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# Final Report

## Hydrogen market research in Thailand and Indonesia

Deloitte Consulting Ltd.
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# Survey hydrogen initiatives of public and private sectors in both TH and ID, and study the high-level possible scenarios and business models

## Project Background

- Carbon neutrality by 2050 has become a mainstream policy target in climate change among nations following the Kyoto Protocol and Glasgow Declaration. In this context, hydrogen and ammonia are expected as alternative carbon-neutral fuels to phase-out from fossil fuels.
- ASEAN countries have also declared carbon neutrality goals. Then it is assumed that introducing renewable energy and establishing a supply chain of hydrogen and ammonia will be accelerated.
- Furthermore, in January 2022, GoJ*1 signed MoU with TH and ID governments on an energy partnership respectively, in which hydrogen is mentioned as a key item. Through the partnership, Japan's contribution to hydrogen development is increasing.
- Japan, however, have not yet fully grasped hydrogen policy and market in TH and ID.

## Project Goal

- This project aims to research the following through desktop research and interviews:
  - State of the art of hydrogen policy and market in TH and IN
  - Future outlook of hydrogen in TH and IN
  - Hydrogen technical readiness toward 2050s-60s
- Based on the information above, the project will create high-level hydrogen business models in the 2030s-40s

*1: The Government of Japan

# Summary

# Both TH and IN are trying to deploy hydrogen while it is still on the nascent stage of hydrogen deployment; ammonia is most likely to be the first hydrogen career to be used for mid-to-long distance transportation

## Executive Summary

### Outlook of Hydrogen

- Different from Japan, **the TH and IN governments have not shown clear hydrogen strategies or numerical targets**
  - On the other hand, they mention hydrogen will be a key technology (transport, power, industry for TH and industry for IN)
- Private enterprises including SOEs, however, agree **that both green and blue hydrogen will be deployed** in TH and IN
- TH and IN are expected to produce green hydrogen at a cheaper cost eventually than Japan; thus, they are less likely to be as dependent on exported hydrogen as Japan

### Technical Readiness & Players

- **Both TH and IN are on the nascent stage** of hydrogen deployment with few projects demonstrated
  - FCEV and HRS demonstration project and geothermal green hydrogen project are at the forefront of hydrogen introduction in TH and IN respectively
  - Numerous MoUs, however, were agreed in the last one year especially between local and Japanese companies
- Many stakeholders agree that **ammonia will be utilized first as hydrogen career in Southeast Asia**
  - Unlike Japan, liquid hydrogen is not and is less likely to be used in TH and IN
- **EGAT and PTT in TH, and Pertamina and PLN in IN are leading** hydrogen market as local enterprises

### Business Models

- In TH, **replacing fossil fuel in industry, power and transport sectors near Bangkok area** seems ideal in near term, due to the government's view and the technical readiness
  - Hydrogen is either locally produced from **solar power**, which is abundant VRE resource in TH, or is transported as ammonia from another area
- In IN, **introducing hydrogen in industry sector in Jawa, Sumatera or potentially Kalimantan Islands** the best reflect the government's policy and the technical readiness
  - Hydrogen is likely to be green hydrogen produced from **geothermal or solar power**, or blue/green ammonia delivered from another area

# Both Thailand and Indonesia will be importing hydrogen to fulfill its growing demand by 2050.

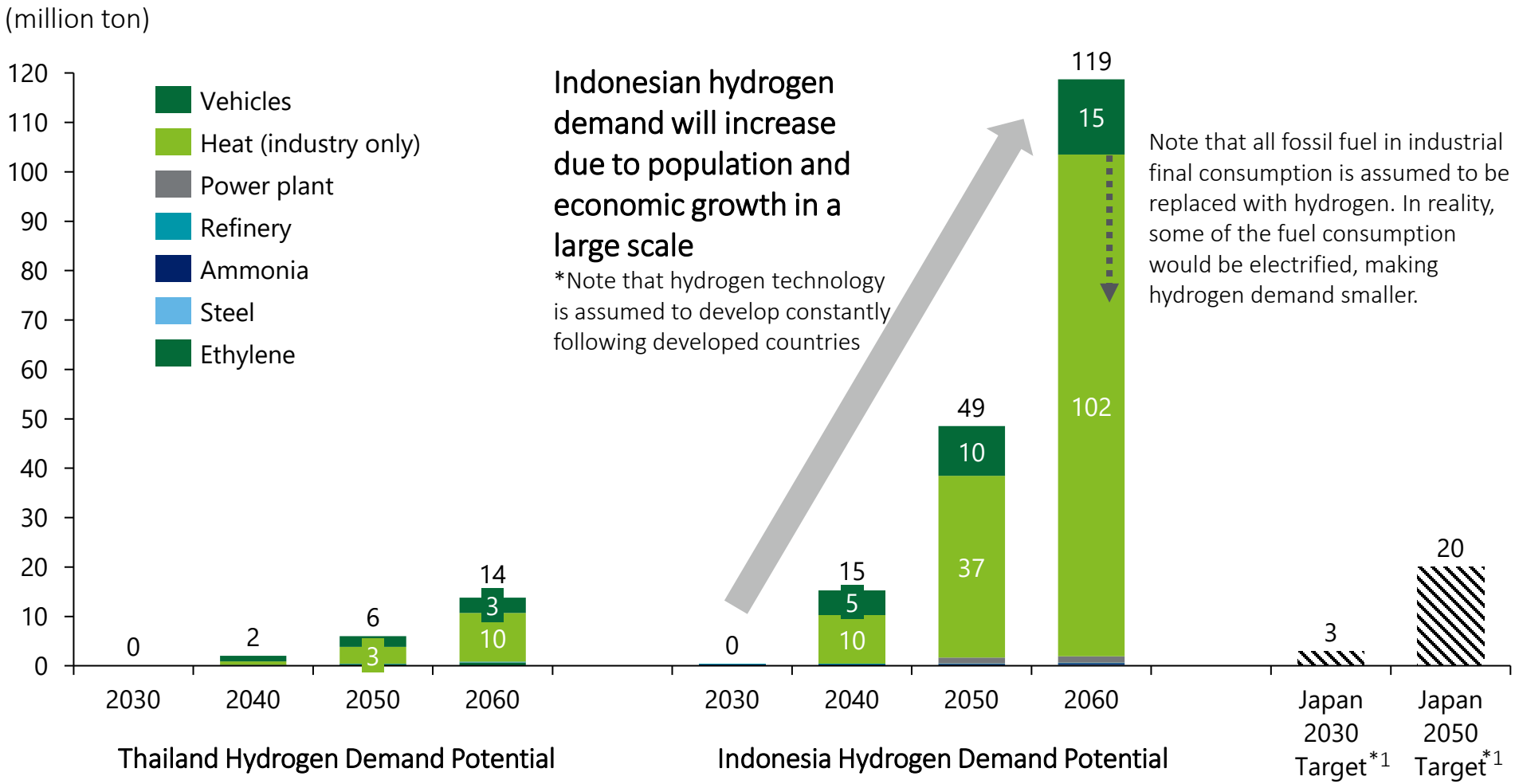
## Summary for hydrogen outlook and state-of-the-art

| | | Present | | | Outlook | | |
|---|---|---|---|---|---|---|---|
| | | Thailand | Indonesia | Japan *ref | Thailand | Indonesia | Japan *ref |
| Use | Hydrogen Demand | unknown | ■ 1.1M t/year (2020)*2 | ■ 2M t/year*1 | ■ 6 Mt/year (2050) *potential | ■ 49 Mt/year (2050) *potential | ■ 20Mt/year (2050)*5 |
| | Major hydrogen users | ■ Industry (steel, chemical) | | | ■ Transport<br>■ Power<br>■ Industry*9 | ■ Industry | ■ Transport<br>■ Power<br>■ Industry*5 |
| | Hydrogen Used | ■ Grey | | | ■ Green/blue | ■ Green/blue | ■ Green/blue |
| Production | Source of hydrogen production | ■ Fossil fuel | | | ■ Renewable | ■ Renewable<br>■ Fossil fuel + CCUS | ■ Renewable<br>■ Fossil fuel + CCUS |
| | Hydrogen Production Cost | ■ 0.7 – 1.6 USD/kgH2 (natural gas) *4 *world average | ■ 1.6USD/kgH2 (natural gas)*9<br>■ 6.7-13.4USD/kgH2 (renewable) *9 | ■ 8-9 USD/kgH2 (low carbon) *1 | ■ 1-2 USD/kgH2 (green) (2050)*6 | | ■ <2.5 - <3.5 USD/kgH2(green) (2050)*6*7 |
| | Importer/Exporter | N/A | | | ■ Importer *Meanwhile some Indonesian companies seek to export hydrogen | | |

*1:「水素を取り巻く国内外情勢と水素政策の現状について」(METI, 2022) *2: “Green Hydrogen in Indonesia: Stakeholders, Regulations and Business Prospects” (IESR, 2022). most likely excludes hydrogen produced for intermediate applications such as for fertilizer plants or refineries *3: “Yearbook of Current Production Statistics Chemical Industry” (METI, 2020). Excludes non-final products. *4: Global average levelized cost of hydrogen production by energy source and technology, 2019 and 2050 (IEA, 2022) *5: “Green Growth Strategy” (METI, 2022) *6: “Global hydrogen trade to meet the 1.5°C climate goal: Part III – Green hydrogen cost and potential” (IRENA, 2022) *7: Japan aims to achieve 20 JPY/Nm3, which is about 220 JPY/kg, around the same value as IRENA estimates. *8: LT-LEDS *9: ANEKA GAS

# Hydrogen demand especially in Indonesia is expected to skyrocket due to high rates in population and economic growth if hydrogen technology develop constantly

## Potential Hydrogen Demand*2




Source: Deloitte analysis

*1: Note that potentials is always larger than targets *2: Does not include self-consumed hydrogen

*Reference

# Calculation assumption for hydrogen demand projection

| | |
|---|---|
| Vehicles | ■ [# of cars (unit)] × [average milage per year (km/year)] × [% of hydrogen vehicles (%)] × [efficiency of hydrogen vehicles (km/kg-H2)]<br>➢ [# of cars (unit)] is assumed to increase along with population<br>➢ [% of hydrogen vehicles (%)] is assumed to increase in a liner way from 0% in 2030 to 50% in 2060/2065 for cars (the rest is for BEVs), to 100% in 2060/2065 for buses and trucks. Cars exclude passenger vehicles<br>➢ [efficiency of hydrogen vehicles (km/kg-H2)] is set at 105 km/kg for cars, 10 for buses, 20 for trucks |
| Heat | ■ [Final fossil fuel energy consumption for manufacturing, const., mining (TJ)] ×[% of hydrogen (%)] × [hydrogen conversion (kg-H2/TJ)]<br>➢ [Final fossil fuel energy consumption for manufacturing, const., mining (TJ)] is assumed to increase along with Indonesian final consumption of energy<br>➢ [% of hydrogen (%)] is assumed to increase in a liner way from 0% in 2030 to 100% in 2060/2065 for Thailand/Indonesia |
| Power plant | ■ [Capacity of natural gas power plant (GW)] ×[% of hydrogen (%)] × [hydrogen conversion (kg-H2/GW)]<br>➢ [Capacity of natural gas power plant (GW)] is aligned with the governments' plans if any. Otherwise, the current capacity was assumed to continue over 2060<br>➢ [% of hydrogen (%)] is set to reach 30% in 2040 for Thailand and in 2050 for Indonesia, since according to the interviews Thailand will have earlier introduction of hydrogen to power plants. 30% is the maximum injection rate target shown by the Japanese government for its 2030 target |

*Reference

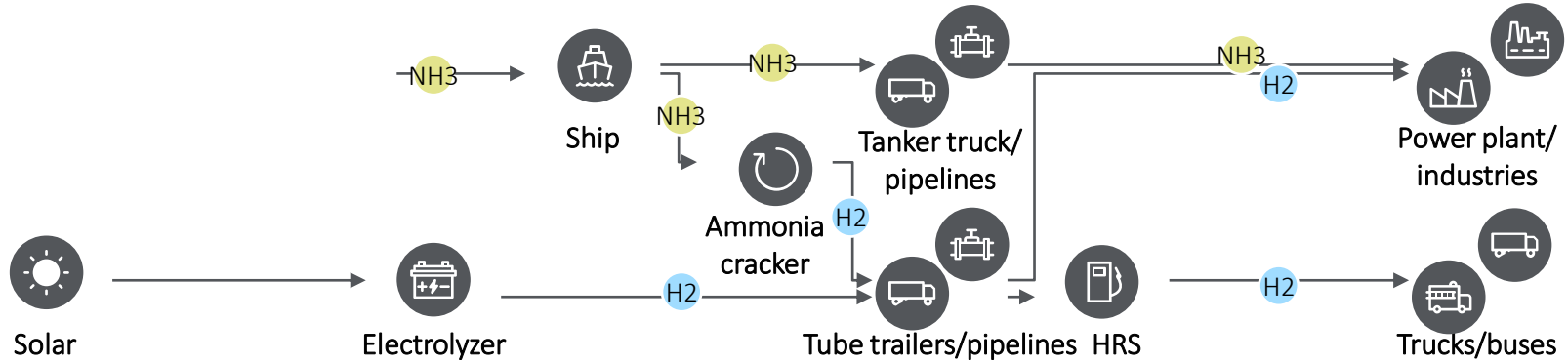
# Calculation assumption for hydrogen demand projection

| | |
|---|---|
| Refinery | ■ [Capacity of refinery plant (b/d)] ×[hydrogen needed to procured (kg-H2/b/d)]<br>➢ [Capacity of refinery plant (b/d)] is not changed from present to 2060 both for Thailand and Indonesia<br>➢ [hydrogen needed to procured (kg-H2/b/d)] is assumed based on the information of hydrogen volume procured for its refinery capacity, which is about 70kg-H2/b/d. Information of ENEOS, an oil and gas company of Japan, was used. |
| Ammonia | ■ [Ammonia production (t/y)] × [Hydrogen needed for ammonia production (kg-H2/t-Nm3)]<br>➢ [Ammonia production (t/y)] is not changed from present to 2060 for Indonesia. Thailand's ammonia production was set to zero, since ammonia plants seem to not exist.<br>➢ [Hydrogen needed for ammonia production (kg-H2/t-Nm3)] was set to 177kg of H2 for 823 kg of N2. |
| Steel | ■ [Capacity of steel production plant (Mt/y)] ×[Hydrogen introduction rate (%)]×[hydrogen needed for steel production (kg-H2/t-crude steel)]<br>➢ [Capacity of steel production plant (Mt/y)] is not changed from present to 2060 both for Thailand and Indonesia<br>➢ [Hydrogen introduction rate (%)] is set the same as IEA forecast introduction rate following 10 years behind.<br>➢ [hydrogen needed for steel production (kg-H2/t-crude steel)] was set at 103kg-H2/t-crude steel |
| Ethylene (MTO) | ■ [Etylene production (t/y)] ×[Hydrogen introduction rate (%)]×[hydrogen needed for ethylene production using MTO (kg-H2/t-etylene)]<br>➢ [Etylene production (t/y)] is set to reach 900,000 for Indonesia in 2030, aligning with the national target (target year is not shown). For Thailand, the current production volume is assumed to continue over 2060.<br>➢ [Hydrogen introduction rate (%)] is set the same as IEA forecast introduction rate following 10 years behind.<br>➢ [hydrogen needed for ethylene production using MTO (kg-H2/etylene)] was set at about 1 t-H2/t-Etylene |

# In Thailand, supply chain would be established by replacing fossil fuel in industry and transport sectors with green hydrogen from solar PV

## A Hydrogen Business Model in Thailand in 2030s-40s

| Production | Transport + Distribution + Supply | Use |
|---|---|---|
| ■ The Thailand Gov't promotes **green hydrogen** for emission reduction, while multiple enterprises seek to **use imported ammonia** as well according to the interviews<br>■ **Solar energy** will be the major VRE in Thailand according to PDP | ■ Multiple enterprises plans to import ammonia from overseas as one of the first hydrogen/ammonia deployments in TH<br>■ **Compressed hydrogen and pipelines** are more likely to be suitable for first stage hydrogen transportation demand given that liquid hydrogen is unlikely to be used in Southeast Asia according to the interviews | ■ The Thailand Gov't highlights hydrogen use in transport/industry/power sectors<br>■ In fact, projects to use hydrogen in the transport sector have already started in Thailand<br>■ Usage in IE, such as EEC, can be expected<br>*IE: Industrial estate*<br>*EEC: Eastern economic corridor* |




**Concept**

■ Reduce emission from transport/industry/power sectors by taking advantage of renewables in Thailand such as solar, which cannot be fully utilized through power grids

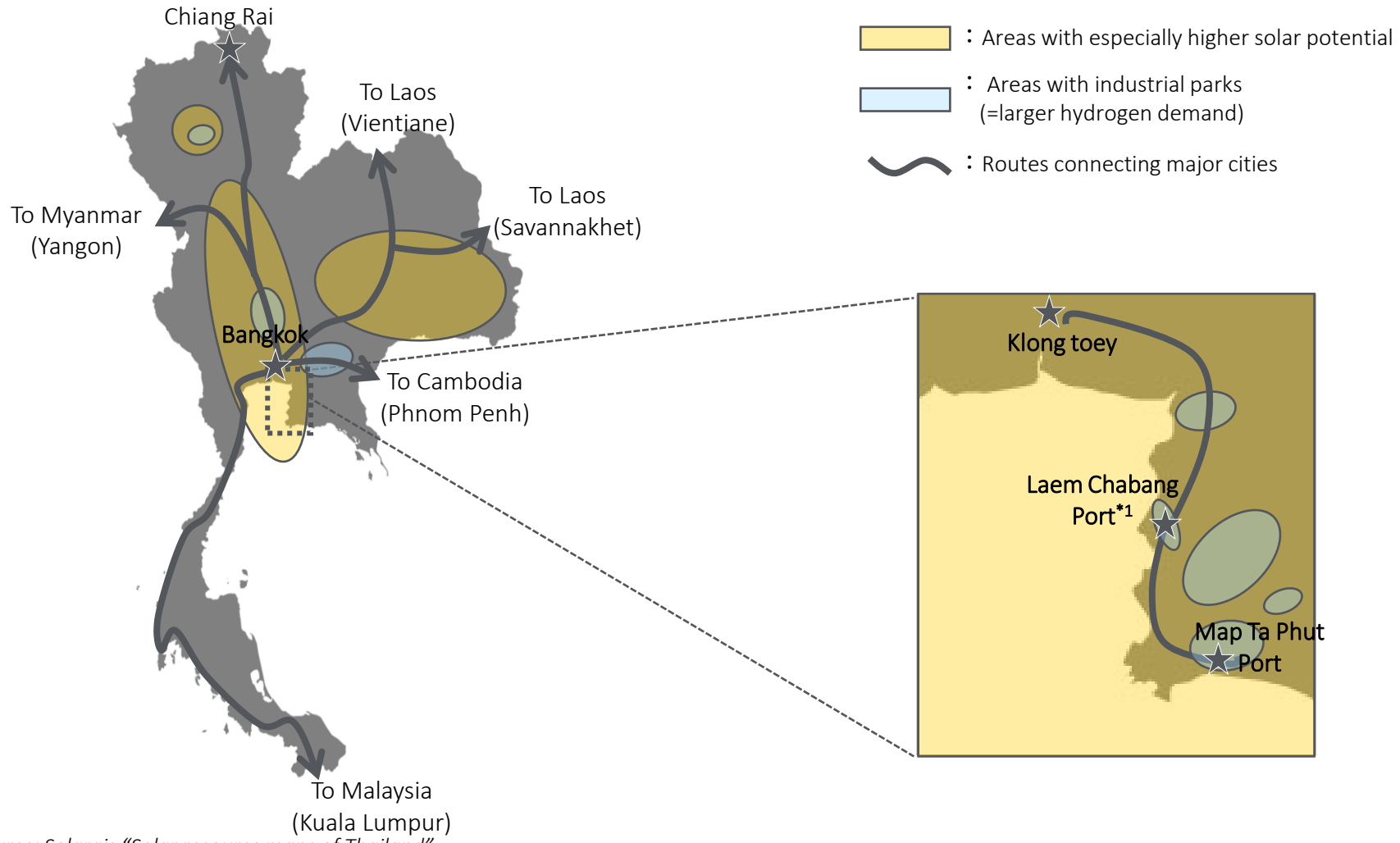
**Area**

■ Bangkok and its surrounding area, which serves as a hub for the logistics in the Mekong area as well as being a concentration of industrial parks

*Reference*

# Bangkok and its surrounding area are ideal for establishing the business model because of hydrogen demand centers and solar PV potential

## Potential Map of Thailand



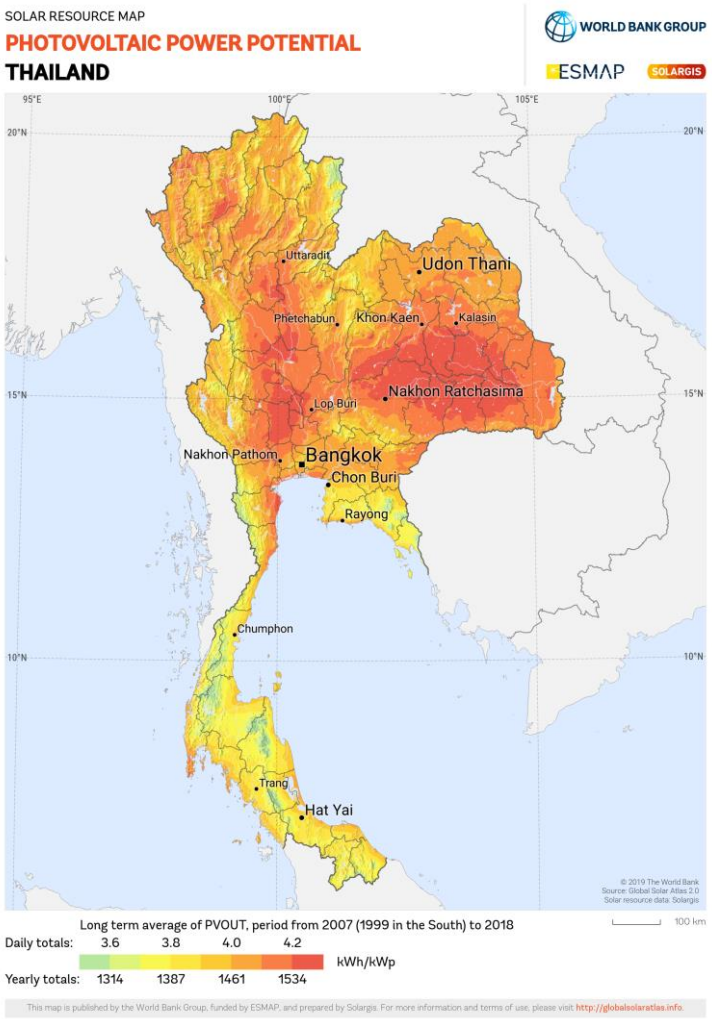

*Source: Solargis "Solar resource maps of Thailand"*

**1: Leam Chabang Port is one of the top 50 biggest container ports in the world, according to World Shipping Council*

*Reference*

# Solar power potential is abundant around the center area

## Thailand Solar Potential Map

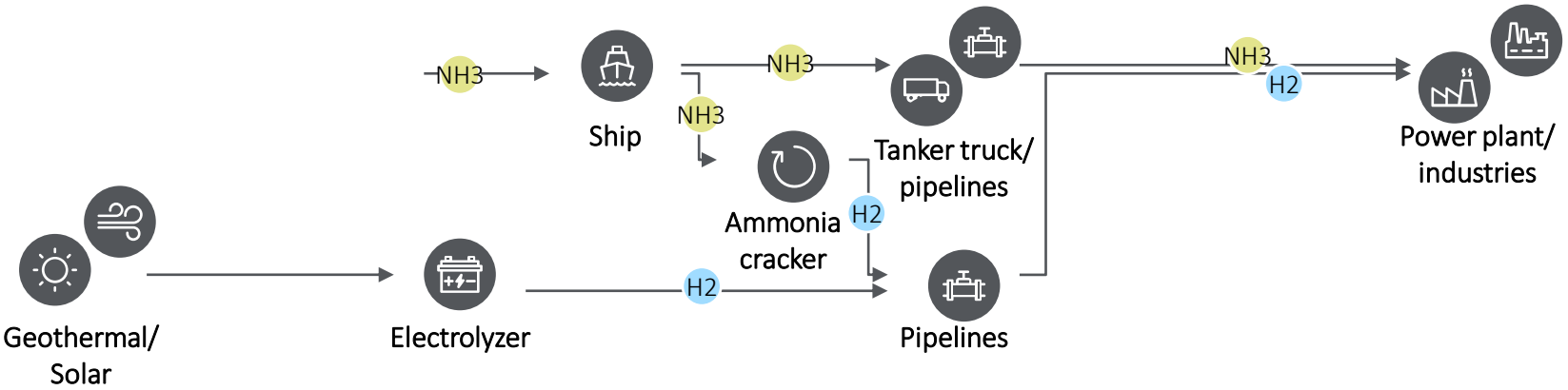



*Source: Solargis "Solar resource maps of Thailand"*

# In Indonesia, supply chain would be established by replacing grey hydrogen or conventional fuel with green hydrogen from geothermal or solar PV

## Hydrogen Business Model in Indonesia in 2030s-40s

| Production | Transport + Distribution + Supply | Use |
|---|---|---|
| ■ The Indonesian Gov't promotes **green hydrogen** for GHG emission reduction, while multiple enterprises seek to **use imported ammonia** as well according to the interviews<br>■ **Geothermal and solar** energy potential are especially high in Indonesia. | ■ Hydrogen pipelines and liquid hydrogen are suitable for large scale hydrogen use, however, the latter will be unlikely to be available in Southeast Asia<br>■ Liquid ammonia delivery on vehicles is already established | ■ The Gov't **highlights the role of hydrogen in industry** for GHG emission reduction over the other sectors such as transport.<br>■ Multiple enterprises seek to use ammonia to **replace coal in thermal power plant** by co-firing<br>■ Vehicles nor HRSs on the other hand, have not yet introduced |




**Concept**

■ Reduce emission from industry sector by taking advantage of renewables in Indonesia such as geothermal and solar power, which cannot be fully utilized through power grids

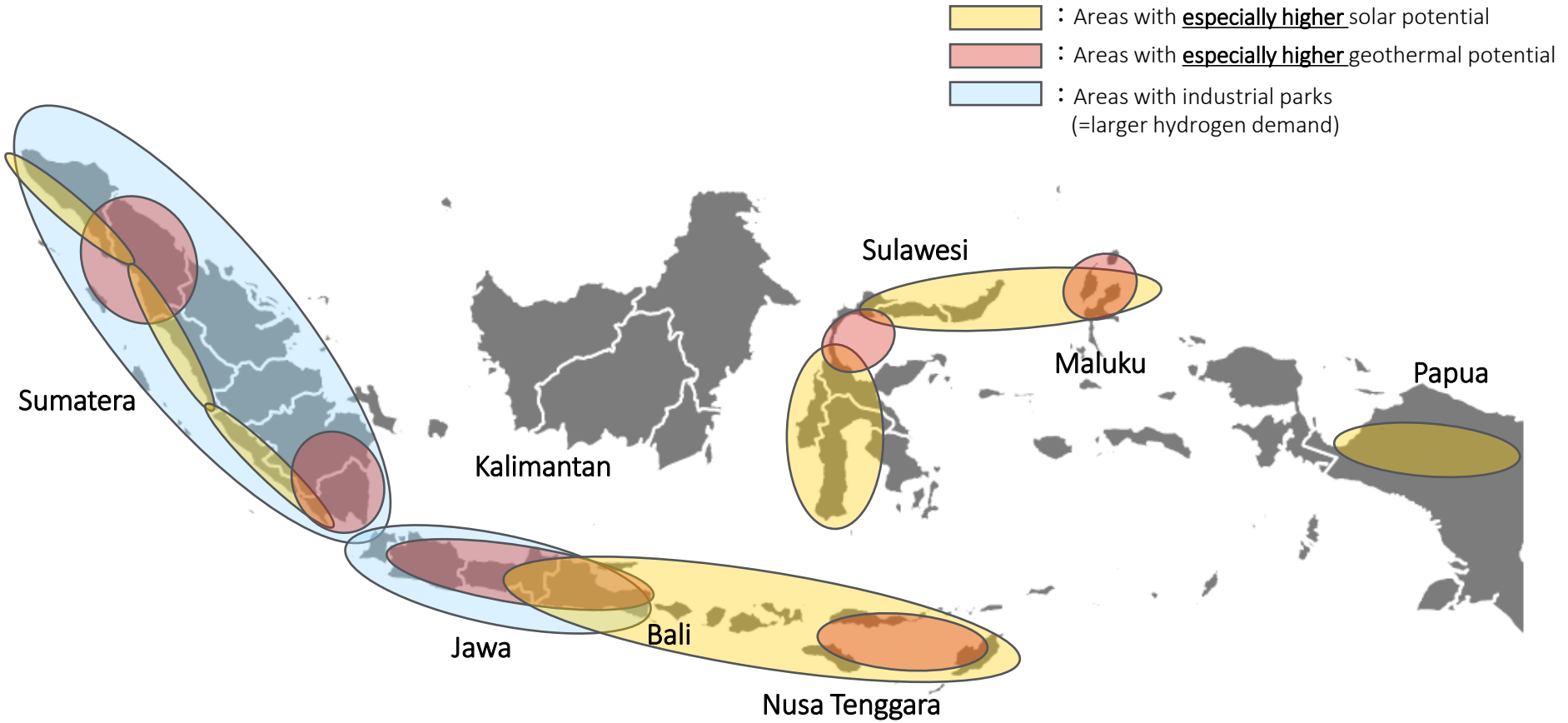
**Area**

■ Jawa Island or Sumatera Island, where both abundant geothermal and solar renewable potential, and industry demand exist

*Reference*

# Java or Sumatera Islands are ideal for the business model because of their hydrogen supply and demand potential

## Distribution map of hydrogen demand and potential

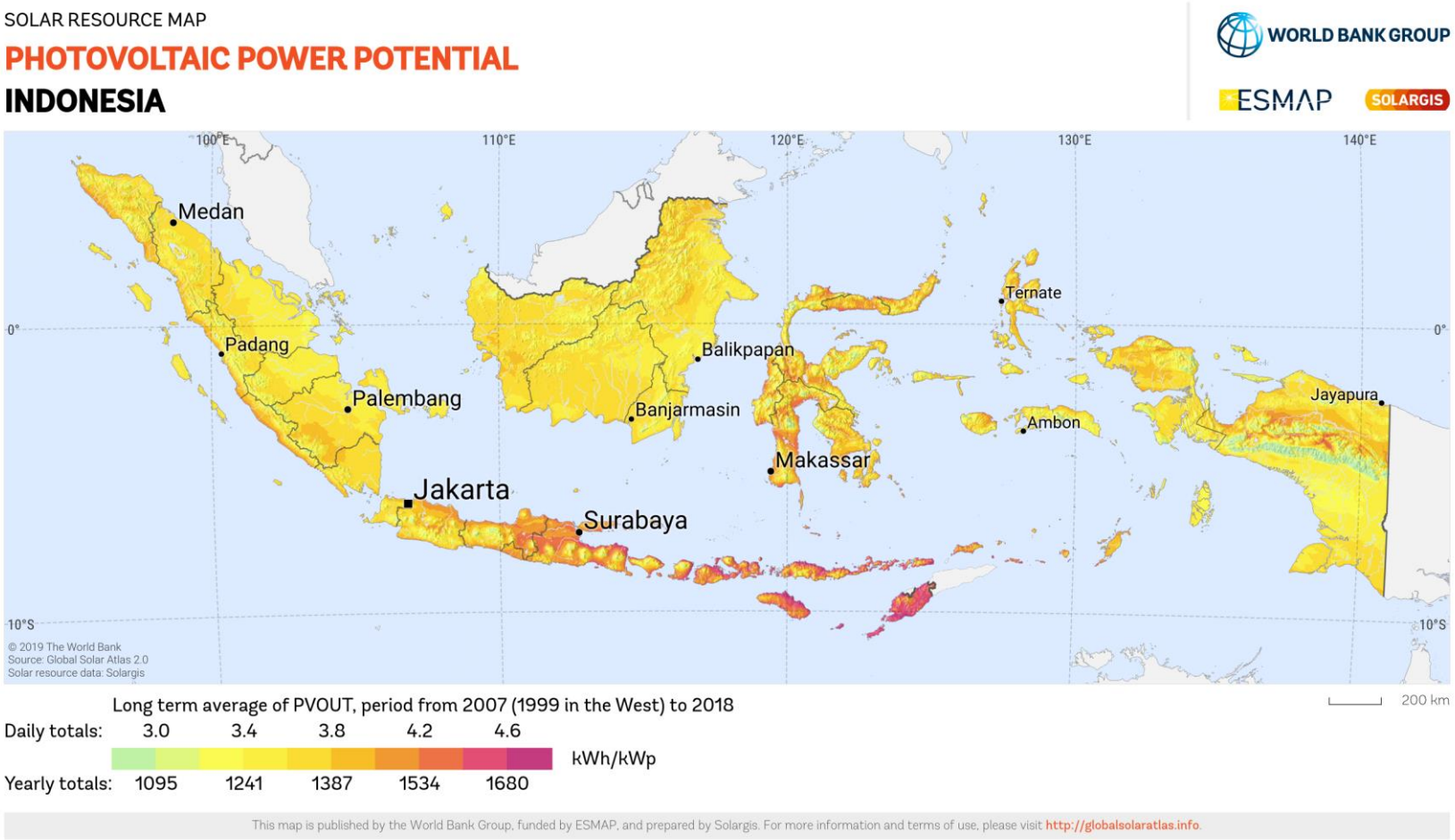



*Source: JBIC (2019)「インドネシアの投資環境」, Nugraha, Saefulhak & Pangaribuan (2017) A Study on the Impacts of Incentives to the Geothermal Energy Electricity Price in Indonesia using Production-based Cost Approach, Solargis "Solar resource maps of Indonesia"*

*Reference*

# PV power potential concentrates on Jawa, Bali, Nusa Tenggara Islands

## Indonesian Solar Potential Map




*Source: Solargis "Solar resource maps of Indonesia"*

*Reference*

# Sumatera and Jawa Islands have especially high geothermal power potential

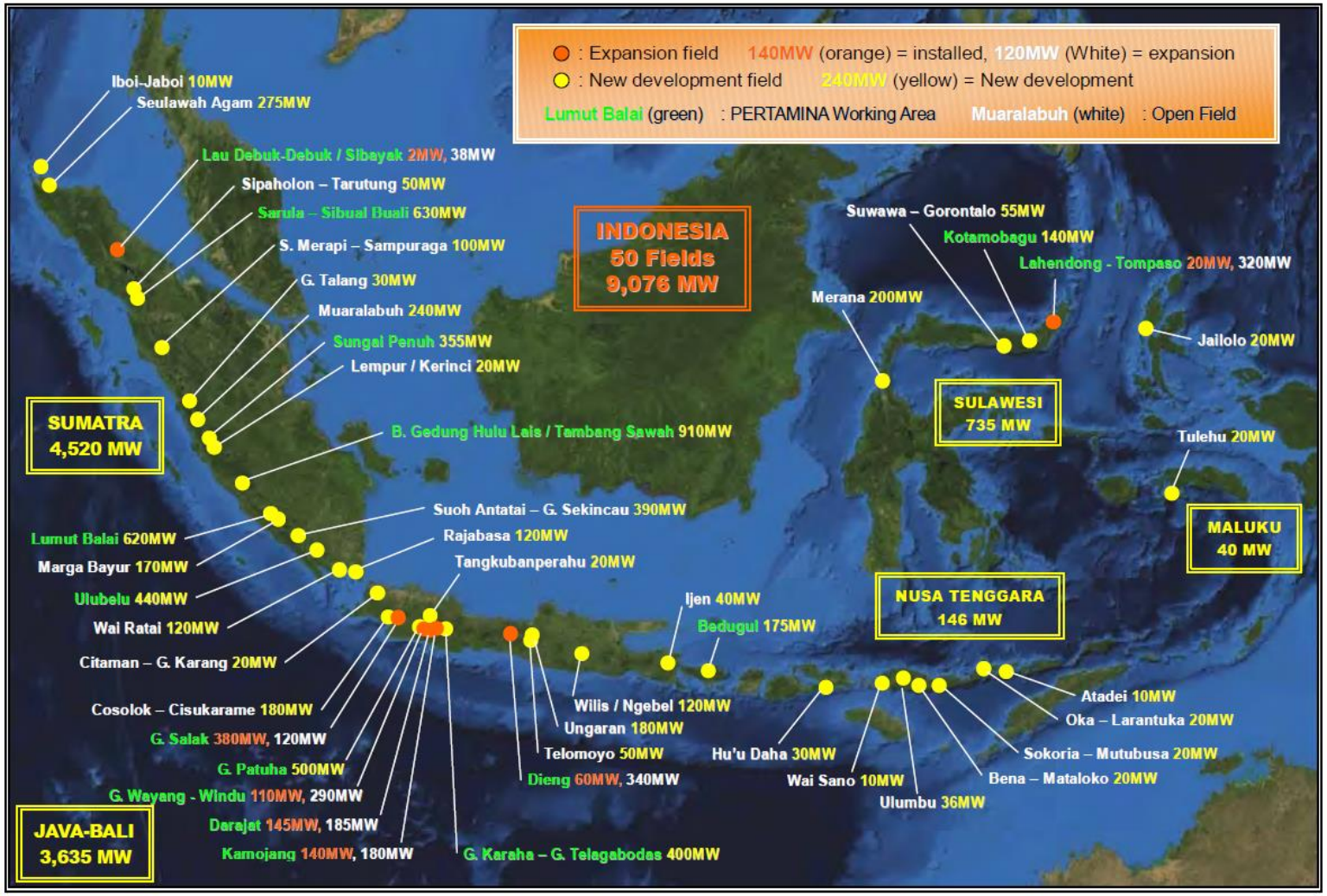
## Indonesian Geothermal Potential Map


*Source: Nugraha, Saefulhak & Pangaribuan (2017) A Study on the Impacts of Incentives to the Geothermal Energy Electricity Price in Indonesia using Production-based Cost Approach*

