Ports play a key role in hydrogen supply chains in the Indo-Pacific

Ports are critical nodes in global supply chains, linking ocean and inland logistics networks. Ports provide the infrastructure, facilities and services that enable intermodal exchange of cargo between shipping and inland transport modes. The efficient functioning of ports is essential for the smooth conduct of seaborne trade, as any disruption to port operations caused by events such as natural or manmade disasters, cyberattacks and port labour strikes will impact global supply chains. Major economies of the world including those in the Indo-Pacific region rely on global supply chains for the prosperity and wellbeing of their citizens.

The Indo-Pacific region houses some of the world's most important and busiest shipping routes and ports for trade and energy. The type of infrastructure and services provided by ports is largely determined by the cargo handling needs of the goods being transported and the types and sizes of vessels transporting them. For example, Australia, being a major exporter of mineral resources and energy, has the world's largest coal and iron ore export ports; while China, the main exporter of consumer goods, has several ports whose container throughput places them among the top ten container ports in the world. The Port of Singapore, on the other hand, is the largest global transhipment hub, moving containers to destinations across the world. In coming years, ports will face pressure to accommodate increasing volumes of cargo such as hydrogen as global supply chains adjust to changing trade commodities, patterns and customer preferences.

Hydrogen as a potential new commodity for energy trade

In 2022, energy trade—consisting of crude oil, oil products, natural gas, and coal—represented about 40 percent of the world seaborne trade. The current energy trade pattern is expected to change as a result of the global transformation of energy systems to meet the net-zero carbon emission goal in 2050 to limit global warming to 1.5°C above pre-industrial levels.

Hydrogen is a key enabler of energy transition as it can be used as fuel, feedstock for other products and for storing renewable energy. Hydrogen has great potential to replace fossil fuels in decarbonising hard-to-abate sectors such as heavy industry and transport. In recognition of hydrogen's potential, 16 of the top 20 GHG emitting countries, responsible for 78.11 percent of global emissions have elevated hydrogen in their national energy strategies and formulated implementation roadmaps. Several countries in the Indo-Pacific region including Japan, South Korea, Australia, Singapore, India, Sri Lanka, New Zealand, Malaysia, and Indonesia have released their national hydrogen strategies/roadmaps and planned projects aimed at producing, exporting, or importing hydrogen and its derivates (methanol and ammonia) for different applications. The Indo-Pacific region is expected to have the second largest share of hydrogen activities in the world after Europe, where Germany, the Netherlands and Belgium, for example, will be the major importers of hydrogen and they have established international partnerships with non-EU countries such as Australia to secure the supply of hydrogen. The development of the hydrogen economy within the Indo-Pacific region will establish a new energy system that could help countries in the region reduce their dependence on fossil fuel imports and mitigate energy security challenges.

National hydrogen strategies and potential trade

The countries in the Indo-Pacific region which have national hydrogen strategies or roadmaps have a clear vision to develop hydrogen-based economies to meet their net-zero greenhouse gas emissions target in the long term. They are planning to utilise green hydrogen (produced by the electrolysis of water using renewable electricity so no carbon emitted) or low carbon hydrogen and derivatives for domestic applications such as power generation, transport (road, rail, shipping, port, aviation), steel production, agriculture, and manufacturing. Some countries such as Australia, India, Malaysia, Sri Lanka, New Zeeland, and Indonesia have clear export goals in their national hydrogen strategies.

Australia was the third country to publish a national hydrogen strategy (NHS) in 2019 (the NHS 2.0 after review will be released in 2024). The strategy aims to transform Australia into a powerhouse of hydrogen production due to its abundant renewable energy resources and to become a key hydrogen exporter while decarbonising Australian industries. Currently, Australia has the world's largest potential investments of AU$300 billion in hydrogen projects in the pipeline across the nation. The Government is investing more than AU$500 million to support the development of hydrogen hubs in regional Australia integrating producers, users and exporters of hydrogen and its derivatives together to share infrastructure and expertise. Five hydrogen hubs have been funded including the Pilbara and Kwinana in Western Australia, the Hunter in New South Wales, Bell Bay in Tasmania, Gladstone and Townsville in Queensland and Port Bonython in South Australia. The potential export markets include Japan, South Korea, Singapore, and the Netherlands.

India has ambitious plans to scale up green hydrogen production capacity to five million metric tons (MMT) per annum by 2030 to make India the global hub for production, usage and export of green hydrogen and its derivatives. The Indian Government provides incentives to support domestic manufacturing of electrolysers and production of green hydrogen. India aims to export about 10 percent of the 2030 forecasted global demand of green hydrogen and ammonia (100 MMT) per annum, relying on competitive production costs. The potential export markets include France, Italy, Germany, Singapore, Japan, and South Korea. Similarly, as per its Hydrogen Economy and Technology Roadmap, Malaysia aims to produce 2.5 MMT per year of green hydrogen by 2050 for domestic use and export to Asia-Pacific countries such as China, Japan, South Korea and Singapore. Indonesia has also identified at least five hydrogen projects for potential international markets including Singapore, South Korea, Japan, and Europe.

