# Chapter 4

## Future Hydrogen Demand and Supply Forecast

Alloysius Joko Purwanto
Ridwan Dewayanto Rusli
Hafis Pratama Rendra Graha
Sirichai Koonaphapdeelert
Reza Miftahul Ulum
Akhmad Zainal Abidin
Citra Endah Nur Setyawati
Dian Lutfiana
Badrul Munir
Deni Ferdian
Veradika Elsye
Ryan Wiratama Bhaskara
Nadiya Pranindita

Purwanto, A.J.,R.D. Rusli, H.P.R.Graha, S.Koonaphapdeelert, R.M.Ulum, A.Z.Abidin,C.E.N.Setyawati, D.Lutfiana, B.Munir, D.Ferdian, V.Elsye, R.W.Bhaskara and N.Pranindita (2024), 'Future Hydrogen Demand and Supply Forecast' in Purwanto, A.J. and R.D.Rusli (eds.) *Hydrogen Demand and Supply in ASEAN's Industry Sector*. Jakarta: ERIA, pp. 88-131.

This chapter provides estimates of hydrogen demand and supply from the ASEAN industry sectors to the horizon 2050. Detailed calculation method, and the estimates in each industry, consecutively oil refining, chemical & other industries ammonia, methanol, and steel are presented in four scenarios, i.e., ERIA-frozen, ERIA-STEPS, ERIA-Likely, and ERIA-APS.

Detailed estimates are given in the four appendices, i.e., Appendix 1: ERIA-Frozen Scenario, Appendix 2: ERIA-STEPS, Appendix 3: ERIA-Likely Scenario and Appendix 4: ERIA-APS. In each of the appendices, the estimates on hydrogen demand/consumption, production, and merchant supply are presented by industry sector broken down into countries.

# 1. Oil Refining

ERIA's estimation basis for long-term 2020–2050E hydrogen demand in ASEAN for the four scenarios is defined in sections 3.2.1 to 3.2.4 and summarised in Table 4.1.

**Table 4.1. ERIA's Projection on Hydrogen Demand in Southeast Asia**

| Scenarios | 2020 – 2030E (CAGR % pa) | 2030E – 2050E (CAGR % pa) | 2020 KTPA $H_2$ | 2030E KTPA $H_2$ | 2050E KTPA $H_2$ | Remarks |
|---|---|---|---|---|---|---|
| Frozen (business as usual) | | | | | | |
| IHS Markit | 4.3% | 2.1% | 1,168 | 1,778 | 2,694 | IHS 2020–2025E CAGR, ERIA's estimates for 2025E–2050E |
| BP Refinery throughput | 0.7% | 2.1% | 1,168 | 1,256 | 1,903 | Extrapolate 2011–2019 CAGR to 2020–030E |
| Average gasoline-diesel | 4.1% | 2.1% | 1,168 | 1,739 | 2,635 | |
| IEA Future $H_2$ | 0.2% | | 1,168 | 1,197 | | IEA's 3.5% SEA share of world $H_2$. |
| | | | | | | Eff. CAGR incl. 3.0% products growth plus capacity/ configuration changes. 2.1% CAGR 2030E–2050E for all |
| **ERIA–Frozen** | **5.2%** | **2.1%** | **1,168** | **1,931** | **2,926** | |
| | | | | | | |
| **IEA STEPS** | | | | | | |
| IEA Refinery throughput | 3.8% | 0.8% | 1,168 | 1,690 | 1,967 | |
| IEA Oil demand | 3.6% | 0.5% | 1,168 | 1,665 | 1,839 | |
| | | | | | | |
| **ERIA–STEPS** | **5.2%** | **0.6%** | **1,168** | **1,931** | **2,177** | Eff. CAGR incl. 3.0% products growth plus capacity/ configuration changes 0.6% CAGR 2030E–2050E. |

| Scenarios | 2020 – 2030E (CAGR % pa) | 2030E – 2050E (CAGR % pa) | 2020 KTPA $H_2$ | 2030E KTPA $H_2$ | 2050E KTPA $H_2$ | Remarks |
|---|---|---|---|---|---|---|
| **IEA APS and DNV** | | | | | | |
| IEA Refinery throughput | 3.0% | -0.4% | 1,168 | 1,567 | 1,444 | |
| IEA Oil demand | 2.5% | -2.1% | 1,168 | 1,491 | 0,969 | |
| IEA Future Hv | -1.1% | | | | | IEA's 3.5% SEA share of world $H_2$ |
| DNV | 1.0% | -0.9% | 1,168 | 1,294 | 1,073 | DNV's 3.5% SEA share of world $H_2$ |
| **ERIA–APS** | **3.5%** | **–2.1%** | **1,168** | **1,649** | **1,078** | Eff. CAGR incl. 1.2% products growth plus capacity/ configuration changes -2.1% CAGR 2030E–2050E |
| **ERIA–Likely (LS)** | **3.3%** | **–0.9%** | **1,168** | **1,620** | **1,352** | Eff. CAGR incl. 1.2% products growth plus capacity/ configuration changes -2.1% CAGR 2030E–2050E |

APS = Announced Pledges Scenario, CAGR = compound annual growth rate, DNV = Det Norske Veritas, E = estimate, ERIA = Economic Research Institute for ASEAN and East Asia, H2 = hydrogen, IEA = International Energy Agency, KTPA = kilotons per annum, pa = per annum, SEA = Southeast Asia, STEPS = Stated Policies Scenario.

Sources: IHS (2021), IEA (2022a; 2002b), DNV (2022), authors.

We discuss the hydrogen demand-supply balances and country-by-country demand forecasts for each scenario.

## ERIA–Frozen Scenario

In the frozen, i.e. business-as-usual scenario, ASEAN governments introduce and implement minimal or no changes to the hydrogen consumption, production, and supply chain in the refinery sector. Table 4.1 compares assumptions and growth projections from several published reports. First, the IHS (2021) estimates for 2020–2025E CAGR are adjusted with lower 2025E–2030E growth rates to estimate an 'IHS-like' case for 2020–2030E CAGR. IHS (2021) projects about 8% per annum growth in hydrogen demand – net of captive supply – in Southeast Asia's oil refining sector between 2022 and 2025. This is higher than IEA's 2020–2030E CAGR estimates for the STEPS and APS.

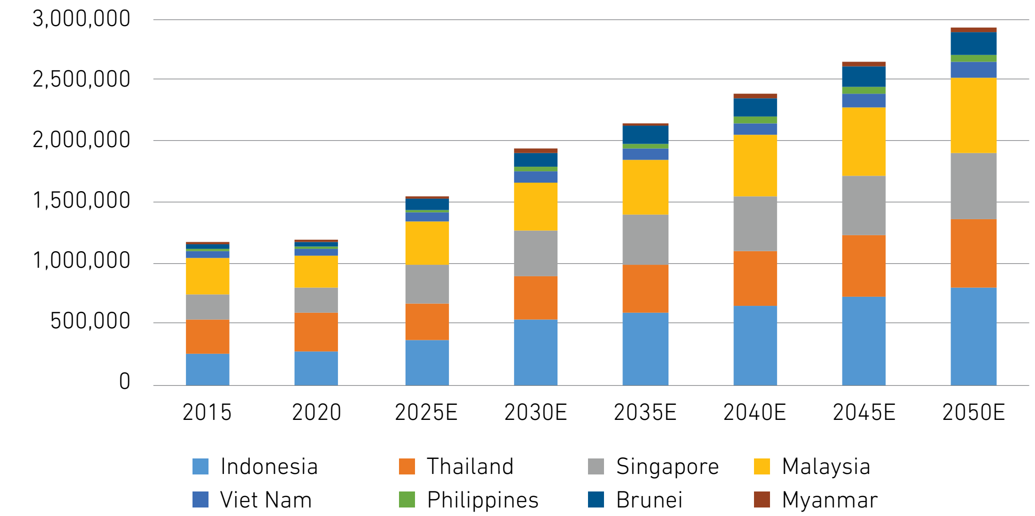
Second, historical refinery throughput volumes for the six countries reported in BP's (2022) statistical yearbook, Indonesia, Thailand, Singapore, Malaysia, Viet Nam, and the Philippines are examined. Adjustments are made for Brunei and Myanmar, whose volumes are much smaller, using public information. Third, average country-level diesel and gasoline consumption figures are analysed using selected data from not only BP (2022) but also Statista, Global Economics, and official government announcements. The 2011–2019 CAGR of refinery throughput volumes and diesel and gasoline consumption data are extrapolated to estimate the regional and country-level hydrogen demand 2020–2030E CAGR. Fourth, for comparison the IEA *Future of Hydrogen report* (IEA, 2019), estimates a similar regional share of 3.5% of world hydrogen demand. The latter was estimated by IEA to grow only by 0.2% CAGR over the same 2020–2030E period, from 40 to 41 million tons per annum (MTPA). This is considered too low for the majority of still industrialising Southeast Asian economies, whose consumers may also not be in a position to shift to electrification and renewable energy solutions as fast as the more developed economies in the West.

Considering the different estimates, demand growth rates of 5.2% per annum (pa) for 2020–2030E and 2.1% pa for 2030E–2050E are projected. The effective 5.2% pa for 2020–2030E is a result of 3% pa refined products demand growth plus the effect of in-progress or announced refinery capacity increases and configuration changes in Indonesia, Thailand, Singapore, Malaysia, Viet Nam, and Brunei. Note that the 3% pa 2020–2030E CAGR compares well with another study's 2018–2025E growth estimates of 3.9% pa, 3.0% pa, and 3.8% pa for gasoline, kerosene respectively diesel consumption in Indonesia, the region's largest market for refined products (Akhmad and Amir, 2018). Furthermore, the estimated 3.0% pa versus 5.2% pa effective CAGR including refinery capacity expansions and configuration changes are consistent with IEA's (2022a) 2020–2030E refined products demand growth forecasts of 3.5%–3.8% in the STEPS (see below). Indeed, in the near and medium term towards 2030E, the BAU/Frozen and STEPS scenarios can be expected to be rather similar, given the complexity and length of the anticipated policy implementation and transformation processes. We discuss the political economy challenges of shifting the region's industries to green hydrogen in Chapter 6.

The long-term region-wide growth rate of 2.1% pa is estimated assuming that demand for refined products in Viet Nam, Brunei, Myanmar, and the rest of the region including Cambodia will continue their more rapid growth, whilst the larger economies Indonesia and Thailand mature and gradually shift away from especially diesel and fuel oil for power and Malaysia and Singapore demand gradually shrink.

Figure 4.1 shows that under the Frozen scenario regional demand for hydrogen from refineries continues growing from 1,167 KTPA in 2020 to 2,926 KTPA in 2050E. Indonesia, Thailand, Singapore, and Malaysia make up approximately 79% of projected regional hydrogen demand from the refinery sector in 2050E, down from 90% in 2020. The difference is the higher demand growth rates in Viet Nam, Brunei and Myanmar (4.5% CAGR 2030E–2050E), at the expense of stagnating demand in Singapore (0% CAGR), and lower growth in Indonesia, Thailand, and Malaysia (2.1% CAGR). This is due to the fact that the latter four governments electrify their transport sectors faster, Indonesia moves away from diesel- and fuel oil-based power, whilst the former economies are growing from a lower demand base.

**Figure 4.1. ASEAN-8 Refineries Hydrogen Demand – BAU/Frozen (TPA)**

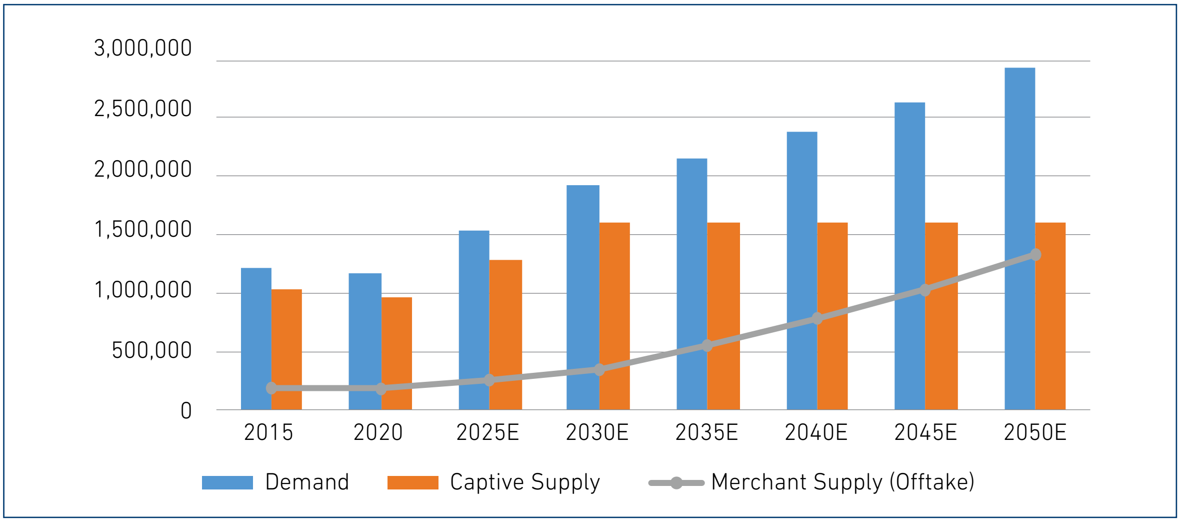



BAU = business-as-usual, E = estimate.

Source: Authors.

Moreover, as regional hydrogen demand continues increasing, the captive supply capacity of Southeast Asian refineries, driven primarily by their steam methane reforming and catalytic reforming capacities, will not be sufficient (Figure 4.2). Indeed, taking all announced and ongoing capacity expansions and configuration changes in the next few years into account, in the Frozen scenario the regional refineries are expected to continue producing hydrogen at their captive capacity limits. Thus, by 2050E, the region's refineries are estimated to require more than 1.3 MTPA of merchant hydrogen supplies, whether imported or independently produced within the region. Therefore, a more important role of independent merchant suppliers in the future is expected, many of which are affiliates of the multinational gas processing companies.

**Figure 4.2. ASEAN-8 Refineries Hydrogen Demand-Supply – BAU/Frozen (TPA)**



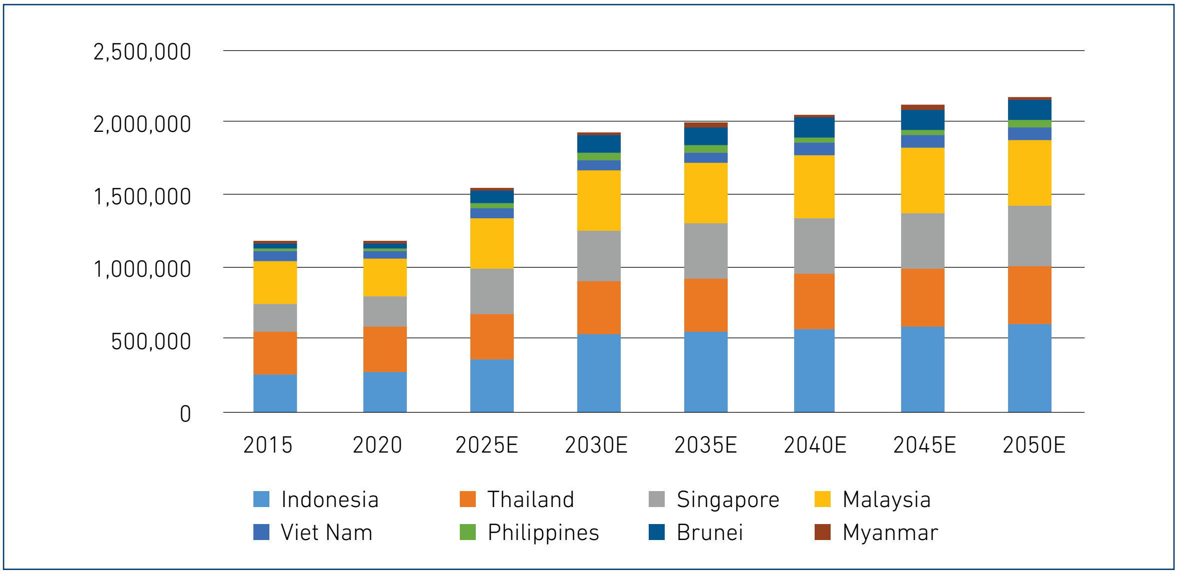

BAU = business-as-usual, E = estimate.

Source: Authors.

## ERIA–STEPS

In this scenario, ASEAN governments are assumed to successfully implement their stated policy. As depicted in Table 4.1, for the STEPS, IEA's refinery throughput and oil demand forecasts assumptions are compared and the resulting CAGRs for the periods 2020–2030E and 2030E–2050E estimated. The 2020–2030E CAGR is assumed to parallel the BAU/Frozen scenario, as described above. However, for the long-term 2030E–2050E projection of 0.6% pa IEA's refinery throughput and oil demand CAGRs for the same time period are used as basis. The results can be seen in Figure 4.4.

**Figure 4.3. ASEAN-8 Refineries Hydrogen Demand – STEPS (TPA)**




STEPS = Stated Policies Scenario.

Source: Authors.

