# Decarbonisation of maritime transport

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# WÄRTSILÄ IN BRIEF

# ENABLING SUSTAINABLE SOCIETIES WITH SMART TECHNOLOGY

**INNOVATING SINCE 1834**

**TOGETHER**

**FOR A SUSTAINABLE FUTURE**

# THE LEADING ENERGY SYSTEM INTEGRATOR

## ENGINE POWER PLANTS

Ultra-flexible internal combustion engine based power plants

## ENERGY STORAGE AND INTEGRATION

Utility-scale energy storage solutions and advanced software

## RENEWABLES

Utility-scale solar power plants integrated with engine power plants and energy storage

## GAS-TO-POWER

LNG solutions integrated with engine power plants in one single project

## LIFECYCLE SERVICES AND ASSET MANAGEMENT

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# SMART TECHNOLOGY OFFERING COVERS ALL MARKET SEGMENTS

| | | |
|---|---|---|
| MERCHANT VESSELS | GAS CARRIERS | CRUISE & FERRY |
| NAVY | SPECIAL VESSELS | OIL & GAS INDUSTRY |

THE WORLD'S WIDEST PRODUCT AND SOLUTIONS PORTFOLIO AND THE MOST EXTENSIVE SERVICE NETWORK

- Power supply
- Power conversion
- Propulsion
- Exhaust treatment

- Parts solutions
- Maintenance and repair services
- Lifecycle solutions

- Automation, navigation & communication
- Simulation & training solutions
- Fleet operations solutions
- Ship traffic control solutions
- Special products
- Entertainment systems

- Water & waste
- Gas solutions for marine and land-based applications

# Combination of efforts

Optimized propulsion systems, propulsion energy saving devices, hull and ballast optimization, trim optimization, air lubrication

Highest efficiency and cleaner fuels

Increasing price per ton of CO2 emission avoided →

Optimized Voyage → Vessel Energy Need → Power Distribution → Efficient Energy Generation

← Fuel price determines technology uptake “profitability limit”

Lowest possible speeds and optimum routing and digital port integration

Hybrids and associated battery storage, power-take-in from renewable sources such as wind, solar

# Level of ambition in the IMO initial strategy of 13-4-2018

- Carbon intensity of the ship to decline through implementation of further phases of the energy efficiency design index (EEDI) for new ships. to review with the aim to strengthen the energy efficiency design requirements for ships with the percentage improvement for each phase to be determined for each ship type, as appropriate;

- Carbon intensity of international shipping to decline. To reduce CO2 emissions per transport work, as an average across international shipping, by at least 40% by 2030, pursuing efforts towards 70% by 2050, compared to 2008

- GHG emissions from international shipping to peak and decline. To peak GHG emissions from international shipping as soon as possible and to reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008 whilst pursuing efforts towards phasing them out as called for in the Vision as a point on a pathway of CO2 emissions reduction consistent with the Paris Agreement temperature goals.

Are these two compatible?

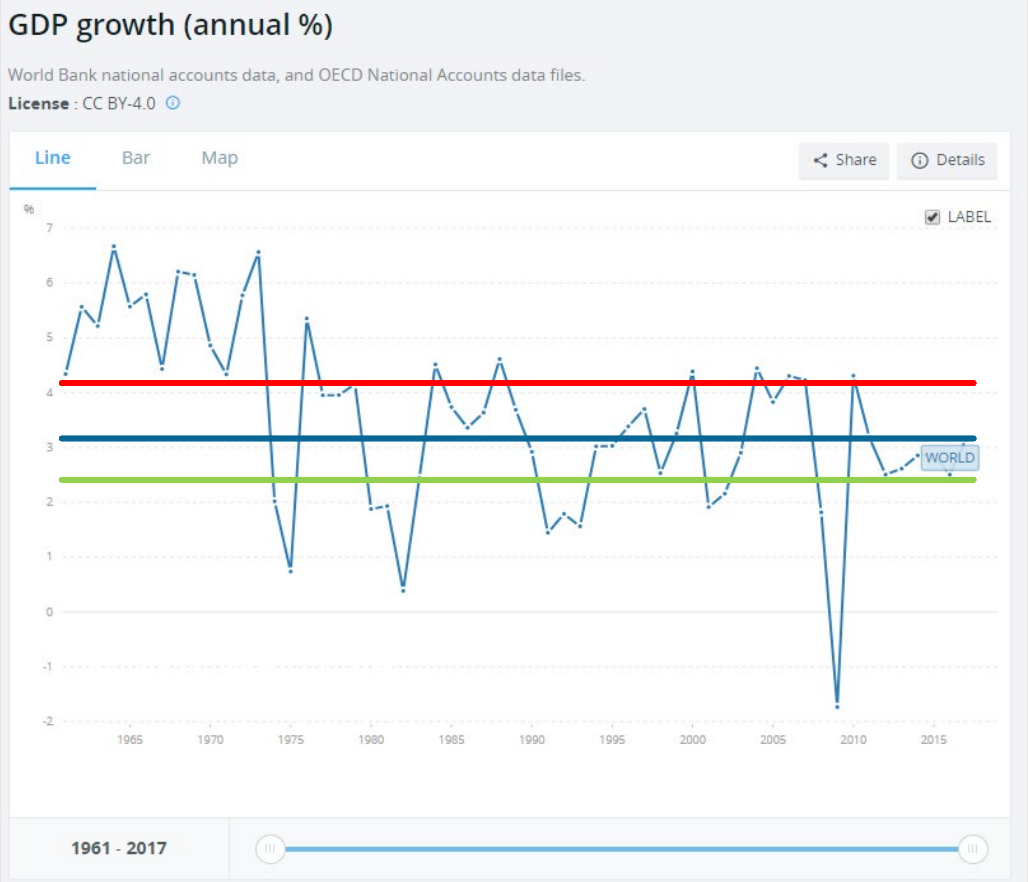
# 2050 fleet modeling under three growth assumptions

