Shipping in Changing Climates

Comparing the lifecycle emissions of marine fuels.

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Talk Outline

- Introduction
- Aims
- Scope and Methodology
- Results
- Discussion & Conclusion

Introduction

- Within a 2°C framing all sectors face a common onus to decarbonise by 2050.
  - Dependent on demand but a > 80% decrease in carbon intensity (per tonne km) of shipping is foreseen.
- Several mitigation measures suggested.
  - Operational measures such as speed reduction.
  - New build and retrofit technologies.
- Fuel switching also identified as a potentially important contributor to emission reductions.

Introduction

- Fuel switching can appear particularly attractive.
  - E.g. Hydrogen zero carbon emissions?
  - Important for emission scenarios.
- However many fuels embody significant emissions in their production.
- Need to generate emission estimates that reflect the entire fuel-cycle.
  - Inform wider scenario work, i.e. GloTraM.
  - Reflect wider sectoral change and important sensitivities.
  - Move beyond “snap shots”.

Lifecycle Assessment (LCA) Aims

- Generate upstream and operational emission estimates for a range of marine fuels.
  - Reflect establishing and emerging fuels.
  - Present results that are compatible with existing tools.
  - Identify important sensitivities in the elements that determine upstream emissions.

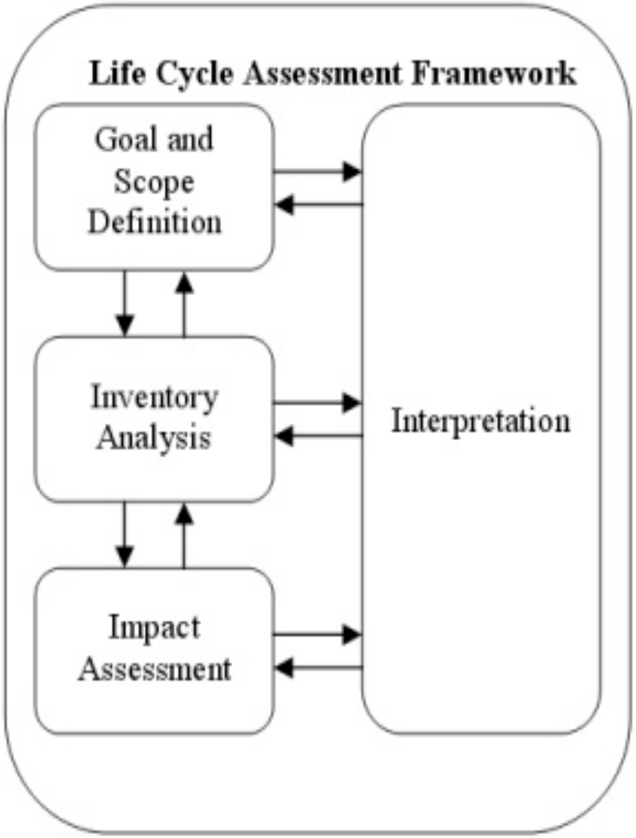
SCOPE AND METHODOLOGY

Scope and Methodology

Fuel and Engines

Fuel	Engine	Region
Heavy Fuel Oil	Slow Diesel	Europe, with average crude import mix
Marine Diesel Oil Biodiesel	Medium Speed Diesel	
(Bio)LNG	Spark Ignition Gas	Europe, Latin America,
Liquid Hydrogen (fossil and renewable, w/o CCS)	Fuel Cell	USA, Europe
Methanol	Dual Fuel engines	Europe
Straight vegetable Oil	Slow Diesel	Latin America, Europe

