Hydroville - The first classed vessel with dual fuel Hydrogen Diesel combustion engines

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CMB Technologies

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- Who is CMB/CMB Technologies?
- Why hydrogen and why combustion engines?
- The Hydroville showcase project and results D4 HyPenta
- Marine projects with hydrogen
- Q&A

CMB (Compagnie Maritime Belge) owns/operates 90 ships

- CMB is a maritime group with its registered office in Antwerp and was founded in 1895.
- The group consists of 4 divisions:
  - Bocimar: active in dry bulk shipping
  - Delphis: container fleet, mainly ice classed
  - Bochem: chemical tanker fleet
  - CMB Technologies

https://www.youtube.com/watch?v=hkfxWEMQE40

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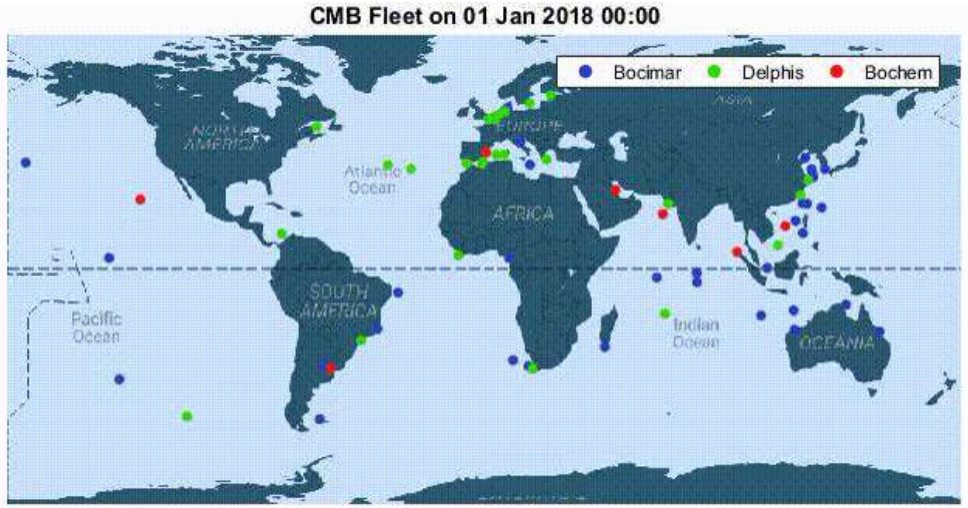
CMB Technologies is the Innovation & Development division of CMB

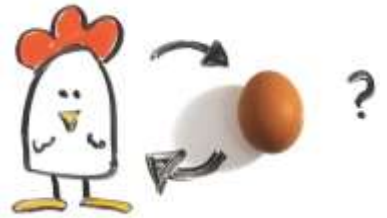
- The division focusses on:
  - Fleet performance monitoring
  - Weather routing software
  - On-board battery pack to reduce emissions for redundancy power
  - Hydrogen technology
  - Energy saving technologies
- Goals:
  - Implementation of cost saving technologies
  - Improvement of the operational performance
  - Reduction of emissions
  - Assure that the new builds are future proof



To achieve 'green shipping', Hydrogen technology is the way forward

- Batteries: Ships require a large energy buffer, resulting in a battery size which is too large, too heavy and too expensive. There are no means to charge this battery during port call;
- Photo-Voltaic panels: the ship's surface is not big enough to even provide 10% of the required power;
- Wind energy: more interesting for slow sailing vessels. Deck space is challenging, but with a projected saving of 10-30% the IMO limit of 50% GHG reduction can not be reached;
- Nuclear: too expensive, not insurable, requires too much personnel;
- LNG: Due to methane slip during production, storage & combustion, GHG effect saving is almost zero;
- Bio fuel: not enough biomass available;
- E-fuels (with Hydrogen as a base):
  - Ammonia: toxic, ADR complexity and produces more NOx during combustion;
  - Methanol: Can be a good solution to solve the storage problem of hydrogen. But the conversion step from Hydrogen to methanol will cost energy. And methanol still emits CO_2 during combustion.
  - DME: same as methanol, it still emits carbon.

