MULTI - CRITERIA DECISION MODEL FOR BIODIESEL SELECTION IN AN ELECTRICAL POWER GENERATOR BASED ON FAHP-GRA-TOPSIS

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Abstract

Energy has become a crucial factor for humanity to continue the economic growth and maintain high standard of living especially after the inauguration of the industrial revolution in the late 18th and early 19th century. In power generation an efficient alternative renewable sources is required to meet present power crisis. Bio fuels are one of the solutions for the power challenge. The power generation in a diesel generator depends on the fuel used in it. The selection of alternate fuel (Bio fuel) is a Multi Criteria Decision Making [MCDM] problem based on many qualitative and conflicting criteria. This paper presents a hybrid MCDM model for fuel selection. The Grey Relation Analysis integrated with Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to analyze the various criteria of each fuel and rank them. This study focuses on seven alternatives with seven evaluation criteria.

Keywords: *GRA, TOPSIS, MCDM, Bio Fuel, Power generation, Diesel power generator*

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1. INTRODUCTION

Energy is fundamental for economic and social development of the country. Due to narrow growth of world population, development in technology and improved standard of living, the average energy consumption rate has also raised. It is estimated that the demand for electric energy is projected to increase at a rate 2.3% per year i.e. from 13,290 billion kilowatt-hours (kWh) (2001)to 23,072 billion kWh (2025) [1]. The demands for energy in most of the countries are met through petrochemical sources, coal and natural gases, all these sources are limited and will be consumed shortly [2]. Nearly 80% of total primary energy depends on the fossil fuels [3].Coal is the primary source in electric power generation [4]. But combustion of coal leads to high carbon dioxide and other emissions [5].The viable solution for environmental problems by fuel emission gases is the use of renewable energy technologies [6]. Renewable energy sources are also often called alternative sources of energy, which provide energy services with almost zero emissions [7]. Bio diesel makes an ideal choice to meet the problems of energy requirement with renewable and bio degradable properties [8]. Bio diesel which is extracted from renewable biological sources, such as vegetable oils of palm, soybean, sunflower, peanut, and olive, can be used as alternative fuels for diesel engines [9]. The biodiesel produced from Jatropha and Karanj oil is blended with diesel shows an increase in the overall efficiency for the biodiesel operated generator [10]. Biodiesel derived from groundnut oil can be mixed with diesel and used in diesel engine based electrical generators without any modifications [11].When Rapeseed methyl ester used as fuel for an electric generator the emission of carbon monoxide and volatile organic carbon were reduced [12]. The emission of CO, SO_2 and C_xH_y are reduced with the mixture of B20 soybean biodiesel and also low consumption of fuel was obtained [13]. Soybean and castor oil blends shows less Specific fuel consumption in the diesel power generator when compare to diesel [14]. The rural areas of India are affected by the centralized principle of government. So to give power to all places including rural area in India allow IRPPs (Independent Rural Power Producers) may be introduced, which in turn give private sector to produce power using biofuel or biomass which will reduce power shortage in India & help in the nations growth. There are more than 350 oil crops identified as potential sources for bio diesel production [15]. Among the identified oil bearing crops the selection of opted alternative is comprehensive one. With the help of MCDM technique selection of the opted alternative could be achieved. MCDM is a branch of a general class of operation research models dealing with decision problems under the presence of multiple factors and criteria. It provides sophisticated methodological tools that are oriented towards the support of the decision makers in facing complex real-world decisions. Bioenergy systems should be considered as a multi criteria problem, it is essential that all suitable aspects are examined from a multi-criteria perspective [16]. From the literature, there is no trace of research that deals with selection of suitable fuel based on their properties for diesel power generator using MCDM technique.

