NEDO成果報告書

Study for Ammonia Supply Chain Development in Indonesia and Vietnam

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

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Nomura Research Institute
Thailand

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Project Overview

Task 1: Overview of the Energy Landscape in Indonesia and Vietnam

Task 2: Public Policy for Ammonia in Indonesia and Vietnam

Task 3: Company Activity for Ammonia Supply Chain Development

Tasks – Objective and Approach

Energy landscape, public policy, activity by companies, and overseas movement will be identified, to understand how ammonia market will develop in the country.

	Name of Task	Objective of Task	Research Scope
Task 1	**Overview of the Energy Landscape in Indonesia and Vietnam**	• To understand the trend for energy which is related to ammonia's supply and demand	• GHG reduction target • Forecast for energy demand by energy source type • Power generation plan
Task 2	**Public Policy for Ammonia in Indonesia and Vietnam**	• To understand how the government is planning on supporting the ammonia development	• Consideration for public policy, roadmap, and regulations • Partnerships with other overseas countries
Task 3	**Activities by Companies for Ammonia Supply Chain Development in ID and VN**	• To understand which players are going to be the key players, and what will be the main focus of the player's activities	• Key local companies within each of the supply chain process • Activities by each of the local companies (e.g. Demonstration projects, partnerships with overseas companies)

Key Takeaways from the Project

- Within Indonesia and Vietnam, to achieve carbon neutral and GHG reduction targets, the government is shifting towards transition to clean energy. Ammonia and hydrogen is considered as one of the key enablers, and this is already reflected in the latest public policies and discussions for policy development

- Major local companies are also aiming to leverage ammonia for decarbonization, in which partnership with international companies across regions (e.g. Asia, Europe) are observed, as well as movement towards the development of both domestic and international supply chains

- Japan's public policy and technology can be leveraged to support the above movement, given that Japanese companies can provide advanced technology across the supply chain for both the supply and demand for fuel ammonia

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Energy Landscape – Summary (1/2)

Future increase in renewable energy supply capacity is expected for both Vietnam and Indonesia.

Summary of Energy Landscape Related to Ammonia (1/2)

Supply Chain	Ammonia Type	Topics Related to Energy		Indonesia	Vietnam	(Reference: Japan)
Production	Ammonia (Overall)	① Ammonia Production		• Total: N/A • [Reference] PT Pupuk (Key producer): **6.2 mn tons** (2020)	• Total: N/A • [Reference] PetroVietnam (Key producer): **0.5 million tons** (2021)	• **0.7 million tons** (2020)
		(Reference): Conversion to energy		• Equivalent to **114 petajoule** (PJ)	• Equivalent to **10 petajoule** (PJ)	• Equivalent to **14 petajoule** (PJ)
	Green Ammonia	②Renewable Energy	Current Installed Capacity (2020)	• **7.6GW** (12% of total) • Breakdown: Hydro 4.9GW, geothermal: 2.4GW, other renewable: 0.3GW	• **38.3GW** (55% of total electricity) • Breakdown: Hydro: 20.8GW, solar: 16.7GW, wind: 0.5GW, biomass 0.4GW	• **121.7GW** (19.8% of total electricity) • Breakdown: solar: 61.6GW, hydro: 50.0GW, biomass: 5.0GW, wind: 4.5GW, geothermal: 0.6GW
			Future Target	• **28GW** in 2030 (28% of total electricity) • Breakdown: Hydro: 15.4GW, geothermal: 5.4GW, others: 6.5GW	• **68.4GW** in 2030 (47% of total electricity) • Breakdown: Hydro: 28.9GW, other renewable (39.5GW)	• **187.8~201.8GW** in 2030 (36~38% of total electricity) • Breakdown: Solar:104~118GW, hydro: 50.7GW, wind: 23.6GW, biomass: 8.0GW, geothermal: 1.5GW
			Relevant Policy for Future Target	• **RUPTL 2021-2030** (Launched in 2021)	• **PDP 8 draft** (Nov 2022 version) *Originally planned to be launched in 2020, but being delayed	• **Sixth Strategic Energy Plan** (Launched in 2021)
			Generation Cost (2020)	• Hydro: **USD 0.05** (kWh) • Solar: **USD 0.03** (kWh)	• Hydro: **USD 0.03** (kWh) • Solar: **USD 0.05** (kWh)	• Hydro: **USD 0.14** (kWh) • Solar: **USD 0.09** (kWh)
	Blue Ammonia	③CCS / CCUS	Inclusion in Green Policy	○ Long-Term Strategy for Low Carbon and Climate Resilience 2050	X (No mention in public policy)	○ Included in major green policy
			Key Milestones	Key project (Tangguh EGR/CCUS) targeted for **2026~**	Focusing on understanding feasibility of CCS/CCUS at the moment	Aims to commercialize by **2030**

Source: Created by NRI based on publicly available sources

Energy Landscape – Summary (2/2)

Installed capacity for coal is expected to increase in both Vietnam and Indonesia, presenting opportunities for ammonia co-fire power generation

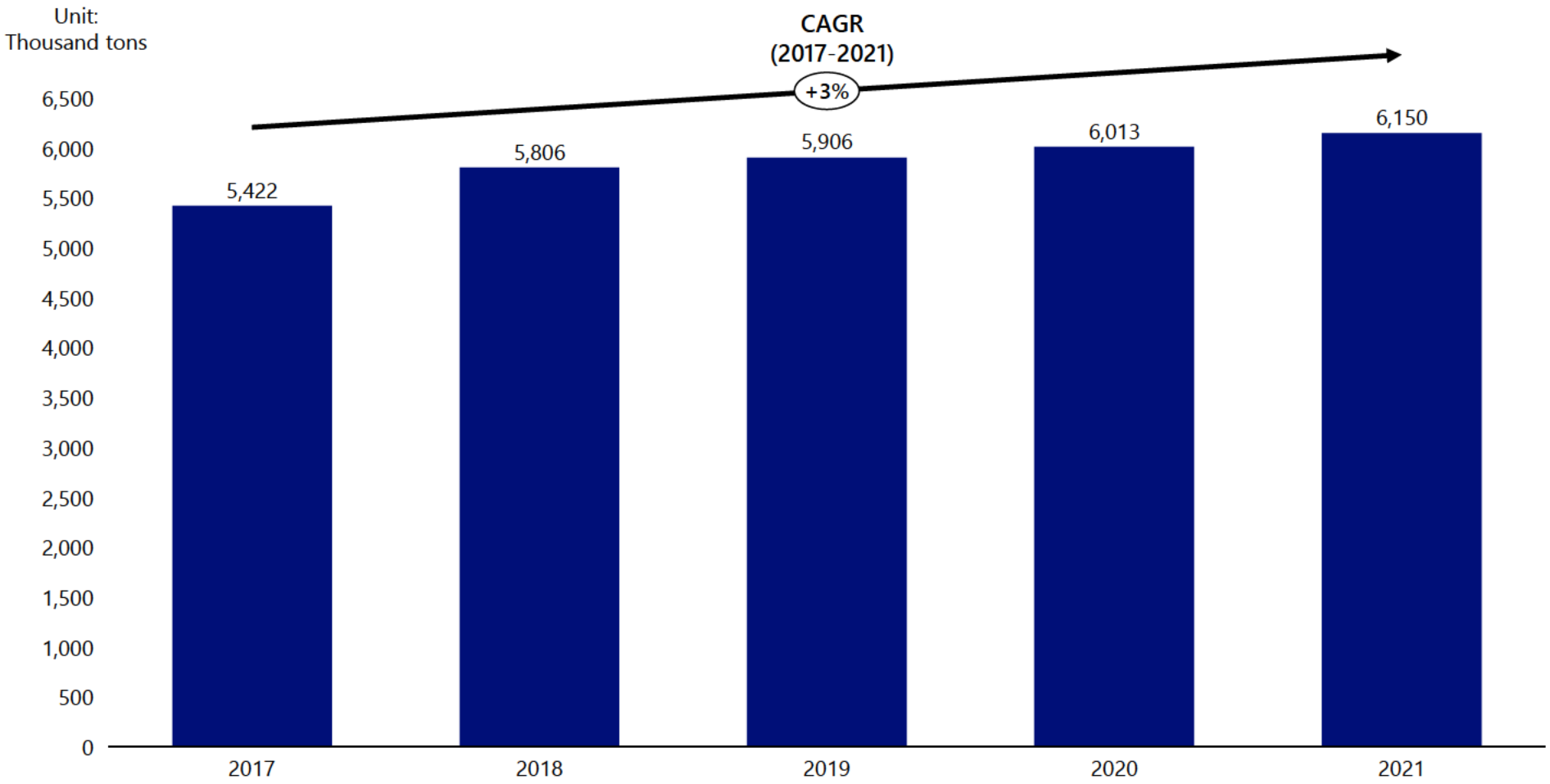
Summary of Energy Landscape Related to Ammonia (2/2)

Supply Chain	Ammonia Type	Question for Energy		Indonesia	Vietnam	Japan
Utilization	Coal-fire Power Generation	④ Power Generation	Current	• Installed Capacity in 2020: **31GW** (51% of total)	• Installed Capacity in 2020: **21.6GW** (31% of total)	• Power generation in 2019: **0.3 million GWh** (32% of total)
			Future Target	• **44.8GW** (44% of total)	• **36.3GW** (25% of total) in 2030	• **0.2 million GWh** (19% of total) in 2030
			(Reference): Ammonia amount if 20% ammonia co-fire is conducted	• Current: **10.5 million tons** (Equivalent to **196 petajoules**) • Future Target: **16.3 million tons** (Equivalent to **303 petajoules**)	• Current: **7.3 million tons** (Equivalent to **136 petajoules**) • Future Target: **12.3 million tons** (Equivalent to **245 petajoules**)	• Current: **13.2 million tons** (Equivalent to **245 petajoules**) • Future Target: **6.9 million tons** (Equivalent to **128 petajoules**)
	Fuel vessels	⑤ Energy utilization for fuels		• N/A	• N/A	• N/A
	Heat utilization	⑥ Energy utilization in the industrial sector		• N/A • (Reference: Energy consumption for industry: ◦ 2020: **45.8 Mtoe** ◦ 2030: **68.0 Mtoe**	• N/A • (Reference: Energy consumption for industry: ◦ 2020: **38.1 Mtoe** ◦ 2030: **55.2 Mtoe**	• N/A • (Reference: Energy consumption for industry: ◦ 2020: **85.0 Mtoe** ◦ 2030: **79.6 Mtoe**

Source: Created by NRI based on publicly available sources

PT Pupuk, key producer of ammonia in Indonesia has produced over 6 million tons of ammonia in 2021, in which production volume has shown stable growth

Production Volume of Ammonia by PT Pupuk Indonesia (Persero)

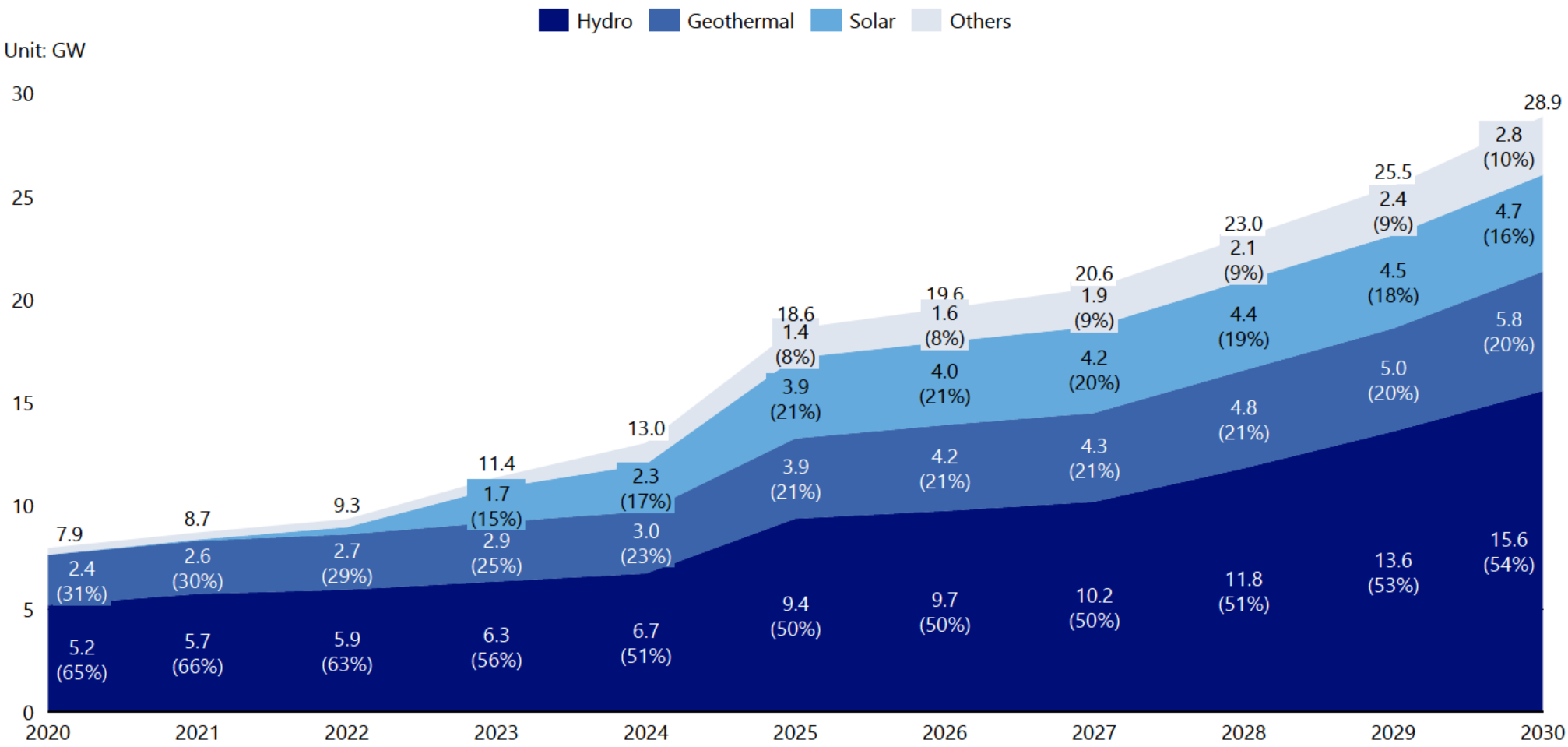


Source: Created by NRI based on company webpage of PT Pupuk Indonesia

② Renewable Energy – Installed Capacity (Current & Target)

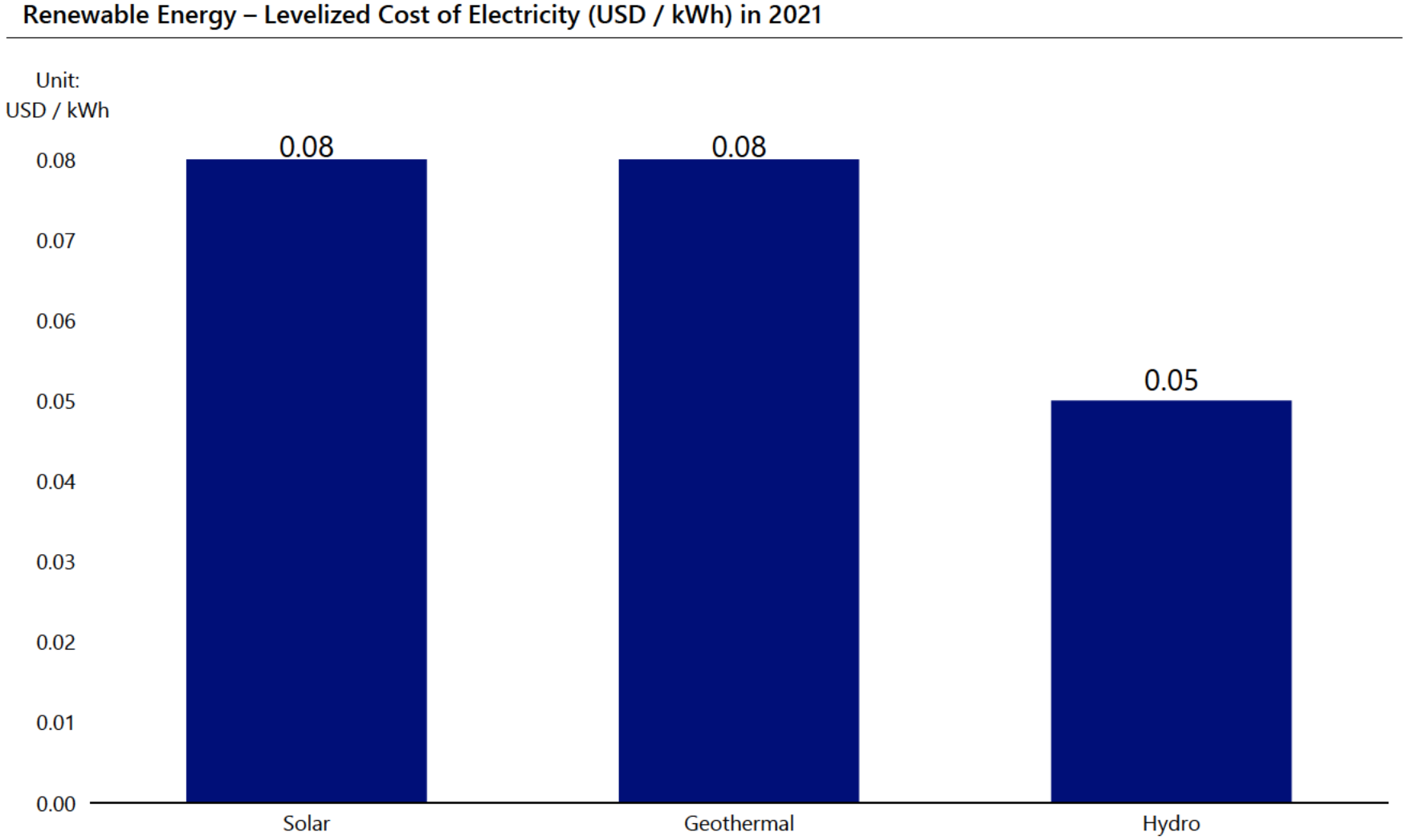
ID aims to increase renewable energy capacity to more than 3 times in 21-30, in which the percentage of solar is expected to increase the most significantly.

