Available online at www.sciencedirect.com

ScienceDirect

IFAC PapersOnLine 59-10 (2025) 649–654

An Analytical Development of Supply-Chain Resilience for UK Waste-Based SAF Feedstocks with a Focus on Achieving a Circular Economy

Eleanor L. Borrill*, Ruoyang Yuan, Lenny S.C. Koh*****

**School of Mechanical, Aerospace, and Civil Engineering, University of Sheffield, Sheffield, UK, (elborrill1@sheffield.ac.uk)*

*** School of Mechanical, Aerospace, and Civil Engineering, University of Sheffield, Sheffield, UK, (ruoyang.yuan@sheffield.ac.uk)*

**** Management School, University of Sheffield, Sheffield, UK, (s.c.l.koh@sheffield.ac.uk)*

Abstract:
The sustainable aviation fuel (SAF) supply-chain faces challenges related to feedstock availability, environmental impact, and complex decision-making, requiring the identification of viable feedstocks, sustainable production pathways, and a structured framework to balance multidisciplinary criteria. This paper presents a prospective SAF feasibility study, based on UK feedstock availability, revealing that biodegradable municipal solid waste (BMSW) is the most viable. Cereal residues, although the second-most abundant, face predictability challenges, necessitating further study of their current uses and the development of new supply-chains. Fats, oils, and greases (FOGs), waste wood, and sewage sludge have minimal availability. A cradle-to-grave lifecycle assessment of BMSW, waste straw, waste wood, and FOGs use in SAF production confirmed at least a 90% global warming potential reduction compared to fossil jet fuel, aligning with existing literature. Three multicriteria decision analysis methods with four weighting schemes were applied to evaluate the SAF production pathways across 26 multidisciplinary criteria. MSW ranked highest, straw and waste wood achieved similar scores, and FOGs consistently ranked lowest. Together, these methodologies form an integrated framework for evaluating supply-chain resilience, sustainability, and decision-maker preferences to address multiple objectives.

Keywords: supply-chain management, circular economy, resilience, SAF, LCA, MCDA.

1. INTRODUCTION

Demand for air travel continues to increase, rising by 10.4% between 2023 and 2024 (IATA, 2025), with aviation contributing around 4% towards anthropogenic radiative forcing (Klower et al., 2021). To address this, many counties have implemented emission targets. For example, the UK's 2022 Jet Zero Strategy aims for net-zero air travel by 2050 (Dep. for Trans., 2024). Sustainable aviation fuels (SAF) offer a key solution to reducing aviation emissions, as they are derived from renewable feedstocks. Biobased SAF offset emissions by sequestering carbon during biomass growth. The primary advantage of SAF over electric- or hydrogen-powered aircraft is their compatibility with existing infrastructure, offering an immediate solution to reduce aviation emissions without modifying current aircraft (Bauen, et al., 2020).

The SAF supply-chain faces several challenges, including limited and uncertain feedstocks availability, varying environmental impacts across different feedstocks and production pathways, and the complexity of supply-chain decisions involving multiple conflicting factors. To address these issues, it is essential to identify viable feedstocks based on availability, distribution, and seasonality, ensuring stable and scalable SAF production. Sourcing sufficient feedstocks to achieve the necessary production volumes to meet aviation demand, while preventing competition with food crops, is a major challenge (O'Malley, et al., 2021). Waste-based feedstocks offer advantages such as cost-effectiveness and minimal food competition. Their diversity, abundance, and continuous availability contribute to supply-chain resilience, while a more circular economy is achieved through mitigating landfill waste and enhanced resource efficiency. Additionally, quantifying greenhouse gas emissions and resource use is crucial for selecting sustainable SAF production pathways that align with emissions targets. A structured framework is also needed to evaluate trade-offs between economic, environmental, and social factors, helping decision-makers choose optimal SAF production strategies based on multiple criteria. By integrating these assessments, stakeholders can build a more resilient and sustainable SAF supply-chain that meets both industry needs and regulatory requirements.

To maximize the efficiency of resource allocation and investment, this paper aims to address the question: from a multidisciplinary perspective, which is the most viable UK-specific waste-based feedstock for SAF production? To answer this, various UK-specific biobased SAF production pathways are investigated using three quantitative approaches: prospective feedstock availability assessment, lifecycle assessment (LCA), and multicriteria decision analysis (MCDA). The results from the feedstock availability assessment and LCA serve as inputs for the MCDA, along with additional data from literature, offering a more evidence-based approach to MCDA than has been previously demonstrated in the literature. The following sections outline related literature and research gaps, the methodologies employed in this study, and a discussion of the experimental results.

