Challenges to Industry

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Hydrotreated vegetable oil production from palm oil mill effluents: Status, opportunities and challenges

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Abstract: The production of hydro-treated vegetable oil (HVO) from palm oil mill effluents (POME) can be particularly interesting for Malaysia and Indonesia, the two major palm oil producers. Potentially, about 0.4 and 0.9 billion liters of HVO may be produced from POME in Malaysia and Indonesia, respectively. Large amounts of POME oil were exported to China for biofuel production in recent years, but the supply–demand dynamics remain under-studied. The current policy trends in the EU are not in favor of POME-based HVO. Exports to the EU are shadowed by uncertainty regarding its eligibility for double counting owing to its links with the oil palm industry, despite it being claimed to be a waste-based biofuel. Domestically, Malaysia is still lagging behind in the policy for advanced biofuels. However, the country has shown its ambition in becoming a bio-jet fuel producer in the recently announced 12th Malaysia Plan (RMK-12). Converting POME oil into sustainable aviation fuel with HVO technology may be a promising option given the global commitment including Malaysia to reducing emissions in the aviation sector. © 2022 Society of Chemical Industry and John Wiley & Sons, Ltd

Key words: HVO; POME; palm oil; advanced biofuels; SAF; Malaysia

Introduction

The evolution of the EU biofuel policy throughout the past two decades has driven structural changes governing supply chains of biofuels and had an enormous impact on global trade. In 2018, the EU-RED ruled that the EU will phase out feedstock that may potentially involve indirect land-use change (ILUC) by 2030, with palm oil-based biofuels as the main target.[1] In contrast, the EU-RED incentivized waste-based biofuels by allowing double counting in meeting the blending targets. As a result, the import of palm-based biodiesel to Europe has decreased while the import of biodiesel made from used cooking oil (UCO) from China has increased sharply.[2]

The double counting mechanism has driven further search for waste-based biofuels. One option is hydro-treated vegetable oil (HVO) derived from waste streams. One key advantage of HVO over fatty acid methyl ester (FAME)-based biodiesel is that it may fully or partly substitute for fossil diesel in conventional diesel engines and contribute to exhaust emission reductions with good engine performance.[3] Importantly, it is also attractive owing to its flexible feedstock requirement. The

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HVO technology can accommodate multi-feedstocks coming from various sources with different qualities, like UCO, tall oil and fats, as well as palm oil mill effluents (POME) – the liquid waste stream disposed from palm oil mills.[4]

Hydro-treated vegetable oil derived from POME oil, i.e. the oil content in POME, could be particularly interesting for Malaysia and Indonesia, the two major palm oil producers, if placed into a broader scope of palm-based biorefineries that also integrate POME treatment. POME is generated at about 3–4 times the quantity of crude palm oil (CPO) produced.[5] Based on these numbers, Malaysia and Indonesia may produce more than 200 million tonnes of POME in a year. The treatment of POME is critical to the environment as it not only can severely pollute water resources but also releases large quantities of methane, a major greenhouse gas, into the atmosphere. POME is said to be more polluting than municipal sewage by approximately 100 times in terms of biochemical and chemical oxygen demand. This high biochemical and chemical oxygen demand depletes the oxygen in the water and poses threat to aquatic life.[6] Moreover, a study also has shown that Malaysia is producing 1000–4200 tonnes of methane from its palm oil mills annually.[7] Converting these waste streams into biofuels like HVO may significantly improve the economic feasibility of the treatment process.

While POME treatment and biogas capture are widely studied in both countries, the potential of HVO production from POME oil is not yet well understood. Using Malaysia as a case study, this study examines the current status as well as opportunities and challenges for POME-based HVO in the country from the perspectives of both industry and government.

Materials and methods

In-depth interviews were conducted in August–October 2021 to gather the experiences, perceptions and thoughts of practitioners in both the public and private sectors. The targeted participants were policymakers and experts in the biofuel industry. The key informants were identified through a snowball approach, i.e. participants would refer subsequent participants who have relevant experience to undertake the interview. In total, there were 11 individual interviews and a group interview with informants from different capacities as shown in Table 1. The interviews were conducted using semi-structured questions revolving around the participants' views on the current advanced biofuel industry in Malaysia and the opportunities and challenges to POME-based HVO production in Malaysia. All of the findings presented in the following section are analyzed based on the information collected from interviews together with data collected from other cited sources.

Current status of HVO and POME in Malaysia

Production of HVO is not a new technology. Globally, there are a number of large-scale commercial HVO production

Table 1. Demographics of the interviewees.

