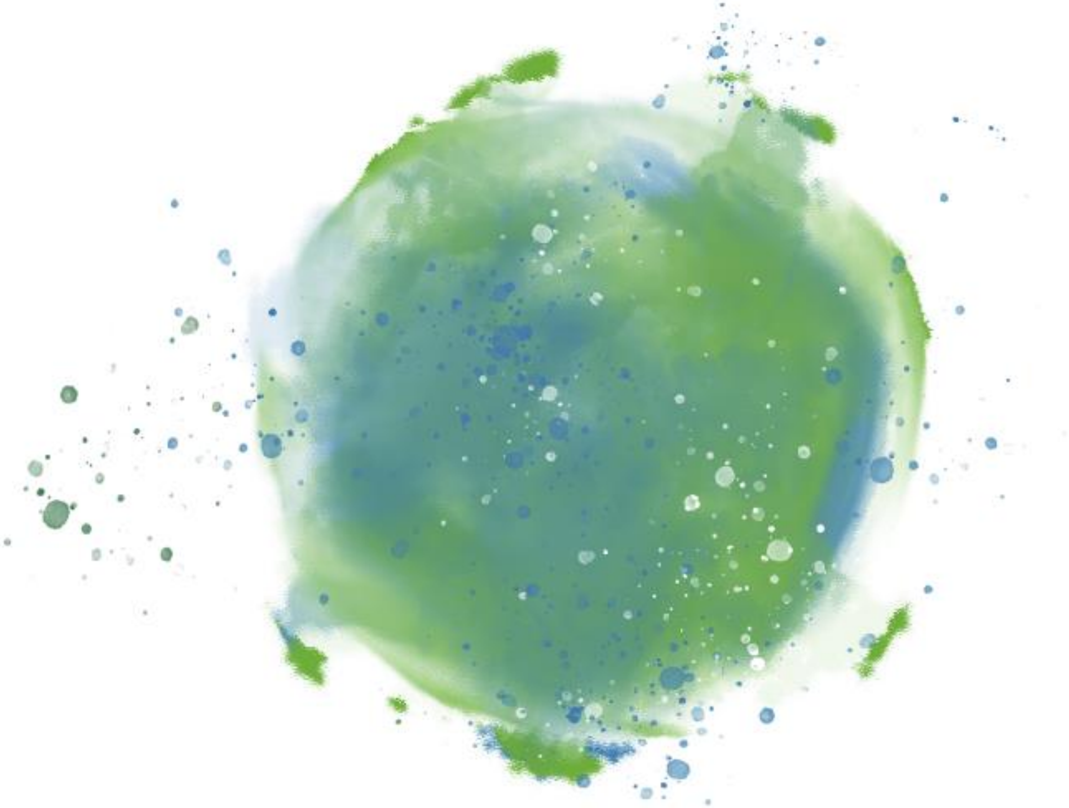
Monitor
Deloitte.

Attn: NEDO Thailand



Study on Policy Recommendation for Biofuel in Indonesia Phase 3

Final Report

Deloitte Consulting Southeast Asia

30 August 2024

Agenda

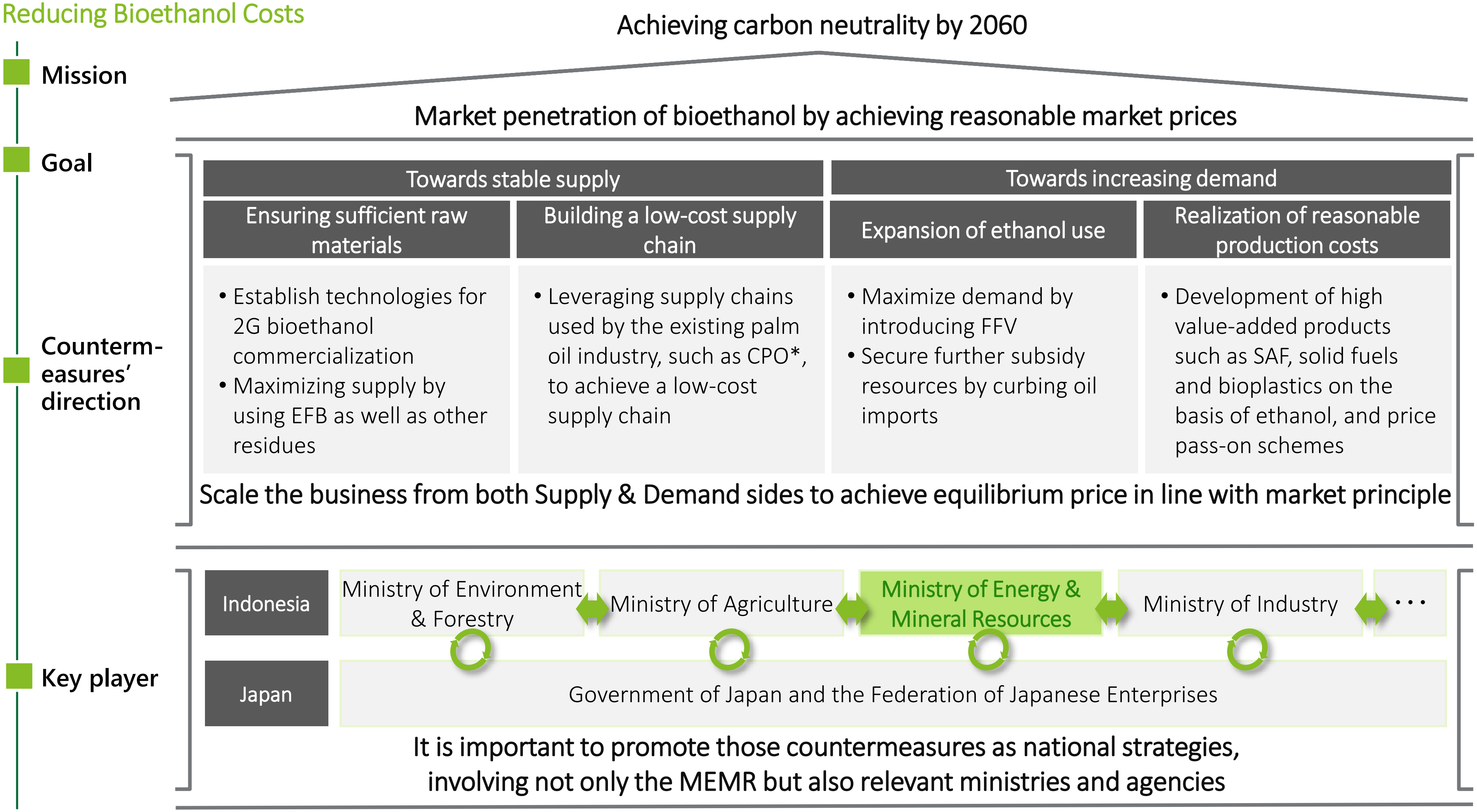
1 Executive Summary
2 2G Ethanol Commercialization Roadmap
3 Identification of Potential Feedstock Including Collection Methods
4 Expansion of Ethanol Use by FFV Introduction
5 Updated Demand-Supply Balance
6 Realization of Reasonable Production Cost
7 Appendix

Executive Summary

Proposed Material Reprinted

As long as the price difference between bioethanol and gasoline is large, it will be difficult to achieve an acceptable price with subsidies that can be assumed at present, and it is essential to consider expansion measures on both supply and demand sides to reduce costs

Reducing Bioethanol Costs



Mission

Achieving carbon neutrality by 2060

Goal

Market penetration of bioethanol by achieving reasonable market prices

Counterm-easures' direction

Towards stable supply		Towards increasing demand	
Ensuring sufficient raw materials	Building a low-cost supply chain	Expansion of ethanol use	Realization of reasonable production costs
• Establish technologies for 2G bioethanol commercialization • Maximizing supply by using EFB as well as other residues	• Leveraging supply chains used by the existing palm oil industry, such as CPO*, to achieve a low-cost supply chain	• Maximize demand by introducing FFV • Secure further subsidy resources by curbing oil imports	• Development of high value-added products such as SAF, solid fuels and bioplastics on the basis of ethanol, and price pass-on schemes

Scale the business from both Supply & Demand sides to achieve equilibrium price in line with market principle

Key player

Indonesia: Ministry of Environment & Forestry ⟷ Ministry of Agriculture ⟷ Ministry of Energy & Mineral Resources ⟷ Ministry of Industry ⟷ · · ·

Japan: Government of Japan and the Federation of Japanese Enterprises

It is important to promote those countermeasures as national strategies, involving not only the MEMR but also relevant ministries and agencies

* CPO: Crude Palm Oil

To establish a bioethanol market in Indonesia, it is necessary to clarify the Indonesian government's position on both supply & demand. To move him in this direction, it is essential to appeal the benefits of introducing ethanol through the TF activities

Executive Summary for Phase 3

Theme	To consider expansion measures on both supply and demand sides to reduce costs
Conclusions	The theory of economies of scale will enable 2G cost reduction and Ethanol market establishment
Supply	If the government clarifies its policy position on bioethanol expansion, it will drive the development of 2G, resulting in a significant supply from EFB and Bagasse
Demand	If the Government shows a strong willingness to promote the introduction of FFVs as part of its decarbonization policy and offers tax incentives for both producers and consumers to introduce FFVs, significant demand for FFVs can be expected.

	Towards stable supply	Towards increasing demand
Re-confirmed	Interviews with several experts reconfirmed that commercialization of 2G ethanol by EFB is highly feasible among palm oil residues	A simple estimation of the demand when FFV is introduced in Indonesia showed that, as initially expected, a very large increase in demand is expected
Found out	Based on interviews with experts, 2G commercialization is on track for about 2030. With the additional sugarcane farmland, 2G using bagasse is expected to produce a significant amount of ethanol.	Interviews with local experts in Brazil on the success factors in Brazil at the time suggest that the entire industry shifted to FFV under the strong will of the government, with the public and private sectors working together.
Challenges	Indonesian government needs to clarify its policy position on bioethanol expansion Possibility of using palm oil residues other than EFB should be explored to secure more supply.	The degree of penetration of FFVs will depend on whether the Indonesian government continues to promote EVs in the future, changes its policy to promote FFVs for the time being, or tries to coexist with them.

Based on the interviews, it is assumed that if the Indonesian government can implement and provide policy position on the necessary drivers, 2G Ethanol commercialization is expected to be realized by 2030

2G Ethanol Commercialization Roadmap

Key Challenges in 2G Ethanol

High Investment Size with Uncertain Commitment

High investment requirements and limited confidence in 2G Ethanol's commercial viability are hindering large-scale funding from private and public sectors

Costly Production Resulting to Uncompetitive Price

High production costs, driven by longer processing times and technological limitations, make 2G Ethanol less competitive, with costs exceeding 1G price

Competing Feedstock Use Limiting Availability

Competing uses for EFB in Indonesia, the primary 2G feedstock, are driving up demand and costs, while also limiting its availability for ethanol

Complex Domestic Ethanol Market

The dominance of cheaper fossil fuels and limited infrastructure poses a major barrier to the adoption and competitiveness of 2G Ethanol in Indonesia

Drivers to Address Issues

Funding Support and Incentives

- Increase project funding and support, offer low-interest loans, and waive import tariffs for 2G ethanol production
- Implement a regulated pricing tier for 2G ethanol to encourage investment and commercialization

Enhanced Supply Chain and Logistics

- Optimize plant locations and establish downstream facilities near key markets to reduce transportation costs
- Secure cost-effective feedstock through strategic partnerships and strengthen supply relationships to improve efficiency

Innovation and Technology

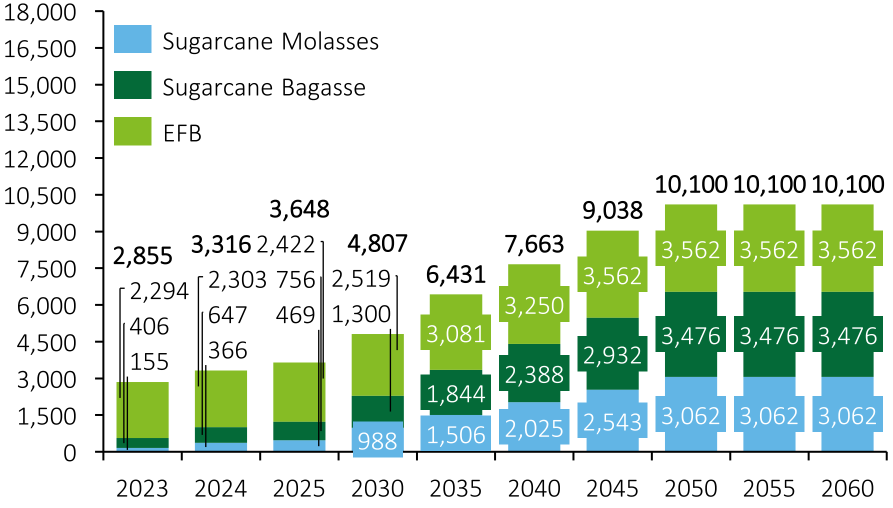
- Accelerate pre-treatment efficiency and simplify production processes to reduce time and costs
- Invest in advanced research and innovations to improve techniques and reduce enzyme costs

2G could be commercialized by 2030 if the government clarifies its policy position on ethanol expansion

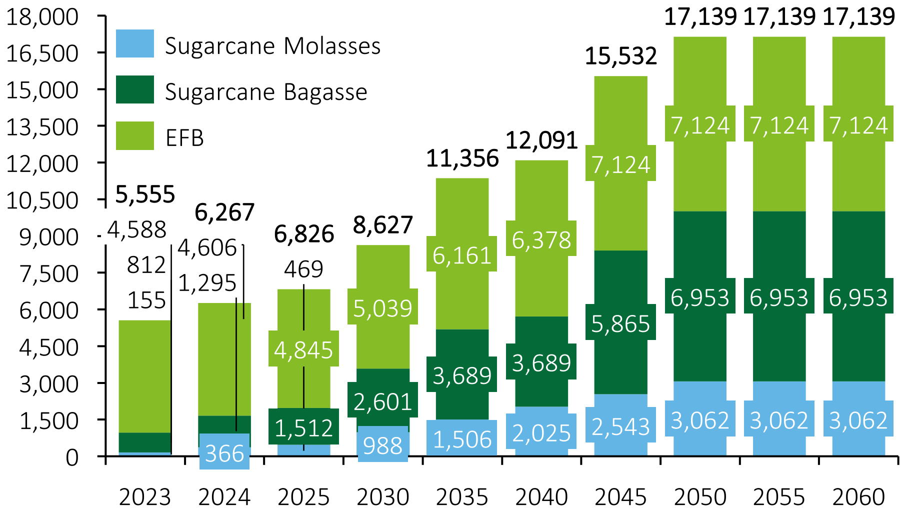
Beyond 2G ethanol from EFB, additional farmland for sugar self-sufficiency (700,000 hectares, 2 million hectares) will provide not only additional 1G ethanol from molasses, but also a significant amount of 2G ethanol from bagasse.

Identification of Potential Feedstock

Conservative scenario (Million Liter)



Maximum scenario (Million Liter)



Molasses	The assumption is that the required amount for existing uses will be kept constant, and any additional molasses expected in the future will be fully allocated to fuel ethanol.	Molasses	← Same as on the left
Bagasse	Assumption that **50%*** of the residues after sugarcane pressing throughout the country will be allocated to fuel ethanol.	Bagasse	Assumption that **100%*** of the residues after sugarcane pressing throughout the country will be allocated to fuel ethanol.
EFB	Assumption that **20%**** of the country's total EFB is allocated to fuel ethanol	EFB	Assumption that **40%**** of the country's total EFB is allocated to fuel ethanol

*Since there is no national target for bagasse use in other industries or for export in Indonesia as of now, the use rates of 50% and 100% are used for the calculation purpose, in detail refer to P71

**Since there is no national target for EFB use in other industries or for export in Indonesia as of now, the use rates of 20% and 40% are set based on the information from BRIN, in detail refer to P82

Sources: *Deloitte Analysis*

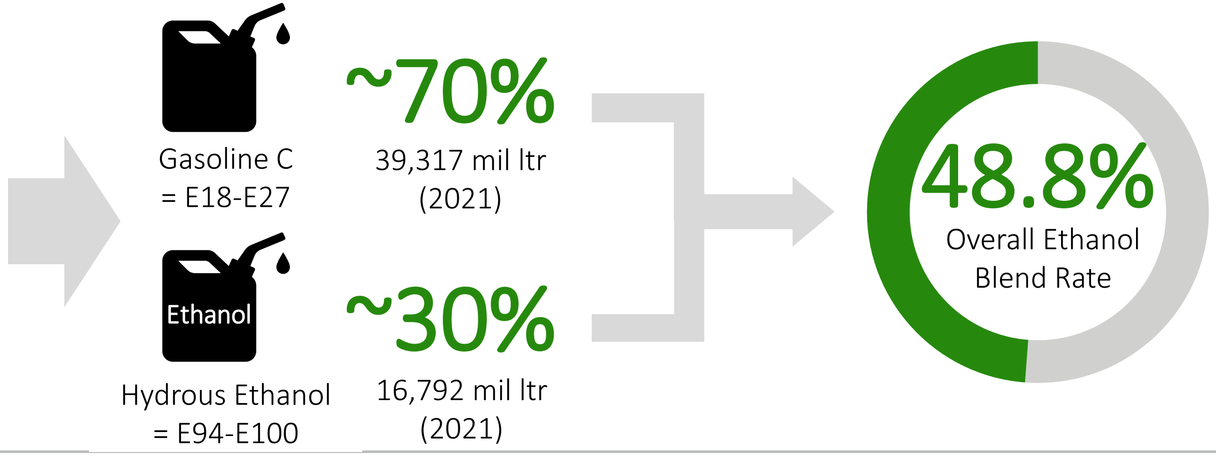
Successes like Brazil's are possible if the government prepares and strongly promotes incentives for private companies like OEMs and consumers to introduce/purchase FFVs as part of its policy toward decarbonization

Expansion of Ethanol Use by FFV Introduction

FFV Penetration in Brazil

Sales share of
Flex Fuel Vehicle
(2022)

~85%



Gasoline C
= E18-E27

~70%

39,317 mil ltr
(2021)

Ethanol

Hydrous Ethanol
= E94-E100

~30%

16,792 mil ltr
(2021)

48.8%

Overall Ethanol
Blend Rate

What is needed to achieve the same success as in Brazil.

Strong Government Support Across Market Participants

- Government involvement drives investment and innovation in new technologies like FFVs
- Pro-Ethanol and FFV policies are essential in addressing entry barriers, including high production costs

Competitive Pricing and State Propaganda

- Lower fuel costs and reduced taxes made FFVs appealing to consumers
- Targeted campaigns effectively communicate the economic and environmental benefits of FFVs, encouraging public adoption

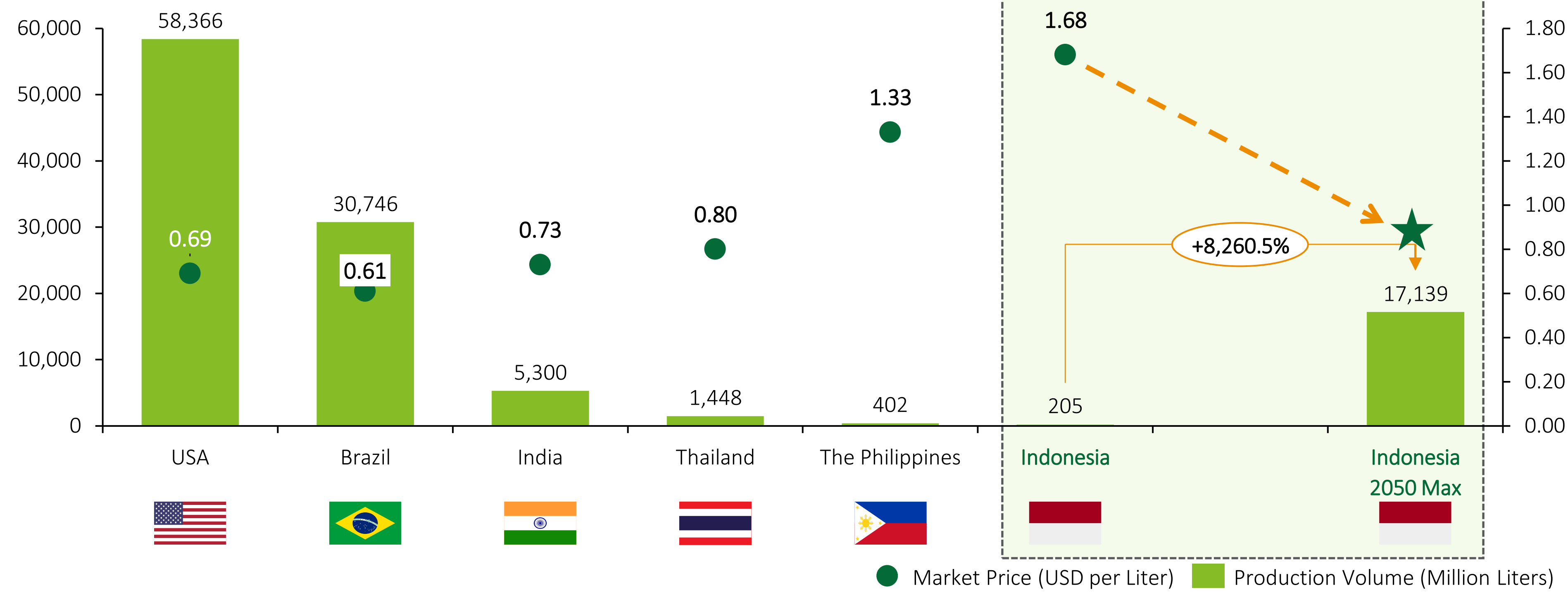
It is necessary to consider cost reduction after examining the ideal portfolio for the entire ethanol industry, including not only the palm oil residue industry but also other feedstocks such as bagasse.

Realization of Reasonable Production Costs

Hypothesis

- The market price of ethanol in Indonesia is high compared to other countries because the volume of ethanol distribution itself is low at this time.
- In the future, when both supply and demand grow significantly, significant reductions in production costs can be expected based on the theory of economies of scale

Cross-Country Ethanol Production Volume and Market Price (2022)



Sources: *1) Source of Data for Ethanol Production is Country Biofuels Report from United States Department of Agriculture, 2) Source for Market Price as follows, USA – US Grains Council, Brazil – Brazil Biofuel Report USDA, India – The Economic Times, Thiland – Krungsi Bank Ethanol outlook, The Philippines – Department of Agriculture, Indonesia – IntraTec Ethanol Prices*

2G Ethanol Commercialization Roadmap

Raizen and GranBio are the leading players in 2G Ethanol, with Raizen currently partnering with Shell, a major oil company, to expand its market

2nd Generation Plants in Brazil

	GranBio enabling NET ZERO	raizen	
Area	Alagoas, Brazil	Piracicaba, Sao Paulo, Brazil	Guariba, Sao Paulo, Brazil
Tech	(2G) AVAP technology	(2G) Iogen Energy's advanced cellulosic biofuel technology	(2G) Iogen Energy's advanced cellulosic biofuel technology
Capacity	• Processed raw material: 400,000 tons /year • Production Capacity: 82 mill ltr ethanol fuel/year	• Processed raw material: 400,000 tons /year • Production Capacity: 40 mill ltr ethanol fuel/year	• Production Capacity: 82 mill ltr ethanol fuel/year
Feedstock	• Corn Stover • Bagasse	• Sugarcane Straw • Bagasse	• Sugarcane Straw • Bagasse
Status	(2014 – Now)	(2014 – Now)	(2023 – Now)
Challenge	• High plant setup cost • Imported materials adding to costly supply chain • Large technology investment prone to replication	• Difficulty in maximizing ROI from large capital expenditure • Cultivation of raw materials that requires additional land management • Lengthy process of technology development suited for 2G Ethanol production	

in collaboration with..

Shell

In a long-term contract until 2037, to buy a total of

3.25-billion-liter

cellulosic ethanol

and to build 3 cellulosic ethanol plants together with Shell

Source: S&PGlobal, Biofuel Digest, Ethanol Producer's Publications, various press releases

Brazilian companies face high production and development costs, along with tariffs from importing countries protecting their domestic E2G industries

Key Challenges on 2G Bioethanol Production

		GranBio	raizen
COST	**Plant Setup**	Requires a total investment of USD 265 million, partially funded by debt from Development Bank	Difficulty in ensuring maximized Return of Investment given large capital expenditure
	Feedstock	• Cultivation of feedstock requires harvesting large plants volume and storing facilities before transporting them to production facilities • Needs for storing and transportation adds to the needs for logistic cost and management	• Cultivation of raw materials including feedstock, requires additional land management • Dependency on crops availability / restrictions, often resulting to volatile feedstock price
	Logistic		
	Supply Chain	Majority of key materials supplied from imports (e.g., Enzymes from Novozymes, Yeast from DSM Holland)	Utilizes enzymes from Novozymes, which operates in a monopoly market, leading to higher prices
	International Trade	Tariffs imposition from importing countries to protect domestic ethanol producers causes Brazilian producers to set higher prices, hence deteriorating competitiveness	
TECH	**Investment**	Investment in 2G-specific technology[1)] prone for duplication by competitors, likely to erode GranBio's competitiveness in the market	Over EUR 100 million (USD 111 million) investment in 2G Ethanol technology development
	Development Period	*Unable to identify*	Lengthy development period, current technology used has been in development for 15 years

***Notes:** 1) GranBio's Technology is specific to 2G, while Raizen's is integrated with 1G production; **Sources:** European Technology and Innovation Platform, Biofuel Digest, Ethanol Producer Magazine, Bloomberg, Reuters, International Energy Agency (IEA), Valor International*

GranBio leveraged debt financing to fund its investment and patented its 2G technology, generating additional income through commercialization and licensing

Key Challenges on 2G Bioethanol Production for GranBio

	COST	*TECH*
Key Challenges	① **High investment cost to set up the plant**	② **Technology investment with likelihood of replication**
Issues *What are the issues identified in 2G Ethanol production?*	• **GranBio's plant required a total investment of USD 265 million** (USD 190 million for plant and an additional cost of USD 75 million for the co-generation system development) • **Costly supply chain with majority of inputs supplied from imports / overseas:** GranBio's facility uses enzymes from Novozymes, and yeast from DSM Holland	• **GranBio is developing a technology dedicated to producing 2G ethanol** (i.e., Raizen's technology is integrated with 1G production) • Replication of this technology by competitors are **likely to erode GranBio's competitiveness** in the market • Despite thorough development, **GranBio acknowledged problems pertaining to pre-treatment** that caused it to change the company's overall production target
Initiatives *What are the measures taken to address the obstacles?*	• **Leveraging debt instrument:** Brazilian Development Bank provided a loan of USD 149 mn (covering ~ 56% of total investment cost) to GranBio for plant construction for bagasse conversion into 2G Ethanol • **High-quality branding of product to justify higher price (from high cost of production):** 2G ethanol produced by GranBio is the cleanest fuel produced on a commercial scale in the world in carbon intensity – 7.55 gCO2/MJ	• **Patenting 2G technology:** Under a partnership with NextChem, an Italian energy transition company, GranBio is co-licensing its technology for 2G ethanol production, **enabling global commercialization and license fee income**

Sources: *European Technology and Innovation Platform, Biofuel Digest, Ethanol Producer Magazine*

Aware of substantial investments and high production costs, Raizen targets customers willing to pay premium price for high quality ethanol

Key Challenges on 2G Bioethanol Production for Raizen

Key Challenges

COST

① High cost of production with uncertain returns / revenues

② Tariff implementation from major importing countries

TECH

③ Long time taken to develop appropriate 2G technology

Issues
What are the issues identified in 2G Ethanol production?

①
- **Enzyme** costs that account for ~ 35 – 50% production cost is **sold under a monopoly market by Novozymes**, often priced higher, further compounding to total costs
- **Cultivation of raw materials** (i.e., quality feedstock) that **requires additional land management**

②
- Growth in 2G industries in importing countries prompts **local governments to impose tariffs on Brazilian ethanol** to protect local producers
- Imposition of tariffs is likely to **deteriorate price competitiveness** of 2G ethanol produced by Raizen

③
- **Long development time** of technology to use for 2G production
- The technology that Raizen uses today **has been in development for over 15 years**

Initiatives
What are the measures taken to address the obstacles?

① ②
- **Sell output under a long-term contract to dedicated buyers:** 91% of the new plant's output is sold under long-term contracts with global energy players (including Shell) hence **providing security** to produce as it secures revenues
- **Focus on customers willing to pay premium, and pass high costs to price charged:** Confident on its quality and demand, Raizen is currently **selling their 2G ethanol at a 70% premium** compared to conventional ethanol
- **Raizen sources raw materials efficiently** by utilising existing land without the need to increase the area under cultivation

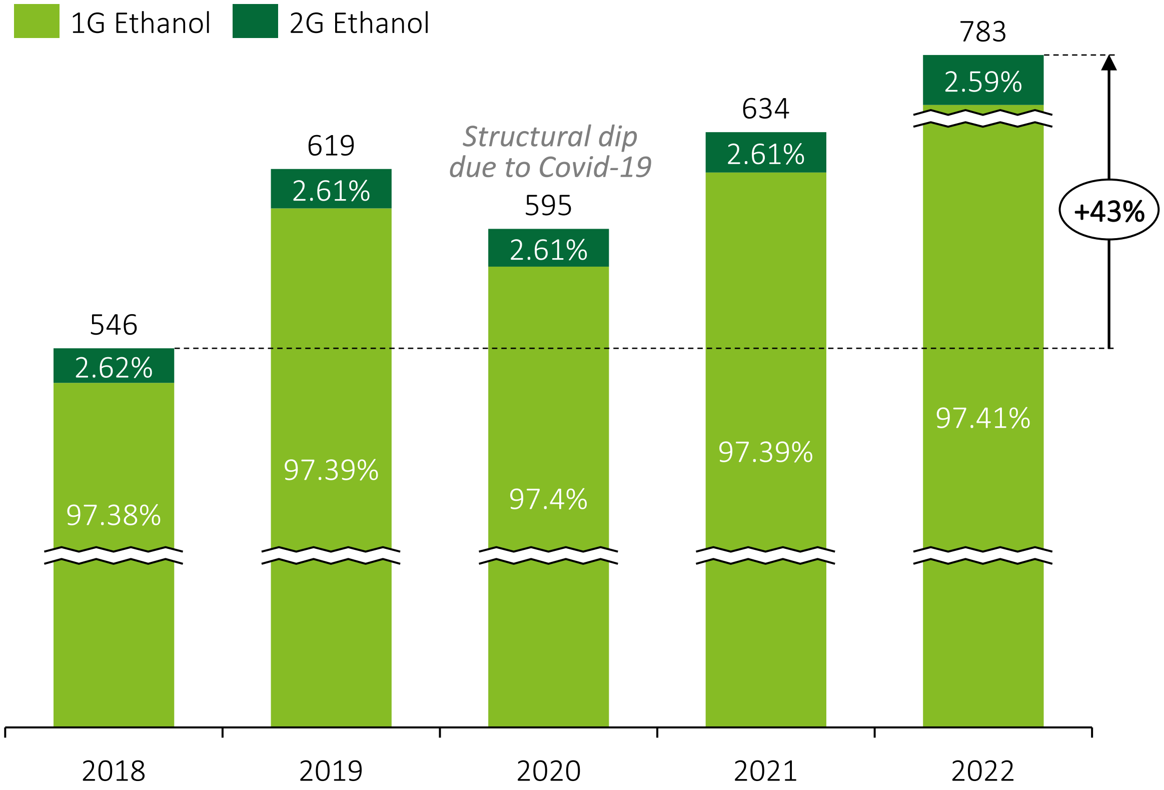
③
- **Optimize investment** by **building multiple plants** and increasing production capacity, **leveraging the same technology**
- **Partner with leading player to deliver best-practice tech:** Raizen uses technology developed by Logan Energy to convert bagasse into ethanol

Sources: *Bloomberg, Reuters, International Energy Agency (IEA), Valor International, Biofuel Digest*

For 5 years, 2G Ethanol remained < 3% of the Indian ethanol market, likely due to cost and technology constraints limiting its scalability compared to 1G production

Market Share of 1G vs 2G Ethanol in India

India Bioethanol Market Value by Type (in Million USD)



Observations on 2G Ethanol

- Despite a 43% total growth over 5 years, **share of 2G remains unchanged and limited at ~ 2.6%**
- **Cost and technology constraints have hindered the development of 2G** ethanol to increase its penetration in the market

Major Industry Challenges

- High Plant Investment
- High Feedstock Costs
- Lack of Infrastructure
- Complex Supply Mechanism
- Lengthy & Advanced Technological Innovations

2G accounts for less than 3% of the Indian ethanol market

Sources: *EMIS Intelligence, CoherentMI Asia Pacific Intelligence Centre*

2G Ethanol plants in India utilise rice straw as feedstock, producing ~ 30 million liters annually, with major companies collaborating with Praj Industries for technology

2nd Generation Plants in India

	IndianOil	Bharat Petroleum
Area	Panipat, Haryana	Bargarh, Odisha
Tech	Enzymatic Ethanol Technology, by Praj	Enzymatic Hydrolysis, by Praj
Capacity1)	• Processed Raw Material: 150,000 tons per year • Production Capacity: 36.5 mn ltr 2G Ethanol per year (0.1 mn ltr per day)	• Processed Raw Material: 178,120 tons per year (488 tons per day) • Production Capacity: 30 - 36.5 mn ltr 2G Ethanol per year (0.1 mn ltr per day)
Feedstock	Rice Straw	Rice Straw (12% Moisture)
Status	2022 – Now	2020 – Now
Challenge	• Uncertainty in securing sufficient feedstock amount at competitive price • Extensive logistics management for 2G Ethanol production	• High expenditure for plant set up, estimated to cost 5 times more expensive than 1G plant development • Limited capability to develop end-to-end technology in-house

Both companies are collaborating with Praj Industries as the technology licensor

Key Features of Praj's 2G Technology:

- Wastewater management for Zero Process Liquid Discharge
- Provides E2E offering from feedstock processing until end-product and waste treatment
- Capability to process multiple feedstock (e.g., rice straw, EFB,)
- Multi-production capability, designed to produce 2G Ethanol, Biogas, etc.
- Process integration for energy optimisation

***Notes:** 1) Assuming that a year has 365 days; **Sources:** Indian Oil Company Website, Praj Industries Company Website, Business Standard Economy, The Hindu Business Line, Energy EC Europe*

Internal Survey

Indian companies face challenges with feedstock acquisition and logistics costs, as well as struggles with technology development capabilities

Key Challenges on 2G Bioethanol Production

		IndianOil	Bharat Petroleum	praj
COST	**Plant Setup**	• Profitability for 2G Ethanol production not yet established • Petrol price lower than cost of blending ethanol	• Setup delays due to high capital constraints • 2G plants estimated to costs 5x more than 1G plants	*Not Available. As a company that primarily provides licenses and on-demand services for 2G production, costs are charged to customers based on the services provided.*
	Feedstock Acquisition	• Concern in securing enough rice straws at competitive price • Due to seasonal availability, Indian Oil requires a large acres of land to store feedstock	Scarce availability compared to 1G feedstock, hence often comes at higher price, which adds to cost	
	Logistics	• Requires multiple parties to handle logistics, adding to logistics costs	*Unable to identify*	
TECH	**Investment Size**	*Unable to identify*		• Focuses on providing technology, hence must heavily invests in R&D and innovation • Praj invests up to USD 30 million for its in-house R&D alone • Deploys > 90 technologists that adds to operational costs
	Capability	• Due to complex nature of the technology, companies tend to not have the capability to develop 2G Ethanol technology by themselves • Indian companies leverage external technology providers to overcome this		

Sources: *The Print India, Economic Times Energy India, Bharat Petroleum Company Website, Environment Clearance India, Bioenergy International, Prajhi Purity*

IOCL prioritises securing competitively-priced feedstock and leverages Praj's technologies, with a government grant covering ~21% of the total investment cost

Key Challenges on 2G Bioethanol Production for IndianOil (IOCL)

	COST			TECH
Key Challenges	① **Feedstock acquisition to meet production target**	② **Management of logistics and land acquisition**	③ **Profitability not yet established**	④ **Limited capability to develop own technology**
Issues *What are the issues identified in 2G Ethanol production?*	• **IOCL requires 2.1 lakh1) tons of rice straw** per year to produce ~ 100 kilo liters per day • While bulk purchase offers price advantage, **concern is securing enough rice straw at competitive price**	• **Feedstock is seasonal;** to store 1 year worth of feedstock requires 150 - 200 acres of land • **IOCL lacked 100 acres** for storage **but secured only ~56 acres** from the local government	• **Cost of ethanol** that is blended in petrol remains costlier **than the selling price of petrol** • Therefore, **price competitiveness remains low** for customers to entirely shift to ethanol	• Despite continued expansion in R&D, IOCL is **not able to deploy an in-house 2G technology** due to its complex nature
Initiatives *What are the measures taken to address the obstacles?*	• **Locating plants within proximity to rice straw producers:** Currently, a 50 km radius yields 8.9 lakh MT of rice straw annually, which meets IndianOil's quantity demand • **Building close relationship with local farmers** to ensure easier coordination for feedstock purchase • **Deploying a network of aggregators** including farmer producer organisations (FPOs), truck drivers, depot managers and contractors **to manage the logistics** • **Expanding 3 depots outside of plant premises** for storage		• **Partnership and cost sharing:** IOCL and Praj agreed to form an alliance to share costs in the development of three 2G ethanol plants • IOCL also **received USD 18 mn from the government,** covering 21% of its total investment cost2)	• IOCL **selected Praj Industries as the licensor and consultant** for their 2G production in Panipat • The **project is based on Praj's proprietary technology** to process Rice Straw as feedstock for Ethanol

Notes: *1) Lakh = hundred thousands; 2) Out of total investment cost of USD 85 million;* ***Sources:*** *The Print India, Economic Times Energy India*

BPCL secures revenues by using its ethanol in the company's petroleum mix, while government assistance covers only about 9% of its total investment cost

Key Challenges on 2G Bioethanol Production for Bharat Petroleum (BPCL)

	COST	*TECH*
Key Challenges	① **Extremely high cost of production for setting up and operating a 2G Ethanol plant**	② **Limited capability to develop own technology**
Issues *What are the issues identified in 2G Ethanol production?*	• BPCL is **in the process of setting up three 2G Ethanol Bio-Refineries** in the states of Odisha, Madhya Pradesh and Maharashtra, but **high capital expenditure remains a constraint** • BPCL estimated that setting up a **2G plant costs 5x more than a 1G plant**	• Due to the complex nature of the required technology, BPLC is **not yet able handle and develop its technology-related needs in-house**
Initiatives *What are the measures taken to address the obstacles?*	• **Securing revenue stream through internal utilization:** The entire product will be used internally by BPCL for the fuel blend (Motor Spirit) and **will not be sold to any retail customer**, ensuring income to cover set-up and production costs • **Utilising government's financial assistance:** The government's financial assistance of USD 18.3 million helps cover 9% of BCPL's USD 197 million investment	• **Partner with existing 2G ethanol technology provider:** BPCL selected Praj as technology partner for the set up and operationalisation of its 2G plant in Odisha • **Partnership with Higher Education Institution for R&D needs:** BPCL signed an agreement with Odisha University of Agriculture and Technology to set up a "Biofuel Chair", specific to conducting R&D on 2G ethanol

Source: *Bharat Petroleum Company Website, Environment Clearance India, Bioenergy International, Economic Times, India Times*

Praj sells licenses for its 2G Bioethanol technology to major Indian producers to offset high R&D and innovation costs

Key Challenges on 2G Bioethanol Production for Praj Industries

Key Challenges	*COST*	*TECH*
	1 *Unable to identify*	2 **Substantial investment size to develop the 2G Bioethanol technology (Enfinity)**
Issues *What are the issues identified in 2G Ethanol production?*	*As a company that primarily supplies technology license and other on-demand service for 2G production, costs are charged to the customers based on the services provided*	- Praj **primarily focuses on providing technology solutions**, hence must heavily invest in innovation for its products - **Investment Size:** Until 2021, Praj has invested **up to USD 30 million in its in-house R&D** - **Human Resources Costs:** Currently hiring > 90 technologists, with plans to expand further to meet the evolving technological landscape and trends
Initiatives *What are the measures taken to address the obstacles?*		- **Praj survived the 2G business by licensing its technology to other producers,** despite high investment costs - Currently, **4 Indian companies are using the Enfinity license,** including BPCL[1], IOCL[2], HPCL[3], and MRPL[4]

Notes: *1) Bharat Petroleum Company Limited, 2) Indian Oil Company Limited, 3) Hindustan Petroleum Corporation Limited; 4) Mangalore Refinery and Petrochemicals Limited*

Sources: *European Commission Energy, Prajhi Purity*

BRIN runs a pilot plant for 2G ethanol production with Korean institutions and demonstrates ongoing involvement through various domestic and global partnerships

Current Development of 2G Production by BRIN

Overview of BRIN's 2G Bioethanol Development

Key Development

- Under a partnership with KOICA, and KIST, BRIN **established a Pilot Plant for 2G Bioethanol production** in Serpong, South Tangerang
- As of 2022, the production of 2G Bioethanol has **achieved a purity level of over 99.6%, qualifying it as fuel-grade**
- **Palm oil residue used as the primary feedstock**, with other types of feedstock under continued development

KOICA
Korea International Cooperation Agency

KIST
Korea Institute of Science and Technology

BRIN's 2G Ethanol Pilot Plant in Serpong, South Tangerang

Other Development

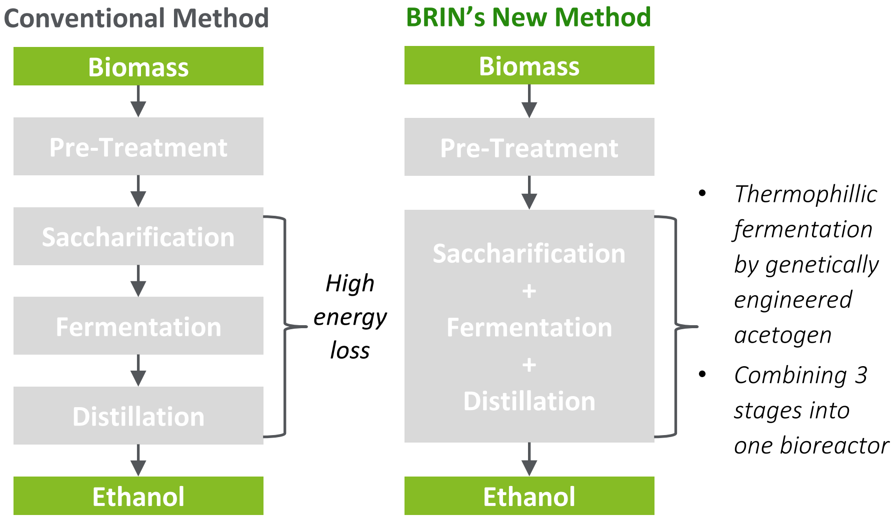
- Started **partnership with PT Bukit Asam** to study coal use for ethanol production as part of government's NZ 2060 strategy
- Received **R&D grants from Japan International Collaboration Agency (JICA)** for material development for 1G ethanol production

Source: *BRIN's Publications, Kumparan Indonesia*

Key Challenges

1 Lengthy Production Time, Due to Difficulty of Ethanol Fermentation

- Biomass is converted through **long stages and process,** which are considered **less effective and causes high production costs**



Conventional Method

Biomass → Pre-Treatment → Saccharification → Fermentation → Distillation → Ethanol

High energy loss

BRIN's New Method

Biomass → Pre-Treatment → Saccharification + Fermentation + Distillation → Ethanol

- *Thermophillic fermentation by genetically engineered acetogen*
- *Combining 3 stages into one bioreactor*

2 Limited Feedstock Availability from Competing Use of Palm Oil Waste

- To expand feedstock sources, BRIN is developing a **new variety of sorghum** with enhanced durability against rotting
- This project is under a collaboration with a Japanese firm (unidentified), **expected for release in 2025**

Pertamina is currently evaluating the construction of a 50 KTA bioethanol plant using Empty Fruit Bunch (EFB) as feedstock

Current Development of 2G Production by Pertamina

Overview of Pertamina's 2G Bioethanol Plant

Production

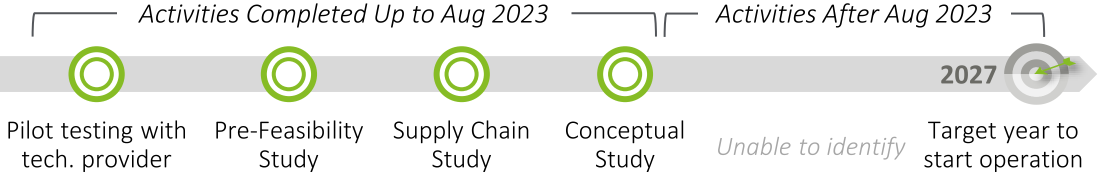
Capacity

50 KTA[1)]

Feedstock

- Main Feedstock: Palm Oil Residues, especially Empty Fruit Bunch (EFB)
- Rationale: Aims to tap into the potential of palm oil biomass in Indonesia

Milestone & Timeline



Location

- The plan is to build the production facility in the **Special Economic Zone of Sei Mangkei**, North Sumatera
- Possibility for other areas with availability of raw materials and infrastructure

Acquisition Plan in the Bioethanol Space

- The president has instructed Pertamina to **acquire a Brazilian Bioethanol company,** currently in <u>**due diligence**</u>
- Transaction is expected for **completion in 2 to 3 years** (~ by 2027)

Objectives of Acquisition

- To **secure bioethanol and sugar supplies**
- To **promote alternative energy sources** other than fossil fuels
- *"To **expand overseas and boost profit** based on future economic and business outlook"* – President of Indonesia

Key Challenges

1 High Cost of Production

- Due to high production costs, ethanol has **lower competitiveness** in the market when sold as end-product (i.e., fuel)
- To tackle this, **integrated partnership** must be established **between related ministries with key players in the automotive sector**

2 Limited Feedstock Availability

- **Competing uses** for palm oil residues
- Only **~32% of palm oil residues in Indonesia can be used** without causing damages to land

3 Limited Penalties and Subsidies

- Currently, there are **no applicable penalty and/or subsidy schemes** for bioethanol programmes – therefore, **limiting the development and expansion of production capacity** at scale

Notes: *1) Kilo Tons per Annum;* ***Source:*** *Pertamina's Presentation for the Association of Indonesian Motor Vehicle Industries (GAIKINDO), CNBC Indonesia, Indonesia Times, Jakarta Globe, International Council on Clean Transportation (ICCT)*

In India, 2G Ethanol is gaining momentum as driven by growth factors, but also facing significant challenges that require strategic navigation

Drivers and Challenges in 2G Ethanol Development in India (1/2)

🟢 Driver 🔴 Challenges

Parameter	Insights	Status
Pricing	Formula for 1G Ethanol price based on ethanol conversion factor of feedstocks and their prices in the market	🔴
	Differential pricing for 2G Ethanol as compared to 1G Ethanol is not being considered by the government in the future	🔴
Ethanol Supply	The government currently has no plans for providing any preferential treatment for 2G Ethanol manufacturers	🟢
	The ethanol supply shortfall is being planned by the government to be bridged through both 1G Ethanol (alternate sources) and 2G Ethanol	🔴
Export Control	Export for ethanol is banned, and only allowed under specific conditions	🟢
Incentives for Private Companies	Viability Gap Funding (VGF) will be provided to 12 commercial projects for setting up 2G Ethanol plants	🔴
	Government is open to private sector participation and VGF funding to project proponents	🟢
Mechanism for Feedstock Collection	A mature Agro waste aggregation market doesn't exist in the country	🔴
	Government may support private companies indirectly through institutions such as NABARD / Self Help Groups, etc.	🟢
	Collaboration between central and state governments for feedstock collection to supply ethanol manufacturers does not exist	🔴

Sources: *Deloitte India, Asia Pacific Centre of Excellence for Sustainability and Climate*

Government bodies, producers, and regulators are working together to address challenges, aiming to bridge gaps and position India as a global leader in bioethanol

Drivers and Challenges in 2G Ethanol Development in India (2/2)

🟢 Driver 🔴 Challenges

Parameter	Insights	Status
Feedstock	True feedstock costs for 2G Ethanol not known with certainty	🔴
	Supply Chain for feedstock procurement for 2G Ethanol production is not well-established	🔴
Transport	Inter-state movement of alcohol creates hindrances	🔴
Long-Term Procurement Cost	The long-term contracting policy (contact of 5 years) been introduced by the government for long term offtake guarantee against capital expenditure invested by companies.	🟢
Overall Cost	Estimated total cost of production for setting up and operating a 2G ethanol plant is extremely high	🔴
Green/ Renewable Certificates/ Carbon Credits for Bio-Refinery	Carbon credits can be claimed by the project proponent, but at present there is no structured market in India for carbon trading, with just the draft version of carbon credit framework released, as of now	🔴
	Even though Green/ renewable certificates can be purchased (implying that the power consumption in bio-refinery needs to be generated from renewable electricity), there is no policy about carbon credits/ green certificates which are specifically related to bio-refinery projects	🔴

Sources: *Deloitte India, Asia Pacific Centre of Excellence for Sustainability and Climate*

In India, technological challenges in 2G production mainly stem from the limited availability of technology licenses available at commercial scale

Technology Challenges in 2G Ethanol Development in India

Key Technological Challenges for 2G Ethanol Production

Commercial scale operation of 2G Ethanol process is only available for one technology licenser and others have demo or pilot scale experience

Higher Cost of Production: The cost of ethanol production from lignocellulosic biomass is higher than first generation ethanol, there is a need for subsidy for economic viability and competitive ethanol pricing

Commercial availability of lignin boiler: Lignin is recommended to be used as fuel in boiler and therefore the commercial availability of such applications need to be ascertained

Commercial experience of pretreatment is not available: Pretreatment forms a critical section that separates the 1G and 2G technologies

Availability of biomass: Biomass availability is dependent on proper pre-planning and essential to build the ecosystem for ensuring biomass supply

Biogas and CO_2 utilization: Finding the right consumer and/or disposal of Biogas and Co2 produced from 2G technology remains an open issue

***Sources:** Deloitte India, Asia Pacific Centre of Excellence for Sustainability and Climate*

High investment, costly production, competing feedstock demand, and a complex market structure are the key challenges in 2G market development in Indonesia