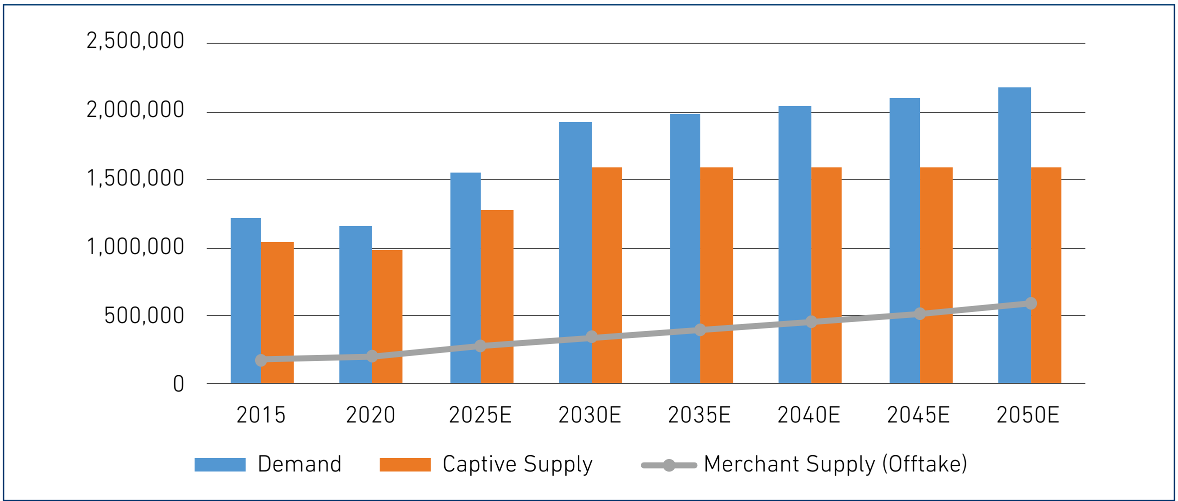
Under the STEPS, Indonesia, Thailand, Singapore, and Malaysia make up approximately 81% of projected regional hydrogen demand from the refinery sector in 2050E, down from 90% in 2020. The difference is the higher demand growth rates in Viet Nam, Brunei, and Myanmar (2.2% CAGR 2030E–2050E), at the expense of declining demand in Singapore (–0.6% CAGR), Indonesia, Thailand and Malaysia (0.6% CAGR). Singapore declines faster as its government electrifies its transport sector faster and exports lower volumes to its increasingly self-reliant neighbours, Indonesia moves away from diesel- and fuel oil-based power. Again, Viet Nam, Brunei, and Myanmar are anticipated to grow faster from a lower demand base.

In this STEPS, hydrogen demand plateaus at about 2.177 KTPA in 2050E. Indonesia, Thailand, Singapore, and Malaysia continue to make up more than four-fifths projected regional hydrogen demand from the refinery sector. Whilst the projected growth rates and hydrogen demand for the 2020–2030E period remains similar to the Frozen scenario above, growth in hydrogen demand slows down in the subsequent 2030E–2050E period. Indeed, under STEPS we maintain the same 2020–2030E CAGR as in the BAU/Frozen scenario, reducing the 2030E–2050E CAGR to 0.6% pa, within the range of IEA's refinery throughput and oil demand projections of 0.5%–0.8% pa.

The demand for refined products in Viet Nam, Brunei, Myanmar, and the rest of the region including Cambodia will continue more rapid growth, whilst the larger economies Indonesia and Thailand mature and gradually shift away from particularly harmful uses of diesel and fuel oil for power and Malaysia and Singapore demand gradually shrink. This results in plateauing demand for hydrogen beyond the 2030s.

Comparing the hydrogen demand supply under STEPS in Figure 4.4we observe similar production forecasts as in the Frozen scenario. This is due to the fact that, in our estimation, under STEPS, captive hydrogen production capacity is fully utilised just like in Frozen, which in return necessitates growing demand for merchant hydrogen supply. Nevertheless, merchant including import requirements under STEPS decrease to about 580 KTPA of hydrogen by 2050E, less than half of the volume projected in the Frozen scenario.

**Figure 4.4. ASEAN-8 Refineries Hydrogen Demand-Supply – STEPS (TPA)**




STEPS = Stated Policies Scenario, TPA = tons per annum.

Source: Authors.

## ERIA–APS

In IEA's strict Conference of the Parties (COP)26 net-zero announced pledges scenario, ASEAN governments accelerate the transition and transform their economies much more quickly than STEPS. Nevertheless, the APS, whilst allowing for only slightly lower growth rates than STEPS towards 2030, is less likely to succeed in the longer 2030E–2050E period due to the extreme decline in oil products demand required to achieve net zero by 20050E.

Table 4.2 summarises ASEAN governments' COP26 pledges.

**Table 4.2. ASEAN Member States Governments' COP26 Pledges**

| Scenarios | Indonesia | Thailand | Singapore | Malaysia | Viet Nam |
|---|---|---|---|---|---|
| Electrification | • 2 million four wheelers and 13 million two wheelers 2030E<br>• 20% produced cars 2025E (IESR, 2022a)<br>• Blue/green $H_2$ (MEMR, 2021a) | • 225,000 cars, 360,000 2-wheelers, 18,000 buses 2025E<br>• 30% of production 2030E (Lim, (2021) | • 60,000 stations 2030E incl. 2,000 carparks (LTA, n.d.)<br>• Diversified imports | • 4,000 EV 2023E<br>• 10,000 charging stations 2025E (Southeast Asia Infrastructure, 2023)<br>• Serawak US$11 trillion by 2050E (Energy Watch, 2021) | • EV production, assembly 2030E<br>• Stop ICE cars 2040E<br>• 100% green EV<br>• 2050E (GRI, 2022) |
| Blue/green $H_2$ | • Green/blue $H_2$ incl. for power 2030E | • 10 ktoe Hy 2036E (Ministry of Energy Thailand, 2015) | • Low-carbon $H_2$ to decarbonise power sector by 2050E<br>• $H_2$-tech, R&D and infrastructure (MTI, n.d.) | • Targeting global $H_2$ market worth US$11 trillion (Energy Watch, 2021) | • 216,000 green ammonia and 30,000 green $H_2$ 2024E |

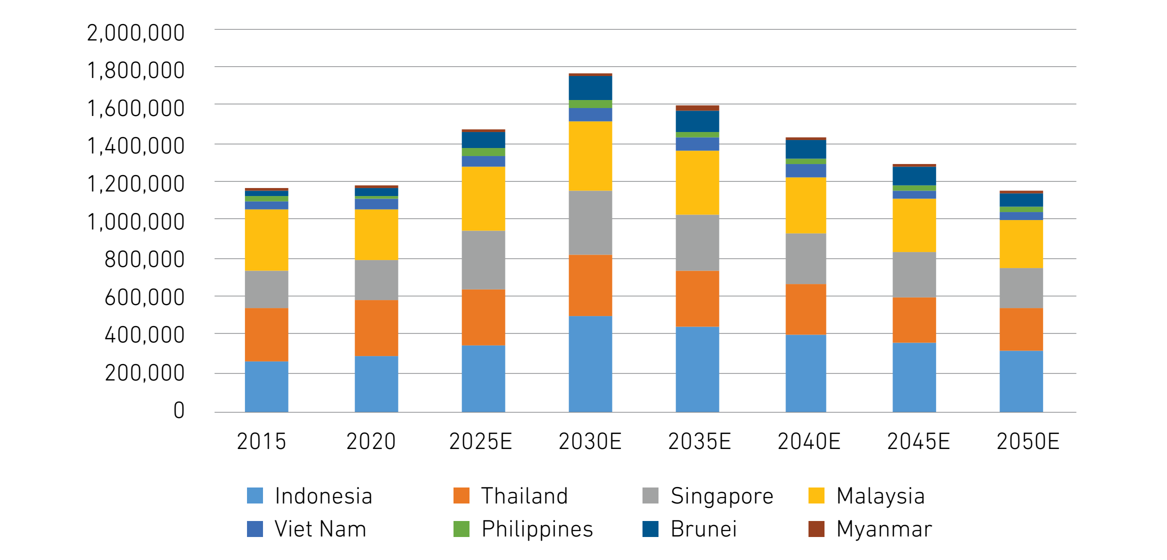
COP = Conference of the Parties, EV = electric vehicle, $H_2$ = hydrogen, ICE = internal combustion engine, R&D = research and development.

Source: Authors' compilation.

As benchmarks IEA's (2022a and 2022b) refinery throughput and oil demand projections of 2.5%–3.0% pa CAGR for the 2020–2030E period and -2.1% to -0.4% CAGR for 2030E–2050E are examined. By contrast, IEA's (2019) future of hydrogen and DNV's (2022) reports project –1.1%–1.0% of hydrogen demand growth for 2020–2030E.

Thus, 2020–2030E CAGR for regional hydrogen demand from the refinery sector is projected to amount to an effective 3.5% including capacity expansion and configuration changes, which corresponds to 1.2% CAGR pure oil products demand. By contrast, post-2030E the announced pledges necessitate strongly negative demand growth rates of about -2.1%, within the range of IEA estimates and much more negative than DNV's 2030E–2050E CAGR estimates. Figure 4.54.5 depicts the estimation results and country-by-country demand break down.

**Figure 4.5. ASEAN-8 Refineries Hydrogen Demand – APS (TPA)**



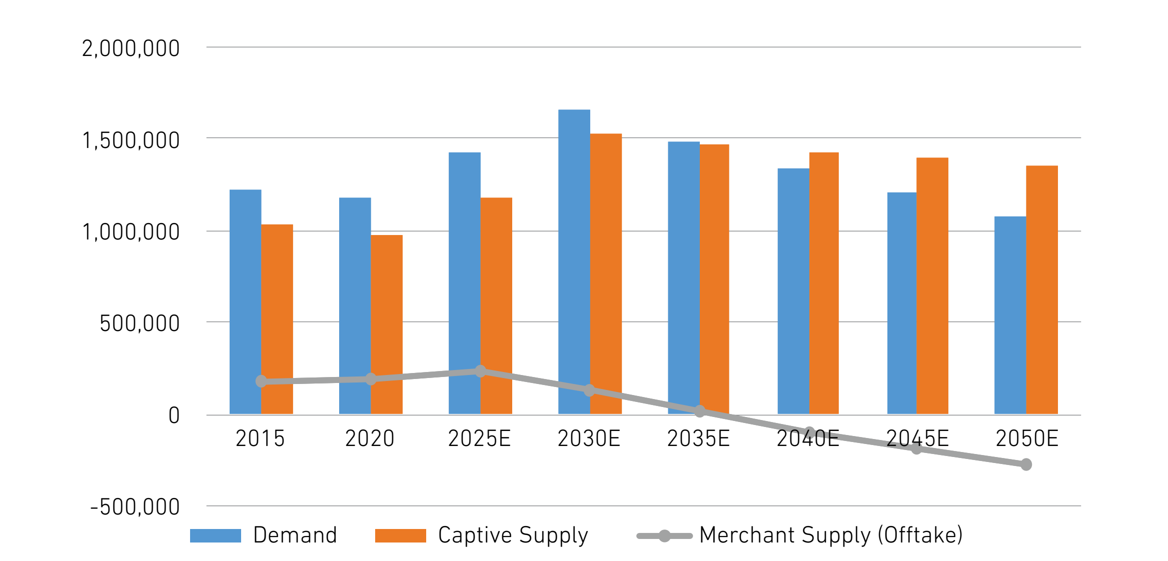

APS = Announced Pledges Scenario, E = estimate, TPA = tons per annum.

Source: Authors.

Under the APS, Indonesia, Thailand, Singapore, and Malaysia make up approximately 81% of projected regional hydrogen demand from the refinery sector in 2050E, down from 90% in 2020. Gradually declining demand for oil products and thus demand from refineries in Viet Nam, Brunei, and Myanmar (–0.7% CAGR 2030E–2050E) contrast Singapore's significant drop (–3.2% CAGR) and Indonesia's, Thailand's, and Malaysia's stronger declines (-2.1% CAGR) over the same period.

Under the APS, regional hydrogen demand increases, albeit more slowly than under BAU/Frozen and STEPS, to peak at 1,650 KTPA in 2030E, before decreasing again to reach 1,078 KTPA by 2050E. Again Indonesia, Thailand, Singapore, and Malaysia dominate the regional demand for hydrogen. Interesting to observe is the fact that captive hydrogen production continues decreasing in the coming years, all the way to 2050E, as shown in Figure 4.6.

**Figure 4.6. ASEAN-8 Refineries Hydrogen Demand and Supply – APS (TPA)**




APS = Announced Pledges Scenario, TPA = tons per annum.

Source: Authors.

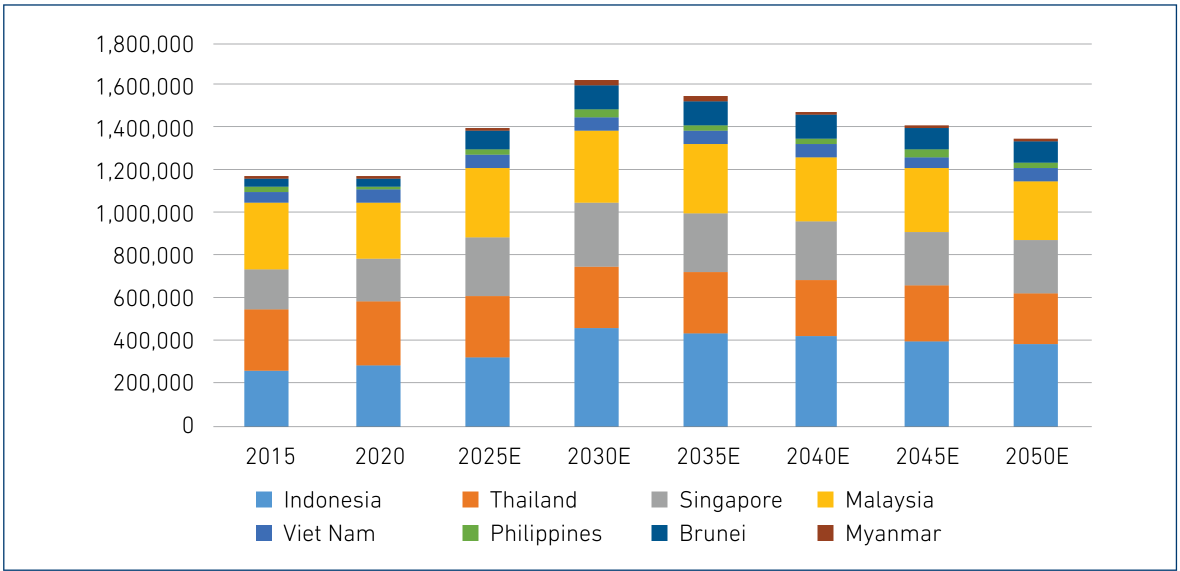
Interesting is the fact that merchant and import shares decrease and actually turn negative beyond 2035E. The latter thus implies that captive hydrogen production capacity would be sufficient to cover the demand through the late 2030s and 2040s. In fact, the regional refineries could supply or export some of their excess hydrogen to the chemical and processing sectors by then, approximately up to 270 KTPA by 2050E.

## ERIA-Likely Scenario (LS)

It is estimated that the long-term APS above is less realistic given the anticipated implementation and political economy hurdles. DNV's projected 2020–2030E CAGR growth rates of about 1.0% is more realistic, although we do anticipate that the future Southeast Asian share of global hydrogen demand must increase from DNV's estimated 3.5%, since Western industrialised countries are expected to transition to greener economies faster than Southeast Asian ones.

Thus projected 2020–2030E CAGR for regional hydrogen demand from the refinery sector could amount to an effective 3.3% including capacity expansion and configuration changes, which corresponds to 1.0% CAGR pure oil products demand. By contrast, post-2030E a flatter decline with CAGR of about -0.9% seems appropriate, comparable to DNV's 2030E–2050E CAGR estimates. This may be a more accurate estimation for future hydrogen demand in the region and thus consider this a Likely Scenario (LS). Figure 4.7 depicts the estimation results and country-by-country demand breakdown:

**Figure 4.7. ASEAN-8 Refineries Hydrogen Demand – Likely Scenario (TPA)**



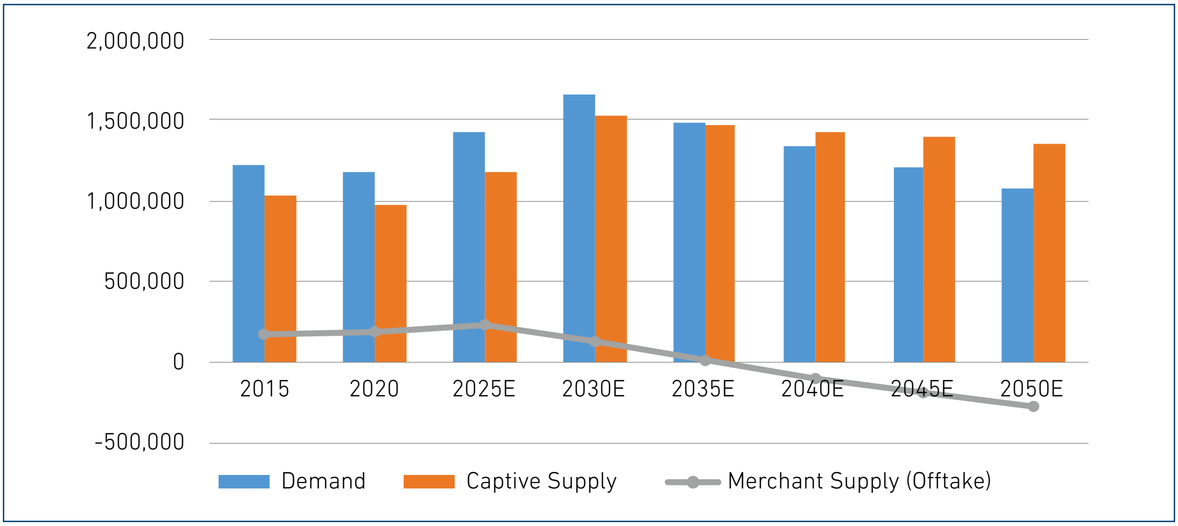

TPA = tons per annum.

