

TOWARDS A GREEN MARITIME TECHNOLOGY

Leo van Ingen
IHC America Inc.

Bernardete Castro
IHC MTI B.V.

Artist's impression of TSHD concept developed for the EU Research Project JOULES:
autonomous, hybrid-electric, fuel cell-driven dredging vessel



**THE TECHNOLOGY
INNOVATOR.**

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GLOBAL TRENDS

2050:

- 9 BILLION PEOPLE
- 1 PLANET EARTH



Food?

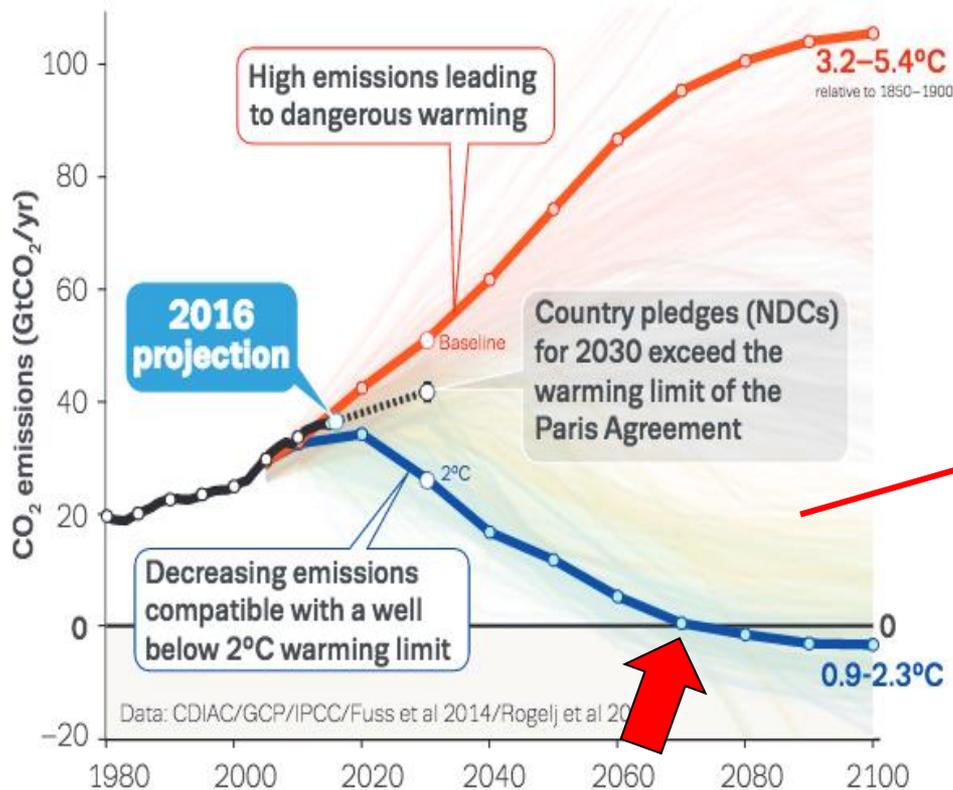


Fresh water?



Energy?