- SSP1 scenario: fast economic growth and consequently high transport demand
- SSP2 scenario: moderate economic growth
- OECD scenario: low growth from latest long-term OECD economic projections

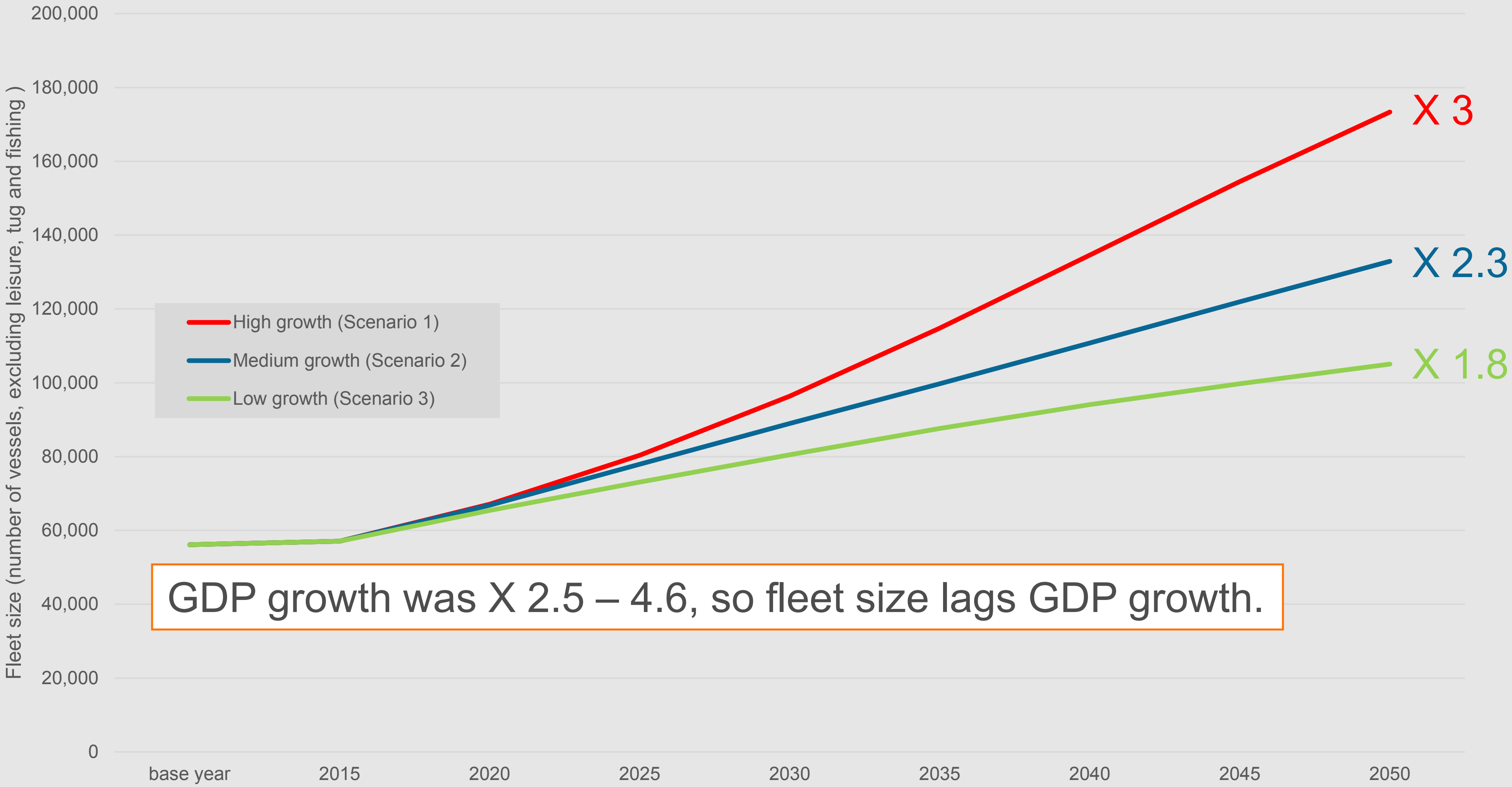
Baseline world GDP 2012: 60.000BUS$/yr

SSP1: 275.000BUS$/yr (CAGR of 4.1%)
SSP2: 200.000BUS$/yr (CAGR of 3.2%)
OECD: 150.000BUS$/yr (CAGR of 2.4%)

