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Hybrid Algorithm of Mathematical Programming for Evaluation of Gasoline Substitutes

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Keywords

Renewable Energy,
Gasoline,
Sustainability,
Biodiesel,
Alternative fuel,
Mathematical modeling.

Abstract

The aim of this paper is to select the most feasible oxygenates and alcohols for fuel manufacturing through the use of a quantitative approach enabling multi-factor decision making procedure and mathematical modeling. Among oxygenates and alcohols, the problem of selecting the most proper one is evaluated, using numerous properties of gasoline substitutes and their related sub-properties. Two separate quantitative techniques are used within the framework of a proposed hybrid algorithm. The first technique applied is the multi-factor evaluation method where each property is appointed a relative weight based on expert evaluations. The second applied method is mathematical modeling where the problem is modeled using integer programming. The objective of the problem is designed as a function to calculate the total absolute difference between the values of gasoline and those of alternatives for each property. Thus, the model tries to find the alternative that minimizes the objective function. The proposed algorithm is a comprehensive decision analysis technique because it considers the significance of each property and incoherence in the rankings are confirmed. The results indicate that the proposed mathematical model enables more advanced choices as it considers the relative weights of the properties. The application of the proposed method and the conclusions of this paper supply an idea on how this method can be performed as a decision-making tool in alcohol and cellulose-derived oxygenates selection as substitutes for gasoline.

1. Introduction

The diesel, kerosene and gasoline that are purified from petroleum-based oil are utilized as fuel for automobile industry [1]. Among these fuels, gasoline has been the choice of world to power vehicles since 1990 [2]. By energy sources, the energy consumption [3] and major fuel manufacturing regions [4] in the world are shown in Figure 1. World fuel demand growth by manufacture and crude demand by region (b) are displayed in Figure 2 [5].

Biomass-derived bio-fuel is a sustainable, renewable and clean energy that is thought to be a potential replacement for traditional automotive fuels (diesel and gasoline) [6, 7]. Rising request from the automotive sector along with environmental laws has encouraged the gasoline fuel's development from vegetable-based resources to substitute traditional automotive fuels. The matters arising from heat-trapping gas emissions and a confined petroleum-based fuel source support research efforts to investigate alternative fuels from sustainable-renewable resources [8, 9]. The bio-based fuels, which are produced from vegetal sources, are obtained in several types of forms, involving alcohols. By many researchers, alcohols, primarily methanol and ethanol, have been considered as optional fuels for internal combustion engines [10–14]. The methanol can also be made from bio-based materials as well as from petroleum-based fuels or coal. By agricultural residues' alcoholic fermentation, the ethanol, which is a bio-based renewable-sustainable fuel (bio-ethanol), is made [15–18]. Due to their high octane numbers, methanol and ethanol are efficient spark-ignition engine fuels. Researches on the utilization of methanol and ethanol in internal combustion gasoline engines, with the principle goal of improving engine effectiveness and emission reduction have been indicated in various articles [19-24]. Generally, the publications displayed an important boost on engine effectiveness and a

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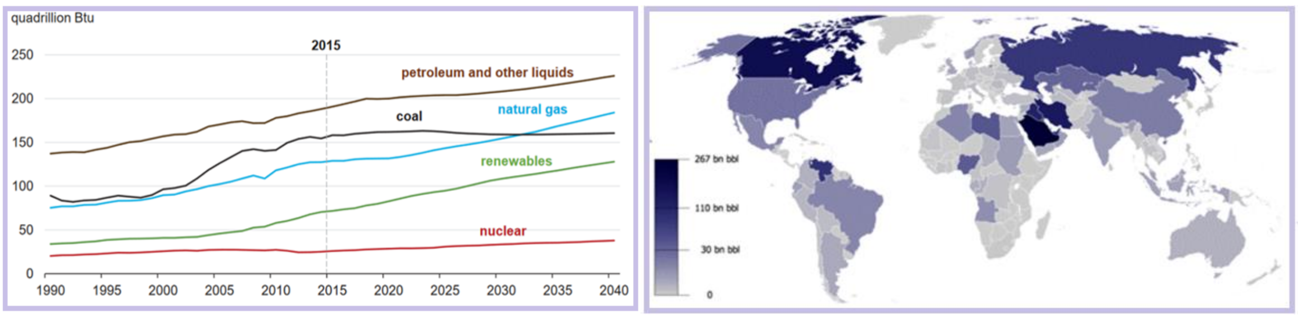
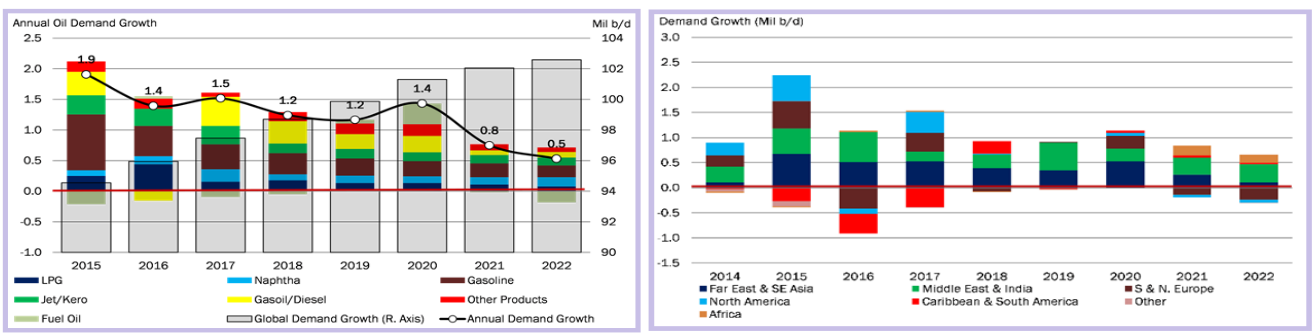
decrease in alcohol blended fuels' pollutant emissions compared to gasoline. The butanol is considered as a clean energy source in spark-ignition engines that can be commonly implemented by blending with gasoline and utilized as a clean fuel [25–29]. The butanol's chemical structure supplies several benefits, compared to methanol and ethanol by its lower vapor pressure that decreases the vapor lock's chance. It has high fuel economy because of its higher energy intensity, it has a skill to utilize current gasoline delivery system, and it can be mixed with gasoline at higher densities without retrofitting vehicles. [30–32]. The butanol chemical structure is formed in four diverse isomers, namely n-butanol (normal butanol or 1-butanol), s-butanol (secondary butanol or 2-butanol), i-butanol (iso-butanol) and t-butanol (tertiary butanol). Even so, it was noted that the utilization of t-butanol and s-butanol as near future bio-fuels is unclear since an encouraging undertake for their generation has not yet been constituted [33]. Compared with t-butanol and s-butanol, diverse methodologies for increasing the generations of n-butanol and iso-butanol are presented lately [34–39]. Researches on the utilization of iso-butanol and n-butanol in internal combustion engines, with the fundamental considerations of pollutant emissions and increasing performance of engines, have been obtained in a number of articles.



