

Perspectives on upgrading of HTL biocrudes

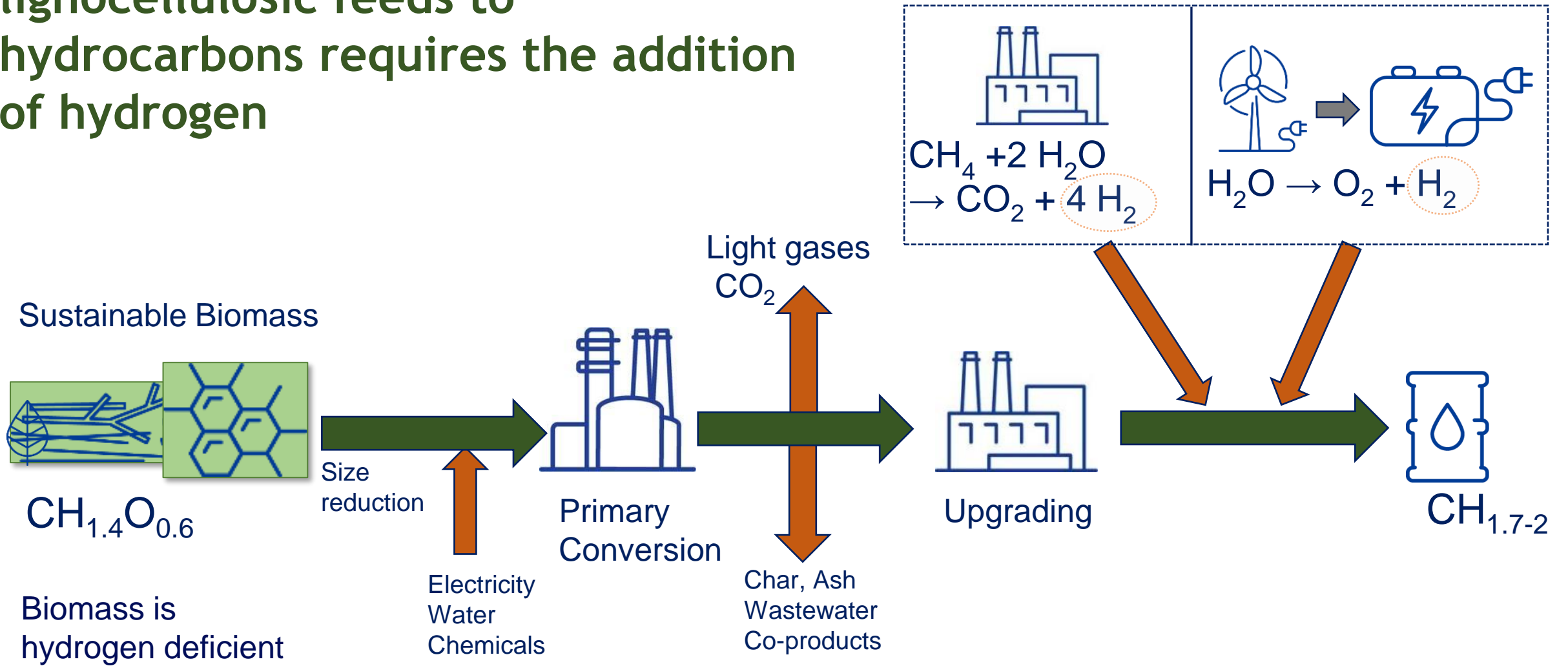
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Thermochemical conversion of lignocellulosic feeds to hydrocarbons requires the addition of hydrogen



HTL of lignocellulosic feeds with hydrotreating to fuel blend components has been known since the 1940s

US Patent # 2,551,579

Production of Valuable Organic Compounds from Plant Material

Liquid hydrocarbons can be **formed easily** from carbohydrates and carbohydrate and **lignin containing materials**.

The conversion is produced continuously by **heating** the raw materials with **aqueous solutions of alkaline reacting substances** such as potassium- calcium- carbonate, sodium hydroxide at an elevated temperature.

