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#002

Green Ports
Embracing sustainable practices to future-proof our ports

Ports are essential to global trade as around 90% of all trade is currently seaborne. However, their virtually non-stop industrial activity across the globe means they are responsible for a fair share of the world's air and water pollution.

With the Paris Agreement on global climate change back in 2015, the publishing of the UN Sustainable Development Goals in the same year, and the current world trends towards Net Zero, it is only natural that ports are increasingly interested in sustainable practices and how they can adopt these to align with the SDGs within their area of responsibility.

This has led to the term "Green Port" becoming growingly popular to refer to ports that are taking proactive measures towards sustainable development and environmental awareness.

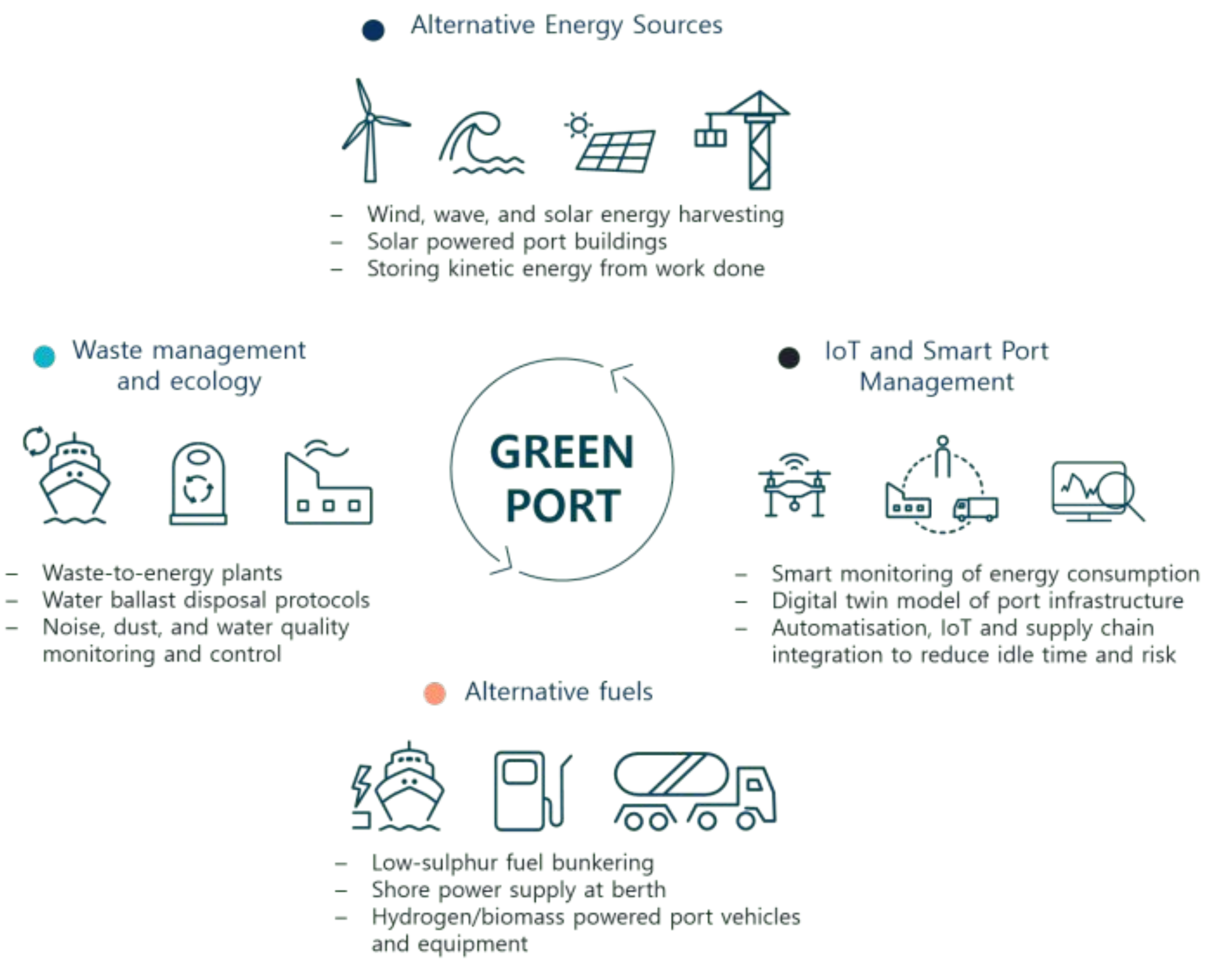
This paradigm shift should not only contribute positively to the planet but it should also help ports future-proof their business in a world where sustainability is making its way up in government's agendas. As at 2020, some of the major environmental challenges the port industry faces are discussed below.

