MW scale fuel cells for passenger ships

Comparing FC hybrid / ICE layouts

S. Bleuanus, GM alternative technologies & competitive intelligence.
Wärtsilä Marine power supply RDE

IEA Advanced Fuel Cell Technology Collaboration Programme
(IEA AFC TCP) workshop, Paris, 6-11-2025

We are a global leader in technology and services

Serving our customers wherever they are in the world

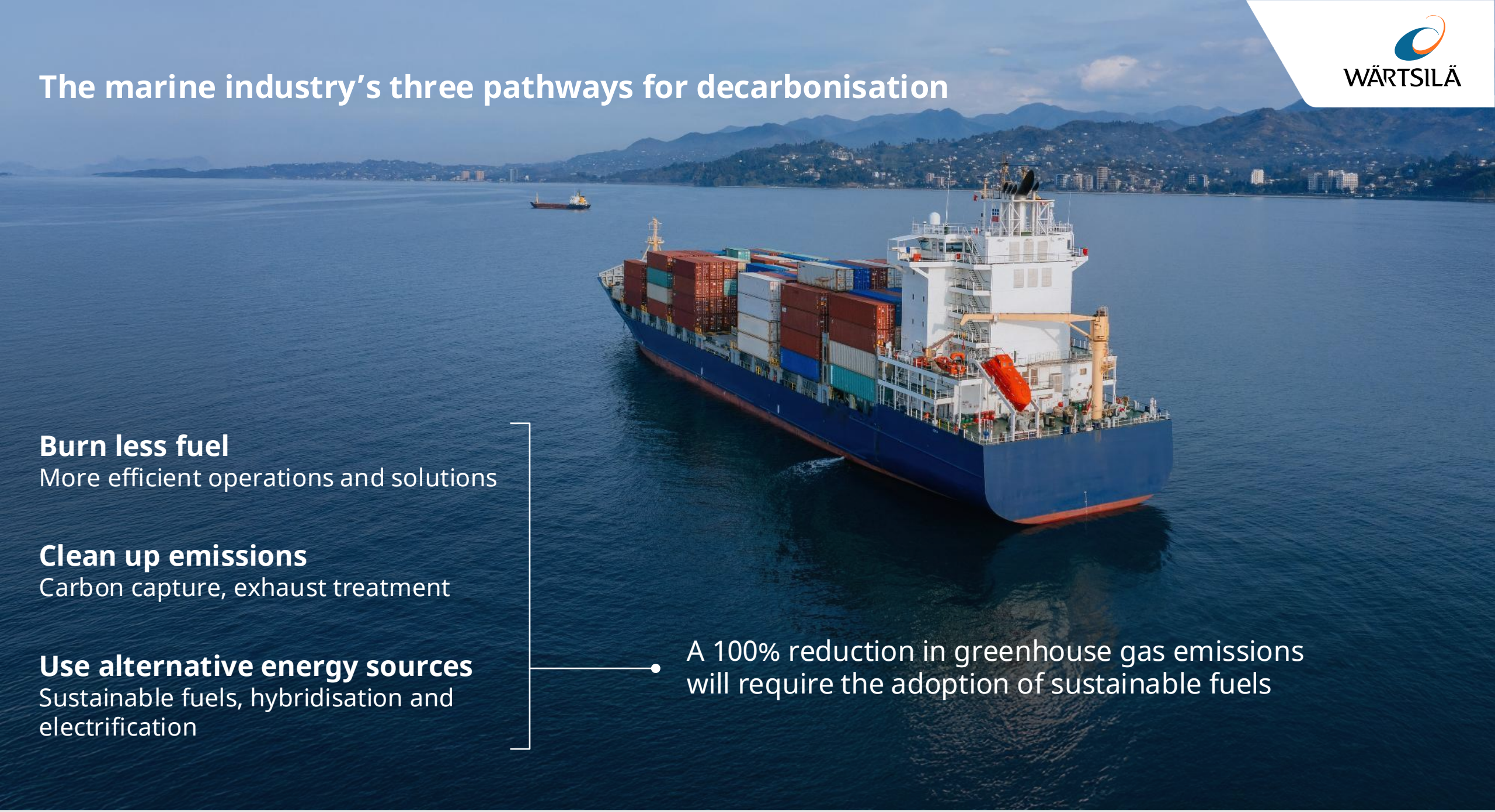
Of the 110,000 large vessels out at sea 1/3