GLOBAL TRENDS

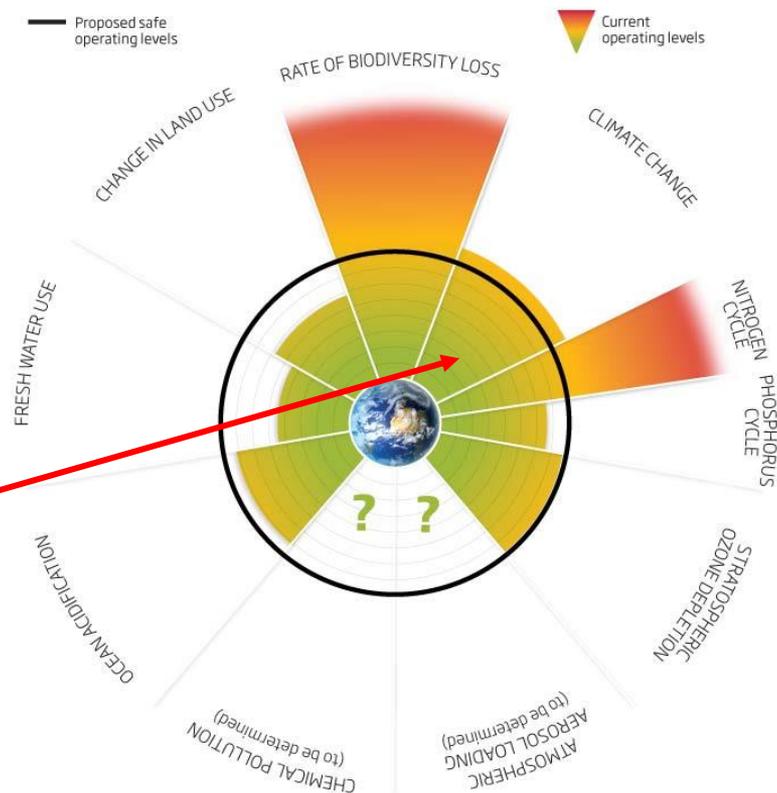


Blue line = Paris agreement

Beyond the boundaries

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We have already overstepped three of nine planetary boundaries and are at grave risk of transgressing several others



