MARINE BIOFUELS

EXPERT WORKSHOP – PROSPECTS FOR ENERGY AND MARITIME TRANSPORT IN THE NORDIC REGION
26 FEBRUARY 2020 - Malmö
THE OPPORTUNITY FOR MARINE BIOFUELS
INTERNATIONAL SHIPPING: IN NEED FOR A SOLUTION

GLOBAL SHIPPING HAS A YEARLY CO2 EMISSION COMPARABLE TO FOR EXAMPLE GERMANY, WITHOUT ACTION SHIPPING WILL ACCOUNT FOR 17% OF GLOBAL CO2 EMISSIONS IN 2050

Shipping uses the dirtiest fuel in the world and legislation is only partially addressing this with the 2020 Sulphur Cap

- From 3500 x more Sulphur than road diesel to 500 x more Sulphur
- Ambition for 50% less GHG by 2050, but no clear policy until 2023 and even then....
Energy efficiency, logistics, speed and the use of low carbon fuels are key to meet IMO’s target. Below a potential pathway to reduce the emissions from international shipping between 2015-2050 is presented.

Source: DNV GL MARITIME (2018)

Source: Bouman et al. (2017)
BIOFUELS: ONE OF THE BEST SOLUTIONS FOR MARINE

CURRENT REGULATIONS AND ENGINE CHARACTERISTICS LIMIT THE COMMERCIAL OPTIONS TO BECOME MORE SUSTAINABLE EXCEPT VIA BIOFUELS.

2020 SULPHUR COMPLIANT

- Biofuels are naturally very low in Sulphur
- Due to regulation increasing baseline fossil fuel price from 2020 onwards
- Already a solution in ECA zones

DROP IN SOLUTION

- Long asset lifetime
- Immediate action required to stop climate change
- We need to change this industry with for an important part the current fleet

HEAVY DUTY APPLICATION

- Over 80,000 KW (100,000 HP) delivered with 1 engine
- Coming decades most likely dependent on liquid fuels

FUEL FRIENDLY ENGINES

- Using the bottom of the fossil barrel is daily practice in shipping
- Marine biofuels require little or no upgrading

INCREASINGLY BENEFICIAL POLICY

- Sector increasingly recognized as key sector for both decarbonization and biofuels through e.g. RED and RED II
- Opt-ins for marine
- Marine multipliers
- ...

3.5% S → 0.5% S
Biofuels as a transition fuels should only be used for these segments for which the options to decarbonize are limited to absent.

**FIVE KEY QUESTIONS**

1. Is it sustainable?
2. Does it work?
3. Is it affordable?
4. Is it available?
5. Is it scalable?

**GOODFUELS MISSION & CORE VALUES**

We fuel the energy transition in heavy duty mobility

- **Passionate about sustainability**
- **Professional, agile & responsive**
- **Fair, straight & transparent**
- **Driven by long-term collaboration**
- **Making work fun & inspiring**
SUSTAINABILITY BOARD

Thanks to an independent sustainability board and our ISCC & RSB certification, we offer complete transparency and traceability of the products to protect the reputation of our clients.

SUSTAINABILITY PRINCIPLES

- Waste and residue based only
- No competition with food
- No direct or indirect land use change
- No deforestation or biodiversity loss
- No higher quality application possible
- Up to 90% CO₂ reduction
- No negative social or legal impacts
- Directly implementable in existing fleet

SUSTAINABILITY CERTIFICATIONS & PARTNERS

- ISCC
- RSB
- NATUUR & MILIEU
- ZERO

SUSTAINABILITY BOARD

Barbara Bramble
Prof. Martin Junginger
Prof. Patricia Osseweijer

BARBARA BRAMBLE – FORMER CHAIRMAN RSB:
“GoodFuels has a wonderful corporate goal: to get rid of fossil fuels. We are proud to partner with game-changers such a GoodFuels.”
GoodFuels Marine: Current Product Offering

The marine propulsion systems and marine fuels of the future are various. GoodFuels delivers bio-derived hydrocarbons that can be used as direct replacement (100%) in the existing fleet.

<table>
<thead>
<tr>
<th>Petroleum-derived conventional fuels</th>
<th>Renewable fuel alternatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residuals (HFO/LSFO)</td>
<td>MR1-100 Bio-residual fuel bio fuel oil</td>
</tr>
<tr>
<td>Distillates (MGO)</td>
<td>MD1-100 Bio-distillate fuel hydrotreated vegetable oil</td>
</tr>
</tbody>
</table>
**What is GoodFuels MR1-100?**

GoodFuels MR1-100/bio-residual fuel is the world’s first (!) bio-residual fuel (Bio Fuel Oil or BFO). It is produced from (organic) waste streams, directly applicable to replace Heavy Fuel Oil as well as ULSFO.

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**Benefits**

- Up to 90% CO₂ emissions reduction*;
- Fossil- and Sulphur-free fuel: low-Sulphur and low-Carbon Bio Fuel Oil;
- No adjustments to fleet or infrastructure needed;
- Direct and most economical replacement for residual fuels, from ULSFO (0.1%) to HFO (3.5%);
- Made from 100% sustainable waste and residue streams;
- Possibility to blend with fossil fuel;
- Best scalable solution in next decade for first movers.

