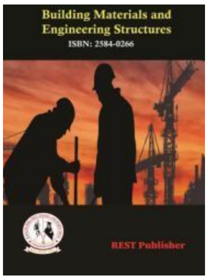
Building Materials and Engineering Structures

Vol: 2(4), December 2024

REST Publisher; ISSN: 2584-0266 (Online)

Website: https://restpublisher.com/journals/bmes/

DOI: http://doi.org/10.46632/bmes/2/4/4



Evaluating Gas Fuels, A DEMATEL-Based Analysis of Emission, Energy, and Economic Factors

***Ramya Sharma, M. Ramachandran, Vimala Saravanan, Manjula Selvam**

REST Labs, Kaveripattinam, Krishnagiri, Tamil Nadu, India

*Corresponding Author Email: ramyasarma242@gmail.com

Abstract: *The evaluation of gas fuels is a critical process that involves assessing the properties, performance, and environmental impact of different gas fuel sources. Petrol fuels like liquefied petroleum gas and natural gas (LPG), are widely used for various applications, including heating, cooking, and power generation. The evaluation process typically includes analyzing the composition and calorific value of the gas fuels to determine their energy content and efficiency. Additionally, factors such as combustion characteristics, emissions profiles, and safety considerations are taken into account. Evaluating gas fuels also involves assessing their availability, accessibility, and cost-effectiveness. This includes considering factors like production methods, infrastructure requirements, and transportation logistics. Moreover, the environmental impact of gas fuels is a significant aspect of the evaluation process. Evaluators examine the greenhouse gas emissions, air pollutants, and overall sustainability of gas fuels, comparing them to alternative energy sources. This analysis helps inform decision-making regarding the adoption and optimization of gas fuels for a cleaner and more sustainable energy future. The evaluation of gas fuels holds significant research significance due to several key reasons. Firstly, as the world seeks to transition to cleaner and more sustainable energy sources, understanding the properties and environmental impact of gas fuels becomes crucial. This research can inform policymakers, industry professionals, and energy consumers in making informed decisions about energy choices. Secondly, evaluating gas fuels enables the optimization of energy production and consumption processes. By understanding the efficiency and combustion characteristics of different gas fuels, researchers can develop technologies and strategies to enhance energy conversion and reduce emissions. Furthermore, the evaluation of gas fuels plays a vital role in energy security and resource management. Assessing the availability, accessibility, and cost-effectiveness of gas fuels helps identify potential energy reserves, infrastructure requirements, and diversification strategies. Overall, research in evaluating gas fuels contributes to sustainable energy development, climate change mitigation, and the switch to an energy system that is more effective and environmentally benign. "One method employed is the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method to analyze complex systems and relationships among various factors". It involves constructing a cause-and-effect network, quantifying the relationships between factors, and assessing their impact on decision-making. DEMATEL helps identify influential factors and prioritize actions for effective decision-making. Evaluation Parameters taken as "Low emission (LE), high energy content (HEC), high quality gas (HQG), easy procurement (EP), affordable unit price (AUP Low emission (LE) has got the first rank followed by high energy content (HEC) at the second rank whereas high quality gas (HQG) had got the last rank preceded by easy procurement (EP) at fourth rank. Affordable unit price (AUP) had got third rank. In conclusion, the evaluation of gas fuels plays a crucial role in shaping energy policies, promoting sustainable development, and mitigating environmental impact. By conducting thorough assessments of gas fuel properties, performance, and environmental implications, researchers and decision-makers can make informed choices regarding energy sources. The significance of gas fuel evaluation extends beyond immediate environmental concerns. It also impacts economic factors, such as infrastructure planning, transportation logistics, and energy pricing. By considering the overall sustainability and long-term viability of gas fuels, stakeholders can establish a balanced and resilient energy framework.*

Keywords: *Gas, Turbines, Fuel, DEMATEL*

1. INTRODUCTION

Air quality has decreased in parallel with rising energy demand. This use is reliant on non-renewable energy derived from fossil sources, whose level of deposits tend to decline [1]. Therefore, it is necessary to find solutions that can both help to minimise pollution emissions and provide fresh insights into the energy sector. High on the list of alternative fuels is natural gas.[2] Due to two key factors, hydrogen is a very desirable fuel for transportation. It can theoretically be found anyplace there is water and a clean power source. It is the least polluting fuel that can be utilised within a combustion engine. "A large portion of the research on hydrogen fuels has been driven by the possibility of a clean, readily accessible transportation fuel.[4] At this point, it could be acceptable to talk about CNG's potential as a substitute fuel for S.I. engines. The two fuels' physical and chemical properties determine how conventional gasoline-fuelled and CNG engine systemsto operate differently. [9] It is crucial to be able to compare the benefits of weight and space savings with the actual increase in fuel consumption in order to assess the technical and financial viability of this approach. [5] There are also available mid-sized turbines for using hydrogen for base-load, CHP, peaking, electricity in commercial and industrial applications, standby/backup, and with other fuels." Additionally, a range of 1-20 MW cogeneration and single or mixed cycle applications are possible for gas turbines.[6] In order to enhance the economic efficiency of biomass heating and combined heat and power (CHP) plants, it is necessary to explore alternative options for generating heat and power from inexpensive feedstocks, considering the escalating costs of traditional biomass fuels like wood. The discovery of new biomass fuels has the potential to create additional employment opportunities in rural regions, thereby bolstering the social aspect of sustainability [7].