Challenges of 2G Ethanol in Indonesia

Key Challenges

High Investment Size to Scale Production with Uncertain Investment Commitment

- To commercialise production, institutions need large investment size compared to current lab-scale production
- In the short to medium term, funding for 2G Ethanol plants from private and public sector at a commercial scale is still emerging
- Private sector investors, in particular, still have limited confidence in the commercial viability of 2G Ethanol technology

High Production Cost Resulting to Uncompetitive Selling Price

- Processing biomass for 2G Ethanol takes longer, especially during fermentation, which ultimately compounds to overall production time and costs compared to 1G Ethanol
- In 2022, 2G Ethanol production costs were IDR 17,000/L, higher than the sugarcane-based ethanol selling price of IDR 12,000/L
- Ideally, 2G ethanol costs should be lower due to cheaper feedstock, but remain high due to technological limitations

Competing Use Impacting Feedstock Availability

- EFB as the primary residue geared for 2G Ethanol development, is gaining interest as a feedstock for other uses in Indonesia
- For example, state-owned utilities plan to use EFB for co-firing, while a renewables SOE targets it for biofuel ethanol, leading to competition and scarcity at scale
- Currently, biomass costs make up 30% of 2G production costs, but are expected to rise due to growing demand

Complex Ethanol Market in Indonesia

- High reliance on cheaper fossil fuels remains a significant barrier to the adoption of 2G Ethanol
- Despite efforts to promote biofuels, fossil fuels dominate the market due to their affordability and established infrastructure, making it challenging for 2G Ethanol to compete on both price and accessibility

Sources: *Experts Interviews*

Reducing 2G production costs can be achieved by streamlining logistics, enhancing feedstock supply through partnerships, and driving innovation in technology

Potential Cost Reduction Approaches for 2G Ethanol in Indonesia

Streamline Logistics Chain

- **Optimize Plant Location:** Locate bioethanol plants closer to the market rather than near palm oil extraction sites. This reduces transport and logistic costs, improving overall cost-efficiency
- **Localize Downstream Facilities:** Given that most bioethanol is shipped to Java, establishing downstream facilities near key markets on the island can further cut transportation costs and improve overall supply chain efficiency

Enhance Feedstock Acquisition Through Strategic Partnership

- **Secure Cost-Effective Feedstock:** Leverage strategic partnerships to ensure a reliable supply of feedstock at reduced prices, addressing the high contribution of feedstock and processing cost to overall production
- **Strengthen Supply Relationships:** Establish agreements that improve feedstock availability and pricing, which directly impacts overall production costs and supports a more stable supply chain

Improve Pre-Treatment Process

- **Accelerate Pre-Treatment Efficiency:** Focus on reducing the duration of the pre-treatment process to lower overall production time and costs for 2G Ethanol – Enhancing pre-treatment speeds up process and reduces operational expenses
- **Invest in Advanced Research:** To tackle this bottleneck, more researches have been deployed to improve the techniques to manage and treat palm oil residues

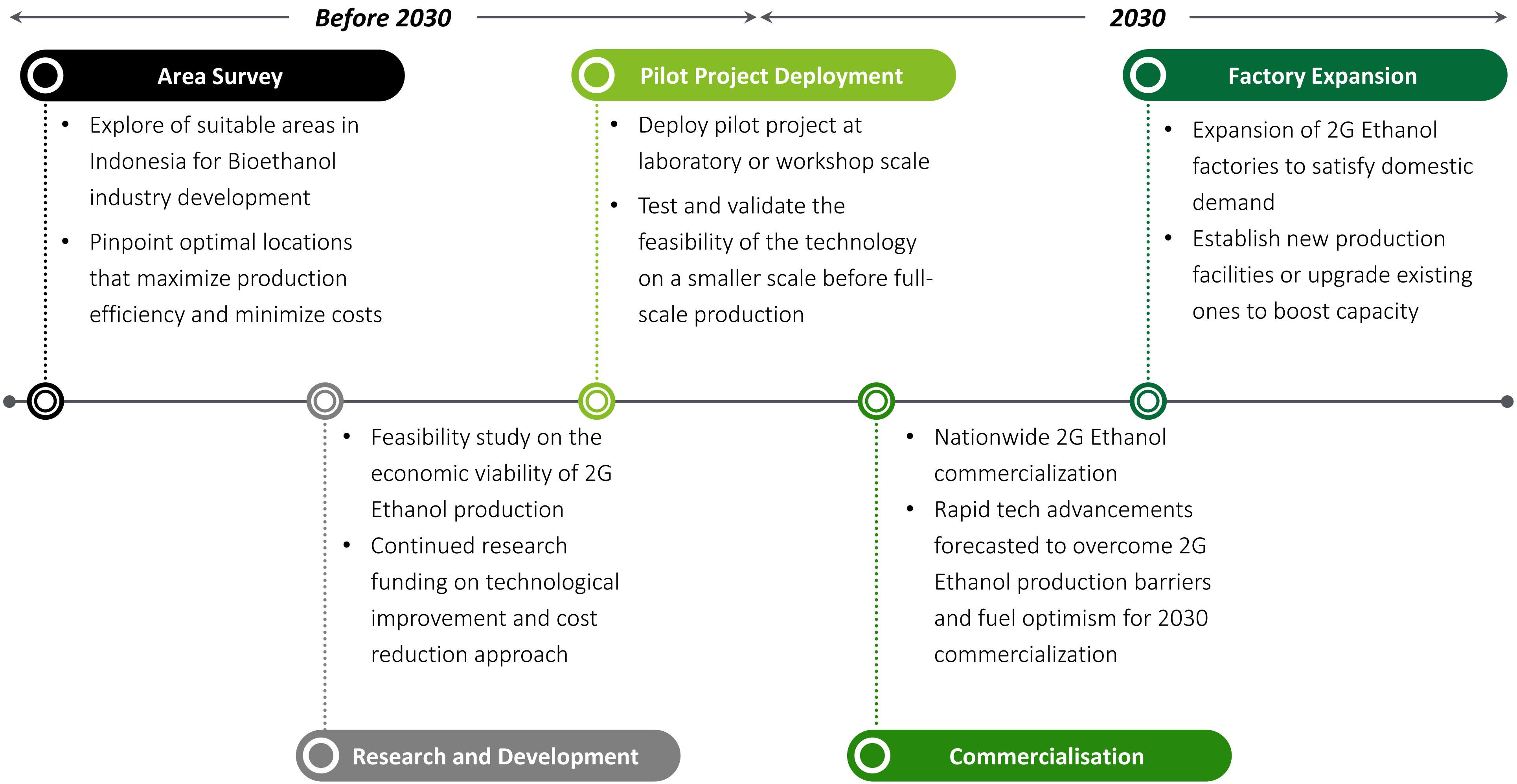
Optimize Technology Through Innovation

- **Simplify Production:** Process for 2G is relatively lengthier and much more difficult, requiring technological innovations to make it faster and more efficient
- **Reduce Enzyme Costs:** Enzyme costs are a significant expense in 2G Ethanol production. Investing in innovations that enhance enzyme efficiency and availability can greatly reduce overall production costs

Sources: *Experts Interviews*

2G Ethanol is expected to be commercialised nationwide by 2030, driven by anticipated tech breakthroughs that could overcome key production barriers

Roadmap Towards 2G Ethanol Commercialisation



Before 2030

2030

Area Survey

- Explore of suitable areas in Indonesia for Bioethanol industry development
- Pinpoint optimal locations that maximize production efficiency and minimize costs

Research and Development

- Feasibility study on the economic viability of 2G Ethanol production
- Continued research funding on technological improvement and cost reduction approach

Pilot Project Deployment

- Deploy pilot project at laboratory or workshop scale
- Test and validate the feasibility of the technology on a smaller scale before full-scale production

Commercialisation

- Nationwide 2G Ethanol commercialization
- Rapid tech advancements forecasted to overcome 2G Ethanol production barriers and fuel optimism for 2030 commercialization

Factory Expansion

- Expansion of 2G Ethanol factories to satisfy domestic demand
- Establish new production facilities or upgrade existing ones to boost capacity

Sources: *Experts Interviews*

The following drivers are crucial to address key challenges and accelerate the national commercialization of 2G Ethanol in Indonesia

Assumed 2G Roadmap

Key Challenges in 2G Ethanol

High Investment Size with Uncertain Commitment

High investment requirements and limited confidence in 2G Ethanol's commercial viability are hindering large-scale funding from private and public sectors

Costly Production Resulting to Uncompetitive Price

High production costs, driven by longer processing times and technological limitations, make 2G Ethanol less competitive, with costs exceeding 1G price

Competing Feedstock Use Limiting Availability

Competing uses for EFB in Indonesia, the primary 2G feedstock, are driving up demand and costs, while also limiting its availability for ethanol

Complex Domestic Ethanol Market

The dominance of cheaper fossil fuels and limited infrastructure poses a major barrier to the adoption and competitiveness of 2G Ethanol in Indonesia

Drivers to Address Issues

Funding Support and Incentives

- Increase project funding and support, offer low-interest loans, and waive import tariffs for 2G ethanol production
- Implement a regulated pricing tier for 2G ethanol to encourage investment and commercialization

Enhanced Supply Chain and Logistics

- Optimize plant locations and establish downstream facilities near key markets to reduce transportation costs
- Secure cost-effective feedstock through strategic partnerships and strengthen supply relationships to improve efficiency

Innovation and Technology

- Accelerate pre-treatment efficiency and simplify production processes to reduce time and costs
- Invest in advanced research and innovations to improve techniques and reduce enzyme costs

Based on the interviews, it is assumed that if the Indonesian government can implement and provide policy position on the necessary drivers, 2G Ethanol commercialization is expected to be realized by 2030

Suggestion

Growth in 2G Ethanol will be driven by ecosystem development and policy advocacy, expected to catalyst a shift towards financially sustainable production

Growth Drivers for 2G Ethanol Sector

Ecosystem Development

Supply Chain
Feedstock sourcing, transportation and storage infrastructure need improvement for better project economics

Feedstock Availability
Ensure year-round biomass availability, as current supply is limited to a few months due to the agricultural cycle (seasonal availability)

Technology Maturity
Limited options are available for commercial scale operation of 2G ethanol process. Also, while technical feasibility has been demonstrated, lowering the cost to 1G ethanol seems difficult

Policy Advocacy

Distinct Pricing
Introduce a distinct pricing tier for cellulosic 2G ethanol, establishing a regulated price point positioned above that of 1G ethanol

Funding Support
Enhance the scope and magnitude of support program by augmenting funding per project and expanding the number of projects supported

Financial Incentives
Introduce supplementary financial incentives, such as offering low-interest loans to cellulosic ethanol producers and waiving import tariffs on equipment, chemicals, and enzymes utilized during production

Sources: *Deloitte India, Asia Pacific Centre of Excellence for Sustainability and Climate*

Suggestion

Potential funding options to incentivise 2G Ethanol production include government revenue, debt instruments, PPPs, and carbon credit trading schemes

Funding Mechanisms to Incentivise 2G Ethanol Production

Government Revenue Sources

Revenue from Excise Duties, Taxes

The government may generate revenue from excise duties and taxes levied on ethanol production and sales. A portion of these revenues can be reinvested in supporting ethanol production initiatives, including subsidies, incentives, and infrastructure development

National Budget Allocation

The government allocates funds from the national budget to support ethanol production programs. These funds may be earmarked under different ministries such as the Ministry of Petroleum and Natural Gas, Ministry of Agriculture, Ministry of Environment, Forest and Climate Change, or Ministry of Finance, depending on the specific objectives and priorities of the programs

Borrowing and Debt Instruments

International Financing Institutions

The government can seek funding from international financing institutions such as the World Bank, Asian Development Bank (ADB), International Finance Corporation (IFC), and bilateral development agencies for ethanol production projects. These institutions offer loans, grants, and technical assistance to support renewable energy and climate change mitigation initiatives in developing countries

Other Mechanisms

Public-Private Partnerships (PPPs)

The government can leverage private sector investment through PPPs to finance ethanol production projects. PPPs involve collaboration between the government and private sector companies to co-finance, develop, and operate ethanol production facilities

Carbon Credit Trading Scheme

Ethanol production projects may generate carbon credits and Renewable Energy Certificates (RECs), which can be monetized through trading on domestic or international markets. The government can facilitate the issuance, trading, and monetization of carbon credits and RECs to generate additional revenue for ethanol producers and incentivize sustainable production practices

Sources: *Deloitte India, Asia Pacific Centre of Excellence for Sustainability and Climate*

Identification of Potential Feedstock Including Collection Methods

Six palm oil biomasses can be utilised as feedstock for ethanol production, with further possibilities for conversion into other derivative products

Potential Palm Oil Biomass in Indonesia

Palm Oil Residues	**Description**	**Potential End Product** *(Non-Exhaustive)*					**Potential Energy Generated (TJ/Year)**[1]
		Ethanol	**SAF**	**Solid Fuel**	**Fertillisers**	**Paper Pulp**	
 **Empty Fruit Bunch (EFB)**	Residues from palm bunch sterilization and fruit removal in CPO production	✓	✓	✓	✓	✓	152,000
 **Oil Palm Trunk (OPT)**	Solid wastes obtained after the felling oil palm trees, available year-round in large quantities	✓	*Likely possible from ethanol, but no studies have indicated SAF production from these feedstocks*	✓	✓	✓	260,000
 **Oil Palm Frond (OPF)**	Decomposed oil palm residues, mainly used for soil conservation and erosion control	✓		✓	✓	✓	1,227,000
 **Palm Kernel Shell (PKS)**	Shell fragments left after palm kernels are removed and crushed in the palm oil mill	✓		✓	✓		110,000
 **Mesocarp Fibre (MF)**	Biomass residue generated after extracting oil from palm fruits	✓		✓		✓	133,000
 **Palm Oil Mill Effluent**	Wastewater from the mill's crude palm oil extraction process	✓	✓		✓		40,300

Notes: *1) Indicates the potential energy that can be generated from residues as feedstock;* ***Sources:*** *National Energy Council of Indonesia (Dewan Energi Nasional), Press Releases, Journals*

To estimate the feedstock conversion rate, various publications were reviewed to derive the approximate yield values across each production process

Summary of Conversion Ratio Inputs Across Journals

Feedstock	Source	Cellulose Content	Cellulose to Glucose	Glucose to Ethanol
 **Empty Fruit Bunch (EFB)**	Journal 1	44%	60.02%	88.44%
	Journal 2	28 – 41%	41 – 79%	-
	Journal 3	43.9%	76%	78.9%
	Journal 4	44.08%	84.44%	56.96 – 79.09%
 **Oil Palm Trunk (OPT)**	Journal 5	56%	80%	-
	Journal 6	80.74%	93.22%	-
	Journal 7	29.41%	-	-
	Journal 8	43.5%	-	-
 **Oil Palm Frond (OPF)**	Journal 9	-	-	48%
	Journal 10	33%	84 – 100%	-
 **Mesocarp Fibre (MF)**	Journal 11	26.1%	-	-
	Journal 12	25 – 28%	63 – 97%	-

Sources: *Various Journals and Publications*

Key obstacles in feedstock acquisition include low farmer awareness, suboptimal production, inadequate infrastructure, and high competing uses that increase prices

Challenges Observed in Feedstock Acquisition

1

Lack of Regulation and Awareness of Palm Oil Residue Use

- **No formal clarification on the legality** of using palm oil residue for ethanol
- **Limited socialisation and education to independent farmers** on proper residue management has caused most wastes to be burnt down rather than preserved and collected as feedstock

2

Suboptimal Production by Small to Medium-Sized (SM) Palm Oil Farmers

- **Lower productivity by SM-sized farmers ultimately limits available residues** to utilise
- Unlike industrial-sized producers, the use of inferior seeds and involvement of intermediaries / middlemen experienced by **smaller farmers has resulted to lower income, forcing them to diversify to other crops**

3

Inadequate Infrastructure and Facilities to Enable Efficient Supply Chain

- **Lack of interconnection, especially in rural areas** where most palm oil plants are located, hinders biomass transfer from farmers to factories
- **Major logistics components$^{1)}$ are interdependent and should be planned from a chain perspective** rather than separately to achieve a cost-effective biomass supply

4

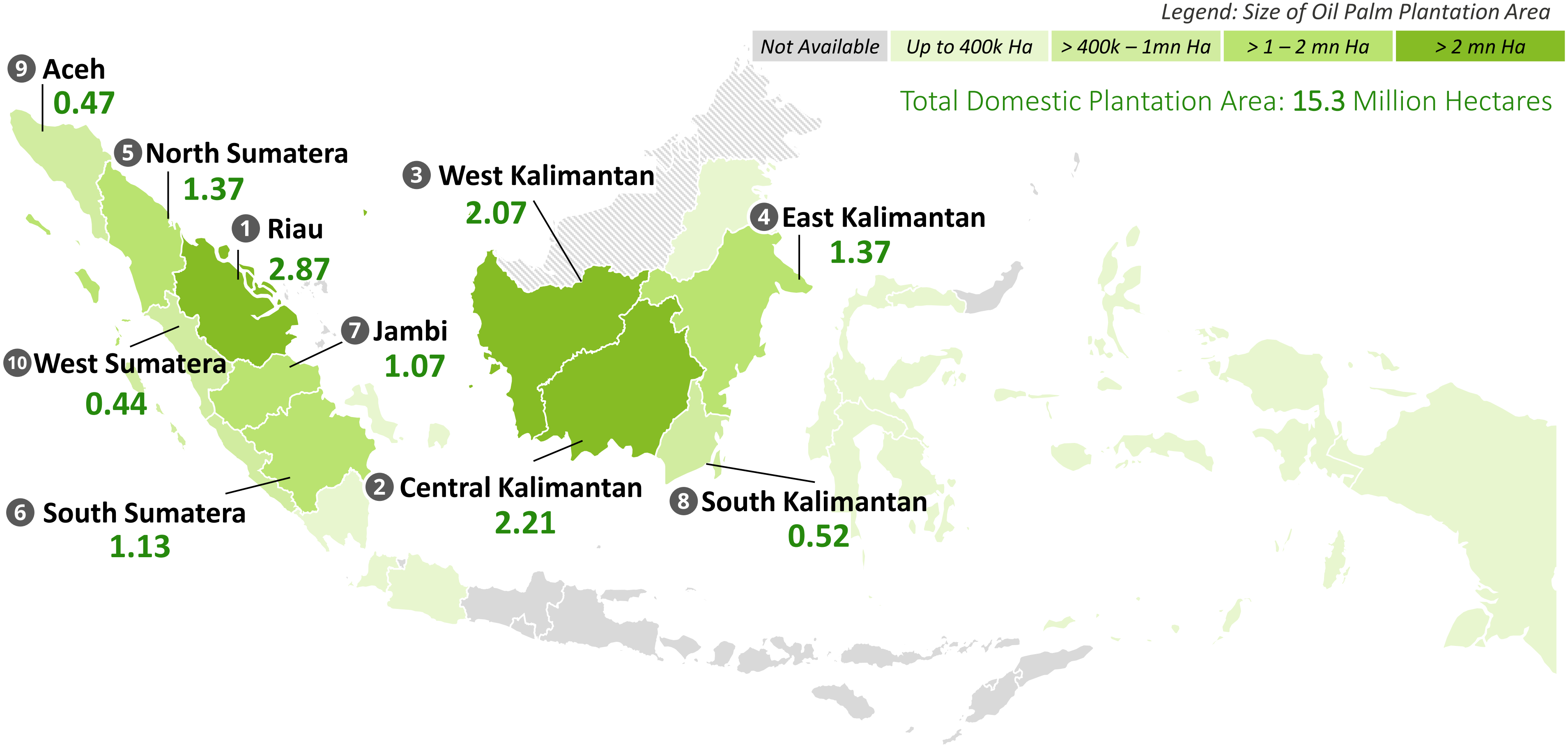
Higher Feedstock Prices Due to Growing Demand

- **Given continued competing uses** (e.g., food, FMCG, gasoline, etc.) of palm oil residues, **demand is pushing the supply limits, with high prices likely to cause a supply crunch**
- **The global shift towards biofuel consumption has also driven up export demands**, which may reduce local feedstock availability and raise domestic prices

Notes: *1) Including Harvesting, Collection, Storage, Pre-Processing, Transporation, etc.;* ***Sources:*** *The International Council on Clean Transportation, Info Sawit Indonesia, International Energy Agency, Chapter on Book "Transition Towards 100% Renewable Energy", Journal of Engineering and Applied Sciences*

While oil palm plantations are relatively spread across the country, including Java, the majority are still heavily concentrated in Sumatera and Kalimantan

Oil Palm Plantation Area by Provinces (2022, in Millions of Hectare)



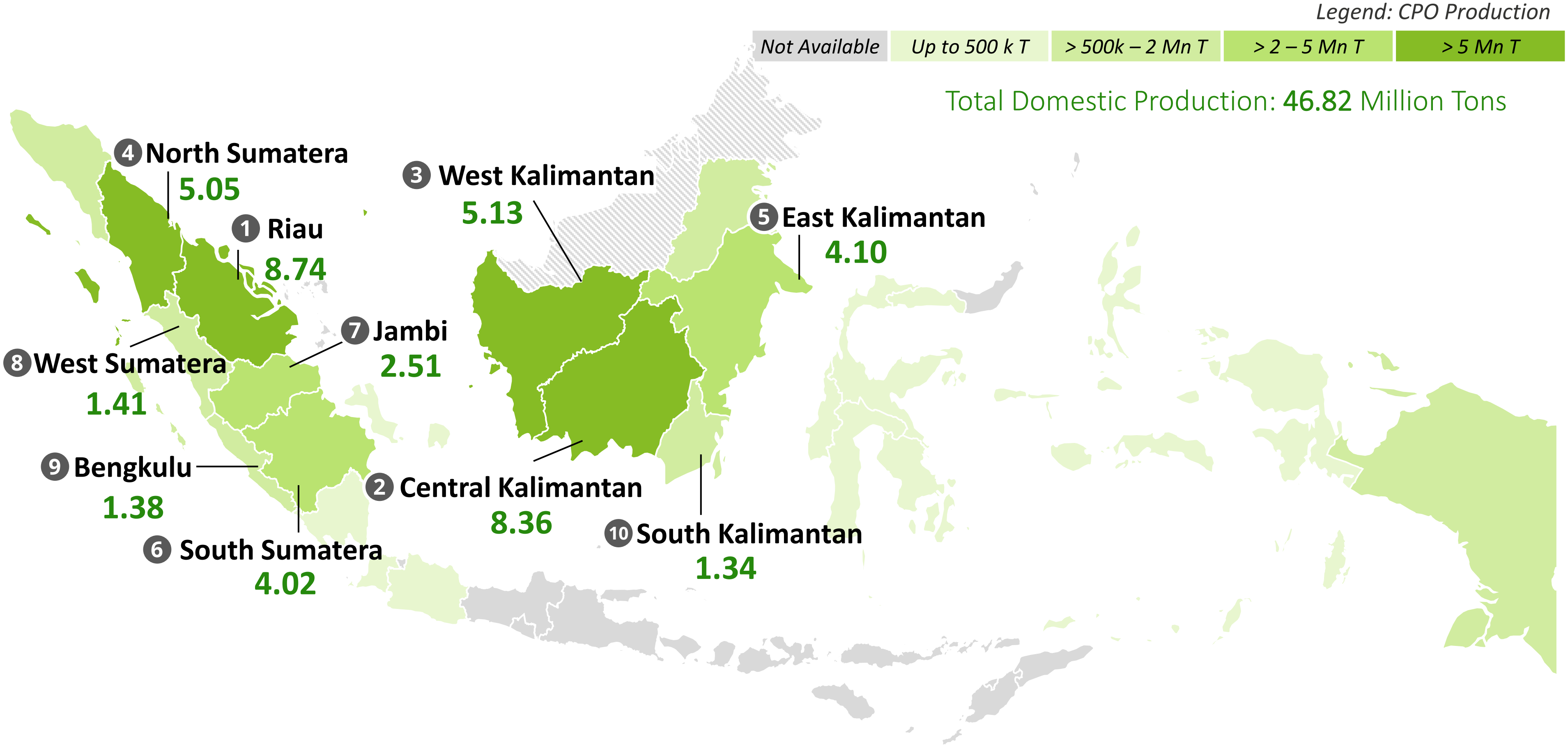
Total Domestic Plantation Area: **15.3** Million Hectares

88% (13.5 out of 15.3 mn hectares) of Indonesia's oil palm plantations are concentrated in 10 provinces across Sumatra and Kalimantan

***Notes:** 1) East Kalimantan = 1,370,592, North Sumatera = 1,370,407; **Sources:** Indonesia Oil Palm Statistics 2022/2023*

Spread of CPO production aligns with the size of oil palm plantation areas, remaining concentrated in Sumatera and Kalimantan

CPO Production by Provinces (2022, in Millions of Tons)



Total Domestic Production: **46.82** Million Tons

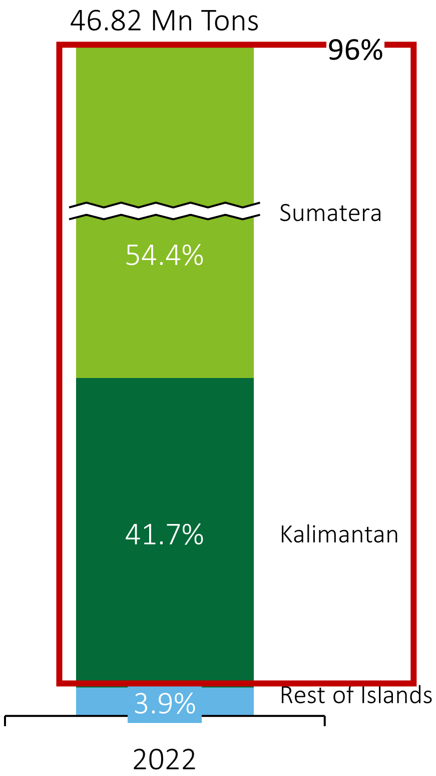
Nearly 90% (42.1 out of 46.82 Mt) of Indonesia's total CPO production is located in 10 provinces across Sumatra and Kalimantan

Sources: *Indonesia Oil Palm Statistics 2022/2023*

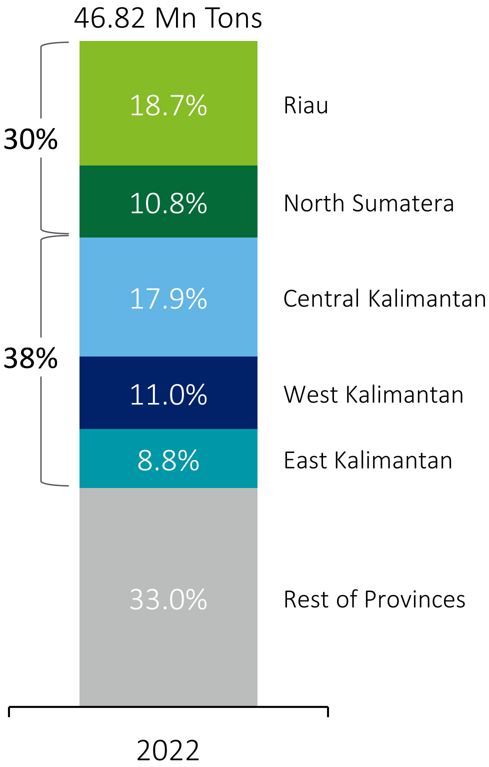
Sumatera and Kalimantan contributed to ~ 96% of CPO production in Indonesia, reinforcing the islands' status as the country's palm oil centres

Overview of CPO Production by Areas (2022, in %)

Contribution by Island



Top 5 Provinces



Insights on CPO Contribution by Provinces

Below factors outline why CPO productions are more concentrated in several provinces (i.e., Sumatera and Kalimantan) than others:

Availability of Peatlands

- **As a prerequisite for CPO**, large areas of peatlands is expected to enable large-scale production
- Currently, **around 99% of peatlands in Indonesia are located in Sumatera, Kalimantan, and Papua**

Moisture and Temperature

- **Optimal palm oil harvesting occurs in areas with year-round rainfall**, i.e., in Sumatera & Kalimantan
- Meanwhile in **Java, a 2–3-month dry season** inevitably adversely impacts harvests

Government's Directives

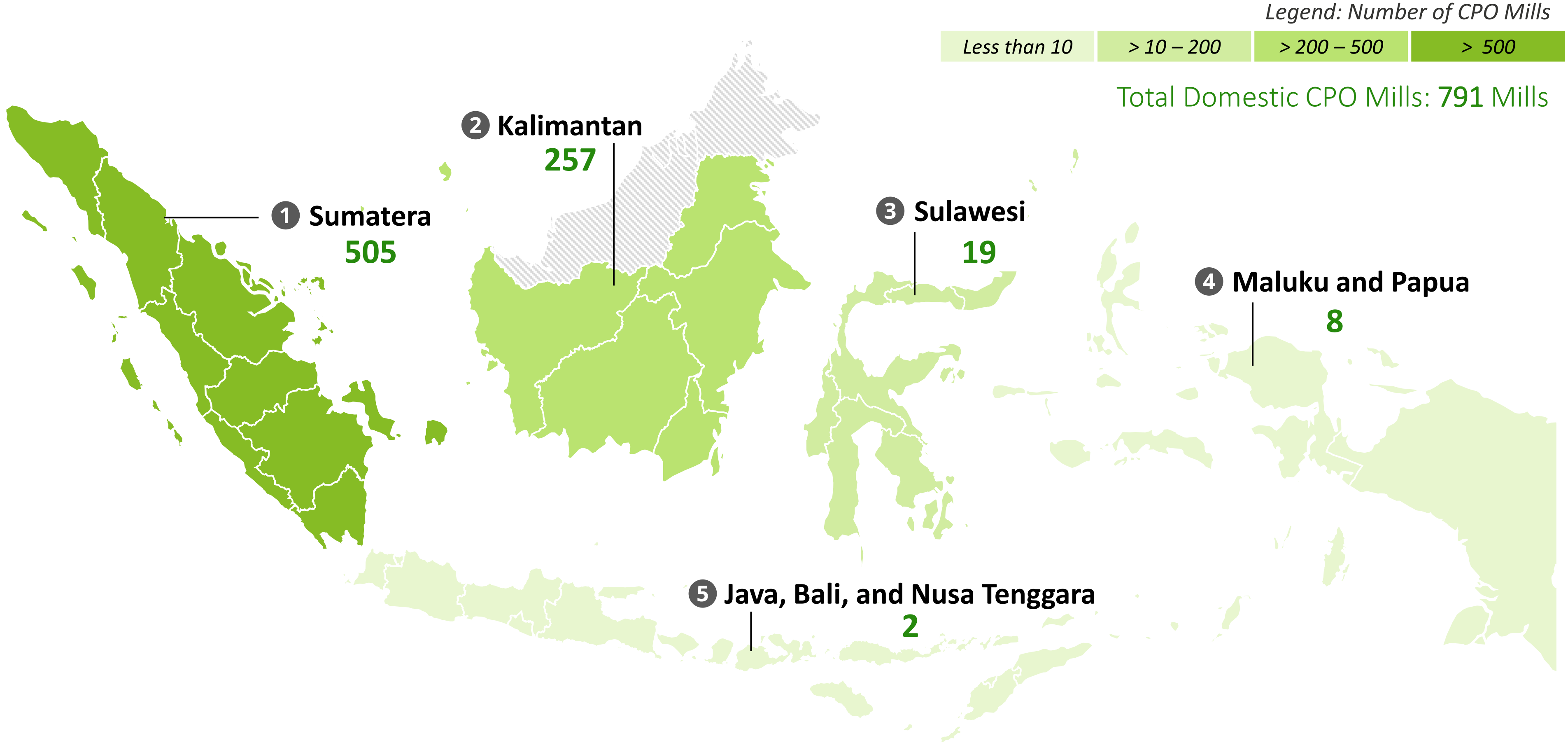
- Since 2011, The Ministry of Cooperatives & SMEs has **designated Sumatra & Kalimantan as oil palm centers**
- The government **agreed to provide optimal management of oil palm cultivation on the two islands**

Sumatera and Kalimantan dominate CPO production, accounting for over 95% of total domestic output. *The top 5 provinces on these islands contribute around 68% of national CPO production, while the remaining 29 provinces make up only about 33%.*

Notes: *1) Total Peatland = 13.43 mn hectare (Sumatera = 5.8 mn hectare, Kalimantan = 4.5 mn hectare, Papua = 3 mn hectare);* ***Sources:*** *Indonesia Oil Palm Statistics 2022/2023, Situs Pantau Gambut Indonesia, Jaringan Pemberitaan Nusantara, Plantation Department of East Kalimantan*

The geographic clustering of palm oil production is further evident, with ~ 95% of domestic CPO Mills located in Sumatera (63%) and Kalimantan (32%)

Spread of CPO Mills by Island (Number of CPO Mills, 2019)

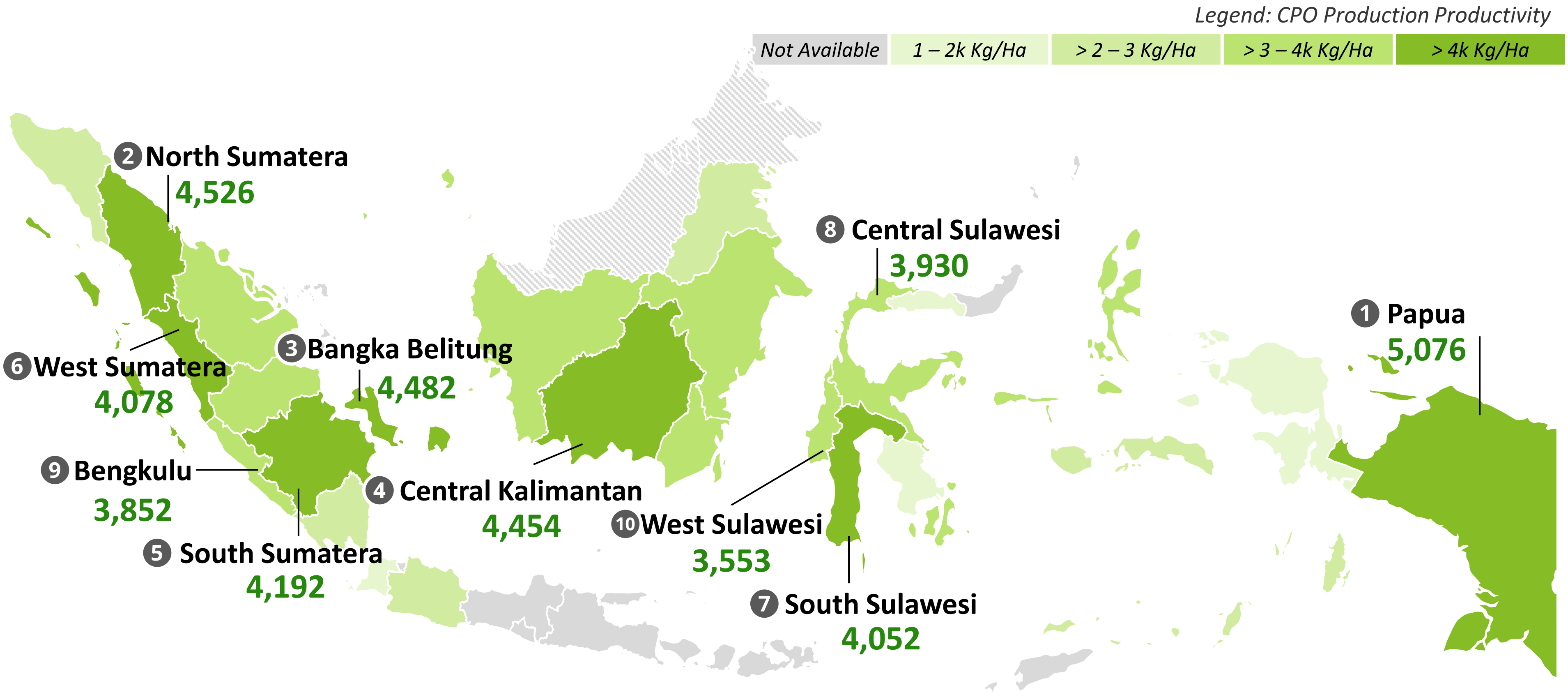


The number of CPO mills generally corresponds to an island's contribution of domestic CPO production, with Sumatera and Kalimantan housing 95% of the facilities and being responsible for the bulk of total production respectively

Sources: *PT Perkebunan Nusantara (PTPN)'s Publication on CPO Indonesian CPO Mills*

In addition to the leading provinces in Sumatera and Kalimantan, provinces in Sulawesi also demonstrate strong CPO productivity

CPO Productivity Yield by Provinces (2022, in Kg per Hectare)

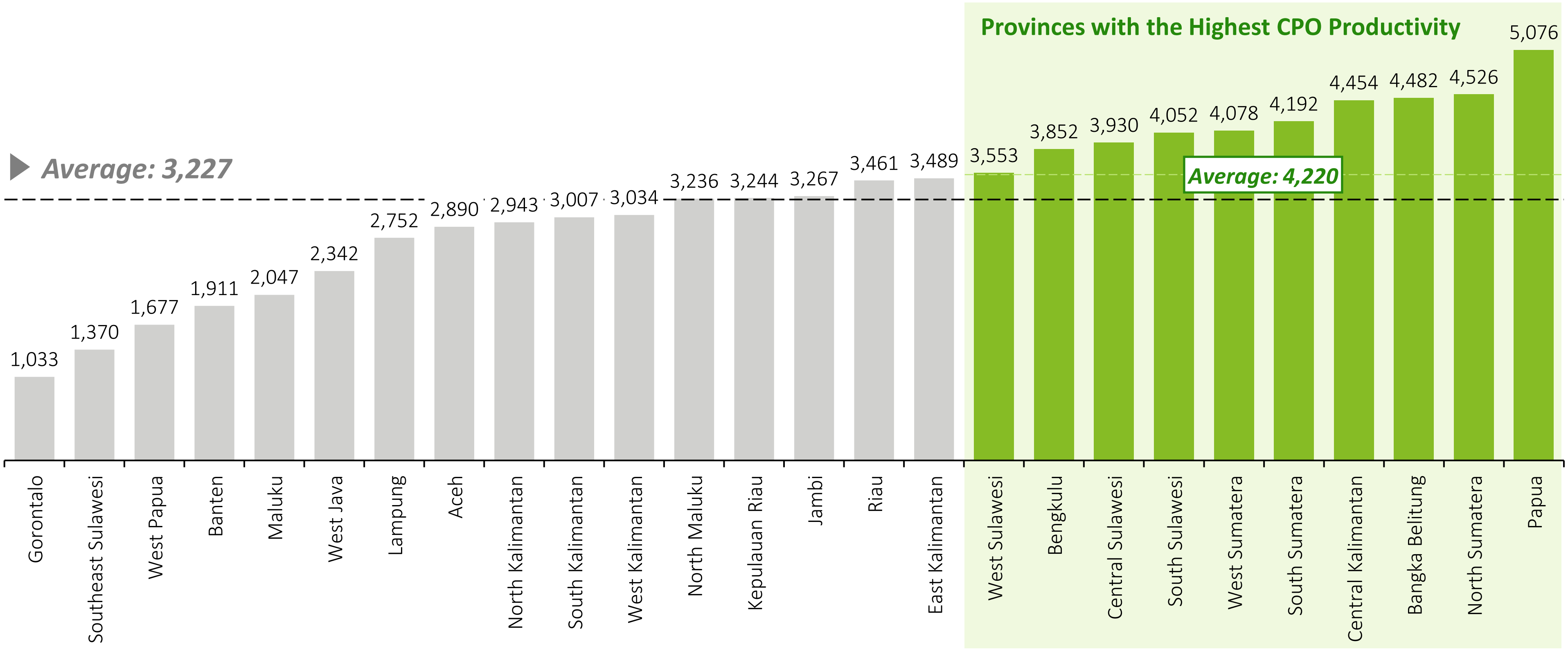


Provinces like Papua, South-, Central-, and West Sulawesi show higher yield productivity relative to their oil palm plantation area and current CPO production, implying potential palm oil cultivation opportunities outside of Sumatera and Kalimantan

Sources: *Indonesia Oil Palm Statistics 2022/2023*

Papua has the highest CPO productivity in Indonesia at 5076 Kg/Ha, followed by North Sumatera, Bangka Belitung, and Central Kalimantan

CPO Productivity by Provinces (in Kg per Hectare, 2022)



Observations

On average, CPO-producing provinces yield 3,227 kg of CPO / hectare, with 15 provinces exceeding this benchmark

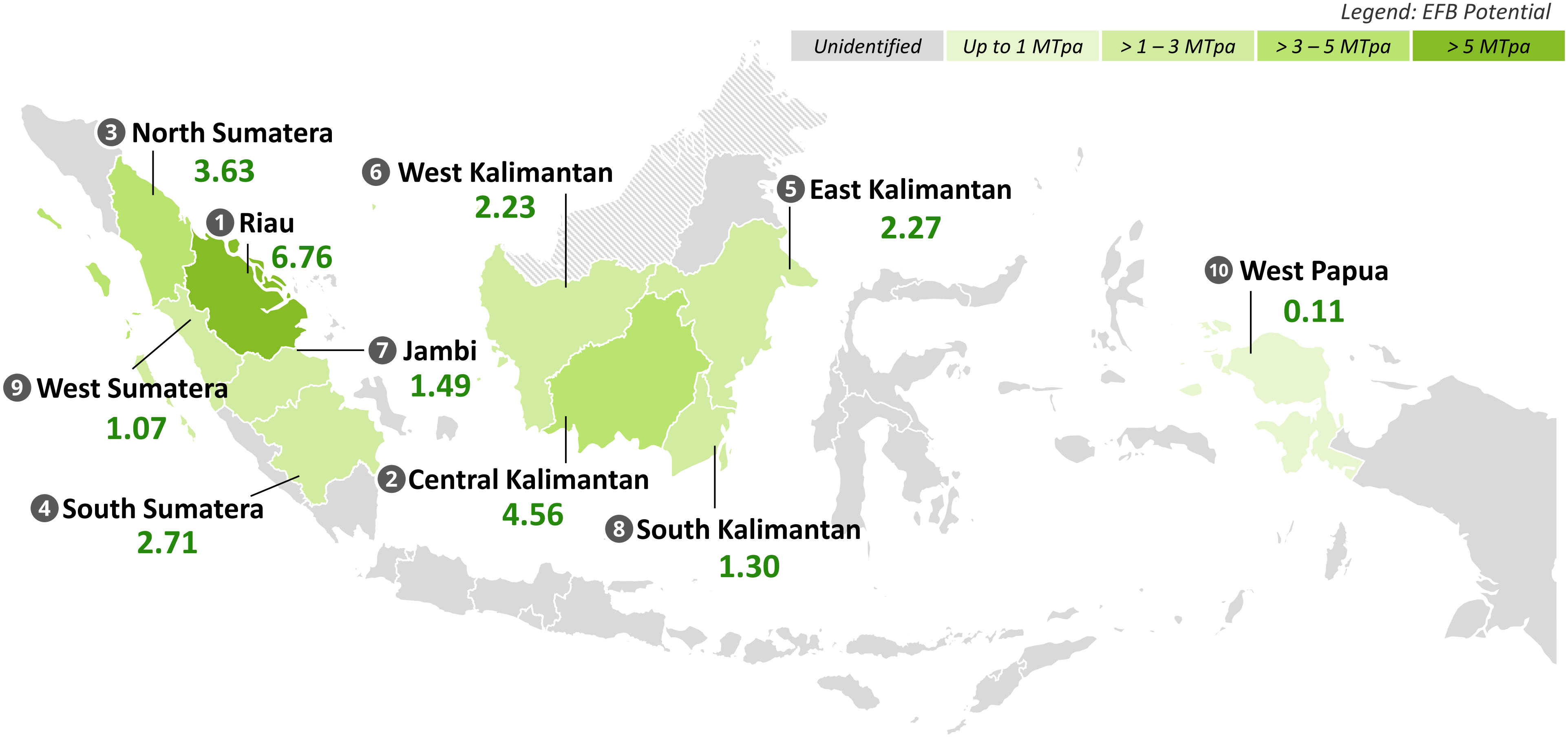
On average, the Top 10 provinces have 31% higher CPO productivity compared to rest of Indonesia

As the most productive province, Papua produces 20% more CPO per hectare than the average of the top 10 provinces

Sources: *Indonesia Oil Palm Statistics 2022/2023*

Approximately 26 million tons of EFB could be cultivated annually across 9 CPO-producing provinces in Indonesia

Potential EFB by Provinces (in Millions of Tons per Annum, 2023)



EFB availability generally corresponds to CPO production, hence, predominantly found in Sumatera, Kalimantan, and potentially West Papua

Sources: *Pertamina's Presentation for the Association of Indonesian Motor Vehicle Industries (GAIKINDO)*

Riau and Central Kalimantan consistently lead in three out of four key metrics: plantation area size, CPO production volume, and EFB residue potential

Comparison Summary of Top 10 Provinces Across Key Metrics

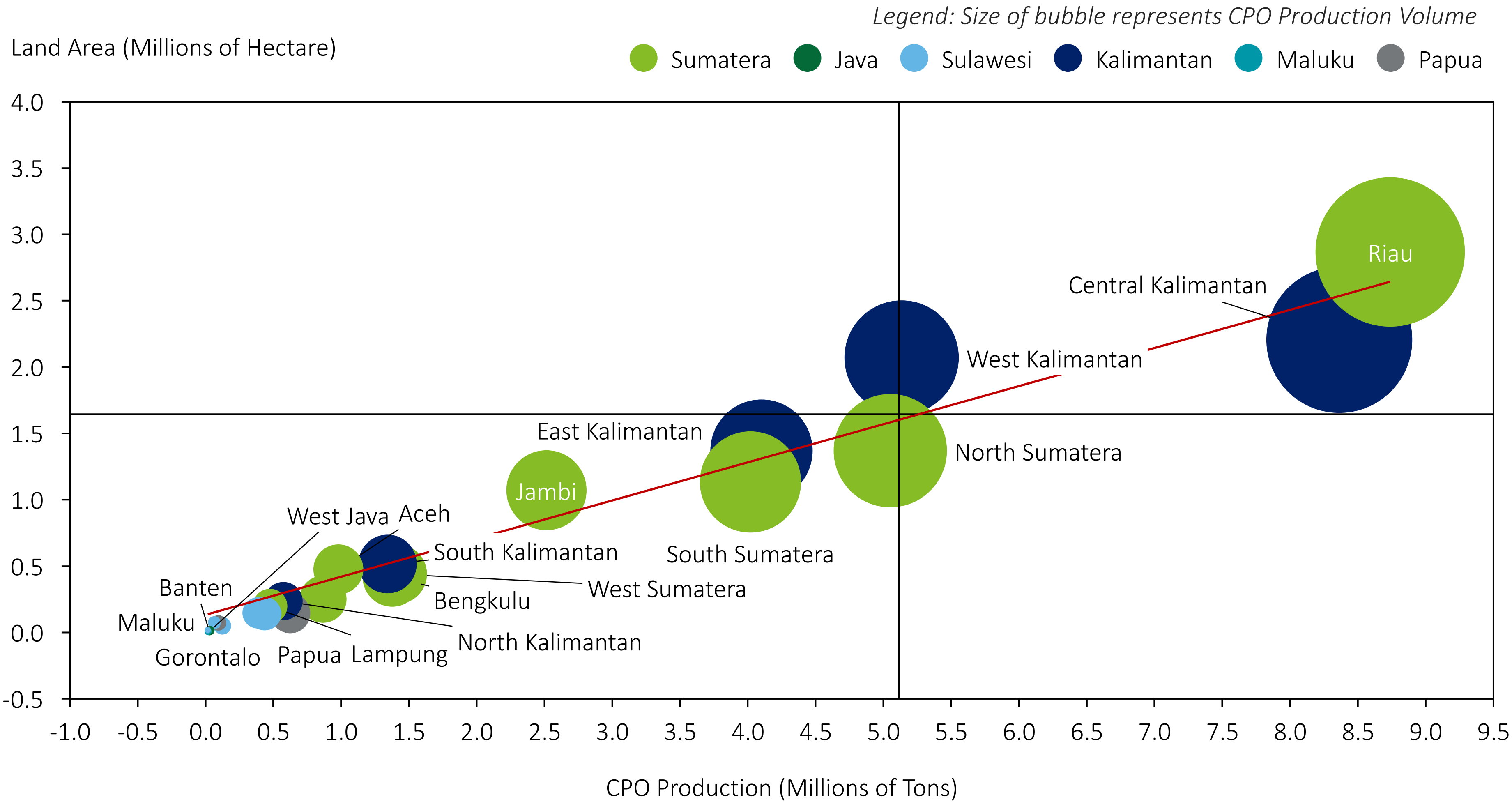
	Size of Oil Palm Plantation Area *Millions of Hectare*	**Volume of CPO Production** *Millions of Tons*	**Productivity of CPO Production** *Yield in Kg per Hectare*	**EFB Residues from CPO Production** *Millions of Tons per Annum*
1	Riau	Riau	Papua	Riau
2	Central Kalimantan	Central Kalimantan	North Sumatera	Central Kalimantan
3	West Kalimantan	West Kalimantan	Bangka Belitung	North Sumatera
4	East Kalimantan	North Sumatera	Central Kalimantan	South Sumatera
5	North Sumatera	East Kalimantan	South Sumatera	East Kalimantan
6	South Sumatera	South Sumatera	West Sumatera	West Kalimantan
7	Jambi	Jambi	South Sulawesi	Jambi
8	South Kalimantan	West Sumatera	Central Sulawesi	South Kalimantan
9	Aceh	Bengkulu	Bengkulu	West Sumatera
10	West Sumatera	South Kalimantan	West Sulawesi	West Papua

*Although other provinces show higher levels of CPO productivity, **environmental concerns may limit the development of new oil palm plantations** in these areas, **emphasizing the needs to Optimize existing plantations for CPO production and residue recovery***

Sources: *Indonesia Oil Palm Statistics 2022/2023, Pertamina's Presentation for the Association of Indonesian Motor Vehicle Industries (GAIKINDO)*

Clear positive correlation between land area and CPO production volume indicates a strong relationship between plantation size and CPO yield