carry Wärtsilä solutions on board

In 180 countries

Wärtsilä energy installations provide reliable power

The marine industry’s three pathways for decarbonisation



Burn less fuel
More efficient operations and solutions

Clean up emissions
Carbon capture, exhaust treatment

Use alternative energy sources
Sustainable fuels, hybridisation and electrification

A 100% reduction in greenhouse gas emissions will require the adoption of sustainable fuels

Wärtsilä Marine: the right combination of solutions for each vessel and fleet

Engine optimisation and fuel flexibility

Ammonia
Bio / E methane
Bio / E diesel
Hydrogen
LNG
LPG
(M)ethanol

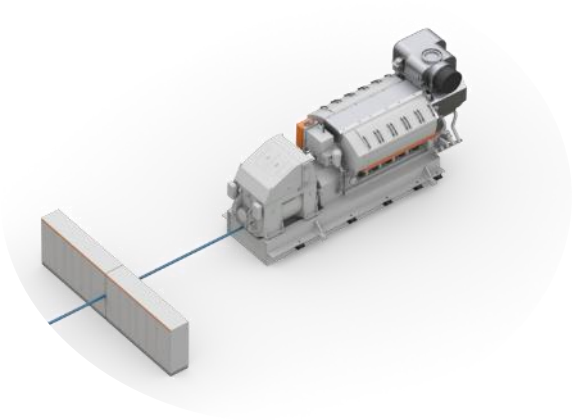
Electrification and hybrid systems

Energy-saving solutions

Abatement systems and carbon capture

Lifecycle solutions and services

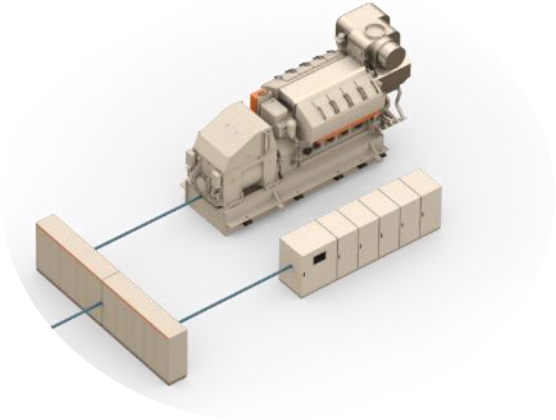
Machinery configurations compared – 23MW total output



Engine Solution

4 x **W10V31NextDF** Genset

- Genset Electrical output: 5625 kW
- Total Electrical Power output: 22500 kW
- Efficiency @85% load: 48%*
- Lifetime: Same as vessel; periodical overhaul (~50 €/kW/year)



Hybrid Solution (Engine + Fuel Cell)

4 x W8V31NextDF + **5MW FC**

- Genset Electrical output: 4500 kW
- FC Electrical output: 5000 kW
- Total Electrical Power output: 23000 kW
- FC Efficiency @85% load: 63.9 – 57% BOL/EOL**
- FC Lifetime: Same as vessel; stack replacement every 40.000 hours

Goal: comparing

1. conventional machinery configuration (engines)
2. hybrid machinery concept (engines and FC)

And evaluate the **Customer value** considering the impact of carbon tax and Fuel EU.