**Status**

- Wärtsilä lab-testing on 4-stroke engine successfully completed in 2018;
- September 2018: first live-test at NORDEN’s bulk vessel ‘Nord Highlander’;
- 2019: several onboard tests with different carriers/ship operators, on different vessels and engines types: NORDEN, CMA CGM, Jumbo Maritime, Boskalis and Jan de Nul.

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* According to the SER fuel vision (IPCC) the Tank-to-Wheel emissions of biofuels is zero.
CO₂-REDUCTION MR1-100

GoodFuels MR1 reduces greenhouse gas emissions with 80-90% compared to fossil heavy fuel oil (HFO).

Example GHG emissions of GoodFuels HVO using standard values*

*These values are based on standard values from the BioGrace database.
What is GoodFuels MD1-100?

GoodFuels MD1-100/ bio-distillate fuel is an Hydrotreated Vegetable Oil (HVO). HVO is a synthetic diesel, produced out of vegetable waste streams, and is directly applicable as replacer for fossil diesel.

Benefits

- Up to 90% CO₂ emissions reduction*;
- Fossil- and Sulphur-free fuel: low-Sulphur and low-Carbon biofuel;
- No adjustments to fleet or infrastructure needed;
- Direct and most economical replacement for distillate fuels;
- Made from 100% sustainable waste and residue streams;
- Substantial reduction of local emissions (NOx, PM);
- Possibility to blend with fossil diesel;
- High quality and long lifetime.

Status

- Commercial product bunkered on a daily basis to various marine clients in different blend ratios;
- Fully compliant with ISO8217:DMA specification;
- Specific OEM approval from all major OEMs.

* According to the SER fuel vision (IPCC) the Tank-to-Wheel emissions of biofuels is zero.
CO₂-REDUCTION MD1-100

GoodFuels MD1 reduces greenhouse gas emissions with 80-90% compared to fossil MGO.

Example GHG emissions of GoodFuels HVO using standard values*

<table>
<thead>
<tr>
<th>Description</th>
<th>CO₂-eq (g/MJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil MGO</td>
<td>83.8</td>
</tr>
<tr>
<td>GoodFuels UCO-HVO</td>
<td>71.3</td>
</tr>
<tr>
<td>Fuel transport: 500 km from refinery</td>
<td>0.96</td>
</tr>
<tr>
<td>Hydro-treatment</td>
<td>9.34</td>
</tr>
<tr>
<td>Refining raw feedstock</td>
<td>1.08</td>
</tr>
<tr>
<td>Feedstock logistics &amp; handling</td>
<td>1.15</td>
</tr>
<tr>
<td>Used Cooking oil (waste stream)</td>
<td>0</td>
</tr>
</tbody>
</table>

- 85.1%

*These values are based on standard values from the BioGrace database. Actual values may be reported by producer. Values can vary based on origin of feedstock and transport distances.
### Decarbonization for Shipping & Heavy Transport

Our view: renewable fuels are the most powerful alternative to current fossil fuels.

<table>
<thead>
<tr>
<th>SUSTAINABILITY</th>
<th>APPLICABILITY</th>
<th>COMMERCIAL ATTRACTIVENESS</th>
<th>READILY AVAILABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MD1-100 Bio-MGO Bio Distillate Fuel</strong></td>
<td>Up to 90% CO₂-reduction</td>
<td>Premium</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>MR1-100 Bio Fuel Oil Bio-residual Fuel</strong></td>
<td>Up to 90% CO₂-reduction</td>
<td>Limited Premium</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>LNG</strong></td>
<td>&lt;10% CO₂-reduction</td>
<td>Premium</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Bio-LNG</strong></td>
<td>~70% CO₂-reduction</td>
<td>...</td>
<td>Very limited</td>
</tr>
<tr>
<td><strong>Hydrogen Green</strong></td>
<td>~74% CO₂-reduction</td>
<td>Expensive</td>
<td>No</td>
</tr>
<tr>
<td><strong>Electricity Green</strong></td>
<td>100% CO₂-reduction</td>
<td>...</td>
<td>No</td>
</tr>
</tbody>
</table>
The cost of marine fuels

In the marine sector, the use of biofuels is under consideration in certain cases, the currently higher costs for biofuels means that the uptake remains low. A study by the Dutch research center (ECN-TNO), shows a preliminary cost overview of the potential prices for the future fuels.

Source: MKC & ECN-TNO (2020)
INDUSTRY EXAMPLES
DREDGING & OFFSHORE SEGMENT

COMPETITIVE ADVANTAGE FOR PUBLIC PROCUREMENT/ TENDERS.

OFFSHORE WIND OR SHIFTING AWAY FROM FOSSIL FUEL INDUSTRY.

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Port Services & Governments

Adoption of marine biofuels in fleet to provide the right example.