Source: Authors.

Again, Indonesia, Thailand, Singapore, and Malaysia make up approximately 81% of projected regional hydrogen demand from the refinery sector in 2050E, down from 90% in 2020. Higher demand growth rates in Viet Nam, Brunei, and Myanmar (0.6% CAGR 2030E–2050E) contrast Singapore's faster (–2.1% CAGR) and Indonesia's, Thailand's, and Malaysia's declines (–0.9% CAGR).

In this Likely Scenario hydrogen demand first increases more slowly than under the BAU/Frozen scenario and the STEPS and comparable to APS, to peak at 1,620 KTPA in 2030E, before decreasing again to reach 1,352 KTPA by 2050E. Again Indonesia, Thailand, Singapore, and Malaysia dominate the regional demand for hydrogen. Interesting to observe is the fact that captive hydrogen production continues decreasing in the coming years, all the way to 2050E, as shown in Figure 4.8.

**Figure 4.8. ASEAN-8 Refineries Hydrogen Demand and Supply – Likely Scenario (TPA)**




TPA = tons per annum.

Source: Authors.

Thus, merchant and import shares decrease and turn negative beyond 2040E. Thus, captive hydrogen production capacity would be sufficient to cover the demand through the 2040s and regional refineries could supply or export some of their excess hydrogen to the chemical and processing sectors to volumes of at least 80 KTPA by 2050E.

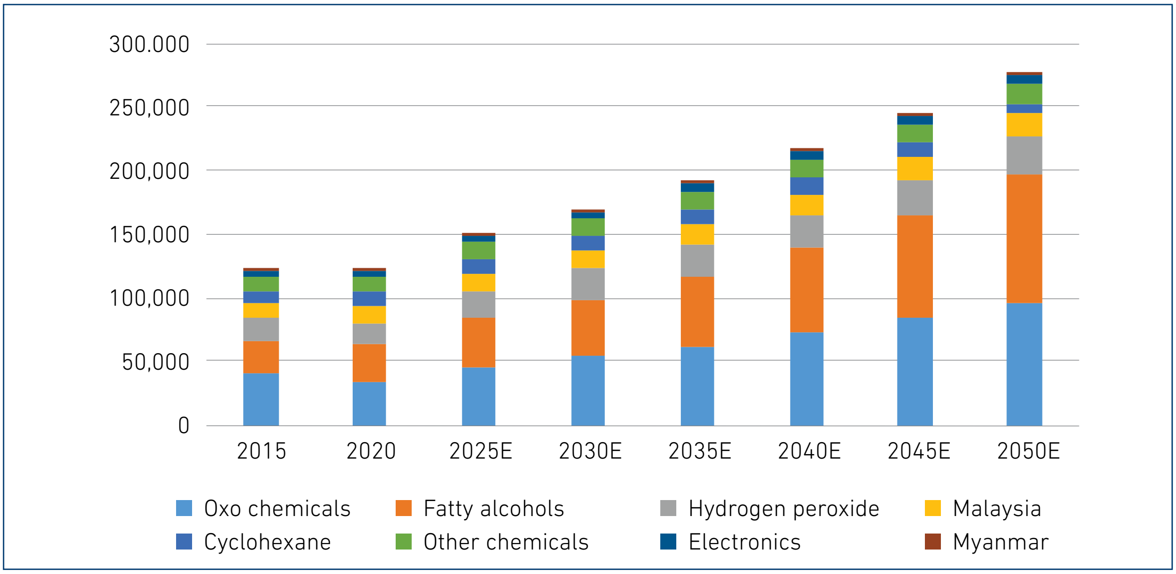
## 2. Chemical and Other Industries

Future projections for the chemical and processing industries follow a similar set of country break down assumptions like in the historical analysis in Section 2.1.6. Whilst the region-wide estimates for the period 2015–2025E follow IHS (2021), we again single out the largest two segments: Fatty alcohols are split amongst the four countries Indonesia, Malaysia, Thailand, and the Philippines, whilst oxo chemicals and plasticisers are split across these countries and Singapore. For the remaining chemical segments and product groups hydrogen demand is split following the estimated hydrogen demand from each country's refinery sector. Given the fragmented nature and comparatively smaller hydrogen demand for this diversified sector, no distinction is made between the four scenarios discussed for the ammonia, refinery, and methanol sectors.

Forward 2025E–2050E CAGR of 2.5% across the region and all segments is assumed. First, the Southeast Asian fatty alcohols market is projected to grow by about 4%–6% per annum in the medium term (Rossall, 2015; IHS, 2021). Second, economic growth in the Asia-Pacific region is expected to boost growth in oxo alcohols to approximately 3%–5% per annum in the medium term (GMI, 2021). For comparison, Global Market Insight's (2021) medium-term growth forecast for oxo alcohols contrasts with IHS' 1.1% per annum growth for 2022–2025. Third, excluding the higher growth oxo chemicals and fatty alcohols segments above, medium-term growth forecasts for the various chemicals and manufacturing sectors in Southeast Asia range from about 1.2%–2% per annum for hydrogen peroxide, 1%–4% butanediol and float glass, about 1.5% for hydrochloric acid and caprolactam, to stagnating growth for cyclohexane and others (IHS 2021).

The resulting projections for Southeast Asian demand for hydrogen from the chemical and processing industries, broken down by subsector and by country, are depicted in Figure 4.9 and Figure 4.10.

**Figure 4.9. Hydrogen Demand in Chemicals by Subsector (TPA)**

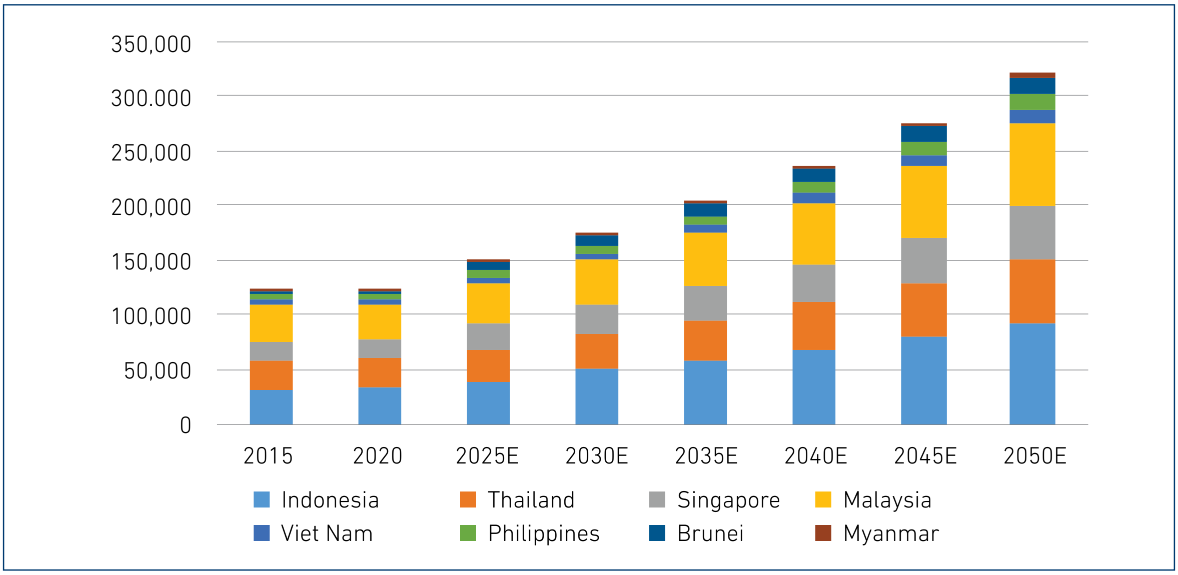



TPA = tons per annum.

Source: Authors.

As observed in Figure 4.94.9, demand for hydrogen from the chemical and processing industries will continue to be dominated by the plasticiser and oxo chemical as well as palm oil-based fatty alcohol segments. Thus, in Figure 4.10 we again see Indonesia, Malaysia, Thailand, Singapore, and the Philippines making up the bulk of hydrogen demand in the region's chemical and processing sectors.

**Figure 4.10.** **Hydrogen Demand in Chemicals by Country (TPA)**




Source: Authors.

Lastly, given the more fragmented nature of the chemical and processing subsectors, most of the hydrogen supply may be non-captive and comprise imported and merchant-produced hydrogen. Notable exceptions are the fatty alcohol production facilities in the region, many of which integrate their own captive hydrogen production units.

# 3. Ammonia Production

There are multiple scenarios that can be utilised to analyse the future demand for ammonia in the ASEAN region from 2020 to 2050. These scenarios consider a range of growth rates and potential novel applications:

1) **Frozen Scenario (Business-as-Usual)**: This scenario is based on historical data on hydrogen demand from Southeast Asia's ammonia industry. Hydrogen demand from the ammonia industry until 2050 is predicted based on a CAGR of real ammonia demand for 2012-2021 of 2.7%. The growth is assumed to be the same for all Southeast Asian members.

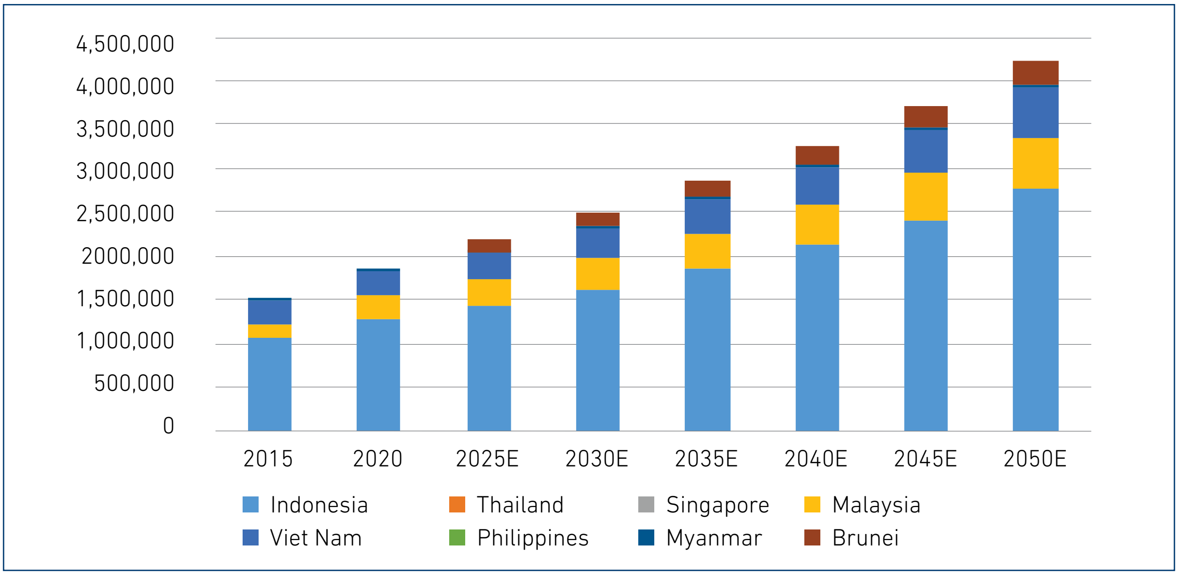
2) **Stated Policies Scenario (STEPS):** This scenario involves employing historical data and applying parameters from IEA's World Energy Outlook, STEPS to forecast the future demand for ammonia. This approach is grounded in the concept that the demand for commodities tends to exhibit consistent periodic growth until the year 2050, primarily driven by the market's increasing interest in green hydrogen energy sourced from ammonia. Consequently, we estimate that the demand for the specified product will experience a compound annual growth rate (CAGR) of 1.4% per annum for the period of 2020–2030 (Southeast Asia average), and a higher CAGR of 3.1% per annum for the following period of 2030–2050 (Southeast Asia average). Hydrogen demand growth rate for each country was estimated from Southeast Asia average growth rate adjusted with population growth projection from the World Bank.

3) **Likely Scenario:** The Likely Scenario is a modest scenario given the numerous political and economic obstacles that currently exist or are anticipated. The prediction is built on parameters from DNV report. We anticipate CAGR of 4.5% from 2030 to 2050 in the share of global ammonia demand in Southeast Asia, considering the prospect of increased adoption of green hydrogen energy in industrialised countries across the West and Southeast Asia. However, it is still higher than the growth rate predicted by the STEPS scenario, which assumes a levelling off of demand in the long run. Furthermore, we estimate that the short-term CAGR for the period of 2020–2030 in regional ammonia demand will be 1.2%, inclusive of capacity expansion and configuration changes. This estimate is supported by Japan's plan to establish an ammonia-based green energy industry in the near future. Hydrogen demand growth rate for each country was estimated from Southeast Asia's average growth rate adjusted with population growth projection from the World Bank.

4) **Announced Pledges Scenario (APS):** The APS is the most optimistic scenario, resulting from the heightened demand from novel energy applications like employing ammonia as a fuel or transforming it into hydrogen for fuel cells. This scenario involves employing historical data and applying parameter from IEA's World Energy Outlook APS to forecast the future demand for ammonia. Under the scenario, the ammonia demand in 2050 will be increased roughly fourfold. Thus, we anticipate that the specified product will encounter a CAGR of 1.2% per annum during the interval between 2020 and 2030, followed by a large rapid CAGR increase of 6.4% per annum from 2030 to 2050. Hydrogen demand growth rate for each country was estimated from Southeast Asia's average growth rate adjusted with population growth projection from World Bank.

## ERIA–Frozen Scenario

**Figure 4.11. Frozen Scenario for Hydrogen Demand from Ammonia Industry in the Region (TPA)**

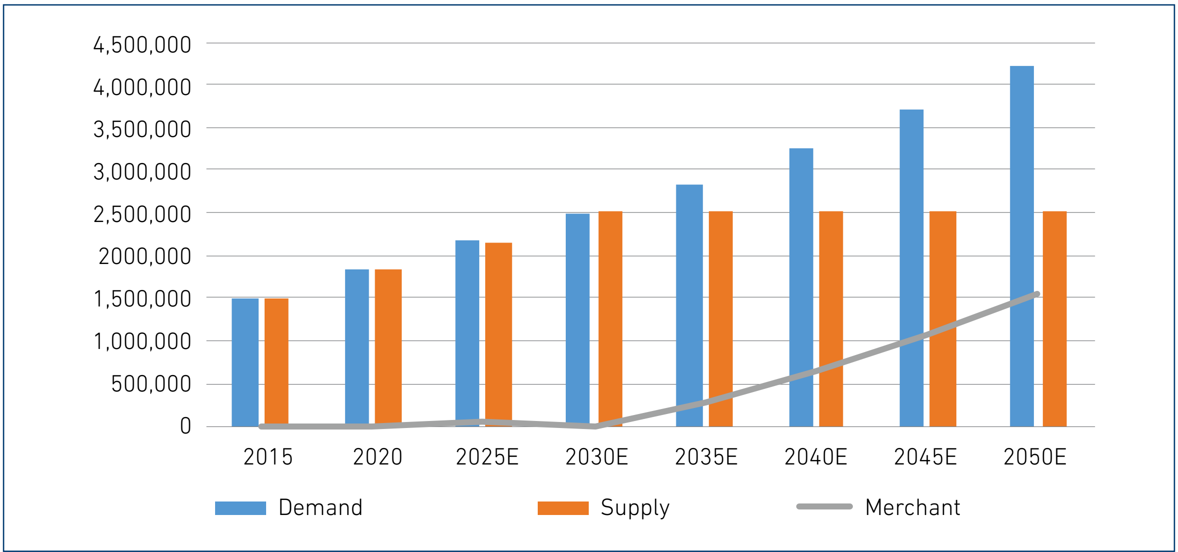



TPA = tons per annum.

Source: Authors.

This scenario relies on historical data related to the demand for hydrogen in Southeast Asia's ammonia industry. As seen in Figure 4.11 and Figure 4.12, the projected CAGR for hydrogen demand for ammonia production up to 2050 is estimated to be 2.7%, with moderate growth in demand for each country, and Indonesia remaining the dominant producer of ammonia in the region.