(a) (b)

Figure 1. By energy sources, global energy consumption (a) and major fuel manufacturing regions (b)



(a) (b)

Figure 2. World fuel demand growth by manufacture (a) and crude demand by region (b)

Martin reported decreases in HC, NOx, CO_2, and CO emissions and increase in engine energy at utilizing 10 % normal butanol in gasoline fuel [40]. Deng et al. examined normal butanol–gasoline mixtures with 35 % normal butanol and displayed that with the normal butanol extra hydrocarbons and carbon monoxide, gas emissions diminished and internal combustion engine effectiveness was fixed [41]. By adding normal butanol to gasoline, Williams et al. argued that thermal performance, fuel combustion performance and pollutant emissions were not affected [42]. By volume, Yang et al. examined performance and emissions of normal butanol–gasoline mixtures, utilizing 35–10% normal butanol [43].

In this paper, the comparative assessment of oxygenates and alcohols is provided. The aim of this paper is to select the most feasible oxygenates and alcohols for fuel manufacturing through the use of a quantitative approach enabling multi-factor decision making procedure and mathematical modeling. Among oxygenates and alcohols, the problem of selecting the most proper one is evaluated, using numerous main factor related sub-properties. Use of hybrid algorithms for multi-factor problems has wide range of applications in the literature [44-45].

This study involves physicochemical properties of the selected alcohol and cellulose-derived oxygenates. The properties are lower heating value, latent heat of vaporization, lower and upper flammability limits, vapor pressure, reid vapor pressure, auto ignition temperature, flash point closed cup, boiling and melting points, RON, MON, viscosity, specific gravity, solubility of water in compound, and solubility of compound in water. 9 different alcohols and 7 cellulose-derived oxygenates are compared using multi-factor analysis and mathematical modeling.

Based on the nature of variables and the limitation, the problem is designed as an integer problem. Thus, integer programming approach was used for the solution of optimization problem. When a model includes integer, binary or all different constraints, it is called an integer programming problem. Integer constraints make a model non-convex, and finding the optimal solution to an integer programming problem is equivalent to solving a global optimization problem. Such problems may require far more computing time than the same problem without the integer constraints. Since nonlinear solution method is used, a *Branch and Bound* method is applied for the integer constraints.

2-Hybrid Algorithm

The method uses a tree diagram of nodes and branches to organize the solution partitioning. This is an intelligent search procedure for either an optimal or a good-enough approximation to the optimal solution to all-integer of mixed-integer problems. Figure 3 presents the tree representation of the algorithm.