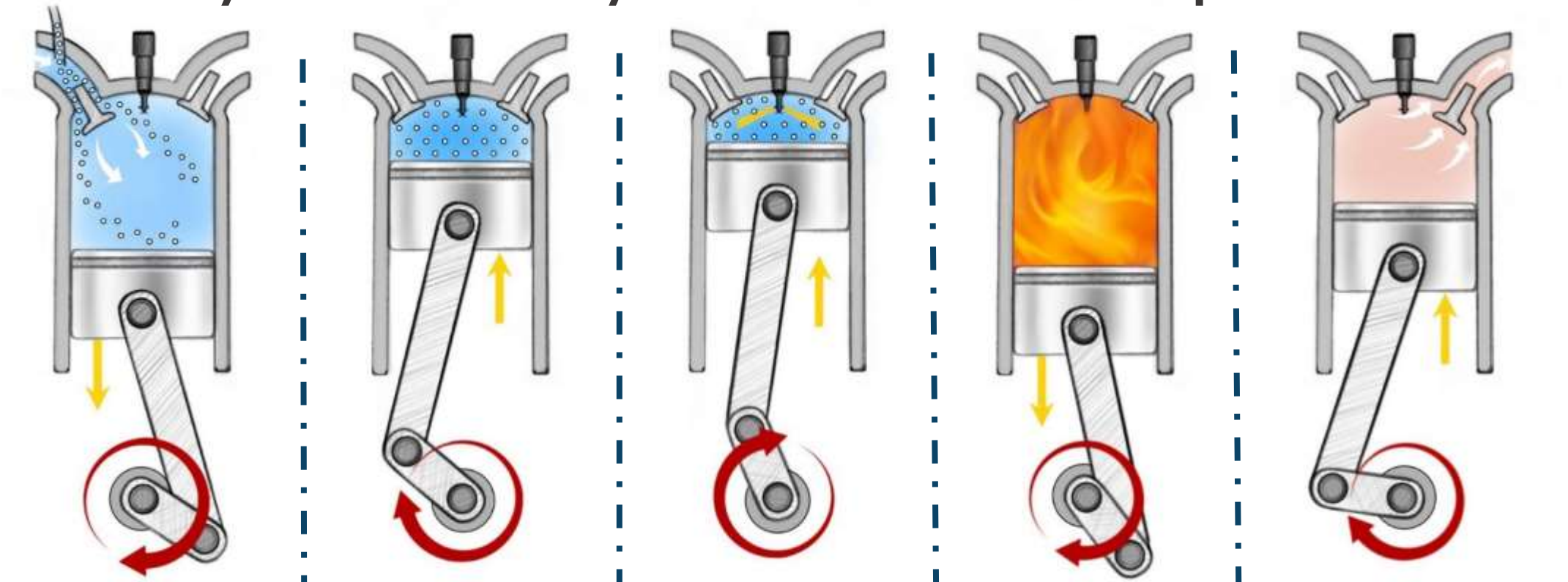
Before 'zero emission technology' can be used widely, one needs a 'low emission technology' as kick starter



- Most people are convinced that H_2 is the future solution to make the energy transition happen, but how to get there is still unclear for heavy industries.
- The transition is mainly blocked by the following:
  - Price: H_2 and fuel cell technology are still very expensive. More than double the diesel variant costs is the standard in CAPEX and OPEX.
  - Reliability/availability: Lifetime is not proven for industrial use yet . Impurities in H_2 or in the air can damage the fuel cell. The amount of H_2 refuelling stations is still limited.
  - Experience: Less knowledge available for problem solving of issues with the H_2 drive train makes it difficult to guarantee a service where penalties are applied.

- A dual fuel hydrogen diesel technology can lower the hurdles to make the energy transition happen. With this low emission technology you can always rely on the proven concept of diesel.

Hydrogen-Diesel co-combustion: ability to combine fuel flexibility and efficiency with environmental performance



Hydrogen is injected at the port and aspirated in the cylinder during intake stroke

Hydrogen mixes further into a uniform and homogeneous mixture during the compression stroke

A small amount of pilot fuel (diesel) is injected into the chamber just before top dead centre

Diesel auto-ignites (due to high temperature and pressure) and co-combusts with all the H_2, forcing the piston down during the power stroke

The cylinder is cleaned during the exhaust stroke, having lower NO_x and CO_2 emission in the exhaust gas