Number	Expertise	Years of experiences
Public		
1	Marketing and commercial in palm oil sustainability	14 years
2	Policymaking and implementor (national)	12–13 years
5	Policymaking, strategy planning (national)	>10 years in policy making, 2–3 years in the biofuel sector
7a	Manufacturing and services sector promotion	14 years
7b		6 years
7c		9 years
7d		2 years
10	Biodiesel technology research	19–20 years
Private		
3	Transportation sustainability	6–7 years
4	Sustainability certification, oil and gas expert	15 years in the oil and gas sector, 5 years in palm oil certification
6	Biodiesel technology provider	21 years
8	Sales and commercial in biodiesel	6 years
9	Sustainability certification expert and HVO producer	25 years in the oil and gas sector, 5–6 years the in biofuel sector
11	Advanced feedstock procurement/aggregator	14 years
12	HVO producer – feedstock procurement	8 years

HVO, Hydro-treated vegetable oil.

plants using vegetable oil as feedstock. The largest plants are Neste in Rotterdam and Singapore (1.28 billion liters per year each) and Diamond Green Diesel in Louisiana (1.04 billion liters per year).[8] At the moment, Malaysia remains at the lowest part of the HVO value chain, i.e. as the feedstock provider. A key informant from the oil and gas industry pointed out that as the HVO production is closer to petroleum refining than conventional biodiesel production. It may attract more interest from the oil and gas sector than the oil palm or conventional biodiesel companies to explore the technology. However, the current research capacity in Malaysia is insufficient to develop the technology domestically.

Furthermore, the capital investment of a HVO plant can be up to several billion dollars. Neste has recently invested USD1.6 billion to expand its production capacity by 1.6 billion liters per year in Singapore.[9] The plant is expected to be up and running by the end of 2022. While HVO enjoys the benefit that it does not need any further modification to be introduced directly into existing diesel engines and refueling stations, the overall cost of HVO production is higher than that of FAME.[10] The plant operation cost may be similar to that of FAME-based biodiesel, but there are additional cost components in the collection and pretreatment of feedstock if POME oil is to be used. It is estimated that a scale of at least 3 times that of a conventional biodiesel plant, or close to 0.5 billion liters, is required to make HVO production financially feasible, considering the economies of scale (especially in terms of feedstock collection and handling). In other words, HVO production is unlikely to be materialized in Malaysia without foreign technology providers and investors.

Currently, the total volume of POME oil generated per year in Malaysia is highly uncertain. It highly depends on the operating efficiency, which is affected by the fruits' oil content as well as the actual operation of individual mills. A rough estimate is that the total volume may be around 0.5 billion liters, assuming 0.6–0.7% oil content and 80–90% conversion efficiency.[5,11,12] If feedstock from Indonesia is also considered, the potential of POME oil in the region may be up to 1.5 billion liters, assuming that Indonesian mills have similar operating efficiencies as their counterparts in Malaysia. Assuming a 1.2:1 conversion rate, a total of 1.3 billion liters of HVO may be produced from POME in the region, with 0.4 billion liters from Malaysia.

However, the total volume may decrease in the near future owing to the improvement in the efficiency of palm oil mills and the slow growth of CPO production. Furthermore, collection cost could be significant as palm oil mills are scattered all over the country. It was revealed by an interviewee that there is already an existing market for POME oil. In Malaysia, POME oil is collected by aggregators like Fathopes Energy and Gunvor and exported to other countries, especially China, for biodiesel production. This may have partly contributed to the rise in the export of biodiesel from China to the EU, which is largely double counted owing to its waste-based feedstock.

The actual volume of POME oil collected and traded, however, is not clearly known, as the supply–demand dynamics remains under-studied. POME oil might be potentially traded across borders under two Harmonized System (HS) codes, i.e. 15 220 090 'Animal or vegetable fats and oil and their cleavage products; prepared edible fats; animal or vegetable waxes' and 38 231 910 'Industrial monocarboxylic fatty acids, acid oils from refining, other, acid oils from refining'. One interesting trend is that the export quantity from Malaysia to China under 38 231 910 has been doubled in 2019 and continued to grow in 2020 to nearly 0.2 billion liters. In the same period, China also saw a dramatic increase in export of biodiesel mainly made of waste streams to Europe[13] (Figure 1). There is, however, no accurate data about the export of POME oil and its relation to waste-based biodiesel production in China.

