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Study on Policy Advocacy for Biofuel in Indonesia

Final report

Deloitte Consulting Southeast Asia

November 2023

Examine the feasibility of introducing and expanding the use of bioethanol and high-level transition scenarios in order to promote efforts towards carbon neutrality in the transport sector in Indonesia

Background & Objectives

- In the transport sector, studies are being conducted on the introduction of Low Carbon Fuel (LCF) and Carbon Neutral Fuel (CNF) in order to achieve the carbon neutral targets, set as policy targets in various countries and as targets for initiatives by individual companies.
- In recent years, the automobile industry has been considering the development and introduction of vehicles adopting new technologies such as EVs and FCEVs, while the use of biofuels such as bioethanol and biodiesel in existing gasoline and diesel vehicles is still being implemented and considered. Gasoline in accordance with E5, E10 of bioethanol and other standards has just been launched, mainly in Europe and the USA.
- In Southeast Asian countries, including Indonesia, full-scale introduction of EVs and studies into the possibility of introducing FCEVs have begun, but it is still early days.
- Little progress has been made in the production, sale and consumption of 1G (edible feedstock) and 2G (inedible feedstock) bioethanol, which are existing technologies, and it is expected that these technologies will be leveraged as soon as possible.
- Based on the above, the following items are to be examined in Indonesia, where significant social, economic and environmental impacts are expected.
  - To study the possibility of introducing and expanding the use of 1G and 2G bioethanol in Indonesia
  - To study the initial feasibility of biofuel interchange within the ASEAN region
  - High-level study on issues, transition scenarios and effects of biofuel conversion from gasoline in Indonesia

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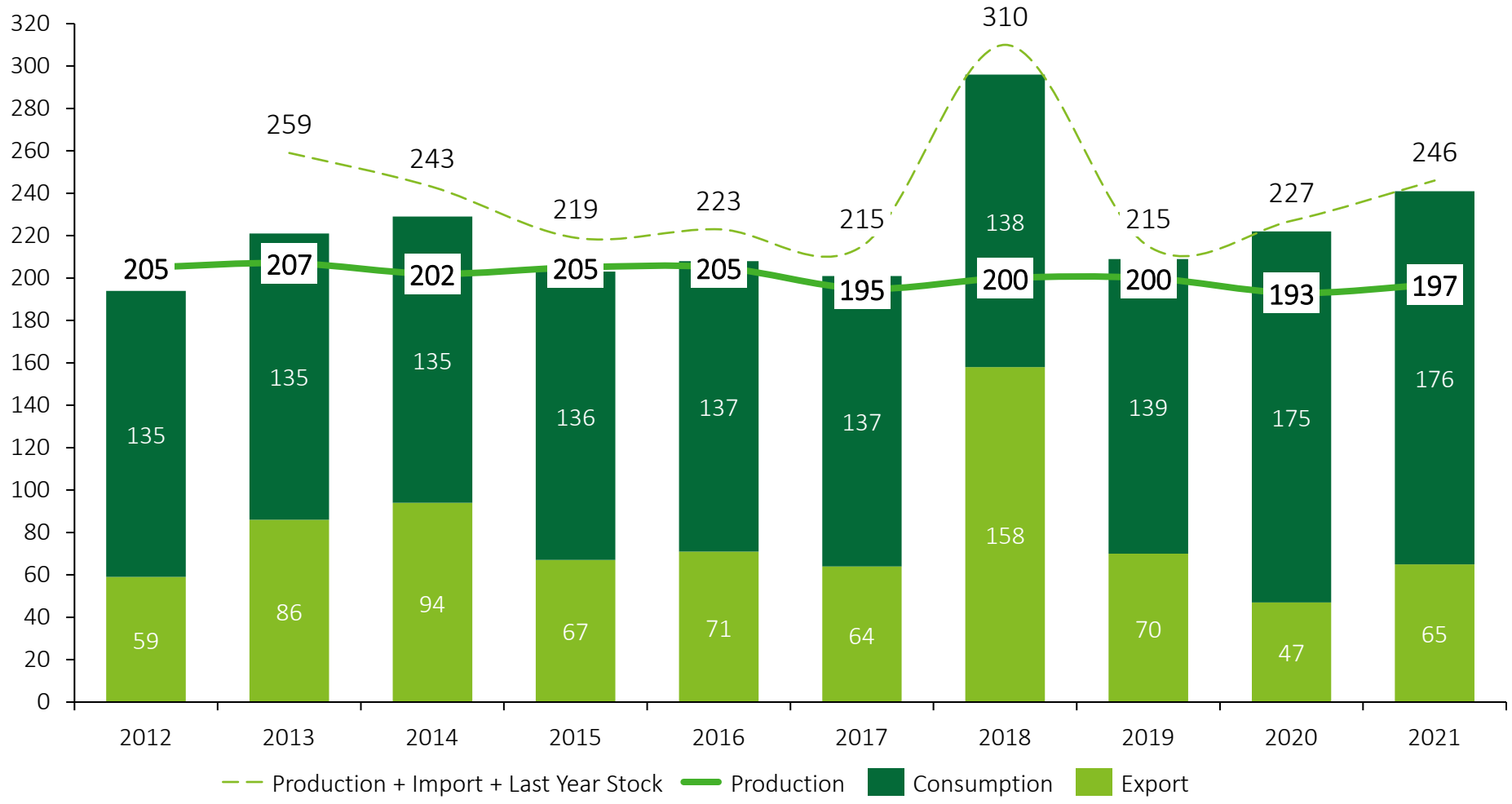
1. Status of Bioethanol in Indonesia

Bioethanol production in Indonesia tends to be constant at ~200 mil liters. In certain years, the increases in export and consumption cause an import of bioethanol

Bioethanol Production Historical Data (mil litre)



Source: US Department of Agriculture (USDA)

Among the contributing factors of unsuccessful attempt of bioethanol introduction in E2 program is related to limited feedstock & high cost of production

Challenges & Potential Solution related to E2 Program in 2006-2009

Key Challenges

- The obstacle faced for the development of bio-ethanol in Indonesia is **limited raw materials**. Between 2006-2009, the raw material used is molasses which is a by-product of the sugar factory.
- Another obstacle for the development of bio-ethanol in Indonesia is land issue. **Investors have difficulties in obtaining agricultural land (extensification) required to plant raw materials**, even though unproductive land is often found in various provinces.
- Other obstacles that are also faced are the **lack of clarity regarding incentives for ethanol plant investors**, notwithstanding the certainty that the use of bio-fuel is mandatory (which is not burdensome), and the **unclear bio-fuel trading system.**
- **The average cost of ethanol production in Indonesia is still higher than in Brazil and Thailand**. This is due to dependence on imported technology, so that factory investment becomes higher. The amount of investment costs depends on the type of raw material, capacity, technology, and waste treatment installation.
- Another challenge is the **lack of research and development of the alternative raw materials** needed to produce bioethanol outside of sugarcane

Potential Solutions

- It is necessary to **encourage the development of the ethanol industry from raw materials other than molasses**, such as cassava, sorghum and sago. Cassava is a prospective raw material for ethanol, but there is a 2F (Food or Fuel) dilemma because cassava is a food ingredient

Production (thousand tons)	2005	2006	2007	2008	2009
Sugarcane	28,300	32,656	34,289	36,003	37,804
Sugar	2,219	2,441	2,686	2,955	3,250
Molasses	1,400	1,470	1,550	1,620	1,700

Source: International Journal, Various News Articles

The government, in cooperation with local university, has developed bioethanol roadmap as guidelines to enhance bioethanol production in Indonesia

Strategic Roadmap to Accelerate the Implementation of Bioethanol in Indonesia

Roadmap Development	▪ The Ministry of Energy and Mineral Resources (ESDM), together with the Bandung Institute of Technology (ITB) research team, supported by the US Grains Council (USGC) have succeeded in compiling a **Strategic Roadmap to Accelerate Bioethanol Implementation in Indonesia.** ▪ The ITB Roadmap prepares the implementation of bioethanol with short term (3 years), medium (5 years), and long-term targets. The short-term target of the roadmap begins with the **limited introduction of 5% ethanol or E5 mixtures in the provinces of DKI Jakarta and Surabaya.** ▪ In the medium term, the government can increase the bioethanol blending to **E10 and expand the bioethanol program to the Java region**, which is the region with the highest fuel consumption. With gradual implementation, it is hoped that Indonesia will be able to implement a **bioethanol blend of E-15 in all regions by 2031.**
Bioethanol Production	▪ The government believes that the amount of national bioethanol production will continue to increase from **40,000 kiloLitres (kl) in 2022 to 1.2 million kl in 2030**. The latest production is **still not sufficient** to fulfill the demand, which estimates around **696,000 kilo Litres/year in East Java & Jakarta.**
Biofuel Potential	▪ ITB research results show that Indonesia has **saved foreign exchange of US $ 2.6 billion** by substituting imported diesel through the palm oil biodiesel program. ▪ Another benefit of bioethanol is the potential for **reducing greenhouse gas emissions by up to 43%** ▪ ITB research shows that sugar-based bioethanol production can **create 83,000 jobs** both on plantations and ethanol production facilities
Key Challenges	▪ There are still challenges in implementing it as a gasoline blend, especially the **low production of bioethanol in Indonesia.** ▪ ITB report also suggests **policy adjustments to introduce the implementation of bioethanol** in Indonesia, especially the establishment of a **price, tax and subsidy policy** that is right on target, for limited implementation in East Java & Jakarta ▪ Various other challenges, especially in the aspects of capital/investment, legal, technology development, and limited markets.

Source: Ministry of Energy and Mineral Resources, various news article

Presidential regulations issued in June 2023 is as follows

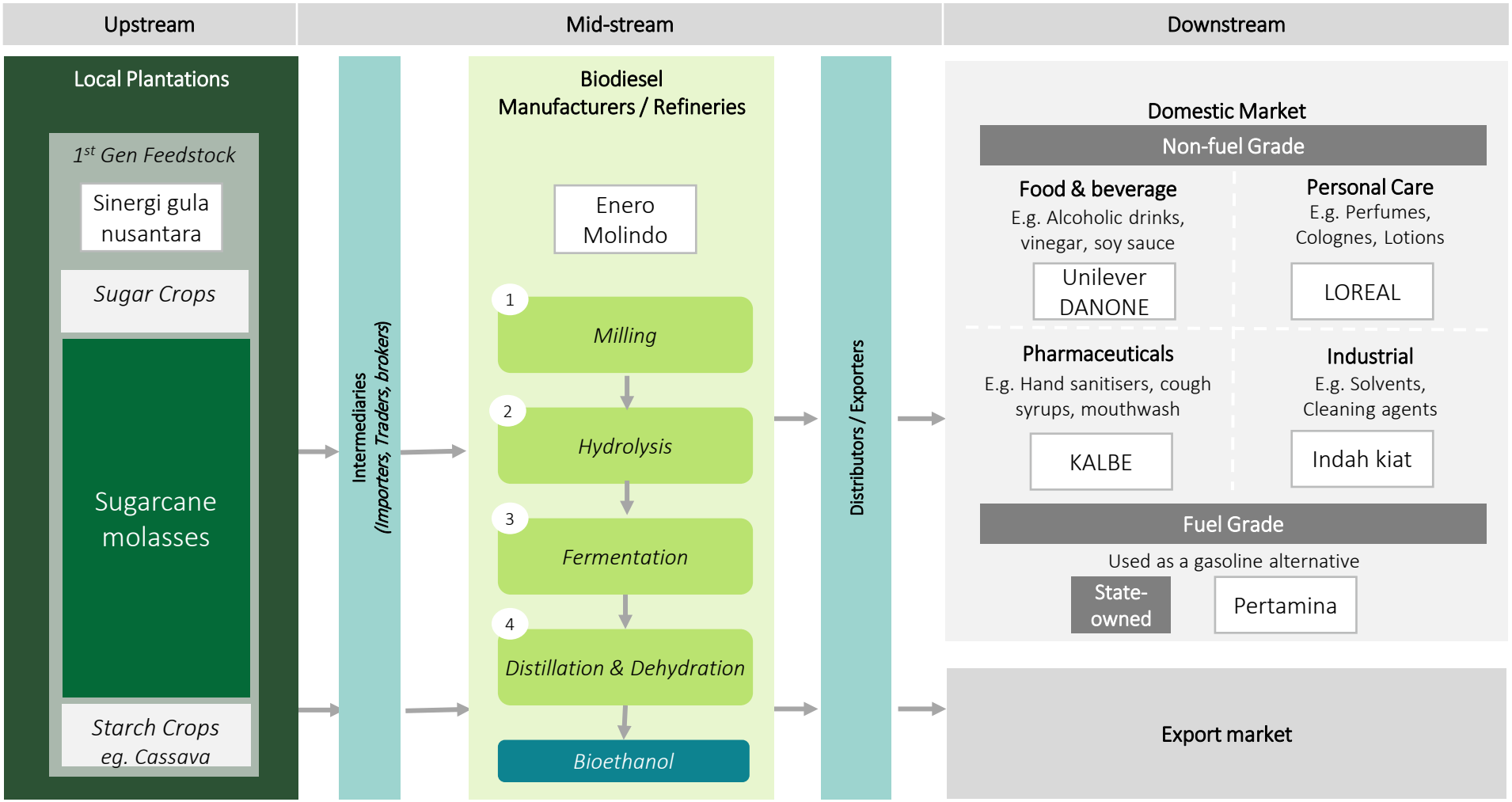
What has been improved comparing with the past action

Use of molasses from sugarcane only	▪ According to latest articles, some of development of **bioethanol still solely relies on** sugarcane as the only main source ▪ The government has been working closely with the 2 producers of bioethanol from sugarcane in Indonesia, which are **PT Molindo Raya Industrial & PT Energi Argo Nusantara (Enero) to improve the production capability** of both companies to be at least 1.2 million kiloLitres (KL) by 2023
Land shortage	▪ Second, the addition of a new area for **sugar cane plantations of 700 thousand hectares** originating from plantation land, people's sugarcane land, and forest area land.
Lack of incentives	▪ President Joko Widodo (Jokowi) issued Presidential Regulation (Perpres) Number 40 of 2023 concerning **Acceleration of National Sugar Self-sufficiency and Provision of Bioethanol as Biofuel**, which was introduced on **16th June 2023**. The policy consider the following: 1) First, an increase in **sugarcane productivity is targeted at 93 tons per hectare** through improved agricultural practices in the form of seeding, planting, plant maintenance, and cutting and loading. 2) Second, the addition of a new area for **sugar cane plantations of** 700 thousand hectares originating from plantation land, people's sugarcane land, and forest area land. 3) Third, increasing the **efficiency, utilization and capacity of the sugar factory to achieve a yield of 11.2 percent**. 4) Fourth, increasing the welfare of farmers. 5) Fifth, namely an increase in **bioethanol production from sugarcane bioethanol plants of at least** 1.2 million kiloLitres (KL). ▪ It is targeted to **achieve self-sufficiency in sugar for consumption no later than 2028**. As for **self-sufficiency in sugar for industrial needs no later than 2030**, so will an increase in bioethanol production be realized no later than the same year.
High capital for technology adoption	▪ Government through **National Research and Innovation Agency (BRIN) start to research and develop bioethanol and hydrogen** as environmentally friendly alternative fuels. ▪ **In 2022 together with KOICA (Korea International Cooperation Agency) and KIST (Korea Institute of Science and Technology),** the BRIN generation 2 (G2) bioethanol production Pilot Plant has been developed and able to produce bioethanol with a purity exceeding 99.6 percent (fuel grade)

Source: Presidential Decree No. 40/2023, BRIN articles, various articles

Indonesia uses sugarcane molasses as the main feedstock for bioethanol production. In comparison to biodiesel, bioethanol is still in the early stages of development

Bioethanol Value Chain

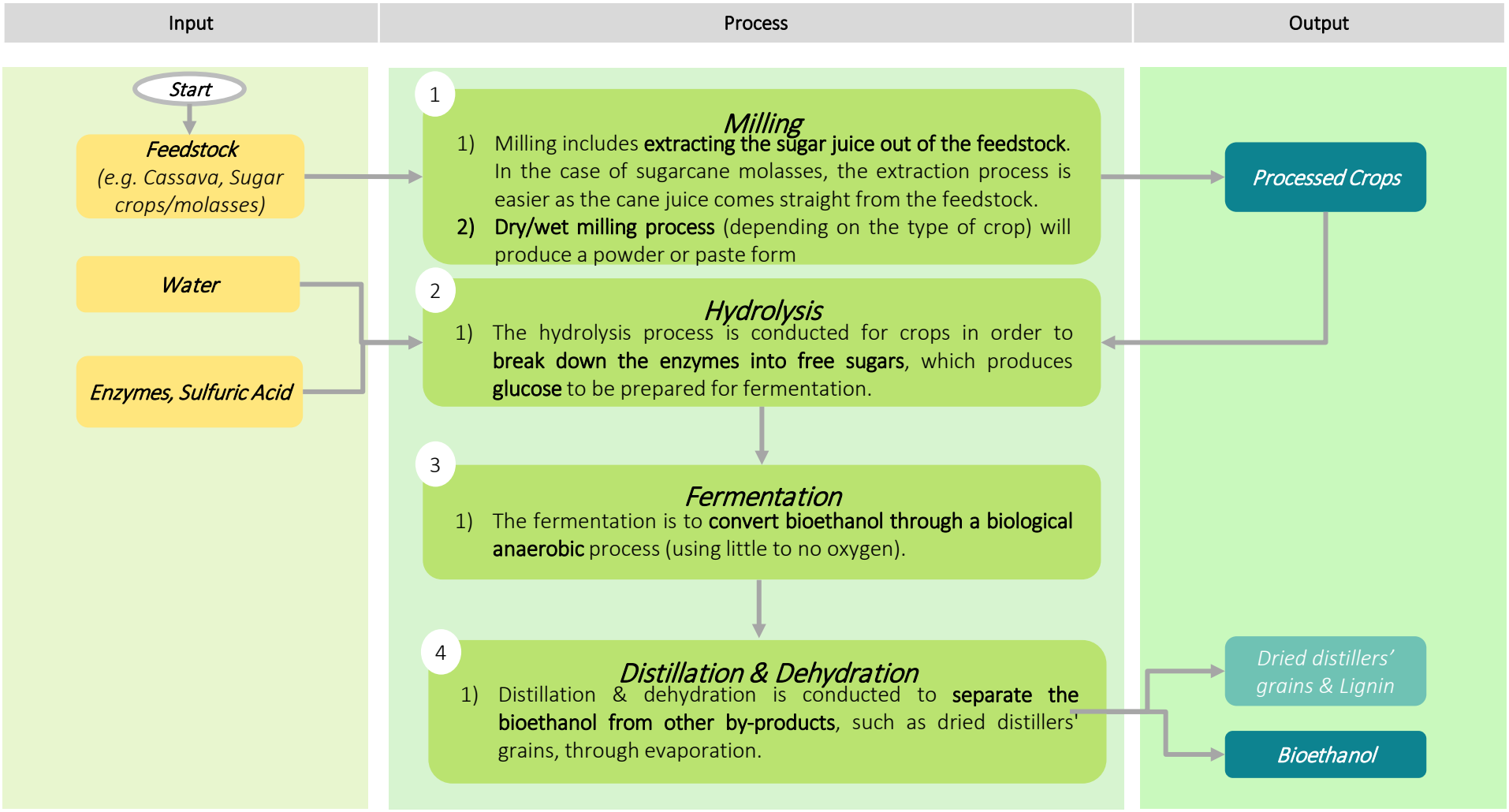


Source: The International Council of Clean Transportation, USDA, AIMS Energy, Reuters, Chain Reaction Research, International Renewable Energy Agency

In order to produce bioethanol, feedstock will be processed through 4 stage, which are milling, hydrolysis, fermentation and distillation & dehydration

Bioethanol Flow Process

Note: Process | Input | Output | By-product



Source: The International Council of Clean Transportation, USDA, AIMS Energy, Reuters, Chain Reaction Research, International Renewable Energy Agency

2. Bioethanol potential

①. Demand forecast

The use of bioethanol should be considered as a decarbonization measure in ICE/ Hybrid, as it is expected to take time to spread the use of high-priced EVs and replace existing registered vehicles

Demand status summary (Registered vehicle forecast)

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: Moderate

When EV/HV penetration is being planned but is not progressing as fast as expected

Percentage of new EV vehicles sold

	2030	2040	2050	2060
4W	10%	25%	50%	75%
2W	25%	50%	75%	100%

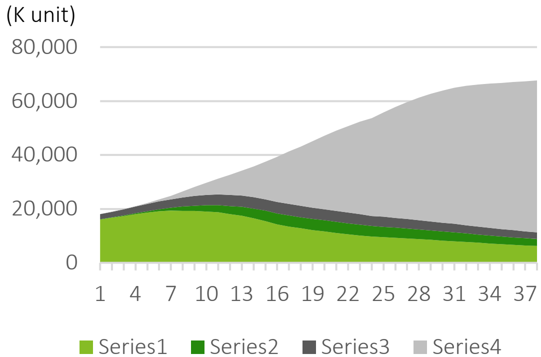
Scenario3: HV penetration instead of EV

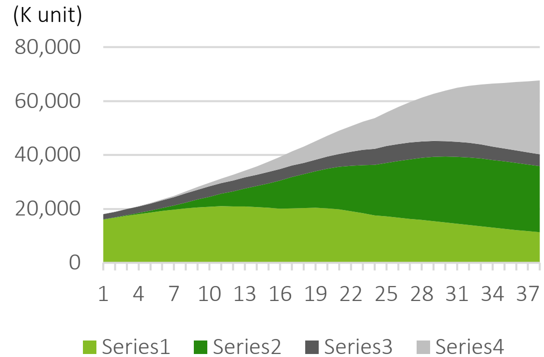
If the government changes direction to HVs and HVs penetrate the market first

