Change of course Symposium

JUMBO

DEK MARITIME

Alternative Fuels in Practice

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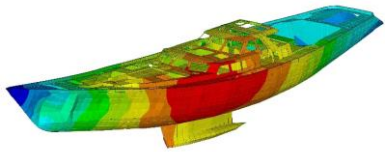
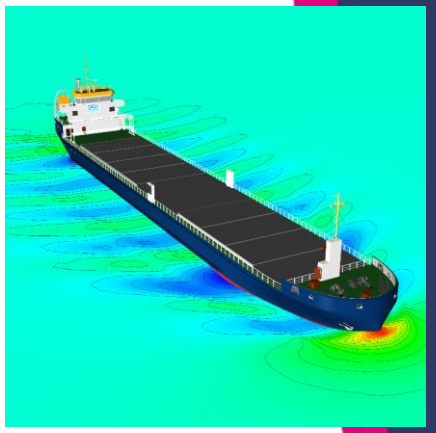
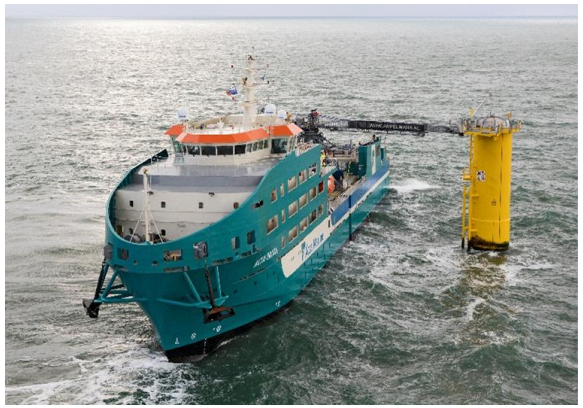
DEKC Maritime
2024-05-16

Change of course Symposium

Who are we?







DEK | MARITIME

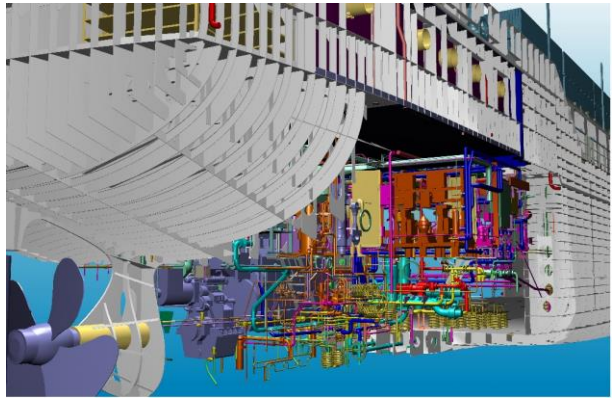
EMPLOYEES

45

- STRUCTURAL DESIGNERS
- MECHANICAL ENGINEERS
- NAVAL ARCHITECTS
- STABILITY EXPERTS
- FEM EXPERTS
- CFD EXPERTS
- PROJECT MANAGERS
- DETAIL STRUCTURES AND OUTFITTING ENGINEERS