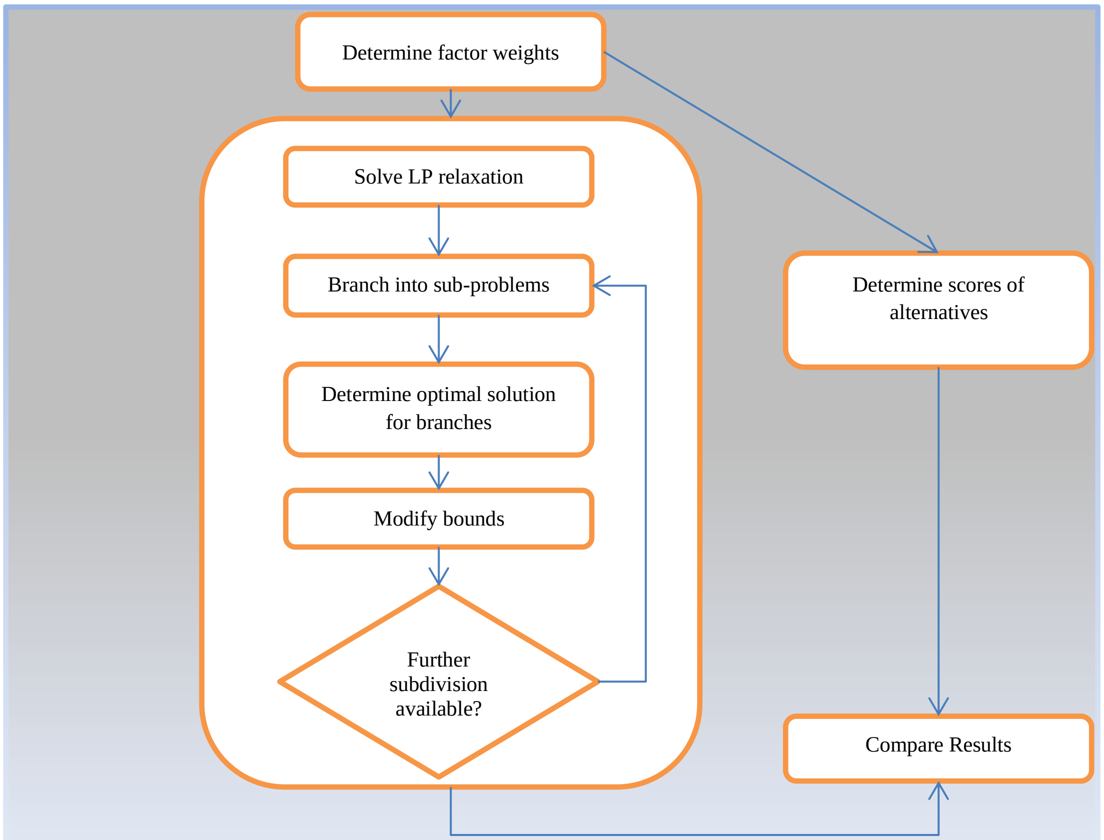


Figure 3. Hybrid Algorithm

In this model for biodiesel production, all decision variables are integer, thus resulting in an all-integer problem. The steps of the algorithm can be summarized as follows:

1- Apply multi-factor analysis to obtain factor weights.
  1a. Calculate factor weights through pairwise comparison of the factors using expert opinions.
  1b. Calculate scores of the alternatives through pairwise comparison of the alternatives using factor weights obtained in previous step.

2- Apply branch and bound algorithm to solve the integer programming problem.
  2a. Solve the LP relaxation of the mathematical model which means treating the problem as a Linear Problem. If the optimal LP solution is integer, it is optimal for the Integer Problem (IP).
  2b. Divide the problem into two or more sub-problems (branching) that divides the feasible area into regions that removes the current LP optimal solution from the new feasible region. An upper bound (UB) and a lower bound (LB) on the value of the objective function is set.
  2c. Start branching from the variable with the greatest fractional part. The variable is branched out to

include only values greater than the integer above and less than the integer value below the optimal LP solution. The branches represent additional constraints to the original problem.

2d. The optimal solution for each branch is determined. Sub-problems whose objective function is worse than the established feasible bounds are eliminated from further consideration.

2e. The remaining sub-problems are used to modify the bounds, then subdivided and investigated

2f. This process is repeated until no further subdivision is possible, at which point the optimal solution has been reached.

3- Compare the results obtained from multi-factor analysis and mathematical modeling.

2.1. Multi-Criteria Evaluation Method

In a method for choosing the best alternative among others, the goal would be to choose the most appropriate alternative that satisfies various types of factors. A large set of 16 factors are considered within this research. 9 different alcohols and 8 cellulose-derived oxygenates are compared with the same properties of gasoline using the proposed technique.

While measurements for some factors are readily available, some others can only be estimated with respect to other variables. As it is the case in all multi-factor decision making methods, the relative weights of such factors need to be determined. This is accomplished by pairwise comparison of the factors. Below are the resulting priorities of related factors shown in Figure 4.