FIGURE 1. Fossil fuel Sources

The structural characteristics of the anode, such as pore size, volume percentage, and tortuosity, have an impact on the diffusion rates of the reactant gases within it. Additionally, they are influenced by the nature of the specific reactant and the make-up of the overall fuel gas [11]. The current techniques employed to enhance biogas encompass adsorption, absorption (both physical and chemical), permeation, and cryogenic methods. These techniques are utilized to separate the main components, methane (50–70% by volume in raw biogas), and carbon dioxide (25–45% in raw biogas). [13] The main applications for fossil fuels are internal combustion engines (ICE), gas turbines (GT), and steam turbines (ST), where direct combustion emissions and the scarcity of fossil fuels provide the greatest obstacles.[12] One alternative fuel idea is natural gas that has been liquefied and is produced from fossil sources. [23]. "The potential use of alternative fuels, such as vegetable oil and compressed natural gas (CNG), instead of diesel oil (D), is being considered to mitigate particulate matter (PM) emissions in urban areas (Coburn et al., 1998). Ester-based fuels derived from vegetable oil, commonly referred to as biodiesel, can be utilized in compression-ignited (CI) engines without requiring any engine modifications [25]. The scientific community is closely monitoring the use of biosyngas generated from biomass gasifiers as a fuel source for such systems [22]. The examination of open absorption systems in natural gas boilers has primarily relied on theoretical simulations and the utilization of a direct-fired unit for regeneration heat (source). However, it is worth noting that employing high-temperature flue gases from boiler combustion chambers as the heat source for solution regeneration is more economically viable compared to using direct-fired units [15]." To conduct the analysis, additional system restrictions and parameters were specified. Recognizing the inevitable heat loss to the surroundings in compact high-temperature systems, a heat loss factor of 3% of the larger heating value of the fuel input was incorporated into the energy balance at the periphery of the stack [18].

2. MATERIALS & METHODOLOGY

Evaluation parameters:

Low emission (LE): Low emission (LE) refers to the evaluation of gas fuel based on its minimal release of pollutants into the environment. Its objective is to minimize greenhouse gas emissions and mitigate the release of other harmful pollutants, thus promoting a sustainable and environmentally friendly energy source.

High energy content (HEC): High energy content (HEC) refers to the evaluation of gas fuel based on its ability to release a large amount of energy per unit of volume or mass. It indicates a more efficient and powerful fuel source, providing greater energy output for various applications.

High quality gas (HQG): High quality gas (HQG) refers to the evaluation of gas fuel based on its purity, composition, and consistency. It signifies a gas that meets stringent standards for safety, reliability, and performance, ensuring optimal combustion and efficiency in various industrial and residential applications.

Easy procurement (EP): Easy procurement (EP) refers to the evaluation of gas fuel based on its accessibility and availability. It indicates that the gas fuel can be readily obtained, whether through reliable supply chains, infrastructure, or easily accessible sources, facilitating convenient and efficient fuel procurement processes.

Affordable unit price (AUP): Affordable unit price (AUP) refers to the evaluation of gas fuel based on its cost-effectiveness. It indicates that the unit price of the gas fuel is reasonable and competitive, making it economically feasible for consumers or businesses to utilize as an energy source.

Decision making trial and evaluation laboratory (DEMATEL) Method: The decision-making trial and evaluation laboratory (DEMATEL) method was initially developed by the Science and Human Affairs Programme of the Battelle Memorial Institute of Geneva between 1972 and 1976. Its purpose was to analyze and address complex and interconnected problem groups (Shieh et al., 2010; Wu et al., 2010) [4]. As one of the approaches in Multi-Criteria Decision Analysis (MCDA), DEMATEL assists in decision-making by establishing direct or indirect relationships among various characteristics or factors.

"[11] Employing the Decision-Making Trial and Evaluation Laboratory (DEMATEL) is a suitable approach for addressing this problem. The DEMATEL method, initially proposed by Gabus and Fontela in 1972 and 1973, proves to be a valuable technique for capturing collective knowledge in order to construct a structural model and illustrate the causal connections between sub-systems using a causal diagram [1]. In the original DEMATEL model, precise numerical values are utilized to measure the relationships among different decision factors, thereby establishing the structural model [10]. By utilizing a hierarchical structure, the DEMATEL method enhances comprehension of the specific problem, facilitates the identification of associated issues, and aids in the identification of viable solutions [2]."