Climate: one of 9 planetary systems

DEVELOPMENTS IN THE MARITIME INDUSTRY

Methanol Engine



SOFC fuel cell + diesel



Hydrogen + PEM fuel cell



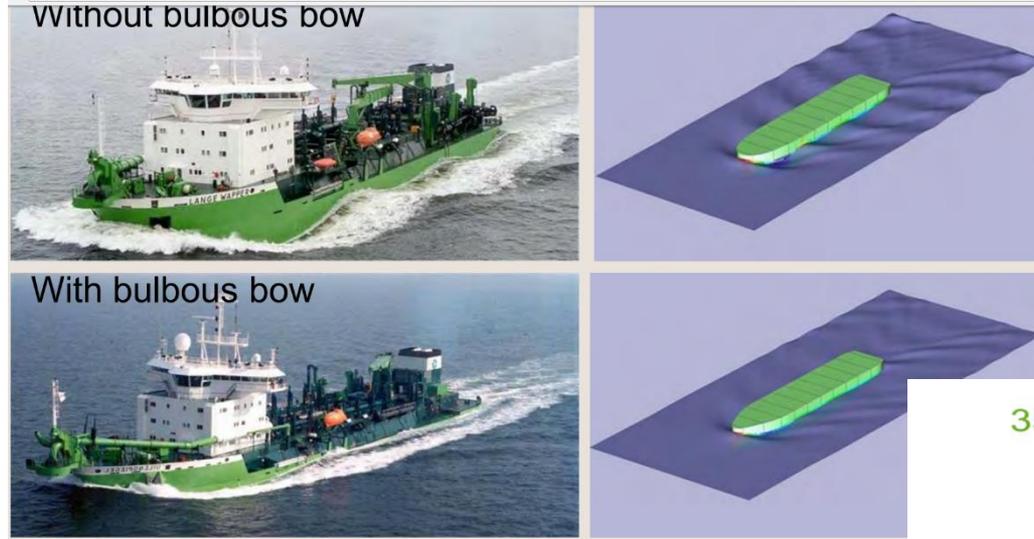
Hydrogen + PEM fuel cell



DEVELOPMENTS IN THE MARITIME INDUSTRY



DEVELOPMENTS IN THE MARITIME INDUSTRY



Efficient & low-emission vessel concepts

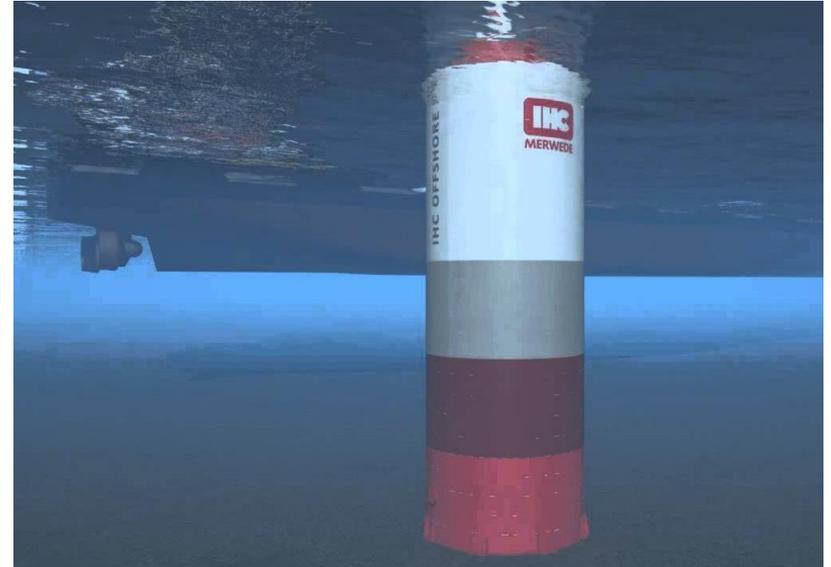


DEVELOPMENTS IN THE MARITIME INDUSTRY



Novel overflow designs (no plume formation)

Low noise pile driving systems



THE JOULES PROJECT

- EU- funded, many maritime technology suppliers, most large Shipyards participated
- Development of component models and a simulation methodology
