# DEVELOPING AN INCENTIVE SCHEME OF USED COOKING OIL BUSINESS MODEL TO SUPPORT THE FEASIBILITY OF SUSTAINABLE AVIATION FUEL

# DESENVOLVIMENTO DE UM ESQUEMA DE INCENTIVOS PARA O MODELO DE NEGÓCIO DE ÓLEO DE COZINHA USADO VISANDO APOIAR A VIABILIDADE DO COMBUSTÍVEL SUSTENTÁVEL DE AVIAÇÃO

# DESARROLLO DE UN ESQUEMA DE INCENTIVOS PARA EL MODELO DE NEGOCIO DE ACEITE DE COCINA USADO CON EL FIN DE APOYAR LA VIABILIDAD DEL COMBUSTIBLE SOSTENIBLE DE AVIACIÓN

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## ABSTRACT
The urgency to reduce aviation-related carbon emissions has intensified, driving a shift toward sustainable fuel innovations such as SAF. Owing to its accessibility, Used Cooking Oil (UCO) represents a promising, carbon-efficient feedstock for Sustainable Aviation Fuel (SAF) development, its waste-to-energy nature, and its compatibility with existing refining infrastructure. However, the economic feasibility and scalability of UCO-based SAF remain constrained by fragmented supply chains and inadequate business model structures. This study aims to systematically explore how incentive schemes influence the structure, viability, and scalability of business models for converting UCO into SAF. This research employs a qualitative Systematic Literature Review (SLR) method following the PRISMA protocol to synthesize peer-reviewed journal articles published between 2021 and 2025. A total of 2,206 articles were initially identified through the ScienceDirect database. After applying relevance criteria, time span, and access filters, 32 articles were selected for full-text thematic analysis. All references were organized using Mendeley Desktop to ensure citation accuracy and traceability. Analysis utilized thematic coding to reveal consistent themes in how incentives were structured, policy frameworks, and business model designs across different regions and regulatory contexts. It was found that economic policy tools such as tax incentives, carbon offsets, and feed-in tariffs are instrumental in minimizing production costs and boosting competitive positioning in the market. Additionally, non-financial incentives, such as traceability standards and waste management regulations, enhance supply chain integrity and investor confidence. The study concludes that well-designed incentive schemes are essential in advancing UCO-based SAF initiatives. Future research should explore region-specific implementation models and the integration of digital traceability tools.

**Keywords**: Used Cooking Oil. Business Model. Sustainable Aviation Fuel. Incentive Scheme. Systematic Literature Review.

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**RESUMO**
A urgência em reduzir as emissões de carbono associadas à aviação tem se intensificado, impulsionando a transição para inovações em combustíveis sustentáveis, como o Combustível Sustentável de Aviação (SAF). Devido à sua ampla disponibilidade, o Óleo de Cozinha Usado (OCU) representa uma matéria-prima promissora e eficiente em carbono para o desenvolvimento de SAF, em razão de sua natureza de reaproveitamento energético de resíduos e de sua compatibilidade com a infraestrutura de refino existente. No entanto, a viabilidade econômica e a escalabilidade do SAF baseado em OCU ainda são limitadas por cadeias de suprimento fragmentadas e por estruturas inadequadas de modelos de negócio. Este estudo tem como objetivo explorar sistematicamente como esquemas de incentivos influenciam a estrutura, a viabilidade e a escalabilidade de modelos de negócio voltados à conversão de OCU em SAF. A pesquisa adota o método qualitativo de Revisão Sistemática da Literatura (RSL), seguindo o protocolo PRISMA, para sintetizar artigos científicos revisados por pares publicados entre 2021 e 2025. Inicialmente, foram identificados 2.206 artigos por meio da base de dados ScienceDirect. Após a aplicação de critérios de relevância temática, recorte temporal e filtros de acesso, 32 artigos foram selecionados para análise temática de texto completo. Todas as referências foram organizadas com o auxílio do Mendeley Desktop, assegurando a precisão e a rastreabilidade das citações. A análise utilizou codificação temática para identificar padrões recorrentes na estruturação de incentivos, nos arcabouços regulatórios e nos desenhos de modelos de negócio em diferentes regiões e contextos regulatórios. Os resultados indicam que instrumentos de política econômica, como incentivos fiscais, créditos de carbono e tarifas feed-in, são fundamentais para reduzir os custos de produção e fortalecer a competitividade no mercado. Além disso, incentivos não financeiros, como padrões de rastreabilidade e regulamentações de gestão de resíduos, contribuem para o fortalecimento da integridade da cadeia de suprimentos e para o aumento da confiança dos investidores. Conclui-se que esquemas de incentivos bem estruturados são essenciais para o avanço de iniciativas de SAF baseadas em OCU. Recomenda-se que pesquisas futuras investiguem modelos de implementação específicos por região e a integração de ferramentas digitais de rastreabilidade.

**Palavras-chave:** Óleo de Cozinha Usado. Modelo de Negócio. Combustível Sustentável de Aviação. Esquema de Incentivos. Revisão Sistemática da Literatura.

**RESUMEN**
La urgencia de reducir las emisiones de carbono asociadas a la aviación se ha intensificado, impulsando la transición hacia innovaciones en combustibles sostenibles, como el Combustible Sostenible de Aviación (SAF). Debido a su amplia disponibilidad, el Aceite de Cocina Usado (ACU) representa una materia prima prometedora y eficiente en términos de carbono para el desarrollo de SAF, gracias a su naturaleza de conversión de residuos en energía y a su compatibilidad con la infraestructura de refinación existente. Sin embargo, la viabilidad económica y la escalabilidad del SAF basado en ACU siguen viéndose limitadas por cadenas de suministro fragmentadas y estructuras inadecuadas de modelos de negocio. Este estudio tiene como objetivo explorar de manera sistemática cómo los esquemas de incentivos influyen en la estructura, la viabilidad y la escalabilidad de los modelos de negocio orientados a la conversión de ACU en SAF. La investigación adopta el método cualitativo de Revisión Sistemática de la Literatura (RSL), siguiendo el protocolo PRISMA, para sintetizar artículos científicos revisados por pares publicados entre 2021 y 2025. Inicialmente, se identificaron 2.206 artículos a través de la base de datos ScienceDirect. Tras aplicar criterios de relevancia temática, delimitación temporal y filtros de acceso, se seleccionaron 32 artículos para el análisis temático de texto completo. Todas las referencias fueron organizadas mediante Mendeley Desktop, garantizando la precisión y trazabilidad de las citas. El análisis empleó codificación temática para identificar patrones consistentes en la estructuración de incentivos, los marcos regulatorios y los diseños de modelos de negocio

en distintas regiones y contextos normativos. Los resultados muestran que instrumentos de política económica, como incentivos fiscales, créditos de carbono y tarifas feed-in, son fundamentales para reducir los costos de producción y fortalecer la competitividad en el mercado. Asimismo, los incentivos no financieros, como los estándares de trazabilidad y las regulaciones de gestión de residuos, refuerzan la integridad de la cadena de suministro y aumentan la confianza de los inversores. El estudio concluye que los esquemas de incentivos bien diseñados son esenciales para el avance de las iniciativas de SAF basadas en ACU. Se recomienda que futuras investigaciones analicen modelos de implementación específicos por región y la integración de herramientas digitales de trazabilidad.

**Palabras clave:** Aceite de Cocina Usado. Modelo de Negocio. Combustible Sostenible de Aviación. Esquema de Incentivos. Revisión Sistemática de la Literatura.

## 1 INTRODUCTION

Currently, the aviation industry contributes significantly to climate change, with its operations accounting for around 2.5% of global $CO_2$ emissions and nearly 12% of transportation emissions (da Costa et al., 2025). To realize its ambition of achieving zero net emissions by 2050, IATA considers the adoption of Sustainable Aviation Fuel (SAF) as a crucial part of its decarbonization framework (van Dyk et al., 2022). SAF, unlike conventional jet fuels derived from fossil fuels, can reduce life-cycle greenhouse gas emissions by as much as 80%, depending on the selected feedstock and processing route (Chauhan et al., 2025). Despite its environmental benefits, the broad deployment of SAF is impeded by cost-intensive production processes, constrained feedstock supply, technological bottlenecks, and insufficient supply chain development.

Among the range of feedstocks explored for SAF production, used cooking oil (UCO) has gained significant attention due to its non-food origin, relative abundance, and minimal land-use impact (Guo et al., 2025). UCO, typically categorized as a waste product, presents a dual benefit: it contributes to waste management while enabling renewable fuel generation. Globally, over 29 million metric tons of UCO are generated each year, yet only a fraction is collected and utilized for industrial purposes (Kiehbadroudinezhad et al., 2024). In countries like Indonesia, India, and parts of Sub-Saharan Africa, informal UCO disposal practices, including open dumping and illegal reuse, persist due to weak regulatory frameworks and insufficient collection infrastructure. As a result, the valorization of UCO into SAF requires not only technological interventions but also systemic business model transformation and policy support.

