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Clean Hydrogen in Asia Pacific: Fuel for Thought

How early wins in Asia Pacific hydrogen can deliver crucial momentum for net zero

Overview

Clean hydrogen is key to decarbonising hard-to-abate sectors across the Asia Pacific economies and unlocking new economic opportunities. But investment flows are governed by risk appetite and predictability of cash flows. To date bankable demand has been limited, resulting in few projects proceeding to financial close. The gulf between net zero aligned announcements and policy targets and committed market activity is widening at an alarming rate.

Key hurdles include economically viable pricing and pricing models, mutually agreeable risk allocation frameworks, and high integrity carbon certification. Limited progress is cause for concern. Stasis and delay are synonymous with rising physical and transition costs, and the recipe for a disorderly transition.

The year 2024 will be make-or-break for Asia Pacific's clean hydrogen aspirations. Leading projects are deep in negotiations with final investment decisions looming. Buyers are preparing bids for various hydrogen-demand underwriting schemes, such as South Korea's recently announced hydrogen power auction. But significant uncertainty remains around the success or otherwise of hydrogen market development in the region. By the end of the year, we should have greater certainty, with the early winners becoming apparent.

Getting early projects to completion will be challenging – for governments, industry players, and other stakeholders in the wider value chain. Radical and transparent cooperation is needed to provide certainty for investment. But if this certainty can be obtained, it would catalyse a $630 billion p.a. low carbon commodity market in Asia Pacific. Progress will hinge on mobilisation of the first tranche of the $3.2 trillion capital investments needed in the clean hydrogen value chain across Asia Pacific over the next 25 years.

All participants within the hydrogen ecosystem – governments, hydrogen suppliers, offtakers, and service providers – must take proactive steps to turn momentum into action this year.

To support this endeavour, we have selected three pressing questions about clean hydrogen's prospects in Asia Pacific to preview:

1. How must the clean hydrogen market in Asia Pacific develop to deliver a net zero region?
2. How much investment is required to deliver an Asia Pacific hydrogen market?
3. How can parties across the value chain turn momentum into bankable actions?

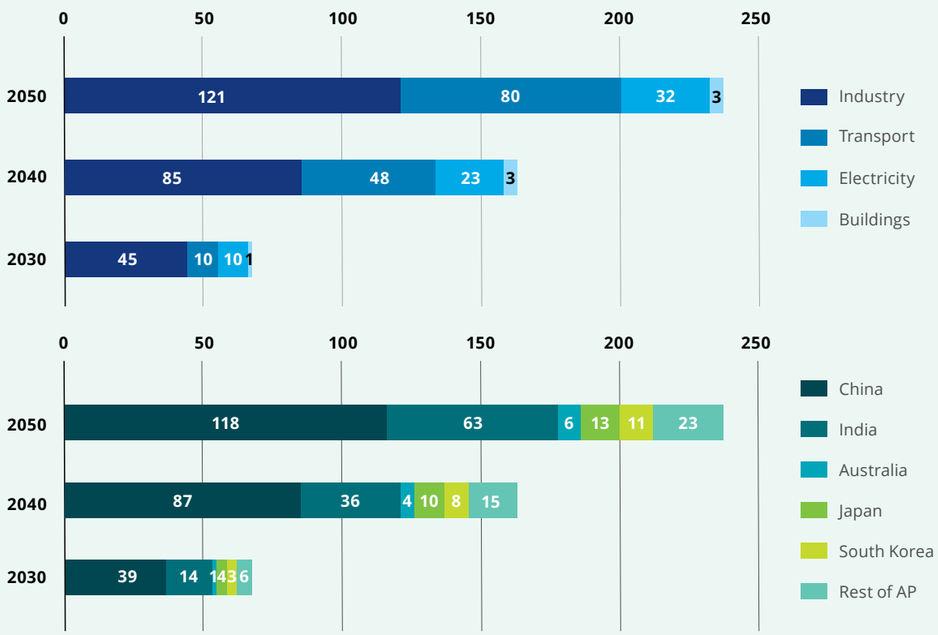
Clean hydrogen's role in a net zero Asia Pacific

The adoption of clean hydrogen is essential if Asia Pacific is to achieve net zero by 2050. The mainstays of Asia's economic growth – steelmaking, industrial chemicals, aviation, shipping, and power – are big emitters, particularly in China, India, Japan, and South Korea. It is essential to decarbonise them in the coming decades.

