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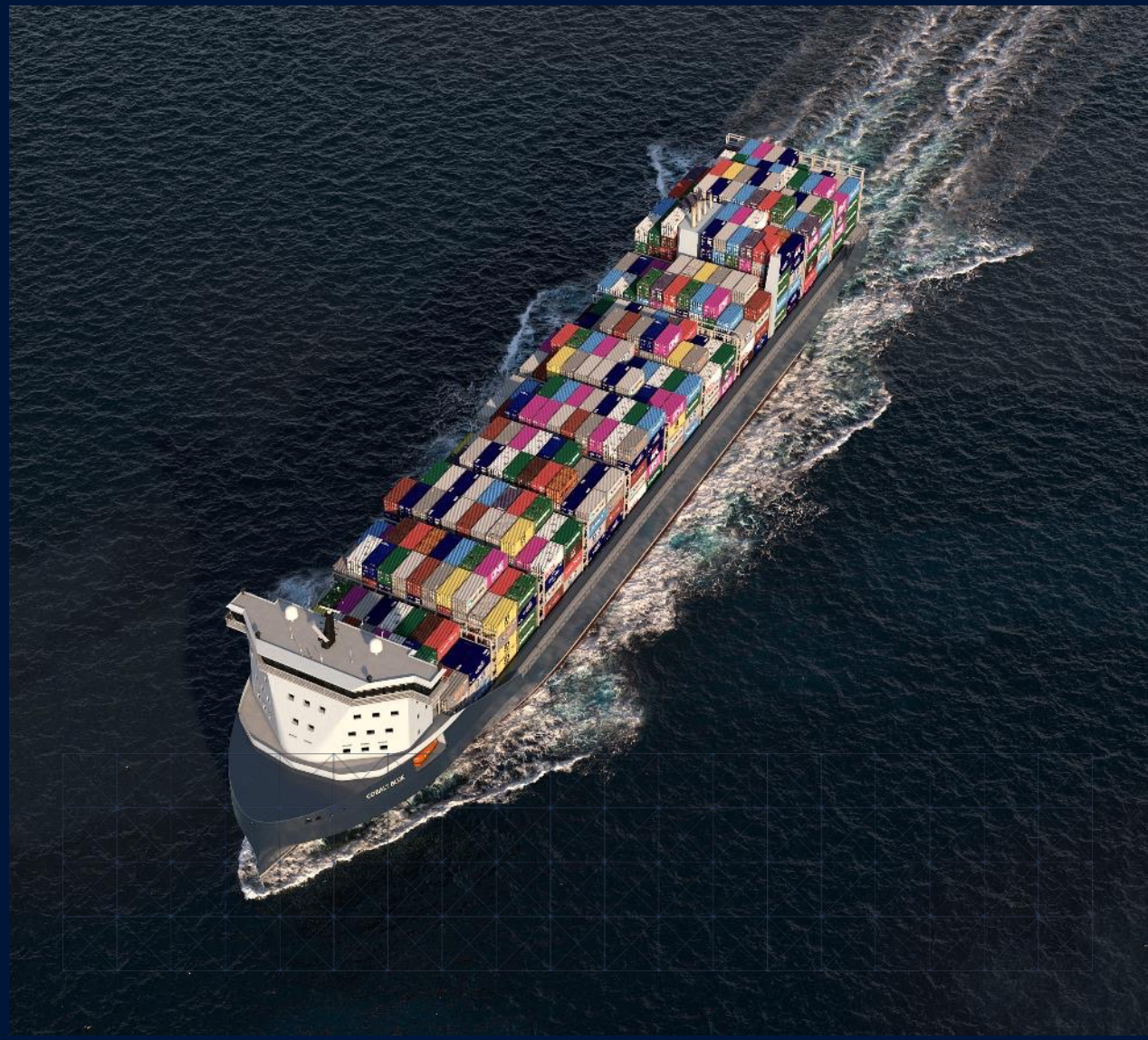
KUINKA TEHDÄÄN SUOMALAINEN HIILINEUTRAALI ALUS?

VAIHTOEHTOISET POLTTOAINEET JA ENERGIALÄHTEET

Helsinki, April 12th, 2023



Oskar Levander, SVP Business Development

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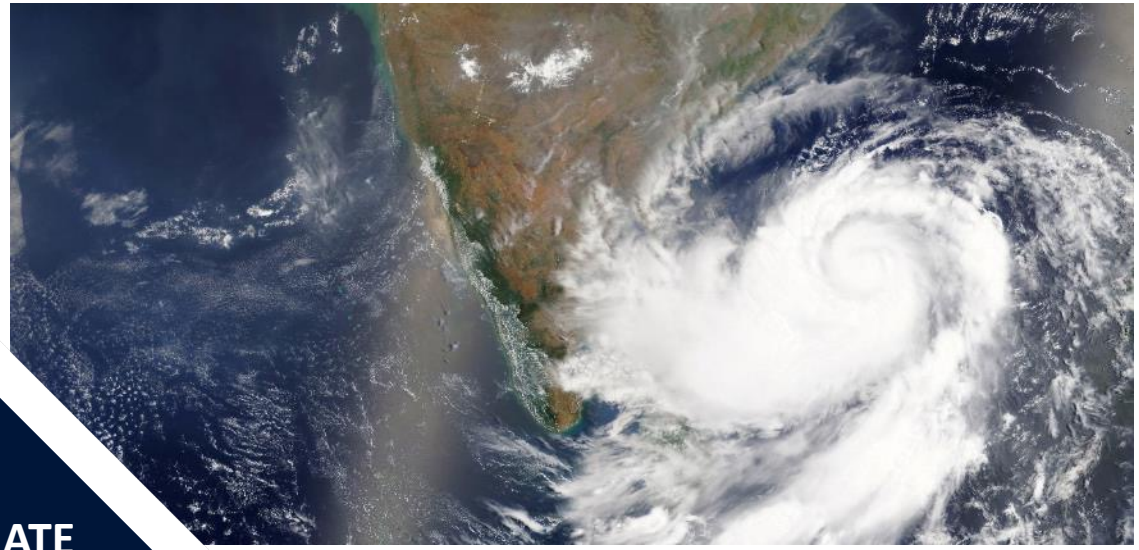
MARINE TREND:
GHG REDUCTION

Society is demanding action!



CLIMATE CHANGE

Environmental ambitions

reduction of Green House Gas (GHG) emissions

New targets in the summer??

IMO ambition:
Levels of ambition compared to 2008

-50%
GHG emissions from international shipping

-40%

-70%
CO_2 emissions per transport work

2030

2050

The European Green Deal
"Fit for 55 package"
Levels compared to 1990 levels

-55%

CLIMATE NEUTRAL

GHG emissions

Means to reduce GHG footprint

Reduce resistance // Hull cleaning

Air lubrication // Green DP

Reduce electric hotel and heat load

Install energy efficient electric consumers

REDUCE ENERGY CONSUMPTION

Remove non value adding activities

Operation planning // Operate at lower speed

Reduce distance travelled

MAXIMISATION OF ENERGY CONVERSION EFFICIENCY

Energy optimisation // Energy management

Propulsion, engine and system efficiency

Waste heat recovery

Fuel Cell // Battery

USE OF CLEAN ENERGY SOURCES & FUELS

Wind power // Wave power // Solar power

Shore power // Battery

Bio fuels // LNG/SNG // H2

NH3 // MeOH

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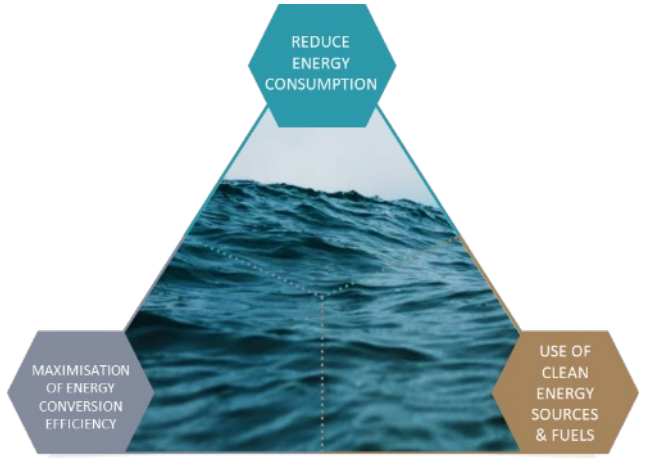
Measures to improve index values or compliance



		IMO			EU		
		EEDI	EEXI	CII	ETS	FuelEU	ETD
CLEAN ENERGY SOURCES	Low carbon fuels	√	√	√	√	√	?
	Fuel blending	–	–	√	√	√	?
	Wind power	√	√	√	√	√	√
	Solar	√	√	√	√	√	√
	Wave power	–	–	√	√	–	√
	Shore power	–	–	√	√	√	√
ENERGY EFFICIENCY	Propulsion efficiency	√	√	√	√	–	√
	Machinery efficiency	√	√	√	√	–	√
	Waste heat recovery	?	?	√	√	–	√
	EcoAdviser	–	–	√	√	–	√
	Smart energy management	–	–	√	√	–	√
ENERGY DEMAND	Route optimisation	–	–	√	√	–	√
	Operate at lower speeds	–	–	√	√	–	√
	Operational efficiency	–	–	√	√	–	√
	Hotel load reduction	√	√	√	√	–	√
	Lower resistance (eg. air lubrication, hull coating, ...)	√	√	√	√	–	√
	Hull cleaning (e.g. Hull skater)	–	–	√	√	–	√
	Engine de-rating	√	√	–	–	–	–