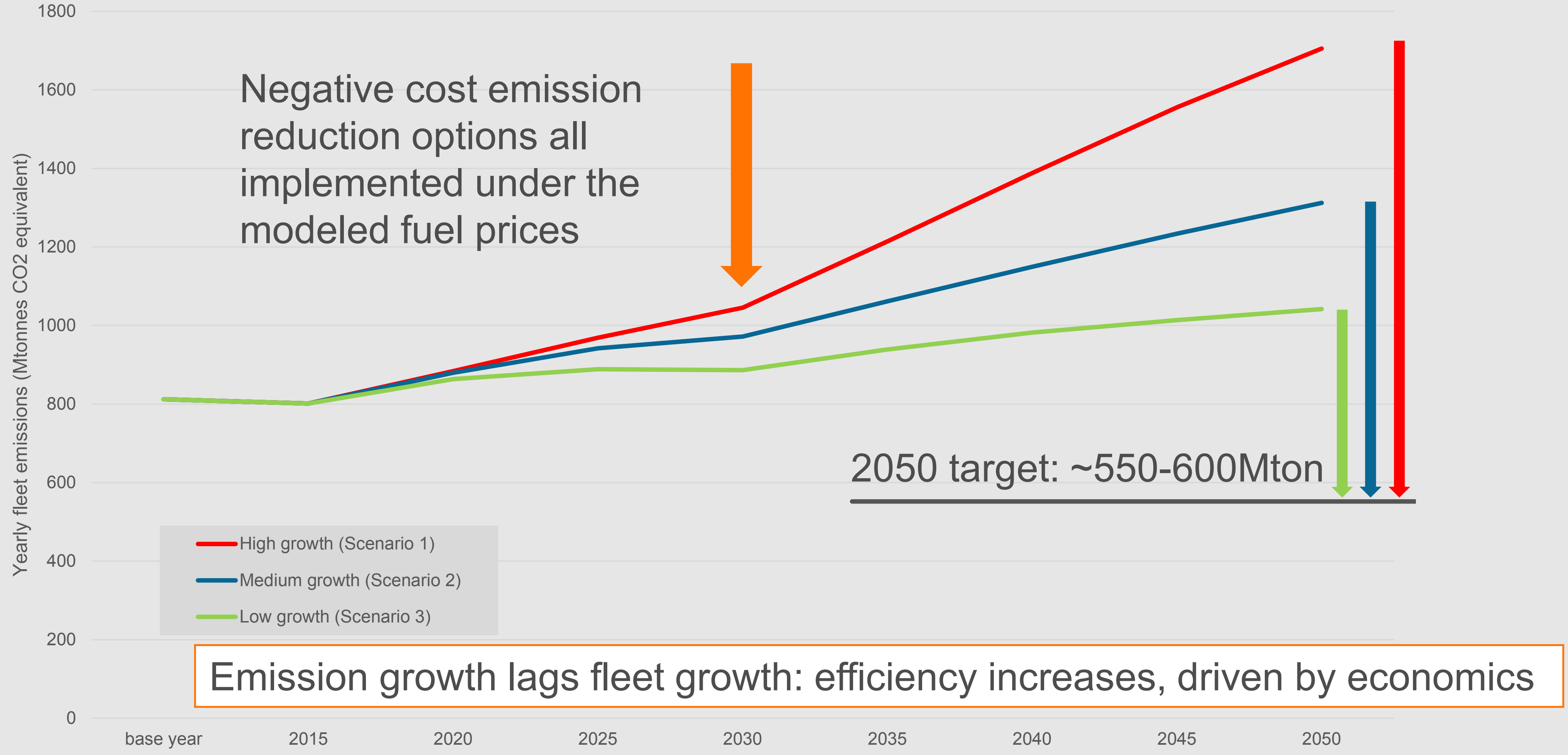
Average over the last 56 years was 3.6%



# 2050 Fleet prediction, number of vessels



# 2050 Fleet emission predictions



# One example ship: a 100.000GT, 300m, 45MW cruiseliner

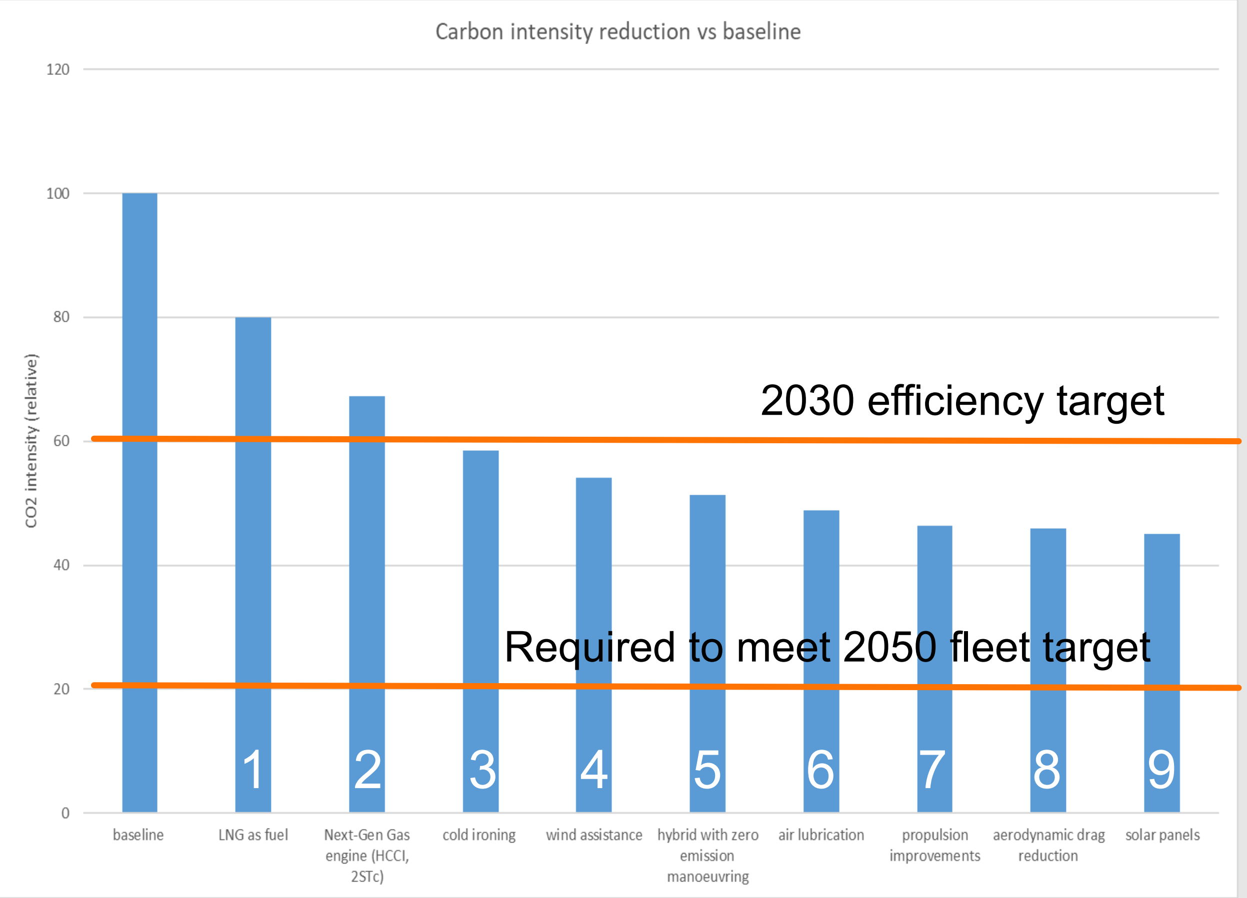
Measures employed; extreme technology takeup without speed reduction

1. Fuel switch from HFO to LNG
2. Next-Generation gas engine
3. Cold ironing during **<u>all port calls</u>** to meet the hotel load
4. Wind assisted propulsion using either Flettner rotors or a towing kite system
5. Vessel hybridization with sufficient battery capacity for all maneuvering
6. Air lubrication of the flat bottom
