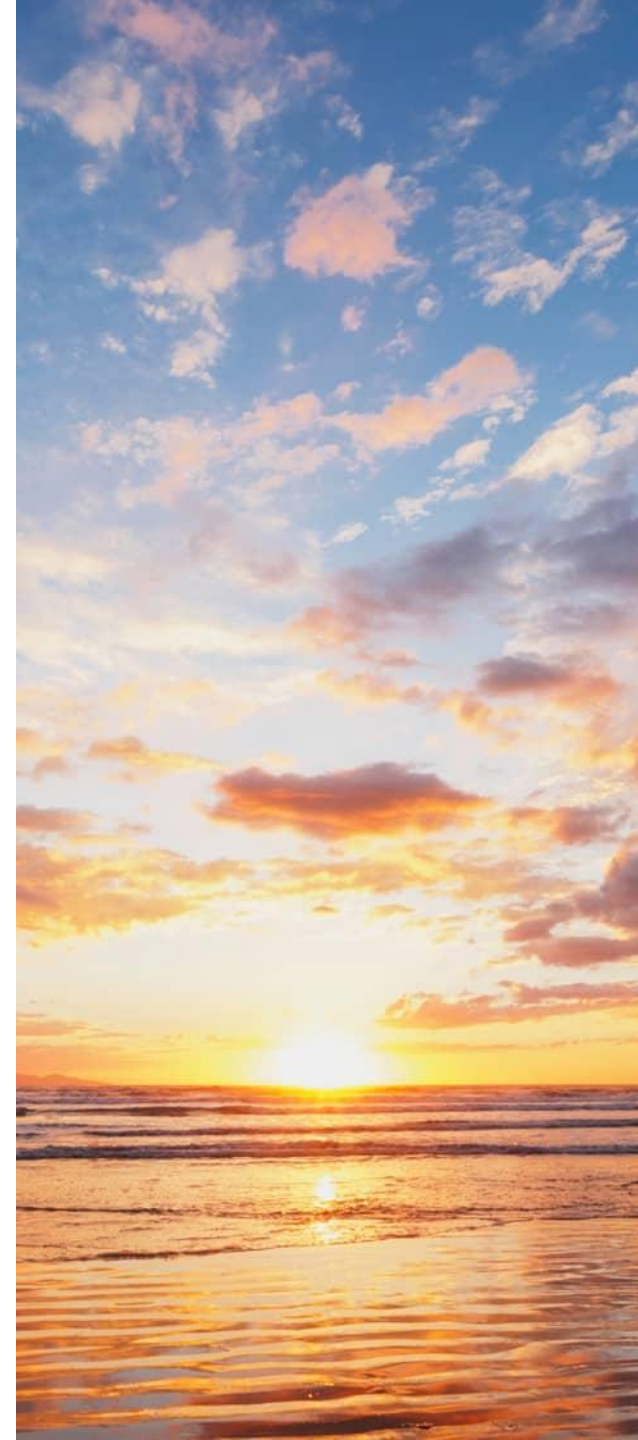
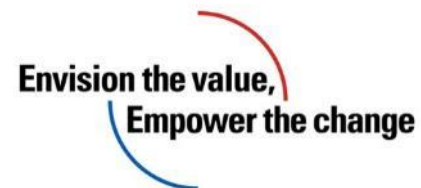


Final Report

Study on Supply and Demand Potential of SAF in ASEAN

NRI Consulting & Solutions (Thailand) Co., Ltd.

Jan 30, 2026



Executive Summary

Chapter 1: Public Policy and Regulations

Chapter 2: Player Activity

Chapter 3: Supply/demand potential

Chapter 4: Needs by Local Players

Chapter 5: Export Potential to Japan

Appendix

Key Takeaways from the Study

- For SAF, Across all ASEAN countries public policy is either implemented, drafted, or draft currently being developed, indicating high political interest. However, regulatory framework is under development, and will need to be developed to drive the implementation in the region
- Based on the political maturity and supply capacity, within the supply-side Malaysia, Thailand, and Indonesia have high potential for SAF supply. Likewise, for the demand-side, based on the political maturity and demand capacity, Singapore, Thailand, and Malaysia have high potential for SAF demand. In this study, the above countries were selected as high priority markets for deep-dive study
- Local companies are in the midst of SAF implementation from both supply and demand side. Within the selected high-priority market for demand-side, the flagship airlines set future SAF adoption targets and are beginning with pilot flights and MOU of SAF procurement. To meet the demand, the supply-side players are aiming to increase supply in which primary technology utilized will be HEFA and the feedstock UCO.
- However, for the alternative feedstock after UCO, there is still issues with adoption which needs to be addressed. For example, some feedstock (e.g. cassava for 1G ethanol) are yet to be recognized by ICAO even though local players find potential in utilization. Also, there are various issues related to technological adoption such as production from HEFA pathway using alternative feedstock such as pongamia, microalgae, etc. and the production from AtJ pathway using feedstock from 2G ethanol. Also, for FT the technology of syngas production is still in development phase. For such technologies, local companies have expressed interest in receiving support from Japanese companies, implicating future business opportunities for Japanese companies in this area
- Based on the supply and demand capacity planned to be developed, there is a significant surplus of supply capacity expected in some markets such as Singapore and Malaysia. Given that demand for SAF is expected to increase in other advanced markets such as Japan, US, and Europe, local companies are aiming to export the products to such overseas markets, indicating potential for Japanese companies to gain revenue from areas such as investment in the SAF production with the local companies, or through the supply-chain development for cross border trade

Executive Summary | Key Policies and Regulations/Incentives

Across all ASEAN countries public policy is either implemented, draft completed, or drafted currently being developed, indicating high political interest

Overview of Policies/Roadmap for SAF in the ASEAN 6 Countries

Topic	Key Policy For SAF	Status	Overview of SAF Related Description	
			Supply	Demand
Singapore	Singapore Sustainable Air Hub Blueprint	Implemented	<ul style="list-style-type: none"> Provides qualitative direction for production support 	<ul style="list-style-type: none"> Provides quantitative target (3-5% of flights departing from SG to use SAF by 2030)
Malaysia	National Energy Transition Roadmap (NETR)	Implemented	<ul style="list-style-type: none"> Provides qualitative direction for production support 	<ul style="list-style-type: none"> Provides quantitative target (Usage: 47% SAF blend by 2050)
	Malaysia Aviation Decarbonisation Blueprint	Implemented	<ul style="list-style-type: none"> - 	<ul style="list-style-type: none"> Provides quantitative target (Contribute to 46% of total CO2 reduction target for 2050)
Thailand	Alternative Energy Development Plan 2024 – 2037 (AEDP 2024)	Draft completed	<ul style="list-style-type: none"> - 	<ul style="list-style-type: none"> Provides quantitative target (Usage: 1.85 MLPD by 2037)
	Oil Plan 2024 – 2037	Draft completed	<ul style="list-style-type: none"> Provides quantitative target (Production capacity: 1.2-1.9 MLPD* by 2033-2037) 	<ul style="list-style-type: none"> Provides quantitative target (Usage: 5-8% SAF blend by 2033-2037)
Indonesia	Indonesia's SAF Industry Development Roadmap	Implemented	<ul style="list-style-type: none"> Provides qualitative direction for production support 	<ul style="list-style-type: none"> Provides quantitative target (Usage: 50% SAF blend by 2060)
Vietnam	Decision No. 876/QD-TTg	Implemented	<ul style="list-style-type: none"> - 	<ul style="list-style-type: none"> Provides quantitative target (10%> for some short flights)
Philippines	n/a	Draft being developed	<ul style="list-style-type: none"> News article indicate the roadmap development has already initiated, but no announcement of the draft being completed 	
Ref: Japan	Basic Policy for Achieving GX, etc.	Implemented	<ul style="list-style-type: none"> Major oil distributors supply SAF at least 5% equivalent to GHG emissions from jet fuel produced/supplied in Japan in FY19 from 2030 	<ul style="list-style-type: none"> Provides quantitative target (Usage: 10% SAF blend by 2030 for Japanese airlines)

Note: MLPD refers to "million liters per day"

Source: Government sources, news article

Executive Summary | Key Policies and Regulations/Incentives

Regulations are still in the phase of being discussed across most countries with no concrete mention of penalties, but Singapore has an implementation timeline

Overview of Regulations for SAF in the ASEAN 6 Countries

Topic	Status for Mandatory Regulation Implementation	
	Supply	Demand
Singapore	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources 	<ul style="list-style-type: none"> The Civil Aviation Authority of Singapore (CAAS) recently revealed it would introduce "Sustainable Aviation Fuel (SAF) Levy" for flights booked from Apr' 26
Malaysia	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources 	<ul style="list-style-type: none"> Draft is currently being developed (For international flights departing from Kuala Lumpur)
Thailand	<ul style="list-style-type: none"> Future development under discussion (Rules on specification and quality requirements has been implemented but for mandatory use under discussion) 	<ul style="list-style-type: none"> Future development under discussion (CAAT signed MOUs with 8 airlines to begin voluntary SAF adoption, with a potential transition to mandatory measures)
Indonesia	<ul style="list-style-type: none"> Future development under discussion (Future regulation development is being proposed in roadmap) 	<ul style="list-style-type: none"> Future development under discussion (Future regulation development is being proposed in roadmap)
Vietnam	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources 	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources
Philippines	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources 	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources
Ref: Japan	<ul style="list-style-type: none"> Future development under discussions in the public-private councils based on publicly available sources 	<ul style="list-style-type: none"> Future development under discussions in the public-private councils based on publicly available sources

Source: Government webpage of each country, news article

Executive Summary | Key Policies and Regulations/Incentives

Malaysia and Thailand have already implemented incentives but are mainly for areas such as tax exemption, whereas for other markets not implemented

Overview of Incentives for SAF in the ASEAN 6 Countries

Topic	Status for Incentive Implementation	
	Supply	Demand
Singapore	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources 	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources
Malaysia	<ul style="list-style-type: none"> Implemented (Corporate tax exemption for SAF production) 	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources
Thailand	<ul style="list-style-type: none"> Implemented (Corporate tax/import duty exemption, non-tax exemption) 	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources
Indonesia	<ul style="list-style-type: none"> Future development under discussion (Future development is being proposed in roadmap) 	<ul style="list-style-type: none"> Future development under discussion (Future development is being proposed in roadmap)
Vietnam	<ul style="list-style-type: none"> Under discussion (Tax exemptions and financial support is being discussed by relevant ministries) 	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources
Philippines	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources 	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources
Ref: Japan	<ul style="list-style-type: none"> Implemented (Tax exemptions (30JPY/L) based on production and sales volume, etc.) 	<ul style="list-style-type: none"> Future development under discussion in the public-private councils based on publicly available sources

Source: Government webpage of each country, news article

Executive Summary | Evaluation Logic for Supply and Demand Potential

NRI evaluated the supply and demand potential for SAF in ASEAN markets, based on the supply/demand potential and maturity

Evaluation Criteria

Evaluation Criteria		Evaluation Indicators	Source of Evaluation Indicator
Supply Side	Supply Potential	<ul style="list-style-type: none"> Availability of non-edible biomass resource* (wood residue, crop residue) 	<ul style="list-style-type: none"> Food and Agricultural Organization (FAO)
		<ul style="list-style-type: none"> Production capacity of SAF in major companies in each country (e.g. Neste, PTT, Petronas, Pertamina) 	<ul style="list-style-type: none"> Publicly available sources
	Policy Maturity	<ul style="list-style-type: none"> Policy development status Policy's level of ambition Regulatory framework Incentives 	<ul style="list-style-type: none"> Publicly available sources
Demand side	Demand Potential	<ul style="list-style-type: none"> Aviation fuel consumption 	<ul style="list-style-type: none"> Publicly available sources
	Policy Maturity	<ul style="list-style-type: none"> Policy development status Policy's level of ambition Regulatory framework Incentives 	<ul style="list-style-type: none"> Publicly available sources

Note: The data of crop residues is as of year 2022 and includes residues from commonly used crop residues for bioenergy based on statistics from FAO (as of 2022), such as (and not limited to) residues from oil palm, corn, rice, sugar canes. The data for wood residues is as of 2021 and includes sawdust and slabs & chips from sawmills.

Source: NRI analysis

Executive Summary | Attractive Markets for SAF Supply

As a result of the evaluation, Indonesia, Malaysia, and Thailand are the most attractive markets based on the supply potential and policy maturity

Attractiveness of Market

Topic	Supply Potential		Policy Maturity				Overall Evaluation	
	Availability of non-edible biomass resource	Production capacity of SAF	Policy development status	Policy's level of ambition	Regulatory framework	Incentives	Score	NRI's Views
Indonesia	5	4	5	2	2	2	20	• High attractiveness
Malaysia	3	4	5	2	1	3	18	• High attractiveness
Thailand	2	3	4	4	1	3	17	• High attractiveness
Singapore	1	5	5	2	1	1	15	• Mid-level attractiveness; production capacity and policy development status is progressive, but domestic raw material supply potential is limited
Vietnam	1	2	2	1	1	2	9	• Low-level attractiveness; Both supply potential and policy maturity is lower than other markets
Philippines	1	1	2	1	1	1	7	• Low-level attractiveness; Both supply potential and policy maturity is lower than other markets

Source: NRI analysis based on government webpage of each country, news article

Executive Summary | Attractive Markets for SAF Demand

As a result of the evaluation, Singapore, Malaysia, and Thailand are the most attractive markets based on the demand potential and policy maturity

Attractiveness of Market

Topic	Demand Potential		Policy Maturity				Overall Evaluation	
	Aviation fuel consumption	Airport Concentration Level	Policy development status	Policy's level of ambition	Regulatory framework	Incentives	Total Score	NRI's Views
Singapore	4	5	5	5	4	1	24	<ul style="list-style-type: none"> Most attractive market; based on overall demand potential as hub airport country and policy maturity
Malaysia	2	4	5	4	3	1	19	<ul style="list-style-type: none"> High-level attractiveness
Thailand	3	4	4	4	2	1	18	<ul style="list-style-type: none"> High-level attractiveness
Indonesia	3	1	5	4	2	2	17	<ul style="list-style-type: none"> Mid-level attractiveness
Vietnam	2	4	5	3	1	1	16	<ul style="list-style-type: none"> Low-level attractiveness; Both demand potential and policy maturity is lower than other markets
Philippines	2	3	2	1	1	1	11	<ul style="list-style-type: none"> Low-level attractiveness; Both demand potential and policy maturity is lower than other markets

Source: NRI analysis based on government webpage of each country, news article

Executive Summary | Activities and Plans by Demand-Side Players

Most airlines set future SAF adoption targets and are beginning with pilot flights and MOU of SAF procurement

	Company	Current demand		Future demand	Initiative and collaboration
		Annual fuel consumption (k tonnes)	SAF % blend	SAF usage target	
SG	Singapore Airlines Group	5,424 (FY2024/25)	N/A	5% blend in 2030	<ul style="list-style-type: none"> Signed a MOU with Aether Fuels to source neat SAF for 5 years. Secured 1 k tonnes neat SAF from Neste for Changi Airport
TH	Thai Airways International Public Company Limited	N/A	2% in 2025	5% in 2030 60% blend in 2050	<ul style="list-style-type: none"> Signed MOU with PTTGC and PTTOR to research and promote the use of SAF
	Bangkok Airways Public Company Limited	N/A	1% (start using for commercial flight)	N/A	<ul style="list-style-type: none"> Signed LOI with PTTOR to use domestically produced SAF supplied by PTTGC
MY	Malaysia Aviation Group	1,026 (2023)	N/A	N/A	<ul style="list-style-type: none"> Signed agreements to purchase SAF from PETRONAS Signed MOU with FatHopes Energy to explore SAF production
	AirAsia Group	1,785 (2024)	5% (for pilot flights)	Use SAF for 5-10% emissions reduction in 2030-2035	<ul style="list-style-type: none"> Signed MOU with Airbus to research on SAF supply expansion
ID	PT Garuda Indonesia (Persero) Tbk	N/A	N/A	Use SAF with both international and domestic flight in 2027	<ul style="list-style-type: none"> Completed pilot flight using UCO-based SAF
	Lion Air Group	N/A	N/A	1% blend in 2030	<ul style="list-style-type: none"> N/A

Source: Company webpage of each company listed in the slide

Executive Summary | Activities and Plans by Supply-Side Players (1/3)

To meet the demand, supply-side players are aiming to increase supply in which primary feedstock and technology utilized across companies are UCO and HEFA

	Company	Annual production capacity (k tonnes)		Feedstock		Technology		Feedstock sourcing
		Current	Future	Main*	Experimental*	Main*	Experimental*	
SG	Neste Corporation	2,600	2,600	<ul style="list-style-type: none"> UCO PFAD Animal fat waste Others e.g., POME, SBEO 	<ul style="list-style-type: none"> Algae Forestry waste e.g., fallen leaves, tree trunks Novel vegetable oils (NVO) 	<ul style="list-style-type: none"> HEFA 	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> Source feedstock from many region by feedstock offices Jointly study future potential feedstock with partners
ID	Pertamina (Persero), PT	5.6	882.4 (2032-2033)	<ul style="list-style-type: none"> UCO 	<ul style="list-style-type: none"> POME PFAD Sorghum 	<ul style="list-style-type: none"> HEFA 	<ul style="list-style-type: none"> AtJ e-SAF 	<ul style="list-style-type: none"> UCO collection from households, hotel, restaurant is being promoted via "Green Movement UCO" program
	PT Essa Industries Indonesia Tbk	0	200 (2027 Q4 -2028 Q1)	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> Technology selection including the feedstock is in the internal planning stage
	Tripatra	0	240 (2030)	<ul style="list-style-type: none"> POME UCO 	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> HEFA 	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> Availability and logistics for local feedstocks have been confirmed in the feasibility study

*Note: Main refers to feedstock and technology mentioned in plan for commercial SAF production facility of each player
 Experimental refers to feedstock and technology under consideration as alternative options e.g. during feasibility study, pilot project etc.
 Source: Company website of each company listed in the slide, news articles, interview

Executive Summary | Activities and Plans by Supply-Side Players (2/3)

While using local UCO as the current main feedstock, PTT and Bangchak also consider alternatives such as ethanol and fusel alcohol for AtJ

	Company	Annual production capacity (k tonnes)		Feedstock		Technology		Feedstock sourcing
		Current	Future	Main*	Experimental*	Main*	Experimental*	
TH	PTT	20	80 (2027)	• UCO	<ul style="list-style-type: none"> • POME • PFAD 	<ul style="list-style-type: none"> • Co-processing HEFA 	<ul style="list-style-type: none"> • AtJ 	<ul style="list-style-type: none"> • Local UCO is currently used as feedstock
	Bangchak Corporation	0	292 (2026 Q3)	• UCO	<ul style="list-style-type: none"> • Ethanol • Fusel alcohol • Molasses • Pongamia • Microalgae • EFB** • Oilseed** • PFAD** • POME** • Tallow** • Crude glycerin** • CPO** • Upstream cellulosic acid** 	<ul style="list-style-type: none"> • HEFA 	<ul style="list-style-type: none"> • AtJ 	<ul style="list-style-type: none"> • Purchase UCO from public at Bangchak service station and food companies via agreement with the government and also purchase from small local UCO collectors • Jointly study fusel alcohol derived from ethanol plants that use molasses and cassavas
	Energy Absolute Public Company Limited	0	25 (2026)	• UCO	<ul style="list-style-type: none"> • PFAD • Agricultural waste • POME 	<ul style="list-style-type: none"> • HEFA 	<ul style="list-style-type: none"> • N/A 	<ul style="list-style-type: none"> • Tentatively utilize feedstock UCO collectors

*Note: Main refers to feedstock and technology mentioned in plan for commercial SAF production facility of each player
Experimental refers to feedstock and technology under consideration as alternative options e.g. during feasibility study, pilot project etc.

**Note: These experimental feedstocks are considered not only by Bangchak, but also by other industry players in Thailand

Source: Company website of each company listed in the slide, news articles, interview

Executive Summary | Activities and Plans by Supply-Side Players (3/3)

To address UCO limitations, Malaysian companies are considering alternative feedstock e.g. POME, microalgae, and Pongamia as well as other pathways

	Company	Annual production capacity (k tonnes)		Feedstock		Technology		Feedstock sourcing
		Current	Future	Main*	Experimental*	Main*	Experimental*	
MY	PETRONAS	0	575 (2028 Q2)	<ul style="list-style-type: none"> UCO (85%) Animal fat (15%) 	<ul style="list-style-type: none"> POME PFAD Microalgae Pongamia Jatropha MSW SBE0 	<ul style="list-style-type: none"> HEFA 	<ul style="list-style-type: none"> AtJ FT 	<ul style="list-style-type: none"> Developing a household UCO ecosystem and sourcing additional UCO through its trading offices, while animal fat sourcing remains under evaluation
	EcoCeres Renewable Fuels	420	420	<ul style="list-style-type: none"> UCO (95%) POME (5%) 	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> HEFA 	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> Import UCO directly from China leveraging network of parent company in Hong Kong
	FatHopes Energy	0	300 (2029)	<ul style="list-style-type: none"> UCO 	<ul style="list-style-type: none"> POME SBE0 (Spent bleaching earth oil) 	<ul style="list-style-type: none"> HEFA 	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> Leverage long-term contracts and strong relationships with major commercial suppliers e.g. chain restaurants Also assess feedstocks across APAC

*Note: Main refers to feedstock and technology mentioned in plan for commercial SAF production facility of each player
 Experimental refers to feedstock and technology under consideration as alternative options e.g. during feasibility study, pilot project etc.
 Source: Company website of each company listed in the slide, news articles, interview

Executive Summary | Difference in Country Characteristics for Supply

In the future, TH is likely to focus more on ethanol and AtJ pathway, while ID and MY will still rely on HEFA with alternative oil-based feedstock than only UCO

Blue font = Potential feedstock/pathway that will be prioritized the future from NRI analysis based on experts' comments

			TH	MY	ID	SG
Feedstock	Current (~2030)	Type	<ul style="list-style-type: none"> UCO Palm oil-based feedstock e.g. POME 	<ul style="list-style-type: none"> UCO Palm oil-based feedstock e.g. POME 	<ul style="list-style-type: none"> UCO Palm oil-based feedstock e.g. POME 	<ul style="list-style-type: none"> UCO Animal waste Palm oil-based feedstock e.g. PFAD
		Source	<ul style="list-style-type: none"> Focus on domestically sourced feedstock 	<ul style="list-style-type: none"> Domestically source feedstock with large amount of UCO imported 	<ul style="list-style-type: none"> Strictly source feedstock domestically due to feedstock import restriction 	<ul style="list-style-type: none"> Import all the feedstock due to resource limitation
	Future (2030~)	<ul style="list-style-type: none"> Oil based feedstock <ul style="list-style-type: none"> UCO Palm oil-based feedstock e.g. POME, CPO Microalgae Pongamia Alcohol based feedstock <ul style="list-style-type: none"> Ethanol from molasse Etc. 	<ul style="list-style-type: none"> Oil based feedstock <ul style="list-style-type: none"> UCO Palm oil-based feedstock e.g. POME, SBEO Pongamia Microalgae Etc. 	<ul style="list-style-type: none"> Oil based feedstock <ul style="list-style-type: none"> UCO Palm oil-based feedstock e.g. POME, PFAD, RBDPKO Non-standard coconut Pongamia Etc. 	<ul style="list-style-type: none"> Oil based feedstock <ul style="list-style-type: none"> UCO Animal waste Palm oil-based feedstock e.g. PFAD Etc. 	
Technology	Current (~2030)	<ul style="list-style-type: none"> HEFA Co-processing 	<ul style="list-style-type: none"> HEFA 	<ul style="list-style-type: none"> HEFA Co-processing 	<ul style="list-style-type: none"> HEFA 	
	Future (2030~)	<ul style="list-style-type: none"> HEFA Co-processing AtJ 	<ul style="list-style-type: none"> HEFA AtJ* FT* 	<ul style="list-style-type: none"> HEFA Co-processing AtJ* 	<ul style="list-style-type: none"> HEFA 	

*Note: These are pathways that will be considered in the future, but the direction is still unclear with lower prioritization

Executive Summary | Difference in Country Characteristics for Supply

In the future, TH is likely to focus more on ethanol and AtJ pathway, while ID and MY will still rely on HEFA with alternative oil-based feedstock than only UCO

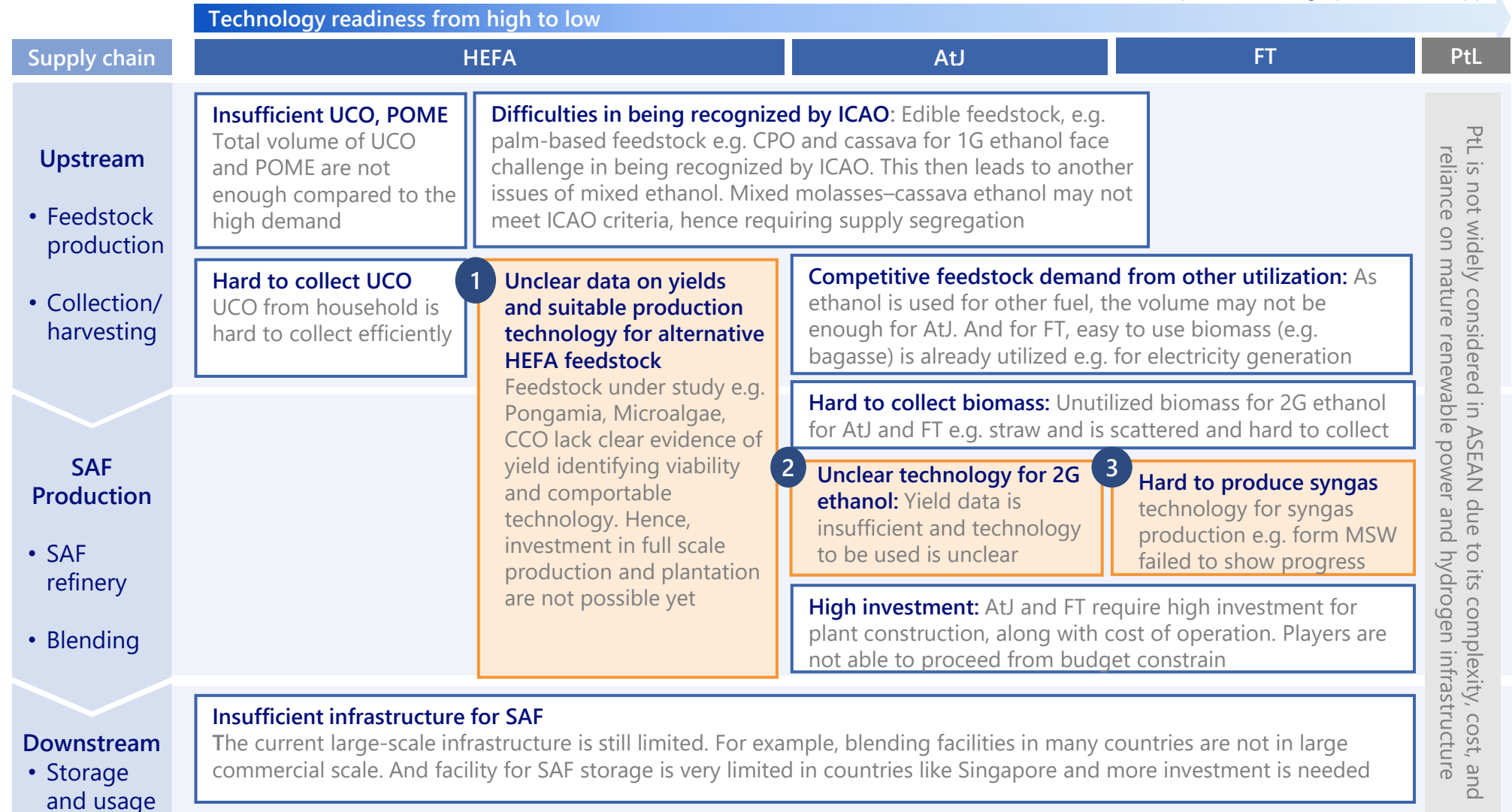
			TH	MY	ID	SG
Feedstock	Current (~2030)	Type	<ul style="list-style-type: none"> UCO Palm oil-based feedstock e.g. POME 	<ul style="list-style-type: none"> UCO Palm oil-based feedstock e.g. POME 	<ul style="list-style-type: none"> UCO Palm oil-based feedstock e.g. POME 	<ul style="list-style-type: none"> UCO Animal waste Palm oil-based feedstock e.g. PFAD
		Source	<ul style="list-style-type: none"> Focus on domestically sourced feedstock 	<ul style="list-style-type: none"> Malaysia is likely to continue prioritizing HEFA, but expand to alternative oil-based feedstocks e.g. microalgae supplementing UCO. 	<ul style="list-style-type: none"> Strictly source feedstock domestically due to feedstock restriction Indonesia is likely to remain HEFA-focused, but utilize a broader range of oil-based feedstocks e.g. CCO. 	<ul style="list-style-type: none"> Import all the feedstock Singapore is an import-driven market due to limited domestic feedstock resources
	Future (2030~)		<ul style="list-style-type: none"> Limited UCO supply will drive Thailand to find alternatives pathways apart from oil-based SAF In future Thailand is likely to become more of an ethanol-driven market, with the AtJ pathway anchored by cassava and sugarcane (molasse) 	<ul style="list-style-type: none"> While AtJ and FT are under consideration, limited feedstock availability e.g. absence of ethanol production restrict their potential. Hence, development of 2G ethanol will be needed 	<ul style="list-style-type: none"> While AtJ production from sugarcane is still technically feasible, its potential is significantly lower than Thailand's due to smaller ethanol volumes 	<ul style="list-style-type: none"> It prioritizes importing cost-effective feedstock from other countries HEFA is likely to remain the main technology due to the lack of feedstock for other pathways
		Technology	<ul style="list-style-type: none"> HEFA Co-processing 	<ul style="list-style-type: none"> HEFA AtJ* FT* 	<ul style="list-style-type: none"> HEFA Co-processing AtJ* 	<ul style="list-style-type: none"> HEFA

*Note: These are pathways that will be considered in the future, but the direction is still unclear with lower prioritization

Executive Summary | Summary of Issues and Challenges by Local Companies

Local supply-side companies has technological challenges which needs to be addressed, in which there are opportunity for Japanese companies to support

Technological challenges
 Area that JP companies have high potential to support



PtL is not widely considered in ASEAN due to its complexity, cost, and reliance on mature renewable power and hydrogen infrastructure

Source: NRI analysis

Needs of local government / company | List of Japanese companies with potential solutions

Japanese company can provide solutions e.g., production process development, trial plantations, and supply chain verification for alternative HEFA feedstocks

Issues	Solutions	Company name	Company type	Related company activities
1 Unclear data on yields and suitable production technology for alternative HEFA feedstock	Develop technology and production of SAF from microalgae	Euglena	Microalgae developer and manufacturer	<ul style="list-style-type: none"> Develop microalgae technology to enable large-scale production of microalgae oil as feedstock for biofuels
		Denso Corporation	Automotive components manufacturer	<ul style="list-style-type: none"> Develop large-scale microalga cultivation technologies
		Mitsubishi Kakoki Kaisha	EPC	<ul style="list-style-type: none"> Develop machines by applying company's separation and extraction technology in order to produce biofuel from cultured microalgae
		Mitsubishi Chemical	Chemical and specialty materials manufacturer	<ul style="list-style-type: none"> Develop microalgae harvesting technologies by leveraging membrane separation technologies
		IHI Corporation	EPC	<ul style="list-style-type: none"> Develop mass-production process of high-performance strain of microalgae called Hyper-Growth Botryococcus Braunii (HGBb) Develop manufacturing process of algal oil
		CHITOSE Group	Biotechnology solution provider	<ul style="list-style-type: none"> Operate large-scale algae production facility using CO2 from exhaust gases emitted by thermal power plant
		Electric Power Development (J-Power)	Energy company	<ul style="list-style-type: none"> Develop large-scale cultivation technology for microalgae, which serve as a feedstock for SAF
		Phycochemistry	Microalgae developer and manufacturer	<ul style="list-style-type: none"> Demonstrate project for cultivating heterotrophic algae using excess sludge and producing crude oil for biodiesel fatty acids

Source: Company website of each company listed in the slide, NEDO, news article

Needs of local government / company | List of Japanese companies with potential solutions

Japanese company can provide solutions e.g., production process development, trial plantations, and supply chain verification for alternative HEFA feedstocks

Issues	Solutions	Company name	Company type	Related company activities
1 Unclear data on yields and suitable production technology for alternative HEFA feedstock	Develop technology and production of SAF from non-standard coconut	Green Power Development Corporation of Japan	EPC	<ul style="list-style-type: none"> Establish ICAO CORSIA recognition of non-standard coconut Develop catalyst efficiently converting Crude Coconut Oil (CCO) into neat SAF Develop SAF business model covering sourcing of non-standard coconuts from major producers (e.g., Indonesia), CCO manufacturing, and import of CCO for neat SAF production
		HighChem	Chemical company	<ul style="list-style-type: none"> Co-develop a catalyst that converts crude coconut oil into neat SAF with Green Power Development Corporation of Japan and the Tokyo University of Agriculture and Technology
	Develop technology and production of SAF from other non-edible oil plant	Idemitsu Kosan	Energy company	<ul style="list-style-type: none"> Conduct feasibility study of the supply potential of non-edible oil feedstock trees, such as Pongamia and Jatropha Conduct trial plantations of Pongamia and verify the supply chain from cultivation to oil extraction and SAF production
		J-Oil Mills	Food manufacturer	<ul style="list-style-type: none"> Produce SAF from oil extracted from Calophyllum indicum seeds and pongamia, meeting ICAO CORSIA criteria
		Yokohama Rubber	Rubber manufacturer	<ul style="list-style-type: none"> Join research to establish a sustainable collection system for para rubber seeds for green products
		Innovare	Rubber seed oil manufacturer	<ul style="list-style-type: none"> Produce rubber seed oil from rubber seed Supply Thailand-sourced natural rubber seed oil to biodiesel fuel manufacturers
		Nomura Jimusho	Specialized trading company	<ul style="list-style-type: none"> Conduct feasibility study to utilize rubber seed oil as raw material for SAF

Needs of local government / company | List of Japanese companies with potential solutions

Japanese companies can provide technology solutions e.g. technology and knowhow for 2G ethanol production from woody biomass, agricultural residues

Issues	Solutions	Company name	Company type	Related company activities
2 Unclear technology for 2G ethanol	Develop technology and production of 2G ethanol from woody biomass	Green Earth Institute	Biotechnology solution provider	<ul style="list-style-type: none"> Provide low-cost bioethanol production processes with growth-arrested bioprocess (RITE Bioprocess) and fermentation process optimization
		Nippon Steel Engineering	EPC	<ul style="list-style-type: none"> Operate 2G bioethanol pilot facilities focusing on integrated processes (pretreatment, saccharification, fermentation) with various residues e.g. food waste, woody biomass
		Kao Corporation	Chemical manufacturer	<ul style="list-style-type: none"> Provide saccharification enzymes efficiently breaking down non-edible biomass e.g. woody biomass used as raw material for producing bioethanol fuel for automobiles
		Nippon Paper Industries	Paper manufacturer	<ul style="list-style-type: none"> Develop low-carbon bioethanol production process using domestic wood biorefinery Establish a JV for the production and sale of bioethanol woody biomass with Sumitomo Corporation and Green Earth Institute
		Biomaterial in Tokyo	Biotechnology solution provider	<ul style="list-style-type: none"> Produce enzymes from specific filamentous fungi that convert difficult-to-decompose woody biomass into monosaccharides Provide know-how in the design and construction of 2G bioethanol production plants and the establishment of supply chains
		Oji Holdings Corporation	Paper manufacturer	<ul style="list-style-type: none"> Launch a large-scale pilot plant in Japan to produce ethanol from woody biomass, converting wood-derived sugars into bioethanol

Needs of local government / company | List of Japanese companies with potential solutions

Japanese companies can provide technology solutions e.g. technology and knowhow for 2G ethanol production from woody biomass, agricultural residues

Issues	Solutions	Company name	Company type	Related company activities
2 Unclear technology for 2G ethanol	Develop technology and production of 2G ethanol from woody biomass	Daio Paper Corporation	Paper manufacturer	<ul style="list-style-type: none"> Develop 2G bioethanol from non-food woody biomass as part of its biorefinery business, progressing from sample provision toward pilot and future commercial-scale production by 2030
	Develop technology and production of 2G ethanol from agricultural residue	Kawasaki Heavy Industries	EPC	<ul style="list-style-type: none"> Provide low-cost bioethanol production from residue such as rice straw using a hot-water saccharification process instead of sulfuric acid or enzymes, resulting in reduced equipment needs and lower production costs
		JGC Group Corporation	EPC	<ul style="list-style-type: none"> Conduct demonstration projects at 20 m³ scale for 2G ethanol production using agricultural residue such as sugarcane bagasse, rice straw, wheat straw, coffee waste, palm trunk, mushroom waste etc.
		Sanyu Plant Service	Waste management company	<ul style="list-style-type: none"> Develop 2G bioethanol from spent coffee grounds as feedstock, applying steam explosion pretreatment and fermentation to convert coffee waste into ethanol as part of its biomass utilization initiative
		Sapporo Breweries	Alcohol drink manufacturer	<ul style="list-style-type: none"> Develop bioethanol from cassava pulp using proprietary fermentation technology, converting biomass residues into fuel through pilot-scale production in Thailand

Needs of local government / company | List of Japanese companies with potential solutions

Japanese companies can provide technology solutions e.g. technology and knowhow for 2G ethanol production from woody biomass, agricultural residues

Issues	Solutions	Company name	Company type	Related company activities
2 Unclear technology for 2G ethanol	Develop technology and production of 2G ethanol from agricultural residue	Iwata Chemical	Chemical manufacturer	<ul style="list-style-type: none"> Participate in R&D on bioethanol production from cassava pulp using heat-tolerant yeast, advancing toward demonstration with Sapporo Holdings
		Tsukishima Kikai	EPC	<ul style="list-style-type: none"> Develop and implemented enzyme-based process for converting bagasse into ethanol by producing cellulase enzymes on-site and conducting pilot-scale demonstration in Thailand
		JFE Engineering Corporation	EPC	<ul style="list-style-type: none"> Support engineering and deployment of the bioethanol production facilities used in the 2G bioethanol from bagasse demonstration project with Tsukishima Kikai
		Kanadevia	EPC	<ul style="list-style-type: none"> Provide engineering and membrane separation technologies for the bioethanol demonstration plant to ferment and purify ethanol from potato starch
		Toray Industries	Textile company	<ul style="list-style-type: none"> Convert sugarcane bagasse into fermentable cellulose sugars, enabling subsequent fermentation and distillation into ethanol or other biochemicals with demonstration plant in Thailand
		DM Mitsui Sugar	Sugar manufacturer	<ul style="list-style-type: none"> Contribute to demonstration of a bagasse-to-cellulose sugar system with Toray by assessing functionality and business potential of polyphenols and other co-products from lignocellulosic biomass that support 2G bioethanol production processes

Needs of local government / company | List of Japanese companies with potential solutions

Japanese companies can provide technology solutions e.g. technology and knowhow for 2G ethanol production from woody biomass, agricultural residues

Issues	Solutions	Company name	Company type	Related company activities
2 Unclear technology for 2G ethanol	Develop technology and production of 2G ethanol from waste and chemical substance	ENEOS	Energy company	<ul style="list-style-type: none"> Conduct demonstration projects with Toppan and Nippon Paper Industries to make bioethanol from hard-to-recycle used paper feedstock for fuels/chemicals
		Taiko Paper	Paper manufacturer	<ul style="list-style-type: none"> Conduct demonstration projects for bioethanol production technology using kraft pulp produced from unused resources such as construction waste as a raw material and enzymes internally produced from industrial microorganisms
		Rengo	Paper manufacturer	<ul style="list-style-type: none"> Co-conduct demonstration projects for bioethanol production from kraft pulp with its subsidiary, Taiko Paper
		Kanadevia	EPC	<ul style="list-style-type: none"> Develop a demonstration bioethanol production system in China that converts waste materials such as food scraps and paper into fuel and aiming for commercialization after the 2024 trial
	Develop technology and production of 2G ethanol from non-food biomass	Sekisui Chemical	Chemical manufacturer	<ul style="list-style-type: none"> Develop technology to convert CO to ethanol Develop biorefinery technology to convert municipal and other waste biomass into ethanol, using a microbial catalyst
		Idemitsu Kosan	Energy company	<ul style="list-style-type: none"> Develop ATJ pathway to produce SAF from bioethanol, focusing on demonstration-scale production and process optimization, including future expansion to 2G ethanol from non-food biomass in the roadmap to support commercialization around 2030

Source: Company website of each company listed in the slide, NEDO, news article

Needs of local government / company | List of Japanese companies with potential solutions

Technologies to produce syngas from waste can be the area that Japanese companies have potential to provide solutions

Issues	Solutions	Company name	Company type	Related company activities
3 Hard to produce syngas	Develop technology and production of syngas from waste	JFE Engineering Corporation	EPC	<ul style="list-style-type: none"> Provide technology branded C-PhoeniX Process® for a waste-to-chemical (WtC) to produce synthesis gas that can be used as raw materials for SAF Conduct demonstration project on commercial scale using C-PhoeniX Process® for production of purified synthesis gas from waste for SAF production and other industrial use
		Sumitomo SHI FW	EPC	<ul style="list-style-type: none"> Provide Air Fluidized Bed Gasification technology by using to heat waste to raw syngas and improve the quality of syngas by a cleaning process to remove impurities for the conversion of waste materials and biomass to syngas
		JGC Group Corporation	EPC	<ul style="list-style-type: none"> Supply waste plastic and produce syngas from waste plastic by technology called EUP, the gasification chemical recycling technology developed by solutions provider companies, Ebara Environment Plant and Ube Industries Ltd.
		Toyo Engineering	EPC	<ul style="list-style-type: none"> Conduct technical feasibility study to produce SAF via gasification FT synthesis and methanol synthesis using a variety of feedstocks, including municipal waste
		United Planning	EPC	<ul style="list-style-type: none"> Conduct demonstration project on SAF production using gasification and FT synthesis technology by utilizing wood resources and waste plastic from Akita Prefecture

Source: Company website of each company listed in the slide, NEDO, news article

Needs of local government / company | List of Japanese companies with potential solutions

Technologies to produce syngas from waste can be the area that Japanese companies have potential to provide solutions

Issues	Solutions	Company name	Company type	Related company activities
3 Hard to produce syngas	Develop technology and production of syngas from waste	ENEOS	Energy company	<ul style="list-style-type: none"> Develop synthetic fuels from CO₂ captured from industrial exhaust or the atmosphere and renewable hydrogen, using Fischer–Tropsch synthesis and fuel upgrading processes.
		United Planning	EPC	<ul style="list-style-type: none"> Conduct demonstration project on SAF production using gasification and FT synthesis technology by utilizing wood resources and waste plastic from Akita Prefecture
	Develop technology and production of syngas from biomass	Mitsubishi Heavy Industries	EPC	<ul style="list-style-type: none"> Provide technology for conversion of woody biomass into syngas using gasification
		Mitsubishi Power	EPC	<ul style="list-style-type: none"> Joint research to develop a commercial-scale supply chain for SAF derived by wood biomass gasification integrated with FT synthesis technology Provide basic design of commercial-scale gasification facilities
		IHI Corporation	EPC	<ul style="list-style-type: none"> Provide technology branded TIGAR® for gasification of biomass resources e.g. bark pellet, wood chip, lignite to syngas

Executive Summary | Supply & Demand Potential | Forecast Methodology for Demand

Forecasts for the volume of SAF demand will be conducted leveraging desktop study and interviews to government and private companies

SAF demand forecast methodology (basic concept)

Definition	<ul style="list-style-type: none"> • "Demand" is defined as "the annual volume which the users (e.g. aviation companies, airports) of SAF will use within the selected country".
Forecast direction	<ul style="list-style-type: none"> • SAF demand is expected to be estimated by multiplying the "total aviation fuel consumption*" and the "Country's SAF blending ratio target*" <ul style="list-style-type: none"> ○ Calculate aviation fuel consumption for passenger and cargo flights based on "total aviation fuel consumption." ○ Calculate the aviation fuel consumptions for passenger and cargo flights (2025–2035) by applying the respective future growth rate (CSGR) and aircraft fuel efficiency improvement rate to each consumption for passenger and cargo. ○ Calculate total consumption by summing these figures. • As potential demand triggers, downward and upward impact towards components of the "total annual aviation fuel consumption" and "SAF blending ratio" will be considered
Unit	<ul style="list-style-type: none"> • SAF volume: million litter/year (Value (e.g. USDXX) will not be estimated in the project)
Forecast duration	<ul style="list-style-type: none"> • 2025-2035
Data source	<ul style="list-style-type: none"> • Desktop study (e.g. government plans, news articles, etc.) • Interviews <ul style="list-style-type: none"> ○ Private companies: 1 interview for demand / country (Singapore, Malaysia, Thailand) ○ Government: 1 interview / country (Singapore, Malaysia, Thailand)

Note: *The volume of aviation fuel consumed within a country

Source: NRI analysis

Executive Summary | Supply & Demand Potential | Forecast Methodology for Supply

Forecasts for the volume of SAF supply will be conducted leveraging desktop study and interviews to government and private companies

Supply forecast methodology (basic concept)

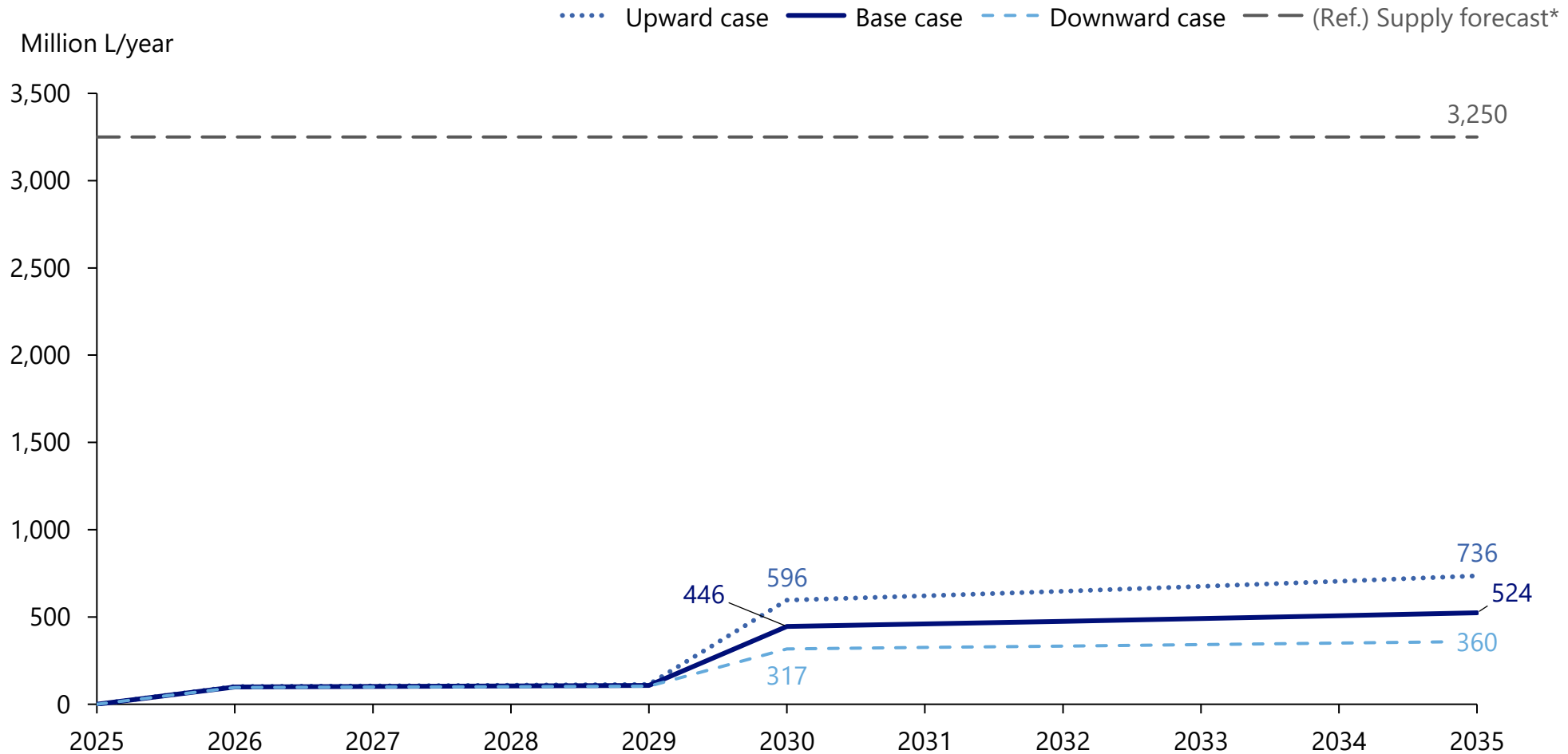
Definition	<ul style="list-style-type: none"> • "Supply" is defined as "annual production capacity of biorefinery which has the SAF production capability"
Forecast direction	<ul style="list-style-type: none"> • The supply forecast are to be calculated based on the capacities of SAF refineries and it can be proposed as the following two methods; <ul style="list-style-type: none"> ○ Pattern A: sum-up all capacities of SAF refineries based on their start operating year ○ Pattern B: sum-up capacities of main SAF players and divided by the market share of the main SAF players • Triggers for downward and upward fluctuations in supply capacity in the future, such as potential volume of feedstocks, will be identified in the survey, and the fluctuations will be examined by taking into account the identified triggers
Unit	<ul style="list-style-type: none"> • SAF volume: million litter/year (Value (e.g. USDXX) will not be estimated in the project)
Forecast duration	<ul style="list-style-type: none"> • 2025-2035
Data source	<ul style="list-style-type: none"> • Desktop study (e.g. government plans, news articles, etc.) • Interviews <ul style="list-style-type: none"> ○ Private companies: 1 interview for supply / country (Indonesia, Malaysia, Thailand) ○ Government: 1 interview / country (Indonesia, Malaysia, Thailand)



Executive Summary | Supply & Demand Potential | Singapore

In the target period, SAF demand will increase; however, demand will continue to be lower than supply, resulting in sufficient supply of SAF in domestic market

SAF demand and supply forecast in Singapore



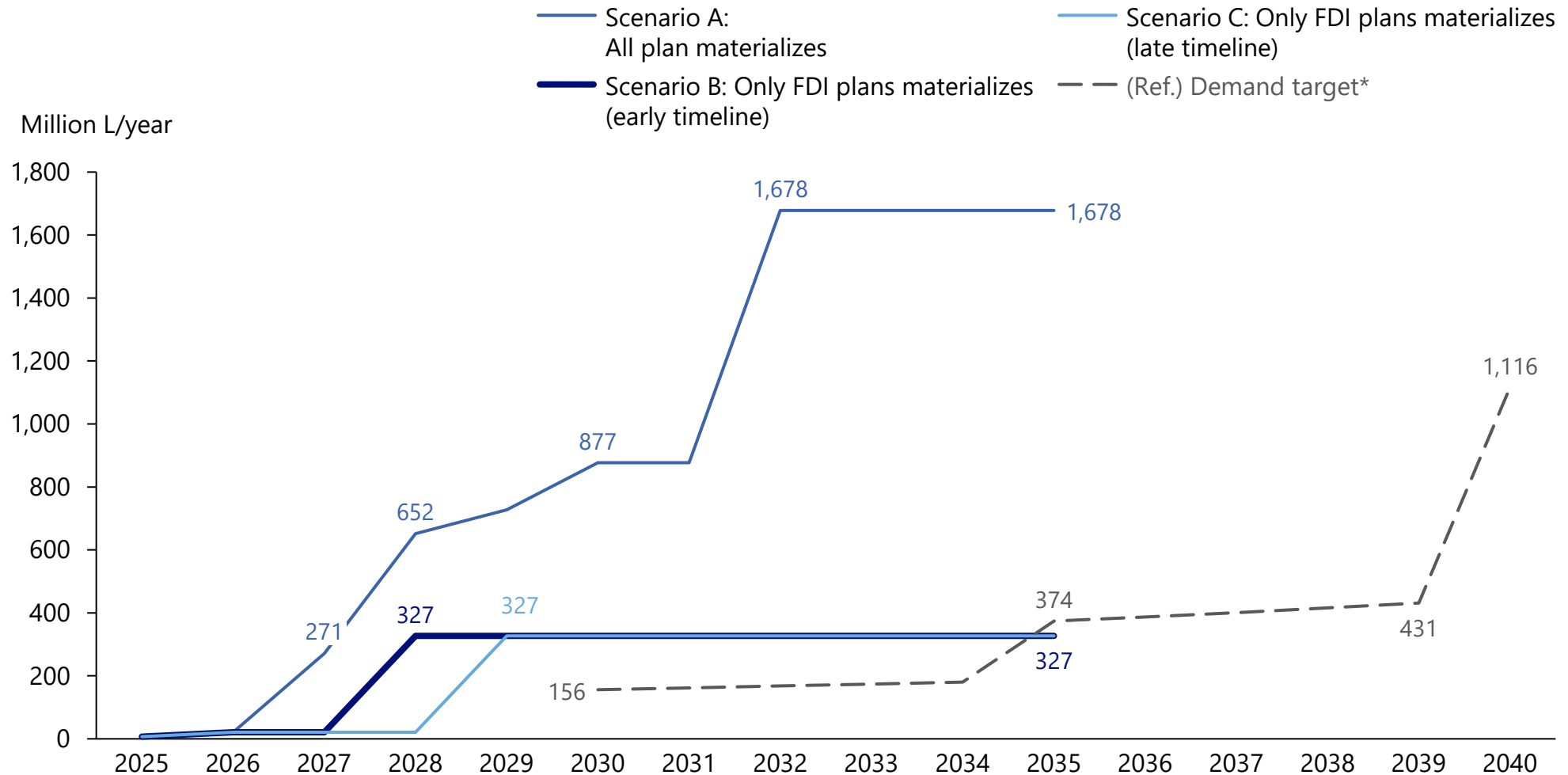
Note) * SAF supply forecast is based on the Neste's facility plan.



Executive Summary | Supply & Demand Potential | Indonesia

Although not many projects have completed FID, SAF supply will exceed the demand targets up to 2034 in scenario B&C

SAF demand and supply forecast in Indonesia



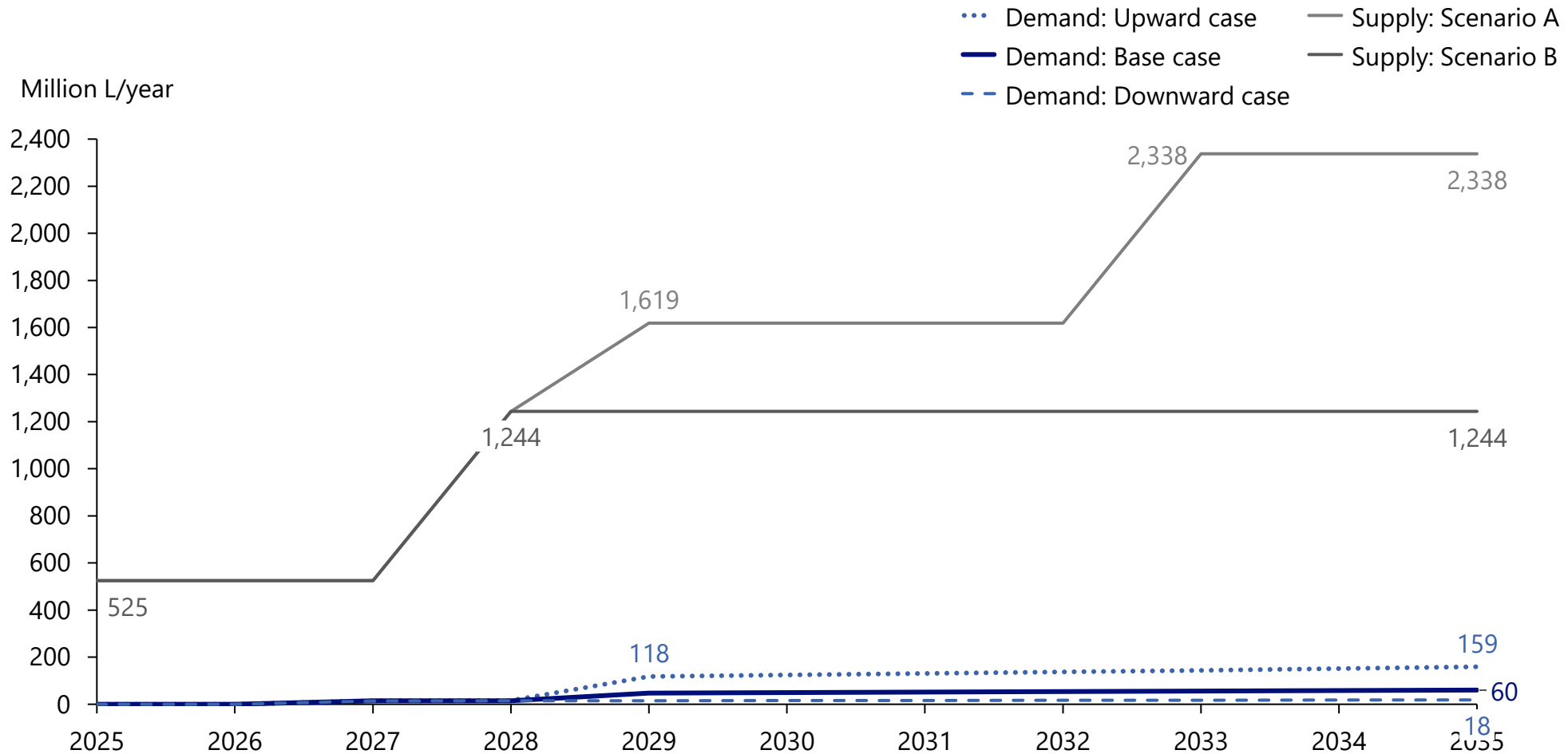
Note) * SAF demand target is referred to targets stated in "SAF Industry Development Roadmap"



Executive Summary | Supply & Demand Potential | Malaysia

In Malaysia, SAF supply exceeds demand significantly throughout the target period

SAF demand and supply forecast in Malaysia

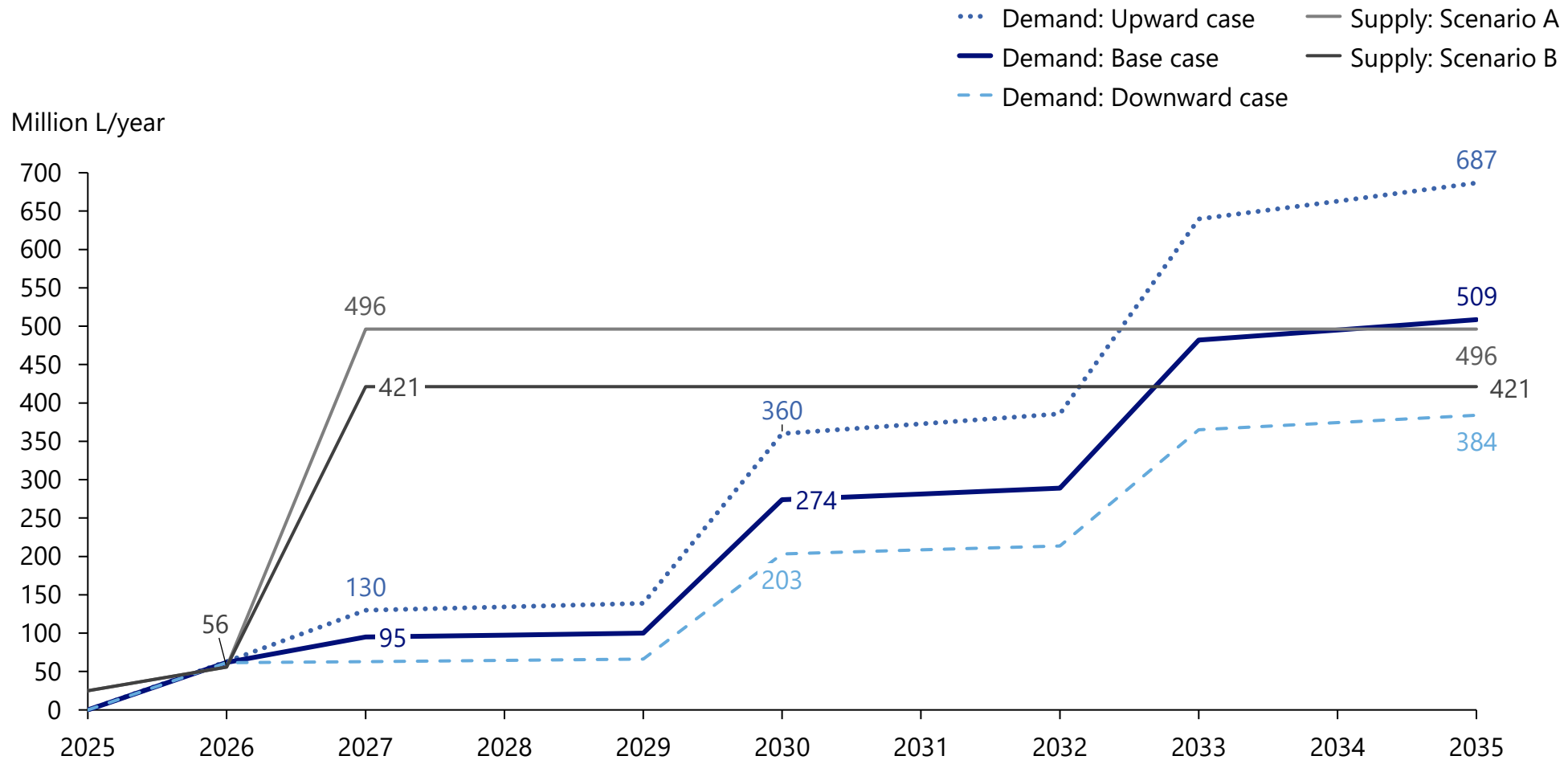




Executive Summary | Supply & Demand Potential | Thailand

In Thailand, SAF demand will reach supply capacity in 2032-2034 except downward case of demand

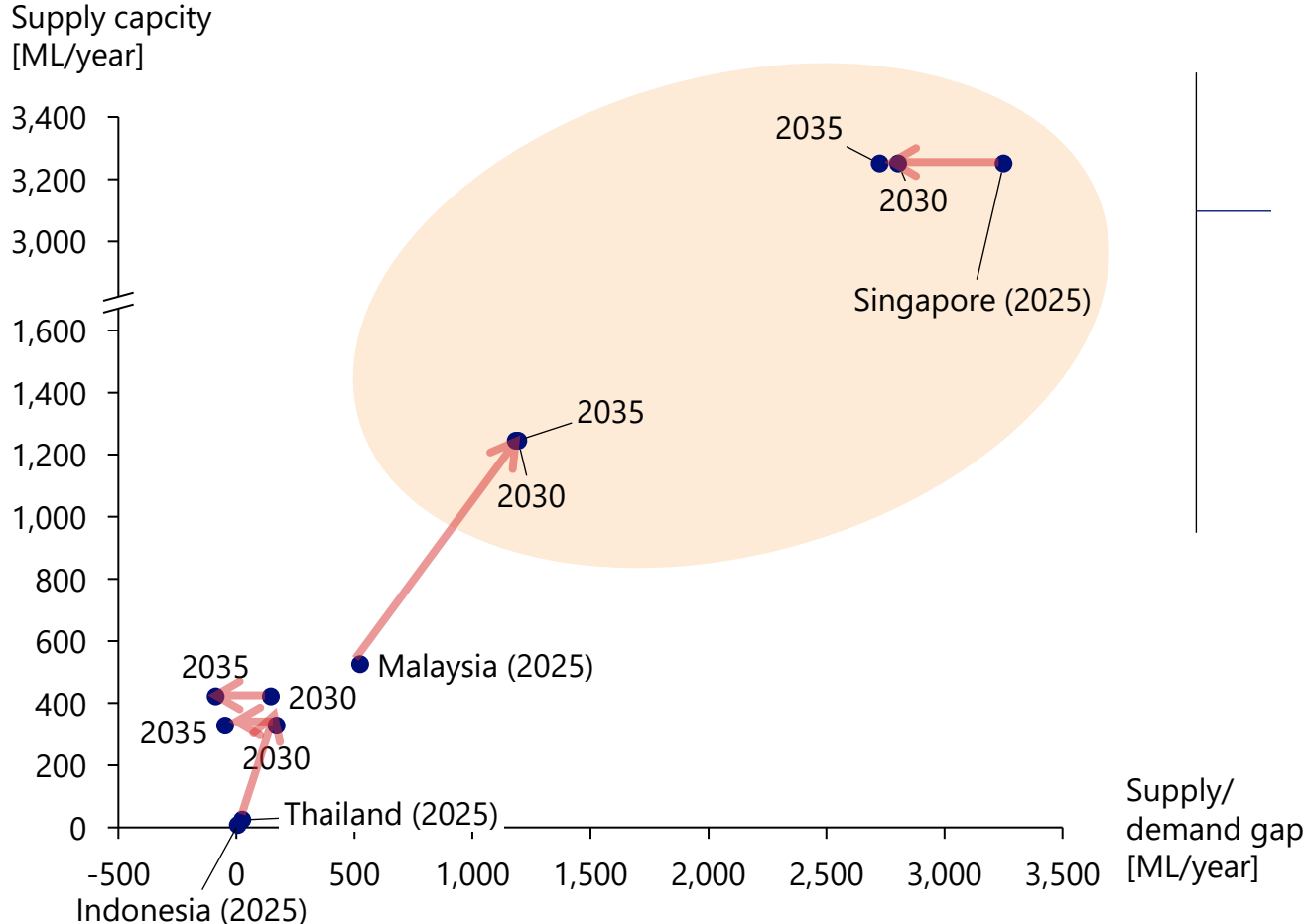
SAF demand and supply forecast in Thailand



Executive Summary | Supply/Demand Balance and Export Interest

Surplus of supply is expected to provide export opportunities, especially for Singapore and Malaysia which has a significant amount of surplus

Supply Capacity and Surplus of Supply Compared to Demand (2025, 2030, 2035)*



Singapore and Malaysia have high surplus for supply capacity, providing export opportunities to overseas countries including Japan

SAF will be produced specifically for export purpose for our company

Former Engineering Manager, EcoCeres



Neste is exporting SAF, and has already exported SAF to EU and North America

Industry player associated and familiar with Neste Singapore



Note) * "The surplus of supply capacity (supply/demand gap)" is calculated as "supply capacity (Scenario B) – demand capacity (Base case)"

Executive Summary | Export Targets by Supply Side Players

Export is considered not only to Japan, but to other regions such as Europe and North America which a high demand for SAF is expected

ASEAN Countries' SAF Export Target Markets

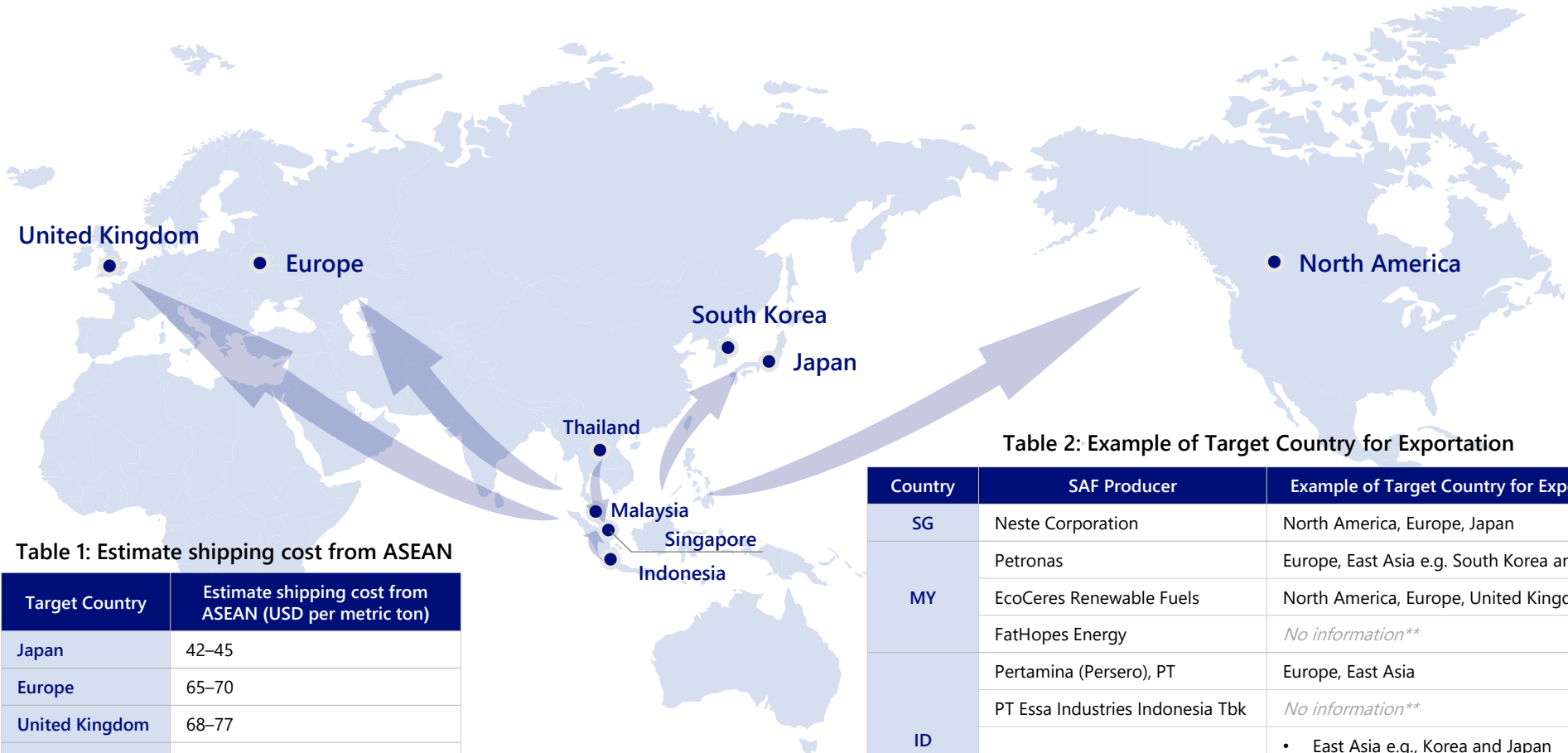


Table 1: Estimate shipping cost from ASEAN

Target Country	Estimate shipping cost from ASEAN (USD per metric ton)
Japan	42-45
Europe	65-70
United Kingdom	68-77
North America	75-83

Table 2: Example of Target Country for Exportation

Country	SAF Producer	Example of Target Country for Exportation
SG	Neste Corporation	North America, Europe, Japan
MY	Petronas	Europe, East Asia e.g. South Korea and Japan
	EcoCeres Renewable Fuels	North America, Europe, United Kingdom
ID	FatHopes Energy	No information**
	Pertamina (Persero), PT	Europe, East Asia
	PT Essa Industries Indonesia Tbk	No information**
TH	Tripatra*	<ul style="list-style-type: none"> East Asia e.g., Korea and Japan Plan to trade SAF through Singapore as a commercial hub, with sales targeted to Europe and the United States
	Bangchak Corporation	Singapore, Japan

* Opinion from the expert from other companies

** No information based on desktop research and interview

Source: NRI analysis, interview, Bangchak

Executive Summary

Chapter 1: Public Policy and Regulations

Summary

Chapter 1-1: Overview of Public Policy and Regulation by Country

Chapter 1-2: Selection of Country for Deep-Dive

Chapter 2: Player Activity

Chapter 3: Supply/demand potential

Chapter 4: Needs by Local Players

Chapter 5: Export Potential to Japan

Appendix

Executive Summary

Chapter 1: Public Policy and Regulations

Summary

Chapter 1-1: Overview of Public Policy and Regulation by Country

Chapter 1-2: Selection of Country for Deep-Dive

Chapter 2: Player Activity

Chapter 3: Supply/demand potential

Chapter 4: Needs by Local Players

Chapter 5: Export Potential to Japan

Appendix

Key Findings



Implementation of regulations will be key for achieving the target set. In this project, Singapore, Malaysia, Thailand, and Indonesia will be deep-dive markets

Key Questions and NRI's Outlook

Key Question

Fact (Desktop Research & Interviews)

NRI's View

Are the policies in ASEAN countries sufficient for utilizing SAF by 2030?

Public Policy

- Across most ASEAN 6 markets, public policy with numerical target for SAF utilization has either been implemented or drafted, indicating high political interest

Regulations & Incentives

- Although policy development initiatives are observed, regulations development is still under discussion for most countries, and incentives are limited
- However, for Singapore there is already a draft for regulation imposed, for Malaysia a draft being developed, and for Thailand and Indonesia, discussion ongoing

- Given that utilization of SAF will cause burden economically, mandatory regulations will be required to drive the SAF utilization, given that incentives in ASEAN (e.g. tax exemptions) typically have low impact, and not expected to be a fundamental driver for implementation
- If regulations currently being developed can be enforced, there will be potential for the mid-term target of SAF to be achieved

Based on the public policies and biomass potential, what countries have high potential from demand/supply side perspective?

Demand-side:

- Overall demand potential: Singapore has the highest potential for aviation fuel consumption
- Policy maturity; Differs across markets, in which maturity in Vietnam and Philippines lower than other markets

Supply-side:

- Overall supply potential: Indonesia has the highest raw material potential, whereas for the capacity development, Singapore, Indonesia, and Malaysia is relatively progressive
- Policy maturity; Differs across markets, in which maturity in Vietnam and Philippines lower than other markets

- Both the potential in overall supply/demand and the policy maturity needs to be taken into consideration for evaluation as a criteria
- Based on the evaluation leveraging the criteria, the attractiveness of the market differs clearly
- Singapore, Malaysia, and Thailand will be the deep-dive study market for demand-side and Thailand, Indonesia, Malaysia for supply-side market

Summary of chapter 1



All ASEAN 6 countries are a member state of ICAO, and have announced to support the achievement of the target, leveraging measures such as SAF

Views of Governments in ASEAN 6 Countries Towards CO2 Reduction in Aviation Industry

- The ASEAN 6 countries are all members states of ICAO, and have publicly announced support for ICAO's long-term goal, as well as implementing measures to achieve the goal



Singapore

Singapore will **play its part in contributing to ICAO's targets** and work with our stakeholders to **implement ICAO's basket of measures**. To demonstrate our commitment, we will **take decisive actions to encourage SAF use and production** in Singapore.
- Civil Aviation Authority of Singapore



Malaysia

As an ICAO Member State, **Malaysia actively supports the ICAO Global Framework**. In **accordance with the ICAO recommended basket of measures**, Malaysia outlined four (4) key initiatives to cap carbon emission growth, namely: a) aircraft technologies, b) operational improvements, **sustainable aviation fuel (SAF)**, market-based measures (MBM) – i.e. CORSIA
- Ministry of Transport, Malaysia



Thailand

In **response to ICAO's Long-Term Global Aspirational Goal (LTAG)**, Thailand has **demonstrated a strong commitment** by actively participating in CORSIA. Recognizing the **critical role of SAF** and CORSIA Eligible Emissions Unit (CEU), Thailand has adopted a progressive, multi-stakeholder approach to meet its international obligations.
- Thai Delegation to Conference of Directors General of Civil Aviation



Indonesia

Global commitments through the ICAO target net zero emissions in the aviation sector by 2050. As Southeast Asia's largest aviation market and potentially the world's fourth-largest market, **Indonesia plays a strategic role in realizing this commitment**. One of the Government of Indonesia's steps to realize this commitment is to **develop a bioavtur ecosystem or SAF in the country**.
- Coordinating Minister for Maritime Affairs and Investment of the Republic of Indonesia



Vietnam

Joining the ICAO's CORSIA is not just about meeting international obligations — it's also a chance for Vietnam's aviation industry to boost its capabilities and raise its technical standards. **SAF plays a vital role in building a greener, more sustainable economy**
- Deputy Prime Minister, Tran Hong Ha



Philippines

The Philippines is exploring other activities able to **decarbonize the aviation sector aligned with the ICAO Long-Term Aspirational Goals (LTAG)**.
- Civil Aviation Authority of the Philippines

CO2 Reduction in Aviation Industry | Position of ASEAN 6 Countries Towards International Target

Most countries align with ICAO's target of net-zero CO2 emissions by 2050. However, most do not have targets for CO2 emissions reduction from SAF

	ICAO target	Singapore	Thailand	Malaysia	Indonesia	Vietnam	Philippines
Long term	Long-Term Global Aspirational Goal (LTAG): Net-zero CO2 emissions by 2050 for international aviation	Aligned with ICAO	Aligned with ICAO	Aligned with ICAO	Not aligned with ICAO Target to achieve net-zero CO2 emissions by 2060 or earlier	Aligned with ICAO	Aligned with ICAO
Near term	5% CO2 emissions reduction by 2030 from SAF and other cleaner energies.	Not aligned with ICAO Singapore does not set CO2 emissions reduction target for SAF. However, the government estimate that SAF will contribute to 4% of CO2 emissions reduction by 2030	No information about target for CO2 emissions reduction from SAF	Not aligned with ICAO Target set to only 0.2-4% CO2 emissions reduction from SAF between 2024-2029	No information about target for CO2 emissions reduction from SAF	No information about target for CO2 emissions reduction from SAF	No information about target for CO2 emissions reduction from SAF

Across all ASEAN countries public policy is either implemented, draft completed, or drafted currently being developed, indicating high political interest

Overview of Policies/Roadmap for SAF in the ASEAN 6 Countries

Topic	Key Policy For SAF	Status	Overview of SAF Related Description	
			Supply	Demand
Singapore	Singapore Sustainable Air Hub Blueprint	Implemented	<ul style="list-style-type: none"> Provides qualitative direction for production support 	<ul style="list-style-type: none"> Provides quantitative target (3-5% of flights departing from SG to use SAF by 2030)
Malaysia	National Energy Transition Roadmap (NETR)	Implemented	<ul style="list-style-type: none"> Provides qualitative direction for production support 	<ul style="list-style-type: none"> Provides quantitative target (Usage: 47% SAF blend by 2050)
	Malaysia Aviation Decarbonisation Blueprint	Implemented	<ul style="list-style-type: none"> - 	<ul style="list-style-type: none"> Provides quantitative target (Contribute to 46% of total CO2 reduction target for 2050)
Thailand	Alternative Energy Development Plan 2024 – 2037 (AEDP 2024)	Draft completed	<ul style="list-style-type: none"> - 	<ul style="list-style-type: none"> Provides quantitative target (Usage: 1.85 MLPD by 2037)
	Oil Plan 2024 – 2037	Draft completed	<ul style="list-style-type: none"> Provides quantitative target (Production capacity: 1.2-1.9 MLPD* by 2033-2037) 	<ul style="list-style-type: none"> Provides quantitative target (Usage: 5-8% SAF blend by 2033-2037)
Indonesia	Indonesia’s SAF Industry Development Roadmap	Implemented	<ul style="list-style-type: none"> Provides qualitative direction for production support 	<ul style="list-style-type: none"> Provides quantitative target (Usage: 50% SAF blend by 2060)
Vietnam	Decision No. 876/QD-TTg	Implemented	<ul style="list-style-type: none"> - 	<ul style="list-style-type: none"> Provides quantitative target (10%>for some short flights)
Philippines	n/a	Draft being developed	<ul style="list-style-type: none"> News article indicate the roadmap development has already initiated, but no announcement of the draft being completed 	
Ref: Japan	Basic Policy for Achieving GX, etc.	Implemented	<ul style="list-style-type: none"> Major oil distributors supply SAF at least 5% equivalent to GHG emissions from jet fuel produced/supplied in Japan in FY19 from 2030 	<ul style="list-style-type: none"> Provides quantitative target (Usage: 10% SAF blend by 2030 for Japanese airlines)

Note: MLPD refers to “million liters per day”

Source: Government sources, news article

Regulations are still in the phase of being discussed across most countries with no concrete mention of penalties, but Singapore has an implementation timeline

Overview of Regulations for SAF in the ASEAN 6 Countries

Topic	Status for Mandatory Regulation Implementation	
	Supply	Demand
Singapore	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources 	<ul style="list-style-type: none"> The Civil Aviation Authority of Singapore (CAAS) recently revealed it would introduce "Sustainable Aviation Fuel (SAF) Levy" for flights booked from Apr' 26
Malaysia	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources 	<ul style="list-style-type: none"> Draft is currently being developed (For international flights departing from Kuala Lumpur)
Thailand	<ul style="list-style-type: none"> Future development under discussion (Rules on specification and quality requirements has been implemented but for mandatory use under discussion) 	<ul style="list-style-type: none"> Future development under discussion (CAAT signed MOUs with 8 airlines to begin voluntary SAF adoption, with a potential transition to mandatory measures)
Indonesia	<ul style="list-style-type: none"> Future development under discussion (Future regulation development is being proposed in roadmap) 	<ul style="list-style-type: none"> Future development under discussion (Future regulation development is being proposed in roadmap)
Vietnam	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources 	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources
Philippines	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources 	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources
Ref: Japan	<ul style="list-style-type: none"> Future development under discussions in the public-private councils based on publicly available sources 	<ul style="list-style-type: none"> Future development under discussions in the public-private councils based on publicly available sources

Malaysia and Thailand have already implemented incentives but are mainly for areas such as tax exemption, whereas for other markets not implemented

Overview of Incentives for SAF in the ASEAN 6 Countries

Topic	Status for Incentive Implementation	
	Supply	Demand
Singapore	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources 	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources
Malaysia	<ul style="list-style-type: none"> Implemented (Corporate tax exemption for SAF production) 	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources
Thailand	<ul style="list-style-type: none"> Implemented (Corporate tax/import duty exemption, non-tax exemption) 	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources
Indonesia	<ul style="list-style-type: none"> Future development under discussion (Future development is being proposed in roadmap) 	<ul style="list-style-type: none"> Future development under discussion (Future development is being proposed in roadmap)
Vietnam	<ul style="list-style-type: none"> Under discussion (Tax exemptions and financial support is being discussed by relevant ministries) 	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources
Philippines	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources 	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources
Ref: Japan	<ul style="list-style-type: none"> Implemented (Tax exemptions (30JPY/L) based on production and sales volume, etc.) 	<ul style="list-style-type: none"> Future development under discussion in the public-private councils based on publicly available sources

Source: Government webpage of each country, news article

NRI proposes to evaluate the attractiveness of the market, based on quantitative indicators for potential, and the policy maturity

Evaluation Criteria

Evaluation Criteria		Evaluation Indicators	Source of Evaluation Indicator
Supply Side	Supply Potential	<ul style="list-style-type: none"> Availability of non-edible biomass resource* (wood residue, crop residue) 	<ul style="list-style-type: none"> Food and Agricultural Organization (FAO)
		<ul style="list-style-type: none"> Production capacity of SAF in major companies in each country (e.g. Neste, PTT, Petronas, Pertamina) 	<ul style="list-style-type: none"> Publicly available sources
	Policy Maturity	<ul style="list-style-type: none"> Policy development status Policy's level of ambition Regulatory framework Incentives 	<ul style="list-style-type: none"> Publicly available sources
Demand side	Demand Potential	<ul style="list-style-type: none"> Aviation fuel consumption 	<ul style="list-style-type: none"> Publicly available sources
	Policy Maturity	<ul style="list-style-type: none"> Policy development status Policy's level of ambition Regulatory framework Incentives 	<ul style="list-style-type: none"> Publicly available sources

Note: The data of crop residues is as of year 2022 and includes residues from commonly used crop residues for bioenergy based on statistics from FAO (as of 2022), such as (and not limited to) residues from oil palm, corn, rice, sugar canes. The data for wood residues is as of 2021 and includes sawdust and slabs & chips from sawmills.

Source: NRI analysis

Based on the evaluation criteria, the supply potential and policy maturity is evaluated on a scale of 1-5

Evaluation of SAF Supply in ASEAN 6 Countries

Evaluation Perspective		Evaluation Criteria	S	M	T	I	V	P		
			G	Y	H	D	N	H		
Supply Potential	Availability of non-edible biomass resource	1. Supply potential of raw materials for biomass (crop and wood): Less than 100 million ton/year	✓				✓	✓		
		2. Supply potential of raw materials for biomass (crop and wood): 100-199 million ton/ year			✓					
		3. Supply potential of raw materials for biomass (crop and wood): 200-299 million ton/year		✓						
		4. Supply potential of raw materials for biomass (crop and wood): 300-399 million ton/year								
		5. Supply potential of raw materials for biomass (crop and wood): Over 400 million ton/year					✓			
	Production capacity of SAF	1. No known activity or announcement on infrastructure development							✓	
		2. Only vague future intentions expressed on scaling SAF production facility (“considering,” “exploring”), without concrete plans (site, capacity, timeline)						✓		
		3. Concrete plans (site, capacity, timeline) announced for SAF production capacity development; Less than 1 MLPD or no clear indication of exceeding 1MLPD				✓				
		4. Concrete plans (site, capacity, timeline) announced for SAF production capacity development; More than 1 MLPD (million liters per day)			✓		✓			
		5. SAF production capacity of over 1 MLPD (million liters per day) is already developed		✓						
Policy Maturity	Policy Status	1. No SAF-related policies exist; discussions within the government are minimal						✓	✓	
		2. Discussion on development of public policy is currently conducted (not drafted)								
		3. Public policy draft is currently being developed								
		4. Public policy is already drafted (not implemented)					✓			
		5. Public policy is already implemented		✓	✓		✓			
	Policy's level of ambition	1. No targets or undefined goals.							✓	✓
		2. Only broad statements like “promote” and no numerical target		✓	✓		✓			
		3. Numerical target provided; long-term target is below 1MLPD (million liters per day)								
		4. Numerical target provided; long-term target is above 1MLPD (million liters per day); target year for achieving 1MLPD is after 2030					✓			
		5. Numerical target provided; long-term target is above 1MLPD (million liters per day); target year for achieving 1MLPD is before 2030								
	Regulatory framework	1. No mandatory regulations; discussions within the government are minimal based on publicly available information		✓	✓	✓		✓	✓	
		2. Mandatory regulations under consideration/discussion						✓		
		3. Mandatory regulations are currently being drafted								
		4. Mandatory regulations are already drafted but not implemented								
		5. Mandatory regulations implemented								
Incentives	1. No incentives; discussions within the government are minimal based on publicly available information		✓					✓		
	2. Incentive implementation is being discussed						✓	✓		
	3. Incentives are implemented; subsidies/grants are not provided (e.g. only tax exemptions)			✓	✓					
	4. Incentives are implemented; subsidies/grants are provided on a small scale									
	5. Incentives are implemented; subsidies/grants are provided on a large scale									

Source: NRI analysis based on government sources, news article

NRI understands that Vietnam and Philippines is the least attractive, and proposes to deep-dive in 3 countries within the remaining 4 countries

Attractiveness of Market

Topic	Supply Potential		Policy Maturity				Overall Evaluation	
	Availability of non-edible biomass resource	Production capacity of SAF	Policy development status	Policy's level of ambition	Regulatory framework	Incentives	Score	NRI's Views
Indonesia	5	4	5	2	2	2	20	• High attractiveness
Malaysia	3	4	5	2	1	3	18	• High attractiveness
Thailand	2	3	4	4	1	3	17	• High attractiveness
Singapore	1	5	5	2	1	1	15	• Mid-level attractiveness; production capacity and policy development status is progressive, but domestic raw material supply potential is limited
Vietnam	1	2	2	1	1	2	9	• Low-level attractiveness; Both supply potential and policy maturity is lower than other markets
Philippines	1	1	2	1	1	1	7	• Low-level attractiveness; Both supply potential and policy maturity is lower than other markets

Source: NRI analysis based on government webpage of each country, news article

Based on the evaluation criteria, the demand-side potential and policy maturity is evaluated on a scale of 1-5

Evaluation of SAF Demand in ASEAN 6 Countries

Evaluation Perspective		Evaluation Criteria	S	M	T	I	V	P	
			G	Y	H	D	N	H	
Demand Potential	Aviation fuel consumption	1. Daily consumption: Less than 25 thousand barrels per day							
		2. Daily consumption: 25-49 thousand barrels per day		✓			✓	✓	
		3. Daily consumption: 50-99 thousand barrels per day				✓	✓		
		4. Daily consumption: 100-499 thousand barrels per day	✓						
		5. Daily consumption: Over 500 thousand barrels per day							
	Airport Concentration Level	1. Very highly fragmented: Over 30 international airports					✓		
		2. Highly fragmented: 20-29 international airports							
		3. Moderate level concentration: 10-19 international airports						✓	
		4. High-mid level concentration: 5-9 international airports		✓	✓				✓
		5. Highly concentrated; Less than 5 international airports	✓						
Policy Maturity	Policy Status	1. No SAF-related policies exist; discussions within the government are minimal							
		2. Discussion on development of public policy is currently conducted (not drafted)						✓	
		3. Public policy draft is currently being developed							
		4. Public policy is already drafted (not implemented)			✓				
		5. Public policy is already implemented	✓	✓		✓	✓		
	Policy's level of ambition	1. No targets or undefined goals.							✓
		2. Only broad statements like "promote" and no numerical target							
		3. Numerical target provided; long-term target for SAF blending is below 5% (or unclear whether above 5%)						✓	
		4. Numerical target provided; long-term target for SAF blending is above 5% (target year is after 2030)		✓	✓	✓			
		5. Numerical target provided; long-term target for SAF blending is above 5% (target year is 2030 or before)	✓						
	Regulatory framework	1. No mandatory regulations; discussions within the government are minimal based on publicly available information							✓
		2. Mandatory regulations under consideration/discussion				✓	✓		✓
		3. Mandatory regulations are currently being drafted			✓				
		4. Mandatory regulations are already drafted but not implemented	✓						
		5. Mandatory regulations implemented							
Incentives	1. No incentives; discussions within the government are minimal based on publicly available information		✓	✓	✓		✓	✓	
	2. Incentive implementation is being discussed					✓			
	3. Incentives are implemented; subsidies/grants are not provided (e.g. only tax exemptions)								
	4. Incentives are implemented; subsidies/grants are provided on a small scale								
	5. Incentives are implemented; subsidies/grants are provided on a large scale								

Source: NRI analysis based on government webpage of each country, news article

NRI understands that Vietnam and Philippines is the least attractive, and proposes to deep-dive in Singapore and 2 countries within ID, MY, and TH

Attractiveness of Market

Topic	Demand Potential		Policy Maturity				Overall Evaluation	
	Aviation fuel consumption	Airport Concentration Level	Policy development status	Policy's level of ambition	Regulatory framework	Incentives	Total Score	NRI's Views
Singapore	4	5	5	5	4	1	24	<ul style="list-style-type: none"> Most attractive market; based on overall demand potential as hub airport country and policy maturity
Malaysia	2	4	5	4	3	1	19	<ul style="list-style-type: none"> High-level attractiveness
Thailand	3	4	4	4	2	1	18	<ul style="list-style-type: none"> High-level attractiveness
Indonesia	3	1	5	4	2	2	17	<ul style="list-style-type: none"> Mid-level attractiveness
Vietnam	2	4	5	3	1	1	16	<ul style="list-style-type: none"> Low-level attractiveness; Both demand potential and policy maturity is lower than other markets
Philippines	2	4	2	1	1	1	11	<ul style="list-style-type: none"> Low-level attractiveness; Both demand potential and policy maturity is lower than other markets

Source: NRI analysis based on government webpage of each country, news article

Executive Summary

Chapter 1: Public Policy and Regulations

Summary

Chapter 1-1: Overview of Public Policy and Regulation by Country

Chapter 1-2: Selection of Country for Deep-Dive

Chapter 2: Player Activity

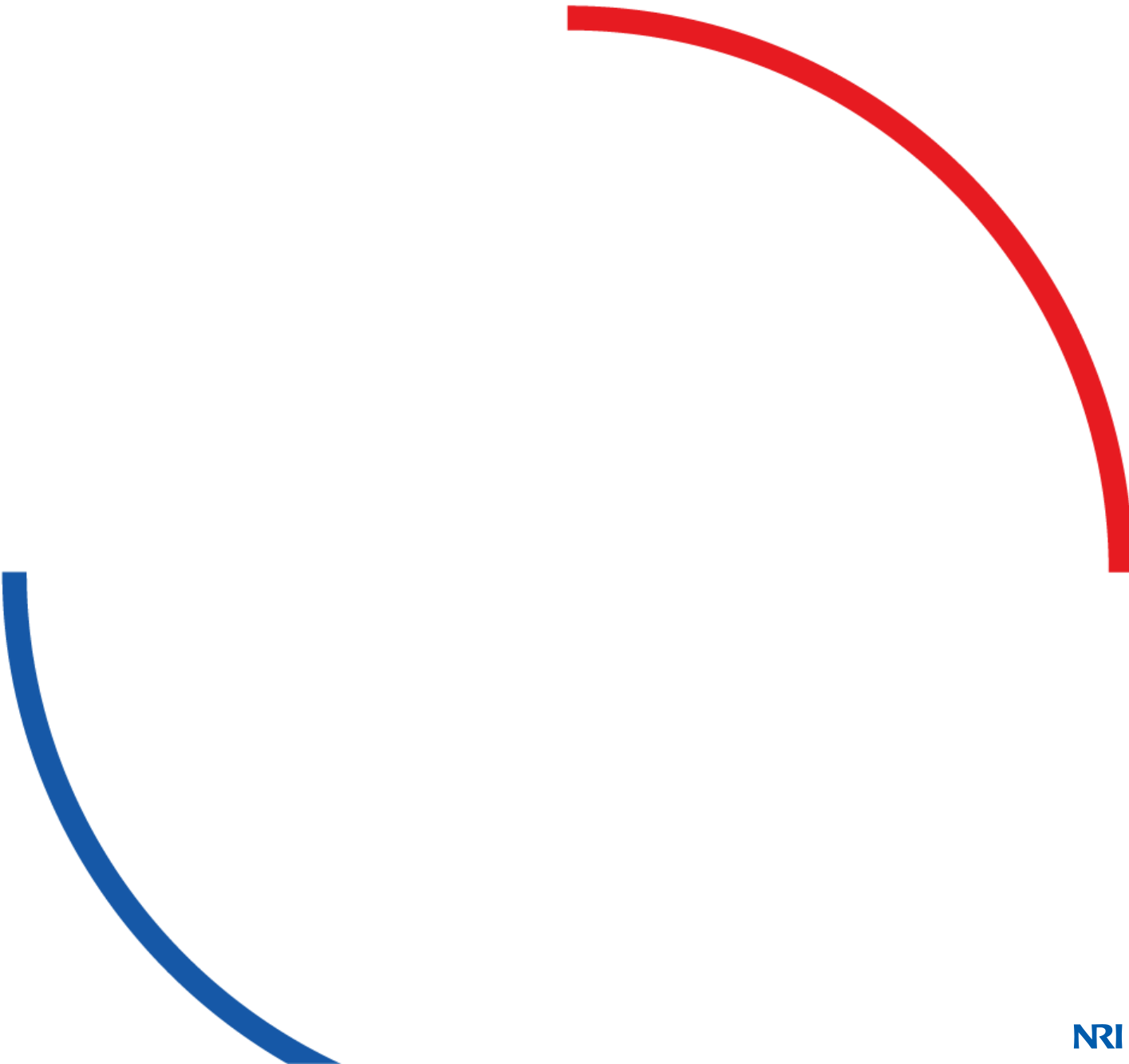
Chapter 3: Supply/demand potential

Chapter 4: Needs by Local Players

Chapter 5: Export Potential to Japan

Appendix

Singapore



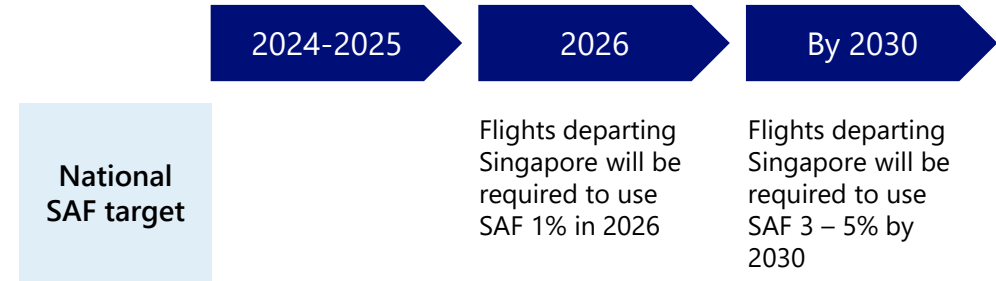


Singapore launched its SAF Blueprint in 2024, outlining a 1% SAF mandate from 2026 to be implemented through a SAF levy and central SAF procurement

Overview of Policies/Roadmap for SAF

Title	Singapore Sustainable Air Hub Blueprint
Date Issued	19 February 2024
Responsible Government Organization	Developed by the Civil Aviation Authority of Singapore (CAAS)
Goal/Objective of Policy	To reduce domestic aviation emissions from airport operations by 20% from 2019 levels in 2030 and achieve net zero domestic and international aviation emissions by 2050
Overview of Policy	To achieve the goals, 12 initiatives across airports, airlines, and air traffic management domains will be rolled out, supported by 5 enablers from CAAS to ensure effective implementation.
SAF Related Targets and Government Initiatives	<ul style="list-style-type: none"> The use of SAF is expected to contribute around 65% of the carbon emissions reduction needed to achieve net zero by 2050. Therefore, SAF-related initiatives to build an ecosystem supporting its use are outlined under the Airline domain: <ul style="list-style-type: none"> ➢ Initiative 1: National SAF target and SAF levy ➢ Initiative 2: Central SAF procurement ➢ Initiative 3: SAF production in Singapore and the region

Action Plans in Policy Roadmap



Initiatives Status Update

	Sep 2025	Oct 2025	2026
Initiative 1: SAF levy	The CAAS (Amendment) Bill was introduced for its first reading in Parliament, proposing legislation to enable CAAS to implement SAF levy and central SAF procurement.	<ul style="list-style-type: none"> The CAAS (Amendment) Bill passed in Parliament. CAAS has set up the Singapore Sustainable Aviation Fuel Company Ltd. (SAFCo) to centrally procure SAF. 	CAAS will introduce a SAF levy on flights departing Singapore from October 2026, applicable to tickets or services sold from 1 April 2026.
Initiative 2: Central SAF Procurement			
Initiative 3: SAF Production	There is no update on this initiative after the Blueprint launched. It only mentions that the government will work closely with partners to expand SAF production capacity, in line with targets set out under the Sustainable Jurong Island plan.		