Fuel transition

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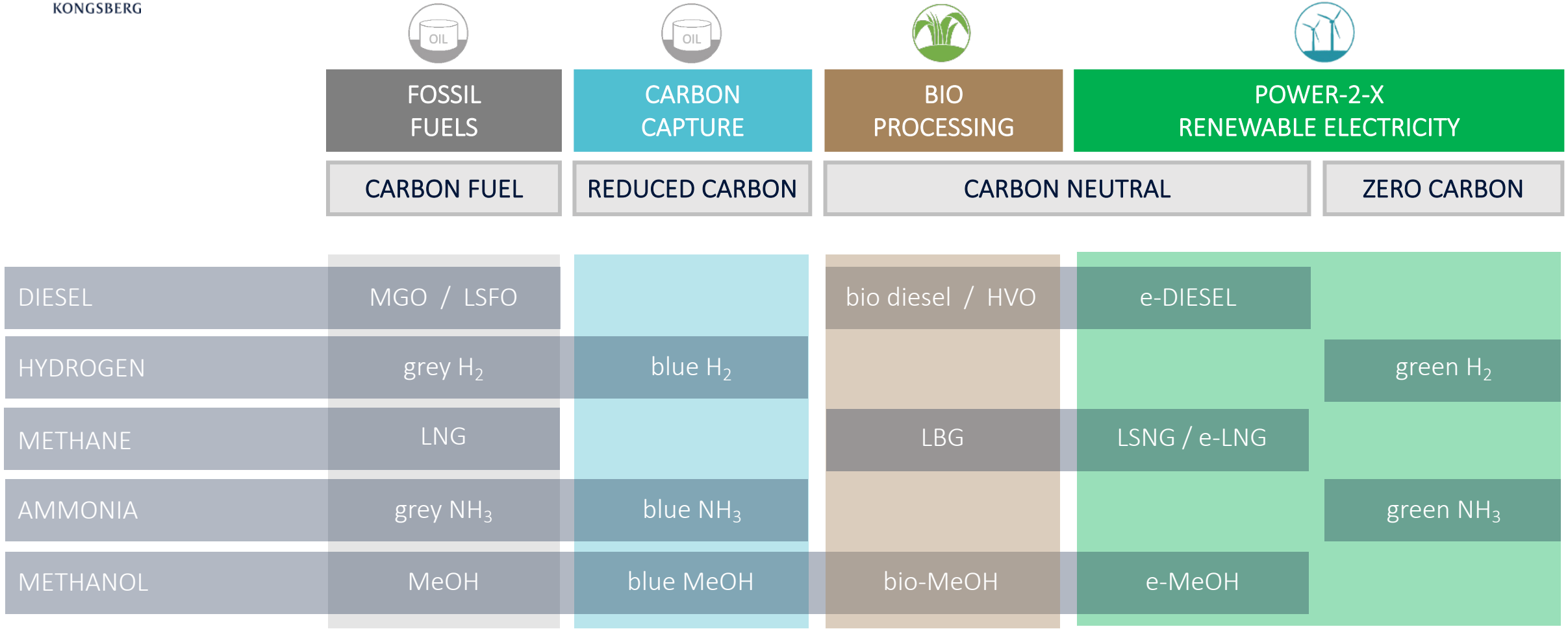
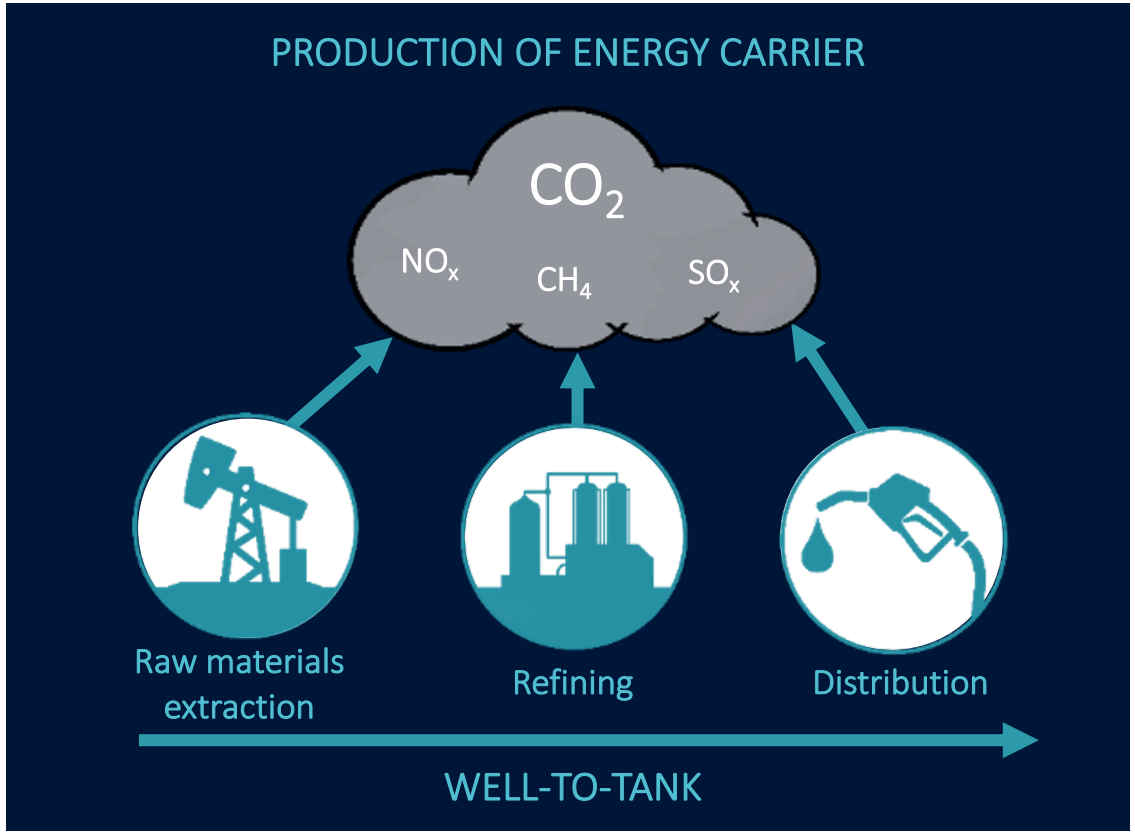
Fuel production pathways

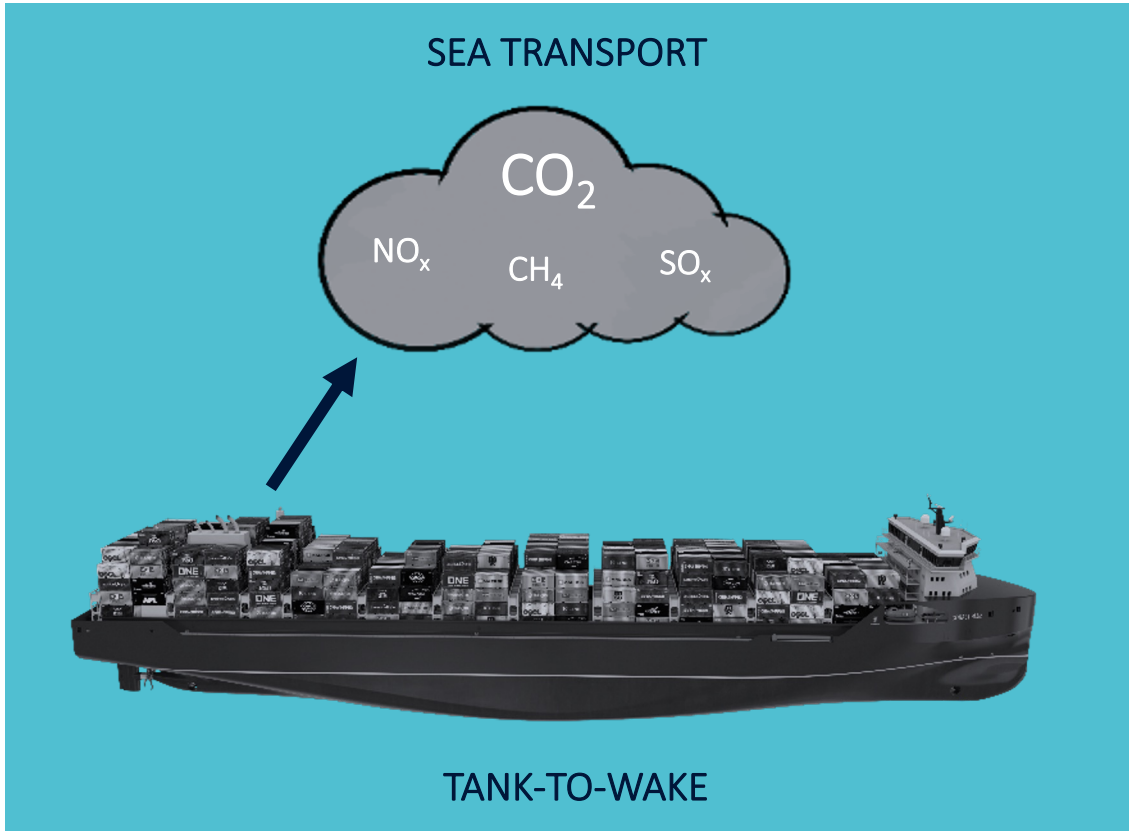


CCS	Carbon Capture and Sequestration	NH3	Ammonia	MeOH	Methanol
LSNG	Liquefied Synthetic Natural Gas	H2	Hydrogen	HVO	Hydrotreated Vegetable Oil

