



Hydrothermal liquefaction (HTL): Sustainable fuel from wastes, residues and advanced energy crops

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DENMARK



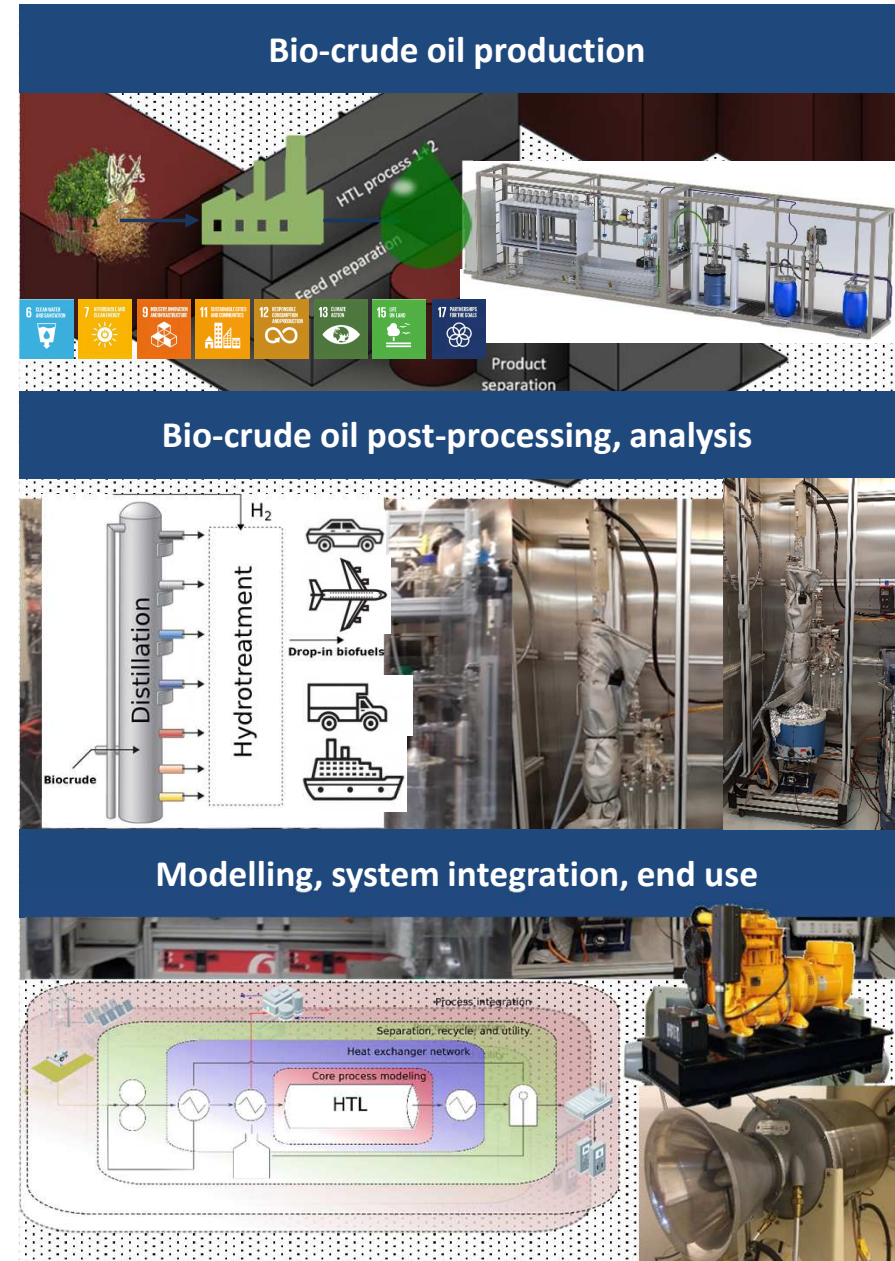
AALBORG UNIVERSITY
DENMARK



DHRTC

Program

- ▶ Short intro to Aalborg University
- ▶ HTL – the fundamentals
- ▶ Pathways to sustainable aviation fuels by HTL
- ▶ Wrap-up



RESEARCH, EDUCATION AND COOPERATION AT INTERNATIONAL LEVEL



BEST ENGINEERING UNIVERSITY IN EUROPE

Within engineering, Aalborg University is ranked No. 4 among world universities.

