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Decarbonizing Asian Economies with Green Hydrogen

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Outline

(1) Background & Objectives

(2) Scope of study & Methodology

(3) Major Findings

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Background and Objectives

- Low-carbon hydrogen can be produced from a wide range of resources; and therefore, it can be produced almost anywhere in the world.

- The development of a green hydrogen economy in the ASEAN region can contribute to accelerating region-wide transition to clean and sustainable energy and raising its energy self-sufficiency, and in turn enhancing the region's energy security.

- The ASEAN region bears great potential for renewable power, including solar, wind, and hydropower. These resources can be used to produce green hydrogen, but this potential has yet to be sufficiently explored.

- Given its proximity, the ASEAN region could promise to be a future supplier of hydrogen to Japan, depending on its potential.

This study explores the ASEAN region's potential for using locally produced green hydrogen to decarbonize its economy, focusing on its application in hard-to-abate sectors.

Background & Objectives: Primary energy mix in ASEAN member countries

- ❖ All countries except Myanmar rely heavily on fossil fuels.
- ❖ In all countries biomass accounts for a dominant share of renewable energy.
- ❖ Solar power and wind power account for less than 1%.

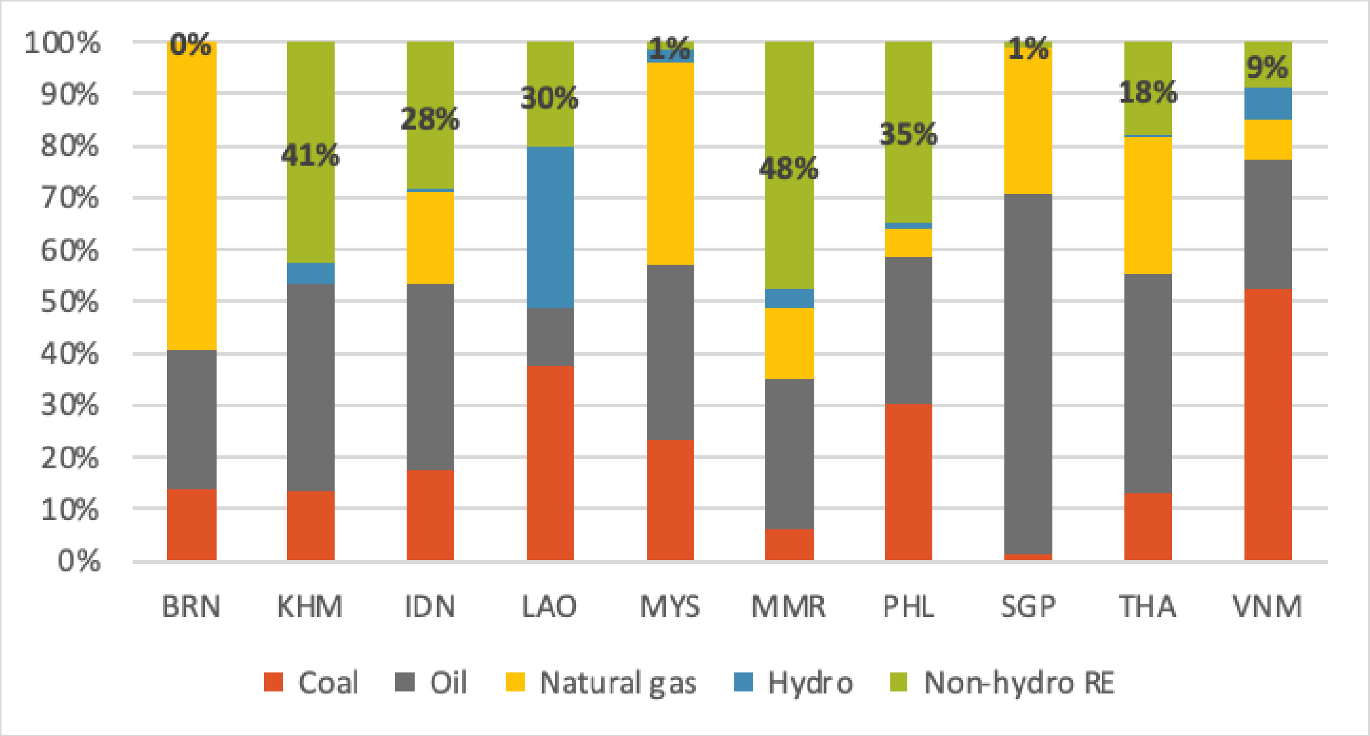

FIG. PRIMARY ENERGY MIX IN ASEAN MEMBER COUNTRIES (2020)

Source: compiled by authors based on IEA (2022b)

Background & Objectives:
Climate policies of ASEAN member countries

- Most countries have CN goals supported by NDCs, many of which have been updated over the past two years.
- Most countries have pledged to phase out coal or not approve new coal projects.
- Decarbonization and increased renewables deployment are urgently called for.