MARKET EXPERIENCE

- YACHTS
- FISHING
- ARCHITECTURE
- PASSENGER TRANSPORT
- SHIPPING
- WIND
- DREDGING
- OFFSHORE
- CONSTRUCTION



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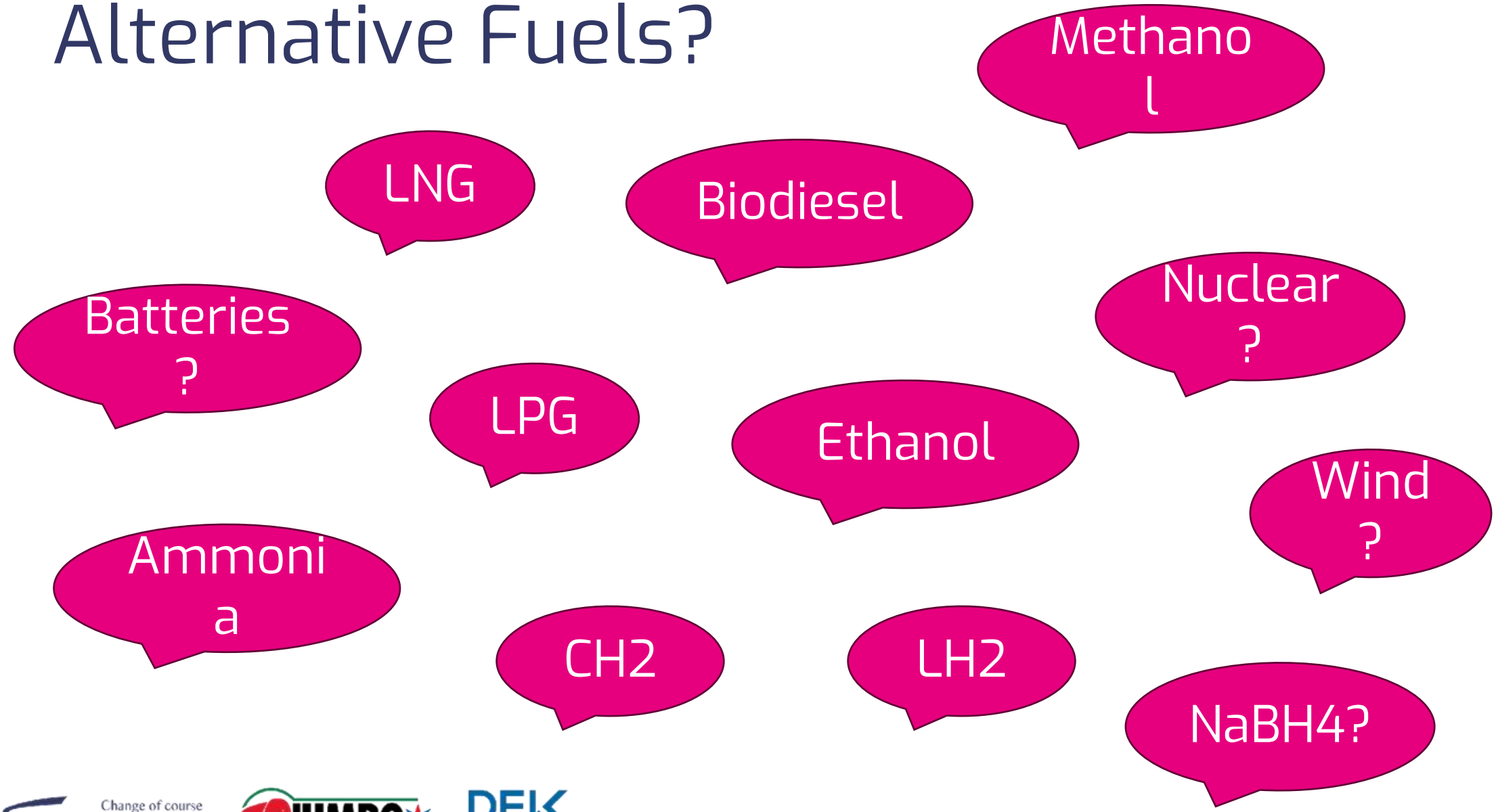
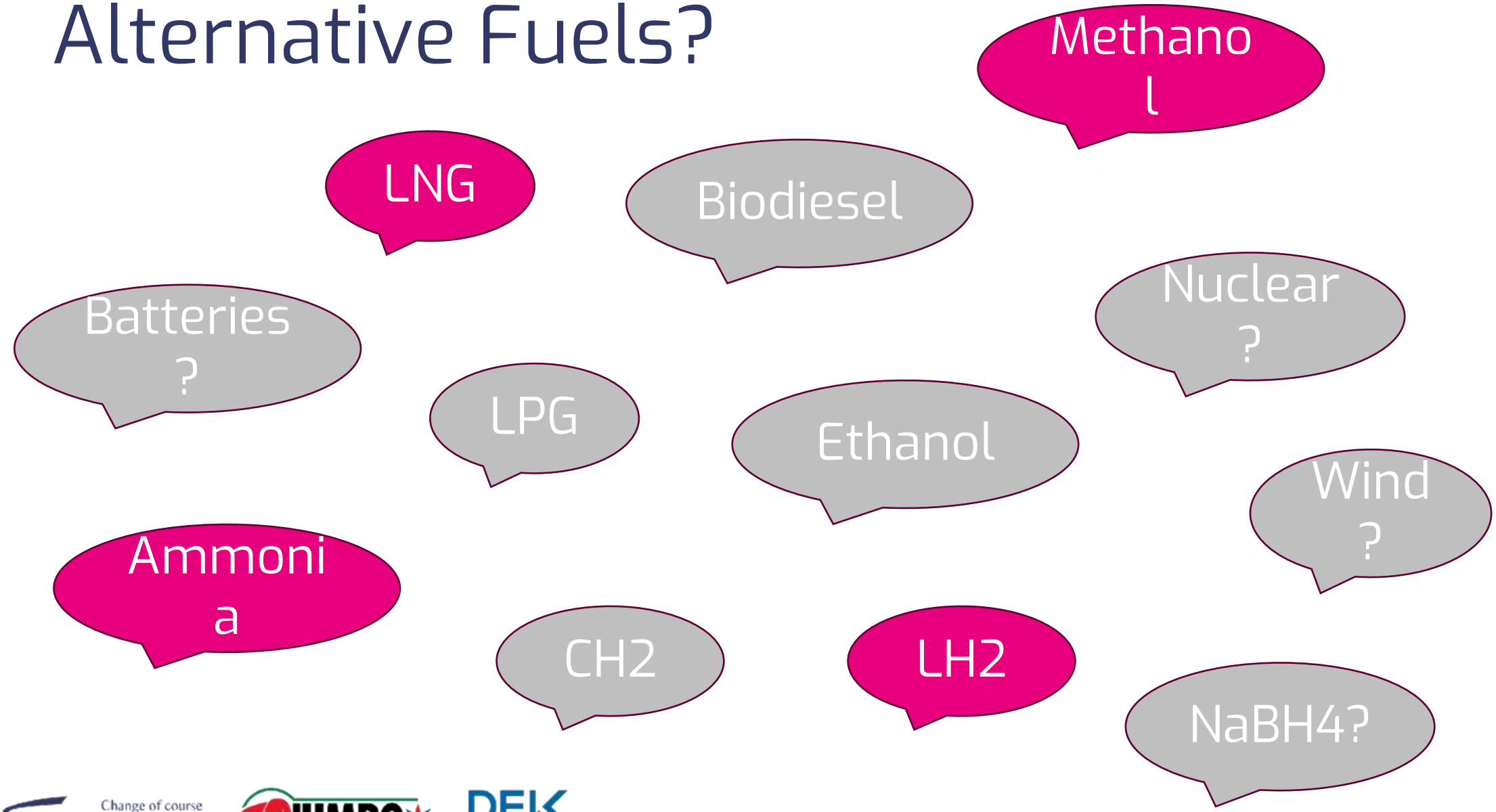
Alternative Fuels?



Alternative Fuels?



Industry Projects

Heidelberg-Felleskjøpet

SH2IPDRIVE
HYDROGEN FOR MARITIME

ENGIMMONIA

C-Job

Hydrogen

Ammonia

LNG (+ CO2 capture)

Methanol

MENENS

GREEN MARITIME METHANOL

LNG ZERO

CO2ASTS

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Selected Alternative Fuels (1)

LNG (CH_4)

- Gas at RTP
- Highly flammable

Methanol (CH_4O)

- Liquid at RTP
- Poisonous

Ammonia (NH_3)

- Gas at RTP
- Environmentally harmful

LH2 (H_2)

- Gas at RTP
- Highly flammable

Selected Alternative Fuels (2)

LNG (CH_4)

- From catalysing H_2 and CO_2
- From fermenting biomass
- From fossil sources

Methanol (CH_4O)

- From catalysing H_2 and CO_2
- From further fermenting CH_4

Ammonia (NH_3)

- From catalysing H_2 and N_2

LH2 (H_2)

- Electrolysing water
- Steam reforming of fossil sources

Some Quick Stats

Fuel	Storage Temperature [°C]	Density [kg/m3]	LHV [MJ/kg]	Energy Density [MJ/m3]
MDO	*15*	*890*	*43*	**38700**
LNG	*-162*	*430*	*49*	**21070**
Methanol	*15*	*790*	*20*	**15840**
Ammonia (liquid)	*-50*	*700*	*19*	**13340**
Hydrogen (liquid)	*-253*	*69*	*121*	**8350**

…In 20 ft Container Storage Units (1)

Fuel	Empty weight [t]	Capacity [m3]	Fuel weight [t]	Tank mass fraction
MDO	*6*	*26*	*23.1*	**26%**
LNG	*7 - 10*	*22*	*9.5*	**74% - 116%**
Methanol	*6*	*26*	*20.5*	**29%**
Ammonia (liquid)	*7 - 10*	*24*	*16.8*	**42% - 60%**
Hydrogen (liquid)	*10+*	*19*	*1.3*	**763%**

…In 20 ft Container Storage Units (2)