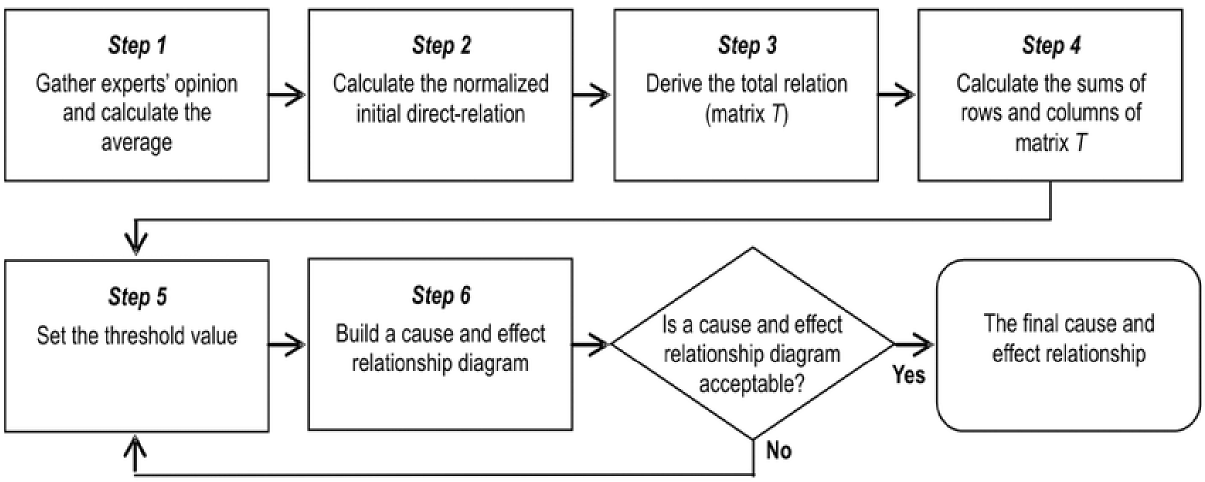


FIGURE 2. Steps of DEMATEL method

The DEMATEL is a thorough method for examining how system components interact while emphasizing the fundamental driving forces. It is based on graphs. In addition, an effect relations map is introduced to show the relationship between variables, with numbers denoting influence strength and arrows denoting influence direction. As a result, it is understood from resolving complex issues, particularly those involving interaction aspects, and providing decision-makers with an intuitive understanding of the relevant decision system.[3] Later, the DEMATEL approach is utilised to not only determine the criteria's weights but also to define how those criteria relate to one another in context.[5] The approach refers to elements that are higher than the other criteria as distributive, and it refers to criteria as buyers when their exposure level is more than their impact on the system (Karaolan, 2016: 13).[6] A hierarchical model for identifying the obstacles to the manufacture of environmentally friendly clothing in the apparel industries[12] was created via the grey-based DEMATEL methodology. "Use the grey-integrated DEMATEL framework to categorise the strategies into their two primary categories, causal and effect strategies.[13] DEMATEL can separate a system's (or subsystem's) involved criteria into cause and effect categories to facilitate decision-making (Wu & Lee, 2007). [7] The power of the relationships can be evaluated using the DEMATEL method[8].” The DEMATEL approach can be used to assess human resources for science and technology (HRST)[9] and to identify the success criteria for any performance endeavour [10]. ANP-DEMATEL's hybrid model's effectiveness and accuracy were assessed, and the results were contrasted with those obtained using the ANP model [14].

3. RESULTS & DISCUSSION

TABLE 1. Evaluation of Gas Fuel

	Low emission (LE),	high energy content (HEC),	high quality gas (HQG),	easy procurement (EP),	affordable unit price (AUP),
Low emission (LE),	0	4	3	4	4
high energy content (HEC),	3	0	5	3	3
high quality gas (HQG),	3	4	0	2	3
easy procurement (EP),	2	3	4	0	2
affordable unit price (AUP),	3	2	2	3	0

Table 1 shows the data of all the evaluative parameters like Low emission (LE), high energy content (HEC), high quality gas (HQG), easy procurement (EP), affordable unit price (AUP).

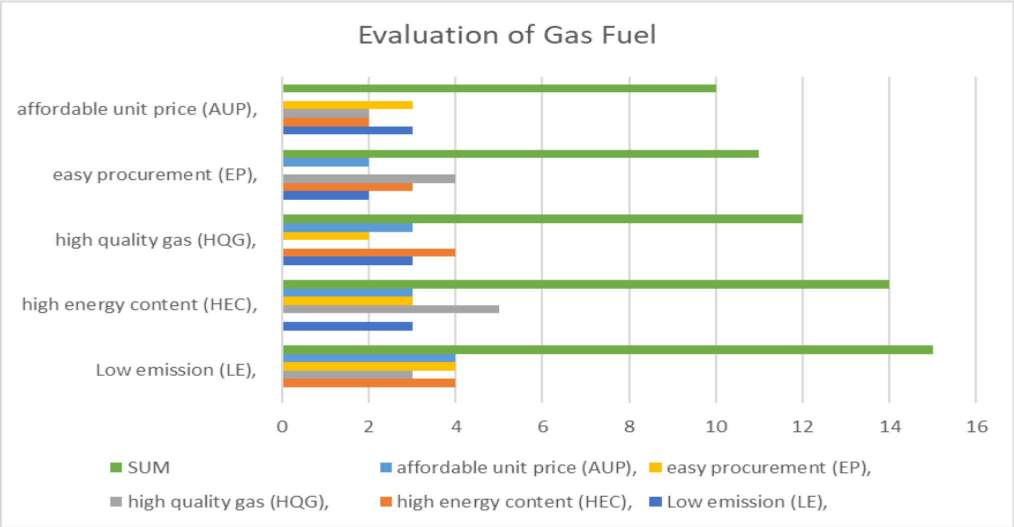


FIGURE 3. Evaluation of Gas Fuel

Figure 1 demonstrates the evaluative parameters like “Low emission (LE), high energy content (HEC), high quality gas (HQG), easy procurement (EP), affordable unit price (AUP).”

