HYDROGEN AS FUEL ON ROPAX VESSELS WITH HIGH POWER DEMAND -TECHNOLOGY OPTIONS

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HOPE

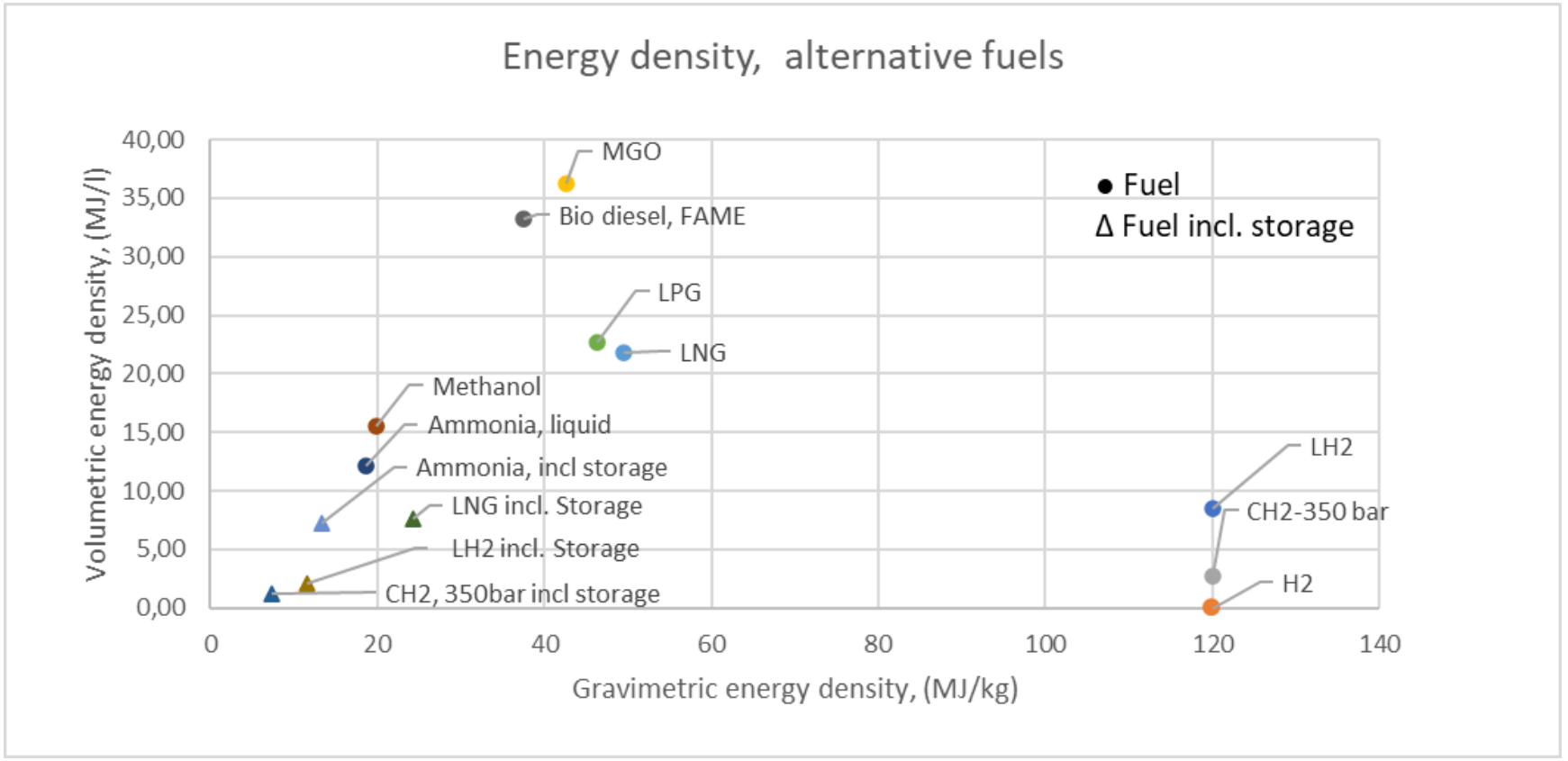
- The project HOPE (Hydrogen fuel cells solutions in shipping in relation to other low carbon options – a Nordic perspective) includes developing and evaluating a concept design for a vessel for short sea shipping that uses hydrogen as fuel and fuel cells for propulsion. Technical aspects are included, as well as barriers and drivers for the realization of such vessels in the Nordic region and the impact on greenhouse gas emissions and air pollution.

Topics

- Low carbon fuels
- Fuel handling and storage options
- Power trains
- Rules and regulations

Marine fuels - energy density

- Reference fuel, MGO
- Low carbon fuel. LNG, LPG, Methanol
- Zero carbon fuel: H2, Ammonia,
- E-fuels
- Biofuels



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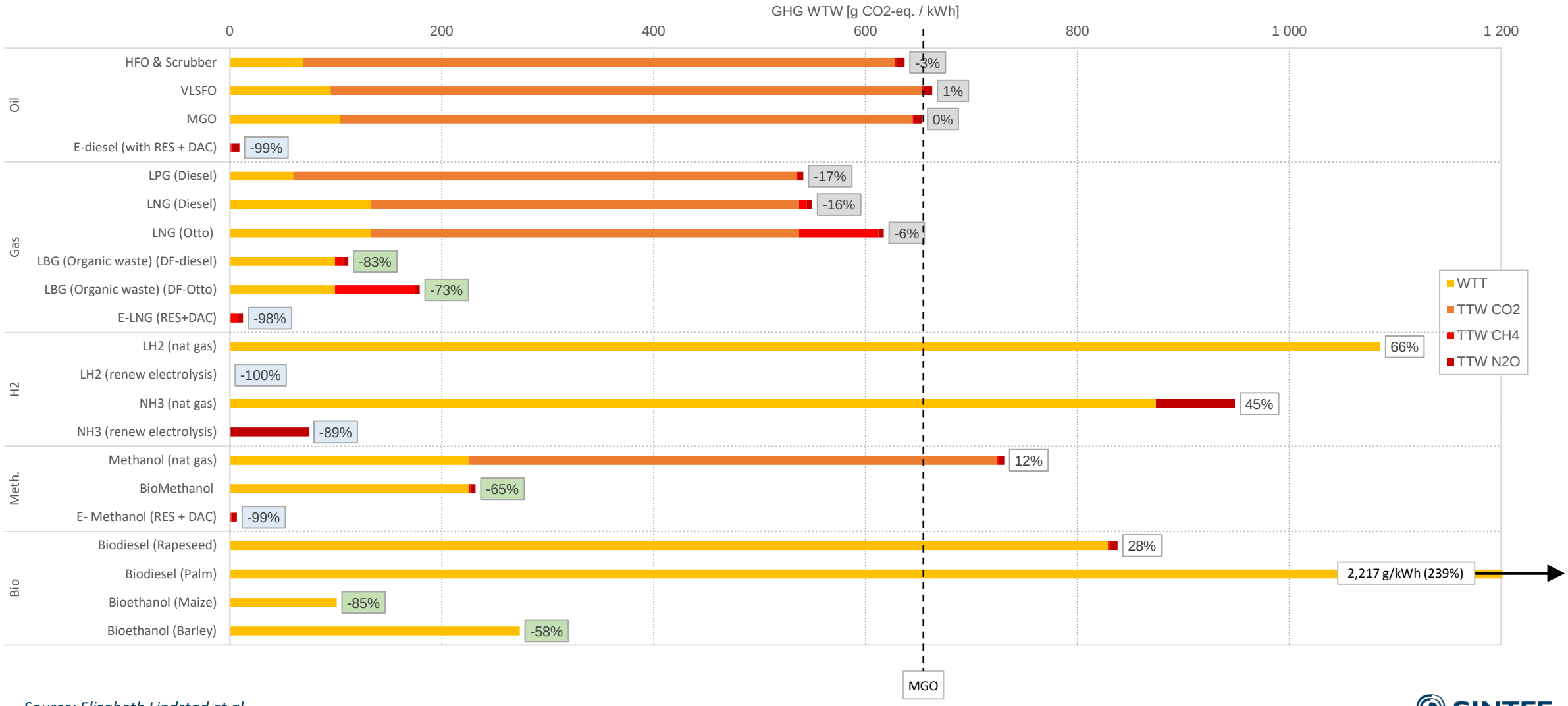
Emissions well to wake (WTW = WTT+TTW)

