# Development of fast pyrolysis in the Netherlands

## Technology & applications

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btg biomass technology group

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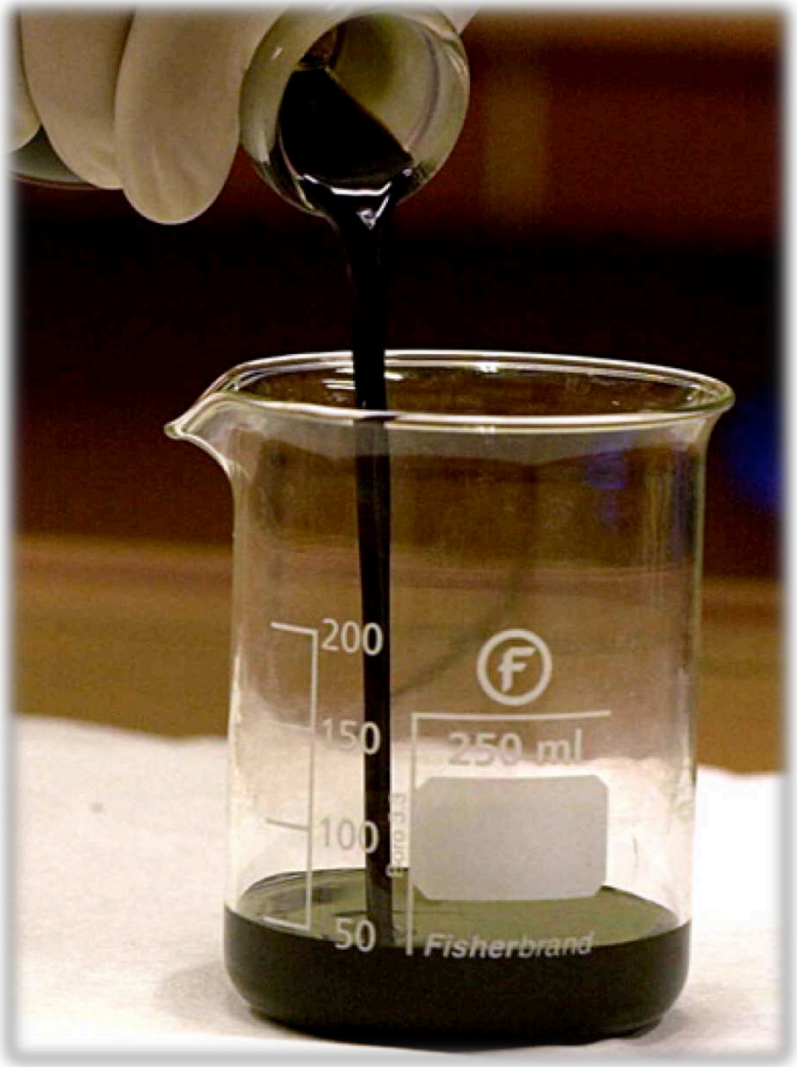
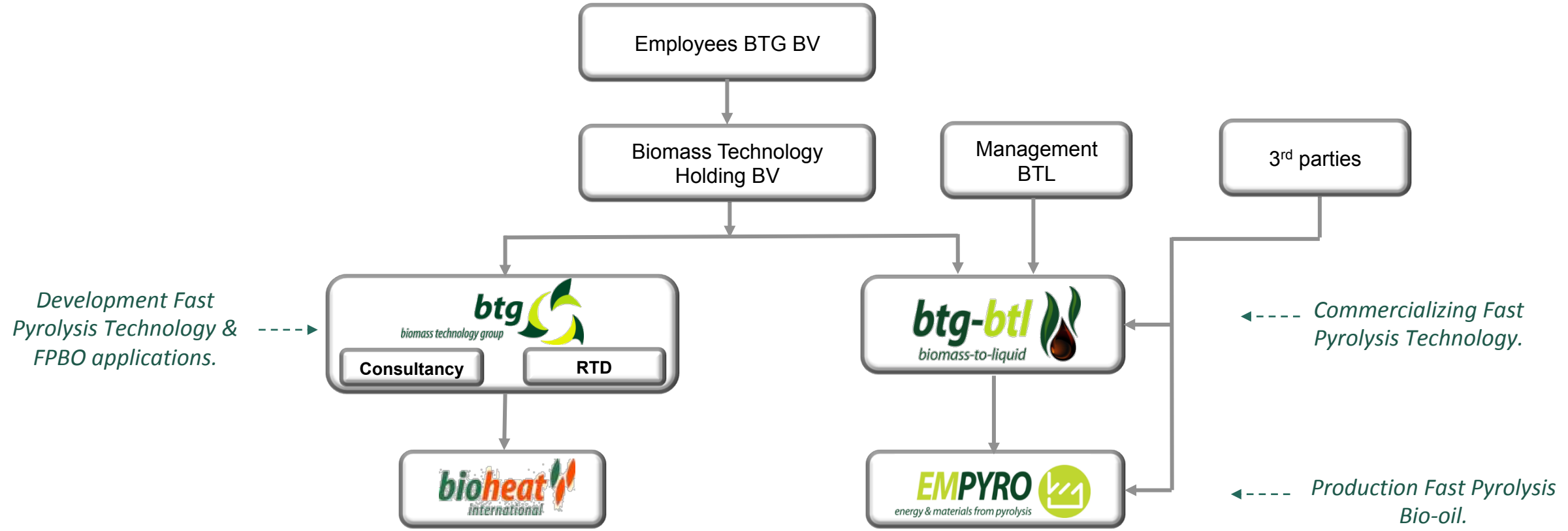
# OUTLINE