Renewable Energy – Installed Capacity Target (RUPTL 2021-2030)



Source: Created by NRI based on Baker McKenzie

Hydro has the lowest power generation cost, compared to solar and geothermal



Source: Created by NRI based on IRENA

③ CCS / CCUS – Current Policy

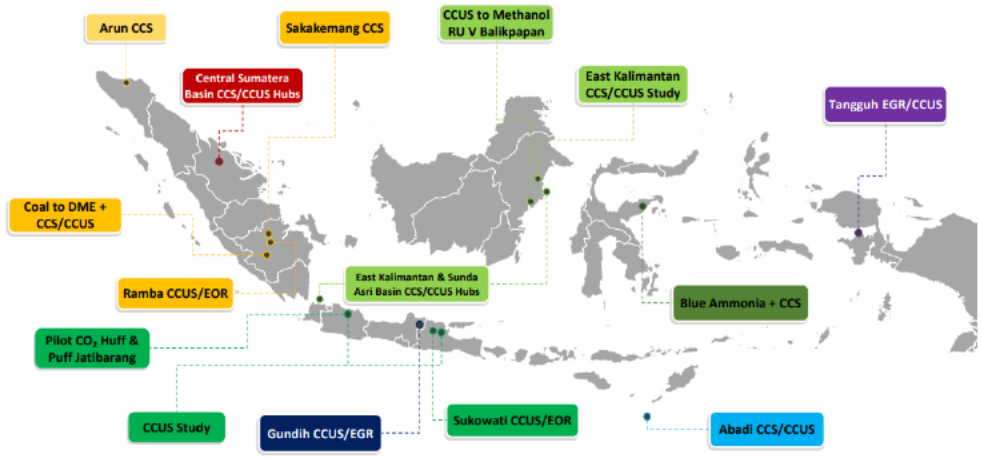
CCS / CCUS consideration is still at an early stage, in which gov. and major local energy companies have yet to set targets on implementation in Vietnam

Government's Green Policy – Commentary on CCS / CCUS

Policy Name	Commentary on CCS / CCUS
Long-Term Strategy for Low Carbon and Climate Resilience 2050	• CCS / CCUS is included within the key green policy Indonesia Long-Term Strategy for Low Carbon and Climate Resilience 2050 (Indonesia LTS-LCCR 2050) • Within the policy, the government states the following for CCS / CCUS ◦ For energy sector, leveraging CCS / CCUS and BECCS is one of the key initiatives for GHG emission reduction, in addition to raising the proportion of renewable energy in energy mix, and increasing the energy efficiency • The government aims for the following by 2050 ◦ 76% of total coal power plants are to be equipped with CCS by 2050 ◦ BECCS accounts for 23GW (Total renewable energy: 271GW) within the installed capacity of renewable energy

Example of CCS/CCUS Projects in Indonesia

- As of August 2022, 15 CCS/CCUS activities in Indonesia are in the study / preparation stage
- Most of the projects are targeted for on-stream before 2030
- Within the projects, CCS for blue ammonia is included, which is a joint study between Pertamina and Japanese companies such as JOGMEC and Mitsubishi

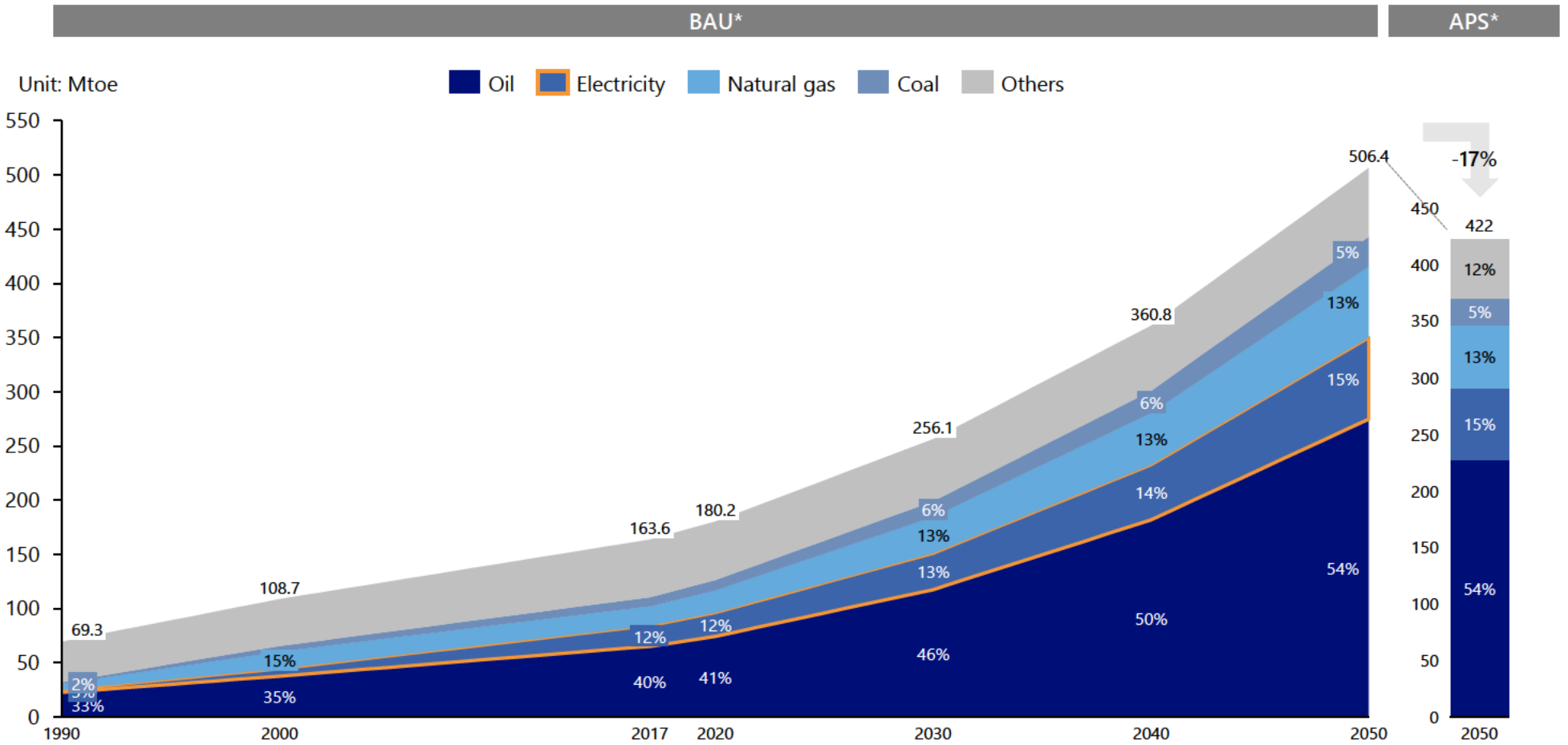


Source: Created by NRI based on UNFCCC, Ministry of Energy and Mineral Resources

④ Power Generation - % within Total Energy

Energy demand is expected to increase in the future, in which increase in electricity consumption will also drive the energy demand.

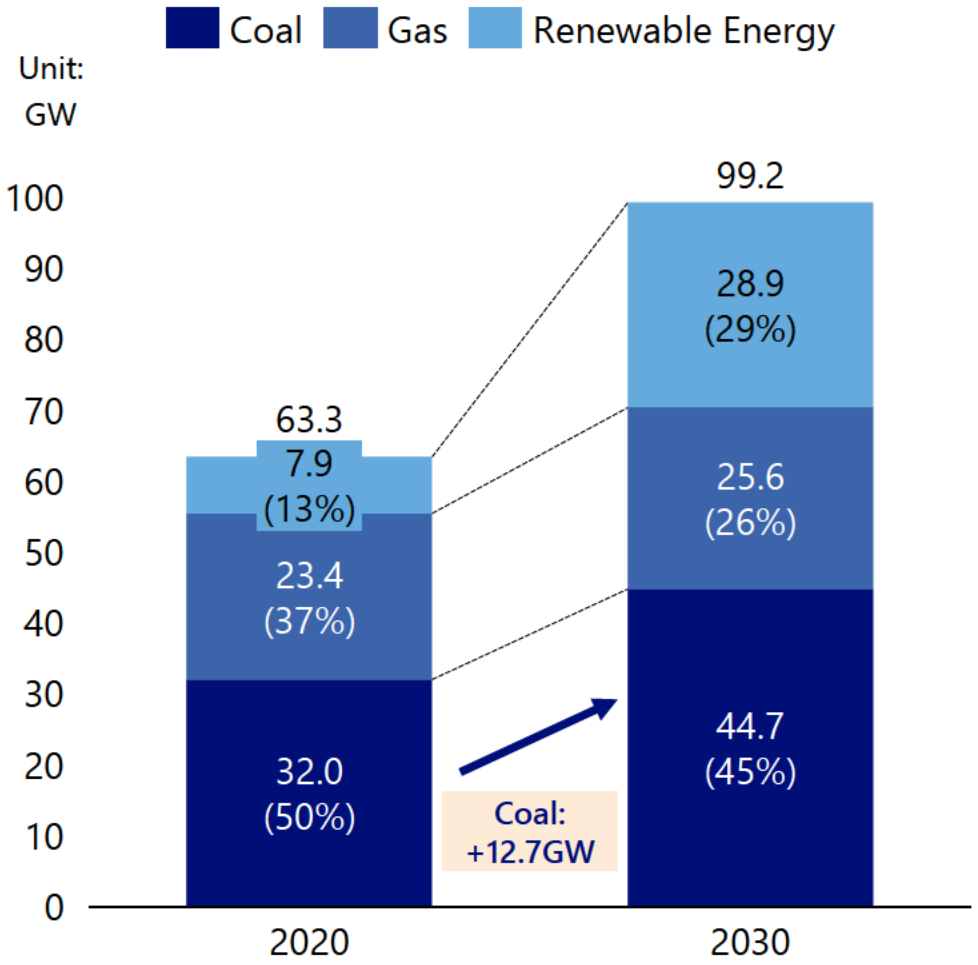
Final Energy Demand by Fuel Type, BAU* and APS*



Source: Created by NRI based on ERIA

Government aims to reduce the proportion of coal power generation, but the installed capacity is expected to increase from 2020 to 2030

Power Generation – Installed Capacity Target (RUPTL 2021-2030)



Source: Created by NRI based on ESDM, Baker McKenzie

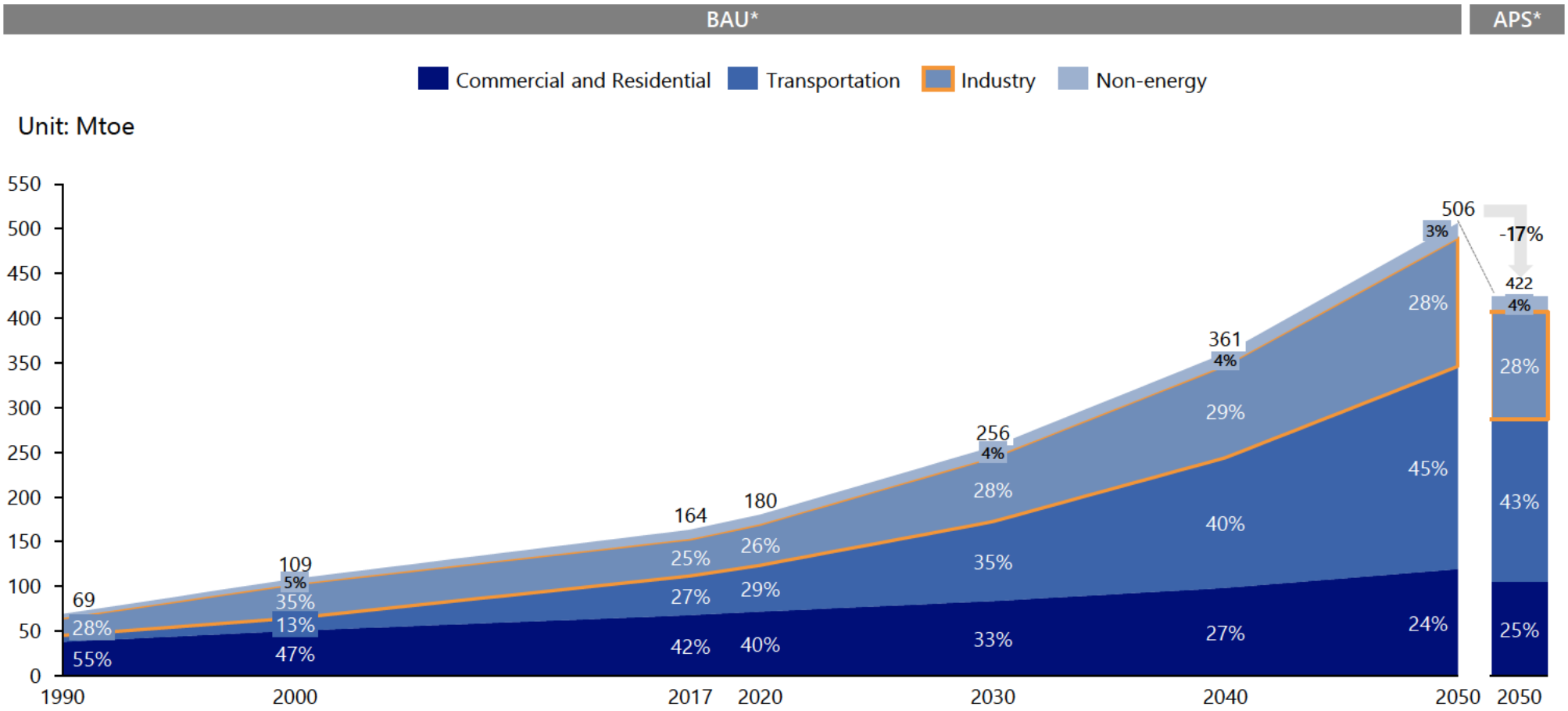
Commentary in RUPTL 2021-2030 on Coal Power Generation

Key Targets	Description
Biomass Co-firing	• The new RUPTL includes PLN's plan to mix coal with biomass for coal fired power plants. • The plan identified 18,895 MW capacity of coal-fired pow er plants located in 52 locations that have the potential for co-firing
Retiring Aging Coal-Fired Power Plants	• The new RUPTL includes a short description of PLN's plan for retiring aging coal-fired pow er plants. • How ever, it does not set a target for the retirement of all coal-fired pow er plants by 2056

⑤ Manufacturing

Energy demand for industry usage is expected to increase from 26% in 2020 to 28 % in 2030.

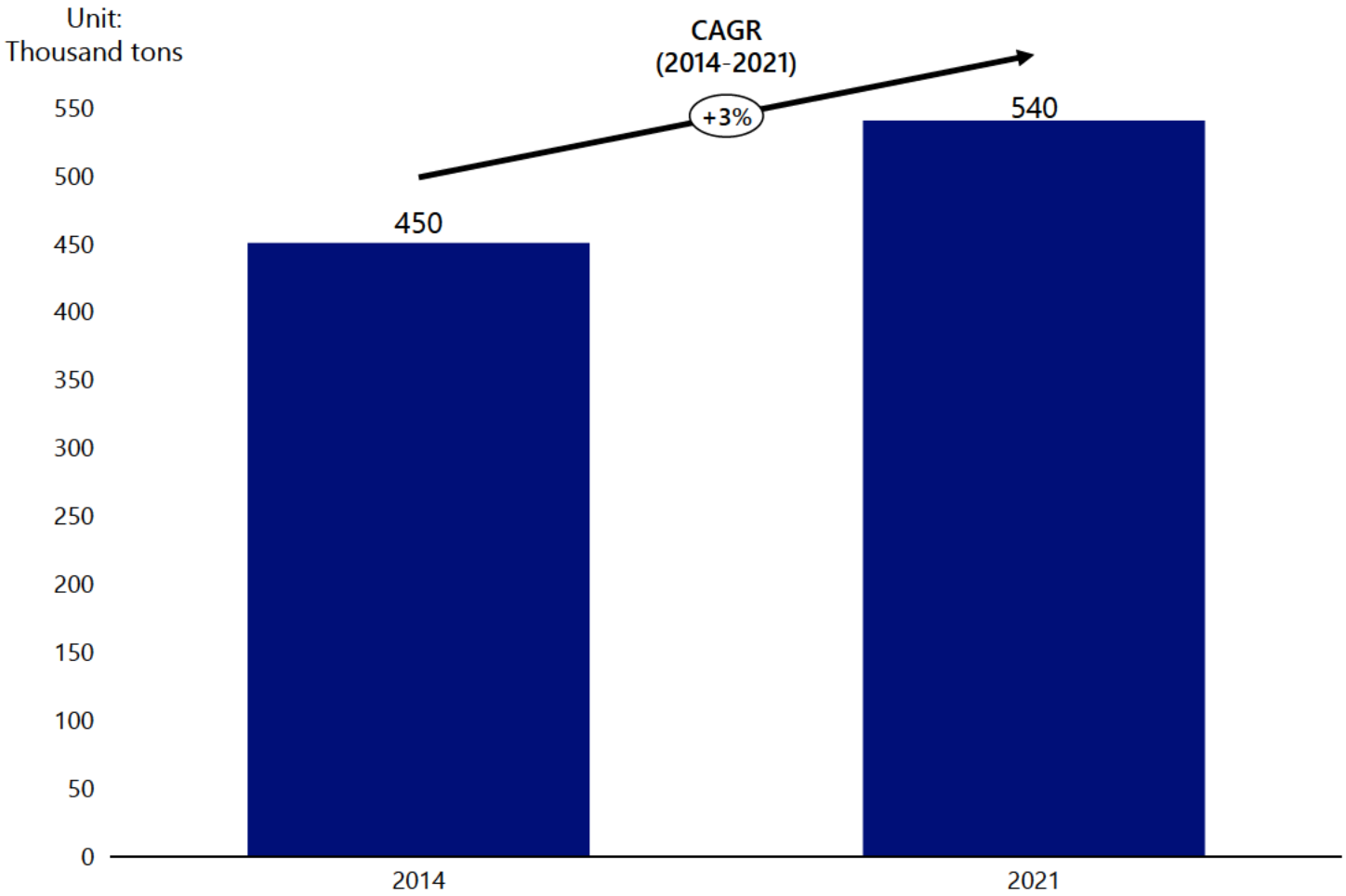
Final Energy Demand by Sector, BAU* and APS*



Source: Created by NRI based on ERIA

PetroVietnam, key producer of ammonia in Vietnam has production capacity of 540 thousand tons of ammonia in 2021.

