btg bioliquids

Advanced Biofuels from Refinery Processing of Fast Pyrolysis Bio-Oil

CONCAWE symposium

27 Sep 2021, Tijs Lammens, BTG Bioliquids B.V.

Agenda

1. About BTG Bioliquids and Fast Pyrolysis
2. Refinery Processing of Fast Pyrolysis Bio-Oil
3. Summary and Conclusions

Company introduction

- As a **technology provider** and **product leader** we are committed to the commercial deployment of our fast pyrolysis technology.

- Fast Pyrolysis Bio-Oil is explicitly made from biomass residues and is known as **second generation** (2G) or **advanced biofuel**. It does not compete with the food chain.

Our company history & milestones

1987

BTG starts as a spin-off from the University of Twente

2008

BTG Bioliquids is established by BTG

2015

Start up of Empyro in the Netherlands

2016

Cooperation agreement with TechnipFMC

Starting BTG Bioliquids webshop

2020

Start up of GFN plant in Finland

2021

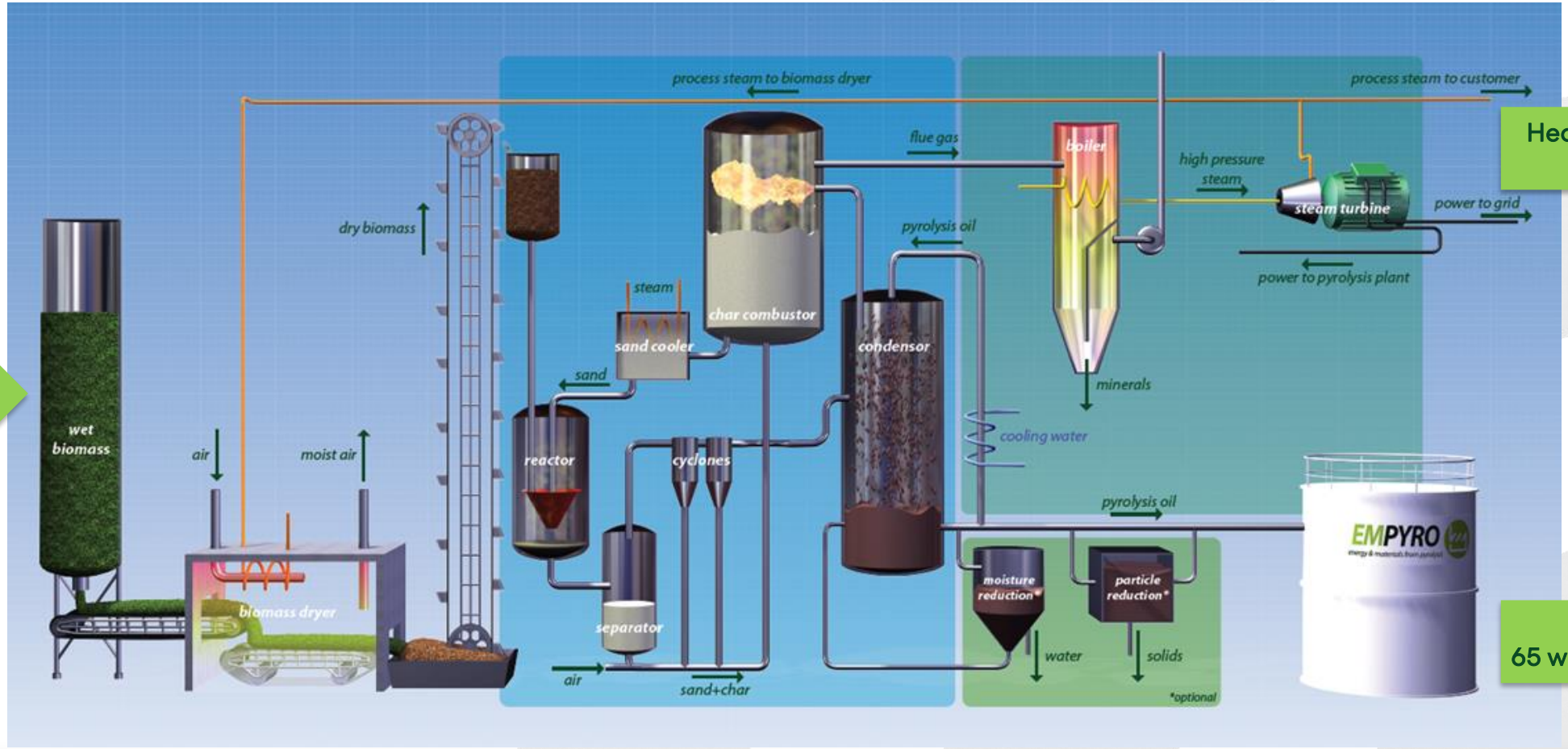
Start up of Pyrocell plant in Sweden

Fast pyrolysis technology

- **Thermochemical decomposition** of biomass residues through rapid heating (450-600 °C) in absence of oxygen.
- Different types of lignocellulosic biomass residues are converted into one homogeneous energy carrier: **Fast Pyrolysis Bio Oil** (FPBO).
- By products are **heat** (steam) and **power** (electricity)

Our process from biomass to FPBO

Wood residue
5 dry ton/hr



Heat + Power
32 E-%

FPBO
65 wt% / 56 E-%

Technology deployment:
Empyro and more

Green Fuel Nordic, Lieksa
Finland - 2020

Start up
Dec 2020

Empyro, Hengelo
The Netherlands - 2015

Sold to Twence
Jan 2019

Pyrocell Setra, Gävle
Sweden - 2021

Start up
Sep 2021

Pyrocell (Sweden)
from sawdust to tank

- Joint Venture of Setra and Preem
- **FPBO from sawdust – started up in 2021**
- Turn-key EPC delivery by TechnipEnergies
- FPBO production: 24,000 tonnes/year
- GHG reduction of 80-90%
- **Preem Lysekil refinery will co-process FPBO to produce advanced biofuels**
- In compliance with EU REDII-Annex 9, etc.

