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Route to 2050: Breaking the barriers towards shipping decarbonisation

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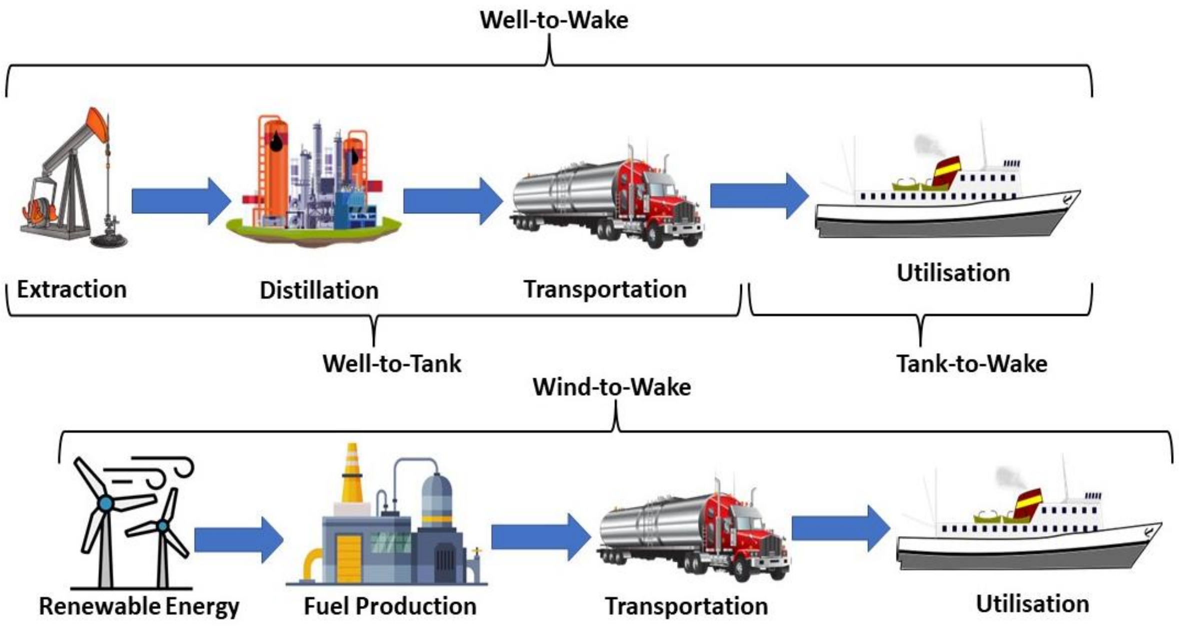
16th April 2024

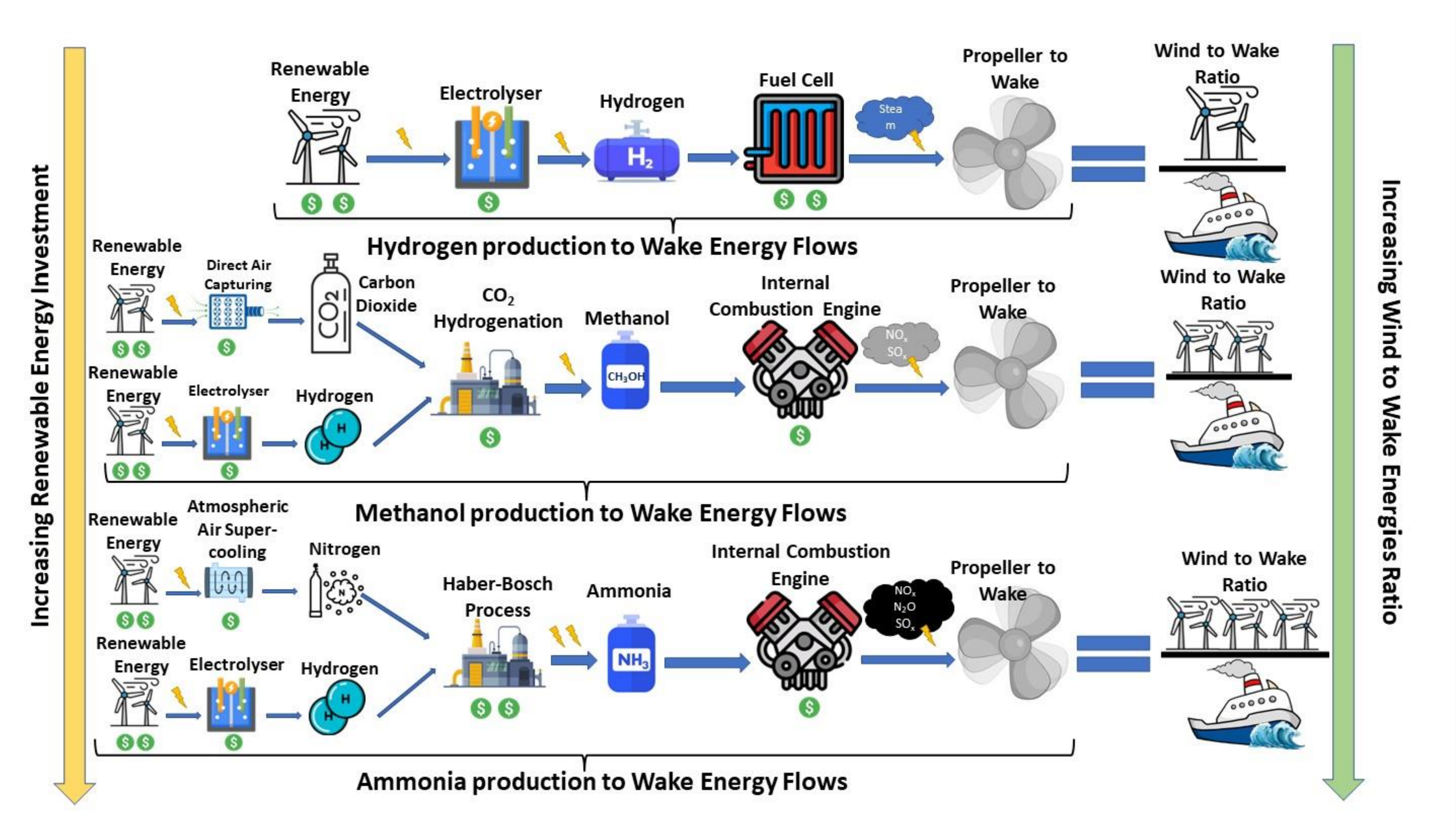
Introduction

- New IMO regulations set to reach net-zero emissions by 2050.
- Many decarbonization solutions, promoted as ideal, only consider funnel emissions.
- A holistic life cycle assessment of fuel production and utilisation onboard is required.



- Shipping resistance towards change, attributed to high reliability standards and profit loss risk.
- Emphasis is mostly given in terms of fueling cost NOT total energy contribution.

