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OUTLOOK FOR THE DEVELOPMENT OF INTERNATIONAL TRADE IN HYDROGEN AND RELATED PRODUCTS

Potential implications for shipping ports

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Executive summary

The development of international trade in renewable hydrogen and its derivatives faces significant challenges that generate uncertainty about the role of ports as logistics hubs for these energy products.

In contrast to the optimistic view in recent years of sustained growth in the hydrogen value chain and global trade, we are recently witnessing a slowdown in many investment and infrastructure development initiatives throughout the hydrogen value chain (and especially in large-scale hydrogen production facilities).

A large majority of green hydrogen projects worldwide are facing implementation problems related to: (i) lack of off-takers (i.e., hydrogen buyers through long-term contracts); (ii) access to renewable energy (and other resources needed for renewable hydrogen production, such as water); (iii) delays and bottlenecks in supply chains; (iv) regulatory uncertainty; and, especially, (v) financing difficulties.

This situation may have an impact on the prospects for the development of shipping ports as logistic hubs for renewable hydrogen and other hydrogen-derived and hydrogen-related products in the short, medium and long term.

The slow development of the global hydrogen market is due to several factors, including market and regulatory variables, slow deployment of key infrastructure, environmental impacts and project financing barriers.

1. Expected evolution of renewable hydrogen demand in the medium to long term.

   Forecasts for global hydrogen demand in the medium (2030) and long term (2050) have been corrected downwards significantly from mid-2023. This will have an impact on the pace of development of global trade in hydrogen and hydrogen-related products.

   The main factors behind this bearish view on hydrogen demand are the evolution of renewable hydrogen production costs, regulatory uncertainty, the slow deployment of infrastructure throughout the value chain, and the expected improvement of alternative technologies in energy end-uses.

2. Renewable hydrogen production costs.

   Forecasts for the evolution of green hydrogen production costs have also worsened, due to increases in electrolyzer costs (partly due to inflation), the cost of renewable energy and financing costs.

   The results of the first auction of premia for the development of renewable hydrogen production projects in the EU suggest that the costs for consumers implicit in the projects are still far from the costs of gray hydrogen.

3. Evolution of supply (production capacity).

   In line with expectations about demand, the outlook for the evolution of hydrogen supply suggests that the rate of growth of renewable hydrogen production capacity is very slow and that

the targets announced by various governments for 2030 will not be met. This is mainly due to the lack of off-takers (hydrogen buyers) and problems with project financing.

Although a significant part of the announced projects are oriented towards hydrogen exports, actual exports are expected to be much lower in practice, due to the lack of maturity of technologies along the hydrogen export-import value chain and the slow development of demand.

4. Feasibility of transport and storage of renewable hydrogen and derived products.

   There are several technological routes that are considered potentially viable for the import-export of hydrogen and hydrogen products by sea over long distances: i) liquid hydrogen, ii) hydrogen carriers (such as LOHCs, including methanol) and iii) ammonia. At present, there is only significant activity in the ammonia shipping segment (albeit without reconversion at the point of delivery).

   All three alternatives face significant technological challenges at some point in the conversion-transport-reconversion value chain (e.g., cost and technological issues related to liquid hydrogen transportation, LOHC and ammonia reconversion, environmental impacts, etc.).

   Ultimately, the technical feasibility and competitiveness of the various hydrogen shipping alternatives depends on multiple factors, including scale of operation, transport distance, and infrastructure and end-uses at import and export points.

5. Development of a regulatory framework for international trade.

   The creation of a global hydrogen market depends, to a large extent, on the development of regional markets with stable regulatory frameworks, a large number of users, infrastructure at export and import points, and internationally recognized standards.

   The foundations are now being laid for the development of an internal hydrogen market in the EU, although there is a long way to go. At the international level, it will be essential to develop a system of renewable hydrogen standards and certifications to facilitate long-distance trade.

6. Development of port infrastructure.

   Among the various technological routes for the transport of hydrogen and derived products by sea, dedicated port infrastructures exist only in the case of ammonia. At present, some 150 ports can handle imports or exports of ammonia in nearly 200 terminals.

