Pathways to Sustainable Hydrogen Supply Chains

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Introduction

Hydrogen promises to play a crucial role as a future energy carrier to decarbonise the global economy[1,2]. Hydrogen supply chains (HSCs) need to be substantially developed in order to support a hydrogen economy[3]. The HSC can be categorised into four key stages: (1) production, (2) storage, (3) transportation, and (4) utilisation[4]. This work introduces a tool to characterise the economic, environmental and technical characteristics of various HSC pathways.

Methods & Results

The range of HSCs is illustrated in the following pathway map (Figure 1). The map presents the four stages (plus input resources) with key technological options for each stage (e.g. for transport, viable options include pipeline, road, rail and ship). These technologies each exhibit different economic, environmental and technical characteristics.

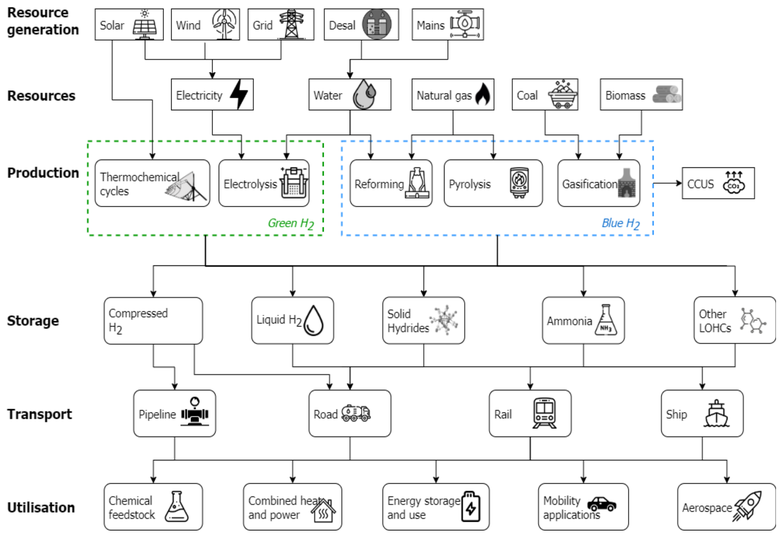

Figure 1 A pathway map illustrating routes within the hydrogen supply chain.

The optimal pathway for a given scenario will depend on variables such as availability of resources, production scale and transportation distance. This is demonstrated in Figure 2 which shows a wide range in the levelized cost of hydrogen (LCOH) for a variety of liquid hydrogen scenarios. The complexity of the supply chain currently makes it very difficult to analyse and compare suitable options for a given scenario. We have begun to develop a web application tool which will enable HSC pathway analysis. This framework will enable (1) easy-to-use operation, (2) integration with an underlying literature database, and (3) a structure which allows flexible use across a wide-range of scenarios.

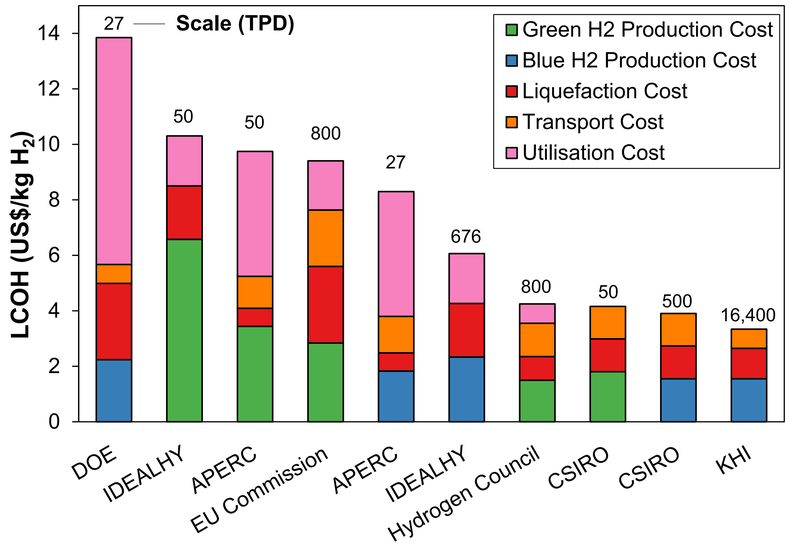

Figure 2 Comparative levelized cost of hydrogen for various LH_2 scenarios.