Strategic ambition to become independent of fossil fuels and to comply with national ambitions.
SEA FREIGHT ON BIO-HFO

DECARBONIZED CARGO SHIPPING VIA THE GOOFSHIPING PROGRAM.
DEVELOPING & COMMERCIALIZING BIOFUELS IN THE SHIPPING SECTOR
BRINGING NEW FUELS TO THE MARINE MARKET

WE GAINED A LOT OF EXPERIENCE BRINGING SUSTAINABLE BIOFUELS TO THE MARINE MARKET AND WE NEED TO CONTINUE BRINGING NEW FUELS TO THIS MARKET

Testing phase
1. Assess Sustainability
2. Biofuel analysis
3. Compatibility & Blending

Proof of concept phase
4. Engine Testing (Lab + Sea)

Commercialization phase
5. OEM Approval
6. Fuel Sales
GOODFUELS INNOVATION

THE INNOVATION TEAM FOCUSES ON 4 IMPORTANT PILLARS. THE ACTIVITIES IN THESE PILLARS ARE SUPPORTED BY SEVERAL INNOVATION PROJECTS. ONE OF OUR STRENGTHS IS COMBINING INNOVATION AND BUSINESS DEVELOPMENT ACTIVITIES WITH GOVERNMENT FUNDS.

- NEW FUELS DEVELOPMENT & TESTING
- SUSTAINABILITY
- MARKET & POLICY INSIGHT
- TOOLS AND DIGITIZATION

INNOVATION PROJECTS

- INTRODUCING BLOCKCHAIN TECHNOLOGY IN MARITIME BUNKERING MARKET
- BILATERAL COLLABORATION WITH FEEDSTOCK PROVIDERS (GEFS, PRYME)
- BTG & GOODFUELS COLLABORATION ON DEDICATED PYROLYSIS (UPGRADING) PLANT FOR MARINE BIOFUEL

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**GOODFUELS INNOVATION: participation in projects EU**

Participating in innovative R&D projects together with technology developers, knowledge institutes and industry is one way of ensuring that we stay on top of the development of sustainable advanced biofuels and ensuring their market potential.

<table>
<thead>
<tr>
<th>EU (H2020) Ongoing Projects</th>
<th>EU (H2020) Kick-Off March/April 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NEXTGENROADFUELS</strong></td>
<td><strong>MUSIC</strong></td>
</tr>
<tr>
<td>Partners</td>
<td>BTG-BTL, Renewi, ENI, Arcelor Mittal</td>
</tr>
<tr>
<td></td>
<td>and others</td>
</tr>
<tr>
<td></td>
<td>TU/e, Vertoro, CSIC, OWI, T4F, Goodfuels, Bloom, UniResearch, Thyssenkrupp marine systems, Winterthur, VARO</td>
</tr>
<tr>
<td>Content</td>
<td>Set up supply chain for upgraded wood based pyrolysis oil for among other road/marine fuel.</td>
</tr>
<tr>
<td></td>
<td>Develop an efficient and low-cost chemical pathway to convert lignocellulosic biomass into a Bio Heavy Fuel Oil. Strategy is to first extract lignin from lignocellulosic biomass as a Crude Lignin Oil (CLO) and to convert the CLO - in a second chemical step - into a Bio-HFO.</td>
</tr>
</tbody>
</table>

**Partners**
- Aalborg University, ENI, Steeper Energy, Haldor Topsoe and others
- BTG-BTL, Renewi, ENI, Arcelor Mittal and others

**Content**
- Development of road and maritime fuels from sewage sludge through HTL technology.
- Set up supply chain for upgraded wood based pyrolysis oil for among other road/marine fuel.
**GoodFuels Innovation: Participation in Projects NL**

Participating in Dutch Innovative R&D projects ensures us to stay on top of the latest sustainable fuel developments in The Netherlands, as well as giving us good insights in the latest Dutch policy developments and further strengthening our relationship with knowledge institutes, governments and industry parties working on the same topic.

<table>
<thead>
<tr>
<th>Partners</th>
<th>PYROLYSE MOERDIJK (EFRO)</th>
<th>CALIBRA (TKI)</th>
<th>MOTOR (TKI)</th>
<th>RENEWELL (TKI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port of Moerdijk, Sabic, PatPert, Teknow, Waste4me, TU Eindhoven and others.</td>
<td>ECN / TNO, Olam, University of Groningen, Enerpy and others.</td>
<td>Smurfit Kappa, Q8, TNO, WUR and others.</td>
<td>BTG-BTL, TU/e</td>
<td></td>
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</thead>
<tbody>
<tr>
<td>Using different waste streams (plastics and woody residues) for the production of valuable products, such as fuels, by means of pyrolysis technology.</td>
<td>Aim is to using lignin residues (nut shells, several woody residues) for renewable marine fuel through pyrolysis technology</td>
<td>Produce an advanced biofuel from 2nd generation biomass (paper sludge) for the production of renewable fuel through an enzymatic process resulting in Guerbet alcohols for application in diesel engines.</td>
<td>Aim is to convert biomass into crude pyrolysis oil to further chemically catalytically upgrade it to a transport fuel.</td>
<td></td>
</tr>
</tbody>
</table>
CONTACT

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rianne@goodfuels.com