April 2024

Green Hydrogen Imports into Europe: An Assessment of Potential Sources

OIES Paper: ET32

Rida Rikabi, Masters Visiting Research Fellow

ISBN 978-1-78467-236-2

The contents of this paper are the author’s sole responsibility. They do not necessarily represent the views of the Oxford Institute for Energy Studies or any of its Members.

Contents

Figures

Tables and boxes

Abstract

This paper compares the potential of three countries Morocco, Chile, and Australia to export green hydrogen to the European Union (EU). The three countries are ranked relative to each other based on ten indicators:

- The estimated levelized cost of green hydrogen delivery over time
- The status of development of hydrogen projects
- Expectations for domestic demand for hydrogen
- The status of the renewable electricity sector
- Collaboration with EU countries and institutions
- Collaboration with non-EU countries and institutions
- The availability of maritime infrastructure
- Chemical handling and export capability
- The general business environment
- Political risks

Based on these indicators, the paper shows that Morocco, Chile, and Australia boast high-potential options for hydrogen exports to the EU, whether in combination or individually. The paper also shows that these three countries have complementary weaknesses and strengths. This paper also details the different financing sources and mechanisms which are likely to fund the development of the green hydrogen production sector in each of these countries.

Note

This paper is mostly based on the Author’s thesis towards obtaining a Masters of Business Administration (MBA) degree from WU Executive Academy in Vienna, Austria (Rikabi, 2023).

1. Introduction

Green hydrogen is expected to play an important role in EU's goal to achieve 55% reduction in its greenhouse gas (GHG) emissions by 2030 compared to 1990 levels (EC, 2020). Green hydrogen is defined as that which is produced through the electrolysis of water using electricity stemming from renewable sources with full-life-cycle GHG emissions of almost zero (EC, 2020; Ludwig, et al., 2021). According to the Hydrogen Council and McKinsey & Company, green hydrogen has the potential to avoid up to 80 gigatonnes of cumulative carbon dioxide (CO2) emissions globally and to contribute to up to 20% of the total abatement needed by 2050 (Hydrogen Council, McKinsey & Company, 2021).

Hydrogen currently represents a small fraction of EU's energy mix and is still largely produced from fossil fuels, thereby resulting in the release of 70-100 megatonnes (MT) of CO2 annually in the EU (EC, 2020). The European Commission (EC) estimates that hydrogen's share in the EU's energy mix could reach 13%-20% by 2050 (EC, 2022), and is therefore determined to scale up development of the 'renewable' (green) variant in order to eliminate the emissions resulting from use of the fossil-fuel-based variant (EC, 2020).

The REPowerEU initiative sets out to increase the share of renewable energy in the EU's final energy consumption to 45% by 2030, and one of the milestones towards achieving this target is to reach 10 MT of EU green hydrogen production – from 65-80 gigawatts (GW) of electrolyser capacity (EC, 2022; IEA, 2022) – plus another 10 MT of supply from non-EU imports by that year (EC, 2022).[1] It is estimated that for Europe to reach Net Zero by 2050, it would need to invest a total of $1.5 trillion in clean hydrogen production facilities, including domestic and non-EU projects (van Gaal, 2023; WEF, 2022). Therefore, the EC announced in March 2023 the establishment of a European Hydrogen Bank (EHB), the purpose of which is to address the initial financial challenges to the creation of an emerging renewable hydrogen market and to the development of production capability to enable imports to the EU (EC, 2023). Prior to that, in May 2022, the EC made a joint declaration with electrolyser manufacturers that it would support them through regulatory measures to increase the manufacturing of electrolysers in the EU ten-fold, thereby reaching 17.5 GW of annual production capacity additions by 2025 to help enable achieving the annual EU production target of 10 MT by 2030 (EC, 2022). The EU clearly deems this to be of strategic importance given that China and the United States (US) are also ramping up their electrolyser manufacturing capacities to levels which are on a par with the EU's (IEA, 2023). Also in 2023, the EC announced that it would hold a fixed-premium pilot auction in November that year as part of its Innovation Fund, which will begin allocating funds of up to 800 million euros to green hydrogen production projects inside the EU (EC, 2023). Regarding infrastructure, the European Hydrogen Backbone has called for 11,600 kilometers (km) of new and repurposed hydrogen pipelines to be ready across the EU by 2030, with the target for 2040 being almost three times higher at 39,700 km (Jens, Wang, van der Leun, Peters, & Buseman, 2021).

There are already industries which use hydrogen and thus have high potential to switch to green hydrogen, including refining, ammonia, and methanol production (ETC, 2021). There are also other sectors which could considerably add hydrogen demand in the future but currently do not use hydrogen due to a combination of technical and economic feasibility limitations, and they include steel, shipping, aviation, and power storage (ETC, 2021). For example, four automakers in the First Movers Coalition have pledged that by 2030 they will source 10% of the steel they use from low-emission sources (IEA, 2022). Also, Maersk has ordered 12 methanol-powered vessels and has signed partnerships to procure 0.7 MT of low-emission methanol[2] in 2025 (IEA, 2022).

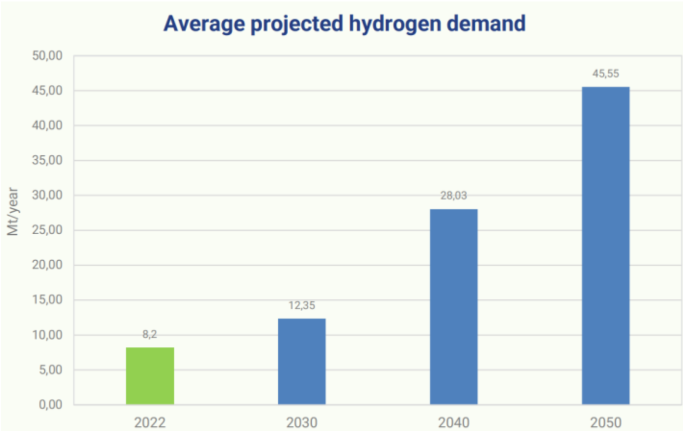
Estimates of future EU hydrogen demand vary considerably, however all five of the forecasts studied by the Florence School of Regulation predict that by 2050 the bloc's demand will have increased significantly – ranging from 172% to 878% of recent levels of 10.7 MT (Dos Reis, 2021). Figure 1 shows averages of projected figures of European hydrogen demand (including that of the UK) based on various

[1] It is worth noting that there is probably still a lot of work to do to improve the clarity of regulations around this initiative given how quickly it had to be drawn up and approved.

[2] It is worth noting that extraction of hydrogen from methanol upon import would necessitate the release of CO2 and thus the additional installation of carbon capture & storage facilities to ensure that the hydrogen remains of the 'low-emission' category, i.e. not an ideal solution (Patonia & Poudineh, 2022).

forecasts by the European Hydrogen Observatory (part of the EC's Clean Hydrogen Joint Undertaking). It also shows that estimates of current demand figures vary as well, as the estimated European hydrogen demand in 2022 according to Figure 1 was 8.2 MT. The European Hydrogen Observatory also estimates that 57% of 2022 European demand came from oil refining, 24% from ammonia production, 3% from methanol production, and 9% from production of other chemicals (Clean Hydrogen JU, 2023).

Figure 1: Average of forecast European hydrogen demand based on various scenarios in 2030, 2040 and 2050



Source: (Clean Hydrogen JU, 2023)

Figure 1 shows that European hydrogen demand in 2030 might exceed 12.35 MT/year. This is lower than the prediction of 2030 demand from the EU-27 alone provided by Rocky Mountain Institute (RMI), which stands at 12.96 MT/year (Tatarenko, Janzow, Rosas, & Homann, 2023). This signifies that even if the EU were to reach its green hydrogen production target of 10 MT/year by 2030, this would still not be enough to cover the bloc's total predicted demand by that year[3]. In fact, the EU is unlikely to even have sufficient renewable power generation capacity (necessary to power green hydrogen production facilities) to produce all of the hydrogen demanded within the bloc by 2030, given the imperative of using its current-plus-future installed capacity to electrify its power grids, buildings, and road transport (Tatarenko, Janzow, Rosas, & Homann, 2023).

This explains why the EU has also set a 2030 green hydrogen import target of 10 MT per year from non-EU countries by that year (EC, 2022)[4]. The success of projects which would be aimed at achieving this target is defined in this paper by the following criteria:

- Support the EU in achieving its net zero target by 2050.
- Supply the EU with its energy needs.
- Minimize the risk of the EU becoming overly dependent on a single supplier.

The main objective of this paper is to compare the potential of three non-EU countries, Morocco, Chile and Australia, to export green hydrogen to the EU. Those countries are ranked relative to each other based on several indicators. The aim is to propose an approach that could be applied at a larger scale to include additional countries. The analysis in this paper is split into three sections. Section 2 provides a detailed comparison of the weaknesses and the strengths of the three countries and their potential to emerge as long-term exporters of green hydrogen to EU Member States. Section 3 combines information obtained from sources in the public domain with insights gained from interviews conducted

[3] Total demand in 2022 from the UK, Norway, and Switzerland (which at the time of writing are non-EU countries) was around 0.75 MT (Clean Hydrogen JU, 2023). By extrapolating this figure to 2030 based on the average total European forecast shown in Figure 1, this would bring total demand from those three countries in 2030 to 1.13 MT per year. Subtracting this figure from the average total European figure gives 11.22 MT per year, which is still higher than the EU production target of 10 MT per year by 2030.

[4] Nevertheless, RMI predicts total EU green hdyrogen imports from outside the bloc to be only 8.7 MT per year by 2030 (Tatarenko, Janzow, Rosas, & Homann, 2023).

with industry experts to explain how the financing of green hydrogen projects might be structured in each of those countries. Section 4 provides a summary of key findings and conclusions.

2. Potential Sources of EU Imports of Hydrogen: The cases of Morocco, Chile and Australia

Hydrogen trade is expected to be underpinned by bilateral agreements long before any possibility of hydrogen or its derivatives becoming globally traded commodities (IEA, 2022). It is on the basis of this bilateral trade that projects would, most likely, get sanctioned and receive the necessary funding from investors (IEA, 2022). While global oil and gas supply has been historically dominated by a few countries in the world, low-emission hydrogen (including green) has the potential to be exported by many more countries in the future (IEA, 2022).

In this paper, the export potential of three countries, Morocco, Chile and Australia, is compared using indicators which are deemed important for the success in developing green hydrogen projects as well as providing secure hydrogen supply to EU countries. Those countries have then been ranked relative to each other in terms of how promising their prospects are based on the following ten indicators:

- The estimated levelized cost of green hydrogen delivery over time
- The status of development of hydrogen projects
- Expectations for domestic demand for hydrogen
- The status of the renewable electricity sector
- Collaboration with EU countries and institutions
- Collaboration with non-EU countries and institutions
- The availability of maritime infrastructure
- Chemical handling and export capability
- The general business environment
- Political risks

These three countries have been chosen because they are among the most likely around the world to be net exporters of hydrogen by 2050 according to the International Renewable Energy Agency (IRENA) (IRENA, 2022). Moreover, these countries happen to be geographically distant from one another, yet they all have strong trade ties with EU countries. Also, these three countries are different in terms of their respective sizes, development levels, and credit ratings.

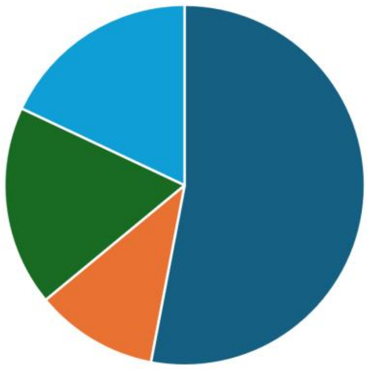
Morocco has been selected due to its geographic proximity to the EU and existing interconnections with Spain (IEA, 2021), also for it having the most advanced renewable energy resources combined with the least abundant hydrocarbon resources in North Africa (Franza, 2021). As for Chile, the country is expected to export the greatest amount of hydrogen from Latin America by 2030, according to the IEA, based on existing plans (IEA, 2022; 2023). Unlike its neighbours, all of Chile's hydrogen exports are expected to be 'green' given the scarcity of the country's hydrocarbon resources (OT, 2021). Moreover, Chile is the leading country in Latin America when it comes to partnership with EU countries on low-carbon hydrogen projects, according to the World Energy Council (WEC) (WEC, 2022). Australia on the other hand is expected to become the biggest exporting country of hydrogen – green and blue combined – by 2030 (WEC, 2022; IEA, 2022). This is partly thanks to the country's huge renewable energy generation potential coming from the abundance of unused areas that can be used to add further capacity in the future (IRENA, 2022). This combined with the country's developed-economy and high-income status (World Data, 2023) makes it a prime candidate for inclusion in any comparison of green hydrogen exporting countries.

2.1 Estimated Levelized Cost of Green Hydrogen Delivery over Time

The two primary components of the Levelized Cost of Green Hydrogen Delivery (referred to here as LCH2) are the levelized cost of production and the levelized cost of transport[5] to the end market.

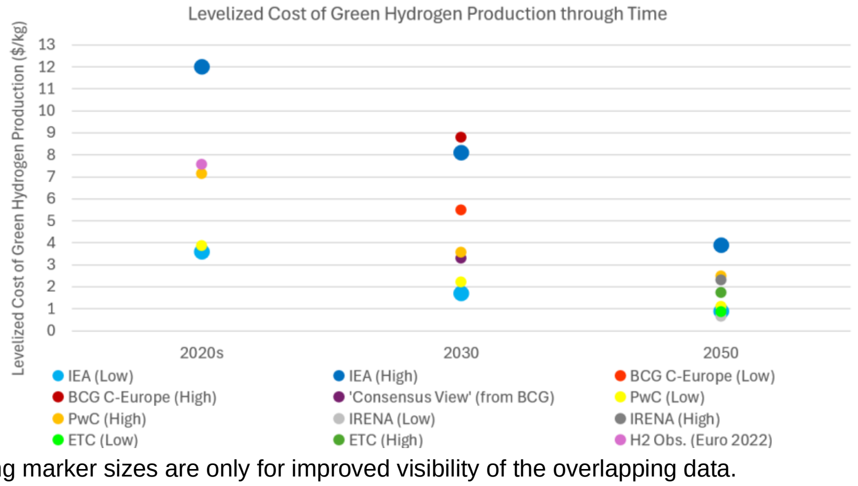
The production cost of green hydrogen can be broadly broken down to the cost of renewable electricity, electrolyser capital expenditure (CAPEX), other CAPEX, and operating expenditure (OPEX), as shown in Figure 2. The European Hydrogen Observatory has provided an estimate of average levelized cost of green hydrogen production in Europe in 2022 (Clean Hydrogen JU, 2023). According to its Net Zero by 2050 Scenario, the IEA predicts worldwide green hydrogen production levelized cost figures to decline significantly between now and 2050 (IEA, 2023; 2022), similar to PricewaterhouseCoopers' (PwC's) prediction (PwC, 2023). In addition, IRENA and the Energy Transitions Commission (ETC) both predict similarly low costs by 2050 worldwide (IRENA, 2022; ETC, 2021). On the other hand, as a result of increased geopolitical tensions, rising interest rates, supply chain bottlenecks, Boston Consulting Group (BCG) has raised its projection for 2030 green hydrogen levelized cost of production in central Europe in 2023 above that of the "consensus view" from 2021 (Burchardt, et al., 2023, pp. 2-3). These estimates can be seen in the timeline plotted in Figure 3.

Figure 2: Breakdown of levelised cost of green hydrogen production



Source: Based on data from Australian Energy Council (Lovell, 2018), Strathgen (part of University of Strathclyde, UK) (Grispiani, 2020), and Structures Insider (Pascal, 2023). This spilt is not exact and is intended to be indicative only.

Figure 3: Timeline showing estimates by various sources of green hydrogen levelized cost of production worldwide



Note: the differing marker sizes are only for improved visibility of the overlapping data.

[5] As mentioned further down, this includes storage costs.

The levelized cost of transport on the other hand includes the costs of conversion to a derivative or carrier (also called a pathway) prior to export (for shipping), storage pre-export, shipping, storage post-import, and reconversion upon import (in the case of carriers only). The levelized cost estimates also consider the likely capital investment and operating costs needed for each pathway. Export of hydrogen as ammonia for example results in conversion losses as well as reconversion losses, the latter being necessary for the extraction of hydrogen through ammonia 'cracking' unless ammonia is the imported end-product rather than gaseous hydrogen (Liebreich, 2022; IEA, 2022).[6]

Figure 4 shows the IEA's assessment for 2030 of the added levelized costs of hydrogen transport from its conversion, storage pre-export, shipping, storage post-import, and reconversion, as a function of transportation distance for each of the carriers (via ship): liquid ammonia, liquefied hydrogen, and liquid organic hydrogen carriers (LOHC) (IEA, 2022). It also includes the added levelized costs of hydrogen transport via a new or repurposed onshore pipeline (operating at 25-75% of design capacity during 5,000 full-load hours) depending on the pipeline's dimensions, as well as the levelized cost of delivering electricity (enough to generate 1 kg of green hydrogen) directly from its generation source via an offshore High-Voltage Direct-Current (HVDC) cable to the electrolyser on the importing end (at 69% efficiency) (IEA, 2022). Figure 5 shows IRENA's assessment of hydrogen transport costs in 2050 assuming a constant annual hydrogen load of 1,500,000 tonnes/annum and depending on the pathway (IRENA, 2022). The costs vary as a function of transportation distance (IRENA, 2022), meaning that it is comparable to Figure 4 from the IEA (albeit the latter is set for 2030).

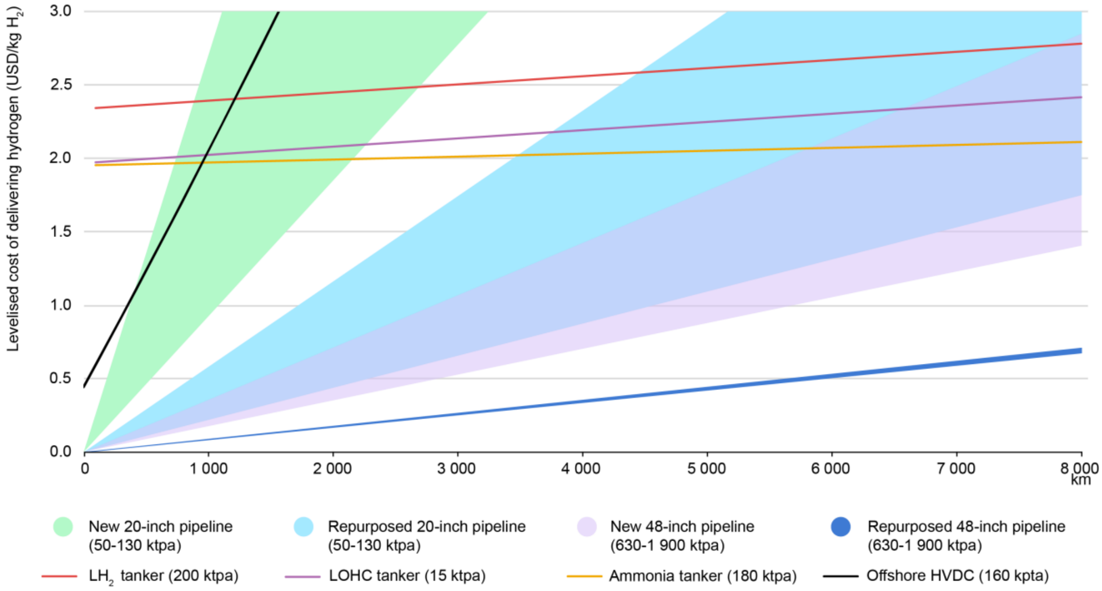
In this paper, the comparison of transport costs from each of the studied host countries to the EU will be for the (liquid) ammonia shipping pathway only because it is considered to be the most effective hydrogen carrier, with an optimum combination of low thermodynamic and conversion losses as well as low direct costs (Gielen & Press, 2022; Liebreich, 2022; Patonia & Poudineh, 2022). This is also the case when liquid ammonia is compared to methanol, given the CO2 emissions associated with extracting hydrogen from the latter upon import (Patonia & Poudineh, 2022). In fact, at least early on, most EU green hydrogen imports are expected to enter the bloc in the form of ammonia (Tatarenko, Janzow, Rosas, & Homann, 2023). Moreover, both the pipeline and HVDC transport options are considered to be unfeasible in this paper. While the reasons for this are obvious in the case of Chile and Australia, the situation for Morocco deserves further explanation, and this is provided further down in this section. It is also worth noting that at this stage there is considerable uncertainty in the estimates shown in Figure 4 and Figure 5.

The estimates for green hydrogen production and transport (via the ammonia pathway) to the EU for all three host countries examined in this paper are summarised for comparison in Table 1. There are other important factors regarding the LCH2 such as water scarcity, especially in Morocco and Australia (IRENA, 2022), as it remains to be seen whether technologies which enable the use of sea water in the electrolysis process are successfully commercialised and deployed in the future (Gates, 2023; Westenhaus, 2023). Another one is the cost of capital, which varies considerably depending on the host country and would thus impact the global distribution of supplied quantities of hydrogen if it were to equalise in the future (IRENA, 2022). On the other hand, the year 2022 saw higher inflation and interest rates (thereby higher WACC) as well as higher labour costs, combined with higher renewable electricity price assumptions (especially in Europe) relative to 2021, thereby resulting in a 9% year-on-year increase in the capital cost of electrolysers worldwide (Roth, Dertinger, Lotz, & Schimmel, 2023; Hyatt, 2023). Moreover, the IEA predicts that the rise in WACC might have increased electrolyser installation costs in 2023 by more than 25% compared to 2021 levels (IEA, 2023). Nevertheless, the assumption in this paper is that these effects would be short-term in nature. The cost of capital for each of the three countries examined in this paper is discussed in further detail in Section 3.

---

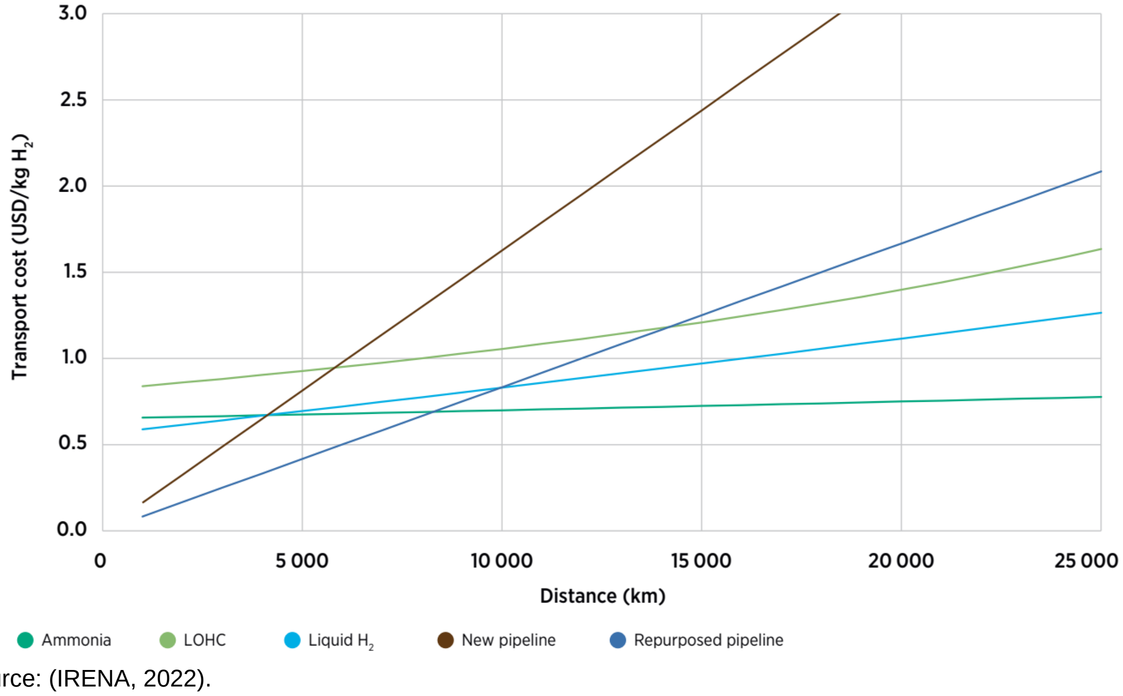
[6] Since the context of this paper is to do with hydrogen exports from non-EU host countries to EU demand centres, the discussion will be structured around the main steps constituting the delivery of green hydrogen to the territory of an EU Member State where a buyer is likely to have an off-take agreement with the project owner(s) in the host country. The cost of transport within the EU is not included in this analysis and is assumed to be the same regardless of where the hydrogen is being imported from (outside the EU) or where the buyer is located (within the EU). Also not discussed here is the cost of transporting hydrogen from the electrolyser or Haber-Bosch ammonia facility to the point of export in the host country because no assumptions have been made regarding the chosen means of doing so or the distances separating these two points for any project.

