Chapter 6

Political Economy of Hydrogen in ASEAN

Ridwan Dewayanto Rusli
Citra Endah Nur Setyawati
Alloysius Joko Purwanto

Rusli, R.D.,C.E.N. Setyawati, and A.J.Purwanto (2024), "Political Economy of Hydrogen in ASEAN' in Purwanto, A.J. and R.D.Rusli (eds.) *Hydrogen Demand and Supply in ASEAN's Industry Sector*. Jakarta: ERIA, pp. 146-160.

Forcing private industry, domestic and multinational, to plan, finance and implement the greening of hydrogen production on their own merit is not feasible. There is ample evidence in the literature that companies' incentives to invest in innovative projects are driven by two main factors. First, competitive pressure and the increased profit potential (including cost reduction or revenue increase) and value enhancement potential of new technologies, products and processes (See for example, Belleflame and Peitz, 2010). Second, climate change and pollution regulation and/or carbon prices, which often exert necessary pressure for companies to innovate to avoid future costs of penalties and fines (Hemous, 2021, Popp, 2022; Aghion et al., 2016). Furthermore, financing costly green projects often requires public sector co-financing.

Considering how costly a transition towards green hydrogen will be for Southeast Asia's emerging and transition economies, one thus expects the need for strong pressure and incentives from international and domestic, public and private, political and economic institutions for ASEAN governments to stand a chance of realising their ambitious decarbonisation objectives. Robinson (2009) writes that industrial policy '...has been successful when those with political power who have implemented the policy have either themselves directly wished for industrialization to succeed, or been forced to act in this way by the incentives generated by political institutions.' In the context of the region's aim to transition the economies and key industries to green hydrogen, the term 'political and economic institutions' capture two dimensions of interaction. First, the horizontal interaction between ASEAN governments and policymakers with foreign partner governments, multilateral agencies, and nongovernment organisations. Second, the vertical interaction between government, policymakers, and regulators with domestic companies and international industrial interests in the region.

Each of these concurrent and complex interactions can be supportive or hampering the transition to green hydrogen. In turn, the interactions with a multitude of domestic and international industrial, government, international and multilateral interest groups will jointly determine the chances of ASEAN governments successfully implementing their stated policies and announced pledges optimally and in a timely manner. Thus any political economy study of a green (or blue) hydrogen transition process must start with an analysis of the key parties involved and how these are anticipated to support or hamper the governments' policies.

1. Role of Governments, Multilaterals, and Nongovernment Organisations ('Horizontal Interactions')

Table 6.1 and Table 6.2 depict a selected, albeit incomplete, list of governmental, international, and multilateral parties with interest in promoting decarbonisation and clean transition and the green and blue hydrogen transitions in Southeast Asia.

Table 6.1. Decarbonisation Recommendation and Projects

Institutions	Decarbonisation recommendations and efforts
International Energy Agency (IEA)	Indonesian Ministry of Energy and Mineral Resources (MEMR) and IEA unveiled Indonesia's 2060 Net-Zero Emissions (NZE) Roadmap.
Just Energy Transition Partnership (JETP) Indonesia 2022 (including International Partners Group)	US$20 billion public and private financing for energy transition, adoption of renewable energy, and coal phase-out, including concessional vs. market loans, grants, guarantees, plus private funds.
United States–Indonesia Strategic Partnership	ExxonMobil and Pertamina inked US$2.5 billion regional CCS hub to decarbonise industry including refining, chemicals, cement, steel.
Asian Development Bank (ADB) 2022	US$15 million technical assistance for climate change adaptation and mitigation in Southeast Asia.
Cleaner Energy Future Initiative for ASEAN (CEFIA)	Government–private platform to accelerate development of cleaner energy and decarbonisation technologies in ASEAN.

Source: Authors compilation.

Table 6.2. Hydrogen Proposals and Projects

Institutions	Green and Blue Hydrogen Proposal and Projects
International Renewable Energy Agency (IRENA)	Published 'Indonesia Energy Transition Outlook' in 2022, in cooperation with MEMR, PT PLN, etc.
World Bank	Hydrogen for Development Partnership (H4D) to accelerate deployment of low-carbon hydrogen in developing countries with public and private funding.
ASEAN Action Plan for Energy Cooperation 2021–2025	Regional integration and connectivity through deployment of renewable technologies, e.g. hydrogen, battery and storage, CCUS.