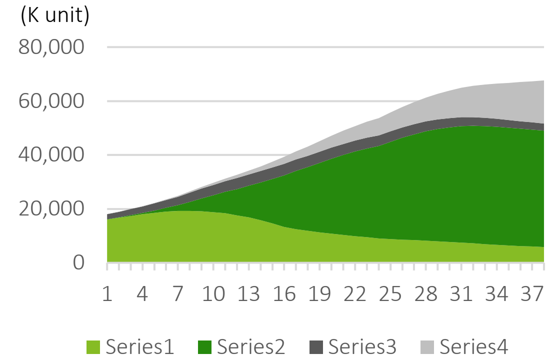
Percentage of new EV vehicles sold

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

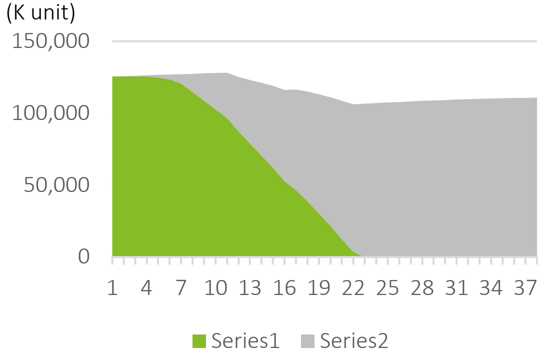
4W

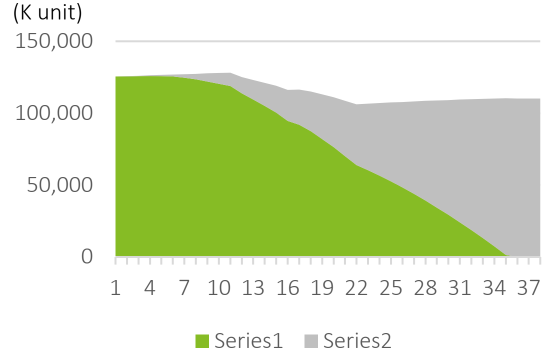


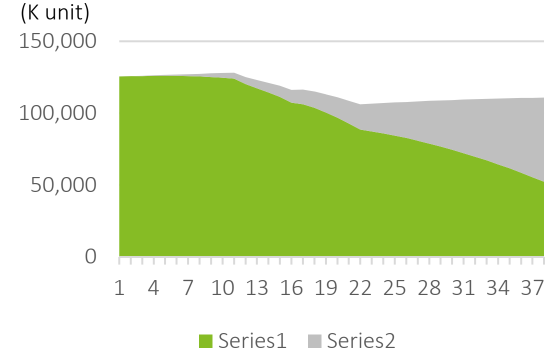




2W







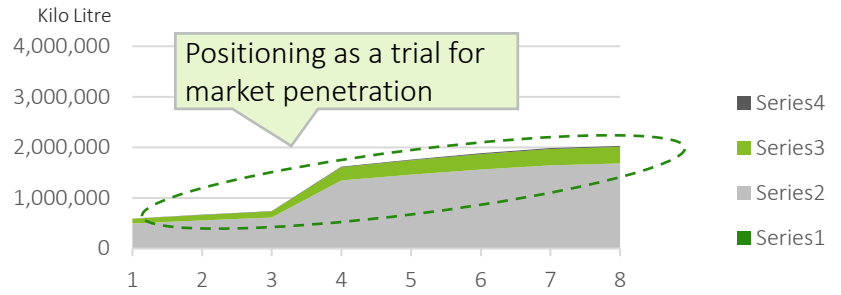
In the short term ~2030, the government and Pertamina have set out a roadmap for the introduction of bioethanol, and short-term demand will be calculated in accordance with this direction

Perspectives on short term demand (~2030)

Short-term (~2030) direction (Presidential Regulation 40/2023)

- Blending ratio : 5% (E5) → 10% (E10)
- Region : Provinces of DKI Jakarta and Surabaya → Java
- Octane rating : RON95 → RON92

Short term Bioethanol demand prediction

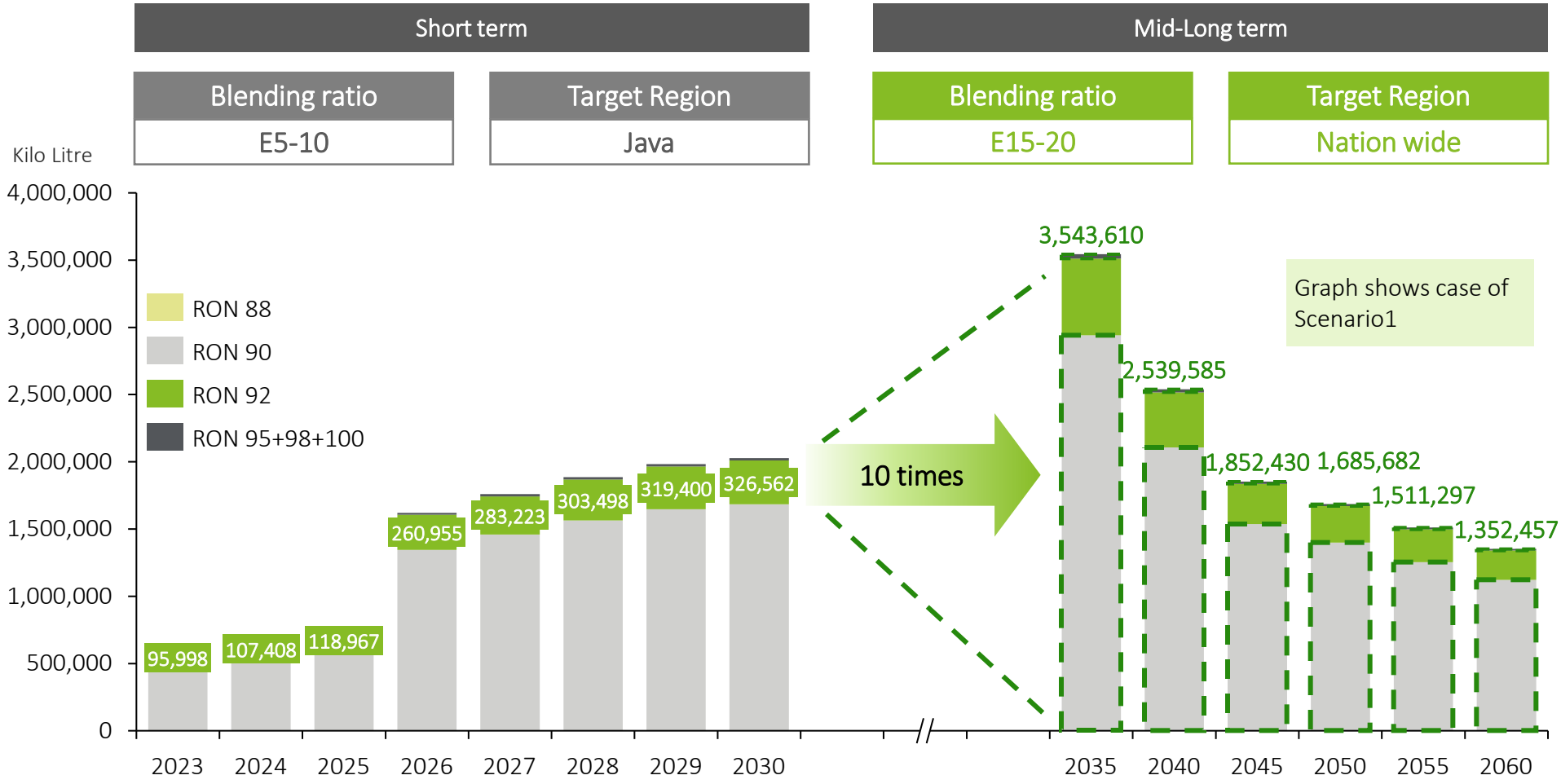


			2023	2024	2025	2026	2027	2028	2029	2030
Registered vehicles (K unit)	Gasoline		16,077	16,731	17,390	18,030	18,614	19,082	19,323	19,295
	Hybrid		58	137	241	379	563	809	1,134	1,565
	2W		125,542	125,817	126,093	126,367	126,638	126,906	127,168	127,425
E10 adapted Vehicles (K unit)	Gasoline		11,623	12,842	14,094	15,355	16,588	17,733	18,679	19,246
	Hybrid		58	137	241	379	563	809	1,134	1,565
	2W		44,421	50,205	55,924	61,474	66,656	71,083	74,012	74,012
Government Direction	Blending ratio		5%			10%				
	Region		DKI Jakarta and Surabaya			Java (60% of entire domestic market)				
										Kilo Litre
Maximum bioethanol demand			596,259	667,129	738,924	1,620,837	1,759,146	1,885,079	1,983,850	2,028,337
Break-down by RON	RON 92	16%*	95,998	107,408	118,967	260,955	283,223	303,498	319,400	326,562
	Others	84%*	500,261	559,721	619,957	1,359,882	1,475,923	1,581,581	1,664,450	1,701,775

After 2031, the blending ratio, target regions and octane rating are expected to be expanded to cover all gasoline-using vehicles in Indonesia

Perspectives on Mid-Long term demand (2031~)

Bioethanol needs to be applied to all gasoline-using vehicles in the mid-long term to accelerate decarbonization in Indonesia



It is assumed that there will be a demand for bioethanol of 2.2 Bil Litre in 2030 and 8.9 Bil Litre in 2050 in the maximum case scenario

Demand calculation result

Mil Litre

			2030	2040	2050	2060
Demand	Scenario1 Gov. EV target	4w*	**1,085**	**1,716**	**1,686**	**1,352**
		2w**	**944**	**824**	**-**	**-**
		Total	2,029	2,540	1,686	1,352
	Scenario2 Moderate	4w*	**1,151**	**3,434**	**5,417**	**5,170**
		2w **	**1,056**	**2,329**	**1,666**	**-**
		Total	2,207	5,763	7,083	5,170
	Scenario3 Stagnation of EV market expansion	4w*	**1,140**	**3,193**	**5,582**	**5,650**
		2w **	**1,082**	**2,837**	**3,352**	**2,224**
		Total	2,222	6,030	8,934	7,874

Pre-condition

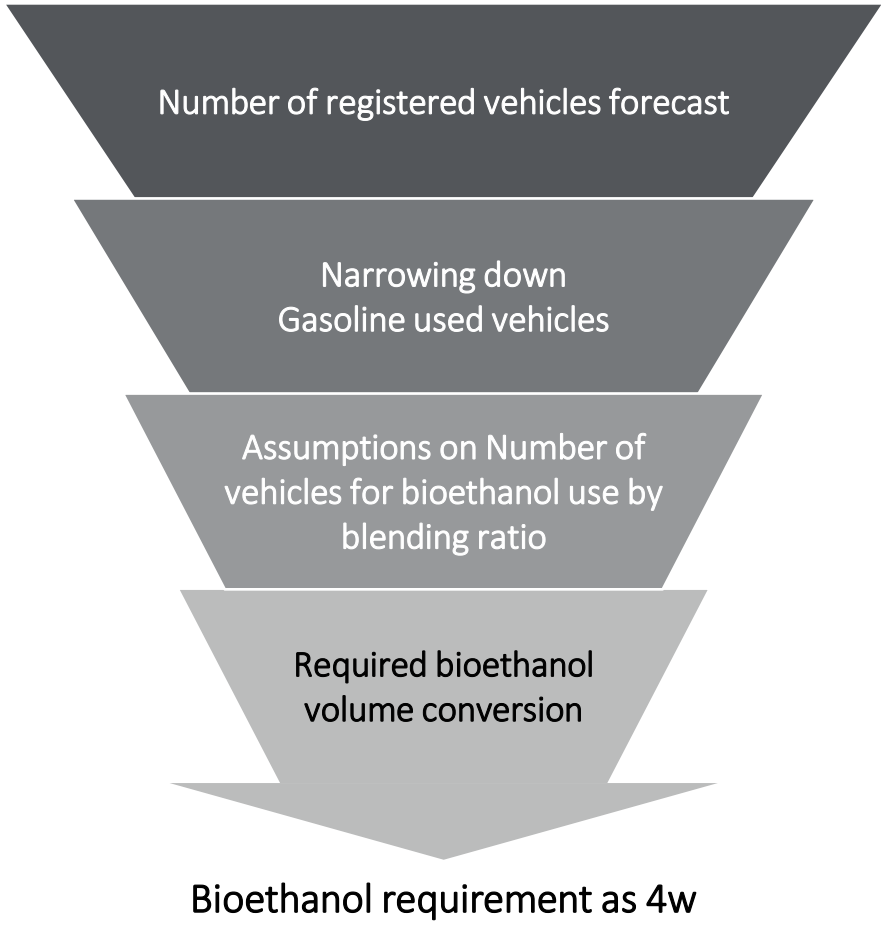
- The price difference between gasoline and bioethanol has not been taken into account in this calculation
- The Government's policy on the introduction of Bioethanol is not taken into account

*: General passenger vehicles and pick-up truck

**: only 2 wheeler motorcycle

First, calculate the total demand for passenger cars, then consider the fuel types that can use bioethanol and the applicable blending ratio to calculate the number of target cars. Then convert the amount of bioethanol to

4W: Calculation step summary



Step1	Calculate future vehicle registrations by taking into consideration of population growth and economic growth
Step2	Predicts the proportion of each fuel type and narrows down the number of vehicles using gasoline
Step3	Predict the applicable blending ratio, as different vehicle types have different applicable blending ratios
Step4	Calculate bioethanol requirements based on the number of vehicles for each blending ratio, average cruising range and fuel consumption information

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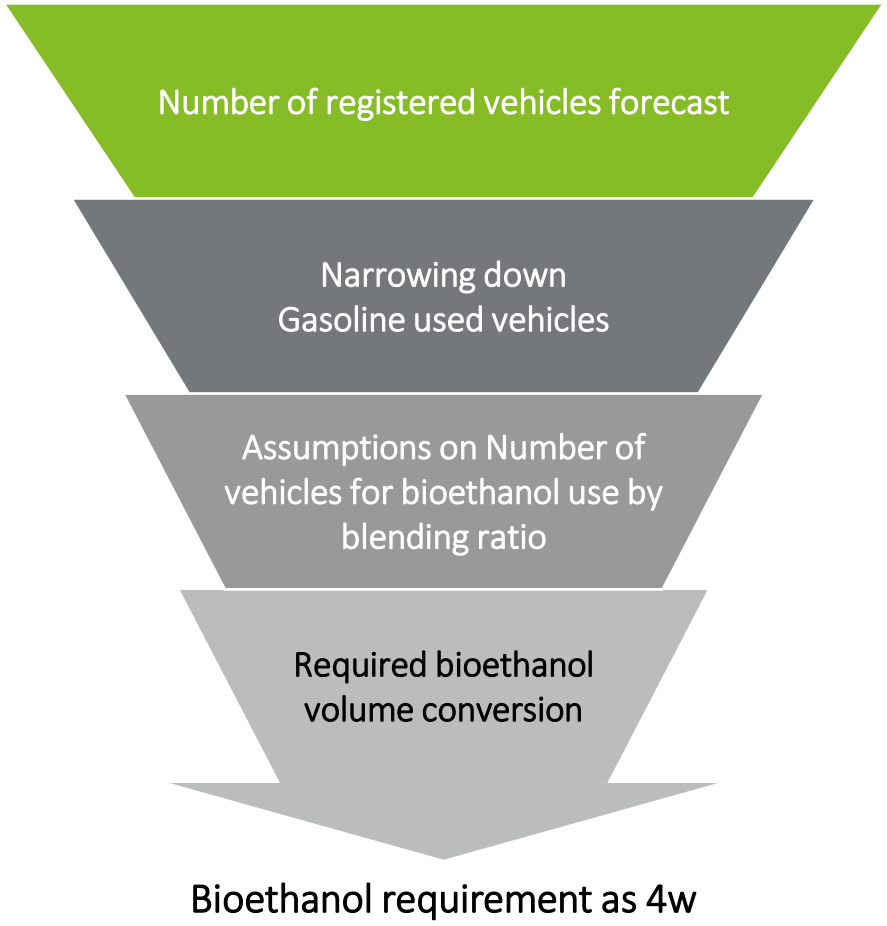

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The forecasted number of passenger vehicle registrations up to 2060, calculated on the basis of the aforementioned calculation steps, is as follows

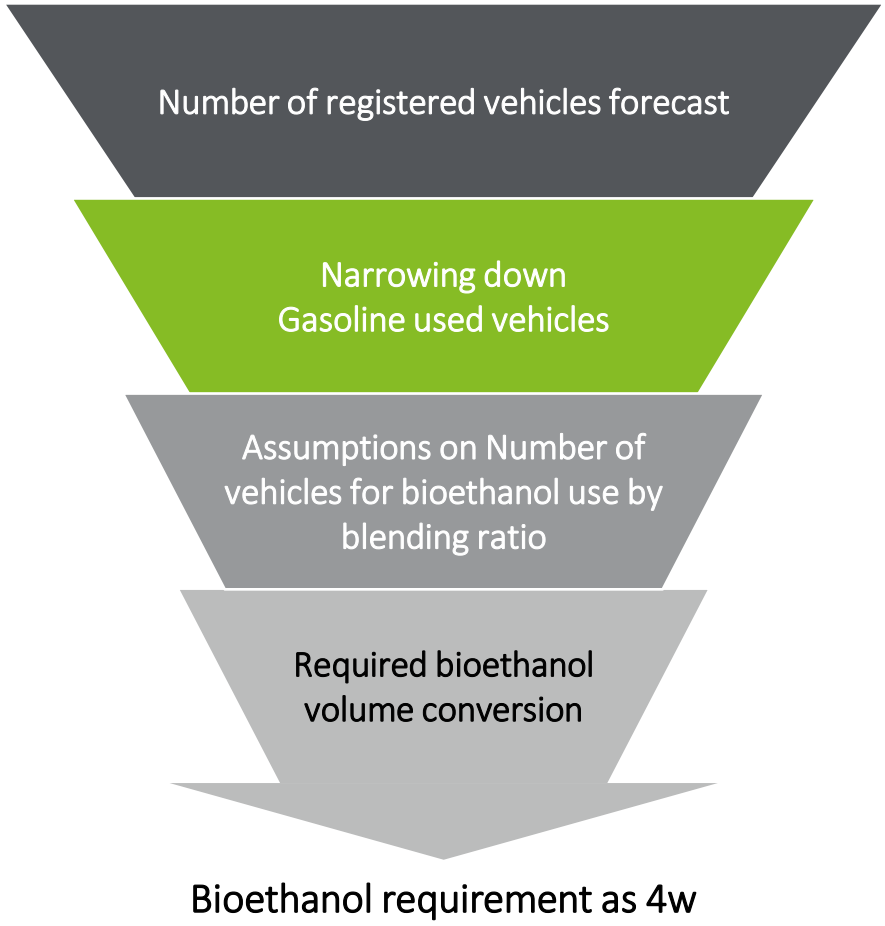
Registered passenger vehicle volume forecast

K units

		2022	2030	2040	2050	2060	Number of vehicles owned per capita
Population		275,501	292,150	308,165	317,225	321,494	
	Population/HH	3.78	3.59	3.46	3.37	3.27	
Households total		72,980	81,320	88,977	94,216	98,275	
Households (US$10,000)		24,890	41,350	75,364	92,332	96,309	
	Ratio	34.11%	50.85%	84.68%	98.00%	98.00%	
Sales Qty		948	2,267	4,132	5,062	5,280	
	vs HH (US$10,000)	3.81%	5.48%	5.48%	5.48%	5.48%	
Number of Registered vehicles		17,176	26,464	43,087	61,241	67,642	0.21

First, calculate the total demand for passenger cars, then consider the fuel types that can use bioethanol and the applicable blending ratio to calculate the number of target cars. Then convert the amount of bioethanol to

4W: Calculation step summary



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

Percentage of sales by fuel EV Max (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

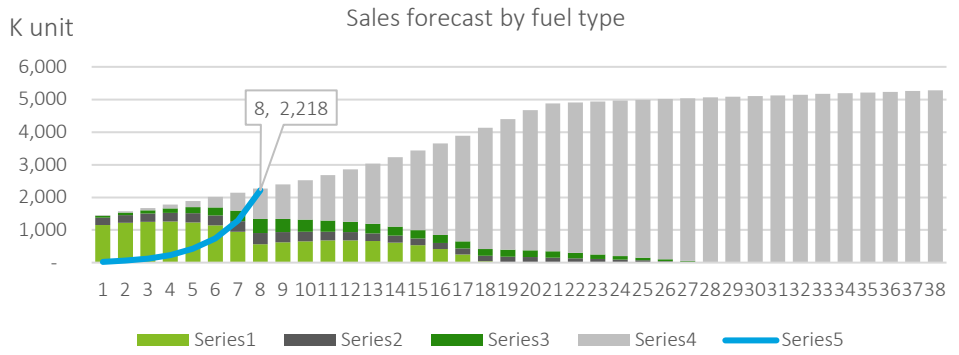
- Assumption that the shift to EVs will continue in line with government targets
- To achieve 2.2mil registrations by 2030, 50% of new car sales must be reached by 2030
- Assumes 100% of new car sales after 2050 as per government target

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



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

Percentage of sales by fuel Moderate

Check past sales performance

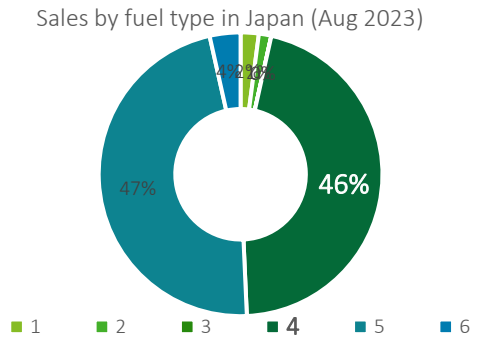
- Percentage of units sold by each fuel in the past based on GAIKINDO sales data

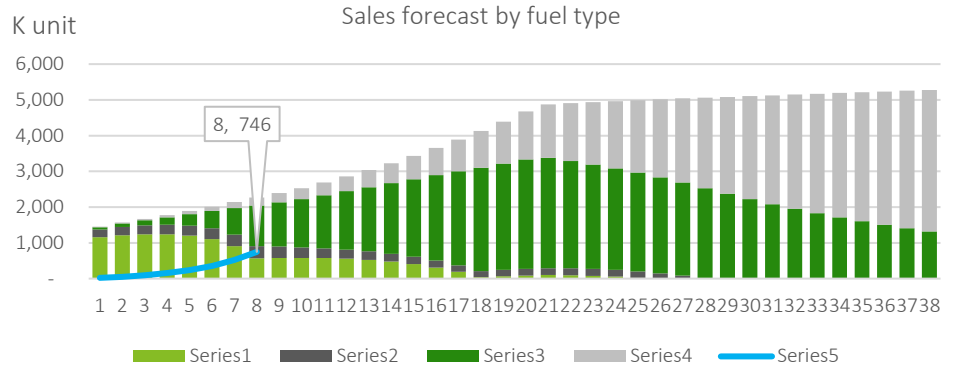
FUEL	2015	2016	2017	2018	2019	2020	2021	2022	2023 (~Jul)
Diesel	8.8%	9.4%	12.1%	12.5%	13.1%	15.4%	14.9%	14.2%	11.7%
EV	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	1.1%	1.3%
Gasoline	91.2%	90.6%	87.9%	87.5%	86.9%	84.3%	84.8%	84.2%	82.7%
HYBRID	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.3%	0.5%	4.2%