7. Propulsion system improvements
8. Superstructure aerodynamic drag reduction
9. Solar panels where possible; 40kW or ~250m$^2$

End result:
~54% CO2 emission reduction
~99% SOx reduction
~90% NOx reduction

Needed is an 80% CO2 reduction

**This gap needs to be filled with sustainable fuels.**



# A primer for future fuels: timescales and industry inertia

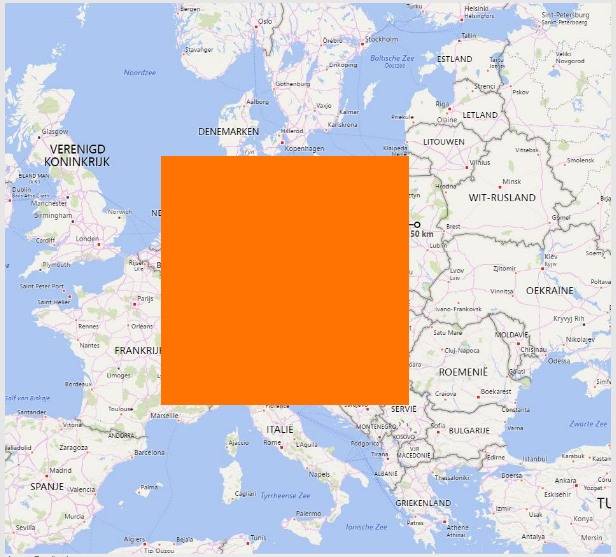
- 1959: first LNG carrier, Methane Pioneer converted from cargo vessel
- 2000: First LNG-powered non-gas carrier, MF Glutra
- 2017: IGF Code for gas-fueled vessels comes into force
- Today: ~120 LNG powered vessels in operation, with as many on order. Infrastructure starts to slowly mature