Life cycle emissions

WELL-TO-TANK – TANK-TO-WAKE

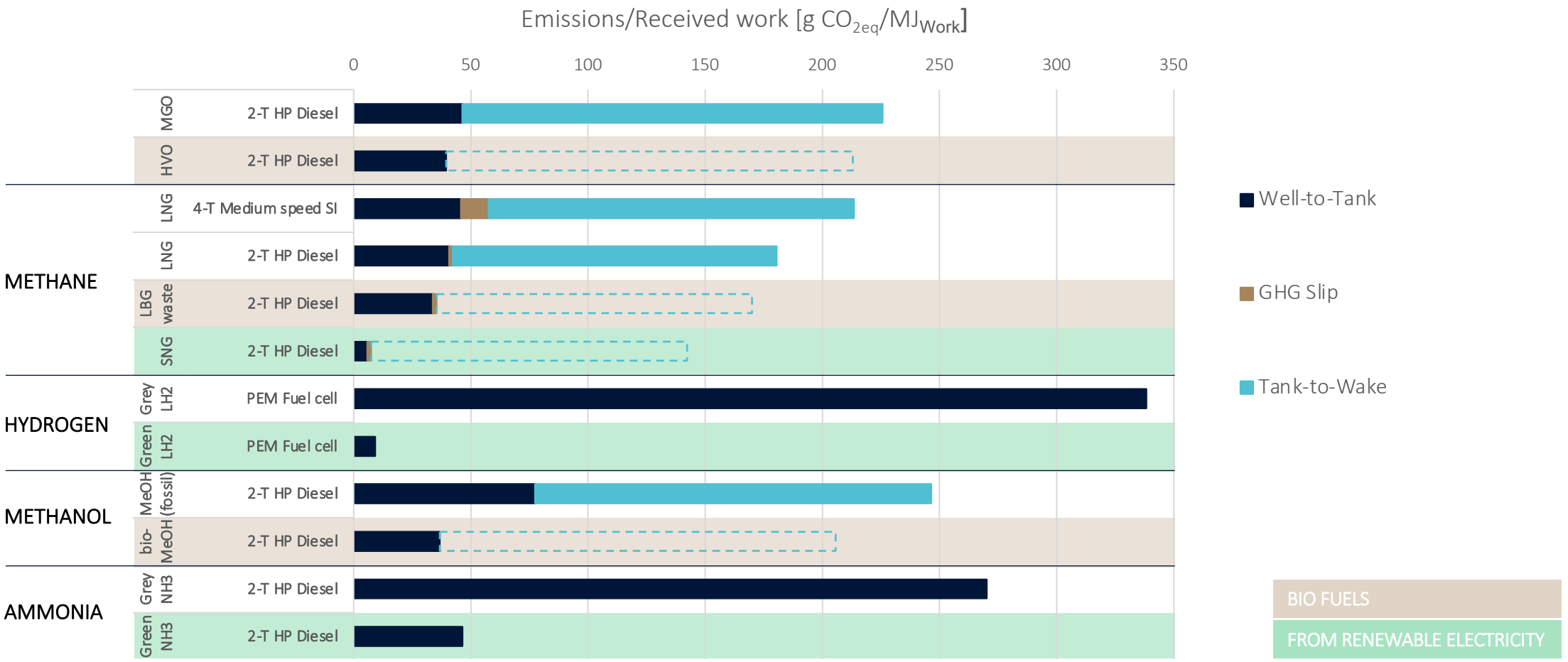




LCA transport (WELL-TO-WAKE)

Well to wake – GHG emissions

Example: 2000 TEU feeder

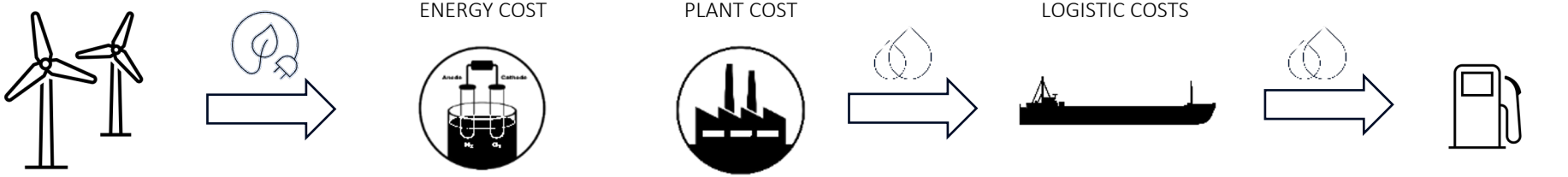


Low carbon fuel options

	HVO	LBG / e-LNG CH_4	Methanol MeOH	Ammonia NH_3	Hydrogen H_2	Battery
Space requirement relative to MGO		2.7 x	2.5 x	3.2 x	8–25	?
Emission reduction comp. to MGO	-57%	-80%	-80%	-85%	-90%	-95%
Safety concerns						
Infrastructure & availability						
Rules & regulations						
Prime mover availability and maturity				2025 +		

Power-2-X fuels will be expensive

Will hydrogen price be attractive in the future?



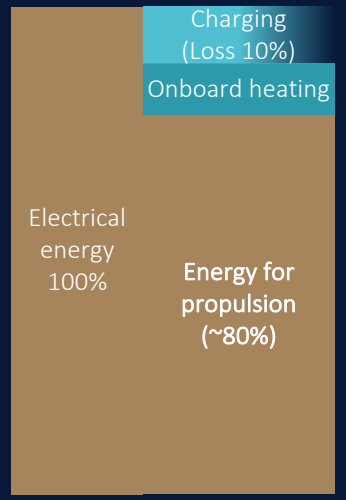
CLEAN ELECTRICITY	ELECTROLYSIS PROCESS (70 % efficiency)	ELECTROLYSIS PLANT & STORAGE TANKS (1000 KG/24 H ~ 4,3 M€)	DISTRIBUTION	BUNKER PRICE (TEORETICAL)
0,10 €/kWh	156 €/MWh	50 €/MWh	> 15 €/MWh	**> 221 €/MWh**
0,05 €/kWh	78 €/MWh	50 €/MWh	> 15 €/MWh	**> 143 €/MWh**
0,02 €/kWh	31 €/MWh	50 €/MWh	> 15 €/MWh	**> 97 €/MWh**

Reference fuel price examples:

- MGO: 600 $/ton ≈ 44 €/MWh
- LNG: 10 $/mmBTU ≈ 34 €/MWh

Efficient use of renewable electricity

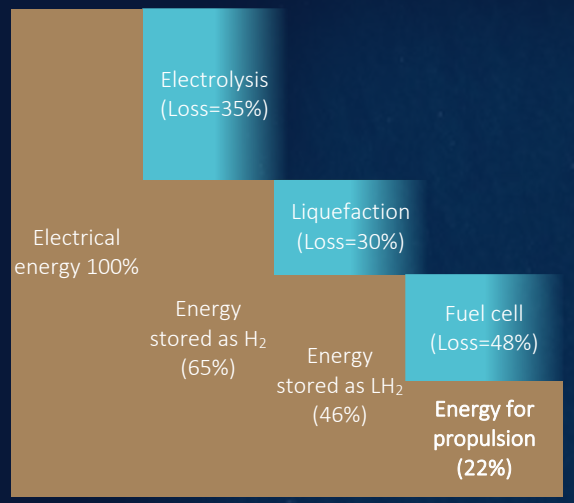
How much energy can be utilized onboard the vessel



BATTERY

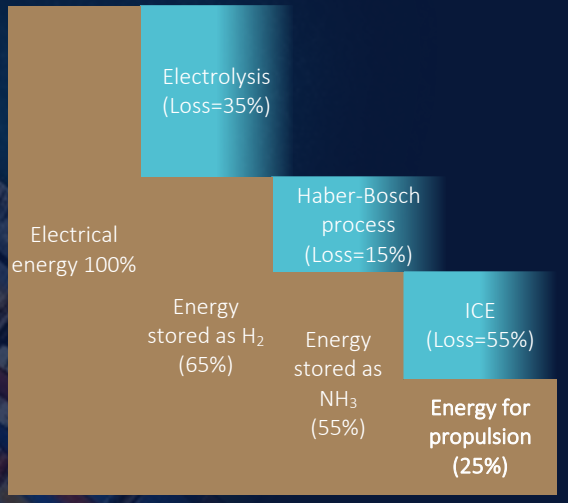
Best efficiency

Limited energy storage capacity



LIQUIFIED HYDROGEN, LH2

Electrolysis and liquefaction process consumes a lot of energy



AMMONIA, NH3

Similar energy efficiency as for LH2

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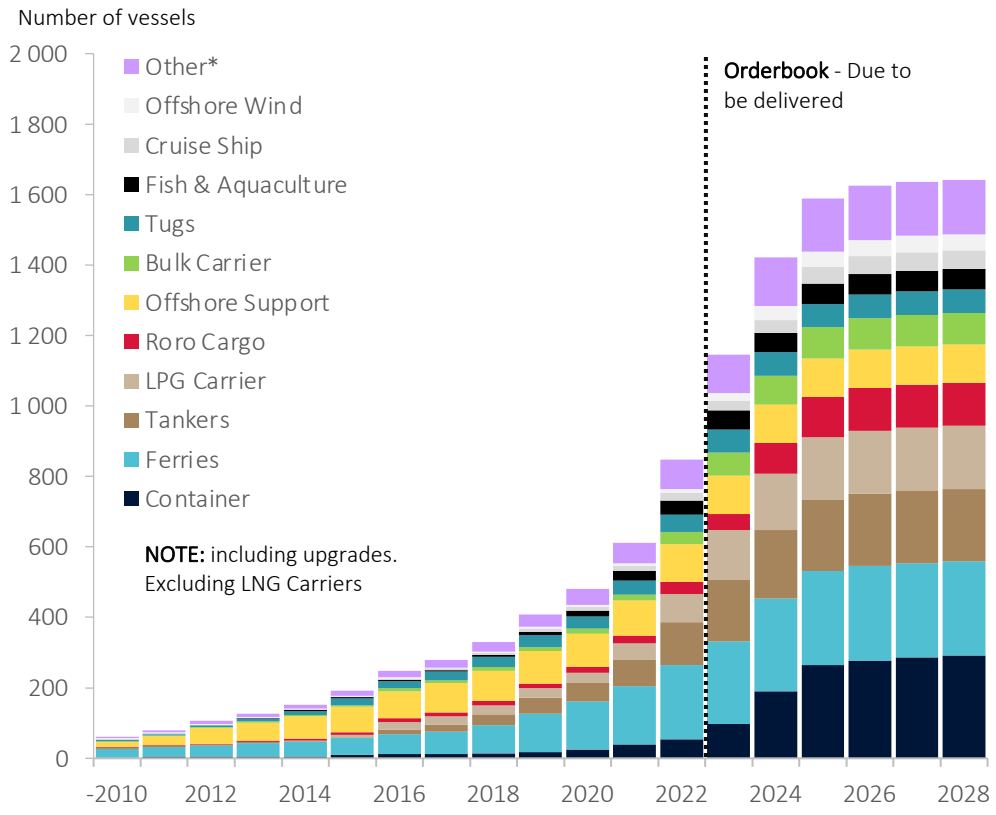
Alternative Fuels

