

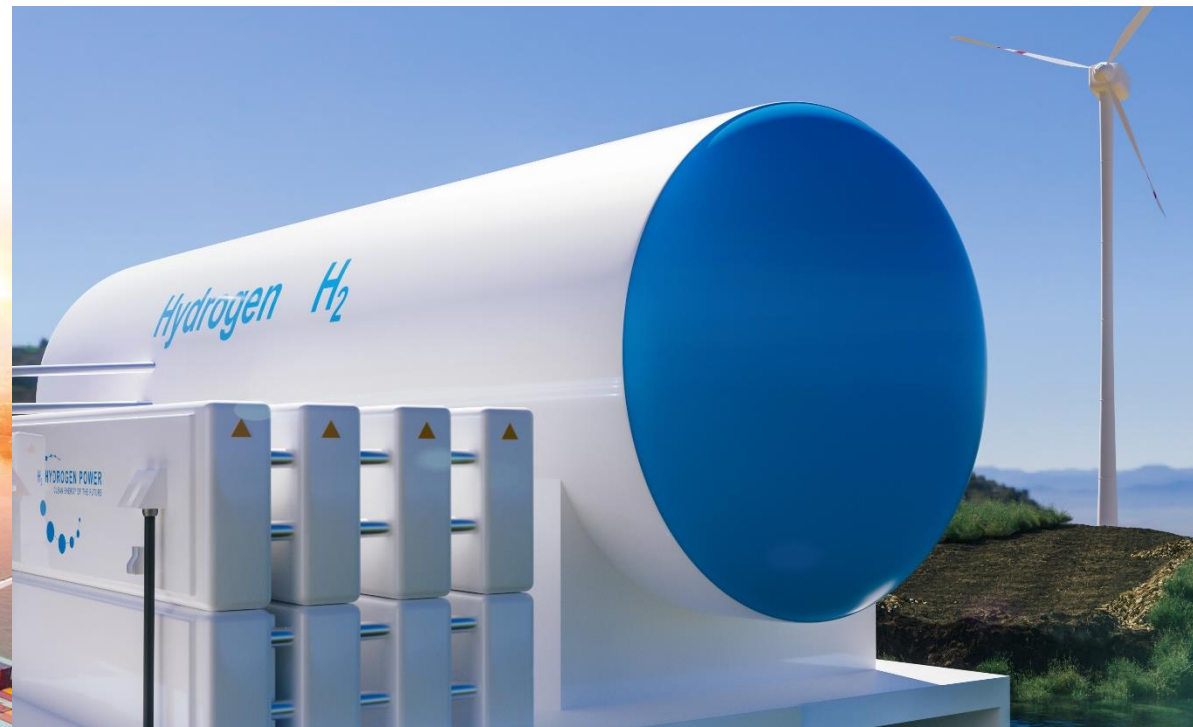


WHEN TRUST MATTERS

Ports: Hubs for powerfuel transport and distribution

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24 June 2021



DNV- An independent assurance and risk management company

157
years

~12,000
employees

100,000
customers

100+
countries

5% R&D
of annual revenue

**Ship and offshore
classification and advisory**