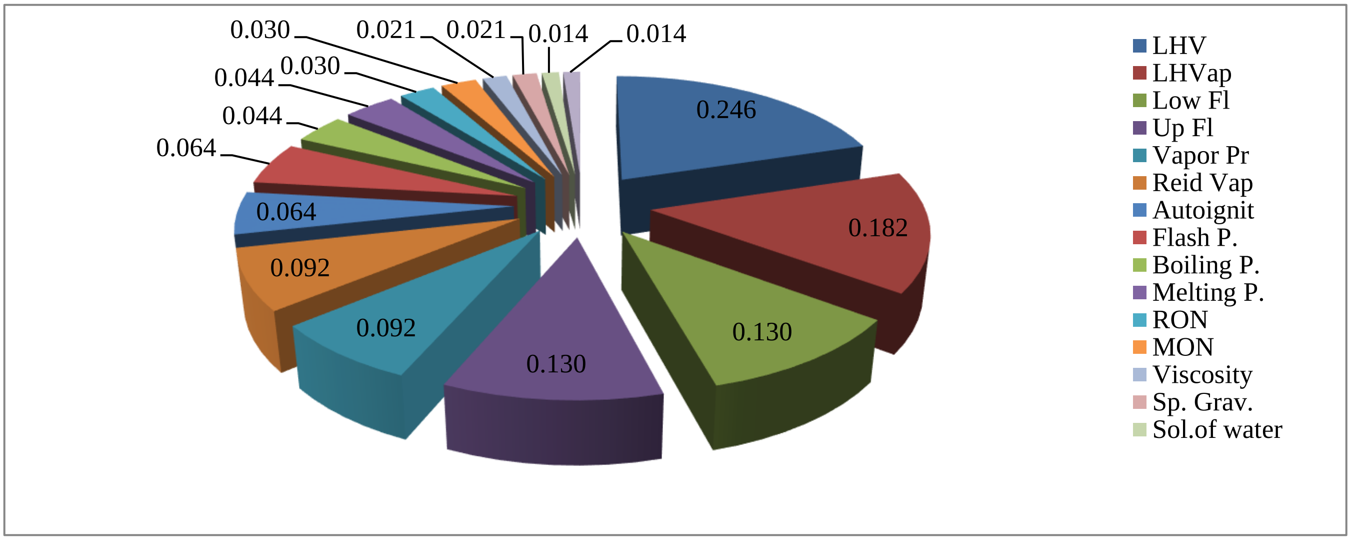


Figure 4. Factor priorities

All these elements are compared as to how significant impact they have on the overall goal.

2.1. Pairwise Comparison of the Alternatives with Respect to the Factors

After determining the priorities of each factor in regard to the objective, pairwise comparison of the alternatives with respect to each factor will also determine the best alternative based on the multi-factor analysis alone. Chemical and physical properties of gasoline and 9 different alternatives determined for the purpose of this investigation are presented in Table 1.

While gasoline and diesel are mixtures of a variety of compounds and thus can exhibit a range of properties, many of those properties are limited by federal regulation and ASTM specifications. In contrast, alcohols are singular compounds with specific chemical properties. Note that the properties of various isomers with the same chemical formula may differ significantly.

The next step in applying the technique is two by tw comparisons of the alternatives with respect to each factc

In order to design an objective scheme for this purpose, the maximum and minimum values of the alternatives for each factor is determined. This range is divided into nine even ranges since the method requires pairwise comparisons on a scale from 1 to 9. Finally, each alternative is placed in one of these ranges based on their values to compare them with each other.

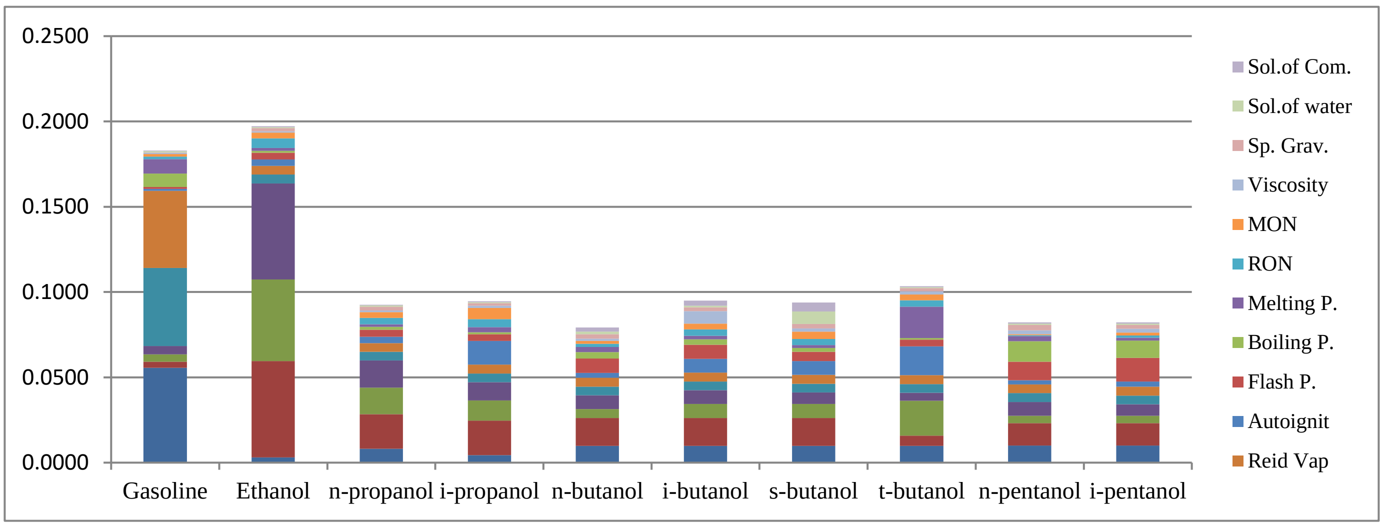
Based on the calculations above, the relative priorities corresponding to the attractiveness of each alcohol alternative about all factors are presented in Figure 5 below.