An interviewee from the industry indicated that the current price of POME oil is roughly 90% of that of CPO. The rise in demand for POME oil may potentially lead to a situation that the mills may configure the processes to optimize the ratio of CPO and oil content in POME in terms of cost and profits (considering the investment needed to improve oil extraction efficiency). This may blur the lines of POME oil as a waste stream and as a by-product, which has important consequences for the double counting mechanism accepted by the EU-RED. This, however, has to be considered together with the policies for waste management as well as the potential for methane capture and biogas production.

Export to the EU: Speculation and uncertainties

The biofuel production in Malaysia has been largely developed for export purposes, especially with the EU as the major destination. A significant decline in palm-based biodiesel was observed in Europe in 2020, mainly owing to the diminished Indonesian export caused by the countervailing duties.[14] However, the export of palm-based biodiesel from Malaysia to the EU was also almost halved in the same year.[2] While these declines were probably linked to the COVID-19 pandemic, the EU has planned to gradually phase out palm-based biodiesel, which is considered as a 'high-risk ILUC' biofuel. In July 2021, the reformulated version of RED, namely RED-II, has come into force.[1] A buffer is given until 2023, when the use of palm-based biodiesel must be capped at the 2019 level.[1]

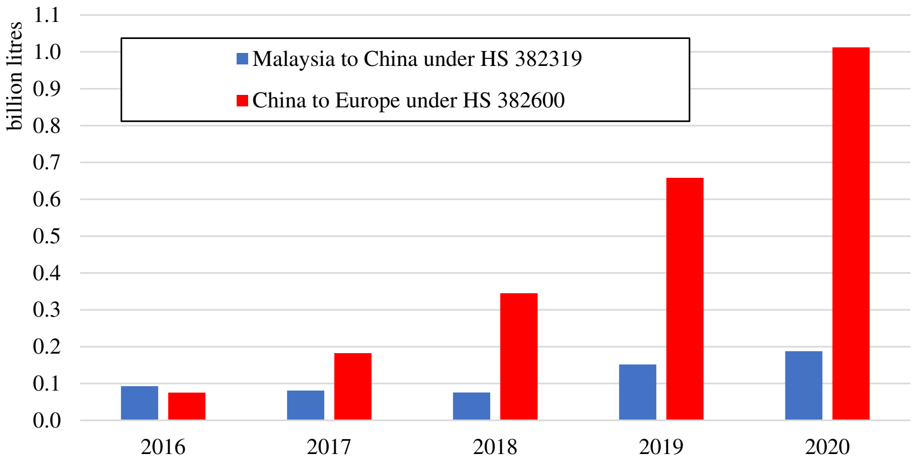

Figure 1. Export of Malaysia to China under HS code 382319 ‘Industrial monocarboxylic fatty acids, acid oils from refining, other, acid oils from refining’ and export of China to Europe under HS code 382600 ‘Biodiesel and mixtures thereof; not containing or containing less than 70% by weight of petroleum oils or oils obtained from bituminous minerals’.

While POME oil is considered as a waste stream, there is a risk that the double counting advantage may be removed owing to the linkages with palm oil. Currently, based on RED-II, POME oil is considered as an ‘advanced feedstock’ listed under Annex IX part A and is eligible for double counting in meeting the blending targets. However, at the national level, Germany has recently announced that it will remove POME oil from its double counting list. There might be a domino effect that the other EU countries might follow. In the past, a similar situation has happened for palm fatty acid distillate. This was once classified as waste and was eligible for double counting. However, it was later excluded from the double counting list in most Member States except Finland.[15]

From the sectorial point of view, both Indonesia and Malaysia have protested, calling the directive discriminatory as oil palm’s competitors, especially when soy oil from North and South America as well as locally grown rapeseed and sunflower oil, are treated differently from palm oil. In 2020, both countries began taking legal action against the EU at the World Trade Organization.[16] However, it is unlikely that palm-based biodiesel will be accepted in the EU market in the near future. Two exemptions to the rule would be if the biofuels are produced on degraded or abandoned land or grown by smallholders.[17] The latter exemption partly explains the increased interest in both Malaysia and Indonesia in improving smallholder production and preparing them for certification under either the commonly known Roundtable on Sustainable Palm Oil or the national schemes, i.e. Indonesia Sustainable Palm Oil and Malaysia Sustainable Palm Oil. The whole debates about the sustainability of palm oil at a sectoral level may have fundamental implications to the eligibility of POME-based biofuels for double counting.