Examples of major environmental and societal challenges faced by the port industry

Although the focus tends to be on air and water pollution from shipping emissions and heavy oil fuels, the wide range of activities taking place within the port area gives rise to a number of environmental and societal threats that cannot be neglected, such as air pollution from road transport and industrial chemical processes, noise and dust pollution from port operations and bulk handling, vessel-generated and port-generated waste collection and management, oil spills and accidental release of hazardous products, increased air and water pollution in neighboring urban areas, ballast water disposal and exchange, and disposal of contaminated dredged sediments.

Measures being implemented by ports

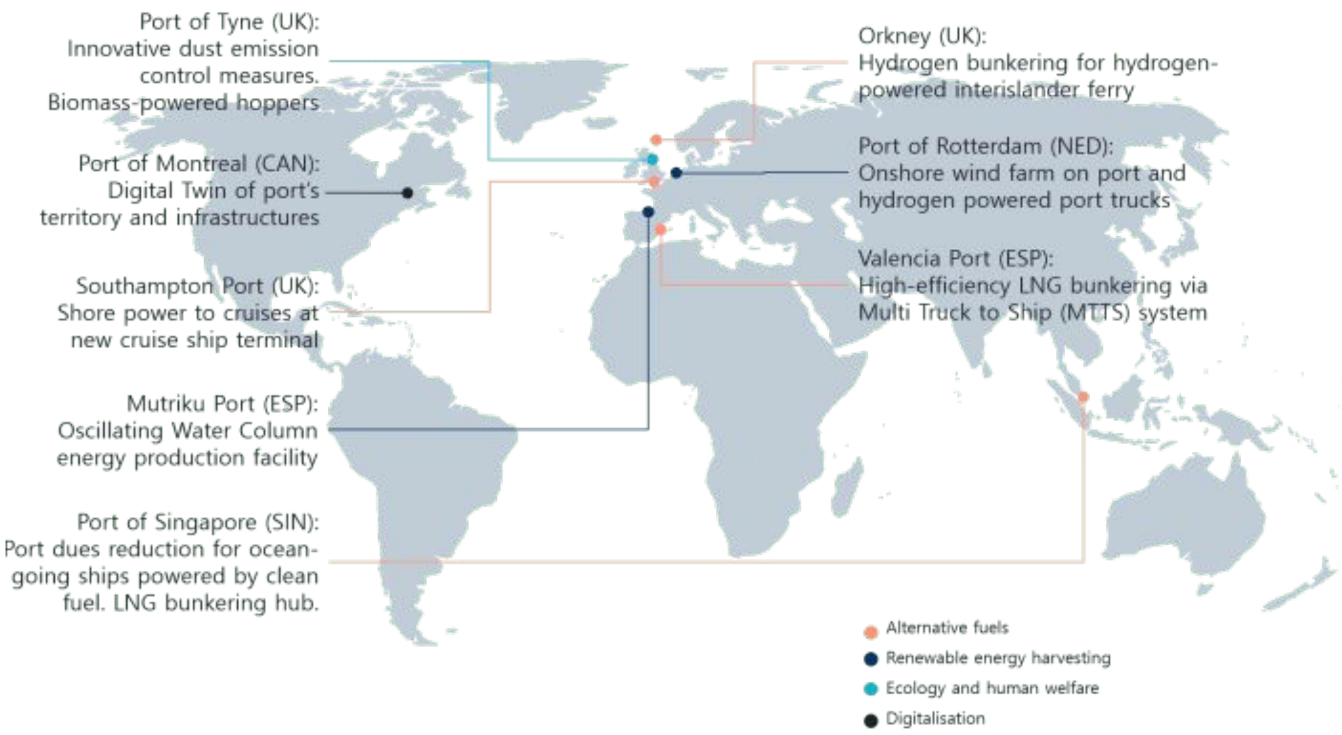
Over the last decade and, in particular, after the release of the IMO GHG Strategy to reduce CO2 emissions across international shipping by at least 40% by 2030, ports have been adopting regulatory, technical, operational and economic actions to start the migration towards a “Green Port” model.



Examples of key areas of development and research within the “Green Port” context

The popularity of the measures and the pace of implementation of these measures is generally closely linked to the investment required and the financial support available. Numerous innovative pilot projects and tried and tested solutions are currently emerging in the port industry.

The figure below shows examples of actual measures currently being implemented across the globe:



Examples of “Green Port” actions being implemented across the globe

Alternative fuels

Currently, the most relevant examples of measures related to the Green port are explained below:

Safe and efficient bunkering of alternative low sulphur fuels such as Liquefied Natural Gas (LNG) are one of the major focuses at the moment. Marine bunkering of other alternative fuels such as hydrogen for hydrogen powered vessels are also undergoing research and development, though it is still an immature market compared to other alternatives such as LNG.

Nonetheless, hydrogen-powered terminal vehicles are being implemented at ports like Rotterdam (NED) and, similarly, the Port of Tyne (UK) is investing in biomass powered eco-hoppers.

The provision of shore power (i.e. cold-ironing) is also becoming increasingly popular to provide an alternative energy source while berthed to stop vessels from using their own generators.

Renewable energy sourcing

The adoption of alternative, cleaner energy sources to fulfill port demands and supply surplus to local grid is also a major trend in the industry.

