MAN Energy Solutions
Future in the making

Decarbonizing Marine Transport

Automotive Logistics & Supply Chain Europe

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MAN Energy Solutions is member of the Volkswagen Group

14,000 employees worldwide

3.3 bn € revenue

120 sites globally

Marine (2-stroke & 4-stroke)

Power

Industries

Aftersales MAN PrimeServ

50% of Power for all World Trade Covered by our Engines

3%

of worldwide CO_2 emissions are caused by shipping (~ 1.2 bn tons of CO2)

90%

of the goods traded around the world are transported via maritime shipping

50%

IMO: Reduction of annual shipping emissions by 2050 (compared to 2008)

With alternative fuels and comprehensive system solutions MAN ES reduces CO_2 emissions in the shipping industry

Drivers for CO_2-Neutral Shipping

Regulatory and Market Requirements

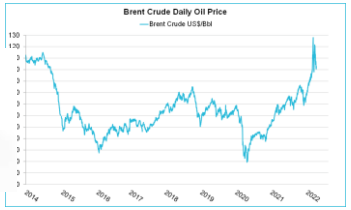
- **IMO** (International Maritime Organization)
  - **CO_2 reduction target** by 2050: 50% (absolute) / 70% (net per transport work)
  - **EEDI / EEXI** (Energy Efficiency Design Index for new and existing vessels) => CO_2 / nominal transport work of vessel
  - **CII** (Carbon Intensity Indicator) => operational index per vessel (from year 2023)
  - So far tank-to-wake approach only, but target to also include well-to-tank analysis to account for carbon neutral eFuels

- **European Union**

  Fit for 55 / FuelEU Maritime (expected entry into force in 2023)
  - Focus on GHG intensity of fuel type / well-to-wake approach
  - Increasing reduction of GHG intensity up to 75% by 2050
  - Relevant for vessels calling EU ports (50% accountability if coming from / going to outside EU)

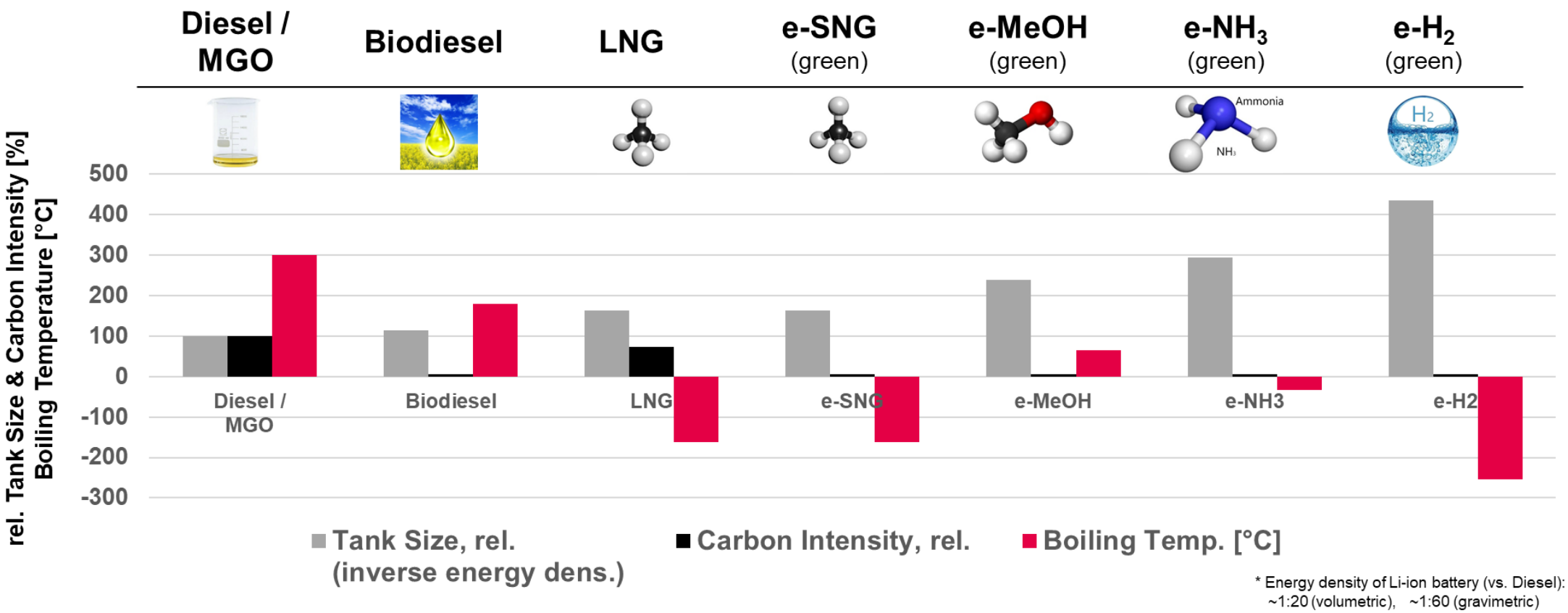
- **Market Request**
  - Customers willing to pay premium for carbon neutral transport in order to support own sustainability targets