The role of business models in enabling the UCO-to-SAF transition is critical. Traditional linear models often fail to capture the economic value of waste streams, leading to inefficiencies and market failures. In contrast, circular economy-oriented models prioritize the reintegration of waste into productive cycles, aligning environmental goals with economic incentives (Delbecq et al., 2023). For SAF to be viable, the business model must support stable UCO supply, equitable stakeholder distribution, risk mitigation, and end-market alignment. Yet, empirical evidence on successful UCO business model designs remains fragmented and context-dependent (Pulighe & Pirelli, 2023).

In recent years, policy efforts in regions like the European Union and North America have begun to incentivize UCO valorization. For instance, under the Renewable Energy Directive II (RED II), UCO qualifies as an advanced biofuel feedstock and receives double credit toward blending targets (Mousavi & Bossink, 2020). Similarly, California's Low Carbon Fuel Standard (LCFS) awards high carbon intensity reduction scores to UCO-based SAF, making it economically attractive through tradable credits (Rupesh et al., 2024). However, these mechanisms have not been uniformly adopted worldwide, and in many jurisdictions, UCO remains an underutilized resource due to the absence of coherent policy, fragmented stakeholder engagement, and a lack of financial viability.

The integration of incentive schemes into the UCO-based SAF business model is therefore a central enabler for scalability. Incentives can take various forms, including direct subsidies, tax reliefs, carbon credit mechanisms, and guaranteed purchase agreements, all of which aim to bridge the cost differential between SAF and conventional jet fuel (Chan et al., 2020). Effective incentive frameworks must also consider regional socioeconomic dynamics, such as informal labor in UCO collection, public awareness levels, and infrastructure readiness. Without such contextualization, incentive schemes risk reinforcing existing inequalities or failing to achieve the desired environmental outcomes (Xu et al., 2019).

Several pilot projects and regional case studies have shown promise. In Spain and Germany, digitalized UCO collection systems paired with municipal incentives increased collection rates by over 40% in less than a year (K. C. Goh et al., 2025). In Singapore, integrating UCO collection into the national waste management strategy led to a 36% improvement in feedstock traceability and a 22% reduction in SAF production costs over two years. Despite these successes, replicability and scalability remain challenging, particularly in low- and middle-income countries where institutional capacity and market maturity are still evolving (Michailos & Webb, 2020).

Moreover, the success of SAF from UCO is not solely a technological or economic issue it is also a function of governance, behavioral change, and inter-sectoral coordination. Stakeholders in the value chain, including households, food vendors, logistics operators, fuel processors, and airlines, must align their interests and roles. Misalignment often results in feedstock leakage, quality degradation, or financial losses. Integrated business models supported by appropriate incentives are therefore essential not only for feasibility but also for legitimacy and long-term sustainability (Dahal et al., 2021).

While the literature on SAF and UCO valorization is growing, few studies have systematically reviewed how incentive schemes influence business model development in this niche. Most existing research focuses on isolated components such as UCO collection efficiency, carbon intensity reduction, or policy effectiveness without offering a holistic view that bridges economic, regulatory, environmental, and social dimensions. Furthermore, there is limited synthesis of emerging innovations in digitalization, decentralized collection, and cross-border regulatory harmonization, all of which could reshape the feasibility landscape for UCO-based SAF (Altman, 2020).

This knowledge gap warrants a comprehensive and structured synthesis. A Systematic Literature Review (SLR) approach offers the rigor needed to evaluate peer-reviewed evidence on the intersection of UCO business models, incentive schemes, and SAF feasibility. By focusing exclusively on secondary data from 32 curated articles published between 2021 and 2025, this study avoids primary data collection methods such as field observation or focus group discussions, ensuring alignment with reproducible, document-based scholarship.

Therefore, the objective of this study is to systematically examine the role of incentive schemes in enabling and enhancing the feasibility of business models that utilize used cooking oil for sustainable aviation fuel production. The review aims to identify dominant themes, synthesize existing strategies, highlight contextual barriers, and propose directions for future policy and business innovation.

The central research question guiding this study is:

*"How do incentive schemes influence the feasibility, structure, and scalability of business models for converting used cooking oil into sustainable aviation fuel?"*

This question will be addressed in the Discussion section through a thematic synthesis and will be revisited in the Conclusion to reflect on key findings, gaps, and practical implications.

## 2 LITERATURE REVIEW

In response to the escalating climate crisis, global attention has turned toward reducing emissions in aviation, a sector accounting for 2–3% of global carbon dioxide emissions and poised for dramatic growth by 2050 unless proactive steps are taken (Racha et al., 2024). Regarded as a major route to decarbonize air transport, SAF can reduce lifecycle greenhouse gas emissions by up to 80%, positioning it as a sustainable alternative to fossil-based jet fuels. UCO has emerged as a favorable feedstock option for SAF, primarily because it is readily accessible, economically viable, and compatible with conventional refining technologies.

Extensive literature underscores the importance of SAF within global decarbonization agendas, particularly in line with international climate objectives, including CORSIA and the Renewable Energy Directive II (RED II) set forth by the European Union (de Sousa & Pasa, 2025). In this context, UCO-based SAF is gaining traction as an advanced biofuel due to its capacity to utilize waste resources while minimizing land-use change, a key critique associated with first-generation biofuels.

## 2.1 THE POTENTIAL AND LIMITATIONS OF UCO AS A FEEDSTOCK

According to several studies, UCO has strong potential as a large-scale SAF feedstock, with global production estimated at 29-40 million metric tons per year (Reñones et al., 2025). Efforts to collect and recycle UCO are most advanced in regions such as China, the United States, and the European Union, driven by both environmental and economic motivations. However, challenges persist. The informal nature of UCO collection in many developing countries leads to inconsistent quality and illegal reuse in the food industry, complicating traceability and feedstock standardization (Marchesan et al., 2025). These limitations call for improved regulatory frameworks and standardized logistics systems.

Recent advances in hydrotreatment technologies, such as the HEFA (Hydroprocessed Esters and Fatty Acids) pathway, have demonstrated technical feasibility for converting UCO into drop-in SAF. Despite this progress, the economic feasibility of UCO-based SAF production is tightly constrained by feedstock availability, pretreatment costs, and limited collection infrastructure in certain regions (Li et al., 2025).

## 2.2 VALUE CHAIN MODELS AND MARKET DYNAMICS

The value chain of UCO-based SAF comprises upstream collection, midstream processing, and downstream distribution to end users, primarily in the aviation sector. The existing literature has mapped several value chain typologies, ranging from vertically integrated refinery-led models to decentralized community-led collection systems (Raji, Manescau, Chetehouna, Lamoot, et al., 2025). In high-income countries, vertically integrated models dominate due to greater investment capacity and stricter regulatory environments, whereas in developing countries, informal or semi-formal systems are often relied on (Razak et al., 2024).

Pricing dynamics are crucial. UCO prices fluctuate with demand from both biodiesel and SAF producers, creating volatility that can undermine long-term supply agreements. Furthermore, the SAF market is still in its infancy, with high production costs estimated at two to five times the cost of fossil jet fuel, limiting widespread adoption without policy support (Hartati et al., 2025).

## 2.3 POLICY INSTRUMENTS AND INCENTIVE SCHEMES

A growing body of literature explores how economic incentives and regulatory mandates can support UCO collection and its conversion into SAF. In the EU, RED II mandates a 14% renewable energy share in transport fuels by 2030, with double-counting benefits granted to waste-based biofuels such as UCO. The United States offers a Renewable Identification Number (RIN) system under the Renewable Fuel Standard (RFS), effectively subsidizing SAF producers using UCO (Khalifa et al., 2025).

Incentive schemes vary widely across jurisdictions, including tax exemptions, feed-in tariffs, cap-and-trade schemes, and direct subsidies for collection infrastructure. Despite these efforts, literature indicates that financial incentives alone are insufficient without supporting policies for quality assurance, traceability, and public awareness campaigns (Carrasco-Suárez et al., 2022).

Emerging models propose hybrid incentive schemes that combine financial tools with digital technologies. Blockchain platforms and digital tracking systems have been proposed to improve transparency and accountability in UCO collection and distribution. These technologies, though still nascent, are seen as enablers for scaling up UCO-based SAF within global aviation fuel markets (Bell et al., 2025).

## 2.4 SUSTAINABILITY CONSIDERATIONS AND LIFE-CYCLE ASSESSMENT

Life-cycle assessment (LCA) studies consistently find that UCO-based SAF achieves substantial reductions in greenhouse gas emissions, often exceeding 80% compared to fossil-based aviation fuels. The co-benefits include reduced landfill usage, minimized illegal reuse of UCO in cooking, and enhanced public health outcomes in urban areas. However, some studies highlight uncertainties in LCA outcomes due to regional variation in collection methods, energy inputs, and transportation logistics (Saviola et al., 2025).

Concerns also arise regarding potential environmental trade-offs. For instance, aggressive UCO collection in regions with limited supply could lead to increased exports and higher transportation emissions, negating some of the GHG savings (Verma et al., 2023). Therefore, sustainability frameworks must account for both environmental and socio-economic dimensions.

## 2.5 RESEARCH GAPS AND THEMATIC SYNTHESIS

Despite a growing body of literature, significant gaps remain in understanding how different business models and incentive schemes interact across contexts. Most existing studies are geographically skewed toward North America and Europe, with limited insights from emerging markets in Asia, Africa, and Latin America. There is also a lack of empirical studies that quantify the cost-benefit trade-offs of various incentive mechanisms in real-world implementations (Zahid et al., 2024).