TABLE 2. Direct relation matrix normalization

Normalisation of direct relation matrix					
	Low emission (LE),	high energy content (HEC),	high quality gas (HQG),	easy procurement (EP),	affordable unit price (AUP),
Low emission (LE),	0	0.363636364	0.27272727	0.363636364	0.363636364
high energy content (HEC),	0.272727273	0	0.45454545	0.272727273	0.272727273
high quality gas (HQG),	0.272727273	0.363636364	0	0.181818182	0.272727273
easy procurement (EP),	0.181818182	0.272727273	0.36363636	0	0.181818182
affordable unit price (AUP),	0.272727273	0.181818182	0.18181818	0.272727273	0

"Table 2 shows the Normalisation of direct relation matrix of evaluative parameters like Low emission (LE), high energy content (HEC), high quality gas (HQG), easy procurement (EP), affordable unit price (AUP)."

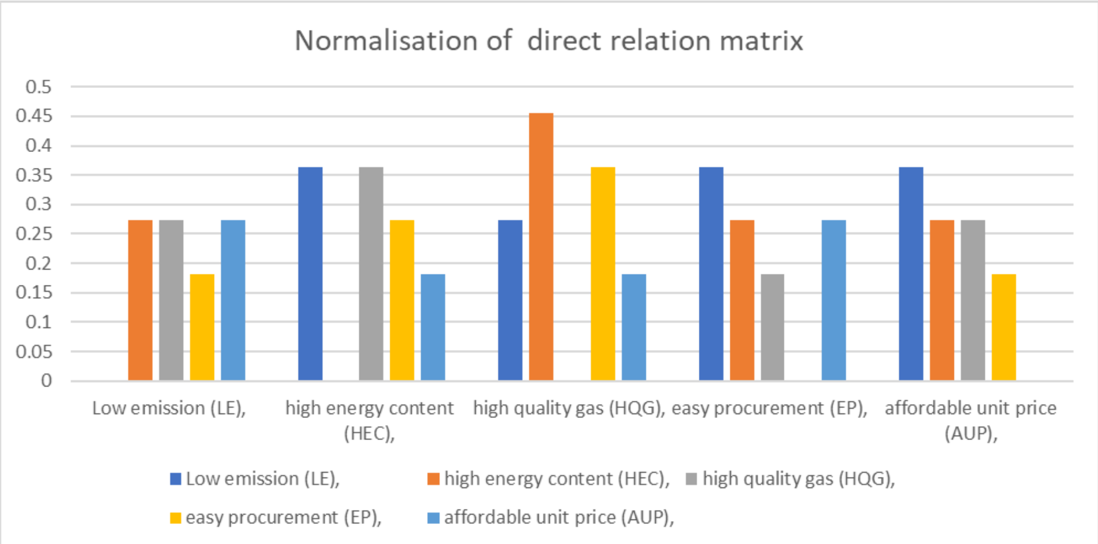


FIGURE 4. Normalisation of direct relation matrix

Figure 2 shows the evaluative parameters like "Low emission (LE), high energy content (HEC), high quality gas (HQG), easy procurement (EP), affordable unit price (AUP)."

TABLE 3. Total Relation Matrix

	Total Relation matrix (T)					Ri
Low emission (LE),	0.890832008	1.100689	1.168345	1.038156	1.010775	**5.208797032**
high energy content (HEC),	1.081081081	0.837838	0.963964	0.864865	0.873874	**4.621621622**
high quality gas (HQG),	0.749867515	0.735559	0.612259	0.81558	0.633104	**3.546369899**
easy procurement (EP),	0.788553259	0.952305	0.832538	0.666137	0.766826	**4.0063593**
affordable unit price (AUP),	1.020137785	1.195019	0.936584	1.031797	0.768239	**4.951775305**
Ci	**4.530471648**	**4.82141**	**4.51369**	**4.416534**	**4.052818**	

"Table 3 shows the Total relation matrix of evaluative parameters like Low emission (LE), high energy content (HEC), high quality gas (HQG), easy procurement (EP), affordable unit price (AUP)."

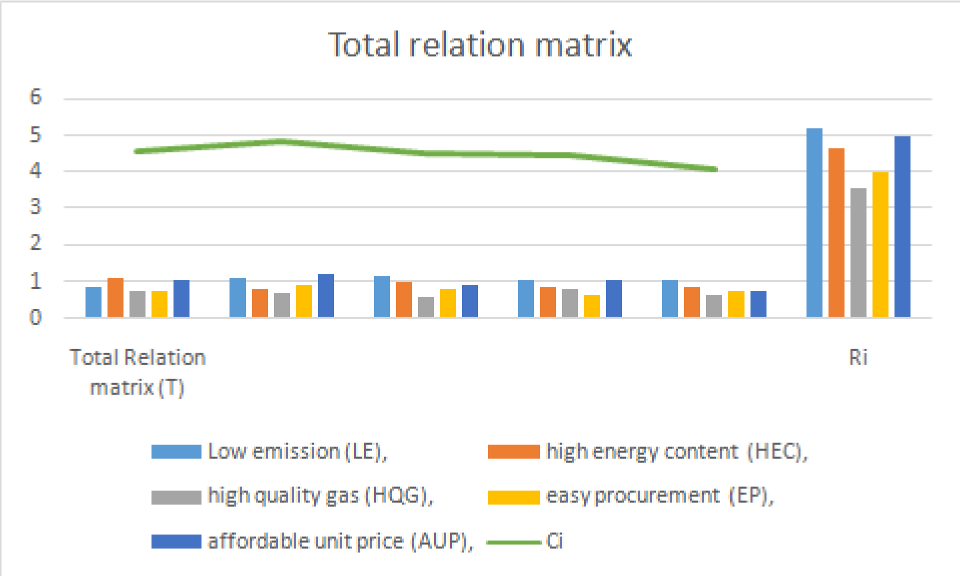


FIGURE 5. Total relation matrix

Figure 3 demonstrates Total relation matrix of evaluative parameters like “Low emission (LE), high energy content (HEC), high quality gas (HQG), easy procurement (EP), affordable unit price (AUP)”.