10.1016/j.ifacol.2025.09.111

2. LITERATURE REVIEW

Few feasibility studies have examined the biobased feedstock potential for SAF or biofuels in general. O'Malley et al. assessed the availability of EU waste feedstocks for SAF production, considering 2030 projections and accounting for competing uses. Their findings showed that agricultural residues and cover crops provided the largest feedstock supply, while waste fats, oils, and greases (FOGs) had the highest SAF production potential. The total estimated feedstock availability was 124.4 Mt, capable of producing 3.4 Mt of SAF, equivalent to 5.5% of the projected 2030 jet fuel demand (O'Malley, et al., 2021). Mahmud et al. evaluated the biofuel production potential of various second- and third-generation feedstocks in Bangladesh, finding that agricultural residues could generate 44.4 Mt of bioethanol, with rice residue accounting for 71% (Mahmud, et al., 2022).

Several LCA studies have been conducted on various SAF production pathways and feedstocks. However, the use of a particular feedstock generally yields a wide range of environmental impact values depending on the method of feedstock production, the LCA boundaries, and the SAF production technology. Waste straw exhibits a particularly wide range of global warming potential (GWP) results, from around 6.1-54.6 gCO_{2eq}/MJ SAF, highly dependent on the SAF production pathway (De Souza Deuber et al. 2023; Tanzil et al., 2021). Other agricultural residues have shown similar GWP ranges to forestry residues, at 7.7-29.3 gCO_{2eq}/MJ SAF and 8.3-23.8 gCO_{2eq}/MJ SAF, respectively. Waste oil feedstocks, such as used cooking oil and tallow (3.1-22.9 gCO_{2eq}/MJ SAF), have demonstrated significantly lower GWP than first-generation oil-based feedstocks, such as palm and soybean oils (2.9-99.1 gCO_{2eq}/MJ SAF) (Chen et al., 2024; Oehmichen et al., 2022; Vardon et al., 2022; Whittle et al., 2024). SAF production from municipal solid waste (MSW) also exhibits a range of GWP values, from 5.2-32.5 gCO_{2eq}/MJ SAF (ICAO, 2024; Vardon et al., 2022). Many LCAs have focussed on SAF production in the USA but few studies have examined UK-specific supply-chains and infrastructure (Rojas-Michaga et al., 2023; Whittle et al., 2024).

Few MCDA studies have been conducted on SAF feedstocks. Mendes De Souza and Aranda used the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method to assess potential oil feedstocks for hydroprocessed esters and fatty acids (HEFA) bio-jet production in Brazil, evaluating economic, environmental, social, production scale, and oilseed quality criteria. Their findings identified soybean as the most suitable option, followed by jatropha and sunflower (Mendes De Souza and Aranda, 2020). This contrasts Anwar's findings, who assessed 16 biodiesel feedstocks based on economic, technical, and environmental criteria, determining coconut to be the most suitable and soybean as the least suitable (Anwar, 2021). MCDA has also been applied to microalgae strains (Mofijur et al., 2022, 2023), as well as the physiochemical properties of biodiesels (Anwar et al., 2019).

This paper addresses the identified research gaps by presenting a novel evaluation of SAF supply-chain resilience, based on a prospective feasibility assessment that focusses on the availability of unutilized biomass waste-based feedstocks produced in the UK. The LCA study presents a novel focus of comparing feedstocks sourced from waste products which, although previously studied independently, have not been directly compared in this manner in the literature. Data from various sources are compiled to conduct a comprehensive analysis under consistent boundary conditions and methods, ensuring an accurate comparison of these UK-specific feedstocks. The results consider all environmental impact categories, not just GWP, to capture the broader direct and indirect effects, an approach rarely seen in previous studies. A novel combination of methods is used to conduct MCDA on the identified feedstocks, incorporating more analytical methods and quantitative data than previously seen in the literature, and integrating the feasibility assessment and LCA results into a single multidisciplinary analysis. Additionally, it focuses on UK supply-chains, which have not been previously explored in the literature.