Institutions	Green and Blue Hydrogen Proposal and Projects
Brunei–Japan (AHEAD) Cooperation[a]	Pilot hydrogen supply chain project, hydrogen supply from Brunei to Japan.
POSCO, Lotte Chemical, Sarawak Economic Development Corporation (SEDC), SEDC Energy, and Samsung Engineering	Sarawak H2biscus green hydrogen and ammonia project. Expected to produce 7,000 TPA green hydrogen, 600 KTPA blue and 630 KTPA green ammonia, 460 KTPA green methanol.
Sarawak Energy – Linde, Germany	Pilot hydrogen electrolysis plant, hydrogen refuelling station and buses. Fuel cell light rail transit system by 2024.
Asia Zero Emission Community (AZEC)	Regional integration and connectivity through deployment of renewable technologies, e.g. hydrogen, battery and storage, CCUS.
(11 energy ministers from Japan, Australia, ASEAN, plus international organisations)	Cooperation for carbon neutrality, energy transition and decarbonisation incl. renewable energy, biomass, hydrogen, LNG.
Germany's TGS Green Hydrogen	Planning green hydrogen plant in Viet Nam (24 KTPA hydrogen, 150 KTPA ammonia) in Mekong Delta province, estimated US$848 million.
Singapore in cooperation with Australia, Chile, New Zealand	Multiple memorandums of understanding to collaborate on hydrogen technologies.
ASEAN Action Plan for Energy Cooperation 2021–2025	Regional integration and connectivity through deployment of renewable technologies, e.g. hydrogen, battery and storage, CCUS.

CCUS = carbon capture utilisation and storage, KTPA = kilotons per annum, LNG = liquefied natural gas, MEMR = Ministry of Energy and Mineral Resources, MOU = memorandum of understanding, TPA = tons per annum.

Note: [a] Japan's Advanced Hydrogen Energy Chain Association for Technology Development (AHEAD).

Sources: Public and company information.

On the levels of government-to-government, multilateral agencies, and nongovernment organisations, i.e. horizontal interactions, it appears that ASEAN governments are encouraged by diverse multilateral organisations, development banks, and partner governments to decarbonise ASEAN economies and achieve their stated policies and announced pledges. A multitude of discussions, joint studies, and pilot projects are progressing or being planned.

International Partners Group, co-led by the United States and Japan, also involving Canada, Denmark, the European Union, France, Germany, Italy, Norway, and the United Kingdom have mobilised US$20 billion funding for Indonesia's energy transition and decarbonisation. The Secretariat of Just Energy Transition Partnership (JETP) was launched by the Ministry of energy and Mineral Resources (MEMR) and relevant stakeholders in February 2023. JETP-financed projects include early retirement of coal-fired power plants, deployment of renewable energy and related infrastructure, energy efficiency, and just transition.

Japan's AHEAD, which comprises Chiyoda Corporation, Mitsubishi Corporation, Mitsui & Co., Ltd. and Nippon Yusen Kabushiki Kaisha, has launched a demonstration project for by-product hydrogen to be shipped as liquid organic hydrogen between Brunei and Japan. The first shipment was completed in April 2020. In addition, initiated by Japan's Ministry of Economy, Trade, and Industry (METI) the Asia Zero Emissions Community Ministerial Meeting and public–private investment forum was held in March 2023. The forum provided support and policy coordination to accelerate clean energy projects including hydrogen, energy transition financing, and decrease costs for new technology implementation.

Also noteworthy is a one-stop online portal for green hydrogen business-related information and activities in Indonesia called the Hydrogen Business Desk Indonesia. The Hydrogen Business Desk was launched by the German–Indonesian Chamber of Industry and Commerce in May 2022 and intends to be the leading source of information on future green hydrogen commercial operations in Indonesia (AHK, 2022).[1]

Moreover, ASEAN member states receive significant support from the Japanese government and companies that play a leading role in hydrogen research, feasibility studies, technical assessments, and production. Focus areas include the blue ammonia project with Mitsubishi in Sulawesi, Indonesia, and the hydrogen pilot project in Brunei in cooperation with Japan. Additionally, the special reports on energy transition pathways in Indonesia supported by IRENA and IEA are also imperative in providing critical analysis and insights on projected energy and decarbonisation trends.