The obtained results from the multi-factor analysis indicate that the *ethanol* with a global priority of 0.1971 is the option that obtains the closest score to the one of Gasoline based on all the criteria selected while *t-butanol* is ranked second.

The properties of the biofuels are listed in Table 2. These data were compiled from a wide range of reference sources. The source of each value is listed below the table and should be considered prior to applying these values.

Table 1. Chemical and Physical Properties of Gasoline and Alcohols

Compound	Gasoline	Ethanol	n-Propanol	i-Propanol	n-Butanol	i-Butanol	s-Butanol	t-Butanol	n-Pentanol	i-Pentanol
CAS Number		64-17-5	71-23-8	67-63-0	71-36-3	78-83-1	78-92-2	75-65-0	71-41-0	125-51-3
Formula		C_2H_6O	C_3H_8O	C_3H_8O	$C_4H_{10}O$	$C_4H_{10}O$	$C_4H_{10}O$	$C_4H_{10}O$	$C_5H_{12}O$	$C_5H_{12}O$
Lower heating value (MJ/kg)	41–44	26.8	30.7	30.4	33.2	33.1	32.9	32.7	34.8	35.4
Latent heat of vaporization (kJ/kg)	352	919.6	792.1	756.6	707.9	686.4	671.1	527.2	647.1	617.1
Lower flammability limit (%)	1.4	3.28	2.13	2.02	1.45	1.68	1.7	2.4	1.2	1.2
Upper Flammability limit (%)	7.6	18.95	13.50	11.80	11.25	10.9	9.0	8.0	10.5	9
Vapor pressure at 20°C (kPa)	50–100	5.8	2	4.4	0.58	1.2	1.7	4	0.6	0.4
Reid Vapor Pressure, (kPa)	54–103	16.0	6.2	12.4	2.2	3.3	5.3	12.2	0.83	1.0
Autoignition temp (°C)	257	363	371	456	343	415	405	478	320	350
Flash point closed cup (°C)	-43	13	15	12	29	28	24	11	43	45
Boiling point (°C)	27–225	78	97.2	82.3	117.7	107.9	99.6	82.4	137.8	132
Melting point (°C)	-40	-114	-126.2	-88.5	-89.3	-108	-114.7	26	-78.2	-117
RON	88-98	109	104*	106	98*	105*	105*	105	(78)	(94)
MON	80-88	90	89*	99	85*	90*	93*	89	(74)	(84)
Viscosity 20°C (cSt)	0.37–0.44	1.5	2.7	3.1	3.6	8.3	4.7	4.2	5	5
Specific gravity, 20°C	0.69–0.79	0.794	0.804	0.789	0.810	0.802	0.808	0.791	0.816	0.8