These sectors will require up to 67 million tonnes of hydrogen (MtH2)[1] by 2030, and up to 235 MtH2 by 2050 to reach net zero (Figure 1). Industrial users are expected to account for about 70 per cent of demand by 2030, accelerating towards 2050 as demand from shipping and aviation rises. The power sector will be an important user market in Japan and Korea in particular, with significant policy support underwriting uptake.

Hydrogen demand in Asia is expected to be dominated by China and India, given their economic heft and industrial make-up. Deloitte estimates these two economies could comprise almost 80 per cent of demand in the Asia Pacific region, with much of this met by domestic supply. In these two countries, the scale of demand to meet industrial needs in a limited timeframe could mean resorting to supplementary imports, despite a large potential for cost-competitive domestic supply. There is much uncertainty, and the outcome will ultimately depend on political choices and public support. By contrast, while Japan and South Korea make up an average of 10 per cent of demand, the vast majority of this is expected to be serviced by imports.

Figure 1
Asia Pacific hydrogen demand by sector and country (in MtH2)



Source: Deloitte analysis adapted from the Green Hydrogen: Energizing the path to net zero (2023) report. The central scenario presented in the latter study has been adapted, pending the finalizing of a deeper recast currently underway.

[1] All quantities for demand of hydrogen and its derivatives are expressed in hydrogen equivalent term. This unit is defined as the mass of hydrogen needed to produce of the mass of the considered molecule (e.g., ammonia, methanol, e-fuels).

Servicing this demand, particularly in Asia Pacific, represents a lucrative commercial opportunity. In a scenario consistent with net zero, the global hydrogen market could be worth almost $550 billion per year by 2030, rising to US$1.2 trillion by 2050. Asia Pacific would account for half of the annual worldwide market[2] by value in 2050 (Figure 2).

From a technological perspective, green hydrogen dominates the supply mix in the region from the beginning, representing more than 85% of volumes locally produced by 2030 and above 95% by mid-century. However, given challenges with market development there is potential for blue hydrogen to play a role in supporting demand-side development.

Who will service this demand and win a share of the emerging clean hydrogen market? Deloitte's analysis suggests that most clean hydrogen will be produced and consumed near demand centres in China (which could be about 90% self-sufficient) and India.

Uncertainty remains high: both countries have significant potential for affordable domestic hydrogen production and could increase the use of complementary low-carbon technologies, such as renewables for power generation, to pilot their demand for clean hydrogen; further enhancing the possibilities for self-sufficiency.

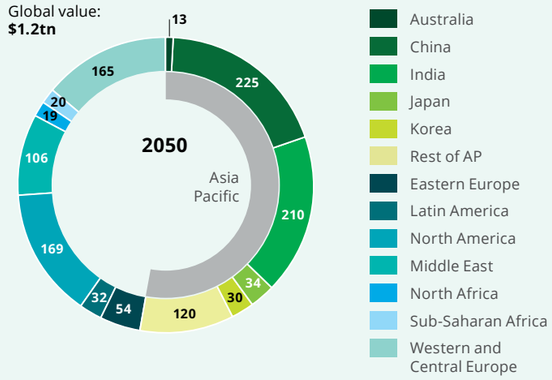
Across Asia Pacific, domestic production will not be enough to meet net zero-aligned demand. We estimate that Asia Pacific countries will need to import 18 MtH2 of clean hydrogen and derivatives by 2030, rising to 53 MtH2 by 2050. This suggests annual cross-border trade worth $145 billion p.a. by 2050.

Deloitte's Net Zero-aligned modelling suggests that the 2050 import market will be governed by four end-use molecules (Figure 3):

- Hydrogen as a fuel source and reactant will account for 45% of import volumes, and will require movement via carriers such as ammonia
- Ammonia, which will service the chemicals and shipping industries, accounts for about a fifth of molecule trade
- E-fuels, to decarbonise aviation, representing about 30 per cent of import volumes
- Methanol will represent the remaining 5% of seaborne demand.