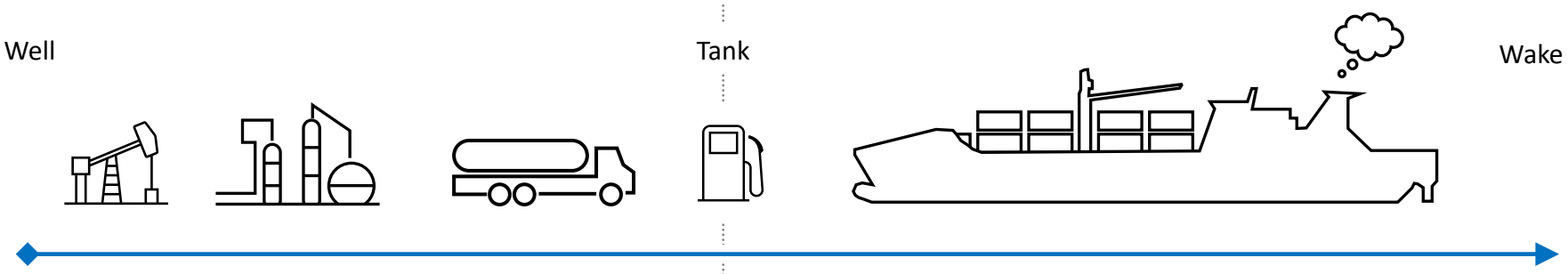


Source: Elizabeth Lindstad et al.

While we know that the type of engine (Diesel or Otto) affect the GHG from LNG, we do not know exactly how the type of engine or fuel cell will impact the emissions with H2 and NH3

Blue colour indicate fuels which depend on renewable electricity to deliver the GHG reductions indicated. Green colour indicate biofuels. Grey indicate fossil fuels.

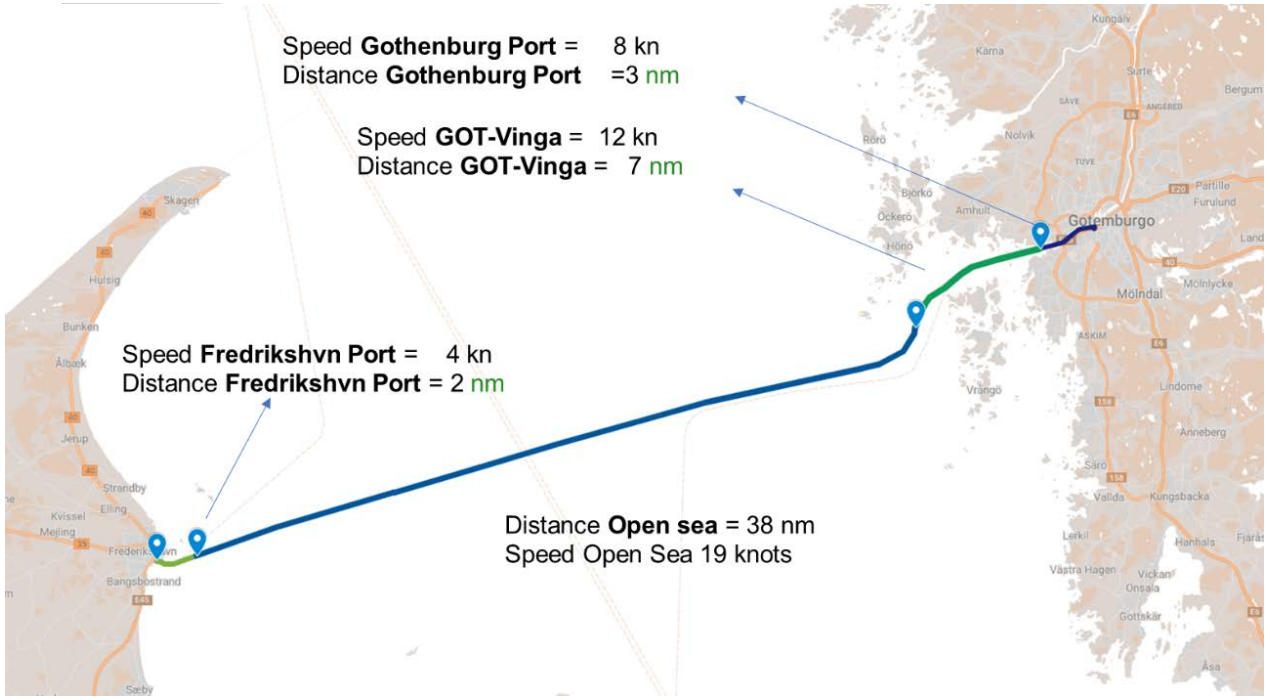
Emissions from H2 and NH3: determined by the user and producer