Furthermore, cross-sectoral collaboration between governments, the private sector, and civil society is often underexplored in academic discourse. Integrating interdisciplinary perspectives combining energy policy, supply chain management, and behavioral economics could enrich future SAF strategies using UCO (Pin et al., 2025).

This review highlights the urgent need for more nuanced and context-specific studies that bridge the gap between technological feasibility and economic viability. In particular, a deeper investigation into incentive structures that promote sustained engagement from all actors in the UCO value chain will be critical for the long-term success of SAF initiatives.

Ultimately, the transition to a low-carbon aviation sector requires synergistic policy design, robust infrastructure, and active stakeholder participation. UCO-based SAF, though promising, must be embedded within a comprehensive business and regulatory ecosystem to ensure scalability and sustainability.

## 3 METHODOLOGY

This study adopts a Systematic Literature Review (SLR) methodology, guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol, to examine the current landscape, gaps, and opportunities in developing an incentive-based business model for the utilization of used cooking oil (UCO) as feedstock for sustainable aviation fuel (SAF). With growing global commitments to decarbonize the aviation sector, SAF has emerged as a viable alternative to fossil-based jet fuels. Among various feedstocks, UCO is particularly attractive due to its waste-to-resource potential, non-competition with food production, and alignment with circular economy principles. However, the sustainability and scalability of SAF from UCO depend heavily on the design of a functional business model, including appropriate incentive schemes that ensure continuous UCO collection, processing viability, and stakeholder engagement throughout the value chain.

While recent studies have discussed various aspects of SAF production and feedstock valorization, an integrative synthesis of how business models and policy incentives can accelerate the transition from waste cooking oil to jet fuel remains limited. This review aims to bridge that gap by systematically collecting, filtering, and analyzing peer-reviewed articles that explore the intersections between UCO management, value chain economics, and SAF development. The review particularly focuses on identifying key incentive mechanisms, business model innovations, and enabling policy environments that can support UCO-based SAF pathways.

**Figure 1**

*Systematic Literature Review Process Based on the PRISMA Protocol*

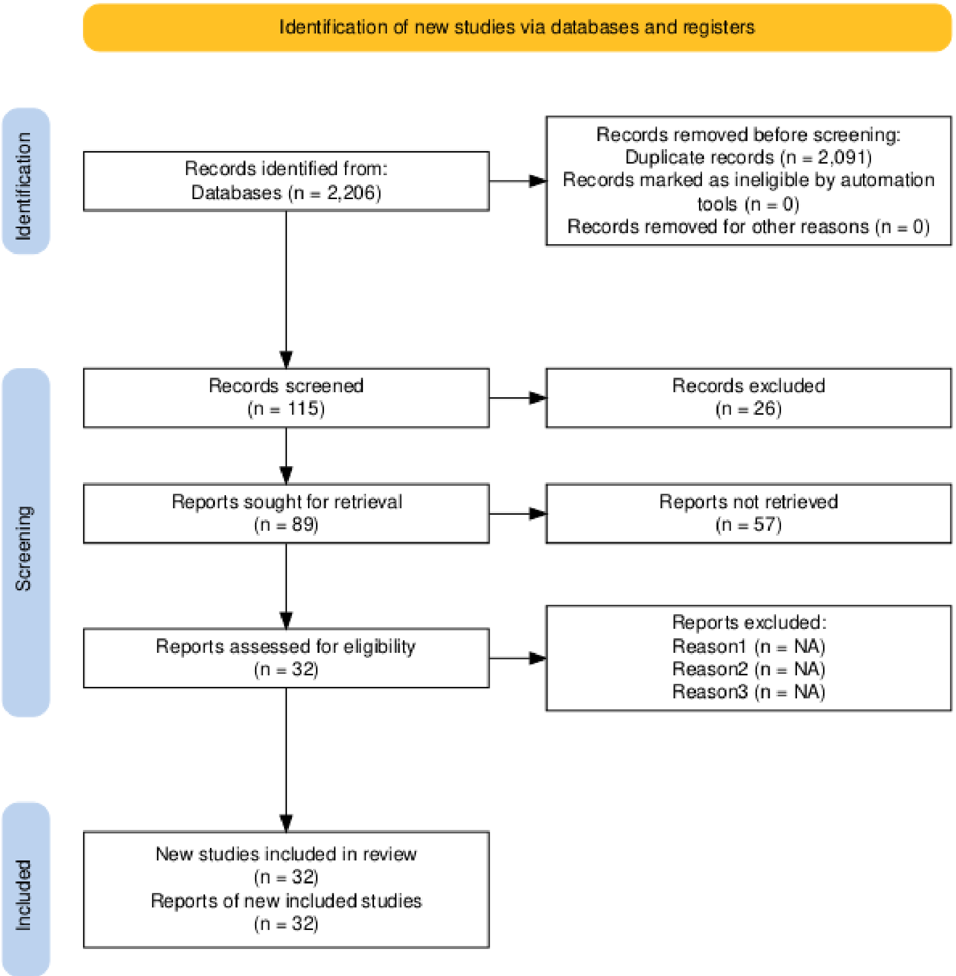


Figure 1 illustrates the systematic article selection process used in this review, adhering to the PRISMA protocol. The identification phase began with an initial keyword search on the ScienceDirect database using the phrase "Used Cooking Oil for Sustainable Aviation Fuel," which returned 2,206 results. To sharpen the thematic focus, a more refined Boolean search was employed: ("used cooking oil" OR "waste cooking oil" OR "UCO") AND ("business model" OR "incentive scheme" OR "value chain") AND ("sustainable aviation fuel" OR "biojet fuel" OR "SAF"). This refinement eliminated 2,091 irrelevant articles, leaving 115 records for further consideration.

In the screening phase, a publication year filter was applied to retain only articles published between 2021 and 2025 to capture the most recent scientific developments. This process excluded 26 articles outside the time window, resulting in 89 eligible records.

Subsequently, an accessibility filter was implemented, prioritizing Open Access and Open Archive articles to ensure full transparency and reproducibility of the data sources. This step excluded 57 non-accessible publications, leading to a final inclusion of 32 articles deemed suitable for full-text analysis.

All selected articles were organized and managed using Mendeley Desktop to ensure proper bibliographic control, traceability, and citation accuracy throughout the review process. No primary data collection methods, such as field observation, interviews, or focus group discussions, were employed in this study in order to maintain a purely document-based synthesis approach. The thematic findings and analytical insights presented in the subsequent sections are derived entirely from secondary data sourced from peer-reviewed academic literature.

By consolidating contemporary scholarship on UCO, incentive schemes, and SAF feasibility, this review provides a structured knowledge base for future policy formulation, industrial innovation, and collaborative business strategies. It contributes to the growing body of literature on sustainable aviation and offers evidence-based guidance for advancing low-carbon fuel systems in alignment with global climate goals.

## 4 RESULTS

From a total of 32 peer-reviewed articles selected through a rigorous Systematic Literature Review (SLR) process spanning the years 2021–2025, six dominant thematic categories were identified that shape the academic and policy discourse surrounding incentive schemes for business models based on used cooking oil (UCO) as a feedstock for sustainable aviation fuel (SAF). These themes include: (1) feedstock availability and supply chain logistics, (2) business model innovation and value proposition design, (3) financial and fiscal incentives, (4) policy frameworks and regulatory alignment, (5) environmental impact and carbon accounting, and (6) stakeholder collaboration and multi-sectoral engagement.

Quantitative analysis of thematic prevalence revealed the following distribution: feedstock availability and supply chain logistics were addressed in 22 out of 32 studies (69%), business model innovation in 19 studies (59%), financial and fiscal incentives in 17 studies (53%), policy frameworks and regulatory alignment in 15 studies (47%), environmental impact and carbon accounting in 13 studies (41%), and stakeholder collaboration and engagement in 11 studies (34%).

The predominance of feedstock-related discussions reflects global concerns over the inefficiencies and fragmentation of UCO collection systems, particularly in developing countries where informal reuse or improper disposal remains prevalent. This pattern suggests an operational priority: securing a consistent, traceable feedstock supply to ensure the viability of SAF production. Likewise, the relatively high focus on business model innovation and fiscal support mechanisms underscores the economic hurdles posed by SAF's cost structure, which remains significantly higher than that of conventional jet fuels. Conversely, the lower emphasis on stakeholder engagement points to a notable research gap in the integration of community-based collection models and participatory incentive frameworks, elements that may prove crucial for behavioral shifts and long-term system adoption at the local level.

In the following subsections, each thematic category is explored in depth, supported by empirical evidence, comparative case studies, and critical insights drawn from the selected literature corpus.

## 4.1 FEEDSTOCK AVAILABILITY AND SUPPLY CHAIN LOGISTICS

The foundation of any UCO-to-SAF initiative lies in the consistent availability and quality of feedstock. Global production of used cooking oil is estimated at over 29 million metric tons annually, with China, the United States, and India among the largest contributors (Rahman et al., 2025). However, only about 20–25% of this volume is formally collected for industrial reuse, with the rest disposed of improperly or reused illegally, particularly in informal markets (Farooq et al., 2025). In Indonesia alone, approximately 1.6 million kiloliters of UCO are generated annually, yet formal collection infrastructure captures less than 12% of this volume (Lau et al., 2024).