- Development of simplified LCA tools (LCPA tool) for sustainability assessment
- Ship concepts developed and simulations with component models performed
- GHG goals established: all concepts achieved goals defined
- Alternative Fuels data (cost, emissions, well-to-tank data)
- External costs information and trends
- Advice to the EU with political recommendations



CONCEPTS > DREDGING CYCLE & LOAD PROFILES

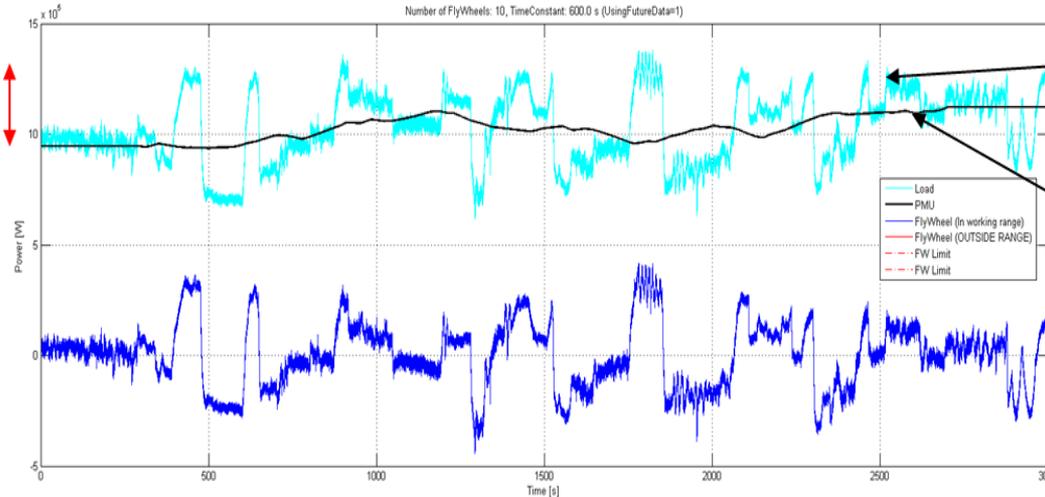
	Time	Speed	Propulsion power	Dredge pump power	Jet pump power	Total power
		(knots)	(kW)	(kW)	(kW)	(kW)
Sailing empty	30%	13	3800	0	0	3800
Sailing loaded	30%	12.5	3800	0	0	3800
Dredging	25%	3	3100	2200	650	5950
Discharge	15%	0	850	1800	650	3300