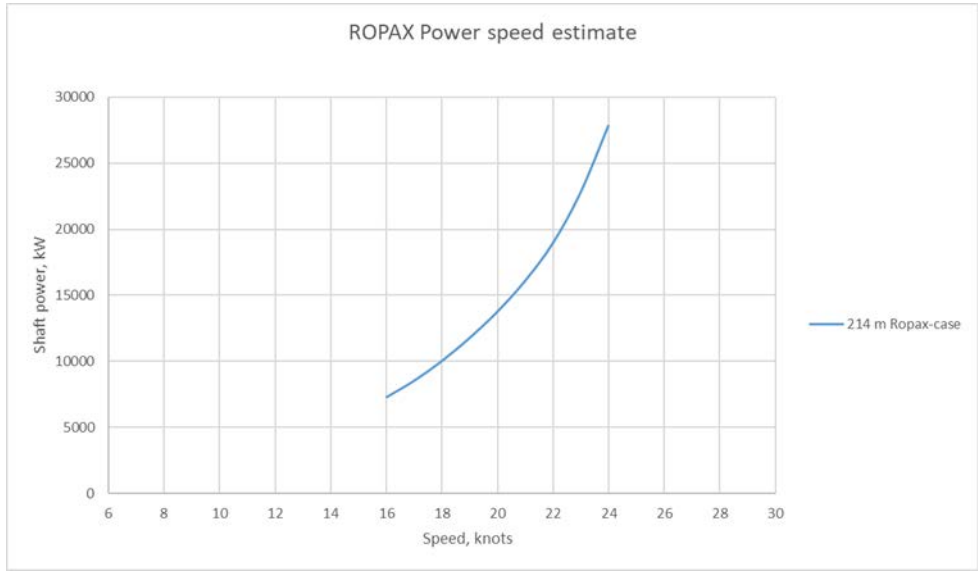


		Well to tank (WTT) / Scope 2 / upstream	*Tank to wake (TTW) / scope 1 / downstream*
Ammonia		Grey: High, higher than fossil fuels Blue: Close to zero with efficient CCS Green: Depending on the electricity	Zero CO_2, some N_2O and NO_x, depending on the engine
Hydrogen			Zero

SOURCE:
Lindstad et al, 2021

Design case - Ropax ship





- H2 consumption/trip: 3,5 tons
- Hydrogen storage capacity: 330 MWh= 10 tons
- Endurance on hydrogen: App.: 150 Nmile
- Propulson power:
  - 10 MW@ 18 knots
  - 15 MW@20,5 knots

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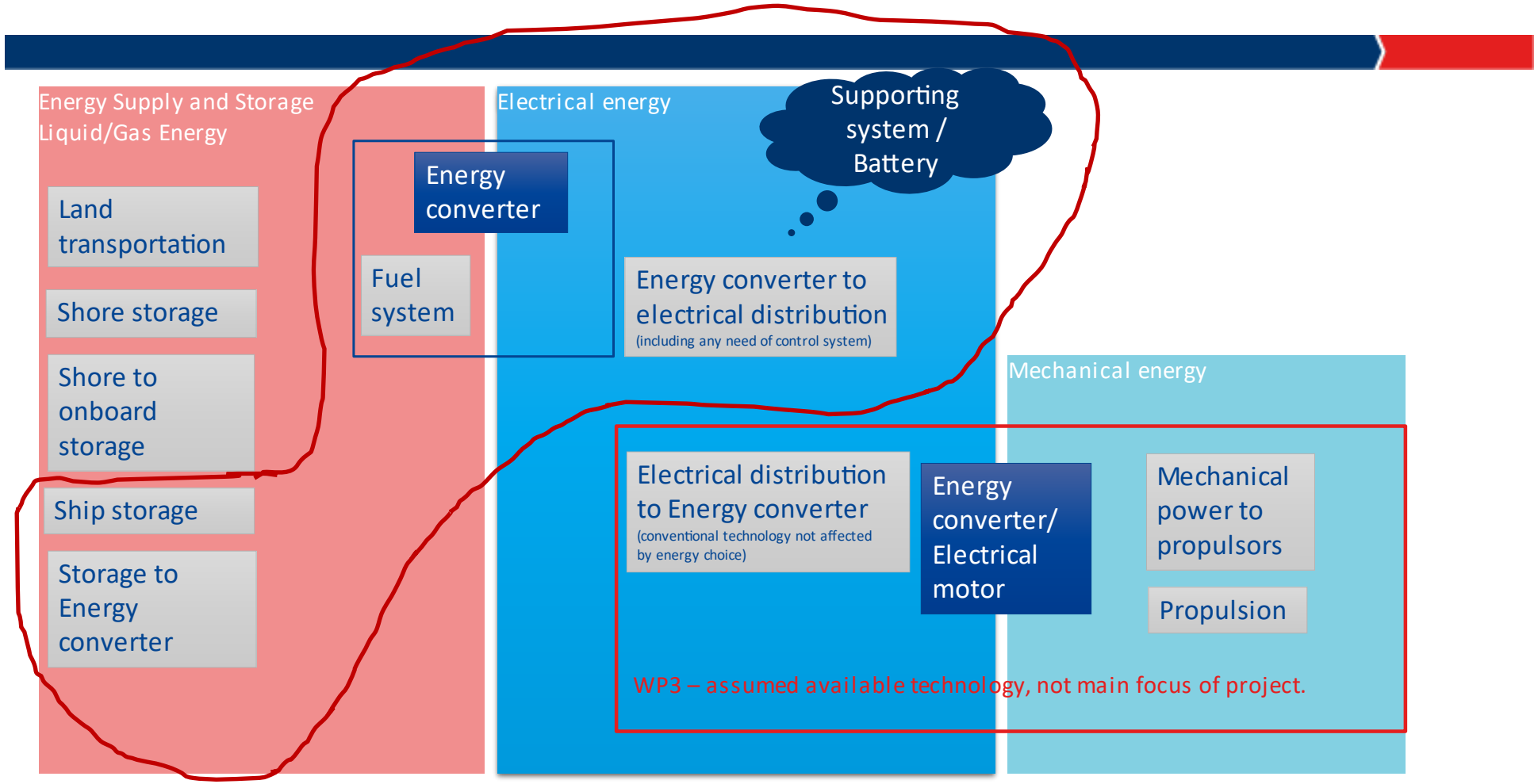
Follow the energy