**Figure 4.12.** Hydrogen Supply and Demand from Ammonia Production in Frozen Scenario (TPA)

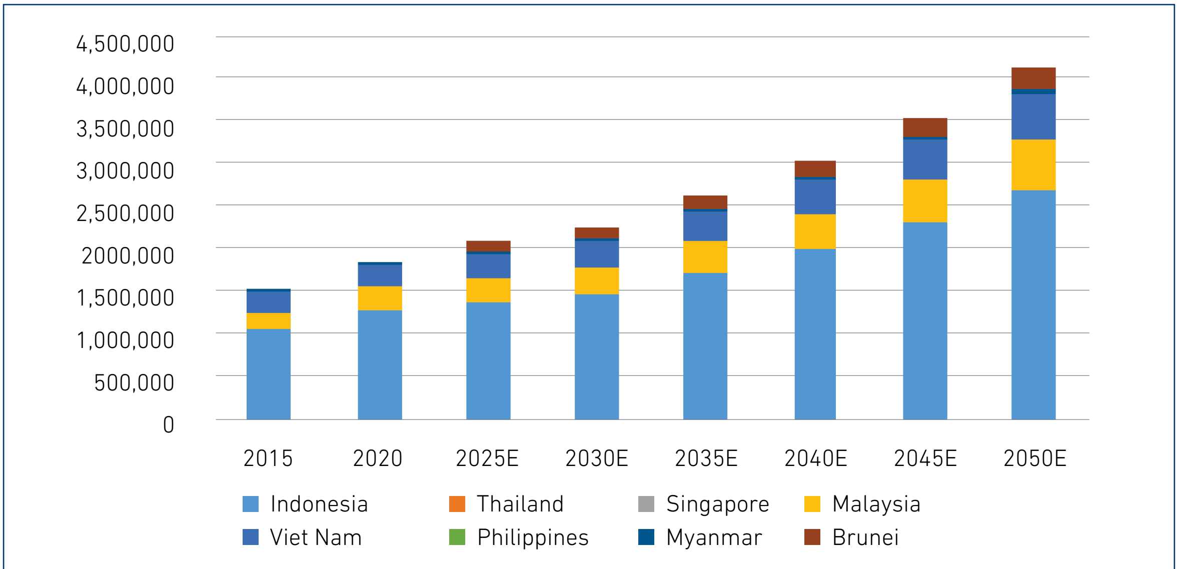



TPA = tons per annum.

Source: Authors.

## ERIA–STEPS

**Figure 4.13.** STEPS for Hydrogen Demand from Ammonia Industry in the Region (TPA)




TPA = tons per annum.

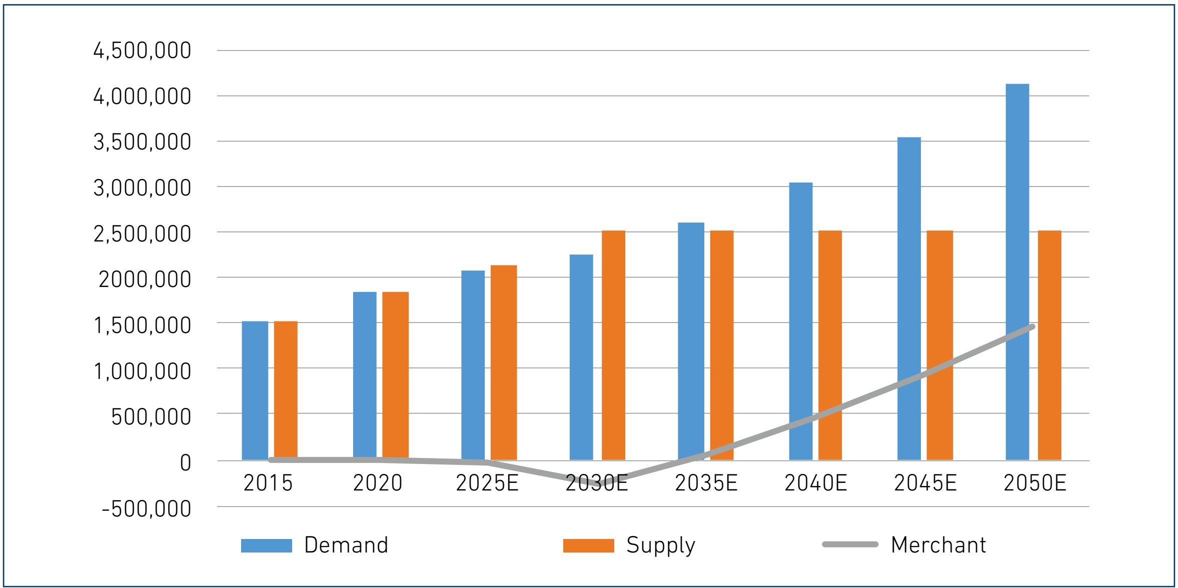
Source: Authors.

As shown in Figure 4.13, in this scenario, it is expected that the demand growth rate for hydrogen in the ammonia industry in the ASEAN region will be largely driven by major economies such as Indonesia, Malaysia, and Viet Nam. Based on the projection, Indonesia's demand for hydrogen is expected to increase from 1,270 KTPA in 2020 to about 2,682 KTPA by 2050, whilst Malaysia's demand is estimated to rise from 281 KTPA in 2020 to approximately 593 KTPA by 2050. Similarly, Viet Nam's demand for hydrogen is predicted to increase from 258 KTPA in 2020 to around 544 KTPA by 2050.

When depicted on a vertical bar chart, the market growth trends for this scenario can be visualised. The chart indicates that in the first few years of the projection (2020–2050), a compound annual growth rate (CAGR) of 1.4% is forecast, and it is anticipated that the demand for hydrogen will rise in many Southeast Asian countries as new applications and technologies emerge. Nonetheless, the bar height for this period is projected to show limited growth due to the ongoing construction phase of policy adjustments and the development of green energy technology.

During the period of 2030–2050, the demand growth rate for hydrogen in the ammonia industry is expected to rise significantly as the market prepares for the transition from conventional energy to green hydrogen energy. This trend is predicted to result in a CAGR of 3.1%, indicating that the bar chart will continue to rise until 2050 as the market has not yet reached its saturation point. However, once the market does reach saturation and countries find new technologies to replace green hydrogen energy from ammonia, a new stationary phase will begin.

**Figure 4.14. Hydrogen Supply and Demand from Ammonia Production in STEPS (TPA)**




STEPS = Stated Policies Scenario, TPA = tons per annum.

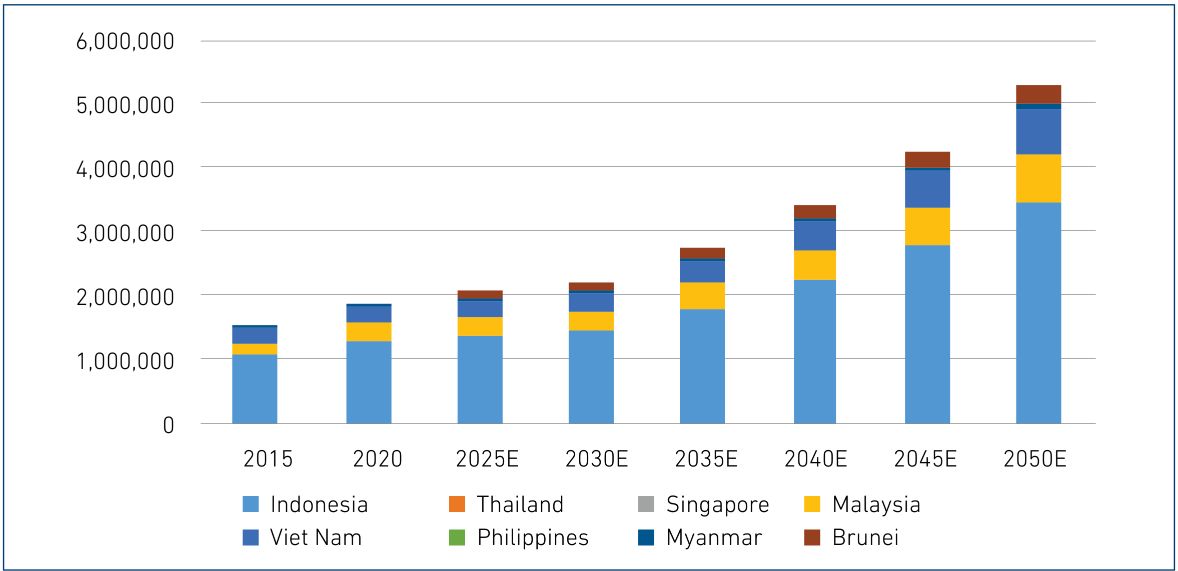
Source: Authors.

In this scenario, an increase in ammonia demand necessitates a corresponding increase in hydrogen supply (Figure 4.14). The CAGR for hydrogen demand is expected to remain in balance with the current industry supply from 2020 to 2030. However, a significant shift is projected to occur from 2030 to 2050, where assuming the hydrogen supply from existing installation capacity remains stagnant, there will be a significant imbalance between hydrogen supply and demand in the ammonia industry. As a result, third-party merchants will need to provide a significant amount of hydrogen to fulfil the demand. This imbalance highlights the necessity of importing hydrogen from external sources to meet ammonia industry demands.

## ERIA–Likely Scenario

The growth rate of hydrogen demand for the ammonia industry in this scenario is moderate and more conservative than the APS scenario. It is projected to have a CAGR of 1.2% per year between 2020 and 2030. The demand for ammonia in ASEAN countries is expected to be consistent with the STEPS as developing countries tend to adopt new technologies at a slower pace compared to developed countries. After 2030, the CAGR is anticipated to increase significantly to 4.5% per year until 2050.

**Figure 4.15. Likely Scenario for Hydrogen Demand from Ammonia Industry in the Region (TPA)**

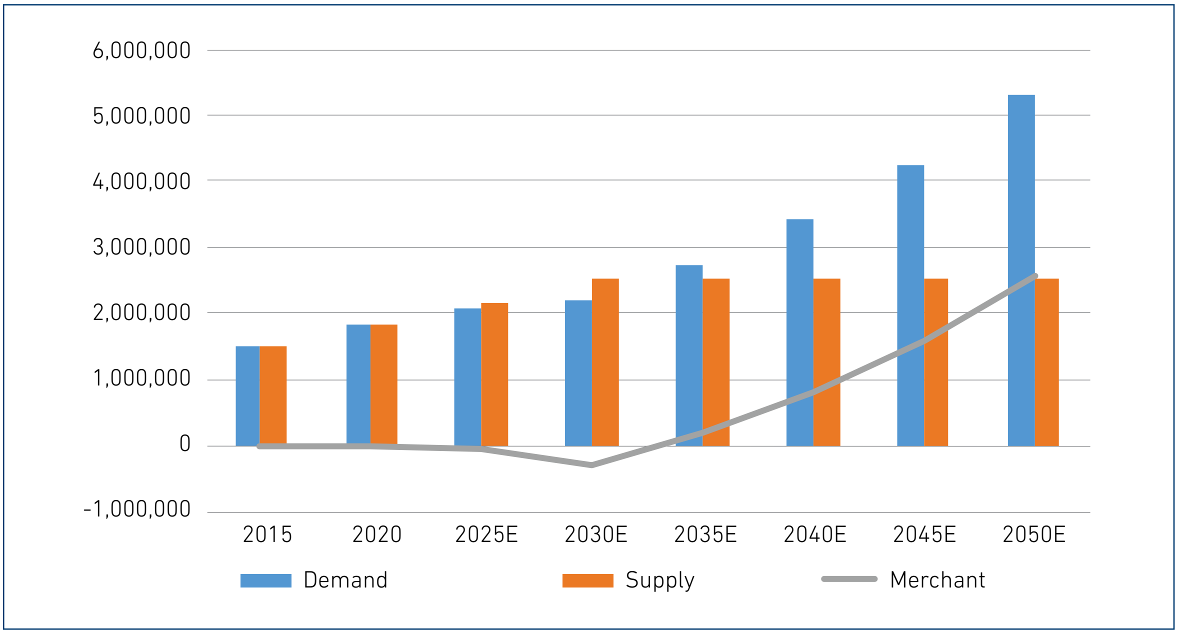



TPA = tons per annum.

Source: Authors.

According to the data presented in Figure 4.15, Indonesia is identified as the top ammonia producer in the region, followed by Malaysia, Viet Nam, and Brunei. This trend indicates an upwards trend in hydrogen demand for ammonia production in the specified countries. Conversely, Singapore, Thailand, and the Philippines, which do not have ammonia production capabilities, did not demonstrate a rise in ammonia demand. It is worth noting that Brunei is projected to commence ammonia production by the end of 2021, and Myanmar is expected to exhibit a low consumption rate of ammonia. The Likely Scenario postulates a gradual expansion in hydrogen demand for ammonia production, matching the earlier mentioned ammonia demand. Indonesia, Malaysia, and Viet Nam display a persistent uptick in hydrogen demand, indicating their growing ammonia consumption.

**Figure 4.16. Hydrogen Supply and Demand from Ammonia Production in ERIA-Likely Scenario (TPA)**




TPA = tons per annum.

Source: Authors.

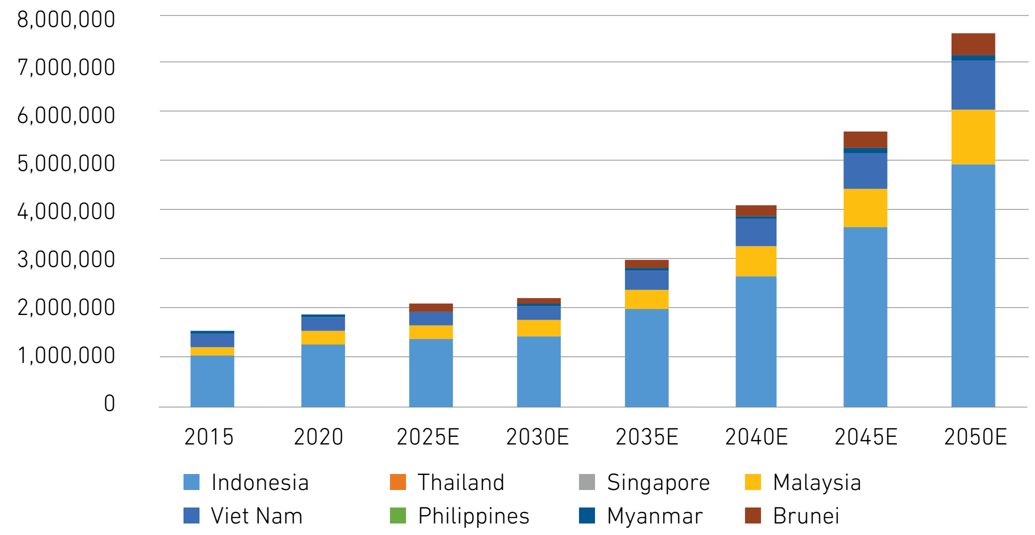
The increasing demand for hydrogen in this scenario necessitates a commensurate rise in the supply of hydrogen (Figure 4.16). Between 2020 and 2030, the hydrogen demand is projected to grow at a CAGR of 1.2%, and the current supply is deemed sufficient to meet demand with minimal reliance on third-party suppliers by early 2025. However, as the share of global ammonia demand in Southeast Asia is expected to grow at a CAGR of 4.5% from 2030 to 2050 and given the potential for an increase in the adoption of green hydrogen energy in developed nations across the West and Southeast Asian regions, the projected scenario indicates that a stagnant hydrogen supply will no longer maintain equilibrium with the increasing demand. Consequently, the hydrogen supply from third-party merchants is likely to increase significantly, and according to the projected scenario, the supply of hydrogen from external sources is expected to be equivalent to domestically-produced hydrogen by 2045–2050. Such a development could lead to stability in ammonia industry production in the region, particularly in the event of supply chain disruptions from foreign suppliers.

The total demand for hydrogen for ammonia production in Southeast Asia rises from 1,834 kilotons per year in 2020 to 5,295 kilotons per year in 2050. Although the growth rate is more conservative than the APS, it is still greater than the growth rate predicted by the STEPS. The moderate increase in demand is affected by the possibility of market saturation and technological advancements that may influence ammonia consumption from time to time.

## ERIA–APS

The current projection with APS reveals a substantial rise in the demand for hydrogen in the production of ammonia in the Southeast Asian region, as demonstrated in Figure 4.17. The projected surge from 1,834 kiloton/year in 2020 to 7,609 kiloton/year in 2050 reflects the growing trend of countries adopting ammonia for new energy applications such as fuel usage and conversion into hydrogen for fuel cells. Indonesia leads amongst the ASEAN countries as the primary driver of ammonia demand, followed by Malaysia and Viet Nam, with expected demand increases of 1,271 to 4,956 kiloton per annum, 281 to 1,097 kiloton per annum, and 258 to 1,005 kiloton per annum, respectively, from 2020 to 2050. According to the APS, the research anticipates that these nations will exhibit a compound annual growth rate of 1.23% from 2020 to 2030, which is predicted to escalate significantly from 2030 to 2050, reaching a CAGR of 6.4%. This growth can be attributed to the flourishing economy, burgeoning industrial operations, and the implementation of sustainable energy sources in these regions.

**Figure 4.17. APS for Hydrogen Demand from Ammonia Industry in the Region (TPA)**

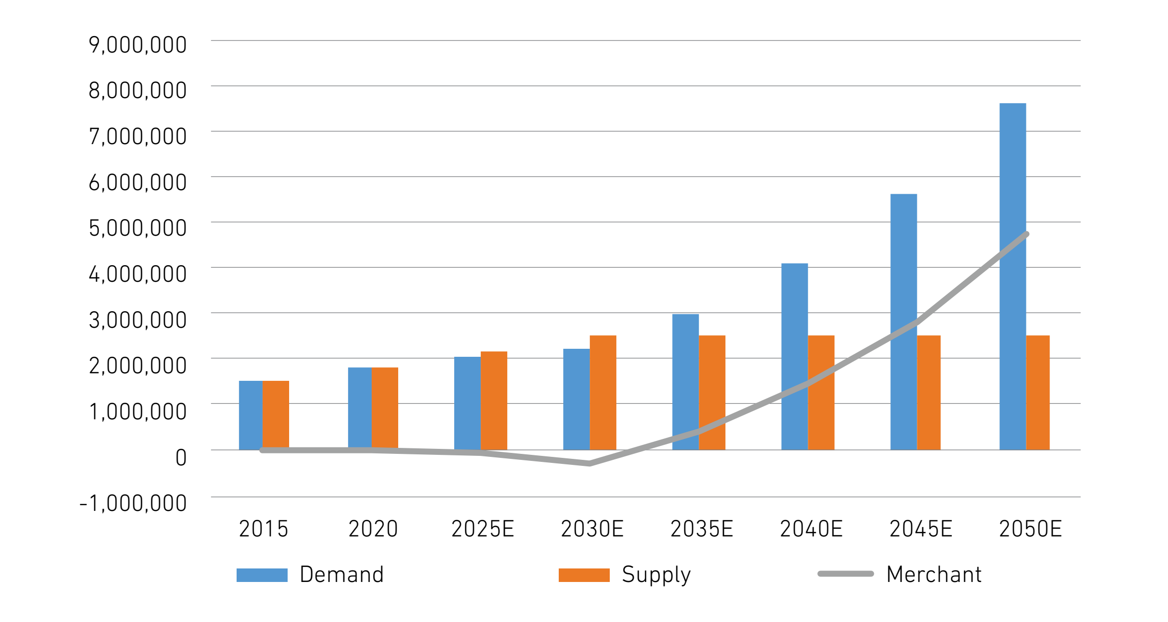



APS = Announced Pledges Scenario.