Figure 4: Levelized transport costs for hydrogen in 2030 by ship, onshore pipeline, and offshore cable, as functions of transportation distance



Source: (IEA, 2022).

Figure 5: Levelized transport costs of hydrogen produced from a fixed project size of 1,500,000 tonnes/annum for different pathways in 2050 as a function of transportation distance



Source: (IRENA, 2022).

Note: Optimistic scenario for costs.

Morocco

According to data from PwC, Morocco's green hydrogen production cost is estimated to be (PwC, 2023):

- 4.25-4.50 euros/kg ($4.55-4.95/kg) in 2020 (present day)
- 2.50-2.75 euros/kg ($2.70-3.05/kg) in 2030
- 1.00-1.25 euros/kg ($1.05-1.35/kg) in 2050

It is important to note that other studies point to wide-ranging estimates of present-day cost of production in Morocco, from $2.50/kg to about $13.50/kg (Khouya, 2020; Touili, et al., 2022; Touili, Merrouni, El Hassouani, Amrani, & Azouzoute, 2020). The upper half of this range would result in an outcome where green hydrogen produced in other countries is more cost-competitive in the short term. Meanwhile, Wouters of The Netherlands' Association for the United Nations has predicted that a levelized production cost of 1 euro/kg ($1.10/kg) could be achievable in Morocco by 2030 (Wouters, 2020). Moreover, IRENA predicts that the levelized cost of green hydrogen production in North Africa will reach $0.65-1.25/kg by 2050 (IRENA, 2022).

It is assumed here that transport of hydrogen from Morocco to an EU buyer would be over a distance of 3,100 km, given that the immediate demand centres are unlikely to be right on the North African country's doorstep. The aforementioned distance is roughly the same as that separating the port of Casablanca in Morocco and the port of Rotterdam in The Netherlands (Ports, 2023). In their comparison of the costs of importing green ammonia into The Netherlands from Morocco to the costs of producing the ammonia (green or blue) in The Netherlands in 2030, Aurora Energy Research estimate that the levelized transport cost, including the Haber-Bosch (prior to export) and ammonia cracking (upon import) processes, to be 1.5 euros/kg ($1.65/kg) (Ganbold, Najjar, Borondo, & Hubert, 2022). Within that, the cost of shipping is estimated to be 0.1 euros/kg ($0.11/kg), and this can be used to calculate the shipping cost from *Chile* to the EU based on distance to derive a Moroccan levelized cost of transport estimate for 2050. The calculated Chilean shipping estimate (of $0.61/kg) can then be subtracted from the 'long-term' (assumed to be in 2050) total estimate for Chile-to-EU levelized cost of transport of $2.20/kg provided by the International Finance Corporation (IFC) (IFC, 2022), giving $1.59/kg. Then, by re-adding $0.11/kg (shipping cost from Morocco) to the result of the prior calculation, this gives a total levelized transport cost estimate of $1.70/kg for Moroccan exports to the EU in 2050. An alternative estimate for 2030 can be obtained based on IEA's data plotted in Figure 4, giving a levelized transport cost of $2.05/kg (for 3,100 km distance). As for 2050, an alternative estimate can be obtained based on IRENA's data plotted in Figure 5, giving a levelized transport cost of $0.65/kg (for 3,100 km distance).

There are three other options for export of green hydrogen from Morocco to the EU: via a repurposed pipeline, via a new pipeline, or green electricity via a HVDC cable (new or existing). If Morocco were to repurpose its section of the Maghreb-Europe natural gas pipeline (48-inch diameter and 45 km offshore section length) connecting it to Spain for hydrogen transport by 2030, the capacity of that could be greater than 2 MT/year (Blinda, 2023; IEA, 2022; Zahw, Peterse, Schimmel, & Cihlar, 2022), thereby incurring only the lower end of the cost estimates shown in Figure 4 and Figure 5. However, an installed electrolyser capacity of more than 25 GW would be needed to produce such an amount of green hydrogen, and as discussed in Section 2.2 below Morocco has not yet announced export projects of such size.

The other challenge is that Morocco is currently a long way away from having the ability to take advantage of such an opportunity due to the lack of gas infrastructure within its borders (OpenStreetMap, 2024), which would be crucial for enabling the transport of its green hydrogen (upon repurposing of pipelines) towards the existing Maghreb-Europe pipeline or a brand new one (Anice, 2023). In addition, the production of green hydrogen close to the pipeline's entry point using electricity which is produced elsewhere in the kingdom is also not possible, as explained in Section 2.4 below. Even Spain, which has a more developed domestic natural gas pipeline network than Morocco, has moved towards shipping of ammonia for its green hydrogen exports to other EU Member States instead of pipeline transport. This is indicated by the recent deal made by Norway's Yara Clean Ammonia and Spain's CEPSA to establish a clean hydrogen corridor between the south of Spain and central Europe via the port of Rotterdam (Yara, 2023). This would comprise a green ammonia shipping route as well as pipelines which would be built/repurposed between the Dutch port and buyers in Belgium and Germany (Yara, 2023). This move might be a reflection of the Iberian country's existing pipeline connections to its EU neighbours being limited, with only one natural gas interconnection between it and France and two between it and Portugal currently available (IEA, 2021).

As for the HVDC option, this is most likely to be economically feasible in the case of low energy transfer amounts (Patonia, Lenivova, Poudineh, & Nolden, 2023).[7] Given the EU's hydrogen import target, which is very large, the HVDC option is deemed to be far less consequential for the purposes of this paper when compared to the shipping or pipeline options.[8]

Chile

According to PwC's data, Chile's green hydrogen production cost is estimated to be (PwC, 2023):

- 3.50-3.75 euros/kg ($3.75-4.10/kg) in 2020 (present day)
- 2.00-2.25 euros/kg ($2.15-2.45/kg) in 2030
- 1.00-1.25 euros/kg ($1.10-1.40/kg) in 2050

The IFC estimates that Chile's green hydrogen production levelized cost is currently at $2.30/kg in Magallanes, Southern Chile; where wind power generation is high, and is $3.50/kg in the north; where solar power generation capacity is high (IFC, 2022). In their techno-economic study of producing green hydrogen from solar energy in the Atacama Desert, northern Chile, and from wind energy in the Patagonia steppes, Argentina, Armijo & Philibert have estimated current levelized cost of green hydrogen production at around $2.00/kg (Armijo & Philibert, 2020). The IFC expects green hydrogen production to become cheaper by 2030, below $2.00/kg, and in the 'long term' (taken here to mean by 2050), below $1.50/kg (IFC, 2022). On the other hand, the IEA has predicted Chile's levelized cost of green hydrogen production, including storage costs, to be $2.00-2.45/kg depending on minimum load factor (set based on an assumed downstream ammonia synthesis process) in 2030 (IEA, 2022). This is very close to the PwC and IFC estimates for that year. Meanwhile, IRENA predicts that the levelized cost of green hydrogen production in Chile will reach $0.65-1.15/kg by 2050 (IRENA, 2022).

As for the cost of transport to the EU, the distance via ship from Chile would be somewhere between 16,210 km (to Spain) and 18,450 km (to Germany) (Ports, 2023). For 2030, Frontier & the Austrian Institute of Technology (AIT) estimate the cost of transporting ammonia to Austria from Chile *excluding* cracking upon import to be around 2.00 euros/kg ($2.20/kg), with the latter adding a further 2.10 euros/kg ($2.30/kg) to the levelized cost of transport (Frontier & AIT, 2022). While the IEA's data in Figure 4 only shows transport cost estimates for distances between 100 and 8,000 km, the trends for shipping costs are straight lines for all carriers. Therefore, since the levelized cost of transporting ammonia 8,000 km is around $0.20/kg higher than that for 100 km, doubling this figure to $0.40/kg (for 16,000 km distance) would be appropriate for transport from Chile to Europe. This means that the cost of transporting 180,000 tonnes annually from Chile to Europe would be $2.30/kg in 2030. As for 2050, IRENA's data in Figure 5 points to ammonia transport costing about $0.75/kg given the aforementioned distances. On the other hand, IFC estimates that transporting hydrogen as ammonia via ship over a distance equivalent to that from Chile to Western Europe would add $2.20/kg to the LCH2 in the 'long term' (taken here to mean 2050) (IFC, 2022).

Australia

According to PwC's data, Australia's green hydrogen production cost is estimated to be (PwC, 2023):

- 4.50-4.75 euros/kg ($4.95-5.20/kg) in 2020 (present day)
- 2.50-2.75 euros/kg ($2.75-3.05/kg) in 2030
- 1.00-1.25 euros/kg ($1.10-1.40/kg) in 2050

---

[7] According to these authors, pipelines have a larger capacity for transporting gaseous hydrogen than HVDC cables have for an equivalent amount of electricity, thus the pipeline option (repurposed or new) is considered to be more cost-effective than the HVDC option in most cases if the amounts are large. That said, converting electricity into hydrogen results in significant losses, which means that it would be more efficient to transport the electricity if the generated amount is not very large (which would otherwise result in produced hydrogen amounts which are too low to pay for the pipeline project).
[8] Therefore, neither of the pipeline or HVDC options is considered when comparing Morocco to the other two host countries in this paper, although this is not to negate the possibility of either of these options materialising for the North African country in the future.

Australia has announced its 'H2 under $2' strategy for 2030, by which time it aims to bring down its hydrogen levelized production cost to 2.00 Australian Dollars (AUD) per kg ($1.40/kg) (GH2, 2023; IRENA, 2022). IRENA on the other hand predicts that if production costs were to go below $4.00/kg by 2030, this would be enough to make Australia a globally competitive supplier of green hydrogen (IRENA, 2022). Moreover, IRENA predicts that the levelized cost of green hydrogen production in Australia will reach $0.70-1.20/kg by 2050 (IRENA, 2022). This estimate could however increase by up to 40% (to $1.70/kg) depending on the CAPEX for installing electrolysers, since Australia is a developed economy which has seen high labour and installation costs for its renewables sector (IRENA, 2022).

As for the cost of transport to the EU, the distance from South Australia to either Germany or Spain would be around 22,300 km (Ports, 2023), so around 1.3 times that from Chile to Western Europe. While the IEA's data in Figure 4 only show transport cost estimates for distances between 100 and 8,000 km, the trends for shipping costs are straight lines for all carriers. Therefore, since the levelized cost of transporting ammonia 8,000 km is around $0.20/kg higher than that for 100 km, tripling this figure to $0.60/kg would be appropriate for exports from Australia to Europe. This means that the cost of transporting 180,000 tonnes annually from Australia to Europe would be $2.50/kg in 2030. By the same logic, multiplying the Frontier & AIT 2030 estimate for shipping ammonia to Austria from *Chile*, of 0.3 euros/kg ($0.33/kg) (Frontier & AIT, 2022), by 1.3 gives $0.43/kg. Combining this figure with the remainder of the Chilean levelized transport cost from Frontier & AIT ($4.17/kg) gives a total Australian levelized transport cost of $4.60/kg in 2030. As for 2050 estimates, IRENA's data in Figure 5 points to Australian ammonia transport costing about $0.75/kg. On the other hand, using the IFC's estimate of $2.20/kg mentioned above for transporting hydrogen from *Chile* in 2050, combining that with the figure from Aurora on transport from *Morocco* in 2030 ($0.11/kg), and using the Australia-to-Europe shipping distance (giving a shipping cost of $0.80/kg), the equivalent for Australia-to-EU transport would be almost $2.40/kg in 2050 (by adding the $0.80/kg to the aforementioned $1.59/kg calculated for Chile).

Comparison

Based on the figures in Table 1, Morocco ranks the highest in terms of the LCH2 indicator thanks to its estimated costs being the lowest. This comes as no surprise given the country's proximity to Europe. However, this also comes with the caveat that LCH2 estimates for the present day put Morocco in a challenged position on the global stage. If the North African country fails to bring down its production costs during the next few years, it risks losing out to competitors who are further away geographically from the EU. The LCH2 from Chile is predicted to be lower than that from Australia, given the longer distance separating Australia and the EU as well as the higher labour costs in Australia.

Table 1: Estimates of levelized cost of production, transport, and total delivery (LCH2) to the EU for each host country in the years 2030 and 2050

	2030			2050		
Country	Production	Transport	LCH2	Production	Transport	LCH2
Morocco	1.10-3.05	1.65-2.05	2.75-5.10	0.65-1.35	0.65-1.70	1.30-3.05
Chile	2.00-2.45	2.30-4.50	4.30[9]-6.95	0.65-1.50	0.75-2.20	1.40-3.70
Australia	1.40-3.05	2.50-4.60	3.90-7.65	0.70-1.70	0.75-2.40	1.45-4.10

2.2 Pilot & Development Projects

This concerns the number and current status of green hydrogen projects, their prospects of completion in time for the EU's 2030 target, as well as their stated production capacities upon completion. Moreover, this also includes indications of the level of progress made by the host governments to enable the development of their respective green hydrogen production sectors so far. The idea here is that a project which has been announced but has not reached Final Investment Decision (FID) yet, or even

[9] According to RMI, Chile's LCH2 would be even lower, at around $3.65/kg (Tatarenko, Janzow, Rosas, & Homann, 2023), however they do not provide a breakdown of that figure. Nevertheless, this is still not as low as the low-end estimate for Morocco in 2030.

one which has reached FID but not been executed yet, always runs the risk of stalling at some point in the future. The outcome of that would be that the supplies which have been earmarked for export to the EU would simply not materialise.[10]

Morocco

Morocco created its National Hydrogen Commission in 2019 and then published a green hydrogen roadmap in January 2021 for what is deemed to be a key growth sector in the national economy, and to require $10 billion of investment to be realised (IRENA, 2022; WEC, 2022; Helmeci, 2023). In March 2021, the country launched its Green Hydrogen Cluster, which envisages an export market of 10 terawatt-hours (TWh) – mainly to Europe – and a local market of 4 TWh (IRENA, 2022; IFC, 2022; Helmeci, 2023).

Several projects have been announced in Morocco, eight in total according to the IEA, all of which aim to produce green ammonia (IEA, 2023). All of these continue to be at the Concept or Feasibility Study stage, however, apart from one small-scale demonstration project by the country's state-owned fertiliser production company, OCP, which has received FID (IEA, 2023). The most significant of these projects is the one which OCP announced in 2023 with an investment plan of $7 billion and with production planned to increase from 0.2 MT of ammonia per year in 2026 to 1 MT by 2027 and then 3 MT by 2032 (Eljechtimi, 2023). In addition to these, Energy China International Construction Group announced a Memorandum of Understanding (MoU) with Saudi Arabia's Ajlan Bros and Morocco's Gaia Energy in 2023 to build a green hydrogen project to produce 1.4 MT of ammonia per year, although the partners are yet to announce a start-up date (Yihe, 2023). So far, according to the IEA, there have been no hydrogen or ammonia export infrastructure projects announced in Morocco (IEA, 2023). All in all, the IEA estimates that Morocco could have a total of less than 0.1 MT per year of hydrogen-equivalent available for export by 2030 if all announced projects were realised (IEA, 2022).

Chile

From a regulatory perspective, the Chilean government's Energy Efficiency Law 21 305, issued in February 2021, gives green hydrogen and its derivatives legal recognition, and enables the creation and implementation of regulations to integrate green hydrogen into the country's energy mix (IFC, 2022; WEC, 2022). Also, that year, the country launched its Ventana al Futuro (Window to the Future) initiative to simplify the administrative procedures to allocate public land for projects to produce green hydrogen with an operational capacity of at least 20 megawatts (MW) by 2025 (IEA, 2022). Moreover, since the Chilean National Development Agency's (Corfo's) call in December 2021 to finance and leverage green hydrogen projects, a total of $50 million has been awarded by Corfo to six green hydrogen initiatives in the country, expected to be operational in 2025 and to produce 45 kilotonnes (KT) of hydrogen annually (IEA, 2023).

According to the IEA, Chile already has six projects which are operational and another three which have received FID (IEA, 2023). Most of these projects are very small, the exceptions being phase one of Haru Oni (operational) producing 1 MW in the form of green methanol (750,000 litres/year) and e-fuels, as well as Walmart's Quilicura Distribution Center (operational) producing 56 tonnes of hydrogen (600 kilowatts) per year to power the company's fuel cell forklift vehicle fleet (IEA, 2023; Walmart, 2023). On top of that, there are 50 projects which are currently either at the Concept or Feasibility Study stage, including major ones like HyEx, Haru Oni (phases two and three), HNH, Atacama Hydrogen Hub, Los Amigos del Verano, and Magallanes (IEA, 2023). Chile's government estimates that 126 GW of green hydrogen could eventually be produced using wind energy from Magallanes (Bartlett, 2022). The HNH and HyEx projects already include (Concept stage) plans for associated ammonia storage capability for export to be developed as well, with the latter project also including feasibility studies to build a dedicated 150 km onshore pipeline (IEA, 2023). Another thing to note is that Chile's announced projects cover a wide range of hydrogen-based products (IEA, 2023). All in all, the IEA estimates that Chile could have a total of up to 2.7 MT per year of hydrogen-equivalent available for export by 2030 if all

[10] In fact, the total amount of low-emission hydrogen to be traded by 2030 based on announced off-take agreements, according to the IEA, is miniscule in comparison to host government stated goals and EU stated import targets (IEA, 2022; 2023).

announced projects were realised, and this represents about 10% of the global total (IEA, 2023). According to RMI, Chilean exports to the EU are expected to reach around 1.2 MT per year by 2030 (Tatarenko, Janzow, Rosas, & Homann, 2023).

Australia

Australia aims to be among the world's top three exporters of hydrogen to Asian markets (Carey, 2021) and its government has invested over $1 billion to stimulate the domestic hydrogen industry, including co-sponsoring seven hydrogen hubs across the country (Government of Australia, 2021). Overall, Australia is second only to Germany in terms of government financial support dedicated to green hydrogen (IRENA, 2022).

According to the IEA, Australia already has nine projects which are operational and another 18 which have received FID (IEA, 2023). The sizeable projects which are currently operational are Hydrogen Park South Australia (1.25 MW) and Jemena's H2toGo (500 kilowatts), which produce hydrogen for blending into existing natural gas networks (IEA, 2023). The former has also received FID to become capable of producing 250 MW of hydrogen for balancing the electricity grid, which is dependent on variable renewable power generation (Parkinson, 2023; IEA, 2023). Another major project which has received FID is Origin's Hunter Valley hydrogen hub, at 55 MW, to be used to produce green ammonia as well as hydrogen to power buses and trucks at the hub (Carroll, 2023; IEA, 2023). Moreover, the Yara Pilbara green ammonia production (10 MW) and storage for export (3.7 MT/year) project is currently under construction, along with the project to repurpose the Parmelia 43 km onshore gas pipeline for hydrogen transport (IEA, 2023). In addition, the country has 102 production, 23 export and shipping, and three new onshore pipeline projects which are either at the Concept, Feasibility Study, or Design stage; including major producers like Murchison (3 GW), H2Perth (3.25 GW), H2-Hub Gladstone (3 GW), HyEnergy Zero Carbon Hydrogen (8 GW), and Western Energy Hub along with its export terminal (20 MT of ammonia per year). Australia's announced projects cover a wide range of hydrogen-based products (IEA, 2023).

In fact, the world's first shipment of liquefied hydrogen (produced from coal) from Australia to Japan took place in February 2022 onboard the Suiso Frontier, which has a maximum capacity of 1,250 cubic meters – equivalent to 75 tonnes of liquified hydrogen per trip (IEA, 2022). In the area of technology leadership, Australia has excelled on the global stage, developing hundreds of patented inventions during 2010-2020, thereby enabling itself to have great influence on standards and operating frameworks across the hydrogen value chain (IRENA, 2022). Since 2018, the country has increased the share of hydrogen in its energy-related research, development and demonstration budget, reaching 25% of a total of $309 in 2021 (IEA, 2023). Moreover, the government of Australia has been proactive in integrating green hydrogen into its energy regulation through a certification scheme (including for ammonia) which it launched in 2021 (IRENA, 2022; IEA, 2022) and translated into regulation in 2023 by incorporating it into the country's National Gas Law and National Energy Retail Law (IEA, 2023).

All in all, the IEA estimates that Australia could have a total of up to 6.0 MT per year of hydrogen-equivalent available for export by 2030 if all announced projects were realised, and this represents about 20% of the global total (IEA, 2023). IRENA predicts, according to its Optimistic Technology scenario, that Australia will have the largest surplus of ammonia production in 2050 and will be the main supplier to Asian countries (IRENA, 2022). According to RMI, Australian exports to the EU are expected to reach around 1.6 MT per year by 2030 (Tatarenko, Janzow, Rosas, & Homann, 2023).

Comparison

Australia ranks the highest in terms of its green hydrogen pilot and development projects thanks to the relatively high number of projects which are either operational or at advanced stages, high production capacity which is expected to be online by 2030, and high amount of exports expected to be EU-bound by 2030. Australia is currently also a global leader in technological aspects, and the level of support provided by the government surpasses that of the other two host countries. Morocco on the other hand ranks the lowest as it has the lowest amount of expected exports by 2030 and the fewest announced projects overall (none of which are operational yet).

2.3 Expectations for Domestic Demand

This indicator measures the likelihood of produced green hydrogen being used to supply the domestic market of the host country and the potential for that to put pressure on supplies which would otherwise be earmarked for export to the EU. It covers indications in the host country which would imply growing future demand potential, such as pilot projects to convert significant domestic industrial applications to use green hydrogen in the future. Given that off-take agreements are yet to be signed for the majority of announced projects worldwide (IEA, 2022), it is fair to consider the situation to be fluid enough for domestic demand to potentially take priority over exports if that is deemed to be most advantageous for the host country's project sponsors and domestic industry.

Morocco

Morocco does not have sufficient power generation to power its domestic market, and has therefore been importing electricity from Spain through its two interconnectors with the EU country in growing amounts since at least 1997 (record figure reached in 2022) (TRADING ECONOMICS, 2023). Morocco plans to expand its existing interconnections and to add a third interconnector to Spain as well as its first to Portugal (IEA, 2019). On the other hand, it is more likely than ever now that a project to develop a giant undersea cable to transfer electricity between Morocco and the United Kingdom (UK) will be executed since Conenergy, a German investor, has committed millions of pounds to the project in partnership with Xlinks, the company developing the cable (Mavrokefalidis, 2022). The investor consortium for this project now includes Abu Dhabi's TAQA, the UK's Octopus Energy Group, and France's TotalEnergies SE (Petrova, 2023).[11] Meanwhile, electricity access is virtually universal across Morocco, connection costs are high, electricity prices for businesses have been increasing, and the country still imports 93% of its energy needs (IFC, 2019). This means that the North African country's remaining renewable power generation potential is currently being competed for by projects to increase its domestic grid power supply and those to generate electricity for export, in addition to its domestic green hydrogen production projects.

As for green hydrogen itself, this is likely to find use in Morocco to produce ammonia to replace imports for fertiliser production and to stabilize the grid as more power gets generated from variable renewables (Wouters, 2020; WEC, 2022; Franza, 2021). According to Wouters, while an electricity grid which receives 50% of its power from variable renewables should still be manageable through conventional means, at 100% it would need up to 20% green hydrogen to keep it stabilised (Wouters, 2020).This implies that if Morocco were to achieve its renewable electricity target of 52% by 2030 (IRENA, 2022) then it would become increasingly (exponentially even) reliant on its green hydrogen stocks in the years to follow (Wouters, 2020). Given OCP's commitment to use domestically produced green ammonia to produce the fertilisers which it exports coupled with the current lack of any announced export terminal project for the kingdom's green hydrogen via any pathway (IEA, 2023), this leads to the presumption that Morocco's primary objective during the current decade is to use its green hydrogen locally to improve the competitiveness[12] of its domestic fertiliser production industry – which itself is largely export-oriented nonetheless.