*Reference*

# Geothermal potential is mainly located in Java and Sumatera Islands according to latest report from Ministry of Energy (MEMR)

## Indonesian Geothermal Potential Map




*Source: Ministry of Energy & Resource's Master Plan of Geothermal Development (2022) & JICA Reports on Indonesia Decarbonization Report (2022)*

# ①Desktop Research

## ①Desktop Research

Energy trend

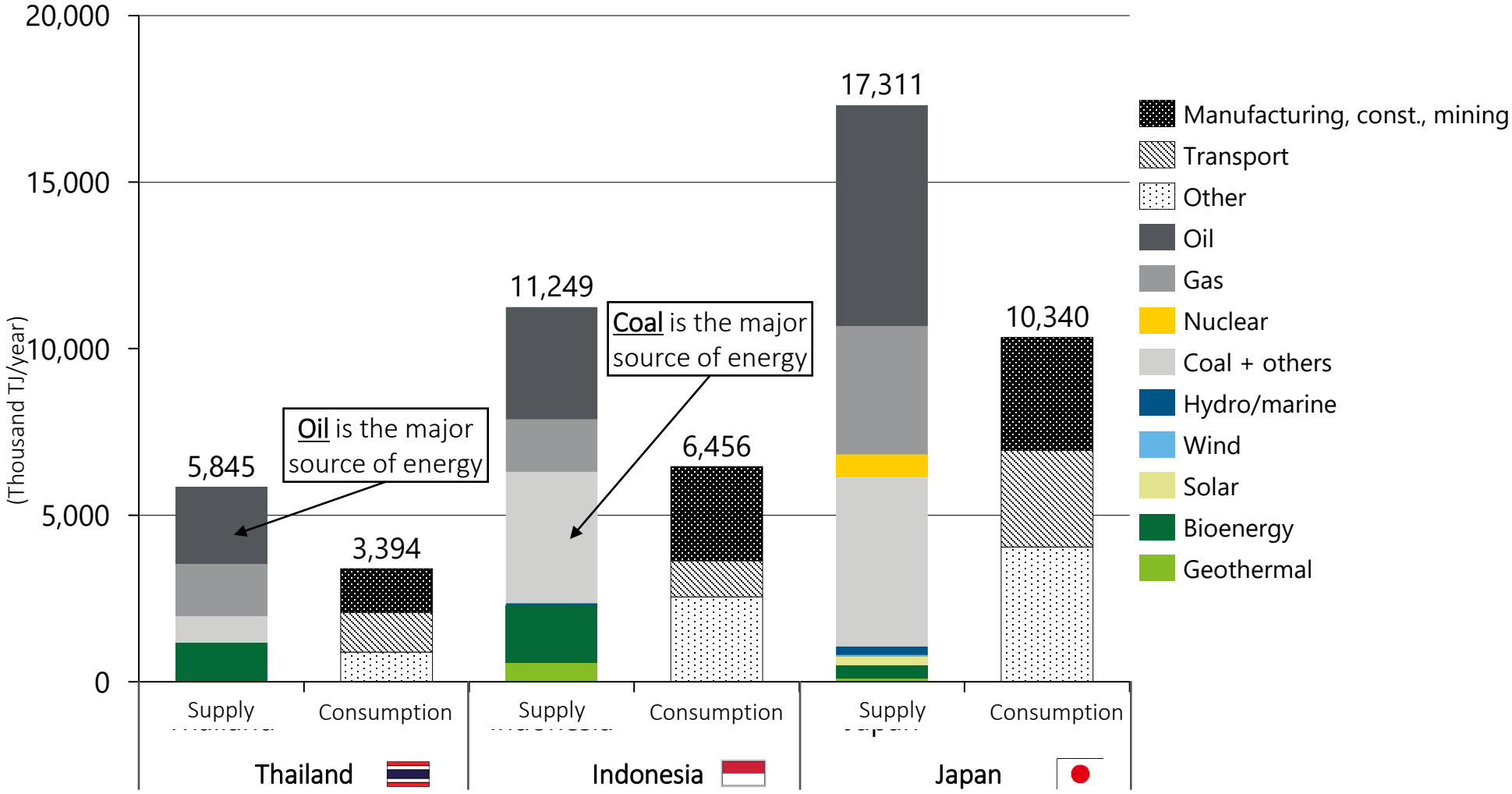
Outlook for hydrogen

Policy

Technical readiness and players

# Thailand's and Indonesia's major energy sources are oil and coal respectively

## Energy supply and consumption by country in 2019

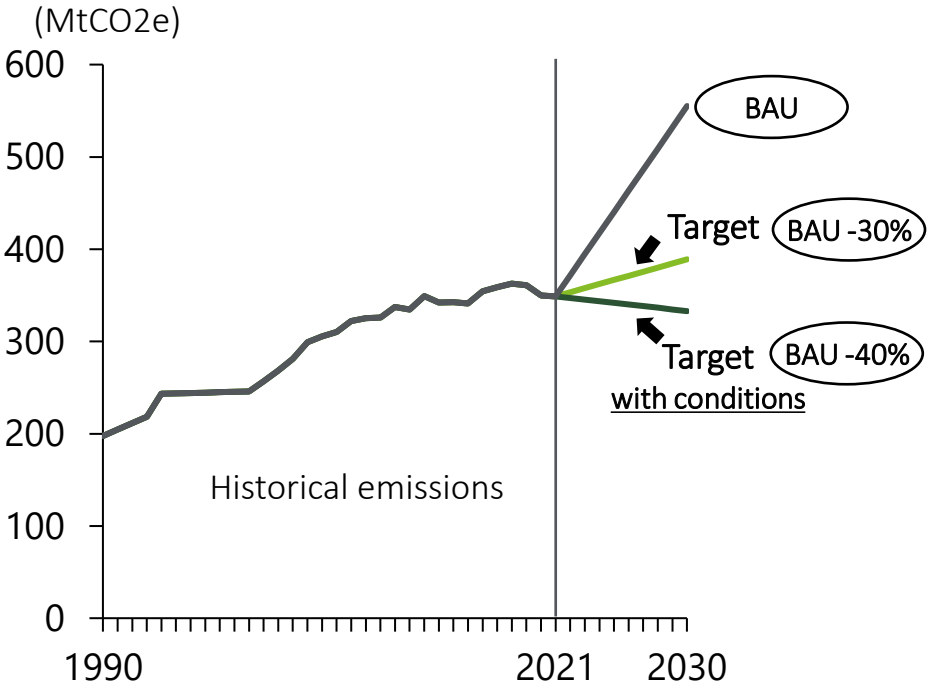



 *Source: Energy Profile (IEA), The 2020 Energy Balances (United Nations, 2020)*

# Thailand

# Thailand's NDC shows that it aims to reduce 30 percent of GHG emissions from the BAU level by 2030

## Thailand's emission reduction target and countermeasures



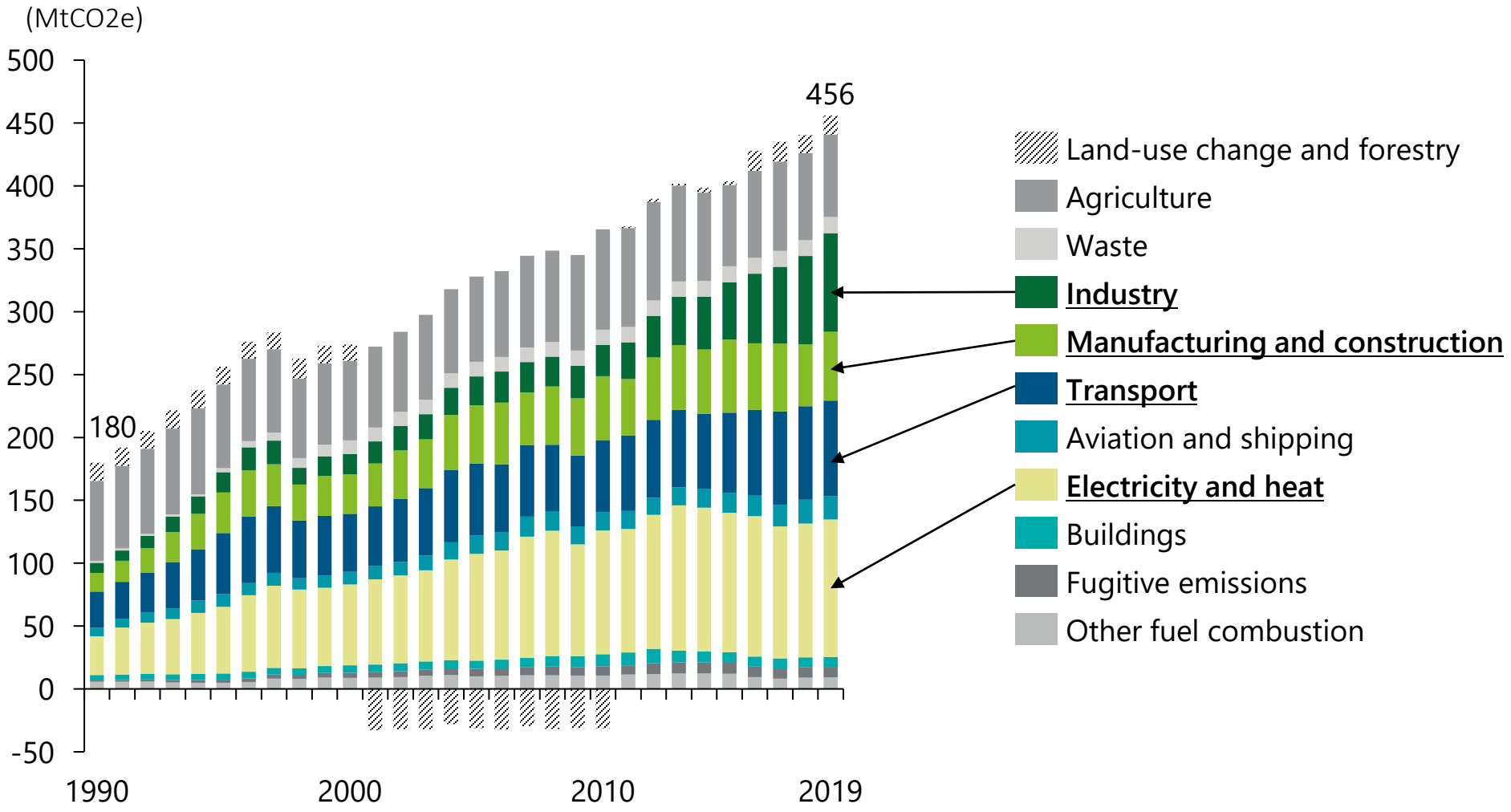

- The level of contribution could be up to 40 percent, subject to adequate and enhanced access to technology development, financial resources, and capacity building support
- Thailand aims to achieve carbon neutrality by 2050 and net-zero GHG emission by 2065

| | |
|---|---|
| Challenge and limitation | ■ High investment and operating costs of technologies and infrastructures<br>■ Limitation of grid connection<br>■ Lack of domestic technological and technical resources<br>■ Negative public perception towards waste-to-energy and biomass power plants |
| Adaptation Component | ■ Thailand has developed the National Adaptation Plan (NAP) which includes 6 priority sectors:<br>➢ Water resources management, agriculture and food security, tourism sector, public health, natural resources management, and human settlements and security |
| Support needs | 1. Policy implementation<br>2. Technology development and transfer e.g., R&D of CCS, CCUS, Bio-energy with CCS, DAC, and hydrogen<br>3. Mechanisms and instruments<br>4. Climate information and M&E systems |

 *Source: Thailand's 2nd Updated Nationally Determined Contribution, Climate Action Tracker*

# Emissions from electricity and heat, transport and industry have been increasing in Thailand

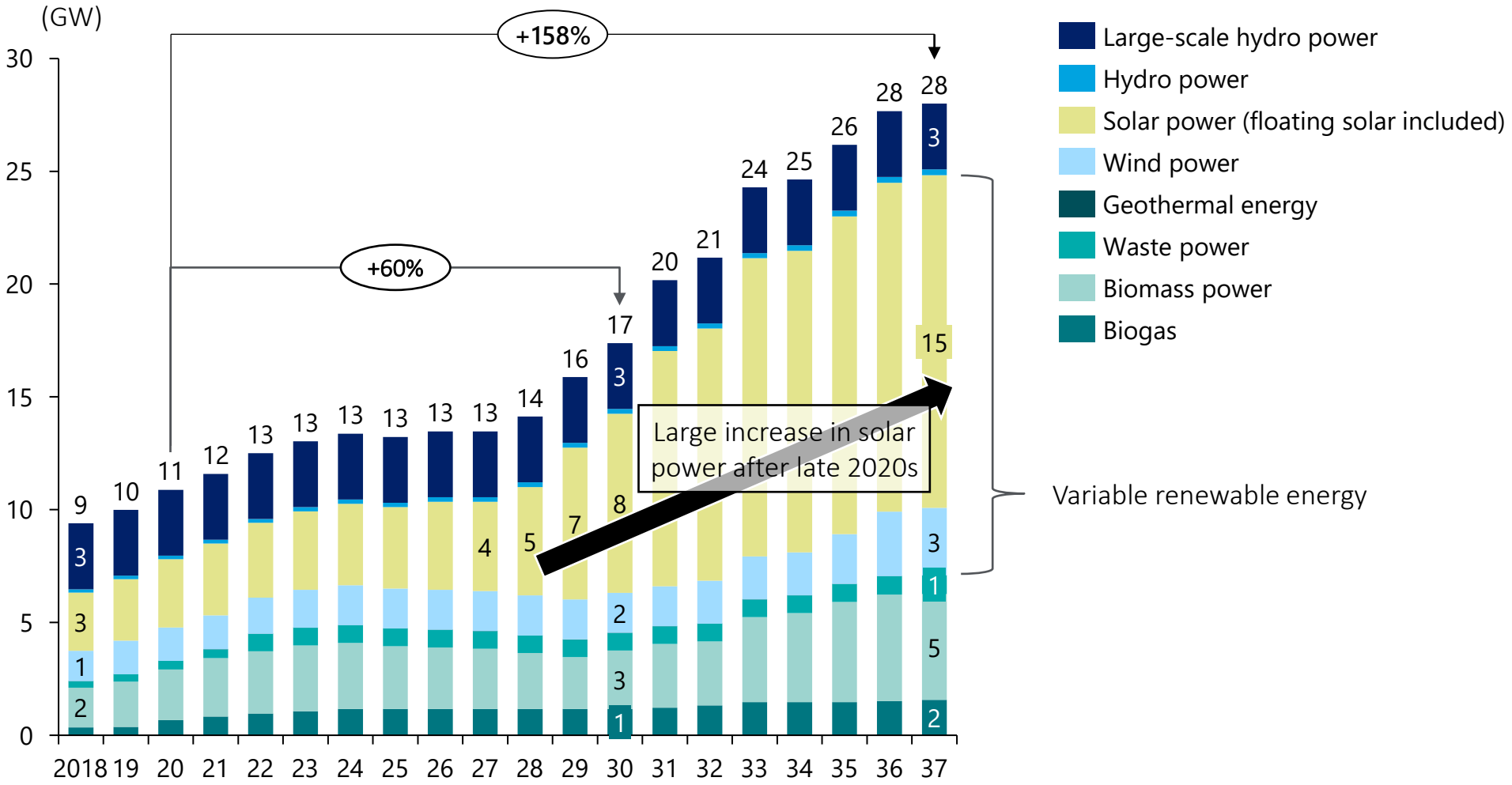
## GHG emission by sector of Thailand




 *Source: Our World in Data*

# Renewable energy capacity is planned to double, with a considerable solar energy capacity increase after the late 2020s onward

## Renewable energy capacity prospect in Thailand



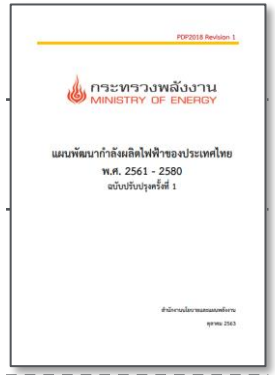

 *Source: Ministry of Energy (2018) "Thailand's Power Development Plan 2018-2037 Revision1"*

*Reference*

# Thailand's Government shows the long-term electricity generation plan in PDP (PDP2018 Rev.1)

## Thailand's Power Development Plan (PDP)

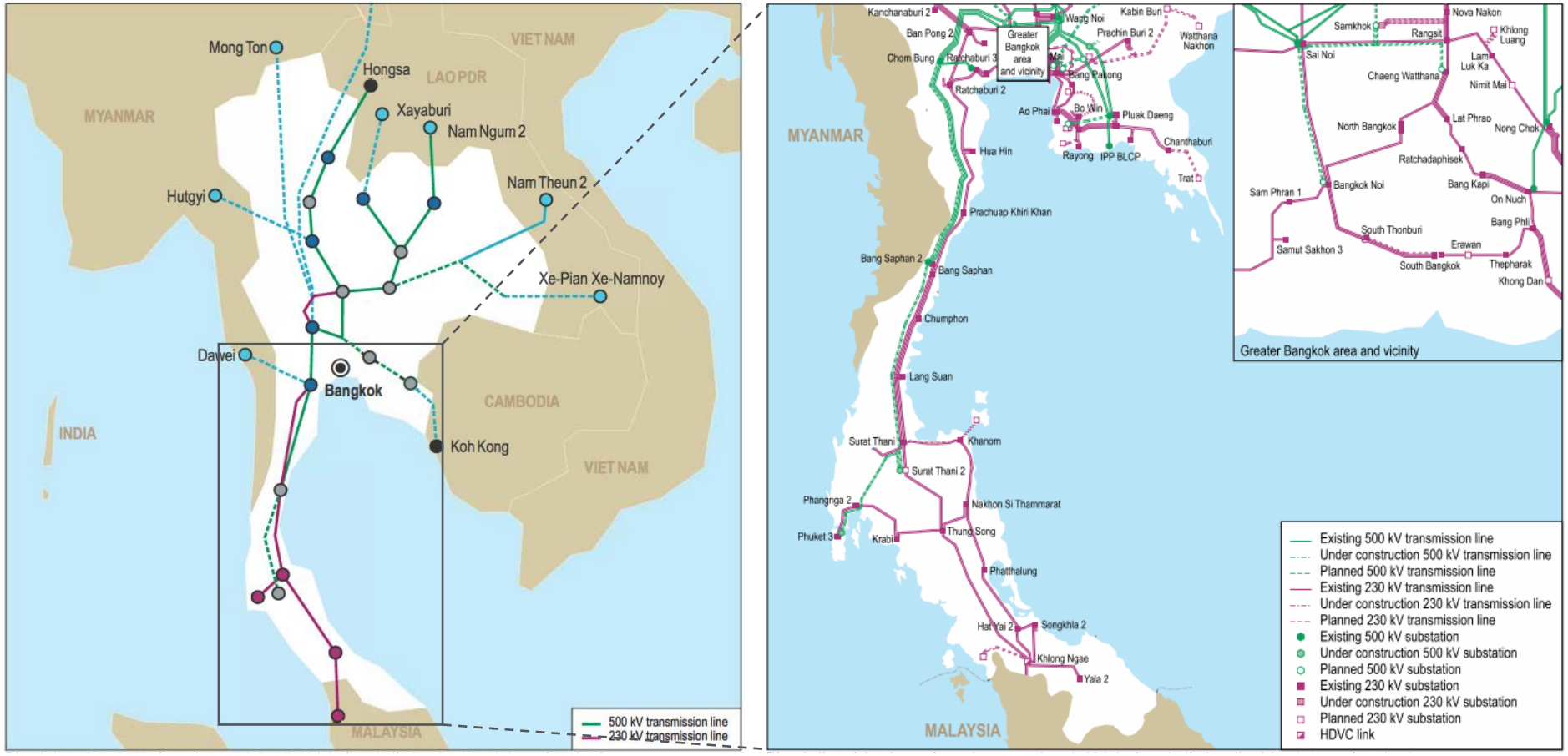
| | | | |
|---|---|---|---|
| Document Name | Thailand's Power Development Plan 2018-2037 Revision1 (PDP2018 Rev.1) | | |
| Year of publishment | 2018 | Issued by | Ministry of Energy |
| Background | ■ Ministry of Energy had been publishing PDPs, and PDP2018 needed adjustment because of the publishment of new Alternative Energy Development Plan (AEDP) | | |
| Purpose | ■ To show the long-term electricity generation blueprint of Thailand's energy transition<br>➢ includes the development of new power plants in the country<br>➢ the development of power transmission systems<br>➢ the purchase of electricity from neighboring countries | | |
| Summary | ■ The plan prioritizes three different areas, which includes energy security, economy, and ecology, for the next decades<br>■ It mentions energy sources such as hydro power, biomass power, solar power, waste power, natural gas, and coal, and 25.7 percent of the total energy is expected to be generated from renewable sources<br>■ Apart from electricity generating plan, It also includes energy efficiency measures | | |




*Source: Ministry of Energy (2020) "The Direction of Electricity Policy in Thailand", Ministry of Energy (2018) "Thailand's Power Development Plan 2018-2037 Revision1"*

# Thailand's power grid is generally robust and reliable, and considering more demand increase, the 500kV T/L is planned to extend to Phuket

## Thailand's Power Grid Overview

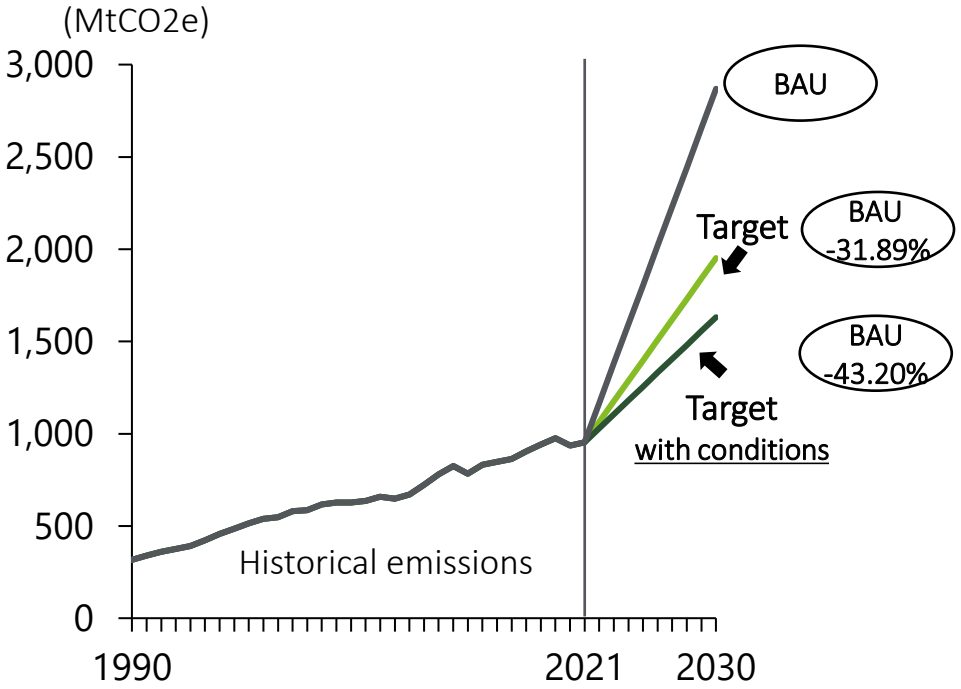



 *Source: IEA (2018) "Thailand Renewable Grid Integration Assessment"*

# Indonesia

# Indonesia's GHG emission is subjected to increase over 2030 according to its NDC

## Indonesia's emission reduction target and countermeasures



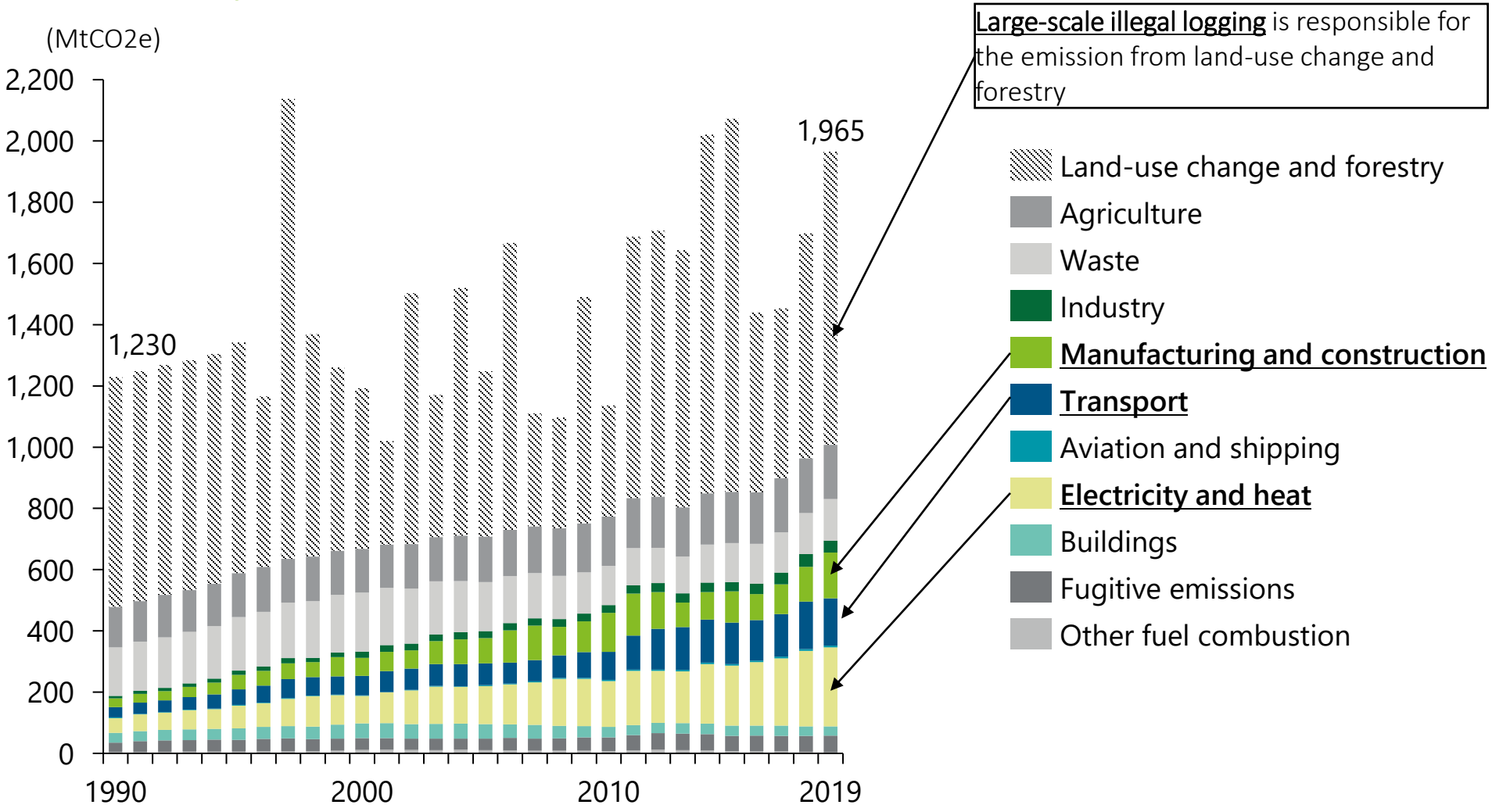

- The level of contribution could be up to 43.20 percent with the support from international parties
- Aims to achieve the peaking of national GHG emissions in 2030 and to explore opportunity to rapidly progress towards net-zero emission in 2060 or sooner

| | |
|---|---|
| Challenge and limitation | ■ Addressing challenges faced by sectors, cities and regions in transitioning to low carbon development and in ensuring a decent future for workers affected by the transition.<br>■ Promoting low GHG emission and sustainable economic activities that will create quality jobs in cities and regions. |
| Adaptation Component | ■ Creating enabling environment to engage wider stakeholders in NDC adaptation<br>■ Developing framework and network for building synergy among all sectors & Ministries<br>■ Developing guidance, policies, planning and incentives program for NDC implementation |
| Support needs | ■ Exact detail and step-by-step programs, which include periodical milestones in accordance with existing NDC planning & initiatives<br>■ Enhance effectiveness and efficiency in implementing & monitoring NDC target as well as in communicating its progress |

 *Source: Enhanced NDC - Republic of Indonesia, Climate Action Tracker*

# Emissions from electricity and heat, transport and manufacturing and construction have been increasing in Indonesia

## GHG emission by sector of Indonesia




 *Source: Our World in Data*

*Reference*

# Forestry contribution to Net Zero has highly fluctuated due to crucial illegal deforestation, which the government is still addressing

## Indonesia's Forestry Sector

**NDC Key Goals for Forestry**

- In forestry sector, Indonesia has set up an ambitious target by 2030 in peat lands restoration of 2 million ha and rehabilitation of degraded land of 12 million ha.
- Indonesia will continue to work on the roles of forest through Reducing Emissions from Deforestation and Forest Degradation (REDD+) Framework by UN to promote climate and development benefits from forests

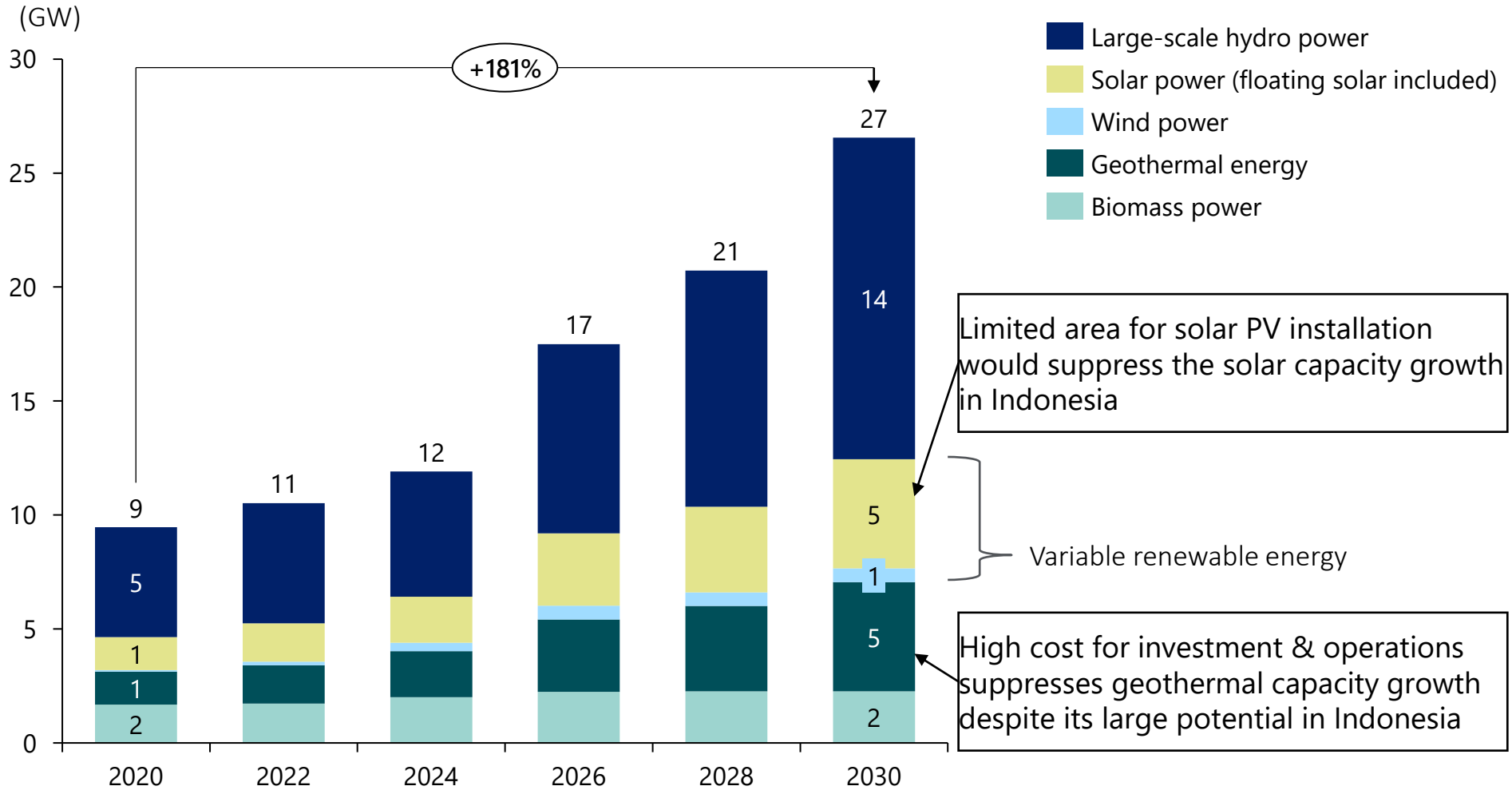
**Challenges**

- Indonesia's illegal logging problem has deep roots. The heavily forested nation supplied 219 million cubic meters of unreported or illegally sourced timber from 1991 to 2014.
- The Indonesian Ministry of Forestry estimates that in recent years Indonesia has been losing 1.6-2.8 million hectares annually (equivalent to 3-5 hectares a minute) to illegal logging and land conversion to housing, mining, etc due to a lack of effective management and law enforcement

 *Source: Indonesia's NDC, Various News Article (Indonesia Has a Carrot to End Illegal Logging; Now It Needs a Stick | World Resources Institute (wri.org)*

# In Indonesia, renewable energy capacity will nearly double in the next 10 years

## Renewable energy capacity prospect in Indonesia

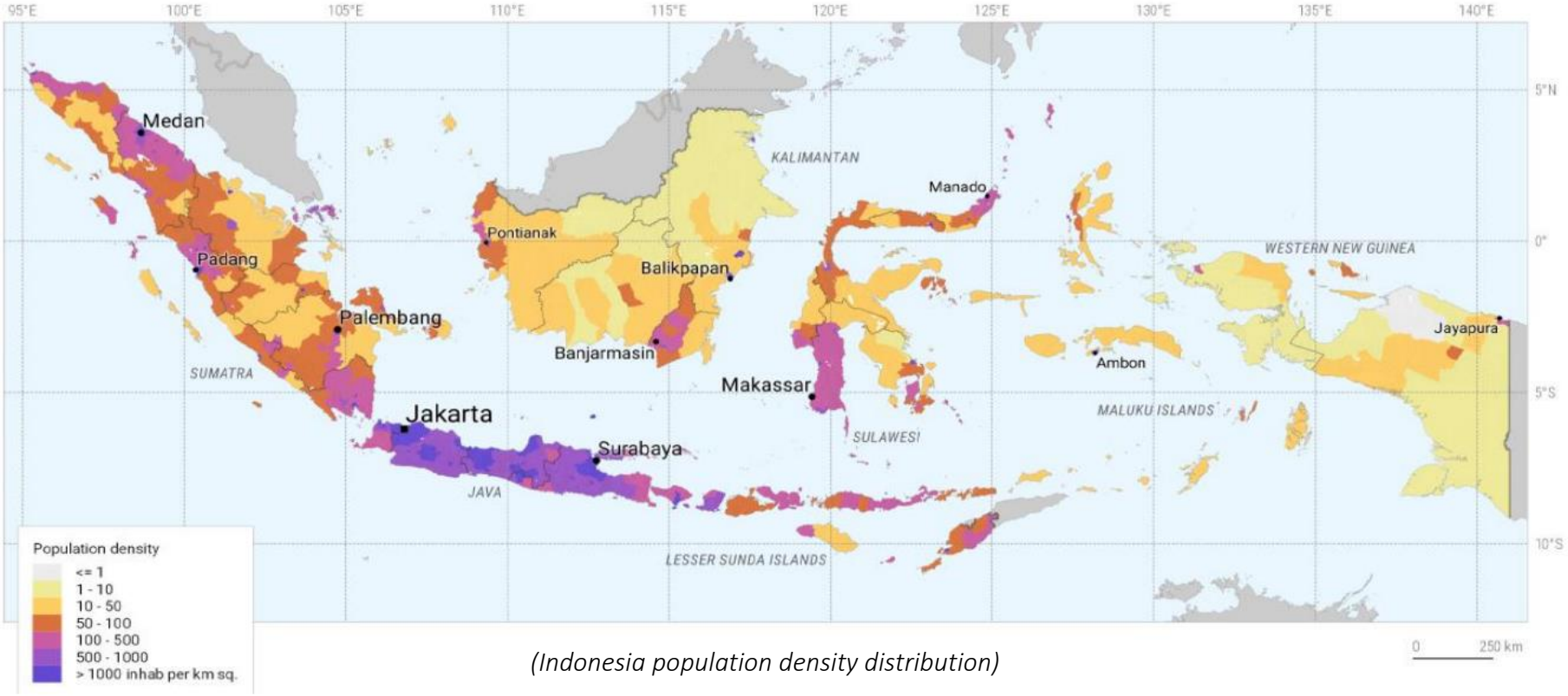



 *Source: Indonesia's Electricity Business Plan 2021-2030 (RUPTL)*

*Reference*

# One of key challenges to accelerate solar power is the land limitations in main grid system in Java-Sumatera, which is highly populated