Fact: Even with pre-matured technology, it took LNG 20 years to gain a 0.4% fleet penetration (240 out of 60.000 ships)

Conclusion: For meaningful fleet penetration, we need to stick with fuels for which a supply chain is existing is developing

# Land use for powering shipping today with low carbon fuels

- Biofuels
  - Land use: 1.300.000 km$^2$
  - That is an 1150x1150km square

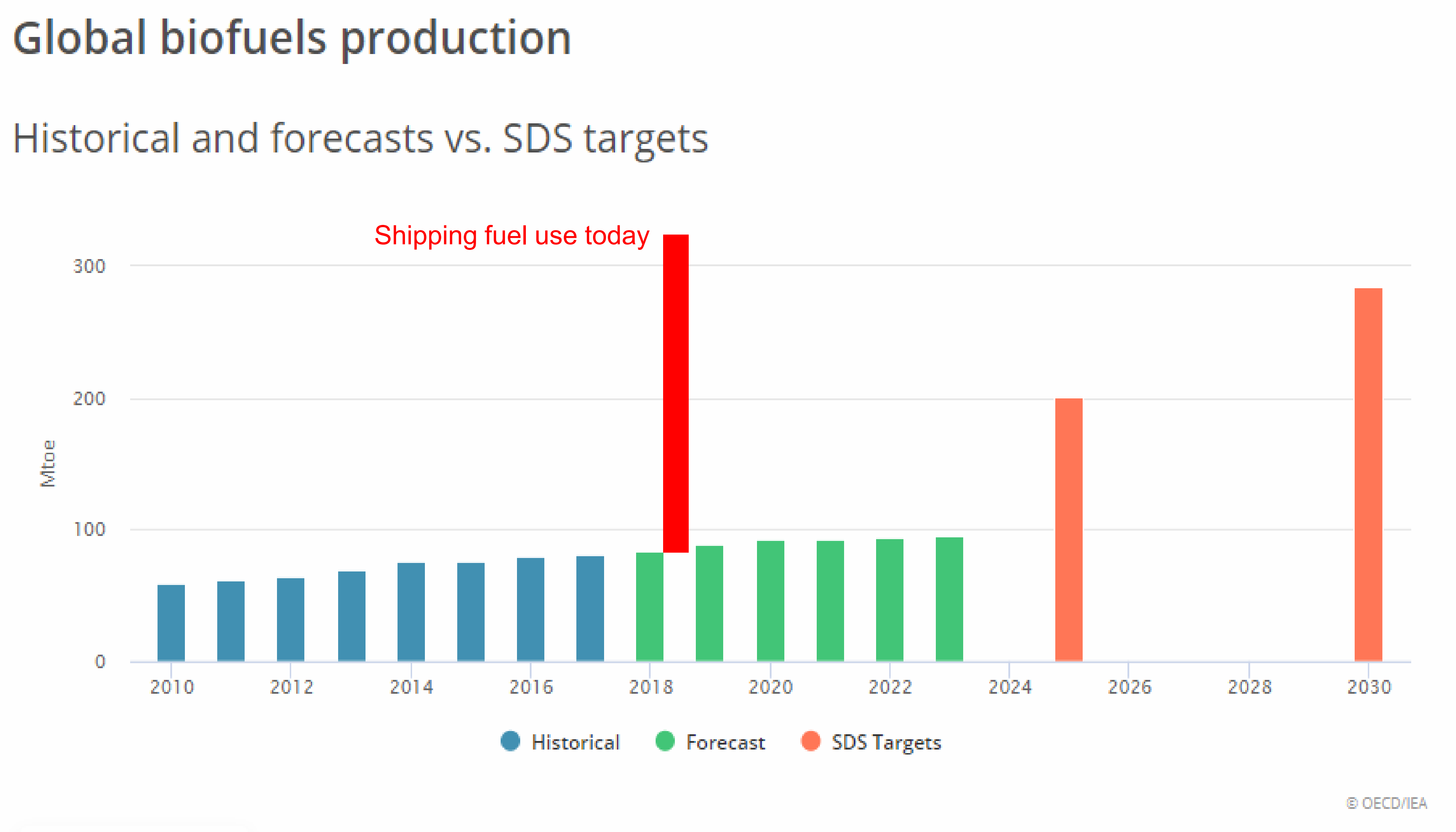



  - Conclusion: biofuels can help but are not the full solution.