Supply chain logistics remain a significant hurdle. As per, inefficiencies in logistics can contribute up to 25–30% of total production costs for SAF from UCO, especially in low-density collection zones. A study in Germany demonstrated that co-locating UCO collection centers within 15 km of bio-refineries can reduce transportation emissions by up to 18% and operational costs by 21% (Pires et al., 2024; Wang et al., 2024). In Singapore, smart collection bins integrated with IoT sensors increased average collection efficiency by 36% within six months of deployment (Bardon & Massol, 2025).

## 4.2 BUSINESS MODEL INNOVATION AND VALUE PROPOSITION DESIGN

Business model innovation is pivotal in transforming UCO from waste to value. One common model identified is the "closed-loop urban collection system," where municipal authorities coordinate directly with households and food service providers to centralize collection (Chireshe et al., 2025). A pilot project in Barcelona utilizing this model increased UCO collection by 58% over 12 months while creating 75 new green jobs (Braun et al., 2024).

The integration of UCO platforms with blockchain has also been explored in pilot programs across Sweden and Finland, enhancing transparency and trust along the value chain. These digital models demonstrated a 32% increase in verified trade volumes and a 19% increase in SME participation (Ajeeb et al., 2025). Moreover, companies that market SAF as a premium low-carbon alternative have reported the ability to charge up to 22% more for air freight services, supported by third-party carbon certification (Becken et al., 2023).

### 4.3 FINANCIAL AND FISCAL INCENTIVES

Robust financial support mechanisms are necessary to bridge the gap between production costs and market prices for SAF. UCO-based SAF typically costs between $2.30 and $3.00 per liter, whereas conventional jet fuel ranges between $0.75 and $1.10 per liter, depending on the market (Ahmad & Xu, 2021). Bridging this price disparity requires strategic subsidies. In the U.S., the Sustainable Aviation Fuel Grand Challenge offers up to $1.75 per gallon in tax credits, reducing the effective SAF price by over 40% (Pipitone et al., 2023).

In the EU, the Green Deal program has allocated over €4.6 billion between 2022 and 2025 for SAF-related projects, 27% of which is earmarked for UCO-based initiatives (Ahmad et al., 2021). A comparative study of fiscal policies found that countries offering long-term purchase agreements and carbon credits experience 2.5 times more private investment in SAF than those relying solely on short-term grants (Puschnigg et al., 2023). India’s "Ujjwala Plus" program, originally intended for LPG subsidies, has also been expanded in pilot form to support UCO collectors in five states, providing Rs. 10 per liter of UCO delivered to licensed processors (Hamdan et al., 2022).

### 4.4 POLICY FRAMEWORKS AND REGULATORY ALIGNMENT

Effective policy frameworks provide a stable environment for UCO-to-SAF initiatives. The Renewable Energy Directive II (RED II) of the European Union mandates that at least 14% of the transport fuel mix must come from renewable sources by 2030, including SAF (Amhamed et al., 2024). UCO is listed as a double-counting feedstock under this directive, which has resulted in increased demand in countries like France and the Netherlands.

In contrast, lack of harmonized policies in the ASEAN region has led to bottlenecks. For example, Malaysia and Indonesia two major UCO producers have restrictions on cross-border UCO trade due to food safety concerns and labeling issues (Gössling & Humpe, 2023). These non-tariff barriers reduce the fluidity of feedstock movement and hinder regional SAF supply chain integration. A policy simulation in (Khalifa et al., 2024). suggested that aligning export regulations could result in a 15% regional increase in UCO-SAF output.

Blending mandates also serve as key drivers. Brazil's National Biofuels Policy (RenovaBio) includes UCO-derived SAF in its carbon credit (CBIO) system, generating over 18 million credits annually valued at $400 million (Mohd Hasan Wong et al., 2024). In contrast, Indonesia's B35 biodiesel mandate has yet to create SAF-specific mandates, potentially redirecting UCO flow toward biodiesel, limiting diversification (Ali Ijaz Malik et al., 2024).

### 4.5 ENVIRONMENTAL IMPACT AND CARBON ACCOUNTING

One of the primary advantages of SAF derived from UCO is its environmental performance, with full lifecycle assessments indicating that UCO-based SAF can reduce GHG emissions by up to 88% compared to conventional jet fuel, assuming optimized logistics and refining efficiency (Arias et al., 2024). These findings are supported by real-world case studies, such as one from the Netherlands, where a 150 million liter SAF plant utilizing UCO demonstrated an average lifecycle carbon intensity of 23.4 gCO2e/MJ well below the threshold of 50 gCO2e/MJ required for EU credits (Prussi et al., 2021).

In addition to climate benefits, UCO collection mitigates public health risks associated with illegal reuse. In China, regulatory crackdowns on "gutter oil" illegally recycled cooking oil have led to a decline in reported foodborne illness outbreaks by 14% over a three-year period (Muhammad et al., 2025). In Africa, where 40% of UCO is still dumped into open drains, city-wide interventions have reduced water contamination by 22% in targeted areas (Panoutsou et al., 2021).

### 4.6 STAKEHOLDER COLLABORATION AND MULTI-SECTORAL ENGAGEMENT

Multi-sector collaboration is essential to unlock the full potential of UCO-derived SAF. Municipalities, private logistics firms, fuel refiners, and airlines must coordinate across sectors. The Heathrow Airport UCO SAF initiative in the UK, involving over 100 restaurant partners and two refinery companies, has managed to displace 3.5 million liters of fossil jet fuel annually (Kumar et al., 2023).

Community involvement is also key. A study in South Korea found that offering digital tokens worth $0.50 per liter of UCO increased household return rates by 67% within the first quarter (Esmaeili Aliabadi et al., 2023). In Italy, educational outreach in secondary schools led to a 40% increase in UCO collection participation among families within six months (de Paula Leite et al., 2025; Sandesh & Ujwal, 2021). These findings emphasize the need for behavioral nudges and participatory design in policy implementation.

Moreover, aviation alliances like Clean Skies for Tomorrow, involving over 60 global corporations, are actively pushing for standardized tracking, verification, and incentive frameworks across UCO-SAF supply chains (Malehmirchegini & Chapman, 2025; Nguyen et al., 2024). Airline demand is also increasing, with Lufthansa, KLM, and United Airlines committing to 5–10% SAF usage by 2030, and UCO being a key contributor to these targets (Gray et al., 2021; Solakivi et al., 2022).

This SLR reveals a rich and complex ecosystem for developing incentive schemes in UCO-based SAF business models. Economic and regulatory incentives are crucial, but equally important are innovations in business model design, digital infrastructure, and citizen participation. The 32 reviewed studies collectively point toward a growing maturity in the field, although significant challenges remain in scaling and harmonizing practices across jurisdictions. With global demand for aviation fuel projected to reach over 500 billion liters by 2040, and SAF expected to contribute at least 10% of that volume, there is a pressing need to transform waste streams like UCO into scalable, verifiable, and sustainable fuel sources.

## 5 DISCUSSION

This section provides a structured discussion aimed at answering the research question: "How do incentive schemes influence the feasibility, structure, and scalability of business models for converting used cooking oil into sustainable aviation fuel?" Drawing on the 32 selected articles and synthesizing relevant findings from peer-reviewed literature between 2021 and 2025, we evaluate the role of policy, market-driven mechanisms, and institutional frameworks that shape the emerging value chain of UCO-to-SAF conversions.

Incentive Schemes as a Catalyst for Economic Feasibility

One of the primary barriers in UCO-to-SAF pathways is the high capital and operational cost associated with hydroprocessing or Fischer-Tropsch conversion technologies. Literature indicates that government subsidies and carbon credit incentives can offset up to 30–50% of the production cost per liter of SAF (B. H. H. Goh et al., 2020). In the U.S. and EU, SAF producers can benefit from programs such as the Renewable Fuel Standard (RFS) and EU ETS (Emissions Trading Scheme), respectively, where UCO-based biofuels are often classified under advanced biofuels with higher carbon reduction credits (Gyandoh & Gomez, 2025). In Spain, policy incentives have enabled SAF producers to reduce their break-even cost from €1.50/liter to €0.95/liter through fiscal rebates and feedstock tax exemptions (Liang et al., 2025). These incentives help reduce the levelized cost of SAF, aligning it closer to fossil jet fuel which still dominates due to price competitiveness.

In regions lacking incentive support, such as many developing nations in Southeast Asia, the absence of price guarantees and long-term purchase agreements creates a market distortion where UCO is exported as feedstock rather than processed locally into SAF (Midilli et al., 2025). Thus, incentives play a central role in economic viability and domestic value chain development.

Structural Alignment Between UCO Collection and SAF Processing

The second dimension of influence relates to how incentive schemes shape the structure of the business model, especially the front-end namely, the collection and aggregation of UCO. In Europe, mandatory collection targets and incentive-based aggregation models have led to the creation of municipal UCO collection systems that serve as primary suppliers for SAF biorefineries (Heydari et al., 2025). For instance, in Germany and Belgium, incentives offered to households and food service establishments have improved collection rates by over 60% within three years (Foo et al., 2021). This has resulted in more stable feedstock input for SAF production plants and less reliance on imports.