TABLE. CLIMATE COALS IN THE ASEAN REGION

Country[1]	CN goal	2030 GHG emission reduction target (NDC)				Coal phase-out policy
		Reduction target type	Unconditional	Conditional[2]	Baseline year	
BRN	2050	Relative emissions	20%	-	BAU	Yes
KHM	2050	Relative emissions	41.7%	-	BAU	Yes[4]
IDN	2060	Relative emissions	29%	41%	BAU	Yes[4]
LAO	2060	Relative emissions	60%	-	Baseline	No
MYS	2050	Carbon intensity	45%	-	2005	Yes[4]
MMR	2050	Other	Avoided emissions: 245 $MtCO_2$	-		No
PHL	-	Relative emissions	2.71%	75%	BAU	Yes[4]
SGP	2050	Carbon intensity	36%[5]	-	2005	Yes
THA	2050[2]	Relative emissions	20%	25%	BAU	No
VNM	2050	Relative emissions	9%	27%	BAU	Yes

Source: compiled by authors based on NDCs and other materials

Notes:

1)The country codes used are as follows: Brunei Darussalam (BRN), Cambodia (KHM), Indonesia (IDN), Lao DPR (LAO), Malaysia (MYS), Myanmar (MMR), the Philippines (PHL), Singapore (SGP), Thailand (THA), and Vietnam (VNM)

2)Conditional targets are dependent on the availability of international support for finance, technology transfer and development, and/or capacity building.

3)Thailand aims to achieve carbon neutrality by 2050 and net zero carbon GHG emissions by 2065.

4)No new projects will be approved.

5)Singapore aims to peak emissions in 2030, which will lead to 36% reductions relative to 2005 in 2030.

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Scope of Study

- **Industries and part of the transport sector** in the ASEAN region that are **difficult to decarbonize by electrification** (**hard-to-abate**).
  *Power generation sector is not included.

- Focus on **Green Hydrogen**, produced by electrolysis using renewable power, such as solar, wind, hydro, geothermal and biomass.

Because…

1. Green hydrogen has low carbon footprint.
   →Can avoid impact of global market and political pressure against using fossil fuels

2. The price of blue hydrogen and its derivatives risk being affected by volatile market fossil fuel prices.

3. Renewables can be found in a wider area.
   → Therefore, any country can become a green hydrogen exporter by harnessing such resources.

4. Green hydrogen supply chains can be diversified.
   →Can contibute to enhancing regional energy security.

Methodology:
Potential hydrogen demand (Industry sector, 2019)

1. Identify **final energy demand** in the industry sector in 2019 for **each ASEAN country by industry and by energy type**.

2. Identify the share of **high temperature (≥400°C) heat demand** against total fossil fuel consumption for each industry (Table).

3. Estimate potential hydrogen demand by **multiplying the total fossil fuel consumption in each industrial sector by the abovementioned sector-specific ratio**.

*The same conversion efficiency is assumed for fossil fuel-based burners/boilers and hydrogen burners/boilers.

TABLE. SHARE OF ≥400°C HEAT DEMAND IN FOSSIL FUEL CONSUMPTION BY INDUSTRY

Iron and steel	98%
Chemical and petrochemical	33%
Non-ferrousmetals	98%
Non-metallicminerals	92%
Transport equipment	44%
Machinery	44%
Food and tobacco	12%
Paper,pulp and printing	58%
Wood and wood products	58%
Textile and leather	5%
Industry not elsewhere specified	44%

Source: MRI (2018)

Methodology:
Potential hydrogen demand (Transport sector, 2019)

1. Identify **final energy demand** in 2019 for **each ASEAN country by mode of transport**

2. **Road transport:**
   - Light-duty vehicles (fuel= gasoline & LPG) →Replaced by battery electric vehicles (BEV)
   - **Heavy-duty vehicles** (assuming fuel = diesel) →Replaced by fuel-cell vehicles (FCEV)

   *The same fuel efficiency is assumed for FCEVs and diesel vehicles..