Reference) Singapore Green Plan 2030 | Sustainable Jurong Island Plan

SAF initiative under Singapore Sustainable Air Hub Blueprint aims to expand SAF production in line with Sustainable Jurong Island’s sustainable products target

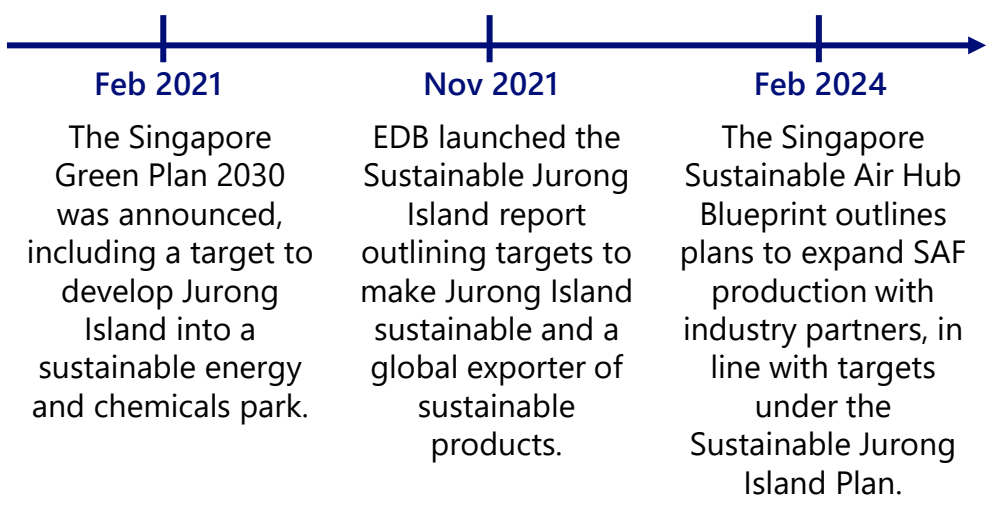
Overview of Policies/Roadmap for SAF

Title	Singapore Green Plan 2030
Date Issued	February 2021
Responsible Government Organization	<ul style="list-style-type: none"> Ministry of Education Ministry of National Development Ministry of Sustainability and the Environment Ministry of Trade and Industry Ministry of Transport
Goal/Objective of Policy	To set concrete targets over the next 10 years that advance Singapore’s sustainability commitments and position the nation for net-zero emissions by 2050.
Overview of Policy	The plan comprises five pillars that set key targets across all aspects of life to achieve its goals.
SAF Related Targets and Government Initiatives	<ul style="list-style-type: none"> Sustainable Jurong Island (JI) is an initiative under the Green Economy Pillar of Singapore Green Plan to transform JI into a sustainable energy and chemicals hub, supported by programs such as funding and infrastructure. The SAF production initiative, under the Singapore Sustainable Air Hub Blueprint, outlines that the government will work with industry partners to expand SAF production capacity, in line with targets set out under the Sustainable Jurong Island plan.

Action Plans in Policy Roadmap

	2025-2029	By 2030	By 2050
Singapore Green Plan Target		Jurong Island to be a sustainable energy and chemicals park	
Sustainable Jurong Island Plan Target		Increase the output of sustainable products by 1.5 times from 2019 levels	Increase the output of sustainable products by 4 times from 2019 levels

Initiatives Status Update



Source: EDB, CAAS, EMA, NCCS, news article



To meet 1% SAF target for 2026, the SAF levy will be applied to flights departing Singapore from 1 Oct 2026, applicable to tickets or services sold from 1 Apr 2026

Overview of Regulation

Status		To be implemented for flights departing Singapore from 1 October 2026, applicable for tickets or services sold from 1 April 2026.
Roles of Government Organizations		<ul style="list-style-type: none"> Ministry of Transport (MOT): Introduces the bill in Parliament. Civil Aviation Authority of Singapore (CAAS): Implements the amendment.
Initiatives/ Discussions	Regulatory Framework	<ul style="list-style-type: none"> The Bill proposes legislative amendments to the Civil Aviation Authority of Singapore Act 2009 to allow for the implementation of SAF policies for air transport. The CAAS (Amendment) Bill has 3 key provisions: <ul style="list-style-type: none"> ➤ SAF Levy be payable to CAAS ➤ A dedicated SAF Fund will be set up to receive all SAF levies collected. ➤ Allow CAAS (or organization set by CAAS) to buy, manage, and distribute SAF and SAF EAs*.
	Penalty	If party liable for the SAF Levy does not pay on time, they could face penalties and interest on the unpaid amount.

* SAF EAs means SAF Environmental Attributes which represent the CO₂ emissions reduction of SAF compared with conventional aviation fuel. They can be used to meet offsetting requirements under CORSIA or other applicable schemes, or reported as sustainability achievements to stakeholders.

Details on SAF Levy

Topic	Description
SAF Levy Target Group	All Origin-Destination passengers**, Origin-Destination cargo shipments, and general and business aviation flights departing Singapore
SAF Levy Rate	<p>The quantum of the SAF Levy is set based on the volume of SAF needed to meet the 1% SAF target for 2026 and the projected price premium of SAF over conventional jet fuel and other costs, including the cost of certification, blending, and delivery.</p> <ul style="list-style-type: none"> SAF Levy for passengers: set on a per-passenger basis and varies based on the distance travelled, and the cabin of travel***. <ul style="list-style-type: none"> ➤ For example, economy class passengers will pay S\$1.00, S\$2.80, S\$6.40 and S\$10.40 to Bangkok, Tokyo, London and New York respectively SAF Levy for Origin-Destination cargo shipments: set on a per-kilogramme basis and varies based on the distance travelled. SAF Levy for general and business aviation flights: charged on a per-aircraft basis and varies based on the distance travelled, and the aircraft's ICAO codes A-F for aircraft wingspan which serve as a proxy for aircraft size.
Allocation of Collected Levy	All levies collected will go into a SAF Fund that will be used to procure SAF or credits for it, and to cover administrative costs.

**A passenger who departs from Singapore to another destination.

*** Economy Cabin includes Economy Class and Premium Economy Class. Premium Cabin includes Business Class and First Class.



On the supply side, Singapore currently has no major discussions on regulation for SAF production or supply based on the available published information.

Overview of Regulation

Details on SAF production or supply in Thailand

Status		No major discussion observed based on publicly available source
Roles of Government Organizations		No published information available
Initiatives/ Discussions	Regulatory Framework	No published information available
	Penalty	No published information available

No published information available regarding mandatory for SAF production or supply

On the both demand and supply side, Singapore currently has no major discussions on incentive measures based on the available published information.

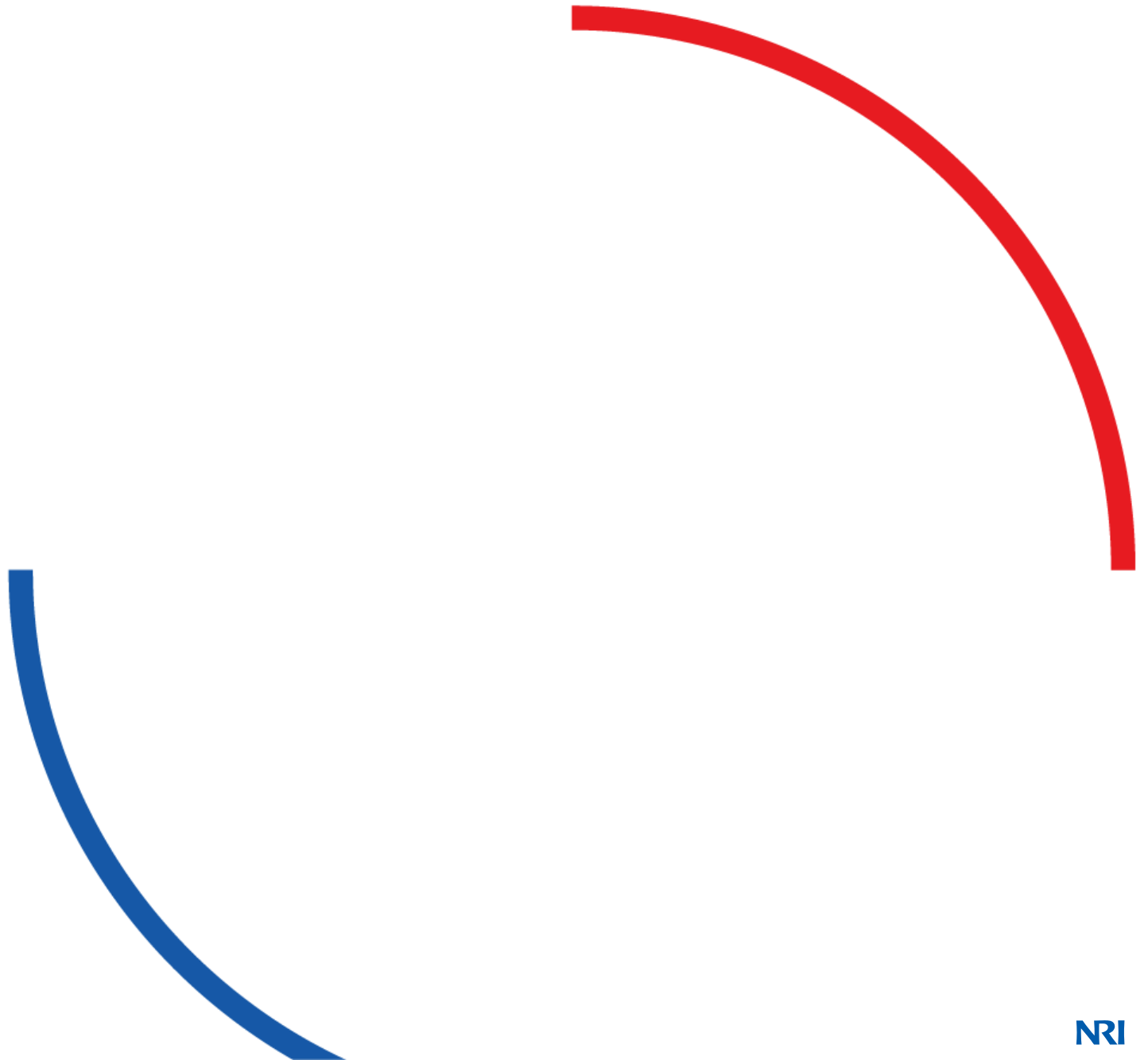
Overview of Incentives

Details on Incentives

Status	No major discussion observed based on publicly available source
Roles of Government Organizations	No published information available
Overview of Incentives Implemented / Under Discussion	No published information available

No published information available regarding Demand/Supply-side incentives for SAF

Malaysia

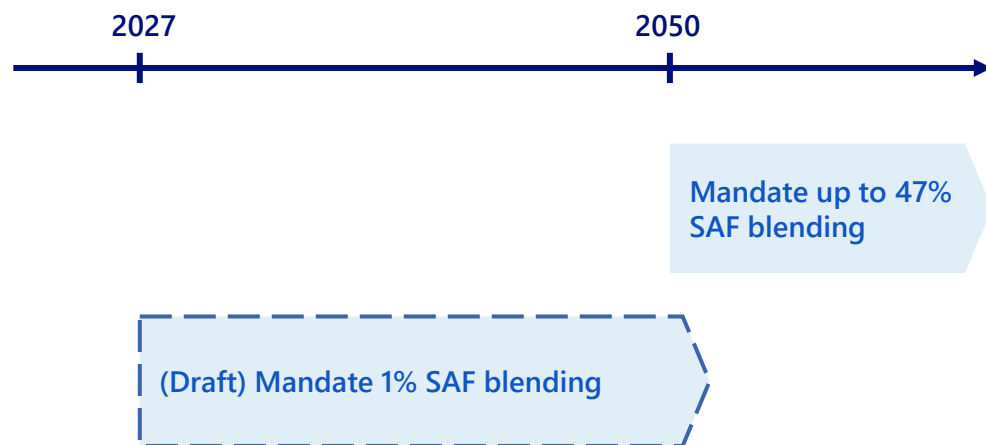


NETR provides a high-level roadmap for energy transition with a mandate target of 47% for SAF by 2050, outlining initiatives on both supply and demand sides

Overview of Policies/Roadmap for SAF

Title	National Energy Transition Roadmap (NETR)
Date Issued	August 29 th , 2023
Responsible Government Organization	Ministry of Economy, Ministry of Natural Resources, Environment and Climate Change, Ministry of Transport etc.
Goal/Objective of Policy	To achieve a sustainable energy system and net-zero greenhouse gas emissions by 2050
Overview of Policy	NETR outlines 50 initiatives under the 6 energy transition levers (energy efficiency, renewable energy, hydrogen, bioenergy, green mobility, and CCUS)
SAF Related Targets and Government Initiatives	<p>Demand</p> <ul style="list-style-type: none"> • Up to 47% SAF blending mandate by 2050 • Establish an initial 1% SAF blending mandate to encourage demand <p>Supply</p> <ul style="list-style-type: none"> • Obtain SAF certification from international bodies • Scale-up UCO collection via increasing awareness campaigns and UCO collection facilities • Incentivize investments in SAF production and infrastructure • Ensure palm oil for SAF production is sourced in a sustainable manner • Re-evaluate emissions related to POME and ILUC to bolster adoption of SAF derived from palm oil

Action Plans in Policy Roadmap



The ministry is also drafting a proposal to introduce a **1% SAF blending mandate for international flights departing from the Kuala Lumpur International Airport starting January 2027.**

Implementation details are being finalized with industry and other stakeholders.



Datuk Chan Foong Hin,
Deputy Plantation and Commodities Minister

MADB serves as a sector-specific extension of NETR by providing more detailed strategies and actions specifically for decarbonizing aviation sector

Overview of Policies/Roadmap for SAF

Title	Malaysia Aviation Decarbonisation Blueprint (MADB)
Date Issued	September 5 th , 2024
Responsible Government Organization	Ministry of Transport and Civil Aviation Authority of Malaysia (CAAM)
Goal/Objective of Policy	To guide Malaysia’s aviation sector to achieve net-zero carbon emissions by 2050 through coordinated national and industry actions
Overview of Policy	The blueprint outlines measures for airlines, air traffic management, airport, and multi-sector co-operation. 4 main strategies for airlines are aircraft technology, operational efficiency, SAF adoption , and carbon offsetting.
SAF Related Targets and Government Initiatives	<p>Civil Aviation Authority of Malaysia (CAAM) developed carbon reduction target based on 4 measures (aircraft technology, operational improvement, SAF, and market-based measures).</p> <p>In 3 stages, SAF should contribute to the reduction of total aviation carbon emission in percentage as follows.</p> <ul style="list-style-type: none"> • Short-term (2024-2029): 0.2%-3.7% • Mid-term (2030-2040): 5.1%-19.9% • Long-term (2041-2050): 46.2%

Opinion from Industry Player

- EcoCeres, a Hong Kong-based global renewable fuel producer, commented on the effect of MADB from a perspective of SAF producer as follows.

The recent launch of the MADB shows the commitment here to reducing the aviation sector’s carbon emissions – **reaffirming that we made the right choice to decide to invest in our second renewables energy facility in Malaysia.**



Dannis KL Poon,
Executive Vice President of Operation, EcoCeres



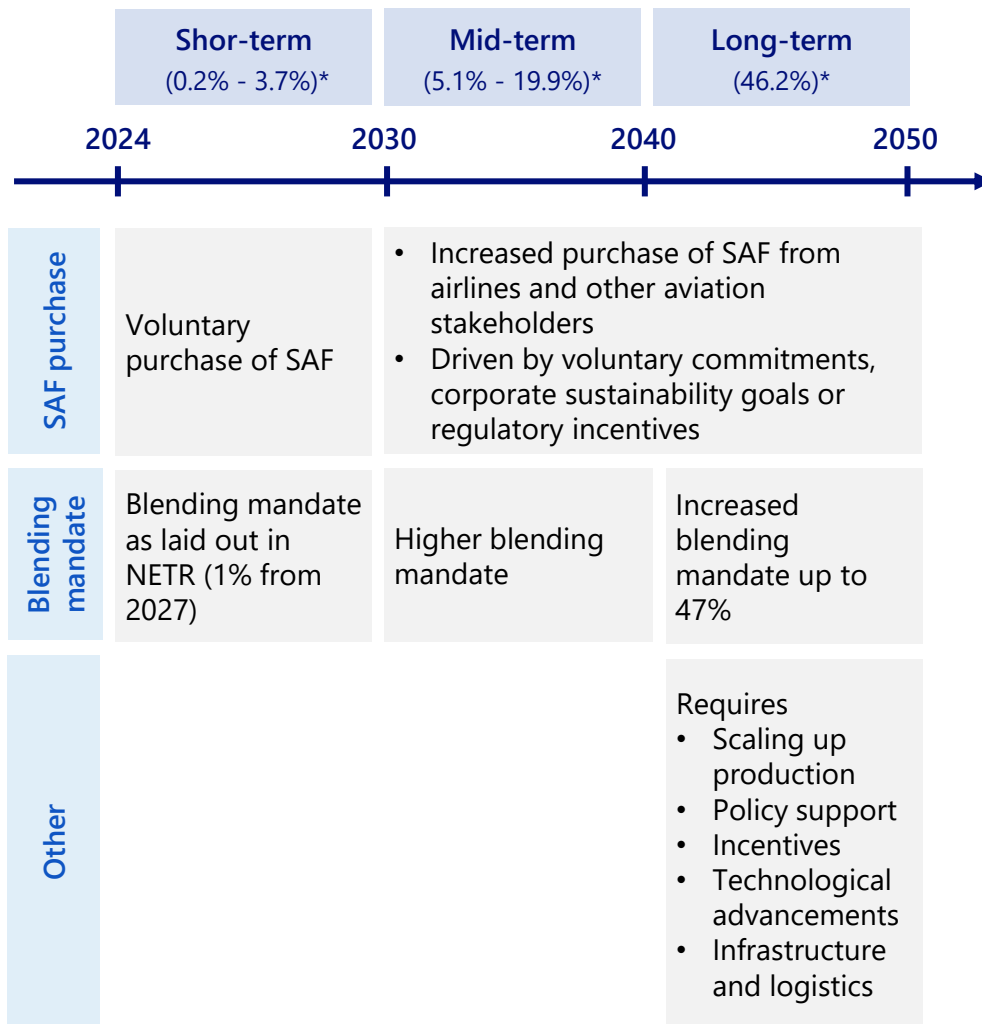
State Action Plan No. 04 specifies the implementation framework for the aviation sector to fulfill the decarbonization objectives defined in the MADB

Overview of Policies/Roadmap for SAF

Title	The Malaysian Green Skies Initiative and Action Plan (State Action Plan No.04)
Date Issued	September 2024
Responsible Government Organization	Civil Aviation Authority of Malaysia (CAAM)
Goal/ Objective of Policy	To outlines a comprehensive strategy as a commitment to ICAO and its initiatives to reduce CO ² emissions from international aviation.
Overview of Policy	The Action Plan sets out short, medium, and long-term measures focusing on advancing green technologies and ensuring implementation through a dedicated Green Skies Task Force
SAF Related Targets and Government Initiatives	<ul style="list-style-type: none"> 3 scenarios have been developed to outline clear short-, medium-, and long-term CO² emissions mitigation measures for SAF Task force on SAF is established to <ul style="list-style-type: none"> ✓ Ensure the effective implementation of SAF ✓ Conduct a feasibility study, cost benefit analysis on the impact and usage of SAF ✓ Establish a roadmap for SAF development ✓ Identify the need for assistance on SAF development

Source: ICAO

Action in the State Action Plan



Note: SAF CO² emission reduction target from MADB

While no regulation or penalty are in place yet, discussions are underway to develop a legal framework for SAF by task force from State Action Plan No. 04

Overview of Regulation

Details on regulation

Status		Discussion ongoing
Roles of Government Organizations		<ul style="list-style-type: none"> National Aerospace Industry Corporation Malaysia (NAICO) – Lead the working group MOT and CAAM – Collaborate with NAICO
Initiatives/ Discussions	Regulatory Framework	<p>This collaborative effort aims to</p> <ul style="list-style-type: none"> Frame SAF initiatives Determine optimal policies, legal frameworks and fiscal solutions to advance SAF development and deployment in Malaysia
	Penalty	No indication of penalty based on publicly available sources

Further detail of regulatory framework is not available yet as of 7th October 2025

Malaysia implemented tax incentive for companies producing biofuel i.e. SAF to boost SAF production. However, incentive for demand side is not established yet

Overview of Incentives

Status	Implemented
Roles of Government Organizations	Chemical & Advanced Material Division of Malaysian Investment Development Authority (MIDA) – Process and implements the incentive
Overview of Incentives Implemented	<p>Demand: N/A</p> <p>Supply: “MIDA Incentives” can be applied with various type of utilization of oil palm biomass to produce value-added products, including biofuel (biodiesel and SAF)</p> <p>Companies owned by Malaysian or foreign investors can refer to MIDA to register. Then the companies will receive incentives as follows.</p> <ul style="list-style-type: none"> • Pioneer status: <ul style="list-style-type: none"> ✓ Income tax exemption between 70%-100% of statutory income for a period of 5-10 years • Investment Tax Allowance: <ul style="list-style-type: none"> ✓ Between 60%-100% of qualifying capital expenditure incurred within a period of 5 years

Example of companies receiving MIDA incentives

- EcoCeres registered its project company in Malaysia in May 2022, starting a journey that will culminate in the development of its second facility, the first SAF facility in Malaysia.

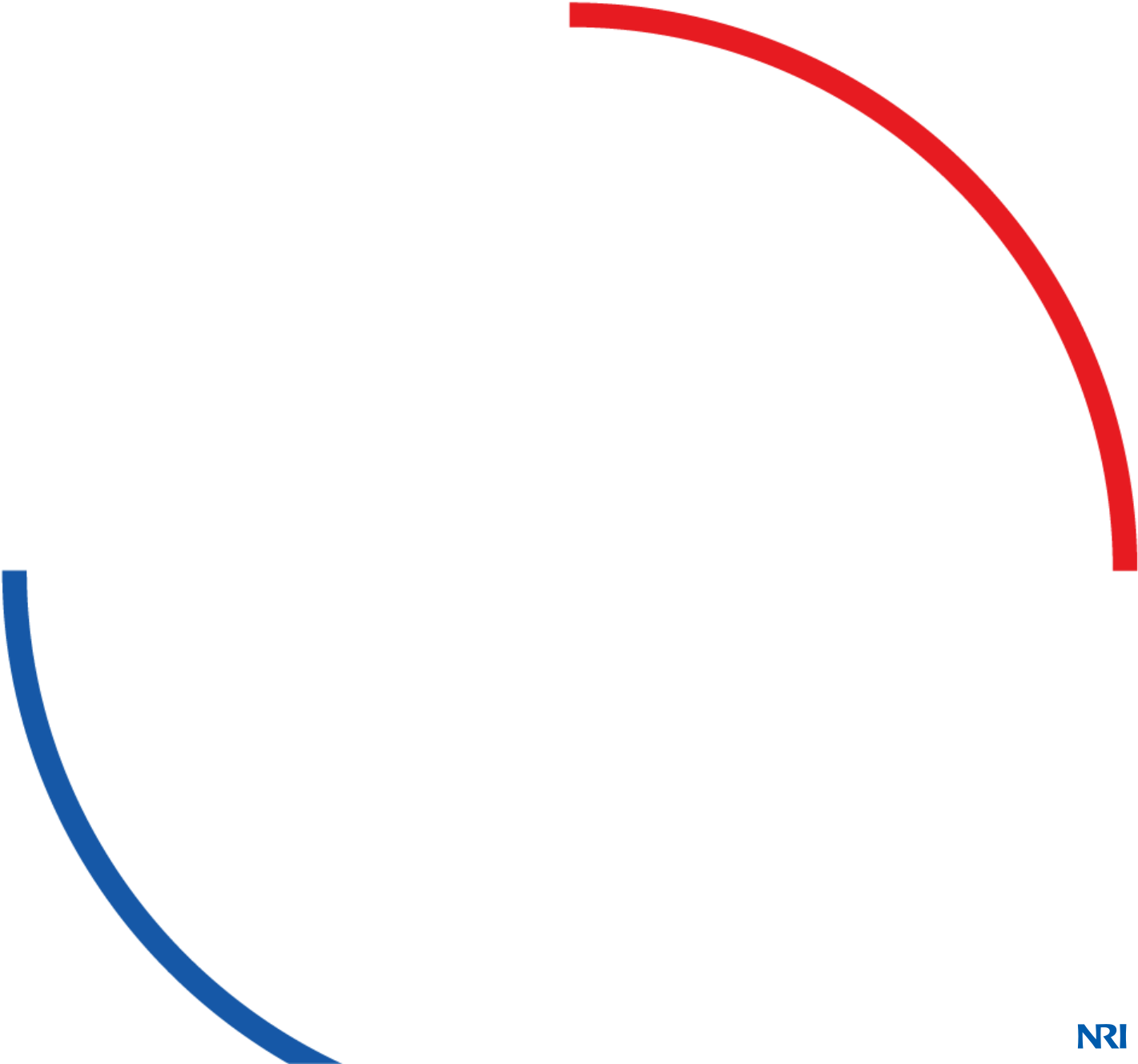
Since the very first contacts with MIDA, EcoCeres has been impressed with the level of advice, **support and investment provided to firms in the renewable energy sector, as well as the tax incentives** that are available.

These are some of the major driving factors that enabled EcoCeres to decide to invest in our second renewables energy facility in Malaysia



Dannis KL Poon,
Executive Vice President of Operation, EcoCeres

Thailand



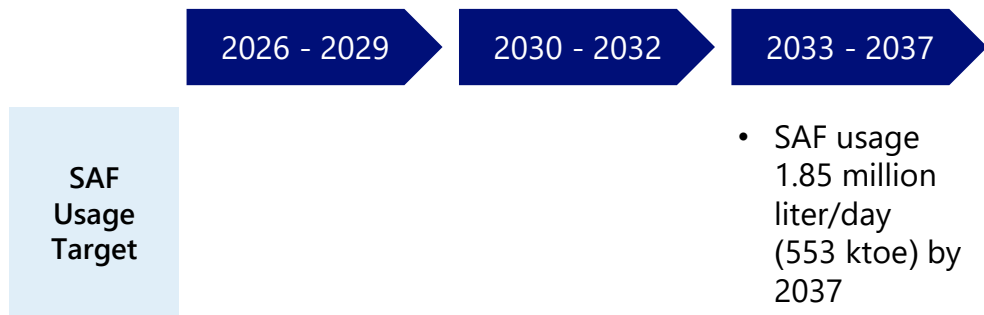


The SAF usage target is set at 1.85 MLPD by 2037 under the new AEDP 2024 plan, which is now in the drafting stage and completed its public hearing in June 2024

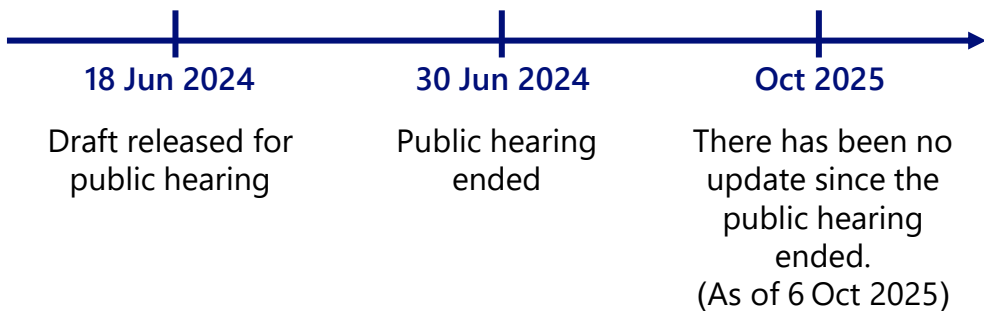
Overview of Policies/Roadmap for SAF

Title	(Draft) Alternative Energy Development Plan 2024 – 2037 (AEDP 2024)
Date Issued	Still in draft stage
Responsible Government Organization	Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy
Goal/ Objective of Policy	To increase the share of renewable and alternative energy in the final energy consumption to 36% by 2037
Overview of Policy	To achieve the goals, the AEDP sets targets to promote renewable energy in the electric power, heat, and transport sectors, including the promotion of biofuels such as SAF.
SAF Related Targets and Government Initiatives	<p>Biofuel Promotion</p> <ul style="list-style-type: none"> The plan aims to promote SAF and sets a target for SAF usage. According to information from the published information about draft plan, the SAF usage target by 2037 is 1.85 million liters per day (533 ktoe).

Action Plans in Policy Roadmap



(Draft) AEDP 2024 Status Update



Note: This is only a draft version, and there may be a lot of changes. The current version of the AEDP plan is AEDP 2018–2037. However, there is no mention of an SAF promotion target in the current version of the plan.

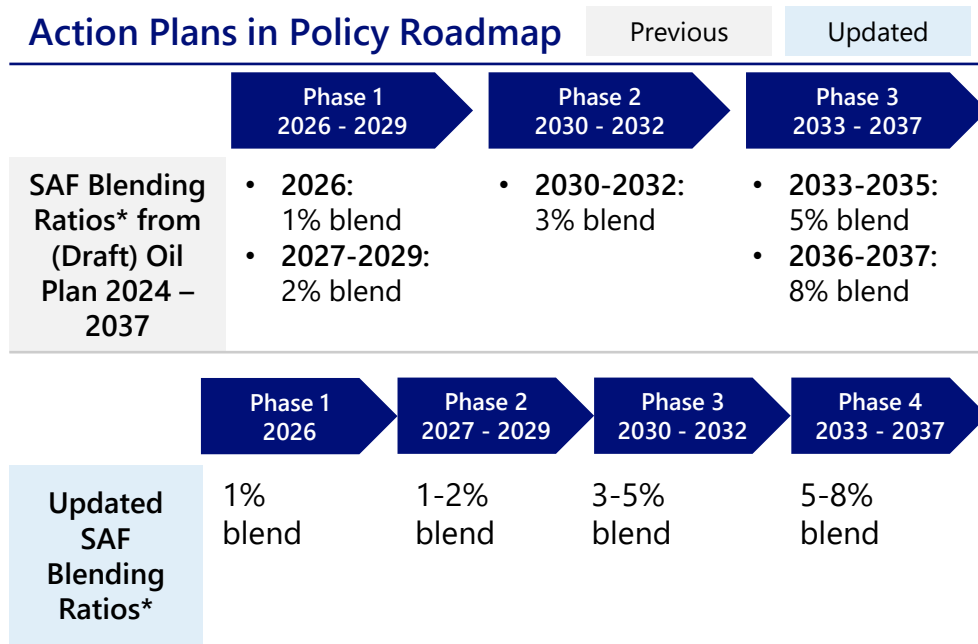


Oil Plan outlines SAF blending ratios based on domestic feedstock potential. The blending ratios were updated in Jan 2026. However, the policy remains in draft

Overview of Policies/Roadmap for SAF

Title	(Draft) Oil Plan 2024 – 2037
Date Issued	Still in the draft stage (public hearing ended on 12 July 2024, and there is news of an updated target published in January 2026)
Responsible Organization	Department of Energy Business (DOEB), Ministry of Energy
Goal/Objective of Policy	To set the direction for fuel management in line with the objectives outlined in other plans, particularly the AEDP, and serves as a framework for formulating future fuel policies and plans.
Overview of Policy	The draft plan has 4 action frameworks for national fuel management: Oil Security, Transport fuels, Infrastructure, and New Business.
SAF Related Targets and Government Initiatives	<p>Under the Transport fuels framework, air transport management is outlined as follows:</p> <ul style="list-style-type: none"> • 2024-2025: Establish policy-level mechanisms to drive the production and use of SAF • 2026-2037: Promote the blending of SAF into aviation fuel <p>Under New Business framework, the plan aims to propose policy measures with other entities, such as DEDE, BOI, and the Excise Department, for example, defining investment incentives for SAF production and establishing regulations for trade and standards for fuels blended with SAF.</p>

Action Plans in Policy Roadmap



Thailand's 5–8% national blending target by 2037 is based on domestically sourced feedstocks at reasonable cost

Department of Alternative Energy Development and Efficiency (DEDE)

The Oil Plan remains in draft form. However, the updated targets are highly likely to be based on the new draft Oil Plan

National Energy Technology Center (ENTEC)

Note: This is only a draft version, and there may be a lot of changes. The current version of the Oil plan is Oil Plan 2015–2036. However, there is no mention of an SAF promotion target in the current version of the plan.

Source: DOEB, news article, interview



SAF production will rely on HEFA initially and reach a maximum capacity of about 0.5 MLPD, with AtJ supplying the rest starting from 2030

SAF Promoting Action Plans in Policy Roadmap

	Phase 1 2026	Phase 2 2027 - 2029	Phase 3 2030 - 2032	Phase 4 2033 - 2037
SAF Blending Ratios based on feedstock potential	1% blend	1-2% blend	3-5% blend	5-8% blend
SAF Production Capacity	Approximately 0.2 MLPD	Approximately 0.2-0.5 MLPD	Approximately 0.7-1.2 MLPD	Approximately 1.2-1.9 MLPD
Potential Production Process and Feedstock	<ul style="list-style-type: none"> • HEFA ➢ Main feedstock: UCO ➢ When UCO collection falls below the target: PFAD 		<ul style="list-style-type: none"> • HEFA ➢ Main feedstock: UCO, PFAD • Alcohol to Jet ➢ Main feedstock: Molasses 	<ul style="list-style-type: none"> • HEFA • Alcohol to Jet ➢ Main feedstock: Depend on feedstock potential at the time

Note: Action plan above is based on (Draft) Oil Plan 2024 – 2037 and updated information based on interview. This is only a draft version, and there may be a lot of changes.

Note: Ethanol used for SAF production via AtJ technology is expected to start production and be ready for use from 2030. It is expected that HEFA technology, which is more commercially mature, will produce at a maximum capacity of approximately 0.5 MLPD; the remaining portion will come from AtJ using alcohol or ethanol.



SAF adoption in Thailand will begin on a voluntary basis through MOUs, before potentially transitioning to mandatory measures

Overview of Regulation

Status		Currently, no regulation has been enforced, as SAF adoption will begin on a voluntary basis through MOUs
Roles of Government Organizations		<ul style="list-style-type: none"> The Civil Aviation Authority of Thailand (CAAT): Study best practices for SAF mandate implementation and propose policy Department of Energy Business (DOEB): Preparation of the Draft Oil Plan 2024 – 2037
Initiatives/ Discussions	Regulatory Framework	SAF adoption will begin on a voluntary basis through MOUs, before potentially transitioning to mandatory measures
	Penalty	No indication of penalty based on publicly available sources

Details on Current Status of SAF Mandate

- To support Thailand’s SAF blending targets, the **government will establish a SAF working group in 2026**, bringing together public and private stakeholders from both the supply and demand sides.
- SAF will initially be introduced at Suvarnabhumi and Don Mueang Airports**, leveraging existing fuel pipeline infrastructure to reduce transport-related emissions.
- SAF adoption will begin on a voluntary basis through MOUs, before potentially transitioning to mandatory measures**, supported by financial incentives for airlines and technical assistance for SAF feedstock producers.

Director General, Department of Energy Business



Update on the Status of the SAF Mandate



*The 8 airlines include Thai Airways, Bangkok Airways, K-Mile Air, Nok Air, Thai AirAsia, Thai AirAsia X, Thai Lion Air, and Thai Vietjet Air.



Department of Energy Business issued the specification and quality requirements for SAF to ensure that SAF producers comply with international standards

Overview of Regulation

Status		Enforced from 1 January 2026
Roles of Government Organizations		Department of Energy Business (DOEB): Issue the Specification and Quality Requirements for Sustainable Aviation Fuel (B.E. 2568)
Initiatives/ Discussions	Regulatory Framework	<ul style="list-style-type: none"> • The Specification and Quality Requirements for Sustainable Aviation Fuel (B.E. 2568) prescribe requirements for SAF such as chemical and physical property verification in accordance with international standards <ul style="list-style-type: none"> ➢ For example, the cycloparaffins content shall not exceed 15% by weight, as determined by ASTM D2425 or other equivalent test methods. • This regulation does not apply to sustainable aircraft fuel sold or intended for sale outside the Kingdom by direct export by sea.
	Penalty	No published information available

Details on SAF production or supply in Thailand

- The regulation specifies the characteristics and quality standards of Sustainable Aviation Fuel (SAF).
- **This regulation has been issued to ensure that SAF producers comply with international standards**, in line with the government’s policy to promote the use of sustainable aviation fuel and low-carbon aviation fuel.
- This aims to support Thailand in achieving its Carbon Neutrality and Net Zero Greenhouse Gas Emissions goals.

Director General, Department of Energy Business



Note: “Sustainable aviation fuel” in this notification means a synthetic hydrocarbon composition of the HEFA (Hydroprocessed Esters and Fatty Acids) type, produced from molecules such as diglycerides, triglycerides, free fatty acids, and fatty acid esters through a hydroprocessing process. It is used as aviation fuel by being blended with conventional aviation fuel produced from petroleum refining processes.



On the demand side, Thailand currently has no major discussions on incentive measures based on the available published information

Overview of Incentives

Details on Demand-side Incentives

Status	No major discussion observed based on publicly available source
Roles of Government Organizations	No published information available
Overview of Incentives Implemented / Under Discussion	No published information available

No published information available regarding Demand-side incentives for SAF



Building on past SAF-related promotions, BOI approved and introduced specific criteria and incentives for SAF and Mixed SAF production in January 2025.

Overview of Incentives

Status	Implementing (Approved on 29 January 2025)
Roles of Government Organizations	Board of Investment (BOI): Formulate investment promotion policies, provide consultation, and coordinate with various agencies to support investors.
Overview of Incentives Implemented / Under Discussion	<ul style="list-style-type: none"> The Thailand Board of Investment launched its 2025 Investment Promotion Guide, introducing new business categories, leveraging agricultural potential, and supporting investment in the bioindustry, including SAF production. <p>SAF Related Business Activities under BOI Promotion Criteria</p> <ol style="list-style-type: none"> SAF Production (Activity Group: A2) <ul style="list-style-type: none"> ➤ Condition: Must be the production of SAF from <ul style="list-style-type: none"> ▪ Agricultural products, agricultural by-products or residues, or ▪ Materials that are considered agricultural waste or residues Mixed SAF Production (Activity Group: A4) <ul style="list-style-type: none"> ➤ Condition: Must involve a co-processing method in the production of SAF

Details on BOI Investment Promotion

Activity Group	Basic Incentives		
	Exemption of corporate income tax	Exemption of import duties on	Non-tax Incentives
A2	8 years*	<ul style="list-style-type: none"> Machinery Raw materials used in R&D Raw materials used in production for export 	For example, Permit to <ul style="list-style-type: none"> Own land Bring skilled workers Remit money abroad in foreign currency
A4	5 years*		

* Income tax exemption cap of 100% investment capital

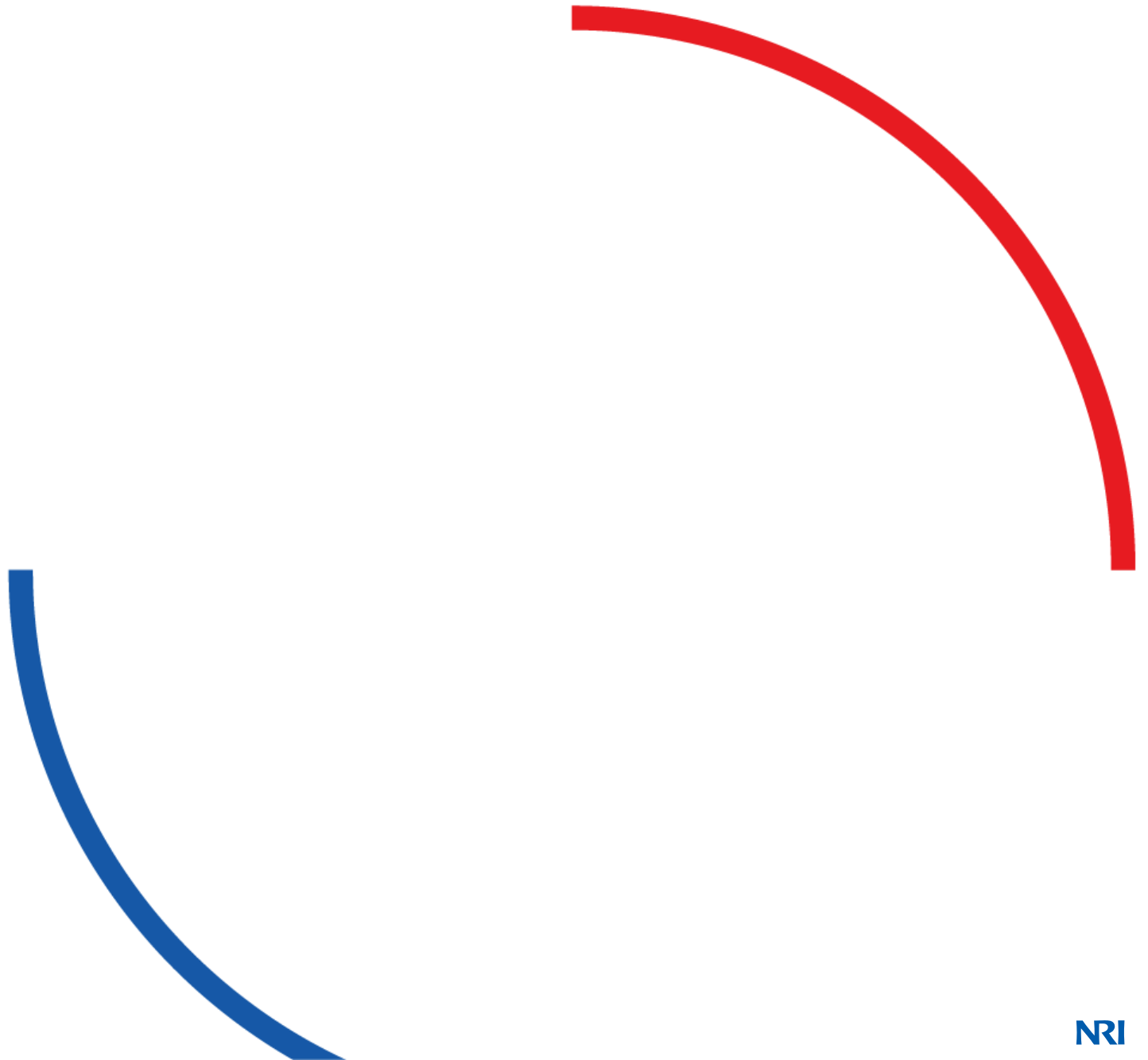
Note: Projects applying for BOI promotion must meet BOI criteria, for example, a minimum investment of 1 million baht (excluding land and working capital), a debt-to-equity ratio not exceeding 3:1 for newly established projects, etc.

Examples of Past SAF Projects Promoted by BOI

Before promotion criteria specifically for SAF production were added to the 2025 Investment Promotion, BOI had already been promoting SAF-related projects (Approved in December 2023)

- **Project owner:** BSGF Co., Ltd.
- **Project Value:** 10 Billion Baht
- **Purpose:** Production of SAF and other biofuels, including green diesel, green naphtha, green LPG from used vegetable oils.
- **Location:** Bangkok
- **All Fuels Annual Production Capacity:** ~411 million liters

Indonesia



The SAF roadmap and action plan were disclosed in 2024, setting out detailed comprehensive programs to achieve a 50% blending target by 2060

Overview of Policies/Roadmap for SAF

Title	Indonesia's Sustainable Aviation Fuel (SAF) Industry Development Roadmap
Date issued	September 18, 2024 (disclosed at Bali International Airshow)
Responsible Government Organization	Main Ministry: Coordinating Ministry for Maritime Affairs and Investment (CMMAI) Cooperation Ministry: Ministry of Energy and Mineral Resources, Ministry of Transportation
Goal of Policy	To achieve the related goals of the national development plan (RPJMN 2020-2025)
Objective of Policy	1) Decarbonation of the aviation sector 2) Energy sovereignty and security 3) Economic value creation
Overview of Policy	<ul style="list-style-type: none"> This roadmap guides how SAF can be spread in Indonesia in order to achieve the blending targets. This SAF roadmap includes the action plan (2025-2030.)
SAF Related Targets and Government Initiatives	<ul style="list-style-type: none"> Proposed SAF blending target (Stepped increase to 50% by 2060) Demand strategy: <ul style="list-style-type: none"> Establishment of partnership between major airlines and SAF provider at DPS Mandate of SAF utilization Mandate of providing "Green Fare" as an option (Mandate to use SAF for gov./business passengers) Supply strategy: <ul style="list-style-type: none"> Securing feedstocks (UCO etc.) by DMO, export quotas, tariffs etc. Development of new technologies Enables <ul style="list-style-type: none"> Provision of SAF standard certification

Source: CMMAI

Action Plans in the Roadmap

		Policy Pillar	Program
Demand side	Pillar 1	Ensure steady demand for initial commercial incubation of SAF	Pilot SAF off-take agreement for intl. flights from DPS
			Incubation SAF mandate, intl. flights DPS & CGK
	Pillar 2	Increase domestic demand to meet higher blending targets	Provision of voluntary SAF usage options
			SAF usage mandate for corporate and government travelers
Supply side	Pillar 1	Securing domestic SAF feedstock for HEFA production	Increased SAF mandate for intl. flights from major airports DPS & CGK and all flight mandate from major airports
			Domestic market obligation (DMO) for PFAD
			Export quota and/or tariff for UCO
	Pillar 2	Scale-up SAF production with AtJ, FT, and PtL technologies	Establishment of UCO collection system
			UCO classification reaffirmation
			Inclusion of next-gen biorefinery into PSN
Pillar 3	Ensure availability of SAF through existing and new distribution channels	Emission-based incentives for SAF	
		Initiate the development of next-gen SAF production	
Enables	Pillar 1	Building a domestic SAF certification ecosystem	SAF distribution channel prioritization strategy to ensure universal availability
			Designate KAN to accredit and certify SAFc certification bodies and establish KAN as a capacity-building channel
			Initiate the development of a SAF Certificate (SAFc) ecosystem

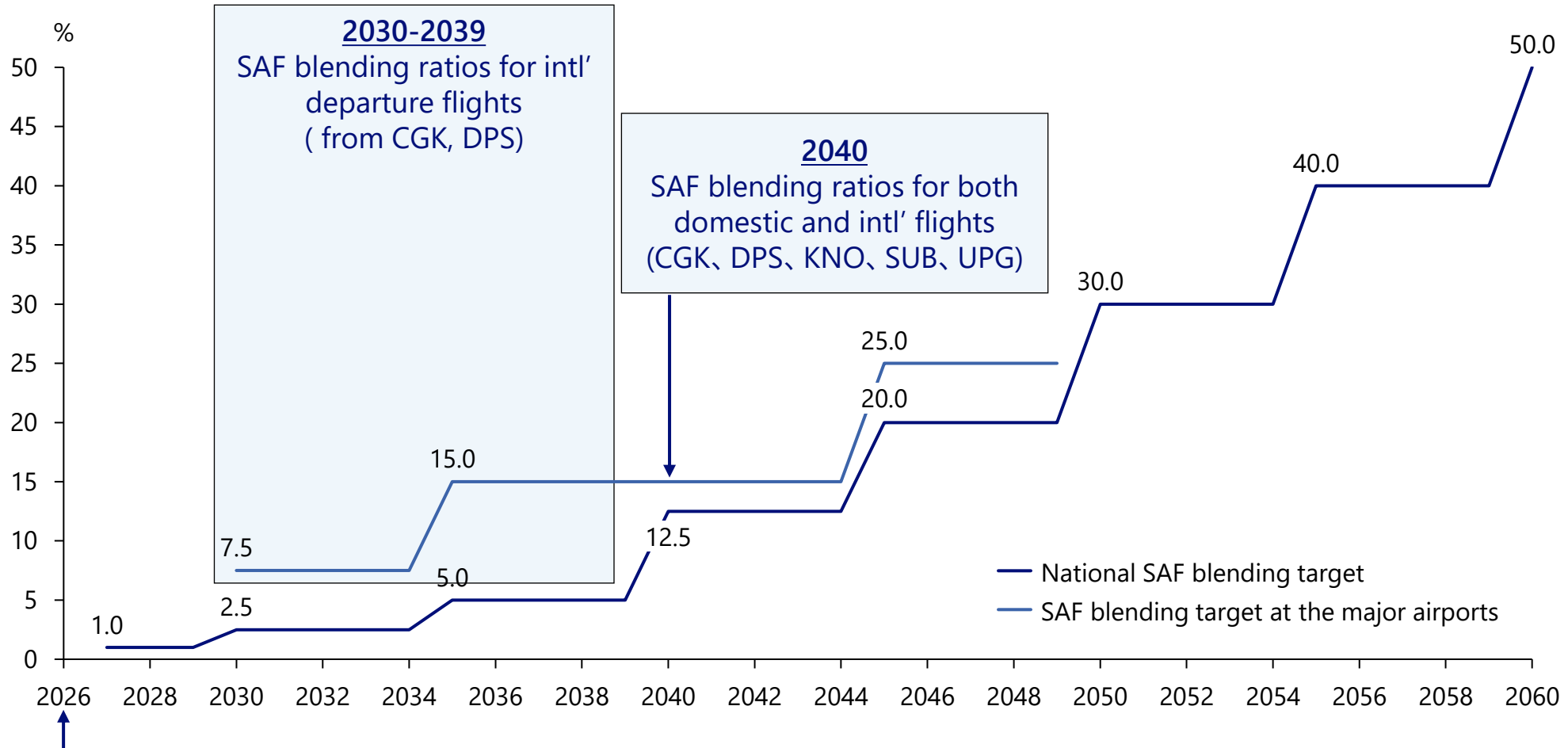
For the demand side, Indonesia will start SAF provision from DPS and expanding to the other major airports by establishing related regulations, guidelines etc.

Action Plan of Demand Side (Overview)

Policy Pillar	Program	Schedule					
		2025	2026	2027	2028	2029	2030
Pillar 1 Ensure steady demand for initial commercial incubation of SAF	Pilot SAF off-take agreement for intl. flights from DPS	Design of SAF usage partnership					
		Expand of SAF usage partnership at DPS					
		Establishment of regulations on SAF sales prices					
	Incubation SAF mandate, intl. flights DPS & CGK	Implementation of F/S, Preparation of technical guideline, Enactment of regulations					
		Establishment of SAF guarantee agreement between airports and SAF producers/distributors					
	Provision of voluntary SAF usage options	Establishment of agreements between airlines and SAF producers on "Green Airfare"					
Enactment of regulations for enacting "Green Airfare", Establishment of SAF usage database							
Pillar 2 Increase domestic demand to meet higher blending targets	SAF usage mandate for corporate and government travelers	Establishment of regulations on mandate to use SAF for gov./business passengers					
	Increased SAF mandate for intl. flights from major airports DPS & CGK and all flight mandate from major airports	Establishment of regulations on increasing SAF blending ratio for CGK and DPS					
		Issuance of SAF supply guarantee at the major airports (CGK, DPS, KNO, UPG, SUB)					

The SAF blending rate targets are not fixed across the country; higher targets are set for the major airports.

New national SAF blending target (proposed base)



The Ministry of Energy has suggested that the SAF blending mandate of 3% will come into effect in 2026. (as of Feb 19, 2025)

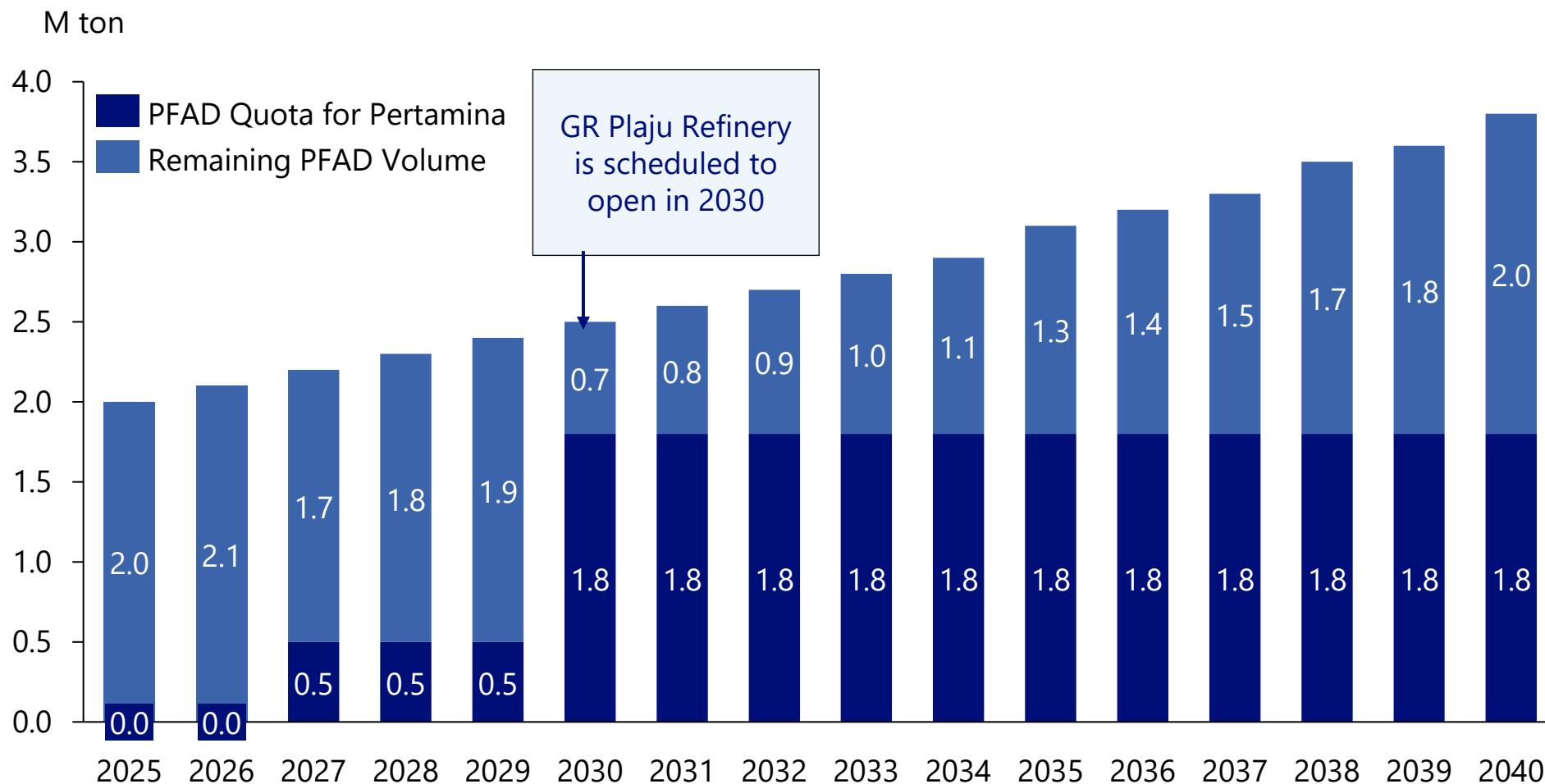
For the supply side, Indonesia will secure feedstocks for SAF by DMO, export quotas, tariffs etc. and develop new technologies.

Action Plan of Supply Side (Overview)

Policy Pillar	Program	Schedule					
		2025	2026	2027	2028	2029	2030
Pillar 1 Securing domestic SAF feedstock for HEFA production	Domestic market obligation (DMO) for PFAD		Establishment of annual DMO guidelines or directives				
	Export quota and/or tariff for UCO		Setting export quotas and/or tariffs for UCO				
	Establishment of UCO collection system	Establishment of a national standardized specification of UCO					
		Socialization of law enforcement on UCO collection activities					
		Used cooking oil recycling public campaign					
UCO classification reaffirmation	Enactment of UCO classification regulations, Socialization of UCO classification						
Pillar 2 Scale-up SAF production with AtJ, FT, and PtL technologies	Inclusion of next-gen biorefinery into PSN	Inclusion of biorefinery project in National Strategic Project (PSN) program					
	Emission-based incentives for SAF	Establishment of national database for life cycle emission SAF produced in Indonesia					
		Establishment of a national carbon tax mechanism					
	Establishment of incentive policies for SAF, Establishment of a biofuel incentive fund						
Initiate the development of next-gen SAF production	Establishment of partnerships for technology development and production of next-gen SAF						
Pillar 3 Ensure availability of SAF through existing and new distribution channels	SAF distribution channel prioritization strategy to ensure universal availability	Enable to use SAF at CGK and DPS		Enable to use SAF at DPS, CGK, KNO, SUB and UPG			
		Upgrading of existing aviation fuel distribution and handling facilities at the airports					

The SAF roadmap indicates the need to secure feedstock, proposing the use of palm fatty acid distillate (PFAD) from palm oil byproducts and production by AtJ.

Estimated PFAD* production and quota required for Pertamina's production



In order to secure the quality of produced SAF and export SAF in the future, Indonesia will designate KAN as a SAF certification (SAFc) body

Action Plan of Enables (Overview)

Policy Pillar	Program	Schedule					
		2025	2026	2027	2028	2029	2030
Pillar 1 Building a domestic SAF certification ecosystem	Designate KAN to accredit and certify SAFc certification bodies and establish KAN as a capacity-building channel	Appointment of national committee as an accreditation body for SAF sustainability certification					
		Announcement to ICAO					
		Agreement with ICAO-recognized sustainability certification body SAF					
		Assistance, competency, and capacity-building activities on the SAFc ecosystem					
	Initiate the development of a SAF Certificate (SAFc) ecosystem	Establishment of a national standardized specification of UCO and SAFs registration system					
		Establishment of regulation on carbon economic value assessment framework					
		Implementation of SAFc trade transaction pilot project					

* KAN: Komite Akreditasi Nasional (National Accreditation Committee, Indonesia)

Currently, no regulations has been established; however, plans are set out in the SAF roadmap.

Overview of Regulation

Status		Currently, no regulation has been established
Roles of Government Organizations		Responsible ministries are stated in the right table
Initiatives/ Discussions	Regulatory Framework	<ul style="list-style-type: none"> The necessary regulations are proposed in the SAF roadmap. The regulations might be enacted based on the SAF roadmap.
	Penalty	<ul style="list-style-type: none"> Penalty is being considered for airlines that do not comply with the SAF mandate use under the SAF roadmap

BSN: Badan Standardisasi Nasional (National Standardization Agency)

GPPA: Government Procurement Policy Agency

MoEF: Ministry of Environment and Forestry

MoEMR: Ministry of Energy and Mineral Resources

MoF: Ministry of Finance

MoT: Ministry of Transportation

MoTr: Ministry of Trade

Details on Regulations stated in the Roadmap

	Regulations	Ministry
Demand Side	Related to SAF usage partnership between state-owned airlines and SAF procurers or distributors	MoT
	Related to SAF sales price	MoEMR
	Related to SAF incubation mandate	MoT
	Related to sanctions to airlines that do not comply with the SAF mandated use	MoT
	Related to provision of "Green Airfare"	MoT
	Related to the mandated use of SAF for business travel	MoT
	Related to the mandated use of SAF for government passengers	MoF
	Related to SAF procurement	GPPA
Supply Side	Related to increased SAF blending international flights from CGK and DPS	MoT
	Related to export quotas and/or tariffs on UCO	MoTr and MoF
	Related to domestic price obligation for UCO	MoTr
	Related to standard specifications of UCO for biofuel feedstock, specifically SAF	MoEMR
Enables	Related to the confirmation of the classification of UCO	MoEF
	Related to the appointment of the accreditation body for SAF sustainability certification	BSN
	Related to the economic value of carbon for air transportation	MoT

Currently, no incentives have been established; however, plans are set out in the SAF roadmap.

Overview of Incentives

Status	Currently, no incentives have been established
Roles of Government Organizations	Responsible ministries are stated in the right table
Overview of Incentives Implemented / Under Discussion	<ul style="list-style-type: none"> The incentives for both demand and supply sides are proposed in the SAF roadmap. The incentives might be established based on the SAF roadmap.

Details on Incentives stated in the Roadmap

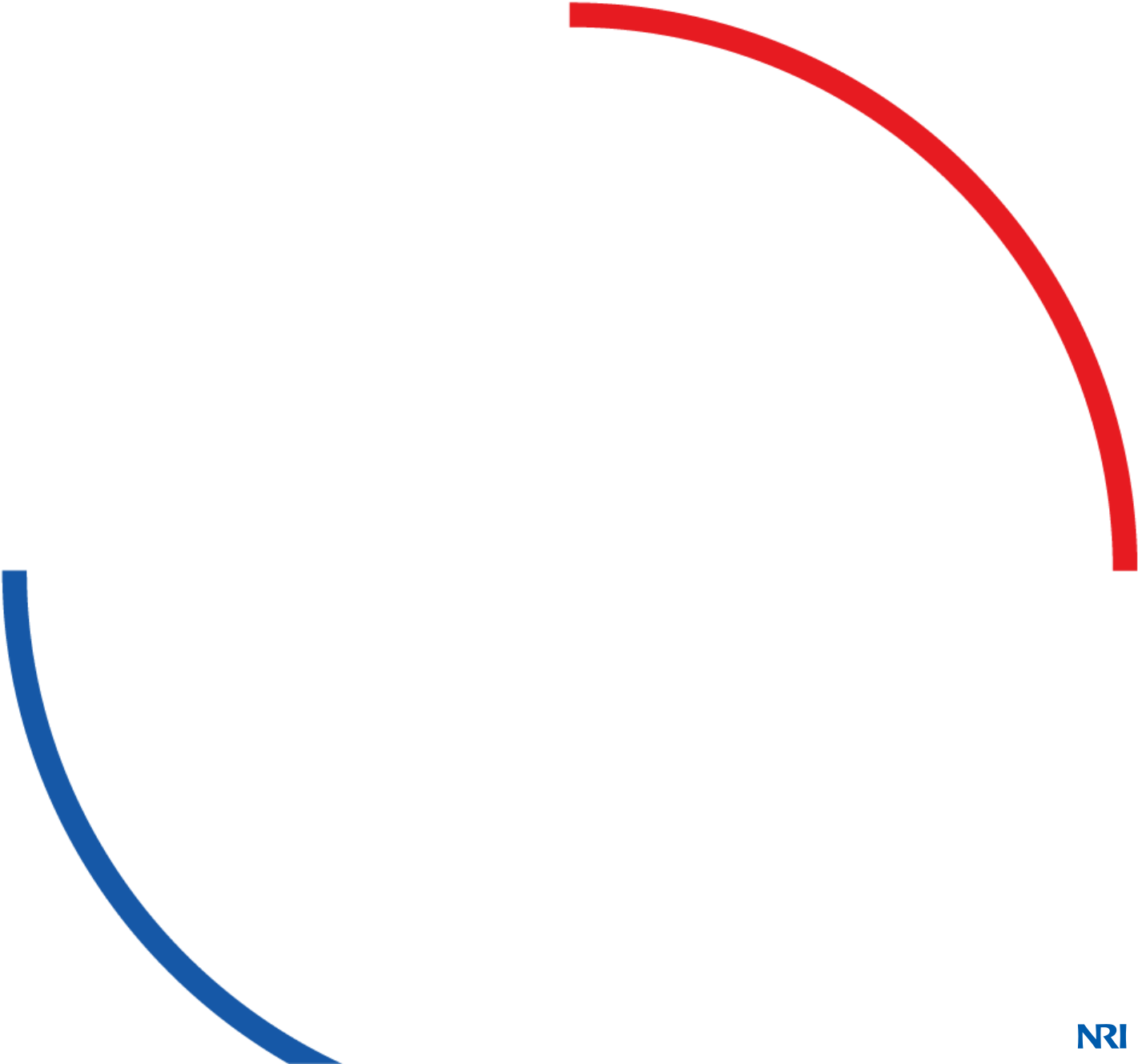
	Incentives	Ministry
Demand Side	Technical guidelines and a feasibility study for providing non-fiscal incentives to airlines and airport operators will be published. (reducing navigation fees, aircraft landing fees, aircraft parking/placement fees, aircraft storage fees, airport taxes, etc.)	MoT
Supply Side	SAF refineries in the National Strategic Project (PSN) are subject to business expediting. (capital grants to offset development costs, the provision of low-interest loans, and the implementation of tax incentives to alleviate financial burdens)	MoEMR
	Decree/regulation on incentive scheme for investment in next-generation SAF production plant will be enacted	MoF

MoEMR: Ministry of Energy and Mineral Resources

MoF: Ministry of Finance

MoT: Ministry of Transportation

Vietnam



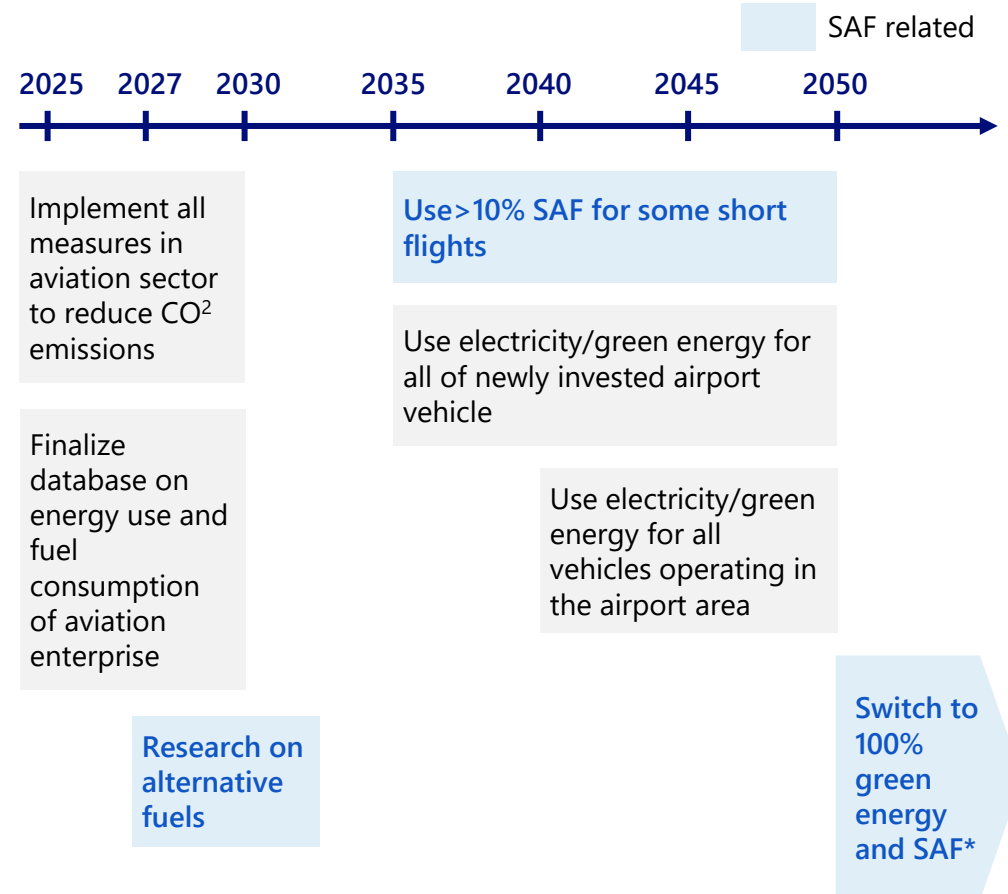


Action Program for Transition to Green Energy is the only SAF-related roadmap implemented with an unclear goal of SAF usage with only some short flights

Overview of Policies/Roadmap for SAF

Title	Decision No. 876/QD-TTg on approving the Action Program for Transition to Green Energy and Mitigation of Carbon Dioxide and Methane Emissions from Transportation
Date Issued	July 22 nd , 2022
Responsible Government Organization	Ministry of Transport and Prime Minister's Office
Goal/Objective of Policy	To develop a green transportation system towards the goal of net-zero greenhouse gas emissions by 2050.
Overview of Policy	The roadmap contains specific targets and concerns roadways, railways, inland waterways, shipping, aviation, and urban traffic.
SAF Related Targets and Government Initiatives	<ul style="list-style-type: none"> From 2027, research on using alternative fuels to supplement a part of aviation fuel From 2035, use at least 10% SAF for some short flights and use electricity/green energy for new purchased airport ground vehicles From 2050, converse to 100% green energy and SAF for aircraft to minimize GHG emissions (subject to technology readiness).

Action Plans in Policy Roadmap



Note: The remaining emissions will be offset by carbon offsets to achieve net zero emissions



Vietnam government plan to come up with National Plan for SAF which will also include regulatory framework. However, further detail is not disclosed yet

Overview of Regulation

Details on regulation draft

Status		Discussion ongoing
Roles of Government Organizations		Ministry of Agriculture and Environment – create the legal framework
Initiatives/ Discussions	Regulatory Framework	<p>In high-level meeting in Hanoi on May 20th 2025, Deputy Prime Minister, Tran Hong Ha, mentioned legal framework related with SAF is being considered.</p> <p>The framework mentioned are as follows.</p> <ul style="list-style-type: none"> • Legal framework for a carbon market • Legal framework for carbon credit trading system • Emission measurement methods for the aviation sector that align with ICAO guidelines
	Penalty	No indication of penalty based on publicly available sources

Further detail of incentive is not available yet as of 7th October 2025

Source: News article



Supply-side incentives are under consideration to boost the SAF production. However, incentive for demand-side is not mentioned

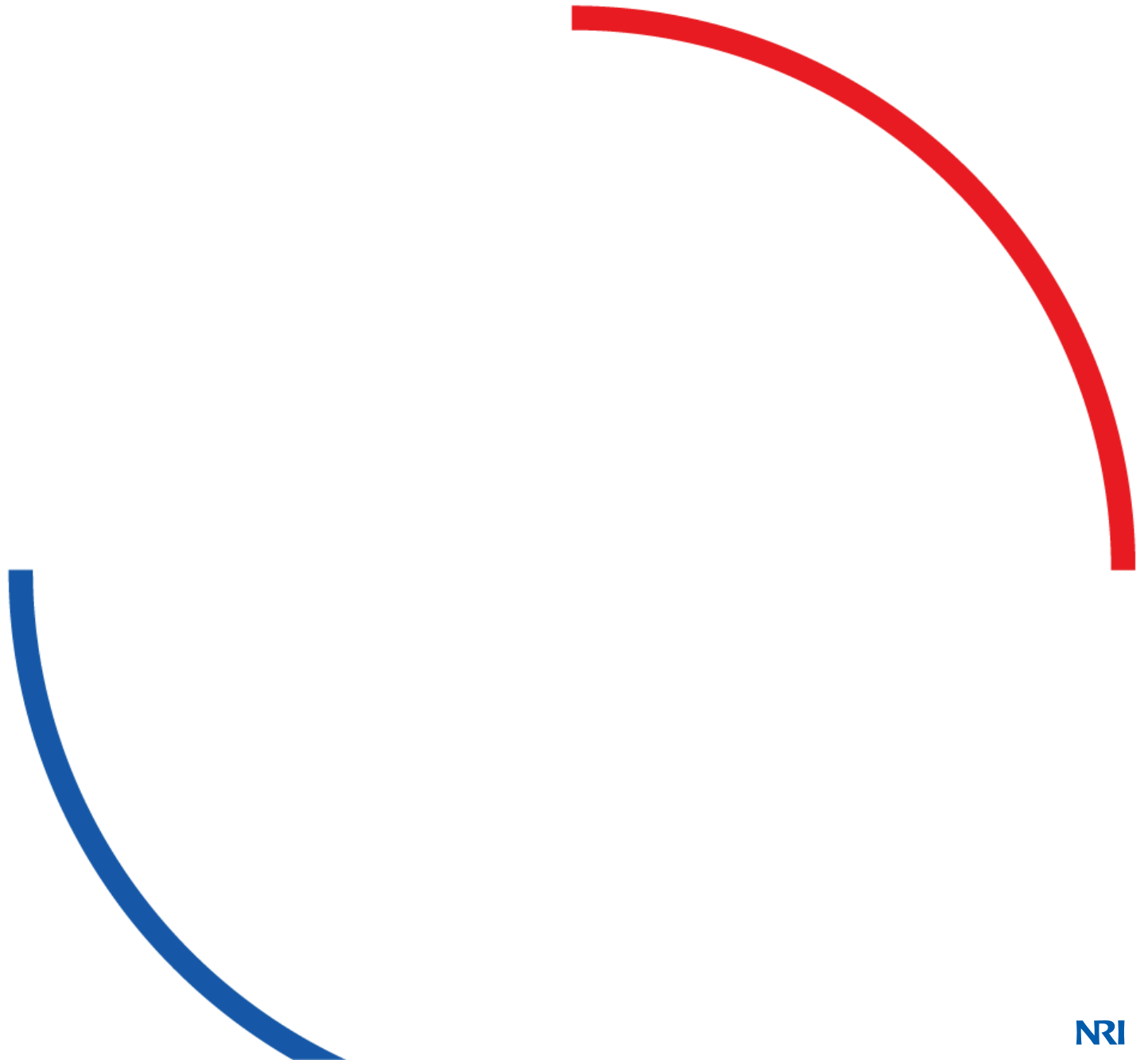
Overview of Incentives

Details on incentive draft

Status	Discussion ongoing
Roles of Government Organizations	Ministry of Finance and the Ministry of Foreign Affairs – exam and propose incentive
Overview of Incentives Implemented	<p>Demand: N/A</p> <p>Supply: In high-level meeting in Hanoi on May 20th 2025, Deputy Prime Minister, Tran Hong Ha, mentioned supply-side incentive for boosting domestic SAF production is being considered.</p> <p>The incentives mentioned are as follows.</p> <ul style="list-style-type: none"> • Tax incentives • Financial support

Further detail of incentive is not available yet as of 7th October 2025

Philippines





Movement for developing roadmap is observed, but there is no clear indication of the completion of the draft based on publicly available sources

Overview of Policies/Roadmap for SAF

Status		Currently being developed
Roles of Government Organizations		N/A
Initiatives/ Discussions	Regulatory Framework	N/A
	Penalty	N/A

Movements related to SAF policies/roadmap

Pub. Date	Description
Dec 11, 2023	<ul style="list-style-type: none"> The government dispatched over 100 delegates to the 3rd ICAP conference on aviation and alternative fuels in Nov.
Jun 28, 2024	<ul style="list-style-type: none"> The government is working on developing a domestic SAF roadmap. The Department of Energy (DoE) stated that the roadmap would be drafted in July, 2024. The DoE stated that public comments will be conducted after drafting it.
Aug 27, 2024	<ul style="list-style-type: none"> SAF Technical Working Group (TWG), in partnership with DoTr and the National Biofuels Board's SAF committee, is working with the private sector and Island Skies Alliance for the SAF roadmap. The initiative prioritizes a clear SAF policy mandate with phased blending, aligned with local feedstocks. The roadmap will define production milestones, ensure cost-competitiveness, and include financial assessments. Mechanisms like SAF certificates will drive investment, supporting a robust SAF roadmap.
Oct 3, 2024	<ul style="list-style-type: none"> The Department of Transportation (DoTr) suggested to welcome support of Airbus in the development of a SAF ecosystem through the F/S. The F/S would include the analysis of macroeconomic data, evaluation of SAF feedstocks and production pathways, assessing relevant implementation support, financing, and policies, as well as drafting an action plan.
Feb 28, 2025	<ul style="list-style-type: none"> The DoTr stated that the Philippines aims to become a leader in SAF production and use, citing abundant agricultural waste that could meet domestic jet fuel demand and support exports The DoTr and Boeing reiterated its commitment to promoting SAF through innovation and collaboration

Source: Department of Energy, SAF Investor, CAA Philippines, Island Skies Alliance, Philippine News

Agency, Manila Standard



While the Philippines is working on creating a SAF roadmap, airlines in the Philippines are seeking to implement their own initiatives related to SAF.

Overview of Regulation

Status		No discussion is ongoing.
Roles of Government Organizations		N/A
Initiatives/ Discussions	Regulatory Framework	N/A
	Penalty	N/A

Overview of Incentives

Status		No discussion is ongoing.
Roles of Government Organizations		N/A
Overview of Incentives Implemented / Under Discussion		N/A

Executive Summary

Chapter 1: Public Policy and Regulations

Summary

Chapter 1-1: Overview of Public Policy and Regulation by Country

Chapter 1-2: Selection of Country for Deep-Dive

Chapter 2: Player Activity

Chapter 3: Supply/demand potential

Chapter 4: Needs by Local Players

Chapter 5: Export Potential to Japan

Appendix

NRI proposes to evaluate the attractiveness of the market, based on quantitative indicators for potential, and the policy maturity

Evaluation Criteria

Evaluation Criteria		Evaluation Indicators	Source of Evaluation Indicator
Supply Side	Supply Potential	<ul style="list-style-type: none"> Availability of non-edible biomass resource* (wood residue, crop residue) 	<ul style="list-style-type: none"> Food and Agricultural Organization (FAO)
		<ul style="list-style-type: none"> Production capacity of SAF in major companies in each country (e.g. Neste, PTT, Petronas, Pertamina) 	<ul style="list-style-type: none"> Publicly available sources (as of Oct 2025)
	Policy Maturity	<ul style="list-style-type: none"> Policy development status Policy's level of ambition Regulatory framework Incentives 	<ul style="list-style-type: none"> Publicly available sources (as of Oct 2025)
Demand side	Demand Potential	<ul style="list-style-type: none"> Aviation fuel consumption 	<ul style="list-style-type: none"> Publicly available sources (as of Oct 2025)
	Policy Maturity	<ul style="list-style-type: none"> Policy development status Policy's level of ambition Regulatory framework Incentives 	<ul style="list-style-type: none"> Publicly available sources (as of Oct 2025)

Note: The data of crop residues is as of year 2022 and includes residues from commonly used crop residues for bioenergy based on statistics from FAO (as of 2022), such as (and not limited to) residues from oil palm, corn, rice, sugar canes. The data for wood residues is as of 2021 and includes sawdust and slabs & chips from sawmills.

Based on the evaluation criteria, the supply potential and policy maturity is evaluated on a scale of 1-5

Evaluation of SAF Supply in ASEAN 6 Countries

Evaluation Perspective		Evaluation Criteria	S	M	T	I	V	P		
			G	Y	H	D	N	H		
Supply Potential	Availability of non-edible biomass resource	1. Supply potential of raw materials for biomass (crop and wood): Less than 100 million ton/year	✓				✓	✓		
		2. Supply potential of raw materials for biomass (crop and wood): 100-199 million ton/ year			✓					
		3. Supply potential of raw materials for biomass (crop and wood): 200-299 million ton/year		✓						
		4. Supply potential of raw materials for biomass (crop and wood): 300-399 million ton/year								
		5. Supply potential of raw materials for biomass (crop and wood): Over 400 million ton/year					✓			
	Production capacity of SAF	1. No known activity or announcement on infrastructure development							✓	
		2. Only vague future intentions expressed on scaling SAF production facility (“considering,” “exploring”), without concrete plans (site, capacity, timeline)						✓		
		3. Concrete plans (site, capacity, timeline) announced for SAF production capacity development; Less than 1 MLPD or no clear indication of exceeding 1MLPD				✓				
		4. Concrete plans (site, capacity, timeline) announced for SAF production capacity development; More than 1 MLPD (million liters per day)			✓		✓			
		5. SAF production capacity of over 1 MLPD (million liters per day) is already developed		✓						
Policy Maturity	Policy Status	1. No SAF-related policies exist; discussions within the government are minimal						✓	✓	
		2. Discussion on development of public policy is currently conducted (not drafted)						✓	✓	
		3. Public policy draft is currently being developed								
		4. Public policy is already drafted (not implemented)					✓			
		5. Public policy is already implemented		✓	✓		✓			
	Policy's level of ambition	1. No targets or undefined goals.							✓	✓
		2. Only broad statements like “promote” and no numerical target		✓	✓		✓			
		3. Numerical target provided; long-term target is below 1MLPD (million liters per day)		✓	✓		✓			
		4. Numerical target provided; long-term target is above 1MLPD (million liters per day); target year for achieving 1MLPD is after 2030					✓			
		5. Numerical target provided; long-term target is above 1MLPD (million liters per day); target year for achieving 1MLPD is before 2030								
	Regulatory framework	1. No mandatory regulations; discussions within the government are minimal based on publicly available information		✓	✓	✓		✓	✓	
		2. Mandatory regulations under consideration/discussion						✓		
		3. Mandatory regulations are currently being drafted								
		4. Mandatory regulations are already drafted but not implemented								
		5. Mandatory regulations implemented								
Incentives	1. No incentives; discussions within the government are minimal based on publicly available information		✓					✓		
	2. Incentive implementation is being discussed						✓	✓		
	3. Incentives are implemented; subsidies/grants are not provided (e.g. only tax exemptions)			✓	✓					
	4. Incentives are implemented; subsidies/grants are provided on a small scale									
	5. Incentives are implemented; subsidies/grants are provided on a large scale									

Source: NRI analysis based on government webpage of each country, news article

NRI understands that Vietnam and Philippines is the least attractive, and proposes to deep-dive in 3 countries within the remaining 4 countries

Attractiveness of Market

Topic	Supply Potential		Policy Maturity				Overall Evaluation	
	Availability of non-edible biomass resource	Production capacity of SAF	Policy development status	Policy's level of ambition	Regulatory framework	Incentives	Score	NRI's Views
Indonesia	5	4	5	2	2	2	20	• High attractiveness
Malaysia	3	4	5	2	1	3	18	• High attractiveness
Thailand	2	3	4	4	1	3	17	• High attractiveness
Singapore	1	5	5	2	1	1	15	• Mid-level attractiveness; production capacity and policy development status is progressive, but domestic raw material supply potential is limited
Vietnam	1	2	2	1	1	2	9	• Low-level attractiveness; Both supply potential and policy maturity is lower than other markets
Philippines	1	1	2	1	1	1	7	• Low-level attractiveness; Both supply potential and policy maturity is lower than other markets

Source: NRI analysis based on government webpage of each country, news article

Based on the evaluation criteria, the demand-side potential and policy maturity is evaluated on a scale of 1-5

Evaluation of SAF Demand in ASEAN 6 Countries

Evaluation Perspective		Evaluation Criteria	S	M	T	I	V	P	
			G	Y	H	D	N	H	
Demand Potential	Aviation fuel consumption	1. Daily consumption: Less than 25 thousand barrels per day							
		2. Daily consumption: 25-49 thousand barrels per day		✓			✓	✓	
		3. Daily consumption: 50-99 thousand barrels per day				✓	✓		
		4. Daily consumption: 100-499 thousand barrels per day	✓						
		5. Daily consumption: Over 500 thousand barrels per day							
	Airport Concentration Level	1. Very highly fragmented: Over 30 international airports					✓		
		2. Highly fragmented: 20-29 international airports							
		3. Moderate level concentration: 10-19 international airports						✓	
		4. High-mid level concentration: 5-9 international airports		✓	✓				✓
		5. Highly concentrated; Less than 5 international airports	✓						
Policy Maturity	Policy Status	1. No SAF-related policies exist; discussions within the government are minimal							
		2. Discussion on development of public policy is currently conducted (not drafted)						✓	
		3. Public policy draft is currently being developed							
		4. Public policy is already drafted (not implemented)			✓				
		5. Public policy is already implemented	✓	✓		✓	✓		
	Policy's level of ambition	1. No targets or undefined goals.							✓
		2. Only broad statements like "promote" and no numerical target							
		3. Numerical target provided; long-term target for SAF blending is below 5% (or unclear whether above 5%)						✓	
		4. Numerical target provided; long-term target for SAF blending is above 5% (target year is after 2030)		✓	✓	✓			
		5. Numerical target provided; long-term target for SAF blending is above 5% (target year is 2030 or before)	✓						
	Regulatory framework	1. No mandatory regulations; discussions within the government are minimal based on publicly available information							✓
		2. Mandatory regulations under consideration/discussion				✓	✓		✓
		3. Mandatory regulations are currently being drafted			✓				
		4. Mandatory regulations are already drafted but not implemented	✓						
		5. Mandatory regulations implemented							
Incentives	1. No incentives; discussions within the government are minimal based on publicly available information		✓	✓	✓		✓	✓	
	2. Incentive implementation is being discussed					✓			
	3. Incentives are implemented; subsidies/grants are not provided (e.g. only tax exemptions)								
	4. Incentives are implemented; subsidies/grants are provided on a small scale								
	5. Incentives are implemented; subsidies/grants are provided on a large scale								

Source: NRI analysis based on government webpage of each country, news article

NRI understands that Vietnam and Philippines is the least attractive, and proposes to deep-dive in Singapore and 2 countries within ID, MY, and TH

Attractiveness of Market

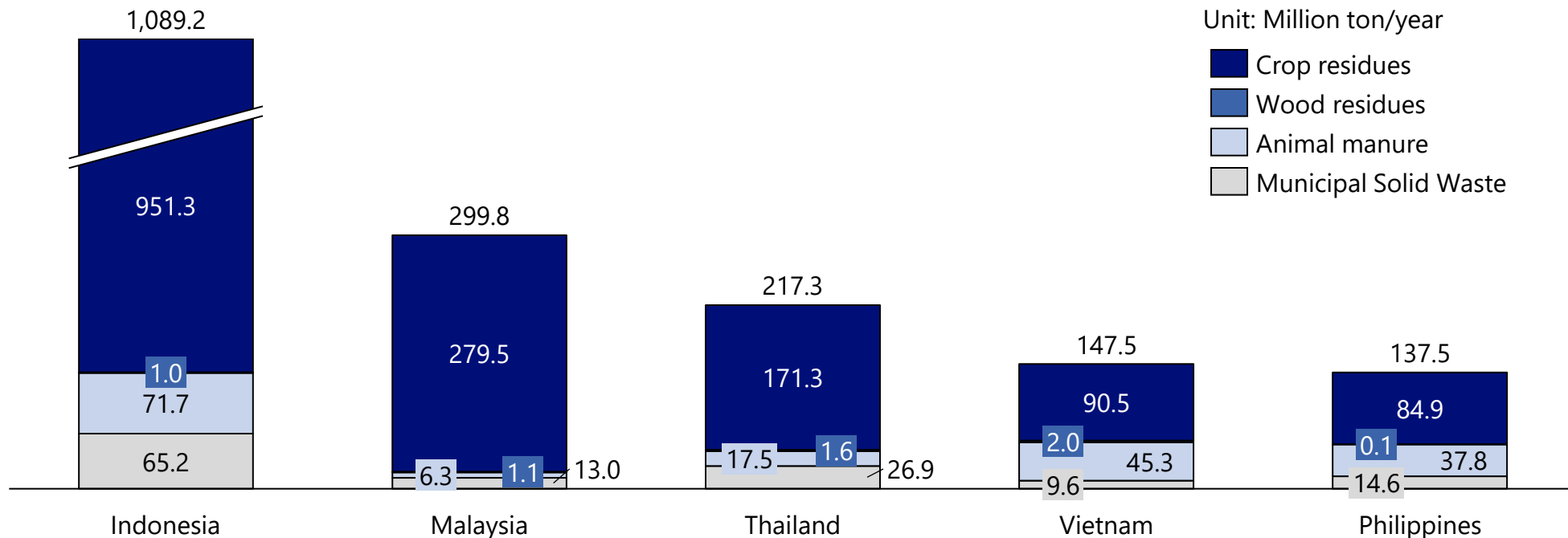
Topic	Demand Potential		Policy Maturity				Overall Evaluation	
	Aviation fuel consumption	Airport Concentration Level	Policy development status	Policy's level of ambition	Regulatory framework	Incentives	Total Score	NRI's Views
Singapore	4	5	5	5	4	1	24	<ul style="list-style-type: none"> Most attractive market; based on overall demand potential as hub airport country and policy maturity
Malaysia	2	4	5	4	3	1	19	<ul style="list-style-type: none"> High-level attractiveness
Thailand	3	4	4	4	2	1	18	<ul style="list-style-type: none"> High-level attractiveness
Indonesia	3	1	5	4	2	2	17	<ul style="list-style-type: none"> Mid-level attractiveness
Vietnam	2	4	5	3	1	1	16	<ul style="list-style-type: none"> Low-level attractiveness; Both demand potential and policy maturity is lower than other markets
Philippines	2	3	2	1	1	1	11	<ul style="list-style-type: none"> Low-level attractiveness; Both demand potential and policy maturity is lower than other markets

Source: NRI analysis based on government webpage of each country, news article

Reference) Supply Side: Availability of non-edible biomass resource

When observing the supply capacity of raw materials, crop residues have the highest potential followed by wood residues

Supply Potential of Raw Materials for Biomass in ASEAN Countries



Notes:

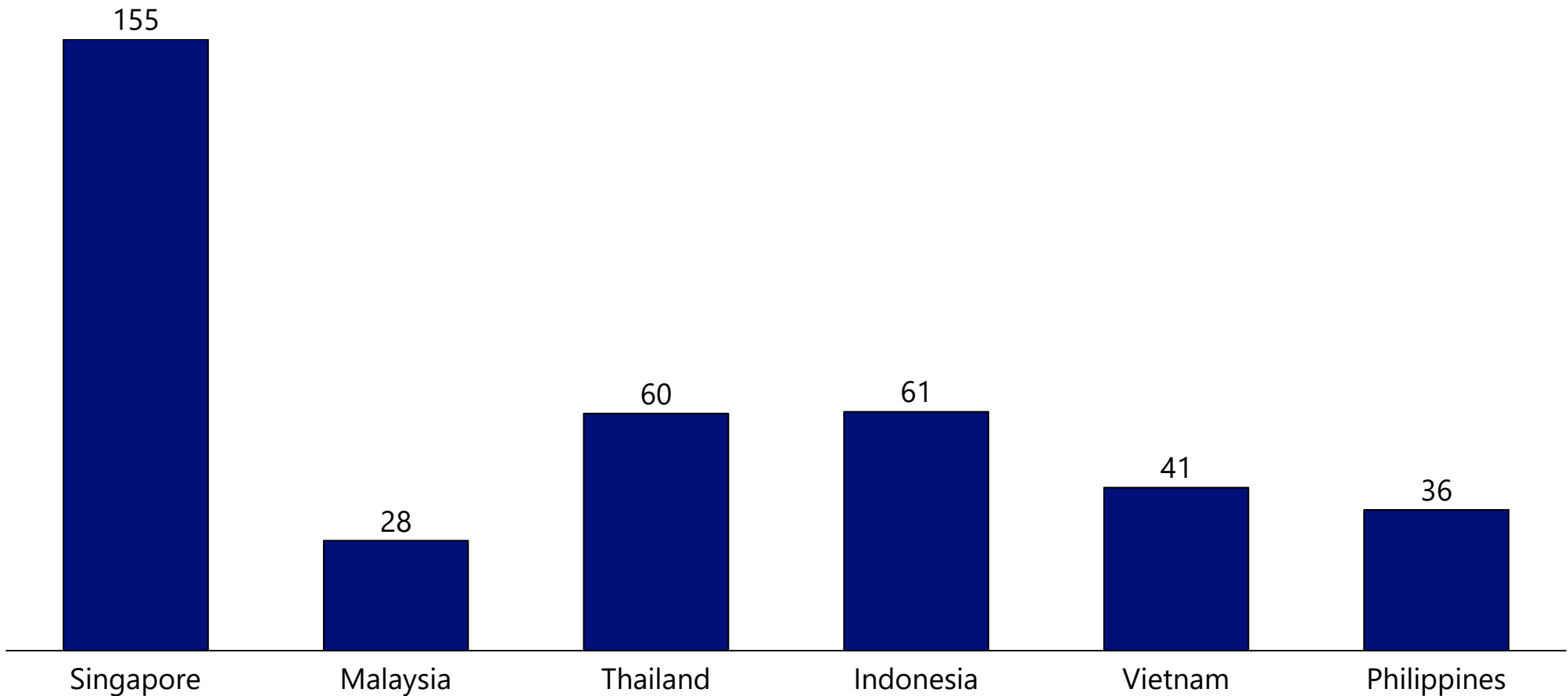
- The data of crop residues of year 2022 is obtained from Food and Agricultural Organization of the United Nations. The list of included residues is shown in the next page.
- The data of wood residues of year 2021 is obtained from Food and Agricultural Organization of the United Nations. It includes sawdust and slabs & chips from sawmill
- The data of animal manure of year 2021 is obtained from World Bank, What a waste global database. It includes urine and faeces of dairy cow, buffalo, swine and chicken
- The data of municipal solid waste is obtained from World Bank, What a waste global database. The year of data in each country is different as followed. Data in 2016 for Indonesia, 2014 for Malaysia, 2015 for Thailand, 2010 for Vietnam and 2016 for Philippines.