3. METHODOLOGIES

3.1 Prospective feasibility assessment

The availability of waste-based feedstocks was assessed to estimate SAF production potential and evaluate prospective supply-chain resilience in terms of resource availability and scalability. Data were taken from UK government databases and various literature sources. In this study, waste volume estimates for each feedstock were calculated based on the volume of end products that currently hold no value and are not utilised in downstream processes but are instead landfilled or incinerated without energy recovery. Prospective feedstock availability and SAF production potential were modelled based on historical feedstock production data and mass-based SAF conversion yields from literature. For cereals, BMSW, waste wood, and jet fuel consumption, data were available from 1984, 2010, 2012, and 2000 onward, respectively. No historical data was available for FOGs; therefore, they were assumed to remain approximately constant in these analyses.

Estimates of agricultural residues from cereals were based on data for annual grain yields and production volumes of wheat, barley, oats, and other cereals at 14.5% moisture, assuming that 10% of the 'other uses and waste' category is waste. For each cereal, straw and chaff production volumes were determined based on their respective weight distributions of the total harvested product. It is assumed that all harvested straw is utilised, while all unharvested straw remains available for SAF production, based on values for straw harvest rates per cereal type. Additionally, it is assumed that 77% of 'other cereals' straw is harvested and 10% of chaff produced is considered waste. The availability of biodegradable (B)MSW for SAF production was derived from the annual volume of BMSW sent to landfill. SAF production potential was estimated using conversion yields reported in the literature.

3.2 Lifecycle assessment (LCA)

A cradle-to-grave LCA was conducted to compare SAF production from UK-specific waste-based feedstocks using the ReCiPe method, calculated via the Brightway2 Activity Browser. The gasification Fischer-Tropsch (GFT) process was modelled for BMSW (Zhang et al., 2024) and waste wood (Ahire, et al., 2024). Fast pyrolysis (FP) was modelled for waste straw (Han, et al., 2019), while the HEFA process was modelled for FOGs (D'Ascenzo, et al., 2024) using literature data. The functional unit is 1 MJ SAF produced with mass-based allocation applied to distribute the environmental impacts among products and by-products. A hybrid approach was used, where foreground process data were sourced from literature, while background processes relied on input-output data from the Ecoinvent database.

The system boundaries include feedstock acquisition, transportation, pretreatment, SAF conversion, and fuel transportation. Since only waste materials are considered, feedstock production is excluded, assuming that these materials would otherwise be landfilled or incinerated without energy recovery. However, this assumption does not apply to cereal straw, which is currently unharvested, so harvesting is included in the analysis. Infrastructure development, such as roads and production plants, is excluded from this study. Transportation distances were assumed as follows. BMSW, cereal straw, and waste wood are assumed to be transported 50 km by heavy truck from landfills, farms, and wood processing sites to the SAF production plant. FOGs are first transported 20 km by light vehicle from homes and restaurants to local collection points, after which they are transported an additional 50 km by heavy truck to the SAF plant. Finally, it is assumed that the SAF production plant is located 10 km from an airport, where all the produced SAF is delivered and sold. As all identified feedstocks are biogenic, it is assumed that carbon emissions from SAF combustion are offset by the carbon sequestered during biomass during.

3.3 Multicriteria decision analysis (MCDA)

For the MCDA, 26 criteria were selected across environmental, technical, economic, logistical, and social categories, based on data from the literature as well as the feasibility assessment and LCA results. Four different methods were used to weight the criteria. Two forms of equal weighting were applied: Equ$_1$, where all criteria were weighted, and Equ$_2$, where categories were weighted equally, with all criteria within a given category receiving equal weight. Additionally, the entropy weighting method (EWM) was used following the methodology outlined by Zhu et al. (Zhu, et al., 2020), along with a novel combined method (Comb), in which criteria were weighted using the EWM within their respective categories, while all categories were weighted equally. The EWM was selected because it provides a purely mathematical approach to determining criteria weights based on the spread of collected data, thereby minimizing decision-maker biases. A summary of the criteria and their weights is shown in Table 1.

Table 1. Summary of MCDA criteria and their weights.