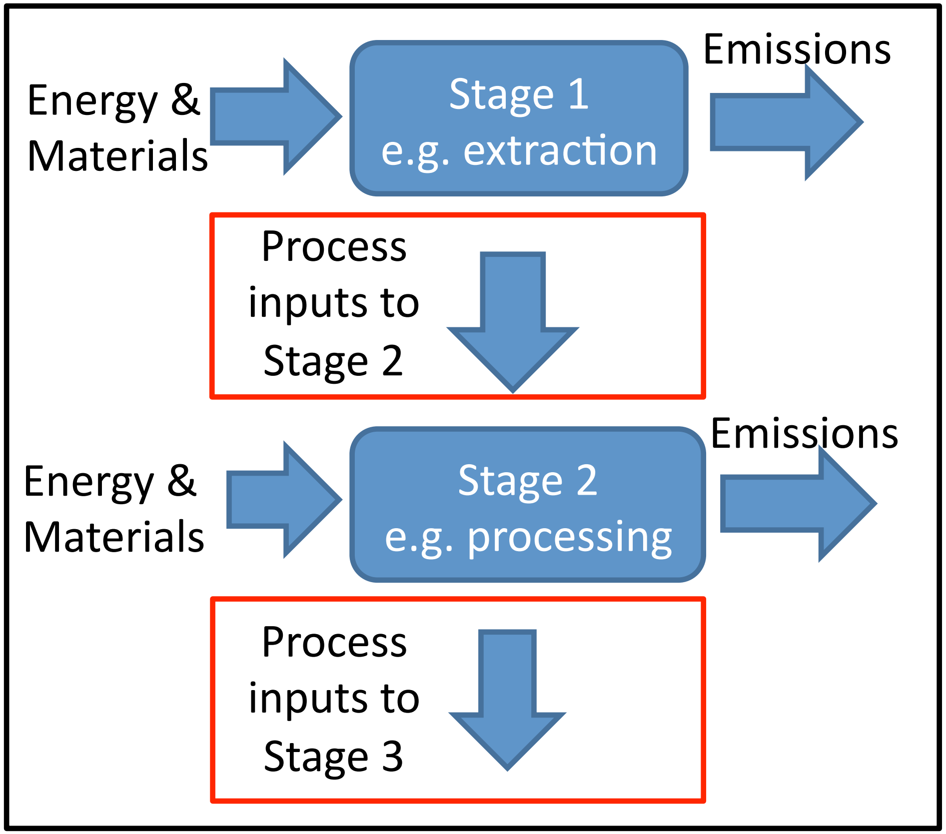
LCA Structure



Scope and Methodology

Attributional LCA

- Linked lifecycle stages.
  - Extraction to combustion.
  - Biogenic CO_2 excluded.
- Results expressed in multiple units.
  - Kg/kg fuel.
  - Kg/kWh (shaft).



