Supporting Clean Energy in the ASEAN: Policy Opportunities from Sustainable Aviation Fuels Initiatives in Indonesia and Malaysia

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Abstract. Sustainable aviation fuels is a strategic long-term solution for zero-carbon aviation industry by 2050, thus underscoring the need to accelerate the deployment through reforms in the relevant key areas. Aligned to the agenda, this paper aims to study the policy opportunities for drop-in sustainable aviation fuel (SAF) deployment in the ASEAN by considering the initiatives undertaken by Indonesia and Malaysia. Four areas are used as coding framework to assess the current status, challenges, and policy opportunities, namely (1) policy, strategy, and reforms; (2) standards and certification system; (3) economic instruments; and (4) international integration. First, the current status and challenges within each country is assessed. Indonesia has shown a more command-and-control approach with an upfront SAF blending mandate. However, it needs to be supported by several compliance measures. Malaysia, on the other hand, has conducted country assessments but no SAF-specific policy has been issued yet. Both countries still lack the economic instruments, while international integration is still relatively under-explored with only limited inter-regional partnerships. As the biggest palm-oil producing countries, Indonesia and Malaysia possess enormous potentials to lead the region in deploying SAF, thus more initiatives are urged.

1. Introduction
Air transport has been relied on by millions of people in business and governments for many purposes worldwide. Aviation accounts for 2% of global greenhouse gas (GHG) emissions [1], while small in the absolute terms, it is an important transportation means with a 13% share of transport sector emissions [2]. To join transport sector decarbonization efforts, air transport is racing towards the 2050 global goals of sustaining carbon-neutral growth and reducing net CO₂ emissions by 50% of what they were in 2005, and eventually, reaching zero-carbon connectivity by 2060/65 [3].

As part of a decarbonization pathway, calls to action have been rolled out both from in-sector and out-of-sector approaches. Unlike cars, planes have no short-term alternatives to liquid fuels, especially for long-haul flights. In addition, air transportation infrastructures are designed to last for decades, therefore new fuels must be drop-in biofuel. Drop-in biojet fuels or termed sustainable aviation fuels (SAF) can be the single largest opportunity to meet and exceed the 2050’s goal as it plays a significant role in the long-term scenarios [3]. However, the industry has been slow to expand due to strong economic barriers to SAF deployment with only 0.01% of global jet fuel use. The barriers include technological maturity, certification of more conversion pathways, scale-up and commercialization, price parity gap with fossil fuels, and competition with road transportation biofuels [4].

Long-term supporting policies are considered crucial to address these challenges until the SAF technology comes out of its infancy. On the other hand, another barrier is the international nature of aviation which has resulted in delayed national policy development [5]. However, enacted measures by the International Civil Aviation Organization (ICAO) only covers emissions from international flights, hence it has stated that it will be upon individual nations to bear the responsibility in deploying SAF, particularly for domestic flights [4]. Therefore, different policies may exist harmoniously at national and international levels. Government institutions will be the spearhead for fostering national SAF industry by defining the goals and targets, legislation, taxation, and support measures.

That being said, every region has strong justification to take their initiatives in supporting SAF deployment, including ASEAN region which is projected to experience CAGR of 5.8% in air travel demand from 2016-2036 [6]. Indonesia, for example, is at the top of the large emerging market economies with expected following air market growth of 3.6% each year and 310 million passengers predicted to travel via Indonesia alone by 2035 [3,6]. With its huge contribution to aviation, the region lacks the initiatives with only apparent progress made in limited ASEAN Member States (AMS) [7–10]. Despite the lagging progress, studies related to SAF development studies scarce, with more focus placed on the technical aspects although lacking of regulation has been spotted as one of the prominent challenges [11,12]. To address the gap, the assessment of policy opportunities in this study will cover the identified four key areas to offer a holistic perspective for a more robust policymaking.
Moreover, ASEAN regions are in possession of tremendous biomass potential, cumulatively accounts for roughly 500 million tons per year. A large portion of it is comprised of palm oil in Indonesia and Malaysia [13]. To date, hydro-processing technologies using vegetable and waste oils also represents the only conversion pathways that are ready for large-scale deployment. It is currently on technology readiness level (TRL) and feedstock readiness level (FRL) of 9, the highest among the other technological pathways [14]. With these two considerations, both countries are said to be in a strategic position to actively participate in steepening the learning curve of SAF deployment. Therefore, in this study, Indonesia and Malaysia are chosen as case studies for ramping up SAF development in the ASEAN.

