hyDonesia®

hyDonesia:
H2 Valley in South Sumatra,
Indonesia

The Role of H2 in Decarbonzied World – Spring 2023

SciencesPo
Paris School of International Affairs

Table of Content

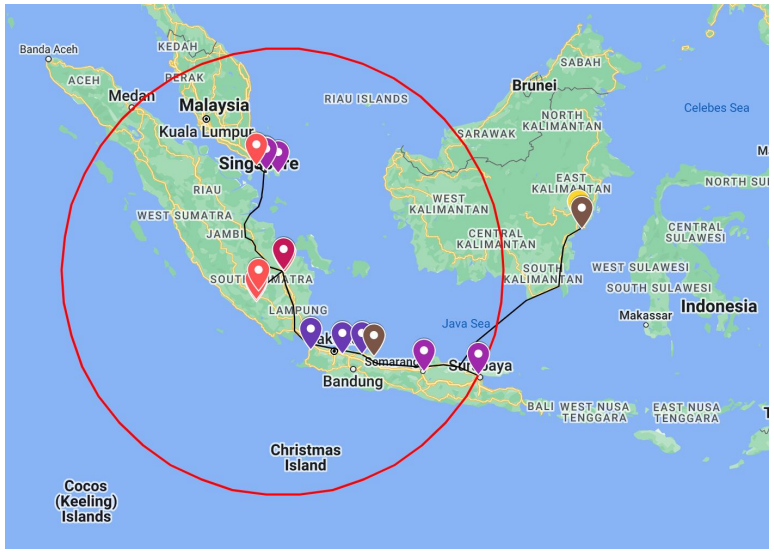
Introducing hyDonesia

Who are we?

- hyDonesia is a hydrogen valley, based in South Sumatra with a **regional focus on Java and Singapore**. Our initiative encompasses the entire hydrogen value chain from **production to transport** and various end-uses in the **industrial and transport sectors**.

Vision

- Indonesia can tap into its exceptional renewable potential, strategic location and industrial capacity to provide a **meaningful contribution to the energy transition**.
- We believe that hydrogen has an important role to play in chanelling new and renewable energy sources into a clean, versatile and transportable carrier that will provide a decarbonised fuel to **power the growing Indonesian economy.**



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Why Indonesia?

Key figures
- $1.1bn GDP (PPP 2014)
- 16th largest economy globally in 2021
- 4.7% avg. GDP growth/ year 2009-2022
- 4Mt/year hydrogen demand in 2025
- 10th largest global emitter in 2022
- 273 million population

2050 Indonesia forecast
- $12.2bn GDP (PPP 2014)
- 4th largest economy globally (PwC)
- 10th largest hydrogen consumer (IRENA)
- Neighboring 9th largest hydrogen consumer Singapore (IRENA)
- 300 million population

Indonesia's decarbonization is crucial to achieving global decarbonization targets, given the country's high emissions profile, which is expected to grow as it continues to develop and industrialize.

In recent years, the Indonesian government has recognized and begun to respond to this need, setting a **net zero by 2060 target** and laying initial **legal groundwork for a carbon price**. The country's decarbonization efforts are expected to scale up significantly following its commitment to the **multi-lateral Just Transition Partnership**.

Hydrogen will be key to decarbonizing Indonesia's economy without sacrificing growth. **Industry will comprise most demand** through 2050, though the government and SOEs have expressed interest in hydrogen for power generation, export and transport as well.

Research by IRENA and others suggests Indonesia has **potential to be nearly self-sufficient in green hydrogen production** to meet robust demand in 2050 by developing **renewable energy resources** in locations such as the **project area of South Sumatra**.

By developing its own hydrogen valley, Indonesia has the potential to curb future import dependencies, profit off exports to nearby Singapore, and develop leadership capabilities in this emerging global value chain.