Production Capacity of Ammonia for PetroVietnam

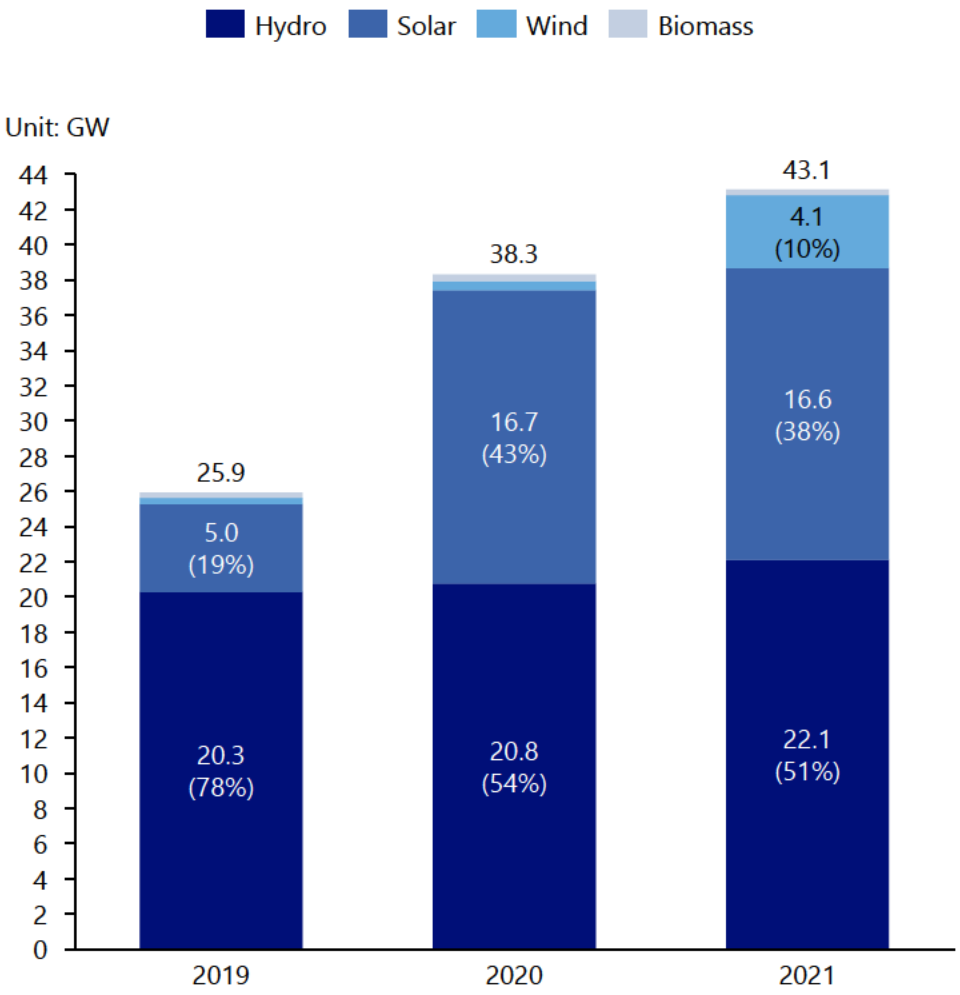


Source: Created by NRI based on news articles and PetroVietnam webpage

② Renewable Energy – Installed Capacity

Vietnam's installed capacity for solar power generation shown increase in 2020, in which the future target is currently being drafted in PDP 8.

Installed Capacity for Renewable Energy in Vietnam (2019-2021)



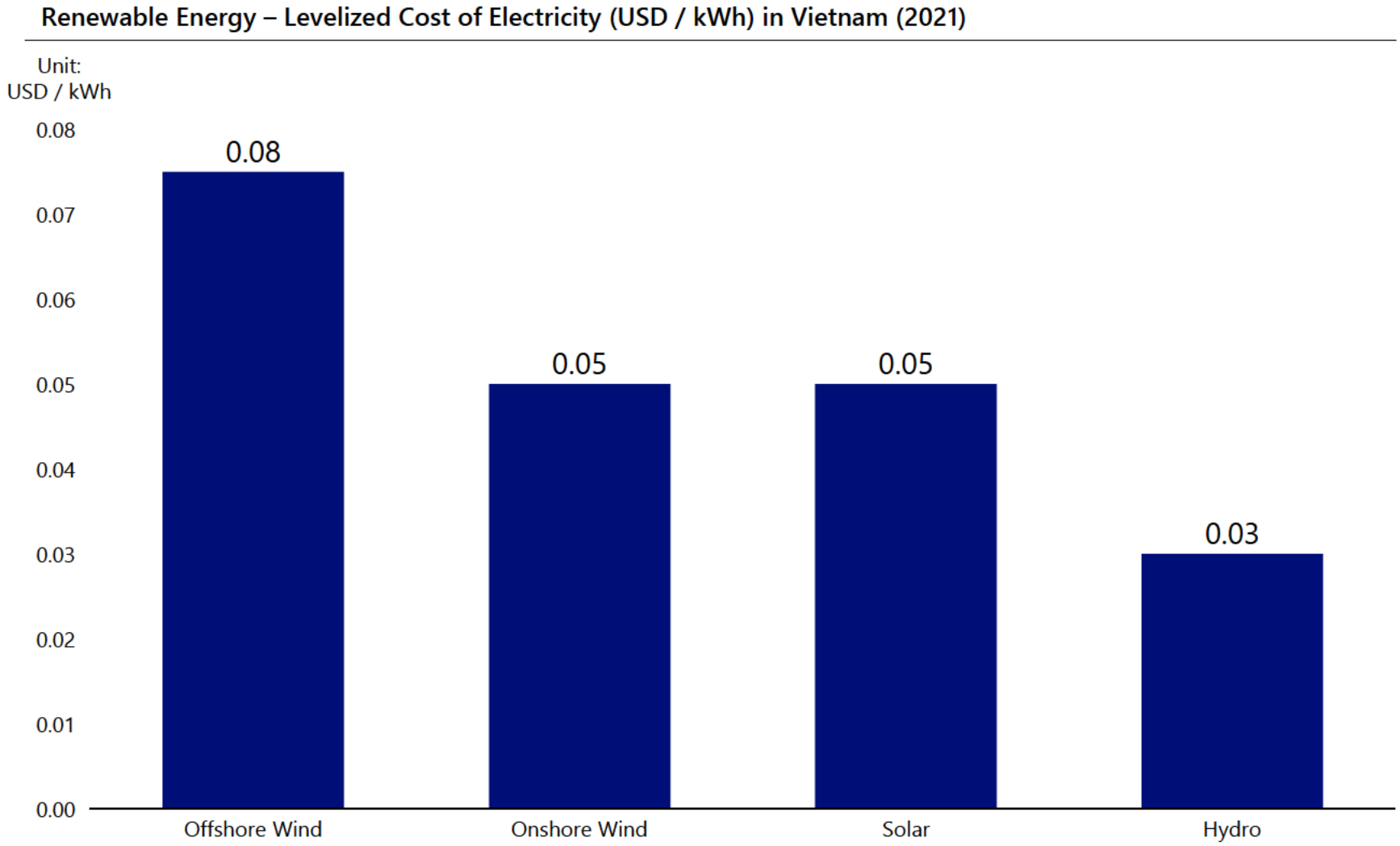
Source: Created by NRI based on JETRO

Installed Capacity for Renewable Energy in VN (Future Draft Target)

Unit: GW

Key Targets	2021	2030 (Draft PDP8 – 6th Draft)
Hydro	22.1	27.4 - 28.9
Solar	16.6	21.9 - 34.5
Wind	4.1	
Biomass	0.3	
Others	0.0	
Renewable Energy Total (Sum of above)	**43.1**	**49.2-68.4**

Hydro has the lowest power generation cost, compared to other renewable energy types.



Source: Created by NRI based on IRENA

CCS / CCUS consideration is at an early stage, in which public policy does not include commentary on CCS, but major energy companies are showing interest.

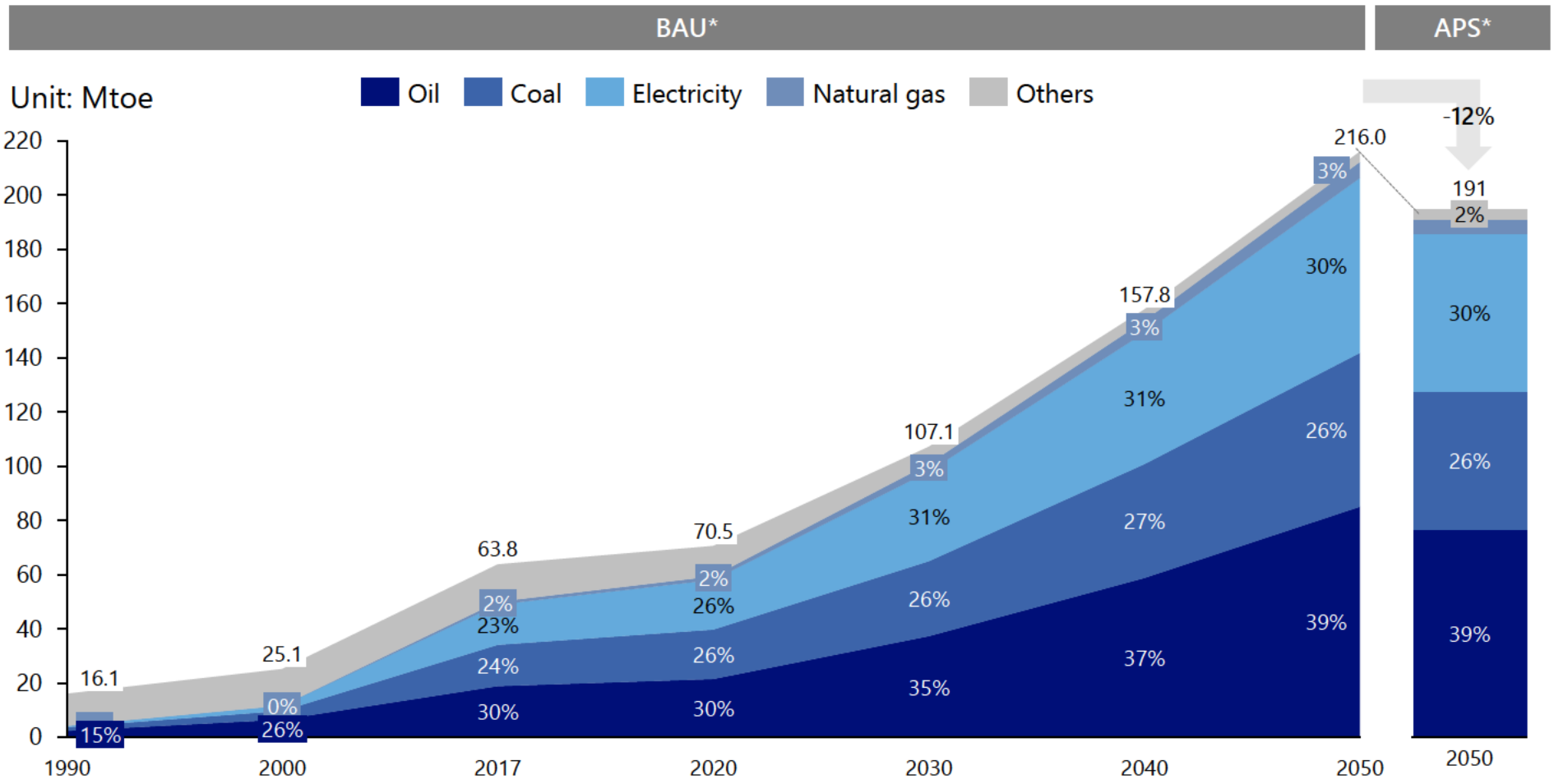
Public Policy for CCS / CCUS

Key Targets	Description of Target
Government Policy	• No target for CCS / CCUS, within the key public policy related to green ("National Green Growth Strategy for the 2021-2030 period, vision towards 2050")
Activities by Private Companies	• PetroVietnam: ◦ Partnered with JOGMEC to conduct a geological evaluation of the target area, CO2 emission source survey, and business environment survey, to investigate the feasibility of possible CCS/CCUS projects in Vietnam. ◦ Signed MOU with Asian Development Bank (ADB) on November 2021, regarding the establishment of a strategic partnership for 2021 – 2024 to promote clean and renewable energy development including CCS/CCUS ◦ Conducted meeting with Norwegian energy firm Equinor, to discuss about partnerships including CCS/CCUS

Source: Created by NRI based on news articles

Energy demand is expected to increase in the future, in which increase in electricity consumption will also drive the energy demand.

Final Energy Demand by Fuel Type, BAU* and APS*

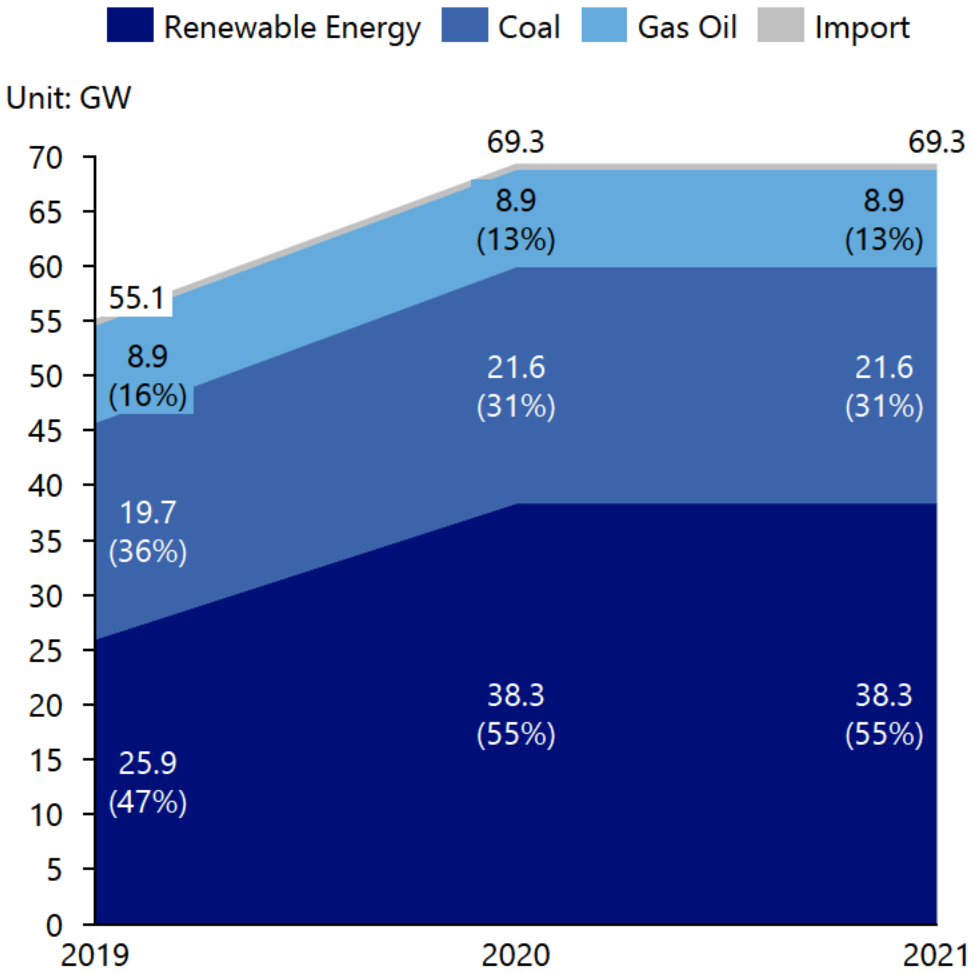


Source: Created by NRI based on ERIA

④ Power Generation – Coal Fire Power Generation Target

Usage of coal will remain to be prominent in power generation, providing opportunities for ammonia to be leveraged for co-fire.