**Energy advisory, certification,
verification, inspection and
monitoring**



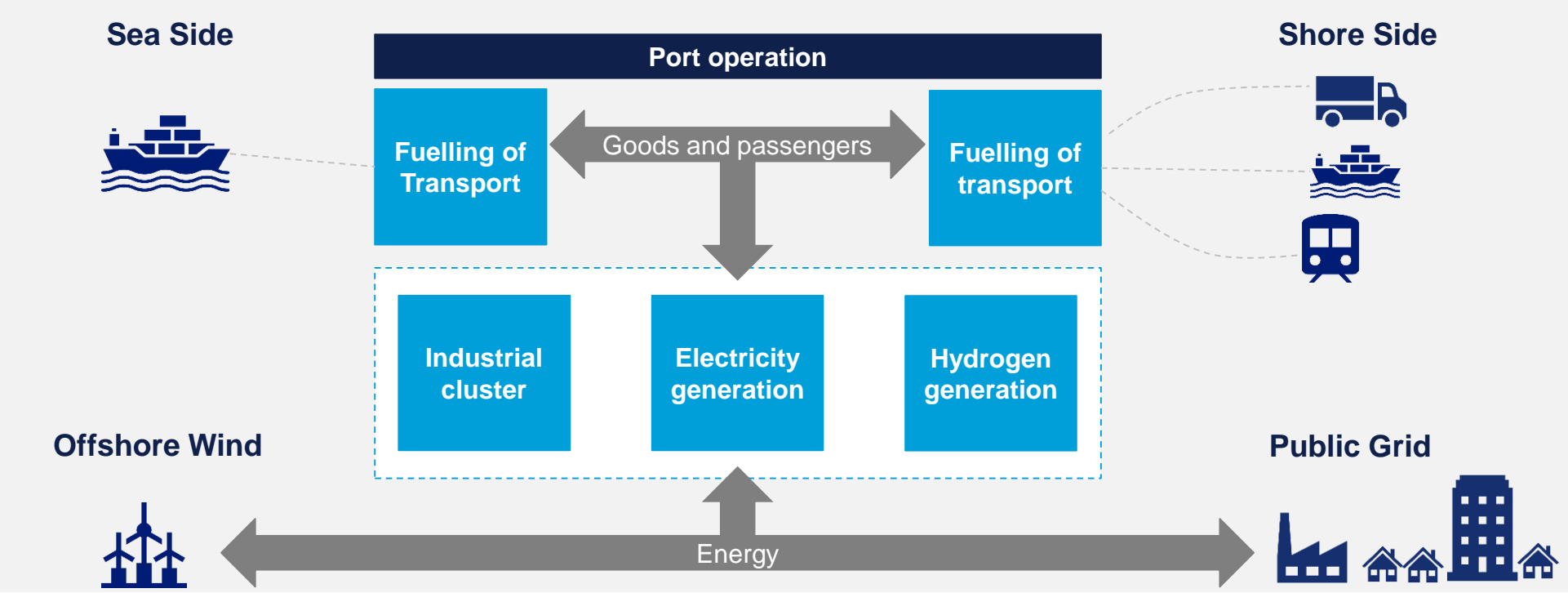
**Management system
certification, supply chain and
product assurance**



Software, platforms and digital solutions



Ports are pivotal for sector coupling in the energy transition as they are centres of energy use, import and export. Focused strategies around ports will provide the momentum for the upscale of hydrogen.