Initiatives such as the installation of wind mills on port land or wave energy harvesting (utilising the port structures or deploying remote equipment) present great opportunities to take advantage of otherwise wasted green energy thanks to the location ports generally benefit from.

Other measures with scalability potential ports are gradually adopting to obtain clean energy are the solar energy harvesting on roof and façades of port buildings or the storing of energy produced by STS (ship-to-shore) cranes during container lowering to reuse it for hoisting.

Digitalisation for energy efficiency

The digitalisation and, particularly, automatisation and the Internet of Things (IoT) have great potential towards achieving sustainability goals at ports, increasing efficiency and, consequently, improving profit. Examples of applications found in the port context are:

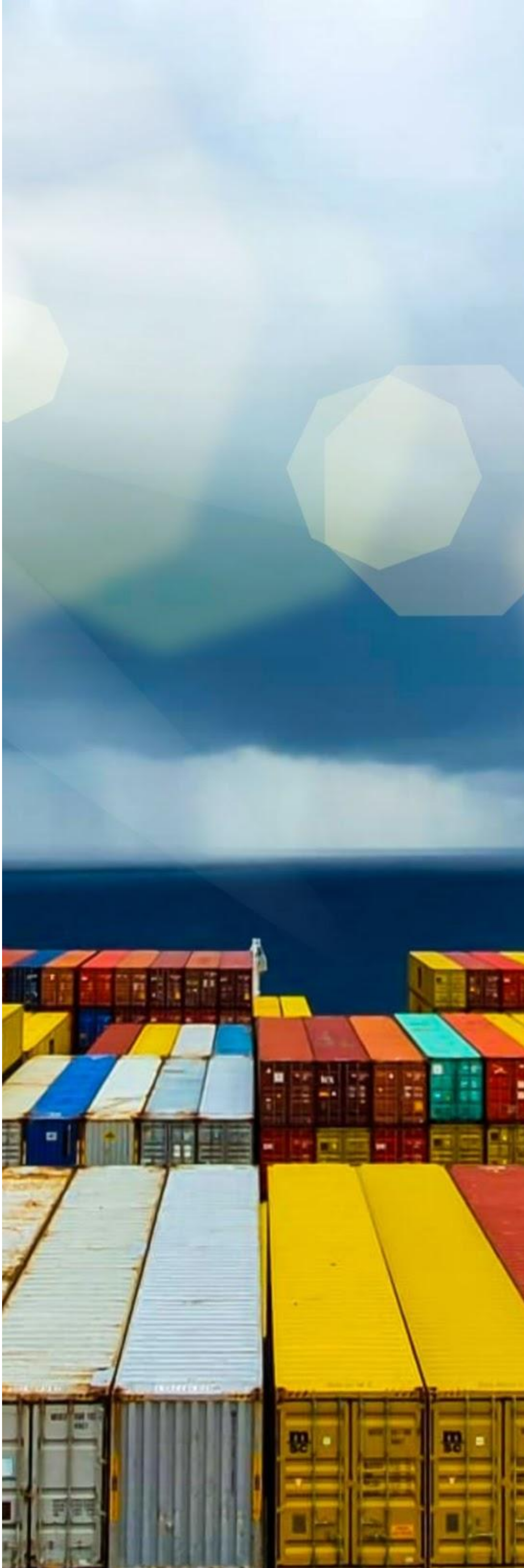
- **Intelligent transport systems and gate controls to minimise wait times.**
- **Optimisation of port calls facilitating just-in-time (JIT) arrival of ships.**
- **Smart port management applications to minimise ship idle time.**
- **Smart monitoring of energy usage and domotics to reduce energy consumption in port buildings.**
- **Digital twin models of the port infrastructure to identify and plan maintenance actions.**

Contaminated dredged sediment management

The stabilization and solidification methods are becoming more and more popular to avoid older, frowned-upon solutions such us landfilling or offshore sediment disposal.

Waste management

A number of ports have or are in the process of building waste-to-energy plants within their land to produce energy from non-recyclable waste to supply to the port and supply surplus back to the local grid.



Ecology and human welfare

Noise, dust, and water quality monitoring allow to take proactive measures to avoid excessive levels of pollution and plan ahead of operations. Substantial investment on dust control measures like dust bosses, skirting on hoppers, and pyramid covers has recently made public by the Port of Tyne (UK), for example.

The devastation of local coastal and intertidal habitat due to discharge of ballast water contaminated with foreign microorganisms is a major issue. Ports must provide safe, adequate ballast water disposal and exchange facilities and have efficient, up to date protocols in place ships must follow to avoid undesired water spills into harbour waters.

Oil spill control

Measures implemented by ports to control accidental spills and reduce harm may include deploying oil containment booms during high-risk operations and ensure oil spill and hazardous matter early-response procedures are in place and up to date.