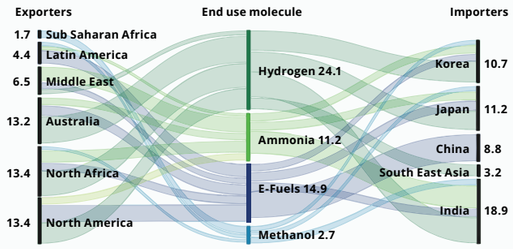
The Japanese and South Korean markets could account for $43 billion per year in use by 2030, rising to $64 billion by 2050. Importantly, widespread adoption of clean hydrogen will cause significant downward pressure on prices. For example, Deloitte expects delivered prices to more than halve between 2030 and 2050 in Japan and South Korea.

Figure 2
Value of 2050 hydrogen market by region



Source: Deloitte analysis adapted from the Green Hydrogen: Energizing the path to net zero (2023) report, based on the Hydrogen Pathway Exploration (HyPE) model.

Figure 3
Hydrogen trade flows to meet AP demand by 2050, MtH2



Source: Deloitte analysis adapted from the Green Hydrogen: Energizing the path to net zero (2023) report, based on the HyPE model.

The interplay between supply and demand of hydrogen is especially stark in the case of India. Deloitte's Net Zero-aligned modelling assumes accelerated decarbonisation in India's industrial and transport sectors with demand outstripping supply over the medium-term necessitating imports. However, India's 2030 targets for green hydrogen production are increasingly framed around export. Recent Indian policy announcements are bolstering these aspirations. If momentum builds and pricing becomes competitive, India has the potential to realise it's export aspirations.

[2] The market value refers here to the value of hydrogen and its derivatives consumed in the presented regions (demand side). The market size of exporting countries such as Australia consequently appears lower than the value of their total supply, a large share of which being dedicated to exports.

The global hydrogen cost curve will determine the degree to which trade within Asia Pacific can scale up to keep pace with demand. Deloitte's analysis suggests that inter-regional trade – primarily supplied by Australia and Southeast Asia – is well positioned to meet around a quarter of Asia Pacific's import needs.

As noted previously, India's export aspirations are also clear and increasingly backed by policy. Suppliers from North America, North Africa, the Middle East and Latin America could all offer competitively priced molecules.

Hydrogen security will quickly emerge as a pillar of energy and national security. At the company level, Asia Pacific importers will need to hedge via a derisked portfolio of suppliers across continents. At the national level, importing governments will need intensify economic, political, and social cooperation across bilateral and regional channels.

Aside from pilot shipments, limited volumes of clean hydrogen have crossed continents. Hydrogen trade corridors remain in their infancy, with rapid scale-up needed to keep global decarbonisation on track.

We expect early success in moving molecules through hydrogen trade corridors to be guided by five factors:

1. Geopolitical stability: a low risk political and geostrategic outlook on the supply and demand sides is essential to provide confidence in a 30+ year project life and 15 year offtake contracts.
2. Streamlined processes for FDI: mobilisation of deep and liquid capital markets is a prerequisite to enable world-scale projects.
3. Bilateral vertical integration: supply chains will scale with early projects and viable economics will require deep integration across multiple tiers up- and downstream of molecule movement.
4. Exchange of skills and intellectual property: deployment speed and sustainment of mutually beneficial trade will require new flexibility for mobility of skills, talent, and intangibles.
5. Cross-border trade governance: overcoming high transaction costs of early projects will require explicit facilitation across bilateral trade corridors, such as the Korea-Japan Hydrogen Cooperation Dialogue and Deloitte's Hydrogen Trade and Investment Corridors initiative (HyTIC).

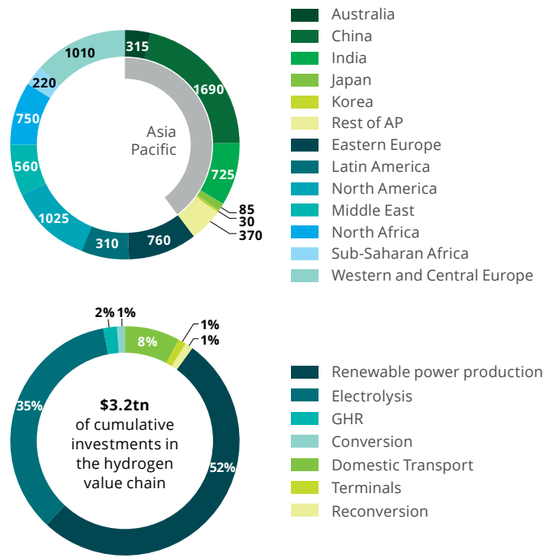
Investment flows to produce a clean hydrogen economy

To realise full adoption of clean hydrogen, the Asia Pacific region will likely require $3.2 trillion of cumulated investment over the next 25 years.