Brief Introduction of Wind to Wake Concept:



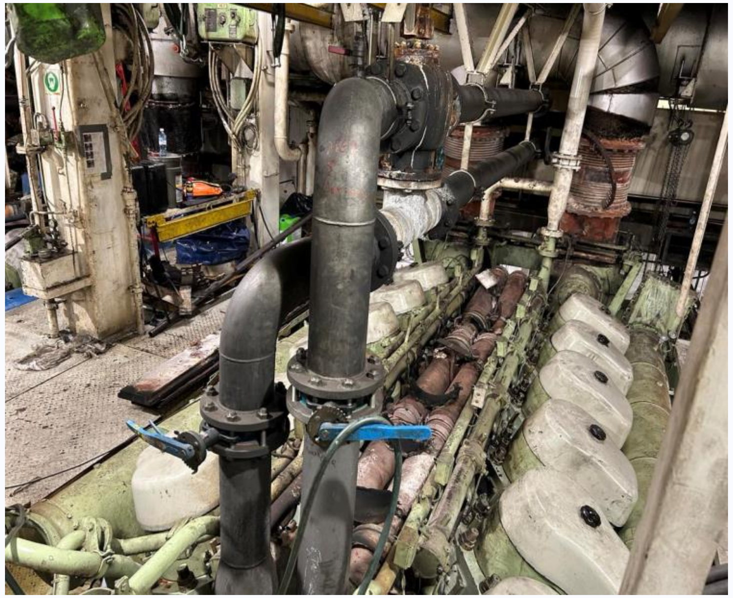
Case Study:
Propose a strategy for decarbonising the Greek Ferry industry

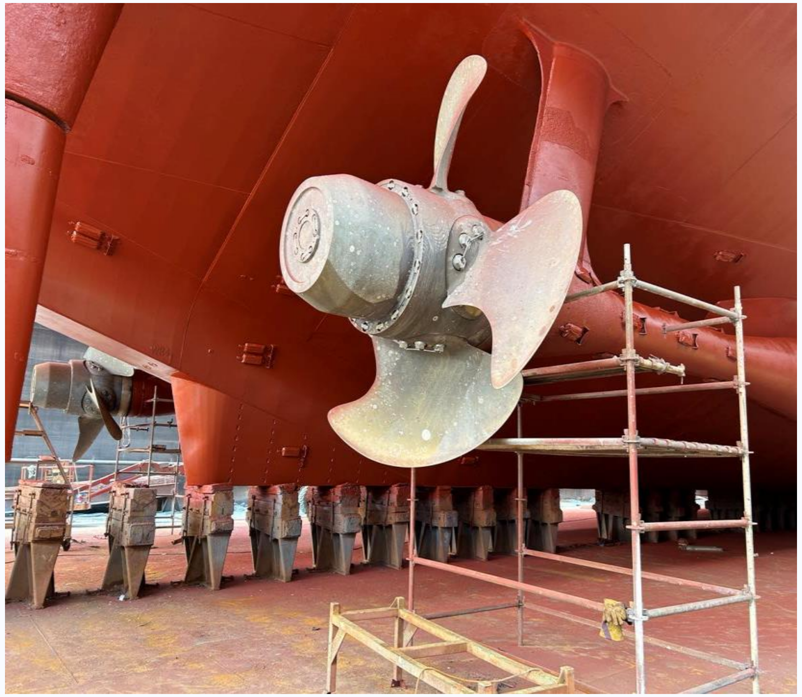
- Objectives:
  - Estimate the current emissions and consumption footprint of a representative vessel case study.
  - Analyse the power demand on board to look for points in need of optimisation.
  - Investigate the benefits of having short-, medium- and long-term decarbonisation solutions.
  - Compare different fueling alternatives in terms of their ‘Wind to Wake’ emissions and energy footprint.

Ferry Case study

Specifications

Type	Cruise ferry (Ice class)
Tonnage	16,850 GT
Length	136.11 m
Beam	24.24 m
Draft	5.4 m
Propulsion & Auxiliary	•4 × S.M.T.-Pielstick 12PC2-2V 17,652 kW (claimed) (MDO), with reduction boxes and CPP •4 x Wärtsilä-Vasa 24 2.5MW (MGO)
Speed	22 kts max speed 18 kts service speed
Capacity	•1,700 passengers •1,184 passenger beds •350 vehicles



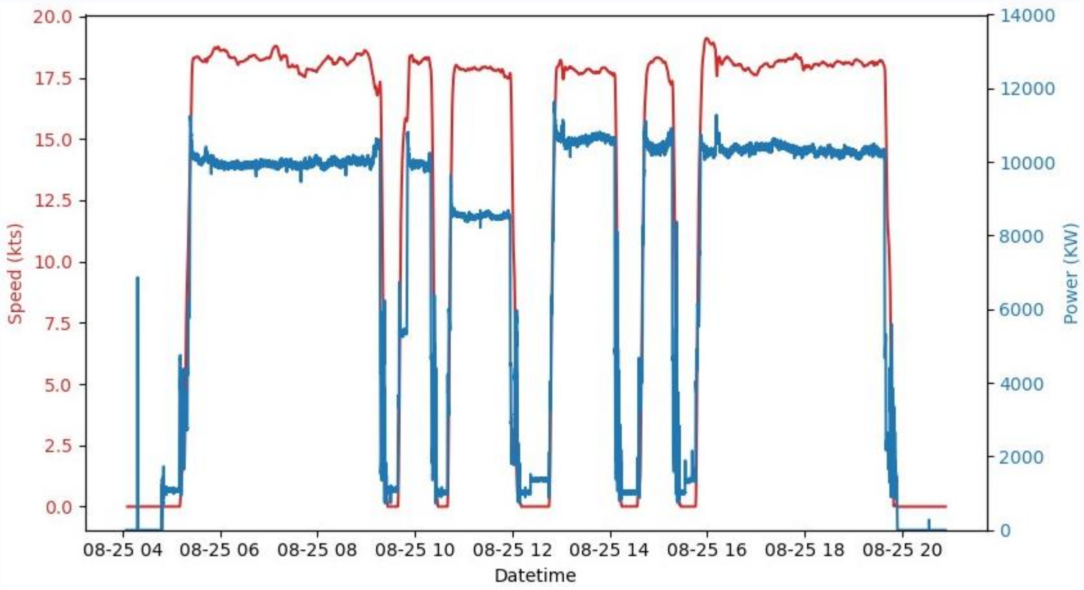


*Lower calorific Values of Fuels Examined:
MGO 42.7 MJ/kg
MDO 41 MJ/kg
LNG 45.5 MJ/kg
Methanol 19.9 MJ/kg
Ammonia 18.6 MJ/kg
Hydrogen 120 MJ/kg

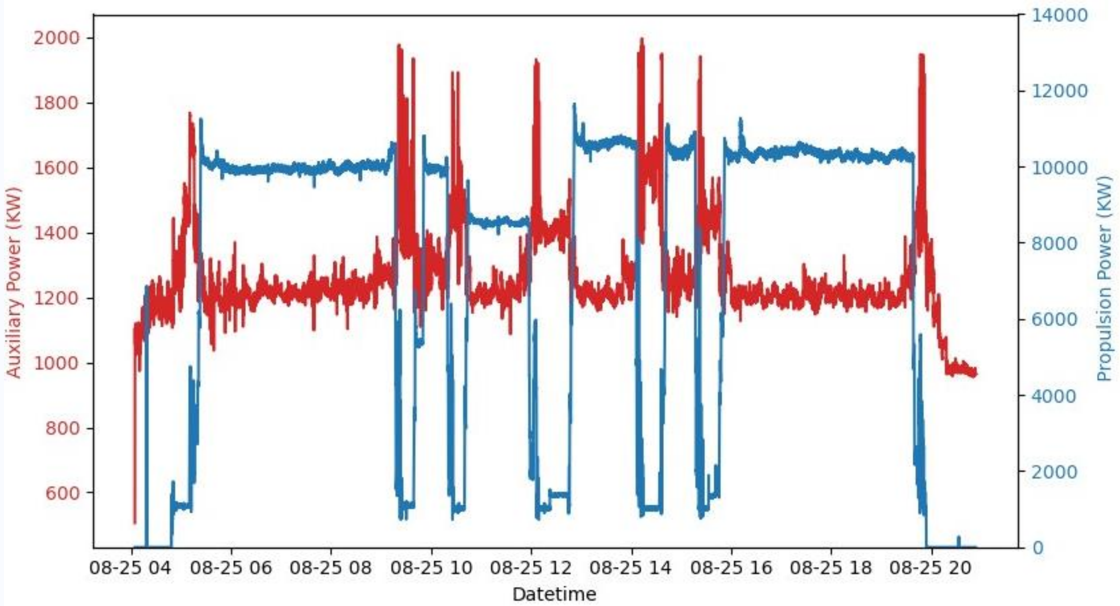
Example Trip: Pireaus-Serifos-Sifnos-Milos

