The recent marine fuel innovations

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17/03/2026 **VTT – beyond the obvious**

Methanol in marine use

Bio/e-fuels production

	Fossil Total (mt)	Bio/e Current (mt)	Bio/e 2030 (mt)	Note
Methanol	135	<8	21	Bio CH_4: 720 mt Potentials are large, but progress is slow
Methane CH_4 and biogas	~3000	32		
HVO FAME Ethanol	–	11 40 84	44 60 114	
Ammonia	240	0.1	90	
Hydrogen	97	<1	49[e]	

Global marine fuel consumption ~210 mt since 2022

As marine fuel (DNV 2025):
Biodiesel+HVO 0.7 Mtoe,
bio-LNG 0.1 Mtoe,
bioMeOH 0.1 Mtoe,
blue NH_3 0 Mtoe
blue H_2 0 Moe

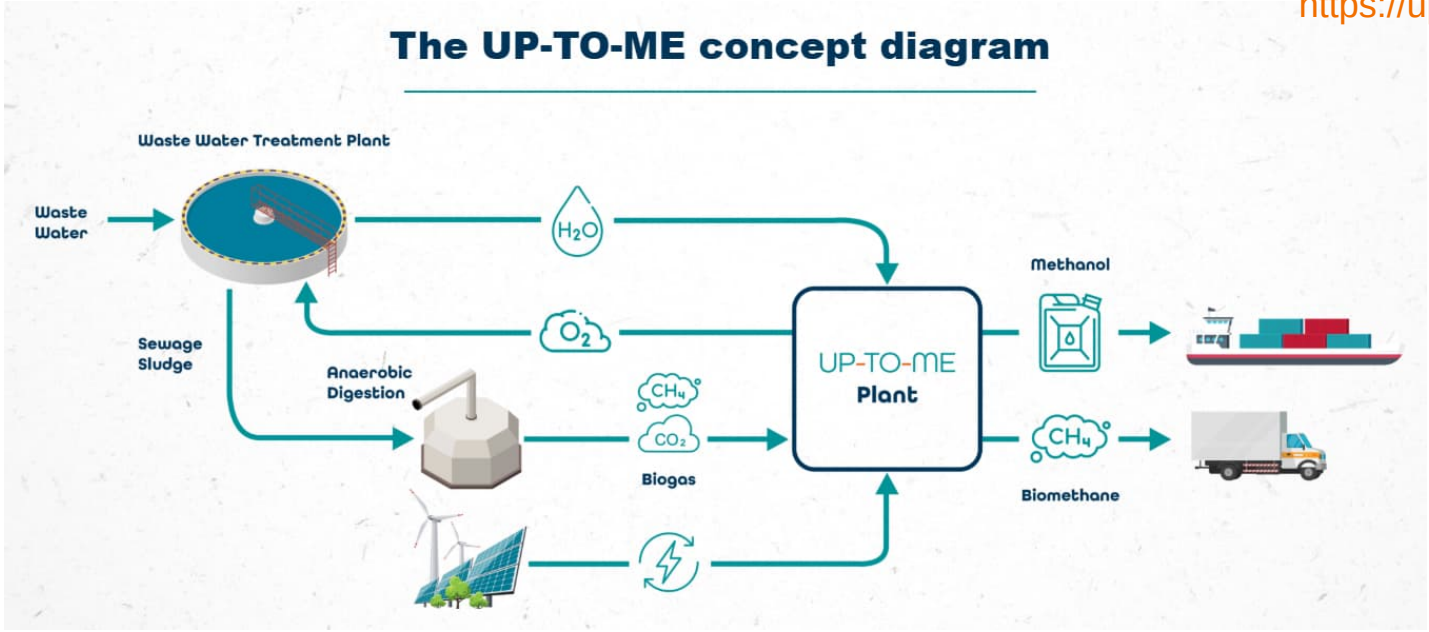
Kassø e-methanol: **42 kt/y** from bio-CO_2 and green H_2. Supplies e.g. Maersk and LEGO Group. (European Energy 2025).

UP-TO-ME e-methanol

VTT led EU “UP-TO-ME” project developed production of e-methanol from the CO_2 point-sources by a fully autonomous, self-optimizing, and compact technology.