Chile

Chile's National Green Hydrogen Strategy of November 2020 anticipates that the first stage of green hydrogen adoption, during the first half of the 2020s, will be mainly aimed at replacing existing grey hydrogen demand in oil refineries as well as replacing ammonia imports which supply the domestic market (IFC, 2022). Meanwhile, the country's National Heat and Cold Strategy of 2021 aims for 80% of household heating and cooling to be powered through 'sustainable' energy use, including electricity

---

[11] Reference is given in this source to powering UK homes, meaning that the electricity which is earmarked for export from Morocco does not seem to be for the purpose of generating hydrogen on the buyer's end or for feeding into any of the applications/processes for which hydrogen is (or will be) needed.

[12] OCP believes that it could cut the overall cost of its existing fertiliser production processes (for existing trade deals) by restructuring its ammonia supply chain, purchasing renewable electricity at a cheaper price, and streamlining its ammonia costs by hedging against price fluctuations (Martin, 2023; Anice, 2023). This means that, separately, there would also be potential for 'green fertiliser' exports to the EU in the future, albeit these would be made at a premium.

from renewable sources (REN21, 2022). Also in 2021, a new energy efficiency law was passed to require hydrogen to be blended into natural gas grids at up to 10% concentration (WEC, 2022). Nevertheless, private sponsors and investors see the economic value of these projects to be based on exports (IFC, 2022; Barros, 2024), a view echoed by PwC (PwC, 2023) and the WEC (WEC, 2022). In fact, Chile has only one cross-border electricity connection (net exporter to Argentina) and has therefore invested heavily in generation capacity to satisfy growing domestic demand (IEA, 2018). As of 2023, more than half of Chile's planned hydrogen generation capacity, and just under half of all projects in the country (mostly in the south), aim to export to overseas off-takers (BNamericas, 2023).

Other potential demand could come from forklifts and heavy-duty trucks for the domestic mining industry, although there are still technological gaps as well as competition from other low-carbon (electric) solutions for this sector (IFC, 2022). Nevertheless, Chilean authorities are keen to see hydrogen replacing diesel to power 87% of the country's 1,390 haulage trucks in the mining sector by 2050, and there is currently a pilot project at Antofagasta PLC's Centinela copper mine to integrate hydrogen into large mining equipment (Barich, 2022). This in fact is only one of more than 40 such projects (at various phases) which have been indicated by the Chilean Energy Ministry (Acosta, et al., 2022). On the other hand, while Chile's local demand for fertiliser is likely to remain low the regional demand is likely to be high, especially in Brazil (IFC, 2022), meaning that some of the green hydrogen produced in Chile could end up being used as feed-in stock to produce fertiliser for export to the Latin American country's neighbours instead of being exported to the EU.

All in all, Chile boasts a combination of self-sufficiency in its electrical energy supplies and limited potential domestic demand, during this decade at least, for the green hydrogen which it plans to produce. Instead, the country's strategy seems to prioritise exports as a driver for growing its domestic green hydrogen sector. This makes it a promising host country as far as green hydrogen export potential is concerned.

Australia

While low-carbon hydrogen is likely to be used in the decarbonisation of Australia's ammonia and methanol production, iron and steel production, and various refining applications, the country's priority is for this sector to be primarily export-driven (WEC, 2022). For example, e-fuels exports are expected to become a key growth vehicle for this emerging industry – especially exports to East Asian markets (Barros, 2024). Nevertheless, the country also wants to see low-carbon hydrogen powering its heavy-duty transport; including heavy trucks, buses, and mining machinery, and is considering its use in power generation and its potential to be blended with natural gas in existing residential appliances (WEC, 2022; IEA, 2022; IEA, 2023).

Studies suggest that it would make better economic sense to produce steel from green hydrogen in Australia and then export it rather than exporting the green hydrogen, via some carrier, to a steel-producing country which would then need to reconvert the hydrogen before using it for its processes (IRENA, 2022). Alternatively, Hot Briquetted Iron (HBI) could be produced in Australia and then exported to steel manufacturers worldwide, as is the case for Fortescue's planned Christmas Creek Green Iron Commercial Plant project (Fortescue, 2024). Australia today exports iron ore as opposed to HBI or steel (IRENA, 2022). Moreover, Australia has started to promote the development of green hydrogen refuelling networks, and in 2022 the New South Wales, Victoria, and Queensland regional governments launched a hydrogen highways initiative aimed at developing a network along the country's eastern seaboard for heavy transport and logistics by 2026 (IEA, 2022). Meanwhile, Australia's Fortescue Metals Group is testing a hydrogen-powered haul truck for roll-out during 2025-2030, and Hyzon Motors plans to imminently deliver five heavy fuel-cell electric trucks to transport zinc concentrate and ingots along a short route which connects a port and a zinc refinery in Australia (IEA, 2022; CEFC, 2023).

All of the above signifies that Australia's green hydrogen ambitions are mainly export-driven, albeit the country also has big ambitions to use this product as part of its own domestic energy transition. This does not come as a surprise given that Australia is a large and advanced economy with high energy demand. That said, while the imperative for exports is clear, the drive behind the domestic energy transition tends to fluctuate depending on the political party governing it during any particular term (Craen, 2023).

Comparison

Given the above, Chile ranks the highest in terms of its domestic demand for green hydrogen, which would intuitively favour low expected demand in the host country to maximise export potential to the EU. This is because the country combines impressive renewable electricity generation potential (like Morocco does) with significant announced hydrogen production capacity (much more than Morocco has) and self-sufficiency of its domestic power sector (unlike Morocco). Also, unlike Australia the Latin American country has limited industrial applications for which it is likely to use the green hydrogen which it produces – at least within the current decade. Morocco on the other hand ranks the lowest because the country looks to be pursuing renewable electricity export projects to Europe alongside those for domestic green hydrogen production, and is yet to achieve self-sufficiency in its domestic power market. Moreover, most of the momentum related to green hydrogen seems to be in supplying the kingdom's domestic fertiliser production industry, at least for the time being.

2.4 Status of Renewable Electricity Sector

In this section, countries are compared in terms of the strength and development level of their domestic renewables sectors, which is measured in terms of generation capacity, government support, integration into the national grid, state of the national grid, regulation, and outlook for future capacity additions. While it is understood that many green hydrogen projects are likely to have dedicated renewable power generation facilities for producing the electrolytic product, it is insightful to look at each country's history and ambitions with regards to renewables as an indication of how their future development and operation might pan out when they get put to use for producing hydrogen. This is particularly important given that the largest component of the levelized cost of green hydrogen production will come from renewable power generation (Patonia & Poudineh, 2022), and much of the electricity supply might still come from the national grid (ETC, 2021). A host country with an underdeveloped or troubled renewable power sector poses significant risk to the developer as well as the operator of a green hydrogen production project which is dependent on ample supply of renewable power.

Morocco

Morocco's priority is to reduce the country's dependence on energy imports, which included 17% of its electricity needs in 2016 (IEA, 2023; Saifaddin, 2023), while also lowering the energy intensity of its economy and fighting climate change (IFC, 2019). Therefore, the government has set a target to achieve 52% installed renewable energy generation capacity relative to total by 2030 in its National Energy Strategy, which was adopted in 2009 (IFC, 2019), and then 70% by 2040 and 80% by 2050 (Helmeci, 2023). In 2021, the government has provided $5.6 billion for major solar projects in the country (REN21, 2022), and the country's electricity imports have gone down during the past few years, reaching just over 5% in 2021 (IEA, 2023; Saifaddin, 2023). On the other hand however, most of Morocco's electricity continues to be generated using coal (IEA, 2023), and the country's coal power plants have been upgraded in recent years to run until 2044 in line with extending the Power Purchase Agreements (PPAs) which underpin them (Anice, 2023). This means that it would not be possible to use the country's grid network to produce green hydrogen close to its Maghreb-Europe natural gas pipeline entry point any time soon.

The leading state-owned enterprises responsible for Morocco's energy infrastructure are ONEE for electricity (including transmission) and water supply, and MASEN for renewable energy, and the expansion of renewables in the North African country has been a largely state-led and centralised undertaking (IFC, 2019; Hydrogen Central, 2022). During the 1990s, Morocco carried out reforms to allow private participation in its power sector and to achieve universal access to electricity, with the national average rate increasing from 18% in 1995 to 98.9% in 2018 (IFC, 2019). Meanwhile, the partial liberalization of the generation segment has allowed private Independent Power Producers (IPPs) to participate in the market through concession contracts, and this is the main reason for the total electricity supply produced by ONEE going down from 95% to below 30% of the country's total during the same period (IFC, 2019). The country has established a competitive IPP auction programme, which has seen corporate PPAs give onshore wind development a boost while the state drove the expansion of solar photovoltaic (PV) and green hydrogen projects (IEA, 2023). On the other hand, MASEN has continued to off-take electricity at a loss while the power sector continued to lack an independent regulator (IFC, 2019). As a result, IPPs currently face too much uncertainty and have too little clarity regarding the integration of renewable energy into Morocco's grid, and these issues would need to be addressed in order for the country to attract more private investment (IFC, 2019; Hydrogen Central, 2022).

Total renewable power generation in Morocco; comprising wind, solar and hydro, stood at 8,140 gigawatt-hours (GWh) in 2021 (IEA data for 2022 unavailable at the time of writing), and made up roughly 19% of the country's overall power generation (IEA, 2023). The Ministry of Energy expects to see an additional 14 GW of renewable energy added to the grid in Morocco by 2027 (Helmeci, 2023) on top of the current capacity of 3.7 GW (Statista, 2023). However, while Morocco's government has been instrumental in facilitating private investment in the country's infrastructure projects through hybrid financing which combines project finance with public funding and state guarantees (IFC, 2019; Baker & Benoit, 2022), this may not be sustainable in the future given the country's limited fiscal space (IFC, 2019). Moreover, the expansion of the grid which accompanied the increase of the country's installed generation capacity has also been accompanied by an increase in network losses to %13.4, a high figure when compared to countries like Egypt (11%) and Saudi Arabia (7%) for example (IFC, 2019). In fact, the IEA predicts only 4.4 GW of renewable capacity to be added in Morocco by 2027, with roughly 10% of that to be dedicated to green hydrogen production (IEA, 2023). Realistically, Morocco would need to multiply its current capacity several times before it could produce green hydrogen in meaningful quantities for export (Anice, 2023).

Chile

This country aims for renewable power to make up 80% of its national electricity mix by 2030 (Buchsbaum, 2023). Thus, as part of Chile's Net-Zero strategy, the country has set a carbon tax since 2017 and has set a retirement schedule for its coal power plants (IEA, 2021; IEA, 2023), with two thirds of these set to be closed by 2025 (IEA, 2023), thereby devising a concessional finance mechanism to monetise avoided carbon emissions (IEA, 2021). The country's investment in renewable energy development has ranged from $1 billion to $5 billion annually during 2013-2020, which is very large relative to other developing economies (IRENA, 2023). Chile has also not pursued a subsidised approach in developing its renewable energy market, relying instead on long-term competitive tenders for PPAs, a strategy which has led electricity prices to decrease significantly during 2013-2017 (IFC, 2022). This has been in combination with the state expanding its role in energy planning in order to help boost project development in the country (IEA, 2023). Another good example of this is in the country's electricity transmission, which has been interconnected since 2017 under one system (IEA, 2023), and has issued one of the two largest Emerging Market & Developing Economy (EMDE) country project bonds (at $1 billion) of 2021 (Baker & Benoit, 2022). To develop its interstate transmission lines, much like other Latin American countries, Chile has allowed private companies to finance, build, and operate the lines under long-term contracts before transferring them over to the government once the contracts have expired (IEA, 2021). In March 2022, Chile became the first country worldwide to issue a sustainability-linked bond in local currency, the aim of which is for the issuer to achieve set GHG targets and produce at least 60% of its energy from renewable sources by 2032 (Madeira & Pérez, 2023).

Total renewable power generation in Chile; comprising wind, solar, hydro, and geothermal, reached 44,231 GWh in 2022, and has risen to make up roughly 50% of the country's overall power generation (IEA, 2023). This might explain why 10 of Chile's announced green hydrogen production projects, all of them slated for start-up during this decade, plan to source their electricity at least partially from the grid (IEA, 2023). On the other hand, the increase in variable renewable power generation is increasingly challenging the country's ability to balance its national grid, which has suffered from inadequate power transmission infrastructure leading to frequent curtailment (IFC, 2022). Moreover, the Chilean public's resistance to the development of additional hydropower generation capacity could further limit the country's ability to balance its national grid as it becomes increasingly reliant on variable renewable power generation (IFC, 2022). Thus, this could result in some of Chile's produced green hydrogen being used to help balance the country's grid. According to the IEA, it is expected that Chile's renewable energy capacity will more than double by 2027, reaching 45 GW, with most of this coming from onshore wind and half of it going towards green hydrogen and ammonia production (IEA, 2023). On the other hand, according to IRENA the combination of Chile's existing *12.5 GW* of renewable generation capacity at the end of 2021, 4.3 GW from wind and solar projects expected to come online by 2024, and more than 10 GW of future capacity additions which have received environmental approval so far, adds up to only 26.8 GW (IRENA, 2022).

Australia

Having achieved its federal target for renewable energy (LRET) in 2019, Australia is currently targeting 43% reduction of its carbon emissions by 2030 compared to 2005 levels through the build-out of renewables (IEA, 2023), which should get them to an 82% share of the national electricity mix by that year (IEA, 2023). Renewable power penetration in Australia is currently greater than demand (IEA, 2023), especially given the geographic unevenness of this penetration, such as solar power's highest concentration being in South Australia (IEA, 2018). On the utility scale, the IEA predicts that Australia's renewable power capacity will increase more than 85% by 2027, encouraged by state-level auctions and incentives as well as strong corporate power purchase activity, adding nearly 40 GW of capacity mainly from solar PV through dedicated renewable energy zones (IEA, 2023). However, this will only add to the existing challenges of intermittency and high transmission costs caused by bottleneck interconnectors between Australia's states, which is why the federal government has been implementing reforms in recent years on the retail, system operation, planning, and market design fronts to secure supplies (IEA, 2018; IEA, 2023).

Total renewable power generation in Australia; comprising wind, solar and hydro, stood at 80,806 GWh in 2022, and made up roughly 30% of the country's overall power generation (IEA, 2023). Seven of Australia's existing and future green hydrogen production projects, with announced start-up dates which are within this decade, use (or will use) grid electricity (IEA, 2023). This is not only fewer than in the case of Chile, but also none of these projects are at the same order of magnitude as the Chilean ones – two of which are at 2,000 MW capacity (IEA, 2023). This might be a reflection of Australia's current percentage of grid electricity generated from renewables being much lower than in Chile. Nevertheless, the IEA predicts that Australia will be second only to China in the amount of renewable generation capacity which it plans to add until 2027 purely for green hydrogen production (17% of the country's total renewable deployment), with the predicted world total addition in that forecast being 50 GW (IEA, 2023).

Comparison

Based on the above, both Chile and Australia seem to have highly developed and integrated renewable power sectors which are incentivised by the government, developed and funded mostly by the private sector, and integrated into national-level deregulated markets. While Australia is the host country with higher current and future generation capacity, Chile is the one where renewables currently contribute a higher share of electricity generation. On the other hand, Chile will likely need to replace its generation capacity from hydropower in the future as that infrastructure ages and becomes less popular with the public. Nevertheless, given the greater progress made so far by Chile towards enabling its national grid to integrate future green hydrogen projects, the Latin American country ranks the highest on this indicator. Morocco on the other hand, while also boasting a strong and highly integrated renewable power sector, is at a disadvantage compared to the other two host countries, and therefore ranks the lowest. This is because the penetration of renewables into its electricity mix is lower, its total renewable generation capacity is lower, its future capacity additions are expected to be lower, and its regulatory uncertainty remains higher.

2.5 Common Initiatives with EU Countries and Institutions

In this section, each country is examined in terms of its existing trade, partnership, and collaboration agreements on green hydrogen with EU Member States, institutions within those Member states, and EU-wide government and financial institutions. The aim is to evaluate how the host countries compare in terms of the likelihood of their green hydrogen developers to strike supply agreements with EU buyers. The deeper and more numerous the commitments between the host country and EU countries, the higher it ranks on this indicator as this translates into higher potential to supply the EU and to increase this supply in the future.

Morocco

When Morocco's government published its green hydrogen roadmap in 2021, this was soon followed by a bilateral trade agreement with Germany (MEM, 2021). The North African kingdom is currently collaborating, either bilaterally or through other channels, with EU Member States including Germany, The Netherlands, Portugal, and Spain on green hydrogen development, trade, transportation, and usage (Fraunhofer, 2019; IEA, 2022; IRENA, 2022; IFC, 2022; WEC, 2022; Green Hysland, 2023; IEA, 2023). More recently, France has shown interest at the industrial and presidential levels in collaborating with Morocco as well (Blinda, 2023). In addition, the North African country is collaborating with the EU as a whole to ensure that there is alignment between its green hydrogen ambitions and those of the EU, including on the Africa Green Hydrogen Alliance (launched on the same day as the EU's REPowerEU plan) and a Green Partnership (the first ever signed by the EU with a partner country) (Kneebone & Piebalgs, 2022; DG NEAR, 2022).

Chile

Chile is currently collaborating, either bilaterally or through other channels, with EU Member States including Germany, Belgium, The Netherlands, Spain, and France on green hydrogen development, trade, transportation, and usage (WEC, 2022; IEA, 2022; 2021; 2023; IRENA, 2022). During COP26 in Glasgow in November 2021, the ports of Antwerp and Zeebrugge signed an agreement with the Chilean Ministry of Energy to supply green hydrogen to Europe at prices which could be as low as 1.10 euros per kg ($1.20/kg) (RN, 2021). In addition, the Haru Oni project has already secured off-take for its entire current production of e-gasoline (130,000 litres a year) from Germany's Porsche (Porsche, 2023), and the HNH project partnership now includes Denmark's Copenhagen Infrastructure Partners (CIP) as part of the private equity firm's Energy Transition Fund alongside the project's developer, AustriaEnergy (CIP, 2023; AustriaEnergy, 2023). Moreover, the EIB and Germany's KfW have agreed to provide up to 100 million euros ($110 million) each to finance Chile's green hydrogen production projects, in addition to a grant of €16.5 million ($18.2 million) from the EU Latin America and Caribbean Investment Facility for the same purpose (Possenti, 2023).

Australia

Australia's supplies of green hydrogen to German companies, totalling 5.1 MT/year, are targeted to commence by 2030 according to MoUs currently in place (Macdonald-Smith & Eyers, 2022; IEA, 2022). Moreover, the governments of the two countries have committed $90 million to support joint research on all aspects of the green hydrogen value chain (IEA, 2022), and this is part of the broader German-Australian Hydrogen Alliance headed by the German-Australian Chamber of Industry and Commerce and including Deutsche Bank (AHK, 2023; Deutsche Bank, 2021). The Netherlands has also agreed, through the Port of Rotterdam, to purchase Australian low-carbon hydrogen (IRENA, 2022; GLOBE NEWSWIRE, 2022), and more recently there are plans for Danish investment to go into several Australian green hydrogen projects via the Nordic country's private equity firm, CIP (Vorrath, 2023), including the Murchison project which forms part of the Danish firm's Energy Transition Fund (CIP, 2023).

As for the EU as a whole, a broad framework agreement was signed between Australia and the bloc in August 2017 and then came into force in October 2022, with areas of cooperation including 'Sustainable development, energy, and transport' (CEU & EC, 2022). This is highly likely to expand the scope of green hydrogen cooperation and trade given the precedent set by Australian-German bilateral relations.

Comparison

Despite its geographic proximity to Europe and the numerous collaboration avenues established between it and EU Member States, as well as the EU as a bloc, Morocco does not seem to have signed any significant firm supply agreement with an EU buyer yet. Meanwhile, Chile is the only one of the three host countries to have secured a firm supply agreement with EU buyers so far. Australia on the other hand has signed two MoUs with EU buyers to supply amounts which are much greater than those of Chile's firm orders. Also, while Morocco has been a big recipient of EU funding towards its infrastructure development, Chile is set to receive EU funds which target its green hydrogen sector specifically. While Australia would likely not be a recipient of any EU development fund support given its advanced economy status, it has secured a bilateral alliance with Germany on the development of the green hydrogen value chain. Thus, Australia ranks the highest when it comes to this indicator and Morocco ranks the lowest.

2.6 Common Initiatives with Non-EU Countries and Institutions

In this section, each host country is examined in terms of its existing trade, partnership and collaboration agreements with other non-EU countries, their institutions, and global financial institutions which are not exclusive to the EU. The aim is to evaluate how the host countries compare in terms of the likelihood of their green hydrogen developers to strike supply agreements with non-EU buyers in the future. The deeper and more numerous the commitments made between the host country and such countries, the higher the competition for its green hydrogen supply capacity is likely to be, which means lower likelihood of the host country being able to ramp up its supply to the EU in the future. Therefore, while global cooperation would rightly be seen as a good thing for a host country's green hydrogen sector overall, here it is deemed to lower the country's ranking as far as its potential to supply the EU is concerned.

Morocco

Outside the EU, Morocco has a bilateral partnership with Singapore (WEC, 2022) and is collaborating with firms in China and Saudi Arabia to develop green ammonia production (Yihe, 2023) as well as with UK firms (Ghilotti, 2022). Meanwhile, the biggest importers of Moroccan fertilisers are non-EU countries (OEC, 2024), meaning that the kingdom would need to attract new buyers in EU Member States, or expand its trade with the existing ones, if it were to turn its fertilisers into a significant EU export pathway for its produced green hydrogen in the future. Moreover, the United Nations Industrial Development Organization (UNIDO) is partnering with Morocco's government on the development of the country's green hydrogen sector through various mechanisms, including the Green Climate Fund (UNIDO, 2022).

Chile

Chile has bilateral partnerships with Colombia, Singapore, the UK, South Korea, and Australia; the latter being on demand-side technology and involving Japanese and French corporations (WEC, 2022; IEA, 2022; Jamasmie, 2021). In addition, the World Bank (WB) is actively supporting Chile's development of its green hydrogen sector through a combination of finance, certification, and carbon pricing (Kane & Gil, 2022), and has agreed to provide $150 million in loans to help develop the Latin American country's green hydrogen sector (Yamashita & Luco, 2023).

Australia

Australia currently has bilateral partnerships on green hydrogen with South Korea (IEA, 2022), the UK (IEA, 2023), India (IEA, 2023), and Japan (WEC, 2022), with the latter's imports expected to grow to 9 MT per year by 2050 and to come mainly from Australia (IRENA, 2022). In 2023, an Australian-South Korean consortium made a preliminary land deal with the regional government of Western Australia to develop, in the latter's state, a green hydrogen and ammonia project which aims to start exporting to South Korea by 2027 (Parkes, 2023). Then there is China, who has high demand for steel and is under pressure to decarbonise its industry, which means that Australian steel manufacturers might seize the opportunity to use green hydrogen to make low-carbon steel and sell it to the East Asian giant (IRENA, 2022; GT, 2023). Another source of competition to future supplies to the EU comes from the Sun Cable project, which aims to develop a 5,000 km long HVDC cable which transmits Australia's renewable electricity domestically to Darwin and internationally to Singapore (Sun Cable, 2023).

Comparison

With the industrialised economies of the Asia-Pacific region being the biggest competitors to the EU for future green hydrogen supplies (Toyama, 2022), it is clear from the discussion above that they have focused most of their investment and efforts on the up-and-coming producer which is geographically closest to that region – Australia. Also, there seems to be more involvement of the high-demand centres of Asia-Pacific, and even from the Australian government, in Chile's green hydrogen projects than in those of Morocco. This may be a reflection of the varied levels of progress made so far by each of these host countries in developing their respective renewable power generation and green hydrogen production capabilities. While several companies based in non-EU countries have plans to develop green hydrogen projects in Morocco, these are not necessarily indicators of future bilateral trade between those countries and Morocco of the product. Thus, Morocco ranks the highest on this indicator because it looks to be the country with the least non-EU competition for its future green hydrogen supplies while Australia ranks the lowest.