- 183 nm
- 25.0 tonnes MDO for propulsion
- 5.1 tonnes of MGO for hotel demand

Propulsion Power vs Speed:



Propulsion Load vs Auxiliary Power Demand:



Fuelling Scenarios Examined

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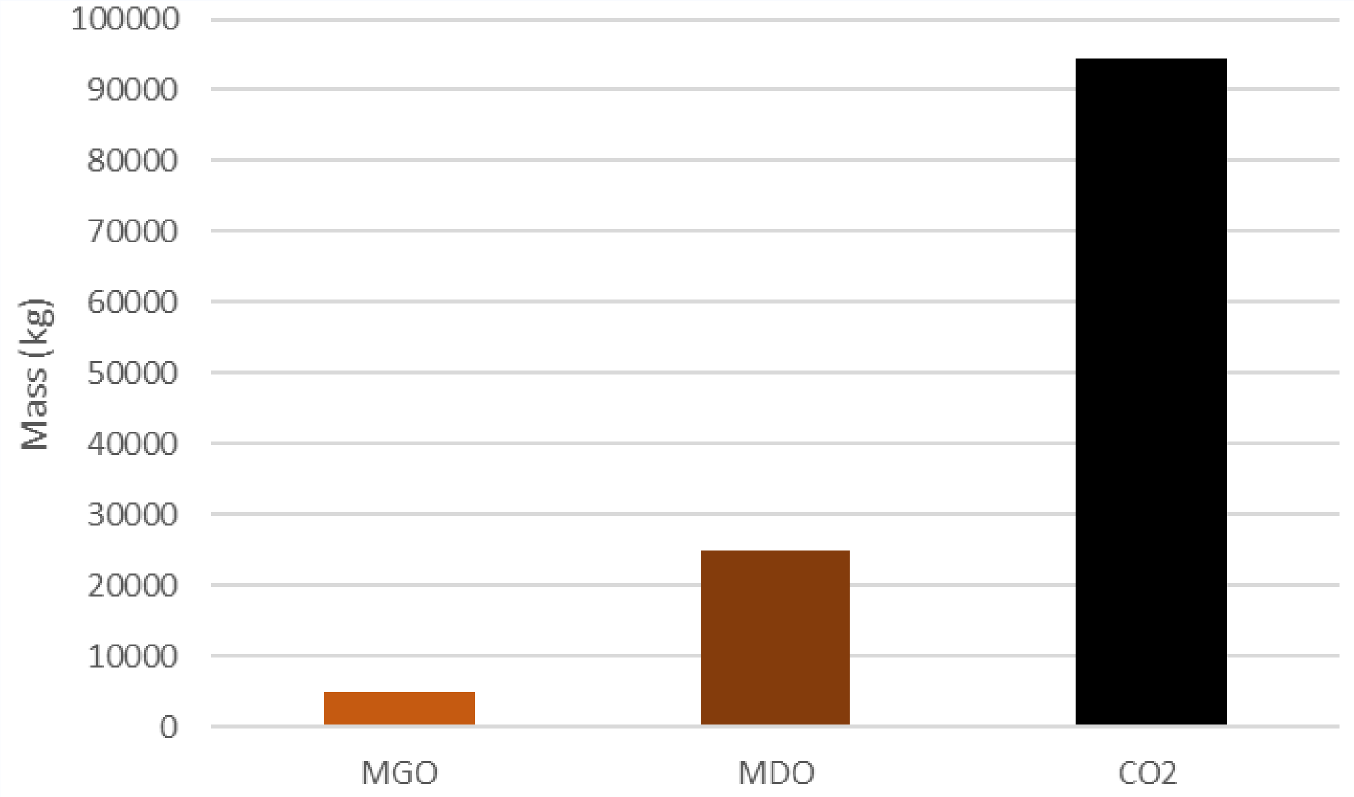
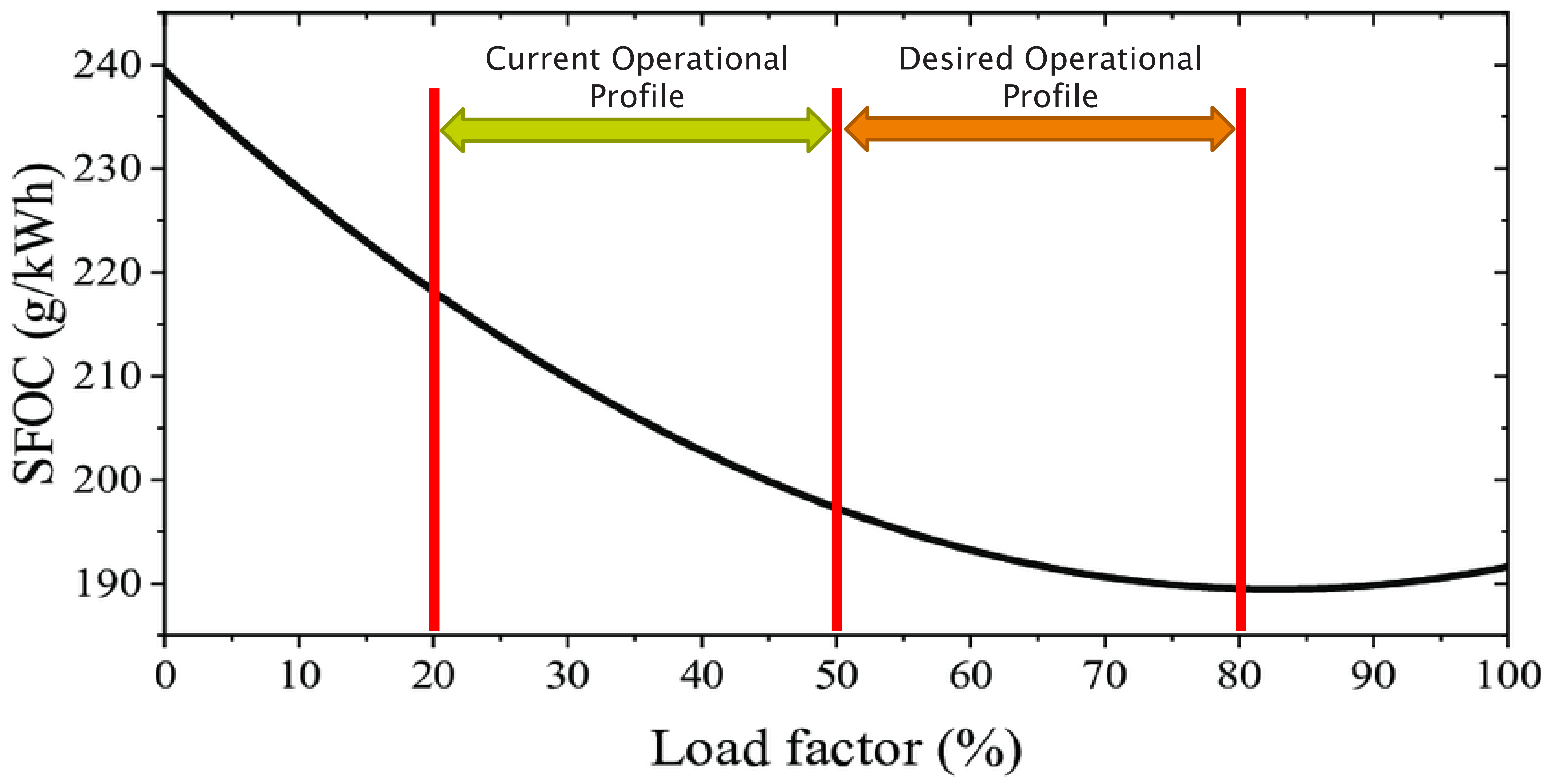
- Original powertrain used as a baseline.
- Decarbonisation strategies are divided into short-, medium- and long-term solutions.
- **Short term solutions (3):**
  - Original powertrain with generator set operational profile optimization
  - New diesel electric powertrain
  - LNG-electric powertrain
- **Medium term solutions (4):**
  - Carbon capturing and storage
  - Methanol electric powertrain
  - Ammonia electric powertrain
  - Batteries
- **Long term Solution:**
  - Hydrogen fuel cell and battery powertrain