** Including generator losses*

*** Electrical efficiency, SOFC assumed as best case*

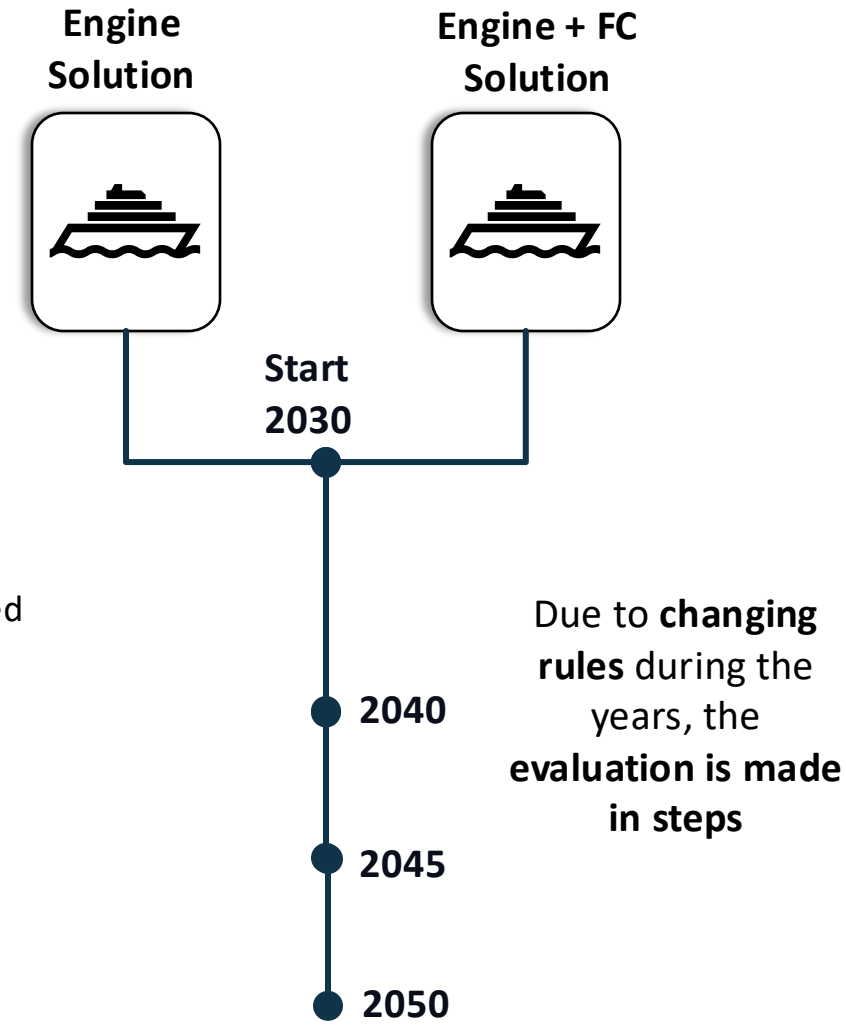
Customer Business case assumptions

- Application: cruise
- FC runs the base load: 4.5 MW
- Engines provide variable load (DF engine): 0-18 MW

- OPEX based on
  - 8618 Running hours/year (98%) – note that using shore power may change this
  - Include **ETS & penalties according to Fuel EU Maritime** (including methane slip from engines)
  - **FC lifecycle cost includes replacement of the stacks every 40.000 hours of operation**
  - ICE maintenance / overhauls based on running hours, will be better in practice when condition based

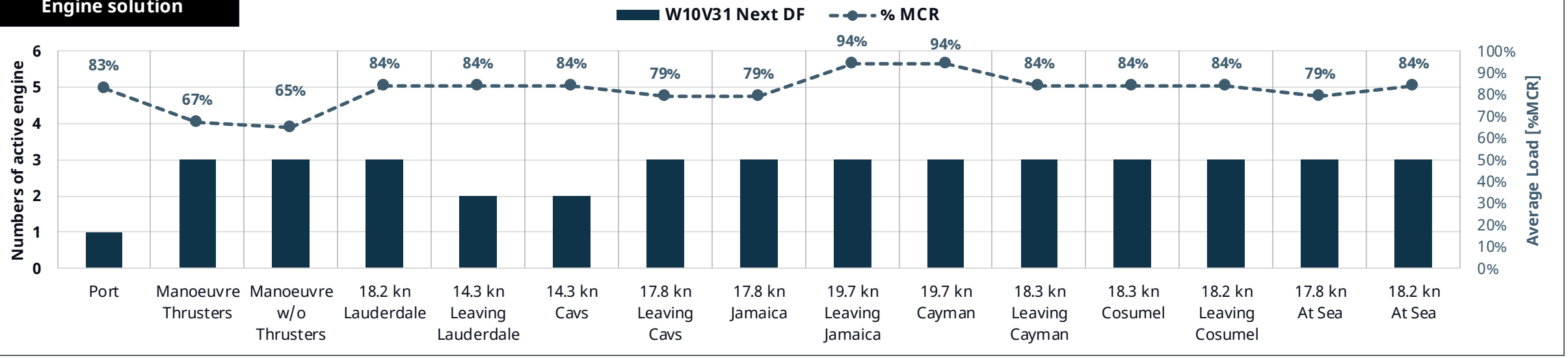
- operational profile
  - **Typical cruise profile – 48 h/week in port**