- Organisation
- Fast Pyrolysis of biomass
- “Empyro” FPBO production plant
- FPBO Applications
- Summary



# Organisation

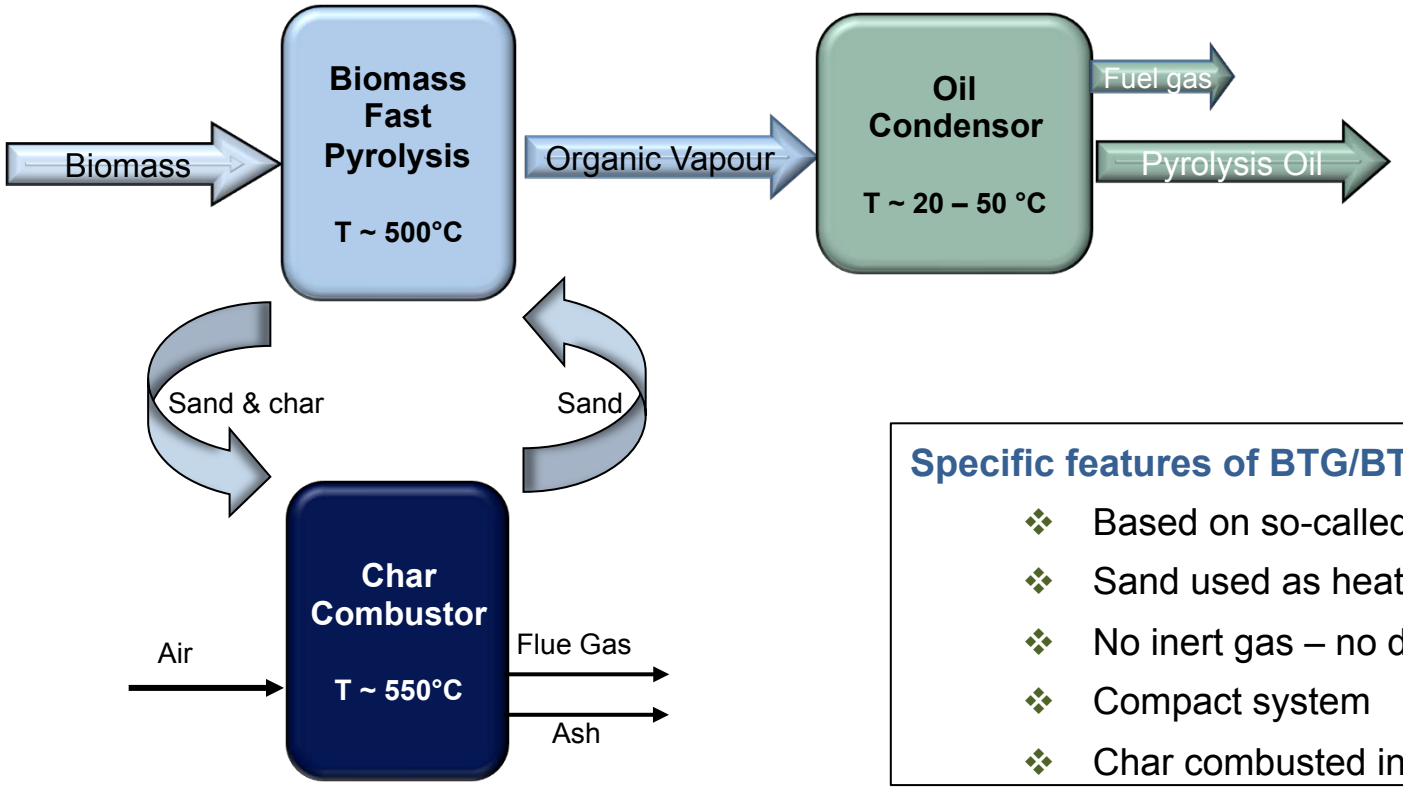




Development of the
Fast Pyrolysis Process

# Fast Pyrolysis Process

- Thermal cracking / depolymerisation of organic material in absence of oxygen
- Main product: liquid bio-oil (FPBO)
- Other products: gas and char
- Minerals recovered at low temperature