Estimated sales ratio by fuel

- Assuming that the shift to EVs does not proceed due to price differences and infrastructure issues
- Hybrid vehicles are assumed to lead the market during the transitional period, as in Japan, within the same xEV group
- After 2050, EV shift will be expected but gradually

Fuel type	2022	2030	2040	2050	2060
Diesel	14.2%	15.0	4.0%	-	-
Gasoline	84.8%	25.0%	1.0%	-	-
Hybrid	0.5%	50.0%	70.0%	50.0%	25.0%
EV	0.1%	10.0%	25.0%	50.0%	75.0%





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

Percentage of sales by fuel EV Min (Stagnation of EV market expansion)

Check past sales performance

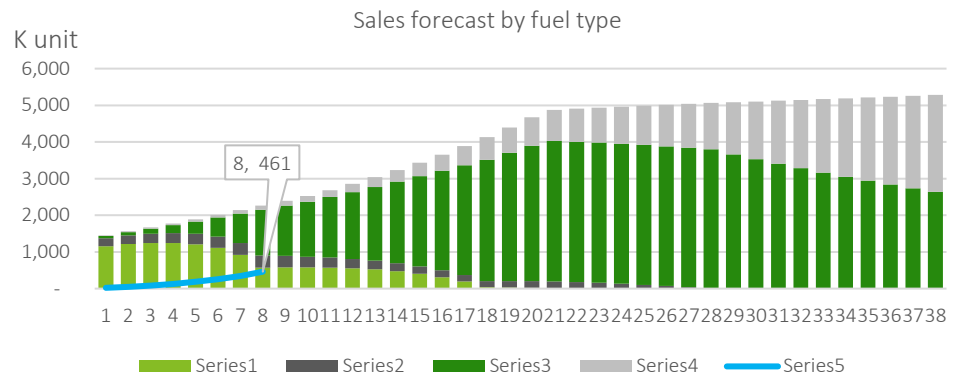
- Percentage of units sold by each fuel in the past based on GAIKINDO sales data

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

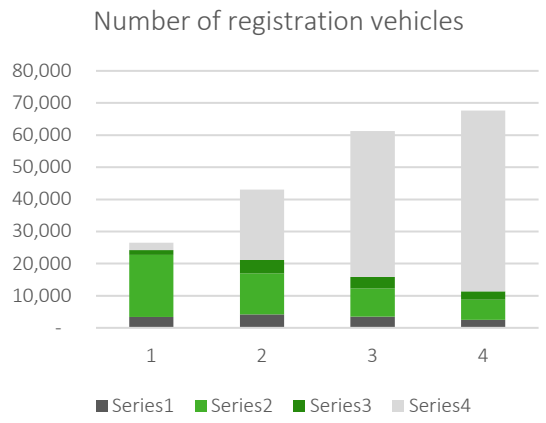
Fuel type	2022	2030	2040	2050	2060
Diesel	14.2%	15.0	4.0%	-	-
Gasoline	84.8%	25.0%	1.0%	-	-
Hybrid	0.5%	55.0%	80.0%	75.0%	50.0%
EV	0.1%	5.0%	15.0%	25.0%	50.0%

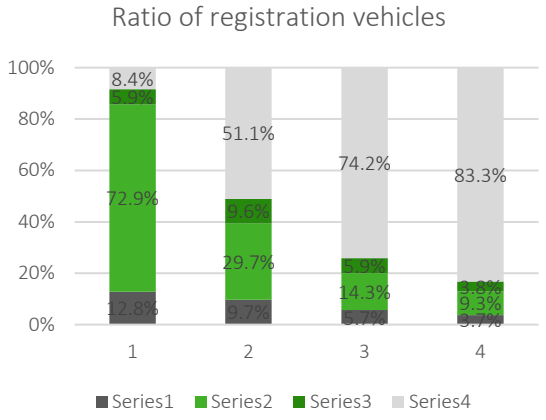


In both scenarios, a certain proportion of gasoline and hybrid vehicles can be assumed, but further consideration of applicable blending ratios is required

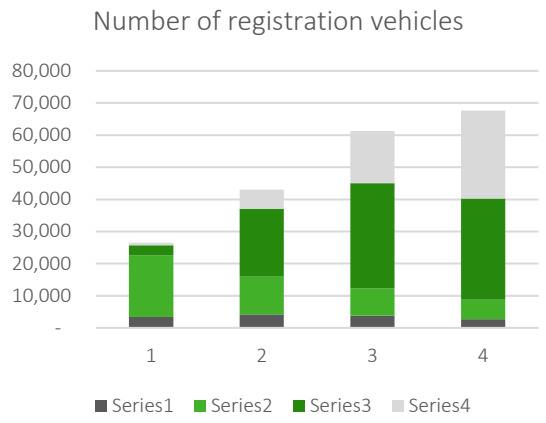
Registered vehicle volume forecast by fuel

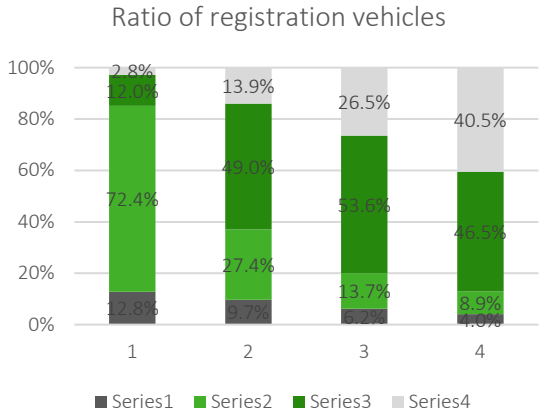
Government EV target



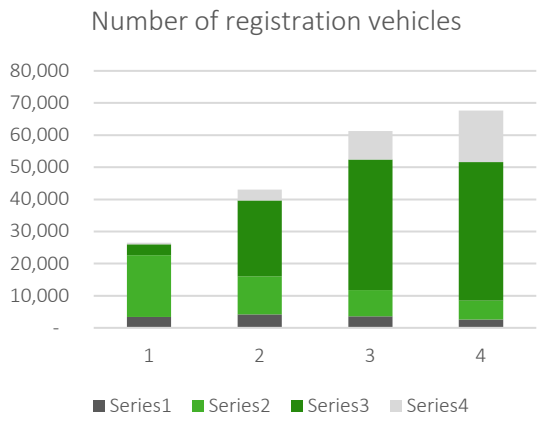


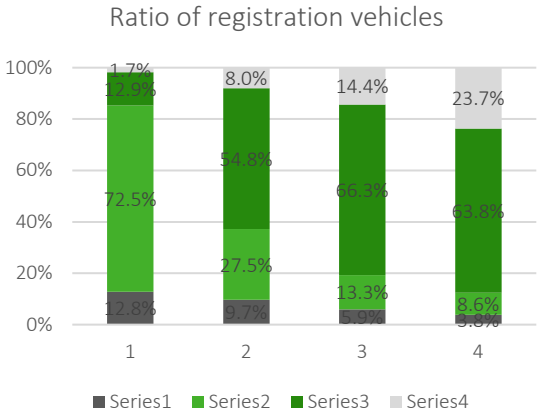
Moderate





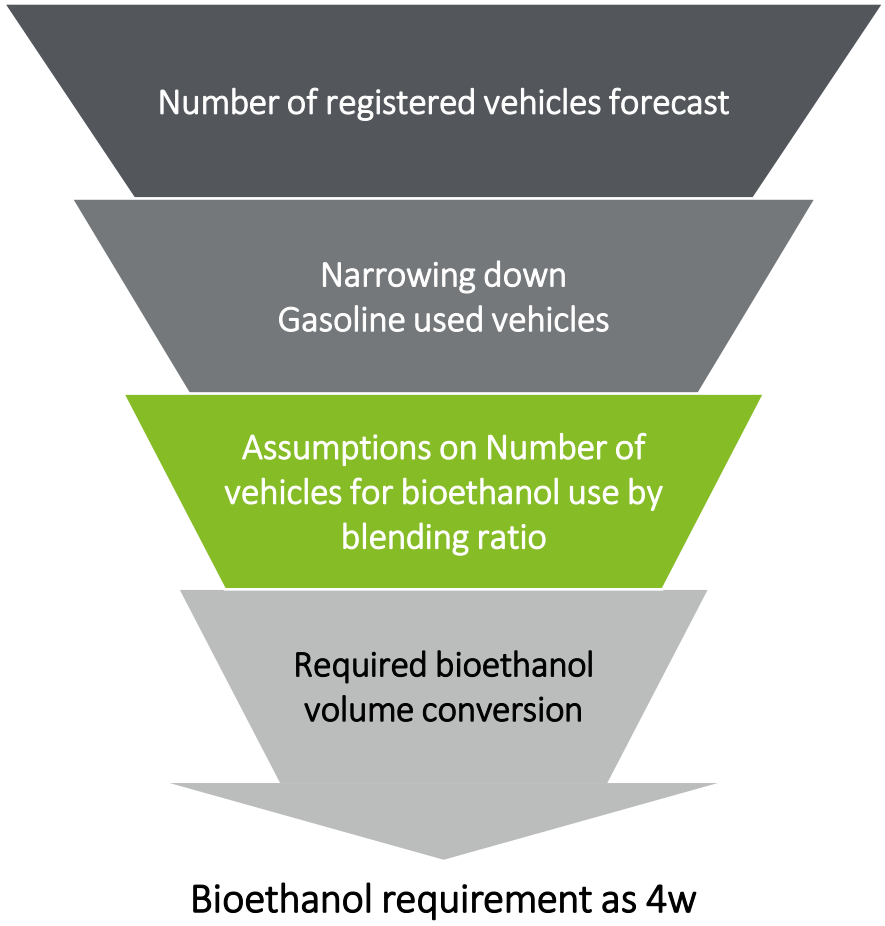
Stagnation of EV market expansion





First, calculate the total demand for passenger cars, then consider the fuel types that can use bioethanol and the applicable blending ratio to calculate the number of target cars. Then convert the amount of bioethanol to

4W: Calculation step summary



Step1	Calculate future vehicle registrations by taking into consideration of population growth and economic growth
Step2	Predicts the proportion of each fuel type and narrows down the number of vehicles using gasoline
Step3	Predict the applicable blending ratio, as different vehicle types have different applicable blending ratios
Step4	Calculate bioethanol requirements based on the number of vehicles for each blending ratio, average cruising range and fuel consumption information

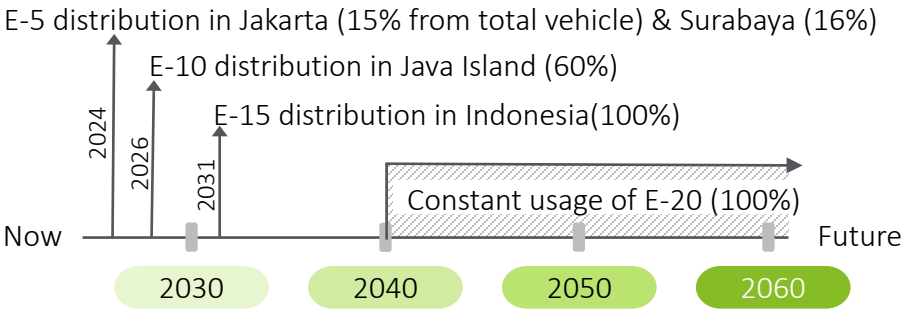
Estimated number of units sold by applicable mixing ratio based on historical sales estimates and government response policy

Percentage of sales by blending ratio

Percentage of sales by blending ratio estimation

Gasoline/Hybrid vehicles

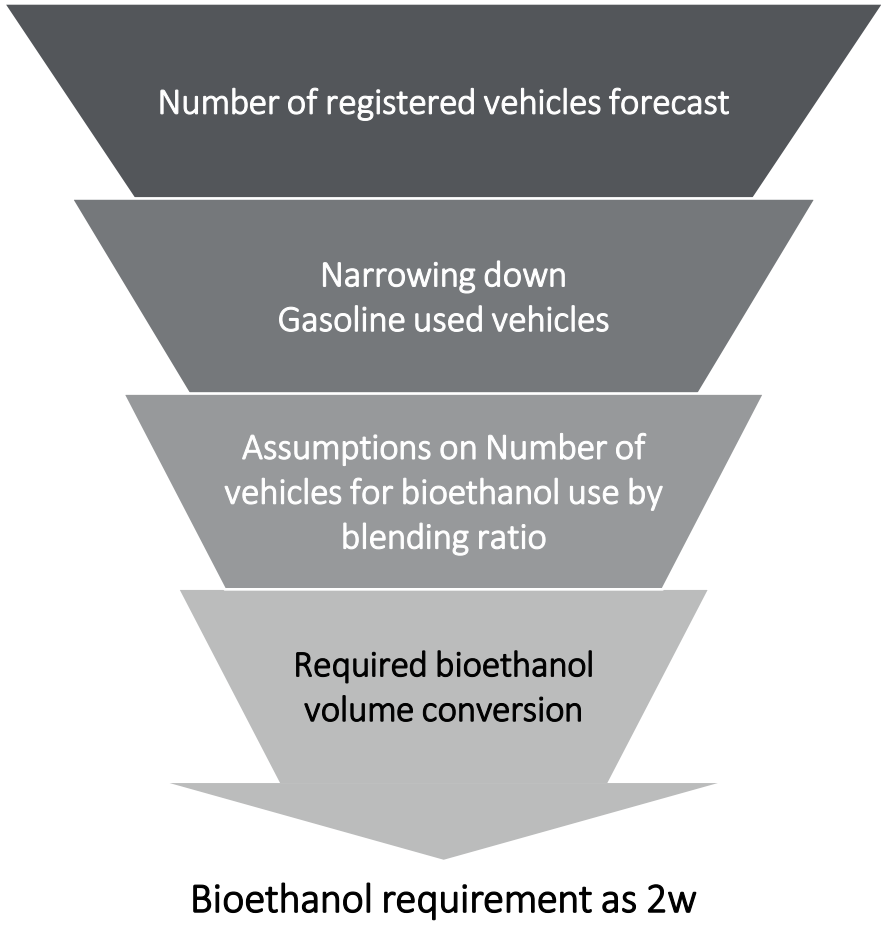
- Assumption that the sales ratio by blending ratio will remain at the same E10 level as the current sales actual until 2029 (taking into account the development period of applicable vehicles)
- After 2030, it is assumed that E20 will apply to all new vehicles sold



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

First, calculate the total demand for 2W. For 2W, all Gasoline vehicles are assumed to be applicable at basically any blending ratio. Convert the amount of bioethanol to

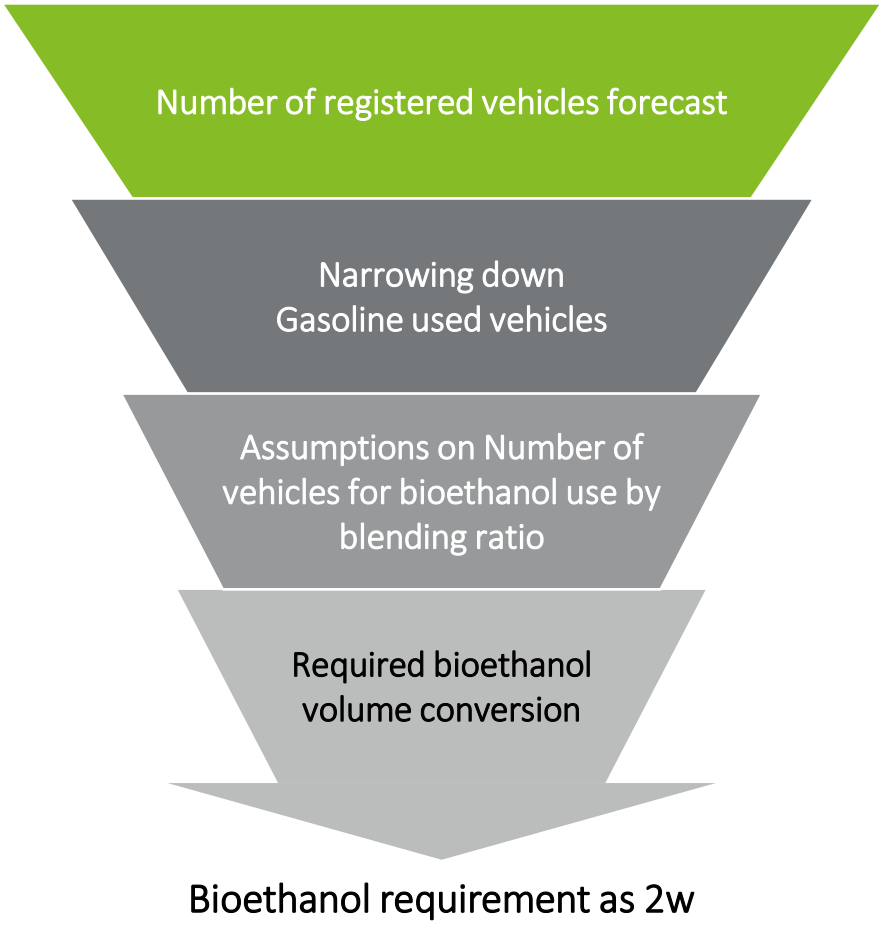
2W: Calculation step summary



Step1	Calculate future vehicle registrations by taking into account population growth and economic growth
Step2	Assume only Gasoline and EV vehicles Then predict how fast EVs will penetrate the market
Step3	2w assumed to be applicable at basically any blending ratio
Step4	Calculate bioethanol requirements based on the number of vehicles, average cruising range and fuel consumption information

First, calculate the total demand for 2W. For 2W, all Gasoline vehicles are assumed to be applicable at basically any blending ratio. Convert the amount of bioethanol to

2W: Calculation step summary



Step1	Calculate future vehicle registrations by taking into account population growth and economic growth
Step2	Assume only Gasoline and EV vehicles Then predict how fast EVs will penetrate the market
Step3	2w assumed to be applicable at basically any blending ratio
Step4	Calculate bioethanol requirements based on the number of vehicles, average cruising range and fuel consumption information

The forecasted number of registrations up to 2060, calculated on the basis of the aforementioned calculation steps, is as follows

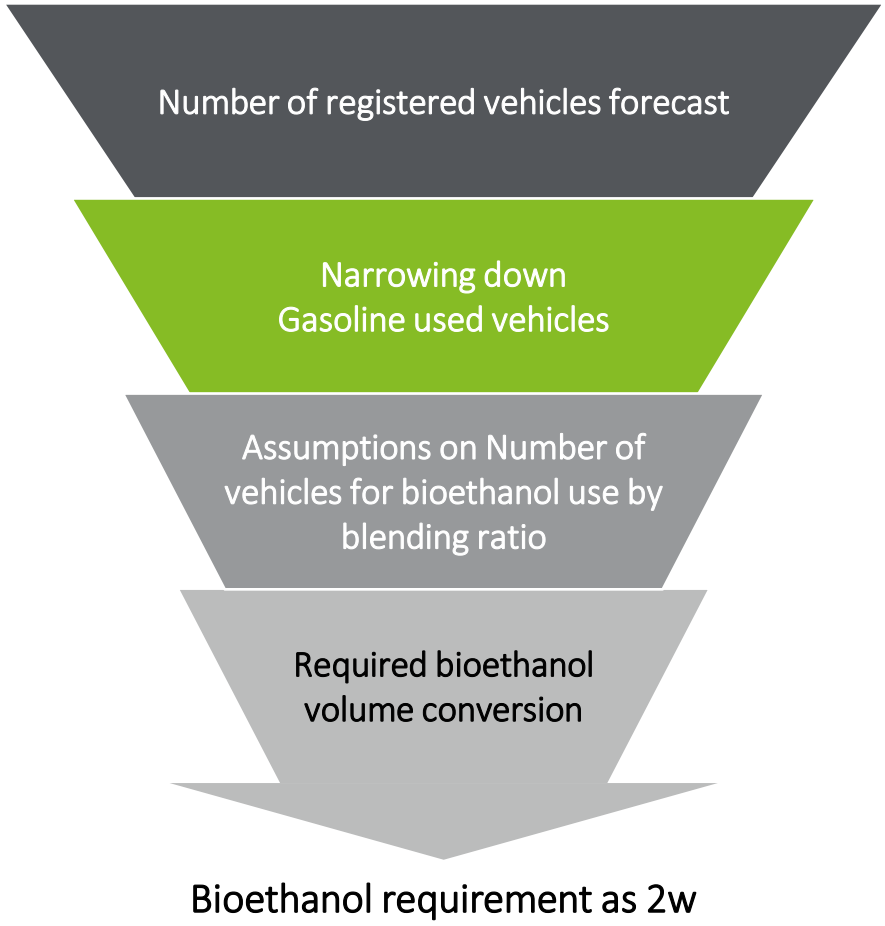
Registered 2W vehicle volume forecast

K units

	2022	2030	2040	2050	2060
Population	275,501	292,150	308,165	317,225	321,494
Sales Qty	5,221	6,163	6,501	6,692	6,782
vs Population	1.9%	2.1%	2.1%	2.1%	2.1%
Number of Registered vehicles	**125,267**	**127,425**	**115,128**	**108,526**	**110,861**

First, calculate the total demand for 2W. For 2W, all Gasoline vehicles are assumed to be applicable at basically any blending ratio. Convert the amount of bioethanol to

2W: Calculation step summary



Step1	Calculate future vehicle registrations by taking into account population growth and economic growth
Step2	Assume only Gasoline and EV vehicles Then predict how fast EVs will penetrate the market
Step3	2w assumed to be applicable at basically any blending ratio
Step4	Calculate bioethanol requirements based on the number of vehicles, average cruising range and fuel consumption information

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

Percentage of sales by fuel EV Max (Government EV Target)

Estimated sales ratio by fuel

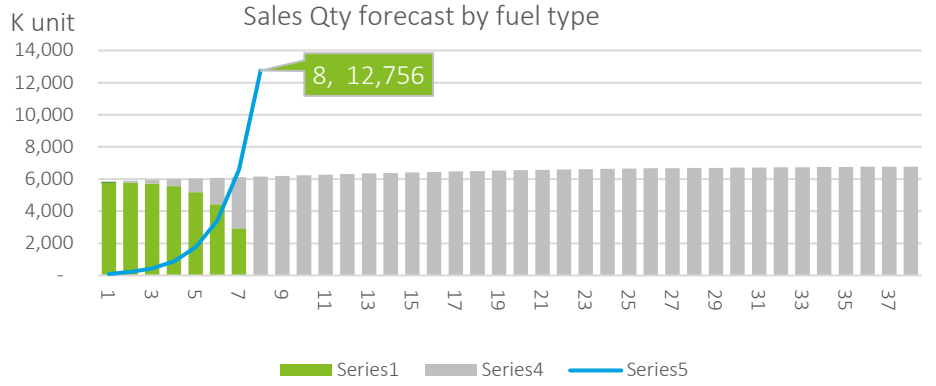
- Assumes shift to EVs in line with government targets
- To achieve 1.3mil registrations by 2030, 100% of new car sales must be achieved by 2030

Fuel type	2022	2030	2040	2050	2060
Gasoline	99.4%	-	-	-	-
EV	0.6%	100.0%	100.0%	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



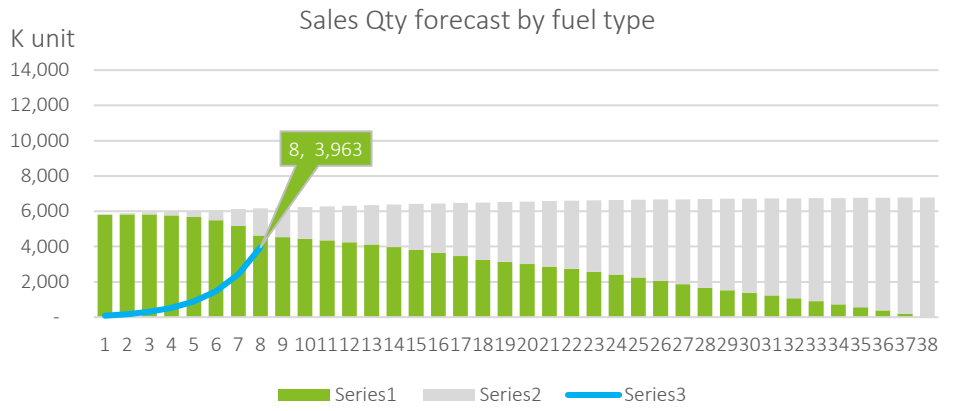
Estimate the number of vehicles sold in cases where the EV shift did not proceed as per government targets

Percentage of sales by fuel Moderate

Estimated sales ratio by fuel

- Assumes that the shift to EVs does not proceed due to price differences and infrastructure problems
- Assumes that a considerable level of demand for Gasoline vehicles will remain until 2050.
- Nevertheless, 100% of new vehicles are expected to be sold by 2060.