The lion's share of this investment is expected in China and India, to satisfy significant production potential (Figure 4). Australia will stand out as the region's pre-eminent export partner, with more than US$300 billion of investment required, largely to service regional demand.

Most expected investment requirements are for renewable generation and transmission (52%), followed by hydrogen production via electrolysis (more than a third). The remainder of capital investment is expected to be spread across a range of transport, conversion and reconversion facilities.

Figure 4
Cumulative hydrogen capital investment requirements by region and value chain stage to 2050

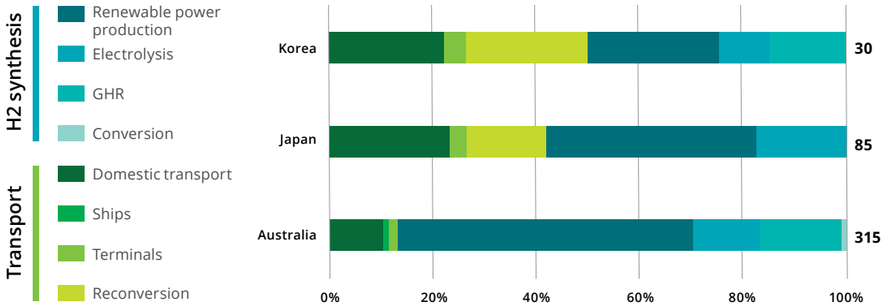


Source: Deloitte analysis adapted from the Green Hydrogen: Energizing the path to net zero (2023) report, based on the HyPE model.

The investment profile of each country within Asia Pacific can be expected to reflect its role in the hydrogen economy.

While Japan and South Korea are likely to secure limited volumes of domestic clean hydrogen supply, both economies must invest substantially in hydrogen transport and reconversion technologies to meet high levels of demand (Figure 5). On the other hand, the investment profile of a major exporter like Australia is expected to be dominated by upstream capital expenditure.

Figure 5
Clean hydrogen investment profiles of select Asia Pacific, cumulative to 2050



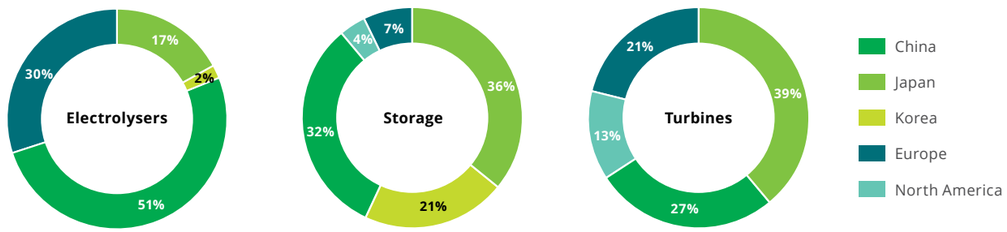
Source: Deloitte analysis adapted from the Green Hydrogen: Energizing the path to net zero (2023) report, based on the HyPE model.

Capital investment trends in the future clean hydrogen economy could represent a significant challenge for Asian players in the emerging supply chains.

Projects are moving ahead faster in other regions, such as Europe and the US, using their own domestic supply chains, which gives them scale and first mover advantage. It may be hard to catch up and become material players in these supply chains without large subsidies.

On the other hand, the region is ahead in terms of technology. Deloitte's review of patents for important hydrogen technologies reveals a regional dominance of key technologies including electrolysers (70%), hydrogen storage (89%) and hydrogen turbines (66%) (Figure 6).

Figure 6
Market share of top 20 patent holders for select hydrogen technologies



Source: Deloitte Hydrogen Patent Landscape

This early advantage, however, is not guaranteed to convert into sales or market share for Asian supply chain players. That can only come from proven performance, rapid feedback loops and development of a value-differentiated offering.