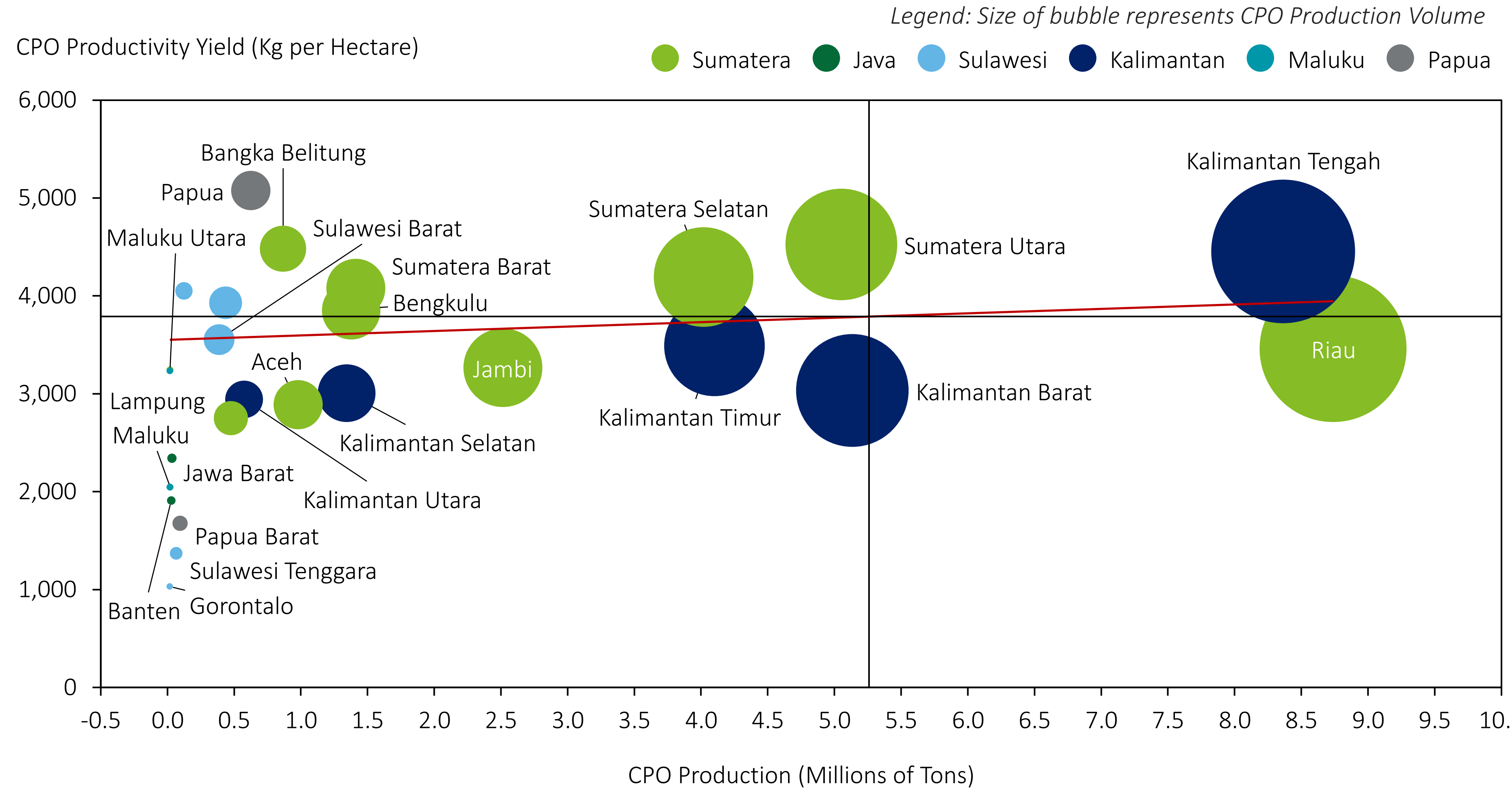
Size of Oil Palm Plantation Area vs. CPO Production Volume



Sources: *Indonesia Oil Palm Statistics 2022/2023*

The lack of a clear relationship between land productivity and CPO production suggests that higher volumes are not always achieved in more productive areas

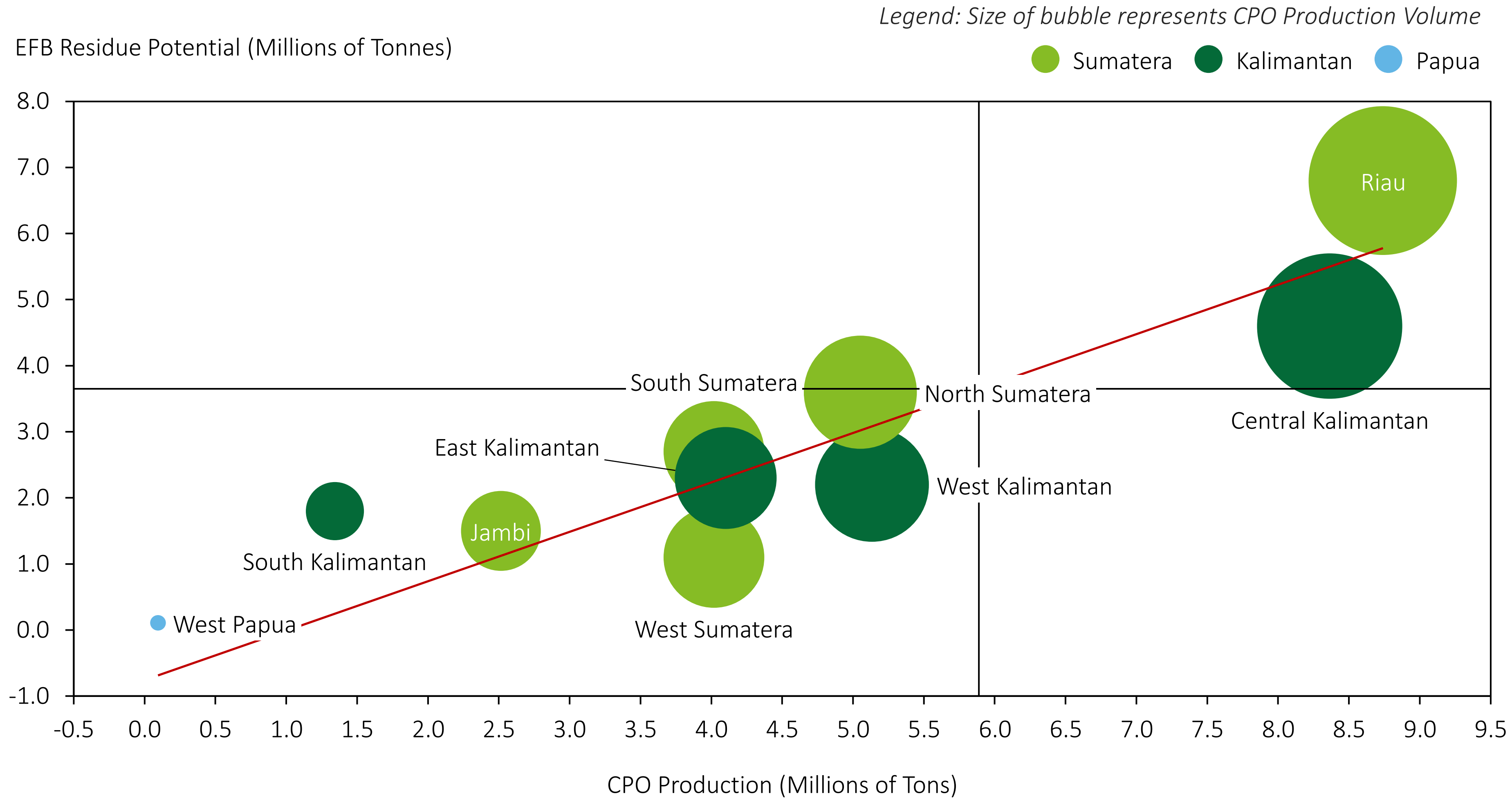
CPO Productivity Yield vs. CPO Production Volume



Sources: *Indonesia Oil Palm Statistics 2022/2023, Pertamina's Presentation for the Association of Indonesian Motor Vehicle Industries (GAIKINDO)*

The size of EFB residue strongly correlates with the volume of CPO production as indicated by the significant upward trend

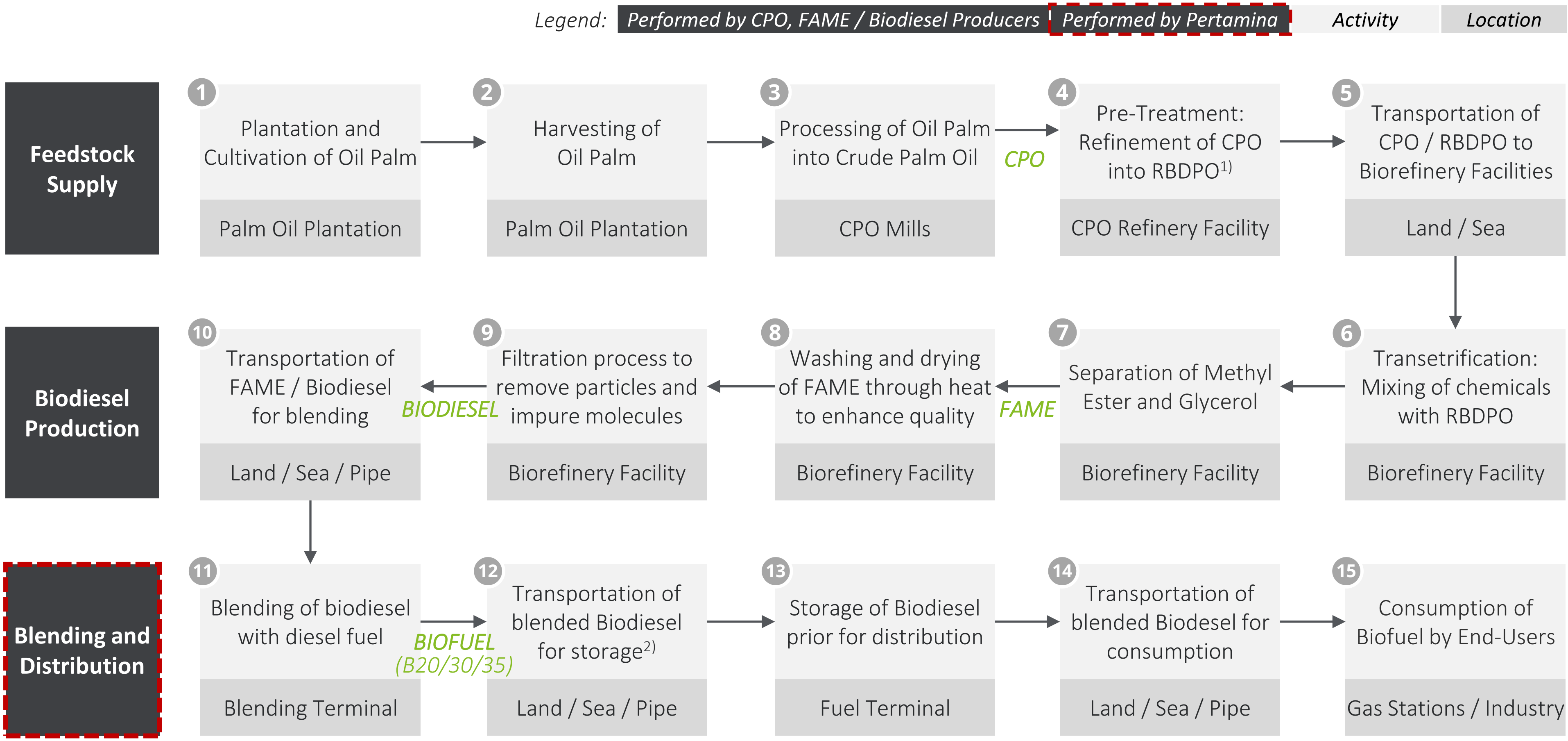
CPO Production Volume vs. EFB Residue Potential



Notes:** 1) Potential EFB Residues data for rest of provinces are not identified;* ***Sources: *Indonesia Oil Palm Statistics 2022/2023, Pertamina's Presentation for the Association of Indonesian Motor Vehicle Industries (GAIKINDO)*

Indonesia's biofuel chain starts with palm oil cultivation, to biodiesel production, blending and distribution, with Pertamina handling most downstream activities

Biofuel Value Chain



Legend: *Performed by CPO, FAME / Biodiesel Producers* | *Performed by Pertamina* | *Activity* | *Location*

Feedstock Supply

1. Plantation and Cultivation of Oil Palm — Palm Oil Plantation
2. Harvesting of Oil Palm — Palm Oil Plantation
3. Processing of Oil Palm into Crude Palm Oil — CPO Mills

CPO

4. Pre-Treatment: Refinement of CPO into RBDPO[1)] — CPO Refinery Facility
5. Transportation of CPO / RBDPO to Biorefinery Facilities — Land / Sea

Biodiesel Production

6. Transetrification: Mixing of chemicals with RBDPO — Biorefinery Facility
7. Separation of Methyl Ester and Glycerol — Biorefinery Facility

FAME

8. Washing and drying of FAME through heat to enhance quality — Biorefinery Facility
9. Filtration process to remove particles and impure molecules — Biorefinery Facility

BIODIESEL

10. Transportation of FAME / Biodiesel for blending — Land / Sea / Pipe

Blending and Distribution

11. Blending of biodiesel with diesel fuel — Blending Terminal

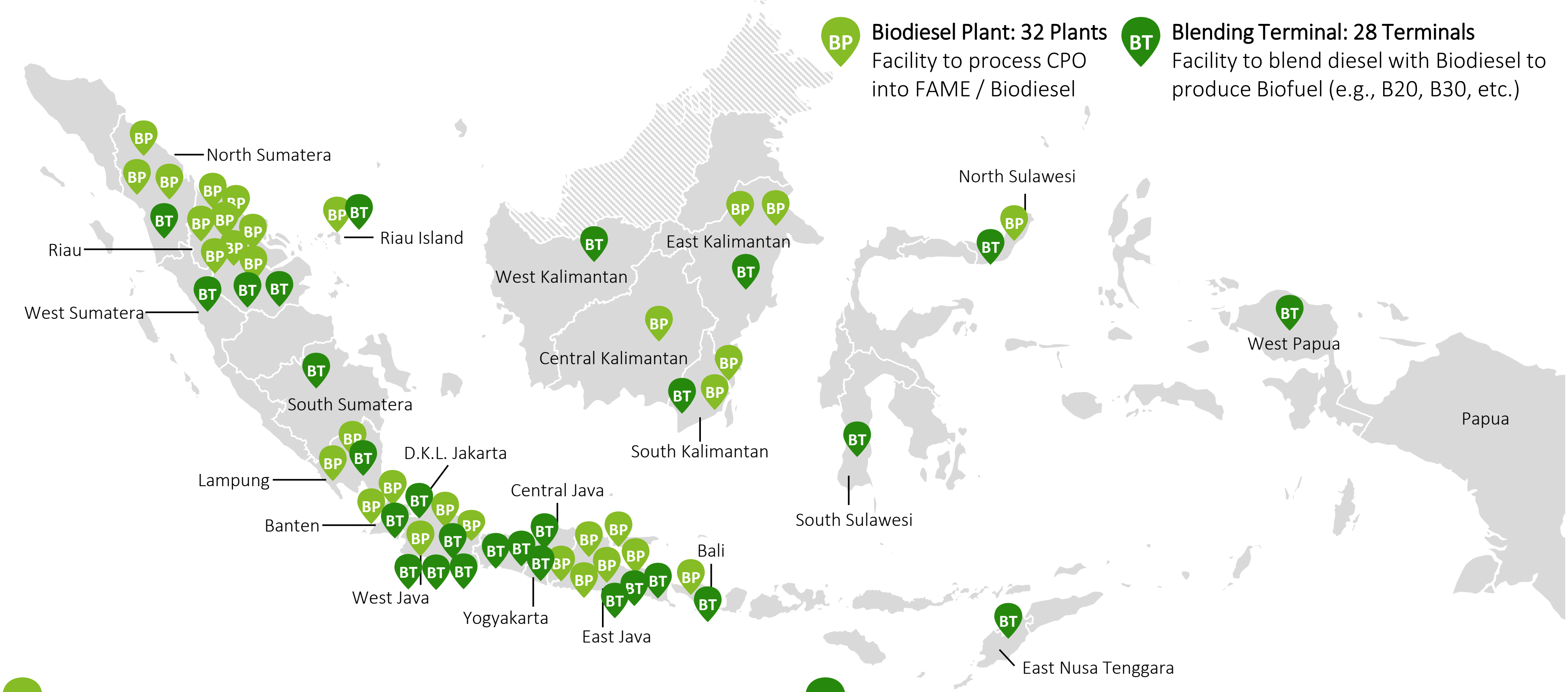
BIOFUEL (B20/30/35)

12. Transportation of blended Biodiesel for storage[2)] — Land / Sea / Pipe
13. Storage of Biodiesel prior for distribution — Fuel Terminal
14. Transportation of blended Biodesel for consumption — Land / Sea / Pipe
15. Consumption of Biofuel by End-Users — Gas Stations / Industry

***Notes:** 1) Refined, Bleached, and Deodorised Palm Oil , 2) In most cases, Blending Points are located in, or within close proximity, to the Fuel Terminal;* ***Sources:** Sinarmas' Publication on Biodiesel, Pertamina's Press Release on Biodiesel, Otomotif Grid Oto*

Biodiesel infrastructure is concentrated in Sumatra and Java, with Sumatra housing most Biodiesel Plants (44%) and Java having the majority of Blending Terminals (46%)

Spread of Biodiesel Plants and Blending Terminals in Indonesia



BP **Biodiesel Plant: 32 Plants**
Facility to process CPO into FAME / Biodiesel

BT **Blending Terminal: 28 Terminals**
Facility to blend diesel with Biodiesel to produce Biofuel (e.g., B20, B30, etc.)

BP

- **Sumatera has the most biodiesel plants** at ~44% (14 of 32), followed by Java at ~34% (11 of 32) and Kalimantan at ~16% (5 of 32)
- **Biodiesel Plants are relatively concentrated in high-activity business area,** as evident by primary presence in West Indonesia

BT

- Around **46% of Blending Terminals are located in Java** (13 of 28), ~25% in Sumatera (7 of 28), and ~11% in Kalimantan (3 of 28)
- **Blending Terminals are more dispersed,** reaching even the easternmost regions of Indonesia (e.g., East Nusa and West Papua)

***Sources:** Palm Oil Agribusiness Strategic Policy Institute, Pertamina's Publication on B30 Production*

Internal Survey

Biofuel facilities are spread across 26 provinces, with Blending Terminals typically present in the same location as Biodiesel Plants

Availability of Biofuel Facilities Across Provinces

BP **Biodiesel Plant:** Facility to process CPO into Biodiesel

BT **Blending Terminal:** Facility to blend diesel with Biodiesel to produce Biofuel

FT **Fuel Terminal:** Facility to store and distribute Biofuel prior to consumption

Island (1/2)	Province (1/2)	BP	BT	FT
Sumatera	Aceh			●
	Bandar Lampung	●	●	
	Bangka Belitung			●
	Bengkulu			●
	Jambi			●
	North Sumatera	●	●	●
	Riau	●	●	●
	Riau Island	●	●	●
	South Sumatera		●	●
	West Sumatera		●	●
Sulawesi	North Sulawesi	●	●	●
	South Sulawesi		●	●
Maluku	Maluku			●

Island (2/2)	Province (2/2)	BP	BT	FT
Java	Banten	●	●	●
	Central Java		●	●
	DKI Jakarta		●	●
	East Java	●	●	●
	West Java	●	●	●
	Yogyakarta		●	●
Kalimantan	Central Kalimantan	●		●
	East Kalimantan	●	●	●
	South Kalimantan	●	●	●
	West Kalimantan		●	●
Bali	Bali	●	●	●
Nusa Tgr.	East Nusa Tenggara		●	●
Papua	West Papua		●	●

Legend: 🟩● *Facility Available*

Notes: *1) Data shown on this page only indicates the presence of a facility (i.e., whether there is a physical facility in this province), and not the number of available facilities in a particular province;*
Sources: *Palm Oil Agribusiness Strategic Policy Institute, Pertamina's Publication on B30 Production, Pertamina Patra Niaga's Press Release on Fuel Terminals*

EFB is regarded as the most suitable feedstock for 2G Ethanol production due to its abundant availability and ease of procurement

Feedstock Feasibility for Bioethanol Production (1/2)

Feedstock	Feasibility	Comments from Experts
 Empty Fruit Bunch (EFB)	●	• Considered as the most suitable Palm Oil Residue for Bioethanol production o Abundant Feedstock Availability: ~ 52 Million Tons of EFB produced annually in Indonesia, 1.1 times the CPO production volume (i.e., ~ 47 Million Tons) o Convenient Procurement Method: EFBs are brought directly to factories by farmers, requiring minimal effort to collect, hence higher economic viability • Around 40% of EFBs are processed further, while 60% are returned to the land for soil sustainability • Nevertheless, EFB alone may not be enough to meet the all the demand for Ethanol, especially as Indonesia moves into the E10 target
 Oil Palm Trunk (OPT)	◕	• Considered as the second most suitable residue for Bioethanol – OPT is one of the residues that ITB has been recommending to the government o High carbohydrate content for ethanol production, with sap water containing 70% starch sugar o Utilizing just 50% of OPT's sap water could meet Indonesia's E10 demand by 2030 • Relatively long rejuvenation time of about 25 years and difficult to gather, as OPTs are often left in plantations and rarely collected at factories • Requires extra processing time during pre-treatment, as the trunk must be powdered first
 Oil Palm Frond (OPF)	◔	• Lower feasibility for Bioethanol production due to inconvenience in residue collection • Comparatively the most difficult to gather among other palm oil residues, which requires additional collection process, hence compounds to production costs • OPFs are scattered across plantations and need extensive effort to collect for further processing

Sources: *Experts Interviews*

After EFB, OPT, sugarcane bagasse, and sorghum show strong feasibility for bioethanol production, given their feedstock content and policy-related directives

Feedstock Feasibility for Bioethanol Production (2/2)

Feedstock	Feasibility	Comments from Experts
 Palm Kernel Shell (PKS)	◔	• Lower feasibility for Bioethanol due to competing usage with other energy products • Despite higher availability of residues, PKS is still mostly utilised for active carbon / solid fuel materials and battery production
 Mesocarp Fibre (MF)	◔	• Expert was not able to make comment on Mesocarp Fibre utilization for Ethanol • Nevertheless, Mesocarp Fibre was mainly targeted for high value-added products (unspecified) due to the higher oil content in the residue
 Palm Oil Mill Effluent	◑	• Medium feasibility due to ease of feedstock procurement with similar gathering method as EFB • However, competing use for POME is high as the residue is: o Still mainly utilised for Biogas through Biomethane for energy supply to villages near CPO plants o Being exported with good trading prospects
 Sugarcane Bagasse	◕	• High feasibility for bioethanol production, supported by forecasted increases in bagasse availability due to the National Self-Sufficiency program boosting domestic sugarcane output • High cellulose content of up to 50%, with residues amounting to 40% of total sugarcane production • However, converting bagasse to ethanol remains costly, as sugarcane production is still concentrated in Java, where significant transport costs are needed to ship bagasse to ethanol plants outside of Java
 Sorghum (First Gen)	◕	• High feasibility for Bioethanol production as sorghum utilization is a part of the government's target, with pilot-scale projects currently run by Pertamina • However, cultivation area remains limited to just 40,000 Ha, restricting feedstock availability for Bioethanol production

Sources: *Experts Interviews*

Bioethanol Forecast from Sugarcane Molasses

Four key factors used to estimate molasses-based ethanol supply: sugarcane and molasses production, bioethanol allocation, and molasses-to-ethanol conversion

Summary of Bioethanol Production Calculation Approach

	Objectives	Methods Used
① Forecast of Sugarcane Production	Forecast sugarcane production based on projected size of plantation area and government-set yield target	Sugarcane Production = Sugarcane Plantation Area × Yield per Hectare
② Estimation of Molasses Generated from Sugarcane	Estimate size of molasses generated from sugarcane production using industry conversion ratio	Molasses Production = Sugarcane Production × Molasses Conversion Ratio
③ Allocation of Molasses for Bioethanol	Calculate potential Bioethanol that can be produced based on a specific allocation of molasses use	Molasses for Bioethanol = Molasses Production × Bioethanol utilization
④ Bioethanol Production from Sugarcane Molasses	Convert molasses estimate (in Ton) into Bioethanol production (in Liter)	Bioethanol Production = Molasses Production for Bioethanol × Bioethanol Conversion Ratio

Sources: *Deloitte Analysis*

Below is the summary of key assumptions and rationale used to calculate Bioethanol Production forecasts through 2060

Key Assumptions for Bioethanol Production Forecasts (1/2)

Input Items		Assumptions and Rationale
General	Project Timeline	Year 2021 will be used as the baseline (i.e., Year 0) in the forecasts
	Population	• Data for Population refers to The World Bank population trend assumptions (~ 2050) • For 2060, calculation is made based on the World Bank population assumptions until ~ 2050
Sugarcane	Sugarcane Production	Sugarcane Production is calculated by multiplying Sugarcane Plantation Area with Sugarcane Yield
	Sugarcane Yield	• From 2021 to 2023, Sugarcane Yield is calculated by dividing Sugarcane Production with Sugarcane Plantation Area as per USDA data • From 2024 onwards, Sugarcane Yield is kept constant at 93 T/Ha as per Indonesian Government's plan of increasing the current Yield of 70 to 93 T/Ha
	Sugarcane Plantation Area	• From 2021 to 2023, input for Sugarcane Plantation follows USDA data at 423,000 Ha, 490,000 Ha, and 495,000 Ha respectively • From 2024 onwards, 495,000 Ha is the base Plantation Area used, assumed to remain constant • An additional 700,000 Ha, as per Presidential Decree No. 40 of 2023, will be added over 7 years, with 100,000 Ha added each year from 2024 to 2030 • An additional 2,000,000 Ha, as per Presidential Decree No. 15 of 2024, will be added over 20 years, with 100,000 hectares added each year from 2031 to 2050 • From 2051 onwards, size of Sugarcane Plantation Area is assumed to remain constant
Sugar	Sugar Consumption	• Sugar Consumption is expected to grow at the same rate of Population • Sugar Consumption is calculated by multiplying Sugarcane per Capita with Population of each year • Based on OECD data of Sugarcane per Capita consumption in 2021, 2022, and 2023 at 27.54, 28.08, and 28.23 Kg respectively, a CAGR (2021-2023) of 1.54% is used to forecast Sugar Consumption until 2060
	Sugar Production	Sugar Production is calculated by multiplying Sugarcane Production with Sugar Yield Rate
	Sugar Yield Rate	Sugar Yield Rate is 7.5%, based on Indonesia's average estimates considering land conditions and productivity

***Sources:** Press Releases, Journals, Deloitte Analysis*

Below is the summary of key assumptions and rationale used to calculate Bioethanol Production forecasts through 2060

Key Assumptions for Bioethanol Production Forecasts (2/2)

Input Items		Assumptions and Rationale
Sugar	Sugar Balance	• Sugar Balance is calculated by subtracting Sugar Production to Sugar Consumption • A negative balance indicates that Sugar Consumption exceeds Sugar Production
	Sugar Self Sufficiency Rate	• Self Sufficiency Rate indicates the rate at which domestic production covers domestic consumption • Self Sufficiency Rate is calculated by dividing Sugar Production to Sugar Consumption • A rate of less than 100% indicates that Indonesia is not able to satisfy demand for domestic sugar consumption from its own supply of sugar production
Molasses for Ethanol Production	Molasses Production	• Based on Kyushu University's Publication, the Conversion Rate of Sugarcane to Molasses is at 4.6% • Molasses Production is calculated by multiplying Sugarcane Production to Molasses Conversion Rate of 4.6%
	Molasses for Bioethanol (Bioethanol Production in Ton)	• Based on Indonesia Ethanol Association (ASENDO), ~ 40% of Molasses are used for Bioethanol production • From 2021 to 2023, Molasses for Bioethanol is calculated by multiplying Molasses Production to Bioethanol Usage Rate of 40% • From 2024 onwards, Calculation Bioethanol Production will be the subtraction of *(Total Molasses Production - (Molasses for Other Purposes + Molasses for Exports))* o Molasses use for exports and other purposes is expected to remain constant after 2023, with the government likely to focus on increasing domestic ethanol production instead
	Molasses for Other Purposes	• Based on ASENDO, ~ 35% of Molasses are used for Other Product Types (e.g., MSG) • Molasses for Other Purposes is calculated by multiplying Molasses Production to Other Usage Rate of 35%
	Molasses for Exports	• Based on ASENDO, ~ 25% of Molasses are used for Exports • Molasses for Export is calculated by multiplying Molasses Production to Exports Usage Rate of 25%
	Ton to Liter Conversion Rate	Based on MEMR Decree No. 350 K/12/DJE/2018, 1 liter of bioethanol is produced from 4.125 kg of Molasses
	Bioethanol Production in Liter	• Bioethanol Production in Liter is calculated by dividing Bioethanol Production in Ton by 4.125 • This figure indicates the final estimate of Bioethanol Production from Sugarcane Molasses for each year

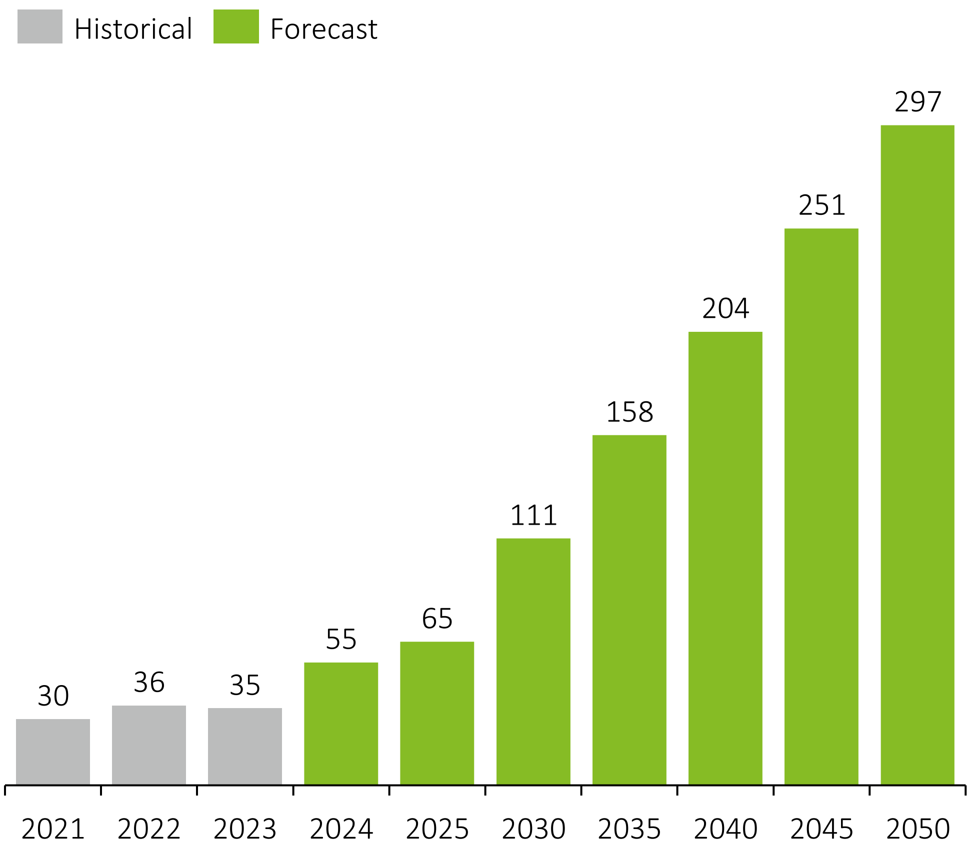
Sources: *Press Releases, Journals, Deloitte Analysis*

Sugarcane production forecast considers total plantation area and yield per hectare, following two presidential decrees on Acceleration of National Sugar Self-Sufficiency

Step 1: Calculate Sugarcane Production Forecast

Item	Assumptions / Rationale
Sugarcane Plantation Area	• Historical Sugarcane data From 2021 to 2023 follows USDA data at 423,000 Ha, 490,000 Ha, and 495,000 Ha respectively • As per Presidential Decree No. 40 of 2023, an additional 700,000 Ha will be added over 7 years, with 100,000 Ha added each year from 2024 to 2030 • As per Presidential Decree No. 15 of 2024, an additional 2,000,000 Ha, will be added over 20 years, with 100,000 hectares added each year from 2031 to 2050 • From 2051 onwards, Sugarcane Plantation area is assumed to remain constant
Yield per Hectare	• From 2021 to 2023, Yield is calculated by dividing Sugarcane Production with Sugarcane Plantation Area as per USDA data • From 2024 onwards, Sugarcane Yield is kept constant at 93 T/Ha, following Presidential Decree No. 40 of 2023

Reference: Sugarcane Production (Millions of Tons)



Notes:* 1**) *2050 forecast is inclusive up to 2060;* ***Sources: *Deloitte Analysis*

Sugarcane production forecast incorporates the government's directives on 700k and 2M hectares of additional plantations, along with a target yield of 93 T/Ha

Step 1: Calculate Sugarcane Production Forecast

Sugarcane Plantation Area (Thousands of Hectare)

Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Base	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495
700k Add.1)	100	200	300	400	500	600	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
2 Mn Add.2)	0	0	0	0	0	0	0	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400	1,500	1,600	1,700	1,800	1,900	2,000
Total	595	695	795	895	995	1,095	1,195	1,295	1,395	1,495	1,595	1,695	1,795	1,895	1,995	2,095	2,195	2,295	2,395	2,495	2,595	2,695	2,795	2,895	2,995	3,095	3,195

Sugarcane Yield (Tons per Hectare)

Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Yield	93																										

Sugarcane Production (Millions of Tons)

Formula Used = Total Plantation Area x Yield

Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Production	55.3	64.6	73.9	83.2	92.5	101.8	111.1	120.4	129.7	139.0	148.3	157.6	166.9	176.2	185.5	194.8	204.1	213.4	222.7	232.0	241.3	250.6	259.9	269.2	278.5	287.8	297.1

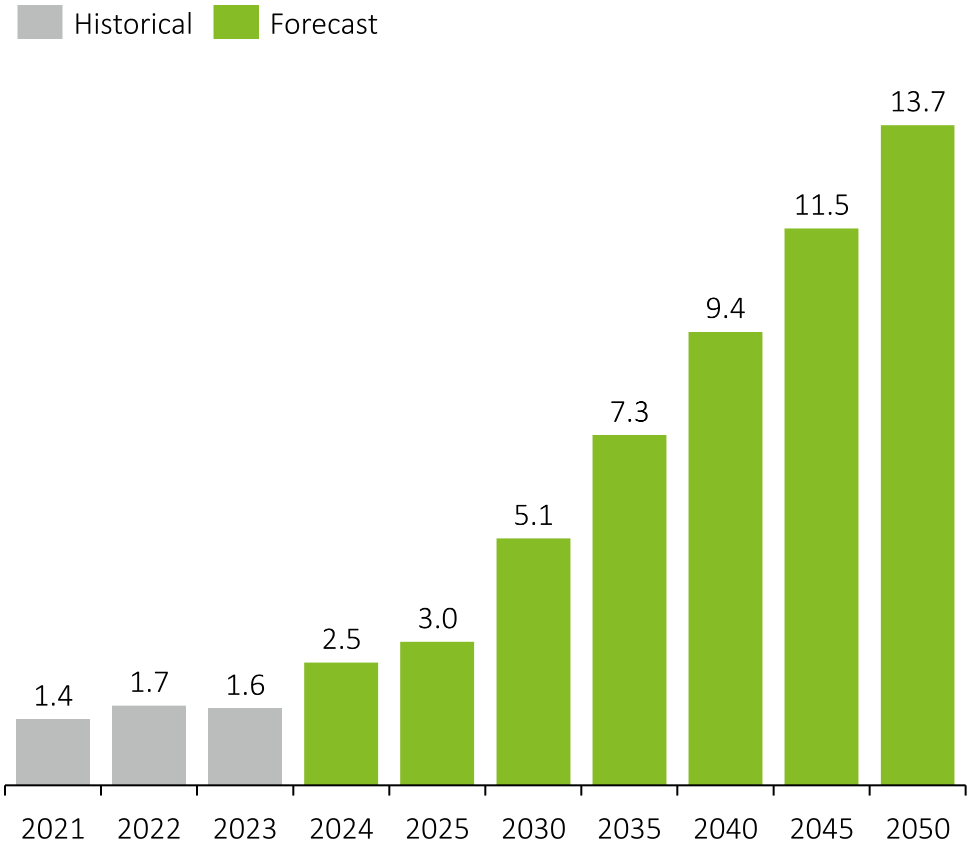
***Notes:** 1) Following Presidential Decree No. 40 of 2023, 2) Following Presidential Decree No. 15 of 2024, 3) 2050 forecast is inclusive up to 2060; **Sources:** Deloitte Analysis*

On average, around 4.6% of total sugarcane produce can be converted into molasses as the by-product

Step 2: Estimate Molasses Production

Item	**Assumptions / Rationale**
Molasses Conversion Ratio	• Molasses production is first calculated by estimating the potential yield from Sugarcane • Following a scientific research from Kyushu University on Sugarcane utilization in Indonesia, the estimated Sugarcane to Molasses Conversion Ratio is 4.6%
Molasses Production Forecast	• Forecast of Molasses Production is calculated by multiplying the Sugarcane Production of each year to the molasses conversion ratio of 4.6%

Reference: Molasses Production (Millions of Tons)



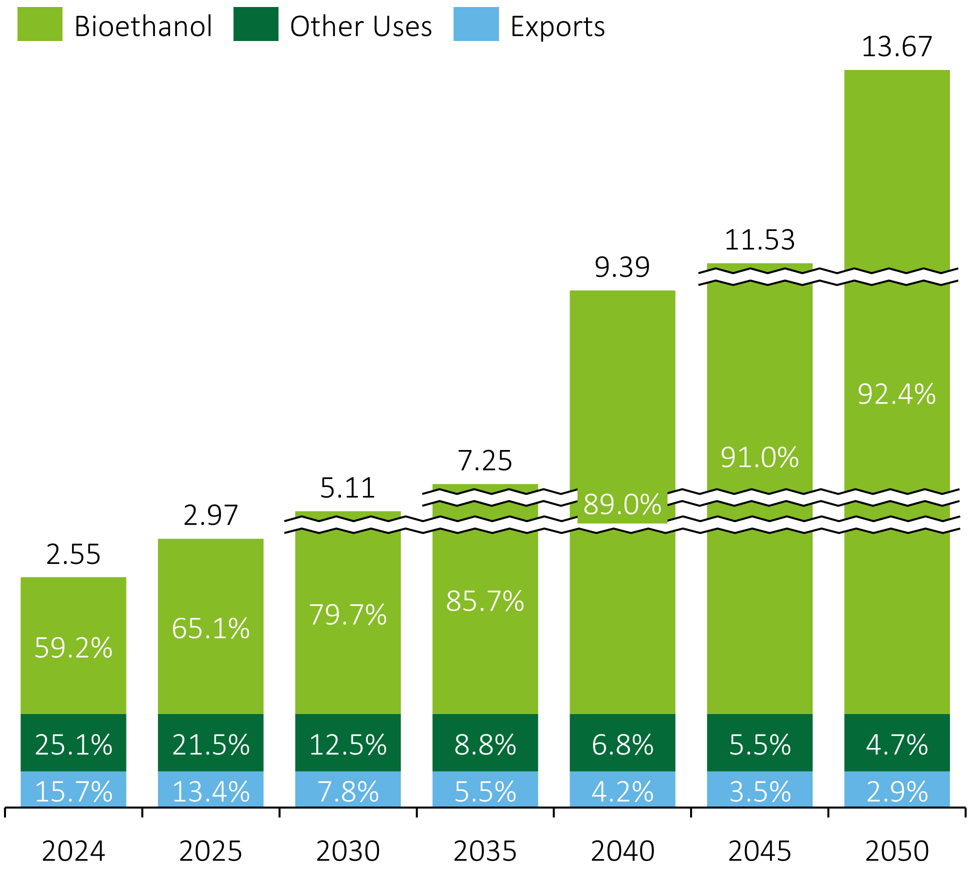
***Notes:** 1) 2050 forecast is inclusive up to 2060; **Sources:** Deloitte Analysis*

To determine the amount of molasses available for bioethanol, 35% allocated for export and 25% for other purposes must be deducted from the total molasses

Step 3: Calculate Molasses Allocation for Bioethanol Production

Item	Assumptions / Rationale
Proportion of Molasses utilization	• Following Indonesia Ethanol Association (ASENDO), below is the breakdown of Molasses production by end-product Bioethanol: 40% Other Purposes: 35% Export: 25%
Proportion of Molasses for Bioethanol	• From 2021 to 2023, Molasses for Bioethanol is calculated by multiplying Molasses Production to Bioethanol Usage Rate of 40% • From 2024 onwards, calculation for Bioethanol Production will be the subtraction of *(Total Molasses - (Molasses for Other Purposes + Molasses for Exports))* • Molasses use for exports and other purposes is expected to remain constant after 2023, under the assumption that the government likely to focus on increasing domestic ethanol production instead

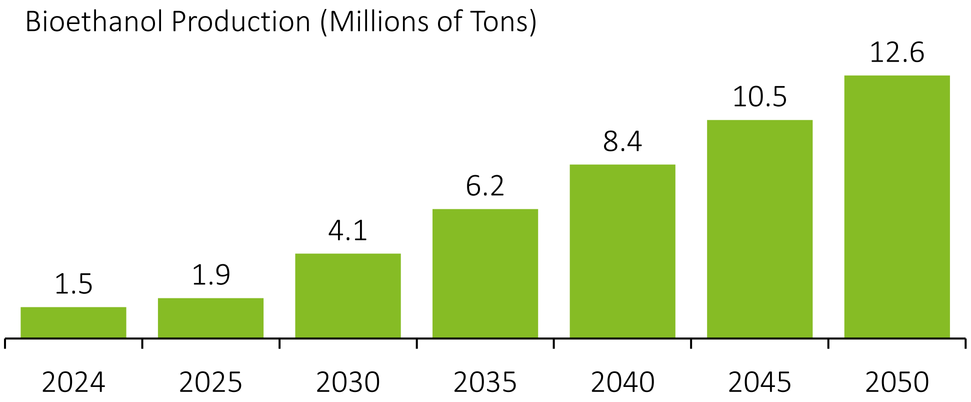
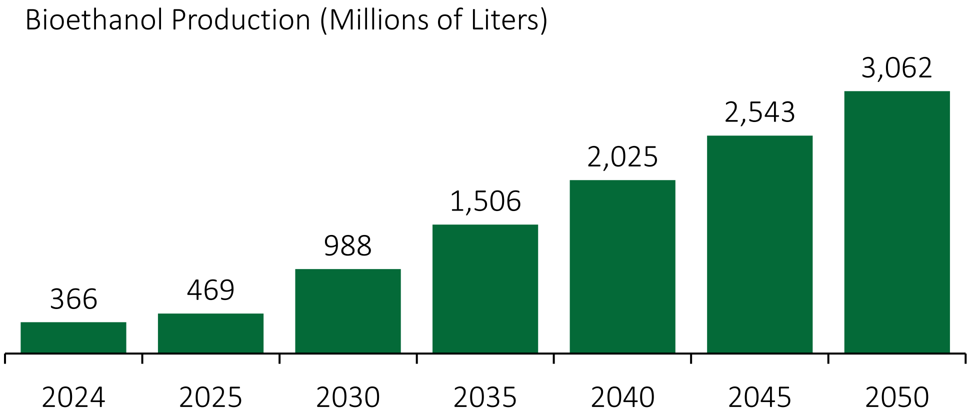
Reference: Molasses Allocation by Product Use



***Notes:** 1) 2050 forecast is inclusive up to 2060; **Sources:** Deloitte Analysis*

Bioethanol production forecast is estimated following the molasses-to-ethanol conversion rate set by the MEMR (1L of Ethanol for every 4.125 kg of molasses)

Step 4: Estimate Bioethanol Production Forecast from Sugarcane Molasses

Item	Assumptions / Rationale	Reference
Molasses Production Forecast for Bioethanol	• Following Step 3, forecasts of Bioethanol Production will be calculated by the following: *(Total Molasses - (Molasses for Other Purposes + Molasses for Exports))* • The above formula will provide the total molasses available for bioethanol in tons	 Bioethanol Production (Millions of Tons)
Molasses to Bioethanol Conversion	• Based on MEMR Decree No. 350 K/12/DJE/2018, 1 liter of bioethanol is produced from 4.125 kg of Molasses • Bioethanol Production in Liter is calculated by dividing the production in tons by 4.125 • This figure indicates the final estimate of Bioethanol Production from Sugarcane Molasses for each year	 Bioethanol Production (Millions of Liters)

Notes: *1) 2050 forecast is inclusive up to 2060;* ***Sources:*** *Deloitte Analysis*

By 2050, Indonesia is projected to achieve a production volume of 3 billion liters of bioethanol from sugarcane molasses

Step 4: Estimate Bioethanol Production Forecast from Sugarcane Molasses

Sugarcane Molasses for Bioethanol Production (Millions of Tons)

Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Allocation	1.5	1.9	2.4	2.8	3.2	3.6	4.1	4.5	4.9	5.4	5.8	6.2	6.6	7.1	7.5	7.9	8.4	8.8	9.2	9.6	10.1	10.5	11.0	11.3	11.8	12.2	12.6

Conversion Rate from Sugarcane Molasses to Bioethanol

Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Conv. Rate	4.125																										

Bioethanol Production from Sugarcane Molasses (Millions of Liter)

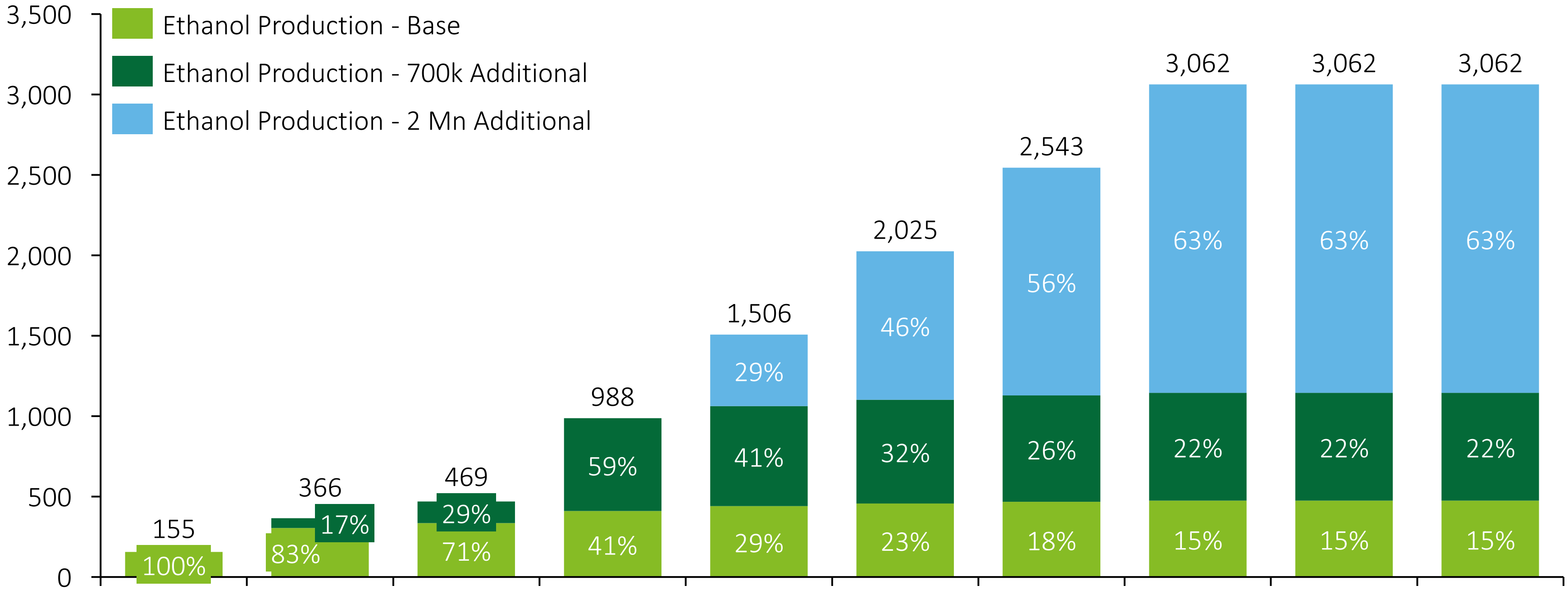
Formula Used = Molasses for Bioethanol ÷ Conversion Rate

Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Production	366	469	573	677	780	884	988	1,092	1,195	1,299	1,403	1,506	1,610	1,714	1,817	1,921	2,025	2,129	2,232	2,336	2,440	2,543	2,647	2,751	2,855	2,958	3,062

Notes: *1) 2050 forecast is inclusive up to 2060;* ***Sources:*** *Deloitte Analysis*

Bioethanol production from Molasses is projected to reach 3.1 bn liters by 2050, with 85% coming from 2.7 mn Ha of additional land and 15% from existing plantations

Bioethanol Production from Sugarcane Molasses (Million Liters)

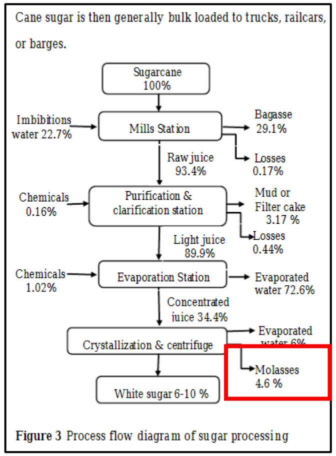
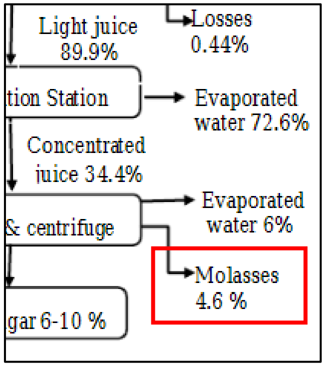
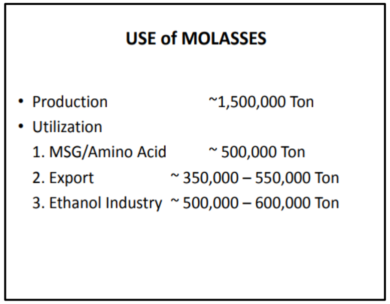
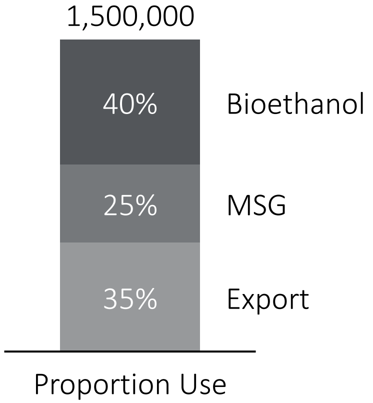