2. METHOD

2.1 FAHP Method

Since Saaty T L [17] developed the AHP (analytic hierarchy process), which is a widely popular technique employed to decision-making problem based on multiple attributes. In AHP, the decision problem is structured hierarchically at different levels with each level consisting of a finite number of elements [18]. Lee S K.et al [19] applied the analytic hierarchy process (AHP) to analyze the hydrogen energy technology development in Korea. Lee S K.et al [20] used AHP in national energy planning to prioritize energy efficiency technologies. Hamalainen R P and Karjalainen R [21] utilized AHP to determine the relative weights of the evaluation criteria of Finland's energy policies. Pilavachi P A.et al [22] applied AHP methodology to choose the electrical generating technologies. Aras.H.et al [23] applied AHP to determine the most convenient location for a wind observation station. Lee A H I, Chen H H and Kang H Y [24] applied AHP to select a suitable location for wind farm project in china. Even though the AHP is used in many decision making problems but it has some limitations of its usage i.e. the ranking of AHP is not precise and cannot reflect the human thinking style Deng J L [25]. Numerical values are exact numbers that are useful only for crisp decision making applications. To deal with the indistinctness of human thought, Zadeh L A [26] introduced fuzzy set theory to express the linguistic terms in decision making process. To overcome this shortcoming the fuzzy linguistic terms are used with AHP and proposed as FAHP. (Chou T Y and Liang G S [27] have applied FAHP for shipping company performance evaluation. Chang Y H, Cheng C H and Wang T C [28] used the FAHP method to determine the weights of criteria for performance evaluation of airports. Hwang H S and Ko W H [29] presented the decision model for the best restaurant site selection using AHP and FAHP. Similarly, Lin M C.et al [30] applied FAHP approach for suitable site selection for airport. Hsieh T Y.et al [31] proposed fuzzy MCDM for choosing the optimum design model for public office building. Hwang H J and Hwang H S [32] proposed FAHP method for food service strategy evaluation process. Ayag Z and Ozdemir R G [33] evaluated machine tool alternatives by applying an intelligent approach based on FAHP. Huang C C.et al [34] presented a FAHP method for selecting government sponsored development projects. Khoram M R.et al [35] used FAHP to prioritize the methods related to reuse of treated wastewater. Khorasani M K and Bafruei O [36] developed FAHP for the selection of potential suppliers in the pharmaceutical industry. Sakthivel G.et al [37] used FAHP integrated with topsis to select the biodiesel blend. Sasirekha.et al [38] proposed FAHP-TOPSIS model for select the most appropriate network in heterogeneous wireless environment. Aydın Çelen.et al [39] utilized FAHP method in determining the relative importance of different quality indicators in electricity distribution. The procedural steps involved in FAHP method are listed below:

Step 1: A complex decision making problem is structured using a hierarchy. The FAHP initially breaks down a complex MCDM problem into a hierarchy of inter-related decision elements (criteria). With the FAHP, the criteria are arranged in a hierarchical structure similar to a family tree. A hierarchy has at least three levels: overall goal of the problem at the top, multi criteria that define criteria in the middle and decision criteria at the bottom.

Step 2: The crisp pairwise comparison matrix *A* is fuzzified using the triangular fuzzy number $M = (l, m, u)$, the l and u represent lower and upper bound range respectively that might exist in the preferences expressed by the decision maker. The TFN is shown in figure 3. The membership function of the triangular fuzzy numbers $M1$,$M3$,$M5$,$M7$, and $M9$ are used to represent the assessment from equally preferred ($M1$), moderately preferred ($M3$), strongly preferred ($M5$), very strongly preferred ($M7$), and extremely preferred ($M9$). This paper employs a TFN to express the membership functions of the aforementioned expression values on five scales.

Let $C = \{C_j | j = 1,2,\ldots,n\}$ be a set of criteria. The result of the pairwise comparison on "n" criteria can be summarized in an (n x n) evaluation matrix A in which every element a_{ij} $(i, j = 1,2,\ldots.n)$ is the quotient of the weights of the criteria, as shown:

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}, a_{ii} = 1, a_{ji} = 1/a_{ij}, a_{ij} \neq 0. \quad (1)$$

Step 3: The mathematical process is commenced to normalize and find the relative weights of each matrix. The relative weights are given by the right Eigen vector (W) corresponding to the largest Eigen value(λ_{max}), as

$$A_w = \lambda_{max}\, w\,. \quad (2)$$

It should be noted that the quality of output of FAHP is strictly related to the consistence of the pairwise comparison judgments. The consistency is defined by the relation between the entries of $A: a_{ij}$ x $a_{jk} = a_{ik}$. The Consistency Index (CI) is

$$\text{CI}=(\lambda_{max} - n)/(n-1). \quad (3)$$

Step 4: The pairwise comparison is normalized and priority vector is computed to weigh the elements of the matrix. The values in this vector sum to 1. The consistency of the subjective input in the pairwise comparison matrix can be determined by calculating a Consistency Ratio (CR). In general, a CR having a value less than 0.1 is good24. The CR for each square matrix is obtained from dividing CI values by the Random Consistency Index (RCI) values.