The role of ports and maritime transportation in the hydrogen future towards the energy transition

Internationally recognized organizations, researchers and governments point hydrogen as a key energy carrier towards the necessary energy transition. Countries with lower potential for renewable electricity will need to import hydrogen from countries with potential for competitive production of hydrogen. This means that international hydrogen supply chains will be created, in which ports are essential nodes in the network.

Hydrogen as a promising option for a sustainable future

Hydrogen (H2), and in particular green hydrogen (CO2-free H2, which is produced by electrolysis of water using clean electricity), is considered as a **promising energy carrier to achieve the global greenhouse gases (GHG) emissions targets** set by many nations in the world. Potential green hydrogen and its derivatives applications include:

- **Steel industry:** shifting from a GHG-intensive to a hydrogen-based steelmaking process.

- **Oil processing and base chemicals:** using green hydrogen instead of grey hydrogen (as it is commonly used nowadays) in refining processes and ammonia production or by replacing current fossil oil-based feedstocks by green H2 in the chemical industry (Power-to-Chem).

- **Energy sector:** for short-term storage (although batteries are a competing and more efficient technology), for long-term storage (in which H2 offer advantages compared to batteries), to reduce the need for the grid expansion (since investment costs of electricity lines are typically lower than for pipelines for H2) or for space heating.

- **Transport sector:** using H2 as a fuel for long distance passenger car travel, heavy duty road freight transport, and smaller boats such as ferries or using H2 derivatives as a fuel (gasoline, diesel, kerosene, methanol, and ammonia) as a replacement of their fossil equivalents, especially in maritime and air transport.

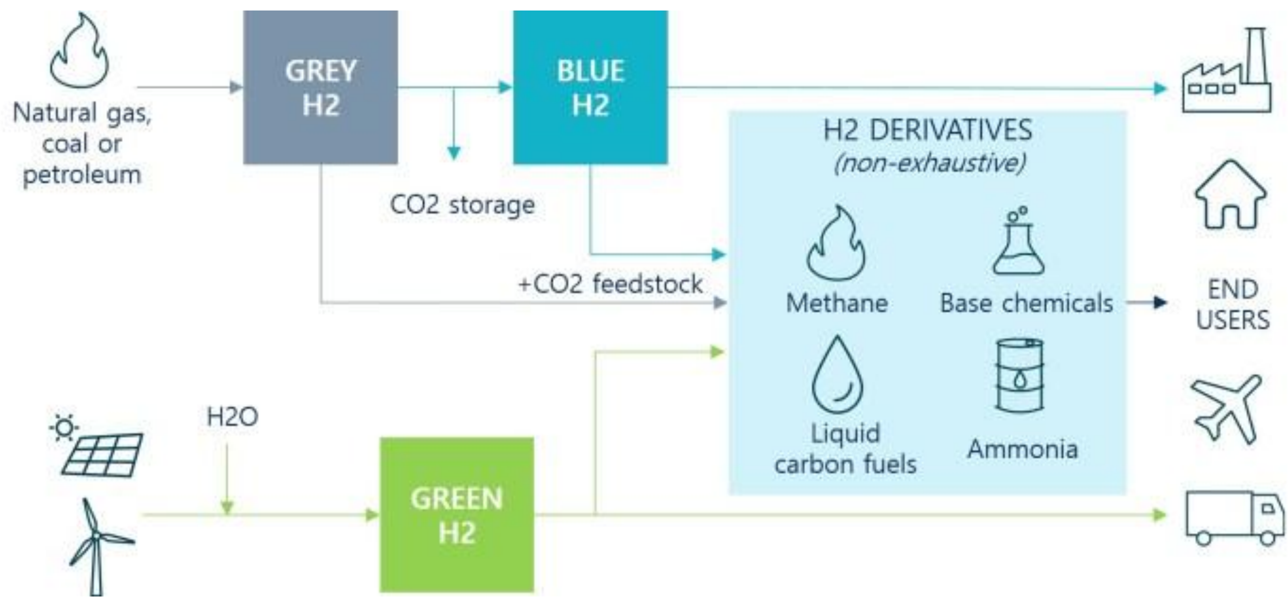


Figure 1. Schematic production routes of hydrogen and its derivatives

Source: Guidehouse

The need to create hydrogen international supply chains to achieve carbon neutral goals

The success of hydrogen for the different applications mainly depends on the technology development cost and the green H2 production cost. Countries with a large and cheap renewable electricity potential are in a better position to produce green hydrogen to both achieve their own climate target goals and to export it to countries located in less favourable geographic conditions, such as North-Western Europe.

Maritime transport of H2 or its carriers may contribute to bridging the imbalance between the geographical demand for green H2 and the regional productional potential, thus opening trade and business opportunities.

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As an example, the Port of Rotterdam predicts a throughput of 20 million tons of hydrogen by 2050. However, only 10% of this volume will be produced with Dutch offshore wind or natural gas, whereas the remaining 90% will need to be imported in order to achieve their climate goals. The imported green hydrogen will need to come from countries where sustainable energy is abundantly available and therefore, green hydrogen production costs are lower, such as Australia, Chile, Iceland, or UAE. The feasibility of these supply chains will depend not only to the production capacity of green energy but also on the stability of the political climate, the development demand (with all its uncertainties), price levels to be reached and competition in supply.

