BioTheRoS

Collaborative actions to bring novel **BIO**fuels **THE**rmochemical **RO**utes into industrial **S**cale

Advanced biofuels from fast pyrolysis bio-oil

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Workshop ‘Towards Sustainable Aviation: From Innovative Fuel Pathways to Scale-Up’

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btg biomass technology group

Fast Pyrolysis Value Chain

Objectives

- Demonstration the value chain from biomass via fast pyrolysis to advanced biofuels:

- Demonstrate this value chain for two different biomasses:
  1. Forestry Residues
  2. Barley Straw
- Final fuel products include drop-in, Sustainable Aviation Fuel (SAF) and Renewable Marine fuel.

Fast Pyrolysis - Biomass to FPBO

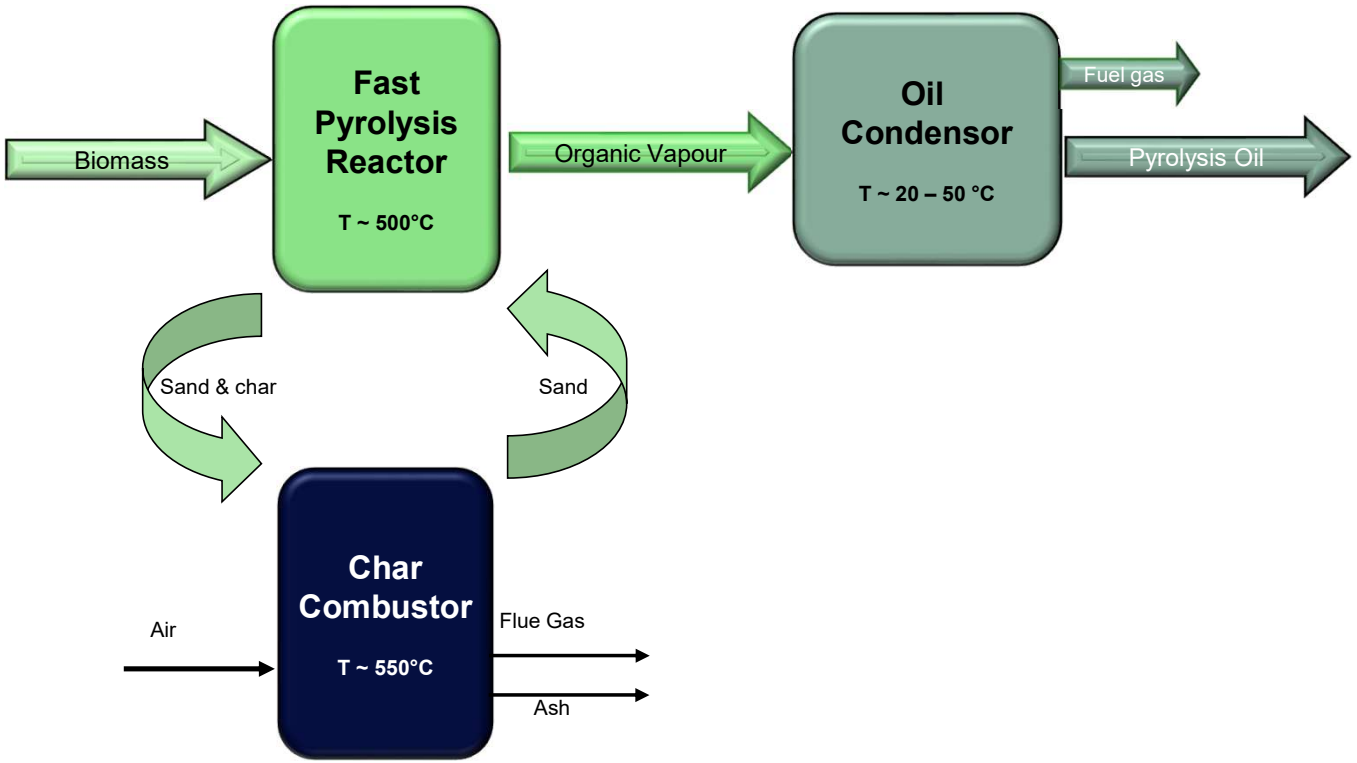
FPBO = Fast Pyrolysis Bio-Oil

- Thermal cracking of organic material in absence of oxygen
- Main product: liquid bio-oil (FPBO)
- Other products: gas and char
- Minerals recovered at low temperature
- Fast heating required to maximize liquid yield