Dredging Cycle and power used from actual measurements

Dynamic simulations show 20% reduction installed power possible with hybrid drive system



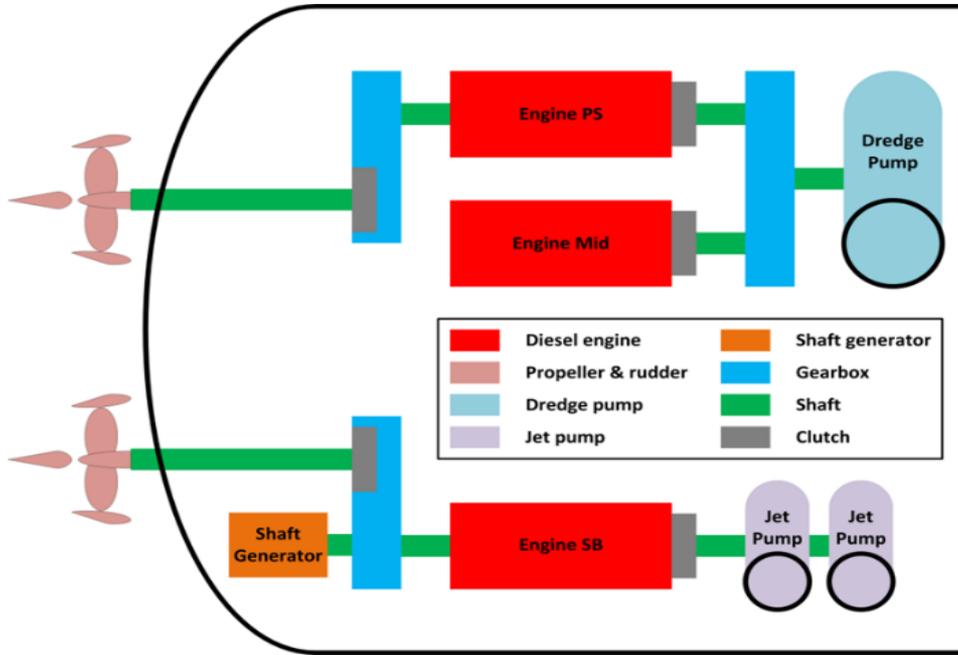
20%



Engine load baseline