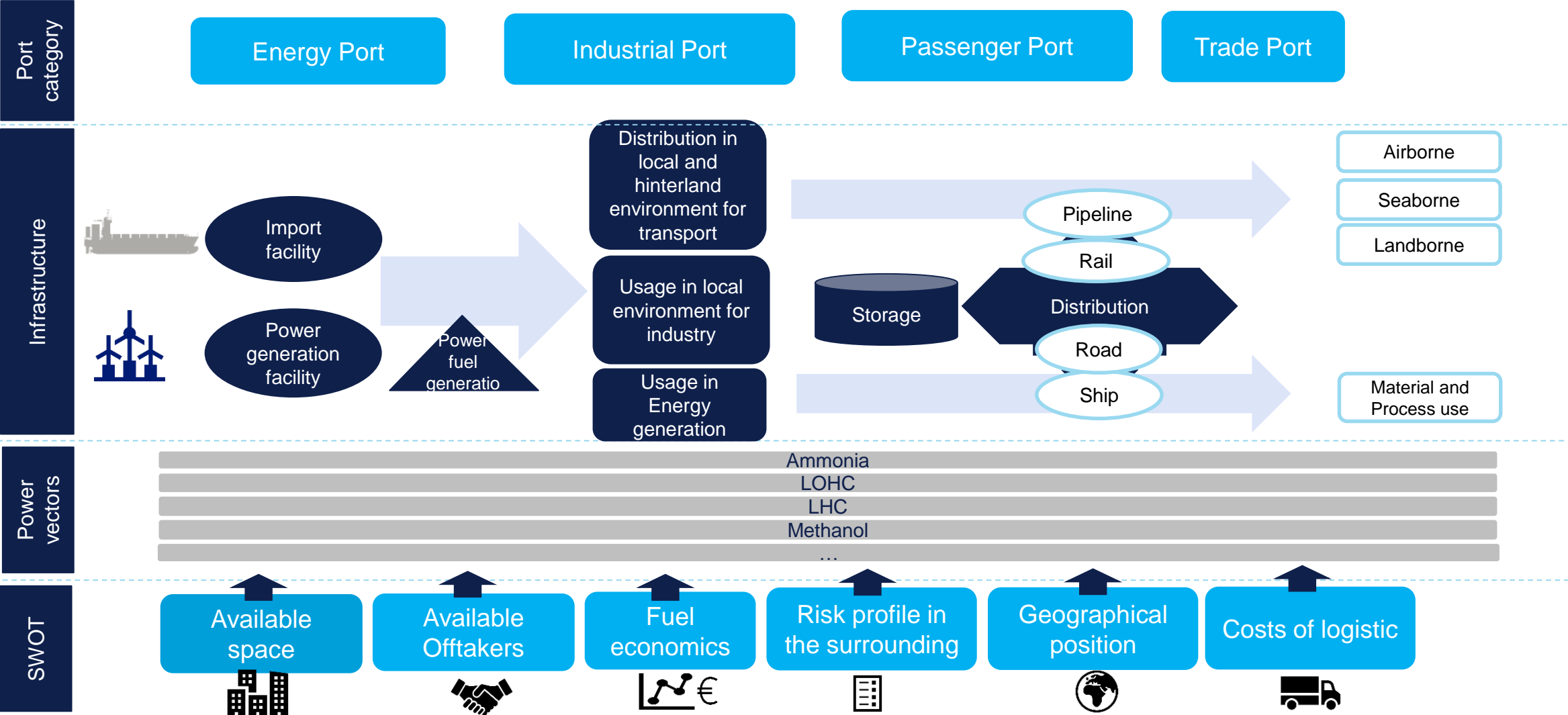
Port Authorities:
Decarbonize operations and reduce energy costs

Maritime sector:
Emissions and pollution reduction

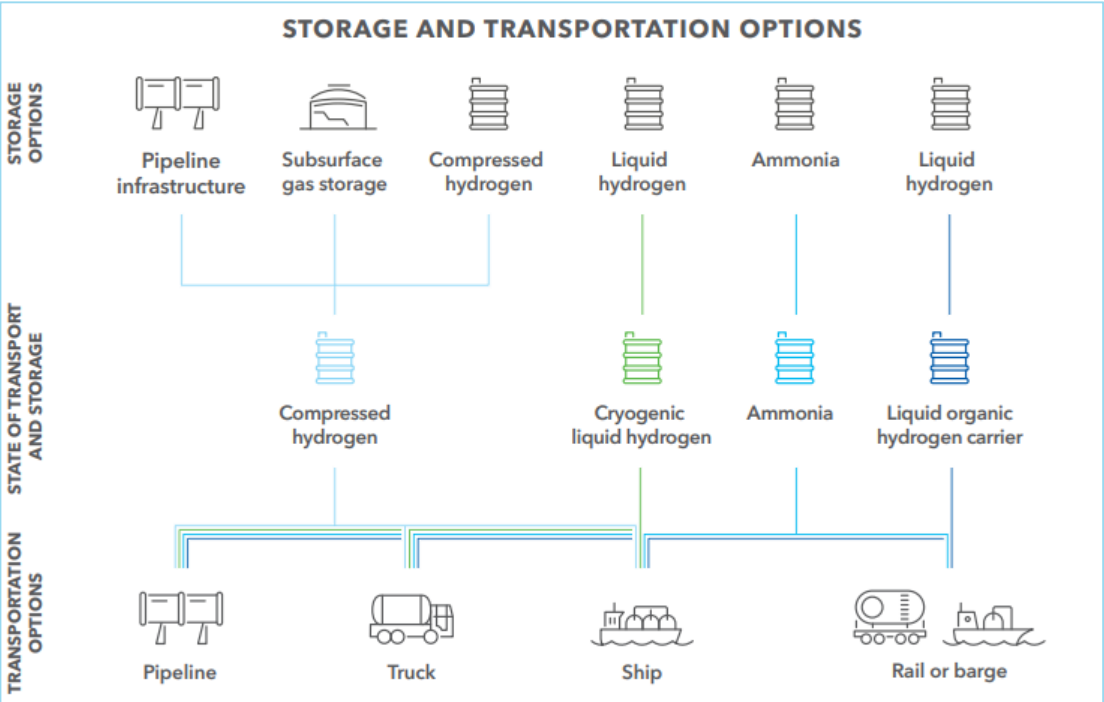
Utilities:
Emissions reduction and asset replacement