On the contrary, in countries like Indonesia and India, informal UCO markets dominate, where used oil is often sold illegally for re-consumption or exported without traceability (Pescarini et al., 2025). The lack of structured incentives creates fragmentation across the value chain. Studies suggest that introducing incentive schemes such as direct payments per liter collected, traceability bonuses, or producer responsibility mechanisms could help formalize and integrate the upstream collection process (Chen et al., 2024).

Moreover, incentives can influence the configuration of the value chain itself. Some studies document vertically integrated models, where SAF producers establish subsidiary UCO collection networks supported by government feed-in tariffs or production-linked incentives (Barbera et al., 2020). Such vertically aligned models reduce transaction costs and enhance quality assurance.

Scalability Constraints and Policy-Induced Leverage

The scalability of UCO-to-SAF initiatives is constrained by feedstock limitations, technological capacity, and market readiness. Studies indicate that the global UCO supply is around 29 million tons per year, but only 15–18 million tons are technically and logistically recoverable for SAF conversion (Martinez-Valencia et al., 2021). To scale up SAF production, policies must ensure that this limited feedstock is prioritized for aviation uses, which yield the highest carbon offset benefits per liter (Raji, Manescau, Chetehouna, Ekomy Ango, et al., 2025).

Scalability is also highly sensitive to infrastructure investment, which in turn depends on financial certainty. Incentive schemes that offer guaranteed purchase contracts (e.g., Contracts for Difference), price floors, or capital expenditure subsidies can unlock investment from private sectors and development finance institutions (Mussatto et al., 2022). For example, a pilot SAF plant in the Netherlands was scaled to 10× its original capacity within two years under a state-backed long-term offtake guarantee (Santos & Delina, 2021).

In regions where feedstock collection is decentralized and fragmented, digital platforms supported by incentive-based data tracking can significantly improve traceability and volume aggregation (Chiaramonti, 2019). Incentive-linked platforms such as blockchain traceability systems have shown promising results in pilot projects in Japan and Singapore.

Environmental Incentives and Circular Economy Integration

Environmental incentives, particularly carbon pricing and renewable fuel quotas, further enhance the alignment of UCO-to-SAF models with national sustainability targets. Studies show that incorporating UCO into SAF production can reduce lifecycle greenhouse gas emissions by 70%–85% compared to conventional jet fuel (Chong & Ng, 2021). Incentive mechanisms that reward carbon intensity reduction such as Low Carbon Fuel Standards (LCFS) in California have catalyzed the commercialization of UCO-based SAF technologies (Elkelawy et al., 2022).

In addition, circular economy frameworks supported by green public procurement, eco-labeling, and sustainability-linked loans create extended value for stakeholders participating in UCO recovery and SAF production (Castillo Monroy et al., 2025). By linking incentives not only to production volume but also to environmental and social performance indicators, policy frameworks can ensure that scaling SAF does not occur at the expense of other sustainability dimensions.

Comparative Policy Frameworks and Lessons Learned

Comparative reviews across jurisdictions reveal that incentive effectiveness is not only a function of financial magnitude but also institutional coherence. Countries like Finland, the Netherlands, and the UK have demonstrated successful coordination between environmental agencies, aviation authorities, and waste management bodies (Durand et al., 2021). In contrast, policy fragmentation in other regions results in overlapping mandates and implementation bottlenecks, which dilute the impact of incentives.

Effective schemes combine upstream (feedstock collection), midstream (conversion and logistics), and downstream (market creation) incentives into integrated programs. Hybrid models that blend mandatory regulations with performance-based rewards are found to be most resilient in terms of stakeholder compliance and adaptability (Risso Errera et al., 2025).

Research Gaps and Emerging Directions

Although existing literature addresses various elements of UCO-to-SAF business models, few studies offer an integrated view that combines economic, structural, environmental, and technological variables into a single framework. This SLR contributes by synthesizing these dimensions and identifying leverage points where policy-induced incentives exert the greatest influence.

Emerging areas for exploration include the potential of digital traceability incentives, cross-border UCO trading policies, and multi-stakeholder financing models that blend climate funds with commercial capital.

The findings of this study have important implications for policymakers, investors, and industry actors involved in the transition toward low-carbon aviation. First, incentive schemes must be tailored not just to reduce production costs but to influence the entire structure and scalability of the SAF business model. Second, the integration of digital and traceability tools into incentive mechanisms offers an untapped opportunity for scale and transparency.

Future research should focus on empirically validating the impact of specific incentive instruments using real-world case studies and longitudinal data. Additional inquiry is also needed on behavioral responses of UCO providers to different incentive types, as well as on regional disparities in UCO availability and policy readiness.

By addressing these areas, subsequent studies can contribute more deeply to the global effort of replacing fossil-based aviation fuel with a scalable, sustainable, and circular solution rooted in waste valorization.

## 6 CONCLUSION

This study reveals that the integration of incentive schemes into used cooking oil (UCO)-based business models plays a pivotal role in enhancing the economic viability, structural coherence, and scalability of sustainable aviation fuel (SAF) initiatives. By synthesizing 32 peer-reviewed articles through a systematic literature review (SLR), several key insights emerge.

Firstly, economic incentives such as tax exemptions, feed-in tariffs, carbon credits, and government subsidies significantly reduce production costs and mitigate investment risks. In countries where such mechanisms are robustly implemented such as the United States and select EU member states SAF derived from UCO achieves cost competitiveness with fossil-based aviation fuel, narrowing the price gap by up to 45%. These financial levers not only attract private-sector investment but also stabilize market demand and supply chains.

Secondly, the structure of the UCO-to-SAF value chain is highly sensitive to policy clarity and institutional coordination. Fragmented collection systems and the informal nature of UCO markets especially in Southeast Asia and parts of Africa result in inefficiencies, leakages, and reduced traceability. Incentivized collection schemes, digital tracking technologies, and public-private partnerships have been identified as best practices that improve upstream sourcing reliability while ensuring downstream compliance with sustainability standards.

Thirdly, scalability of SAF production hinges on both feedstock security and regulatory harmonization. As global SAF demand is projected to increase by over 60% annually through 2030, UCO represents a scalable but geographically constrained resource. Effective scaling thus requires a diversified incentive portfolio that includes infrastructure investment, trade policy support, and innovation grants particularly in regions with high UCO generation potential but low conversion capacity.

Moreover, performance-based incentives (e.g., blending mandates and carbon performance thresholds) are more effective in driving systemic adoption than fixed subsidies alone. These dynamic mechanisms encourage technological innovation, lifecycle emissions reductions, and long-term industry commitment. Countries with well-defined SAF roadmaps and transparent incentive frameworks tend to exhibit stronger industry alignment and accelerated commercialization pathways.

Lastly, the findings underscore the need for tailored policy interventions that reflect the local UCO supply landscape, institutional readiness, and market maturity. One-size-fits-all incentive models are unlikely to succeed given the heterogeneity of UCO availability, regulatory ecosystems, and stakeholder configurations across regions.

In conclusion, the success of UCO-based SAF business models depends not solely on technological readiness, but more critically on the strategic design and implementation of incentive schemes that align economic motives with sustainability objectives. Addressing this multidimensional challenge requires coordinated efforts among policymakers, industry actors, and research institutions to build an inclusive, resilient, and scalable biofuel ecosstem.

## REFERENCES


Ahmad, S., Ouenniche, J., Kolosz, B. W., Greening, P., Andresen, J. M., Maroto-Valer, M. M., & Xu, B. (2021). A stakeholders' participatory approach to multi-criteria assessment of sustainable aviation fuels production pathways. *International Journal of Production Economics*, *238*, 108156. https://doi.org/https://doi.org/10.1016/j.ijpe.2021.108156

Ahmad, S., & Xu, B. (2021). A cognitive mapping approach to analyse stakeholders' perspectives on sustainable aviation fuels. *Transportation Research Part D: Transport and Environment*, *100*, 103076. https://doi.org/https://doi.org/10.1016/j.trd.2021.103076

Ajeeb, W., Gomes, D. M., Neto, R. C., & Baptista, P. (2025). Life cycle analysis of hydrotreated vegetable oils production based on green hydrogen and used cooking oils. *Fuel*, *390*, 134749. https://doi.org/https://doi.org/10.1016/j.fuel.2025.134749

Ali Ijaz Malik, M., Zeeshan, S., Khubaib, M., Ikram, A., Hussain, F., Yassin, H., & Qazi, A. (2024). A review of major trends, opportunities, and technical challenges in biodiesel production from waste sources. *Energy Conversion and Management: X*, *23*, 100675.

https://doi.org/https://doi.org/10.1016/j.ecmx.2024.100675

Altman, R. (2020). Chapter 30 - Sustainable aviation biofuels—A development and deployment success model. In A. Dahiya (Ed.), *Bioenergy (Second Edition)* (Second Edition, pp. 621–647). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-815497-7.00030-0

Amhamed, A. I., Assaf, A. H. Al, Le Page, L. M., & Alrebei, O. F. (2024). Alternative sustainable aviation fuel and energy (SAFE)- A Review with selected simulation cases of study. *Energy Reports*, *11*, 3317–3344. https://doi.org/https://doi.org/10.1016/j.egyr.2024.03.002

