

Biofuels from residues via fast pyrolysis and hydrotreatment

Technologies for biofuel hybrid micro gas turbines

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Content

- Biomass residues - opportunities and limitations
- Fast pyrolysis – converting solid biomass into a liquid bioenergy carrier
- Hydrotreatment – production of a drop-in biofuel
- Biofuel applications and quality control



Biomass residues – **opportunities** and limitations

- Residues from food / feed / forestry processing are widely available.
- Huge potential, in EU over 123 MTOE which can be made available (no / low competitive use) and technically suitable for this route ¹
- Feedstocks under consideration comply with RED II-III, Annex IX part A (advanced biofuels without cap)

¹: <https://op.europa.eu/en/publication-detail/-/publication/95ae9c55-c4e4-11ee-95d9-01aa75ed71a1>



Biomass residues – opportunities and **limitations**

1. There is a very large variation in composition

- Forest residues \neq straw \neq bark \neq corn stover
 - Physical: structure, density, etc.
 - Chemical: Cellulose, Hemicellulose, Lignin, Ash

**Flexibility
needed**

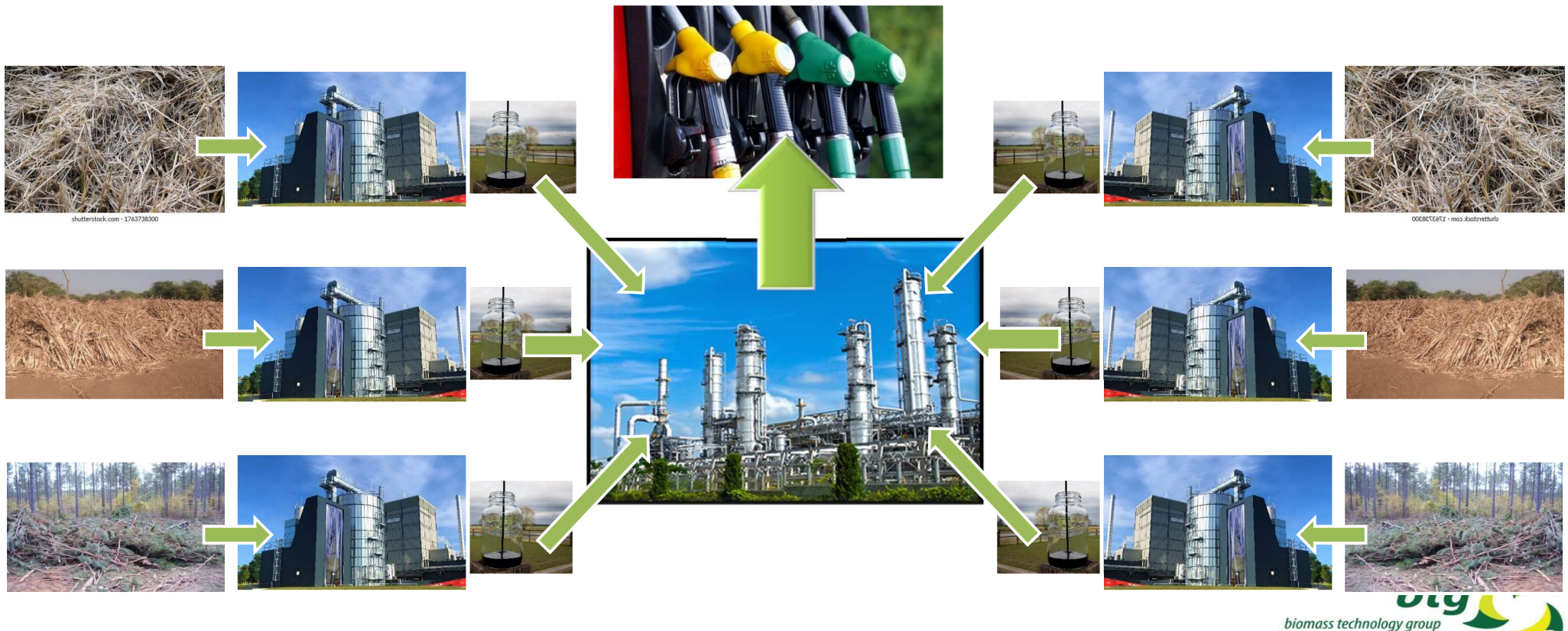
2. Residues are usually available in decentralized(rural) locations

- Scale mismatch with current oil refinery operations
- Low energy density limits maximum transport distances
- Economics however do dictate a minimum scale of operation