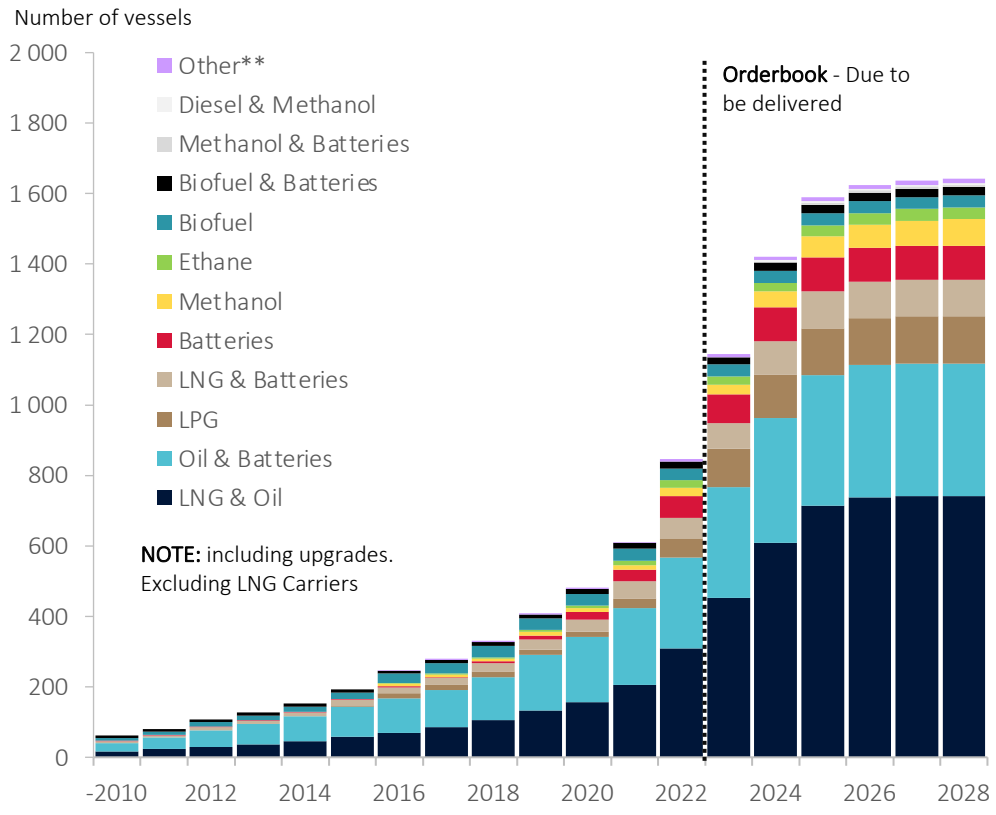
Fleet- and orderbook development by delivery year

VESSEL TYPES WITH ALTERNATIVE FUEL



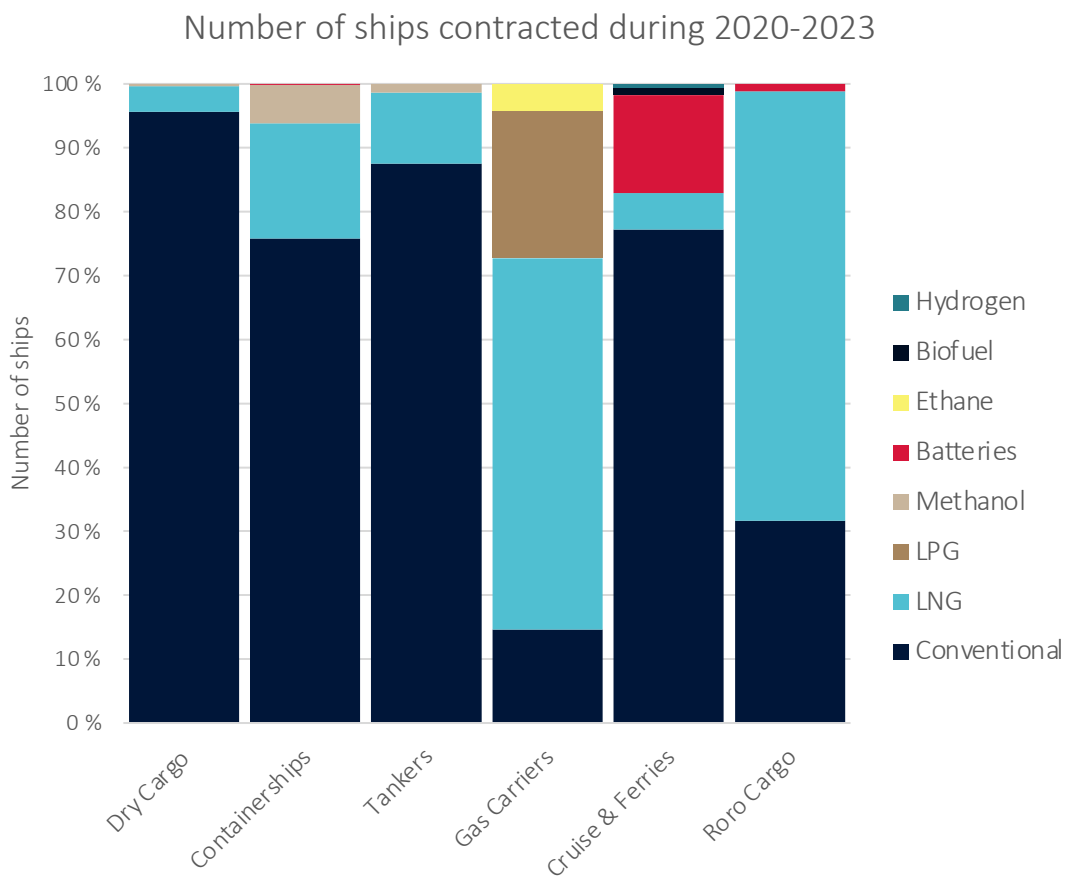
*Other: General Cargo, Multi-purpose Cargo, Yachts, Research, Dredgers, Cable layers, Anti-Pollution Vessels, Work / Repair Vessels, misc. Offshore and misc. other.

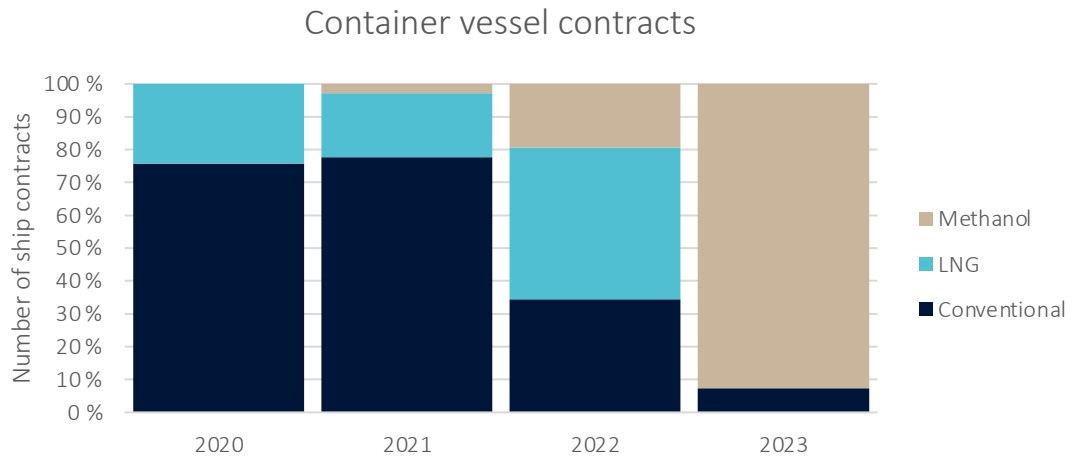
ALTERNATIVE FUEL TYPES

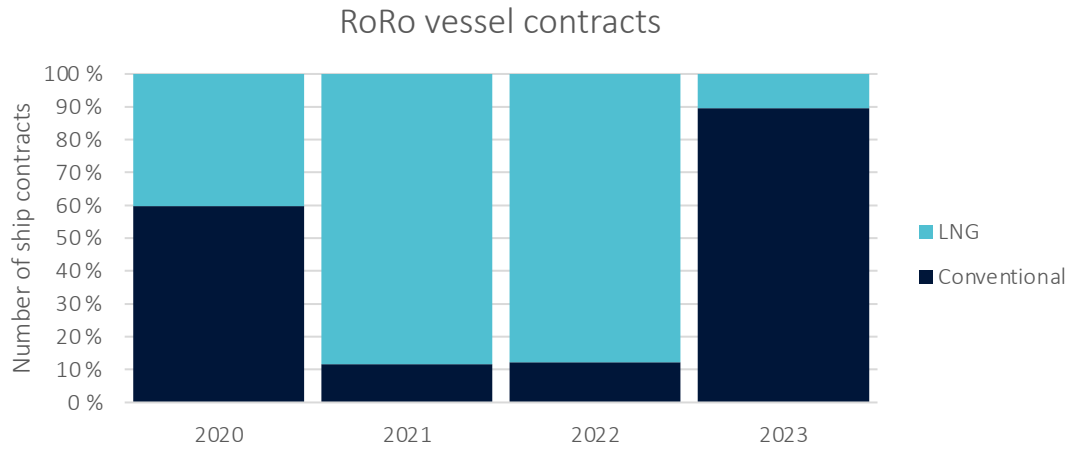


**Other: Diesel & Methanol, Hydrogen, Diesel & LPG, Heavy Fuel Oil & LNG, CNG & Batteries, Diesel & CNG

Uptake of alternative fuels







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Future fuel vs ship segments

	CRUISE	ROPAX	ROADFERRY	TUG	TRAWLER	OSV	SOV	SHORT SEA	CONTAINER	BULKER
PURE BATTERY (shore power)	–	–	√	√	–	–	√	√	–	–
COMPRESSED HYDROGEN	–	–	√	√	√	–	–	√	–	–
LIQUIFIED HYDROGEN	–	–	√	–	√	–	–	–	–	–
AMMONIA	–	–	–	–	–	√	–	√	√	√
METHANE	√	√	√	–	–	√	–	√	√	√
METHANOL	√	√	√	–	–	√	√	√	√	√
HVO	√	√	√	√	√	√	√	√	–	–

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Future fuel vs ship segments

Case studies

	CRUISE	ROPAX	ROADFERRY	TUG	TRAWLER	OSV	SOV	SHORT SEA	CONTAINER	BULKER
PURE BATTERY (shore power)	–	–	√	√	–	–	√	√	–	–
COMPRESSED HYDROGEN	–	–	√	√	√	–	–	√	–	–
LIQUIFIED HYDROGEN	–	–	√	–	√	–	–	–	–	–
AMMONIA	–	–	–	–	–	√	–	√	√	√
METHANE	√	√	√	–	–	√	–	√	√	√
METHANOL	√	√	√	–	–	√	√	√	√	√
HVO	√	√	√	√	√	√	√	√	–	–

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CASE STUDY:

FUTURE PROOF

2 000 TEU FEEDER

Future proof

What should ship owners invest in today?