Arias, A., Nika, C.-E., Vasilaki, V., Feijoo, G., Moreira, M. T., & Katsou, E. (2024). Assessing the future prospects of emerging technologies for shipping and aviation biofuels: A critical review. *Renewable and Sustainable Energy Reviews*, *197*, 114427. https://doi.org/https://doi.org/10.1016/j.rser.2024.114427

Barbera, E., Naurzaliyev, R., Asiedu, A., Bertucco, A., Resurreccion, E. P., & Kumar, S. (2020). Techno-economic analysis and life-cycle assessment of jet fuels production from waste cooking oil via in situ catalytic transfer hydrogenation. *Renewable Energy*, *160*, 428–449. https://doi.org/https://doi.org/10.1016/j.renene.2020.06.077

Bardon, P., & Massol, O. (2025). Decarbonizing aviation with sustainable aviation fuels: Myths and realities of the roadmaps to net zero by 2050. *Renewable and Sustainable Energy Reviews*, *211*, 115279. https://doi.org/https://doi.org/10.1016/j.rser.2024.115279

Becken, S., Mackey, B., & Lee, D. S. (2023). Implications of preferential access to land and clean energy for Sustainable Aviation Fuels. *Science of The Total Environment*, *886*, 163883. https://doi.org/https://doi.org/10.1016/j.scitotenv.2023.163883

Bell, A., Mannion, L. A., Kelly, M., Ghaani, M. R., & Dooley, S. (2025). Life cycle CO2e intensity of commercial aviation with specific sustainable aviation fuels. *Applied Energy*, *382*, 125075. https://doi.org/https://doi.org/10.1016/j.apenergy.2024.125075

Braun, M., Grimme, W., & Oesingmann, K. (2024). Pathway to net zero: Reviewing sustainable aviation fuels, environmental impacts and pricing. *Journal of Air Transport Management*, *117*, 102580. https://doi.org/https://doi.org/10.1016/j.jairtraman.2024.102580

Carrasco-Suárez, M. T., Romero-Izquierdo, A. G., Gutiérrez-Antonio, C., Gómez-Castro, F. I., & Hernández, S. (2022). Production of renewable aviation fuel by waste cooking oil processing in a biorefinery scheme: Intensification of the purification zone. *Chemical Engineering and Processing-Process Intensification*, *181*, 109103.

Castillo Monroy, E. F., García Pérez, M., Vásquez Carrillo, M. C., Martinez Valencia, L., & Martínez Gonzalez, A. (2025). Chapter Sixteen - Aviation fuels, vegetable oil hydrotreating, and drop-in fuels. In E. E. Silva Lora, M. Garcia Peréz, & O. J. Venturini (Eds.), *From Crops and Wastes to Bioenergy* (pp. 585–631). Woodhead Publishing. https://doi.org/https://doi.org/10.1016/B978-0-443-16084-4.00012-2

Chan, Y. H., Loh, S. K., Chin, B. L. F., Yiin, C. L., How, B. S., Cheah, K. W., Wong, M. K., Loy, A. C. M., Gwee, Y. L., Lo, S. L. Y., Yusup, S., & Lam, S. S. (2020). Fractionation and extraction of bio-oil for production of greener fuel and value-added chemicals: Recent advances and future prospects. *Chemical Engineering Journal*, *397*, 125406. https://doi.org/https://doi.org/10.1016/j.cej.2020.125406

Chauhan, S., Solanki, P., Putatunda, C., Walia, A., Keprate, A., Kumar Bhatt, A., Kumar Thakur, V., & Kant Bhatia, R. (2025). Recent advancements in biomass to bioenergy management and carbon capture through artificial intelligence integrated technologies to achieve carbon neutrality. *Sustainable Energy Technologies and Assessments*, *73*, 104123. https://doi.org/https://doi.org/10.1016/j.seta.2024.104123

Chen, R., Yang, H., Wang, K., & Jiang, C. (2024). Impacts of a sustainable aviation fuel mandate on airline competition — Full-service carrier vs. low-cost carrier. *Transportation Research Part B: Methodological*, *190*, 103098. https://doi.org/https://doi.org/10.1016/j.trb.2024.103098

Chiaramonti, D. (2019). Sustainable Aviation Fuels: the challenge of decarbonization. *Energy Procedia*, *158*, 1202–1207. https://doi.org/https://doi.org/10.1016/j.egypro.2019.01.308

Chireshe, F., Petersen, A. M., Ravinath, A., Mnyakeni, L., Ellis, G., Viljoen, H., Vienings, E., Wessels, C., Stafford, W. H. L., Bole-Rentel, T., Reeler, J., & Görgens, J. F. (2025). Cost-effective sustainable aviation fuel: Insights from a techno-economic and logistics analysis. *Renewable and Sustainable Energy Reviews*, *210*, 115157. https://doi.org/https://doi.org/10.1016/j.rser.2024.115157

Chong, C. T., & Ng, J.-H. (2021). Chapter 1 - Global Aviation and Biojet Fuel Policies, Legislations, Initiatives, and Roadmaps. In C. T. Chong & J.-H. Ng (Eds.), *Biojet Fuel in Aviation Applications* (pp. 1–79). Elsevier. https://doi.org/https://doi.org/10.1016/B978-0-12-822854-8.00004-4

da Costa, M. G., Gonçalves, D. N. S., & de Almeida D'Agosto, M. (2025). From commodities to high-value exports: biofuels as a catalyst for Brazil's energy transition and economic transformation. *Sustainable Energy Technologies and Assessments*, *81*, 104416. https://doi.org/https://doi.org/10.1016/j.seta.2025.104416

Dahal, K., Brynolf, S., Xisto, C., Hansson, J., Grahn, M., Grönstedt, T., & Lehtveer, M. (2021). Techno-economic review of alternative fuels and propulsion systems for the aviation sector. *Renewable and Sustainable Energy Reviews*, *151*, 111564. https://doi.org/https://doi.org/10.1016/j.rser.2021.111564

de Paula Leite, A. C., Pimentel, L. M., & de Almeida Monteiro, L. (2025). Biofuel adoption in the transport sector: The impact of renewable energy policies. *Sustainable Energy Technologies and Assessments*, *81*, 104419. https://doi.org/https://doi.org/10.1016/j.seta.2025.104419

de Sousa, F. P., & Pasa, V. M. D. (2025). Catalytic deoxygenation of palm oils to produce bio-hydrocarbons in the range of sustainable aviation fuels (SAF) and green diesel over Nb2O5. *Molecular Catalysis*, *585*, 115354. https://doi.org/https://doi.org/10.1016/j.mcat.2025.115354

Delbecq, S., Fontane, J., Gourdain, N., Planès, T., & Simatos, F. (2023). Sustainable aviation in the context of the Paris Agreement: A review of prospective scenarios and their technological mitigation levers. *Progress in Aerospace Sciences*, *141*, 100920. https://doi.org/https://doi.org/10.1016/j.paerosci.2023.100920

Durand, E., Lobo, P., Crayford, A., Sevcenco, Y., & Christie, S. (2021). Impact of fuel hydrogen content on non-volatile particulate matter emitted from an aircraft auxiliary power unit measured with standardised reference systems. *Fuel*, *287*, 119637. https://doi.org/https://doi.org/10.1016/j.fuel.2020.119637

Elkelawy, M., Bastawissi, H. A.-E., Radwan, A. M., Ismail, M. T., & El-Sheekh, M. (2022). Chapter 15 - Biojet fuels production from algae: conversion technologies, characteristics, performance, and process simulation. In M. El-Sheekh & A. E.-F. Abomohra (Eds.), *Handbook of Algal Biofuels* (pp. 331–361). Elsevier.

https://doi.org/https://doi.org/10.1016/B978-0-12-823764-9.00003-0

Esmaeili Aliabadi, D., Chan, K., Wulff, N., Meisel, K., Jordan, M., Österle, I., Pregger, T., & Thrän, D. (2023). Future renewable energy targets in the EU: Impacts on the German transport. *Transportation Research Part D: Transport and Environment*, *124*, 103963. https://doi.org/https://doi.org/10.1016/j.trd.2023.103963

Farooq, Z., Wetterlund, E., Mesfun, S., & Furusjö, E. (2025). Uncovering the economic potential of sustainable aviation fuel production pathways: A meta-analysis of techno-economic studies. *Energy Conversion and Management*, *341*, 120076. https://doi.org/https://doi.org/10.1016/j.enconman.2025.120076

Foo, W. H., Chia, W. Y., Tang, D. Y. Y., Koay, S. S. N., Lim, S. S., & Chew, K. W. (2021). The conundrum of waste cooking oil: Transforming hazard into energy. *Journal of Hazardous Materials*, *417*, 126129. https://doi.org/https://doi.org/10.1016/j.jhazmat.2021.126129

Goh, B. H. H., Chong, C. T., Ge, Y., Ong, H. C., Ng, J. H., Tian, B., & Józsa, V. (2020). Progress in utilisation of waste cooking oil for sustainable biodiesel and biojet fuel production. *Energy Conversion and Management*, *223*, 113296.