Original Powertrain Consumption and Emissions Profile

- 4 Main engines coupled to reduction boxes, fuelled by MDO, average sfc estimated to be 205 g/kWh
- 4 Generators fuelled by MGO with Calculated Average fuel consumption of 240g/kWh
- Powertrain energy efficiency: 40.1%
- Suggested course of action to improve Generator operational profile



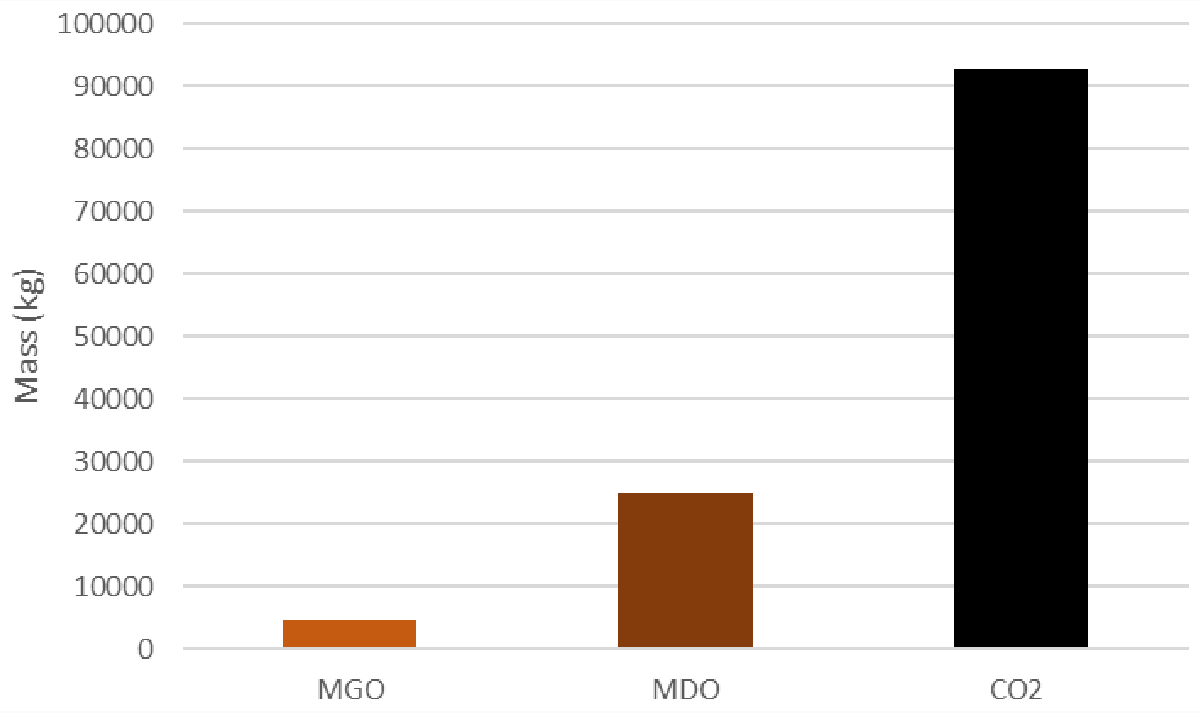
Operational Profiles of Auxiliary Generator Sets



Optimised Powertrain Consumption and Emissions Profile

Short Trip:

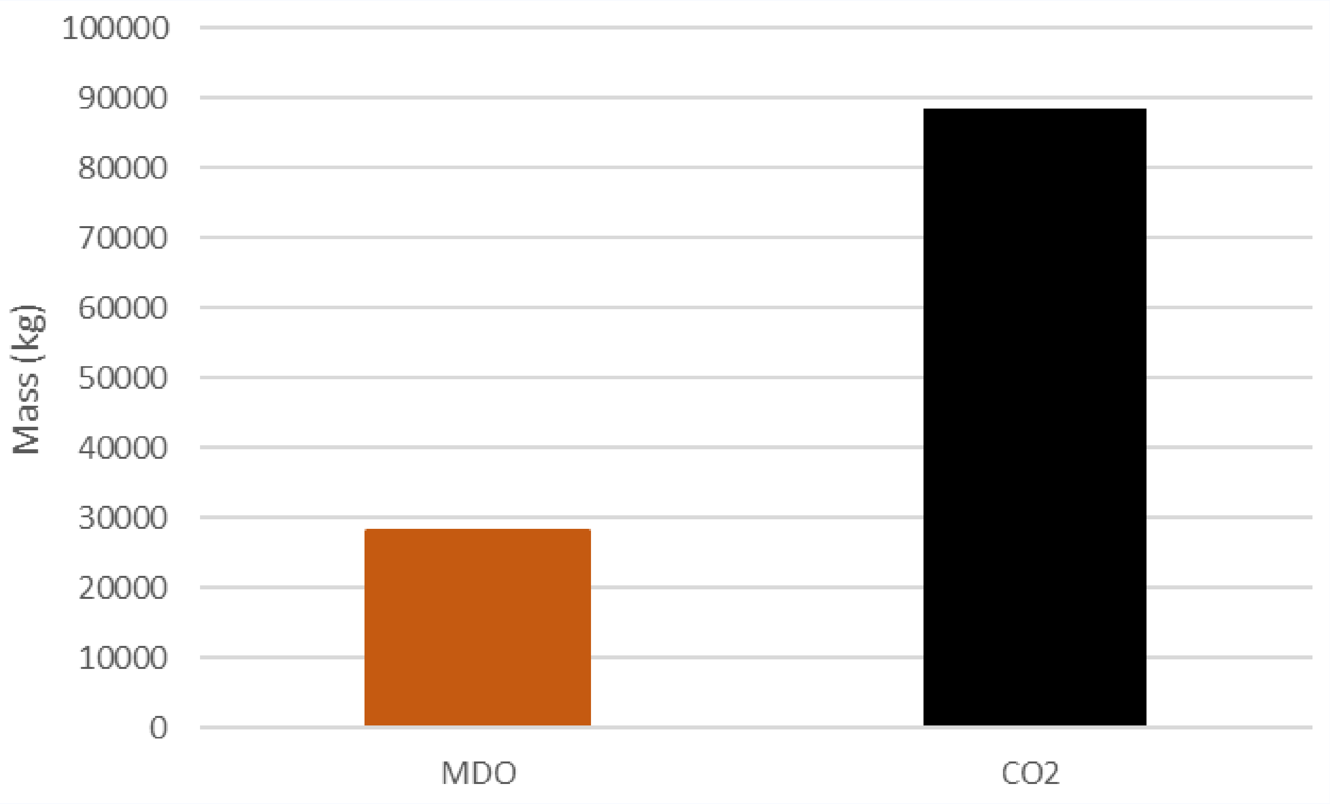
- Generators are now running within their optimum power range.
- Powertrain efficiency increased to 40.7% (+0.6%)
- CO2 Emissions reduced by 1.7% compared to original scenario