Source: Authors.

According to the APS, the demand for hydrogen in the Southeast Asian region for ammonia production shows a significant increasing trend from 2020 to 2050. The exponential rise in hydrogen demand can be attributed to the growing interest in ammonia as a sustainable energy source. Figure 4.18 indicates that whilst hydrogen consumption is projected to increase between 2030 and 2050, there will not be a concurrent increase in hydrogen-producing countries in the region, due to limitations in their reserves of natural gas resources.

**Figure 4.18. Hydrogen Supply and Demand from Ammonia Production in APS (TPA)**




APS = Announced Pledges Scenario, TPA = tons per annum.

Source: Authors.

The APS analysis reveals that the increasing demand for ammonia in the Southeast Asia region will require a corresponding increase in the supply of hydrogen. The projected CAGR of 1.2% for hydrogen demand from 2020 to 2030 is expected to be met by current supply levels with little dependence on third-party suppliers. However, an optimistic CAGR of 6.4% from 2030 to 2050 implies that the current stagnant supply of hydrogen will be grossly insufficient to meet the increasing demand for ammonia production. As a result, the reliance on third-party suppliers is projected to increase significantly, with the supply from these traders almost doubling the region's available supply. Ammonia-producing countries may need to consider alternative strategies to meet their hydrogen requirements, such as exploring more environmentally friendly energy sources or seeking supplies from abroad. Nonetheless, too much reliance on third-party suppliers can pose significant risks, including price fluctuations and unreliable supply availability. Therefore, it is essential for ammonia producers to prioritise the sustainability and reliability of hydrogen supply by developing domestic production capabilities and energy resources in a more sustainable manner.

The total hydrogen demand for ammonia production in the ASEAN region is expected to increase rapidly from 1834 kilotons per annum in 2020 to 7609 kilotons per annum in 2050. It is important to note that this scenario represents an extreme case in which all ASEAN countries aggressively pursue net-zero emissions, make significant investments, and incur all the necessary costs to achieve their ambitious climate targets.

# 4. Methanol Production

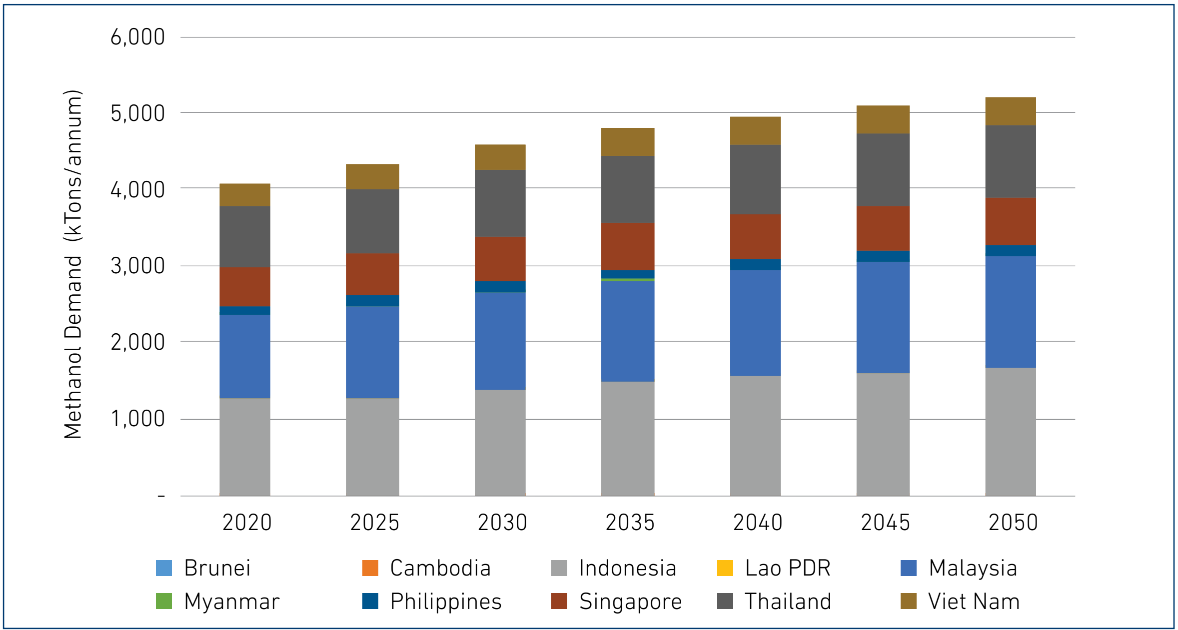
The future demand for methanol in the ASEAN region from 2020 to 2050 can be analysed using three different scenarios, which consider various growth rates and potential new applications:

1) STEPS: This scenario uses historical data and fits it with a logarithmic model to predict future demand. This is based on the assumption that commodity demand usually levels off in the long run, as economies mature, and markets become more saturated. Under this scenario, the growth rate of methanol demand might slow down over time, with the demand curve eventually reaching a plateau.
2) APS: This scenario assumes a progressive linear growth rate due to increased demand from new applications in the energy sector, such as using methanol as a fuel or converting it into hydrogen for fuel cells. Under this scenario, the demand for methanol in 2050 is estimated to be approximately three times the demand in 2020. This corresponds to a CAGR of 5.5%, which would lead to a substantial increase in methanol demand in the region.
3) Likely Scenario: This scenario predicts a more moderate increase in methanol demand, with the growth period split into two main phases. In the first phase, lasting until 2030, methanol consumption in ASEAN nations is projected to mirror that in STEPS, as developing countries are expected to adapt at a slower pace than their developed counterparts. Post 2030, the CAGR is estimated to be 4% per annum until 2050.
   This growth rate is more conservative than the APS, as it takes into account potential market saturation and technological advancements that may impact methanol demand. However, it is still higher than the growth rate predicted by the STEPS, which assumes a levelling off of demand in the long run.

It is important to note that these scenarios are based on different assumptions and projections, and the actual future demand for methanol in the ASEAN region will depend on a variety of factors, such as economic growth, technological advancements, government policies, and market dynamics. As new information and data become available, these scenarios may need to be updated or revised to better reflect the evolving context.

## ERIA–STEPS

**Figure 4.19. STEPS for Methanol Demand in the Region**




STEPS= Stated Policies Scenario.

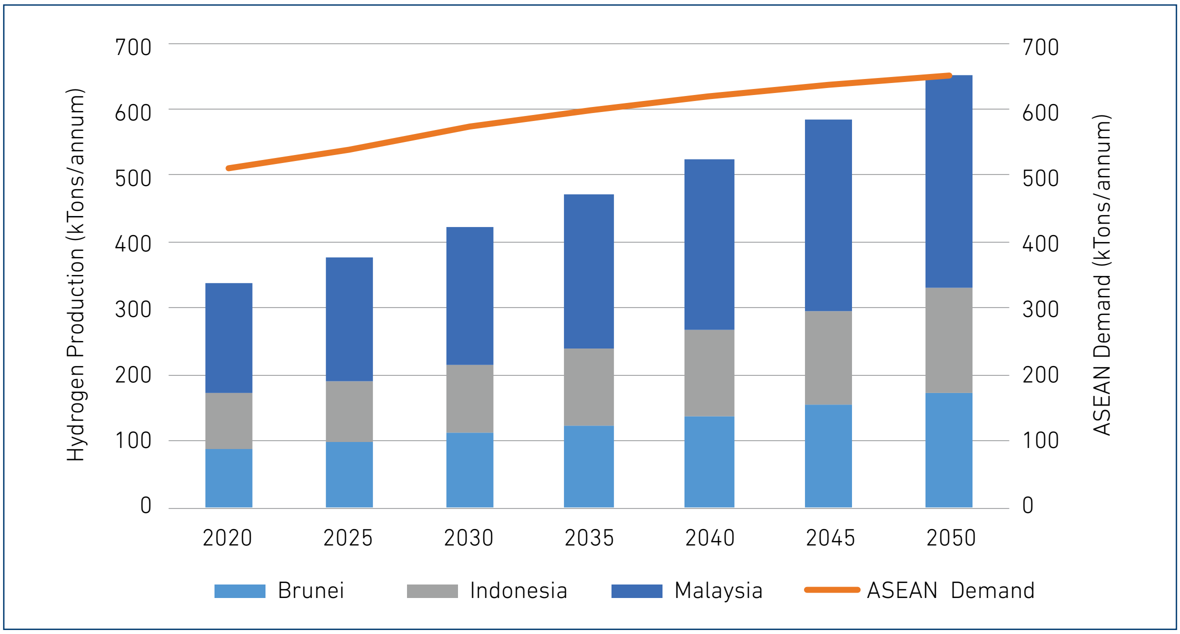
Source: Authors.

In the STEPS, the methanol demand in the ASEAN region is projected based on historical data and trends, following a logarithmic growth pattern. This assumes that the demand will level off in the long run as markets mature and become more saturated. When visualising this scenario on a vertical bar chart, you can expect to observe the following trends:

- Initial growth: In the early years (2020–2030), you would likely see a period of growth in methanol demand across most ASEAN countries, as new applications and technologies emerge, and the regional economies continue to expand. The height of the bars would increase during this period.
- Slowing growth: Moving towards the middle years (2030–2040), the growth rate of methanol demand would begin to slow down, as the market approaches saturation and the low-hanging fruit in terms of applications have been captured. In this phase, the height of the bars on the chart would continue to increase, but at a slower rate.
- Plateau: As we approach the later years (2040–2050), the methanol demand would start to level off, reaching a plateau. This would be due to market saturation, advances in alternative technologies, or shifts in government policies that might limit the growth of methanol demand. During this phase, the height of the bars on the chart would remain relatively constant, showing little to no increase.

The major economies in the ASEAN region such as Indonesia, Malaysia, and Thailand, would contribute significantly to the methanol demand in this scenario. For example, Indonesia's demand might grow from 1,256 KTPA in 2020 to around 1,653 KTPA by 2050. Similarly, Malaysia's demand could increase from 1,110 KTPA in 2020 to approximately 1,473 KTPA by 2050. Thailand might see its demand grow from 793 KTPA in 2020 to around 943 KTPA by 2050.

**Figure 4.20. Hydrogen Demand from Methanol Production in STEPS**



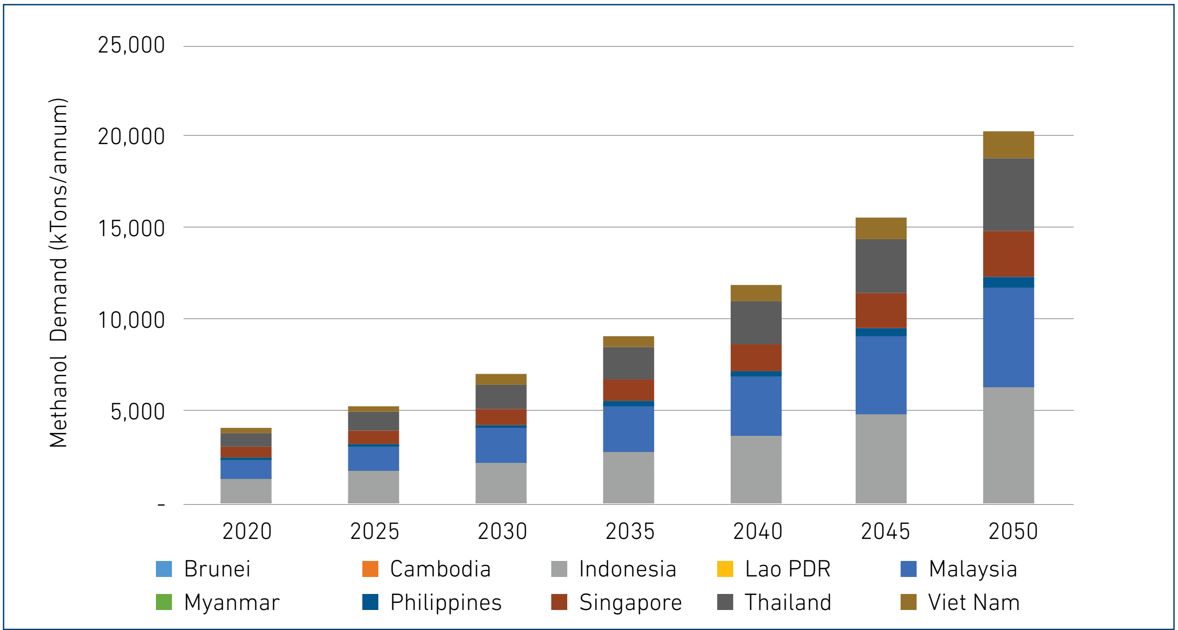

STEPS = Stated Policies Scenario.

Source: Authors.

In response to the growing methanol demand, more hydrogen is needed for its production. Figure 4.20 shows both evolutions of hydrogen demand and supply from methanol production in ASEAN in STEPS. Based on the assumption, the hydrogen demand is projected to grow at a relatively modest CAGR of 2.2% between 2020 and 2050. This limited growth is likely due to the assumption that the STEPS scenario will not attract new producers, which will restrain the growth potential of hydrogen production. Amongst the existing methanol producers, Malaysia has the highest hydrogen demand, increasing from 166.5 kilotons per annum in 2020 to an estimated 319.8 kilotons/annum in 2050 and will play a significant role in the regional hydrogen production landscape. Both Indonesia and Brunei are projected to experience steady growth in hydrogen demand during the period. Indonesia's hydrogen production is expected to rise from 82.5 kilotons/annum in 2020 to 158.5 kilotons per annum in 2050, whilst Brunei's production is predicted to increase from 90.3 kilotons per annum in 2020 to 173.5 kilotons per annum in 2050. The total hydrogen demand for the ASEAN region is projected to grow from 339.3 kilotons/annum in 2020 to 651.8 kilotons per annum in 2050. This growth, albeit modest, highlights the region's efforts to meet the demand for methanol production within the constraints of the STEPS.

## ERIA–APS

**Figure 4.21. APS for Methanol Demand in the Region**



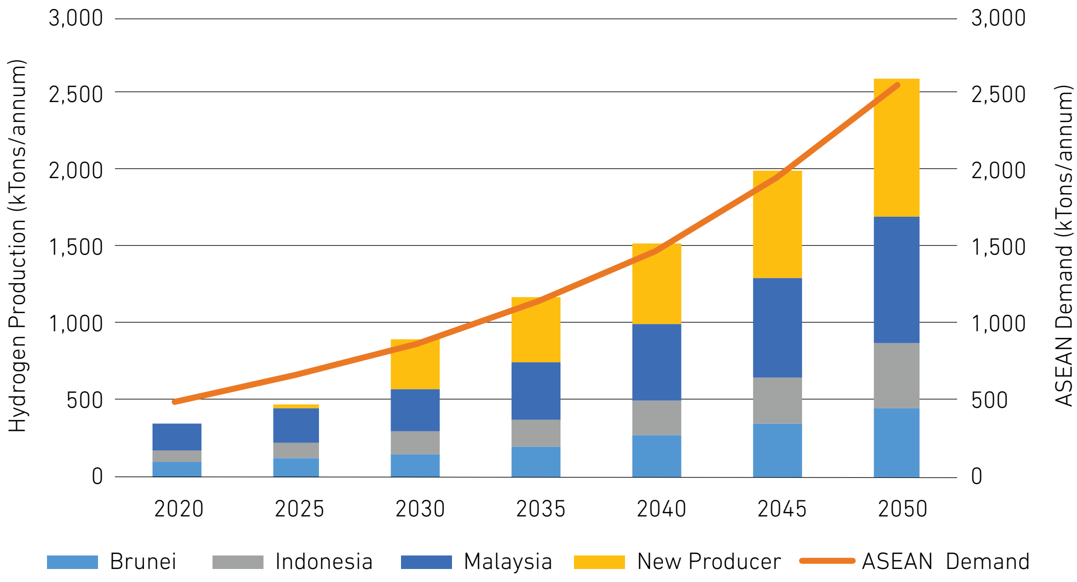

APS = Announced Pledges Scenario.

Source: Authors.

