MINISTRY OF ENERGY
AND ENVIRONMENTAL SUSTAINABILITY
SARAWAK

SARAWAK HYDROGEN ECONOMY ROADMAP (SHER)

2025

Sarawak Hydrogen Economy Roadmap (SHER)

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Foreword by

THE RIGHT HONOURABLE DATUK PATINGGI TAN SRI (DR) ABANG HAJI ABDUL RAHMAN ZOHARI BIN TUN DATUK ABANG HAJI OPENG

THE RIGHT HONOURABLE PREMIER OF SARAWAK AND MINISTER OF ENERGY AND ENVIRONMENTAL SUSTAINABILITY SARAWAK

- Hydrogen is emerging as a cornerstone of the global energy transition to decarbonisation and climate resilience. As nations accelerate hydrogen adoption, demand could reach 480 MTPA by 2050, reinforcing its role in achieving net-zero greenhouse gas (GHG) emissions. Guided by the Post COVID-19 Development Strategy 2030 (PCDS 2030), Sarawak is committed to integrating hydrogen solutions as a catalyst to economic prosperity, social inclusivity, and environmental stewardship. This strategy aligns with the United Nations Sustainable Development Goals (SDGs) and supports national ambitions for a low-carbon economy.

- Green and blue hydrogen are at the forefront of Sarawak's hydrogen economy, with applications across industry, transport, power, and buildings. Momentum is building globally with progressive policies shaping Sarawak's hydrogen transition (i.e., PCDS 2030, National Energy Transition Roadmap, National Hydrogen Economy & Technology Roadmap) and flagship projects (e.g., H2biscus, H2ornbill projects). Strategic investments in hydrogen-fuelled transport (via ART and MFS projects) will also enhance domestic H_2 utilisation and strengthen energy security.

- In response to this opportunity, the Sarawak Hydrogen Economy Roadmap (SHER) articulates a clear policy direction, anchored on five strategic initiatives and five enablers. This roadmap ensures economic competitiveness in the low-carbon economy, setting key interim milestones towards unlocking clean hydrogen production potential. Developed in tandem with the Sarawak Energy Transition Policy (SET-P), it guarantees policy coherence and long-term sustainability.

- With Sarawak's geographical advantage and proximity to key regional markets, the state is uniquely positioned to emerge as a competitive clean hydrogen exporter. Realising this vision requires a whole-of-government approach to unlock inclusive economic opportunities, improve livelihoods, and secure long-term sustainability. By advancing low-carbon energy solutions and embracing innovation, Sarawak reaffirms its commitment to responsible energy leadership and supporting a sustainable energy transition.

Preface by

THE HONOURABLE DATUK DR HAJI HAZLAND BIN ABANG HAJI HIPNI

THE DEPUTY MINISTER OF ENERGY AND ENVIRONMENTAL SUSTAINABILITY SARAWAK

- The Sarawak Hydrogen Economy Roadmap (SHER) represents a pivotal step forward in realising Sarawak's aspiration to lead in clean hydrogen, while catalysing local socio-economic development and forging global partnerships. Building on Sarawak's rich resource base, SHER outlines actionable pathways for translating potential into tangible outcomes—especially in empowering local industries, strengthening supply chains, and nurturing human capital in emerging hydrogen technologies.

- Developed through close collaboration across ministries, agencies, and stakeholders, this roadmap reflects a unified commitment to integrated policymaking and effective governance. It charts a clear course for aligning infrastructure planning, investment facilitation, and regulatory readiness in support of the hydrogen ecosystem.

- As the Ministry responsible for energy development in Sarawak, we are dedicated to ensuring that SHER is not just a policy document, but a living framework that will guide implementation, monitor progress, and adapt to emerging opportunities. This strategic blueprint will anchor Sarawak's efforts to ensure affordability, accessibility, and sustainability in our energy transition.

- I extend my sincere appreciation to The Right Honourable Premier, members of the SHER Working Committee, and the various public and private sector stakeholders for their dedication and partnership in shaping this landmark roadmap. Together, we are laying the groundwork for a resilient and inclusive hydrogen economy for Sarawak.

Executive summary

Executive summary

Globally, **clean hydrogen is emerging as a key solution to drive decarbonization for many countries**. There is a **broad range of sources and production methods for hydrogen production with green and blue hydrogen being the most relevant for Sarawak**. Hydrogen can be utilized in various sectors including Industry, Transport, Power and Buildings. Global momentum is trending upwards with many countries adopting its own hydrogen strategy. Furthermore, **global hydrogen demand could potentially reach up to 430 MTPA by 2050 in a global net zero scenario depending on the pace of the energy transition.**

There is a **clear opportunity for Sarawak** to take advantage of the emerging trend of clean hydrogen production. This can already be observed the **existing policies** that promotes the development of the **hydrogen economy in Malaysia and Sarawak** (i.e., Post-COVID Development Strategy, National Energy Transition Roadmap, Hydrogen Economy & Technology Roadmap) as well as **ongoing development of projects (e.g., H2biscus, H2ornbill projects). The development of hydrogen as a fuel for transport (via ART and MFS projects) bodes well with the need to ensure domestic H_2 utilization within Sarawak** for greater energy security.

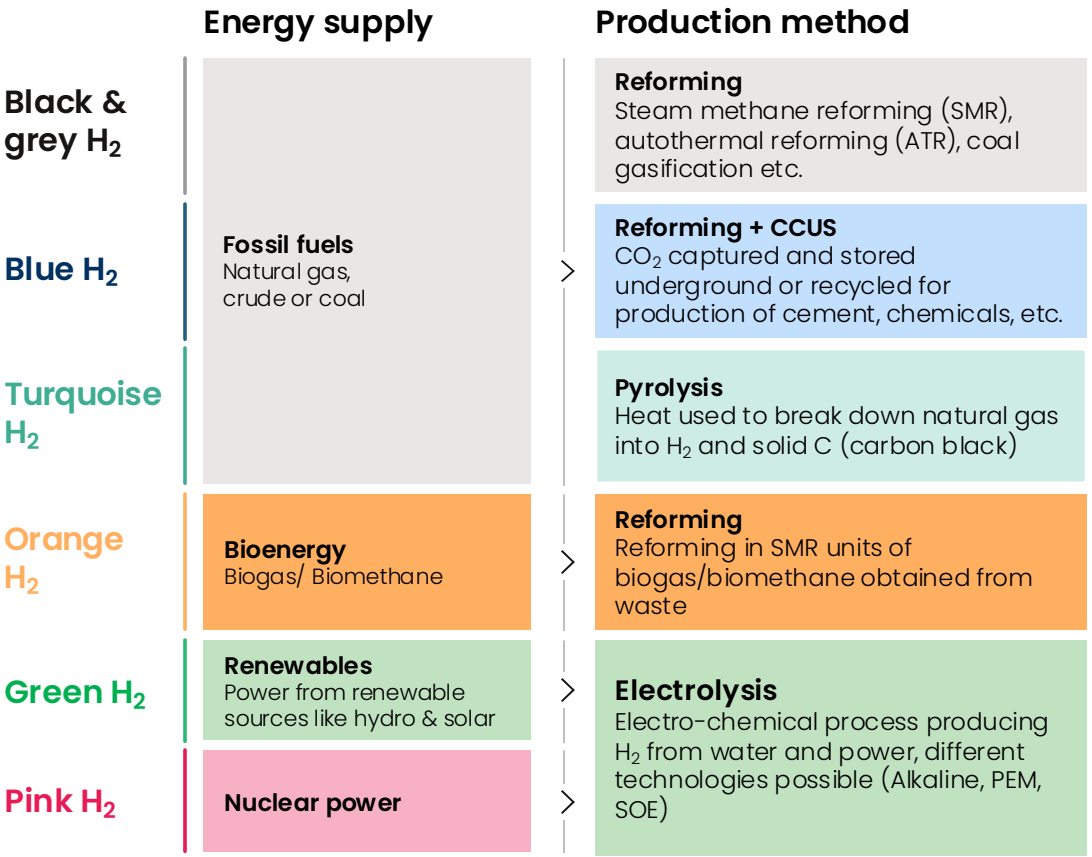
The Sarawak Hydrogen Economy Roadmap (SHER) sets out a clear path forward for the state on the key targets and outcomes that should be strived to be achieved by 2035 and beyond, with key interim milestones. The strategic thrusts under SHER addresses key elements: **lowering the cost of H_2 production** to be cost competitive via hub development; **generating long-term local and international demand** for Sarawak's clean hydrogen; and ensuring **holistic development of world-class H_2 infrastructure** along the value chain. The **development of Sarawak's clean hydrogen economy needs to be balanced** with **key considerations such as energy security, social factors and energy utilization for other.**

There are five key enablers that are critical elements or conditions that facilitate the achievement of the goals set out in the roadmap. The key enablers under SHER: **Governance and Regulations, Financing & Investment, Infrastructure, Technology & Innovation, Workforce and Skilling** highlight the key efforts needed to facilitate Sarawak's clean hydrogen development. These enablers support **5 key policy initiatives that addresses the existing barriers of hydrogen development.** Understanding and strategically deploying these enablers will significantly increase the likelihood of development of thriving hydrogen economy in Sarawak.