Resource endowments of Indonesia

Natural gas

Although the 7th largest LNG exporter in 2021, Indonesia **faces important natural gas supply challenges**. In 2021, its natural gas reserves were half of what they were in 2019. Furthermore, although its production exceeds domestic demand, the domestic market regularly faces **natural gas shortages** as its industry and power sectors struggle to compete with international LNG prices. Nonetheless, the government aims to use **natural gas as a transition fuel** in its plan to phase-out coal.

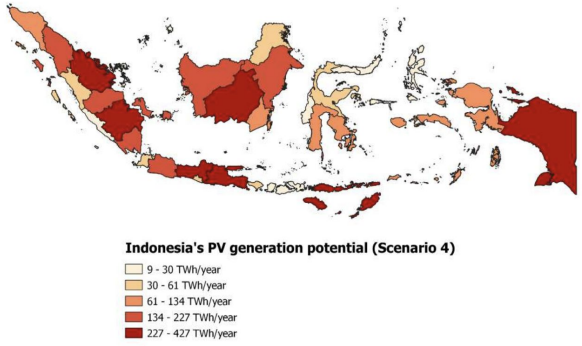


Figure 11. Indonesia's nationwide solar PV generation potential map (Scenario 4)

PV generation potential of Indonesia per region following restrictive land availability assumption (IESR, 2021)

Solar PV

Indonesia benefits from important untapped **PV potential, estimated at 3000 GW** by IRENA. Nonetheless, the real potential of PV in Indonesia is limited by considerations of **protection of its natural resources such as its natural forest**. Using restrictive scenarios of land availability (removing agricultural land, plantation forests, natural forests and settlement areas) a few regions stand out as having particularly important PV potential: East Java, **Sumatra**, Nusa Tenggara and Sulawesi regions.

Geothermal

Indonesia is estimated to have the **largest geothermal resources in the world**, with 29,000 MW. Yet, 70% of the geothermal potential is located in protected areas making **its exploitation difficult**. Therefore, while plans exist to use geothermal or power generation, it can be difficult to assess the extent to which this source will be accessible for hydrogen production. Nonetheless, **the region of South Sumatra has recently begun opening new land** for geothermal exploitation.

hyDonesia's hydrogen production strategy

South Sumatra, using geothermal and potentially PV

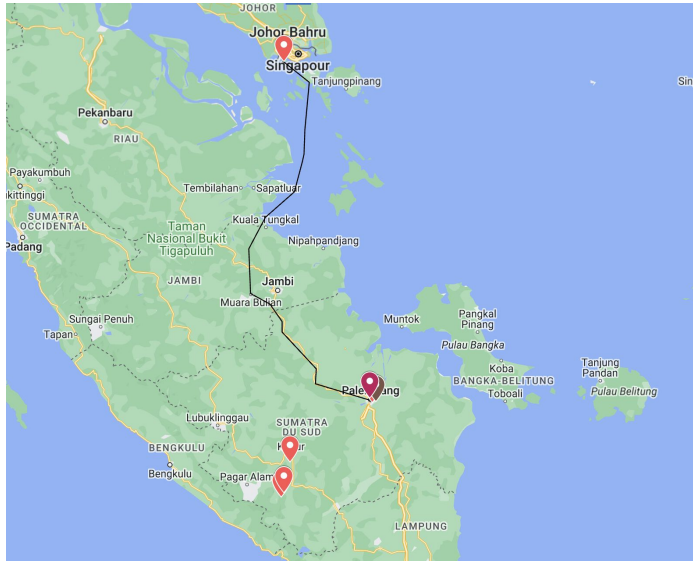
- hyDonesia considers that South Sumatra, because of its important geothermal and solar generation potential, as well as its strategic location in-between Jakarta, Singapore, and Malaysia, provides the most strategic location to produce hydrogen.

Project development phases

hyDonesia is a multi-phase local and intra-regional hydrogen valley covering a wide range of applications along the hydrogen value chain with a focus on indutry; power generation; shipping and transport.