Plantation Area (Ha)	2023	2024	2025	2030	2035	2040	2045	2050	2055[3)]	2060[3)]
Base	495,000	495,000	495,000	495,000	495,000	495,000	495,000	495,000	495,000	495,000
700 k Additional[1)]	0	100,000	200,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000
2 Mn Additional[2)]	0	0	0	0	500,000	1,000,000	1,500,000	2,000,000	2,000,000	2,000,000
Total	495,000	595,000	695,000	1,195,000	1,695,000	2,195,000	2,695,000	3,195,000	3,195,000	3,195,000

Notes: *1) Following Presidential Decree No. 40 2023, 2) Following Presidential Decree No. 15 2024, 3) Sugarcane Plantation area assumed to remain constant from 2051;* ***Sources:*** *Deloitte Analysis*

The following list outlines the references from various sources used as inputs to forecast molasses-based ethanol production

Reference Lists: Molasses-Based Ethanol Calculation Assumptions (1/2)

Section	Information Used	Source	Details from Source
Step 2: Estimate Molasses Production	Sugarcane to Molasses Conversion Ratio is 4.6%	• Publication Title: Overview of Indonesian Sugarcane Industry and utilization of its Solid Waste • Presented during The Annual Fall Meeting of the Mining and Materials Processing Institute of Japan (MMIJ) • [Link]()	 Cane sugar is then generally bulk loaded to trucks, railcars, or barges. **Figure 3** Process flow diagram of sugar processing 
Step 3: Calculate Molasses Allocation for Bioethanol	Proportion of Molasses used for Ethanol is 40%	• Publication Title: Indonesian BioEthanol Industry – Current Condition and Opportunity for Development • Published by the Chairman of Indonesian Ethanol Association (ASENDO) • [Link]()	 **USE of MOLASSES** • Production ~1,500,000 Ton • Utilization 1. MSG/Amino Acid ~ 500,000 Ton 2. Export ~ 350,000 – 550,000 Ton 3. Ethanol Industry ~ 500,000 – 600,000 Ton 

Sources: *Press Releases, Journals, Deloitte Analysis*

The following list outlines the references from various sources used as inputs to forecast molasses-based ethanol production

Reference Lists: Molasses-Based Ethanol Calculation Assumptions (2/2)

Section	Information Used	Source	Details from Source
Step 4: Estimate Bioethanol Production from Molasses	1 Liter of bioethanol is produced from 4.125 kg of Molasses	• Regulation Title: MEMR Formulation in MEMR Decree No. 350 K/12/DJE/2018 • Adopted by State-Owned Energy Enterprises such as ENERO starting from 2020 • Link 1 • Link 2	 HARGA INDEKS PASAR (HIP) BAHAN BAKAR NABATI (BBN) BIOETHANOL BULAN APRIL 2020 BIOETANOL Rp.11.210 HIP = (Harga Tetes Tebu KPB Rata - Rata Periode 3 Bulan x 4,125 kg/L) + 0,25 USD/L • Harga Tetes Tebu KPB Rata - Rata 15 November 2019 s.d. 14 Maret 2020 = Rp1.863/kg • 4,125 kg/L adalah faktor satuan dari kg ke L • 0.25 USD/L* Adalah nilai konversi bahan baku menjadi bieoetanol *Konversi nilai kurs menggunakan rata - rata kurs tengah Bank Indonesia periode kurs : 15 Desember 2019 s.d. 14 Januari 2020 sumber : ebtke.esdm.go.id

Sources: *Press Releases, Journals, Deloitte Analysis*

Bioethanol Forecast from Sugarcane Bagasse

Four key factors used to estimate bagasse-based ethanol supply: sugarcane and bagasse production, bioethanol allocation, and bagasse-to-ethanol conversion

Summary of Bioethanol Production Calculation Approach

	Objectives	Methods Used
① Forecast of Sugarcane Production	Forecast sugarcane production based on projected size of plantation area and government-set yield target	Sugarcane Production = Sugarcane Plantation Area × Yield per Hectare
② Estimation of Bagasse Generated from Sugarcane	Estimate size of Bagasse generated from sugarcane production using industry conversion ratio	Bagasse Production = Sugarcane Production × Bagasse Conversion Ratio
③ Allocation of Bagasse for Bioethanol	Calculate potential Bioethanol that can be produced based on the maximum and conservative scenarios	Bagasse for Bioethanol = Bagasse Production × Bioethanol utilization Rate
④ Bioethanol Production from Sugarcane Bagasse	Convert Bagasse estimate (in Ton) into Bioethanol production (in Liter)	Bioethanol Production = Bagasse Production for Bioethanol × Bagasse to Bioethanol Conversion Rate

Sources: *Deloitte Analysis*

Below is the summary of key assumptions and rationale used to calculate Bioethanol Production forecasts from Sugarcane Bagasse through 2060

Key Assumptions for Bioethanol Production Forecasts

Input Items		Assumptions and Rationale
Sugarcane	Sugarcane Production	Sugarcane Production is calculated by multiplying Sugarcane Plantation Area with Sugarcane Yield
	Sugarcane Yield	• From 2021 to 2023, Sugarcane Yield is calculated by dividing Sugarcane Production with Sugarcane Plantation Area as per USDA data • From 2024 onwards, Sugarcane Yield is kept constant at 93 T/Ha as per Indonesian Government's plan of increasing the current Yield of 70 to 93 T/Ha
	Sugarcane Plantation Area	• From 2021 to 2023, input for Sugarcane Plantation follows USDA data at 423,000 Ha, 490,000 Ha, and 495,000 Ha respectively • From 2024 onwards, 495,000 Ha is the base Plantation Area used, assumed to remain constant • An additional 700,000 Ha, as per Presidential Decree No. 40 of 2023, will be added over 7 years, with 100,000 Ha added each year from 2024 to 2030 • An additional 2,000,000 Ha, as per Presidential Decree No. 15 of 2024, will be added over 20 years, with 100,000 hectares added each year from 2031 to 2050 • From 2051 onwards, size of Sugarcane Plantation Area is assumed to remain constant
Bagasse for Ethanol Production	Bagasse Production	• Based on a scientific research from Integral University in India, Each Ton of Sugarcane produces 130 kg dry weight of Bagasse (implying a Sugarcane-to-Bagasse rate of 13.0%) • Bagasse Production is calculated by multiplying the Sugarcane Production of each year to the Sugarcane-to-Bagasse conversion ratio of 13.0%
	Bagasse for Ethanol Production	• Two scenarios of Maximum and Conservative are applied • Maximum: Sugarcane Bagasse is assumed to be entirely allocated for Bioethanol production (100%) – this assumption is based on the current absence of national directions for Bagasse utilization • Conservative: 50% of Sugarcane Bagasse is allocated for Bioethanol, with the rest of 50% allocated for others – assumption is based on the forecast that future demand for bagasse in other sectors may increase
	Ethanol Production in Liter	Based on a Bioethanol study by the European Commission, 1 Ton of Dry Bagasse can produce 180 L of Ethanol

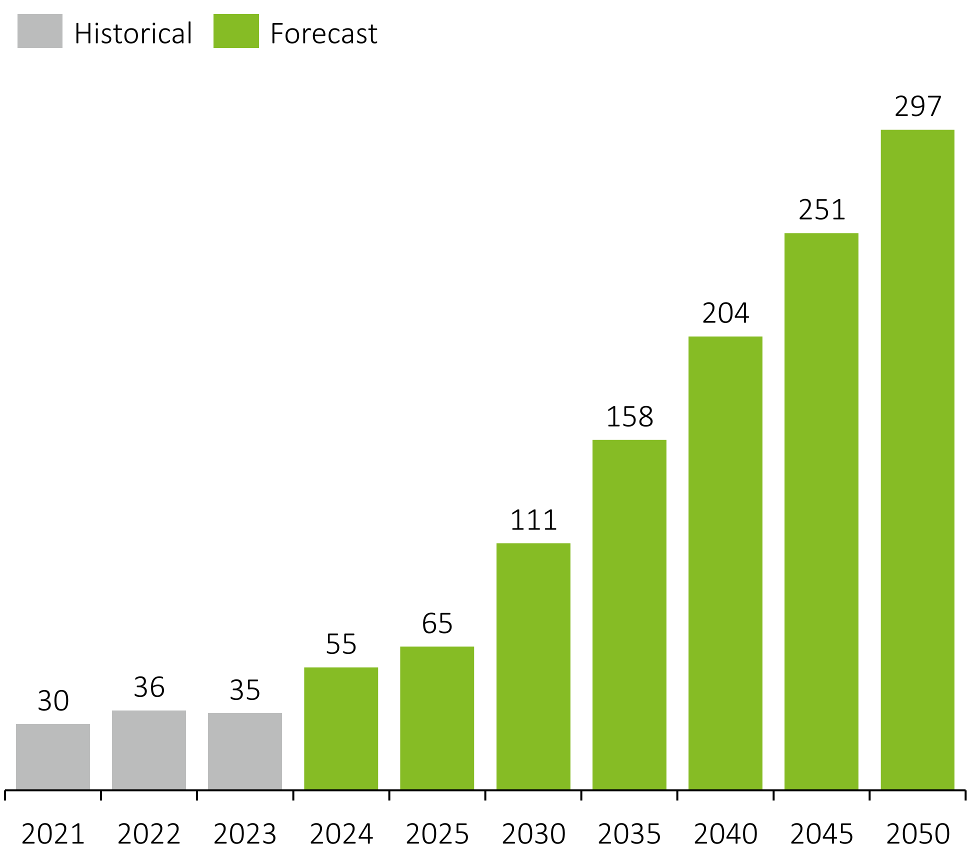
Sources: *Press Releases, Journals, Deloitte Analysis*

Sugarcane production forecast considers total plantation area and yield per hectare, following two presidential decrees on Acceleration of National Sugar Self-Sufficiency

Step 1: Calculate Sugarcane Production Forecast

Item	**Assumptions / Rationale**
Sugarcane Plantation Area	• Historical Sugarcane data From 2021 to 2023 follows USDA data at 423,000 Ha, 490,000 Ha, and 495,000 Ha respectively • As per Presidential Decree No. 40 of 2023, an additional 700,000 Ha will be added over 7 years, with 100,000 Ha added each year from 2024 to 2030 • As per Presidential Decree No. 15 of 2024, an additional 2,000,000 Ha, will be added over 20 years, with 100,000 hectares added each year from 2031 to 2050 • From 2051 onwards, Sugarcane Plantation area is assumed to remain constant
Yield per Hectare	• From 2021 to 2023, Yield is calculated by dividing Sugarcane Production with Sugarcane Plantation Area as per USDA data • From 2024 onwards, Sugarcane Yield is kept constant at 93 T/Ha, following Presidential Decree No. 40 of 2023

Reference: Sugarcane Production (Millions of Tons)



***Notes:* 1) 2050 forecast is inclusive up to 2060; *Sources:* Deloitte Analysis**

Sugarcane production forecast incorporates the government's directives on 700k and 2M hectares of additional plantations, along with a target yield of 93 T/Ha

Step 1: Calculate Sugarcane Production Forecast

Sugarcane Plantation Area (Thousands of Hectare)

Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Base	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495
700k Add.1)	100	200	300	400	500	600	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
2 Mn Add.2)	0	0	0	0	0	0	0	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400	1,500	1,600	1,700	1,800	1,900	2,000
Total	595	695	795	895	995	1,095	1,195	1,295	1,395	1,495	1,595	1,695	1,795	1,895	1,995	2,095	2,195	2,295	2,395	2,495	2,595	2,695	2,795	2,895	2,995	3,095	3,195

Sugarcane Yield (Tons per Hectare)

Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Yield	93																										

Sugarcane Production (Millions of Tons)

Formula Used = Total Plantation Area x Yield

Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Production	55.3	64.6	73.9	83.2	92.5	101.8	111.1	120.4	129.7	139.0	148.3	157.6	166.9	176.2	185.5	194.8	204.1	213.4	222.7	232.0	241.3	250.6	259.9	269.2	278.5	287.8	297.1

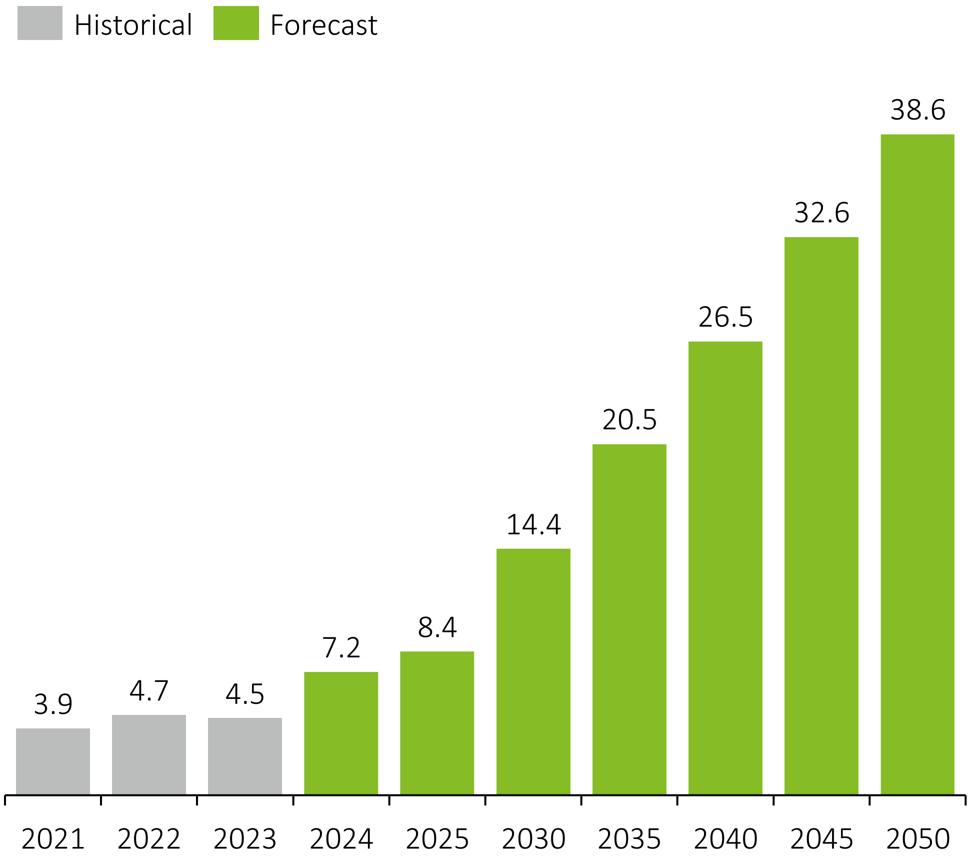
***Notes:** 1) Following Presidential Decree No. 40 of 2023, 2) Following Presidential Decree No. 15 of 2024, 3) 2050 forecast is inclusive up to 2060; **Sources:** Deloitte Analysis*

Based on a 13% conversion ratio, each ton of sugarcane production approximately generates 130 kg of dry Bagasse

Step 2: Estimate Bagasse Production

Item	Assumptions / Rationale
Sugarcane to Bagasse Conversion Ratio	• Bagasse production is first calculated by estimating the potential residues that can be generated from Sugarcane production • Following a scientific research from Integral University, India on Bioethanol Production from Sugarcane Bagasse, it is estimated that Each Ton of Sugarcane produces 130 kg dry weight of Bagasse (13.0%)
Bagasse Production Forecast	• Forecast of Bagasse Production is calculated by multiplying the Sugarcane Production of each year to the Sugarcane-to-Bagasse conversion ratio of 13.0%

Reference: Bagasse Production (Millions of Tons)



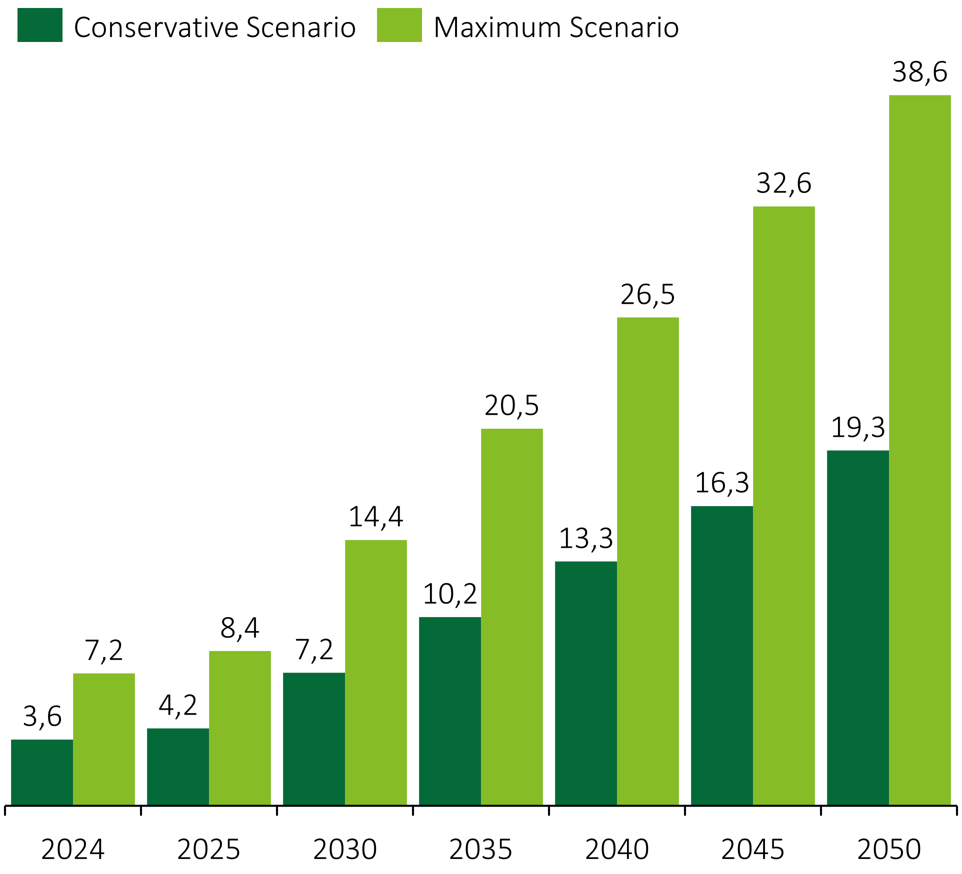
Notes:** 1) 2050 forecast is inclusive up to 2060;* ***Sources: *Deloitte Analysis*

Under the Maximum Scenario, 100% of Bagasse is allocated for ethanol production, whereas the Minimum Scenario assumes a 50% allocation

Step 3: Calculate Proportion of Bagasse Allocation for Bioethanol Production

Item	Assumptions / Rationale
Maximum Proportion of Bagasse for Bioethanol	Maximum Scenario: • Sugarcane Bagasse is entirely allocated for Bioethanol production (100%) • Above assumption is underpinned by the absence of national targets for utilization in other industries or export purposes • National targets will be a key variable in this forecast, as bagasse allocation for ethanol will likely depend on future policy decisions
Conservative Proportion of Bagasse for Bioethanol	Conservative Scenario: • 50% of Sugarcane Bagasse is allocated for Bioethanol, with the rest of 50% allocated for other and export purposes • This assumption is based on the forecast that future demand for bagasse in other sectors may increase, potentially reducing the share allocated for ethanol production

Reference: Bagasse Allocation for Bioethanol (Million Tons)



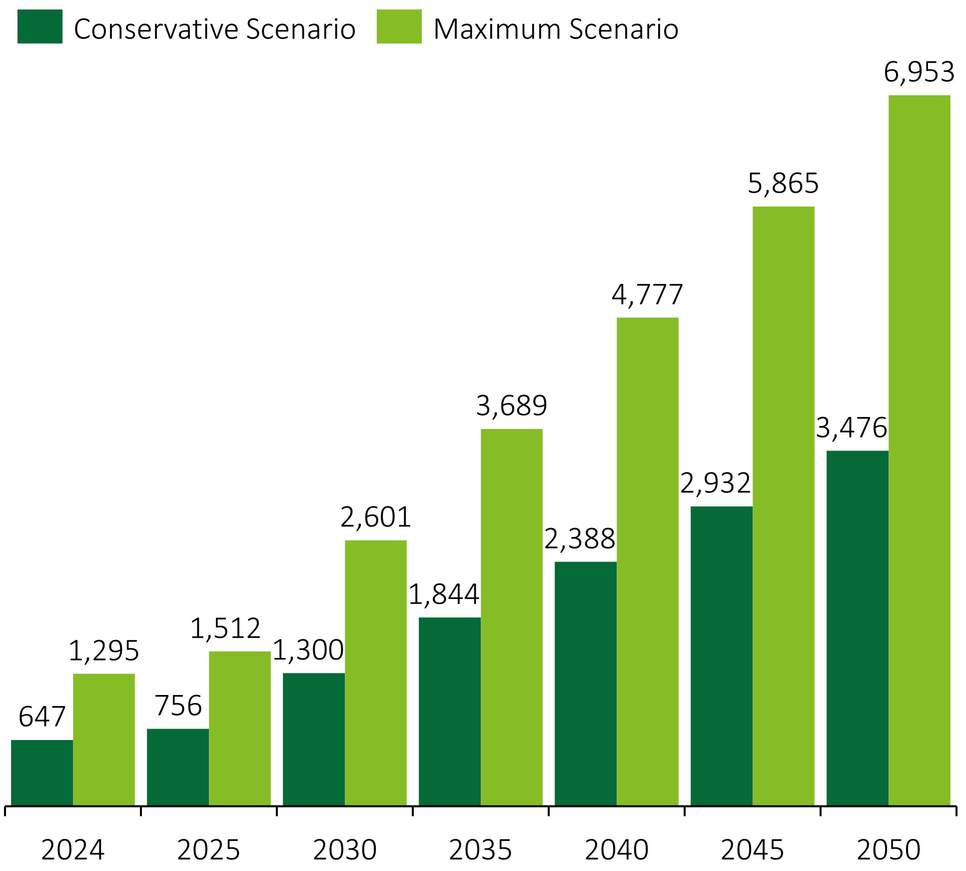
Notes: 1) 2050 forecast is inclusive up to 2060; ***Sources:*** *Deloitte Analysis*

Bioethanol production is forecasted using the conversion rate studied by the European Commission, which estimates 180 Liters of Ethanol for every Ton of Bagasse

Step 4: Estimate Bioethanol Production Forecast from Sugarcane Bagasse

Item	Assumptions / Rationale
Bagasse to Bioethanol Conversion	• Based on a Bioethanol study by the European Commission in Brazil, 1 Ton of Dry Bagasse is expected to produce 180 Liters of Ethanol • There is no difference in conversion rates between scenarios – therefore, the same ratio will apply to both the Maximum and Conservative scenarios
Bioethanol Production Forecast	• For each scenario, Bioethanol Production in Liter is calculated by multiplying the size of Bagasse allocated for Ethanol to 180 • The resulting figures provide the final estimate of Bioethanol production from Sugarcane Bagasse for each year, following both the Maximum and Conservative scenarios

Reference: Bagasse-Based Ethanol Production (Million Tons)



***Notes:** 1) 2050 forecast is inclusive up to 2060; **Sources:** Deloitte Analysis*

By 2050, Indonesia is projected to produce 7 Bn L of Bioethanol from Sugarcane Bagasse under the maximum scenario, and 3.5 Bn L under the conservative scenario

Step 4: Estimate Bioethanol Production Forecast from Sugarcane Bagasse

Sugarcane Bagasse for Bioethanol Production (Millions of Tons)

Maximum Scenario

Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Allocation	7.2	8.4	9.6	10.8	12.0	13.2	14.4	15.7	16.9	18.1	19.3	20.5	21.7	22.9	24.1	25.3	26.5	27.7	29.0	30.2	31.4	32.6	33.8	35.0	36.2	37.4	38.6

Conservative Scenario

Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Allocation	3.6	4.2	4.8	5.4	6.0	6.6	7.2	7.8	8.4	9.0	9.6	10.2	10.9	11.5	12.1	12.7	13.3	13.9	14.5	15.1	15.7	16.3	16.9	17.5	18.1	18.7	19.3

Conversion Rate from Sugarcane Bagasse to Bioethanol

Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Conv. Rate	1 Ton of Sugarcane Bagasse = 180 Liter of Ethanol																										

Bioethanol Production from Sugarcane Molasses (Millions of Liter)[1)]

Maximum Scenario

Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Production	1,295	1,512	1,730	1,948	2,165	2,383	2,601	2,818	3,036	3,253	3,471	3,689	3,906	4,124	4,342	4,559	4,777	4,994	5,212	5,430	5,647	5,865	6,082	6,300	6,518	6,735	6,953

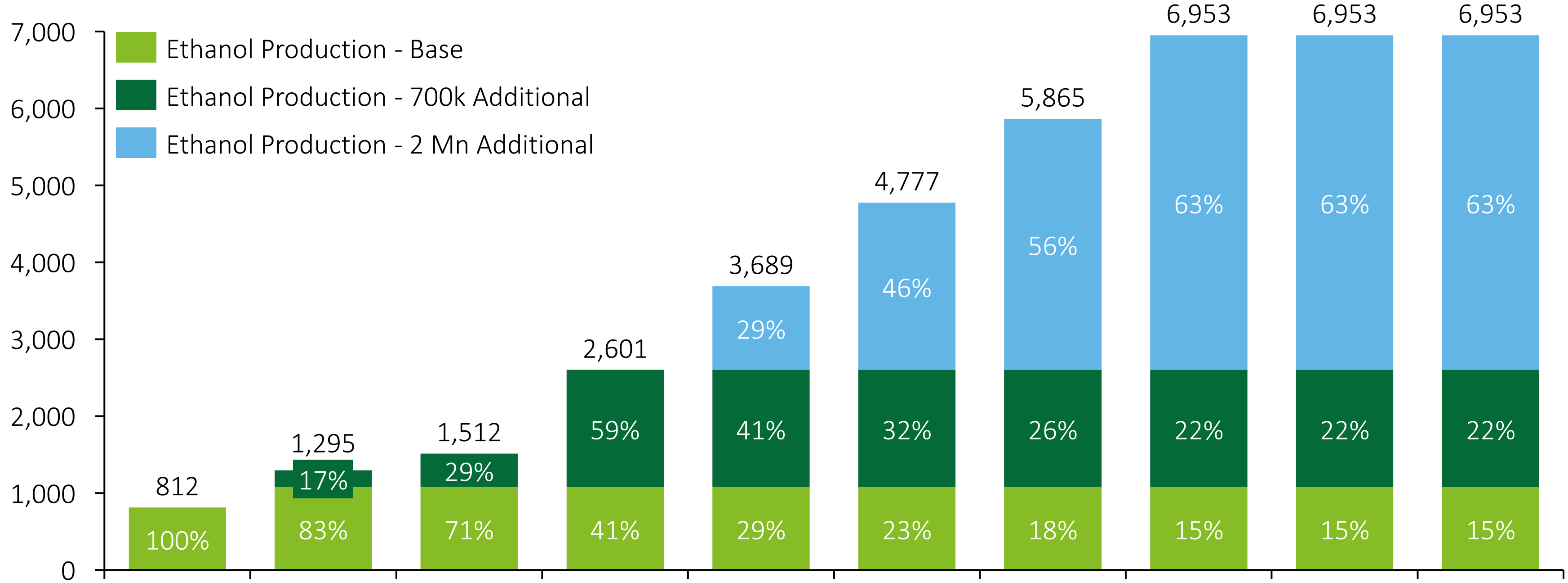
Conservative Scenario

Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Production	647	756	865	974	1,081	1,191	1,300	1,409	1,518	1,627	1,736	1,844	1,953	2,062	2,171	2,280	2,388	2,497	2,606	2,715	2,823	2,932	3,041	3,150	3,259	3,368	3,476

Notes: *1) Calculated by Multiplying Sugarcane Bagasse for Bioethanol by Conversion Rate (180), 2) 2050 forecast is inclusive up to 2060;* ***Sources:*** *Deloitte Analysis*

Under the optimistic assumption of fully utilising bagasse for Bioethanol (100%), production could reach approximately 7 billion liters in 2050

Bioethanol Production from Sugarcane Bagasse: Maximum Scenario (Million Liters)

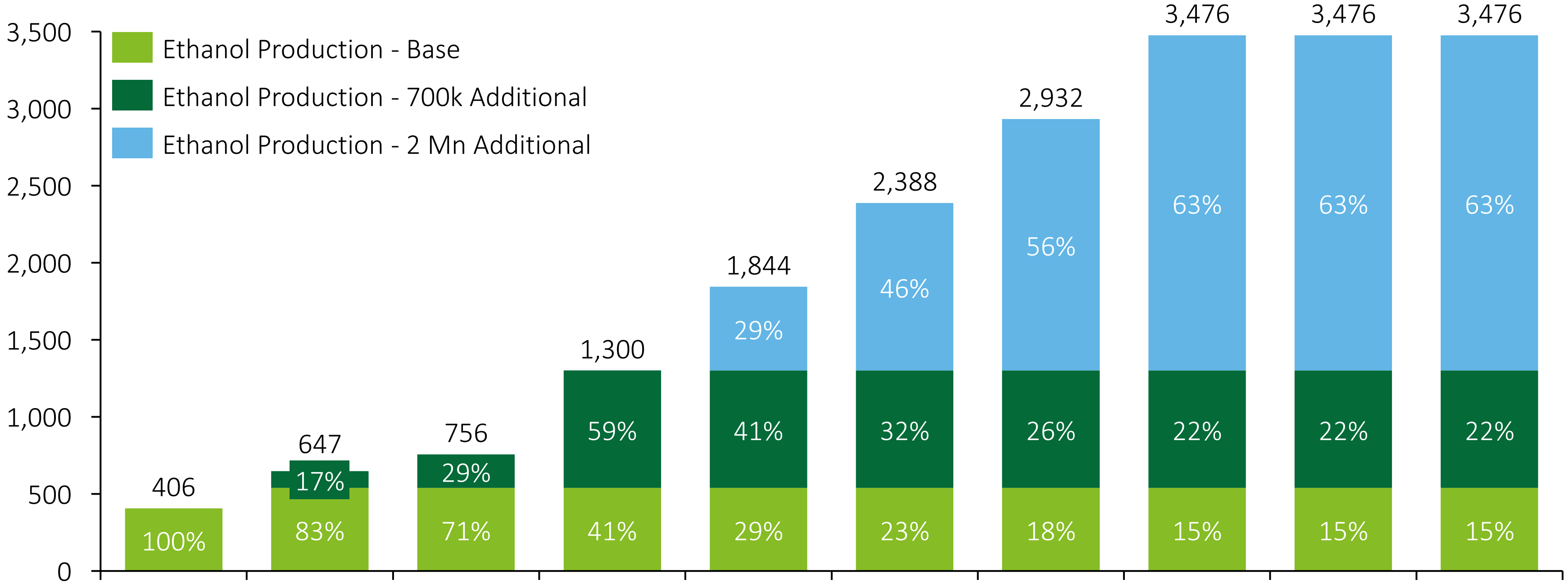


Plantation Area (Ha)	2023	2024	2025	2030	2035	2040	2045	2050	2055$^{3)}$	2060$^{3)}$
Base	495,000	495,000	495,000	495,000	495,000	495,000	495,000	495,000	495,000	495,000
700 k Additional$^{1)}$	0	100,000	200,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000
2 Mn Additional$^{2)}$	0	0	0	0	500,000	1,000,000	1,500,000	2,000,000	2,000,000	2,000,000
Total	495,000	595,000	695,000	1,195,000	1,695,000	2,195,000	2,695,000	3,195,000	3,195,000	3,195,000

Notes: *1) Following Presidential Decree No. 40 2023, 2) Following Presidential Decree No. 15 2024, 3) Sugarcane Plantation area assumed to remain constant from 2051;* ***Sources:*** *Deloitte Analysis*

Under the conservative assumption of utilizing 50% of bagasse for Bioethanol, production could reach ~3.5 bn liters by 2050 with 85% sourced from additional land

Bioethanol Production from Sugarcane Bagasse: Conservative Scenario (Million Liters)

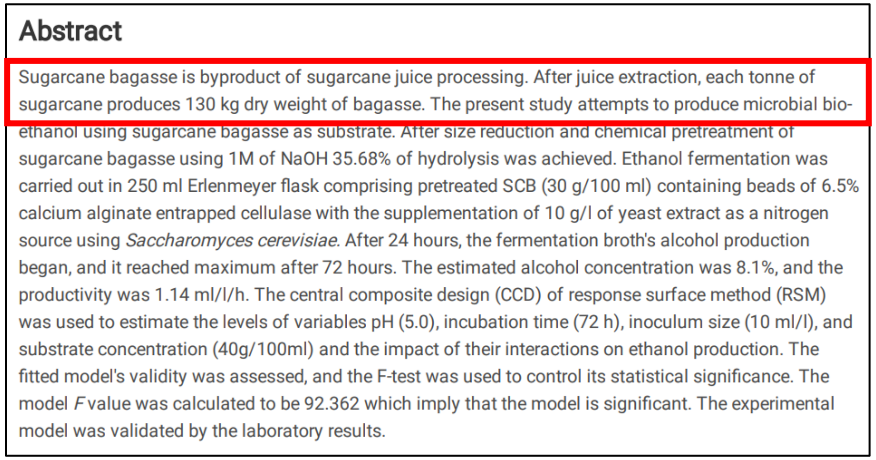
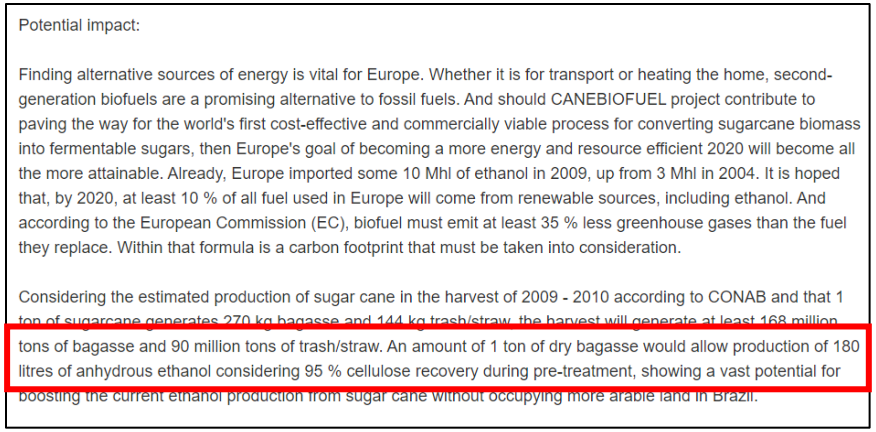


Plantation Area (Ha)	2023	2024	2025	2030	2035	2040	2045	2050	2055[3)]	2060[3)]
Base	495,000	495,000	495,000	495,000	495,000	495,000	495,000	495,000	495,000	495,000
700 k Additional[1)]	0	100,000	200,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000
2 Mn Additional[2)]	0	0	0	0	500,000	1,000,000	1,500,000	2,000,000	2,000,000	2,000,000
Total	495,000	595,000	695,000	1,195,000	1,695,000	2,195,000	2,695,000	3,195,000	3,195,000	3,195,000

***Notes:** 1) Following Presidential Decree No. 40 2023, 2) Following Presidential Decree No. 15 2024, 3) Sugarcane Plantation area assumed to remain constant from 2051; **Sources:** Deloitte Analysis*

The following list outlines the references from various sources used as inputs to forecast bagasse-based ethanol production

Reference Lists: Bagasse-Based Ethanol Calculation Assumptions

Section	Information Used	Source	Details from Source
Step 2: Estimate Bagasse Production	Each Ton of Sugarcane produces 130 kg dry weight of Bagasse	• Publication Title: Bioethanol Production from Sugarcane Bagasse – Optimisation Through Response Surface Methodology and Experimental Validation • The research published in 2023 was led by Integral University, India • Link	 **Abstract** Sugarcane bagasse is byproduct of sugarcane juice processing. After juice extraction, each tonne of sugarcane produces 130 kg dry weight of bagasse. The present study attempts to produce microbial bio-ethanol using sugarcane bagasse as substrate. After size reduction and chemical pretreatment of sugarcane bagasse using 1M of NaOH 35.68% of hydrolysis was achieved. Ethanol fermentation was carried out in 250 ml Erlenmeyer flask comprising pretreated SCB (30 g/100 ml) containing beads of 6.5% calcium alginate entrapped cellulase with the supplementation of 10 g/l of yeast extract as a nitrogen source using *Saccharomyces cerevisiae*. After 24 hours, the fermentation broth's alcohol production began, and it reached maximum after 72 hours. The estimated alcohol concentration was 8.1%, and the productivity was 1.14 ml/l/h. The central composite design (CCD) of response surface method (RSM) was used to estimate the levels of variables pH (5.0), incubation time (72 h), inoculum size (10 ml/l), and substrate concentration (40g/100ml) and the impact of their interactions on ethanol production. The fitted model's validity was assessed, and the F-test was used to control its statistical significance. The model *F* value was calculated to be 92.362 which imply that the model is significant. The experimental model was validated by the laboratory results.
Step 4: Estimate Bioethanol Production from Molasses	Each Ton of Dry Bagasse is expected to produce 180 Liters of Ethanol	• Publication Title: Conversion of Sugar Cane Biomass into Ethanol • The report was published by the European Commission to understand the Brazilian second-generation bio-ethanol scenario • Link	 Potential impact: Finding alternative sources of energy is vital for Europe. Whether it is for transport or heating the home, second-generation biofuels are a promising alternative to fossil fuels. And should CANEBIOFUEL project contribute to paving the way for the world's first cost-effective and commercially viable process for converting sugarcane biomass into fermentable sugars, then Europe's goal of becoming a more energy and resource efficient 2020 will become all the more attainable. Already, Europe imported some 10 Mhl of ethanol in 2009, up from 3 Mhl in 2004. It is hoped that, by 2020, at least 10 % of all fuel used in Europe will come from renewable sources, including ethanol. And according to the European Commission (EC), biofuel must emit at least 35 % less greenhouse gases than the fuel they replace. Within that formula is a carbon footprint that must be taken into consideration. Considering the estimated production of sugar cane in the harvest of 2009 - 2010 according to CONAB and that 1 ton of sugarcane generates 270 kg bagasse and 144 kg trash/straw, the harvest will generate at least 168 million tons of bagasse and 90 million tons of trash/straw. An amount of 1 ton of dry bagasse would allow production of 180 litres of anhydrous ethanol considering 95 % cellulose recovery during pre-treatment, showing a vast potential for boosting the current ethanol production from sugar cane without occupying more arable land in Brazil.

Sources: *Press Releases, Journals, Deloitte Analysis*

Bioethanol Forecast from Empty Fruit Bunch (EFB)

Four key factors used to estimate EFB-based ethanol supply: CPO, CPKO and EFB production, bioethanol allocation, and EFB-to-ethanol conversion

Summary of Bioethanol Production Calculation Approach

	Objectives	Methods Used
① Forecast of CPO and CPKO Production	Forecast CPO and CPKO production using Ministry's projection data between 2020 and 2045	CPO-CPKO Production = Extract CPO-CPKO Production forecast from 2020 to 2045 based on Ministry's estimate
② Estimation of EFB from CPO and CPKO Production	Estimate size of EFB generated from CPO and CPKO production using industry conversion ratio	EFB Production = CPO-CPKO Production × CPO-CPKO to EFB Conversion Ratio
③ Allocation of EFB for Bioethanol	Calculate potential Bioethanol that can be produced following assumption of usage proportion	EFB for Bioethanol = EFB Production × Bioethanol utilization Rate
④ Bioethanol Production from EFB	Convert EFB estimate (in Ton) into Bioethanol production (in Liter)	Bioethanol Production = EFB Production for Bioethanol × EFB to Bioethanol Conversion Rate

Sources: *Deloitte Analysis*

Below is the summary of key assumptions and rationale used to calculate Bioethanol Production forecasts from EFB through 2060

Key Assumptions for Bioethanol Production Forecasts

Input Items		Assumptions and Rationale
CPO-CPKO	CPO-CPKO Production	• Data for CPO-CPKO Production from 2020 – 2045 is extracted from a cross-ministerial and associations study, involving the Ministry of Agriculture, Ministry of Industry, and Ministry of Trade, among others • CPO-CPKO production from 2045 onwards is assumed to remain constant
EFB for Ethanol Production	EFB Production	• Based on an on-going scientific research from Badan Riset and Inovasi Nasional (BRIN), EFB will account for approximately 64% of the total CPO-CPKO production • EFB Production is calculated by multiplying the CPO-CPKO Production of each year to the CPO-CPKO-to-EFB conversion ratio weight of 64%
	EFB utilization Rate	• Based on an on-going scientific research from Badan Riset and Inovasi Nasional (BRIN), only 40% of the EFB generated is usable and suitable for further processing, while the remaining must be left back to the soil • Utilisable EFB is calculated by multiplying EFB Production to the Estimated utilization Rate of 40%
	EFB Portion for Ethanol Production	• Two scenarios of Maximum and Conservative are applied • Maximum: EFB is assumed to be entirely allocated for Bioethanol production (100%) – this assumption is based on the current absence of national directions for EFB utilization • Minimum: 50% of EFB is allocated for Bioethanol, with the rest of 50% allocated for others – this assumption is based on the forecast that future demand for bagasse in other sectors may increase
	Ethanol Production in Liter	• Based on a Bioethanol study by Indonesian Institute of Science, 1 ton of EFB is estimated to yield approximately 301 liters of ethanol • Final estimate of Ethanol production in Liter is is calculated by multiplying the size of EFB allocated for Ethanol to EFB-to-Ethanol production ratio of 301

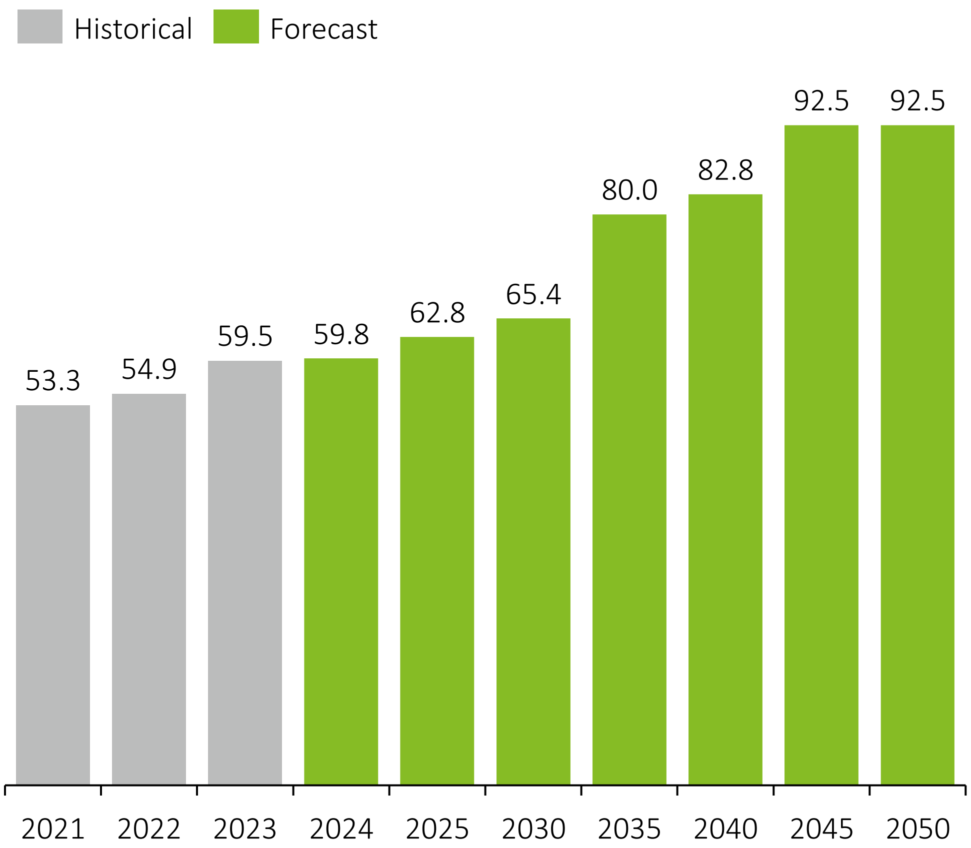
Sources: *Press Releases, Journals, Deloitte Analysis*

The CPO-CPKO production forecast is based on a cross-ministerial and industry association study, projecting approximately 92.5 million tons by 2045

Step 1: Calculate CPO-CPKO Production Forecast

Item	Assumptions / Rationale
CPO-CPKO Production Forecast from GAPKI	• The data for CPO-CPKO Production estimate from 2020 up to 2045 is extracted from a cross-ministerial and associations study • This study involved multiple directorates across the Ministry of Agriculture, Ministry of Industry, and Ministry of Trade, among others
CPO-CPKO Production Forecast from 2045 Onwards	• CPO-CPKO production from 2045 onwards is assumed to remain constant, using 2045 figure of 92,450,000 Tons • The assumption to keep the production constant from 2045 onwards is based on the timeline and unpredictable factors that affecting the CPO-CPKO market dynamics

Reference: CPO-CPKO Production Forecast (Million Tons)



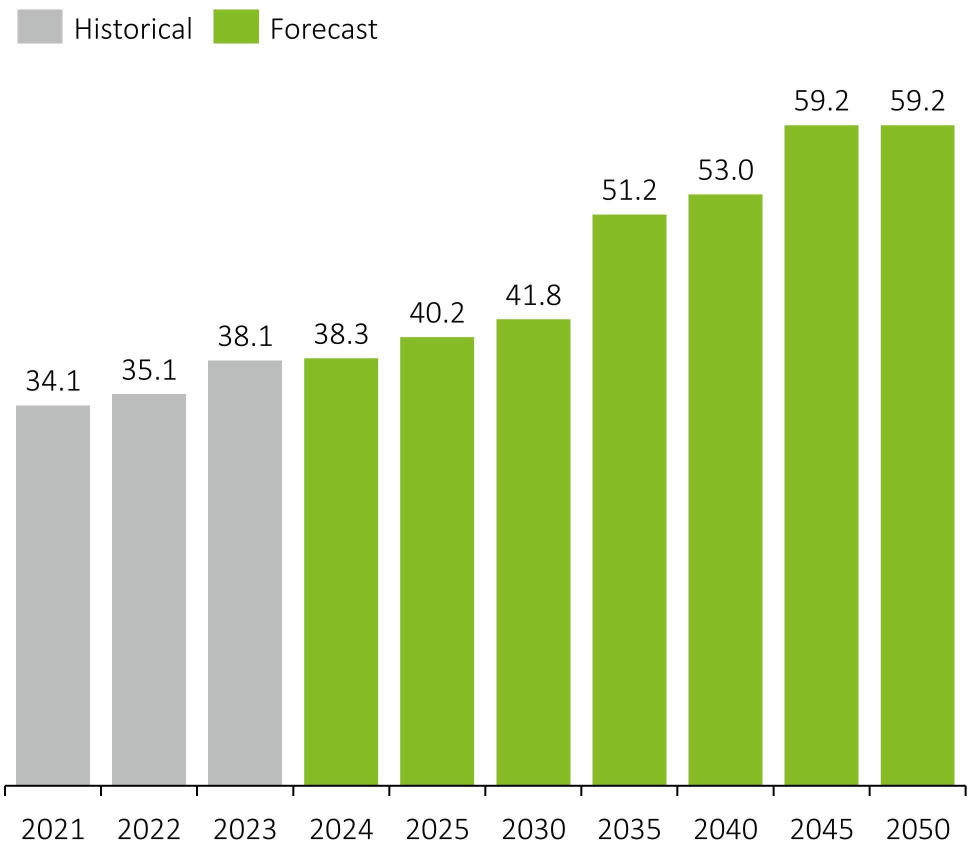
***Notes:** 1) 2050 forecast is inclusive up to 2060; **Sources:** Deloitte Analysis*

In line with BRIN's direction, EFB volume is expected to account for approximately 64% of total CPO-CPKO production

Step 2: Estimate EFB Production

Item	Assumptions / Rationale
CPO-CPKO Production to EFB Conversion Ratio	• According to a research conducted by Badan Riset and Inovasi Nasional (BRIN), a CPO-CPKO production of 67.75 Million Tons is expected to generate approximately 43.36 Million Tons of EFB • BRIN's findings suggest that EFB will account for approximately 64% of the total CPO-CPKO production
EFB Production Forecast	• Forecast of EFB Production is calculated by multiplying the CPO-CPKO Production of each year to the CPO-CPKO Production to EFB conversion ratio of 64%

Reference: EFB Production (Millions of Tons)



***Notes:** 1) 2050 forecast is inclusive up to 2060;* ***Sources:** Deloitte Analysis*

BRIN's study estimates 40% of EFB is usable. The Maximum Scenario allocates 100% of EFB for ethanol, while the Conservative Scenario allocates 50%

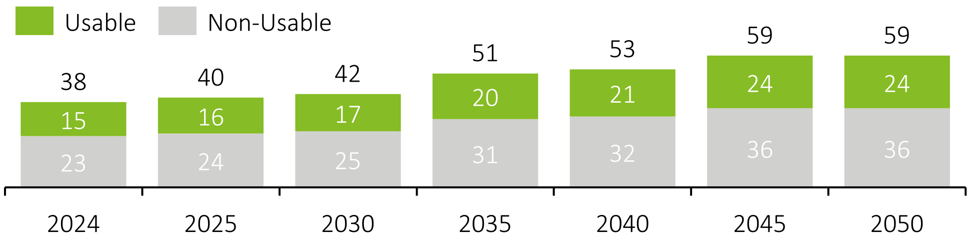
Step 3: Calculate Proportion of EFB Allocation for Bioethanol Production

Item | **Assumptions / Rationale** | **Reference**

EFB utilization Rate

According to a research conducted by Badan Riset and Inovasi Nasional (BRIN), only 40% of the EFB generated is usable and suitable for further processing, with the remaining portion likely to be left on the soil as mulch

EFB Size Based on Usage Eligibility (Million Tons)



Proportion of EFB for Bioethanol[2)]