AAU is the best-placed university in Europe

*U.S. News & World Report
2017, 2018, 2019*



4TH BEST ENGINEERING UNIVERSITY IN THE WORLD

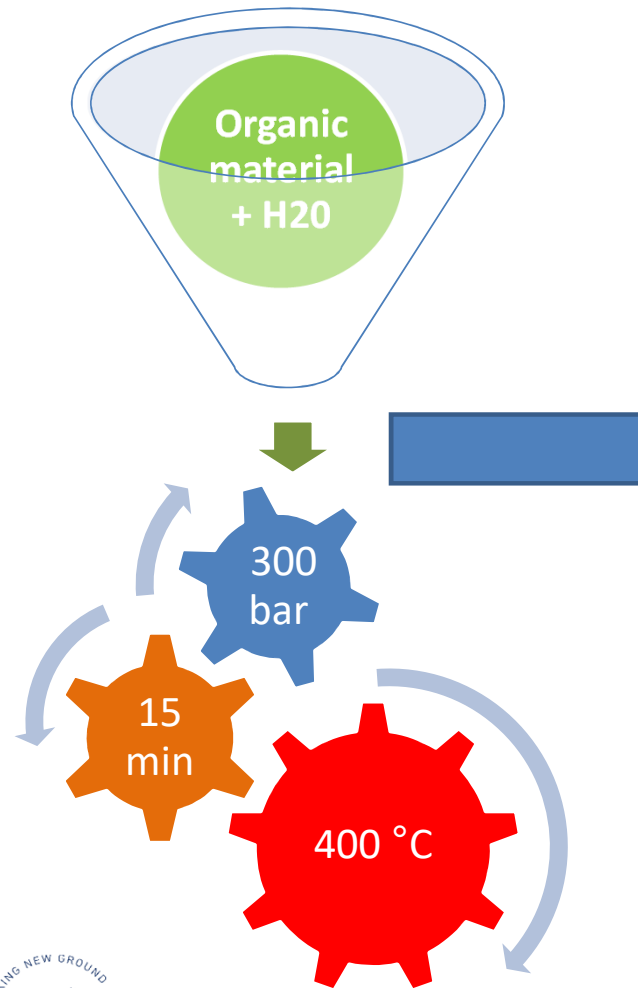
MIT's analysis marks AAU as the world's fourth-BEST university in engineering.

MIT report "The global state of the art in engineering education, 2018"

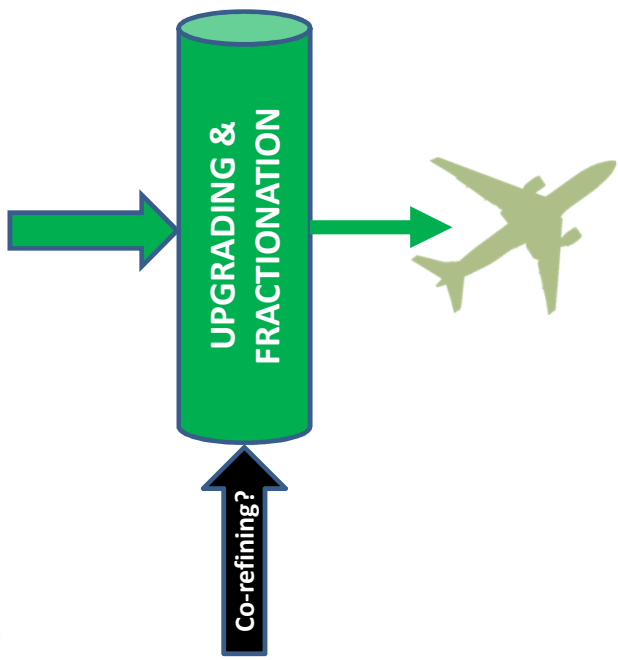
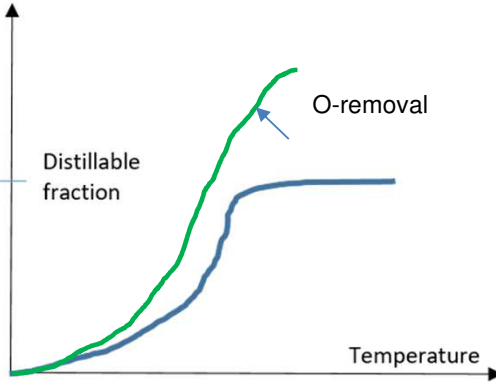
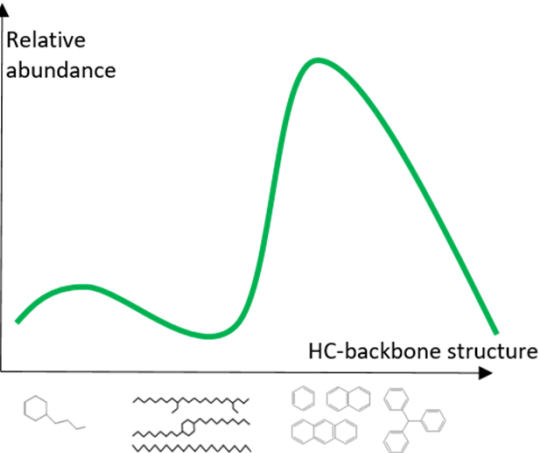
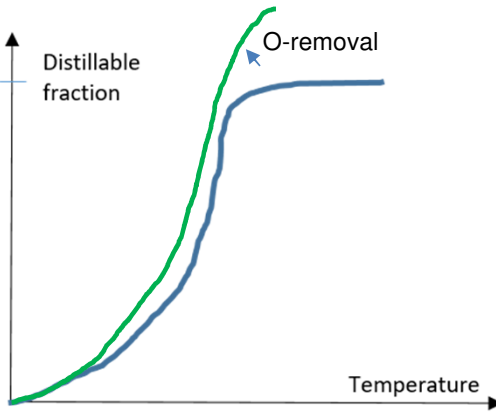
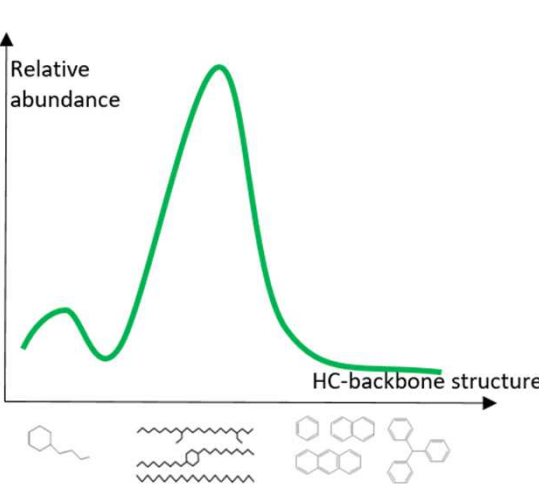