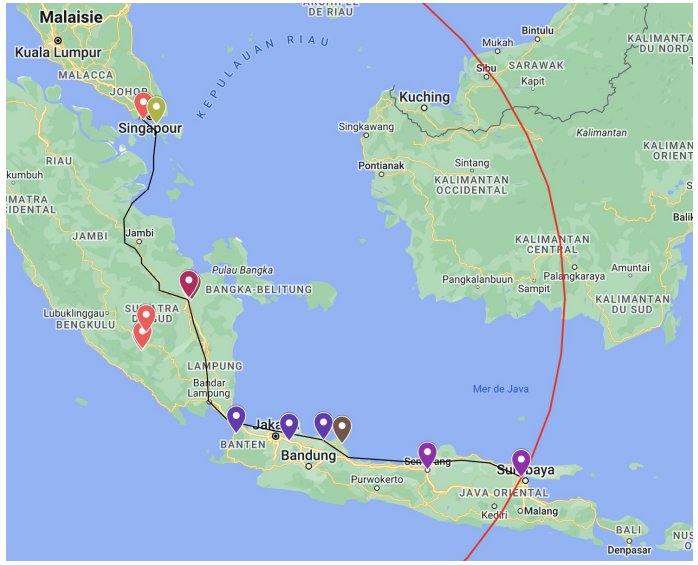
Phase I: 2030

Refinery and amonia feedstock in Indonesia and power generation in Singapore using refurbished pipeline



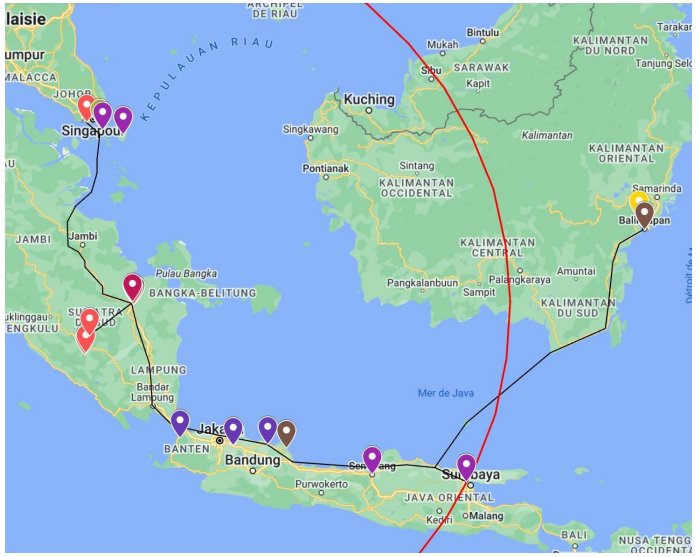
Phase II: 2035

Shipping fuels in Singapore
Steel and aluminium in SEZs with Java pipeline extension



Phase III: 2040/45

Transport fuel for Nusantara
Serving additional demand in SEZs in chemicals, petrochemicals, glass, etc.



- Fertiliser plant
- Power plant
- E-fuel plant
- Refinery plant
- Steel plant
- Special Economic Zone, with expected hydrogen demand
- Urban transport demand

To view the hyDonesia map in more detail, click here or paste the link: https://www.google.com/maps/d/u/0/edit?mid=1yBdEkxa3JSA5ojA8Y_QTe1Y_rLuNe2M&usp=sharing.

H2 Value Chain: Production

Source

Geothermal

- Capacity: 2095 MW
- Cost: 0.04~0.08 $/kWh[1]
- Locations: Muara Enim, Ogan Komering Ulu

Solar PV

- Capacity: 285 GW
- Cost: 0.06 ~0.10 $/kWh[1]
- Locations: Palembang, Tanjung Enim

+) Commercial feasibility

($/kg)	2030	2050
Domestic Geothermal H2 production[2]	2.6-5.3	2-3.2
Domestic Solar H2 production[2]	4.3-11.5	2.6-5.7
Australian green H2 forecast[3]	3 (4.5 AUD)	1.6 (2.45 AUD)

