Wed, Jan 26, 2022

Notice to readers

Dear readers:

The economic report contained in this report was produced by SCB Economic Intelligence Center (SCB EIC) and SCB Securities (SCBS) has been granted permission by Siam Commercial Bank to distribute this report to its clients. In doing so, SCBS has reviewed the report and agrees with the contents of this report.

SCBS is distributing this economic research report on its own behalf for general information only.

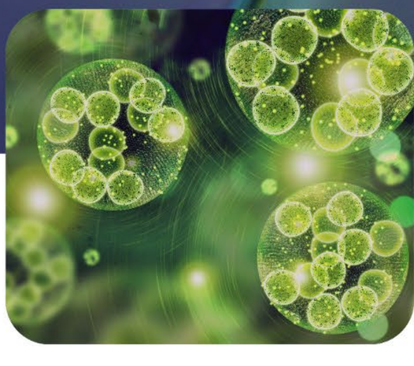
SCB Securities Company Limited

NOTE
EIC CLIMATE

SCB
Economic Intelligence Center

THE ROLE OF ADVANCED BIOFUELS
in the Energy Transition

16 December 2021



KEY SUMMARY

- **Advanced biofuels will play a crucial role in reducing greenhouse gas (GHG) emissions for heavy-duty vehicles: namely trucks and airplanes.** Since advanced biofuels are functionally equivalent to petroleum-derived fuels and thus compatible with existing infrastructure and engine technology, they are considered the prime alternatives for the energy transition of the transport sector, especially the hard-to-decarbonize vehicles.
- **Biofuels are facing debates over life-cycle sustainability, particularly in terms of food security and cultivation problems.** Food-based biofuels cause competition between food and biofuel feedstock, leading to food insecurity and rising food prices. Also, biofuel production usually consumes massive resources, resulting in extensive impacts on the environment and ecosystem.
- **Advanced biofuels have thus been introduced to solve life-cycle sustainability issues.** Unlike food-based biofuels, advanced biofuels are derived from non-food resources—such as agricultural residues and energy crops—with more environment-friendly cultivation and conversion processes.
- **Yet, advanced biofuel technology is still in its infancy. Without a technological breakthrough, they are unable to compete with other alternative fuels** due to higher prices and insufficient drop-in properties to replace fossil fuels. Hence, investing in technology research and development is essential to establish a solid and efficient foundation for the advanced biofuel industry.
- **Thailand has the potentials to transform an existing biofuel industry into advanced biofuels, with feedstock advantage and knowledge at the ready.** There are substantial and diverse residues from Thai agricultural sector that can be converted into advanced biofuels. Besides, Thailand could seize this opportunity to promote agricultural waste valorization and transition to a circular economy.
- **In particular, the Sustainable Aviation Fuel (SAF) offers a golden opportunity for Thailand to meet growing demand from aviation firms around the world.** As global air transports are pivoting to more sustainable jet fuels in order to meet the net-zero emissions target, flights to and from Thailand will call for SAF supply availability at Thai airports as well.
- **The key to making headway in advanced biofuel development requires significant government supports and stakeholder synergy.** The policy should be consistent with clear direction, flexible and adaptable to changes, and also align with current technological capabilities. Furthermore, the government should develop a favorable environment that fosters market competition and collective efforts from all stakeholders in paving the way towards sustainable development in the energy sector.

CONTENT

Click ⊕ to read more

The transport sector is by far one of the largest greenhouse gas (GHG) emitters, contributing approximately 17% of global GHG emission intensity[1]. The internal combustion engine and jet engine powered by fossil fuels are among the main sources of GHG discharges. That is why the transport sector has been of central interest in GHG mitigation as the world is striving to meet the net-zero target.

For the transport sector, the efforts to reduce GHG emissions are currently directed to:

1. Increasing public transport
2. Enhancing fuel economy in vehicle engines
3. Developing the zero tailpipe emission technology, such as battery electric vehicle and hydrogen fuel cell electric vehicle; and
4. Researching on alternative sources to displace fossil fuels

In this article, we will **focus on the development of biofuels to reduce GHG emission intensity from vehicles that face difficulties in pivoting to clean technology—**such as electric battery and hydrogen fuel cell. The analysis is parted into 3 sections:

- **The role of biofuels** in reducing GHG emissions from the transport sector: Since advanced biofuels are compatible with current infrastructure and engine technology, they are preferred alternatives in energy transition, especially for the hard-to-decarbonize transportation such as heavy-duty vehicles. Plus, biofuels are value-added products from waste and thus the integral parts of a circular economy.
- **The challenges of advanced biofuels** to achieve life-cycle sustainability, enhance competitiveness to level other fuel alternatives, and develop fuel qualities that can be alternatives to fossil fuel—or the so-called 'drop-in properties.'
- **Thailand's opportunity** to switch from conventional to advanced biofuel industry, building on feedstock advantages to enhance the existing biofuel sector: In particular, the **Sustainable Aviation Fuel (SAF) is an opportunity ready to take off** with rising demand across a global market.

---

[1] GHG emissions share in 2018, based on data from Climate Watch Historical GHG Emissions (World Resources Institute, 2021)

Biofuels will play a vital role to cut down GHG emissions in the transport sector, owing to 3 key advantages :

- Compatible with existing infrastructure and engine, thus considered a promising option for the transport sector in energy transitionสามารถใช้กับยานพาหนะขนาดใหญ่ (heavy duty vehicles)
- Viable for heavy-duty vehicles which face constraints in new technology development such as electric battery and hydrogen fuel cell
- Considered another approach to a circular economy through the valorization of agricultural wastes

Biofuels play a vital role in reducing GHG emissions from transport sector

The transport sector is in the race of energy transition, and biofuels are among the top picks for GHG emission savings, as they require no investment for infrastructural change or new engine technology. Nowadays, biofuels (such as ethanol and biodiesel) used in vehicle engines are blended with petroleum so they can be used with the existing petroleum infrastructure: from fuel transportation, pipeline, storage, filling station to engines. Biofuels thus have relatively less distribution contraints to end-users, compared with battery-electric and hydrogen technologies that require an entirely new infrastructure development and supply chain.