Source: Food and Agricultural Organization, World Bank-What a waste global database

Reference) Supply-side: Aviation Fuel Consumption

Singapore has the highest aviation fuel consumption, given that it is one of the most representative hub for aviation network in Asia

Aviation Fuel Consumption per Day in 2023 (Unit: Thousand barrels per day)



Executive Summary

Chapter 1: Public Policy and Regulations

Chapter 2: Player Activity

Summary

Chapter 2-1: Activity of Demand-side Player

Chapter 2-2: Activity of Supply-side Player

Chapter 3: Supply/demand potential

Chapter 4: Needs by Local Players

Chapter 5: Export Potential to Japan

Appendix

Executive Summary

Chapter 1: Public Policy and Regulations

Chapter 2: Player Activity

Summary

Chapter 2-1: Activity of Demand-side Player

Chapter 2-2: Activity of Supply-side Player

Chapter 3: Supply/demand potential

Chapter 4: Needs by Local Players

Chapter 5: Export Potential to Japan

Appendix

Key Findings



Demand-side player's future activity will be impacted by future cost mechanisms. Supply-side players are developing capacity with focus on UCO based HEFA

Key Questions and NRI's Outlook

Key Question	Fact (Desktop Research & Interviews)	NRI's View
<p>Are the targets and activities by demand-side players sufficient?</p>	<ul style="list-style-type: none"> In Singapore, Thailand, Malaysia, the flagship airlines have set a SAF blending target for 2030, which is at a same standard with what governments have set for the demand-side in on a mid-term basis To meet the target, currently flagship airlines have signed agreements with major supply-side players in the respective market such as Neste, PTT, and Petronas However, SAF will have a significantly higher price compared to conventional aviation fuel, and therefore will need government mechanisms to ensure future activities are sufficient to meet target For example, in advanced countries there are mechanisms such as incentives towards SAF producers to make SAF more affordable (e.g. US) and providing fines to SAF suppliers to forcefully enhance demand (e.g. UK) In ASEAN, for Singapore the country introduced a SAF levy towards passengers, but for Thailand and Malaysia currently lack concrete cost-sharing mechanisms (e.g. subsidies, incentives) to bridge the price gap 	<ul style="list-style-type: none"> The demand-side players have set a target which is at a same standard with national targets and currently have initiated activities to procure SAF, but sufficiency of future demand-side activities will depend on speed and depth of government policy development regarding financial mechanisms to support the demand Consequently, demand-side targets by aviation companies will face difficulties to be met under current conditions. Success is contingent on governments shifting from voluntary frameworks to financial bridging mechanisms
<p>Are the targets and activities by supply-side players sufficient?</p>	<p>Manufacturing Technology</p> <ul style="list-style-type: none"> In Singapore, Thailand, and Malaysia, major players have already initiated the construction of SAF production facilities or made final investment decisions (FID) to establish supply systems However, projects that have progressed to construction or FID are primarily focused on HEFA technology. For AtJ and FT pathways, most initiatives remain at the stage of feasibility studies and collaboration with overseas partners <p>Feedstock Procurement</p> <ul style="list-style-type: none"> To secure feedstock, companies are procuring UCO and other oil-based feedstocks (such as POME and PFAD) from both domestic and international sources. Meanwhile, for other feedstocks that have not yet been commercialized, companies are still in the stage of feedstock selection, research and development, and pilot or demonstration projects. 	<ul style="list-style-type: none"> Efforts to establish supply systems based on HEFA using UCO as feedstock are at a sufficiently advanced level in Singapore, Thailand, Malaysia, and Indonesia In contrast, initiatives related to other feedstocks and technologies remain at an early stage, and further development and scaling efforts will be required going forward

Summary of Chapter 2-1

Overview of Government Policies Related to SAF Demand

For the countries under study, mid-term targets between 2030-2040 are set at a standard which is lower than 10%

Overview of Policies/Roadmap for SAF in the ASEAN 6 Countries

Topic	Key Policy For SAF	Status	Overview of SAF Related Description	
			Supply	Demand
Singapore	Singapore Sustainable Air Hub Blueprint	Implemented	<ul style="list-style-type: none"> Provides qualitative direction for production support 	<ul style="list-style-type: none"> Provides quantitative target (3-5% of flights departing from SG to use SAF by 2030)
Malaysia	National Energy Transition Roadmap (NETR)	Implemented	<ul style="list-style-type: none"> Provides qualitative direction for production support 	<ul style="list-style-type: none"> Provides quantitative target (Usage: 47% SAF blend by 2050)
	Malaysia Aviation Decarbonisation Blueprint	Implemented	<ul style="list-style-type: none"> - 	<ul style="list-style-type: none"> Provides quantitative target (Contribute to 46% of total CO2 reduction target for 2050)
Thailand	Alternative Energy Development Plan 2024 – 2037 (AEDP 2024)	Draft completed	<ul style="list-style-type: none"> - 	<ul style="list-style-type: none"> Provides quantitative target (Usage: 1.85 MLPD by 2037)
	Oil Plan 2024 – 2037	Draft completed	<ul style="list-style-type: none"> Provides quantitative target (Production capacity: 1.2-1.9 MLPD* by 2033-2037) 	<ul style="list-style-type: none"> Provides quantitative target (Usage: 5-8% SAF blend by 2033-2037)
Indonesia	Indonesia's SAF Industry Development Roadmap	Implemented	<ul style="list-style-type: none"> Provides qualitative direction for production support 	<ul style="list-style-type: none"> Provides quantitative target (Usage: 50% SAF blend by 2060)
Ref: Japan	Basic Policy for Achieving GX, etc.	Implemented	<ul style="list-style-type: none"> Major oil distributors supply SAF at least 5% equivalent to GHG emissions from jet fuel produced/supplied in Japan in FY19 from 2030 	<ul style="list-style-type: none"> Provides quantitative target (Usage: 10% SAF blend by 2030 for Japanese airlines)

Note: MLPD refers to "million liters per day"

Source: Government sources, news article

Price of SAF and Conventional Aviation Fuel

However, SAF will have a significantly higher price compared to conventional fuel which will be a barrier to achievement of targets set by the companies

Current and Future SAF Prices in Japan and ASEAN

Current SAF Price (2025)

- SAF prices can range from 2 to 5 times those of conventional aviation fuel.
- The current SAF FOB price is approximately 2,100–2,950 USD per metric ton and is similar across countries, as commercial plants are based solely on HEFA technology.

Future SAF Price (2035)

- SAF prices are unlikely to decline significantly because feedstocks and production technologies remain costly.
- Feedstock: Low-cost alternatives for HEFA beyond UCO and animal fats are not yet available.
 - Production technology: Emerging pathways such as AtJ and FT are unlikely to scale fast enough to undercut HEFA, which is the current lowest-cost technology.

Industry Expert Perspective on SAF Price

SAF prices are 2–4 times higher than conventional jet fuel.

Inspector Aviation Facilities, Pertamina



Singapore SAF FOB price is around 2,600-2,700 USD per metric ton and the price is very close between Singapore and Japan.

Industry player associated and familiar with Neste Singapore



Based on Argus Media, SAF FOB price is based on HEFA technology, and FOB prices for ASEAN and Japan are broadly similar, ranging from 2,100 to 2,950 USD per metric ton. Price fluctuations are driven by variations in demand across periods.

Industrial expert in Singapore



By 2035, SAF prices are unlikely to decrease significantly, even with the introduction of new technologies, as HEFA remains the cheapest production pathway. Other pathways, such as ATJ and FT, have higher production costs than HEFA.

Business Development Manager, Petronas



Cost-Sharing Mechanism for SAF

For the demand-side players to achieve the target, a framework to be able to address the issue on price will need to be developed

Views by Local Companies Towards Cost of SAF

- There may be a scenario that airlines will not be willing to pay for SAF due to the high price, if the government provides only mandates and not incentives
- Also, if many passengers are not willing to pay premium for SAF, it can challenge the SAF adoption of airlines

Inspector Aviation Facilities, Pertamina



- The most challenging factor for SAF adoption by airlines is the economic aspect, regarding the price of SAF
- Singapore imposed a SAF levy, but if the government requirement for SAF blending % increases in the future, airlines will have to find other ways to address the higher price

Industry player associated and familiar with Neste Singapore



Example of Approach by Advanced Countries

US

- Provides a tax credit of up to \$1.75 per gallon for qualifying SAF to the producer of SAF, to lower the cost of SAF purchase for demand-side player

EU

- Mandates fuel suppliers to increase the share of sustainable aviation fuel (SAF), so that the demand-side players need to purchase SAF to procure aviation fuel

Japan

- Government approves the “book & claim” which allows airline companies to sell the environmental value from usage of SAF towards corporations

Current Situation of Cost-Sharing Mechanism for SAF in ASEAN

For Singapore, a SAF levy has already been introduced, but for other markets cost-sharing mechanisms to bridge price-gaps are yet to be introduced

Overview of Regulations for SAF in the ASEAN 6 Countries

Topic	Status for Mandatory Regulation Implementation	
	Supply	Demand
Singapore	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources 	<ul style="list-style-type: none"> The Civil Aviation Authority of Singapore (CAAS) recently revealed it would introduce "Sustainable Aviation Fuel (SAF) Levy" for flights booked from Apr' 26
Malaysia	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources 	<ul style="list-style-type: none"> Draft is currently being developed (For international flights departing from Kuala Lumpur)
Thailand	<ul style="list-style-type: none"> Future development under discussion (Rules on specification and quality requirements has been implemented but for mandatory use under discussion) 	<ul style="list-style-type: none"> Future development under discussion (CAAT signed MOUs with 8 airlines to begin voluntary SAF adoption, with a potential transition to mandatory measures)
Indonesia	<ul style="list-style-type: none"> Future development under discussion (Future regulation development is being proposed in roadmap) 	<ul style="list-style-type: none"> Future development under discussion (Future regulation development is being proposed in roadmap)
Vietnam	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources 	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources
Philippines	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources 	<ul style="list-style-type: none"> No major discussion observed based on publicly available sources
Ref: Japan	<ul style="list-style-type: none"> Future development under discussions in the public-private councils based on publicly available sources 	<ul style="list-style-type: none"> Future development under discussions in the public-private councils based on publicly available sources

Demand Player Current Status & Future Plans

Despite current SAF usage being minimal, most airlines set future SAF adoption targets and are beginning with pilot flights and MOU of SAF procurement

	Company	Current demand		Future demand	Initiative and collaboration
		Annual fuel consumption (k tonnes)	SAF % blend	SAF usage target	
SG	Singapore Airlines Group	5,424 (FY2024/25)	N/A	5% blend in 2030	<ul style="list-style-type: none"> Signed a MOU with Aether Fuels to source neat SAF for 5 years. Secured 1 k tonnes neat SAF from Neste for Changi Airport
TH	Thai Airways International Public Company Limited	N/A	2% in 2025	5% in 2030 60% blend in 2050	<ul style="list-style-type: none"> Signed MOU with PTTGC and PTTOR to research and promote the use of SAF
	Bangkok Airways Public Company Limited	N/A	1% (start using for commercial flight)	N/A	<ul style="list-style-type: none"> Signed LOI with PTTOR to use domestically produced SAF supplied by PTTGC
MY	Malaysia Aviation Group	1,026 (2023)	N/A	N/A	<ul style="list-style-type: none"> Signed agreements to purchase SAF from PETRONAS Signed MOU with FatHopes Energy to explore SAF production
	AirAsia Group	1,785 (2024)	5% (for pilot flights)	Use SAF for 5-10% emissions reduction in 2030-2035	<ul style="list-style-type: none"> Signed MOU with Airbus to research on SAF supply expansion
ID	PT Garuda Indonesia (Persero) Tbk	N/A	N/A	Use SAF with both international and domestic flight in 2027	<ul style="list-style-type: none"> Completed pilot flight using UCO-based SAF
	Lion Air Group	N/A	N/A	1% blend in 2030	<ul style="list-style-type: none"> N/A

Source: Company webpage of all companies listed in the slide

Demand Player Current Activity

Most collaborations of airlines are SAF procurement partnerships for pilot flight, as well as joint research aimed at supporting SAF adoption

	Category	Company activity and collaboration
SG	Joint procurement of SAF	<ul style="list-style-type: none"> Singapore Airlines and the Cathay Group have signed an MoU to collaborate on expanding SAF usage, including joint procurement at selected airports to boost production and adoption
	Joint SAF development fund	<ul style="list-style-type: none"> Singapore Airlines and Oneworld Alliance member airlines build an investment fund that will advance SAF production innovation to make SAF affordable
TH	SAF supply for pilot flights	<ul style="list-style-type: none"> Thai Airways was supplied with blended SAF by PTTOR at Phuket Airport for the return flight to Bangkok International Airport Bangkok Airways was supplied with blended SAF by PTTOR to operate a pilot flight from Samui to Bangkok
	Joint research on development of SAF	<ul style="list-style-type: none"> Thai Airways signed MOU with Bangchak to collaborate on exchanging technical knowledge and expertise related to the use of SAF Thai Airways signed MOU with PTTOR and PTTGC to integrate in research and promote use of SAF
MY	SAF supply for pilot flights	<ul style="list-style-type: none"> Malaysia Aviation Group was supplied with locally blended SAF by PETRONAS, allowing Malaysia Airlines to operate SAF pilot flights in early September 2025
	Joint research on development of SAF	<ul style="list-style-type: none"> Malaysia Aviation Group and FatHopes Energy signed an MoU to advance UCO-based SAF, with FatHopes Energy providing technical support and both parties assessing infrastructure needs AirAsia and Airbus signed an MOU to explore decentralized SAF production using alternative feedstocks in Southeast Asia
ID	SAF supply for pilot flights	<ul style="list-style-type: none"> Garuda Indonesia has operated flights supplied with SAF produced by Pertamina on a Boeing 737-800 aircraft demonstrating good and controlled response

Summary of Chapter 2-2



Currently there are 8 conversion processes that are approved under the category of standard for SAF production with HEFA as the most mature technology

SAF Conversion processes approved by ASTM D7566*

ASTM	Year	Annex	Conversion process	Abbreviation	Possible Feedstocks	Maximum Blend Ratio	TRL**
D7566	2009	A1	Fischer-tropsch hydroprocessed synthesized paraffinic kerosene	FT	Coal, natural gas, biomass	50%	7-8
	2011	A2	Synthesized paraffinic kerosene from hydroprocessed esters and fatty acids	HEFA	Vegetable oils, animal fats, UCO	50%	8-9
	2014	A3	Synthesized iso-paraffins from hydroprocessed fermented sugars	SIP	Biomass used for sugar production	10%	6-7
	2015	A4	Synthesized kerosene with aromatics derived by alkylation of light aromatics from non-petroleum sources	FT-SKA	Coal, natural gas, biomass	50%	6-7
	2016	A5	Alcohol to jet synthetic paraffinic kerosene	AtJ-SPK	Ethanol, isobutanol and isobutene from biomass	50%	7-8
	2020	A6	Catalytic hydrothermolysis jet fuel	CHJ	Vegetable oils, animal fats, UCO	50%	7-8
	2020	A7	Synthesized paraffinic kerosene from hydrocarbon-hydroprocessed esters and fatty acids	HC-HEFA-SPK	Algae	10%	5-6
	2023	A8	Synthetic Paraffinic Kerosene with Aromatics	AtJ-SKA	C2-C5 alcohols from biomass	50%	7-8

*Note: ASTM refers to standard test methods developed by ASTM International for evaluating a wide range of equipment and product. ASTM D7566 refers to Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons.

**TRL refers to Technology Readiness Level, a system for measuring the maturity of a technology from 1 (basic principles observed) to 9 (operational use for deliverable)

Source: ICAO, ASTM International

Additionally, there are many SAF technology pathways under development being evaluated by ASTM as new conversion processes

SAF Conversion processes not approved by ASTM

	Conversion process under evaluation	Abbreviation	Lead developers
Listed on ICAO website	Synthesized Aromatic Kerosene	SAK	Virent
	Integrated Hydropyrolysis and Hydroconversion	IH2	Shell
	Single Reactor HEFA	DILSAAF	Indian CSIR-IIP
	Pyrolysis of non-recyclable plastics	ReOIL	OMV
	Co-processing of pyrolysis oil from used tires	TPO	Philips 66
	Methanol to Jet	MTJ	ExxonMobil
	HEFA with higher cycloparaffins	-	Revo
	Biomass pyrolysis	-	Alder
	Biomass/Waste pyrolysis	-	Green Lizard
	Cycloalkanes from Ethanol	-	Vertimass
	Increase in fatty acid/ester co-processing from 5% to 30%	-	-

Note: There are other pathways not approved by ASTM and not listed on ICAO website as well e.g. Isoprene to Jet and Hydrothermal Liquefaction etc. However, in this table NRI focuses on only those listed on ICAO website

Source: ICAO, IEA, The Royal Society of Chemistry

Under the CORSIA framework of ICAO, SAF feedstocks are broadly categorized into five categories based on characteristic as follows

Feedstock categorization by ICAO

Category	Description	Example of feedstock
Primary and Co-products	<ul style="list-style-type: none"> • Main products of a production process • Have significant economic value and elastic supply* 	Primary product: <ul style="list-style-type: none"> • Palm fresh fruit bunches • Sugarcane Co-product: <ul style="list-style-type: none"> • Molasses
By-products	<ul style="list-style-type: none"> • Secondary products of a production process • Have lower economic value than primary and co-products with inelastic supply* 	<ul style="list-style-type: none"> • PFAD (Palm fatty acid distillate) • Tallow (Animal fat e.g. cow and sheep)
Wastes	<ul style="list-style-type: none"> • Materials from a production process • Any substance which the holder discards. Raw materials or substances that have been intentionally modified or contaminated to meet this definition are not covered. • Have no economic value and inelastic supply 	<ul style="list-style-type: none"> • UCO (Used cooking oil) • MSW (Municipal solid waste)
Residues	<ul style="list-style-type: none"> • Secondary materials from a production process • Have little economic value and inelastic supply 	<ul style="list-style-type: none"> • Bagasse • Empty palm fruit bunches

Note: Elastic supply refers to when the quantity of feedstock produced can increase or decrease in response to changes in market demand or price.

Inelastic supply refers when the quantity of feedstock produced remains largely unchanged regardless of fluctuations in demand or price as the supply is essentially determined by the production of the primary product rather than by demand for the secondary material

Source: ICAO

SAF feedstock under primary and co-product category are as follows. Feedstock not recognized by ICAO are listed from desktop research and interviews

Primary product and co-product list

	Primary product recognized by ICAO		Primary product not recognized by ICAO	
	#	Feedstock	#	Feedstock
Sugar / Starch-feedstock	1	Corn grain	1	Algae
	2	Sugar beet	2	Sorghum
	3	Sugarcane	3	Pongamia
Oil feedstocks	4	Brassica carinata oilseed	4	Canola
	5	Camelina oilseed	5	Cactus
	6	Jatropha oilseed	6	Cassava
	7	Palm fresh fruit bunches	7	CPO (Crude Palm Oil)
	8	Rapeseed oilseed	8	Rubber seed oil
Lignocellulosic feedstocks	9	Soybean oilseed		
	10	Miscanthus (herbaceous energy crops)		
	11	Poplar (short-rotation woody crops)		
	12	Switchgrass (herbaceous energy crops)		
Co-product recognized by ICAO				
#	Feedstock			
1	Molasses			

SAF feedstock under by-product and waste category are as follows. Feedstock not recognized by ICAO are listed from desktop research and interviews

By-product and waste list

By-product recognized by ICAO	
#	Feedstock
1	PFAD (Palm fatty acid distillate)
2	Technical Corn oil
3	Tallow
4	Beef Tallow
5	Non-Standard Coconuts
6	Poultry Fat
7	Lard Fat
8	Mixed Animals Fat

Oil feedstocks

Waste recognized by ICAO	
#	Feedstock
1	MSW (Municipal solid waste)
2	UCO (Used cooking oil)
3	Waste gases

By-product not recognized by ICAO	
#	Feedstock
1	Fusel alcohol
2	SBEO (Spent bleaching earth oil)
3	RBDPKO (Refined, bleached, and deodorized palm kernel oil)

Waste not recognized by ICAO	
#	Feedstock
1	Wastewater

SAF feedstock under residues category are as follows

Residues list

		Residues recognized by ICAO				Residues recognized by ICAO	
		#	Feedstock			#	Feedstock
Lignocellulosic feedstocks	1	Bagasse		Lignocellulosic feedstocks	17	Empty palm fruit bunches	
	2	Cobs			18	Forestry processing residues	
	3	Husks			Oil feedstocks	19	Crude glycerin
	4	Manure		20		Crude Tall Oil	
	5	Nut shells		21		POME (Palm oil mill effluent)	
	6	Stalks		22		Sewage sludge	
	7	Stover		23		Tall oil pitch	
	8	Straw		Starch-feedstock		24	Wheat starch slurry
	9	Bark					
	10	Branches					
	11	Cutter shavings					
		12	Leaves				
		13	Needles				
		14	Pre- commercial thinning				
		15	Slash				
		16	Tree tops				

Source: ICAO, news articles, interview

Waste-derived SAF such as those made from UCO can achieve over 80% GHG emissions reduction, unlike SAF from crop that has lower reduction rate

Emission reductions from different pathway and feedstock

Black text = crop Blue text = waste and by-product

	Feedstock	GHG emission (g CO ₂ e per MJ)	% GHG reduction*
HEFA	UCO	14.4	84%
	Tallow	22.5	75%
	Distillers corn oil	17.1	81%
	Rapeseed oil	73.8	18%
	Soybean oil	65.7	27%
	Palm oil	99.9	+11%
AtJ	Corn grain	86.4	4%
	Sugarcane	33.3	63%
Advanced**	Agricultural residues	8.1	91%
	Forestry residues	8.1	91%
	Municipal solid waste	5.4	94%

*Note: % GHG reduction is calculated based on the fossil jet baseline at 89 gCO₂e/MJ

**Note: Advanced refers to other pathways under development, e.g. e-SAF and FT

Supply Player Current Status & Future Plans (1/3)

Primary feedstock and technology utilized across companies are UCO and HEFA. Neste primarily relies on imported UCO, while Pertamina leverages local UCO

	Company	Annual production capacity (k tonnes)		Feedstock		Technology		Feedstock sourcing
		Current	Future	Main*	Experimental*	Main*	Experimental*	
SG	Neste Corporation	2,600	2,600	<ul style="list-style-type: none"> • UCO • PFAD • Animal fat waste • Others e.g., POME, SBEO 	<ul style="list-style-type: none"> • Algae • Forestry waste e.g., fallen leaves, tree trunks • Novel vegetable oils (NVO) 	<ul style="list-style-type: none"> • HEFA 	<ul style="list-style-type: none"> • N/A 	<ul style="list-style-type: none"> • Source feedstock from many region by feedstock offices • Jointly study future potential feedstock with partners
ID	Pertamina (Persero), PT	5.6	882.4 (2032-2033)	<ul style="list-style-type: none"> • UCO 	<ul style="list-style-type: none"> • POME • PFAD • Sorghum 	<ul style="list-style-type: none"> • HEFA 	<ul style="list-style-type: none"> • AtJ • e-SAF 	<ul style="list-style-type: none"> • UCO collection from households, hotel, restaurant is being promoted via "Green Movement UCO" program
	PT Essa Industries Indonesia Tbk	0	200 (2027 Q4 -2028 Q1)	<ul style="list-style-type: none"> • N/A 	<ul style="list-style-type: none"> • N/A 	<ul style="list-style-type: none"> • N/A 	<ul style="list-style-type: none"> • N/A 	<ul style="list-style-type: none"> • Technology selection including the feedstock is in the internal planning stage
	Tripatra	0	240 (2030)	<ul style="list-style-type: none"> • POME • UCO 	<ul style="list-style-type: none"> • N/A 	<ul style="list-style-type: none"> • HEFA 	<ul style="list-style-type: none"> • N/A 	<ul style="list-style-type: none"> • Availability and logistics for local feedstocks have been confirmed in the feasibility study

*Note: Main refers to feedstock and technology mentioned in plan for commercial SAF production facility of each player
 Experimental refers to feedstock and technology under consideration as alternative options e.g. during feasibility study, pilot project etc.
 Source: NRI analysis

Supply Player Current Status & Future Plans (2/3)

While using local UCO as the current main feedstock, PTT and Bangchak also consider alternatives such as ethanol and fusel alcohol for AtJ

	Company	Annual production capacity (k tonnes)		Feedstock		Technology		Feedstock sourcing
		Current	Future	Main*	Experimental*	Main*	Experimental*	
TH	PTT	20	80 (2027)	• UCO	• POME • PFAD	• Co-processing HEFA	• AtJ	• Local UCO is currently used as feedstock
	Bangchak Corporation	0	292 (2026 Q3)	• UCO	• Ethanol • Fusel alcohol • Molasses • Pongamia • Microalgae • EFB** • Oilseed** • PFAD** • POME** • Tallow** • Crude glycerin** • CPO** • Upstream cellulosic acid**	• HEFA	• AtJ	• Purchase UCO from public at Bangchak service station and food companies via agreement with the government and also purchase from small local UCO collectors • Jointly study fusel alcohol derived from ethanol plants that use molasses and cassavas
	Energy Absolute Public Company Limited	0	25 (2026)	• UCO	• PFAD • Agricultural waste • POME	• HEFA	• N/A	• Tentatively utilize feedstock UCO collectors

*Note: Main refers to feedstock and technology mentioned in plan for commercial SAF production facility of each player
Experimental refers to feedstock and technology under consideration as alternative options e.g. during feasibility study, pilot project etc.

**Note: These experimental feedstocks are considered not only by Bangchak, but also by other industry players in Thailand

Source: Company webpage of all companies listed in the slide, news articles, interview

Supply Player Current Status & Future Plans (3/3)

To address UCO limitations, Malaysian companies are considering alternative feedstock e.g. POME, microalgae, and Pongamia as well as other pathways

	Company	Annual production capacity (k tonnes)		Feedstock		Technology		Feedstock sourcing
		Current	Future	Main*	Experimental*	Main*	Experimental*	
MY	PETRONAS	0	575 (2028 Q2)	<ul style="list-style-type: none"> UCO (85%) Animal fat (15%) 	<ul style="list-style-type: none"> POME PFAD Microalgae Pongamia Jatropha MSW SBE0 	<ul style="list-style-type: none"> HEFA 	<ul style="list-style-type: none"> AtJ FT 	<ul style="list-style-type: none"> Developing a household UCO ecosystem and sourcing additional UCO through its trading offices, while animal fat sourcing remains under evaluation
	EcoCeres Renewable Fuels	420	420	<ul style="list-style-type: none"> UCO (95%) POME (5%) 	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> HEFA 	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> Import UCO directly from China leveraging network of parent company in Hong Kong
	FatHopes Energy	0	300 (2029)	<ul style="list-style-type: none"> UCO 	<ul style="list-style-type: none"> POME SBE0 (Spent bleaching earth oil) 	<ul style="list-style-type: none"> HEFA 	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> Leverage long-term contracts and strong relationships with major commercial suppliers e.g. chain restaurants Also assess feedstocks across APAC

*Note: Main refers to feedstock and technology mentioned in plan for commercial SAF production facility of each player
 Experimental refers to feedstock and technology under consideration as alternative options e.g. during feasibility study, pilot project etc.
 Source: Company webpage of all companies listed in the slide, news articles, interview

Executive Summary

Chapter 1: Public Policy and Regulations

Chapter 2: Player Activity

Summary

Chapter 2-1: Activity of Demand-side Player

Chapter 2-2: Activity of Supply-side Player

Chapter 3: Supply/demand potential

Chapter 4: Needs by Local Players

Chapter 5: Export Potential to Japan

Appendix



Singapore Airlines Group aims to replace 5% of its fuel needs with SAF by 2030. The Group has also begun purchasing SAF for flights departing Singapore

Company overview

Name	Singapore Airlines Group (SIA Group)
Established year	1972
International airline brands with SAF initiative	<ul style="list-style-type: none"> Singapore Airlines Scoot
Major shareholder	<ul style="list-style-type: none"> Napier Investments Pte. Ltd. (31.33%) Temasek Holdings (Private) Limited (22.12%)
Number of flights per year (FY2024/25)	<ul style="list-style-type: none"> Singapore Airlines operated 1,184 weekly services Scoot operated 591 weekly services
Network	<ul style="list-style-type: none"> Singapore Airlines: 79 destinations Scoot: 71 destinations
Total amount of fuel consumption (k tonnes)	<ul style="list-style-type: none"> SIA Group : 5,424 k tonnes (FY2024/25)
Type of airlines	<ul style="list-style-type: none"> Singapore Airline: Full services Scoot: Low-cost

Initiative to increase SAF usage

- In September 2023, SIA, CAAS, and GenZero, concluded a 20-month SAF pilot.
- Under this project, 1 k tonnes of neat SAF were imported, blended in Singapore, and uplifted via Changi Airport’s fuel hydrant system on SIA and Scoot flights.

Note: FY2024/25 means the financial years ended 31 March 2025

Source: SIA Group

SAF utilization plan

	Year	% blend	Usage/year (k tonnes)	Applied flights	Initiative
Current	FY2024/25	N/A	2.1*	N/A	<ul style="list-style-type: none"> May 2024: Secured an offtake of 1 k tonnes of EU-RED-certified neat SAF, from Neste and supplied out of Changi Airport. Feb 2025: Signed a MoU with Aether Fuels to source neat SAF for 5 years.
		N/A		Flights departing Singapore	<ul style="list-style-type: none"> Mar 2025: Secured an offtake of 1 k tonnes of CORSIA-certified neat SAF from Neste, to be supplied out of Changi Airport.
Future plan	2030	5%	N/A	N/A	<ul style="list-style-type: none"> Singapore Airline and Scoot set goal to replacing 5% of their total fuel needs with SAF by 2030.

*In FY2024/25, a total of 2,104 tonnes of neat SAF was delivered to SIA for voluntary purpose.

SAF sourcing

- After announcing its SAF target in Nov 2023, the SIA Group has primarily procured SAF from **Neste**.
- In Feb 2025, the SIA Group signed an MoU with **Aether Fuels** to secure neat SAF for 5 years from their planned SAF production plant in USA and South East Asia. The SAF will be blended with regular jet fuel for use at selected airports served by Singapore Airlines and Scoot.

Singapore Airlines and the Cathay Group signed an MoU to jointly develop SAF use through initiatives such as the joint procurement of SAF at selected locations

Overview of collaboration

Company	Singapore Airlines
Partner country and organization	Cathay Group
Status and date	The MoU was signed in June 2024
Objective	To advocate for the development and use of SAF in the Asia-Pacific region
Collaboration detail	<p>The agreement has 2 main focus areas</p> <ol style="list-style-type: none"> SAF: SIA and Cathay will jointly advocate for greater use of SAF in the Asia-Pacific by <ul style="list-style-type: none"> ➤ Raise public awareness about SAF's role in decarbonizing aviation. ➤ Work to promote supportive policies and establish a global standard reporting framework for SAF use and verified emissions reductions. ➤ Explore potential opportunities for joint procurement of SAF at selected locations to boost its production and adoption. Operational sustainability improvements: Minimize waste and improve energy efficiency in both ground and cargo operations.

Singapore Airlines and Cathay Group CEOs' statements

- Singapore Airlines is committed to embedding sustainability in all aspects of our operations. At the same time, we recognize that we cannot achieve our targets alone.
- Our partnership with Cathay signifies our mutual ambition to enhance collaboration in sustainability initiatives in the Asia-Pacific region.

Chief Executive Officer of Singapore Airlines, Mr. Goh Choon Phong



- Our collaboration with Singapore Airlines **aims to accelerate the development of SAF supply chain in the region**, fostering a reliable SAF ecosystem to enable the industry to achieve its long-term decarbonization goals.
- **Cathay** was one of the first airlines in Asia to **set a target of 10% SAF for total fuel consumption by 2030**.

Chief Executive Officer of Cathay Group, Mr. Ronald Lam



Oneworld Alliance and its member airlines launched the oneworld BEV Fund to accelerate SAF production innovation in order to make SAF more affordable.

Overview of Oneworld BEV Fund

Company	Oneworld Alliance
Partner country and organization	<ul style="list-style-type: none"> • Breakthrough Energy Ventures (BEV), the climate-focused investment firm • Alliance member airlines, e.g., Japan Airlines • Non-alliance member e.g., Singapore Airlines
Status and date	Announced the launch of a new investment fund on 17 September 2025
Objective	To build an investment fund that will advance innovation to make SAF affordable
Collaboration detail	<ul style="list-style-type: none"> • The oneworld BEV Fund was created to accelerate SAF production because airlines are under growing pressure to cut carbon emissions. • The fund, led by cornerstone investors Alaska Airlines and American Airlines. <p>The oneworld BEV Fund will:</p> <ul style="list-style-type: none"> ➤ Invest in novel, next-generation Sustainable Aviation Fuel technologies ➤ Support the growth of alternative fuel markets to meet the long-term needs of the global aviation industry ➤ Develop a diverse and resilient SAF supply chain to meet future demand

Key stakeholder statement

- The fund won't favour particular production pathways like HEFA or alcohol-to-jet based on current market dynamics or regional policy preferences. Instead, investments must demonstrate genuine scalability.

Director of Sustainability and Innovation, The oneworld Alliance
Matthew Ridley



- Our investment in this fund demonstrates Singapore Airlines' strong support for developing and commercializing next generation SAF.

Chief sustainability officer, Singapore Airlines, Ms. Lee Wen Fen



CAAS established SAFCo in October 2025 to centrally procure SAF using SAF levy and encourage airlines and other stakeholders to join its procurement scheme

Overview of partnership

Topic	Establishment of the Singapore Sustainable Aviation Fuel Company (SAFCo) by CAAS
Responsible government organization	Civil Aviation Authority of Singapore (CAAS)
Partner organization	Airlines, corporate buyers of SAF, SAF producers, carbon market platforms
Status and date	CAAS announced the establishment of the SAFCo on 30 October 2025
Objective	To centrally procure SAF and support the implementation of Singapore's SAF policy
Engagement detail	<ul style="list-style-type: none"> CAAS established a non-profit company called Singapore Sustainable Aviation Fuel Company Ltd. (SAFCo) to centrally procure SAF for the Singapore air hub and support the implementation of Singapore's SAF policy. With predictable cashflows from the SAF Levy, SAFCo will be able to go into competitive price agreements to secure a more stable and affordable SAF supply. SAFCo will reach out to businesses and airlines to encourage them to partner SAFCo and use its central procurement mechanism for voluntary SAF purchases.

Source: CAAS, interview

SAFCo key stakeholders' statement

By working closely with airlines, businesses and suppliers, we aim to facilitate greater SAF adoption in the region and contribute to the decarbonization of aviation.

Chief Executive Officer of SAFCo, Ms. Tan Seow Hui



Interview insights

- The levy scheme allows purchases from multiple companies, including those outside Singapore, not just from Neste.
- Moreover, while Neste is the only major SAF producer in Singapore, there are many SAF traders in the country.

Industry player associated and familiar with Neste Singapore



CAAS conducted a 20-month SAF pilot project with partners such as Singapore Airlines and GenZero to validate Singapore's SAF supply chain readiness

Overview of pilot project

Project name	20-month Sustainable Aviation Fuel (SAF) pilot
Responsible government organization	The Civil Aviation Authority of Singapore (CAAS)
Partner organization	<ul style="list-style-type: none"> Singapore Airlines, GenZero, Changi Airport Group, Neste, ExxonMobil
Status and date	<ul style="list-style-type: none"> Commenced in February 2022 Completed in November 2023
Objective	<ul style="list-style-type: none"> To validate SAF supply chain readiness To understand demand for SAF credits and end-to-end cost of SAF deployment
Project detail	<ul style="list-style-type: none"> The pilot affirmed that SAF can be safely deployed to Changi Airport and uplifted onto flights without any modification to existing airport infrastructure. Under the pilot, SIA purchased 1,000 tonnes of SAF, generating 1,000 SAF credits and reducing about 2,500 tonnes of CO₂. Using the RSB Book & Claim System, the pilot showed that SAF credit transactions can be transparent. About two-thirds of the credits were sold, demonstrating market demand while highlighting the need for further outreach and policy support for SAF adoption.

Source: CAAS, ICAO, interview

Statement of key stakeholders in the pilot project

- SAF will be a key component of Singapore aviation's decarbonization efforts.
- CAAS is developing a structured offtake mechanism to support SAF adoption.

Director-General of CAAS, Mr. Han Kok Juan



- Through this pilot, GenZero partnered with Climate Impact X and the RSB to launch SAF credits.
- This helped test corporate willingness to offset travel emissions and showed ways to attract more carbon financing to offset the price premium and support the adoption of SAF.

Chief Executive Officer of GenZero, Mr Frederick Teo



Interview insights

- All pilot projects were completed in 2024, and there is no further SAF demand for them, as they are not continuous.
- Demand will start increasing from 2026, when the mandate becomes active.

Industry player associated and familiar with Neste Singapore





Malaysia Aviation Group has already started using SAF on pilot flights and plans to begin large-scale SAF procurement from PETRONAS starting in 2027

Company overview

Name	Malaysia Aviation Group
Established year	2015
International airline brands with SAF initiative	<ul style="list-style-type: none"> Malaysia Airlines Firefly
Major shareholder	Khazanah Nasional Bhd (100%) (government sovereign wealth fund)
Number of total flights in 2024	N/A
Network	<ul style="list-style-type: none"> 74 destinations
Total fuel consumption in 2023 (k tonnes)	1,026
Type of airlines	<ul style="list-style-type: none"> Malaysia Airlines: Full-service Firefly: Low-cost

SAF utilization plan

	Year	% blend	Usage/year (k tonnes)	Applied flights	Initiative
Current	2025	N/A	N/A	Only apply with pilot flights for Malaysia Airlines and Firefly	<ul style="list-style-type: none"> Conducted test flights using a SAF blend since 2022 until 2025 In September 2025, conducted a test flight with SAF with flights from Kuala Lumpur to London
	2027	N/A	N/A	N/A	<ul style="list-style-type: none"> Signed agreements to purchase SAF from PETRONAS for over 230k tonnes of SAF deliveries expected to start in 2027

Initiative to increase SAF usage

- Malaysia Aviation Group has formed partnerships, such as with FatHopes Energy, to explore the production of SAF from sources such as UCO

SAF sourcing

- Malaysia Aviation Group is aligning with PETRONAS as the key supplier of SAF in Malaysia, moving from pilot deliveries toward a more scalable sourcing relationship with off-take agreement signed in May 2023



AirAsia prepares for SAF adoption by 2027 with planned research into palm biowaste feedstocks and MOU about SAF supply expansion in ASEAN

Company overview

Name	AirAsia Group
Established year	2001
International airline brands with SAF initiative	AirAsia
Major shareholder	Capital A Berhad (100%)
Number of total flights in 2024	387,518 flights
Network	<ul style="list-style-type: none"> • 264 routes • 134 destinations • 15 hubs
Total fuel consumption in 2024 (k tonnes)	<ul style="list-style-type: none"> • 1,785
Type of airlines	<ul style="list-style-type: none"> • Low-cost

Initiative to increase SAF usage

- AirAsia plans to impose a mandatory carbon fee on passengers starting in Q2 of 2025. This fee will support the purchase of high-quality carbon credits, **investment in SAF** and **research and development to advance both solutions**.
- AirAsia also formalized its membership of the RSPO* to explore ways to **support technical research into palm biowaste as a potential SAF feedstock**.

* Note: RSPO refers to Roundtable on Sustainable Palm Oil
Source: News article, AirAsia Group

SAF utilization plan

	Year	% blend	Usage/year (k tonnes)	Applied flights	Initiative
Current	2025	5%	N/A	All Airbus aircraft deliveries to AirAsia from 2024	<ul style="list-style-type: none"> • Signed MOU with Airbus to research on SAF supply expansion in ASEAN
	2027	N/A	N/A	N/A	<ul style="list-style-type: none"> • Plans to adopt SAF usage from 2027 with the prospective introduction of SAF mandates in one or more of AirAsia's AOC countries** • SAF use will account for between 5 to 10% of emissions reduction between 2030 and 2035

** Note: AOC countries refers to countries that AirAsia has Air Operator's Certificates (AOCs) e.g. Thailand, Indonesia, the Philippines, and Cambodia

SAF sourcing

- No published information available regarding AirAsia SAF sourcing

Petronas delivered Malaysia's first locally blended SAF for Malaysia Aviation Group's pilot flights, marking breakthrough in aviation decarbonization

Overview of pilot project

Company	Malaysia Aviation Group (MAG)
Partner country and organization	Petronas (Malaysia's national oil and gas company)
Status and date	Announced in September 2025 and completed
Objective	To establish in-house capability and readiness to provide continuous, scalable SAF supply in Malaysia
Collaboration detail	<p>Petronas has successfully delivered Malaysia's first locally blended SAF to KL International Airport for the Malaysia Aviation Group.</p> <p>The SAF will be uplifted for Malaysia Airlines' daily late evening MH2 service from Kuala Lumpur to London between 1st to 16th September 2025, marking a tangible step in integrating SAF into its regular operations.</p>

Petronas executive's statement

This pilot project is a **strategic long-term investment to build in-house capabilities through advancements in technology and infrastructure**, as well as talent development to deliver reliable, cost-effective solutions to our partners and customers

Petronas Vice President for refining, marketing and trading,
Ahmad Adly Alias



Interview insights

MAS showed a commitment in SAF adoption with offtake agreement with Petronas which is a solid movement for airlines

Business Development Manager, Petronas



Malaysia Aviation Group and FatHopes Energy signed MOU to jointly drive SAF production innovation from UCO

Overview of the collaboration

Company	Malaysia Aviation Group (MAG)
Partner country and organization	FatHopes Energy (FHE) (Malaysian biofuel producer and feedstock supplier)
Status and date	Announced in February 2025 and on-going
Objective	To explore the full potential of UCO as feedstock for SAF production in Malaysia
Collaboration detail	<p>Through this partnership, FHE will provide advisory expertise to MAG, including technical support to facilitate the collection, processing, and conversion of UCO into neat SAF, ensuring compliance with both environmental and industry regulations.</p> <p>This partnership will also focus on a comprehensive assessment of fuel suppliers, other airlines, and all airports within MAG's network to evaluate existing infrastructure and identify necessary enhancements required for SAF deployment in Malaysia.</p>

MAG executive's statement

We continuously seek innovative solutions to minimize the environmental impact of our operations.

Partnering with FatHopes to explore SAF production from UCO presents a valuable opportunity to contribute to the aviation industry's broader sustainability goals.

This collaboration represents a significant step toward making SAF more accessible and scalable across our global network.

Group Chief Sustainability Officer of MAG, Philip See





AirAsia and Airbus announced MOU to accelerate aviation sustainability with research partnership on SAF expansion in ASEAN

Overview of the collaboration

AirAsia executive's statement

Company	AirAsia Aviation Group Limited
Partner country and organization	Airbus (European aircraft manufacturer)
Status and date	Announced in September 2024 and on-going
Objective	To identify opportunities to support the onward commercial development of promising projects to expand SAF supply in the region
Collaboration detail	<p>AirAsia signed MOU partnership with Airbus to establish a collaboration to explore decentralized SAF production using alternative feedstock and technologies in Southeast Asia.</p> <p>As part of the partnership, both parties met with key producers in the region and feedstock suppliers to build a SAF network in the region and to have an overview of the supply landscape.</p>

AirAsia will be a key partner of Airbus in ASEAN **to test the feasibility of SAF output developed using alternative feedstock and technologies**, as well as ground-breaking air traffic management (ATM) initiatives supported by Airbus' innovation teams.

As a regional carrier based in five ASEAN countries, we bring unparalleled operational experience in the region to complement Airbus' technological expertise

Capital A Chief Sustainability Officer, Yap Mun Ching

To manage the higher cost of SAF, Malaysia may follow Singapore's approach, as it is the most advanced in ASEAN through mechanisms like the SAF levy

Interview insights from Business Development Manager, Petronas

Factors influencing the purchase decision

- Price
 - The main concern to procure SAF is the price. Hence, SAF from HEFA pathway tend to be preferred due to the lowest price
- Certification
 - Certification is also the crucial factor.
 - There is no strict fixation on the feedstock as long as it is ISCC approved and have certification.
- Other: Effect on other region i.e. Europe
 - High price will effect the buying decision less than players in ASEAN as European consumers are more acceptant toward high price from sustainability. And the government also have more policy e.g. carbon tax to promote the usage of SAF
 - Feedstock would not largely effect the buying decision as long as it is not palm-based which is debatable for some parties

Method to address the higher cost from SAF

- Price increase and effect of adopting SAF
 - In every 1% SAF blend, the cost of the airlines will go up by 6%. Hence, the low-cost airlines will face difficulties in adopting
- Adaptation of model from Singapore
 - In ASEAN, Singapore is the most advanced country in SAF adoption as they have SAF Levy. Malaysia may adopt similar approach, and the burden will be transferred to passenger at the end as there might not be the support from Malaysian government such as subsidy like that of the US government
 - The reason is that, the ratio of international passengers in Malaysia is higher than that of the US. Hence, the Malaysian government may not want to pay subsidy for non-Malaysian that might take 50% of the total passengers



Thai Airways has a plan to increase the percentage of SAF blend and has joined PTTGC and PTTOR in researching and promoting the use of SAF

Company overview

Name	Thai Airways International Public Company Limited
Established year	1960
International airline brands with SAF initiative	Thai Airways
Major shareholder	Ministry of Finance: 38.90% (as of March 2025)
Number of total flights in 2024	No information disclosed
Network	<ul style="list-style-type: none"> • 115 routes • 61 destinations
Total fuel consumption in 2024 (k tonnes)	No information disclosed
Type of airlines	<ul style="list-style-type: none"> • Thai Airways: Full services

Initiative to increase SAF usage

- **December 2023:** Thai Airways operated its first flight using SAF from Neste on the Phuket-Bangkok flight. The blended SAF was supplied by PTT International Trading (PTTT), a subsidiary of the PTT group in collaboration with Petco Trading Labuan Company Ltd, a marketing and trading arm of Petronas

**Note: BAR stands for Board of Airline Representatives Business Association

Source: Thai Airways, news article

SAF utilization plan

	Year	% blend	Usage/year (k tonnes)	Applied flights	Initiative
Current	As of 2025	2%	N/A	N/A	<ul style="list-style-type: none"> • May 2023: Thai Airways signed MOU with Bangchak to share knowledge and expertise on the use of SAF • November 2024: Thai Airways signed MOU with PTTGC and PTTOR to integrate research and development, and promote the use of SAF • May 2025: Thai Airways and BAR** co-hosted the "Flying Green: Thailand's Sustainable Aviation Fuel Forum", bringing key stakeholders to share knowledge and discuss about SAF
	2030	5%	N/A	N/A	<ul style="list-style-type: none"> • The airline will gradually increase the use of SAF, targeting 2% by 2025, 5% by 2030, and 60% by 2050.
Future plan	2050	60%	N/A	N/A	

SAF sourcing

- No published information available regarding Thai Airways SAF sourcing in the future



Bangkok Airways began using SAF on commercial flights in July 2025 on international routes, initially partnering PTTOR to use domestically produced SAF

Company overview

Name	Bangkok Airways Public Company Limited
Established year	1968
International airline brands with SAF initiative	Bangkok Airways
Major shareholder	Mr. Puttipong Prasarttong-osoht: 24.92% (as of March 2025)
Number of flights in 2024	48,077 flights
Network	<ul style="list-style-type: none"> 25 routes 19 destinations
Total fuel consumption in 2024 (k tonnes)	No information disclosed
Type of airlines	<ul style="list-style-type: none"> Bangkok Airways: Full services

Initiative to increase SAF usage

- June 2024: Bangkok Airways launched the “Low Carbon Skies by Bangkok Airways” to drive the airline towards sustainability. In collaboration with PTTOR, the airline began using SAF on a pilot flight operating between Samui and Bangkok.

SAF utilization plan

	Year	% blend	Usage/year (k tonnes)	Applied flights	Initiative
Current	2025	1%	N/A	Apply for flights from Bangkok (Suvarnabhumi Airport) to Phnom Penh, Siem Reap, Luang Prabang, and the Maldives**	<ul style="list-style-type: none"> July 2025: Driving its “Low Carbon Skies by Bangkok Airways”, the airline started using SAF blended at 1% with 99% Jet A-1 fuel on commercial flights
	2027-2030	N/A	N/A	N/A	<ul style="list-style-type: none"> Plan to increase rate on use of SAF as a mid-term goal of the “Low Carbon Skies by Bangkok Airways” to drive the airline towards sustainability

** Note: No published information whether SAF is applied to all flights on the routes

SAF sourcing

- On pilot flight between Samui and Bangkok, SAF was sourced and imported by PTT International Trading (PTTT), a subsidiary of PTT.
- May 2025: Signed Letter of Intent (LOI) with PTTOR to cooperate in using SAF produced domestically by PTTGC



Thai Airways signed MOU with Bangchak to collaborate on exchanging technical knowledge and expertise related to the use of SAF

Overview of the collaboration

Company	Thai Airways International Public Company Limited
Partner country and organization	Bangchak Corporation PLC
Status and date	Announced in May 2023 and on-going
Objective	<ul style="list-style-type: none"> To share knowledge, experiences, and expertise in conducting technical studies on enhancing the efficiency of SAF usage
Collaboration detail	<p>Thai Airways and Bangchak have signed MOU to share technical knowledge and expertise on the use of SAF</p> <p>This collaboration will support both companies in advancing SAF deployment, reduce carbon dioxide emissions from aviation, and promote sustainable growth domestically and internationally — in line with standards set by International Civil Aviation Organization (ICAO) and International Air Transport Association (IATA)</p>

Thai Airways executive’s statement

Our partnership with Bangchak **enables domestic and international SAF consumption** and helps us to achieve our goal of net zero emission in 2050.

It is **the opportunity to share knowledge, experiences and expertise in researching and developing SAF**, which would contribute to net zero emission goal as well as forthcoming collaborations in business and environmental benefits for the sustainable growth of Thai Airways and Bangchak

Chief of Corporate Strategy at Thai Airways International,
Taviroj Songkumpol



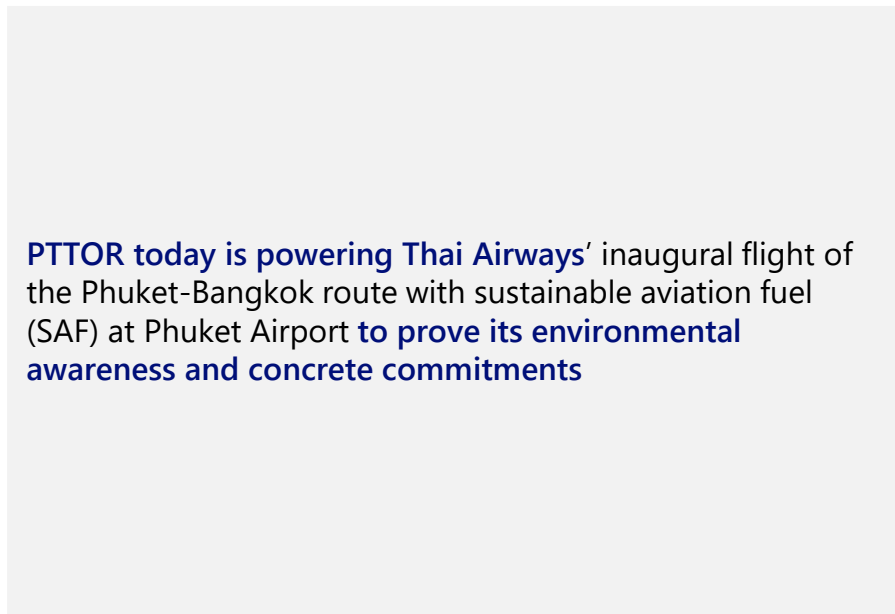


In December 2023, Thai Airways partnered with PTTOR and PTLCL to launch the pilot flight using SAF from Phuket Airport to Bangkok

Overview of the collaboration

PTTOR executive's statement

Company	Thai Airways International Public Company Limited
Partner country and organization	<ul style="list-style-type: none"> • PTT Oil and Retail Business Public Company (PTTOR) • Petco Trading Labuan Company Ltd (PTLCL)
Status and date	Pilot project conducted in December 2023
Objective	<ul style="list-style-type: none"> • To demonstrate the feasibility of SAF use in Thailand's aviation industry • To illustrate the airline's commitment to achieving the aviation industry's 2050 net zero carbon emission goal
Collaboration detail	<p>Thai Airways operated its first flight using blended SAF at Phuket Airport for the return flight to Bangkok International Airport</p> <p>The blended SAF was supplied by PTTOR in collaboration with Petco Trading Labuan Company Ltd (PTLCL), the marketing and trading arm of Petronas who was responsible for transferring Neste MY Sustainable Aviation Fuel to Phuket</p>



PTTOR today is powering Thai Airways' inaugural flight of the Phuket-Bangkok route with sustainable aviation fuel (SAF) at Phuket Airport to prove its environmental awareness and concrete commitments

Chief Executive Officer PTT Oil and Retail Business Public Company Limited (OR), Mr. Disathat Panyarachun





Thai Airways signed MOU with PTTOR and PTTGC to integrate in research and promote use of SAF in Thailand

Overview of the collaboration

Company	Thai Airways International Public Company Limited
Partner country and organization	<ul style="list-style-type: none"> • PTT Oil and Retail Business Public Company Limited (PTTOR) • PTT Global Chemical Public Company Limited (PTTGC)
Status and date	Announced in November 2024 and on-going
Objective	<ul style="list-style-type: none"> • To integrate in research and development, production, and promoting the use of SAF • To exchange knowledge, experience, and technological skills in the production, use and maintenance of sustainable aviation fuel
Collaboration detail	<p>Thai Airways signed MOU partnership with PTTOR and PTTGC to promote the use of SAF.</p> <p>This partnership among the three companies marks an important step toward uniting efforts in research and development, production, and the promotion of SAF use, covering from utilizing agricultural waste as feedstock and testing fuel quality to distribution and carbon offset applications</p>

Thai Airways executive's statement

This collaboration includes working together **to consider new future projects related to alternative energy for the Thai aviation business**, which will help promote the Thai aviation industry to move forward in a sustainable direction

Chief Financial Officer and Accounting Officer at Thai Airways,
Ms. Cherdchom Thetsathirasak





Bangkok Airways operated a pilot flight using SAF from Samui to Bangkok in collaboration with PTTOR

Overview of the pilot project

Company	Bangkok Airways Public Company Limited
Partner country and organization	PTT Oil and Retail Business Public Company Limited (PTTOR)
Status and date	Pilot project conducted in June 2024
Objective	<ul style="list-style-type: none"> To pioneer the use of SAF on the pilot flight To enhance the sustainability of airport under Bangkok Airways' management
Collaboration detail	<p>Bangkok Airways in partnership with PTTOR operated a pilot flight using SAF on the Samui-Bangkok route, demonstrating its commitment to clean energy and the reduction of CO2 emissions</p> <p>For this flight, SAF is sourced and imported by PTT International Trading (PTTT), a subsidiary of PTT</p>

Bangkok Airways executive's statement

Bangkok Airways aims to **enhance sustainability across our three airports (Samui, Sukhothai, and Trat)** through the 'Green Airport' concept. Samui Airport, the first to be certified with the carbon footprint label by the Thailand Greenhouse Gas Management Organization, serves as the model for this initiative

Senior Executive Vice President of Operations at Bangkok Airways, Dechit Chareonwong





Bangkok Airways has signed LOI with PTTOR to use SAF produced domestically by PTTGC

Overview of the collaboration

Company	Bangkok Airways Public Company Limited
Partner country and organization	PTT Oil and Retail Business Public Company Limited (PTTOR)
Status and date	Announced in May 2025 and on-going
Objective	To cooperate in using SAF produced domestically
Collaboration detail	<p>Bangkok Airways has signed LOI with PTTOR for collaboration in using SAF produced domestically to support Thailand's future SAF implementation policies</p> <p>Through this partnership, Bangkok Airways will use SAF that is produced domestically by PTT Global Chemical Public Company Limited (PTTGC)</p>

Bangkok Airways executive's statement

This marks another significant step for **Bangkok Airways in collaboration with PTTOR** to elevate Thailand's aviation industry toward a green flight path by **using SAF produced domestically for the first time in Thailand**

This integrated cooperation will **lead to promoting and preparing for the use of biofuels in Thailand's aviation industry in the future**, responding to the sustainable trend in Thailand's aviation business.

Senior Executive Vice President of Operations at Bangkok Airways, Dechit Chareonwong





GIZ Thailand organized SAF Working group meeting with Thai key stakeholders to discuss on SAF adoption in Thailand

Overview of partnership

Topic	SAF Working Group Meeting
Responsible government organization	GIZ Thailand under the International Hydrogen Ramp-up Programme (H2Uppp)**
Partner organization	<ul style="list-style-type: none">• Private: Energy Absolute PLC, PTT Global Chemical (PTTGC), etc.• Public: The Civil Aviation Authority of Thailand (CAAT), Department of Alternative Energy Development and Efficiency (DEDE), etc.
Status and date	Meeting held in March 2025
Objective	To encourage discussions on main challenges and opportunities to promote SAF adoption in Thailand's aviation sector
Engagement detail	Key stakeholders from the private sector and governmental agencies presented their insights on policies, perspectives towards SAF production and relevant lessons from the EU's SAF policy framework. The key stakeholders also identified 5 key challenge areas: insufficient policy support, high production costs, uncertain market demand, limitations in feedstock availability and complex certification/qualification processes in the group discussion

** Note: The International Hydrogen Ramp-up Programme or H2Uppp program is financed by the German Federal Ministry for Economic Affairs and Climate Action (BMWK)



CAAT has signed MOU with 8 airlines to promote the use of SAF, supporting the goal of achieving Net-Zero carbon emissions

Overview of partnership

Topic	MOU signing on promoting the use of SAF
Responsible government organization	The Civil Aviation Authority of Thailand (CAAT)
Partner organization	<ul style="list-style-type: none"> • Thai Airways • Bangkok Airways • K-Mile Air • Nok Air • Thai AirAsia • Thai AirAsia X • Thai Lion Air • Thai Vietjet
Status and date	Announced in November 2025 and on-going
Objective	To advance the adoption of SAF in Thailand
Engagement detail	<p>CAAT, together with eight Thai airlines certified as Air Operators, has signed MOU to promote the use of SAF.</p> <p>Additionally, CAAT is also considering a voluntary approach for airlines to separately list a “Carbon Surcharge” on international flight routes. Implementation is expected to begin in 2026. The purpose of this surcharge is to transparently reflect the costs associated with reducing and offsetting carbon emissions in Thailand’s aviation sector</p>

Key stakeholder’s statement

The use of Sustainable Aviation Fuel (SAF) not only helps reduce carbon emissions in line with international standards, but also **prepares the country to remain competitive in the new aviation ecosystem**, which places greater emphasis on environmental responsibility.

CAAT will continue working with airlines, government agencies, and the industrial sector to **move Thailand toward becoming a regional leader in Green Aviation**

Board and Secretary at CAAT, Manat Chavanaprayoon





Garuda Indonesia and Citilink had operated the pilot flights in 2023 and 2024; however, both airlines have not had plans to utilize SAF in the future

Company overview

Name	PT Garuda Indonesia (Persero) Tbk
Established year	1950
International airline brands with SAF initiative	<ul style="list-style-type: none"> Garuda Indonesia Citilink
Major shareholder (Oct, 2024)	Government of Indonesia (64.54%)
Number of flights per year (2024)	<ul style="list-style-type: none"> Garuda Indonesia: 163,271 flights Citilink: N/A
Total amount of fuel consumption (k tonnes)	N/A
Type of airlines	<ul style="list-style-type: none"> Garuda Indonesia: Full-service Citilink: Low-cost

Initiative to increase SAF usage

N/A

Source: Garuda Indonesia, news article

SAF utilization plan

	Year	% blend	Usage/year (k tonnes)	Applied flights	Initiative
Current	As of 2025	N/A	N/A	Only applied with pilot flights for Garuda Indonesia and Citilink	<ul style="list-style-type: none"> Garuda Indonesia operated the first pilot flight using SAF (UCO base) from CGK (Jakarta) to SOC (Solo, Central Java) in Oct, 2023 Citilink operated the demonstration flights using SAF (UCO base) during Bali International Airshow in Sep, 2024
	2027	N/A	N/A	Intl flights Dom flights	<ul style="list-style-type: none"> Garuda Indonesia will also be using SAF, in accordance with the Indonesian SAF Roadmap target
Future plan	2030	N/A	N/A	N/A	<ul style="list-style-type: none"> Garuda Indonesia will increase the use of SAF in accordance with the targets set by ICAO

SAF sourcing

- For the SAF utilized for the pilot/demonstration flights operated by Garuda Indonesia and Citilink, SAF produced by Pertamina was utilized



Lion Air Group has plans to utilize SAF for all aircraft by 2030; however, no specific targets have not been published yet

Company overview

Name	Lion Air Group
Established year	1999
International airline brands with SAF initiative	<ul style="list-style-type: none"> • Lion Air • Batik Air
Major shareholder	N/A
Number of flights per year	N/A
Total amount of fuel consumption (k tonnes)	N/A
Type of airlines	<ul style="list-style-type: none"> • Lion Air: Low-cost • Batik air: Full-service

Initiative to increase SAF usage

N/A

SAF utilization plan

	Year	% blend	Usage/year (k tonnes)	Applied flights	Initiative
Current	2025	N/A	N/A	N/A	N/A
	By 2030	N/A	N/A	All flights	<ul style="list-style-type: none"> • Lion Air Group aims to incorporate a percentage of SAF in all aircrafts by 2030 as part of the company's larger effort to become "more sustainable".

SAF sourcing

- N/A



Collaborated with Pertamina, Garuda Indonesia has operated flights using SAF to check SAF's equivalence to normal aviation fuel in performance and safety

Overview of collaboration

Company	Garuda Indonesia
Partner country and organization	Pertamina (Indonesia)
Status and date	Announced and completed in 2023
Objective	In order to confirm quality and safeness by using actual aircrafts
Collaboration detail	<ul style="list-style-type: none"> • Pilot flights using SAF produced by Pertamina <ul style="list-style-type: none"> • The commercial flight using SAF on Oct 4, 2023 • The pilot flight using SAF from CGK (Jakarta) to SOC (Solo, Central Java) on Oct 23, 2023 • Technical Verification and Safety Assessment <ul style="list-style-type: none"> • Cell test at Garuda maintenance facility • Ground runs • Static test

Research team's statement

The SAF utilized in the collaboration on a Boeing 737-800 aircraft demonstrated good and controlled response.

These positive results further strengthen the synergy between Pertamina and Garuda Indonesia as they move into the next phase, namely the planned use of SAF in commercial aviation.

PT LAPI ITB, Research Team



Executive Summary

Chapter 1: Public Policy and Regulations

Chapter 2: Player Activity

Summary

Chapter 2-1: Activity of Demand-side Player

Chapter 2-2: Activity of Supply-side Player

Chapter 3: Supply/demand potential

Chapter 4: Needs by Local Players

Chapter 5: Export Potential to Japan

Appendix



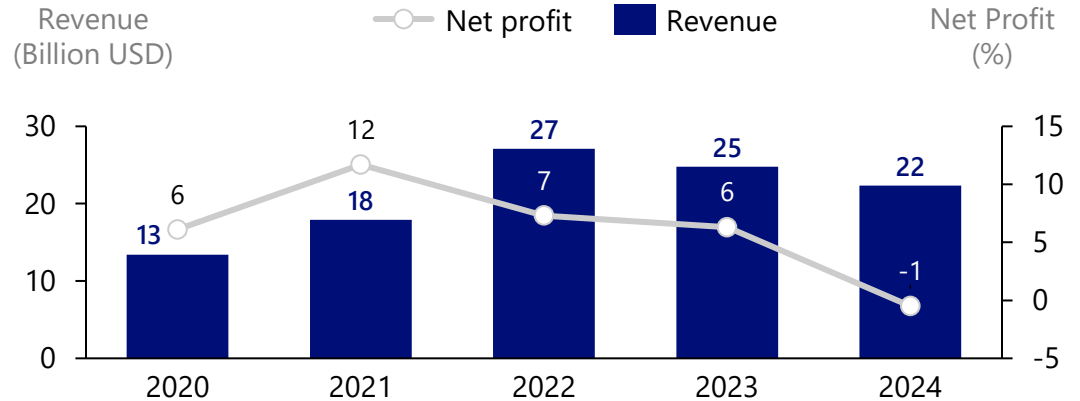
Neste Singapore Pte. Ltd. is the largest sustainable aviation fuel producer in Singapore, with its parent company, Neste Oyj, headquartered in Finland

Company overview

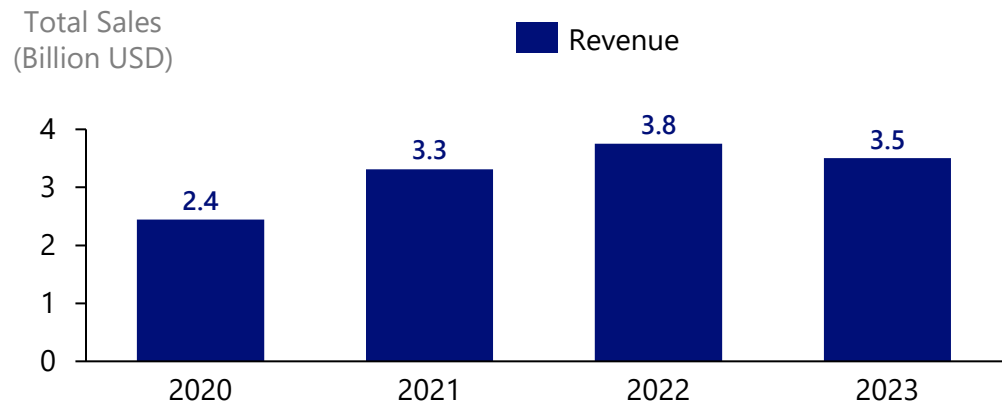
Name	Neste Corporation (Neste Oyj)
Established year	1948
Country of origin	Finland
Major shareholder	Prime Minister's Office of Finland 44.22%
Business overview	Neste Oyj provides renewable products and solutions, as well as oil products, including diesel, gasoline, aviation and marine fuels.
Key subsidiary company responsible for SAF	<ul style="list-style-type: none"> Neste Asia Pacific Pte. Ltd <ul style="list-style-type: none"> Responsible for commercial activities in Asia Pacific region Neste Singapore Pte. Ltd. <ul style="list-style-type: none"> Responsible for SAF production in Singapore
Market share of SAF production volume in the country (%)	100% as Neste is the only major SAF producer in Singapore

Source: Neste, Speeda, interview

Financial highlights of Neste Oyj



Financial highlights of Neste Singapore Pte. Ltd.



Note: No data on the net profit of Neste Singapore Pte. Ltd. and financial highlights of Neste Asia Pacific Pte. Ltd were disclosed in the publicly available information.



Neste has a refinery in Singapore with a SAF production capacity of 1 million tonnes per year, using waste and residues such as used cooking oil as feedstocks

Biorefinery facility overview

	Location	Capacity (k tonnes/year)	Technology	Feedstock	Operating year	Status
Total	1 plants	2,600*	• HEFA	<ul style="list-style-type: none"> • UCO • PFAD • Animal fat waste • Others e.g., POME, SBEO 	2023	• Operating
Current	Tuas, west of Singapore	2,600 (all products) 1,000 (SAF)	• HEFA	<ul style="list-style-type: none"> • UCO • PFAD • Animal fat waste • Others e.g., POME, SBEO 	2023	<ul style="list-style-type: none"> • The refinery was firstly set up in 2010. • The construction of the expansion project started in 2019 and operations started in April 2023.
Future plan	-	-	-	-	-	<ul style="list-style-type: none"> • Currently, Neste in Singapore has no plans for plant expansion or building a new plant.

Feedstock sourcing

Current Feedstock:

- Neste has feedstock sourcing offices that procure feedstocks from around the world. For example, they source used cooking oil from China and India, animal fats from slaughterhouses, such as cow, sheep, and pork, from both Australia and New Zealand, and fish oil from Thailand and Vietnam.
- Based on the feedstock sourced only in APAC, the approximate feedstock composition is as follows: 40% UCO, 25% PFAD, 20% animal fat, and 15% other feedstocks, such as POME and SBEO.

Future Feedstock:

- Neste is currently conducting R&D on various feedstocks, but yields remain low and GHG reductions may also be insufficient. Examples include algae; forestry waste e.g., fallen leaves, tree trunks, and used wooden pallets; and novel vegetable oils (NVO) from canola, Pongamia, and cactus.

*The expanded refinery increases the Singapore refinery's total production capacity to 2.6 million tons annually, including up to 1 million tons of SAF
SBEO means Spent bleaching earth oil

Source: Neste, ICAO, Bayer, news article, interview

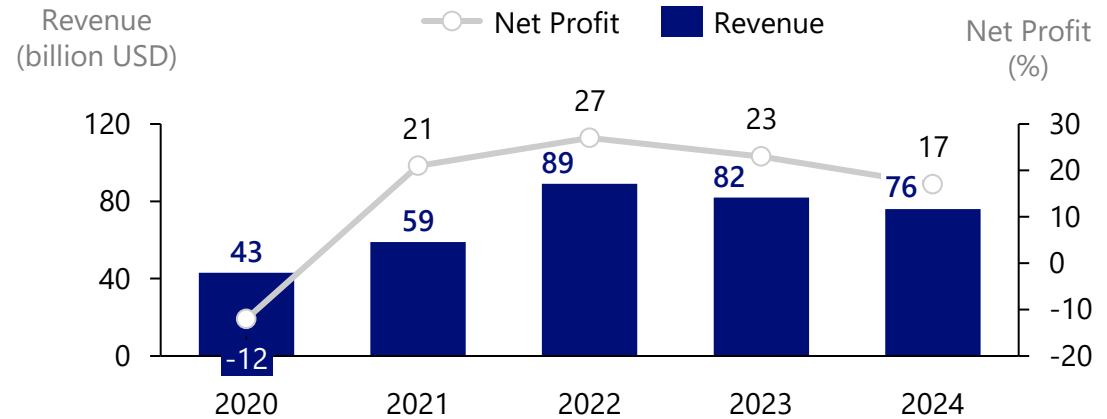


PETRONAS is Malaysia's national energy company engaged across the oil, gas, petrochemicals, and clean energy with growing efforts toward SAF

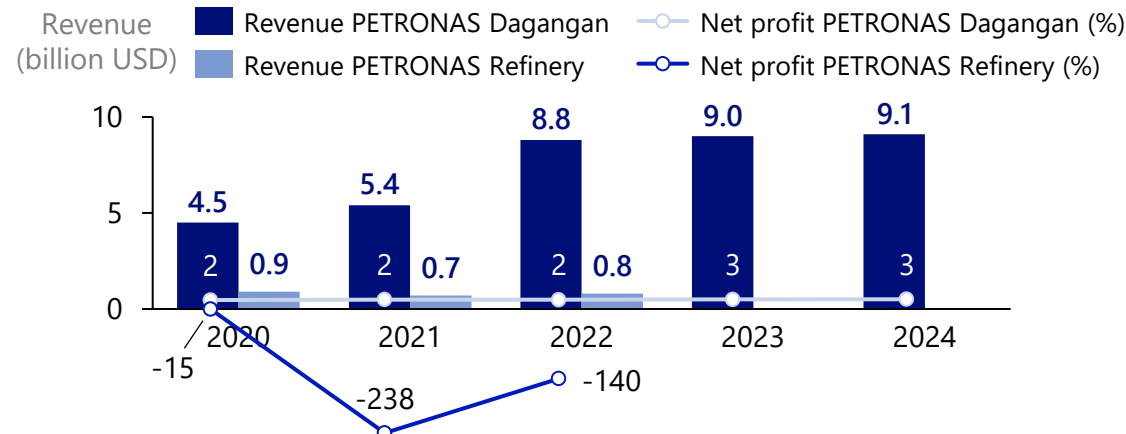
Company overview

Name	Petroleum Nasional Berhad (PETRONAS)
Established year	1974
Country of origin	Malaysia
Major shareholder	The Malaysian federal government (100%)
Business overview	<ul style="list-style-type: none"> PETRONAS is a state-owned, largest oil and gas producer in Malaysia, producing an average of 2.4 million barrels of oil per day in 2024
Key subsidiary company responsible for SAF	<ul style="list-style-type: none"> PETRONAS Mobility Lestari <ul style="list-style-type: none"> A newly formed subsidiary of PETRONAS and partners as JV to build a SAF plant PETRONAS Refinery & Petrochemical Corporation <ul style="list-style-type: none"> Oversee development and management of Pengerang Integrated Complex (site for SAF plant) PETRONAS Dagangan <ul style="list-style-type: none"> Responsible marketing of petroleum product including SAF
Market share of SAF production volume in the country (%)	N/A

Financial highlights of PETRONAS



Financial highlights of main subsidiaries*



*Note: Based on data availability

MYR to USD conversion rate: 1 USD = 4.19 MYR (as of 31 October 2025)

Source: Petronas, Speeda, Central Bank of Malaysia

Petronas plans to operate its first SAF production facility in Johor in 2028 with UCO and animal fat as main feedstock

Biorefinery facility overview

	Location	Capacity (k tonnes/year)	Technology	Feedstock	Operating year	Status
Total	1 plant	575*	• HEFA	• UCO (85%) • Animal fats (15%)	2028 (Q2)	• Under construction
Current	-	-	-	-	-	-
Future plan	Pengerang biorefinery, Pengerang, Johor	575 (all products) 400-450 (SAF)*	• HEFA	• UCO (85%) • Animal fats (15%)	2028 (Q2)	<ul style="list-style-type: none"> • Petronas completed FID together with partners i.e. Eni SpA and Euglena in July 2024 • The partners established a JV to construct and operate the plant • The groundbreaking ceremony was in November 2025. Currently the progress is on track
	N/A (The plant may be in the same area i.e. Pengerang Integrated Complex)	N/A (The plant may have roughly the same capacity as the Pengerang biorefinery)	N/A (It is likely that the plant might use other pathways i.e. AtJ, FT, or HEFA with non-UCO feedstock)	N/A	N/A (The earliest the new plant can operate will be at 2033)	<ul style="list-style-type: none"> • There are no solid plans for expansion yet in this early stage as Petronas will see the result and performance of Pengerang biorefinery first before invest further. • The information is from insights of the expert only

* Note: This number is the ratio at the point of interview. SAF production can reach only 80-90% due to technical constrain

Petronas is expanding feedstock sources beyond UCO and exploring next-generation SAF pathways beyond HEFA like AtJ and FT

Biorefinery facility overview

Feedstock sourcing

Main feedstock:

- Petronas is building a domestic UCO ecosystem focused on household collection to support national waste-to-fuel goals and to not compete with FatHopes Energy in UCO from commercial sectors. Petronas also sources UCO through its trading offices in the UK, Dubai, and Singapore.
- For animal fat, sourcing plans are not finalized, but Petronas expects to rely on its trading arm as the project progresses

Experimental feedstock:

- Petronas is exploring additional waste-based or non-food feedstocks that require small land and resource to grow to match with ICAO criteria such as POME, PFAD, microalgae, pongamia, jatropha, and algae oil.
- Pongamia is attractive as it can grow on non-arable land and aligns well with ICAO sustainability criteria
- Petronas' partner Euglena is researching algae oil. However, more efficient algae strains or production methods would be needed before it becomes a practical feedstock.

Technology development

Overall:

- Petronas recognizes that developing another UCO-based HEFA refinery will be challenging due to feedstock limitations, and is therefore exploring alternative SAF pathways such as AtJ and FT
- The company has not entered partnerships yet and is currently assessing technology startups, evaluating potential licensors, and reviewing technical feasibility and high-level commercial viability.
- While AtJ and FT are not immediate investment priorities, Petronas remains open to proposals from companies with proven technologies, which may be considered when planning a second refinery

AtJ:

- ✓ Petronas sees potential in ethanol as a more abundant feedstock compared to UCO or animal fat, but prefers waste-based or second-generation ethanol due to sustainability and certification concerns associated with first-generation ethanol.
- ✓ Although Malaysia has limited ethanol supply relative to Thailand, Petronas is interested in evaluating partners capable of supplying second-generation ethanol.

FT:

- ✓ In parallel, Petronas continues to monitor developments in FT, particularly the progress of power companies such as Aether Fuels in Singapore, and may consider collaboration when timing aligns



EcoCeres Renewable Fuels, a subsidiary of EcoCeres, converts waste oils to produce waste-based advanced biofuels such as SAF and HVO in Malaysia

Company overview

Name	EcoCeres Renewable Fuels
Established year	2022
Country of origin	Hong Kong
Major shareholder	EcoCeres (100%)
Business overview	<ul style="list-style-type: none"> EcoCeres Renewable Fuels, the Malaysian subsidiary of EcoCeres, Inc., is a renewable fuel producer focused on transforming waste-based feedstocks into advanced biofuels e.g. SAF, HVO
Key subsidiary company responsible for SAF	<ul style="list-style-type: none"> No subsidiary company
Market share of SAF production volume in the country (%)	N/A

Financial highlights of EcoCeres

No published information available regarding of financial performance of EcoCeres

Financial highlights of EcoCeres Renewable Fuels

No published information available regarding of financial performance of EcoCeres Renewable Fuels



EcoCeres will soon operate its first HEFA-based SAF plant in Malaysia with 100% waste-based feedstock,

Biorefinery facility overview

	Location	Capacity (k tonnes/year)	Technology	Feedstock	Operating year	Status
Total	1 plant	420*	• HEFA	• UCO (95%) • POME (5%)	2025 (Q4)	• Operating
Current	-	-	-	-	-	-
Future plan	Johor	420 (all products) 210 (SAF)*	• HEFA	• UCO (95%) • POME (5%)	2025 (Q4)	<ul style="list-style-type: none"> • The plant successfully deliver the first batch of SAF in November 2025. By 2026 (Q2) it is expected to increase to commercial. • EcoCeres will begin exporting SAF from 2026 to countries like USA, EU, Japan, Korea

Feedstock sourcing

Main feedstock:

- For UCO, EcoCeres imports all UCO from China leveraging the existing supply chain from parent company in Hong Kong
- For POME, the company source it from palm oil plantation in the peninsular or Borneo in Malaysia.

Experimental feedstock:

- EcoCeres does not explore any other feedstocks than UCO and POME at the moment

Technology development

- EcoCeres has no plan to use other technologies (e.g. AtJ, FT etc.) and plan to focus mainly on HEFA

* Note: This number is the ratio at the point of interview. SAF production was around 50-55% due to the demand at that time



FatHopes Energy is a Malaysian growth-stage private company with core activities involve the collection and pre-treatment of waste-based feedstock

Company overview

Financial highlights of FatHopes Energy

Name	FatHopes Energy
Established year	2010
Country of origin	Malaysia
Major shareholder	N/A
Business overview	<ul style="list-style-type: none"> FatHopes Energy is a Malaysia-based renewable energy company specializing in the collection, aggregation, and pre-treatment of waste-based feedstocks, primarily UCO and POME for the production of biofuels, including SAF and HVO
Key subsidiary company responsible for SAF	<ul style="list-style-type: none"> No subsidiary company
Market share of SAF production volume in the country (%)	N/A

No published information available regarding of financial performance of FatHopes Energy

FatHopes Energy is developing a 300k tpa HEFA-based SAF plant in Port Klang targeted operation for 2029 with UCO as main feedstock

Biorefinery facility overview

	Location	Capacity (k tonnes/year)	Technology	Feedstock	Operating year	Status
Total	1 plant	300*	• HEFA	• UCO	2029	• FEED stage
Current	-	-	-	-	-	-
Future plan	Port Klang	300 (all products) 170 (SAF)*	• HEFA	• UCO	2029	<ul style="list-style-type: none"> • The project is currently in the feasibility/FEED stage (including feedstock mapping, technology partner agreements, approvals) and aiming for FID with Bin Zayed International Group in mid-2026 • The plant is set to start the groundbreaking in 2026 • However, the plan is not finalized yet as it is still in an early stage has not completed the FID yet

Feedstock sourcing

- FatHopes Energy is Malaysia’s largest UCO collector. The company has long-established relationships and contracts with major commercial UCO suppliers such as chain restaurants, making it a dominant player in the commercial collection market.
- FatHopes Energy signed an initial agreement at the event with testing, inspection and certification company AmSpec Group. They aim to identify, assess and document feedstocks across Asia-Pacific, Australia and New Zealand that can be used at the planned plant.
- Besides UCO, other waste feedstocks such as POME oil and spent bleaching earth oil (SBEO) will be explored.

* Note: This number is the ratio at the point of interview. SAF production was around 50-55% due to the demand at that time



PTT Public Company Limited, a Thai state-owned energy company, engages in SAF production and marketing through its subsidiaries, PTTGC and PTTOR

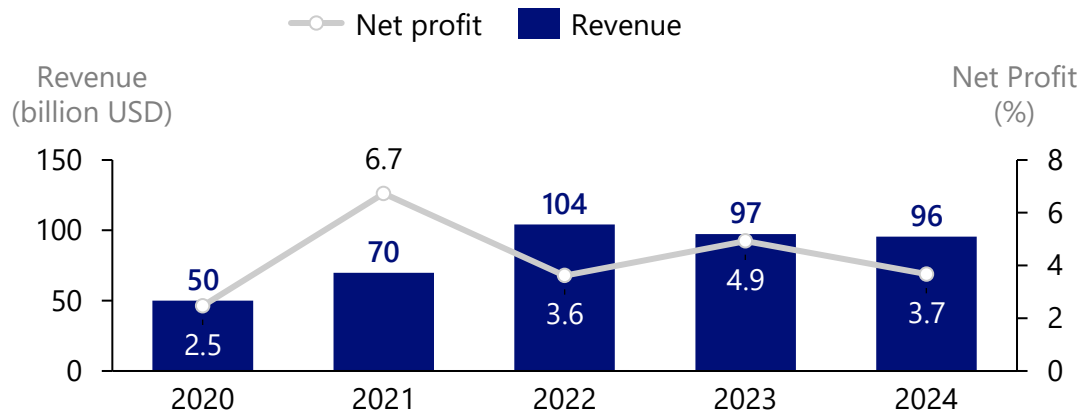
Company overview

Name	PTT Public Company Limited (PTT)
Established year	1978
Country of origin	Thailand
Major shareholder	Ministry of Finance: 51.36% (as of Oct 2025)
Business overview	PTT is a state-owned integrated energy company, with business spanning the full value chain of oil, natural gas, petrochemicals, refining, marketing and retail
Key subsidiary company responsible for SAF	<ul style="list-style-type: none"> PTT Global Chemical Public Company Limited (PTTGC) <ul style="list-style-type: none"> Integrated petrochemical and refining business Responsible for SAF production PTT Oil and Retail Business Public Company Limited (PTTOR) <ul style="list-style-type: none"> Retail and mobility arm of PTT group, operating network for fuel stations under "PTT station" Responsible for SAF commercial marketing
Market share of SAF production volume in the country (%)	N/A

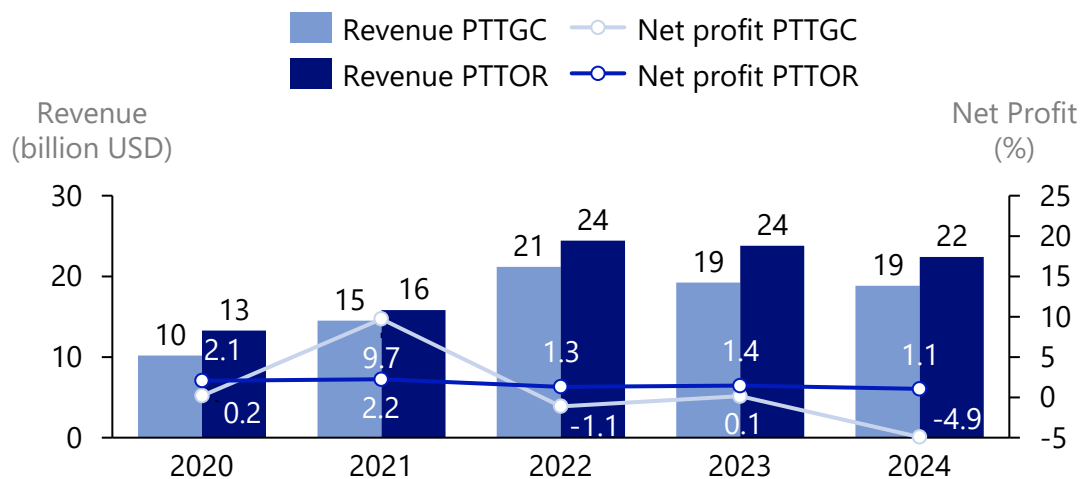
THB to USD conversion rate: 1 USD = 32.325 (as of 31 October 2025)

Source: PTT, Corpus

Financial highlights of PTT



Financial highlights of PTTGC and PTTOR





PTTGC started SAF operation in January 2025, using Co-processing HEFA technology by mixing UCO with crude oil

Biorefinery facility overview

	Location	Capacity (k tonnes/year)	Technology	Feedstock	Operation starting year	Status
Total	1 plant	80*	• Co-processing HEFA	• Mixed 5% of UCO with crude oil	2027	• Operating the 1 st phase production in January 2025
Current	Map Ta Phut, Rayong	20	• Co-processing HEFA	• Mixed 5% of UCO with crude oil	2025	• FID is already completed for the 1 st phase • The operation started operation in January 2025
Future plan		80 (all products) 40 (SAF)*	• Co-processing HEFA	• Mixed 5% of UCO with crude oil	2027	• FID for plant expansion is not completed yet • PTTGC has a plan to gradually increase the design capacity from 20 KTA to 40 KTA and ultimately to 80 KTA

Feedstock sourcing

Main feedstock:

- UCO is sourced from domestic collectors, who collect it from food manufacturers, restaurants, fresh markets, schools, and hospitals. Some major collectors are developing methods to collect currently untapped UCO.