Criteria	Equ$_1$	Equ$_2$	EWM	Comb
Climate change (LCA data)				
Global warming (GWP)	0.0385	0.1429	0.0374	0.1429
Ecosystem quality (LCA data)				
Terrestrial acidification (TAP)	0.0385	0.0159	0.0383	0.0152
Freshwater ecotoxicity (FETP)			0.0367	0.0162
Marine ecotoxicity (METP)			0.0379	0.0159
Terrestrial ecotoxicity (TETP)			0.0364	0.0152
Freshwater eutrophication (FEP)			0.0389	0.0156
Marine eutrophication (MEP)			0.0382	0.0186
Land occupation (LOP)			0.0364	0.0153
Ozone depletion (ODP)			0.0375	0.0152
Ecosystems photochemical oxidant formation (EOFP)			0.0445	0.0156
Economic (Ahire et al., 2024; D'Ascenzo et al., 2024; Han et al., 2019; Klein et al., 2018; Li et al., 2018; Niziolek et al., 2017)				
Cost of production	0.0385	0.0714	0.0366	0.0725
Energy consumption			0.0364	0.0732
Technical (Bashir et al., 2022; Borrill et al., 2024; D'Ascenzo et al., 2024; Erdei, 2010; ICAO, 2024; O'Malley et al., 2021; Pearson et al., 2013)				
Blending limit	0.0385	0.0476	0.0375	0.0444
Technology readiness level			0.0436	0.0548
SAF yield			0.0365	0.0437
Logistical (feasibility data)				
Feed availability	0.0385	0.0476	0.0365	0.0412
Total SAF production			0.0397	0.0519
Feed reliability			0.0367	0.0492
Social (LCA data)				
Carcinogenic human toxicity (HTPc)	0.0385	0.0286	0.0365	0.0278
Non-carcinogenic human toxicity (HTPnc)			0.0438	0.0317
Ionising radiation (IRP)			0.0397	0.0275
Particulate matter formation (PMFP)			0.0442	0.0280
Human health photochemical oxidant formation (HOFP)			0.0372	0.0278
Political (LCA data)				
Surplus ore (SOP)	0.0385	0.0476	0.0391	0.0460
Fossil fuels (FFP)			0.0372	0.0448
Water consumption (WCP)			0.0368	0.0520

For each criterion, quantitative data were sourced from the literature whenever possible. If direct data were unavailable, estimations were made based on literature findings. Three MCDA methods were used to calculate preferences: Analytic Hierarchy Process (AHP), PROMETHEE II with a type III preference function, and TOPSIS. AHP was applied using an online eigenvector calculator, which enabled consistency ratio checking (Cinelli et al., 2014; Goepel, 2022). The TOPSIS (Celikbilek and Tuysuz, 2020) and PROMETEE (Abdullah et al., 2019; Mareschal, 2018) techniques were coded from first principles in Python, following the methodologies outlined in the identified literature. AHP enables hierarchical structuring of criteria, TOPSIS ranks options based on their proximity to an ideal solution, and PROMETHEE provides preference ranking. These methods represent each of the three different categories of MCDA approaches, helping to reduce methodological biases by balancing the strengths and weaknesses of each technique.

4. RESULTS AND DISCUSSION

Table 2 summarises the current production volumes of each identified feedstock and their potential for SAF production. If the entire estimated volume of all the identified feedstocks were fully exploited to produce SAF at the current best practice conversion yields, this could generate around 20% of the UK's jet fuel demand, with the main contributions coming from BMSW and cereal residues. This percentage is significantly higher than the results found by O'Malley et al. due to the different locations studied and the significantly different SAF conversion yield used for gasification of MSW (O'Malley, et al., 2021). Since sewage sludge has a comparatively low unused production volume and a very low SAF conversion yield, its contribution to the overall SAF production potential is considered negligible and is therefore excluded from the following analyses.

Figure 1a shows historical UK waste feedstock production, from which prospective values were estimated. The historical data for BMSW sent to landfill were fitted with a logarithmic regression line, yielding an R^2 value of 0.9818, suggesting that BMSW production is accurately predicted. As recycling technologies and environmental awareness have improved over time, the UK's annual production of BMSW has declined and is expected to continue decreasing. Therefore, although this feedstock is currently the most abundant, provisions must be made to account for future reductions in availability to ensure supply-chain resilience. Agricultural yields are inherently difficult to predict due to their dependence on favourable weather conditions and potential losses from diseases. The historical data for total cereal residues from waste grain, chaff, and unharvested straw were fitted with a linear regression. Due to the large annual fluctuation in yields and area harvested, this yielded an R^2 value of 0.0145, indicating that cereal residue production is likely to be a highly variable feedstock source. For scale-up, it is likely that technological capabilities for using mixed feedstocks will be necessary. The historical data for non-recycled waste were fitted with a logarithmic regression, yielding an R^2 value of 0.4111. Data for total wood waste provided an R^2 value of 0.9408, indicating that these data are more accurately predicted than wood recycling rate. The predicted trend shows a gradual increase over time. It should be noted that further investigation is needed to determine whether the current uses of these feedstocks are advantageous or disadvantageous compared to diverting these wastes into SAF production.