Hydrothermal liquefaction – the short version

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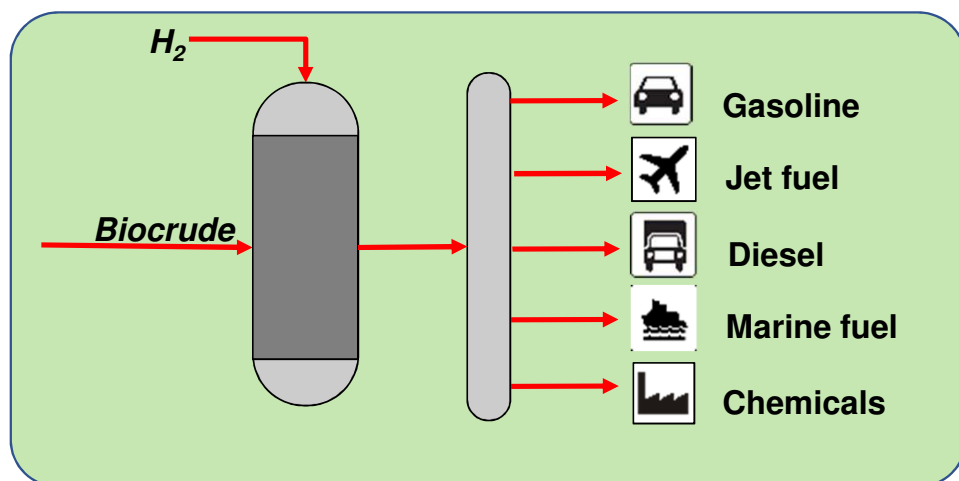


Feedstocks influence biocrude characteristics

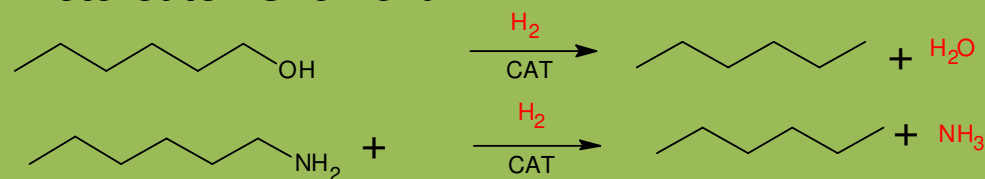


Upgrading to drop-in fuels

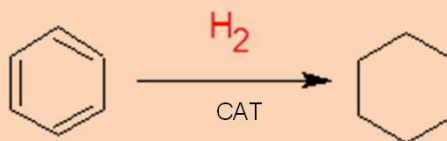
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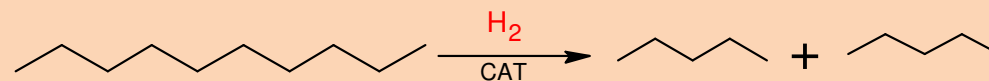
Heteroatoms removal



Hydrogenation



Hydrocracking



Pathways to HTL-derived sustainable aviation fuels

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ASTM
certification



Grant no
818413



Stand-alone hydrotreating (+isomerization)



Grant no
764734

Full

Co-hydrotreating miscible/stabilized HTL
fractions with fossil SRGO



Grant no
727531

Full

/ fast-track?