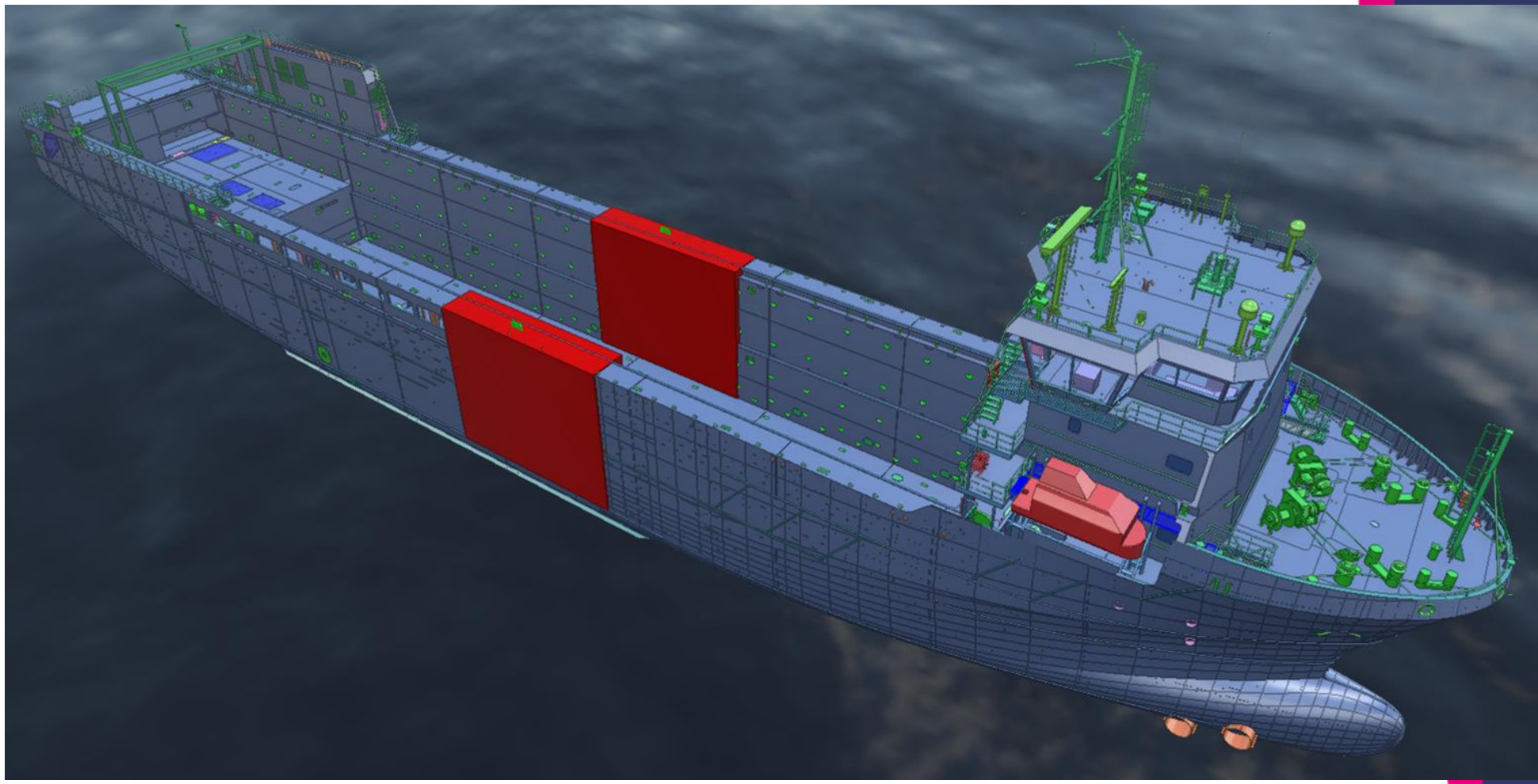
Fuel	Energy Capacity [GJ/TEU]	Equiv. “LHV” (incl tank) [MJ/kg]
MDO	995	34
LNG	464	24 - 28
Methanol	411	16
Ammonia (liquid)	319	12 - 13
Hydrogen (liquid)	159	14

Conversion to Alternative Fuels in Practice

- Sample case
  - 100 m 6000 TDW multi-purpose vessel
  - DEKC design
  - Diesel-electric
- Equivalent energy storage
  - Assume similar efficiency for ICEs for all fuels
  - Different for fuel cells or batteries
  - What needs to be sacrificed?