Thailand has witnessed a growing market for biofuels in the past decades. Since 2007, the government has made it mandatory that all gasoline and diesel used in Thailand must be blended with biofuels. Blending mandates at the start were 10% ethanol for gasoline and 2% biodiesel for diesel, before gradually increasing afterward. Currently, biofuels available at filling stations across Thailand include gasohol E10, E20, and E85 and diesel B7, B10, and B20[2]. The consumption of ethanol and biodiesels stood at 4.4 and 5.2 million liters per day[3], marking the annual average growth at 17% CAGR and 32% CAGR, respectively.

In the near future, electric vehicles (EVs) will likely displace light- and medium-duty automobiles, such as passenger cars and pickup trucks. The International Energy Agency (IEA) reported that fuel consumption in road transport would slowly decline as the adoption of passenger EVs accelerates. Indeed, the number of EVs across the globe is expected to jump from 7.2 million in 2019 to 60 million in 2026. The fuel consumption shrinkage will be more profound among light- and medium-duty automobiles, while **other heavy-duty vehicles would remain highly dependent on internal combustion engines**.

[2] The numbers after E (Ethanol) and B (Biodiesel) indicate the proportion of biofuel contents.

[3] Fuel consumption in 2019 (before the COVID-19 pandemic), based on DOEB data

Battery-electric and hydropgen technologies have been receiving intense interest as green alternatives for the transport sector[4]. Nonetheless, only EVs are likely to see extensive adoption in forthcoming years yet limited to light- and medium-duty vehicles.

Looking ahead, **large and heavy-duty vehicles**—which contribute as high as 50% of GHG emissions in the transport sector —**will continue to rely heavily on fossil fuels, together with internal combustion engines and jet engines.** Hence, the ready-to-use biofuels are considered the key technology in decarbonizing the transport industry and achieving the net-zero emission target.

Listed below are vehicles fleets with short-to-medium-term constraints to adopting clean technology, such as electric battery and hydrogen fuel cell.

Heavy-duty truck: Heavy-duty trucks are powered by diesel engines, so their viable bioenergy alternative is biodiesel. At present, there is a wide range of biodiesel blends varied by each country's policy, such as 7%, 10%, 20%, or 30%.

Biofuels will become transition fuels for heavy-duty trucks, while clean technologies like electric battery and hydrogen fuel cell are still decades away from widescale adoption.

Aviation: For the aviation sector, restructuring engines and aircraft is confronted with numerous constraints. Although battery- or hydrogen-powered airplanes could potentially see extensive market uptake in the long term (2050 onwards), industrial experts view that they will be limited to small and short-haul aircraft. Meanwhile, long-haul flights are mainly powered by jet engines and fuel alternatives equivalent to jet fuel[5].

Sustainable Aviation Fuel (SAF)[6] is, therefore, a key transition fuel for air transport. Bio-jet for blending with conventional jet counterparts can be produced from the same feedstocks as ethanol and biodiesel because jet fuel characteristics are in between gasoline and diesel. The SAF production can be varied by technology pathway and predominant feedstocks. Nowadays, bio-jet contribution in total world's aviation fuel consumption remains lower than 1%[7] as its production technology is still in the early stage or just kicked off the trial.

Shipping: Compared to automobiles and jet engines, most internal combustion engines used in ships are more flexible. They are designed to operate safely on fuels with wide-ranging properties[8] without much specification requirements, unlike those in cars and airplanes. Furthermore, the advancement of new multi-fuel engine technology would help expand the maritime energy market to more fuel choices.

[4] The ratio as of 2018, based on data from "Beyond road vehicles: Survey of zero-emission technology options across the transport sector" (Hall, Pavlenko & Lutsey, 2018)

[5] The US Federal Aviation Administration (FAA) and US Long Term Strategy on Net-Zero (2021) viewed that battery-electric airplanes will not see a widespread adoption at least until 2037 for short-haul and 2050 for medium-to-long-haul air routes, and that hydrogen aircraft still face numerous challenges. Hence, SAF is a likely viable solution for air transport in short to medium term.

[6] SAF consists of bio-jet fuel and synthetic fuel—produced from hydrogen. SAF mentioned in air transport is primarily bio-jet fuel, since the latter is still a nascent technology that would see a broader market uptake in the longer term (2050 onwards). Likewise, SAF in this article solely refers to bio-jet fuel.

[7] Annual Review (IATA, 2021)

[8] Marine engines can tolerate low-quality or high-viscosity fuels such as low- and medium-speed marine diesel oil and fuel oil.

Feasible biofuels for the marine sector include biodiesel, which has similar properties to the commonly-used fuel oil and marine diesel oil. However, due to higher costs and competition for supply with road and air transports, biofuels remain implausible to be preferable choices in decarbonizing marine transportation.

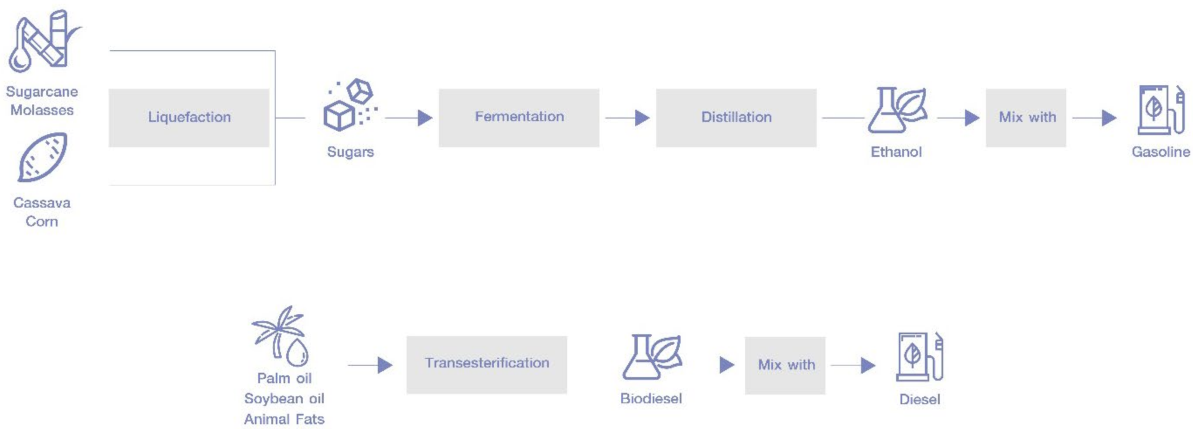
3 Challenges for the biofuels industry

- To achieve the life-cycle sustainability
- To bridge the price gap between biofuels and other fuel alternatives
- To develop drop-in fuels from biomass to substitute fossil fuels