3. **Air, maritime, and rail transport:** assumed that all fuels are replaced with hydrogen.

   *Should be noted that synthesized fuels (e-fuel) produced from hydrogen may be chosen for these modes of transportation.

   *The same fuel efficiency is assumed for conventional fuels and hydrogen.

Potential hydrogen demand (2050) = Potential hydrogen demand (2019)

×(final energy consumption in the industry & transport sectors in ASEAN countries(2050)

/ final energy consumption in the industry & transport sectors in ASEAN countries (2019))

Methodology:
Potential hydrogen supply (2050)

Given that **increasing renewable power generation should be prioritized in the ASEAN region**, renewable power generation is assumed to be primarily used to replace fossil fuel-fired thermal power generation, after which the **remaining renewable power could be used to produce hydrogen.**

1. Renewable energy potential (potential installed capacity) is estimated from existing studies (ERIA, 2021; IRENA & ACE, 2022).
2. Capacity factor of renewable power generation in each ASEAN country is derived from IRENA Data & Statistics.
3. **Renewable energy potential (potential power output)** is calculated.

Potential hydrogen supply (2050) ＝ Renewable energy potential (TWh)

－ (①Total power generation (2050) ＋②Additional power generation*)

*"Additional power generation" = Potential hydrogen demand in the industry and transport sectors (2050)
Considering that all applications using fossil fuels that can electrified in 2050 will run on electric power

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Major Findings:
Potential hydrogen demand (Industry sector)

- Despite improvements in energy efficiency, energy consumption in the industry sector will increase significantly in 2050 driven by economic growth. →Potential hydrogen demand will increase accordingly.
- Potential hydrogen demand is largest in Indonesia (62 Mtoe).
- Potential hydrogen demand of the entire ASEAN region is 152 Mtoe, equivalent to 40% of total final energy consumption across the industry sector.