GREEN AGENDA

When will cargo owners and end consumers demand green transport?

FUEL TRANSITION

What are the next marine fuels?
When will the fuel shift take place?

NEW TECHNOLOGY

When will R&A ships set a new cost level?

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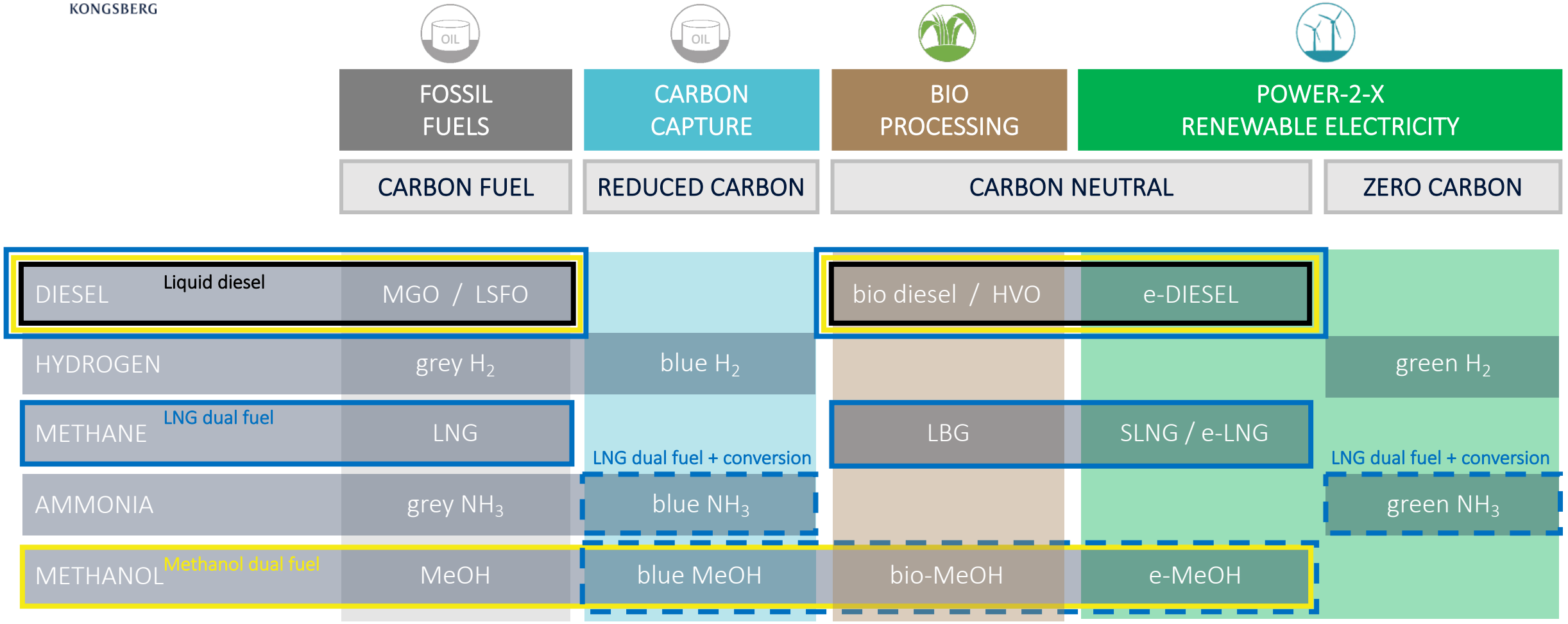
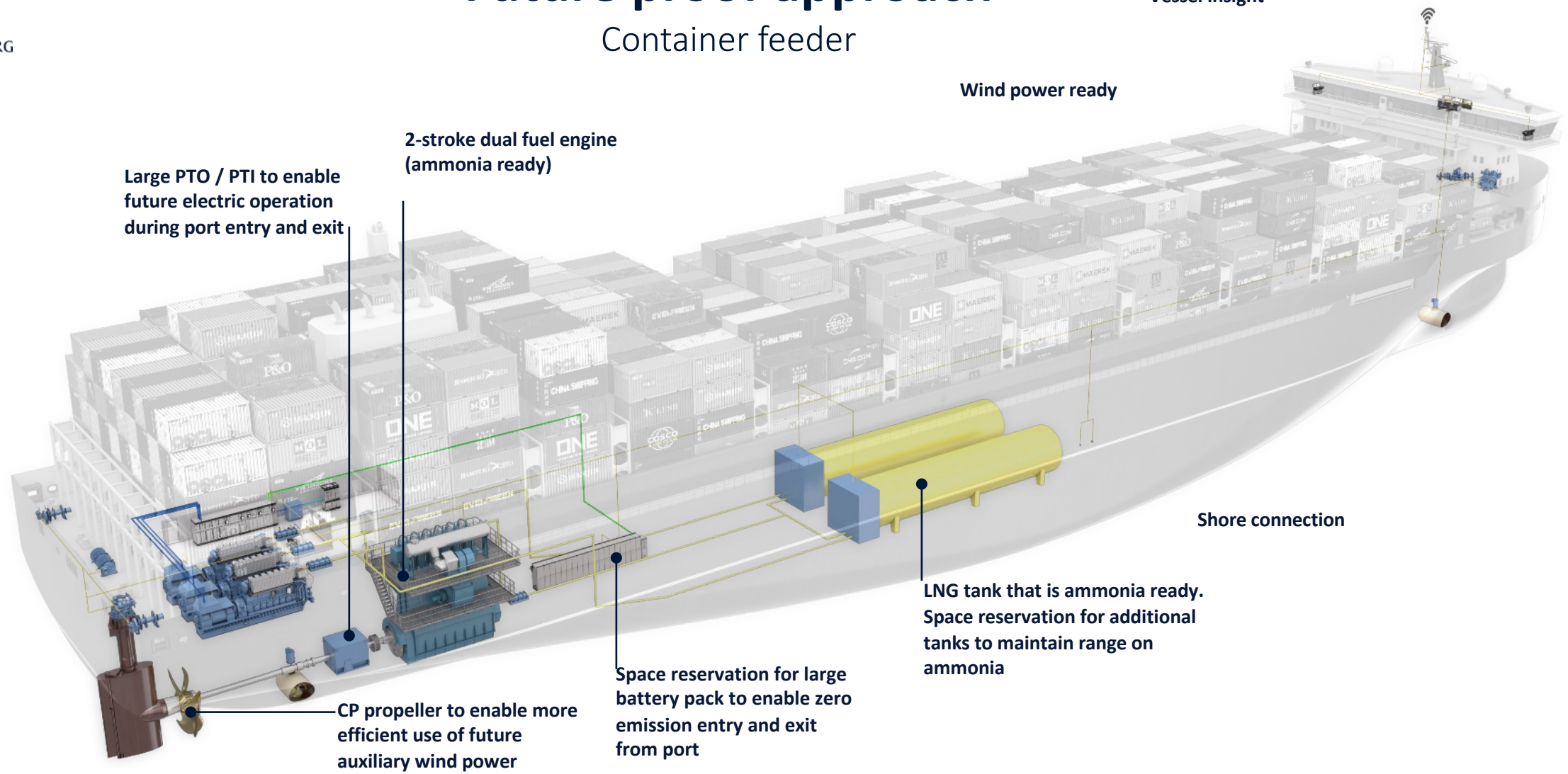
Fuel transition pathways



CCS	Carbon Capture and Sequestration	NH3	Ammonia	MeOH	Methanol
LSNG	Liquefied Synthetic Natural Gas	H2	Hydrogen	HVO	Hydrotreated Vegetable Oil