btg bioliquids

Refinery Processing of FPBO

to produce advanced biofuels

The FPBO supply chain

Biomass conversion

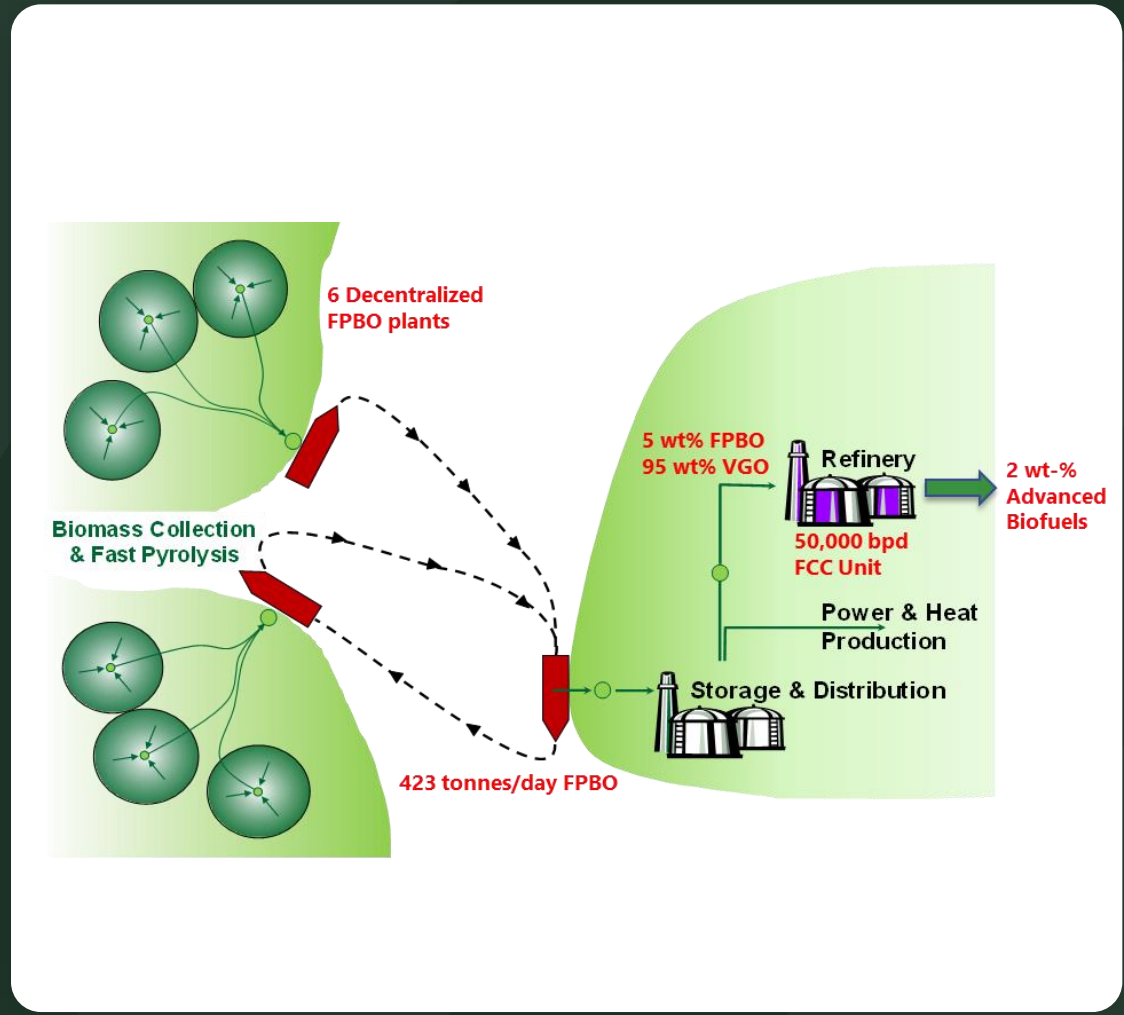
- Local processing of biomass residue
- Returning minerals to the soil