Installed Capacity for Power Generation (2019-2021)



Source: Created by NRI based on JETRO, News Article

Installed Capacity for Power Generation (Target from Draft PDP 8)

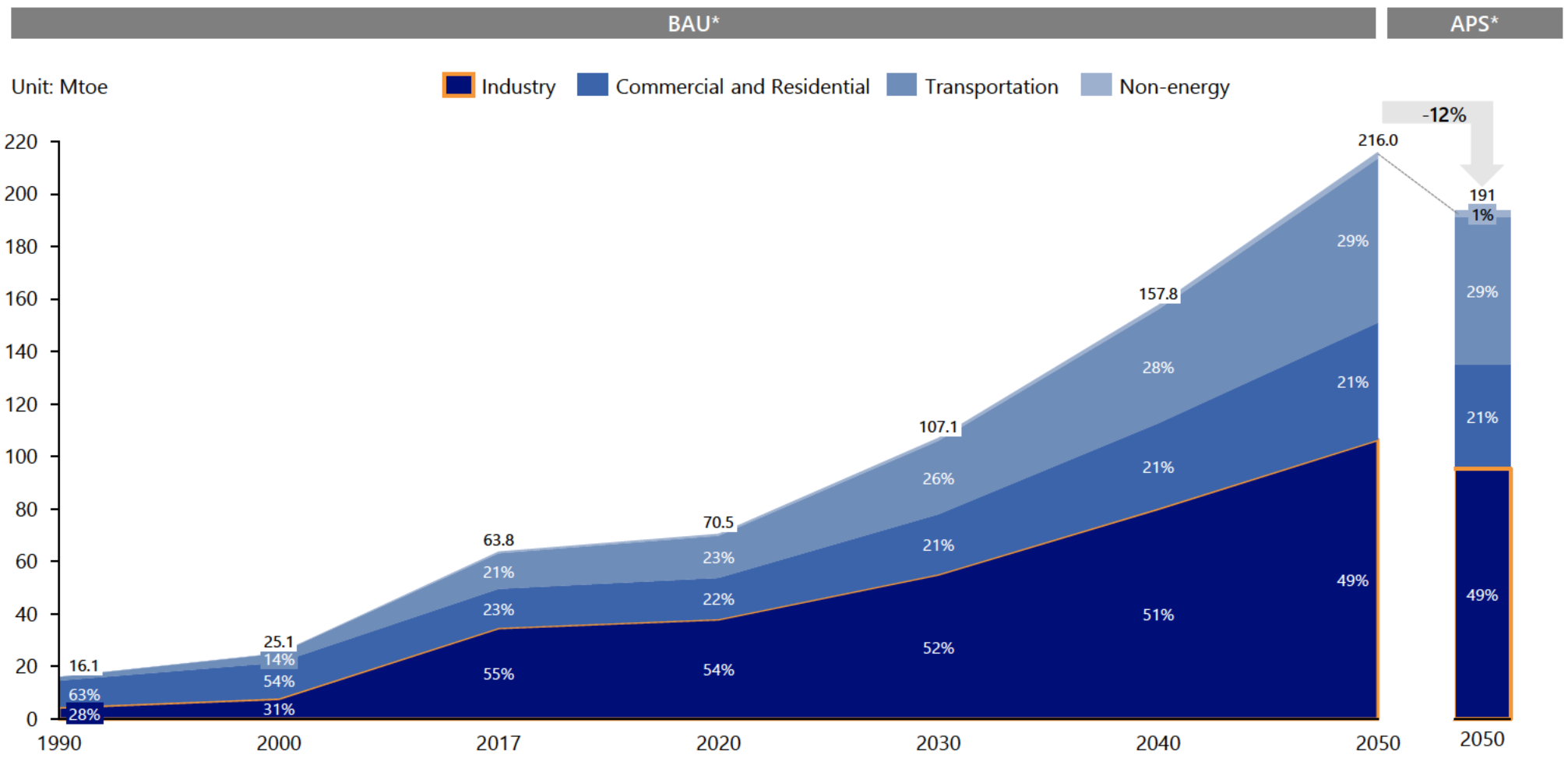
Unit: GW

Key Targets	2021	2030 (Draft PDP8 – 6th Draft)
Renewable Energy	38.3	49.2-68.4
Coal	21.6	30.1-36.3
Gas Oil	8.9	30.3-39.4
Import	0.6	4.1-5.0
Energy Total (Sum of above)	**55.1**	**121.8-146.0GW**

⑤ Manufacturing

Energy demand for industry usage is expected to remain as the industry with the highest energy consumption, accounting for over 50% in both 2020 and 2030.

Final Energy Demand by Fuel Type, BAU* and APS*



Source: Created by NRI based on ERIA

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ID's public policy / roadmap covers both production of green/blue ammonia and utilization, whilst for VN, the focus is on utilization of ammonia.

Summary of Public Policy (1/2)

Category	Sub-category	Indonesia		Vietnam	
1. Carbon Neutral and GHG Policy	Carbon Neutral target	○	• Announced in COP26, to achieve net-zero emission by **2060 or sooner**	○	• Announced in COP26, to achieve net-zero emission by **2050**
	GHG reduction target by 2030	• Unconditionally: **29%** (NDC 2021) ⇒ **31.89%** (NDC 2022) • Conditionally: **41%** (NDC 2021) ⇒ **43.2%** (NDC 2022)		• Unconditionally: **9%** (NDC 2020)⇒ **15.8%** (NDC 2022) • Conditionally: **27%** (NDC 2020)⇒ **43.5%** (NDC 2022)	
	Key public policies related to green	• Long-term Strategy for Low Carbon and Climate Resilience 2050 (LTS-LCCR 2050)		• National Green Growth Strategy for the 2021-2030 period, vision towards 2050	
2. Public Policy for Ammonia	Inclusion ammonia in green policy	○	• LTS-LCCR 2050 aims to reduce the natural gas consumption during the ammonia production (Current: **45GJ/ton**⇒2050 Target: **37-40GJ/ton**)	X	• Green policy does not include commentary on ammonia
	Activities and Discussions Related to Public Policy for Ammonia	○	• Production: ◦ Identifies state-owned enterprise as key player for the development of **green ammonia** • Utilization ◦ Power generation: ▪ Identifies ammonia as one of the key solutions to be used for **coal-fire power generation** in addition to biomass co-firing and CCS/CCUS ▪ Understands however, that cost reduction will be required for further development	○	• Utilization: PDP VIII draft states; ◦ **Ammonia co-fire** will start with 20% and gradually increase to 100% ◦ Demand for hydrogen to replace gas and produce ammonia to replace coal will be 23 million tons by 2050 ◦ Biomass/**ammonia-fired power** will account for 5.1-7.8% of the total capacity ◦ Above hydrogen/ammonia will mainly be from **wind and solar power sources**
	Availability of roadmap	○	• "Energy Sector Roadmap to Net Zero Emissions in Indonesia by 2060" includes future plans for following: ◦ Production: ▪ Increase in **blue ammonia** supply (2/3 of plants equipped with CO2 capture by 2060) ◦ Utilization: ▪ **Coal fire power generation** ▪ Low emission fuel supply	X	• There is no roadmap with information regarding ammonia

Task 2: Public Policy for Ammonia in Indonesia and Vietnam – Summary (2/2)

Cooperation is observed with countries in which development of hydrogen / ammonia is advanced, such as Japan, Australia, Singapore, and South Korea.

Summary of Public Policy (2/2)

Category	Indonesia	Vietnam
3. International Cooperation	• Japan ◦ Signed MoC to collaborate in the development and deployment of technologies that contribute to realistic energy transitions ◦ The above technology includes ammonia as a fuel, in addition to hydrogen, CCS and carbon capture utilization and storage (CCUS) • Australia ◦ Signed MoU to explore and study the potential of green hydrogen and green ammonia production	• Japan ◦ Joint statement to provide support on financial and technical support to introduce clean technology ◦ Above includes fuel ammonia, in addition to next-generation renewable energy technology, hydrogen, and CCUS/Carbon Recycling. • Singapore ◦ Signed MoU on Energy Cooperation to develop and deploy low-carbon energy technologies and solutions such as ammonia, hydrogen, and energy storage systems. • South Korea ◦ Signed MoU on cooperation on electric power generation for the technology development of ammonia, wind power and other renewable energy.
4. Regulations for Ammonia	• Current regulations which includes ammonia are mainly for the following areas; ◦ Registration and notification ◦ Symbol and labelling ◦ Waste management	• Current regulations related to ammonia are mainly for the following areas; ◦ Safety ◦ Symbol and labelling ◦ Quality control

Indonesia is accelerating the movement for decarbonization, by pushing forward the carbon neutral target and raising the country's emission related targets.

Carbon Neutral and GHG Reduction Target

Key Targets	Time	Description of Target
Carbon Neutral	Before COP 26	• Reach net-zero emission by 2070
	COP 26	• Reach net-zero emission by 2060 or sooner
GHG Reduction Target	NDC (As of Jul 2021)	• Country's 2030 emission reduction target: ◦ Unconditional: 29% ◦ Conditional: 41%
	NDC (As of Sep 2022)	• Country's 2030 emission reduction target: ◦ Unconditional: 31.89% ◦ Conditional: 43.2%

Source: Created by NRI based on UNFCCC

Inclusion of Ammonia in Key Green Policy

Key green policy includes ammonia as one of the key enablers for GHG reduction, focusing on reducing the consumption of natural gas during the production.

Key Green Policy	• Policy Name: Long-term Strategy for Low Carbon and Climate Resilience 2050 (LTS-LCCR 2050) • Regulatory Body: Ministry of Environment and Forestry

Commentary on Ammonia in the Green Policy

Item	Description	
Background Situation	• Ammonium fertilizer industry is considered is related to the GHG emissions intensives. • The production of ammonia is also expected to continue to grow with the growth rate of 1% per year to achieve 10.3 M ton in 2050.	
Mitigation Action	• Improving technology of New Ammonia-Urea Plants o The improved technology can be efficient ammonia plant and/or efficient urea in absorbing CO2. o The technology improves the consumption of natural gas from 45 GJ/ton ammonia to 40 GJ/ton ammonia in the ammonia production.	
Projection in 2050	1) Current policy scenario	38% of ammonia production: Consume natural gas at the rate of 40 GJ/ton ammonia
	2) Transition scenario	Most ammonia productions: Consume natural gas at the rate of 40 GJ/ton ammonia
	3) Low carbon scenario compatible with Paris Agreement target	Most ammonia productions: Consume natural gas at the rate of 36.6 GJ/ton ammonia or at least Best Practice Technology

Source: Source: Created by NRI based on UNFCCC

Activity / Discussion on Public Policy for Ammonia

Ongoing discussion regarding policy development not only includes co-fire power generation, but also includes usage in transportation such as vessel fuels.

Indonesia Government Organizations - Activity / Discussion Related to Public Policy for Ammonia

Organization	Speaker	Supply Chain Area	Media	Description of Activity / Discussion
Ministry of Energy and Mineral Resources	Director of Various New and Renewable Energy	Utilization	Statement at COP27 (Nov 2022)	• Ammonia in vehicle energy: ◦ Hydrogen and ammonia fuel can be used as fuel for ships, trains, heavy trucks, and buses. • Ammonia in power generation: ◦ Hydrogen and ammonia can also be used as fuel in power plants. • Limitation: ◦ Development of hydrogen / ammonia in the country is still not optimal due to the lack of infrastructure and high cost of hydrogen production ◦ The government has not issued special regulations governing the development of hydrogen and ammonia.
Ministry of State-Owned Enterprises	Deputy Minister	Production	Dubai's Representative Office opening remark (Oct-2022)	• Ammonia production: ◦ The state-owned enterprise of Indonesia can become one of the producers of products related to a green and circular economy ◦ Above includes green ammonia, green hydrogen, or in the medium term including blue ammonia and blue hydrogen.
	First Deputy Minister	Utilization	Cooperation agreement signing between PT Pupuk Indonesia, PT Pertamina and Mitsubishi Corp. (Mar 2022)	• Ammonia in power generation: ◦ Indonesia has developed the ammonia and biomass co-firing as well as the utilization of carbon capture technology to reduce the usage of coal at power plants.

Source: Source: Created by NRI based on AHK Indonesien, and company webpage of Pupuk

Indonesia's Roadmap by IEA (1/9)

ID has developed a net-zero emissions by 2060 roadmap with IEA. The Announced Pledges Scenario (APS) is applied as the main scenario.

Roadmap	• Name of Roadmap: ◦ An Energy Sector Roadmap to Net Zero Emissions in Indonesia by 2060 (Published in 2022) • Developer of Roadmap ◦ Ministry of Energy and Mineral Resources (MEMR) ◦ International Energy Agency (IEA)

Details in the Roadmap

Topic	Item	Commentary	
Background	**Modelling**	• The IEA's Global Energy and Climate Model (GEC - M)	
	Assumption	• Year 2021 - 2030	• GDP growth rate: 5% growth rate per year • Population: 275 million in 2021, 1.3% growth per year • Urbanization rate: 57% in 2021
		• Year 2030 - 2050	• GDP growth rate: 4% growth rate per year • Population: 330 million in 2050, 1.3% growth per year • Urbanization rate: n/a
		• Year 2050 - 2060	• GDP growth rate: 2% growth rate per year • Population: 336 million in 2060, 0.2% growth per year • Urbanization rate: 80% in 2060
	Applied scenario	• The Announced Pledges Scenario (APS) – Main scenario ◦ The APS assumes that net zero emissions pledges are met in full and on time, regardless of whether they are currently backed by detailed implementing laws, policies and regulations. • The Stated Policies Scenario (STEPS) ◦ The STEPS takes a more conservative and granular approach, integrating the impacts of established and announced policies and regulations.	

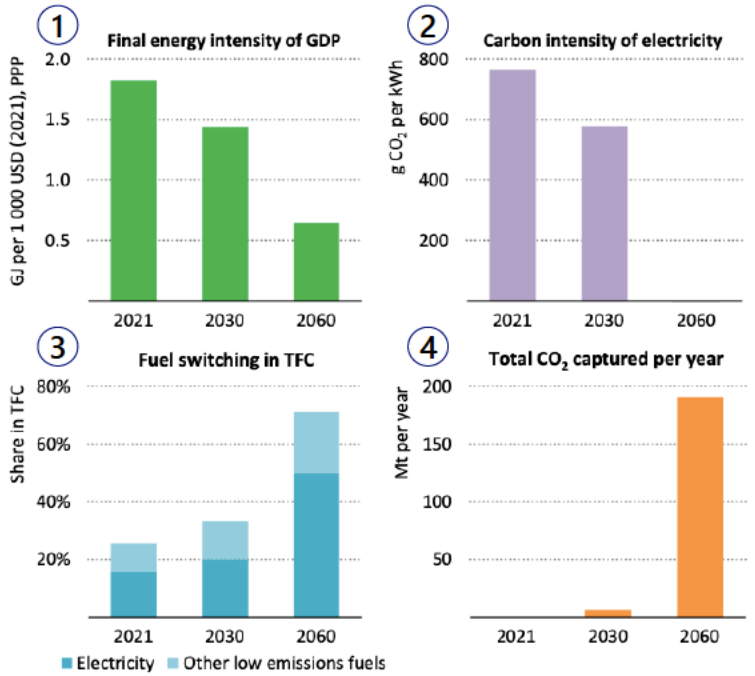
Source: IEA "An Energy Sector Roadmap to Net Zero Emissions in Indonesia" Sep 2022

Key mitigations to achieve the net-zero emissions in ID are improving energy intensity, decarbonizing electricity generation, switching to low emissions fuels.

Key Initiatives to Reach Net-Zero Emissions

Ammonia-directly related

Topic	Item	Commentary
Key areas to reach net zero emissions	① Energy intensity improvements	• Estimation in the APS: the final energy intensity is improving 20% by 2030 and more than 60% by 2060, relative to 2021 levels.
	② Decarbonizing electricity generation	• Estimation in the APS: the carbon intensity of electricity generation reduces by almost 25% by 2030, and almost 100% by 2060 relative to 2021 levels.
	③ Switching to low emissions fuels in end-uses*	• Estimation in the APS: in 2050 and 2060, electricity serves demand in end-uses around 50% of total final consumption (TFC). By 2060, low emissions fuels and electricity account for almost 75% of TFC, with fossil fuel use with CCUS in industry accounting for another 5%. Oil retains a role in transport.
	④ Carbon capture, utilisation and storage (CCUS)	• Estimation in the APS: by 2060, around 190 Mt CO2/year are captured across Indonesia's energy system.