Short term solution #1

New-Era Generator Powertrain Consumption and Emissions profile

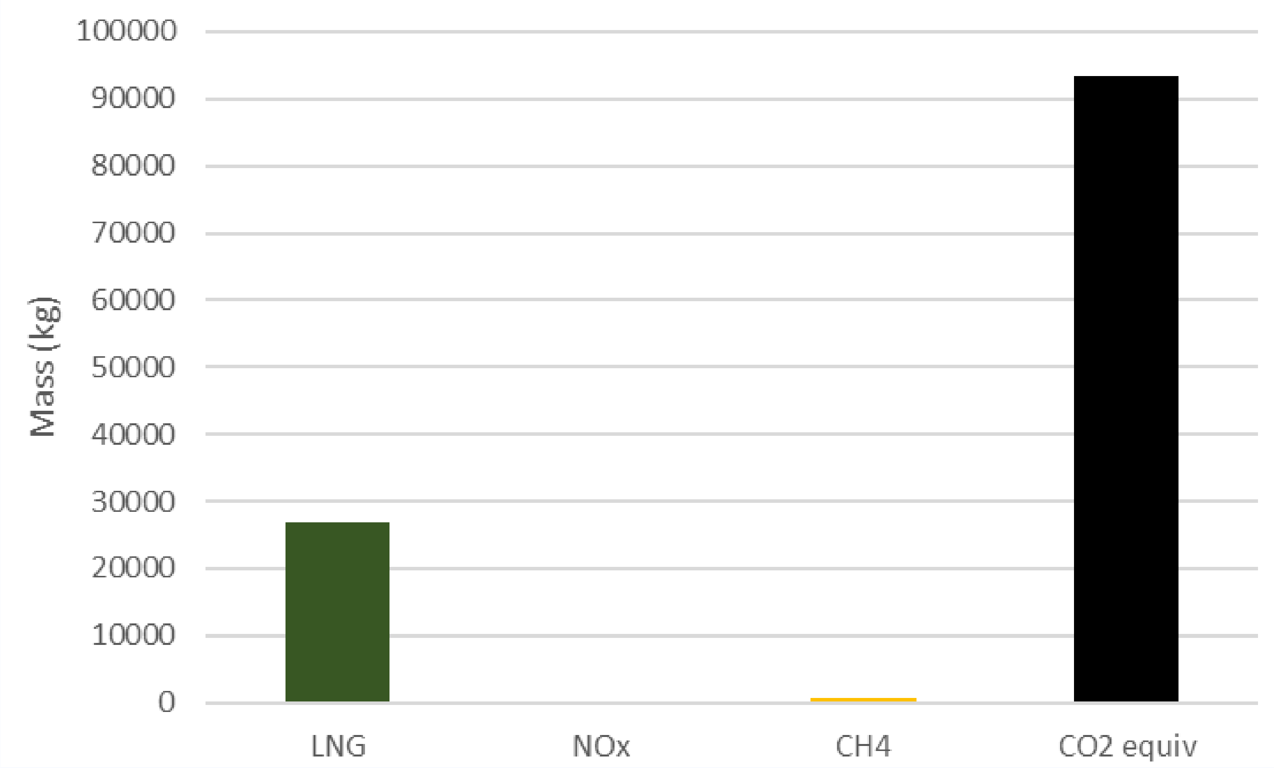
- 2 main generator sets (propulsion) with a combined output of 17MW, fuelled by MDO and 4 generators for auxiliary demand
- Powertrain efficiency 42.7% due to engines being more efficient and yet suffering from electricity conversion losses
- CO_2 Emissions reduced by 5% due to higher efficiency (+2%)



Short term solution #2

LNG Powertrain
Consumption and Emissions Profile

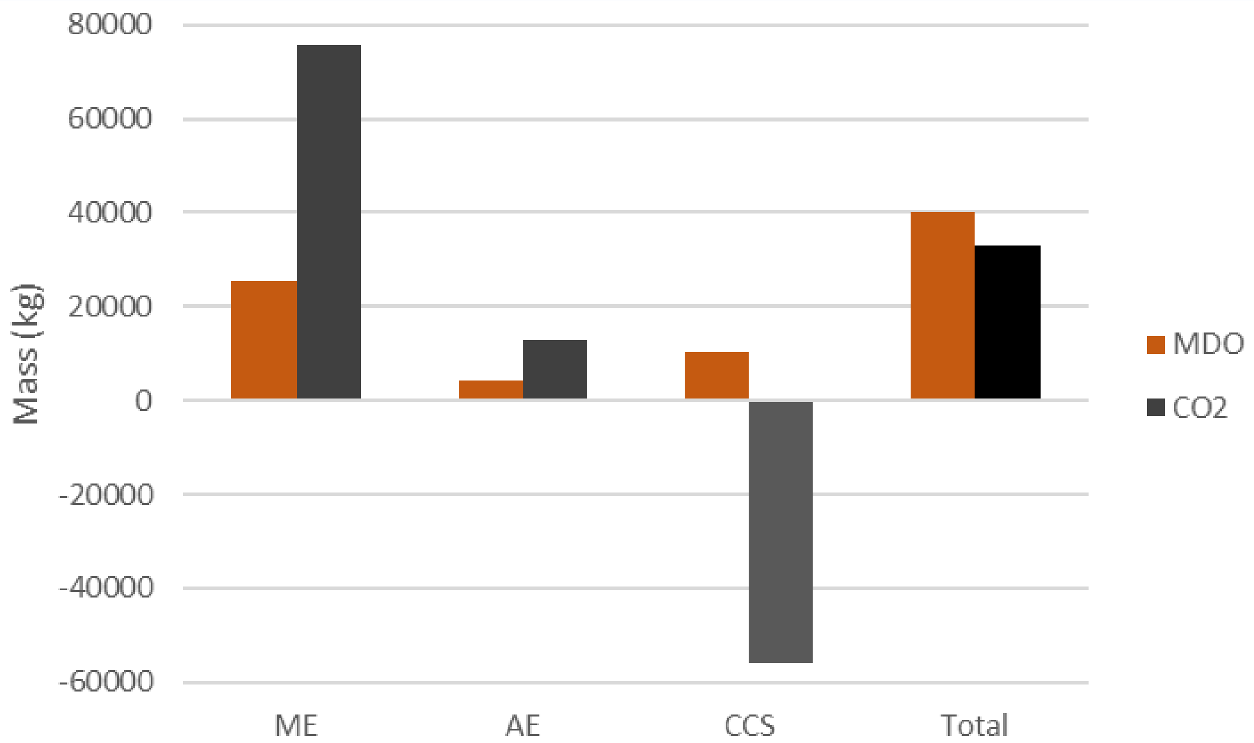
- All generator-sets are fuelled by LNG
- Powertrain overall efficiency is 41.9%
- CO_{2equiv} Emissions decreased by 1.3% compared to original Powertrain scenario, when a 30x CO_{2equiv} factor is assumed for methane slip.
- Emissions footprint can be worse than “modern” MDO powertrain, depending on methane slip factors.