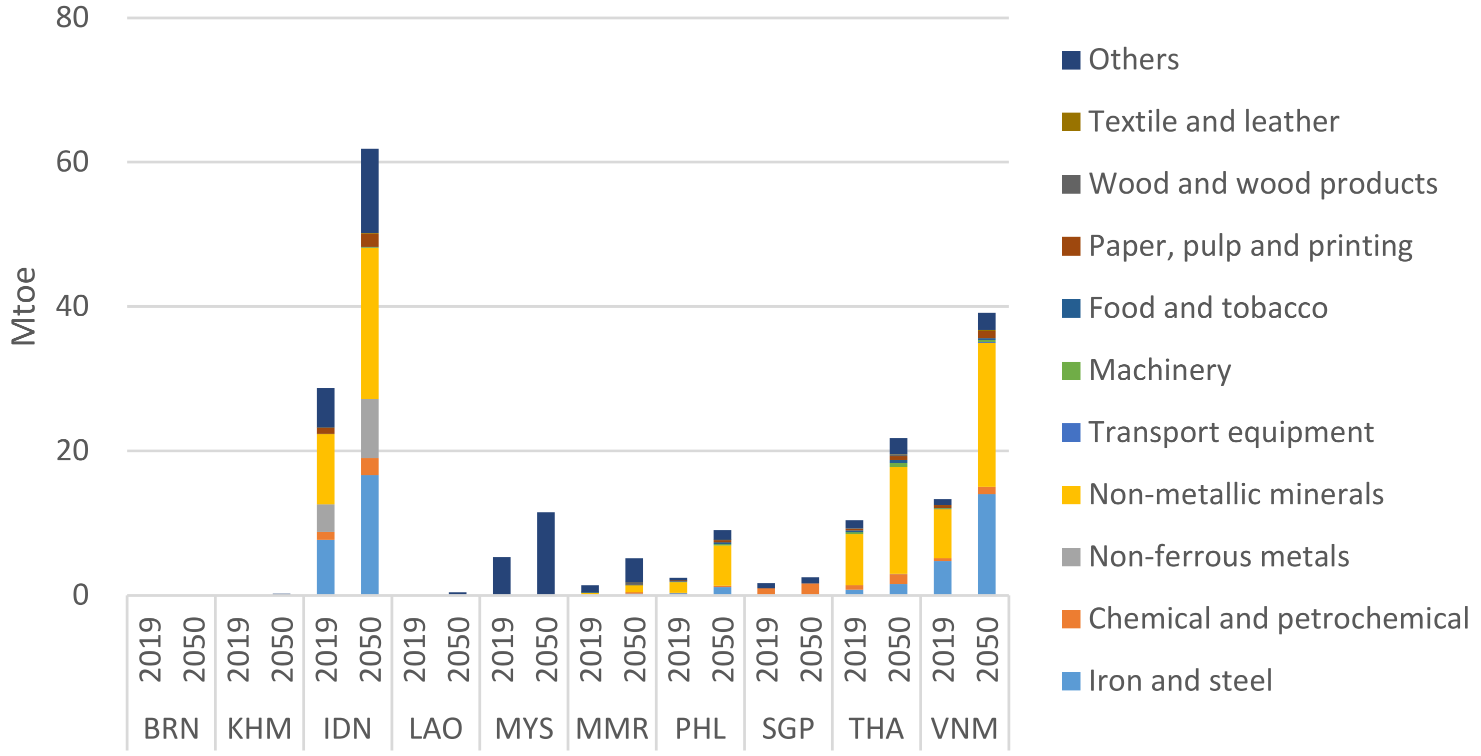

FIG. POTENTIAL INDUSTRY HYDROGEN DEMAND (2019 AND 2050)

Major Findings:
Potential hydrogen demand (Transport sector)

- ❖ Hydrogen demand will increase in 2050 with increased energy consumption in the transport sector driven by economic growth. →Potential hydrogen demand will increase accordingly.
- ❖ Given its large population, Indonesia is home to the largest potential hydrogen demand (73 Mtoe).
- ❖ Potential hydrogen demand in the transport sector across the entire ASEAN region is 166 Mtoe, accounting for 44% of final energy consumption in the sector.
- ❖ Road transport (vehicles) accounts for approximately 80% of total potential hydrogen supply.

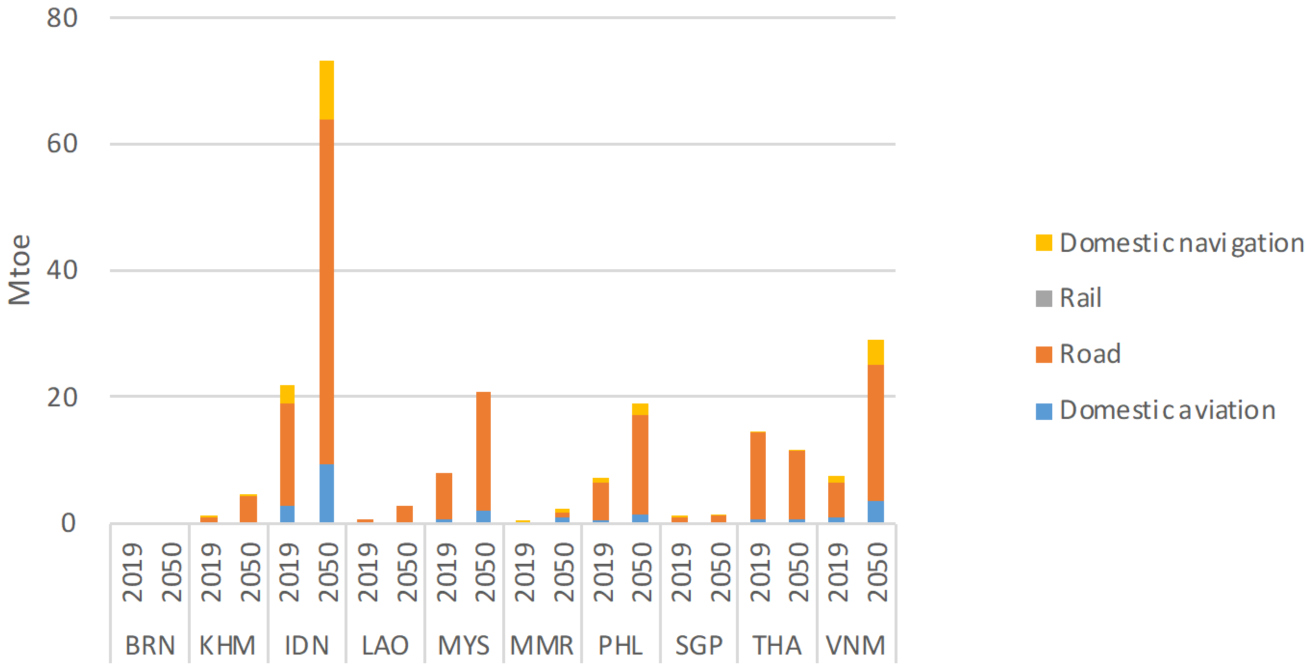

FIG. POTENTIAL TRANSPORT HYDROGEN DEMAND (2019 AND 2050)