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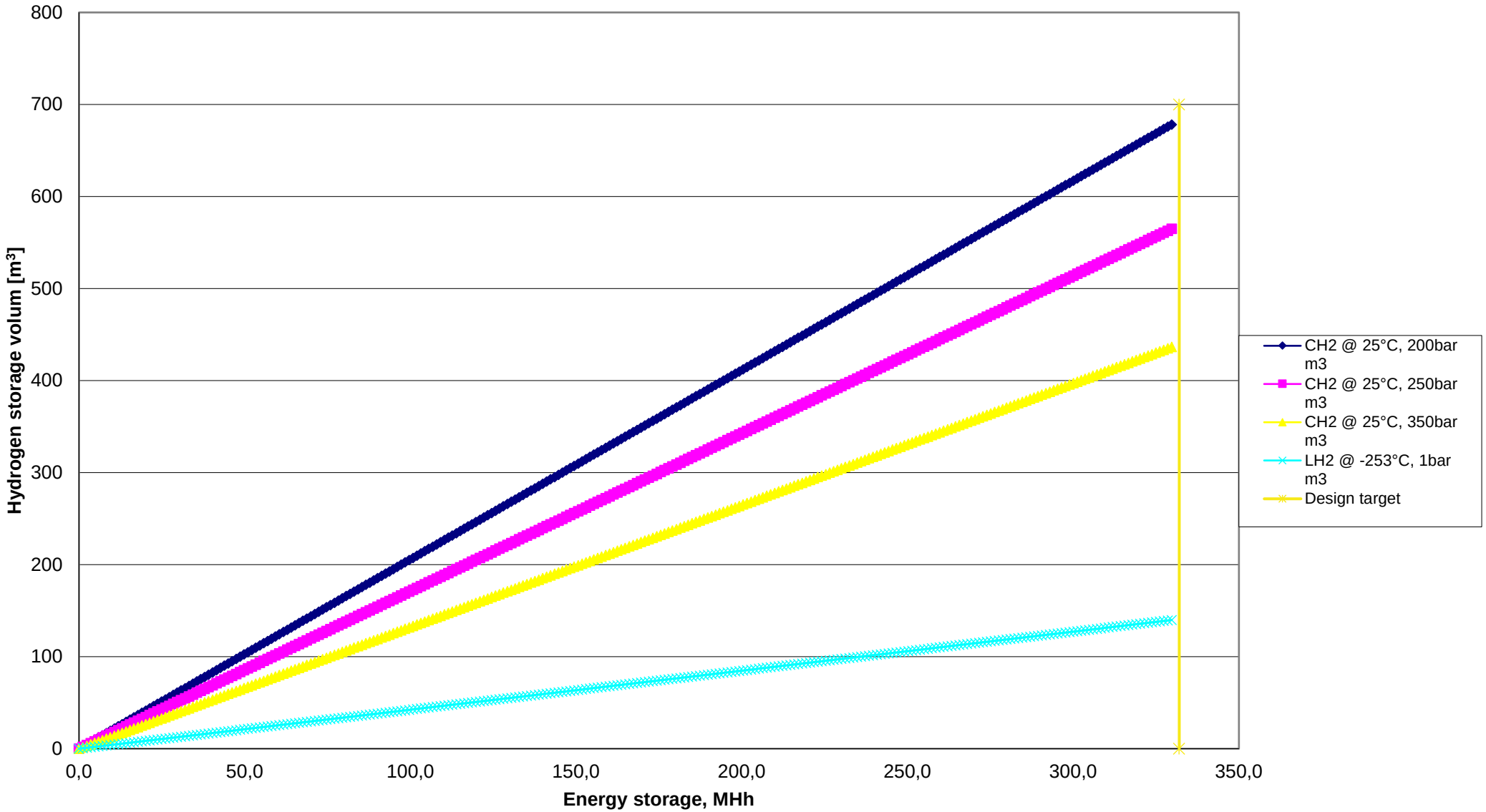
Stena Teknik

Hydrogen storage volume (m3) for alternative CH2 storage pressure and for LH2



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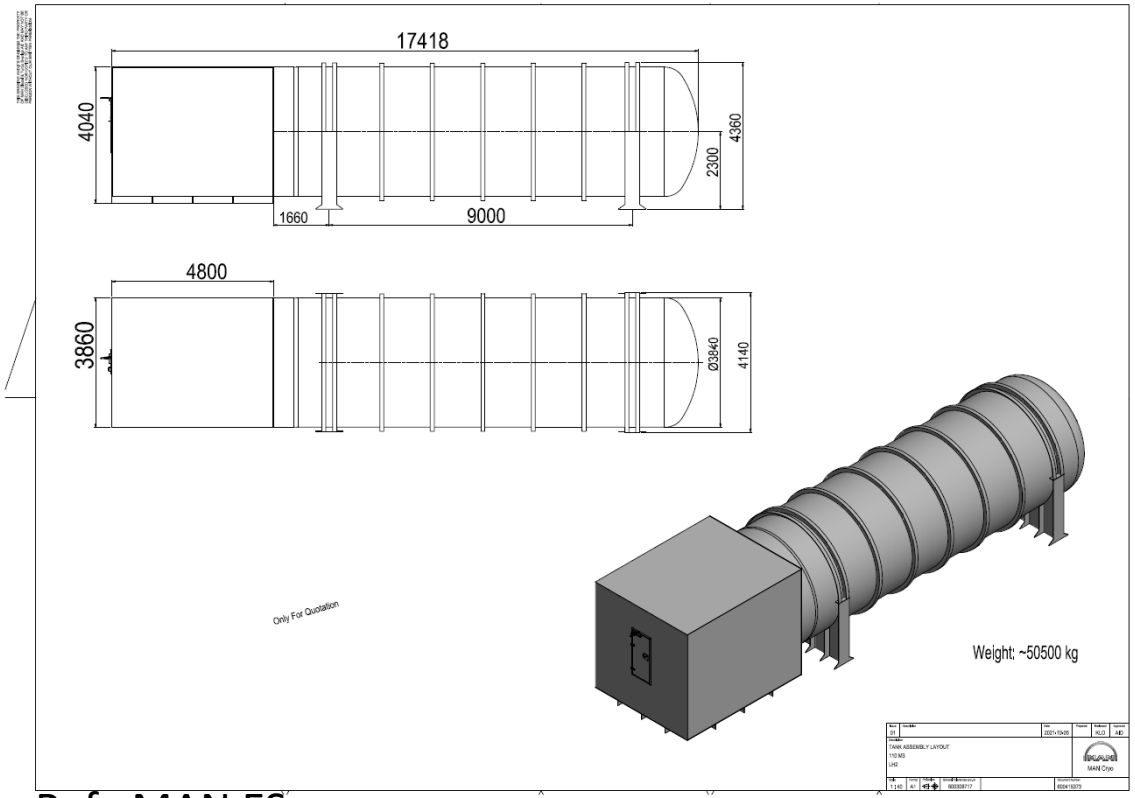
H2 Storage