Co-hydrotreating full HTL range with fossil
SRGO, using surfactants for enhanced
miscibility



Grant no
889067

Full

Co-hydrotreating up to 10 % stabilized HTL
biocrude with UCO/vegetable oil/animal fat

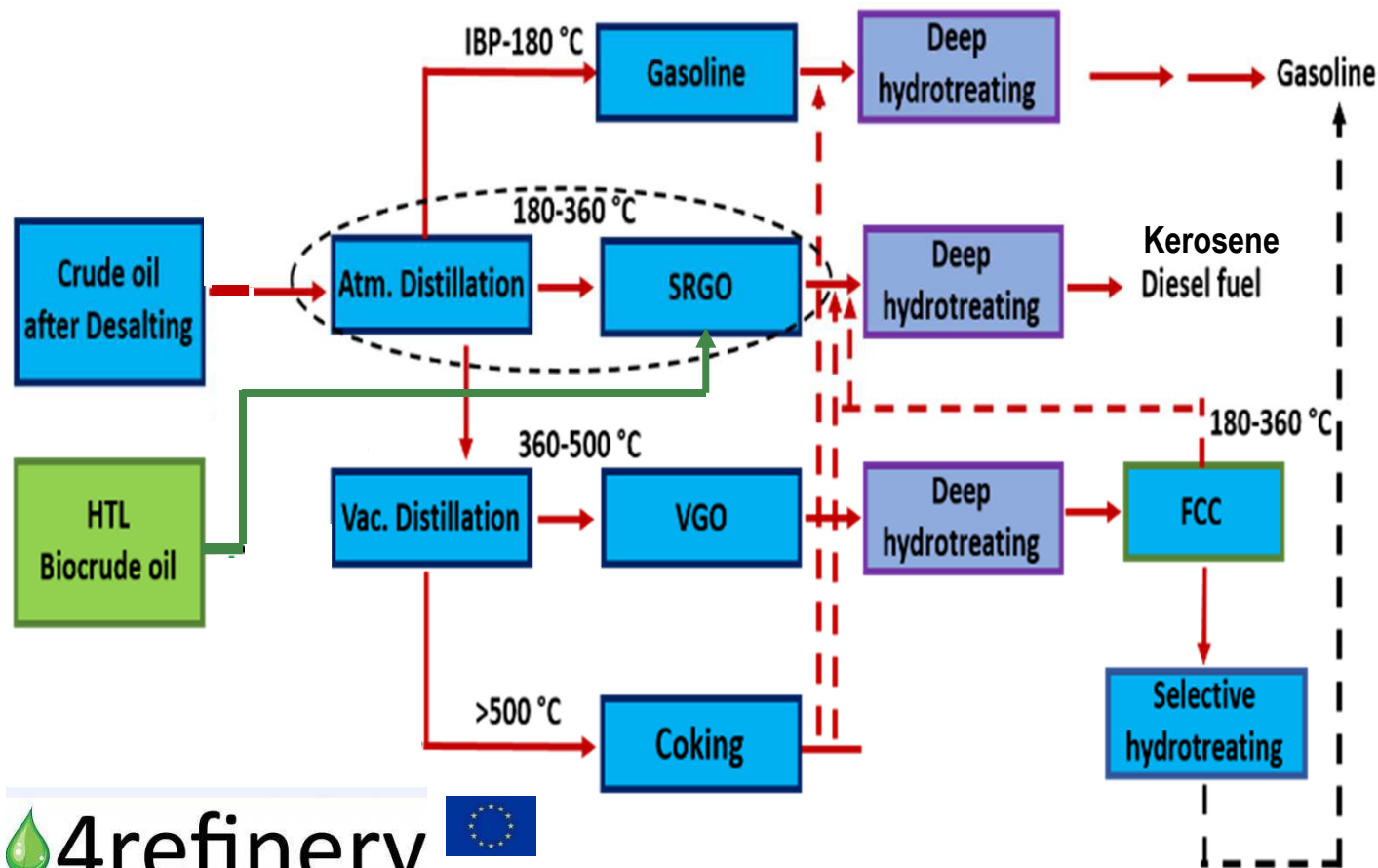


Grant no
727531

Fast-track?

Co-refining – SRGO identified as optimal drop-in point

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Challenge: bio-crude contains oxygen
→ Polarity <> miscibility