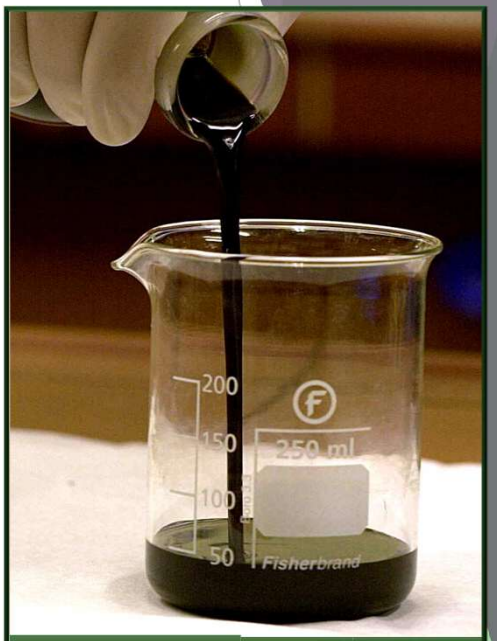
- Typical Process conditions
  - T = 400 - 600 °C
  - P = atmospheric
  - τ_{gas} ~ seconds

- '*Liquid Composition*': carboxylic acids, ketones, aldehydes, alcohols, carbohydrates, depolymerized lignin, extractives, water,…