Background and **Context**

Broad range of sources and production methods for hydrogen production with a wide variety of applications

HYDROGEN PRODUCTION METHODS



1. Primarily for enhanced oil recovery (EOR) today
Source: Kraussler, 2018; Yao et al., 2017; IEA Bioenergy 2018; IEA

Hydrogen is an energy carrier with high energy density, storable, and has the potential to be produced with low to no carbon emissions.

It can be produced from various sources making it a versatile component in the global energy transition. The different production methods for hydrogen are shown in Exhibit 1, with green and blue hydrogen being the most relevant for Sarawak.

Green hydrogen is produced through a process called electrolysis, which involves splitting water into hydrogen and oxygen using renewable energy sources.

Blue hydrogen, on the other hand, is produced using natural gas through a process called Steam Methane Reforming (SMR), combined with Carbon Capture, Utilization, and Storage (CCUS) to reduce carbon emissions.

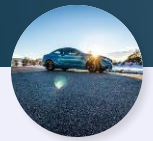
Switching to clean hydrogen can support decarbonization in many sectors

Hydrogen can be considered to replace high-carbon sources in various sectors

INDUSTRY

Hydrogen can be used as a feedstock in industries such as steel production, ammonia production, and refineries.

It helps decarbonize these hard-to-abate sectors by replacing fossil fuels in high-temperature processes and chemical reactions.



TRANSPORT

Hydrogen is being explored to be used in fuel cell vehicles, including private cars, buses, taxis, and trucks.

Moreover, hydrogen is being explored as a fuel for long-distance shipping and aviation due to its high energy density and potential to reduce emissions.

POWER

Hydrogen can be used in fuel cells and hydrogen-fueled gas turbines to generate electricity.

At the same time, hydrogen can be used for long-term and seasonal energy storage, helping to balance supply and demand in renewable-based electric systems.

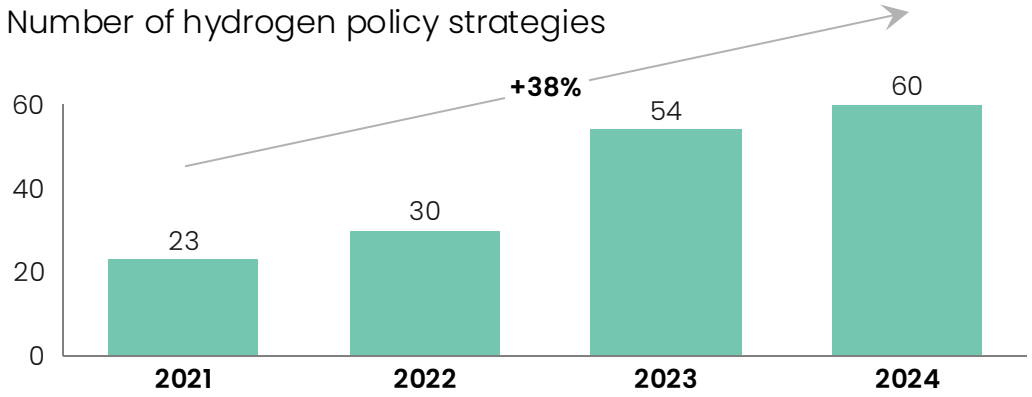
BUILDINGS

Hydrogen can be used for heating and power generation in buildings. It can replace natural gas in boilers and be used in fuel cells for residential and commercial heating.

However, this application is still in the early stages and faces challenges related to cost and infrastructure.

The global momentum for the hydrogen economy is growing

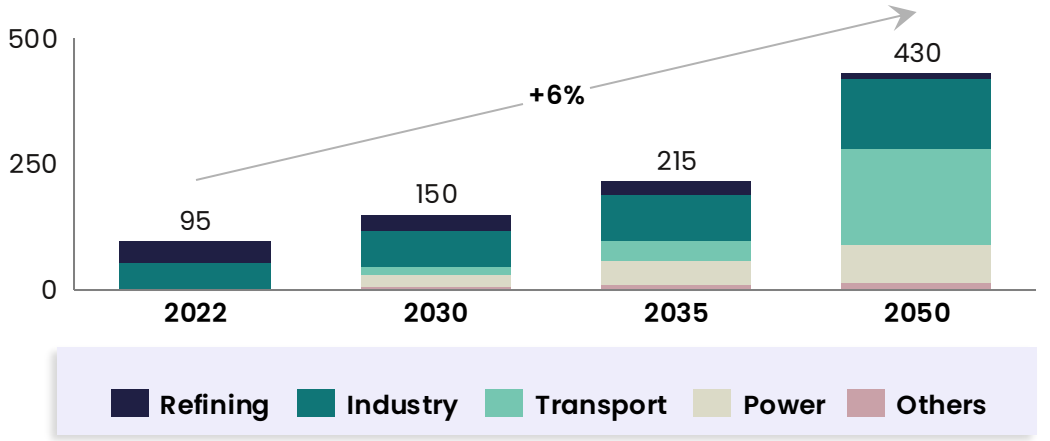
GLOBAL GROWTH OF HYDROGEN POLICY STRATEGIES



58 governments, along with the EU and the Economic Community of West African States—representing >84% of global energy-related CO_2 emissions—have now implemented hydrogen strategies.

This demonstrates growing global interest in hydrogen which requires strong implementation of policy to ensure sustained development.

GLOBAL HYDROGEN DEMAND PROJECTIONS *(2050 NET ZERO EMISSIONS SCENARIO)*



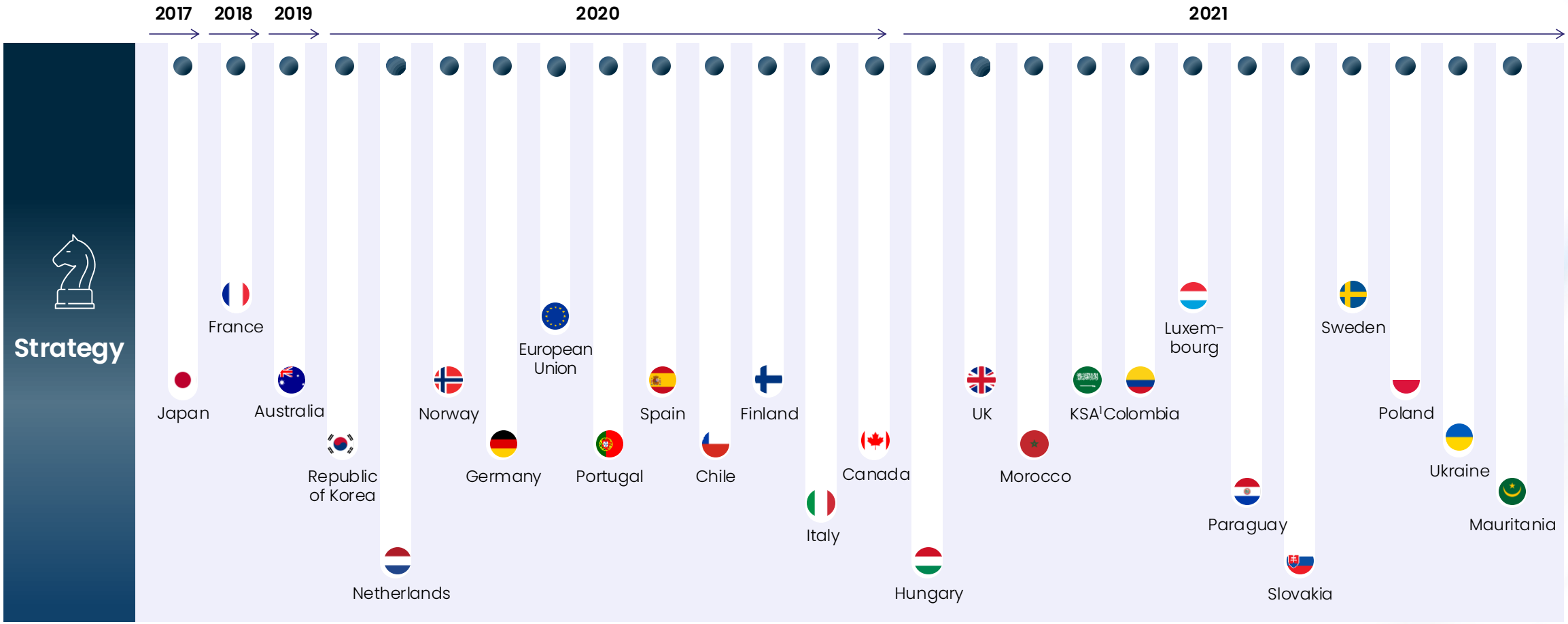
Hydrogen will have a key role to play in supporting global decarbonization efforts as it can be utilised in different sectors and industries.

