Fast pyrolysis based advanced biofuels

New Delhi, 8th March 2018, René Venendaal (CEO BTG)
What is fast pyrolysis?

- Thermal cracking of organic material in the absence of oxygen
  - Main Product = Liquid Bio-oil (65% on wood)
  - Process conditions:
    - $T = 400 - 600 \, ^\circ C$
    - $P = \text{atmospheric}$
  - By products:
    - Heat (steam)
    - Power (electricity)

- Works with most lignocellulosic (non-edible) feedstocks
  - Wood chips, sugar cane bagasse, straw, sunflower husk, etc.

**Typical Pyrolysis Oil Characteristics**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composition</td>
<td>$C_2H_5O_2$</td>
</tr>
<tr>
<td>Density</td>
<td>1100 - 1200 kg/m$^3$</td>
</tr>
<tr>
<td>Heating value</td>
<td>17 - 20 GJ/m$^3$</td>
</tr>
<tr>
<td>Water content</td>
<td>20 - 30 wt.%</td>
</tr>
<tr>
<td>Ash</td>
<td>&lt; 0.1 wt.%</td>
</tr>
<tr>
<td>Acidity (pH)</td>
<td>2.5 - 3</td>
</tr>
</tbody>
</table>

Technip
biomass-to-liquid
Why fast pyrolysis?

- Decouple biomass resource from location and scale of application
- Works with a variety of biomass feedstocks
- Yields a homogeneous, advanced biofuel, that serves as a sustainable alternative to fossil fuels
- Produces bio-oil which is easier to store and transport due to significant volume reduction of solid biomass of about 12 on average
- High overall efficiency of ~ 85%: Conversion of biomass to main & by-products
- 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.
  - Renewable feedstock for petrochemical industry in the production advanced biofuels
Fast Pyrolysis Bio-Oil Process

- Intensive mixing of **biomass** particles and **hot sand** in absence of air in the **REACTOR**
- **Char** and **sand** are recycled to a **COMBUSTOR** where the char is burned to reheat the sand
- Vapours leaving the reactor are rapidly cooled in the **CONDENSER** yielding the **pyrolysis oil** and some gases.
- The **gases** and the surplus heat from the combustor can be used to generate **steam** for **power** generation, **biomass drying** or **external use**
- The minerals contained in biomass stay behind in the **ashes**. They can be **reused** locally, thus avoiding mineral depletion
Commercial Demo

Empyro Plant in Hengelo, the Netherlands (since 2015)

Plant Data

<table>
<thead>
<tr>
<th>Plant Capacity</th>
<th>120 t input /day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Feedstock</td>
<td>wood residues</td>
</tr>
<tr>
<td>Plant Output per year</td>
<td></td>
</tr>
<tr>
<td>• Oil</td>
<td>20 million litres</td>
</tr>
<tr>
<td>• Electricity</td>
<td>2,200 MWh</td>
</tr>
<tr>
<td>• Steam</td>
<td>80,000 tonnes</td>
</tr>
<tr>
<td>• CO2- eq. reduction</td>
<td>24,000 tonnes</td>
</tr>
</tbody>
</table>
Fast Pyrolysis Bio-Oil Applications

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**Co-refining** FPBO in FCC enables production of **advanced bio-fuels** while utilizing existing refining infrastructure. Low CAPEX and low OPEX.
TechnipFMC FCC Capabilities

- Over 35 years experience in the development, design and construction of its own FCC technology
- The most experience in revamping technology upgrades on FCC licensed by others
- Formed FCC Alliance in 1993 with IFP/Axens and Total
- Several FCC Alliance achievements including
  - 61 grassroots FCCs
  - More than 250 FCC revamps
  - 90 FCC related patents

Offer cost-effective solutions to meet refiner’s bio-energy challenges and obligations via application of FCC Co-feeding route
Production costs crude FPO (NL, 1st plant)

EMPYRO – key figures

- Indicative pyrolysis oil price (EMPYRO - plant):

| Pyrolysis oil | ~ 300 €/ton |
| ~ 18 - 20 €/GJ |
| ~ 65 – 75 €/MWh |

(Biomass costs ~ 80 €/dry ton)

- Cost breakdown

- Biomass feedstock (~43%)
- Personnel (~ 10%)
- Other variable costs (~3%)
- Other fixed (~2%)
- Finance costs (~42%)
  (incl. equity & depreciation)
Costs of advanced biofuels (SGAB, February 2017)

Figure 1. Summary of production cost
Thank you