Fast Pyrolysis: biomass to FPBO

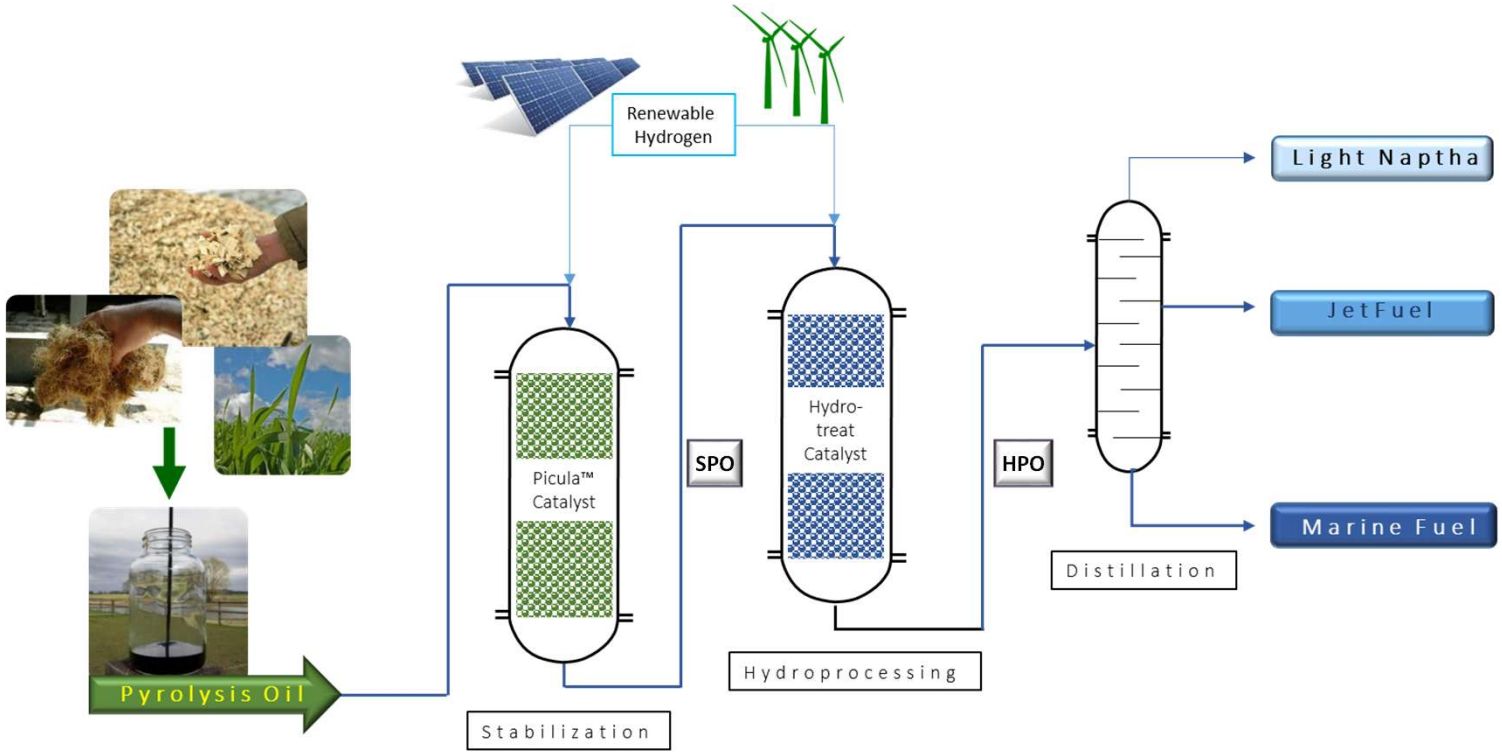


Simplified representation of BTG's pyrolysis process



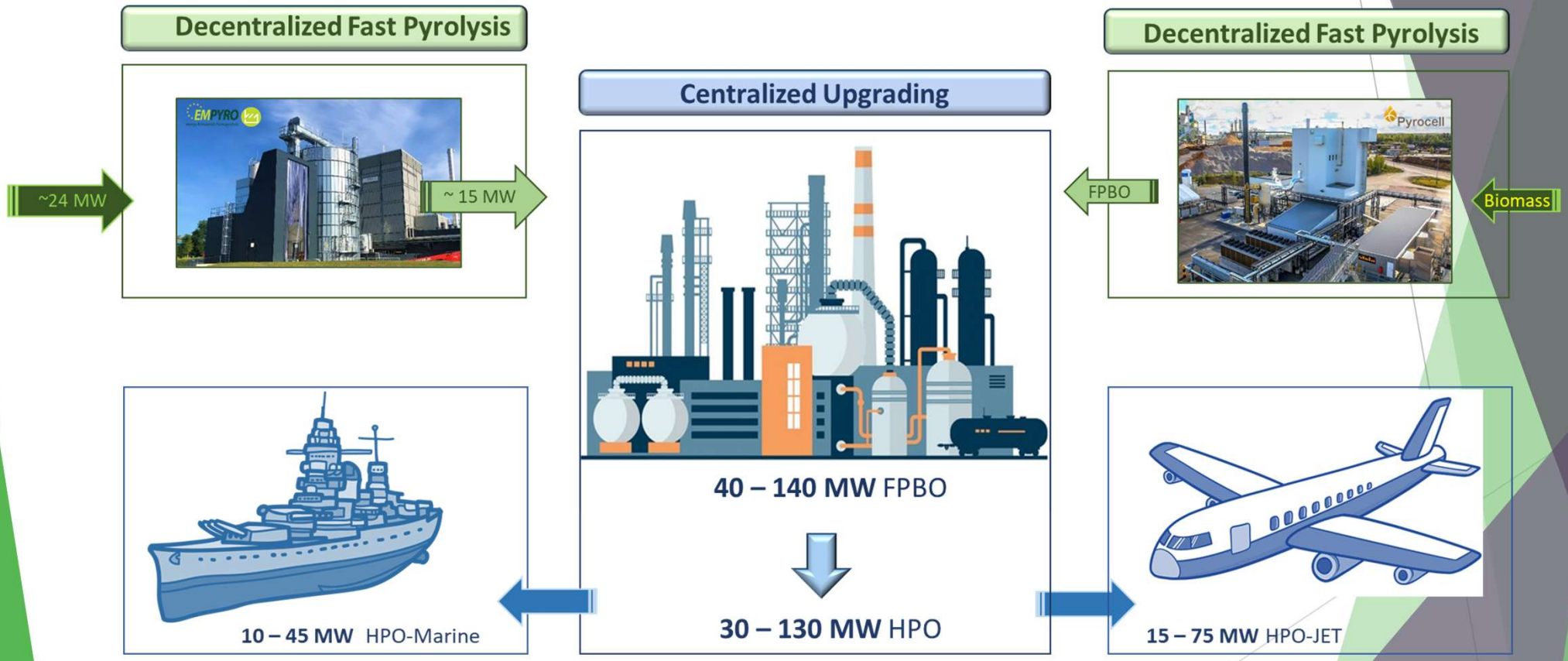
Water content	25	wt%
Density	1,170	kg/m^3
LHV	16	MJ/kg
Acid Number	70	mg_{KOH}/g
Sulfur	< 0.05	wt%
FlashPoint	?	°C
Cetane Number	< 20	-
MCRT	> 15	wt%