Industry:
Emissions reduction and technology selection

Depending on the port category, the existing infrastructures and locational possibilities the P2X strategies need to be developed individually.



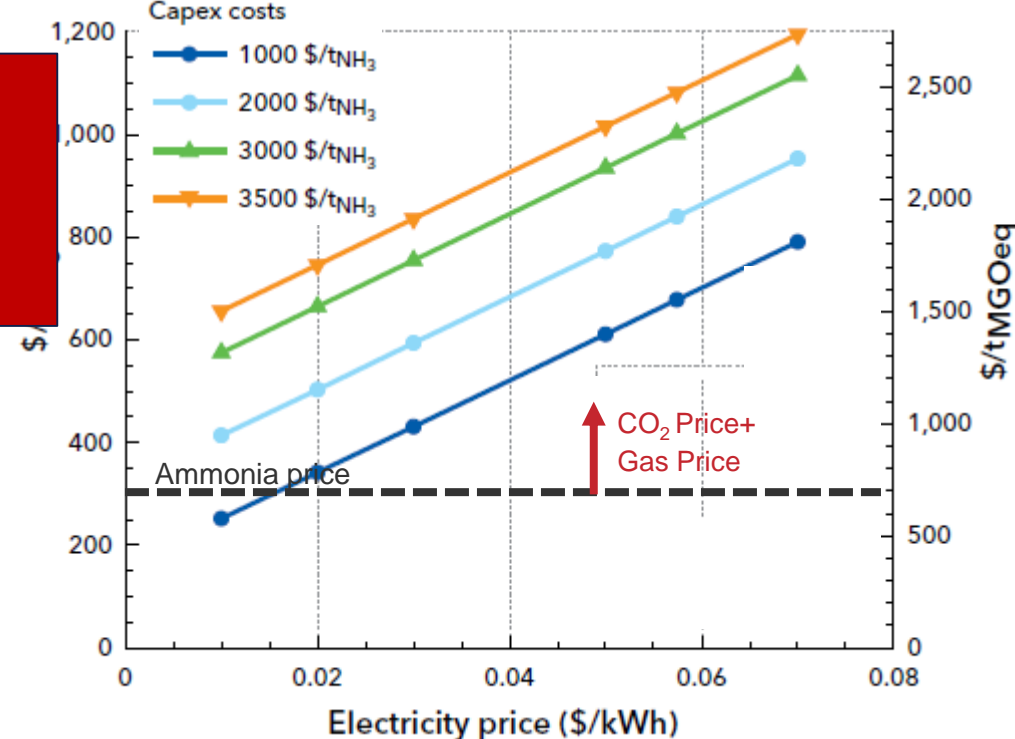
Power fuel decisions will be based on their specific profile in an given port environment – and also on the reusability of existing infrastructure.