## Indonesia Population Distribution




*(Indonesia population density distribution)*

**Latest Condition**

- As seen in the Figure above, the upmost dense population is <u>located in Java Island that consist of > 1000 inhabitant per km sq.</u> With that amount of density, it is very challenging to develop new renewable energy within the main electricity grid in Java.
- According to PLN, it still possible to build <u>solar power plant in the Eastern Region of Java</u> since less population density & still be able to be <u>connected to Indonesia's main electricity grid</u>

 *Source: Data Collection Survey on Power Sector in Indonesia for Decarbonization by Japan International Cooperation Agency (JICA) March 2022*

*Reference*

# Geothermal challenges is predominantly due to high cost for investment & operations as well as high risk for technical & safety

## Challenges in Promoting Geothermal Development

| | |
|---|---|
| High CAPEX | In geothermal development, many large risks exist in development. Long-term surveys and large-scale investment are required, as with the development of oil, natural gas and mineral resources. Three large issues exist regarding geothermal development:<br>1) Large initial investment, generation cost usually exceeds selling price.<br>2) Characteristics of geothermal resource greatly affect profit on projects.<br>3) Long lead time before development and large initial investment. |
| High OPEX | Generation costs of geothermal power plants exceed those of coal-fired power plants, and both are base load generation. Low carbonization might increase the generation costs of coal-fired power plants, and geothermal power plants might become superior |
| High Technical Risk | At each stage of geothermal development, which consists of survey, development, and operation, important technical risks exist, which may affect the development costs and power output, and be directly linked to profitability, as follows:<br>a) Survey stage: Difficulty in constructing access roads, difficulty in surveying due to characteristics of the survey area, Success rate for survey well drilling<br>b) Development stage: Depth of geothermal potential, productivity of geothermal potential, properties of geothermal fluid, concentration of non-condensed gas, success rate for production well drilling, increase in costs for construction and equipment<br>c) Operation stage: Attenuation of steam amount, Capacity factor decrease |

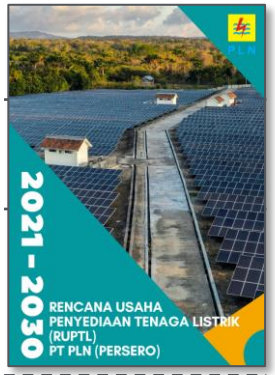
*Source: RUPTL PLN 2021-2030, Ministry of Energy & Resource report*

*Reference*

# RUPTL by PLN shows the long-term electricity generation plan in Indonesia

## Indonesia's Electricity Business Plan (PLN RUPTL) until 2030

| | | | |
|---|---|---|---|
| Document Name | Indonesia's Electricity Business Plan 2021-2030 (RUPTL*1) | | |
| Year of publishment | 2021 | Issued by | PLN |
| Background | ■ PLN, an Indonesian national power company, updates its electricity business plan every year, which requires an approval of The Minister of Energy and Mineral Resources | | |
| Purpose | ■ Shows PLN's business plan of electricity generation, distribution and transmission project developments for the next 10 years (2021-2030) | | |
| Summary | ■ RUPTL 2021-2030 marks a turning point in the country's energy transition as, for the first time, renewable energy development accounts for additional 20 GW of total installed capacity between 2020 to 2030<br>■ The plan comes in support of the Government's objectives to achieve a 23% share of renewable energy in the energy mix by 2025 (as stated in the National Electricity General Plan or RUKN) as well as to reduce greenhouse gas emissions by 29-41% by 2030 and achieve Net-Zero emissions by 2060 in line with the county's Nationally Determined Contributions<br>■ The key plan is to shift reliance away from fossil fuels, with larger renewable capacity additions planned. Therefore, within RUPTL most renewables have their own initiatives to accelerate its development<br>■ In addition, PLN is also stated its commitment to support energy-related infrastructure such as smart grid, charging station for EV, applying latest energy technology (e.g., CCS, coal bed methane & gasification) | | |




*Source: PLN (2021) "RENCANA USAHA PENYEDIAAN TENAGA LISTRIK", HHP Law Firm (2021)* 「インドネシア: 国有電力公社の新事業計画 -高い期待と『環境により優しい』プロジェクト

*1: RUPTL = RENCANA USAHA PENYEDIAAN TENAGA LISTRIK

*Reference*

# PLN has introduced several program to accelerate renewable energy adoption, which are specified for each type of renewables

## Indonesia's Electricity Business Plan (PLN RUPTL) until 2030

| | |
|---|---|
| RUPTL 2021-2030 Key Points | ■ The development of renewable power plant is intended to electrify remote areas & reduce the use of fossil fuel (e.g. coal, oil, gas) as Indonesia's commitment to achieve the target of utilizing **Renewable Energy around 23% by 2025.** |
| Solar Energy Program | ■ As an effort to accelerate the development of solar energy, the Government/PLN has introduced the following plan:<br>1. The utilization of **rooftop solar power plants** (Rooftop PV) is regulated through the Minister of Energy and Mineral Resources Regulation Number 26 of 2021<br>2. PLN also plans to develop Solar Panel in the following locations: **Ex-Mining & Dam/Water Reservoir for Floating Solar Plant**<br>3. **De-dieselization Power Plant Program** |
| Geothermal Energy Program | ■ The Geothermal Law was enacted in 2003 as a **"Geothermal Development Road Map"** The 2015 revision of the Geothermal Law **determines the geothermal targets to be 1,200 MW in 2020**<br>■ The government aims to achieve the target by introducing **initiatives such as Geothermal Investment Funding (Geothermal Resource Risk Mitigation (GREM) & Geothermal Exploration Upstream Development Project (GEUDP) & IPPs Partnerships** |
| Biomass Energy Program | ■ Implementation of **coal power plant co-firing by utilizing biomass** (wood pellets, saw dust etc.), with an average portion of **10% for Java-Bali (biomass requirement of up to 14 million tons/year)**<br>■ The above trial implementation for co-firing will be held between 2026-2028. |
| Wind Energy Program | ■ Over the next 10 years, **Indonesia plans to install just under 600 MW, but in the future, it may be able to increase capacity in some areas with low wind speeds**, or offshore, by improving turbine efficiency, including developing technology for low-speed wind turbines. |

# Indonesian islands operate power grids independently, without being connected with each other

## Indonesia's Power Grid Overview


 *Source: IEA (2022) "Enhancing Indonesia's Power System: Pathways to meet the renewables targets in 2025 and beyond"*

## ①Desktop Research

Energy trend

Outlook for hydrogen

Policy

Technical readiness and players

# Indonesia is considered to led hydrogen market in SEA while Thailand is still within the early stage of hydrogen development

## Hydrogen Demand in Thailand and Indonesia

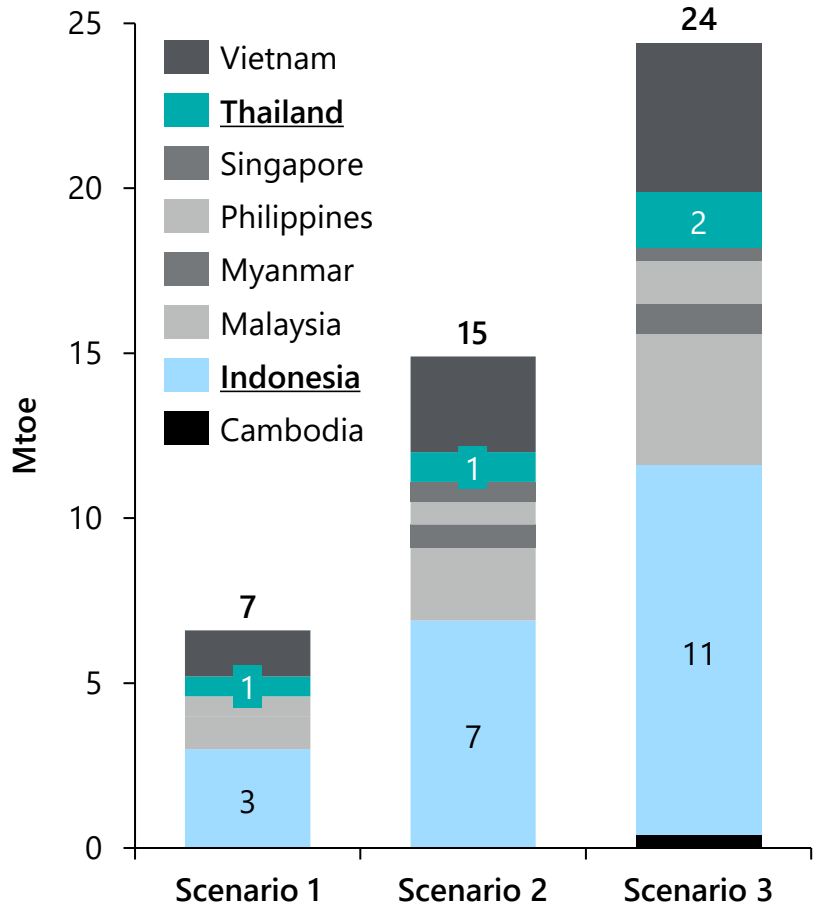
**Hydrogen Demand Scenario**

- ERIA*1 have forecasted scenario-based calculations on the potential demand for hydrogen by 2040, using the following scenarios for power generation:

| | % of hydrogen | % of natural gas |
|---|---|---|
| Scenario 1 | 10% | 90% |
| Scenario 2 | 20% | 80% |
| Scenario 3 | 30% | 70% |

**Key Takeaway**

- Overall, by 2040, the potential ASEAN hydrogen demand is 7 Mtoe (Scenario 1), 15 Mtoe (Scenario 2) and 24 Mtoe (Scenario 3)
- Indonesia is leading with 3 Mtoe (Scenario 1), 7 Mtoe (Scenario 2) & 11 Mtoe (Scenario 3) while Thailand is only managed to gain demand of 1 Mtoe (Scenario 1), 1 Mtoe (Scenario 2) & 2 Mtoe (Scenario 3)
- Indonesia has the largest hydrogen demand potential amongst ASEAN member countries, followed by Vietnam and Malaysia




*Hydrogen demand forecast by ERIA in ASEAN region in 2040*

*Source: Demand and Supply Potential of Hydrogen Energy in East Asia ERIA, JICA Indonesia Decarbonization Survey (2022)*

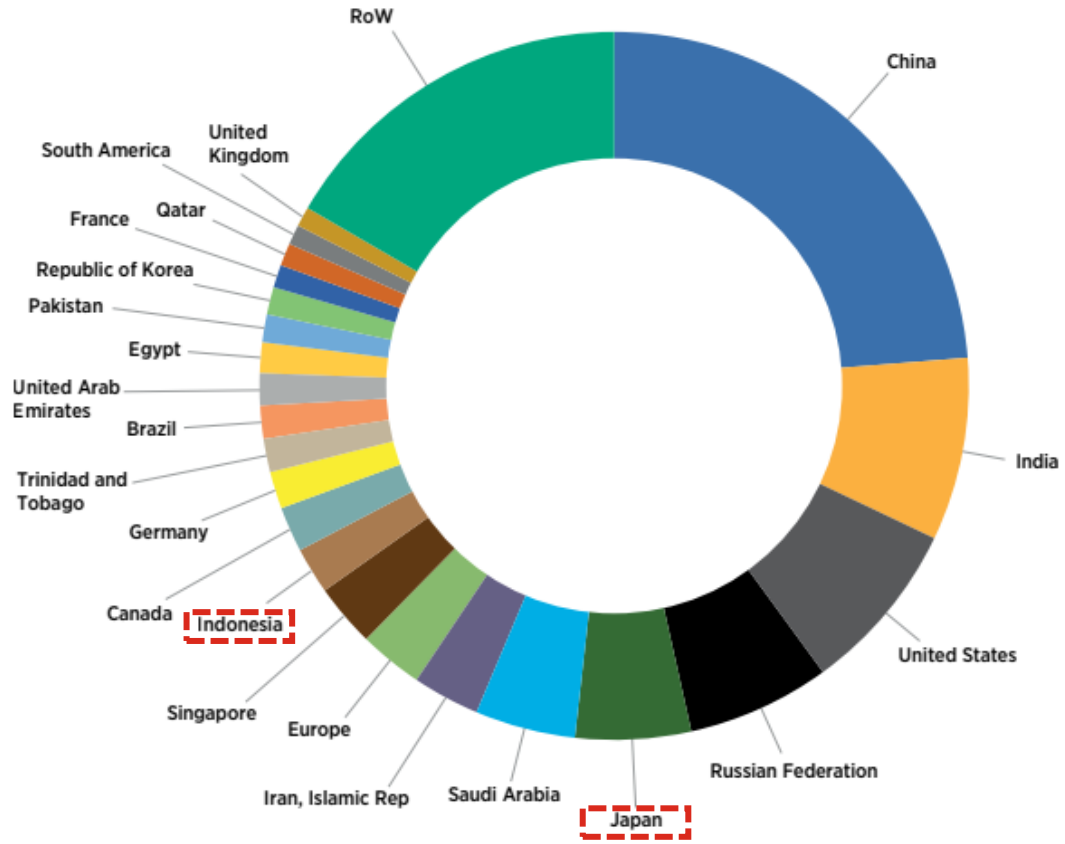
**1:* Economic Research Institute for ASEAN (ERIA)

*Reference*

# In 2050, Indonesian hydrogen demand is expected to be the 10th in the world.

## Hydrogen demand by country in 2050 in a 1.5℃ scenario

FIGURE 2.2. Hydrogen demand by country in 2050 in a 1.5°C scenario

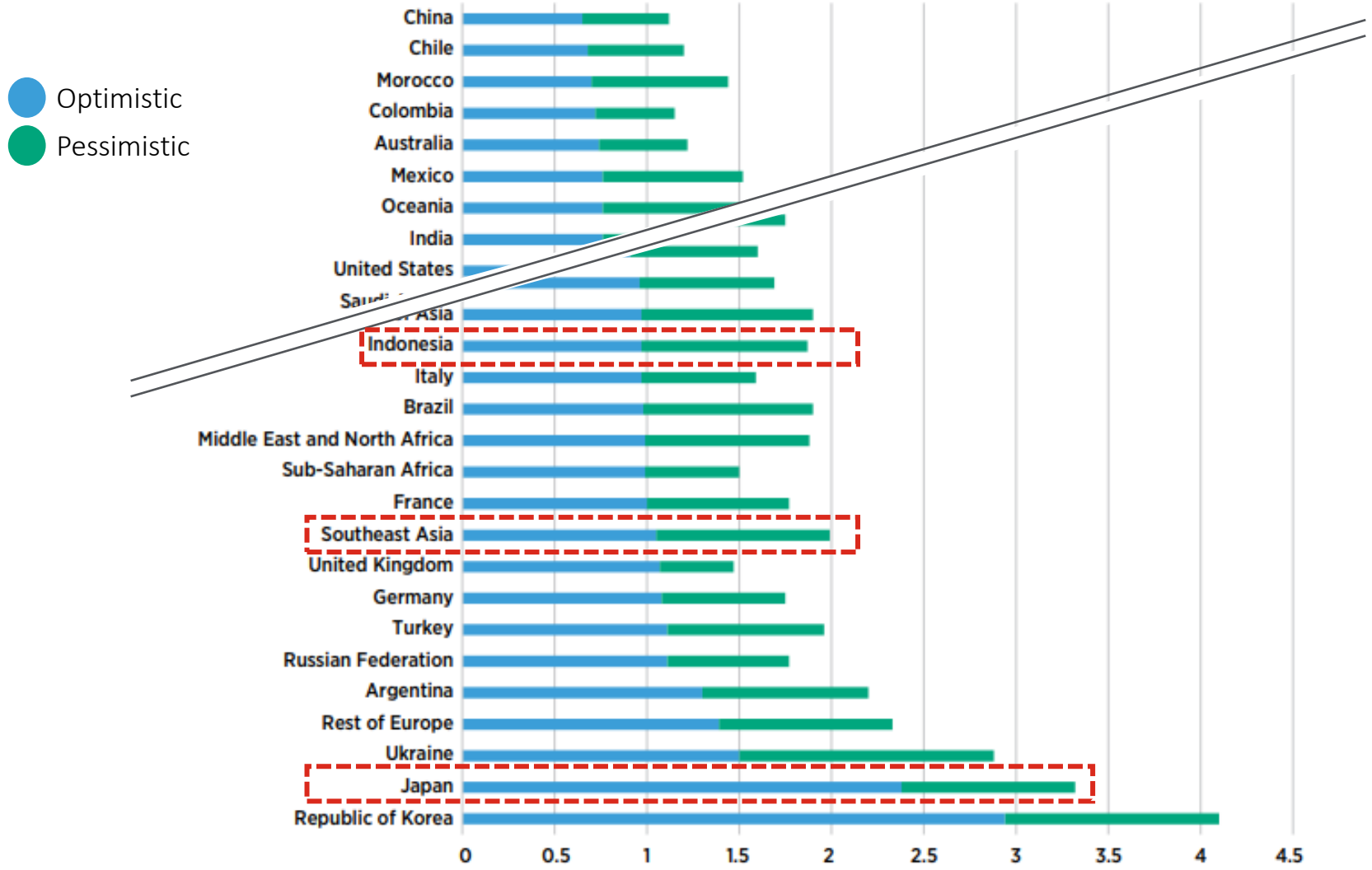



Note: RoW = rest of the world.

 *Source: Global hydrogen trade to meet the 1.5 ℃ climate goal: Part I – Trade outlook for 2050 and way forward, International Renewable Energy Agency (2022)*

# According to IRENA, hydrogen production cost in Thailand and Indonesia will be 1~2 USD/kg in 2050.

## Levelized cost of hydrogen in 2050

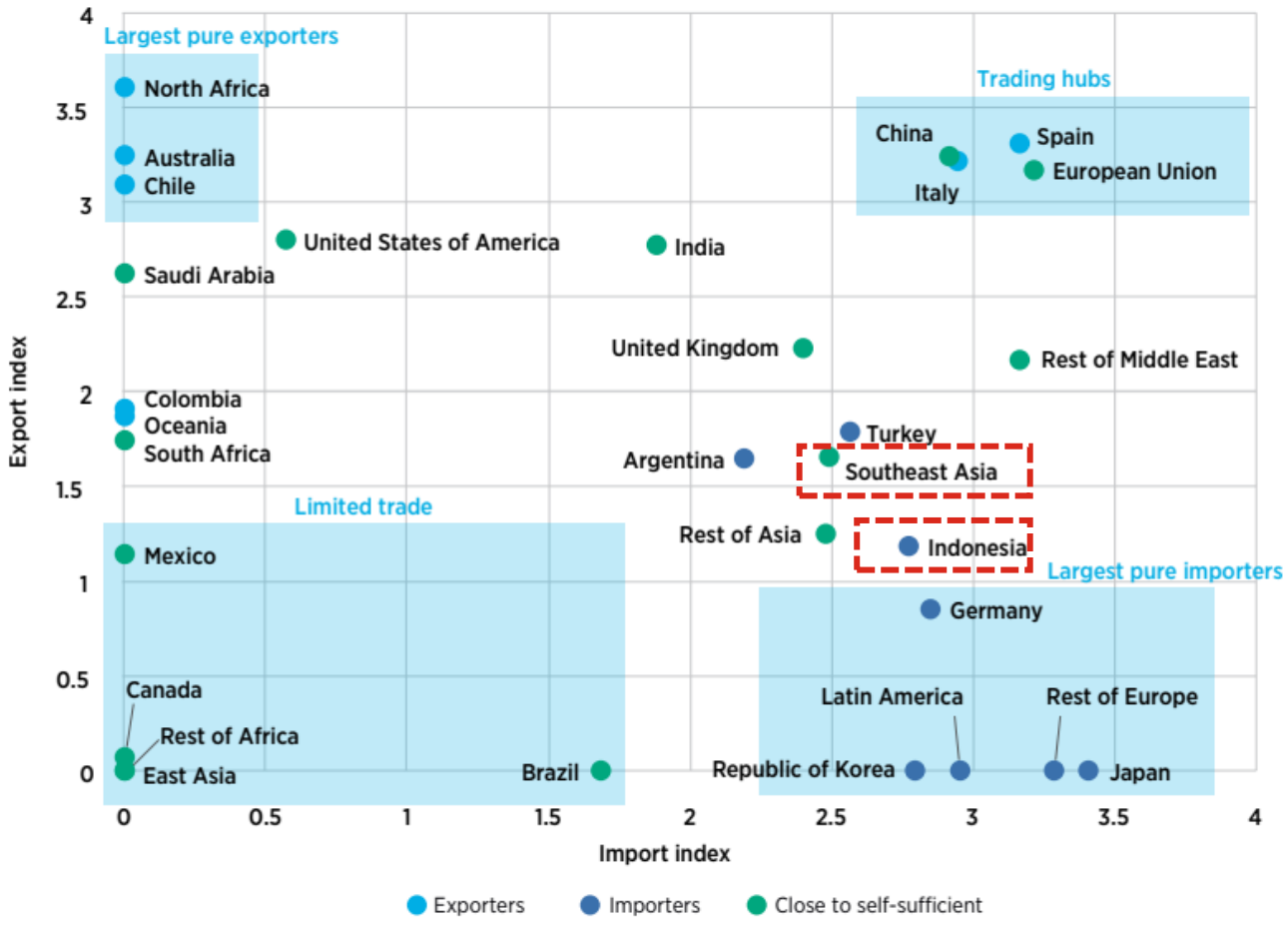



 *Source: Global hydrogen trade to meet the 1.5 ℃ climate goal: Part III – Green hydrogen cost and potential,, International Renewable Energy Agency (2022)*

# Indonesia will be one of the large importers of hydrogen, and southeast Asian countries in general fall in-between close-to-self-sufficient and importers.

## Volumes of hydrogen export and import for regions in 2050 (optimistic)

**FIGURE 3.17. Volumes of hydrogen export and import for regions around the world in 2050 with *optimistic* technology assumptions**




*"The largest net importers are Germany, Indonesia, Italy, Japan, Southeast Asia and the rest of Asia. " (IRENA, 2022)*

 *Source: Global hydrogen trade to meet the 1.5 ℃ climate goal: Part I – Trade outlook for 2050 and way forward, International Renewable Energy Agency (2022)*

## ①Desktop Research

Energy trend

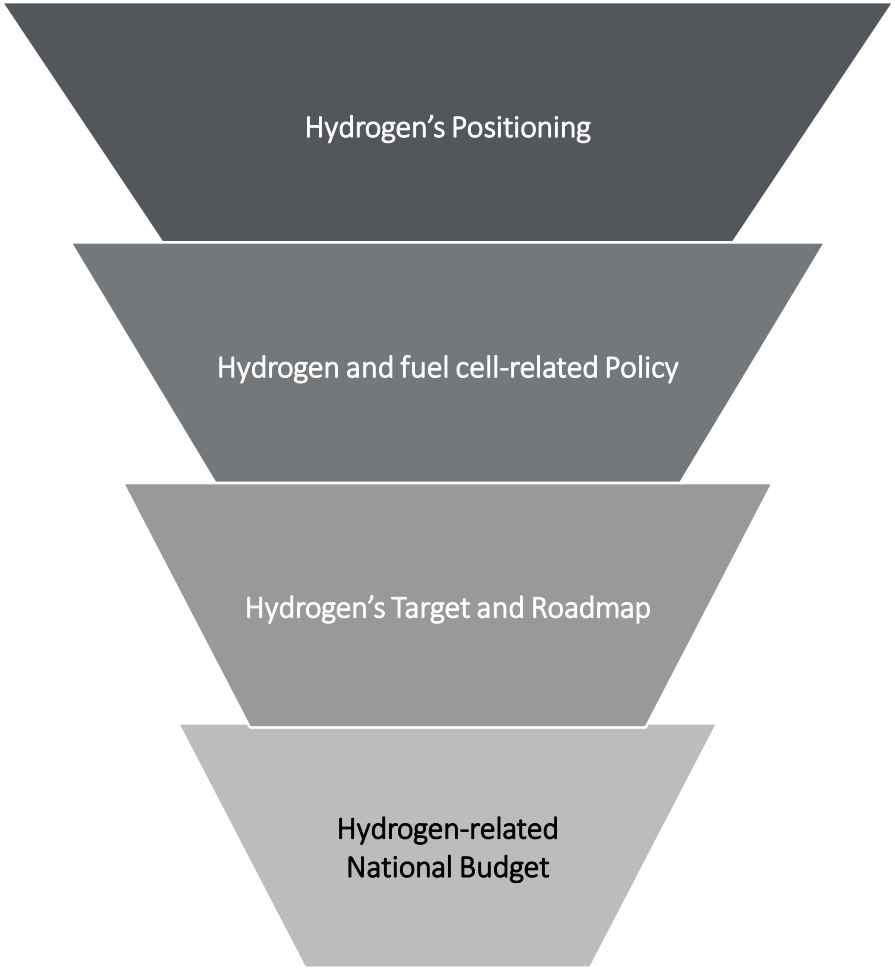
Outlook for hydrogen

**Policy**

Technical readiness and players

# Hydrogen policy will be surveyed from the concept to implementation, namely from positioning to budget for Thailand and Indonesia

## Research process on hydrogen-related policy




| | |
|---|---|
| Positioning | • To understand hydrogen's positioning in environmental policy by studying National Determined Commitment (NDC), a mid-term target based on the Paris Agreement and Long-term strategy.<br>• To survey emission reduction target |
| Policy | • To investigate the policy frameworks (strategies and plans) related to hydrogen and fuel cell<br>• To identify and scrutinize related entities that implement policies |
| Target | • To understand level of focus on hydrogen and fuel cell policies quantitatively by survey of hydrogen and fuel cell adoption target |
| Budget | • To understand the degree to which Thailand and Indonesia are promoting these measures and the types of projects that are being focused on by investigating the budgets for R&D and demonstration projects |

# Neither Thailand nor Indonesia has any hydrogen strategy. However, both governments have started projects to promote hydrogen

## Summary

| | Thailand | Indonesia |
|---|---|---|
| Overview | ■ There is **no clear vision for hydrogen set yet**<br>➢ LT-LEDS*1, however, recognizes **hydrogen as a key mitigation for emission reduction in power, industry and transportation sectors**<br>➢ In addition, LT-LEDS states that **green hydrogen fuel** will likely be used in Thailand in 2045 | ■ There is **no strategy dedicated for hydrogen**; however, the government expects green hydrogen **to be the main pillar of industrial decarbonization** in Indonesia up until 2060 |
| Hydrogen Strategy (strategy and plans dedicated for hydrogen and fuel cell) | N/A<br>However, Ministry of Energy seems to be working on building hydrogen strategy in energy sector by selecting project partners | N/A<br>However, DPR*2 & MEMR*3 **developed proposal** of RUU-EB-ET*4 Draft Plan to support **Green Hydrogen implementations.** The government has also **appointed several ministry-and-state-owned Enterprises (SOEs)** to **develop hydrogen to be used in the energy sector** as well as its production to be utilize in **electricity & electric vehicle** |
| Hydrogen quantitative target | N/A<br>However, according to the most recent AEDP 2018, hydrogen is included as part of the "Alternative Fuels" category with a set target goal of 10 kilotons of oil equivalent (KTOE) in total by 2036 | N/A<br>According to the government's estimates, **green hydrogen generation capacity** is projected to reach **approximately 52 GW by 2060.** |
| Hydrogen project and support | ■ EGAT, a state-owned company, conduct studies and have partnerships with other companies<br>■ Board of Investment (BOI) has **announced incentives related to hydrogen** | ■ **Specific policy for hydrogen** (e.g., Presidential Regulation No. 22/2017 on National Energy Plan (RUEN)<br>■ Collaboration between **ministry, SOEs & private sectors** |

**1: long-term low emission development strategy *2: People's Representative Council of the Republic of Indonesia (Indonesia's Legislative Institution) *3: Ministry of Energy & Resources*

# Thailand

# The Thailand Government doesn't have a clear vision of hydrogen yet while they have started hydrogen related projects including water electrolysis

## Policy overview - Thailand

**Expected role of hydrogen**

- The government recognizes hydrogen could be a key mitigation for emission reduction in sectors like iron, steel, aluminum and cement, and also as alternative fuel (LT-LEDS*1, AEDP*2)

**Hydrogen strategy and planning**

- The national government is yet to have a hydrogen strategy as the hydrogen industry is in the early development phase
  - However, Ministry of Energy seems to be working on building hydrogen strategy in energy sector by selecting Chulalongkorn University and Chiang Mai university as project partners*3
- The government states that green hydrogen fuel will likely be used in Thailand in 2045, while there is no clear goal for hydrogen (LT-LEDS)

**Quantitative target**

(Not established yet)

**Projects and support**

- EGAT (Electricity Generating Authority of Thailand, state-owned enterprise)
  - Conducting projects of water electrolysis, ammonia, SOEC/SOFC
  - Signed MOUs with private companies in Thailand to conduct research and share knowledge about hydrogen
- Board of Investment (BOI) has announced incentives related to hydrogen in November 2022

*Source: Thailand's Long-term Low Greenhouse Gas Emission Development Strategy, Alternative Energy Development Plan*

**1: Long-term Low Greenhouse Gas Emission Development Strategy *2: Alternative Energy Development Plan *3: According to announcement on January 19, 2023*

# Thailand's LT-LEDS states that green hydrogen will be important in energy, industry and transport sectors

## Hydrogen in Thailand's LT-LEDS


### Long-Term mitigation actions related to **hydrogen in energy sector**

- Research and development of hydrogen can be one of the key mitigation actions
- technologies related to hydrogen and green hydrogen are considered to achieve GHG emissions by 2065
  - From the net zero GHG timeline presented in the LT-LEDS, **green hydrogen fuel will likely be used in Thailand in 2045**

### Long-Term mitigation actions related to **hydrogen in industry sector**

- **Green hydrogen** will be important in sectors like **iron, steel, aluminum and cement**

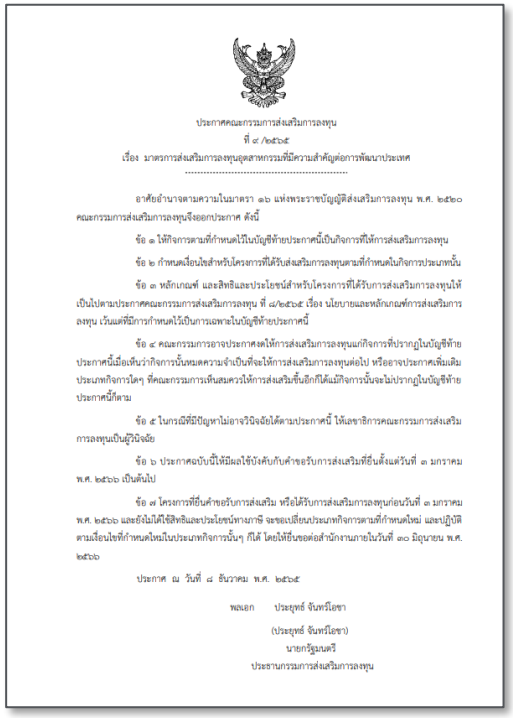
### Long-Term mitigation actions related to **hydrogen in transport sector**

- Decarbonization opportunities in the transport sector include hybrid, plug-in hybrid, electric and **FCEV**
- Cost of hydrogen-powered FCEV is expected to be **lower in the near future**, similar to costs of EVs

 *Source: Thailand's Long-term low Greenhouse gas emission development strategy*

# Board of Investment has announced new tax incentives for hydrogen-related investment and research

## Announcement of BOI No. 8/2565



ประกาศคณะกรรมการส่งเสริมการลงทุน
ที่ ๘ /๒๕๖๕
เรื่อง มาตรการส่งเสริมการลงทุนอุตสาหกรรมที่มีความสำคัญต่อการพัฒนาประเทศ

อาศัยอำนาจตามความในมาตรา ๑๖ แห่งพระราชบัญญัติส่งเสริมการลงทุน พ.ศ. ๒๕๒๐ คณะกรรมการส่งเสริมการลงทุนจึงออกประกาศ ดังนี้

ข้อ ๑ ให้กิจการตามที่กำหนดไว้ในบัญชีท้ายประกาศนี้เป็นกิจการที่ให้การส่งเสริมการลงทุน

ข้อ ๒ กำหนดเงื่อนไขสำหรับโครงการที่ได้รับส่งเสริมการลงทุนตามที่กำหนดในกิจการประเภทนั้น

ข้อ ๓ หลักเกณฑ์ และสิทธิและประโยชน์สำหรับโครงการที่ได้รับการส่งเสริมการลงทุนให้เป็นไปตามประกาศคณะกรรมการส่งเสริมการลงทุน ที่ ๘/๒๕๖๕ เรื่อง นโยบายและหลักเกณฑ์การส่งเสริมการลงทุน เว้นแต่ที่มีการกำหนดไว้เป็นการเฉพาะในบัญชีท้ายประกาศนี้

ข้อ ๔ คณะกรรมการอาจประกาศงดให้การส่งเสริมการลงทุนแก่กิจการที่ปรากฏในบัญชีท้ายประกาศนี้เมื่อเห็นว่ากิจการนั้นหมดความจำเป็นที่จะให้การส่งเสริมการลงทุนต่อไป หรืออาจประกาศเพิ่มเติมประเภทกิจการใดๆ ที่คณะกรรมการเห็นสมควรให้การส่งเสริมขึ้นอีกก็ได้แม้กิจการนั้นจะไม่ปรากฏในบัญชีท้ายประกาศนี้ก็ตาม

ข้อ ๕ ในกรณีที่มีปัญหาไม่อาจวินิจฉัยได้ตามประกาศนี้ ให้เลขาธิการคณะกรรมการส่งเสริมการลงทุนเป็นผู้วินิจฉัย

ข้อ ๖ ประกาศฉบับนี้ให้มีผลใช้บังคับกับคำขอรับการส่งเสริมที่ยื่นตั้งแต่วันที่ ๓ มกราคม พ.ศ. ๒๕๖๖ เป็นต้นไป

ข้อ ๗ โครงการที่ยื่นคำขอรับการส่งเสริม หรือได้รับการส่งเสริมการลงทุนก่อนวันที่ ๓ มกราคม พ.ศ. ๒๕๖๖ และยังไม่ได้ใช้สิทธิและประโยชน์ทางภาษี จะขอเปลี่ยนประเภทกิจการตามที่กำหนดใหม่ และปฏิบัติตามเงื่อนไขที่กำหนดใหม่ในประเภทกิจการนั้นๆ ก็ได้ โดยให้ยื่นขอต่อสำนักงานภายในวันที่ ๓๐ มิถุนายน พ.ศ. ๒๕๖๖

ประกาศ ณ วันที่ ๘ ธันวาคม พ.ศ. ๒๕๖๕

พลเอก ประยุทธ์ จันทร์โอชา
(ประยุทธ์ จันทร์โอชา)
นายกรัฐมนตรี
ประธานกรรมการส่งเสริมการลงทุน

- The Board of Investment (BOI) published the "Announcement of BOI No. 8/2565: Promotion of investment in industries that are important to national development" in November 2022
  - BOI is a government body that helps in promoting direct investment in Thailand by devising investment policies

- BOI announced new incentives for **hydrogen-related investment and research**
  - Apart from investment in EVs (including FCEVs), following activities are eligible for **tax exemption up to 10 – 13 years** starting in January 2023:
    - ✓ **Hydrogen and its derivatives from water using renewable energy**
    - ✓ **Electricity generating from hydrogen**

# Indonesia

# The government has offered several programs & policy to achieve carbon neutrality by 2060

## Policy Overview – Indonesia

**Target of GHG emission reduction**

| NDC | Long-term target |
|---|---|
| ▪ Reducing **31.89% from the BAU level** by 2030.<br>▪ **Conditional target up to 43.20%**<br>Sep 2022 updated (enhanced cover letter) | ▪ **Carbon neutrality by 2050 and net-zero by 2060** |

**2 Positioning**

▪ **Hydrogen is expected to be the main pillar of industrial decarbonization** in Indonesia

**Policy**

- Long-term Strategy for Low Carbon and Climate Resilience 2050
- Electricity Supply Business Plan (RUPTL 2021-2030)
- Energy Law No. 30/2007, 2009
- Government Regulation No. 79/2014 on National Energy Policy (KEN)
- Presidential Regulation No. 22/2017 on National Energy Plan (RUEN)
- New and Renewable Energy Bill (RUU EB-ET)

**3 Overview of Hydrogen Policy**

▪ **Indonesia's Legislative Institutional (DPR) & Ministry of Energy & Resources (MEMR) developed proposal** of the New and Renewable Energy (RUU EB-ET) Draft Plan to support **Green Hydrogen implementations**

▪ The government also has **appointed several Ministry** (e.g., MEMR, Industrial, Finance) & **State-Owned Enterprises (SOEs)** (e.g., Pertamina, Perusahaan Listrik Negara (PLN)) as **main stakeholder to develop green hydrogen** to be used in the **energy sector** as well as its production of green hydrogen to be **utilize in electricity**.