Medium scale

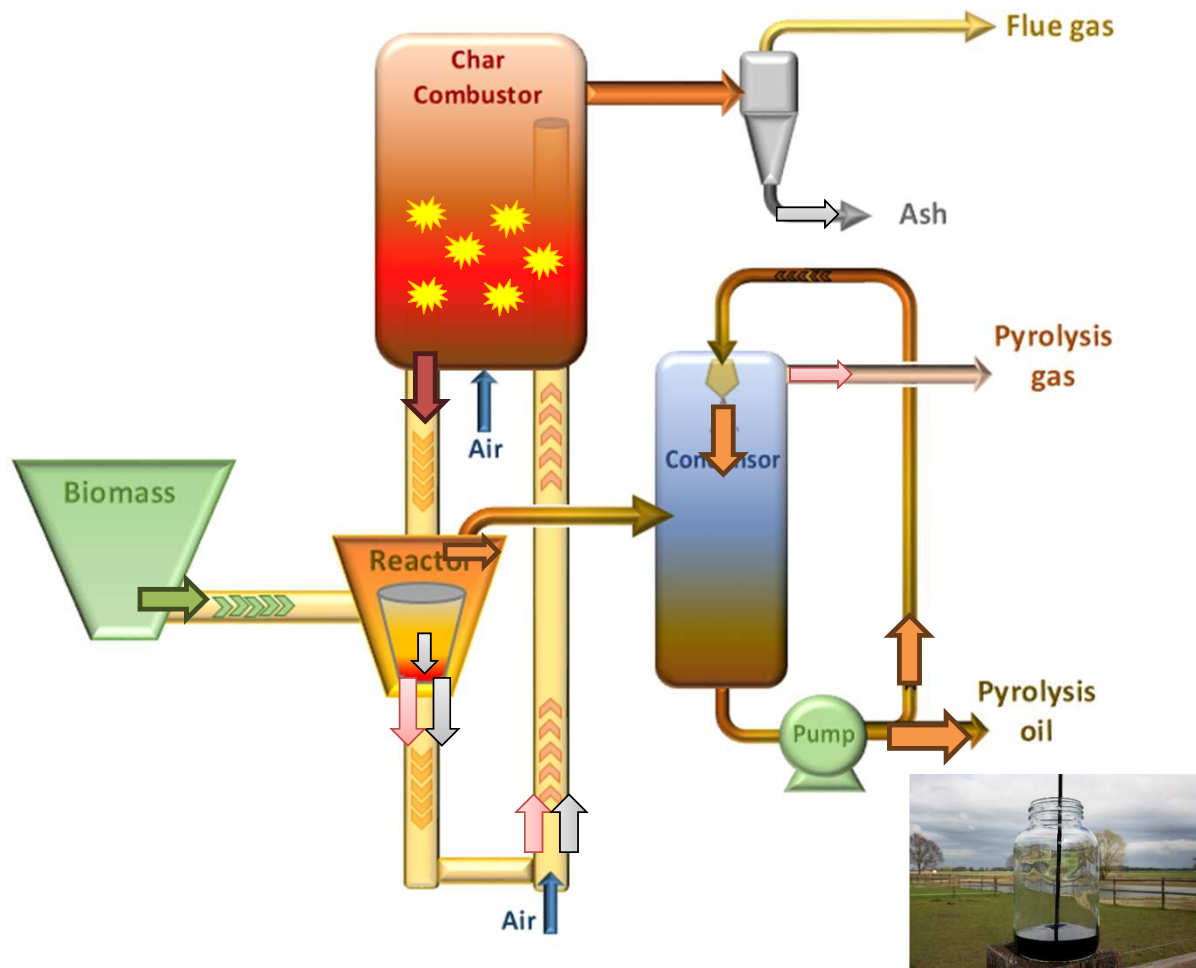
Approach: Biofuels via fast pyrolysis and hydrotreatment

- Spoke-and-hub approach to deal with the various challenges
 - ✓ Fast pyrolysis is feedstock flexible & economical at medium scale (~25 MW input)
 - ✓ Hydrotreatment benefits from economy of scale & matches with refinery infrastructure



Fast pyrolysis – producing a liquid bioenergy carrier (FPBO)

- Rapid heating in an oxygen free atmosphere (thermal decomposition)



- ✓ Feedstock flexible
- ✓ High liquid yields ~ 70 wt.%
- ✓ No external energy required
- ✓ No chemicals required for processing
- ✓ No waste generated
- ✓ Economically feasible on medium scale

Fast pyrolysis – producing a liquid bioenergy carrier (FPBO)

- ✓ FPBO production reached TRL-9, three full scale installations in Europe with BTG technology
- ✓ Order your FPBO in the webshop ¹
- ✓ Order your own pyrolysis plant!