MDO

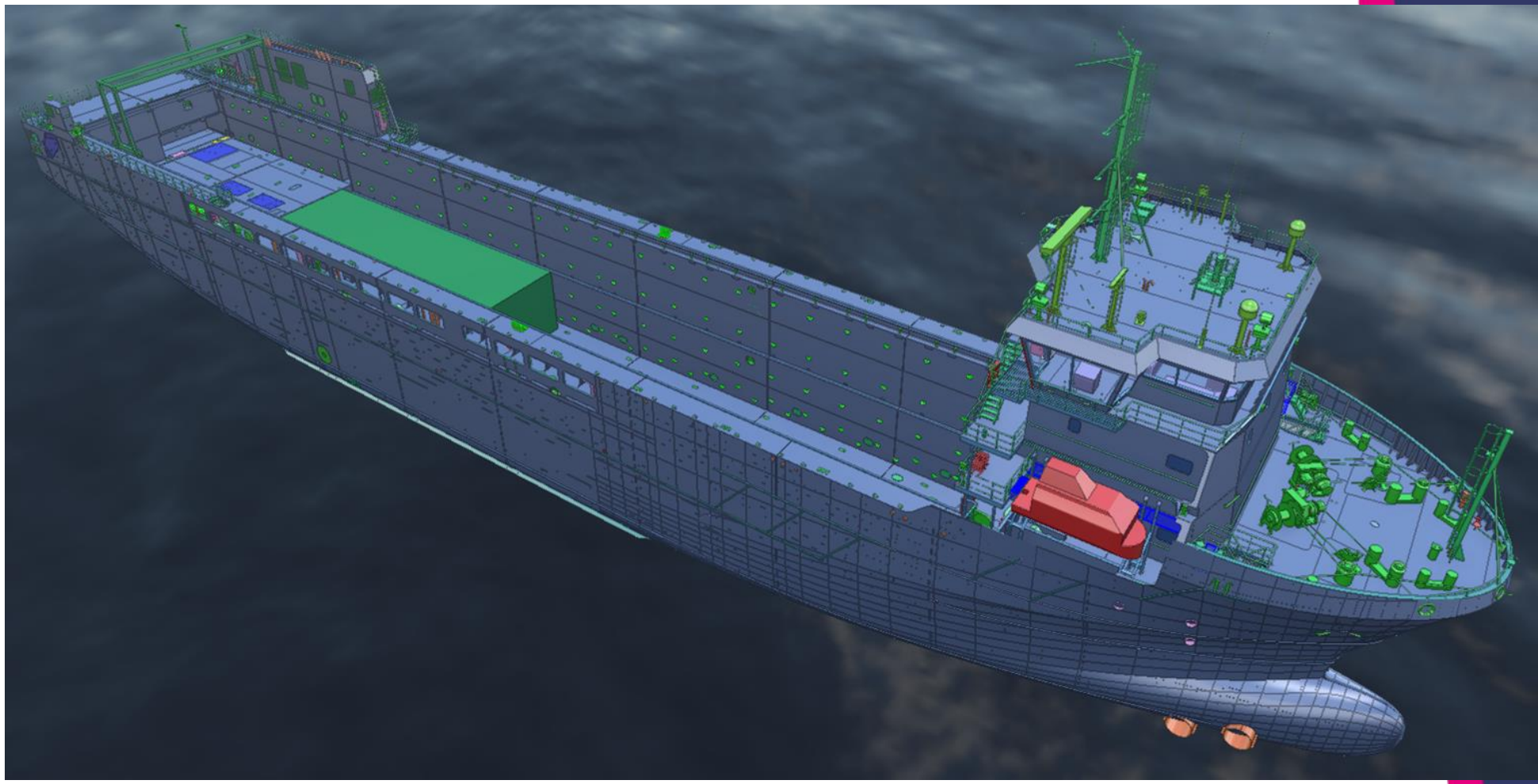
- 15300 GJ
- 400 m^3
- 356 t



LNG

- 15300 GJ
- ~32 TEU
- ~550 t

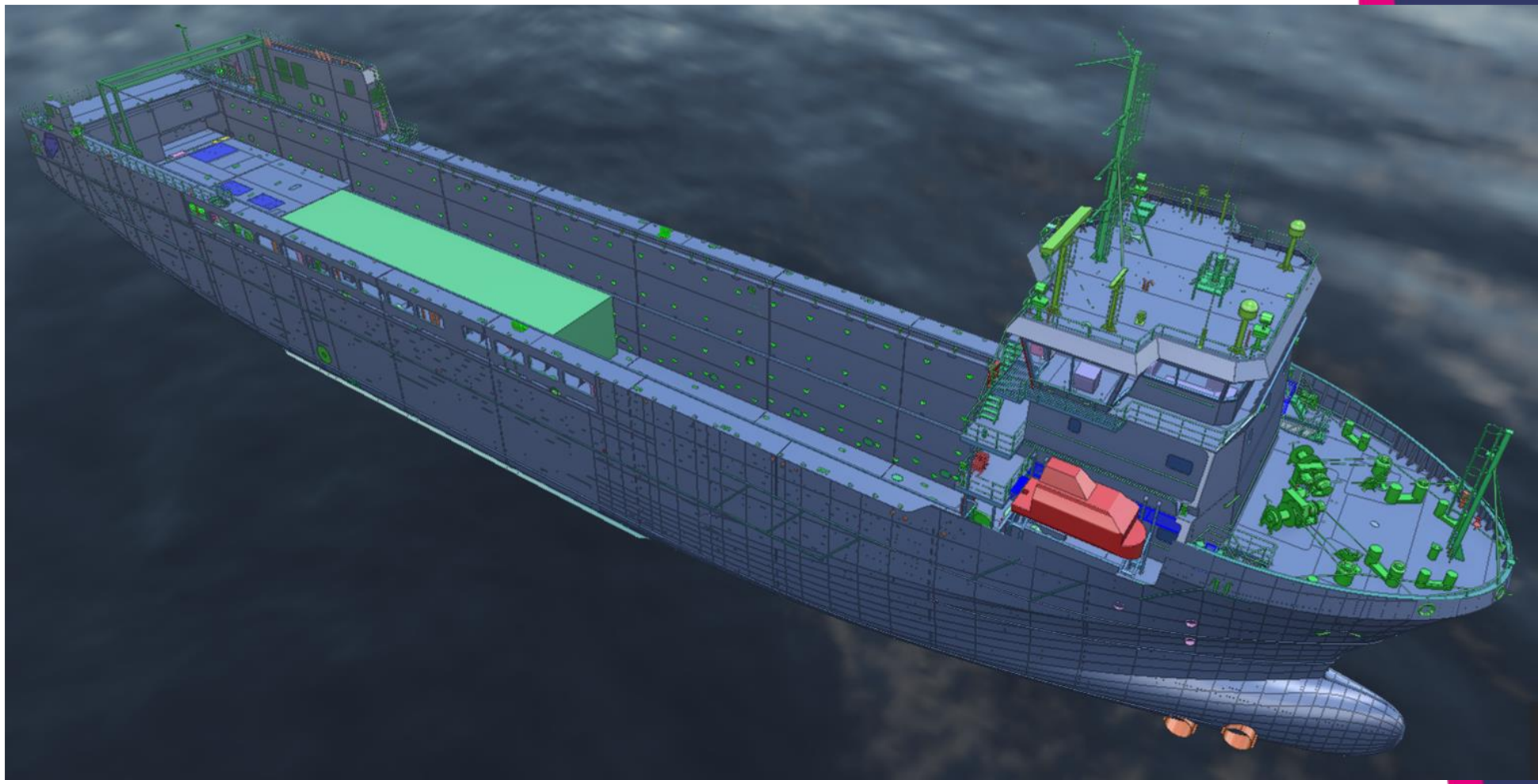
- -200 t DWT
- -1200 m^3 hold



Methanol

- 15300 GJ
- ~40 TEU