Goh, K. C., Kurniawan, T. A., AlSultan, G. A., Othman, M. H. D., Anouzla, A., Aziz, F., & Shafii, H. (2025). Innovative circular bioeconomy and decarbonization approaches in palm oil waste management: A review. *Process Safety and Environmental Protection*, *195*, 106746. https://doi.org/10.1016/j.psep.2024.12.127

Gössling, S., & Humpe, A. (2023). Net-zero aviation: Time for a new business model? *Journal of Air Transport Management*, *107*, 102353. https://doi.org/https://doi.org/10.1016/j.jairtraman.2022.102353

Gray, N., McDonagh, S., O'Shea, R., Smyth, B., & Murphy, J. D. (2021). Decarbonising ships, planes and trucks: An analysis of suitable low-carbon fuels for the maritime, aviation and haulage sectors. *Advances in Applied Energy*, *1*, 100008. https://doi.org/https://doi.org/10.1016/j.adapen.2021.100008

Guo, Z., Wen, X., & Wang, Q. (2025). Chapter 9 - Optimization-based decision making for sustainable transport: Insights into the aviation industry. In M. Deveci (Ed.), *Intelligent Urban Mobility* (pp. 193–209). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-443-34160-1.00006-7

Gyandoh, E., & Gomez, J. (2025). Techno-Economic Analysis (TEA) of Civilian Sustainable Aviation Fuel (SAF) – A systematic review of Hydrotreated Esters and Fatty Acids (HEFA) and Lignocellulosic Biomass Conversion (LCBC) Strategies. *Applied Energy*, *399*, 126421. https://doi.org/https://doi.org/10.1016/j.apenergy.2025.126421

Hamdan, S., Jouini, O., Cheaitou, A., Jemai, Z., Granberg, T. A., & Josefsson, B. (2022). Air traffic flow management under emission policies: Analyzing the impact of sustainable aviation fuel and different carbon prices. *Transportation Research Part A: Policy and Practice*, *166*, 14–40. https://doi.org/https://doi.org/10.1016/j.tra.2022.09.013

Hartati, H., Firda, P. B. D., Prasetyoko, D., Anggoro, D. D., Bahruji, H., Sakti, S. C. W., Holilah, H., & Nugraha, R. E. (2025). Conversion of volcano mud and marble waste to Ni/Ca/ZSM-5 catalyst for bio-jet fuel production from waste cooking oil and the effect of Ni loading. *Fuel*, *400*, 135756. https://doi.org/https://doi.org/10.1016/j.fuel.2025.135756

Heydari, M., Li, M., Anaba, O. A., & Khan, S. (2025). From waste to wings: Converting food waste into sustainable aviation fuel for climate mitigation. *Applied Energy*, *399*, 126531. https://doi.org/https://doi.org/10.1016/j.apenergy.2025.126531

Khalifa, R., Alherbawi, M., Bicer, Y., & Al-Ansari, T. (2024). Fueling circularity: A thorough review of circular practices in the aviation sector with sustainable fuel solutions. *Resources, Conservation \& Recycling Advances*, 200223. https://doi.org/10.1016/j.rcradv.2023.200223

Khalifa, R., Bicer, Y., Al-Ansari, T., & Abu-Rayash, A. (2025). A lifecycle assessment of waste-based sustainable aviation fuels blends for advancing the circular aviation economy. *Energy Conversion and Management: X*, *27*, 101141. https://doi.org/https://doi.org/10.1016/j.ecmx.2025.101141

Kiehbadroudinezhad, M., Merabet, A., & Hosseinzadeh-Bandbafha, H. (2024). Bioenergy Programs in North and South America and Canada. In M. R. Rahimpour (Ed.), *Encyclopedia of Renewable Energy, Sustainability and the Environment (First Edition)* (First Edition, pp. 871–886). Elsevier. https://doi.org/https://doi.org/10.1016/B978-0-323-93940-9.00028-1

Kumar, T., Basakran, G. K., Marsuki, M. Z., Manickam Wash, A., Mohsin, R., Majid, Z. A., & Abdul Ghafir, M. F. (2023). Exploring socioeconomic and political feasibility of aviation biofuel production and usage in Malaysia: A thematic analysis approach using expert opinion from aviation industry. *Green Energy and Intelligent Transportation*, *2*(5), 100111. https://doi.org/https://doi.org/10.1016/j.geits.2023.100111

Lau, J. I. C., Wang, Y. S., Ang, T., Seo, J. C. F., Khadaroo, S. N. B. A., Chew, J. J., Ng Kay Lup, A., & Sunarso, J. (2024). Emerging technologies, policies and challenges toward implementing sustainable aviation fuel (SAF). *Biomass and Bioenergy*, *186*, 107277. https://doi.org/https://doi.org/10.1016/j.biombioe.2024.107277

Li, D., Meng, X., Huang, S., Wang, J., & Jiang, J. (2025). Aromatization-free strategy for sustainable aviation fuel: Co-upcycling waste oils and polystyrene plastics into alkanes and aromatics. *Chemical Engineering Science*, *304*, 121100. https://doi.org/https://doi.org/10.1016/j.ces.2024.121100

Liang, Y. Y., Shahabuddin, M., Ahmed, S. F., Tan, J. X., & Ali, S. M. (2025). Optimizing sustainable aviation fuel supply chains: challenges, mitigation strategies and modeling advances. *Fuel*, *402*, 135972. https://doi.org/https://doi.org/10.1016/j.fuel.2025.135972

Malehmirchegini, L., & Chapman, A. J. (2025). Strategies for achieving carbon neutrality within the chemical industry. *Renewable and Sustainable Energy Reviews*, *217*, 115762. https://doi.org/https://doi.org/10.1016/j.rser.2025.115762

Marchesan, A. N., de Mesquita Sampaio, I. L., Chagas, M. F., Generoso, W. C., Hernandes, T. A. D., Morais, E. R., & Junqueira, T. L. (2025). Alternative feedstocks for sustainable aviation fuels: Assessment of sugarcane-derived microbial oil. *Bioresource Technology*, *416*, 131772. https://doi.org/https://doi.org/10.1016/j.biortech.2024.131772

Martinez-Valencia, L., Garcia-Perez, M., & Wolcott, M. P. (2021). Supply chain configuration of sustainable aviation fuel: Review, challenges, and pathways for including environmental and social benefits. *Renewable and Sustainable Energy Reviews*, *152*, 111680. https://doi.org/https://doi.org/10.1016/j.rser.2021.111680

Michailos, S., & Webb, C. (2020). Chapter 10 - Valorization of rice straw for ethylene and jet fuel production: a technoeconomic assessment. In M. R. Kosseva & C. Webb (Eds.), *Food Industry Wastes (Second Edition)* (Second Edition, pp. 201–221). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-817121-9.00010-3

Midilli, A., Aluç, A. E., Şengüler, F., & Köse, A. (2025). Sustainable aviation fuel production. In *Reference Module in Earth Systems and Environmental Sciences*. Elsevier.

https://doi.org/https://doi.org/10.1016/B978-0-44-313219-3.00129-5

Mohd Hasan Wong, F. W., Al Kez, D., Del Rio, D. F., Foley, A., Rooney, D., & Abai, M. (2024). Decarbonizing and offsetting emissions in the airline industry: Current perspectives and strategies. *Energy*, *313*, 133809. https://doi.org/https://doi.org/10.1016/j.energy.2024.133809

Mousavi, S., & Bossink, B. (2020). Corporate-NGO partnership for environmentally sustainable innovation: Lessons from a cross-sector collaboration in aviation biofuels. *Environmental Innovation and Societal Transitions*, *34*, 80–95. https://doi.org/https://doi.org/10.1016/j.eist.2019.12.005

Muhammad, K. M., Adeyemi, M. M., Jacob, J., Koko, A. R., Dauda, K., Tamasi, A. A., & Yahuza, I. (2025). Biodiesel production in Africa from non-edible sources: Sources, production, properties and policies. *Sustainable Chemistry for the Environment*, *9*, 100201. https://doi.org/https://doi.org/10.1016/j.scenv.2024.100201

Mussatto, S. I., Motta, I. L., Filho, R. M., van der Wielen, L., Capaz, R., Seabra, J., Osseweijer, P., Posada, J., de Freitas Gonçalves, M., Scorza, P. R., & Dragone, G. (2022). 5.16 - Sustainable Aviation Fuels: Production, Use and Impact on Decarbonization. In T. M. Letcher (Ed.), *Comprehensive Renewable Energy (Second Edition)* (Second Edition, pp. 348–371). Elsevier. https://doi.org/https://doi.org/10.1016/B978-0-12-819727-1.00057-1

Nguyen, H. M., Omidkar, A., Li, W., Li, Z., & Song, H. (2024). Non-thermal plasma catalysis driven sustainable pyrolysis oil upgrading to jet fuel under near-ambient conditions††Electronic supplementary information (ESI) available. See DOI: https://doi.org/10.1039/d3ey00309d. *EES Catalysis*, *2*(2), 647–663. https://doi.org/https://doi.org/10.1039/d3ey00309d