2.7 Maritime Infrastructure Availability

A key element of a host country's ability to export its green hydrogen via the ammonia, methanol, e-fuel, liquified hydrogen, or LOHC pathways is the availability of maritime infrastructure. This is also an important indicator of the quality of a host country's supply chains in general and will thus have a direct impact on the costs of developing and operating its green hydrogen production infrastructure. Hydrogen processing, storage, and shipping will require a combination of new infrastructure development, upgrade of existing infrastructure, and technological advancement anywhere in the world. While the status of port infrastructure upgrade projects for green hydrogen export in each host country has been discussed in Section 2.2 above, the discussion here is about all available ports in each country.

Morocco has a total of 22 ports on its coast (Ports, 2023) and a land surface area of 446,550 km² (World Data, 2023). In comparison, Chile has 74 ports (Ports, 2023); more than three times the number of ports that Morocco has, and only roughly 60% larger land surface area; at 756,700 km² (World Data, 2023). This does not only mean that Chile has more numerous shipping outlets and inlets for its green hydrogen production projects, but also that a facility hosted in the Latin American country is likely to be closer to the nearest port than in the case of Morocco – thus lower domestic land transportation costs. Australia on the other hand has 221 ports (Ports, 2023); about three times as many as Chile, and a surface area of 7,741,220 km² (World Data, 2023); more than 10 times that of Chile. This means that a green hydrogen producer in Australia is likely to be further away from the nearest port than one located in Chile. This makes sense considering that Chile, unlike Australia or Morocco, stretches a long way from north to south along its coast (on the Pacific Ocean) and extends very narrowly inland (World Data, 2023).

Since Chile has the highest number of ports relative to its land surface area and enjoys the advantage of having a long coastline relative to its surface area, the country ranks the highest on this indicator. Australia on the other hand has the lowest number of ports relative to its land surface area. The combination of that with the country's relatively high wages will likely result in its green hydrogen supply chains incurring relatively high costs. For this reason, the Oceanic country ranks the lowest on this indicator.

2.8 Chemicals Handling and Export Capability

An important factor for a country's domestic green hydrogen production sector to pick up at a high pace is the availability of infrastructure and capability to handle and export chemicals. Since most of Europe's demand for hydrogen currently goes towards oil refining, ammonia production (mostly for fertilisers), and methanol production, these are the sectors which are compared here for the three host countries.

While oil-derived products are used widely around the world, some countries possess the capability to extract these from crude oil on a large scale while others need to import them in large amounts to fulfil their domestic demand. The refining of crude oil requires the input of hydrogen to remove sulphur from the output products (Mohammadi, 2022). Morocco has an oil refinery which had been operational since 1959 but is currently idle as of 2015 (Menas Associates, 2022). Chile on the other hand has three operational oil refineries (APERC, 2019), the first having come into service in 1954 (DEVAID, 2023). Australia has two remaining oil refineries which are operational after having had two others close down in 2021, before being converted into import terminals (F&L Asia, 2022). The country's first oil refinery came into service in 1949 (Laidlaw, 2020).

Regarding ammonia, this is produced using hydrogen and is considered to be a carrier for hydrogen transport (IEA, 2022; Royal Society, 2024). Morocco is one of the world's biggest importers of ammonia (OEC, 2024), however it has been using this chemical to produce fertilisers domestically via two phosphate processing facilities, the first of which started up in 1965 (OCP, 2024), and is a major exporter of these worldwide (Statista, 2023). This includes exports to the EU worth 100s of million US dollars (OEC, 2024). Meanwhile, Chile imports ammonia in large amounts and re-exports some of it (not to the EU) in very small amounts (OEC, 2023), and the rest is used to produce ammonium nitrate domestically (Rouwenhorst, 2023), with some of the latter being exported to buyers in EU Member States (Volza, 2023). On the other hand, Australia has produced ammonia since 1967 (EPA, 2023) and is the 15th largest exporter of it worldwide (OEC, 2024). The country also uses some of its ammonia to produce ammonium nitrate and fertilisers (EPA, 2023; Fertilizer Australia, 2024) and has been an exporter of these for decades (TRADING ECONOMICS, 2024).

As for methanol, this is conventionally produced by steam-reforming of natural gas (AFDC, 2024), although an alternative is to combine green hydrogen with captured CO2 (Patonia & Poudineh, 2022). While methanol could also serve as a hydrogen carrier, this is not considered to be optimum as discussed in Section 2.1 above. Morocco currently does not produce or export this chemical. Chile on the other hand has been producing methanol since 1988 (Methanex, 2016), currently from two plants since another two went idle in 2014 (Methanex, 2014), and has been an exporter of this chemical for decades (CEIC Data, 2024) - mostly to buyers in Latin America and Asia Pacific (Methanex, 2024). Australia used to produce methanol between 1994 and 2016, when its only methanol production plant closed down (Smith, 2017).

In summary, Morocco does not have domestic oil refining operations anymore, whereas Chile and Australia still do. Moreover, while all three countries produce and export various types of fertilisers, Australia is the only country which also produces and exports the ammonia which is mainly used in producing the former. As for methanol, Morocco does not have a domestic production sector whereas Chile does, and it continues to export this chemical. Meanwhile, Australia used to have an operational methanol production plant but not anymore. Thus, while all three countries continue to have strong chemicals handling and export industries, it is Chile which is currently domestically involved in all of the aforementioned sectors. On the other hand, Australia is the one which currently has domestic ammonia production facilities and operations, and it is this chemical which is considered to be the most important pathway for growing the green hydrogen sector worldwide.

2.9 Business Environment and Political Risk

Here, countries are compared in terms of ease of doing business, macroeconomic indicators, and how developed their economies are. The idea is that once long-term green hydrogen development and off-take contracts have been signed involving a host country, its internal business environment will be a key determinant of the trajectory which the execution and fulfilment of these contracts will take, which in turn will ultimately determine their level of success from all stakeholders' perspectives. This is particularly important for green hydrogen, which will involve a network of complex operations and supply chains that are yet to be streamlined anywhere in the world. According to the IEA, the level of financial system development in a country is a strong determinant of its potential to fund clean energy projects (IEA, 2021).

In addition, political unrest in a host country, its involvement in conflict with any of its neighbours, or the introduction of policies which are unfavourable towards green hydrogen production/export, could result in major disruptions to the continuity of the supply of hydrogen from that country to the EU if they were to occur in the future. While the likelihood of such events is usually not very high, the expected long durations of green hydrogen contracts do leave everyone involved exposed to the risk of any such event occurring at some point during a project's lifetime.

Morocco

According to Atradius, Morocco is a country of 'moderate' overall risk (Atradius, 2023), and the WB ranks the country 53rd out of 190 countries worldwide in terms of 'ease of doing business' (WB, 2020). Moreover, as of 2022 the country is ranked 94th out of 180 countries in terms of a Corruption Perception

Index by Transparency International (TI, 2023). Similar to other Middle East & North Africa countries, the government's strategy has historically been to maintain the status-quo by providing its population with social security through subsidized goods such as energy, a practice which became so difficult to abandon without risking significant political unrest (Shaar & Leal-Arcas, 2022). Regarding the private sector, although a number of public-private equity funds have been established in Morocco during the 2010s through public initiatives (ADB, EBRD & EIB, 2021), it is likely that the public sector will play a big role in the future development of Morocco's infrastructure as it has done in the past (IFC, 2019). Yet, the future investments needed are high and meeting them will require less reliance on public spending and public guarantees (IFC, 2019).

During the past few decades, Morocco has had mostly positive GDP and private consumption growth (Atradius, 2021); at 1.3% and -0.7% in 2022, respectively (WB, 2023). The GDP per capita was $3,495 in 2022 (WB, 2023) and has increased by 70% in real terms during 2000-2019 (Atradius, 2021). The country had traditionally been a leading producer of agricultural products and phosphates, and has more recently diversified its economy through structural reforms which have resulted in the development of industrial manufacturing, including export-driven sectors such as cars, aeronautics, and electronics (Atradius, 2021). Another important asset for Morocco is its geographic proximity to Europe which, along with low unit labour costs and a slightly undervalued currency, makes the region its main export market and allows the kingdom to be a strategic trade and investment hub connecting Europe and Africa together (Atradius, 2021).

Morocco has been a stable monarchy for decades now, with its current king continuing to hold most of the power and the state's powers being limited (Atradius, 2021). While the king is popular with the people and there is no immediate threat to the monarchy, protests have been taking place periodically due to ongoing economic problems and corruption (Atradius, 2021). From a regional perspective, Morocco has claimed sovereignty over the Western Sahara for decades, while fighting has broken out again since 2020 between the kingdom and the independence-seeking Polisario Front after a 29-year-long ceasefire (Atradius, 2021). Moreover, Morocco's relationship with its neighbour, Algeria, has deteriorated in the last three years (Euractiv, 2022; Vasques, 2023) as part of an ongoing rivalry between the two nations, which has also been going on for decades (Dworkin, 2022).

Chile

According to Atradius, Chile is a country of 'moderate-low' overall risk (Atradius, 2023), and the country is ranked by the WB 59th out of 190 countries worldwide in terms of 'ease of doing business' (WB, 2020). The latter (relatively low) ranking is reflected, for example, in the long time which it takes just to get an environmental permit for an infrastructure project in Chile – around two years (Barros, 2024). Moreover, as of 2022 the country is ranked 27th out of 180 countries in terms of a Corruption Perception Index by Transparency International (TI, 2023). Chile joined the Organisation for Economic Co-operation and Development (OECD) in 2010, having become the first country in Latin America to reach high-income status (IFC, 2022). The country has established a robust regulatory framework which has successfully promoted competition and competent institutions while also keeping corruption levels low (IFC, 2022; Atradius, 2021). These reforms were initiated during the late 1970s and early 1980s, with private sector support and price deregulation at their heart, and together with sustained commodity demand from China have resulted in rapid economic growth ever since (IFC, 2022). Chile has 29 free trade agreements with over 65 countries covering 88% of the global market by size (GOV.UK, 2023). The challenge for Chile now is meeting the expectations of its population, whose standard of living is much higher on average than it had been one or two generations prior, and this is not easy given that economic growth has slowed down since the mid-2000s (IFC, 2022).

Chile's GDP per capita of $15,356 in 2022 (WB, 2023) has grown 10-fold since the mid-1980s (WB, 2023), and its GDP growth of 2.4% and private consumption growth of 2.9% in 2022 (WB, 2023) have both remained mostly positive during 2008-2021 (Atradius, 2021). Copper exports have historically been a mainstay of Chile's economy, and they continue to account for more than 40% of the country's export earnings; more than 30% of which come from China, and 10% of its GDP (Atradius, 2021). The latter figure has decreased however compared to when it was more than 25% a decade ago (Atradius, 2021). The country was also the world's second largest lithium producer in 2022, and unlike copper production this sector is currently in the hands of private companies (Dempsey & White, 2023).

Moreover, Chile's service sector currently accounts for more than 60% of its GDP and the country is highly integrated into the global financial markets (Atradius, 2021). The flipside to Chile's relatively high level of economic development is that concessional finance is now more difficult for it to obtain than it used to be (IFC, 2022).

While this Latin American country has managed to maintain stability domestically for decades, during a time when others in the region were plagued by war, organised crime, and/or political instability, there are signs that the tide might be turning against Chile now (Miranda, 2023). Large social riots broke out in October 2019 as a result of unhappiness caused by economic issues as well as the Pinochet-era constitution (Atradius, 2021). As a result, the government had been trying to introduce a new constitution since March 2022, however this did not go smoothly (Miranda, 2023; Buschschlüter, 2023) and voters have rejected two proposed drafts (Cooney, 2023). Thus, political uncertainty is currently a concern in Chile. Moreover, two challenges which are likely to have a direct impact on future green hydrogen projects are left-leaning politics and environmental activism. For example, the current president has stated in April 2023 that the state needs to increase its hold on Chile's lithium industry significantly, raising fears of outright nationalization in the future (Miranda, 2023; Dempsey & White, 2023). On the environmental front, 2014 saw protestors forcing the HydroAysén dam development to be blocked on environmental grounds, even though the project had been approved in 2012 (IEA, 2021). More recently, a 38-square-kilometer wind farm north of Punta Arenas slated for power generation to produce green hydrogen got withdrawn from Chile's environmental evaluation system (Bartlett, 2022). Finally, while not directly related to the green hydrogen sector, Chile continues to experience recurring flare-ups of violence and unrest resulting from long-standing grievances from its indigenous groups, especially in the Araucanía region (GOV.UK, 2023).

Australia

According to Atradius, Australia is a country of 'low' overall risk (Atradius, 2023), and the country is ranked by the WB 14th out of 190 countries worldwide in terms of 'ease of doing business' (WB, 2020). Moreover, as of 2022 the country is ranked 13th out of 180 countries in terms of a Corruption Perception Index by Transparency International (TI, 2023). While historically this Anglo country had been reliant on foreign investment and vulnerable to world markets, its governments have usually shown themselves to be ready and able to intervene in the economy when necessary (Britannica, 2023). Nevertheless, foreign interests have tended to play a significant role in this country's affairs; starting with the UK, followed by the US, and most recently by giant multi-national corporations (Britannica, 2023). In general, the country has become increasingly involved in the Asia-Pacific region and has increasingly accepted the inevitability of its comprehensive trade activity with that region, as well as of domestic deregulation (Britannica, 2023). Most of Australia's economic growth during the last few decades has been in the services sector; including finance, transport, and trade, and this currently contributes about four fifths of the country's GDP while also employing three quarters of its labour force (Britannica, 2023). Over the decades, Australia's banking system has seen the federal and state governments gradually relinquish their involvement in it (Britannica, 2023). Interestingly, the country's liberal credit policy seems to have resulted in some businesses falling increasingly short of their invoice settlement due dates in recent years (Atradius, 2022).

In Australia, GDP ($1.69 trillion in 2022) and GDP per capita ($65,100 in 2022) have increased dramatically; the former almost four-fold and the latter almost three-fold, during the 20 years from 2003 until 2022 (WB, 2023). Moreover, Australia's current account balance has been positive since 2019, unlike Chile's or Morocco's which have been negative for many years now (WB, 2023). Another important industry in Australia is its highly advanced mining sector, including coal, iron ore, nickel, and lignite (Britannica, 2023). The country holds one quarter of the world's known low-cost uranium reserves, however limited demand plus environmentalist objections have kept extraction rates intermittent and low on average (Britannica, 2023). Moreover, Australia has the world's largest recoverable reserves of zinc and lead, as well as very large bauxite reserves, and has had a long history of producing all of these in significant quantities (Britannica, 2023). Gold is another highly valuable mineral of which Australia is a major producer worldwide (Britannica, 2023). Iron and steel manufacturing are also very important – especially given that they are virtually monopolised by an Australian-based multi-national company, BHP Billiton (Britannica, 2023).

Given its geographical place in the world and its deep political and military ties to powerful Western countries such as the US, Australia has hardly seen any armed conflict on its own soil since the dawn of the 20th century (Britannica, 2023). Moreover, for just as long the country has been internally stable politically (Britannica, 2023). Although the looming threat of a war in Taiwan would almost certainly involve Australia in one way or another, thus bringing armed conflict pretty close to its doorstep, this would most likely remain a localised conflict and not endanger Australia's own sovereignty – albeit its hydrogen shipments to the rest of the world would very likely come under threat in such an event (Hurst, 2023; Needham, 2023). As for internal politics, Australia's energy policies remain a heated topic of debate in a country which produces a lot of fossil fuels and yet has set itself ambitious decarbonisation targets (Green, 2022). For example, the government rejected the development of the Asian Renewable Energy Hub project in June 2021 on environmental grounds (Smyth, 2021). This is understandable in a country in which 85% of the population lives in coastal areas, where infrastructure – including that which will be used in the green hydrogen value chain – is vulnerable to the recurring extreme weather events which have been taking place in recent years as well as sea level rise over time (IEA, 2018).

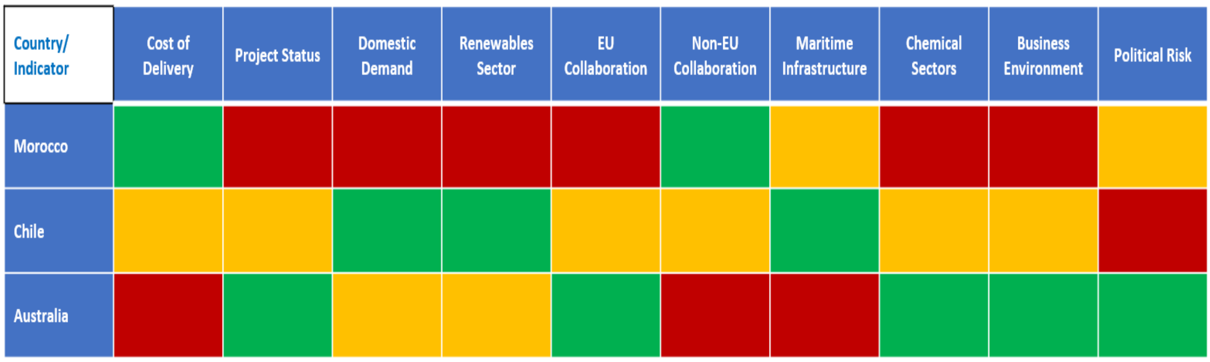
Comparison

In terms of GDP and GDP per capita, Australia has the largest economy and Morocco has the smallest of the three host countries. Moreover, Australia and Chile look to have the most deregulated industries while Morocco continues to retain a high degree of government involvement and market entry barriers. Nevertheless, it's Chile which seems to have the least developed manufacturing sector. In addition, Chile seems to be the most bureaucratic of the three while Australia looks to be the easiest to do business in. Regarding corruption, Morocco is perceived to have the most of it while Australia is perceived to have the least. In conclusion, Australia ranks the highest on the Business Environment indicator and Morocco ranks the lowest. Regarding the Political Risk indicator, the virtual absence of both armed conflict and political instability for more than a century inside Australia makes it rank the highest. As for Morocco and Chile, the former is the one with higher geopolitical risk while the latter has the higher risk of rising domestic turmoil and political uncertainty. While Morocco's regional tensions still show little sign of significant escalation in the near future, Chile's internal turmoil has already had a profound impact on the country. For these reasons, Chile is ranked the lowest on this indicator.

2.10 Comparison Roll-up

Taking the rankings of all ten indicators discussed above and rolling them up together yields the matrix shown in Figure 6. While only three countries have been compared in this paper, and a diversified investment portfolio would most likely include many more countries, the selection evaluated here makes for a good example of how green hydrogen host country risks can be managed effectively through diversification. The analysis shows that these three host countries complement each other's strengths and weaknesses in a manner which is well balanced.

Figure 6: Country rankings per indicator



Note: Green is for highest rank, yellow is for middle rank, and red is for lowest rank. This is according to the Author's own assessment.

3. Financing Hydrogen Projects

Given the scale, longevity, and fixed nature of hydrogen projects, many of them will most likely be financed through the 'project finance' framework[13]. Moreover, hydrogen projects in themselves are unlikely to be economic on a stand-alone basis and would thus rely on incentives to take off (Craen, 2023).

Historically, 'project finance' has been used to fund the development of large-scale infrastructure projects in emerging economies and has been characterised by a high proportion of debt in its financing; more than 60% (Eiteman, Stonehill, & Moffett, 2020). On a global level, according to IRENA, project finance made up most funding for renewable energy projects during 2013-2016 (59-67%) (IRENA, 2023). During 2017-2020 however, balance sheet financing has taken the lead instead (54-68%), with ever increasing proportions of corporate debt, while project-level equity saw a decrease in its share of the annual totals compared to the prior years (IRENA, 2023). Thus, the IEA predicts that off-balance-sheet (project) financing of clean energy projects in EMDEs would only constitute 30-35% of the total according to the Agency's climate-driven scenarios (IEA, 2021). The contribution of off-balance-sheet financing to green hydrogen projects would be even lower, at around 14% (IEA, 2021).

Offshore wind projects provide a useful precedent to green hydrogen projects around the world, and thus it is likely that initial project financing for the latter will be highly leveraged, with debt making up 60-65% of total investment, and terms will be limited to around 15-16 years to begin with before increased confidence results in longer loan terms and even higher proportions of debt – 70-80% of total investment (Craen, 2023). Historically, leverage (the relative level of debt in total financing) for greenfield offshore wind power projects has increased from around 60% in 2006-2007 to around 80% during the 2010s, a level similar to that seen historically in thermal power projects (PFI, 2021). According to IRENA, the proportion of debt in financing renewable energy projects around the world has increased from around 23% in 2013 to around 57% in 2020 after peaking in 2017 at around 61% (IRENA, 2023). This resulted largely from the introduction of significant amounts of corporate balance sheet debt, starting in 2015 (IRENA, 2023). Interestingly, while private investors contributed around double the amount of funds provided by public investors during 2013-2020, with corporations providing around $1.13 trillion in total, debt made up 75% of overall public investors' financing as opposed to the 44% which made up the overall financing from private investors (IRENA, 2023). Moreover, corporations provided 58-77% of annual private investment in renewable energy projects worldwide between 2013 and 2018, before their leading position was taken over by commercial financial institutions, who contributed 43% of financing during 2019-2020 (IRENA, 2023).

Also according to IRENA, the cumulative number of agreements announced (including supply commitments, feasibility studies, and memoranda of co-operation) for hydrogen trade around the world has increased from only three in January 2018 to 90 in February 2022, with 43 of these being between private entities (on both the buying end and the selling end), 24 between public entities, and the remaining 23 between private and public entities (IRENA, 2022).

Long-term bilateral contracts with either clear pricing mechanisms or fixed prices are currently underpinning the development of the green hydrogen sector because the developers and the governments supporting them are assuming high risk given the lack of a hydrogen market (and thus price) as well as the capital-intensive nature of such projects (IEA, 2022; IRENA, 2022). A common provision, which gives added income certainty to sellers and helps developers reach project FID, is the

---

[13] This section draws on interviews conducted with industry professionals who are knowledgeable about each of the countries, and examples from publications and news articles which support the opinions of the interviewees. The interviewees are:

- Othmane Anice, a Lawyer who is based in Morocco and has extensive experience working on infrastructure projects in the kingdom (Anice, 2023).
- Stephen Craen, an Energy Transition and Hydrogen Finance Specialist who is based in New Zealand and is a Visiting Research Fellow at the Oxford Institute for Energy Studies with extensive knowledge of the Australian energy sector (Craen, 2023).
- Helmut Kantner, General Manager at AustriaEnergy who is based in Austria and is involved in Chilean green hydrogen projects (Kantner, 2023).
- Maria Ignacia Varela Barros, Head of Corporate and Project Finance at HIF Global who is based in Chile and is involved in both Chilean and Australian green hydrogen projects (Barros, 2024).

‘take-or-pay‘ framework (IEA, 2022); in which the buyer must either off-take the volumes agreed or pay the seller in lieu (Eiteman, Stonehill, & Moffett, 2020). Once there is enough confidence in the green hydrogen sector and market mechanisms have become more developed, future growth of this sector could be underpinned by more flexible arrangements, whereby buyers could be exempt from destination clauses for example and thus able to adapt to changing supply needs or market prices (IEA, 2022).

Another key consideration will be the allocation of risks. For example, lenders to Liquified Natural Gas (LNG) projects have often received completion guarantees from project sponsors, whereas this has often not been the case for offshore wind, such as the Dogger Bank offshore wind project in the UK in which the lender group accepted the pre-completion risk (Craen, 2023).

3.1 Morocco

Historically, more than half of public infrastructure investment in Morocco has come from state-owned enterprises, who have sourced a sizable amount of their funds from state-guaranteed long-term foreign currency concessional loans and state-guaranteed domestic loans, altogether amounting to 15% of the country’s GDP as of end-2017 (IFC, 2019). The state’s strategy however is for green hydrogen production to be led by the private sector, same as for the dedicated (off-grid) renewable power generation necessary for it (Anice, 2023). Indeed, all projects announced so far are intended to have their own dedicated power generation (IEA, 2023). Moreover, the trade in green hydrogen between producers in Morocco and buyers abroad is also predicated to be conducted by the private sector, with off-take agreements having durations of 15-20 years (Anice, 2023). That said, the most important driver for the green hydrogen business to take off anywhere in the world will be the availability of a large-scale buyer (Anice, 2023). Box 1 explains how this is currently taking shape in Morocco.