- ~1050 t

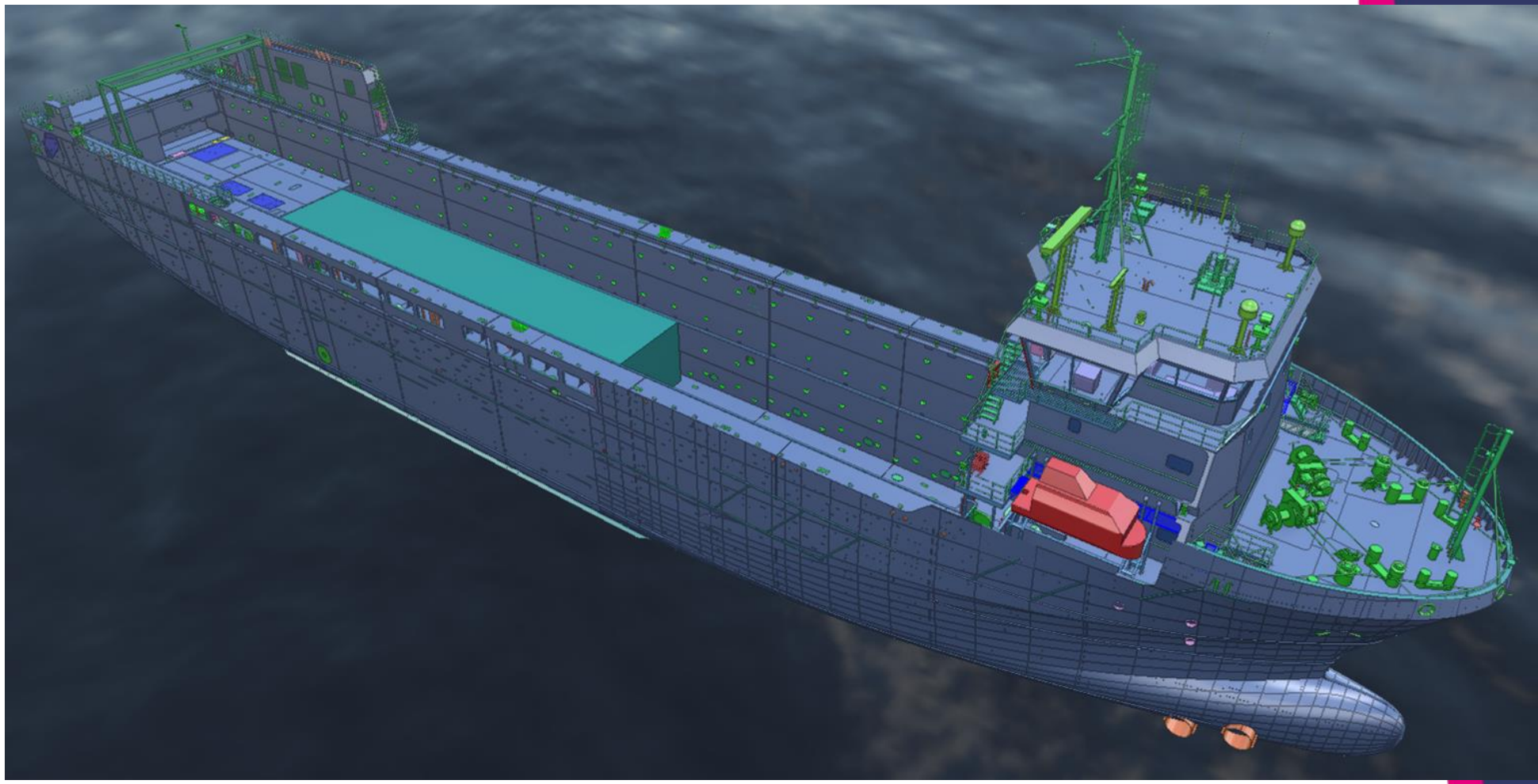
- -700 t DWT
- -1500 m^3 hold



Ammonia

- 15300 GJ
- ~48 TEU
- ~1200 t

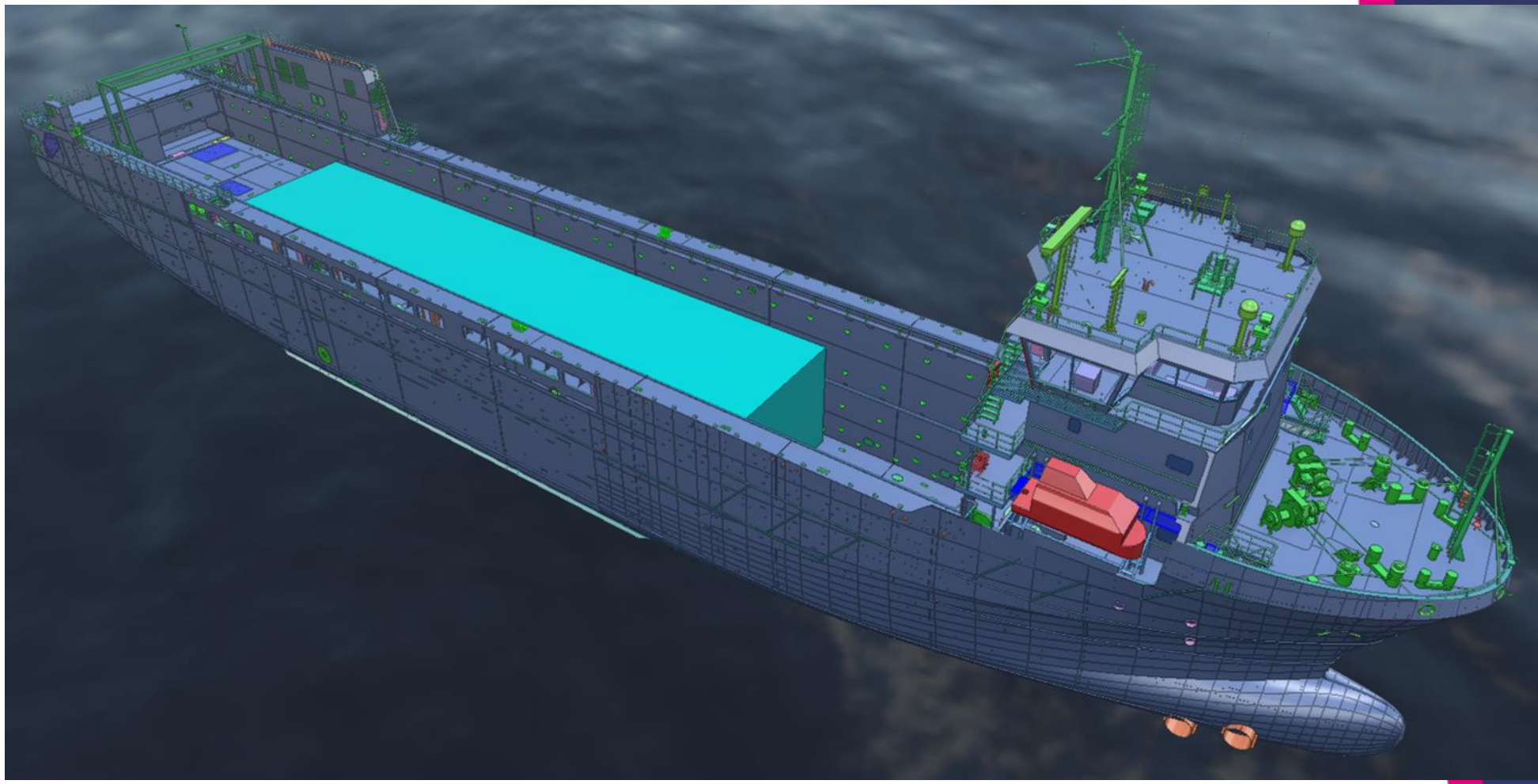
- -850 t DWT
- -1800 m^3 hold



Hydrogen

- 15300 GJ
- ~96 TEU