*Depending on source and electrolyser types, domestic H2 production could be competitive to Australian green H2 imports considering the transportation cost

Geothermal energy will be the main source of hydrogen, producing 40,000 Mt of green H2 annually in South Sumatra. **PT Pertamina** signed a joint study agreement with Singapore-based Keppel Infrastructure and Chevron to explore feasibility of a green H2 facility in Sumatra, powered by 250~400 MW of geothermal energy. **PT Supreme Energy Rantau Dedap (SERD)** has also started commercial operation of Rantau Dedap Geothermal Power Plant which has 91 MW capacity. Solar PV currently lacks competitiveness in cost and capacity compared to geothermal but will increasingly contribute to the hydrogen production by 2040. **PT Bukit Asam**, a state-owned coal mining company, plans to build a 200 MW solar park in one of its former coal mine sites. Coal producer **SESM** is planning a 10 MW off-grid solar plant and **PT Pertamina** has built 2.25 MW solar power plant in Palembang to directly feed electricity into its Plaju refinery which could be used to produce hydrogen onsite.

1) IESR (2019), 2) IESR (2022), 3) PwC (2021)

H2 Value Chain: Distribution and Storage

Domestic Transportation

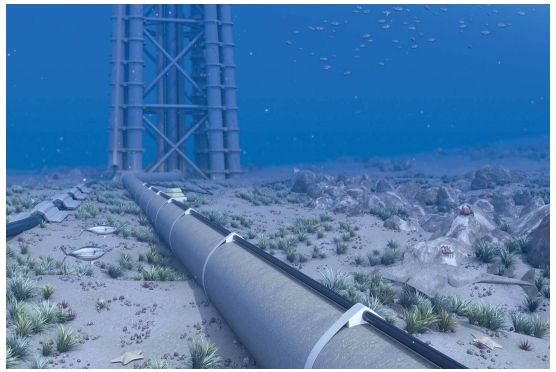
Tube trailers (350 bar)

- Coverage: 159 km
- Trajectory: Rural production sites to Palembang or other nearby demand sites

H2 Pipelines

- Coverage: 1200+ km
- Trajectory: Palembang to other regions and islands

Overseas Transportation



Grissik-Singapore Pipeline

- Coverage: 482km
- Trajectory: Palembang to Singapore

Storage

Depleted hydrocarbon reserves

- Capacity: 537 Mt/CO2
- Location: 45 depleted oil and gas fields in the South Sumatra basin

For local and regional distribution, compressed hydrogen will be transported via tube trailer (TT) trucks and pipelines. The east-west land transportation in the island of Sumatra is interfered by mountains, however, Trans Sumatra Highway connects to main cities situated along the rivers and the coast. Pipeline transport will step in where TT coverage is unavailable or too expensive, especially for intra-regional transportation. The national inter-island gas pipelines owned by **PT PGN**, could eventually be used to transport hydrogen. For international transport, the existing underwater Grissik-Singapore pipeline gas pipeline is planned to cease operation in 2028, and will be refurbished to export hydrogen to Singapore by 2030, reducing overall capital costs for Phase I. In terms of storage, South Sumatra basin has a huge potential to store gas (CO_2 and hydrogen) underground in depleted hydrocarbon reserves, such as the South Central Sumatra Field operated by **PT Medco E&P Indonesia.**

H2 Value Chain: International Demand

Phase I: Singaporian Demand Centers

Power generation

- Planned year: 2026
- Location: Keppel Sakra Cogen Plant in Jurong Island

Maritime fuel

- Planned year: 2030
- Location: Jurong Port

Singapore will be the main demand location and export destination for hydrogen in the initial phase. According to its H2 strategies, hydrogen could supply up to 50% of power needs by 2050. However, due to its limited resources and land availability, Singapore is looking into Indonesia to import hydrogen. **Keppel** is exploring a partnership with **Pertamina** and **Chevron** that would tap geothermal energy on Sumatra to produce 40,000t of green hydrogen a year. Another prominent off-taker is the maritime sector as Singapore aims to use low-carbon hydrogen as a shipping fuel. **Sembcorp marine** is conducting a feasibility study on H2 production in Indonesia with **Pertamina** and **IGNIS** Energy, and the **Port of Singapore** is preparing for a multi-fuel future that will require storing and bunkering a variety of e-fuels, including hydrogen, by 2030. This would signal the Indonesian counterparts to produce and export green hydrogen in the near term.