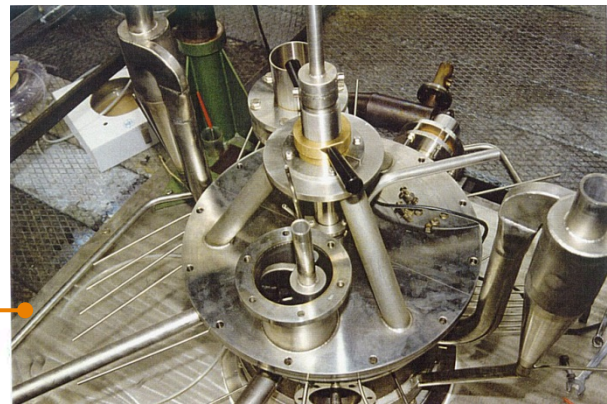

**Specific features of BTG/BTL FP process:**

- Based on so-called *Rotating Cone Technology*;
- Sand used as heat carrier
- No inert gas – no dilution of vapor stream
- Compact system
- Char combusted internally to provide heat

*Simplified representation of BTG's fast pyrolysis process*

# Fast Pyrolysis – development timeline

| | |
|---|---|
| 2016 | Co-production of FPBO, process steam and electricity |
| **2015** | Start-up Empyro plant & Process steam boiler at FrieslandCampina |
| 2014 | Start construction 120 t/d Empyro plant in Hengelo (NL) |
| 2013 | Long-term FPBO supply contract signed |
| 2009 | Establishment of Empyro BV to demonstrate FP technology |
| **2007** | Establishment of BTG Bioliquids BV to commercialize BTG Fast Pyrolysis technology |
| 2005 | Delivery of 50 t/d FP-plant to Malaysia |
| 2004 | Large-scale co-firing test at Harculo Power Plant |
| **1998** | Start-up of 200 kg/hr FP pilot plant in BTG Laboratory |
| 1994 | Delivery semi-continous test unit (50 kg/hr) to Shenyang (China) |
| 1993 | First fast pyrolysis project at BTG |
| 1987 | Rotating cone reactor invented at University of Twente |



# Commercial Scale Demonstration Plant

## OBJECTIVE

- Design, built and operate a 25 $MW_{th}$ fast pyrolysis plant to produce simultaneously ***electricity***, **process *steam*** and ***fuel oil*** from woody biomass.
- Demonstrate the use of pyrolysis oil in natural gas fuelled boiler for the production of process steam.
- Reference plant for BTG-BTL's Fast Pyrolysis Process.

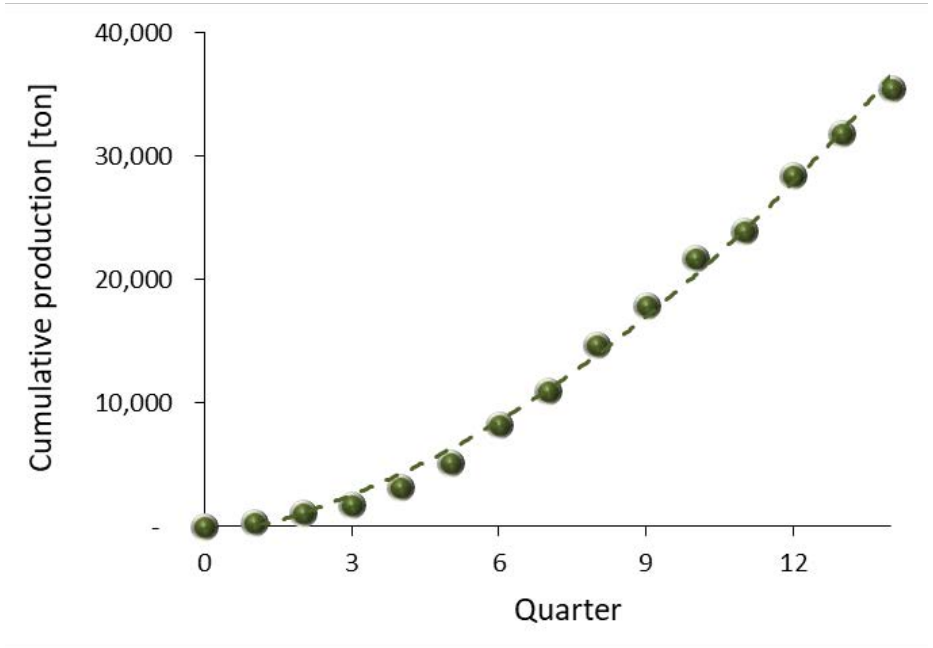
## KEY FIGURES

- Industrial site in Hengelo, the Netherlands
- Feedstock: clean woody biomass
- Capacity: 5 ton feed/hr (@ 5wt% moisture)
- Output:
  - 3.2 t/hr FPBO
  - 7.4 $MW_{th}$ steam
  - 650 $kW_e$ Electricity