➢ According to the government's estimates, green hydrogen generation capacity will reach **approximately 52 GW by 2060 with a constant increase from 328 MW in 2031**

**4 Quant. target**

▪ **No known target for FCV & its refill stations**

➢ However, the government is targeted to adopted **2.1 million e-motorcycles and 400,000 e-cars (20% of all locally manufactured cars) by 2025**

**5 Policy Implementation**

▪ **No detail on budget information** for hydrogen development, but the government supports projects to implement FCVs such as R&D and feasibility studies

➢ In addition, recent G20 updates announced that a coalition of developed nations, comprising the US and Japan, **launched a $20 billion climate finance package for Indonesia to support's its goal to achieve carbon neutrality**

# Green hydrogen is foreseen as one of main energy sources to support decarbonization especially in industry due to its abundant potential

## Indonesia's Green Hydrogen Overview 2 3

| | |
|---|---|
| Strategy & Plan | ▪ Green hydrogen is **expected to be the main pillar of industrial decarbonization** in Indonesia because the industrial sector is the first and main target for accelerating energy sources, which will contribute to the energy transition. Therefore, the **Indonesia's Legislative Institutional (DPR) & Ministry of Energy & Resources (MEMR) developed proposal** of the New and Renewable Energy (RUU EB-ET) Draft Plan to support **Green Hydrogen implementations**<br>➢ Currently, hydrogen utilization is almost completely for the **chemical and refining** utilization sub-sectors on desulfurization in the oil refining process, as an additive in the steel making process, and **other industrial purposes**<br>➢ The potential of **green hydrogen production in Indonesia was 1,895 kT/year in 2021**, as concluded by a study from the Ministry of Energy and Mineral Resources of the Republic of Indonesia and the German Agency for International Cooperation (GIZ)<br>➢ According to the government's estimates, green hydrogen generation capacity will reach **approximately 52 GW by 2060 with a constant increase from 328 MW in 2031**. That would be a 10% contribution to the total power generated from clean energy in 2060<br>➢ The Indonesian government, Ministry of Energy & Resources (MEMR), estimates that the country would require **US$25.2 billion in investments to underpin green hydrogen development from 2030 to 2060**. Mass adoption would be at its peak in 2050 |
| Government Support | ▪ Indonesia is in constant development of **progressive policy breakthrough** on green hydrogen energy-related regulations.<br>▪ The government also has **appointed several Ministry** (e.g., MEMR, Industrial, Finance) & **State-Owned Enterprises (SOEs)** (e.g., Pertamina, Perusahaan Listrik Negara (PLN)) as **main stakeholder to develop green hydrogen** to be used in the **energy sector** as well as its production of green hydrogen to be **utilize in electricity**. |

 *Source: JICA Indonesia Decarbonization Survey (2022), Ministry of Energy & Resources (MEMR) 2023*

# Though FCV is not yet established in Indonesia, the government has shown a strong support for electric vehicle usage to achieve decarbonization

## Quantitative Target and Support for FCV [4][5]

| | |
|---|---|
| Latest Condition | ▪ **Fuel cell vehicle (FCV) not yet available** in Indonesia<br>▪ However, several major automotive leader, such as Toyota Indonesia, is preparing on introducing its FCV line-up called, Toyota Mirai FCV to the public if the infrastructure for charging stations is already established |
| Quantitative Target | ▪ There is **no exact quantitative target available specifically for FCV**<br>▪ However, the government has set an ambitious target on the adoption of electric vehicles with **2.1 million e-motorcycles and 400,000 e-cars (20% of all locally manufactured cars)** expected to take the road **by 2025**.<br>▪ At present, the government, in collaboration with Perusahaan Listrik Negara (PLN), is **preparing fiscal infrastructure and facilities** to support the effort to enter the electric motor vehicle industry, with **8,000 charging stations ready in 2025** and **12,000 charging stations by 2030**<br>▪ As of **November 2022**, according to **The Association of Indonesia Automotive Industries (GAIKINDO),** the total number of **4W EV sold was 2,794** units with Battery Electric Vehicle (BEV) sold was 1,965 units and Hybrid Electric Vehicle (HEV) sold was 829 units while **the number of charging station was 346 units** spread throughout 295 across Indonesia |
| FCV Regulatory Support | ▪ As a form of support for FCV adoption, the government has introduced policy in **Presidential Regulation No. 22/2017 on National Energy Plan (RUEN)** that further details the preparation of FCV prototypes, collaboration with both public & private parties for FCV research & development, FCV feasibility study on its infrastructure as well as potential incentives for FCV utilization in Indonesia. |

 *Source: National Energy Plan (RUEN) 2017, Several News Articles*

*Reference*

# Several policies introduced by the government on decarbonization roadmap, which include hydrogen implementation

## Policy Implementation (incl. budget info)

| | Detailed Information | Policy Framework | Budget |
|---|---|---|---|
| Long-term Strategy for Low Carbon and Climate Resilience 2050 | ▪ The LTS-LCCR 2050 provides **long-term national policy direction on climate change**, with the pathway scenario based on the best scenario available | ▪ LTS-LCCR 2050 proposes to equip **76% of coal-fired power capacity with carbon capture, utilization, and storage (CCUS)** to curb emissions by 2050, which indicates that coal will continue to have an important role in the power sector<br>▪ It also estimates that by 2050 **coal will contribute to 40% of the country's total power demand**, and **coal + CCUS alone will account for 30%.**<br>▪ The LCCP scenario expects that by 2050 the power sector will nearly be decarbonized through massive **renewable deployment, coal power plants equipped with CCUS, and biomass-coal cofiring power plants** that are also connected with CCS | ▪ None |
| Electricity Supply Business Plan (RUPTL 2021-2030) | ▪ The government and PLN (Persero) provides a **larger portion of new renewable energy power** plants in the 2021 - 2030 | 1) In the RUPTL, the portion of **renewable energy power plants reaches 48% while fossil fuel power plants' reaches 52%.**<br>2) To reach 23% new renewable energy mix in 2025, the government has **decided to no longer receive proposals for new coal-fired power plants**, except for ones that have entered the financial closing stage or have commenced construction<br>3) **Various strategies are prepared to achieve the new renewable energy target**, including by prioritizing solar power plants, boosting co-firing in coal fired power plants, and replacing fossil fuel with new renewable power plants. | ▪ None |

 *Source: Indonesia's LTS-LCCR Plan 2050 (2022), Indonesia's RUPTL 2021-2030 (2022), Several News Articles*

*Reference*

# Several policies introduced by the government on decarbonization roadmap, which include hydrogen implementation

## Policy Implementation (incl. budget info)

| | Detailed Information | Policy Framework | Budget |
|---|---|---|---|
| Law 30/2007-2009 on Energy Law | ▪ **General emphasis** on energy security, sustainable development, energy resilience, and environmental preservation | ▪ The government enact a Law on Energy as a legal basis and guidelines in the framework of regulation and management in the energy sector, which includes:<br>1) energy regulation which consists of **control and regulation of energy resources**;<br>2) the **authority of the Government and regional governments** in regulating the energy sector;<br>**3) fostering and supervising management activities** in the energy sector (such as research and development) | ▪ None |
| Government Regulation No. 79/2014 on National Energy Policy (KEN) | ▪ Targets an increase of NRE share in **primary energy mix to 23% in 2025 and 31% in 2050** | **1) Reducing energy exports** to fulfill national needs, especially gas and coal, as well as set a time limit for stopping exports, which was later enacted in early January 2022<br>2) Progressive application of electricity tariffs through **a feed-in-tariff mechanism for renewable energy**, which was updated later in September 2022<br>3) The target **electrification ratio is targeted to reach 85% in 2015** and close to **100% in 2020**. Meanwhile, the **ratio of household gas usage reaches 85% in 2015**<br>4) In **2025**, the portion of **renewable energy will be 23%, oil 25%, coal 30% and gas 22%** while in **2050** the share of **renewable energy will be 31%, oil 20%, coal 25% and gas 24%** | ▪ None |

 *Source: Ministry of Energy & Resources (MEMR) 2023, Ministry of Industrial (MOI) 2023, Several News Articles*

*Reference*

# Several policies introduced by the government on decarbonization roadmap, which include hydrogen implementation

## Policy Implementation (incl. budget info)

| | Detailed Information | Policy Framework | Budget |
|---|---|---|---|
| Presidential Regulation No. 22/2017 on National Energy Plan (RUEN) | ▪ Sets up a development plan until 2050, specifically including **preparation for hydrogen usage as FCV** (Fuel Cell Vehicle) | 1) Developing technology for the **production and use of synthetic fuels and hydrogen** for transportation<br>**2) Establish regulations for synthetic and hydrogen fueled cars** for public transport and private vehicles<br>3) Building a **hydrogen-fueled motorized vehicle industry (fuel cell)**<br>4) Provide **fiscal incentives for gas, synthetic fuel and hydrogen fueled vehicles**, in accordance with applicable taxation and customs laws and regulations<br>**5) Developing vehicle prototypes (synthetic and hydrogen fueled),** solar powered and electric/hybrid powered, to commercial readiness | ▪ None |
| New Energy and Renewable Energy Law (RUU EB-ET) (Draft) | ▪ **Regulates New Renewable Energy (NRE) development**, including pricing, incentives, etc. In the latest draft, hydrogen is mentioned as a new energy. | 1) Based on the latest draft bill, it is known that **new energy and renewable energy definitions are separated**. That way, the Bill on New and Renewable Energy (EBT) has now changed its name to the New Energy and Renewable Energy Bill.<br>2) In the latest draft of the bill, article 9 states that **new energy sources consist of several types**. Among them are nuclear, **hydrogen**, coal bed methane, coal liquefaction, coal gasification; and other New Energy Sources.<br>3) Meanwhile, article 26 states that the provision of **New Energy by the Central Government and/or Regional Governments is prioritized in underdeveloped areas**, remote areas, and rural areas by using local New Energy Sources. | ▪ None |

 *Source: National Energy Plan (RUEN) 2017, Several News Articles*

*Reference*

# Singapore's National Hydrogen Strategy shows the approach to utilize hydrogen as its main renewable source

## Singapore's National Hydrogen Strategy

| | | | |
|---|---|---|---|
| Document Name | Singapore's National Hydrogen Strategy | | |
| Year of publishment | Oct 2022 | Issued by | Ministry of Trade & Industry |
| Background | ■ For Singapore, hydrogen will complement and diversify Singapore's power mix & it is estimated that hydrogen could supply up to half of Singapore's power needs by 2050 | | |
| Purpose | ■ Shows Singapore's hydrogen potential in various industry (such as power generation, industrial, feedstock, maritime, aviation) & framework in order to advancing Hydrogen's transition usage transitions | | |
| Summary | ■ Singapore will pace hydrogen deployment and infrastructure in line with technological and global progress, implementing five key actions:<br>1. Experiment with the use of advanced hydrogen technologies at the cusp of commercial readiness through pathfinder projects<br>2. Invest in research and development to unlock technological bottlenecks<br>3. Pursue international collaborations to enable supply chains for low-carbon hydrogen<br>4. Undertake long-term land and infrastructure planning<br>5. Support workforce training and development of our broader hydrogen economy. | | |


*Source: Singapore's National Hydrogen Strategy (Singapore's National Hydrogen Strategy (mti.gov.sg)) 2022*

## ①Desktop Research

Energy trend

Outlook for hydrogen

Policy

Technical readiness and players

# Both Thailand and Indonesian companies have already started several hydrogen related projects by collaborating internationally

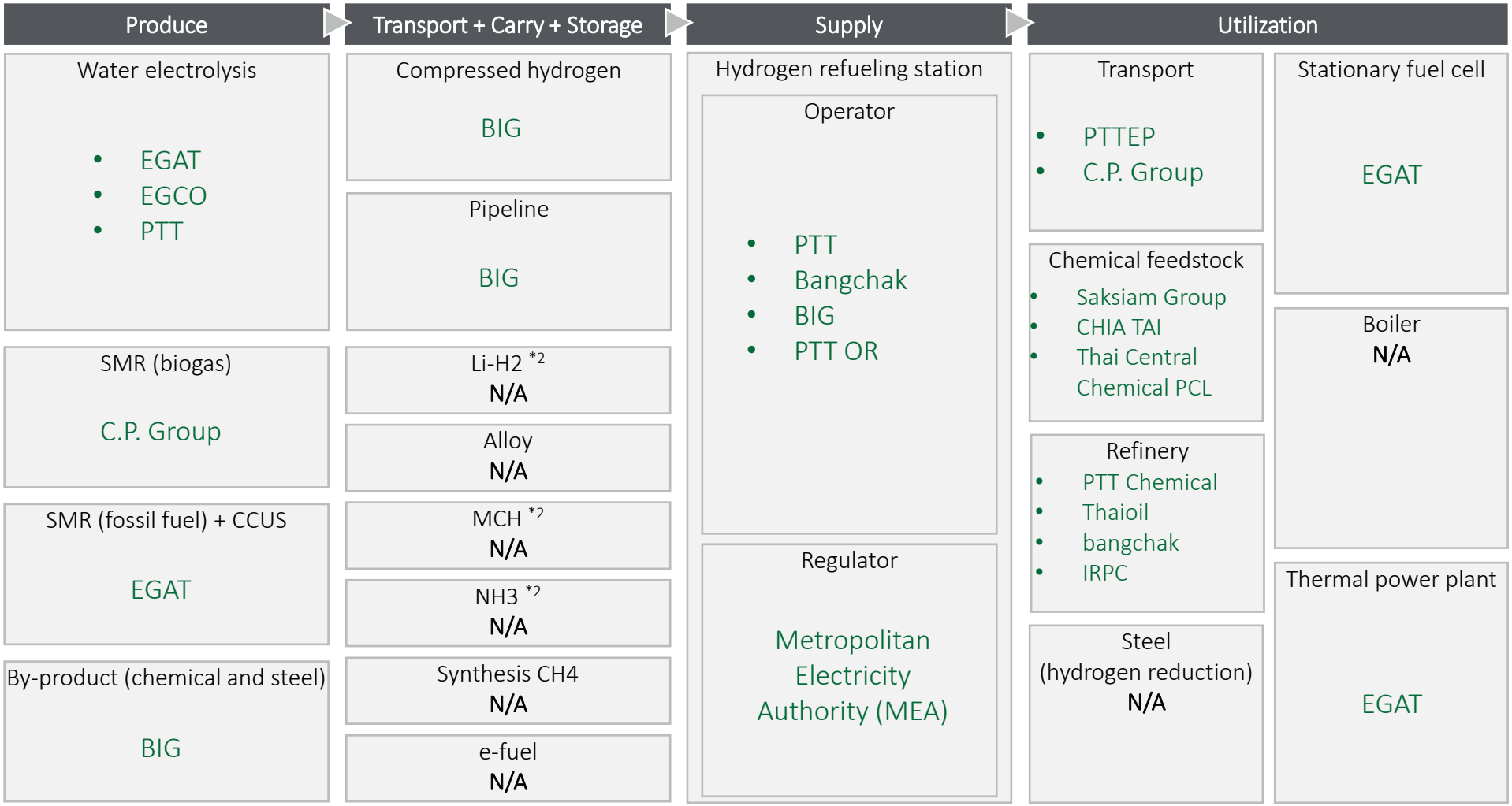
## Summary

| | | Thailand | Indonesia |
|---|---|---|---|
| Current production and use of hydrogen | | ■ Currently, it is mostly used in **chemical and oil refining sector** | ■ Currently, hydrogen utilization is almost completely for **chemical and oil refining, steel making process, and other industrial purposes** |
| Major hydrogen projects | Production | ■ **EGAT** brought new technology, **Wind Hydrogen Hybrid System and Fuel Cell**, which allows them to store electricity produced from wind turbines in form of hydrogen and convert it into electricity through fuel cell when needed | ■ **Pertamina & Pertamina Geothermal Energy (PGE)** plans to **produce up to 100 kg/day of green hydrogen** from **Ulubelu Geothermal Power Plant** to **supply its polypropylene factory** in Plaju and supply the needs of the **local petrochemical industry** |
| | Carry, Storage and Supply | ■ First **hydrogen fueling prototype station** began operating in **November 2022** | ■ **Pertamina NRE, Krakatau Steel, and RAJA collaborate** to develop **Green Hydrogen Pipelines** for distribution from **upstream/production to user** |
| | Use | ■ **EGAT** has signed an MOU with **ATE, EGCO Group, and Bloomenergy to develop hydrogen with SOFC and SOEC** in December 2021<br>■ **EGAT** has signed an MOU with **MHI to study clean energy technologies** | ■ A consortium, involving **PT Panca Amara Utama, a chemical company, Mitsubishi and the Institut Teknologi Bandung** announced **trial plans to mass produce ammonia** in combination with **Carbon Capture Storage (CCS)**<br>■ Three major SOEs: **PLN, Pertamina, and Pupuk Indonesia** just recently launched the Green Industry Cluster which aims to **develop green and blue ammonia** in the long term. |

# Thailand

# Companies in Thailand cover all the parts of hydrogen supply chain except for advanced carry and storage technologies

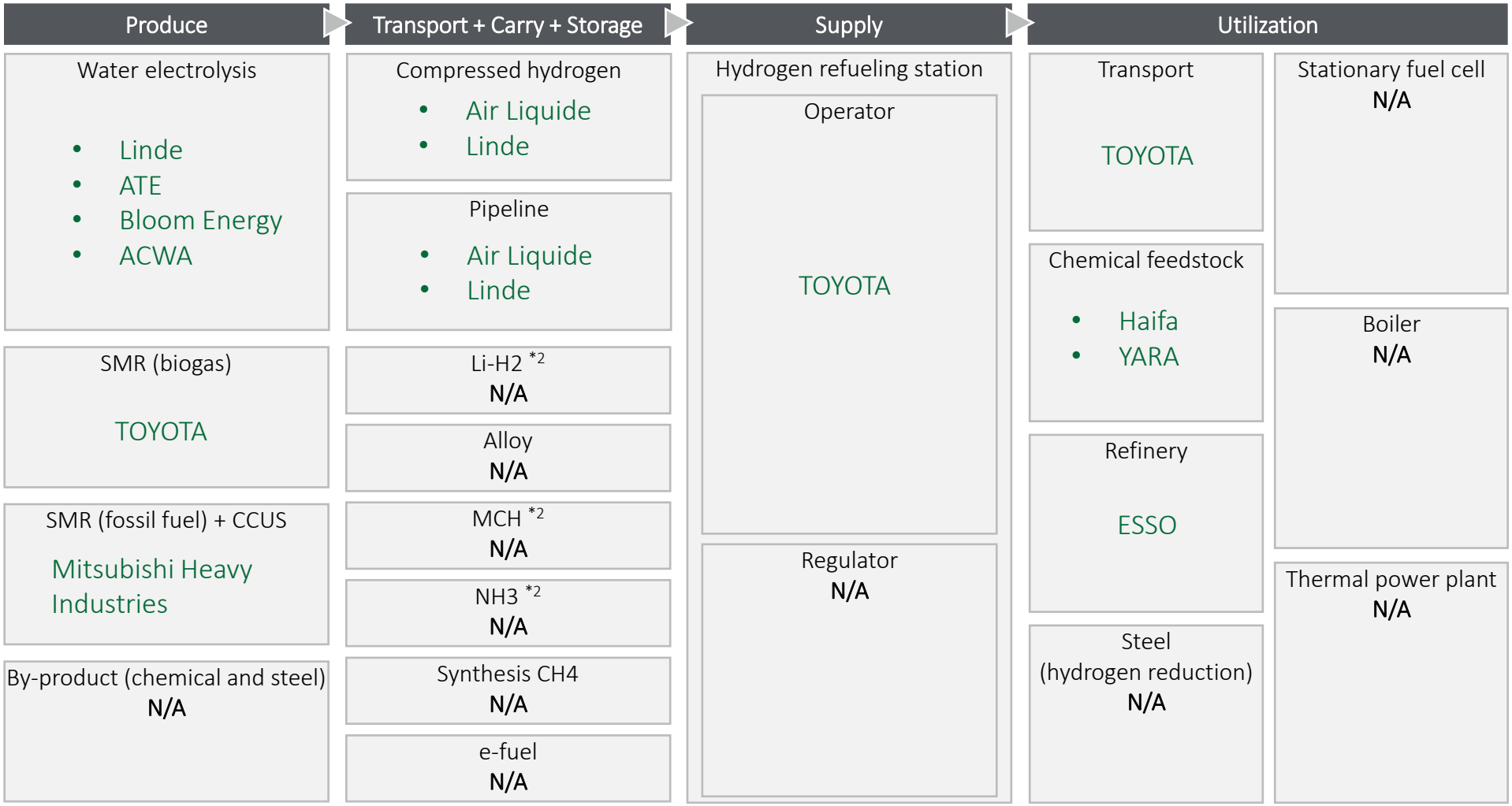
## Local hydrogen player map in Thailand*1




**1: Note that hydrogen players do not just include players that have core technologies but also those who are engaged with related projects. *2: Hydrogen careers that are likely to be options for hydrogen shipping*

# Companies in Thailand cover all the parts of hydrogen supply chain except for advanced carry and storage technologies

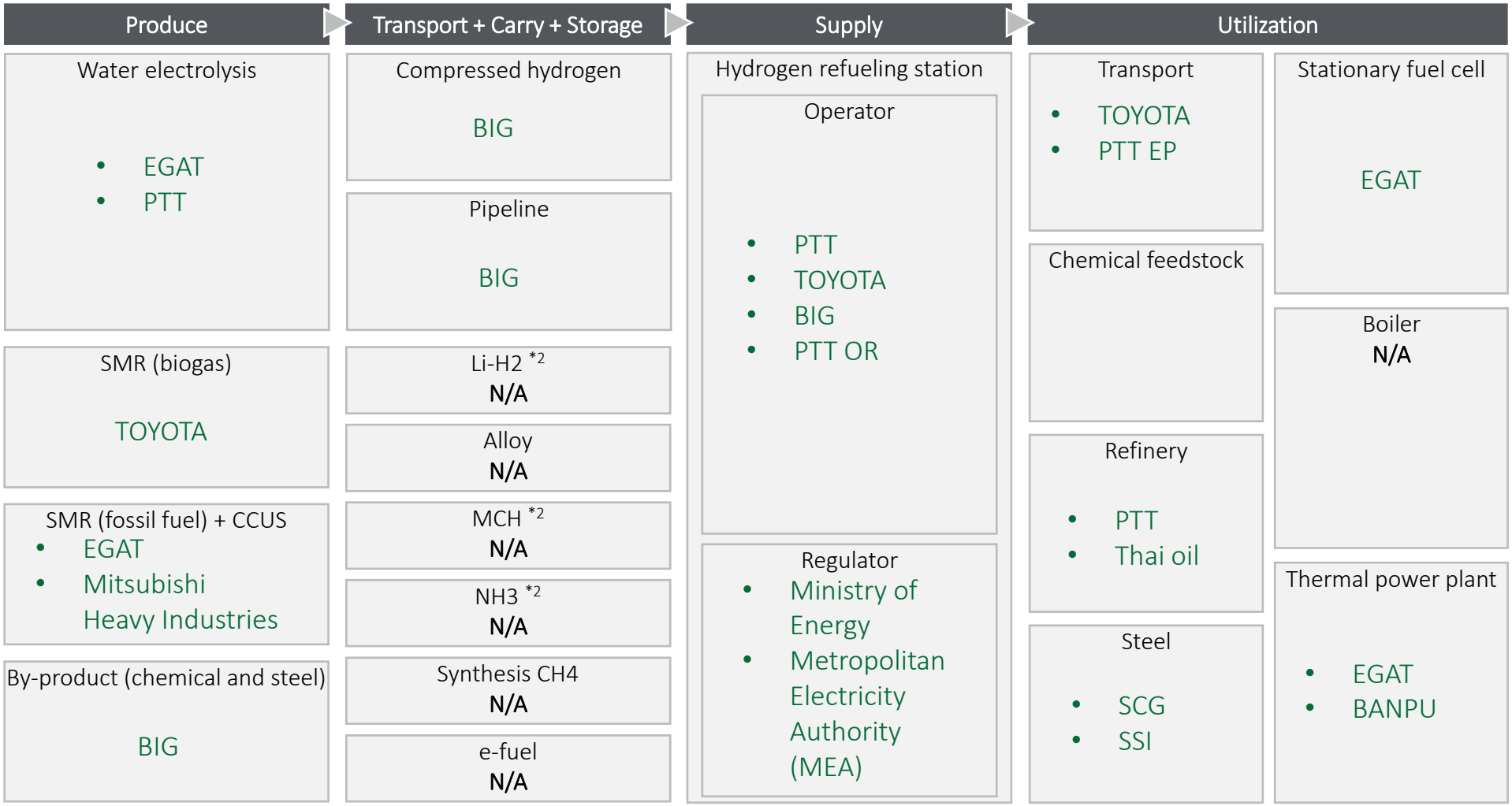
## External/global hydrogen player map in Thailand*1




*1: Note that hydrogen players do not just include players that have core technologies but also those who are engaged with related projects. *2: Hydrogen careers that are likely to be options for hydrogen shipping

# Companies in Thailand could cover all the parts of hydrogen supply chain except for advanced carry and storage technologies

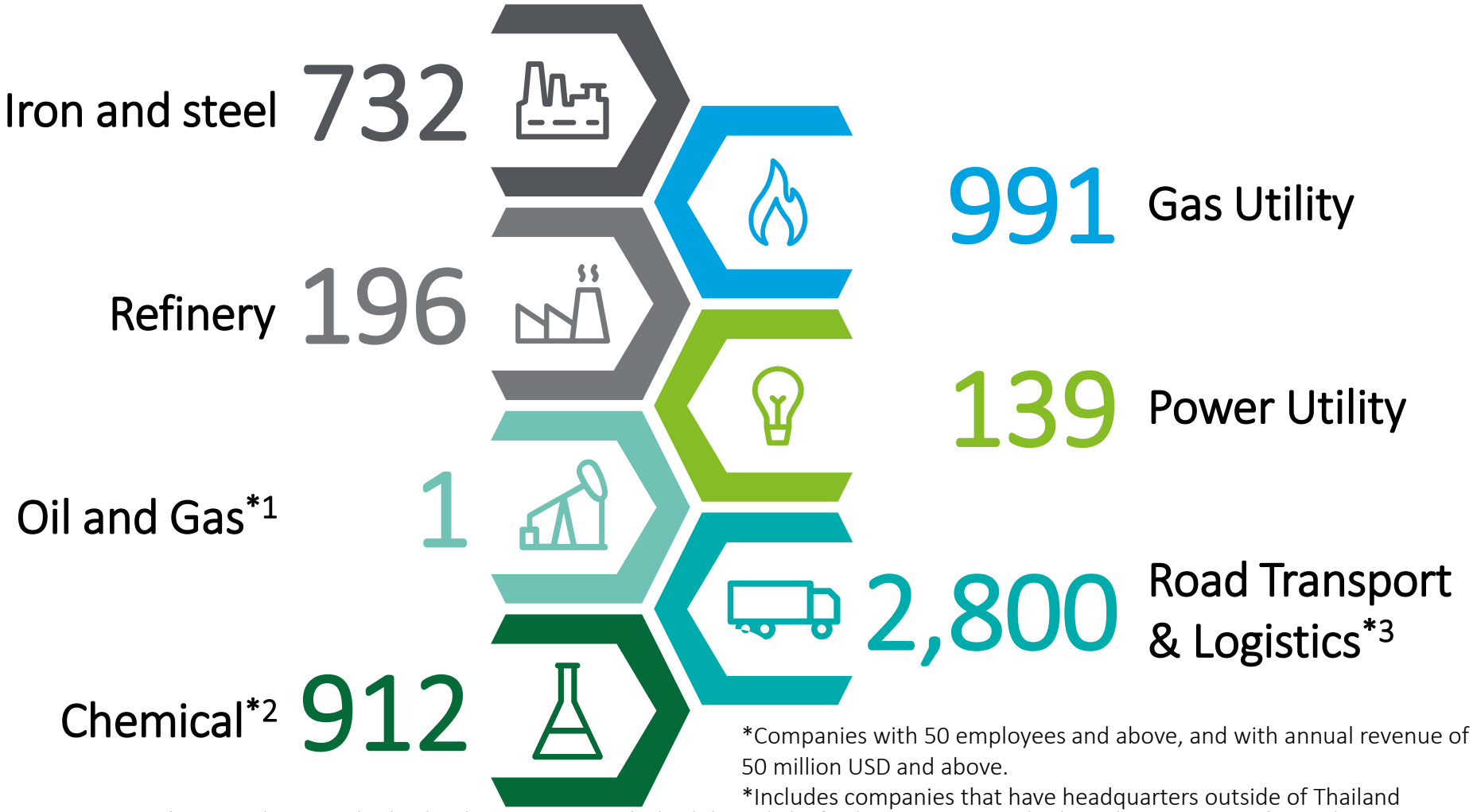
## Potential hydrogen player map in Thailand*1




**1: Note that hydrogen players do not just include players that have core technologies but also those who are engaged with related projects. *2: Hydrogen careers that are likely to be options for hydrogen shipping*

# There are larger potential in each sector in Thailand

## The potential number of companies in Thailand




*Companies with 50 employees and above, and with annual revenue of 50 million USD and above.
*Includes companies that have headquarters outside of Thailand

*Source: D&B Hoovers *1: PTT is the one and only oil and gas company in Thailand *2: includes fertilizer companies and industrial gas companies *2: road transport except for rail and logistics companies (freight transport and courier)*

# Byproduct and SMR hydrogen are both in mobilization status, while water electrolysis is in R&D phase

## Hydrogen Production in Thailand

Status: Not yet | R&D | Demonstration | scaling | mobilization

| | Water electrolysis | SMR (biogas) | SMR (fossil fuel) + CCUS |
|---|---|---|---|
| Status | R&D | R&D | R&D |
| Status Detail | 1. **EGAT** signed an MOU with EGCO, ATE, and Bloomenergy to **study about SOEC/SOFC**<br>2. In the future, **Linde is planning to produce hydrogen by doing water electrolysis** | 1. True Leasing (CP's transportation service business) has partnered with Isuzu Motors, Toyota subsidiary Hino Motors to **turn farm waste into fuel for hydrogen-powered car** | 1. EGAT signed an MOU with MHI to study about green energy technologies, in which CCUS is one of the topic |
| Challenge | Some challenges, which include: *1<br>1) Incentives & technology uncertainty<br>2) Limitations in regulatory support & technical standard | Some challenges, which include: *1,2<br>1) Incentives & technology uncertainty<br>2) Limitations in regulatory support & technical standard<br>3) Negative perspective towards waste-to-energy | Some challenges, which include: *1<br>1) Limited infrastructure readiness<br>2) Incentives & technology uncertainty<br>3) Limitations in regulatory support & technical standard |
| Potential | The state enterprise has an interest in water electrolysis. In addition, Linde's joint venture, ITM Linde Electrolysis (ILE), is a supplier of PEM electrolyzer technologies | This project could possibly be expanded into other countries | EGAT aims to apply technologies studied with powerplant in Thailand, so it could potentially be scaled |
| Player | 1. EGAT, EGCO, ATE, and Bloomenergy<br>2. Linde | 1. Toyota and C.P. Group | 1. EGAT and MHI |

*Source: *1 The Future of Hydrogen by IEA 2022 (The Future of Hydrogen (windows.net), *2 Thailand's 2nd Updated Nationally Determined Contribution (Thailand's 2nd Updated NDC (windows.net)*

# Byproduct and SMR hydrogen are both in mobilization status, while water electrolysis is in R&D phase

## Hydrogen Production in Thailand

Status: Not yet | R&D | Demonstration | scaling | mobilization

| | Byproduct (chemical and steel) |
|---|---|
| Status | Mobilization |
| Status Detail | 1. There has been hydrogen production for industrial use with byproduct method in Thailand |
| Challenge | Some challenges, which include: *1<br>1. Steel production in Thailand is decreasing, which might decrease hydrogen<br>2. Less incentives for hydrogen utilizations |
| Potential | Total steel production in November 2022 is about 1.76M tons, which decreases from November 2021 according to Iron and Steel Institute of Thailand |
| Player | 1. Bangkok Industrial Group (BIG) |

*Source: *1 Iron and Steel Technology Roadmap by IEA 2022 (Iron and Steel Technology Roadmap - Towards more sustainable steelmaking (windows.net)*

# Li-H2 seems to be not yet available in Thailand

## Hydrogen Carry and Storage in Thailand (1/3)

Status: Not yet | R&D | Demonstration | scaling | mobilization

| | Compressed hydrogen | pipeline | Li-H2 |
|---|---|---|---|
| Status | mobilization | Not yet | Not yet |
| Status Detail | Some hydrogen manufacturers supply hydrogen in compressed hydrogen form | Not known public information on pipeline | Not known public information on Li-H2 |
| Challenge | Some challenges, which include: *1<br>1. Expensive method of transport, which increase hydrogen price<br>2. Limited development plan for hydrogen infrastructure by government | Some challenges, which include: *2<br>1. High R&D cost<br>2. Limited expert and knowledge<br>3. Limited incentive from the government (BOI) | Some challenges, which include: *2<br>1. High R&D cost<br>2. Limited expert and knowledge<br>3. Limited incentive from the government (BOI) |
| Potential | This method has long been used with other gases | Not known public information about potential | Not known public information about potential |
| Player | 1. Air Liquide<br>2. Bangkok Industrial Gas (BIG)<br>3. Linde | Not known public information about player | Not known public information about player |

*Source: *1 Global Hydrogen Review by IEA 2022 (Global Hydrogen Review 2022 (windows.net) , *2 Global Hydrogen Trade to Meet The 1.5 C Climate Goal by IRENA 2022 (Global hydrogen trade to meet the 1.5℃ climate goal: Trade outlook for 2050 and way forward (irena.org )*

# Advance hydrogen carry and storage technology is not available in Thailand, and there are no players at this moment

## Hydrogen Carry and Storage in Thailand (2/3)

Status: Not yet | R&D | Demonstration | scaling | mobilization

| | Alloy | MCH | NH3 |
|---|---|---|---|
| Status | Not yet | Not yet | Not yet |
| Status Detail | No known public information on Alloy | Not known public information on MCH | Not known public information on NH3 |
| Challenge | Some challenges, which include: *1<br>1. High R&D cost<br>2. Limited expert and knowledge<br>3. Limited incentive from the government | Some challenges, which include: *1<br>1. High R&D cost<br>2. Limited expert and knowledge<br>3. Limited incentive from the government | Some challenges, which include: *1<br>1. High R&D cost<br>2. Limited expert and knowledge<br>3. Limited incentive from the government |
| Potential | No known public information about its potential | No known public information about its potential | No known public information about its potential |
| Player | No known public information about player | No known public information about player | No known public information about player |

*Source: *1 Global Hydrogen Trade to Meet The 1.5 C Climate Goal by IRENA 2022 (Global hydrogen trade to meet the 1.5 ℃ climate goal: Trade outlook for 2050 and way forward (irena.org )*

# Advance hydrogen carry and storage technology is not available in Thailand, and there are no players at this moment

## Hydrogen Carry and Storage in Thailand (3/3)

Status: Not yet | R&D | Demonstration | scaling | mobilization

| | Synthesis CH4 | e-fuel |
|---|---|---|
| Status | Not yet | Not yet |
| Status Detail | No known public information on synthesis CH4 | No known public information on e-fuel |
| Challenge | Some challenges, which include: *1<br>1. High R&D cost<br>2. Limited expert and knowledge<br>3. Limited incentive from the government | Some challenges, which include: *1<br>1. High R&D cost<br>2. Limited expert and knowledge<br>3. Limited incentive from the government |
| Potential | No known public information about its potential | No known public information about its potential |
| Player | No known public information about player | No known public information about player |

*Source: *1 Global Hydrogen Trade to Meet The 1.5 C Climate Goal by IRENA 2022 (Global hydrogen trade to meet the 1.5 ℃ climate goal: Trade outlook for 2050 and way forward (irena.org )*