LH2 storage: 2x 110 m^3 watervolum
Filling degree: 69%
Gross tank volume: ~ 2x 300 m^3 incl cold box
Tare weight: ~ 100 tons



Ref.: MAN ES

CH2@350 bar: 440 m3 water volume
Gross volume: 1000 m3 (10x ISO 45' containers)
Tare weight: ~ 160 tons

https://hexagongroup.com/companies/hexagon-purus

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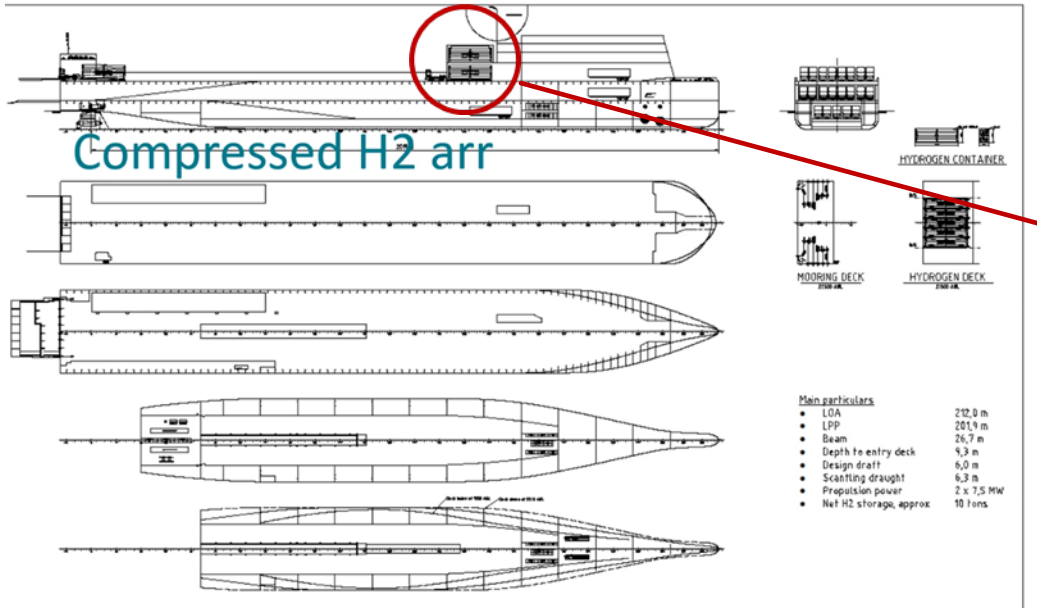
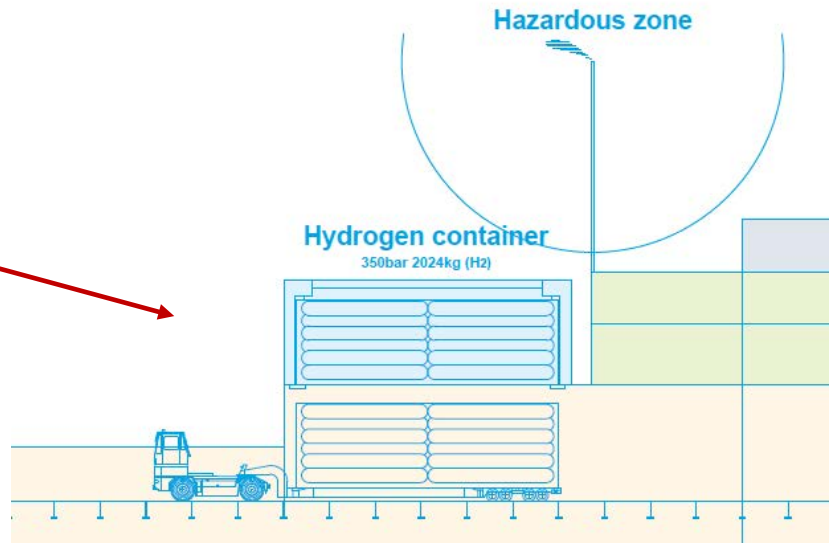
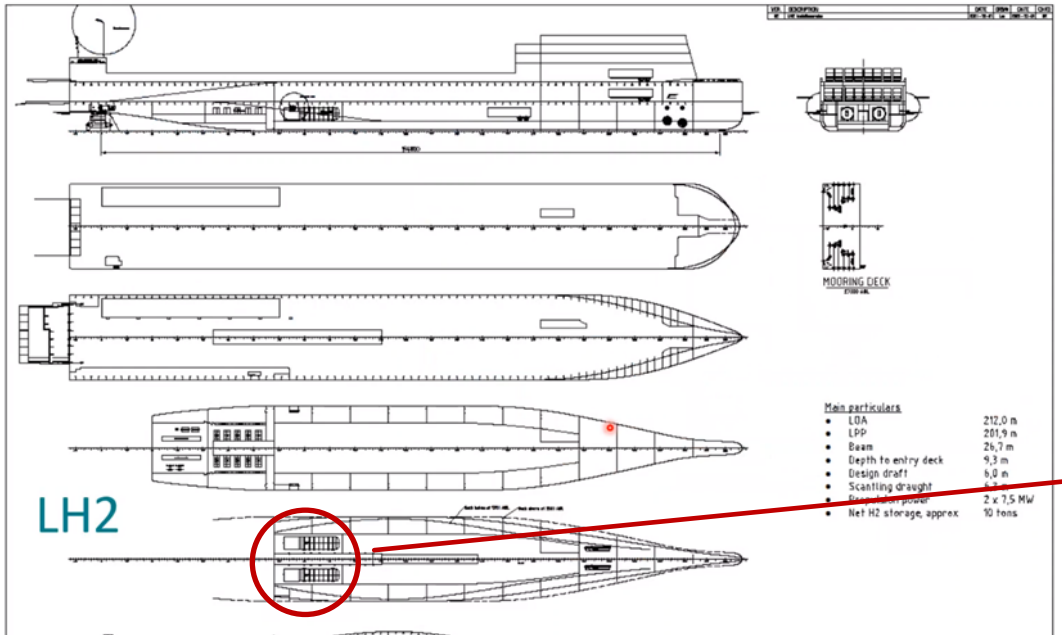

Compressed H2 arr
HYDROGEN CONTAINER
MOORING DECK
HYDROGEN DECK
Main particulars
LOA 212,0 m
LPP 201,9 m
Beam 26,7 m
Depth to entry deck 9,3 m
Design draft 6,0 m
Scantling draught 6,3 m
Propulsion power 2 x 7,5 MW
Net H2 storage, approx 10 tons