- **Fossil Fuel Cost**
  - Zero carbon and carbon neutral fuels become attractive as conventional fuel prices rise steeply



Fuels Towards Carbon Neutrality

Alternative Future Fuel Options

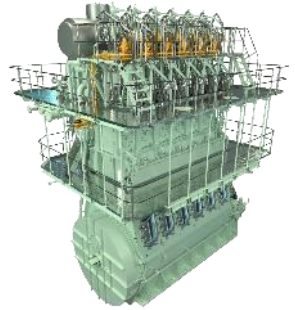


* Energy density of Li-ion battery (vs. Diesel):
~1:20 (volumetric), ~1:60 (gravimetric)

The engine can burn all => cost, infrastructure & handling are decisive

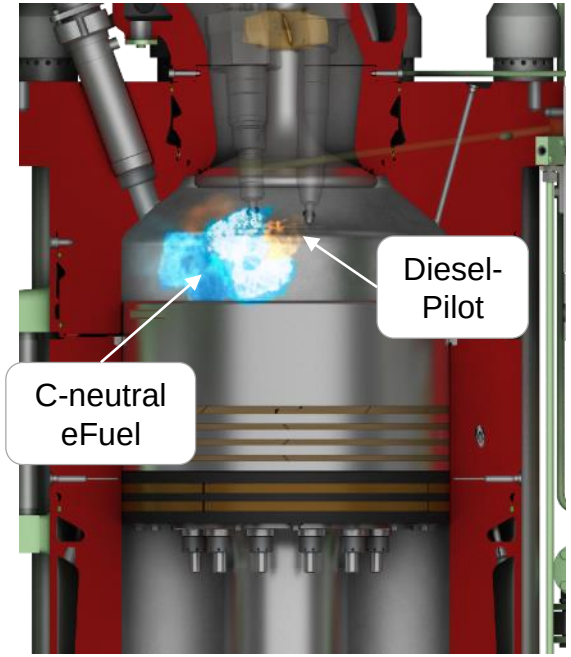
2-Stroke Modular & Future Proof Design

Built-in fuel flexibility - A necessity to avoid stranded assets



Fuel types	MC	ME-B	ME-C	ME-GI	ME-GA	ME-GIE	ME-LGIM	ME-LGIP
0-0.50% S VLSFO	Design	Design	Design	Design	Design	Design	Design	Design
High-S HSHFO	Design	Design	Design	Design	Design	Design	Design	Design
LNG	-	-	Retrofit***	Design	Design	Retrofit***	Retrofit***	Retrofit***
LEG (Ethane)	-	-	Retrofit***	Retrofit***	-	Design	Retrofit***	Retrofit***
Methanol / Ethanol	-	-	Retrofit**	Retrofit**	-	Retrofit**	Design	Retrofit**
LPG	-	-	Retrofit**	Retrofit**	-	Retrofit**	Retrofit**	Design
Biofuels	Design	Design	Design	Design	Design	Design	Design	Design
Ammonia****	-	-	(Retrofit**)	(Retrofit**)	-	(Retrofit**)	(Retrofit**)	(Retrofit**)

Fuel by original design of type | ** One second fuel per retrofit | *** Both LNG and LEG | **** available in 2024