Experimental feedstock:

- POME and PFAD are the first two options considered as future alternative feedstocks

* Note: This number is the ratio planned at the point of interview. SAF production is around 40-50%



Bangchak Corporation Public Company Limited is a listed Thai energy company producing SAF through its JV company, BSGF Company Limited

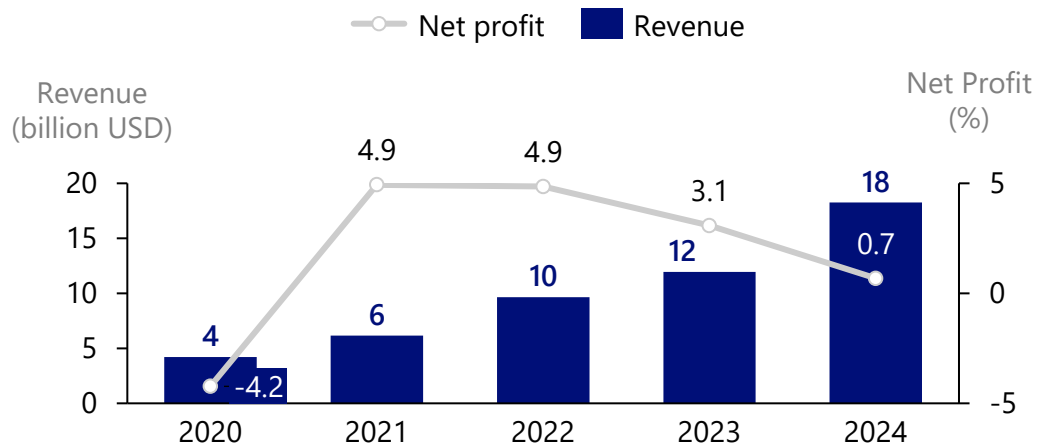
Company overview

Name	Bangchak Corporation Public Company Limited (BCP)
Established year	1984
Country of origin	Thailand
Major shareholder	Alpha Chartered Energy: 20.01% (As of Jun 2025)
Business overview	BCP is a listed Thai energy company operating businesses in oil refining, fuel marketing, renewable power generation, bio-based products, and natural resources.
Key subsidiary company responsible for SAF	<ul style="list-style-type: none"> BSGF Company Limited <ul style="list-style-type: none"> A joint venture initiated by BCP alongside partners BBGI and Thanachok Oil Light Responsible for SAF production
Market share of SAF production volume in the country (%)	N/A

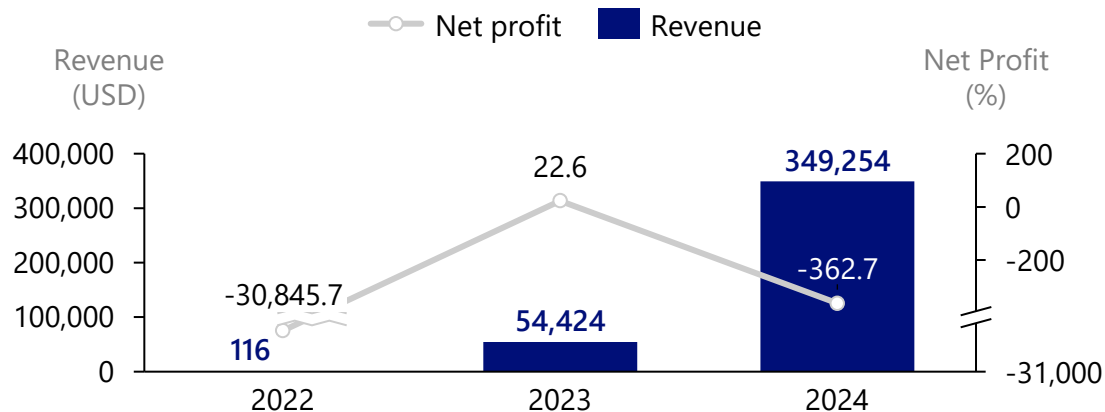
THB to USD conversion rate: 1 USD = 32.325 (as of 31 October 2025)

Source: Bangchak, Corpus

Financial highlights of BCP



Financial highlights of BSGF





Bangchak SAF plant is expected to complete in 2026, using UCO as main feedstock sourced from its own “Fry to Fly” project and local partners

Biorefinery facility overview

	Location	Capacity (k tonnes/year)	Technology	Feedstock	Operation starting year	Status
Total	1 plant	292	HEFA	• UCO	2026 (Q3)	• Under construction
Current	-	-	-	-	-	-
Future plan	Phra Khanong, Bangkok	292	HEFA	• UCO	2026 (Q3)	<ul style="list-style-type: none"> • FID is already completed • Construction is expected to complete by middle of 2026 • Aim for an initial target production at 5 KBD* (232 k tonnes/year) in 2026 • Plan to produce in full capacity of 7 KBD (292 k tonnes/year) from 2027 onwards • Commercial production will start as soon as the facility opens • No plans on the expansion of the facility yet

Feedstock sourcing

Main feedstock: BSGF prioritizes the use of domestically sourced UCO from two main channels

- “Fry to Fly” project: Bangchak is purchasing UCO from public at Bangchak service station network
- Strategic partners in the food processing and manufacturing sector: Bangchak has signed agreements with local governments and food and beverage companies to collect UCO

*Note: KBD means thousand barrels per day

Source: Bangchak, news article, interview



Bangchak is considering next-generation SAF pathways apart from HEFA like AtJ with current progress of high-level feasibility study of AtJ SAF refinery

SAF production facility overview

Feedstock sourcing

Experimental feedstock:

- BSGF is considering other alternative feedstock which are cassava and molasses. Cassava will be questioned whether it can be recognized as a SAF feedstock or not. However, no producers are currently taking any initiative to promote cassava as a feedstock until AtJ investment can be justified and proved that it is feasible
- Other feedstocks under consideration are EFB, POME, PFAD, pongamia, microalgae, tallow, crude glycerin etc. However, the potential are still considered rather low from the current yield result

Technology development

AtJ:

- AtJ is seen to be the next generation of SAF production in Thailand as Thailand has surplus ethanol from ethanol plants.
- It may not take long to adopt AtJ technology as there are licensors who are active in Thailand (e.g. Axens). Most ethanol producers are also exploring the option and running feasibility on their existing refinery.
- As of now, many players, including BSGF, is working on a high-level feasibility (consideration of feedstock, technology, power costs etc.) of AtJ refinery
- Licensor of AtJ, Axens, is offering investment feasibility for those who are interested in AtJ



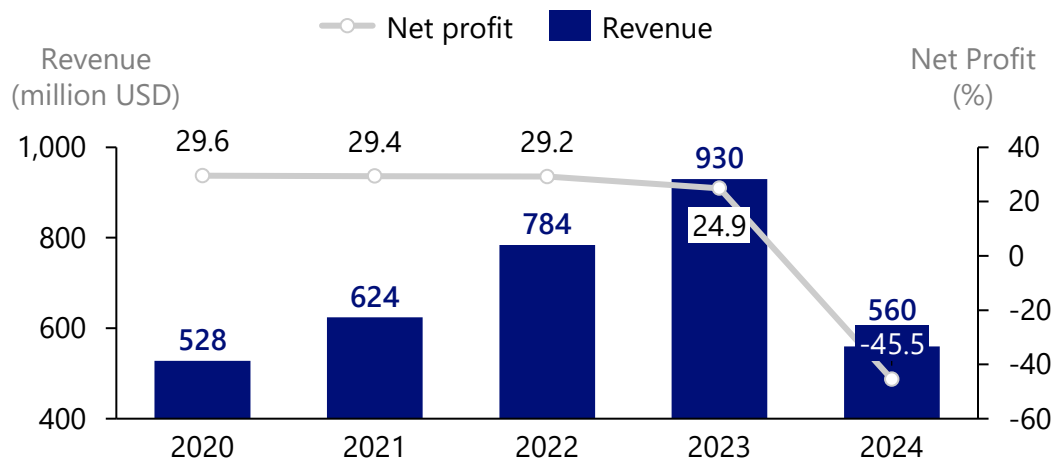
Energy Absolute is a renewable energy company operating SAF plant through its subsidiary, EA Bio Innovation Co., Ltd.

Company overview

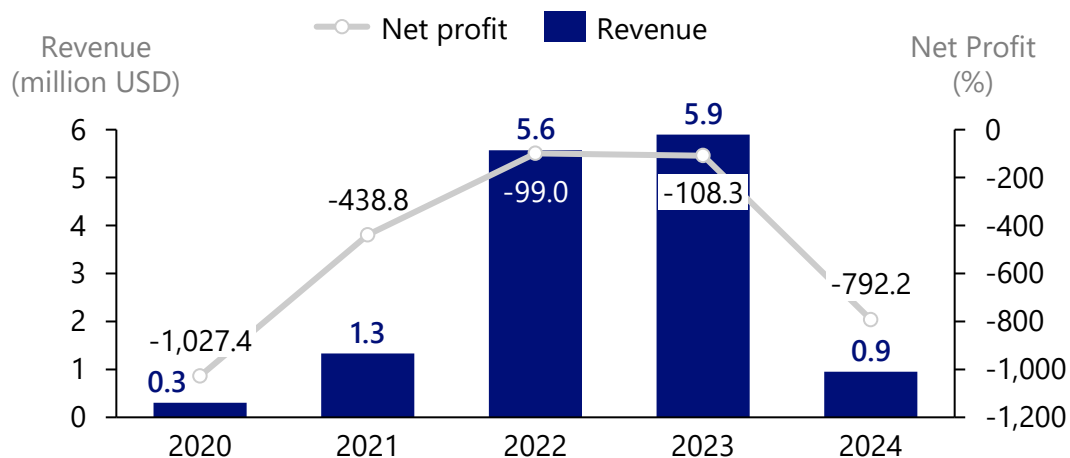
Name	Energy Absolute Public Company Limited
Established year	2006
Country of origin	Thailand
Major shareholder	UBS AG SINGAPORE BRANCH: 22% (As of April 2025)
Business overview	EA is a renewable energy and sustainable technology company that manufactures and distributes biodiesel and glycerol products, generates and supplies solar and wind power, and develops electric vehicles, charging infrastructure and related energy solutions
Key subsidiary company responsible for SAF	<ul style="list-style-type: none"> EA Bio Innovation Co., Ltd. (EBI) <ul style="list-style-type: none"> Develops and manufactures bio-based energy produce, including patented bio-based phase change materials (Bio-PCM) and SAF
Market share of SAF production volume in the country (%)	N/A

THB to USD conversion rate: 1 USD = 32.325 (as of 31 October 2025)
 Source: Energy Absolute, Corpus

Financial highlights of EA



Financial highlights of EBI





Energy Absolute has one HEFA plant in Rayong province, using UCO as main feedstock with plans to commence SAF production in 2026

Biorefinery facility overview

	Location	Capacity (k tonnes/year)	Technology	Feedstock	Operation starting year	Status
Total	1 plant	25	HEFA	• UCO	2026	• Under the test run
Current	-	-	-	-	-	-
Future plan	Rayong	25	HEFA	• UCO	2026	<ul style="list-style-type: none"> • FID is already completed • The plant is under the test run phase as of December 2025 • EA is upgrading its biodiesel refinery facility to be capable of producing SAF from UCO • The company targets SAF output from the first phase of production capacity at 100k liters/day in 2025F

Feedstock sourcing

Current feedstock sourcing

- EA tentatively utilizes UCO collectors for feedstock sourcing

Future feedstock sourcing

- Procurement of feedstocks will likely be agricultural waste from cultivation of energy crops rather than UCO
- EA aims to use POME and PFAD from biodiesel production process

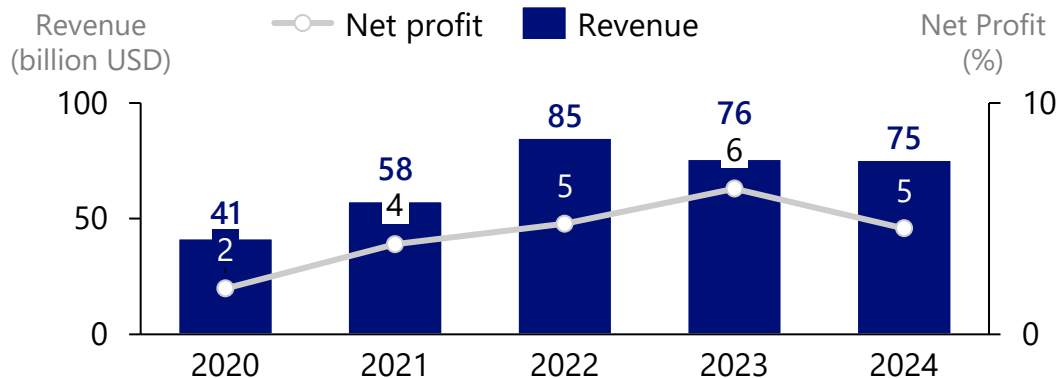


Pertamina, a government-owned company, is a biggest SAF producer in Indonesia and has the largest market share

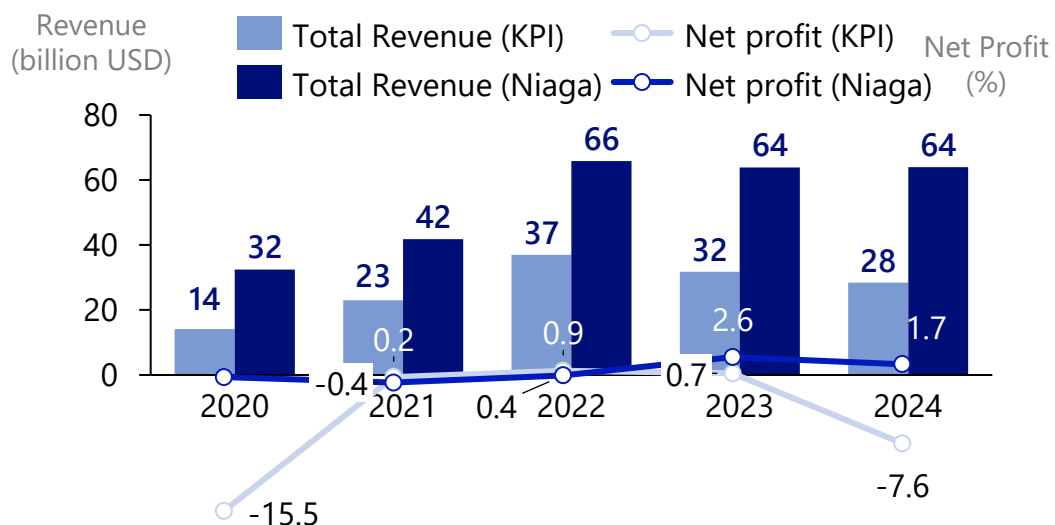
Company overview

Name	Pertamina (Persero), PT
Established year	1957
Country of origin	Indonesia
Major shareholder	Government of the Republic of Indonesia (100%)
Business overview	Pertamina is a state-owned, largest oil and gas producer in Indonesia. Pertamina is the leading domestic petroleum producer, producing an average of 556 thousand barrels of oil per day in 2024.
Key subsidiary company responsible for SAF	<ul style="list-style-type: none"> PT Kilang Pertamina International (KPI) <ul style="list-style-type: none"> Responsible for SAF processing and development Pertamina Patra Niaga (Niaga) <ul style="list-style-type: none"> Responsible for distributing SAF Pertamina New & Renewable Energy <ul style="list-style-type: none"> Responsible for development of new and renewable energy technology PT Pelita Air Service <ul style="list-style-type: none"> Airlines under Pertamina
Market share of SAF production volume in the country (%)	N/A (NRI's hypothesis: 100% (as of Oct, 2025))

Financial highlights (Pertamina (Persero), PT)



Financial highlights (Main subsidiaries*)



Note) *Among the key subsidiaries, the financial status of the two companies with the highest revenue is shown.

Source: Speeda, Pertamina, Bank Indonesia



Pertamina has been operating Cilacap Refinery, and also produced SAF has been utilized for the actual flights. Other refineries are to be operated in future.

Biorefinery facility overview

	Location	Capacity (k tonnes/year)	Technology	Feedstock	Operating year	Status
Total	4 plants	882.4	<ul style="list-style-type: none"> • Co-processing • HEFA • AtJ 	<ul style="list-style-type: none"> • UCO • POME • PFAD 	2032 or 2033	-
Current	TDHT Cilacap, Central Java (Phase-1)	5.6	<ul style="list-style-type: none"> • Co-processing 	<ul style="list-style-type: none"> • UCO (100%) 	2025 (Q2)	<ul style="list-style-type: none"> • The produced SAF has been shipped to CGK for the flight to DPS by Pelita Air
Future plan	Dumai, Riau	5.6	<ul style="list-style-type: none"> • Co-processing 	<ul style="list-style-type: none"> • UCO 	2026 (Q1)	<ul style="list-style-type: none"> • In evaluation to determine the capacity and pilot preparation phase (as of Aug, 2025)
	Balongan, West Java	5.6	<ul style="list-style-type: none"> • Co-processing 	<ul style="list-style-type: none"> • UCO 	2026 (Q4)	<ul style="list-style-type: none"> • In evaluation to determine the capacity and pilot preparation phase (as of Aug, 2025)
	Cilacap, Central Java (Green Refinery Cilacap)	224.8	<ul style="list-style-type: none"> • HEFA 	<ul style="list-style-type: none"> • UCO 	End of 2028 or early 2029	<ul style="list-style-type: none"> • Currently in an engineering design phase and will go into FID in 2026 • Already delayed 2 times
	Plaju, South Sumatra (Green Refinery Plaju)	640.8	Under consideration (AtJ, HEFA)	Under consideration (UCO, POME , PFAD, Sorghum)	2032 or 2033	<ul style="list-style-type: none"> • Currently planning and considering feedstock and pathway • The plan will be confirmed after the Green Refinery Cilacap starts operating to ensure it meets market demand.



Pertamina is considering next-generation SAF feedstock like POME, PFAD as the feedstock with highest potential, followed by Sorghum and Pongamia

Biorefinery facility overview

Feedstock sourcing

Main feedstock:

- Currently Pertamina is sourcing UCO from 2 sources
 - HORECA (Hotel, Restaurant, and Café/Catering), and hostel: This is the main source of UCO of Pertamina. Pertamina Patra Niaga, a subsidiary of Pertamina doing feedstock business, directly gathers UCO from these places and acts as the first hand in collecting and delivering to the refinery.
 - Household and small collectors via collecting spot at gas station: Pertamina Patra Niaga buys and collects UCO at Pertamina gas station (around 100 stations in Java Island) from smaller collectors and individuals then transport them to their own refinery
- In Cilacap, as part of the “Green Movement UCO” program, UCO collection from households and small businesses is being promoted. (e.g. collection boxes at gas stations, hospitals, and rental locations to collect UCO from households and restaurants.)

Experimental feedstock:

- Pertamina believe that there’s enough UCO for their SAF production until 2030-2032. After that when there are chances that the supply may not be enough, the company will expand to other type of feedstock e.g. POME and PFAD.
 - Pertamina is exploring POME as they believe that the POME industry is mature enough to provide feedstock as there are many palm plantation e.g. in Sumatra Island that can supply a lot of POME
 - However, Tripatra will operate refinery in Sumatra Island using POME as the main feedstock. So, Pertamina cannot fight for the same feedstock, so the company is prioritizing UCO over POME
- Alternative feedstock e.g. Sorghum and Pongamia oil is also another alternative, but Pertamina believes that now the industry is not mature enough to supply as SAF feedstock. And for Sorghum, it is mainly studied for bioethanol

Technology development

- **HEFA:** HEFA is still the top priority and main technology for green refinery in Cilacap, so it is Pertamina’s current priority
- **AtJ:** AtJ is under consideration as 2nd priority and as one of the pathway options for plant in the future because Indonesia also has ethanol production
- **E-SAF:** Pertamina would not say that it prioritize E-SAF at the moment, but the company is trying to explore the potential as seen in collaboration news with French company, MGH Energy

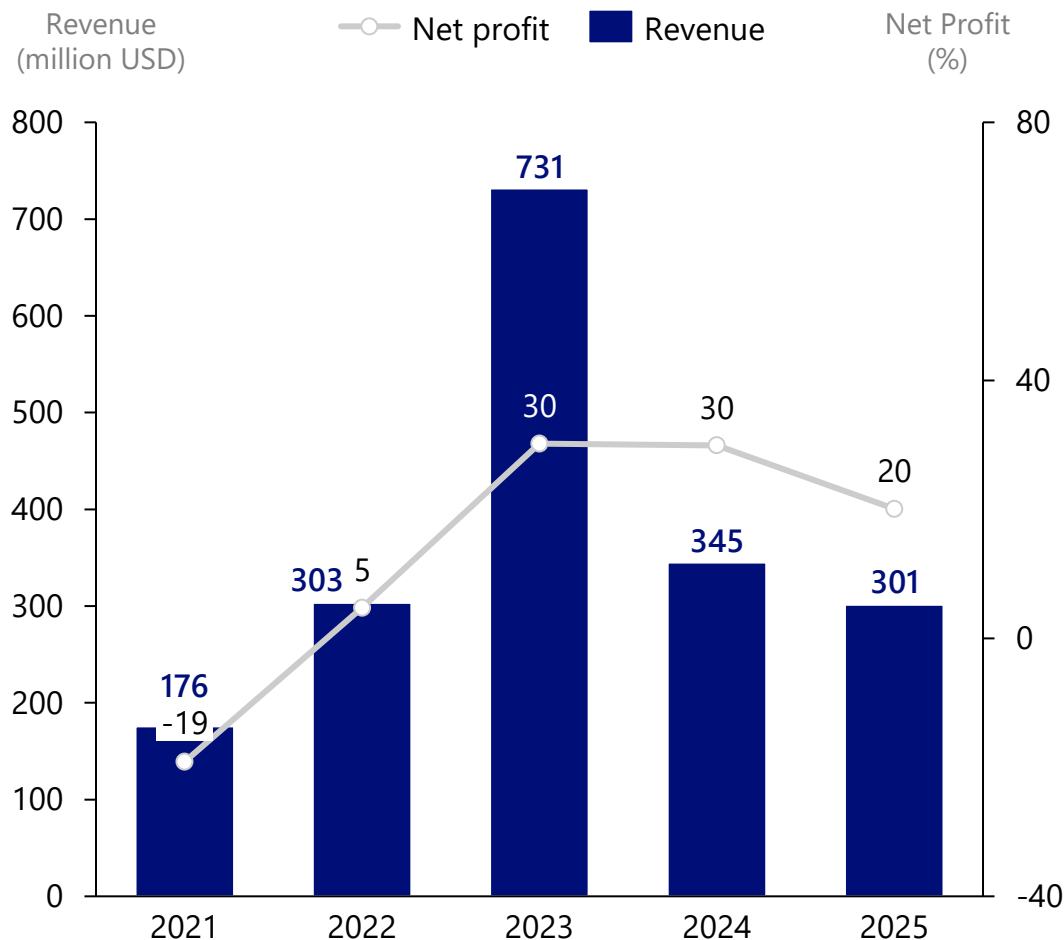


ESSA has announced its entry into the production of SAF, which aligns with the commitment to advancing Indonesia’s foray into clean energy solutions

Company overview

Name	PT Essa Industries Indonesia Tbk (old name: PT Surya Esa Perkasa Tbk)
Established year	2006
Country of origin	Indonesia
Major shareholder	Chander Vinod Laroya (16.38%) Garibaldi Thohir (14.55%) PT Akraya International (7.84%) Theodore Permadi Rachmat (7.16%)
Business overview	ESSA is a private company engaged in the energy and chemicals sector in Indonesia. It operates the country’s largest privately-owned domestic LPG (liquefied petroleum gas) refinery, with a capacity of 190 tons per day of LPG and 500 barrels per day of condensate.
Key subsidiary company responsible for SAF	<ul style="list-style-type: none"> PT ESSA SAF Makmur Responsible for SAF related activities
Market share of SAF production volume in the country (%)	N/A (NRI’s hypothesis: 0% (as of Oct, 2025))

Financial highlights of ESSA



Note) No financial data available for PT ESSA SAF Makmur



ESSA has announced its entry into the production of SAF; however, it is still in the initial stage and no detail information has not been disclosed.

Biorefinery facility overview

	Location	Capacity (k tonnes/year)	Technology	Feedstock	Operating year	Status
Total	1 plant	200	HEFA*	UCO*	-	-
Current	-	-	-	-	-	-
Future plan	Central Java	200	HEFA*	UCO*	2027 (Q4) -2028 (Q1)	<ul style="list-style-type: none"> In the internal planning stage including technology selection (as of Feb 4, 2025) ESSA aims to export the SAF produced by this refinery

Feedstock sourcing

- Technology selection including the feedstock is in the internal planning stage. (as of Feb 4, 2025)

Note *based on the interview results to Pertamina

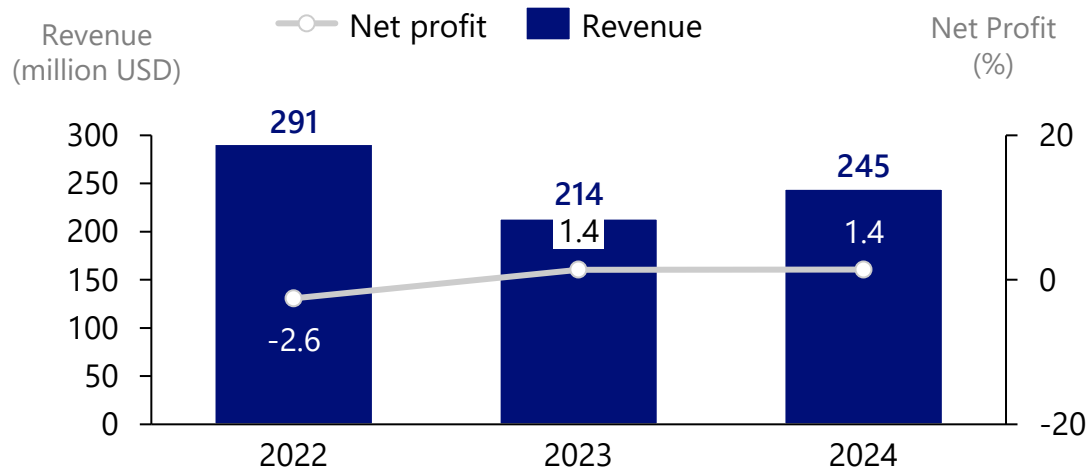


Tripatra has announced its entry into the production of SAF though conducting the feasibility study in 2024

Company overview

Name	Tripatra
Established year	1973
Country of origin	Indonesia
Major shareholder	Tripatra Multi Energu, PT (Private) (51.16%) PT Indika Energy Tbk (48.84%)
Business overview	Tripatra delivers engineering solutions for energy infrastructure, specializing in EPC, project management, and asset services. It emphasizes ethics, innovation, and agility, and collaborates with partners to advance sustainable, downstream-focused energy solutions.
Key subsidiary company responsible for SAF	Tripatra Engineers and Constructors, PT
Market share of SAF production volume in the country (%)	N/A (NRI's hypothesis: 0% (as of Oct, 2025))

Financial highlights of Tripatra



Financial highlights of Tripatra Engineers and Constructors, PT

No published information available regarding of financial performance of Tripatra



Tripatra will operate SAF refineries starting in 2028 onwards by collaboration with Shell Indonesia, however, the details have not been disclosed yet.

Biorefinery facility overview

	Location	Capacity (k tonnes/year)	Technology	Feedstock	Operating year	Status
Total	3 plants	240	• HEFA	• POME • UCO	2030	-
Current	-	-	-	-	-	-
Future plan	Sei Mangkei, North Sumatra	60	• HEFA	• POME • UCO	2028 (Q3/Q4)	<ul style="list-style-type: none"> • Technology will be by NextChem, an Italian engineering company • Currently running the front-end engineering design which should end by 2025 and then move to FID
	Kalimantan	60	-	• POME • UCO	2029	<ul style="list-style-type: none"> • To be constructed by collaboration with Shell Indonesia • Realizability has not been confirmed yet
	North Sumatra	60	-	-	2030	-
	North Sumatra or Kalimantan	60	-	• POME • UCO	2030	<ul style="list-style-type: none"> • To be constructed by collaboration with Shell Indonesia • Realizability has not been confirmed yet

Feedstock sourcing

- Details of feedstock sourcing is not published yet

Executive Summary

Chapter 1: Public Policy and Regulations

Chapter 2: Player Activity

Chapter 3: Supply/demand potential

Summary

Chapter 3-1: Demand Potential

Chapter 3-2: Supply Potential

Chapter 4: Needs by Local Players

Chapter 5: Export Potential to Japan

Appendix

Executive Summary

Chapter 1: Public Policy and Regulations

Chapter 2: Player Activity

Chapter 3: Supply/demand potential

Summary

Chapter 3-1: Demand Potential

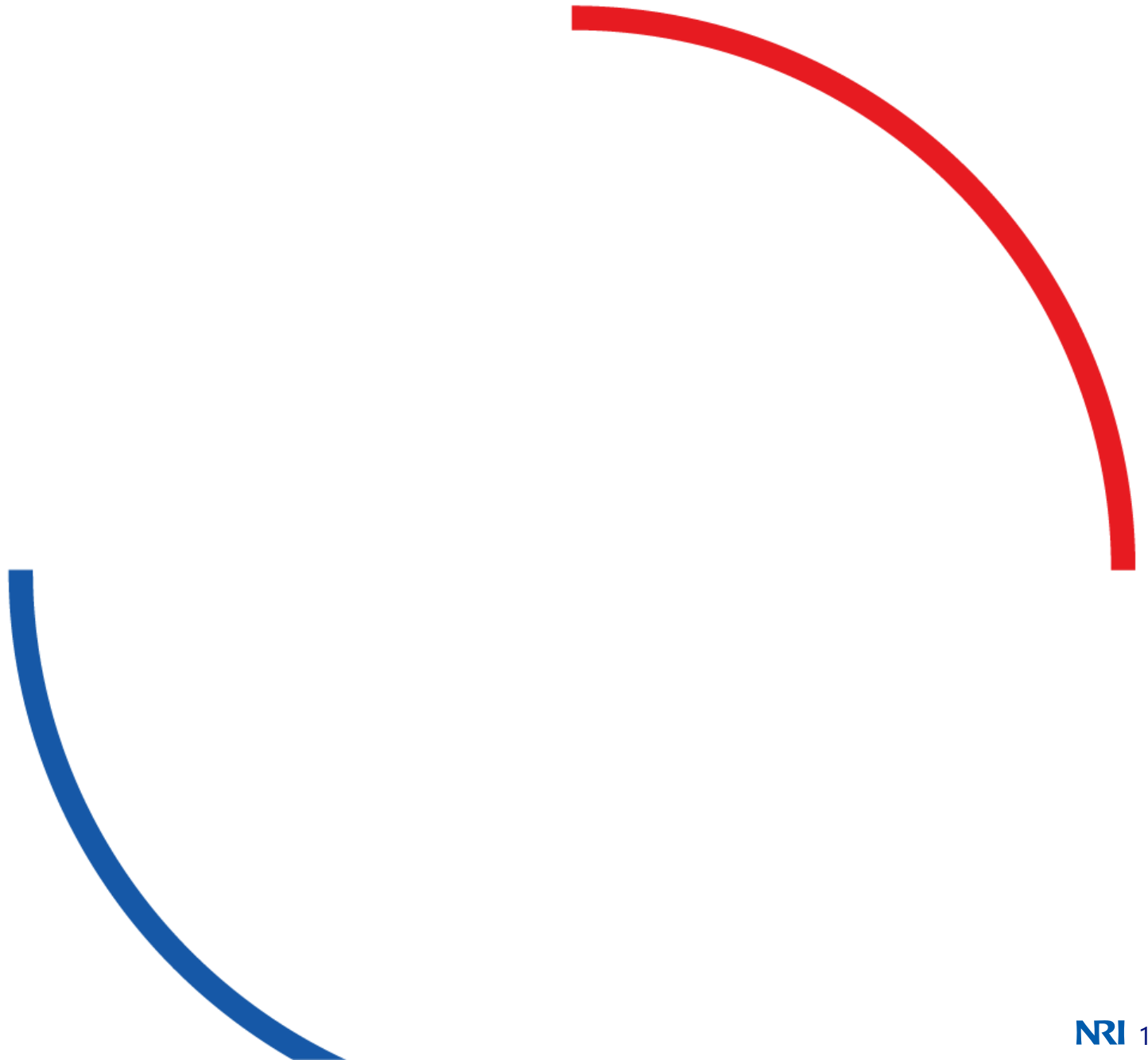
Chapter 3-2: Supply Potential

Chapter 4: Needs by Local Players

Chapter 5: Export Potential to Japan

Appendix

Key Findings



From a supply–demand perspective, the SAF market presents an attractive scale for Japanese companies seeking to participate in export-oriented projects

Key Questions and NRI's Outlook

Key Question

Are the demand and supply potential at an attractive level for Japanese companies to enter the market?

Fact (Desktop Research & Interviews)

Demand and Supply Capacity

- **Demand (Estimated for 2035)**
 - Singapore: 360–736 million liters
 - Malaysia: 18–159 million liters
 - Thailand: 384–687 million liters
 - Indonesia: 374 million liters (reference value)
- **Potential Supply Capacity (Estimated for 2035)**
 - Singapore: 3.3 billion liters (reference value)
 - Malaysia: 1.2–2.3 billion liters
 - Thailand: 421–496 million liters
 - Indonesia: 327 million–1.7 billion liters

Export potential

- In particular, both Singapore and Malaysia are expected to have supply capacities that significantly exceed their domestic demand. The surplus volumes are therefore anticipated to be directed toward exports. Local industry players are also considering Europe, the United States, and Japan as potential export destinations.

NRI's View

- In the SAF sector, supply capacity is expected to significantly exceed domestic demand. From the perspective of Japanese companies, the supply–demand potential is therefore at an attractive level for participating in export-oriented businesses targeting Japan, Europe, and the United States.

Summary of Chapter 3

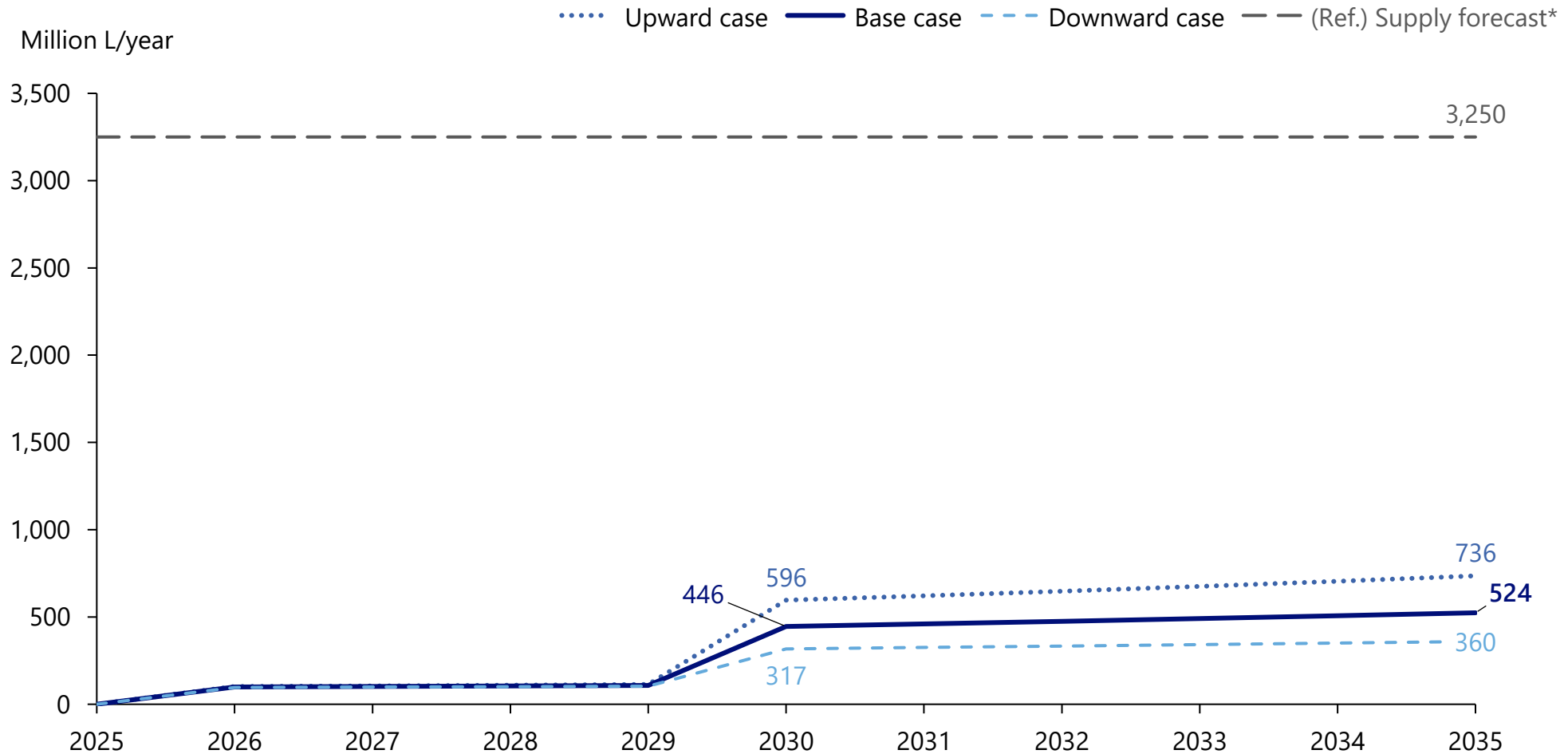




Supply and demand comparison | Singapore

In the target period, SAF demand will increase; however, demand will continue to be lower than supply, resulting in sufficient supply of SAF in domestic market

SAF demand and supply forecast in Singapore

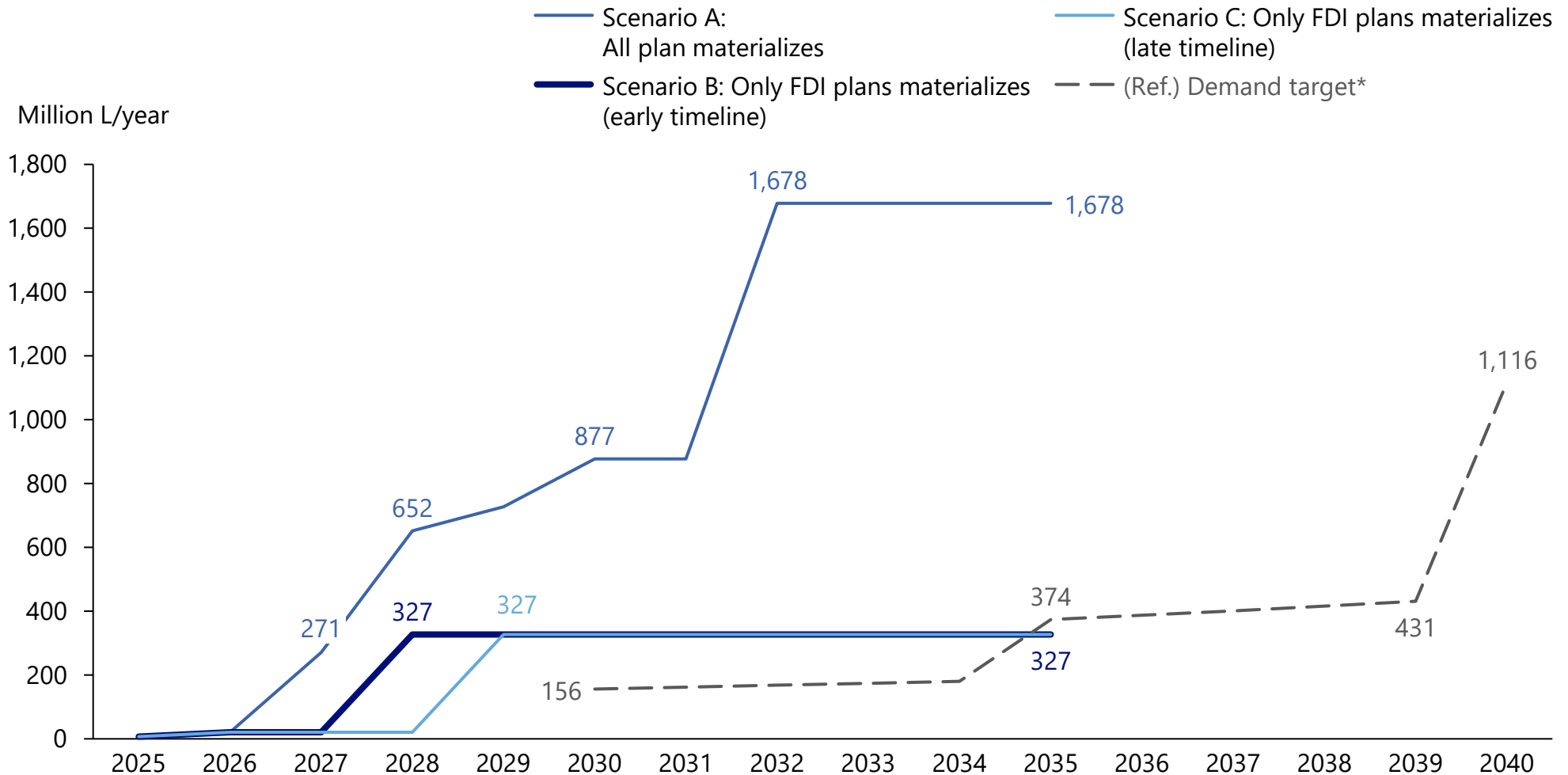


Note) * SAF supply forecast is based on the Neste's facility plan.



Although not many projects have completed FID, SAF supply will exceed the demand targets up to 2034 in scenario B&C

SAF demand and supply forecast in Indonesia

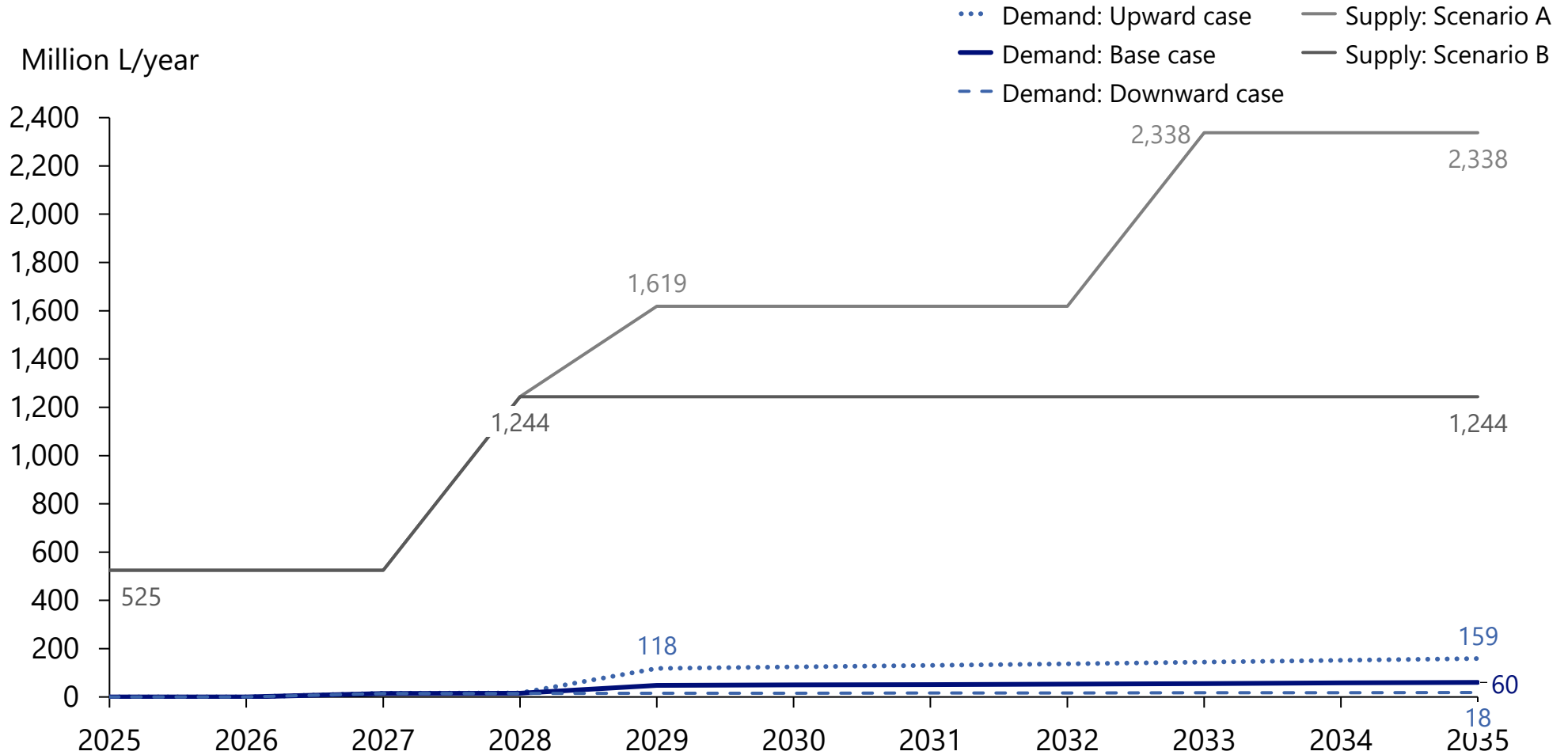


Note) * SAF demand target is referred to targets stated in "SAF Industry Development Roadmap"



In Malaysia, SAF supply exceeds demand significantly throughout the target period

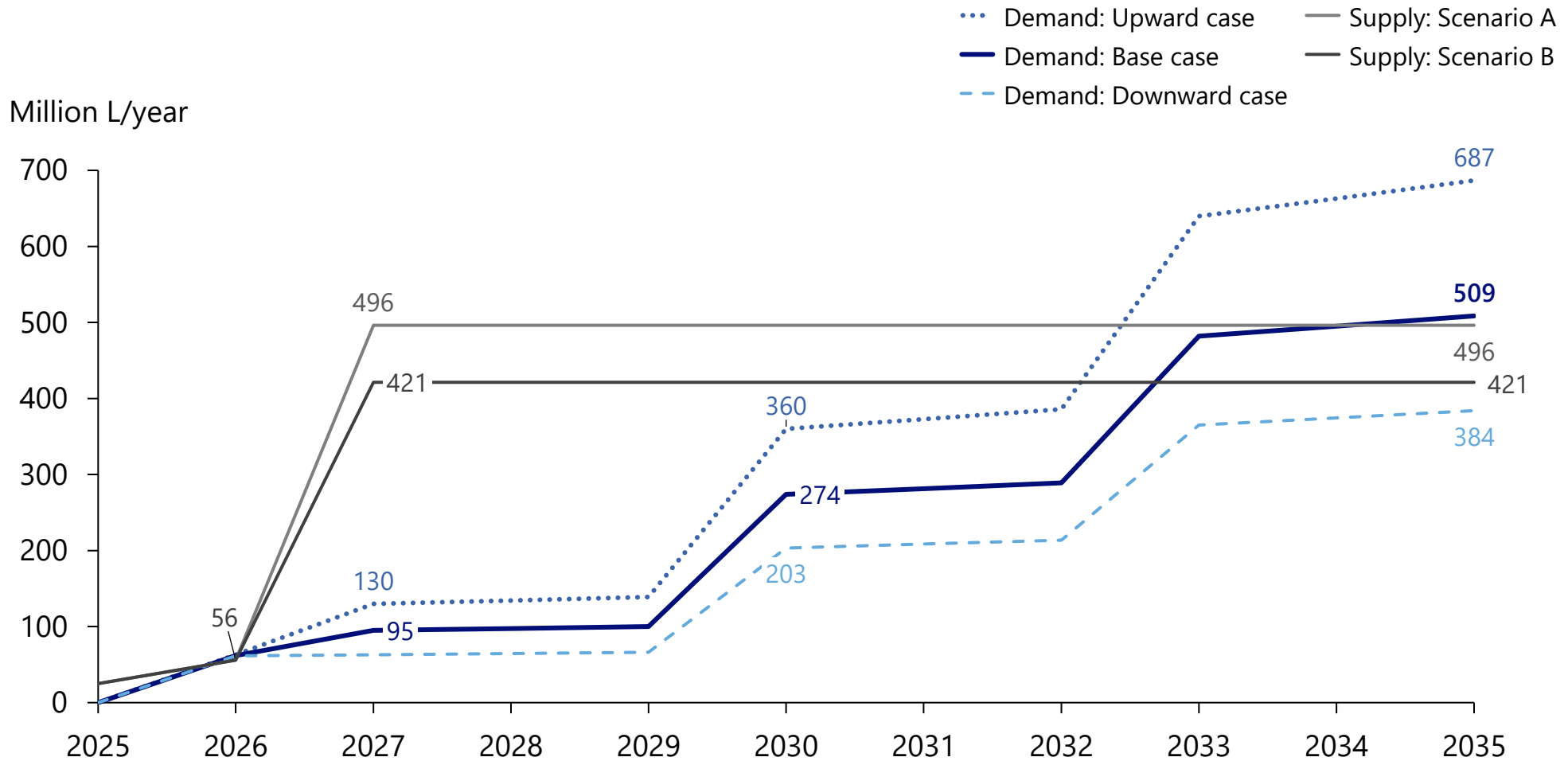
SAF demand and supply forecast in Malaysia





In Thailand, SAF demand will reach supply capacity in 2032-2034 except downward case of demand

SAF demand and supply forecast in Thailand

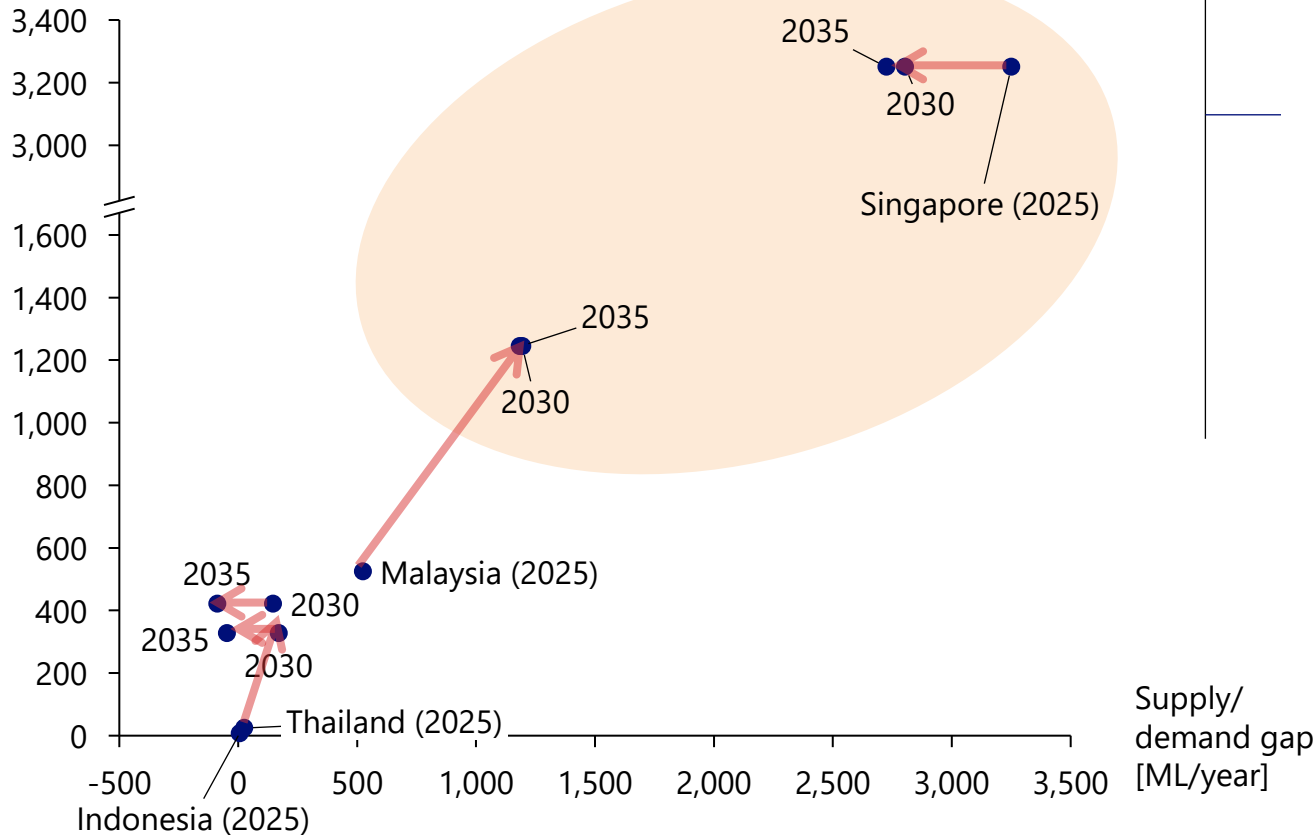


Supply/Demand Balance and Export Interest

Singapore's surplus supply capacity is the largest throughout the target years, whereas Malaysia's increases considerably among the target countries

Supply Capacity and Surplus of Supply Compared to Demand (2025, 2030, 2035)*

Supply capacity
[ML/year]



Singapore and Malaysia have high surplus for supply capacity, providing export opportunities to overseas countries including Japan

SAF will be produced specifically for export purpose for our company

Former Engineering Manager,
EcoCeres



Neste is exporting SAF, and has already exported SAF to EU and North America

Industry player associated and familiar
with Neste Singapore



Note) * "The surplus of supply capacity (supply/demand gap)" is calculated as "supply capacity (Scenario B) – demand capacity (Base case)"

Executive Summary

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Chapter 3-1: Demand Potential

Chapter 3-2: Supply Potential

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Appendix

Forecast Direction for Demand

Forecasts for the volume of SAF demand will be conducted leveraging desktop study and interviews to government and private companies

SAF demand forecast methodology (basic concept)

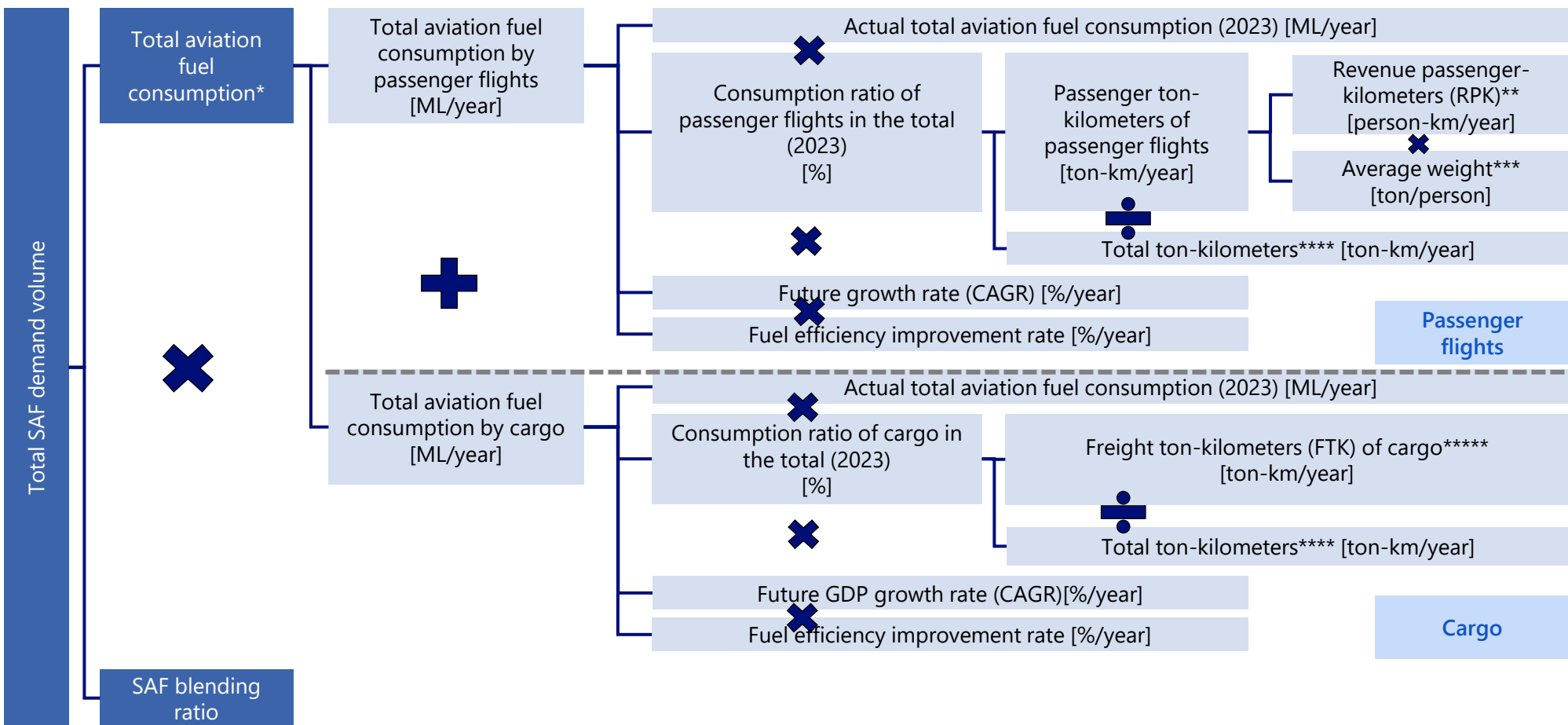
Definition	<ul style="list-style-type: none">• "Demand" is defined as "the annual volume which the users (e.g. aviation companies, airports) of SAF will use within the selected country".
Forecast direction	<ul style="list-style-type: none">• SAF demand is expected to be estimated by multiplying the "total aviation fuel consumption*" and the "Country's SAF blending ratio target*" <ul style="list-style-type: none">○ Calculate aviation fuel consumption for passenger and cargo flights based on "total aviation fuel consumption."○ Calculate the aviation fuel consumptions for passenger and cargo flights (2025–2035) by applying the respective future growth rate (CSGR) and aircraft fuel efficiency improvement rate to each consumption for passenger and cargo.○ Calculate total consumption by summing these figures.• As potential demand triggers, downward and upward impact towards components of the "total annual aviation fuel consumption" and "SAF blending ratio" will be considered
Unit	<ul style="list-style-type: none">• SAF volume: million litter/year (Value (e.g. USDXX) will not be estimated in the project)
Forecast duration	<ul style="list-style-type: none">• 2025-2035
Data source	<ul style="list-style-type: none">• Desktop study (e.g. government plans, news articles, etc.)• Interviews <ul style="list-style-type: none">○ Private companies: 1 interview for demand / country (Singapore, Malaysia, Thailand)○ Government: 1 interview / country (Singapore, Malaysia, Thailand)

Note: *The volume of aviation fuel consumed within a country

Source: NRI analysis

For Singapore and Thailand, SAF demand is calculated by multiplying “annual aviation fuel consumption” and “SAF blending ratio (international & domestic)”

SAF demand forecast calculation (logic)



Note) * Thailand and Singapore: both domestic and international flights, Malaysia: only international flights

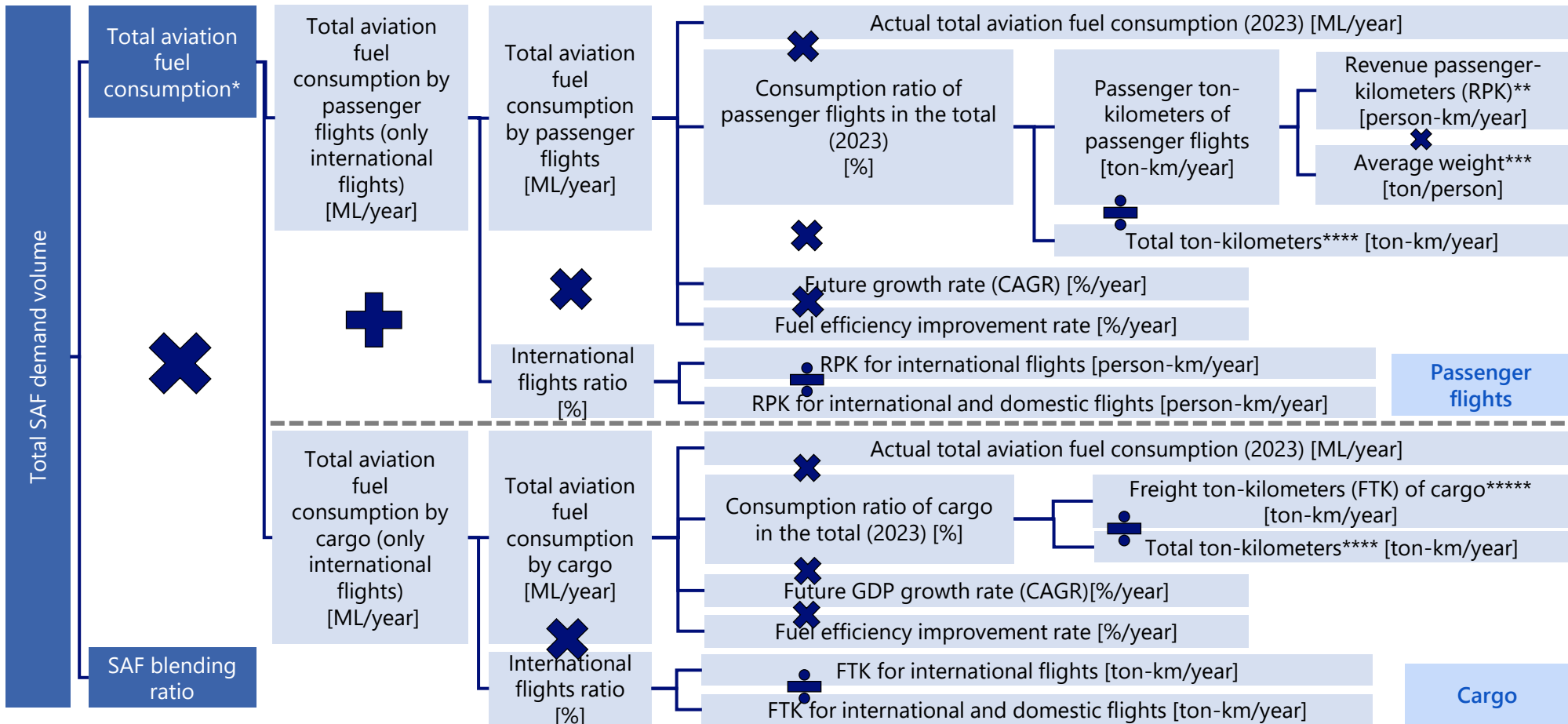
** RPK: Total travelled distance by total revenue passengers, *** Average weight: Total weight of each passenger and luggage,

**** "Total ton-kilometers" = "Passenger ton-kilometers of passenger flights" + "FTK", ***** FTK: Total transported distance by total freight weight

Source: NRI analysis

For Malaysia, SAF demand is calculated by multiplying “annual aviation fuel consumption” and “SAF blending ratio (only international flights)”

SAF demand forecast calculation (logic)



Note) * Thailand and Singapore: both domestic and international flights, Malaysia: only international flights

** RPK: Total travelled distance by total revenue passengers, *** Average weight: Total weight of each passenger and luggage,

**** "Total ton-kilometers" = "Passenger ton-kilometers of passenger flights" + "FTK", ***** FTK: Total transported distance by total freight weight

Source: NRI analysis



Demand forecasts are made utilizing reliable sources such as international organizations to the extent possible

SAF demand forecast calculation (sources of applied values)

		Item	Unit	Downward	Base	Upward	
Passenger flight	Actual total aviation fuel consumption (2023)	[ML/year]	Actual consumption in 2023 (Source: U.S. Energy Information Administration)				
	Revenue passenger-kilometers (RPK) (2023)	[person-km/year]	Actual RPK in 2023 (Source: ICAO)				
	Average weight	[ton/person]	Mean passenger weight for adults plus the carry-on luggage (Source: European Union Aviation Safety Agency)				
	Future growth rate (CAGR) (2023-2035)	[%/year]	Calculated based on published sources by NRI (Source: ICAO)	Calculated based on published sources by NRI (Source: data.gov.sg, The Straits Times)	Calculated based on published sources by NRI (Source: ICAO)		
	Fuel efficiency improvement rate	[%/year]	ICAO's target (Source: ICAO)	ICAO's prospective (Source: ICAO)			
	Actual total aviation fuel consumption	[ML/year]	Same as "Passenger flight"				
Cargo	Freight ton-kilometers (FTK) of cargo (2023)	[ton-km/year]	Actual FTK in 2023 (Source: ICAO)				
	Future GDP growth rate (CAGR) (2023-2035)	[%/year]	Calculated based on published sources by NRI (Source: DBS)	Calculated based on published sources by NRI (Source: DBS)	Calculated based on published sources by NRI (Source: DBS)		
	Fuel efficiency improvement rate	[%/year]	Same as "Passenger flight"				
	SAF blending ratio	[%]	National SAF targets stated in Singapore Sustainable Air Hub Blueprint (Source: CAAS)				
			Lowest target of 2030-35	Median target of 2030-35	Highest target of 2030-35		

Source: NRI analysis, EIA, ICAO, EASA, data.gov.sg, The Straits Times, DBS, CAAS, Aviation Benefits



Demand forecasts are calculated based on listed numbers, and the reliability of numbers will be validated based on further interviews

SAF demand forecast calculation (applied values)

	Item	Unit	Downward	Base	Upward
Passenger flight	Actual total aviation fuel consumption (2023)	[ML/year]	8,995.425 ML/year* (155 K barrel/day)		
	Revenue passenger-kilometers (RPK) (2023)	[persons-km/year]	165,637,000,000 persons-km/year		
	Average weight	[ton/person]	0.084 ton/person		
	Future growth rate (CAGR) (2023-2035)	[%/year]	5.68%/year (x -3.45% of base**)	5.88%/year**	7.10%/year (x +20.69% of base**)
	Fuel efficiency improvement rate	[%/year]	98.00 %/year (100-2.00 %/year)	98.47 (100-1.53 %/year)	
Cargo	Actual total aviation fuel consumption	[ML/year]	Same as "Passenger flight"		
	Freight ton-kilometers (FTK) of cargo (2023)	[ton-km/year]	7,604,000,000 ton-km/year		
	Future GDP growth rate (CAGR) (2023-2035)	[%/year]	1.92 %/year (x -20.00% of base**)	2.40 %/year**	2.88 %/year (x +20.00% of base**)
	Fuel efficiency improvement rate	[%/year]	Same as "Passenger flight"		
SAF blending ratio		[%]	2025: 0%, 2026-2029: 1% 2030-2035: 3%	2025: 0%, 2026-2029: 1% 2030-2035: 4%	2025: 0%, 2026-2029: 1% 2030-2035: 5%

Note) * Calculated based on "1 barrel=159L" and "1 year=365days"

** Refer to Appendix of this section

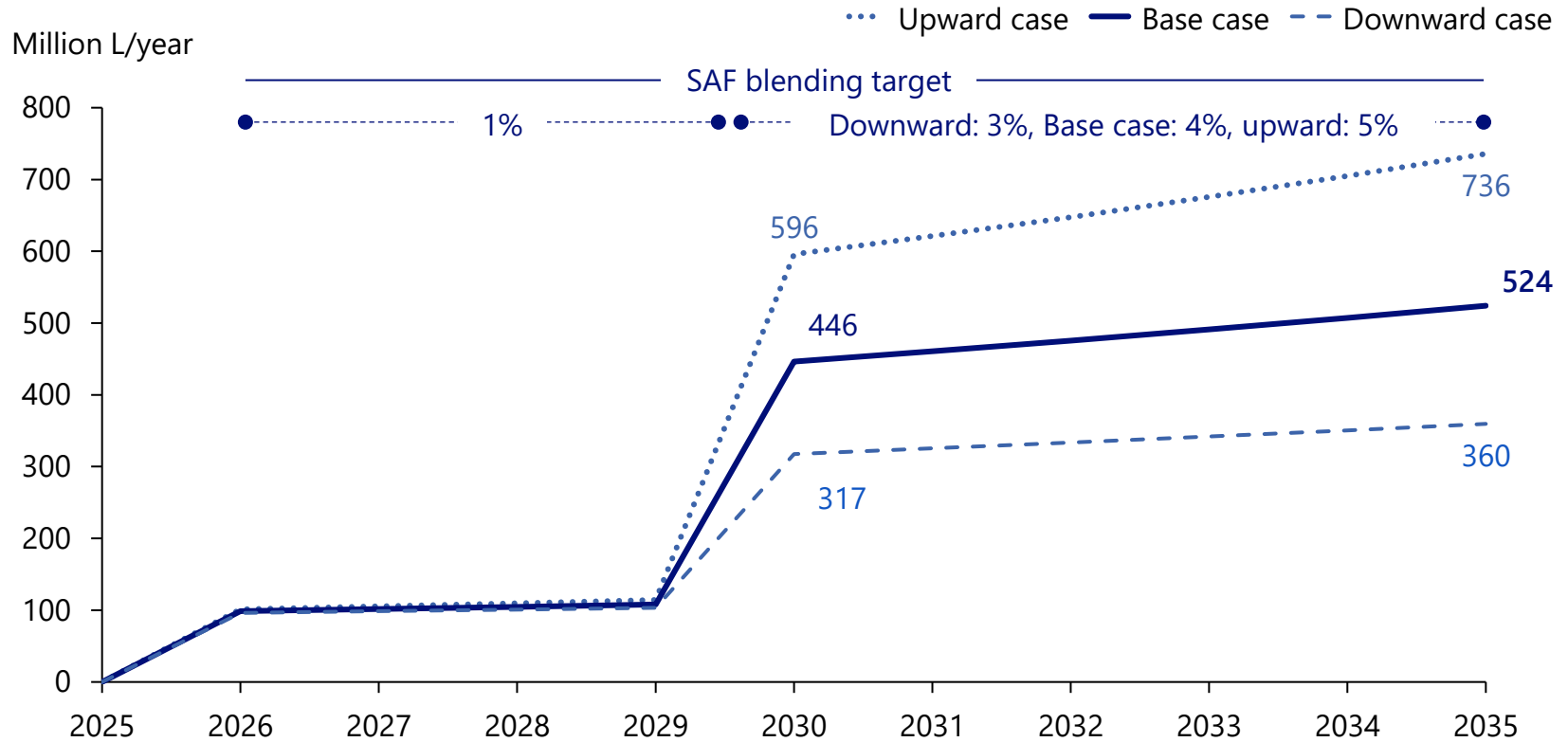
Source: NRI analysis, EIA, ICAO, EASA, data.gov.sg, The Straits Times, DBS, CAAS, Aviation Benefits

Beyond Borders



In Singapore, the SAF blending targets will increase to 3-5% during the target period, leading to increase in the SAF demand volume

SAF demand forecast in Singapore



Upward case	0	81	84	88	91	477	497	518	540	564	589
Base case	0	79	81	84	86	357	368	380	393	406	419
Downward case	0	77	79	81	83	254	260	267	273	280	288

Note) * Converted based on "1ton=1,250L"



Demand forecasts are made utilizing reliable sources such as international organizations to the extent possible

SAF demand forecast calculation (sources of applied values)

	Item	Unit	Downward	Base	Upward
Passenger flight	Actual total aviation fuel consumption (2023)	[ML/year]	Actual consumption in 2023 (Source: U.S. Energy Information Administration)		
	International flights ratio (2023)	[%]	RPK for international flights / RPK for both international and domestic flights in 2023 (Source: ICAO)		
	Revenue passenger-kilometers (RPK) (2023)	[person-km/year]	Actual RPK in 2023 (Source: ICAO)		
	Average weight	[ton/person]	Mean passenger weight for adults plus the carry-on luggage (Source: European Union Aviation Safety Agency)		
	Future growth rate (CAGR) (2023-2035)	[%/year]	Calculated based on published sources by NRI (Source: ICAO)	Calculated based on published sources by NRI (Source: Malaysia Airports and MAVCOM etc.)	Calculated based on published sources by NRI (Source: ICAO)
	Fuel efficiency improvement rate	[%/year]	ICAO's target (Source: ICAO)	ICAO's prospective (Source: ICAO)	
Cargo	Actual total aviation fuel consumption	[ML/year]	Same as "Passenger flight"		
	International flights ratio (2023)	[%]	FTK for international flights / FTK for both international and domestic flights in 2023 (Source: ICAO)		
	Freight ton-kilometers (FTK) of cargo (2023)	[ton-km/year]	Actual FTK in 2023 (Source: ICAO)		
	Future GDP growth rate (CAGR) (2023-2035)	[%/year]	Calculated based on published sources (NIMP 2030*) by NRI (Source: Ministry of Investment, Trade and Industry)	Calculated based on published sources by NRI (Source: Ministry of Economy etc.)	Calculated based on published sources (NIMP 2030*) by NRI (Source: Ministry of Investment, Trade and Industry)
	Fuel efficiency improvement rate	[%/year]	Same as "Passenger flight"		
	SAF blending ratio	[%]	National Energy Transition Roadmap (NETR) and Civil Aviation Authority of Malaysia (CAAM) (Source: Ministry of Economy, Interview)		

Note: *NIMP 2030 (New Industrial Master Plan 2030)

Source: NRI analysis, EIA, ICAO, EASA, Malaysia Airports, MAVCOM, ReportLinker, Ministry of Economy (Department of Statistics Malaysia), malaymail, Ministry of Investment, Trade and Industry, NETRA



Demand forecasts are calculated based on listed numbers, and the reliability of numbers will be validated based on further interviews

SAF demand forecast calculation (applied values)

	Item	Unit	Downward	Base	Upward
Passenger flight	Actual total aviation fuel consumption (2023)	[ML/year]	1,616.275 ML/year* (27.9 K barrel/day)		
	International flights ratio (2023)	[%]	78% (= 62,848,000,000/80,759,000,000)		
	Revenue passenger-kilometers (RPK) (2023)	[persons-km/year]	62,848,000,000 persons-km/year		
	Average weight	[ton/person]	0.084 ton/person		
	Future growth rate (CAGR) (2023-2035)	[%/year]	5.82 %/year (x -3.45% of base**)	6.03 %/year** (2023-2028)	7.28 %/year (x +20.69% of base**)
	Fuel efficiency improvement rate	[%/year]	98.00 %/year (100-2.00 %/year)	98.47 (100-1.53 %/year)	
Cargo	Actual total aviation fuel consumption	[ML/year]	Same as "Passenger flight"		
	International flights ratio (2023)	[%]	79% (= 1,506,000,000/1,910,000,000)		
	Freight ton-kilometers (FTK) of cargo (2023)	[ton-km/year]	1,506,000,000 ton-km/year		
	Future GDP growth rate (CAGR) (2023-2035)	[%/year]	3.42 %/year (x -10.00% of base**)	3.80 %/year** (2023-2035)	4.18 %/year (x +10.00% of base**)
	Fuel efficiency improvement rate	[%/year]	Same as "Passenger flight"		
SAF blending ratio		[%]	2025: 0%, 2026-2028: 1% 2029-2035: 1%	2025: 0%, 2026-2028: 1% 2029-2035: 3%	2025: 0%, 2026-2028: 1% 2029-2035: 7%

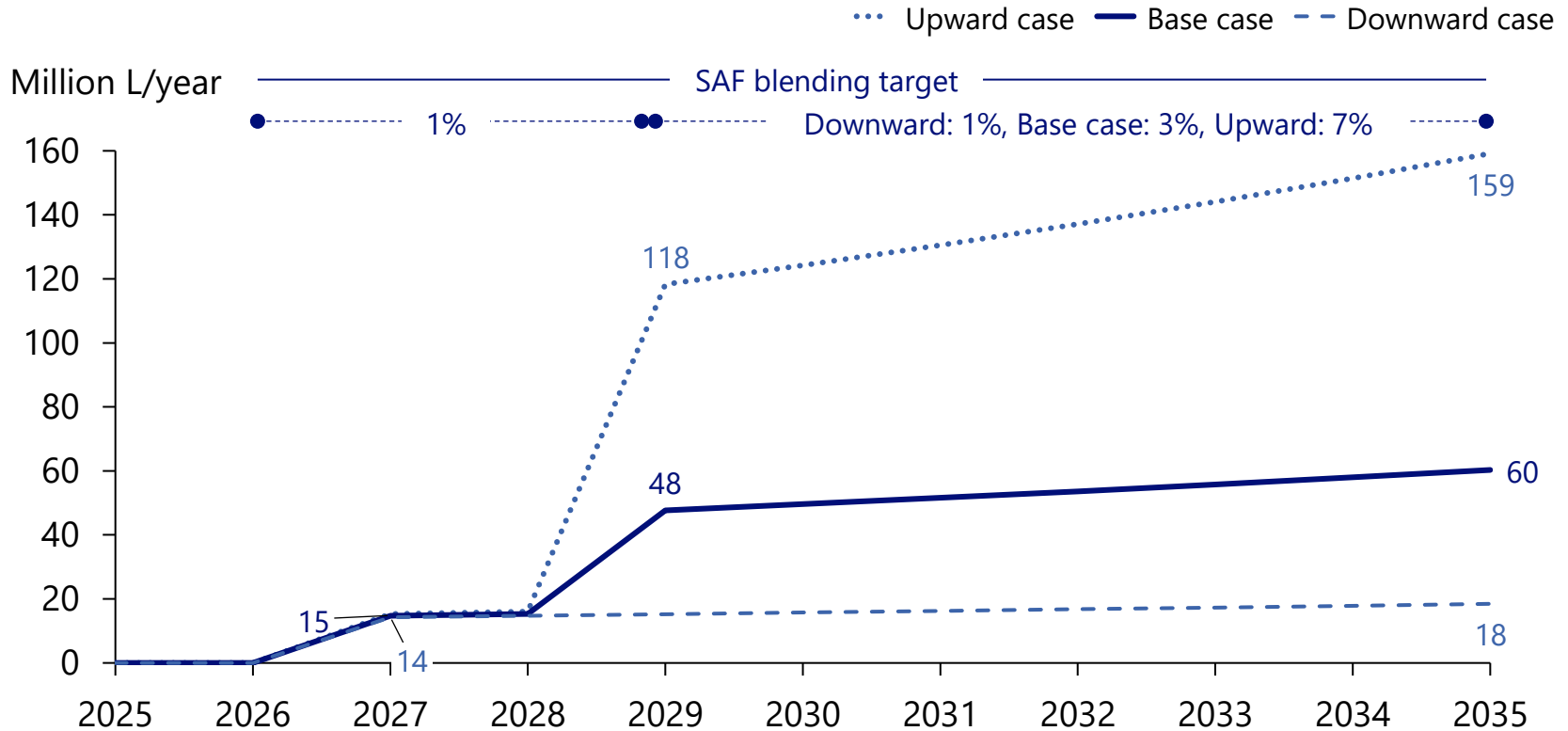
Note) * Calculated based on "1 barrel=159L" and "1 year=365days"

** Refer to Appendix of this section



In Malaysia, the SAF blending target is 1%, which is low during the target period; therefore, demand volume remains low

SAF demand forecast in Malaysia



Unit: K ton/year*

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Upward case	0	0	15	16	118	124	131	137	144	151	159
Base case	0	0	12	12	38	40	41	43	45	46	48
Downward case	0	0	11	12	12	13	13	13	14	14	15

Note) * Converted based on "1ton=1,250L"



Demand forecasts are made utilizing reliable sources such as international organizations to the extent possible

SAF demand forecast calculation (sources of applied values)

		Item	Unit	Downward	Base	Upward
Passenger flight	Actual total aviation fuel consumption (2023)	[ML/year]	Actual consumption in 2023 (Source: Department of Alternative Energy Development and Efficiency (DEDE))			
	Revenue passenger-kilometers (RPK) (2023)	[person-km/year]	Actual RPK in 2023 (Source: ICAO)			
	Average weight	[ton/person]	Mean passenger weight for adults plus the carry-on luggage (Source: European Union Aviation Safety Agency)			
	Future growth rate (CAGR) (2023-2035)	[%/year]	Calculated based on published sources by NRI (Source: ICAO)	Calculated based on data of IATA, AOT and DOA (Source: NRI's calculation)	Calculated based on published sources by NRI (Source: ICAO)	
	Fuel efficiency improvement rate	[%/year]	ICAO's target (Source: ICAO)	ICAO's prospective (Source: ICAO)		
Cargo	Actual total aviation fuel consumption	[ML/year]	Same as "Passenger flight"			
	Freight ton-kilometers (FTK) of cargo (2023)	[ton-km/year]	Actual FTK in 2023 (Source: ICAO)			
	Future GDP growth rate (CAGR) (2023-2035)	[%/year]	Calculated based on published sources by NRI (Source: OECD)	Calculated based on published sources by NRI (Source: Bank of Thailand and OECD)	Same fluctuated range with downward case	
	Fuel efficiency improvement rate	[%/year]	Same as "Passenger flight"			
SAF blending ratio		[%]	(Draft) Oil Plan 2024 –2037, News article, Interview			



Demand forecasts are calculated based on listed numbers, and the reliability of numbers will be validated based on further interviews

SAF demand forecast calculation (applied values)

	Item	Unit	Downward	Base	Upward
Passenger flight	Actual total aviation fuel consumption (2024)*	[ML/year]	5,864 ML/year		
	Revenue passenger-kilometers (RPK) (2023)	[persons-km/year]	85,750,000,000 persons-km/year		
	Average weight	[ton/person]	0.084 ton/person		
	Future growth rate (CAGR) (2023-2035)	[%/year]	4.61%/year (x -3.45% of base**)	4.77 %/year** (2023-2035)	5.76%/year (x +20.69% of base**)
	Fuel efficiency improvement rate	[%/year]	98.00 %/year (100-2.00 %/year)	98.47 (100-1.53 %/year)	
Cargo	Actual total aviation fuel consumption	[ML/year]	Same as "Passenger flight"		
	Freight ton-kilometers (FTK) of cargo (2023)	[ton-km/year]	1,650,000,000 ton-km/year		
	Future GDP growth rate (CAGR) (2023-2035)	[%/year]	1.37 %/year (x -15.15% of base*****)	1.62 %/year**** (2023-2035)	1.87%/year (x +15.15% of base*****)
	Fuel efficiency improvement rate	[%/year]	Same as "Passenger flight"		
	SAF blending ratio	[%]	2025: 0%, 2026: 1%, 2027-2029: 1% 2030-2032: 3%, 2033-2035: 5%	2025: 0%, 2026: 1%, 2027-2029: 1.5% 2030-2032: 4%, 2033-2035: 6.5%	2025: 0%, 2026: 1%, 2027-2029: 2% 2030-2032: 5%, 2033-2035: 8%

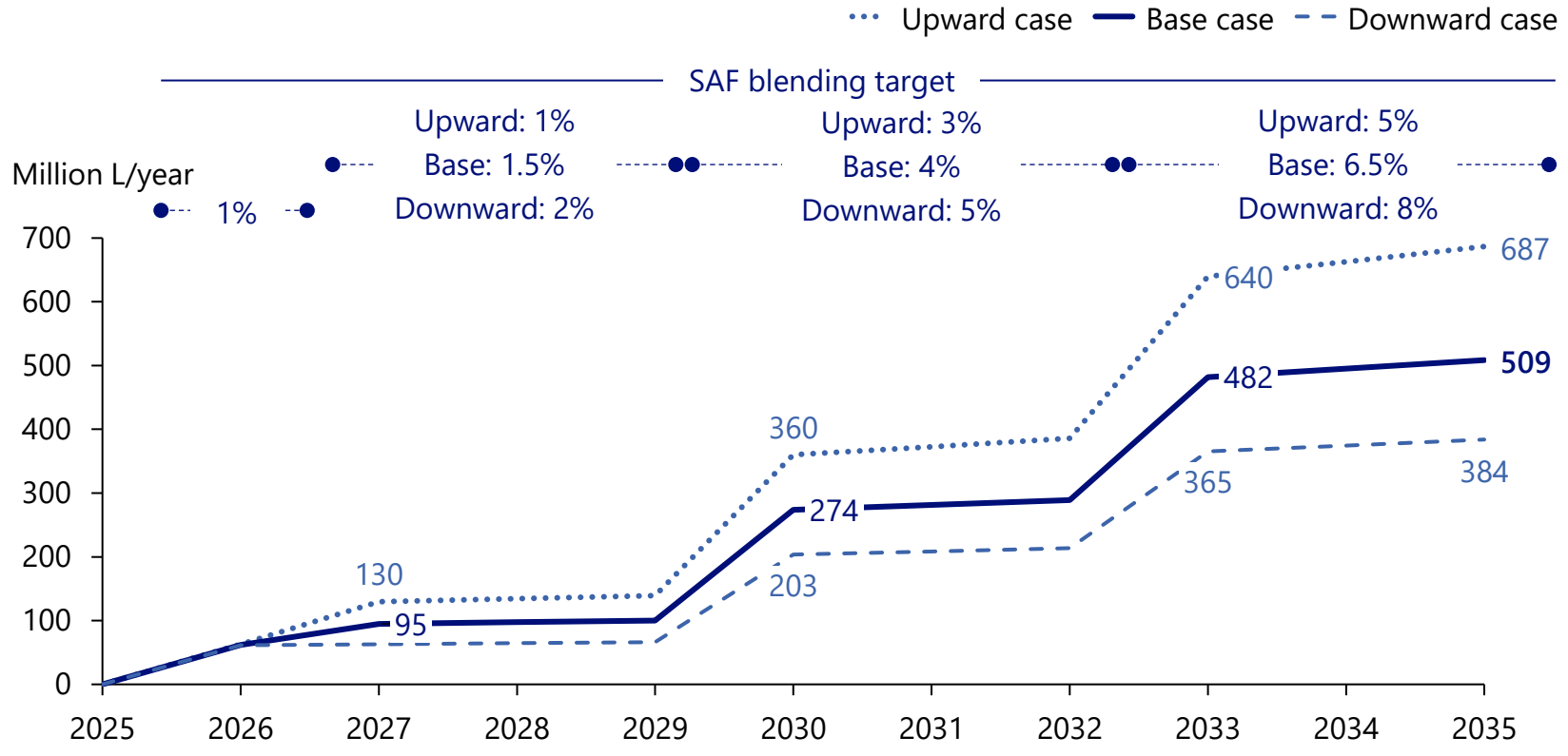
Note) * Calculated based on "1 barrel=159L" and "1 year=365days"

** Refer to Appendix of this section



In Thailand, the SAF blending targets will increase to 8% during the target period, leading to increase in the SAF demand volume

SAF demand forecast in Thailand



Unit: K ton/year*

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Upward case	0	50	104	107	111	288	298	309	512	530	549
Base case	0	49	76	78	80	219	225	231	386	396	407
Downward case	0	49	50	52	53	163	167	171	292	300	307

Note) * Converted based on "1ton=1,250L"

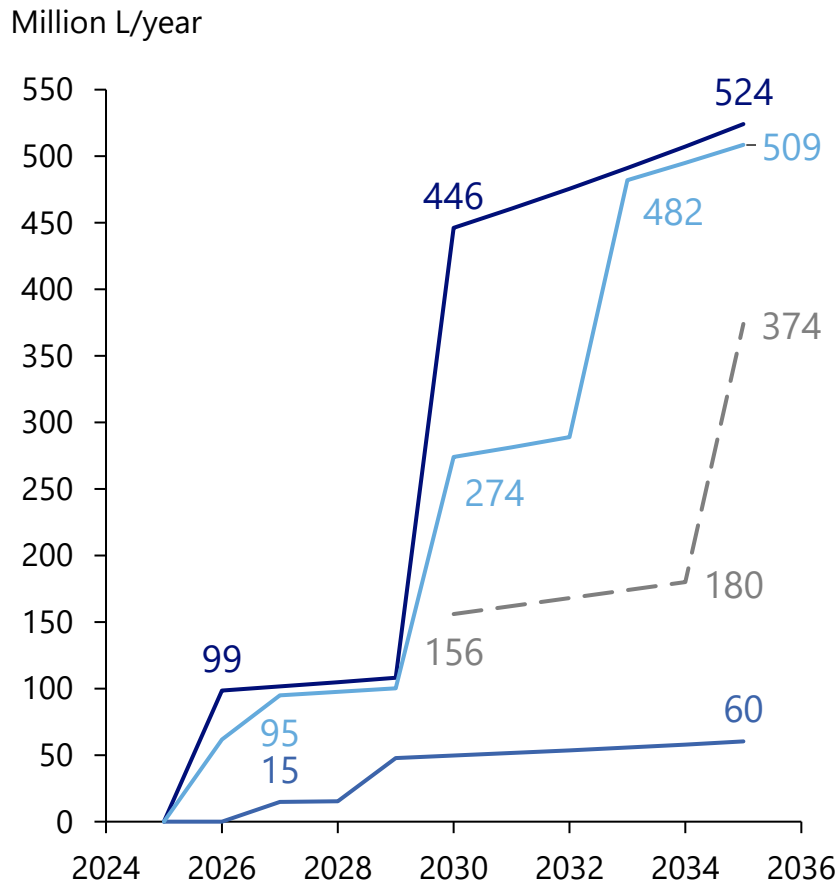
Demand Forecast

In all three cases, SAF demand of Singapore and Thailand are larger than Malaysia during 2025-2035

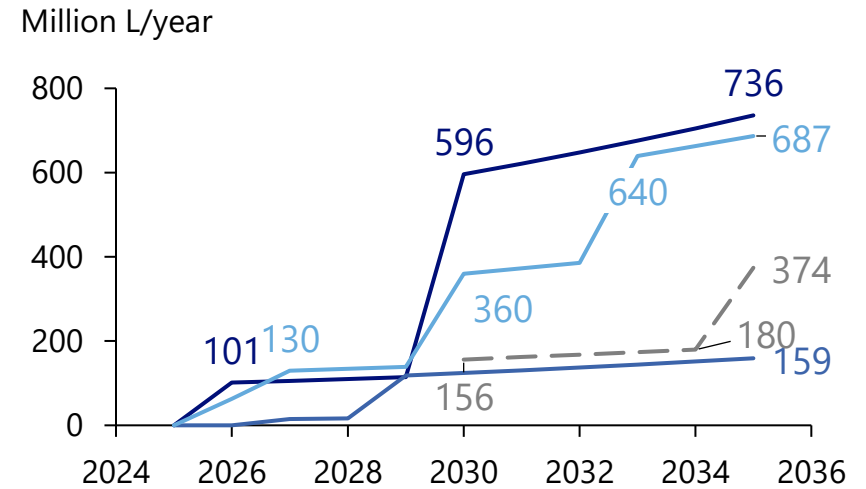
SAF demand forecast in 3 countries

— Singapore — Thailand
— Malaysia — (Ref.) Indonesia

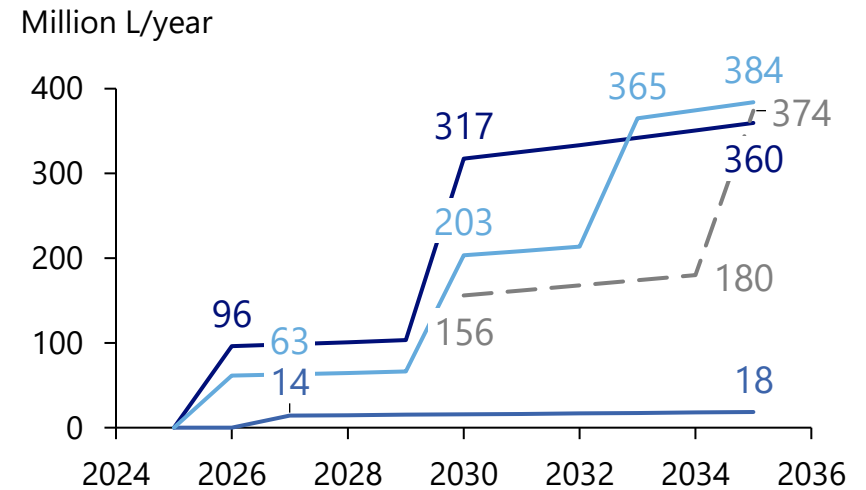
Base case



Upward



Downward



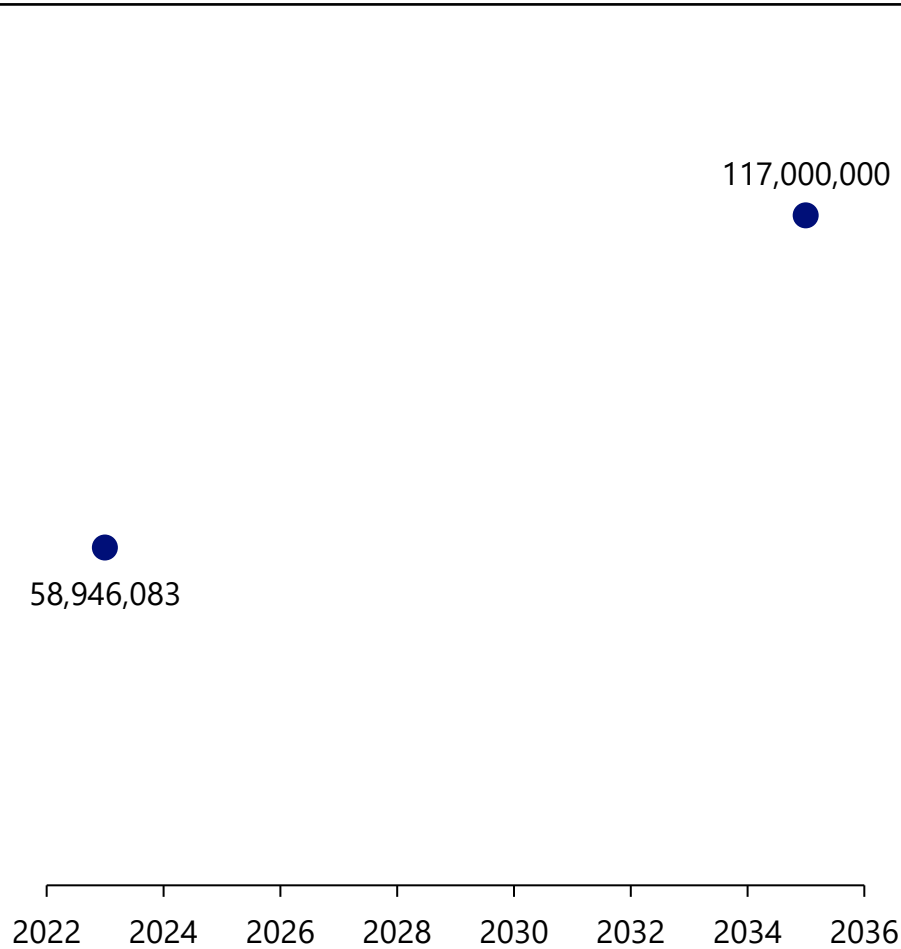


CAGR of passenger numbers was calculated as 5.88% based on actual passenger numbers in 2023 and future forecast numbers in 2035