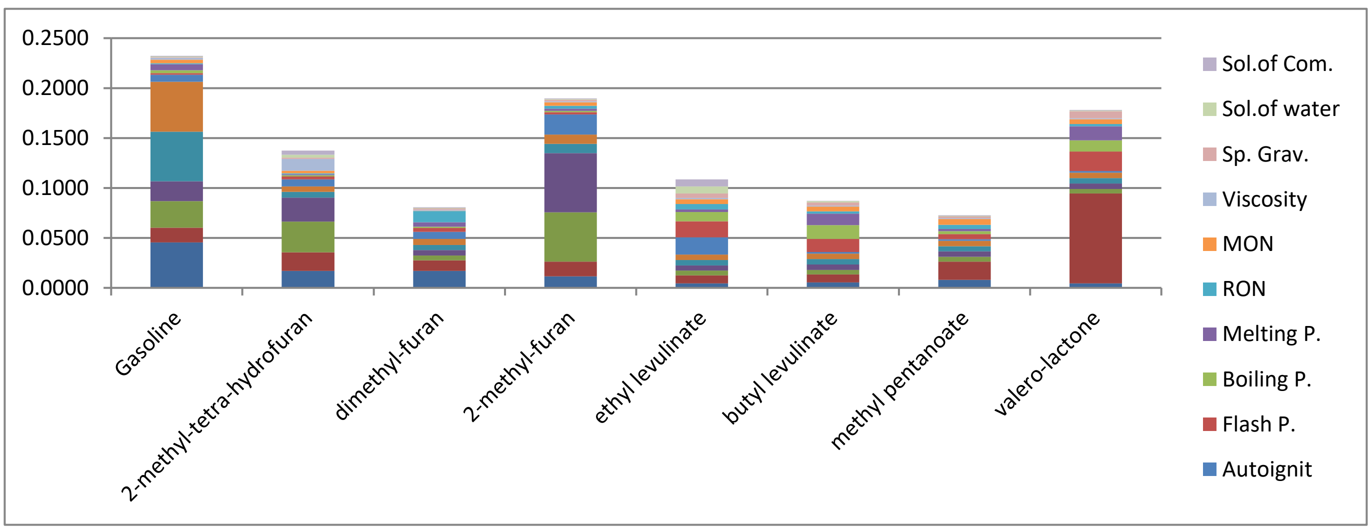
	Gasoline	Ethanol	n-propanol	i-propanol	n-butanol	i-butanol	s-butanol	t-butanol	n-pentanol	i-pentanol
LHV	0,0555	0,0030	0,0081	0,0044	0,0099	0,0099	0,0099	0,0099	0,0100	0,0100
LHVap	0,0036	0,0566	0,0203	0,0203	0,0163	0,0163	0,0163	0,0060	0,0131	0,0131
Low Fl	0,0044	0,0477	0,0155	0,0118	0,0052	0,0082	0,0082	0,0203	0,0044	0,0044
Up Fl	0,0048	0,0564	0,0160	0,0107	0,0081	0,0081	0,0067	0,0048	0,0081	0,0067
Vapor Pr	0,0458	0,0051	0,0051	0,0051	0,0051	0,0051	0,0051	0,0051	0,0051	0,0051
Reid Vap	0,0452	0,0052	0,0051	0,0052	0,0051	0,0051	0,0051	0,0052	0,0051	0,0051
Autoignit	0,0011	0,0038	0,0038	0,0139	0,0030	0,0081	0,0081	0,0168	0,0024	0,0030
Flash P.	0,0012	0,0040	0,0040	0,0040	0,0083	0,0083	0,0055	0,0040	0,0110	0,0139
Boiling P.	0,0079	0,0011	0,0017	0,0011	0,0039	0,0031	0,0023	0,0011	0,0119	0,0102
Melting P.	0,0084	0,0016	0,0016	0,0029	0,0029	0,0022	0,0016	0,0184	0,0029	0,0016
RON	0,0014	0,0056	0,0037	0,0048	0,0018	0,0037	0,0037	0,0037	0,0005	0,0014
MON	0,0016	0,0034	0,0034	0,0066	0,0016	0,0034	0,0043	0,0034	0,0007	0,0016
Viscosity	0,0007	0,0008	0,0010	0,0014	0,0014	0,0072	0,0018	0,0018	0,0023	0,0023
Sp. Grav.	0,0003	0,0018	0,0022	0,0014	0,0027	0,0022	0,0027	0,0018	0,0032	0,0022
Sol.of water	0,0006	0,0006	0,0006	0,0006	0,0014	0,0010	0,0072	0,0006	0,0008	0,0008
Sol.of Com.	0,0005	0,0005	0,0005	0,0005	0,0024	0,0030	0,0054	0,0005	0,0006	0,0006
Total	0,1830	0,1971	0,0926	0,0946	0,0791	0,0950	0,0939	0,1033	0,0822	0,0822

Figure 5. Scores of Alcohol Alternatives

Table 2. Chemical and Physical Properties of Biofuels Compared to Gasoline

Compound	Gasoline	MTHF 2-Methyl- tetra-hydrofuran	DMF imethyl- furan	MF 2-Methyl-furan	EL Ethyl Levulinate	BL Butyl Levulinate	MP Methyl Pentanoate	GVL g-Valero-lactone
CAS Number		96-47-9	625-86-5	534-22-5	539-88-8	2052-15-5	624-24-8	108-29-2
Formula		$C_5H_{10}O$	C_6H_8O	C_5H_6O	$C_7H_{12}O_3$	$C_9H_{16}O_3$	$C_6H_{12}O_2$	$C_5H_8O_2$
Lower heating value (MJ/kg)	41–44	32.8	33.8	*31.2*	24.3	27.4	*28.6*	*24.2*
Latent heat of vaporization (kJ/kg)	352	375.3	330.5	358.4	306.7	277.5	371.5	543.9
Lower flammability limit	1.4%	1.5%	--	1.9%	--	--	--	--
Upper flammability limit	7.6%	8.9%	--	14%	--	--	--	--
Vapor pressure at 20 °C (kPa)	50–100	13.6	--	18.5	0.01 @ 17°C	--	1 @ 19°C	--
Reid Vapor Pressure, (kPa)	54–103	--	13.4	18.5	2.1	--	4.0	--
Autoignition temp (°C)	257	270	286	450	425	--	--	--
Flash point closed cup (°C)	-43	-11	16	-22	90	79	22	96
Boiling point (°C)	27–225	78	94	64.7	206	237.5	126	218–220
Melting point (°C)	-40	-136	-63	-91	<-82	-22.6	-91	-12.5
RON	88–98	86	119	103	110	(98)	(105)	100
MON	80-88	73	--	86	102	(96)	(105)	100
Viscosity 20°C (cSt)	0.37–0.44	1.52	--					
Specific gravity (20°C)	0.69–0.79	0.855	0.8883	0.9132	1.0111	0.9735	0.8947	1.0794

The relative priorities corresponding to the attractiveness of each cellulose-derived oxygenates alternative about all factors are presented in Figure 6 below. The obtained results in Figure 6 indicate that the *valero-lactone* with a global priority of 0.1782 is the option that obtains the closest score to the one of gasoline based on all the factors selected.