$$CR = CI/RCI. \quad (4)$$

The RCI which is obtained from a large number of simulations runs and varies depending upon the order of the matrix. Table VI lists the values of the RCI for matrices of order 1 to 10 obtained by approximating random indices using a sample size of 500. The acceptable CR range varies according to the size of the matrix that is 0.05 for a 3 by 3 matrix, 0.08 for a 4 by 4 matrix and 0.1 for all larger matrices having $n \geq 5$. If the value of CR is equal to, or less than that value, it implies that the evaluation within the matrix is acceptable or indicates a good level of consistency in the comparative judgments represented in that matrix. In contrast, if CR is more than the accepted value, inconsistency of judgments within that matrix has occurred and the evaluation process should therefore be reviewed, reconsidered and improved.

2.2 GRA-TOPSIS Method

The grey relational analysis, proposed by Deng [40], is a method that can measure the correlation between series and belongs to the category of the data analytic method or geometric method. The purpose of grey rational analysis technique is to measure the relation between the reference schemes. There are a few studies that applied GRA in the literature. Fu et al. evaluated the effect of environmental factors on corrosion of tubes in gas wells and found out the main factors using GRA Fu et al [41]. Lin and Lin proposed GRA for the optimization of the electrical discharge machining process with multiple performance characteristics [42]. Chen and TZeng solved the problem of choosing the best host country for an expatriate assignment using GRA [43]. Lai et al. determined the best design combination of product form elements for matching a given product image represented by a word pair using GRA [44]. Xu.et al [45] introduced the idea of GRA,and proposed a method for electrocardiogram heartbeat discrimination using GRA to quantity the frequency components among the various ECG beats . Hsu and Wang proposed GRA for forecasts integrated circuit outputs [46]. Sakthivel.et al used GRA techniques to evaluate the best automobile purchase model [47]. The TOPSIS (Technique for Older Preference by Similarity to Ideal Solution) was first developed by Hwang and Yoon. TOPSIS is relatively simple and fast, with a systematic produce [48]. It's has been proved as one of the best methods in addressing the rank reversal issue .The basic idea of TOPSIS is that the best decision should be made to be closest to ideal and farthest from the non-ideal. Such ideal and negative –ideal solution are computed by considering the other over all alternatives [49]. The positive-ideal solution is a solution that maximizes the benefit criteria and maximizes the cost criteria ,whereas the negative ideal solution maximizes the cost criteria and maximizes the cost criteria and maximizes the benefit criteria [50],[51] . Many researchers have proposed the TOPSIS to solve the Multi Criteria Decision Making Problem. Ho.et al proposed TOPSIS approaches for supplier evaluation and selection [52]. Rouhani.et al presented fussy TOPSIS for the evaluation of enterprise system [53].The procedure of GRA-TOPSIS method is as follows.

Step 1: Normalization of the evaluation matrix: This process is to transform different scales and units among various criteria into common measurable units to allow comparisons across the criteria.

$$r_{ij} = \frac{f_{ij}}{\sqrt{\sum_{j=1}^{J} f_{ij}^{2}}}, \text{ j = 1, 2, 3,.,n, i = 1,2,3,.,n} \ \ldots\ldots(5)$$

Step 2: Determination of the positive and negative ideal solutions: The positive ideal solution A^+ indicates the most preferable and the negative ideal solution A^- indicate the least preferable alternative.

$$A_i^{*} = \{A_i^{*} \ldots Ai^{*}\} = \{(\max_j A_{ij}|i\epsilon I), (\min_j A_{ij}| i\epsilon I^u)\} \quad (6)$$

$$A_i^{-} = \{A_i^{-} \ldots Ai^{-}\} = \{(\min_j A_{ij}|i\epsilon I), (\max_j A_{ij}|i\epsilon I^u)\} \quad (7)$$

Step 3 : For taking the positive and negative ideal solution as the refrential sequence and each of the alternatives to be the comparative sequence,in order to obtain the grey relation coefficient of each alternative to the ideal $r(A^+(j),A_i(j))$ and the negative ideal $r(A^-(j),A_i(j))$ solution.