Sustainability Concerns

When biofuels are burned, they emit less GHG than fossil-based fuels. That is why biofuels are considered cleaner substitutes for combustion engines. Still, biofuel deployment is facing debates about life-cycle sustainability, particularly adverse impacts on food security and land-use. Most biofuels used nowadays are **first-generation (or conventional) biofuels** made of food-based crops such as cassava, sugar cane, oil palm, corn, soybean, etc. These crops are also grown for food and animal feeds, so many critics argue that a large-scale deployment of biofuels might cause competition between food and fuel production, thus leading to supply shortages and rising food prices. Such argument did come with evidence. The year 2021 witnessed a three-fold surge in vegetable oil prices[9] in response to a rising biofuel demand from US refineries, backed by the national clean fuels policy incentives, which also led to skyrocketing demand for vegetable oils.

Figure 1: An Example of Feedstocks and Production Processes of First-Generation Biofuels



Source: Generations of Biofuels (Oregon State University)

[9] 'Diesel vs. doughnuts': new biofuel refineries squeeze US food industry (Financial Times, 2021)

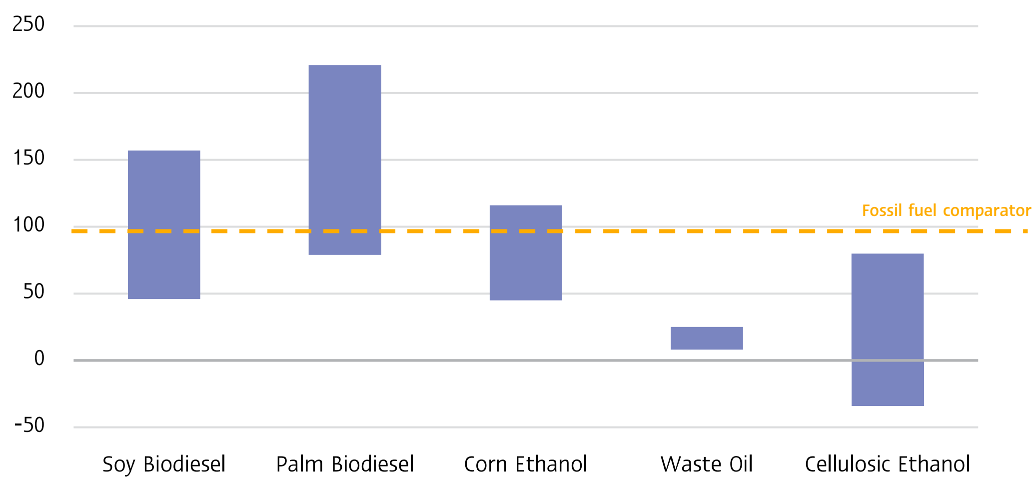
Besides, increased biofuel demand from the transport sector has spurred cropland expansion in an attempt to scale up feedstock yields. In some regions, this includes deforestation, which results in further loss of forests that are the central pillar of an ecosystem and help absorb carbon. If considering deforestation and GHG discharges from biomass crop farms, the well-to-wheel emissions from biofuels might level that of fossil fuels, or worse, even higher. As these concerns arise, many countries announce efforts to cut down first-generation biofuel deployment. For example, the EU is planning to limit and set a long-term target to quit using biodiesel from palm oil linked to deforestation in Indonesia and Malaysia.

In addition, scaling up biofuel production consumes massive resources and increasingly causes extensive impacts on the environment and ecosystems: substantial water consumption, soil degradation and water pollution from fertilizers and chemicals uses, the monocultures of biofuel crops that could harm biodiversity, just to name a few. When it comes to sustainability and environmental footprint, the first-generation biofuels from food-based crops might not be as environment-friendly as they first appear to be.

Figure 2: Some types of biofuels might have greater life-cycle GHG emissions than fossil fuels

Life-cycle GHG emissions estimates for common biofuels

Unit: gCO2 eq./MJ



Note: Data is sourced from various major regulatory studies (for more information see the source)

Source: U.S. biofuels policy: Let's not be fit for failure (O'Malley, 2021)

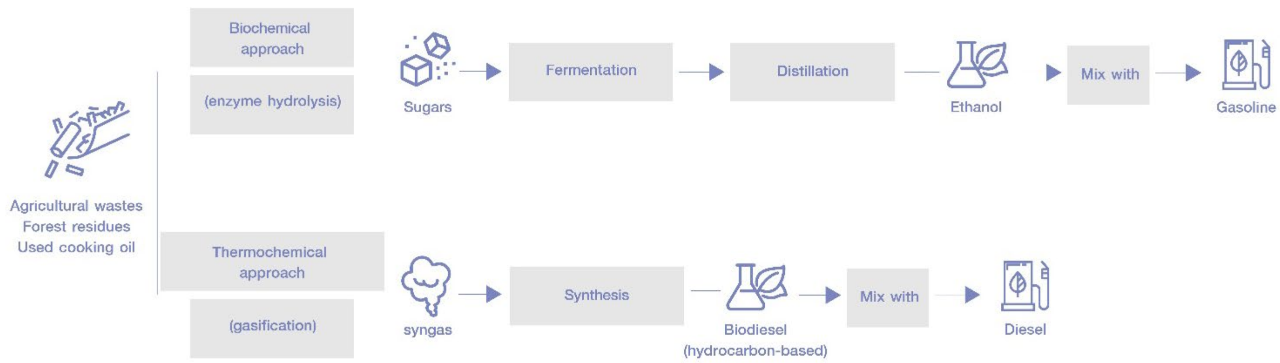
Advanced Biofuel: An Alternative for Better Sustainability

Life-cycle sustainability debates bring to the fore the new biofuels produced from non-food feedstocks. Unlike the first-generation biofuels, the development of new biofuels addresses environmental sustainability issues such as water management, competition between food and fuel, deforestation, ecological balance, and life-cycle GHG emissions—from feedstock production, fuel transportation, and refinery to end-use.