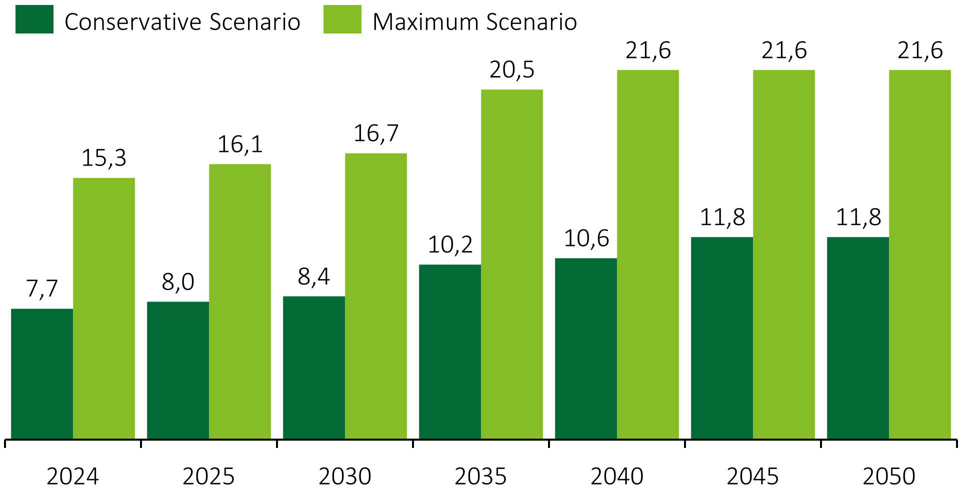
Maximum Scenario:

- EFB is fully allocated to Bioethanol production (100%)
- Above assumption is based on the absence of national targets for other uses or exports

Conservative Scenario:

- 50% of EFB is allocated to Bioethanol; the rest to other uses and exports
- This assumption is based on the forecast that future demand for EFB in other sectors may reduce EFB for ethanol production portion

EFB Allocation for Bioethanol (Million Tons)



***Notes:** 1) 2050 forecast is inclusive up to 2060, 2) National targets will be a key variable in this forecast, as EFB allocation for ethanol will depend on future policy decisions, **Sources:** Deloitte Analysis*

Bioethanol production is forecasted using the conversion rate studied by the Indonesian Institute, which estimates 301 Liters of Ethanol for every Ton of EFB

Step 4: Estimate Bioethanol Production Forecast from EFB

Item | **Assumptions / Rationale**

EFB to Bioethanol Conversion

- Research by the Indonesian Institute of Science shows 1 ton of EFB can produce 301 liters of ethanol
- The figure is derived by multiplying the following figures found in the study

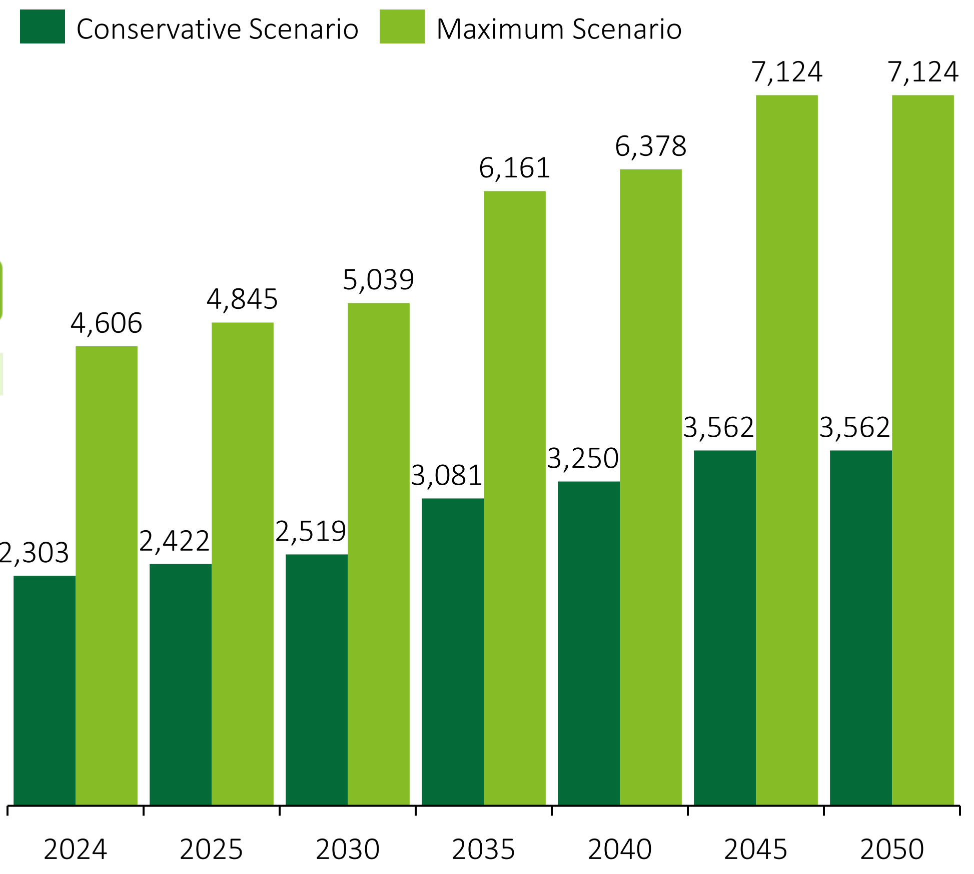
(① Cellulose Content of Feedstock	×	② Glucose Content of Cellulose	×	③ Ethanol Yield from Glucose)	÷	④ Density of Ethanol	=	Conversion Ratio
44%		60.02%		88.4%		0.78 k/L		30.1%

- 30.1% indicates that 1 ton of EFB can produce 301 liters of ethanol
- There is no difference in conversion ratios between scenarios

Bioethanol Production Forecast

For each scenario, Bioethanol Production in Liter is calculated by multiplying the size of EFB allocated for Ethanol to 301, providing the annual estimate of EFB-based ethanol

Reference: EFB-Based Ethanol Production (Million Tons)



***Notes:** 1) 2050 forecast is inclusive up to 2060; **Sources:** Deloitte Analysis*

By 2050, Indonesia is projected to produce 7 Bn Liter of Bioethanol from EFB under the maximum scenario, and 3.6 Bn Liter under the conservative scenario

Step 4: Estimate Bioethanol Production Forecast from EFB

EFB for Bioethanol Production (Millions of Tons)

Maximum Scenario

Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Allocation	15.3	16.1	16.5	16.57	16.59	16.67	16.7	17.4	18.2	18.9	20.0	20.5	20.7	20.8	20.9	21.1	21.2	21.6	22.1	22.8	23.1	23.7	23.7	23.7	23.7	23.7	23.7

Conservative Scenario

Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Allocation	7.7	8.0	8.2	8.28	8.30	8.34	8.4	8.7	9.1	9.5	10.0	10.2	10.3	10.4	10.5	10.6	10.8	11.0	11.4	11.4	11.6	11.8	11.8	11.8	11.8	11.8	11.8

Conversion Rate from EFB to Bioethanol

Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Conv. Rate	1 Ton of EFB = 301 Liters of Ethanol																										

Bioethanol Production from Sugarcane Molasses (Millions of Liter)[1)]

Maximum Scenario

Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Production	4,606	4,845	4,954	4,987	4,995	5,019	5,039	5,229	5,488	5,690	6,008	6,161	6,228	6,263	6,305	6,336	6,378	6,500	6,638	6,859	6,965	7,124	7,124	7,124	7,124	7,124	7,124

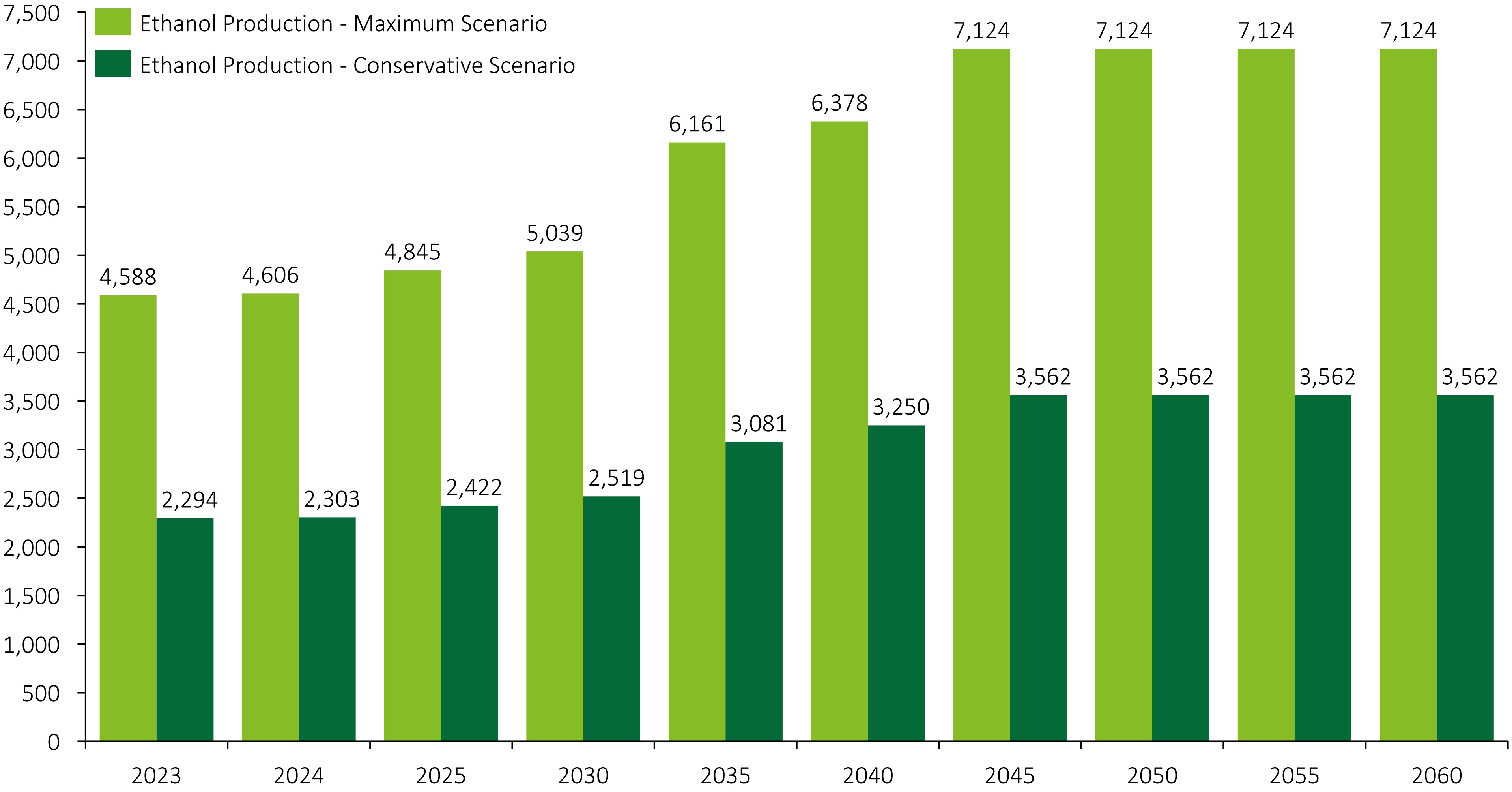
Conservative Scenario

Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Production	2,303	2,422	2,477	2,494	2,497	2,509	2,519	2,615	2,744	2,845	3,004	3,081	3,114	3,132	3,153	3,168	3,189	3,250	3,319	3,429	3,483	3,562	3,562	3,562	3,562	3,562	3,562

***Notes:** 1) Calculated by Multiplying EFB for Bioethanol by Conversion Rate (301), 2) 2050 forecast is inclusive up to 2060; **Sources:** Deloitte Analysis*

Under the Max. Scenario of full EFB utilization, Ethanol production could reach 7 bn liters by 2050, or 3.6 bn liters under the Conservative Assumption with 50% utilization

Bioethanol Production from Empty Fruit Bunch (Million Liters)

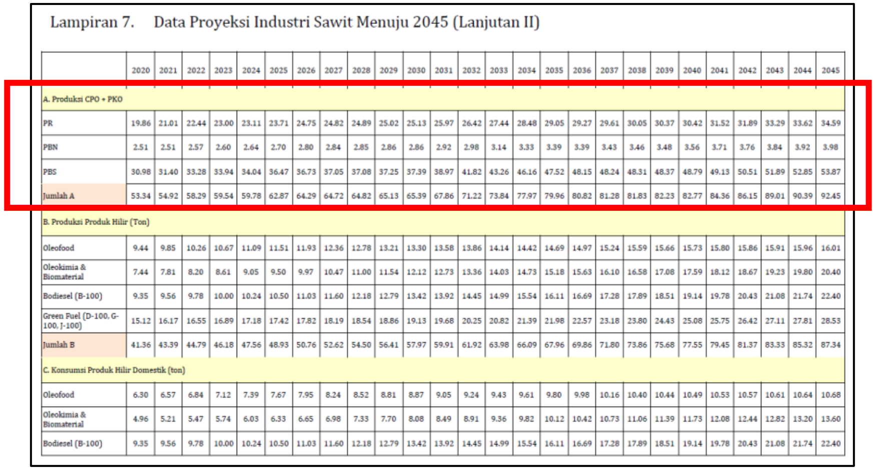
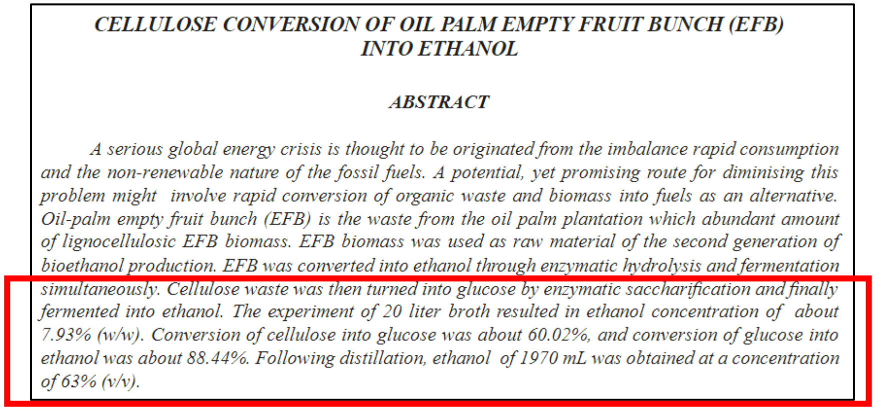


	2023	2024	2025	2030	2035	2040	2045	2050	2055	2060
Ethanol Production - Maximum Scenario	4,588	4,606	4,845	5,039	6,161	6,378	7,124	7,124	7,124	7,124
Ethanol Production - Conservative Scenario	2,294	2,303	2,422	2,519	3,081	3,250	3,562	3,562	3,562	3,562

Sources: *Deloitte Analysis*

The following list outlines the references from various sources used as inputs to forecast EFB-based ethanol production

Reference Lists: EFB-Based Ethanol Calculation Assumptions

Section	Information Used	Source	Details from Source
Step 1: Calculate CPO-CPKO Production Forecast	CPO-CPKO Production Estimate from 2020 until 2045	• Publication Title: National Palm Oil Industry Roadmap and Guide Towards 2045 • The research was conducted by the Ministry of Agriculture, Ministry of Industry, and Ministry of Trade, among others • The research, not publicly accessible, was obtained from an expert interview	
Step 4: Estimate EFB Production	1 ton of EFB can produce 301 liters of ethanol	• Publication Title: Conversion of Cellulose from Empty Fruit Bunch into Ethanol • The research was conducted by The Indonesian Institute of Sciences in 2016 • Link	

Lampiran 7. Data Proyeksi Industri Sawit Menuju 2045 (Lanjutan II)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
A. Produksi CPO + PKO																										
PR	19.86	21.01	22.44	23.00	23.11	23.71	24.75	24.82	24.89	25.02	25.13	25.97	26.42	27.44	28.48	29.05	29.27	29.61	30.05	30.37	30.42	31.52	31.89	33.29	33.62	34.59
PBN	2.51	2.51	2.57	2.60	2.64	2.70	2.80	2.84	2.85	2.86	2.86	2.92	2.98	3.14	3.33	3.39	3.39	3.43	3.46	3.48	3.56	3.71	3.76	3.84	3.92	3.98
PBS	30.98	31.40	33.28	33.94	34.04	36.47	36.73	37.05	37.08	37.25	37.39	38.97	41.82	43.26	46.16	47.52	48.15	48.24	48.31	48.37	48.79	49.13	50.51	51.89	52.85	53.87
Jumlah A	53.34	54.92	58.29	59.54	59.78	62.87	64.29	64.72	64.82	65.13	65.39	67.86	71.22	73.84	77.97	79.96	80.82	81.28	81.83	82.23	82.77	84.36	86.15	89.01	90.39	92.45
B. Produksi Produk Hilir (Ton)																										
Oleofood	9.44	9.85	10.26	10.67	11.09	11.51	11.93	12.36	12.78	13.21	13.30	13.58	13.86	14.14	14.42	14.69	14.97	15.24	15.59	15.66	15.73	15.80	15.86	15.91	15.96	16.01
Oleokimia & Biomaterial	7.44	7.81	8.20	8.61	9.05	9.50	9.97	10.47	11.00	11.54	12.12	12.73	13.36	14.03	14.73	15.18	15.63	16.10	16.58	17.08	17.59	18.12	18.67	19.23	19.80	20.40
Bodiesel (B-100)	9.35	9.56	9.78	10.00	10.24	10.50	11.03	11.60	12.18	12.79	13.42	13.92	14.45	14.99	15.54	16.11	16.69	17.28	17.89	18.51	19.14	19.78	20.43	21.08	21.74	22.40
Green Fuel (D-100, G-100, J-100)	15.12	16.17	16.55	16.89	17.18	17.42	17.82	18.19	18.54	18.86	19.13	19.68	20.25	20.82	21.39	21.98	22.57	23.18	23.80	24.43	25.08	25.75	26.42	27.11	27.81	28.53
Jumlah B	41.36	43.39	44.79	46.18	47.56	48.93	50.76	52.62	54.50	56.41	57.97	59.91	61.92	63.98	66.09	67.96	69.86	71.80	73.86	75.68	77.55	79.45	81.37	83.33	85.32	87.34
C. Konsumsi Produk Hilir Domestik (ton)																										
Oleofood	6.30	6.57	6.84	7.12	7.39	7.67	7.95	8.24	8.52	8.81	8.87	9.05	9.24	9.43	9.61	9.80	9.98	10.16	10.40	10.44	10.49	10.53	10.57	10.61	10.64	10.68
Oleokimia & Biomaterial	4.96	5.21	5.47	5.74	6.03	6.33	6.65	6.98	7.33	7.70	8.08	8.49	8.91	9.36	9.82	10.12	10.42	10.73	11.06	11.39	11.73	12.08	12.44	12.82	13.20	13.60
Bodiesel (B-100)	9.35	9.56	9.78	10.00	10.24	10.50	11.03	11.60	12.18	12.79	13.42	13.92	14.45	14.99	15.54	16.11	16.69	17.28	17.89	18.51	19.14	19.78	20.43	21.08	21.74	22.40

CELLULOSE CONVERSION OF OIL PALM EMPTY FRUIT BUNCH (EFB) INTO ETHANOL

ABSTRACT

A serious global energy crisis is thought to be originated from the imbalance rapid consumption and the non-renewable nature of the fossil fuels. A potential, yet promising route for diminising this problem might involve rapid conversion of organic waste and biomass into fuels as an alternative. Oil-palm empty fruit bunch (EFB) is the waste from the oil palm plantation which abundant amount of lignocellulosic EFB biomass. EFB biomass was used as raw material of the second generation of bioethanol production. EFB was converted into ethanol through enzymatic hydrolysis and fermentation simultaneously. Cellulose waste was then turned into glucose by enzymatic saccharification and finally fermented into ethanol. The experiment of 20 liter broth resulted in ethanol concentration of about 7.93% (w/w). Conversion of cellulose into glucose was about 60.02%, and conversion of glucose into ethanol was about 88.44%. Following distillation, ethanol of 1970 mL was obtained at a concentration of 63% (v/v).

Notes: *1) The information in Steps 2 and 3 is drawn from an ongoing, unpublished study by BRIN, with printed references not yet available;* ***Sources:*** *Press Releases, Journals, Deloitte Analysis*

Expansion of Ethanol Use by FFV Introduction

The rapid growth of FFVs in Brazil within five years of launch can be attributed to the positive market sentiment and strong policy uptake by the government

Success Factors for Brazilian FFV Market During 2003 – 2008

← *Market / Consumer – Driven* →

← *Government / Policy–Driven* →

Flexibility to switch fuel choices based on price and convenience

- **Price Advantage: Ethanol in Brazil was ~ 40% cheaper than gasoline,** offering significant cost savings for consumers
- The global oil crisis in the early 2000s, which spiked gasoline prices, increased the attractiveness of ethanol during this period
- **Flexibility: The ability to switch between ethanol and gasoline** without engine modifications was a key selling point for FFVs

Large availability of FFVs for public to access

- **Widespread availability of FFVs in the market made it easier for consumers to own** these vehicles
- **Major OEMs invested** heavily in FFV production, leading to **a greater variety of models**
- By 2007, Brazilian OEMs offered > 63 FFV models ranging from Passenger Cars, SUVs, Pickup Trucks, and Light Commercial Vehicles (LCVs)

Competitive tax incentives on FFV cars from the government

- **For Consumers:** The **sales tax for FFVs and ethanol-fueled cars is 14%, which is 2% lower** than the 16% tax on non-ethanol cars
- **For Producers: FFV manufacturers received tax breaks[1],** encouraging them to increase FFV production
- Initially, preferential tax treatments were exclusive to ethanol cars but were later extended to FFVs to scale their market penetration

Direct intervention to maintain competitive ethanol pricing

- As part of the national mandate, **ethanol prices have been consistently set and adjusted to remain below gasoline prices** since the launch of FFVs
- For instance, before 2011, tax for pure gasoline was > 100%, while tax for E100 (pure ethanol) was < 40%
- In case of exogenous shocks[2], **Government would negotiate with ethanol producers** to reduce ethanol prices

Import restrictions on used diesel vehicles

- **Imports of used automobiles into Brazil are not allowed** under any circumstances, with special authorization required for the import of used parts
- Brazil also **banned the import of diesel passenger cars,** a measure **likely to further restrict the access and use of non-FFVs** in the Brazilian market

Notes: *1) Tax scheme unidentified, 2) Example: Sudden rise in demand for E100;* ***Sources:*** *Rapid Transition Alliance, Global Fuel Economy, Independent Commodity Intelligence Services' Publication on Brazilian FFV Market, Energy Economics' Publication on Transportation Fuel Policies in Brazil, ELLA Area's Policy Brief on Government Intervention to Strengthen the Brazilian Ethanol Sector*

The Brazilian market is expected to shift its national policy towards EV adoption, leaving the future role of FFVs uncertain

Observation on the Policy Direction for the Brazilian Transport Sector

No clear prioritisation between FFVs and EVs for GHG reduction in the Transport sector

- The government has not explicitly prioritized between FFVs and EVs
- The new administration is expected to implement several environmentally friendly measures, potentially introducing improved EV incentives, though the status of FFV support remains uncertain

Price Intervention on EV geared towards protecting domestic industries

- The tax imposition on EVs aims to protect domestic industries, particularly from Chinese products, rather than implicitly promoting further FFV adoption
- Since January 2022, EVs have faced a 10% import tax, which is set to increase to 35% by July 2026

Over the next 15 years, Brazil aims to establish the EV market as a national focus

- Despite discussions on shifting policy towards expanding Brazil's EV market, many experts recommend focusing on FFV development
- Due to high costs, EVs will likely be inaccessible for most Brazilians, thus limiting their impact on GHG reductions

Points to clarify

1 Prioritisation of vehicle types to reduce GHG emissions

Under the new government, is there a specific direction towards prioritising a particular vehicle type – if so, what are the reasons?

2 Status of FFV in the Brazilian market

What is the status of FFVs in the Brazilian market, and do they still hold priority in the country's transport sector development?

3 Future new preferential policies on EV and/or FFV

Based on the government's direction and national priorities, what are the current & planned policies for the EV & FFV sectors?

4 Role of FFV if national policy is shifted towards EV adoption

What role will FFVs play in Brazil if the government considers new measures for environmental sustainability (i.e., EV)?

Sources: *Climate Transparency Policy Paper, The Brazilian Report, Fast Markets*

India introduced FFVs in 2023 to enhance domestic energy reliance, driven by significant progress in the ethanol sector and numerous government initiatives

FFV Trends in the Indian Market

Introduction of FFV in India

FFV has been introduced in India for < 1 year

- FFV **was first launched in India in August 2023** (Toyota Innova 100% ethanol-fueled variant)
- The introduction of FFV is **expected to reduce the petroleum imports** and promote India's self-reliance in energy

Confidence in FFV driven by Ethanol sector

- **India is expected to advance the target for E20** blending to 2025, from the original plan of 2030
- E20 fuel is currently available at > 3300 fuel stations and will be **nationwide by April 2025**
- As FFVs are powered by ethanol, the government is confident that its strong ethanol industry can support widespread FFV adoption

Government's Initiative to Drive FFV Adoption

1 Encouraging OEMs to Commence FFV Production

- Since August 2021, the Minister of Road Transport and Highways has **urged auto industry CEOs to introduce FFVs capable of running on 100% ethanol** and gasoline
- OEMs are also asked comply with E20 standards by April '23

2 Research Funding for FFV Development

- Since April 2022, the Indian government has **funded a project to develop technology for diesel vehicles to run in flex-fuel mode**
- The project involved Indian Institute of Technology, Indian Oil Corporation (IOC) and Ashok Leyland Ltd.

3 Regulation to Reduce Conventional Fuels Use

- The government had **asked the Mass Emission Standards to introduce gasoline blends (E10-20) and flex-fuel (E85, E100)**
- The government anticipates that offering more fuel alternatives will ease overall transition to FFVs

4 Tax Benefits for Producers and Biofuel Products

- In October 2023, the Ministry of Road Transportation **urged all states to reduce or exempt road tax on FFVs to promote sales**
- India also expanded excise exemptions for biofuels to encourage higher ethanol blends with petrol & diesel

***Notes:** 1) MES are government-instituted emission standards that all motor vehicles must comply with if they are to be sold and driven in India; **Sources:** Business Standards India, Press Release from the Ministry of Petroleum and Natural Gas of India, India Science and Technology*

The FFV industry in India is still at an early stage, with leading OEMs remain focused on vehicle showcases and pilot projects

Recent Development of Major OEMs

TOYOTA

- Toyota firstly introduced the Innova HyCross, which can run 100% on Ethanol in 2023
- They also launched a pilot project on Corolla flex-fuel hybrid sedan to support the government in commercializing FFV at scale

HONDA

- Honda introduced India's first flex-fuel 2W in 2024, to run on E85 fuel, which is the OEM's first FFV
- Based on Honda's FFV development in Brazil, they are planning to introduce more ethanol vehicles in India in the coming years

TATA MOTORS

- As of 2023, TATA Motors is still focusing on making their vehicles E20-compliant
- Nevertheless, TATA is also working towards achieving up to E85 flex-fuel compatibility, with timeline of release still not confirmed

MARUTI SUZUKI

- Maruti Suzuki is scheduled to launch its first FFV in India by 2025
- The OEM's first model, WagonR flex-fuel car has been designed to run on any ethanol-petrol blend between 20% (E20) and 85% (E85) fuel

Mahindra

- In early 2024, Mahindra showcased its first FFV model, currently the only sub-4m SUV in the market
- Earlier in 2022, the company also partnered with a Canadian firm to boost biofuel access for Indian consumers via fuel dispensers

TVS

- TVS showcased its first flex-fuel 2W, the Raider 125 FFT, in early 2024, compatible with E20 to E85 ethanol
- Additionally, TVS partnered with Indian Oil, BPCL, and HPCL to set up flex-fuel pumps in India since 2022

Sources: *Indian Express, Financial Express India, Coherent Market Insights Report*

Low awareness, high vehicle costs, and underdeveloped infrastructure may restrain the Indian FFV market, highlighting the need for strategic countermeasures

Challenges in the Indian FFV Market

Negative Perceptions & Low Awareness

- **Limited awareness** on FFV continues to exist among Indian consumers
- **Perceptions associated with lower performance and higher price** when it comes to new vehicle technologies
- In 2023, only 0.2% fuel stations offer E100, indicating minimal awareness of ethanol utilization as vehicle fuel

Higher Cost of Vehicles

- The **incremental cost of flex-fuel components and advanced systems is likely to increase vehicle prices,** potentially discouraging price-sensitive buyers
- In 2021, India's per capita income stood at USD 2,122, making expensive FFVs unaffordable for most individuals

Underdeveloped Infrastructure

- There is still a **lack of adequate ethanol pumps** for retail distributions
- Supply chains and fuel production using renewable feedstock still require significant improvement
- Until March 2022, there were only 276 operational ethanol pumps out of the ideal requirement of 25,000[1)]

Countermeasures

- **Emphasis on education initiatives,** showcasing long-term benefits of FFVs, including lower ethanol cost compared to petrol and diesel
- **Provide test drive experience** to demonstrate vehicle capabilities

- Work with automotive OEMs to **increase local FFVs production** in
- **Leverage scale economies** to reduce per unit manufacturing costs and **pass the savings on to consumers**

- **Implement a phased approach upon rollout,** firstly targeting regions with i) High vehicle density, and/or ii) Close proximity to ethanol facilities

Notes: *1) Based on estimate, India will need at least 25,000 E85 pumps to achieve its target of 20% blending ;* ***Sources:*** *Coherent Market Insights Report*

Brazil's well-structured market dynamic across the ethanol industry, government, consumers, and OEMs turbocharged the promotion of FFV in its early years of release

Success Factors for Brazilian FFV Market in 2003 – 2008

Well-Established Ethanol Industry

- Brazil's long-established sugarcane industry has historically made ethanol more accessible, with abundant availability of biomass as feedstock enabling large-scale production
- In Brazil, 1.2% of the country's territory is dedicated to sugarcane cultivation, with 0.9% allocated for ethanol production from both sugarcane and corn

Steadfast Government's Intervention

- FFV adoption was highly advertised by the government due to its environmentally friendly effect that is less polluting than the gasoline cars
- The government imposed preferential tax and pricing policies for manufacturers and end-users to make FFVs more attractive than single-fuel vehicles

Consumers Empowerment

- On average, ethanol selling prices were 30% lower than that of gasoline
- The lower cost of fuel alternatives, coupled with flexibility to switch fuel choices based on price attracted consumers to switch to FFVs instead of sticking to the single-fuel vehicles

Reliable and Receptive OEMs

- Manufacturers were broadly supportive of Brazil's FFV mandate and responded quickly, driven by government incentives, to mass-produce FFVs
- OEMs complied with Brazil's mandatory Energy Efficiency Program that required them to produce more efficient, eco-friendly vehicles in every succeeding marketing year

Sources: *Deloitte Brazil, Expert Interview, Brazil's Ministry of Agriculture and Livestock*

The incentive scheme, originally applied in 2003 – 2008, is expected to stay in effect until 2026 and sustain the adoption of FFVs nationwide

Incentive Schemes for FFV Adoption

Incentives Scheme in 2003 - 2008

Double" Tax Incentives for OEMs and Consumers Leading to Lower Vehicle Prices

- **OEM Incentive:** FFV Manufacturers receive 30% reduction in excise tax compared to non-FFV producers
- **Consumer Incentive:** Consumers benefit from a tax reduction ranging from 14% to 28%, depending on factors such as car models and state of registration
- **Independent Mechanisms:** The tax reductions for OEMs and consumers are separate and do not influence each other; OEM tax savings are not passed on to consumers, and consumer tax reductions do not impact OEMs

Preferential Credit Terms for FFV Manufacturers

- FFV manufacturers were eligible for financing facilities at lower interest rates

Current Policy and Future Outlook

The incentive scheme applied between 2003 and 2008 is expected to remain in place until 2026

- Future policy beyond this period remains unclear, but the following directions are forecasted:
  - ↳ Taxation for FFVs likely to be lower than ICEs, but higher than of EVs
  - ↳ The government is expected to maintain its support for FFVs to keep them competitive, given the ethanol market's importance to Brazil's economy

Implementation of the “Sin Tax” Bill

- The "Sin Tax" Bill, approved in December 2023, introduces a selective tax on products harmful to health or the environment
- This tax is expected to reduce the prevalence of high-emitting vehicles and promote the use of more environmentally friendly options, such as FFVs

***Sources:** Deloitte Brazil, Expert Interview, The Brazilian News Report*

The Brazilian government launched a targeted campaign to promote FFVs, while simultaneously facing strong agribusiness lobbying for sector support

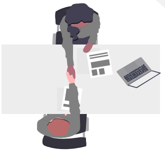
Other Factors Promoting FFV Development

1 Government Propaganda on Domestic Fuel Sufficiency

- Throughout the early 2000s, Brazil faced a petroleum shortage, prompting the government to build a domestic fuel industry by utilising ethanol
- The propaganda was built up around Brazil wanting to foster an Ethanol market as a solution to the country's fuel supply challenges
- Through targeted campaigns and advertisements, the Government tried to effectively communicate and instill the benefits of Ethanol and FFVs
- As a result, the successful promotion led to a widespread adoption of FFVs and increased public support for the overall Ethanol industry

2 Strong Lobbying Activities from the Agribusiness Sector

- The Agribusiness sector has a powerful influence in the Brazilian economy, evidenced by its continued profitability even during global crises
- Strong lobbying, particularly from the Sugarcane industry, led to state support being focused on sugar and ethanol production
- Early market imbalance occurred with Anhydrous Ethanol (E100) which is used in vehicles running solely on Ethanol
- Market stabilization was achieved only after the introduction of FFVs capable running on Ethanol blends



Sources: *Deloitte Brazil, Expert Interview, Brazil's Ministry of Agriculture and Livestock*

India promotes FFV development by offering financial incentives of up to USD 3 million to boost domestic production of Advanced Automotive Technology products

Incentives for FFV Production in India

Objective

- The scheme offers financial incentives to boost domestic manufacturing of **Advanced Automotive Technology** products and attract investments in the automotive manufacturing value chain
- Prime objectives include overcoming cost disabilities, creating economies of scale, and building a robust supply chain in areas of Advanced Automotive Technology products

Target Segment

- The scheme is divided into Champion OEM Incentive Scheme and Component Champion Incentive Scheme
- Six auto components of Flex Fuel Engine (capable of running upto Ethanol 85 (E85) Fuel) have been included in the list of Advanced Automotive Technology components as eligible products for incentivization under this scheme1)

Tenure

- Incentive will be applicable on Determined Sales Value starting from Financial Year 2022-23 for a total of five consecutive financial years until FY2026-27

Incentives

- The Scheme has a budgetary outlay of ₹25,938 crore, for incentives, equivalent to USD 3 Million

Notes: *1) BS6 compliant Flex Fuel Engine capable of running up to Ethanol 85; 2) Heated Fuel Rail for Flex Fuel Engine; 3) Heating Element for Flex Fuel Engine; 4) Heating control Unit for Flex Fuel Engine; 5) Electronic Control Unit for Flex Fuel Engine and 6) Ethanol sensor for Flex Fuel Engine;* ***Sources:*** *Deloitte India, Asia Pacific Centre of Excellence for Sustainability and Climate*

Suggestion

FFVs are key to decarbonisation and stimulating Ethanol demand. To drive adoption, governments should offer state support and implement targeted campaigns

Takeaways from Brazilian FFV Market to Indonesia

WAYS TO IMPLEMENT

	Stimulate Ethanol Demand	**Mobilise the Market for Large-Scale FFV Adoption**		**Achieve Decarbonisation**
		Strong Government Support Across Market Participants	Competitive Pricing and State Propaganda	
Lessons from Brazil	• Early government support for the sugarcane industry led to an excess ethanol supply • Upon the introduction of FFVs from 2003 onwards, market for Ethanol began to stabilize due to increased demand for E100 and fuel blends	• Beyond agribusiness support, the Brazilian government offers incentives for OEMs to mass-produce FFVs • FFV manufacturers enjoy 30% lower excise taxes and better financing compared to non-FFV producers	• Consumers adopted FFVs to save ~30% on fuel, with FFV car taxes 14-28% lower • Facing a fuel crisis, Brazil promoted ethanol through targeted campaigns to drive widespread adoption and public support	• Brazil introduced the Sin Tax Bill to reduce high carbon-emitting vehicles and promote more eco-friendly options such as FFVs • OEMs must also comply with the national Energy Efficiency Program, requiring them to improve vehicle efficiency annually
Takeaways for Indonesia	• FFV implementation can create a versatile Ethanol demand base • The growth of FFVs will necessitate a supportive infrastructure development, including widespread availability of ethanol-blended fuels nationwide	• Government involvement drives investment and innovation in new technologies like FFVs • Pro-Ethanol and FFV policies are essential in addressing entry barriers, including high production costs	• Lower fuel costs and reduced taxes made FFVs appealing to consumers • Targeted campaigns effectively communicate the economic and environmental benefits of FFVs, encouraging public adoption	• Decarbonisation can be achieved by regulating the transport sector • National standards can push automakers to build energy-efficient vehicles

***Sources:** Deloitte Brazil, Expert Interview, Deloitte Analysis*

Updated Demand Forecasts (Accounting for FFVs)

Based on the demand calculation in Phase 1, three key assumptions are updated in Phase 3 to account for the additional ethanol demand from FFVs

Refreshed Assumptions Under New Demand Calculation

	Old Assumption in Phase 1	Refreshed Assumption in Phase 3
Definition of Hybrid Vehicles	In Phase 1, Hybrid Electric Vehicle (HEV) refers to a vehicle that combines a petrol or diesel engine with an electric motor, using both energy sources to work together to power the vehicle	• In Phase 3, HEVs are replaced by Hybrid FFVs • Hybrid FFV refers to an HEV that can also run on flexible fuels like ethanol or ethanol-gasoline blends
Government Mandate	In Phase 1, the Blending Mandate is as follows: • 2026 – 2030: 0% • 2031 – 2040: 15% • 2041 – 2060: 20%	• In Phase 3, it is assumed that there is no blending mandate by the government due to the introduction of FFVs
Blending Rate	In Phase 1, the blending rate for all car types is assumed to match the specified ethanol content of each fuel blend (e.g., for E20, the blending rate is 20%)	In Phase 3, the blending rate for E20 in Hybrid FFVs is expected to follow the Brazilian model, with a blending rate of 48.8%

Sources: *Deloitte Analysis*

Orange text indicates changes in this simulation

Estimate the number of units sold if sales proceed as per government targets

③Percentage of sales by fuel EV Maximum scenario (Government EV target)

Check past sales performance

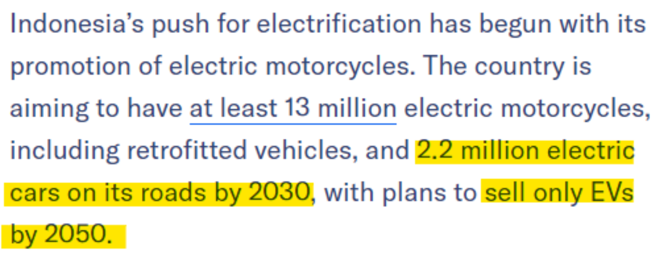
- Percentage of units sold by each fuel in the past based on GAIKINDO sales data

FUEL	2015	2016	2017	2018	2019	2020	2021	2022	2023 (~Jul)
Diesel	8.8%	9.4%	12.1%	12.5%	13.1%	15.4%	14.9%	14.2%	11.7%
Gasoline	91.2%	90.6%	87.9%	87.5%	86.9%	84.3%	84.8%	84.2%	82.7%
HYBRID	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.3%	0.5%	4.2%
EV	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	1.1%	1.3%

Estimated sales ratio by fuel

- Assumption that the shift to EVs will continue in line with government targets
- To achieve 2.2mil registrations by 2030, 50% of new car sales must be reached by 2030
- Assumes 100% of new car sales after 2050 as per government target

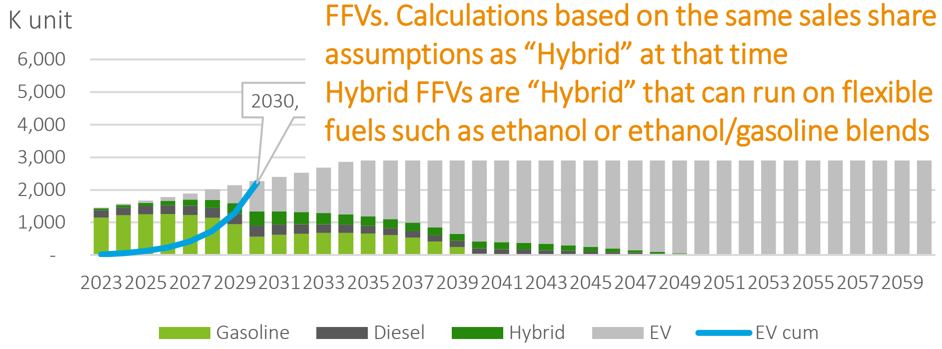
Fuel type	2022	2030	2040	2050	2060
Diesel	14.2%	15.0	4.0%	-	-
Gasoline	84.8%	25.0%	1.0%	-	-
Hybrid	0.5%	19.0%	5.6%	-	-
EV	0.1%	41.0%	90.0%	100.0%	100.0%



Indonesia's push for electrification has begun with its promotion of electric motorcycles. The country is aiming to have at least 13 million electric motorcycles, including retrofitted vehicles, and 2.2 million electric cars on its roads by 2030, with plans to sell only EVs by 2050.

Indonesia's automotive industry is driving toward the future with electrification

Published on 10 Aug 2023



Assume that "Hybrid" will be replaced by hybrid FFVs. Calculations based on the same sales share assumptions as "Hybrid" at that time

Hybrid FFVs are "Hybrid" that can run on flexible fuels such as ethanol or ethanol/gasoline blends

Orange text indicates changes in this simulation

Estimate the number of vehicles sold in cases where the EV shift did not proceed as per government targets

③Percentage of sales by fuel EV Minimum scenario (Stagnation of EV market expansion)

Check past sales performance

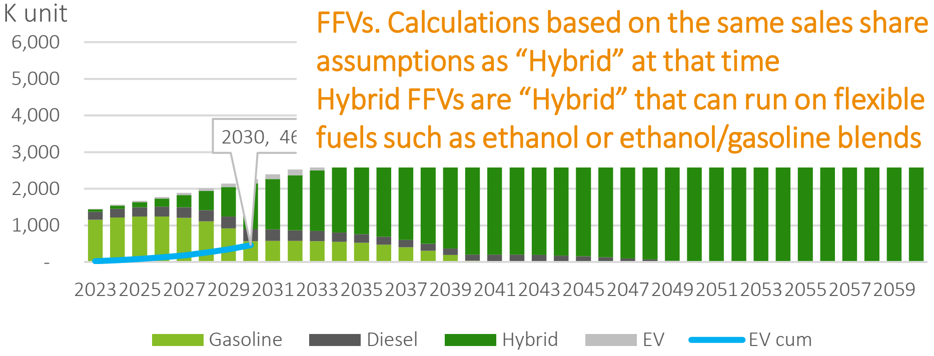
- Percentage of units sold by each fuel in the past based on GAIKINDO sales data

FUEL	2015	2016	2017	2018	2019	2020	2021	2022	2023 (~Jul)
Diesel	8.8%	9.4%	12.1%	12.5%	13.1%	15.4%	14.9%	14.2%	11.7%
EV	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	1.1%	1.3%
Gasoline	91.2%	90.6%	87.9%	87.5%	86.9%	84.3%	84.8%	84.2%	82.7%
HYBRID	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.3%	0.5%	4.2%

Estimated sales ratio by fuel

- Assuming that the shift to EVs does not proceed due to price differences and infrastructure issues at all
- Hybrid vehicles are assumed to lead the market during the transitional period within the same xEV group

Fuel type	2022	2030	2040	2050	2060
Diesel	14.2%	15.0	4.0%	-	-
Gasoline	84.8%	25.0%	1.0%	-	-
Hybrid	0.5%	55.0%	80.0%	75.0%	50.0%
EV	0.1%	5.0%	15.0%	25.0%	50.0%



Assume that "Hybrid" will be replaced by hybrid FFVs. Calculations based on the same sales share assumptions as "Hybrid" at that time

Hybrid FFVs are "Hybrid" that can run on flexible fuels such as ethanol or ethanol/gasoline blends

Excerpts from past phase deck

Orange text indicates changes in this simulation

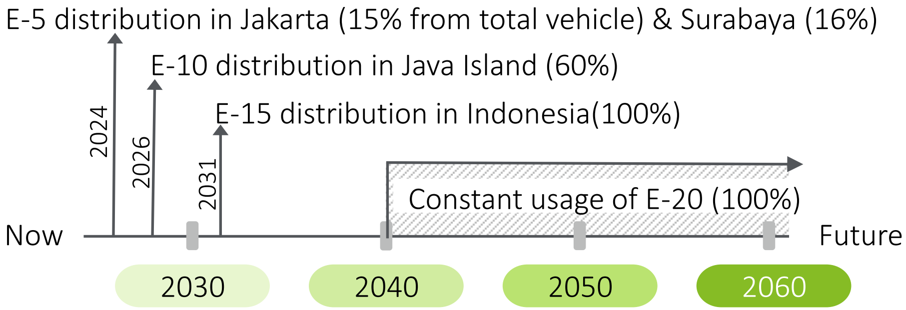
Estimated number of units sold by applicable mixing ratio based on historical sales estimates and government response policy

②Percentage of sales by blending ratio

Percentage of sales by blending ratio estimation

Gasoline/Hybrid vehicles

- Assumption that the sales ratio by blending ratio will remain at the same E10 level as the current sales actual until 2029 (taking into account the development period of applicable vehicles)
- After 2030, it is assumed that E20 will apply to all new vehicles sold



E-5 distribution in Jakarta (15% from total vehicle) & Surabaya (16%)

E-10 distribution in Java Island (60%)

E-15 distribution in Indonesia(100%)

Constant usage of E-20 (100%)

		2023-2029	2030-2060
Gasoline Hybrid	Normal		
	E5		
	E10	100%	
	E15		
	E20		100%

Assumption that the introduction of FFV to the market will eliminate the government's mixed rate mandate

E20 → No mandate

Excerpts from past phase deck

Orange text indicates changes in this simulation

Nowadays, almost all of the gasoline in Brazil is blended-ethanol gasoline, mostly made from sugarcane, with Gasoline C dominating 70% of the market

Current Condition

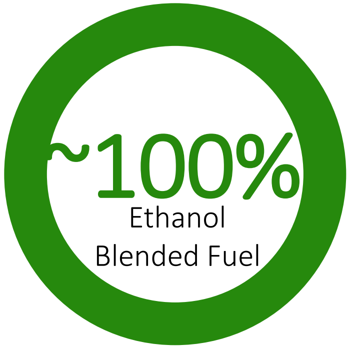
Feedstock for Ethanol

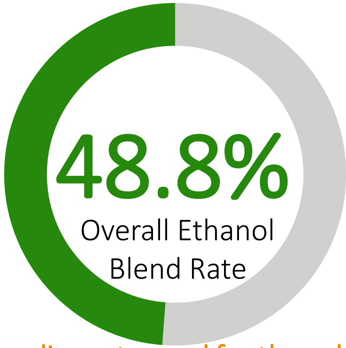
Sugarcane, Corn, Bagasse

	% in Feedstock	% in Ethanol
Sugarcane	~97% 333,050 k MT (2021)	~87% *23.3 b Ltr (2021)
Corn	~2% 7,904 k MT (2021)	~12% *3.2 b Ltr (2021)
Bagasse	~<1% 0.222 k MT (2021)	~<1% *32 m Ltr (2021)

Ethanol Fuel Share

Almost no pure gasoline was sold in Brazil, it is only used for blending with anhydrous ethanol





Blending rate used for the calc.