*End-use sector includes industry, transport and buildings

Source: IEA "An Energy Sector Roadmap to Net Zero Emissions in Indonesia" Sep 2022

Indonesia's Roadmap by IEA (3/9)

ID also defines that improving and developing the production and utilization of ammonia is a part of achieving the net zero emissions

Key Initiatives for Ammonia Production and Utilization

Ammonia-directly related

Supply chain	Sector		Commentary
Production	Industry	Capacity APS target	• By 2060, 2/3 of ammonia production plants are equipped with CCUS technologies. • By 2060, the production of hydrogen and ammonia in combination with CCUS results in over 30 Mt CO2 being captured and stored annually Part of the key area 4: Carbon capture, utilisation and storage (CCUS)
Utilization	Electricity generation	Capacity APS target	• By 2030, coal-fired power generation drop to just over 50% from about 60% in 2021. • By 2030, coal-fired power capacity should peak at just above 45 GW, representing about 1/3 of total installed capacity projected in 2030. • In coal plants without CCUS, co-firing with ammonia picks up quickly around 2040, with blending rates rising to nearly 60% ammonia by volume in 2050 and nearing 100% by 2060. • By 2060, ammonia and hydrogen account for around 4% of electricity generation (assumed 2% for ammonia) Part of the key area 2: Decarbonizing electricity generation
		Cost APS target	• An ammonia cost of USD 350/t NH3 (domestically produced from hydrogen at USD 1.8/kg H2 using solar electricity) and a CO2 price of at least USD 170/t CO2 would be needed to make co-firing or 100% ammonia-firing competitive with generation from unabated coal at electricity costs of USD 180/MWh Part of the key area 2: Decarbonizing electricity generation
	Low emissions fuels supply	Capacity APS target	• By 2060, total demand for hydrogen and hydrogen-based fuels (including ammonia) reaches almost 7 Mt, covering just under 4% of the final energy demand. Part of the key area 3: Switching to low emissions fuels in end-uses
	Transport	Capacity APS target	• By 2060, hydrogen and ammonia emerge as the dominant energy sources for maritime shipping, with each accounting for about 25% of total demand. Part of the key area 3: Switching to low emissions fuels in end-uses

Source: IEA "An Energy Sector Roadmap to Net Zero Emissions in Indonesia" Sep 2022

Indonesia's Roadmap by IEA (4/9)

In the NZE, co-firing and CCUS deployment is set to achieve in the shorter period

Ammonia-related plan in APS
Ammonia-related plan in NZE

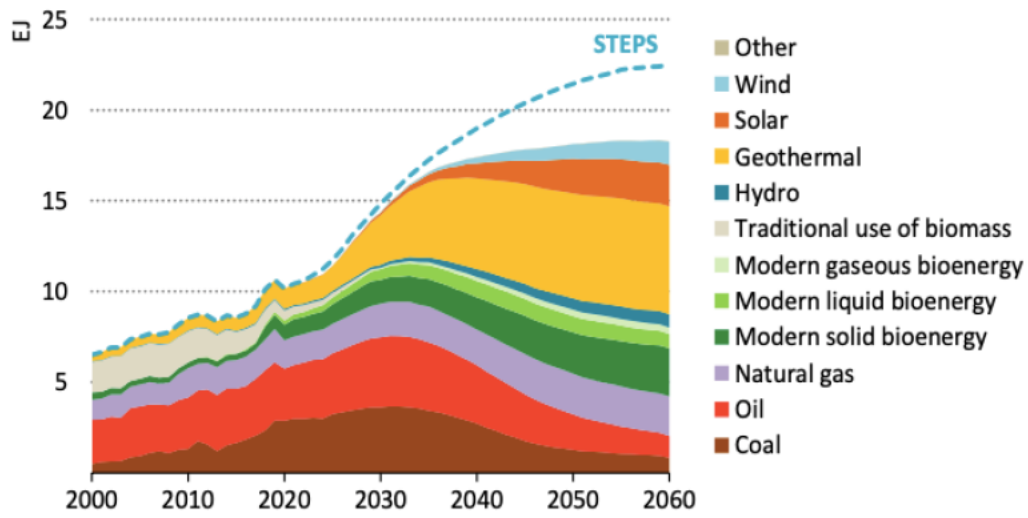
Summary of Ammonia Plan on "An Energy Sector Roadmap to Net Zero Emissions in Indonesia by 2060"

	2021	2030	2050	2060
PRODUCTION				
Industry			• More than 60% of ammonia production is equipped with CCUS	• 2/3 of ammonia production plants are equipped with CCUS technologies • Hydrogen and ammonia production with CCUS captures and store over 30 Mt CO2 annually
UTILIZATION				
Electricity generation	• 60% share of coal-fired power generation in total generation	• Co-firing with ammonia in coal plants without CCUS • 50% share of coal-fired power generation in total generation	• Co-firing with ammonia in coal plants without CCUS with 60% blend • Ammonia-fired power plants contribute only 2% of total generation	• Co-firing with ammonia in coal plants without CCUS with 100% blend • Ammonia and hydrogen account for 4% of electricity generation (assumed 2% for ammonia) • Ammonia cost of USD 350/t NH3 (domestically produced from hydrogen at USD 1.8/kg H2), a CO2 price of at least USD 170/t CO2, electricity costs from coal at USD 180/MWh to make 100% ammonia-firing competitive
Low emissions fuels supply				• Total demand for hydrogen and hydrogen-based fuels (including ammonia) reaches almost 7 Mt, covering around 4% of the final energy demand
Transport				• Ammonia accounts for 25% of total demand for maritime shipping.

Source: IEA "An Energy Sector Roadmap to Net Zero Emissions in Indonesia" Sep 2022

In APS, increasing of renewables and phasing out of unabated coal use in electricity sector are the major drive of the change of the energy supply mix

Projection for Energy Supply – Overview

Topic	Item	Commentary
APS scenario	Total energy supply	• By 2030, total energy supply is 14,400 PJ, increasing from 10,500 PJ in 2022 • By 2060, total energy supply is almost 19,000 PJ.
	Total energy supply in APS by sources from 2000 - 2060	

Source: IEA "An Energy Sector Roadmap to Net Zero Emissions in Indonesia" Sep 2022

Indonesia's Roadmap by IEA (6/9)

In 2060, more supply from renewable energy is expected at 74% while the coal supply shrinks to 4% of total energy supply

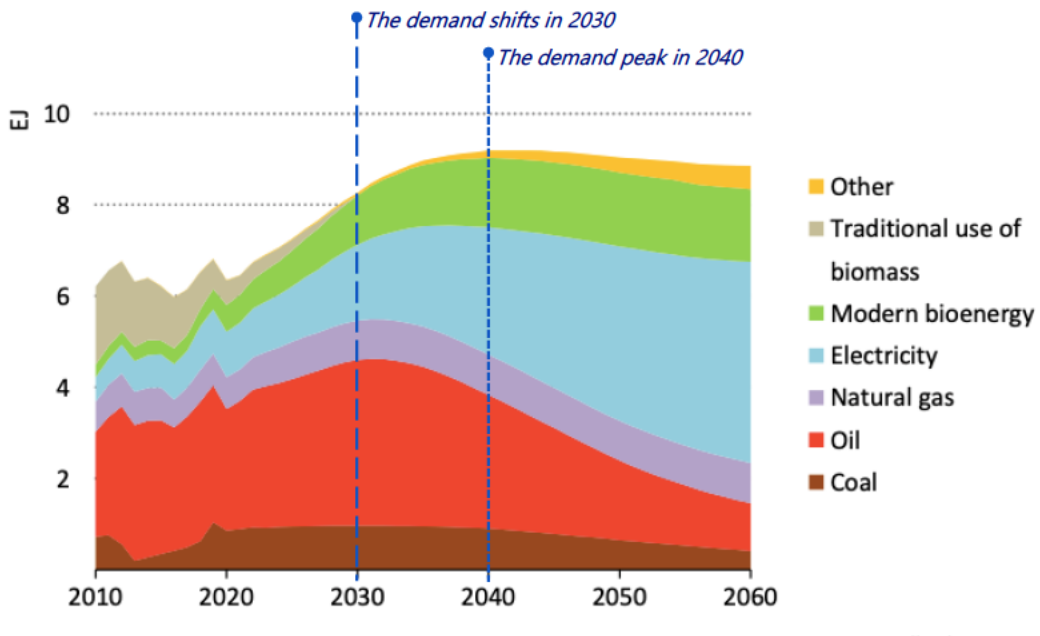
Projection for Energy Supply – By Fuel Type

Topic	Item	Commentary
APS scenario: Total energy supply	**Source: Fossil fuels**	• Share of fossil fuels is decreasing from 72% in 2021 to be 65% by 2030 and 22% by 2060. o Coal demand declines as its use in electricity generation is reduced after 2030. Thereafter, the decline of coal accelerates, dropping a further 2,800 PJ to account for only 4% of total energy supply in 2060. o Oil and natural gas demand continues to rise to meet rapid demand growth in the industry and transport sectors o Oil's share in the primary energy mix falls slightly from 28% in 2021 to 27% by 2030, but then drops to 6% by 2060. o Natural gas's share declines from 15% in 2021 to 13% in 2030. After 2030, the use of natural gas in non-emitting processes, including hydrogen production with CCUS, sees demand increase slightly from 2030 levels.
	Source: Renewable energy	• By 2030, renewable energy is 2,600 PJ accounts for 35% of the energy supply mix. • By 2060, renewable energy is 11,500 PJ accounts for 74% of the energy supply mix. o More than 80% in the power sector, 4% in transport and 2% in industry

Source: IEA "An Energy Sector Roadmap to Net Zero Emissions in Indonesia" Sep 2022

In APS, from 2030, electricity plays important role in the energy demand while the fossil fuels consumption gradually declines

Projection for Energy Demand - Overview

Topic	Item	Commentary
APS scenario	Final energy demand	• By 2030, total final consumption is 8,300 PJ, increasing from 6,450 PJ in 2021. Average growth 2.8%. • In early 2040s, peak final consumption 9,200 PJ. • By 2060, total final consumption is 8,850 PJ.
	Final energy demand in APS by sources from 2010 - 2060	

Source: IEA "An Energy Sector Roadmap to Net Zero Emissions in Indonesia" Sep 2022

Indonesia's Roadmap by IEA (8/9)

By 2060, the energy demand from coal reduces to 2% per year while around half of the total energy consumption is for electrification.

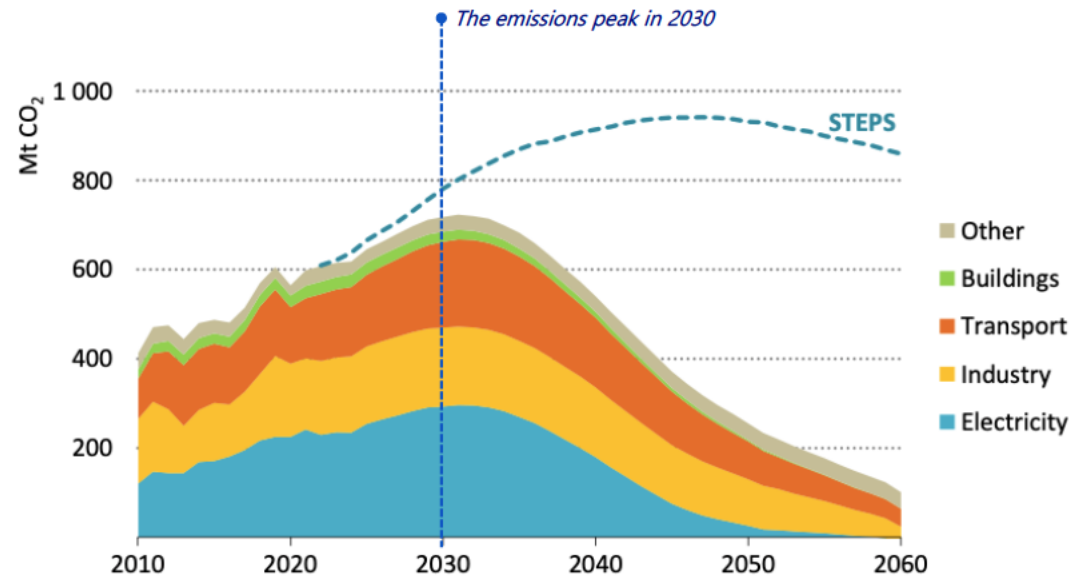
Projection for Energy Demand – By Fuel Type

Topic	Item	Commentary
APS scenario: Final energy demand	**Fossil fuels**	• Share of fossil fuels is decreasing declines from 68% in 2022 to around 25% in 2060. o Coal demand declines by an average 2% per year to 2060 o Oil demand declines by an average of 2.5% per year to 2060 o Natural gas with demand rising in the short term before plateauing over the following decades to 2060 • Electrification rises from 15% in 2022 to 50% by 2060.

Source: IEA "An Energy Sector Roadmap to Net Zero Emissions in Indonesia" Sep 2022

ID aims to have around 100 Mt CO2 from energy sector by 2060 under the APS by reducing emissions mainly from electricity, transport and industry.

Projection for CO2 Emission

Topic	Item	Commentary
APS scenario	Emission from energy sector	• By 2030, peak at 20% above the level of 2021 • By 2040, energy sector emissions are 10% lower than 2021 • By 2060, those emissions amount to just over 100 Mt
	Total CO2 emissions in APS by sector from 2010 - 2060	

Source: IEA "An Energy Sector Roadmap to Net Zero Emissions in Indonesia" Sep 2022

International Cooperation with Overseas Organizations (1/2)

In addition to the government, regional government bodies are also developing partnerships, to seize the opportunity for green ammonia production.

Indonesia Government Organizations – International Cooperation with Overseas Organizations

Overseas Partner			Indonesian Stakeholder	Year	Activity Related to Ammonia
Country Name	Organization Name	Organization Type	Organization Name		
Japan	• Ministry of Economy, Trade and Industry	• Government	• Ministry of Energy and Mineral Resources	2022	Utilization • Signed MoC (memorandum of cooperation) to collaborate in the development and deployment of technologies that contribute to realistic energy transitions such as hydrogen, ammonia as a fuel, and CCS / CCUS
Australia	• Fortescue Future Industries (FFI)	• Green energy company	• North Kalimantan Provincial Government	2021	Production • Signed a Cooperation Agreement to explore and study the potential for renewable energy and green hydrogen and ammonia projects. • A proposed project is to produce green hydrogen and green ammonia using renewable energy in North Kalimantan for domestic use and export markets. • FFI will undertake further studies of developing an industrial processing facility that is capable of producing approximately 650,000 tonnes of green hydrogen for conversion to 3.7 million tonnes of green ammonia per annum.

Source: Created by NRI based on Cabinet Secretariat of Indonesia, Fortesuce

Indonesian academic institutions are also developing partnerships with overseas organizations, for technology development in both production and utilization.

Indonesia Academic Institutions – International Cooperation with Overseas Organizations

Overseas Partner			Indonesian Stakeholder	Year	Activity Related to Ammonia
Country Name	Organization Name	Organization Type	Organization Name		
Japan	• Mitsubishi Heavy Industries	• Industrial company	• Bandung Institute of Technology	2022	Utilization • Signed an agreement to conduct joint research and development of ammonia-fired power generation by gas turbine.
	• JOGMEC • Mitsubishi Corporation	• Government • Conglomerate	• Bandung Institute of Technology • PT Panca Amara Utama	2021	Production • Signed MoU to conduct a joint study on CCS / CCUS for clean fuel ammonia production in Central Sulawesi

Source: Created by NRI based on news articles and company webpage of Mitsubishi Corporation

Regulations Related to Ammonia (1/5)

Ammonia is classified as a hazardous and toxic substance which has regulations for handling in specific step

Overview of Regulations Related to Ammonia in Indonesia

Process	Related Regulations
General	• Government Regulation No. 74/2001 on Hazardous and Toxic Substances Management
Registration and notification	• Regulation of the Minister of Environment and Forestry No. 36/2017 on Procedure about Registration and Notification of Hazardous and Toxic Substances
Symbol and Labelling	• Regulation of the Minister of Environment No. 3/2008 on Procedures for Issuing Symbols and Labels for Hazardous and Toxic Substances • Regulation of the Minister of Industry No. 87/2009 on the Global Harmonization System on Classification and Labelling of Chemical Substances
Waste Management	• Government Regulation no. 22/2021 on Environmental Protection, Organisation and Management • Regulation of the Minister of the Environment and Forestry No. 6/2021 on the Procedures and Requirements for the Management of Hazardous Wastes • Regulation of the Minister of Environment and Forestry No. 12/2020 on the storage of hazardous waste (B3 waste)

Source: Created by NRI based on Ministry of Environment and Forestry, Ministry of Industry, Enviliance ASIA

Regulations related to ammonia includes the registration and notification due to the fact that the product is a hazardous substance.

Regulations Related to Ammonia in Indonesia (1/4)

Classification	Name of Regulation	Issuer	Effective year	Overview of the Regulation
General	**Government Regulation No. 74/2001 on Hazardous and Toxic Substances Management**	Ministry of Environment and Forestry	2001	• Providing definition, scope, classification • Regulating registration, notification, storage, package, symbol and label, transportation, usage, controlling, import and export. • List of chemicals
Registration and notification	**Regulation No. 36/2017 on Procedure about Registration and Notification of Hazardous and Toxic Substances**	Minister of Environment and Forestry	2017	• Providing procedures for the registration and notification of hazardous and toxic substances for producing, import and export

Source: Created by NRI based on Ministry of Environment and Forestry, Enviliance ASIA

Regulations includes ensuring that the procedures to present the symbols and labels are clearly provided.

Regulations Related to Ammonia in Indonesia (2/4)

Classification	Name of Regulation	Issuer	Effective year	Overview of the Regulation
Symbol and Labelling	**Regulation No. 3/2008 on Procedures for Issuing Symbols and Labels for Hazardous and Toxic Substances**	Minister of Environment and Forestry	2008	• Providing procedures for presenting symbols and labels of hazardous and toxic material • Regulating packaging place for storing packaging
	Regulation No. 87/2009 on the Global Harmonization System on Classification and Labelling of Chemical Substances	Minister of Industry	2009	• Providing the application of The Globally Harmonized System of Classification and Labeling of Chemicals (GHS) to define and classify chemical hazards and communicate this information on labels and sheets.

Source: Created by NRI based on Ministry of Environment and Forestry, Ministry of Industry, Enviliance ASIA

Waste management is also a crucial part of the regulation, due to the potential damage towards the environment.

Regulations Related to Ammonia in Indonesia (3/4)

Classification	Name of Regulation	Issuer	Effective year	Overview of the Regulation
Waste Management	**Government Regulation no. 22/2021 on Environmental Protection, Organisation and Management**	Government	2021	• Regulating the protection and management of water quality, air quality, sea water quality • Explaining the standard criteria for environmental damage and control • Providing waste management rules for hazardous and toxic substance waste and non-hazardous substance • Elaborating the obligation to develop Environmental Information System including hazardous and toxic substance waste management • Providing guidance, monitoring administrative sanction and transitional provisions

Source: Created by NRI based on Ministry of Environment and Forestry, Ministry of Industry, Enviliance ASIA

Waste management is also a crucial part of the regulation, due to the potential damage towards the environment.

Regulations Related to Ammonia in Indonesia (4/4)

Classification	Name of Regulation	Issuer	Effective year	Overview of the Regulation
Waste Management	**Regulation No. 6/2021 on the Procedures and Requirements for the Management of Hazardous Wastes**	Minister of Environment and Forestry	2021	• Stipulating the reduction, storage, recovery, transport, use, treatment, accumulation dumping and cross-border movement of the waste of hazardous and toxic substances • Providing procedure of application and issuance of technical certification and operational qualification certificate in waste of hazardous and toxic substances management
	Regulation No. 12/2020 on the storage of hazardous waste (B3 waste)	Minister of Environment and Forestry	2020	• Providing the detailed storage requirements such as locations, methods, and duration of the waste of hazardous and toxic substances that must be complied with by all parties involved with this waste activities (e.g., generators, collectors, and processors)

Source: Created by NRI based on Ministry of Environment and Forestry, Enviliance ASIA

Vietnam is accelerating the movement for decarbonization, by pushing forward the carbon neutral target and raising the country's emission related targets.

