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Selection of Important Parameter for Financial Performance of Hydro Power Plant

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Abstract: The main aims of the present investigation identify the Most Important Factor (MIF) for feasibility of Hydro Power Plants (HPP) by a hybrid MCDM method. According to the results rate of electricity charged from industry and agriculture consumer to be the most influential parameter in financial performance of HPP.

Key words: MCDM, X-bar, HPP, financial performance, financial performance, agriculture

INTRODUCTION

According to a World Bank report hydropower is treated as the most inexpensible and reliable form of alternative energy among all the available source of renewable energy. Hydropower plants convert the potential energy of water column into the kinetic energy of the turbine which produces electricity by rotating the attached synchronisers.

The approval of any new hydropower projects always includes the evaluation of financial feasibility. This aspect of hydropower plants depends upon the recovery time of the initial investments and potential of profit from the plant. Although, the above two factors are functions of many another related parameter, identifying the most important parameters will help to optimally control the overall cost with minimum effort.

In 2016, an optimization-MCDM approach applied for fanatical performance of HPP (Majumder *et al*., 2016d). Fuzzy decision making applied for evaluation of HPP with respect to cost (Majumder *et al*., 2016a). MACBETH-GMDH approach applied for assessment of operational efficiency of HPP (Majumder *et al*., 2016c). In 2014, MCDM applied for efficiency assessment of hydroelectric power plants in Canada (Wang *et al*., 2014). Application of decision making for optimal condition method to analyze operational efficiency of HPP (Majumder *et al*., 2016b).

The main aim of the present study is identify the MIF for financial performance of HPP. For finding the rank of the parameters we use one statistical control chart namely X-bar and at the end use one MCDM method viz. DEMATEL for finding the priority value of that considering factor.

MATERIALS AND METHODS

In this study, apply one statistical namely X-bar control chart and one MCDM method viz. DEMATEL. X-bar control chart apply for find the rank of the factors. DEMATEL apply for selection of parameter. Table 1 showing the method and why use this method.

X-bar control chart: An X-bar chart is used to monitor the average value or mean, of a process over time. For each subgroup, the X-bar value is plotted. The upper and lower control limits define the range of inherent variation in the subgroup means when the process is in control. This control chart basically based on five impotent steps:

- Find the mean of each subgroup XBAR(1), XBAR(2), XBAR(3), ..., XBAR(k) and the grand mean of all subgroups using:

$$\overline{\overline{X}} = \frac{1}{k}\sum_{i=1}^{k} XBAR(i)$$

- Find the UCL and LCL using the following equations:

$$UCL = \overline{\overline{X}} + A(2)RBAR$$

$$LCL = \overline{\overline{X}} - A(2)RBAR$$

A(2) can be found in the following Table 1.

Table 1: Selection of A(2)

n	2	3	4	5	6	7	8	9
A(2)	1.880	1.023	0.729	0.577	0.483	0.419	0.373	0.337

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- Plot the LCL, UCL, centerline and subgroup means
- Interpret the data using the following guidelines to determine if the process is in control, one point outside the 3 sigma control limits:
  - Eight successive points on the same side of the centerline
  - Six successive points that increase or decrease
  - Two out of three points that are on the same side of the centerline both at a distance exceeding 2 sigma from the centerline 4 out of 5 points that are on the same side of the centerline
  - Four at a distance exceeding 1 sigma from the centerline
  - Using an Average Run Length (ARL) for determining process anomalies

Decision-making trial and evaluation laboratory: One of the multiple criteria approaches proposed by Gabus and Fontela (1972), known Decision-Making Trial and Evaluation Laboratory (DEMATEL) by which analyzing decisions only for criteria. DEMATEL method has been applied to illustrate the interrelations among criteria and to find the central criteria to represent the effectiveness of factors/aspects. In the current study, hence, utilize DEMATEL decision-making method to determine the importance weights of evaluation criteria. This decision making basically based on five impotent steps.

Generating the direct-relation matrix: Consider the number of criteria is n. Construct a direct-relation matrix by:

$$B_1 = \left[b^{(1)}_{ij}\right]_{n\times n},\ B_2 = \left[b^{(2)}_{ij}\right]_{n\times n},\ B_3 = \left[B^{(3)}_{ij}\right] n\times n, \ldots,$$
$$B_m \left[b^{(m)}_{ij}\right] n\times n \text{ such that } A = \left[a_{ij}\right] n\times n$$

where, $a_{ij} = \{b^{(1)}_{ij} + b^{(2)}_{ij} + b^{(3)}_{ij} +, \ldots, +b^{(m)}_{ij}\}/m$, $\forall i, j = 1, 2, 3, \ldots, n$ and $i \neq j$. $a_{ii} = 0$, $\forall i = j = 1, 2, 3, \ldots, n$. Also, $B_1, B_2, B_3, \ldots, B_m$ denote the m number of experts is asked to make pairwise comparisons in terms of influence between criteria by an evaluation scale showing in Table 2.

Normalizing the direct-relation matrix: For a fixed $\lambda > 0$ $\exists$ a normalized direct-relation Matrix M such that $M = \lambda A$. Here taking:

$$\lambda = \min\left\{(\max_i \sum_{j=1}^{n} a_{ij})^{-1}, (\max_j \sum_{i=1}^{n} a_{ij})^{-1}\right\}$$

Table 2: Evaluation scale for DEMATEL preferences

Verbal judgments of preference	Numerical rating
No influence	0
Low influence	1
Medium influence	2
High influence	3
High influence	4

Obtaining the total-relation matrix: Since, M is a n×n matrix then $(I-M)^{-1}$ must be exist and it is also n×n matrix. Where I is a n×n identity matrix. As M and $(I-M)^{-1}$ both are squire matrix and same order, so, $M(I-M)^{-1}$ must exist, called total-relation matrix and is denoted by $T = [t_{ij}]_{n\times n}$.