$$r\,(A^+(j),A_i(j)) = \frac{\min i \min j\ |A+(j)-Ai\ (j)| + \vartheta \max i \max j\ |A+(j)-Ai\ (j)|}{|A+(j)-Ai(j)| + \vartheta \max i \max j\ |A+(j)-Ai(j)|} \text{ --------- } (8)$$

$$r\,(A^-(j),A_i(j)) = \frac{\min i \min j\ |A-(j)-Ai\ (j)| + \vartheta \max i \max j\ |A-(j)-Ai\ (j)|}{|A-(j)-Ai(j)| + \vartheta \max i \max j\ |A-(j)-Ai(j)|} \text{ --------- } (9)$$

Step 4: In order to determine the grade of grey relation of each alternative to the positive and negative ideal solutions and its calculation equations are as follows.

$$r(A^+,A_i) = \sum_{f=1}^{n} \omega_j r\,(A^+(j),A_i(j)), \text{ -----------}(10)$$

$$r(A^-,A_i) = \sum_{f=1}^{n} \omega_j r\,(A^-(j), A_i(j)), \text{ ----------}(11)$$

$$\sum_{f=1}^{n} \omega_j = 1 \text{ ----------- } (12)$$

Step 5: In order to find the relatives closeness Ci of distance that an alternative disclose to positive ideal solution which is defined as shown in table 4.

$$C_i = \frac{r\,(A^+,A^\sim)}{r\,(A^-,A^i)} \text{ ------------- } (13)$$

Step 6: Alternatives are ranked according to the value of relative closeness to each of the alternative and a greater value of Ci indicates priority of the alternatives. The weight of each criteria is calculated.

3. PROPOSED METHODOLOGY

The proposed methodology consists of three basic stages: (1) Identification of the criteria to be used in the model (2) Weight computation using FAHP (3) Ranking the alternatives using GRA-TOPSIS. In the first stage, fuel alternatives and the evaluation criteria are identified and a decision hierarchy is framed. The GRA is used for calculation of the positive and negative ideal solutions and evaluating the weights of the criteria. Fuel ranks are determined by using TOPSIS method is the third stage. TOPSIS is used to rank the alternatives with the use of observed readings and relative weights of the evaluation criteria.

3.1Criteria for selecting an Optimum fuel

The evaluation criteria for selection of optimum fuel identified through literature [54] and experts. The identified evaluation criteria are described as follows:

Density: The density of a fuel is related to fuel's energy content. For high density the potential of the fuel is greater on volume basis. The energy content of the biodiesel is low to that of diesel, but its difference reduces when compared on volumetric basis due to high density of biodiesel.

Viscosity: Viscosity of the affects the quality of atomization, combustion and engine wear. High viscosity of fuels leads to poor atomization and poor fuel injection whereas low viscous fuels lead to power loss by leakage.

Cetane Number: The ability of fuel to auto ignites quickly after being injected is measured by cetane number which is proportional to chain length of fatty acids. A high value in cetane number shortens the combustion delay

Flash Point: The flash point is defined as the lowest temperature in which the vapours of the specimen ignite when an ignition source is introduced.

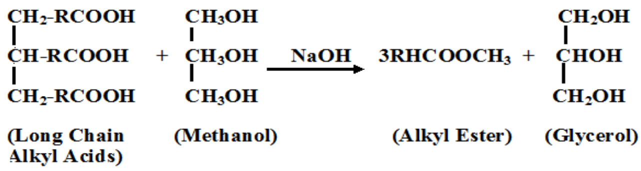
Cloud Point: The cloud point is the temperature in which a cloud of wax crystals starts to appear in a fuel when cooled. Higher cloud point can be of a problem in winter.

Pour Point: The pour point is the lowest temperature at which a fuel can flow. It has an effect over the fuel in cold condition.

Calorific Value: Caloric value is the amount of heat produced by the complete combustion of a fuel. It is used as an indicator of the energy content of the fuel.

4. TEST FUEL

The non-edible oils which are extracted from the seeds or kernals of Flax, Mahua, Jatropha, Cotton, Neem, Pongamia and MeusaFerra. The problems with crude vegetable oils are characterized by high viscosity, low volatility and polyunsaturated. These problems can be overcome by trans-esterification. Biodiesel is the main product of this process. Transesterification consists of a number of consecutive, reversible reactions [55]. The general equation for the process is shown below.