Carbon Neutral and GHG Reduction Target

Key Targets	Time	Description of Target
Carbon Neutral	Before COP 26	• No carbon neutral target
	COP 26	• Reach net-zero emission by 2050
GHG Reduction Target	NDC (2020)	• Country's 2030 emission reduction target: ◦ Unconditional: 9% compared to BAU ◦ Conditional: 27% compared to BAU
	NDC (2022)	• Country's 2030 emission reduction target: ◦ Unconditional: 15.8% compared to BAU ◦ Conditional: 43.5% compared to BAU

Source: Created by NRI based on Ministry of Industry and Trade, National Climate Change Strategy to 2050, News Article

Government does see the importance and urgency to develop ammonia-related technology to fulfil the future plan on ammonia utilization in power generation.

Vietnam Government Organizations - Activity / Discussion Related to Public Policy for Ammonia (1/2)

Organization	Speaker	Supply Chain Area	Occasion	Description of Activity / Discussion
Ministry of Industry and Trade	Deputy Minister	Utilization	Conference regarding impact of COP26 (Aug-2022)	• Ammonia in power generation: ◦ It is necessary to raise awareness of the importance and urgency of cooperation in research and development of energy science and technology on a global scale ◦ Above is especially for technology regarding large-scale power generation from new primary sources such as hydrogen, ammonia, advanced energy storage technology, and CCS
			Conference regarding PDP VIII (Apr-2022)	• Ammonia in power generation: ◦ The draft of PDP VIII has made drastic reductions of CO2 emissions with no new coal-fired power plants to be built in the planning period, and with the switch from coal and natural gas to biomass, ammonia and hydrogen

Source: Created by NRI based on Ministry of Industry and Trade, Vietnam Plus

Ammonia is expected to be a key enabler for CO2 reduction in coal-fire power generation, aiming to achieve 20% and above for co-fire proportion.

Vietnam Government Organizations - Activity / Discussion Related to Public Policy for Ammonia (2/2)

Organization	Supply Chain Area	Occasion	Description of Activity / Discussion
Ministry of Industry and Trade	Utilization	Power Development Plan VIII (Draft)	• Ammonia in power generation: ◦ Production of new forms of energy such as hydrogen, and green ammonia will be promoted (Apr 2022 draft) ◦ New coal-fired power plants will be put to stop after 2030. After 20 years of operation, coal-fired power plants will burn biomass fuel or ammonia, starting at 20% and gradually increasing to 100%. (Nov 2022 draft) ◦ It is projected that by 2050, biomass/ammonia-fired power will account for 5.1-7.8% of the total capacity (Nov 2022 draft) ◦ It is estimated that the demand for hydrogen to replace gas and to produce ammonia to replace coal will be at 23 million tons by 2050, produced from wind and solar power sources (Nov 2022 draft)

Source: Created by NRI based on Ministry of Industry and Trade, news articles

Several international cooperation already took place to support on both financial and technical on ammonia-related technology.

Vietnam Government Organizations – International Cooperation with Overseas Organizations (1/2)

Overseas Partner			Vietnam Stakeholder	Year	Activity Related to Ammonia
Country Name	Organization Name	Organization Type	Organization Name		
Japan	• Ministry of Trade, Economy and Industry	• Government	• Ministry of Industry and Trade	2021	Utilization • Joint statement to provide support on financial and technical support to introduce clean technology such as next-generation renewable energy technology, hydrogen, fuel ammonia and CCUS/Carbon Recycling.
Singapore	• Ministry of Trade and Industry	• Government		2022	Utilization • Signed MoU on Energy Cooperation to develop and deploy low-carbon energy technologies and solutions such as hydrogen, ammonia and energy storage systems.
South Korea	• Ministry of Industry	• Government		2022	Utilization • Signed MoU on cooperation on electric power generation for the technology development of ammonia, wind power and other renewable energy.

Source: Created by NRI based on each Ministry's website and news articles

Ammonia co-fire power generation is the key focus for partnership between government-owned research institutions and overseas organizations as well.

Vietnam Government Organizations – International Cooperation with Overseas Organizations (2/2)

Overseas Partner			Vietnam Stakeholder	Year	Activity Related to Ammonia
Country Name	Organization Name	Organization Type	Organization Name		
South Korea	• Doosan Enerbility Co. • Korea Electronics Technology Research Institute (KETI)	• Power plant builder • Research institute	• Institute of Energy (IE)	2022	Utilization • Under the signed MoU, three parties will set up a consultative body to support the adoption of ammonia co-fired power plants in Vietnam. • IE will conduct a feasibility study for the application of ammonia-mixed combustion, and KETI will promote the modernization of Vietnamese power plants, while Doosan will be responsible for the development of ammonia co-fired power generation technology.

Source: Created by NRI based on news articles

Regulations related to ammonia are provided mainly for usage as chemical substance.

Overview of Regulations Related to Ammonia in Vietnam

Type of ammonia by HS code	Related regulations
HS code 2814 Ammonia, Anhydrous or in aqueous solution	1. Law on Chemical 06/2007 2. Decree 113/2017/ND-CP specifying and providing guidelines for implementation of certain articles of the law on chemicals 3. Circular 32/2017/TT-BCT guidelines for implementation of certain articles of the law on chemicals and the government's decree 113/2017/ND-CP specifying and providing guidelines for implementation of certain articles of the law on chemicals 3a. Circular 17/2022/TT-BCT amending Circular 32/2017/TT-BCT
HS code 2814 1000 Anhydrous ammonia	*Relevant to the type of ammonia used in energy and industry sectors*
HS code 2814 2000 Ammonia in aqueous solution	1. National technical regulation QCVN 05A:2020/BCT national technical regulation on safety in production, commerce, use, storage and transportation of hazardous chemicals 2. National Technical Regulation QCVN 07A:2020/BCT* on the Quality of Industrial Ammonia 3. Circular 36/2019/TT-BCT Management of quality of products and goods under the Ministry of Industry and Trade's responsibility 4. Circular 28/2012/TT-BKHCN providing for declaration of standard conformity and declaration of technical-regulation conformity and method to assess conformity with standards and technical regulations and (4a) Circular 02/2017/TT-BKHCN on amendments to certain articles of the Circular 28/2012/TT-BKHCN

*National technical regulation stipulates the requirement and rules for ammonia in aqueous solution 10-35% content (HS code: 2814200), excluded highly pure ammonia and ammonia for food processing.

Source: Created by NRI based on International Labour Organization, Vietnamese Government, Ministry of Industry and Trade, Enviliance ASIA

Examples of major regulations relevant for ammonia fuels are the following 3 regulations.

Summary of Regulations Related to Ammonia in Vietnam

	Regulation/Source	Detail
1	Law on Chemical 06/2007/QH12	• This Law provides regulations on chemical handling, safety in chemical handling, right and obligations of organizations and individuals engaged in chemical handling, and state management of chemical handling.
2	Decree 113/2017/ND-CP	• The Decree designates lists of chemicals subject to regulatory control under the Law on Chemical and specifies detailed conditions and requirement on chemical manufacturers and traders.
3	Circular 32/2017/TT-BCT Circular 17/2022/TT-BCT (amending)	• These Circulars include guidance on compiling chemical safety data sheet, classification and labelling, declaration of imported chemicals, and plans and measures to prevent and respond to chemical incidents.

Source: Created by NRI based on International Labour Organization, Vietnamese Government, Ministry of Industry and Trade, Enviliance ASIA

Regulations Related to Ammonia - 1. Law on Chemical 06/2007/QH12 (1/6)

The regulation covers usage of chemical products including the classification, labelling and packaging, registration, environmental protection, and responsibility of authorities.

Regulation	1. Law on Chemical 06/2007/QH12 ◦ Issuer: Government ◦ Effective year: 2008

Details of the Regulation

Content of regulations		Description
1	General provisions	Overview of the Law, scope of regulation, subject of application, principles and prohibited acts
2	Developing the chemical industry	The requirements regarding regulations compliance, work standard and responsibility on community and environment
3	Chemical production and trading	Fundamental requirements on starting business, certificate and license, storage and transport, safety, waste treatment and advertisement
4	Chemical classification, labelling and packaging and safety data sheets	The requirements that chemicals are required to be classified, labelled and recorded on the safety data sheet (specifically hazardous chemicals)
5	Chemical use	The rights and obligations on using chemicals and hazardous chemicals. Also, the storage and preservation of hazardous chemicals in use and treatment and disposal of residues
6	Accident prevention and mitigation	Chemical business to take responsibility and to prepare for chemical incidents with the approved incident prevention and response plan
7	Declaration, registration and provision of chemical information	Chemical producer and importer to declare and to supply information, especially on hazardous chemicals to the authorities
8	Environmental protection and safety for community	Responsibility of chemical business on the safety of the community and environment protection
9	State management responsibility for chemical handling	The responsibilities of the authorities on chemical business handling

Source: Created by NRI based on Vietnamese Government

Regulations Related to Ammonia - 1. Law on Chemical 06/2007/QH12 (2/6)

The chapter provides overview of the law, scope of regulation, subject of application, interpretation of terms, principles and prohibited acts.

Regulation	1. Law on Chemical 06/2007/QH12

Details of the Regulation

Topic	Detail
1. General Provisions	This chapter provides overview of the Law, scope of regulation, subject of application, interpretation of terms, principles and prohibited acts. • Scope of regulation ◦ Providing regulations for chemical-related activities, safety in chemical-related activities, rights and obligations of organizations and individuals engaged in chemical-related activities, and state management of chemical-related activities. • Subjects of application ◦ Organizations and individuals engaged in chemical-related activities and organizations and individuals related to chemical-related activities in the territory of the Socialist Republic of Vietnam. • Interpretation of terms ◦ *Chemical* means an element, a compound or a mixture which is exploited or created by humans from natural or artificial raw materials. ◦ *Hazardous chemical* means a chemical having one or several of the following hazardous properties according to classification principles of the Globally Harmonized System of Classification and Labeling of Chemicals (GHS); Explosive, Highly oxidized, Highly corrosive, Flammable, Acute toxic, Chronically toxic, Causing irritation to humans, Causing cancer or danger of cancer (carcinogenicity), Causing genetic modification (germ cell mutagenicity), Toxic to reproduction, Biological accumulation, Causing disintegration resistant organic pollution, Toxic to environment. • Principles of chemical-related activities • State policies on chemical-related activities • Prohibited acts in chemical-related activities

Source: Created by NRI based on Vietnamese Government

Regulations Related to Ammonia - 1. Law on Chemical 06/2007/QH12 (3/6)

The chapters cover the requirements regarding regulations compliance, work standard, and fundamental requirements for initiating the business for chemical products.

Regulation	1. Law on Chemical 06/2007/QH12

Details of the Regulation

Topic	Detail
2. Developing the chemical industry	This chapter prescribes the requirements regarding regulations compliance, work standard and responsibility on community and environment. • Requirements on chemical industry plannings • Responsibilities for elaborating chemical industry plannings • Requirements for chemical production and/or trading projects
3. Chemical production and trading	This chapter generally provides information on fundamental requirements on starting business, certificate and license, storage and transport, safety, waste treatment and advertisement. • Responsibilities for assuring safety • Requirements on technical facilities • Requirements on professional • Order and procedures for issuing Certificates, Licenses • Contents of a certificate or license • Extension, amendment and withdrawal of certificate or license • Transportation of hazardous chemicals • Storage and preservation of hazardous chemicals in chemical production or trading • Safety distances of hazardous chemical production and trading facilities • Export, import, temporary import, re-export and transit transport of chemicals • Treatment and disposal of residual chemicals, waste materials and chemical containers • Advertisements on chemicals

Source: Created by NRI based on Vietnamese Government

Regulations Related to Ammonia - 1. Law on Chemical 06/2007/QH12 (4/6)

The chapters cover the chemical classification, labelling / packaging, and the obligations for using chemical products.

Regulation	1. Law on Chemical 06/2007/QH12

Details of the Regulation

Topic	Detail
4. Chemical classification, labelling and packaging and safety data sheets	This chapter prescribes that chemicals (specifically hazardous chemicals) are required to be classified, labelled and recorded on the safety data sheet. • Classification and labeling of chemicals • Packaging of chemicals • Chemical safety data sheet
5. Chemical use	This chapter regulates the right and obligations on using chemicals and hazardous chemicals. Also, the storage and preservation of hazardous chemicals in use and treatment and disposal of residues. • Rights and obligations of organizations and individuals using chemicals to produce other products and goods. • Rights and obligations of organizations and individuals using hazardous chemicals for production of other products and goods • Rights and obligations of organizations and individuals using chemicals for consumption purposes • Use of chemicals for scientific experimentation and research • Storage and preservation of hazardous chemicals in use • Treatment and disposal of chemical residues in using

Source: Created by NRI based on Vietnamese Government

Regulations Related to Ammonia - 1. Law on Chemical 06/2007/QH12 (5/6)

The chapters cover the articles related to accident prevention, mitigation, as well as the necessary procedures for the declaration, registration of chemical information.

Regulation	1. Law on Chemical 06/2007/QH12

Details of the Regulation

Topic	Detail
6. Accident prevention and mitigation	This chapter requires the chemical business to take responsibility and to prepare for chemical incidents with the approved incident prevention and response plan. • Prevention of chemical incidents • Chemical incident-response equipment, devices and forces • List of hazardous chemicals requiring elaboration of chemical incident prevention and response plans • Contents of chemical incident prevention and response plans • Dossiers, order and procedures for approval of chemical incident prevention and response plans • Authority for approval of the incident prevention and response plans • Responsibilities for coordination in chemical incident prevention and response
7. Declaration, registration and provision of chemical information	This chapter regulates that chemical producer and importer shall declare and supply information, especially on hazardous chemicals to the authorities. • Declaration of chemicals • Registration of new chemicals • Organization for New Chemical Assessments • Management of activities related to new chemicals • Supply of information on toxic chemicals and hazardous chemicals by the authorities • Information on new hazardous properties of chemicals • Obligations to supply information • Confidentiality of information • Use of confidential information • Preservation of information on hazardous chemicals • Retention period of reports • National Chemical Catalog and National Chemical Database

Source: Created by NRI based on Vietnamese Government

Regulations Related to Ammonia - 1. Law on Chemical 06/2007/QH12 (6/6)

The chapters cover the articles related to environmental protection, and responsibilities by the government authorities for chemical handling.

Regulation	1. Law on Chemical 06/2007/QH12

Details of the Regulation

Topic	Detail
8. Environmental protection and safety for community	This chapter prescribes how chemical business responsible to the community and environment. • Responsibilities for protection of the environment and safety for the community • Rights and obligations of organizations and individuals in the protection of the environment and safety for the community • Publicization of information on chemical safety • Responsibilities for disposal of residual toxic chemicals and confiscated toxic chemicals and toxic chemical-containing products • Responsibilities to dispose of residual toxic chemicals of wars • Insurance for the liability to pay compensation for damage in chemical-related activities
9. State management responsibility for chemical handling	This chapter states the responsibilities of the authorities on chemical business handling. • State management responsibilities for chemical-related activities • Management responsibilities of ministries and ministerial-level agencies directly concerning chemical-related activities • Management responsibilities of ministries and ministerial-level agencies directly concerning chemical-related activities • State management responsibilities for chemical-related activities of Peoples Committees at various levels • Inspection of chemical-related activities • Handling of violations • Settlement of disputes in chemical-related activities

Source: Created by NRI based on Vietnamese Government

Regulations Related to Ammonia - 2. Decree No. 113/2017/ND-CP (1/5)

The regulation designates lists of chemicals subject to regulatory control under the 'Law on Chemical' and specifies conditions and requirement for manufacturers and traders.

Regulation	2. Decree No. 113/2017/ND-CP specifying and providing guidelines for implementation of certain articles of the law on chemicals ◦ Issuer: Government ◦ Effective year: 2017

Details of the regulation

	Content of regulations	Description
1	General provisions	Overview of the areas under the guidelines for implementation and regulated entities
2	Chemical production and trade	The fundamental requirements on production and trade of different chemical classifications (industrial chemicals, industrial precursor chemicals, restricted industrial chemicals, banned chemicals and toxic chemicals)
3	Chemical incident prevention and response plans and measures	The requirements on preparing and getting approval on plans and measures on incident prevention and incident response from hazardous chemicals business
4	Classification of chemicals and safety data sheets	Defining the classification of chemicals based on rules and technical guidance of GHS and the requirement on safety data sheets for hazardous chemicals
5	Declaration of chemicals	The requirement on the declaration on production or import of specified chemicals
6	Training in chemical safety	The requirement on the proper and timely training and assessment in chemical safety
7	Implementation	The requirement on the annual general reports on chemical-related activities submission

Note: Ammonia (Anhydrous) is listed as 1. "hazardous chemical requiring chemical indecent prevention and response plan" and 2. "chemical subjected to compulsory declaration"

Source: Created by NRI based on Vietnamese Government, Vietnam National Chemical Database System

Regulations Related to Ammonia - 2. Decree No. 113/2017/ND-CP (2/5)

The chapter provide general guidelines for implementation and the relevant entities for the regulation.

Regulation	2. Decree No. 113/2017/ND-CP specifying and providing guidelines for implementation of certain articles of the law on chemicals

Details of the regulation

Topic	Detail
1. General provisions	This chapter prescribes the scope of content on the guidelines for implementation and regulated entities • Scope of regulation ◦ This Decree deals with and provides guidelines for implementation of certain articles of the Law on Chemicals with the following contents: 1. General requirements for safety in chemical production and trade. 2. Conditional industrial chemicals; requirements, application and procedures for a certificate of eligibility for production or trade in conditional industrial chemicals (hereinafter referred to as "certificate"). 3. Requirements for industrial precursor chemical production and trade; application and procedures for issuance of a license for industrial precursor chemical export/import. 4. Restricted industrial chemicals; requirements, application and procedures for issuance of a license for restricted industrial chemical production/trade. 5. Banned chemicals and toxic chemicals. 6. Plans and measures for prevention of and response to chemical emergencies. 7. Safety distance of hazardous chemical factories/stores. 8. Classification of chemicals and safety data sheets. 9. Declaration on chemicals and information about chemicals. 10. Training courses in chemical safety. • Subjects of application ◦ This Decree applies to entities having chemical-related activities; and entities involving in chemical-related activities in the territory of the Socialist Republic of Vietnam. • Interpretation of terms

Source: Created by NRI based on Vietnamese Government

Regulations Related to Ammonia - 2. Decree No. 113/2017/ND-CP (3/5)

This chapter covers fundamental requirements on production and trade of different chemical classifications.