Major Findings:
Potential hydrogen supply

- Two cases (RE P1 & RE P2) represent potential hydrogen supply.
- Even under the assumption that renewables will cover both total power generation in 2050 as projected in ERIA (2021) and the additional power generation needed to accommodate increased electrification demand driven by further electrification in 2050 and beyond (PG 2050), the renewable energy potential in most ASEAN countries exceeds total power generation. Therefore, surplus renewable energy is available for use in hydrogen production.
- The potential for hydrogen production is especially large in Cambodia, Indonesia, Laos PDR, Myanmar,

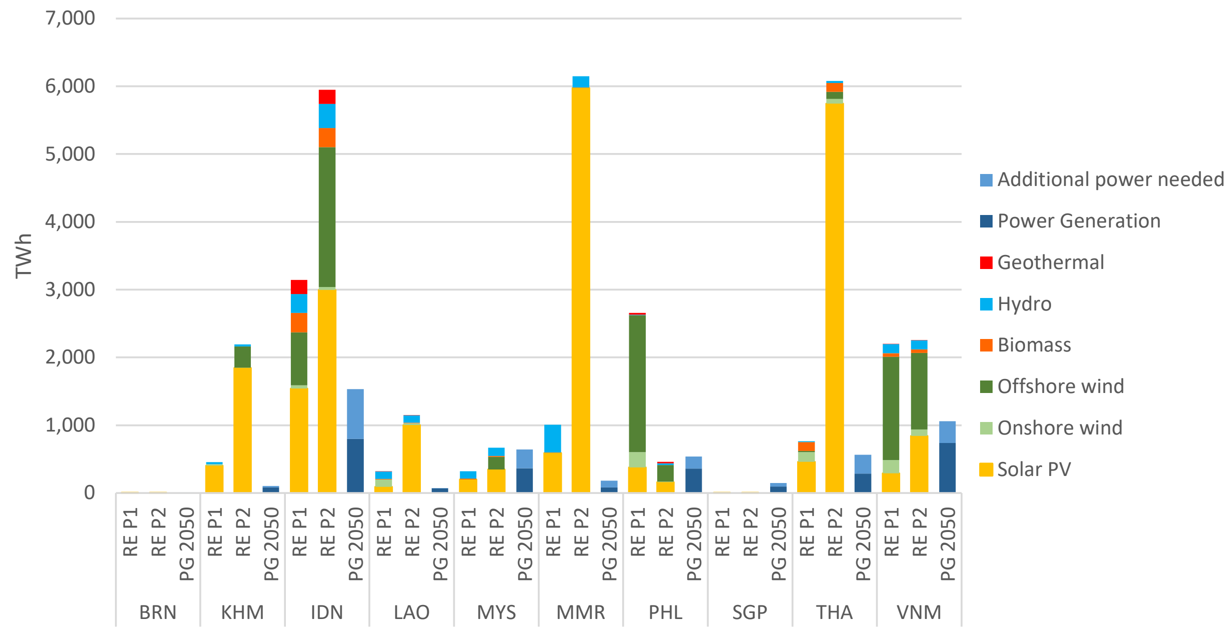

FIG. RENEWABLE ENERGY POTENTIAL FOR HYDROGEN PRODUCTION

- **Across the ASEAN region**, total power generation is projected to be 2,900TWh in 2050. Additional electric power generation to accommodate electrification demand in 2050 and beyond will amount to 2,000TWh, leading to a **total electric power demand of 4,900 TWh.**
- ASEAN-wide renewable energy potential ranges between 11,000 (RE P1) ~ 25,000 (RE P2) TWh.
- 6,000 ~ 20,000 TWh of renewable energy can be used for hydrogen production.

Major Findings:
Comparison of potential green hydrogen supply & demand

- ❖ In all countries except Malaysia, as well as Brunei Darussalam and Singapore where both supply and demand will be limited, potential supply exceeded demand.
- ❖ Myanmar and Thailand have an outstanding amount of potential surplus supply.
- ❖ the ASEAN region bears the potential to supply three times the potential hydrogen demand in 2050.

