attractive because of (i) the electric utility's need to reduce risk by avoiding large long term capital expenditure, and (ii) the potential for low cost energy from third party capacity. On the other hand, NUG projects are highly leveraged and the third party investors also are attracted by the potential for high investment returns. This has generated large volume of NUG capacity offers which are consistently several times greater than the electric utility's need specified in their Request for Proposals (RFPs).

Thus, the task of all source bidding and the evaluation of offers are becoming a regular function for the utility companies. However, despite the apparent shift of long term investment risk from the utilities to the individual third party, and the potential savings in energy cost to the consumer, it is difficult to precisely estimate such advantages. Many factors in addition to dollar amounts will have to be carefully analyzed to evaluate all consequences thoroughly. The reality remains that the utilities are still in full control of distribution systems and, therefore, bear the ultimate responsibility for the system performance. The utilities need to ascertain the details of the NUG operation for the life of any accepted facility. This unbreakable link between the system performance and the utility responsibility makes the evaluation of NUG options much more complex and involved for the utility company.

Many approaches have been suggested for this purpose [1,2], using elaborate theoretical models. These models require many parameters to be specified which are difficult from practical standpoint. The difficulty arises partly because of the fact that different utility system characteristics dictate different requirements. Even the requirements of the same system change over time in response to the changing environment. Therefore, for a model to be of practical value, it should be versatile, and applicable to diverse conditions of utility requirements. It should be capable of handling the complexity and the diversity of the problem and be simple and practical to be of operational value. The technique of Analytic Hierarchy Process (AHP) should be very useful for this purpose to capture the essence of the whole process rather than dwelling on details of individual evaluation problem. The application of AHP to quantify the degrees of importance of the significant factors in the context of TPG acquisition and their use in the evaluation of offers is presented in this paper. It assumes familiarity with Analytic Hierarchy Process and does not include any discussion on the subject. Details on the method can be found in [3].

2.0 THE EVALUATION PROCESS

A complete approach to third party generation evaluation should adequately address the incentive of financial gain to the utility and the customers, as well as numerous other concerns related to the system performance over the life time of the capacity to be added. Since, the characteristics and hence the requirements of different systems vary, the objectives behind capacity acquisition by different utility companies also differ to some extent. The objectives of the same company even change over time with addition of NUGs. Therefore, prior to actual evaluation of the offers, it will be appropriate to analyze the objectives behind the acquisition, identify the important factors which contribute to the objectives, and develop proper weights for these factors. These weights will be, then, used as the guiding criteria in the evaluation stage. However, the extent of such specification of criteria and hence the guidelines in preparing the offers are subject to the individual utility's perspective. Requiring the offers to completely conform to a fixed framework to fit these criteria will minimize subjective judgments during evaluation, making it possible to have more objective evaluation. But, too restrictive conditions will make it difficult for innovative offers (which could be the best offer) to comply. Thus, the stringent conditions could potentially exclude the innovative offers while the lack of sufficient structure will make it difficult to identify the best offers.

The actual practice of different utilities shows a wide range of variation. For example, stricter formats are employed by some utilities who provide floppy diskettes to fill in the responses to specific queries prepared by the utility. Some other utilities use very little stringent guidelines except for some broad statements in the form of evaluation criteria. A proper balance between these approaches is desirable to be able to identify the best alternative. The AHP approach provides flexibility in this respect treating the evaluation problem in two stages.

- The first stage consists of expressing the requirements and objectives behind each NUG acquisition according to the utility's perception. Such specifications of objectives will be extracted from the judgments of the experts and management of the company. This can be carried out to the extent to which the utility is willing to specify the criteria of evaluation beforehand.

- The second stage consists of the actual evaluation of the NUG offers using the information (and the indices derived from them) provided in the offers. This will be carried out in accordance with the requirements specified in the first step.

If the utility can foresee the nature of the offers, it can set up a detailed evaluation criteria, thus simplifying the evaluation part. On the other hand, if a diverse mixture of offers are expected, then it can concentrate on the evaluation phase. This flexibility in selecting the nature of evaluation process makes it applicable to utility companies with diverse practice and perspectives.