FPBO transportation

- Biomass liquified
- 10x denser than solid biomass

FPBO (co-)processing

- Centralized location
- Make use of existing infrastructure



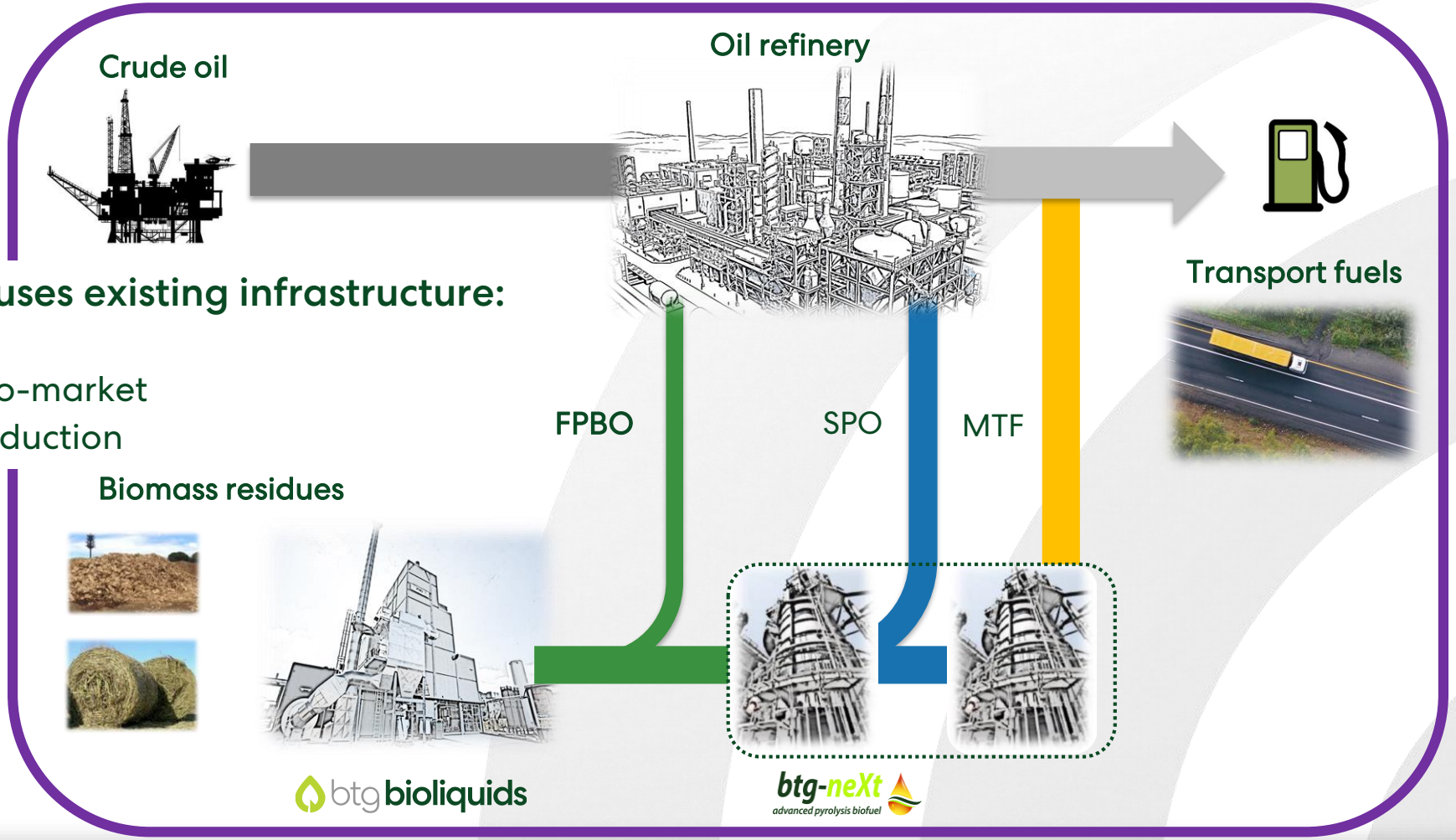
Properties of Fast Pyrolysis Bio-Oil

- **Lignocellulosic:** sawdust, forestry / agro residues, etc.
- **Water** content: 20 – 30 wt-%
- **Oxygen** content: 45 – 50 wt-%
- **Density:** 1.1 – 1.2 kg/L

FPBO is “an emulsion of lignin fragments in a sugar syrup”.

It ís a dark liquid...
... but not a typical refinery feedstock!

Routes from FPBO to transport fuels



Co-processing uses existing infrastructure:

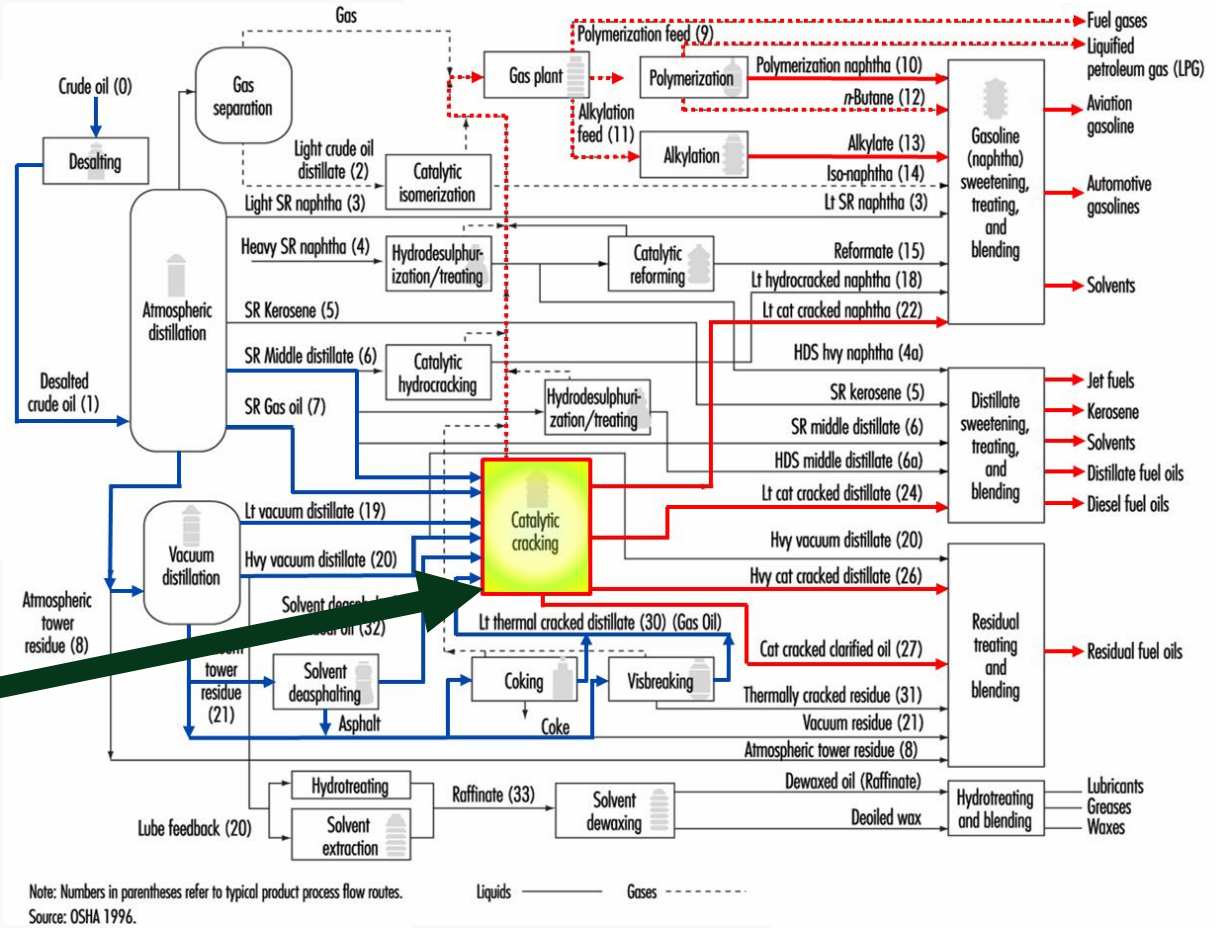
- Low CAPEX
- Short time-to-market
- Fast GHG reduction

FPBO: fast pyrolysis bio-oil