Table 2. UK feedstock production (in thousand tonnes) for the year 2022/3, maximum mass-based SAF conversion yields, maximum potential SAF production, and percentage of UK jet fuel demand.

Feed	Feed prod. (kt)	Max yield	Max SAF (kt)	UK jet (%)	Data source
B MSW	6,310	0.31	1,956	13.0	DEFRA, 2024b; ICAO, 2024; O'Malley et al., 2021
Cereal res.	4,017	0.25	1,004	6.65	AHDB 2024; DEFRA 2024a; Erdei, 2010; ICAO, 2024; O'Malley et al., 2021; Quaker, 2019
FOGs	142	0.90	128	0.85	Collin et al., 2020, 2022; ICAO, 2024; O'Malley et al., 2021; Pearson et al., 2013
Waste wood	100	0.23	23	0.15	Community wood recycling, 2024; ICAO, 2024; O'Malley et al., 2021
Sewage sludge	50.8	0.015	0.76	0.01	Bashir et al., 2022; DEFRA, 2002, 2022; Environment Agency, 2024
Total	10,620	-	3,112	20.6	

Figure 1b shows that the total potential SAF production from waste materials is likely to decrease over time without significant improvements in SAF conversion yields, while our jet fuel usage continues to increase. Therefore, the development of other second- and third-generation feedstock supply-chains that do not compete with food production is of high importance in achieving our Jet Zero targets.

MSW-GFT, FOG-HEFA, straw-FP, and wood-GFT led to reductions in GWP compared to the fossil jet fuel benchmark of 89 gCO_{2eq}/MJ (Vardon et al., 2022), with reductions of 94.9%, 90.0%, 91.1%, and 90.4%, respectively. Figure 2 shows that FOG-HEFA and MSW-GFT generally result in higher environmental impact category values than straw-FP. The gasification and pyrolysis steps generally account for the highest proportion of emissions in the SAF production process due to the direct emissions of CO_2. FOG-HEFA showed the highest GWP due to its reliance on methane and electricity for the SAF conversion process.

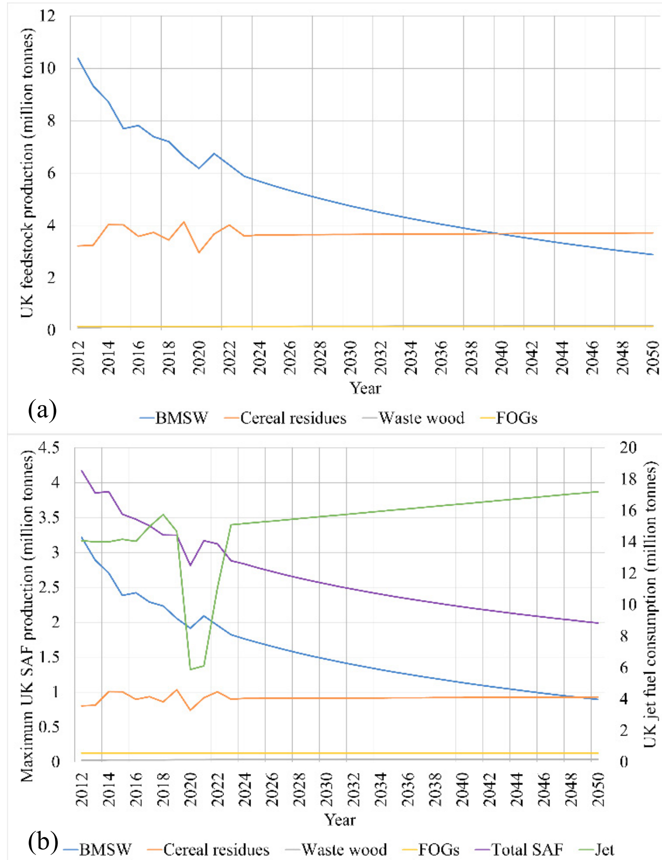

Figure 1. Prospective UK production of (a) waste-based feedstocks and (b) maximum potential SAF production and jet fuel demand.