Figure 4.21 shows the significant demand growth of methanol in the ASEAN region. It is projected to rise from 4,074 kilotons per annum in 2020 to 20,303 kilotons per annum in 2050. This substantial increase suggests that these countries are adopting methanol for new applications in the energy sector, such as using it as a fuel or converting it into hydrogen for fuel cells. Indonesia and Malaysia are the major drivers of methanol demand in the region. Indonesia's demand is expected to increase from 1,256 kilotons per annum in 2020 to 6,262 kilotons per annum in 2050, whilst Malaysia's demand is projected to rise from 1,110 kilotons per annum in 2020 to 5,530 kilotons per annum in 2050. The growth in these countries can be attributed to their expanding economies, increased industrial activities, and adoption of cleaner energy sources.

Thailand's methanol demand is forecasted to grow from 793 kilotons per annum in 2020 to 3,951 kilotons per annum in 2050. Singapore, being a significant regional hub for trade and refining, is also expected to see a substantial increase in methanol demand from 505 kilotons per annum in 2020 to 2,517 kilotons per annum in 2050. Countries such as the Philippines, Viet Nam, and Myanmar will experience moderate growth in methanol demand. The demand in these countries is projected to increase due to factors like economic development, urbanisation, and growing energy needs. The significant methanol demand growth in the APS for ASEAN countries can be attributed to increased demand from new applications in the energy sector, economic expansion, industrial growth, and the pursuit of cleaner energy sources. The growth is particularly notable in Indonesia, Malaysia, Thailand, and Singapore, as these countries lead the region in economic and industrial development.

**Figure 4.22. Hydrogen Demand from Methanol Production in the APS**




APS = Announced Pledges Scenario.

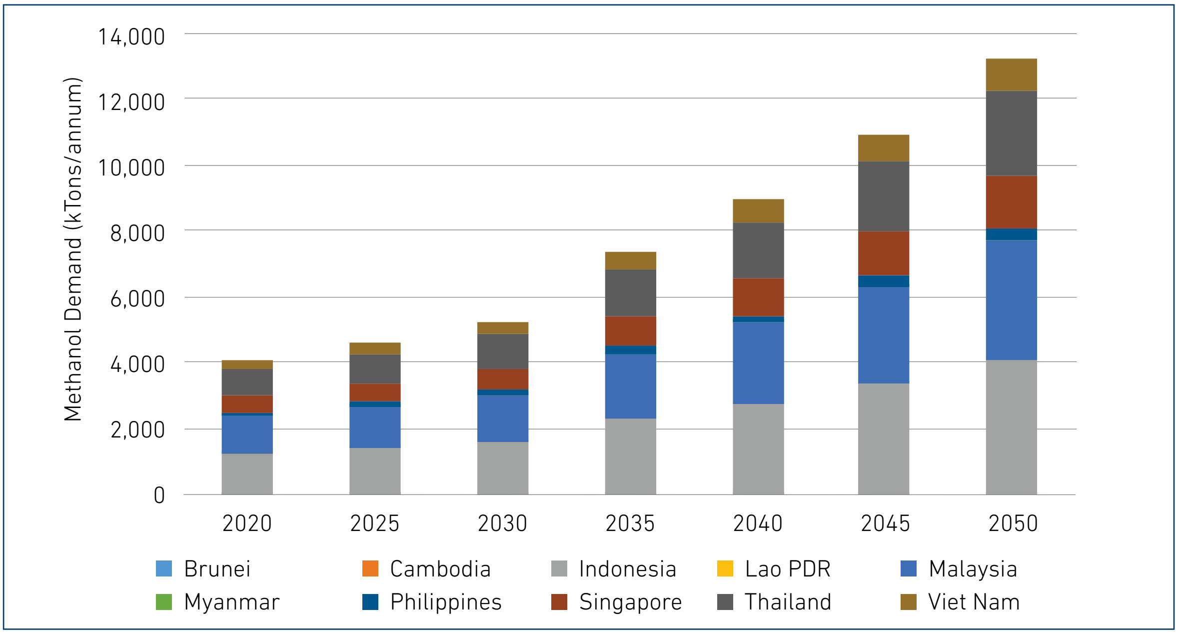
Source: Authors.

In the APS, hydrogen demand for methanol production (kilotons per annum) in the ASEAN region demonstrates a significant upwards trend between 2020 and 2050. Hydrogen demand experiences a rapid increase, which can be attributed to the growing interest in methanol as an alternative energy source. Figure 4.22 shows the appearance of new producers, starting from 2025, to cater to the burgeoning demand for green methanol. These new producers play a crucial role in serving the emerging market of green methanol as a marine transport fuel, which is gaining traction as a cleaner and more sustainable alternative to conventional fossil fuels. This development is driven by stringent environmental regulations and the shipping industry's commitment to reducing its carbon footprint.

Brunei, Indonesia, and Malaysia as regional leaders show substantial growth in hydrogen demand for methanol production throughout the forecast period. The continued growth in these countries indicates their central role in the regional hydrogen production landscape, as well as their potential to capitalise on new market opportunities. The total ASEAN hydrogen demand for methanol production increases considerably, from 339.3 kilotons per annum in 2020 to 2,602.9 kilotons per annum in 2050. It is worth noting that this represents an extreme case where growth in hydrogen demand for methanol production is exceptionally high. In this scenario, all countries in the ASEAN region are rushing towards net-zero emissions, making significant investments and bearing any costs necessary to achieve their ambitious climate goals.

## ERIA–Likely Scenario

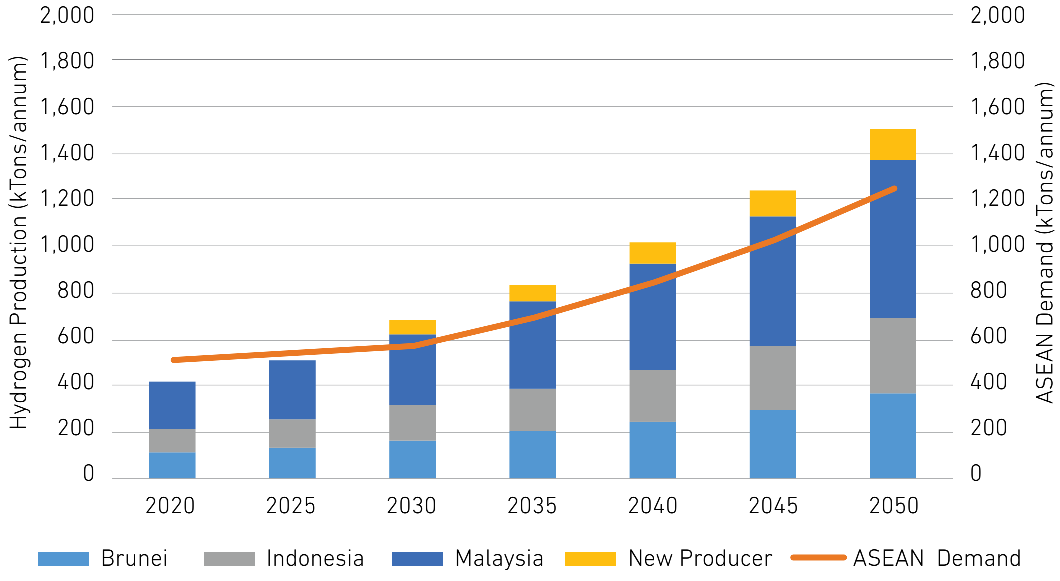
**Figure 4.23. The Methanol Demand in the Region in the ERIA Likely Scenario**




Source: Authors.

Figure 4.23 shows the methanol demand in the region in the ERIA likely scenario. In this scenario, methanol demand experiences moderate growth, with a more conservative increase compared to the APS scenario. Until 2030, methanol consumption in ASEAN countries is expected to resemble the demand in the STEPS, as developing countries are likely to adapt more slowly compared to the developed world. After 2030, the compound annual growth rate (CAGR) is estimated to be 4% per annum until 2050. Figure 4.23 indicates that Indonesia and Malaysia are the largest consumers of methanol in the region, with their demand continuing to increase steadily throughout the entire period. Singapore, Thailand, and the Philippines also exhibit a consistent growth pattern in methanol demand. The total ASEAN methanol demand increases from 4,074 kilotons per annum in 2020 to 10,034 kilotons per annum in 2050. This growth rate, although more conservative than the APS, is still higher than the growth rate predicted by the STEPS. The moderate increase in demand is influenced by the potential market saturation and technological advancements that may impact methanol consumption over time.

**Figure 4.24. Hydrogen Demand from Methanol Production in the Most-likely Scenario**




Source: Authors.

In the ERIA–Likely Scenario as shown in Figure 4.24, hydrogen demand for methanol production increases moderately, in line with the methanol demand discussed earlier. The hydrogen demand in Indonesia, Malaysia, and Brunei rises steadily throughout the period, reflecting their increased methanol consumption.

A new producer emerges by 2030, contributing to the overall growth of hydrogen demand in the region. This addition might be due to the need to serve the emerging green methanol market, particularly as a marine transport fuel. A multinational partnership aims to establish the first green e-methanol plant in Southeast Asia was announced (PTTGC, 2022). The hydrogen demand in the ASEAN region grows from 421.8 kilotons per annum in 2020 to 1,500 kilotons per annum in 2050, with a CAGR of approximately 4% per annum after 2030. The Most-Likely Scenario takes into account potential market saturation and technological advancements that may impact methanol demand, leading to a more moderate growth rate in hydrogen demand for methanol production compared to the APS.

# 5. Raw Steel Production

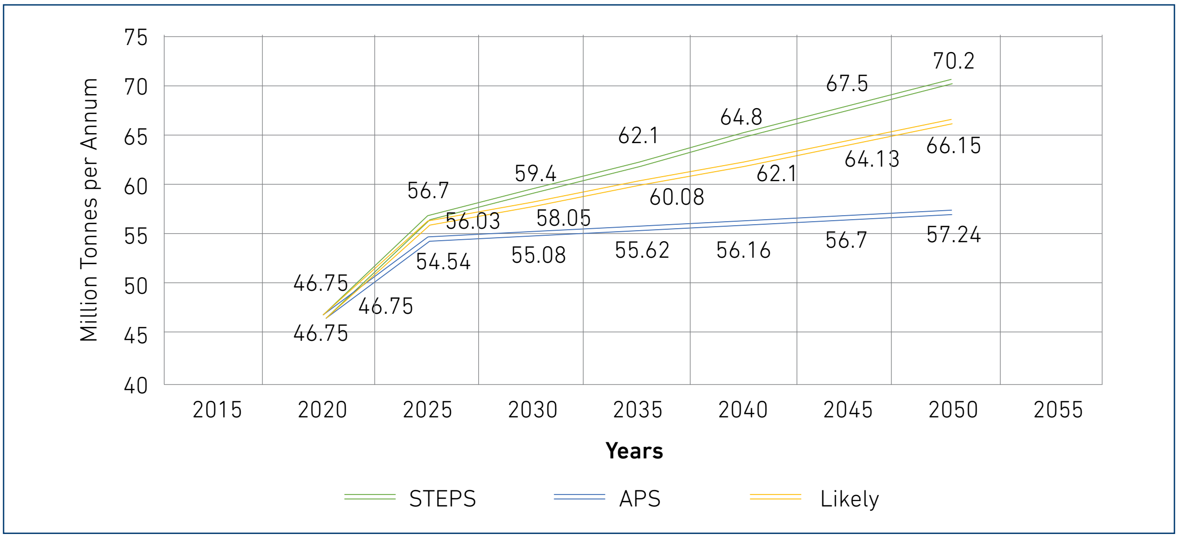
In recent years, ASEAN countries have implemented policies and initiatives to encourage the development of renewable energy sources, such as solar, wind, and hydroelectric power, and to promote the use of these sources in the iron and steel industry. One example of this is the ASEAN Plan of Action for Energy Cooperation, which sets out a framework for the development of renewable energy sources in the region (ACE, 2022b). Another initiative is the ASEAN Centre for Energy, which is a regional intergovernmental organisation that promotes energy cooperation and supports the development of renewable energy sources in the ASEAN region. The centre provides technical assistance, training, and research support for the adoption of renewable energy technologies in the iron and steel industry and other sectors (ACE, 2021a). In addition, many ASEAN countries have implemented their own policies and incentives to promote the use of renewable energy in the iron and steel industry. For example, Indonesia has launched a program to encourage the development of solar power plants in the iron and steel industry, whilst Thailand has provided tax incentives for companies that invest in renewable energy sources (MEMR, 2021b; Asia Pacific Energy, 2015).

The increasing demand for iron and steel for the future as well as the transition to renewable energy is expected to be the right solution without affecting the world's demand for and supply of steel and iron. Renewable energy infrastructure, such as wind turbines and solar panels, requires large amounts of steel and iron for construction. In addition, there is an increasing trend to use sustainable and low-carbon steel production methods, such as hydrogen-based direct reduction iron (DRI) technology. This technology uses renewable energy sources to produce steel, which reduces greenhouse gas emissions and environmental impact.

Hydrogen-based DRI technology is a new and innovative method of producing iron that has been gaining popularity in the iron and steel industry. The process involves using hydrogen gas to reduce iron oxide pellets, producing high-quality iron with low impurity levels, resulting in a cleaner and more sustainable iron production process. Hydrogen gas can be produced from renewable energy sources, such as wind and solar power. The hydrogen gas is then fed into the reduction reactor, where it reacts with iron oxide pellets to produce metallic iron and water vapour. The iron produced through this process has a purity level of up to 98%, making it suitable for use in high-quality steel production. Then, hydrogen-based DRI technology is its low carbon footprint. As it uses renewable energy sources and produces water vapour as the only by-product, it is a clean and sustainable iron production method. It also has a higher energy efficiency compared to traditional iron production methods, reducing energy consumption and costs. In addition, by using renewable energy sources for hydrogen production and incorporating carbon capture and storage (CCS) technologies, the entire iron and steel production process can become more sustainable and environmentally friendly (Ramakgala and Danha, 2019; Kim, 2022). Until now, there has been no steel plant In ASEAN that uses pure hydrogen as a reductant. The current MIDREX or HyL plant uses natural gas, reformed into CO and H2 gases (a mixture of CO and $H_2$) inside the reformer. The illustration of hydrogen production in this case is shown in Figure 2.34.

Demand for iron and steel will continue to increase to meet the needs of various sectors. Predictions related to iron and steel production, especially in the ASEAN region, can be seen in Figure 4.25. There are various prediction methods used, including the STEPS, APS, and Likely Scenario methods. In each method, iron and steel production reaches around 57.24 million tons per year for the APS, 70.20 million tons per year for the STEPS, and 66.15 million tons per year in 2050. Thus, for meeting the demand for iron and steel and the pressures associated with the renewable energy transition to achieve net-zero emissions by 2050 will be a challenge for countries that produce iron and steel. With this also, the use of hydrogen-based direct reduction iron (DRI) technology will also require increased demand and supply of hydrogen in the future.

**Figure 4.25. Demand and Supply of Iron and Steel in the ASEAN Region Using the STEPS, APS, and Likely Scenario Methods**



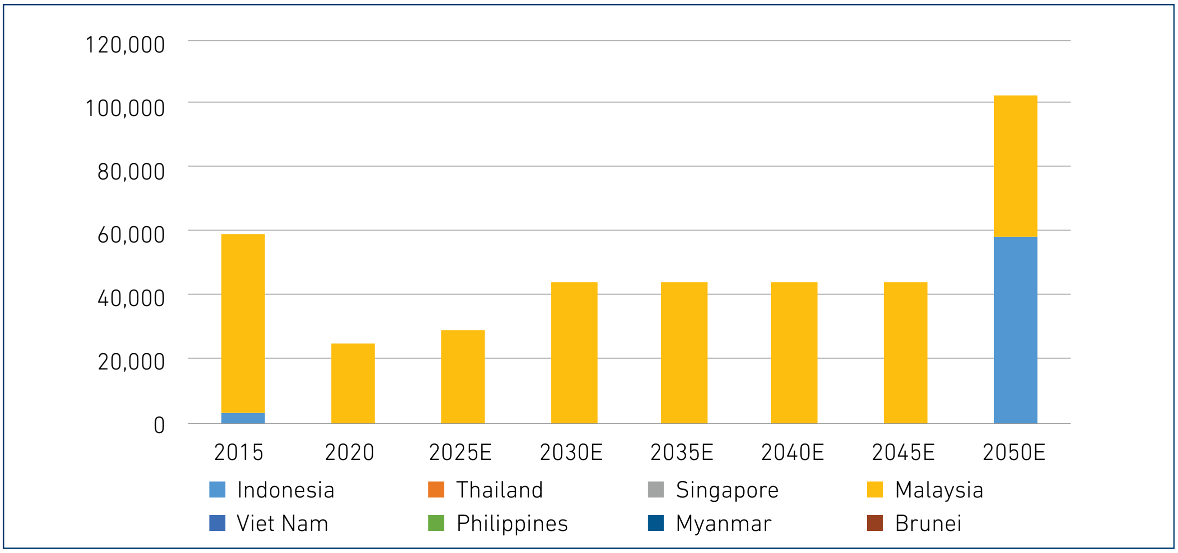

APS = Announced Pledges Scenario, STEPS = Stated Policies Scenario.

Source: Authors.

## ERIA–Frozen Scenario

Figure 4.25 shows that in the Frozen scenario, regional demand for hydrogen from the iron and steel industry increases. From 2025E to 2030E, demand for hydrogen will increase at a CAGR of around 8%. Then, the demand for hydrogen will be stable until 2045E and increase again in 2050E with a CAGR of 18%. The high demand in 2050E is supported by Indonesia's high demand for hydrogen in crude steel production.