# Fast Pyrolysis Oil Production plant

## KEY FIGURES

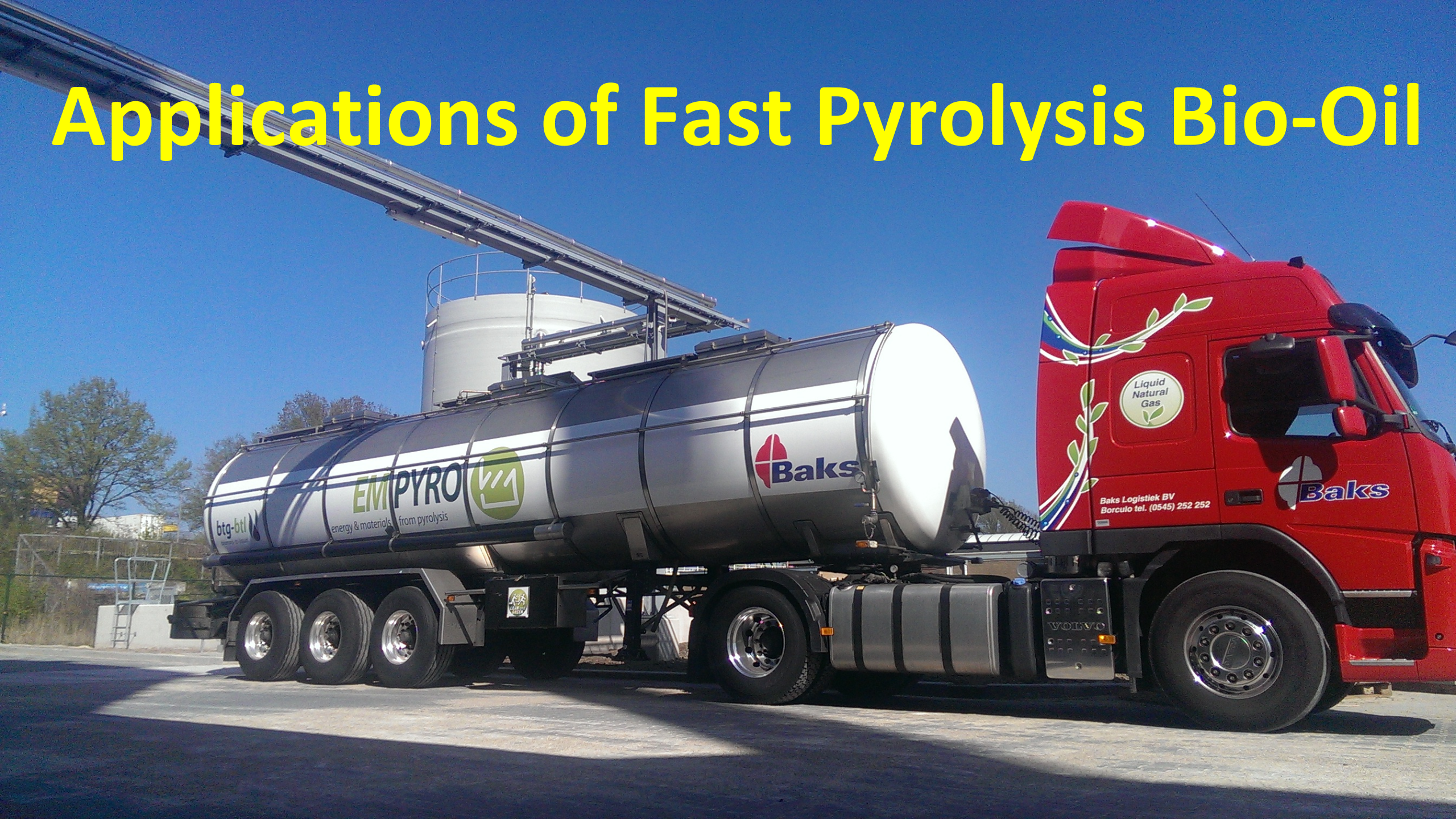
- Plant construction 2014-2015
- Plant commissioned in 2015
- > 14,000 hrs operation
- > 30 million litre FPBO produced