New applications of hydrogen in Transport, Industry and Power will be critical in scaling total global demand until 2050.

Source: Global Hydrogen Review 2024 (IEA), Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach (IEA, 2023)

Global regulatory overview: Increased momentum globally today with 60+ countries releasing H_2 ambition and many more to come (I/II)

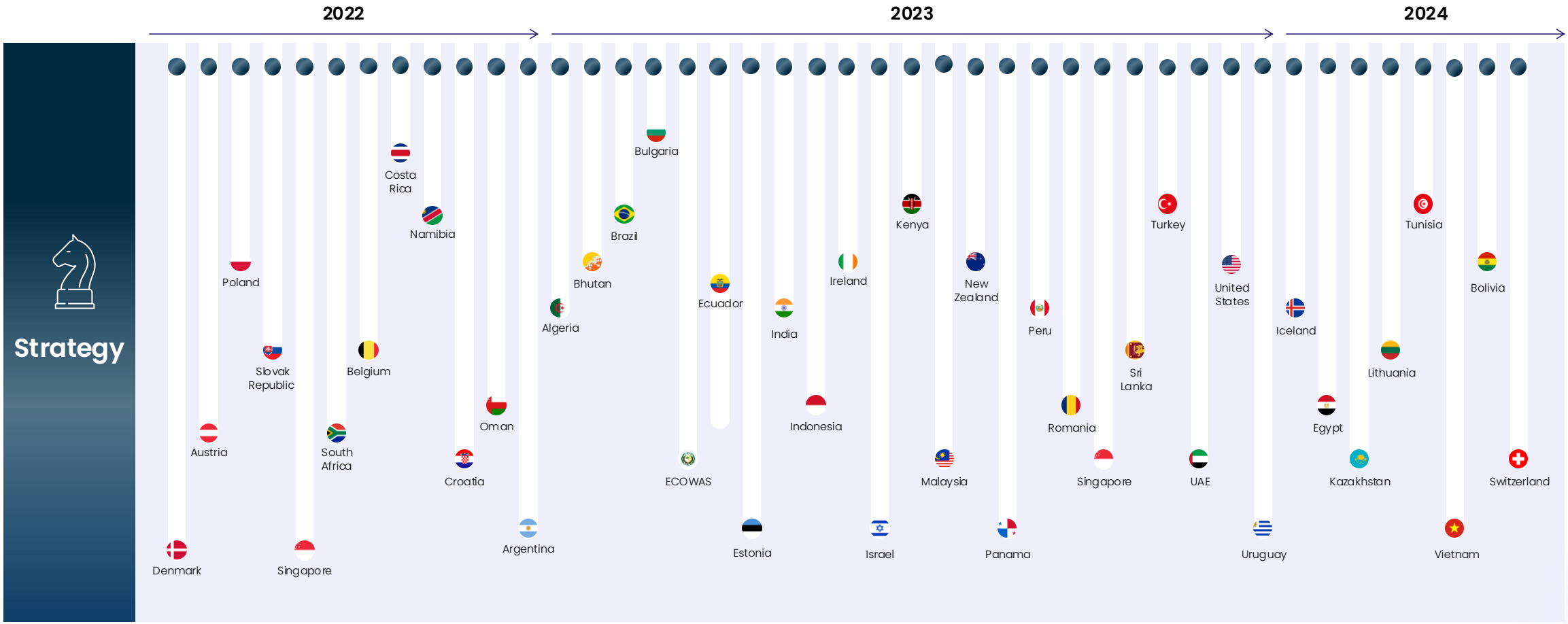
STRATEGIC POLICY DOCUMENTS ON HYDROGEN ECONOMY LAUNCHED BETWEEN 2017-2024



1. Strategies not public yet
Source: IRENA; GlobalData; WEC; IEA; Press search

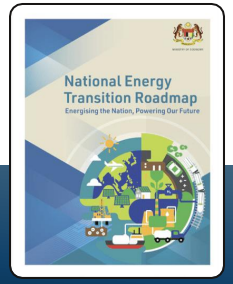
Global regulatory overview: Increased momentum globally today with 60+ countries releasing H_2 ambition and many more to come (II/II)

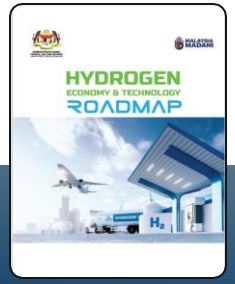
STRATEGIC POLICY DOCUMENTS ON HYDROGEN ECONOMY LAUNCHED BETWEEN 2017-2024

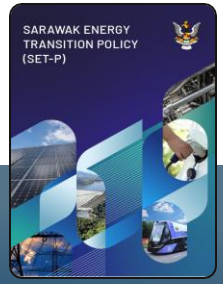


1. Strategies not public yet
Source: IRENA; GlobalData; WEC; IEA; Press search

Sarawak is accelerating its push for a thriving hydrogen economy, **building on strong policy momentum**







	POST COVID-19 DEVELOPMENT STRATEGY 2030	NATIONAL ENERGY TRANSITION ROADMAP (NETR)	HYDROGEN ECONOMY & TECHNOLOGY ROADMAP (HETR)	SARAWAK ENERGY TRANSITION POLICY (SET-P)
KEY HIGHLIGHTS	**Sarawak's hydrogen economy initiatives:** • Attract investment for H_2 production and value chain • Establish hydrogen refueling station network • Power Automated Rapid Transit (ART) with hydrogen fuel	Key national targets for hydrogen: • **Blue H_2**: Phase out grey H_2 use by 2050 • **Green H_2:** Achieve 2.5 Mtpa production from RE by 2050 • **Low-Carbon H_2 Hubs:** Establish one hub by 2030 and expand to three by 2050	**Strategic thrusts:** • Institutionalize a national hydrogen governance system & regulatory mechanism • Accelerate circular hydrogen economy to drive market integration • Accelerate commercialization of tech to enable export and domestic uptake • Develop skilled hydrogen workforce • Foster hydrogen economy awareness	Unified framework for energy sector transformation: • Considers the state's specific context and consolidates existing energy sector strategies • Stimulate Sarawak's hydrogen economy and become a regional hydrogen leader • Capitalise on Sarawak's abundant renewable energy resources and fast-developing carbon capture capabilities

Distribution of Gas (Amendment) Ordinance 2024 established in Sarawak to Regulate Hydrogen

Distribution of Gas (Amendment) Ordinance 2024

Clear, strong framework for hydrogen generation, storage, distribution, and use across Sarawak

Scope Expansion: Establish a comprehensive legal framework for hydrogen generation, storage, distribution, and utilisation across the state

Dedicated Regulator: Appointment of a dedicated Regulator to administer all hydrogen-related activities within Sarawak, from generation and storage to distribution, both domestically and for export

Standards: New licensing requirements to ensure hydrogen operations meet safety and sustainability standards

Consequence Management: Strengthens penalties for unlicensed activities and regulatory non-compliance, emphasizing Sarawak's commitment on the enforcements oversight

Sarawak's ongoing clean hydrogen projects present a strong opportunity to drive further growth of the industry

Kuching Urban Transportation System (KUTS)

KUTS targets to utilize 5 tons of H_2 daily, supplied by SEDC Energy's Rembus H_2 Plant to power the autonomous rapid transit (ARTs) and H_2 powered feeder buses.

Project H2biscus

H2BISCUS

SEDC ENERGY · LOTTE CHEMICAL · SAMSUNG E&A · KNOC

Samsung E&A, Korea National Oil Corporation, Lotte Chemical in partnership with SEDC Energy in Bintulu region aims to produce green hydrogen, exported in the form of ammonia.

Miri

Project H2ornbill

H2ornbill

SEDC ENERGY · Sumitomo Corporation · ENEOS

Sumitomo, in cooperation with ENEOS and SEDC Energy, in the Bintulu region aim to produce green hydrogen per year, exported as methyl cyclohexane (MCH).