H2 Value Chain: Domestic Demand (1)

Phase II: Local Demand Centers

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PERTAMINA

Ammonia (fertilizer) plant

- Capacity: 4.45 Mtpa
- H2 demand: 0.9 Mtpa
- Location: PT Pupuk-Sriwidjaja Palembang Complex

Refineries

- Capacity: 118,000 b/d
- Location: PT Pertamina Plaju refinery and petro-chemical complex

Local demand for hydrogen will mainly rise in Palembang, the capital of South Sumatra Province. Palembang has largest ammonia production capacity in Indonesia and actively exports it around the world. **PT Pupuk**, a state-owned ammonia producer, is the largest producer and consumer of hydrogen, and plans to develop green hydrogen and green ammonia value chain in partnership with **PT Pertamina** and **Mitsubishi Corporation**. Another anchor off-taker will be **PT Pertamina**'s Plaju refinery and petrochemical complex has a combined refining capacity of 118,000 barrels per day. It processes crude oil and intermediate products to produce gasoline, kerosene, diesel, B20 biodiesel, aviation fuel, and fuel oil. Our project would support the construction of a new unit of "green refinery" in 2024 which has stand-alone 20,000 barrels per day and could take advantage of the locally produced green hydrogen. PT Pertamina has already completed one refinery development for hydrogen use.

H2 Value Chain: Domestic Demand (2)

Phase III: Intra-regional Demand Centers

Steel

- Capacity: 5.2 Mt
- H2 demand: 0.25 Mt
- Location: Cilegon, Jakarta, Surabaya

Special Economic Zones (SEZs)

- Sub-industries: Electronics, Pharmaceutical, Smelting, Glass
- Location: Bitung, Galang Batang, Kendal, Gresik, Sorong

Nusantara

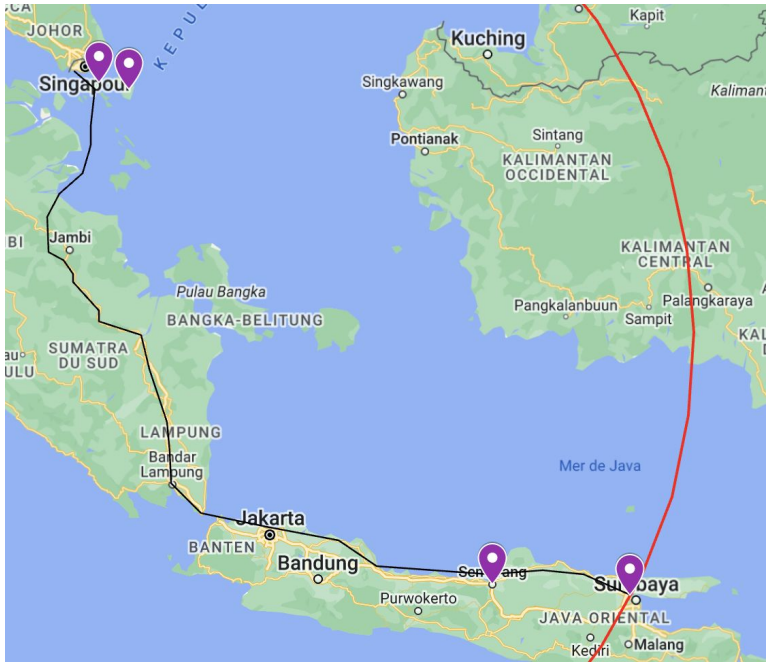
- Sub-industries: mobility, power generation
- Location: Province of East Kalimantan
- Expected year: 2024