- ~1100 t

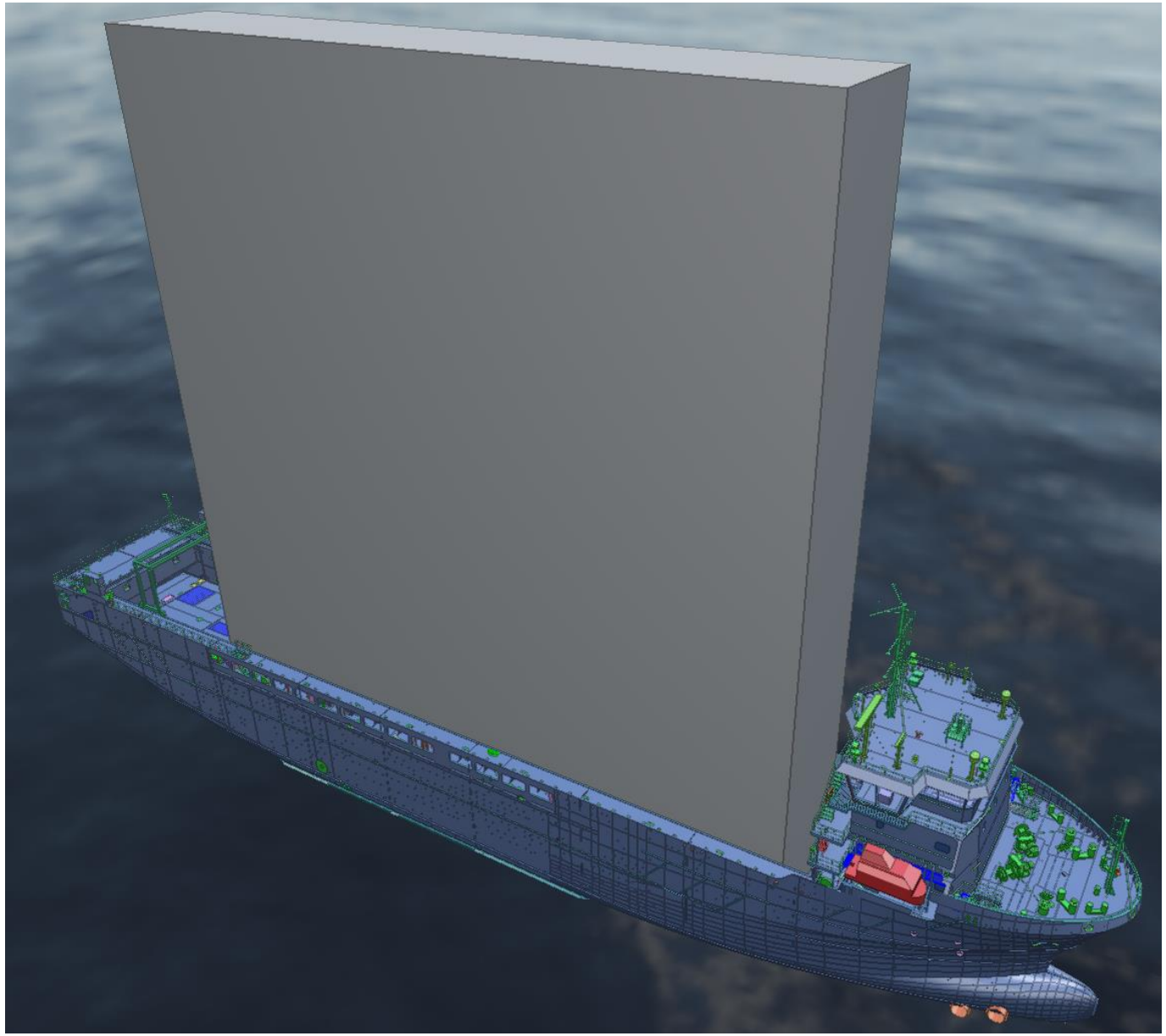
- -750 t DWT
- -3600 m^3 hold



Batteries (LFP)

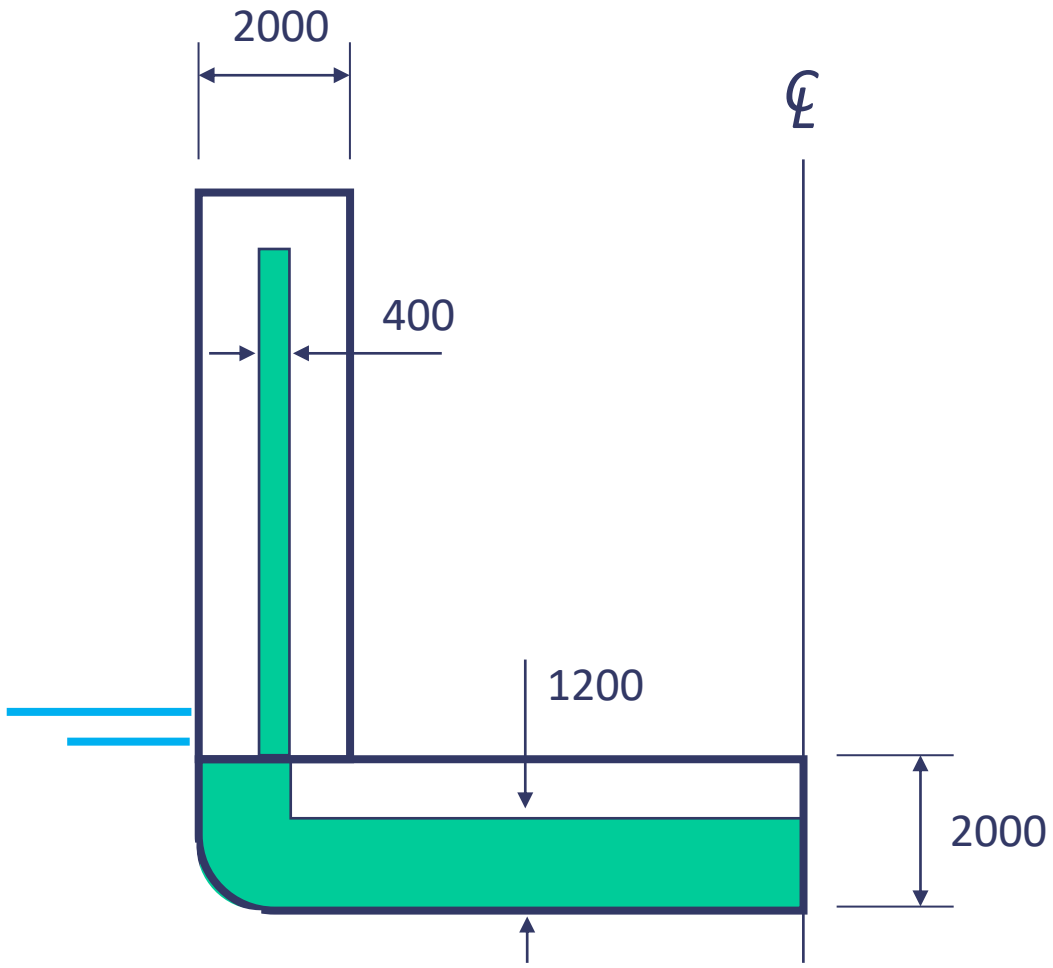
- 15300 GJ
- ~1000 TEU
- ~26000 t

- Sunk



Methanol in integrated tanks (1)