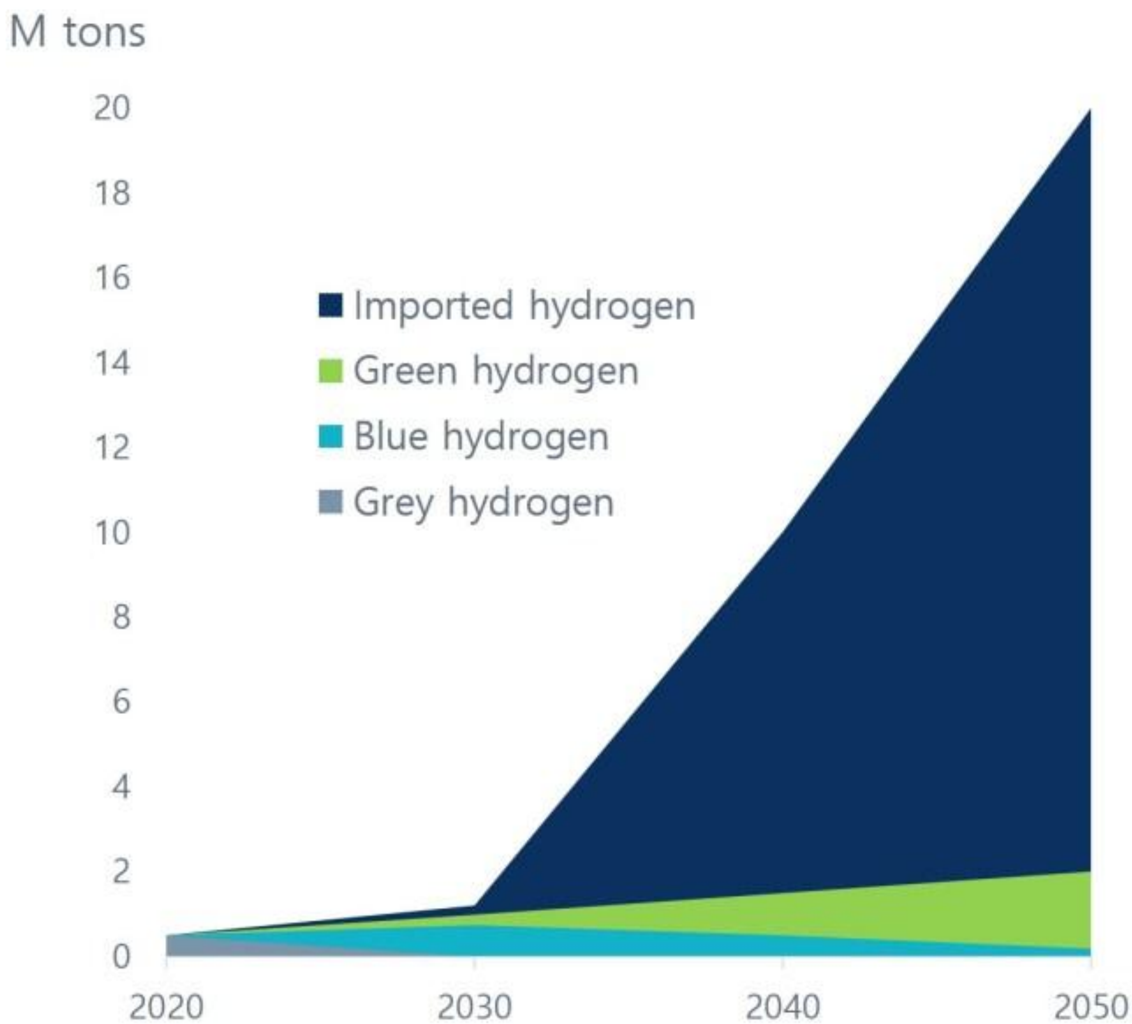

Figure 2. Expected hydrogen flow in the Port of Rotterdam

Source: Port of Rotterdam Authority

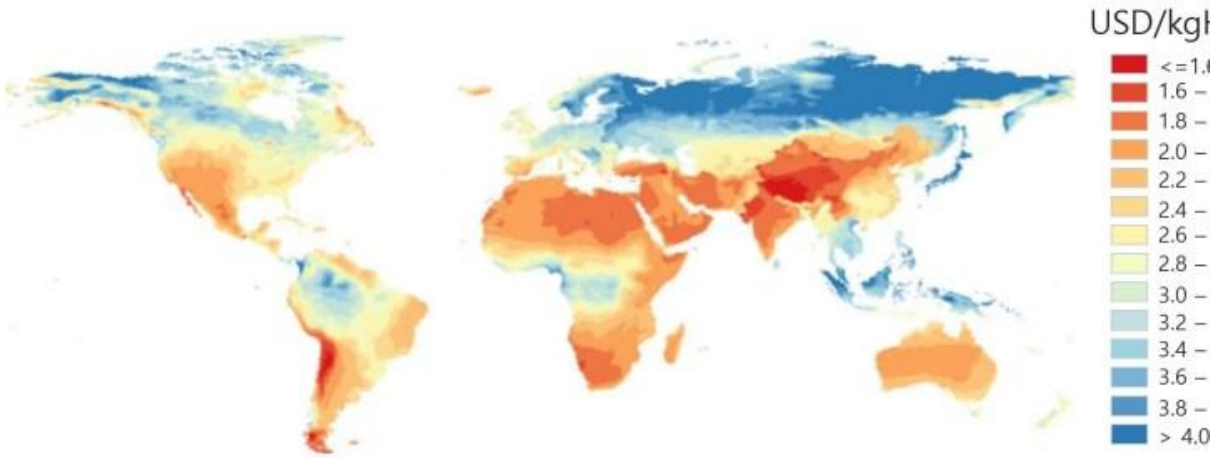

Figure 3. Hydrogen costs from solar PV and onshore wind systems in the long term

Source: IEA (2019). The future of hydrogen: Seizing today's opportunities. Report prepared by the IEA for the G20, Japan.

The global energy system is already strongly based on international trade. For instance, Germany imported 72% of its primary energy consumption in 2019.
In a strive towards decarbonization, it is likely that current energy importer countries will continue to be so, for which hydrogen trade is a very promising alternative.

Besides being a necessity to achieve carbon neutral goals, **trading green hydrogen and derivatives internationally brings the following benefits** for importing and exporting countries:

- **Cost benefits:** renewable energy supply from countries with cheap production potentials can reduce costs of the energy transition for importing countries.
- **Volume benefits:** some countries may have a large technical potential for renewable electricity (larger than the demand) but in practice many potential sites cannot be used for renewable electricity generation (e.g. land use by agriculture).