SPO: stabilised pyrolysis oil
MTF: mixed transportation fuels

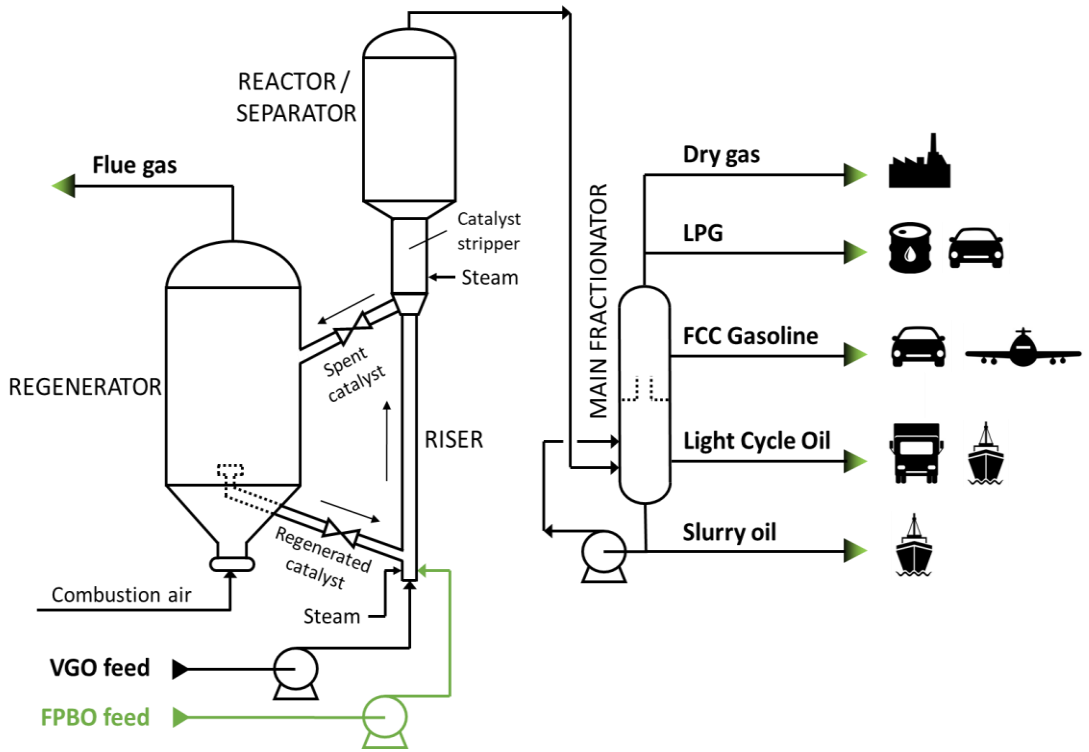
Fluid Catalytic Cracker (FCC)