Green hydrogen investment in Morocco will likely assume the project finance model and be comprised of much off-balance-sheet financing for future projects (Anice, 2023). This is largely thanks to Morocco’s relatively low country risk – for an EMDE country – and long experience with project finance, but also due to its exceptional potential for green hydrogen production resulting from its excellent wind and solar resources (Anice, 2023). Morocco has a long history of project finance transactions, the first of these being 1997’s Jorf Lasfar 600-MW coal-fired power plant (IFC, 2019). Since then, more than $12 billion of project finance investment, mostly since 2012, has been secured by private investors to fund more than 20 large-scale greenfield infrastructure projects (IFC, 2019). The kingdom’s local commercial banks have great experience in project finance, for both local and West African projects, whereby they formed syndicates which comprised other local banks as well as international ones (Anice, 2023). In fact, 5% of the total credit extended by local Moroccan banks in 2019 went towards the energy and water sectors, and local public-private equity funds have been established during the previous decade to target industries such as agriculture and green energy (ADB, EBRD & EIB, 2021).

International banks which would likely provide debt include JBIC, like in the example mentioned in Box 2. As for European banks, the European Investment Bank (EIB) has mobilised a total of €2.5 billion ($2.75 billion) during 2017-2022 in Morocco’s economy, with 20% of that going towards renewable energy (EIB, 2023). Moreover, the European Bank for Reconstruction and Development (EBRD) has agreed to provide senior debt worth 44 million euros ($48 million) to the Koudia Al Badia Energy company, which operates a wind farm in Morocco and is owned by the country’s Agency for Sustainable Energy (MASEN), along with other international and Moroccan banks (Zgheib, 2022). In addition, the EBRD has provided a total of 200 million euros ($220 million) in debt to Morocco’s Société Nador West Med (NWM) to support the development of the country’s Nador West Med (NWM) port, and has extended a further package worth 1 million euros ($1.1 million) to support NWM in becoming the operator of the port and assessing its role in the hydrogen value chain (Zgheib, 2022). Another example is Morocco’s Noor Ouarzazate solar PV project, to which Germany’s KfW and France’s Agence Française de Développement have provided a large part of the 2 billion euros ($2.2 billion) of investment needed; alongside the WB, the German government, and the EU; the latter in the form of subsidies (Ristau, 2021; WB, 2023).

Box 1: Morocco's OCP's investment in green ammonia production facilities

OCP, a state-owned enterprise, currently imports around 2 MT of ammonia from abroad to produce fertilisers, a key export of the kingdom's economy (MEM, 2021; Anice, 2023). Buying locally produced ammonia at a fixed price (less than $700/tonne) would enable OCP to hedge its future ammonia costs given the market volatility in recent years, especially for natural gas markets, which has resulted in large fluctuations ($300-1,200/tonne since 2020) in the price of ammonia (Martin, 2023). Thus, locally sourced ammonia would effectively bring down OCP's fertiliser production costs through de-risking its ammonia supply chain while also helping to decarbonise its business (MEM, 2021; OCP, 2022). This is why OCP has recently announced an investment, all equity-funded (Anice, 2023), of $7 billion in a green ammonia production project in Morocco (IEA, 2023). OCP's investment is in the entire production process, including power generation (Anice, 2023). Thus, one of OCP's aims is to achieve a levelized cost of renewable electricity which is lower than the price which it has historically paid to Nareva Holding (Anice, 2023). Once the green ammonia supply chain has been established, it is possible that it would serve as a catalyst for the creation of a Moroccan ecosystem, from which future projects aimed at exporting to EU off-takers would eventually emerge (Anice, 2023).This project serves as an example of the IEA's aforementioned prediction for project financing to underpin only a minority of green hydrogen projects in EMDE countries. It also seems to follow a similar pattern to the aforementioned historical one for most renewable energy projects worldwide, whereby the bulk of financing initially came in the form of equity from corporations before debt from commercial financial institutions took a larger share later on. According to IRENA, 65% of all North African renewable energy investment in 2020 came from private actors after having increased from 11% in 2013 (IRENA, 2023). While the expectation is that the bulk of financing in Morocco's green hydrogen sector will be private (Anice, 2023), state-owned OCP's project suggests a similar pattern to that for North African projects during 2013-2020, with perhaps a public-private model becoming established later on in the future (MEM, 2021).

Within Morocco's project finance framework, other investors including banks; both commercial and multi-lateral, Export Credit Agencies (ECAs), and local bonds would also contribute funds (Anice, 2023). In fact, during the period between 1999 and 2019 ECAs played an important role in adding valuable debt capacity and some risk mitigation to clean energy projects in the Middle East and North Africa either by lending in parallel with uncovered bank debt or guaranteeing the bank debt (Baker & Benoit, 2022). Usually, ECAs have a high tolerance for political risk and a low tolerance for credit risk (Craen, 2023). Box 2 provides two examples of project financing structures which have underpinned Moroccan infrastructure projects.

Box 2: Project financing examples in Morocco

An example of an investment structure can be found in the Agadir desalination plant project, which received total funding of $457 million in the form of debt (about 40% of total) from a commercial bank, BMCE (Bank of Africa), and in the form of equity (the remainder) (Anice, 2023). The equity funding came partly from the state (about 45% of total) and partly from Spain's Abengoa (about 15% of total) (Anice, 2023). Abengoa formed a consortium with Morocco's state-owned financial institution, CDG, to operate the plant (GIHub, 2019). The equity holders also established the Special Purpose Vehicle (SPV) through which funding was channelled to that project, with SPV ownership split 51/49 between Abengoa and the Moroccan state, respectively (Anice, 2023). Another example is the Safi coal-fired power plant, the debt for which was provided by Japan Bank for International Cooperation (JBIC) (PT, 2014). The equity for this project was split roughly equally between Japan's Mitsui, France's GDF Suez, and Morocco's Nareva (Mitsui, 2014).

As for the project sponsors, these will likely be the developers of green hydrogen production infrastructure, and in the case of Morocco they are likely to be international renewable energy companies, such as the aforementioned Abengoa (Anice, 2023). So far, the only major oil & gas company to publicly show interest in Morocco's green hydrogen potential has been TotalEnergies, which took over the renewables company, Total Eren, in 2023 (Kar-Gupta, 2023) after the latter had announced plans to invest 9.4 billion euros ($10.3 billion) in Morocco's sector, including ammonia production facilities (REN21, 2022; Biogradlija, 2022). Other equity investors will likely be private equity firms and sovereign wealth funds, such as the Mohammed VI fund (Anice, 2023). Corporate (senior) debt on the other hand is more likely to come from commercial banks than from energy companies, with further debt funding likely coming from multi-lateral banks and ECAs (Anice, 2023).

Given the risks associated with green hydrogen technology coupled with Morocco's 'non-investment-grade' credit ratings (Countryeconomy.com, 2024), such projects would be expected to require a tailored project finance framework, the WACC of which would be higher than that which a major corporation would be able to secure for projects which are included in its balance sheet (Anice, 2023; Craen, 2023). Moreover, the WACC for green hydrogen projects around the world will likely be higher initially than that for renewable power projects because lenders are likely to demand a higher cost of debt until they become more comfortable with the technology the way they eventually did with renewable power (Barros, 2024). On the other hand, green hydrogen projects of which the off-taker is based in an 'investment-grade' country and of which the revenues are in hard currency would likely attract capital at lower costs, if correctly structured, than renewable power projects of which the (domestic) off-taker is based in a non-investment-grade country and of which the revenues are in local (EMDE) currency (Craen, 2023). This is especially valid for projects hosted in Morocco and aimed for exports to the EU. Again, the current global macroeconomic landscape has resulted in higher cost of capital for projects worldwide since the turn of the 2020s (IEA, 2023).

Being an EMDE country which is smaller in terms of GDP per capita than Brazil, Mexico, South Africa and Indonesia (but larger than India) (WPR, 2023), yet having credit ratings which are comparable to those countries' (higher than those of Brazil and South Africa) (Countryeconomy.com, 2024), it is reasonable to expect Morocco's WACC to be close to that which is achievable in those countries – although there are also project-specific factors which would influence this figure. According to the IEA, 100 MW solar PV projects financed in India, Brazil, Mexico, South Africa and Indonesia in 2019, 2021, and 2022 have achieved WACCs (nominal post tax) ranging from 5.0% to 18.3% (IEA, 2023). Indeed, the median for projects in Brazil and South Africa has been higher than that in the other three countries (apart from South Africa's being equal to Mexico's in 2022), and has ranged from 10.3% to 13.0% (IEA, 2023). This appears to be in line with the lower credit ratings of Brazil and South Africa compared to the other three countries. In Morocco, similar projects have achieved cost of debt within the range of 6.5-7.5% (Anice, 2023). This is about double that which has been realised for similar projects in Spain (Anice, 2023). This has resulted in a significantly lower levelized cost of electricity in Spain, an outcome which is likely to repeat itself for the two countries' green hydrogen projects (Anice, 2023), especially if CAPEX costs turn out to be higher than expected (IRENA, 2022). It comes as no surprise, for example, that Morocco's current renewable power generation capacity sits at around 5% that of Spain, which is about 70 GW (IRENA, 2023).

The Moroccan state has historically only provided sovereign guarantees in relation to what it deemed to be critical infrastructure and is therefore unlikely to cover green hydrogen project completion or debt servicing risks (Anice, 2023). The former risk would likely be borne by the project sponsor(s) along with the associated Engineering, Procurement, and Construction (EPC) company(ies) to begin with, before the sector becomes more mature and lenders become comfortable guaranteeing this risk themselves (Anice, 2023; Craen, 2023). The latter risk, that of lenders not receiving debt servicing payments for whatever reason, would likely be underwritten by insurance which is arranged by the project sponsor(s) (Anice, 2023), possibly through a company like Munich RE given its precedent of involvement in the kingdom via Nareva (Mohanty, 2010).

3.2 Chile

Export of green hydrogen from Chile is likely to be via the ammonia pathway, with most projects which are geared for export being designed for that, although methanol and e-fuels offer other possibilities (BNamericas, 2023). For example, US-headquartered HIF Global is sponsoring the Haru Oni and Cabo Negro projects (HIF Global, 2023), the former of which has already secured off-take agreements for its e-gasoline from Germany's Porsche (also a partner in the project) and the Ministry of Transport for Baden-Württemberg in Germany (Raveau & Díaz, 2022; Collins, 2023). Nevertheless, the IEA predicts that traded amounts of e-fuels will be much lower than those of green ammonia, both from Chile and worldwide (IEA, 2023). Moreover, global prices of ammonia have fluctuated significantly during the past three years, between $300 and $1,300 per tonne in the US and Europe (Business Analytiq, 2023), mainly as a result of fluctuations in global natural gas prices (Kantner, 2023). This has made the case for green ammonia more compelling for AustriaEnergy for example (Kantner, 2023). On the other hand, the greater clarity of EU regulations covering e-fuels compared to those for green ammonia has driven HIF Global to prioritise the production of the former for export to EU buyers (Barros, 2024). That said, EU demand for e-gasoline is unlikely to be as high as that for Sustainable Aviation Fuels (SAF) or e-methanol given the drive to expand the use of electric vehicles in the bloc (Barros, 2024).

The financing of green hydrogen projects in Chile will likely be in the form of project finance, mainly due to the technology risks, and major developers are unlikely to fund such projects from their own balance sheets at this stage (Kantner, 2023; Barros, 2024). The aforementioned Cabo Negro project for example plans to receive 70% of its funds through project financing and the rest from debt and equity markets (BNamericas, 2023). According to Kantner, commercial banks offered debt interest rates as low as 4% for a long time in Chile until the geopolitical events of the past couple of years took place and resulted in worldwide inflation and interest rate hikes (Kantner, 2023).

In 2022, IRENA predicted that Chilean green hydrogen projects would benefit from a relatively low cost of capital in the near term, at 5.2%, with this advantage eroding if other countries were to reduce theirs in the long term (IRENA, 2022). Nevertheless, the combination of relatively low WACC and rich renewable resources makes Chile resilient to the risk of high future renewable power generation costs worldwide, according to IRENA (IRENA, 2022). Given that Chile's credit ratings are at investment ('upper medium') grade and are even higher than those of some EU Member States (Countryeconomy.com, 2024), it is reasonable to expect a cost of debt for Chilean green hydrogen projects which is pretty close to that of EU-hosted projects. On the other hand, when IRENA made its prediction, the Secured Overnight Financing Rate (SOFR)[14], based on which the cost of debt would be calculated (Barros, 2024; CFI Team, 2024), was roughly 10 times lower than its current levels – sitting at around 5.3% since August 2023 (NewYorkFed, 2024). The cost of equity will likely be 9.0-9.5% for 'preferred' equity holders and 13.0-14.0% for 'common' equity holders (Barros, 2024). While preferred equity holders will get priority over their common counterparts when receiving project net cash flows (top priority going to lenders of course), most preferred stocks are redeemable by the issuer at a predetermined price or date (Barros, 2024; Drinkard, 2023). In some cases, preferred stocks have the option to be converted into common stocks at a predetermined date or milestone (Barros, 2024; Drinkard, 2023).

Regarding the relative amounts of debt and equity, funding of renewable energy projects has historically been mostly (60-85%) from debt, a range which is likely to be similar for green hydrogen projects (Kantner, 2023; Barros, 2024). That said, it is expected for green hydrogen project financing to constitute 60-70% debt to begin with before lenders can gain confidence in this technology and agree to provide up to 85% in debt financing at later stages or for future projects (Kantner, 2023; Barros, 2024). Indeed, lenders are currently being conservative when providing funds to green hydrogen projects, and are thus demanding Debt Service Coverage Ratios (DSCRs) of 1.4-1.5 for Chilean projects – meaning that net operating income must be at least one-and-a-half times total debt obligations (Barros, 2024). This is higher than the investment-grade DSCR threshold for solar PV (1.2) and for wind (1.3)[15] projects seen around the world during the 2010s, according to Fitch Ratings (Fitch Ratings, 2020). It is important to clarify here that this comparison is predicated on all projects being underpinned by long-term fixed-price off-take agreements of the same duration. For example, European lenders to green hydrogen projects currently seem unwilling to fix the off-take price for more than 10-15 years because they are betting on there being a (variable and potentially more lucrative) market price for hydrogen beyond that timeframe (Craen, 2023).

[14] This is not directly comparable to the WACC (Craen, 2023) as the latter is calculated using the after-tax cost of debt (Hawawini & Viallet, 2019).
[15] Wind power projects tend to demand slightly higher DSCRs than their solar counterparts, all else equal, due to the former's higher costs of maintenance over the lifetime of a project (Craen, 2023).

The sponsors and equity holders are likely to be international private companies (Kantner, 2023). As mentioned above, Denmark's private equity firm, CIP, is already a partner in the HNH project as part of its Energy Transition Fund. In addition, HIF Global has secured a total of $260 million in equity investment into its green hydrogen projects, including those in Chile, from investors such as Germany's Porsche AG and the US-headquartered institutional investor, EIG (Aleina, 2022). Much of the investment will likely come from US companies, including banks, since US companies are deeply involved in Chile's energy sector (Kantner, 2023). In the future, these could possibly include the aforementioned HIF Global as well as AES, which is the second largest power producer in the Latin American country (ITA, 2023).

While it would be most cost-effective to secure all of the debt from commercial banks, Chilean projects which have a capital cost of more than $2 billion are unlikely to receive all of the debt which they need from banks only, hence the need for additional funding from ECAs and/or development banks (Barros, 2024). ECAs would typically either require that specific equipment manufactured in their respective countries is used in a project, or that the exported product's end-destination is that of their respective countries (Kantner, 2023; Barros, 2024). US-based suppliers have provided 5-7% of all electrical equipment imported by Chile in recent years (ITA, 2023), meaning that the ECA of the world's largest economy could also get involved in Chile's green hydrogen investments. Meanwhile, European ECAs will also likely provide funding if equipment for the projects is sourced from European manufacturers (Kantner, 2023; Barros, 2024). In the case of HIF Global's projects for example, electrolysis and product synthesis equipment is coming from EU manufacturers (Barros, 2024). Chilean commercial banks on the other hand have indicated that they would finance such projects only after off-take agreements have been signed, providing the public-private partnership model for financing Chile's highway construction projects as an example (BNamericas, 2023).

The government in Chile will likely not be an investor in green hydrogen projects (Kantner, 2023; Barros, 2024). That said, the Chilean government has been providing significant support to developers of such projects, such as Corfo's $50 million award mentioned in Section 2.2. Moreover, the state's oil & gas company, ENAP, has agreed to collaborate with HIF Global on their Cabo Negro project by repurposing their nearby oil & gas terminal and associated infrastructure in Magallanes for the purpose of exporting e-fuels from that project (BNAmericas, 2023). ENAP has also signed an MoU with HIF Global to purchase renewable electricity from the US company (Barros, 2024).

Since Chile became a member of the OECD, the role of development banks in the country has steadily diminished as the country is no longer deemed to be in need of their funding (Kantner, 2023). Nevertheless, given the novelty of green hydrogen technology, these banks could make an exception for these projects (Kantner, 2023). As mentioned in Section 2.6 above, the WB seems to have already made such an exception in the case of Chile. Moreover, as mentioned in Section 2.5 above the EU, EIB, and Germany's KfW have already agreed to provide funds to help develop Chile's green hydrogen production sector. The country will nonetheless need to continue to find innovative ways to access climate-related funds to help grow its green energy sector (IFC, 2022). Moreover, regarding the possibility to refinance projects during the expected lifespan of their off-take agreements (15-20 years), thereby seeking more favourable terms once confidence in a project has been increased, this is unlikely to happen (Kantner, 2023) given the scale of green hydrogen projects relative to Chile's banks' liquidity and the limitations typically set by ECAs and development banks (Barros, 2024). These limitations typically include the requirement for a debt agreement to have a tenor which matches the duration of the off-take agreement (Barros, 2024). Meanwhile, the Chilean bonds which are mentioned in Section 2.4 above are too small to make a significant contribution to the financing of the country's green hydrogen projects (Kantner, 2023).

In many cases all stages of the production process will likely be financed as one single project, from renewable electricity generation to ammonia production (Kantner, 2023; Barros, 2024). That said, the creation of separate SPVs for upstream and downstream processes with different financing structures and terms, thereby minimising the WACC of the overall project, is also a possibility (Barros, 2024). For example, HIF Global's Haru Oni project has an SPV set up with Italy's Enel for the renewable electricity generation and hydrogen production (electrolysis) processes, and this is separate from the downstream processes for which the US company is the only sponsor (Barros, 2024). However, due to the remoteness of the Magallanes region where this project is located, it has not been possible to separate the project risks, or the financing structures, of the upstream and downstream processes from each other since failure of any stage would result in the others becoming stranded assets (Barros, 2024). Thus, the separation of financing structures would only be possible in a future scenario in which there is a local green hydrogen ecosystem which could offer options for any stage of a project to connect to facilities from other neighbouring projects in case failure were to occur in one or more of its other stages.

Generally, while lenders might take on some project risk, especially multi-lateral banks (BNamericas, 2023), the distribution of risk will not be even and most of it will fall onto the project sponsors (Kantner, 2023). While every project will have its own dedicated renewable power generation, the ones in the north and centre of the country will benefit from being able to connect to the grid, whereas the ones in the south of the country will not have that benefit (Kantner, 2023; Barros, 2024). So far, all projects which have received FID have their own dedicated power generation, apart from one which will also receive grid electricity, albeit most of these are very small (IEA, 2023). Moreover, the northern projects will be mostly powered by solar while the southern ones mostly by wind (BNamericas, 2023). In either case, curtailment risk is not a concern for such projects (Kantner, 2023). In the Magallanes region, lack of access to the national grid is compensated for by the high – 70% (Njovu, 2023) – capacity factor achieved by wind power generation (Barros, 2024).

3.3 Australia

Australia's green hydrogen projects will probably be exporting ammonia, however most of the amounts of this commodity are produced where they are consumed, while the amounts which are traded globally are currently low (Craen, 2023). This contributes to the volatility of the market price of ammonia, which creates a risk for off-take agreements (Craen, 2023). Moreover, as mentioned above, the greater clarity of EU regulations covering e-fuels compared to those for green ammonia has driven HIF Global to prioritise the production of the former for export to EU buyers (Barros, 2024). In addition, much of Australia's exports are destined for Japanese buyers who have high demand for e-gasoline, which is intended to help decarbonise the East Asian country's transportation sector (Barros, 2024). This is evidenced by the announcement made by Japan's Ministry of Economy, Trade and Industry (METI) in 2023 of the country's revised target of commercializing e-fuels over 2030-2034, ahead of the previously announced target of 2040 (Kumagai, 2023). This comes in parallel with Japan's efforts to coordinate the establishment of a joint supply network for green ammonia with South Korea, through which the two East Asian countries will negotiate prices and volumes and facilitate raising funds for projects overseas (Sugiyama & Golubkova, 2023). Another highly promising way to utilise Australian green hydrogen could be in the domestic production of green HBI or green steel, which is further discussed in Box 3.

The debt portion of total funding for substantially contracted[16] renewable projects in Australia has generally gone up over time, sitting at around 70-80% nowadays, and similar proportions can be expected for green hydrogen projects – assuming long-term and fixed-price off-take (Craen, 2023). On the other hand, it is likely that debt levels would be lower initially, at 60-70%, before increasing gradually towards 80-85% at a later stage (Barros, 2024). A precedent to this can be found in an LNG project developed in Darwin in Western Australia, Ichthys, for which the proportion of debt relative to total funding when it was first financed was only 59%[17], with some of the debt coming from ECAs and some of it from commercial banks – and some of the latter being covered by ECAs (Pooler, 2013). On the other hand, if domestically produced HBI or steel were to be a pathway of choice for Australia's green hydrogen production, then an example of how this could play out is provided in Box 3. As mentioned above, lenders are currently demanding relatively high DSCRs for green hydrogen projects, with Australian ones also being set at 1.4-1.5 (Barros, 2024) – again, as mentioned above, this notion is predicated on projects being underpinned by long-term fixed-price off-take agreements.

The cost of capital of a green hydrogen project will likely be higher to begin with since, given the relative novelty of the technology and in the absence of completion guarantees from the sponsors, lenders

[16] Projects with a larger merchant (market-based and variable pricing) component have seen lower debt proportions, at around 50-60% (Craen, 2023).

[17] This project was fully exposed to variable LNG market price risk, which is linked to the oil price risk (Craen, 2023).

would want to have some equity from the onset (Craen, 2023). This could be subsequently divested as investors get more comfortable with the project's performance (Craen, 2023). Given that Australia's credit ratings are at investment ('prime') grade (Countryeconomy.com, 2024), it is reasonable to expect the country's cost of debt to be lower than it would be for the vast majority of other countries around the world. In 2022, IRENA predicted that Australian green hydrogen projects were expected to benefit from a relatively low cost of capital in the near term, 3.7-4.6%, with this advantage eroding if other countries were to reduce theirs in the long term (IRENA, 2022). Nevertheless, the combination of relatively low WACC and rich renewable resources would make Australia resilient to the risk of high future renewable power generation costs worldwide, according to IRENA (IRENA, 2022). On the other hand, as mentioned above, when IRENA made its prediction the SOFR, based on which the cost of debt would be calculated (Barros, 2024; CFI Team, 2024), was roughly 10 times lower than its current levels (since August 2023) (NewYorkFed, 2024). Moreover, as is the case for Chile, the cost of equity will likely be much higher at 9.0-9.5% for preferred equity holders and 13.0-14.0% for common equity holders (Barros, 2024).

Box 3: Green steel or HBI financing prospects in Australia

Green HBI and green steel are produced using green hydrogen that feeds the Direct Reduced Iron (DRI) process and green electricity that feeds the electric arc furnace process (for the latter) (AFRY, 2024). One advantage of using steel/HBI as a pathway for green hydrogen trade is that it would be much cheaper to transport steel/HBI as a finished product than it would be to transport ammonia, and then crack it, if the aim is to supply hydrogen as a feedstock for a steel/HBI production process in the importing country (Craen, 2023). Another advantage is that it would simplify the terms of trade – the steel/HBI manufacturer would have sole responsibility to sell the product to a buyer in order to generate the revenues which pay for the overall project (Craen, 2023). Fortescue looks to be a likely equity holder in such projects in Australia, since the company has announced that it would invest in a green iron pilot project in Christmas Creek, Western Australia, along with green hydrogen production facilities, and that it aims to hold a 25-50% stake in these projects (Burton & Akhand, 2023). Meanwhile, a study which has received government funding is currently being carried out by Australia's Calix Limited to design a potential demonstration-scale hydrogen DRI production plant in the country (ARENA, 2022). Sweden's H2 Green Steel project serves as a useful precedent for how financing might be structured for such projects. This project has attracted 4.2 billion euros ($4.6 billion) in debt and 2.1 billion euros ($2.3 billion) in equity (H2 Green Steel, 2024), so the debt makes up slightly more than 65% of total funding.