*Cumulative FPBO production*

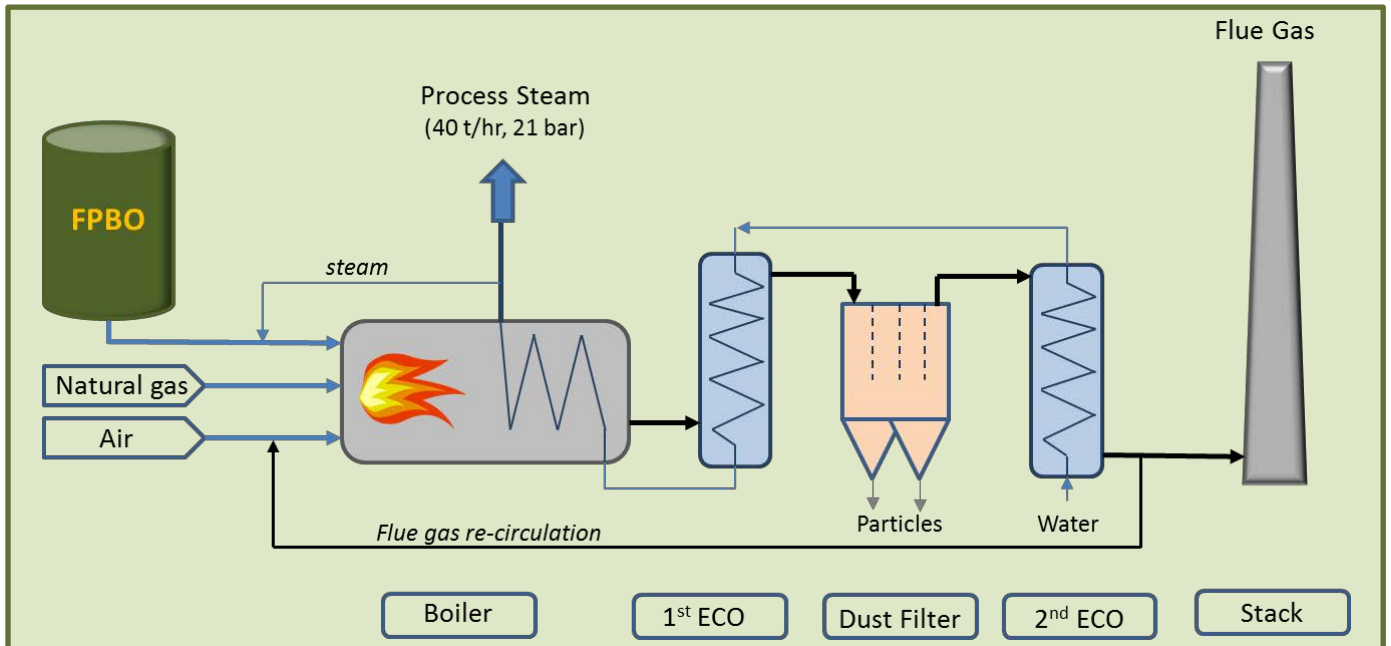
*EMPYRO: Commercial Fast Pyrolysis demonstration plant (Hengelo, NL)*

# Applications of Fast Pyrolysis Bio-Oil



# FPBO Application: BioEnergy

- Pyrolysis oil is co-fired with natural gas producing process steam for dairy company FrieslandCampina.
- Annual saving of 10 million m³ of natural gas.
- 100% back-up of natural gas (= guaranteed process steam supply)
- Pyrolysis oil is transported by tank truck from Hengelo to Borculo (~ 30 km).
- > 99% of FPBO produced by Empyro used as fuel in this boiler




**KEY FIGURES STEAM BOILER**

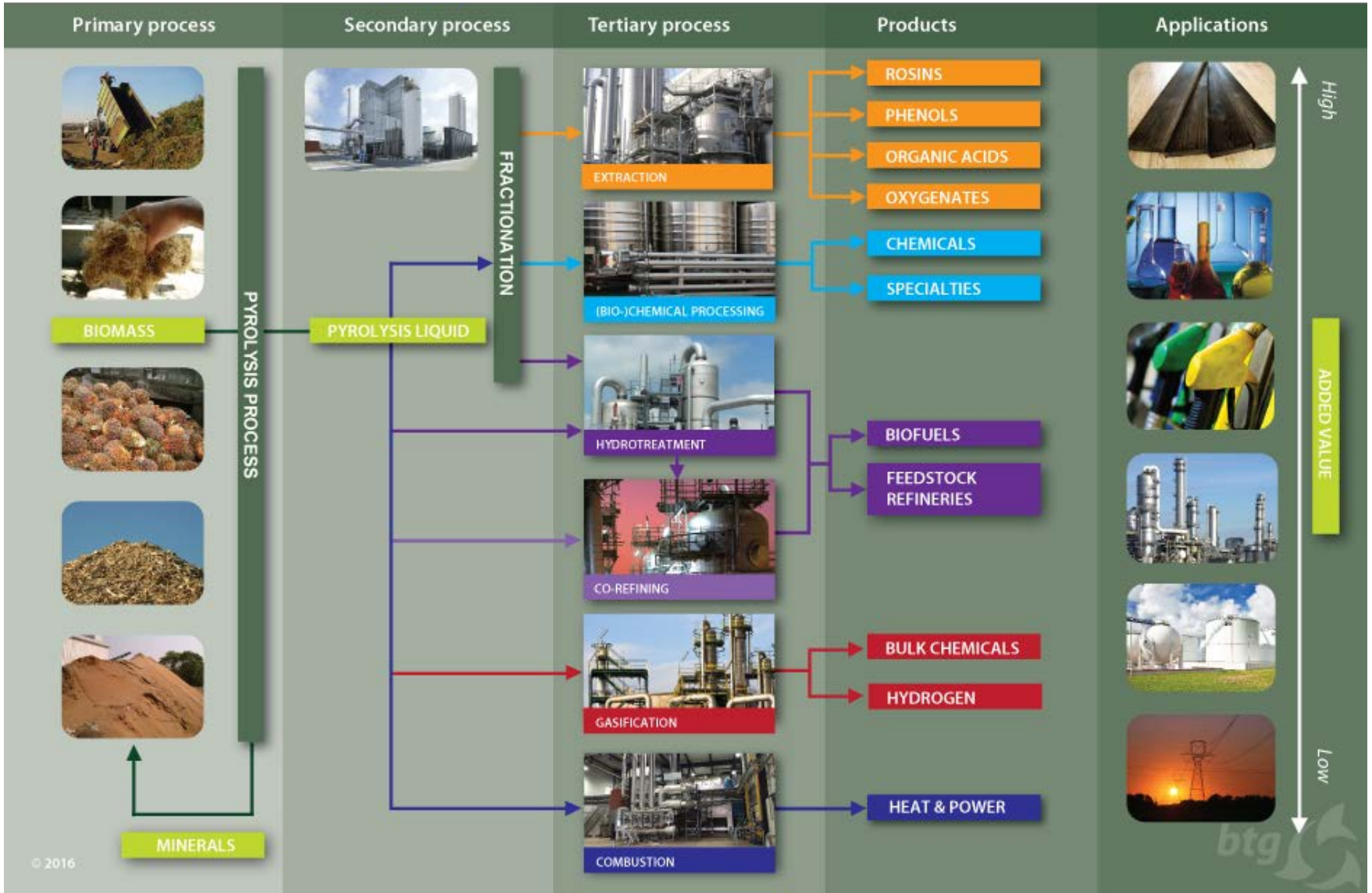
- Process steam: 40 t/hr, 20 bar
- Pyrolysis oil : 5 – 18 $MW_{th}$
- Natural gas: 6 – 29 $MW_{th}$
- Overall efficiency: 95.5 %