# Hydrogen refueling station is in demonstration status, with a first prototype launched in Nov 2022 in Thailand

## Hydrogen Supply in Thailand

Status: Not yet | R&D | Demonstration | scaling | mobilization

| | Hydrogen Refueling Station |
|---|---|
| Status | Demonstration |
| Status Detail | 1. First hydrogen fueling prototype station was launched in November 2022 *1 |
| Challenge | Some challenges, which include: *2<br>1. Limited hydrogen demand due to hydrogen-powered car is not widely used in Thailand |
| Potential | 1. Results from the prototype station can be used to improve hydrogen stations in the future<br>2. It can potentially be scaled if there is enough demand |
| Player | Collaboration among PTT, OR, Toyota and BIG |

*Source: *1 Various News Articles (Thailand to launch its first hydrogen filling station in Pattaya by year end - The Pattaya News ) *2 Thailand's Public Company Limited (PTT) Company Articles (PTT Public Company Limited: News : Launching Thailand's first hydrogen fueling prototype station, "PTT - OR - TOYOTA - BIG" joins forces to embark on future energy. (pttplc.com)*

# Hydrogen is utilized in chemical and refinery sectors in Thailand, while hydrogen usage in transportation industry is being studied

## Hydrogen Utilization in Thailand

Status: Not yet | R&D | Demonstration | scaling | mobilization

| | Transportation | Chemical (feedstock) | Refinery |
|---|---|---|---|
| Status | R&D | Mobilization | Mobilization |
| Status Detail | 1. Toyota and C.P. group has signed an MoU to collaboratively turn farm waste into fuel for hydrogen-powered car | 1. Currently, hydrogen utilization is almost completely for the chemical and refining, steel making process, and other industrial purposes | 1. Currently, hydrogen utilization is almost completely for the chemical and refining, steel making process, and other industrial purposes |
| Challenge | Some challenges, which include: *2<br>1) Limited expert & knowledge | Some challenges, which include: *1<br>1) Lack of policies that promote hydrogen development | Some challenges, which include: *1<br>1) Lack of policies that promote hydrogen development |
| Potential | The government has been promoting EV lately and households seem to be interested in EV/FCV/FCEV | Cereal production has increased dramatically over the past years, which can potentially result in an increase in agricultural products, including fertilizer | Thailand produces 532,328.59 barrels of oil per day as of 2016, and it ranks 29th in the world |
| Player | 1. Toyota and C.P. Group | Fertilizer producers such as Thai Central Chemical PCL., Saksiam Group, Chia Tai, Haifa, and Yara | 1. Thai Oil<br>2. IRPC<br>3. ESSO<br>4. PTTGC<br>5. Bangchak |

*Source: *1 Global Hydrogen Trade by IRENA 2022 (Global hydrogen trade to meet the 1.5℃ climate goal: Trade outlook for 2050 and way forward (irena.org) *2 Various News Articles (Hydrogen for ASEAN Countries' Clean Energy Transition in Road Transport Sector - News and Views : ERIA, The Future Lies In : EV? or FCEV? – Hyundai Motor Group TECH )*

# EGAT has experimented fuel cell technology with wind-hydrogen energy in Thailand

## Hydrogen Utilization in Thailand

Status: Not yet | R&D | Demonstration | scaling | mobilization

| | Steel | Fuel cell (CHP) | Boiler |
|---|---|---|---|
| Status | Not yet | Demonstration | Not yet |
| Status Detail | No known public information on steel | 1. EGAT brought new technology, Wind Hydrogen Hybrid System and Fuel Cell, in which it converts hydrogen stored to electricity through fuel cell | No known public information on boiler |
| Challenge | Some challenges, which include: *1<br>1. High R&D cost<br>2. Limited expert and knowledge<br>3. Limited incentive from the government | 1. High investment cost*2 | Some challenges, which include: *1<br>1. High R&D cost<br>2. Limited expert and knowledge<br>3. Limited incentive from the government |
| Potential | Not known public information about its potential | It could potentially be expanded or adapted in the future | Not known public information about its potential |
| Player | Not known public information about its player | 1. EGAT | Not known public information about its player |

*Source: *1 Global Hydrogen Trade to Meet The 1.5 C Climate Goal by IRENA 2022 (Global hydrogen trade to meet the 1.5 ℃ climate goal: Trade outlook for 2050 and way forward (irena.org ) *2 EGAT and Thailand Construction and Engineering News*

# Power Generation is in demonstration status as EGAT conducts ammonia power plant project

## Hydrogen Utilization in Thailand

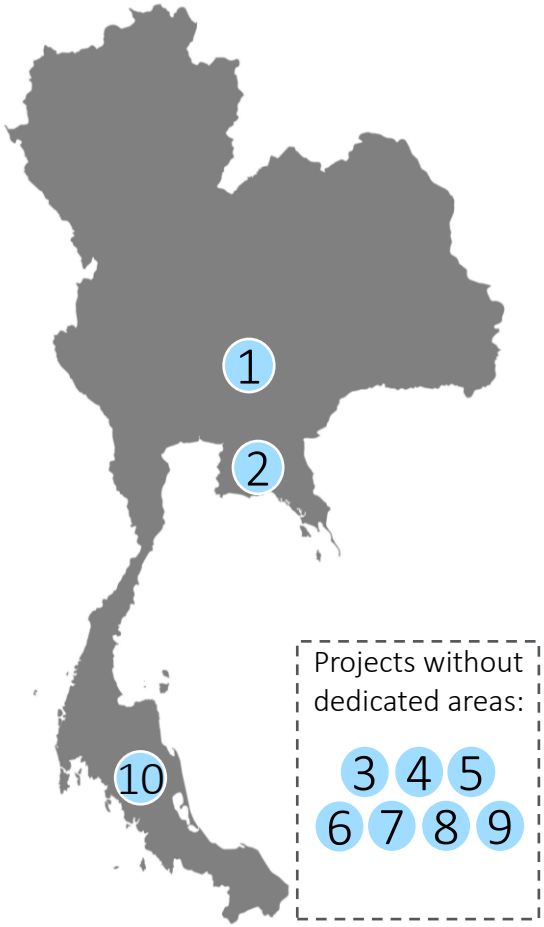
Status: Not yet | R&D | Demonstration | scaling | mobilization

| | Power Generation |
|---|---|
| Status | Demonstration |
| Status Detail | 1. EGAT is experimenting with a project to use ammonia, which has nitrogen and hydrogen, as fuel together with coal to generate electricity and also in partnership with Mitsubishi for knowledge sharing |
| Challenge | Some challenges, which include: *1<br>1. High R&D cost<br>2. Limited expert and knowledge<br>3. Limited incentive from the government |
| Potential | No known public data on the result of the trial research |
| Player | EGAT |

*Source: *1 Global Hydrogen Trade to Meet The 1.5 C Climate Goal by IRENA 2022 (Global hydrogen trade to meet the 1.5 ℃ climate goal: Trade outlook for 2050 and way forward (irena.org )*

# Multiple projects are in progress in Thailand, and two of them are located in the central part of Thailand

## Hydrogen Project Map of Thailand



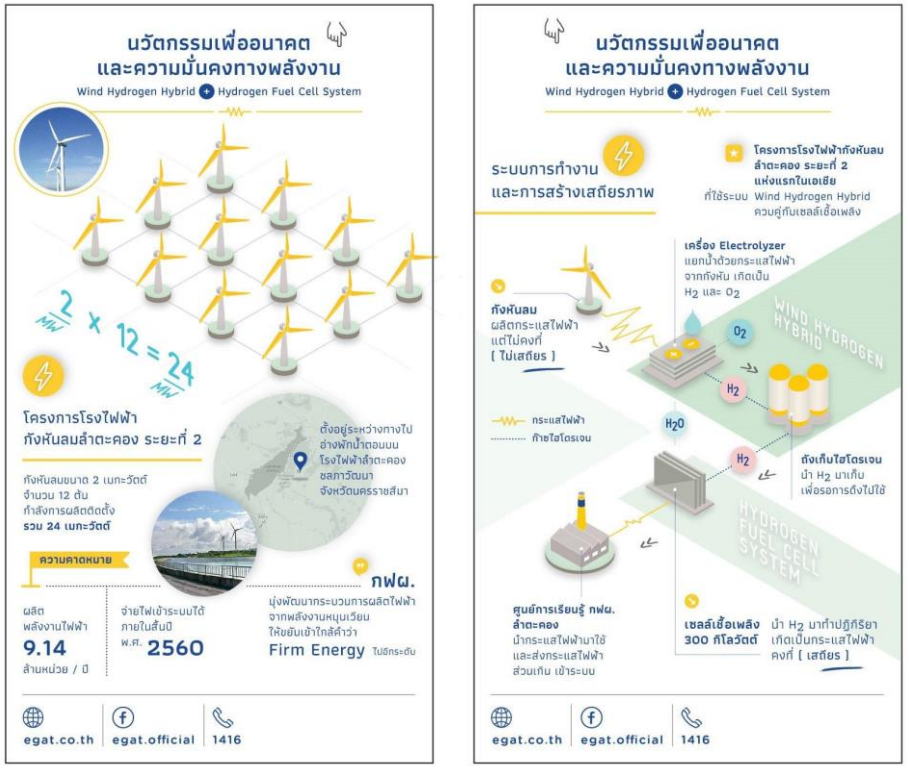

| # | Name of project | Supply chain | | | Status | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Production | Carry /transport | Use | Agreement | R&D | FS | Demo | Commercial |
| 1 | Lam Ta Khong Wind Turbines | ● | ● | ● | | | | | |
| 2 | Hydrogen Refueling Prototype Station | | | ● | | | | | |
| 3 | Hydrogen Fuel Project | ● | | ● | | | | | |
| 4 | TH-JP: Carbon Neutral Smart Park Project | ● | ● | ● | | | | | |
| 5 | Clean Energy Development | ● | | | | | | | |
| 6 | Carbon Neutral Roadmap on the Usage of Hydrogen, Ammonia, and CCUS | ● | | | | | | | |
| 7 | Feasibility Study on Ammonia Co-firing power generation | ● | | | | | | | |
| 8 | Green hydrogen and derivatives development project | ● | | | | | | | |
| 9 | Investment Opportunity in Solid Fuel Cells and Electrolyzer Technology Exploration | ● | | ● | | | | | |
| 10 | Building a Clean Hydrogen and Ammonia Value Chain Derived from Renewable Energy Sources in Southern Thailand | ● | ● | ● | | | | | |

# EGAT constructed 12 wind turbines with wind hydrogen hybrid system and fuel cell to stabilize electricity

1

| | |
|---|---|
| Name of project | Lam Ta Khong Wind Turbines |
| Period | September 2016 – 2017 (construction),<br>2017 – Present (commercial operation) |
| Place | Nakhon Ratchasima Province, Thailand |
| Partners | ■ Energy Generating Authority of Thailand (EGAT)<br>■ Hydrochina Corporation *(Energy Company)*<br>■ Hydrogenics Europe N.V. *(Hydrogen Technology Investor)*<br>■ Phraram 2 Civil Engineering Co., Ltd *(developer)* |
| Purpose | ■ It was constructed in response to governments policy on power stability by <u>diversifying fuel mix and promoting renewable energy</u><br>■ EGAT brought new technology, <u>Wind Hydrogen Hybrid System and Fuel Cell</u>, to conduct research and help stabilizing electricity generation from renewable energy |
| Budget | ■ 42M USD (1.407B THB) |
| Future plan | N/A |

Images




*Lam Ta Khong, Nakhon Ratchasima, Thailand*

 *Source: EGAT and Thailand Construction and Engineering News*

# PTT, OR, Toyota, and BIG collaborated on launching the first hydrogen fueling prototype station in Thailand

2

| | |
|---|---|
| Name of project | Hydrogen Refueling Station |
| Period | November 2022 - Present |
| Place | Chonburi, Thailand |
| Partners | ■ PTT Public Company Limited *(Oil and Gas Company)*<br>■ PTT Oil and Retail Public Company Limited (OR) *(Oil and Retail Company)*<br>■ Toyota Daihatsu Engineering and Manufacturing Co., Ltd (TDEM) *(Engineering and Manufacturing Company)*<br>■ Toyota Motor Thailand Company Limited (TMT) *(Vehicle Manufacturing Company)*<br>■ Bangkok Industrial Group (BIG) *(Hydrogen Producer)* |
| Purpose | ■ To align with Thailand's goal to achieve carbon neutrality and net zero emissions<br>■ Data from this project will be gathered to improve performance in the future |
| Budget | ■ 302,315 USD (10M THB) |
| Future plan | ■ Potentially more hydrogen fueling stations in the future |

Images


*Chonburi, Thailand*

 *Source: PTT website, and news articles*

# Toyota and C.P. Group are collaborating on Hydrogen Fuel Project

3

| | |
|---|---|
| Name of project | Hydrogen Fuel Project |
| Period | December 2022 – unknown |
| Place | Thailand |
| Partners | ■ True Leasing *(CP's transportation service business)*<br>■ Isuzu Motors *(Vehicle Manufacturer)*<br>■ Toyota subsidiary Hino Motors *(Vehicle Manufacturer)* |
| Purpose | ■ To study potential possibilities to improve efficiency in the logistics industry by turning farm waste into fuel for hydrogen-powered car To reduce carbon emissions in Thailand |
| Budget | N/A |
| Future plan | ■ Expanding to other countries |

Images


*CP Group Senior Chairman and Toyota Motor CEO*

 *Source: Nikkei Asia*

# Thai and Japanese companies conducted a feasibility study to construct a carbon-neutral industrial park in Rayong funded

4

| | |
|---|---|
| Name of project | TH-JP: Carbon Neutral Smart Park Project |
| Period | Spring 2021 – Feb 2022 |
| Place | Rayong province, Thailand |
| Partners | ■ Toyota Motor Thailand *(vehicle manufacturer)*<br>■ Toyota Tsusho *(trading company)*<br>■ Osaka Gas *(gas company)*<br>■ Kansai Electricity *(electricity company)*<br>■ IEAT *(industrial park operator)*<br>■ PTT *(gas company)*<br>■ PTTGC *(chemical company)*<br>■ Bangkok Industrial Gas *(industrial gas company) etc.* |
| Purpose | ■ To conduct a <u>feasibility study about "carbon-neutral industrial park"</u> (600 acre) near Map Ta Put in the east part of Rayong province<br>■ The project aims to <u>construct a whole hydrogen supply chain within the park</u> including renewable power development and fuel cell vehicle introduction |
| Budget | N/A (funded in FY 2021 by METI) |
| Future plan | ■ Plan to start the construction of the park in 2023 to be in operation in 2025<br>■ Become a model case for industrial parks in other Southeast Asian countries such as Indonesia or Vietnam |

Images


*Conceptual Image of Carbon-neutral Industrial Park*

 *Source: NNA ASIA*

# EGAT and MHI signed an MOU to study clean energy technologies

5

| | |
|---|---|
| Name of project | Clean Energy Development between Electricity Generating Authority of Thailand (EGAT) and Mitsubishi Heavy Industries (Thailand) Ltd. |
| Period | November 2022 – 2025 (3 years) |
| Place | N/A |
| Partners | ■ Energy Generating Authority of Thailand (EGAT)<br>■ Mitsubishi Heavy Industries *(Industrial Machinery Manufacturer)* |
| Purpose | ■ To develop and share knowledge on clean energy technologies such as CCUS, hydrogen, and ammonia fuels<br>■ To apply clean technologies with power plants in Thailand to reduce carbon emissions to achieve carbon neutrality by 2050 |
| Budget | N/A |
| Future plan | ■ This MOU aims to support the national goals of reducing 40 percent of GHG by 2030 and achieving carbon neutrality by 2050 and net-zero emissions by 2065 |

Images


*EGAT Headquarter, Bangkok, Thailand*

 *Source: EGAT*

# ECGO Group signed an MoU with JERA Asia to study the use of hydrogen, ammonia, and CCUS and achieve its carbon neutral goal

6

| | |
|---|---|
| Name of project | Carbon Neutral Roadmap on the Usage of Hydrogen, Ammonia, and CCUS |
| Period | January 2023 - unknown |
| Place | Bangkok, Thailand |
| Partners | ■ Electricity Generating Public Company Limited (EGCO) *(Power Producer)*<br>■ JERA Asia Pte. Ltd. *(Energy Services Provider)* |
| Purpose | ■ To study and research about CCUS and its implication in Thailand for decarbonization of EGCO |
| Budget | N/A |
| Future plan | ■ EGCO to achieve carbon neutral goal by 2050 |

Images


79 *Source: EGCO Website*

# ECGO Group signed an MoU with companies to conduct feasibility study on ammonia co-firing power generation

7

| | |
|---|---|
| Name of project | Feasibility Study of Ammonia Co-firing Power Generation |
| Period | January 2023 - unknown |
| Place | Bangkok, Thailand |
| Partners | ■ Electricity Generating Public Company Limited (EGCO) *(Power Producer)*<br>■ Banpu Power Public Company Limited (BPP) *(Electricity Generator)*<br>■ BLCP Power Company Limited *(Electricity Generator)*<br>■ JERA *(Energy Services Provider)*<br>■ Mitsubishi Corporation *(Trading Company)*<br>■ Mitsubishi Heavy Industries Ltd. *(Industrial Machinery Manufacturer)* |
| Purpose | ■ To collaboratively <u>study technical application, economic evaluation and carbon reduction plan for ammonia co-firing</u> up to 20 percent at the BLCP 1,434 MW coal-fired power plant |
| Budget | N/A |
| Future plan | ■ Not mentioned; however, results from the study can be beneficial in the implementation process |

Images


80 *Source: EGCO Website*

# ACWA Power, PTT, EGAT have signed an MoU to collaborate on establishing green hydrogen and derivative production facilities in Thailand

8

| | |
|---|---|
| Name of project | Green hydrogen and derivatives development project |
| Period | November 2022 - unknown |
| Place | Thailand |
| Partners | ■ ACWA Power *(Electricity Generator)*<br>■ PTT Public Company Limited *(Oil and Gas Company)*<br>■ Electricity Generating Authority of Thailand (EGAT) |
| Purpose | ■ To conduct an investment feasibility study to plan on establishing large-scale renewable-powered green hydrogen and derivatives production facilities in Thailand |
| Budget | ■ 7B USD |
| Future plan | ■ Target production is 225,000 tons of hydrogen per year |

Images

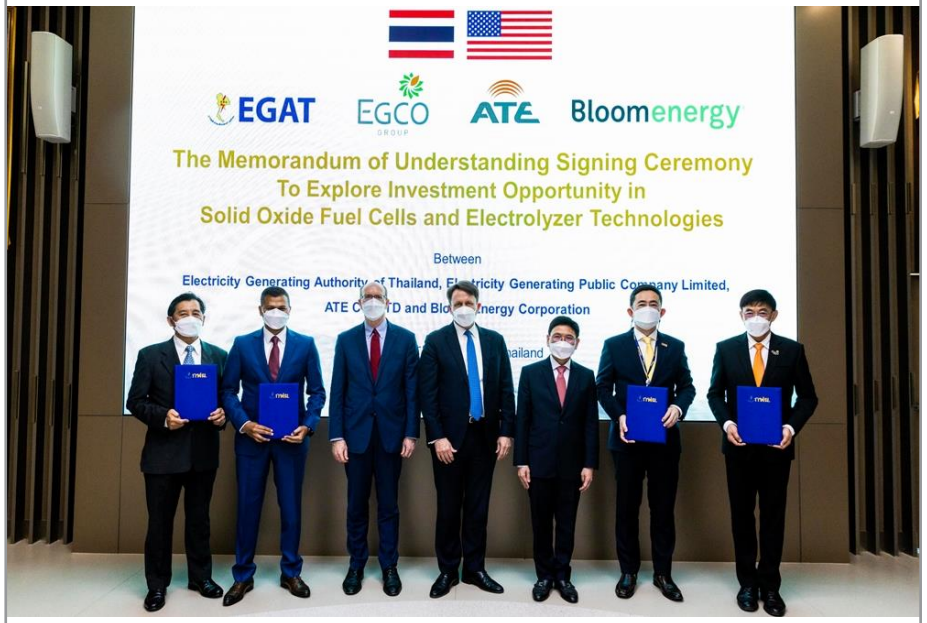
81 *Source: Thai PR*

# EGAT, ATE, EGCO, and Bloom Energy signed an MoU to develop hydrogen technologies

9

| | |
|---|---|
| Name of project | Investment Opportunity in Solid Oxide Fuel Cells and Electrolyzer Technology Exploration |
| Period | December 2021 |
| Place | N/A |
| Partners | ■ Energy Generating Authority of Thailand (EGAT)<br>■ ATE *(Energy Company)*<br>■ Electric Generating Public Company Limited (EGCO) *(Power Producer)*<br>■ Bloom Energy *(Electricity Generator and Hydrogen Producer)* |
| Purpose | ■ To develop power plants in Thailand using <u>new energy alternatives and SOEC and SOFC technology</u> to pave the way to Thailand's decarbonization and energy transition to hydrogen |
| Budget | N/A |
| Future plan | ■ This MOU aims to support the nation in achieving carbon neutrality |

Images




*EGAT Headquarter, Bangkok, Thailand*

 *Source: EGAT*

# Japanese companies and EGAT signed an MoU to Collaborate on Building Clean Hydrogen/Ammonia Value Chain in Thailand

## Clean Hydrogen and Ammonia Value Chain

10

| | |
|---|---|
| Name of project | Building a Clean Hydrogen and Ammonia Value Chain Derived from Renewable Energy Sources in Southern Thailand |
| Period | March 2023 onwards |
| Place | Southern Thailand |
| Partners | ■ Electricity Generation Authority of Thailand (EGAT)<br>■ Mitsubishi Company Ltd.<br>■ Chiyoda Corporation<br>■ Mitsui O.S.K. Lines, Ltd. |
| Purpose | ■ To collaborate on decarbonization projects by conducting a study on possible options to establish a series of clean hydrogen and ammonia's supply chain from renewable energy sources in Southern Thailand |
| Budget | N/A |
| Future plan | ■ Supply clean hydrogen and ammonia domestically and internationally |

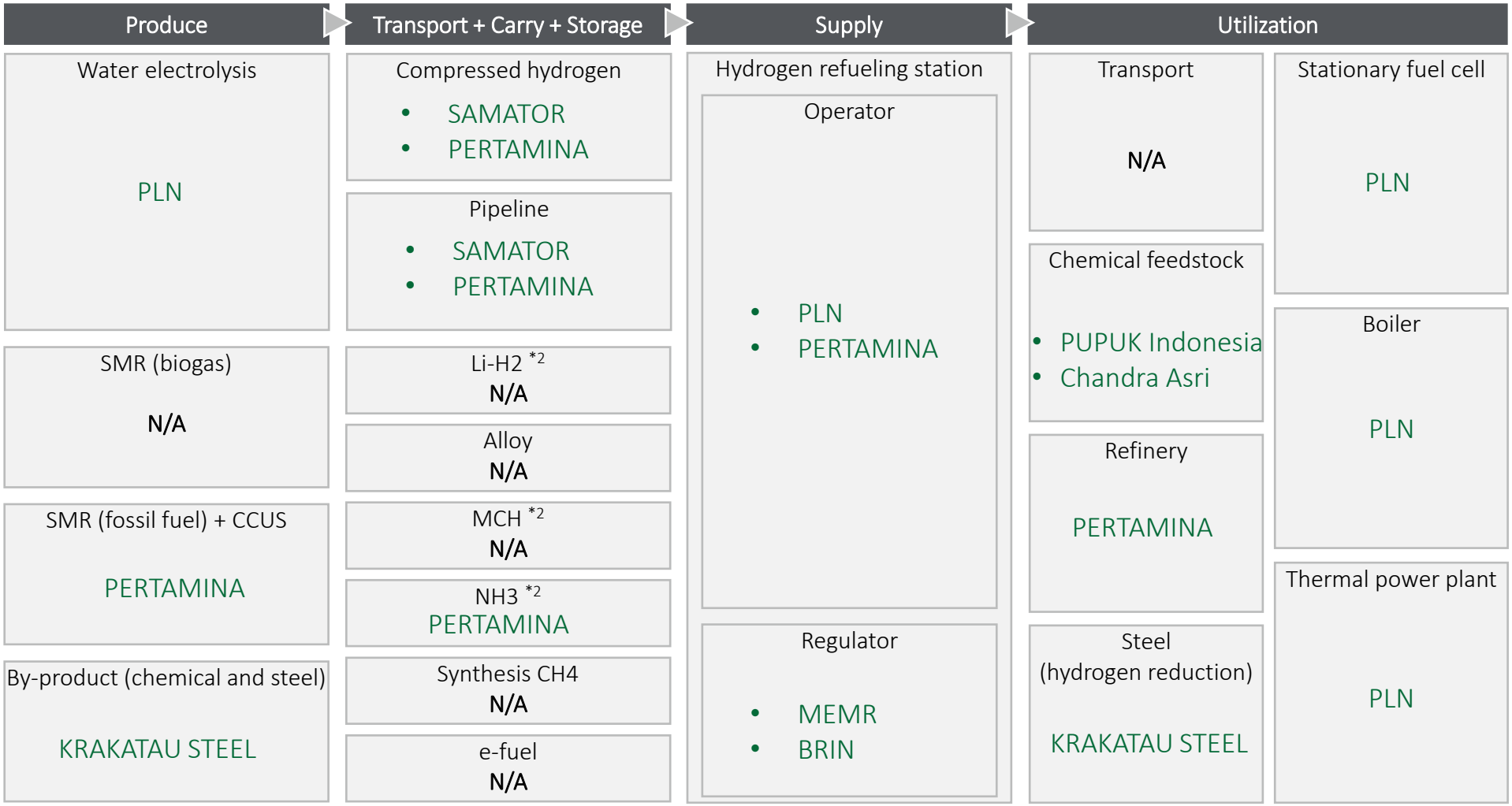
Images

83 *Source: EGCO Website*

# Indonesia

# Companies in Indonesia cover all the parts of hydrogen supply chain except for advanced carry and storage technologies

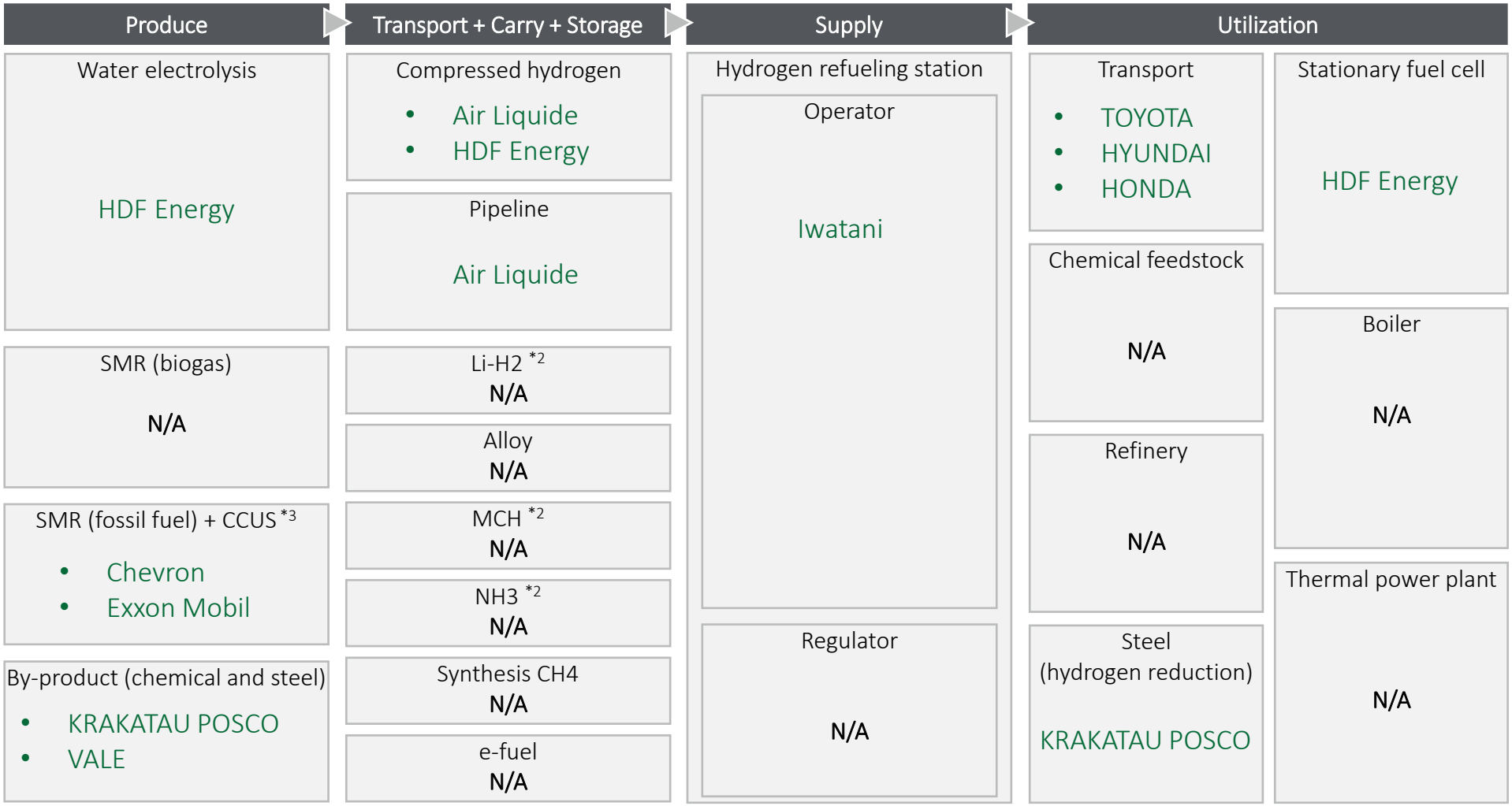
## Local hydrogen player map in Indonesia*1




*1: Note that hydrogen players do not just include players that have core technologies but also those who are engaged with related projects. *2: Hydrogen careers that are likely to be options for hydrogen shipping

# Companies in Indonesia cover all the parts of hydrogen supply chain except for advanced carry and storage technologies

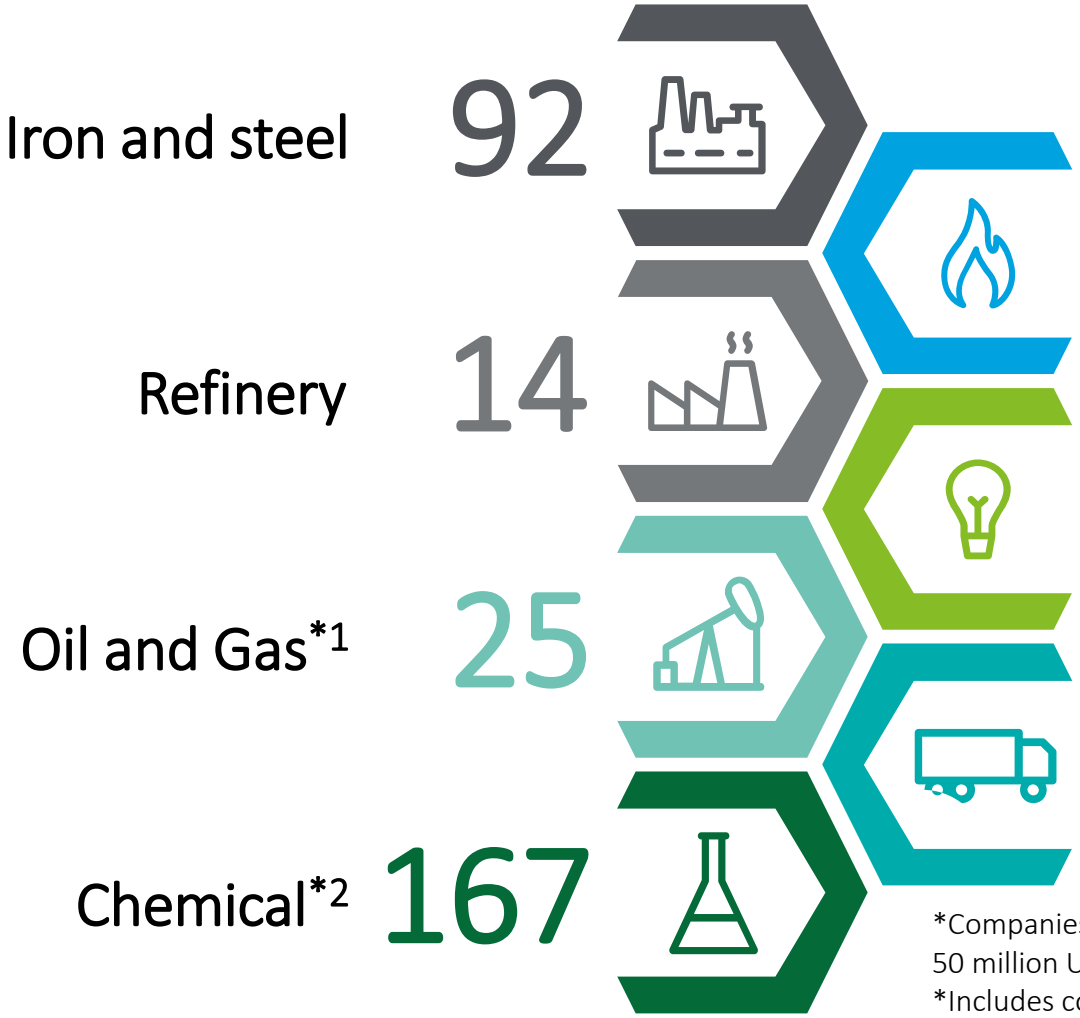
## External/global hydrogen player map in Indonesia*1




*1: Note that hydrogen players do not just include players that have core technologies but also those who are engaged with related projects. *2: Hydrogen careers that are likely to be options for hydrogen shipping

# There are larger potential especially in iron and steel, and chemical in Indonesia

## The potential number of companies in Indonesia




*Companies with 50 employees and above, and with annual revenue of 50 million USD and above.
*Includes companies that have headquarters outside of Indonesia

*Source: D&B Hoovers *1: PTT is the one and only oil and gas company in Thailand *2: includes fertilizer companies and industrial gas companies *2: road transport except for rail and logistics companies (freight transport and courier)*

*Reference*

# Chevron and ExxonMobill are top oil and gas companies in Indonesia

## Oil and Gas Industry Leaders [*1]

| | Company name | Headquarters of parent company | Production amount (BpD / Barrels per Day) |
|---|---|---|---|
| 1 | Chevron Pacific Indonesia | United States | 210,582 |
| 2 | ExxonMobil Cepu Limited | | 207,936 |
| 3 | Pertamina EP | Indonesia | 73,618 |
| 4 | Pertamina Hulu Mahakam | | 44,346 |
| 5 | CNOOC | China | 31,141 |

*Source: *1 What Are the Biggest Oil & Gas Companies in Indonesia? | Indonesia Investments (indonesia-investments.com)*

# Byproduct and SMR hydrogen are both in mobilization status, while water electrolysis is in demonstration phase

## Hydrogen Production in Indonesia

Status: Not yet | R&D | Demonstration | scaling | mobilization

| | Water electrolysis | SMR (biogas) | SMR (fossil fuel) + CCUS |
|---|---|---|---|
| Status | Demonstration | Not Yet | R&D |
| Status Detail | There are several trial projects that has been conducted to produce green hydrogen using electrolysis within geothermal power generation | Not known public information on SMR from biogas | 1) Hydrogen for industrial uses is mainly produced through steam methane reforming (SMR)<br>2) CCUS application is still under study |
| Challenge | Some challenges, which include: *1<br>1) Incentives & technology uncertainty<br>2) Limitations in regulatory support & technical standard | Some challenges, which include: *1<br>1) Limited infrastructure readiness<br>2) Incentives & technology uncertainty<br>3) Limitations in regulatory support & technical standard | Some challenges, which include: *1<br>1) Limited infrastructure readiness<br>2) Incentives & technology uncertainty<br>3) Limitations in regulatory support & technical standard |
| Potential | According to PLN, the potential from renewable energy to be utilized in electrolysis is quite large, with hydropower (95 GW) & geothermal (24 GW) *3 | Not known public information about potential | 1) According to ID's Federal Statistic, hydrogen production was 117,040 tonnes in 2019*2<br>2) There has been feasibility study conducted by Mitusbishi Corporation, Pertamina & Pupuk Indonesia on CCUS |
| Player | 1) Utility sectors (PLN)<br>2) Electrolyzer producer (HDF Energy) | Not known public information about player | 1) Oil & gas sectors (Pertamina) |

*Source: *1 The Future of Hydrogen by IEA 2022 (The Future of Hydrogen (windows.net)), *2 Green Hydrogen in Indonesia by IESR-EKONID 2022 (EKONID Team Site - Green Hydrogen Market Study FINAL.pdf - All Documents (sharepoint.com))), *3 JICA Indonesia Decarbonization Survey (2022), Hydrogen Indonesia (hydrogen-indonesia.id)*