International private equity firms, such as Denmark's CIP with its aforementioned partnership on the Murchison project, will likely get involved in Australia's projects (Barros, 2024). Indeed, smaller developers will likely team up with equity and debt investors from the start of a project, similar to Australia's Edify Energy who teamed up with Luxembourg's Generali Investments for their battery storage project at the Renewable Energy Zone of Victoria, Australia (Colthorpe, 2023). Equity investors have in fact been showing interest in co-investing alongside the major developers of Australia's green hydrogen projects, with Siemens equity reported to have already committed some funds for example (Macdonald-Smith & Eyers, 2022). In addition, HIF Global has secured a total of $260 million in equity investment into its green hydrogen projects, including the Australian Tasmania eFuels facility (HIF, 2023), from investors such as Germany's Porsche AG and the US-headquartered institutional investor, EIG (Aleina, 2022). On the other hand, major developers like Fortescue Future Industries and BP might decide to go all-in with their own (corporate) equity funding to begin with instead, thereby eliminating the red tape and interference which banks typically impose on their lendees, and then subsequently seek out loans from banks post project completion (Craen, 2023).

Lenders in Australia – mostly commercial banks – usually have a large appetite for investing in renewable energy projects (Macdonald-Smith & Eyers, 2022), and project finance is the framework which will likely dominate investment in green hydrogen projects (Craen, 2023; Barros, 2024) like it has done for offshore wind for example, with about 80% of such projects around the world having been project-financed (Craen, 2023). European, US, and especially Japanese commercial banks have a strong presence in Australia (Barros, 2024). For example lenders DNB, Commonwealth Bank, and BNP Paribas provided the long-term syndicated debt facility for Edify Energy's battery storage project mentioned above (Colthorpe, 2023). Indeed, given their high liquidity, Australia's commercial banks could potentially provide all the necessary debt for green hydrogen projects in the country without the need for other sources of debt (Barros, 2024). Banks in Australia have in fact been showing great interest in investing in the country's green hydrogen projects thanks to their high tolerance to technology risks (Macdonald-Smith & Eyers, 2022).

In the case of Australia, given the country's highly liberalised economy, the government is unlikely to have any equity in the green hydrogen projects which the country will host (Craen, 2023; Barros, 2024). Instead, its support has been and will be mostly in the form of policies which include tax breaks and selective subsidies (Craen, 2023). Given the relative strength of Australia's economy, the government will be able to provide more support to the country's green hydrogen projects than the Chilean government can (Barros, 2024). Indeed, the Australian government has been providing significant support to green hydrogen project developers (IEA, 2023). For example, it has approved grants to multiple projects, including $47.5 million for the development of an electrolyser powered by solar PV generation in Karratha, Western Australia (ARENA, 2022), $69.2 million for developing the Central Queensland Hydrogen Hub in Gladstone (DCEEW, 2023), and $34 million to develop the wind-powered renewable hydrogen plant in Wodonga, Victoria state (McKeith, 2023). Moreover, Australia's CEFC; the world's largest government-owned green bank (IEA, 2023), aims to invest up to $300 million to support the growth of the country's hydrogen industry through either debt or equity, especially in projects for which the state or territory government is also providing financial support (CEFC, 2023). Altogether, the Australian government has put aside $500 million for its Regional Hydrogen Hubs program to develop its national green hydrogen sector (DCCEEW, 2023).

As for green hydrogen project sponsors, these might be relatively diverse given that renewable power developers are unlikely to take on the combination of electrolyser and ammonia plant project risks (Craen, 2023). Oil & gas majors on the other hand have experience in developing and operating Haber-Bosch ammonia facilities, however they do not have experience with steel-making facilities, for example (Craen, 2023). Fortescue looks to be a likely equity holder in such projects in Australia, as mentioned in Box 3. Thus, it is possible to envisage a commercial agreement being drawn up between the sponsors of the various parts of the overall project, and for the agreement to include a framework where the sponsors of the higher-performing part of the project receive a higher share of what remains of its revenues after paying for its operational and financial costs (Craen, 2023). Moreover, the creation of separate SPVs for upstream and downstream processes, with different financing structures and terms so as to minimise the overall project's WACC, is another possibility (Barros, 2024). In the case of HIF Global's project, this has been done indirectly by the company receiving the renewable electricity which the project requires via a PPA which it has with the owner of a nearby power generation facility instead of developing one itself (Barros, 2024). Nonetheless, as mentioned above, the separation of financing structures in a deliberate manner would only be possible in a future scenario in which there is a local green hydrogen ecosystem which could offer options for any stage of a project to connect to facilities from other neighbouring projects in case failure were to occur in one or more of its other stages.

As mentioned above, the Ichthys project also attracted funding and debt cover from international ECAs, and this included several Japanese ones (Inpex, 2012; Pooler, 2013). As was the case with this project, an ECA would likely provide funding for a green hydrogen project if the equipment which is used in the project is supplied by manufacturers who are based in the home country of that ECA (Craen, 2023; Barros, 2024). An example of this is the Australian-South Korean consortium mentioned above in Section 2.6. The equipment for this project is expected to come from German and US suppliers (Parkes, 2023), meaning that the ECAs of these countries could potentially be involved. On the other hand, since the off-take will be in South Korea, the ECAs of the East Asian country might also be involved. In fact, the consortium for this project includes South Korea's Samsung and the country's state-owned utility, Korean Midland Power Co (Parkes, 2023). Generally though, since Australia is a developed economy, ECAs will likely play a lesser role in funding its green hydrogen projects when compared to projects in EMDEs (Craen, 2023; Barros, 2024). Nevertheless, the involvement of a foreign ECA in an Australian project would in turn encourage the banks of that country to get involved as well (Craen, 2023). Indeed, some ECAs have already shown interest in Australia's green hydrogen projects, and are keen to support the involved banks' financial products and to provide additional credit cover (Macdonald-Smith & Eyers, 2022).

During the construction phase of a green hydrogen project, bond markets are unlikely to get involved, however long-term bonds with low yields may very well be issued post construction (Craen, 2023). That said, it is not possible to refinance a bond, which limits their attractiveness in this case (Craen, 2023). In Australia especially, refinancing of major infrastructure projects during their lifetime is quite common (Craen, 2023; Barros, 2024). This will likely be the case for green hydrogen projects during the expected lifespan of their off-take agreements of 15-20 years (Barros, 2024). Thus, priority is often given to the flexibility to refinance a project over the long-term predictability of financing cost afforded by project bonds (Craen, 2023).

The green hydrogen trade deals which Australian producers will strike will very likely be private-private agreements (Craen, 2023). Any government support would be for purposes other than revenue generation or hydrogen supply, such as local job creation and technological development (Craen, 2023). For example, the government of South Australia announced in October 2023 the potential partners in the consortium which will see the construction of its landmark green hydrogen facilities, and this forms part of the Hydrogen Jobs Plan, which the state is funding with $593 million (Parkinson, 2023). On the other hand, EU Member State governments might get more involved in the future, such as the German government with its H2 Global Initiative (Craen, 2023) – especially given the strong bilateral collaboration between Germany and Australia on green hydrogen mentioned above in Section 2.5. For example, Germany's E.ON has an MoU with Australia's Fortescue Future Industries for the latter to supply up to 5 MT of green hydrogen per year to the former by 2030 (IEA, 2022).

3.4 Comparison Roll-up

In short, there is a wide variety of possibilities which are yet to be realised in each of Morocco, Chile and Australia given the early stages of development of the green hydrogen sector. In all three countries, the expectation is for highly leveraged project finance frameworks to be adopted, for commercial banks to provide significant funding, and for investment and trade to be carried out for the most part by the private sector. In addition, off-take agreements in all three countries are likely to have long durations (15-20 years) and fixed prices given the current lack of a hydrogen market. Another thing is the absence of foreign currency risk from export projects in all three host countries due to the off-take agreements being performed in hard currency (with EU buyers for example). As for the key differences between the three host countries' likely financing structures, Figure 7 provides a qualitative illustration of these at a high level.[18]

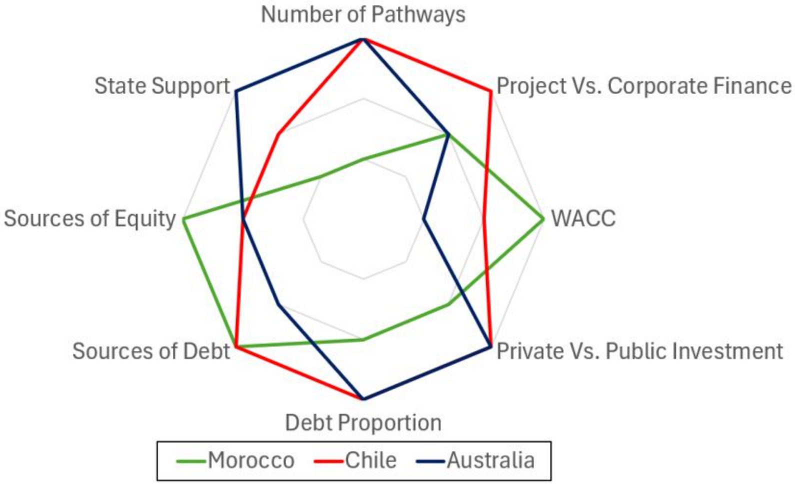
Regarding the number of pathways, green ammonia production currently looks to be the one which is taking off in Morocco – especially for domestic fertiliser production. Chile on the other hand looks very likely to become a key green ammonia exporter on the world stage by 2030 and is also on track to become an exporter of e-fuels as well as other products. Australia is similar to Chile that way but is also pursuing the use of green hydrogen to decarbonise its domestic steel and/or HBI production sectors. Regarding financing frameworks, Chile is likely to have the most projects which are project-financed since it does not seem to have a corporate finance (on-balance-sheet) precedent like that of OCP's project (all equity) in Morocco or a company like Fortescue (could possibly go all-equity) in Australia. As for the WACC, while this is expected to decrease over time for green hydrogen projects worldwide as confidence in the technology increases, it is likely that Moroccan projects will incur the highest WACC of the three host countries while Australian projects incur the lowest.

While investment in Chile and Australia is expected to be fully private, public entities and those linked to the monarchy in Morocco are likely to have a stake in the country's projects. Moreover, it looks like projects in Chile and Australia are likely to have a higher debt proportion (50-60%), during this decade at least, when compared to those in Morocco (0-40%). Much of the debt to Moroccan and Chilean projects is likely to come from commercial banks, ECAs, and development banks, whereas Australia is

[18] Note that the scores shown are not necessarily synonymous with 'better' or 'worse'.

unlikely to have access to the latter given its developed economy status.[19] As for sources of equity, while Morocco will likely have access to funds from private equity firms, energy companies (including project developers), and public entities (such as OCP), Chile and Australia are unlikely to have access to the latter given their more liberalised and privatised economies. Regarding direct state support, Australian projects seem to have received the most support, both from federal and regional governments, through a variety of schemes, whereas the Moroccan state seems to have provided the least direct support out of the three host countries.

Figure 7: Radar chart to illustrate the Author's view of the high-level differences between the three host countries regarding their likely green hydrogen production project financing structures



4. Summary of Findings and Conclusions

Based on ten indicators, the paper shows that Morocco, Chile, and Australia boast high-potential options for hydrogen exports to the EU, whether in combination or individually. The paper also shows that these three countries have complementary weaknesses and strengths.

Morocco has the advantage of geographic proximity to EU Member States and is very likely to have a lower LCH2 (shipped as green ammonia) compared to Chile and Australia by 2030 and by 2050. However, while Morocco has announced a national green hydrogen roadmap in 2021 as well as several production projects, none of the latter has reached FID at the time of writing. Meanwhile, Morocco's growth in demand for electricity has outpaced both its renewable and total power generation capacity growth, meaning that the North African country has been reliant on (mostly coal) imports for its power sector and has frequently been importing electricity via its interconnection with Spain in recent years. This also means that it will take a long time before grid electricity can be used to produce Morocco's green hydrogen. Thus, it is no surprise that none of the collaborations which have been announced between the kingdom and the EU has translated into a significant firm supply agreement as of yet.

While there is an expectation for the private sector to lead the development of Morocco's green hydrogen sector using project finance structures to supply private international off-takers, it is telling that most of the momentum is currently in state-owned OCP's $7 billion equity (on-balance-sheet) investment in green ammonia production facilities. This comes as no surprise given North African, EMDE, and global trends observed for renewable energy investment in the past. Nevertheless, Morocco has had a long history of project finance with significant private debt underpinning the development of its infrastructure projects.

[19] This is not to say that Australia would have less access to debt however, as banks over there actually have higher liquidity than in the other two host countries.

Given Chile's geographic location in South America, its LCH2 is likely to be higher than Morocco's due to the added transport (shipped as green ammonia) cost. This is partly compensated for however by Chile's low production cost estimates, which are on a par with those of Morocco and could possibly turn out to be lower. In addition, Chile has many more announced projects than Morocco does, including six which are currently operational and another three which have received FID. These include multiple pathways such as e-methanol and e-fuels. Moreover, Chile's domestic demand for green hydrogen is likely to be low. This in combination with the country's renewables-heavy (50% of overall power generation in 2022) power network, which unlike Morocco's is also self-sufficient, explains why Chile is considered by the Author to be the most export-oriented out of the three countries when it comes to green hydrogen production.

Chile is currently collaborating closely with the EU in developing its green hydrogen projects and is the only one of the three countries with announced firm off-take agreements with EU buyers. The country is also collaborating with non-EU partners. Moreover, Chile has the highest number of seaports along its coast relative to its land surface area out of the three host countries, and the distances to these ports from anywhere in the country are relatively short thanks to its unique geography. This is an important advantage because it means that the supply chains within Chile which are related to green hydrogen production and export are likely to have relatively low costs. In addition, three seaport upgrade projects have been announced in Chile so far. While Chile does not produce ammonia, it does import it to produce (and then export) ammonium nitrate domestically in significant quantities, has three operational oil refineries, and is also a major producer and exporter of methanol worldwide. This combines well with the country's advanced financial sector and strong liberalised economy, which has earned the Latin American country membership of the OECD.

Being a highly liberalised economy with an advanced financial sector, Chile is likely to attract significant private debt for its green hydrogen projects within project finance frameworks. Due to the limited liquidity of commercial banks in Chile, projects hosted in the country which have a capital cost of more than $2 billion will need to secure additional financing from ECAs and/or development banks. Indeed, the involvement of these will limit the long-term flexibility of the financing arrangements for Chilean projects. The government on the other hand will most likely not be an investor in such projects, however it has made efforts to support the development of the domestic green hydrogen sector, including through grants to multiple initiatives.

Due to Australia's geographic distance from the European continent, its LCH2 (shipped as green ammonia) is estimated to be the highest of the three host countries. There is also a higher risk of increased CAPEX costs due to higher labour costs. On the other hand, Australia has the highest number of announced projects out of the three countries, including nine which are operational and another 18 which have received FID. The Australian government has provided the most support out of the three countries, and there are many green hydrogen pathways being pursued, including blending into gas networks (operational), balancing of the electricity grid, and green ammonia. The development of Australia's green hydrogen production sector is being driven primarily by the desire to export the product in its various forms overseas, albeit the country's energy-intensive industries such as ammonia and methanol production, oil refining, heavy-duty transport, and mining, will likely necessitate significant domestic off-take as well. On the other hand, Australia is predicted to add more renewable power generation capacity purely for green hydrogen production than the other two countries by 2027.

Australia seems to have the most extensive collaboration with the EU on its green hydrogen production capability out of the three host countries, especially with Germany given the existing MoUs for it to supply a total of 5.1 MT/year to the EU Member State by 2030. On the other hand, Australia seems to also have the most extensive collaboration with non-EU states, especially those in East Asia which are geographically closer to it than Europe is. Like the other two host countries, Australia has many seaports which it can use for its green hydrogen project supply chains and could use to export various green hydrogen products. It has in fact announced 24 seaport upgrade projects, one of which is already under construction (Yara Pilbara ammonia storage). In addition, Australia has significant experience in handling and exporting chemicals. The country boasts an advanced and highly liberalised economy – largest of the three host countries – with a world-class banking system and strong mining and iron/steel manufacturing sectors.

Much like Chile, Australia is likely to attract significant private debt for its green hydrogen sector. On the other hand, Australia has a significant advantage over the Latin American country (and Morocco) when it comes to liquidity of its commercial banks (local as well as international). This in combination with Australia's advanced economy status means that development banks are unlikely to play a role in financing its green hydrogen projects. ECAs on the other hand will likely get involved, by providing either loans or debt cover, and are likely to include those from Japan, South Korea, the US, and the EU. Their involvement will nonetheless be more limited than in Chile or Morocco, meaning that Australian projects are likely to benefit from some flexibility in their financing arrangements. Like in Chile, the Australian government will most likely not be an investor in such projects, however it has made more significant efforts than the government of the former to support the development of its domestic green hydrogen sector. These include grants to multiple projects and investment from the CEFC; the world's largest government-owned green bank. With credit ratings which are at investment (prime) grade, Australia's green hydrogen projects are expected to secure very low cost of debt compared to the vast majority of countries around the world.

References

Acosta, K., Salazar, I., Saldaña, M., Ramos, J., Navarra, A., & Tor, N. (2022). Chile and its Potential Role Among the Most Affordable Green Hydrogen Producers in the World. *Frontiers in Environmental Science, Volume 10*.

ADB, EBRD & EIB. (2021, September). *Private sector development in Morocco Challenges and opportunities in times of Covid-19.* Retrieved from European Investment Bank: https://www.eib.org/attachments/country/private-sector-morocco-covid.pdf

AFDC. (2024). *Methanol*. Retrieved from U.S. Department of Energy Alternative Fuels Data Center: https://afdc.energy.gov/fuels/emerging_methanol.html#:~:text=This%20fuel%20is%20generally%20produced,is%20currently%20the%20most%20economical.

AFRY. (2024). *Green Steel*. Retrieved from AFRY: https://afry.com/en/competence/green-steel

AHK. (2023). *German-Australian Hydrogen Alliance*. Retrieved from German-Australian Chamber of Industry and Commerce: https://australien.ahk.de/en/market-entry/german-australian-hydrogen-alliance

Aleina. (2022, April 07). *HIF Global Secures US$ 260 Million in Equity Investments*. Retrieved from PVTIME: https://www.pvtime.org/hif-global-secures-us-260-million-in-equity-investments/

Anice, O. (2023, November 10). Green Hydrogen Financing in Morocco. (R. Rikabi, Interviewer)

APERC. (2019, December). *APEC Oil and Gas Security Exercise in Chile.* Retrieved from Asia Pacific Energy Research Centre: https://aperc.or.jp/file/2022/7/4/219_ewg_apec-oil-and-gas-security-exercise-in-chile.pdf

ARENA. (2022, September 16). *Australia's first large scale renewable hydrogen plant to be built in Pilbara.* Retrieved from Australian Renewable Energy Agency: https://arena.gov.au/blog/australias-first-large-scale-renewable-hydrogen-plant-to-be-built-in-pilbara/

ARENA. (2022, November 08). *New iron reduction technology targets low emissions steel*. Retrieved from Australian Renewable Energy Agency: https://arena.gov.au/news/new-iron-reduction-technology-targets-low-emissions-steel/

Armijo, J., & Philibert, C. (2020). Flexible production of green hydrogen and ammonia from variable solar and wind energy: Case study of Chile and Argentina. *International Journal of Hydrogen Energy, Volume 45, Issue 3*, 1541-1558.

Atradius. (2021, May 11). *Country Report Chile - May 2021.* Retrieved from Atradius: https://group.atradius.com/publications/country-report/south-america-chile-may-2021.html

Atradius. (2021, April). *Morocco Country Report.* Retrieved from Atradius: https://atradius.co.uk/reports/country-report-mena-morocco-april-2021.html

Atradius. (2022, May). *Australia: companies anxious amid cascade of troubles.* Retrieved from Atradius: https://atradiuscollections.com/global/reports/payment-practices-barometer-australia-2022-companies-anxious-amid-cascade-of-troublesl.html#:~:text=There%20are%20several%20major%20future,a%20negative%20impact%20on%20profits%20.

Atradius. (2023). *Country Risk Map 2022 Q4*. Retrieved from Atradius: https://group.atradius.com/publications/trading-briefs/risk-map.html

AustriaEnergy. (2023). *Green Hydrogen*. Retrieved from AustriaEnergy: https://www.austriaenergy.com/en/green-hydrogen/

Baker, R., & Benoit, P. (2022). How Project Finance Can Advance the Clean Energy Transition in Developing Countries. *The Oxford Institute for Energy Studies*.

Barich, A. (2022, April 06). *First pilot project in Chile for hydrogen in mining to launch prototype in June*. Retrieved from S&P Global: https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/first-pilot-project-in-chile-for-hydrogen-in-mining-to-launch-prototype-in-june-69585431

Barros, M. V. (2024, January 08). Green Hydrogen Financing in Chile and Australia. (R. Rikabi, Interviewer)

Bartlett, J. (2022, December). CHILE'S BET ON GREEN HYDROGEN. *International Monetary Fund Finance & Development*, pp. 42-43.

Biogradlija, A. (2022, January 27). *MOROCCO FOURTH IN WORLDS' HYDROGEN RACE: TOTAL EREN LAUNCHES $10.69BLN HYDROGEN MEGAPROJECT*. Retrieved from Energy News: https://energynews.biz/morocco-fourth-in-worlds-hydrogen-race-total-eren-launches-10-69bln-hydrogen-megaproject/

Blinda, M. (2023, March 16). *Alemania impulsa el uso de hidrógeno verde en Marruecos: una victoria para la energía limpia*. Retrieved from Atalayar: https://www.atalayar.com/en/articulo/economy-and-business/germany-boosts-moroccos-use-green-hydrogen-victory-clean-energy/20230316160821182244.html

BNamericas. (2023, November 15). *Chile hydrogen financing: 'You've got to have a contract, a good contract'*. Retrieved from BNamericas: https://www.bnamericas.com/en/news/chile-hydrogen-financing-youve-got-to-have-a-contract-a-good-contract

BNAmericas. (2023, October 06). *HIF submits US$830mn Chile e-fuels project for environmental review*. Retrieved from BNAmericas: https://www.bnamericas.com/en/news/hif-submits-us830mn-chile-e-fuels-project-for-environmental-review

Britannica. (2023). *Australia*. Retrieved from Britannica: https://www.britannica.com/place/Australia/

Buchsbaum, L. M. (2023, August 29). *Lithium-rich Chile, already a global renewable energy leader, proposes a new strategy*. Retrieved from Energy Transition: https://energytransition.org/2023/08/lithium-rich-chile-already-a-global-renewable-energy-leader-proposes-a-new-strategy/

Burchardt, J., Hegnsholt, E., Holm, M., Klose, F., Ritter, D., & Schönberger, S. (2023, October). *Turning the European Green Hydrogen Dream into Reality: A Call to Action.* Retrieved from Boston Consulting Group: https://media-publications.bcg.com/Turning-the-European-Green-H2-Dream-into-Reality.pdf

Burton, M., & Akhand, H. (2023, November 21). *Australia's Fortescue approves $750 million investment for three green projects*. Retrieved from Reuters: https://www.reuters.com/business/energy/australias-fortescue-approves-750-mln-investment-three-green-projects-2023-11-20/

Buschschlüter, V. (2023, May 09). *Chile constitution: Far-right party biggest in new assembly*. Retrieved from BBC: https://www.bbc.co.uk/news/world-latin-america-65524068

Business Analytiq. (2023, November). *Ammonia price index*. Retrieved from Business Analytiq: https://businessanalytiq.com/procurementanalytics/index/ammonia-price-index/

Carey, L. (2021, October 14). *Australia's Hydrogen Industrial Strategy*. Retrieved from Center for Strategic & International Studies: https://www.csis.org/analysis/australias-hydrogen-industrial-strategy

Carroll, D. (2023, September 29). *Origin lands $45 million to progress Hunter Valley hydrogen hub*. Retrieved from PV Magazine: https://www.pv-magazine-australia.com/2023/09/29/origin-lands-45-million-to-progress-hunter-valley-hydrogen-hub/#:~:text=The%20Hunter%20Valley%20Hydrogen%20Hub%20project%2C%20led%20by%20Origin%20Energy,capacity%20over%20the%20next%20decade.