Experiences on e-methanol quality gained.

https://up-to-me.com/



Marine methanol fuel standard ISO 6583:2024

		ISO 6583:2024 limits[a]		
		MMA	MMB	MMC
Density at 15 °C	kg/m^3	795.0-797.0	795.0-797.0	795.0-798.0
Methanol mass fraction on dry basis	%	min 99.85	min 99.85	min 99.70
Impurities mass fraction on dry basis	%	max 0.15	max 0.15	max 0.30
Ethanol content on a dry basis	mg/kg	max 50	max 50	max 150
Acetone content on a dry basis	mg/kg	max 30	max 30	max 30
Total sulfur content	mg/kg	max 0.5	max 0.5	max 10.0
Water content by mass	%	max 0.100	max 0.100	max 0.500
Distillation range at 101.3 kPa	°C	max 1.0	max 1.0	Report
Chloride content as Cl-	mg/kg	max 0.5	max 0.5	max 0.5
Acidity as acetic acid	mg/kg	max 30	max 30	max 30

- MMC grade with wider limits is interesting
- UP-TO-ME e-methanol batch: 0.6 wt% water.
- E-methanol water does not necessarily indicate impurities.
- Separate limit values for impurities.

Marine methanol engines are available for newbuilds and retrofits

- **9.7% of the tonnage ordered** is methanol-fuelled ships (DNV 2024).
- **Large ships, methanol-diesel DF engines:** a) Wärtsilä: 4-stroke. b) MAN Energy Solutions 2-stroke.
- **Small vessels:** Enmar engines' a) retrofit kits, conversions to methanol DF. B) CI engine M97 concept.

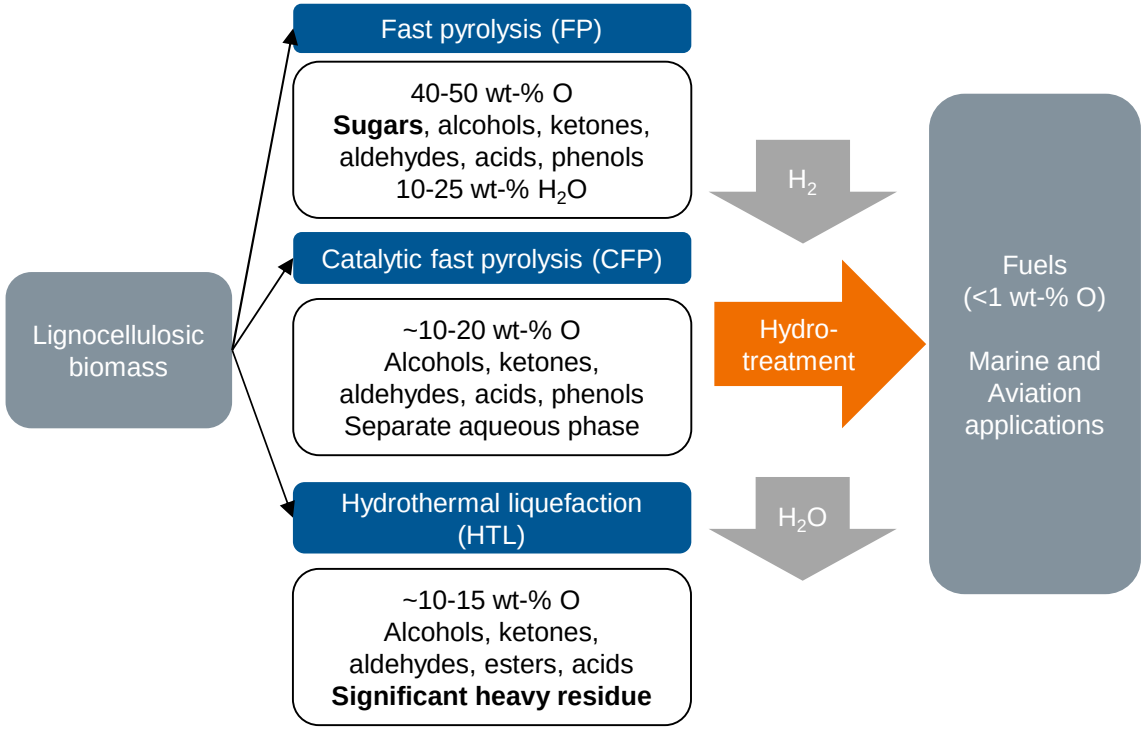
UP-TO-ME e-methanol demonstrated in retrofitted engine at VTT

- Methanol DF, retrofitted with Enmar Engines dual-fuel kit.
- Low pressure port fuel injection (PFI).
- Replacement of diesel fuel up to 40% (limited by unit injectors and PFI).
- Exhaust aftertreatment is necessary for this engine.