Thus, the evaluation process consists of two phases - (i) the establishment of the criteria, and (ii) the evaluation. Both these tasks are to be carried out with respect to several factors which are important in NUG acquisition. The identification of these factors and their classification will depend on the perspective of the utility. For example, some utility may consider *System Performance* as an integral issue to be considered separately. Then it will include the performance of all related components such as, the generation system and the transmission system under this factor. On the other hand, some utility may treat generation planning as an integral factor. Then all the factors pertaining to generation planning such as generation performance, generation cost and reliability indices will be analyzed under this factor. Obviously, numerous designs of classifications are possible for any system and the choice will depend on the perspective and practice of the utility company. An example problem, described in the following paragraphs, is used to illustrate the application of AHP.

3.0 EXAMPLE

This example represents the perspective and practice which considers Generation Planning, Transmission Planning, System Operations, and Fuel Issues as the primary concerns during TPG acquisition. Brief descriptions of these issues are given in the following.

1. **Generation Planning** : This factor will consider all aspects related to Generation Planning. It will address issues related to capacity requirements, means to fulfil the requirements, and the evaluations of feasible alternatives to satisfy the system demand. In the context of third party generation acquisition, some of the specific issues under this category might be: i) Generation type, ii) Generation Cost, iii) Plant Location, and iv) Reliability Indices.

2. **Transmission Planning:** This factor should include all the issues related to transmission of power from generation site to the load centers. In the context of TPG, it should include issues such as: i) Transmission line length, ii) Transmission cost (including substations), and iii) Wheeling requirements.

3. **Operational Issues:** It covers wide ranging issues related to operation of the system. In this scenario, it is assumed to be include all issues handled independently by the operations department and will include issues like: i) Capacity Factor, ii) Outage Rates, and iii) Dispatchability.

4. **Fuel Considerations:** It will address all concerns related to fuel, ranging from fuel efficiency to environmental impacts. The basic issues in TPG might be: i) Fuel Type, ii) Availability, iii) Diversity, and iv) Storage & transportation.

Each item of any of these sub-groups may be divided further into a number of simpler factors. The depth of such division will depend on the level of analysis desired. Also, the factors involved at any of these levels may be simple quantitative numbers or complex qualitative concepts. The presence of the non-quantifiable factors pose special difficulty in the evaluation, which can be adequately handled in the proposed approach using expert judgments.

Identification of the primary factors and the desired level of analysis defines a framework for analyzing the factors to establish the evaluation criteria. Then these criteria can be used in the evaluation of the offers. In the first part, the judgments (which may be the result of the deliberations and discussions among the policy makers and experts) will be used to extract the perspective of the utility. Then the criteria together with the information provided in the offers will be used to conduct a comparative evaluation of the offers.

3.1 Establishment of Evaluation Criteria

The application of AHP in the process of establishing weights for various factors in our example problem is illustrated here. The framework for this analysis is shown in the hierarchy of Figure 1. Expert judgments comparing the relative importances of these factors will be used in this analysis. Figure 1 shows each of these factors further classified into two categories (i) price factors and (ii) non price factors. Again, expert opinions on the price/non-price composition of these factors will be required for the analysis. Using such expert judgments, the weights for (i) price and non-price factors, and (ii) the four basic factors can be easily computed. The input required for the analysis are the judgment ratios (i) comparing the relative importance of factors at level 2 taken two at a time, and (ii) the composition of each factor broken down into price and non-price categories shown at level 3 of the hierarchy. Data to extract such pairwise comparisons will not be easily available, except as the judgments of the experts who were actually involved in or who are familiar with the whole process of acquiring TPG capacity.

Let the judgment ratios, comparing the relative importances of two factors at a time, be based on the contentions (or the expert judgments) that,

- 'Generation Planning' is strongly more important than 'Transmission Planning', 'Operational Issues' as well as 'Fuel Considerations' in the process of TPG acquisition.
- 'Transmission Planning' is equally important as 'Operational Issues', but very slightly more important than 'Fuel Considerations'.
- 'Operational Issues' is equally important as 'Fuel Considerations'.