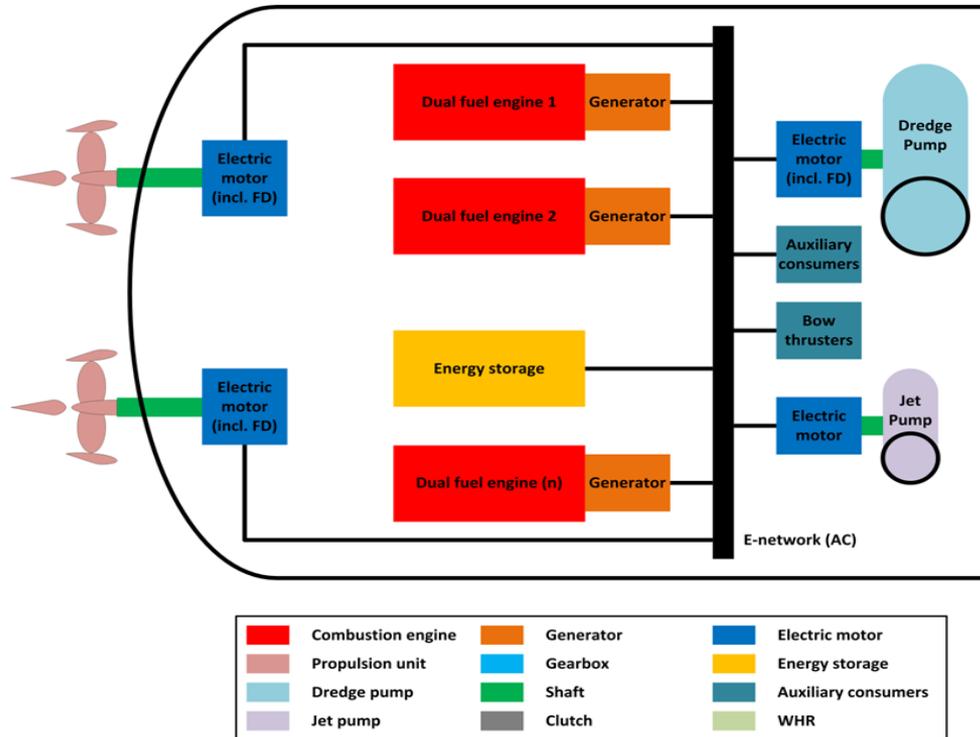
Engine load hybrid system

CONCEPTS > BASELINE



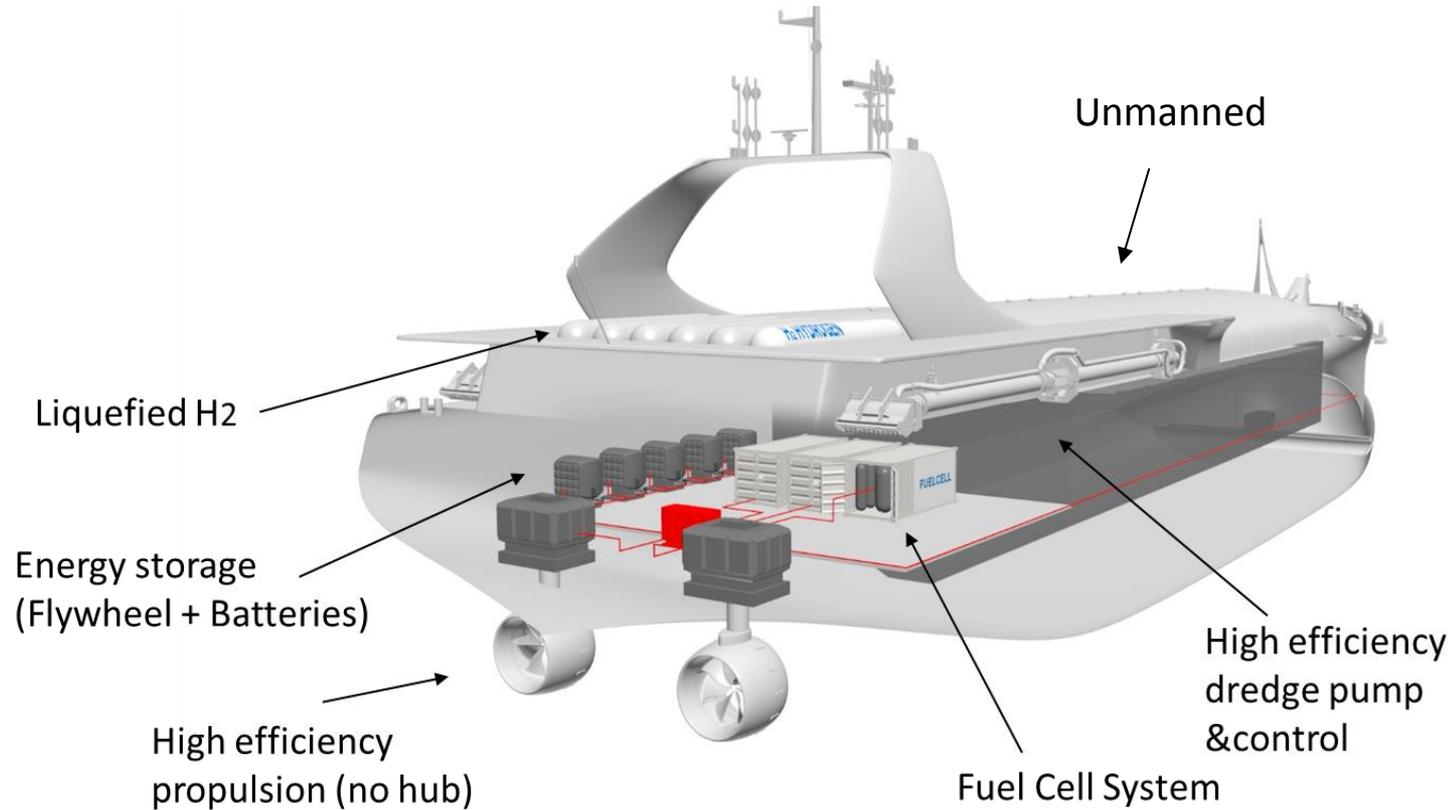
- Diesel-direct
- Three equal engines
- Load sharing dredge pump/propeller
- State-of-the-art for direct driveline
- HFO