- Allowable **ΔCAPEX FC**: installed cost estimated delta 2030 to enable 20yr break-even

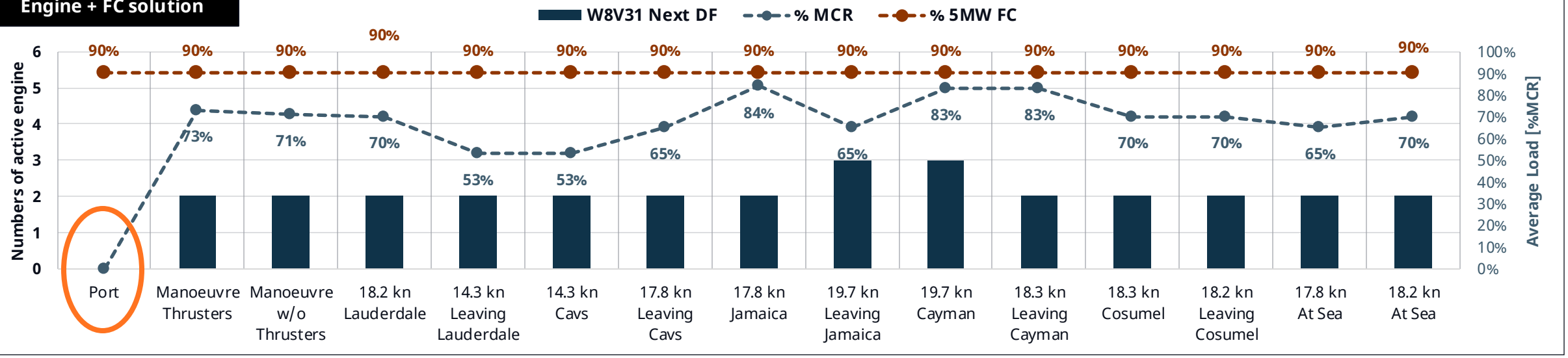


Cruise operational profile

Engine solution

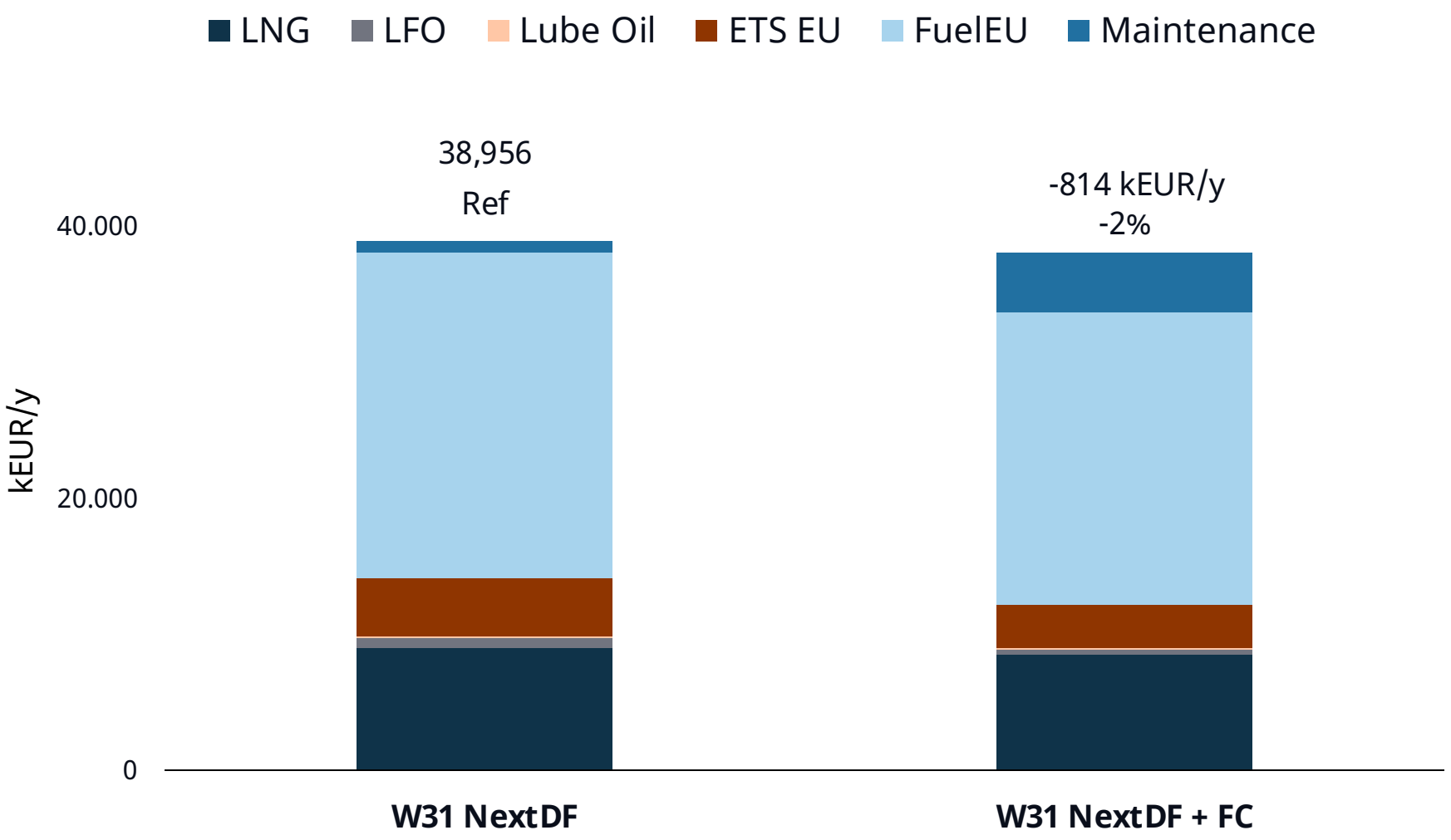


Engine + FC solution

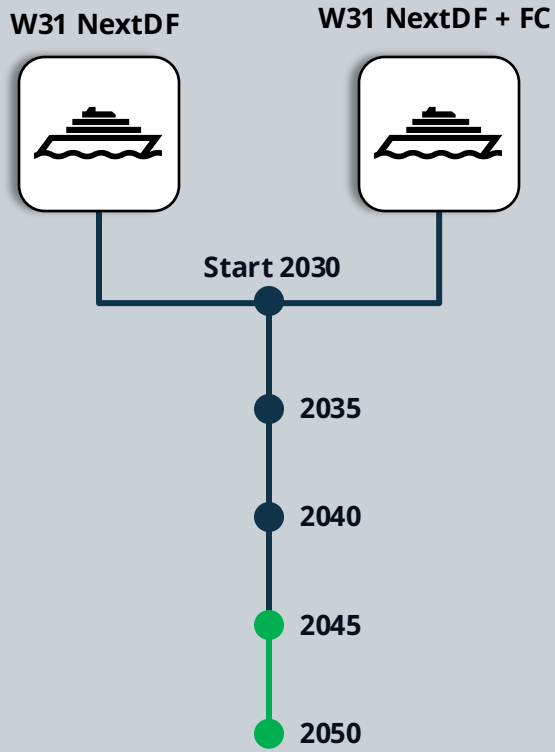


Example: Annual OpEx 2045-2050

Maintenance 20 years + ETS cost + FuelEu fines