Ethanol Blending Ratio

- Gasoline C = E18-E27

(mixed of anhydrous ethanol & pure gasoline)

- Hydrous Ethanol = E94-E100

Anhydrous Ethanol (10,616 mill ltr - 2021) + Pure Gasoline

Gasoline C: ~70%, 39,317 mil ltr (2021)

Ethanol

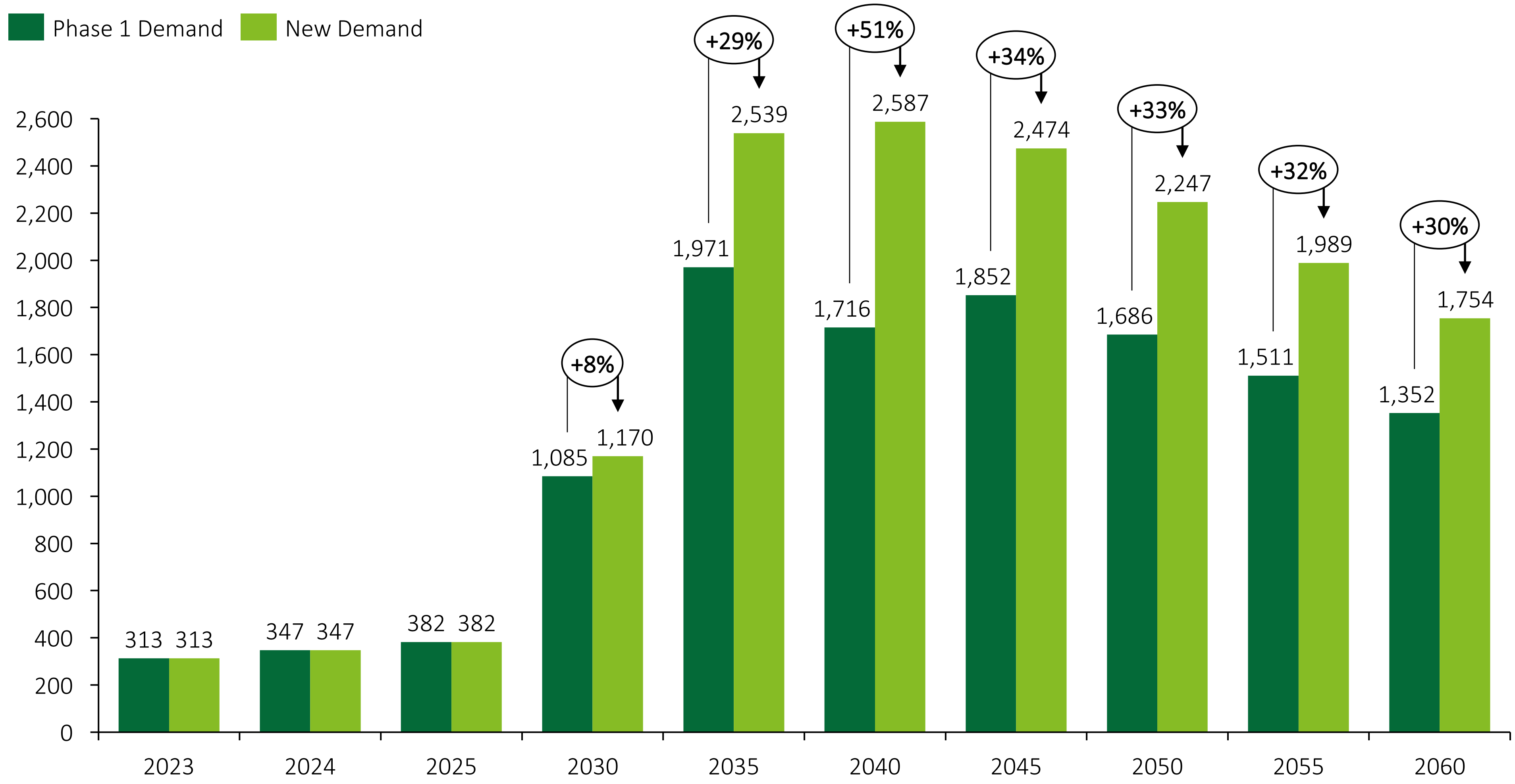
Hydrous Ethanol: ~30%, 16,792 mil ltr (2021)

** : Deloitte's Calculation*

Source: Government Intervention to Strengthen the Ethanol Sector-ELLA, The Story of Brazil's Ethanol Programme-ELLA, Brazil's Biofuel Annual Report-USDA

With the new assumptions accounting for FFVs, ethanol demand under the Maximum Scenario is, on average, approximately 31% higher than in Phase 1

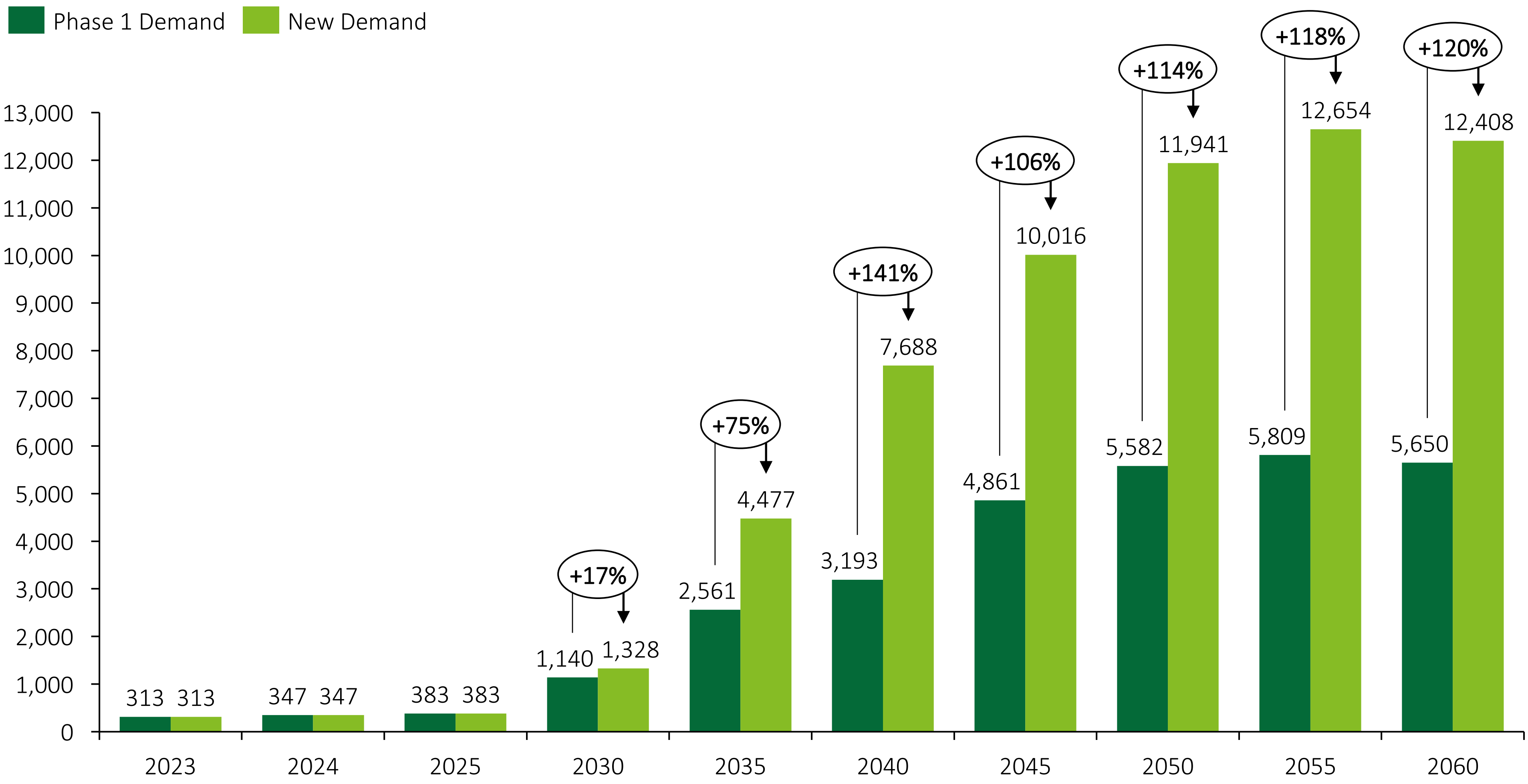
Refreshed Demand Forecasts: Maximum Scenario (Million Liters)



***Sources:** Deloitte Analysis*

Meanwhile, under the Minimum Scenario, the new ethanol demand forecast is almost always about double the Phase 1 estimates

Refreshed Demand Forecasts: Minimum Scenario (Million Liters)

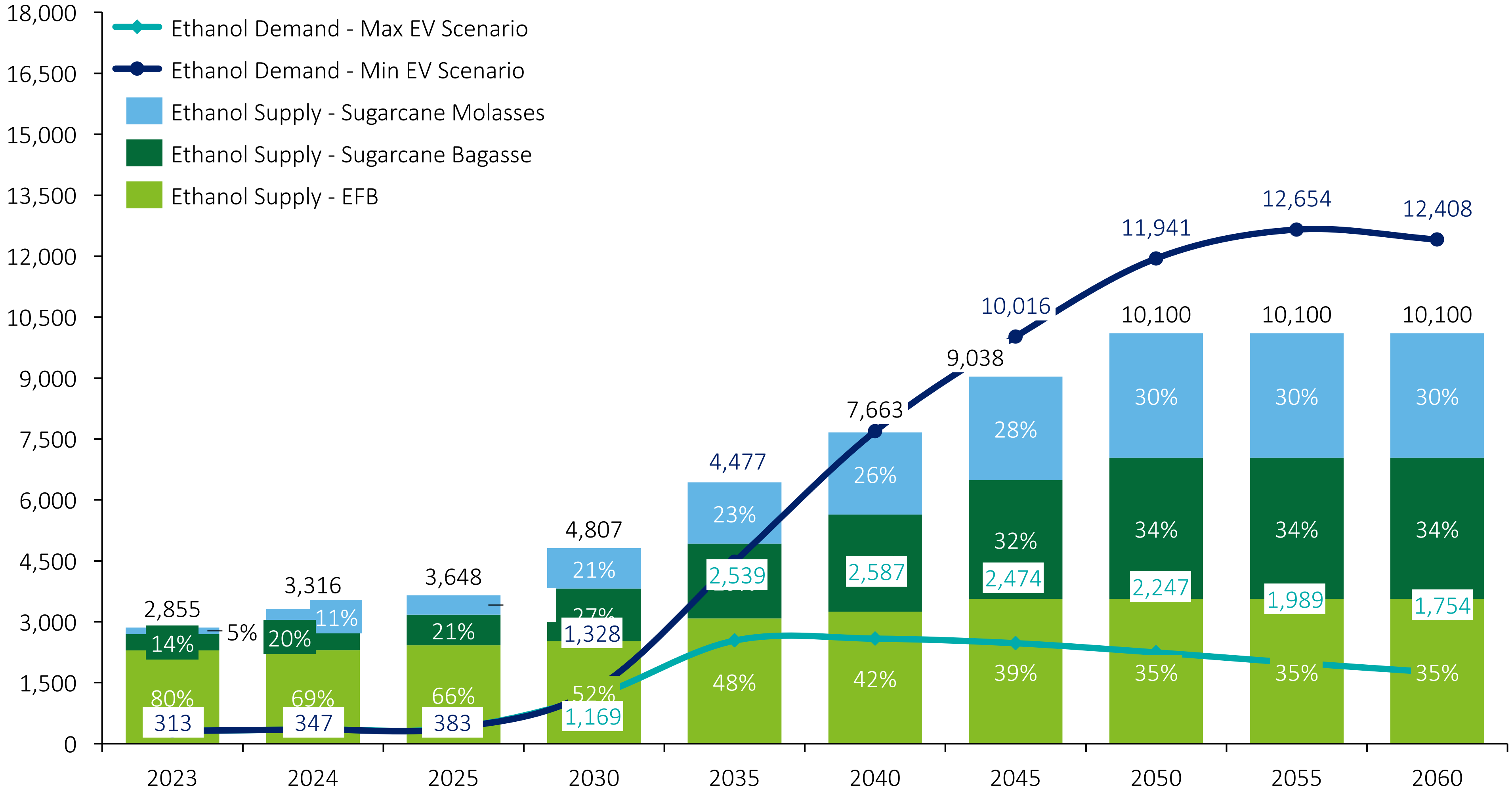


***Sources:** Deloitte Analysis*

Updated Demand Supply Balance

The conservative scenario projects 10 billion liters of ethanol by 2050, sufficient for the Minimum EV scenario across years and the Maximum EV scenario until 2035

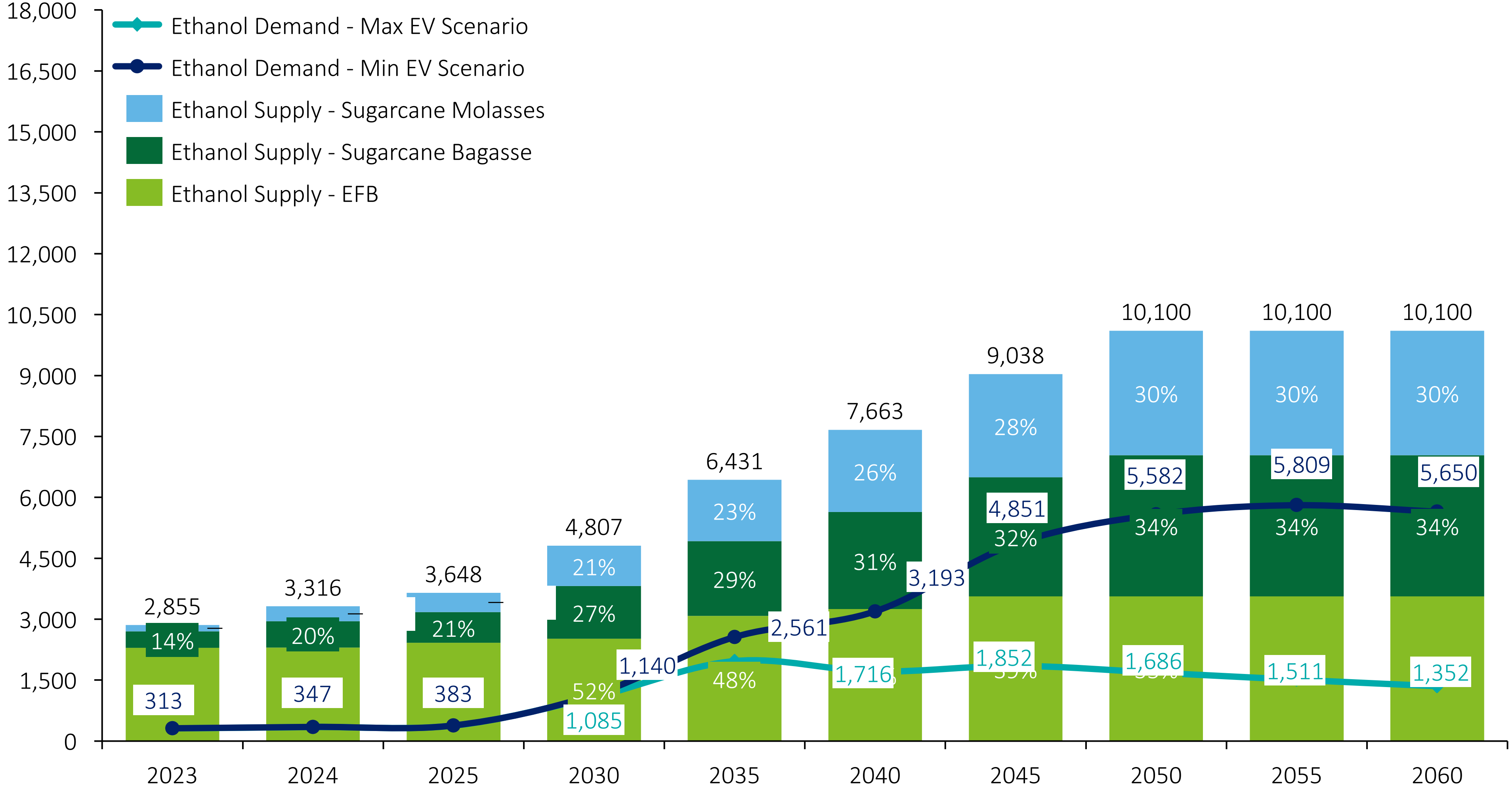
Bioethanol Production Forecast: Conservative Scenario (Million Liters)



Sources: *Deloitte Analysis*

The conservative scenario projects a total ethanol supply of 10 billion liters by 2050, sufficient to meet the demand across all EV scenarios over the years

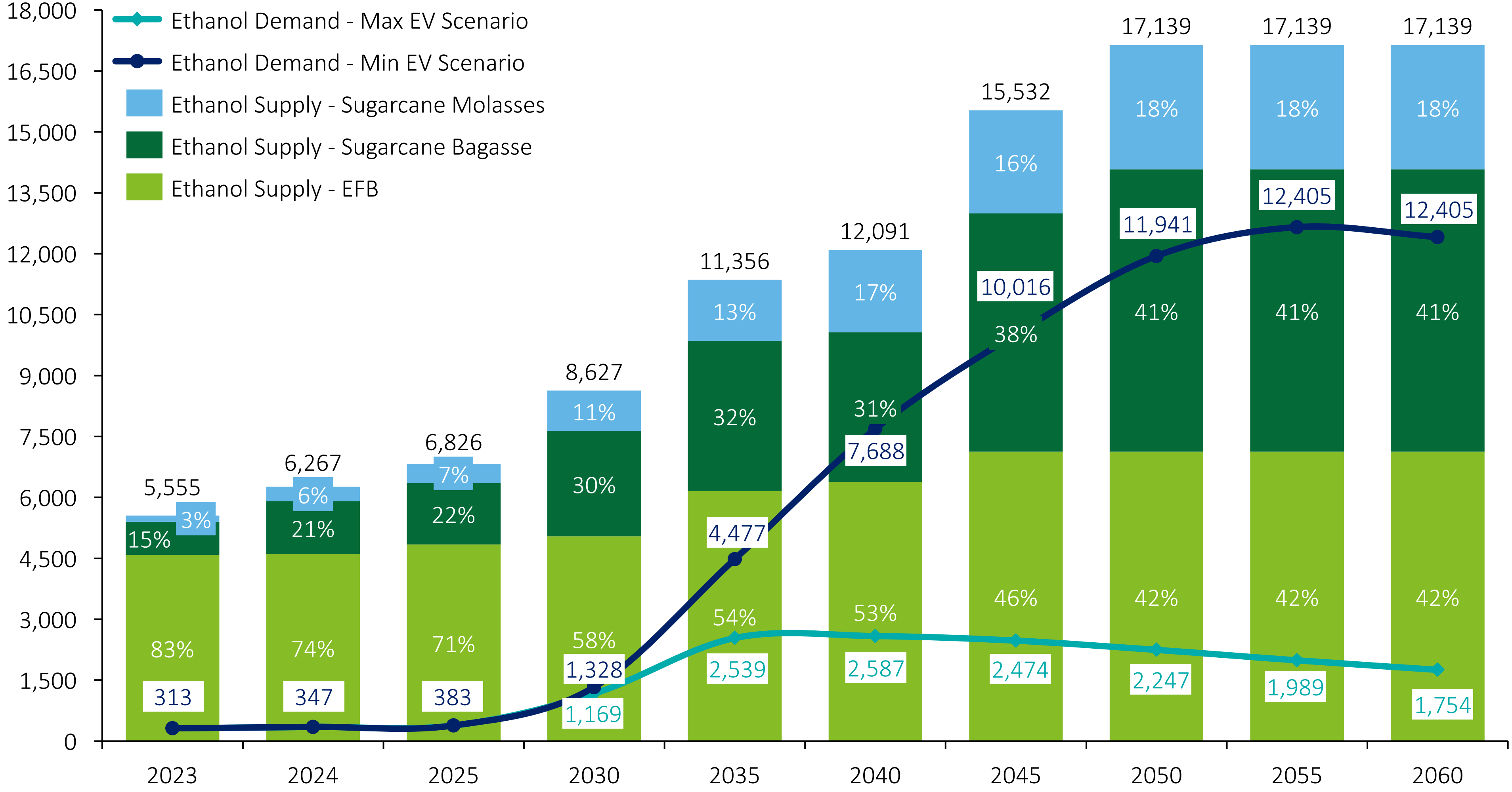
Bioethanol Production Forecast: Conservative Scenario (Million Liters)



Sources: *Deloitte Analysis*

The maximum scenario forecasts a total ethanol supply of 17 billion liters, sufficient to meet the demand across all EV scenarios over the years

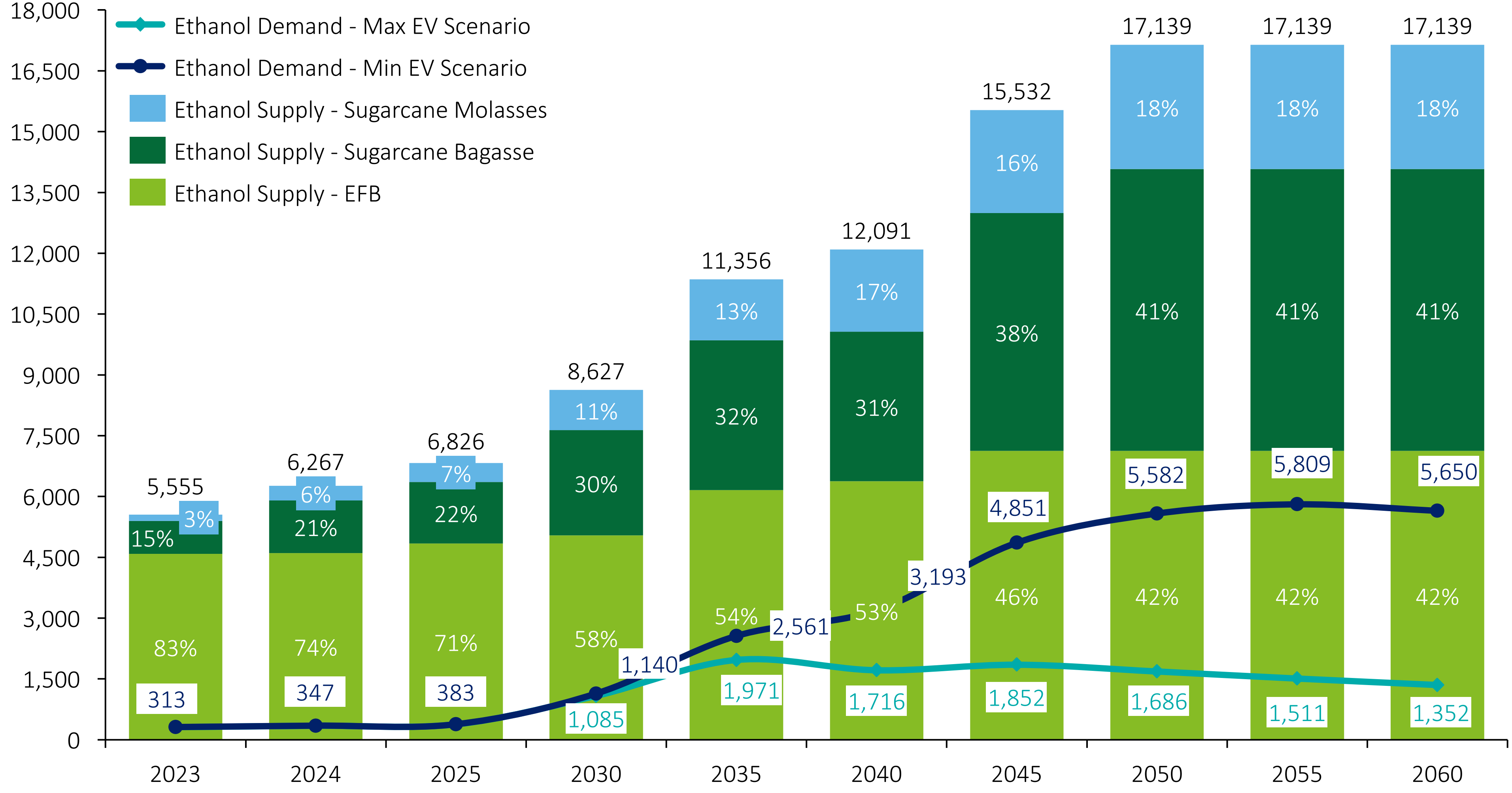
Bioethanol Production Forecast: Maximum Scenario (Million Liters)



Sources: *Deloitte Analysis*

The maximum scenario forecasts a total ethanol supply of 17 billion liters, further exceeding the ethanol demand under both EV scenarios

Bioethanol Production Forecast: Maximum Scenario (Million Liters)

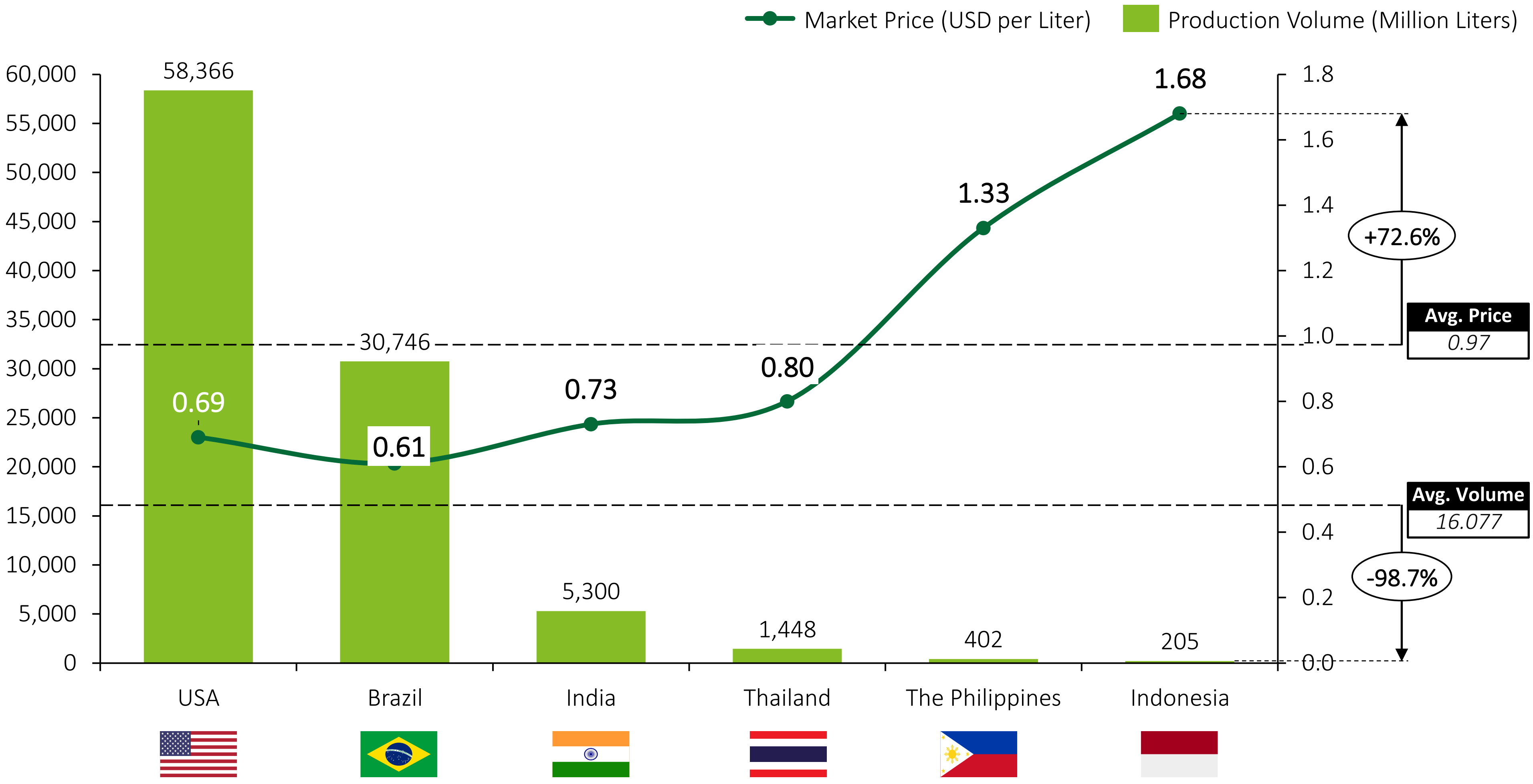


Sources: *Deloitte Analysis*

Realization of Reasonable Production Costs

The price of Ethanol in Indonesia is ~73% higher than average, while production volume is ~99% lower than average

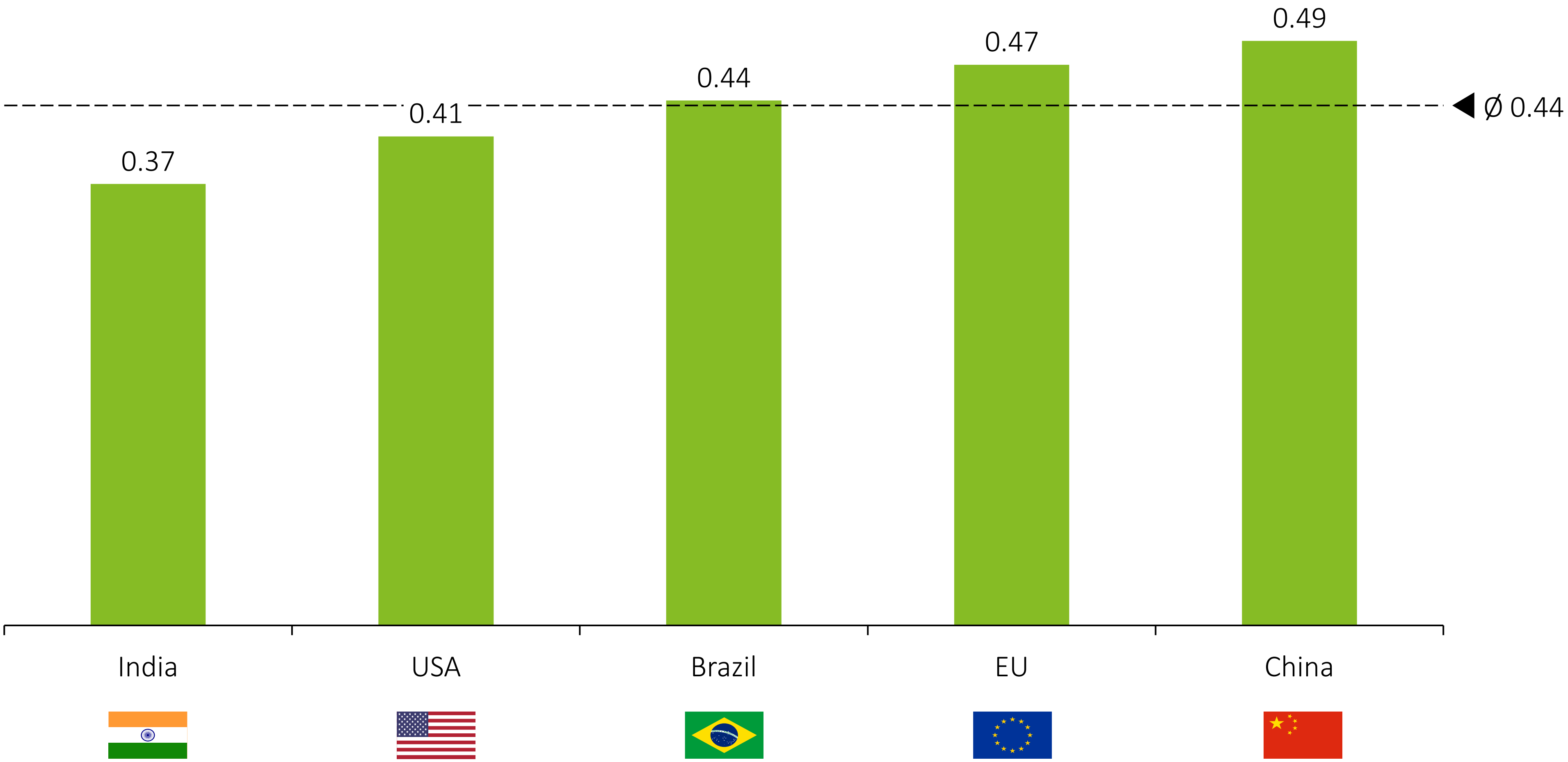
Cross-Country Ethanol Production Volume and Market Price (2022)



Sources: *1) Source of Data for Ethanol Production is Country Biofuels Report from United States Department of Agriculture, 2) Source for Market Price as follows, USA – US Grains Council, Brazil – Brazil Biofuel Report USDA, India – The Economic Times, Thiland – Krungsi Bank Ethanol outlook, The Philippines – Department of Agriculture, Indonesia – IntraTec Ethanol Prices*

Leading ethanol-producing countries manufacture first-generation ethanol at an average cost of USD 0.44 per liter, equivalent to Brazil's production costs

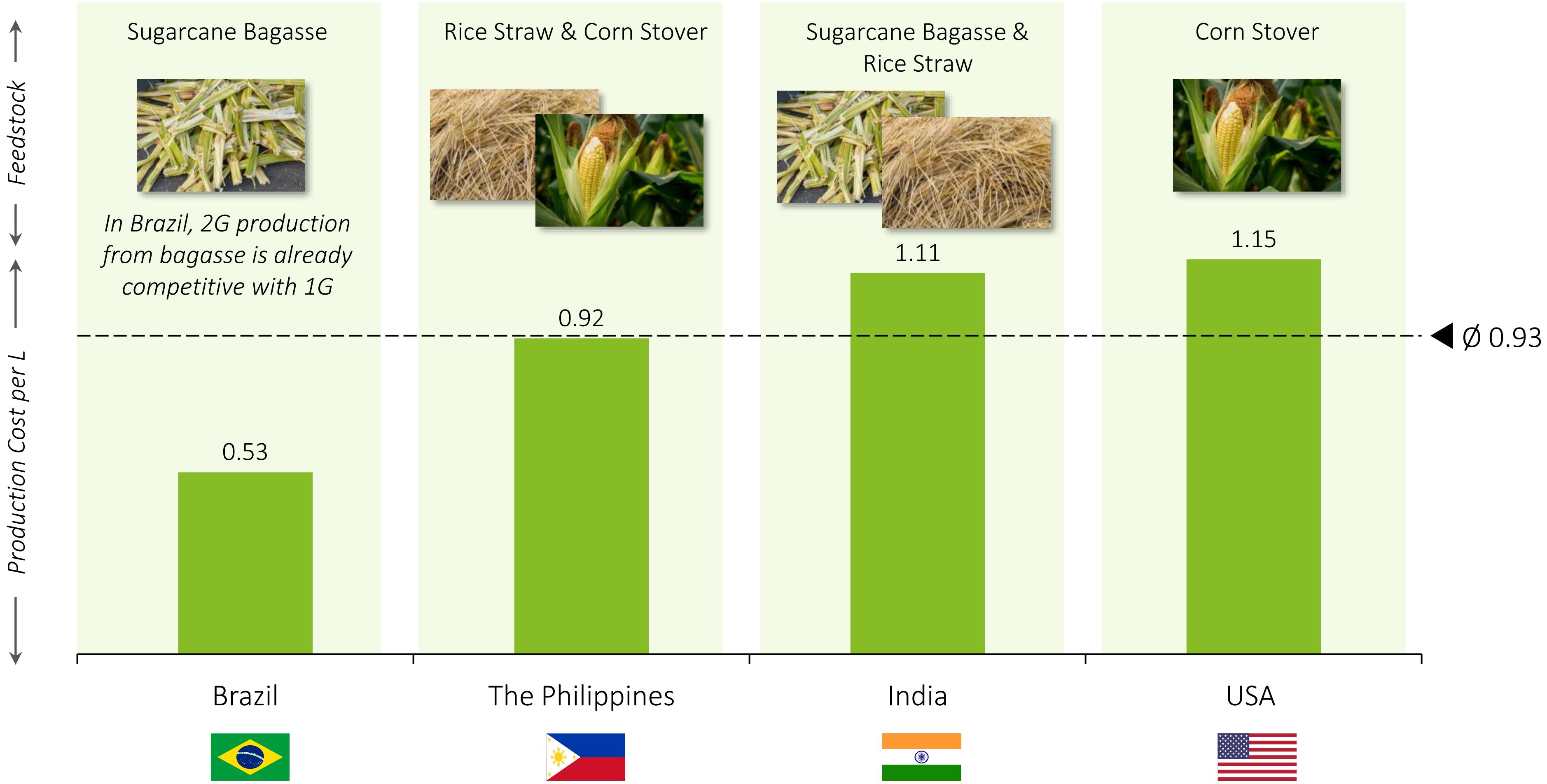
Cross-Country Comparison of 1G Ethanol Production (USD per Liter, 2019)



Sources: *Scientific Publication on Economic Aspects and Sustainability of Ethanol Production*

2G Ethanol approximately costs USD 0.93 per Liter to produce, about 1.1 times higher than it costs to produce 1G Ethanol

Cross-Country Comparison of 2G Ethanol Production (USD per Liter)



In Brazil, 2G production from bagasse is already competitive with 1G

Notes/Sources: *1) Brazil Data is as of 2018 from Journal on Second-Generation Ethanol and Bioelectricity, 2) The Philippines Data is as of 2021 from Journal of Biotechnology for Biofuels, Journal of Biomass and Bioenergy 3) India Data is as of 2021 from International Clean Council on Clean Transportation (ICCT), 4) US Data is as of 2012 from Journal of Biomass and Bioenergy*

Increasing economic viability of 2G Ethanol can be achieved by utilising co-products and implementing cost optimisation measures

Potential Cost Reduction Approaches for 2G Ethanol

How can we make 2G production more economically viable?

Sell High-Value Byproducts

- Co-produce by-products to lower the minimum viable ethanol sales price
- Generate additional revenue by utilizing high-value co-products like SAF, solid fuel, and pulp, improving overall economic feasibility

Implement Contract Systems with Buyers / End-Users

- Secure long-term contracts with buyers to stabilize revenues, enabling bulk production and potential cost reductions through scale economies
- Improve financing terms by boosting creditworthiness through guaranteed sales, lowering loan rates and procurement costs

Reduce Capital Costs

- Scale up plant size and integrate process steps to streamline production, which can lead to significant cost savings
- Co-locate with other processing facilities to share infrastructure to reduce capital expenditure

Enhance Investors' Confidence to Improve Firm's Financing Rates

- Lower technical risks and secure feedstock supply to enhance investor confidence, leading to better financing terms and reduced borrowing costs

Integrate 2G Plant with 1G Facilities

- Maximize ethanol yields and revenue by integrating 2G processes with existing 1G facilities, reducing the need for additional capital investment

Sources: *International Energy Agency Bioenergy Publication, Renewable and Sustainable Energy Reviews, Sustainable Energy Technologies and Assessments,*

Reducing 2G production costs can be achieved by streamlining logistics, enhancing feedstock supply through partnerships, and driving innovation in technology

Potential Cost Reduction Approaches for 2G Ethanol

Streamline Logistics Chain

- **Optimize Plant Location:** Locate bioethanol plants closer to the market rather than near palm oil extraction sites. This reduces transport and logistic costs, improving overall cost-efficiency
- **Localize Downstream Facilities:** Given that most bioethanol is shipped to Java, establishing downstream facilities near key markets on the island can further cut transportation costs and improve overall supply chain efficiency

Enhance Feedstock Acquisition Through Strategic Partnership

- **Secure Cost-Effective Feedstock:** Leverage strategic partnerships to ensure a reliable supply of feedstock at reduced prices, addressing the high contribution of feedstock and processing cost to overall production
- **Strengthen Supply Relationships:** Establish agreements that improve feedstock availability and pricing, which directly impacts overall production costs and supports a more stable supply chain

Improve Pre-Treatment Process

- **Accelerate Pre-Treatment Efficiency:** Focus on reducing the duration of the pre-treatment process to lower overall production time and costs for 2G Ethanol – Enhancing pre-treatment speeds up process and reduces operational expenses
- **Invest in Advanced Research:** To tackle this bottleneck, more researches have been deployed to improve the techniques to manage and treat palm oil residues

Optimize Technology Through Innovation

- **Simplify Production:** Process for 2G is relatively lengthier and much more difficult, requiring technological innovations to make it faster and more efficient
- **Reduce Enzyme Costs:** Enzyme costs are a significant expense in 2G Ethanol production. Investing in innovations that enhance enzyme efficiency and availability can greatly reduce overall production costs

Sources: *Experts Interviews*

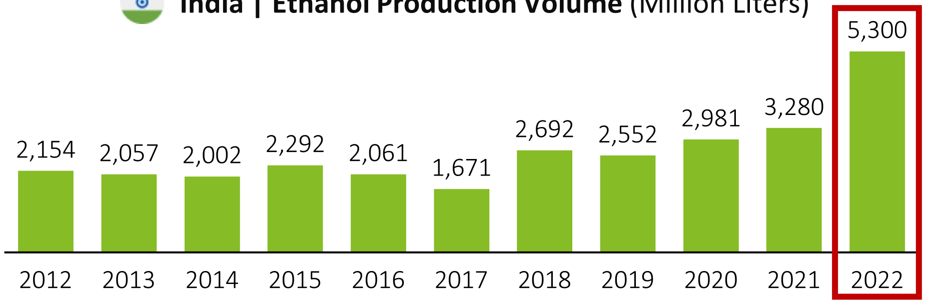
Producing 2G Ethanol in India at USD 1.11/L costs more than the highest price for 1G Ethanol of USD 0.85/L, implying the needs for government intervention to compete

Scenario 1: Cost of Ethanol Production in India

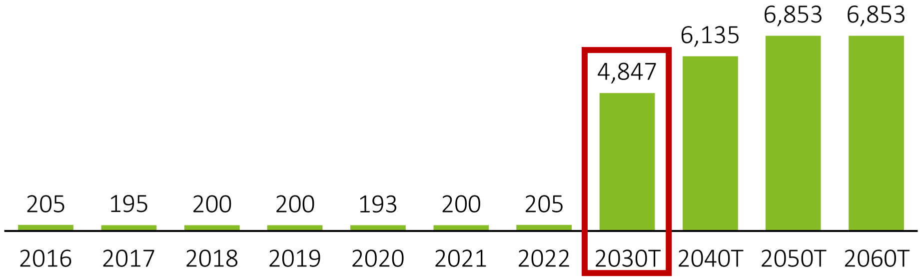
① Considerations to Use India's Cost as Baseline

Applicability	*Low* ● ● ● ● ○ *High*
Justification	**Level of Production:** India's current ethanol production matches Indonesia's 2030 target from EFB utilization, suggesting similar costs level due to comparable output size

India | Ethanol Production Volume (Million Liters)

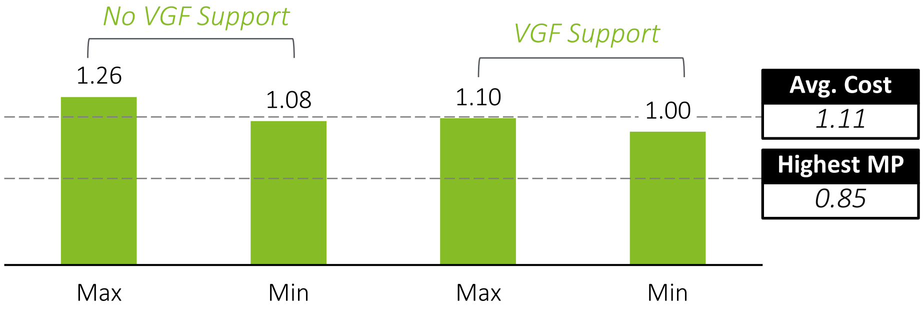


Indonesia | Ethanol Production Target with EFB (Million Liters)

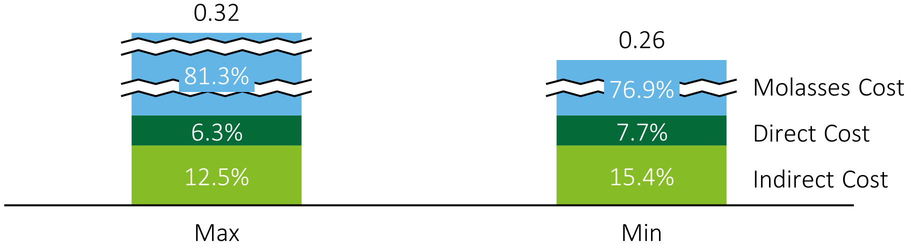


② Cost of Ethanol Production in India

Cost of 2G Ethanol Production (USD per Liter, 2021)



Cost of 1G Ethanol Production (USD per Liter, 2011)



Observation

- 2G production is almost 3.8 times more expensive than 1G
- Production cost of 2G Ethanol in India exceeds the peak market price of 1G Ethanol, making financial returns challenging
- Subsidies or higher pricing for 2GE shall be considered to ensure competitiveness with 1GE and attract private investment

Notes: *1) VGF refers to Viability Gap Funding – a programme by the Indian government to provide a funding cap of USD 20 million for 12 key ethanol projects in India, 2) Highest MP refers to highest market price of 1G Ethanol in the market, 3) Currency exchange is as of August 2024 (INR 1 = USD 0.012);* ***Sources:*** *India Biofuels Report from USDA, ICCT, ICRIER*

Internal Survey

On average, ethanol costs USD 0.42/L to produce in Thailand. Its identical economic landscape provides a compelling baseline for Indonesia's cost benchmark

Scenario 2: Cost of Ethanol Production in Thailand

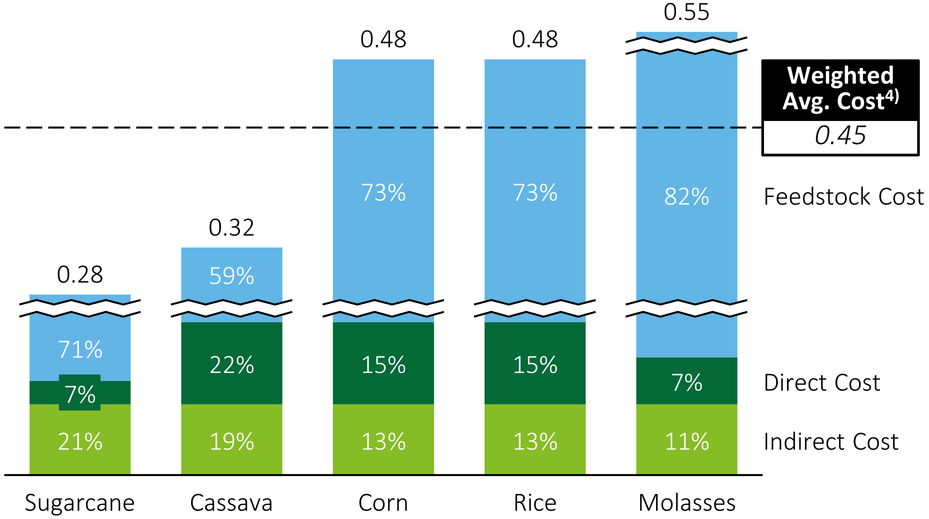
① Considerations to Use Thailand's Cost as Baseline

Applicability	*Low* ● ● ● ● ○ *High*
Justification	**Economic Profiles:** As ASEAN peers, Indonesia and Thailand share a similar economic landscape, as indicated by key metrics, making Thailand a strong cost benchmark

	TH	ID	Comments
Real GDP Growth	1.9%	5.0%	Both countries experiencing positive economic growth, indicating similar economic trajectories
Real GDP per Head Growth	1.7%	4.2%	Both countries exhibit positive GDP per Head growth, implying comparable economic environment
Consumer Price Inflation	1.2%	3.7%	Both countries maintain manageable inflation rates, suggesting similar economic pressures and cost impacts
Labour Productivity Growth	1.1%	1.6%	Both countries demonstrate similar productivity level, indicating comparable level of output produced per worker
Average Monthly Wage	USD 441	USD 216	ID's lower wages offset other higher indicators, making TH's production costs a conservative benchmark to use

② Cost of Ethanol Production in Thailand

Cost of 1G Ethanol Production by Feedstock (USD per Liter, 2007)



Observation

- Cost of raw materials (i.e., feedstock) accounts for the highest proportion to the total unit cost of the 1G Ethanol production, comprising at least ~60% of total cost
- Sugarcane and cassava are the most competitive feedstocks for ethanol production, outperforming alternatives with significantly higher production costs

Notes: *1) Economic Metrics are as of 2023, 2) Direct Costs include all operating expenses on water, enzymes, maintenance, labour, etc. 2) Indirect Costs include expenses on machine, equipment, engineering consulting, etc. 3) Currency exchange is as of August 2024 (THB 1 = USD 0.028), 4) WAC is calculated based on feedstock use to ethanol production in Thailand (59% by Molasses, 37% by Cassava, Sugarcane 4%) ;* ***Sources:*** *The Economist Intelligence Unit (EIU), Journal on Ethanol Production Cost in Thailand, Deloitte Analysis*

At USD 0.92/L, production cost of 2G is ~70% higher than 1G. Given similar economic conditions, The Philippines’ cost structure serves a strong benchmark for Indonesia

Scenario 3: Cost of Ethanol Production in The Philippines

1 Considerations to Use The Philippines’ Cost as Baseline

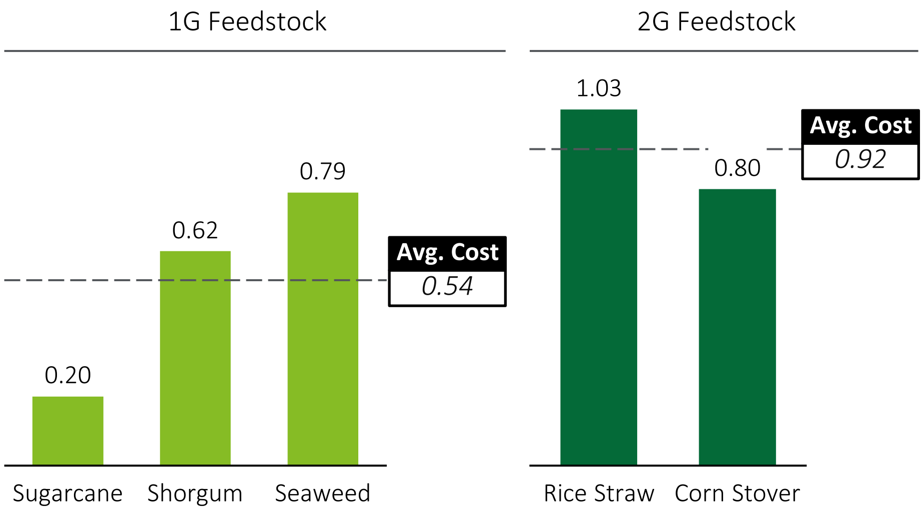
Applicability: *Low* ● ● ● ● ○ *High*

Justification: **Economic Profiles:** As ASEAN peers, Indonesia and The Philippines share similar economic landscape, shown by key metrics, making The Philippines a strong cost benchmark

	PH	ID	Comments
Real GDP Growth	5.5%	5.0%	Close figures suggest that both countries are at a similar stage of development, indicating comparable economic environments
Real GDP per Head Growth	3.9%	4.2%	
Consumer Price Inflation	6.0%	3.7%	Both countries maintain manageable inflation rates, suggesting similar economic pressures and cost impacts
Labour Productivity Growth	3.0%	1.6%	Both countries show a positive trajectory in productivity, demonstrating efficiency improvements that impact costs
Average Monthly Wage	USD 213	USD 216	Identical wages indicate comparable labor costs, with minimal differences having a limited impact on overall costs

2 Cost of Ethanol Production in The Philippines

Cost of Ethanol Production by Feedstock (USD per Liter, 2021)



Observation

- On average, production cost for 2G Ethanol is ~70% higher than 1G Ethanol production
- If market price is set for uniformity between 1G and 2G Ethanol, 2G producers might be at a disadvantage by settling with lower margins
- Public sector’s interventions in the form of price setting, investment aid, tax breaks, etc. needed to ensure competitiveness for 2G market

***Notes:** 1) Economic Metrics are as of 2023, 2) Currency exchange is as of August 2024 (PHP 1 = USD 0.017); **Sources:** The Economist Intelligence Unit (EIU), IntechOpen Journal/Book Publication on Comparative Analysis of Bioethanol Production in The Philippines*

2G production costs of USD 0.53/L to decrease by 13% in 2030. With similar large-scale crop production, Brazil's cost structure is a considerable baseline for Indonesia

Scenario 4: Cost of Ethanol Production in Brazil

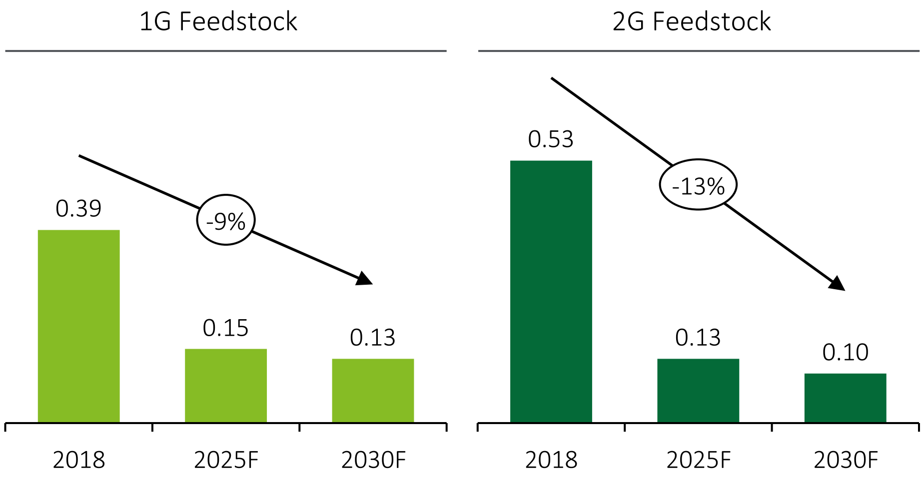
① Considerations to Use Brazil’s Cost as Baseline