Future proof approach

Container feeder

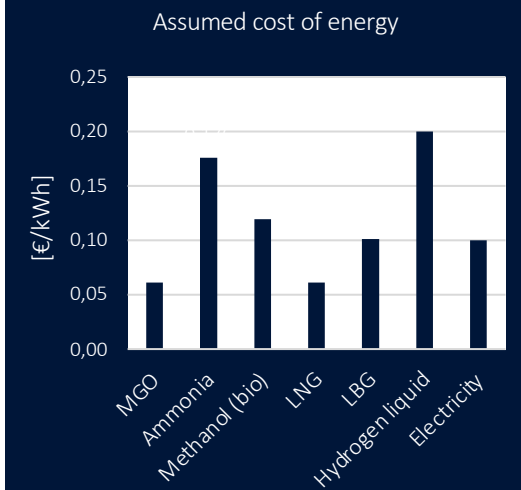


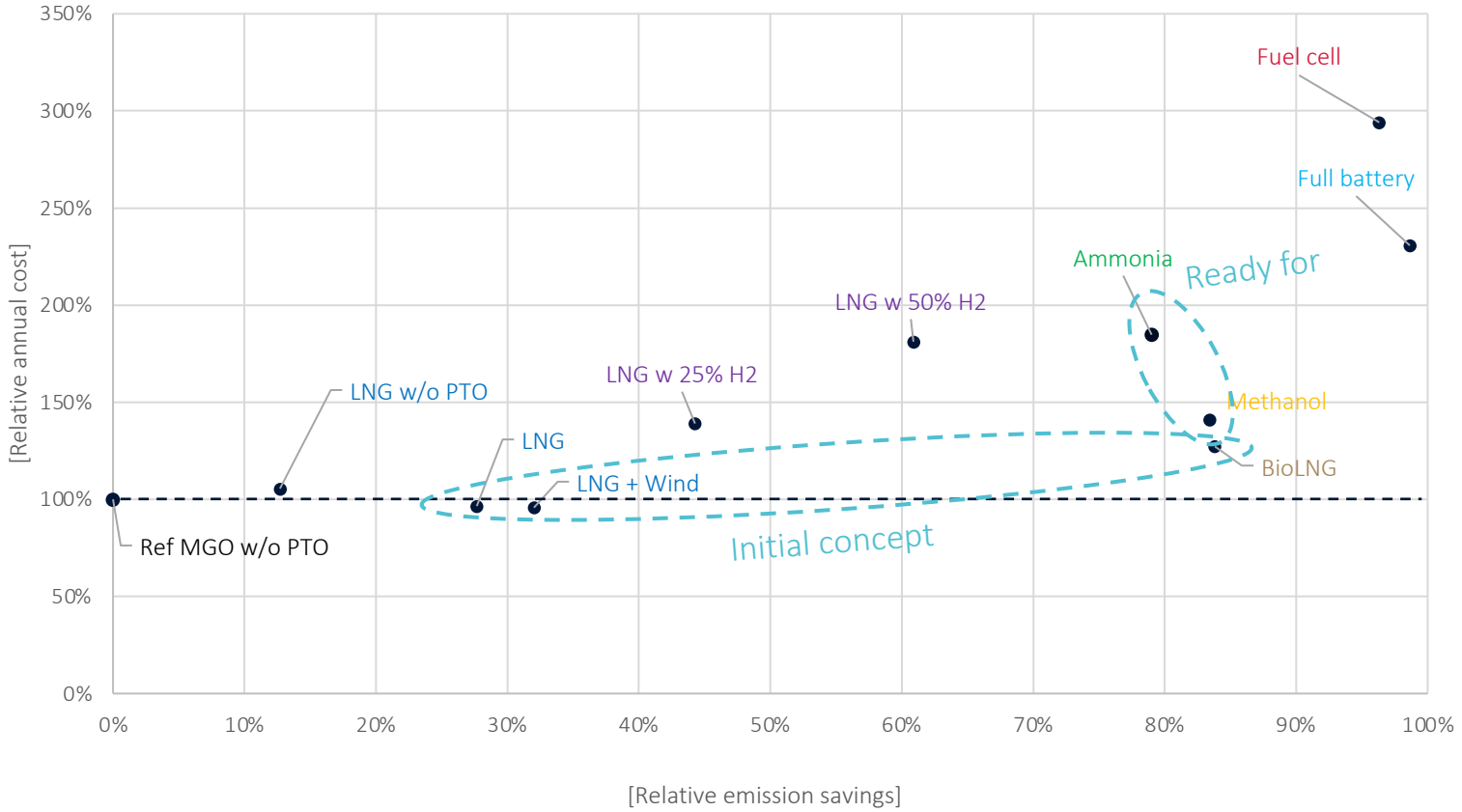
Container feeder

Relative annual cost (OPEX+CAPEX) vs CO_2 benefit

Assumptions:

- Fuel range: 3 000 nm
- Battery capacity for 500 nm (@ 13 knots)





Hydrogen
Hydrogen blending
Battery
Bio Methanol
Ammonia
Bio LNG
LNG

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ELECTRIFICATION AND ENERGY STORAGE

Hybrid ships

Hurtigrutten: Roald Amundsen & Fridtjof Nansen

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Battery retrofits

Energy Storage Deckhouse

Integration into DP, PMS & Alarm System

20-43%

MAINTENANCE REDUCTION BY REDUCED RUNNING HOURS OF GENERATORS

10-28%

FUEL SAVINGS BY RUNNING ONLINE GENERATORS MORE EFFICIENT

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Battery power is becoming a reality for small ships

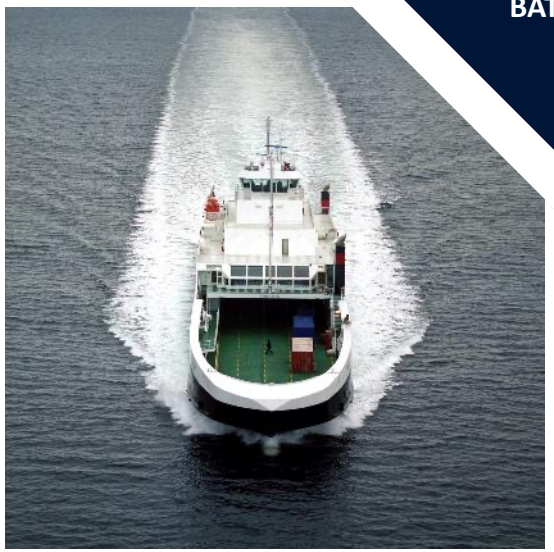
Road ferries

Coastal cargo

Tugs

...

PURE BATTERY



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Fuel cells

HYSEAS III - Fuel cell and battery full scale test bed

FUEL CELL INTEGRATOR

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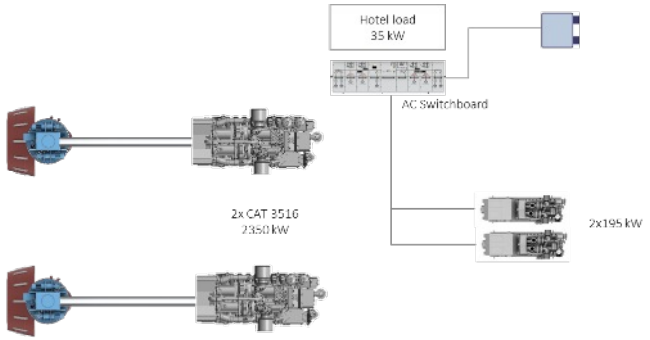
CASE STUDY:

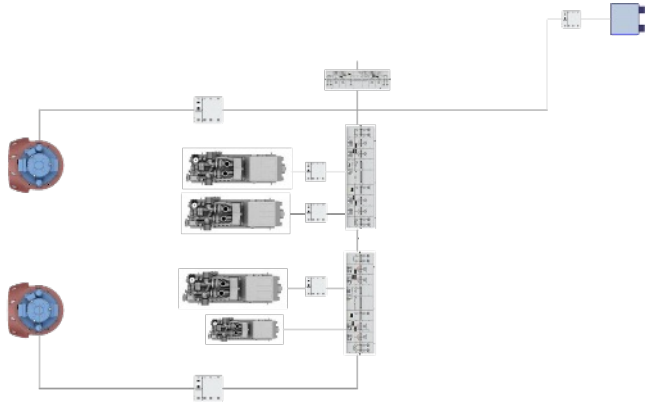
LOW EMISSION HARBOUR TUGS

Power and propulsion systems for tugs

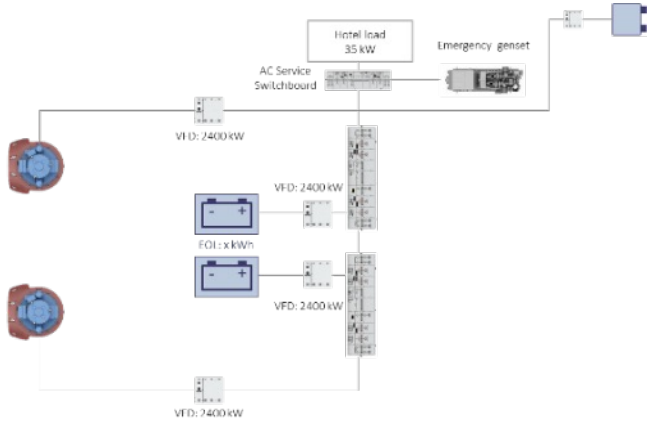
Mechanical



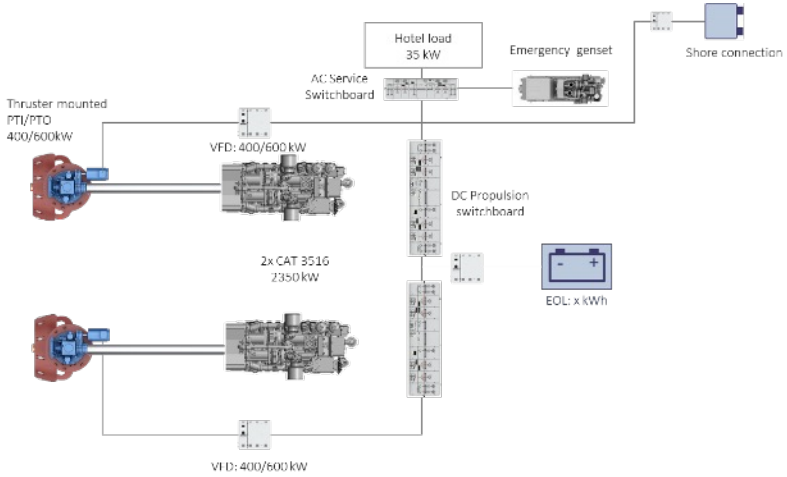
Diesel-Electric



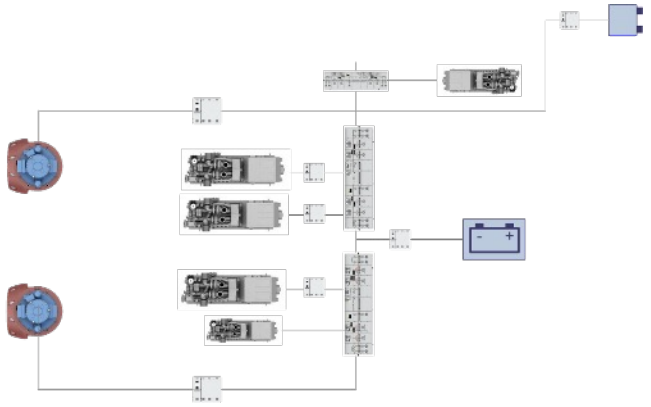
Pure electric



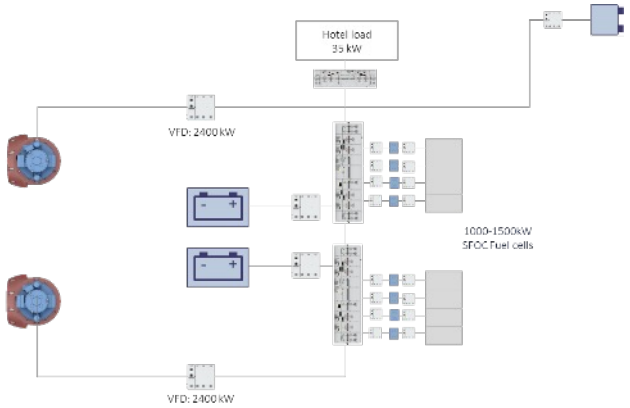
Mechanical Hybrid



Diesel-Electric Hybrid



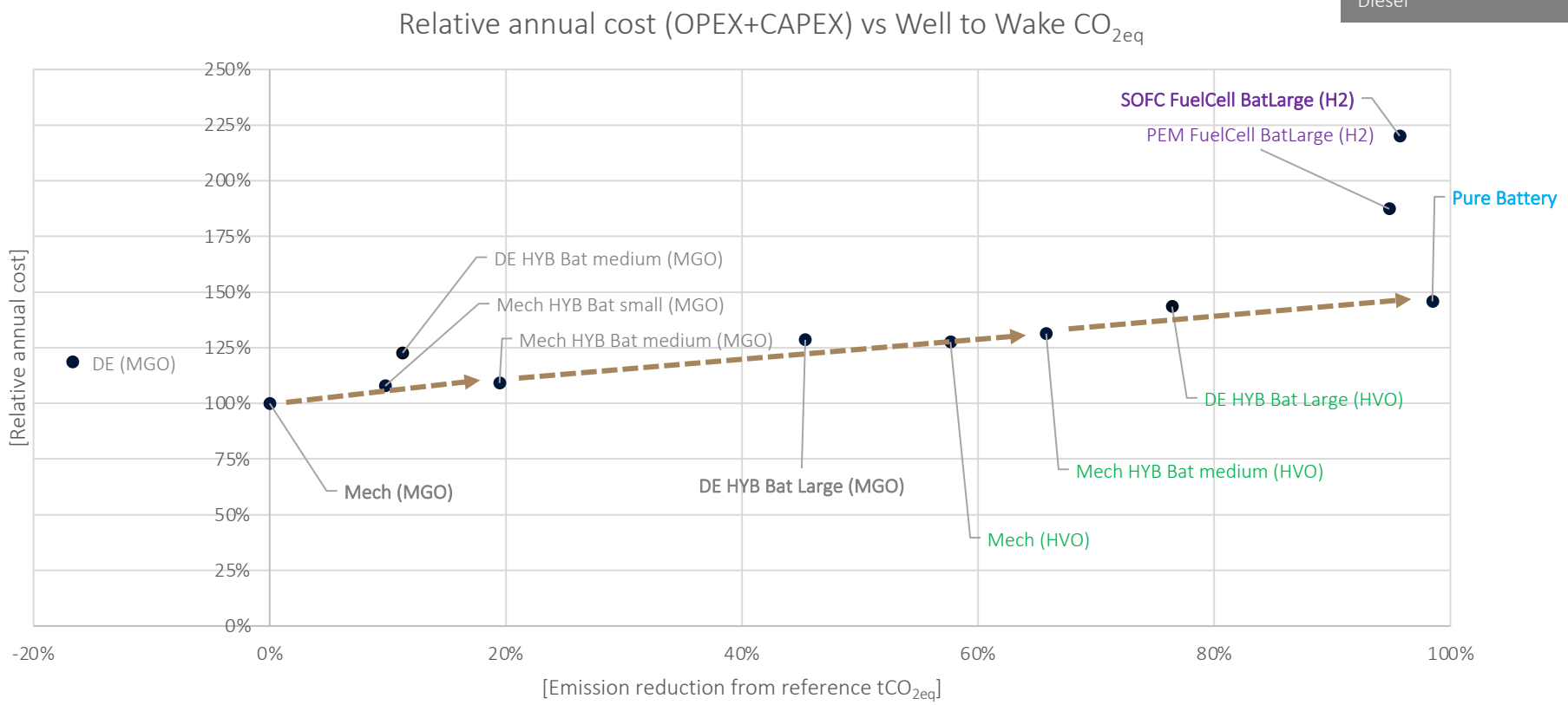
Fuel cell electric Hybrid



Harbour Tugs

Relative annual cost (OPEX+CAPEX) vs CO_2 benefit

Hydrogen
Renewable electricity
HVO – renewable diesel
Diesel



Relative annual cost
OPEX (fuel, engine maintenance, battery replacement cost)
CAPEX financing @6% for 10 years with no residual value

Energy prices
MGO $600/ton (17.0€/GJ) Compressed H2 8000€/ton (66.7€/GJ)
HVO $2000/ton (42.2€/GJ) Electricity 0.15€/kWh (41.7€/GJ)

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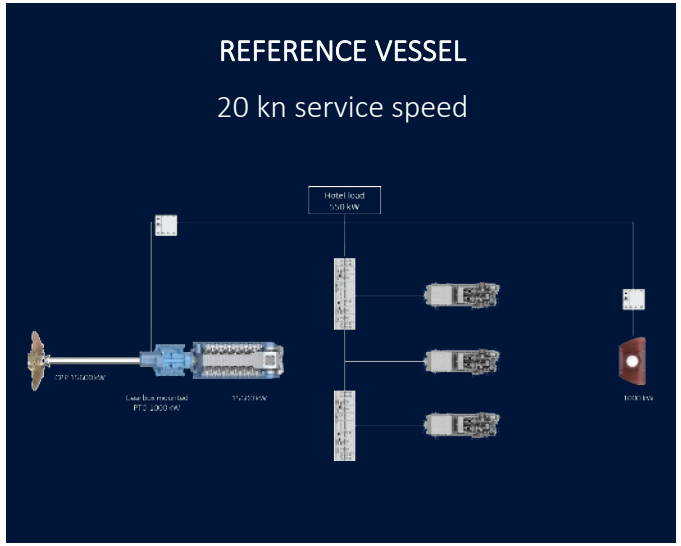
CASE STUDY:

ZERO EMISSION 1 500 LM RORO

RoRo vessel study

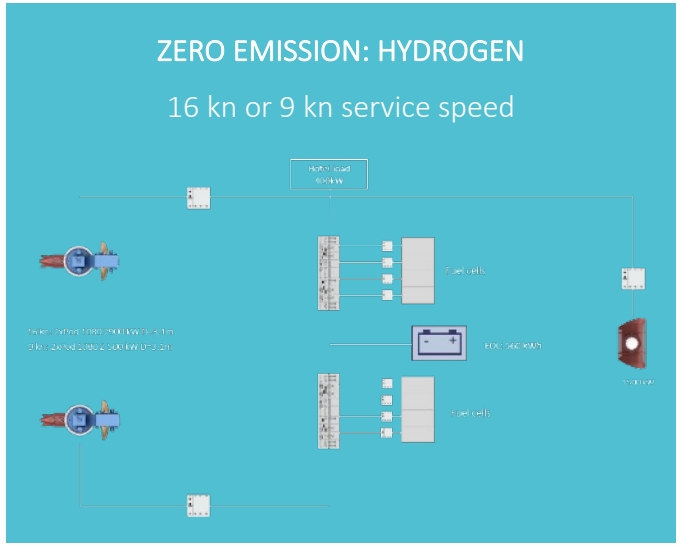
Machinery options



DIESEL OR HVO

1 x diesel engine 15,6 MW

3 x diesel gensets

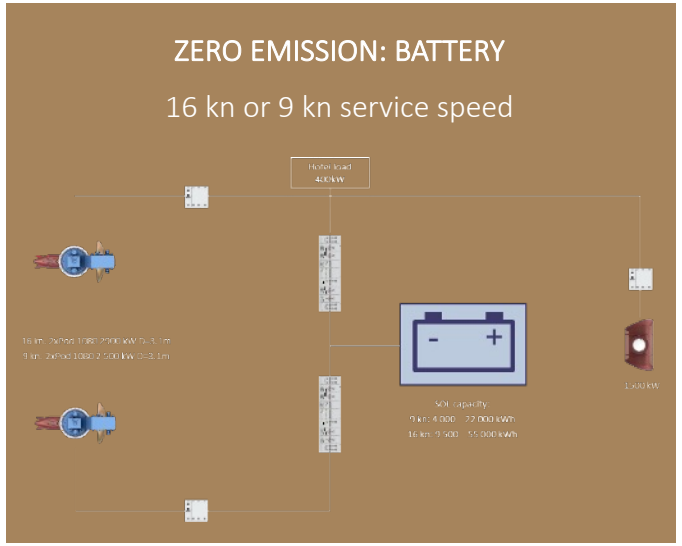


HYDROGEN AND FUEL CELLS

Installed fuel cell power:

16kn: 12 000 kW (30 x 400 kW)

9kn: 3 600 kW (9 x 400 kW)