Here come **Advanced Biofuels**[10] the new biofuels developed from non-food materials and offering more sustainable and environment-friendly alternatives. To date, advanced biofuels include:

- **Second-generation Biofuel:** biofuels made of non-food and lignocellulosic biomass from agricultural residues such as corn stover, straw, palm bunch, wood waste, and other waste materials. In contrast to food-based crops, these feedstocks are initially leftovers, so they are cheaper, more abundant, and able to solve the food-vs.-fuel matters.

Figure 3: An Example of Feedstocks and Production Processes of Second-Generation Biofuels

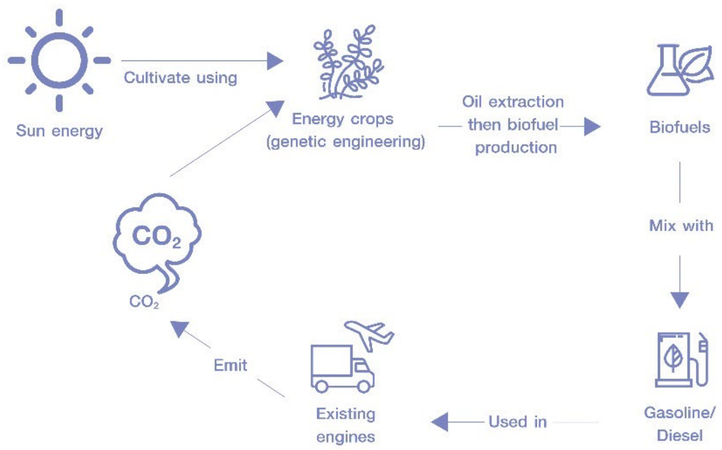


Source: Generations of Biofuels (Oregon State University)

[10] Based on the definition of advanced biofuels stated in Annex IX, Part A of the EU's Renewable Energy Directive (RED) II

- **Third-generation Biofuel:** Still, second-generation biofuels are residues from food or energy crops, so there remain concerns over land and resource grabbing. The next-generation biofuels then pursue biomass from new energy crops such as algae. Algae is advantageous as it can grow in unfavorable environments, like low fertility soils, and sequester carbon dioxide naturally. Also, growing algae consumes less water than other biofuel crops and can make use of non-consumptive water such as saline water and industrial wastewater. Through photosynthesis, these new energy crops generate fat or oil that will be extracted to produce biofuels. Yet, the development of third-generation materials is still in a laboratory phase.

Figure 4: An Example of Feedstocks and Production Processes of Third-Generation Biofuels



Source: Generations of Biofuels (Oregon State University)

Price Competitiveness Challenges

The price of advanced biofuels is among the major impediments to market uptake. Since the industry is still commercially immature and not well-established, there remains a significant price gap between advanced biofuels and other renewable energy alternatives. For instance, SAF costs about 3-5 times higher than fossil jet fuels[11]. Since fuels account for 20-30% of airline operating costs, advanced biofuels are seen as less competitive in this market. Currently, production costs for biofuels are expensive and thus weigh on breakeven prices for advanced biofuel refineries. With high production costs, only few advanced biofuel projects are economically viable, and that becomes a major barrier for industry development.

[11] CompensaidxSwiss (2021)

Drop-in Property: A Vital Element for Advanced Biofuels

Another challenge is to develop a 'drop-in' biofuel that is functionally equivalent to petroleum-derived ones, thus can be safely mixed with conventional fuels in varying degrees. In general, biofuels contain different chemical compositions and functional characteristics from fossil-based counterparts, such as high viscosity and high flash point, which could entail ignition delay and incomplete combustion, thus affecting fuel capability and safety. In this way, biofuels cannot fully use the existing petroleum infrastructures and are subject to a blending wall. Without significant modifications in infrastructure or engines, ethanol and biodiesel can be mixed up to 15% with gasoline and 20% with diesel, respectively[12].

As the name suggests, drop-in biofuels can be immediately 'dropped into' existing infrastructure and engine technology since they are functionally identical to petroleum fuels. The biofuel industry nowadays thus seeks to enhance drop-in properties, in a way to scale down investment in research and development for new infrastructures that fit with conventional biofuels. In the aviation sector, SAF must be physically and chemically equivalent to fossil-based jet fuel, so that they can be mixed to a higher degree without significant modification on current infrastructure and jet engines—which are regulated under stringent safety and quality standards.

Some technical challenges await drop-in biofuel development: (1) Deoxygenation—biofuels contain 10-45% of oxygen depending on predominant feedstocks[13] while crude oils comprise oxygen below 2%. Plus, the advancement in the deoxygenation of biofuels remains underway. (2) Effective hydrogen-to-carbon ratio (H/C ratio)—which indicates energy density of fuels. The H/C ratio in biofuels is lower than in petroleum, meaning that more hydrogen needs to be injected into biomass-derived fuels to achieve drop-in alternatives. Since hydrogen is essential in both deoxygenation and hydrogen enrichment procedures, the development of drop-in biofuels will likely increase demand for hydrogen as well.

Yet, hydrogen today is in short supply. Hydrogen consumption is currently concentrated to two major users: first, the refinery using self-produced hydrogen to improve petroleum quality, and second, fertilizer producers using hydrogen to make ammonia. That is to say, finding sufficient and low-price green hydrogen supply is another challenge for drop-in biofuel development.