2. ASEAN Hydrogen Policies vs. Frozen, STEPS, Likely, and APS Scenarios

Notwithstanding the implementational challenges and costs involved, and despite the fact that pledges of financial assistance are yet to translate into firm commitments, ASEAN governments seem to have started introducing hydrogen into their decarbonisation policies for the next decades.

Table 6.3. Hydrogen Policies and Emission Reduction Targets of ASEAN Governments

Country	Government Policy and Targets
Brunei	• National Energy Policy 2022–2040: Leader in high growth renewable energy, energy storage, hydrogen economy, etc. • 10% share of renewables in national energy mix by 2035.
Cambodia	• Study of hydrogen and other zero-carbon fuels for the trucking sector, announced hydrogen R&D and studies. • Reduce GHG emissions by 27% through aggregate reductions from energy, transport, manufacturing.

[1] Japan's Advanced Hydrogen Energy Chain Association for Technology Development (AHEAD).

Country	Government Policy and Targets
Indonesia	• 23% new and renewable energy portion in the National Energy Mix. • 29% GHG emissions reduction by 2030. • Energy sector net-zero emissions by 2060. • Emissions reduction by 388 million ton CO_2e: Green hydrogen for transport by 2031. • Emissions reduction by 1,043.8 million ton CO_2e. Green hydrogen to replace natural gas for high temperature heating processes in industry by 2041.
Lao PDR	• 60% reduction in GHG emissions (unconditional).
Malaysia	• Reduce GHG emissions intensity of GDP by 45% by 2030.
Myanmar	• Emissions reduction of 244.5 million ton CO2e (unconditional) and 414.8 million ton CO_2e (conditional) by 2030
Philippines	• 2.7% reduction in GHG emissions (unconditional), 72.3% (conditional) by 2030.
Singapore	• Reduce GHG emissions intensity by 36% from 2005 to 2030. • Singapore's long-term low-emissions strategy (2020): hydrogen as a low-carbon alternative, the country plan to become a hydrogen hub for the Asian region.
Thailand	• 20% reduction in GHG emissions (unconditional), 25% (conditional) vs. BAU by 2030. • Alternative Energy Development Plan includes hydrogen. Target of 10 ktoe (3.5 kt of hydrogen) by 2036. • Energy Regulatory Commission stipulates that 'renewable energy' to be purchased by Provincial or Metropolitan Electricity Authorities and Electricity Generating Authority of Thailand (EGAT).
Viet Nam	• 7.3% and 9% (unconditional) reductions in GHG emissions, 27% reduction (conditional). • Hydrogen to be developed under Viet Nam's Power Development Plan 8.

BAU = business-as-Usual, CO_2e = carbon dioxide equivalent, GHG = greenhouse gas, GDP = gross domestic product, ktoe = kiloton of oil equivalent, R&D = research and development.

Sources: Public and company information.

3. Company and Industry-level Dynamics ('Vertical Interactions')

Horizontal interaction has led ASEAN governments to introduce green and blue hydrogen transition projects across the region. What is important for successful implementation is to assess the potential support for a green transition that governments may expect from key domestic and foreign industrial interests. To this end we examine the relevant companies and activities and their anticipated support for a green and blue hydrogen transition in the region.

3.1. Relevant Parties and Projects

Several ASEAN and foreign companies have announced plans or initiated preparations to shift their industrial hydrogen infrastructure towards blue or green hydrogen in Southeast Asia. Table 6.4 lists the relevant hydrogen-related activities of several companies originating from or taking place in Southeast Asia.