Hazardous zone
Hydrogen container
350bar 2024kg (H2)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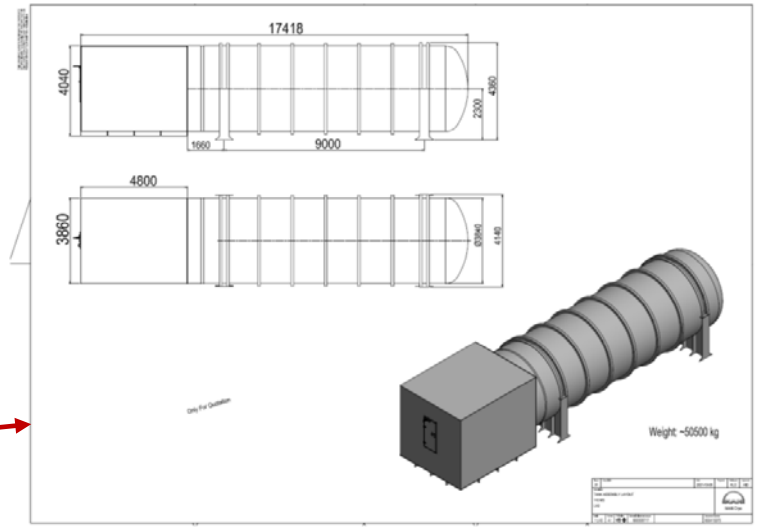
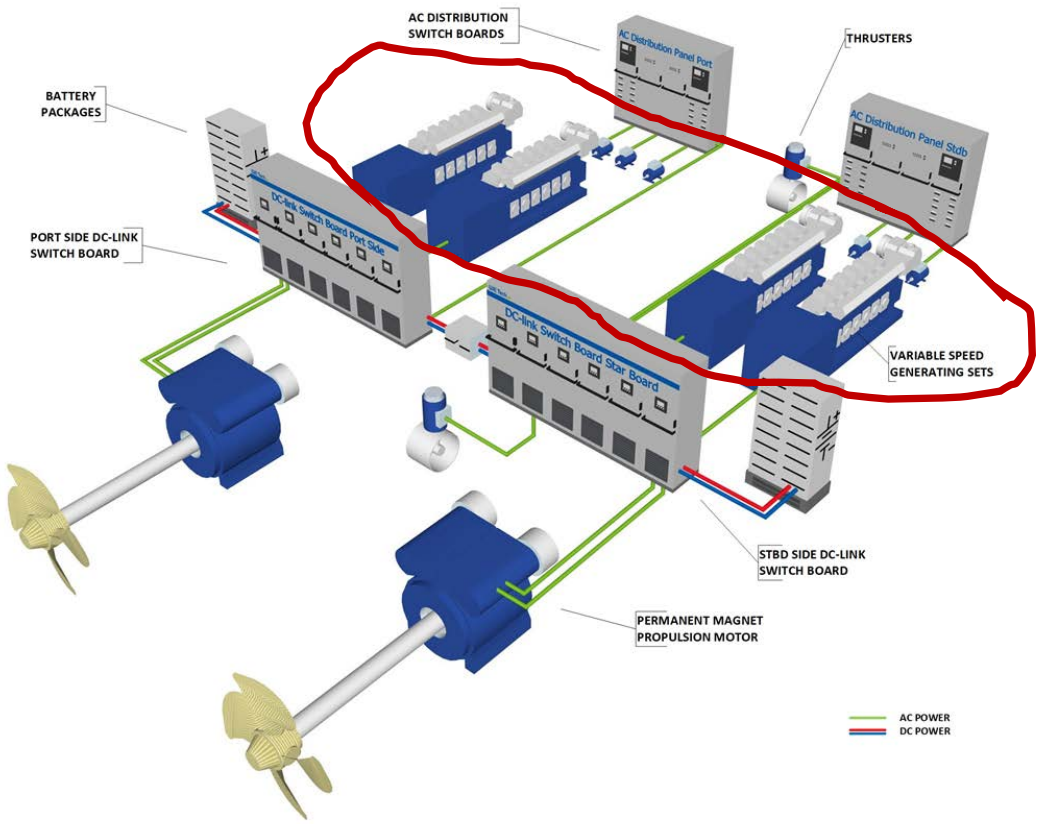

17418
4040
9000
1660
2300
4800
3660
Weight ~50500 kg

Power trains



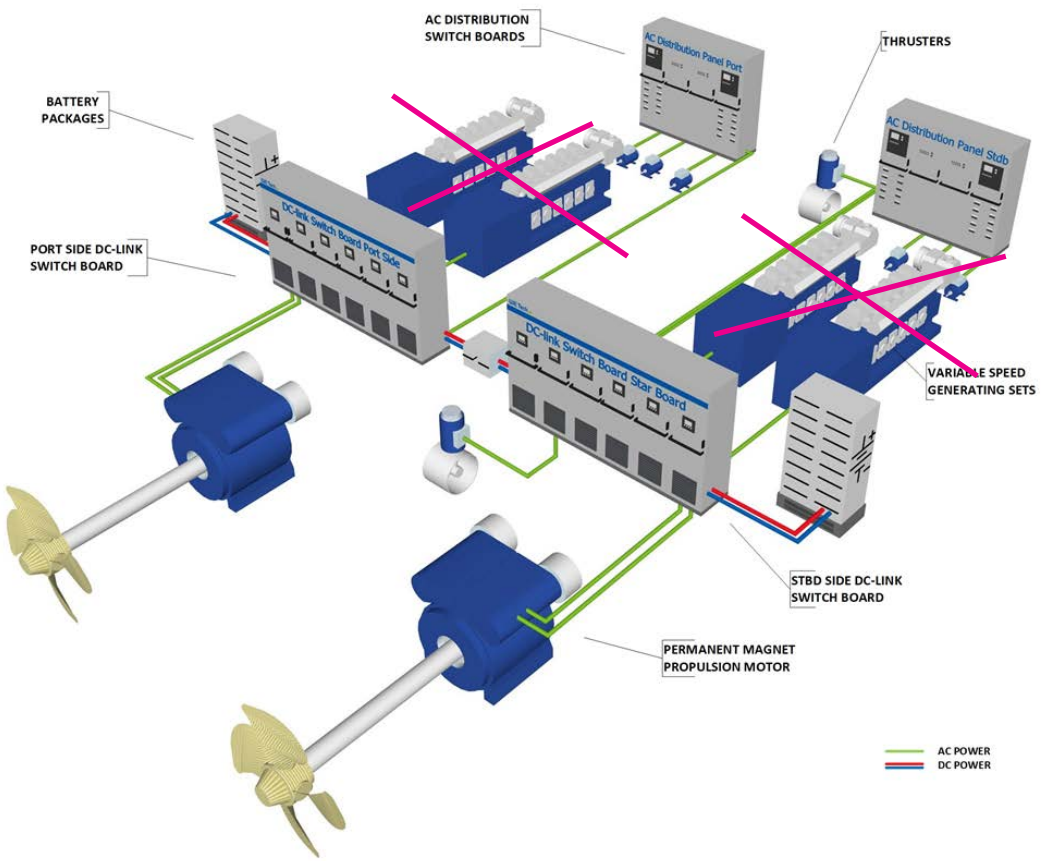
- Diesel-electric layout, but with hydrogen powered ICE