[12] The exception is a flexible-fuel vehicle (FFV) which can safely run on a mixture with higher biofuel contents since their internal combustion engines are distinct from regular cars. To date, FFVs only operate with gasoline. (IEA Bioenergy, 2019)

[13] Combustion Efficiency Impacts of Biofuels (Demirbas, 2009)

Investment in advanced biofuel is, therefore, of the utmost importance. Advanced biofuel development is still a nascent technology, and without a technological breakthrough, they cannot compete with fossil fuels both in terms of fuel properties and production cost. However, development in advanced biofuel technology is falling behind other clean technologies. The number of patent filings in biofuel technology has plummeted since 2011, following an energy crisis. Likewise, global biofuel investment has been losing pace as the world reckons that the biofuel industry is ground to a halt, especially when compared with other clean technologies such as solar, wind power, and lithium-ion battery[14].

" Advanced biofuel technology is still in its infancy. Without a technological breakthrough, they are unable to compete with fossil fuels in terms of fuel quality and production cost. Compared to other clean technologies, research and investment in advanced biofuels remain much lower. "

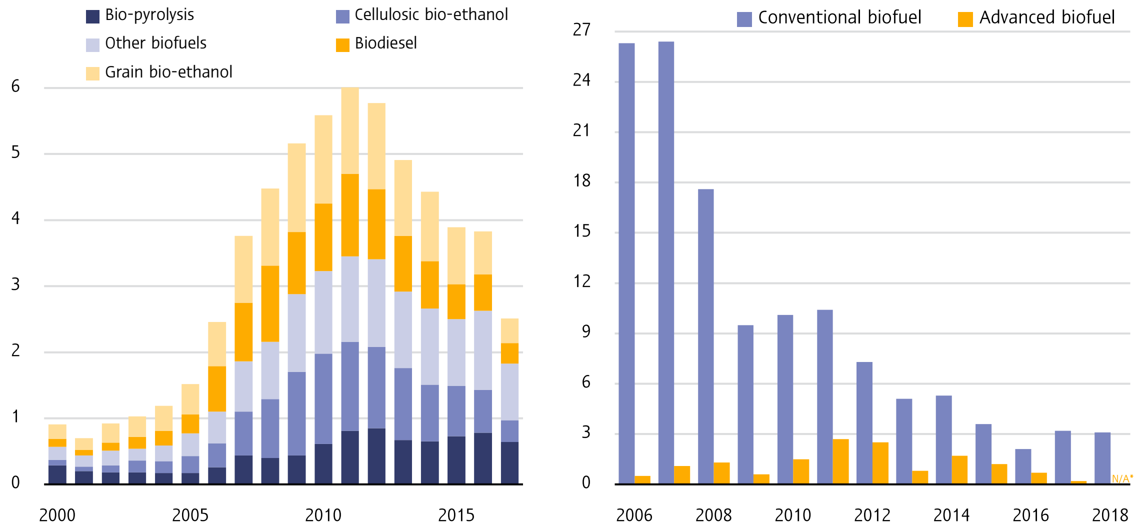
Figure 5: Investment on advanced biofuels technology development has been recently low

Patent filing by classification

Unit : thousand filings

Global biofuel investment

Unit : billion USD



Note: The patent data is categorized by the Climate Change Mitigation Technologies (Y02) Classification of the European Patent office; the blue shades represent conventional biofuels while the yellow shades represent advanced biofuels.

Source: Biofuels: slump in investment and innovations must be reversed (Energypost, 2019) and IRENA INSPIRE

Note : *2018 data is not available yet

Source : Global trends in renewable energy investment (UNEP/BNEF, 2019) and Advanced Biofuels: What holds them back? (IRENA, 2019)

However, advanced biofuels are brought to the limelight again as key solutions to guide the global journey to net-zero emissions especially for the hard-to-decarbonize transport sector. With rising market demand, advanced biofuels offer a lucrative opportunity to foster investment in technology research and development to establish a firm and practical foundation for the cleaner fuel industry.

14 Biofuels: slump in investment and innovations must be reversed (Energypost, 2019)

The Opportunity for Thailand

Advanced biofuels offer an opportunity for Thailand to harness feedstock advantage and uplift an existing biofuel industry. As highlighted above, biofuels play a vital role in reducing GHG emissions for the transport sector on its energy transition. Biofuels also provide cleaner solutions to vehicles facing constraints in decarbonizing, such as heavy-duty trucks and airplanes. The world is now striving to meet the net-zero target, and this is a promising opportunity for Thai biofuels to fill up the global demand tank.

In Thailand, ample and diverse residues from agriculture can be converted into advanced biofuels. Notably, major cash crops and raw materials for ethanol and biodiesel production generate massive—now an oversupply of—wastes such as bagasse, cassava pulp, and palm bunch. Together with existing knowledge in biofuel production, these abundant but unwanted wastes from agriculture can be experimental resources to jumpstart advanced biofuel production. Looking ahead, agricultural residues of other economic crops—such as corn stover and fruit waste from factories—are also potential sources to make advanced biofuels. Furthermore, diversifying feedstock options would help minimize the risks of over-reliance on a single raw material.

"Thailand has abundant and wide-ranging farm residues that can be converted into advanced biofuels. Also, this is an opportunity to shore up the Thai agricultural sector and promote a pathway to the circular economy."

On the back of global commitment to reduce GHG emissions and growing demand for advanced biofuels, Thailand could seize this opportunity to promote value-added agriculture and transition to the circular economy, through strengthening the supply chain of economic crops—from cultivation, production, utilization, and waste management.

