Advanced Biofuels from Fast Pyrolysis Bio Oil

Jacco Kroeze, PRC Europe 2019, May 20-21, 2019

TechnipFMC Process Technology and BTG BioLiquids B.V.
EU POLICY FRAMEWORK ON CLIMATE AND ENERGY

2003-2010 Biofuels Directive
- 5.75% Renewable fuels and Biofuels

2010-2020 RED
- 20% Renewable Energy
- -20% GHG Emissions
- 20% Energy Efficiency

2020-2030 REDII
- 32% Renewable Energy
- -40% GHG Emissions
- 30% Energy Efficiency

- Dedicated sub target for Transportation fuels
- EU member states must require fuel suppliers to supply minimum of 14% of the energy consumed in road and rail transport by 2030 as renewable energy

Art.25
## HOW TO REACH 14%: FEEDSTOCK CLASSIFICATIONS

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<th>Classification in REDII</th>
<th>Alternative Classification</th>
<th>Feedstocks</th>
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<td>First Generation</td>
<td>Conventional biofuels</td>
<td>Sugar Crops</td>
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<td>Starch Crops</td>
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<td>Vegetable Oils</td>
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<td>Palm Oil</td>
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<td>Second Generation</td>
<td>Ambiguous (Annex IX Part B)</td>
<td>Used Cooking Oil</td>
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<td>Capped 1.7%</td>
<td>Animal Fats</td>
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<td>Energy Crops</td>
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<td>Advanced Biofuels (Annex IX Part A)</td>
<td>Agricultural Residues</td>
<td>Municipal Solid Waste</td>
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Advanced Biofuels must be supplied at a **minimum** of:
- > 0.2% in 2022
- > 1.0% in 2025
- > 3.5% in 2030
WHY FAST PYROLYSIS?

- Decouple biomass resource from location and scale of application
- Works with a variety of lignocellulosic biomass feedstocks
- Produces a homogeneous bio-liquid; a sustainable alternative to fossil fuels
- Fast Pyrolysis Bio-Oil is easier to store and transport than solid biomass due to significant volume reduction (on average factor 12)
- High overall efficiency of > 85%
- Versatile application: Heat, power and transportation fuels
- Utilize existing fossil fuel infrastructure:
  - Pyrolysis oil provides a viable link between the agriculture and (petro-) chemical industry.
  - Can be used as a renewable feedstock for petrochemical industry for the production of Advanced Biofuels
WHAT IS FAST PYROLYSIS?

Thermal cracking of organic material in the absence of oxygen

- Main Product = bio-liquid
- Process conditions:
  - $T = 400 - 600 \, ^\circ C$
  - $P = $ atmospheric
- By-products:
  - Heat (Steam)
  - Power (Electricity)

Works with most lignocellulosic (waste) feedstocks

- Wood chips, sugar cane bagasse, straw, sunflower husk, etc.
COMMERCIAL FAST PYROLYSIS BIO-OIL PRODUCTION

FPBO 65 wt% / 56 E%

Heat + P (32 E%)

Wood residue (5 dry t/h)
COMMERCIAL FAST PYROLYSIS BIO-OIL PRODUCTION

BTG-BTL hands over Empyro pyrolysis plant to Twence

In the Netherlands, biomass technology developers BTG-BTL has announced that effective January 1, 2019, the Empyro pyrolysis plant in Hengelo will be taken over by municipal energy utility Twence Holding B.V. The parties will continue working closely together to further develop the plant and explore new sustainable initiatives.

Finland first for Dutch pyrolysis technology developers

Finland is set to invest up to EUR 100 million in bio-oil production facilities using pyrolysis technology developed in the Netherlands and sawmill residues. An initial investment of EUR 25 million will be used for the purchase of a single production facility, but the client intends to purchase three more such facilities, bringing the total order to EUR 100 million.

Source: www.bioenergyinternational.com
TECHNIPFMC-BTG-BTL COLLABORATION

Rolling out Fast Pyrolysis Bio-Oil technology & commercial production:
- Complete turnkey (EPC) delivery of Fast Pyrolysis Bio-Oil (FPBO) units
- Operational support for commercial production of pyrolysis oil

About TechnipFMC:
- Global footprint with ~37,000 people in 48 countries.
- Technology leader in hydrogen, ethylene, refining & petrochemical projects.
- >35 years experience in development, design and construction of proprietary FCC technology.

About BTG-BTL:
- Founded in 2007, BTL (BTG BioLiquids B.V.) is a biomass technology provider based in The Netherlands.
- Owns the first commercial scale plant in The Netherlands.
- Owns proprietary technology, originally developed at the University of Twente.
- BTL owns international patents regarding biomass pyrolysis.
ADVANCED BIOFUELS: DROP IN & CO-PROCESSING

- **Drop-in route**, using new conversion units (e.g. hydrotreaters) & existing blending infrastructure.

- **Co-processing** in existing refinery units (e.g. FCC).

Existing infrastructure to refinery to customer
FAST PYROLYSIS IN THE BIO-BASED ECONOMY

1. Biomass conversion
   • Local processing
   • Returning minerals

2. FPBO transport
   • Biomass liquified
   • 12x densified

3. Processing & distribution
   • Centralized
   • Existing infrastructure

FPBO, the link between agricultural & petrochemical industries!
CO-REFINING OF FPBO, HOW DOES IT WORK?

Typical Fluidized Cat Cracker scheme:

- Flue gas to particulates removal and energy recovery
- Combustion air
- Raw oil charge
- Regenerated catalyst
- Catalyst Stripper
- Dry Gas
- LPG
- Gasoline
- Light Cycle Oil
- Heavy Cycle Oil
- Slurry oil

Figure adapted from U.S. Energy Information Administration
CO-REFINING OF FPBO; WHAT ABOUT YIELDS?

Co-processing up to 5wt% FPBO has limited/no impact on yields of the products:

- **100% VGO**
  - LPG + Gasoline + LCO: 74.0 wt%

- **95% VGO + 5% FPBO**
  - LPG + Gasoline + LCO: 74.0 wt%

- **90% VGO + 10% FPBO**
  - LPG + Gasoline + LCO: 70.5 wt%

Source: DOE Bioenergy Technologies Office (BETO) 2015 Project Peer Review 2.4.2.303 Brazil Bilateral: Petrobras-NREL CRADA
CO-REFINING OF FPBO; WHAT HAPPENS TO THE GREEN CARBON & HYDROGEN?

- Half of the mass of FPBO comes from oxygen atoms, in water or oxygenates
- About 30% of the bio-Carbon becomes FCC-naphtha + LCO
- The rest of the bio-Carbon is not lost, and still reduces the use of crude oil for other products (e.g. LPG, olefins, etc.) and energy.
- Local EU legislation will determine how bio-credits are calculated for the different products.

Data: Petrobras 2015, using FPBO in an FCC demo unit
BIOFUELS PRODUCTION COSTS

Source: Sustainable Transport Forum, Sub Group on Advanced Biofuels, 2017, final report

(EUR / MWh)$^1$
SUMMARY

• Waste and residues based biofuels are being promoted in the EU biofuels policy
• EU mandate for Advanced Biofuels requires refiners to look at an alternative way to meet the obligations starting from 2020.
• Co-processing small quantities of crude FPBO has little to no impact on refinery operations.
• Co-processing of crude Fast Pyrolysis Bio-Oil in an (existing) FCC is a cost effective and efficient way to meet REDII.
• Co-processing with higher FPBO contribution may call for a mild hydrotreatment of FPBO.
THANK YOU FOR YOUR ATTENTION!

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FAST PYROLYSIS BIO-OIL IN A REFINERY