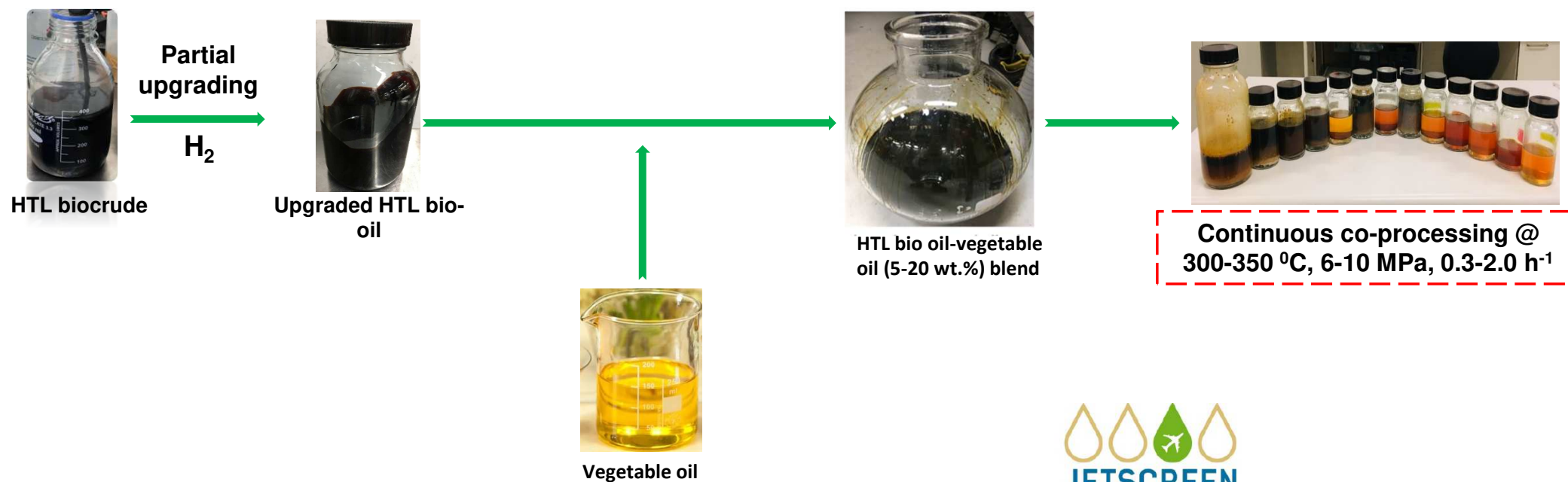
4refinery



Grant no
727531

Co-HDO with vegetable oils

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 **4refinery**



Grant no
727531



Low TRL

Co-refining miscible fractions of HTL biocrude with SRGO

Lignocellulosic
HTL biocrude



Fractionation
by distillation



Light fractions &
residue immiscible

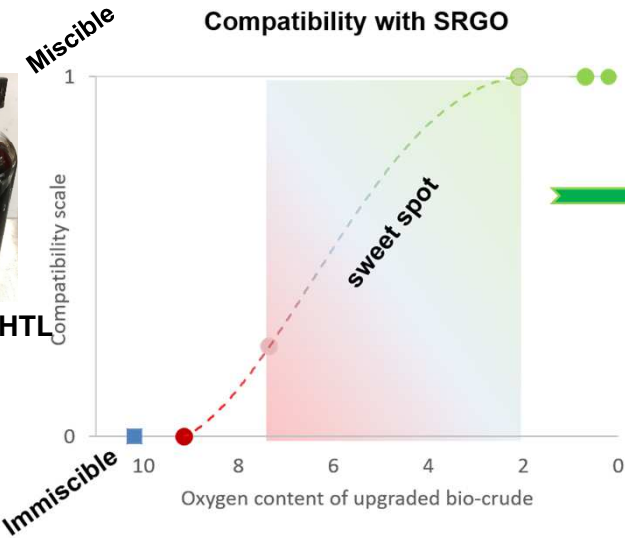
25 % of total
biocrude miscible



Grant no
727531



Upgraded HTL
bio-oil