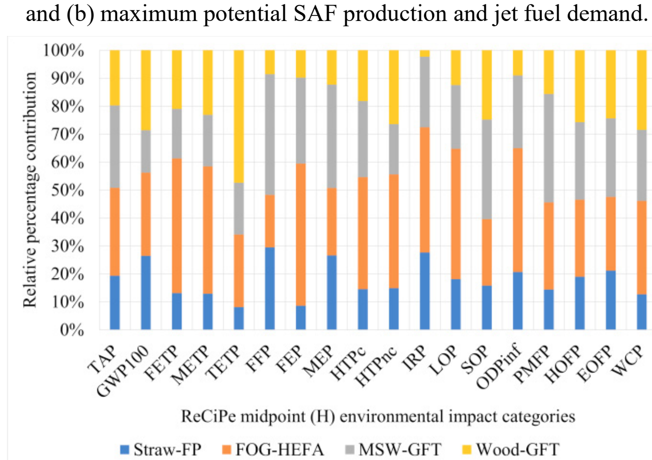

Figure 2. Preliminary LCA results of relative percentage contribution to each environmental impact category.

Figure 3 shows the preliminary MCDA results calculated using the AHP, TOPSIS, and PROMETHEE methods with each weighting distribution. The rankings from all methods agree that the use of FOGs in HEFA production is the least preferable pathway. The use of cereal residues and waste wood generally provide relatively similar scores across all methodologies; however, cereal residues are ranked higher than waste wood in 10 out of the 12 methods. The TOPSIS method determines that MSW is the most preferable option for all weighting methods, whereas the results from AHP and PROMETHEE vary. The Equ_2 and Comb weighting methods tend to yield higher rankings for MSW, likely because these methods place a much higher weighting on GWP than Equ_1 or EWM, as GWP is the only criterion in the climate change category. For the Equ_1 and EWM methods, there is a high level of variability in the ranking of MSW, as it is ranked first by TOPSIS, second by PROMETHEE, and third by AHP. These results highlight the importance of the choice of methodology in conducting MCDA.

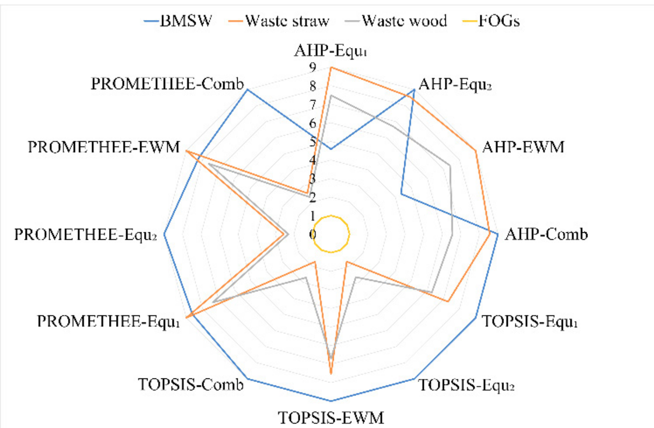

Figure 3. Preliminary MCDA results for the use of BMSW, waste straw, waste wood, and FOGs in SAF production.

6. CONCLUSION

This work implemented three analytical methods to evaluate supply-chain resilience, sustainability, and decision-maker preferences: prospective feasibility assessment, LCA, and MCDA, in a novel UK-focussed multidisciplinary study. BMSW has the highest SAF potential but is declining, while cereal residues, the second most abundant, have unpredictable availability. Optimizing their use and developing second- and third-generation supply-chains is crucial to ensure SAF supply-chain resilience. A cradle-to-grave LCA on MSW-GFT, FOG-HEFA, straw-FP, and wood-GFT yielded results agreeing with those found in the literature, showing at least 90% reductions in GWP compared to fossil jet fuel, with BMSW yielding the lowest value. AHP, TOPSIS, and PROMETHEE MCDA methods were applied with four different weighting distributions to assess the SAF production pathways across 26 multidisciplinary criteria. FOG-HEFA consistently ranked lowest, waste straw and wood had similar scores in second and third, and BMSW generally ranked highest. Future work will focus on applying these methodologies to a wider range of SAF conversion technologies and collecting a broader dataset for MCDA calculations across a wider range of criteria.