Advanced Biofuel Pathways and Government Supports

Policy supports play a big part in driving advanced biofuel development. Similarly, on the way to becoming the global leader in the advanced biofuel industry, Thailand could incentivize the utilization of knowledge and resources by:

1. Enforce policy with clear and consistent direction on advanced biofuel deployment to establish a well-found market demand
2. Encourage market and pricing mechanisms that help lower advanced biofuel production cost and increase industry competitiveness against fossil-based counterparts
3. Embolden life-cycle sustainability in the ecosystem

Blending Mandate

As evident in past decades, blending mandate is another critical tool to establish a domestic market for advanced biofuels. Going forward, blending mandate will also help usher investment in technology and production capacity. Given unstable demand, a well-found market for advanced biofuels seems far-fetched since private sector investment would sit in a wait-and-see attitude. Blending mandate, therefore, should take into account existing technological competence both in terms of production capacity and resource availability, so that the obligation aligns with technology and industry readiness. Also, a gradual increase in blending mandate will help sustain market demand and supply for advanced biofuels in a longer horizon.

> “Blending mandate should be in line with country’s technological competence.”

For example, France has enforced the law mandating that all flights from French territory use at least 1% of SAF in total jet fuels by 2022. The mandate will gradually increase to 2% by 2025, 5% by 2030, and 50% by 2050. In response to that, Air France-KLM, Total, Groupe ADP, and Airbus agreed to pioneer the SAF technology development so as to ensure there will be ample SAF supply available to meet the government obligation.

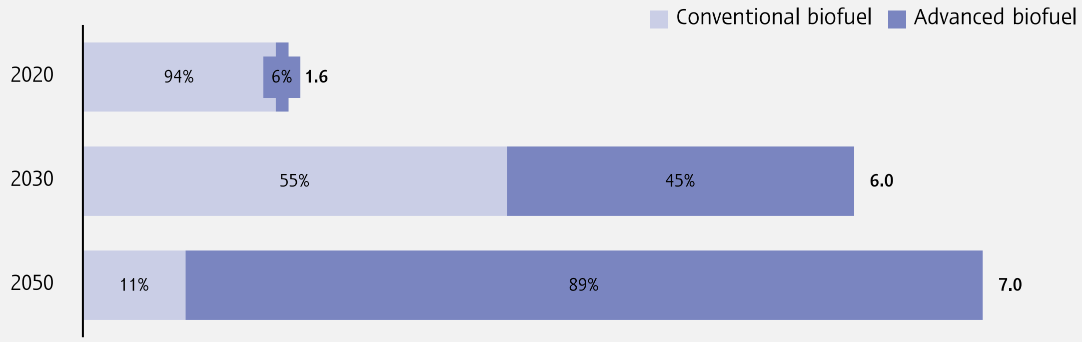
In addition, the government should thoroughly assess the impact of blending mandates on each stakeholder in the advanced biofuel ecosystem. Apart from that, it is necessary to identify problems and barriers whilst calibrating the policy supports in parallel with future changes in the energy industry, ecosystem, as well as technological advancement.

BOX : Advanced Biofuel Targets around the World

Governments across the globe pledge to increase the use of sustainable biofuels. Such ambitious moves have helped foster technology development and biofuel deployment in various vehicle fleets. Most recently, IEA (2021) emphasized that if net-zero targets in each interval are to be met, the global transport sector must scale up the contribution of advanced biofuels in total biofuel usage from 6% in 2020 to 45% and 90% in 2030 and 2050, respectively.

Key deployment milestones to achieve the net zero target by 2050

Unit : % of total usage, million barrels of oil equivalent per day



Note: Liquid biofuels for transportation only

Source: EIC analysis based on the information from Net Zero by 2050 (IEA, 2021)

The past recent years also witnessed more regional targets to shift from conventional to advanced biofuels, with the EU in the lead. In particular, the Renewable Energy Directive (RED) II—launched in 2018—introduced a 7% cap on the final consumption of conventional biofuels in road and rail transportation for the EU member state. The recast directive also set a sub-target for advanced biofuel deployment of at least 0.2%, 1%, and 3.5% of total final energy consumption in the transport sector in 2022, 2025, and 2030, respectively[15]. Another prominent mandate is the EU's proposal of Refuel Aviation Initiative currently under consideration. If approved, all airlines from the EU airports will be required to use at least 2% of SAF starting from 2025 and gradually increase to 5% in 2030, 32% in 2040, and 63% in 2050.

On the national front, France set a 7% cap on crop-based biofuels in total fuel consumption and blending mandates of advanced biofuels at 3.8% for gasoline and 2.8% for diesel from 2028 onwards. Lastly, many energy firms also announced targets and development roadmap to buttress the advanced biofuel industry. In September 2021, Shell made a final investment decision to build the facility for advanced biofuel production at its Pernis refinery in the Netherlands. The facility is due to start commercial production by 2024, using agricultural residues, used cooking oil, wasted animal fats, and certified sustainable vegetable oil as feedstocks.

[15] The EU's 'Fir for 55' package, currently under consideration, might add some changes to the target, such as higher blending mandates. (Sidley, 2021)

Competitive Market Mechanism for Advanced Biofuel

To incentivize a transition to clean energy, the government should have in place a market mechanism in which fuel prices fully reflect environmental costs. Advanced biofuels are more costly than petroleum, since general fuel prices have not yet covered the cost of environmental externality. Hence, **the government should introduce a pricing mechanism that reflects environmental costs into fuel charges, in line with the global climate change policy direction.** By doing so, fuel users will be made aware of environmental impacts from each fuel choice, as signaled in a higher cost for more emission-heavy alternatives, and become more likely to shift away to cleaner energy options. These policy incentives could be in the form of carbon tax hikes or subsidy withdrawal for all fossil fuels.

For example, in Sweden, biofuels contribute about 20% of fuel consumption in the transport sector. The reading was even higher than the EU average, owing to Swedish bold incentives such as tax exemption for bioenergy, carbon tax hikes, and additional energy tax levied on fossil fuels[16]. Most recently, the EU is drafting the Energy Taxation Directive, seeking to abolish fossil fuel subsidies, particularly in aviation and maritime, to promote cleaner fuel alternatives. The EU also considers raising the levy on heavy-emission fossil fuels[17].

> "The government should encourage a market mechanism in which environmental costs are reflected in fuel prices, in a way to promote the global climate change ambitions. Besides, there should be a pricing structure that determines advanced biofuel prices based on technological advancement, thus motivating producers to enhance technology and reduce production costs."