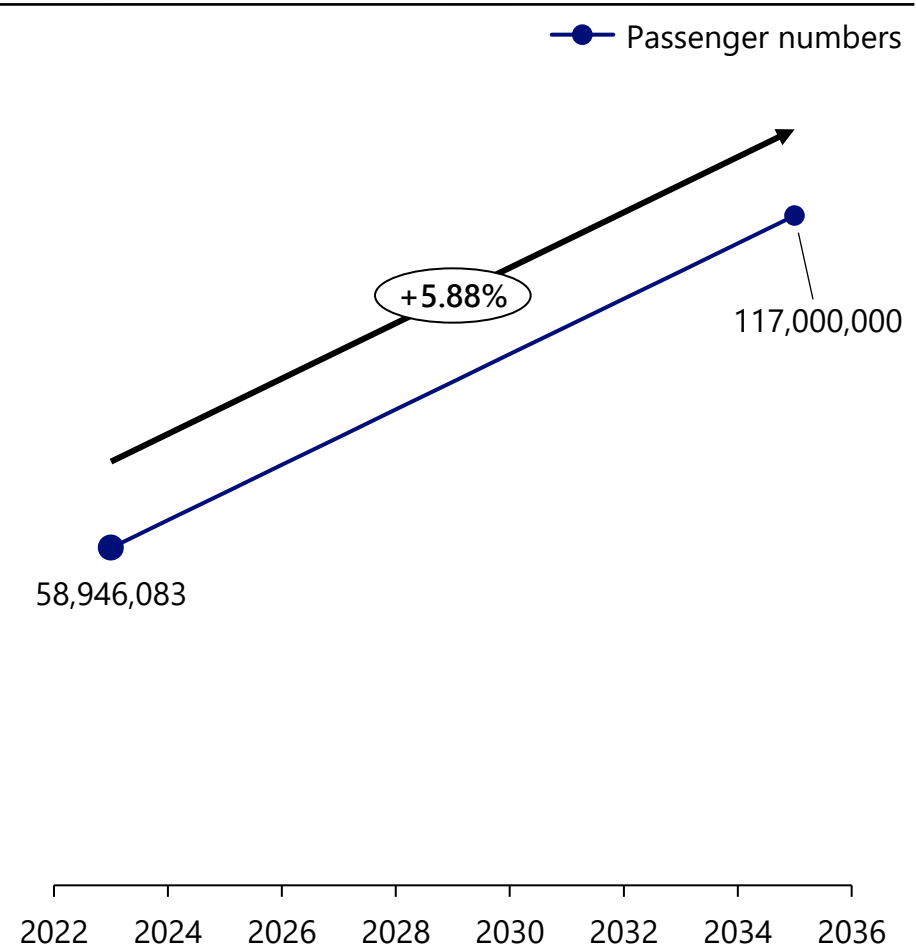
Future growth rate of passenger numbers (base case)

Unit: People

Actual data



Calculation results



Upward and downward CAGRs of passenger numbers were calculated as 7.10% and 5.68%, respectively, by considering RPK deviation between 2019-2050

Future growth rate of passenger numbers (downward and upward)

Step	Description	Calculation Method
Step 1	<ul style="list-style-type: none"> Calculation of Singapore's base case RPK CAGR in 2023-2035 	<ul style="list-style-type: none"> Calculate Singapore's base case RPK CAGR (See slide 189) <ul style="list-style-type: none"> Base case: 5.88%
Step 2	<ul style="list-style-type: none"> Calculation of deviation based on the RPK CAGR (2019-2050) <ul style="list-style-type: none"> Upward: 3.50% ("2021 Baseline: High" of "North Asia - Pacific South East Asia") Base case: 2.90% ("2021 Baseline: Mid" of "North Asia - Pacific South East Asia") Downward: 2.80% ("2021 Baseline: Low" of "North Asia - Pacific South East Asia") 	<ul style="list-style-type: none"> Calculate the deviation from the base case by division <ul style="list-style-type: none"> Upward deviation: 20.69% ($=3.50/2.90-1$) Downward deviation: -3.45% ($=2.80/2.90-1$)
Step 3	<ul style="list-style-type: none"> Calculation of upward and downward RPK CAGRs 	<ul style="list-style-type: none"> Calculate upward and downward CAGRs by multiplying the deviation calculated in Step 2 with Singapore's base case CAGR. <ul style="list-style-type: none"> Upward CAGR: 7.10% ($=5.88\% \times (1+20.69\%)$) Downward CAGR: 5.68% ($=5.88\% \times (1-3.45\%)$)

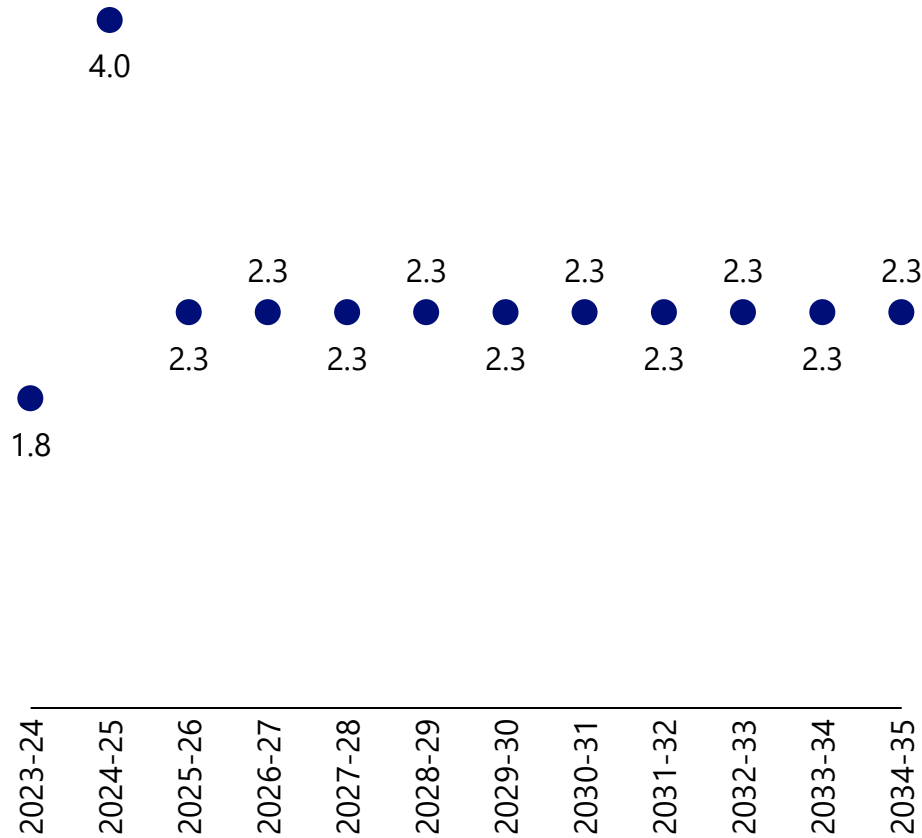


GDP growth rate was calculated as 2.40% based on the average of GDP growth rate between 2023 and 2035

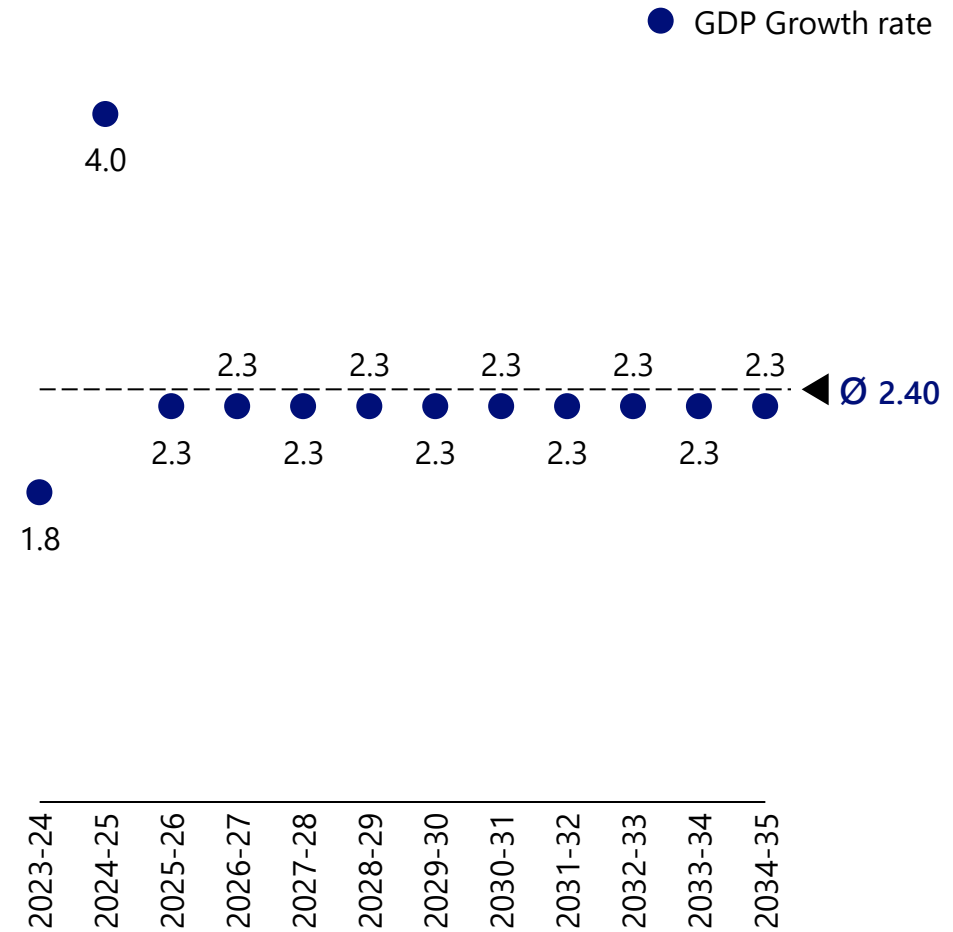
Future GDP growth rate (base case)

Unit: %

Actual data



Calculation results



Upward and downward GDP growth rates were calculated as 2.87% and 1.91%, respectively, by considering deviation of government targets

GDP growth rate (downward and upward)

Step	Description	Calculation Method
Step 1	<ul style="list-style-type: none"> Calculation of Singapore's base case GDP growth rate in 2023-2035 	<ul style="list-style-type: none"> Calculate Singapore's base case GDP growth rate (See slide 191) <ul style="list-style-type: none"> Base case: 2.40%
Step 2	<ul style="list-style-type: none"> Calculation of deviation based on the Singapore government's GDP growth rate target (2-3%/year) <ul style="list-style-type: none"> Upward: 3.0% Base case: 2.5% (The base case value was set as the median value of the range.) Downward: 2.0% 	<ul style="list-style-type: none"> Calculate the deviation from the base case by division <ul style="list-style-type: none"> Upward deviation: 20.0% ($=3.0/2.5-1$) Downward deviation: -20.0% ($=2.0/2.5-1$)
Step 3	<ul style="list-style-type: none"> Calculation of upward and downward GDP growth rates 	<ul style="list-style-type: none"> Calculate upward and downward GDP growth rates by multiplying the deviation calculated in Step 2 with Singapore's base case GDP growth rate <ul style="list-style-type: none"> Upward CAGR: 2.87% ($=2.40\% \times (1+20.0\%)$) Downward CAGR: 1.92% ($=2.40\% \times (1-20.0\%)$)

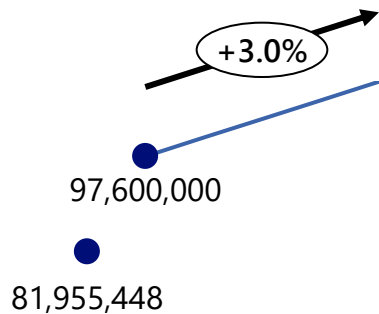


CAGR of passenger numbers was calculated as 6.03% based on actual passenger numbers in 2023 and 2024 and forecast CAGR between 2024 and 2028

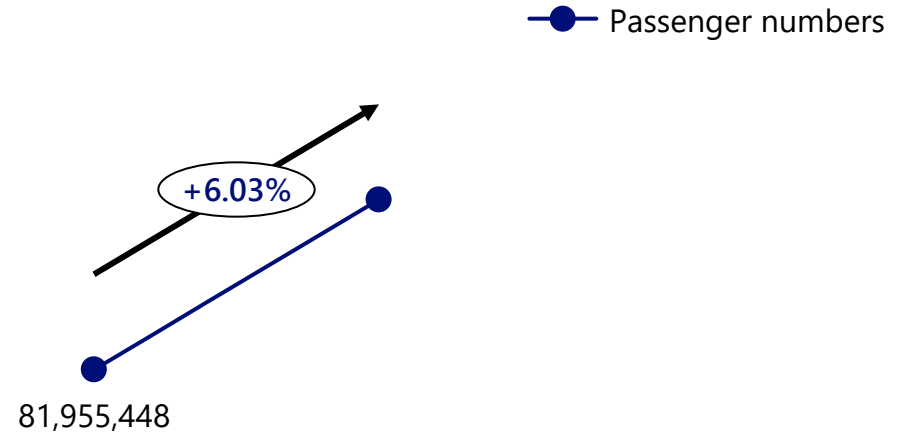
Future growth rate of passenger numbers (base case)

Unit: People

Actual data



Calculation results



2022 2024 2026 2028 2030 2032 2034 2036

2022 2024 2026 2028 2030 2032 2034 2036

Upward and downward CAGRs of passenger numbers were calculated as 7.28% and 5.82%, respectively, by considering RPK deviation between 2019-2050

Future growth rate of passenger numbers (downward and upward)

Step	Description	Calculation Method
Step 1	<ul style="list-style-type: none"> Calculation of Malaysia's base case RPK CAGR in 2023-2028 	<ul style="list-style-type: none"> Calculate Thailand's base case RPK CAGR (See slide 193) <ul style="list-style-type: none"> Base case: 6.03%
Step 2	<ul style="list-style-type: none"> Calculation of deviation based on the RPK CAGR (2019-2050) <ul style="list-style-type: none"> Upward: 3.50% ("2021 Baseline: High" of "North Asia - Pacific South East Asia") Base case: 2.90% ("2021 Baseline: Mid" of "North Asia - Pacific South East Asia") Downward: 2.80% ("2021 Baseline: Low" of "North Asia - Pacific South East Asia") 	<ul style="list-style-type: none"> Calculate the deviation from the base case by division <ul style="list-style-type: none"> Upward deviation: 20.69% ($=3.50/2.90-1$) Downward deviation: -3.45% ($=2.80/2.90-1$)
Step 3	<ul style="list-style-type: none"> Calculation of upward and downward RPK CAGRs 	<ul style="list-style-type: none"> Calculate upward and downward CAGRs by multiplying the deviation calculated in Step 2 with Malaysia's base case CAGR. <ul style="list-style-type: none"> Upward CAGR: 7.28% ($=6.03\% \times (1+20.69\%)$) Downward CAGR: 5.82% ($=6.03\% \times (1-3.45\%)$)



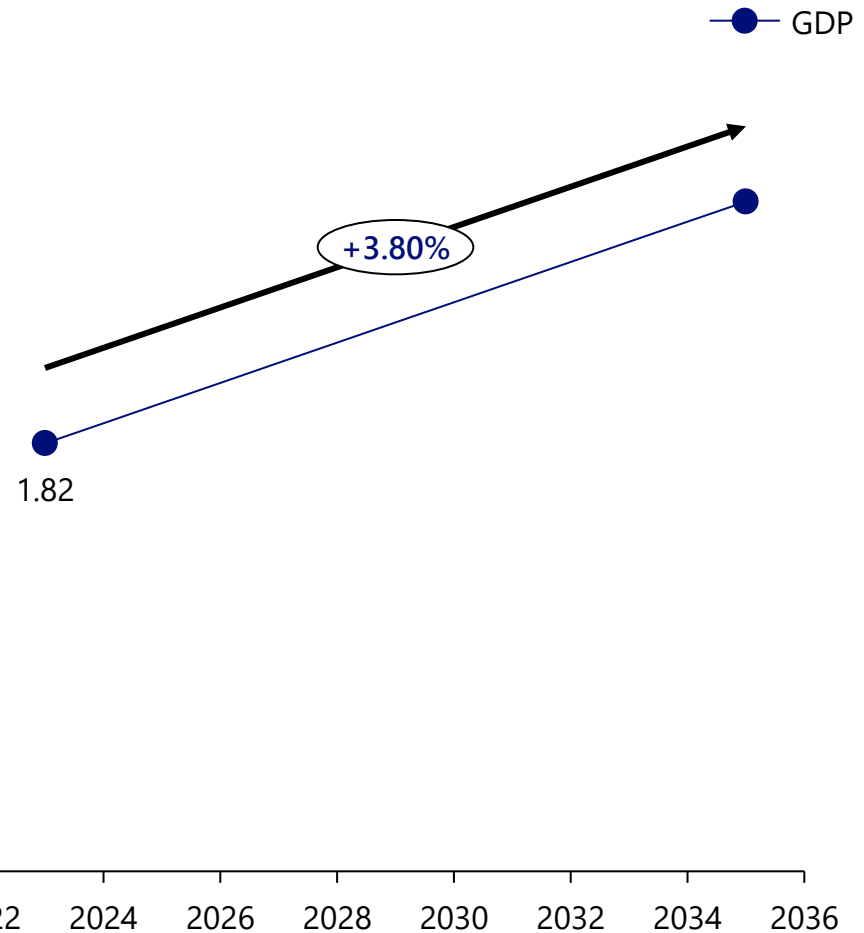
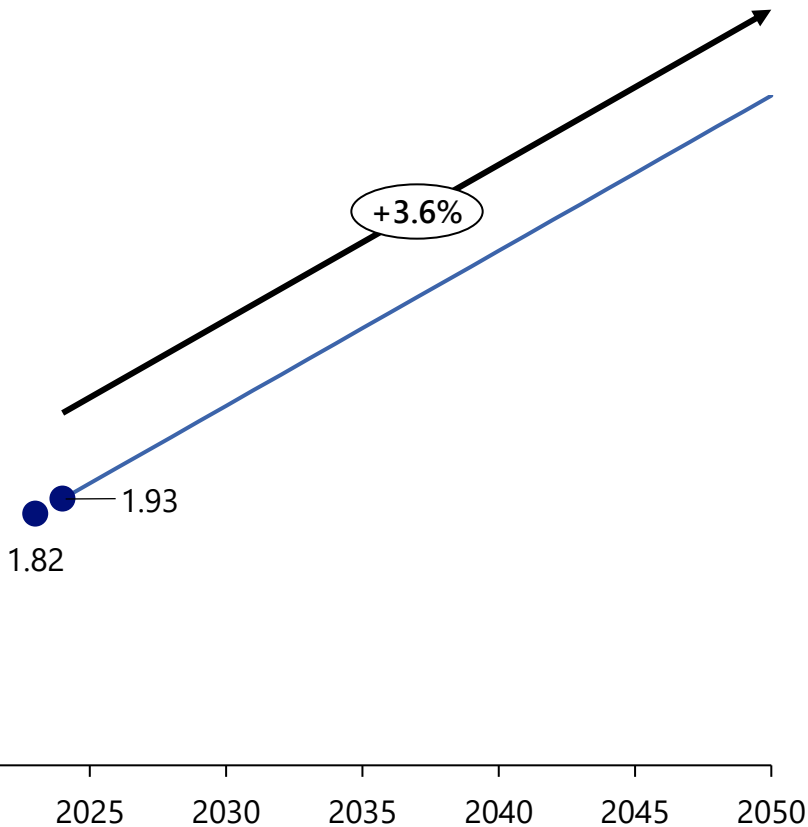
GDP growth rate was calculated as 3.80% based on actual GDP in 2023 and 2024 and forecast CAGR between 2024 and 2050

Future GDP growth rate (base case)

Unit: Trillion RM

Actual data

Calculation results



Upward and downward GDP growth rates were calculated as 4.18% and 3.42%, respectively, by considering deviation of government targets

GDP growth rate (downward and upward)

Step	Description	Calculation Method
Step 1	<ul style="list-style-type: none"> Calculation of Malaysia's base case GDP growth rate in 2023-2035 	<ul style="list-style-type: none"> Calculate Malaysia's base case GDP growth rate (See slide 195) <ul style="list-style-type: none"> Base case: 3.80%
Step 2	<ul style="list-style-type: none"> Calculation of deviation based on the Malaysia government's GDP growth rate target (4.5-5.5%/year) <ul style="list-style-type: none"> Upward: 5.5% Base case: 5.0% (The base case value was set as the median value of the range.) Downward: 4.5% 	<ul style="list-style-type: none"> Calculate the deviation from the base case by division <ul style="list-style-type: none"> Upward deviation: 10.0% (=5.5/5.0-1) Downward deviation: -10.0% (=4.5/5.0-1)
Step 3	<ul style="list-style-type: none"> Calculation of upward and downward GDP growth rates 	<ul style="list-style-type: none"> Calculate upward and downward GDP growth rates by multiplying the deviation calculated in Step 2 with Malaysia's base case GDP growth rate <ul style="list-style-type: none"> Upward CAGR: 4.18% (=2.40% x (1+10.0%)) Downward CAGR: 3.42% (=2.40% x (1-10.0%))

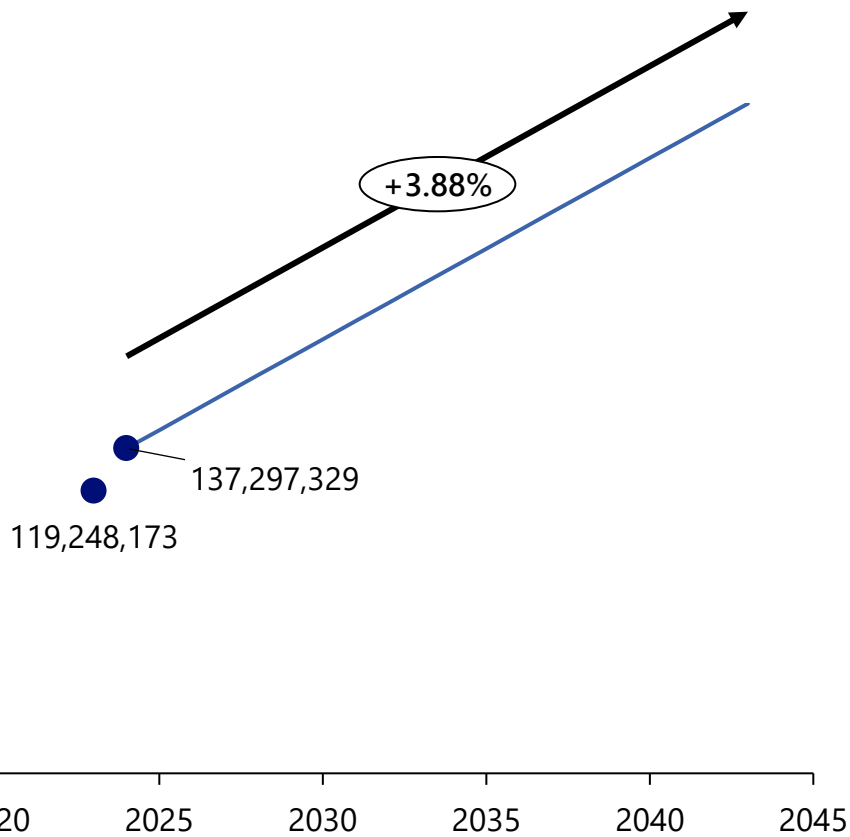


CAGR of passenger numbers was calculated as 4.77% based on actual passenger numbers in 2023 and 2024 and forecast CAGR between 2024 and 2043

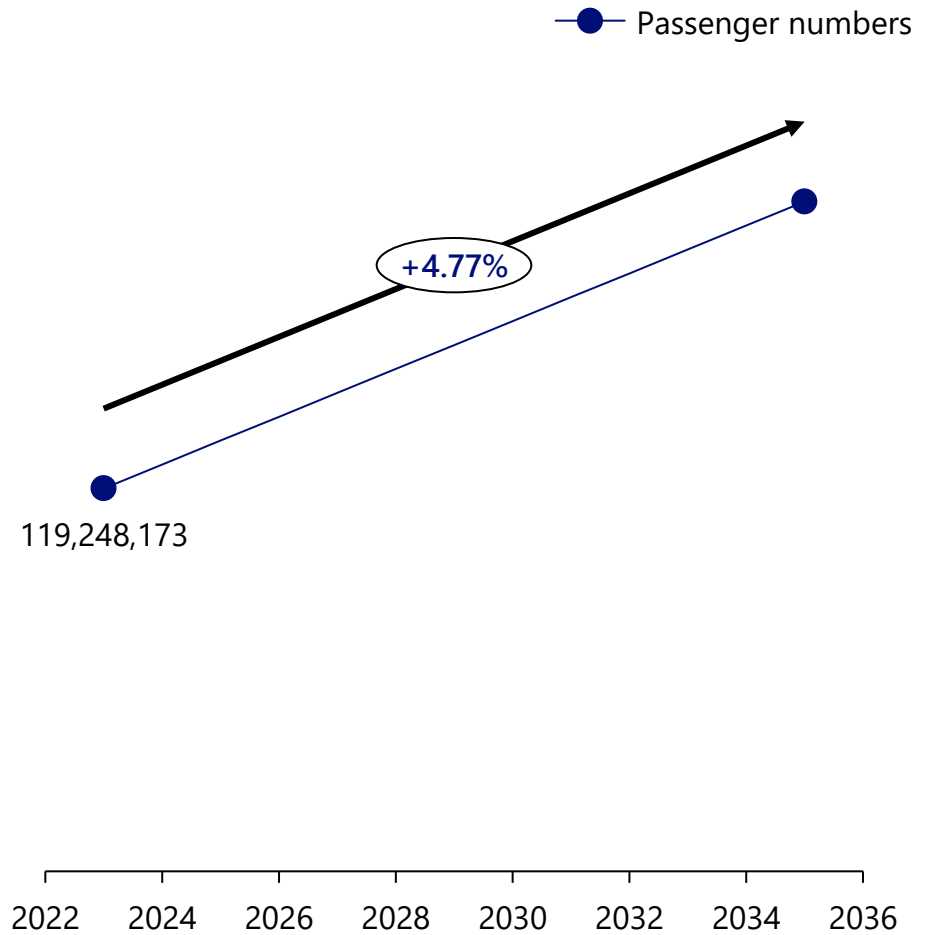
Future growth rate of passenger numbers (base case)

Unit: People

Actual data



Calculation results





Upward and downward CAGRs of passenger numbers were calculated as 7.10% and 5.68%, respectively, by considering RPK deviation between 2019-2050

Future growth rate of passenger numbers (downward and upward)

Step	Description	Calculation Method
Step 1	<ul style="list-style-type: none"> Calculation of Thailand's base case RPK CAGR in 2023-2035 	<ul style="list-style-type: none"> Calculate Thailand's base case RPK CAGR (See slide 197) <ul style="list-style-type: none"> Base case: 4.77%
Step 2	<ul style="list-style-type: none"> Calculation of deviation based on the RPK CAGR (2019-2050) <ul style="list-style-type: none"> Upward: 3.50% ("2021 Baseline: High" of "North Asia - Pacific South East Asia") Base case: 2.90% ("2021 Baseline: Mid" of "North Asia - Pacific South East Asia") Downward: 2.80% ("2021 Baseline: Low" of "North Asia - Pacific South East Asia") 	<ul style="list-style-type: none"> Calculate the deviation from the base case by division <ul style="list-style-type: none"> Upward deviation: 20.69% ($=3.50/2.90-1$) Downward deviation: -3.45% ($=2.80/2.90-1$)
Step 3	<ul style="list-style-type: none"> Calculation of upward and downward RPK CAGRs 	<ul style="list-style-type: none"> Calculate upward and downward CAGRs by multiplying the deviation calculated in Step 2 with Thailand's base case CAGR. <ul style="list-style-type: none"> Upward CAGR: 5.76% ($=4.77\% \times (1+20.69\%)$) Downward CAGR: 4.61% ($=4.77\% \times (1-3.45\%)$)

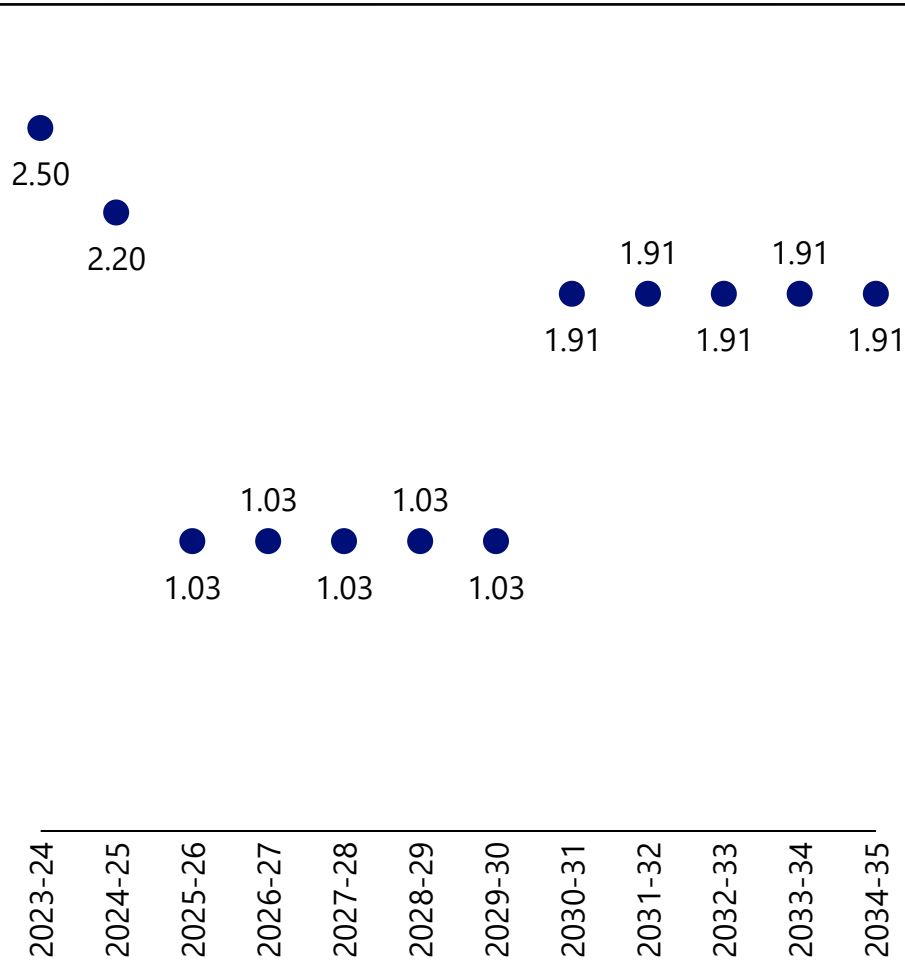


GDP growth rate was calculated as 1.62% based on the average of GDP growth rate between 2023 and 2035

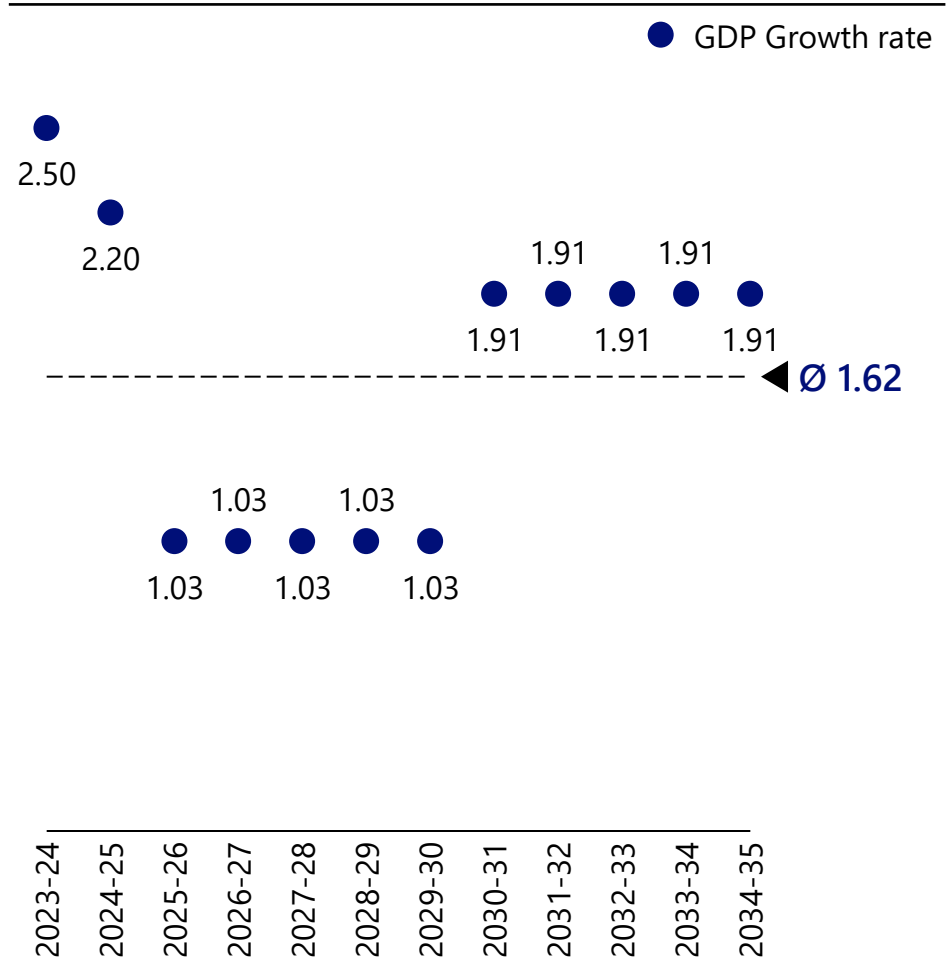
Future GDP growth rate (base case)

Unit: %

Actual data



Calculation results





Upward and downward GDP growth rates were calculated as 1.87% and 1.37%, respectively, by considering future projection between 2025-2035

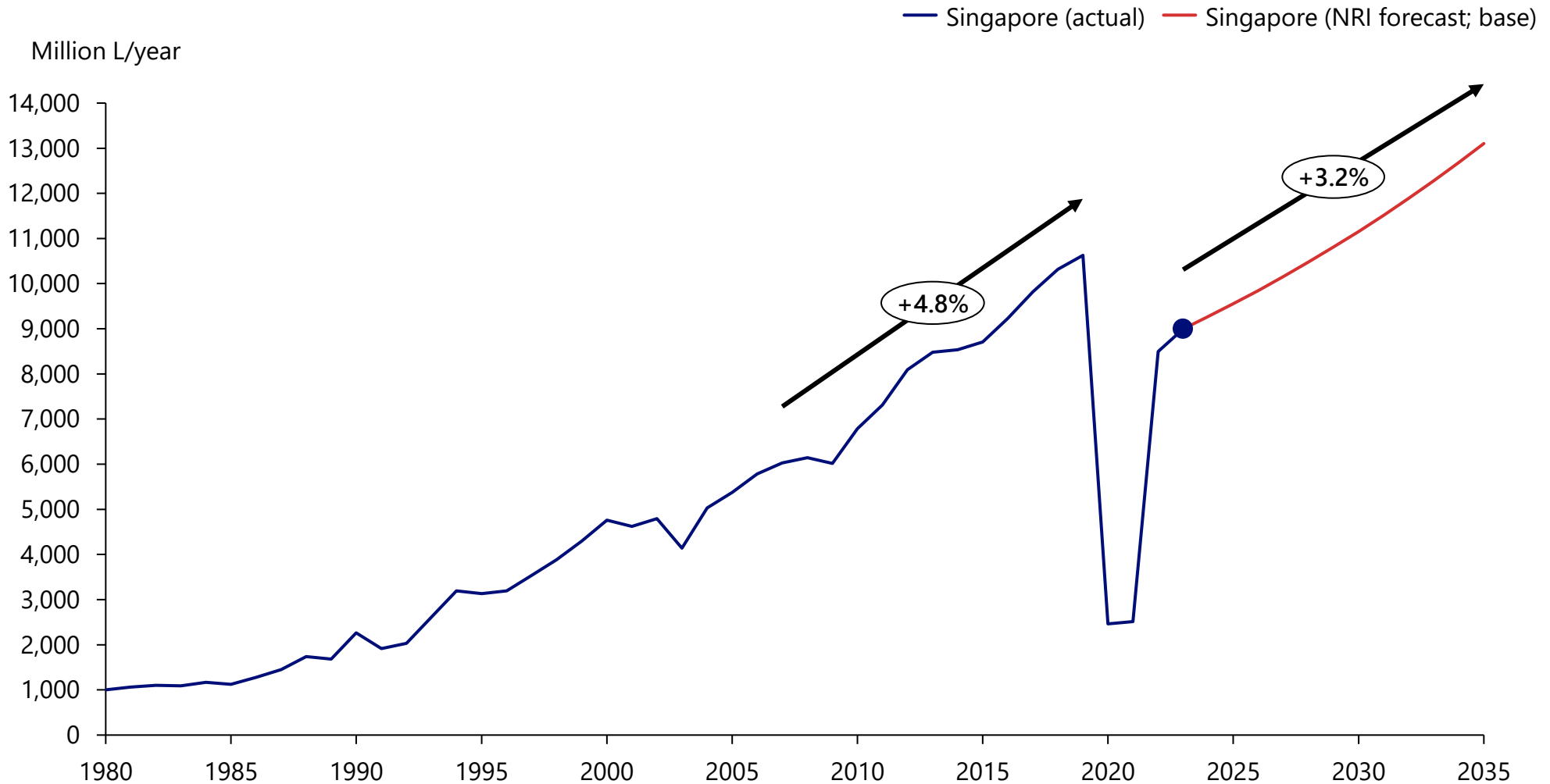
GDP growth rate (downward and upward)

Step	Description	Calculation Method
Step 1	<ul style="list-style-type: none"> Calculation of Thailand's base case GDP growth rate in 2023-2035 	<ul style="list-style-type: none"> Calculate Thailand's base case GDP growth rate (See slide 199) <ul style="list-style-type: none"> Base case: 1.62%
Step 2	<ul style="list-style-type: none"> Calculation of deviation based on the OECD's GDP growth rate forecast <ul style="list-style-type: none"> Base case ("Potential output" of "Business as usual (BAU1)" scenario in Thailand) <ul style="list-style-type: none"> ✓ 2025-30: 1.033829% ✓ 2030-35: 1.911521% Downward ("Potential output" of "Energy transition 3 (ET3)" scenario in Thailand) <ul style="list-style-type: none"> ✓ 2025-30: 0.825841% ✓ 2030-35: 1.673212% 	<ul style="list-style-type: none"> Calculate the base case and downward GDP growth rates (average) which are used to calculate deviation <ul style="list-style-type: none"> Base case: 1.472675% $(=(1.033829\%+1.911521\%)/2)$ Downward: 1.249527% $(=(0.825841\%+1.673212\%)/2)$ Calculate the downward deviation by division <ul style="list-style-type: none"> Downward deviation: -15.15% $(=1.249527/1.472675-1)$
Step 3	<ul style="list-style-type: none"> Calculation of upward and downward GDP growth rates (The downward deviation was used to calculate the upward GDP growth rate (15.15%)) 	<ul style="list-style-type: none"> Calculate upward and downward GDP growth rates by multiplying the deviation calculated in Step 2 with Thailand's base case GDP growth rate <ul style="list-style-type: none"> Upward CAGR: 1.87% $(=1.62\% \times (1+15.15\%))$ Downward CAGR: 1.37% $(=1.62\% \times (1-15.15\%))$



While aviation fuel consumption had grown at an average rate of 4.8% in the past, forecasts after 2023 show an estimated growth rate of 3.2%

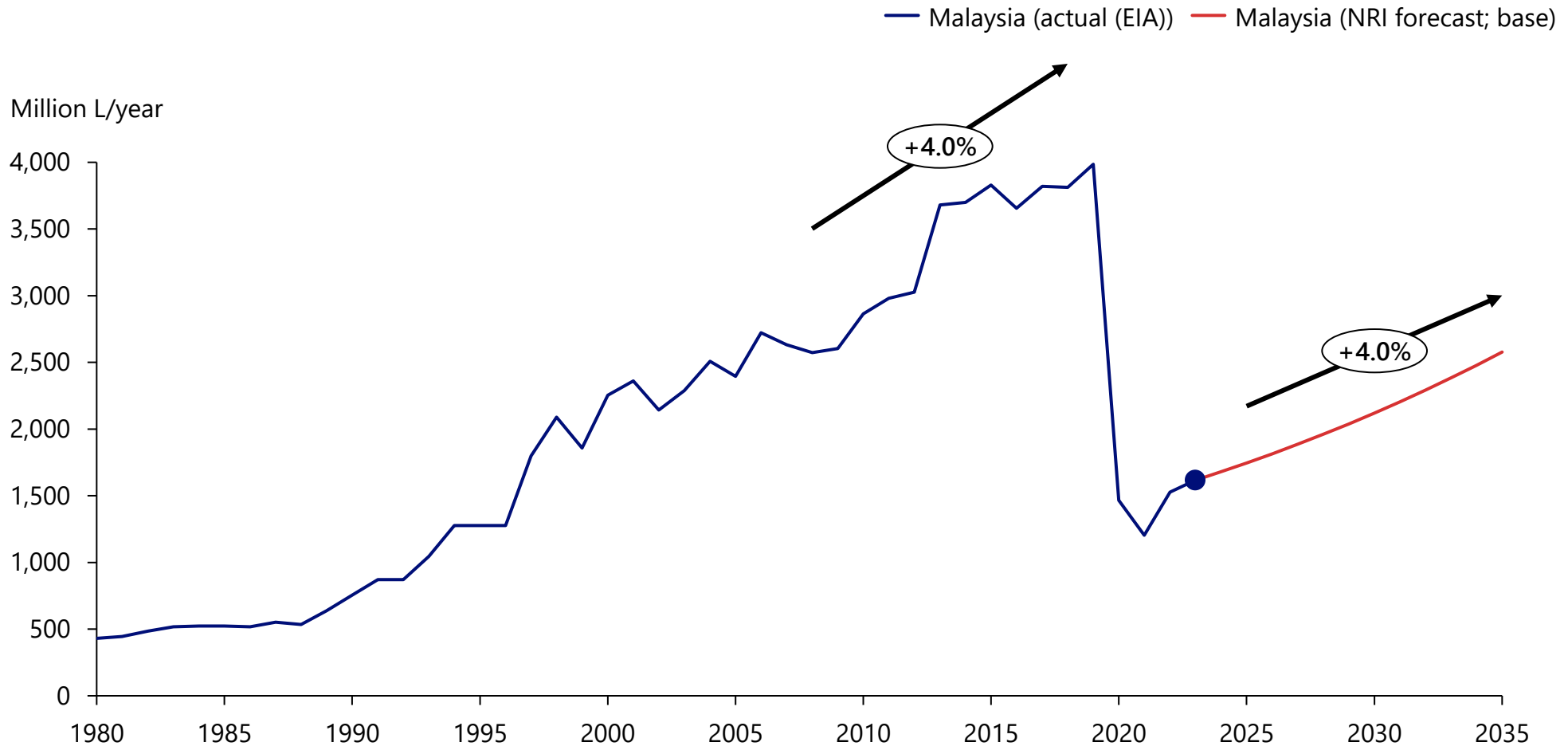
Trend of aviation fuel consumption in Singapore





The growth rate of aviation fuel consumption forecasts by NRI and the actual consumption trend show no significant difference

Trend of total aviation fuel consumption in Malaysia*

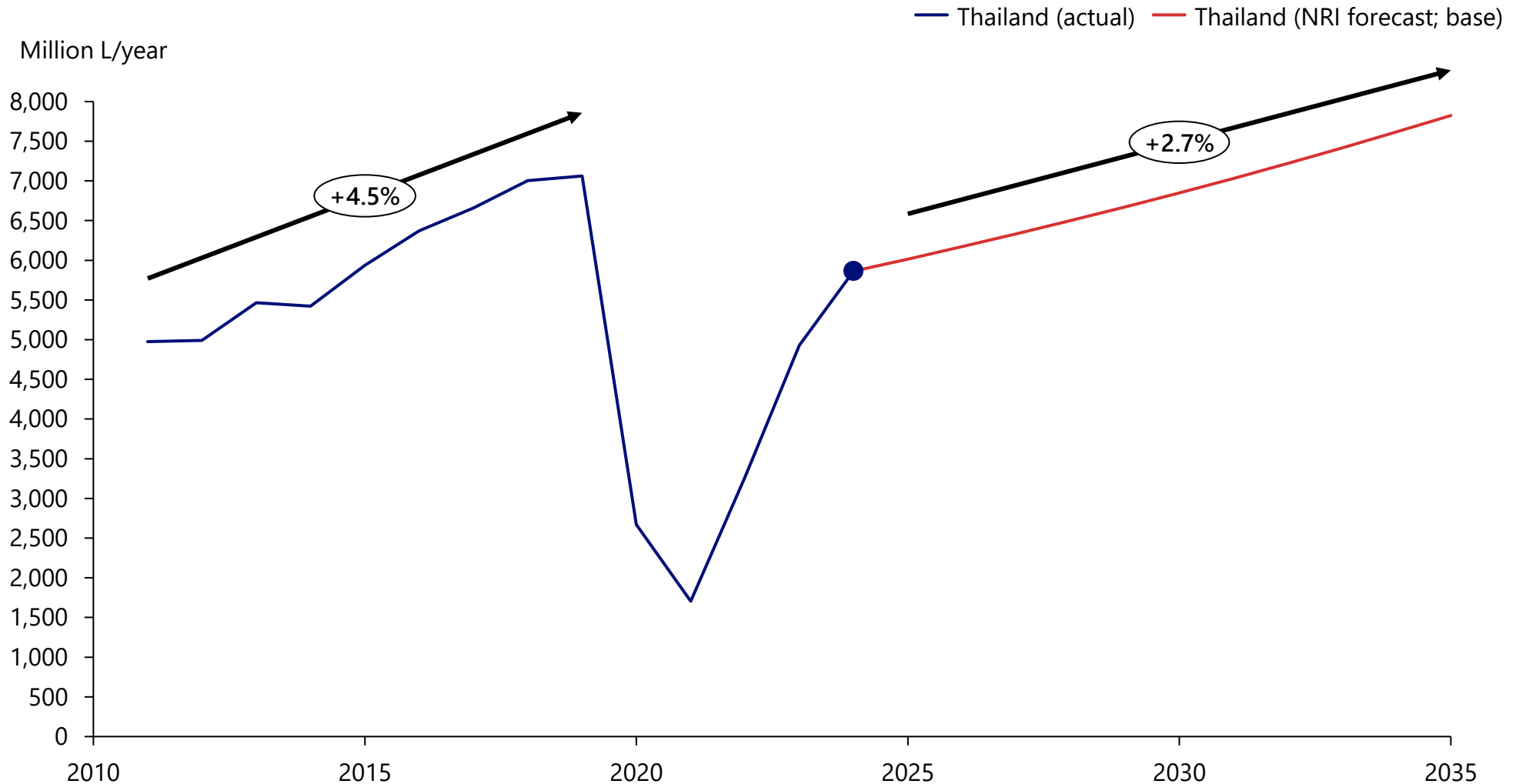


Note) *Although demand forecast of Malaysia is calculated based on only international flights, this graph includes both international and domestic flights.



While aviation fuel consumption had grown at an average rate of 4.5% in the past, forecasts after 2024 show an estimated growth rate of 2.7%

Trend of total aviation fuel consumption in Thailand



Executive Summary

Chapter 1: Public Policy and Regulations

Chapter 2: Player Activity

Chapter 3: Supply/demand potential

Summary

Chapter 3-1: Demand Potential

Chapter 3-2: Supply Potential

Chapter 4: Needs by Local Players

Chapter 5: Export Potential to Japan

Appendix

Forecast Direction for Supply

Forecasts for the volume of SAF supply will be conducted leveraging desktop study and interviews to government and private companies

Supply forecast methodology (basic concept)

Definition	<ul style="list-style-type: none">• "Supply" is defined as "annual production capacity of biorefinery which has the SAF production capability"
Forecast direction	<ul style="list-style-type: none">• The supply forecast are to be calculated based on the capacities of SAF refineries and it can be proposed as the following two methods;<ul style="list-style-type: none">○ Pattern A: sum-up all capacities of SAF refineries based on their start operating year○ Pattern B: sum-up capacities of main SAF players and divided by the market share of the main SAF players• Triggers for downward and upward fluctuations in supply capacity in the future, such as potential volume of feedstocks, will be identified in the survey, and the fluctuations will be examined by taking into account the identified triggers
Unit	<ul style="list-style-type: none">• SAF volume: million litter/year (Value (e.g. USDXX) will not be estimated in the project)
Forecast duration	<ul style="list-style-type: none">• 2025-2035
Data source	<ul style="list-style-type: none">• Desktop study (e.g. government plans, news articles, etc.)• Interviews<ul style="list-style-type: none">○ Private companies: 1 interview for supply / country (Indonesia, Malaysia, Thailand)○ Government: 1 interview / country (Indonesia, Malaysia, Thailand)

Supply Forecast Methodology for Biorefinery which has SAF Production Capability

For the target countries, the supply volume is forecasted by summing up the capacities of all SAF refineries based on their operation starting year

Supply forecast methodology (calculation formula)

Pattern A	Calculation formula	SAF supply capacity (Company A) + SAF supply capacity of (Company B) + SAF supply capacity of (Company C, D) = Total SAF supply capacity of Indonesia
	Forecast methodology	<ul style="list-style-type: none"> Future forecast will be estimated based on plans announced for capacity development and analysis of future prospect <p>Indonesia, Malaysia, Thailand</p>
Pattern B	Calculation formula	SAF supply capacity of main player(s) ÷ Total production shares of main player(s) = Total SAF supply capacity of the country
	Forecast methodology	<ul style="list-style-type: none"> Estimation based on plans announced for capacity development and analysis of future prospect Estimation based on analysis of key player's view of share projections

Supply Forecast Scenario

SAF supply are forecasted under three scenarios based on two axes: (1) progress and (2) operation starting year

Supply forecast methodology (definition)

Case	(1) Progress			(2) Operation starting year
	In operation/No need Final Investment Decision (FID)	Under/Completed FID	Before starting FID	Operation starting year for supply forecast (if range available)
Scenario A: All plan materializes	✓	✓	✓	Earliest operation starting year
Scenario B*: Only FID plans materializes (early timeline)	✓	✓	X	Earliest operation starting year
Scenario C*: Only FID plans materializes (late timeline)	✓	✓	X	Latest operation starting year

Note: * In Malaysia and Thailand, only Scenarios A and B are shown because Scenarios B and C are the same timelines, as the time ranges for "(2) Operation starting year" could not be confirmed in desktop researches and interview.



In Indonesia, multiple SAF refineries have been planned to be constructed; however, not many projects completed FID yet

Supply forecast methodology (major premises)


	SAF Refinery	(1) Progress		(2) Operation starting year	Source
		Progress	Remarks		
Pertamina	Cilacap, Central Java (Phase-1)	In operation	-	2025 (Q2)	(1) Desktop (2) Desktop
	Dumai, Riau	No need investment	<ul style="list-style-type: none"> SAF will be produced by co-processing at existing refinery 	2026 (Q2)	(1) Interview (2) Desktop
	Balongan, West Java	No need investment	<ul style="list-style-type: none"> SAF will be produced by co-processing at existing refinery 	2026 (Q4)	(1) Interview (2) Desktop
	Cilacap, Central Java (Green Refinery)	Under FID	-	2028-2029	(1) Desktop (2) Interview
	Plaju, South Sumatra	Before starting FID	<ul style="list-style-type: none"> The design will be confirmed after the Green Refinery starts operating to ensure it meets market demand 	2032-2033	(1) Interview (2) Interview
ESSA	Central Java	Before starting FID	<ul style="list-style-type: none"> In the internal planning stage including technology selection 	2027 (Q4) – 2028 (Q1)	(1) Desktop/Interview (2) Desktop
Tripatra	Sei Mangkei, North Sumatra	Before starting FID	<ul style="list-style-type: none"> Feasibility study was completed, and now in designing stage. 	2028 (Q3-Q4)	(1) Desktop/Interview (2) Desktop/Interview
	Kalimantan	Before starting FID	No information available	2029	(1) Desktop/Interview (2) Desktop/Interview
	North Sumatra	Before starting FID	No information available	2030	(1) Desktop/Interview (2) Desktop/Interview
	North Sumatra or Kalimantan	Before starting FID	No information available	2030	(1) Desktop/Interview (2) Desktop/Interview



SAF supply capacity forecast is calculated by summing the respective capacities for each scenario in each year

Unit: million L/year

Supply forecast methodology (Numbers used for calculation)

 : NOT operational in scenario

SAF Refinery		Scenario	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	
Pertamina	Cilacap, Central Java (Phase-1)	A	7	7	7	7	7	7	7	7	7	7	7	
		B	7	7	7	7	7	7	7	7	7	7	7	
		C	7	7	7	7	7	7	7	7	7	7	7	
	Dumai, Riau	A		7	7	7	7	7	7	7	7	7	7	7
		B		7	7	7	7	7	7	7	7	7	7	7
		C		7	7	7	7	7	7	7	7	7	7	7
	Balongan, West Java	A		7	7	7	7	7	7	7	7	7	7	7
		B		7	7	7	7	7	7	7	7	7	7	7
		C		7	7	7	7	7	7	7	7	7	7	7
	Cilacap, Central Java (Green Refinery)	A					306	306	306	306	306	306	306	306
		B					306	306	306	306	306	306	306	306
		C						306	306	306	306	306	306	306
Plaju, South Sumatra	A									801	801	801	801	
	B/C													
ESSA	Central Java	A			250	250	250	250	250	250	250	250	250	
		B/C												
Tripatra	Sei Mangkei, North Sumatra	A				75	75	75	75	75	75	75	75	
		B/C												
	Kalimantan	A					75	75	75	75	75	75	75	
		B/C												
	North Sumatra	A						75	75	75	75	75	75	
		B/C												
North Sumatra or Kalimantan	A							75	75	75	75	75		
	B/C													

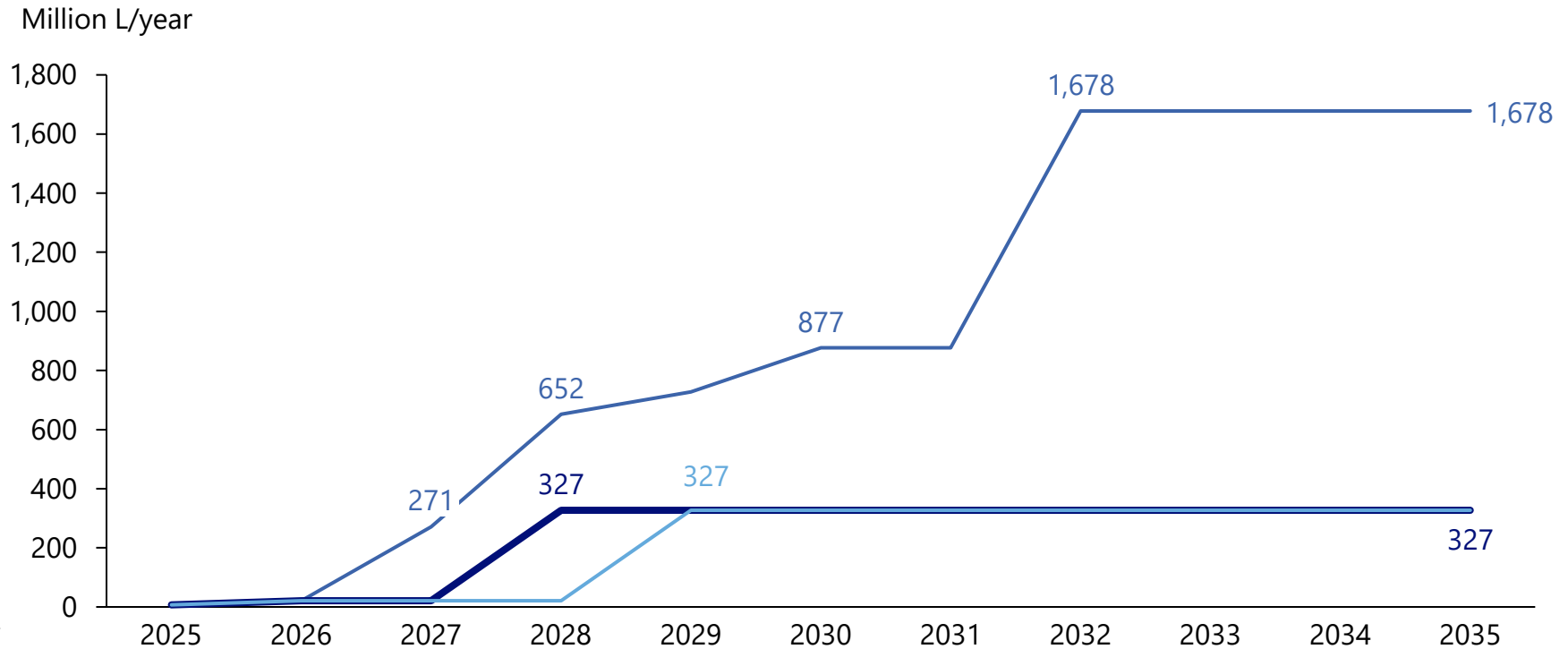


Supply Forecast | Indonesia

In Indonesia, many projects have been planned, but few have completed FID, leading to a large gap between scenarios A and B/C.

Supply forecast in Indonesia

— Scenario A: All plan materializes
— Scenario B: Only FDI plans materializes (early timeline)
— Scenario C: Only FDI plans materializes (late timeline)



Scenario	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Scenario A	6	17	217	522	582	702	702	1,342	1,342	1,342	1,342
Scenario B	6	17	17	262	262	262	262	262	262	262	262
Scenario C	6	17	17	17	262	262	262	262	262	262	262

Note) * Converted based on "1ton=1,250L"

In Malaysia, one SAF refinery is in operation since 2025, and multiple SAF refineries have been planned.

Supply forecast methodology (major premises)

	SAF Refinery	(1) Progress		(2) Operation starting year	Source
		Progress	Remarks		
Petronas	Johor	Completed FID	-	2028	(1) Desktop study (2) Desktop study
	-	Before starting FID	<ul style="list-style-type: none"> The plan will be considered after the Johor Refinery starts operating to ensure it meets market demand 	2033	(1) Interview (2) Desktop/interview
EcoCeres	Johor	In operation	-	2025 (Q4)	(1) Desktop/interview (2) Desktop/interview
FatHopes	Port Klang	Before starting FID	<ul style="list-style-type: none"> The project is currently in the feasibility/FEED stage 	2029	(1) Desktop/interview (2) Desktop/interview






Supply Forecast | Malaysia

Supply capacity forecast is calculated by summing the respective capacities for each scenario in each year

Unit: million L/year

Supply forecast methodology (Numbers used for calculation)

 : NOT operational in scenario

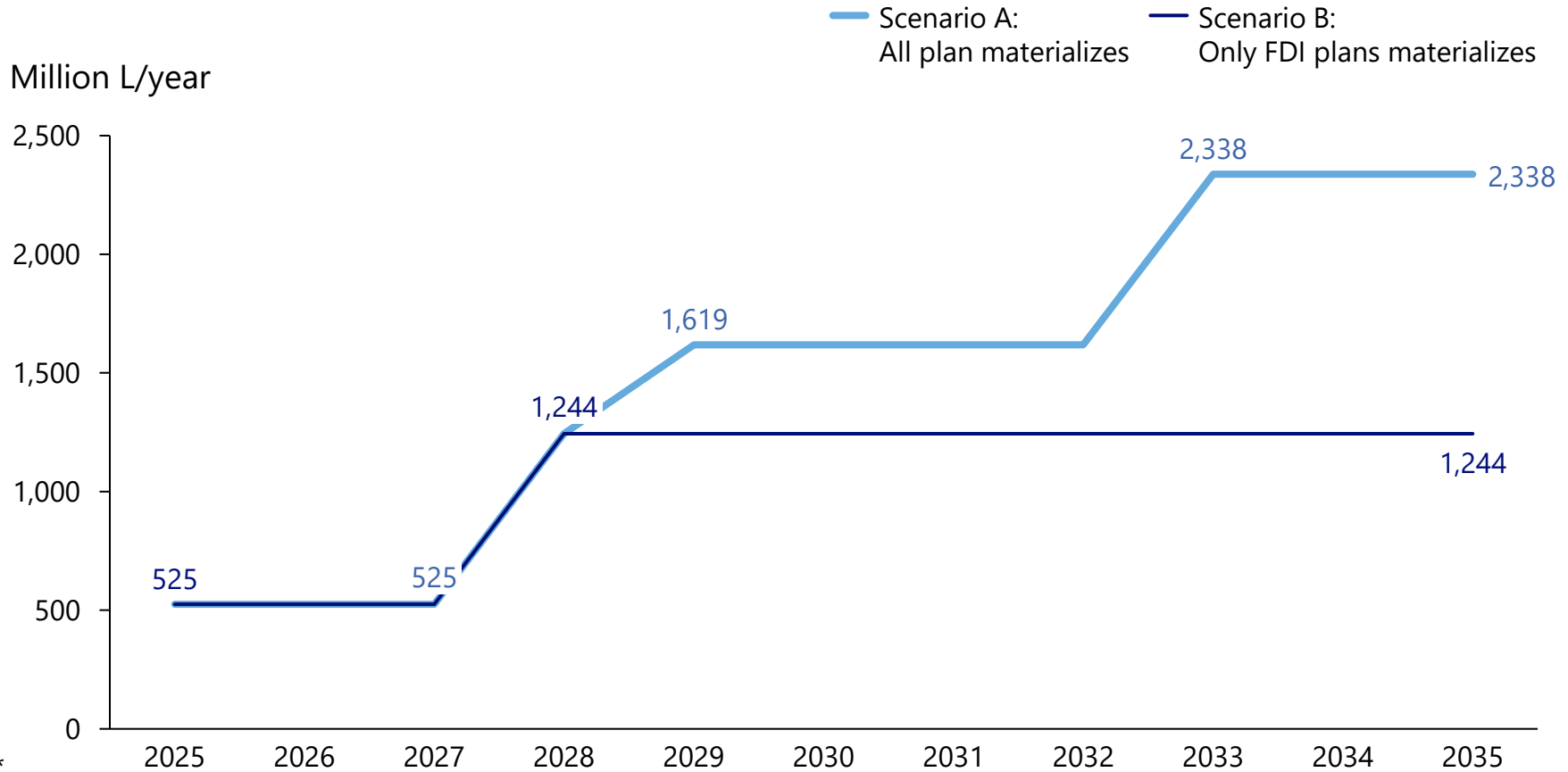
	SAF Refinery	Scenario	2025	2026	2027	2028	2029	2030	2031	2032	3033	2034	2035
Petronas	Johor	A					719	719	719	719	719	719	719
		B					719	719	719	719	719	719	719
	N/A	A									719	719	719
		B											
EcoCeres	Johor	A	525	525	525	525	525	525	525	525	525	525	525
		B	525	525	525	525	525	525	525	525	525	525	525
FatHopes	Port Klang	A					375	375	375	375	375	375	375
		B											



Supply Forecast | Malaysia

In Malaysia, EcoCeres' SAF refinery is already operational, and SAF supply volume will increase when Petronas' SAF refinery becomes operational

Supply forecast in Malaysia



Scenario A	420	420	420	995	1,295	1,295	1,295	1,295	1,870	1,870	1,870
Scenario B	420	420	420	995	995	995	995	995	995	995	995

Note) * converted based on "1ton=1,250L"



In Thailand, one SAF refinery is in operation since 2025 in a small scale, and a large-scale SAF refinery by Bangchak will plan to be operated in 2026

Supply forecast methodology (major premises)


	SAF Refinery	(1) Progress		(2) Operation starting year	Source
		Progress	Remarks		
PTT	Mao Ta Phut, Rayong (Existing)	In operation	-	2025	(1) Desktop/interview (2) Desktop/interview
	Mao Ta Phut, Rayong (Expansion)	Before starting FID	-	2027	(1) Desktop/interview (2) Desktop/interview
Bangchak	Phra Khanong, Bangkok	Completed FID	-	2026	(1) Desktop/interview (2) Desktop/interview
Energy Absolute	Rayong	Completed FID	<ul style="list-style-type: none"> EPC has been completed, and currently under test run of the refinery 	2026	(1) Desktop/interview (2) Desktop/interview



SAF supply capacity forecast is calculated by summing the respective capacities for each scenario in each year

Unit: million L/year

Supply forecast methodology (Numbers used for calculation)

 : NOT operational in scenario

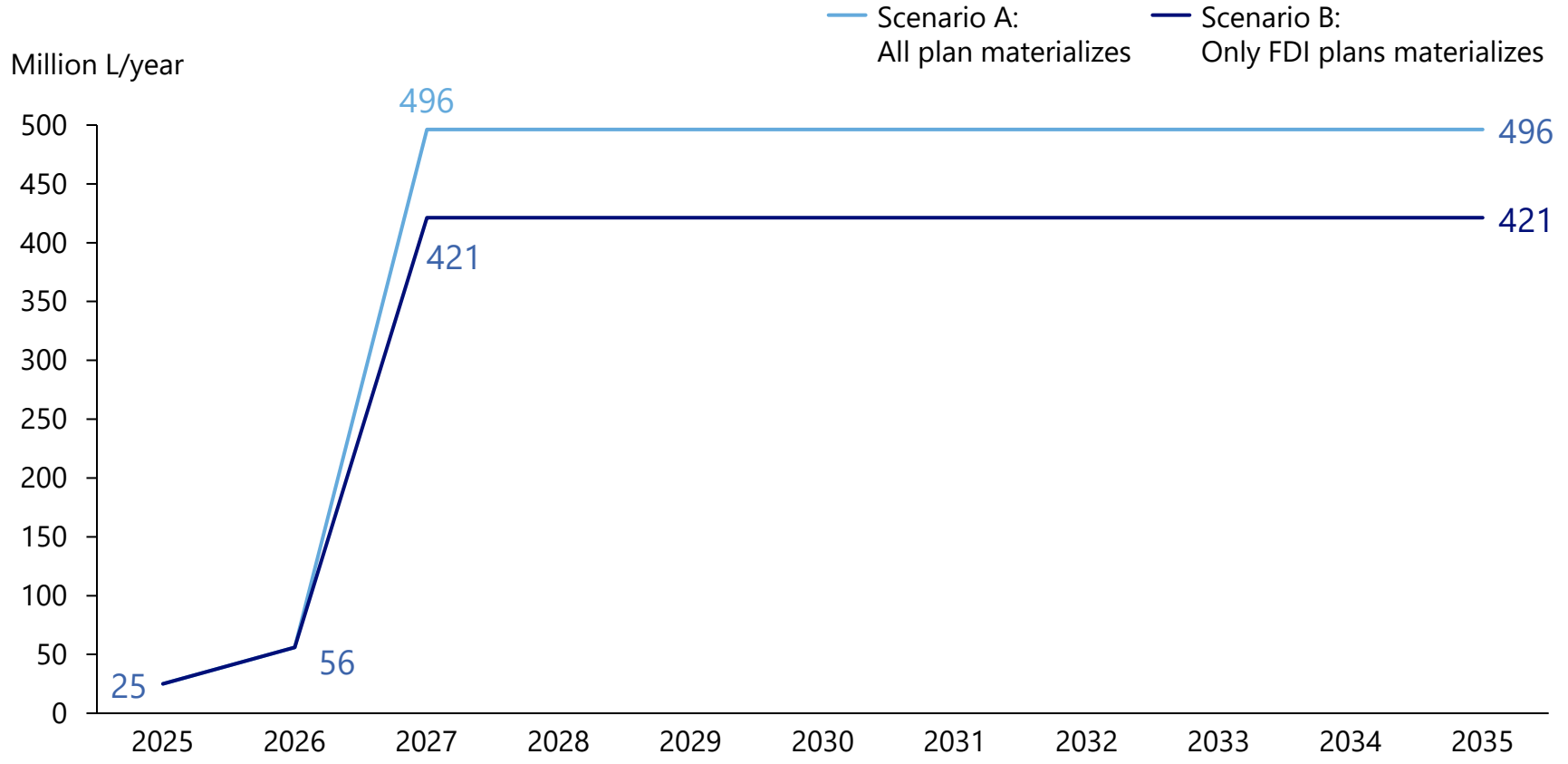
		SAF Refinery	Scenario	2025	2026	2027	2028	2029	2030	2031	2032	3033	2034	2035
PTT	Mao Ta Phut, Rayong (Existing)	A	25	25	25	25	25	25	25	25	25	25	25	25
		B	25	25	25	25	25	25	25	25	25	25	25	25
	Mao Ta Phut, Rayong (Expansion)	A			75	75	75	75	75	75	75	75	75	75
		B												
Bangchak	Phra Khanong, Bangkok	A		365	365	365	365	365	365	365	365	365	365	365
		B		365	365	365	365	365	365	365	365	365	365	365
Energy Absolute	Rayong	A		31	31	31	31	31	31	31	31	31	31	31
		B		31	31	31	31	31	31	31	31	31	31	31



Supply Forecast | Thailand

In Thailand, only Bangchak is the only company with plans for a large-scale SAF refinery, leading the rapid increase in SAF supply forecast in 2026

Supply forecast in Thailand



Scenario A	20	45	397	397	397	397	397	397	397	397	397
Scenario B	20	45	337	337	337	337	337	337	337	337	337

Note) * converted based on "1ton=1,250L"

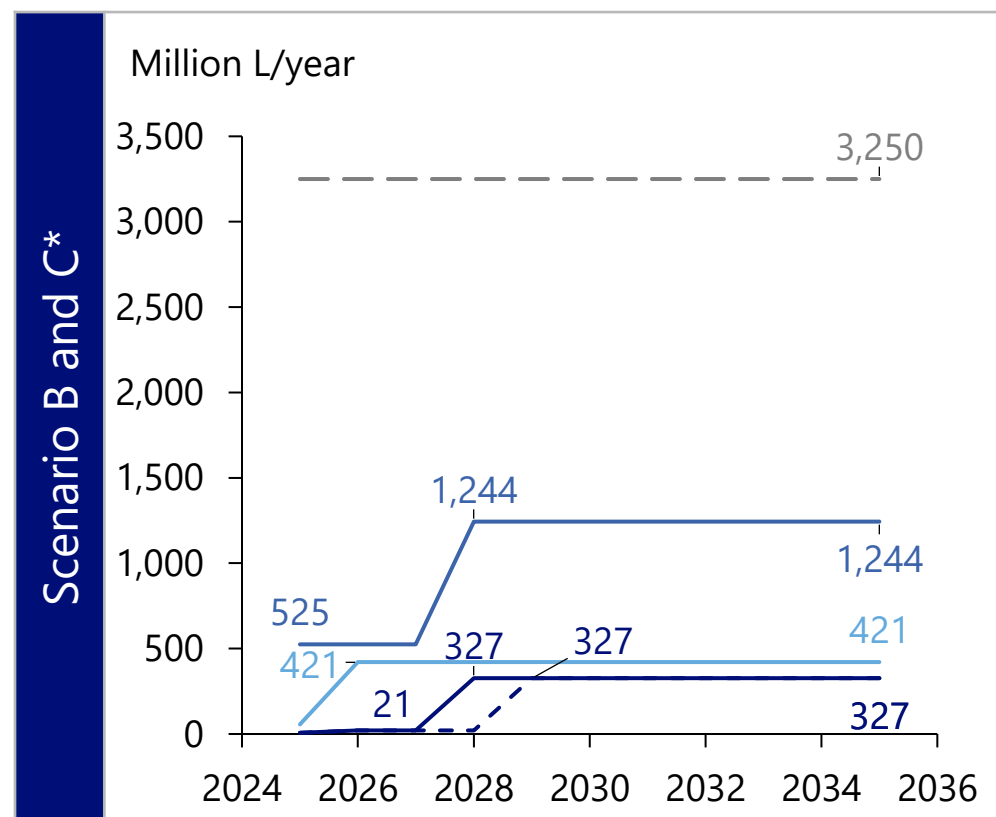
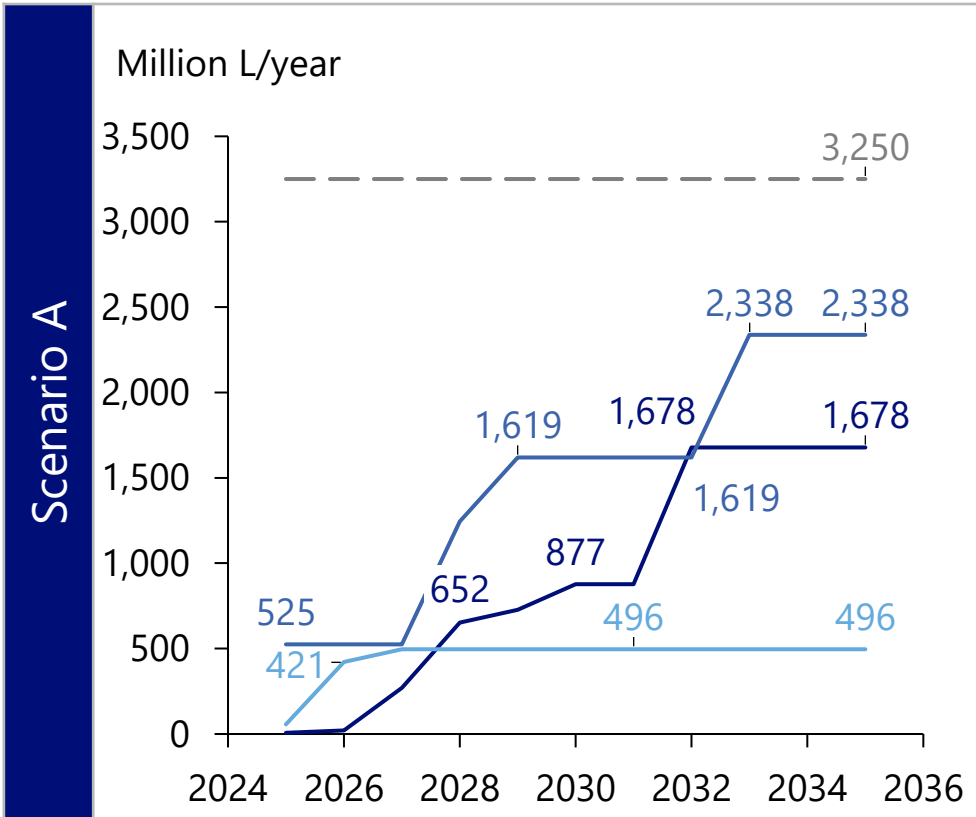
Source: NRI analysis, Aviation Benefits Beyond Borders

Supply Forecast | 3 Countries

In all three scenarios, SAF supply of Malaysia is the largest among the three target countries during 2025-2035

Supply forecast in 3 countries

— Indonesia (early timeline) - - - Indonesia (late timeline) — Malaysia — Thailand — (Ref.) Singapore



- Scenario A: All plan materializes
- Scenario B: Only FID plans materializes (early timeline)
- Scenario C: Only FID plans materializes (late timeline)

Note: * In Malaysia and Thailand, only Scenarios B is shown because Scenarios B and C are the same timelines, as the time ranges for "(2) Operation starting year" could not be confirmed in desktop researches and interview.

Supply and demand comparison

SAF is not produced at the maximum supply capacity of biorefineries, and SAF production volumes are adjusted according to demand

Actual production of SAF

- At SAF refineries, SAF is not produced at the maximum supply capacity, and SAF production volumes are adjusted according to demand. Also, other products such as HVO and Naphtha can be produced at the same biorefineries.
- However, regardless of SAF demand, there is a minimum production volume, and SAF is produced. Actual produced volume is confidential.
- And, produced SAF is stored
 - In general, SAF can be stored for up to two years.
 - With proper storage, SAF can be stored up to five years, as it does not contain oxygen or double bonds and therefore does not oxidize.

Industry player associated and familiar with Neste Singapore



- At SAF refineries, SAF is not produced at the maximum supply capacity, and SAF production volumes are adjusted according to demand.
- Actual produced volume is confidential, however, in Pertamina, produced range is 60-80%.
- It takes 1-3 month to adjust the production volume by changing temperature and input flow (no need to change equipment or catalyst)

Inspector Aviation Facilities, Pertamina





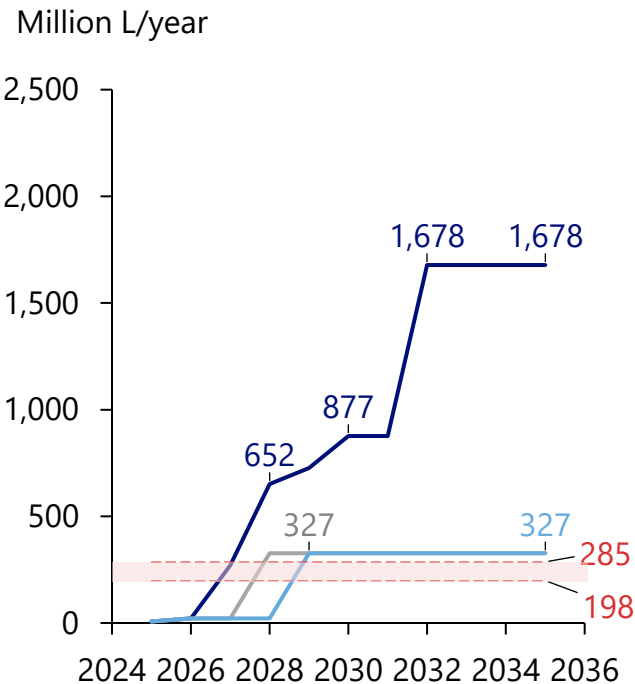
Supply Forecast | Feasibility of UCO Usage as Feedstock (1/2)

UCO which can be realistically collected in each market based on current collection rate will not be sufficient to meet the total supply capacity for SAF

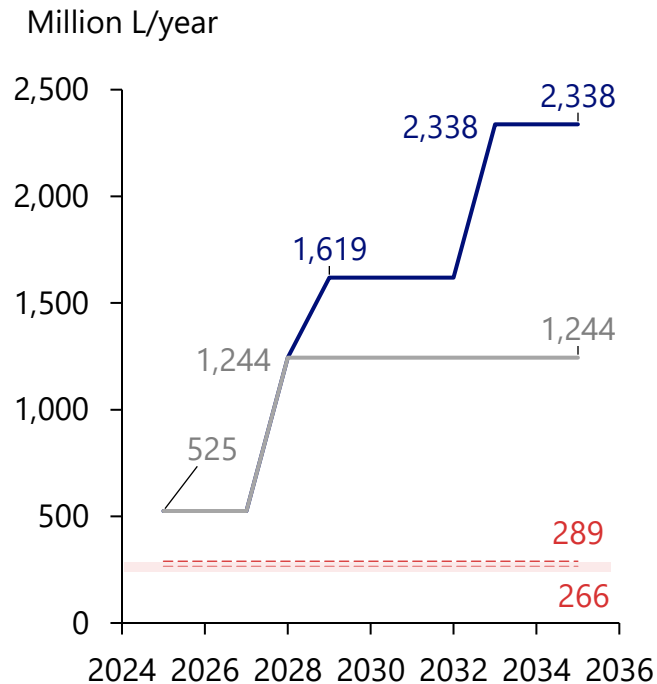
Supply forecast and SAF produced from potential UCO in 3 countries

— Scenario A — Scenario B — Scenario C - - - SAF produced from potential UCO*

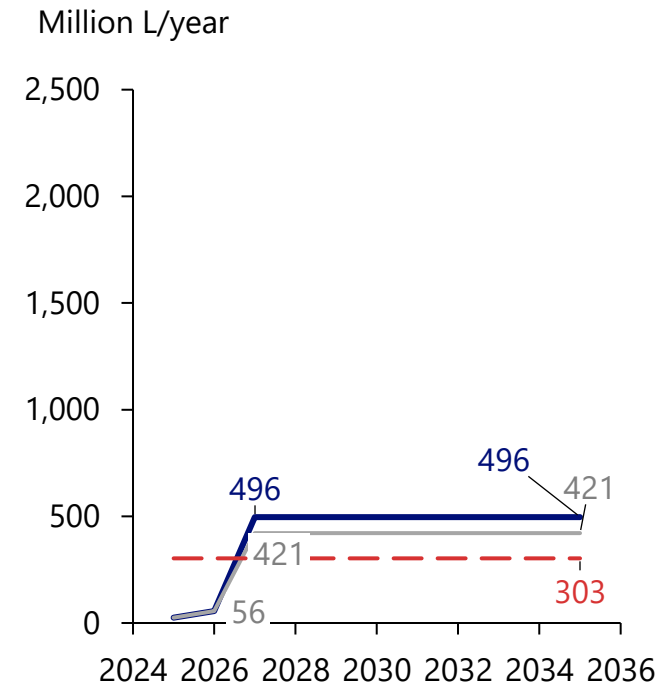
Indonesia



Malaysia



Thailand



Note: *"Current potential UCO" includes UCO collected from households, restaurants and food processing facilities and UCO imported from other countries. Also, the collection rates (Indonesia: 25-37%, Malaysia: 30-45%) are taken into account. (Data on potential UCO in Thailand is under collection.) SAF yields from UCO is set at 83%.

- Indonesia: "273-375 K ton/year (Current potential UCO (calculated in 2023))" x "1,250 L/ton (Conversion rate)" x "83% (SAF yields)"
- Malaysia: "256-279 K ton/year (Current potential UCO (calculated in 2023))" x "1,250 L/ton (Conversion rate)" x "83% (SAF yields)"
- Thailand: "1 ML/day (2025)" x "365 days/year" x "83% (SAF yields)"

Source: NRI analysis, Interview, International Council on Clean Transportation (ICCT), ICAO, Aviation

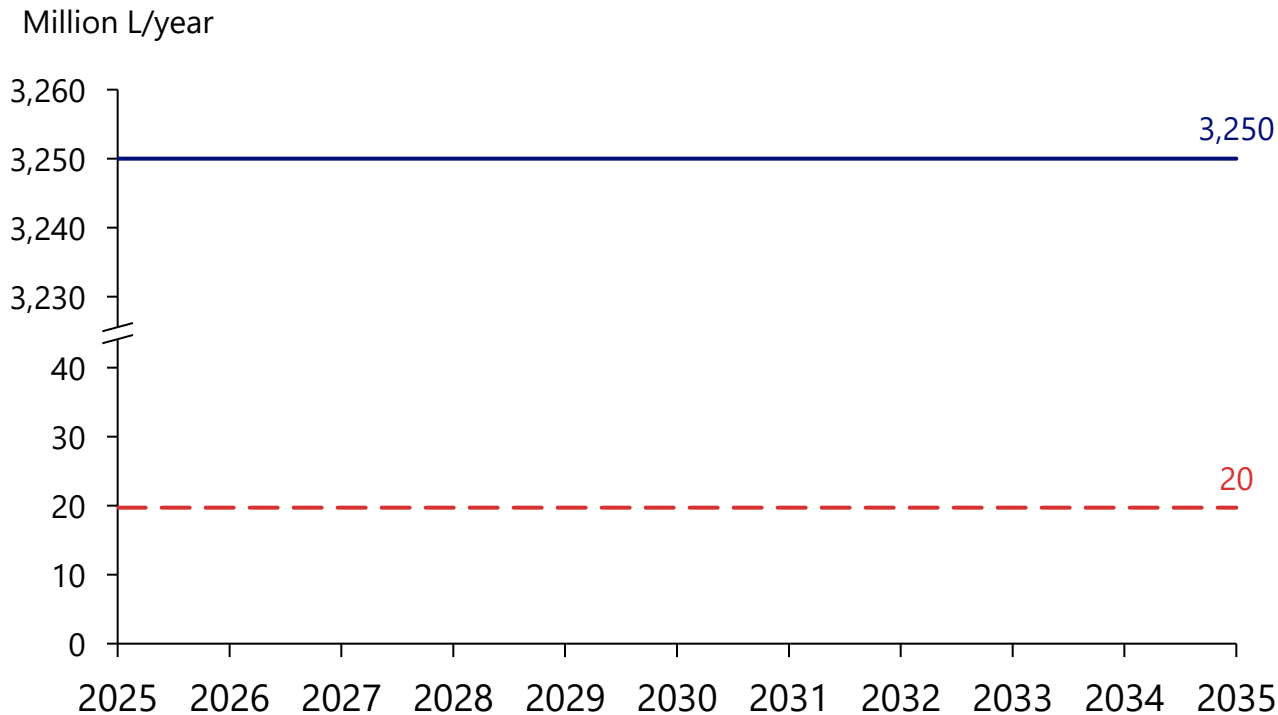


UCO which can be realistically collected domestically in Singapore will not be sufficient to meet the total supply capacity for SAF

Supply forecast and SAF produced from potential UCO in Singapore (Reference)

— Supply capacity of biorefinery which has SAF production capability — SAF produced from potential domestic UCO*

Singapore



Note: *"Current potential UCO" includes UCO collected from households, restaurants and food processing facilities (not including SAF imported from other countries). Also, the collection rates are taken into account. SAF yields from UCO is set at 83%.

- Singapore: "19 K ton/year (Current domestic potential UCO (2021-2024))" x "1,250 L/ton (Conversion rate)" x "83% (SAF yields)"

UCO is scattered in countries, making it difficult to establish UCO collection supply chains, which prevent a significant improvement in UCO collection rates

Supply chain of UCO

- In Thailand, licensed contractors collect UCO, and UCO that is easy to collect is being collected.
- However, collecting UCO scattered in the country is the main challenge for collection.

Department of Alternative Energy Development and Efficiency (DEDE), Thailand



- It is difficult to collect UCO in the country, and it requires a lot of effort.
- Pertamina's massive logistics networks will be utilized to increase the UCO collection volume across Indonesia
- Pertamina will utilize feedstock other than UCO for the future refinery in Plaju.

Inspector Aviation Facilities, Pertamina



- Current domestic UCO volume is insufficient, and it is difficult to increase the domestic UCO collection rate.

Civil Aviation Authority of Malaysia



- Domestic UCO volume is insufficient, and Neste does not collect UCO from households since UCO collection from each household is not economical.

Industry player associated and familiar with Neste Singapore



Executive Summary

Chapter 1: Public Policy and Regulations

Chapter 2: Player Activity

Chapter 3: Supply/demand potential

Chapter 4: Needs by Local Players

Summary

Chapter 4-1: Overview of Needs by Country

Chapter 4-2: Cross-country Comparison of Needs

Chapter 5: Export Potential to Japan

Appendix

Executive Summary

Chapter 1: Public Policy and Regulations

Chapter 2: Player Activity

Chapter 3: Supply/demand potential

Chapter 4: Needs by Local Players

Summary

Chapter 4-1: Overview of Needs by Country

Chapter 4-2: Cross-country Comparison of Needs

Chapter 5: Export Potential to Japan

Appendix

Key Findings



Technological needs beyond HEFA is increasing in which Japanese companies has solutions to support. Characteristic of needs differs across markets

Key Questions and NRI's Outlook

Key Question

Fact (Desktop Research & Interviews)

NRI's View

Can Japanese companies support with addressing the needs of local companies in each country?

- Local companies are actively working to expand SAF supply; however, they face several challenges in scaling up production
- For example, when utilizing HEFA pathways, technologies for producing SAF from alternative feedstocks—such as pongamia, microalgae, and coconut oil—are still under development, particularly in terms of achieving commercially viable production volumes. Similarly, with respect to ethanol, the deployment of second-generation ethanol remains at a developmental stage.
- Against this backdrop, expectations are rising for Japanese companies with advanced technological capabilities to help address these challenges and support further scale-up.

- There is room for Japanese companies to contribute to addressing the needs of local companies in each country
- In particular, substantial opportunities exist for Japanese firms to enter as technology partners in the demonstration to early commercial stages of less mature pathways, such as AtJ and FT. In addition, Japanese companies can support the expansion of HEFA-based production through the utilization of alternative feedstocks beyond UCO and POME

Are there country-specific differences that Japanese companies should take into account when deploying solutions to address the needs they can help resolve?






- In the target countries covered by this study, used cooking oil (UCO) is expected to serve as the primary feedstock in the initial phase.
- However, based on interviews with local stakeholders, there is a notable trend toward interest in alternative feedstocks. In Malaysia and Indonesia, there is relatively stronger interest in lipid-based feedstocks such as coconut oil and microalgae. In contrast, in Thailand, there is comparatively greater interest in alcohol-based feedstocks, including ethanol.