World's 1st **LNG** driven container vessel

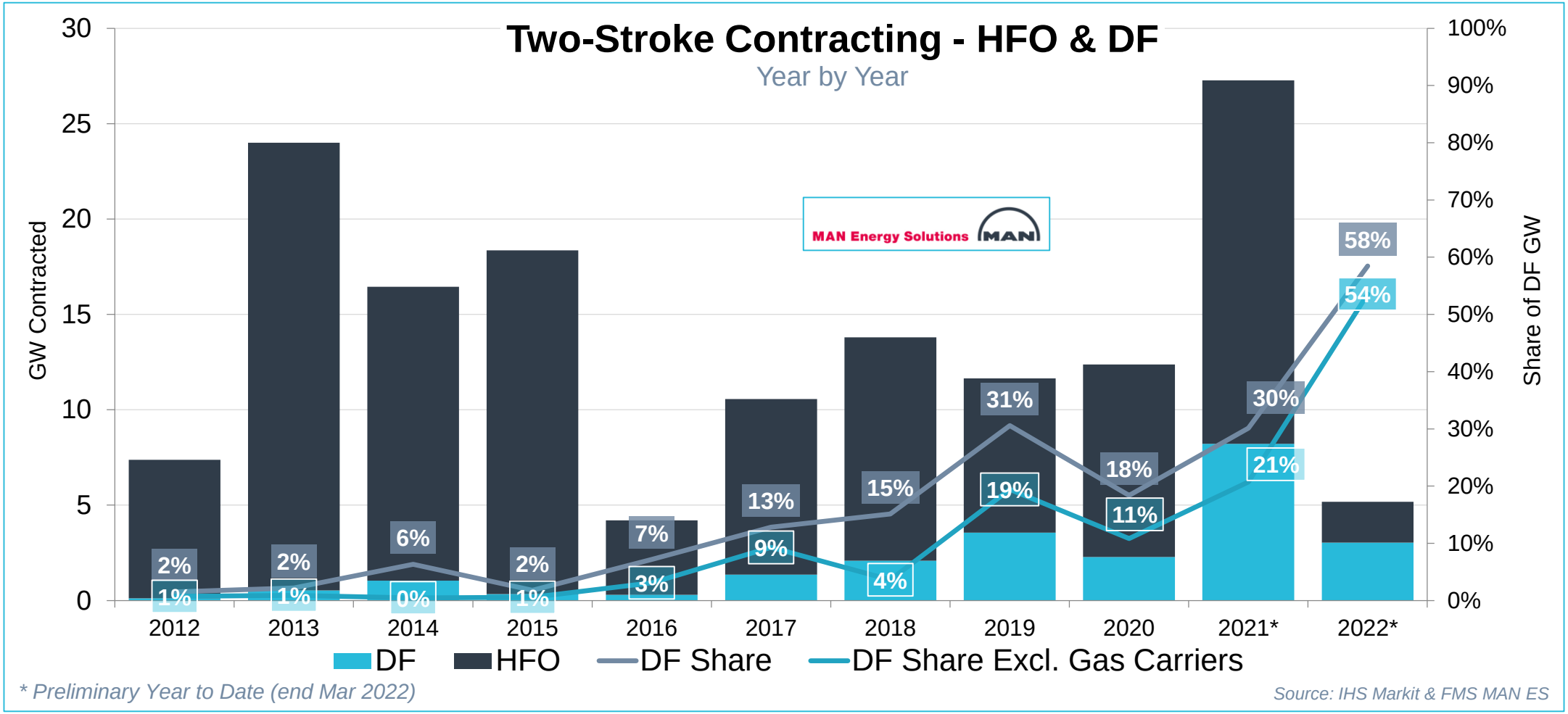
World's 1st **MeOH** driven vessel

World's 1st **Ethane** driven vessel

World's 1st **LPG** driven vessel

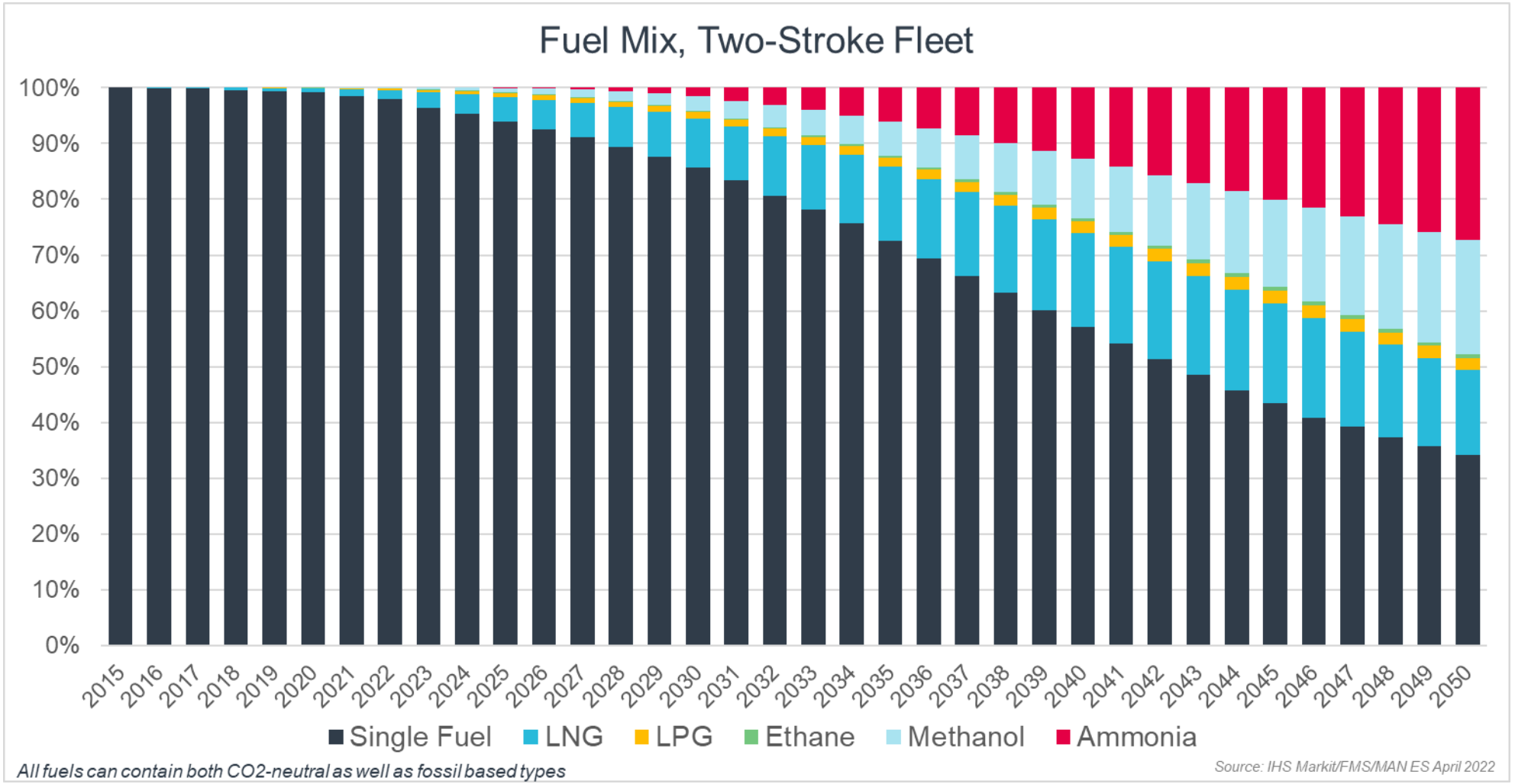
Dual Fuel Contracting is Picking Up

In 2021 DF contracting gained pace in a high volume market, and the trend is continuing



Forecast of Fuel Consumption Mix, Two-Stroke Fleet

Percent of Propulsion Power in GW – Single Fuel Technology >30% in 2050
– If shipping CO_2 neutrality should be achieved by 2050 synthetic fuels and retrofits are essential



Dual Fuel Retrofit Conversions

Accelerating the Maritime Energy Transition

⇒ **Retrofits necessary** to accelerate marine energy transition; **available today**

⇒ **Future-proofing investments** by conversion-options

CV Feeder ELBBLUE*

48/60 => 51/60DF

Balearia RoPax Ferries

48/60 => 51/60DF

15.000 TEU CV

9S90ME-C => ME-GI

BW LPG

6G60ME-C => ME-LGIP

*) Utilizing 20 tons of 100% renewable SNG per round-trip

Fuels available today: Diesel, Biodiesel, LNG / eSNG, LPG, Ethane, Methanol

Under development: Ammonia (NH_3) and Hydrogen (H_2)

Summary

Decarbonizing Large Bore Engines

- **Maritime energy transition** driven by both regulation & market demand
- Alternative **fuel selection not obvious –** optimum depends on application
- **Fuel flexibility** and **retrofit options** are decisive!
- **Natural gas (LNG) is available now** – both engine technology and infrastructure
- Smooth, gradual transition by **drop-in of eSNG** possible
- **MeOH, NH_3,** H_2 as additional future fuels with zero carbon potential
- **CO_2 -pricing** & **regulation** to drive decarbonization
  – must be **Globally Harmonized**
- **Ramp-up of eFuel production** is critical factor

Thank you very much!

Driving the maritime energy transition

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