Fuel type	2022	2030	2040	2050	2060
Gasoline	99.4%	75.0%	50.0%	25.0%	-
EV	0.6%	25.0%	50.0%	75.0%	100.0%



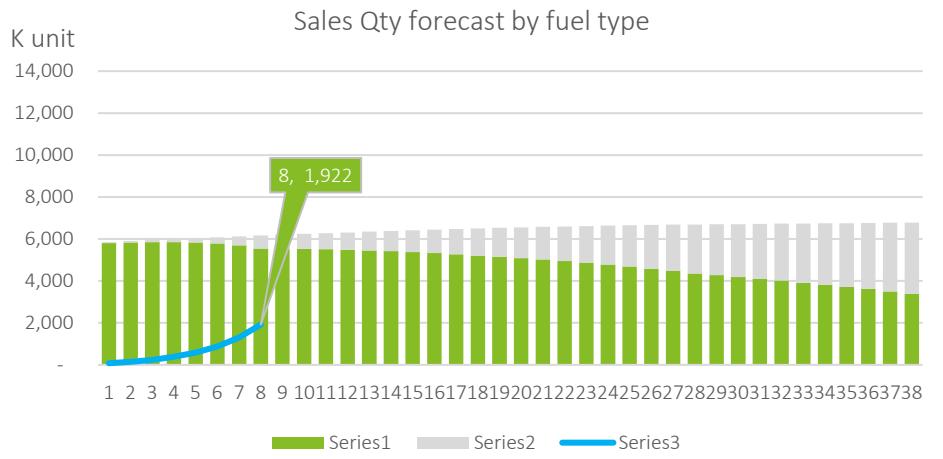
Estimate the number of vehicles sold in cases where the EV shift did not proceed as per government targets

Percentage of sales by fuel EV Min (Stagnation of EV market expansion)

Estimated sales ratio by fuel

- Assumes that the shift to EVs does not proceed due to price differences and infrastructure problems
- Assumes that a considerable level of demand for Gasoline vehicles will remain until 2060

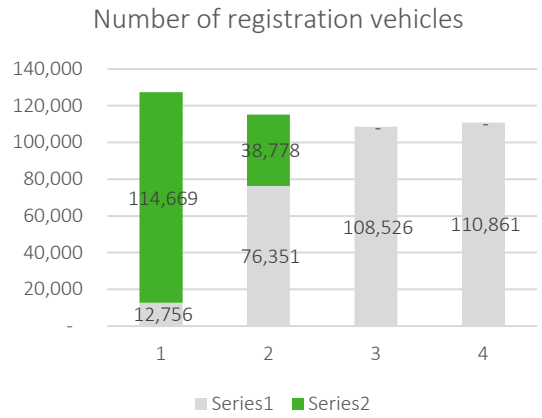
Fuel type	2022	2030	2040	2050	2060
Gasoline	99.4%	50.0%	80.0%	65.0%	50.0%
EV	0.6%	10.0%	20.0%	35.0%	50.0%

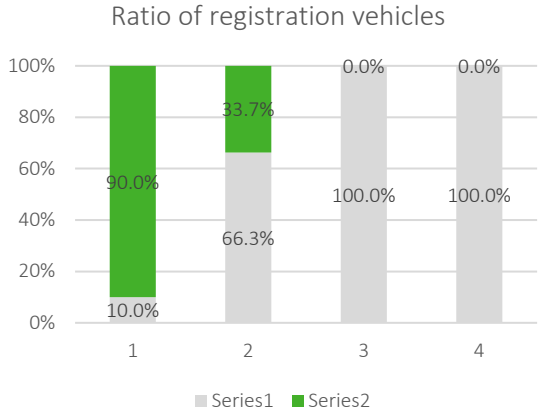


Assumption that a significant number of gasoline vehicles will remain in both cases, irrespective of whether the Government's EV shift target is achieved or not

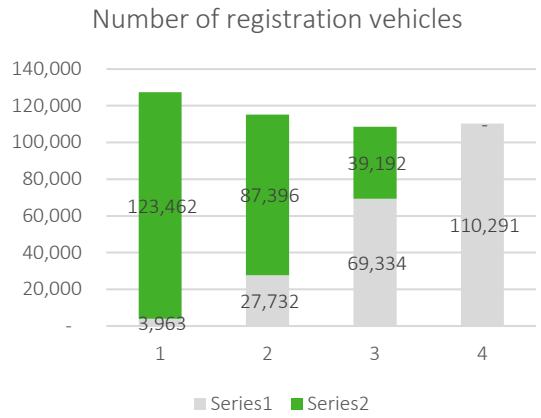
Registered vehicle volume forecast by fuel type

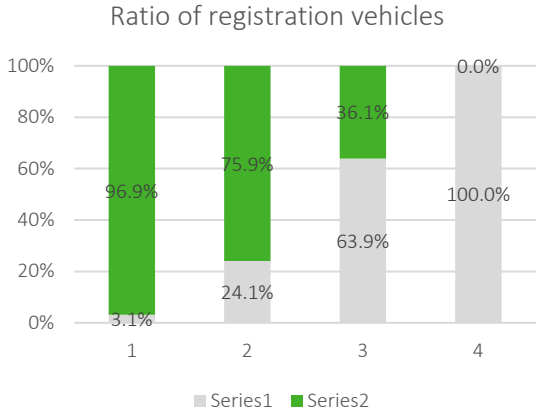
Government EV target



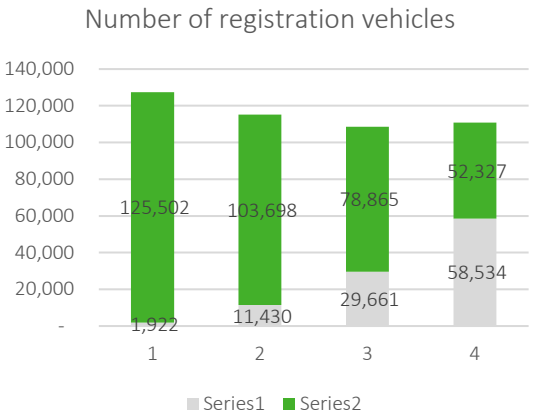


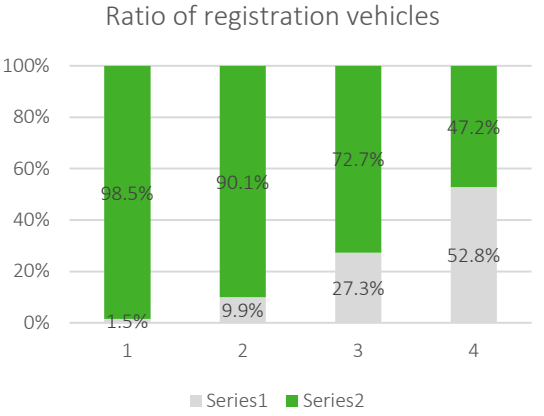
Moderate





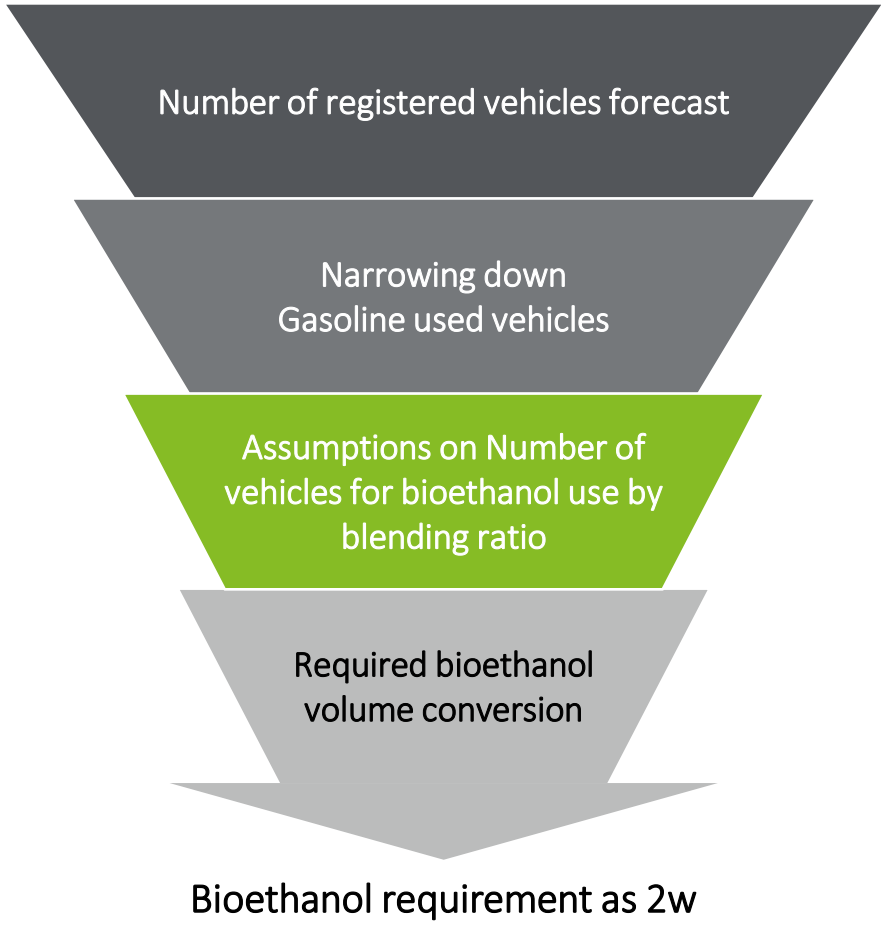
Stagnation of EV market expansion





First, calculate the total demand for 2W. For 2W, all Gasoline vehicles are assumed to be applicable at basically any blending ratio. Convert the amount of bioethanol to

2W: Calculation step summary



Step1	Calculate future vehicle registrations by taking into account population growth and economic growth
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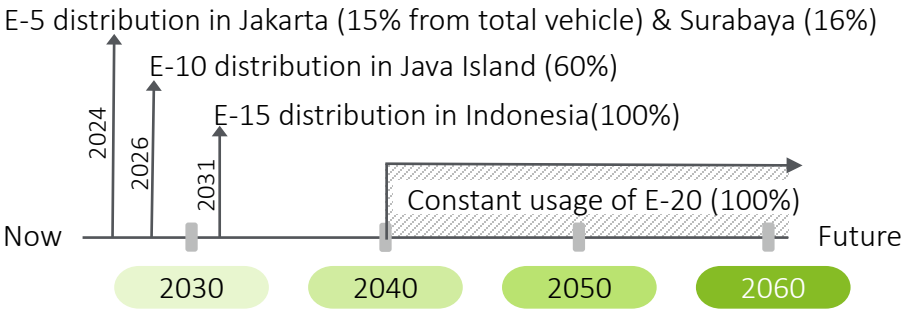
Estimated number of units sold by applicable mixing ratio based on historical sales estimates and government response policy

Percentage of sales by blending ratio

Estimated Percentage of sales by blending ratio

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



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

②. Supply forecast

Promotion of 1G bioethanol is limited from a greenwash perspective (food competition, land-use change), so sustainable 2G and later generations should be the mainstay of supply

Supply candidate options

Type		Overview	Subject feedstock	Supply availability	Tech-readiness	Immediacy	Green wash related: No Food conflict	Green wash related: No Land-use change	
Bioethanol	1G	**Edible parts-derived** Produced by microbial fermentation and distillation of sugars contained in starchy and sugary raw materials	Sugarcane Molasses	Short: ○ Long: ×	○	○	○	×	Short term measure targets
			Sugarcane Juice	?	○	×	×	×	Excluded due to high potential for food conflict /land-use change impacts
			Cassava	?	○	×	×	×	
			Maize	?	○	×	×	×	
			Sorghum	?	○	×	×	×	
	2G	**Cellulosic-derived** Produced from residues	Palm oil residues	○	△	×	○	○	Mid-Long term measure targets
	3G	**Microscopic algae-derived**	Microscopic algae	?	×	×	○	○	Excluded due to uncertain technical future outlook
	4G	**Genetically modified derived**	Genetically modified microorganisms / feeds	?	×	×	○	○	
Palm oil gasoline		**Biohydrocarbon gasoline**	Palm oil	?	×	×	×	?	

Sugarcane Juice / Cassava / Maize are NOT included in this study due to possible food competition and land use change

1G: Sugarcane Juice / Cassava / Maize

Production of Sugarcane for Centrifugal in Indonesia

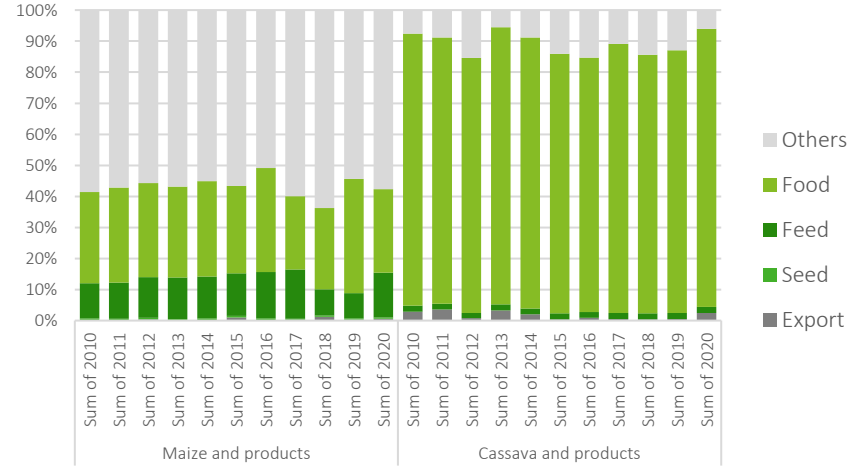
Sugar Cane for Centrifugal	2021/2022	2022/2023
Market Begin Year	May 2021	May 2022
Area Planted	448	450
Area Harvested	445	447
Production	32,200	32,400
Total Supply	32200	32,400
Utilization for Sugar	32,200	32,400
Utilization for Alcohol	0	0
Total Utilization	32,200	32,400

USDA Indonesia: Sugar Annual (1000 HA), (1000 MT)

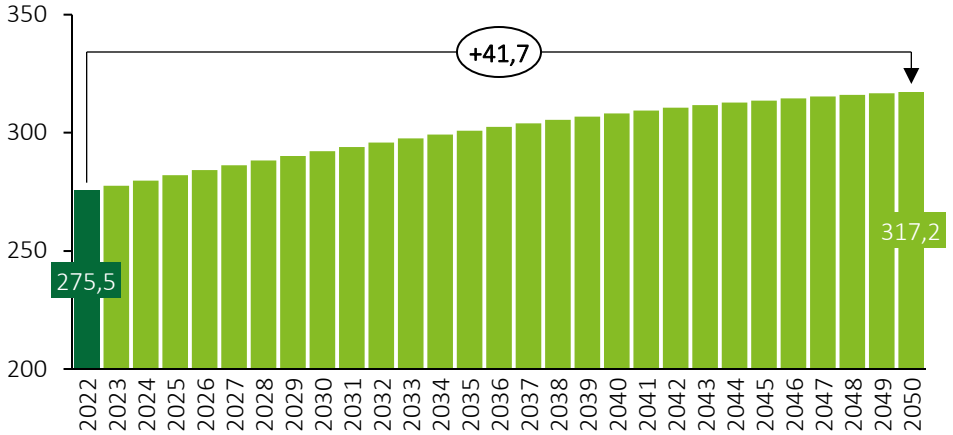
- With regard to edible feedstocks such as sugarcane, cassava and maize, there are current usages, of which a significant number are for food and feed
- Population will be increased. To avoid future food crises, agricultural land should be settled for food

➢ **Bioethanol use of edible feedstocks such as sugarcane, cassava and maize should be avoided in view of food competition and land-use change**

Production of Maize/Cassava in Indonesia



Population forecast (World Bank)



Source：FAO STAT, World Bank data

Sorghum is also considered to have potential due to the size of its production and yield, although it is one of the 1G bioethanol

1G: Sorghum

Habitat	Tropical and subtropical crops that are resistant to drought and can grow in areas where rice (rice) and wheat (wheat) cannot grow
Season	Grows year-round in parts of the temperate to tropical zones
Harvest cycle	The growing season generally lasts from 70 to 80 days for early maturing and 150 to 160 days for late maturing
Usage	Staple food sources , Cattle feed, Poultry feed, and potable alcohol

President Jokowi: Sorghum Can Be Alternative Food Source

Indonesia needs food diversification and alternatives to face the threat of the ongoing and future global food crises, which the Food and Agriculture Organization (FAO) and the United Nations (UN) have warned about.

"We will expand the planting of sorghum in the province so we can we have **alternative food sources to face global food crises**. If there is an excess, if there is a supply, it will be alright. In fact, we aim to export it in order to generate foreign exchange for our country,"

Cabinet Secretariat of the Republic of Indonesia

Market introduction seems difficult from the technological development perspective

3G/4G status

1st Generation

Edible
- Sugarcane
- Maize
- Cassava
- Corn

Already in practical use

2nd Generation

Cellulosic
- Wood
- Straw
- Grass
- Waste

Commercialization phase

3rd Generation

Algae
- Macroscopic algae
- Microscopic algae

R&D phase

4th Generation

Genetically modified
- Pyrolysis
- Solar-to-Fuel
- Engineered Algae
- Gasification

Initial research phase

Market introduction seems difficult from the technological development and food conflict perspective, but the Indonesian Government and ITB are considering it as a future possibility. So to be investigated in detail in the next phase

Palm oil gasoline

Overview

- Palm Oil Gasoline/BENSA is a **biohydrocarbon gasoline**.
- **Zeolite-based catalysts or known as "Merah Putih" is the key element** in the production process.
- The development of "Merah Putih" catalyst and Palm Oil Gasoline production is **still at the community scale**
- **The capacity of the pilot plant is at 1,000 L/day**

Sample of Palm Oil Gasoline


Existing Pilot Plant

- Pros: **less corrosive, lower wear effect** on rubber, requires **minimal adjustments** to the engine
- Cons: **other use cannibalization** (food, biodiesel, etc.) & **technology readiness** (Reactor configuration, etc.)