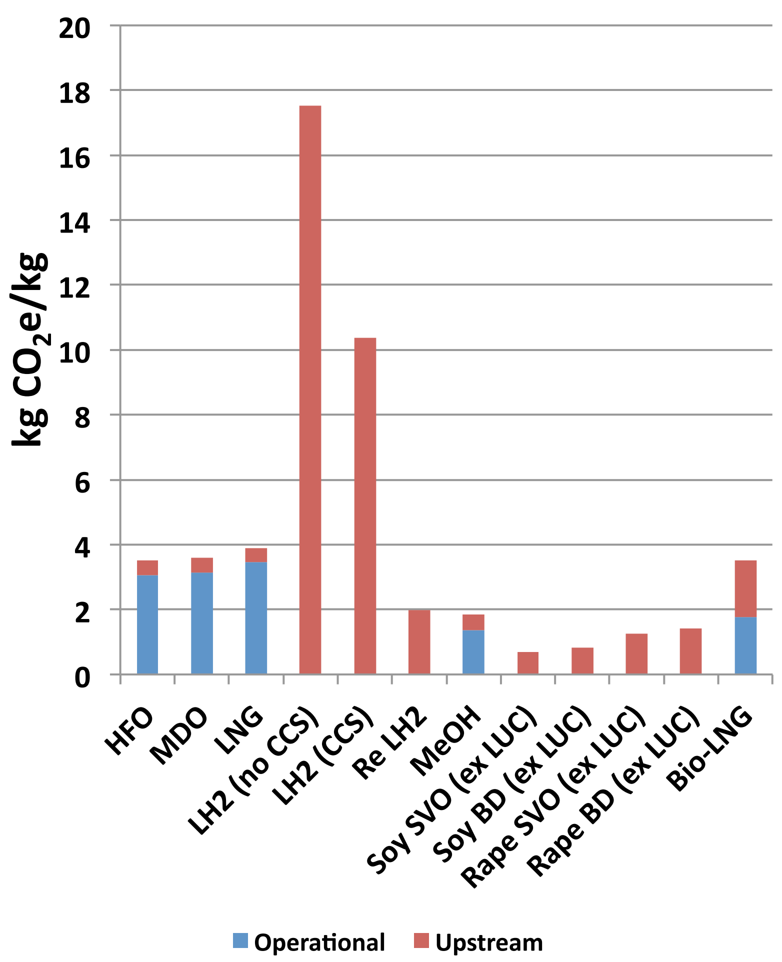
RESULTS

Baseline Results

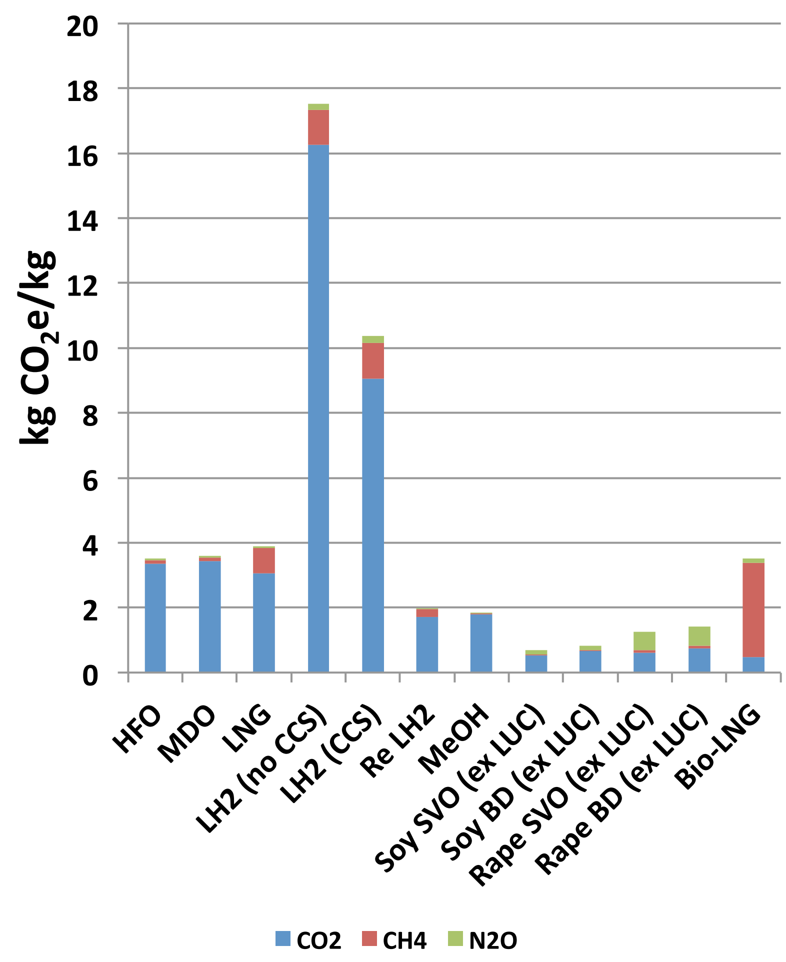
- For each fuel a baseline value is presented reflecting current (2010) technology.
  - Focus on green house gases (GHGs).
  - Reflects established technology.
  - E.g. Marine diesel based on European distillery configuration.
- Results expressed in CO_2 equivalents.
  - GWP (100 years) from AR5.

Lifecycle GHG emissions by mass of fuel (exc. operational biogenic CO_2)