TABLE 4. I values

1	0	0	0	0
0	1	0	0	0
0	0	1	0	0
0	0	0	1	0
0	0	0	0	1

Table 4 shows the I values for the evaluation parameters.

TABLE 5. Y values

0	0.181818	0.363636	0.181818	0.272727
0.363636	0	0.181818	0.090909	0.181818
0.181818	0.090909	0	0.272727	0.090909
0.090909	0.272727	0.181818	0	0.181818
0.181818	0.363636	0.090909	0.272727	0

Table 5 shows the Y values for the evaluation parameters.

TABLE 7. (I-Y)-1

1.890832008	1.100689	1.168345	1.038156	1.010775
1.081081081	1.837838	0.963964	0.864865	0.873874
0.749867515	0.735559	1.612259	0.81558	0.633104
0.788553259	0.952305	0.832538	1.666137	0.766826
1.020137785	1.195019	0.936584	1.031797	1.768239

Table 5 shows the (I-Y)-1 values for the evaluation parameters.

TABLE 8. Ri+Ci and Ri-Ci and identity

Ri+Ci	Ri-Ci	Rank	Identity
9.739269	0.678325	1	cause
9.443031	-0.19979	2	effect
8.06006	-0.96732	5	effect
8.422893	-0.41017	4	effect
9.004593	0.898958	3	cause

Table 8shows the Ri+Ci and Ri-Ci of evaluative parameters like "Low emission (LE), high energy content (HEC), high quality gas (HQG), easy procurement (EP), affordable unit price (AUP) along with identity whether it is effect or cause".

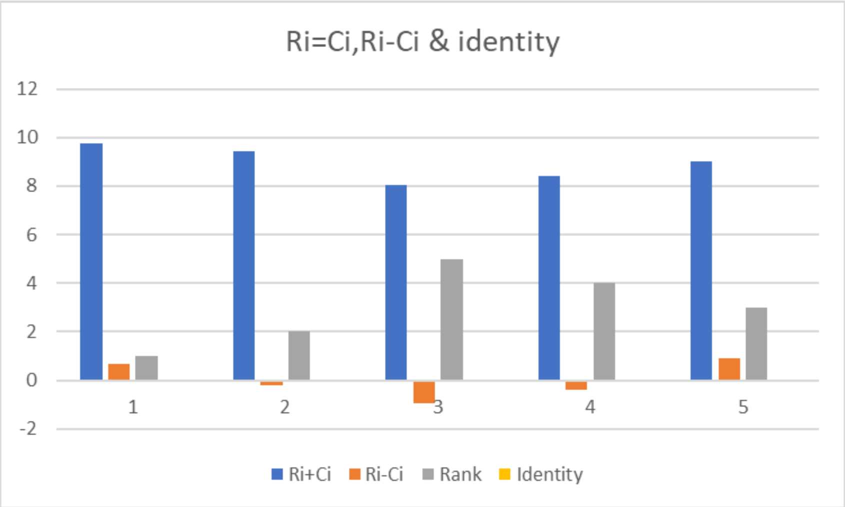


FIGURE 6. Ri+Ci and Ri-Ci

Figure 4 demonstrates Ri+Ci ,Ri-Ci and Identity of evaluative parameters like "Low emission (LE), high energy content (HEC), high quality gas (HQG), easy procurement (EP), affordable unit price (AUP)".

TABLE 9. T matrix values

0.890832	**1.100689**	**1.168345**	**1.038156**	**1.010775**
1.081081	0.837838	**0.963964**	0.864865	0.873874
0.749868	0.735559	0.612259	**0.81558**	0.633104
0.788553	**0.952305**	0.832538	0.666137	0.766826
1.020138	**1.195019**	**0.936584**	**1.031797**	0.768239

Table 9 shows the T matrix values for the evaluation parameters greater than Threshold value (alpha = 0.893397) in bold

TABLE 10. Rank

	Rank
Low emission (LE),	1
high energy content (HEC),	2
high quality gas (HQG),	5
easy procurement (EP),	4
affordable unit price (AUP),	3

Table 10 shows the rank of evaluative parameters like "Low emission (LE), high energy content (HEC), high quality gas (HQG), easy procurement (EP), affordable unit price (AUP)'.