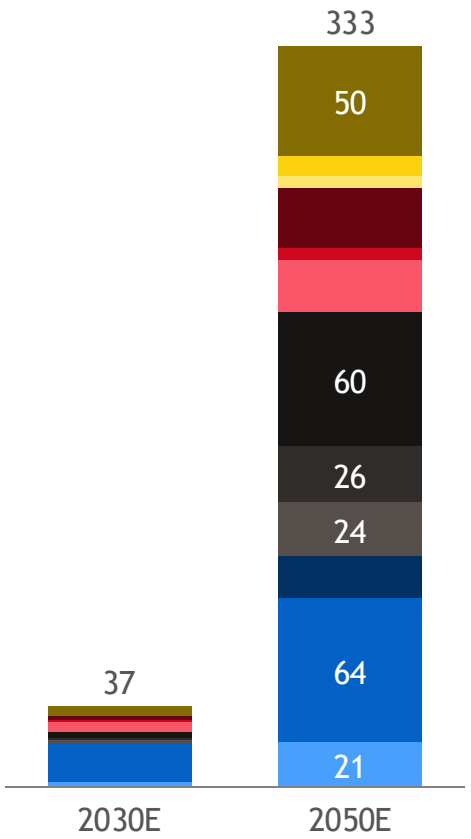
Bintulu

Kuching

MFS (Multifuel Refueling Station)

- 1 MFS in operation and ready to commercially supply H_2 by 2025.
- By 2030, 6 MFSs planned to be constructed strategically across Sarawak.

On the international front, **Japan, Korea and Singapore** likely importers of low-carbon H_2 due to their limited renewable potential



Region	Market conditions to supply	Key import market?
North America	Favorable PV and wind, cheap gas, CCUS potential	✗ Likely exporter
South America	Favorable PV and wind	✗ Likely exporter
Africa	Favorable PV and wind	✗ Likely self-sufficient
Middle East	Favorable PV and wind, cheap gas, CCUS potential	✗ Likely exporter
Oceania	Favorable PV and wind, CCUS potential	✗ Likely exporter
India	Favorable renewables potential	? Uncertain
China	Favorable renewables potential, large investments	? Uncertain
Japan	Limited natural resources and renewables potential	✓ Likely major importer
South Korea	Limited natural resources and renewables potential	✓ Likely major importer
Rest of Asia	Fragmented smaller markets, favorable RE potential	✓ Low import to SG
Western Europe	Limited RE and CCUS potential particularly DE and NL	✗ Likely supplied by ME
Rest of Europe	More favorable renewables potential	✗ Likely self-sufficient

1. Hydrogen-derivative fuels are normalized to hydrogen equivalent. Note: scenario used SDS = Sustainable Development Scenario
Source: IEA World Energy Balances; GlobalData; Nexant

Our priorities for the **Sarawak Hydrogen Economy**

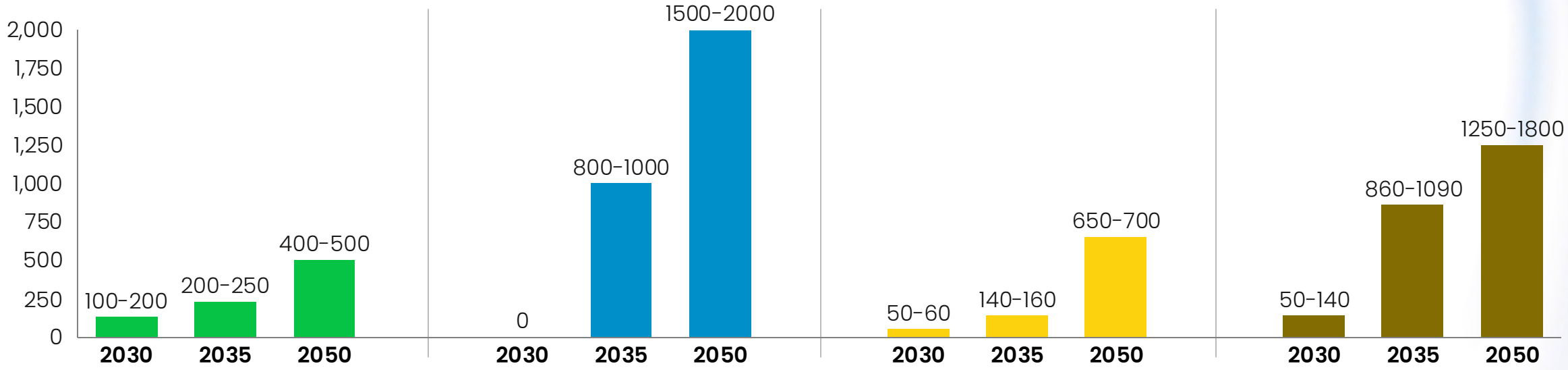
Sarawak is taking a structured and phased approach to unlock the potential of clean hydrogen

GREEN HYDROGEN POTENTIAL (ktpa)

BLUE HYDROGEN POTENTIAL (ktpa)

DOMESTIC HYDROGEN CONSUMPTION POTENTIAL (ktpa)

HYDROGEN EXPORT POTENTIAL (ktpa)



Development of blue hydrogen is subject to development of CCS storage and infrastructure, optimal economics, off-taker agreements and implementation of supporting policies, which forms the basis of Sarawak Hydrogen Economy Roadmap (SHER)

SHER has the potential to generate **positive socioeconomic outcomes**

	CUMULATIVE GDP UPLIFT GENERATED[1]	SUBSTANTIAL NUMBER OF JOBS CREATED[2]	INVESTMENT OPPORTUNITIES GENERATED
Short-term *(by 2030)*	RM **15** Bn	**4–5**k new jobs created	RM **10–15** Bn
Medium-term *(by 2035)*	RM **40** Bn	**5–6**k new jobs created	RM **20–25** Bn
Long-term *(by 2050)*	RM **90** Bn	**9–10**k new jobs created	RM **50–60** Bn

1. GDP impact vs. 2023 baseline levels 2. New additional jobs created vs. 2023 baseline levels

Major domestic industries that can potentially utilize hydrogen in Sarawak

INDUSTRY


Iron & Steel


Cement


Alumina


Glass


Semiconductors

PETROCHEMICALS


Ammonia


Methanol

TRANSPORT


Public transport


Heavy transport


Shipping

TRANSVERSAL (FUELS)


Synthetic Methane


Synthetic Diesel


Synthetic Jet Fuel

Our vision for **Sarawak's hydrogen economy**

The Sarawak Hydrogen Economy Roadmap aims to position Sarawak as a regional clean hydrogen leader

VISION

SARAWAK AS A REGIONAL CLEAN HYDROGEN LEADER

STRATEGIC INITIATIVES

- Achieve competitive H_2 production costs via large-scale hub development
- Stimulate and accelerate domestic uptake of clean H_2
- Secure long-term clean H_2 demand via international offtakes
- Establish the Sarawak Certification Platform for Hydrogen
- Advance development & commerciality of critical technologies

KEY ENABLERS

- Governance & Regulations
- Financing & Investment
- Infrastructure
- Technology & Innovation
- Workforce & Skilling

Source: Global Hydrogen Review 2024 (IEA), Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach (IEA, 2023)

The goal of the roadmap is to establish **Sarawak as a leading hydrogen producer and supplier in the APAC region**

By leveraging its abundant **renewable energy sources,** particularly in hydropower and solar power, along with **natural gas resources and Carbon Capture & Storage (CCS) technology**, Sarawak aims to

- Become a cost-competitive clean hydrogen hub with large-scale production capacity
- Expand domestic and international hydrogen adoption, fostering demand in various industries
- Position itself as a major exporter of clean hydrogen, meeting global decarbonization goals

Key initiatives of **SHER**

The Sarawak Hydrogen Economy Roadmap aims to position Sarawak as a regional clean hydrogen leader

VISION

SARAWAK AS A REGIONAL CLEAN HYDROGEN LEADER

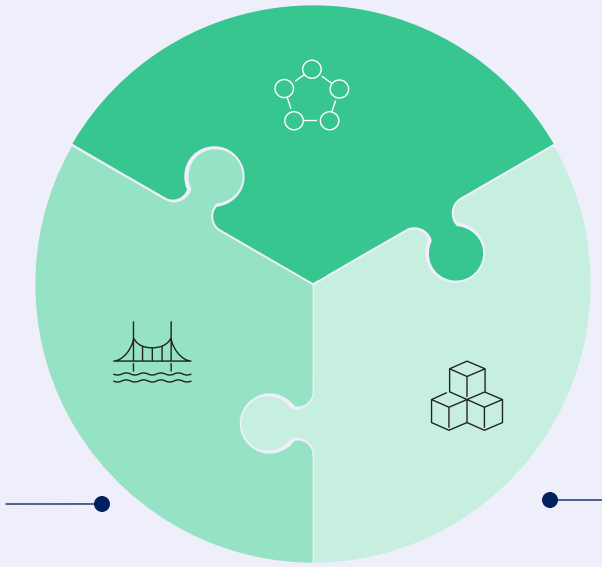
STRATEGIC INITIATIVES

1. Achieve competitive H_2 production costs via large-scale hub development
2. Stimulate and accelerate domestic uptake of clean H_2
3. Secure long-term clean H_2 demand via international offtakes
4. Establish the Sarawak Certification Platform for Hydrogen
5. Advance development & commerciality of critical technologies