	Gasoline	2-methyl-tetra-hydrofuran	dimethyl-furan	2-methyl-furan	ethyl levulinate	butyl levulinate	methyl pentanoate	valero-lactone
LHV	0,0454	0,0171	0,0171	0,0116	0,0046	0,0056	0,0079	0,0046
LHVap	0,0147	0,0184	0,0104	0,0147	0,0078	0,0078	0,0184	0,0898
Low Fl	0,0266	0,0308	0,0047	0,0492	0,0047	0,0047	0,0047	0,0047
Up Fl	0,0201	0,0240	0,0054	0,0592	0,0054	0,0054	0,0054	0,0054
Vapor Pr	0,0497	0,0059	0,0053	0,0094	0,0053	0,0053	0,0053	0,0053
Reid Vap	0,0497	0,0053	0,0059	0,0094	0,0053	0,0053	0,0053	0,0053
Autoignit	0,0071	0,0071	0,0071	0,0202	0,0172	0,0017	0,0017	0,0017
Flash P.	0,0017	0,0028	0,0037	0,0021	0,0161	0,0131	0,0049	0,0195
Boiling P.	0,0029	0,0013	0,0014	0,0013	0,0094	0,0137	0,0029	0,0114
Melting P.	0,0060	0,0010	0,0046	0,0024	0,0024	0,0116	0,0024	0,0138
RON	0,0012	0,0010	0,0109	0,0028	0,0057	0,0023	0,0040	0,0023
MON	0,0035	0,0025	0,0004	0,0035	0,0048	0,0048	0,0058	0,0048
Viscosity	0,0019	0,0120	0,0011	0,0011	0,0011	0,0011	0,0011	0,0011
Sp. Grav.	0,0005	0,0012	0,0012	0,0015	0,0044	0,0031	0,0015	0,0071
Sol.of water	0,0007	0,0027	0,0007	0,0007	0,0072	0,0012	0,0007	0,0007
Sol.of Com.	0,0005	0,0043	0,0005	0,0005	0,0070	0,0005	0,0005	0,0005
Total	0,2322	0,1375	0,0807	0,1897	0,1086	0,0872	0,0726	0,1782

Figure 6. Scores of cellulose-derived oxygenates Alternatives

2.2. Mathematical Modeling Algorithm

$$\min Z = \frac{\sum_i \sum_j \left| G_j - C_{ij} \right| * w_j x_i}{\left| G_j \right|} \quad (1)$$

$subject\ to$:

$$\sum_i x_i = 1 \quad (2)$$

$$\forall x_i = \{0,1\} \quad (3)$$

where;

G_j: j^th factor value of gasoline

C_{ij}: j^th factor value of i^th alternative

x_i: solution value i^th lubricant

The objective function (Eq. (1)) of the model aims to minimize the total absolute difference between the reference value of gasoline for a given factor and the value of an alternative for the same factor. The function calculates the total absolute differences throughout the factors as defined by the cost parameter $G_j - C_{ij}$. Absolute differences of each alternative for each factor are divided by the absolute value of gasoline for each factor. Finally, the resulting value is multiplied by the factor weight obtained from the multi-factor analysis. The variable for each alternative is represented by X_i, where *i* is the alternative number.

The first constraint (Eq. (2)) ensures that only one the best alternative is chosen by the model. The last constraint (Eq. (3)) forces the model to assign only binary values to the variables.

First, nine different alcohols are evaluated through the application of branch and bound algorithm. As opposed to the multi-factor analysis which determined ethanol as the best alternative to gasoline, the obtained results from the hybrid model indicate that the *t-butanol* is the option that contributes the most to the goal of selection the best alternative that satisfies all the factors selected (Table 3).

Table 3. Solution of the Mathematical Model

	Ethanol	n-propanol	i-propanol	n-butanol	i-butanol	s-butanol	t-butanol	n-pentanol	i-pentanol
Z =	1.2141	1.0116	0.9497	402.9823	416.2854	1049.7086	0.8635	186.0250	178.7898
LHV	0,0928	0,0704	0,0722	0,0561	0,0567	0,0578	0,0590	0,0470	0,0435
LHVap	0,2933	0,2274	0,2090	0,1839	0,1728	0,1649	0,0905	0,1525	0,1370
Low Fl	0,1750	0,0679	0,0577	0,0047	0,0261	0,0279	0,0931	0,0186	0,0186
Up Fl	0,1946	0,1011	0,0720	0,0626	0,0566	0,0240	0,0069	0,0497	0,0240
Vapor Pr	0,0846	0,0892	0,0863	0,0909	0,0902	0,0896	0,0868	0,0909	0,0912
Reid Vap	0,0731	0,0845	0,0773	0,0891	0,0878	0,0855	0,0775	0,0907	0,0905
Autoignit	0,0264	0,0284	0,0495	0,0214	0,0393	0,0368	0,0550	0,0157	0,0232
Flash P.	0,0833	0,0863	0,0818	0,1071	0,1056	0,0997	0,0804	0,1280	0,1309
Boiling P.	0,0168	0,0101	0,0153	0,0029	0,0064	0,0093	0,0153	0,0041	0,0021
Melting P.	0,0818	0,0953	0,0536	0,0545	0,0752	0,0826	0,0729	0,0422	0,0851
RON	0,0052	0,0036	0,0042	0,0016	0,0039	0,0039	0,0039	0,0049	0,0003
MON	0,0022	0,0018	0,0054	0,0004	0,0022	0,0032	0,0018	0,0036	0,0000
Viscosity	0,0547	0,1149	0,1350	0,1601	0,3959	0,2153	0,1902	0,2303	0,2303
Sp. Grav.	0,0015	0,0018	0,0014	0,0019	0,0017	0,0019	0,0014	0,0021	0,0017
Sol.of water	0,0145	0,0145	0,0145	290,7660	289,3194	867,9871	0,0145	153,3325	141,7591
Sol.of Com.	0,0145	0,0145	0,0145	111,3791	125,8458	180,8192	0,0145	31,8123	36,1523
Z=0,8635	0	0	0	0	0	0	1	0	0