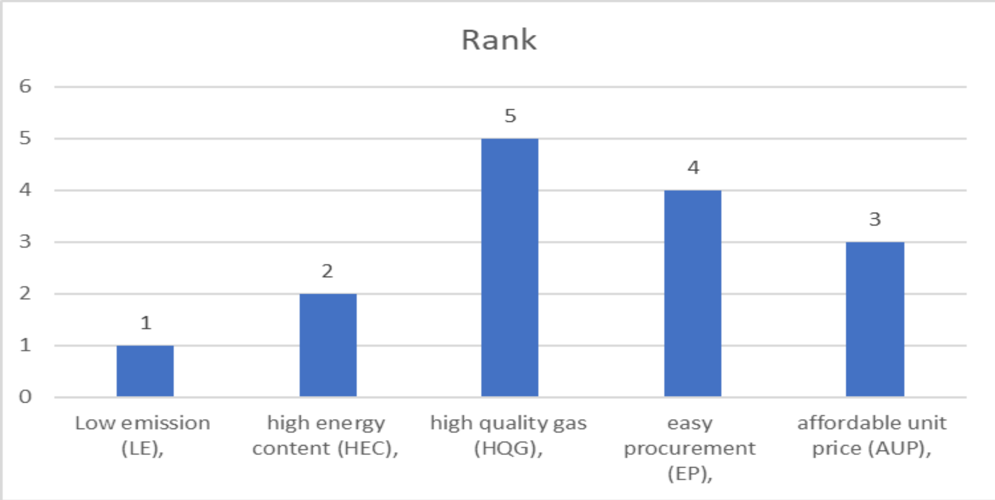


FIGURE 7. Rank

Figure 5 shows that Low emission (LE) has got the first rank followed by high energy content (HEC) at the second rank whereas high quality gas (HQG) had got the last rank preceeded by easy procurement (EP) at fourth rank. Affordable unit price (AUP) had got third rank.

4. CONCLUSION

Gas fuel evaluation encompasses various aspects, including analyzing composition, calorific value, combustion characteristics, and emissions profiles. These evaluations enable the optimization of energy conversion processes, improving efficiency and reducing environmental pollution. Understanding the availability, accessibility, and cost-effectiveness of gas fuels also helps in ensuring energy security and resource management. The evaluation of gas fuels holds significant importance for several reasons: Energy Transition: As the world seeks to transition from fossil fuels to cleaner and more sustainable energy sources, evaluating gas fuels becomes crucial. Understanding their properties, performance, and environmental impact helps identify their role in the energy mix and aids in the development of effective transition strategies. Environmental Impact: Gas fuels, while generally considered cleaner than coal or oil, still contribute to greenhouse gas emissions and air pollution. Evaluating gas fuels allows us to assess their environmental impact, including carbon dioxide emissions, methane leakage, and other pollutants. This information helps in understanding their overall sustainability and guides efforts to minimize their environmental footprint. Energy In conclusion, the evaluation of gas fuels is important for driving the energy transition, understanding environmental impacts, optimizing energy efficiency, ensuring energy security, informing policy decisions, and considering economic factors. These evaluations are essential for achieving a sustainable and resilient energy future.In summary, the evaluation of gas fuels is vital for achieving a more sustainable and efficient energy future. It guides decision-making processes, informs policy development, and promotes the adoption of cleaner energy sources. Through comprehensive assessments, we can optimize gas fuel usage, reduce emissions, and work towards a greener and more resilient energy ecosystem.

REFERENCES

[1]. Wu, Wei-Wen, and Yu-Ting Lee. "Developing global managers' competencies using the fuzzy DEMATEL method." *Expert systems with applications* 32, no. 2 (2007): 499-507.

[2]. Shieh, Jiunn-I., Hsin-Hung Wu, and Kuan-Kai Huang. "A DEMATEL method in identifying key success factors of hospital service quality." *Knowledge-Based Systems* 23, no. 3 (2010): 277-282.

[3]. Du, Yuan-Wei, and Xiao-Xue Li. "Hierarchical DEMATEL method for complex systems." *Expert Systems with Applications* 167 (2021): 113871.

[4]. Prabakaran Nanjundan, Sathiyaraj chinnasamy, M. Ramachandran, Chandrasekar Raja, "Material Comparative Design of Penstock Pipe for Hydroelectric Pumped Storage Station Using MOORA Method", /Building Materials and Engineering Structures, 2(3), September 2024, 1-5.

[5]. Nihari Paladugu, Deepak Das, Somesh Nagalla, Network Function Virtualization (NFV) for flexible network services by using TOPSIS method, Computer Science, Engineering and Technology, 2(2), June 2024, 44-51.

[6]. Shieh, Jiunn-I., and Hsin-Hung Wu. "Measures of consistency for DEMATEL method." *Communications in Statistics-Simulation and Computation* 45, no. 3 (2016): 781-790.

[7]. Wu, Hsin-Hung, Hsuan-Kai Chen, and Jiunn-I. Shieh. "Evaluating performance criteria of employment service outreach program personnel by DEMATEL method." *Expert Systems with Applications* 37, no. 7 (2010): 5219-5223.