- **Seasonal benefits:** international trade of renewable energy could match complementary patters of supply-demand (e.g. high demand in north Europe in winter and in UAE in summer), leading to better resource utilization and lower system costs.
- **Diversification benefits:** exporting synthetic fuels (produced from H2) could diversify fossil fuel exports and compensate for shrinking oil exports in the course of long-term decarbonization.

The formation of stable international hydrogen and derivatives market require the feasible and reliable transportation of these energy carriers. The two main promising options for large-scale hydrogen transport at a considerable distance (over 1,500 km) are pipelines and shipping.

Pipelines are economical at large traded volumes due to economies of scale in pipeline construction and high-fixed costs, and for lower distances.

Although it is a promising option if existing natural gas pipelines are retrofitted, **shipping becomes the preferred alternative for long-distance and deep-sea transport**, which will be the case, for example, for the trade between North Europe and south hemisphere potential exporting countries. The distance of the breakeven point between pipelines and shipping is still debatable, but it is expected to be around 3,500 km as estimated by the International Energy Agency.

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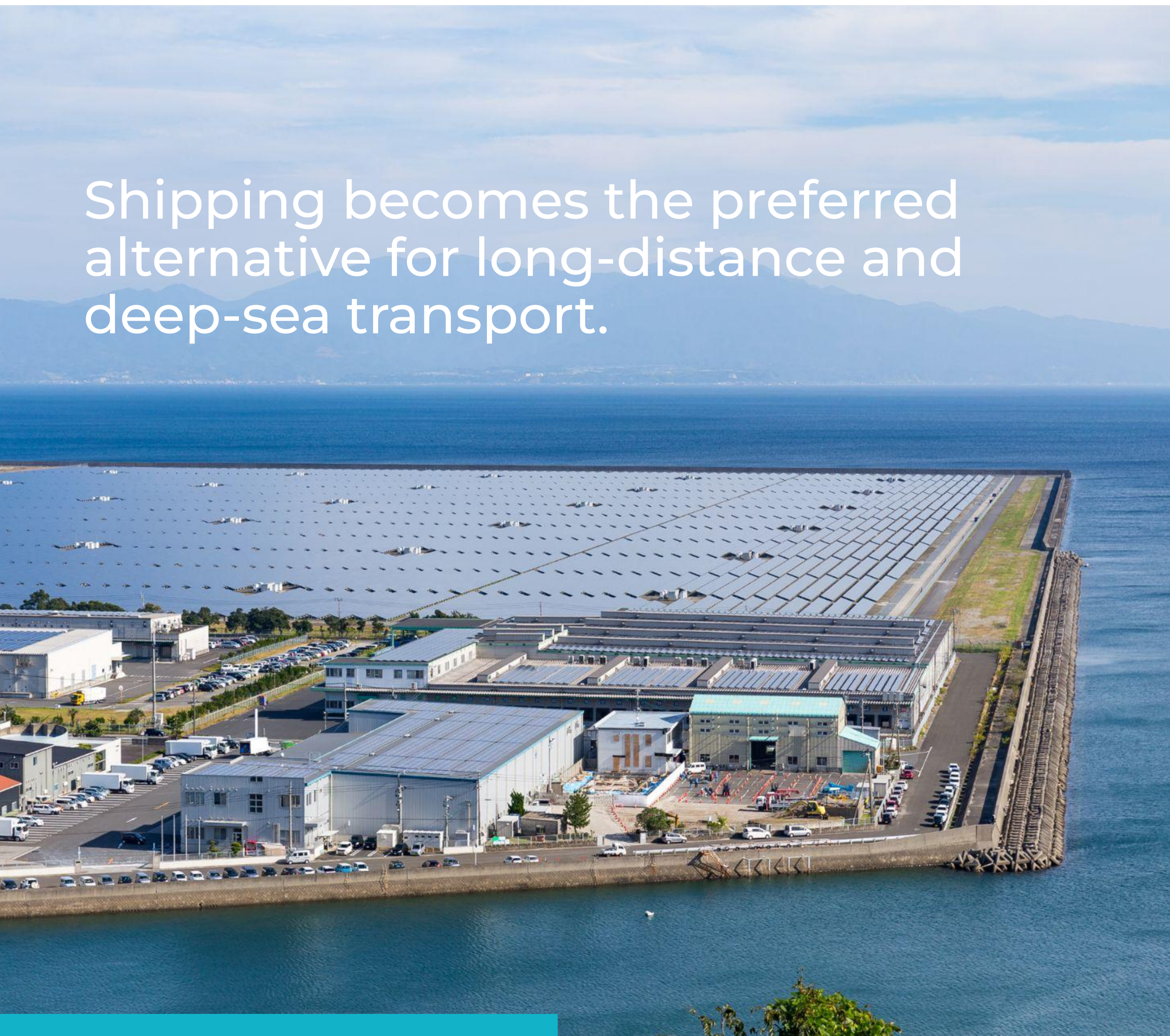