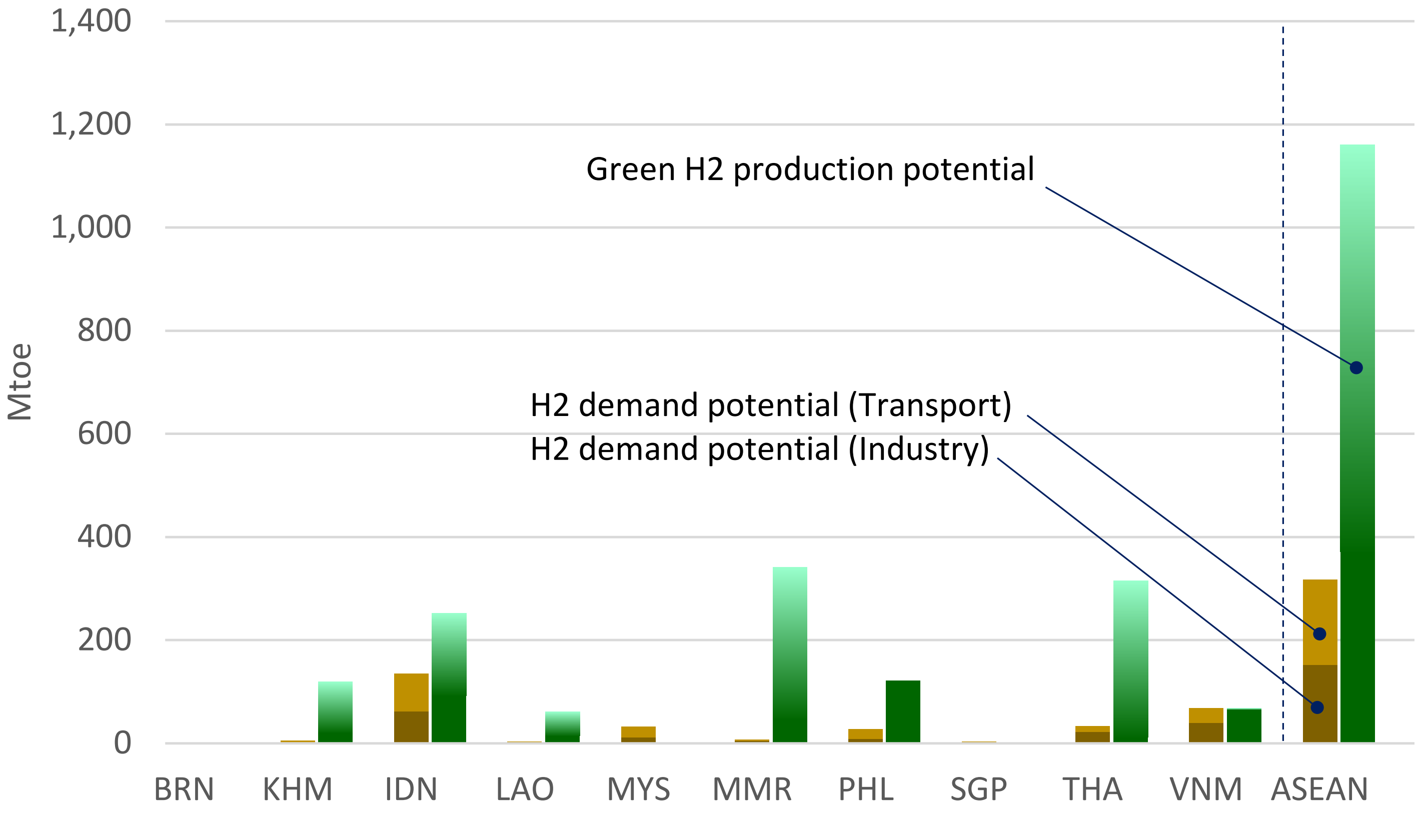

FIG. COMPARISON OF POTENTIAL GREEN HYDROGEN SUPPLY & DEMAND (2050)

Major Findings:
Sufficiency of potential green hydrogen supply (2050)

- Myanmar, Lao PDR, and Cambodia will have sufficient hydrogen supply to cover domestic demand.
- Thailand, the Philippines, and Indonesia may have a shortage of domestic supply when the physical potential is not fully harnessed.
- With 54~843Mtoe of surplus supply, even in the most pessimistic case, there is an ample potential supply of green hydrogen across the entire ASEAN region to cover regional hydrogen demand.