Table 6.4. Hydrogen-related Activities of Companies in Southeast Asia

	State Controlled vs. Private, Domestic, Multinational	Green and Blue Hydrogen Transition
Refineries		
Exxon Singapore Refinery (592 KBPD)	• Private, multinational	• 1 billion cubic feet per day of blue hydrogen at Baytown (2027) • Green hydrogen and ammonia study (Norway)
Pertamina and ExxonMobil	• State controlled • Private, multinational	• US$2.5 billion regional CCS hub to decarbonise refining, chemicals, cement, steel
Shell Pulau Bukom Refinery (458 KBPD)	• Private, multinational	• Europe's largest renewable hydrogen plant from wind (2025)
PetroChina (Singapore Refining Corporation Jurong Island Refinery – 285 KBPD)	• State controlled • Domestic, multinational	• Blue hydrogen with CCUS (2021) • First Asian state-owned company to set near-zero emissions target by 2050
Pertamina's Cilacap (348 KBPD) and Balikpapan (260 KBPD) refineries	• State controlled • Domestic, multinational	• Green hydrogen study with Keppel Infrastructure, Chevron, Tokyo Electric Power Company • Green hydrogen with geothermal (2023) • Green hydrogen for mobility project in West Java (on-going technical assessment)

	State Controlled vs. Private, Domestic, Multinational	Green and Blue Hydrogen Transition
Ammonia		
Pupuk Indonesia	• State controlled • Domestic	• 2023–2030: Hydropower, reduce emissions • 2030–2040: Blue ammonia with CCS • 2040–2050: Green ammonia with hydropower • Feasibility studies for hybrid green ammonia in Aceh and West Java.
Pertamina and Mitsubishi	• State controlled • Private, multinational	• Invest US$11 billion to accelerate clean energy transition incl. hydrogen • Brownfield blue ammonia project from 338 tons per day hydrogen plant in central Sulawesi
Petronas Chemical Ammonia	• State controlled • Domestic, multinational	• Building a 'zero-emissions' Aframax dual-fuel tanker running on green ammonia
Methanol		
PT Kaltim Methanol Industri	• State controlled • Domestic	• Cooperation with Pupuk Indonesia, Pertamina, PLN, developing green hydrogen
PTT Exploration and Production plc (PTTEP)	• State controlled • Domestic, multinational	• Green hydrogen with Electricity Generating Authority of Thailand and the Saudi government
Petronas, Malaysia	• State controlled • Domestic, multinational	• Partnership with ENEOS to explore low carbon hydrogen production (2021)
Steel		
Krakatau Steel	• State controlled • Domestic, multinational	• Green hydrogen pipelines plan with Pertamina and PT Rukun Raharja (RAJA)
Hoa Phat, Viet Nam	• Private, domestic.	• Green, energy-saving technology in steel
Power and Multi-industries		
Fortescue Metals Group (Australia)	• Private, multinational	• Memorandum of understanding for green hydrogen, green ammonia, and renewable power in North Kalimantan
AEDP Power, Saudi Arabia	• Private, multinational	• Green hydrogen from hydropower with PLN
HDF Energy, Paris	• Private, multinational	• Green hydrogen storage and transport solutions with Indonesian state electricity company PLN and US Development Finance Corporation

AEDP = Alternative Energy Development Plan, CCS = carbon capture and storage, CCUS = carbon capture utilisation and storage, KBPD = thousand barrels per day, PLN = Perusahaan Listrik Negara.

Sources: Public and company information.

Whilst Exxon, PetroChina, and Shell, oil supermajors with refinery presence in Singapore, Malaysia, and Thailand are planning blue and green hydrogen projects in the United States, Europe, and China, they have yet to release details of their hydrogen plans in ASEAN. It is interesting to note that ExxonMobil is engaging in a major collaboration project with Pertamina to develop a carbon capture and storage (CCS) hub to serve multiple industries. Concurrently, Pertamina is engaging with Keppel Infrastructure, Chevron Corporation, and Tokyo Electric (Cariaga, 2022, Shetty, 2022, Chandak, 2023) on blue and green hydrogen projects for its Balikpapan and Cilacap refineries. The Indonesian state-controlled oil, gas, and chemicals company has also announced joint studies with the state-controlled fertiliser and electricity companies, Pupuk Indonesia and PT Perusahaan Listrik Negara (PLN), to develop future green hydrogen solutions. A Joint Study Agreement and memorandum of understanding (MOU) has been signed by Pertamina Power Indonesia with several companies to investigate the development of green hydrogen and green ammonia in Indonesia.