- Differences can be observed across countries in terms of the alternative feedstocks beyond UCO, that are attracting strong interest for future utilization
- Accordingly, when expanding their business, Japanese companies will need to adopt differentiated technology portfolios tailored to the specific characteristics and priorities of each country






Summary of Chapter 4



Alternative feedstocks for UCO still face issues in getting recognized by ICAO as SAF feedstock and/or feasibility study that prove the yield for investment

	Issues / challenges	
Primary product / co-product	<p>MY: Pongamia and Jatropha align with ICAO sustainability requirements (i.e. can be planted in non-arable land without competing with food crop) and are suitable for long-term development, but the feasibility study and yield data is not ready yet. Hence, companies are still unsure with investment further than research.</p>	
	<p>MY: For microalgae, as the ICAO committee will consider the land and resources needed for the plantation, technology and method of production are the challenge and important point to indicate how to sustainably cultivate the microalgae. However, the clear evidence of the yield and the data identifying viability is not available as of now. So, companies and the government has not put any target on microalgae yet</p>	
	<p>TH: CPO and cassava struggle to gain recognition as sustainable SAF feedstock due to concerns of competing with food and deforestation. Suppliers and government are advocating for certification e.g. ENTEC and FTI are conducting studies to submit to ICAO, demonstrating that Thailand does not engage in deforestation for CPO production. However, the progress is rather slow.</p>	
By product	<p>ID: RBDPKO (Refined, bleached, and deodorized palm kernel oil) is not recognized by ICAO as SAF feedstock yet, but the feedstock itself is mature and ready to be used. There is even successful flying test already. The government is working to make it recognized by ICAO and is studying further about the feedstock, but it may take at least 2 years to complete the process</p>	
	<p>MY: SBEO (Spent Bleaching Earth Oil) is technically ready to be used, but industry concern is ICAO recognition, which affects eligibility for SAF crediting. Hence, companies have to try getting the certification for SBEO</p>	

The limitation of UCO volume and biomass availability remain challenges for TH while MY and ID requires support in usage development of MSW










	Issues / challenges	
Waste	<p>MY, ID: MSW for FT requires complex pre-treatment and decontamination before conversion into syngas. Past pitches lacked proven efficiency, so companies like Petronas did not proceed to invest further.</p>	
	<p>TH, ID: Securing "untapped UCO" is critical for having sufficient UCO. However, funding for feedstock mapping and collection expansion is limited. This can be a critical challenge as the UCO volume will not be sufficient if there are more producers who plan to use UCO to produce SAF in the future. Additionally, currently UCO also have other utilization e.g. use as animal feed which offer high price for UCO supplier</p>	
Residue	<p>TH, MY: EFB is highlighted as the promising residue for second-generation ethanol production due to the abundance in both countries, but yield data is insufficient and the technology to be used with the EFB is still unclear</p>	
	<p>TH: Biomass suitable for SAF production (e.g. bagasse etc.) is already used in electricity generation, so available supply is very limited. Hence, the government is considering biomass types that are not currently used in electricity generation and are typically produced in small, scattered quantities such as straw and husks as these materials have fewer competing uses and therefore become potential feedstock opportunities. However, the hardship in collection and lower yield is to be discussed further</p>	
	<p>TH: There is research project by universities about rubber seed oil to be used as feedstock for HEFA pathway. However, currently rubber seed oil is not recognized as feedstock for ICAO yet. And as it is abandoned in rubber field and cannot be collected by machine, it will be hard to collect and require manpower and logistics cost</p>	

Needs of local government / company | Example of feedstock-related collaboration

In Malaysia, Indonesia, and Thailand, suppliers collaborate in areas like joint research on alternative feedstocks, and development of UCO supply chains

	Category	Collaboration & Technology Needs	
		Private company	Public organization
MY	Joint research on alternative feedstock	<ul style="list-style-type: none"> PETRONAS and Euglena signed an agreement to jointly research and develop large-scale microalgae oil production technology for SAF PETRONAS and Idemitsu signed an MoU to study SAF production from non-edible oil feedstocks e.g. Pongamia and Jatropha* PETRONAS partnered with SEDC Energy to research and develop microalgae strains for SAF production in Sarawak 	<ul style="list-style-type: none"> InvestSarawak, a Sarawak state agency and Marubeni began a feasibility study on producing SAF from biomass in Sarawak
	UCO supply chain building support	<ul style="list-style-type: none"> SEDC Energy signed agreement with partners in pilot plant development. Apeiron Bioenergy will build supply chain for UCO to supply the plant, including collection, verification, logistics, and storage 	<ul style="list-style-type: none"> N/A
ID	Joint research on feedstock	<ul style="list-style-type: none"> Pertamina partnered with Airbus to jointly research SAF feedstocks and support SAF ecosystem development in Indonesia. Airbus will contribute aviation industry expertise 	<ul style="list-style-type: none"> BRIN partnered with local companies and Green Power Development Corporation of Japan (GPDJ) to research about using the CCO from nonedible coconut as feedstock
	UCO supply chain building support	<ul style="list-style-type: none"> KPI (Pertamina subsidiary) partnered with Gapura Mas Lestari, a local UCO supplier, to establish a domestic UCO feedstock supply chain 	<ul style="list-style-type: none"> N/A
TH	Joint research on feedstock	<ul style="list-style-type: none"> BAFS signed MOU with Mitr Phol Biofuel to conduct feasibility study on producing bio-jet fuels and SAF from sugarcane-based ethanol Bangchak and RMUTI have signed MOU to drive research on pongamia as a feedstock to support a larger scale of SAF production 	<ul style="list-style-type: none"> Ministry of Agriculture and Cooperatives and BBGI (a subsidiary of Bangchak) joined in development and research of microalgae for SAF production
	UCO supply chain building support	<ul style="list-style-type: none"> DIPROM signed MOU with private companies to promote UCO supply chain to support SAF production 	

ID requires feedstock R&D and yield optimization for HEFA, while TH and MY need support in second-generation ethanol and cost-effective AtJ technologies

	Issues / challenges	
HEFA	ID: Indonesia is technically ready for HEFA, but companies may need investment & strategic feedstock partnerships. Companies offering feedstock R&D or yield optimization for HEFA can gain immediate interest as the companies and government already fix at HEFA as main pathway	
	ID: CCO from nonedible coconut has high potential in Indonesia from the feedstock abundance in the country as well as from the fact that it is already being recognized as SAF feedstock by ICAO. But further development via technology from external parties is needed as Indonesia does not have advanced technology yet	
	TH, MY, ID: High price will be the largest issue. Currently HEFA-based SAF cost 3 times more than conventional jet fuel. Hence, companies that can minimize production costs would be highly attractive to both airlines and producers. For example, catalyst cost and economies of scale are critical for both HEFA and AtJ, and lower catalyst costs are essential for competitiveness	  
AtJ	TH: As the policy direction under the PDP is not yet finalized, local producers lack confidence to invest in AtJ and 2G ethanol. Currently, ethanol producers rely on 1G ethanol and still have ample feedstock and production capacity, resulting in limited interest in 2G investments. However, if the government introduces a SAF blending mandate in the future, demand for SAF and interest in 2G ethanol are expected to increase.	
	ID: Ethanol volume might not be enough for SAF production. For Indonesia, ethanol will have to be spitted for other fuel product, so the utilization of SAF production may not be prioritized by the government	
	TH, MY: Second-generation ethanol is expected to be crucial alternative pathway as there are concerns that the first-generation ethanol will face difficulties getting recognized as SAF feedstock. But it is not yet commercial and requires high amount of investment which can be challenge for ethanol producers <ul style="list-style-type: none"> In case of Petronas, due to budget constraints, the company will not start R&D from zero but look for only partners with existing data/pilot results that can show solid progress within around 5 years 	 

Needs of local government / company | By technology

For FT, MY, ID and TH need support in waste gasification and syngas technologies, while TH and SG need support in facilities development

	Issues / challenges	
AtJ	TH: One key challenge in Thailand is that ethanol supply is mixed between molasses and cassava, which may not meet ICAO sustainability criteria, requiring upstream upgrading and feedstock supply segregation.	
	TH: Currently Thailand does not have technology to convert ethanol into jet fuel. The government is considering buying technology from other countries	
FT	MY, ID: Technology itself is mature, but the bottleneck is producing syngas efficiently from waste. Previous proposals for MSW-to-syngas failed to show credible pilot proof, so companies like Petronas and Pertamina rejected investment.	 
	TH: Electrolyzers for hydrogen are cost-intensive, reducing project feasibility.	
	TH, ID: Thailand does not yet have licensed FT technology providers	 
	TH: Biomass is in high demand across various energy industries, leading to increased biomass prices and higher cost for SAF produced by FT	
Overall	TH, SG: Blending capability is needed outside airport zones, as on-site blending is restricted due to safety/space. For Thailand, currently there's no large scale blending facility for neat SAF yet.	 
	SG: SAF currently shares the same HS code as Jet A1, making taxation, tracking, and import/export handling ambiguous. Hence, differentiation of HS code is needed for clearer customs processes and policy incentive alignment.	
	SG: Currently there is not enough storage for SAF in Singapore. In periods that the production is high, sometime producers need to store SAF product in a ship due to lack of space. Hence, investment for storage facility is needed	
	TH: If the Japanese sustainability certification scheme (SCS) ClassNK is pushed to be used widely, the certification can support feedstock certification especially in the APAC region. Then Thailand and other ASEAN countries would not need to rely solely on EU-based certification schemes and may have more potential to use alternative feedstock	

In Malaysia, suppliers collaborate mainly on knowledge sharing and improving efficiency of HEFA, while in Indonesia Pertamina has collaboration on e-SAF

	Category	Collaboration & Technology Needs	
		Private company	Public organization
MY	Technology support and knowledge sharing	<ul style="list-style-type: none"> • SEDC Energy signed agreement with partners in pilot plant development. Sulzer will provide its modular “BioFlux” technology (high-performance, low-emissions solution for SAF production) to effectively convert renewable oils 	<ul style="list-style-type: none"> • N/A
		<ul style="list-style-type: none"> • SEDC Energy signed agreement with partners in pilot plant development. Oiltek will provide engineering and construction support for the plant, leveraging its experience in large-scale refining facilities in Sarawak • FatHopes Energy signed an agreement to access advanced technologies such as Topsoe’s “HydroFlex” (refinery process for converting wide variety of feedstock into high-quality SAF), along with catalyst support and engineering expertise 	
ID	Joint research on innovative pathway	<ul style="list-style-type: none"> • Pertamina NRE partnered with MGH Energy, a French energy company, to develop low-carbon and renewable fuels, including e-SAF 	<ul style="list-style-type: none"> • N/A
	Joint research on technology for alternative feedstock	<ul style="list-style-type: none"> • N/A 	<ul style="list-style-type: none"> • BRIN is leading Indonesia–Japan collaboration to develop SAF from non-standard coconuts, now assessing the applicability of Japanese-developed technology

Needs of local government / company | Example of technology-related collaboration

In Thailand, suppliers collaborate through development in pathway technology such as AtJ and SAF delivery pilot project

	Category	Collaboration & Technology Needs	
		Private company	Public organization
TH	Joint development on innovative pathway	<ul style="list-style-type: none"> PTT and its subsidiaries have signed MOU to collaborate on exploring HEFA and AtJ technologies for SAF production Bangchak collaborated with Desmet and Honeywell UOP in developing the production process of its refinery 	<ul style="list-style-type: none"> N/A
	Joint knowledge exchange of SAF	<ul style="list-style-type: none"> Energy Absolute has signed MOU with BAFS to develop knowledge, experience, and technology in SAF production 	<ul style="list-style-type: none"> ENTEC partnered with GIZ to organize SAF Working Group Milestone meeting
	SAF delivery pilot project	<ul style="list-style-type: none"> Bangchak, in collaboration with BAFS and BPT, initiated a pilot project to deliver SAF via pipeline to Suvarnabhumi and Don Mueang Airport 	<ul style="list-style-type: none"> N/A

*Note: Pongamia and Jatropha refer to types of plant with oil-rich seed that can be processed into biofuel

Source: News articles

Needs of local government / company | Example of activity from public organizations

While overall government support is limited, Singapore and Malaysia partner with private firms to advance SAF development e.g. CO₂-to-Fuel conversion

	Organization	Pilot projects	Initiative and collaboration
SG	A*STAR Institute of Sustainability for Chemicals, Energy and Environment (A*STAR ISCE ²)	<ul style="list-style-type: none"> A*STAR ISCE² together with IHI completed and inaugurated a bench-scale test rig for producing SAF via direct CO₂-to-liquid hydrocarbon conversion, simplifying production and improving energy efficiency with current capacity of 5 kg per day 	<ul style="list-style-type: none"> N/A
TH	National Research Council of Thailand (NRCT) and Airports of Thailand Public Company Limited (AOT)	<ul style="list-style-type: none"> NRCT, together with Bangchak and RMUTI, has signed an MOU to develop a green innovation project aimed at producing SAF from fusel alcohol derived from ethanol plants that use molasses and cassava 	<ul style="list-style-type: none"> AOT has established a subsidiary under the name "Airport Energy Absolute Company Limited (AEA)", a joint venture with EA to operate tank farm facilities and SAF blending system.
MY	Malaysian Palm Oil Board (MPOB), Ministry of Plantation Industries and Commodities	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> MPOB signed an MOU with Chinese partners to develop an HVO plant with potential SAF output, leveraging waste and off-spec oils to enhance the value of Malaysian palm oil through a waste-to-wealth strategy
ID	N/A	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> N/A

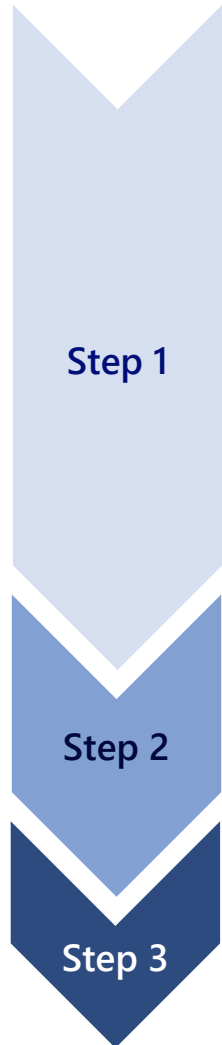
Japanese companies have opportunities to support in area of developing immature feedstock for HEFA and technology advancement for AtJ and FT

Technological challenges Area that JP companies have high potential to support

Technology readiness from high to low

Supply chain	HEFA	AtJ	FT	PtL
Upstream • Feedstock production • Collection/harvesting	Insufficient UCO, POME Total volume of UCO and POME are not enough compared to the high demand	Difficulties in being recognized by ICAO: Edible feedstock, e.g. palm-based feedstock e.g. CPO and cassava for 1G ethanol face challenge in being recognized by ICAO. This then leads to another issues of mixed ethanol. Mixed molasses–cassava ethanol may not meet ICAO criteria, hence requiring supply segregation		PtL is not widely considered in ASEAN due to its complexity, cost, and reliance on mature renewable power and hydrogen infrastructure
	Hard to collect UCO UCO from household is hard to collect efficiently	1 Unclear data on yields and suitable production technology for alternative HEFA feedstock Feedstock under study e.g. Pongamia, Microalgae, CCO lack clear evidence of yield identifying viability and comfortable technology. Hence, investment in full scale production and plantation are not possible yet	Competitive feedstock demand from other utilization: As ethanol is used for other fuel, the volume may not be enough for AtJ. And for FT, easy to use biomass (e.g. bagasse) is already utilized e.g. for electricity generation	
SAF Production • SAF refinery • Blending		2 Unclear technology for 2G ethanol: Yield data is insufficient and technology to be used is unclear	3 Hard to produce syngas technology for syngas production e.g. form MSW failed to show progress	
		Hard to collect biomass: Unutilized biomass for 2G ethanol for AtJ and FT e.g. straw and is scattered and hard to collect		
Downstream • Storage and usage	High investment: AtJ and FT require high investment for plant construction, along with cost of operation. Players are not able to proceed from budget constrain			
	Insufficient infrastructure for SAF The current large-scale infrastructure is still limited. For example, blending facilities in many countries are not in large commercial scale. And facility for SAF storage is very limited in countries like Singapore and more investment is needed			

To create list as example of companies with potential solutions, NRI listed up companies from various sources using keywords to identify relevant technology



Primary screening of companies with technology via NEDO website

- Reviewed NEDO website in the following areas
 - ✓ 持続可能な航空燃料（SAF）等の安定的・効率的な生産技術開発事業
 - ✓ バイオジェット燃料生産技術開発事業
 - ✓ CO2等を用いた燃料製造技術開発
 - ✓ バイオものづくり革命推進事業
 - ✓ バイオものづくり技術によるCO2を直接原料としたカーボンリサイクルの推進
 - ✓ カーボンリサイクル・次世代火力発電等技術開発
 - ✓ 脱炭素化・エネルギー転換に資する我が国技術の国際実証事業
- Focused only on companies with technologies and excluding trading companies unless they focus on relevant technology development

Selection with technology-focused keywords

- Identified relevant SAF technologies using targeted keywords as follows
 - ✓ **HEFA**: Microalgae, non-standard coconuts, pongamia, plant-derived oils and fats that do not compete with food, etc.
 - ✓ **AtJ**: Bioethanol, second generation ethanol, 2G ethanol etc.
 - ✓ **FT**: FT synthesis, gasification, syngas etc.

Supplementary research based on publicly available source

- Conducted additional desktop research beyond NEDO website using the same keywords across news articles and company websites

Japanese company can provide solutions e.g., production process development, trial plantations, and supply chain verification for alternative HEFA feedstocks

Issues	Solutions	Company name	Company type	Related company activities
1 Unclear data on yields and suitable production technology for alternative HEFA feedstock	Develop technology and production of SAF from microalgae	Euglena	Microalgae developer and manufacturer	<ul style="list-style-type: none"> Develop microalgae technology to enable large-scale production of microalgae oil as feedstock for biofuels
		Denso Corporation	Automotive components manufacturer	<ul style="list-style-type: none"> Develop large-scale microalga cultivation technologies
		Mitsubishi Kakoki Kaisha	EPC	<ul style="list-style-type: none"> Develop machines by applying company's separation and extraction technology in order to produce biofuel from cultured microalgae
		Mitsubishi Chemical	Chemical and specialty materials manufacturer	<ul style="list-style-type: none"> Develop microalgae harvesting technologies by leveraging membrane separation technologies
		IHI Corporation	EPC	<ul style="list-style-type: none"> Develop mass-production process of high-performance strain of microalgae called Hyper-Growth Botryococcus Braunii (HGBb) Develop manufacturing process of algal oil
		CHITOSE Group	Biotechnology solution provider	<ul style="list-style-type: none"> Operate large-scale algae production facility using CO2 from exhaust gases emitted by thermal power plant
		Electric Power Development (J-Power)	Energy company	<ul style="list-style-type: none"> Develop large-scale cultivation technology for microalgae, which serve as a feedstock for SAF
		Phycochemistry	Microalgae developer and manufacturer	<ul style="list-style-type: none"> Demonstrate project for cultivating heterotrophic algae using excess sludge and producing crude oil for biodiesel fatty acids

Japanese company can provide solutions e.g., production process development, trial plantations, and supply chain verification for alternative HEFA feedstocks

Issues	Solutions	Company name	Company type	Related company activities
1 Unclear data on yields and suitable production technology for alternative HEFA feedstock	Develop technology and production of SAF from non-standard coconut	Green Power Development Corporation of Japan	EPC	<ul style="list-style-type: none"> Establish ICAO CORSIA recognition of non-standard coconut Develop catalyst efficiently converting Crude Coconut Oil (CCO) into neat SAF Develop SAF business model covering sourcing of non-standard coconuts from major producers (e.g., Indonesia), CCO manufacturing, and import of CCO for neat SAF production
		HighChem	Chemical company	<ul style="list-style-type: none"> Co-develop a catalyst that converts crude coconut oil into neat SAF with Green Power Development Corporation of Japan and the Tokyo University of Agriculture and Technology
	Develop technology and production of SAF from other non-edible oil plant	Idemitsu Kosan	Energy company	<ul style="list-style-type: none"> Conduct feasibility study of the supply potential of non-edible oil feedstock trees, such as Pongamia and Jatropha Conduct trial plantations of Pongamia and verify the supply chain from cultivation to oil extraction and SAF production
		J-Oil Mills	Food manufacturer	<ul style="list-style-type: none"> Produce SAF from oil extracted from Calophyllum indicum seeds and pongamia, meeting ICAO CORSIA criteria
		Yokohama Rubber	Rubber manufacturer	<ul style="list-style-type: none"> Join research to establish a sustainable collection system for para rubber seeds for green products
		Innovare	Rubber seed oil manufacturer	<ul style="list-style-type: none"> Produce rubber seed oil from rubber seed Supply Thailand-sourced natural rubber seed oil to biodiesel fuel manufacturers
		Nomura Jimusho	Specialized trading company	<ul style="list-style-type: none"> Conduct feasibility study to utilize rubber seed oil as raw material for SAF

Japanese companies can provide technology solutions e.g. technology and knowhow for 2G ethanol production from woody biomass, agricultural residues

Issues	Solutions	Company name	Company type	Related company activities
2 Unclear technology for 2G ethanol	Develop technology and production of 2G ethanol from woody biomass	Green Earth Institute	Biotechnology solution provider	<ul style="list-style-type: none"> Provide low-cost bioethanol production processes with growth-arrested bioprocess (RITE Bioprocess) and fermentation process optimization
		Nippon Steel Engineering	EPC	<ul style="list-style-type: none"> Operate 2G bioethanol pilot facilities focusing on integrated processes (pretreatment, saccharification, fermentation) with various residues e.g. food waste, woody biomass
		Kao Corporation	Chemical manufacturer	<ul style="list-style-type: none"> Provide saccharification enzymes efficiently breaking down non-edible biomass e.g. woody biomass used as raw material for producing bioethanol fuel for automobiles
		Nippon Paper Industries	Paper manufacturer	<ul style="list-style-type: none"> Develop low-carbon bioethanol production process using domestic wood biorefinery Establish a JV for the production and sale of bioethanol woody biomass with Sumitomo Corporation and Green Earth Institute
		Biomaterial in Tokyo	Biotechnology solution provider	<ul style="list-style-type: none"> Produce enzymes from specific filamentous fungi that convert difficult-to-decompose woody biomass into monosaccharides Provide know-how in the design and construction of 2G bioethanol production plants and the establishment of supply chains
		Oji Holdings Corporation	Paper manufacturer	<ul style="list-style-type: none"> Launch a large-scale pilot plant in Japan to produce ethanol from woody biomass, converting wood-derived sugars into bioethanol

Japanese companies can provide technology solutions e.g. technology and knowhow for 2G ethanol production from woody biomass, agricultural residues

Issues	Solutions	Company name	Company type	Related company activities
2 Unclear technology for 2G ethanol	Develop technology and production of 2G ethanol from woody biomass	Daio Paper Corporation	Paper manufacturer	<ul style="list-style-type: none"> Develop 2G bioethanol from non-food woody biomass as part of its biorefinery business, progressing from sample provision toward pilot and future commercial-scale production by 2030
	Develop technology and production of 2G ethanol from agricultural residue	Kawasaki Heavy Industries	EPC	<ul style="list-style-type: none"> Provide low-cost bioethanol production from residue such as rice straw using a hot-water saccharification process instead of sulfuric acid or enzymes, resulting in reduced equipment needs and lower production costs
		JGC Group Corporation	EPC	<ul style="list-style-type: none"> Conduct demonstration projects at 20 m³ scale for 2G ethanol production using agricultural residue such as sugarcane bagasse, rice straw, wheat straw, coffee waste, palm trunk, mushroom waste etc.
		Sanyu Plant Service	Waste management company	<ul style="list-style-type: none"> Develop 2G bioethanol from spent coffee grounds as feedstock, applying steam explosion pretreatment and fermentation to convert coffee waste into ethanol as part of its biomass utilization initiative
		Sapporo Breweries	Alcohol drink manufacturer	<ul style="list-style-type: none"> Develop bioethanol from cassava pulp using proprietary fermentation technology, converting biomass residues into fuel through pilot-scale production in Thailand

Japanese companies can provide technology solutions e.g. technology and knowhow for 2G ethanol production from woody biomass, agricultural residues

Issues	Solutions	Company name	Company type	Related company activities
2 Unclear technology for 2G ethanol	Develop technology and production of 2G ethanol from agricultural residue	Iwata Chemical	Chemical manufacturer	<ul style="list-style-type: none"> Participate in R&D on bioethanol production from cassava pulp using heat-tolerant yeast, advancing toward demonstration with Sapporo Holdings
		Tsukishima Kikai	EPC	<ul style="list-style-type: none"> Develop and implemented enzyme-based process for converting bagasse into ethanol by producing cellulase enzymes on-site and conducting pilot-scale demonstration in Thailand
		JFE Engineering Corporation	EPC	<ul style="list-style-type: none"> Support engineering and deployment of the bioethanol production facilities used in the 2G bioethanol from bagasse demonstration project with Tsukishima Kikai
		Kanadevia	EPC	<ul style="list-style-type: none"> Provide engineering and membrane separation technologies for the bioethanol demonstration plant to ferment and purify ethanol from potato starch
		Toray Industries	Textile company	<ul style="list-style-type: none"> Convert sugarcane bagasse into fermentable cellulose sugars, enabling subsequent fermentation and distillation into ethanol or other biochemicals with demonstration plant in Thailand
		DM Mitsui Sugar	Sugar manufacturer	<ul style="list-style-type: none"> Contribute to demonstration of a bagasse-to-cellulose sugar system with Toray by assessing functionality and business potential of polyphenols and other co-products from lignocellulosic biomass that support 2G bioethanol production processes

Japanese companies can provide technology solutions e.g. technology and knowhow for 2G ethanol production from woody biomass, agricultural residues

Issues	Solutions	Company name	Company type	Related company activities
2 Unclear technology for 2G ethanol	Develop technology and production of 2G ethanol from waste and chemical substance	ENEOS	Energy company	<ul style="list-style-type: none"> Conduct demonstration projects with Toppan and Nippon Paper Industries to make bioethanol from hard-to-recycle used paper feedstock for fuels/chemicals
		Taiko Paper	Paper manufacturer	<ul style="list-style-type: none"> Conduct demonstration projects for bioethanol production technology using kraft pulp produced from unused resources such as construction waste as a raw material and enzymes internally produced from industrial microorganisms
		Rengo	Paper manufacturer	<ul style="list-style-type: none"> Co-conduct demonstration projects for bioethanol production from kraft pulp with its subsidiary, Taiko Paper
		Kanadevia	EPC	<ul style="list-style-type: none"> Develop a demonstration bioethanol production system in China that converts waste materials such as food scraps and paper into fuel and aiming for commercialization after the 2024 trial
		Sekisui Chemical	Chemical manufacturer	<ul style="list-style-type: none"> Develop technology to convert CO to ethanol Develop biorefinery technology to convert municipal and other waste biomass into ethanol, using a microbial catalyst
	Develop technology and production of 2G ethanol from non-food biomass	Idemitsu Kosan	Energy company	<ul style="list-style-type: none"> Develop ATJ pathway to produce SAF from bioethanol, focusing on demonstration-scale production and process optimization, including future expansion to 2G ethanol from non-food biomass in the roadmap to support commercialization around 2030

Technologies to produce syngas from waste can be the area that Japanese companies have potential to provide solutions

Issues	Solutions	Company name	Company type	Related company activities
3 Hard to produce syngas	Develop technology and production of syngas from waste	JFE Engineering Corporation	EPC	<ul style="list-style-type: none"> Provide technology branded C-PhoeniX Process® for a waste-to-chemical (WtC) to produce synthesis gas that can be used as raw materials for SAF Conduct demonstration project on commercial scale using C-PhoeniX Process® for production of purified synthesis gas from waste for SAF production and other industrial use
		Sumitomo SHI FW	EPC	<ul style="list-style-type: none"> Provide Air Fluidized Bed Gasification technology by using to heat waste to raw syngas and improve the quality of syngas by a cleaning process to remove impurities for the conversion of waste materials and biomass to syngas
		JGC Group Corporation	EPC	<ul style="list-style-type: none"> Supply waste plastic and produce syngas from waste plastic by technology called EUP, the gasification chemical recycling technology developed by solutions provider companies, Ebara Environment Plant and Ube Industries Ltd.
		Toyo Engineering	EPC	<ul style="list-style-type: none"> Conduct technical feasibility study to produce SAF via gasification FT synthesis and methanol synthesis using a variety of feedstocks, including municipal waste
		United Planning	EPC	<ul style="list-style-type: none"> Conduct demonstration project on SAF production using gasification and FT synthesis technology by utilizing wood resources and waste plastic from Akita Prefecture

Technologies to produce syngas from waste can be the area that Japanese companies have potential to provide solutions

Issues	Solutions	Company name	Company type	Related company activities
3 Hard to produce syngas	Develop technology and production of syngas from waste	ENEOS	Energy company	<ul style="list-style-type: none"> Develop synthetic fuels from CO₂ captured from industrial exhaust or the atmosphere and renewable hydrogen, using Fischer–Tropsch synthesis and fuel upgrading processes.
		United Planning	EPC	<ul style="list-style-type: none"> Conduct demonstration project on SAF production using gasification and FT synthesis technology by utilizing wood resources and waste plastic from Akita Prefecture
	Develop technology and production of syngas from biomass	Mitsubishi Heavy Industries	EPC	<ul style="list-style-type: none"> Provide technology for conversion of woody biomass into syngas using gasification
		Mitsubishi Power	EPC	<ul style="list-style-type: none"> Joint research to develop a commercial-scale supply chain for SAF derived by wood biomass gasification integrated with FT synthesis technology Provide basic design of commercial-scale gasification facilities
		IHI Corporation	EPC	<ul style="list-style-type: none"> Provide technology branded TIGAR® for gasification of biomass resources e.g. bark pellet, wood chip, lignite to syngas

Reference) Example of Other Latest Activities by Japanese Companies for SAF

Other activities include development of supply chain for raw materials between ASEAN and Japan, and development of SAF produced from hydrogen and CO2

Supply chain	Current Situation in ASEAN and Japan	Examples (Non-exhaustive) of Latest Activities by Japanese Companies
<p>Upstream</p> <ul style="list-style-type: none"> • Feedstock production • Collection/harvesting 	<ul style="list-style-type: none"> • Japan is aiming to increase SAF production, but needs to increase the procurement of raw materials • ASEAN has a significant amount of raw materials, in which Japanese companies are aiming to develop a supply chain for raw material export from Japan to ASEAN 	<ul style="list-style-type: none"> • Japanese trading companies are aiming to develop a supply-chain with regards to export of raw materials from ASEAN to Japan • For example, Sumitomo Corporation is currently conducting a study on export of bioethanol from Thailand to Japan for further implementation of energy policies, in which the study included infrastructure, legal framework, and feasibility of business development in the Global South Future-Oriented Co-Creation Subsidy Program
<p>SAF Production</p> <ul style="list-style-type: none"> • SAF refinery • Blending 	<ul style="list-style-type: none"> • In ASEAN, the production of SAF using CO2 and hydrogen is still in a very early phase of consideration, but is one of technologies shown interest for long-term implementation • Japanese companies are developing advanced technology for production of SAF using CO2 and hydrogen, which can be leveraged in the future 	<ul style="list-style-type: none"> • Japanese companies are currently working on development of technology in this area • For example, IHI (Japanese EPC), ISCE (Institute of Sustainability for Chemicals, Energy, and Environment), and A*Star signed MOU towards 3rd AZEC Ministerial Meeting regarding synthesis of hydrocarbons directly from hydrogen and CO2 for use in SAF, to scale up SAF production technology • Also, Fujifilm is also conducting development and demonstration of manufacturing technologies using microorganisms capable of producing materials from CO2 as a feedstock (selected as NEDO's Green Innovation Fund Project), in which production of fuel (including SAF) from CO2, is considered as one of the potential target industry

Executive Summary

Chapter 1: Public Policy and Regulations

Chapter 2: Player Activity

Chapter 3: Supply/demand potential

Chapter 4: Needs by Local Players

Summary

Chapter 4-1: Overview of Needs by Country

Chapter 4-2: Cross-country Comparison of Needs

Chapter 5: Export Potential to Japan

Appendix

Neste's APAC Innovation Center in Singapore develops new raw material and pretreatment processes for feedstock and collaborates across the region.

Overview of Neste APAC Innovation Center

Expert interview insights

Company	Neste APAC Innovation Center in Singapore
Partner country and organization	Neste's network in the Asia-Pacific region including academia, research institutions and industry players
Status and date	The center was officially opened on 15 February 2023
Objective	<ul style="list-style-type: none"> To research raw materials and pretreatment processes to unlock new possibilities for sustainable fuels. To drives collaboration with Neste's network in the Asia-Pacific region.
Collaboration detail	<ul style="list-style-type: none"> The first R&D facility outside of Finland headquarters and operational since 2023. The Innovation Center is located in the Science Park II in the western part of Singapore, and has hired more than 20 researchers and professionals (as of 2023) The center with laboratory equipment and advanced analytical capabilities focuses on research around raw materials and the pretreatment processes.

Neste has an R&D center in Singapore to support research on new feedstocks.

For example, they are studying novel vegetable oils (NVO) as a feedstock in Singapore, but in practice, this feedstock would need to be produced in countries with significant farming activity, where land can be used during the low season to grow non-edible crops specifically for SAF production.

Industry player associated and familiar with Neste Singapore



IHI and A*STAR ISCE² have inaugurated a bench-scale test rig for producing SAF via direct CO₂-to-liquid hydrocarbon conversion, with a capacity of 5 kg per day

Overview of pilot project

Project name	New Bench-Scale Sustainable Aviation Fuel (SAF) Test Rig in Singapore
Responsible government organization	A*STAR Institute of Sustainability for Chemicals, Energy and Environment (A*STAR ISCE ²)
Partner organization	IHI Corporation IHI ASIA PACIFIC PTE. LTD.
Status and date	<ul style="list-style-type: none"> Signed MoU in October 2024 Held an opening ceremony in January 2025
Objective	To evaluate catalyst durability, optimize operating conditions, and validate the complete SAF production process from CO ₂ and hydrogen
Project detail	<ul style="list-style-type: none"> IHI, together with A*STAR ISCE² in Singapore, has completed and inaugurated a bench-scale test rig for producing SAF via direct CO₂-to-liquid hydrocarbon conversion. The rig has a capacity of 5 kg per day. This technology enables single-step CO₂ conversion to liquid hydrocarbons, simplifying production and improving energy efficiency.

Opening Ceremony of SAF production test rig

- At IHI, we recognise the urgent need to decarbonise aviation, and this project demonstrates our dedication to developing next-generation sustainable fuels.
- By bringing this test rig to Singapore, we are not only advancing technological frontiers but also contributing to the global effort to achieve net-zero emissions in aviation.



Dr Nobuhiko Kubota, Managing Executive Officer of IHI Corporation

- The launch of this test rig is a testament to our shared vision of driving decarbonisation through innovation.
- By enabling a direct, energy-efficient pathway from carbon dioxide to sustainable aviation fuel, we are proud to contribute to advancing low-carbon technologies that support Singapore's Green Plan 2030 and global climate goals.



Dr Ng Wai Kiong, Executive Director at A*STAR ISCE²

Aether can use waste-carbon feedstocks, a key advantage for next-generation SAF production in Singapore, which lacks enough UCO to meet future demand

Overview of pilot project

Project name	Aether's commercial demonstration facility
Responsible government organization	Singapore Economic Development Board (EDB)
Partner organization	<ul style="list-style-type: none"> Aether Fuels (Aether), a SAF producer Aster, a leading provider of energy and chemical solutions in Southeast Asia
Status and date	Signed an agreement to develop the facility on 11 Nov 2025
Objective	To produce SAF from waste gas and biomethane
Project detail	<ul style="list-style-type: none"> Project Beacon, Aether's commercial demonstration facility, will utilize the company's Aurora™ technology to produce up to 50 barrels of fuel per day (2,000 tons of fuel per year). It will convert industrial waste gas and biomethane into CORSIA certified SAF. Aster will provide renewable power, waste carbon feedstock, utilities, and site support to accelerate the commercialization of Aether's scalable solution. The project is expected to commence construction in 2026 and begin commercial operations in 2028

Aether Fuels' Project Beacon in Singapore

This new SAF facility strengthens Singapore's competitiveness as a hub for sustainable products. We welcome more companies to partner with us in advancing sustainable solutions, to shape the growth for Singapore and the region.

Chairman of the Singapore Economic Development Board (EDB), Png Cheong Boon



Expert interview insights

This project received support from the Singapore government. However, its annual capacity of 2,000 tonnes is considered relatively small.

Industry player associated and familiar with Neste Singapore



Note: Aurora™ is a simplified evolution of a common industrial gas-to-liquid process. It produces fuel from feedstock that can be converted into CO, CO₂, CH₄, and H₂.

Source: EDB, Aether, interview

SEDC Energy, together with partner companies, works towards a 15k tonnes UCO-based SAF pilot plant to kick start Sarawak’s sustainable aviation journey

Overview of the collaboration

Company	SEDC Energy Sdn Bhd (subsidiary of Sarawak Economic Development Corporation)
Partner country and organization	<ul style="list-style-type: none"> • Sulzer (Swiss industrial engineering firm and SAF technology provider) • Apeiron Bioenergy (Singaporean waste feedstock supplier) • Oiltek (Malaysian vegetable and edible oil process engineering company)
Status and date	Announced in July 2025 and on-going
Objective	To explore possibility in establishing local SAF production capacity in Sarawak
Collaboration detail	<p>The pilot is planned for 15k tonnes capacity and will convert algae oil, palm oil mill effluent (POME), animal fats and UCO into SAF via HEFA with Sulzer’s modular “BioFlux” technology.</p> <ul style="list-style-type: none"> • BioFlux features a proprietary liquid-full reactor design that optimizes hydrogen availability and eliminates the need for a vapor recycle loop, resulting in a high-performance, low-emissions solution for SAF production • Apeiron will build supply chain for UCO including collection, verification, logistics, and storage to ensure sustainable feedstock

SEDCE executive’s opinion from interview article

Hydrogen is needed in removing oxygen from the feedstock, which will then convert this into jet fuel or in this case, SAF. Hence, **with advanced technologies like BioFlux, we are tapping into the potential of our local resources to produce world-class SAF.**

Our partnership with Sulzer represents a major step toward realizing the vision of a sustainable energy future in Sarawak.

SEDCE Chief Executive Officer, Robert Hardin



FatHopes Energy signed agreement with Topsoe to explore potential of developing SAF production in Malaysia

Overview of the collaboration

Company	FatHopes Energy (FHE)
Partner country and organization	Topsoe (Danish carbon reductions advanced technology and solutions provider)
Status and date	Announced in September 2024 and on-going
Objective	To develop a feasibility study to evaluate Malaysia’s suitability to host a SAF refinery
Collaboration detail	<p>Under the MOU, Topsoe will provide its cutting-edge technologies e.g. “HydroFlex technology”, including catalyst solutions and engineering expertise, to assess the feasibility of establishing the proposed refinery. FatHopes Energy will utilize its know how and network of feedstock aggregation to ensure a robust supply chain of waste-based raw materials.</p> <p>The facility, once developed, could either be operated by FatHopes Energy or licensed to a third-party operator for commercialization.</p> <p>The first phase of this collaboration will involve a detailed feasibility study focused on evaluating Malaysia as the ideal location for SAF facility</p>

FatHopes Energy’s opinion from news article

We are proud to join forces with Topsoe to drive the development of a SAF refinery in Malaysia.

This partnership will **leverage waste-based feedstocks such as UCO and cutting-edge HydroFlex* technology to help decarbonize the aviation industry at scale**

FatHopes Energy Chief Executive Officer, Vinesh Sinha



* Note: HydroFlex technology refers to process that allows a refinery to take a wide variety of renewable oils and fats e.g. UCO, animal fat, vegetable oil, and waste oils etc. and convert them with hydrogen and specific catalysts, into high-quality “drop-in” fuel

PETRONAS Research and Euglena Co. signed a joint agreement to research and develop large-scale microalgae oil production technology for their SAF plant

Overview of the collaboration

Company	PETRONAS Research Sdn Bhd (subsidiary of PETRONAS)
Partner country and organization	Euglena Co. (Japanese algae cultivation firm)
Status and date	Announced in August 2024 and on-going
Objective	To create a reliable supply chain for biofuel production plants, focusing on microalgae with an ultimate goal to provide feedstock for a SAF plant being built by Euglena, Petronas, and Enilive
Collaboration detail	<p>Petronas Research announced a joint research agreement with Euglena Co to implement a research with a mission to materialize the future large-scale commercial production of microalgae oil for SAF and other biofuels.</p> <p>Both parties form partnership to develop microalgae technology which includes cultivation, harvesting, extraction and by-product usage, enabling the delivery of techno-economical solution for large-scale commercial production of microalgae oil for biofuels</p>

Euglena’s opinion from news article

Upon success of technology development, Euglena and Petronas Research will **potentially further collaborate to scale up the microalgae cultivation technology** targeting to start a large-scale commercial production and valorization of defatted algae by-products **in the early 2030s.**

This collaborative effort will solidify Euglena’s position as the leading biotechnology company and “sustainable first” solutions provider.

Euglena Co., Ltd. Public Relations Department



PETRONAS and Idemitsu signed MOU to collaborate and study the development of SAF from non-edible oil feedstock

Overview of the collaboration

Company	PETRONAS (Malaysia's national oil and gas company)
Partner country and organization	Idemitsu Kosan (Japanese petroleum and energy company)
Status and date	Announced in October 2023 and on-going
Objective	To jointly conduct a feasibility study to develop a scalable, efficient supply chain for SAF
Collaboration detail	<p>Under the terms of the MOU, PETRONAS and Idemitsu will focus on a feasibility study to scale-up bio feedstock possibilities, production cost analysis and security in ensuring a steady and efficient supply chain for the sustainable development of SAF.</p> <p>This includes exploring the supply potential of non-edible oil feedstock trees suitable to produce SAF, such as Pongamia and Jatropha.</p> <p>In addition, both companies will also work on establishing a robust SAF sales and distribution network to ensure SAF accessibility to airlines.</p>

Idemitsu executive's opinion from interview article

We expect this new initiative will contribute to the achievement of carbon neutrality in the aviation industry through the early implementation and deployment of SAF in society.

Idemitsu is **engaged in the development of various raw materials and marketing for SAF, and we will utilize and further develop them in this joint study.**

Idemitsu Director and Managing Executive Officer,
Masahiko Sawa



PETRONAS partnered with SEDC Energy to research and develop microalgae strains for SAF production in Sarawak

Overview of the collaboration

Company	PETRONAS Research Sdn Bhd (subsidiary of PETRONAS)
Partner country and organization	SEDC Energy Sdn Bhd (Malaysian subsidiary of Sarawak Economic Development Corporation)
Status and date	Announced in February 2023 and on-going
Objective	To jointly develop technology for SAF production from microalgae
Collaboration detail	<p>PETRONAS Research and SEDC Energy have signed an agreement to jointly develop algae production technology which includes developing algae strains with high oil content at a competitive production cost, commercial production requirements for the cultivation, extraction of crude algae oil to be refined to SAF.</p> <p>Both parties are currently working with technology partners to further enhance the production yield and reducing cost by exploring the potential of locally manufactured equipment to reduce costs from importing equipment, and upscaling to large scale commercial farming to reduce the overall production cost.</p>

PETRONAS executive's opinion from interview article

We believe **crude algae oil has the potential to support PETRONAS' Net Zero Carbon Emissions by 2050** aspiration, and we **welcome collaborations with like-minded partners like SEDC** who share our vision.

We also look forward to playing our role in realizing the state's sustainability goals,

PETRONAS Senior Vice President of Project Delivery and Technology, Datuk Bacho Pilog



MPOB signed an MOU with Chinese partners to develop a HVO production facility in Malaysia which also has potential for SAF production

Overview of the engagement

Ministry's statement

Topic	MOU to develop HVO facility in Malaysia
Responsible government organization	Malaysian Palm Oil Board (MPOB), under the Ministry of Plantation Industries and Commodities
Partner organization	<ul style="list-style-type: none"> • Pengerang Maritime Industries • Shanxi Construction Investment Group • Institute of Coal Chemistry, Chinese Academy of Sciences
Status and date	Announced in December 2021 and on-going
Objective	To strengthen Malaysia-China cooperation in producing second-generation biofuel (HVO) for biodiesel and biojet fuel (SAF) and to enhance value-addition of Malaysian palm oil products in higher-value markets
Engagement detail	MPOB has signed a MOU with Chinese partners to develop a large-scale HVO facility in Malaysia that also has the potential to produce SAF which is also known commonly as biojet fuels. The HVO can be produced using waste and off-spec oils or by-products which complement the waste-to-wealth holistic approach other than using normal palm oil products (CPO, RBD palm olein or RBD palm stearin).

The planned HVO plant is expected to **involve foreign direct investment of around RM3 billion, create nearly 800 jobs in Malaysia**, and support both countries' decarbonization commitments (Malaysia's carbon-intensity reduction by 2030 and China's carbon-neutrality by 2060)

Plantation Industries and Commodities Ministry



Malaysian state government agency joined force with Marubeni to study feasibility of SAF production from biomass in Sarawak

Overview of the collaboration

Topic	MOU on Feasibility Study for a Biomass to SAF Project in Malaysia
Responsible government organization	InvestSarawak (Sarawak state government agency)
Partner country and organization	Marubeni Corporation (Japanese trading and investment business conglomerate)
Status and date	Announced in May 2024 and on-going
Objective	To investigate the feasibility of producing and SAF from biomass in Sarawak
Collaboration detail	<p>Marubeni Corporation signed a MOU regarding a feasibility study on the production and sales of SAF utilizing biomass resources in collaboration with InvestSarawak, a state government agency under the Ministry of International Trade, Industry and Investment.</p> <p>This study assesses the viability of establishing a large-scale SAF production chain in Sarawak and will explore various technological pathways for producing SAF from biomass feedstock</p>

Key stakeholder's statement

Both parties aim to establish a commercial-scale SAF value chain for local consumption or export by 2030.

Marubeni's extensive experience and global network will be instrumental in realizing Sarawak's ambition to be a global player in the SAF market

InvestSarawak Chief Executive Officer, Timothy Ong





BAFS signed MOU with Mitr Phol Biofuel to conduct feasibility study on producing bio-jet fuels and SAF

Overview of collaboration

Company	Bangkok Aviation Fuel Services (BAFS)
Partner country and organization	Mitr Phol Biofuel Company Limited
Status and date	Announced in June 2022 and on-going
Objective	To conduct feasibility study related to bio-jet fuels and SAF manufacturing
Collaboration detail	<p>Through this partnership, BAFS and Mitr Phol Biofuel will conduct a feasibility study covering technology, production, marketing, rules, and standards related to bio-jet fuels and the manufacturing of SAF.</p> <p>Mitr Phol Biofuel Company Limited is a subsidiary of Mitr Phol Group, one of Thailand’s largest sugar producers. The company manufactures, processes, and develops high-quality, 99.5% pure ethanol, utilizing sugarcane byproducts, specifically molasses remaining from sugar production and sugarcane juice, as their primary raw materials.</p>

Mitr Phol Group executive’s opinion from article

Mitr Phol Group’s ethanol business is ready to be upgraded from the production of sugarcane-based ethanol used in the automotive industry **to the development of highly innovative fuel for the large-scale aviation industry**, supported by the company’s sustainable ethanol certification plans in line with the Carbon Offsetting and Reduction Scheme for International Aviation (CORSA) measures determined by the ICAO

Chief Executive Officer of Thai Sugar, Energy, and New Business at Mitr Phol Group, Verajet Vongkusolkit





PTT and its subsidiaries have signed MOU to collaborate on exploring HEFA and ATJ technologies for SAF production

Overview of collaboration

Company	PTT Public Company Limited (PTT)
Partner country and organization	<ul style="list-style-type: none"> • PTT Global Chemical Public Company Limited (PTTGC) • PTT Oil and Retail Business Public Company Limited (PTTOR) • Thai Oil Public Company Limited (TOP) • IRPC Public Company Limited (IRPC)
Status and date	Announced in November 2022 and on-going
Objective	To integrate knowledge in SAF refinery
Collaboration detail	<p>Through this collaboration, PTT Group will integrate refinery knowledge, expertise, experiences, state-of-the-art technology, and continuous development on refinery products of from Thai Oil, GC, and IRPC to drive the project. The project will also adopt global-standard production technology, e.g. HEFA and ATJ to help reduce greenhouse gas emissions in the aviation industry.</p> <p>Updated in 2024, Thai Oil is exploring investment opportunities to produce biojet fuel and SAF using HEFA alongside AtJ, in collaboration with the PTT Group</p>

PTT Group executive's opinion from news article

PTT Group is committed to creating low carbon society in Thailand, pushing for Net Zero target, reducing greenhouse gas emission, while **adding more value to local biochemical products by utilizing existing resources.**

PTT will also promote sustainable energy, propel the country's economy and upgrade quality of Thais, aligning with the vision of Powering Life with Future Energy and Beyond

Chief Operating Officer at PTT Public Company Limited
Noppadol Pinsupa





EA has signed MOU with BAFS to develop knowledge, experience, and technology in SAF production

Overview of collaboration

Company	Energy Absolute Public Company Limited (EA)
Partner country and organization	Bangkok Aviation Fuel Services (BAFS)
Status and date	Announced in April 2024 and on-going
Objective	To integrate knowledge, experience, and technology in SAF production
Collaboration detail	<p>EA has signed an MOU with BAFS to combine knowledge, experience, and technology to create potential in production, storage and managing SAF and other businesses in the future both in Thailand and in ASEAN</p> <p>Through this collaboration, EA and BAFS have agreed to form a joint venture to co-develop SAF using BAFS's refueling service for jet A-1, a kerosene-grade fuel for turbine-engine aircraft.</p>

Source: News article

BAFS executive's opinion from news article

BAFS, as an integrated provider of aviation fuel services meeting international standards, we prioritize **conducting business in parallel with social and environmental development plans.**

Through this collaboration, we are leveraging over 40 years of expertise and **combining our strengths with EA to advance SAF** as a key driver in the aviation industry's transition to sustainable energy

President at BAFS, ML Nathasit Diskul





Bangchak, in collaboration with BAFS and BPT, initiated a pilot project to deliver SAF via pipeline to Suvarnabhumi and Don Mueang Airport

Overview of pilot project

Company	Bangchak Corporation Public Company Limited
Partner country and organization	<ul style="list-style-type: none"> • Bangkok Aviation Fuel Services (BAFS) • BAFS Pipeline Transportation Limited (BPT)
Status and date	Pilot project conducted in October 2024
Objective	To prepare the infrastructure to support SAF production and utilization
Collaboration detail	<p>Bangchak in partnership with BAFS and BPT, has launched a pilot project to deliver SAF into the pipeline system to Suvarnabhumi and Don Mueang International Airports.</p> <p>This collaboration includes blending SAF with Jet A1 and initiating its delivery via pipeline to Suvarnabhumi and Don Mueang International Airports.</p> <p>This pilot project aims to ready the necessary infrastructure for future SAF production, enhance economic opportunities, and strengthen Southeast Asia's position as a leader in clean energy</p>

Bangchak executive's opinion from news article

The delivery of SAF into the pipeline system **demonstrates Bangchak's readiness** and commitment to becoming a leader in clean energy in Southeast Asia.

The SAF blended with Jet A1 will help reduce carbon dioxide emissions in the aviation sector and support Thailand's air transport system in becoming more environmentally friendly

Group Chief Executive Officer and President of Bangchak Corporation Public Company Limited, Chaiwat Kovavisarach





Bangchak has collaborated with international companies to develop the production process of its first Neat SAF facility

Overview of collaboration

Company	Bangchak Corporation Public Company Limited
Partner country and organization	<ul style="list-style-type: none"> • Desmet • Honeywell UOP
Status and date	Announced in April 2025 and on-going
Objective	To operate Neat SAF facility in Thailand
Collaboration detail	<p>Bangchak has commenced Thailand's first facility to produce 100% Neat SAF at the Bangchak Phra Khanong Refinery.</p> <p>Bangchak has collaborated with Desmet and Honeywell UOP in developing the production process of the refinery</p> <p>The refinery, with an initial production capacity of 1 million liters per day, uses HEFA technology to process fatty acids or vegetable oils, including used cooking oil into SAF and produces Bio-LPG and Bio-Naphtha as byproducts. The facility is currently undergoing Plant Performance Test Runs</p>

Bangchak PLC executive's opinion from article

The production process was developed in collaboration with two global technology leaders: **Desmet of Belgium**, specializing in **pretreatment technologies**, and **UOP Honeywell of the United States**, a pioneer in **hydroprocessing systems**.

This collaboration ensures quality control across all stages, including **feedstock handling, hydrogenation, molecular restructuring, and fractionation**, resulting in SAF that meets ASTM aviation fuel standards

Group Chief Executive Officer and President of Bangchak Corporation Public Company Limited, Chaiwat Kovavisarach



DIPROM signed MOU with private companies to promote UCO supply chain, supporting SAF production and Thailand’s clean energy ambitions

Overview of collaboration

Topic	MOU on the “Management of Used Cooking Oil (UCO) for the production of SAF”
Responsible government organization	The Department of Industrial Promotion (DIPROM)
Partner organization	<ul style="list-style-type: none">• Bangchak Corporation PCL• Central Group• Thai Beverage PCL• Charoen Pokphand Foods PCL• Thai President Foods PCL• Thai Food Processors Association
Status and date	Announced in March 2025 and on-going
Objective	To establish a nationwide UCO supply chain as a key feedstock for commercial-scale SAF production
Engagement detail	DIPROM has signed MOU on the “Management of Used Cooking Oil (UCO) for the Production of SAF in Line with the Bio-Circular-Green (BCG) Economy Policy” with private leading business organizations. By supplying large volumes of UCO in their industrial and service operations , the key partners will support the supply chain required for producing SAF on a massive scale

Source: News article

DIPROM executive’s opinion from news article

This initiative will promote public awareness, education, and **supply chain network-building** to transform UCO into value-added SAF.

It also **aims to set a precedent for UCO collection in households**, supporting long-term sustainability in both energy and waste management

Director at DIPROM, Natthinya Netyasupha





ENTEC partnered with GIZ to organize SAF Working Group Milestone meeting to share knowledge and strengthen collaboration on SAF development in Thailand

Overview of collaboration

Topic	SAF Working Group Milestone Meeting
Responsible government organization	<ul style="list-style-type: none">• National Energy Technology Center (ENTEC)• Ministry of Higher Education, Science, Research and Innovation (MHESI)
Partner organization	GIZ Thailand under the International Hydrogen Ramp-up Programme (H2Uppp)
Status and date	Meeting held in October 2025
Objective	<ul style="list-style-type: none">• To encourage knowledge exchange in SAF• To strengthen collaboration on SAF development in Thailand
Engagement detail	<p>Through this meeting, experts from leading organizations including, NSTDA, ICAO, Bangchak, Energy Absolute shared insights and progress about SAF development in Thailand</p> <p>The event also included a panel discussion, moderated by GIZ and ENTEC, on “Decentralization to Centralization of Bio-resources to PtX Products in Thailand”, which examined strategies to connect bio-resource management with PtX-based SAF production as a pathway to a low-carbon economy</p>



NRCT, Bangchak and RMUTI have signed MOU to drive research on fusel alcohol from ethanol plants using molasses and cassavas for SAF production

Overview of collaboration

Project name	MOU for the green innovation project to pilot the production of SAF from the research project "The production of biofuels from fusel alcohol from ethanol plants"
Responsible government organization	National Research Council of Thailand (NRCT)
Partner organization	<ul style="list-style-type: none"> • Bangchak Corporation Public Company Limited • BBGI Public Company Limited • Rajamangala University of Technology Isan (RMUTI)
Status and date	Announced in January 2022 and on-going
Objective	<ul style="list-style-type: none"> • To drive research on fusel alcohol from ethanol plants • To study commercial and investment feasibility for producing low-carbon aviation fuel from by-products of commercial ethanol plants
Project detail	NRCT, in collaboration with Bangchak and RMUTI, has signed an MOU to develop a green innovation project aimed at producing SAF from fusel alcohol derived from ethanol plants that use molasses and cassava.

NRCT executive's opinion from news article

The research project 'Production of Biofuel from Fusel Alcohol Derived from Ethanol Plants' has achieved laboratory-scale success in producing bio-based aviation fuel which is derived from fusel alcohol sourced from ethanol plants that use molasses and cassava.

The signing of this MOU aims to drive research result from the laboratory to nationwide application, while assessing the commercial and investment feasibility of producing low-carbon aviation fuel from by-products of commercial ethanol plants.

Director at National Research Council of Thailand,
Wiparat De-ong





Thailand’s state-owned enterprise, AOT, has partnered with Energy Absolute to establish a joint venture company dedicated to SAF production

Overview of collaboration

Topic	AOT partners with EA to establish Airport Energy Absolute Company Limited (AEA)
Responsible government organization	Airports of Thailand Public Company Limited (AOT)
Partner organization	Energy Absolute Public Company Limited (EA)
Status and date	Announced in September 2024 and on-going
Objective	To produce and supply SAF for airlines departing from Thailand
Engagement detail	<p>AOT has established a subsidiary under the name “Airport Energy Absolute Company Limited (AEA)”, a joint venture with EA to operate tank farm facilities and SAF blending system.</p> <p>Through this partnership, the company is to produce and supply SAF for airlines departing from Thailand. The project aims to develop an SAF production and distribution hub to serve the region.</p> <p>Bangkok Aviation Fuel Services (BAFS) also has shown interest in investing in the company</p>

Source: News article

AOT executive’s opinion from news article

The development of the tank farm and SAF production facilities is currently **undergoing a comprehensive study** of all feasible investment models.

AOT’s investment in AEA **focuses on the tank farm development and the SAF blending system**, which will allow fuel to be blended at ratios of 1%, 2%, or 3%, depending on the airline’s requirements. Meanwhile, **EA, the partner, will primarily be responsible for producing the SAF**

President and Secretary at the AOT Board of Directors,
Kerati Kijmanawat





Bangchak and RMUTI have signed MOU to drive research on pongamia as a feedstock to support a larger scale of SAF production

Overview of collaboration

Project name	MOU for research and development on the cultivation of pongamia under the Farm to Fly approach to advance toward commercial production of SAF
Responsible government organization	Rajamangala University of Technology Isan (RMUTI)
Partner organization	<ul style="list-style-type: none"> Bangchak Corporation Public Company Limited
Status and date	Announced in January 2026 and on-going
Objective	To drive research and development on the utilization of pongamia for SAF feedstock
Project detail	RMUTI in collaboration with Bangchak , has signed an MOU to develop and research on pongamia, high-potential energy crop to support future commercial scale for SAF production

Bangchak executive's opinion from news article

The collaboration with RMUTI builds on the ongoing partnership between the two organizations in the development of SAF, grounded in research and **the utilization of domestically sourced bio-based feedstocks**.

This initiative aims to support future SAF production while **reducing reliance on a single feedstock source**, such as used cooking oil.

Acting President, Refinery and Marketing Business Group at Bangchak Corporation, Budit Hansapiboon





BBGI with Ministry of Agriculture and Cooperatives have joined in the promotion of cultivating microalgae for SAF production

Overview of collaboration

Project name	MOU for the promotion of microalgae cultivation to produce SAF
Responsible government organization	Ministry of Agriculture and Cooperatives
Partner organization	<ul style="list-style-type: none"> • BBGI Public Company Limited • Advance Biocarbon Co.,Ltd.
Status and date	Announced in September 2025 and on-going
Objective	To research, develop, and advance microalgae cultivation technologies including technology for the utilization of microalgae for SAF production
Project detail	<p>BBGI (a subsidiary of Bangchak), Ministry of Agriculture and Cooperatives and Advance Biocarbon have signed an MOU to develop and research microalgae cultivation technologies including crude oil extraction from microalgae, use in SAF production and the development of animal feed from residual materials to reduce waste and elevate Thailand's bioenergy industry to international standards.</p> <p>The project has an implementation period of five years.</p>

BBGI executive's opinion from news article

Sustainable Aviation Fuel represents the future of the aviation and clean energy industries.

BBGI is committed **to leveraging its expertise in biotechnology** by joining forces with the Ministry of Agriculture and Cooperatives and Advance Biocarbon **to drive Thailand's bioeconomy forward**

Chief Executive Officer and President of BBGI Public Company Limited, Dechapol Lertsuwanroj





Pertamina partnered with Airbus to conduct joint research related to SAF feedstocks in order to develop SAF ecosystem in Indonesia

Overview of collaboration

Company	Pertamina
Partner country and organization	Airbus (France)
Status and date	September 18, 2024
Objective	Joint research on the potential volume, logistics, and commercial viability of SAF feedstocks in Indonesia, and consideration of collaboration toward SAF expansion
Collaboration detail	<ul style="list-style-type: none">• Through the MoU, technical and market studies will be conducted.• Airbus will provide aviation industry expertise, while Pertamina will supply feedstock and provide data/demonstration support from the refining side.• The framework aims to build an ecosystem encompassing supply chains, certification, and distribution.

Airbus executive's opinion from news article

A study will be conducted on the kinds of local feedstocks which can drive the local SAF development and the commercial development opportunities that comes with it, and **its results will be the base to support the growth of Indonesia's SAF production which is in compliance with the various requirements.**

Airbus, APAC, Head of International Cooperation & Sustainability,
Helene Burger





KPI, a subsidiary of Pertamina, partnered with a local company selling UCO in order to establish the UCO feedstock supply chain in Indonesia

Overview of collaboration

Pertamina executive's opinion from news article

Company	PT Kilang Pertamina Internasional (KPI)
Partner country and organization	PT Gapura Mas Lestari (GML) (Indonesia)
Status and date	December 17, 2024
Objective	Securing a stable supply of UCO for the production of recycled diesel and SAF at Cilacap Refinery.
Collaboration detail	<ul style="list-style-type: none"> • MoU on Procurement and Supply of UCO. • KPI will produce renewable fuels and SAF using UCO as feedstock in processing and manufacturing facilities (HEFA, etc.). • GML will supply UCO as the SAF feedstocks • Cooperation on supply schemes, quality control, and logistics

The collaboration between KPI and GML with experience in the supply chain from collection to UCO supply is **expected to support and guarantee the supply of feedstock for the Cilacap Refinery project,**

PT Kilang Pertamina Internasional , President Director,
Taufik Aditiyawarman





Pertamina NRE, a subsidiary of Pertamina, partnered with a French energy company in order to develop low-carbon and renewable fuels such as e-SAF


Overview of collaboration

Pertamina executive's opinion from news article

Company	Pertamina New & Renewable Energy (Pertamina NRE)
Partner country and organization	MGH Energy (France)
Status and date	May 28, 2025
Objective	Establish frameworks for low-carbon and renewable fuels (e-fuels, e-SAF)
Collaboration detail	<ul style="list-style-type: none"> • Framework for; <ul style="list-style-type: none"> ○ Feasibility studies ○ Technology exchanges ○ Potential investment in low-carbon energy projects ○ Explore projects involving hydrogen derivatives such as e-SAF etc. • Also, the MoU enables; <ul style="list-style-type: none"> ○ to explore projects involving hydrogen derivatives such as e-SAF. ○ to make potential offtake agreements for these products ○ to evaluate joint investment opportunities in both Indonesia and France

This collaboration underscores our commitment to being a key player in the energy transition, not only in Indonesia but also on the international stage.

Partnering with MGH Energy, we are optimistic about driving **the development of innovative low-carbon technology solutions**

PT Kilang Pertamina Internasional , President Director, John Anis 



Indonesia and Japan are collaborating through BRIN and industry partners to develop SAF based on non-standard coconut

Overview of collaboration

Project name	Indonesia-Japan Bioavtur Industry Development Project
Responsible government organization	National Research and Innovation Agency (BRIN)
Partner organization	<ul style="list-style-type: none"> Green Power Development Corporation of Japan (GPDJ) PT ABE Indonesia Berjaya
Status and date	Announced in July 2024 and on-going
Objective	To develop SAF from non-standard coconut
Project detail	<p>The initial cooperation, began with joint research of IJNet, GPDJ, and BRIN, is now in its 4th year. For the current project, it is already at the plant construction stage in Banyuasin, South Sumatra.</p> <ul style="list-style-type: none"> GPDJ chose Indonesia as a place for CCO manufacturing from the abundant potential of coconuts in Indonesia (30% of the total coconuts produced) PT ABE Indonesia Berjaya will act as the project implementer. The company is targeted to produce 100 tonnes of CCO per day from non-standard coconut raw materials.

CMEA's opinion from interview

CCO is the alternative feedstock that the government is interested in as it's abundant in Indonesia. Additionally, the nonedible coconut is already being recognized by ICAO as SAF feedstock as well.

Now the team is studying whether they can use technology for CCO developed by Japan in Indonesia or not

Deputy Assistant Office for Energy Transition Acceleration,
Coordinating Ministry for Economic Affairs (CMEA)



Executive Summary

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Chapter 2: Player Activity

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Chapter 4: Needs by Local Players

Summary

Chapter 4-1: Overview of Needs by Country

Chapter 4-2: Cross-country Comparison of Needs

Chapter 5: Export Potential to Japan

Appendix

Needs of local government / company | Comparison across countries

In the future, TH is likely to focus more on ethanol and AtJ pathway, while ID and MY will still rely on HEFA with alternative oil-based feedstock than only UCO

Blue font = Potential feedstock/pathway that will be prioritized the future from NRI analysis based on experts' comments

			TH	MY	ID	SG
Feedstock	Current (~2030)	Type	<ul style="list-style-type: none"> UCO Palm oil-based feedstock e.g. POME 	<ul style="list-style-type: none"> UCO Palm oil-based feedstock e.g. POME 	<ul style="list-style-type: none"> UCO Palm oil-based feedstock e.g. POME 	<ul style="list-style-type: none"> UCO Animal waste Palm oil-based feedstock e.g. PFAD
		Source	<ul style="list-style-type: none"> Focus on domestically sourced feedstock 	<ul style="list-style-type: none"> Domestically source feedstock with large amount of UCO imported 	<ul style="list-style-type: none"> Strictly source feedstock domestically due to feedstock import restriction 	<ul style="list-style-type: none"> Import all the feedstock due to resource limitation
	Future (2030~)	<ul style="list-style-type: none"> Oil based feedstock <ul style="list-style-type: none"> UCO Palm oil-based feedstock e.g. POME, CPO Microalgae Pongamia Alcohol based feedstock <ul style="list-style-type: none"> Ethanol from molasse Etc. 	<ul style="list-style-type: none"> Oil based feedstock <ul style="list-style-type: none"> UCO Palm oil-based feedstock e.g. POME, SBEO Pongamia Microalgae Etc. 	<ul style="list-style-type: none"> Oil based feedstock <ul style="list-style-type: none"> UCO Palm oil-based feedstock e.g. POME, PFAD, RBDPKO Non-standard coconut Pongamia Etc. 	<ul style="list-style-type: none"> Oil based feedstock <ul style="list-style-type: none"> UCO Animal waste Palm oil-based feedstock e.g. PFAD Etc. 	
Technology	Current (~2030)	<ul style="list-style-type: none"> HEFA Co-processing 	<ul style="list-style-type: none"> HEFA 	<ul style="list-style-type: none"> HEFA Co-processing 	<ul style="list-style-type: none"> HEFA 	
	Future (2030~)	<ul style="list-style-type: none"> HEFA Co-processing AtJ 	<ul style="list-style-type: none"> HEFA AtJ* FT* 	<ul style="list-style-type: none"> HEFA Co-processing AtJ* 	<ul style="list-style-type: none"> HEFA 	

*Note: These are pathways that will be considered in the future, but the direction is still unclear with lower prioritization

In the future, TH is likely to focus more on ethanol and AtJ pathway, while ID and MY will still rely on HEFA with alternative oil-based feedstock than only UCO

			TH	MY	ID	SG
Feedstock	Current (~2030)	Type	<ul style="list-style-type: none"> UCO Palm oil-based feedstock e.g. POME 	<ul style="list-style-type: none"> UCO Palm oil-based feedstock e.g. POME 	<ul style="list-style-type: none"> UCO Palm oil-based feedstock e.g. POME 	<ul style="list-style-type: none"> UCO Animal waste Palm oil-based feedstock e.g. PFAD
	Future (2030~)	Source	<ul style="list-style-type: none"> Focus on domestically sourced feedstock Limited UCO supply will drive Thailand to find alternatives pathways apart from oil-based SAF In future Thailand is likely to become more of an ethanol-driven market, with the AtJ pathway anchored by cassava and sugarcane (molasse) 	<ul style="list-style-type: none"> Malaysia is likely to continue prioritizing HEFA, but expand to alternative oil-based feedstocks e.g. microalgae supplementing UCO. While AtJ and FT are under consideration, limited feedstock availability e.g. absence of ethanol production restrict their potential. Hence, development of 2G ethanol will be needed 	<ul style="list-style-type: none"> Strictly source feedstock domestically due to feedstock restriction Indonesia is likely to remain HEFA-focused, but utilize a broader range of oil-based feedstocks e.g. CCO. While AtJ production from sugarcane is still technically feasible, its potential is significantly lower than Thailand's due to smaller ethanol volumes 	<ul style="list-style-type: none"> Import all the feedstock Singapore is an import-driven market due to limited domestic feedstock resources It prioritizes importing cost-effective feedstock from other countries HEFA is likely to remain the main technology due to the lack of feedstock for other pathways
Technology	Current (~2030)	<ul style="list-style-type: none"> HEFA Co-processing 	<ul style="list-style-type: none"> HEFA Co-processing 	<ul style="list-style-type: none"> HEFA Co-processing 	<ul style="list-style-type: none"> HEFA Co-processing 	
	Future (2030~)	<ul style="list-style-type: none"> HEFA Co-processing AtJ 	<ul style="list-style-type: none"> HEFA AtJ* FT* 	<ul style="list-style-type: none"> HEFA Co-processing AtJ* 	<ul style="list-style-type: none"> HEFA 	

*Note: These are pathways that will be considered in the future, but the direction is still unclear with lower prioritization

Executive Summary

Chapter 1: Public Policy and Regulations

Chapter 2: Player Activity

Chapter 3: Supply/demand potential

Chapter 4: Needs by Local Players

Chapter 5: Export Potential to Japan

Summary

Chapter 5-1: Export Potential to Japan

Appendix

Executive Summary

Chapter 1: Public Policy and Regulations

Chapter 2: Player Activity

Chapter 3: Supply/demand potential

Chapter 4: Needs by Local Players

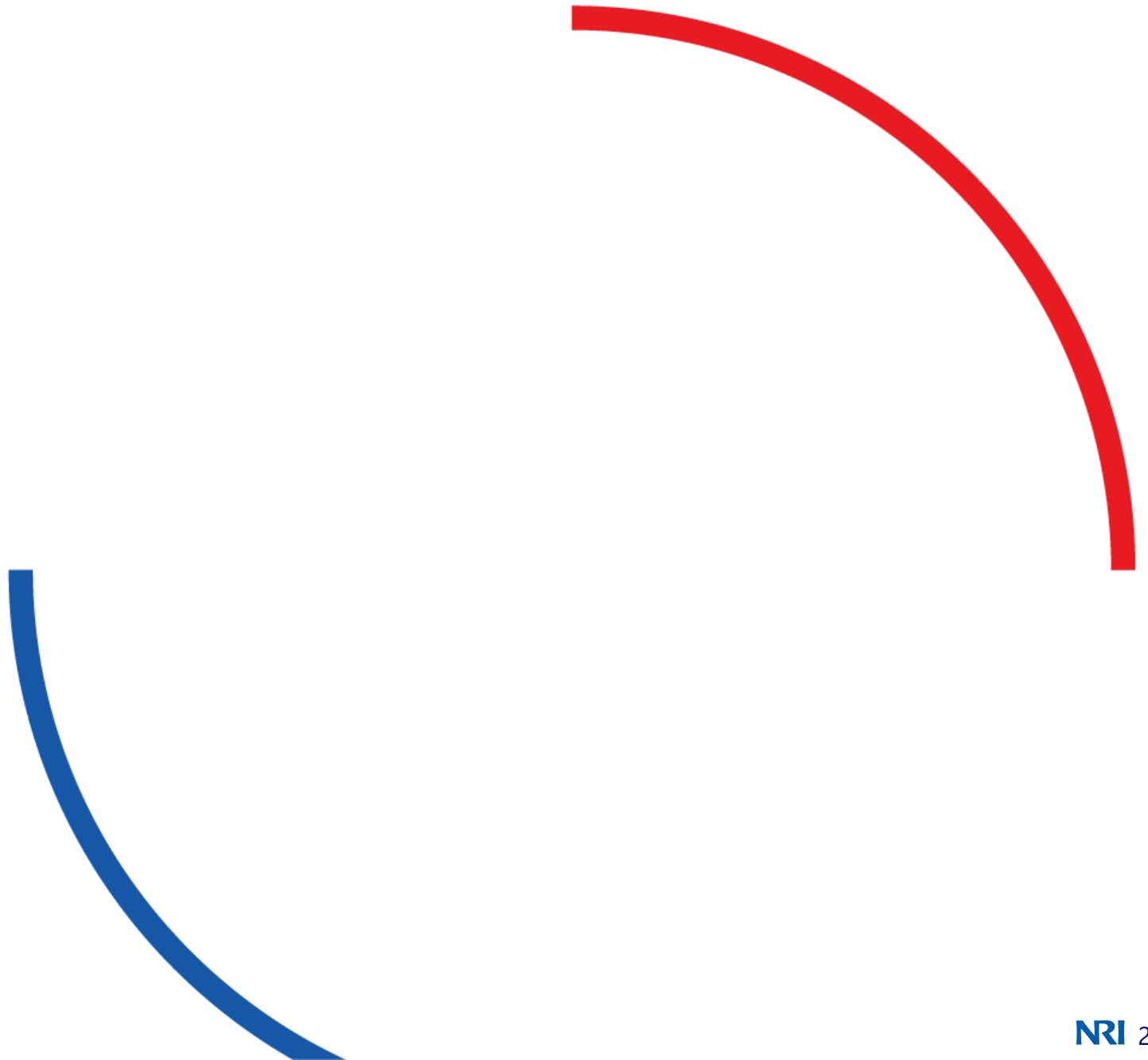
Chapter 5: Export Potential to Japan

Summary

Chapter 5-1: Export Potential to Japan

Appendix

Key Findings



Based on demand in Japan and price differences, there is high possibility of export to Japan, and will provide business opportunities for export and investment

Key Questions and NRI's Outlook

Key Question

From the perspective of ensuring a stable supply of SAF in Japan, will imports from overseas be necessary?

Taking into account the price differences, would the pricing be attractive for Japanese offtakers?

Fact (Desktop Research & Interviews)

Necessity of SAF Imports into Japan

- In Japan, the government is promoting the establishment of an import framework for SAF as part of its policy efforts to ensure stable supply and accelerate adoption. In parallel, major airlines are also aiming to procure SAF from overseas in order to meet their decarbonization targets and are actively exploring partnerships with international SAF producers

Interest in SAF Exports from ASEAN

- In major Southeast Asian countries—including Singapore, Malaysia, Thailand, and Indonesia—there are clear initiatives underway to promote SAF exports. In particular, in Singapore and Malaysia, where potential supply capacity is expected to significantly exceed domestic demand, SAF producers are demonstrating a strong willingness to pursue exports
- Europe, North America, and Japan are being considered as key target markets

Price Differential with Domestic SAF

- Transportation costs from ASEAN to Japan are estimated at approximately USD 42–45 per ton, compared with USD 65–70 per ton to Europe. At the same time, trading companies that efficiently manage the entire value chain may be able to narrow the overall price gap—including logistics costs—through optimization and scale efficiencies
- Moreover, Japan's domestic SAF production capacity is expected to be insufficient to meet policy-driven demand targets, necessitating overseas procurement. In addition, rising domestic production costs are a concern. Taking these factors into account, there remains scope for Japanese offtakers to consider importing SAF, even after incorporating transportation costs

NRI's View

- Taking into account the need to ensure a stable supply of SAF in Japan, as well as the price differentials, there is sufficient potential for SAF to be supplied to the Japanese market
- For Japanese companies, this creates promising business opportunities, including equity participation in SAF production projects in Southeast Asia and involvement in export businesses targeting Japan, Europe, and the United States

Summary of Chapter 5



After identifying Japan's SAF import needs, target countries' export potential and price attractiveness will be assessed, considering shipping costs

Overview of Chapter 5: Investigating the Feasibility of Supplying SAF to Japan

	① Need for SAF Supplies from Overseas to Japan	② SAF Export Potential of Target Countries	③ Price Attractiveness of Target Countries' SAF Supply to Japan
Goal	<ul style="list-style-type: none"> To understand need for SAF supplies from overseas to Japan 	<ul style="list-style-type: none"> To understand the export potential of SAF from Singapore, Indonesia, Malaysia, and Thailand 	<ul style="list-style-type: none"> To understand the price attractiveness of SAF supply from target countries compared to SAF produced domestically in Japan
Key Questions	<ul style="list-style-type: none"> From the perspective of stable SAF supply in Japan, is overseas supply necessary? 	<ul style="list-style-type: none"> Are the target ASEAN countries interested in exporting SAF, or will they mainly focus on producing it for their own domestic use? 	<ul style="list-style-type: none"> Considering the price differential, is the price attractive to Japanese consumers?
Output	<ul style="list-style-type: none"> The need for SAF supplies from overseas to Japan <ul style="list-style-type: none"> ➤ National targets for SAF mandates ➤ Government plans for importing SAF ➤ Current airline SAF demand and overseas sourcing activities to support government initiatives 	<ul style="list-style-type: none"> The current situation and future export plans for SAF in each country <ul style="list-style-type: none"> Country's situation <ul style="list-style-type: none"> ➤ National ambition of SAF export ➤ National prohibition of SAF export ➤ Supply and demand balance within country Private company's situation <ul style="list-style-type: none"> ➤ Current and future SAF production capacity ➤ Current and future SAF export plans 	<ul style="list-style-type: none"> Estimation of the price differential based on the current domestic supply prices of local SAF producers and the sea-freight transportation costs from each country to Japan (unit: USD/ton) <ul style="list-style-type: none"> ➤ Domestic SAF selling price in Japan and target countries ➤ Sea-freight shipping cost from selected potential ports in target countries to selected potential ports in Japan



① Need for SAF Supplies from Overseas to Japan | Ongoing Discussion in Japan

In Japan, a public-private consultative body on SAF is in place, and discussions on SAF imports are ongoing

Overview of SAF Public-Private Councils

Name	SAF Public-Private Councils (SAFの導入促進に向けた官民協議体)
Establishment	April 22, 2022
Responsible Government Organization	<ul style="list-style-type: none"> Agency for Natural Resources and Energy, METI MLIT
Member	<ul style="list-style-type: none"> Public: Responsible gov. organizations, Ministry of Agriculture, Forestry and Fisheries, Ministry of Environment, NEDO Private: Airline, Airport company, Trading company, Oil distributor, related org.
Structure	<ul style="list-style-type: none"> SAF Public-Private Councils consist of "Production and Supply WG (製造・供給WG)" and "Distribution WG (流通WG)" <ul style="list-style-type: none"> Production and Supply WG (製造・供給WG)* <ul style="list-style-type: none"> ✓ Theme: SAF Supply Outlook, Domestic SAF Production and Supply, and Stable Securing of SAF Feedstock Distribution WG (流通WG)* <ul style="list-style-type: none"> ✓ Theme: SAF supply chain development, registration and certification of domestically produced SAF as CORSIA-qualified fuel

Note: *Discussion materials of both WGs are not disclosed.

Source: METI, MLIT

Discussions under SAF Public-Private Councils

No.	Date	Discussion topics on SAF import
1 st	Apr 22, 2022	<ul style="list-style-type: none"> MLIT: Announcement of schedule for fully accepting imported SAF starting in 2030 (SAF and Neat SAF) Petroleum Association: Request for policy support for SAF import (such as tariff and tax exemptions etc.) ENEOS, Idemitsu, Itochu: Explanation on SAF imports from overseas by member companies
2 nd	Nov 7, 2022	<ul style="list-style-type: none"> Free discussion: SAF import is needed to short-term carbon offsets, as domestic SAF production can't reach demand MLIT: Promote demonstration project for SAF supply chain establishment, from import to use for aircraft
3 rd	May 26, 2023	<ul style="list-style-type: none"> METI: Tariff and oil and coal tax exemptions for SAF imports produced by overseas projects that Japanese companies participate in MLIT: Report on the demonstration project on SAF supply chain which discussed in the 2nd council
4 th	Jan 31, 2024	<ul style="list-style-type: none"> METI: Same discussion on tariff and tax exemptions discussed in 3rd council
5 th	Jun 27, 2024	No discussion on SAF importation
6 th	Feb 26, 2025	No discussion on SAF importation
7 th	Jun 25, 2025	No discussion on SAF importation
8 th	Jan 28, 2026	<ul style="list-style-type: none"> MLIT: Confirmation of the importance of preventing the outflow of national wealth by reducing SAF imports when domestic SAF production expands in Japan

② SAF Export Potential of Target Countries | Export Plans by Supply-Side Companies

Many companies have indicated future interest for SAF exportation to overseas

Summary of major SAF producers' potential and export plans

*Expert opinion from another company ** result from task 3-2

	Company	Annual production capacity (k tonnes)		Demand supply sufficiency**	Current activity of exporting self-produced SAF	Future plan of SAF exportation	Year ready to export SAF
		Current	Future				
S G	Neste Corporation	2,600	2,600	SAF supply is projected to exceed demand	• Has activity e.g., exporting to Europe, America, Japan	• Has plan Continue exporting to high demand countries e.g., Europe and North America	Currently exporting
	Petronas	0	575 (2028 Q2)	SAF supply is projected to exceed demand	• No activity	• Has plan Ready to export immediately after the plant begins operations. However, it will also sell domestically*	2028
M Y	EcoCeres Renewable Fuels	420	420		• No activity	• Has plan Plan to export all of the SAF produced	2026
	FatHopes Energy	0	300 (2029)	• No data based on desktop research and interview	• Has plan Plan to focus on export*	No data	
I D	Pertamina (Persero), PT	5.6	882.4 (2032-2033)	• No activity Focus on SAF for domestic usage due to regulation	• Has plan Plan to fulfill domestic demand to enable exports	2028-2029	
	PT Essa Industries Indonesia Tbk	0	200 (2027 Q4 -2028 Q1)	• No activity	• Has plan Aim to produce SAF for exportation*	2028*	
	Tripatra	0	180 (2030)	• No activity	• Has plan Aim to produce SAF for exportation*	2028*	
	PTT	20	80 (2027)	• No activity	• No plan As PTT's product is not neat SAF, the export price is lower than the domestic selling price	No plan	
T H	Energy Absolute PCL	0	25 (2026)	SAF demand is projected to get close to supply in 2035	• No activity* Highly likely to have no activity*	• No potential to export SAF As the production capacity is quite low*	No potential*
	Bangchak Corporation	0	292 (2026 Q3)	• Has activity in beginning phase e.g., sign MoU with Shell and Cosmo oil	• Has plan Plan to export if there is no SAF mandate in Thailand yet	2026	

Japan Ref: According to Japan's State Action Plan for promoting the introduction of SAF, the full-scale adoption of imported SAF will start after 2030.

③ Price Attractiveness of Target Countries' SAF Supply to Japan | Export Price to Japan

As of 2 January 2026, marine shipping costs from the target ASEAN countries to Japan are in the range of 42–45 USD per metric ton

Marine shipping cost of SAF from each country representative SAF producers to Japan (as of 2 January 2026)

Representative SAF producer in ASEAN			Marine shipping of SAF			
Country	Target SAF producer	Target Refinery	Departure marine port	Destination marine port	Sea distance from the departure point to the Destination (km)*	Marine shipping cost (USD per metric ton)*
Singapore	Neste Corporation	Tuas, west of Singapore	Neste Jetty C Port (Neste's own port in refinery)	Chiba port, Port of Sakai-Semboku	~5,426	~43
Malaysia	EcoCeres Renewable Fuels	Pasir Gudang, Johor	Tanjung Langsat Port		~5,384	~42
Indonesia	Pertamina (Persero), PT	Cilacap, Central Java	Pertamina RU IV Cilacap Area 70 (Pertamina's own marine port located near the refinery)		~6,434	~45
Thailand	Bangchak Corporation	Phra Khanong, Bangkok	BCP refinery port Chao Phraya jetties (Bangchak's own port in refinery)		~5,458	~44
			Port of Bangkok (Khlong Toei Port)		~5,545	~44

Note: The maximum sea distance and shipping cost are based on the shipping cost to Chiba Port. Shipping to Port of Sakai-Semboku is expected to be lower due to the shorter distance from the representative ports in target ASEAN countries.

Source: Interview

③ Price Attractiveness of Target Countries' SAF Supply to Japan | Views Towards Export Price

Japan needs to import SAF to secure supply, and the associated marine shipping costs are acceptable, making target ASEAN countries a potential sourcing region

Reasons for SAF import necessity in Japan

SAF production capacity

Even if all planned SAF plants in Japan become operational in the future, Japan will still need to import the remaining 500–600 kt to meet demand.

- **SAF Demand:** Japan has 10% SAF blending target by 2030 which will be around 1.5-1.7 million ton.
- **SAF Supply:**
 - Current: Japan only has 1 domestic SAF refinery
 - Future: Even there is future planned SAF refinery the total capacity will be around 1.13 million tons. However, there is high chance the future plant will be delayed again.

Limited feedstock availability

There is relatively limited feedstock in Japan.

- If the SAF projects proceed as planned, Japan will need significant quantities of CORSIA-eligible oil and fat and bioethanol feedstocks to meet SAF production targets. Securing sufficient feedstocks will be a major challenge.

Cost of SAF production

- Japan faces challenges from high land and labor costs, leading to high SAF refinery development costs and rising feedstock prices due to limited availability, which delay investment decisions for domestic SAF refinery.

Price attractiveness when considering shipping cost

- The shipping cost will not affect Japan SAF buying decision from ASEAN that much as Japan has no choice as it does not have enough SAF.
- Even after 2028 that many plants in Japan will become active, it is not likely that the production will be enough. Because Japan does not have enough feedstock, and when other countries limit the feedstock exportation, the cost of production will be much higher.

Industry player associated and familiar with Neste Singapore



- If Japan cannot achieve the 10% target, it will have no choice but to import and will need cost-competitive sourcing options, including:
 - Nearby suppliers such as Korea and China
 - Logistics-convenient hubs such as Singapore, which has SAF blending capabilities
 - Among ASEAN countries, Malaysia has strong potential, while Thailand's export potential will depend on post-election government policy, especially the adoption of a 1% blending mandate, which would affect domestic demand and export availability.

Industrial expert in Singapore



③ Price Attractiveness of Target Countries' SAF Supply to Japan | Views Towards Export Price

Even with exports from ASEAN to Europe, costs remain acceptable, giving Japan an opportunity to invest in ASEAN SAF production and supply European market

ASEAN SAF Export Potential to Europe and Strategic Opportunities for Japan

- Neste Singapore also exports SAF to Europe and North America, as demand in these regions is higher than in Asia-Pacific.
- Neste Singapore also exports SAF to Europe and North America, as demand in these regions is higher than in Asia-Pacific.
- Shipping costs from Singapore to North America are not prohibitively high due to well-established logistics, and many shipping companies are capable of providing these services.
- The export decision is therefore driven primarily by demand constraints rather than shipping costs, which can be absorbed.

Industry player associated and familiar with Neste Singapore



- Shipping costs from ASEAN to the Europe are generally higher than those to Japan due to longer distances.
- Specifically, shipping from ASEAN to the Europe costs around 65–70 USD per metric ton, compared with 42–45 USD per metric ton for shipments from ASEAN to Japan.
- However, the Europe typically purchases in larger batches, which helps keep overall pricing competitive.
- Ultimately, demand is the key driver behind exports to the Europe.
- The shipping cost from ASEAN to North America is around 75–83 USD per metric ton, and to the United Kingdom is around 68–77 USD per metric ton.

Industrial expert in Singapore



- Japanese companies can jointly invest in SAF refineries in ASEAN countries to benefit from lower land and labor costs, enabling SAF to be sold to Japan at lower prices as a partner supply.
- Moreover, if Japan's demand is already met, the SAF can also be exported to Europe, where demand is higher.

Inspector Aviation Facilities, Pertamina



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Summary

Chapter 5-1: Export Potential to Japan

Appendix

After identifying Japan's SAF import needs, target countries' export potential and price attractiveness will be assessed, considering shipping costs

Overview of Approach: Investigating the Feasibility of Supplying SAF to Japan

	Need for SAF Supplies from Overseas to Japan	SAF Export Potential of Target Countries	Price Attractiveness of Target Countries' SAF Supply to Japan
Goal	<ul style="list-style-type: none"> To understand need for SAF supplies from overseas to Japan 	<ul style="list-style-type: none"> To understand the export potential of SAF from Singapore, Indonesia, Malaysia, and Thailand 	<ul style="list-style-type: none"> To understand the price attractiveness of SAF supply from target countries compared to SAF produced domestically in Japan
Key Questions	<ul style="list-style-type: none"> From the perspective of stable SAF supply in Japan, is overseas supply necessary? 	<ul style="list-style-type: none"> Are the target ASEAN countries interested in exporting SAF, or will they mainly focus on producing it for their own domestic use? 	<ul style="list-style-type: none"> Considering the price differential, is the price attractive to Japanese consumers?
Output	<ul style="list-style-type: none"> The need for SAF supplies from overseas to Japan <ul style="list-style-type: none"> ➤ National targets for SAF mandates ➤ Government plans for importing SAF ➤ Current airline SAF demand and overseas sourcing activities to support government initiatives 	<ul style="list-style-type: none"> The current situation and future export plans for SAF in each country <ul style="list-style-type: none"> Country's situation <ul style="list-style-type: none"> ➤ National ambition of SAF export ➤ National prohibition of SAF export ➤ Supply and demand balance within country Private company's situation <ul style="list-style-type: none"> ➤ Current and future SAF production capacity ➤ Current and future SAF export plans 	<ul style="list-style-type: none"> Estimation of the price differential based on the current domestic supply prices of local SAF producers and the sea-freight transportation costs from each country to Japan (unit: USD/ton) <ul style="list-style-type: none"> ➤ Domestic SAF selling price in Japan and target countries ➤ Sea-freight shipping cost from selected potential ports in target countries to selected potential ports in Japan



Need for SAF Supplies from Overseas to Japan

Assessing the Need for SAF Supplies from Overseas to Japan

Japan's State Action Plan mentions plans to develop facilities for SAF import and to fully acceptance of import SAF by 2030 to support the SAF blending targets

Overview of Policies/Roadmap for SAF in Japan

Policy/Plan title	Responsible organization	Status	Overview of SAF Related Description	
			SAF Blending target	SAF Import
Japan's State Action Plan related to SAF Roadmap: Promotion of the Introduction of SAF	Minister of Land, Infrastructure, Transport and Tourism (MLIT)	Implemented	<ul style="list-style-type: none"> Replace 10% of the fuel consumed by domestic airlines with SAF by 2030 	<ul style="list-style-type: none"> 2021–2023: Introduction of blended SAF; Demonstration study of neat SAF import 2024–2025: Accept imported blended SAF via domestic supply chains and overseas airport refueling; Support facility for SAF importation at domestic airports 2026–2030: Partial commercialization of imported neat SAF 2030: Full-scale adoption of imported SAF
Basic Policy for Promoting Decarbonization in Aviation	Civil Aviation Bureau, Ministry of Land, Infrastructure and Transport and Tourism (MLIT)	Implemented	<ul style="list-style-type: none"> Promote JP airlines to set decarbonization plan including SAF usage 10% SAF blend targets were set by JP airlines 	<ul style="list-style-type: none"> This basic policy was prepared based on the overall SAF-related schedule discussed in "Working Group on CO2 Reduction in Aviation Operations", which is align with the one in "Japan's State Action Plan related to SAF Roadmap"
Basic Policy for Achieving GX	Ministry of Economy, Trade and Industry (METI)	Implemented	<ul style="list-style-type: none"> 10% SAF blend by Japanese airlines by 2030 	<ul style="list-style-type: none"> Not mentioned

The demonstration project was conducted to establish a SAF supply chain, from importing neat SAF and domestic blending with jet fuel to quality control, customs clearance, safe handling, and aircraft refueling.

Japan SAF Public-Private Councils



Even after 2028 that many plants in Japan will become active, it is not likely that the production will be enough as Japan does not have enough feedstock. And when other countries limit the feedstock exportation, cost of production in Japan will be higher

Industry player associated and familiar with Neste Singapore



Assessing the Need for SAF Supplies from Overseas to Japan

Japanese airlines set SAF blending targets to align with the national SAF blending target and also source SAF from overseas to support the achievement

Overview of Airlines' Overseas SAF Sourcing Movements to Support Government SAF Blending Initiatives

Company	Current demand		Future demand	SAF sourcing from overseas
	Annual fuel consumption (k tonnes)	SAF % blend	SAF % blend	
JAL Group	3,125.6	1%	<ul style="list-style-type: none"> 2030: 10% 	<ul style="list-style-type: none"> In 2022, through partnership with Itochu, JAL used Neste SAF on a domestic flight from Tokyo (Haneda) to Okinawa (Naha) In 2023, JAL has purchased domestically blended SAF supplied by Itochu and Fuji Oil, with the neat SAF for blending provided by Neste to use on flights from Chubu Centrair Airport
ANA Holdings Inc.	3,432	N/A	<ul style="list-style-type: none"> 2030: 10% 2050: 70% 	<ul style="list-style-type: none"> In 2023, ANA has agreed to use SAF blended in Japan, supplied by Itochu and Fuji Oil, with the neat SAF for blending provided by Neste for international and domestic flights departing from Haneda and Narita airports
Ref	Japan National SAF Blending target		10% SAF blend by 2030 by Japanese airlines	



In Japan, a public-private consultative body on SAF is in place, and discussions on SAF imports are ongoing

Overview of SAF Public-Private Councils

Name	SAF Public-Private Councils (SAFの導入促進に向けた官民協議体)
Establishment	April 22, 2022
Responsible Government Organization	<ul style="list-style-type: none"> Agency for Natural Resources and Energy, METI MLIT
Member	<ul style="list-style-type: none"> Public: Responsible gov. organizations, Ministry of Agriculture, Forestry and Fisheries, Ministry of Environment, NEDO Private: Airline, Airport company, Trading company, Oil distributor, related org.
Structure	<ul style="list-style-type: none"> SAF Public-Private Councils consist of "Production and Supply WG (製造・供給WG)" and "Distribution WG (流通WG)" <ul style="list-style-type: none"> Production and Supply WG (製造・供給WG)* <ul style="list-style-type: none"> ✓ Theme: SAF Supply Outlook, Domestic SAF Production and Supply, and Stable Securing of SAF Feedstock Distribution WG (流通WG)* <ul style="list-style-type: none"> ✓ Theme: SAF supply chain development, registration and certification of domestically produced SAF as CORSIA-qualified fuel

Note: *Discussion materials of both WGs are not disclosed.
Source: METI, MLIT

Discussions under SAF Public-Private Councils

No.	Date	Discussion topics on SAF import
1 st	Apr 22, 2022	<ul style="list-style-type: none"> MLIT: Announcement of schedule for fully accepting imported SAF starting in 2030 (SAF and Neat SAF) Petroleum Association: Request for policy support for SAF import (such as tariff and tax exemptions etc.) ENEOS, Idemitsu, Itochu: Explanation on SAF imports from overseas by member companies
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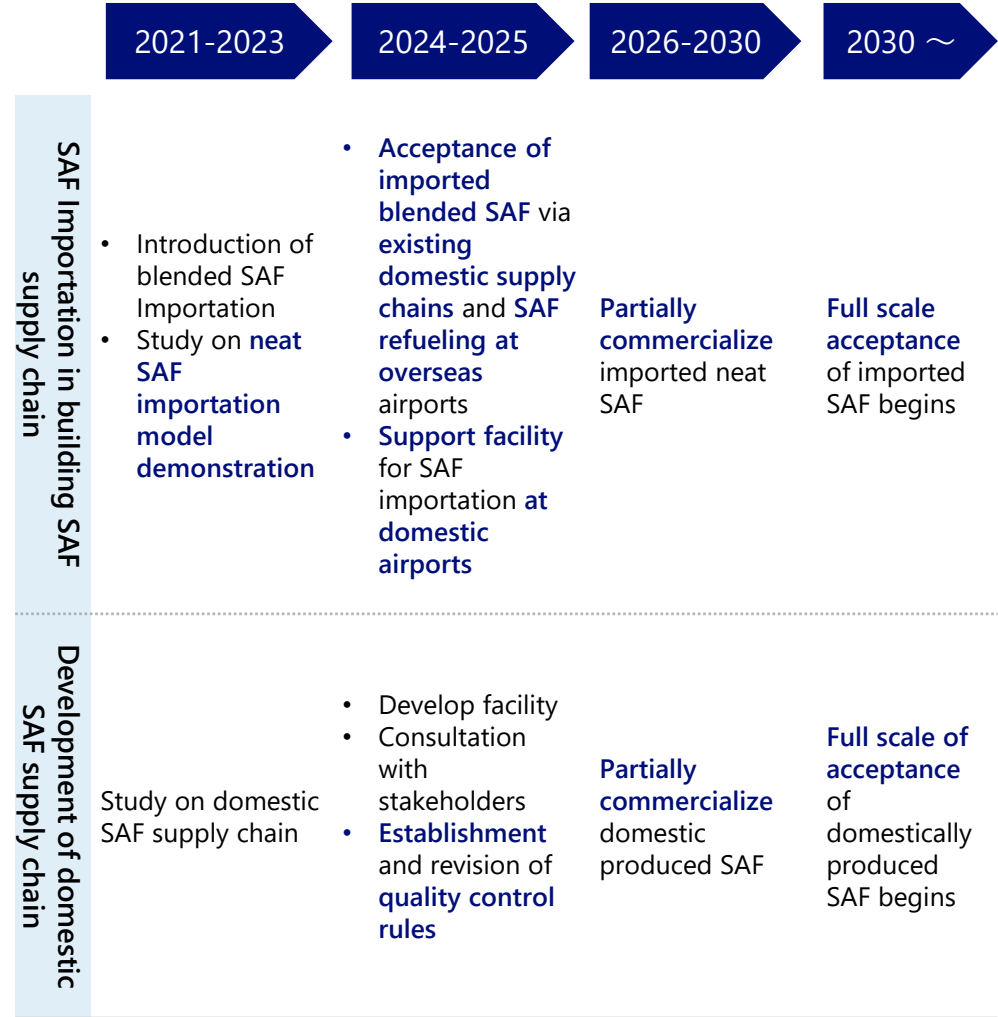


Japan's State Action Plan related to SAF by MLIT aims to develop domestically produced SAF and SAF supply chain in Japan

Overview of Policies/Roadmap for SAF

Title	Japan's State Action Plan related to SAF Roadmap: Promotion of the Introduction of SAF
Date Issued	2021
Current progress	<ul style="list-style-type: none"> Completed neat SAF importation demonstration project in 2022 Presented the progress of the roadmap at ICAO 2024 Regional Seminar on Environment
Responsible Government Organization	Civil Aviation Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT) (国土交通省航空局)
Goal/Objective of Policy	<ul style="list-style-type: none"> To outline the development and production of domestic SAF To build stable SAF supply chain in Japan
Overview of Policy	Announced in 2021, the plan is to support Japan's SAF supply chain, International standardization, Local Production for Local Consumption, etc. The full-scale acceptance of imported SAF and domestically produced SAF is expected to begin from 2030 onwards
SAF Related Targets and Government Initiatives	<ul style="list-style-type: none"> Target: Replace 10% of the fuel consumed by domestic airlines with SAF by 2030

Action Plans in Policy Roadmap





This policy was developed based on the SAF schedule, drafted by MLIT, and it urges airlines to adopt concrete decarbonization strategies

Overview of Policies/Roadmap for SAF

Title	Basic Policy for Promoting Decarbonization in Aviation (航空脱炭素化推進基本方針)
Date Issued	December 1, 2022
Responsible Government Organization	Civil Aviation Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT) (国土交通省航空局)
Goal/Objective of Policy	<p><Aircraft operation sector></p> <ul style="list-style-type: none"> International: Limits on the increase in total CO2 emissions after 2020 Domestic: Reduce CO2 emissions by 16% compared to FY2013 levels by FY2030 International and Domestic: CN by 2050 <p><Airport sector></p> <ul style="list-style-type: none"> Reduce GNG emissions by 46% by 2030 Promote new technology and expand credit
Overview of Policy	<ul style="list-style-type: none"> Promoting decarbonization in the aircraft operations and airport sectors Cooperation among MLIT, MOE, METI, and other relevant ministries and agencies
SAF Related Targets and Government Initiatives	<ul style="list-style-type: none"> This basic policy is based on the overall schedule, including SAF import. JAL Groups and ANA Holdings developed "Plans to promote decarbonization in the air transportation business" under the policy

Action Plans in Policy Roadmap

		By 2025	2026-2030	2030 onwards
Referred SAF schedule on import		Consideration	Partial commercialization	Fully accepting imported SAF
SAF target by JP airlines	JAL Group	1% SAF blend	10% SAF blend	-
	ANA Holdings	10% SAF blend		70% SAF blend

Process to set company policy

Entity	JP airlines		Government (MLIT)
Policy	Plans to promote decarbonization in the air transportation business (航空運送事業脱炭素化推進計画)	Apply →	Basic Policy for Promoting Decarbonization in Aviation (航空脱炭素化推進基本方針)
Remarks	Plans by JAL Group and ANA Holdings were approved on Jan 24, 2024	← Approve	This basic policy was developed based on "Civil Aeronautics Act"



This basic policy provides national SAF blending target towards promoting decarbonization; however, it does not mention on SAF import

Overview of Policies/Roadmap for SAF

Title	Basic Policy for Achieving GX (GX実現に向けた基本方針)
Date Issued	February 10, 2023
Responsible Government Organization	Ministry of Economy, Trade and Industry (METI) (経済産業省)
Goal/Objective of Policy	<ul style="list-style-type: none"> Promote decarbonization efforts to secure stable energy supply. Realize GX by implementing incentives
Overview of Policy	<ul style="list-style-type: none"> Promote the use of fuels for decarbonization, including SAF, technology development, demonstration, and capital investment will be pursued over the next decade. Develop regulations, and engage in efforts toward establishing international rules
SAF Related Targets and Government Initiatives	<ul style="list-style-type: none"> GX investment: Public-private investment in SAF production technology development, large-scale demonstration, and refineries Strategy: Establishment of a collaborative framework with overseas feedstock suppliers, Establishing a structure for CORSIA certification of domestic produced SAF, Action to increase upper limits of SAF blending ratio

Note: * as of Nov 29, 2025

Source: METI, Cabinet Secretariat

Action Plans in Policy Roadmap



Discussions under GX Implementation Council Meeting

- GX Implementation Council Meeting have been conducted (1st-15th*)
- Member: Cabinet, METI, MOFA, MOF, MOE and external experts
- SAF is one of the topics discussed in GX meetings.