Regulation	2. Decree No. 113/2017/ND-CP specifying and providing guidelines for implementation of certain articles of the law on chemicals

Details of the regulation

Topic	Detail
2. Chemical production and trade	This chapter regulates the fundamental requirements on production and trade of different chemical classifications (industrial chemicals, industrial precursor chemicals, restricted industrial chemicals, banned chemicals and toxic chemicals) Section 1. GENERAL REQUIREMENTS FOR SAFETY IN CHEMICAL PRODUCTION AND TRADE • Factories and warehouses • Technology, equipment, tools and packages • Storage and transport • Extraction and packaging Section 2. PRODUCTION AND TRADE IN CONDITIONAL INDUSTRIAL CHEMICALS • Conditional industrial chemicals • Requirements for issuance of certificates • Applications and procedures for issuance of certificates Section 3. PRODUCTION AND TRADE IN INDUSTRIAL PRECURSOR CHEMICALS • Requirements for production and trade in industrial precursor chemicals • Applications and procedures for issuance of licenses for industrial precursor chemical export/import • Exemption and revocation of licenses for industrial precursor chemical export/import Section 4. PRODUCTION AND TRADE IN RESTRICTED INDUSTRIAL CHEMICALS • Restricted industrial chemicals • Requirements for issuance of licenses for restricted industrial chemical production or trade • Applications and procedures for issuance of licenses for restricted industrial chemical production or trade • Control of restricted industrial chemicals Section 5. BANNED CHEMICALS AND TOXIC CHEMICALS • Banned chemicals • Toxic chemicals

Source: Created by NRI based on Vietnamese Government

Regulations Related to Ammonia - 2. Decree No. 113/2017/ND-CP (4/5)

The chapters cover the chemical incident prevention, as well as the classification and declaration of chemicals.

Regulation	2. Decree No. 113/2017/ND-CP specifying and providing guidelines for implementation of certain articles of the law on chemicals

Details of the regulation

Topic	Detail
3. Chemical incident prevention and response plans and measures	This chapter regulates the requirement on plans and measures on incident prevention and incident response from hazardous chemicals business Note: Ammonia (Anhydrous) is listed as "hazardous chemical requiring chemical indecent prevention and response plan" • Incident prevention and response plans ("plans") • Incident prevention and response measures ("measures") • Determination of safety distance of hazardous chemical factories/stores
4. Classification of chemicals and safety data sheets	This chapter defined the classification of chemicals based on rules and technical guidance of GHS and the requirement on safety data sheets for hazardous chemicals • Classification of chemicals • Safety data sheets
5. Declaration of chemicals	This chapter requires the declaration on production or import of specified chemicals. Note: Ammonia (Anhydrous) is listed as "chemical subjected to compulsory declaration" • Declared chemicals • Declaration of produced chemicals • Declaration of imported chemicals • Cases where declaration of chemicals is exempted • Confidential information • Development of the list of national chemicals and national chemical database

Source: Created by NRI based on Vietnamese Government

Regulations Related to Ammonia - 2. Decree No. 113/2017/ND-CP (5/5)

The chapters cover articles relevant to the training and implementation of chemicals.

Regulation	2. Decree No. 113/2017/ND-CP specifying and providing guidelines for implementation of certain articles of the law on chemicals

Details of the regulation

Topic	Detail
6. Training in chemical safety	This chapter requires the proper and timely training and assessment in chemical safety • Provision of training courses in chemical safety • Individuals provided with training courses in chemical safety • Programs, trainers and period of training courses in chemical safety • Assessment of results and retention of documents on training in chemical safety • Inspection of training courses in chemical safety
7. Implementation	This chapter requires the annual general reports on chemical-related activities submission to the authorities • Reporting • State management of chemical-related activities
Appendix	• LIST OF INDUSTRIAL CHEMICALS SUBJECT TO CONDITIONAL PRODUCTION AND TRADING • LIST OF INDUSTRIAL CHEMICALS RESTRICTED FROM PRODUCTION AND TRADING • LIST OF BANNED CHEMICALS • LIST OF HAZARDOUS CHEMICALS REQUIRING CHEMICAL INCIDENT PREVENTION AND RESPONSE PLAN • LIST OF CHEMICALS SUBJECT TO COMPULSORY DECLARATION • FORMS

Source: Created by NRI based on Vietnamese Government

Regulations Related to Ammonia - 3. Circular 32/2017/TT-BCT (1/6)

The regulation includes guidance on compiling safety data, classification and labelling, declaration of imported chemicals, and measures to prevent and respond to incidents.

Regulation	3. Circular 32/2017/TT-BCT guidelines for implementation of certain articles of the law on chemicals and the government's decree 113/2017/ND-CP specifying and providing guidelines for implementation of certain articles of the law on chemicals ◦ Issuer: Ministry of Industry and Trade ◦ Effective year: 2017 3a. Circular 17/2022/TT-BCT amending Circular 32/2017/TT-BCT ◦ Issuer: Ministry of Industry and Trade ◦ Effective year: 2022

Details of the regulation

	Content of regulations	Description
1	General provisions	Overview of the areas under the guidelines for implementation and regulated entities
2	Carrying out administrative procedures on chemical management in the industrial sector	The granting process of the certificate of chemical production and trading in the industrial sector including import and export
3	Publishing forms	Forms of application and reports used in chemical handling
4	Plans and Measures for preventing and responding to chemical incidents in the industrial sector	The developing of chemical incident prevention and response plan
5	Chemical classification and labelling	The requirements on the classification and labelling of produced and imported chemicals
6	Construction of chemical safety sheet	The requirements on the Chemical Safety Data Sheet of produced and imported hazardous chemicals
7	Declaration of imported chemical	The guideline of the declaration on imported chemicals
8	Report regime	The requirements on the yearly reports on chemical activities and a report on incidents or termination of chemical activities

Source: Created by NRI based on Ministry of Industry and Trade

Regulations Related to Ammonia - 3. Circular 32/2017/TT-BCT (2/6)

This chapter prescribes the scope of content on the guidelines for implementation and regulated entities.

Regulation	3. Circular 32/2017/TT-BCT guidelines for implementation of certain articles of the law on chemicals and the government's decree 113/2017/ND-CP specifying and providing guidelines for implementation of certain articles of the law on chemicals 3a. Circular 17/2022/TT-BCT amending Circular 32/2017/TT-BCT

Details of the regulation

Topic	Detail
1. General provisions	This chapter prescribes the scope of content on the guidelines for implementation and regulated entities • Scope of regulation ◦ This Circular provides guidelines for implementation and provisions specifically: 1. Responsibilities for carrying out administrative procedures on chemical management in the industrial sector 2. Several types of forms include: form of control form for purchase and sale of toxic chemicals; chemical activity reporting forms; forms used in the process of appraising and approving chemical incident prevention and response plans 3. Develop Plans and Measures for preventing and responding to chemical incidents in the industrial sector 4. Chemical classification and labelling 5. Construction of chemical safety sheet 6. Declaration of imported chemicals 7. Report mode • Subjects of application ◦ This circular applies to organizations and individuals engaged in chemical activities; organizations and individuals related to chemical activities on the territory of the Socialist Republic of Vietnam • Interpretation of terms

Source: Created by NRI based on Ministry of Industry and Trade

Regulations Related to Ammonia - 3. Circular 32/2017/TT-BCT (3/6)

This chapter covers the granting process of the certificate of chemical production and trading in the industrial sector, including import and export.

Regulation	3. Circular 32/2017/TT-BCT guidelines for implementation of certain articles of the law on chemicals and the government's decree 113/2017/ND-CP specifying and providing guidelines for implementation of certain articles of the law on chemicals 3a. Circular 17/2022/TT-BCT amending Circular 32/2017/TT-BCT

Details of the regulation

Topic	Detail
2. Carrying out administrative procedures on chemical management in the industrial sector	This chapter regulates the granting process of the certificate of chemical production and trading in the industrial sector including import and export • Granting, re-granting, adjusting and recovering the certificate of eligibility for production and trading of chemicals for production and business conditional in the industrial sector • The Chemical Bureau receives dossiers, grant, re-grant, adjustment, renew, revoke export license, import of industrial precursors • The Department of Chemicals shall receive the application for granting the license for production and trading of chemicals in the industrial field of organizations and individuals; organization of appraisal, records, check the actual conditions • The Department of Chemicals receives information on declaring imported chemicals from organizations and individuals to perform chemical declarations through the national one-stop portal, and formulate and implement inspection plans, periodic inspections and inspections, and unexpected checks when necessary • Limitations of the License for Manufacture and Trade in Chemicals and Business in Industrial sector

Source: Created by NRI based on Ministry of Industry and Trade

Regulations Related to Ammonia - 3. Circular 32/2017/TT-BCT (4/6)

The chapter covers articles relevant to the forms for production and trading, as well plans and measures for preventing and responding to chemical incidents.

Regulation	3. Circular 32/2017/TT-BCT guidelines for implementation of certain articles of the law on chemicals and the government's decree 113/2017/ND-CP specifying and providing guidelines for implementation of certain articles of the law on chemicals 3a. Circular 17/2022/TT-BCT amending Circular 32/2017/TT-BCT

Details of the regulation

Topic	Detail
3. Publishing forms	This chapter provides forms of production and trading, import and export, approval for chemical incident prevention and response plan, stock card on buying and selling chemicals and reports in chemical operations • Application forms for granting, re-granting, adjustment certificates of eligibility for production and trading of chemicals for production and business conditional in the industrial sector; License of production and trading of limited chemicals in the field of industry • Application forms for granting, renewing, granting and adjusting the export license, import of industrial precursors • Forms used in the process of appraising and approving the chemical incident prevention and response plan • Samples Control Card for buying and selling toxic chemicals • Report forms in chemical operations
4. Plans and Measures for preventing and responding to chemical incidents in the industrial sector	This chapter describes on the developing of chemical incident prevention and response plan • Presentation forms, layouts, contents of the Plan and Prevention Measures, responding to chemical incidents according to the instructions • For the subject of having to build measures for the prevention and response of chemical incidents, during the period of 10 (ten) working days from the date of the Decision on the issuance of the Measures, the investor sends 01 Decision and 01 books Measures for prevention, response and chemical incidents to the Department of Industry and Trade of Provinces and cities where the construction of chemical activity project for monitoring and management • In case of changes in the investment and operation process related to the contents of approved plans, organizations or individuals send reports to the Chemical Departments for guidance

Source: Created by NRI based on Ministry of Industry and Trade

Regulations Related to Ammonia - 3. Circular 32/2017/TT-BCT (5/6)

The chapter covers articles relevant to the chemical classification and labelling, as well as construction of chemical safety sheet.

Regulation	3. Circular 32/2017/TT-BCT guidelines for implementation of certain articles of the law on chemicals and the government's decree 113/2017/ND-CP specifying and providing guidelines for implementation of certain articles of the law on chemicals 3a. Circular 17/2022/TT-BCT amending Circular 32/2017/TT-BCT

Details of the regulation

Topic	Detail
5. Chemical classification and labelling	This chapter regulates the classification and labelling of produced and imported chemicals • Organizations and individuals producing and importing chemicals are obliged to classify and label chemicals, are responsible before laws for the results of chemical classification and information shown on chemical labels • The general guidelines and criteria for classification of chemicals under the GHS • Chemical labeling • Placement of chemical labels • The warning picture in the transport of dangerous chemicals
6. Construction of chemical safety sheet	This chapter requires the Chemical Safety Data Sheet of produced and imported hazardous chemicals to be prepares and well stored • Organizations and individuals producing and importing hazardous chemicals, before putting chemicals into use and circulation on the market, they must prepare a chemical safety sheet including information and take responsibility before law for the contents of the Chemical Safety Data Sheet • Organizations and individuals must keep Chemical Safety Sheets for all hazardous chemicals in the facility and ensure all objects related to hazardous chemicals are provided Chemical Safety Sheets of those harzadous chemicals

Source: Created by NRI based on Ministry of Industry and Trade

Regulations Related to Ammonia - 3. Circular 32/2017/TT-BCT (6/6)

The chapter covers articles relevant to declaration of imported chemicals, and the reporting structure for incidents and termination of chemical activities.

Regulation	3. Circular 32/2017/TT-BCT guidelines for implementation of certain articles of the law on chemicals and the government's decree 113/2017/ND-CP specifying and providing guidelines for implementation of certain articles of the law on chemicals 3a. Circular 17/2022/TT-BCT amending Circular 32/2017/TT-BCT

Details of the regulation

Topic	Detail
7. Declaration of imported chemical	This chapter regulates the declaration on imported chemicals • Organizations and individuals who import chemicals must declare responsible for carrying out the declaration of imported chemicals before going through the National One-Stop Portal • Immediately after the customs declaration is in the state of customs clearance, Customs feedback to the system of the Ministry of Industry and Trade the information including the declaration number and other information • No declaration of imported chemicals for organizations or individuals who buy chemicals in the territory of Vietnam • Upon notification, organizations and individuals may perform declarations of imported chemicals through a back-up system. Organizations and individuals shall be responsible before the law on raw materials and information declaring chemicals through the back-up system as when performing through the National One-Stop Portal

8. Report regime	This chapter requires the yearly reports on chemical activities and a report on incidents or termination of chemical activities
	
	• Reporting regime of organizations and individuals
	  ○ Before February 15 of each year, organizations and individuals engaged in chemical activities in the industrial field are responsible for making a general report on the situation of chemical activities of the previous year.
	  ○ Organizations and individuals engaged in chemical activities in the industrial sector are responsible for reporting upon incidents occurring in chemical activities or termination of chemical activities
	• Before March 1 every year, the Departments of Industry and Trade of the provinces and centrally-run cities are responsible for reporting on the management of chemical activities of organizations and individuals in the area under their management
	• When requested, agencies and units assigned responsibilities shall report on the chemical management according to the functions, tasks, send the Department of Chemical Synthesis

Source: Created by NRI based on Ministry of Industry and Trade

Project Overview

Task 1: Overview of the Energy Landscape in Indonesia and Vietnam

Task 2: Public Policy for Ammonia in Indonesia and Vietnam

Task 3: Company Activity for Ammonia Supply Chain Development

① Ammonia / Hydrogen Production: International Cooperation

Key partners for Vietnamese companies are Japanese and western companies with advanced technology for ammonia and hydrogen development.

International Cooperation: Companies with Plans for Green or Blue Ammonia / Hydrogen Production

Company	Partnership Status			
	Country	Organization Type	Organization Name	Description
PetroVietnam	Japan	Gov. organization	Japan Organization for Metals and Energy Security	• Signed MoU to pursue oil and natural gas, hydrogen and ammonia production and CCS/CCUS projects
	Norway	Energy company	Equinor	• Discussion on building a roadmap development involving wind power, hydrogen, ammonia, and CCS/CCUS in Vietnam
	France	Energy company	HDF Energy	• Signed MoU to collaboratively plan, finance, and construct HDF's Renewable and HyPower hydrogen power facilities in Vietnam • Discussing the possibility of making green hydrogen in Vietnam for both the domestic market and APAC area
The Green Solutions Group	Germany	Industrial engineering company	Thyssenkrupp	• Signed a contract to cooperate in producing green hydrogen and green ammonia in Vietnam for the period of 2022-2050 • The partnership includes produce 216,000 tones of blue ammonia and 36,000 tones of blue hydrogen annually
	US	Engineering company	Black & Veatch	• Signed MoU to study renewable hydrogen and ammonia production via wind or solar electricity supplied through Vietnam's national grid
Electricity of Vietnam (EVN)	Japan	Trading company	Marubeni	• Signed MoU to study carbon emission reduction of existing thermal power plants in Vietnam and the development of biomass, ammonia, and hydrogen

Source: Created by NRI based on company webpage of PetroVietnam, the Green Solutions Group, EVN and news articles

③ Ammonia Utilization: International Cooperation

Japanese and Korea organizations are collaborating with Vietnamese companies for ammonia utilization.

International Cooperation with Organizations in other Countries

Utilization Type	Company	Partnership			
		Country	Organization Type	Company Name	Description
Power Generation	PetroVietnam	Korea	Energy company	• GS Energy	• GS Energy CEO offered PetroVietnam in recent meeting that they company could help the Vietnamese government and PetroVietnam make the transition from coal to blue ammonia for power plants' fuel
	Vietnam Electricity (EVN)	Japan	Public organization	• METI • NEDO • Coal Energy Center of Japan	• EVN, along with the Ministry of Industry and Trade of Vietnam, discuss clean coal technology towards carbon neutralization with Japanese partners
	Truong Thanh Vietnam Group	Japan	Energy company	• Tokyo Gas • Kyuden International	• Signed MoU to further investigate the possibility of introduction of the new technologies to mitigate emission of greenhouse gas (e.g. utilization of fuel mixed with hydrogen or ammonia)
	Institute of Energy	Korea	Heavy industrial company	• Doosan Enerbility	• Signed MoU with the Institute of Energy, a scientific and technological research agency of Vietnam, and the Korea Electronics Technology Research Institute in Hanoi • The MoU is regarding cooperation in the electric power industry, involving offshore wind power and ammonia co-firing

Source: Created by NRI based on news articles

① Ammonia / Hydrogen Production: International Cooperation

Japan and South Korea are supporting the current producers, to transition from conventional ammonia / hydrogen production to green / blue production.

