Green Hydrogen Port Site Selection

David Aubourg[1] and David Teahan[2]
[1] Advisian, Sydney, Australia; david.aubourg@advisian.com
[2] Advisian, Perth, Australia

Summary
Global organisations such as the International Energy Agency (IEA) have identified a requirement for increased use of hydrogen to meet global net zero CO_2 emissions by 2050. This requires a significant increase in production and transport of hydrogen carriers, of a similar magnitude to existing volumes of oil and gas, however there are limited ports presently setup to export hydrogen carriers. This paper presents some issues for port operators and project developers to consider when undertaking a site selection study.

Keywords: climate change, hydrogen, site selection, port planning, infrastructure reuse

Introduction

To meet the target of net zero global CO_2 emissions by 2050, there will need to be a substantial move away from fossil fuels. Global organisations such as the International Energy Agency (IEA) have identified a requirement for increased use of hydrogen in areas of industry that are hard to abate with other sources of energy. Due to different technical and safety risks, several chemical “hydrogen carriers”, such as liquid hydrogen, ammonia, gaseous hydrogen and ammonia have been proposed to store and transport hydrogen. Hydrogen and its carriers can be produced from renewable energy, are generally abundant, store and produce a large amount of energy, are transportable and can be stored for extended periods with relatively low loss rates. Unfortunately it is not without its disadvantages, which are also discussed within this paper.

Countries such as Singapore, Japan and South Korea do not have the renewable power resources or vacant land area to produce sufficient amounts of green fuels for their own use. To reduce their emissions and reliance on fossil fuels, these countries are developing alternate fuels for power and transport, such as hydrogen or hydrogen carriers. However, they will rely on importing these hydrogen carriers from other renewable energy rich countries, such as Australia and New Zealand.

To export hydrogen carriers from energy rich countries, suitable port sites are required. Several port operators and project developers are investigating the suitability of existing port infrastructure or new port sites to produce and export hydrogen. The purpose of this paper is to outline alternative hydrogen carriers, how these impact port site selection and factors to be considered when determining suitable export sites.

Hydrogen Carriers

There are several methods (hydrogen carriers) to transport hydrogen from the production plant to its end destination. Each hydrogen carrier has advantages and disadvantages, with the selected carrier typically determined by the product the end user is utilising, varied safety and risk profiles, and production infrastructure. Some commonly discussed hydrogen carriers are:

- Liquid Hydrogen
  Liquid hydrogen is stored at ambient pressure but cooled to -253°C, therefore cryogenic pipelines are required to transport it from storage to a ship. However, this can only be done over short distances to prevent excessive boil-off gas. Liquid hydrogen has a low specific gravity requiring large storage tanks compared to other carriers.

- Liquid Ammonia
  Transporting liquid ammonia is an established method and utilises existing technologies such as LPG ships. Liquid ammonia is also hydrogen dense and can be directly used in specialised engines. However ammonia is extremely toxic to terrestrial and aquatic life, including humans, if spilled.

- Liquid Organic Hydrogen Carriers (LOHC)
  LOHCs can be transported using similar technologies to petroleum products, therefore standard bulk liquid ships, pipelines and loading arms can be utilised. However, the hydrogen may need to be extracted from the LOHC at the import facility and a dehydrogenated carrier shipped back to the production facility. Alternatively green sources of carbon may need to be used to produce the LOHC.

- e-LNG and Biomethane
  Large amounts of LNG are presently transported and used around the world, providing an established network of export and import berths. However green sources of carbon are needed to produce zero emission LNG.

Port Site Considerations

Some of the key considerations when performing a site selection on the suitability of ports for the production and/or export of commercial quantities of green hydrogen include:

- **Proximity to developed and undeveloped renewable energy zones (REZ)**
  While large amounts of electricity are required, transmission or pipeline losses between REZs and ports increase the levelized cost of hydrogen (LCOH) produced. Ports closer to REZs reduce these losses, decreasing the LCOH.

- **Suitability of the surrounding power infrastructure**
  The large amount of power required to produce hydrogen carriers means that expensive power transmission infrastructure or transport pipelines for hydrogen and its carriers are required. Ports close to suitable power transmission infrastructure, which may include existing power stations, will have an advantage.

- **Proximity to clean water sources, or suitability of desalination, for electrolysis**
  Significant volumes of high-quality water is required for the production of hydrogen through electrolysis, with additional large volumes of clean water required for conversion into hydrogen carriers. Use of desalination plants may be a requirement for many locations which will therefore require approvals for intakes and outfalls.

- **Distance from production facility and storage to export berth**
  Depending on the hydrogen carrier, the distance from the production facility to storage, and subsequently from storage to the berth can be critical. In the case of liquid hydrogen these distances need to be minimised, while products such as LCOHs can be located at some distance from a port.

- **Availability of on port land to produce the required volume of hydrogen carrier**
  In the case of some carriers (e.g. liquid hydrogen) it will be important to have production and facility storage on port land to reduce distances, while other carriers could be located off port land.

- **Impacts to the surrounding environment and communities**
  As with all port developments, the impact of the development and construction of the production sites, transmission, pipelines and storage need to be considered. Also, the impact in the event of a spill may be critical in selecting suitable locations or preferred carriers.

- **Location of suitable Material Offload Facility (MOF)**
  In many cases it is expected that large modules and/or large amounts of smaller specialised components will be required for production facilities. While some of these may be produced within Australia and New Zealand, it is also likely that some components will be sourced overseas. Suitable MOFs will be required to handle not only the hydrogen and hydrogen carrier plants, but also the components for the renewable energy resources, such as wind turbines and solar arrays.

- **Suitability and proximity of existing marine infrastructure for the design export vessels and product**
  With the aim of producing an environmentally friendly and sustainable product, the re-use of existing assets is an important consideration in site selection.

- **Ability to safely produce and export hydrogen carriers while continuing existing and future port operations**
  Most hydrogen carriers have a safety and risk profile that may impact other port operations if not managed effectively. The siting within the port of production, storage and export facilities needs to be considered to ensure it does not adversely impact existing and future port operations.

- **Ability to minimise the level of development required, such as dredging and reclamation**
  Developments such as dredging and land reclamation will increase the LCOH and environmental impact, and if possible should be avoided.

- **Understanding and awareness of new technologies in shipping and loading**
  The expected volumes of hydrogen carriers to be transported are significantly greater than present volumes (if any volumes are transported). As seen in the development of many other markets within the last 70 years, if the demand grows as expected, new technologies will be developed to cater for this growth. This may include larger ships, higher volume loading equipment, new or repurposed loading methods, transhipment, or a range of other new or improved technologies.

Conclusion

As the transportation, power and heavy industry sectors transition to green fuels and energies, being able to identify suitable export and production facilities which minimise the required development will become a priority. With the onus placed onto the port operators and owners to shift to a more sustainable operating methodology, being able to identify opportunities to reuse existing facilities for new commodities and reduce overall emissions are key to maintaining a viable future.