Generation Process

Biohydrocarbon		1st Gen Bioethanol	2nd Gen Bioethanol
Cracking & Deoxygenation		Milling	Pre-treatment
2nd Cracking & Decarboxylation	Vs	Hydrolysis	Enzymatic Hydrolysis
Hydro isomerization		Fermentation	Fermentation
Cyclization		Distillation & Dehydration	Distillation & Dehydration

Government Development Plan

NATIONAL PRIORITY PROGRAM: GREEN FUELS – 1 "MERAH PUTIH" CATALYST FACTORY, WEST JAVA	**NATIONAL PRIORITY PROGRAM: GREEN FUELS – 2** GREEN REFINERY PLAJU, SOUTH SULAWESI	**NATIONAL PRIORITY PROGRAM: GREEN FUELS – 3** GREEN REFINERY CILACAP UNIT TDHT (REVAMPING)	**NATIONAL PRIORITY PROGRAM: GREEN FUELS – 4** HIDROGENASI CPO AT RU IV CILACAP
IVO DEVELOPMENT DEMOPLANT AT MUSI BANYUASIN	**PALM OIL GASOLINE DEVELOPMENT** DEMOPLANT AT KUDUS, CENTRAL JAVA	**BIOAVTUR DEVELOPMENT** DEVELOPMENT OF BIOAVTUR J2.4	**UCO FOR GREENFUELS** MoU PERTAMINA AND APJETI

Several programs has been introduced regarding the development of Palm oil Gasoline

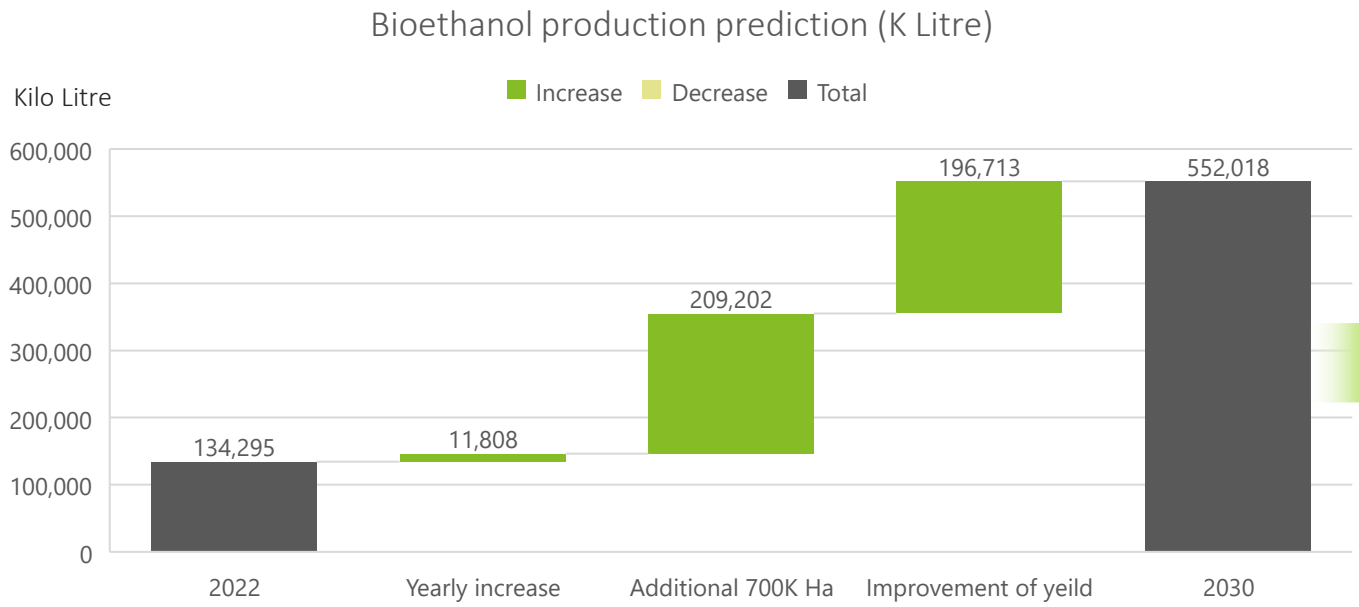
Unit : Million KL	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Biodiesel	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.2	10.5	10.8	11.1	11.3	11.5	11.5	11.6	11.6	11.6	11.7	11.7
Co-processing Green Diesel	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Standalone Green Diesel	0.0	0.2	0.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Co-processing Green Gasoline	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Standalone Green Gasoline	0.0	0.0	0.1	0.3	0.5	0.8	1.1	1.4	1.7	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Total Biofuels	9.2	9.7	10.0	11.3	11.6	12.0	12.4	12.8	13.4	14.0	14.3	14.6	14.8	15.0	15.0	15.1	15.1	15.1	15.2	15.2

Source : MEMR presentation material at GIIAS 2023, FGD ITB Bioethanol presentation material, international journals and various articles

1G : Sugarcane Molasses

Initial market development and formation will be achieved through 1G bioethanol using molasses without food competition. However, the development of 700 K ha of land, improved yields and in addition the business shift to fuel grade are precondition

Perspectives on short term supply



Bioethanol production is divided into **fuel** and **non-fuel** grades, now only 60K (0.04%) for fuel grade due to low demand

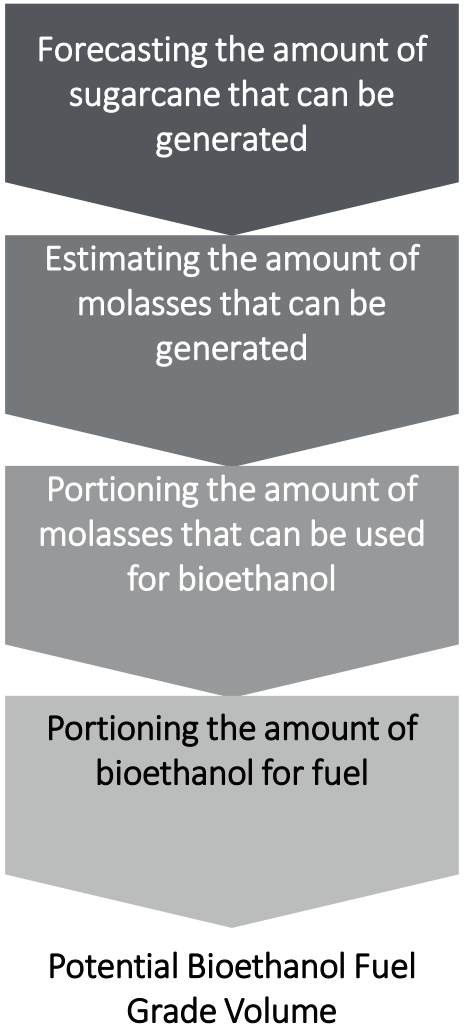
The key point on the supply will be how much can be shifted to fuel grade

To cover the demand in 2030, around 60% shift will be expected at least

Measures	Description	Change
Yearly increase	Assumes comparable historical growth rates in sugarcane production	101% average annual growth
Additional 700K Ha	Expected amount of bioethanol from government-prepared land for sugar self-sufficiency (Presidential regulation No.40/2023)	Approx. 450 K Ha → 1,150 K Ha
Improvement of yield	Government is trying to increase sugarcane yields to 130 t/ha	67 t/Ha → 130 t/Ha

4 steps in calculating the supply of 1G: sugarcane production, molasses production, molasses proportion for bioethanol, and the portion of bioethanol for fuel

1st Gen Supply: Calculation step summary



Step1	Forecast future sugarcane production by using linear trend
Step2	Estimate molasses production from sugarcane production by using conversion ratio
Step3	Narrow down from the total uses of molasses into specific use for bioethanol
Step4	Convert molasses into bioethanol and narrow down from the total uses of bioethanol into specific use for fuel

Each of the steps has its own calculation logic before finally get the potential bioethanol fuel grade volume

1st Gen Supply: Calculation step summary

Forecasting the amount of sugarcane that can be generated

Sugarcane

Sugarcane production forecast = FY22 actual × Linear growth prediction

Estimating the amount of molasses that can be generated

Molasses

Molasses Production forecast = Sugarcane production forecast × Molasses Conversion Ratio

Portioning the amount of molasses that can be used for bioethanol

MSG

or

Export

or

Ethanol

Molasses Production forecast for Bioethanol = Molasses Production forecast × Molasses Utilization Proportion

Portioning the amount of bioethanol for fuel

Molasses

Conversion

Ethanol

Bioethanol Production forecast = Molasses Production forecast for Bioethanol × Bioethanol conversion ratio

Potential Bioethanol Fuel Grade Volume

However, there are 3 variables that can affect the forecast accuracy: sugarcane yield rate, shift from other-uses of molasses, and shift from non-fuel-use of bioethanol

Variable Factor

Improvement on Sugarcane Yield Rate

- (ENERO) Currently, the government is striving for **intensification measures**, by increasing the **sugarcane yield rate to reach 135 tons/ha**
- Based on the journal titled "Estimating the age and productivity of sugarcane using Object-Oriented Image Analysis (OOIA)" , **the standard yield ratio is 100 ton/Ha**

Illustrative

Current Yield Rate
67 ton/Ha

Future Yield Rate
TBD ton/Ha

Shift from Other-uses of Molasses to Bioethanol

There is a possibility of a **shift in the amount of molasses used for export and other purposes moving to the use for bioethanol**

Molasses Proportion by End-use

47% → TBD

Other Purpose (MSG, etc.)

13% → TBD

Export

40% → TBD

Ethanol

Shift from Non-fuel-use of Bioethanol to Fuel

Although the current use of bioethanol fuel grade is almost zero (0), this is majorly caused by the small demand from Pertamina. Therefore, **when the demand for bioethanol fuel grade increases, it is highly possible that there will be a shift in the proportion of bioethanol from non-fuel to fuel**

Bioethanol Proportion by End-use

~0% → TBD

Bioethanol Fuel Grade

~100% → TBD

etc..

Bioethanol Industrial Grade

Source: Expert Interviews, International Journals

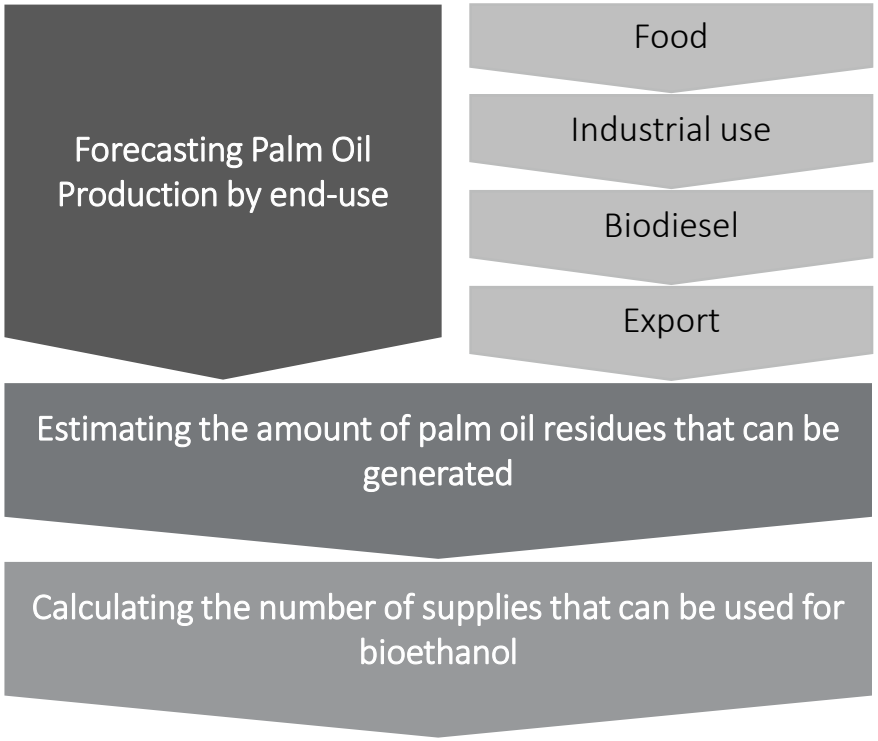
2G : Palm oil residues

It is desirable to use 2G ethanol from palm oil residues as a source of supply, both in terms of strengthening Indonesia's unique industry and protecting environment

Perspectives on mid-long term supply

- Indonesia is the world's largest palm oil producer and will continue to be a growing industry as its economy grows
- Although certain results have been published for all related residues, EFB is the most feasible at the moment
- If other residues become feasible, a significant amount of bioethanol is expected to be produced.

Prediction approach



Bioethanol supplies from Palm Oil 2nd Gen

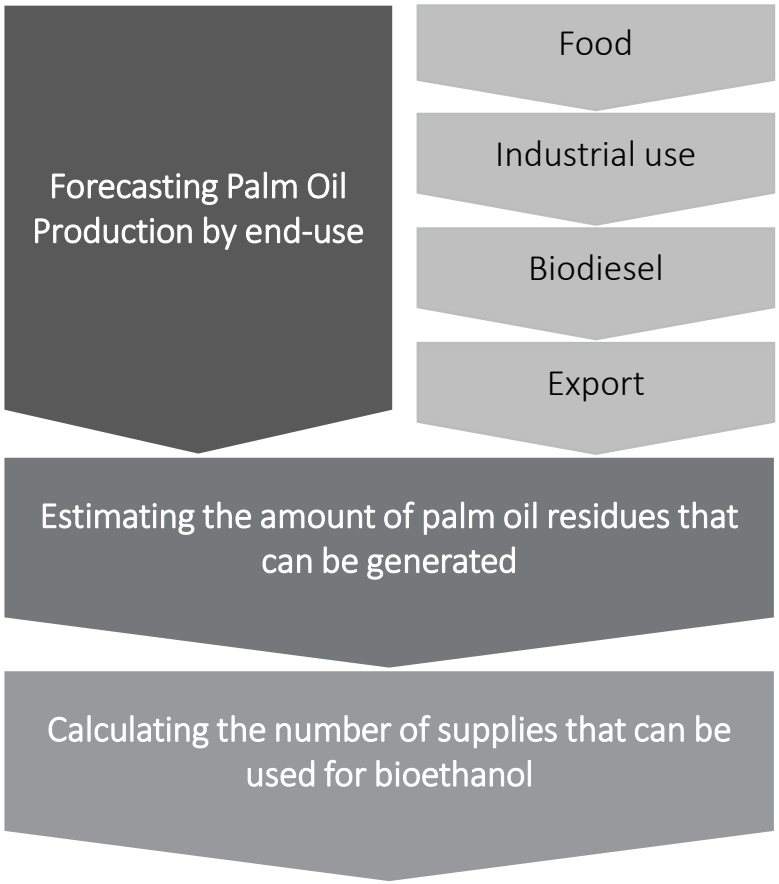
Forecast of Bio-ethanol production from each residue

Residues	2030	2040	2050	2060	Utilization
Palm oil production (K ton)	84,911	135,981	168,716	178,067	
					Amount (Mil Litre)
From Empty Fruit Bunches (EFB)	4,811	7,705	9,560	10,090	10%*
From Mesocarp Fiber (MF)	8,051	12,893	15,996	16,883	30%**
From Oil Palm Frond (OPF)	18,050	28,906	35,865	37,853	30%**
From Oil Palm Trunk (OPT)	18,956	30,358	37,666	39,753	30%**

*EFB: there are several usages for Fertilizer, Animal feed and Biomass for Power Plant
**Others: currently there is no massive-scale usage for this specific part

The supply estimation from the 2nd generation is focused on palm oil residues, by considering palm oil production to determine potential residue for bioethanol

Calculation step summary



Bioethanol supplies from Palm Oil 2nd Gen

Step1	Calculate future palm oil production by taking into account usage for food, usage for industrial use, usage for biodiesel and usage for export
Step2	Assume the proportion of palm oil components that arise as residues from the current palm oil production
Step3	Calculate bioethanol supplies based on the number of palm oil residues available, percentage of residues' utilization, and bioethanol conversion rate

Source: Indonesia Palm Oil Association

In our estimates, we forecast future palm oil production based on GAPKI's historical palm oil production

Basis Data to be Used in Forecasting

Source of Data	▪ GAPKI is Indonesia Palm Oil Association (IPOA) established in 1981 ▪ GAPKI consist of domestic and foreign companies, as well as micro scale player such as community farmers
Data Description	▪ The data listed next to it represents the quantity in the form of palm oil (as an oil). ▪ This quantity is being categorized according to its respective usage purposes (i.e., Food, Biodiesel, Industrial Use, Export)
Reference	▪ GAPKI's data

Palm oil production records

		2018	2019	2020	2021	2022
Amount (K ton)						
Domestic	Food	8,704	9,860	8,428	8,954	9,941
	Industrial use	963	1,056	1,695	2,126	2,185
	Biodiesel	3,824	5,831	7,226	7,342	8,842
		13,491	16,747	17,349	18,422	20,968
Export		36,333	37,430	34,007	33,674	30,803
Total production		**49,824**	**54,177**	**51,356**	**52,096**	**51,771**
Share						
Domestic	Food	17.5%	18.2%	16.4%	17.2%	19.2%
	Industrial use	1.9%	1.9%	3.3%	4.1%	4.2%
	Biodiesel	7.7%	10.8%	14.1%	14.1%	17.1%
		27.1%	30.9%	33.8%	35.4%	40.5%
Export		72.9%	69.1%	66.2%	64.6%	59.5%
Total production		100.0%	100.0%	100.0%	100.0%	100.0%

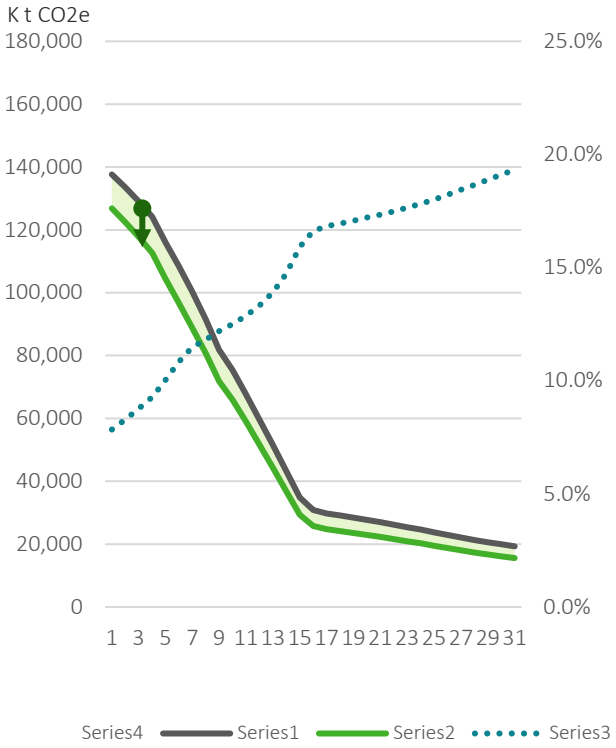
Source: Indonesia Palm Oil Association

③. Expected effects

In all scenarios, a certain number of registered gasoline-using vehicles will remain until 2060, and the introduction of bioethanol is expected to reduce GHG emissions by 10-20% compared to BAU

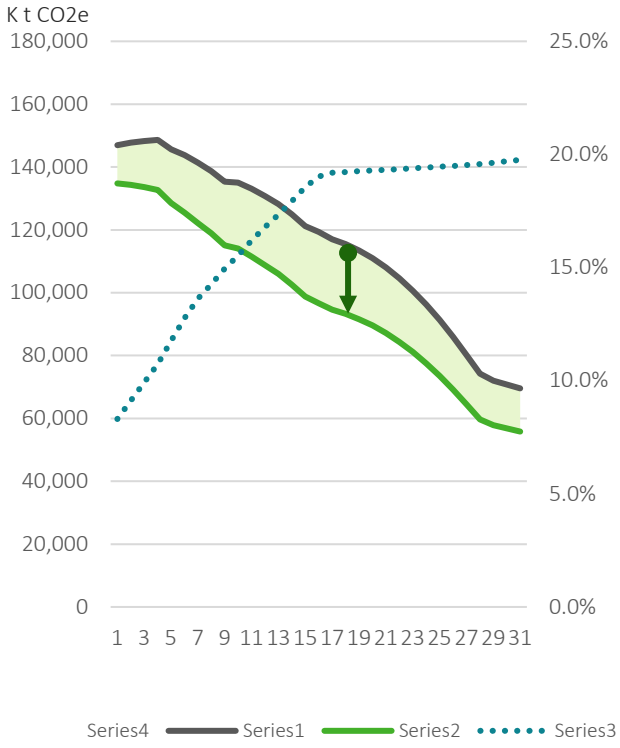
GHG emission reductions in Tank To Wheel (during driving)

Scenario1: EV adoption at target levels



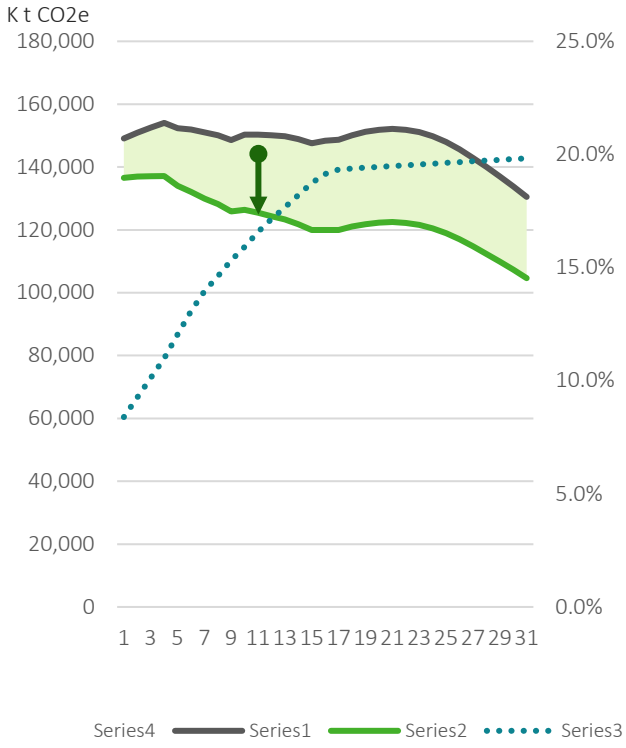
GHG reduction	216 Million tCO2e Accumulation from 2030 to 2060
Potential Carbon Credit	8,647 Million USD

Scenario2: Moderate



GHG reduction	579 Million tCO2e Accumulation from 2030 to 2060
Potential Carbon Credit	23,167 Million USD

Scenario3: HV penetration instead of EV



GHG reduction	775 Million tCO2e Accumulation from 2030 to 2060
Potential Carbon Credit	30,994 Million USD

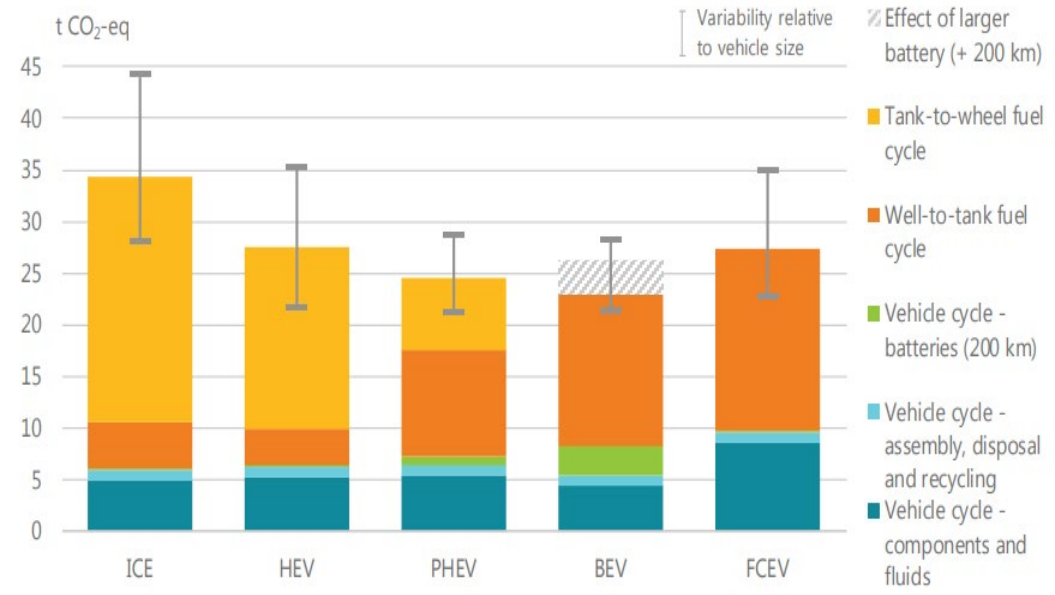
Condition: 40 USD / t CO2 e

This calculation is only a reduction in GHG emissions when driving gasoline vehicles, which is expected when E10-E20 bioethanol is applied