FCC unit: the FPBO gateway into a refinery:

- Can deal with water, oxygenates, coking
- Many possible outlets for FCC products
- **Challenge: how to track green content?**



Co-FCC of FPBO how does it work?

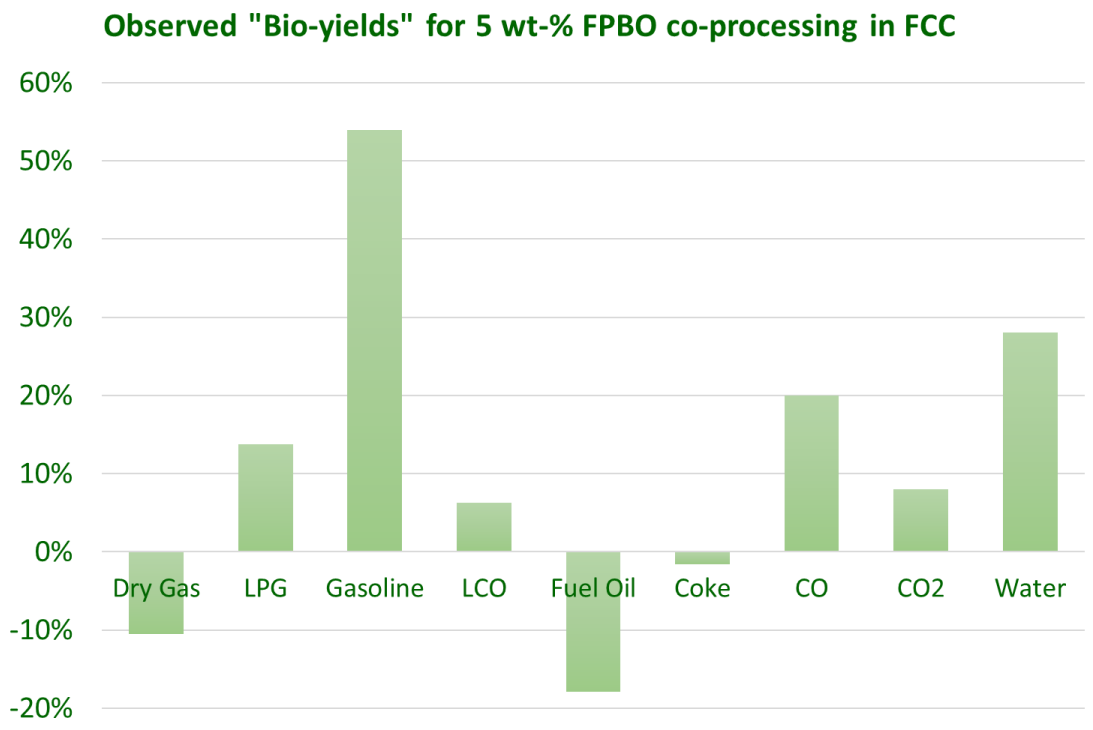


Indicative co-FCC scheme

- **FPBO fed by separate injection line & nozzles**
- Biomolecules cracked together with regular feed
- Acidity disappears upon contact with hot catalyst
- Green content distributed across the products
- **Commercial FCC operability proven for 5 % FPBO**
- Pilot scale operability proven for 10 % FPBO

FPBO impact on FCC product yields

- **Co-processing 5 wt-% FPBO has little impact on the overall FCC product yields**
- Gasoline yield increased
- LPG yield the same
- Dry gas, LCO, fuel oil and coke decreased slightly
- Oxygen in FPBO is turned into CO, CO_2 and water
- **FCC “bio-yields” from FPBO shown; calculated from overall yield shifts when co-processing**



Bio-product yields calculated from FCC yield shifts reported by Petrobras (Pinho *et al.)*

Other refinery pathways

Hydrotreating (standalone)

- 1st step: FPBO stabilisation
- 2nd step: 'regular' hydrotreatment
- BTG neXt develops demoplant for marine biofuel (1 kta, 2023)

Gasification

- DME, methanol, Fischer-Tropsch fuels
- 2002: entrained flow gasifier (Shell)
- 2012: black liquor gasifier (ETC)

Hydrotreating + co-FCC

- FCC co-processing of stabilised FPBO possible at > 10 wt-%
- Provides higher bio-carbon yield

(Fang *et al.*, 2018)

Hydrocracking

- Fixed bed requires FPBO upgrading
- 20% FPBO co-processing in slurry hydrocracker pilot plant (RISE)

(Bergvall *et al.*, 2020)

Summary and Conclusions

- **Fast Pyrolysis Bio-Oil production reached commercial maturity**
- **Advanced biofuels from FPBO co-processing has high potential**