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Hydroville Showcase Project

HYDROVILLE

https://www.youtube.com/watch?v=5kNxUqClDno

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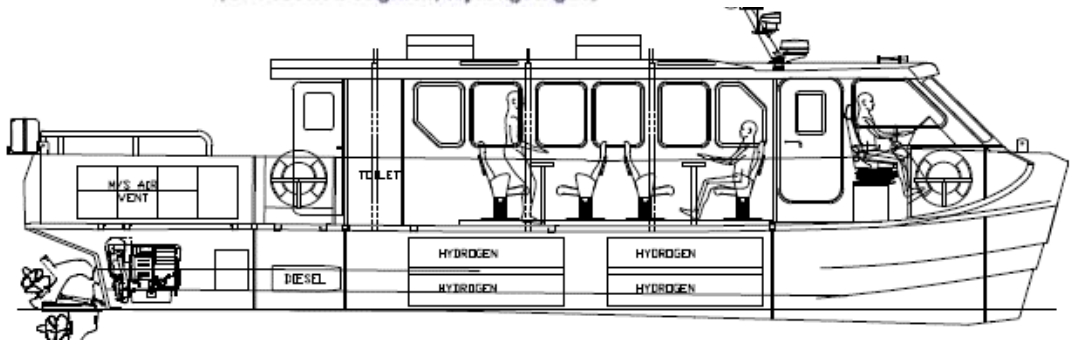
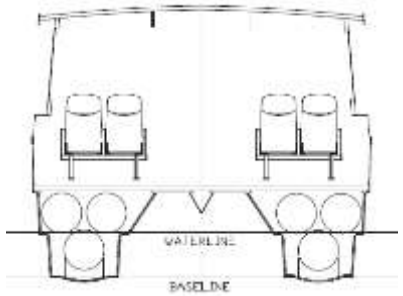
Hydroville: Hydrogen Powered Catamaran (hi-speed with non-planing hull)

GENERAL SPECIFICATIONS

Passenger shuttle

Length	14 m
# of passengers	16
Beam	4.2 m
Max Draft	0.65 m
Displacement at full load	14 ton
Lightweight	12 ton
Propulsion	2x dual fuel (diesel and hydrogen) internal combustion engines (H2ICED) with a total shaft power of 441kW
Fuel	12 hydrogen tanks (205 liter @ 220bar or 36kg of useable hydrogen) and 2 diesel fuel tanks (2×265 liter) as pilot/backup fuel
Max speed	27 kn
Cruise speed	22 kn
Classification notation	Lloyd's Register ✠100A1 Special Service Craft, Crewboat, Catamaran, High Speed Craft, G2, MCH Descriptive note for Low Flash Point Fuels (Gas fuelled engines, Hydrogen gas)





SPECIFICATIONS H_2 TANKS

Cylinder life	20 years
Weight	66kg (35kg aluminium liner, 31kg composite laminate)
Water volume	205 liter
Service pressure	200 bar
Max. developed pressure	260 bar
Test pressure	300 bar
Min. burst pressure	558.4 bar
Working temperature	-40°c to +82°c
Hydrogen Cylinders Frame Structure	Stainless steel 316L
Supported frame accelerations	Forward 12g, afterwards 2g, transverse 2g, vertical 2g

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Since the launch of the Hydroville, CMB could establish a cooperation with Volvo Penta

- With the support of Volvo Penta, the diesel injection timing on the D4 could be optimised for hydrogen. Without hardware modifications to the base engine, significant emissions savings were achieved:

Engine Parameters				Diesel Mode			Hydrogen Mode					Improvement	
Speed rpm	Power kW	Speed kn	Torque Nm	Diesel Flow l/h	NOx g/kWh	Efficiency %	H2 factor %	Diesel Flow l/h	H2 Flow kg/h	NOx g/kWh	Efficiency %	NOx decrease	Efficiency increase
2000	56.5	11	270	17.3	9.0	32.1	65	5.21	2.97	2.8	37.2	-69%	16%
2200	72.6	12.6	315	20.3	7.1	34.6	64.3	6.82	3.6	2.74	38.3	-61%	11%
2400	90.5	14.4	360	26.3	7.5	36.1	59	9.76	4.07	2.29	38.6	-69%	7%
2600	106.2	16.5	390	29.1	6.1	35.3	60.5	10.9	4.85	1.99	39	-67%	10%
2800	**124.6**	**18.7**	**425**	**34**	**6.3**	**35.7**	**55.2**	**14.36**	**4.86**	**2.19**	**40.4**	**-65%**	**13%**
3000	144.5	20.8	460	38.5	5.6	36.4	51.9	18.15	4.9	2.73	41.5	-51%	14%
3200	169.9	22.7	507	45.1	5.1	36.4	47.8	23.25	4.89	3.63	42.2	-29%	16%

- At a cruise speed of 19kn, the total CO_2 savings is 62% (H2 displacement factor plus higher thermal efficiency) and the NO_x savings 65%.
- The high torque request by the propeller (high BMEP) in combination with the high compression ratio of the base engine limited the max. H_2 displacement. Tests have been conducted up to 92% of H_2 displacement with ultra low NO_x.