Current Producers - International Cooperation with Organizations in other Countries

Company	Partnership Status			
	Country	Organization Type	Organization Name	Description
Pupuk Indonesia Group	Japan	Private co. (Conglomerate)	Mitsubishi Corp.	• Signed MOU to develop green hydrogen and ammonia value chain and CCUS businesses
	Japan	Private co. (Engineering service)	TOYO Engineering Corp.	• Conducted feasibility study on developing green ammonia production at fertilizer plants with consideration of selecting proper renewable energy power source, countermeasure against the fluctuation of renewable energy power supply, etc.
	Japan	Private co. (Conglomerate)	Mitsui & Co.	• Signed MOU to prepare a blue ammonia implementation study at the fertilizer plants in Indonesia
PT Parna Raya Group	South Korea	Private co. (Chemicals)	Namhae Chemical Corp	• Signed MOU to cooperate on developing green ammonia supply chain covering production with a focus on using hydroelectricity as a raw material, storage, and transportation in Indonesia and Korea
	South Korea	Private co. (Trading)	Posco International	
PT Surya Esa Perkasa Group	Japan	Private co. (Oil, Gas)	Japan Oil, Gas and Metals National Corp.	• Signed MOU to conduct a joint feasibility study for blue ammonia production at the Group's ammonia plant and CCS during the production phase, which mainly contributes to secure energy supply for Japan
	Japan	Private co. (Conglomerate)	Mitsubishi Corp.	
	Japan	Private co. (Engineering service)	JGC Corp.	• Signed MOU to collaborate on measuring Greenhouse Gas (GHG) Emissions at the Group's ammonia plant for the improvement of guidelines on clean ammonia production

Source: Created by NRI based on news articles and company webpages

① Ammonia / Hydrogen Production: International Cooperation

Pertamina collaborates with a wide range of companies in Asia, Middle East, US, and Europe to develop capability for ammonia and hydrogen production.

Future Producers - International Cooperation with Organizations in other Countries (1/2)

Company	Partnership Status			
	Country	Organization Type	Organization Name	Description
PT Pertamina Group	Singapore	Private co. (Energy)	Keppel New Energy	• Conducted joint feasibility study to explore the development of green hydrogen and ammonia mainly in Sumatra, Indonesia with capacity target of ≈ 40K-160K tonnes/year of green hydrogen using ≈ 250 - 400 MW of geothermal energy
	US	Private co. (Oil, Gas)	Chevron Corporation	
	Saudi Arabia	Private co. (Energy)	Saudi Aramco	• Signed MOU to study the investment viability, the commercialization options, including business organization and commercial structures for clean ammonia and hydrogen, expected to be conducted over 2023-24
	Japan	Private co. (Power generation)	Tokyo Electric Power Company Holdings	• Conducted joint study on developing green hydrogen and ammonia to establish the optimal operational technology and achieve cost-competitive production and transportation
	Japan	Private co. (Oil, Gas)	JX Nippon Oil & Gas Exploration Corp.	• Signed MOU to implement joint studies and business plans of blue hydrogen and ammonia production using CCS technology
	Japan	Private co. (Oil, Gas)	Japan Oil, Gas and Metals National Corp.	
	US	Private co. (Oil, Gas)	ExxonMobil	• Signed Heads of agreement (HOA) to assess the feasibility of CCS technologies, low-carbon hydrogen, and geologic data related to CCS project
	UK	Private co. (Energy)	IGNIS Energy Holdings	• Conducted a joint feasibility study to evaluate the potential development of green hydrogen production facilities from renewable energy sources in several locations in Sumatra
	Singapore	Private co. (Energy)	Sembcorp Industries	

Source: Created by NRI based on news articles and company webpages

① Ammonia / Hydrogen Production: International Cooperation

Industrial companies and power generation companies partner with partners across regions, mainly to receive support for development of production facilities.

Future Producers - International Cooperation with Organizations in other Countries (2/2)

Company	Partnership Status			
	Country	Organization Type	Organization Name	Description
PT PLN Group	Japan	Private co. (Oil, Gas)	INPEX Corp.	• Signed MOU to conduct a joint feasibility study on producing blue hydrogen and ammonia using natural gas produced from the LNG Project as co-firing fuel for the Group's thermal power plants
	Saudi Arabia	Private co. (Energy)	ACWA Power	• Signed MOU to conduct a joint feasibility study on developing green hydrogen and ammonia facility powered by hydroelectricity
PT Krakatau Steel	UK	Private co. (Energy)	IGNIS Energy Holdings	• Conducted a joint feasibility study on developing green/blue hydrogen plant in the Krakatau Steel industrial area integrated with an offshore wind power in order to produce electricity up to 500 MWp – 1.5 GWp
Anantara Energy Holdings	Australia	Private co. (Energy)	ReNu Energy	• Signed MOU to conduct a joint feasibility study on developing a large-scale green hydrogen production facility using electricity from solar power of at least 100 MW with capacity target of 1,650 tonnes/year

Source: Created by NRI based on news articles and company webpages

② Ammonia Transportation / Storage: International Cooperation

South Korean companies are providing support for the cross-border transportation of ammonia.

International Cooperation With Organizations In Other Countries

Type	Company	Partnership			
		Country	Organization Type	Company Name	Description
Transportation	PT Parna Raya Group	South Korea	Private co. (Chemicals)	Namhae Chemical Corp	• Signed MOU to cooperate on developing green ammonia storage and whole ammonia logistics in Indonesia and Korea
		South Korea	Private co. (Trading)	Posco International	
		South Korea	Private co. (Logistics)	KSS Line Ltd.	• Signed contract for ammonia transportation
Storage	Pertamina Group	Dubai	Private co. (Trading)	BGN International	• Signed Heads of agreement to to collaborate on acquiring and operating very large gas carriers with consideration of endorsing the ammonia cargo market

Source: Created by NRI based on company website and news articles

③ Ammonia Utilization: International Cooperation

For power generation, Japanese companies are the key partners, whilst for other utilization methods, international companies support with the technology.

International Cooperation with Organizations in other Countries

Utilization Type	Company	Partnership			
		Country	Organization Type	Company Name	Description
Power Generation	Pertamina Group	Japan	Private co. (Conglomerate)	Mitsubishi Corp.	• Signed MOU to develop green ammonia for the utilization in co-combustion at Power plant
	PT PLN Group	Japan	Private co. (Energy)	INPEX Corp.	• Conduct joint study on producing blue hydrogen and ammonia as co-firing fuel for thermal power plants
		Japan	Private co. (Conglomerate)	Mitsubishi Heavy Industries	• Signed MOU to conduct a feasibility study on applying ammonia co-firing technology at existing boiler and hydrogen co-firing in an gas turbine
		Japan	Private co. (Conglomerate)	IHI Corporation	• Signed MOU to jointly verify the application of ammonia co-firing and mono-firing technologies, and their economic feasibility
Fuel Vessels	Pertamina Group	Singapore	Private co. (Energy)	Keppel New Energy	• Conducted joint study to explore the feasibility of developing green hydrogen and ammonia, which can potentially be used to replace bunker fuel in the maritime industry*
		American	Private co. (Energy)	Chevron Corp.	
	PT Adaro Energy Indonesia	Australia	Private co. (Iron ore mining incl. transportation)	Fortescue Metals	• Signed Joint statement of intent to develop the usage of green ammonia as fuel in heavy equipment vehicles, trucks and ships
Heat Utilization	Pertamina Group	Saudi Arabia	Private co. (Energy)	Saudi Aramco	• Signed MOU to conduct a pre-feasibility study to assess the possibility of developing a clean hydrogen and ammonia, which are expected to be used for power generation, heavy transport, heating and industrial processes*

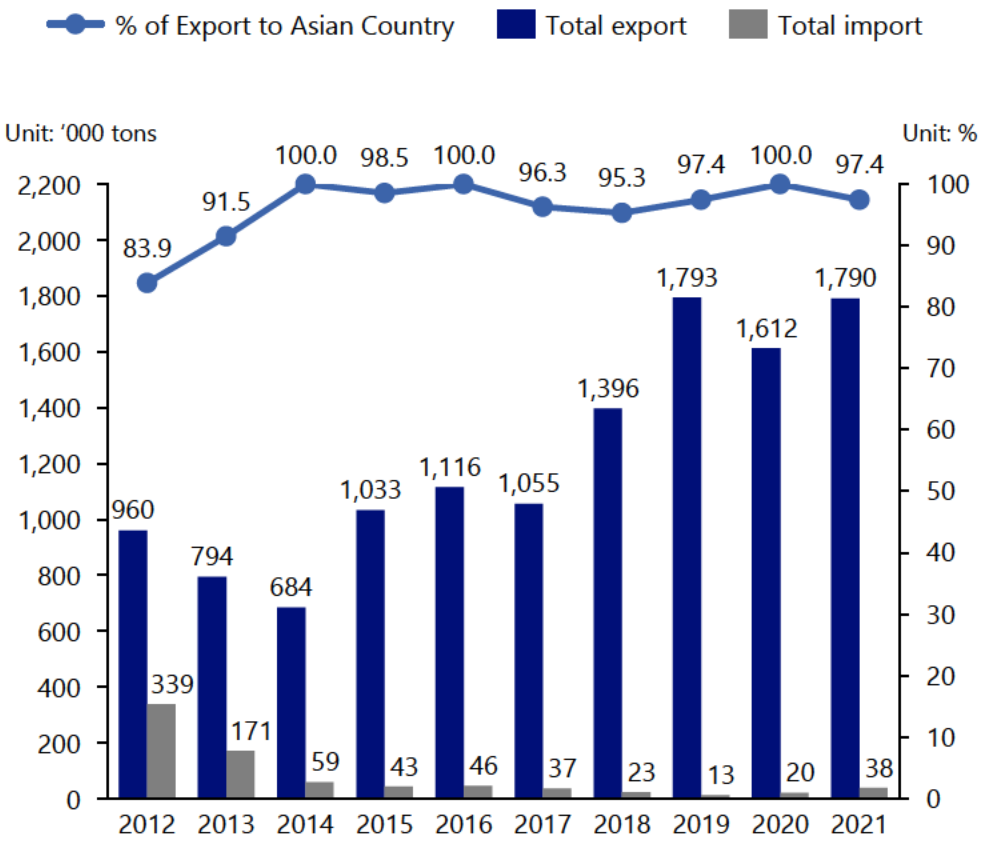
Note: *Subject to a certain level of unclarity on developing the utilization of ammonia for their commercialization

Source: Created by NRI based on company website and news articles

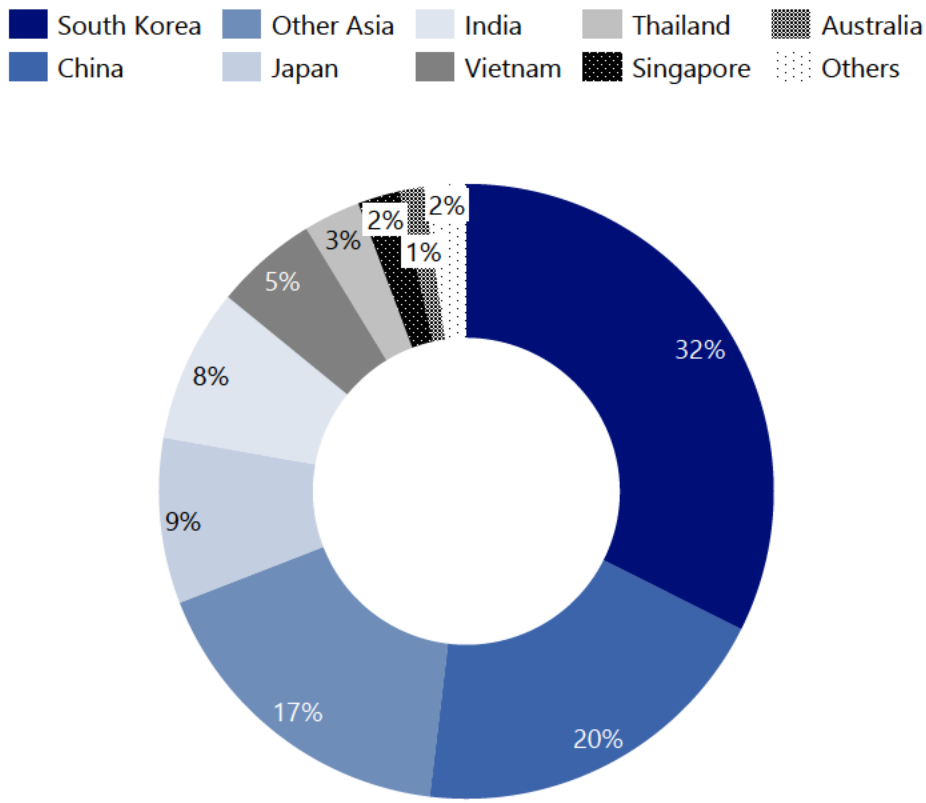
Indonesia's current export network is primarily for the Asian market with large economic scale such as South Korea, China, Japan, and India.

- Due to the large amount of supply capacity from major producers such as PT Pupuk, Indonesia's export is significantly higher than the import
- Majority of export is to Asian countries, in which key countries are East Asian countries with a large economic scale, such as South Korea, China and Japan

Ammonia – Export and Import for Indonesia (2012-2021)



Ammonia – Key Export Countries (2021)



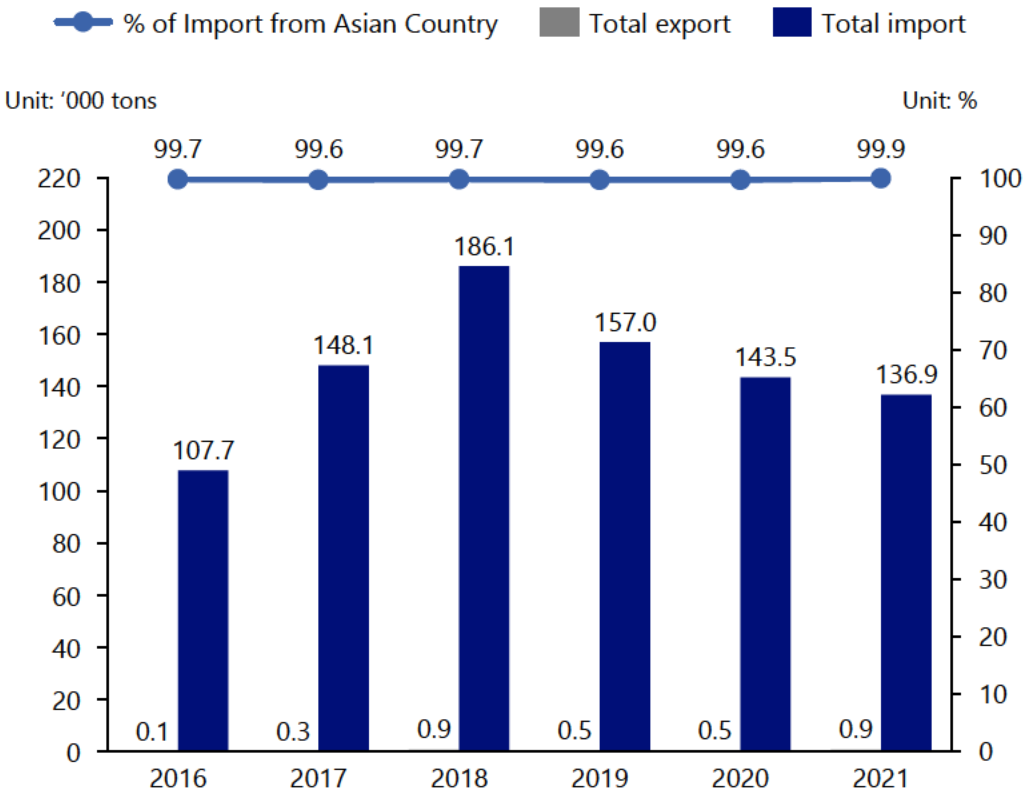
Source: Created by NRI based on UN Comtrade

Ammonia Trade for Vietnam

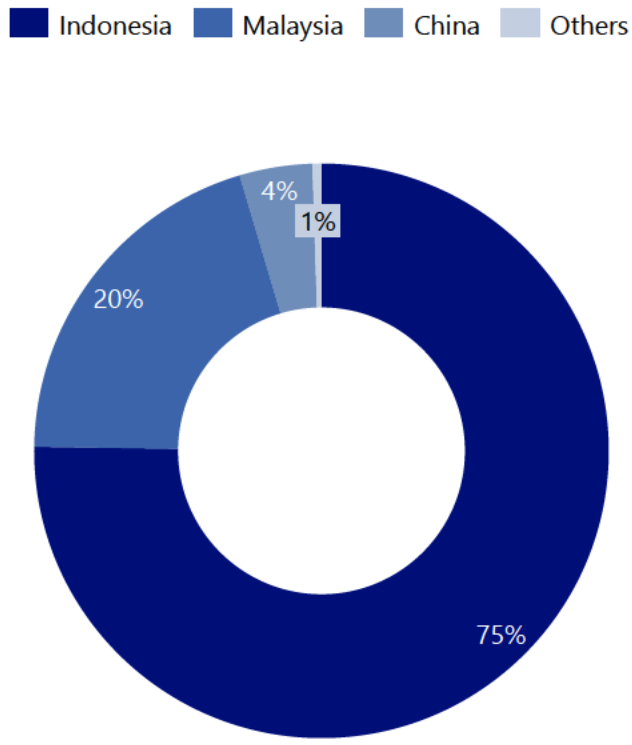
Vietnam's ammonia import is mainly from neighboring countries with high production capacity such as Indonesia and Malaysia.

- Majority of the domestic production for ammonia is used for domestic usage, resulting in limited amount of export to overseas market
- For the import of ammonia, the country primarily imports from neighboring ASEAN countries with high production capacity such as Indonesia and Malaysia

Ammonia – Export and Import for Vietnam (2016-2021)



Ammonia – Key Import Countries for Vietnam (2021)



Source: Created by NRI based on UN Comtrade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