The selected seven cellulose-derived oxygenate alternatives are evaluated through the algorithm. The obtained results as shown in Table 4 indicate that the *Valero-lactone* is the option that contributes the most to the goal of selection the best alternative that satisfies all the factors selected. This result is aligned with the one obtained from running the multi-factor analysis alone.

Table 4. Solution of the Mathematical Model

	2-methyl-tetra-hydrofuran	dimethyl-furan	2-methyl-furan	ethyl levulinate	butyl levulinate	methyl pentanoate	valero-lactone
Difference	249,3058	4,4485	4,8929	343,7579	57,2998	2,2306	1,0515
LHV	0,0584	0,0527	0,0676	0,1071	0,0893	0,0825	0,1077
LHVap	0,0120	0,0111	0,0033	0,0234	0,0385	0,0101	0,0991
Low Fl	0,0093	0,1303	0,0465	0,1303	0,1303	0,1303	0,1303
Up Fl	0,0223	0,1303	0,1097	0,1303	0,1303	0,1303	0,1303
Vapor Pr	0,0750	0,0917	0,0690	0,0916	0,0917	0,0904	0,0917
Reid Vap	0,0917	0,0761	0,0702	0,0892	0,0917	0,0870	0,0917
Autoignit	0,0032	0,0072	0,0481	0,0418	0,0640	0,0640	0,0640
Flash P.	0,0476	0,0878	0,0312	0,1979	0,1815	0,0967	0,2068
Boiling P.	0,0168	0,0112	0,0215	0,0281	0,0391	0,0000	0,0326
Melting P.	0,1061	0,0254	0,0564	0,0464	0,0192	0,0564	0,0304
RON	0,0023	0,0084	0,0032	0,0055	0,0016	0,0039	0,0023
MON	0,0040	0,0302	0,0007	0,0065	0,0043	0,0075	0,0058
Viscosity	0,0557	0,0206	0,0206	0,0206	0,0206	0,0206	0,0206
Sp. Grav.	0,0032	0,0041	0,0048	0,0075	0,0065	0,0043	0,0094
Sol.of water	73,7657	0,0145	0,0145	122,9524	37,5989	0,0145	0,0145
Sol.of Com.	175,0325	3,7469	4,3255	219,8793	18,7922	1,4322	0,0145
Z = 1,051	0	0	0	0	0	0	1

3-Conclusions

The continuously diminishing fossil sources and the growing demand for energy have led to the research for alternative fuel types which are sustainable and renewable. This study aims to find the most appropriate alternatives based on various factors based on available standards and regulations. Two separate quantitative techniques are used within a proposed hybrid algorithm as a way of confirming the results. The first technique applied is the multi-factor evaluation method where each factor is appointed a relative weight as a result of expert evaluations. Then, the multi-factor evaluation method is applied to the resulting scheme to determine the best alcohol and biofuel alternative to the gasoline as a source of confirmation to the results to be obtained from the hybrid algorithm. The second applied method is mathematical modeling where the problem is modeled using integer programming. The objective function of the problem is designed to calculate the total absolute difference between the values of gasoline and those of alternatives. Thus, the model tries to find the alternative that minimizes that objective function. The factor weights obtained from the multi-factor analysis are used within the objective function. The results indicate that the proposed mathematical model makes more advanced choices as it considers the relative weights of the factors and minimizes the total difference between the factor values of gasoline and those of the alternatives.

The proposed algorithm is a comprehensive decision analysis technique because it considers the significance of each of the factors and incoherence in the rankings are confirmed.

The application of the mathematical modeling and multi-factor decision analysis techniques and the conclusions from this paper supplies an idea of how both methods can be performed together as a decision-making tool in alcohol and cellulose-derived oxygenates selection.

This analysis presented here could be beneficial for both policymakers and researchers. The results of this paper aids researchers working on a broad array of fields on related subjects compare relative effects of the fields in which they can potentially contribute. In a global context, playmakers can also utilize from the conclusions of this analysis by assessing the multidirectional performance of their R & D investments on related fields.

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