Characteristics	Volvo Penta D16
Power, kW	478
Torque, Nm	3263
Number of cylinders	6
Displacement, L	16.1
Compression ratio	17.5:1
Fuel system	Electronic unit injectors Twin entry turbo, charge air cooler

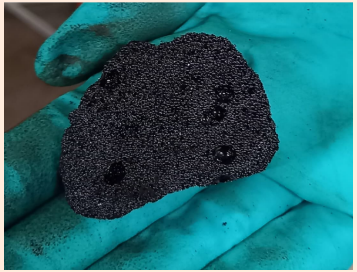
From liquefied biomass to marine fuels

Biomass liquefaction and bio-oil hydrotreatment

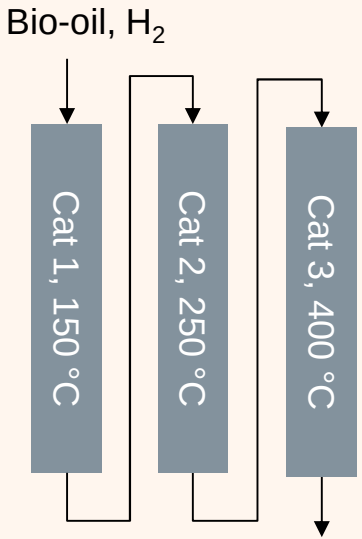


Challenges for catalyst and process development

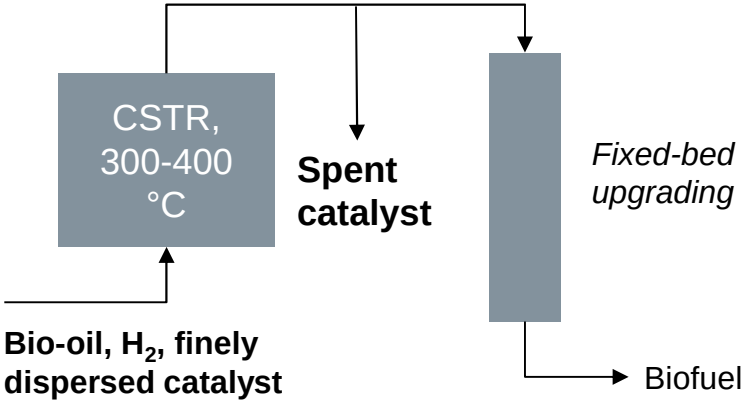
- Thermal instability
- Catalyst coking
- Catalyst poisoning
- Catalyst cost



Slurry hydroprocessing of bio-oil

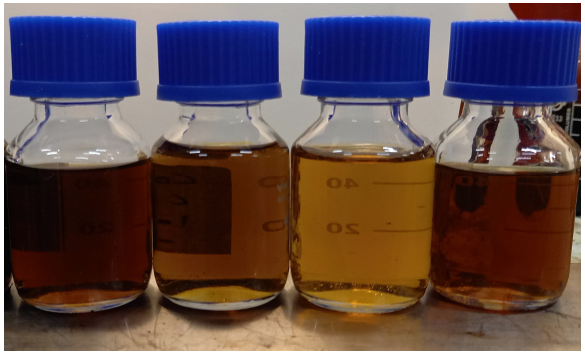


- Bio-oil stabilization
  - Removal of unstable oxygen compounds
  - Adjustment of physical and chemical properties for further upgrading
- Continuous catalyst removal and replacement
- Recirculation and/or recovery of catalyst