ACKNOWLEDGEMENTS

The authors declare that financial support was received for the research, authorship, and publication of this article. The authors would like to acknowledge EPSRC for the funding support of the research project (Grant Ref: EP/W524360/1).

REFERENCES

Abdullah, L., Chan, W. & Afshari, A. (2019). Application of PROMETHEE method for green supplier selection: a comparative result based on preference functions. *Journal of Industrial Engineering International*, Volume 15, pp. 271-285.

AHDB (2024). Knowledge library. [Online] Available at: ahdb.org.uk [Accessed 01 12 2024].

Ahire, J.P. et al. (2024). Techno-economic and environmental impacts assessments of sustainable aviation fuel production from forest residues. *Sustainable Energy & Fuels*, 8(19), pp. 4602-4616.

Anwar, M. (2021). Biodiesel feedstocks selection strategies based on economic, technical, and sustainable aspects. *Fuel*, 283(119204).

Anwar, M., Rasul, M.G. & Ashwath, N. (2019). The efficacy of multiple-criteria design matrix for biodiesel feedstock selection. *Energy Conversion and Management*, 198(111790).

Bashir, M.A. et al. (2022). A step change towards sustainable aviation fuel from sewage sludge. *Journal of Analytical and Applied Pyrolysis*, 163(105498).

Bauen, A. et al. (2020). Sustainable Aviation Fuels : Status, challenges and prospects of drop-in liquid fuels, hydrogen and electrification in aviation. *Johnson Matthey Technology Review*, 64(3), pp. 263-278.

Borrill, E., Koh, S.C.L. & Yuan, R. (2024). Review of technological developments and LCA applications on biobased SAF conversion processes. *Frontiers in Fuels*, Volume 2.

Celikbilek, Y. & Tuysuz, F. (2020). An in-depth review of theory of the TOPSIS method: An experimental analysis. *Journal of Management Analytics*, 7(2), pp. 281-300.

Chen, P.H. et al. (2024). Life-cycle analysis of sustainable aviation fuel production through catalytic hydrothermolysis. *Biofuels, Bioproducts and Biorefining*, 18(1), pp. 42-54.

Cinelli, M., Coles, S.R. & Kirwan, K. (2014). Analysis of the potentials of multi criteria decision analysis methods to conduct sustainability assessment. *Ecological Indicators*, Volume 46, pp. 138-148.

Collin, T. et al. (2022). Energy potential of household fats, oils and grease waste. *Water and Environment Journal*, 36(1), pp. 132-141.

Collin, T., Cunningham, R., Jefferson, B. & Villa, R. (2020). Characterisation and energy assessment of fats, oils and greases (FOG) waste at catchment level. *Waste Management*, Volume 103, pp. 399-406.

Community wood recycling (2024). Recycling wood in the UK. [Online] Available at: communitywoodrecycling.org.uk [Accessed 01 12 2024].

D'Ascenzo, F. et al. (2024). Comparative Life Cycle Assessment of Sustainable Aviation Fuel Production from Different Biomasses. *Sustainability*, 16(16).

De Souza Deuber, R. et al. (2023). Production of Sustainable Aviation Fuels from Lignocellulosic Residues in Brazil through Hydrothermal Liquefaction: Techno-Economic and Environmental Assessments. *Energies*, 16(6), p. 2723.

DEFRA (2002). Sewage Treatment in the UK UK Implementation of the EC Urban Waste Water Treatment Directive. [Online] Available at: assets.publishing.service.gov.uk

DEFRA (2022). Wastewater treatment in England: data for 2020. [Online] Available at: https://www.gov.uk/government/publications/wastewater-treatment-in-england/wastewater-treatment-in-england-data-for-2020 [Accessed 01 12 2024].

DEFRA (2024a). Chapter 7: Crops. [Online] Available at: https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs [Accessed 01 12 2024].

DEFRA (2024b). UK statistics on waste. [Online] Available at: https://www.gov.uk/government/statistics/uk-waste-data/uk-statistics-on-waste [Accessed 01 12 2024].

Department for Transport (2024). Pathway to net zero aviation: Developing the UK sustainable aviation fuel mandate. [Online] Available at: www.gov.uk [Accessed 31 08 2024].

Environment Agency (2024). Water and sewerage companies in England: environmental performance reports 2017-2023. [Online] Available at: www.gov.uk

Erdei, B. et al. (2010). Ethanol production from mixtures of wheat straw and wheat meal. *Biotechnology for Biofuels*, 3(16).