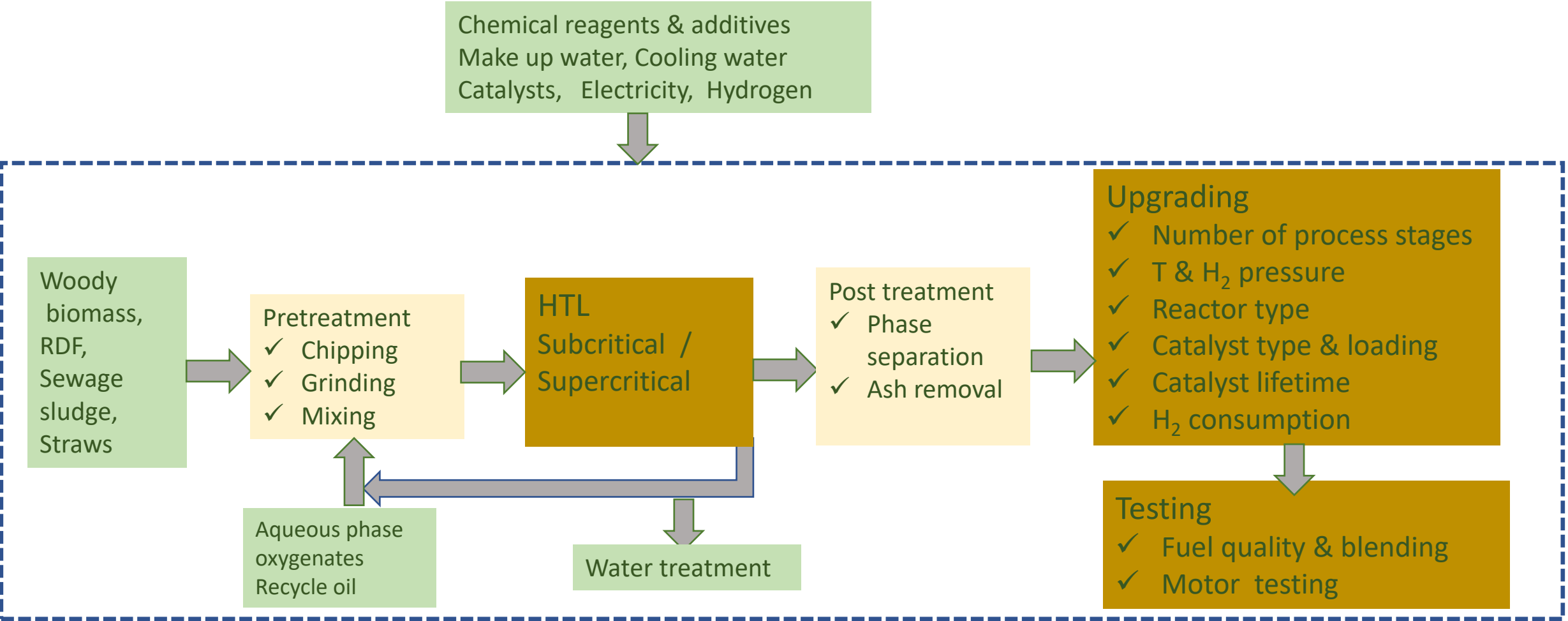
Under the influence of these alkaline materials at temperatures between 150 C and 370 C **a bitumen-like material is produced**, which is composed of alipathic, hydroaromatic and aromatic compounds with large amounts of phenols.

It can be **converted by hydrogenation or cracking into liquid hydrocarbons**, containing alipathic, hydroaromatic and aromatic hydrocarbons.