# Byproduct and SMR hydrogen are both in mobilization status, while water electrolysis is in demonstration phase

## Hydrogen Production in Indonesia

Status: Not yet | R&D | Demonstration | scaling | mobilization

| | By product H2 |
|---|---|
| Status | Mobilization |
| Status Detail | 1) No known exact statistic on hydrogen specifically produced as by product.<br>2) However, the amount is estimated to be large due to massive amount of steel-making industry |
| Challenge | Some challenges, which include: *1<br>1) Lack of policies that promote hydrogen |
| Potential | According to Indonesian Iron and Steel Industry Association (IISIA), steel production is recorded at 19.6 million tons in 2022 & expected to increase to 23.34 million tons in 2025 *2 |
| Player | 1) Steel-making sector (Krakatau Posco, Vale Indonesia) |

*Source: *1 Global Hydrogen Trade to Meet The 1.5 C Climate Goal by IRENA 2022 (Global hydrogen trade to meet the 1.5 ℃ climate goal: Trade outlook for 2050 and way forward (irena.org)*2 Various News Articles (Produksi Baja Nasional Turun 2,9 Persen Tahun Lalu (bisnis.com), Kemenperin: Industri Logam Tumbuh 7,90 Persen pada Kuartal I 2022 (tirto.id)*

# Injection of hydrogen into existing pipeline is in demonstration phase

## Hydrogen Carry and Storage in Indonesia (1/3)

Status: Not yet | R&D | Demonstration | scaling | mobilization

| | Compressed hydrogen | Pipeline | Li-H2 |
|---|---|---|---|
| Status | Mobilization | Demonstration | Not yet |
| Status Detail | Currently, hydrogen for industrial uses is transported by trucks in the form of compressed hydrogen | **There has been several trial for hydrogen distribution utilizing existing natural gas pipelines by blending hydrogen to natural gas** | No known public research on Li-H2 |
| Challenge | Some challenges, which include: *1<br>1) Limitations in regulatory support & additional incentives | Some challenges, which include: *1<br>1) Limited infrastructure readiness<br>2) Limitations in regulatory support & technical standard | Some challenges, which include: *2<br>1) Lack of policies that promote hydrogen infrastructure development |
| Potential | The only method that is already in Mobilization status | By March 2020, there was 14,855 km of natural gas pipeline available, consisting of 5,254 transmission pipelines and 6,163 distribution pipelines, which available to be used for hydrogen transport*3 | No known information about its potential |
| Player | 1) Oil & gas sectors (Pertamina, Samator Indo Gas, Air Products, Air Liquide, and Linde) | 1) Oil & gas sectors (Pertamina, Samator Indo Gas, Air Liquide) | No known player |

*Source: *1 The Future of Hydrogen by IEA 2022 (The Future of Hydrogen (windows.net)), *2 Global Hydrogen Trade to Meet The 1.5 C Climate Goal by IRENA 2022 (Global hydrogen trade to meet the 1.5 ℃ climate goal: Trade outlook for 2050 and way forward (irena.org ),*3 JICA Indonesia Decarbonization Survey (2022)*

# NH3 as energy carrier is in R&D phase in Indonesia

## Hydrogen Carry and Storage in Indonesia (2/3)

Status: Not yet | R&D | Demonstration | scaling | mobilization

| | Alloy | MCH | NH3 |
|---|---|---|---|
| Status | Not yet | Not yet | R&D |
| Status Detail | No known public research on Alloy transport | No known public research on MCH transport | There has been trial project conducted by government, private & university to use NH3 (ammonia) transport, some of which considering using Carbon Capture Storage (CCS) in Sulawesi & Kalimantan Island*2 |
| Challenge | Some challenges, which include: *1<br>1) Limited infrastructure readiness<br>2) Incentives & technology uncertainty<br>3) Limitations in regulatory support & technical standard | Some challenges, which include: *1<br>1) Limited infrastructure readiness<br>2) Incentives & technology uncertainty<br>3) Limitations in regulatory support & technical standard | Some challenges, which include: *1<br>1) Limited infrastructure readiness<br>2) Incentives & technology uncertainty<br>3) Limitations in regulatory support & technical standard |
| Potential | No known information about its potential | No known information about its potential | One of trial project conducted by Mitsubishi & Insitut Teknologi Bandung estimated potential NH3 plant to produce around 660 kilo tonnes/year using CCS in Central Sulawesi*3 |
| Player | No known player | No known player | 1) Private sectors (Mitsubishi)<br>2) SOEs (Pertamina & PLN)<br>3) Public (Institut Teknologi Bandung, Ministry of Energy (MEMR) |

*Source: *1 The Future of Hydrogen by IEA 2022 (The Future of Hydrogen (windows.net), *2 Various News Articles (Pertamina, PT Pupuk Indonesia, and Mitsubishi Corporation Agree to Develop Blue/Green Hydrogen and Ammonia Business | Pertamina), *3 JICA Indonesia Decarbonization Survey (2022)*

# Advanced technologies such as synthetic fuel is not yet available

## Hydrogen Carry and Storage in Indonesia (3/3)

Status: Not yet | R&D | Demonstration | scaling | mobilization

| | Synthesis CH4 | e-fuel |
|---|---|---|
| Status | Not yet | Not yet |
| Status Detail | No known public research on synthesis CH4 | 1) No exist infrastructure and/or facilities for e-fuel production & infrastructure<br>2) There has been interest both public & private to invest in e-fuel for Electric Vehicle (EV) *2 |
| Challenge | Some challenges, which include: *1<br>1) Limited infrastructure readiness<br>2) Incentives & technology uncertainty<br>3) Limitations in regulatory support & technical standard | Some challenges, which include: *1<br>1) Limited infrastructure readiness<br>2) Incentives & technology uncertainty<br>3) Limitations in regulatory support & technical standard |
| Potential | No known information about its potential | 1) No known information about its potential<br>2) However, the government & private sector has shown interest in pursing e-fuel to accelerate net zero adoption*2 |
| Player | No known player | 1) Indonesia's government (specifically Ministry of Energy (MEMR))<br>2) Some private sector in automotive such as Toyota, Honda, Hyundai |

*Source: *1 The Future of Hydrogen by IEA 2022 (The Future of Hydrogen (windows.net), *2 Various News Articles (Toyota Mungkin Hadirkan Mirai FCEV di Indonesia - Carmudi Indonesia, content-rencana-umum-energi-nasional-ruen.pdf (esdm.go.id)*

# Hydrogen refueling station is not yet available while there is government's interest

## Hydrogen Supply in Indonesia

Status: Not yet | R&D | Demonstration | scaling | mobilization

| | HRS (Hydrogen Refueling Station) |
|---|---|
| Status | R&D |
| Status Detail | The government has shown interest to develop refueling station infrastructure for hydrogen in Presidential Regulation No. 22/2017 on National Energy Plan (RUEN) |
| Challenge | Some challenges, which include: *1<br>1) High cost in R&D<br>2) Limited technical knowledge & experts<br>3) Limited supporting policy |
| Potential | There's a research discussion between the National Research and Innovation Agency (BRIN), Agency for the Assessment and Application of Technology (BPPT) with Japanese Fueling Station Developer, IWATANI on hydrogen refueling station*2 |
| Player | 1) Indonesia's government (National Research & Innovation Agency (BRIN), Agency for the Assessment & Application of Technology (BPPT)<br>2) HRS developer (IWATANI)<br>3) Energy-related SOEs (Pertamina & PLN) |

*Source: *1 Global Hydrogen Trade to Meet The 1.5 C Climate Goal by IRENA 2022 (Global hydrogen trade to meet the 1.5 ℃ climate goal: Trade outlook for 2050 and way forward (irena.org)*2 Interview result conducted by NEDO-Deloitte with Pertamina 2023*

# Oil refinery and chemical industry, such as fertilizer, has been the main user of hydrogen

## Hydrogen Utilization in Indonesia (1/3)

Status: Not yet | R&D | Demonstration | scaling | mobilization

| | Transportation | Chemical (feedstock) | Refinery |
|---|---|---|---|
| Status | Not yet | Mobilization | Mobilization |
| Status Detail | 1) There has been interest both public & private to invest & developed FCV as the new e-vehicle<br>2) Exist general policy for FCV by government | Hydrogen has been widely used for chemical industry, specifically for fertilizer production | Hydrogen used as a "catalyst" (to stimulate chemical reactions) and as a process byproduct that (in certain concentrations) can be an indicator that some critical action must be taken. |
| Challenge | Some challenges, which include: *1<br>1) Limited infrastructure readiness<br>2) Incentives & technology uncertainty<br>3) Limitations in regulatory support & technical standard | Some challenges, which include: *2<br>1) Lack of policies that promote hydrogen development | Some challenges, which include: *2<br>1) Lack of policies that promote hydrogen development |
| Potential | The government has targeted 2.1 million e-motorcycles and 400,000 e-cars by 2025, which might include FCV adoption *3 | The largest fertilizer producer & Indonesia's SOEs, Pupuk Indonesia (Persero), recorded a total production of 11,764,234 tons of fertilizer throughout 2022. *3 | The Special Task Force for Upstream Oil and Gas Business Activities (SKK Migas) reported that Indonesia's actual oil production is 612.3 thousand barrels of oil per day (mbopd) in 2022 *3 |
| Player | 1) Indonesia's government (specifically Ministry of Energy (MEMR))<br>2) Some private sector in automotive such as Toyota, Honda, Hyundai for FCV | 1) Fertilizer producer (Pupuk Indonesia, Petrochemical Gresik, Pupuk Kujang Cikampek, Pupuk Kalimantan Timur, Pupuk Iskandar Muda | 1) Oil & gas refinery (Pertamina) |

*Source: *1 The Future of Hydrogen by IEA 2022 (The Future of Hydrogen (windows.net), *2 Global Hydrogen Trade by IRENA 2022 (Global hydrogen trade to meet the 1.5 ℃ climate goal: Trade outlook for 2050 and way forward (irena.org) *3 Various News Articles (bumn.go.id, Pertamina & Pupuk Indonesia Sepakat Bakal Garap Hidrogen (cnbcindonesia.com), Hydrogen In Oil Refineries:)*

# Other usage of hydrogen has not yet been implemented

## Hydrogen Utilization in Indonesia (2/3)

Status: Not yet | R&D | Demonstration | scaling | mobilization

| | Steel | Fuel cell (CHP) | Boiler |
|---|---|---|---|
| Status | Not yet | Not yet | Not yet |
| Status Detail | All the steel maker in Indonesia still uses conventional blast furnace firing, using coal/coke as key ingredients for combustion process & chemical additives | Currently, fuel cell (CHP) development in Indonesia is still in very early stage of research & development | Hydrogen boiler has not been used for household and/or industrial uses in Indonesia |
| Challenge | Some challenges, which include: *1<br>1) Limited infrastructure readiness<br>2) Incentives & technology uncertainty<br>3) Limitations in regulatory support & technical standard | Some challenges, which include: *1<br>1) Limited infrastructure readiness<br>2) Incentives & technology uncertainty<br>3) Limitations in regulatory support & technical standard | Some challenges, which include: *1<br>1) Limited infrastructure readiness<br>2) Incentives & technology uncertainty<br>3) Limitations in regulatory support & technical standard |
| Potential | According to Indonesian Iron and Steel Industry Association (IISIA), steel production is recorded at 19.6 million tons in 2022 & expected to increase to 23.34 million tons in 2025*2 | Some early research indicates that fuel cell utilization is for hydrogen electrolysis from renewable source (such as water) to produce electricity & fuel cell electric vehicle (FCV/FCEV)*2 | No known public data on the result of the research |
| Player | 1) Steel manufacturer (Krakatau Posco/Steel, Bekaert Wire Indonesia, Gunung Raja Paksi, Master Steel Manufactory, Jakarta Cakratunggal Steel Mills | 1) Regulatory (Ministry of Energy & Resources (MEMR), Indonesia Fuel Cell and Hydrogen Energy Association (INAFHE) | 1) Regulatory (Ministry of Energy & Resources (MEMR), Indonesia Fuel Cell and Hydrogen Energy Association (INAFHE) |

*Source: *1 The Future of Hydrogen by IEA 2022 (The Future of Hydrogen (windows.net), *2 Various News Articles (Anggota | IISIA, Produksi Baja Nasional Turun 2,9 Persen Tahun Lalu (bisnis.com), Kemenperin: Industri Logam Tumbuh 7,90 Persen pada Kuartal I 2022 (tirto.id)*

# Hydrogen, especially green hydrogen for power generation has been within R&D stage to support Indonesia's decarbonization

## Hydrogen Utilization in Indonesia (3/3)

Status: Not yet | R&D | Demonstration | scaling | mobilization

| | Thermal Power Plant |
|---|---|
| Status | R&D |
| Status Detail | There has been initial research conducted by government, SOEs & university (Institut Teknologi Bandung) to estimates the potential capacity produced by hydrogen for electricity |
| Challenge | Some challenges, which include: *1<br>1) High cost in R&D<br>2) Limited technical knowledge & experts<br>3) Limited supporting policy |
| Potential | No known public data on the result of the trial research |
| Player | 1) Regulatory (Ministry of Energy & Resources (MEMR), Indonesia Fuel Cell and Hydrogen Energy Association (INAFHE)<br>2) SOEs (PLN)<br>3) State university (Institut Teknologi Bandung) |

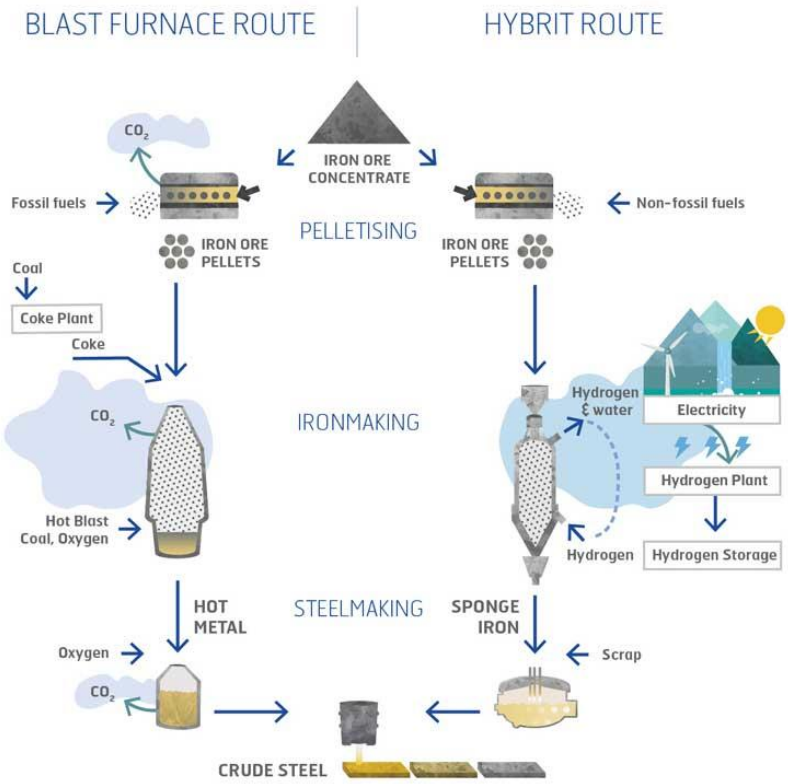
*Source: *1 Global Hydrogen Trade to Meet The 1.5 C Climate Goal by IRENA 2022 (Global hydrogen trade to meet the 1.5 ℃ climate goal: Trade outlook for 2050 and way forward (irena.org)*

*Reference*

# Steel production uses hydrogen mainly as chemical additives for chemical reactions during steel-making process

## Hydrogen usage in steel industry

| | |
|---|---|
| Hydrogen Usage | ▪ Hydrogen can be used as the **sole chemical additives** in a process known as **direct reduction of iron impurities or DRI** |
| Blast Furnace Process | ▪ The **Blast Furnace Combustion Firing** route, also known as the primary production route, accounts for **majority steel production in Indonesia.**<br>▪ Most of the emissions come from the blast furnace and the coke plant. The coke plant produces "coke coal", which is used in the blast furnace both as **a heat source and to reduce iron impurities** |
| Latest Steel Production Innovation | ▪ There has been new method by using hydrogen in the process of blast furnace firing **(H2-BF) has the potential to reduce emissions both in the coke plant and blast furnace** because it reduces the amount of coal needed and only forms water after reacting with iron ore instead of carbon dioxide |
| Current Situation | ▪ All the steel maker in Indonesia still uses **conventional blast furnace combustion firing, using coal/coke** as key ingredients for combustion process & chemical additives<br>▪ However, due to **technical reasons** (related to heat fluctuations), it is not feasible to only use hydrogen in a blast furnace |
| Steel Producer | ▪ **Krakatau Posco/Steel, Bekaert Wire Indonesia, Gunung Raja Paksi, Master Steel Manufactory, Jakarta Cakratunggal Steel Mills** |




 *Source: Iron and Steel Institute of Japan, Several International Journal Articles*

*Reference*

# Stationary Fuel Cell (CHP) is still within the early stage of R&D

## CHP Development

| | |
|---|---|
| Latest Condition | ▪ Currently, **fuel cell (CHP) development in Indonesia is still in very early stage** of research & development<br>▪ Some early research indicates that fuel cell utilization is for **hydrogen electrolysis from renewable source (such as water) to produce electricity & fuel cell electric vehicle** (FCV/FCEV) |
| Gov. Plans | ▪ According to **Ministry of Energy & Mineral Resources (MEMR),** In the **short term**, the production of **distributed hydrogen through reforming natural gas or by electrolysis** will be the most likely approach to introduce hydrogen technology and the start of building a **hydrogen infrastructure**.<br>▪ Meanwhile, in the **long term**, **centralized large-scale hydrogen production facilities** based on hydrogen production **through coal gasification and through biomass gasification** will provide economic benefits and will be needed to meet hydrogen needs and, in the future, will have a positive effect on the national economy |
| Additional Info | ▪ Seeing the huge potential and opportunities for fuel cells in the future in Indonesia, **the Agency for the Assessment and Application of Technology (BPPT) initiated the establishment of the Indonesia Fuel Cell and Hydrogen Energy Association (INAFHE)** as a forum for all elements engaged in the development of fuel cells in Indonesia. |

 *Source: Ministry of Energy & Mineral Resources (MEMR), Indonesia Fuel Cell and Hydrogen Energy Association (INAFHE) , Several News Articles*

# Hydrogen projects is initially start in Sumatera & Java Island, however, it will expand throughout Indonesia

## Hydrogen Project Map in Indonesia


Projects without dedicated areas:

2 3 5

6 7 9

| # | Name of project | Supply chain | | | Status | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Production | Carry/transport | Use | Agreement | R&D | FS | Demo | Commercial |
| 1 | Green hydrogen production in Ulubelu Geothermal Power Plant | ● | ● | ● | | | | | |
| 2 | Feasibility Study on Business Green Hydrogen, Ammonia and CCUS | ● | ● | ● | | | | | |
| 3 | De-dieselization to renewables-based fuel power generation | ● | ● | ● | | | | | |
| 4 | Co-Firing Study for Hydrogen, Biomass and Ammonia in Power Plants | ● | | | | | | | |
| 5 | Joint study agreement (JSA) on The Development of Green Hydrogen & Ammonia | ● | | | | | | | |
| 6 | Study on Integrated Wind Energy and Green Hydrogen Facility | ● | | | | | | | |
| 7 | MoU for Development of Green Hydrogen & Ammonia Production Study | ● | | | | | | | |
| 8 | Memorandum of understanding (MoU) for feasibility study on green hydrogen pipelines | | ● | | | | | | |
| 9 | Hydrogen Refueling Station Research Study | | ● | | | | | | |

# Pertamina & its subsidiary is conducting a green hydrogen production demonstration using geothermal electricity in Ulubelu city

## Green Hydrogen Production Trial Project

1

| | |
|---|---|
| Name of project | Green hydrogen production in Ulubelu Geothermal Power Plant |
| Period | Trials starts in early Jan until Dec 2023 |
| Place | Ulubelu City, Lampung Province (Southern Sumatera) |
| Partners | ■ Pertamina (*Investor & Developer*)<br>■ Pertamina Geothermal Energy (PGE) (*Investor & Developer*) |
| Purpose | ■ Pertamina plans to **produce up to 100 kg/day of green hydrogen** to supply its **polypropylene factory in Plaju** and supply the needs of the **local petrochemical industry**<br>■ The **initial trial start will be in 2023**, which plans to be scaled up if the trial successful |
| Budget | ■ According to PGE, **initial investments is around US$ 5 million**<br>➢ However, the estimated investment costs **only cover the upstream side** & not included transportation & storage |
| Future plan | ■ If the trials is successful, **Pertamina plans to scale it up** and being fully implemented as Indonesia's first green hydrogen production **by 2024/2025** |

Images

*Ulubelu Geothermal Power Plant*

*Ulubelu City, Lampung Provinces*

 *Source: Pertamina Geothermal Energy (PGE), Several News Article*

# Indonesia Starts Working on Green Hydrogen, Ammonia and CCUS

## Green Hydrogen & Ammonia Value Chain with CCUS Study

2

| | |
|---|---|
| Name of project | Feasibility Study on Business Blue/Green Hydrogen, Ammonia and CCUS |
| Period | 4th Mar 2022 (MoU sign) – no known end date |
| Place | Throughout Indonesia (no exact place/facilities) |
| Partners | ■ Pertamina (*Investor & Developer*)<br>■ PT Pupuk Indonesia (*Ammonia Producer*)<br>■ Mitsubishi Corporation (*Investor*) |
| Purpose | ■ Pertamina cooperates to develop blue/green hydrogen, blue/green ammonia, and Carbon Capture Utilization and Storage (CCUS), with the facilitation of Pupuk Indonesia's production and co-combustion of ammonia at the Coal Steam Power Plant<br>■ The green hydrogen produced from the RE plant will be used to produce green ammonia. Meanwhile, blue hydrogen will be used to produce green ammonia, which can be used for ammonia co-combustion in coal fired power plant. |
| Budget | ■ No known information found yet |
| Future plan | ■ Pertamina will develop necessary infrastructure & value chain for green hydrogen production and power generation |

Images


*Offical MoU Signing at 4th March 2022 between Pertamina, Pupuk Indonesia & Mitsubishi Corporation on Study Program*

 *Source: Pertamina (Persero), Several News Article*

# HDF Energy & PLN to develop first renewable-hydrogen hybrid power plant

## Joint Collaboration on De-dieselization Program

3

| | |
|---|---|
| Name of project | De-dieselization to renewables-based fuel power generation |
| Period | Mar 2022 (MoU sign) – no known end date |
| Place | ■ Diesel power plant facility throughout Indonesia (specifically remote areas) |
| Partners | ■ Perusahaan Listrik Negara (PLN) (*Power Generator & Infrastructure Developer*)<br>■ HDF Energy (*Power Generator Developer, specifically for renewables*) |
| Purpose | ■ PLN has launched a "de-dieselization" program by converting around 5,200 diesel power plants, which are currently still operating in remote areas all over the country, to new renewable energy-based plants (EBT)<br>■ HDF Energy, is engaged with PLN & Ministry of Energy, to developed renewables power plant project, including hydrogen, solar and wind under the independent power producer (IPP) scheme |
| Budget | ■ No known information found yet |
| Future plan | ■ No known information found yet |

Images


*PLN G20 Seminar Discussion on accelerating De-dieselization Program to increase renewable energy mix*

 *Source: Perusahaan Listrik Negara (PLN), HDF Energy Website, Several News Article*

# Mitsubishi Heavy Industries (MHI) and Indonesia Power to examine co-firing up to 100% with hydrogen & ammonia

## Joint Feasibility Research Program

4

| | |
|---|---|
| Name of project | Co-Firing Study for Hydrogen, Biomass and Ammonia in Power Plants Across Indonesia |
| Period | 2nd Nov 2022 (MoU sign) – no known end date |
| Place | Suralaya & Tanjung Priok city, West Java |
| Partners | ■ MHI, with assistance from Mitsubishi Power (*Investor & Developer*)<br>■ Perusahaan Listrik Negara (PLN) (*Power Generator & Infrastructure Developer*) |
| Purpose | ■ The first study will examine the technical and economic feasibility of co-firing up to 100% biomass at the Suralaya coal-fired power plant (CFPP).<br>■ The second study, which will also use Suralaya CFPP as the reference plant, will investigate co-firing of ammonia produced by existing ammonia plants in Indonesia.<br>■ The third study will evaluate technical and economic feasibility of hydrogen co-firing in an M701F gas turbine at the Tanjung Priok gas turbine combined cycle (GTCC) facility. |
| Budget | ■ No known information found yet |
| Future plan | ■ The result of study will be used as key references for future co-firing program in Indonesia, especially hydrogen & ammonia |

Images


*[Pictured from left to right] Osamu Ono (Chief Regional Officer, Asia Pacific & India/MHI), Rachmad Handoko (Director/Indonesia Power) and Darmawan Prasodjo (President Director/PLN) at signing ceremony*

 *Source: Perusahaan Listrik Negara (PLN), Several News Article*

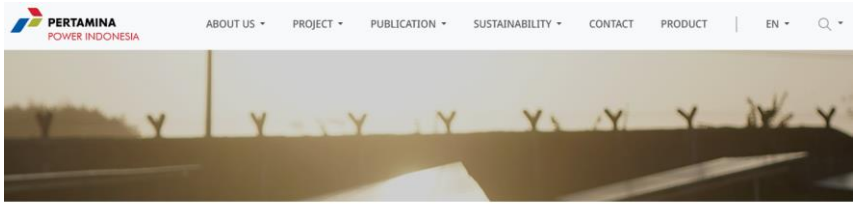
# Joint study agreement (JSA) on The Development of Green Hydrogen & Ammonia

## Pertamina – TEPCO HD Study on Green Hydrogen & Ammonia

5

| | |
|---|---|
| Name of project | Pertamina NRE - TEPCO HD Joint Study on The Development of Green Hydrogen and Green Ammonia |
| Period | 19th Oct 2022 (MoU sign) – no known end date |
| Place | ■ Throughout Indonesia (no exact places) |
| Partners | ■ Pertamina New & Renewable Energy (Pertamina NRE) with assistance from Pertamina Power Indonesia (PPI) (*Investor*)<br>■ Tokyo Electric Power Company Holdings (TEPCO HD) (*Investor*) |
| Purpose | ■ Pertamina NRE and TEPCO HD will combine Pertamina's geothermal power generation technology and TEPCO HD's hydrogen production technology to establish optimal operational technology and achieve <u>cost-competitive green hydrogen & green ammonia production and transportation through the Joint Study</u> |
| Budget | ■ No known information found yet |
| Future plan | ■ No known information found yet |

Images




*Pertamina Power Indonesia (Pertamina NRE) and Tokyo Electric Power Company Holdings, Incorporated (TEPCO HD) signed a joint study agreement (JSA) at the G20 State-owned Enterprises International Conference in Nusa Dua, Bali.*

 *Source: Pertamina New & Renewable Energy (Pertamina NRE) Website, TEPCO HD Company Articles*

# Joint study agreement (JSA) on the Integrated Offshore Wind Energy & Green Hydrogen Production Facility

## Study on Green Hydrogen & Wind Power Development

6

| | |
|---|---|
| Name of project | Pertamina NRE - Pondera Study on Integrated Wind Energy and Green Hydrogen Facility |
| Period | 2nd Sep 2022 (MoU sign) – no known end date |
| Place | ■ Throughout Indonesia (no exact places) |
| Partners | ■ Pertamina New & Renewable Energy (Pertamina NRE) (*Investor*)<br>■ Pondera Development BV (Pondera) (*Investor & Developer*) |
| Purpose | ■ The collaboration between Pertamina NRE and Pondera is to unleash wind energy potential that is not yet utilized enough<br>■ The study also aims to research about the green hydrogen production facility development in the wind power plant facility<br>■ Pondera has experience in developing on- and offshore wind projects in Europe and Asia. The Dutch-based company's experience includes conducting wind measurements, feasibility studies, wind modeling, wind farm engineering |
| Budget | ■ No known information found yet |
| Future plan | ■ No known information found yet |

Images


*Pertamina Power Indonesia (Pertamina NRE) and Pondera Development BV (Pondera) signed a joint study agreement (JSA) at the B20 International Summit on Tuesday (30/8) in Nusa Dua, Bali.*

 *Source: Pertamina New & Renewable Energy (Pertamina NRE) Website, Pondera Development BV (Pondera) Company Website*

# Joint Study Agreement (JSA) for the Development of Green Hydrogen & Ammonia Projects

## Green Hydrogen & Ammonia Development Projects

7

| | |
|---|---|
| Name of project | Memorandum of understanding (MoU) for Development of Green Hydrogen & Ammonia Production Study |
| Period | 11th Nov 2022 (MoU sign) – no known end date |
| Place | ■ Throughout Indonesia (no exact places) |
| Partners | ■ Pertamina Power Indonesia (Pertamina NRE) (*Investor*)<br>■ Keppel New Energy Pte. Ltd. (*Investor*)<br>■ Chevron New Energies International Pte. Ltd. (*Investor*) |
| Purpose | ■ The JSA intends to explore the feasibility of developing a green hydrogen facility, with a production capacity of at least 40,000 tonnes per annum, powered by 250-400 megawatts of geothermal energy in the initial phase.<br>■ The hydrogen production facility could have the potential to scale up to 80,000-160,000 tonnes per annum, depending on the availability of geothermal energy as well as market demands. |
| Budget | ■ No known information found yet |
| Future plan | ■ No known information found yet |

Images


*From left: Director of Chevron New Energies International, Pte. Ltd., Andrew S. Mingst; CEO of Pertamina NRE, Dannif Danusaputro; Director of Keppel New Energy Pte., Ltd., Chua Yong Hwee.*

 *Source: Various News Articles (Chevron to explore development of green hydrogen — Chevron)*

# Pertamina NRE, Krakatau Steel, and RAJA Collaborate to Develop Green Hydrogen Pipelines

## Joint Study Agreement on Green Hydrogen Pipeline

8

| | |
|---|---|
| Name of project | Memorandum of understanding (MoU) for feasibility study on green hydrogen pipelines |
| Period | 11th Nov 2022 (MoU sign) – no known end date |
| Place | ■ Ulubelu City, Lampung Province<br>■ Throughout Indonesia (no exact facilities) |
| Partners | ■ Pertamina New & Renewable Energy (Pertamina NRE) with assistance from Pertamina Geothermal Energy (PGE) (*Investor & Developer*)<br>■ Krakatau Steel (KS) (*Investor & Hydrogen End User*)<br>■ PT Rukun Raharja (RAJA) *(Investor & Developer for Gas Production*) |
| Purpose | ■ Develop pipeline for green hydrogen distribution from production to user<br>■ For the first stage of study mainly will focuses on distribution pipeline from Ulubelu Geothermal Power Plant (in which the first green hydrogen production is expected to be operated from) |
| Budget | ■ No known information found yet |
| Future plan | ■ Will continue to develop pipeline for other green hydrogen production facilities & connects them to user |

Images


*Pertamina NRE, Krakatau Steel, and PT Rukun Raharja signed a memorandum of understanding for the development of a green hydrogen pipeline, in the series of B20 Summit activities in Nusa Dua Bali*

 *Source: Pertamina New & Renewable Energy (Pertamina NRE, Pertamina Geothermal Energy (PGE), Several News Article*

# Hydrogen Refueling Station (HRS) Initial Study

## Hydrogen Refueling Station (HRS) R&D

9

| | |
|---|---|
| Name of project | Hydrogen Refueling Station Research Study |
| Period | No known information found yet |
| Place | ■ Throughout Indonesia (no exact places) |
| Partners | ■ Iwatani Industrial Gas Indonesia (*Developer*)<br>■ National Research and Innovation Agency (BRIN) (*Regulator*)<br>■ Agency for the Assessment and Application of Technology (BPPT) (*Regulator*) |
| Purpose | ■ During an interview with Pertamina, there has been research discussion between the National Research and Innovation Agency (BRIN), Agency for the Assessment and Application of Technology (BPPT) with Japanese Fueling Station Developer, IWATANI on hydrogen refueling station<br>■ IWATANI has previously experienced in hydrogen station development in Japan. The company took the initiative in building hydrogen infrastructure together with the development of Japan's first "Mobile Hydrogen Station" |
| Budget | ■ No known information found yet |
| Future plan | ■ No known information found yet |

Images


*IWATANI's hydrogen refueling station in Yokohama, Japan*

 *Source: Iwatani Industrial Gas Indonesia , NEDO-Deloitte Interview Session*

# Appendix –
# Presentation deck for Hydrogen Thailand

# Over 300 Participants, from Both Thai and Japanese Companies Attended Hydrogen Thailand Event

## Hydrogen Thailand Event

| | |
|---|---|
| Name of Event | Hydrogen Thailand Event |
| Period | 23 February 2023 |
| Venue | Holiday Inn Pattaya |
| Participants | 300 – 400 People |
| Presenters | ■ JERA Power Co., Ltd.<br>■ New Energy and Industrial Technology Development Organization (NEDO)<br>■ Deloitte Touche Tohmatsu Ltd.<br>■ Energy Generating Authority of Thailand (EGAT)<br>■ Japan Hydrogen Association (JH2A)<br>■ Chiyoda Corporation<br>■ Mitsui & Co., Ltd.<br>■ Arthur D. Little |
| Purpose | ■ For companies and individuals to share and discuss their knowledge, process, and initiatives for hydrogen production, storage and usage in Thailand |

Images


Monitor Deloitte.

NEDO

# Hydrogen Thailand

## Hydrogen market overview in Thailand

デロイト トーマツ コンサルティング合同会社

23 February 2023

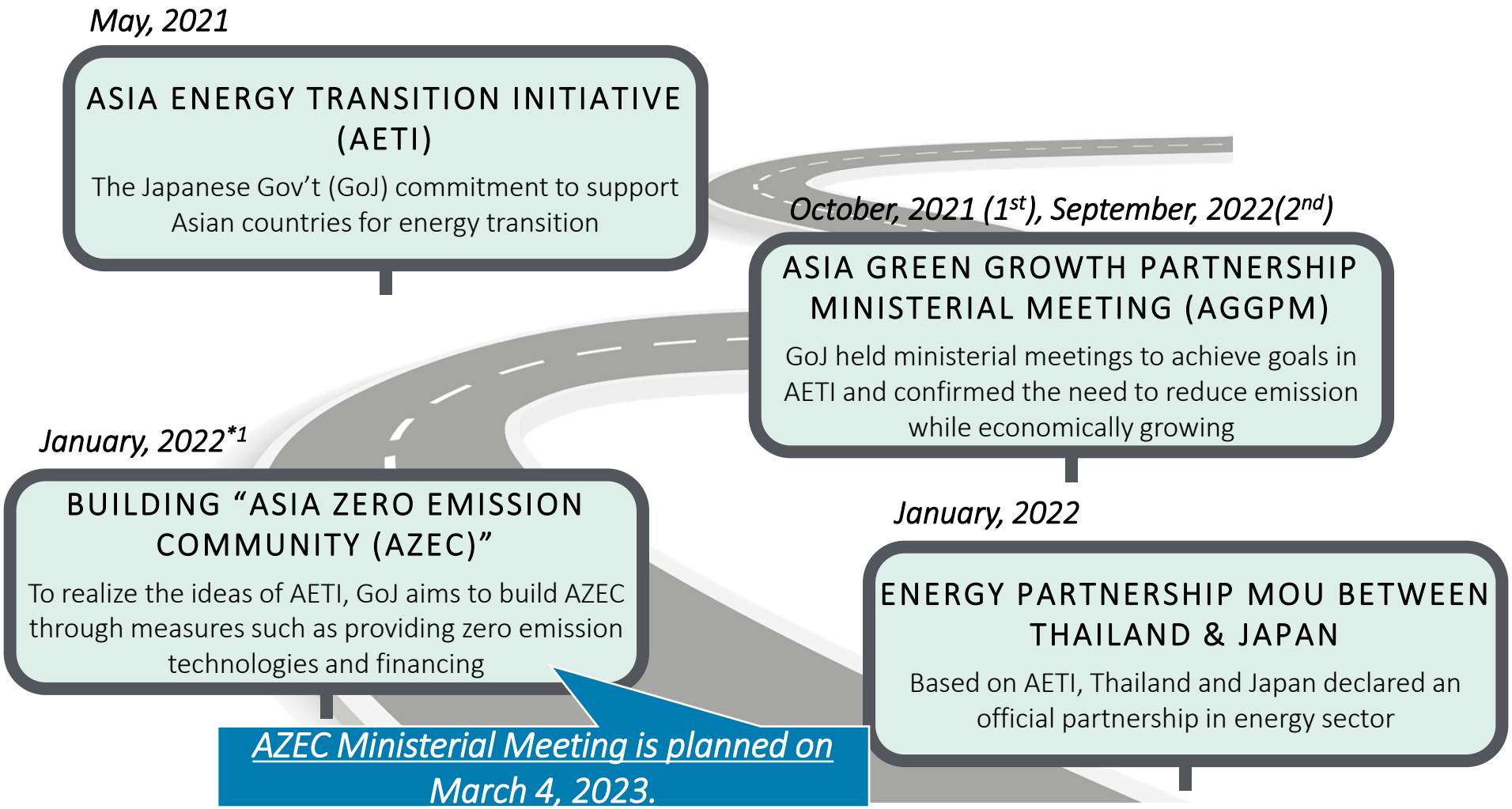
MAKING AN IMPACT THAT MATTERS since 1845

# Table of Contents

# Japan-Asia Energy Partnership and NEDO's Project

# The Japanese Government has been collaborating with other Asian countries as in AETI, AGGPM and AZEC in energy sector, and individually with Thailand

Japan's energy-related collaboration with Asian countries including Thailand




*1: Japan's PM Kishida declared his ambition to build the community at World Economic Forum

# METI supports energy transition of Asian countries in AETI, “Asia Energy Transition Initiative”

Asia Energy Transition Initiative (AETI) by METI

## Asia Energy Transition Initiative (AETI)

- “**Asia Energy Transition Initiative (AETI)**” includes a variety of support for the realisation of various and pragmatic energy transitions in Asia.