The last phase of demand will be driven by regional industrial partners across Indonesia. These domestic locations will be supplied with green hydrogen produced in South Sumatra transported via new or converted long-distance pipelines. The steel industry will account for a large part of hydrogen demand since Indonesia presently ranks fourth in global stainless steel production. **PT Krakatau**, the largest steel producer in the country, will start green steel production from 2025. The “hard-to-abate” sectors in **SEZs** such as smelting, metal processing, pharmaceutical, and high-tech products will also account for increase in hydrogen demand. Last but not least, the country’s new capital of **Nusantara** is targeted to be a hydrogen hub, according to Law No. 3/2022, characterized by hydrogen mobility and city gas network designed to accommodate 100% hydrogen.

H2 Value Chain: Domestic Demand Centers (3)

Phase III: Intra-regional Demand Centers

The bulk of expanding domestic demand in phases II and III will be located in 4 SEZs



SEZ Kendal
Hydrogen demand: chemicals and export-oriented industry.

SEZ Batam Aero Technic
Hydrogen demand: Located near Hang Nadim airport, facing Singapore,it could be using hydrogen by 2050 for aviation fuel.

SEZ Gresik
Hydrogen demand: mineral smelting and glass industry

SEZ Galang Batang
Hydrogen demand: aluminum production

Benefits of focusing on SEZs:

- Provide concentrated demand for hydrogen which increases transport efficiency
- Location along existing/planned pipelines further minimizes costs of developing transport infrastructure
- Companies competing on international markets (generally located in SEZs) must contend with CBAM and similar policies
- Favorable regulatory environment and existing facilities will attract additional foreign partners

hyDonesia commercial partners

Our project will be a public-private partnership composed of a diverse array of foreign and domestic stakeholders encompassing the financial resources, technical, local know-how and political influence to ensure success.

Project development and management	Ministry of Energy and Mineral Resources	Strong interest in hydrogen sector development, key in ensuring political support, assistance with land procurement, permitting, and coordinating with government stakeholders, pipeline development
	PUPUK INDONESIA HOLDING COMPANY	Indonesian fertilizer SOE and country's largest hydrogen producer, multiple agreements to produce hydrogen, existing and planned projects with hydrogen demand
	KRAKATAU POSCO	JV between largest steel producer in Indonesia and Korea's POSCO. POSCO is pioneering H-DRI process entering pilot phase in 2028 and is an active investor in green hydrogen production globally
	Keppel Corporation	Singaporean conglomerate with experience in infrastructure development and offshore engineering investing in hydrogen globally and in Indonesia
Production and infrastructure partners	PERTAMINA	Largest Indonesian SOE, aggressively pursuing geothermal power as well as hydrogen and ammonia production as a business opportunity; retrofitting one existing refinery to use hydrogen and owner of refinery in Palembang; majority shareholder in gas pipeline with Singapore
	Keppel Corporation	Keppel Energy leading development of hydrogen-compatible power plants in Singapore Keppel New Energy seeking opportunities to develop geothermal power in Sumatra
	ignis Energy	US company with experience and interest developing geothermal power in Indonesia
	Air Liquide	Industrial gas producer and operator of pipelines for industrial gases in Indonesia; parent company interested in hydrogen as energy carrier and member of Global Hydrogen Council

Stakeholder mapping: Government stakeholders

Our stakeholder analysis has identified the key entities within the Indonesian government whose support will be needed throughout the stages of project development. We expect this list to grow as Phase III plans become concrete and Indonesia's policy and regulatory framework for decarbonization continues to evolve.