Japan, South Korea, and Singapore have limited production capacity of green hydrogen due to limited renewable resources; hence their hydrogen strategy is to establish hydrogen supply from foreign sources by strengthening international partnerships to meet their demand. Japan depends heavily on overseas fossil fuels and now faces the challenge of low energy self-sufficiency following the shutdown of nuclear power plants due to the catastrophic earthquake in 2011. Therefore, Japan has been strongly engaged in hydrogen-related initiatives to reduce energy supply risk and reduce carbon use. Its world's-first adopted national hydrogen strategy emphasises reducing the price of hydrogen for the nation by establishing a large-scale hydrogen supply system. Japan proactively creates viable international hydrogen supply chains via global partnerships with Australia, Brunei, Malaysia, Saudi Arabia, and Indonesia. The revised Basic Hydrogen Strategy in June 2023 further specifies Japan's long term goals are to increase the international supply of hydrogen and ammonia through supporting private and public investments. Similarly, South Korea strengthens international cooperation in Southeast Asia and the Middle East to establish an overseas hydrogen import base. For example, the

State of Sarawak, East Malaysia, is a major green hydrogen production hub and has two catalyst projects planned, in collaboration with Japanese and South Korean companies respectively. Singapore also pursues international collaborations to build low-carbon hydrogen supply chains.

Despite the lack of resources for hydrogen production, Japan, South Korea, and Singapore are pioneers in the development of relevant hydrogen technologies applied to either downstream or upstream of the hydrogen supply chain. South Korea has the capability to be a leader of the downstream application of hydrogen. This includes fuel cell electric vehicles and hydrogen fuel cells manufacturing for vehicles. Japan has available technology in power generation and mobility, in particular shipping of liquified hydrogen. Singapore has very proactively committed to research and development in advanced hydrogen technologies. As a maritime transport hub, Singapore has made significant efforts to promote maritime decarbonisation utilising ammonia for power generation and bunkering, led by the Global Centre for Maritime Decarbonisation.

Opportunities for ports

With the planned development of hydrogen economies in the Indo-Pacific region, trade of hydrogen and its different forms (i.e., liquified hydrogen, ammonia, methanol, methylcyclohexane) is expected to occur in future, either within the region (e.g., Australia to Japan, South Korea, and Singapore; Malaysia to China, Japan and South Korea, and Singapore) or between regions (e.g., Australia to the Netherlands; Indonesia to Europe). Ports have a great opportunity to leverage their strategic locations, infrastructure, and expertise to facilitate the emerging hydrogen trade. Opportunities include business transition (e.g., additional business or transitioning from existing declining activities), increasing trade, and improving utilisation of port infrastructure. For example, ports can become green hydrogen hubs if they are situated close to renewable energy sources and industries. Australia's five approved green hydrogen hubs using either solar, wind or hydro energy for hydrogen production located near ports are good examples. Other examples include the hydro-powered H2ornbill hydrogen project near Bintulu Port in Sarawak East Malaysia; the solar based Batam hydrogen project close to Batam Port in Indonesia; and VOC Port in Tamil Nadu and Deendayal Port in Kandla Gujarat in India.

Additionally, ports can be enablers of decarbonisation by adopting hydrogen fuel for their operations and providing hydrogen or its derivatives as bunkering/refuelling for ships, which is likely to drive the demand for green hydrogen-based fuel. The Indian Government, in its National Green Hydrogen Mission, includes discussion of the prospects of developing green hydrogen/ammonia refuelling hubs at Indian ports. The projects for decarbonising shipping and ports will be implemented by the Ministry of Ports, Shipping and Waterways, with financial support to transform major Indian ports as hydrogen-based alternative fuel bunkering facilities. In Australia, the Port of Melbourne is conducting a feasibility study for providing methanol bunkering, while Pilbara Ports are considering the potential for ammonia bunkering.

Challenges for ports

Despite the opportunities, there are challenges for ports in managing the emerging international hydrogen supply chain. The research Integration of ports in global hydrogen supply chains: opportunities and challenges, using ports in Australia, Japan and the UK for study, identifies major challenges faced by ports, including port development, workforce development, regulation and policy, and social licence. In developing hydrogen ports, large land space within ports is needed for hydrogen production, storage, and port safety zones to manage hydrogen safety risks and ports could face challenges acquiring enough land. Besides, existing infrastructure may be inadequate for handling hydrogen and building new infrastructure may be necessary. This requires technology and funding sources. As there is no prior experience for ports in handling hydrogen as commodities, there is insufficient understanding of the safety risks associated with hydrogen. Hence, developing standards, regulations and policy for hydrogen port operation, and education and training for workforce development is critical. Hydrogen and its forms such as ammonia are explosive or toxic that may cause harm to residents and the natural environment if incidents occurred during production or handling process. Therefore, how to build public confidence and obtain social acceptance from the local community is another challenge. For ports considering applying hydrogen to decarbonise their assets and providing bunkering, they face challenges of regulatory support and costs associated with investment.