No.	Date	Discussion topics on SAF
2 nd	Aug 24, 2022	<ul style="list-style-type: none"> Bold investment in low-environmental-impact technologies is essential.
4 th	Nov 29, 2022	<ul style="list-style-type: none"> Establishment of SAF supply chain etc. will be promoted through SAF Public-Private Councils. Promote the introduction of SAF based on the revised Civil Aeronautics Act and related laws.
5 th	Dec 22, 2022	<ul style="list-style-type: none"> A Growth-Oriented Carbon Pricing Scheme can be introduced
9 th	Nov 28, 2023	<ul style="list-style-type: none"> The key point is if the end consumer will bear a corresponding cost of SAF introduction.
12 th	Aug 27, 2024	<ul style="list-style-type: none"> Important to create markets through support such as subsidies and tax incentives from governments



JAL has partnered with both Japanese and international energy companies to procure SAF for its domestic and international flights

Company overview

Name	JAL Group
Established year	1951
Airline brands with SAF initiative	<ul style="list-style-type: none"> Japan Airlines ZIPAIR
Major shareholder	Japan Airlines Co., Ltd: Nomura Asset Management Co., Ltd.: 6.2% (As of November 2025)
Number of total flights in 2024	Japan airlines: 311,798 flights
Network	Japan Airlines: <ul style="list-style-type: none"> 131 domestic routes 66 international routes
Total fuel consumption in 2024 (k tonnes)	JAL Group: 3,125.6
Type of airlines	<ul style="list-style-type: none"> Japan Airlines: Full-service ZIPAIR: Low-cost

SAF Blending target

	2025	By 2030
SAF Blending target	1%	10%

SAF Sourcing from overseas

SAF imported to Japan

Timeline	Partner (Country)	Details
March 2022	<ul style="list-style-type: none"> oneworld alliance Gevo Inc. (US) 	<ul style="list-style-type: none"> JAL and 5 members of the oneworld alliance signed an agreement to procure SAF from Gevo Inc. to use across the alliance over a 5-year period starting in 2027. JAL plans to use the SAF on flights departing from Los Angeles Airport, San Francisco Airport, and San Diego Airport
November 2022	<ul style="list-style-type: none"> Itochu Corporation (Japan) Neste (Finland) 	<ul style="list-style-type: none"> JAL used Neste SAF on a flight departing from Los Angeles International Airport JAL used Neste SAF on a domestic flight from Tokyo (Haneda) to Okinawa (Naha)
April 2023	<ul style="list-style-type: none"> Itochu Corporation (Japan) Fuji Oil Company (Japan) Neste (Finland) 	<ul style="list-style-type: none"> JAL has purchased locally blended SAF supplied by Itochu and Fuji Oil, with the neat SAF for blending provided by Neste to use on flights from Chubu Centrair Airport

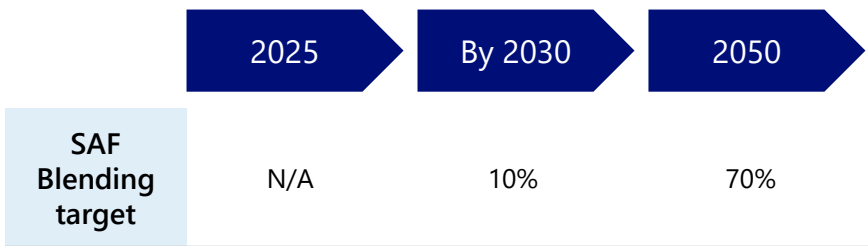


ANA has begun its initiatives in SAF adoption by partnering with Japanese and foreign firms to secure domestically produced and imported SAF

Company overview

Name	ANA Holdings Inc.
Established year	1952
Airline brands with SAF initiative	All Nippon Airways
Major shareholder	The Master Trust Bank of Japan ,Ltd: 15% (As of September 2025)
Number of total flights in 2024	All Nippon Airways: 320,042 flights
Network	All Nippon Airways: • 100 international routes • 76 origin airports
Total fuel consumption in 2024 (k tonnes)	ANA Holdings: 3,224
Type of airlines	Full-service

SAF Blending target



SAF Sourcing from overseas

SAF imported to Japan

Timeline	Partner (Country)	Details
January 2019	<ul style="list-style-type: none"> Showa Shell Sekiyu K.K. (Japan) World Energy (US) 	<ul style="list-style-type: none"> ANA has partnered with Showa Shell Sekiyu K.K. to purchase 265 kL of SAF from World Energy to use on commercial flights from San Francisco to Tokyo
January 2023	<ul style="list-style-type: none"> Itochu Corporation (Japan) Raven SR (US) 	<ul style="list-style-type: none"> ANA signed MOU with Itochu and Raven SR for the long-term procurement of SAF produced by Raven SR in the US
March 2023	<ul style="list-style-type: none"> Itochu Corporation (Japan) Fuji Oil Company (Japan) Neste (Finland) 	<ul style="list-style-type: none"> ANA has agreed to use SAF blended in Japan, supplied by Itochu and Fuji Oil, with the neat SAF for blending provided by Neste for ANA's international and domestic flights departing from Haneda and Narita airports

Source: ANA, news article

SAF Export Potential of Target Countries



NRI proposes to assess potential of target countries based on direction toward SAF exports, sufficiency for export, and export plans of private companies

Assessment Criteria for Target Countries' SAF Export Potential

Evaluation Criteria		Evaluation Indicators	Source of Evaluation Indicator
Country situation	Does the national plan mentioned of the ambition to export SAF or to be export hub?	<ul style="list-style-type: none"> Policy's ambition to export Policy development status 	<ul style="list-style-type: none"> Publicly available sources (as of December 2025) Interview with country's major player and government
	Does the government prohibit exporting SAF? What is the condition?	<ul style="list-style-type: none"> Policy/regulation development status Condition of prohibition 	
	Does the country have enough supply for domestic use and still have a surplus for export?	<ul style="list-style-type: none"> Demand and supply sufficiency forecast result from task 3-2 	
Private company situation	How much production capacity does the company have?	<ul style="list-style-type: none"> Current and future capacity of major players 	
	Does the private company currently export SAF?	<ul style="list-style-type: none"> Current activity of exporting SAF e.g., MoU signing 	
	Does the private company have plan to export SAF?	<ul style="list-style-type: none"> The planned year in which the company is expected to generate a surplus of SAF and be ready for exports 	

All countries state ambitions to export SAF, but some governments intend for SAF producers to prioritize domestic supply and export only surplus

Overview of policy ambitions for SAF exports in Singapore, Malaysia, Indonesia, and Thailand

Country	Policy Title	Responsible Organization	Status	Overview of SAF Export Related Description		Comment from government from interview
				Ambition to export	Detail	
SG	Singapore Sustainable Air Hub Blueprint	Civil Aviation Authority of Singapore (CAAS)	Implemented	Mentioned	<ul style="list-style-type: none"> As part of the airline domain, CAAS and the Singapore Government will collaborate with industry partners to expand SAF production capacity in Singapore and the region, supporting growing SAF demand in Singapore and the wider region. 	No information
MY	Malaysia Green Investment Strategy	Ministry of International Trade and Industry	Implemented	Mentioned	<ul style="list-style-type: none"> As part of the Investment Opportunity in the aviation sector, it is mentioned to focus on expanding domestic production capacity and, opportunistically, capturing export opportunities for palm- and non-palm-based SAF by 2030 	<ul style="list-style-type: none"> Malaysia recognizes the strategic opportunity to position ourselves as a regional SAF hub with ambitions to export SAF to regional markets While specific export incentives are under development, potential measures are in the pipeline (Civil Aviation Authority of Malaysia)
ID	Indonesia's SAF Industry Development Roadmap	Coordinating Ministry for Maritime Affairs and Investment	Implemented	Mentioned	<ul style="list-style-type: none"> As part of the "Economic Value Creation" element in Indonesia's SAF Roadmap, it mentioned that economic value can be created through the export sales of SAF 	<ul style="list-style-type: none"> SAF export is restricted by the regulation in order to fulfill domestic SAF demand first. If surplus SAF is available, SAF can be exported (Coordinating Ministry for Economic Affairs)
TH	Oil Plan 2024 – 2037	Department of Energy Business, Ministry of Energy	Draft completed	Mentioned	<ul style="list-style-type: none"> As part of "New Business framework", the plan aims to promote SAF exports through international cooperation mechanisms and agreements 	<ul style="list-style-type: none"> Thailand aims to prioritize domestic use and prefers having international flights refuel SAF within Thailand rather than exporting (Department of Alternative Energy Development and Efficiency)

Among the four countries, Indonesia has a regulation stating that companies have to fulfill the domestic demand before exporting SAF

Overview of Policies/Regulations Prohibiting SAF Exports in Singapore, Malaysia, Indonesia, and Thailand

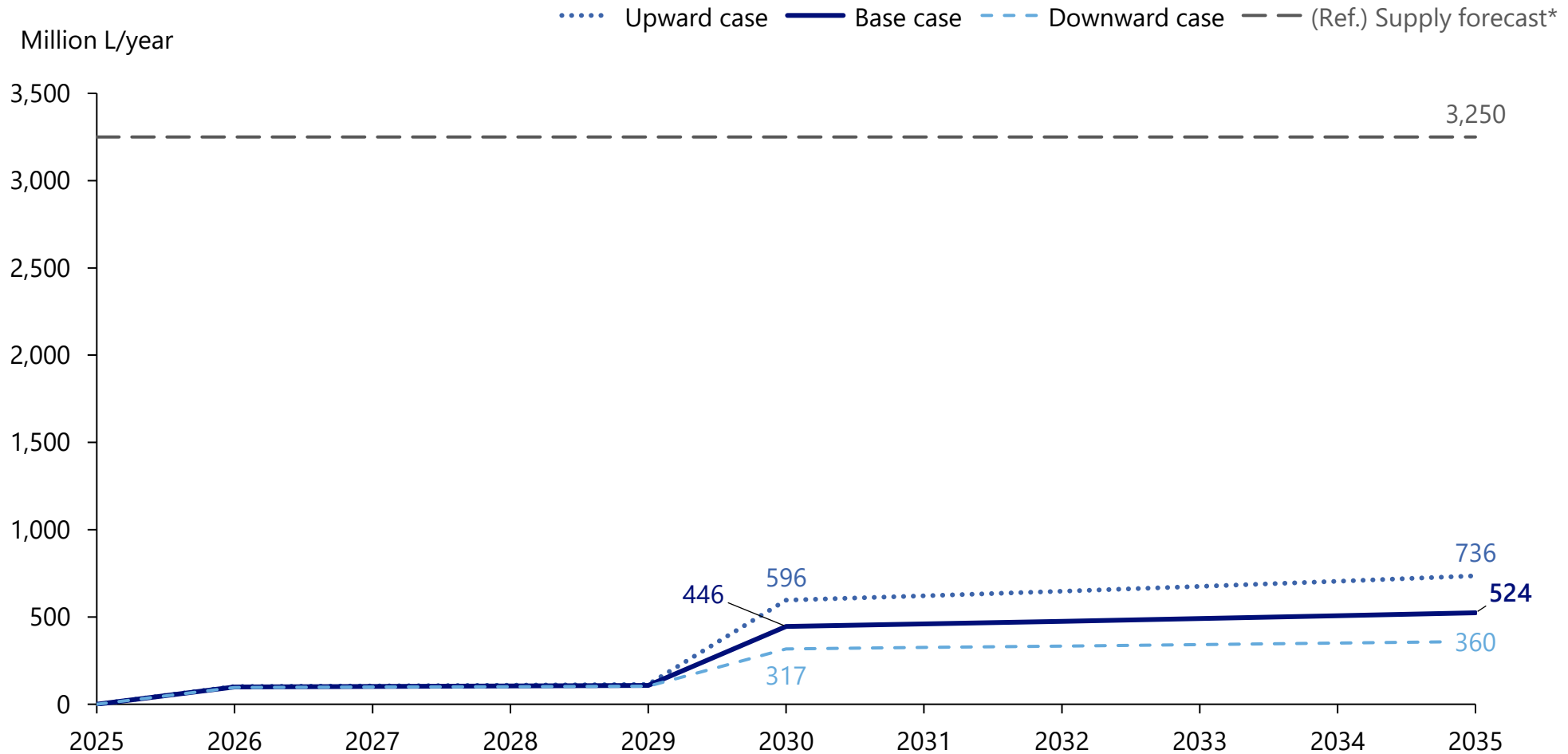
Topic	Policies/Regulations Title	Responsible Organization	Status	Overview of SAF Export Related Description	
				Policies outlining the prohibition to export	Condition
Singapore	N/A	N/A	No major discussion observed based on publicly available sources	N/A	N/A
Malaysia	N/A	N/A	No major discussion observed based on publicly available sources	N/A	N/A
Indonesia	Regulation of the Minister of Energy and Mineral Resources Number 4 of 2025 concerning the Use and Utilization of Biofuels	Ministry of Energy and Mineral Resources	Implemented	<ul style="list-style-type: none"> Mentioned 	<ul style="list-style-type: none"> SAF export can be carried out based on evaluations of the fulfillment of domestic demand conducted by the Minister. (Pasal 9)
Thailand	N/A	N/A	No major discussion observed based on publicly available sources	N/A	N/A



Supply and demand comparison | Singapore

In the target period, SAF demand will increase; however, demand will continue to be lower than supply, resulting in sufficient supply of SAF in domestic market

SAF demand and supply forecast in Singapore

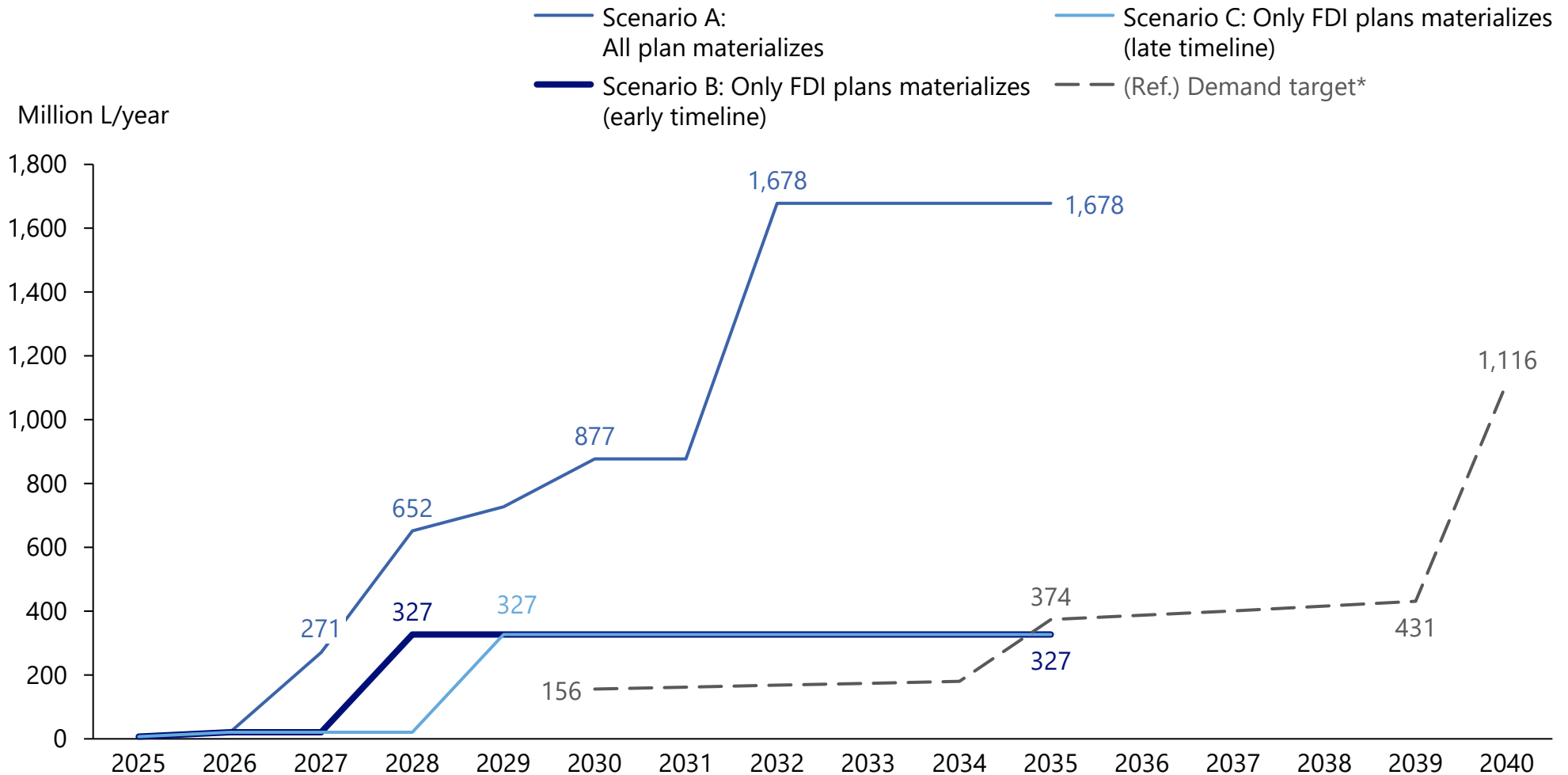


Note) * SAF supply forecast is based on the Neste's facility plan.



Although not many projects have completed FID, SAF supply will exceed the demand targets up to 2034 in scenario B&C

SAF demand and supply forecast in Indonesia

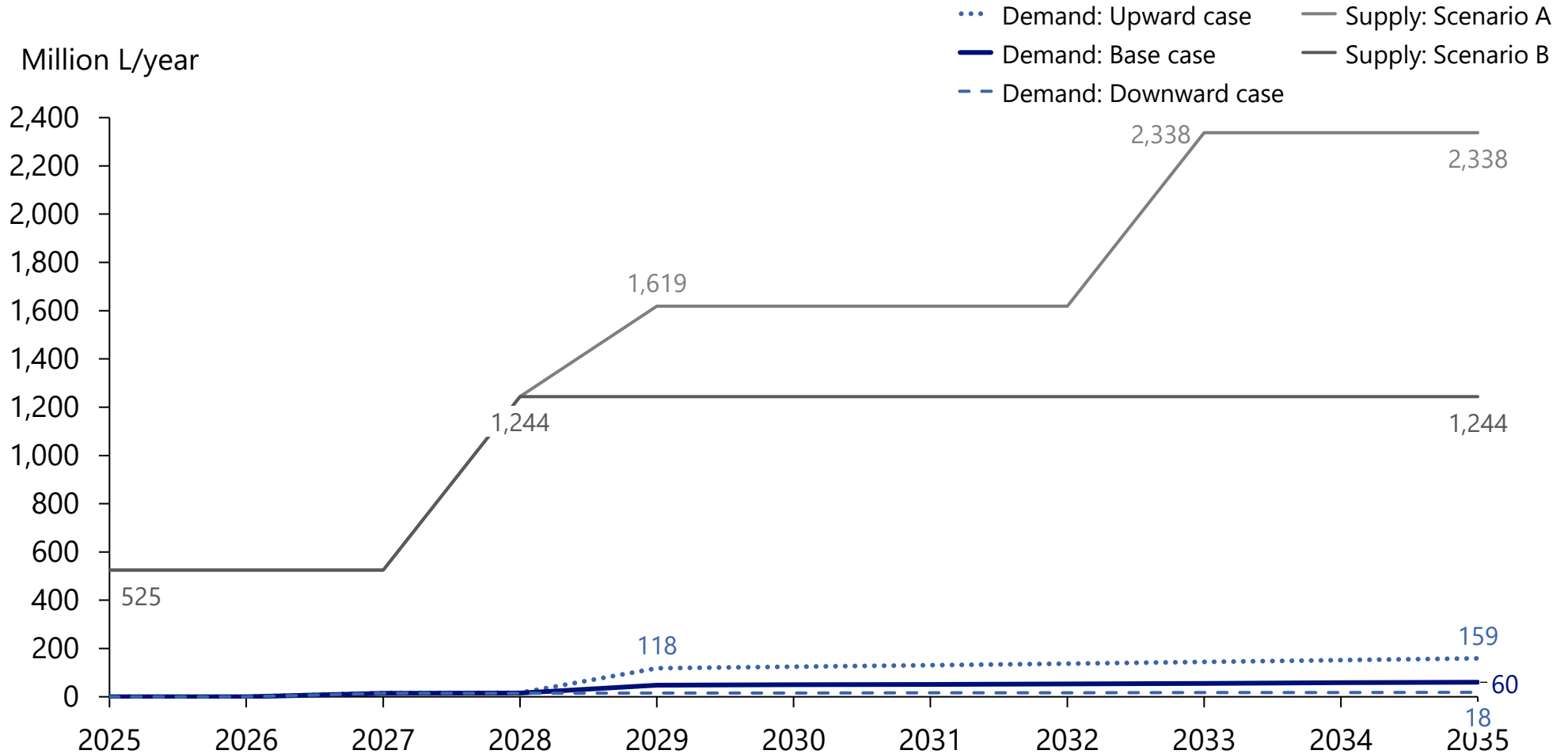


Note) * SAF demand target is referred to targets stated in "SAF Industry Development Roadmap"



In Malaysia, SAF supply exceeds demand significantly throughout the target period

SAF demand and supply forecast in Malaysia

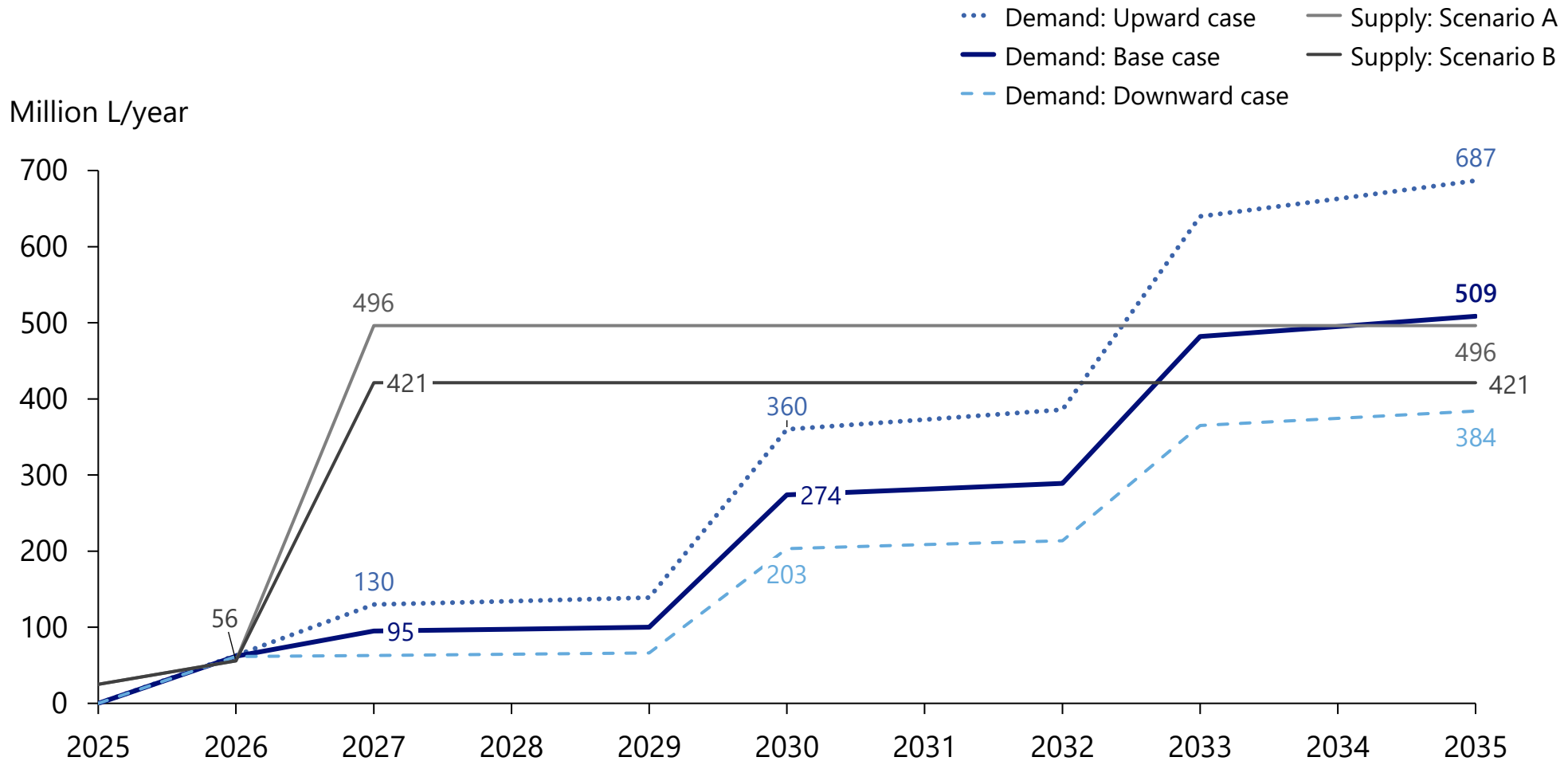




Supply and demand comparison | Thailand

In Thailand, SAF demand will reach supply capacity in 2032-2034 except downward case of demand

SAF demand and supply forecast in Thailand



SAF Export Potential of Target Countries | Country and private company situations

Many companies have indicated future interest for SAF exportation to overseas

Summary of major SAF producers' potential and export plans

*Expert opinion from another company ** result from task 3-2

	Company	Annual production capacity (k tonnes)		Demand supply sufficiency**	Current activity of exporting self-produced SAF	Future plan of SAF exportation	Year ready to export SAF
		Current	Future				
S G	Neste Corporation	2,600	2,600	SAF supply is projected to exceed demand	<ul style="list-style-type: none"> • Has activity e.g., exporting to Europe, America, Japan 	<ul style="list-style-type: none"> • Has plan Continue exporting to high demand countries e.g., Europe and North America 	Currently exporting
	Petronas	0	575 (2028 Q2)	SAF supply is projected to exceed demand	<ul style="list-style-type: none"> • No activity 	<ul style="list-style-type: none"> • Has plan Ready to export immediately after the plant begins operations. However, it will also sell domestically* 	2028
M Y	EcoCeres Renewable Fuels	420	420		SAF supply is projected to exceed demand	<ul style="list-style-type: none"> • No activity 	<ul style="list-style-type: none"> • Has plan Plan to export all of the SAF produced
	FatHopes Energy	0	300 (2029)	<ul style="list-style-type: none"> • No data based on desktop research and interview 		<ul style="list-style-type: none"> • Has plan Plan to focus on export* 	No data
I D	Pertamina (Persero), PT	5.6	882.4 (2032-2033)	SAF supply is projected to exceed demand targets until 2034	<ul style="list-style-type: none"> • No activity Focus on SAF for domestic usage due to regulation 	<ul style="list-style-type: none"> • Has plan Plan to fulfill domestic demand to enable exports 	2028-2029
	PT Essa Industries Indonesia Tbk	0	200 (2027 Q4 -2028 Q1)		<ul style="list-style-type: none"> • No activity 	<ul style="list-style-type: none"> • Has plan Aim to produce SAF for exportation* 	2028*
	Tripatra	0	240 (2030)		<ul style="list-style-type: none"> • No activity 	<ul style="list-style-type: none"> • Has plan Aim to produce SAF for exportation* 	2028*
	PTT	20	80 (2027)		<ul style="list-style-type: none"> • No activity 	<ul style="list-style-type: none"> • No plan As PTT's product is not neat SAF, the export price is lower than the domestic selling price 	No plan
T H	Energy Absolute PCL	0	25 (2026)	SAF demand is projected to get close to supply in 2035	<ul style="list-style-type: none"> • No activity* Highly likely to have no activity* 	<ul style="list-style-type: none"> • No potential to export SAF As the production capacity is quite low* 	No potential*
	Bangchak Corporation	0	292 (2026 Q3)		<ul style="list-style-type: none"> • Has activity in beginning phase e.g., sign MoU with Shell and Cosmo oil 	<ul style="list-style-type: none"> • Has plan Plan to export if there is no SAF mandate in Thailand yet 	2026

Japan Ref: According to Japan's State Action Plan for promoting the introduction of SAF, the full-scale adoption of imported SAF will start after 2030.



Price Attractiveness of Target Countries' SAF Supply to Japan

The estimation of SAF prices and sea-freight transportation costs will be conducted using desktop research and interviews with private company

Price attractiveness methodology (basic concept)

<p>Definition</p>	<ul style="list-style-type: none"> • “Price attractiveness” is defined as the estimated price differential, based on the current domestic FOB prices of local operators in the target countries plus sea-freight transportation costs from each target country to Japan, compared with the Japanese domestic SAF selling price.
<p>Estimation direction</p>	<p>The SAF selling price in Japan and target countries</p> <ul style="list-style-type: none"> ○ <u>Current SAF selling price (2025)</u> is expected to be estimated as a range based on the FOB price from publicly available data and expert interviews. <ul style="list-style-type: none"> ➢ Hypothesis: The current SAF price is around 2,500 – 2,700 USD/metric ton and expected to be similar across countries, as most commercial plants are based on HEFA technology. ○ <u>Future SAF selling price (2035)</u> is expected to be estimated as a qualitative description of future prices, based on the potential next-generation production technologies in each country, using publicly available data and expert interviews. <ul style="list-style-type: none"> ➢ Hypothesis: SAF prices are unlikely to decline significantly because feedstocks and production technologies remain costly. Low-cost alternatives beyond UCO and animal fats are not yet available, and emerging pathways such as AtJ and FT are unlikely to scale fast enough to undercut HEFA, which is the current lowest-cost technology. <p>Sea-freight transportation cost from target countries to Japan is expected to be estimated by shipping cost based on distance from selected representative port in each country to 2 selected potential ports in Japan.</p>
<p>Unit</p>	<ul style="list-style-type: none"> • SAF selling price: USD per ton • Sea-freight transportation costs: USD per ton
<p>Data source</p>	<ul style="list-style-type: none"> • Desktop study (e.g. report from IATA, Argus media, news articles, etc.) • Interviews <ul style="list-style-type: none"> ○ SAF selling price based on previous interviews with private companies from SG, MY, ID and TH ○ Sea-freight transportation costs: Based on 1 interview with a trading company (SAF supply chain developer) or marine logistics company (SAF marine logistics), or an energy company (SAF blender)

Current SAF FOB prices are similar across countries, driven by HEFA as the only commercial pathway. Prices are unlikely to decline significantly by 2035, as other pathways are unlikely to scale fast enough to become cheaper

Current and Future SAF Prices in Japan and ASEAN

Current SAF Price (2025)

- SAF prices can range from 2 to 5 times those of conventional aviation fuel.
- The current SAF FOB price is approximately 2,100–2,950 USD per metric ton and is similar across countries, as commercial plants are based solely on HEFA technology.

Future SAF Price (2035)

- SAF prices are unlikely to decline significantly because feedstocks and production technologies remain costly.
- Feedstock: Low-cost alternatives for HEFA beyond UCO and animal fats are not yet available.
 - Production technology: Emerging pathways such as AtJ and FT are unlikely to scale fast enough to undercut HEFA, which is the current lowest-cost technology.

Industry Expert Perspective on SAF Price

SAF prices are 2–4 times higher than conventional jet fuel.

Inspector Aviation Facilities, Pertamina



Singapore SAF FOB price is around 2,600-2,700 USD per metric ton and the price is very close between Singapore and Japan.

Industry player associated and familiar with Neste Singapore



Based on Argus Media, SAF FOB price is based on HEFA technology, and FOB prices for ASEAN and Japan are broadly similar, ranging from 2,100 to 2,950 USD per metric ton. Price fluctuations are driven by variations in demand across periods.

Industrial expert in Singapore



By 2035, SAF prices are unlikely to decrease significantly, even with the introduction of new technologies, as HEFA remains the cheapest production pathway. Other pathways, such as ATJ and FT, have higher production costs than HEFA.

Business Development Manager, Petronas



Reference) Future SAF Price

MSP shows the price level that can cover the cost of each technology. Production cost is the key reason why SAF prices are higher than conventional jet fuel prices

IATA average MSP of major SAF pathways per five-year period over 2020-2050

Year	IATA average minimum selling price (MSP) of major SAF pathways per five-year period over 2020-2050 (USD per tonne)			
	HEFA*	AtJ	FT	PtL
2020	1,181	2,338	4,838	6,169
2025	1,206	1,988	2,375	5,850
2030	1,238	1,888	2,238	3,894
2035	1,263	1,788	2,083	3,144
2040	1,313	1,706	1,975	2,613
2045	1,394	1,619	1,867	2,181

Note: MSP is the price at which fuel suppliers will sell SAF to airlines without losing money and allowing them to cover their cost of capital. Ultimately, airlines are most likely to pay a premium price for SAF on top of the MSPs, which is the product price of SAF.

* HEFA MSPs are expected to increase somewhat over time as HEFA feedstock becomes more expensive because of stringent supply and demand dynamics.

Even if SAF is imported to Japan, the price can still be attractive due to traders' strategies to manage additional costs across the value chain

Possible strategy to lower the cost of importing SAF

Process	Strategy
Production	<ul style="list-style-type: none"> Japanese companies can jointly invest in SAF refineries in ASEAN countries to benefit from lower land and labor costs, enabling SAF to be sold to Japan at lower prices as a partner supply.
Procurement	<ul style="list-style-type: none"> Oversea SAF Producer: Trader usually give the lower price to oversea SAF producer to be able to cover the additional cost such as shipping and insurance. Domestic SAF producer: Trader typically give premium around 20-80 USD per metric ton to the domestic produced SAF to attract SAF producer to sell to trader.
Transportation	<ul style="list-style-type: none"> Traders may use time charter rather than spot charter to ship SAF, allowing them to co-load multiple products and serve multiple destinations on the same vessel. This enables freight costs to be shared across cargos, potentially reducing the average shipping cost per ton.
Sale	<ul style="list-style-type: none"> Traders typically buy neat SAF when prices are low, store the neat SAF, and sell it when prices rise, as storage costs are relatively low. As SAF prices typically fluctuate, they tend to rise during September–November as airlines purchase SAF to meet SAF mandate requirements.

Source: Interview

Expert Perspective on cost management

- Import costs typically include insurance and logistics in addition to the FOB price.
- SAF producers generally sell SAF on an FOB basis; therefore, all insurance and logistics costs incurred after FOB are borne by buyer or trader.
- Consequently, when exporting SAF overseas, producers may need to price SAF lower than the domestic selling price to remain competitive with global suppliers.
- As a result, buyers may offer a domestic premium of approximately 20–30 USD per metric ton to incentivize local SAF producers to sell domestically to them rather than export.

Industrial expert in Thailand



- To encourage domestic offtake in Japan, buyers typically purchase domestic produced SAF at a premium of 30–80 USD per metric ton.

Industrial expert in Singapore



NRI proposes selecting 2 potential SAF import ports near airports with past SAF deliveries, the highest 2024 aircraft traffic, and oil fuel import capabilities

Selection of SAF Import Ports in Japan

Step 1 Identify Japanese airports that have historical SAF delivery records

- Create a list of airports in Japan with recorded SAF deliveries, based on publicly available data (e.g., the ICAO website).
 - Hypothesis: Haneda Airport, Narita Airport, Chubu Centrair International Airport, Kansai International Airport

Step 2 Select 2 target airports


- From the list of airports, select 2 target airports based on the following criteria and input from the interview
 - ✓ Airports with the highest aircraft movements in 2024, including both international and domestic flights, based on publicly available data (e.g., airport websites)
 - Hypothesis:
 - Haneda Airport: 480,022 (2024)
 - Narita Airport: 242,071 (2024)
 - Kansai International Airport: 198,825 (2024)
 - Chubu Centrair International Airport: 95,212 (2024)

Step 3 Identify potential seaports for SAF import near the selected airports

- Create list of seaport near the selected airport based on publicly available data
 - Hypothesis:
 - Haneda: Port of Tokyo (6 km), Port of Kawasaki (7 km), Port of Yokohama (17 km), Port of Chiba (31 km)
 - Narita: Port of Chiba (31 km), Port of Kashima (34 km), Port of Tokyo (59 km), Port of Kawasaki (65 km)
- Select 1 port for each airport based on the following criteria and validate through interview
 - ✓ Ports capable of handling oil fuel imports, based on publicly available data
 - ✓ The port located closest to the airport, based on publicly available data
 - Hypothesis:
 - Haneda Airport: Port of Tokyo (6 km)
 - Narita Airport: Port of Chiba (31 km)

Marine shipping costs will be calculated based on the distance from representative ports in each country to the 2 selected Japanese ports

Selection of SAF Import Ports in Malaysia, Indonesia and Thailand

- 
- Step 4** Exclude SAF refineries and players with high uncertainty in SAF production in each country
- Exclude SAF producers and their refineries in each country based on the following criteria
 - ✓ Refineries that have not yet completed FID
 - ✓ SAF producers that do not yet have an SAF refinery with a completed FID.
- Step 5** Select 1 target SAF producer from major SAF players in each country and representative refinery
- Select 1 target SAF producer from major SAF players in each country based on the following criteria:
 - ✓ Level of interest in exporting SAF
 - ✓ Production capacity
 - ✓ Timeline for SAF exports
 - Select 1 representative refinery for each SAF producer from refineries that are already operating or scheduled to start operations the soonest.
- Step 6** Create list of the potential port near the refinery and select representative port
- Create a list of potential ports based on publicly available data and interview input
 - ✓ List the ports that the target refinery has used for marine oil shipping
 - ✓ List the ports near the refinery that are capable of exporting oil
 - Select representative port based on criteria e.g., ports recommended from interview, port that is nearest to refinery
- Step 7** Identify the distance based on the marine shipping route from the representative port to 2 target ports in Japan
- Identify marine shipping distance from representative port to the selected port in Japan, based on publicly available data or data from marine logistic company
- Step 8** Estimate marine shipping cost
- Estimate the marine shipping cost based on the average cost, using interview inputs or publicly available reports (e.g., GHD Advisory's report mentions that sea freight ranges from approximately 0.001 to 0.007 USD per ton-km), and the distance obtained from publicly available data

Narita Airport and Kansai International Airport are selected as the two most promising airports for SAF usage due to high number of international flights

Japanese airports with historical SAF delivery records

Selected airport by expert History of SAF import

Airport	Example of SAF usage		Number of departing flights	
	Timeline	Detail	International	Domestic
Haneda Airport	Oct 2020	Neste, ITOCHU and ANA established a SAF supply chain in Japan enabling Neste's first SAF delivery into Asia at Haneda and Narita Airports	58,121 (FY2024)	N/A
	Jun 2021	JAL and ANA operated demonstration domestic commercial flights using domestically developed SAF from wood chips and microalgae		
	Jul 2025	JGC Holdings started supplying domestically produced SAF to scheduled passenger flights from Haneda Airport		
Narita Airport	Oct 2020	Neste, ITOCHU and ANA established a SAF supply chain in Japan enabling Neste's first SAF delivery into Asia at Haneda and Narita Airports	95,490 (2024)	24,895 (2024)
	Sep 2024	Neste, ITOCHU, and GS Caltex has brought the first batch of CORSIA-eligible SAF to Narita Airport. Neste supplied over 1,000 tons of neat SAF to GS Caltex's South Korean refinery, where it was blended and shipped to Japan.		
Chubu Centrair International Airport	Apr 2023	Locally blended SAF is supplied to Chubu to use in flight inspection aircraft owned by the Civil Aviation Bureau. ITOCHU imported neat SAF from Neste MY into Japan where it is locally blended by Fuji Oil Company	18,970 (FY2024)	28,638 (FY2024)
	Apr 2025	DHL began using domestically produced SAF for regular cargo operations from Chubu, reportedly purchasing about 7,200 kL/year		
Kansai International Airport	Apr 2025	Cosmo Oil Marketing supplied its first batch of domestically produced SAF to Japan Air Self-Defense Force's at Kansai International Airport	78,722 (2024)	23,536 (2024)
	May 2025	JAL flight to Shanghai became the first passenger flight from Kansai International Airport fueled with domestically produced SAF		
Kobe Airport	FY 2025	Saffaire Sky Energy, a JV of Cosmo Oil, JGC Holdings Corporation and Revo International, is scheduled to supply domestically produced SAF to Starlux Airlines at Kobe Airport through the Cosmo Energy Group in fiscal 2025	8 (2024)	16,619 (2024)

Narita Airport has strong demand potential for imported SAF due to frequent international flights, SAF blending facility, and transfer pipeline from Chiba Port

Potential marine port near Narita airport

Topic	Location
Narita airport	Narita, Chiba Prefecture, Japan
Chiba port	Chiba city, Chiba Prefecture, Japan

Expert Perspective on Potential Marine Port

- Narita airport has the most potential for SAF demand from a lot of international flights. Currently, there is no airport SAF blending facility and they use Fuji oil's facility near Chiba port for SAF blending.
- There is a pipeline for transporting aviation fuel from Chiba Port to Narita Airport. Therefore, once SAF is imported to the port, we can utilize the pipeline and infrastructure.

Industrial expert in Singapore



KIX has strong demand potential due to its high volume of international flights; however, SAF must be transported from the marine port to the airport by truck

Potential marine port near Kansai International Airport

Topic	Location
Kansai International Airport (KIX)	Izumisano City, Osaka Prefecture, Japan
Port of Sakai-Semboku	Sakaiminato City, Osaka Prefecture, Japan

Expert Perspective on Potential Marine Port

- Kansai International Airport has strong demand due to a high number of international flights.
- However, there is currently no pipeline for SAF transportation from the port to the blending facility, so shipping by truck is required.
- The only available SAF blending facility is Cosmo Oil's, which is suitable only for small-scale operations.
- In addition, there is a risk that Cosmo Oil may not allow blending of SAF imported by other companies, as it also produces its own SAF.

Industrial expert in Singapore



NRI recommends excluding refineries and SAF producers with no refineries having completed FID, due to production uncertainty

Evaluation of SAF refineries and players with high uncertainty in production

Excluded because there is high uncertainty in SAF production, since refinery has not yet completed FID

		SAF Refinery	(1) Progress		(2) Operation starting year
			Progress	Remarks	
SG	Neste	Tuas, west of Singapore	In operation	-	2023
MY	Petronas	Johor	Completed FID	-	2028
		-	Before starting FID	<ul style="list-style-type: none"> The plan will be considered after the Johor Refinery starts operating to ensure it meets market demand 	2033
	EcoCeres	Johor	In operation	-	2025 (Q4)
	FatHopes	Port Klang	Before starting FID	<ul style="list-style-type: none"> The project is currently in the feasibility/FEED stage 	2029
TH	PTT	Map Ta Phut, Rayong (Existing)	In operation	-	2025
		Mao Ta Phut, Rayong (Expansion)	Before starting FID	-	2027
	Energy Absolute	Rayong	Completed FID	<ul style="list-style-type: none"> EPC has been completed, and currently under test run of the refinery (as of December 2025) 	2026
	Bangchak	Phra Khanong, Bangkok	Completed FID	-	2026

NRI recommends excluding refineries and SAF producers with no refineries having completed FID, due to production uncertainty

Excluded because there is high uncertainty in SAF production, since refinery has not yet completed FID

Evaluation of SAF refineries and players with high uncertainty in production

	SAF Refinery	(1) Progress		(2) Operation starting year	
		Progress	Remarks		
ID	Pertamina	Cilacap, Central Java (Phase-1)	In operation	-	2025 (Q2)
		Dumai, Riau	No need investment	• SAF will be produced by co-processing at existing refinery	2026 (Q2)
		Balongan, West Java	No need investment	• SAF will be produced by co-processing at existing refinery	2026 (Q4)
		Cilacap, Central Java (Green Refinery)	Under FID	-	2028-2029
		Plaju, South Sumatra	Before starting FID	• The design will be confirmed after the Green Refinery starts operating to ensure it meets market demand	2032-2033
	ESSA	Central Java	Before starting FID	• In the internal planning stage including technology selection	2027 (Q4) – 2028 (Q1)
	Tripatra	Sei Mangkei, North Sumatra	Before starting FID	• Feasibility study was completed, and now in designing stage.	2028 (Q3-Q4)
		Kalimantan	Before starting FID	No information available	2029
		North Sumatra	Before starting FID	No information available	2030
North Sumatra or Kalimantan		Before starting FID	No information available	2030	

Based on the evaluation criteria, the SAF producers in each target country are evaluated on a scale of 1–4

Evaluation of SAF producer from major SAF players in each country

Evaluation Perspective	Evaluation Criteria	SG	MY		ID	TH		
		Neste	Petronas	EcoCeres	Pertamina	PTT	EA	Bangchak
Production capacity	1. Total capacity of current and planned future capacity 0–200 k tonnes/year					✓	✓	
	2. Total capacity of current and planned future capacity 201–500 k tonnes/year			✓				✓
	3. Total capacity of current and planned future capacity 501–900 k tonnes/year		✓		✓			
	4. Total capacity of current and planned future capacity more than 900 k tonnes/year	✓						
Level of interest in exporting SAF	1. No/minimal intention to export SAF					✓	✓	
	2. Plan to partially export SAF	✓	✓		✓			✓
	3. Plan to fully export SAF			✓				
	4. Plan to fully export SAF and already started the activity e.g., MoU signing							
Timeline for SAF exports	1. Expected to be ready after 2029 or No plan/ No confirmed timeline for SAF export readiness					✓	✓	
	2. Ready to export SAF by 2029		✓		✓			
	3. Ready to export SAF by 2026			✓				✓
	4. Currently exporting SAF	✓						

Based on the total score, the target SAF producer from major SAF players in each country will be selected

Evaluation of SAF producer from major SAF players in each country

Selected player

Country	Player	Production capacity	Level of interest in exporting SAF	Timeline for SAF exports	Overall Evaluation	
					Score	NRI's Views
SG	Neste Corporation	4	2	4	10	Neste is the only major player in Singapore.
MY	Petronas	3	2	2	7	Petronas plans to export SAF in the future after the plant starts operations in 2028. However, Petronas will also sell SAF domestically.
	EcoCeres Renewable Fuels	2	3	3	8	EcoCeres' capacity is not significantly different from Petronas's, but it plans to export all SAF produced and is expected to begin exports as early as 2026.
ID	Pertamina (Persero), PT	3	2	2	7	Even though Pertamina must meet domestic demand before exporting, the company is confident it can begin exports from 2028-2029.
TH	PTT	1	1	1	3	PTT has no plans to export SAF, as its product is not neat SAF. When the company discussed with overseas traders, such as Japanese traders, the export price offered was lower than the domestic selling price.
	Energy Absolute	1	1	1	3	Due to the small capacity, it might be difficult for EA to export SAF
	Bangchak Corporation	2	2	3	7	Bangchak is the only major SAF producer in Thailand that has both a clear plan to export SAF and the capability to do so.

Many companies have indicated future interest for SAF exportation to overseas

Summary of major SAF producers' potential and export plans

*Expert opinion from another company ** result from task 3-2

	Company	Annual production capacity (k tonnes)		Demand supply sufficiency**	Current activity of exporting self-produced SAF	Future plan of SAF exportation	Year ready to export SAF
		Current	Future				
S G	Neste Corporation	2,600	2,600	SAF supply is projected to exceed demand	<ul style="list-style-type: none"> • Has activity e.g., exporting to Europe, America, Japan 	<ul style="list-style-type: none"> • Has plan Continue exporting to high demand countries e.g., Europe and North America 	Currently exporting
	Petronas	0	575 (2028 Q2)	SAF supply is projected to exceed demand	<ul style="list-style-type: none"> • No activity 	<ul style="list-style-type: none"> • Has plan Ready to export immediately after the plant begins operations. However, it will also sell domestically* 	2028
M Y	EcoCeres Renewable Fuels	420	420		SAF supply is projected to exceed demand	<ul style="list-style-type: none"> • No activity 	<ul style="list-style-type: none"> • Has plan Plan to export all of the SAF produced
	FatHopes Energy	0	300 (2029)	<ul style="list-style-type: none"> • No data based on desktop research and interview 		<ul style="list-style-type: none"> • Has plan Plan to focus on export* 	No data
I D	Pertamina (Persero), PT	5.6	882.4 (2032-2033)	SAF supply is projected to exceed demand targets until 2034	<ul style="list-style-type: none"> • No activity Focus on SAF for domestic usage due to regulation 	<ul style="list-style-type: none"> • Has plan Plan to fulfill domestic demand to enable exports 	2028-2029
	PT Essa Industries Indonesia Tbk	0	200 (2027 Q4 -2028 Q1)		<ul style="list-style-type: none"> • No activity 	<ul style="list-style-type: none"> • Has plan Aim to produce SAF for exportation* 	2028*
	Tripatra	0	240 (2030)		<ul style="list-style-type: none"> • No activity 	<ul style="list-style-type: none"> • Has plan Aim to produce SAF for exportation* 	2028*
	PTT	20	80 (2027)		<ul style="list-style-type: none"> • No activity 	<ul style="list-style-type: none"> • No plan As PTT's product is not neat SAF, the export price is lower than the domestic selling price 	No plan
T H	Energy Absolute PCL	0	25 (2026)	SAF demand is projected to get close to supply in 2035	<ul style="list-style-type: none"> • No activity* Highly likely to have no activity* 	<ul style="list-style-type: none"> • No potential to export SAF As the production capacity is quite low* 	No potential*
	Bangchak Corporation	0	292 (2026 Q3)		<ul style="list-style-type: none"> • Has activity in beginning phase e.g., sign MoU with Shell and Cosmo oil 	<ul style="list-style-type: none"> • Has plan Plan to export if there is no SAF mandate in Thailand yet 	2026

Japan Ref: According to Japan's State Action Plan for promoting the introduction of SAF, the full-scale adoption of imported SAF will start after 2030.

Based on Steps 5 and 6, NRI recommends the following players and refineries as representatives for an analysis of SAF shipping prices from nearby marine ports

Summary of selected players and refineries

Country	Target SAF producer	Target Refinery	Representative marine port for exportation
Singapore	Neste Corporation	Tuas, west of Singapore	Neste Jetty C Port (Neste's own port in refinery)
Malaysia	EcoCeres Renewable Fuels	Pasir Gudang, Johor	Tanjung Langsat Port
Indonesia	Pertamina (Persero), PT	Cilacap, Central Java	Pertamina RU IV Cilacap Area 70 (Pertamina's own marine port located near the refinery)
Thailand	Bangchak Corporation	Phra Khanong, Bangkok	BCP refinery port Chao Phraya jetties (Bangchak's own port in refinery)
			Port of Bangkok (Khlong Toei Port)

Neste refinery in Singapore has own port for SAF exportation which is located in the same area as the refinery in Tuas, west of Singapore.

Potential port near the Neste's refinery in Tuas

Topic	Location
Selected SAF Refinery	Tuas, west of Singapore
Neste Jetty C Port	Tuas, west of Singapore

Expert Perspective on Potential Marine Port

Neste refinery in Singapore has own port for SAF exportation which is located in the same area as the refinery in Tuas, west of Singapore.

Industry player associated and familiar with Neste Singapore



EcoCeres uses Tanjung Langsat Port located right by the refinery as main port to export SAF and also import UCO via direct pipeline from the refinery to the port

Potential port near the EcoCeres's refinery in Jorhor

Topic	Location
Selected SAF Refinery	Pasir Gudang, Johor
Tanjung Langsat Port	Pasir Gudang, Johor

Detail of Tanjung Langsat Port

- **Main activities:** handling and logistics for liquid bulk (oil, chemicals, renewable fuels), heavy industry support, container cargo, and warehouse
- **Facilities:** liquid bulk tank storage, marine berths and jetties, pipeline connections to nearby refineries/industrial plants, and supporting logistics infrastructure

Expert Perspective on Potential Marine Port

EcoCeres refinery is located in Tanjung Langsat Industrial Complex (TLIC) which located just next to Tanjung Langsat Port. Hence, it is the marine port that EcoCeres is using for export SAF. This port also has direct pipeline from refinery to the port to export produced SAF and import UCO

Former Engineering Manager, EcoCeres



The Pertamina SAF refinery in Cilacap, Central Java, Indonesia, has its own port for SAF exports, located in the same area as the refinery

Potential port near the Pertamina's refinery in Cilacap

Topic	Location
Selected SAF Refinery	Cilacap, Central Java
Pertamina's own marine port	Pertamina RU IV Cilacap Area 70 (Pertamina's own marine port located near the refinery)

Expert Perspective on Potential Marine Port

Pertamina has its own marine port with the capability to load various types of vessels, including MR (Medium Range) tankers. The potential export port is located in the Pertamina RU IV Cilacap Area 70.

Inspector Aviation Facilities, Pertamina



Bangchak tends to export via its own port in the same area as the refinery. Another potential port for exportation is Port of Bangkok

Potential port near Bangchak's refinery in Phra Khanong

Topic	Location
Selected SAF Refinery	Phra Khanong, Bangkok
BCP refinery port Chao Phraya jetties	Phra Khanong, Bangkok
Port of Bangkok (Klong Toei Port)	Klong Toei, Bangkok

Expert Perspective on Potential Marine Port

Port of Bangkok is considered the most viable option. Bangchak may also utilize its own refinery port facilities such as oil tank for logistics.

Department of Alternative Energy Development and Efficiency (DEDE)



Bangchak exports oil via their own port in Phra Khanong, delivering by small ships. All Bangchak refinery has its own port.

Industrial expert in Thailand



Sea-freight transportation costs estimation process | Step 7 & 8 | Identify sea distance and shipping cost

As of 2 January 2026, marine shipping costs from the target ASEAN countries to Japan are in the range of 42–45 USD per metric ton

Marine shipping cost of SAF from each country representative SAF producers to Japan (as of 2 January 2026)

Representative SAF producer in ASEAN			Marine shipping of SAF			
Country	Target SAF producer	Target Refinery	Departure marine port	Destination marine port	Sea distance from the departure point to the Destination (km)*	Marine shipping cost (USD per metric ton)*
Singapore	Neste Corporation	Tuas, west of Singapore	Neste Jetty C Port (Neste's own port in refinery)	Chiba port, Port of Sakai-Semboku	~5,426	~43
Malaysia	EcoCeres Renewable Fuels	Pasir Gudang, Johor	Tanjung Langsat Port		~5,384	~42
Indonesia	Pertamina (Persero), PT	Cilacap, Central Java	Pertamina RU IV Cilacap Area 70 (Pertamina's own marine port located near the refinery)		~6,434	~45
Thailand	Bangchak Corporation	Phra Khanong, Bangkok	BCP refinery port Chao Phraya jetties (Bangchak's own port in refinery)		~5,458	~44
			Port of Bangkok (Khlong Toei Port)		~5,545	~44

Note: The maximum sea distance and shipping cost are based on the shipping cost to Chiba Port. Shipping to Port of Sakai-Semboku is expected to be lower due to the shorter distance from the representative ports in target ASEAN countries.

Source: Interview

Japan needs to import SAF to secure supply, and the associated marine shipping costs are acceptable, making target ASEAN countries a potential sourcing region

Reasons for SAF import necessity in Japan

SAF production capacity	<p>Even if all planned SAF plants in Japan become operational in the future, Japan will still need to import the remaining 500–600 kt to meet demand.</p> <ul style="list-style-type: none">• SAF Demand: Japan has 10% SAF blending target by 2030 which will be around 1.5-1.7 million ton.• SAF Supply:<ul style="list-style-type: none">➢ Current: Japan only has 1 domestic SAF refinery➢ Future: Even there is future planned SAF refinery the total capacity will be around 1.13 million tons. However, there is high chance the future plant will be delayed again.
Limited feedstock availability	<p>There is relatively limited feedstock in Japan.</p> <ul style="list-style-type: none">• If the SAF projects proceed as planned, Japan will need significant quantities of CORSIA-eligible oil and fat and bioethanol feedstocks to meet SAF production targets. Securing sufficient feedstocks will be a major challenge.
Cost of SAF production	<ul style="list-style-type: none">• Japan faces challenges from high land and labor costs, leading to high SAF refinery development costs and rising feedstock prices due to limited availability, which delay investment decisions for domestic SAF refinery.

Price attractiveness when considering shipping cost

- The shipping cost will not affect Japan SAF buying decision from ASEAN that much as Japan has no choice as it does not have enough SAF.
- Even after 2028 that many plants in Japan will become active, it is not likely that the production will be enough. Because Japan does not have enough feedstock, and when other countries limit the feedstock exportation, the cost of production will be much higher.

Industry player associated and familiar with Neste Singapore



- If Japan cannot achieve the 10% target, it will have no choice but to import and will need cost-competitive sourcing options, including:
 - Nearby suppliers such as Korea and China
 - Logistics-convenient hubs such as Singapore, which has SAF blending capabilities
 - Among ASEAN countries, Malaysia has strong potential, while Thailand's export potential will depend on post-election government policy, especially the adoption of a 1% blending mandate, which would affect domestic demand and export availability.

Industrial expert in Singapore



Even with exports from ASEAN to Europe, costs remain acceptable, giving Japan an opportunity to invest in ASEAN SAF production and supply European market

ASEAN SAF Export Potential to Europe and Strategic Opportunities for Japan

- Neste Singapore also exports SAF to Europe and North America, as demand in these regions is higher than in Asia-Pacific.
- Neste Singapore also exports SAF to Europe and North America, as demand in these regions is higher than in Asia-Pacific.
- Shipping costs from Singapore to North America are not prohibitively high due to well-established logistics, and many shipping companies are capable of providing these services.
- The export decision is therefore driven primarily by demand constraints rather than shipping costs, which can be absorbed.

Industry player associated and familiar with Neste Singapore



- Shipping costs from ASEAN to the Europe are generally higher than those to Japan due to longer distances.
- Specifically, shipping from ASEAN to the Europe costs around 65–70 USD per metric ton, compared with 42–45 USD per metric ton for shipments from ASEAN to Japan.
- However, the Europe typically purchases in larger batches, which helps keep overall pricing competitive.
- Ultimately, demand is the key driver behind exports to the Europe.
- The shipping cost from ASEAN to North America is around 75–83 USD per metric ton, and to the United Kingdom is around 68–77 USD per metric ton.

Industrial expert in Singapore



- Japanese companies can jointly invest in SAF refineries in ASEAN countries to benefit from lower land and labor costs, enabling SAF to be sold to Japan at lower prices as a partner supply.
- Moreover, if Japan's demand is already met, the SAF can also be exported to Europe, where demand is higher.

Inspector Aviation Facilities, Pertamina



Not only Japan, but major SAF producers in ASEAN countries also aim to export SAF to higher demand markets such as Europe and North America

ASEAN Countries' SAF Export Target Markets

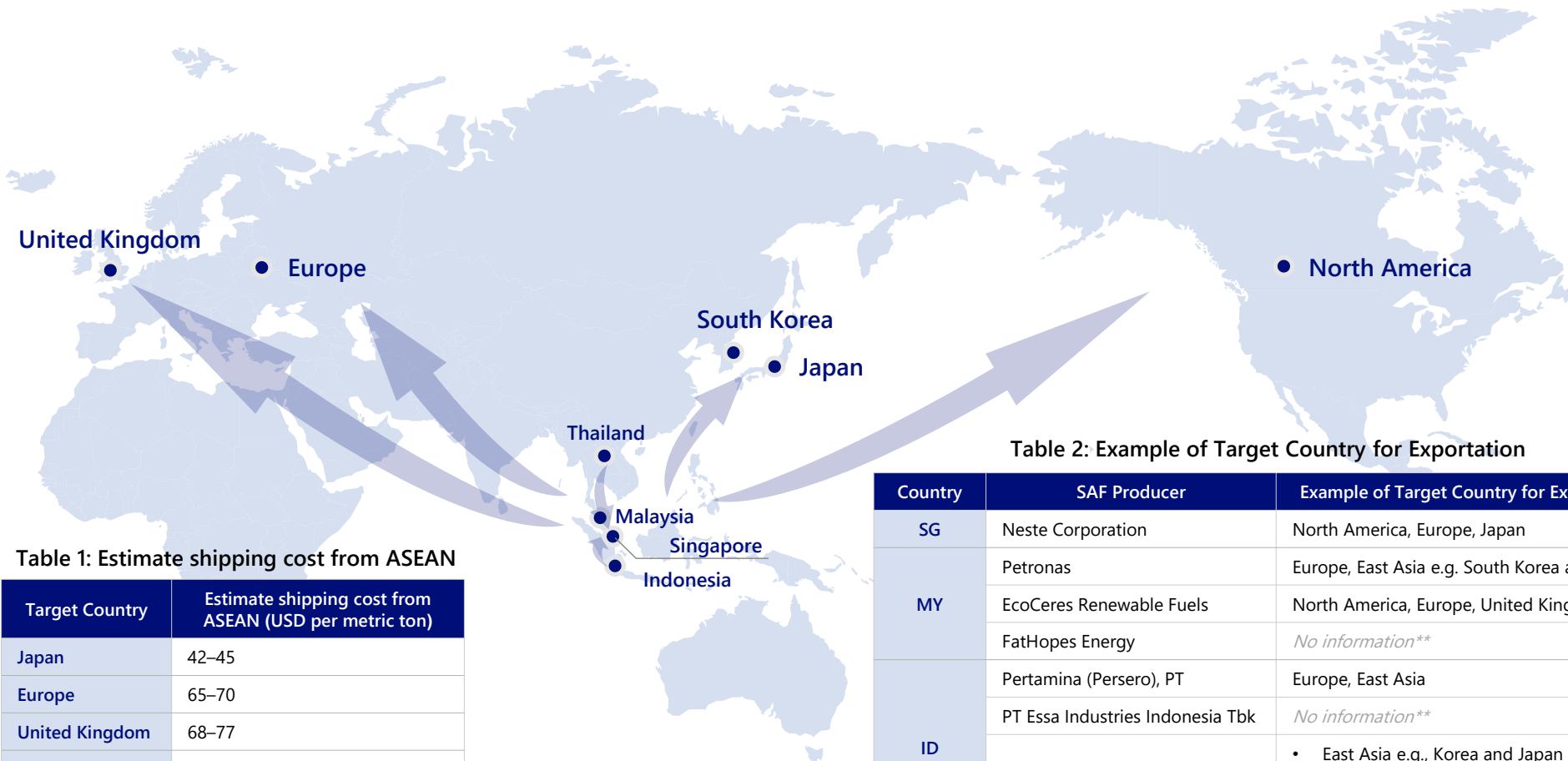


Table 1: Estimate shipping cost from ASEAN

Target Country	Estimate shipping cost from ASEAN (USD per metric ton)
Japan	42–45
Europe	65–70
United Kingdom	68–77
North America	75–83

Table 2: Example of Target Country for Exportation

Country	SAF Producer	Example of Target Country for Exportation
SG	Neste Corporation	North America, Europe, Japan
MY	Petronas	Europe, East Asia e.g. South Korea and Japan
	EcoCeres Renewable Fuels	North America, Europe, United Kingdom
ID	FatHopes Energy	<i>No information**</i>
	Pertamina (Persero), PT	Europe, East Asia
	PT Essa Industries Indonesia Tbk	<i>No information**</i>
TH	Tripatra*	<ul style="list-style-type: none"> East Asia e.g., Korea and Japan Plan to trade SAF through Singapore as a commercial hub, with sales targeted to Europe and the United States
	Bangchak Corporation	Singapore, Japan

* Opinion from the expert from other companies

** No information based on desktop research and interview

Source: NRI analysis, interview, Bangchak

Reference) Current situation of domestic SAF refinery development in Japan

Imported SAF can help ensure supply certainty, as high costs and limited feedstock have delayed Japan SAF producers' investment decisions and projects

Ongoing Major Japanese SAF Projects

*2026 → 2028 means the operating schedule has been postponed from 2026 to 2028

Oil company	Main Partners	Location	Operation Start	Estimated Annual Production		Feedstock	Status
				million L	k ton		
Cosmo	JGC, Revo	Sakai, Osaka	April 2025	30	24	UCO	Operation
ENEOS	Mitsubishi	Arida, Wakayama	2026 → 2028*	400	320	UCO, animal fat	Planned
Idemitsu	No information	Chiba	2026 → 2028*	100	80	Ethanol	Planned
Idemitsu	No information	Tokuyama	2028	250	200	UCO, oil/fat	Planned
Taiyo Oil	Mitsui	Okinawa	2028	220	176	Ethanol	Planned
Cosmo	Mitsui	Sakaide	2027 → 2029*	220	176	Ethanol	Planned
Fuji Oil Corp.	Itochu	Sodegaura, Chiba	2027 → no go	180	144	UCO, oil/fat	Canceled

Current situation of SAF projects in Japan

- Despite these ambitious projects, several challenges are delaying investment decisions and project timelines. Obstacles include escalating costs for building SAF plants, difficulty in securing workers for plant construction, increasing prices and limited supply of UCO and other feedstocks, and challenges in scaling up ATJ SAF production technologies.
- In May 2025, Fuji Oil Company announced the cancellation of its planned HEFA SAF plant in Sodegaura, Chiba, citing concerns over profitability. This marked the first cancellation of a large-scale SAF plan in Japan.

There is a possibility that all of the plants mentioned above, except Cosmo, which has already started operating, may be delayed again beyond the above-mentioned schedule.



Industrial expert in Singapore

Reference) Operating expenditure (OPEX) of SAF production in Japan | Feed stock cost

UCO prices are currently similar across countries, but rising demand and supply shortages may increase prices and SAF production costs in Japan

Overview of UCO FOB Price

Country	Date	FOB Price (USD/ton)
Singapore	2025	1,060*
Malaysia	October-November 2025	903.5
Indonesia	November 2025	1,056
Thailand	February 2025	975
Japan	2025	1,085*
China	November 2025	1,093-1,115

*Data from an interview with an industrial expert from a Japanese trading company in Singapore, based on the expert's actual trading experience.

Current and Future UCO Price

- Currently, UCO prices do not differ significantly by country, as they are driven by global demand, which keeps prices consistently high.
- For example, if Malaysian SAF producers offer lower prices, UCO collectors will divert supply to Singapore, where margins are higher.

Industry player associated and familiar with Neste Singapore



- Japan generates approximately 400 k ton of UCO per year, of which around 50–60% is used for animal feed, as this market offers higher prices than overseas exports. While the remaining ~40% is exported to other countries for SAF production or animal feed.
- Currently, Cosmo will require only approximately 33–35 k ton of UCO.
- However, in the future, as additional SAF plants begin operations, domestic UCO supply will become insufficient, requiring higher-cost imports to attract suppliers to sell to Japan.

Industrial expert in Singapore



Executive Summary

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Chapter 2: Player Activity

Chapter 3: Supply/demand potential

Chapter 4: Needs by Local Players

Chapter 5: Export Potential to Japan

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	Ministry of Economy	National Energy Transition Roadmap (NETR)	https://ekonomi.gov.my/sites/default/files/2023-09/National%20Energy%20Transition%20Roadmap_0.pdf	3
	Ministry of Transport of Malaysia	Malaysia Aviation Decarbonisation Blueprint	https://www.mot.gov.my/en/Pages/Aviation/MADBlueprint%20BI%20FA.pdf	3
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	Department of Energy Business	Public Hearing Document for the (Draft) Oil Plan 2024–2037	https://image.makewebeasy.net/makeweb/0/u3EjrB8bq/Document/Oil_Plan_2024สารสำคัญรับฟังความคิดเห็น_ร่าง_Oil_Plan_2024.pdf?v=202405291424	3
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	Government Electronic Information Portal	Decision No. 876/QD-TTg	https://vanban.chinhphu.vn/?pageid=27160&docid=206188	3

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	The Asahi Shimbun Company	Overview of Japan SAF supply side policy	https://www.asahi.com/article/ASR5T752LR5TULFA02J.html	3
	Nikkei Inc		https://www.nikkei.com/article/DGXZQOUA23B7A0T20C23A5000000/	3
			https://www.nikkei.com/article/DGXZQOUA25CV00V20C24A6000000/	3
Executive summary	Ministry of Economy, Trade and Industry	Overview of Japan SAF demand side policy	https://www.meti.go.jp/shingikai/enecho/shigen_nenryo/nenryo_seisaku/pdf/016_04_00.pdf	3
	Civil Aviation Authority of Singapore	New Sustainable Aviation Fuel Levy to Apply From 1 April 2026 for Flights Departing From 1 October 2026	https://www.caas.gov.sg/who-we-are/newsroom/Detail/new-SAF-levy-to-apply-from-1-apr-2026-for-flights-departing-from-1-oct-2026	4
	International Trade Administration U.S. Department of Commerce	Proposal to mandate a 1% SAF blend for all international flights departing from Kuala Lumpur	https://www.trade.gov/market-intelligence/malaysia-energy-sustainable-aviation-fuel	4

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	Reuters	Malaysia: Keen to be Green: MIDA Incentives	https://www.reuters.com/plus/malaysia-keen-to-be-green	5
	Board of Investment (BOI)	Thailand BOI Approves Investment Applications in Sustainable Aviation Fuel	https://osos.boi.go.th/EN/news/1783/Thailand-BOI-Approves-Investment-Applications-Worth-USD535-M/	5
	BioEnergy Times	Vietnam steps up push for sustainable aviation fuel, carbon reduction program	https://bioenergytimes.com/vietnam-steps-up-push-for-sustainable-aviation-fuel-carbon-reduction-program/	5
	Tokyo Metropolitan Government	Status for Japanese incentive implementation	https://www.my.metro.tokyo.lg.jp/w/029-20250508-106945996	5
	Ministry of Economy, Trade and Industry		https://www.meti.go.jp/policy/economy/kyosoryoku_kyoka/senryaku_zeisei.html	5
	Singapore Airlines Group	Fuel consumption	https://www.singaporeair.com/content/dam/sia/web-assets/pdfs/about-us/information-for-investors/annual-report/annualreport2425.pdf	9

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		2024 , 2025 Initiative	https://www.singaporeair.com/content/dam/sia/web-assets/pdfs/about-us/information-for-investors/annual-report/annualreport2425.pdf	9
		Singapore Airlines Group and Aether Fuels Sign Memorandum of Understanding for Sustainable Aviation Fuel	https://www.singaporeair.com/en_UK/sg/corporate/newsroom/press-release/2025/January-March/sia_aether_fuels_mou_saf/	9
		Singapore Airlines Group's Sustainability Initiatives	https://www.singaporeair.com/content/dam/sia/web-assets/pdfs/about-us/information-for-investors/annual-report/annualreport2425.pdf	9
		Bangchak Corporation	https://www.bangchak.co.th/en/newsroom/bangchak-news/1117/bangchak-and-thai-sign-mou-on-sustainable-aviation-fuel-saf	9
PTTGC Group	Thai Airways SAF utilization plan initiatives	https://www.pttgcgroup.com/en/newsroom/news/1408/gc-or-และ-tg-ฝึกกำลัง-ขับเคลื่อนอุตสาหกรรมการบินไทยสขคพลังงานยั่งยืนเดชนหน้าผลักดัน-saf-เชื้อเพลิงอากาศยานแบบยั่งยืน-ปฏิวัติอุตสาหกรรมการบินไทยอย่างเต็มรูปแบบ	9	
Bangchak Corporation		https://www.bangchak.co.th/en/newsroom/bangchak-news/1638/bangchak-reaffirms-leadership-role-as-thailand-s-neat-saf-pioneer-at-flying-green-forum	9	

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		Initiative to increase SAF usage	https://www.bangkokair.com/press-release/view/Bangkok-Airways-Launches-the-Low-Carbon-Skies-Campaign	9
	Malaysia Aviation Group	2023 aviation fuel consumption	https://www.malaysiaairlines.com/content/dam/mas/about-us/sustainability/MAG-SUSTAINABILITY-REPORT.pdf?utm	9
		Partnerships with FatHopes Energy to explore the production of SAF from UCO	https://malaysiaaviationgroup.com.my/en/MAG-media-centre/news-releases/2025/malaysia-aviation-group-and-fathopes-energy-partner-to-drive-saf-innovation.html	9
		Off-take SAF agreement with Petronas	https://malaysiaaviationgroup.com.my/content/dam/mag/en/sustainability/sustainability-publications/sustainability-reports/MAG%20Sustainability%20Report%202023.pdf	9
		2024 aviation fuel consumption	https://www.capitala.com/misc/4Q24-presentation-capitala.pdf	9
	AirAsia	Initiative to increase SAF usage	https://www.capitala.com/misc/Capital_A_ar2024.pdf	9
		Partnership with Airbus to research on SAF supply expansion in ASEAN	https://newsroom.airasia.com/news/airasia-and-airbus-announce-wide-ranging-partnership-to-accelerate-aviation-sustainability#gsc.tab=0	9

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		Neste and Bayer to collaborate on developing novel vegetable oils from regenerative agriculture concepts	https://www.neste.com/news/neste-and-bayer-to-collaborate-on-developing-novel-vegetable-oils-from-regenerative-agriculture-concepts	10
		Neste and Chevron Lummus Global are developing a novel technology for processing lignocellulosic waste and residues into renewable fuels	https://www.neste.com/news/neste-and-chevron-lummus-global-are-developing-a-novel-technology-for-processing-lignocellulosic-waste-and-residues-into-renewable-fuels	10
			https://www.neste.com/about-neste/how-we-operate/production/singapore-refinery	10
			https://www.neste.com/products-and-innovation/sustainable-aviation/sustainable-aviation-fuel	10
		Biorefinery facility overview	https://www.neste.com/products-and-innovation/sustainable-aviation/questions-and-answers-about-saf	10
			https://www.neste.com/files/pdf/6eSvPdgCwnODZvWXU2Zz9d-Neste_Annual_Report_2024_Annual_Review.pdf	10

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	CMMAI	Biorefinery facility overview (Cilacap, Plaju)	https://imsis-djpu.kemenuh.go.id/PortalDKPPU/(English%20Translation)%20Indonesia%20Sustainable%20Aviation%20Fuel%20(SAF)%20Roadmap.pdf	10
	Biofuels international		https://biofuels-news.com/news/pertamina-set-to-produce-first-batch-of-certified-saf/	10
	Reuters	Biorefinery facility overview (Cilacap)	https://www.reuters.com/business/energy/indonesias-pertamina-delivers-first-used-cooking-oil-aviation-fuel-2025-08-12/	10
	Bisnis.com		https://hijau.bisnis.com/read/20250827/652/1906337/pertamina-dorong-dekarbonisasi-di-kilang-cilacap?utm_source=chatgpt.com	10
	SAF Investor		https://www.safinvestor.com/project/142902/pertamina-cilacap-java/	10
	Biobased Diesel Daily	Biorefinery facility overview (Plaju)	https://www.biobased-diesel.com/post/pertamina-signs-uco-supply-agreement-for-cilacap-biorefinery-in-Indonesia	10
	GHD Advisory		https://asean.org/wp-content/uploads/2025/04/12634962-RPT-6-Techno-Economic-Assessment-Final-Report_April-2025.pdf	10

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	kumoaranBisnis	Biorefinery facility overview (Balongan)	https://kumparan.com/kumparanbisnis/kilang-balongan-bakal-uji-coba-produksi-avtur-dari-minyak-jelantah-maret-2026-264JCjd9aDQ	10
	ESSA	Biorefinery facility overview	https://essa.id/wp-content/uploads/2024/12/ESSA-SAF-Press-Release-English-1.pdf	10
	ICAO	ESSA biorefinery facility overview	https://www.icao.int/SAF/SAF-production-facilities	10
	Blue Finance Indonesia	ESSA biorefinery facility overview & Feedstock sourcing	https://bluefindo.com/2025/02/04/proyek-pabrik-bahan-bakar-berkelanjutan-essa-2027	10
	S&P Global	Tripatra biorefinery facility overview (Sei Mangkei, North Sumatra)	https://www.spglobal.com/commodity-insights/en/news-research/latest-news/refined-products/122024-italys-nextchem-secures-waste-based-saf-plant-project-in-indonesia	10
	S&P Global	Tripatra biorefinery facility overview (North Sumatra and Kalimantan)	https://www.orissa-international.com/business-news/shell-to-develop-bioavtur-refinery-in-indonesia/	10
	Asia Today.id	Tripatra biorefinery facility overview (North Sumatra and Kalimantan)	https://asiatoday.id/read/shell-and-tripatra-to-build-bioavtur-refinery-in-indonesia	10

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	Prachachat	PTTGC feedstock sourcing	https://www.prachachat.net/economy/news-1852156	11
	Bangchak Corporation	Bangchak feedstock sourcing	https://investor.bangchak.co.th/en/document/viewer/stream/147649/analyst-meeting-q1-2025	11
			https://www.bangchak.co.th/en/newsroom/bangchak-news/1647/june-5-world-environment-day-bangchak-group-expands-fry-to-fly-across-all-service-stations-in-the-bangkok-metropolitan-area-from-june-30-invites-the-public-to-reduce-emissions-increase-income-with-communications-support-from-winnonie-and-robinhood	11
	Thanachart Securities	Energy Absolute future feedstock sourcing	https://tnsthinkwebcontent.thanachartsec.com/wp-content/uploads/2024/06/EA240620E.pdf	11
	Bangkok Post	Energy Absolute current feedstock sourcing	https://www.bangkokpost.com/business/general/2773646/new-green-aviation-fuel-venture-formed	11
	Petronas	Biorefinery facility overview	https://www.petronas.com/media/media-releases/groundbreaking-ceremony-new-biorefinery-petronas-enilive-and-euglena-pengerang	12
			https://www.petronas.com/media/media-releases/groundbreaking-ceremony-new-biorefinery-petronas-enilive-and-euglena-pengerang	12

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	EcoCeres	Biorefinery facility overview	https://www.eco-ceres.com/en/news/view?id=85	12
			https://www.ecoceres.com/en/news/view?id=5	12
	ICAO	SGS SAF certificate of EcoCeres	https://hub.iscc-system.org/FileHandler/download/certificateFile/OTUxMDRfSVNDQy1DT1JTSUEtQ2VydC1ERTeWMC0yNTg4NDEyNQ==	12
	Argus Media group	EcoCeres biorefinery facility overview	https://www.argusmedia.com/en/news-and-insights/latest-market-news/2746595-ecoceres-malaysia-plant-produces-first-on-spec-saf	12
	FatHopes Energy	Biorefinery facility overview	https://www.fathopesenergy.com/blog/bin-zayed-international-fathopes-energy-saf-refinery-malaysia/	12
	Argus Media group	FatHopes Energy biorefinery facility overview	https://www.argusmedia.com/en/news-and-insights/latest-market-news/2678190-malaysian-fathopes-to-reach-saf-plant-fid-by-1q-2026	12
	Star Media Group		https://www.thestar.com.my/news/nation/2025/04/26/jet-fuel-refinery-to-break-ground#goog_rewarded	12

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	Euglena		https://www.euglena.jp/en/news/20201005-2/	16
	NEDO	Denso Corporation's activities related to microalgae	https://www.nedo.go.jp/news/press/AA5_101363.html	16
	Denso Corporation		https://www.denso.com/global/en/news/newsroom/2015/20150819-01/	16
	Itochu Corporation	Mitsubishi Kakoki Kaisha's activities related to microalgae	https://www.itochu.co.jp/en/news/press/2020/201005.html	16
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	IHI Corporation	IHI Corporation's activities related to microalgae	https://www.ihico.jp/en/all_news/2021/other/1197475_3370.html	16
	CHITOSE Group	CHITOSE Group's activities related to microalgae	https://chitose-bio.com/jp/news/5124	16
			https://chitose-bio.com/project/10225	16
	NEDO		https://www.nedo.go.jp/english/whatsnew_00302.html	16
	NEDO		https://www.nedo.go.jp/content/800017530.pdf	16
	Keidanren (Japan Business Federation)	Electric Power Development (J-Power)'s activities related to microalgae	https://www.challenge-zero.jp/en/casestudy/462	16
	Phycochemistry	Company profile	https://www.phycochemistry.jp/overview/	16
	NEDO	Phycochemistry activities related to microalgae	https://www.nedo.go.jp/content/800040186.pdf	16
	The Green Power Development Corporation of Japan (GPD)	The Green Power Development Corporation of Japan (GPD)'s activities related to non-standard coconut	https://gpdj.jp/en/saf	17

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	HighChem	Initiatives for application of green catalysts	https://highchem.co.jp/services/catalyst/?lang=en	17
	SAF Investor		https://www.safinvestor.com/news/143232/petronas-idemitsu-kosan-sign-agreement-to-develop-saf/	17
	Petronas	Idemitsu Kosan's activities related to other non-edible oil plant	https://www.petronas.com/media/media-releases/petronas-and-idemitsu-collaborate-accelerate-development-sustainable-aviation	17
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	SAF Investor	J-Oil Mills's activities related to other non-edible oil plant	https://www.safinvestor.com/news/146877/j-oil-mills/	17
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	Yokohama Rubber	Yokohama Rubber's activities related to other non-edible oil plant	https://www.y-yokohama.com/release/pdf/2024110611mg001.pdf	17
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	NEDO	Nomura Jimusho's activities related to rubber oil seed	<a "="" href="https://www.nedo.go.jp/content/800046726.pdf#:~:text=Development%20of%20open%2Dclosed%20hybrid%20culture%20technology%20for%20marine%20diatoms%20(FY2020%2D2024).%20J%2DPOWER&text=the%20need%20for%20domestic%20production%20of%20sustainable%20aviation%20fuel%20(">https://www.nedo.go.jp/content/800046726.pdf#:~:text=Development%20of%20open%2Dclosed%20hybrid%20culture%20technology%20for%20marine%20diatoms%20(FY2020%2D2024).%20J%2DPOWER&text=the%20need%20for%20domestic%20production%20of%20sustainable%20aviation%20fuel%20(17
	Nomura Jimusho		https://nomjim.co.jp/en/pages/245/#:~:text=The%20Rubber%20Authority%20of%20Thailand,competitiveness%20with%20Thailand's%20rubber%20sector.	17
	NEDO	NEDO's efforts toward the social implementation of SAF	<a "="" href="https://www.nedo.go.jp/content/800046726.pdf#:~:text=Development%20of%20open%2Dclosed%20hybrid%20culture%20technology%20for%20marine%20diatoms%20(FY2020%2D2024).%20J%2DPOWER&text=the%20need%20for%20domestic%20production%20of%20sustainable%20aviation%20fuel%20(">https://www.nedo.go.jp/content/800046726.pdf#:~:text=Development%20of%20open%2Dclosed%20hybrid%20culture%20technology%20for%20marine%20diatoms%20(FY2020%2D2024).%20J%2DPOWER&text=the%20need%20for%20domestic%20production%20of%20sustainable%20aviation%20fuel%20(16, 17, 18, 19, 20, 21, 22, 23
	NEDO	Biomanufacturing revolution promotion project	https://www.nedo.go.jp/activities/ZZJP_100246.html	16, 17, 18, 19, 20, 21, 22, 23
		Project management sheet of Green Earth Institute	https://www.nedo.go.jp/content/800029677.pdf	16, 17, 18, 19, 20, 21, 22, 23
		Project management sheet of Taiko Paper	https://www.nedo.go.jp/content/800029664.pdf	21

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		Development of cellulosic ethanol production technology	https://www.eng.nipponsteel.com/files_publish/page/155/vol11_07_en.pdf	18
	Kao	Kao began supplying saccharification enzymes "CRESCENTISTM" to the research association of biomass innovation for next generation automobile fuels news	https://www.kao.com/global/en/newsroom/news/release/2023/20230621-001/	18
https://chemical.kao.com/content/dam/sites/kao/chemical-kao-com/global/topics/pdf/20241226-001.pdf			18	

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	NEDO	Project management sheet of Nippon Paper Industries	https://www.nedo.go.jp/content/800029676.pdf	18
	Biomaterial in Tokyo	Corporate overview	https://biomt.co.jp/company/information/	18
		2nd Generation Bioethanol	https://biomt.co.jp/product/2nd-generation-bioethanol/	18
	Oji Holdings Corporation	Pilot plant for wood-derived sugar solution and ethanol	https://www.ojiholdings.co.jp/news/detail_002233.html	18
	Daio Paper Corporation	Promoting biorefinery business to realize a sustainable society	https://www.daio-paper.co.jp/news/%E3%82%B5%E3%82%B9%E3%83%86%E3%83%8A%E3%83%96%E3%83%AB%E3%81%AA%E7%A4%BE%E4%BC%9A%E3%81%AE%E5%AE%9F%E7%8F%BE%E3%81%AB%E5%90%91%E3%81%91%E3%81%9F%E3%83%90%E3%82%A4%E3%82%AA%E3%83%AA%E3%83%95%E3%82%A1/	19
	Kawasaki Heavy Industries	Bioethanol Production System	https://global.kawasaki.com/en/energy/solutions/renewable/bioethanol.html	19
	JGC Group Corporation	2nd Generation Bioethanol Production Process	https://www.jgc.com/en/business/tech-innovation/environment/biomass.html	19
	Sanyu Plant Service	Bioethanol production CFE Project	https://www.g-sanyu.co.jp/service/service_c2/	19

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	NEDO	Tsukishima Kikai and JFE Engineering's activities on on bioethanol production from	https://www.nedo.go.jp/content/100872852.pdf	20
	Agriculture & Livestock Industries Corporation		https://www.alic.go.jp/joho-s/joho07_001760.html	20
	Logistics Today	Kanadevia's activities on bioethanol production from potato starch	https://www.logi-today.com/27396	20
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	Toray Industries	Toray and DM Mitsui Sugar's activities on bioethanol production from cassava pulp and bagasse	https://www.toray.co.jp/sustainability/articles/vol03.html	20
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	NEDO	Project management sheet of ENEOS	https://www.nedo.go.jp/content/800029678.pdf	21
	Rengo	Rengo subsidiary, taiko paper mfg., commences 2G bioethanol production demonstration project	https://www.rengo.co.jp/english/news/2024/24_e_news_007.html	21
		Rengo Collaborates with Sumitomo Forestry in Bioethanol Business	https://www.rengo.co.jp/english/news/2025/25_e_news_009.html	21
	Nikkei Inc	Kanadevia's activities on bioethanol from waste	https://www.nikkei.com/article/DGXZQOUF184U50Y2A011C2000000/	21
	Sekisui Chemical	Sekisui's activities on bioethanol production from waste	https://www.sekisui.co.jp/bio-refinery/	21
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	NEDO		Idemitsu development of AtJ demonstration facilities	https://green-innovation.nedo.go.jp/resources/pdf/development-fuel-manufacturing-technology-co2/item-002/vision-idemitsu-003.pdf

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		Development for commercial scale	https://www.jt-kankyo.co.jp/en/topics/2025/11/20251112.html	22
	Sumitomo SHI FW	Air Fluidized Bed Gasification: Convert waste to energy	https://www.shi-fw.com/our-solutions/energy-generation/air-fluidized-bed-gasification/	22
	JGC Group Corporation	EUP the gasification chemical recycling technology	https://www.jgc.com/en/media/pdf/catalog_02.pdf	22
	PR TIMES Corporation	TOYO Development of SAF Production Technologies Utilizing Diverse Feedstocks	https://prtimes.jp/main/html/rd/p/000000187.000107878.html	22
	United Planning	SAF manufacturing technology, utilizing local wood resources and waste plastics	https://www.united-k.jp/business/circular-energy/saf	22
	Velocys	SAF FT technology of Toyo Engineering Corporation from woody biomass	https://velocys.com/wp-content/uploads/2025/06/Velocys-Biomass-to-SAF-Case-Study-1.pdf	22

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	ENEOS	ENEOS's activities related to synthetic fuels	https://www.eneos.co.jp/english/rd/special/plant.html	23
	NEDO		https://green-innovation.nedo.go.jp/project/development-fuel-manufacturing-technology-co2/scheme/#anchorContents	23
	UNIDO ITPO Tokyo	Biomass gasification plant: Twin IHI GASifieR: TIGAR®	https://itpo-tokyo.unido.org/en/technology_db/5730/	23
	Mitsubishi Power	Mitsubishi Power's activities related to gasification technology for SAF	https://power.mhi.com/news/210830.html	23
	NEDO		https://www.nedo.go.jp/content/100929110.pdf	23

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	Civil Aviation Authority of Singapore	Singapore Sustainable Air Hub Blueprint	https://www.caas.gov.sg/docs/default-source/docs---so/singapore-sustainable-air-hub-blueprint.pdf	37, 38, 39
	Ministry of Transport of Malaysia	Malaysia Aviation Decarbonisation Blueprint	https://www.mot.gov.my/en/Pages/Aviation/MADBlueprint%20BI%20FA.pdf	37, 38, 39
	ICAO	Implementation of SAF and CORSIA Eligible Emissions Units in Thailand	https://www.icao.int/sites/default/files/APAC/Meetings/2025/2025%20DGCA60/Agenda%20Item07-Aviation%20and%20Environment/60-IP-07-02%20IMPLEMENTATION%20OF%20SAF%20AND%20CEU%20IN%20THAILAND.pdf	37
	BioEnergy Times	Vietnam steps up push for sustainable aviation fuel, carbon reduction program	https://bioenergytimes.com/vietnam-steps-up-push-for-sustainable-aviation-fuel-carbon-reduction-program/	37
Civil Aviation Authority of The Philippines	Action Plan on CO2 Emission Reduction	https://www.icao.int/sites/default/files/sp-files/environmental-protection/Documents/ActionPlan/CAAP-SAP-ao-June.pdf	37	