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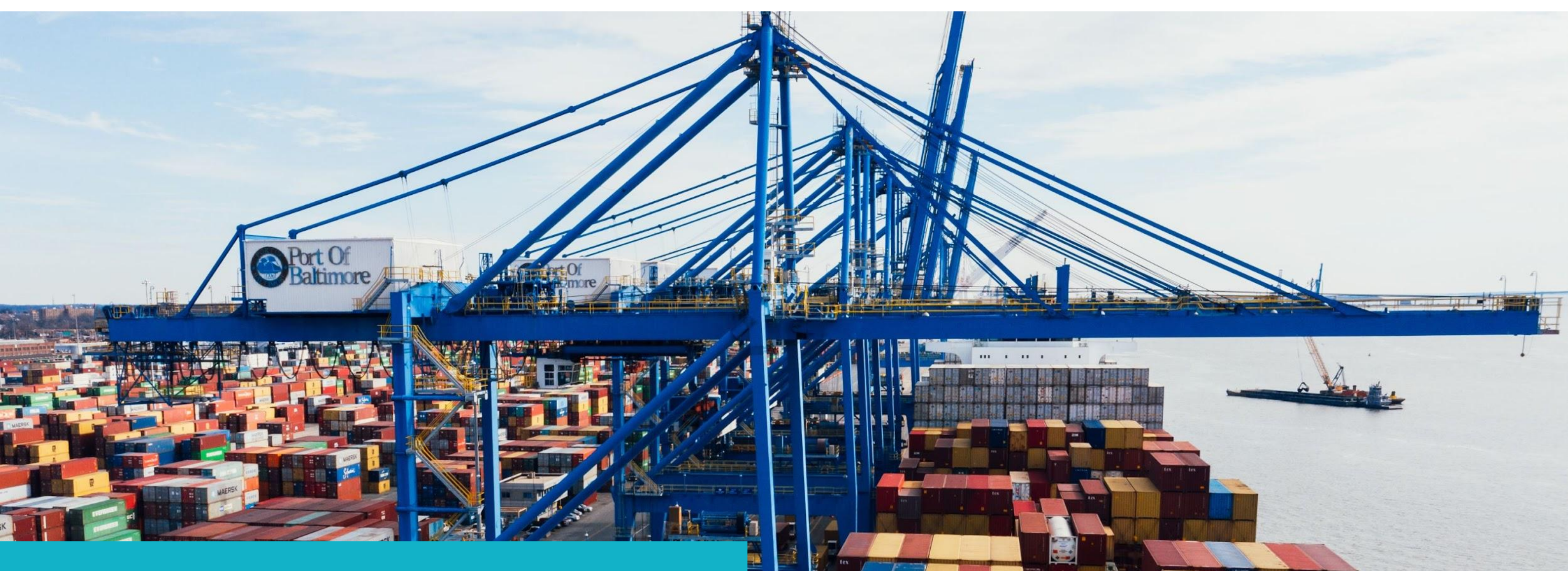
The role of ports and shipping in the hydrogen market

Considering the previously described benefits of trading H2, it is expected that H2 trade will occur between regions located at a considerable distance. Therefore, maritime transportation of hydrogen is essential to develop these supply chains, for which ports are the origin and destination nodes. Additionally, shipping offers advantages for smaller trading volumes and import terminals require less upfront investment than pipelines.