¹: <https://www.btg-bioliquids.com/oil-samples/>

Hydrotreatment – producing a drop in biofuel

- FPBO is a liquid bioenergy carrier, but still contains water and oxygen.
- FPBO can be directly used for heat and power, but existing systems need modifications ¹
- FPBO can be directly co-processed in a refinery in low blend ratios ²
- However, upgrading by hydrotreatment greatly improves the properties!
 - ✓ Application in micro gas turbine for small scale CHP
 - ✓ Suitable as advanced biofuel in transport sector (diesel, kerosene, gasoline)

Water content	25	wt%
Density	1,170	kg/m ³
LHV	16	MJ/kg
Acid Number	70	mg _{KOH} /g
Sulfur	< 0.05	wt%
MCRT	> 15	wt%



Fast Pyrolysis Bio Oil
FPBO

Water content	< 0.1	wt%
Density	870	kg/m ³
LHV	> 40	MJ/kg
Acid Number	< 0.15	mg _{KOH} /g
Sulfur	< 0.05	wt%
MCRT	<< 1	wt%



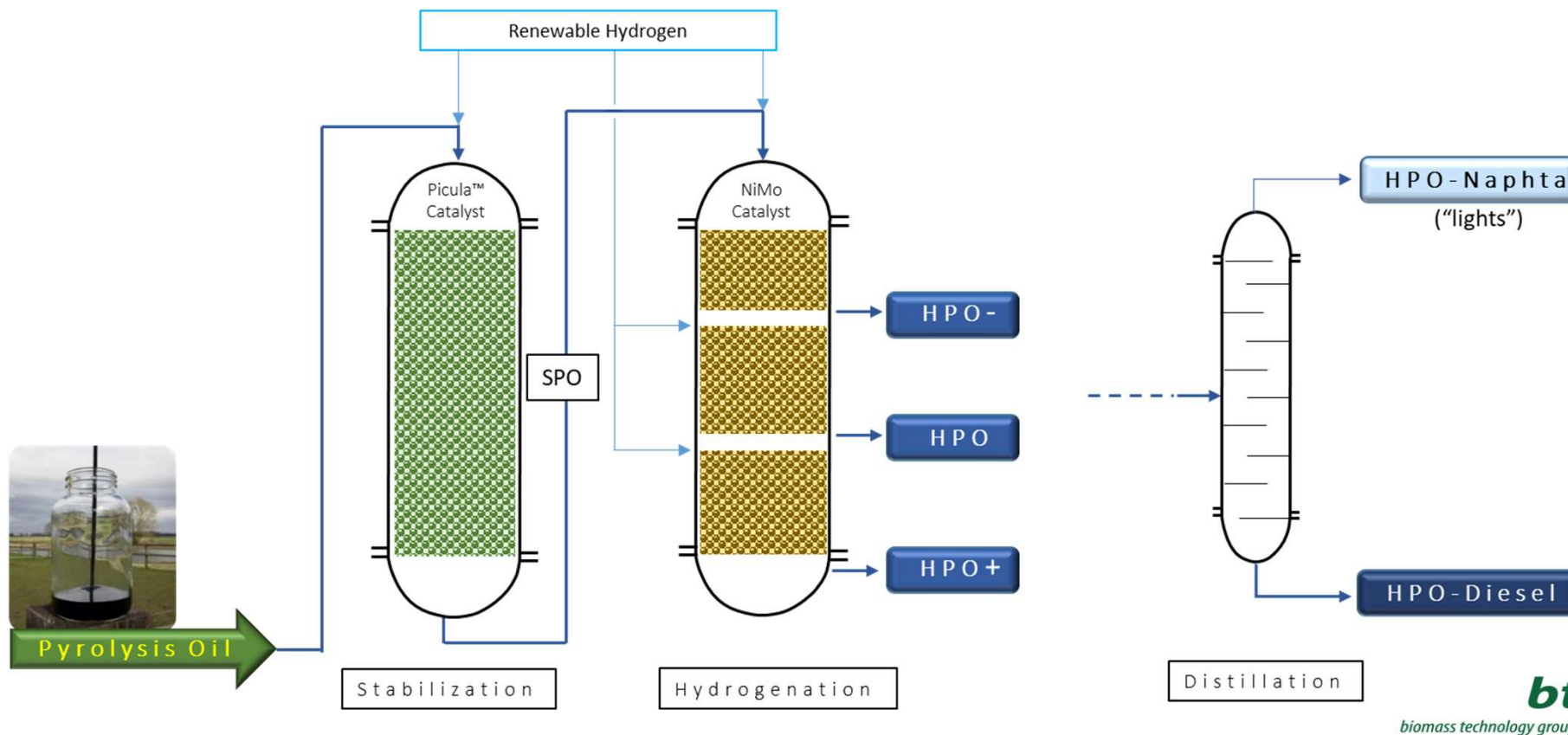
Hydrotreated Pyrolysis Oil
(HPO)

¹: see for example <https://www.smartchp.eu/>

²: <https://www.preem.com/en/investor-relations/about-preem-holding-ab/renewable-fuels-projects/>