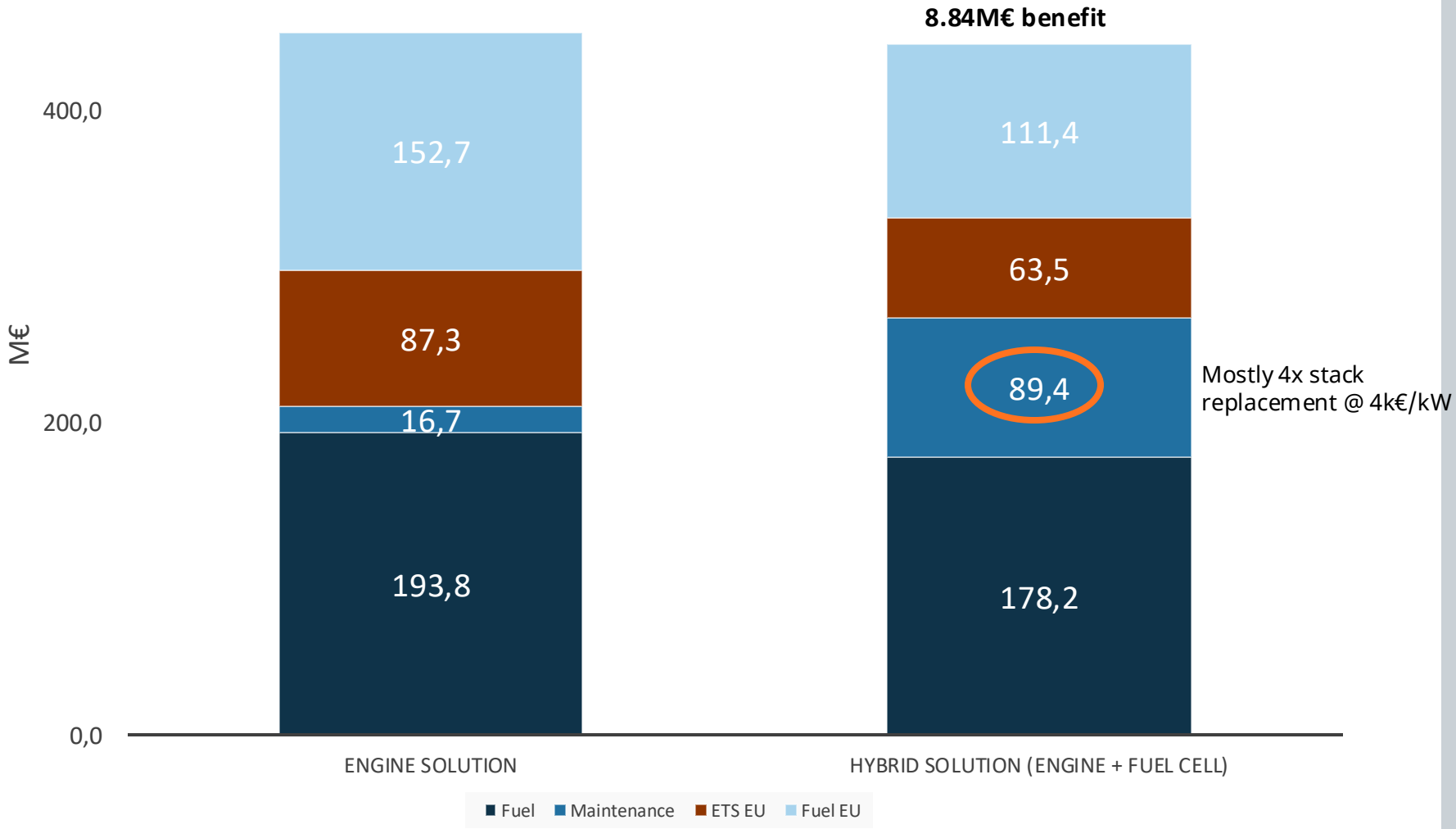


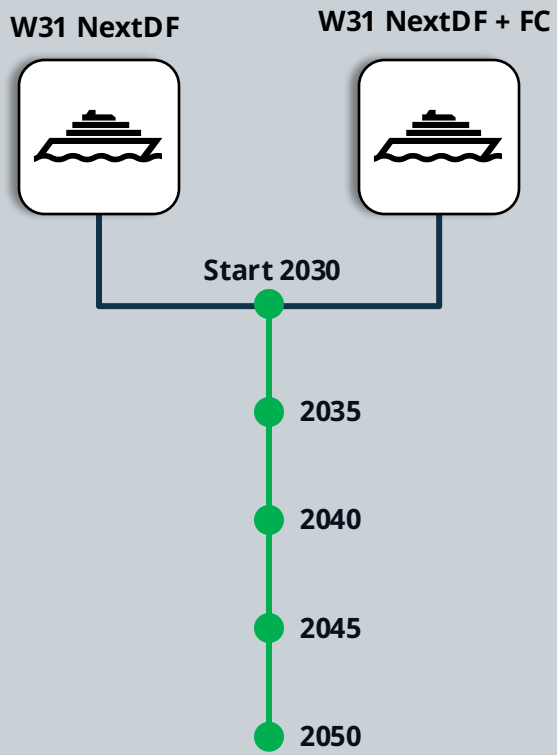
	EUR/ton
LNG	667
LFO	646
Lube Oil	2300
ETS EU	100



Cumulative OPEX 2030-2050

Maintenance 20 years + ETS cost + FuelEu fines



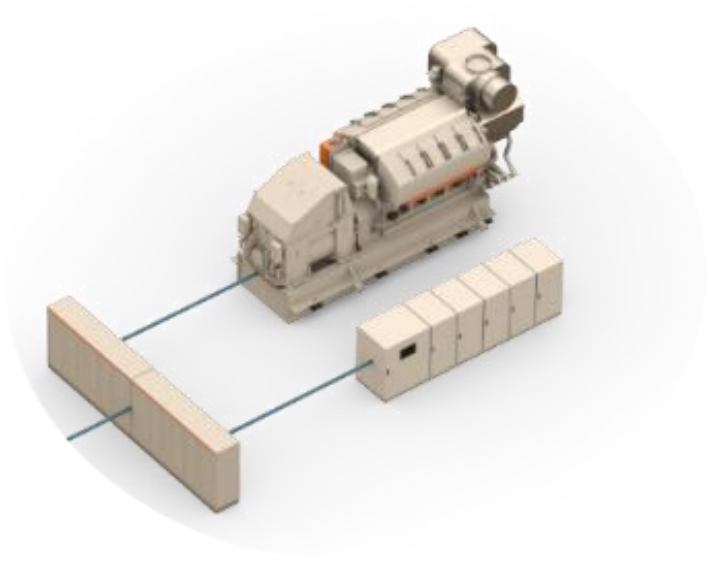


Conclusions

- The Hybrid solution has an **OPEX benefit** (2030-50): 8,84 M€
- Maximum FC ΔCAPEX per kW: 1768 €/kW versus ICE
- Key driver: stack replacement every 40k hours

- Higher fuel EU maritime penalties **improve** FC competitiveness
- Higher fuel prices **improve** FC competitiveness, but…
- Higher cost of capital (0 assumed) **decreases** FC competitiveness
- Shore power availability **decreases** FC competitiveness

- Risk v Reward tradeoff on a 1B€ asset: breaking even won't cut the mustard



Notes:
- Additional **'soft' benefits of SOFC** are not included (static system with less moving parts and NVH)
- For carbon tax impact, NEXTDF methane slip reduction is partly compensated by pilot fuel increase
- Zero cost of capital assumed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