FPBO to advanced biofuels



SPO = Stabilized Pyrolysis **HPO** = Hydrotreated Pyrolysis Oil

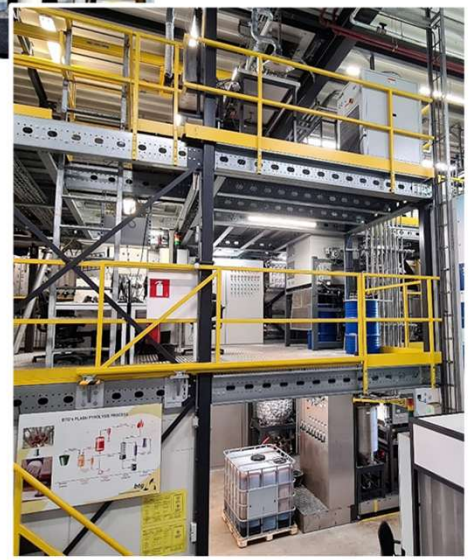
FPBO to advanced biofuels



Experimental facilities

Bench-scale pyrolysis
- 2-4 kg/h
- Day operation – typical 2 -4 h runs

Bench- & pilot scale fast pyrolysis test facilities



Pyrolysis Pilot Plant
- 100 – 200 kg/h
- Day operation – typical 4 -10 h runs

Bench- & pilot scale hydrotreating facilities

Labscale hydrotreaters (5 units):
- 0.5 – 1.5 kg feed/day
- 24/7 operation
- Cumulative > 20,000 h

PDU
- 20 – 50 kg feed/day
- 24/5 operation
- Cumulative > ~4,000 h

HPO	Softwood reference	Forestry Residue	Barley Straw	
Density (@ 15°C)	0.843	0.853	0.855	kg/L
Acidity	<0.01		0.004	mg KOH/g
Viscosity (20 °C)	2.1	3.3	3.3	cSt
Initial Boiling Point (IBP)	116		125	°C
Final Boiling Point (FPB)	418		431	°C
Carbon	86.5	87.4	87.3	wt.%
Hydrogen	13.8	12.8	13.1	wt.%
Nitrogen	<10		48	mg/kg
LHV, calculated	44.6	43.9	44.1	MJ/kg
LHV, measured	42.8		42.4	MJ/kg

Distillation

Typical ranges:

- HPO - Naphtha: < 150 °C
- HPO - Jet: 150 – 275 °C
- HPO - Marine > 275 °C

Barley Straw

HPO	Naphtha	JET	Marine
	11.9%	52.3%	34.6%

Forestry Residue

HPO	Naphtha	JET	Marine
	12.0%	52.4%	34.6%

HPO-JET

Parameter	Unit	ASTM Specifications			HPO - JET		
		D1655 ('final')	D7566 ('clean')	D4054 ('gate')	Wood Ref	Barley Straw	Forestry Residue
Density (T = 15 °C)	kg/L	775 - 840		730 - 800	834.1	837.3	835.8
Viscosity (+20 °C)	cSt				2.01	2.00	2.03
Viscosity (-20 °C)	cSt	< 8	< 12 (at -40°C)		5.074	5.217	
Acidity	mg KOH/g	< 0.10		< 0.015	0.006		
Flashpoint	°C	> 38		38 - 66	49	45	44
Freeze Point	°C	< -40 / -47		< -40	-89.1	-62.0	
Net Heat of combustion	MJ/kg	> 42.8		-	43.2	42.7	
Sulfur content	mg/kg	< 3,000		< 15	2.4	1.9	
Nitrogen content	mg/kg			<2	< 0.5	24.9	
Hydrogen	wt%				13.6	13.1	13.2
DCN/ICN	-			35 - 60	38.3	34.7	
IBP (ASTM D86)	°C			130 – 190	161.0	155.1	
10% recovered	°C	< 205		150 - 200	175.9	173.9	
FPB (ASTM D86)	°C	< 300		195 - 296	264.6	272.4	
Aromatics	v%	< 25	8 - 25	< 20	11.165	19.624	
Mono-aromatics	v%				11.165	19.624	
Diaromatics	v%				<0.001	<0.001	

Summary

- Barley straw and Forestry residues have been successfully pyrolyzed and upgraded to advanced biofuels using “standard processing conditions”.
- Analysis shows that jet fuel fuel properties are within or close to specifications.
- Hydrotreatment severity should be slightly increased for both feedstocks to achieve similar high-quality products as with softwood.

Thank you!

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