As an effort to establish the common ground, this research will study the current status, challenges, and future policies related to upgrading of bio-oil into jet fuel in Indonesia and Malaysia as case studies for the other AMS. Based on the regional assessment supported by lessons learned taken from various countries, key recommendations within the four areas will be laid out in the hope to give insights for policymakers in the ASEAN region to arrange a more comprehensive strategy for SAF development.

2. Method
Systematic content analysis is employed to describe the meaning of qualitative data as presented in Figure 1. The inferred aspects of meaning must be related to the overall research questions to guide the selection of the materials. A selection of the materials is examined to identify themes or coding frameworks, which are the primary instruments to sort qualitative materials into categories associated with the indicators. The selection uses the bioenergy roadmap development and implementation phase classification, which comprised of (1) planning and preparation, (2) visioning, (3) roadmap development, and (4) implementation, monitoring, and revision [15]. A minimum of four countries are assigned to each of the phases to reflect the full diversity of data sources. The time framework taken to select the materials are limited by omiting those prior to 2010. The materials are studied through a desk-review method to develop the main categories and subcategories in the coding framework in which the first is developed in a concept-driven way while the latter takes data-driven way approach. Concept-driven way means basing on previous knowledge e.g. a theory and prior research. The data-driven way approach takes subsumption strategy which involves reading the material until all relevant concepts is covered in the subcategories. The coding framework is then applied in a consistent manner, tried out, and expanded to be used in the main analysis phase. Assessment of the current status, challenges, and the policy opportunities are then presented according to the respective structure to answer the research questions [16,17].

![Figure 1. Qualitative content analysis method.](image-url)
3. Results and discussion

3.1. Current status and challenges of SAF initiatives in Indonesia

Begun in 2016, Indonesia pursues a strategy to use aviation biofuels by mandating national rules to incorporate the use of bio-jet fuel of 2% until 2016 and 5% in 2025 based on Ministry of Energy and Mineral Resources (MEMR) Decree No. 25 Year 2013. To meet that goal, Indonesia’s government established the Indonesian Aviation Biofuels and Renewable Energy Task Force (ABRETF). However, the task force has missed the initial deadline and failed to implement the SAF blending 2016 target.

Although there are a broad range of possible feedstock for producing SAF, including palm, coconut, microalgae, and lastly the most feasible and abundant feedstock—palm oil [11], at present, not a single flight in Indonesia uses bio-jet fuels in daily operations and only few airlines set firm plans to do so in the future. Bio-jet fuel development in Indonesia is still at the pilot phase by national airline—Garuda Indonesia—, while Pertamina as Indonesia’ state owned oil company is still currently demonstrating the feasibility of using biofuel on regular flights.

Starting from January 2021, Indonesia voluntarily participated in the Carbon Offsetting Reduction Scheme for International Aviation (CORSIA) offsetting requirements pilot phase that was adopted by ICAO to offset international aviation carbon emissions above baseline levels. There is also a domestic carbon market proposal announced in Indonesia called Archipelagic Carbon Scheme (Skema Karbon Nasional) that includes the commercial aviation industry as market’s participant for cutting greenhouse gases. However, this scheme operates on a wholly voluntary basis, meaning that there will be no legal consequences for those who are unwilling to report and certify their GHG emissions.