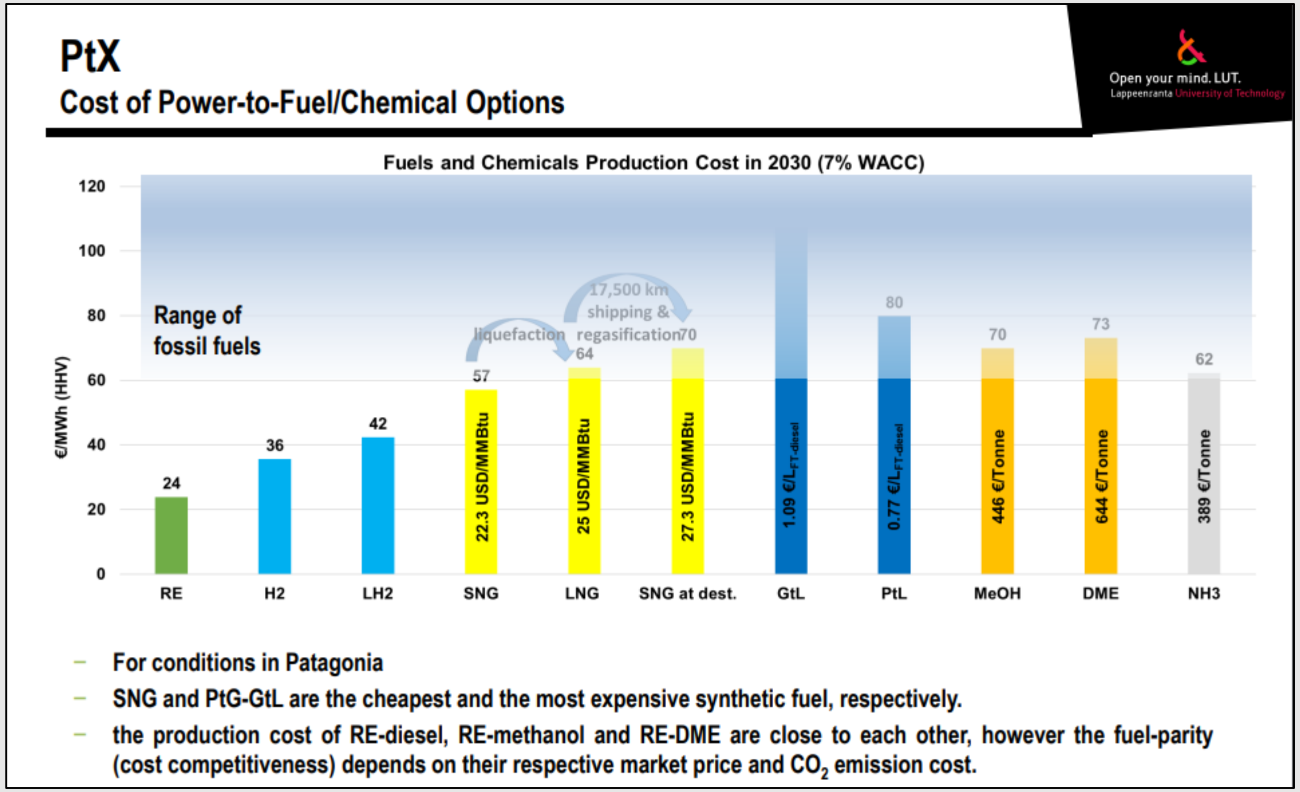
- Electrofuels @ 50% conversion efficiency
  – Land use: 26.000 km$^2$
  – That is an 160x160km square


Indonesia has 80.000km$^2$ of palm oil plantations, growth of 4.000km$^2$ per year

# Various liquid biofuels exist today – limited in availability and volume



# So do PtX fuels make sense? And if so: which ones?




For electricity cost of 24€/MWh in 2030, these are the expected costs per MWh LHV for synthetic fuels:

$LH_2$: 50
LSNG: 72 ← read: methane
PtL: 86 ← diesel replacement
MeOh: 81
DME: 80
$NH_3$: 75

average: 74

HFO today ~ 31€/MWh (400€/ton)
Cost of $CO_2$ reduced ~ 150€/ton
Current ETS $CO_2$ cost ~ 20€/ton

Conclusion: PtX fuels will be ~2-3x the cost of HFO today, and methane will be at cost parity with $NH_3$.