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	The Government Public Relations Department	CAAT, Thai airlines commit to sustainable aviation fuel push for net-zero by 2050	https://thailand.prd.go.th/en/content/category/detail/id/2078/iid/449427	38
	Ministry of Economy	National Energy Transition Roadmap (NETR)	https://ekonomi.gov.my/sites/default/files/2023-09/National%20Energy%20Transition%20Roadmap_0.pdf	39
	Thailand Energy Academy	(Draft) Alternative Energy Development Plan 2024 – 2037 (AEDP 2024)	https://www.thailand-energy-academy.org/assets/upload/coursedocument/file/Renewable%20Energy,%20Power%20for%20Life.pdf	39
	Department of Energy Business	Public Hearing Document for the (Draft) Oil Plan 2024–2037	https://image.makewebeasy.net/makeweb/0/u3EjrB8bq/Document/Oil_Plan_2024สารสำคัญรับฟังความคิดเห็น_ร่าง_Oil_Plan_2024.pdf?v=202405291424	39
	Government Electronic Information Portal	Decision No. 876/QD-TTg	https://vanban.chinhphu.vn/?pageid=27160&docid=206188	39

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	The Asahi Shimbun Company	Overview of Japan SAF supply side policy	https://www.asahi.com/article/ASR5T752LR5TULFA02J.html	39
	Nikkei Inc		https://www.nikkei.com/article/DGXZQOUA23B7A0T20C23A5000000/	39
			https://www.nikkei.com/article/DGXZQOUA25CV00V20C24A6000000/	39
	Ministry of Economy, Trade and Industry	Overview of Japan SAF demand side policy	https://www.meti.go.jp/shingikai/enecho/shigen_nenryo/nenryo_seisaku/pdf/016_04_00.pdf	39
	Civil Aviation Authority of Singapore	New Sustainable Aviation Fuel Levy to Apply From 1 April 2026 for Flights Departing From 1 October 2026	https://www.caas.gov.sg/who-we-are/newsroom/Detail/new-SAF-levy-to-apply-from-1-apr-2026-for-flights-departing-from-1-oct-2026	40
International Trade Administration U.S. Department of Commerce	Proposal to mandate a 1% SAF blend for all international flights departing from Kuala Lumpur	https://www.trade.gov/market-intelligence/malaysia-energy-sustainable-aviation-fuel	40	

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	Reuters	Malaysia: Keen to be Green: MIDA Incentives	https://www.reuters.com/plus/malaysia-keen-to-be-green	41
	Board of Investment (BOI)	Thailand BOI Approves Investment Applications in Sustainable Aviation Fuel	https://osos.boi.go.th/EN/news/1783/Thailand-BOI-Approves-Investment-Applications-Worth-USD535-M/	41
	BioEnergy Times	Vietnam steps up push for sustainable aviation fuel, carbon reduction program	https://bioenergytimes.com/vietnam-steps-up-push-for-sustainable-aviation-fuel-carbon-reduction-program/	41
	Tokyo Metropolitan Government	Status for Japanese incentive implementation	https://www.my.metro.tokyo.lg.jp/w/029-20250508-106945996	41
	Ministry of Economy, Trade and Industry		https://www.meti.go.jp/policy/economy/kyosoryoku_kyoka/senryaku_zeisei.html	41

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	CAAT	Number of airports in Thailand	https://www.caat.or.th/wp-content/uploads/2021/05/STATE-OF-THAI-AVIATION-INDUSTRY-2020.pdf	45
	MAVCOM	Number of airports in Malaysia	https://www.caam.gov.my/wp-content/uploads/2025/07/MAVCOM_ENGAR2023.pdf	45
	International Trade Administration	Number of airports in Indonesia	https://www.trade.gov/country-commercial-guides/indonesia-aviation#:~:text=Currently%2C%20Indonesia%20has%20683%20airports,was%20433%2C887%20tons%20of%20cargo.	45

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	Argus Media	Singapore introduces bill to implement SAF policies	https://www.argusmedia.com/en/news-and-insights/latest-market-news/2735017-singapore-introduces-bill-to-implement-saf-policies	49
	Civil Aviation Authority of Singapore	CAAS Sets Up Singapore Sustainable Aviation Fuel Company Ltd. (SAFCo) to Centrally Procure SAF	https://www.caas.gov.sg/who-we-are/newsroom/Detail/caas-sets-up-singapore-sustainable-aviation-fuel-company-ltd.-safco-to-centrally-procure-saf/	49
	Civil Aviation Authority of Singapore	New Sustainable Aviation Fuel Levy to Apply From 1 April 2026 for Flights Departing From 1 October 2026	https://www.caas.gov.sg/who-we-are/newsroom/Detail/new-SAF-levy-to-apply-from-1-apr-2026-for-flights-departing-from-1-oct-2026	49
	The Ministries of Sustainability and the Environment (MSE)	Singapore Green Plan 2030	https://www.greenplan.gov.sg/overview/	50

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	Singapore Economic Development Board	Sustainable Jurong Island	https://www.edb.gov.sg/en/business-insights/market-and-industry-reports/sustainable-jurong-island.html	50
	Civil Aviation Authority of Singapore	CAAS (Amendment) Bill Introduced in Parliament to Implement Sustainable Aviation Fuel	https://www.caas.gov.sg/who-we-are/newsroom/Detail/caas-amendment-bill-introduced-in-parliament-to-implement-SAF	51
	Civil Aviation Authority of Singapore	New Sustainable Aviation Fuel Levy to Apply From 1 Apr 2026 for Flights Departing From 1 Oct 2026	https://www.caas.gov.sg/who-we-are/newsroom/Detail/new-SAF-levy-to-apply-from-1-apr-2026-for-flights-departing-from-1-oct-2026	51
	Ministry of Economy	National Energy Transition Roadmap (NETR)	https://ekonomi.gov.my/sites/default/files/2023-09/National%20Energy%20Transition%20Roadmap_0.pdf	55

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	Ministry of Transport of Malaysia	Malaysia Aviation Decarbonisation Blueprint	https://www.mot.gov.my/en/Pages/Aviation/MADBlueprint%20BI%20FA.pdf	56
	Reuters	Malaysia: Keen to be Green: MIDA Incentives	https://www.reuters.com/plus/malaysia-keen-to-be-green	56, 59
	ICAO	The Malaysian Green Skies Initiative and Action Plan (State Action Plan No.04)	https://www.icao.int/sites/default/files/environmental-protection/State_Action_Plans/CAAM-SAP-2024-v3.pdf	57, 58
	Thailand Energy Academy	(Draft) Alternative Energy Development Plan 2024 – 2037 (AEDP 2024)	https://www.thailand-energy-academy.org/assets/upload/coursedocument/file/Renewable%20Energy,%20Power%20for%20Life.pdf	61
	Energy News Center	News about (Draft) Alternative Energy Development Plan 2024 – 2037 (AEDP 2024)	https://www.energynewscenter.com/%E0%B9%80%E0%B8%9B%E0%B8%B4%E0%B8%94%E0%B8%A3%E0%B9%88%E0%B8%B2%E0%B8%87-aedp2024-%E0%B8%AB%E0%B8%99%E0%B8%B8%E0%B8%99%E0%B9%84%E0%B8%9F%E0%B8%9F%E0%B9%89%E0%B8%B2%E0%B8%88%E0%B8%B2%E0%B8%81%E0%B8%9E/	61

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	Department of Energy Business	Public Hearing Document for the (Draft) Oil Plan 2024–2037	https://image.makewebeasy.net/makeweb/0/u3EjrB8bq/Document/Oil_Plan_2024สารสำคัญรับฟังความคิดเห็น_ราง_Oil_Plan_2024.pdf?v=202405291424	62, 63
	Bangkok biz news	Interview with the Director General of the Civil Aviation Authority of Thailand on SAF in April 2025	https://www.bangkokbiznews.com/environment/1176675	62, 63

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Chapter 1	Civil Aviation Authority Thailand	CAAT joins forces with eight airlines, the public sector, and the private sector to promote the adoption of Sustainable Aviation Fuel (SAF)	https://www.caat.or.th/caat-media/191110/#:~:text=%E0%B8%9E%E0%B8%A5%E0%B9%80%E0%B8%A3%E0%B8%B7%E0%B8%AD%E0%B8%99%E0%B9%81%E0%B8%AB%E0%B9%88%E0%B8%87%E0%B8%9B%E0%B8%A3%E0%B8%B0%E0%B9%80%E0%B8%97%E0%B8%A8%E0%B9%84%E0%B8%97%E0%B8%A2-,CAAT%20NEWS26/2568%20CAAT%20%E0%B8%9C%E0%B8%99%E0%B8%B6%E0%B8%81%208%20%E0%B8%AA%E0%B8%B2%E0%B8%A2%E0%B8%81%E0%B8%B2%E0%B8%A3%E0%B8%9A%E0%B8%B4%E0%B8%99%20%E0%B8%A0%E0%B8%B2%E0%B8%84,%E0%B9%81%E0%B8%8A%E0%B8%A3%E0%B9%8C%E0%B9%84%E0%B8%9B%E0%B8%A2%E0%B8%B1%E0%B8%87%E0%B8%AD%E0%B8%B5%E0%B9%80%E0%B8%A1%E0%B8%A5	64
	Thansettakij	The Director General of the Department of Energy Business announced the direction for promoting the use of SAF in Thailand	https://www.thansettakij.com/sustainable/net-zero/648174#google_vignette	64, 65

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	Board of Investment (BOI)	Thailand BOI Approves Investment Applications in Sustainable Aviation Fuel	https://osos.boi.go.th/EN/news/1783/Thailand-BOI-Approves-Investment-Applications-Worth-USD535-M/	67
Chapter 1	Energy News Center	BOI Board Launches Investment Promotion Measures for Sustainable Aviation Fuel Projects	https://www.energynewscenter.com/%E0%B8%9A%E0%B8%AD%E0%B8%A3%E0%B9%8C%E0%B8%94%E0%B8%9A%E0%B8%B5%E0%B9%82%E0%B8%AD%E0%B9%84%E0%B8%AD%E0%B9%80%E0%B8%9B%E0%B8%B4%E0%B8%94%E0%B8%AA%E0%B9%88%E0%B8%87%E0%B9%80%E0%B8%AA%E0%B8%A3%E0%B8%B4/	67
	Board of Investment (BOI)	Thailand BOI Approves Investment Applications in Sustainable Aviation Fuel	https://www.boi.go.th/index.php?page=press_releases_detail&topic_id=136465&_module=news&from_page=press_releases2&language=th&fbclid=IwY2xjawlIEPFleHRuA2FlbQIxMAABHXnYj_-2bfYcin0OBxhiG6ZatyHXgoV1ZUKC87_r8F2wRLR_3uTb0pNkFA_aem_bjkFdsvs8fSTvB6Y_jbVGw	67
	Board of Investment (BOI)	Investment Promotion Guide 2025	https://www.boi.go.th/upload/content/BOI_A_Guide_EN.pdf	67

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	SAF Investor	Indonesia mulling 3% SAF mandate from 2026 onwards	https://www.safinvestor.com/news/146989/indonesia-2/	71
	Government Electronic Information Portal	Decision No. 876/QD-TTg	https://vanban.chinhphu.vn/?pageid=27160&docid=206188	78
	GIZ	Roadmap for the transition to green energy in the transport sector - Decision No. 876/QD-TTg	https://changing-transport.org/wp-content/uploads/2023_policy_brief_vietnam-1.pdf	78
	BioEnergy Times	Vietnam steps up push for sustainable aviation fuel, carbon reduction program	https://bioenergytimes.com/vietnam-steps-up-push-for-sustainable-aviation-fuel-carbon-reduction-program/	79, 80
	Ministry of Agriculture And Environment	Vietnam's aviation to join carbon offsetting and reduction scheme from 2026	https://en.mae.gov.vn/vietnams-aviation-to-join-carbon-offsetting-and-reduction-scheme-from-2026-8930.htm	79, 80

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	CAAP	Philippines joins ICAO CAAF/3	https://www.caap.gov.ph/philippines-joins-icao-caaf-3/	82
	Island Skies Alliance	Driving Philippine SAF Development, an SGV-led SAF TWG Launch	https://www.islandskiesalliance.org/post/driving-philippine-saf-development-an-ey-led-saf-twg-launch	82
	Philippine Manila Standard Publishing	PH wants to become major producer of SAF	https://manilastandard.net/business/314563138/ph-wants-to-become-major-producer-of-saf.html	82
	Expat.Guide	Number of airports in Singapore	https://expat.guide/singapore-airports/	88
	CAAT	Number of airports in Thailand	https://www.caat.or.th/wp-content/uploads/2021/05/STATE-OF-THAI-AVIATION-INDUSTRY-2020.pdf	88
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	International Trade Administration	Number of airports in Indonesia	https://www.trade.gov/country-commercial-guides/indonesia-aviation#:~:text=Currently%2C%20Indonesia%20has%20683%20airports,was%20433%2C887%20tons%20of%20cargo.	88

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	World Bank-What a waste global database	Statistics on municipal solid waste	https://datacatalog.worldbank.org/search/dataset/0039597/what-a-waste-global-database	90
	TheGlobal Economy.com	Statistics on aviation fuel consumption	https://www.theglobaleconomy.com/rankings/jet_fuel_consumption/	91

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	Ministry of Economy	National Energy Transition Roadmap (NETR)	https://ekonomi.gov.my/sites/default/files/2023-09/National%20Energy%20Transition%20Roadmap_0.pdf	97
	Ministry of Transport of Malaysia	Malaysia Aviation Decarbonisation Blueprint	https://www.mot.gov.my/en/Pages/Aviation/MADBlueprint%20BI%20FA.pdf	97
	Thailand Energy Academy	(Draft) Alternative Energy Development Plan 2024 – 2037 (AEDP 2024)	https://www.thailand-energy-academy.org/assets/upload/coursedocument/file/Renewable%20Energy,%20Power%20for%20Life.pdf	97
	Department of Energy Business	Public Hearing Document for the (Draft) Oil Plan 2024–2037	https://image.makewebeasy.net/makeweb/0/u3EjrB8bq/Document/Oil_Plan_2024สารสำคัญรับฟังความคิดเห็น_ร่าง_Oil_Plan_2024.pdf?v=202405291424	97
	Coordinating Ministry for Maritime & Investment Affairs	Indonesia’s Sustainable Aviation Fuel (SAF) Industry Development Roadmap	https://imsis-djpu.kemenuh.go.id/PortalDKPPU/(English%20Translation)%20Indonesia%20Sustainable%20Aviation%20Fuel%20(SAF)%20Roadmap.pdf	97
	Government Electronic Information Portal	Decision No. 876/QD-TTg	https://vanban.chinhphu.vn/?pageid=27160&docid=206188	97

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	The Asahi Shimbun Company	Overview of Japan SAF supply side policy	https://www.asahi.com/article/ASR5T752LR5TULFA02J.html	97
	Nikkei Inc		https://www.nikkei.com/article/DGXZQOUA23B7A0T20C23A5000000/	97
			https://www.nikkei.com/article/DGXZQOUA25CV00V20C24A6000000/	97
	Ministry of Economy, Trade and Industry	Overview of Japan SAF demand side policy	https://www.meti.go.jp/shingikai/enecho/shigen_nenryo/nenryo_seisaku/pdf/016_04_00.pdf	97
	IATA	SAF prices can range from 2 to 5 times those of conventional aviation fuel	https://www.iata.org/en/programs/sustainability/reports/saf-handbook/section-5/	98
	U.S. Department of Energy	USA Sustainable Aviation Fuel (SAF) Tax Credit	https://afdc.energy.gov/laws/13160	99
	Civil Aviation Authority of Singapore	New Sustainable Aviation Fuel Levy to Apply From 1 April 2026 for Flights Departing From 1 October 2026	https://www.caas.gov.sg/who-we-are/newsroom/Detail/new-SAF-levy-to-apply-from-1-apr-2026-for-flights-departing-from-1-oct-2026	100

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	S&P Global	Thailand's Civil Aviation Authority has signed a memorandum of understanding with eight domestic airlines	https://www.spglobal.com/energy/en/news-research/latest-news/agriculture/111725-caat-thai-airlines-agree-2026-saf-rollout-regulator-weighs-carbon-fee-mechanism	100
	Singapore Airlines Group	Fuel consumption	https://www.singaporeair.com/content/dam/sia/web-assets/pdfs/about-us/information-for-investors/annual-report/annualreport2425.pdf	101
		SAF blending target	https://www.singaporeair.com/content/dam/sia/web-assets/pdfs/about-us/information-for-investors/annual-report/annualreport2425.pdf	101
	Singapore Airlines Group	2024 , 2025 Initiative	https://www.singaporeair.com/content/dam/sia/web-assets/pdfs/about-us/information-for-investors/annual-report/annualreport2425.pdf	101
	Singapore Airlines Group and Aether Fuels Sign Memorandum of Understanding for Sustainable Aviation Fuel	https://www.singaporeair.com/en_UK/sg/corporate/newsroom/press-release/2025/January-March/sia_aether_fuels_mou_saf/	101	

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	Bangchak Corporation		https://www.bangchak.co.th/en/newsroom/bangchak-news/1117/bangchak-and-thai-sign-mou-on-sustainable-aviation-fuel-saf	101
	PTTGC Group	Thai Airways SAF utilization plan initiatives	https://www.pttggroup.com/en/newsroom/news/1408/gc-or-และ-tg-ผนึกกำลัง-ขับเคลื่อนอุตสาหกรรมการบินไทยสขคพลังงานยั่งยืนเดชนหน้าผลักคั้น-saf-เชอเพลงอากาศขานแบบขงขณ-ปฏิวัตอศสาหกรรมการบินไทยขงเดชมรูปแบบ	101
	Bangchak Corporation		https://www.bangchak.co.th/en/newsroom/bangchak-news/1638/bangchak-reaffirms-leadership-role-as-thailand-s-neat-saf-pioneer-at-flying-green-forum	101
	Bangkok Airways	SAF utilization plan initiatives	https://www.bangkokair.com/press-release/view/bangkok-airways-officially-introduces-sustainable-aviation-fuel-saf-on-commercial-flights	101
	Bangkok Airways	Initiative to increase SAF usage	https://www.bangkokair.com/press-release/view/Bangkok-Airways-Launches-the-Low-Carbon-Skies-Campaign	101
	Malaysia Aviation Group	2023 aviation fuel consumption	https://www.malaysiaairlines.com/content/dam/mas/about-us/sustainability/MAG-SUSTAINABILITY-REPORT.pdf?utm	101

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		Off-take SAF agreement with Petronas	https://malaysiaaviationgroup.com.my/content/dam/mag/en/sustainability/sustainability-publications/sustainability-reports/MAG%20Sustainability%20Report%202023.pdf	101
Summary of chapter 2-1		2024 aviation fuel consumption	https://www.capitala.com/misc/4Q24-presentation-capitala.pdf	101
	AirAsia	Initiative to increase SAF usage	https://www.capitala.com/misc/Capital_A_ar2024.pdf	101
		Partnership with Airbus to research on SAF supply expansion in ASEAN	https://newsroom.airasia.com/news/airasia-and-airbus-announce-wide-ranging-partnership-to-accelerate-aviation-sustainability#gsc.tab=0	101
	ANTARA	Garuda and Pertamina collaboration in the use of SAF	https://www.antaranews.com/berita/5184685/pertamina-perkuat-kolaborasi-industri-aviasi-dalam-penggunaan-saf	101

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		SAF pathways approved by ASTM	https://www.icao.int/sites/default/files/environmental-protection/Documents/ACT-SAF/ACT-SAF-Series-15-coprocessing-and-revamping.pdf	104
		Summary of ASTM approved SAF conversion processes, associated feedstocks, and estimated technology readiness level (TRL)	https://www.icao.int/sites/default/files/environmental-protection/Documents/ACT-SAF/Ethiopia-full-Feasibility-Study-Report.pdf	104
	IATA	SAF production pathways and associated feedstocks	https://www.iata.org/contentassets/d13875e9ed784f75bac90f000760e998/saf-handbook.pdf	104
	ICAO	New Sustainable Aviation Fuels (SAF) technology pathways under development	https://www.icao.int/sites/default/files/environmental-protection/Documents/EnvironmentalReports/2022/ENVReport2022_Art49.pdf	105
	IEA	Hydrothermal Liquefaction	https://www.ieabioenergy.com/wp-content/uploads/2024/06/IEA-Bioenergy-Chapter-39-SAF-report.pdf	105
	The Royal Society of Chemistry	Isoprene to Jet	https://pubs.rsc.org/en/content/articlehtml/2022/ya/d2ya00017b	105

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	ICCT	Emission reductions from current SAF pathways	https://theicct.org/understanding-the-ghg-emissions-of-different-saf-pathways-sept25/	110	
	Neste	Neste and Bayer to collaborate on developing novel vegetable oils from regenerative agriculture concepts	https://www.neste.com/news/neste-and-bayer-to-collaborate-on-developing-novel-vegetable-oils-from-regenerative-agriculture-concepts	111	
		Neste and Chevron Lummus Global are developing a novel technology for processing lignocellulosic waste and residues into renewable fuels	https://www.neste.com/news/neste-and-chevron-lummus-global-are-developing-a-novel-technology-for-processing-lignocellulosic-waste-and-residues-into-renewable-fuels	111	
			https://www.neste.com/about-neste/how-we-operate/production/singapore-refinery	111	
		Biorefinery facility overview		https://www.neste.com/products-and-innovation/sustainable-aviation/sustainable-aviation-fuel	111
				https://www.neste.com/products-and-innovation/sustainable-aviation/questions-and-answers-about-saf	111

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	ICAO	Biorefinery facility overview(Cilacap, Plaju, Dumai, Balongan)	https://www.icao.int/SAF/SAF-production-facilities	111
	CMMAI	Biorefinery facility overview (Cilacap, Plaju)	https://imsis-djpu.kemenuh.go.id/PortalDKPPU/(English%20Translation)%20Indonesia%20Sustainable%20Aviation%20Fuel%20(SAF)%20Roadmap.pdf	111
	Biofuels international		https://biofuels-news.com/news/pertamina-set-to-produce-first-batch-of-certified-saf/	111
	Reuters		https://www.reuters.com/business/energy/indonesias-pertamina-delivers-first-used-cooking-oil-aviation-fuel-2025-08-12/	111
	Bisnis.com	Biorefinery facility overview (Cilacap)	https://hijau.bisnis.com/read/20250827/652/1906337/pertamina-dorong-dekarbonisasi-di-kilang-cilacap?utm_source=chatgpt.com	111
	SAF Investor		https://www.safinvestor.com/project/142902/pertamina-cilacap-java/	111
	Biobased Diesel Daily	Biorefinery facility overview (Plaju)	https://www.biobased-diesel.com/post/pertamina-signs-uco-supply-agreement-for-cilacap-biorefinery-in-Indonesia	111

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	Bisnis.com	Biorefinery facility overview (Dumai and Balongan)	https://hijau.bisnis.com/read/20250827/652/1906337/perta-mina-dorong-dekarbonisasi-di-kilang-cilacap	111
	kumooaranBisnis	Biorefinery facility overview (Balongan)	https://kumparan.com/kumparanbisnis/kilang-balongan-bakal-uji-coba-produksi-avtur-dari-minyak-jelantah-maret-2026-264JCjd9aDQ	111
	ESSA	Biorefinery facility overview	https://essa.id/wp-content/uploads/2024/12/ESSA-SAF-Press-Release-English-1.pdf	111
	ICAO	ESSA biorefinery facility overview	https://www.icao.int/SAF/SAF-production-facilities	111
	Blue Finance Indonesia	ESSA biorefinery facility overview & Feedstock sourcing	https://bluefindo.com/2025/02/04/proyek-pabrik-bahan-bakar-berkelanjutan-essa-2027	111
	S&P Global	Tripatra biorefinery facility overview (Sei Mangkei, North Sumatra)	https://www.spglobal.com/commodity-insights/en/news-research/latest-news/refined-products/122024-italys-nextchem-secures-waste-based-saf-plant-project-in-indonesia	111
	S&P Global	Tripatra biorefinery facility overview (North Sumatra and Kalimantan)	https://www.orissa-international.com/business-news/shell-to-develop-bioavtur-refinery-in-indonesia/	111
	Asia Today.id	Tripatra biorefinery facility overview (North Sumatra and Kalimantan)	https://asiatoday.id/read/shell-and-tripatra-to-build-bioavtur-refinery-in-indonesia	111

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	Prachachat	PTTGC feedstock sourcing	https://www.prachachat.net/economy/news-1852156	112
	Bangchak Corporation	Bangchak feedstock sourcing	https://investor.bangchak.co.th/en/document/viewer/stream/147649/analyst-meeting-q1-2025	112
			https://www.bangchak.co.th/en/newsroom/bangchak-news/1647/june-5-world-environment-day-bangchak-group-expands-fry-to-fly-across-all-service-stations-in-the-bangkok-metropolitan-area-from-june-30-invites-the-public-to-reduce-emissions-increase-income-with-communications-support-from-winnonie-and-robinhood	112
	Thanachart Securities	Energy Absolute future feedstock sourcing	https://tnsthinkwebcontent.thanachartsec.com/wp-content/uploads/2024/06/EA240620E.pdf	112
	Bangkok Post	Energy Absolute current feedstock sourcing	https://www.bangkokpost.com/business/general/2773646/new-green-aviation-fuel-venture-formed	112
	Petronas	Biorefinery facility overview	https://www.petronas.com/media/media-releases/groundbreaking-ceremony-new-biorefinery-petronas-enilive-and-euglena-pengerang	113
			https://www.petronas.com/media/media-releases/groundbreaking-ceremony-new-biorefinery-petronas-enilive-and-euglena-pengerang	113

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	EcoCeres	Biorefinery facility overview	https://www.eco-ceres.com/en/news/view?id=85	113
			https://www.ecoceres.com/en/news/view?id=5	113
	ICAO	SGS SAF certificate of EcoCeres	https://hub.iscc-system.org/FileHandler/download/certificateFile/OTUxMDRfSVNDQy1DT1JTSUEtQ2VydC1ERTEwMC0yNTg4NDEyNQ==	113
	Argus Media group	EcoCeres biorefinery facility overview	https://www.argusmedia.com/en/news-and-insights/latest-market-news/2746595-ecoceres-malaysia-plant-produces-first-on-spec-saf	113
	FatHopes Energy	Biorefinery facility overview	https://www.fathopesenergy.com/blog/bin-zayed-international-fathopes-energy-saf-refinery-malaysia/	113
	Argus Media group	FatHopes Energy biorefinery facility overview	https://www.argusmedia.com/en/news-and-insights/latest-market-news/2678190-malaysian-fathopes-to-reach-saf-plant-fid-by-1q-2026	113
	Star Media Group		https://www.thestar.com.my/news/nation/2025/04/26/jet-fuel-refinery-to-break-ground#goog_rewarded	113

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		SAF Sourcing	https://www.singaporeair.com/content/dam/sia/web-assets/pdfs/about-us/information-for-investors/annual-report/annualreport2425.pdf	115
		Fuel consumption	https://www.singaporeair.com/content/dam/sia/web-assets/pdfs/about-us/information-for-investors/annual-report/annualreport2425.pdf	115
		SAF blending target	https://www.singaporeair.com/content/dam/sia/web-assets/pdfs/about-us/information-for-investors/annual-report/annualreport2425.pdf	115
		2024 , 2025 Initiative	https://www.singaporeair.com/content/dam/sia/web-assets/pdfs/about-us/information-for-investors/annual-report/annualreport2425.pdf	115
		Shareholder	https://www.singaporeair.com/content/dam/sia/web-assets/pdfs/about-us/information-for-investors/annual-report/annualreport2425.pdf	115
		2030 target	https://www.singaporeair.com/en_UK/sg/corporate/newsroom/press-release/2023/October-December/jr0723-231114/	115

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	Singapore Airlines Group	Singapore Airlines Group and Aether Fuels Sign Memorandum of Understanding for Sustainable Aviation Fuel	https://www.singaporeair.com/en_UK/sg/corporate/newsroom/press-release/2025/January-March/sia_aether_fuels_mou_saf/	116
		Singapore Airlines Group's Sustainability Initiatives	https://www.singaporeair.com/content/dam/sia/web-assets/pdfs/about-us/information-for-investors/annual-report/annualreport2425.pdf	116
Chapter 2-1	Oneworld alliance	oneworld alliance, airlines and Breakthrough Energy Ventures launch investment fund to advance and commercialize SAF technologies	https://www.oneworld.com/news/oneworld-alliance-airlines-and-breakthrough-energy-ventures-launch	117
	Greenairnews	Oneworld airline partners join with Breakthrough Energy Ventures to invest in new SAF technologies	https://www.greenairnews.com/?p=8063	117
	Resourcewise	Oneworld and Breakthrough Energy Ventures Launch SAF Innovation Fund	https://www.resourcewise.com/blog/oneworld-and-breakthrough-energy-ventures-launch-saf-innovation-fund	117

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	Aviation Week	Singapore To Centrally Procure SAF With New Company	https://aviationweek.com/air-transport/aircraft-propulsion/singapore-centrally-procure-saf-new-company	118	
	CAAS	CAAS Sets Up Singapore Sustainable Aviation Fuel Company Ltd. (SAFCo) to Centrally Procure SAF	https://www.caas.gov.sg/who-we-are/newsroom/Detail/caas-sets-up-singapore-sustainable-aviation-fuel-company-ltd.-safco-to-centrally-procure-saf	118	
		Singapore is Operationally Ready for Sustainable Aviation Fuel But More is Needed to Support Adoption	https://www.caas.gov.sg/who-we-are/newsroom/Detail/singapore-is-operationally-ready-for-sustainable-aviation-fuel-but-more-is-needed-to-support-adoption	119	
		Aerospace Singapore	20-month Sustainable Aviation Fuel (SAF) Pilot Completed at Changi	https://aerospace.sg/20-month-sustainable-aviation-fuel-saf-pilot-completed-at-changi/	119
		Singapore Airlines Group	Singapore Airlines Group's Deployment of SAF	https://www.singaporeair.com/content/dam/sia/web-assets/pdfs/about-us/information-for-investors/annual-report/sustainabilityreport2425.pdf	119

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		Network	https://www.malaysiaairlines.com/content/dam/mas/about-us/sustainability/MAG-SUSTAINABILITY-REPORT.pdf?utm	120
		2023 aviation fuel consumption	https://www.malaysiaairlines.com/content/dam/mas/about-us/sustainability/MAG-SUSTAINABILITY-REPORT.pdf?utm	120
		History of SAF flight in 2022	https://www.malaysiaairlines.com/content/dam/mas/about-us/sustainability/MAG-SUSTAINABILITY-REPORT.pdf	120
		Partnerships with FatHopes Energy to explore the production of SAF from UCO	https://malaysiaaviationgroup.com.my/en/MAG-media-centre/news-releases/2025/malaysia-aviation-group-and-fathopes-energy-partner-to-drive-saf-innovation.html	120, 123
		Off-take SAF agreement with Petronas	https://malaysiaaviationgroup.com.my/content/dam/mag/en/sustainability/sustainability-publications/sustainability-reports/MAG%20Sustainability%20Report%202023.pdf	120
	Reuters	Off-take SAF agreement with Petronas	https://www.reuters.com/sustainability/climate-energy/petronas-delivers-first-local-sustainable-aviation-fuel-malaysia-airlines-2025-09-12/	120
	Rigzone	Pilot SAF flight from Kuala Lumpur to London	https://www.rigzone.com/news/petronas_delivers_first_blen ded_saf_in_malaysia-15-sep-2025-181791-article/	120, 122
Travel And Tour World	AirAsia number of total flights in 2024	https://www.travelandtourworld.com/news/article/passenger-traffic-in-airasia-records-an-11-per-cent-surge-in-2024-carrying-over-63-million-travelers/	120	

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		Initiative to increase SAF usage	https://www.capitala.com/misc/Capital_A_ar2024.pdf	121
		SAF utilization plan and initiative	https://www.capitala.com/misc/sr2024.pdf	121
	Partnership with Airbus to research on SAF supply expansion in ASEAN	https://newsroom.airasia.com/news/airasia-and-airbus-announce-wide-ranging-partnership-to-accelerate-aviation-sustainability#gsc.tab=0	121, 124	
	Asian Downstream Summit	Petronas delivered Malaysia's first locally blended SAF for Malaysia Aviation Group's pilot flights	https://www.asiandownstreamsummit.com/petronas-delivers-malaysias-first-locally-blended-saf-marking-breakthrough-in-aviation-decarbonisation/	122
	Thai Airways	Company overview	https://www.thaiairways.com/en-th/content/company-profile/thais-journey/	126
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	Bangchak Corporation		https://www.bangchak.co.th/en/newsroom/bangchak-news/1117/bangchak-and-thai-sign-mou-on-sustainable-aviation-fuel-saf	126
	PTTGC Group	Thai Airways SAF utilization plan initiatives	https://www.pttgcgroup.com/en/newsroom/news/1408/gc-or-และ-tg-ปีนี้กำลัง-ขับเคลื่อนอุตสาหกรรมการบินไทยสขพล้งงานยั่งยืนเดนหน้าผลักคั้น-saf-เชื้อเพลิงอากาศยานแบบยั่งยืน-ปฏิวัติอุตสาหกรรมการบินไทยอย่างเต็มรูปแบบ	126
	Bangchak Corporation		https://www.bangchak.co.th/en/newsroom/bangchak-news/1638/bangchak-reaffirms-leadership-role-as-thailand-s-neat-saf-pioneer-at-flying-green-forum	126
	Neste	Thai Airways initiative to increase SAF usage	https://www.neste.com/news/neste-enables-first-thai-airways-flight-using-sustainable-aviation-fuel-in-cooperation-with-ptt-and-petco-trading	126
		Company Overview	https://investor.bangkokair.com/en/investment-information/operation-statistics	127
	Bangkok Airways	SAF utilization plan initiatives	https://www.bangkokair.com/press-release/view/bangkok-airways-officially-introduces-sustainable-aviation-fuel-saf-on-commercial-flights	127
		Initiative to increase SAF usage	https://www.bangkokair.com/press-release/view/Bangkok-Airways-Launches-the-Low-Carbon-Skies-Campaign	127

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	Bangchak Corporation	Bangchak and THAI Sign MoU on Sustainable Aviation Fuel (SAF)	https://www.bangchak.co.th/en/newsroom/bangchak-news/1117/bangchak-and-thai-sign-mou-on-sustainable-aviation-fuel-saf	128
	Travel News Asia	Thai Airways executive's statement	https://www.travelnewsasia.com/news23/255-SAFThailand.shtml	128
	Neste	Neste enables first Thai Airways flight using sustainable aviation fuel in cooperation with PTT and Petco Trading	https://www.neste.com/news/neste-enables-first-thai-airways-flight-using-sustainable-aviation-fuel-in-cooperation-with-ptt-and-petco-trading	129
	ThaiPR.net	PTTOR executive's statement	https://www.thaipr.net/en/energy_en/3422199	129
	Thai Airways	Overview of the collaboration	https://ir.thaiairways.com/wp-content/uploads/2025/08/THAI_2Q-2025-Opportunity-Day.pdf	130
	Money & Banking Online	Thai Airways executive's statement	https://moneyandbanking.co.th/en/2024/141418/	130
	Bangkok Airways	Overview of the pilot project	https://investor.bangkokair.com/en/newsroom/initiatives/77/bangkok-airways-launches-the-low-carbon-skies-campaign-in-partnership-with-or-pioneering-use-of-sustainable-aviation-fuel-saf-and-elevating-green-airport-initiatives-towards-net-zero-goal	131

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	German Cooperation	Overview of partnership	https://www.thai-german-cooperation.info/en_US/saf-working-group-meeting-discusses-challenges-and-opportunities-for-thailands-saf-market-growth/	133
	The Civil Aviation Authority of Thailand	Overview of partnership	https://www.caat.or.th/caat-media/191110/	134
	PT Garuda Indonesia	Company overview	https://www.garuda-indonesia.com/static/content/dam/garuda/files/pdf/invest-or-relations/corporate-governance/Materi%20Public%20Expose%20Nov%202024_11112024_Final.pdf	135
	IDNFinancials	Garuda number of total flights in 2024	https://www.idnfinancials.com/news/53606/garuda-indonesia-targets-to-add-100-aircraft-this-year	135
	Detikcom	Demonstration flights of Citilink using SAF	https://finance.detik.com/energi/d-7548466/perdana-citilink-mulai-pakai-avtur-dari-minyak-jelantah-pertamina	135

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	SAF Investor	Indonesia's Lion Air targets SAF usage on all flights by 2030	https://www.safinvestor.com/news/145629/lion-air/	136
	ANTARA	Lion Air vows all fleets to use SAF by 2030	https://www.thejakartapost.com/business/2024/07/31/lion-air-vows-all-fleets-to-use-saf-by-2030.html	136
	CNN Indonesia	Pertamina's test flight using SAF on Garuda Indonesia	https://www.cnnindonesia.com/ekonomi/20231010121316-625-1009314/uji-terbang-pertamina-gunakan-saf-pada-garuda-indonesia-sukses	137
	ANTARA	Garuda Indonesia making its first commercial flight using SAF with Pertamina collaboration	https://www.antaraneews.com/berita/3795294/garuda-indonesia-lakukan-penerbangan-komersial-pertama-menggunakan-saf	137
			https://megapolitan.antaraneews.com/berita/263166/garuda-indonesia-dan-pertamina-kolaborasi-rampungkan-uji-coba-bioavtur-pesawat-komersial	137

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Chapter 2-2	Neste	Neste and Bayer to collaborate on developing novel vegetable oils from regenerative agriculture concepts	https://www.neste.com/news/neste-and-bayer-to-collaborate-on-developing-novel-vegetable-oils-from-regenerative-agriculture-concepts	140
		Neste and Chevron Lummus Global are developing a novel technology for processing lignocellulosic waste and residues into renewable fuels	https://www.neste.com/news/neste-and-chevron-lummus-global-are-developing-a-novel-technology-for-processing-lignocellulosic-waste-and-residues-into-renewable-fuels	140

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			https://www.neste.com/files/pdf/6eSvPdgCwnODZvWXU2Zz9d-Neste_Annual_Report_2024_Annual_Review.pdf	140
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	Petronas	Biorefinery facility overview	https://www.petronas.com/media/media-releases/groundbreaking-ceremony-new-biorefinery-petronas-enilive-and-euglena-pengerang	142
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Chapter 2-2	Malaysian Investment Development Authority	EcoCeres company overview	https://www.mida.gov.my/wp-content/uploads/2023/03/Chemical-and-Advanced-Materials.pdf	144	
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				https://hub.iscc-system.org//FileHandler/download/certificateFile/OTUxMDRfSVNDQy1DT1JTSUEtQ2VydC1ERTEwMC0yNTg4NDEyNQ==	145
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		Biorefinery facility overview	https://www.fathopesenergy.com/blog/bin-zayed-international-fathopes-energy-saf-refinery-malaysia/	147
	Argus Media group	FatHopes Energy biorefinery facility overview	https://www.argusmedia.com/en/news-and-insights/latest-market-news/2678190-malaysian-fathopes-to-reach-saf-plant-fid-by-1q-2026	147
	Star Media Group		https://www.thestar.com.my/news/nation/2025/04/26/jet-fuel-refinery-to-break-ground#goog_rewarded	147

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	CorpusX	Financial data	https://corpusxweb.bol.co.th/corpus/home	148
Chapter 2-2	Bangkok Post	PTTGC feedstock	https://www.bangkokpost.com/business/general/3076796/gc-eager-to-expand-its-biorefinery	149
	Prachachat	PTTGC feedstock sourcing	https://www.prachachat.net/economy/news-1852156	149
	Bangchak Corporation	Company overview	https://investor.bangchak.co.th/en/document/viewer/flipbook/8/company-profile	150
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	Bangchak Corporation	Bangchak feedstock sourcing	https://www.bangchak.co.th/en/newsroom/bangchak-news/1647/june-5-world-environment-day-bangchak-group-expands-fry-to-fly-across-all-service-stations-in-the-bangkok-metropolitan-area-from-june-30-invites-the-public-to-reduce-emissions-increase-income-with-communications-support-from-winnonie-and-robinhood	151
	Energy Absolute	Company overview	https://ww2.energyabsolute.co.th/EBI?lang=E	153
	CorpusX	Financial data	https://corpusxweb.bol.co.th/corpus/home	153
	Thanachart Securities	Energy Absolute future feedstock sourcing	https://tnsthinkwebcontent.thanachartsec.com/wp-content/uploads/2024/06/EA240620E.pdf	154
	Bangkok Post	Energy Absolute current feedstock sourcing	https://www.bangkokpost.com/business/general/2773646/new-green-aviation-fuel-venture-formed	154
	Pertamina (Persero), PT	Company overview	https://www.pertamina.com/en/tentang-kami	155

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	PT Kilang Pertamina International	Company overview	https://kpi.pertamina.com/en/profil-perusahaan/tentang-kami	155
		Financial data	https://kpi.pertamina.com/en/hubungan-investor/laporan-tahunan	155
	Pertamina Patra Niaga	Company overview	https://pertainapatraniaga.com/page/profil	155
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	Bank of Indonesia	Exchange rate	https://www.bi.go.id/en/statistik/informasi-kurs/transaksi-bi/default.aspx	155
	ICAO	Biorefinery facility overview(Cilacap, Plaju, Dumai, Balongan)	https://www.icao.int/SAF/SAF-production-facilities	156
	CMMAI	Biorefinery facility overview (Cilacap, Plaju)	https://imsis-djpu.kemenuhub.go.id/PortalDKPPU/(English%20Translation)%20Indonesia%20Sustainable%20Aviation%20Fuel%20(SAF)%20Roadmap.pdf	156

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	Reuters		https://www.reuters.com/business/energy/indonesias-pertamina-delivers-first-used-cooking-oil-aviation-fuel-2025-08-12/	156
	Bisnis.com	Biorefinery facility overview (Cilacap)	https://hijau.bisnis.com/read/20250827/652/1906337/pertamina-dorong-dekarbonisasi-di-kilang-cilacap?utm_source=chatgpt.com	156
	SAF Investor		https://www.safinvestor.com/project/142902/pertamina-cilacap-java/	156
	Biobased Diesel Daily	Biorefinery facility overview (Plaju)	https://www.biobased-diesel.com/post/pertamina-signs-uco-supply-agreement-for-cilacap-biorefinery-in-Indonesia	156
	GHD Advisory		https://asean.org/wp-content/uploads/2025/04/12634962-RPT-6-Techno-Economic-Assessment-Final-Report_April-2025.pdf	156
	Bisnis.com	Biorefinery facility overview (Dumai and Balongan)	https://hijau.bisnis.com/read/20250827/652/1906337/pertamina-dorong-dekarbonisasi-di-kilang-cilacap	156
	kumooaranBisnis	Biorefinery facility overview (Balongan)	https://kumparan.com/kumparanbisnis/kilang-balongan-bakal-uji-coba-produksi-avtur-dari-minyak-jelantah-maret-2026-264JCjd9aDQ	156

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		Biorefinery facility overview	https://essa.id/wp-content/uploads/2024/12/ESSA-SAF-Press-Release-English-1.pdf	158
	ICAO	ESSA biorefinery facility overview	https://www.icao.int/SAF/SAF-production-facilities	159
	Blue Finance Indonesia	ESSA biorefinery facility overview & Feedstock sourcing	https://bluefindo.com/2025/02/04/proyek-pabrik-bahan-bakar-berkelanjutan-essa-2027	159
	Tripatra	Company overview and financial data	https://www.tripatra.com/en/information-media/reports/sustainability-report-2024	160
	Bank of Indonesia	Exchange rate	https://www.bi.go.id/en/statistik/informasi-kurs/transaksi-bi/default.aspx	160
S&P Global	Tripatra biorefinery facility overview (Sei Mangkei, North Sumatra)	https://www.spglobal.com/commodity-insights/en/news-research/latest-news/refined-products/122024-italys-nextchem-secures-waste-based-saf-plant-project-in-indonesia	161	

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	Asia Today.id		https://asiatoday.id/read/shell-and-tripatra-to-build-bioavtur-refinery-in-indonesia	161

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	European Union Aviation Safety Agency	Average passenger weight for adults plus the carry-on luggage	https://www.easa.europa.eu/en/newsroom-and-events/news/easa-review-standard-passenger-weights-2022-shows-no-significant-change	176, 177, 179, 180, 182, 183
	Government Technology Agency of Singapore	Passenger numbers (2023) in Singapore	https://data.gov.sg/datasets/d_744e62bfb1c524508bce0a64a2488243/view	176, 177, 186
Chapter 3-1	The Starits Times	Passenger numbers (2035) in Singapore	https://www.straitstimes.com/singapore/transport/aviation-could-be-worth-88b-to-economy-in-20-years-iata	176, 177, 186
		Future GDP growth rate (2023) in Singapore	https://www.dbs.com.hk/treasures-private-client/aics/economics/templatedata/article/generic/data/en/GR/macro_strategy/022025/250225_portal_singapore.xml	176, 177, 188
	Development Bank of Singapore (DBS)	Future GDP growth rate (2024) in Singapore	https://www.dbs.com.sg/treasures/aics/archive/templatedata/article/generic/data/en/GR/112025/251121_insights_singapore.xml	176, 177, 188
		Future GDP growth rate (2025-2040) in Singapore	https://www.dbs.com.sg/corporate/aics/templatedata/article/generic/data/en/GR/102025/251022_singapore_2040_outlook_quality_and_inclusive_growth.xml	176, 177, 188

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	Malaysia Airports	Passenger numbers (2023) in Malaysia	https://mahbseadrmprodsa.blob.core.windows.net/corporate-prod-cms/2025-07/2023%20Airport%20Statistics_1.pdf	179, 180, 190
	Malaysia Aviation Commission (MAVCOM)	Passenger numbers (2024) in Malaysia	https://www.mavcom.my/wp-content/uploads/2025/01/MALAYSIAS-AIR-PASSENGER-TRAFFIC-OUTLOOK-2025.pdf	179, 180, 190
	ReportLinker	Growth rate of passenger numbers (-2028) in Malaysia	https://www.reportlinker.com/clp/country/665603/726406	179, 180, 190
	Ministry of Economy (Department of Statistics Malaysia)	GDP (2023) in Malaysia	https://www.dosm.gov.my/site/downloadrelease?id=gross-domestic-product-2023&lang=English&admin_view=	179, 180, 192
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	malaymail	Future GDP growth rate (2024-2050) in Malaysia	https://www.malaymail.com/news/malaysia/2024/09/05/understanding-rmk-13-how-the-13th-malaysia-plan-aims-to-address-global-local-challenges-for-countrys-economic-future/149382	179, 180, 192

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	AOT	Passenger numbers of AOT (2024) in Thailand	https://www.airportthai.co.th/wp-content/uploads/2025/06/%E0%B8%A3%E0%B8%B2%E0%B8%A2%E0%B8%87%E0%B8%B2%E0%B8%99%E0%B8%9B%E0%B8%A3%E0%B8%B4%E0%B8%A1%E0%B8%B2%E0%B8%93%E0%B8%81%E0%B8%B2%E0%B8%A3%E0%B8%88%E0%B8%A3%E0%B8%B2%E0%B8%88%E0%B8%A3%E0%B8%97%E0%B8%B2%E0%B8%87%E0%B8%AD%E0%B8%B2%E0%B8%81%E0%B8%B2%E0%B8%A8%E0%B8%82%E0%B8%AD%E0%B8%87-%E0%B8%97%E0%B8%AD%E0%B8%97.%E0%B8%9B%E0%B8%B5-2567-Airport-Traffic-Report-2024.pdf	182, 183. 194
	International Air Transport Association (IATA)	Growth rate of passenger numbers (2024-2043) in Thailand	https://www.iata.org/en/pressroom/2024-releases/2024-10-30-02/	182, 183. 194
	Bank of Thailand (BOT)	GDP growth rate (2023) in Thailand	https://app.bot.or.th/BTWS_STAT/statistics/BOTWEBSTAT.aspx?language=ENG&reportID=409	182, 183. 196
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Chapter 3-2	Aviation Benefits Beyond Borders	Conversion rate	https://aviationbenefits.org/other-environmental-challenges/climate-action/sustainable-aviation-fuel/conversions-for-saf	176, 177, 178, 179, 180, 181, 182, 183, 184, 198, 199, 200
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	CMMI	Supply forecast methodology (Indonesia: Cilacap, Plaju)	https://imsis-djpu.kemenhub.go.id/PortalDKPPU/(English%20Translation)%20Indonesia%20Sustainable%20Aviation%20Fuel%20(SAF)%20Roadmap.pdf	205, 206

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	Reuters	Supply forecast methodology (Indonesia: Cilacap)	https://www.reuters.com/business/energy/indonesias-pertamina-delivers-first-used-cooking-oil-aviation-fuel-2025-08-12/	205, 206
	Bisnis.com	Supply forecast methodology (Indonesia: Cilacap, Dumai and Balongan)	https://hijau.bisnis.com/read/20250827/652/1906337/pertamina-dorong-dekarbonisasi-di-kilang-Cilacap	205, 206
	SAF Investor	Supply forecast methodology (Indonesia: Cilacap)	https://www.safinvestor.com/project/142902/pertamina-cilacap-java/	205, 206
	Biobased Diesel Daily	Supply forecast methodology (Indonesia: Plaju)	https://www.biobased-diesel.com/post/pertamina-signs-uco-supply-agreement-for-cilacap-biorefinery-in-Indonesia	205, 206
	GHD Advisory	Supply forecast methodology (Indonesia: Plaju)	https://asean.org/wp-content/uploads/2025/04/12634962-RPT-6-Techno-Economic-Assessment-Final-Report_April-2025.pdf	205, 206
	kumoaranBisnis	Supply forecast methodology (Indonesia: Balongan)	https://kumparan.com/kumparanbisnis/kilang-balongan-bakal-uji-coba-produksi-avtur-dari-minyak-jelantah-maret-2026-264JCjd9aDQ	205, 206

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	Orissa International	Supply forecast methodology (Indonesia: North Sumatra and Kalimantan)	https://www.orissa-international.com/business-news/shell-to-develop-bioavtur-refinery-in-indonesia/	205, 206
	Asia Today.id	Supply forecast methodology (Indonesia: North Sumatra and Kalimantan)	https://asiatoday.id/read/shell-and-tripatra-to-build-bioavtur-refinery-in-indonesia	205, 206
	Petronas	Supply forecast methodology (Malaysia: Johor (Petronas))	https://www.petronas.com/media/media-releases/groundbreaking-ceremony-new-biorefinery-petronas-enilive-and-euglena-Pengerang	208, 209
	Argus	Supply forecast methodology (Malaysia: Port Klang)	https://www.argusmedia.com/en/news-and-insights/latest-market-news/2746595-ecoceres-malaysia-plant-produces-first-on-spec-saf?utm_source=chatgpt.com	208, 209
			https://www.amspecgroup.com/resources/fathopes-energy-and-amspec-group-collaborate-to-boost-sustainable-aviation-fuel-production-in-asia-pacific/	208, 209

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		Supply forecast methodology (Thailand: Rayong)	https://www.bangkokpost.com/business/general/2773646/new-green-aviation-fuel-venture-formed	211, 212
	Bangchak	Supply forecast methodology (Thailand: Phra Khanong)	https://investor.bangchak.co.th/en/document/viewer/stream/162946/investor-forum-2025	211, 212
			https://investor.bangchak.co.th/storage/document/presentation/2025/bcp-transcript-investor-forum-2025.pdf	211, 212
	International Council on Clean Transportation (ICCT)	Potential UCO volume in Indonesia and Malaysia	https://theicct.org/publication/asia-fuels-waste-oil-estimates-feb22/	216
	ICAO	SAF yields	https://rsb.org/wp-content/uploads/2024/09/rsb-sustainable-feedstock-assessment-saf-in-southeast-asia.pdf	216, 217
	The Starits Times	Potential UCO volume in Singapore	https://www.straitstimes.com/world/turbulence-ahead-how-used-cooking-oil-could-hinder-aviations-green-fuel-hopes	217

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	Euglena		https://www.euglena.jp/en/news/20201005-2/	234
	NEDO	Denso Corporation's activities related to microalgae	https://www.nedo.go.jp/news/press/AA5_101363.html	234
	Denso Corporation		https://www.denso.com/global/en/news/newsroom/2015/20150819-01/	234
	Itochu Corporation	Mitsubishi Kakoki Kaisha's activities related to microalgae	https://www.itochu.co.jp/en/news/press/2020/201005.html	234
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	IHI Corporation	IHI Corporation's activities related to microalgae	https://www.ihico.jp/en/all_news/2021/other/1197475_3370.html	234
	CHITOSE Group	CHITOSE Group's activities related to microalgae	https://chitose-bio.com/jp/news/5124	234
			https://chitose-bio.com/project/10225	234
	NEDO		https://www.nedo.go.jp/english/whatsnew_00302.html	234
	NEDO		https://www.nedo.go.jp/content/800017530.pdf	234
	Keidanren (Japan Business Federation)	Electric Power Development (J-Power)'s activities related to microalgae	https://www.challenge-zero.jp/en/casestudy/462	234
	Phycochemistry	Company profile	https://www.phycochemistry.jp/overview/	234
	NEDO	Phycochemistry activities related to microalgae	https://www.nedo.go.jp/content/800040186.pdf	234
	The Green Power Development Corporation of Japan (GPD)	The Green Power Development Corporation of Japan (GPD)'s activities related to non-standard coconut	https://gpdj.jp/en/saf	235

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	HighChem	Initiatives for application of green catalysts	https://highchem.co.jp/services/catalyst/?lang=en	235
	SAF Investor		https://www.safinvestor.com/news/143232/petronas-idemitsu-kosan-sign-agreement-to-develop-saf/	235
	Petronas	Idemitsu Kosan's activities related to other non-edible oil plant	https://www.petronas.com/media/media-releases/petronas-and-idemitsu-collaborate-accelerate-development-sustainable-aviation	235
	Idemitsu Kosan		https://www.idemitsu.com/en/2050future/action/250624.html	235
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	SAF Investor	J-Oil Mills's activities related to other non-edible oil plant	https://www.safinvestor.com/news/146877/j-oil-mills/	235
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	NEDO		https://www.nedo.go.jp/news/press/AA5_101805.html	235
	Yokohama Rubber	Yokohama Rubber's activities related to other non-edible oil plant	https://www.y-yokohama.com/release/pdf/2024110611mg001.pdf	235
Babcox Media Inc	https://www.tirereview.com/yokohama-rubber-seeds-sustainability/		235	

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	NEDO	Nomura Jimusho's activities related to rubber oil seed	<a "="" href="https://www.nedo.go.jp/content/800046726.pdf#:~:text=Dvelopment%20of%20open%2Dclosed%20hybrid%20culture%20technology%20for%20marine%20diatoms%20(FY2020%2D2024).%20J%2DPOWER&text=the%20need%20for%20domestic%20production%20of%20sustainable%20aviation%20fuel%20(">https://www.nedo.go.jp/content/800046726.pdf#:~:text=Dvelopment%20of%20open%2Dclosed%20hybrid%20culture%20technology%20for%20marine%20diatoms%20(FY2020%2D2024).%20J%2DPOWER&text=the%20need%20for%20domestic%20production%20of%20sustainable%20aviation%20fuel%20(235
	Nomura Jimusho		https://nomjim.co.jp/en/pages/245/#:~:text=The%20Rubber%20Authority%20of%20Thailand,competitiveness%20with%20Thailand's%20rubber%20sector.	235
	NEDO	NEDO's efforts toward the social implementation of SAF	<a "="" href="https://www.nedo.go.jp/content/800046726.pdf#:~:text=Development%20of%20open%2Dclosed%20hybrid%20culture%20technology%20for%20marine%20diatoms%20(FY2020%2D2024).%20J%2DPOWER&text=the%20need%20for%20domestic%20production%20of%20sustainable%20aviation%20fuel%20(">https://www.nedo.go.jp/content/800046726.pdf#:~:text=Development%20of%20open%2Dclosed%20hybrid%20culture%20technology%20for%20marine%20diatoms%20(FY2020%2D2024).%20J%2DPOWER&text=the%20need%20for%20domestic%20production%20of%20sustainable%20aviation%20fuel%20(234, 235, 236, 237, 238, 239, 240, 241
	NEDO	Biomanufacturing revolution promotion project	https://www.nedo.go.jp/activities ZZJP_100246.html	234, 235, 236, 237, 238, 239, 240, 241
		Project management sheet of Green Earth Institute	https://www.nedo.go.jp/content/800029677.pdf	234, 235, 236, 237, 238, 239, 240, 241
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	Nippon Steel Engineering	Completion of the second-generation bioethanol production facility news	https://www.eng.nipponsteel.com/en/news/detail/20241226/	236
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		Development of cellulosic ethanol production technology	https://www.eng.nipponsteel.com/files_publish/page/155/vol11_07_en.pdf	236
	Kao	Kao began supplying saccharification enzymes "CRESCENTISTM" to the research association of biomass innovation for next generation automobile fuels news	https://www.kao.com/global/en/newsroom/news/release/2023/20230621-001/	236
https://chemical.kao.com/content/dam/sites/kao/chemical-kao-com/global/topics/pdf/20241226-001.pdf			236	

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	NEDO	Project management sheet of Nippon Paper Industries	https://www.nedo.go.jp/content/800029676.pdf	236
	Biomaterial in Tokyo	Corporate overview	https://biomt.co.jp/company/information/	236
		2nd Generation Bioethanol	https://biomt.co.jp/product/2nd-generation-bioethanol/	236
	Oji Holdings Corporation	Pilot plant for wood-derived sugar solution and ethanol	https://www.ojiholdings.co.jp/news/detail_002233.html	236
	Daio Paper Corporation	Promoting biorefinery business to realize a sustainable society	https://www.daio-paper.co.jp/news/%E3%82%B5%E3%82%B9%E3%83%86%E3%83%8A%E3%83%96%E3%83%AB%E3%81%AA%E7%A4%BE%E4%BC%9A%E3%81%AE%E5%AE%9F%E7%8F%BE%E3%81%AB%E5%90%91%E3%81%91%E3%81%9F%E3%83%90%E3%82%A4%E3%82%AA%E3%83%AA%E3%83%95%E3%82%A1/	237
	Kawasaki Heavy Industries	Bioethanol Production System	https://global.kawasaki.com/en/energy/solutions/renewable/bioethanol.html	237
	JGC Group Corporation	2nd Generation Bioethanol Production Process	https://www.jgc.com/en/business/tech-innovation/environment/biomass.html	237
Sanyu Plant Service	Bioethanol production CFE Project	https://www.g-sanyu.co.jp/service/service_c2/	237	

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	NEDO	Tsukishima Kikai and JFE Engineering's activities on on bioethanol production from	https://www.nedo.go.jp/content/100872852.pdf	238
	Agriculture & Livestock Industries Corporation		https://www.alic.go.jp/joho-s/joho07_001760.html	238
	Logistics Today	Kanadevia's activities on bioethanol production from potato starch	https://www.logi-today.com/27396	238
	NEDO		https://www.nedo.go.jp/content/100888832.pdf	238
	Toray Industries	Toray and DM Mitsui Sugar's activities on bioethanol production from cassava pulp and bagasse	https://www.toray.co.jp/sustainability/articles/vol03.html	238
	NEDO		https://www.nedo.go.jp/content/100972171.pdf	238

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	NEDO	Project management sheet of ENEOS	https://www.nedo.go.jp/content/800029678.pdf	239
	Rengo	Rengo subsidiary, taiko paper mfg., commences 2G bioethanol production demonstration project	https://www.rengo.co.jp/english/news/2024/24_e_news_007.html	239
		Rengo Collaborates with Sumitomo Forestry in Bioethanol Business	https://www.rengo.co.jp/english/news/2025/25_e_news_009.html	239
	Nikkei Inc	Kanadevia's activities on bioethanol from waste	https://www.nikkei.com/article/DGXZQOUF184U50Y2A011C2000000/	239
	Sekisui Chemical	Sekisui's activities on bioethanol production from waste	https://www.sekisui.co.jp/bio-refinery/	239
	NEDO		https://green-innovation.nedo.go.jp/resources/pdf/bio-manufacturing-technology/item-002-003/vision-sekisui-002.pdf	239
	NEDO	Idemitsu development of AtJ demonstration facilities	https://green-innovation.nedo.go.jp/resources/pdf/development-fuel-manufacturing-technology-co2/item-002/vision-idemitsu-003.pdf	239

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	JFE Engineering Corporation	C-PhoeniX Process®	https://www.jfe-eng.co.jp/en/news/2024/20240207.html	240
		Development for commercial scale	https://www.jt-kankyo.co.jp/en/topics/2025/11/20251112.html	240
	Sumitomo SHI FW	Air Fluidized Bed Gasification: Convert waste to energy	https://www.shi-fw.com/our-solutions/energy-generation/air-fluidized-bed-gasification/	240
	JGC Group Corporation	EUP the gasification chemical recycling technology	https://www.jgc.com/en/media/pdf/catalog_02.pdf	240
	PR TIMES Corporation	TOYO Development of SAF Production Technologies Utilizing Diverse Feedstocks	https://prtimes.jp/main/html/rd/p/000000187.000107878.html	240
	United Planning	SAF manufacturing technology, utilizing local wood resources and waste plastics	https://www.united-k.jp/business/circular-energy/saf	240
	Velocys	SAF FT technology of Toyo Engineering Corporation from woody biomass	https://velocys.com/wp-content/uploads/2025/06/Velocys-Biomass-to-SAF-Case-Study-1.pdf	240

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	NEDO		https://green-innovation.nedo.go.jp/project/development-fuel-manufacturing-technology-co2/scheme/#anchorContents	241
	UNIDO ITPO Tokyo	Biomass gasification plant: Twin IHI GASifieR: TIGAR®	https://itpo-tokyo.unido.org/en/technology_db/5730/	241
	Mitsubishi Power	Mitsubishi Power's activities related to gasification technology for SAF	https://power.mhi.com/news/210830.html	241
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	A*STAR ISCE ²	IHI and A*STAR Unveil Groundbreaking Sustainable Aviation Fuel (SAF) Production Process And One Of The World's Largest Test Rigs	https://www.a-star.edu.sg/isce2/news-and-highlights/ih-astar-sustainable-aviation-fuel	245
Chapter 4		Organization overview	https://www.a-star.edu.sg/isce2	245
	IHI	IHI signs an MoU with the A*STAR Institute of Sustainability for Chemicals, Energy and Environment in Singapore to accelerate SAF commercialization	https://www.ihico.jp/en/all_news/2024/technology/1201109_13699.html	245
	IHI	IHI Launches New Bench-Scale Sustainable Aviation Fuel (SAF) Test Rig in Singapore with and A*STAR ISCE ²	https://www.ihico.jp/en/all_news/2024/technology/1201228_13699.html	245

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	Aether Fuels	Aster and Aether Fuels Partner on the First Next-Generation Commercial Sustainable Aviation Fuel Plant in Singapore	https://aetherfuels.com/news-and-press/aster-and-aether-fuels-partner-on-the-first-next-generation-commercial-sustainable-aviation-fuel-plant-in-singapore	246
		Sulzer to provide tech for Sarawak SAF pilot plant in Malaysia	https://www.safinvestor.com/news/147983/sulzer-2/	247
		Malaysia's FatHopes teams up with Topsoe for SAF	https://www.safinvestor.com/news/147005/fathopes/	248
	SAF Investor	Euglena, Petronas team up for large-scale Algae biofuel production	https://www.safinvestor.com/news/145772/algae/	249
		Petronas, Idemitsu Kosan sign agreement to develop SAF	https://www.safinvestor.com/news/143232/petronas-idemitsu-kosan-sign-agreement-to-develop-saf/	250
		Marubeni, InvestSarawak team up to explore SAF in Malaysia	https://www.safinvestor.com/news/145014/marubeni-investsarawak-team-up-to-explore-saf-in-malaysia/	253

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		Pertamina, Airbus partner to develop SAF ecosystem in Indonesia	https://www.safinvestor.com/news/145963/indonesia	265
	S&P Global	Malaysia's Sarawak advances SAF plant with Sulzer, Apeiron, Oiltek	https://www.spglobal.com/energy/en/news-research/latest-news/agriculture/070225-malaysias-sarawak-advances-saf-plant-with-sulzer-apeiron-oiltek	247
	Topsoe	HydroFlex® technology detail	https://www.topsoe.com/solutions/technologies/process-licensing/hydroflex-technology	248
	Woodcote Media Limited	FatHopes Energy and Topsoe forge partnership to advance SAF production in Malaysia	https://biofuels-news.com/news/fathopes-energy-and-topsoe-forge-partnership-to-advance-saf-production-in-malaysia/	248
	Euglena	Euglena Co., Ltd. signs with Petronas Research Sdn. Bhd., Concluded a joint development agreement to execute R&D to develop large-scale production technology for microalgae oil for biofuels	https://www.euglena.jp/en/news/20240828-2/	249

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	F&L Asia Limited	PETRONAS and SEDC to develop algae strains for SAF production	https://www.fuelsandlubes.com/petronas-and-sedc-to-develop-algae-strains-for-saf-production/	251
	Ministry of Transport Sarawak	SAF part of Sarawak govt's vision for a green economy	https://mot.sarawak.gov.my/web/subpage/news_view/642	251
	New Straits Times	MPOB, Chinese partners to produce biodiesel and biojet fuel in Malaysia	https://www.nst.com.my/business/2021/12/753889/mpob-chinese-partners-produce-biodiesel-and-biojet-fuel-malaysia	252
	Marubeni Corporation	Commencement of a Feasibility Study for a Biomass to SAF Project in Malaysia	https://www.marubeni.com/en/news/2024/info/00027.html	253
	BioEnergy Times	InvestSarawak and Marubeni conducting joint pre-feasibility study for a commercial scale SAF value chain	https://bioenergytimes.com/investsarawak-and-marubeni-conducting-joint-pre-feasibility-study-for-a-commercial-scale-saf-value-chain/?utm	253

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	The Nation	Two big names fostering collaboration on 'Net-Zero' mission for low-carbon fuels towards further step of aviation fueling excellence	https://www.nationthailand.com/pr-news/business/40016878	254
	Bangkok Post	BAFS aims to be the real deal	https://www.bangkokpost.com/business/general/2824118/bafs-aims-to-be-the-real-deal	254
	Bangkok Post	DIPROM, Bangchak Unite to Advance Sustainable Aviation Fuel	https://www.bangkokpost.com/thailand/pr/2992029/diprom-bangchak-unite-to-advance-sustainable-aviation-fuel	259
	Thansettakij	Thai Oil is accelerating its study of SAF using ethanol as a raw material to expand its business and reduce risk	https://www.thansettakij.com/climatecenter/new-energy/614485	255
	Thansettakij	EA partners with BAFS to promote sustainable aviation fuel and drive a Net Zero aviation industry	https://www.thansettakij.com/climatecenter/new-energy/598681	256

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Chapter 4	Bangkok Aviation Fuel Services	EA partners with BAFS to promote the use of sustainable aviation fuel (SAF), aiming to reduce CO2 emissions and achieve net zero by 2030.	https://www.bafsthai.com/th/newsroom/press-releases/636/ea-%E0%B8%88%E0%B8%B1%E0%B8%9A%E0%B8%A1%E0%B8%B7%E0%B8%AD-bafs-%E0%B8%A5%E0%B8%B8%E0%B8%A2%E0%B8%AA%E0%B9%88%E0%B8%87%E0%B9%80%E0%B8%AA%E0%B8%A3%E0%B8%B4%E0%B8%A1%E0%B8%81%E0%B8%B2%E0%B8%A3%E0%B9%83%E0%B8%8A%E0%B9%89%E0%B8%99%E0%B9%89%E0%B8%B3%E0%B8%A1%E0%B8%B1%E0%B8%99%E0%B9%80%E0%B8%8A%E0%B8%B7%E0%B9%89%E0%B8%AD%E0%B9%80%E0%B8%9E%E0%B8%A5%E0%B8%B4%E0%B8%87%E0%B8%AD%E0%B8%B2%E0%B8%81%E0%B8%B2%E0%B8%A8%E0%B8%A2%E0%B8%B2%E0%B8%99%E0%B9%81%E0%B8%9A%E0%B8%9A%E0%B8%A2%E0%B8%B1%E0%B9%88%E0%B8%87%E0%B8%A2%E0%B8%B7%E0%B8%99-saf-%E0%B8%9B%E0%B8%B1%E0%B8%81%E0%B8%AB%E0%B8%A1%E0%B8%B8%E0%B8%94%E0%B8%A5%E0%B8%94%E0%B8%81%E0%B8%B2%E0%B8%A3%E0%B8%9B%E0%B8%A5%E0%B9%88%E0%B8%AD%E0%B8%A2-co2-%E0%B8%81%E0%B9%89%E0%B8%B2%E0%B8%A7%E0%B8%AA%E0%B8%B9%E0%B9%88-net-zero-%E0%B9%83%E0%B8%99%E0%B8%9B%E0%B8%B5-2573	256

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	DataSet	EA and BAFS join forces to venture into the SAF oil business, studying the establishment of service stations and supporting producers to promote Thailand as a hub	https://www.infoquest.co.th/2024/390125	256
	The Journalist Club	"EA-BAFS" – Two big energy companies, new players in the sustainable aviation fuel market (SAF)	https://thejournalistclub.com/economics-news-ea-20240409/	256
	Sdperspectives	Bangchak, BAFS, and BPT are adding SAF to the pipeline system, delivering it directly to Suvarnabhumi and Don Mueang airports	https://www.sdperspectives.com/sd-daily/26174-bangchak-bafs-bpt-saf-via-pipeline/	257

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Chapter 4	Bangchak Corporation	Bangchak Group reaffirms its readiness as a leading SAF producer, partnering with BAFS and BPT to pilot the replenishment of SAF into the pipeline system supplying Suvarnabhumi and Don Mueang International Airports	https://www.bangchak.co.th/th/newsroom/bangchak-news/1494/%E0%B8%81%E0%B8%A5%E0%B8%B8%E0%B9%88%E0%B8%A1%E0%B8%9A%E0%B8%A3%E0%B8%B4%E0%B8%A9%E0%B8%B1%E0%B8%97%E0%B8%9A%E0%B8%B2%E0%B8%87%E0%B8%88%E0%B8%B2%E0%B8%81%E0%B8%A2%E0%B9%89%E0%B8%B3%E0%B8%84%E0%B8%A7%E0%B8%B2%E0%B8%A1%E0%B8%9E%E0%B8%A3%E0%B9%89%E0%B8%AD%E0%B8%A1%E0%B8%9C%E0%B8%B9%E0%B9%89%E0%B8%99%E0%B8%B3%E0%B8%81%E0%B8%B2%E0%B8%A3%E0%B8%9C%E0%B8%A5%E0%B8%B4%E0%B8%95-saf-%E0%B8%88%E0%B8%B1%E0%B8%9A%E0%B8%A1%E0%B8%B7%E0%B8%AD-bafs-%E0%B9%81%E0%B8%A5%E0%B8%B0-bpt-%E0%B8%99%E0%B8%B3%E0%B8%A3%E0%B9%88%E0%B8%AD%E0%B8%87%E0%B9%80%E0%B8%95%E0%B8%B4%E0%B8%A1-saf-%E0%B9%80%E0%B8%82%E0%B9%89%E0%B8%B2%E0%B8%A3%E0%B8%B0%E0%B8%9A%E0%B8%9A%E0%B8%97%E0%B9%88%E0%B8%AD-%E0%B8%AA%E0%B8%B9%E0%B9%88%E0%B8%97%E0%B9%88%E0%B8%B2%E0%B8%AD%E0%B8%B2%E0%B8%81%E0%B8%B2%E0%B8%A8%E0%B8%A2%E0%B8%B2%E0%B8%99%E0%B8%99%E0%B8%B2%E0%B8%99%E0%B8%B2%E0%B8%8A%E0%B8%B2%E0%B8%95%E0%B8%B4%E0%B8%AA%E0%B8%B8%E0%B8%A7%E0%B8%A3%E0%B8%A3%E0%B8%93%E0%B8%A0%E0%B8%B9%E0%B8%A1%E0%B8%B4-%E0%B8%94%E0%B8%AD%E0%B8%99%E0%B9%80%E0%B8%A1%E0%B8%B7%E0%B8%AD%E0%B8%87	257

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Chapter 4	Bangchak Corporation	Bangchak Group Drives Low-Carbon Aviation Unveiling Thailand's First Dedicated SAF Facility Certified to International Standards	https://www.bangchak.co.th/en/newsroom/bangchak-news/1623/bangchak-group-drives-low-carbon-aviation-unveiling-thailand-s-first-dedicated-saf-facility-certified-to-international-standards	258
		Bangchak Group targets Net Zero Piloting Sustainable Aviation Fuel (SAF) production Expanding on local research	https://www.bangchak.co.th/en/newsroom/bangchak-news/832/bangchak-group-targets-net-zero-piloting-sustainable-aviation-fuel-saf-production-expanding-on-local-research	261
		RMUTI and Bangchak overview of collaboration	https://www.bangchak.co.th/en/newsroom/bangchak-news/1826/bangchak-group-advances-saf-feedstock-security-through-farm-to-fly-partners-with-rmuti-to-develop-pongamia-using-smart-technology	263
	National Energy Technology Center	ENTEC and GIZ held the SAF Working Group Milestone Meeting to drive cooperation in developing sustainable aviation fuel in Thailand and the region	https://www.entec.or.th/th/2025-10-30-entec-nstda-and-giz-host-saf-working-group-milestone-meeting-to-advance-sustainable-aviation-fuel-development-in-thailand-and-the-region/	260
	Rajamangala University of Technology Isan	RMUTI joins hands with NRCT, Bangchak and BBGI to expand production of SAF leading Thailand towards Net Zero goals	https://en.rmuti.ac.th/one/news250165/	261

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	ASEAN Secretariat	Promoting the Production of Sustainable Aviation Fuels from Agricultural Waste in the ASEAN Region	https://asean.org/wp-content/uploads/2025/04/12634962-RPT-6-Techno-Economic-Assessment-Final-Report_April-2025.pdf	265
	RonKo Media Productions	Pertamina signs UCO-supply agreement for Cilacap biorefinery in Indonesia	https://www.biobased-diesel.com/post/pertamina-signs-uco-supply-agreement-for-cilacap-biorefinery-in-indonesia	266
	Pertamina	Pertamina NRE Teams Up with French Company to Develop Low-Carbon and Renewable Fuels	https://www.pertaminanre.com/publication/news/pertamina-nre-gandeng-perusahaan-prancis-kembangkan-bahan-bakar-rendah-karbon-dan-terbarukan	267
	National Research and Innovation Agency	Indonesia-Japan develop bioavtur industry as an eco-friendly aircraft fuel solution	https://www.brin.go.id/en/news/119715/indonesia-japan-develop-bioavtur-industry-as-an-eco-friendly-aircraft-fuel-solution	268

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	Ministry of Economy, Trade and Industry (METI)	Study on export of bioethanol from Thailand to Japan	https://www.meti.go.jp/information/publicoffer/saitaku/2026/s260205001.html	234, 235, 236, 237, 238, 239, 240, 241
	Ministry of Economy, Trade and Industry (METI)	MOU for synthesis of hydrocarbons directly from hydrogen and CO ₂ for use in SAF	https://www.meti.go.jp/policy/energy_environment/global_warming/azec/3rd_ministerial_meeting/09_3rd_AZEC_mm_mou_abstract_en.pdf	234, 235, 236, 237, 238, 239, 240, 241

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	Ministry of Economy, Trade and Industry (METI)	Overview of Japan's SAF Public-Private Councils (Production and Supply WG)	https://www.meti.go.jp/shingikai/energy_environment/saf/seizo_wg/index.html	278, 286, 287, 288
	Ministry of Land, Infrastructure, Transport and Tourism (MLIT)	Overview of Japan's SAF Public-Private Councils (Distribution WG)	https://www.mlit.go.jp/koku/content/001633107.pdf	278, 286, 288
	Public-Private Council to Promote the Introduction of Sustainable Aviation Fuel	Japan's State Action Plan related to SAF Roadmap: Promotion of the Introduction of SAF	https://www.meti.go.jp/shingikai/energy_environment/saf/pdf/001_06_00.pdf	289
	Ministry of Land, Infrastructure, Transport and Tourism (MLIT)	Overview of Japan's Policies/Roadmap for SAF & Action Plans in Policy Roadmap	https://www.mlit.go.jp/report/press/content/001573999.pdf	290

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	Ministry of Land, Infrastructure, Transport and Tourism (MLIT)	Overview of Japan's Policies/Roadmap for SAF & Process to set company policy	https://www.mlit.go.jp/report/press/content/001573998.pdf	290
	Ministry of Justice, Japan		https://www.japaneselawtranslation.go.jp/outline/42/905R312.pdf	290
	Ministry of Economy, Trade and Industry (METI)	Overview of Japan's Policies/Roadmap for SAF	https://www.meti.go.jp/press/2022/02/20230210002/20230210002_1.pdf	291
	Ministry of Economy, Trade and Industry (METI)		https://www.enecho.meti.go.jp/about/special/johoteikyo/saf_torikumi.html	291
	Ministry of Economy, Trade and Industry (METI)	Japan's Action Plans in Policy Roadmap	https://www.meti.go.jp/press/2022/02/20230210002/20230210002_3.pdf	291
	Ministry of Economy, Trade and Industry (METI)		https://www.enecho.meti.go.jp/about/special/johoteikyo/saf_torikumi.html	291
	Cabinet Secretariat	Discussions under GX Implementation Council Meeting	https://www.cas.go.jp/jp/seisaku/gx_jikkou_kaigi/index.html	291

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		JAL's fuel consumption	https://www.jal.com/en/sustainability/esg/pdf/esg.pdf	287, 292	
		JAL's SAF sourcing from Gevo Inc. and oneworld alliance	https://www.jal.com/en/sustainability/environment/climate-action/saf/#specific-overseas	287, 292	
		JAL's SAF sourcing from Neste and Itochu Corporation on a flight departing from Los Angeles	https://press.jal.co.jp/en/release/202211/007016.html	287, 292	
			JAL's SAF sourcing from Neste and Itochu Corporation on a domestic flight	https://press.jal.co.jp/en/release/202210/006953.html	287, 292
	Neste	JAL's SAF purchase from Neste, Itochu Corporation, Fuji oil	https://www.neste.com/news/neste-itochu-and-fuji-oil-supply-sustainable-aviation-fuel-to-all-nippon-airways-and-japan-airlines	287, 292	
	All Nippon Airways (ANA)	ANA's company overview	https://www.ana.co.jp/group/investors/irdata/annual/pdf/25f/25_FB_00.pdf	287, 293	
		ANA's consolidated fuel consumption	https://www.ana.co.jp/group/en/investors/irdata/annual/pdf/25/25_E_00_1.pdf	287, 293	
		ANA's network	https://www.ana.co.jp/group/investors/irdata/annual/pdf/25f/25_FB_00.pdf	293	

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	The Official Airline Guide (OAG)	ANA's number of total flights in 2024	https://www.oag.com/all-nippon-airways-performance-stats	293
	SAF Investor		https://www.safinvestor.com/news/142259/ana-signs-10-year-saf-agreement-with-raven-sr/	293
	All Nippon Airways (ANA)	ANA's 10-year SAF memorandum of understanding with Raven SR	https://www.anahd.co.jp/group/en/pr/202301/20230117.html	293
	Raven SR		https://ravensr.com/ana-strikes-saf-pact-with-itochu-and-raven-sr/	293
	Neste	ANA's SAF is procured from Neste as neat SAF, blended and supplied by Fuji Oil and Itochu	https://www.anahd.co.jp/group/en/pr/202303/20230330.html	287, 293

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	Ministry of International Trade and Industry	Malaysia Green Investment Strategy	https://www.miti.gov.my/miti/resources/Banner%20Announcement%202024/Green_Investment_Strategy_Summary.pdf	296
	Coordinating Ministry for Maritime Affairs and Investment	Indonesia's SAF Industry Development Roadmap	https://imsis-djpu.kemenuh.go.id/PortalDKPPU/(English%20Translation)%20Indonesia%20Sustainable%20Aviation%20Fuel%20(SAF)%20Roadmap.pdf	296
	Department of Energy Business	Public Hearing Document for the (Draft) Oil Plan 2024–2037	https://image.makewebeasy.net/makeweb/0/u3EjrB8bq/Document/Oil_Plan_2024-2037.pdf?v=202405291424	296
	Ministry of Energy and Mineral Resources	Indonesia's Regulation of the Minister of Energy and Mineral Resources Number 4 of 2025 concerning the Use and Utilization of Biofuels	https://peraturan.bpk.go.id/Details/317626/permen-esdm-no-4-tahun-2025	297
	Ecadin	Summary of "Indonesia's Regulation of the Minister of Energy and Mineral Resources Number 4 of 2025 concerning the Use and Utilization of Biofuels"	https://ecadin.org/minister-of-energy-and-mineral-resources-regulation-no-4-2025-a-landmark-move-towards-indonesias-biofuel-future/	297

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			https://www.neste.com/products-and-innovation/sustainable-aviation/sustainable-aviation-fuel	279, 302, 317
			https://www.neste.com/products-and-innovation/sustainable-aviation/questions-and-answers-about-saf	279, 302, 317
			https://www.neste.com/files/pdf/6eSvPdgCwnODZvWXU2Zz9d-Neste_Annual_Report_2024_Annual_Review.pdf	279, 302, 317
	Petronas	Petronas's biorefinery facility overview	https://www.petronas.com/media/media-releases/groundbreaking-ceremony-new-biorefinery-petronas-enilive-and-euglena-pengerang	279, 302, 317
			https://www.petronas.com/media/media-releases/groundbreaking-ceremony-new-biorefinery-petronas-enilive-and-euglena-pengerang	279, 302, 317
	EcoCeres	EcoCeres's biorefinery facility overview	https://www.eco-ceres.com/en/news/view?id=85	279, 302, 317
			https://www.ecoceres.com/en/news/view?id=5	279, 302, 317
	Argus Media group		https://www.argusmedia.com/en/news-and-insights/latest-market-news/2746595-ecoceres-malaysia-plant-produces-first-on-spec-saf	279, 302, 317
	FatHopes Energy	Biorefinery facility overview	https://www.fathopesenergy.com/blog/bin-zayed-international-fathopes-energy-saf-refinery-malaysia/	279, 302, 317

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	Star Media Group		https://www.thestar.com.my/news/nation/2025/04/26/jet-fuel-refinery-to-break-ground#goog_rewarded	279, 302, 317
	ESSA	ESSA's biorefinery facility overview	https://essa.id/wp-content/uploads/2024/12/ESSA-SAF-Press-Release-English-1.pdf	279, 302, 317
	Blue Finance Indonesia		https://bluefindo.com/2025/02/04/proyek-pabrik-bahan-bakar-berkelanjutan-essa-2027	279, 302, 317
	S&P Global	Tripatra's biorefinery facility overview (North Sumatra and Kalimantan)	https://www.orissa-international.com/business-news/shell-to-develop-bioavtur-refinery-in-indonesia/	279, 302, 317
	Asia Today.id		https://asiatoday.id/read/shell-and-tripatra-to-build-bioavtur-refinery-in-indonesia	279, 302, 317
	CMMAI	Pertamina's biorefinery facility overview (Cilacap, Plaju)	https://imsis-djpu.kemenuhub.go.id/PortalDKPPU/(English%20Translation)%20Indonesia%20Sustainable%20Aviation%20Fuel%20(SAF)%20Roadmap.pdf	279, 302, 317

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	Reuters	Pertamina's biorefinery facility overview (Cilacap)	https://www.reuters.com/business/energy/indonesias-pertamina-delivers-first-used-cooking-oil-aviation-fuel-2025-08-12/	279, 302, 317
	Bisnis.com		https://hijau.bisnis.com/read/20250827/652/1906337/pertamina-dorong-dekarbonisasi-di-kilang-cilacap?utm_source=chatgpt.com	279, 302, 317
	SAF Investor		https://www.safinvestor.com/project/142902/pertamina-cilacap-java/	279, 302, 317
	Biobased Diesel Daily	Pertamina's biorefinery facility overview (Plaju)	https://www.biobased-diesel.com/post/pertamina-signs-uco-supply-agreement-for-cilacap-biorefinery-in-Indonesia	279, 302, 317
	GHD Advisory		https://asean.org/wp-content/uploads/2025/04/12634962-RPT-6-Techno-Economic-Assessment-Final-Report_April-2025.pdf	279, 302, 317
	Bisnis.com	Pertamina's biorefinery facility overview (Dumai and Balongan)	https://hijau.bisnis.com/read/20250827/652/1906337/pertamina-dorong-dekarbonisasi-di-kilang-cilacap	279, 302, 317
	kumooanBisnis	Pertamina's biorefinery facility overview (Balongan)	https://kumparan.com/kumparanbisnis/kilang-balongan-bakal-uji-coba-produksi-avtur-dari-minyak-jelantah-maret-2026-264JCjd9aDQ	279, 302, 317
	Bangchak	Bangchak enters SAF supply agreement with Shell	https://www.bangchak.co.th/en/newsroom/bangchak-news/1509/bangchak-enters-saf-supply-agreement-with-shell	279, 302, 317
	Bangchak	Bangchak Group and Cosmo Oil's strategic partnership for SAF	https://www.bangchak.co.th/en/newsroom/bangchak-news/1245/bangchak-group-and-cosmo-oil-in-japan-forge-strategic-partnership-for-sustainable-aviation-fuel	279, 302, 317

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	International Air Transport Association	Average MSP of major SAF pathways per five-year period over 2020-2050	https://www.iata.org/en/programs/sustainability/reports/saf-procurement-pricing-options-for-different-strategies/	306
	International Air Transport Association	Average MSP of major SAF pathways per five-year period over 2020-2050	https://www.iata.org/contentassets/8d19e716636a47c184e7221c77563c93/finance-net-zero-roadmap.pdf	306
	Neste	Haneda Airport's historical SAF delivery record on Oct 2020	https://www.neste.com/news/neste-and-itochu-expand-partnership-to-grow-the-availability-of-sustainable-aviation-fuel-in-japan	310
	Green Air News	Haneda Airport's historical SAF delivery record on Jun 2021	https://www.greenairnews.com/?p=1239	310
	SAF Investor	Haneda Airport's historical SAF delivery record on Jul 2025	https://www.safinvestor.com/news/148004/haneda/	310
	Neste	Narita Airport's historical SAF delivery record on Oct 2020	https://www.neste.com/news/neste-and-itochu-expand-partnership-to-grow-the-availability-of-sustainable-aviation-fuel-in-japan	310
	SAF Investor	Narita Airport's historical SAF delivery record on Sep 2024	https://www.safinvestor.com/news/145960/narita/	310

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	SAF Investor	Chubu Centrair International Airport's historical SAF delivery record on Apr 2025	https://www.safinvestor.com/news/146863/dhl-express/	310
	Reuters	Chubu Centrair International Airport's historical SAF delivery record on Apr 2025	https://www.reuters.com/sustainability/climate-energy/dhl-express-buy-sustainable-aviation-fuel-japans-cosmo-starting-april-2025-01-28	310
	SAF Investor	Kansai International Airport's historical SAF delivery record on Apr 2025	https://www.safinvestor.com/news/147389/cosmo-3/	310
	Kansai Airports	Kansai International Airport's historical SAF delivery record on May 2025	https://www.kansai-airports.co.jp/news/j-250501-pressrelease-j_250501_pressrelease_commercializeddomsaf	310
	SAF Investor	Kobe Airport's historical SAF delivery record on May 2025	https://www.safinvestor.com/news/147420/cosmo-oil/	310
	Ministry of Land, Infrastructure, Transport and Tourism (MLIT)	Number of departing flights at airports in Japan	https://www.mlit.go.jp/koku/15_bf_000185.html	310
	Tokyo International Air Terminal Corporation (TIAT)	Haneda airport's number of departing flights	https://www.tiat.co.jp/result/docs/8ee1c8f69436be09d50c0f95a606d12be7908c66.pdf	310

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	Central Japan International Airport	Chubu Centrair International Airport's number of departing flights	https://www.centrair.jp/assets/doc/corporate/media-center/result/2024results_JP.pdf	310
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	Kansai Airports	Kansai International Airport's number of departing flights	https://www.kansai-airports.co.jp/business/in-figures/#kix-arrival-and-departure	310
	Kansai Airports	Kobe Airport's number of departing flights	https://www.kansai-airports.co.jp/wp-content/themes/kap-corporate/assets/document/A-7-3_kobe_overview_jn.pdf	310

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		Evaluation of SAF refineries and players (Malaysia: Port Klang)	https://www.argusmedia.com/en/news-and-insights/latest-market-news/2678190-malaysian-fathopes-to-reach-saf-plant-fid-by-1q-2026?utm_source=chatgpt.com	313
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	PTT	Evaluation of SAF refineries and players (Thailand: Mao Ta Phut)	https://shorturl.at/1zbHG	313
	Bangkok Post	Evaluation of SAF refineries and players (Thailand: Mao Ta Phut)	https://www.bangkokpost.com/business/general/2889342/gc-set-to-produce-sustainable-aviation-fuel	313
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		Evaluation of SAF refineries and players (Thailand: Rayong)	https://www.bangkokpost.com/business/general/2773646/new-green-aviation-fuel-venture-formed	313
	Bangchak	Evaluation of SAF refineries and players (Thailand: Phra Khanong)	https://investor.bangchak.co.th/en/document/viewer/stream/162946/investor-forum-2025	313
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	GHD Advisory	Evaluation of SAF refineries and players (Indonesia: Plaju)	https://asean.org/wp-content/uploads/2025/04/12634962-RPT-6-Techno-Economic-Assessment-Final-Report_April-2025.pdf	314
	kumoaranBisnis	Evaluation of SAF refineries and players (Indonesia: Balongan)	https://kumparan.com/kumparanbisnis/kilang-balongan-bakal-uji-coba-produksi-avtur-dari-minyak-jelantah-maret-2026-264JCjd9aDQ	314
	S&P Global	Evaluation of SAF refineries and players (Indonesia: Sei Mangkei, North Sumatra)	https://www.spglobal.com/commodity-insights/en/news-research/latest-news/refined-products/122024-italys-nextchem-secures-waste-based-saf-plant-project-in-indonesia	314
	Orissa International	Evaluation of SAF refineries and players (Indonesia: North Sumatra and Kalimantan)	https://www.orissa-international.com/business-news/shell-to-develop-bioavtur-refinery-in-indonesia/	314
	Asia Today.id	Evaluation of SAF refineries and players (Indonesia: North Sumatra and Kalimantan)	https://asiatoday.id/read/shell-and-tripatra-to-build-bioavtur-refinery-in-indonesia	314

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	CMMI	Evaluation of SAF refineries and players (Indonesia: Cilacap, Plaju)	https://imsis-djpu.kemenuh.go.id/PortalDKPPU/(English%20Translation)%20Indonesia%20Sustainable%20Aviation%20Fuel%20(SAF)%20Roadmap.pdf	314
	biofuels international	Evaluation of SAF refineries and players (Indonesia: Cilacap)	https://biofuels-news.com/news/pertamina-set-to-produce-first-batch-of-certified-saf/	314
	Reuters	Evaluation of SAF refineries and players (Indonesia: Cilacap)	https://www.reuters.com/business/energy/indonesias-pertamina-delivers-first-used-cooking-oil-aviation-fuel-2025-08-12/	314
	Bisnis.com	Evaluation of SAF refineries and players (Indonesia: Cilacap, Dumai and Balongan)	https://hijau.bisnis.com/read/20250827/652/1906337/pertamina-dorong-dekarbonisasi-di-kilang-Cilacap	314
	SAF Investor	Evaluation of SAF refineries and players (Indonesia: Cilacap)	https://www.safinvestor.com/project/142902/pertamina-cilacap-java/	314
	Biobased Diesel Daily	Evaluation of SAF refineries and players (Indonesia: Plaju)	https://www.biobased-diesel.com/post/pertamina-signs-uco-supply-agreement-for-cilacap-biorefinery-in-Indonesia	314

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	Offshore Energy	New biofuel hub at Tanjung Langsat Port	https://www.offshore-energy.biz/bac-re-tlp-terminal-and-dovechem-join-forces-on-new-biofuel-hub-at-tanjung-langsat-port/#:~:text=The%20hub%20is%20designed%20to:%20*%20Capitalize,busiest%20transshipment%20hub%20and%20largest%20bunkering%20port.	320
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	United States Department of Agriculture	Overview of SAF Projects in Japan	https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Biofuels%20Annual_Tokyo_Japan_JA2025-0063	281, 324
	Bangchak	Bangchak Enters SAF Supply Agreement with Shell	https://www.bangchak.co.th/en/newsroom/bangchak-news/1509/bangchak-enters-saf-supply-agreement-with-shell	31, 279, 302, 317, 326
	Bangchak	Bangchak Group and Cosmo Oil's strategic partnership for SAF	https://www.bangchak.co.th/en/newsroom/bangchak-news/1245/bangchak-group-and-cosmo-oil-in-japan-forge-strategic-partnership-for-sustainable-aviation-fuel	31, 279, 302, 317, 326

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	Quantum Commodity Intelligence	Used Cooking Oil/UCO (Malaysia)	https://cbonds.com/indexes/180529/	328
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