By lifecycle stage

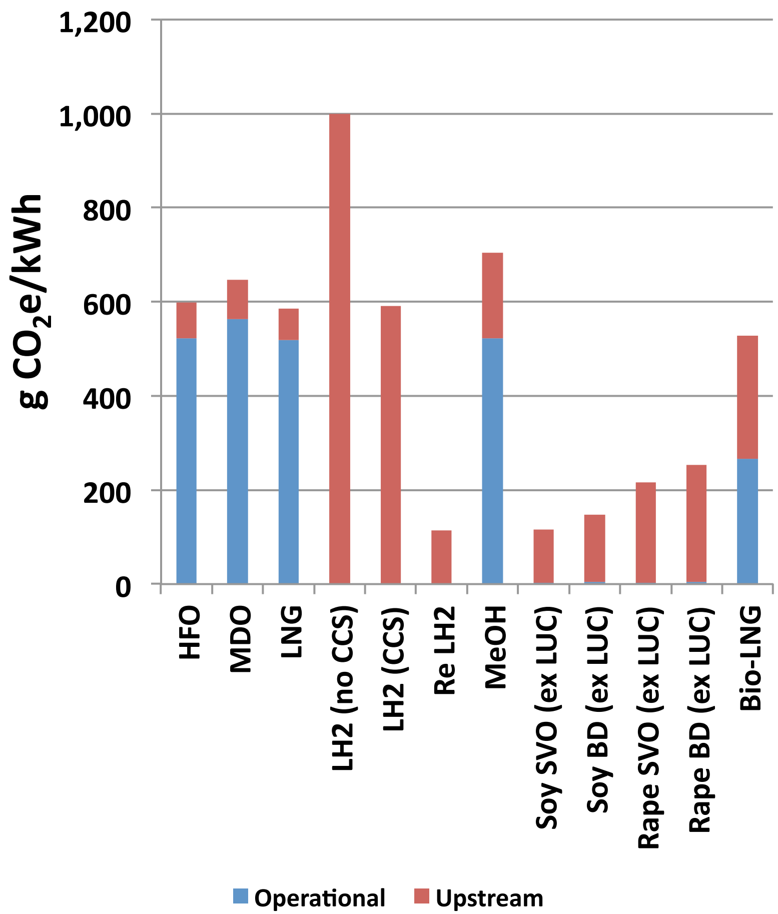


By emission species



Lifecycle GHG emissions by engine work (exc. operational biogenic CO_2)

By lifecycle stage



Impact of engine type

- Arguably a more meaningful comparator of fuels.
- Reflects the impact of engine efficiency and energy content.
  - LH_2 (high emissions, low SFC).
  - MeOH (low emissions, high SFC).

DISCUSSION

Discussion

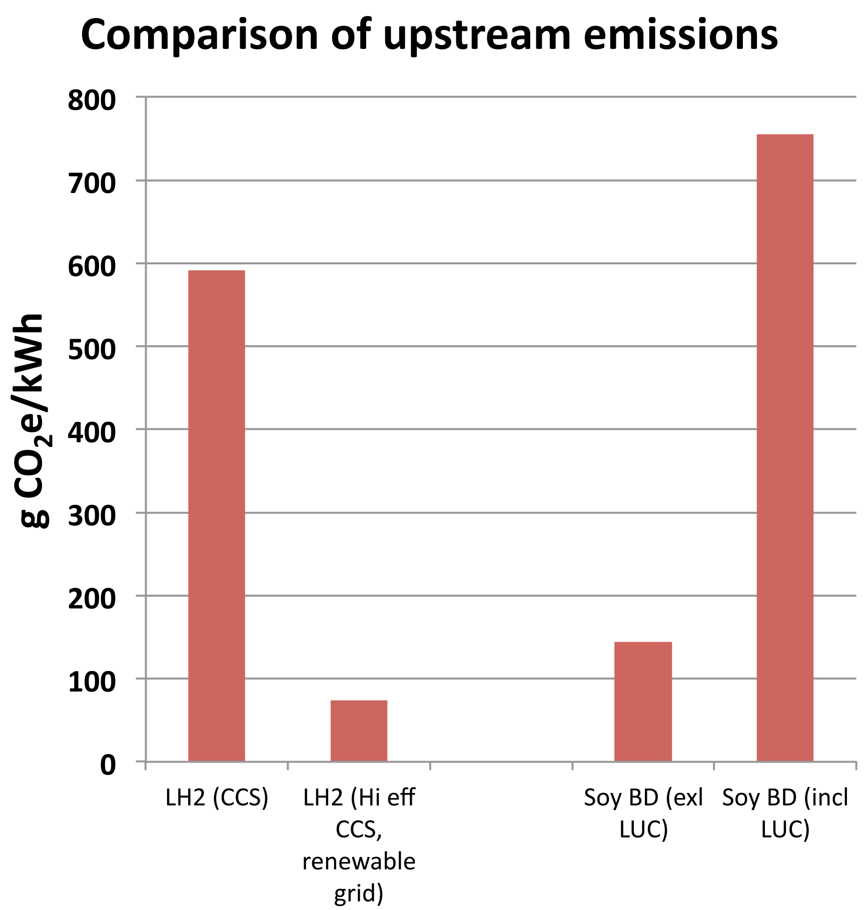
- Results demonstrate comparable emissions for established marine fuels.
- LNG not a low GHG option.
  - Especially if higher venting, flaring, in-process use and methane slips are considered.
  - Biofuels demonstrate higher upstream emissions.
- Examination of lifecycle ‘hot spots’ allows for hypothetical modification of important sensitivities.