# Cost estimates – Synthetic methane LUT (a closer look)

- Numbers in the preceding slides are for low-volume production

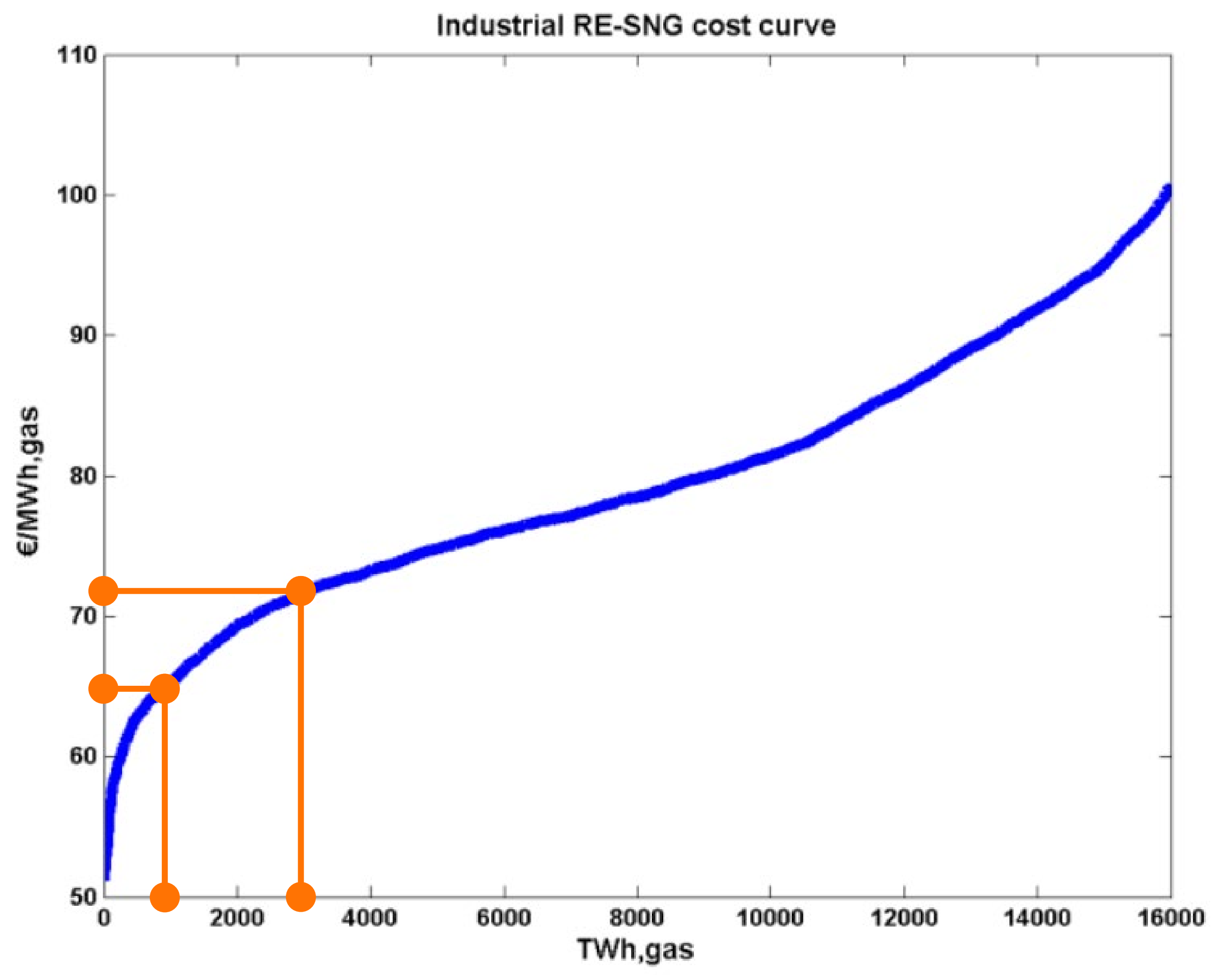
64€/MWh = 1000Twh of gas at HHV

64€/MWh HHV = 71€/MWh LHV

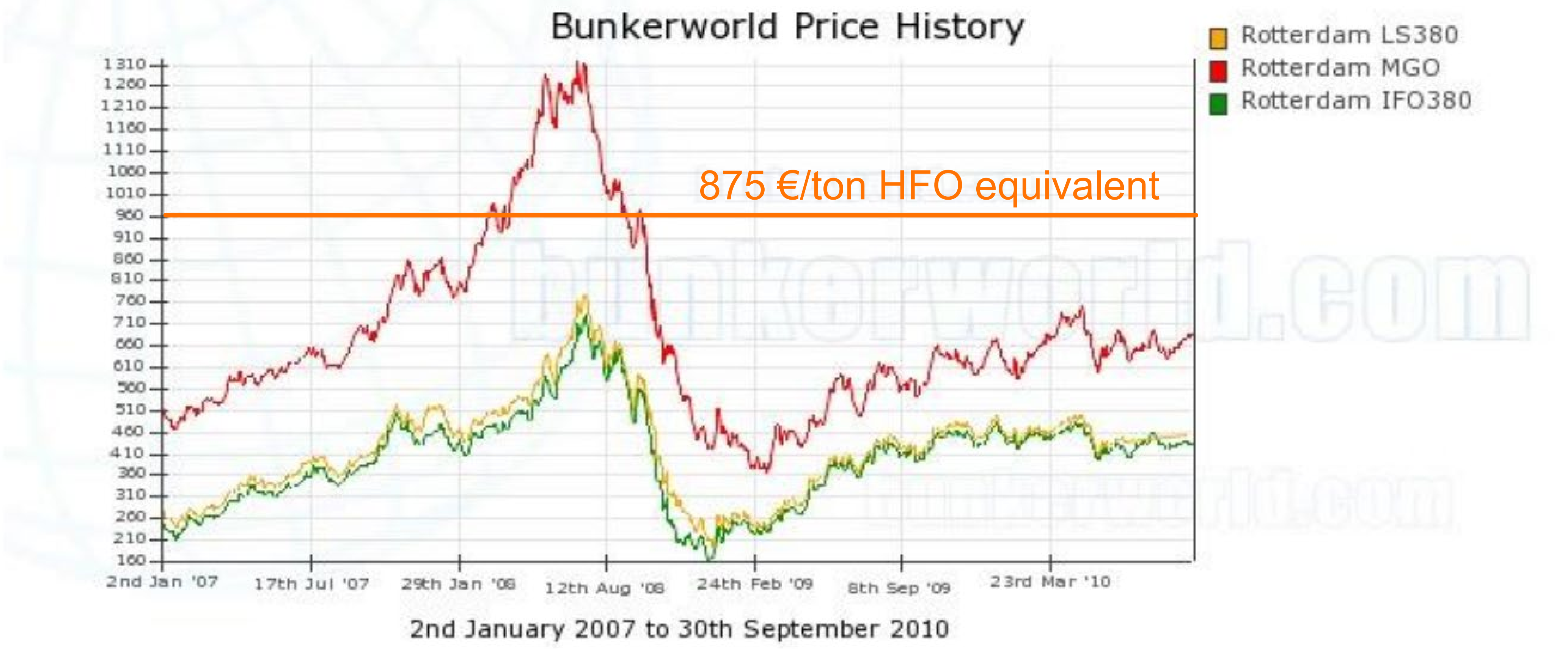
71€/MWh LHV ~ 775 €/THFOe

250 MtHFOe equals 3000TWh

72 vs 64 €/MWh HHV, so **875 €/tHFOe**



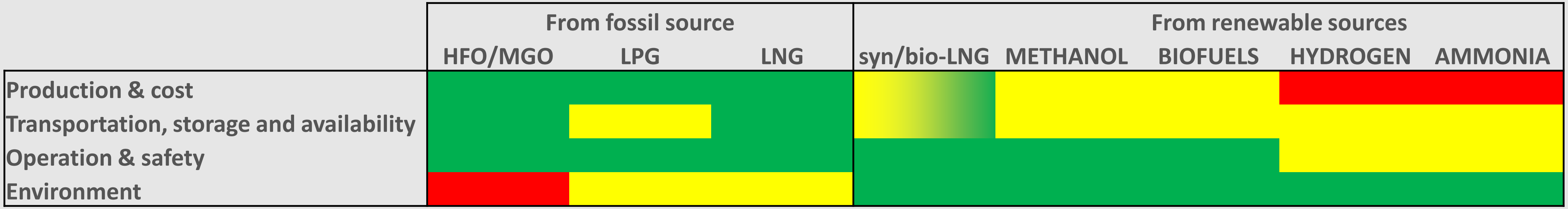
# A brief reminder….




Graph 1: Price history in USD/tonne (source: Bunkerworld)

# Fuel overview – today and near term future

Fuels and technologies differ in their potential to reduce well-to-tank and tank-to-propeller/grid emissions from ships and power plants.
Green indicates high potential, red low potential




- ”zero-carbon content” fuels $H_2$ and $NH_3$ will cause higher GHG emissions when produced from fossil fuels without CCS
- No rules and regulations exist for $H_2$ or $NH_3$. LNG got the IGF code only in 2016, although being used as fuel for decades.
- LNG is a marine fuel of today, and still there are challenges in availability. What would be the case for $NH_3$ or $H_2$?
- LNG (methane) can also be made from renewable hydrogen (via PtX) or from biomass (as upgraded biogas). As such, it has the potential to become renewable and still be compatible with todays infrastructure and vessels and provide huge air quality benefits versus other fuels.

# Discussion

- If the initial IMO goals remain firm, the challenge is sizable and cannot be met without carbon neutral fuels
- Almost any kind of economic growth will lead to an increase in shipping fleet size and emissions
- Carbon neutral fuels will likely be expensive compared to todays fuels, so:
  - more fuel consumption reducing technologies will become economically viable
  - efficiency in power generation will be key
- The fuel options for the future are quite limited if we take the required timing (large scale introduction from 2030) into account:
  - Needs to have an existing or incumbent infrastructure
  - Needs to have existing operational experience
  - Needs to have a viable way of storing on board
- Fuel flexibility more important now than ever, de-risking todays investment decisions
- Combining CAPEX, OPEX, safety, reliability and flexibility, the internal combustion engine remains unchallenged

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