[8]. Koca, Gözde, and Seda Yıldırım. "Bibliometric analysis of DEMATEL method." *Decision Making: Applications in Management and Engineering* 4, no. 1 (2021): 85-103.
[9]. Amiri, Maghsud, J. Sadaghiyani, Nafiseh Payani, and Mahdi Shafieezadeh. "Developing a DEMATEL method to prioritize distribution centers in supply chain." *Management Science Letters* 1, no. 3 (2011): 279-288.
[10]. Khan, Shahbaz, Abid Haleem, and Mohd Imran Khan. "Enablers to implement circular initiatives in the supply chain: a grey DEMATEL method." *Global Business Review* (2020): 0972150920929484.
[11]. Lin, Kuo-Ping, Ming-Lang Tseng, and Ping-Feng Pai. "Sustainable supply chain management using approximate fuzzy DEMATEL method." *Resources, Conservation and Recycling* 128 (2018): 134-142.
[12]. Seleem, Sameh N., El-Awady Attia, and Ahmed El-Assal. "Managing performance improvement initiatives using DEMATEL method with application case study." *Production Planning & Control* 27, no. 7-8 (2016): 637-649.
[13]. Kimijima, Shinji, and Nobuhide Kasagi. "Performance evaluation of gas turbine-fuel cell hybrid micro generation system." In *Turbo Expo: Power for Land, Sea, and Air*, vol. 3607, pp. 351-360. 2002.
[14]. Nihari Paladugu, Somesh Nagalla, Deepak Das, Unveiling the Dynamics of E-Commerce A Comprehensive Study on Big Data Analytics, Environmental Impact, Socioeconomic Effects, and Platform Assessment, Computer Science, Engineering and Technology, 2(4), December 2024, 24-33.
[15]. Mohiuddin, Mohammed Quadir. "Retention strategies for talent." *International Journal of Management, IT and Engineering* 4, no. 10 (2014): 26-42.
[16]. Shankari, L., and S. Suja. "Benchmarking on HR Scorecard in the hospitality industry." *Management and Labour Studies* 33, no. 1 (2008): 80-102.
[17]. Mello, Pedro, Giovani Pelliza, Renato Cataluña, and Rosângela da Silva. "Evaluation of the maximum horsepower of vehicles converted for use with natural gas fuel." *Fuel* 85, no. 14-15 (2006): 2180-2186.
[18]. Dooley, Stephen, Sang Hee Won, Joshua Heyne, Tanvir I. Farouk, Yiguang Ju, Frederick L. Dryer, Kamal Kumar et al. "The experimental evaluation of a methodology for surrogate fuel formulation to emulate gas phase combustion kinetic phenomena." *Combustion and Flame* 159, no. 4 (2012): 1444-1466.
[19]. DeLuchi, Mark A. "Hydrogen vehicles: an evaluation of fuel storage, performance, safety, environmental impacts, and cost." *International Journal of Hydrogen Energy* 14, no. 2 (1989): 81-130.
[20]. Juste, G. L. "Hydrogen injection as additional fuel in gas turbine combustor. Evaluation of effects." *International Journal of Hydrogen Energy* 31, no. 14 (2006): 2112-2121.
[21]. Sommersacher, Peter, Thomas Brunner, and Ingwald Obernberger. "Fuel indexes: a novel method for the evaluation of relevant combustion properties of new biomass fuels." *Energy & Fuels* 26, no. 1 (2012): 380-390.
[22]. Yakabe, H., M. Hishinuma, M. Uratani, Y. Matsuzaki, and I. J. J. P. S. Yasuda. "Evaluation and modeling of performance of anode-supported solid oxide fuel cell." *Journal of Power Sources* 86, no. 1-2 (2000): 423-431.
[23]. Vidhya Prasanth, Ramya Sharma, M. Ramachandran, Sathiyaraj chinnasamy, "Evaluation of Automotive Brake Disc Material Selection Using Weighted Sum Method (WSM)", REST Journal on Advances in Mechanical Engineering, 3(3), September 2024, 9-18.
[24]. Somesh Nagalla, Deepak Das, Nihari Paladugu, A Study on Key Drivers and Deterrents in Digital Payment in the State of Odisha, Journal on Electronic and Automation Engineering, 3(2), June 2024, 25-41.
[25]. Ambhore, Dhairysheel, Akash Tiwari, Ujval Patel, Jishnu Patil, and M. Ramachandran. "Effect of aluminium oxide nano filler in tetrafluoroethane (R-134a) refrigerant." In *IOP Conference Series: Materials Science and Engineering*, vol. 810, no. 1, p. 012018. IOP Publishing, 2020.
[26]. Suja, S. "WOMEN EMPOWERMENT THROUGH SELF-HELP GROUP-AN EVALUATIVE STUDY." *Global Management Review* 6, no. 3 (2012).
[27]. Ozcan, Hasan, and Ibrahim Dincer. "Performance evaluation of an SOFC based trigeneration system using various gaseous fuels from biomass gasification." *International journal of hydrogen energy* 40, no. 24 (2015): 7798-7807.
[28]. Sathish, Thanikodi, Raviteja Surakasi, Lakshmana KishoreT, Saravanan Rathinasamy, Ümit Ağbulut, Saboor Shaik, Sung Goon Park, and Asif Afzal. "Waste to fuel: Pyrolysis of waste transformer oil and its evaluation as alternative fuel along with different nanoparticles in CI engine with exhaust gas recirculation." *Energy* 267 (2023): 126595.
[29]. Wang, Zhenying, Xiaoyue Zhang, and Zhen Li. "Evaluation of a flue gas driven open absorption system for heat and water recovery from fossil fuel boilers." *Energy Conversion and Management* 128 (2016): 57-65.
[30]. Deepak Das, Somesh Nagalla, Nihari Paladugu, Autonomous Drones and Their Applications in Various Industries Using COPRAS Method, Aeronautical and Aerospace Engineering, 2(2), June 2024, 17-23.
[31]. Mohiuddin, Mohammed Quadir. "Evaluation of Organizational Psychology using GRA Method.", Trends in Finance and Economics, 1(1), June 2023, 8-14.
[32]. Cavaliere, Luigi Pio Leonardo, Ruby Khan, Suja Sundram, Kirti Jainani, Girish Bagale, M. Kalyan Chakravarthi, R. Regin, and S. Suman Rajest. "The Impact of customer relationship management on customer satisfaction and retention: The mediation of service quality." *Turkish Journal of Physiotherapy and Rehabilitation* 32, no. 3 (2021): 22107-22121.
[33]. Park, Sung Ku, Ji-Ho Ahn, and Tong Seop Kim. "Performance evaluation of integrated gasification solid oxide fuel cell/gas turbine systems including carbon dioxide capture." *Applied energy* 88, no. 9 (2011): 2976-2987.
[34]. Fu, Xuehai, Yong Qin, Geoff GX Wang, and Victor Rudolph. "Evaluation of gas content of coalbed methane reservoirs with the aid of geophysical logging technology." *Fuel* 88, no. 11 (2009): 2269-2277.
[35]. Braun, R. J., S. A. Klein, and D. T. Reindl. "Evaluation of system configurations for solid oxide fuel cell-based micro-combined heat and power generators in residential applications." *Journal of Power Sources* 158, no. 2 (2006): 1290-1305.