Approach to GHG emission reduction estimates

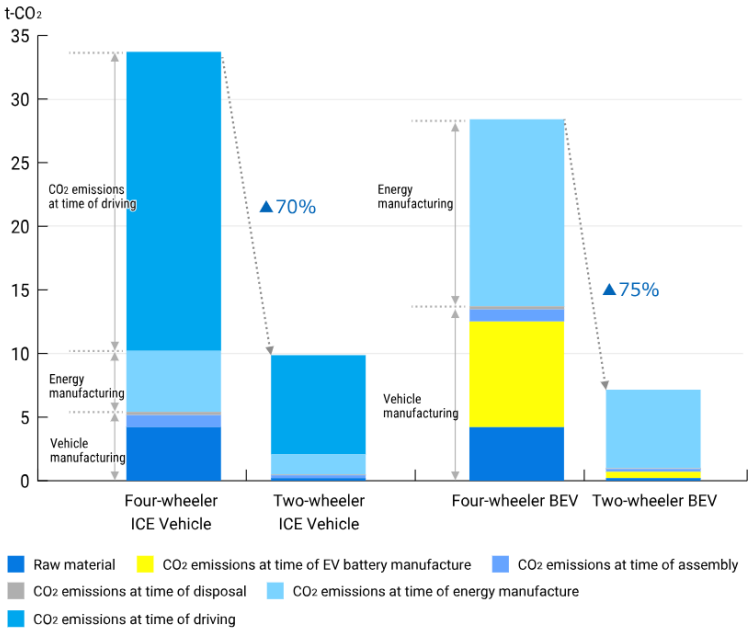
GHG emissions reduction = [Number of registered Vehicle(ICE/HV) × Gasoline 100% − Number of registered Vehicle (ICE/HV) × Gasoline 80-90% (E10-E20 applied)] × GHG Emissions per vehicle

Figure 4.2. Comparative life-cycle GHG emissions of a global average mid-size car by powertrain, 2018



Source: IEA “Global EV Outlook 2019”

Comparison of CO_2 Emission Amounts for the Product Life Cycle (ICE Vs. BEV)



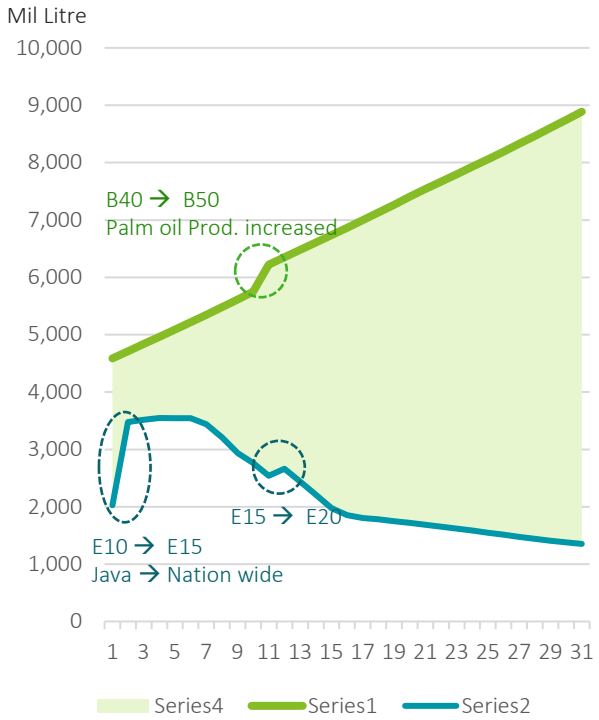
Source: Overview of "Yamaha Motor Group Environmental Plan 2050"

Introduction of 2G bioethanol from palm oil residues is expected to supply more than domestic demand. Foreign currency can be earned by exporting the excess, which can be assumed to be used to generate funds for subsidies

Potential foreign currency acquisition

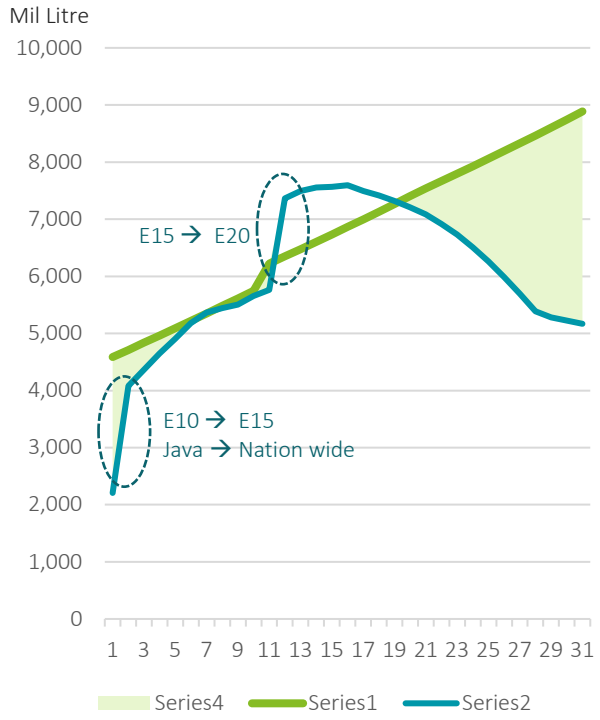
Condition:
- 12,825IDR based on MEMR Bioethanol price as of Oct.2023. Without taking into consideration customs duties, export taxes, etc.
- Assumption that EFB is used as feedstock for 2G bioethanol, with a utilization of 10% of total EFB production.

Scenario1: EV adoption at target levels



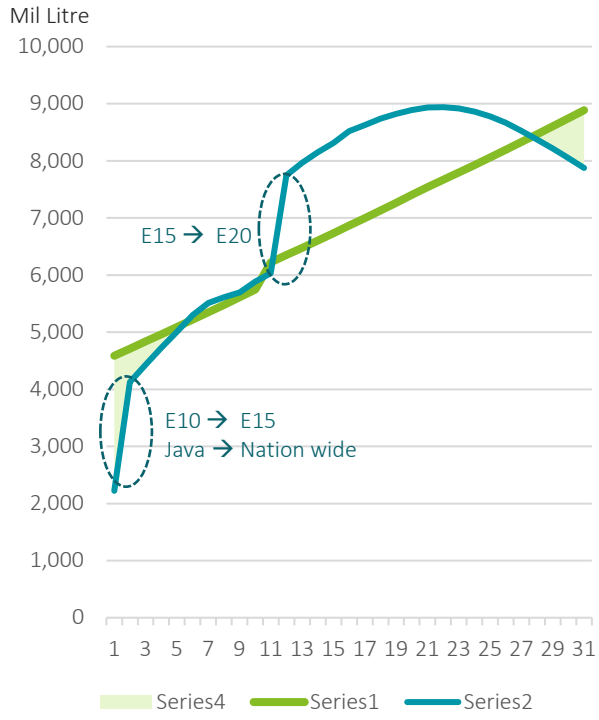
Excess Bioethanol	140 Billion Litre
Potential foreign currency acquisition	1,801 Trillion IDR (113 Billion USD)

Scenario2: Moderate



Excess Bioethanol	29 Billion Litre
Potential foreign currency acquisition	370 Trillion IDR (23 Billion USD)

Scenario3: HV penetration instead of EV

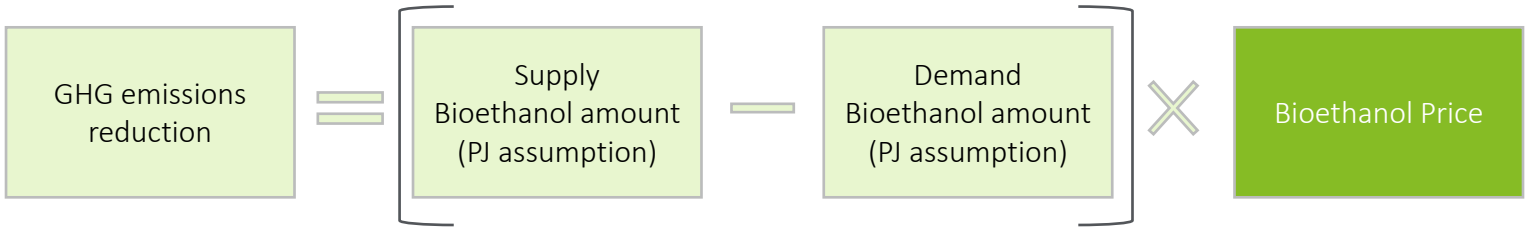


Excess Bioethanol	6 Billion Litre
Potential foreign currency acquisition	78 Trillion IDR (5 Billion USD)

1USD=15,907IDR as of 30th Oct (www.oanda.com)

Estimate calculated with reference to the latest version of the national market price (October 2023) provided by MEMR.Export taxes and duties are not taken into account

Approach to foreign currency acquisition estimates



Lampiran Surat
Nomor : T-4167/EK.05/DJE.B/2023
Tanggal : 25 September 2023

PERHITUNGAN BESARAN HARGA INDEKS PASAR (HIP)
BAHAN BAKAR NABATI (BBN) JENIS BIOETANOL
BULAN OKTOBER 2023

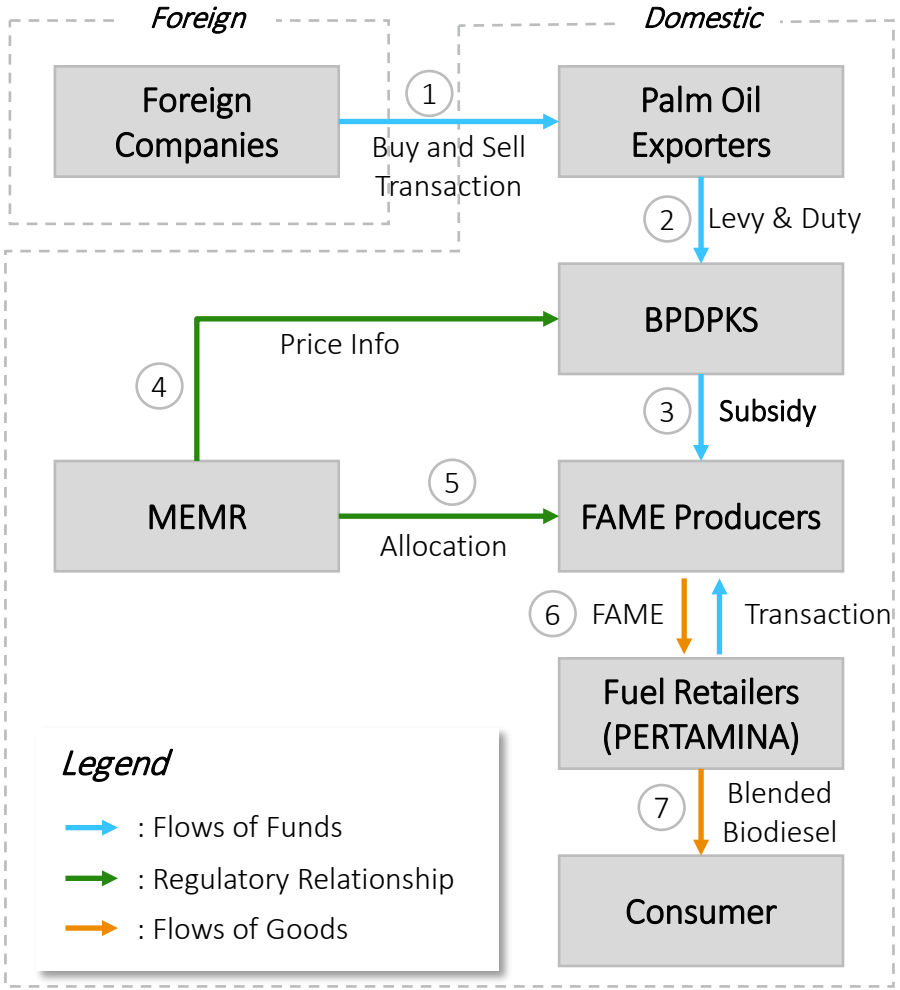
BBN	BIOETANOL				
	RATA-RATA TETES TEBU KPB (RUPIAH/KILOGRAM)		FORMULA	HIP BIOETANOL (RUPIAH/LITER)	
	15 Juni 2023 s.d. 14 September 2023	2.182	HIP = (Rata-rata tetes tebu KPB periode 3 bulan x 4,125 Kg/L) + 0,25 USD/Liter	Oktober 2023	12.825

Keterangan:
Konversi nilai kurs menggunakan referensi rata-rata kurs tengah Bank Indonesia periode 15 Agustus 2023 s.d. 14 September 2023 sebesar Rp15.302,-

Source: Harga Indeks Pasar Bahan Bakar Nabati (HIP BBN) Jenis Bioetanol Bulan September 2023

Funding mechanism from palm oil export as a source of subsidy used in the biodiesel case can potentially be considered to be adopted in the bioethanol case

Example : scheme to secure foreign currency earnings / export taxes to subsidies in Biodiesel



1. **Foreign exchange** from export activities of palm oil-related products **contribute to the inflow of money into Indonesia**
2. Export activities will be imposed of export levy and export duty as **CPO Supporting Fund (CSF), collected by BPDPKS**
3. **CSF will be used to overcome the price gap difference between biodiesel and crude oil price**
4. **MEMR will provide price index** (Biodiesel and CPO) that will **influence the export levy structure**
5. **MEMR will arrange the allocation of biodiesel (FAME) volume** for each producer company
6. **Producer will sell FAME to PERTAMINA** with an agreed price
7. **PERTAMINA will distribute biodiesel** fuel across all gas stations **to the end-user**

source: USDA, Indonesia: Biofuels Annual 2021

3. Assumed challenges

There are multiple challenges to overcome for the successful market introduction of both 1G and 2G bioethanol. They are categorized as Policy-related, Supply chain-related and Technology-related challenges

Assumed challenge structure

Area	Point of view	Target	Detailed challenges	Type of challenges
Demand	Politics	Common	Control of Market price	Expansion of policies and subsidies
Supply	Politics	Common	Removal/reduction of excise fee	
		1G	Restrictions on molasses export	
	Economy	1G	Consideration of target regions/supply chains	Building efficient supply chain
		2G	Development/investment for efficient supply chains	
		2G	Development/investment for production sites	
	Society	2G	Environmental concerns due to inappropriate treatment of inhibitors	2nd Gen technological innovation
	Technology	2G	Study of the solution for the Lignin Removal	

Expansion of policies and subsidies

Looking at the background story in the past, the fluctuated price has become one of the challenges for Pertamina as the major buyer of bioethanol for fuel

Bioethanol Pricing (1/4)

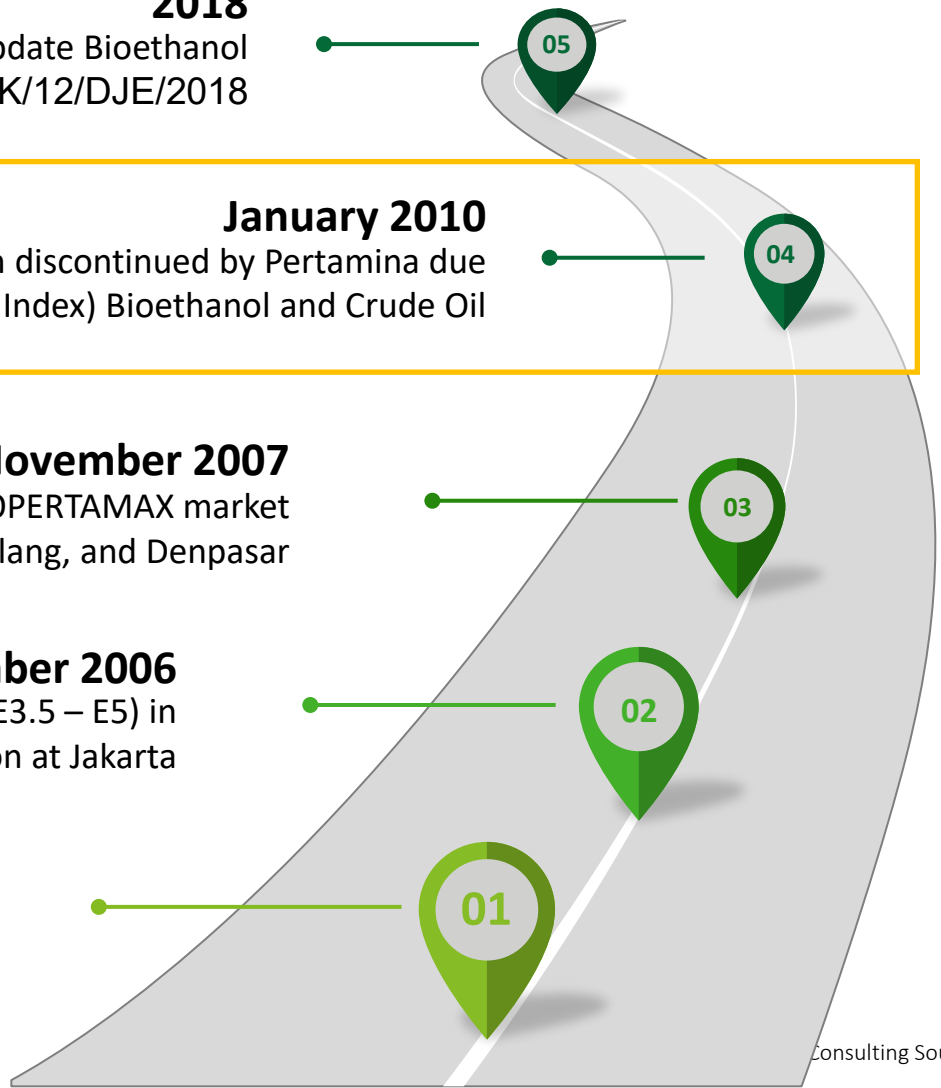
2018
MEMR released the latest pricing formula update Bioethanol Price Index (HIP) → MEMR Decree No. 350 K/12/DJE/2018

January 2010
BIOPREMIUM and BIOPERTAMAX has been discontinued by Pertamina due to the price gap between HIP (Price Index) Bioethanol and Crude Oil

November 2007
Pertamina extended BIOPERTAMAX market to Surabaya, Malang, and Denpasar

December 2006
First launch of BIOPERTAMAX (E3.5 – E5) in 4 Gas Station at Jakarta

August 2006
Pertamina launched BIOPREMIUM (E5) at gas station in Malang



Source: FGD ITB Bioethanol material, MEMR press release

Key factors that influences the price of bioethanol are molasses prices and exchange rates, and upon observation, the price of bioethanol and crude oil does not significantly correlate with each other

Bioethanol Pricing (2/4)

Formula of Bioethanol Price Index (HIP)

$$\textbf{\textit{Bioethanol Price Index}}\ (HIP)\ \frac{IDR}{Litre} =$$

$$\left(4.125\ \frac{kg}{L}\ x\ Molasses\ KPB\ Price\ \frac{IDR}{Kg}\right) + \left(0.25\ \frac{USD}{L}\ x\ Exchange\ Rate\ \frac{IDR}{USD}\right)$$

Calculation Sample:

- Average Molasses KPB Price (15 May' 23 – 14 Aug' 23) = 2,170 IDR/ltr
- Average Exchange Rate (15 May' 23 – 14 Aug' 23) = 15,095 IDR/USD

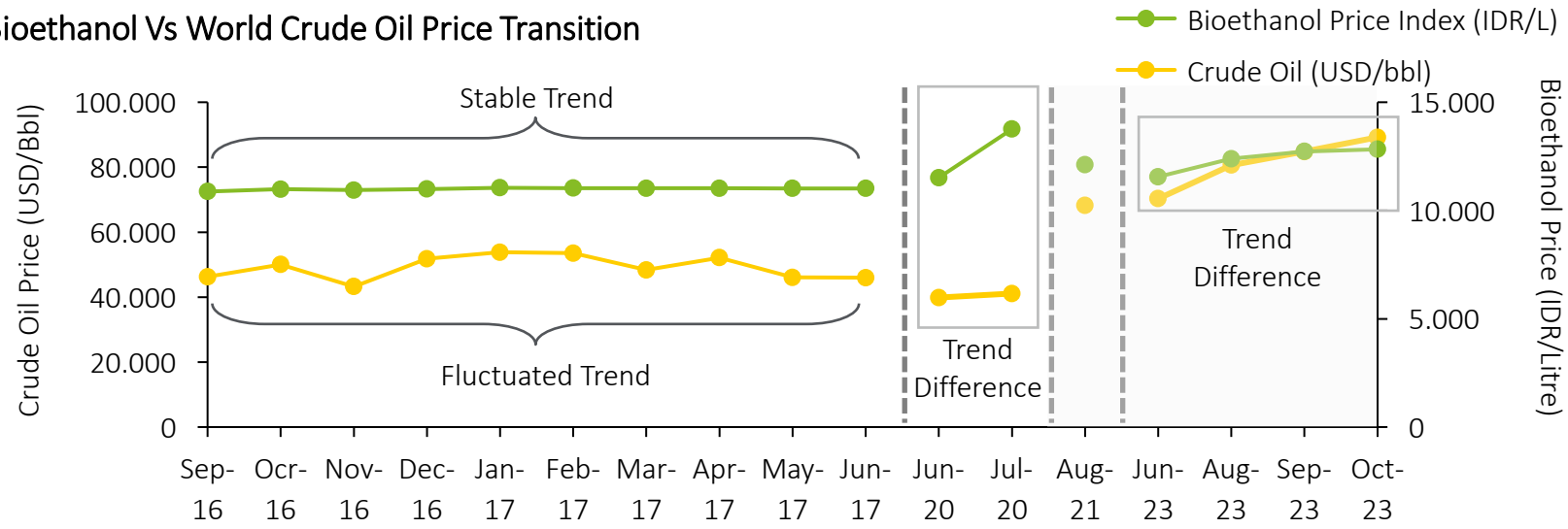
$$Bioethanol\ Price = (\mathbf{4.125\ x\ 2,170}) + (\mathbf{0.25x\ 15,095}) = \mathbf{12,725\ IDR/litre}$$

where

- **4.125** is ratio of molasses to bioethanol (1 ltr of bioethanol is produced from 4.125 kg of molasses).
- **Molasses KPB Price** is the average molasses price index in the last 3 months
- **0.25** is the determination of production costs and profit margin (conversion rate from raw material to bioethanol)
- **Exchange Rate** is the average exchange rate from USD to IDR based on Bank Indonesia in the last 3 months