	Liquid Hydrogen	Compressed pure Hydrogen	LOHC	Ammonia	Gas blended with H2
Storage					
Tank	new	existing to scale for high volumes	existing	existing	existing
Underground	n.a	existing to scale	-	n.a.	existing
Pipeline	n.a. on large scale		-	n.a. on large scale	existing
Transport					
Pipeline	-	possible - but due to integrity of the pipeline to be investigated case by case	-	n.a. on large scale	existing
Ship	new	n.a.	existing	existing	existing
Truck	new	existing	existing	existing	existing
Rail	new	existing	existing	existing	
Advantages					
Distance	++	pipeliens for longer distance	+++	+++	++
Volume	++	+++		+++	+++
Purity	+++	Ship or trucks favorable over pipeline	Cleaning required and possible	cracking required and high purity possible	-
Conversion losses			20-25%	20-25%	

Capex cost and electricity price influence the price for P2X fuels (e.g. a ton ammonia from less than 250\$/tNH3 up to 1200\$/tNH3)

Production cost green ammonia [USD/t_{NH3}] in relation to electricity price

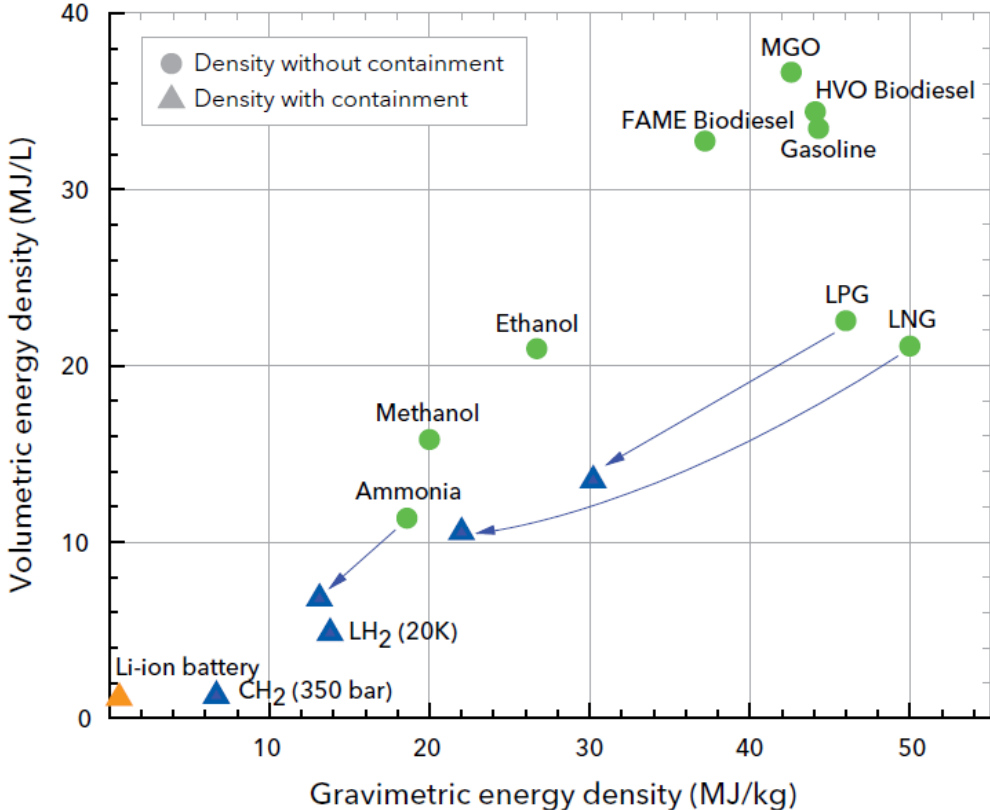


Source: DNV "Ammonia as a Shipping fuel", 2020
MGO = Marine Gas Oil

- 1.5 t_{CO2}/t_{NH3} is released by conventional production of ammonia → The price of brown ammonia is connected to the CO₂ price