Intra-regional trade of green hydrogen could offer a solution to the region-wide decarbonization of hard-to-abate industries using local resources

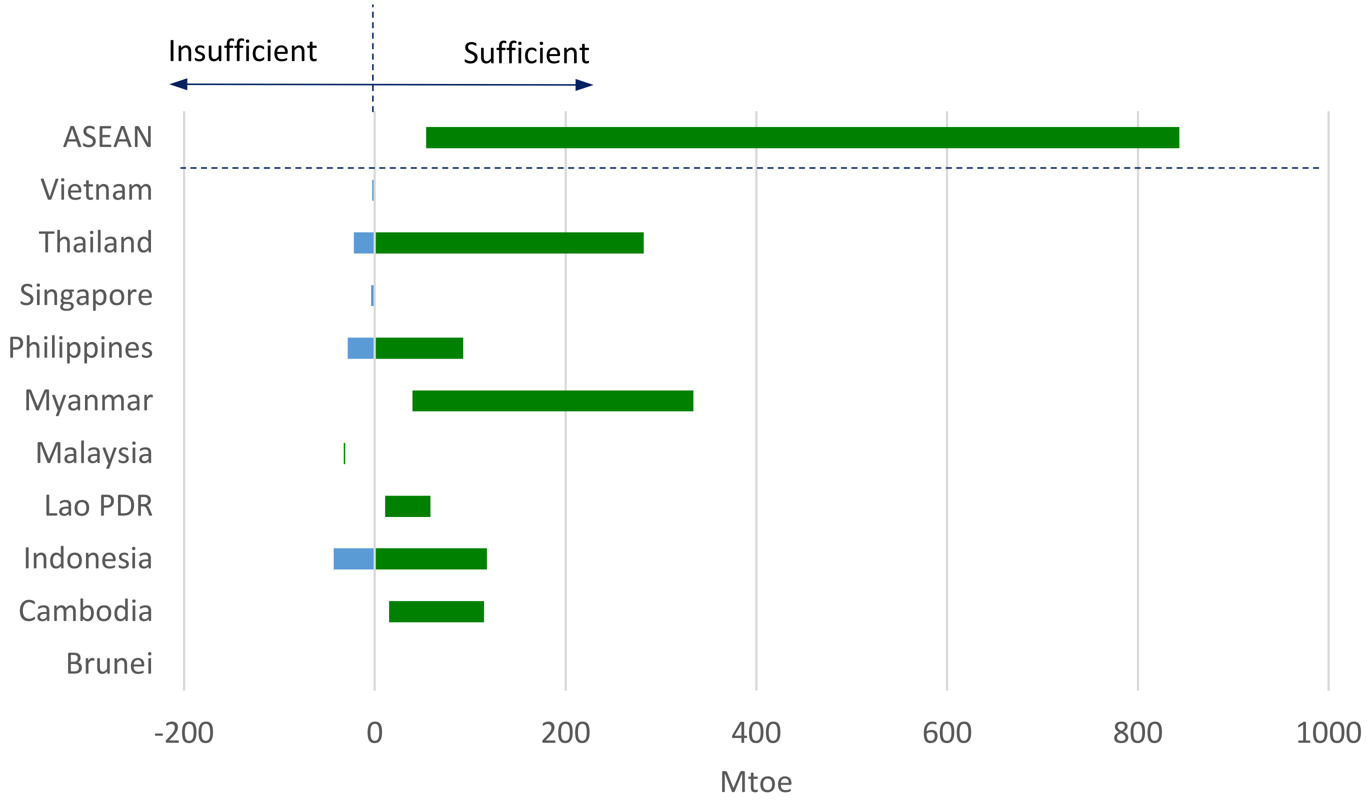

FIG. SUFFICIENCY OF POTENTIAL GREEN HYDROGEN SUPPLY (2050))

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Implications:
Potential geopolitical changes in the ASEAN region

- Green hydrogen production may change the geopolitics of the ASEAN region
- Low-income economies, such as Myanmar, Lao PDR, and Cambodia, will have the opportunity to become the region's energy supplier
- However, most ASEAN countries have yet to develop national hydrogen strategies.

TABLE. HYDROGEN IN ASEAN ENERGY POLICIES

Brunei	Concluded MOUs with Asian countries such as Japan and Singapore on cooperation on building an international hydrogen supply chain. Ongoing studies and pilots led by private sector.
Indonesia	National Energy Plan (RUEN) includes a general action plan for hydrogen development.
Malaysia	National Energy Policy 2022-2040 includes initiatives to formulate a hydrogen roadmap, a national strategy, and relevant regulations. Aims to establish an internationally competitive hydrogen energy hub in Sarawak in the long term (2031-2040).
Singapore	National Hydrogen Strategy 2022

Implications:
Policy challenges to developing the full renewable energy potential