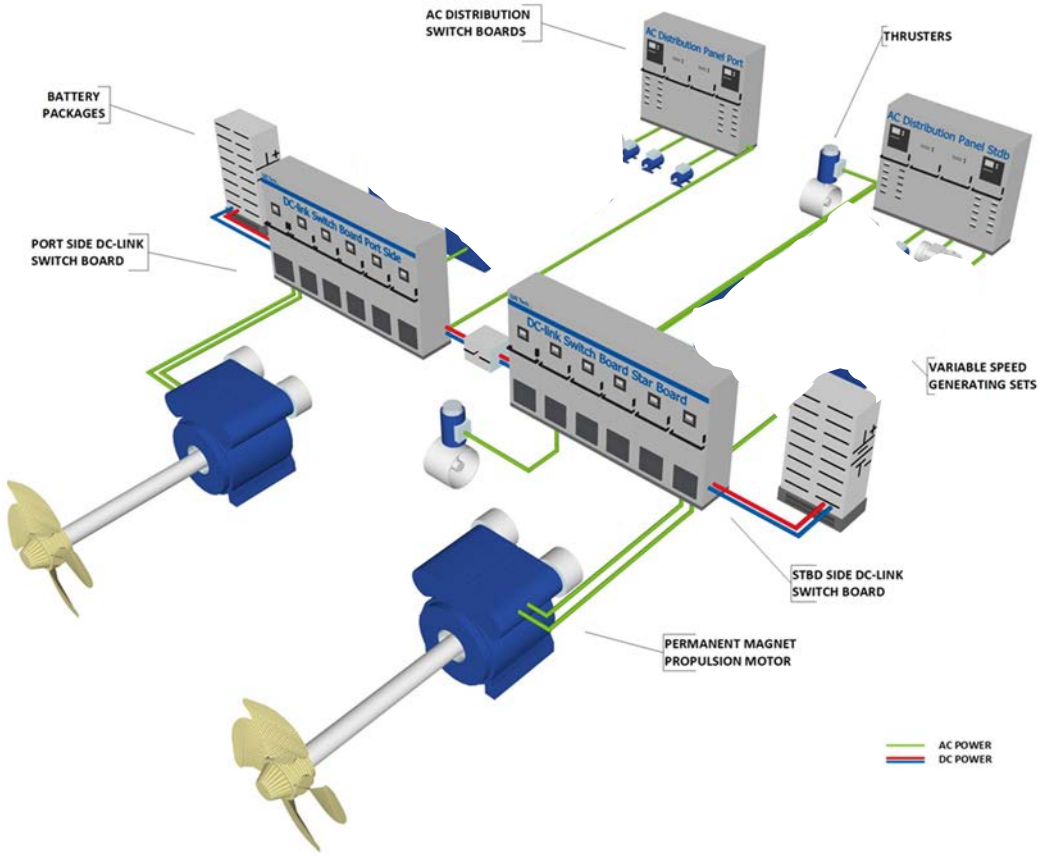
- Main challenge:
  - Hydrogen powered ICE is not available in high power range
  - Only one supplier has launched this as a product for maritime application
  - Development work from several suppliers are under way, marked interest decide