Fuel-cycle sensitivities

- 2 examples

1. LH_2 with renewable electricity, gaseous feedstock, and increased (95%) CCS capture rate.

2. Soy derived bio-diesel **including** impact of land use change.

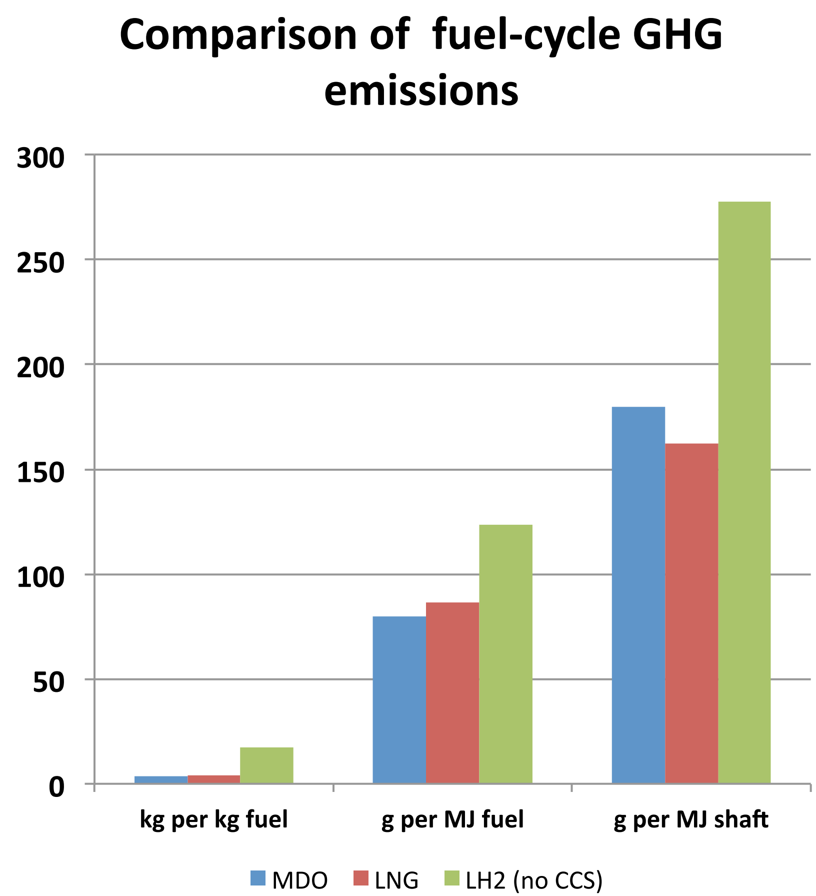


Discussion

- Important to consider the units and system boundary when presenting and comparing lifecycle emissions.
- Risk of misrepresentation of results.
  - Especially when comparing fuels with different fuel cycle characteristics.

Importance of Units

- Example; MDO, LNG, LH_2
  - Compared based on mass, fuel energy content and shaft energy.
- Comparison of LH_2 with other fuels dependent on system boundary and units.
- Also remember increase in GWP for CH_4 (AR5).



Conclusions

- Results demonstrate that significant emission reductions are difficult to achieve by fuel switching alone.
  - Low carbon fuels (LH_2 and biofuels) entail challenges.
- However drastic emission reductions in the shipping sector can coincide with system level efforts such as grid decarbonisation.

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Thank You

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