Then, using the numerical scales for these qualitative judgments given by Saaty [3], the judgment matrix can be formed as,

$$\begin{bmatrix} 1 & 5 & 5 & 5 \\ 1/5 & 1 & 1 & 2 \\ 1/5 & 1 & 1 & 1 \\ 1/5 & 1/2 & 1 & 1 \end{bmatrix}$$

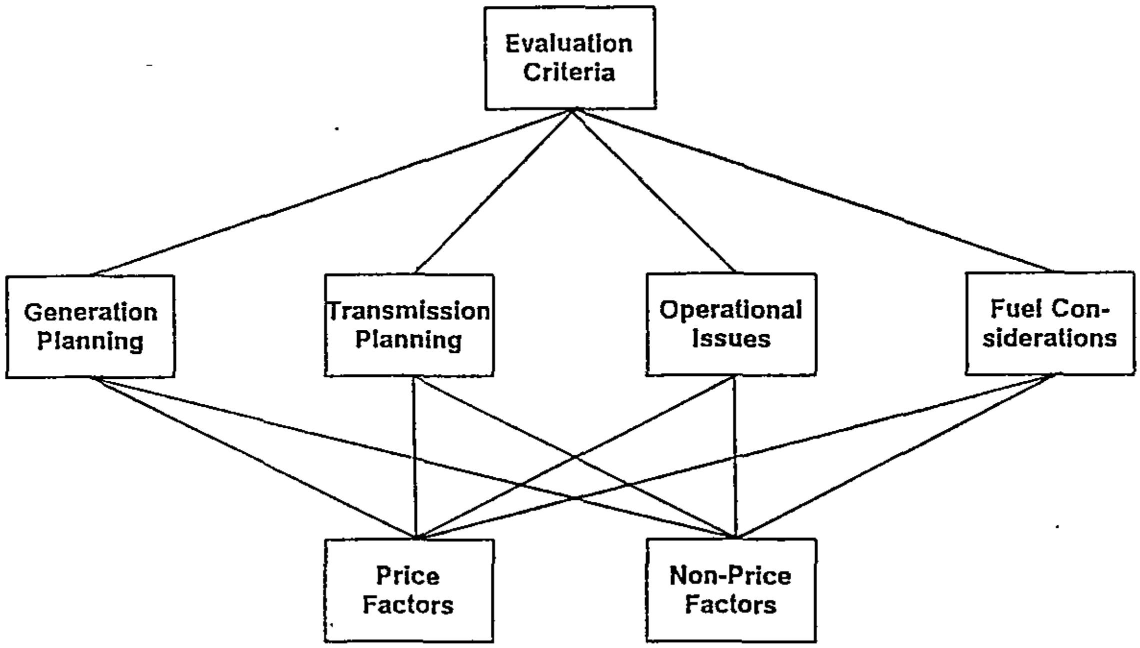

Figure 1. Hierarchical Structure to Establish the Evaluation Criteria

Analysis of this matrix gives the priority vector as, $[0.620\ 0.150\ 0.124\ 0.106]^T$ which simply means that the relative importances of these four factors are 62.0%, 15.0%, 12.4% and 10.6% respectively as indicated by the expert judgments.

Next, the judgment matrices comparing price and non-price composition of each of the four factors are formed. Let these matrices be,

$$\text{Generation Planning}: \begin{bmatrix} 1 & 3 \\ 1/3 & 1 \end{bmatrix} \qquad \text{Transmission Planning}: \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}$$

$$\text{Operational Issues}: \begin{bmatrix} 1 & 1/2 \\ 2 & 1 \end{bmatrix} \qquad \text{Fuel Considerations}: \begin{bmatrix} 1 & 5 \\ 1/5 & 1 \end{bmatrix}$$

These matrices are based on the judgments that:

- 'Generation Planning' is slightly more of a price factor than non-price factor;

- 'Transmission Planning' is price and non-price factor to equal extent;
- 'Operational Issues' is very slightly less of a price factor than non-price factor; and
- 'Fuel Considerations' is strongly a price factor than non-price factor.