Source: Global Hydrogen Review 2024 (IEA), Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach (IEA, 2023)

Initiative #1: Reduce cost of hydrogen production through hub development

Design streamlined regulatory and permitting process to enable seamless development of hydrogen hubs

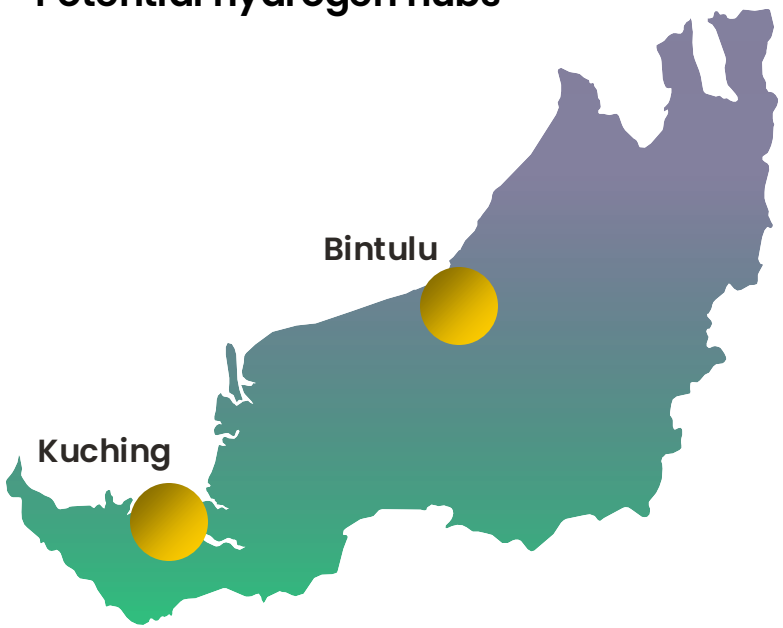


Upgrade and expand the port facilities in Bintulu and Kuching to support the export of hydrogen derivatives to international markets

Consolidate infrastructure for hydrogen production to lower the initial capital costs and enable economies of scale for clean hydrogen

Key success factors to be considered in the development of Sarawak's hydrogen hubs

Potential hydrogen hubs



Value-Driven Approach

- Hubs must stand on a solid business case while ensuring a commercially viable structure that fosters real opportunities for developers

Public Sector Backing

- Securing early commitment from state leaders is crucial for visibility, stakeholder buy-in, and the success of multi-state partnerships

Strong Leadership

- Given the complexity of Hub initiatives, a decisive leader is essential to set timelines, drive decisions, and ensure accountability across stakeholders

Societal Impact at the Forefront

- Evaluate job creation and GDP growth alongside techno-economics, ensuring these impacts are central to the Hub's narrative

Strategic Location Advantage

- Leverage proximity to low-cost natural resources and robust transport & storage infrastructure, while ensuring value chain coverage and technology choices

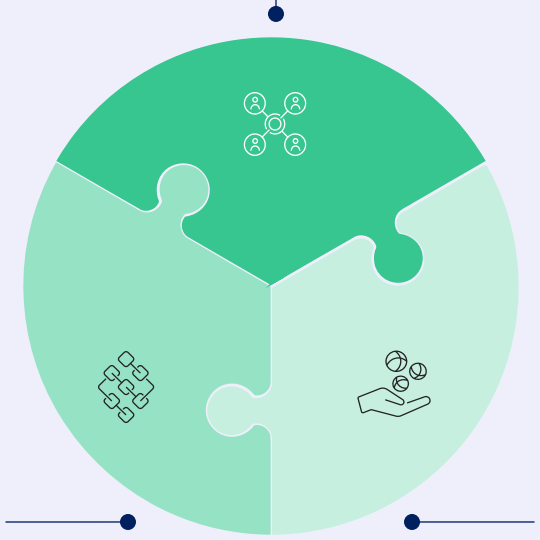
Access to Green Capital & Smart Financing

- Tap into both public and private funding sources, ensuring enough public investment to bridge gaps and drive success

Initiative #2: Drive local hydrogen demand stimulation for industries in Sarawak

Collaborate closely with industry to identify barriers to hydrogen adoption in prospective domestic sectors, such as steel, chemicals, refining, and transport

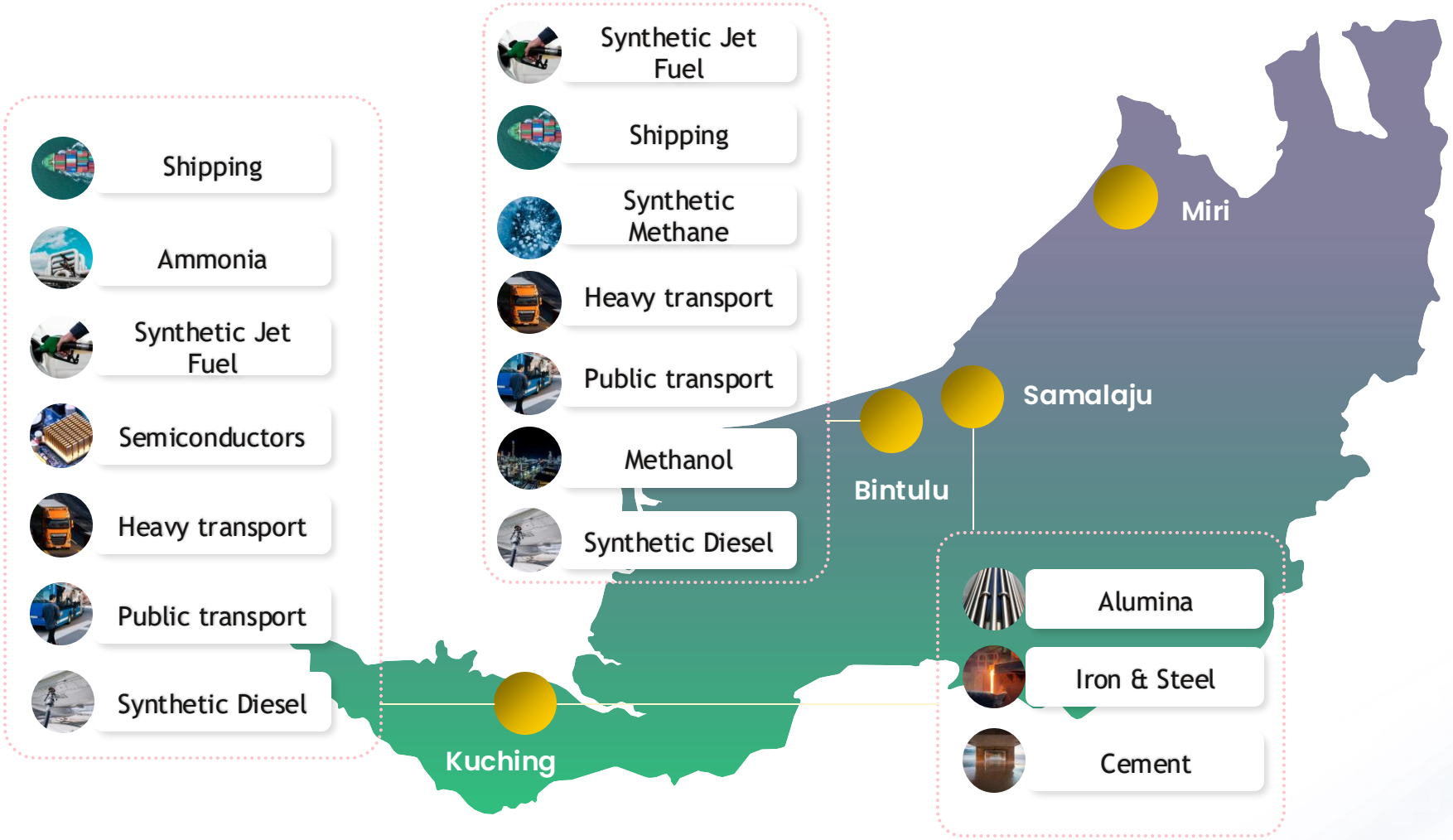
Design schemes to attract investors to develop downstream value chain in Sarawak to utilise clean hydrogen for various applications (e.g., clean ammonia/methanol/SAF)



Explore and design targeted incentive schemes for industries to switch to hydrogen, in alignment with federal schemes (e.g., Green Investment Tax Allowance (GITA) and Green Income Tax Exemption (GITE))