Example. Ref.: http://wetech.fi/solutions/solution-five/

Power trains

- PEMFC running on hydrogen



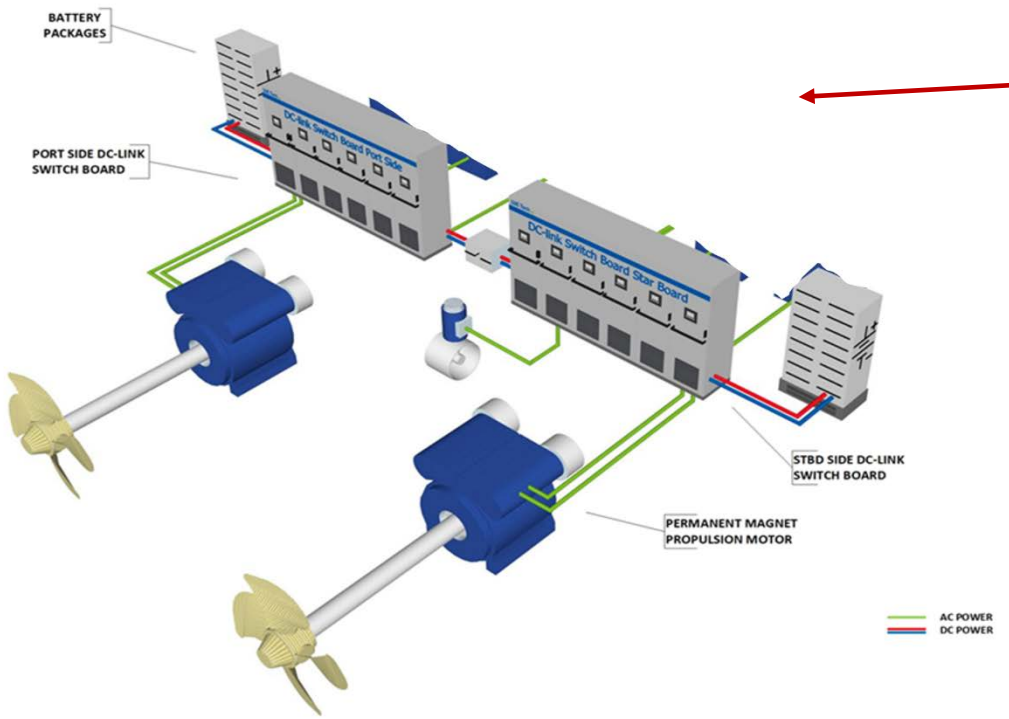


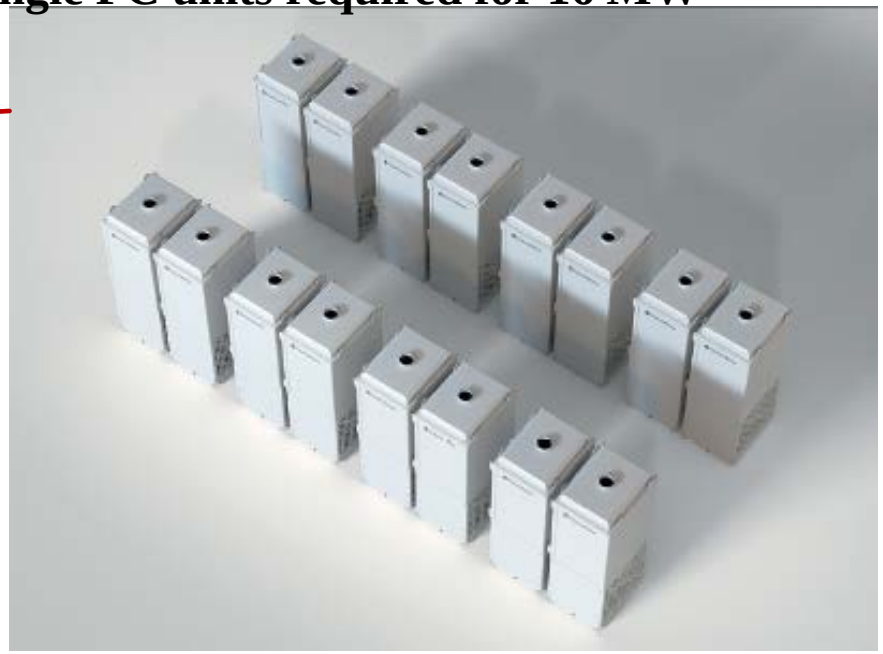
Power train

- PEMFC running on hydrogen

Concept design of 3,2 MW Fuel cell block, 16 single FC units arranged in pairs of two units, ref Powercell-

Total 80 single FC units required for 16 MW





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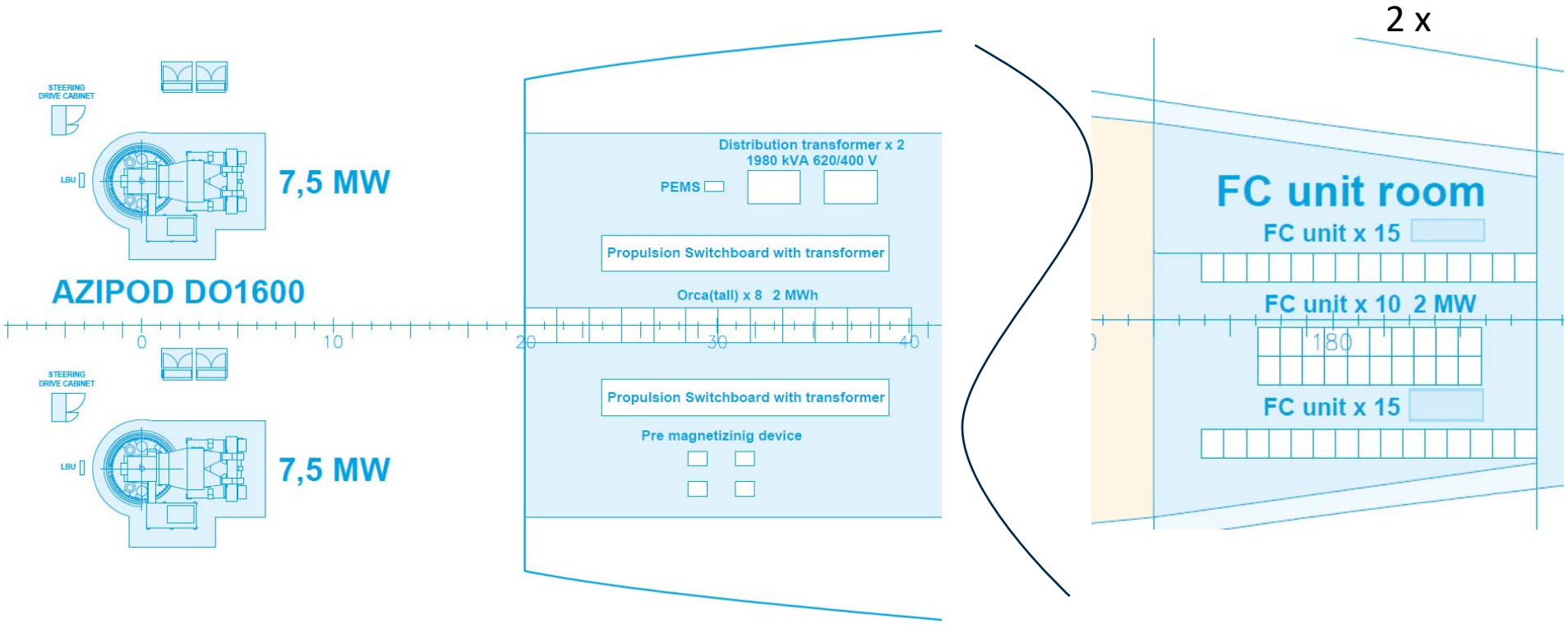
Power train with fuel cells



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Rules and regulations

Ref.:The Handbook for hydrogen fuelled vessels, MarHySafe JDP Phase 1
1st Edition (2021-06)

- The IMO IGF Code - International Code of Safety for Ship Using Gases or Other Low-flashpoint Fuels
  - Fully developed for LNG, not for other alternative fuels
  - For these alternatives the "Alternative Design process" should be followed
  - Class societies has developed additional class notations for ships with fuel cells and other specific equipment.
  - Several standards apply for single components and systems which is required in hyfrogen fuelled ships. (ISO, ASME, CGA, EN, NFPA,, EU-directive,
- Classification societies has type approved FC systems and components
  - Fuel cells – type approved, project under way
  - LH2 tank systems – approval in principle, approved in specific project
  - CH2 pressure vessel: Pressure vessels: Type approved. System: approval in principle and for specific project

MarHySafe project.

https://www.dnv.com/expert-story/maritime-impact/Five-lessons-to-learn-on-hydrogen-as-ship-fuel.html

- Knowledge gaps: More testing needed on the safety aspects of handling, storage and bunkering hydrogen
- Safety: Hydrogen's unique properties make it very different from natural gas
- Fuel system: Use hydrogen in its pure form when possible
- Framework: The Alternative Design process is currently the best approach
- Implementation: Scaling up hydrogen operations will be a challenge

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Teknologi for et bedre samfunn