Co-refining



SRGO



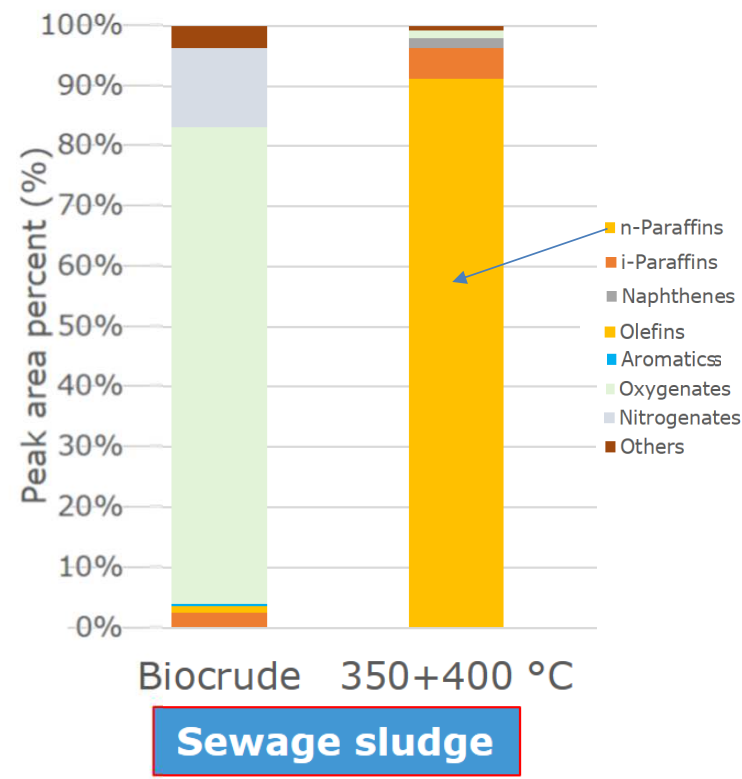
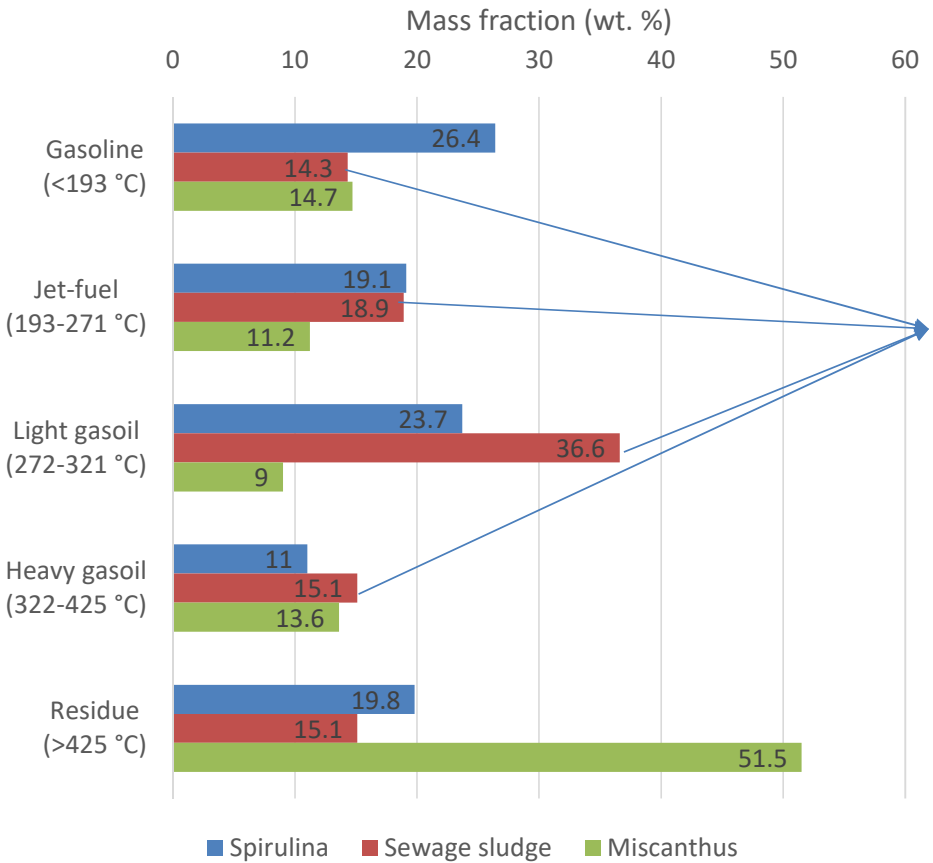
Biorefineries



Transport fuels

Low TRL

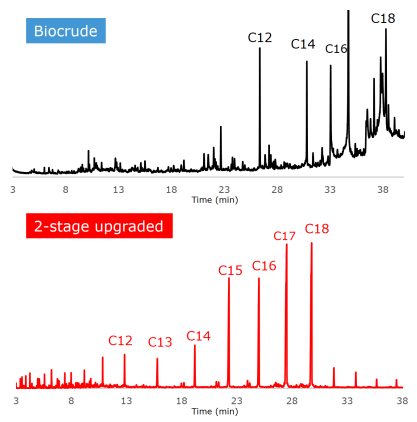
Stand-alone hydrotreating – oils from different feedstocks



- Large part of the sewage sludge biocrude is constituted by fatty acids, especially in the range C12-C18
- The upgrading converts fatty acids into straight-chain alkanes
- High potential in the jet-fuel and diesel range