Bioethanol Price Index Vs World Crude Oil Price

Bioethanol Vs World Crude Oil Price Transition



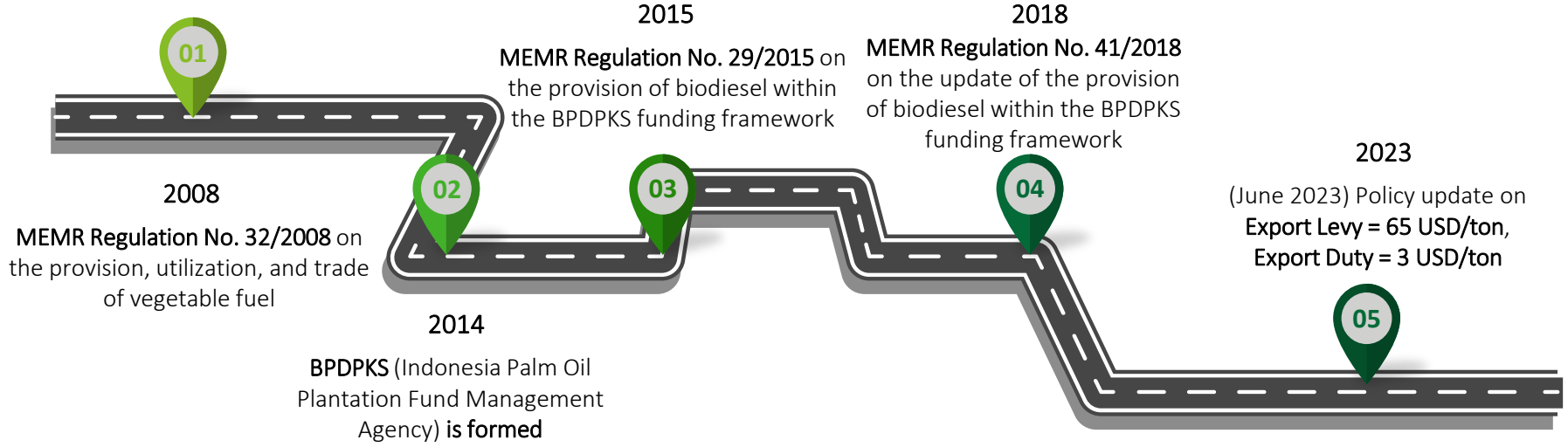
Source: MEMR press release, TradingEconomics

An inspiration from Biodiesel subsidy mechanism that can be adapted to penetrate Bioethanol market

Bioethanol Pricing (3/4)

Behind Biodiesel Pricing Success Story	• (2014) Establishment of a dedicated government agency (BPDPKS) responsible to collect funds from plantation business actors or better known as the CPO Supporting Fund (CSF) which will be used to support sustainable palm oil development programs. One of the activities at BPDPKS is to provide biodiesel price incentives • (2015) the transition period from state budget (APBN) subsidy to the incentive of BPDPKS • Source of fund collection: ➢ Impose an export levy (Pungutan Ekspor – PE) : certain amount of fee for every ton of crude palm oil (CPO) and/or processed CPO product being exported ➢ Impose an export duty (Bea Keluar - BK) : certain amount of percentage from the export value for CPO and its derivative products to be charged as export duty. • CPO Supporting Fund will be used as subsidy to cover price gap when the price of biodiesel is higher than the price of diesel fuel

Biodiesel Journey



Source: Book of "BIODIESEL, a long struggle journey" 2021 by MEMR, P3tek, APROBI

Balancing supply and demand in the auction activities are the key factors to stabilize molasses KPB price

Bioethanol Pricing (4/4)

Formation of KPB Price

- PT *Kharisma Pemasaran Bersama Nusantara* (KPBN) is a company engaged in the **marketing of plantation commodities** as a transformation/change from the *Kantor Pemasaran Bersama* (joint marketing office) of PT. Perkebunan Nusantara
- Several plantation commodities sold at KPBN: **palm oil, molasses, rubber, latex, tea leaves, coffee beans, chocolate**
- Sales of these commodities (**domestic and international**) are **conducted through tenders, auctions, and negotiations, with reference to market prices** monitored from **London, Rotterdam, Kuala Lumpur, Singapore, Tokyo, and New York.**
- **Auction periods vary depending on the type of commodity** (i.e., once every 3 months to 3 times a week)
- The price of KPB is driven by several factors: **the quantity of supply, the quantity of demand, and international price references**

Formula of Biodiesel Price Index (HIP)

$$\textbf{\textit{Biodiesel Price Index}}\ (HIP)\ \frac{IDR}{Litre} =$$

$$\left[\left(\left(0.085\ \frac{USD}{kg}\ x\ exchange\ rate\ \frac{IDR}{USD}\right) + CPO\ KPB\ Price\ \frac{IDR}{Kg}\right) x\ 0.87\ \frac{kg}{litre}\right] + transport\ cost\ \frac{IDR}{Litre}$$

where

- **0.085** is the conversion rate from raw material to biodiesel
- **Exchange Rate** is the average exchange rate from USD to IDR based on Bank Indonesia in the last 1 month
- **CPO KPB Price** is the average CPO price index in the last 1 month
- **0.87** is the unit conversion from kg to litre
- Transport cost refer to MEMR Decree 146.K/HK.02/DJE/2021

BESARAN MAKSIMAL ONGKOS ANGKUT
BAHAN BAKAR NABATI JENIS BIODIESEL YANG DICAMPURKAN
KE DALAM BAHAN BAKAR MINYAK JENIS MINYAK SOLAR

No.	Titik Serah	Titik Suplai	Ongkos Angkut (Rp/Liter)
A. ACEH			
1	Krueng Raya	Belawan/Medan	285
2	Lhokseumawe	Belawan/Medan	200
3	Meulaboh	Belawan/Medan	370
4	Sabang	Belawan/Medan	600
5	Simuelue Sinabang	Belawan/Medan	980
B. SUMATERA UTARA			
6	Medan*	Medan/Batam	116
		Medan (jalur pipa)	12
		Bayas-Riau	275
		Dumai	240
7	Medan**	Belawan/Medan	23
8	Pematang Siantar	Belawan/Medan	132
9	Kisaran	Belawan/Medan	143
10	Sibolga	Belawan/Medan	245
11	Gunung Sitoli, Nias	Belawan/Medan	735

Maximum amount of transportation cost for biodiesel/vegetable fuel has been defined per each delivery point vs supply point

Source: MEMR press release, KPBN website

Although ethanol is considered as excisable goods but bioethanol as fuel can get an excise fee exemption facility

Removal/reduction of Excise Fee & Ease of Terminal Permit Application

Excise Fee on Bioethanol as Fuel	• **Latest Policy: Law No. 7 of 2021 on Tax Regulation Harmonization** regarding list of goods with properties and characteristics classified as **Excisable Goods**, which include: **Ethanol**, Alcoholic Beverages, and Tobacco Products • The term "Ethanol" refers to a clear, colorless liquid substance that is an organic compound with the chemical formula **C2H5OH**. It can be obtained through various methods, including fermentation and distillation, as well as chemical synthesis, **including the fermented and distillated sugar**. • The excise fee rate for all types of Ethyl Alcohol (Ethanol) is **20,000 IDR per liter.** This is regulated by the **Minister of Finance Regulation No. 158/PMK.010/2018** regarding the tariff for excise fee on ethyl alcohol, alcoholic beverages containing ethyl alcohol, and concentrates containing ethyl alcohol
Excise Fee Exemption	• There is a **tax exemption facility** where businesses can apply for an **excise fee exemption** for goods classified as excisable goods **when they are used as raw materials** in the production **of final products that are not subject to excise tax.** • **(Aug 2023) PT Pertamina (Persero) has requested the government to exempt excise fee on ethanol's raw material**, namely alcohol. This is part of **Pertamina's efforts to increase the octane rating of RON 90 fuel** (Pertalite), **to RON 92, as in Pertamax Green 92**

Law No.7 of 2021

Pasal 4

(1) Cukai dikenakan terhadap Barang Kena Cukai yang terdiri atas:

a. etil alkohol atau etanol, dengan tidak mengindahkan bahan yang digunakan dan proses pembuatannya;

b. minuman yang mengandung etil alkohol dalam kadar berapa pun, dengan tidak mengindahkan bahan yang digunakan dan proses pembuatannya, termasuk konsentrat yang mengandung etil alkohol; dan

c. hasil tembakau, yang meliputi sigaret, cerutu, rokok daun, tembakau iris, rokok

"Excise tax is imposed on Excisable Goods consisting of ethyl alcohol or ethanol, regardless of the material used and the manufacturing process."

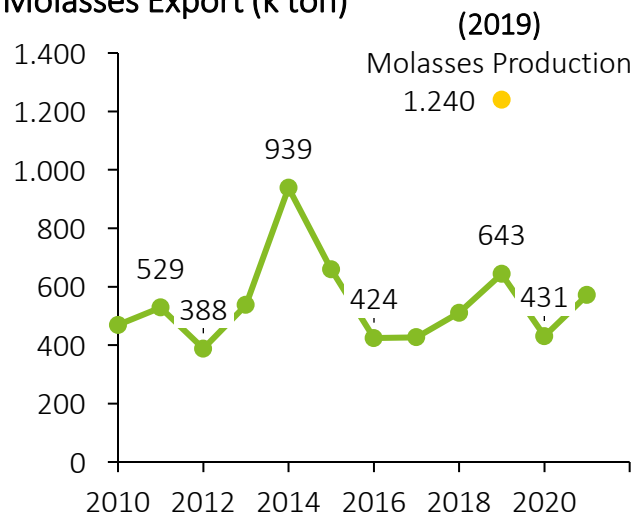
Source: Tax Directorate articles

A similar mechanism to the DMO can be applied to secure the domestic raw materials (molasses) quantity from export and shift them to bioethanol.

Restrictions on Molasses Export

Current Export Condition	• **Currently Indonesia there's still certain amount of molasses export volume, due to the small amount of molasses demand.** • (Molindo) There is no policies to limit the export of molasses (e.g., DMO), even though the **molasses quantity is still insufficient** to meet the fuel mixture needs. • (Molindo) **Traders have a critical role in influencing export values this will reflect the fluctuation of molasses price** • **In 2019, ~52% from total molasses production is being exported** • If the amount of molasses exports can be controlled to prioritize domestic needs, then **this export proportion can be shifted for use as bioethanol**.
Biodiesel Case	• **Indonesia has been facing a cooking oil crisis since late 2021,** with bulk cooking oil prices rising by ~47% and packaged cooking oil prices by ~73% • Government released "**Minister of Trade Regulation Number 30 of 2022** on the Export Provisions for Crude Palm Oil, Refined, Bleached and Deodorized Palm Oil, Refined, Bleached and Deodorized Palm Olein, and Used Cooking Oil" regarding **DMO and DPO policies** • **To be able to export a certain quantity**, palm oil producer must **meet domestic sales volume** (Domestic Market Obligation - DMO) **at a predetermined price** (Domestic Price Obligation – DPO)

Molasses Export (k ton)



Recent Updates on Palm Oil's DMO

(Jan 2022)
DMO volume : 20% from total export

(Mar 2022)
DMO volume : 30% from total export

Source: BPS Sugarcane Statistic Report 2021, Sugarcane Outlook 2022 by Ministry of Agriculture, various articles

Current use of EFB as fertilizer, biomass and other purpose are still expected to grow, this will have an impact on the stability of EFB prices

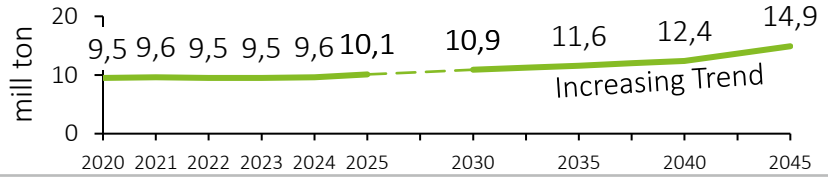
Realization of Stable EFB Price

Current Use of EFB

EFB as Fertilizer

- (GAPKI) Almost 50% of the Palm Oil Mills utilize their EFB as fertilizer for their oil palm plantation

Fertilizer Demand for Oil Palm Plantations



Fertilizer from EFB

EFB as Biomass

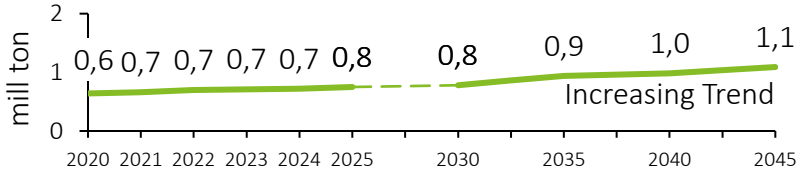
- (GAPKI) EFB will be used as a biomass for the "steam boiler" of palm oil mills
- (GAPKI) Approximately ~20% from the total EFB being generated (as waste) will be use as biomass for their own palm oil mills

Biomass from EFB

EFB as Other Purpose

- Aside from the main uses above, EFB is also usually used as animal feed and bioplastic

Potential Bioplastic Production from EFB



Animal Feed from EFB

Bioplastic from EFB

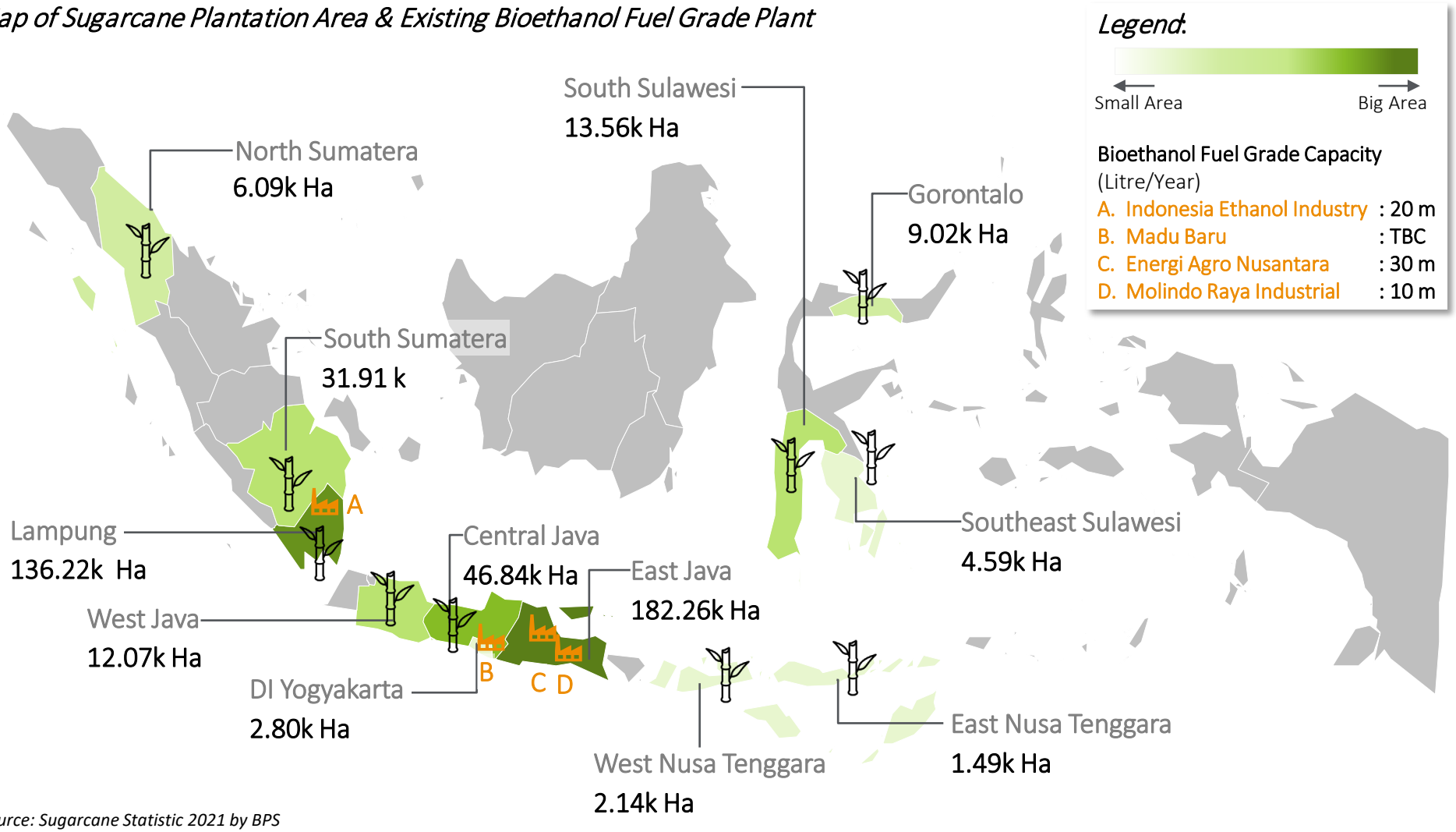
Source: The Indonesia Oil Palm Roadmap towards 2045 by GAPKI

Building the supply chain

Existing plantations is concentrated in Java, it's aligned with the government's target to prioritize bioethanol distribution in Java, the next step is to consider distribution networks outside Java

Development/investment for distribution chain

Map of Sugarcane Plantation Area & Existing Bioethanol Fuel Grade Plant

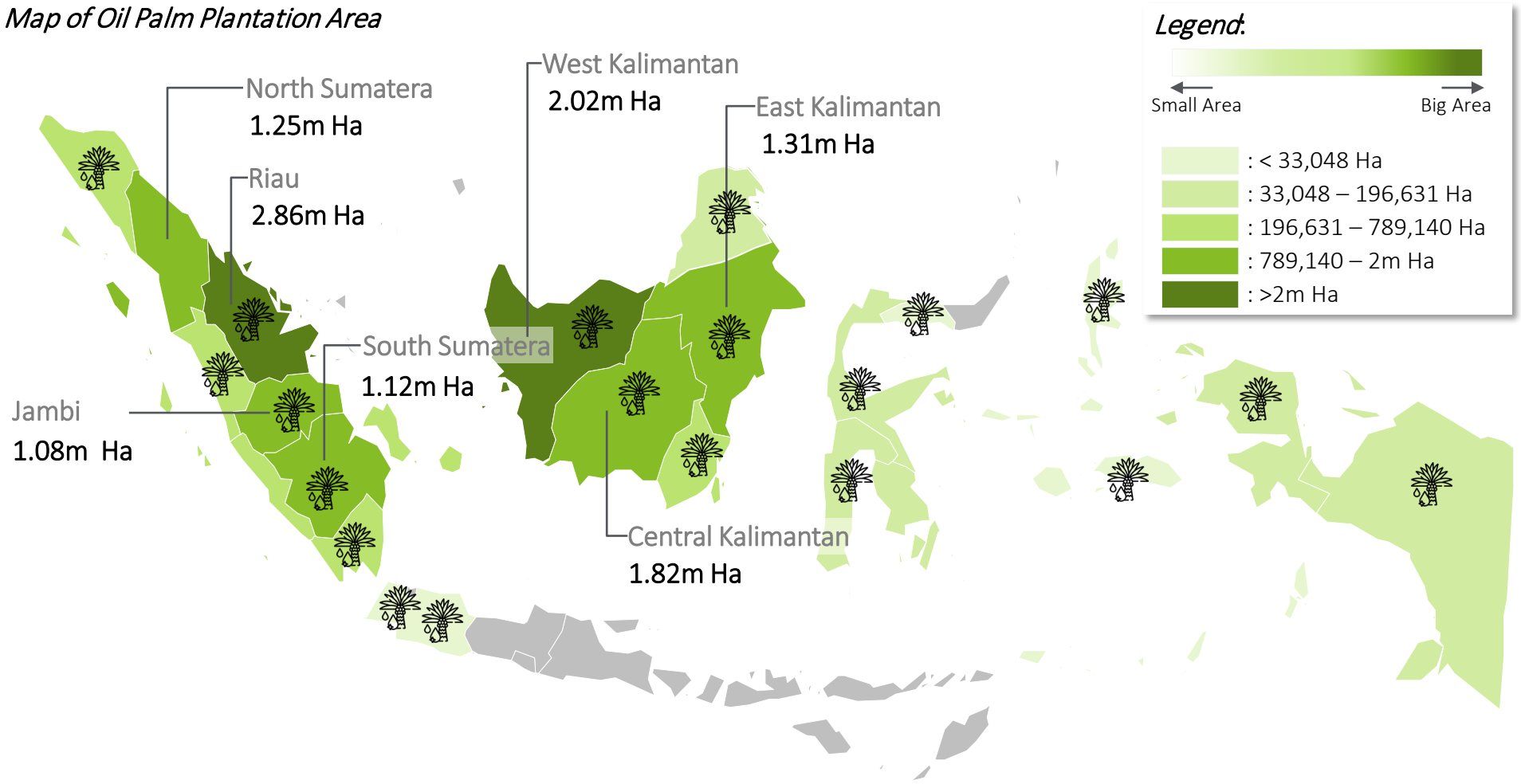


Source: Sugarcane Statistic 2021 by BPS

Oil palm plantation are more evenly distributed; even though it's quite rare on Java, oil palm is still easier to distribute compared to sugarcane

Development/investment for Efficient Supply Chain (1/3)