3.2. Current status and challenges of SAF initiatives in Malaysia

The National Biomass Strategy established in 2011 has raised the nation's initiatives in biofuels development, including bio-jet fuel. The deployment of SAF is still subject to several considerations, of which is the choice of feedstock. From Malaysia’s primary potential feedstock—rubber, sugarcane, coconut, paddy, palm oil, oil palm trees and wood residues are the most abundant resource and highly favored as the source of feedstock [9]. However, their use in bio-jet fuel production must be addressed by the certification scheme to ensure their sustainability. Palm oil has been the subject to a mandatory and internationally recognized certification scheme—Malaysian Sustainable Palm Oil (MSPO).

Malaysian Palm Oil Board (MPOB) had signed a MoU with the China Chamber of Commerce Foodstuffs and Native Producers in April 2019 that will allow China to invest at least US$ 480 million in developing a bio-jet fuel plant. Subsequently, the Malaysian government allocated funds of RM 30 million in their 2020 budget, allowing collaborations with academia and industry to develop palm oil-based high-value products, including bio-jet fuel. These emerging initiatives were followed by Malaysia’s participation in the first phase of CORSIA in early 2021 that will undoubtedly initiate other collaboration and initiatives in the future.

However, despite the condition, a specific policy that fosters the national SAF industry is still not come yet. The non-existence of the government’s role in establishing the national framework of SAF development results in a lack of synergy among the stakeholders. As of now, the Economic Master Plan (EMP) framework proposed by the Malaysian Aviation Commission (MAVCOM) is the only policy that guides the Malaysian Civil Aviation Sector development from economic perspective. The framework only covers economic aspects and is meant to maximize Malaysia’s air connectivity, while technical aspects as well as fuel and sustainability are not covered yet. The circumstance shows that there is no clear picture regarding SAF development, therefore further actions need to be taken to unite key stakeholders, forming the same vision needed to promote and commercialize the implementation of SAF in Malaysia.
3.3. Policy Opportunities for SAF Deployment in ASEAN

3.3.1. Policy, strategy, and reforms. Define long-term biojet-specific policy targets and measures to ensure compliance.

Biojet-specific or aviation sector emissions policy will be needed to attribute SAF contribution towards the goal. In addition to the biojet-specific sector, several countries declare their targets in terms of the aviation sector emissions as in the case of the EU, UK, US, and Scandinavian countries. Biojet-specific policies include supply-push and demand-pull policies in the form of producer or blender credits, blending mandates, consumption incentives, and capital loan guarantees. It is worth to note that the establishment of a biojet mandate will be premature until a regular supply of biojet can be guaranteed [5]. Indonesia’s inability to achieve its 2016’s SAF target can be a signal that its own ambitious mandate may be insufficient. Along with mandate, the Indonesian government should also pursue measures to ensure compliance through incentives or penalties. The first has been practiced in the UK’s Renewable Transport Fuel Obligation in the form of buyout penalty per liter of fuel and the US EPA’s civil penalty. The latter can take form as tradable certificates or credits for the unit compliance [4]. Since palm oil is also the main feedstock for biofuels in Indonesia and Malaysia, policy incentives applied for SAF are also needed to avoid competition with lower-cost road transportation biofuels.

Conduct and report eligibility framework based on a comprehensive assessment to map the potential feedstock, establish the whole supply chain, production technology, distribution routes, and the legal framework. Indonesia has already established ABRETF as the responsible institution to set up the eligibility framework; however, the assessment report is not found, thus the recommendation can not be taken any further than to suggest a comprehensive assessment for the policy implementation. While in Malaysia, five primary potential feedstocks have been identified, however there is still no eligibility framework to utilize them in SAF production. Similar approach has been adopted by many pioneering countries. Japan formed the Initiatives for Next Generation Aviation Fuels (INAF) to plan the whole supply chain strategy resulting in a comprehensively documented report. Meanwhile, the UK conducted consultations to compose the SAF uptake scenarios and to know how high and when to set up the mandates. In addition, Brazil as the vanguard of biofuels (bioethanol) deployment has also come up with the Biojet Fuel Matrix that maps the SAF feedstock potentials and its sustainability impacts.