Short term solution #3

New-Era Generator + CCS Powertrain Consumption and Emissions profile

- Generator configuration remains the same.
- Powertrain fuel efficiency dropped to 30% due to the addition of Carbon capturing equipment
- CO_2 Emissions reduced by 65% compared to original scenario



Medium term solution #1

Methanol Powertrain
Consumption and Emissions Profile

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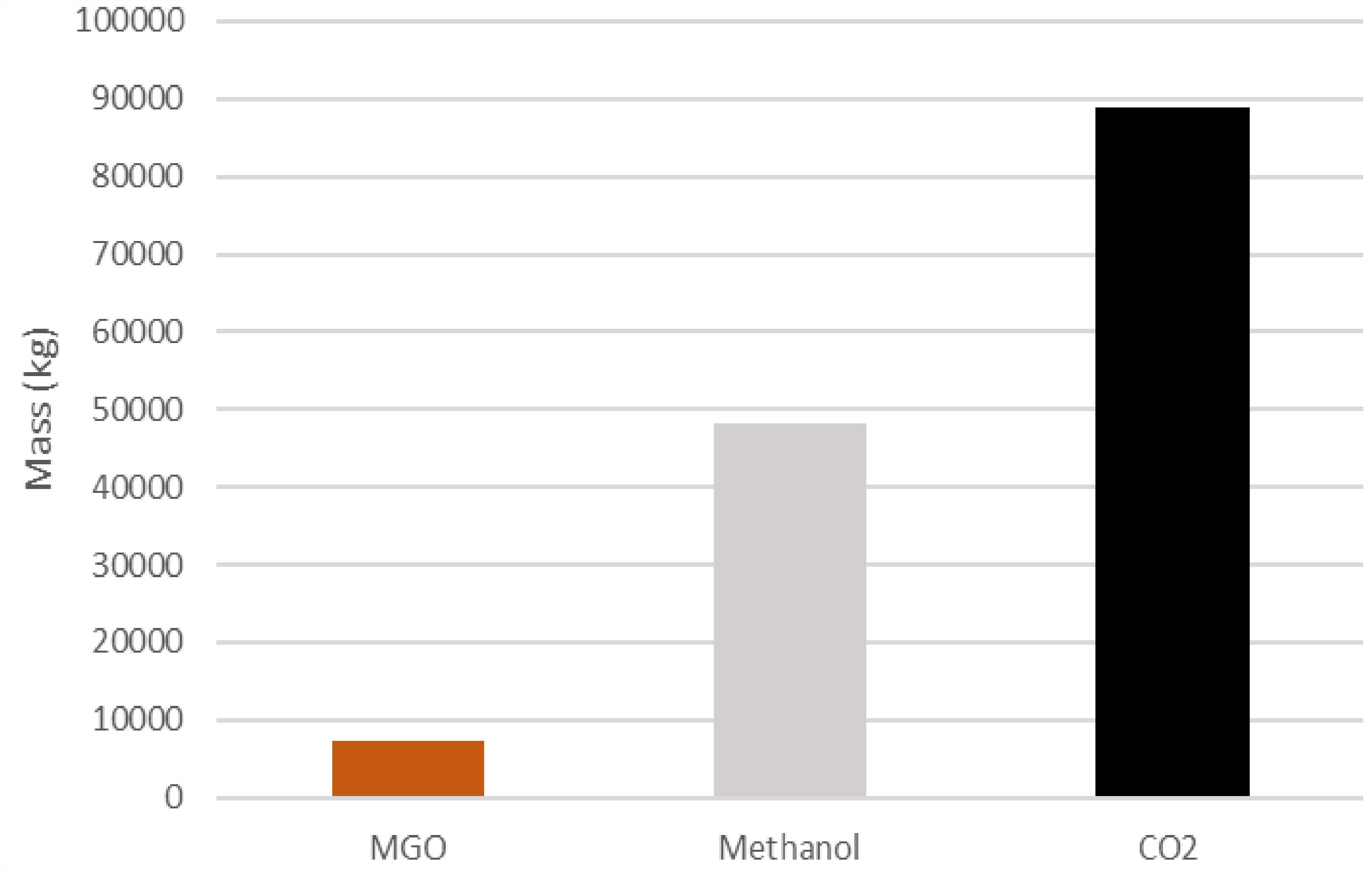
- All generator sets are fuelled by Methanol
- Powertrain efficiency is 41%
- CO_2 Funnel Emissions decreased by 5.9% compared to original Powertrain.
- Net emissions reduced by 76%
- Fuel consumption increased 1.84x by mass and 2x by volume (69.9 m^3)