Analyses of these matrices give the price/non-price composition of the factors as,

$$\text{Generation Planning}: \begin{bmatrix} 0.75 \\ 0.25 \end{bmatrix} \qquad \text{Transmission Planning}: \begin{bmatrix} 0.50 \\ 0.50 \end{bmatrix}$$

$$\text{Operational Issues}: \begin{bmatrix} 0.33 \\ 0.67 \end{bmatrix} \qquad \text{Fuel Considerations}: \begin{bmatrix} 0.83 \\ 0.17 \end{bmatrix}$$

Now, combining the two levels of analysis, the overall nature of price/non-price composition is obtained as,

$$\begin{bmatrix} 0.75 & 0.50 & 0.33 & 0.83 \\ 0.25 & 0.50 & 0.67 & 0.17 \end{bmatrix} \cdot \begin{bmatrix} 0.620 \\ 0.150 \\ 0.124 \\ 0.106 \end{bmatrix} = \begin{bmatrix} 0.67 \\ 0.33 \end{bmatrix}$$

Thus, this simple exercise determines the weights for two sets of criteria. The weights for the four factors are :

Cost Reduction : 62.0 % System Performance : 15.0 %

Operation & Control : 12.5 % Project Development : 10.6 %

And the weights for the overall price and non-price components are :

Price factor : 67.0 % Non-price factor 33.0 %

The final breakdown between the price and non-price factors reflects the importance of the four factors, and how important price and non-price factors are to each factor. The use of these weights in the evaluation of offers is illustrated later.

It should be noted here that the hierarchy presented in Figure 1 is a very simplistic representation. Consequently, the exercise does not fully reflect the difficulty encountered in real problems. For example, the judgment ratios used in the above example cannot be obtained with such ease if they have to represent the actual practice. This exercise is only intended to illustrate the method. However, the exercise can be readily extended to address the complexity of real problems. The individual objectives can be represented in terms of its components parts as already discussed. These components should be identified to represent the actual problem. Such detail representation is always helpful in visualizing the situation and to extract meaningful judgment ratios.

3.2 The Evaluation of Proposals

The second phase of the process consists of the evaluation of the NUG offers. The procedure will use the information provided in the offers (or derived from them) to compare their relative merits. The criteria set in the first phase will be used to match these merits against the utility's requirements. The evaluation process for the simple problem in this example is illustrated in the following.

The structure of analysis is shown in Figure 2 (a) to compare the offers using their composition with respect to price and non-price factors. Similarly, the procedure can be applied to compare the offers using their relative standing against the four basic factors using the the hierarchy shown in Figure 2 (b). It may be noted that the preliminary screening, which basically checks the adherence to minimal requirements clearly stated in the RFP, seldom poses any difficulty. For example, determining whether a proposal was submitted by the specified hour or whether the proposal is accompanied by required deposits of fee, are not sources of difficulty in the evaluation process. All it requires is comparing the offers against a standard check-list. Therefore, this aspect of evaluation is not of much concern for this procedure. After these preliminary screenings, the final comparison is reduced to a few best offers. This example compares four offers A, B, C, and D.

The evaluation using price and non-price composition of the offers will require the judgment ratios comparing two offers at a time with respect to each of these factors. Let the judgment matrix comparing the four offers with respect to price factors be,

$$\begin{bmatrix} 1 & 1.2 & 1.8 & 1 \\ 1/1.2 & 1 & 1.5 & 1.2 \\ 1/1.8 & 1/1.5 & 1 & 0.8 \\ 1 & 1/1.2 & 1/0.8 & 1 \end{bmatrix}.$$