hexadecanoic acid

hexadecane

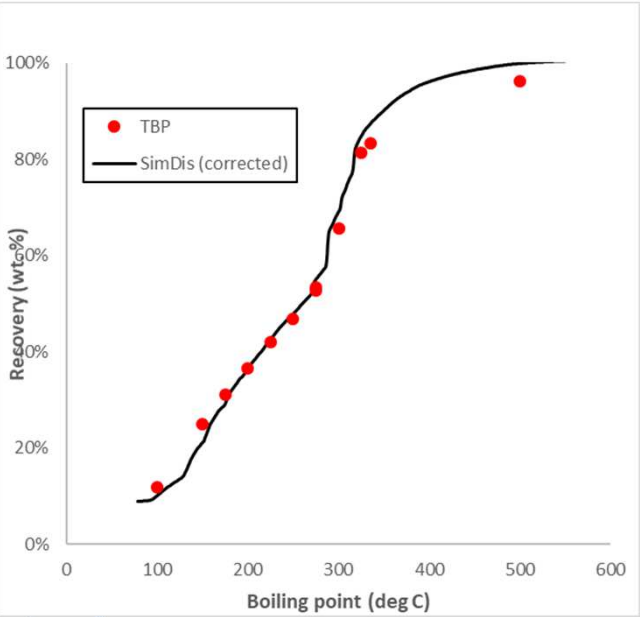


Standalone hydrotreatment + distillation of spirulina HTL biocrude

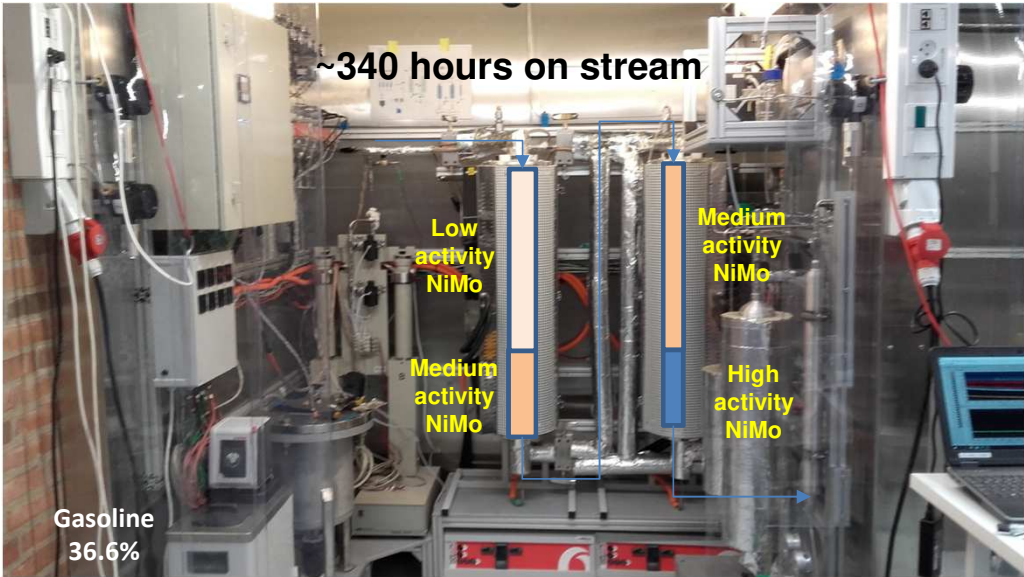
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Boiling point



	Temp. (°C)	Recovery (wt. %)
	IBP = 27.5	0.0
1	100	11.8
2	150	24.9
3	175	31.1
4	200	36.6
5	225	42.1
6	250	46.9
7	275	53.5
8	300	65.6
9	325	81.3
10	335	83.3
11	500	96.2



Cloud point: -92 → -14 °C
Pour point: -100 → -17 °C
HHV: ~45 MJ/kg
Density: 810 – 828 kg/m³

Jet fuel
16.9%

Diesel
29.8%



Going forward – next steps for HTL-derived sustainable aviation fuels

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HyFlexFuel Horizon 2020 project

- First data from JETSCREEN analysis of microalgae HTL-derived SAF
- Continuous hydrotreatment of sewage sludge AND miscanthus HTL biocrude
- JETSCREEN analysis of
 - Sewage sludge HTL SAF
 - Miscanthus HTL SAF



4refinery Horizon 2020 and DHRTC projects

- Continued work on co-refining of fossil and HTL biocrudes
 - Fractions, surfactants, enablers ...
 - Co-HDO vegetable oil/lignocellulosic HTL