*FPBO boiler at FrieslandCampina*


*FPBO transport*

# Applications of Fast Pyrolyis Bio-Oil (FPBO)

bioliquids refinery



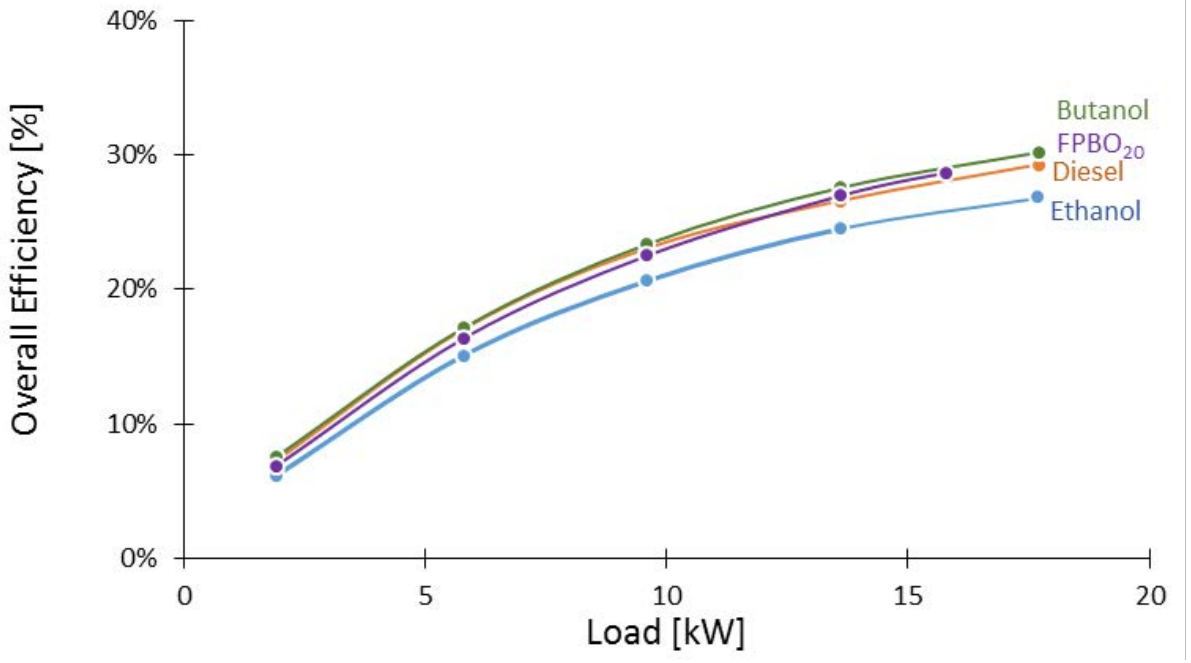

Bio-based Products

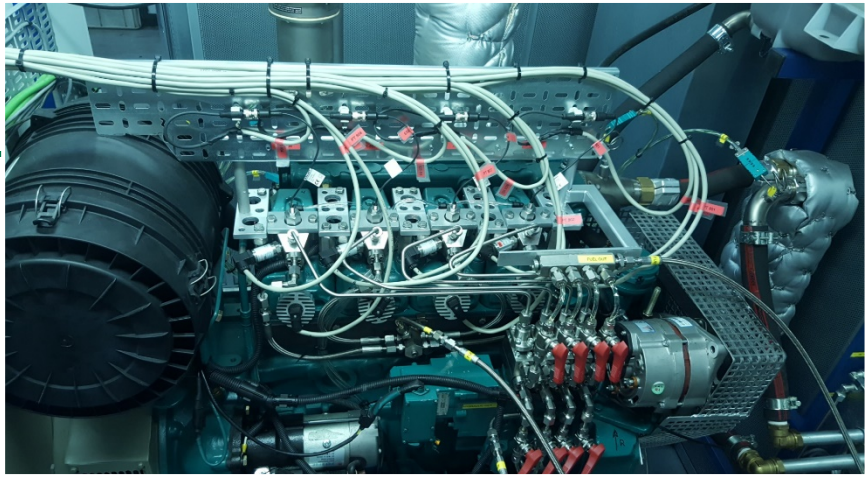
BioFuels

BioEnergy

# FPBO Application: BioEnergy

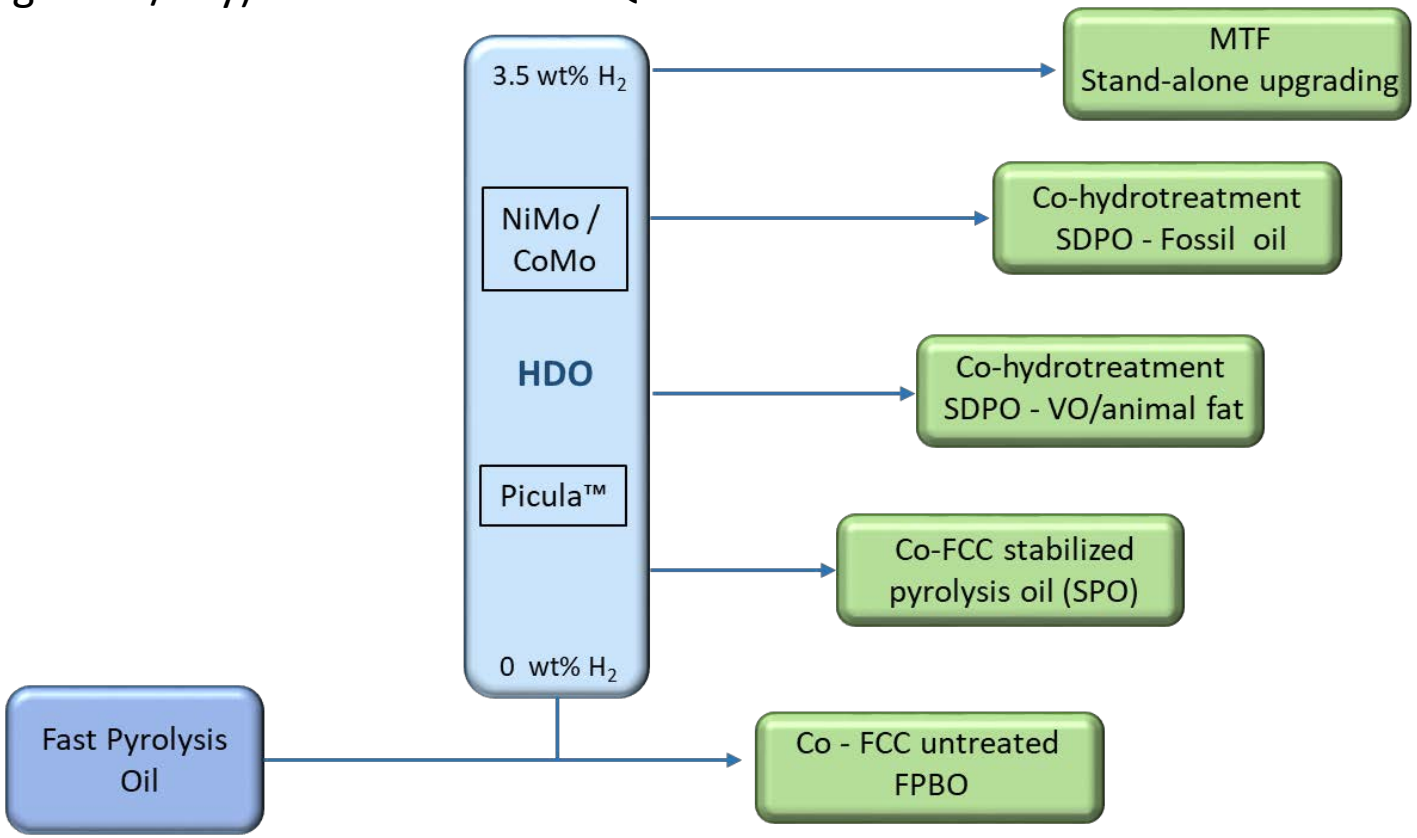
- Combined Heat & Power (CHP) production on basis of a modified diesel engine
- FPBO is acidic and difficult to ignite (low Cetane number);
- Modified fuel supply system required + increased air inlet temperature and/or compression ratio;
- BTG operates a 1-cylinder and a 50 $kW_e$ 4 cylinder engine on FPBO
- In total > 700 hrs operation on FPBO
- Efficiency comparable to standard diesel;



