



Marine biofuels -potentials and compatibility

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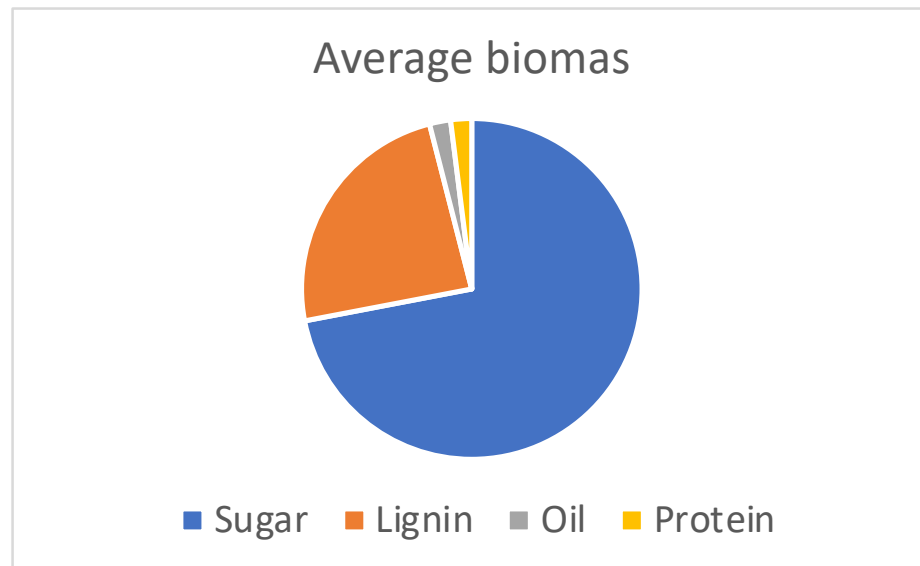
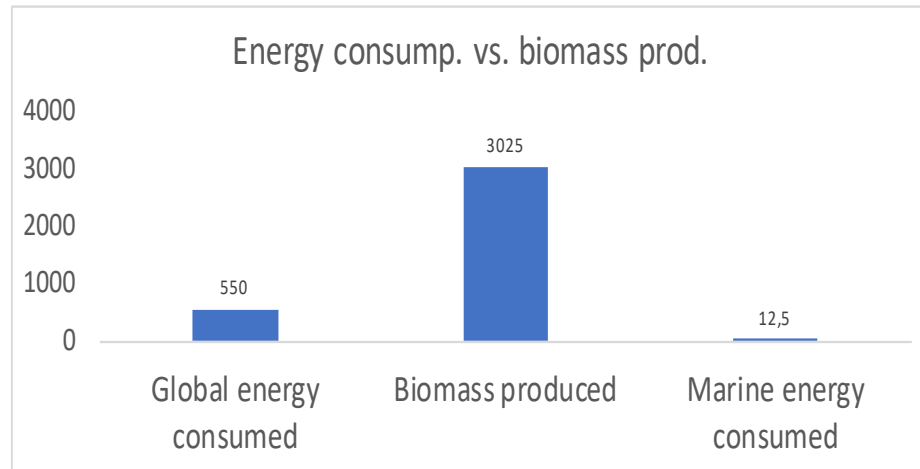
- The aim is to improve cooperation and information exchange between countries with national programmes in bioenergy research, development and deployment.
- The IEA Task 39 is dedicated to sustainable development and deployment of transportation biofuels.
- Participants from 15 countries representing academia, government and industry
- Focus include: Technology development & assesment, and sustainability evaluation. Multidisciplinary approach



Biofuels

-fuel types, global potential

- Biofuels are made from biomass, the current largest renewable energy source
- Biofuels can be directly compatible with marine diesel engines. Very low in sulphur, potentially low in GHG
- Biofuels are prepared from whole biomass or its main components:
 - Sugar, Lignin & Oil
- Four types of biofuels:
 - **Plant oils (Biodiesel)**
 - **Alcohols (Bioethanol)**
 - **Biomethane**
 - **Synfuels (Fischer-Tropsch)**
- Potential for development of dedicated marine biofuels