  - Low CAPEX
  - Short time-to-market
  - Fast GHG emissions reduction
- **Feasibility of FPBO co-processing in FCC is proven up to 5 wt-%**
  - Operability was demonstrated at commercial scale
  - FCC products show a favourable gasoline yield
  - Exact yields depend on unit, feedstock and process conditions
- **Other refinery pathways of FPBO at various stages of maturity**
  - Hydrotreating, Hydrocracking, Gasification (Fischer-Tropsch)

btg bioliquids

Thank you

Josink Esweg 34
7545 PN Enschede
The Netherlands

W: www.btg-bioliquids.com
T: +31 (0)53 486 22 87
E: office@btg-bioliquids.com

@BTG Bioliquids

/BTG Bioliquids

Back-up slides

Tracing biogenic content

- Certification systems for co-processing are based on:
  1. Radiocarbon determination ("^{14}C")
  2. Bookkeeping methods (e.g. mass / energy balance)

- Tracing biogenic content through a supply chain is easy and well-established for products with a high biogenic content.

- **The challenge for tracing the bio-content of FPBO is unique:**
  - Scale difference of pyrolysis plant *vs.* FCCU is ~ 1 : 100
  - FPBO co-processing volume is limited to about 5 - 10 wt-%
  - Biogenic content is distributed across many refinery products

- **The result is a diluted biogenic content, making ^{14}C analysis unfeasible and bookkeeping methods a necessity.**

- More details: see our position paper on www.btg-bioliquids.com

BETTER BIOMASS
NTA 8080 CERTIFIED
WWW.BETTERBIOMASS.COM

FPBO application
at FrieslandCampina

- FPBO from Empyro replaces 10 million m^3 natural gas
- Sustainable heat is used for producing dairy products
- Switch from gas to FPBO provides 90% GHG reduction
- Boiler runs without problems; processed all FPBO from Empyro
- Borculo site reduced overall CO_2 footprint by 15%

BTG Bioliquids

we replace fossil fuels