**Figure 4.26.** ASEAN-8 Raw Steel Hydrogen Demand– Frozen Trend (TPA)

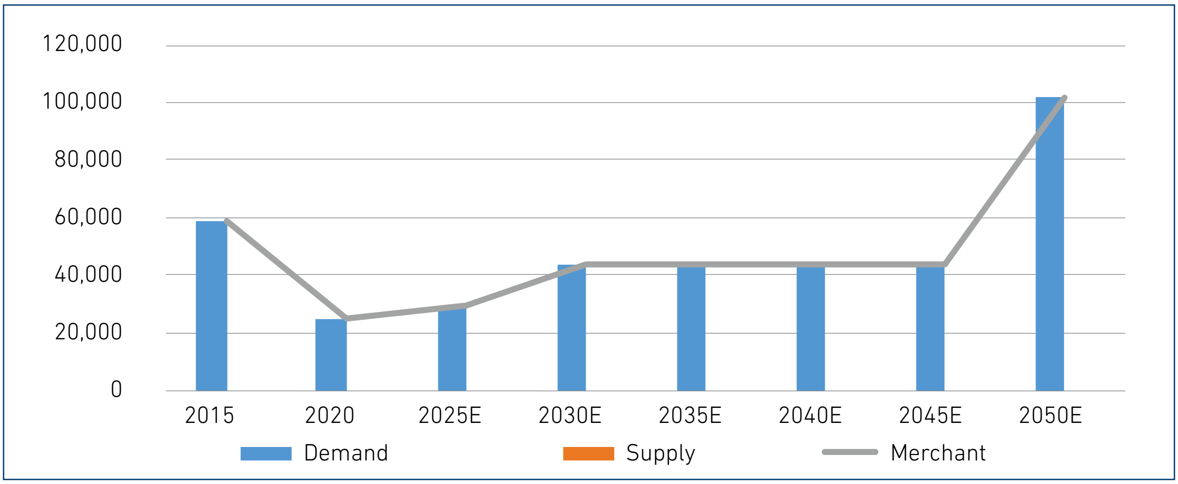



E = estimate, TPA = tons per annum.

Source: Authors.

Figure 4.26 shows the related demand and supply of hydrogen in the raw steel sector under the Frozen scenario. It can be seen that the captive supply is zero from year to year. The supply of traders has increased as well as the demand for hydrogen. Demand and supply of hydrogen in raw steel production is only seen in two countries – Indonesia and Malaysia.

**Figure 4.27.** ASEAN-8 Raw Steel Hydrogen Demand-Supply– Frozen Trend (TPA)



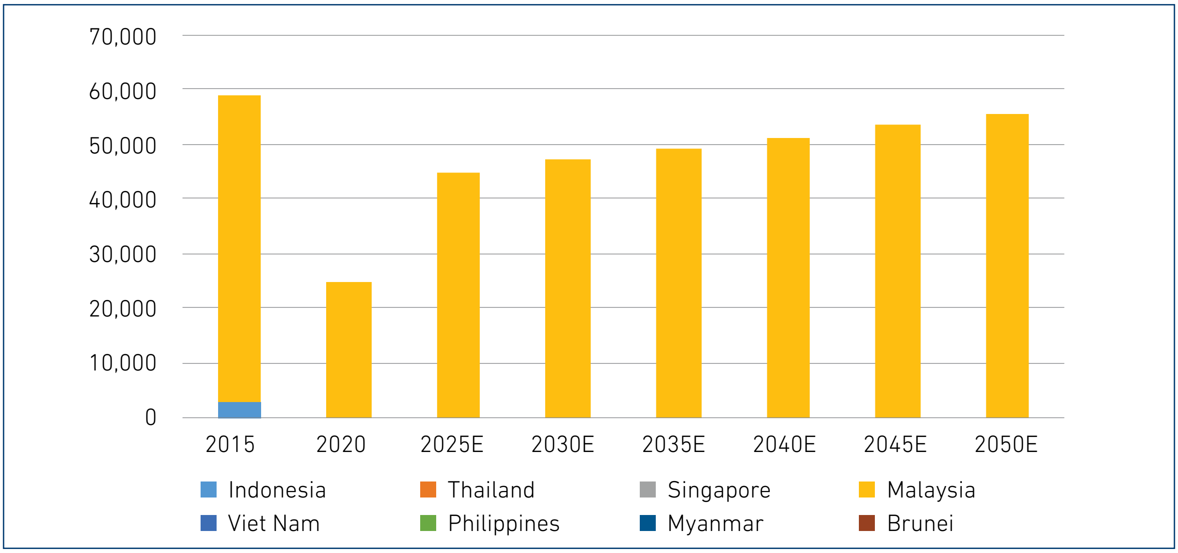

TPA = tons per annum.

Source: Authors.

## ERIA–STEPS

Figure 4.28 shows the demand for hydrogen in the raw steel sector using the STEPS. It is estimated that hydrogen demand will increase from year to year with a CAGR of 13% from 2020 to 2025E and a CAGR of 1% from 2025E to 2050E. In this STEPS, it is estimated that Indonesia has demand related to H2 for crude steel production as in the Frozen scenario. Growth in demand for hydrogen will continue to be dominated by Malaysia from year to year.

**Figure 4.28. ASEAN-8 Raw Steel Hydrogen Demand– STEPS (TPA)**

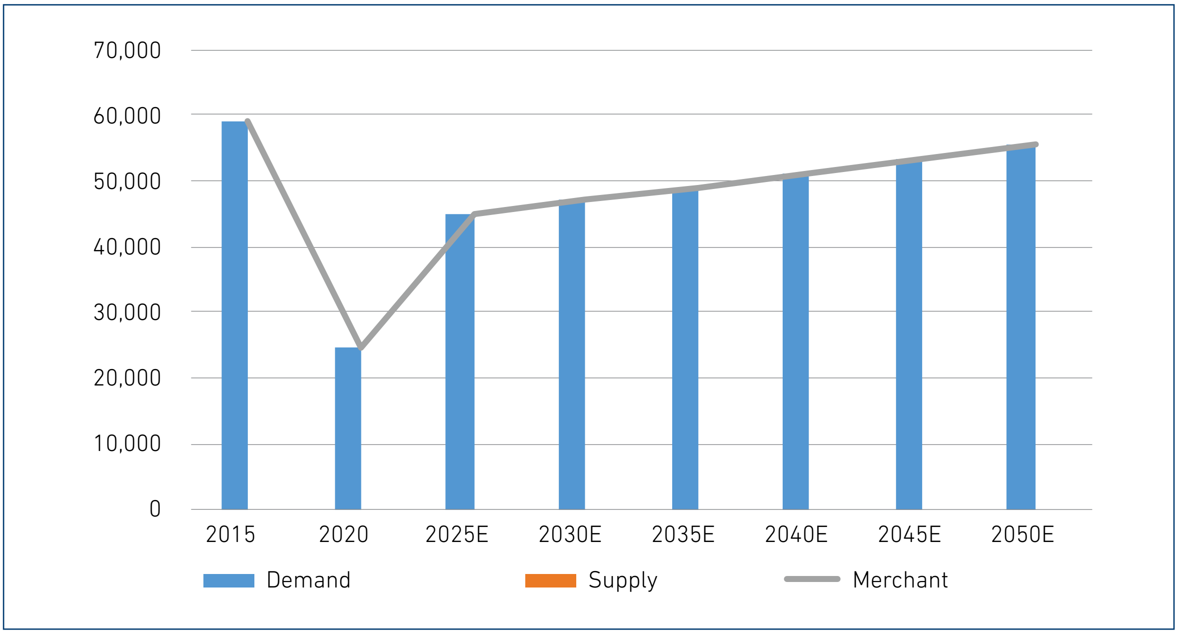



STEPS = Stated Policies Scenario, E= estimate, TPA = tons per annum.

Source: Authors.

Figure 4.29 illustrates the supply and demand for hydrogen in the iron and steel sector using the STEP. In this scenario, the demand for hydrogen will increase year by year. It can be seen that the captive supply is zero year to year. Hydrogen requirements do not rule out the possibility for countries in ASEAN to import to meet hydrogen needs. Merchant supply increases at 1% CAGR from 2025E to 2050E.

**Figure 4.29.** ASEAN-8 Raw Steel Hydrogen Demand and Supply – STEPS (TPA)



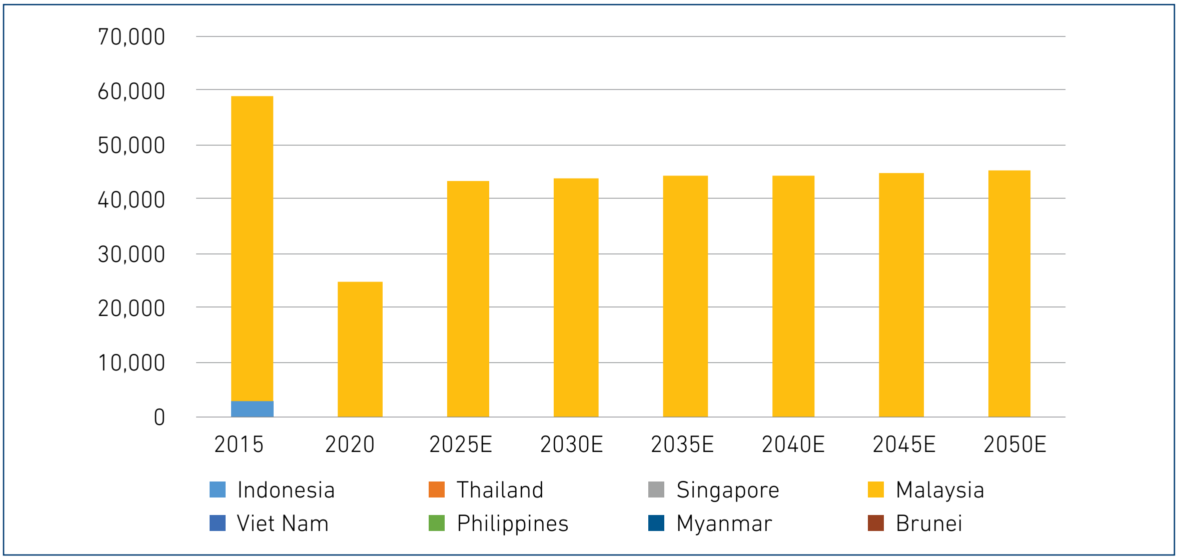

STEPS = Stated Policies Scenario, E= estimate, TPA = tons per annum.

Source: Authors.

## ERIA–APS

Figure 4.30 shows data related to hydrogen demand in the raw steel sector using the APS. In this scenario, the demand for hydrogen will increase from year to year until 2050E, where the CAGR from 2025E to 2050E is 0.2%. Hydrogen demand in this scenario has the smallest growth compared to other scenarios. Malaysia is a country with the largest amount of hydrogen demand for raw steel production.

**Figure 4.30. SEAN-8 Raw Steel Hydrogen Demand – APS (TPA)**

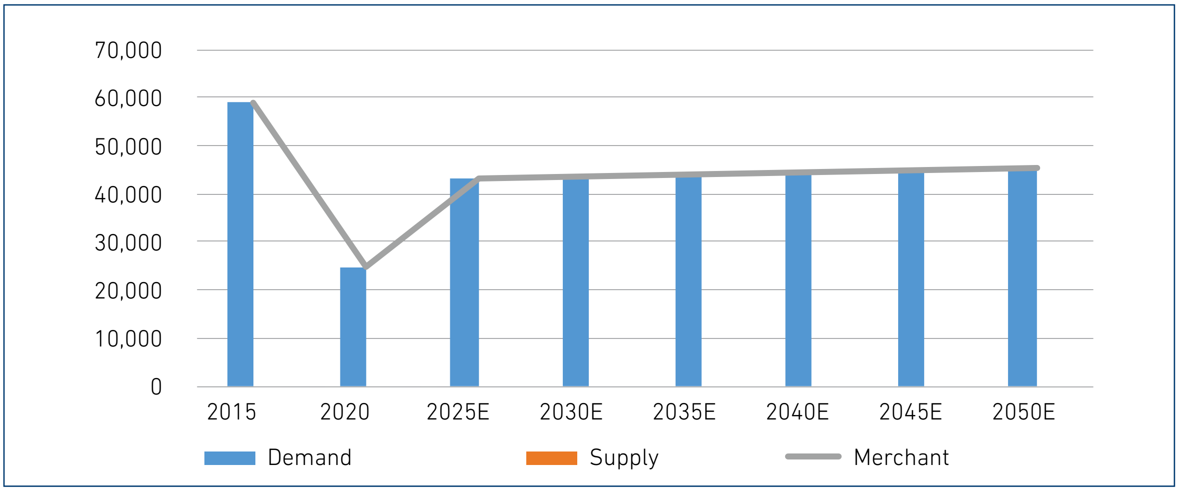



APS = Announced Pledges Scenario, E = estimate, TPA = tons per annum.

Source: Authors.

Figure 4.31 shows data related to demand and supply from the hydrogen scenario with APS in the raw steel production industry. The hydrogen demand in this scenario is the demand with the smallest CAGR compared to other scenarios. The captive supply is assumed to be zero year to year. On the other hand, Merchant supply of hydrogen continues to increase in proportion to the demand for $H_2$ for raw steel production.

**Figure 4.31. ASEAN-8 Raw Steel Hydrogen Demand-Supply – APS (TPA)**



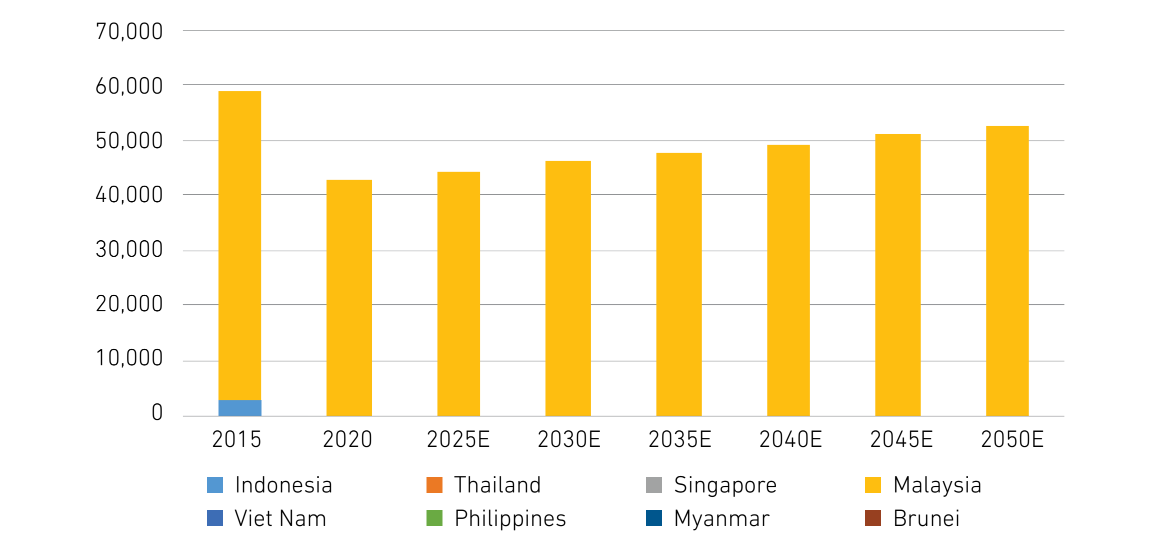

APS = Announced Pledges Scenario, E = estimate, TPA = tons per annum.

Source: Authors.

## ERIA–Likely Scenario

Figure 4.32 presents the Likely scenario of regional demand for hydrogen in the iron and steel industry. Demand for hydrogen in this scenario has increased year to year. Hydrogen demand will increase from 2025E to 2050E with a CAGR of 0.7%. Again, the demand for hydrogen in raw steel production is dominated by Malaysia.

**Figure 4.32. ASEAN-8 Raw Steel Hydrogen Demand – Likely Scenario (TPA)**

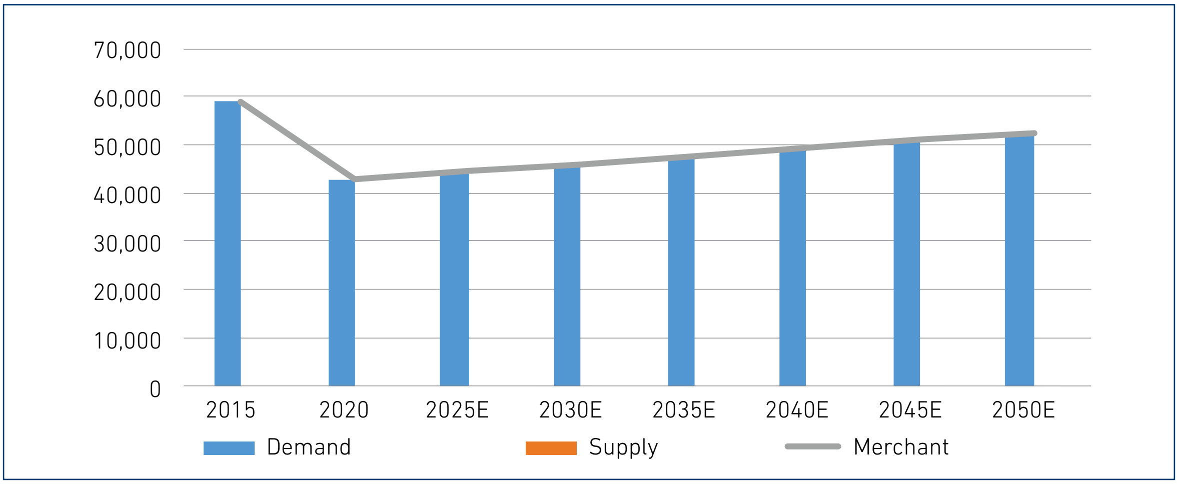



E= estimate, TPA = tons per annum.