- Liquid at RTP
  - No cooling/pressure required
  - Can be stored in integrated tanks
- However, for safety…
  - 800 mm cofferdam around tank
  - Up to shell when always under water



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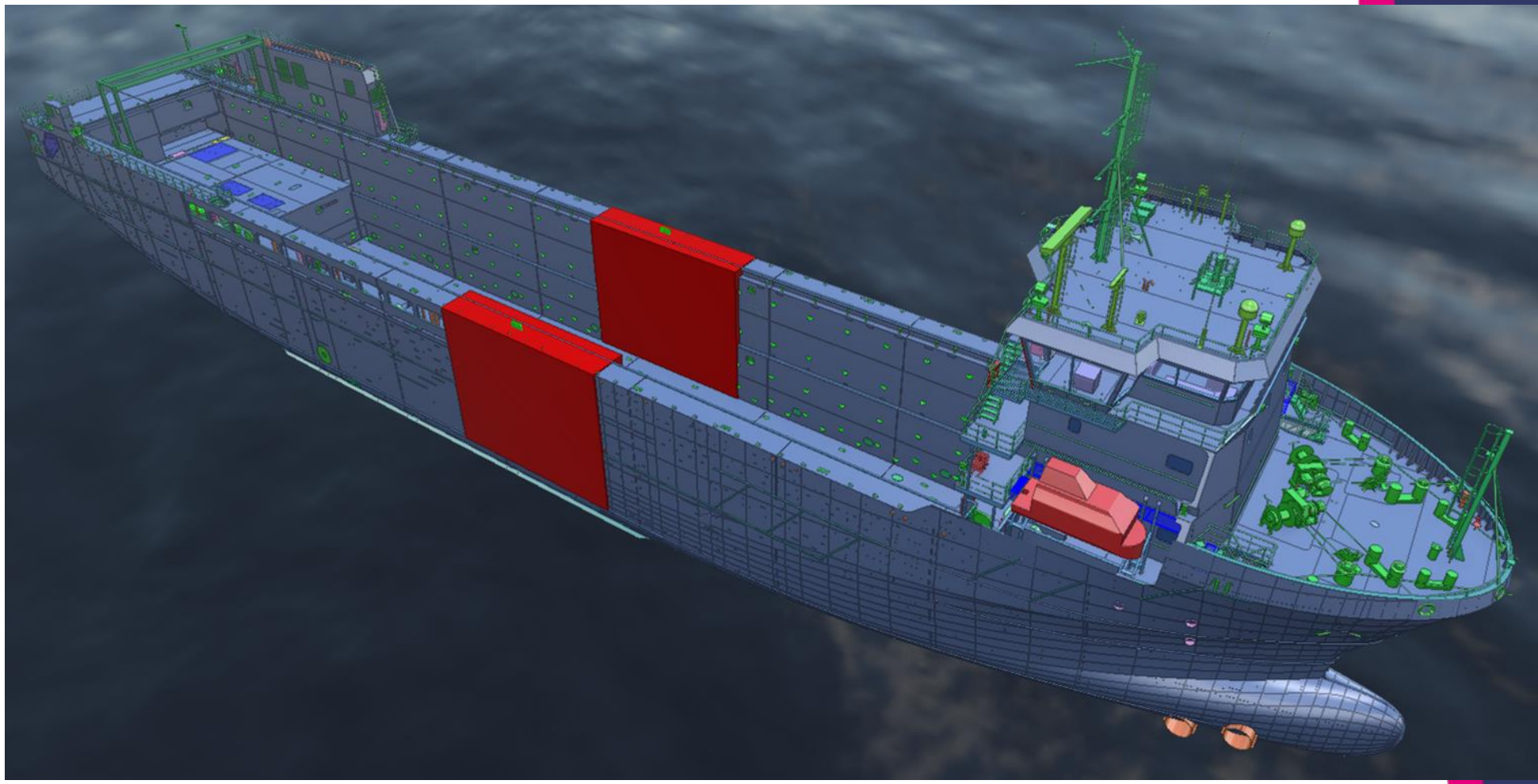
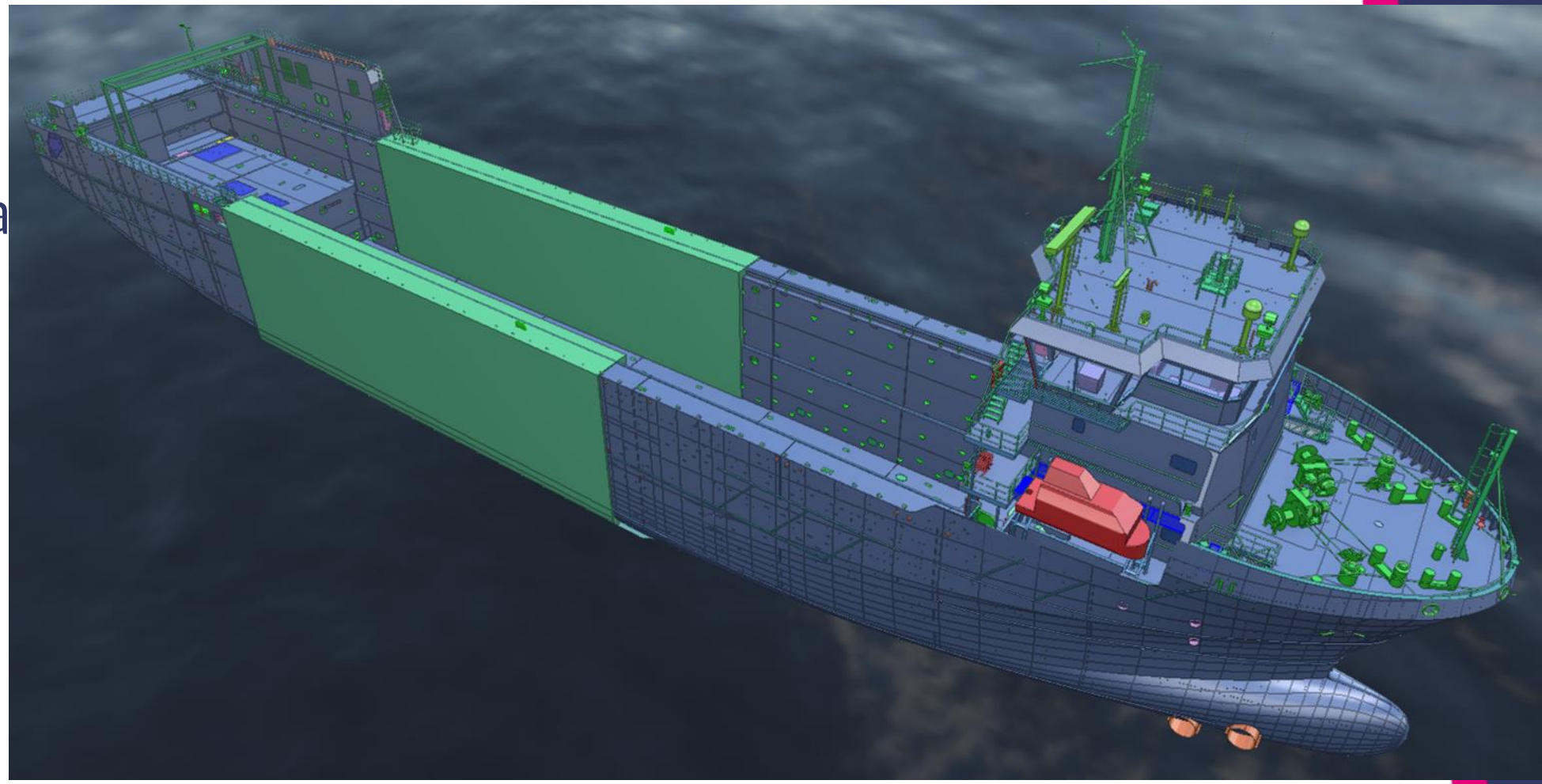
- 356 t