CONCEPTS > 2025 CONCEPT



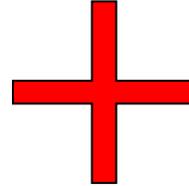
- Gas-electric Hybrid (DF engines)
- Three equal engines
- 20% lower installed power
- Flywheel system + energy management
- Natural gas + Diesel (pilot fuel)

CONCEPTS > 2050 CONCEPT



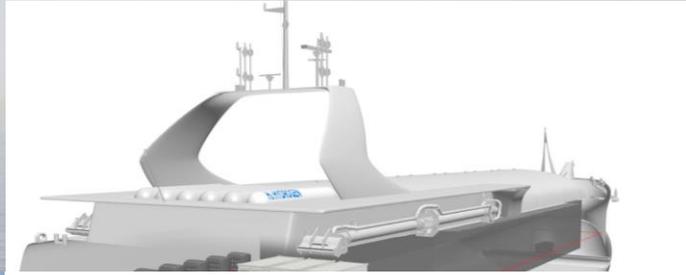
RESULTS > 2025 CONCEPT

3500 m³ TSHD "Minerva"



- Simulations JOULES models
- Fuel saving: 14%
- CO₂ -22%
- NO_x -82%
- Sox -99%

RESULTS > 2050 CONCEPT



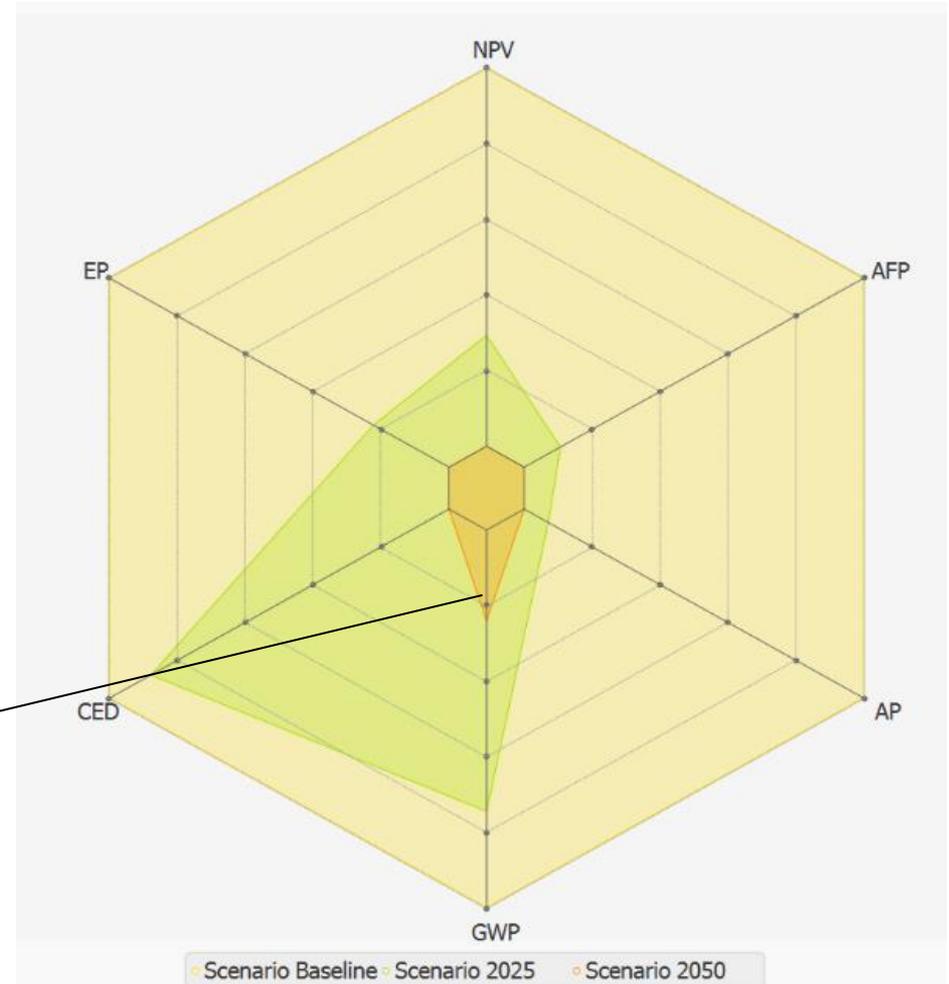
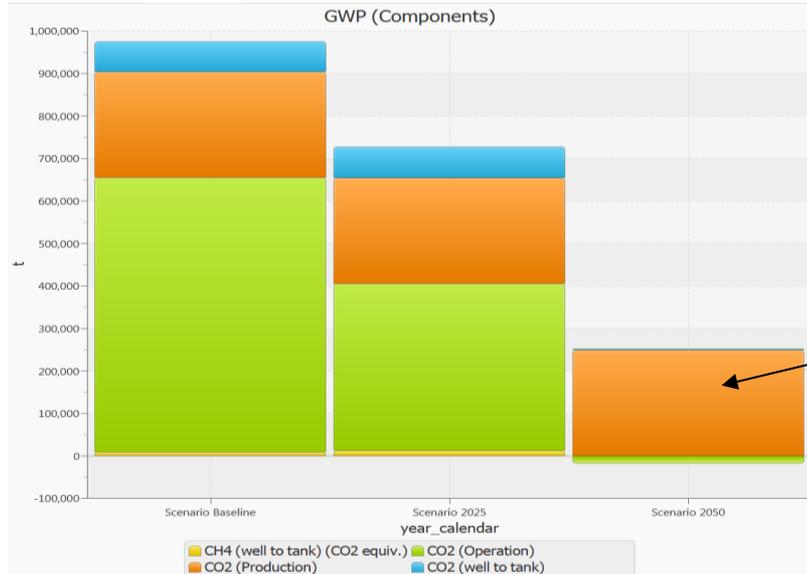
- Fuel saving: 40%
- CO₂ -80% (operation -100%)
- NO_x -100%
- Sox -100%



RESULTS > LCPA

Life Cycle Performance Assessment tool

- Developed within JOULES
- Based on LCA methodology,
- 6 axes, 1 economic assessment (NPV)