Additionally, consistent with their track records of technology and market diversification and internationalisation, Malaysia's Petronas and Thailand's PTT are already planning projects in green hydrogen incl., in the case of Petronas Chemical, ammonia for future shipping and energy applications. Concurrently, state-controlled Krakatau Steel in Indonesia and private Hoa Phat in Viet Nam are planning green hydrogen infrastructure and technology solutions for the future.

Several private multinationals have been actively identifying green hydrogen opportunities in Southeast Asia. In 2021, Fortescue Metals Group, Australia, agreed with the Indonesian government on a plan to develop a green hydrogen industry in North Kalimantan (Heynes, 2021). During the Indonesia Group of Twenty (G20) presidency in 2022, the government of Indonesia received a bilateral and multilateral support in financing transition, with one of its initiatives being the country's hydrogen development. HDF Energy Paris, a pioneer in hydrogen power plants and a manufacturer of high-power fuel cells, has formalised a collaboration with Indonesian state-controlled electricity company PLN and the United States Development Finance Corporation to support the development of Renewstable® green hydrogen power plants in Indonesia (Hydrogen Central, 2022). In November 2022, ACWA Power (Saudi Arabia) signed an MOU with PLN on the development of a green hydrogen facility that is powered by hydroelectricity (ACWA, 2022).

3.2. Industry-level Political Economy

When it comes to the vertical interactions with industrial players including national oil companies, fertiliser and steel companies as well as domestic and international private corporations we must examine their ownership structures, assess the revenue and cost impacts, i.e. incentives of transitioning to green or blue hydrogen and study how unified, i.e. concentrated or fragmented a political force they may be, in terms of either supporting or resisting this transition.

Table 6.5 depicts a selected list of industrial, government, international, and multilateral parties relevant to our study.

Table 6.5. Characteristics of and Potential Support from Industrial Actors

Countries and firms	State-Owned	Public Private*	Private Domes-tic	Private Interna-tional	Financial	Fragmenta-tion	Expected Support/ Resistance
Indonesia							
Pertamina	√		√	√	Cost ++,Rev. -	Conc.**	Support (long term)
Natural gas producers	√	√	√	√	Rev. - -	Fragm.	Resistance
Fuel product importers		√	√		0	Conc.	Resistance
Pupuk fertiliser	√	√			Cost +++	Conc.	Support (long term)
Sojitz			√	√	Cost +++	Conc.	Support
Krakatau Steel	√				Cost +++	Conc.	Support (long term)
Chemical industry			√	√	Cost ++	Fragm.	Support (long term)
Gas merchants				√	Cost ++	Conc.	Support
Thailand							
PTT		√	√	√	Cost +, Rev. -	Conc.	Support (long term)
Thai Oil, refineries		√	√	√	Cost ++	Conc.	Support (long term)
Natural gas producers		√	√	√	Rev. - -	Fragm.	Resistance
Gas merchants			√	√	Cost ++	Conc.	Support

Countries and firms	State-Owned	Public Private*	Private Domes-tic	Private Interna-tional	Financial	Fragmenta-tion	Expected Support/ Resistance
Singapore							
Exxon		√		√	Cost ++	Conc.	Support
Shell		√		√	Cost ++	Conc.	Support
PetroChina		√		√	Cost ++	Conc.	Support
Gas merchants				√	Cost ++	Conc.	Support
Malaysia							
Petronas	√	√	√	√	Cost +, Rev. -	Conc.	Support
Natural gas producers		√	√	√	Rev. - -	Conc.	Resistance
Gas merchants		√	√	√	Cost ++	Conc.	Support
Philippines							
PNOC gas	√	√			Rev. -	Conc.	Support
Petron	√	√			Cost ++	Conc.	Neutral
Viet Nam							
PetroVietnam	√				Cost +, Rev. -	Conc.	Support (long term)
Hoa Phat DQ Steel			√	√	Cost +++	Conc.	Resistance
Brunei							
Brunei LNG		√			0	Conc.	Neutral
Myanmar							
Natural gas producers		√			0	Fragm.	Neutral

Notes: * Including partially privatised national oil and gas, state-owned companies, and public–private partnerships (PPP). projects.
** Concentrated vs. fragmented political negotiation power to support or resistance a green transition.

Source: Authors' own analysis.