Furthermore, the pricing structure of advanced biofuels should incentivize producers to seek technological advancement to improve efficiency and minimize production costs. In an early stage, the government could intervene to help establish a pricing structure that fosters investment in advanced biofuels, then **allows the mechanism to determine fuel prices and motivate producers to pursue new technology development to minimize production costs.**

When the advanced biofuel industry becomes more commercially mature and well-established, the government should allow fuel prices to rise and fall in line with the market mechanism. Doing so will help enhance the competitiveness of advanced biofuels against other fuel alternatives, thus urging producers to speed up development in technology and production process in order to cut down

---

16 Advanced Biofuels: What holds them back? (IRENA, 2019)

17 Brussels targets aviation fuel tax in drive to reduce carbon emissions (Financial Times, 2021)

production costs, improve fuel quality, reduce GHG emissions (which are environmental externalities), and establish a perfectly competitive market environment.

Towards Ecosystem with Life-cycle Sustainability

The government should develop a market environment that encourages investment in advanced sustainable biofuels. Life-cycle sustainability does not encompass only production and utilization but every stage in the ecosystem. Accordingly, **the advanced biofuel roadmap must embrace all stakeholders** from raw material sourcing, cultivation, fuel production, transportation, fuel consumption by vehicles, and waste management to end-users. Given strong linkages within the ecosystem, the industry roadmap should consider each stakeholder's capability and viability as well as policy impacts on relevant sectors.

Advanced biofuel technology also comes with high risk and requires massive investment, particularly when feedstock conversion and drop-in property technologies are still nascent. Under such circumstances, private investment is unlikely to take place **unless the government acts on measures to shoulder the risks and incentivize investment** in efforts to kick-start the industry. In doing so, the government should put in place an environment and policy incentives that encourage a trial-and-error approach in devising new ideas and pushing technology limits, thus driving breakthrough innovation that will eventually become a new technology.

> “The advanced biofuel roadmap should embrace all relevant sectors to nurture sustainability throughout the ecosystem. The government could incur risks of technology development in an early stage to incentivize private investment, provide room for trial and experiment, and motivate the inventor to go beyond the boundary—turning a new discovery into the breakthrough innovation.”

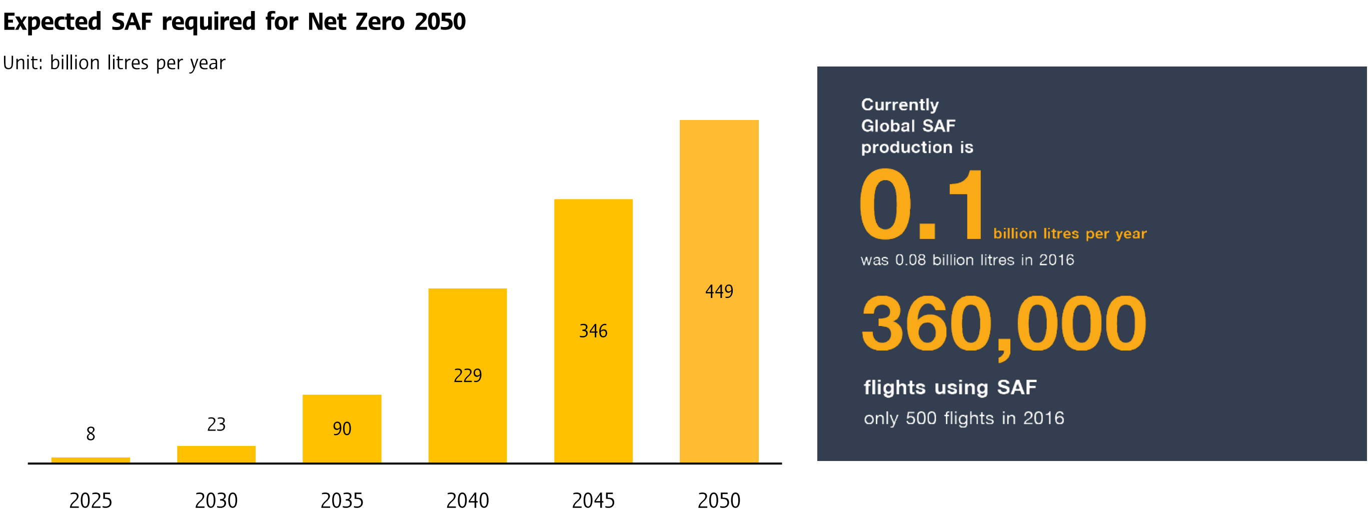
Thailand has the potential to provide room for advanced biofuel trials and development. Farm crops that can be converted into sizeable biomass and diverse agricultural wastes that can be used in further experimental studies are Thailand's key advantages. Also, an established biofuel industry coupled with market and infrastructure readiness would facilitate further development in advanced biofuel technology. With these advantages in hand, policy supports with clear direction plus accommodative ecosystem will help attract technology funding from both Thai and foreign investors, **paving the way for Thailand to become the regional hub of advanced biofuel research and development.**

Sustainable Aviation Fuel (SAF): An Opportunity Ready to Take Off

Aside from government subsidies, collective efforts of private sectors play a vital role in fostering market uptake for advanced biofuels, as apparent in the case of Sustainable Aviation Fuels (SAF). As one of the super GHG emitters, aviation has been facing fierce criticism over climate change. That prompts the air transport business to join forces in working toward GHG emission abatement, and SAF is considered the most viable alternatives for aviation today and into the future.

In October 2021, the International Air Transport Association (IATA) announced the net-zero target 2050 with SAF as the key solution. The current level of global SAF production is approximately 100 million liters per year. To meet greater future demand, IATA then set the SAF production milestone at 8,000 million liters by 2025, before accelerating to 230,000 and 450,000 million liters by 2040 and 2050, respectively[18].