1. **Support for formulating energy transition roadmaps**
2. **Presentation and promotion of the concept of Asia Transition Finance**
3. **US$10 billion financial support for various projects**
   - (e.g.) Renewable Energy, Energy Efficiency, LNG, CCUS etc.
4. **Technology development and deployment, utilizing the achievement of “Green Innovation Fund”**
   - (e.g.) Offshore wind, Fuel-ammonia, Hydrogen etc.
5. **Human resource development, knowledge sharing and rule-making on decarbonization technologies**
   - Capacity building of decarbonization technologies for 1,000 people in Asian countries
   - Hold workshops and seminars related to energy transition
   - Asia CCUS network

*Source: METI (2022) Asia Energy Transition Initiative （AETI）*

# 11 MoUs were signed for carbon neutrality at AGGPM 2022

## The 2nd AGGPM Ministerial Meeting

| | |
|---|---|
| Date | September 28, 2022 |
| Place | Tokyo / virtual |
| Attendees | 20 countries and 3 international organizations (Asian countries, Middle-eastern countries, North American countries, ASEAN*1, ERIA*2, IEA*3) |


**Key points**

- Government
  - Minister of Economy, Trade and Industry's declaration to achieve carbon neutrality while resolving challenges related to energy security, economic growth and climate change
  - AETI-related projects reported
- Private sector
  - Presentations of "Asia Transition Finance Guideline" final report, ten energy-transition technologies and projects related to Asia Transition Finance (ATF)
  - Presentations of nine projects led by Japanese companies
  - <u>11 MoUs were signed</u>

*Source: METI Website*

# To realize the ideas of AETI, GoJ aims to build AZEC through measures such as providing zero emission technologies and financing

Asia Zero Emission Community (AZEC)

## Asia Energy Transition Initiative (AETI)

## Asia Zero Emission Community (AZEC)

| | |
|---|---|
| Support for zero emission technologies | ■ Provide support to build energy transition roadmaps<br>■ Zero emission demonstration and roll-out projects, such as hydrogen, ammonia or CCUS |
| International investment & funding | ■ Build a transition finance rule<br>■ Build hydrogen and ammonia international corridors<br>■ Finance LNG, hydrogen, ammonia projects |
| Standardization of technologies | ■ Development of international standards for “green growth”<br>■ Environment-and-climate-related rule makings<br>■ Establishment of digital platforms to share CO2 emission data |
| Carbon transaction market | ■ Scale-up JCM by incorporating CCUS<br>■ Initiate a carbon transaction market by taking advantage of private funding |

*Source: METI (2022)「カーボンニュートラル実現に向けた国際戦略」*

# Thailand and Japan agreed on collaboration in the energy sector in January 2022

## Energy partnership MoU between Thailand and Japan

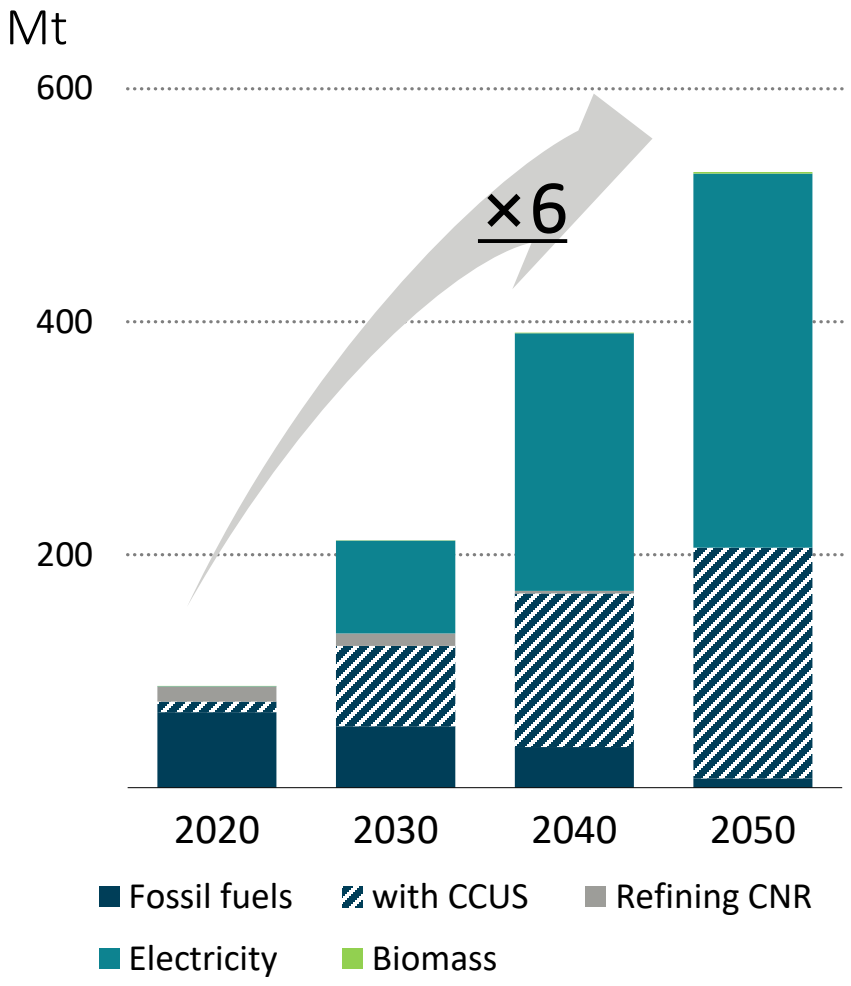
| | |
|---|---|
| Name of MoU | The Realization of Energy Partnership |
| Date | 13 January 2022 |
| Place | Bangkok, Thailand |
| Partners | Ministry of Economy, Trade, and Industry of Japan (METI) and Ministry of Energy of the Kingdom of Thailand |
| Areas of partnership | ■ Industries cooperated include oil and gas, electricity, renewable energy, energy efficiency, nuclear energy, innovation, technology, smart technology, decarbonization technologies*1 (e.g., hydrogen and CCUS), and other areas of energy cooperation to be determined by the participants<br>■ Cooperation activities include bilateral consultation, exchange of energy information and statistical data, skill development activities, promotion of joint energy investment, operating and disseminating joint projects, formulation of CN roadmap*2, and any other forms determined by the participants |
| Progress | ■ The policy dialogue was held in January 2023 where representatives from both country share about energy policy implementation, specifically focusing on achieving carbon neutrality in 2050, and discuss about technologies necessary to achieve the goal e.g., CCUS, hydrogen and ammonia |
| Future plan | ■ Industries cooperated and cooperation activities to be later added |

Images

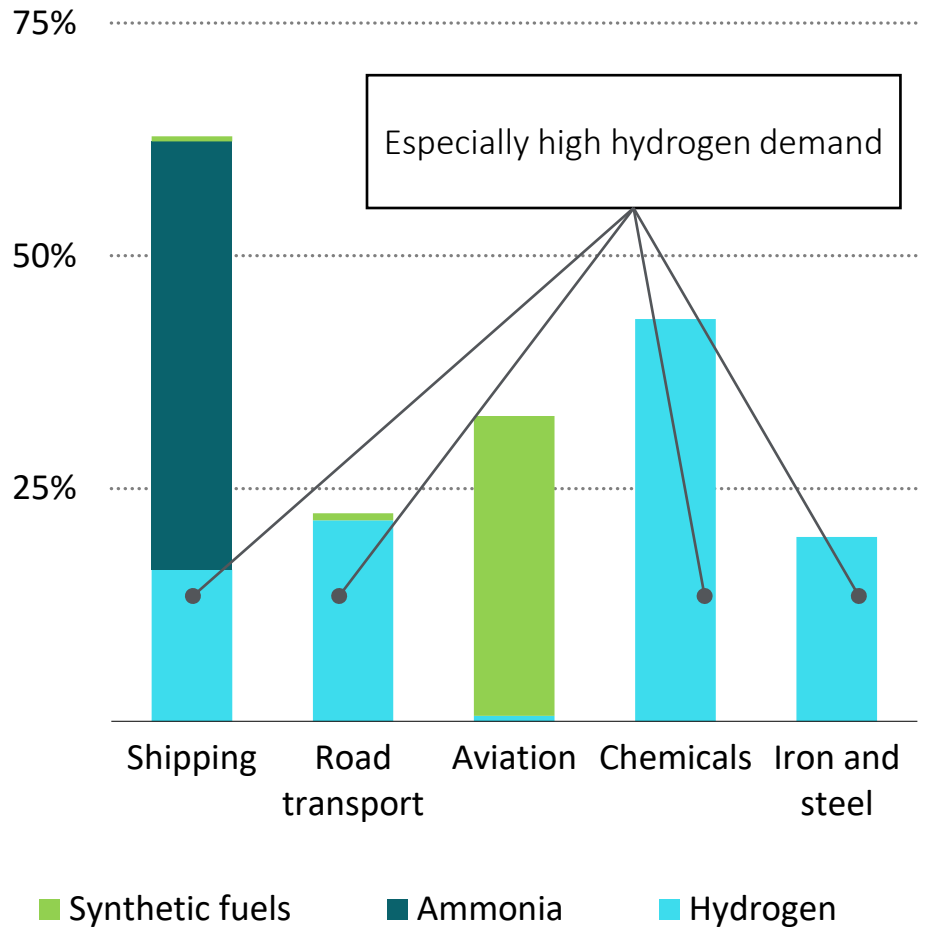
**1: Prioritized industry *2: Prioritized activities, Source: METI Website*

# Hydrogen production jumps sixfold by 2050, driven by water electrolysis and natural gas with CCUS, to meet rising demand in shipping, road transport and heavy industry

## Hydrogen production




## Share of hydrogen production by sector in 2050




 *Source: Net Zero by 2050 A Roadmap for the Global Energy Sector (IEA, 2021)*

# NEDO studies hydrogen initiatives of public and private sectors and possible high-level scenarios and business models in Thailand

## Project Background

- Carbon neutrality by 2050 has become a mainstream policy target in climate change among nations following the Kyoto Protocol and Glasgow Declaration. In this context, hydrogen and ammonia are expected as alternative carbon-neutral fuels to phase-out from fossil fuels.
- ASEAN countries have also declared carbon neutrality goals. Then it is assumed that introducing renewable energy and establishing a supply chain of hydrogen and ammonia will be accelerated.
- Furthermore, in January 2022, GoJ*1 signed MoU with Thailand government on an energy partnership, in which hydrogen is mentioned as a key item. Through the partnership, Japan's contribution to hydrogen development is increasing.
- Japan, however, have not yet fully grasped hydrogen policy and market in Southeast Asia, including Thailand.

## Project Goal

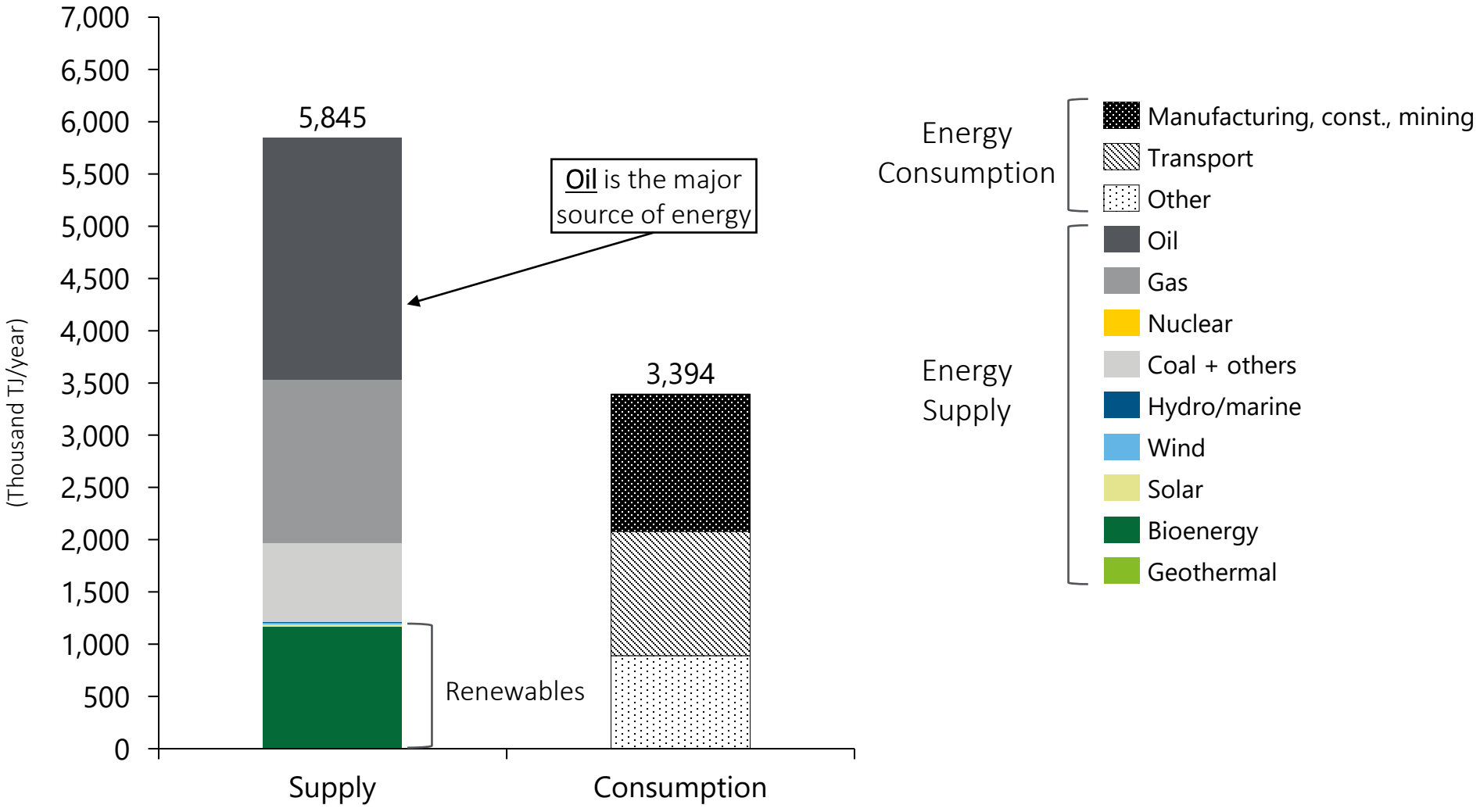
- This project aims to research the following through desktop research and interviews:
  - State of the art of hydrogen policy and market in Thailand
  - Future outlook of hydrogen in Thailand
  - Hydrogen technical readiness toward 2050s-60s
- Based on the information above, the project will create high-level hydrogen business models in the 2030s-40s

*1: The Government of Japan

# Energy Trend in Thailand

# Oil and gas are the major source of energy in Thailand. Most of the renewables currently originate from bioenergy

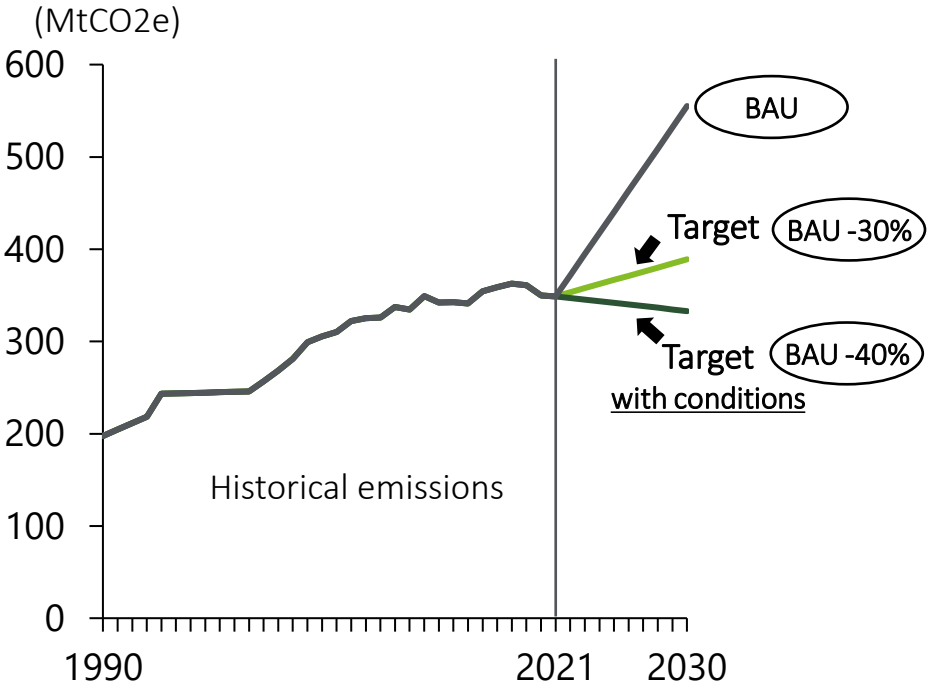
Energy supply and consumption of Thailand in 2019




 *Source: Energy Profile (IEA), The 2020 Energy Balances (United Nations, 2020)*

# Thailand aims to reduce 30 percent of GHG emissions from the BAU level by 2030

## Thailand's emission reduction target and countermeasures




- The level of contribution could be up to 40 percent, subject to adequate and enhanced access to technology development, financial resources, and capacity building support
- Thailand aims to achieve carbon neutrality by 2050 and net-zero GHG emission by 2065*1

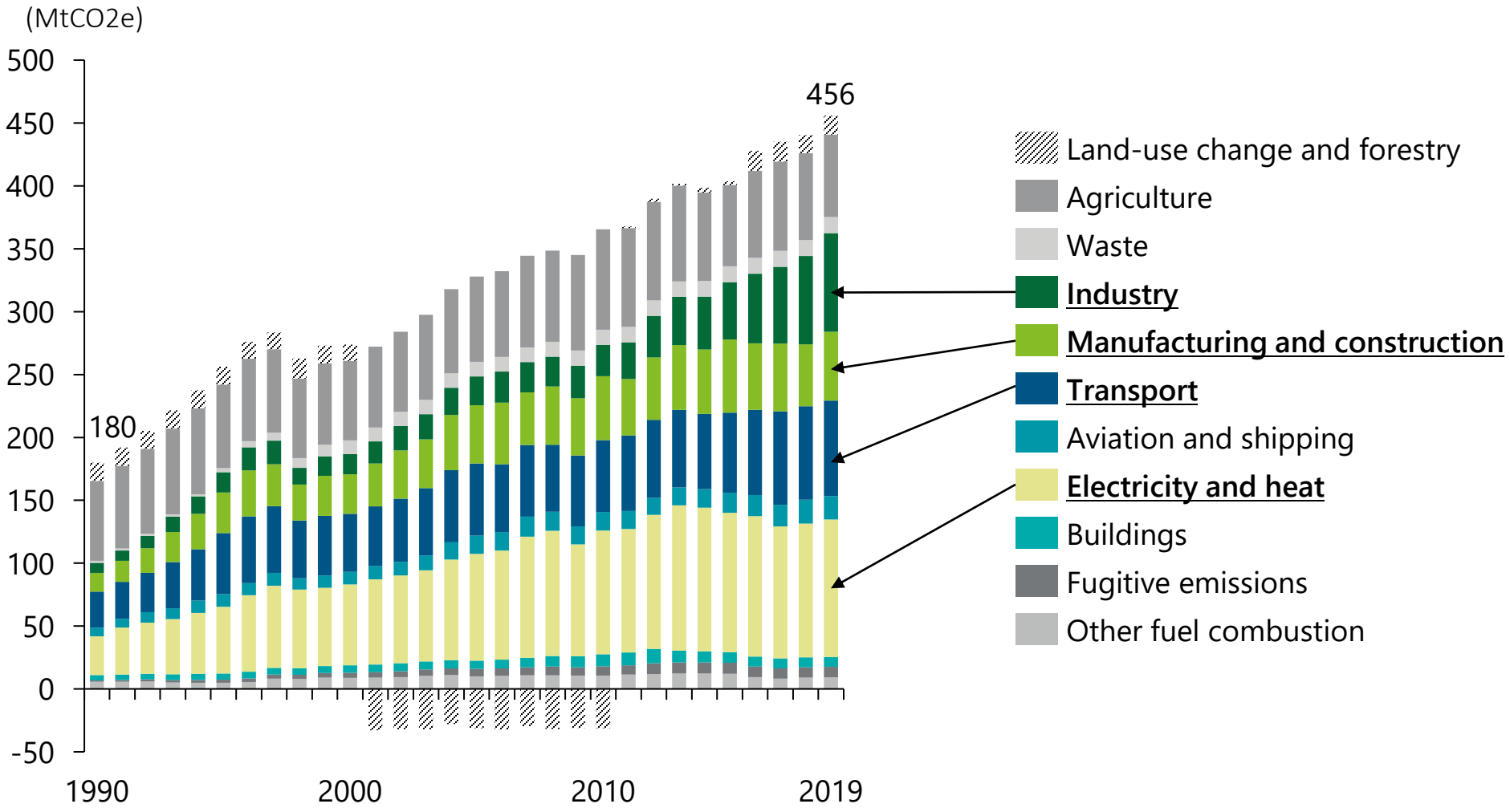
| | |
|---|---|
| Challenge and limitation | ■ High investment and operating costs of technologies and infrastructures<br>■ Limitation of grid connection<br>■ Lack of domestic technological and technical resources<br>■ Negative public perception towards waste-to-energy and biomass power plants |
| Adaptation Component | ■ Thailand has developed the National Adaptation Plan (NAP) which includes 6 priority sectors:<br>➢ Water resources management, agriculture and food security, tourism sector, public health, natural resources management, and human settlements and security |
| Support needs | 1. Policy implementation<br>2. Technology development and transfer e.g., R&D of CCS, CCUS, Bio-energy with CCS, DAC, and hydrogen<br>3. Mechanisms and instruments<br>4. Climate information and M&E systems |

*Source: Thailand's 2nd Updated Nationally Determined Contribution, Climate Action Tracker*

**1: Carbon neutral means the amount carbon emission equals to the amount absorbed. Net-zero means carbon emission is zero when the amount of emission and the amount of absorption are combined.*

# Emissions from electricity and heat, transport and industry have been increasing in Thailand

GHG emission by sector of Thailand

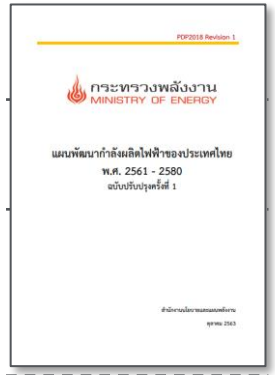



 *Source: Our World in Data*

# Thailand's Government shows the long-term electricity generation plan in PDP (PDP2028 Rev.1)

## Thailand's Power Development Plan (PDP)

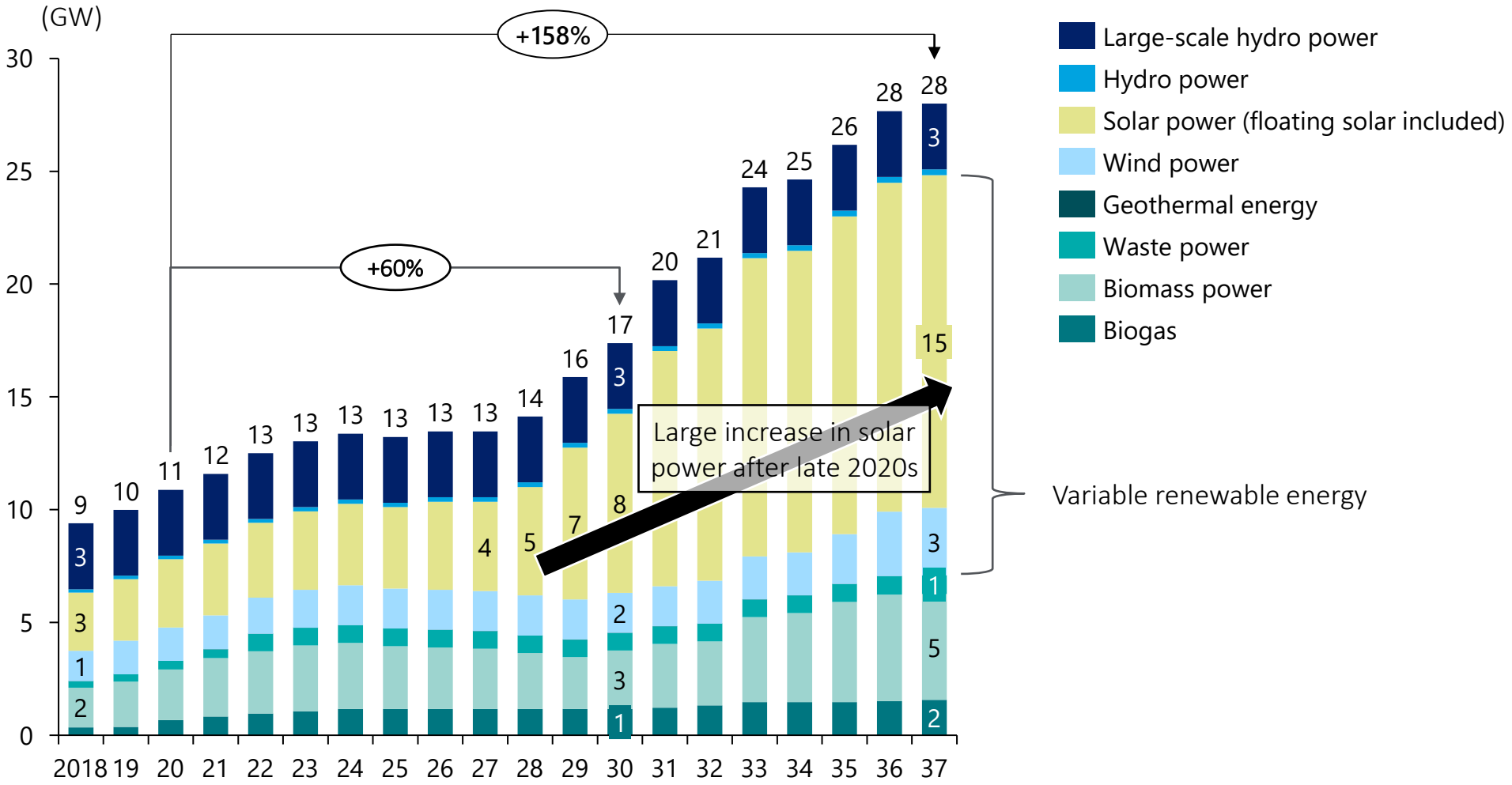
| | | | |
|---|---|---|---|
| Document Name | Thailand's Power Development Plan 2018-2037 Revision1 (PDP2018 Rev.1) | | |
| Year of publishment | 2018 | Issued by | Ministry of Energy |
| Background | ■ Ministry of Energy had been publishing PDPs, and PDP2018 needed adjustment because of the publishment of new Alternative Energy Development Plan (AEDP) | | |
| Purpose | ■ To show the long-term electricity generation blueprint of Thailand's energy transition<br>➢ includes the development of new power plants in the country<br>➢ the development of power transmission systems<br>➢ the purchase of electricity from neighboring countries | | |
| Summary | ■ The plan prioritizes three different areas, which includes energy security, economy, and ecology, for the next decades<br>■ It mentions energy sources such as hydro power, biomass power, solar power, waste power, natural gas, and coal, and 25.7 percent of the total energy is expected to be generated from renewable sources<br>■ Apart from electricity generating plan, It also includes energy efficiency measures | | |




*Source: Ministry of Energy (2020) "The Direction of Electricity Policy in Thailand", Ministry of Energy (2018) "Thailand's Power Development Plan 2018-2037 Revision1"*

# Renewable energy capacity is projected to grow, with especially large solar energy capacity increase after later 2020s

Renewable energy capacity prospect in Thailand

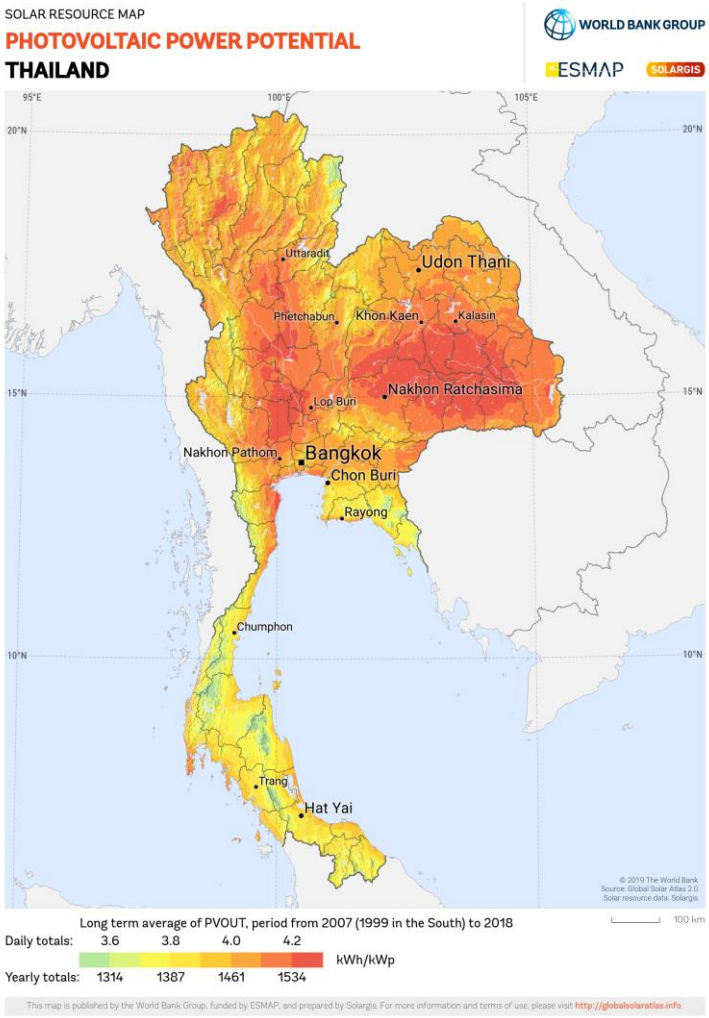



 *Source: Ministry of Energy (2018) "Thailand's Power Development Plan 2018-2037 Revision1"*

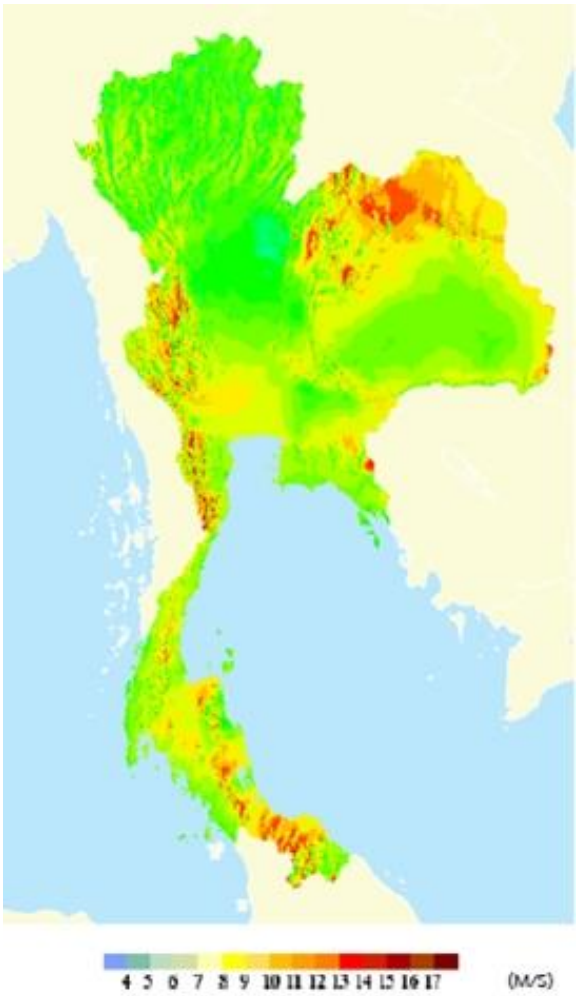
*Reference*

# While solar power potential is abundant around the center, wind potential exists on the margins in Thailand

## Thailand Solar Potential Map




## Thailand Wind Potential Map




*Source: Department of Alternative Energy Development and Efficiency "Wind power and its potential in Thailand", Solargis "Solar resource maps of Thailand"*

# Hydrogen Policy in Thailand

# Thai Government has already started hydrogen projects and support schemes. In addition, they seem to be in the process of developing a hydrogen strategy

## Policy overview - Thailand

**Expected role of hydrogen**

- The government recognizes hydrogen could be a key mitigation for emission reduction in energy, industry and transportation sectors (LT-LEDS*1, AEDP*2)

**Hydrogen strategy and planning**

- The national government is yet to have a hydrogen strategy as the hydrogen industry is in the early development phase
  - However, Ministry of Energy seems to be working on building hydrogen strategy in energy sector by selecting Chulalongkorn University and Chiang Mai University as project partners*3
- The government states that green hydrogen fuel will likely be used in Thailand in 2045, while there is no clear goal for hydrogen (LT-LEDS)

**Quantitative target**

(Not established yet)

**Projects and support**

- EGAT (Electricity Generating Authority of Thailand, state-owned enterprise)
  - Conducting projects of water electrolysis, ammonia, SOEC/SOFC
  - Signed MOUs with private companies in Thailand to conduct research and share knowledge about hydrogen
- Board of Investment (BOI) has announced incentives related to hydrogen in November 2022

*Source: Thailand's Long-term Low Greenhouse Gas Emission Development Strategy, Alternative Energy Development Plan*

**1: Long-term Low Greenhouse Gas Emission Development Strategy *2: Alternative Energy Development Plan *3: According to announcement on January 19, 2023*

# Thailand's LT-LEDS states that green hydrogen will be important in energy, industry and transport sectors

## Hydrogen in Thailand's LT-LEDS


### Long-Term mitigation actions related to **hydrogen in energy sector**

- Research and development of hydrogen can be one of the key mitigation actions
- technologies related to hydrogen and green hydrogen are considered to achieve GHG emissions by 2065
  - From the net zero GHG timeline presented in the LT-LEDS, **green hydrogen fuel will likely be used in Thailand in 2045**

### Long-Term mitigation actions related to **hydrogen in transport sector**

- **Green hydrogen** will be important in sectors like **iron, steel, aluminum and cement**

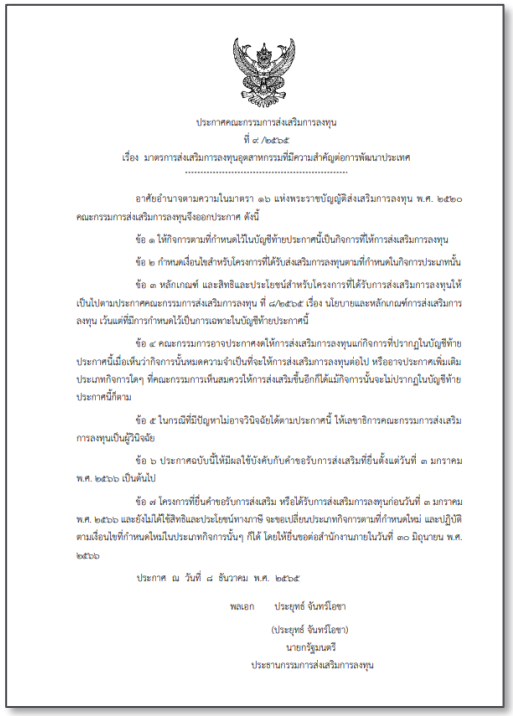
### Long-Term mitigation actions related to **hydrogen in transport sector**

- Decarbonization opportunities in the transport sector include hybrid, plug-in hybrid, electric and **FCEV**
- Cost of hydrogen-powered FCEV is expected to be **lower in the near future**, similar to costs of EVs

 *Source: Thailand's Long-term low Greenhouse gas emission development strategy*

# Board of Investment has announced new tax incentives for hydrogen-related investment and research

## Announcement of BOI No. 8/2565



ประกาศคณะกรรมการส่งเสริมการลงทุน
ที่ ๘ /๒๕๖๕
เรื่อง มาตรการส่งเสริมการลงทุนอุตสาหกรรมที่มีความสำคัญต่อการพัฒนาประเทศ

อาศัยอำนาจตามความในมาตรา ๑๖ แห่งพระราชบัญญัติส่งเสริมการลงทุน พ.ศ. ๒๕๖๐ คณะกรรมการส่งเสริมการลงทุนจึงออกประกาศ ดังนี้