   There are, however, no conversion or reconversion infrastructures for any of the technological alternatives (liquid or compressed hydrogen, hydrogen carriers or ammonia). Nor are there any operational vessels (in the commercial phase) for the transport of liquid or compressed hydrogen.

   The various types of infrastructure required for maritime transport and port processes face technological challenges related to energy efficiency and consumption, scaling of production and transport operations, hydrogen separation, leakage and other potential environmental impacts.

7. Environmental impacts linked to the transport of hydrogen and related products and other risks (health, safety, etc.).

   The environmental impact (from a life-cycle perspective) of the various alternative technological routes for international seaborne hydrogen trade depends on the scale of the operations and the

distance. The greater the distance over which the hydrogen or hydrogen product is transported, the greater the environmental impact and the lower the aggregate efficiency of the production-storage-transport-storage-supply value chain.

In general, the pure hydrogen supply alternatives (especially in liquid form) have a lower environmental impact than the other alternatives (LOHC, methanol, syngas and ammonia, in ascending order). The environmental performance of ammonia is particularly unfavorable in environmental categories such as acidification, particulate emissions and water consumption, in addition to impacts in terms of eutrophication –especially, land- and photochemical ozone formation.

8. Barriers to the financing of projects.

   Financing of hydrogen projects in the market must overcome the barriers usually faced by projects with high capex levels and related to technologies in the development phase or "first of a kind".

   Potential investors perceive significant barriers and risks related to: (i) market conditions (especially the outlook for demand evolution); (ii) the underdeveloped regulatory and policy framework; (iii) the difficulty of accessing financing (public and private); (iv) the insufficient development of value chains and the financing ecosystem in the hydrogen sector; and (v) the difficulty of applying financing models based on project finance and other innovative financing structures due to the lack of off-takers.

Main conclusions

The role renewable hydrogen will play in the global energy transition in the long term has relevant implications for ports.

Despite the uncertain evolution of the global renewable hydrogen market, renewable hydrogen is expected to be a relevant energy vector in regional industrial hubs, with a limited volume of international trade and generally confined to continental regions (Europe, Southeast Asia, North America, South America…).

Opportunities arise in energy consumption niches where renewable hydrogen may have a competitive advantage over other energy sources (electricity) and where electrification is very difficult (e.g. many current uses of grey hydrogen, high temperature heat generation or certain segments of the transport sector), as well as in areas where a high demand for non-energy consumption of ammonia is developing.

The following factors should be taken into account when analyzing the strategy of individual ports as logistics hubs for the international trade of renewable hydrogen and related products:

- The future growth of the global hydrogen market will depend crucially on the (cost) competitiveness of green hydrogen in different end-uses, the existence of significant differentials in production costs in different regions, and transportation costs.
- The generation of a local demand base for green hydrogen and hydrogen products that helps to foster the development of the global market will depend on the existence of economic incentives and clear regulatory signals to make decisions related to the

substitution of gray hydrogen and other fossil fuels such as natural gas with renewable hydrogen.

- The strategy for infrastructure deployment at the various ports should value their potential strengths, including i) potential demand for green hydrogen; ii) proximity to hydrogen or ammonia production and consumption centers; iii) the development of adjacent hydrogen valleys or corridors; iv) the availability of renewable and affordable electric power and other necessary resources (e.g., water); v) the existence of energy, transportation and communications infrastructure, etc.; vi) renewable hydrogen promotion strategies at different geographic levels (e.g., regional, state, etc.); vii) the state of development of dedicated infrastructure; viii) collaboration agreements with other ports, potential exporters or off-takers, etc.; or ix) the level of social acceptance.
- The combination of these strengths and the specific weight of each of them determines the pace of initial development and subsequent scaling of strategies and infrastructures aimed at importing or exporting renewable hydrogen and/or other energy products.
- This strategy must also incorporate and balance in a coherent and consistent manner a short term vision with a medium and long term vision. In an initial phase (short term), for example, the optimal development of infrastructure in the port should probably focus, as a priority, on the local reality and context (demand in the port and in the local industrial sector, development of the hydrogen value chain, etc.).
- From a territorial point of view, it is interesting to promote agreements and alliances between ports in the same market in larger regions (e.g., Northwest Europe) that enhance the strengths and competitive advantages of local ports in the value chain of renewable hydrogen and derived products.

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