CaSH
BUSINESS FINLAND
Circular Fuels
Funded by the European Union

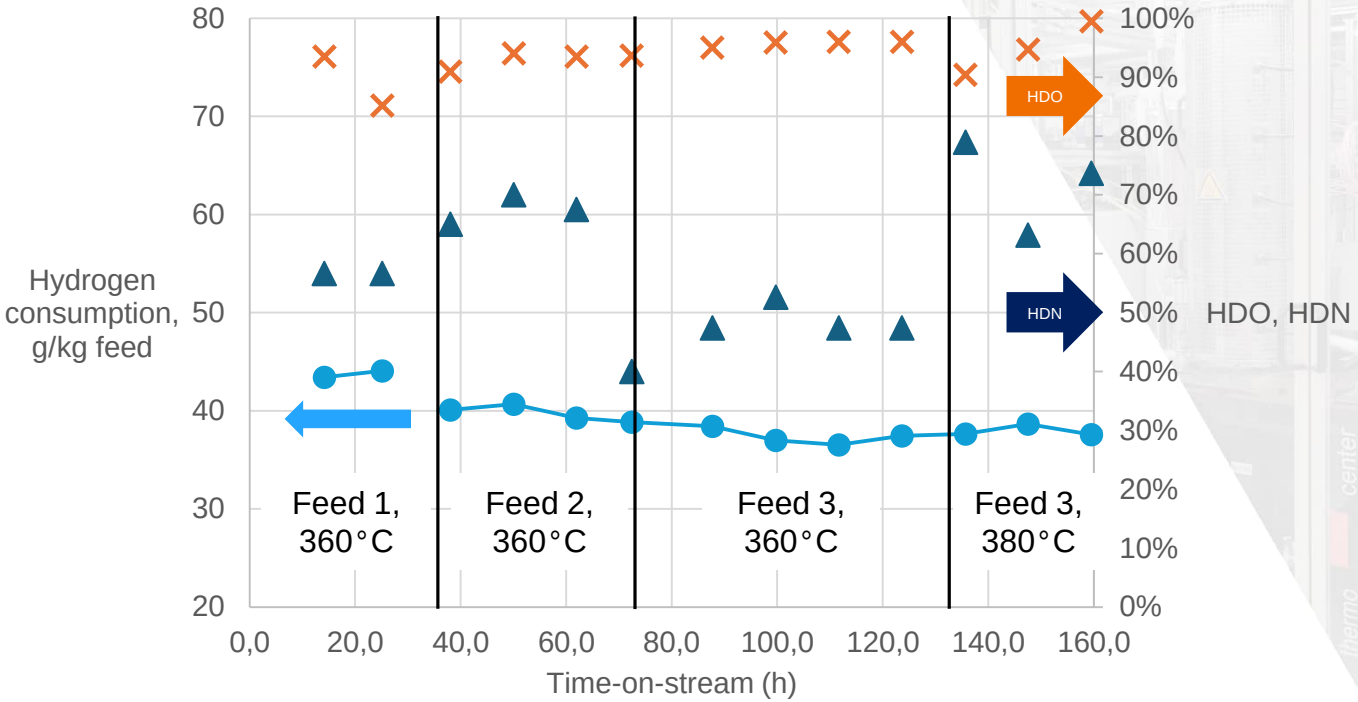
Successful proof of concept in pilot scale: 70 hours of continuous operation of slurry hydroprocessing