CEFC. (2023). *CEFC Advancing Hydrogen Fund.* Retrieved from Clean Energy Finance Corporation: https://www.cefc.com.au/media/bnqfczbg/cefc_investmentinsights_hydrogenfund.pdf

CEIC Data. (2024, February). *Chile Exports: fob: BoP: GG: Industry: Chemical: Methanol*. Retrieved from CEIC Data: https://www.ceicdata.com/en/chile/exports-by-goods-bpm6-monthly/exports-fob-bop-gg-industry-chemical-methanol

CEU & EC. (2022, October 21). *EU-Australia relations: framework agreement enters into force today*. Retrieved from Council of the EU and the European Council: https://www.consilium.europa.eu/en/press/press-releases/2022/10/21/eu-australia-relations-framework-agreement-enters-into-force-today/#:~:text=Today%2C%20the%20framework%20agreement%20between,leaders%2C%20business%20and%20civil%20society.

CFI Team. (2024). *SOFR*. Retrieved from CFI Education Inc.: https://corporatefinanceinstitute.com/resources/commercial-lending/sofr-rate/

CIP. (2023). *https://www.cip.com/funds/energy-transition-fund/*. Retrieved from Copenhagen Infrastructure Partners: https://www.cip.com/funds/energy-transition-fund/

Clean Hydrogen JU. (2023, November). *The European hydrogen market landscape (Report 01).* Retrieved from European Hydrogen Observatory: https://observatory.clean-hydrogen.europa.eu/sites/default/files/2023-11/Report%2001%20-%20November%202023%20-%20The%20European%20hydrogen%20market%20landscape.pdf

Collins, L. (2023, March 24). *First batch of e-fuel, made from green hydrogen and captured CO2, heading from Chile to UK for Porsche testing*. Retrieved from Hydrogen Insight: https://www.hydrogeninsight.com/transport/first-batch-of-e-fuel-made-from-green-hydrogen-and-captured-co2-heading-from-chile-to-uk-for-porsche-testing/2-1-1425160

Colthorpe, A. (2023, October 30). *Edify closes on 370MWh BESS to support Renewable Energy Zone in Victoria, Australia*. Retrieved from Energy Storage: https://www.energy-storage.news/edify-closes-on-370mwh-bess-to-support-renewable-energy-zone-in-victoria-australia/

Cooney, C. (2023, December 18). *Chileans vote not to replace Pinochet-era constitution*. Retrieved from BBC News: https://www.bbc.co.uk/news/world-latin-america-67745456

Countryeconomy.com. (2024, March 06). *Sovereigns Ratings List*. Retrieved from Countryeconomy.com: https://countryeconomy.com/ratings

Craen, S. (2023). Financing a world scale hydrogen export project. *Oxford Institute for Energy Studies*, ET21.

Craen, S. (2023, November 26). Green Hydrogen Financing in Australia. (R. Rikabi, Interviewer)

DCCEEW. (2023, October 26). *Building regional hydrogen hubs*. Retrieved from Department of Climate Change, Energy, the Environment and Water: https://www.dcceew.gov.au/energy/hydrogen/building-regional-hydrogen-hubs

DCEEW. (2023, October 26). *$69 million awarded for Central Queensland Hydrogen Hub*. Retrieved from Department of Climate Change, Energy, the Environment and Water: https://www.dcceew.gov.au/about/news/69-million-awarded-central-queensland-hydrogen-hub

Dempsey, H., & White, E. (2023, May 03). *Chile's move to control lithium alarms industry*. Retrieved from The Financial Times: https://www.ft.com/content/6cbc4d6f-fc7f-4039-93fc-bf64421984bc

Deutsche Bank. (2021, October 07). *Deutsche Bank joins the German-Australian Hydrogen Alliance as the inaugural Presenting Partner*. Retrieved from Deutsche Bank: https://www.db.com/news/detail/20211007-deutsche-bank-joins-the-german-australian-hydrogen-alliance-as-the-inaugural-presenting-partner?language_id=1

DEVAID. (2023, February 13). *ENAP - Empresa Nacional del Petróleo/ National Petroleum Company (Chile)*. Retrieved from Development Aid: https://www.developmentaid.org/organizations/view/164842/enap-empresa-nacional-del-petroleo-national-petroleum-company-chile

DG NEAR. (2022, October 18). *The EU and Morocco launch the first Green Partnership on energy, climate and the environment ahead of COP 27*. Retrieved from European Commission: European Neighbourhood Policy and Enlargement Negotiations (DG NEAR): https://neighbourhood-enlargement.ec.europa.eu/news/eu-and-morocco-launch-first-green-partnership-energy-climate-and-environment-ahead-cop-27-2022-10-18_en

Dos Reis, P. C. (2021, January 18). *Hydrogen demand: several uses but significant uncertainty*. Retrieved from Florence School of Regulation: https://fsr.eui.eu/hydrogen-demand-several-uses-but-significant-uncertainty/#_ftn3

Drinkard, T. (2023, December 11). *How Does Preferred Stock Work?* Retrieved from Investopedia: https://www.investopedia.com/articles/stocks/06/preferredstock.asp

Dworkin, A. (2022, April 08). *North African standoff: How the Western Sahara conflict is fuelling new tensions between Morocco and Algeria*. Retrieved from European Council on Foreign Relations: https://ecfr.eu/publication/north-african-standoff-how-the-western-sahara-conflict-is-fuelling-new-tensions-between-morocco-and-algeria/

EC. (2020, July 8). *COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A hydrogen strategy for a climate-neutral Europe*. Retrieved from EUR-Lex: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0301

EC. (2022, May 18). *COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS REPowerEU Plan*. Retrieved from EUR-Lex: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A230%3AFIN&qid=1653033742483

EC. (2022, May 05). *Hydrogen: Commission supports industry commitment to boost by tenfold electrolyser manufacturing capacities in the EU*. Retrieved from European Commission: https://ec.europa.eu/commission/presscorner/detail/e%20n/ip_22_2829

EC. (2022, November 15). *In focus: Renewable hydrogen to decarbonise the EU's energy system*. Retrieved from European Commission: https://commission.europa.eu/news/focus-renewable-hydrogen-decarbonise-eus-energy-system-2022-11-15-0_en#:~:text=Renewable%20hydrogen%20production%20from%20solar%20and%20wind%20resources,could%20be%20as%20much%20as%2013-20%25%20in%202050.

EC. (2022, May 18). *REPowerEU: A plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition**. Retrieved from European Commission: https://ec.europa.eu/commission/presscorner/detail/en/IP_22_3131

EC. (2023, March 16). *Commission outlines European Hydrogen Bank to boost renewable hydrogen*. Retrieved from European Commission: https://energy.ec.europa.eu/news/commission-outlines-european-hydrogen-bank-boost-renewable-hydrogen-2023-03-16_en

EC. (2023). *Competitive bidding*. Retrieved from European Commission: https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/innovation-fund/competitive-bidding_en

EIB. (2023, February 22). *EIB Global in Morocco: Large-scale investment of €2.5 billion with a private sector focus*. Retrieved from European Investment Bank: https://www.eib.org/en/press/all/2023-067-eib-global-in-morocco-large-scale-investment-of-eur2-5-billion-with-a-private-sector-focus#:~:text=Between%202017%20and%202022%2C%20the,of%20the%20projects%20being%20implemented.

Eiteman, D. K., Stonehill, A. I., & Moffett, M. H. (2020). Chapter 18: Multinational Capital Budgeting and Cross-Border Acquisitions. In D. K. Eiteman, A. I. Stonehill, & M. H. Moffett, *Multinational Business Finance, Enhanced eBook, Global Edition (15th Edition)* (pp. 575-576). Harlow, Essex, United Kingdom: Pearson International Content.

Eljechtimi, A. (2023, June 20). *Morocco's OCP plans $7 billion green ammonia plant to avert supply problems*. Retrieved from Reuters: https://www.reuters.com/sustainability/climate-energy/moroccos-ocp-plans-7-mln-green-ammonia-plant-avert-supply-problems-2023-06-20/

EPA. (2023, November). *Ammonia Expansion Project (Report 1753).* Retrieved from Environmental Protection Authority of Western Australia: https://www.epa.wa.gov.au/sites/default/files/EPA_Report/EPA%20Report%201753%20-%20Ammonia%20Expansion%20Project%20-%20Assessment%20report.pdf

ETC. (2021, April). *Making the Hydrogen Economy Possible – Accelerating Clean Hydrogen in an Electrified Economy.* Retrieved from Energy Transitions Commission: https://energy-transitions.org/wp-content/uploads/2021/04/ETC-Global-Hydrogen-Report.pdf

Euractiv. (2022, April 28). *Algeria threatens to cut gas contract with Spain*. Retrieved from Euractiv.com: https://www.euractiv.com/section/global-europe/news/algeria-threatens-to-cut-gas-contract-with-spain/

F&L Asia. (2022, January 19). *The end of oil refining in Australia?* Retrieved from Fuels & Lubes: https://www.fuelsandlubes.com/fli-article/the-end-of-oil-refining-in-australia/#:~:text=The%20sole%20remaining%20crude%20oil,Viva%20Energy%20Refinery%20in%20Geelong.

Fertilizer Australia. (2024). *Australian Fertiliser Market*. Retrieved from Fertilizer Australia: https://fertilizer.org.au/about-fertiliser/the-fertiliser-industry/australian-fertilizer-market#:~:text=Australian%20Fertilizer%20Market,-About%20Fertiliser%20%3E%20The&text=This%20provides%20around%201%2C000%2C000%20tonnes,manufactured%20from%20imported%

Fitch Ratings. (2020, January 16). *Global Renewables Performance Review (Solar Continues to Surpass Wind)*. Retrieved from Fitch Ratings: https://www.fitchratings.com/research/infrastructure-project-finance/global-renewables-performance-review-solar-continues-to-surpass-wind-16-01-2020

Fortescue. (2024). *Christmas Creek Green Iron Pilot*. Retrieved from Fortescue: https://fortescue.com/what-we-do/our-projects/christmas-creek-green-iron-pilot

Franza, L. (2021, April 12). *Clean Molecules across the Mediterranean. The Potential for North African Hydrogen Imports into Italy and the EU.* Retrieved from Istituto Affari Internazionali: https://www.iai.it/en/pubblicazioni/clean-molecules-across-mediterranean#:~:text=The%20Potential%20for%20North%20African%20Hydrogen%20Imports%20into%20Italy%20and%20the%20EU&text=Hydrogen%20is%20the%20most%20promising,largely%20untapped%20renewable%20ener

Fraunhofer. (2019, September 25). *Carbon-neutral energy from power-to-X: Economic opportunity and ecological limitations for Morocco*. Retrieved from Fraunhofer Institute for Systems and Innovation Research ISI: https://www.isi.fraunhofer.de/en/presse/2019/presseinfo-24-klimaneutrale-energie-aus-power-to-x-marokko.html

Frontier & AIT. (2022, December). *Importmöglichkeiten für erneuerbaren Wasserstoff.* Retrieved from Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie: https://www.bmk.gv.at/themen/energie/publikationen/importmoeglichkeiten.html

Ganbold, A., Najjar, Z., Borondo, P., & Hubert, C. (2022, December 08). *The Economics of Green Hydrogen in The Netherlands and France.* Retrieved from Aurora Energy Research: https://auroraer.com/insight/the-economics-of-green-hydrogen-in-the-netherlands-and-france/

Gates, S. (2023, February 13). *How to make hydrogen straight from seawater – no desalination required*. Retrieved from RMIT University: https://www.rmit.edu.au/news/all-news/2023/feb/hydrogen-seawater

GH2. (2023). *Australia*. Retrieved from Green Hydrogen Organisation: https://gh2.org/countries/australia

Ghilotti, D. (2022, November 04). *Chariot increases green hydrogen pitch with Morocco project*. Retrieved from Upstream Online: https://www.upstreamonline.com/hydrogen/chariot-increases-green-hydrogen-pitch-with-morocco-project/2-1-1346623

Gielen, D., & Press, E. (2022, October). THE BREAKTHROUGH AGENDA—ACCELERATING ACTION IN HYDROGEN, POWER, ROAD TRANSPORT, AND STEEL. *The Oxford Institute for Energy Studies Forum A Quarterly Journal for Debating Energy Issues and Policies Issue 133*, pp. 47-52.

GIHub. (2019, May 15). *WATER & WASTE CASE STUDY: MOROCCO Agadir Mutualized Desalination Plant.* Retrieved from Global Infrastructure Hub: https://cdn.gihub.org/umbraco/media/2740/case-study-agadir-mutualized-desalination-plant.pdf

GLOBE NEWSWIRE. (2022, August 30). *Europe Turns to Australia for Green Hydrogen Amidst Energy Crisis*. Retrieved from Yahoo Finance: https://finance.yahoo.com/news/europe-turns-australia-green-hydrogen-130000545.html?guccounter=1&guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_sig=AQAAAAmQcYnpSLORaPljHKpWkfo0W_WyAfkmH-7DVHncnTgOqhOqNiG8dj_MTy3WQ8fsGGUMsU1ACG7bjpejOrfCCSVvMC

GOV.UK. (2023, June 20). *Overseas business risk: Chile*. Retrieved from UK Government: https://www.gov.uk/government/publications/overseas-business-risk-chile/overseas-business-risk-chile

Government of Australia. (2021, September 20). *Future hydrogen industry to create jobs, lower emissions and boost regional Australia*. Retrieved from Ministers for the Department of Industry, Science and Resources: https://www.minister.industry.gov.au/ministers/taylor/media-releases/future-hydrogen-industry-create-jobs-lower-emissions-and-boost-regional-australia

Green Hysland. (2023). *Green Hysland Deployment of a H2 Ecosystem on the Island of Mallorca*. Retrieved from Green Hysland: https://greenhysland.eu/

Green, F. (2022, June 21). *Opinion: Australia's opportunity to break the stranglehold fossil fuels have on our politics*. Retrieved from University College London: https://www.ucl.ac.uk/news/2022/jun/opinion-australias-opportunity-break-stranglehold-fossil-fuels-have-our-politics

Grispiani, L. (2020). *Cost of Hydrogen Production*. Retrieved from Strathgen: https://www.esru.strath.ac.uk/EandE/Web_sites/19-20/Offshore%20H2/projects/economic-analysis/cost-of-hydrogen-production/index.html

GT. (2023, June 04). *China, Australia in partnership to explore green hydrogen after resumption of high-level economic dialogue*. Retrieved from Global Times: https://www.globaltimes.cn/page/202306/1291912.shtml

H2 Green Steel. (2024, January 22). *H2 Green Steel raises more than €4 billion in debt financing for the world's first large-scale green steel plant*. Retrieved from H2 Green Steel: https://www.h2greensteel.com/latestnews/h2-green-steel-raises-more-than-4-billion-in-debt-financing-for-the-worlds-first-large-scale-green-steel-plant

Hawawini, G., & Viallet, C. (2019). *Finance For Executives Managing for Value Creation (6th Edition).* Cengage Learning EMEA.

Helmeci, D. (2023, February 02). *Realizing North Africa's green hydrogen potential*. Retrieved from Atlantic Council: https://www.atlanticcouncil.org/blogs/energysource/realizing-north-africas-green-hydrogen-potential/

HIF. (2023, November 29). *HIF Global and Forico team up to deliver Australia´s first eFuels plant.* Retrieved from HIF Global: https://hifglobal.com/docs/default-source/documentos-noticias/chile/pr-2023-11-28-hif-and-forico-agreement-(final).pdf?sfvrsn=6f90842d_1

HIF Global. (2023). *HIF Chile*. Retrieved from HIF Global: https://www.hifglobal.com/region/hif-chile

Hurst, D. (2023, March 19). *Australia has 'absolutely not' committed to join US in event of war over Taiwan, Marles says*. Retrieved from The Guardian: https://www.theguardian.com/world/2023/mar/19/australia-has-absolutely-not-committed-to-join-us-in-event-of-war-over-taiwan-marles-says

Hyatt, D. (2023, March 23). *Here's How Much Central Banks Around the World Are Raising Interest Rates.* Retrieved from Investopedia: https://www.investopedia.com/how-much-central-banks-around-the-world-are-raising-interest-rates-7370617

Hydrogen Central. (2022, June 16). *Green Hydrogen from Morocco – No Magic Bullet for Europe's Climate Neutrality*. Retrieved from Hydrogen Central: https://hydrogen-central.com/green-hydrogen-morocco-no-magic-bullet-europes-climate-neutrality/

Hydrogen Council, McKinsey & Company. (2021, November). *Hydrogen for Net-Zero A critical cost-competitive energy vector.* Retrieved from Hydrogen Council: https://hydrogencouncil.com/wp-content/uploads/2021/11/Hydrogen-for-Net-Zero.pdf

IEA. (2018, January). *Energy Policies Beyond IEA Countries: Chile 2018 Review.* Retrieved from International Energy Agency: https://iea.blob.core.windows.net/assets/8c16efa0-41b1-47be-b12a-a29483a0c635/EnergyPoliciesBeyondIEACountriesChile2018Review.pdf

IEA. (2018, February). *Energy Policies of IEA Countries: Australia 2018 Review.* Retrieved from International Energy Agency: https://iea.blob.core.windows.net/assets/fd84879e-c950-4da0-ad6f-60d2b8cf0098/EnergyPoliciesofIEACountriesAustralia2018Review.pdf

IEA. (2019, May). *Energy Policies beyond IEA Countries: Morocco 2019*. Retrieved from International Energy Agency: https://iea.blob.core.windows.net/assets/138e3195-d0e6-4345-a66c-92ebe4abbeaf/Energy_Policies_beyond_IEA_Countries_Morocco.pdf

IEA. (2021, June). *Financing Clean Energy Transitions in Emerging and Developing Economies.* Retrieved from International Energy Agency: https://iea.blob.core.windows.net/assets/6756ccd2-0772-4ffd-85e4-b73428ff9c72/FinancingCleanEnergyTransitionsinEMDEs_WorldEnergyInvestment2021SpecialReport.pdf

IEA. (2021, May). *Spain 2021 Energy Policy Review.* Retrieved from IEA Website: https://www.iea.org/reports/spain-2021

IEA. (2022, September). *Global Hydrogen Review 2022.* Retrieved from International Energy Agency: https://iea.blob.core.windows.net/assets/c5bc75b1-9e4d-460d-9056-6e8e626a11c4/GlobalHydrogenReview2022.pdf

IEA. (2023, April). *Australia 2023 Energy Policy Review.* Retrieved from International Energy Agency: https://iea.blob.core.windows.net/assets/02a7a120-564b-4057-ac6d-cf21587a30d9/Australia2023EnergyPolicyReview.pdf

IEA. (2023, January). *Cost of Capital Observatory*. Retrieved from International Energy Agency: https://www.iea.org/reports/cost-of-capital-observatory

IEA. (2023). *Countries: Australia*. Retrieved from International Energy Agency: https://www.iea.org/countries/australia

IEA. (2023). *Countries: Chile*. Retrieved from International Energy Agency: https://www.iea.org/countries/chile

IEA. (2023). *Countries: Morocco*. Retrieved from International Energy Agency: https://www.iea.org/countries/morocco

IEA. (2023, July 10). *Electrolysers*. Retrieved from International Energy Agency: https://www.iea.org/energy-system/low-emission-fuels/electrolysers

IEA. (2023, September). *Global Hydrogen Review 2023*. Retrieved from International Energy Agency: https://iea.blob.core.windows.net/assets/8d434960-a85c-4c02-ad96-77794aaa175d/GlobalHydrogenReview2023.pdf

IEA. (2023, October 31). *Hydrogen Production and Infrastructure Projects Database*. Retrieved from International Energy Agency: https://www.iea.org/data-and-statistics/data-product/hydrogen-production-and-infrastructure-projects-database

IEA. (2023, January). *Renewables 2022 Analysis and forecast to 2027*. Retrieved from International Energy Agency: https://iea.blob.core.windows.net/assets/ada7af90-e280-46c4-a577-df2e4fb44254/Renewables2022.pdf

IFC. (2019, October). *CREATING MARKETS IN MOROCCO.* Retrieved from World Bank Group: https://www.ifc.org/content/dam/ifc/doc/mgrt/201910-cpsd-morocco-en.pdf

IFC. (2022, June). *CREATING MARKETS IN CHILE.* Retrieved from World Bank Group: https://www.ifc.org/content/dam/ifc/doc/mgrt/cpsd-chile.pdf

Inpex. (2012, December 08). *Ichthys LNG Project Completes Project Financing Arrangements.* Retrieved from Inpex: https://www.inpex.com.au/media/4ysmaf51/ichthys_lng_project_completes_project_financing_arrangements.pdf

IRENA. (2022, January). *Geopolitics of the Energy Transformation The Hydrogen Factor.* Retrieved from International Renewable Energy Agency: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jan/IRENA_Geopolitics_Hydrogen_2022.pdf?rev=1cfe49eee979409686f101ce24ffd71a

IRENA. (2022, April). *Global Hydrogen Trade to Meet the 1.5°C Climate Goal Part II: Technology Review of Hydrogen Carriers.* Retrieved from International Renewable Energy Agency: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Apr/IRENA_Global_Trade_Hydrogen_2022.pdf?rev=3d707c37462842ac89246f48add670ba

IRENA. (2022, May International Renewable Energy Agency). *Global Hydrogen Trade to Meet the 1.5°C Climate Goal Part III: Green Hydrogen Cost and Potential.* Retrieved from https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/May/IRENA_Global_Hydrogen_Trade_Costs_2022.pdf?rev=00ea390b555046118cfe4c448b2a29dc

IRENA. (2022, July). *Global hydrogen trade to meet the 1.5°C climate goal: Part I: Trade outlook for 2050 and way forward.* Retrieved from International Renewable Energy Agency: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jul/IRENA_Global_hydrogen_trade_part_1_2022_.pdf

IRENA. (2023, August 08). *Energy Profile Spain*. Retrieved from IRENA: https://www.irena.org/-/media/Files/IRENA/Agency/Statistics/Statistical_Profiles/Europe/Spain_Europe_RE_SP.pdf

IRENA. (2023, February). *Global landscape of renewable energy finance, 2023.* Retrieved from International Renewable Energy Agency: https://mc-cd8320d4-36a1-40ac-83cc-3389-cdn-endpoint.azureedge.net/-/media/Files/IRENA/Agency/Publication/2023/Feb/IRENA_CPI_Global_RE_finance_2023.pdf?rev=8668440314f34e588647d3994d94a785

ITA. (2023, July 07). *Chile - Country Commercial Guide*. Retrieved from International Trade Administration: https://www.trade.gov/country-commercial-guides/chile-energy

Jamasmie, C. (2021, October 08). *Antofagasta to test use of hydrogen in mining equipment*. Retrieved from Mining.com: https://www.mining.com/antofagasta-to-test-use-of-hydrogen-in-mining-equipment/

Jens, J., Wang, A., van der Leun, K., Peters, D., & Buseman, M. (2021, April). *Extending the European Hydrogen Backbone.* Retrieved from European Hydrogen Backbone: https://ehb.eu/files/downloads/European-Hydrogen-Backbone-April-2021-V3.pdf

Kane, M. K., & Gil, S. (2022, June 23). *Green Hydrogen: A key investment for the energy transition*. Retrieved from World Bank Blogs: https://blogs.worldbank.org/ppps/green-hydrogen-key-investment-energy-transition

Kantner, H. (2023, November 29). Green Hydrogen Financing in Chile. (R. Rikabi, Interviewer)

Kar-Gupta, S. (2023, July 25). *TotalEnergies to take full control of renewables company Total Eren*. Retrieved from Reuters: https://www.reuters.com/markets/deals/totalenergies-buy-full-control-renewables-company-total-eren-2023-07-25/

Khouya, A. (2020). Levelized costs of energy and hydrogen of wind farms and concentrated photovoltaic thermal systems. A case study in Morocco. *international journal of hydrogen energy 45*, 31632-31650.