ข้อ ๑ ให้กิจการตามที่กำหนดไว้ในบัญชีท้ายประกาศนี้เป็นกิจการที่ให้การส่งเสริมการลงทุน

ข้อ ๒ กำหนดเงื่อนไขสำหรับโครงการที่ได้รับส่งเสริมการลงทุนตามที่กำหนดในกิจการประเภทนั้น

ข้อ ๓ หลักเกณฑ์ และสิทธิและประโยชน์สำหรับโครงการที่ได้รับการส่งเสริมการลงทุนให้เป็นไปตามประกาศคณะกรรมการส่งเสริมการลงทุน ที่ ๘/๒๕๖๕ เรื่อง นโยบายและหลักเกณฑ์การส่งเสริมการลงทุน เว้นแต่ที่มีการกำหนดไว้เป็นการเฉพาะในบัญชีท้ายประกาศนี้

ข้อ ๔ คณะกรรมการอาจประกาศงดให้การส่งเสริมการลงทุนแก่กิจการที่ปรากฏในบัญชีท้ายประกาศนี้เมื่อเห็นว่ากิจการนั้นหมดความจำเป็นที่จะให้การส่งเสริมการลงทุนต่อไป หรืออาจประกาศเพิ่มเติมประเภทกิจการใดๆ ที่คณะกรรมการเห็นสมควรให้การส่งเสริมขึ้นอีกก็ได้แม้กิจการนั้นจะไม่ปรากฏในบัญชีท้ายประกาศนี้ก็ตาม

ข้อ ๕ ในกรณีที่มีปัญหาไม่อาจวินิจฉัยได้ตามประกาศนี้ ให้เลขาธิการคณะกรรมการส่งเสริมการลงทุนเป็นผู้วินิจฉัย

ข้อ ๖ ประกาศฉบับนี้ให้มีผลใช้บังคับกับคำขอรับการส่งเสริมที่ยื่นตั้งแต่วันที่ ๓ มกราคม พ.ศ. ๒๕๖๖ เป็นต้นไป

ข้อ ๗ โครงการที่ยื่นคำขอรับการส่งเสริม หรือได้รับการส่งเสริมการลงทุนก่อนวันที่ ๓ มกราคม พ.ศ. ๒๕๖๖ และยังไม่ได้ใช้สิทธิและประโยชน์ทางภาษี จะขอเปลี่ยนประเภทกิจการตามที่กำหนดใหม่ และปฏิบัติตามเงื่อนไขที่กำหนดใหม่ในประเภทกิจการนั้นๆ ก็ได้ โดยให้ยื่นขอต่อสำนักงานภายในวันที่ ๓๐ มิถุนายน พ.ศ. ๒๕๖๖

ประกาศ ณ วันที่ ๘ ธันวาคม พ.ศ. ๒๕๖๕

พลเอก ประยุทธ์ จันทร์โอชา

(ประยุทธ์ จันทร์โอชา)
นายกรัฐมนตรี
ประธานกรรมการส่งเสริมการลงทุน

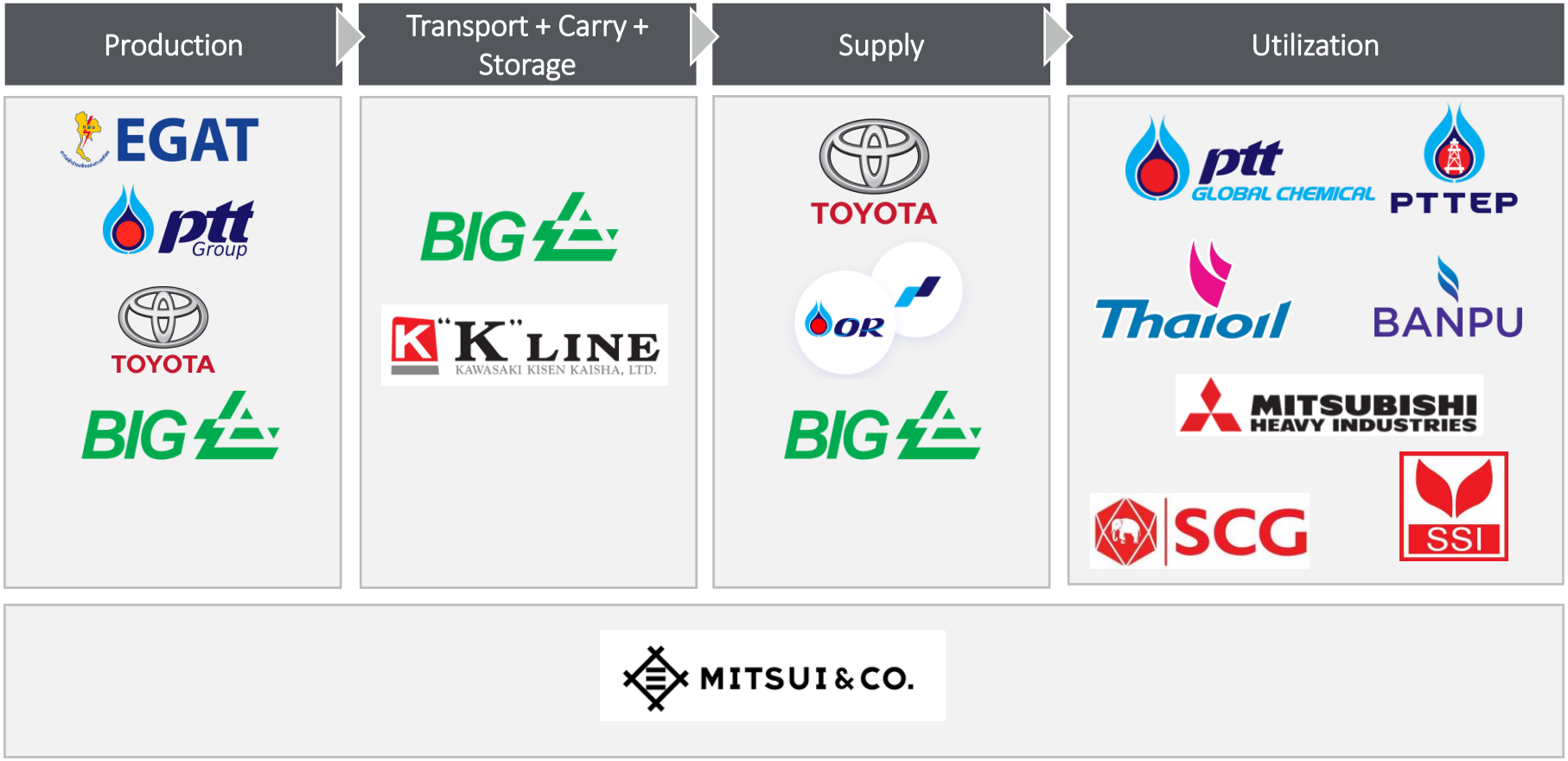
- The Board of Investment (BOI) published the “Announcement of BOI No. 8/2565: Promotion of investment in industries that are important to national development” in November 2022
  - BOI is a government body that helps in promoting direct investment in Thailand by devising investment policies
- BOI announced new incentives for **hydrogen-related investment and research**
  - Apart from investment in EVs (including FCEVs), following activities are eligible for **tax exemption up to 10 – 13 years** starting in January 2023:
    - ✓ **Hydrogen and its derivatives from water using renewable energy**
    - ✓ **Electricity generated from hydrogen**

# Hydrogen Market and Projects in Thailand

# Members of Hydrogen Thailand could build hydrogen supply chains in Thailand in corporation with each other

## Potential hydrogen player map in Thailand*1

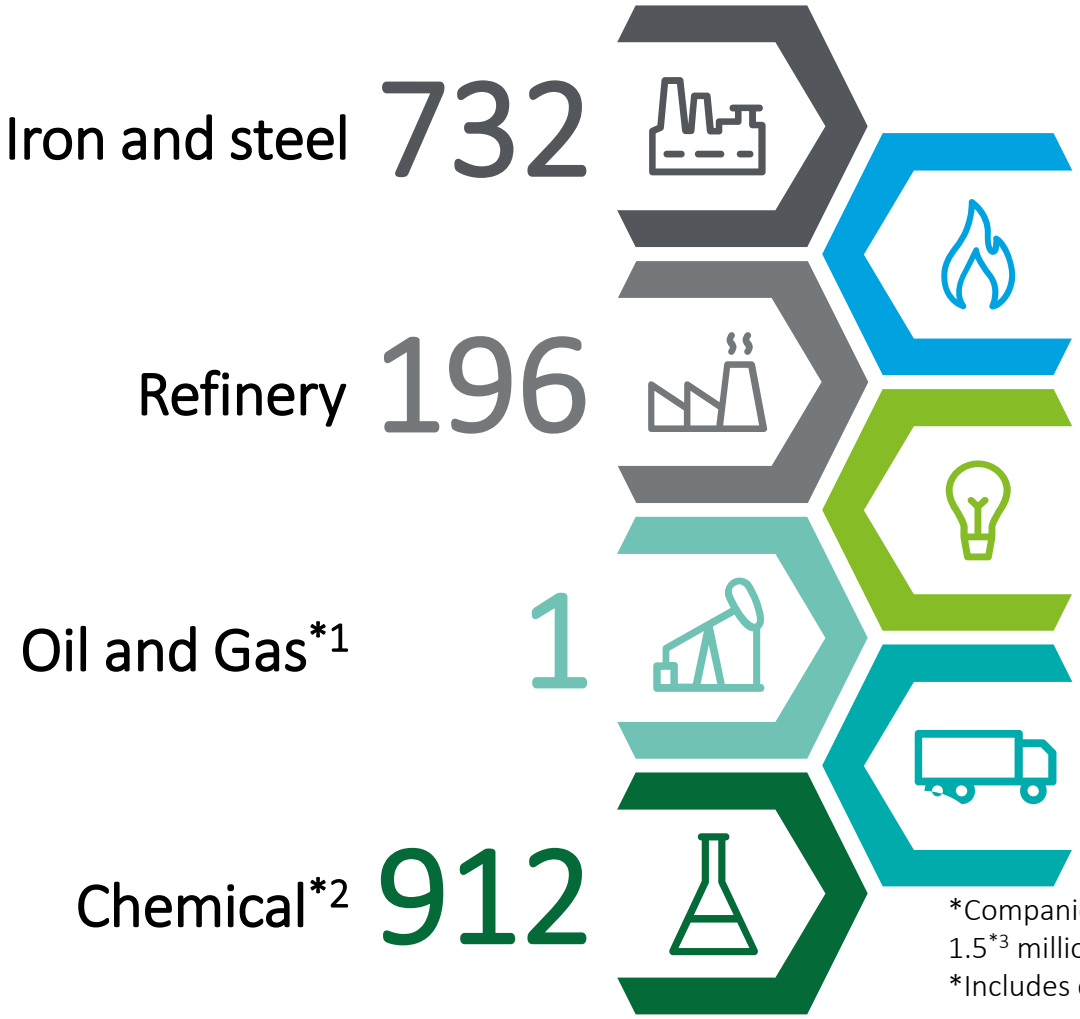
*Based on current products/services and hydrogen/fuel cell projects of the members of Hydrogen Thailand …*




*1: Note that hydrogen players do not just include players that have core technologies but also those who are engaged with related projects

# There is large potential in Thailand hydrogen market; 5,771 medium-to-large enterprises

The potential number of companies in Thailand




Potential stake holder **5,771**

- **991** Gas Utility
- **139** Power Utility
- **2,800** Road Transport & Logistics*3

*Companies with 50 employees and above, and with annual revenue of 1.5*3 million USD and above.
*Includes companies that have headquarters outside of Thailand

*Source: D&B Hoovers *1: PTT is the one and only oil and gas company in Thailand *2: includes fertilizer companies and industrial gas companies *2: road transport except for rail and logistics companies (freight transport and courier) *3: Minimum annual revenue for medium sized companies in Thailand*

# Thailand's companies such as EGAT and PTT are leading hydrogen projects in collaboration with international companies

Hydrogen project players in Thailand

: Demonstration/operation
: Agreement/study

| Project Name & Description | Supply Chain Coverage & Players |
|---|---|
| | Production ▷ Transport,Carry, Storage ▷ Supply ▷ Utilization |
| 1 **Lam Ta Khong Wind Turbines**<br>■ Produce hydrogen from wind power and use it for **stationary fuel cells** | EGAT, 中国水电顾问 HYDROCHINA, HYDROGENICS SHIFT POWER \| ENERGIZE YOUR WORLD, PHRARAM 2 CIVIL ENGINEERING Co.,Ltd |
| 2 **Hydrogen Refueling Station**<br>■ Operate the first **HRS** prototype in Thailand | ptt Group, TOYOTA, BIG, OR, TOYOTA |
| 3 **Hydrogen Fuel Project**<br>■ Study on production of hydrogen from farm waste and usage for **hydrogen-powered vehicles** | C.P.GROUP, TOYOTA |
| 4 **TH-JP: Carbon Neutral Smart Park Project**<br>■ Study on construction of carbon-neutral industrial park in Rayong using hydrogen | TOYOTA, 豊田通商 TOYOTA TSUSHO, OSAKA GAS, THE KANSAI ELECTRIC POWER CO.,INC., The Industrial Estate Authority of Thailand, ptt Group, ptt GLOBAL CHEMICAL, BIG |

# Thailand's companies such as EGAT and PTT are leading hydrogen projects in collaboration with international companies

## Hydrogen project players in Thailand

: Demonstration/operation
: Agreement/study

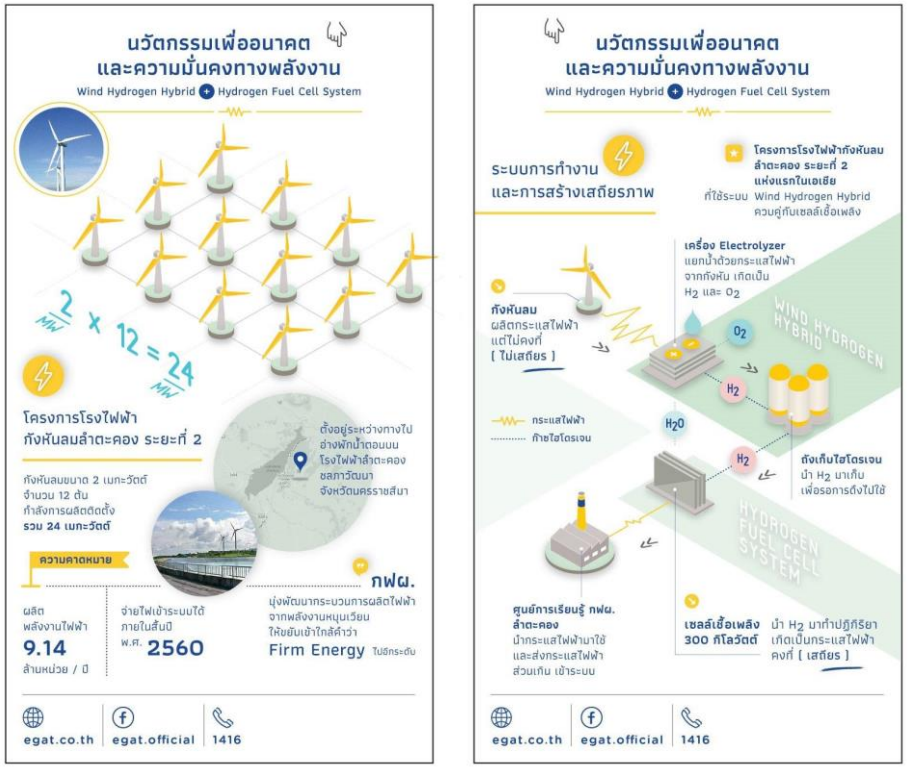
| Project Name & Description | Supply Chain Coverage & Players |
|---|---|
| | Production \| Transport,Carry, Storage \| Supply \| Utilization |
| 5 **Clean Energy Development**<br>■ Develop and share knowledge on clean energy technologies such as CCUS, hydrogen, and ammonia fuels | EGAT, MITSUBISHI HEAVY INDUSTRIES |
| 6 **Investment Opportunity in Carbon Neutral Roadmap on Hydrogen, Ammonia, and CCUS**<br>■ Study on CCUS and its implication in Thailand for decarbonization of EGCO | EGCO GROUP, Jera |
| 7 **Feasibility Study of Ammonia Co-firing Power Generation**<br>■ Study on technical, economic and environmental aspects ammonia co-firing | EGCO GROUP, BANPU, BLCP POWER, Jera, MITSUBISHI HEAVY INDUSTRIES, Mitsubishi Corporation |
| 8 **Green Hydrogen and Derivatives Development project**<br>■ Establish large-scale green hydrogen and derivatives production facilities in Thailand | ACWA POWER, ptt Group, EGAT |
| 9 **Investment Opportunity in SOFC and SOEC Technology Exploration**<br>■ Develop power plants in Thailand using SOEC and SOFC technology | EGAT, EGCO GROUP, ATE, Bloomenergy |

# EGAT constructed 12 wind turbines with wind hydrogen hybrid system and fuel cell to stabilize electricity

1

| | |
|---|---|
| Name of project | Lam Ta Khong Wind Turbines |
| Period | September 2016 – 2017 (construction),<br>2017 – Present (commercial operation) |
| Place | Nakhon Ratchasima Province, Thailand |
| Partners | ■ Energy Generating Authority of Thailand (EGAT)<br>■ Hydrochina Corporation *(Energy Company)*<br>■ Hydrogenics Europe N.V. *(Hydrogen Technology Investor)*<br>■ Phraram 2 Civil Engineering Co., Ltd *(developer)* |
| Purpose | ■ It was constructed in response to governments policy on power stability by <u>diversifying fuel mix and promoting renewable energy</u><br>■ EGAT brought new technology, <u>Wind Hydrogen Hybrid System and Fuel Cell</u>, to conduct research and help stabilizing electricity generation from renewable energy |
| Budget | ■ 42M USD (1.407B THB) |
| Future plan | N/A |

Images




*Lam Ta Khong, Nakhon Ratchasima, Thailand*

 *Source: EGAT and Thailand Construction and Engineering News*

# PTT, OR, Toyota, and BIG collaborated on launching the first hydrogen fueling prototype station in Thailand

2

| | |
|---|---|
| Name of project | Hydrogen Refueling Station |
| Period | November 2022 - Present |
| Place | Chonburi, Thailand |
| Partners | ■ PTT Public Company Limited *(Oil and Gas Company)*<br>■ PTT Oil and Retail Public Company Limited (OR) *(Oil and Retail Company)*<br>■ Toyota Daihatsu Engineering and Manufacturing Co., Ltd (TDEM) *(Engineering and Manufacturing Company)*<br>■ Toyota Motor Thailand Company Limited (TMT) *(Vehicle Manufacturing Company)*<br>■ Bangkok Industrial Group (BIG) *(Hydrogen Producer)* |
| Purpose | ■ To align with Thailand's goal to achieve carbon neutrality and net zero emissions<br>■ Data from this project will be gathered to improve performance in the future |
| Budget | ■ 302,315 USD (10M THB) |
| Future plan | ■ Potentially more hydrogen fueling stations in the future |

Images


*Chonburi, Thailand*

 *Source: PTT website, and news articles*

# Toyota and C.P. Group are collaborating on Hydrogen Fuel Project

3

| | |
|---|---|
| Name of project | Hydrogen Fuel Project |
| Period | December 2022 – unknown |
| Place | Thailand |
| Partners | ■ True Leasing *(CP's transportation service business)*<br>■ Isuzu Motors *(Vehicle Manufacturer)*<br>■ Toyota subsidiary Hino Motors *(Vehicle Manufacturer)* |
| Purpose | ■ To study potential possibilities to improve efficiency in the logistics industry by turning farm waste into fuel for hydrogen-powered car To reduce carbon emissions in Thailand |
| Budget | N/A |
| Future plan | ■ Expanding to other countries |

Images


*CP Group Senior Chairman and Toyota Motor CEO*

 *Source: Nikkei Asia*

# Thai and Japanese companies conducted a feasibility study to construct a carbon-neutral industrial park in Rayong funded

4

| | |
|---|---|
| Name of project | TH-JP: Carbon Neutral Smart Park Project |
| Period | Spring 2021 – Feb 2022 |
| Place | Rayong province, Thailand |
| Partners | ■ Toyota Motor Thailand *(vehicle manufacturer)*<br>■ Toyota Tsusho *(trading company)*<br>■ Osaka Gas *(gas company)*<br>■ Kansai Electricity *(electricity company)*<br>■ IEAT *(industrial park operator)*<br>■ PTT *(gas company)*<br>■ PTTGC *(chemical company)*<br>■ Bangkok Industrial Gas *(industrial gas company) etc.* |
| Purpose | ■ To conduct a <u>feasibility study about "carbon-neutral industrial park"</u> (600 acre) near Map Ta Put in the east part of Rayong province<br>■ The project aims to <u>construct a whole hydrogen supply chain within the park</u> including renewable power development and fuel cell vehicle introduction |
| Budget | N/A (funded in FY 2021 by METI) |
| Future plan | ■ Plan to start the construction of the park in 2023 to be in operation in 2025<br>■ Become a model case for industrial parks in other Southeast Asian countries such as Indonesia or Vietnam |

Images


*Conceptual Image of Carbon-neutral Industrial Park*

 *Source: NNA ASIA*

# EGAT and MHI signed an MOU to study clean energy technologies

5

| | |
|---|---|
| Name of project | Clean Energy Development between Electricity Generating Authority of Thailand (EGAT) and Mitsubishi Heavy Industries (Thailand) Ltd. |
| Period | November 2022 – 2025 (3 years) |
| Place | N/A |
| Partners | ■ Energy Generating Authority of Thailand (EGAT)<br>■ Mitsubishi Heavy Industries *(Industrial Machinery Manufacturer)* |
| Purpose | ■ To develop and share knowledge on clean energy technologies such as CCUS, hydrogen, and ammonia fuels<br>■ To apply clean technologies with power plants in Thailand to reduce carbon emissions to achieve carbon neutrality by 2050 |
| Budget | N/A |
| Future plan | ■ This MOU aims to support the national goals of reducing 40 percent of GHG by 2030 and achieving carbon neutrality by 2050 and net-zero emissions by 2065 |

Images


*EGAT Headquarter, Bangkok, Thailand*

 *Source: EGAT*

# ECGO Group signed an MoU with JERA Asia to study the use of hydrogen, ammonia, and CCUS and achieve its carbon neutral goal

6

| | |
|---|---|
| Name of project | Carbon Neutral Roadmap on the Usage of Hydrogen, Ammonia, and CCUS |
| Period | January 2023 - unknown |
| Place | Bangkok, Thailand |
| Partners | ■ Electricity Generating Public Company Limited (EGCO) *(Power Producer)*<br>■ JERA Asia Pte. Ltd. *(Energy Services Provider)* |
| Purpose | ■ To study and research about CCUS and its implication in Thailand for decarbonization of EGCO |
| Budget | N/A |
| Future plan | ■ EGCO to achieve carbon neutral goal by 2050 |

Images


143 *Source: EGCO Website*

# ECGO Group signed an MoU with companies to conduct feasibility study on ammonia co-firing power generation

7

| | |
|---|---|
| Name of project | Feasibility Study of Ammonia Co-firing Power Generation |
| Period | January 2023 - unknown |
| Place | Bangkok, Thailand |
| Partners | ■ Electricity Generating Public Company Limited (EGCO) *(Power Producer)*<br>■ Banpu Power Public Company Limited (BPP) *(Electricity Generator)*<br>■ BLCP Power Company Limited *(Electricity Generator)*<br>■ JERA *(Energy Services Provider)*<br>■ Mitsubishi Corporation *(Trading Company)*<br>■ Mitsubishi Heavy Industries Ltd. *(Industrial Machinery Manufacturer)* |
| Purpose | ■ To collaboratively <u>study technical application, economic evaluation and carbon reduction plan for ammonia co-firing</u> up to 20 percent at the BLCP 1,434 MW coal-fired power plant |
| Budget | N/A |
| Future plan | ■ Not mentioned; however, results from the study can be beneficial in the implementation process |

Images


144 *Source: EGCO Website*

# ACWA Power, PTT, EGAT have signed an MoU to collaborate on establishing green hydrogen and derivative production facilities in Thailand

8

| | |
|---|---|
| Name of project | Green hydrogen and derivatives development project |
| Period | November 2022 - unknown |
| Place | Thailand |
| Partners | ■ ACWA Power *(Electricity Generator)*<br>■ PTT Public Company Limited *(Oil and Gas Company)*<br>■ Electricity Generating Authority of Thailand (EGAT) |
| Purpose | ■ To conduct an investment feasibility study to plan on establishing large-scale renewable-powered green hydrogen and derivatives production facilities in Thailand |
| Budget | ■ 7B USD |
| Future plan | ■ Target production is 225,000 tons of hydrogen per year |

Images

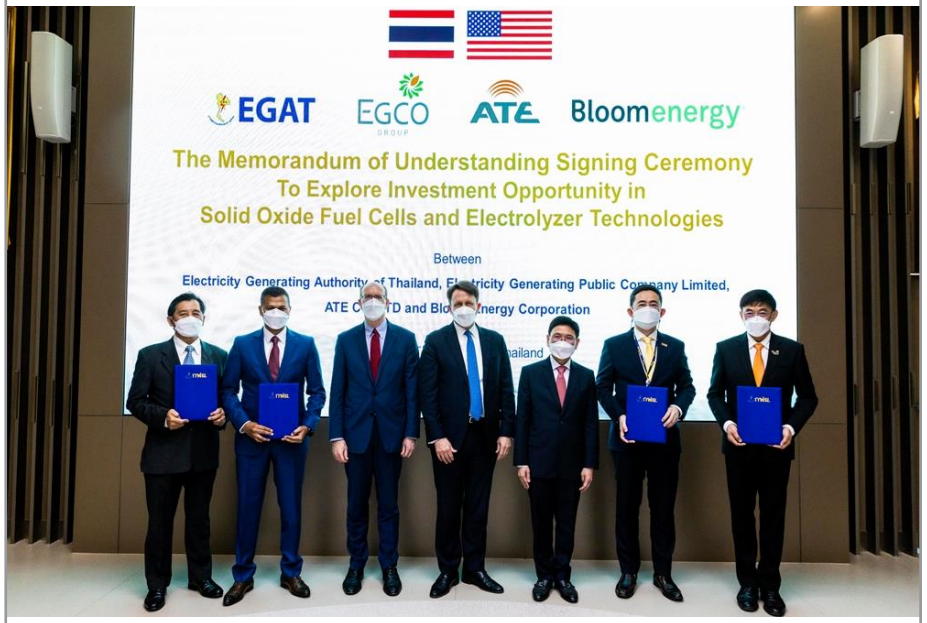
 *Source: Thai PR*

# EGAT, ATE, EGCO, and Bloom Energy signed an MoU to develop hydrogen technologies

9

| | |
|---|---|
| Name of project | Investment Opportunity in Solid Oxide Fuel Cells and Electrolyzer Technology Exploration |
| Period | December 2021 |
| Place | N/A |
| Partners | ■ Energy Generating Authority of Thailand (EGAT)<br>■ ATE *(Energy Company)*<br>■ Electric Generating Public Company Limited (EGCO) *(Power Producer)*<br>■ Bloom Energy *(Electricity Generator and Hydrogen Producer)* |
| Purpose | ■ To develop power plants in Thailand using <u>new energy alternatives and SOEC and SOFC technology</u> to pave the way to Thailand's decarbonization and energy transition to hydrogen |
| Budget | N/A |
| Future plan | ■ This MOU aims to support the nation in achieving carbon neutrality |

Images




*EGAT Headquarter, Bangkok, Thailand*

 *Source: EGAT*

# There is large growth potential in Thai hydrogen market

Key Takeaways

**Energy Partnership** of Thailand and Japan

- The Thai and Japanese Governments has been closely collaborating in energy sector as in AETI, AGGPM and AZEC

**Energy Trend** in Thailand

- The government is planning to increase renewables, especially solar energy over 2037, to achieve the goals of -30% compared to BAU in 2030, and eventually carbon neutrality by 2050 and net-zero GHG emission by 2065

**Hydrogen Policy** in Thailand

- The government has recently started promoting the technology by conducting projects and signing MoUs together with private companies as well as initiating the tax exemption program for hydrogen
- The government seems to be in the process of developing a hydrogen strategy

**Hydrogen Market** in Thailand

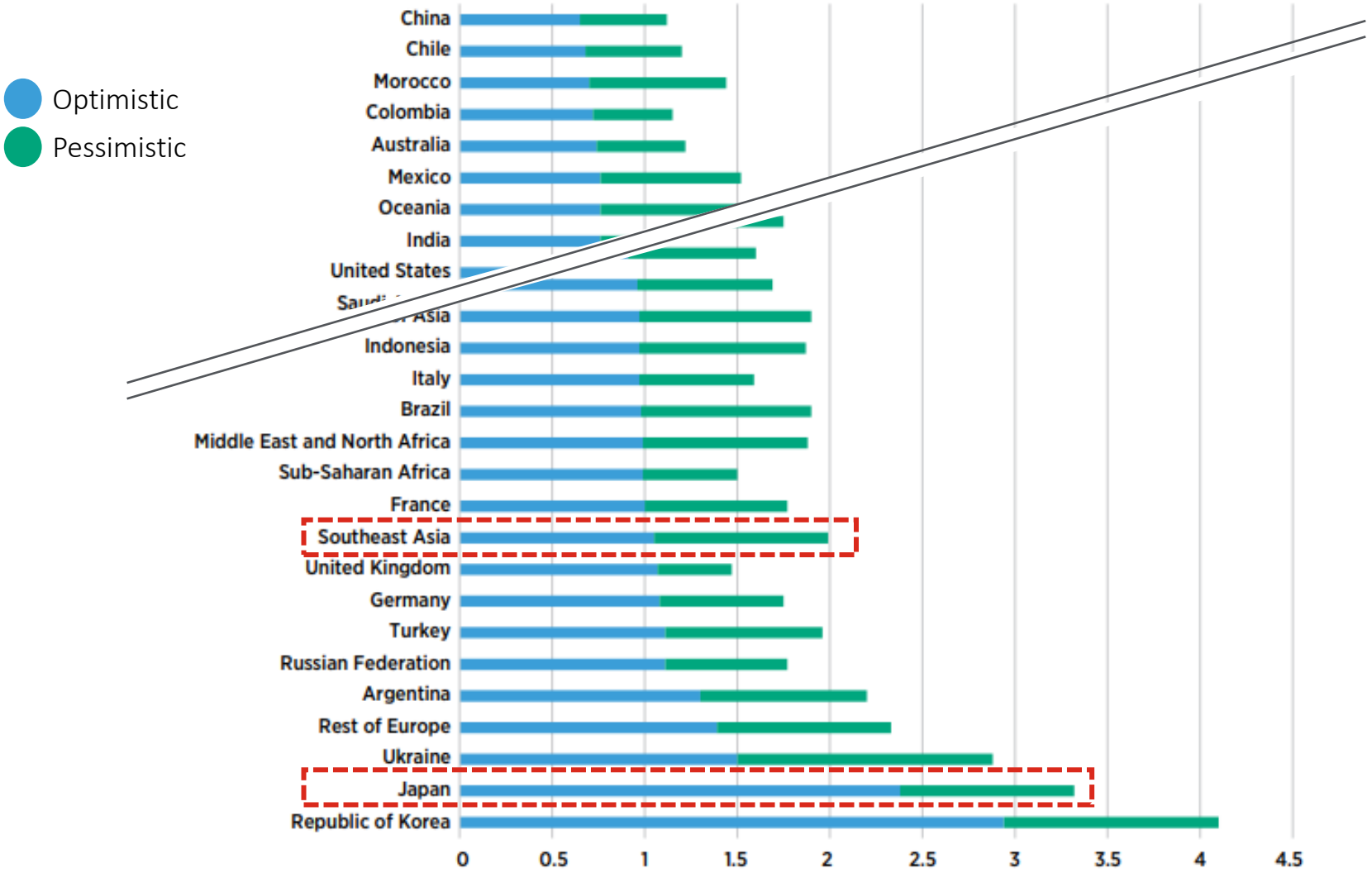
- Major local Thai companies have been starting hydrogen/fuel cell projects in Thailand
- There is large potential in hydrogen related sectors in Thailand

*Thai-Japan collaboration could bring synergy in the hydrogen market for both sides*

# Reference

# According to IRENA, hydrogen production cost in Southeast Asia is expected be 1~2 USD/kg

Levelized cost of hydrogen in 2050

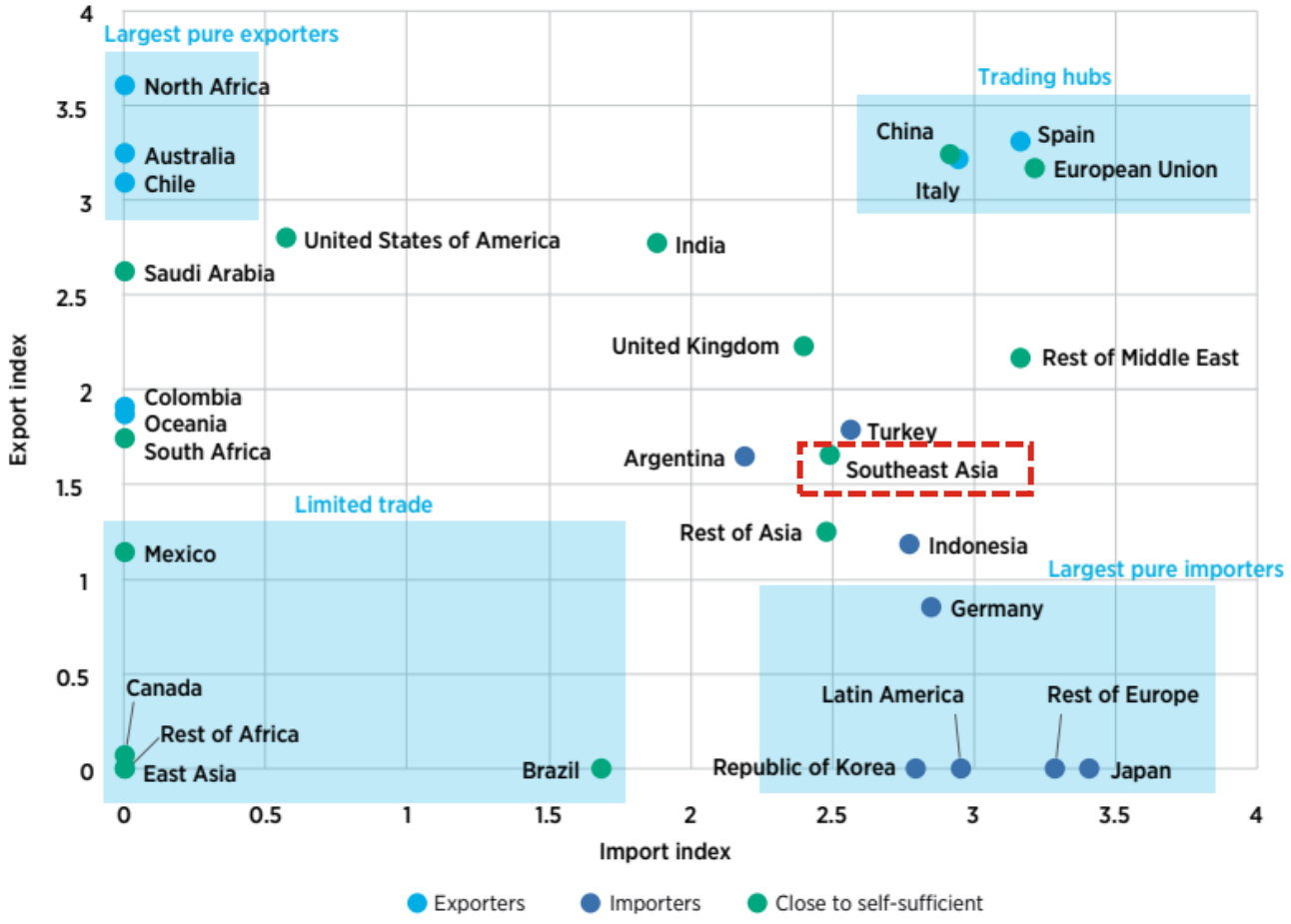



 *Source: Global hydrogen trade to meet the 1.5 ℃ climate goal: Part III – Green hydrogen cost and potential,, International Renewable Energy Agency (2022)*

# Southeast Asia is likely to be a hydrogen importer or self-sufficient rather than an exporter

Volumes of hydrogen export and import for regions in 2050 (optimistic)

**FIGURE 3.17. Volumes of hydrogen export and import for regions around the world in 2050 with *optimistic* technology assumptions**




*"The largest net importers are Germany, **Indonesia**, Italy, Japan, **Southeast Asia** and the rest of Asia. " (IRENA, 2022)*

 *Source: Global hydrogen trade to meet the 1.5 ℃ climate goal: Part I – Trade outlook for 2050 and way forward, International Renewable Energy Agency (2022)*

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