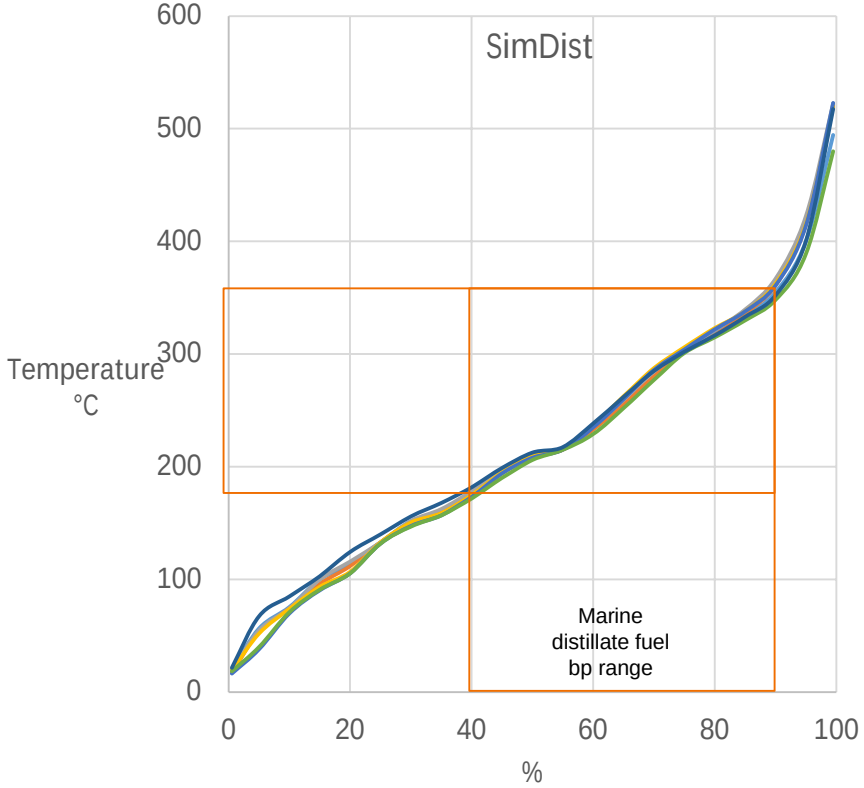
Equipment	2 L CSTR
Residence time	1.5 h
Catalyst loading	1500 wt-ppm Mo in bio-oil
H2-to-bio-oil	1127 NL H_2/ L bio-oil

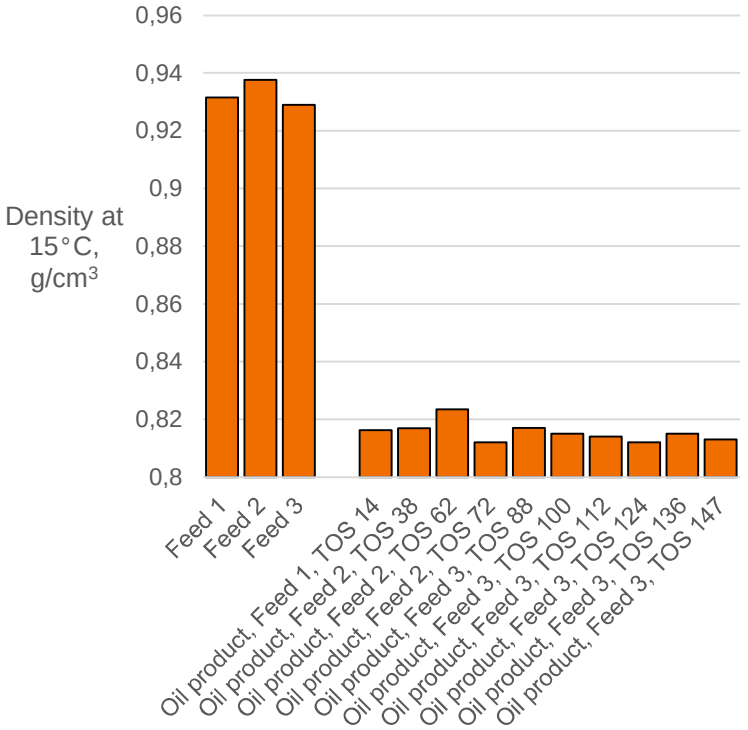
Catalyst	Temperature	Pressure bar	Hydrogen consumption g/kg bio-oil	Degree of deoxygenation
VTT	350 °C	140	30.1	49.0%
VTT	380 °C	75	36.8	54.9%
VTT	380 °C	140	35.7	56.6%
VTT	410 °C	140	45.5	58.1%