Kneebone, J., & Piebalgs, A. (2022, September 23). *Redrawing the EU's energy relations: Getting it right with African renewable hydrogen.* Retrieved from Florence School of Regulation, European University Institute: https://cadmus.eui.eu/bitstream/handle/1814/74890/PB_2022_50.pdf?sequence=1&isAllowed=y

Kumagai, T. (2023, May 16). *Japan advances commercial launch of e-fuel to 2030 from 2040: METI*. Retrieved from S&P Global Inc.: https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/051623-japan-to-advance-commercial-launch-of-e-fuel-to-2030-from-2040-meti

Laidlaw, H. (2020, December 17). *Australian oil refineries and fuel security*. Retrieved from Parliament of Australia: https://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/FlagPost/2020/December/Oil_refineries_and_fuel_security#:~:text=Australian%20refineries,1965%20(see%20Table%201).

Liebreich, M. (2022). Cleaning Up. Leadership in an age of climate change. Audioblog 8: 'The Unbearable Lightness of Hydrogen' [Recorded by M. Liebreich].

Lovell, J. (2018, August 16). *Green hydrogen: Is it still in the pipeline?* Retrieved from Australian Energy Council: https://www.energycouncil.com.au/analysis/green-hydrogen-is-it-still-in-the-pipeline/

Ludwig, M., Lüers, M., Lorenz, M., Hegnsholt, E., Minjee, K., Pieper, C., & Meidert, K. (2021, April 12). *The Green Tech Opportunity in Hydrogen*. Retrieved from Boston Consulting Group: https://www.bcg.com/publications/2021/capturing-value-in-the-low-carbon-hydrogen-market

Macdonald-Smith, A., & Eyers, J. (2022, September 15). *Germany wants Australian hydrogen within three years*. Retrieved from The Australian Financial Review: https://www.afr.com/companies/energy/how-hydrogen-will-reshape-energy-trade-routes-20220914-p5bhvz

Madeira, C., & Pérez, A. (2023, October 16). *The Role of Sovereign Green Bonds in Chile's Development*. Retrieved from Georgetown Journal of International Affairs: https://gjia.georgetown.edu/2023/10/16/the-role-of-sovereign-green-bonds-in-chiles-development/

Martin, P. (2023, December 06). *Hedging strategy | 'Producing green hydrogen and ammonia protects us from volatile gas prices', says fertiliser giant*. Retrieved from Hydrogen Insight: https://www.hydrogeninsight.com/production/hedging-strategy-producing-green-hydrogen-and-ammonia-protects-us-from-volatile-gas-prices-says-fertiliser-giant/2-1-1565155

Mavrokefalidis, D. (2022, November 18). *Giant UK-Morocco interconnector attracts new investment*. Retrieved from Energy Live News: https://www.energylivenews.com/2022/11/18/giant-uk-morocco-interconnector-attracts-new-investment/

McKeith, S. (2023, June 24). *Australia commits to build $34 million renewable hydrogen plant in Victoria*. Retrieved from Reuters: https://www.reuters.com/business/energy/australia-commits-build-34-mln-renewable-hydrogen-plant-victoria-2023-06-24/

MEM. (2021, January). *Feuille de Route de l'Hydrogène Vert.* Retrieved from MINISTERE DE LA TRANSITION ENERGETIQUE ET DU DEVELOPPEMENT DURABLE: https://www.mem.gov.ma/Lists/Lst_rapports/Attachments/36/Feuille%20de%20route%20de%20hydrog%C3%A8ne%20vert.pdf

Menas Associates. (2022, December 17). *SAMIR Refinery is on the Agenda Again.* Retrieved from Menas: https://menas.co.uk/blog/samir-refinery-is-on-the-agenda-again

Methanex. (2014). *Methanex: Global Methanol Production Facilities.* Retrieved from Methanex: https://www.methanex.com/sites/default/files/news/media-resources/MX_Global_Methanol_Production_Facilities_2014.pdf

Methanex. (2016, May). *Methanex Investor Presentation.* Retrieved from Methanex: https://www.methanex.com/sites/default/files/investor/MEOH%20Presentation%20-%20May.pdf

Methanex. (2024). *Chile*. Retrieved from Methanex: https://www.methanex.com/about-us/global-locations/chile/#:~:text=Our%20two%20production%20facilities%20in,logistics%20operations%20in%20those%20regions.

Miranda, N. A. (2023, January 23). *Crime, inflation hammer support for Chile's Boric in tough first year*. Retrieved from Reuters: https://www.reuters.com/world/americas/crime-inflation-hammer-support-chiles-boric-tough-first-year-2023-01-23/

Mitsui. (2014, September 19). *Mitsui enters into Finance Agreements for the Safi IPP Project in Morocco*. Retrieved from Mitsui: https://www.mitsui.com/jp/en/release/2014/1204942_6473.html

Mohammadi, P. (2022). Hydrodesulfurization. In M. Jawaid, A. Ahmad, & A. V. Reddy, *Ionic Liquid-Based Technologies for Environmental Sustainability* (pp. 61-74). Elsevier Inc.

Mohanty, A. (2010, March 22). *Desertec: Enel Green Power, NAREVA Holding, Red Eléctrica de España and Saint-Gobain Solar become part of joint venture Dii.* Retrieved from Munich RE: https://www.munichre.com/en/company/media-relations/media-information-and-corporate-news/corporate-news/2010/2010-03-22-desertec-enel-green-power-nareva-holding-red-electrica-de-espana-and-saint-gobain-solar-become-part-of-joint-venture-dii.html

Needham, K. (2023, June 20). *Australians say they would support Taiwan if China attacked, with limits, poll shows*. Retrieved from Reuters: https://www.reuters.com/world/asia-pacific/australians-say-they-would-support-taiwan-if-china-attacked-with-limits-poll-2023-06-20/

NewYorkFed. (2024, January 10). *Secured Overnight Financing Rate Data*. Retrieved from Federal Reserve Bank of New York: https://www.newyorkfed.org/markets/reference-rates/sofr#:~:text=Secured%20Overnight%20Financing%20Rate%20Data%20%20%20,%20%205.38%20%2021%20more%20rows%20

Njovu, G. (2023, May 12). *Guaranteeing fuel access to ease the transition: Glenfarne & Samsung Engineering*. Retrieved from Ammonia Energy Association: https://www.ammoniaenergy.org/articles/guaranteeing-fuel-access-to-ease-the-transition-glenfarne-samsung-engineering/

OCP. (2022, December 16). *OCP Group launches a $13 billion Green Investment Strategy*. Retrieved from OCP: https://www.ocpgroup.ma/news-article/ocp-group-launches-its-new-green-investment-program-2023-2027#:~

OCP. (2024). *Our history*. Retrieved from OCP: https://www.ocpgroup.ma/history#:~:text=OCP%20began%20phosphate%20production%20in,and%20Jorf%20Lasfar%20(1984).

OEC. (2023, December). *Ammonia in Chile*. Retrieved from Observatory of Economic Complexity: https://oec.world/en/profile/bilateral-product/ammonia/reporter/chl

OEC. (2024, January). *Ammonia in Australia*. Retrieved from Observatory of Economic Complexity: https://oec.world/en/profile/bilateral-product/ammonia/reporter/aus

OEC. (2024, January). *Anhydrous Ammonia in Morocco*. Retrieved from Observatory of Economic Complexity: https://oec.world/en/profile/bilateral-product/anhydrous-ammonia/reporter/mar

OEC. (2024, January). *Mixed Mineral or Chemical Fertilizers in Morocco*. Retrieved from Observatory of Economic Complexity: https://oec.world/en/profile/bilateral-product/mixed-mineral-or-chemical-fertilizers/reporter/mar

OEC. (2024, January). *Phosphatic Fertilizers in Morocco*. Retrieved from Observatory of Economic Complexity: https://oec.world/en/profile/bilateral-product/phosphatic-fertilizers/reporter/mar

OpenStreetMap. (2024). *Africa Gas Tracker Map*. Retrieved from Global Energy Monitor: https://globalenergymonitor.org/projects/africa-gas-tracker/tracker-map/

OT. (2021, December 13). *Chile exploration and production outlook*. Retrieved from Offshore Technology: https://www.offshore-technology.com/comment/chile-exploration-production/

Parkes, R. (2023, August 02). *Samsung and partners plan billion-dollar green hydrogen project in Australia for export to South Korea*. Retrieved from Hydrogen Insight: https://www.hydrogeninsight.com/production/samsung-and-partners-plan-billion-dollar-green-hydrogen-project-in-australia-for-export-to-south-korea/2-1-1494985

Parkinson, G. (2023, October 22). *South Australia names winners of world-leading hydrogen tender in race to 100 pct renewables*. Retrieved from Renew Economy: https://reneweconomy.com.au/south-australia-names-winners-of-world-leading-hydrogen-tender-in-race-to-100-pct-renewables/

Pascal, T. (2023, September 21). *Green Hydrogen current and projected production costs*. Retrieved from Structures Insider: https://www.structuresinsider.com/post/green-hydrogen-current-and-projected-production-costs

Patonia, A., & Poudineh, R. (2022). Cost-competitive green hydrogen: how to lower the cost of electrolysers? *The Oxford Institute for Energy Studies*, EL 47.

Patonia, A., & Poudineh, R. (2022). Global trade of hydrogen: what is the best way to transfer hydrogen over long distances? *The Oxford Institute for Energy Studies*, ET16.

Patonia, A., Lenivova, V., Poudineh, R., & Nolden, C. (2023). Hydrogen pipelines vs. HVDC lines: Should we transfer green molecules or electrons? *The Oxford Institute for Energy Studies*, ET27.

Petrova, V. (2023, November 29). *TotalEnergies joins huge Morocco-UK renewables export project*. Retrieved from Renewables Now: https://renewablesnow.com/news/totalenergies-joins-huge-morocco-uk-renewables-export-project-841554/#:~:text=The%20link%20will%20export%20electricity,20%20GWh%20of%20battery%20storage

PFI. (2021, December 16). *Offshore wind debt 15 years on*. Retrieved from Project Finance Institute: https://www.pfie.com/story/3151364/offshore-wind-debt-15-years-on-cqwp8mbjh8

Pooler, M. (2013, January 22). *Ichthys LNG, Australia*. Retrieved from IJGlobal: https://www.ijglobal.com/articles/81726/ichthys-lng-australia

Porsche. (2023, February 14). *eFuel for thought*. Retrieved from Porsche: https://newsroom.porsche.com/en/2023/company/porsche-efuels-pilot-plant-haru-oni-chile-synthetic-fuels-behind-the-scenes-31167.html

Ports. (2023). *Port of Rotterdam to Port of Casablanca: 1683 nautical miles*. Retrieved from Ports: http://ports.com/sea-route/port-of-rotterdam,netherlands/port-of-casablanca,morocco/#/?a=0&b=0&c=Port%20of%20Rotterdam,%20Netherlands&d=Port%20of%20Casablanca,%20Morocco

Ports. (2023). *ports in Morocco (22)*. Retrieved from Ports: http://ports.com/browse/africa/morocco/map-view/

Ports. (2023). *ports in Oceania (373)*. Retrieved from Ports: http://ports.com/browse/oceania/#/?cf=AU&df=&tf=&view=list&page=false

Ports. (2023). *ports in South America (453)*. Retrieved from Ports: http://ports.com/browse/south-america/#/?cf=CL&df=&tf=&view=list&page=false

Ports. (2023). *Sea route & distance*. Retrieved from Ports: http://ports.com/sea-route/puerto-valparaiso,chile/bilbao-port,spain/#/?a=0&b=15995&c=Puerto%20Valparaiso&d=Erimo%20Port,%20Japan

Possenti, E. (2023, June 14). *Chile: EU, EIB and KfW to finance renewable hydrogen projects with up to €216.5 million*. Retrieved from European Investment Bank: https://www.eib.org/en/press/all/2023-223-eu-eib-and-kfw-to-finance-renewable-hydrogen-projects-in-chile-with-up-to-eur216-5-million

PT. (2014, September 18). *Safi Energy secures $2.6bn loan for coal-fired power plant in Morocco*. Retrieved from Power Technology: https://www.power-technology.com/marketdata/newssafi-energy-secures-26bn-loan-for-coal-fired-power-plant-in-morocco-4378637/?cf-view&cf-closed

PwC. (2023). *The green hydrogen economy Predicting the decarbonisation agenda of tomorrow*. Retrieved from PwC: https://www.pwc.com/gx/en/industries/energy-utilities-resources/future-energy/green-hydrogen-cost.html

Raveau, S., & Díaz, X. (2022, December 20). *HIF Global and its partners celebrate the first liters of synthetic fuels from Haru Oni, Chile*. Retrieved from HIF Global: https://www.hifglobal.com/docs/default-source/documentos-noticias/chile/hif-global-and-its-partners-celebrate-the-first-liters-of-synthetic-fuels-from-haru-oni-chile.pdf?sfvrsn=691ef4ad_1

REN21. (2022). *Renewables 2022 Global Status Report.* Retrieved from REN21 Website: https://www.ren21.net/reports/global-status-report/

Rikabi, R. (2023). *Master's Thesis: Optimum Investment Structure into International Green Hydrogen Projects from a European Union Perspective.* Vienna, Austria: WU Executive Academy.

Ristau, O. (2021, October 27). *Solar power from the desert*. Retrieved from KfW: https://www.kfw.de/stories/environment/renewable-energy/solarstrom-aus-der-wueste/

RN. (2021). *Belgium-Chile deal to boost cheap EU green hydrogen supply*. Retrieved from Renewables Now: https://renewablesnow.com/news/belgium-chile-deal-to-boost-cheap-eu-green-hydrogen-supply-760830/

Roth, A., Dertinger, A., Lotz, B., & Schimmel, M. (2023, December 18). *Making sense of green hydrogen costs and recent market developments in Europe*. Retrieved from Euractiv: https://www.euractiv.com/section/energy-environment/opinion/making-sense-of-green-hydrogen-costs-and-recent-market-developments-in-europe/?cx_testId=4&cx_testVariant=cx_1&cx_artPos=3&cx_experienceId=EXLQ9EV18G4H#cxrecs_s

Rouwenhorst, K. (2023, March 08). *HyEx: ammonia from the Chilean desert*. Retrieved from Ammonia Energy Association: https://www.ammoniaenergy.org/articles/hyex-ammonia-from-the-chilean-desert/

Royal Society. (2024). *Ammonia: zero-carbon fertiliser, fuel and energy store*. Retrieved from The Royal Society: https://royalsociety.org/news-resources/projects/low-carbon-energy-programme/green-ammonia/#:~:text=However%2C%20the%20process%20of%20making,is%20from%20the%20SMR%20process.

Saifaddin, G. (2023, June 19). *Imports of electrical energy in Morocco from 2010 to 2021*. Retrieved from Statista: https://www.statista.com/statistics/1308826/imports-of-electricity-in-morocco/#:~:text=Morocco%20imported%201.8%20billion%20kilowatt%20hours%20of%20electricity,6.1%20billion%20kilowatt%20hours%20in%202014%20and%202017.

Shaar, T. L., & Leal-Arcas, R. (2022). Fuel subsidy reform, decentralized electricity markets and renewable energy trade: evidence for a successful energy transition in the Middle East and North Africa Region. *Journal of World Energy Law and Business*, 1-15.

Smith, S. (2017, August 25). *Power played*. Retrieved from West Business Insider: https://insider.thewest.com.au/august-2017/power-played/

Smyth, J. (2021, June 21). *Green groups fume as Canberra rejects world's biggest renewables project*. Retrieved from Financial Times: https://www.ft.com/content/c0a9a866-d2dd-497c-9563-581cd6d908dc

Statista. (2023, September). *Leading fertilizer exporting countries worldwide in 2022, based on value*. Retrieved from Statista: https://www.statista.com/statistics/1278057/export-value-fertilizers-worldwide-by-country/

Statista. (2023, November 15). *Statista*. Retrieved from Renewable energy capacity in Morocco from 2013 to 2022: https://www.statista.com/statistics/1014757/morocco-renewable-energy-capacity/

Sugiyama, S., & Golubkova, K. (2023, November 10). *Japan, South Korea to set up joint hydrogen, ammonia supply network - Nikkei*. Retrieved from Reuters: https://www.reuters.com/world/asia-pacific/japan-south-korea-set-up-joint-hydrogen-ammonia-supply-network-nikkei-2023-11-10/

Sun Cable. (2023). *Sun Cable*. Retrieved from Sun Cable: https://suncable.energy/

Tatarenko, O., Janzow, N., Rosas, J., & Homann, Q. (2023). *The Value of Green Hydrogen Trade for Europe*. Retrieved from RMI: https://rmi.org/insight/the-value-of-green-hydrogen-trade-for-europe/

TI. (2023). *Corruption Perceptions Index*. Retrieved from Transparency International: https://www.transparency.org/en/cpi/2022/

Touili, S., Bouaichi, A., Merrouni, A., Amrani, A.-i., El Amrani, A., El Hassouani, Y., & Messaoudi, C. (2022). Performance analysis and economic competiveness of 3 different PV technologies for hydrogen production under the impact of arid climatic conditions of Morocco. *International Journal of Hydrogen Energy, Volume 47, Issue 74*, 31596-31613.

Touili, S., Merrouni, A. A., El Hassouani, Y., Amrani, A.-i., & Azouzoute, A. (2020). Techno-economic investigation of electricity and hydrogen production from wind energy in Casablanca, Morocco. *IOP Conference Series: Materials Science and Engineering*.

Toyama, N. (2022, December 18). *Green hydrogen booms in Asia as companies rush into projects*. Retrieved from Nikkei Asia: https://asia.nikkei.com/Spotlight/Environment/Green-hydrogen-booms-in-Asia-as-companies-rush-into-projects

TRADING ECONOMICS. (2023). *Spain Exports of electrical energy to Morocco*. Retrieved from TRADING ECONOMICS: https://tradingeconomics.com/spain/exports/morocco/electrical-energy

TRADING ECONOMICS. (2024, March). *Australia Exports of fertilizers*. Retrieved from TRADING ECONOMICS: https://tradingeconomics.com/australia/exports/fertilizers

UNIDO. (2022, May). *DEVELOPMENT DIALOGUE Second Session UNIDO's Global Partnership for Hydrogen in Industry.* Retrieved from United Nations Industrial Development Organization: https://www.unido.org/sites/default/files/files/2022-05/MS-Dialogue-GH2-short.pdf van Gaal, W. (2023, March 17). *EU launches 'Hydrogen Bank' — but what is it?* Retrieved from EU Observer: https://euobserver.com/green-economy/156845

Vasques, E. (2023, January 09). *US open to Western Sahara options as Morocco steps up lobbying effort*. Retrieved from Euractiv.com: https://www.euractiv.com/section/global-europe/news/us-open-to-western-sahara-options-as-morocco-steps-up-lobbying-effort/

Volza. (2023, December 14). *Ammonium nitrate Exports from Chile*. Retrieved from Volza: https://www.volza.com/p/ammonium-nitrate/export/export-from-chile/

Vorrath, S. (2023, May 18). *Danish giant adds massive green hydrogen hub to 30GW Australia pipeline*. Retrieved from Renew Economy: https://reneweconomy.com.au/danish-giant-adds-massive-green-hydrogen-hub-to-30gw-australia-pipeline/

Walmart. (2023, August 15). *Walmart Chile To Create First Industrial-Use Green Hydrogen Production Plant in Latin America*. Retrieved from Walmart: https://corporate.walmart.com/news/2023/08/15/walmart-chile-to-create-first-industrial-use-green-hydrogen-production-plant-in-latin-america

WB. (2020). *Doing Business 2020.* Retrieved from World Bank Group: https://openknowledge.worldbank.org/server/api/core/bitstreams/75ea67f9-4bcb-5766-ada6-6963a992d64c/content

WB. (2023, October). *Chile Macro Poverty Outlook*. Retrieved from World Bank Group: https://thedocs.worldbank.org/en/doc/e408a7e21ba62d843bdd90dc37e61b57-0500032021/related/mpo-chl.pdf

WB. (2023). *Country Data: Australia*. Retrieved from World Bank Group: https://data.worldbank.org/country/australia?view=chart

WB. (2023, March 01). *Current account balance (% of GDP)*. Retrieved from World Bank Group: https://data.worldbank.org/indicator/BN.CAB.XOKA.GD.ZS?view=map

WB. (2023). *GDP per capita (current US$) - Chile*. Retrieved from World Bank Group: https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=CL

WB. (2023, October). *Morocco Macro Poverty Outlook*. Retrieved from World Bank Group: https://thedocs.worldbank.org/en/doc/65cf93926fdb3ea23b72f277fc249a72-0500042021/related/mpo-mar.pdf

WB. (2023, September 25). *Morocco: Noor Solar Power Project*. Retrieved from World Bank: https://projects.worldbank.org/en/projects-operations/project-detail/P131256

WEC. (2022, April). *REGIONAL INSIGHTS INTO LOW-CARBON HYDROGEN SCALE UP.* Retrieved from World Energy Council: https://www.worldenergy.org/assets/downloads/World_Energy_Insights_Working_Paper_Regional_insights_into_low-carbon_hydrogen_scale_up.pdf?v=1680701563

WEF. (2022, April 27). *How much will it cost Europe to switch to clean energy by 2050?* Retrieved from World Economic Forum: https://www.weforum.org/agenda/2022/04/bnef-european-energy-transition-2022/

Westenhaus, B. (2023, February 12). *Scientists Successfully Split Seawater To Produce Green Hydrogen*. Retrieved from Oil Price: https://oilprice.com/Alternative-Energy/Fuel-Cells/Scientists-Successfully-Split-Seawater-To-Produce-Green-Hydrogen.html

World Data. (2023). *Australia*. Retrieved from World Data: https://www.worlddata.info/australia/australia/index.php

World Data. (2023). *Morocco*. Retrieved from World Data: https://www.worlddata.info/africa/morocco/index.php#:~:text=The%20land%20has%20a%20total,of%20area%20ranked%2058th%20worldwide.

World Data. (2023). *World Data*. Retrieved from Chile: https://www.worlddata.info/america/chile/index.php

Wouters, F. (2020, April 14). *Hydrogen, a new energy vector in Morocco*. Retrieved from NVVN: https://nvvn.nl/hydrogen-a-new-energy-vector-in-morocco-2/

WPR. (2023). *World Countries by GDP*. Retrieved from World Population Review: https://worldpopulationreview.com/countries/by-gdp

Yamashita, Y. S., & Luco, R. (2023, June 29). *Chile to Accelerate its Green Hydrogen Industry with World Bank Support*. Retrieved from The World Bank: https://www.worldbank.org/en/news/press-release/2023/06/29/chile-to-accelerate-its-green-hydrogen-industry-with-world-bank-support

Yara. (2023, June 14). *Yara Clean Ammonia and Cepsa seal an alliance to connect southern and northern Europe with clean hydrogen*. Retrieved from Yara: https://www.yara.com/corporate-releases/yara-clean-ammonia-and-cepsa-seal-an-alliance-to-connect-southern-and-northern-europe-with-clean-hydrogen/

Yihe, X. (2023, April 21). *Chinese contractor to build green hydrogen project in Morocco*. Retrieved from Upstream: https://www.upstreamonline.com/energy-transition/chinese-contractor-to-build-green-hydrogen-project-in-morocco/2-1-1438501

Zahw, T., Peterse, J., Schimmel, M., & Cihlar, J. (2022, October 1). *Facilitating hydrogen imports from non-EU countries.* Retrieved from Guidehouse: https://gasforclimate2050.eu/wp-content/uploads/2022/10/2022_Facilitating_hydrogen_imports_from_non-EU_countries.pdf

Zgheib, N. (2022, July 19). *EBRD and CTF to repower Africa's oldest wind farm*. Retrieved from European Bank for Reconstruction and Development: https://www.ebrd.com/news/2022/ebrd-and-ctf-to-repower-africas-oldest-wind-farm.html

Zgheib, N. (2022, December 12). *EBRD lends further support to Moroccan Nador West Med port*. Retrieved from European Bank for Reconstruction and Development: https://www.ebrd.com/news/2022/ebrd-lends-further-support-to-moroccan-nador-west-med-port.html