Source: ERIA estimates.

Figure 4.33 shows data related to the demand and supply of hydrogen with the ERIA-Likely scenario in the raw steel production industry. Hydrogen demand growth in this scenario obtains a CAGR of 0.7% from 2025E to 2050E. Likewise with the increase in merchant supply from 2025E to 2050E with a CAGR of 0.7%. This scenario also assumes a zero year-to-year supply of captive hydrogen.

**Figure 4.33. ASEAN-8 Raw Steel Hydrogen Demand and Supply – Likely Scenario (TPA)**




E= estimate, TPA = tons per annum.

Source: Authors.

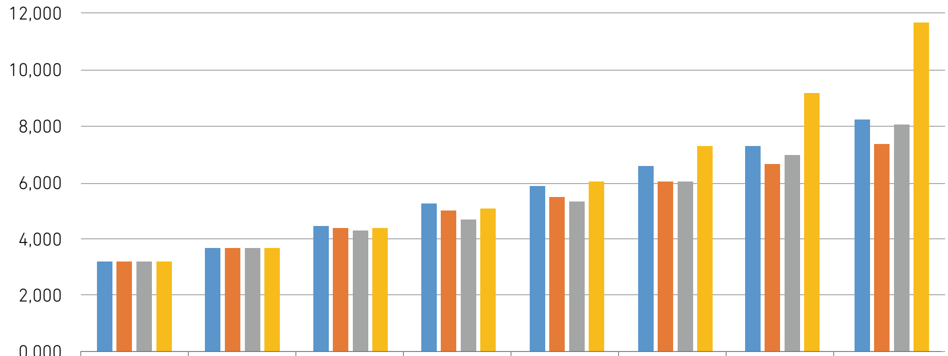
# 6. Total Hydrogen Demand and Supply for Industry Sector in ASEAN

The ERIA–APS appears to be the scenario where total hydrogen demand for the industry sector in ASEAN will increase the fastest during the simulated 2020–2050 period. As shown in Table 4.3, the CAGR of the hydrogen demand in the ERIA-APS between 2020 and 2050 reaches 3.9%. During the 2020–2030 period, the CAGR of the ERIA–APS is 3.3%, i.e. below ERIA–Frozen Scenario whose CAGR would reach 3.6%. During this period, the need for hydrogen in the oil refining of the ERIA–APS decreases as the use of electric vehicles is getting intensified and at the same time the production of hydrogen needed as feedstock for methanol production for new applications in the energy sector, such as using it as a low-carbon fuel starts to slowly kick in, therefore 2020–2030 ERIA–APS hydrogen demand growth rate is slightly higher than that of ERIA–STEPS (3.1%). The CAGR of the ERIA-APS would take off starting from the 2030–2040 period as the use of hydrogen to produce e-fuels and ammonia carriers start to really take place commercially and this strong CAGR can be expected to continue until the end of the simulation period, i.e. 2050. In the meantime, together with electric vehicles, hydrogen fuelled vehicles, such as fuel cell electric vehicle (FCEV) will also kick in during the 2040–2050 decade which will reduce the need for conventional transport fuel such as gasoline and diesel fuel even more. The share of oil refining's hydrogen demand will drop to reach a level below 10% by 2050.

In this scenario where net-zero emissions targets are assumed to be reached by ASEAN Member States (AMS) by mid 21st century, the hydrogen demand for the industry sector in ASEAN would increase from around 3.7 million tons per annum (MTPA) in 2020 to 11.7 MTPA in 2050. The use of hydrogen as energy carrier as feedstock to produce e-methanol, ammonia fuels, and e-kerosene is the main driving factor of this fast growth and the used hydrogen in this scenario must be low-carbon (intensity) hydrogen and only the use of low-carbon hydrogen will lead to net-zero emissions.

As shown in Table 4.3, the CAGR of the hydrogen demand in the ERIA-APS between 2020 and 2050 reaches 3.9%. During the 2020–2030 period, the CAGR of the ERIA–APS is 3.3%, i.e. below ERIA–Frozen Scenario whose CAGR would reach 3.6%. During this period, the need for hydrogen in the oil refining of the ERIA–APS decreases as the use of electric vehicles is getting intensified and at the same time the production of hydrogen needed as feedstock for methanol production for new applications in the energy sector, such as using it as a low-carbon fuel starts to slowly kick in, therefore 2020–2030 ERIA–APS hydrogen demand growth rate is slightly higher than that of ERIA–STEPS (3.1%). The CAGR of the ERIA-APS would take off starting from the 2030–2040 period as the use of hydrogen to produce e-fuels and ammonia carriers start to really take place commercially and this strong CAGR can be expected to continue until the end of the simulation period, i.e. 2050. In the meantime, together with electric vehicles, hydrogen fuelled vehicles, such as fuel cell electric vehicle (FCEV) will also kick in during the 2040–2050 decade which will reduce the need for conventional transport fuel such as gasoline and diesel fuel even more. The share of oil refining's hydrogen demand will drop to reach a level below 10% by 2050.

**Figure 4.34. Total Hydrogen Demand for Industry Sector in ASEAN by Scenario (million tons per annum)**




| | 2015 | 2020 | 2025E | 2030E | 2035E | 2040E | 2045E | 2050E |
|---|---|---|---|---|---|---|---|---|
| ERIA-Frozen Scenario | 3,216 | 3,657 | 4,445 | 5,212 | 5,830 | 6,520 | 7,302 | 8,227 |
| ERIA-STEPS | 3,216 | 3,657 | 4,367 | 4,961 | 5,444 | 5,990 | 6,610 | 7,319 |
| ERIA-Likely Scenario | 3,216 | 3,657 | 4,245 | 4,687 | 5,272 | 6,009 | 6,933 | 8,088 |
| ERIA-APS | 3,216 | 3,657 | 4,406 | 5,060 | 5,978 | 7,292 | 9,130 | 11,669 |

ERIA-Frozen Scenario  ERIA-STEPS  ERIA-Likely Scenario  ERIA-APS

APS = Announced Pledges Scenario, E = estimate, STEPS = Stated Policies Scenario.

Source: Authors.

**Table 4.3. Compound Annual Growth Rate of Hydrogen Demand for Industry Sector in ASEAN by Period and Scenario**

| Scenario | 2015–2020 | 2020–2030 | 2030–2040 | 2040–2050 | 2020–2050 |
|---|---|---|---|---|---|
| ERIA-Frozen | 2.61% | 3.61% | 2.26% | 2.35% | 2.74% |
| ERIA-STEPS | 2.61% | 3.10% | 1.90% | 2.02% | 2.34% |
| ERIA-Likely | 2.61% | 2.46% | 2.52% | 3.02% | 2.66% |
| ERIA-APS | 2.61% | 3.30% | 3.72% | 4.81% | 3.94% |

APS = Announced Pledges Scenario, STEPS = Stated Policies Scenario.

Source: Authors.

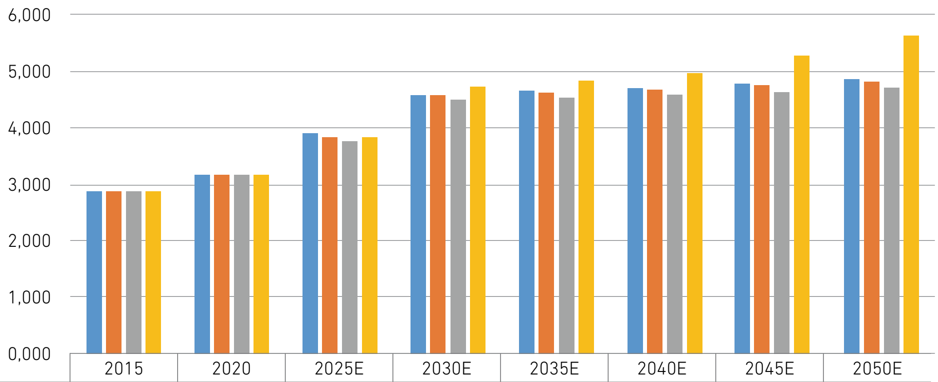
It is interesting to remark how close the 2050 total hydrogen demand of ERIA-Frozen and ERIA-Likely scenarios appears. It is the composition and sequence of the two scenarios that matters. In the ERIA-Likely scenario, traditional demand in oil refining, ammonia, and methanol industries decrease over the simulated period but demand for ammonia for energy carrier and methanol e-fuels overcompensates. Between 2020 and 2030, the CAGR of the total hydrogen demand in ERIA–Likely is lowest of all scenarios as traditional hydrogen demand, especially in oil refining due to the mobility electrification declines, whilst at the same time ammonia-energy and e-fuels technology have not been introduced yet. During the same period, the ERIA–Frozen scenario's hydrogen demand, grows faster as traditional demand for hydrogen such as in oil refining increases strongly. The hydrogen demand growth in the ERIA–Likely scenario is expected to catch up relative to ERIA–Frozen starting from 2030–2040 as the use of e-fuels and ammonia carriers start to contribute to decarbonisation. Therefore, even if in term of total hydrogen demand, the two scenarios, ERIA–Frozen and ERIA–Likely reach about similar levels by 2050, carbon emissions in the ERIA–Likely decrease much more significantly than in the ERIA–Frozen scenario.

The ERIA–STEPS is the scenario where hydrogen demand in the industry sector in ASEAN grows with the weakest CAGR, i.e. 2.3% during the 2020–2050 period. This slow growth results in the weakest hydrogen consumption by 2050 compared to other scenarios, i.e. 7.3 million MTPA or less than two-thirds of hydrogen demand in the ERIA–APS. This is caused by two factors. The first factor is the reduction of hydrogen use in oil refining due to the limited mobility electrification and the second one is the very limited use of hydrogen in the production of e-fuels and ammonia carriers. In this scenario, no significantly impacting policy measure is implemented in the ammonia, methanol, and iron and steel industries so that the changes in the total hydrogen demand is mainly caused by the changes in the oil refining sector.

# 6.1. Total Hydrogen Production

Total hydrogen produced onsite in the four scenarios is shown in Figure 4.35. Hydrogen production will increase in all four scenarios, with ERIA–APS being the scenario where hydrogen produced in the four sectors shall increase at the fastest rate from around 3.2 MTPA of hydrogen in 2020 to 5.6 MTPA of hydrogen in 2050. This means that the produced hydrogen in this ERIA–APS follows the growth of demand which is also the fastest. On the other hand, the ERIA–Likely scenario is the scenario where hydrogen produced in the four sectors grows at the slowest rate, i.e. from 3.2 MTPA in 2020 to 4.6 MTPA in 2050.

**Figure 4.35. Total Hydrogen Production in Industry Sector in ASEAN by Scenario (million tons per annum)**




| | 2015 | 2020 | 2025E | 2030E | 2035E | 2040E | 2045E | 2050E |
|---|---|---|---|---|---|---|---|---|
| ERIA-Frozen Scenario | 2,844 | 3,148 | 3,826 | 4,554 | 4,612 | 4,677 | 4,750 | 4,833 |
| ERIA-STEPS | 2,844 | 3,148 | 3,805 | 4,542 | 4,591 | 4,645 | 4,706 | 4,773 |
| ERIA-Likely Scenario | 2,844 | 3,148 | 3,696 | 4,474 | 4,509 | 4,554 | 4,608 | 4,671 |
| ERIA-APS | 2,844 | 3,148 | 3,812 | 4,658 | 4,782 | 4,968 | 5,229 | 5,587 |

ERIA-Frozen Scenario ERIA-STEPS ERIA-Likely Scenario ERIA-APS

APS = Announced Pledges Scenario, E= estimate, STEPS = Stated Policies Scenario.

Source: Authors.

The ratios or proportions of onsite or captive hydrogen production to the total hydrogen demand in the industry sectors increase from 2020 to 2030 and then decrease to the horizon 2050. By 2020, the ASEAN ratio of the onsite and/or captive production to the total hydrogen demand was recorded at around 86%. By 2030, the ratio varies from 87.5% in the ERIA–Frozen scenario to more than 95% in the ERIA–Likely. By 2050, these ratios range from around 58% in ERIA–Frozen and ERIA–Likely scenarios to around 65.2% in the ERIA–STEPS.

The relatively low onsite and/or captive hydrogen production in the ERIA–Likely scenario after 2030 compared to other scenarios is presumably caused by the need to produce low-carbon hydrogen to meet higher hydrogen demand in the industry sector in the scenario in comparison to ERIA–Frozen scenario and ERIA–STEPS. The need for hydrogen feedstock to produce e-fuels and ammonia carriers in the ERIA–Likely scenario starts to kick-in after 2030 but the quantity is less than in ERIA–APS so that the economy of scale of producing low carbon hydrogen is not high enough to decrease low-carbon hydrogen prices. Therefore, the onsite and/or captive of (low-carbon) hydrogen production in the ERIA–Likely scenario becomes lower than in ERIA–Frozen and ERIA–STEPS, the two scenarios where carbon intensities of hydrogen are higher.

On the other hand, the ratios of onsite production to hydrogen demand in the ERIA–APS are the highest. What happens in this scenario is the strong increase of hydrogen demand as feedstock that triggers an economy of scale high enough to reduce the low carbon hydrogen price.

## 6.2. Supply from Merchants

As shown in Table 4.4, the role of hydrogen merchants in the ASEAN industry sector will become more important after 2030 as the demand for hydrogen will grow but supply from onsite and/or captive production and by-products are yet to be announced.

The first source of growth is the ammonia sector where supply from onsite production and by-products increases only until 2030 and then remains at the same level between 2030 and 2050 regardless of the scenarios. The oil refining sector is generally less dependent on hydrogen supplied by merchants, whilst the methanol sector shows an important increase only in the ERIA-APS. Iron and steel and chemical industries on the other hand are often dependent on supply of hydrogen from merchants.

Decarbonisation imperative grows from ERIA–STEPS to ERIA–Likely to ERIA–APS, which is followed by the increasing share of supply from the merchants. The increasing merchant supply therefore indicates the important roles expected from the hydrogen merchants to supply low-carbon hydrogen.

**Table 4.4. Part of Supply from Merchant in Total Hydrogen Demand in Industry Sector in ASEAN**

| Scenario | 2015 | 2020 | 2025E | 2030E | 2035E | 2025E | 2025E | 2025E |
|---|---|---|---|---|---|---|---|---|
| ERIA-Frozen | 5.3% | 8.0% | 7.6% | 5.1% | 11.1% | 16.5% | 21.3% | 26.2% |
| ERIA-STEPS | 5.3% | 8.0% | 6.7% | 1.0% | 7.7% | 13.9% | 19.9% | 25.5% |
| ERIA-Likely | 5.3% | 8.5% | 7.2% | 1.8% | 12.3% | 22.3% | 31.7% | 40.3% |
| ERIA-APS | 5.3% | 8.0% | 7.7% | 3.2% | 17.1% | 30.0% | 41.2% | 50.5% |

APS = Announced Pledges Scenario, E= estimate, STEPS = Stated Policies Scenario.
Source: Authors.

# 7. Potential Carbon Emissions from Hydrogen Production and Supply from Merchants

Looking only at hydrogen demand and supply might hide the significance of the composition of the demand and supply forecasts from the perspective of hydrogen uses and their sequence that are essential in analysing their impacts on carbon emissions. One of the examples that has already been shown briefly in the previous section are the very similar mid-century total hydrogen demand estimates under the ERIA–Frozen and ERIA–Likely scenarios. These hide the fact that fundamental hydrogen demand composition and sequences should result in very different patterns of $CO_2$ emissions under these scenarios.

Different emissions factor or emission intensity estimates are available to calculate carbon dioxide emission from grey hydrogen production routes. For example, Bassani et al. (2020) estimate that 1 kg of hydrogen production from SMR should emit 7 kg of $CO_2$, while the average emission intensity of global hydrogen from the use of unabated natural gas ranges around 10–13 kg $CO_2$ eq per kg $H_2$ according to IEA (2023). Taking these values, ASEAN's 2020 hydrogen demand (and supply) would emit up to 48 million tons of $CO_2$-eq. Assuming that hydrogen continue to be produced from unabated natural gas, emissions under the ERIA Frozen scenario should reach 107 tons of $CO_2$-eq by 2050.

IEA (2023) estimates that the use of partial oxidation of natural gas with carbon capture and storage (CCS) will bring down the emission intensities to reach 0.8–4.6 kg $CO_2$ eq per kg $H_2$. IEA's Announced Pledges Scenario (APS) and Net-Zero Emissions (NZE) by 2050 Scenario see levels of emission intensities in 2050 of 3 kg $CO_2$ eq per kg $H_2$ and under 1 kg $CO_2$ eq per kg $H_2$, respectively by 2050E.

By 2050, ERIA–APS should be the scenario that reaches the lowest average emissions factor or intensity followed by the ERIA–Likely scenario and then ERIA–STEPS as more hydrogen uses that require low- or lower carbon intensive hydrogen will penetrate the strongest in ERIA–APS followed by ERIA–Likely scenario and then ERIA–STEPS. However, the quantification of emissions will need a more detailed description of the sequence of the appearance of those uses and a dissection of hydrogen production routes in each of the scenarios that are beyond the scope of this study.