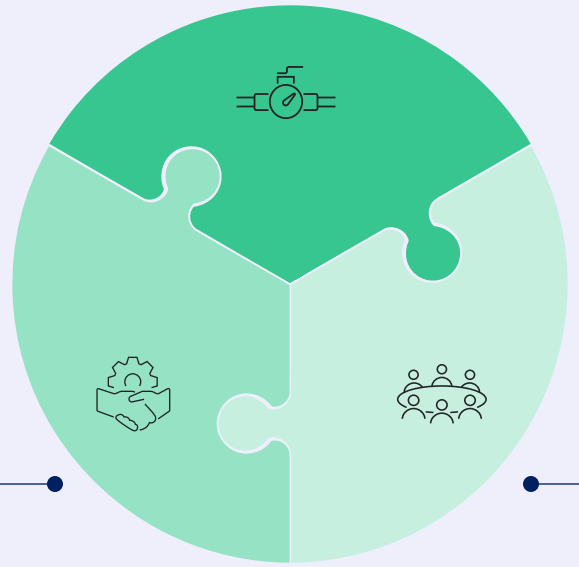
Major domestic industries that can potentially utilize hydrogen in Sarawak

Illustrative



Initiative #3: Ensure steady and long-term demand for hydrogen production

Negotiate long-term hydrogen supply contracts with key markets, such as South Korea, Japan, and Singapore, to ensure a steady demand for Sarawak's clean hydrogen



Initiate discussions with key markets to present Sarawak's hydrogen export value proposition

Strengthen trade partnerships to create a stable and predictable hydrogen export market for Sarawak

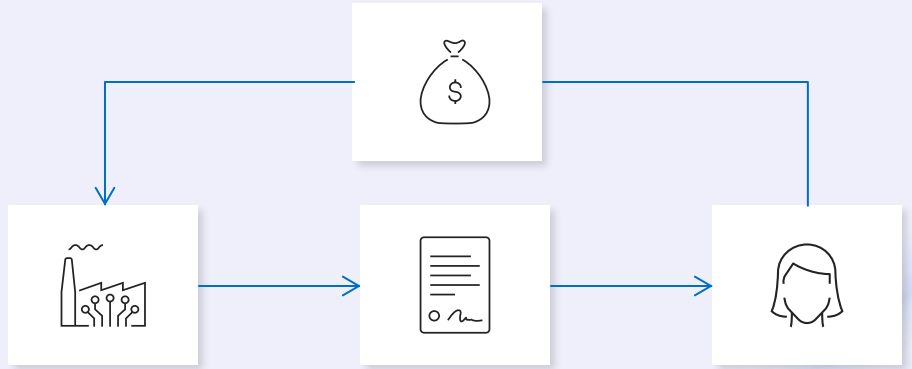
Long-term offtake agreements **for hydrogen can help to catalyze funding for projects and provides certainty over demand**

LONG TERM OFFTAKE AGREEMENTS WITH CREDITWORTHY COMPANIES HELP PROVIDE CASH FLOW CERTAINTY

Ideal offtake agreements will have four key provisions to limit risk

- **Extended duration**, generally 15+ years, to guarantee cash flows required to hit IRR targets
- **Fixed purchase price** to minimize market pricing volatility
- Credit-worthy/**investment grade off-takers** to remove counterparty risk
- **Minimum contracted quantity** wherein off-takers are committed to purchase specific output in order to limit plant curtailment

SARAWAK GOVERNMENT ACTIVELY SUPPORT ARRANGEMENTS FOR ENABLING THE LONG-TERM OFFTAKE AGREEMENTS IN HYDROGEN



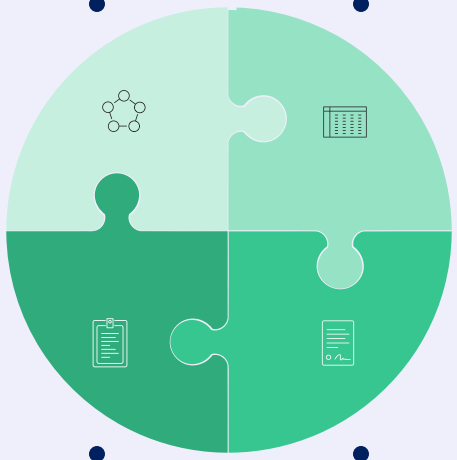
Source: Expert interviews

Initiative #4: Provide certainty on the low-carbon credentials of hydrogen produced

ESTABLISH THE SARAWAK CERTIFICATION PLATFORM FOR HYDROGEN

Adopt a system to account for GHG emissions and other critical data from the production and export of hydrogen

Centralize the platform streamlining data input from operators to provide standardized certification outputs for export destinations



Enhance investor confidence through a standardized, government-backed certification system

Ensure alignment with global hydrogen certification standards, enabling Sarawak's hydrogen to be accepted in key international markets

Sarawak can lead the charge in clean hydrogen by setting clear standards and implementing robust carbon accounting systems

01

DEFINITION OF HYDROGEN

Countries differ in their definition of hydrogens within their respective regulatory framework.

Sarawak has clearly defined hydrogen under the passing of the Distribution of Gas (Amendment) Ordinance 2024 which expands the definition of gas to include Hydrogen.

02

CARBON ACCOUNTING SYSTEM

Two common carbon accounting boundaries utilized:

- Well-to-gate: Target the hydrogen upstream process all the way to its point of production.
- Well-to-wheel: Also include the transport and possible conversion of hydrogen, reconversion of hydrogen into other carriers and the final use of hydrogen.

Sarawak will study to ensure appropriate system is in place for boundaries on carbon accounting.

03

ELIGIBLE TECHNOLOGIES

Typically, eligible technologies for each hydrogen standards are defined. Examples for each includes:

"Green" hydrogen: Electrolysis of water using renewable energy sources.

"Blue" hydrogen: Combination of CCUS with methods of producing grey hydrogen.

04

CARBON INTENSITY (CI)

Sarawak will study an appropriate carbon intensity threshold to set for broad spectrum of low-carbon hydrogen.

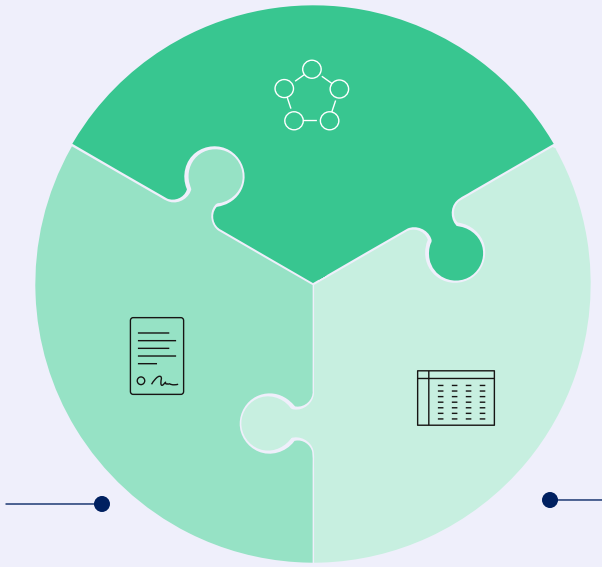
Existing standards have a carbon intensity threshold in gCO2e/unit of hydrogen (in energy or mass).

The CI will differ depending on the choice of (1) types of hydrogens, (2) system boundaries, and (3) technology/production pathways used.

Initiative #5: Ensure targeted efforts in clean hydrogen development to directly support clean hydrogen production

Collaborate with industry players to drive research and development (R&D) initiatives on hydrogen value chain advancements, including the development of critical technologies such as hydrogen fuel cell component parts

Explore and research downstream applications for clean hydrogen in prospective sectors to demonstrate feasibility and scalability



Initiate pilot projects in selected sectors to test clean hydrogen applications and showcase real-world feasibility

Establishing a **Centre of Excellence for R&D and innovation** in Sarawak can bridge research with real-world issues to drive practical solutions for hydrogen development

THIS COE CAN ENDEAVOR TO ACHIEVE 3 KEY OBJECTIVES

STRATEGIC ALIGNMENT TO ADDRESS STATE CHALLENGES

Match the appropriate research and innovation activities with the specific energy transition challenges that need to be addressed

01

STRATEGIC PARTNERSHIP ACQUISITION

Attract strategic partners to provide technical and technological support for research and innovation development

02

EXTENSIVE INNOVATION NETWORK ESTABLISHMENT

Create innovation network of specialised nodes, each dedicated to a specific research priority, ensuring coverage of energy transition areas

03

Key enablers of **SHER**

The Sarawak Hydrogen Economy Roadmap aims to position Sarawak as a regional clean hydrogen leader

VISION

SARAWAK AS A REGIONAL CLEAN HYDROGEN LEADER

KEY ENABLERS

- Governance & Regulations
- Financing & Investment
- Infrastructure
- Technology & Innovation
- Workforce & Skilling

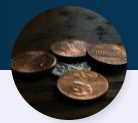
Source: Global Hydrogen Review 2024 (IEA), Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach (IEA, 2023)

These **key enablers** will provide the necessary support to sustain long-term hydrogen development in Sarawak