The complete project was realized within a timeframe of 1.5 year

- First ideas of the project were generated in June 2016
- By December 2016 the building contract was signed with the ship yard
- Plan approval by Lloyd's Register (hull & machinery)
- The vessel was christened in Antwerp on 29th of November 2017

https://www.youtube.com/watch?v=HkOSvV-UvBg

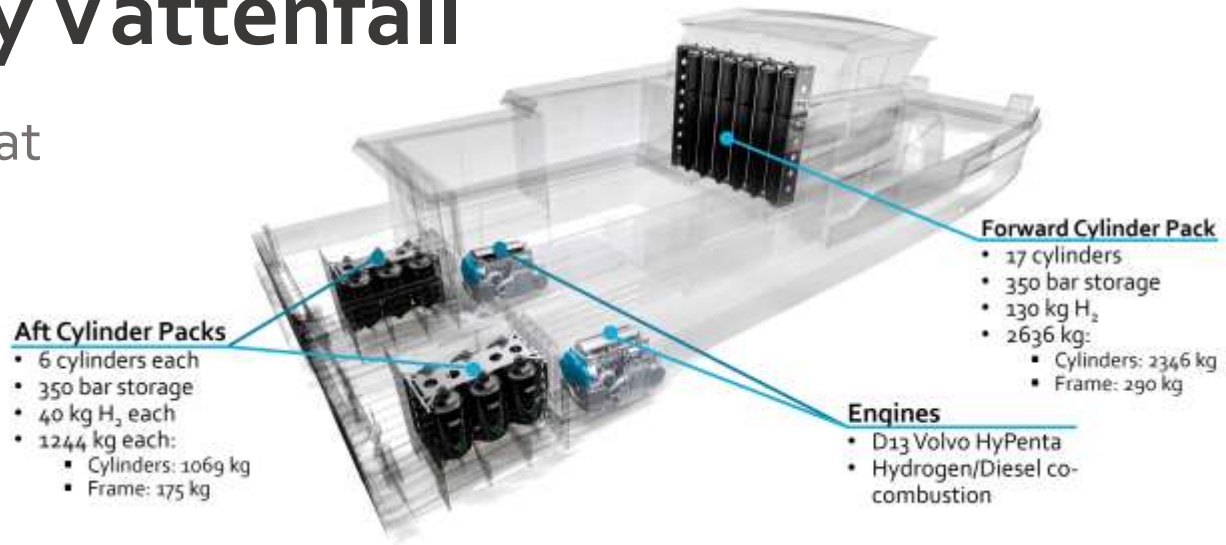
Port areas will be equipped with multi MW electrolysers connected with offshore wind parks

- Hamburg, Rostok, Zeebrugge, Amsterdam, Rotterdam, Aberdeen, Eemshaven, Dunkerque, Emsland already revealed plans to investigate and to install up to 100MW sized electrolysers. Just for Benelux the total capacity announced adds up to 700MW.
- CMB believes that the marine industry could be an enabler for the hydrogen technology. The potential emission savings can be huge and due to the high power demand batteries are often not an option.
- First applications will be mainly with a local focus (ferry, dredger, tug boat, patrol vessel and port equipment).
- The business case of these large electrolysers can only be made if there is a significant consumer found. A transport sector is willing to pay the price of green hydrogen.
- City of Antwerp has a low emission zone, but the port has nothing similar. While port area is large and offers enough space to accommodate an H_2 infrastructure.

Glomflord, 1953-1991, 135MW supplied by renewable hydro

A Hydrocat is being developed in cooperation with Windcat and will be used by Vattenfall

- Based on Hydroville technology, the Hydrocat is being developed in a joint venture with Windcat Workboats to be operated at an offshore wind park.
- Design is based on the proven and efficient WindCat MK3.5.
- Dual fuel capability diesel – hydrogen.
- The H_2 storage is distributed over 3 locations.
- H_2 refuelling of 200kg saving 1.9ton CO_2.
- 2x1000hp in total resulting in a 30 knots max speed with 13,3t bollard pull.
- The Hydrocat is expected to sail Q3 2020.