[36]. Khoo, Hsien H., and Reginald BH Tan. "Environmental impact evaluation of conventional fossil fuel production (oil and natural gas) and enhanced resource recovery with potential CO2 sequestration." *Energy & fuels* 20, no. 5 (2006): 1914-1924.
[37]. Aravind, Pa Ve, T. Woudstra, N. Woudstra, and H. Spliethoff. "Thermodynamic evaluation of small-scale systems with biomass gasifiers, solid oxide fuel cells with Ni/GDC anodes and gas turbines." *Journal of power sources* 190, no. 2 (2009): 461-475.
[38]. König, Daniel H., Nadine Baucks, Ralph-Uwe Dietrich, and Antje Wörner. "Simulation and evaluation of a process concept for the generation of synthetic fuel from CO2 and H2." *Energy* 91 (2015): 833-841.
[39]. Gupta, K. K., A. Rehman, and R. M. Sarviya. "Evaluation of soya bio-diesel as a gas turbine fuel." *Iranian (Iranica) Journal of Energy & Environment* 1, no. 3 (2010).
[40]. Manjula selvam, Vidhya Prasanth, M. Ramachandran, Ramya Sharama, "A Study on Economic Models of Animal Communication Methods" Journal on Innovations in Teaching and Learning, 3(2), June 2024, 13-19.
[41]. Sundram, Suja, P. S. Venkateswaran, Vipin Jain, Y. Yu, Lis M. Yapanto, Ismail Raisal, Ashish Gupta, and R. Regin. "The impact of knowledge management on the performance of employees: The case of small medium enterprises." *Productivity Management* 25, no. 1 (2020): 554-567.
[42]. Deepak Das, Nihari Paladugu, Somesh Nagalla, Automation and Remote Monitoring by using TOPSIS METHOD, Journal on Electronic and Automation Engineering, 3(3), September 2024, 16-24.
[43]. Joshi, Ritvik, Jishnu Patil, Sidakdeep Singh Luthra, and Sankalp Gaud Prof Giridhar Chavan. "Three Wheeled Omnidirectional Soccer Robot Modelling and Wireless controlling using Bluetooth enabled PlayStation Controller." *REST J. Emerg. trends Model. Manuf* 5, no. 2 (2019).
[44]. Mohiuddin, Mohammed Quadir. "Role of a women entrepreneur in agcc (ARAB GULF cooperation council) women empowerment." *Journal of Interdisciplinary Research (ISSN: 2408-1906)* 1, no. 2 (2016).
[45]. Turrio-Baldassarri, Luigi, Chiara Laura Battistelli, Luigi Conti, Riccardo Crebelli, Barbara De Berardis, Anna Laura Iamiceli, Michele Gambino, and Sabato Iannaccone. "Evaluation of emission toxicity of urban bus engines: Compressed natural gas and comparison with liquid fuels." *Science of the Total Environment* 355, no. 1-3 (2006): 64-77.
[46]. Narayanamoorthy, Samayan, L. Ramya, Samayan Kalaiselvan, Joseph Varghese Kureethara, and Daekook Kang. "Use of DEMATEL and COPRAS method to select best alternative fuel for control of impact of greenhouse gas emissions." *Socio-Economic Planning Sciences* 76 (2021): 100996.
[47]. Sara, Juliana, Rob M. Stikkelman, and Paulien M. Herder. "Assessing relative importance and mutual influence of barriers for CCS deployment of the ROAD project using AHP and DEMATEL methods." *International Journal of Greenhouse Gas Control* 41 (2015): 336-357.
[48]. Deepak Das, Somesh Nagalla, Nihari Paladugu, Enhancing Connectivity and Communication in Underserved Rural and Remote Areas - An EDAS-Based Invest, Journal on Electronic and Automation Engineering, 3(4), December 2024, 22-29.
[49]. Venkateswaran, P. S., and Suja Sundram. "Impact of retail service quality and store service quality on patronage intention towards organized retail industry." *Turkish Journal of Computer and Mathematics Education (TURCOMAT)* 12, no. 3 (2021): 1462-1471.