- The CO₂ price in Europe 2025 will be between 30€/ t_{CO2} (DNV Energy Transition Outlook 2020) and 55€/t_{CO2} (German tax system for private CO₂ emissions)
- Electricity prices between 0.03 and 0.05 \$/kWh are possible for green energy in 2050 in Europe – even lower prices are possible in areas closer to the equator especially for PV.
- The key challenge in green ammonia plant design is the limited flexibility of the Haber-Bosch (HB) synthesis loop, which is unable to mirror the incoming variable renewable energy profile.
- In a first instance, hydrogen storage can mitigate the HB flexibility requirements. However, new HB technology will likely have increased flexibility to reduce the need for hydrogen storage, and thus reduce cost.

Depending on role e.g. for ship fuels the lower volumetric energy density of new fuels such as ammonia with a combination of larger tanks and more frequent bunkering stops

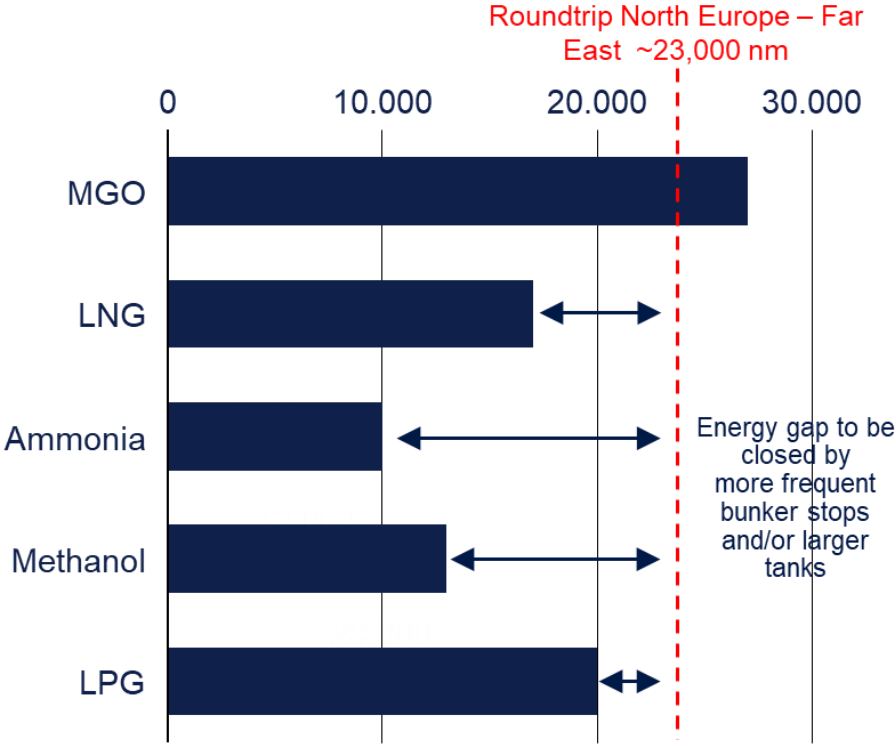
Energy densities of different maritime fuels



Source: DNV

Mileage of ULCV with full tank with 12.000m³ [nm]

Ultra large container vessel (ULCV),
 24,000 teu, 75MW



Source: DNV



Port internal strategies need to be accompanied by governmental stimulus and consistent regulation.