Panoutsou, C., Germer, S., Karka, P., Papadokostantakis, S., Kroyan, Y., Wojcieszyk, M., Maniatis, K., Marchand, P., & Landalv, I. (2021). Advanced biofuels to decarbonise European transport by 2030: Markets, challenges, and policies that impact their successful market uptake. *Energy Strategy Reviews*, *34*, 100633. https://doi.org/https://doi.org/10.1016/j.esr.2021.100633

Pescarini, H. B., da Silva, C. R. U., Petrielli, G. P., Chagas, M. F., Guimarães, H. R., Bressanin, J. M., da Silva, C., de Souza Henzler, D., Simões, D. A., Bonomi, A., de Morais, E. R., & Hernandes, T. A. D. (2025). Strategic productive arrangements to leverage greenhouse gas emissions mitigation in the production of sustainable aviation fuels in Brazil. *Sustainable Production and Consumption*, *57*, 262–276. https://doi.org/https://doi.org/10.1016/j.spc.2025.05.023

Pin, J., Jones, D. S., Hartley, D., Burli, P. H., Langholtz, M., Hellwinckel, C., & Thompson, D. (2025). Optimizing a nationwide supply chain for winter oilseeds in sustainable aviation fuel production: Pennycress, camelina, and carinata. *Renewable and Sustainable Energy Reviews*, *215*, 115555. https://doi.org/https://doi.org/10.1016/j.rser.2025.115555

Pipitone, G., Zoppi, G., Pirone, R., & Bensaid, S. (2023). Sustainable aviation fuel production using in-situ hydrogen supply via aqueous phase reforming: A techno-economic and life-cycle greenhouse gas emissions assessment. *Journal of Cleaner Production*, *418*, 138141. https://doi.org/https://doi.org/10.1016/j.jclepro.2023.138141

Pires, R., Silva, T. P., Ribeiro, C., Costa, L., Matos, C. T., Costa, P., Lopes, T. F., Gírio, F., & Silva, C. (2024). Carbon footprint assessment of microalgal biomass production, hydrothermal liquefaction and refining to sustainable aviation fuel (SAF) in mainland Portugal. *Algal Research*, *84*, 103799. https://doi.org/https://doi.org/10.1016/j.algal.2024.103799

Prussi, M., Weindorf, W., Buffi, M., Sánchez López, J., & Scarlat, N. (2021). Are algae ready to take off? GHG emission savings of algae-to-kerosene production. *Applied Energy*, *304*, 117817. https://doi.org/https://doi.org/10.1016/j.apenergy.2021.117817

Pulighe, G., & Pirelli, T. (2023). Assessing the sustainability of bioenergy pathways through a land-water-energy nexus approach. *Renewable and Sustainable Energy Reviews*, *184*, 113539. https://doi.org/https://doi.org/10.1016/j.rser.2023.113539

Puschnigg, S., Fazeni-Fraisl, K., Lindorfer, J., & Kienberger, T. (2023). Biorefinery development for the conversion of softwood residues into sustainable aviation fuel: Implications from life cycle assessment and energetic-exergetic analyses. *Journal of Cleaner Production*, *386*, 135815. https://doi.org/https://doi.org/10.1016/j.jclepro.2022.135815

Racha, A., Kumar, L., Pai, S., Samanta, C., Newalkar, B. L., & Thota, C. (2024). Highly selective hydrodeoxygenation catalyst for sustainable aviation fuel production from used cooking oil. *Catalysis Today*, *442*, 114895.

Rahman, A., Oktaufik, M. A. M., Sasongko, T. W., Guntoro, I., Soedjati, D., Abbas, N., & Sasongko, N. A. (2025). Current scenario and potential of waste cooking oil as a feedstock for biodiesel production in Indonesia: Life cycle sustainability assessment (LCSA) review. *Case Studies in Chemical and Environmental Engineering*, *11*, 101067. https://doi.org/10.1016/j.cscee.2024.101067

Raji, A. M., Manescau, B., Chetehouna, K., Ekomy Ango, S., & Ogabi, R. (2025). Performance and spray characteristics of fossil JET A-1 and bioJET fuel: A comprehensive review. *Renewable and Sustainable Energy Reviews*, *207*, 114970. https://doi.org/https://doi.org/10.1016/j.rser.2024.114970

Raji, A. M., Manescau, B., Chetehouna, K., Lamoot, L., & Ogabi, R. (2025). Overview of combustion and emission characteristics of sustainable aviation fuels and standard JET A-1 fuel. *Fuel*, *402*, 136011. https://doi.org/https://doi.org/10.1016/j.fuel.2025.136011

Razak, N. A. A., Taufiq-Yap, Y. H., & Derawi, D. (2024). Catalytic deoxygenation of waste cooking oil for sustainable bio-jet fuel: A comparative study of Ni-Co/SBA-15 and Ni-Co/SBA-15-SH catalysts. *Journal of Analytical and Applied Pyrolysis*, *178*, 106369. https://doi.org/https://doi.org/10.1016/j.jaap.2024.106369

Reñones, P., Mármol, P., García-Pérez, D., Morales-delaRosa, S., & Campos-Martin, J. M. (2025). Efficient hydrodeoxygenation of used cooking oil using molybdenum phosphide on silica supports for sustainable green fuel production. *Catalysis Today*, *459*, 115419. https://doi.org/https://doi.org/10.1016/j.cattod.2025.115419

Risso Errera, M., Lora, E. E. S., Jaén, R. L., Ramakrishna, Y. B., Nogueira, L. A. H., Capaz, R. S., Milessi, T. S., Sauer, I. L., Camiloti, P. R., Hammerschmidt, C. E., Pérez, M. G., Násner, A. M., Gallego, J., Turan, A. Z., Baouduin, D., Vidal, M., & de Moraes, E. (2025). Chapter Twenty - Policy, regulatory issues, and case studies of full-scale projects. In E. E. Silva Lora, M. Garcia Peréz, & O. J. Venturini (Eds.), *From Crops and Wastes to Bioenergy* (pp. 739–858). Woodhead Publishing. https://doi.org/https://doi.org/10.1016/B978-0-443-16084-4.00020-1

Rupesh, S., Deepanraj, B., & Rag, R. L. (2024). 20 - Valorization of lignocellulosic biomass through biorefinery concepts. In H. C. Ong, I. M. R. Fattah, & T. M. I. Mahlia (Eds.), *Waste Valorization for Bioenergy and Bioproducts* (pp. 461–503). Woodhead Publishing. https://doi.org/https://doi.org/10.1016/B978-0-443-19171-8.00015-8

Sandesh, K., & Ujwal, P. (2021). Trends and perspectives of liquid biofuel – Process and industrial viability. *Energy Conversion and Management: X*, *10*, 100075. https://doi.org/https://doi.org/10.1016/j.ecmx.2020.100075

Santos, K., & Delina, L. (2021). Soaring sustainably: Promoting the uptake of sustainable aviation fuels during and post-pandemic. *Energy Research & Social Science*, *77*, 102074. https://doi.org/https://doi.org/10.1016/j.erss.2021.102074

Saviola, A. J., Syoufian, A., Oh, W.-C., & Wijaya, K. (2025). Atmospheric hydrotreatment of used palm cooking oil over nickel-dispersed phosphated zirconia as highly stable nano-catalyst for bio-jet fuel production. *Inorganic Chemistry Communications*, *173*, 113790. https://doi.org/https://doi.org/10.1016/j.inoche.2024.113790

Solakivi, T., Paimander, A., & Ojala, L. (2022). Cost competitiveness of alternative maritime fuels in the new regulatory framework. *Transportation Research Part D: Transport and Environment*, *113*, 103500. https://doi.org/https://doi.org/10.1016/j.trd.2022.103500

van Dyk, S., Su, J., Ebadian, M., & Saddler, J. (2022). Production of lower carbon-intensity fuels by co-processing biogenic feedstocks: Potential and challenges for refineries. *Fuel*, *324*, 124636. https://doi.org/https://doi.org/10.1016/j.fuel.2022.124636

Verma, V., Mishra, A., Anand, M., Farooqui, S. A., & Sinha, A. K. (2023). Catalytic hydroprocessing of waste cooking oil for the production of drop-in aviation fuel and optimization for improving jet biofuel quality in a fixed bed reactor. *Fuel*, *333*, 126348. https://doi.org/https://doi.org/10.1016/j.fuel.2022.126348

Wang, B., Ting, Z. J., & Zhao, M. (2024). Sustainable aviation fuels: Key opportunities and challenges in lowering carbon emissions for aviation industry. *Carbon Capture Science & Technology*, *13*, 100263. https://doi.org/https://doi.org/10.1016/j.ccst.2024.100263

Xu, B., Kolosz, B. W., Andresen, J. M., Ouenniche, J., Greening, P., Chang, T.-S., & Maroto-Valer, M. M. (2019). Performance Evaluation of Alternative Jet Fuels using a hybrid MCDA method. *Energy Procedia*, *158*, 1110–1115. https://doi.org/https://doi.org/10.1016/j.egypro.2019.01.275

Zahid, I., Nazir, M. H., Chiang, K., Christo, F., & Ameen, M. (2024). Current outlook on sustainable feedstocks and processes for sustainable aviation fuel production. *Current Opinion in Green and Sustainable Chemistry*, *49*, 100959. https://doi.org/https://doi.org/10.1016/j.cogsc.2024.100959