The extracted oil is passed to a container, where it is heated at a temperature 60^{o}C. Then the mixture of methanol and NaOH are added to the oil, for every 1litre of oil 150ml of methanol and 7gm of NaOH are added. The oil and the mixture are stirred for 90 minutes at a constant speed of 750 rpm. Then the content is left undisturbed for about 30 minutes. Now the glycerol gets settled at the bottom and the biodiesel makes the top layer. The biodiesel is separated and moved in another container for washing. Washing of biodiesel is characterized by 4 washes, first in hot water with 150ml of acetic acid at 50^{o}C and second by hot water with 75ml of acetic acid at 50^{o}C and the next two washes are with 50^{o}C hot water. The washed fuel is heated at 110^{o}C to remove the moisture in it. The various properties of each biodiesel are listed in table 1.

Table 1: Fuel Properties

	Pongamia	Jatroba	Cotton	Neem	Linseed	Mahua	Meusaferra
Calorific value KJ/Kg	10677.63	9799	9417.69	9528.46	8905.2	9420.52	10093.21
Viscosity mm^2/sec	5.07	4.92	4.58	5.21	4.863	4.94	6.2
Density Kg/m^3	928	878	878.6	839	910	920	890
Cetane number	65	51.8	52.6	46	54	51	54
Flash ^{0}C	210	170	204	76	155	131	112
Cloud ^{0}C	3.5	8	14	18	-3.6	4	16
Pour ^{0}C	-3	-2	5	2	-9	7	3

5. COMPUTATION

5.1 Computation of Criteria Weights using FAHP

The decision hierarchy diagram is formed using the evaluation criteria and the alternate biodiesel are shown in the fig.1. There are three levels in the decision hierarchy structure. The selection of optimum fuel, i.e. the overall goal of the decision process is the first level of the hierarchy, the criteria are at the second level and the alternate biodiesels are at the third level of the hierarchy. Then the individual pairwise comparison matrix is formed using crisp scale and triangular fuzzy scale from tables 2& 3. The pairwise comparison matrix of the evaluation criteria are tabulated in table 4. Based on the values of the final comparison matrix the individual weights, CI and CR are evaluated by using RCI values which are tabulated in table 5. The calculated CI, CR and weights of the criteria for FAHP are tabulated in Table 6.

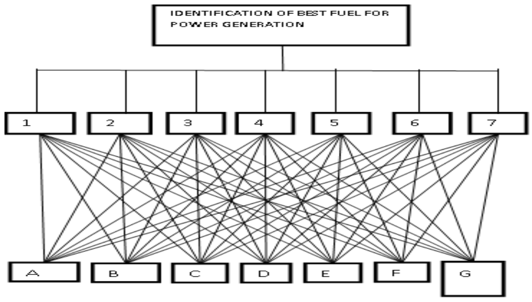


Fig 1 Decision hierarchy of fuel selection

Where the fig 1 denotes are,

1.	Calorific Value	A. Pongamia
2.	Viscosity	B. Jatroba
3.	Density	C. Cotton
4.	Cetane Number	D. Neem
5.	Fire Point	E.Linseed
6.	Flash Point	F. Mahua
7.	Pour Point	G. Meusa ferra

Table 2: Pair-Wise Comparison Scale

Scale of importance	Crisp score	Reciprocal of crisp score
Equal importance	1	1.00
Moderate	3	0.33
Strong importance	5	0.20
Very strong importance	7	0.14
Extremely preferred	9	0.11

Table 3: Membership function of Fuzzy numbers

Scale of Importance	Triangular Fuzzy Number (TFN) (L, M, U)	Reciprocal of TFN (1/L, 1/M, 1/U)
Just equal	(1, 1, 1)	(1, 1, 1)
Equal importance	(1, 1, 3)	(0.33, 1, 1)
Moderate	(1, 3, 5)	(0.20, 0.33, 1)
Strong importance	(3, 5, 7)	(0.14, 0.20, 0.33)
Very strong importance	(5, 7, 9)	(0.11, 0.14, 0.20)
Extremely preferred	(7, 9, 9)	(0.11, 0.11, 0.14)

Table 4: Pairwise comparison matrix

	Calorific	Viscosity	Density	Cetane	Flash	Fire	Pour
Calorific	1	3	5	5	7	7	9
Viscosity	0.333	1	3	5	7	7	9
Density	0.2	0.333	1	3	5	5	7
Cetane	0.2	0.2	0.333	1	3	3	7
Flash	0.142	0.142	0.2	0.333	1	3	7
Fire	0.142	0.142	0.2	0.333	0.333	1	5
Pour	0.111	0.111	0.142	0.142	0.142	0.2	1