Figure 6: IATA sets SAF usage targets in order to achieve Net Zero by 2050



Source: EIC analysis based on the information from Net zero 2050: sustainable aviation fuels (IATA, 2021)

Using SAF is more costly than fossil-derived jet fuel. Yet, the airlines could pass on these cost increases to customers since the demand for air travel is relatively inelastic compared to other transport options[19]. Given such incentives, the aviation industry set forth the clear ambition to increase SAF deployment, which entails a reduction in SAF production cost and price, thus encouraging the private sector to invest more in SAF technology.

[18] Net zero 2050: sustainable aviation fuels (IATA, 2021)

[19] Sustainable jet fuel for aviation (Wormslev et al., 2016)

Figure 7: More and more airlines pledge to use SAF

The example of airlines that pledge to use SAF (as of 2021)

Airline	Target
oneworld® Alliance	Using SAF for 10% of combined fuel volumes by 2030
International Airline Group (IAG)	10% of all flights powered by SAF by 2030
Cathay Pacific	10% of total fuel consumption is SAF by 2030
Delta Air Lines	10% of total fuel consumption is SAF by 2030
Norwegian Air Shuttle (ASA)	16-28% of total fuel consumption is SAF by 2030
Ryanair	12.5% of all flights powered by SAF by 2030

Source: EIC analysis based on the information from airline companies, Eurocontrol, Weforum and Greenaironline

For instance, the International Airlines Group (IAG) pledged to ramp up SAF use to 10% of total fuel consumption by 2030, and also planned to make a USD-400-million investment in SAF production development and purchase at least 1.25 billion liters of SAF per year. Likewise, the Airlines for America (A4A) agreed on joint investment to produce 13.6 billion liters of SAF within 2030. On the Asian front, All Nippon Airways (ANA) announced the investment plan with partners to develop integrated production technology for SAF. ANA also provided SAF research funds to the New Energy and Industrial Technology Development Organization (NEDO). In June 2021, IHI Corporation—the industrial machinery manufacturer and ANA partner—successfully powered the first domestic flight with blending from SAF and fossil-based jet fuels.

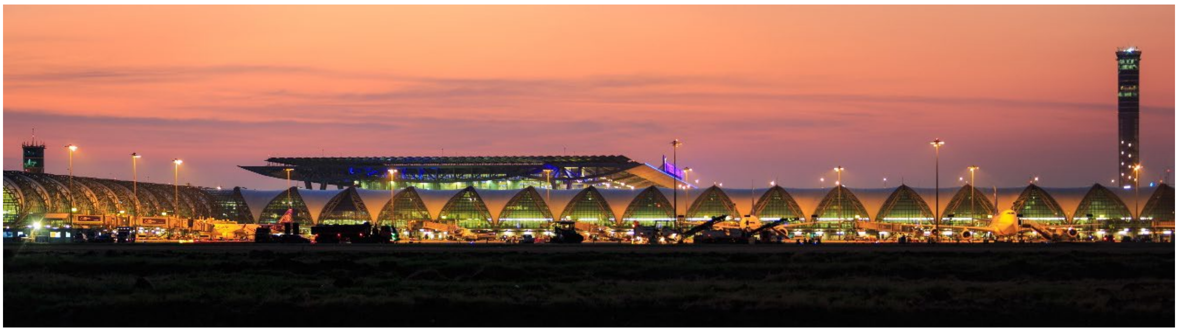
As for other businesses in the aviation ecosystem, Boeing announced its ambition to deliver aircraft fleets that can safely operate on 100% SAF within 2030. Some major airports also started to develop SAF infrastructure and stockpiles to meet growing demand from airlines worldwide. Most recently, Heathrow has become the first UK airport to pilot SAF distribution to airlines in June 2021.

The Clean Skies for Tomorrow—a coalition of air transport and relevant businesses—also commits to promoting and funding technology advancement to attain the global SAF target of 10% by 2030.

With these ambitions of the private sector, coupled with policy mandates in some areas, the SAF market is ready to take off. SAF demand should continue to gain ground globally as SAF-powered flights will also call for supply availability at destination airports. Thailand has welcomed umpteen international flights in the past decades, making Suvarnabhumi the 9th world's busiest airport in 2019[20]. As the net-zero emission target has been resonated among aviation firms worldwide, there will be a thriving demand for SAF distribution at Thai airports to serve SAF-powered flights both to and from Thailand. Despite lacking government support, SAF offers a golden opportunity for the Thai aviation sector to meet the growing demand from airlines across the world striving to clean up the sky.

"More SAF flights to and from Thailand will foster demand for SAF supply availability at Thai airports. With existing capability, Thailand should make headway in SAF to seize this growing demand."

This is an opportunity for Thailand to make the fullest use of our advantages in filling up the global demand tank for SAF in the near future. With abundant agricultural residues, existing biofuels knowledge and technology, and infrastructures readiness—from refinery to storage and fueling station at airports, **Thailand could seize these advantages to become the leading regional SAF producer and technology if the industry is to be progressed expeditiously.**



All in all, advanced biofuels will be essential in reducing GHG emissions from the transport sector, particularly for heavy-duty trucks and aviation. Advanced biofuels are the preferred alternative in energy transition since they can immediately fit into existing petroleum-based infrastructure and engine technology. Nonetheless, given arising concerns on life-cycle sustainability, biofuel development must consider environmental aspects throughout the supply chain—from feedstocks to production and end-use. Advanced biofuels offer the Thai energy sector a golden opportunity to seize the country's advantages: infrastructure readiness and diverse feedstocks from abundant agricultural residues. Thailand could use this opportunity to uplift the existing biofuel industry and also promote the transition to a circular economy. Still, technology challenges and substantial investment in R&D are

[20] Airports Council International (2020)

among big hurdles to industry development. Collective efforts from all relevant sectors and clear policy direction from the government are, therefore, the key to upholding the advanced biofuel industry. To this end, value creation through stakeholder synergy is of paramount importance to achieve the ultimate goal of better and sustainable development for all ■

By : Puthita Yamchinda (puthita.yamchinda@scb.co.th)
Analyst

Economic Intelligence Center (EIC)
Siam Commercial Bank
EIC Online: www.scbeic.com
Line: @scbeic

#EICclimate