Biofuels -sustainability

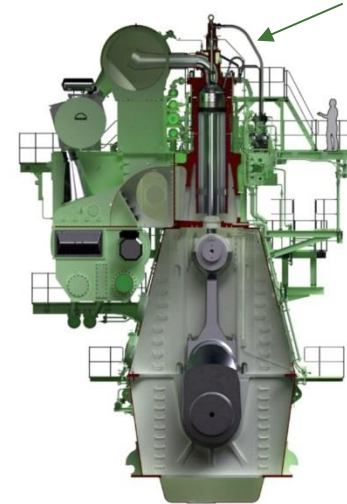
- Biofuels comes in many sizes and feedstocks.
- Sustainability of biofuels are complex. Certification ongoing
- 1st generation (1G) biofuels are based on crops and 2nd generation (2G) biofuels are based on waste and residues
- 1G biodiesel made from plant oils may not be sustainable and are limited in potential.
- 2G biodiesel and 2G bioethanol are sustainable, up to 90% CO₂ reduction
- Biomethane, high sustainability, but beware of methane leaks
- Synfuels are made from waste and residues in a thermal process, but are still far from commercial scale
- Feedstock is the main sustainability parameter



New engine technologies – multifuel engines

- 2-stroke diesel engines can run on a wide range of fuels with very high efficiency
- LCI multifuel engines can run both heavy oil, LNG, alcohol (methanol and ethanol) in a **diesel cycle**
- Only renewable alcohol available in commercial quantities is bioethanol

Fuel system



Low sulphur, low carbon –technical opportunities

| Energy carrier | Combustion engine | Engine/fuel tank retrofitting | Long haul | Potential GHG reduction | Technology readiness |
|--------------------------------|-------------------|-------------------------------|-----------|-------------------------|----------------------|
| Ammonia | Yes | Yes (major) | Yes | Large | Medium term |
| Hydrogen | Yes | Yes (major) | Yes/No | Large | Medium term |
| Batteries | No | Yes (major) | No | Large | Short term |
| Fuel cells | No | Yes (major) | Yes | Large | Long term |
| Sails (wind) | Hybrid | No | Yes | Partial | Short term |
| Nuclear | No | Yes (major) | Yes | Large | Short term |
| LNG | Yes | Yes (major) | Yes | None ->increase | Short term |
| ULSD | Yes | No | Yes | None ->increase | Short term |
| Scrubbers | Yes | No | Yes | None | Short term |
| Biofuels plant oils | Yes | No | Yes | Large | Short term |
| Biofuels methane | Yes | Yes (major) | Yes | Partial | Short term |
| Biofuels alcohols | Yes | Yes | Yes | Large | Short term |
| Electrofuels | Yes | No | Large | Partial | Long term |
| Higher mileage | Yes | No | Yes | Partial | Short term |

Large GHG reduction = more than 50%

Technology readiness; short term 0-5 years, medium term 5-15 years, long term 15-50 years