Fixed-bed HDO of slurry-hydroprocessed bio-oil



Physical properties of the product





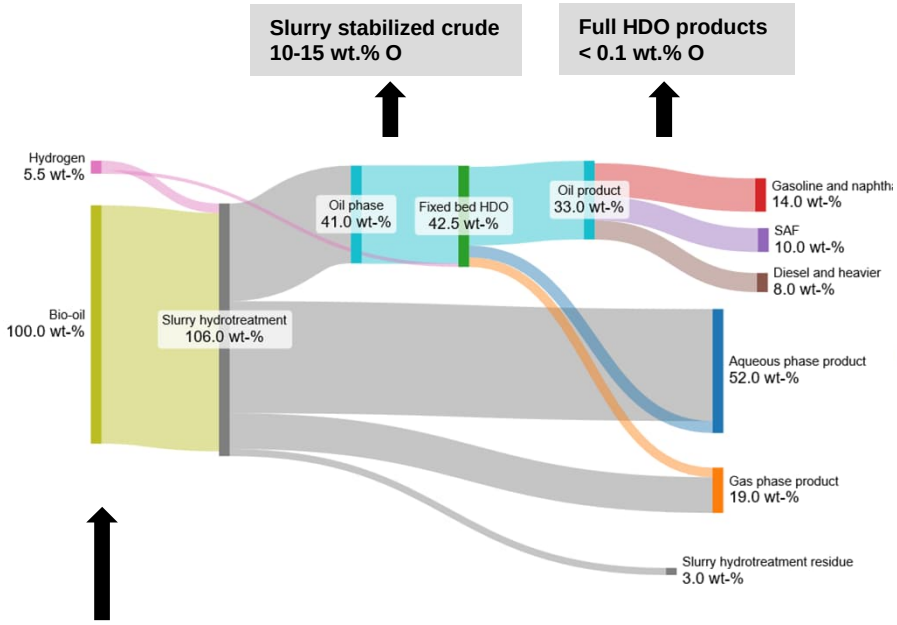
Fixed-bed HDO process severity does not have major effect on final product boiling point range nor density

Properties of the product

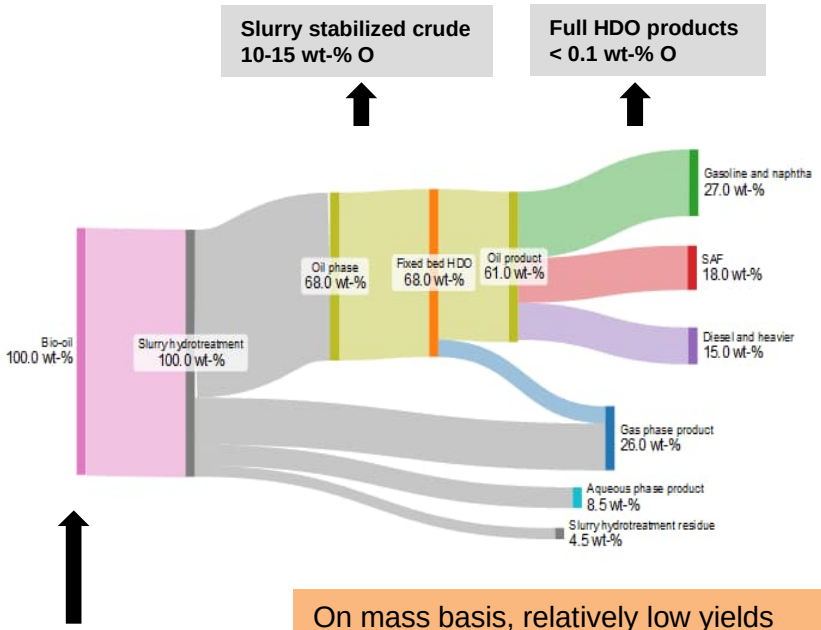
Analysis	Result		Method
Total sulfur (S)	3.8	ppm	ASTM D7039
Total nitrogen (N)	15	ppm	ASTM D4629
Cloud point	-33.1	°C	ASTM D7689
Pour Point	-34.0	°C	ASTM D7346
Density at 15 °C	0.8496	kg/dm3	ASTM D4052
Carbon and Hydrogen	100.2	wt-%	ASTM D5291
Simulated distillation			ASTM D2887
10 % recovered, T10	211.5	°C	
20 % recovered, T20	215	°C	
50 % recovered, T50	241	°C	
80 % recovered, T80	279	°C	
90 % recovered, T90	294	°C	
99.5% recovered	310	°C	

Mass & carbon balances

Mass balance



Carbon balance



Sawdust-based FPBO 45-49 wt.% O

Mass-based total aqueous phase 52 wt-%

Sawdust-based FPBO 45-49 wt.% O

On mass basis, relatively low yields observed due to high water formation. On carbon basis, 61% yield from bio-oil to liquid range hydrocarbons.

beyond

the obvious

Thank you!

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