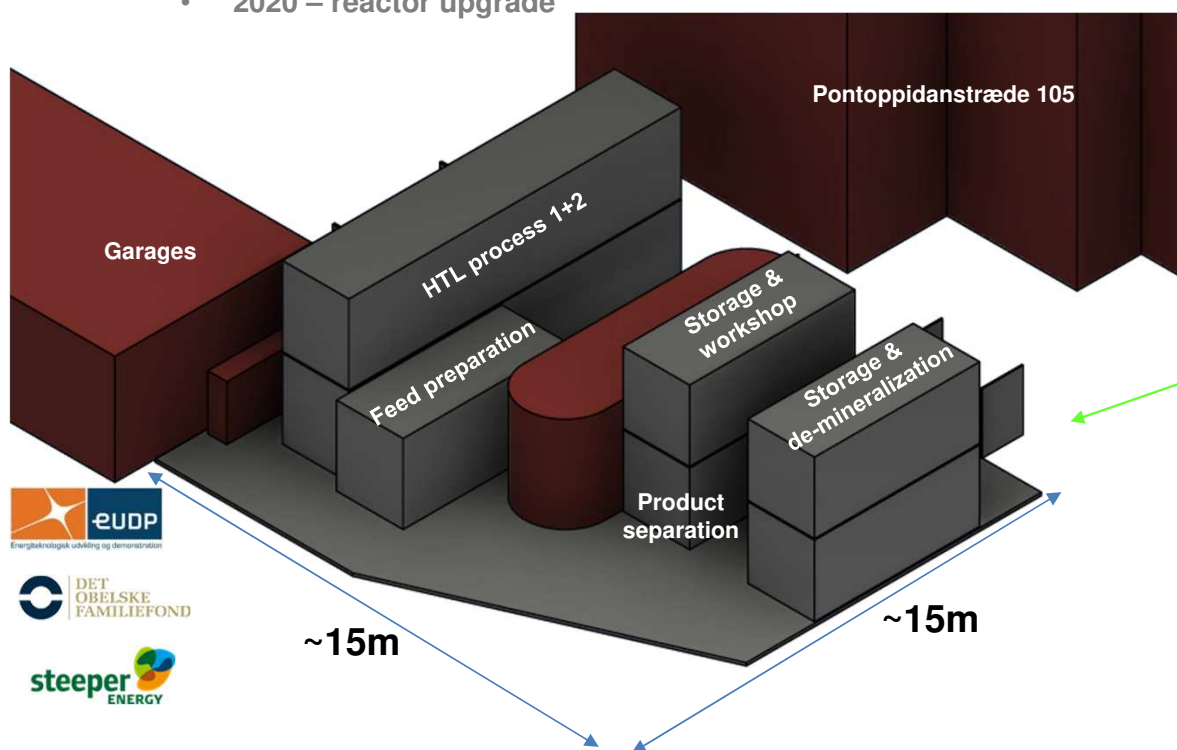


LowCarbFuels - New proposal to Horizon 2020 LC-SC3-RES-23-2019 Development of next generation biofuel and alternative renewable fuel technologies for aviation and shipping

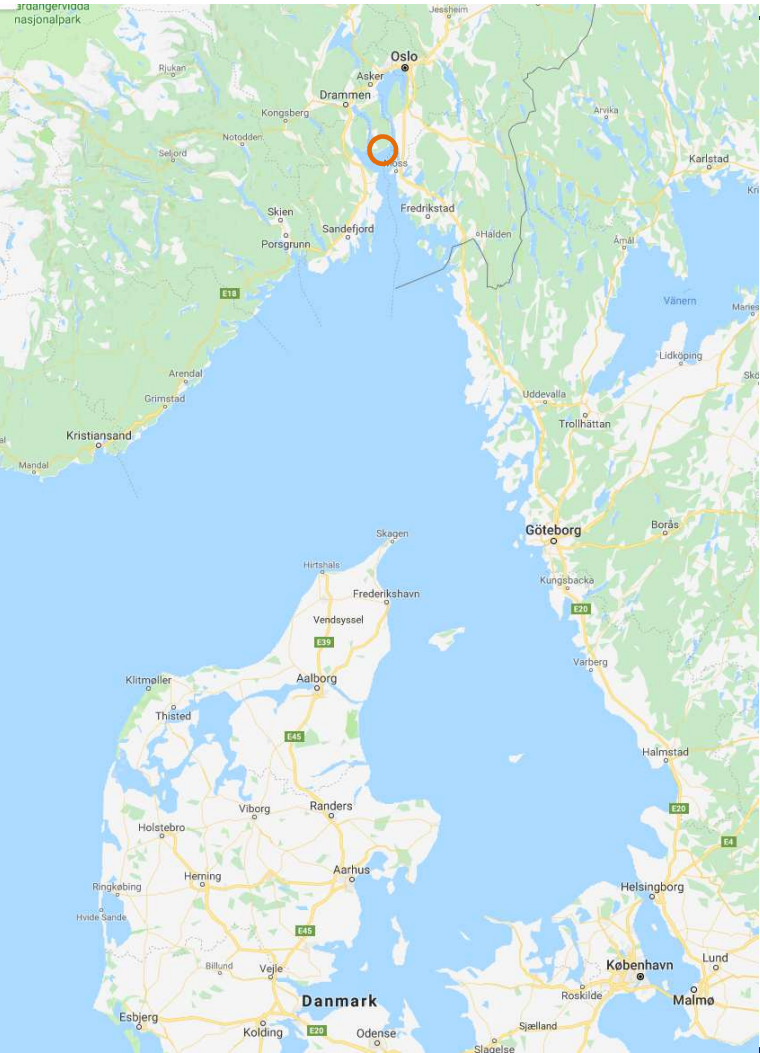
- “large” quantities of HTL biocrudes
- Efficient pathways for upgrading/isomerization
- Certification issues

Pilot scale HTL facility – CBS1

- Continuous Hydrothermal Liquefaction (HTL) facility (CBS-1)
- 1 ton/day input (sludge), processing conditions up to 500 °C, 350 bar
- Designed in collaboration with and constructed by Steeper Energy
- Commissioned 2013, recommissioned 2018 with improved up- and downstream handling
- 2020 – reactor upgrade



First HTL demonstration in EU underway -



HTL chosen after 2 year screening of 40 technologies



Silva Green Fuel

A white icon of a factory with three buildings.

Demo plant for
**2ND GENERATION
BIO FUEL**

A blue icon of three stylized trees.

Made from
**FOREST
FEEDSTOCK**

A blue location pin icon.

TOFTE
in Norway

A blue icon of two interlocking gears.

Test period
2019 - 2020

A blue donut chart icon.

OWNERSHIP
Statkraft 51%
Södra 49%

A blue icon of a fuel pump nozzle with a drop of fuel.

Can produce
4000 LITER
of bio fuel per day



Investment:
EUR +50 Mill.



THANK YOU FOR YOUR ATTENTION

WWW.ADVANCEDBIOFUELS.ET.AAU.DK