Rather than the shipping distance, **the main factor that influences the feasibility of hydrogen maritime transport is energy density**, due to vessels space limitation. Gaseous H2 counts with a very low energy density, so in that sense, alternative carriers are more favourable:



- **Liquid H2** energy density is almost twice as high as gaseous H2 (at 700 bar) making it a more attractive transport form; however, the liquefaction process consumes approx. one-third of H2's energy content. In addition, liquid H2 transport conditions are challenging and the process of loading and unloading could induce H2 losses.

- **H2 derivatives** are easier and cheaper to transport due to their higher energy density, lower volatility and easier storage requirements.

Nevertheless, conversion and reconversion processes at origin and destination incur in high costs and energy losses. These costs are expected to decrease with economies of scale. The advantage of some H2 derivatives like ammonia is that they can be used directly for some final applications (e.g. as feedstock for the chemical industry) and no reconversion to H2 needs to take place, avoiding the associated costs and energy losses in the process. Loading and unloading of H2 derivates at ports do not pose any difficulties since it is a common practice in the present.

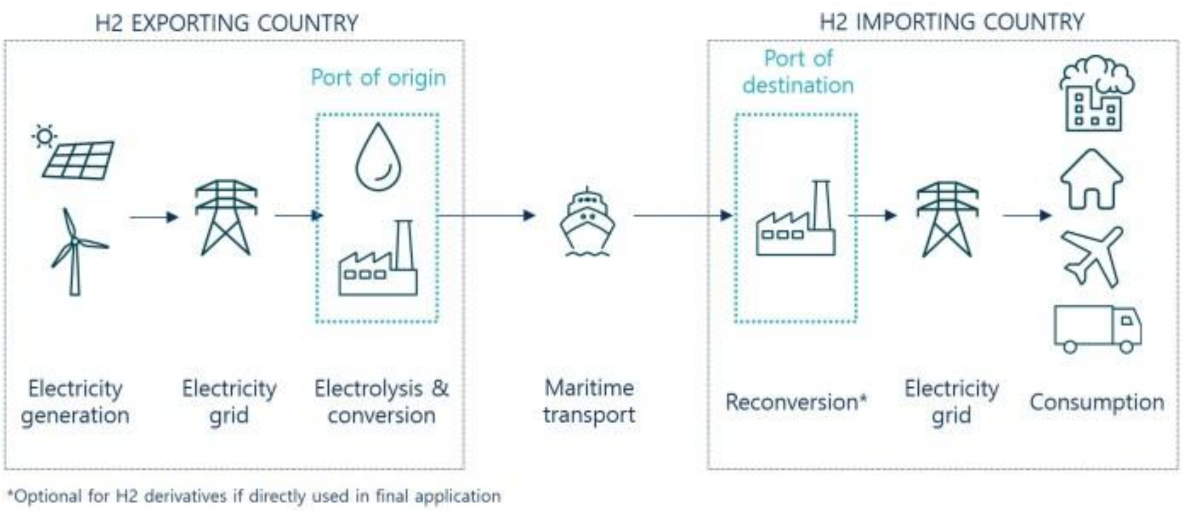


Figure 4. Schematic overview of the hydrogen supply chain through maritime transportation

Source: ALG

The first generation of liquid H2 ships are currently being developed based on LNG ships. They are small scale ships with a limited capacity (170-300 ton H2 per ship), making transport a relevant cost in the supply chain. However, it is expected that **transport costs will reduce significantly in 2030 thanks to the increase of vessels capacity** (up to 6,500-11,000 ton H2 per ship) which will be specifically developed for liquid H2 and derivatives, paving the way for large-scale maritime hydrogen transport. The most impactful costs of the transport chain will then be shifted to the port storage infrastructure.

Are ports prepared for the projected future hydrogen supply chains?

The answer is clear: not yet. However, ports located in the main potential importing and exporting countries are in the process of studying how to do so, and pilot projects are under development.

There is potential for retrofitting existing infrastructure of ports industrial and petrochemical clusters such as oil and gas pipelines, marine loading arms, jetties, or tanks. Moreover, derivatives such as (grey) ammonia are already handled in numerous ports. The alternative option would be developing new hydrogen import and export terminals or ports, for which an optimal site shall be selected based on supply and demand locations, physical conditions or synergies with existing infrastructure, among other factors.

The main investment for existing ports lies on the H2 conversion and reconversion plants, which are yet to be developed in existing ports. Using centralised (re-) conversion plants lower the costs compared to decentralised processes, since H2 double handling and transport can be avoided by injecting the H2-based electricity directly into the existing grid. This will undoubtedly favour the development of future hydrogen supply chains and is a key development for ports located in future H2 exporting and importing locations.

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