- **Power development plans and renewable power targets fall substantially short of their renewable energy potential** (Table).
- Many policy challenges remain in developing renewable energy:
  - Lack of financial support and channels
  - Lack of experience and regulatory frameworks
  - Insufficient coordination among government agencies
  - Limited infrastructure (e.g. grid enhancement for massive renewable integration)

TABLE. COMPARISON OF RENEWABLE TARGETS AND POTENTIAL (GW)

	Renewable target	Potential supply (RE P1)
IDN	552 GW (2060) (Proposed National Grand Energy Strategy)	1,884 GW
MYS	18 GW (2035) (MyRER)	225 GW
PHL	61 GW (2040) (NREP 2020-2040)	963 GW
THA	19 GW (2037) (AEDP 2018)	378 GW

Source: compiled by authors based on various sources, as indicated

Implications:
Exporting green hydrogen outside the ASEAN region

- The ASEAN region will have 54~843Mtoe of green hydrogen (≒20～300 Mt-H_2)
- The ASEAN regionbears the **potential to become a major supplier of green hydrogen for Japan**. The proximity of the region to Japan will be an **advantage in diversifying energy imports and enhancing energy security**.

  *Japan aims to introduce 3 million tonnes of hydrogen in 2030 and 20 million tonnes in 2050.

- Green hydrogen will play an important role in **decarbonizing marine fuels**. While the potential regional e-fuel supply is unlikely to cover all marine bunker fuel sales by Singapore (around 50 million tonnes), if the surplus supply of green hydrogen (around 50～850 Mtoe) were to be converted to e-fuel, the region would be able to **supply around 40～600 Mtoe of e-fuel**
- A reasonable amount of **regionally produced e-fuel can be collected in Singapore** from across the ASEAN region, **potentially offering large business opportunities for the ASEAN region**.

Implications:
Building an intra-regional green hydrogen supply chain

- Areas with high hydrogen demand are not always located close to potential production hubs; and therefore, **new international supply chains and networks will need to be built**. By establishing an intra-regional supply chain and distribution network, **all ASEAN countries will gain access to green hydrogen**.

- **Regional use of regionally produced green hydrogen** will help enhance **regional energy security**.

- **Regional agreement** will be essential to overcome many challenges:
  - Selection of the **hydrogen carrier** in light of various factors, including cost, infrastructure availability (including repurposing), and end-use applications
  - Selection of green hydrogen production site / mode of distribution (international transmission lines, pipleines, etc.)
  - Infrastructure (shipping and receiving ports, storage facilities, etc) that can accomodate the preferred hydrogen carrier.
  - **Regional certification scheme** for hydrogen that is consistent across borders.

Implications:
Further promoting renewable energy deployment

- Renewable power should **primarily be fully harnessed to decarbonize sectors whose carbon footprint can be lowered by using it directly.**
- For green hydrogen to be a realistic and optimal solution for decarbonizing the economy, the **renewable power used in its production should be available in surplus to that needed for more efficient uses.**
- **Investment should first be targeted at renewable power projects**.
- It is essential that polices are secured for the massive deployment of renewable energy in each country.
  - Abolishing fossil fuel subsidies
  - Grid enhancements to integrate more variable renewable energy.

Implications:
Japan's role in promoting green hydrogen development in the ASEAN region

- Proximity of the ASEAN serves **Japan's energy security**.
- **Increased investment and government support in the earlier phases** (renewable power generation & hydrogen production, including electrolyzer technology development, etc.) **of the supply chain**
  - Accelerated decarbonization of the electric power sector in the ASEAN region
  - Increased access for Japanese actors to renewables for green hydrogen production
- Players may be able to enjoy **first-mover advantage** in establishing the **business environment for green hydrogen**.
- 2023 marks the "**50th Year of ASEAN-Japan Friendship and Cooperation**." Under the cooperation frameworks launched for supporting ASEAN countries' energy transition, **Japan can also support the designing of aggressive but feasible decarbonization policies with consideration of region-specific circumstances and needs:**
  - Technological and financial support
  - Sharing experiences with infrastructure, transport and storage technologies, rules and regulations, safety standards, etc.
  - In-depth studies to reveal local challenges and solutions
  - Support in formulating master plans based on such studies
  - Stakeholder dialogue

Major references

Ratio of high temperature （≧400℃）heat demand against total fossil fuel consumption :

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Capacity factor for power generation facilities in ASEAN member countries:

IRENA Data & Statistics

Thank you very much for your attention.

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