Goepel, K. D. (2022). AHP Priority Calculator. [Online] Available at: bpmsg.com [Accessed 2024].

Han, D., Yang, X., Li, R. & Wu, Y. (2019). Environmental impact comparison of typical and resource-efficient biomass fast pyrolysis systems based on LCA and Aspen Plus simulation. *Journal of Cleaner Production*, Volume 231, pp. 254-267.

IATA (2025). Global Air Passenger Demand Reaches Record High in 2024. [Online] Available at: www.iata.org [Accessed 17 02 2025].

Klein, B. C. et al. (2018). Techno-economic and environmental assessment of renewable jet fuel production in integrated Brazilian sugarcane biorefineries. *Applied Energy*, Volume 209, pp. 290-305.

Klöwer, M. et al. (2021). Quantifying aviation’s contribution to global warming. *Environmental Research Letters*, 16(104027).

Li, X., Mupondwa, E. & Tabil, L. (2018). Technoeconomic analysis of biojet fuel production from camelina at commercial scale: Case of Canadian Prairies. *Bioresource Technology*, Volume 249, pp. 196-205.

Mahmud, S. et al. (2022). Bioethanol and biodiesel blended fuels — Feasibility analysis of biofuel feedstocks in Bangladesh. *Energy Reports*, Volume 8, pp. 1741-1756.

Mareschal, B. (2018). Preference functions and thresholds. [Online] Available at: bertrand.mareschal.web.ulb.be.

Mendes De Souza, L. M. P. A. & Aranda, D. A. (2020). Oleaginous feedstocks for hydro-processed esters and fatty acids (HEFA) biojet production in southeastern Brazil: A multi-criteria decision analysis. *Renewable Energy*, Volume 149, pp. 1339-1351.

Mofijur, M. et al. (2023). Screening of non-edible (second-generation) feedstocks for the production of sustainable aviation fuel. *Fuel*, 331(125879).

Mofijur, M. et al. (2022). Selection of microalgae strains for sustainable production of aviation biofuel. *Bioresource Technology*, 345(126408).

Niziolek, A. M., Onel, O. & Floudas, C. A. (2017). Municipal solid waste to liquid transportation fuels, olefins, and aromatics: Process synthesis and deterministic global optimization. *Computers & Chemical Engineering*, Volume 102, pp. 169-187.

Oehmichen, K., Majer, S., Müller-Langer, F. & Thrän, D. (2022). Comprehensive LCA of Biobased Sustainable Aviation Fuels and JET A-1 Multiblend. *Applied Sciences*, 25 03.12(7).

O'Malley, J., Pavlenko, N. & Searle, S. (2021). Estimating sustainable aviation fuel feedstock availability to meet growing European Union demand, s.l.: *International Council on Clean Transportation*.

Pearson, R., Coe, A. & Paterson, J. (2021). Innovation in Fischer-Tropsch: A Sustainable Approach to Fuels Production. *Johnson Matthey Technology Review*, 65(3), pp. 395-403.

Quaker (2019). Oat growth guide. [Online] Available at: www.hutton.ac.uk

Rojas-Michaga, M. F. et al. (2023). Sustainable aviation fuel (SAF) production through power-to-liquid (PtL): A combined techno-economic and life cycle assessment. *Energy Conversion and Management*, 292(117427).

Tanzil, A. H. et al. (2021). Production of Sustainable Aviation Fuels in Petroleum Refineries: Evaluation of New Bio-Refinery Concepts. *Frontiers in Energy Research*, 9(735661).

Vardon, D. R. et al. (2022). Realizing "net-zero-carbon" sustainable aviation fuel. *Joule Future Energy*, Volume 6, pp. 16-21.

Whittle, J. et al. (2024). A new high-level life cycle assessment framework for evaluating environmental performance: An aviation case study. *Journal of Cleaner Production*, 471(143440).

Zhang, L. et al. (2024). Sustainable jet fuel from municipal solid waste–Investigation of carbon negativity and affordability claims. *Resources, Conservation and Recycling*, 210(107819).

Zhu, Y., Tian, D. & Yan, F. (2020). Effectiveness of Entropy Weight Method in Decision-Making. *Mathematical Problems in Engineering*, Volume 7, pp. 1-5.