Ernst BERL, 1944, Popular Science, Protoproduct



Hydrothermal liquefaction offers the potential for high C conversion but commercial upgrading is not proven



Multi stage upgrading removes residual metals, handles inherent reactivity while increasing the H/C ratio

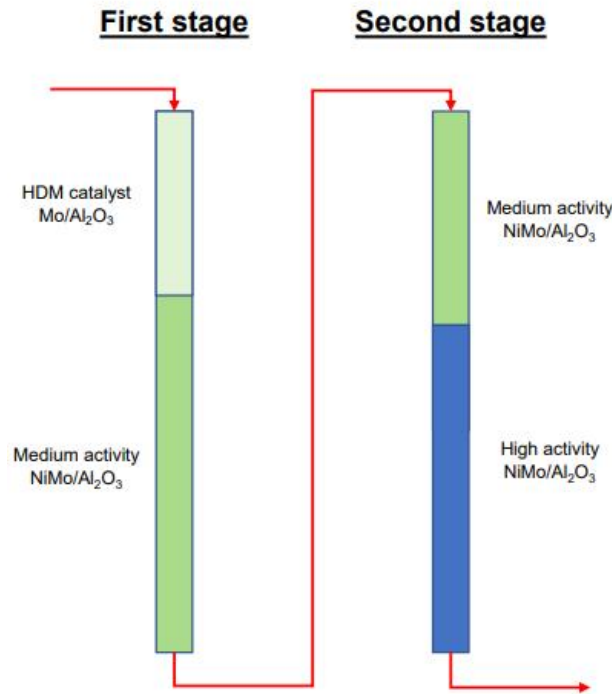
Choosing the right catalysts



AALBORG UNIVERSITY
DENMARK



1 Oct. 2017 to 30 Sept. 2021



- Sulfided hydroprocessing catalysts are used
- Biocrude has typically high inorganic content (often from 500 to 4000 ppm)
- Proper catalyst selection is crucial
- Temperature profile and grading are specific to each biocrude → know-how is needed!



HALDOR TOPSØE

AAU will perform all hydrotreating experiments in batch and continuous mode as well as analysis on inputs and outputs to these.



Effective removal of catalyst poisons to low levels < 5 ppm is needed to ensure long catalyst lifetime

Filtering, centrifugation and electrocoalescence have been found ineffective, as the emulsion alkalinity needs to be reduced for effective demineralization.

A washing procedure using a diluent and 0.1 M citric acid was developed for pilot scale, resulting in repeatable demineralization of Hydrofaction™ oil to <50 ppm metals.

A **3-Zone hydrotreating process** was developed, proving the upgrading of Hydrofaction™ oil to drop-in transportation fuels.

A critical step was configuration of the first reactor **to keep reaction rates and exothermic heat release at manageable levels.**

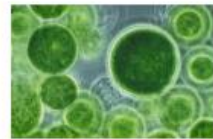
Source: PIUS - Hydrofaction™ Platform with Integrated Upgrading Step, January 2018

Authors: **Claus Uhrenholt Jensen**

<https://www.researchgate.net/project/PIUS-Hydrofaction-Technology-Platform-with-Integrated-Upgrading-Step>

HTL conversion to biocrudes and upgrading will need to be tailored to the different feeds