Directorate of Various New and Renewable Energy (MEMR)	Main point of contact within MEMR for new energy projects; approval required to develop renewable energy projects
Ministry of Industry	Currently in charge of regulating hydrogen, which is categorized as an industrial gas; oversees electrolyzer manufacturing
Ministry of State-Owned Enterprises	Oversight of SOE project partners and prospective offtakers; no significant interest in hydrogen
Ministry of Finance	In charge of developing incentives for investment, including future hydrogen incentives
Investment Coordinating Board (Ministry of Investment)	Government agency overseeing foreign investment and business licensing; focal point for permitting
Coordinating Ministry for Economic Affairs and relevant SEZ management companies	Ministry and committees oversee SEZs in Indonesia, essential for approving new and refurbished industrial sites for hydrogen use as well as developing related infrastructure
BPH Migas and PT PGN (Persero)	Downstream oil and gas regulatory authority, and SOE with near monopoly on natural gas transmission and distribution; likely to have oversight/participation in future hydrogen pipelines
Energy Market Authority of Singapore	Regulator for power and gas networks in Singapore; point of contact for introducing pipeline hydrogen import and hydrogen power generation in Singapore
Maritime and Port Authority of Singapore	Essential for enabling import of hydrogen and development of infrastructure for ammonia and methanol at Singapore ports to decarbonize shipping industry
Nusantara Capital City Authority	Contact point to explore potential for supplying hydrogen to new capital city in Phase III

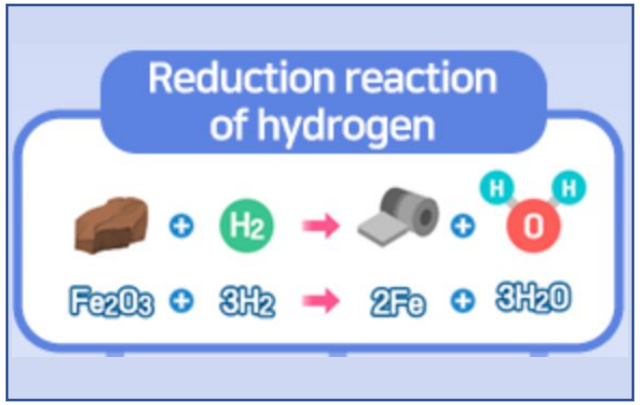
Stakeholder mapping: R&D and academic partners

hyDonesia will spur new innovation across the value chain and make Indonesia a regional leader in hydrogen with a robust R&D program coordinated via the **National Research and Innovation Agency**. We currently have three focus areas tied to our initial project phases, with plans to expand based on project evolution and partner interests.

Hydrogen Safety Training Institute

Palembang will host the world's first institute for development and training in safety standards for hydrogen and ammonia handling in the power and shipping sectors.

PUPUK INDONESIA HOLDING COMPANY · MPA SINGAPORE · PELINDO INDONESIA MARITIME GATEWAY · HANJIN



Innovation in low-carbon steel production

POSCO will continue to test and refine its low-carbon steel production technologies and processes with research support from top Indonesian universities.

UNIVERSITAS GADJAH MADA · KRAKATAU POSCO · POSCO · KRAKATAU STEEL

Hydrogen power storage and co-firing

Indonesian and Singaporean stakeholders will join forces to research and pilot hydrogen deployment methods in the power sector

PLN · UNIVERSITAS GADJAH MADA · SP group Empowering the Future of Energy · Keppel Corporation

Existing investment incentives and policy outlook

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Investment incentives

Several existing investment incentives can **lower the costs of developing green H_2 production facilities** and **R&D**:

- **Pioneer industries** tax holiday (incl. ammonia, renewables, possibly H_2)
- **Import duty exemptions** for renewable power projects
- **Tax allowance** (30% of net income) for geothermal power projects
- **Super tax deductions** for:
  - Vocational activities (200% of gross income)
  - R&D in new and renewable energy (NRE) (300% of gross income)

Enabling environment outlook

Indonesia has **limited policies and regulations in place** to support the development of low-carbon hydrogen supply and demand:

- 2014 National Energy Plan (KEN) targets NRE share in primary energy mix of 23% in 2025 and 31% in 2050
- National standard on hydrogen fuel safety, including for industrial use
- Ministry of Industry targets and luxury tax exemptions for FCEVs

However**, interest is high among key government entities** in green hydrogen, including:

- **Ministry of Energy and Mineral Resources** developing energy transition roadmap, including hydrogen capacity targets for power sector; MoU for production feasibility study
- **National Energy Council's** net zero roadmap projecting rapid increase in H_2 demand in transport sector

Many **enabling policies are in the works** and expected to roll out as Indonesia refines its plans to achieve net zero by 2060:

- 2021 Carbon Economic Value regulation **will expand CO_2 price to industry** in medium term
- 2017 National Energy Plan (RUEN) includes **action plan for hydrogen development**, including regulatory framework, technological and manufacturing capacity, and investment incentives

Stakeholder mapping: Financing prospects

In addition to the financial contribution from our commercial partners, hyDonesia procure financing from many sources, with a particular focus on development and climate funds keen to support Indonesia's decarbonization. A sample of potential financing sources is included below.

Source of finance		Description of the financial actor	Benefits to hyDonesia
Asian Development Bank	ADB	ADB provided a $500 million loan to support Indonesia's energy sector reforms to improve fiscal sustainability and expand private sector investments. ADB provides additional funding and risk guarantees for infrastructure projects via the ASEAN Catalytic Green Finance Facility	Increased **capital availability for the Indonesian government** to fiscally assist projects such as hyDonesia Will support hydrogen infrastructure and end-uses projects
WB Geothermal Resource Risk Mitigation (GREM)		650 million fund for finance, technical assistance, regulatory support and business models for geothermal projects in Indonesia 100M$ yet to be allocated	Will support **geothermal plant** with: - Project funding - De-risking of project finance - Regulatory process
Indonesia Infrastructure Guaranteed Fund		Run by Indonesian Ministry of Finance improves creditworthiness of infrastructure projects, including energy supply and distribution infrastructure	Secures **financial obligations** for hyDonesia's public partner, the MEMR
Commercial banks Pension funds Private finance	IIGCC	The public-private partnerhsips will ensure access to initial funding and de-risk the project which will facilitate attractive rates or debt packages from commercial actors. Indonesia's Just Transition Energy Partnership with industrialized countries includes a deal to facilitate access to 10bn$ of private finance through the Glasgow Financial Alliance for Net Zero	Closing of potential **financial gaps**

Conclusion: Breaking down the barriers

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While some may see Indonesia as a challenging market for hydrogen project development, we have identified a number of measures to mitigate major risks.

Type of barrier	Challenge to hyDonesia	Solution
International competitiveness	Competition risk from Australian hydrogen	Regional focus with pipeline transport, maximizing pipeline refurbishment, potential (Phase 1 = 500km / Phase 2 = 1,100km)
Weak domestic demand	Low purchasing power will inhibit penetration of retail-oriented technologies like FCEV; hydrogen green premium unaffordable; industries may pass costs on to domestic consumers	Initial focus on Singaporean market with stronger reislience to green premium; R&D to lower costs of hydrogen end-uses (steel); focus on export-oriented industrial customers
Lack of national enabling policies	Indonesia hydrogen policy still in nascent stage; existing environment favors competing fossil fuel-based technologies	PPP with MEMR and inclusion of SOEs to ensure political support and encourage policy development; long project development timeline to allow Indonesia to develop planned and new decarbonization policies
Availability of ressources	Extensive natural protected areas in South Sumatra may pose challenges for land acquisition	Geothermal production initially favored to limit land needs and customers are located in existing developed/urban areas
High investment risk	Indonesian market has relatively high investment risk; higher weighted average cost of capital and cost for developing renewables than neighboring countries	Securing demand from several project partners to reduce overall risk; targeting development finance institutions with higher risk appetite and more generous financing terms; seeking guarantees from Indonesian government institutions

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