Managing hydrogen on a large scale for trade is new to ports. It necessitates planning and coordinating different infrastructure and transport logistics for export or import of different forms of hydrogen and bunkering for ships if suitable. Port infrastructure and facilities required for facilitating hydrogen supply chains include processing plants (liquification plants, regasification plants, hydrogenation plants, and dehydrogenation plants), storage tanks, pipelines, berths (common or dedicated), loading/unloading equipment, powerlines, roads, refuelling stations, bunkering vessels/barges, security systems, and safety systems. The required infrastructure and operations are complex, so significant new development or modification of terminals is needed, and investing in advanced technology and financial assistance is critical to development. The sufficiency level for required infrastructure and facilities with regulations and standards, safety measures, personnel training, and government support are important factors in determining port's readiness for international hydrogen trade. Considering that the hydrogen trade is still at an early stage, ports' readiness level is still under development.

Collaboration is the key to accelerate hydrogen port readiness

On a global scale, hydrogen supply chains are developing rapidly, and ports need to develop at a corresponding pace to prevent becoming a chokepoint in the chain. Strategies that can be considered to transform ports with the development of hydrogen supply chains include:

- acquiring key technologies for building large-scale port facilities for managing hydrogen trade; exploring international standardised port risk management protocols for hydrogen operations;
- creating information and knowledge sharing platforms to promote public acceptance of hydrogen ports;
- establishing port-specific regulations and standards for hydrogen handling and use; and
- developing education and training courses for personnel involved.

Implementing these strategies requires collaboration between stakeholders, capability in technology and infrastructure development, and expertise in risk management. Knowledge sharing and collaboration among countries should be promoted to harmonise regulations that will facilitate international hydrogen trade.

To accelerate hydrogen economy development and hydrogen port readiness in the Indo-Pacific region, support from governments and collaboration between industry stakeholders is crucial. Collaboration can be at national, regional, or global levels, between industries, between industries and governments, or between governments.

Japan is the leader in hydrogen port development with Kobe Port being the world's first liquified hydrogen-receiving terminal used by ships. The terminal is used for the Hydrogen Energy Supply Chain project transporting liquified hydrogen from Port of Hastings Victoria to Kobe Port, a collaboration between businesses in Japan and Australia with funding support from the Victorian and Federal Governments. Japanese businesses have also been heavily involved in partnership with more than half of ASEAN countries for 25 hydrogen related projects either through loans, feasibility studies or actual development. Some projects are export-oriented, involving transport and ports. For example, in Malaysia's H2ornbill hydrogen project in Sarawak near Bintulu Port, Japanese companies provide technical, sea transport, and financial support in collaboration with Malaysia's energy company SEDC. In Australia, the governments in Queensland, Tasmania, South Australia and Western Australia have signed Memorandums of Understanding (MoUs) with the Port of Rotterdam, a potential trade partner. The MoUs seek collaboration in the development of port infrastructure and hydrogen supply chain, hydrogen trade policy and certification schemes, hydrogen technology in shipping, and government policies on safety, regulations and social license for hydrogen. The Governments of Australia and Singapore have formed a partnership to share technical knowledge and experience to accelerate the development of low emissions fuels and technologies that aim to reduce emissions in maritime and port operations.

At the regional level, leadership is needed to accelerate hydrogen port readiness for the emerging energy trade system. Feasibility studies on hydrogen ports' development to accommodate hydrogen supply chains will be necessary, funded either by the government in each economy or industry trade partners. To capture the new energy trade network/system for the Indo-Pacific region, a roadmap of potential ports in each economy involving hydrogen supply chains and bunkering activities would be very useful. Such a research project could be conducted through collaboration at a regional level, either via multinational government agreements or regional economic forums/associations such as APEC or ASEAN. The project that studies hydrogen in ports funded by the European Union, aiming to help create a European hydrogen port roadmap, is a good reference. Development of a similar hydrogen port roadmap could help initiate strategies and plans to increase port readiness to manage hydrogen supply chains in the Indo-Pacific region.

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Image: Liquid hydrogen tank section of SUISO FRONTIER at Kawasaki Heavy

Industries Kobe Shipyard October 18, 2020. Credit: Hunini/Wiki Commons.

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