Domestic market: Missing policies for advanced biofuel

Presently, Malaysia regulates the domestic use of biofuels with the Malaysia Biofuel Industry Act 2007. This act, however, only covers conventional biofuels, in particular, palm olein- and FAME-based biodiesel. Advanced biofuel like POME-based HVO is currently not mandated in Malaysia. With priority given to export, the domestic market of biofuel has been designed, in a way, to function as a price control mechanism for palm oil with subsidies from the government. This creates a buffer for the industry, especially when the price of CPO is too low and the stock is too high. In other words, the biofuel policies in Malaysia are driven mainly by the economic considerations but not the emission reduction targets. This partly explains the lack of progress in advanced biofuel policies in the country.

Under the current circumstances, the introduction of POME-based HVO may face stiff competition from FAME-based biodiesel in the country. In 2011, more than 60 licenses were issued for palm biodiesel production, amounting to a total production capacity of 8.7 million liters per year. However, the utilization rate is relatively low. By 2021, the Malaysian Biodiesel Association had only 18 active biodiesel-producing members with a production capacity of 2.9 million liter per year.[18] Even increasing the blending target to with the current B20 biodiesel programme (a blend of 20% palm biodiesel and 80% of petroleum diesel), the domestic demand for biodiesel remains low at around 1 million tonnes a year. The unfavorable market conditions in the EU may further increase the importance of the local market serving as a buffer for the palm oil industry.

Taking the renewable energy surcharge (1.6%) embedded in the electricity billing system as an example, an industrial representative suggested that a similar tax system may be adopted on vehicle fuels to collect funds for advanced biofuels. However, the current economic situation in Malaysia may not permit such a mechanism to be implemented. Moreover, the price of HVO can be up to 3–5 times higher than fossil-based diesel or FAME-based diesel per joule.[19] It is likely that the domestic market will maintain its role as a buffer for the palm oil industry with limited opportunities for advanced biofuels like POME-based HVO.

From POME to sustainable aviation fuel

The increasing demand for reducing aviation emissions from international flights could act as a strong motivating factor for the production of POME-based biofuel, as POME oil can be converted to sustainable aviation fuel (SAF) using the HVO technology. In 2010, the International Civil Aviation Organization (ICAO) set the goals to improve energy efficiency by 2% per year until 2050 and to have carbon-neutral growth from 2020 onward.[20] The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) was established as the first global market-based measure for international aviation to reduce greenhouse gas emissions. Using 2019 as the baseline, it is estimated that about 2.5 billion tonnes of CO_2 emissions need to be offset from 2021 to 2035 to achieve a carbon-neutral growth.[21] CORSIA is planned to be implemented in three phases, i.e, the pilot phase in 2021–2023, the first phase in 2024–2026 and the second phase in 2027–2035. Participation by state members is voluntary for the first two phases (2021–2026) and mandatory for the phase 2027 onwards, except for the least developed countries, small developing states and landlocked countries.

As of 14 July 2021, a total of 106 states have volunteered to participate in the 2021–2026 phase. This represents about 77% of international aviation activities.[22] Malaysia is one of the voluntary states. In other words, starting from 2021, Malaysia is committed to achieving a carbon neutral growth in international aviation with SAF utilization as one of the measures to achieve this. In the latest Twelfth Malaysia Plan, Malaysia is also aiming to be a key producer of bio-jet fuel in the region.[23] Although no clear policy roadmap exists at this moment, Malaysia's first bio-jet fuel prototype using locally developed technology will be launched in early 2022. This plan was initiated to meet the ICAO regulations. Given the uncertainties of existing biofuel markets, the aviation fuels market might be the potential niche market for POME-based SAF.

Conclusions

While POME oil can be a potential feedstock, HVO production in Malaysia may only be financially feasible with a wider range of feedstock, including UCO owing to the limited volume of available POME oil and the economies of scale. There is a need to study the supply–demand dynamics of POME oil to better understand the potential and risk of feedstock supply. In the absence of policy support, it is unlikely that there will be a domestic market for POME-based HVO. However, export to the EU is also fraught with uncertainties in terms of the eligibility for the double counting mechanism owing to its links to the palm oil sector. In this context, converting POME oil into SAF with the HVO technology may be a prospective option given the global commitment, including Malaysia, to reducing the emissions in the aviation sector. This is in line with the country's ambition to establish its own bio-jet fuel industry as a part of its development plan in the coming decade. Nevertheless, in view of the cost difference between petroleum jet fuel and SAF, long-term national policy support will be significant to drive the use of SAF locally. While the oil palm sector has the feedstock, the oil and gas industry may be more relevant in the downstream development considering the readiness for technology adaptation and end-product development.

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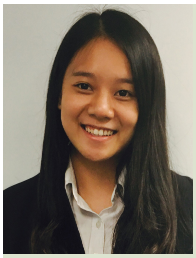

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