But it does point to an important route for Asia Pacific to capture outsized value from the emerging hydrogen economy. Early projects using local intellectual property and manufacturers will accelerate technology scale up and establish industry benchmarks.

Turning hydrogen momentum into bankable action

2024 is the make-or-break year for Asia Pacific's clean hydrogen aspirations.

To date, hydrogen projects have struggled to overcome key bankability hurdles including: economically viable pricing and pricing models, mutually agreeable risk allocation frameworks, and high integrity carbon certification.

Deloitte expects the significant acceleration in policy support – much of which will come online by the end of the year – will prove decisive. Collectively, governments in Australia, India, South Korea, Japan and Singapore have announced programs which represent $44.5 billion of investment for clean hydrogen (Figure 7).

Figure 7
Key Asia Pacific policy incentives and timing

Country	Policy	Estimated magnitude	Award of funding/contract
Australia	Supply-side support (Hydrogen Headstart)	• AU$2bn (US$1.33bn) – first round • Additional AU$2bn (US$1.33bn) in second round • AU$2/kg (US$1.33/kg) tax credit for 10 years in future – budgeted at AU$12.2bn (US$8.1bn)	Q4 2024 (first phase)
India[(1)]	Supply-side support (National Green Hydrogen Mission)	• Estimated initial funding round of 30.5bn rupees (US$0.37bn) • Further funding expected under 197.44bn rupees (US$2.37bn)	Awarded January 2024
South Korea[(2)]	Demand-side support (auctions)	• Targeting 6500GWh of clean hydrogen in 15 year contracts • Estimated budget of more than 13.2tn won (~US$10bn)	Q4 (November) 2024
Japan	Demand-side support (Contracts-for-Difference) (CfD)	• Total funds alloted are 3.1tn yen (~US$20bn) for 15 year contracts	Not expected until Q1 (March 2025)
Singapore[(3)]	Demand-side support (Ammonia Tender)	• Estimated at over SG$1.4bn (US$1.07bn)	Not expected until Q4 2025

Source: Budget documents and government announcements. Budget amounts in South Korea and Singapore have been calculated based on announced target clean hydrogen volumes, a reference price in the power sector and the cheapest delivered blue ammonia price from the Deloitte Hydrogen Model to each market. See endnote for more detail[i].

Governments across Asia Pacific have announced these programs to support first mover projects to overcome unpriced carbon externalities and scale up the early hydrogen market.

But to date, these programs have been designed in isolation and without considering the wider regional policy context.

Deloitte anticipates four challenges that will need to be overcome as governments begin to assess cross-border bids for their respective programs:

1. **Inconsistent certification regimes:** Misaligned lifecycle carbon assessment and verification frameworks risk double-counting abatement, ignoring sources of emissions, and creating unnecessary investment uncertainty and compliance burdens for developers.
2. **Carbon and cost trade-offs:** The cost difference between blue and green hydrogen will lead importing governments to favour blue but locking in 15 year offtake agreements could impede opportunities in green hydrogen value chains.
3. **Contingent offtake and bid pricing:** Misaligned bid scheme timing between countries will create commitment problems. Supply-side programs require offtake certainty which hinges on demand-side support. The lowest bids in demand-side programs are likely from projects receiving supply-side support. Government-to-government negotiations seem inevitable – and desirable – for initial projects.
4. **Cross-border equity:** Governments lack a fact base for bilateral negotiations regarding an equitable distribution of the cost gap needed to underwrite early offtake agreements. Clear and transparent expectations – for example, setting out the respective economic benefits created in supply and demand regions – are needed for market participants to support decision making.

Though public investment in clean hydrogen is both welcome and significant, it remains targeted and time limited. Demand certainty for both offtakers and exporters is crucial to form the clean hydrogen market. This should be the primary outcome sought by policy programs across the region.