3.3.2. Standards and certification system. Actively support the collective improvements of SAF technical feasibility through research and development

Both countries can utilize their abundant feedstock potential by rolling ample efforts in R&D. This can be done through foreign direct investment to facilitate efficient technology transfer. Domestic efforts to develop R&D can also be approached by allocating national budget to commission national institutions, as done by Malaysia to MPOB, or else the budget can be opened to public through competitions as in the case of the UK with their Future Fuels for Flight and Freight Competition (F4C).

Apply a strict compliance system to technical and sustainability standards by abiding to international certification schemes or by developing nationalized methodology. To facilitate the alignment of SAF with international standards, national certification body can be established with the example of the Aviation Fuel and Chemicals Certification Center (FCC) by China’s Civil Aviation Administration of China (CAAC). Specifically in the sustainability aspect, the aviation’s GHG intensity target should be accompanied with a specified life-cycle assessment (LCA) methodology. Besides CORSIA eligible fuel (CEF) Sustainability Criteria, international feedstock sustainability schemes also exist such as Roundtable on Sustainable Biomaterials (RSB) and International Sustainability and Carbon Certification (ISCC), or specifically within palm oil – RSPO. National standards can also be adopted to adjust with the country condition, for example, to devise own LCA method as in CA-GREET model for California’s LCFS fuel life cycle analysis.
3.3.3. Economic instruments. Pursuing alternatives of direct financial support or market-based measures to settle a robust effort towards decarbonization.

To avoid chicken-and-egg problem between investment and reaching economics of scale, Indonesian and Malaysian governments should play their roles in breaking the cycle. One alternative is to give a combination of direct financial support through varied measures from the government funding, including subsidies, capital grants, low-interest loans, and procurement contracts best suited to the country’s condition. In addition, a central auction mechanism called Contracts for Difference (CfD) might provide a smoother transition between direct support and a mandate while signaling a longer-term commitment for emerging technologies. In the CfD, potential projects will compete a reverse auction to identify the lowest-cost projects which able to deliver fuel at the lowest price [4].

In designing the economic instruments, policymakers must consider how to fund SAF policies and where to put the fiscal burden of decarbonization programs. To place the obligation to airlines directly by applying blending mandate in Indonesia case might split the incentives between fuel producers and airlines fuel customers. A suggestion was made from Swedish Ministry of Infrastructure Regulators to similar airlines obligation in the ReFuelEU that implementing an obligation at the fuel supplier level can be a better approach. Other scheme is to share the cost burden with customers through goods and service tax as in the case of India’s SAF deployment. However, it is worth to assess whether the national aviation industry is price sensitive that may inflict the airline’s price competitiveness and create opposition to the imposed tax [4,18].

Depending on the necessary production scale, SAF support schemes can require a substantial amount of public funding. The alternative can be to apply market-based measures in which the funding can be derived from emissions allowances with gradually declining emissions cap as in the case of the EU ETS [4]. Considering the underdeveloped carbon trading system in Malaysia and Indonesia, the ICAO’s CORSIA scheme turns up as another way to crediting aviation emission reduction although in practice it puts SAF at a strong economic disadvantage due to the cost of deploying SAF’s on a per-tonne of carbon abated basis are several times higher than paying for carbon offsets. Adoption of national or regional blending mandate will also put the related airlines at a competitive disadvantage with the current SAF price premium, indicating preference over global blending mandate as part of CORSIA. As policy intervention in solving the economic constraints still proven to be challenging, collective approach is of utmost urgency to find the alternative practices.

3.3.4. International integration. Integrating national effort by participating at international initiatives and inter-regional partnership.

Besides submitting commitments to the ICAO CORSIA scheme, the efforts can also be made through the Association of Asia Pacific Airlines (AAPA) by including SAF within its environmental focus. Inter-regional partnerships are also the key in facilitating effective technology transfer in the form of joint ventures and technology transfer agreements with multilateral development institutions. Notable collaborations have been made by Indonesia and Malaysia however still limited only to several countries.