Hydrotreatment – producing a drop in biofuel

- Reaction of FPBO with hydrogen at elevated temperature and pressure over a catalyst
- Two stage processing, first stabilization, then hydrogenation
- HPO quality can be steered with operating conditions



Hydrotreatment – producing a drop in biofuel

- Hydrotreatment of FPBO under development, currently TRL~5

*Bench-scale hydrotreater
(24/7 operation – 1 kg/day)*



Pilot-scale hydrotreater (24/5 operation – 50 kg/day)

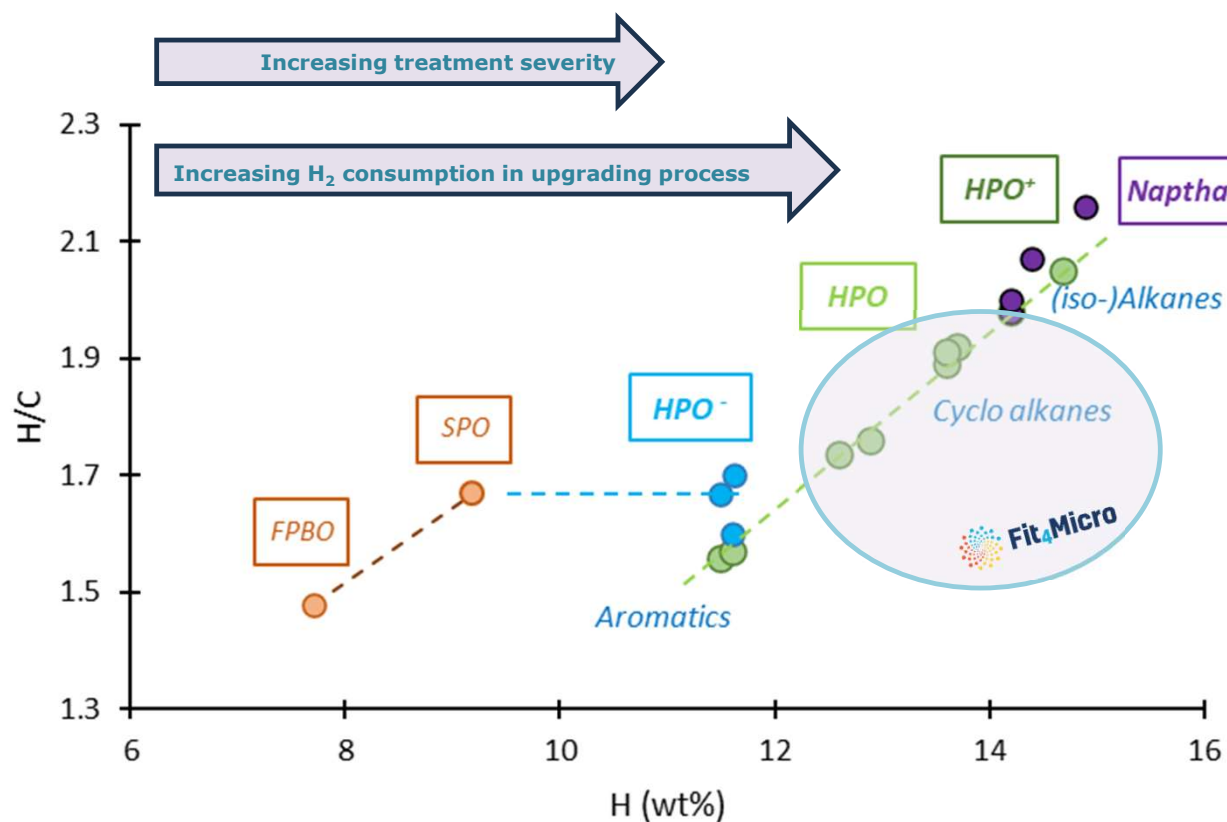


*Feeding and control Pilot-scale
scale hydrotreater*



Biofuel quality control and applications

- HPO quality can be steered with operating conditions



Product qualities as function of hydrogen content



Biofuel quality control and applications

- ✓ First results indicate reference HPO already suitable for micro gas turbines!
 - ✓ Tests underway to lower severity (production costs) while maintaining a suitable fuel quality, complying with emission regulations.



Reference HPO



Total production
so far
in Fit4Micro

Biofuel quality control and applications

- ✓ High severity treatment followed by distillation produces a sustainable aviation fuel (SAF) and a road diesel.
 - ✓ For a 'high severity' biorefinery approach, there will be by-products that can be considered for micro gas turbine usage as well.



Summary

- ✓ Biomass residues are widely available and provide a renewable resource for biofuel production.
- ✓ Fast pyrolysis followed by hydrotreatment is a way to overcome the limitations of biomass residues and connect bioprocessing with refinery scale fuel production.
- ✓ Various fuel qualities can be produced, limiting the fuel costs for less demanding applications.



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