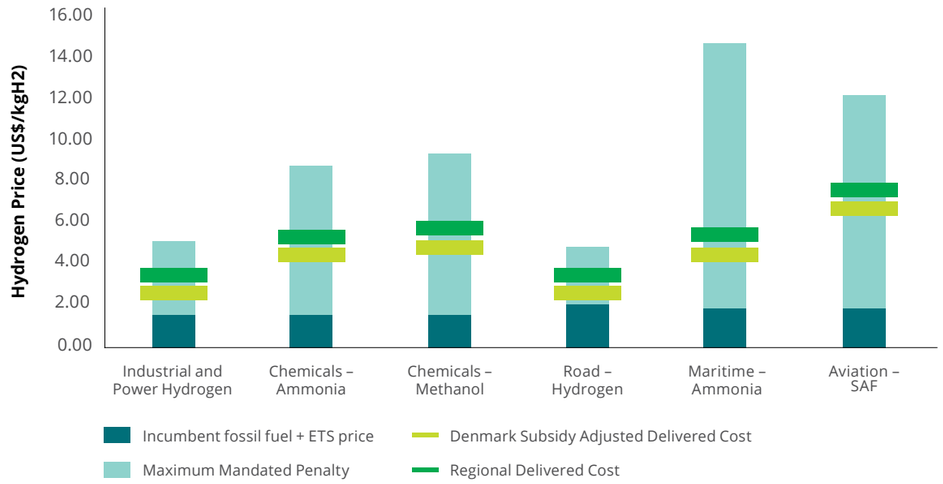
Asia Pacific economies – while faced with different challenges such as a younger asset fleet – still have lessons to learn from Europe where a series of demand and supply-side policies are working together to create investment certainty. Hydrogen demand in Europe is anchored in a rising carbon price via the European Union Emissions Trading System (EU-ETS), which, combined with price reductions, is likely to ultimately see green hydrogen emerge as the dominant option. While Australia, Japan and South Korea each have carbon pricing schemes, these remain materially lower than Europe's ETS.

Today, the EU-ETS price appears still insufficient to bridge the cost gap for many end users and trigger fast-paced adoption of zero-carbon processes in the short term. This is particularly acute for hydrogen deployment in the industry, which requires significant upfront investments for hydrogen direct reduced iron (DRI) in steel manufacturing. To overcome this, Europe has introduced a series of hydrogen mandates for industry and transport sectors.

The legislated penalties under these mandates exceed clean hydrogen production costs, creating the conditions for viable long-term offtake contracts. As the ETS price rises and clean hydrogen prices fall, the difference between mandate penalties and the incumbent fossil fuel price will shrink and eventually disappear.

Beyond pricing and predictability concerns, industrial facilities may be reluctant to expose themselves to the risks, including supply availability, associated with this greenfield market. This is why Germany, for example, has launched it's $50 billion Climate Protection Contracts scheme as a complement. This transfers a portion of the transformation costs and market risks from industrials and consumers to governments for 15 years. Supply side support in Europe, such as Denmark's Power-to-x (PtX) auction and the European Hydrogen Bank are also playing a role in bridging the gap, but considerably less so than demand-side certainty (Figure 8).

Figure 8
Indicative European willingness to pay by end-use sector in 2030, and impact of supply-side support



Source: Deloitte analysis based on ETS price forecasts, mandate penalties, hydrogen production costs from the Deloitte Hydrogen Model and the average support from the 2023 Danish PtX auction. See endnote for further detail[ii].

Actions to close hydrogen's implementation gap

The window of opportunity to galvanise a clean hydrogen economy in the major Asia Pacific is rapidly closing.

Achieving the twin objectives of decarbonisation and economic development will require project developers, offtakers, financiers and policymakers to collectively break down barriers to cross-border value chains. The immediate priority is making sure there is bankable demand and realising positive final investment decisions (FID) from world-scale supply chains.

With clean hydrogen support mechanisms opening in many major Asia Pacific economies in the coming months, the time to act is now. More needs to be done to achieve a faster, cheaper, cleaner and self-perpetuating hydrogen market across the region.