Compute the dispatcher group and receiver group: The sum of rows and the sum of columns of T are separately denoted as D and R:

$$D = \sum_{j=1}^{n} t_{ij}$$
$$R = \sum_{i=1}^{n} t_{ij}$$

The D+R value indicates the degree of importance that the corresponding criterion plays in the entire system. The factor having greater value of D+R has more interrelationships with other factors. On the other hand, criteria having positive values of D-R are on the cause group and dispatches effects to the other criteria. On the contrary, criteria having negative values of D-R are on the effect group and receive effects from the other criteria.

Set up a threshold value to obtain the causal diagram: Since, the Total-relation matrix T provides the information on how one criterion affects another, decision maker group should set up a threshold value in order to filter out some negligible relationships. This way enables the decision maker to choose only the relationships greater than the threshold value and to map the cause-effect relationship accordingly. The causal diagram can be acquired by mapping the dataset of the (D+R, D-R) where the horizontal axis D+R and the vertical axis D-R.

Methodology: The main aim of the present investigation is selection of most important factor for financial performance of HPP. The objective can be mathematically represented by Eq. 1 where MIP represents the most important parameter of financial performance of HPP:

$$MIP = f(w, P) \quad (1)$$

If P denotes the factors that affect the financial performance of HPP and w is the weight of importance of each parameter. This weight of importance is evaluated by MCDM techniques.

Use of MCDM to estimate priority value of the factors in regard to present problem: The MCDM methods comprise three steps namely:

- Selection of parameters
- Selection of ranking method
- Application of aggregation method

The next study explain the method by which criteria and alternatives were selected and the way aggregation method was applied.

Selection of criteria: Nearly 100 literatures were analysed to find out the significant factors controlling expenditure in HPP. A survey was carried out within the experts of related fields where participants were asked to suggest and rank about the cost parameters which can induce effect on the plant income. A survey was carried out within local people of the plant area where participants were asked to suggest about the cost parameters which can induce effect on the plant income. From the above surveys, it was found that rate of electricity changed from the industrial and Agricultural consumers (A), rate of electricity collected from Domestic consumer (D), civil Cost (C), energy Equipment cost (E) as well as labour and engineering cost (N) are the five most parameters which influences the overall financial performance of any HPP. Therefore:

$$P = \{A, D, C, E, N\}$$

Selection of ranking method: In this investigation criteria are selected as some Statistic Process Control (SPC) chart for finding the rank of the parameters based on its impact on the output. In this present study for finding the rank of each factor use some Statistic method. For finding the rank of sub criteria with respect to X-bar first collect some random data in (0, 1) for each criteria also corresponding priority value taken randomly in that range. Here taken the sample space is 5 and size is taken 50. In next step apply the efficiency index on this data then we get 4 sets of data corresponding to each criteria. Then apply X-bar on this index value. For finding the rank of each factor select that corresponding average weighted value in which average X-bar value is maximum index.

Application of aggregation method: In the present study, the DEMATEL method was applied for the identification of weight of importance of the criteria. A 3×3 matrix of criteria is developed to find the weight of the criteria. If B is the criteria matrix, then:

Table 3: Rank of the parameter selected by X-bar

Name of factors	Ranks
Rate of electricity collected from industrial and agricultural consumers (A)	1
Rate of electricity collected from domestic consumers (D)	2
Cost due to infrastructure development (C)	4
Cost due to energy equipment (E)	5
Cost due to the labour and engineers (N)	3

Table 4: Priority vector of each of the parameters

Criteria	D	R	D+R	D-R
A	4.8039	3.7710	8.5749	1.0328
D	4.4268	3.0900	7.5168	1.3368
C	3.0015	4.8308	7.8323	-1.8293
E	4.4004	4.0267	8.4270	0.3737
N	3.6534	4.5675	8.2210	-0.9140

$$B = \{n(P) \times n(P)\} \quad (2)$$

n(P) = Ranking of each criteria collected from Table 3 and 4.

RESULTS AND DISCUSSION

The results for this present investigation can be subdivided into one parts, viz., results of the MCDM method to estimate the weights of importance.

Result from MCDM: Table 3 shows the rank of the parameters based on X-bar method. Rate of electricity changed from the industrial and agricultural consumers was found to be the most important factor. Least important criteria were found to be rate of electricity collected from domestic consumer. Table 4 presents the weight vector of each of the parameters as found from the DEMATEL MCDM method. The direct-relation matrix:

$$A = \begin{pmatrix} 0 & 1 & 3 & 4 & 4 \\ 2 & 0 & 4 & 3 & 2 \\ 1 & 2 & 0 & 1 & 3 \\ 4 & 3 & 1 & 0 & 2 \\ 2 & 1 & 4 & 2 & 0 \end{pmatrix}$$

The dispatcher group and receiver group: Aghelie *et al.* (2016) suggested rate of electricity collected from Industrial and agricultural customer by which profitability of any HPP control.

CONCLUSION

In this study, we first find the different parameter of financial performance of HPP. For finding the rank of the parameters we use X-bar. DEMATEL for finding the priority value of that considering factor. The conclusions

drawn from the above analysis is as follows: rate of electricity collected from industrial and agricultural consumers is MIP of financial performance of HPP.

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