Medium term solution #2

Ammonia Powertrain
Consumption and Emissions Profile

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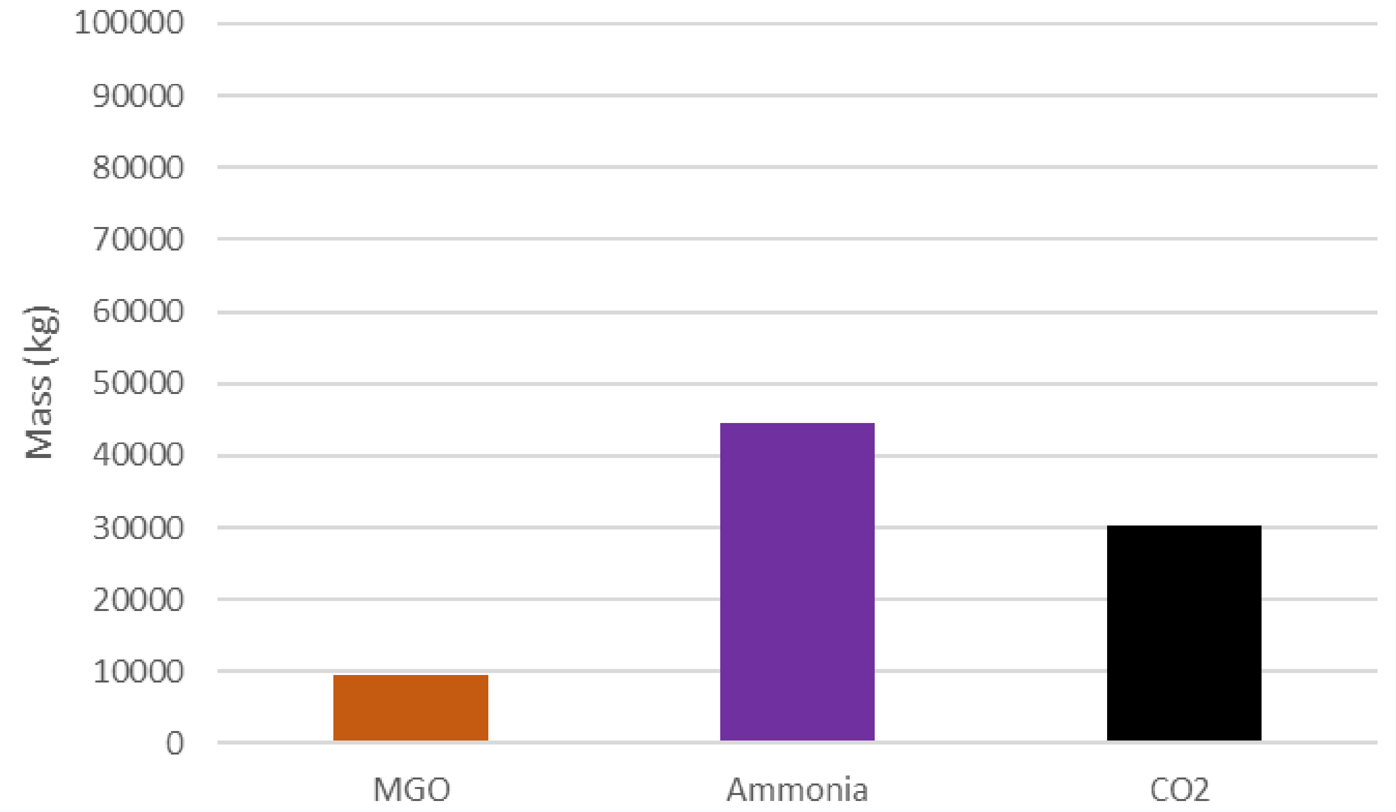
- All generator sets are fuelled by ammonia and results are based on experimental engines running on ammonia-diesel blends
- Powertrain efficiency is 41.7%
- CO_2 Funnel Emissions decreased by 68% compared to original Powertrain scenario
- N_2O emissions are NOT included 30x CO_{2equiv} factor
- Fuel consumption increased 1.8x by mass and 2.2x by volume (71.9 m^3)



Medium term solution #3

Battery Powertrain

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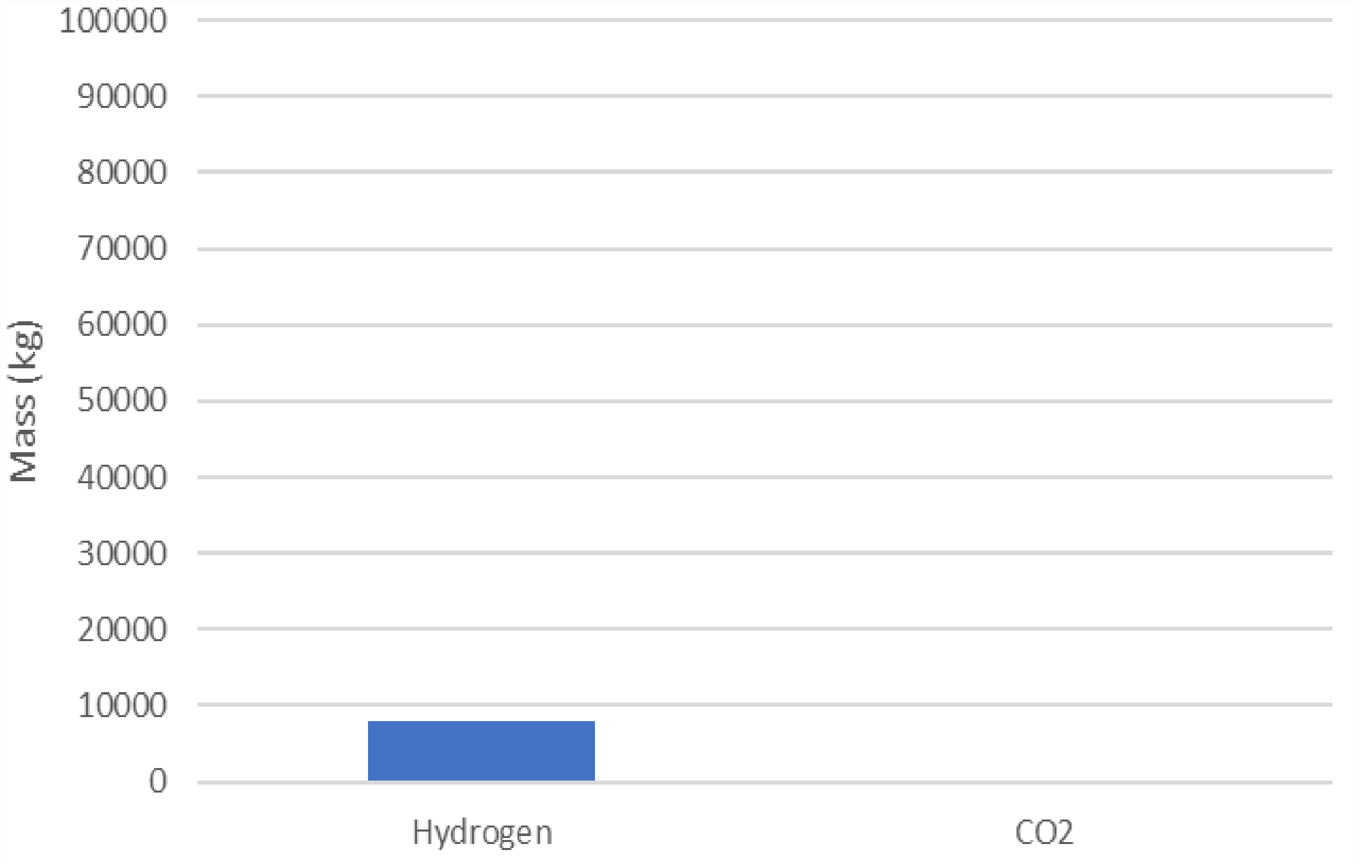
- Battery capacity is 50 MWh_e, including a 10% safety margin.
- Minimum battery size is expected to be 204 m^3.
- To recharge the same battery sufficiently, 40MWe of grid output must be employed, with a prolonged stay of 1hour per port stop instead of 30 mins.
- Local electricity grid capacity is exceeded. Extra batteries must be employed on shore, at each port stop.