Applicability	*Low* ● ● ○ ○ ○ *High*
Justification	**Feedstock Abundance:** As top producers of key agricultural products for ethanol feedstock, Brazil and Indonesia could see comparable production costs due to the abundant availability of residues, although utilising different crops

	Brazil	Indonesia
Main Crop	Sugarcane	Palm Oil
Global Positioning	Brazil is the biggest Sugarcane producer, accounting for ~32.5% of total global production	Indonesia is the biggest Palm Oil producer, accounting for ~60% of total global production
Production Volume	705 Million Tonnes	47 Million Tonnes
Potential Residues	415 Million Tonnes	44 Million Tonnes[2)]
Direction	Policy shift on sugarcane use from sugar more towards ethanol production	Clustering of ethanol & biofuel production near CPO areas to boost efficiency

② Cost of Ethanol Production in Brazil

Cost of Ethanol Production (USD per Liter, 2018)



	2018	2025F	2030F
1G Feedstock	0.39	0.15	0.13
2G Feedstock	0.53	0.13	0.10

Observation

- In the short term (2018), 1G Ethanol production in Brazil is 36% lower than 2G Ethanol, demonstrating strong cost-competitiveness
- However, in the long-run (2030 onwards), 2G Ethanol is projected to be around 30% cheaper than 1G, highlighting future cost advantages
- Acceleration in investment and improvement in industrial process and biomass production systems are expected to drive overall cost reduction in 2G production

Notes: *1) Currency exchange is as of August 2024 (BRL 1 = USD 0.18), 2) Solid Waste = 20.07 Mn Tons, Liquid Wastes / POME = 23,7 Mn Tons;* ***Sources:*** *São Paulo Research Foundation, Federal Government of Brazil, Ministry of Science, Technology, and Innovation, USDA, Journal on Potential of Biomass Residues from Oil Palm Agroindustry in Indonesia, The World Bank*

Currently, production for 1G costs ~95% less than 2G. The US and Indonesia share similarities as major crop producers, making US costs relevant as Indonesia's baseline

Scenario 5: Cost of Ethanol Production in USA

① Considerations to Use The US' Cost as Baseline

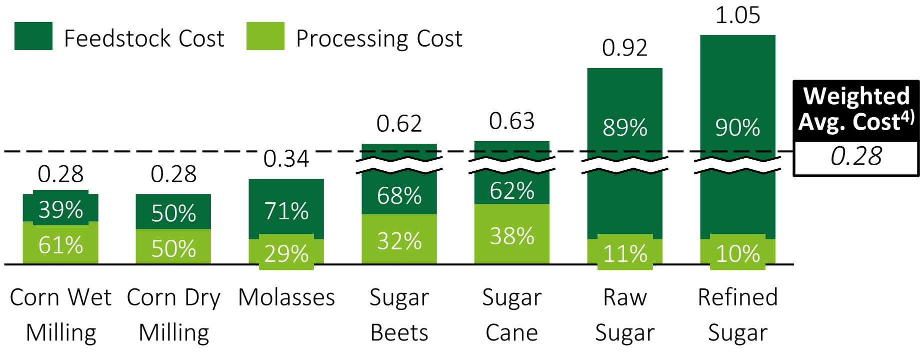
Applicability: *Low* ● ● ○ ○ ○ *High*

Justification: **Feedstock Abundance:** As top producers of key agricultural products for ethanol feedstock, The US and Indonesia could see comparable production costs due to the abundant availability of residues, <u>although utilising different crops</u>

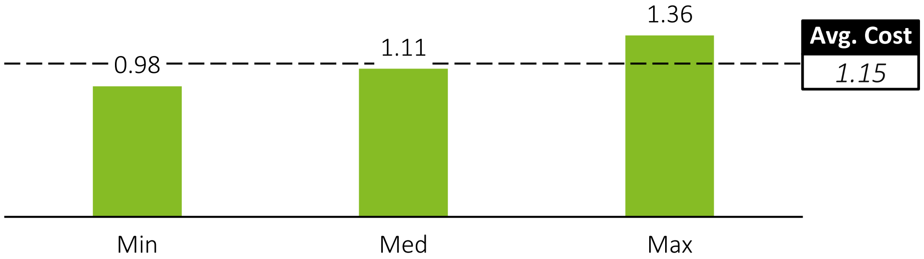
	The US	Indonesia
Main Crop	Corn	Palm Oil
Global Positioning	The US is the biggest Corn producer, accounting for ~31% of total global production	Indonesia is the biggest Palm Oil producer, accounting for ~60% of total global production
Production Volume	384 Million Tonnes	47 Million Tonnes
Potential Residues	216 Million Tonnes	44 Million Tonnes[3)]
Direction	Introduction of tax credit / benefits to corn ethanol fuel producers from May 2024	Clustering of ethanol & biofuel production near CPO areas to boost efficiency

② Cost of Ethanol Production in The US

Cost of 1G Ethanol Production (USD per Liter, 2006)



Cost of 2G Ethanol Production (USD per Liter, 2012)



Observation

- On average, cost to produce 2G Ethanol is 95% higher than 1G
- 2G Ethanol, produced at a minimal cost, is well-positioned to compete with higher-priced 1G feedstocks such as Refined Sugar

***Notes:** 1) Processing Cost includes Variable, Fixed, and GA expenses, 2) Range of 2G Ethanol costs vary based on production technicalities (e.g., enzyme amount, distillation approach, fermentation method, etc., 3) Solid Waste = 20.07 Mn Tonnes, Liquid Wastes / POME = 23,7 Mn Tonnes, 4) WAC is calculated based on feedstock use to ethanol production in USA (99% by Corn); **Sources:** Journal of Biotechnology for Biofuels, Journal of Biomass and Bioenergy, US Department of Agriculture (USDA), The World Bank, Deloitte Analysis*

Increasing 1G production volume can lower costs, while 2G costs can be reduced by selling high-value byproducts, optimizing capital, and integrating 2G with 1G facilities

Suggestions to Reduce Ethanol Costs in Indonesia

1G

Increase production volume to enable cost savings

- The Indonesian Government is working towards expanding sugarcane cultivation, which should significantly boost production volume
- As feedstock supply increases, the higher availability of raw materials will drive cost reductions for 1G ethanol, leading to more competitive pricing

2G

Sell High Value By-Products

Generate additional revenues from valuable by-products (e.g., SAF, Solid Fuel, Pulp, etc.) through integrated processing to reduce ethanol production costs

Implement Contract System

Implement long-term contracts to secure revenues, enabling scale economies from bulk production/purchasing, to reduce raw material and financing costs

Integrate 2G Plant with 1G Facilities

Maximize ethanol yields and revenue by integrating 2G processes with existing 1G facilities, reducing the need for additional capital investment

Streamline Logistics and Supply Chain

Optimize plant locations and establish downstream facilities near key markets to cut transportation costs and secure cheaper feedstock through strategic partnerships

Optimize Technology Innovation

Invest in advanced research to accelerate pre-treatment efficiency, simplify production process, and lowering enzyme expenses

All of palm oil residues can be converted into 2G Ethanol and its derivatives, but only EFB and POME hold the potential for producing high-value products such as SAF

Potential Products from Palm Oil Residues

__L1:__ Products require further processing, __L2:__ Products ready for use

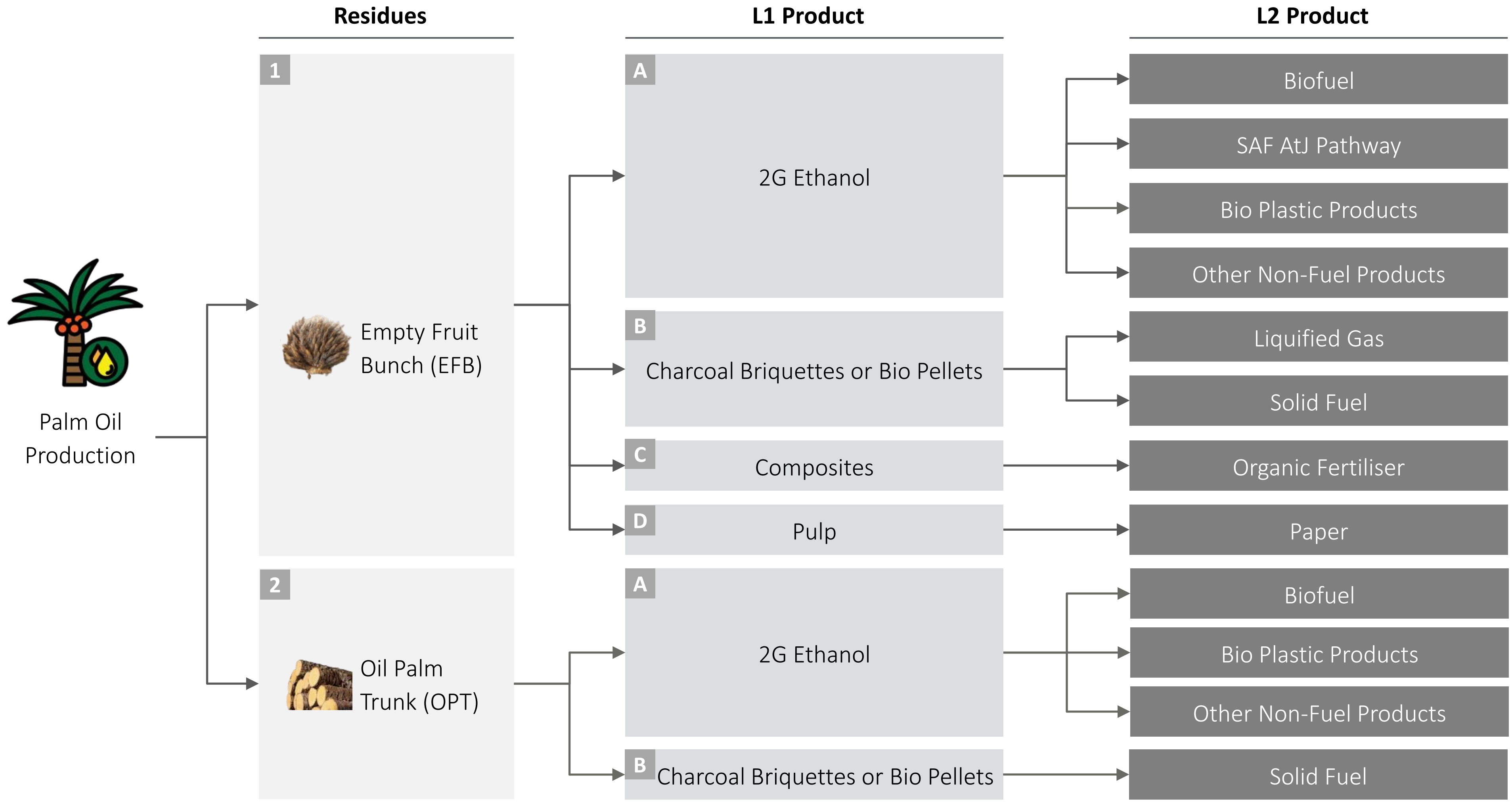
L1 Products	L2 Products	EFB	OPT	OPF	PKS	MF	POME
2G Ethanol	Biofuel	●	●	●	●	●	●
	SAF AtJ Pathway	●	*Likely possible from ethanol, but no studies have indicated SAF production from these feedstocks*				●
	Bio Plastic Products	●	●	●	●	●	●
	Other Non-Fuel Products	●	●	●	●	●	●
Charcoal Briquettes or Bio Pellets	Solid Fuel	●	●	●	●	●	
	Liquified Gas (LPG)	●					
Composites	Organic Fertiliser	●	●	●	●		●
	Animal Feed			●	●		
Pulp	Paper	●	●	●	●	●	
Sap Water	Palm Sugar (Aren)		●				
(Wood) Fiber	Industrial Wood Products		●	●		●	
Ashes	Industrial Products Filler				●		
Activated Charcoal	Purification & Filtration Products[1]				●		
Methane	Biogas	●					●

***Notes:** 1) Sample applications such as water filtration, air purification, and waste treatment; **Sources:** National Energy Council of Indonesia (Dewan Energi Nasional), Press Releases, Journals*

In addition to SAF as a high-value derivative, EFB can also be used to produce liquefied gas, which is widely utilised in Indonesia

Mapping of Potential Products from Palm Oil Residues (1/4)

L1: Products require further processing, ***L2:*** *Products ready for use*



Residues | **L1 Product** | **L2 Product**

Palm Oil Production

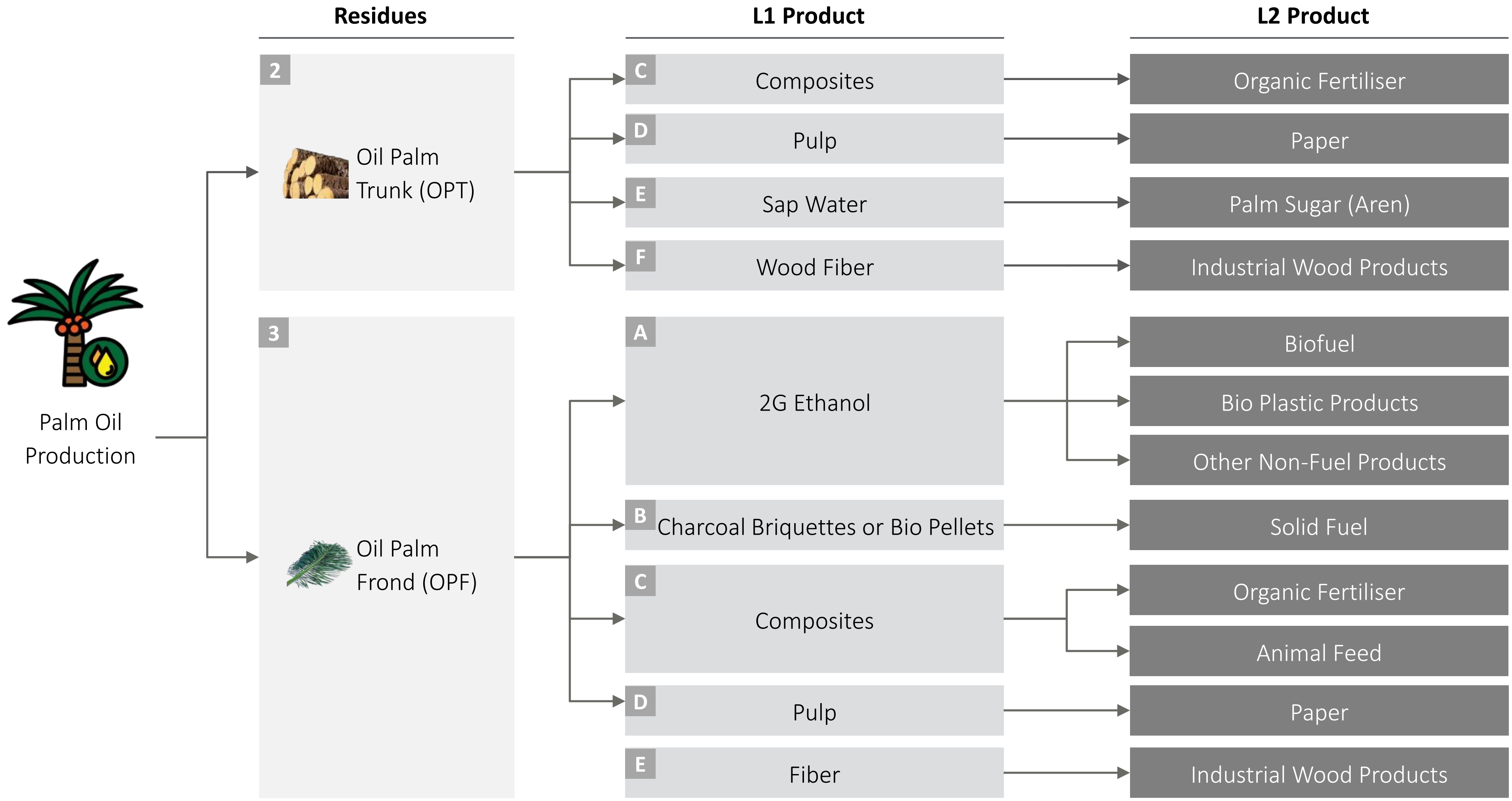
- 1 Empty Fruit Bunch (EFB)
  - A 2G Ethanol
    - Biofuel
    - SAF AtJ Pathway
    - Bio Plastic Products
    - Other Non-Fuel Products
  - B Charcoal Briquettes or Bio Pellets
    - Liquified Gas
    - Solid Fuel
  - C Composites
    - Organic Fertiliser
  - D Pulp
    - Paper
- 2 Oil Palm Trunk (OPT)
  - A 2G Ethanol
    - Biofuel
    - Bio Plastic Products
    - Other Non-Fuel Products
  - B Charcoal Briquettes or Bio Pellets
    - Solid Fuel

Sources: *National Energy Council of Indonesia (Dewan Energi Nasional), Press Releases, Journals*

A unique use of OPT is in producing Palm (Aren) Sugar from its sap water, while OPF's composites serve as animal feed

Mapping of Potential Products from Palm Oil Residues (2/4)

L1: *Products require further processing,* *L2:* *Products ready for use*



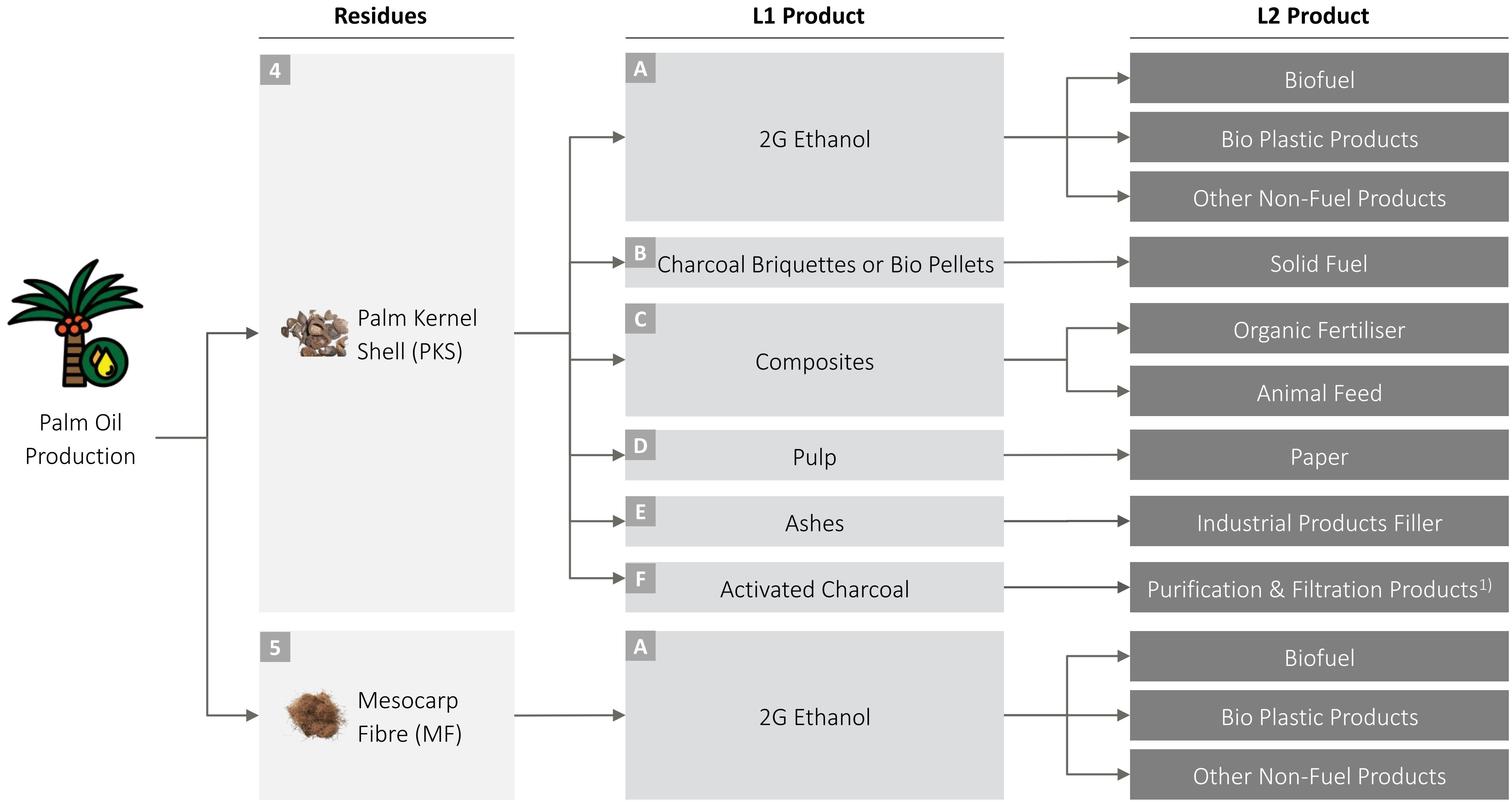
	Residues	L1 Product	L2 Product
Palm Oil Production	2 Oil Palm Trunk (OPT)	C Composites	Organic Fertiliser
		D Pulp	Paper
		E Sap Water	Palm Sugar (Aren)
		F Wood Fiber	Industrial Wood Products
	3 Oil Palm Frond (OPF)	A 2G Ethanol	Biofuel Bio Plastic Products Other Non-Fuel Products
		B Charcoal Briquettes or Bio Pellets	Solid Fuel
		C Composites	Organic Fertiliser Animal Feed
		D Pulp	Paper
		E Fiber	Industrial Wood Products

Sources: *National Energy Council of Indonesia (Dewan Energi Nasional), Press Releases, Journals*

In addition to being used as Solid Fuel, PKS waste is also utilised in industrial fillers and filtration products

Mapping of Potential Products from Palm Oil Residues (3/4)

L1: Products require further processing, L2: Products ready for use



Residues | **L1 Product** | **L2 Product**

Palm Oil Production

4 Palm Kernel Shell (PKS)
- A 2G Ethanol → Biofuel; Bio Plastic Products; Other Non-Fuel Products
- B Charcoal Briquettes or Bio Pellets → Solid Fuel
- C Composites → Organic Fertiliser; Animal Feed
- D Pulp → Paper
- E Ashes → Industrial Products Filler
- F Activated Charcoal → Purification & Filtration Products[1)]

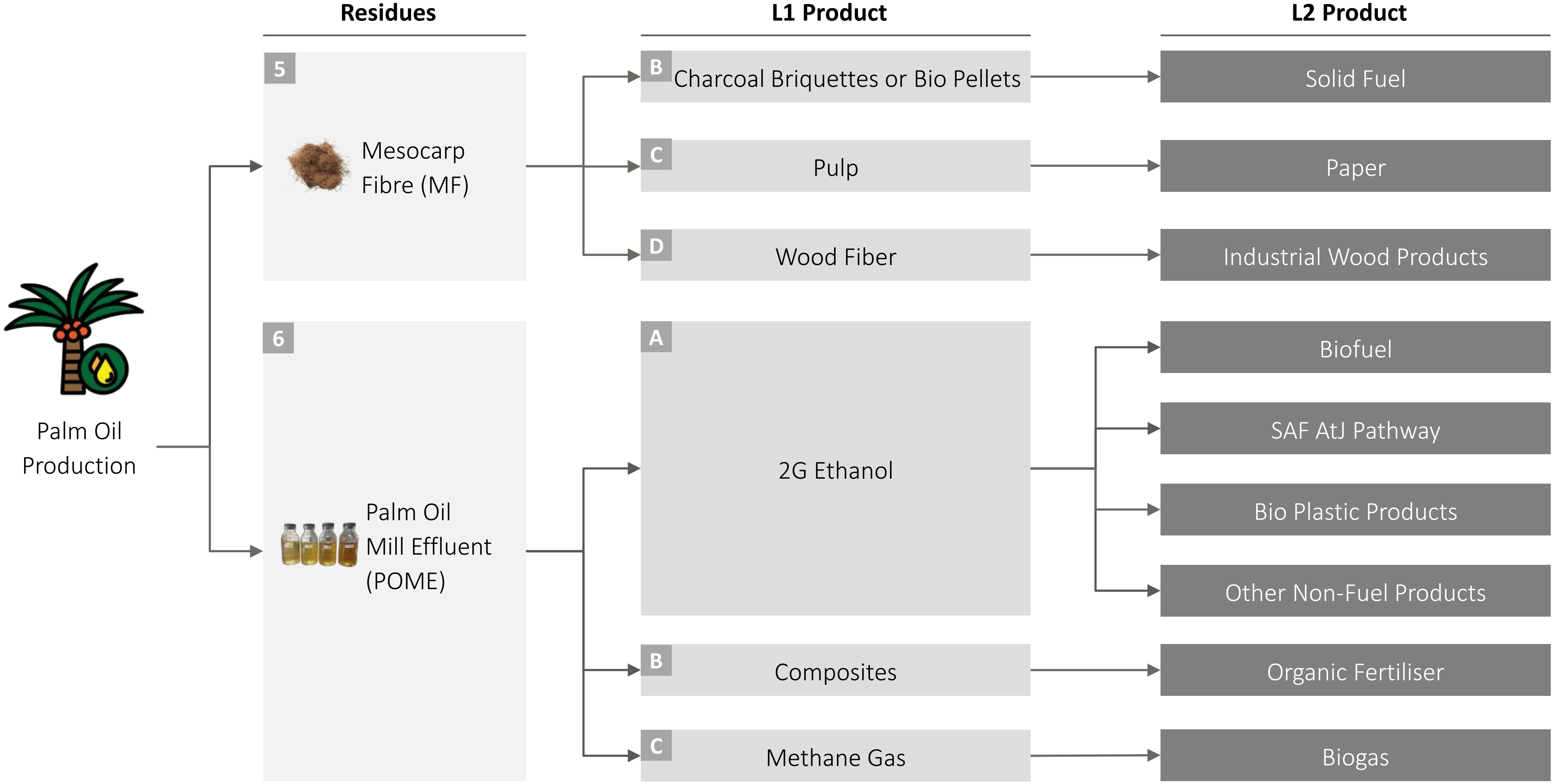
5 Mesocarp Fibre (MF)
- A 2G Ethanol → Biofuel; Bio Plastic Products; Other Non-Fuel Products

Notes: *1) Sample applications such as water filtration, air purification, and waste treatment;* ***Sources:*** *National Energy Council of Indonesia (Dewan Energi Nasional), Press Releases, Journals*

Besides EFB, POME is another residue suitable for SAF production and is also used for Biogas generation

Mapping of Potential Products from Palm Oil Residues (4/4)

L1: Products require further processing, L2: Products ready for use



Residues

L1 Product

L2 Product

Palm Oil Production

5 Mesocarp Fibre (MF)

B Charcoal Briquettes or Bio Pellets → Solid Fuel

C Pulp → Paper

D Wood Fiber → Industrial Wood Products

6 Palm Oil Mill Effluent (POME)

A 2G Ethanol → Biofuel; SAF AtJ Pathway; Bio Plastic Products; Other Non-Fuel Products

B Composites → Organic Fertiliser

C Methane Gas → Biogas

***Sources:** National Energy Council of Indonesia (Dewan Energi Nasional), Press Releases, Journals*

SAF and Solid Fuel offer the most potential from palm oil residues and Ethanol. Deeper survey is needed to understand the synergy within the palm oil industry

Portfolio Suggestions to Enable 2G Ethanol Cost Reduction

Based on Experts Interviews, Sustainable Aviation Fuel and Solid Fuel are considered as the highest-value-added products from Palm Oil Residues

Current Status

Sustainable Aviation Fuel (SAF)

- SAF Market has not been established, with most activity limited to pilot projects and feasibility studies
- SAF costs 2.5 – 5 times more than conventional jet fuel, with pertaining uncertainties due to the market's early stage of development
- There is no formal national roadmap for SAF, but commercialization is anticipated to align with the Global NZE Aviation Target in 2050

Solid Fuel

- The waste-based Solid Fuel market has been growing in Indonesia, primarily for fuels made from Palm Kernel Shells (PKS)
- According to the MEMR, price for residue-based solid fuel used for co-firing generation is 1.2 times higher than that of coal
- As for export itself, the potential export of PKS to Japan is estimated to reach USD 12 million per year

Way Forward

To identify the industrial synergy, further exploration is required for palm oil residues and other alternative feedstock such as bagasse

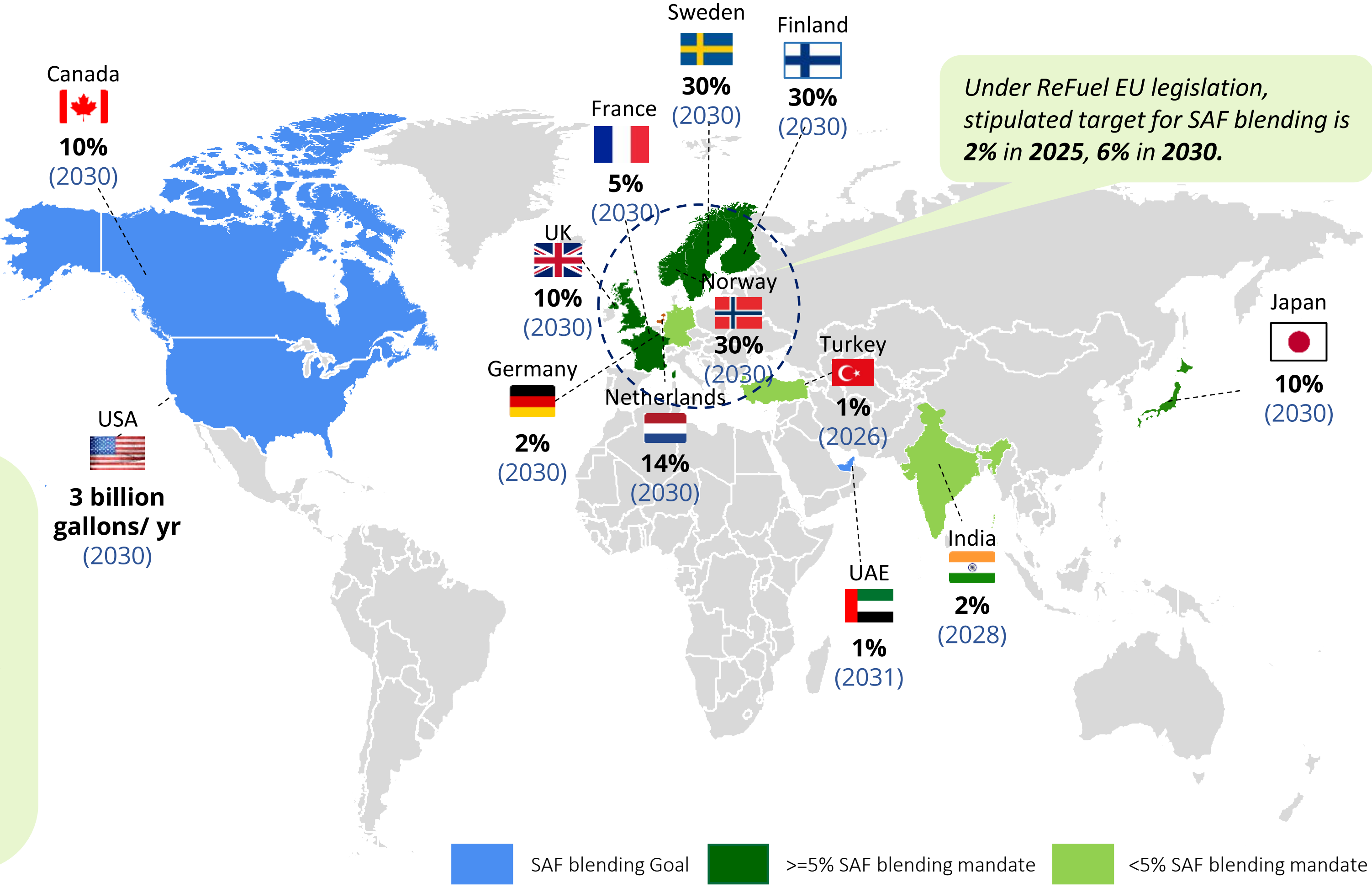
Notes: *1) PLN or Pembangkit Listrik Negara is the State Electricity Company, 2) PTPN or PT Perkebunan Nusantara is the State-Owned Enterprise holding company in the plantation sector*

Appendix :
SAF Development Status

SAF blending targets differ by country, but net-zero aviation is anticipated by 2050, aligning with the International Air Transport Association (IATA)'s goal

Global SAF Blending Targets

- IATA targets for aviation to achieve net zero by 2050
- CORSIA mandated phase will start from 2027: The airlines' emissions above the baseline set by CORSIA multiplied by the growth factor of the industry emissions above the same baseline represents the total emissions that must be offset for the given year)



*Under ReFuel EU legislation, stipulated target for SAF blending is **2%** in **2025**, **6%** in **2030.***

- *US government has not defined SAF blending mandate yet, however US has set a goal to produce **3 billion gallons per year** SAF by **2030** which is equivalent to **~14%** SAF blending[1)]*
- *Canada has aspirational goal of **10%** blending of SAF by **2030***

***Notes:** 1) Equivalent to ~14% SAF blending considering total ATF consumption in USA (2021) and 3 billion gallons per year SAF production goal by 2030; **Sources:** Deloitte India, Asia Pacific Centre of Excellence for Sustainability and Climate*

Major airlines are also voluntarily setting their own SAF blending targets, implying the needs to ramp up production to meet future demand

Blending Targets by Major Airlines

Demand is expected to increase further with voluntary targets of airlines

Out of top **15** airlines (by passenger km covers ~44% global market1)), **6** airlines2) have taken SAF blending target.

jetBlue

10% SAF blending by **2030**

DELTA

10% SAF blending by **2030**

UNITED AIRLINES

100% SAF blending by **2050**

Southwest

10% SAF blending by **2030**

AIR FRANCE KLM

10% SAF blending by **2030**

Lufthansa

10% SAF blending by **2030**

Some of the Asian airlines have also taken SAF blending targets

SINGAPORE AIRLINES

5% SAF blending by **2030**

JAL JAPAN AIRLINES

10% SAF blending by **2030**

Expected SAF Demand:

43 Airlines have committed different SAF uptake levels going from 5 to 30% by 2030, most of them committing to 10% SAF use

13 Mn tons — Expected SAF demand by 2030 projected by IATA

vs

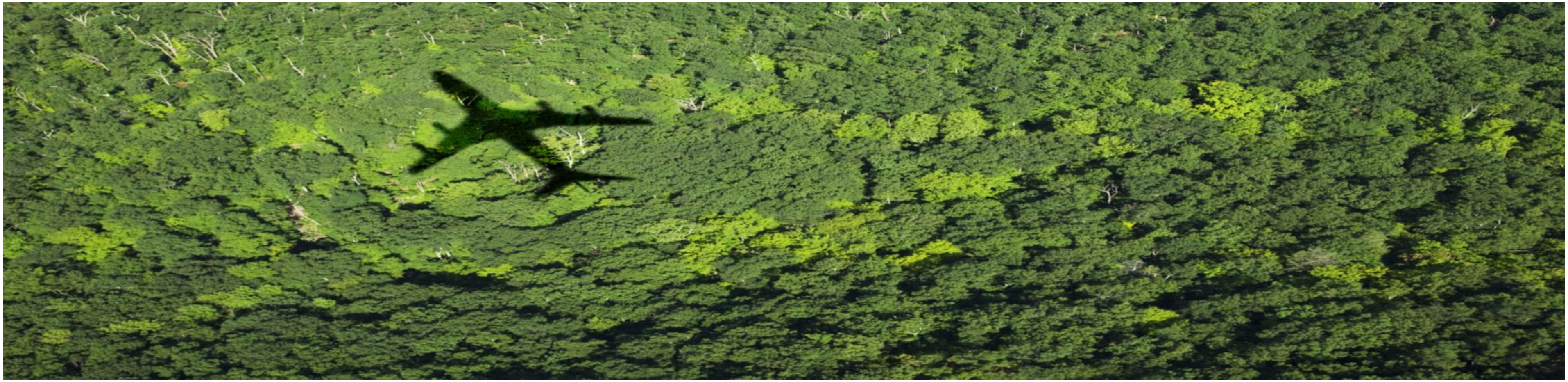
0.5 Mn tons — Current SAF production in 2023

***Notes:** 1) Market share calculated based on passenger km numbers for year 2021, 2) Six airlines has ~24% global market share in terms of passenger km; 3) Information provided is based on publicly available information, not exhaustive; **Sources:** International Air Transport Association, Deloitte India, Asia Pacific Centre of Excellence for Sustainability and Climate*

Increasing SAF adoption requires collaboration across market stakeholders, including producers, airlines, financial institutions, and even flyers

Market Dynamics to Promote SAF Adoption

Producers	Airlines	Financial Institutions	Flyers
• Allocate resources for R&D • Establish efficient supply chain • Forge strategic partnership with airlines, aircraft manufacturers, airports, government agencies etc. • Look at joint venture opportunities for investments and tech transfer	• Long term offtake agreements • Participate in joint initiatives/pilot projects with SAF producers • Adopt SAF compatible aircraft and engine technology • Implementation of voluntary carbon offsetting program	• Allocation of funds for green projects • Special project financing terms for SAF production facilities • Financial instruments such as green bonds to promote low carbon technology	• Customers willing to pay green premium • Customers with preference towards SAF-friendly airlines



Sources: *Deloitte India, Asia Pacific Centre of Excellence for Sustainability and Climate*

Increased SAF production through the ATJ route can drive demand for agricultural residues, raising farmers' incomes in middle-income countries like India

Synergy Between SAF Production to Farmers' Welfare

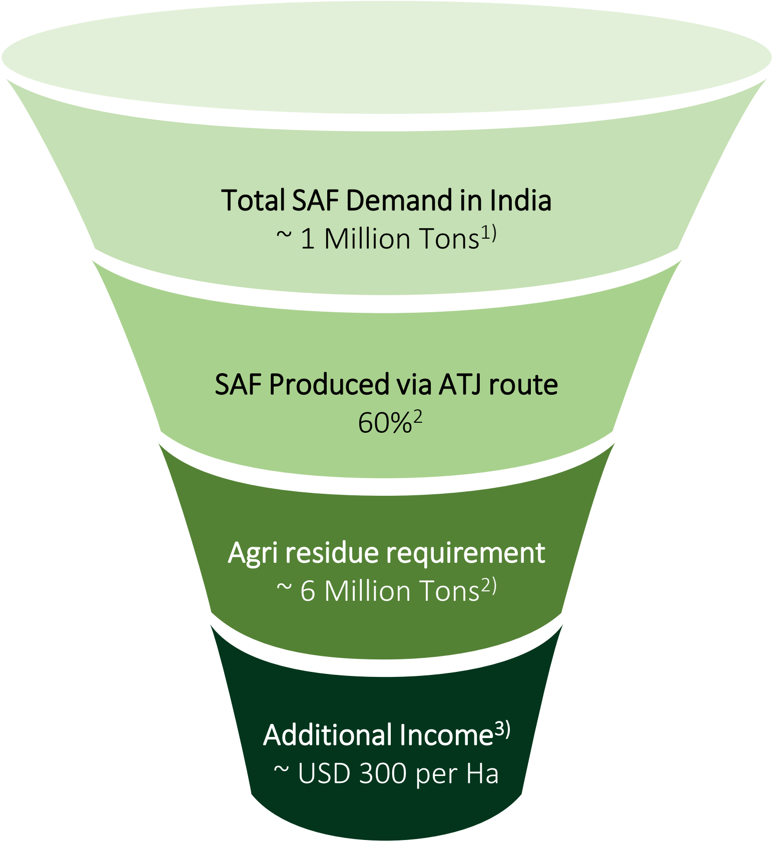
Initiatives for Increasing Farmers' Income

Involvement of Farmer Producer Organizations (FPOs) or Farmer Producer Companies (FPCs): Leveraging FPOs and FPCs for SAF feedstock collection would ensure continuous supply. It will also empower farmers by giving them collective bargaining power and access to resources

Strengthening Supply Chain: It will help to reduce post-harvest losses and enable farmers to access distant markets

Policy Support from Government: Facilitating access to credit and financial resources through government schemes will help FPO to develop infrastructure, equipment purchase & working capital. Government support for building infrastructure and logistics networks is crucial

Increment in Farmers' Income



Total SAF Demand in India
~ 1 Million Tons[1)]

SAF Produced via ATJ route
60%[2]

Agri residue requirement
~ 6 Million Tons[2)]

Additional Income[3)]
~ USD 300 per Ha

Notes: *1) Considering 5% blending (2030), 2) Assuming 40% of SAF is produced via other technology pathways, 3) Additional Farmers' Income: Considering Agro residue selling price INR 4 – 5 per kg, Considered USD 1,140 per hectare farmer income, overall INR 24-30 billion income increase for farmers;* ***Sources:*** *Deloitte India, Asia Pacific Centre of Excellence for Sustainability and Climate*

Promoting SAF requires a multi-faceted market approach, including leveraging SAFc, enhancing feedstock processing, and driving consumer willingness to pay a premium

Market Mechanisms for SAF Promotion

SAF Certificates (SAFc)

- SAFc is a **market-based mechanism** following Book & Claim method that can be tracked and traded independently
- Sustainability attributes of SAF are de-coupled from fuel as SAFc
- SAFc makes it **viable to produce SAF** in economically feasible or distant areas and allows airlines to **consume SAF** independent of its physical availability at their location
- SAFc increases **involvement of corporates outside aviation industry** hence increasing SAF adoption

Customer Willingness to Pay Premium

- Implementing **comprehensive awareness campaigns** to inform customers about the benefits of SAF, including reduced carbon footprint & environmental sustainability
- Introducing incentives such as loyalty rewards or discounts for customers who choose SAF-powered flights, encouraging them to opt for environmentally friendly options
- Advocating for policies that **incentivize SAF adoption**, such as tax breaks or subsidies for airlines and consumers who use SAF, thereby reducing relative cost compared to traditional jet fuel

Feedstock Processing Machinery Support

- Allocating **funding towards R&D initiatives** focused on improving feedstock processing machinery for SAF production
- Facilitating **partnerships between equipment manufacturers, research institutions, & SAF producers** to exchange knowledge and develop specialized machinery tailored for SAF production
- Offering **training workshops** to equipment operators and technicians to enhance their proficiency in operating and maintaining feedstock processing machinery, ensuring optimal performance and longevity

Corporate Willingness to Pay Premium

- Promote integrating SAF into corporate strategies for carbon reduction and CSR
- Establishing **industry standards and certification programs** for SAF to verify its environmental credentials, enabling corporations to make informed decisions and justify the premium associated with purchasing SAF
- Working with suppliers to develop strategies to incorporate **SAF into corporate travel policies & procurement processes**, fostering a culture of sustainability throughout the business ecosystem

Sources: *Deloitte India, Asia Pacific Centre of Excellence for Sustainability and Climate*

Efforts from the government in the form of R&D funding, mandates enactment, and price setting would be necessary to increase overall SAF consumption

Policy Suggestions to Stimulate SAF Development

Feedstock Availability

- **PLIs, financing, or tax exemptions** to incentivize investment in supply infrastructure
- Set **min. selling prices** to reduce feeds price volatility & increase production

Research & Development

Funding research, (academic and/or private) through **grants, low-cost loans** or easy **financing from bank,** creation of **innovation hubs**

Production Capacity

- New plants and capacity expansions can be provided with **direct grants, PLIs, FDIs, priority lending, low-interest loans, loan guarantees, tax exemptions**
- Allowing **green bonds, accelerated depreciation, purchase guarantees**

Policy suggestions for government to stimulate SAF supply, demand, and trading:

SAF Use Mandate

- **Corporate users** can be **obligated** to minimize their **air travel emissions**

Reduce SAF-ATF Price Gap

- Reduce SAF prices with **exemptions, subsidies, or tax incentives to airlines/flyers** or increase ATF prices via **taxation** or **carbon pricing**

Enhance SAF Market

- Facilitate **efficient international trade** by adopting internationally recognized sustainability standards and global accounting mechanisms to track emission
- Allow emission reduction trading though **Cap & Trade, Book & Claim (SAFc),** etc

***Sources:** Deloitte India, Asia Pacific Centre of Excellence for Sustainability and Climate*

The main challenges in SAF production include inadequate infrastructure for efficient feedstock collection and high production costs

Key Challenges in SAF Production

1 Lacking Feedstock Collection Infrastructure

- Concern on consistent & reliable feedstock supply at a stable price due to lacking **collection & processing infrastructure for waste/feedstock**
- **UCO** from households is **disposed of in drains**, while the commercial UCO is **sold back for reuse** in the market
- **Surplus agricultural waste is burned** by Farmers due to the absence of disposal capabilities, hence creating wastage and pollution
- Large amount of **Bio-MSW**[1] **is not treated** and **directly dumped** into landfills, while also **requires proper segregation** for any use
- Palm oil cultivation is primarily **concentrated in specific regions**. Establishing a **collection of infrastructure** that can efficiently gather palm oil from these dispersed locations while **minimizing transportation costs** remains challenging

2 High Costs of SAF Production

- The production **costs of SAF are higher than that of ATF**
- Indian consumers are highly **price-sensitive**, and domestic airlines operate at very **low margins**
- SAF must be cost-competitive with conventional fuel to stimulate its use in market
- There is a need for policies and mechanisms that allow cost to be borne across multiple stakeholders, i.e., government, airlines, producers, and flyers

Notes: *1) Municipal Solid Waste;* ***Sources:*** *Deloitte India, Asia Pacific Centre of Excellence for Sustainability and Climate*

Producing SAF from agricultural residues via the AtJ pathway offers the highest feasibility based on feedstock availability, affordability, and ease of procurement

Feasibility of SAF Production by Pathway

Pathway	Type	Feedstock		Availability	Affordability	Ease of Procurement
HEFA	Crop Based	Edible Oil Crops/Palm Oil		◔	◔	◑
	Waste	Waste & Residue Lipids	Used Cooking Oil	◔	◔	◔
			Animal Waste Fat	◔	◔	◔
			Others	◔	◔	◔
	Others	Oil Trees, Oil cover crops, Algae, Halophytes		◔	◑	◔
AtJ	Crop Based	Sugary/Starch crops		◑	◕	◕
FT	Waste	Municipal Solid Waste		◕	●	◔
AtJ/FT	Agricultural Waste	Agricultural Residues		●	◕	◕
		Forestry Residue		◑	◕	◑
PtL	Carbon Capture	Point Source & Direct Carbon Capture		◔	◔	◔
	Waste	Reusable Plastic Waste		◔	◑	◑

Sources: *Deloitte India, Asia Pacific Centre of Excellence for Sustainability and Climate*

The SAF-ATF cost gap can be reduced through mechanisms such as corporate initiatives, SAF certificates, and sharing premiums across stakeholders

Methodologies to Fund SAF Production (1/2)

Transferring SAF premium to SAFc

SAFc Overview

- It is a **market-based mechanism** following **Book & Claim method**
- The **sustainability attributes** of SAF are **de-coupled** from fuel as SAFc
- The **SAFc** can be **tracked and traded** independently
- The fuel is treated just like a conventional jet fuel

Impact

- Makes it **viable to produce** in economically feasible or distant areas
- Allows airlines to **consume SAF** independent of its physical availability at their location
- Funds generated by SAFc transactions **offset SAF's premium** over ATF
- SAFc increases **involvement of corporates outside aviation industry** hence increasing SAF adoption

Industry Experts Overview

*'SAF is the single most important technology for decarbonizing aviation in the short to medium term. We need supportive **government policies, including blending mandates and sustainable aviation fuel** credit mechanisms, to incentivize its production and use"*

Sources: *Deloitte India, Asia Pacific Centre of Excellence for Sustainability and Climate*

Additional costs can be obtained from less price elastic customers

Examples of Environmental Integration in Business Strategies

A growing number of environmentally conscious corporations are integrating sustainability goals into their business strategies

Examples:

- **Microsoft:** Partners with SkyNRG to purchase SAF for corporate travel, demonstrating their commitment to sustainability
- **DHL:** Committed to utilizing SAF for a portion of its global operations, actively contributing to market demand

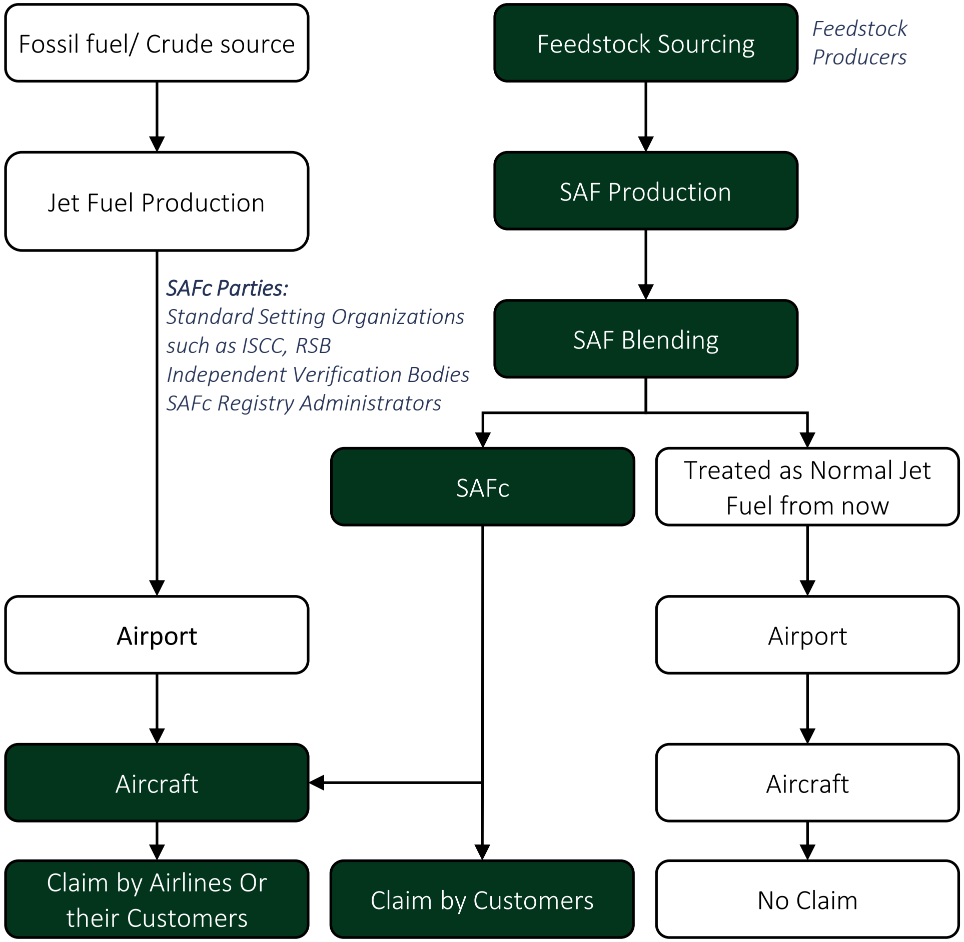
Customer Willingness To Pay For SAF

- According to a Forbes report – **"**It was reported that, on average, consumers were willing to pay **13% more for the biofuel ticket"**
- Roland Berger's Future of Long-Distance Travel Report found that **90% of respondents said they are willing to pay more for sustainability** in air travel
- "Companies are willing to pay a **'green premium'** when they purchase SAF to reduce their business travel emissions,"
  - Neste's renewable aviation business

The SAF-ATF cost gap can be reduced through mechanisms such as corporate initiatives, SAF certificates, and sharing premiums across stakeholders

Methodologies to Fund SAF Production (2/2)

Transferring SAF premium to SAFc



Fossil fuel/ Crude source

Jet Fuel Production

Airport

Aircraft

Claim by Airlines Or their Customers

Feedstock Sourcing

Feedstock Producers

SAF Production

SAF Blending

SAFc Parties:
Standard Setting Organizations such as ISCC, RSB
Independent Verification Bodies
SAFc Registry Administrators

SAFc

Claim by Customers

Treated as Normal Jet Fuel from now

Airport

Aircraft

No Claim

Valid SAF Certificates Examples

SAF Certificate Issuance for S-Oil Corporation

- Issued by: Control Union Certifications Germany GmbH
- Place of Issue: Berlin, Germany
- Date of Issue: 08.04.2024
- Certification System: ISCC CORSIA (International Sustainability and Carbon Certification), approved by the ICAO Council
- Certified Entity: S-OIL Corporation
- Validity Period: From 08.04.2024 to 07.04.2025

SAF Certificate Issuance for Arikira Co., Ltd.