PURE BATTERY

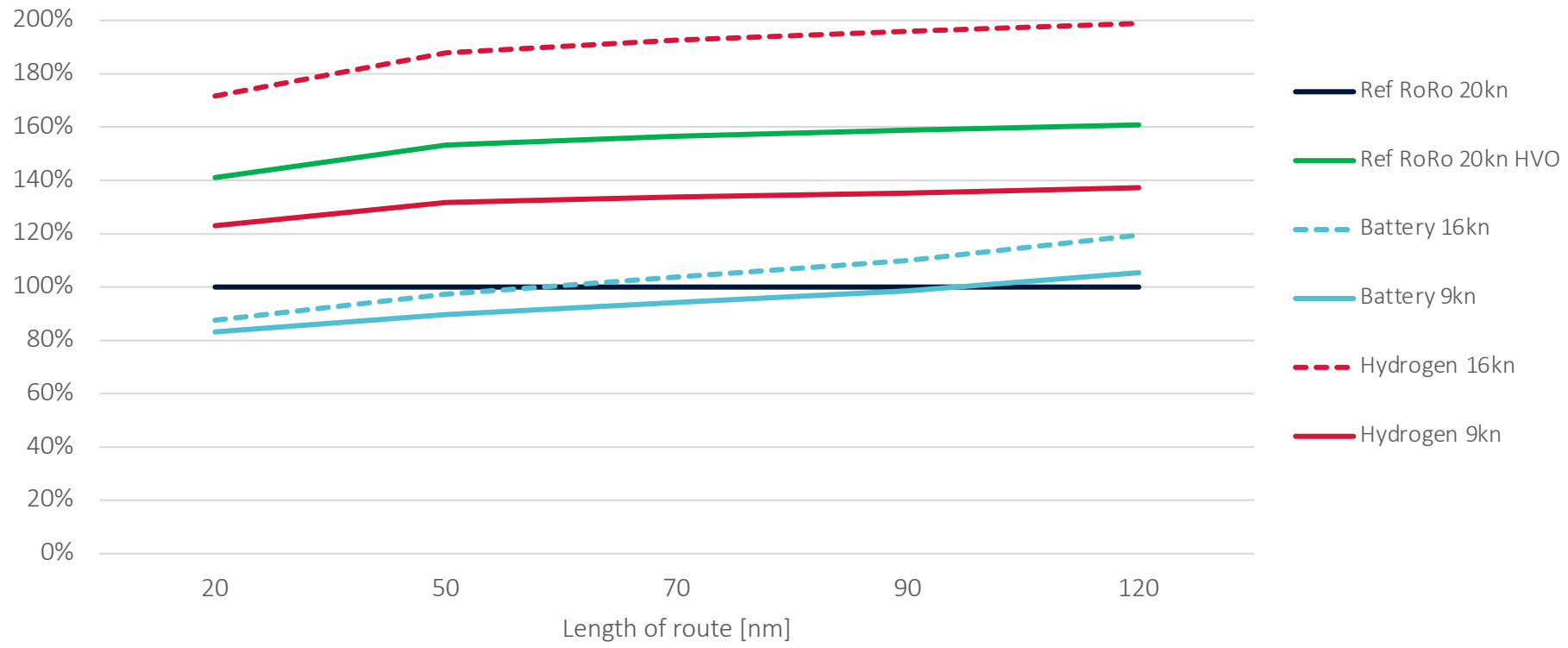
Installed battery capacity

16kn: 9 500 – 55 000 kWh

9kn: 4 000 – 22 000 kWh

Total transport cost

Relative annual cost per transported RoRo lanemeter

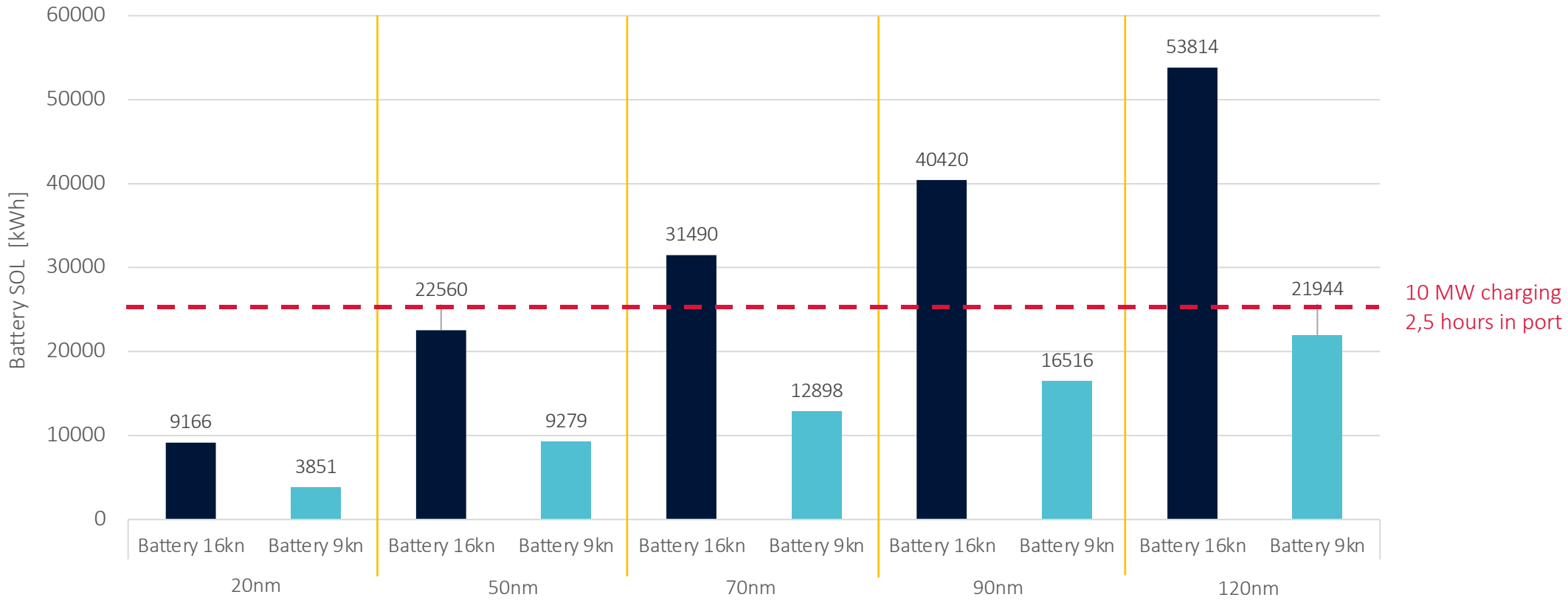


ASSUMPTIONS:

- MGO = $600/ton ~550€/ton
- HVO = ~2xMGO ~1100/ton
- Hydrogen compressed = 4300€/ton
- Grid = 0.8€/kWh

Battery capacity

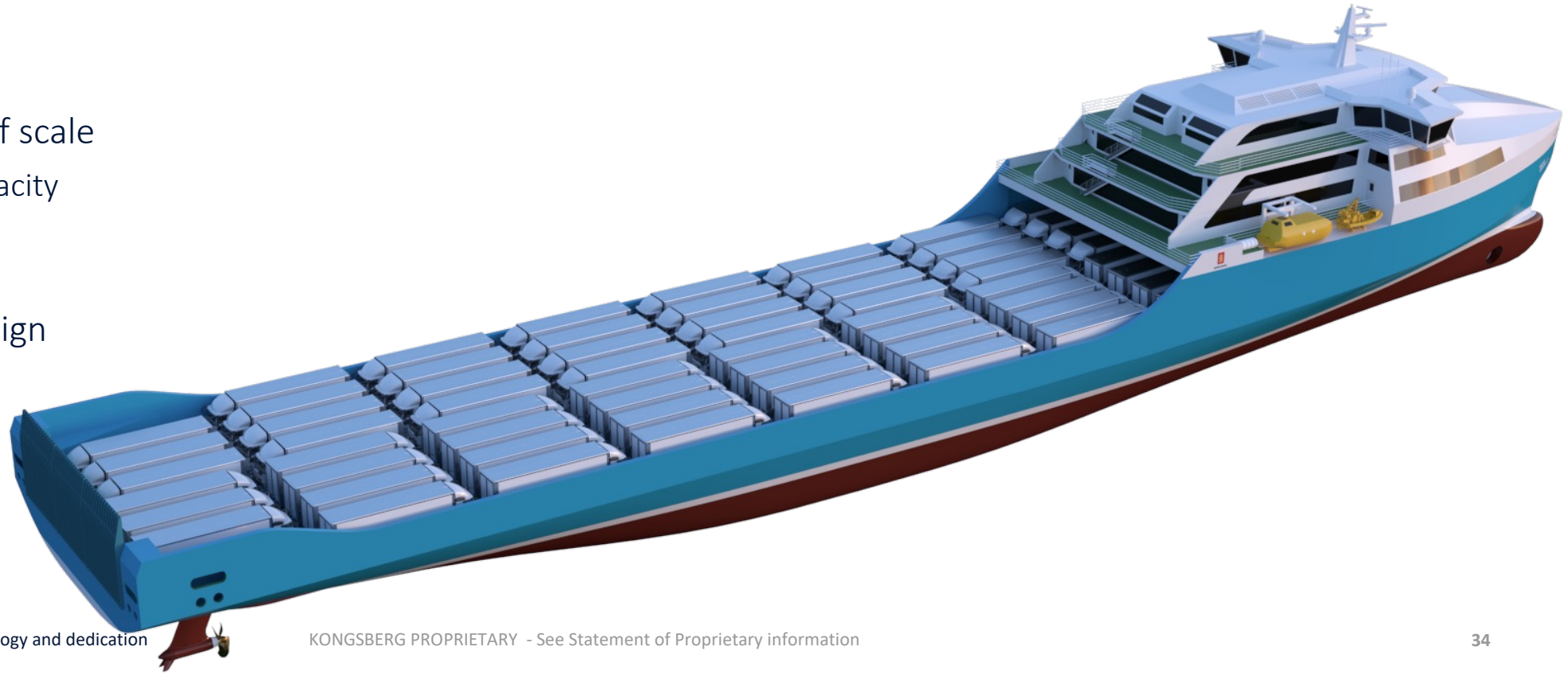
Electric RoRo



Making electric feasible

Electric RoRo

- Short routes
- Lower speed
- Rethink economy of scale
  - Energy storage capacity
  - Charging power
- New novel ship design



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SUMMARY

Summary

Finding the path towards carbon neutral shipping

ELECTRIC

Green technologies support increased electrification

Batteries is the most efficient way to use renewable electricity

Growing number of hybrids and pure electric vessels

FUTURE PROOF

Competitive in today's market - ready for low carbon fuels:

- Ammonia or Methanol ready LNG system
- Battery ready

Best efficiency:

- PTO/PTI
- Wind propulsion

NAVIGATE FUEL TRANSITION

Multifuel capability:

- LNG – BioLNG – LSNG
- Bio and green methanol
- Green ammonia
- HVO

Aim for highest efficiency

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PROTECHTING PEOPLE AND PLANET