Each participant across the hydrogen ecosystem could play a leadership role in realising these opportunities:

System participant	Potential next steps
Governments	• Undertake impact analysis of the costs and benefits of introducing mandates or other demand-side measures for clean hydrogen • Align hydrogen certification frameworks and carbon intensity thresholds across Asia Pacific and globally • Simplify and harmonise cross-border hydrogen trade requirements • Align timing of hydrogen support mechanisms and where possible back-to-back support conditions to balance risk and compliance costs; this should extend to derisking instruments such as guarantees • Provide transparent assessment criteria for support mechanisms and clear expectations of the evidence base for bidders to provide
Hydrogen suppliers	• Agree joint development principles and a consistent co-investment approach with upstream and downstream value chain • Prepare transparent progress updates highlighting key blockers on development pathway and role of government policy in mitigating challenges • Develop a clear strategy to manage construction costs and reduce production costs over time, particularly through asset optimisation, maintenance, and facility utilisation • Prepare assessments of value chain economic benefits and distribution of benefits across participating markets
Hydrogen offtakers	• Develop innovative risk sharing mechanisms to allocate risk and rewards across the value chain • Conduct in-market tenders to secure market-tested pricing to inform strike price bids into local auctions • Consider linking pricing to carbon intensity of delivered molecules to create incentives to maximise emissions reduction and to underpin credibility of end-green premiums
Service providers	• Launch assurance and monitoring services for hydrogen emissions intensity and abatement outcomes • Support price discovery and work towards spot reference pricing for clean hydrogen in Asia Pacific

We urge all participants within the hydrogen ecosystem – governments, hydrogen suppliers, offtakers, and service providers – to take proactive steps, as outlined in this document.

It is imperative for all stakeholders to act now and act decisively to close the implementation gap and capitalise on the opportunities within the clean hydrogen economy.

Together, let's seize this moment to advance towards a cleaner, more sustainable future.

References

[i]**Figure 7 notes:**

(1) Initial funding round estimated from announced volumes and subsidies by year (over the three year support period).

(2) Lower bound of South Korean funding estimated based upon the supply of low cost blue hydrogen to meet 6500 GWh of auctions in 2024 and 2025. The efficiency ranges for ammonia co-firing are based on turbine specifications including the Mitsubishi Power JAC turbine which has an efficiency of 64%. The incumbent fuel price used to calculate the cost gap has been set at an LNG price of $13/GJ; equivalent to a hydrogen price of ~$1.75/kg. A green premium for low carbon energy could reduce the cost gap. The blue ammonia price is developed from Platts Ammonia Price.

(3) Lower bound of Singapore funding estimated based upon the supply of low cost blue hydrogen to meet a potential 200 ktpa of ammonia demand. The incumbent fuel price used to calculate the cost gap has been set at an LNG price of $13/GJ; equivalent to a hydrogen price of ~$1.75/kg. A green premium for low carbon energy could reduce the cost gap. The blue ammonia price is developed from Platts Ammonia Price.

[ii]**Figure 8 notes:**

(1) The price ranges are indicative only and do not incorporate the cost of capital equipment replacement for hydrogen use which could lower the offtake price range in sectors such as iron and steel, industrial heat, road, maritime and power.

(2) The Regional Delivered Cost indicatively shows an approximate price anticipated within the European market from pipeline supply and domestic production from internal Deloitte analysis.

(3) The mandated penalties incorporate the effect of volume multipliers for SAF and maritime fuel, considering an upper bound on the penalty impacts from RefuelEU. The Maximum Mandated Penalty also indicatively illustrates the impact of the SAF style mandate penalty applied in the enforcement of REDIII mandates at the member state level. It should be noted the enforcement of REDIII in the industrial and chemicals sector will vary between European member states in penalty design, which would result in a deviation from the results presented. Mandates within the power sector for RFNBO have not been implemented in Europe.

(4) The Reference Price refers to the cost of the incumbent fuel plus the ETS price projection. Assumed incumbent fuels being replaced by sector are: Industrial & Power – natural gas; chemicals – natural gas; road – diesel; maritime – heavy fuel oil; and aviation – Jet A1. The Industrial and Power Sector is assumed to include iron and steel, industrial heat and power generation.

(5) The Denmark Subsidy Adjusted Delivered Cost assumes the Regional Delivered Cost less the average subsidy realised within the Danish hydrogen auctions (~US$0.92/kg). This subsidy serves as an upper bound on announced European Union subsidies, with the recently announced hydrogen bank results (weighted average ~US$0.5/kg) between the reference price and this Danish price.

(6) The implementation of subsidies across Europe would reduce the market price, resulting in a lower willingness to pay band relative to the illustrative depiction in the figure.

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