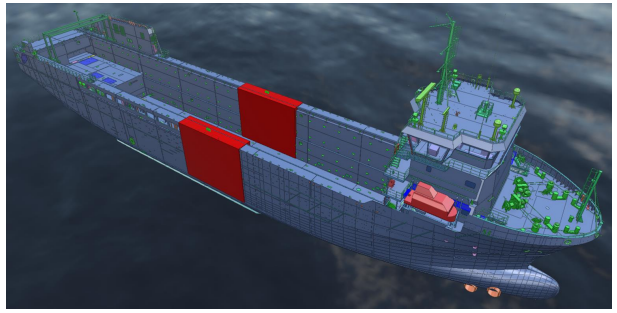


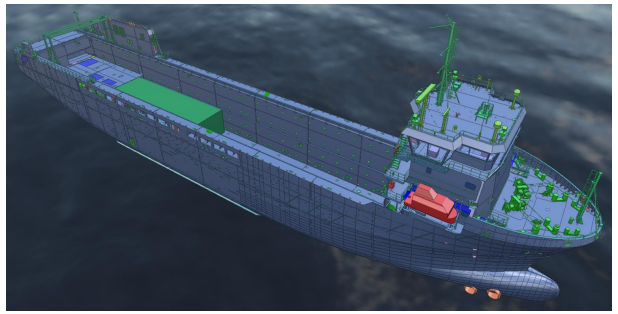
Methanol in integrated tanks (2)

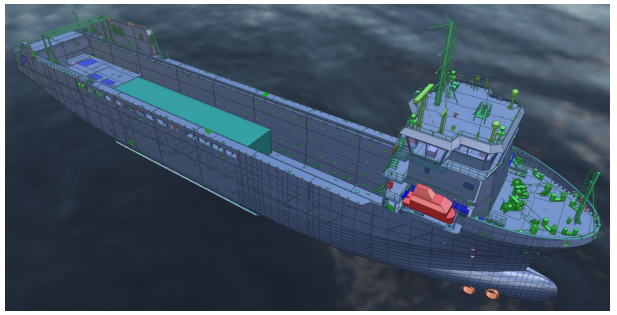
- 15300 GJ
- 966 m^3
- 763 t (+ extra for internal structure!)

- -400 t DWT (at least)
- -1000 m^3 ballast water

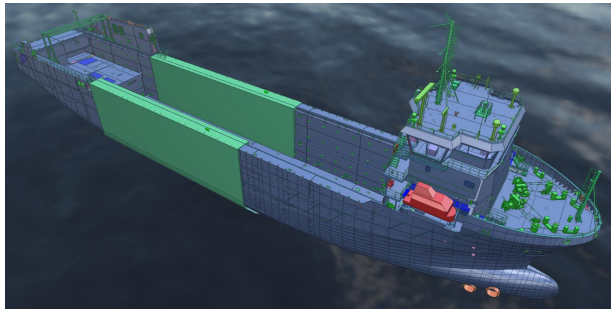


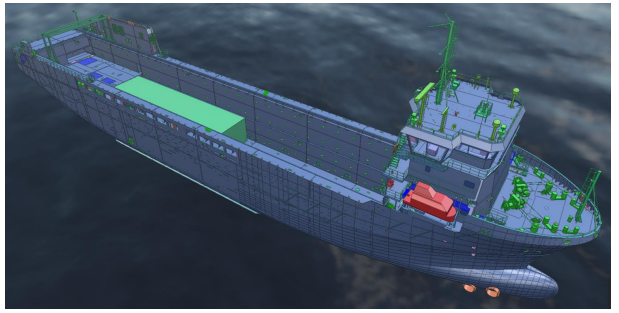


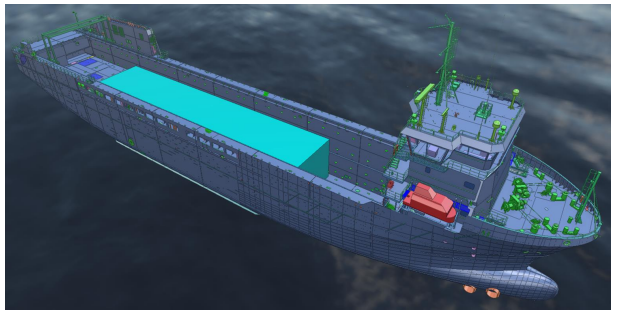




Energy storage is a major issue!







What about safety? (1)

- Fuel tank protection
  - LNG, ammonia, LH2 → Tanks at least B/5 from side
  - Methanol → 800 mm cofferdam above waterline
- Ventilation
  - LNG and methanol → 10 m from air inlets
  - Ammonia → 25 m from air inlets
  - Hydrogen → Clearance to be determined by analysis
- Explosion-proof zones
  - At least 3 m around any outlet or bunker station

What about safety? (2)

- Fuel preparation
  - Supplied to ICEs as gas
  - Separate room required for fuel preparation
- Fuel supply
  - Double-walled piping, or inside ventilated duct
  - Inert gas system required

Concluding remarks

- Equivalent energy storage requires great sacrifice
  - Reduce energy requirements
  - Reduce endurance
- Safety requirements pose no major obstacles
  - LNG vessel have been operating for years
  - Most regulations similar
- Different fuels suitable for different vessels!
- Fuel availability?

Thank you for your attention!

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