These enablers are developed in detail under the Sarawak Energy Transition Policy (SET-P)

GOVERNANCE & REGULATIONS

- Designate a single regulatory entity
- Develop, implement and enforce ordinances across the value chain
- Set up clean hydrogen working team



FINANCING & INVESTMENT

- Promote targeted incentive schemes for H2 technology adoption
- Aim to attract international investors and financial institutions

INFRASTRUCTURE

- Support physical infrastructure development through funding
- Ensure adequate build out for pipeline and storage
- Encourage public-private partnerships to accelerate infrastructure development

TECHNOLOGY & INNOVATION

- Ensure sufficient support provided to drive R&D efforts
- Reduce costs - drive advancements in electrolysis efficiency
- Support innovation in fuel cell applications for transportation and industrial use

WORKFORCE & SKILLING

- Develop specialized hydrogen training programs
- Equip the workforce with relevant skills
- Partner with universities and technical institution
- Develop certification programs in H_2 technology

Governance & Regulations: Regulate key aspects in the development of clean hydrogen, as part of Distribution of Gas (Amendment) Ordinance, 2024

Regulation and Licensing

- Oversee the regulation and licensing processes for hydrogen and hydrogen derivatives for generation, distribution, transportation and utilization
- Ensure compliance with safety standards, approve tariffs, and grant licenses for clean hydrogen projects

Market Oversight and Competition

- Promote the development of competitive, flexible, and secure clean hydrogen markets by eliminating trade restriction and fostering market integration
- Establish and review the certification standards for clean hydrogen, ensure alignment with trading partners

Policy Development and Coordination

- Align renewable expansion capacity with clean hydrogen production goals
- Ensure alignment of hydrogen development with policies
- Enforce ordinance in respect of the efficiency, economy and safety for the supply of hydrogen distribution

Governance & Regulations: A comprehensive governance structure to drive the implementation of SHER

ROLE & RESPONSIBILITY

Sarawak Energy Council (SEC)

- Executive policy and strategic decision-making on key areas for Sarawak's clean hydrogen development with respect to overall energy transition
- Members: Chaired by Sarawak Premier with senior ministers and stakeholders

Hydrogen Regulatory Authority

MEESty

- Authority to issue licenses for activities such as H_2 generation; building/maintaining a H_2 generation facility; use of premises, building, installation or land for H_2 storage; the distribution, H_2 transportation within Sarawak/for export; and sale, retail and utilization or use of H_2
- Promote economic development of Sarawak's H_2 industry and its export
- Promote investment in the generation and utilization of hydrogen
- Authority to impose financial penalties for non-compliance with Distribution of Gas (Amendment) Ordinance, 2024

Clean Hydrogen Ministries and Agencies Working Team

MEESty MUT MINTRED MIPD MEITD SFS SAGC

- Team comprised of government and agencies members and key private sector stakeholders
- Collaborate with implementation leads to drive the execution and implementation of clean hydrogen initiatives and projects
- Provide support to SEC secretariat on information collation to track energy transition progress
- Provide regular progress updates to MEESty and SEC on H_2 development

Policy incentives that can be considered to catalyze H_2 production and demand across value chain by lowering production costs

Range of incentives/subsidies applicable along the H_2 value chain that have been leveraged globally

H_2 PRODUCTION

- Land allocation
- Production tax credits
- O&M subsidies
- Direct financing/subsidies
- Loan guarantees
- Price guarantees/CfD (auctions)

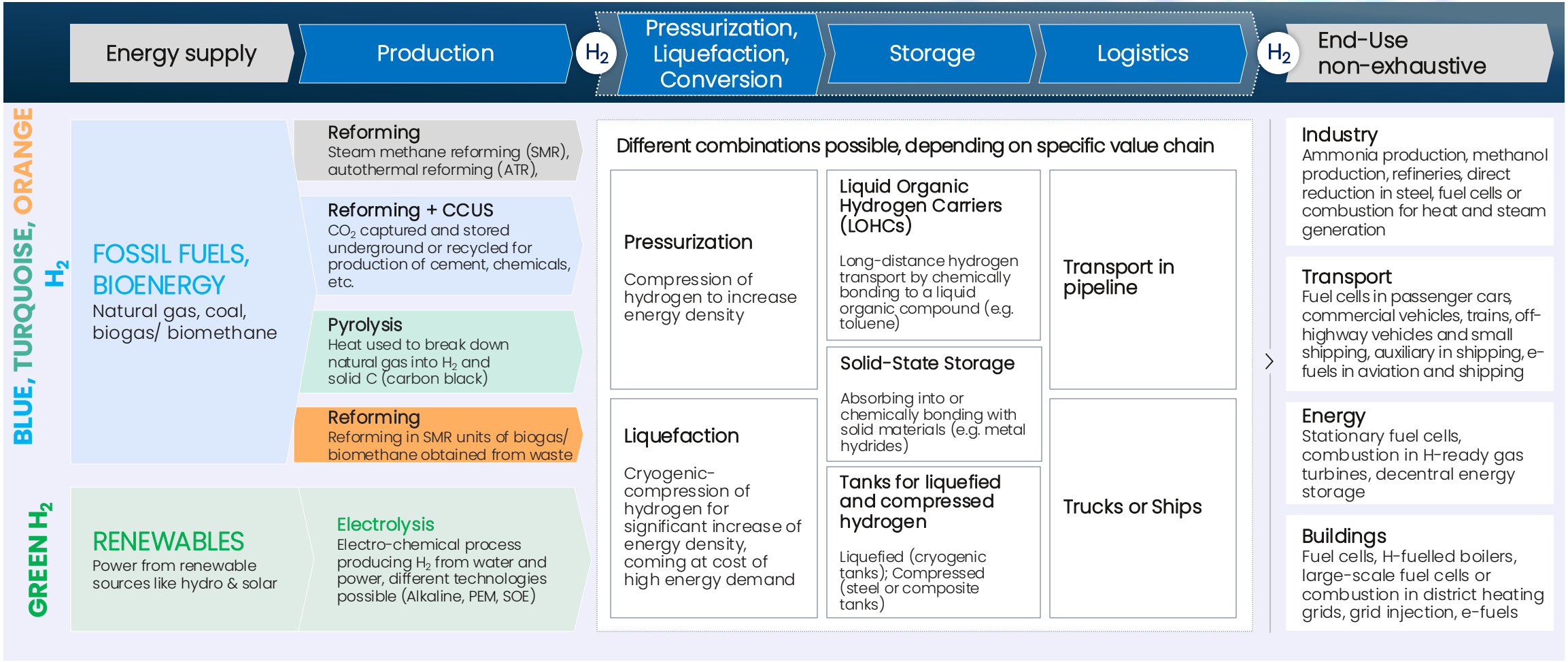
H_2 TRANSPORT, INFRASTRUCTURE AND LOGISTICS

- H_2 pipeline investment financing/subsidy
- Export financing
- Hydrogen storage investment financing/subsidy
- Land allocation/urban planning
- Hydrogen Transportation Tax Credits
- Hydrogen Storage Tax Credits
- Hydrogen Transportation O&M Subsidies
- Hydrogen Storage O&M Subsidies
- Financing of import infrastructure in off-taker countries

H_2 DEMAND/UTILIZATION

- G2G support for off-taker agreements
- Blending requirements
- Hydrogen fuel subsidies
- Port entry fee waivers for ammonia fueled ships
- ICE vehicle emission caps
- Emission trading system
- Carbon taxes
- Consumption taxes on fossil fuels and energy
- Mandatory use of clean hydrogen products (e.g. steel)

Critical physical infrastructure across the hydrogen value chain **overview will be developed in Sarawak**



Promote R&D and innovation in Sarawak to bridge research with real-world issues to drive practical solutions

ACHIEVE 3 KEY OBJECTIVES

01 Strategic alignment to address state challenges

- Match the appropriate research and innovation activities with the specific energy transition challenges that need to be addressed

02 Strategic partnership acquisition

- Attract strategic partners to provide technical and technological support for research and innovation development

03 Extensive innovation network establishment

- Create innovation network of specialised nodes, each dedicated to a specific research priority, ensuring coverage of energy transition areas

WITH SEVERAL KEY DIMENSIONS REQUIRED TO DEFINE APPROPRIATE STRUCTURE

Activities & services	Define **required services and functions** to effectively **support research outcomes**
Partners	Identify and select the **right local industry and academic partners to support efforts**
Funding	Establish a **sustainable funding model** to **support the activities**
Human capital	Allocate **research, support, management manpower** with the required expertise to **effectively support the activities**
Infra & locations	Establish **necessary infrastructures and physical locations** as per the requirements
Governance	Develop a **governance model suitable for the chosen partnership** archetype
Guidelines	Implement **necessary guidelines to promote and facilitate partnerships**

Positioning Sarawak as a **hydrogen innovation hub** through targeted R&D across the entire hydrogen value chain

These key areas can be further evaluated as part of R&D and innovation in Sarawak focusing on energy transition

HYDROGEN PRODUCTION TECHNOLOGIES

Electrolysis Advancements: Research is focused on improving the efficiency and reducing the cost of electrolyzers, particularly Proton Exchange Membrane (PEM) and Solid Oxide Electrolysis Cells (SOEC). Innovations in materials and designs are critical to enhance performance and scalability.