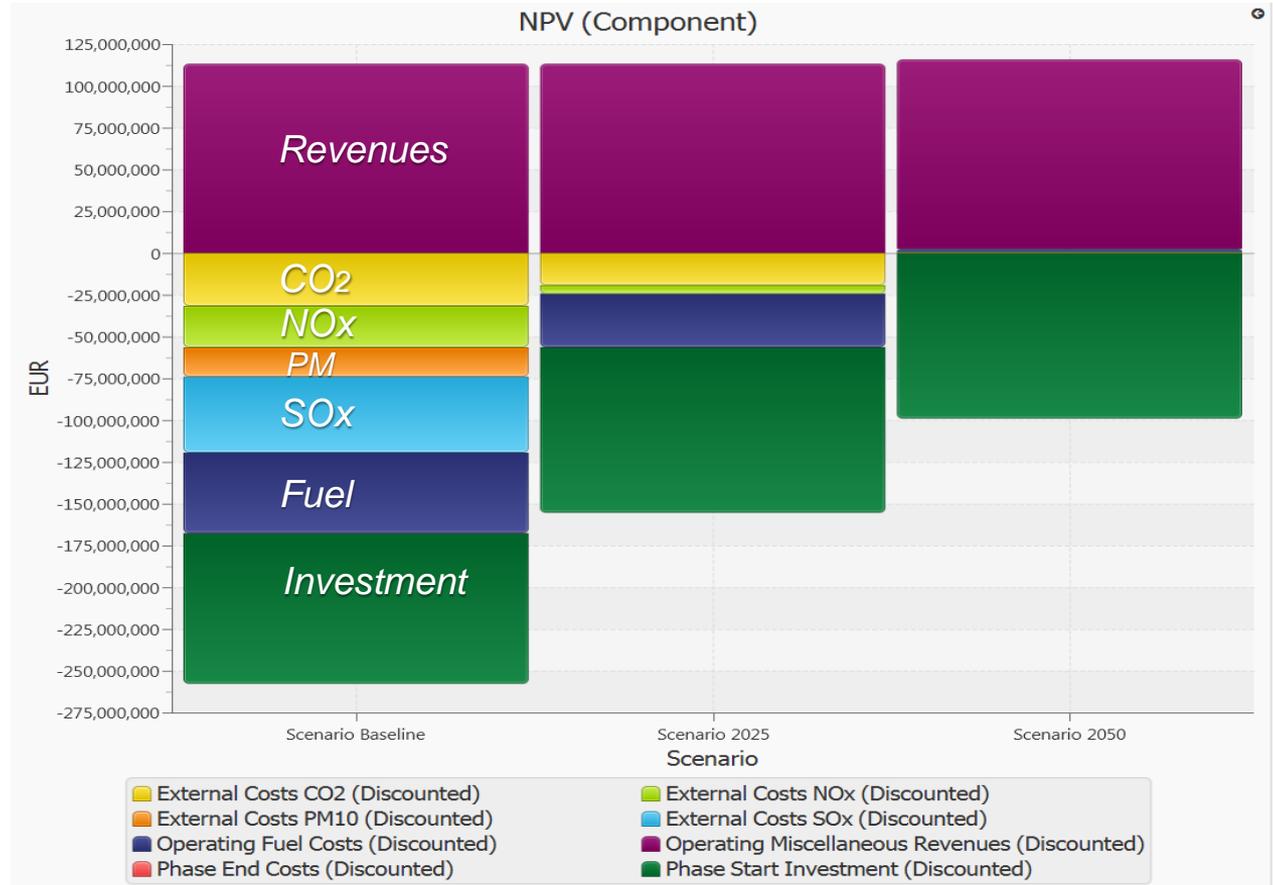


RESULTS > NPV and External Costs

External Costs:
Cost assigned to certain
emissions, e.g. CO2 tax

External costs: reality in
5 to 10 years!
(GHG fund IMO/EU)

Trend: accelerating,
from other sectors +
Paris agreement



CONCLUSIONS

- Many challenges ahead for the maritime industry towards a fossil-free society
 - Also much work and investment is already done the last decades
 - Zero emission technology for work vessels:
 - technically possible and
 - upscaling to the sizes we need
 - Economic aspects as high investment + high risk of innovation very important
 - Introduction of external costs might shift the balance to more sustainable technologies
 - GHG fund discussions at IMO and developments accelerating: no-return to business-as usual
- 



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