To demonstrate the intended application of the tool, we present an example scenario and compare potential pathways. Japan has long been a valuable export market for Australian liquefied natural gas (LNG). However this is anticipated to change given Japans' intention of decarbonising its' energy sector by importing low-emissions hydrogen. Various studies have explored transporting liquid hydrogen (LH_2) to Japan. A potential alternative to such transportation is to utilise LNG as an energy vector for transporting hydrogen in a closed-carbon cycle. This pathway is illustrated in Figure 3.

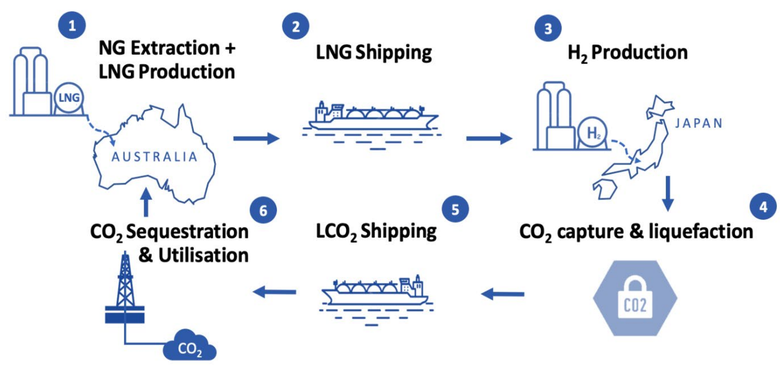

Figure 3 LNG vector hydrogen supply chain for an Australia-Japan scenario.

The economics and emissions of four energy pathways are compared in Figure 4:

1. Current LNG production
2. SMR with CCS (i.e. blue hydrogen) in Australia, with LH_2 transport
3. Wind electrolysis (i.e. green hydrogen) in Australia, with LH_2 transport
4. The suggested closed-carbon cycle pathway (in Figure 2)

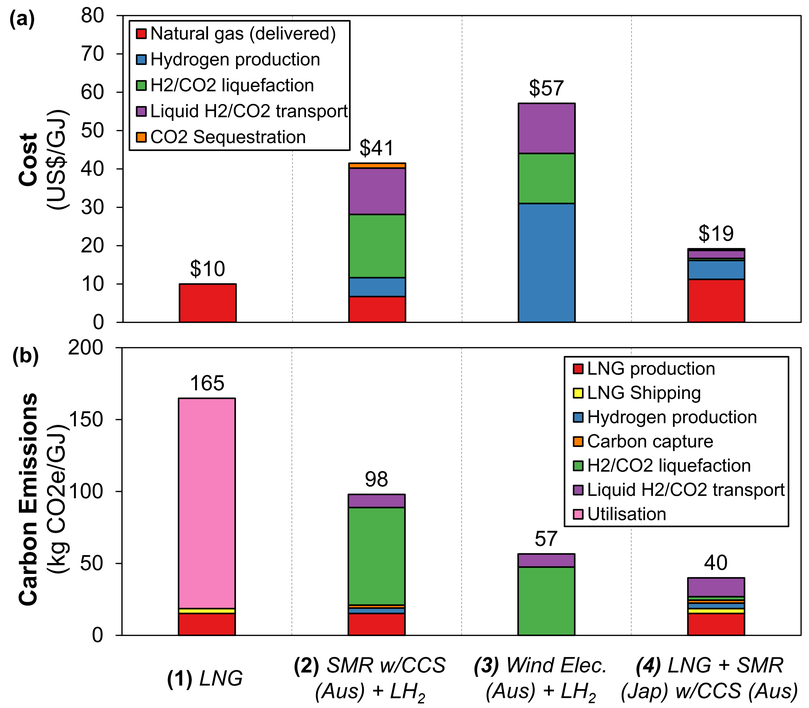

Figure 4 Comparison of **(a)** cost and **(b)** emissions for four export pathways.

The closed-carbon cycle (scenario 4) presents a low cost (US$ 19/GJ) and low emissions (40 kg CO2-e/GJ) relative to the alternative hydrogen supply pathways.

Conclusion

This work discusses a tool which will be used to analyse feasible options for HSCs. Such a tool will assist in evaluating economic, environmental and technical characteristics of HSC pathways. The example pathway presented offers a low-cost and low-emissions option which may be suitable for short-medium term exports.

References

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