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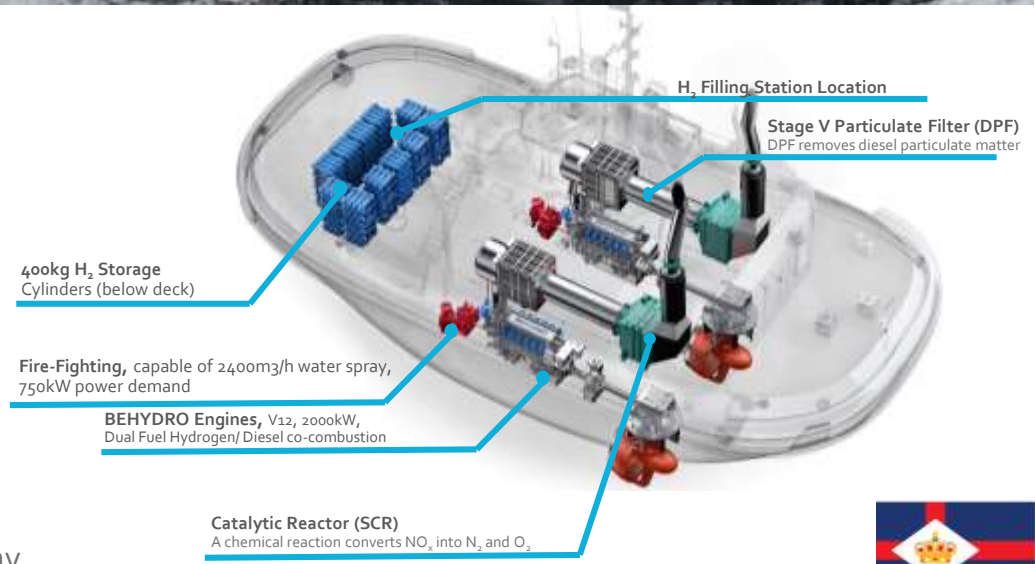
WINDCAT WORKBOATS VATTENFALL

Hydrotug: using a clean fuel while guaranteeing its service as usual

- The modifications to the vessel are minor and the new components are already proven in other industries (H2 tanks, valves, connectors, etc) ➔ low risk for the operator and owner.
- 400kg of H_2 is stored in the aft compartment below deck. Each refilling saves the total emissions of 1 car during 1 year.
- This project can be an enabler for large H_2 infrastructure in port areas.
- The vessel will be used by Port of Antwerp for its daily operations.
- The Hydrotug will sail by Summer 2021.



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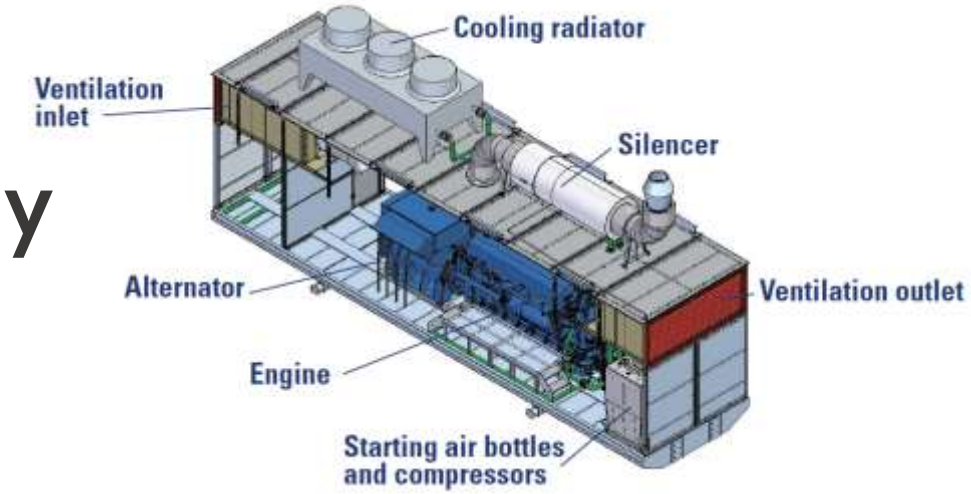
Other H_2 applications: Cold ironing with clean technology



- Marine gen-set delivers automatically at correct Voltage/Frequency next to the vessel ➔ no expensive power converters required.
- Mobile & safe solution, available as mono fuel as well as dual fuel.
- Up to 2,5 MW power available.
- 1x 40ft container can hold up to 1ton of H_2, enough to run for 24h on 100% pure H_2 at 700kW hotel load avoiding 10 tons of CO_2 a day while all soot, SO_x and 95% of the NO_x are saved from the port location.
- Low pressure H_2 piping can provide fuel for the cold ironing gen set.

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The port of Antwerp will house the first dual use (maritime and public) H2 station developed by CMB

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Q&A

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