Each of the aforementioned groups have their distinct strategic and financial interests in the relevant sectors, and their inherent demands for and captive supply of hydrogen. Generally, whilst natural gas producers may lose part of their natural gas revenues, the refineries, fertiliser (i.e. ammonia, methanol), and steel companies must incur additional costs to invest either in carbon capture (in case of blue hydrogen) or renewable power capacity (for green hydrogen), unilaterally or in partnership with domestic and multinational companies. Moreover, the degree of support or resistance from each group of companies depends on how concentrated or fragmented their decision making and political lobbying powers are.

The combined effects of these special interests and interactions can be expected to drive their medium and long-term incentives in supporting a transition towards green hydrogen production and usage. The group of national oil, gas and petrochemical companies. The four largest ones – PTT, Petronas, Pertamina, and PetroVietnam – are fully integrated, encompassing upstream oil and gas production including liquefied natural gas (LNG) exports, midstream gas pipeline operations, downstream oil refining, and fuel marketing as well as petrochemical production. On the one hand, whilst PTT and Petronas are partially privatised on holding level and or subsidiary levels and Pertamina is still fully state-owned, they produce natural gas through partnerships with domestic and large multinational oil and gas corporations, with Petronas and Pertamina being amongst the world's largest LNG exporters. We anticipate that their upstream gas production subsidiaries and private partners would prefer to maintain gas production levels and promote a transition towards blue hydrogen, making use of carbon capture technologies, rather than fully abolishing steam reforming to make way for a completely green hydrogen supply chain. This is a motivating factor for companies like ExxonMobil, as can be observed from their planned CCS collaboration with Pertamina.

On the other hand, refinery, methanol and, in the case of Petronas, ammonia subsidiaries may be willing to help promote green hydrogen as feedstock, as long as the costs are not too high, no ongoing projects are jeopardised, and provided they are offered fiscal incentives or enter partnerships with financially strong multinationals. Whilst Brunei's National Petroleum Company's public–private partnership with Mitsubishi is an important LNG exporter, Philippine National Oil Company (PNOC), Myanmar Oil and Gas, and Singapore's oil companies and their partners have comparatively smaller upstream gas production presence and focus on their downstream oil refining operations. We anticipate that these will support a transition to green hydrogen in the long-run, as long as the cost impact is not too high or sufficient fiscal support is offered over time.

In terms of political and institutional strength particularly vis-à-vis their domestic and international private sector partners and competitors, the Singaporean government-linked entities Temasek, GIC and EDB, national oil, gas, and chemical companies PTT, Petronas, and PetroVietnam are strong policy drivers and often dominate their counterparty relationships. Thus, once they are on board and support the green hydrogen transition, the private sector might be more easily persuaded to support climate change policies.

By contrast, PNOC and Brunei with their strong upstream partners Shell and Mitsubishi may follow their partners' long-term strategies with regards to greening hydrogen, whilst Pertamina and Petronas may be supportive as long as the cost impact can be mitigated. Whilst the Japanese conglomerates follow METI in supporting hydrogen transitions in general, Shell may be pursuing a strategy of balancing its upstream gas, LNG and future green business interests, modernising and decarbonising its refineries, whilst setting the stage for a stronger future focus on renewables and hydrogen. The most extreme cost increases of transitioning to green hydrogen will be experienced by the fertiliser, methanol and, depending on the proportional capacity shifts intended, steel producers.

Whilst Pupuk Indonesia (in Indonesia), Petronas (in Malaysia), and Brunei Fertilizer Industries Sdn Bhd (BFI) (in Brunei) are state controlled, the Sojitz methanol joint venture is partially Japanese-owned. We thus expect limited resistance and support in the long term, as long as the costs increases can be compensated for through some combination of fiscal incentives or in partnership with hydrogen-supportive multinationals. Many Japanese conglomerates are keen to engage in such endeavours. Additionally, shifting traditional basic oxygen furnace (BOF) steelmaking to direct reduced iron-electric arc furnace (DRI–EAF) will require huge investments and necessitates sufficient supply of scrap iron in the region. The cost increase will be significant, which is countered by the fact that state-owned steel companies like Krakatau Steel and private groups and partners like POSCO and Hoa Phat may be open to compromises to a gradual, fiscally mitigated transition.