Medium term solution #4

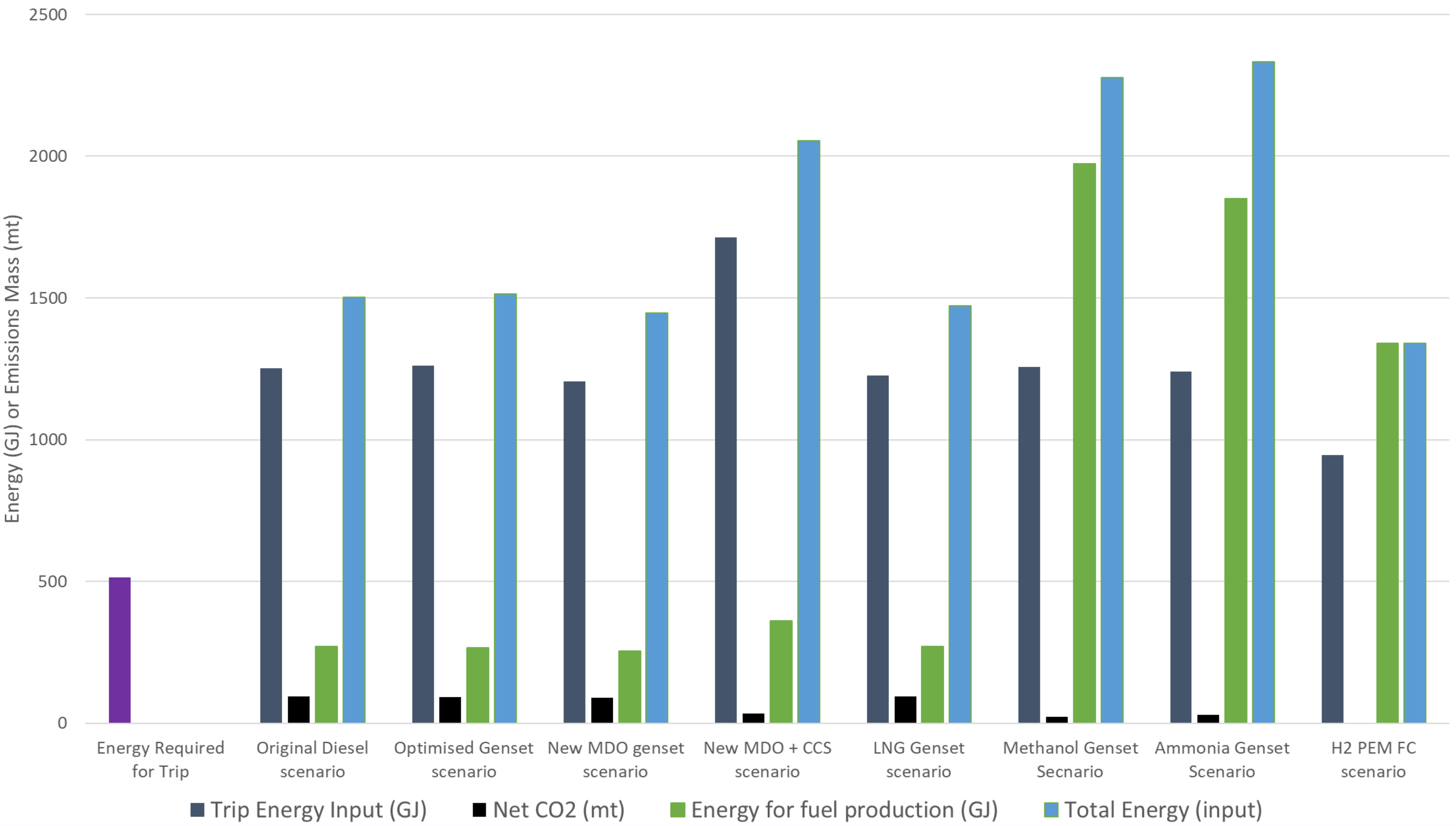
Hydrogen Powertrain
Consumption and Emissions Profile

- Powertrain is comprised of Hydrogen PEM cells (18MW) and batteries (2.5MWh)
- Powertrain efficiency increased to 54.4%
- CO_2 Funnel Emissions are eliminated
- Fuel consumption decreased 3.7x by mass and increased 3.3x by volume (111.4 m^3)

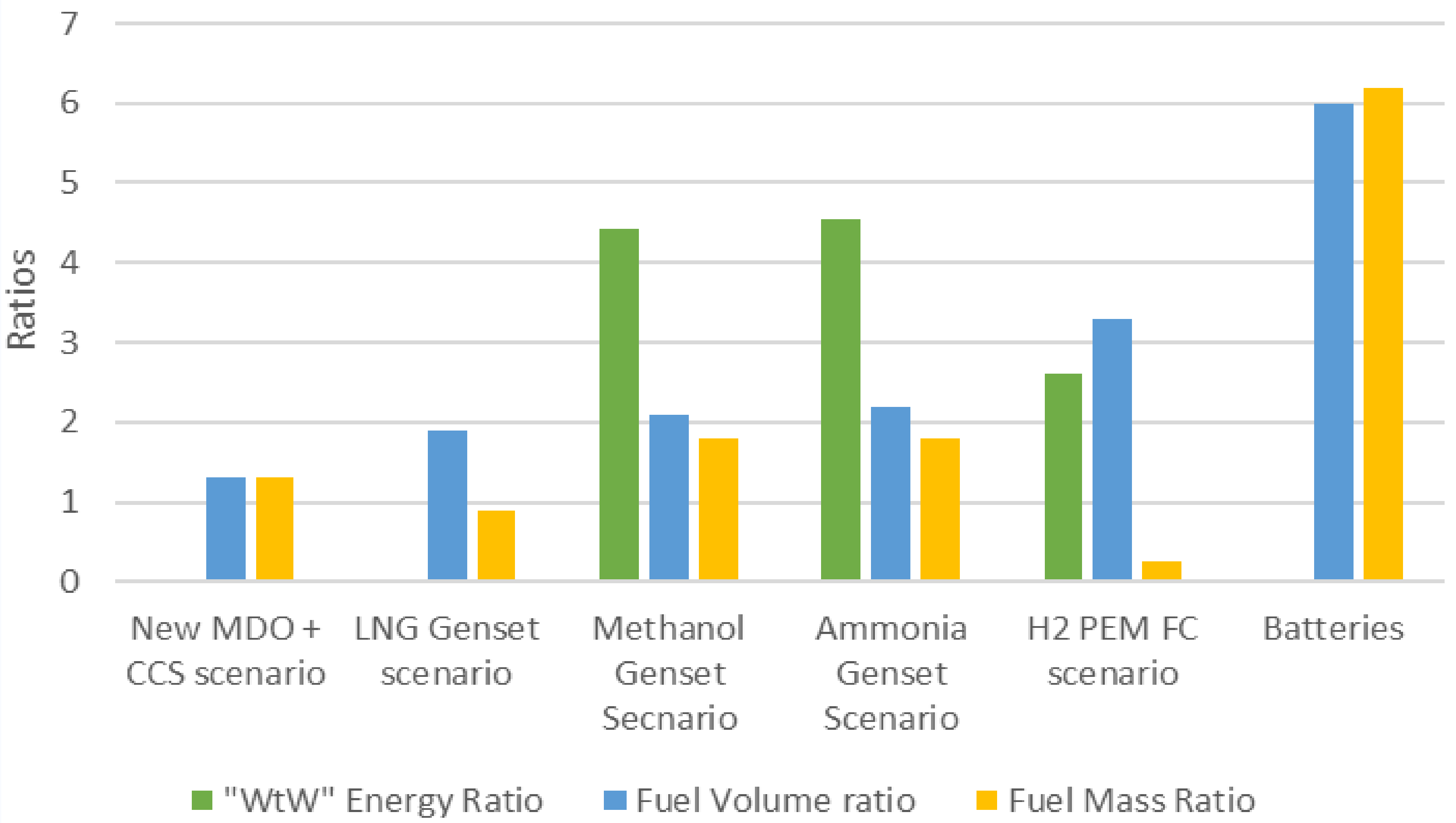


Long term solution

“Wind to Wake” Energies summary



“Take home” message



- All alternative fuel propositions, are comparable in terms of additional volume sacrifice compared to the original powertrain scenario

- Hydrogen system is the best option in terms of emissions output against total renewable energy investment.

YOUR QUESTIONS

Thank you for your attention

Any further questions:
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