Table 5: Random Consistency Index (RCI)

No	1	2	3	4	5	6	7	8	9	10
RCI	0	0	0.5	0.9	1.1	1.25	1.35	1.4	1.45	1.49

Table 6: Crisp Weights of FAHP

	AHP Crisp Weights	
C1	0.3426	CI=0.11201 RI=1.35 CR=CI/RI=0.08297
C2	0.2610	
C3	0.1614	
C4	0.1064	
C5	0.0603	
C6	0.0472	
C7	0.0211	
Sum	1	

5.2 GRA-TOPSIS Computations

The normalized matrix is computed using the equation 5 and tabulated in table7. The positive and negative ideal solutions are calculated using equation 6,7 and shown in table 8.Then the positive ideal $r(A^+(j),A_i(j))$ and the negative ideal $r(A^-(j),A_i(j))$ solution using equation 8,9 and tabulated in table 9. The weight of the criteria is calculated using the ideal solution. The relative closeness is then calculated for both positive and negative solution. The closeness coefficient value of C_i is obtained using the equation 13 and tabulated in 10.

Table 7: Normalized decision matrix (rij)

	Pongamia	Jatroba	Caster	Neem	Linseed	Mahua	Meusa
Calorific Value	0.9960	0.9958	0.9954	0.9961	0.9947	0.9952	0.9961
Viscosity	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0006
Density	0.0866	0.0892	0.0929	0.0877	0.1016	0.0972	0.0878
Cetane Number	0.0061	0.0053	0.0056	0.0048	0.0060	0.0054	0.0053
Flash *Point*	0.0196	0.0173	0.0216	0.0079	0.0173	0.0138	0.0111
Cloud Point	0.0003	0.0008	0.0015	0.0019	-0.0004	0.0004	0.0016

Pour Point	-0.0003	-0.0002	0.0005	0.0002	-0.0010	0.0007	0.0003

Table 8: Max & Min values for alternatives

Alternatives	MAX		MIN	
	A^+- A	A- A^-	A^+- A	A- A^-
Pongamia	0.0151	0	0.0020	0
Jatropha	0.0124	0.0001	0.0043	2.7065
Cotton Seed	0.0136	0.0001	0.0063	0
Neem	0.0139	0	0.0136	-0.001
LinSeed	0.0094	0	0.0151	0
Mahua	0.0059	0	0.0106	-4.890
MeusaFerra	0.0138	0	0.0105	0.0001

Table 9: Crisp Weights of GRAY-TOPSIS

Criteria	Weights	λ	MaxMax		MinMin	
			A^+- A	A- A^-	A^+- A	A- A^-
Calorific Value	0.3426	0.5	0.015	0.015	0	-0.001
Viscosity	0.2610					
Density	0.1614					
Cetane Number	0.1064					
Flash Point	0.0603					
Cloud Point	0.0472					
Pour Point	0.0211					

6. RESULTS AND DISCUSSION

The results of proposed methodology are tabulated in Table 10. The ranking of fuels are Pongamia> LinSeed> Mahua>Neem>Jatropha> Cotton >Meusaferra placed in an ascending order based on closeness coefficient of alternatives. The alternate fuel Pongamia which has the highest performance value is selected as the best fuel using GRA-TOPSIS methodology. In addition, the strength of the proposed decision making approach is to eliminate the uncertainty and vagueness during the pairwise comparison process using fuzzy set theory.

Table 10: Results obtained with FAHP-GRAY-TOPSIS

Alternatives	GRAY-TOPSIS	
	Performance	Rank
Pongamia	1.0263	1
Jatropha	0.9682	5
Cotton Seed	0.9570	6
Neem	0.9741	4
LinSeed	1.0154	2
Mahua	1.0131	3
MeusaFerra	0.9370	7

7. CONCLUSIONS

In this paper, a decision making model is proposed for evaluating the fuel alternatives and select the best for power generation based on various conflicting criteria. The selection of optimum fuel plays an imperative role for biodiesel in diesel generator. The process of fuel selection is based on qualitative criteria. The proposed model, the GRA is integrated with TOPSIS. The TOPSIS is used to determine the priorities of alternatives. The ranking method helps the customer identify the appropriate fuel. The research work can be extended with application of other MCDM techniques such as ELECTRE, VIKOR and PROMETHEE.

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