1 Stimulate P2X of port-connected activities in key ports

2 Facilitate a stakeholder dialogue between ports and the different stakeholders (maritime, industry, power) to gain momentum

3 Funding research, development and innovation

4 European coordination for environmentally friendly incentives and fees for maritime through ports

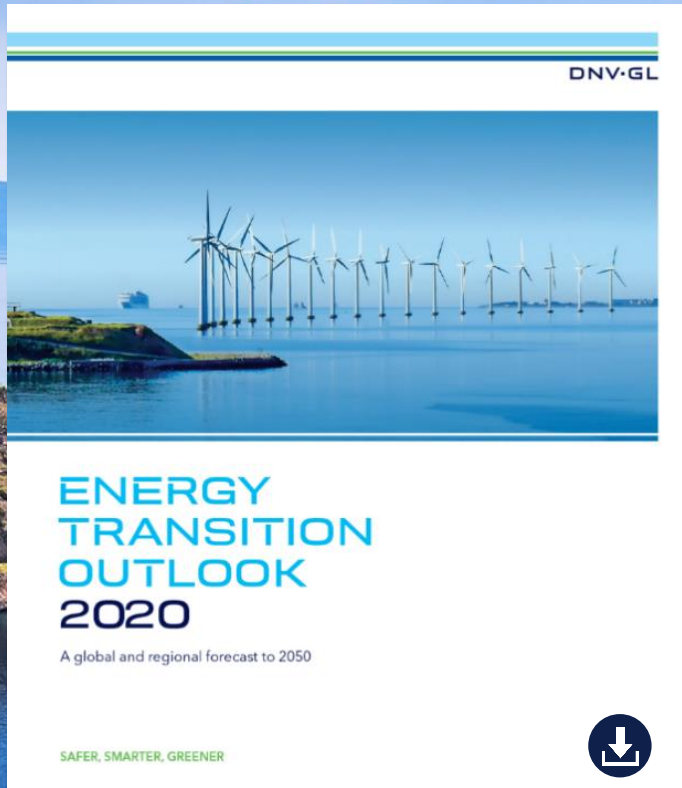
5 Support the initial investments for hydrogen production through electrolysis at ports

5 Support fast development of new permitting procedures

Thank you for your attention!

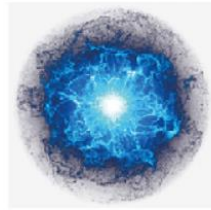
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Heading for hydrogen

The oil and gas industry's outlook for hydrogen, from ambition to reality



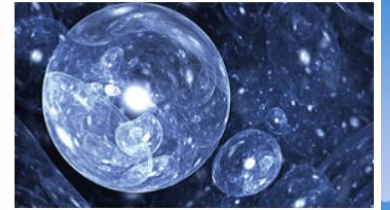
Hydrogen as an energy carrier

Forecasts decarbonization driving significantly greater use of hydrogen for energy by 2050



Hydrogen - Decarbonizing the heat

The benefits and challenges of hydrogen in decarbonizing



Hydrogen in the electricity value chain

More variability in the generation and demand of electricity

Putting our expertise to the test

ISO 17025 Accredited



Gas analytical laboratory

Analyses of oils and gaseous fuels



Engines laboratory

Fuel combustion behaviour and performance testing



Technology Qualification

Multi purpose laboratory for sustainable technology testing



Fuel Research

Facilitating the introduction of new fuels



Multi-phase flow laboratory

Testing with different fluids (liquids, gases & solids)



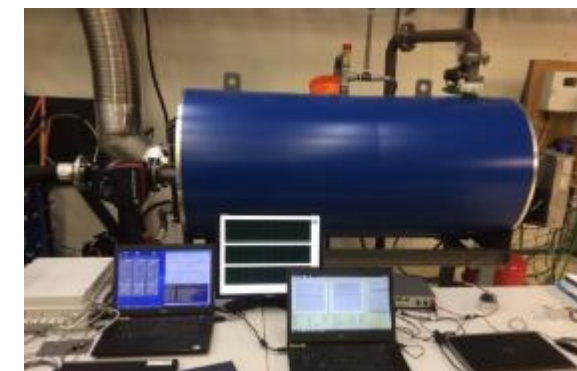
Flow Calibration centres

Flow testing and calibration in the UK and NL



Hydrogen Research

Full-scale hazardous trials in simulated real-world environments.



Hydrogen test facility

Development qualification of safe and reliable equipment