Map of Oil Palm Plantation Area

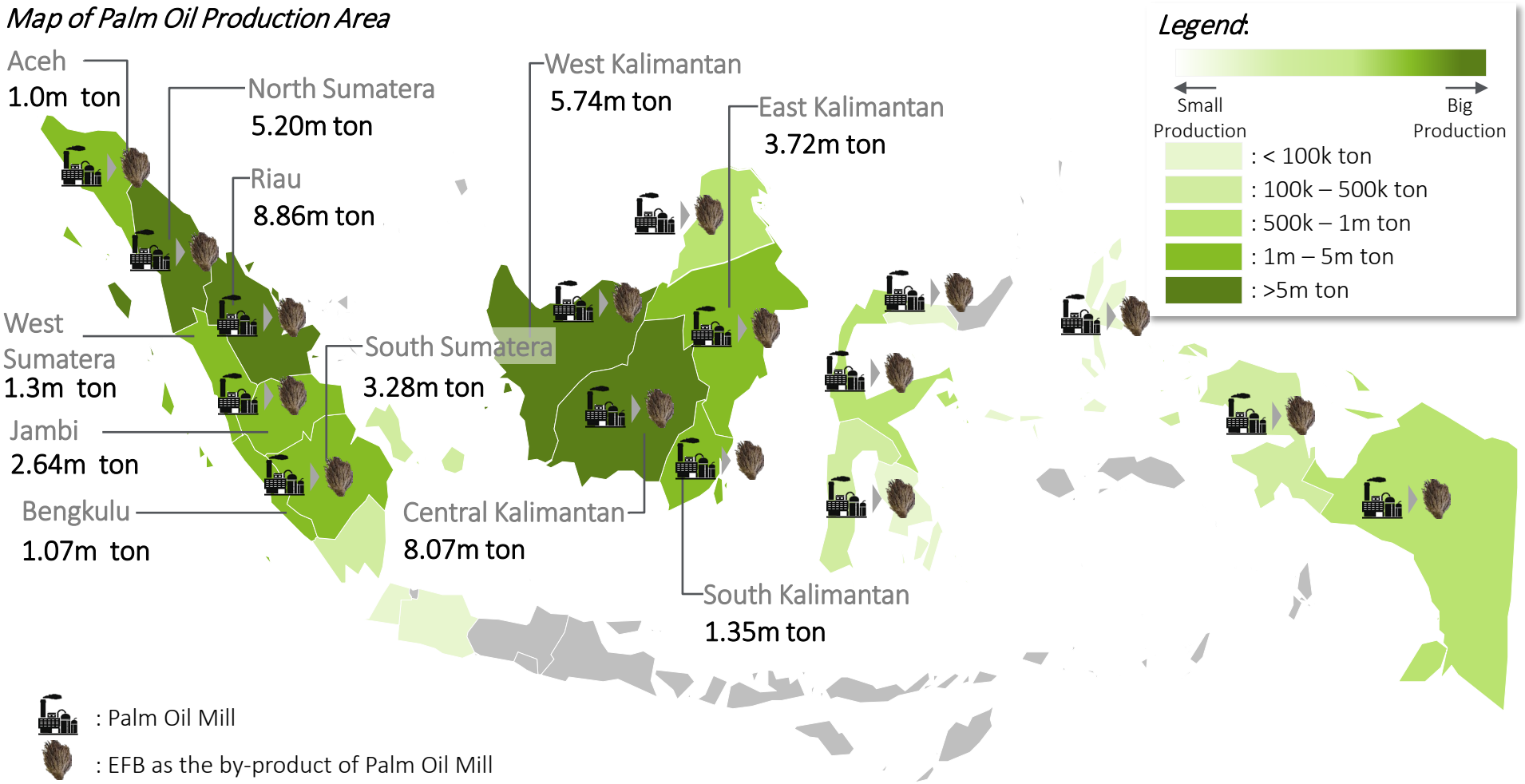


Source: Oil Palm Statistic 2021 by BPS

Palm Oil production map is an indicative way to locate EFB sources, the next step is to re-map the availability of EFB as raw material of 2nd gen from each palm oil mills

Development/investment for Efficient Supply Chain (2/3)

Map of Palm Oil Production Area

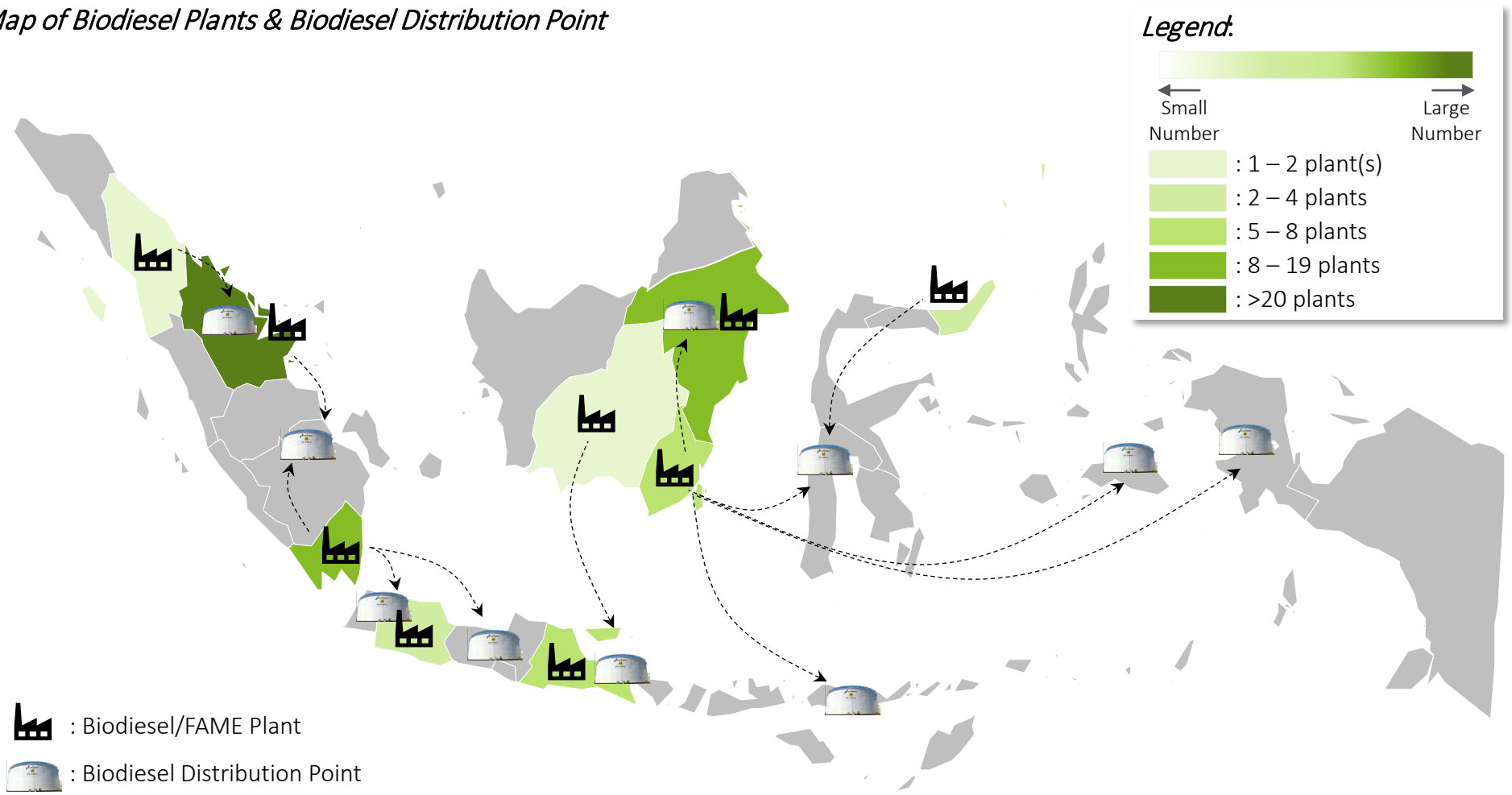


Source: Oil Palm Statistic 2021 by BPS

Although the biodiesel network has been established for 73 biodiesel plants and 10 distribution point, investigation is still needed to accommodate 2nd gen for EFB distribution network

Development/investment for Efficient Supply Chain (3/3)

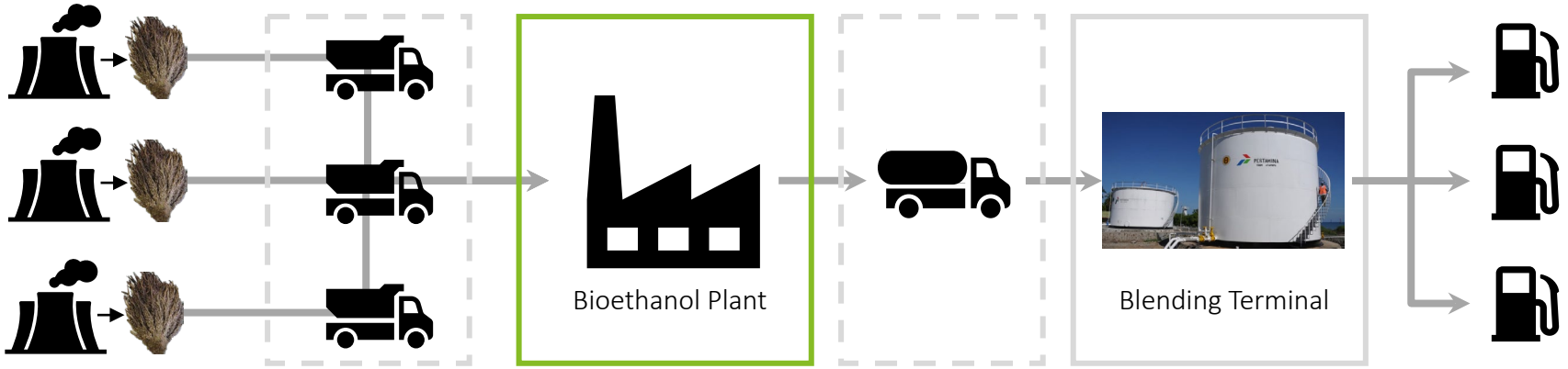
Map of Biodiesel Plants & Biodiesel Distribution Point



Source: MEMR Decree No. 252.K/10/MEM/2021, Journal titled "Meeting the bioenergy targets from palm oil based biorefineries: An optimal configuration in Indonesia"

If Bioethanol is to be proceeded, the plant and blending terminal cost components need to be considered. However, the transportation should also not be overlooked

2nd Generation Bioethanol Production Value Chain

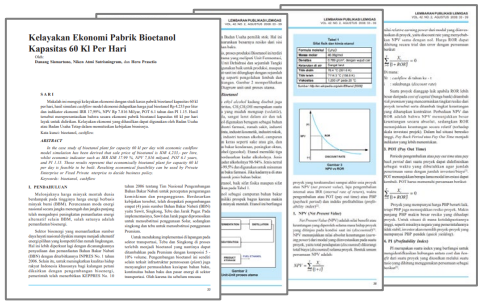


	Gathering	Transporting EFB	Processing	Transporting Bioethanol	Blending	Distributing
Detailed Activities	**Gathering Oil Palm Residue in form of Empty Fruit Bunches** (EFB) as a byproduct of several oil palm processing plants	**Transporting EFB** (as raw material) from several oil palm processing plant waste **to the bioethanol plant**	**Processing EFB to produce Bioethanol** in the Bioethanol Plant	**Transporting bioethanol to the blending terminal**	**Blending the gasoline with bioethanol to produce bio-gasoline** in blending terminal	**Distributing bio-gasoline** to several gas stations
Goods	Empty Fruit Bunches (EFB)		Bioethanol ~100 (~E-100)		Bio-gasoline (E-5/E-10/E-15, etc.)	

Source: GIIAS seminar materials by Pertamina

We have gathered some preliminary information regarding the costs/investment required to build a bioethanol plant and blending terminal

Benchmark Case(s)


Kelayakan Ekonomi Pabrik Bioetanol
Kapasitas 60 Kl Per Hari

1	Data Reference	Journal titled **"Economic Feasibility of a Bioethanol Plant" from** MEMR
	Year	2008
	Production Capacity	60 kilo liters / day
	Investment Needed	**82,389,225,000 IDR ~ 5.4 million USD (1 USD = 15,200 IDR)**

Case 2

2	Data Reference	PTPN X and NEDO built bioethanol plant
	Year	2012
	Production Capacity	30 million liters / year
	Investment Needed	**461,210,000,000 IDR ~ 30.3 million USD (1 USD = 15,200 IDR)**

Case 3

3	Data Reference	PTPN X built bioethanol plant in East Java
	Year	2015
	Production Capacity	30 million liters / year
	Investment Needed	**525,000,000,000 IDR ~ 34.5 million USD (1 USD = 15,200 IDR)**

Source: MEMR Journal, Ministry of Industry publications, various articles

2nd Gen technological innovation

The use of palm oil residue won't have any impact on environment, but activities at the 2nd gen plant still have the potential problems for the surrounding area.

2nd Generation Bioethanol from Environmental Perspective

Benefits of 2nd Gen

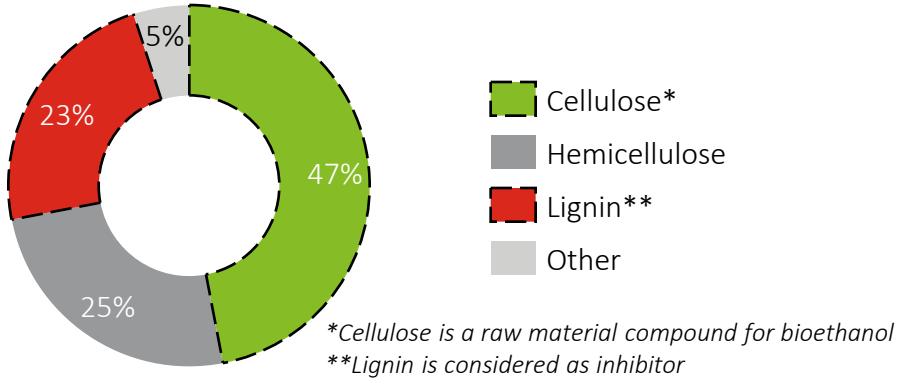
The use of oil palm residue won't cause **massive deforestation** due to expansion of palm oil plantation.

Potential issue for 2nd Gen

Data Reference: Journal titled **"Review of 2nd Generation Bioethanol Production from Residual Biomass"**

- Generally, **many inhibitors are generated during the pre-treatment** of lignocellulosic biomass, which can have a negative influence on ethanol production. **Inhibitors create severe environments**, seriously weakening fermentative microbes or causing their death.
- Potential local environmental issue has been identified on 2nd generation bioethanol plant caused by waste if not managed properly

Lignocellulose content in EFB



**Cellulose is a raw material compound for bioethanol*
***Lignin is considered as inhibitor*

Inhibitor	Description
 *Isolated Lignin (illustrative)*	Lignin is not a desirable component in plant cell walls, as it is **particularly difficult to biodegrade**. Its **recalcitrant character** makes this three-dimensional polymer molecule a **physical obstacle to the action of enzymes**. It is the most common aromatic polymer, and is considered the 'glue' that holds plants together

Source: International Journals

Several 2nd gen bioethanol feasibility studies have been carried out with EFB as raw material, but there has been no realization of the 2nd gen plant on a massive scale

Current state of technology in Indonesia

Local Independent Research	• Several local universities have done independent researches for 2nd generation bioethanol process:
	  ○ ITB (Bandung Institute of Technology)
	  ○ IPB (Bogor Agricultural Institute)
	  ○ UGM (Universities of Gajah Mada)
	• Most of the local researches **used empty fruit bunches (EFB)** as the raw material, considering **the abundance of EFB in Indonesia**

Government Research 1	• **In 2022**, BRIN together with KOICA (Korea International Cooperation Agency) and KIST (Korea Institute of Science and Technology), **bioethanol production 2nd gen Pilot Plant has been developed** and **able to produce bioethanol with a purity exceeding 99.6 percent**. • The raw material for 2nd Gen bioethanol is **lignocellulosic biomass** derived from palm plantation waste, specifically **empty fruit bunches (EFB).**
Government Research 2	• In 2008, together with MHI, BPPT started to conduct **feasibility study for 2nd gen Bioethanol plant using EFB as the raw material.** • BPPT established a small bioethanol plant with capacity of **8 kilo liters/day**

Source: International Journals, BRIN publication

Generally, there are some differences between 1st generation and 2nd generation production process, especially in the “pre-treatment” & “enzymatic hydrolysis”

Reference : Production processes between 1st gen and 2nd gen

Production Process of 1st generation Bioethanol

1

Milling

1) Milling includes **extracting the sugar juice out of the feedstock**. In the case of sugarcane molasses, the extraction process is easier as the cane juice comes straight from the feedstock.
2) **Dry/wet milling process** (depending on the type of crop) will produce a powder or paste form

2

Hydrolysis

1) The hydrolysis process is conducted for crops in order to **break down the enzymes into free sugars**, which produces **glucose** to be prepared for fermentation.

3

Fermentation

1) The fermentation is to **convert bioethanol through a biological anaerobic** process (using little to no oxygen).

4

Distillation & Dehydration

1) Distillation & dehydration is conducted to **separate the bioethanol from other by-products**, such as dried distillers' grains, through evaporation.

: major difference compared to the 1st gen

Production Process of 2nd generation Bioethanol

1

Pre-Treatment

Pre-treatment is conducted to **increase the surface area of carbohydrate** available for enzymatic hydrolysis (delignification), while minimizing the content of inhibitors through **Biological, Physical, Chemical, Physiochemical**.

2

Enzymatic Hydrolysis or Saccharification

The enzymatic hydrolysis process is conducted in order to **releases fermentable sugars, which are converted by microbial catalysts (enzymes) into ethanol.**

3

Fermentation

The fermentation is to **convert bioethanol by fermenting microorganisms** such as Saccharomyces cerevisiae yeasts.

4

Distillation & Dehydration

Distillation & dehydration is conducted to **separate the bioethanol from other components of the mixture, such as** unconverted polysaccharides, ash & compounds from delignification.

: minor difference compared to the 1st gen

Source: International Journals, BRIN publication

From a 2G technology perspective, the challenges lie in conditioning the quality of EFB as input material and ensuring the availability of the enzymes

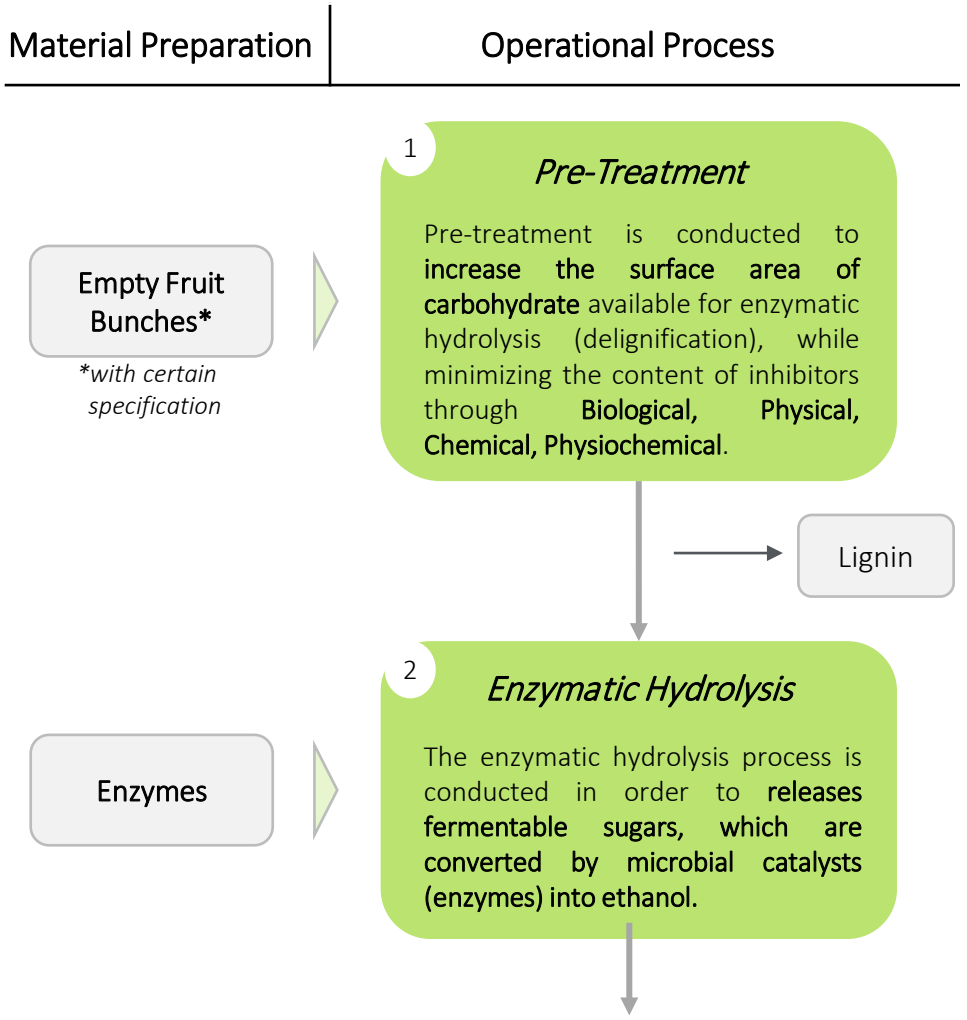
Study of the solution for the Lignin Removal

Difficulties in EFB Preparation

- (Molindo) **EFB as an input/raw material has a specific specification requirements** (e.g., wet/dry EFB) before entering the pre-treatment stage.
- **The specifications is very important**, it will affect the **hemicellulose compounds within the EFB**, which will **impact the yield and overall operational process efficiency.**
- (Molindo) **It's difficult to maintain the quality of EFB inputs according to the required specifications** due to the variability of raw materials obtained from each palm oil mills.

Unavailability of the Enzymes

- **Currently the enzymes being used for hydrolysis is not commercially available in Indonesia**.
- Based on current research, **the need to import enzymes from Denmark** has an impact on high production costs
- Enzymes have been produced in Indonesia but **in a small-scale production** / research purpose only (laboratory scale)
- (Molindo & ITB) **Enzymes is very substantial** in the 2nd gen bioethanol, **it accounts for ~50% from total production cost**



Source: BRIN publication, Indonesian Institute of Sciences (LIPI) articles, International Journals, Expert Interviews

4. Suggestions for next actions

Continued in-depth research needs to be carried out to establish a path to some degree of resolution for the issues highlighted in this phase. Engage stakeholders on the basis of the results

Suggestions for next actions

Phase 2 onwards: further capability studies (continued deep dive)

	Type	Challenges identified	Next action
Short term	Expansion of policies and subsidies	Realization of stable prices based on price differentials with gasoline	Policy framework study
		Realization of stable domestic prices through elimination of excise duty and introduction of DMOs to control exports	
	Building efficient SC	Clarification of 1G supply capability	1G's ideal supply chain study
Mid-Long term	Risk hedge	Selection of sustainable raw materials as a medium- and long-term measure	Alternative raw material capability studies
	Building efficient SC	Achieving effective residue recovery	2G's ideal supply chain study
		Realization of cost-minimizing SC	
		Investment decisions for new facilities	
	2nd Gen technological innovation	Narrowing down target raw materials	R&D promotion direction study
		Establishing lignin removal process	
		Establishing domestic production & procurement schemes for enzymes	

Bioethanol National commercialization concept

Involve the government and stakeholders mainly for 2G deployment and launch as a national PJ

- Establishment of Public-Private Councils/Platform
- Scheme review
- Alliance study
- Profitability simulation
- Planning of implementation plan

etc.

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