Methane Pyrolysis and SMR with CCUS: Developing more efficient and cost-effective methods for methane pyrolysis and Steam Methane Reforming (SMR) integrated with Carbon Capture, Utilization, and Storage (CCUS) to produce blue hydrogen with lower emissions.

HYDROGEN STORAGE SOLUTIONS

Compressed and Liquefied Hydrogen Tanks: Research aims to improve the storage capacity, safety, and cost of tanks for both compressed and liquefied hydrogen. This includes developing new materials and technologies for better storage solutions.

Advanced Storage Methods: Exploring alternative storage methods such as metal hydrides, chemical carriers, and salt caverns to enhance the efficiency and safety of hydrogen storage.

HYDROGEN TRANSPORT INFRASTRUCTURE

Pipeline Development: Research is needed to develop and expand hydrogen pipeline networks, focusing on materials and technologies that can handle hydrogen's unique properties and ensure safe and efficient transport.

Liquefaction and Shipping: Improving the energy efficiency of hydrogen liquefaction processes and developing specialized ships for hydrogen transport are critical areas of focus.

HYDROGEN UTILIZATION TECHNOLOGIES

Fuel Cells: Advancing fuel cell technologies for various applications, including transportation, stationary power generation, and portable devices. Research is focused on increasing efficiency, reducing costs, and improving durability.

Hydrogen Derivatives: Developing processes for converting hydrogen into other chemicals and fuels, such as ammonia and methanol, which can be used as energy carriers or industrial feedstocks.

SAFETY AND REGULATORY FRAMEWORKS

Safety Measures: Researching and developing safety protocols and technologies to handle hydrogen's flammability and storage challenges. This includes creating robust safety standards and certification processes.

Regulatory Support: Establishing comprehensive regulatory frameworks to support hydrogen technology development and deployment. This involves creating policies that encourage investment and innovation in the hydrogen sector.

Sarawak needs to plan for the right-skilled workforce to support its **vision in enabling the hydrogen economy**

Iterate as needed

IDENTIFICATION OF KEY TRENDS IN CLEAN HYDROGEN DEVELOPMENT

Identify key areas in clean hydrogen with **high demand for specialized talent,** including:

- Electrolysis plant operations
- CCS technology and operations
- Application of hydrogen in aluminum, steelmaking, etc.

ANALYSIS OF WORKFORCE GAP REQUIRED

Develop a comprehensive view on the **skills needed and size of gap** to enable targeted skill planning.

Identify potential collaboration partners based on gap identified.

DEVELOP TARGETED SKILLING PROGRAMS

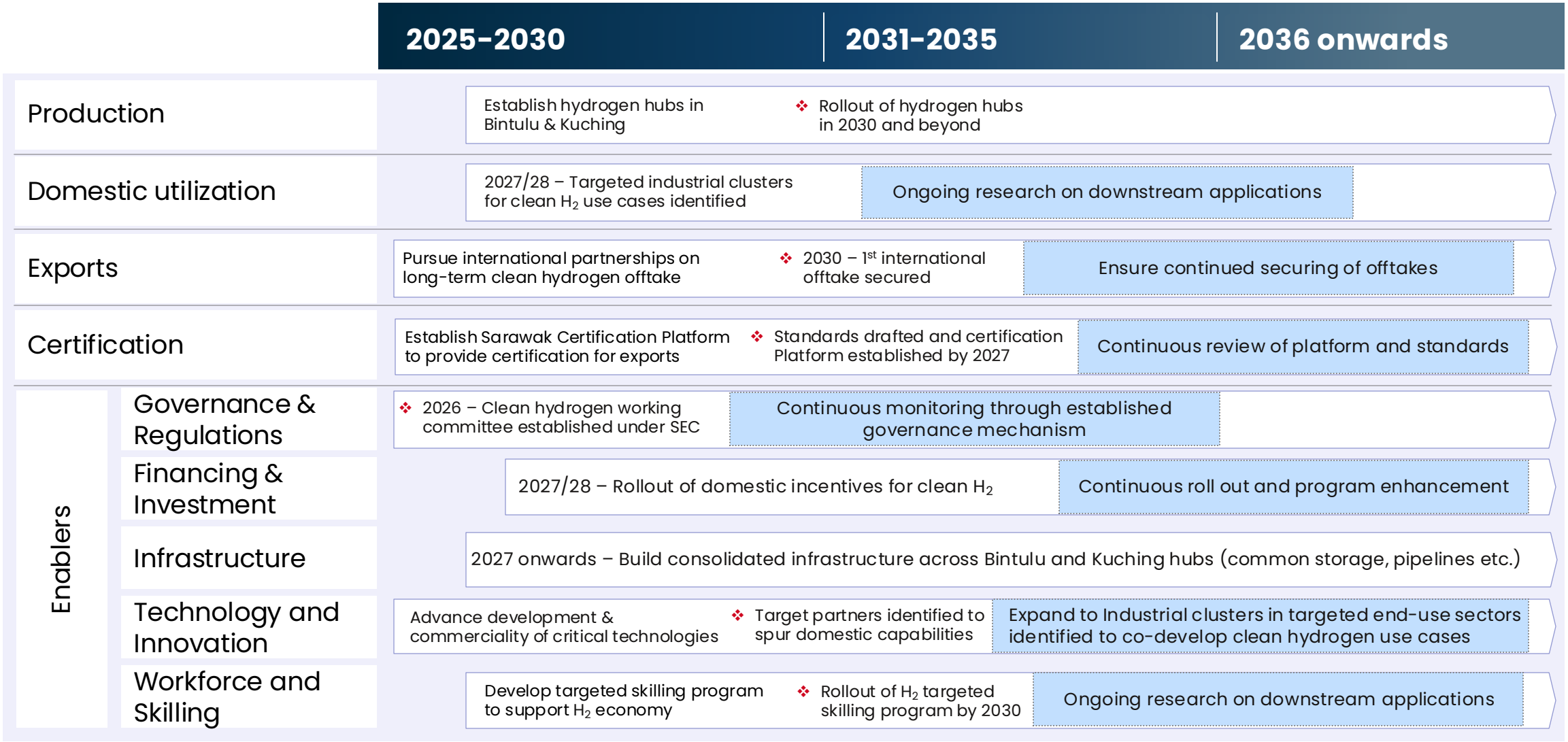
Develop targeted upskilling/ reskilling programs.

Design and roll out targeted TVET and degree programs.

Enable performance diffusion by connecting academia to industry.

Further details on workforce and skilling are detailed out under SET-P

Proposed action plan for **Sarawak Hydrogen Economy Roadmap**



GLOSSARY (I/II)

ART	Autonomous Rapid Transit
ATR	Autothermal Reforming
CCS	Carbon Capture and Storage
CCUS	Carbon Capture, Utilization, and Storage
CfD	Contracts for Difference
CI	Carbon Intensity
DGO	Distribution of Gas Ordinance
G2G	Government-to-Government
gCO_2e	Grams of carbon dioxide equivalent
GHG	Greenhouse Gas
H_2	Hydrogen
HETR	Hydrogen Economy & Technology Roadmap
ICE	Internal Combustion Engine
KTPA	Kilo tonnes per annum
KUTS	Kuching Urban Transportation System
MCH	Methyl Cyclohexane
MEESty	Ministry of Energy and Environmental Sustainability Sarawak
MEITD	Ministry for Education, Innovation and Talent Development Sarawak
MFS	Multifuel Refueling Station

GLOSSARY (II/II)

MINTRED	Ministry for International Trade, Industry and Investment Sarawak
MIPD	Ministry for Infrastructure and Port Development Sarawak
MTPA	Million tonnes per annum
NETR	National Energy Transition Roadmap
O&M	Operation and Maintenance
PCDS 2030	Post COVID-19 Development Strategy 2030
PEM	Proton Exchange Membrane
PETROS	Petroleum Sarawak Berhad
RE	Renewable Energy
R&D	Research & Development
SDG	Sustainable Development Goals
SEA	Sarawak Energy Authority
SEC	Sarawak Energy Council
SEDC	Sarawak Economic Development Corporation
SET-P	Sarawak Energy Transition Policy
SHER	Sarawak Hydrogen Economy Roadmap
SMR	Steam Methane Reforming
SOE	Solid Oxide Electrolysis
TVET	Technical and Vocational Education and Training

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