- Issued by: PT Intertek Utama Services
- Place of Issue: Jakarta, Indonesia
- Date of Issue: 24.04.2024
- Certification System: ISCC CORSIA (International Sustainability and Carbon Certification), approved by the ICAO Council
- Certified Entity: ARIKIRA CO., LTD.
- Validity Period: From 24.04.2024 to 23.04.2025

Sources: *Deloitte India, Asia Pacific Centre of Excellence for Sustainability and Climate*

Appendix 1 :
Roadmap for Ethanol Introduction by the Indonesian Government

Two ministries are developing Ethanol Acceleration Roadmaps. While the Coordinating Ministry's plan is unpublished, the MEMR has proposed new targets

Roadmaps for Ethanol Acceleration in Indonesia

① Acceleration of Bioethanol Implementation

② Acceleration of National Sugar Self-Sufficiency and the utilization of Bioethanol for Biofuel

Owner / Developer

①
Ministry of Energy & Mineral Resources
Bandung Institute of Technology (ITB)
United States Grains Council

②
KEMENTERIAN KOORDINATOR BIDANG PEREKONOMIAN REPUBLIK INDONESIA
Coordinating Ministry of Economic Affairs

Timeline

① Launched in 2022

② Expected for completion in March 2024

Details

① The Roadmap aims to promote bioethanol use in vehicle fuel and develops Indonesia's bioethanol industry through these targets:

	Short-Term	Med-Term	Long-Term 2031
Ethanol Blend	**5%**	**10%**	**15%**
Coverage	JKT & SBY[1)]	Java-wide	Nationwide

②
- The Roadmap prepared by the Coordinating Ministry of Economic Affairs is a continuation / derivative of Presidential Regulation No. 40 of 2023[2)]
- The Roadmap is expected to be promulgated in the form of a Ministerial Decree
- Information on blending targets, national strategies, and other related details is not yet available

Recent Development

① As of June 2024, the Roadmap is currently being revised to propose the following 10-year Ethanol Blend Target, likely lower than the initial plan (i.e., introducing E15 by 2031)

2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
5%	5%	5%	5%	5%	10%	10%	10%	10%	10%	10%	10%

②
- As of June 2024, the Ministry was still refining the roadmap
- As of July 2024, there is still no confirmation on the expected completion and release of the roadmap

Notes: *1) Jakarta and Surabaya, 2) Regulation concerning the accelerating national sugar self-sufficiency and bioethanol use as biofuel;* ***Sources:*** *Japan-Indonesia Policy Dialogue, Press Releases from the Coordinating Ministry of Economics Affairs, Kompas Nasional News, Antara News*

Appendix 2 :
Material presented at
the 5th Indonesia Japan Automobile Policy Dialogue

Study on Policy advocacy for Biofuel in Indonesia

The 5th Indonesia Japan Automobile Dialogue

Deloitte Consulting Southeast Asia
27 June 2024

Table of Contents

Need for bioethanol in Indonesia 3

Case study for advanced market : Brazil 8

Potential of bioethanol to combat challenges 12

Way forward 20

Need for bioethanol in Indonesia

The Indonesian Government is tackling three key challenges: "Improvement of Air Quality", "Utilization of Domestic Resources" and "Transition Away from Reliance on Fossil Fuel"

Three key challenges facing Indonesia

1 Improvement of Air Quality

Air pollution global ranking (IQAir)
By country: 14th
By city: 7th (Jakarta)

Vehicles account for 44% of Jakarta's air pollution sources

Need to reduce GHG emissions and PN

2 Utilization of Domestic Resources

An economy dependent on unprocessed resource exports (primary industry), which are susceptible to trends in global resource demand

Need to upgrade domestic industry to a processing export-oriented economy, which is a higher value-added industry

3 Transition Away from Reliance on Fossil Fuel

Trade deficit due to significant excess imports of crude oil

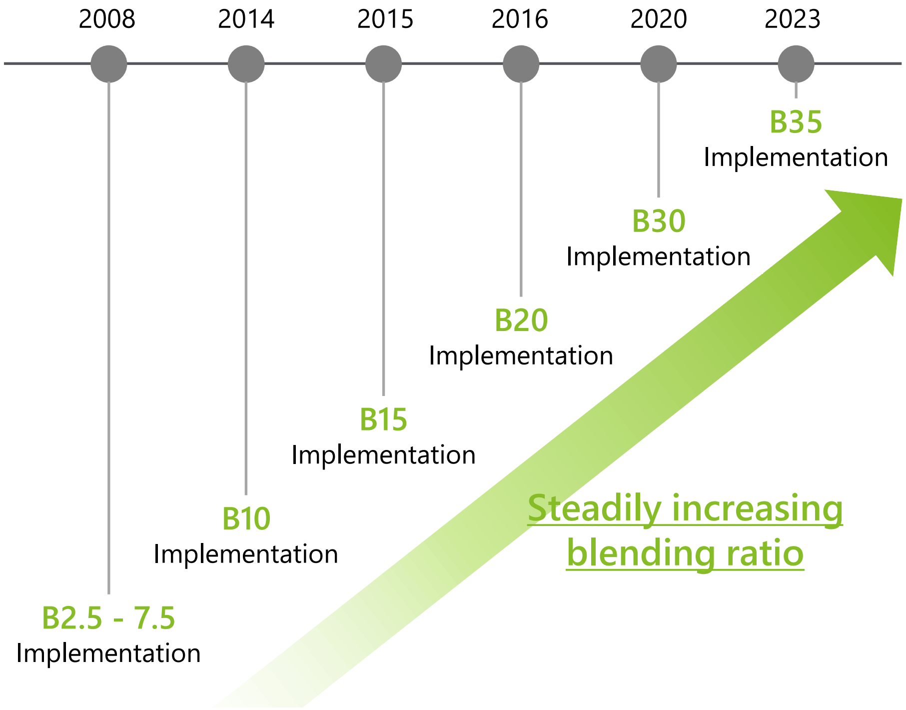
Vulnerability in energy security

Increased fuel subsidy spending

Need to move away from dependence on crude oil imports

Biodiesel was introduced in the 2000s to reduce dependence on oil imports, alleviate poverty and bolster employment opportunity. Various policies proved successful, resulting market expansion and deployment of B35

Status of biodiesel introduction



2008 – **B2.5 - 7.5** Implementation

2014 – **B10** Implementation

2015 – **B15** Implementation

2016 – **B20** Implementation

2020 – **B30** Implementation

2023 – **B35** Implementation

Steadily increasing blending ratio

Main policies

- CPO Funds to rejuvenate oil palm plantation & farmer's well-being
- Mandated to use FAME in certain blending ratio amount progressively
- Sanction system for fuel blender & FAME producer
- Subsidy Biodiesel price from export levy of CPO and its derivatives

Feedstock for Biodiesel

100%

Palm oil as feedstock

Bio blended diesel Fuel Share

94.5%

Bio-blended diesel's share in total diesel fuel

Biodiesel Blending Ratio

B35

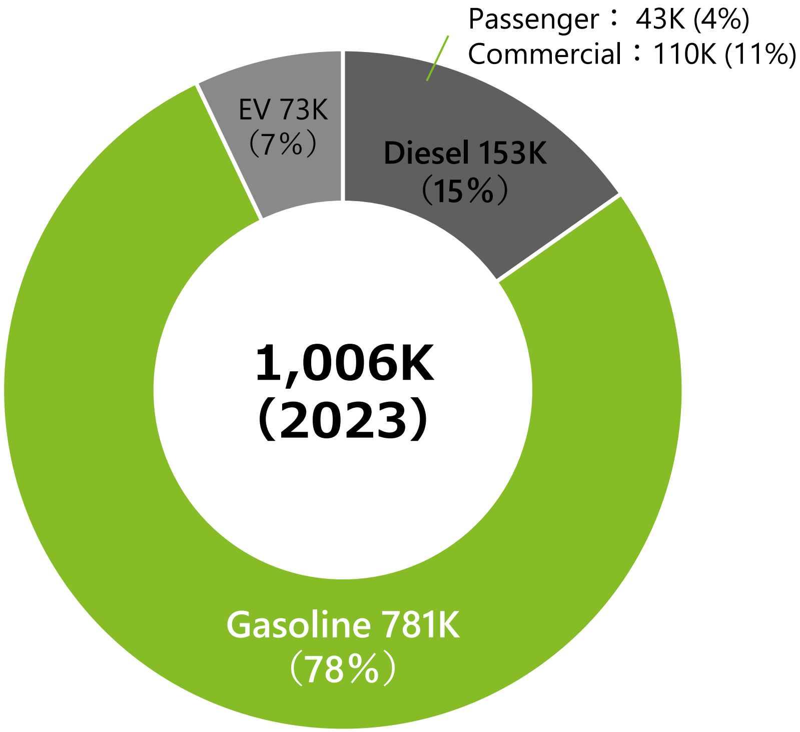
Blending mandate as of 2023

Source: Indonesia's Biofuel Annual Report-USDA, Handbook of Energy and Economic Statistics of Indonesia - MEMR

Gasoline constitutes a larger portion of the four-wheeled vehicle market compared to diesel, and ministers have expressed a strong inclination to advocate for the introduction of bioethanol alongside biodiesel

Need for bioethanol in the transport sector (1/2)

Four-wheeled vehicles (passenger cars & commercial vehicles), % of total sales



Gasoline vehicles (including HEV) account for approximately 80% of all four-wheeled vehicles

Source : GAIKINDO

"Then it was decided to consolidate the acceleration of sugar self-sufficiency. Because indeed, if we follow what is now, we will continue to import. Then we will also ***encourage it to become bioethanol****. Incidentally, yesterday because many people have asked to accelerate development, this task force was formed"*

Jakarta, May 2nd

Investment Minister : Bahlil Lahadalia

Coordinating Minister: Luhut Binsar Pandjaitan

Mr. Luhut Binsar Pandjaitan, Coordinating Minister for Maritime Affairs, has revealed that Plutamina plans to acquire an **ethanol** and sugar production company in Brazil *"Pertamina 's promotion of biofuels could achieve an early replacement of fossil fuels. A gradual* ***bioethanol transition is necessary*** *to mitigate standby pollution such as that currently occurring in the capital, Jakarta"*

Jakarta, June 10th

Bioethanol holds the potential to address the key challenges of "Improvement of Air Quality", "Utilization of Domestic Resources" and "Transition Away from Reliance on Fossil Fuel"

Need for bioethanol in the transport sector (2/2)

Definition

Scenario1: EV adoption at target levels

If EVs penetrate as per current EV policy and targets

Percentage of new EV vehicles sold

	2030	2040	2050	2060
4W	41%	90%	100%	100%
2W	100%	100%	100%	100%

Scenario2: HV penetration instead of EV

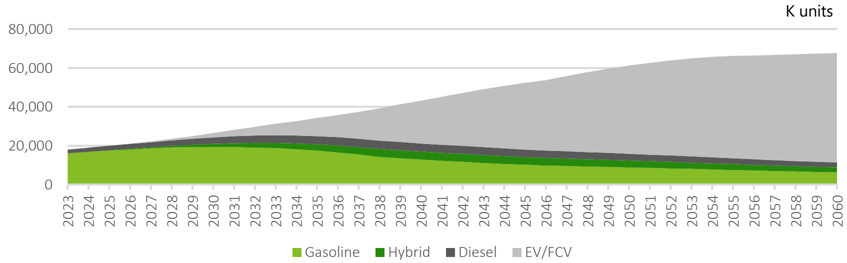
If the government changes direction to HVs and HVs penetrate the market first

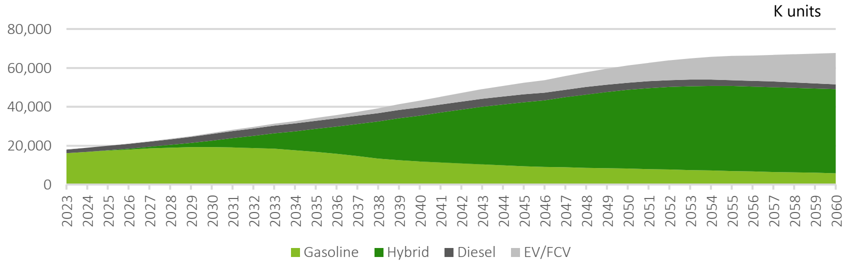
Percentage of new EV vehicles sold

	2030	2040	2050	2060
4W	5%	15%	25%	50%
2W	10%	20%	35%	50%

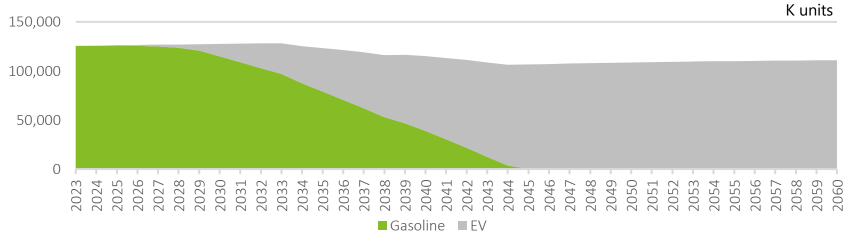
Trend forecast for # of registered vehicles

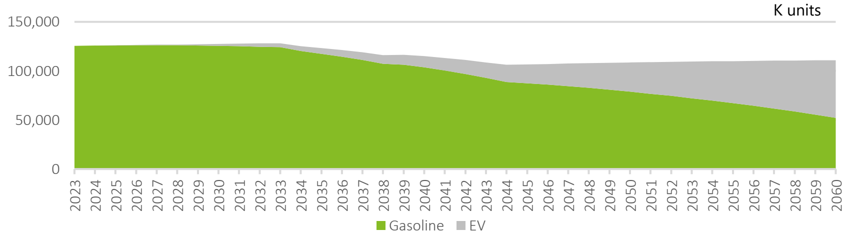
4W





2W





Ethanol requirement (mn Liter)

Scenario1: 2030	2040	2050	2060	Scenario2: 2030	2040	2050	2060
1,085	1,716	1,686	1,352	1,140	3,193	5,582	5,650
E10	E20	E20	E20	E10	E20	E20	E20

Source : Estimation by the project based on various datapoints incl. EIU

Case study for advanced market : Brazil

Brazil produces ethanol from sugarcane, the nation's most significant agricultural product, and has developed it as a new national industry, becoming one of the world's foremost bioethanol producers

Case study on the introduction of ethanol in Brazil (Ethanol market)

Feedstock for Bioethanol

~97% (~87%)

Sugarcane as feedstock (% in Bioethanol)

Bioethanol Fuel Share

~100%

Bioethanol blended gasoline sales ratio

Sales ratio by Bioethanol fuel type

70 : 30

70	30
Gasoline C 27% ethanol blended	Hydrous Ethanol 100% pure ethanol

Source: Government Intervention to Strengthen the Ethanol Sector-ELLA, The Story of Brazil's Ethanol Programme-ELLA, Brazil's Biofuel Annual Report-USDA

Strong Gov't-led promotion of FFV to utilize domestic resources and reduce reliance on oil imports, results over 90% of passenger cars in the domestic market are now FFVs, facilitating economic recycling and contributing to CO2 reduction

Case study on the introduction of ethanol in Brazil (FFV market)

Policy promotion in FFV

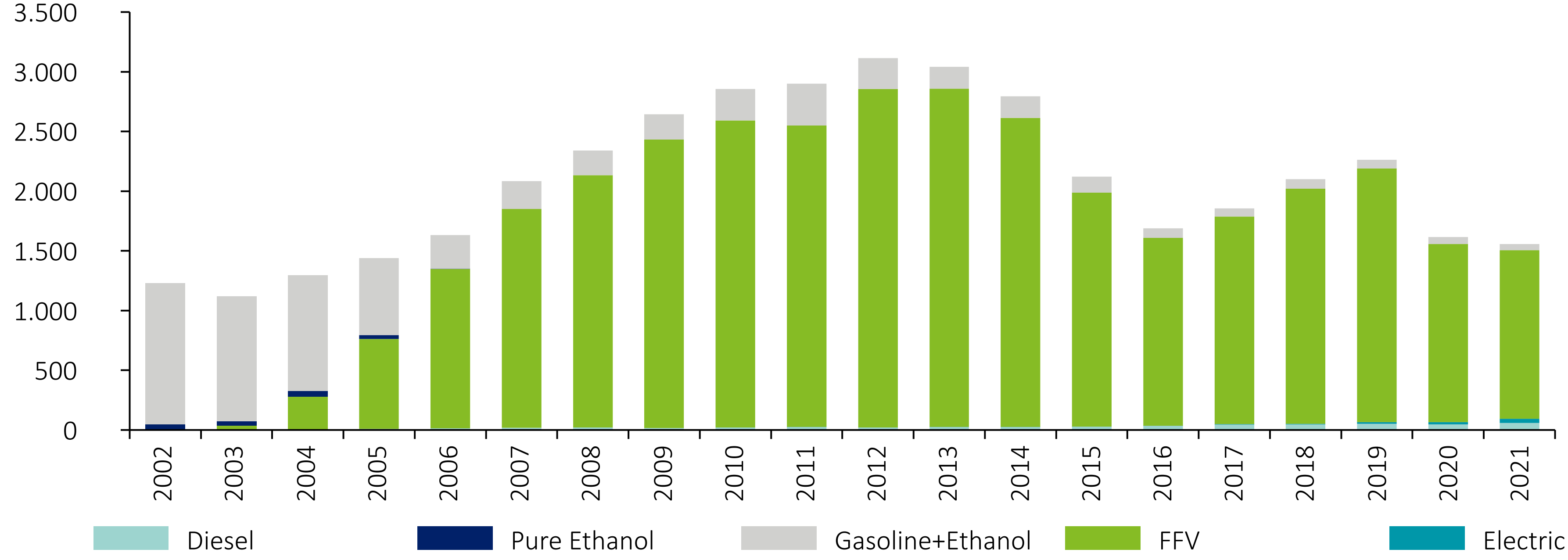
Manufacturer

- Tax breaks for car manufacturer (ethanol-fueled vehicle including FFV)

End-User

- Tax reduction for vehicle purchase and licensing
- Exemption of tax for ethanol-fueled commercial transport
- Flat Road Tax reduction

❑ Registration of new car by fuel type (k unit)

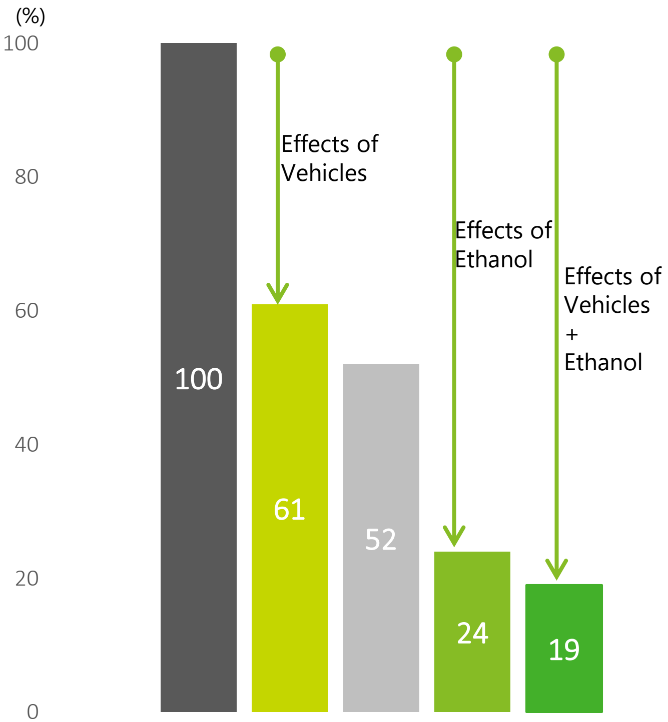


Source: Government Intervention to Strengthen the Ethanol Sector-ELLA, The Story of Brazil's Ethanol Programme-ELLA, Brazil's Biofuel Annual Report-USDA, Brazilian Automotive Industry Report

Brazil is advancing the introduction of flex HEVs as part of its efforts to achieve a decarbonized society, which are expected to reduce CO2 emissions

Effects of ethanol utilization in Brazil

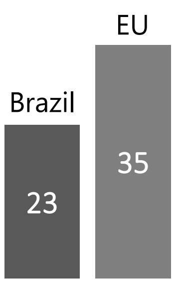
CO2 Reduction Effect



Vehicle	ICE	HEV	HEV	ICE	HEV
Fuel	Gasoline	Gasoline	E27	E100	E100
CO_2	Base	-39%	-48%	-76%	-81%

Source : Data of JETRO

Case of BEV



-77% -65%

86% of Brazil's electricity is renewables = Very high

The Japan Times 6th Mar. 2024

Toyota is increasing its bet on flex fuel-hybrid vehicles with an investment of 11 billion reais ($2.2 billion) in its Brazilian operations between 2023 and 2030

Toyota's competitors have also been pumping money into Brazil this year. U.S. giant **General Motors** announced plans to invest 7 billion reais in January, with **Volkswagen** of Germany setting aside 9 billion reais the following month along with 5.5 billion reais from South Korea's **Hyundai Motor**.

All of them are seeking to begin the electrification of their product lines in the Brazilian market, **investing in flex-hybrid versions, which combine electric and combustion engines** that can be fueled with gasoline or ethanol.

Source : https://www.japantimes.co.jp/business/2024/03/06/companies/toyota-investment-brazil-hybrid/

Potential of bioethanol to combat challenges

Drawing an analogy from Brazil, Indonesia's gasoline market presents a compelling opportunity to leverage its abundant natural resources; by fostering the development of a bioethanol market, Indonesia can address critical challenges in the energy sector

Direction of solutions to key challenges

1 Improvement of Air Quality

Air pollution global ranking (IQAir)
By country: 14th
By city: 7th (Jakarta)

Vehicles account for 44% of Jakarta's air pollution sources

Need to reduce GHG emissions and PN

2 Utilization of Domestic Resources

An economy dependent on unprocessed resource exports (primary industry), which are susceptible to trends in global resource demand

Need to upgrade domestic industry to a processing export-oriented economy, which is a higher value-added industry

3 Transition Away from Reliance on Fossil Fuel

Trade deficit due to significant excess imports of crude oil

Vulnerability in energy security

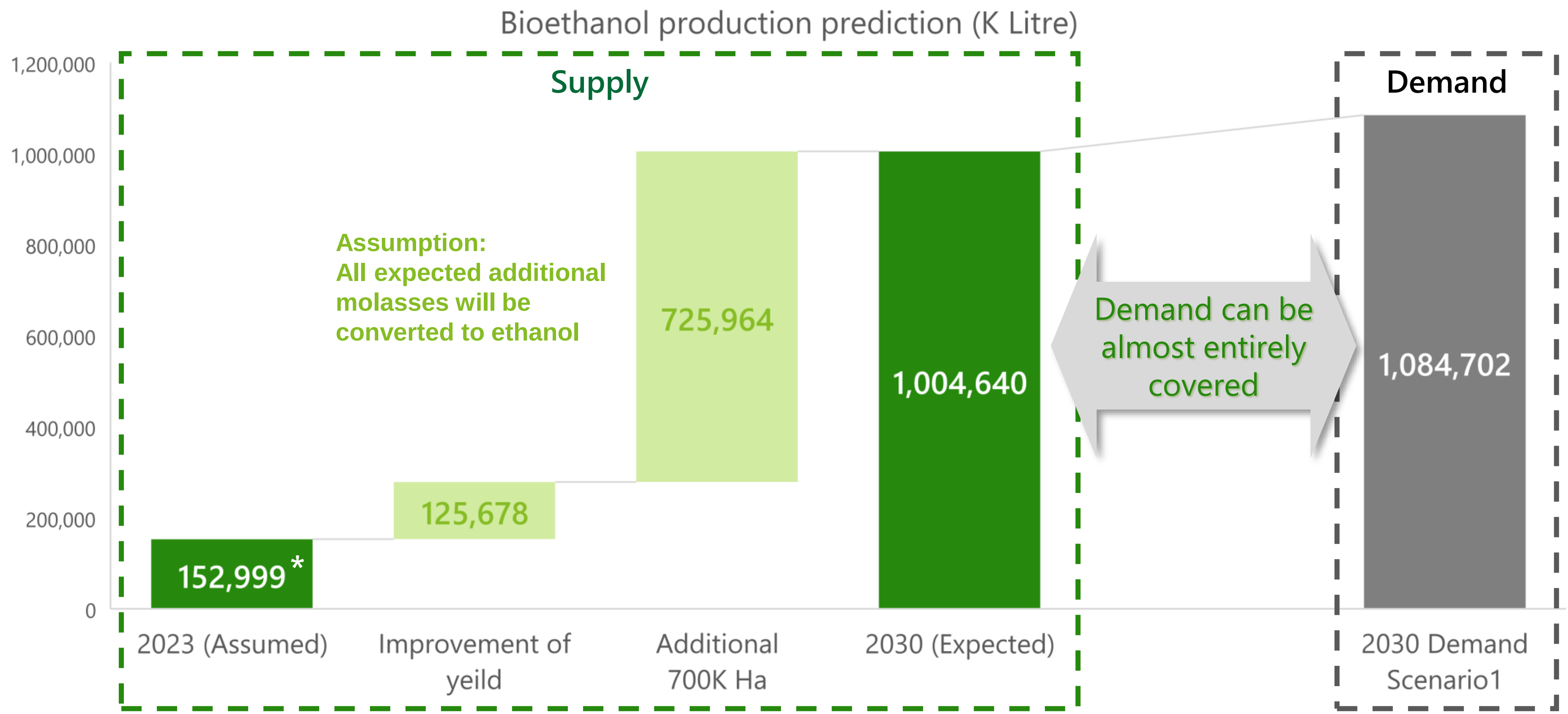
Increased fuel subsidy spending

Need to move away from dependence on crude oil imports

Solving key challenges by forming a bioethanol market from the own natural resources (sugarcane molasses/palm oil residues)

Steadily promote initiatives to increase sugar self-sufficiency through the promotion of 1G ethanol using sugarcane waste molasses, thereby taking the first steps towards creating a market and supply chain

1G Sugarcane molasses supply feasibility



Effects of estimated ethanol production from Presidential Decree No.40/2023

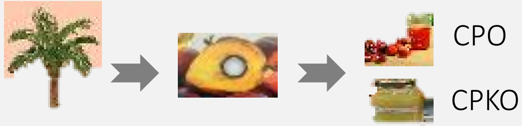
* Assumption: 40% of the waste molasses is allocated to ethanol production (based on current status: 40% for ethanol use, 35% MSG, 25% for export)

A press release by the Ministry of Investment in response to Presidential Decree No. 15/2024, presented in April 2024, stated the direction of an additional 2 million ha of agricultural land in Papua, which could lead to higher ethanol production than projected above

Source : Sugar Annual USDA, Food and Agriculture Organization of the United Nations (FAO)

Upon the successful implementation of 2G technology, it is anticipated that 2G ethanol derived from palm residues could not only satisfy domestic vehicle fuel demand but also generate a potential surplus

2G Palm oil residues supply feasibility

Product		2030	2040	2050	2060
Palm oil production (K ton)		65,390	82,770	92,450	92,450

Source: Indonesia Oil Palm Roadmap (2045)

		Residues generated Ratio	**Utilization Ratio**	**Ethanol conversion Ratio**	**Estimation** Mil Litre			
Empty Fruit Bunch (EFB)		**82%**	**30%**	**30.1%**	**4,847**	**6,135**	**6,853**	**6,853**
Oil Palm Frond (OPF)		333%	30%	21.3%	13,900	17,595	19,653	19,653
Oil Palm Trunk (OPT)		92%	30%	81.3%	14,598	18,478	20,639	20,639
Bioethanol demand (Scenario2: HV penetration instead of EV)					**1,140**	**3,193**	**5,582**	**5,650**

Source: International Journal from IOPScience, Expert interviews, various international journals, and public articles

The deployment of 2G bioethanol derived from palm oil residues is projected to deliver significant reductions in GHG emissions over the period 2030 to 2060

Improvement of air quality (1/2)

1 Improvement of Air Quality

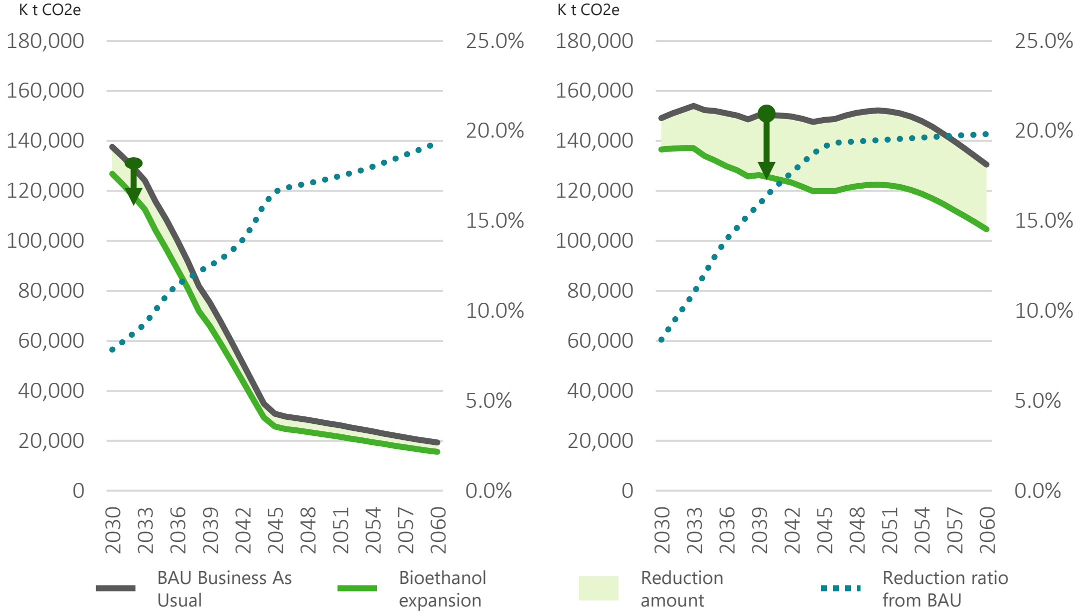
Air pollution global ranking (IQAir)
By country: 14th
By city: 7th (Jakarta)

Vehicles account for 44% of Jakarta's air pollution sources

Need to reduce GHG emissions and PN

Scenario1: EV adoption at target levels

Scenario2: HV penetration instead of EV



GHG reduction	216 mn tCO2e Accumulation from 2030 to 2060	775 mn tCO2e Accumulation from 2030 to 2060
Potential Carbon Credit	8,647 mn USD	30,994 mn USD

Condition: 40 USD / t CO2 e

Source : Estimation by the project based on various datapoints

In-house assessments conducted by a Japanese OEM have indicated a propensity for ethanol-petrol blends to enhance PN emission profiles

Improvement of air quality (2/2)

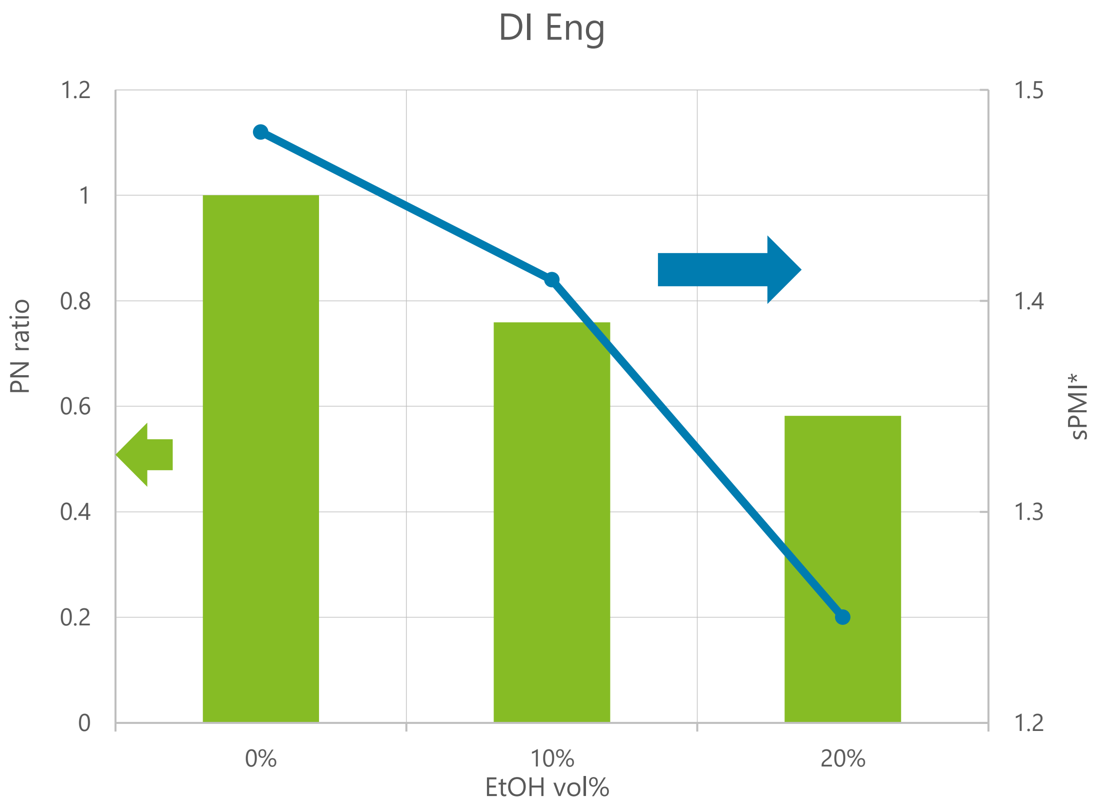
1 Improvement of Air Quality

Air pollution global ranking (IQAir)
By country: 14th
By city: 7th (Jakarta)

Vehicles account for 44% of Jakarta's air pollution sources

Need to reduce GHG emissions and PN

Effect of ethanol on Exhaust Emission (PN)



*sPMI: Simplified PM Index →Quantified impact on PM emissions

Source: in house data

The introduction of bioethanol is anticipated to generate new jobs across the entire bioethanol value chain, while facilitating efficient use of waste natural resources

Utilization of domestic resources

2 Utilization of Domestic Resources

An economy dependent on unprocessed resource exports (primary industry), which are susceptible to trends in global resource demand

Need to upgrade domestic industry to a processing export-oriented economy, which is a higher value-added industry

Natural resource utilization

Effective use of waste natural resources

Molasses waste

EFB

OPF

OPT

Human resource utilization (Job creation)

	Scenario1: EV adoption at target levels	Scenario2: HV penetration instead of EV
Direct job	10,006	25,238
Indirect job	16,291	41,091

Source: Estimation by the project based on Indonesia Input Output Table Database by BPS (2016), World Input Output Table Database by WIOD (2014), Socio Economic Accounts Database by WIOD (2014)

The adoption of bioethanol is projected to diminish crude oil imports, consequently mitigating the trade deficit and bolstering energy security

Transition Away from Reliance on Fossil Fuel

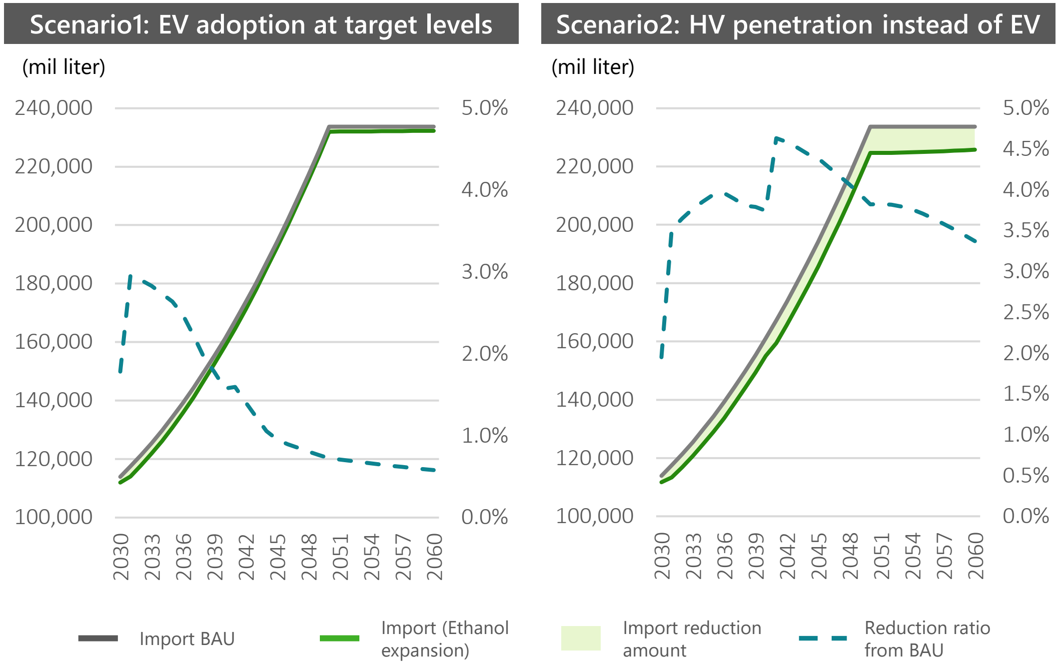
3 Transition Away from Reliance on Fossil Fuel

Trade deficit due to significant excess imports of crude oil

Vulnerability in energy security

Increased fuel subsidy spending

Need to move away from dependence on crude oil imports



Scenario1: EV adoption at target levels

Scenario2: HV penetration instead of EV

Crude oil import volume reduction	**69.4 bn Liter** Accumulation from 2030 to 2060	**224.4 bn Liter** Accumulation from 2030 to 2060
Crude oil import cost reduction	**38.9 bn USD**	**125.8 bn USD**

Exchange rate = 1 USD ~ 15,800 IDR

Source : Estimation by the project based on various datapoints

Way forward

To cultivate a robust market for bioethanol as a viable gasoline alternative in Indonesia and address critical challenges within the energy sector, the following actions are recommended;

Proposals for bioethanol deployment

Formulating comprehensive roadmap outlining key milestones on both supply and demand side to facilitate sustainable proliferation of bioethanol

- ☐ Demand side: Formulate a plan for blending rate transitions, study introduction of FFV and Flex HEV
- ☐ Supply side: Formulate a supply plan for 1G sugarcane waste molasses as a transitional measure
  Determine target timing for introduction of 2G palm oil residue

Concurrently fostering the development of a robust supply chain and a strong demand base for 1G ethanol derived from sugarcane waste molasses

- ☐ Demand side: Identify targets (sales areas, mixing rates, target RON)
- ☐ Supply side: Develop an additional 700 K Ha of land to secure supply/promote productivity-enhancing activities
- ☐ Supply and demand: Study the policy framework needed to promote deployment

Initiating a comprehensive investigation into the feasibility of establishing an ecosystem for the utilization of palm oil residues in 2G bioethanol production

- ☐ Consideration of new industrial development such as ATJ and solid fuels using palm oil residues to reduce ethanol costs
- ☐ Examine the possibility of earning foreign currency by exporting the above products and creating a source of subsidies through export taxes, etc.
- ☐ Consider further ethanol demand creation through the introduction of FFV and flex HEVs

The establishment of a robust bioethanol market in Indonesia is likely to encounter numerous hurdles. Resolute backing from the Indonesian government will be indispensable in overcoming these obstacles

Challenges to realization

1G Sugarcane waste molasses

- ☐ Study and implement a promotion scheme for the early realization of 700 K Ha of additional plantation land
- ☐ Support producers to increase productivity / Study and implement a promotion scheme to realize improved efficiency in sugarcane production processes (production management, cutting and transportation)
- ☐ Identification and early implementation of reasonable and effective policies

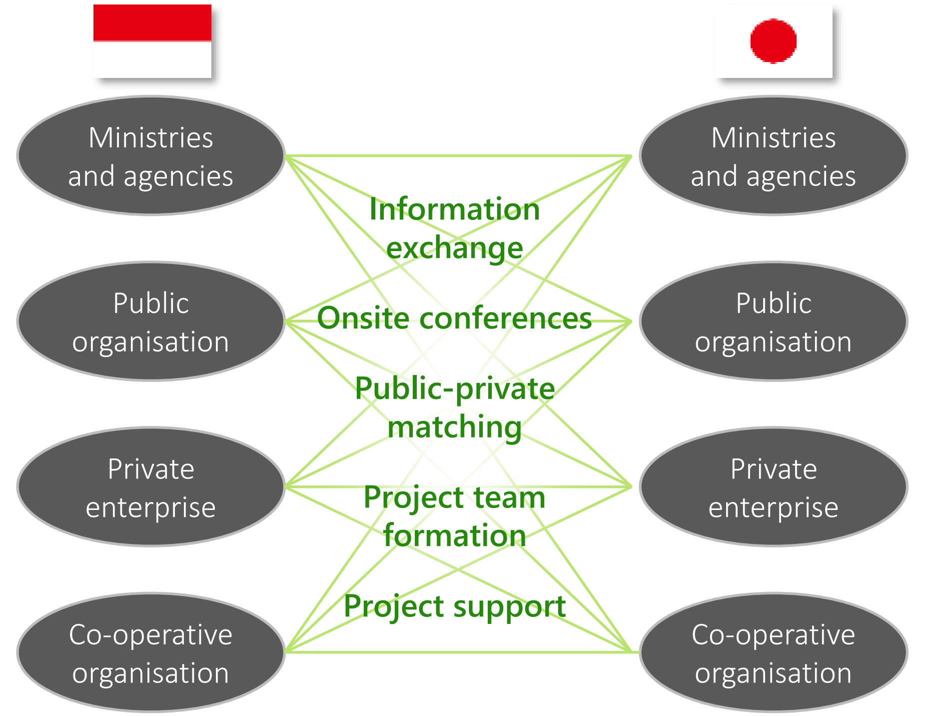
2G Palm oil residues

- ☐ **Technology:** Early establishment of 2G technology
- ☐ **Supply chain:** Study/establish feedstock collection schemes and distribution supply chains
- ☐ **Cost:** Consider other businesses that make effective use of residues to reduce ethanol costs
- ☐ **Policy:** Study of policies such as tax incentives for producers and consumers.
  Consideration of schemes to generate subsidy funding

Let's work together to become the World # 1 producer and exporter of biofuels, which are needed around the world, while steadily solving Indonesia's own challenges first

Proposed activities to solve challenges

Building a system for promoting bilateral cooperation



Ministries and agencies

Public organisation

Private enterprise

Co-operative organisation

Information exchange

Onsite conferences

Public-private matching

Project team formation

Project support

Ministries and agencies

Public organisation

Private enterprise

Co-operative organisation

Many Japanese companies have high hopes and interest in the bioethanol potential of Indonesia

utilization of ISFM

Japan-Brazil summit on 3rd May 2024

The two leaders launched a new international framework, the ISFM, to achieve carbon neutrality together with global partners by combining Brazil's high potential in decarbonized fuels such as biofuels and synthetic fuels with high-performance Japanese mobility equipment such as hybrid engines.

Comprehensive global promotion of Bioethanol x FFV/HEV combinations

Source: https://www.mofa.go.jp/mofaj/la_c/sa/br/pageit_000001_00603.html

Important notice

This document has been prepared by Deloitte Consulting Southeast Asia (as defined below) for the sole purpose of providing a proposal to the parties to whom it is addressed in order that they may evaluate the capabilities of Deloitte Consulting Southeast Asia to supply the proposed services.

The information contained in this document has been compiled by Deloitte Consulting Southeast Asia and includes material which may have been obtained from information provided by various sources and discussions with management but has not been verified or audited. This document also contains confidential material proprietary to Deloitte Consulting Southeast Asia. Except in the general context of evaluating our capabilities, no reliance may be placed for any purposes whatsoever on the contents of this document or on its completeness. No representation or warranty, express or implied, is given and no responsibility or liability is or will be accepted by or on behalf of Deloitte Consulting Southeast Asia or by any of its partners, members, employees, agents or any other person as to the accuracy, completeness or correctness of the information contained in this document or any other oral information made available and any such liability is expressly disclaimed.

This document and its contents are confidential and may not be reproduced, redistributed or passed on, directly or indirectly, to any other person in whole or in part without our prior written consent.

This document is not an offer and is not intended to be contractually binding. Should this proposal be acceptable to you, and following the conclusion of our internal acceptance procedures, we would be pleased to discuss terms and conditions with you prior to our appointment.

In this document, references to Deloitte are references to Deloitte Consulting Southeast Asia which is an affiliate of Deloitte Southeast Asia Ltd, a member firm of Deloitte Touche Tohmatsu Limited.

About Deloitte

Deloitte refers to one or more of Deloitte Touche Tohmatsu Limited, a UK private company limited by guarantee ("DTTL"), its network of member firms, and their related entities. DTTL and each of its member firms are legally separate and independent entities. DTTL (also referred to as "Deloitte Global") does not provide services to clients. Please see www.deloitte.com/about to learn more about our global network of member firms.

Deloitte provides audit, consulting, financial advisory, risk management, tax and related services to public and private clients spanning multiple industries. Deloitte serves four out of five Fortune Global 500® companies through a globally connected network of member firms in more than 150 countries and territories bringing world-class capabilities, insights, and high-quality service to address clients' most complex business challenges. To learn more about how Deloitte's approximately 225,000 professionals make an impact that matters, please connect with us on Facebook, LinkedIn, or Twitter.

About Deloitte Southeast Asia

Deloitte Southeast Asia Ltd – a member firm of Deloitte Touche Tohmatsu Limited comprising Deloitte practices operating in Brunei, Cambodia, Guam, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam – was established to deliver measurable value to the particular demands of increasingly intra-regional and fast growing companies and enterprises.

Comprising 270 partners and over 7,300 professionals in 25 office locations, the subsidiaries and affiliates of Deloitte Southeast Asia Ltd combine their technical expertise and deep industry knowledge to deliver consistent high quality services to companies in the region.

All services are provided through the individual country practices, their subsidiaries and affiliates which are separate and independent legal entities.

Disclaimer

Important notice

This document has been prepared by Deloitte Consulting Southeast Asia (as defined below) for the sole purpose of providing a proposal to the parties to whom it is addressed in order that they may evaluate the capabilities of Deloitte Consulting Southeast Asia to supply the proposed services.

The information contained in this document has been compiled by Deloitte Consulting Southeast Asia and includes material which may have been obtained from information provided by various sources and discussions with management but has not been verified or audited. This document also contains confidential material proprietary to Deloitte Consulting Southeast Asia. Except in the general context of evaluating our capabilities, no reliance may be placed for any purposes whatsoever on the contents of this document or on its completeness. No representation or warranty, express or implied, is given and no responsibility or liability is or will be accepted by or on behalf of Deloitte Consulting Southeast Asia or by any of its partners, members, employees, agents or any other person as to the accuracy, completeness or correctness of the information contained in this document or any other oral information made available and any such liability is expressly disclaimed.

This document and its contents are confidential and may not be reproduced, redistributed or passed on, directly or indirectly, to any other person in whole or in part without our prior written consent.

This document is not an offer and is not intended to be contractually binding. Should this proposal be acceptable to you, and following the conclusion of our internal acceptance procedures, we would be pleased to discuss terms and conditions with you prior to our appointment .

In this document, references to Deloitte are references to Deloitte Consulting Southeast Asia which is an affiliate of Deloitte Southeast Asia Ltd, a member firm of Deloitte Touche Tohmatsu Limited.

About Deloitte

Deloitte refers to one or more of Deloitte Touche Tohmatsu Limited, a UK private company limited by guarantee (“DTTL”), its network of member firms, and their related entities. DTTL and each of its member firms are legally separate and independent entities. DTTL (also referred to as “Deloitte Global”) does not provide services to clients. Please see www.deloitte.com/about for a more detailed description of DTTL and its member firms.

Deloitte provides audit, consulting, financial advisory, risk management, tax and related services to public and private clients spanning multiple industries. With a globally connected network of member firms in more than 150 countries, Deloitte brings world-class capabilities and high-quality service to clients, delivering the insights they need to address their most complex business challenges. Deloitte’s more than 225,000 professionals are committed to making an impact that matters. Deloitte serves 4 out of 5 Fortune Global 500® companies.

About Deloitte Southeast Asia

Deloitte Southeast Asia Ltd – a member firm of Deloitte Touche Tohmatsu Limited comprising Deloitte practices operating in Brunei, Cambodia, Guam, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam – was established to deliver measurable value to the particular demands of increasingly intra-regional and fast growing companies and enterprises. Comprising 270 partners and over 7,300 professionals in 25 office locations, the subsidiaries and affiliates of Deloitte Southeast Asia Ltd combine their technical expertise and deep industry knowledge to deliver consistent high quality services to companies in the region.

All services are provided through the individual country practices, their subsidiaries and affiliates which are separate and independent legal entities.

Disclaimer