More inter-regional partnerships can be formed between various stakeholders. It can be in the form of governmental alliance as in the Sustainable Aviation Fuel Alliance of Australia and New Zealand (SAFAAANZ). Concurrently, private stakeholders can contribute to improve technical feasibility. Several examples include SkyNRG and SunChem’s partnership to produce fuel from tobacco oil in Limpopo, South Africa; Japan’s collaborating private parties in establishing the first certified HEFA-SPK biojet fuel from algae; and many other technological breakthroughs made in the EU and the US. Partnerships with original equipment manufacturer (OEM) will also be crucial to help with the SAF deployment adjusted to existing fleet infrastructure. Lastly, initiatives from multilateral development institutions e.g., World Bank and World Economic Forum in conducting country’s feasibility study and consultation are equally important in assisting national SAF development.
4. Conclusion
Both ASEAN countries have taken different strategies in SAF deployment. Indonesia has a command-and-control approach by enacting SAF mandates, however, it is not accompanied by comprehensive assessment to create eligibility framework in reaching the targeted share. Malaysia is a little bit on the opposite with a more robust country assessment but without SAF regulation enacted so far. Both countries are still in the pilot phase in establishing the economic instruments. While several international integrations have been made, partnership opportunities are still broadly unexplored. Accordingly, several recommendations are made which cover the four areas—(1) policy, strategy, and reforms; (2) standards and certification system; (3) economic instruments; and (4) international integration—as a call-to-action for various stakeholders within the ASEAN to address SAF deployment early and become the world’s leading countries in biojet fuel development. The findings of this study have to be seen in light of some limitations suggested to be addressed in further studies. First, the limitation of comprehensive report of SAF initiatives needs strengthening by employing other methods e.g., interview with the key relevant stakeholders. A wider data set of other ASEAN countries will also complement the key recommendations. Last, a deeper study of the economic instrument is needed considering the complexity identified in this study.

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References
[1] IATA 2015 IATA Sustainable Aviation Fuel Roadmap
[2] ICAO 2016 On Board a Sustainable Future - ICAO Environmental Report: Aviation and Climate Change
[3] Air Transport Action Group 2020 Waypoint 2050: An Air Transport Action Group Project
[4] Pavlenko N 2021 An assessment of the policy options for driving sustainable aviation fuels in the European Union
[5] Dyk S Van and Saddler J 2016 Flying Green: Policy Recommendations for Development of Production and Consumption of Biojet Fuels in Canada
[6] Aero Professional 2017 The ASEAN Tiger Takes on the Chinese Dragon
[7] Trikoranto H 2018 Biofuel Business Development in Pertamina
[8] Widiyanto S 2016 Indonesia Aviation Biofuels Policy: CAAFI Biennial General Meeting
[9] Goralski M, Benoist A, Baptiste A, Boudjema V, Galanos T, Georget M, Hévin J-E, Lavergne S, Eychenne F, Liew K E, Schwob C, Djama M and Tahir P M 2015 Sustainability of bio-jetfuel in Malaysia
[10] Singaporeair 2020 Sustainability Report FY2019/20 139
[11] Sasongko N A, Marini A T and Chrsnanto F X 2018 Study of Bio-Jet Fuel Resources Potential Development as Alternative Sources of Air Fuel Supply in Indonesia
[12] Mohsin R, Kumar T, Majid Z A, Kumar I and Wash A M 2017 Assessment of usage of biofuel in aviation industry in Malaysia Chem. Eng. Trans. 56 277–82
[13] Tun M M, Juchelkova D, Win M W, Thu A M and Puchor T 2019 Biomass Energy: An Overview of Biomass Sources, Energy Potential, and Management in Southeast Asian Countries Nature 388 1–14
[14] Anon 2019 European Aviation Environmental Report 2019
[15] IEA and FAO 2017 Bioenergy Roadmap Development and Implementation
[16] Selvi A F 2019 Qualitative content analysis Routledge Handb. Res. Methods Appl. Linguist. 440–52
[17] Hall D M and Steiner R 2020 Policy content analysis: Qualitative method for analyzing sub-national insect pollinator legislation MethodsX 7 100787
[18] WEF 2021 Deploying sustainable aviation fuels at scale in India: A clean skies for tomorrow publication 62