Summary of the hydrotreating campaigns



Spirulina



	C	H	N	O	H/C
Biocrude	75.1	10.8	7.6	6.5	1.73
Upgraded	83.8	15.5	0.6	0	2.21



Sewage sludge



	C	H	N	O	H/C
Biocrude	75.6	95	3.0	11.8	1.51
Upgraded	84.5	14.7	0.8	0	2.09



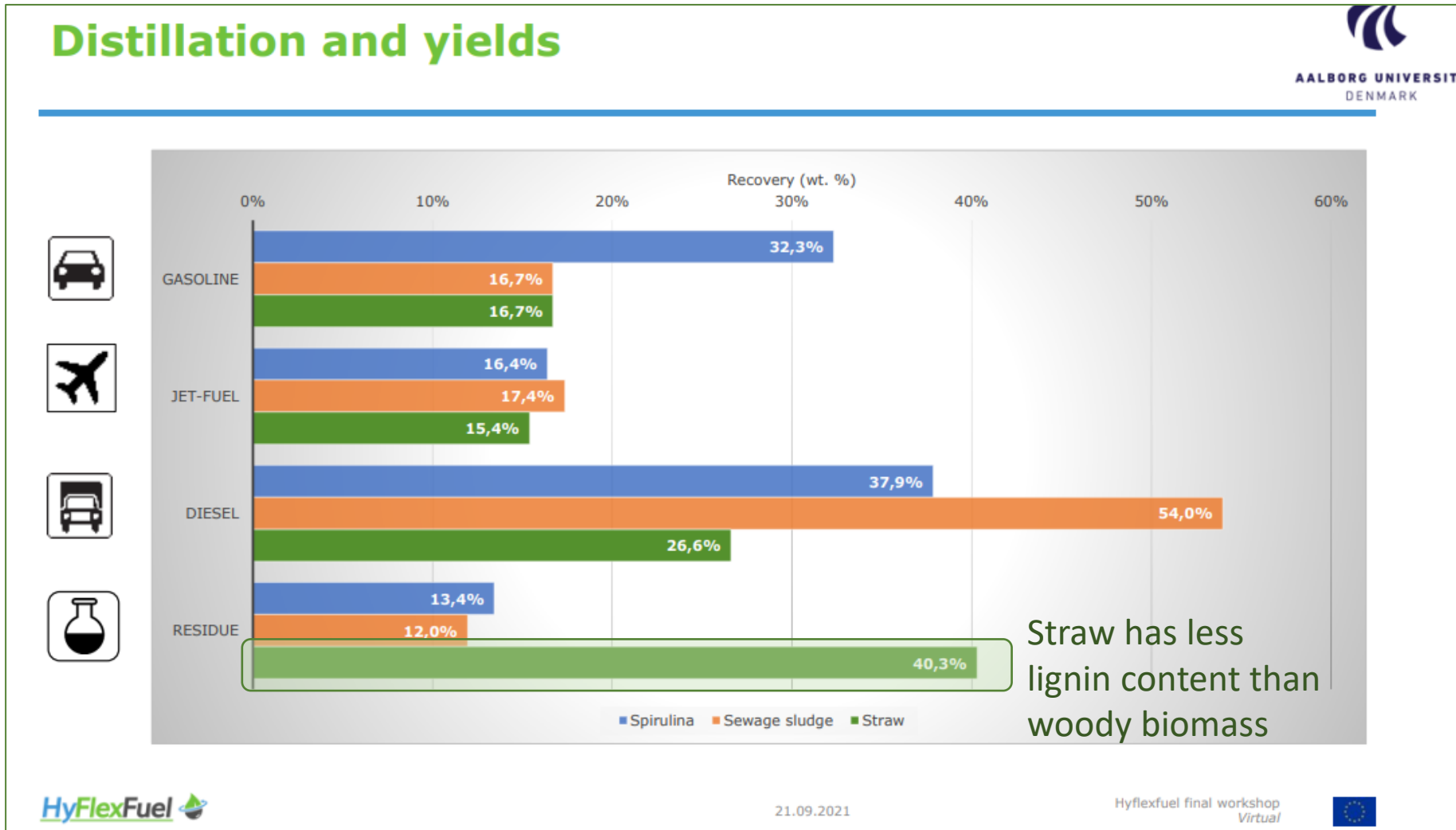
Wheat straw



Further hydrocracking will be needed but this will negatively affect the GHG when using fossil based hydrogen

	C	H	N	O	H/C
Biocrude	72.3	7.2	1.2	19.3	1.19
Upgraded	87.7	12.1	0.9	0	1.66

It will be important to minimize the amount of high boiling point residue in order to achieve maximum product value



Closing remarks

Understanding of HTL processing and upgrading is being advanced in EU projects, research institutes, universities and by companies i.e. HyFlexFuel, NextGenRoadFuel, PNNL, BL2F, 4REFINERY, Bio4Fuels, Silva Green Fuels, Steeper, Licella, Circlia Nordic, GeniFuel

..... but experiences from large scale demonstration projects are lacking

Barrels of upgraded products produced using commercially relevant equipment produced in long continuous runs for engine tests will be required