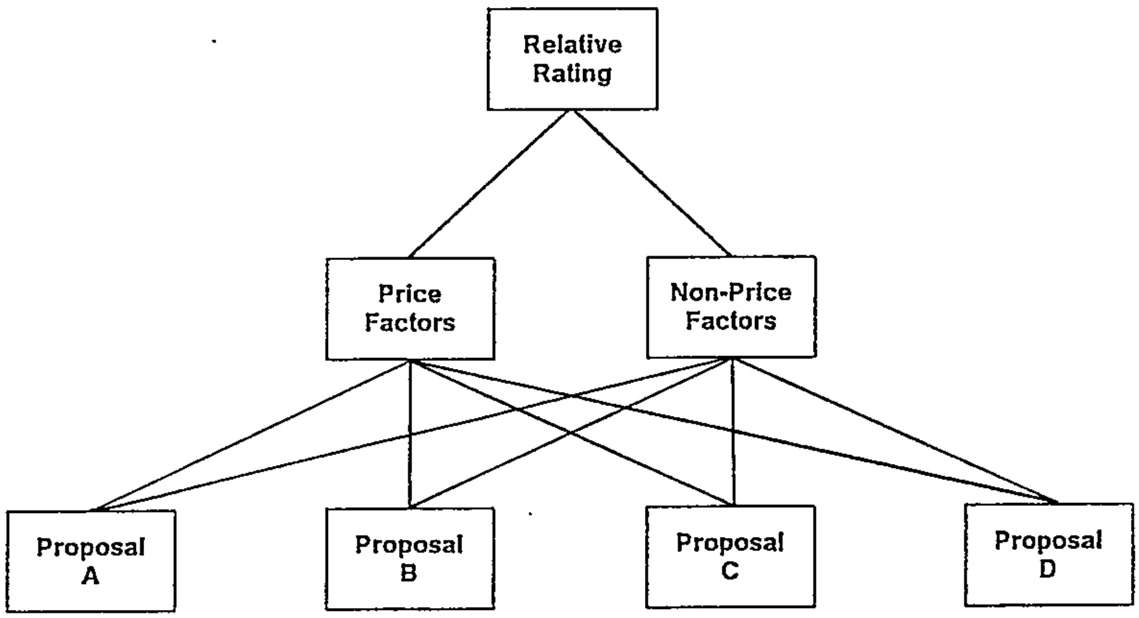

Figure 2(a). Hierarchical Structure for Evaluation of Proposals Using Price/Non-price Criteria

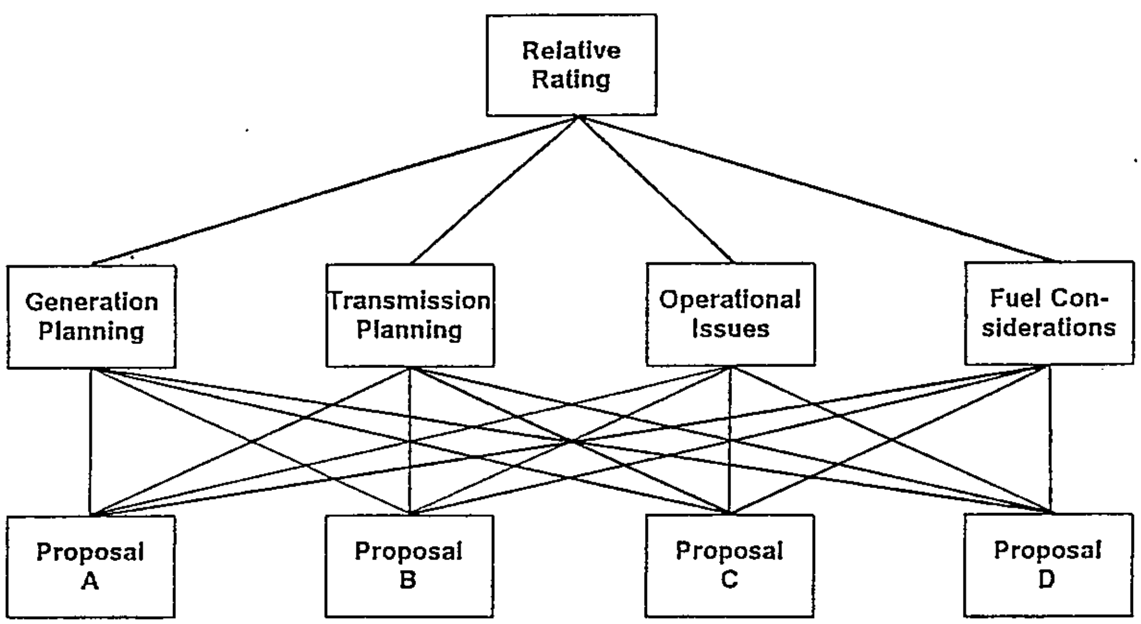

Figure 2(b). Hierarchical Structure for Evaluation of Offers Using Basic Factors Criteria