On the fuel and energy side, the fuel import interests in the region may be somewhat indifferent to a green or blue transition for industry. They may me motivated to resist or slow down the overall process of electrification of road transport but may largely support or be indifferent to cleaner refined fuel products in the region. A green hydrogen transition may affect the long-term demand for hydrogen across the region's refineries and slow down the declining demand for refining capacity and thus hydrogen beyond 2030E but may not directly reduce fuel import and trade volumes. By contrast, the shipping and airline industries, which are more concentrated, can be expected to resist the significant cost increases associated with the use of ammonia as energy carriers and methanol for e-fuels. Again, this may affect the long-term demand for hydrogen in the ERIA–Likely scenario and the ERIA–APS.

Last but not least, whilst the cost impact for fatty alcohols, oxo alcohols, hydrochloric acid, cyclohexane, and other chemical producers might deter a speedy transition to green hydrogen, we anticipate limited resistance from these sectors given the fragmented nature of these sectors. By contrast, the large multinational gas merchants and producers may deem it too expensive to rapidly transition to only producing green hydrogen to serve the chemical and processing industries, notwithstanding their awareness and, in some cases, proactive initiatives towards greening their operations in general and hydrogen production in particular. As a consequence, significant fiscal support will be welcomed and necessary, as governments in the region may wish to ensure the continued survival and continue implementing their respective industrial policies and economic development.

Next, it is noteworthy that, the region's primarily state-controlled electricity companies will be watching the technological developments and pilot projects in Japan, Europe, China, and North America with regard to the potential co-firing of ammonia and hydrogen in their natural gas and coal power plants. Any medium-term cost impact will be low or moderate, unless the proportion of ammonia or hydrogen grows to make-up significant proportions of their electricity generation capacities.

4. Determinants of Success

In summary, ASEAN governments should leverage on their financially strong national oil and gas, fertiliser, and state-controlled power, and in the case of Indonesia, steel companies to help promote decarbonisation and a more rapid transition to green hydrogen-based refinery, ammonia, methanol, and steel sectors. The region's energy, industrial, state-owned enterprises, power, infrastructure, and finance ministries should empower coherent 'green hydrogen-for-industry transition' taskforces with mandates to work with both domestic and multinational private sector companies and their regional counterparts. These ministries, led by the finance, energy, environmental and industrial ministries should coordinate with relevant multilateral agencies, partner governments and nongovernment organisations to explore possible public and private financing alternatives, including taking advantage of carbon pricing and credit instruments. The objective is to incentivise state-controlled and private companies to support ASEAN governments' green hydrogen transition.

Particularly private sector ammonia, methanol, steel, and industrial gas companies must be encouraged to seek all possible financing alternatives and, if necessary, fiscally supported to either purchase costlier green hydrogen or to collaborate with renewable electricity companies to co-invest in the kind of large-scale solar PV, wind, or geothermal power-based electrolysis technologies and infrastructures discussed in chapter 5. The fiscal support can partially be sourced directly from each country's public budget. However, domestic public co-financing must be augmented by external financings promised throughout the United Nations Climate Change Conference (COP) negotiations and following bilateral or multilateral discussions with partner governments, multilateral development banks and institutions, and nongovernment organisations. Additionally, private companies and their investors, shareholders, and lenders require well thought-through and credible regulation to better assess their investment risks and returns.

Finally, in terms of sequencing the green transition, the lowest cost and immediate focus should be on selected and coordinated CCS technology and infrastructure investments to produce blue hydrogen. The cost increases are moderate and the infrastructure and technological requirements more incremental. Concurrently detailed cross-industry plans must be formulated to ensure timely development of large-scale solar PV, geothermal, and other renewable electricity capacities critically necessary to produce the green hydrogen volumes required. Cross-country regional coordination and cooperation are required to find the optimal regional mix of hydrogen capacities and supply chains, to maximise economies of scale and scope. By contrast, given the significant costs involved in transitioning the shipping and airline sectors to a future with ammonia- and e-fuels, significant multilateral and fiscal efforts must be expanded. It is not a coincidence that international energy and environmental agencies and their stakeholders only integrate the use of ammonia for fuel and e-fuels into their long-term APS.