Fuel specifications and price

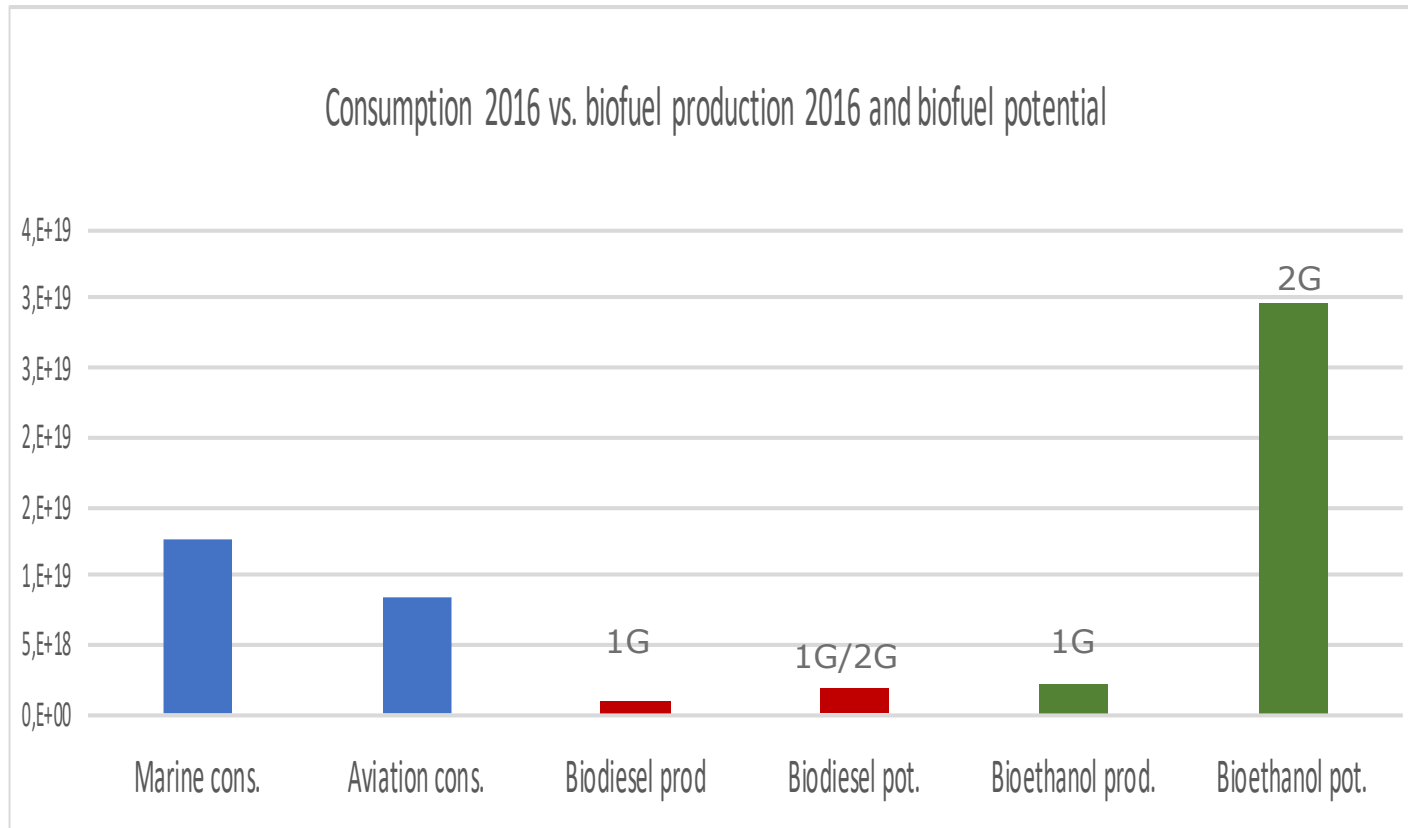
Marine fuels vs. biodiesel and bioethanol

| | HFO Heavy fuel oil | MDO Marine diesel oil | MGO Marine gas oil | ULSD | FAME Biodiesel | HVO Hydrotreated vegetable oil | Ethanol |
|--|---------------------------------|---------------------------------------|---------------------------------|--------------------|--------------------------|---|--------------------|
| Kinematic viscosity (mm ² /s) | <380 | 2 - 11 | 2 - 6 | 1.9-4.1 | 4.2 - 4.5 | 2.5 - 3.5 | 1.5 |
| Heating value (MJ/kg) | 40.5 -43 | 42 - 48 | 44 -45.3 | 42 | 37-40 | 44 - 47 | 27 |
| Density at 15°C | <991 | <900 | <890 | 875 | 880 - 920 | 770 - 790 | 790 |
| Flash point (°C) | >60 | >60 | >60 | >52 | 110 - 195 | >61 | 17 |
| Pour point (°C) | >30 | 0 - 6 | -6 - 0 | -12 | -4 - 6 | -5 - -25 | -114 |
| Sulfur (%) | <3.5 | 0.3-2.0 | 0.1-1.5 | 0.00015 | Close to 0 | Close to 0 | Close to 0 |
| Price \$/mt \$/GJ 08 Oct 2018 | 540 13 | 757 17,2 | 821 18,5 | 690 16,4 | 1130 29 | 990 21,5 | 469 17,3 |

- Fuels regulated by ISO 8217:2017
- Biofuels initially substitutes MDO and MGO
- HVO is also a feedstock for bio jetfuels
- Feedstock competition between marine and aviation fuels



What are the biofuel potentials?



Biofuel potentials based on agricultural production vs. fuel consumption. Note distinction between 1st and 2nd generation biofuels. For 2G bioethanol a 50% use of residues is assumed. 2G numbers based on global agricultural residue potentials, see Bentsen et al. 2014 Progress in Energy and Combustion Science 40 59-73.



Marine biofuels are keep-it-simple fuels

- Renewable fuels has a higher cost
- Biofuels for marine engines can be simpler (dum fuels) compared to other biofuels
- Marine biofuels open for more efficient biomass use i.e. higher sustainability and lower cost
- Some fuels are produced commercial scale, established industry.
- Scaling of marine fuels is the big issue
- Speed of transition; years to decades
- Partnerships are needed (chicken and egg situation)