One way to generate these ratios will be to estimate the measures of total price for each offer and then take the ratios of appropriate pairs to form the ratios. Under these conditions, the judgment matrix will be consistent, as the one given above. However, it may be difficult to obtain such price measures. Then expert opinion has to be used to obtain these ratios on the basis of the information provided in the offers. Similarly, let the judgment matrix comparing the relative desirability of the four offers with respect to (wrt) non-price factor be obtained as,

$$\begin{bmatrix} 1 & 1 & 1.5 & 1.2 \\ 1 & 1 & 1.2 & 1.5 \\ 1/1.5 & 1/1.2 & 1 & 1.2 \\ 1.2 & 1/1.5 & 1/1.2 & 1 \end{bmatrix}$$

It is assumed in this illustrative example that the judgment ratios used in these matrices can be obtained from the information provided in the proposals. Rahman and Shrestha [4,5] have utilized such imprecise information in several applications. However, this important issue will have to be addressed in greater detail while applying the process to real problems. The analysis of these matrices gives the relative rating of the four offers with respect to these two factors.

$$\text{wrt price factors}: \begin{bmatrix} 0.3181 \\ 0.2850 \\ 0.1900 \\ 0.2069 \end{bmatrix} \qquad \text{wrt non-price factors}: \begin{bmatrix} 0.2485 \\ 0.2875 \\ 0.2598 \\ 0.2042 \end{bmatrix}$$

It can be observed that in terms of price factors offer A gets the highest rating while offer B get the highest rating in terms of non-price factors. These separate ratings can now be used along with the weights developed for price and non-price factors to obtain the overall ratings of the offers.

$$\begin{bmatrix} 0.3181 & 0.2485 \\ 0.2850 & 0.2875 \\ 0.1900 & 0.2598 \\ 0.2069 & 0.2042 \end{bmatrix} \times \begin{bmatrix} 0.670 \\ 0.330 \end{bmatrix} = \begin{bmatrix} 0.295 \\ 0.286 \\ 0.213 \\ 0.206 \end{bmatrix}$$

Thus, offer A is found to be the best offer in accordance with the criteria developed and the judgments used during the evaluation of this example problem. It should be noted that the ratios used in above judgment matrices may not be directly available from the offers, except in a few special situations. For example, if we are comparing the pure dollar amounts of two offers, they may be obtained as the direct ratio of their costs. However, if we are comparing a non-price factor, say, outage rates quoted in two offers, which are 2% and 3%, it remains up to the experts/decision makers to make a judgment as to how good is 2% outage rate compared to 3% outage rate in fulfilling the objectives of the RFP. Thus, though we will be using the information in the offers, we still need the judgments during the evaluation phase. The numbers used in the above judgment matrices are only for illustrations and assumed to be obtained in this fashion.

This evaluation exercise can, similarly, be carried out in the framework of Figure 2(b) using the four factors Generation Planning, Transmission Planning, Operational Issues and Fuel Considerations as the evaluation criteria along with the weights determined in section 3.1.

4.0 CONCLUDING REMARKS

The general outline of the approach has been presented to show the value of AHP technique in the evaluation process of third party generation acquisition. It provides a flexible procedural method that can be adjusted to varying conditions of individual utility company. This can be utilized to quantify the criteria for evaluations according to the requirements of the company. The success of this technique will depend, however, on the ability to collect proper input data which reflect the reality of situations. Therefore, a clear understanding of the problem and maintaining a match between the actual problem and the structure adopted to analyze it will be crucial in the application of the method. And, good understanding of the practices followed by the electric utilities, (whether explicitly defined or implicitly stated in the form of policies), is very important in obtaining the input data.

The application of the process has been illustrated considering a simple problem. The evaluation process can be elaborated by extending the hierarchies to represent more elementary factors under each basic factor. Such extensions will serve two important purposes : (i) It can represent more detail about the process, and (ii) It makes the extractions of judgment ratios more practical and realistic. The level of extension should be chosen to make optimal use of expert judgments and the information contained in the proposals.

5.0 REFERENCES

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