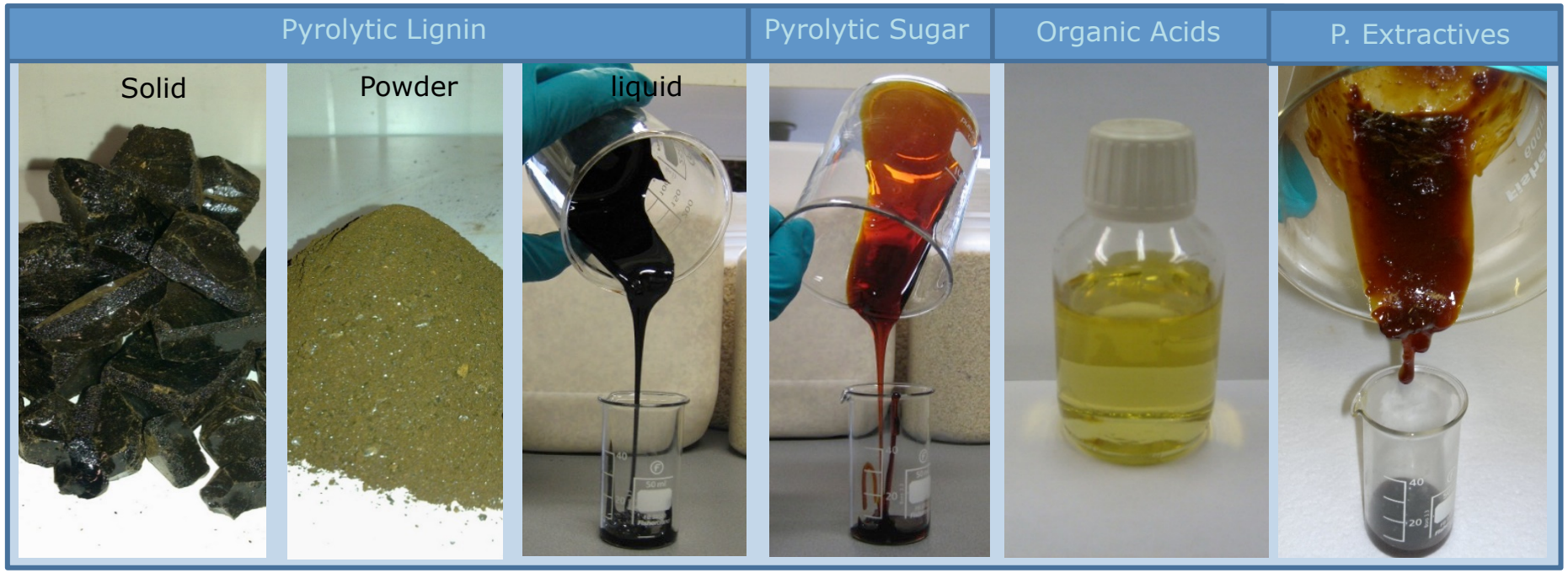
# FPBO Application: BioFuels

- FPBO as such not compatible with fossil diesel/gasoline/kerosene;
- 2-step approach: 1: Stabilisation using Picula™ catalyst
  2: Further upgrading using commercial catalysts (NiMo/CoMo)
- 4 continuous hydrotreaters at lab-scale (~ 1 kg/day)
- 1 pilot unit (~ 50 kg FPBO/day) commissioned in Q3-2018




# FPBO Application: Biobased products

- Pyrolysis oil can be fractionated in its main fractions: *extractives*, *lignin*, *sugar syrup* and an *aqueous* fraction;
- Each of the fraction is starting point for dedicated chemical, catalytic or biotechnological conversion into fuels, chemicals and biobased products;
- Process based on 2-step liquid-liquid extraction proven on bench-scale (10-12 kg/h)



# FPBO Application: Biobased products

BIO4 PRODUCTS
Creating sustainable resources for process industry

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## Sustainable feedstock

- Exploiting renewable and non-food residues


## Bio-based products

- Processing sustainable resources into end products


## Innovative conversion

- Combining fast pyrolysis & fractionation




 

BIO4 PRODUCTS

Creating sustainable resources for process industry

- Input capacity: 3 t/d FPBO
- Production ***extractives***, ***pyrolytic lignin (S/L)***, ***pyrolytic sugars***
- Start-up in Q4-2018


BIO4 PRODUCTS
Creating sustainable resources for process industry

# FPBO Application: Biobased products

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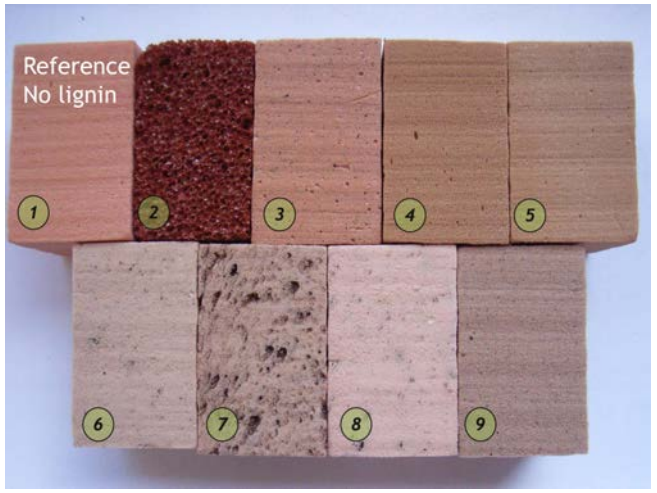
Creosote replacement

Molding resin

Wood modification

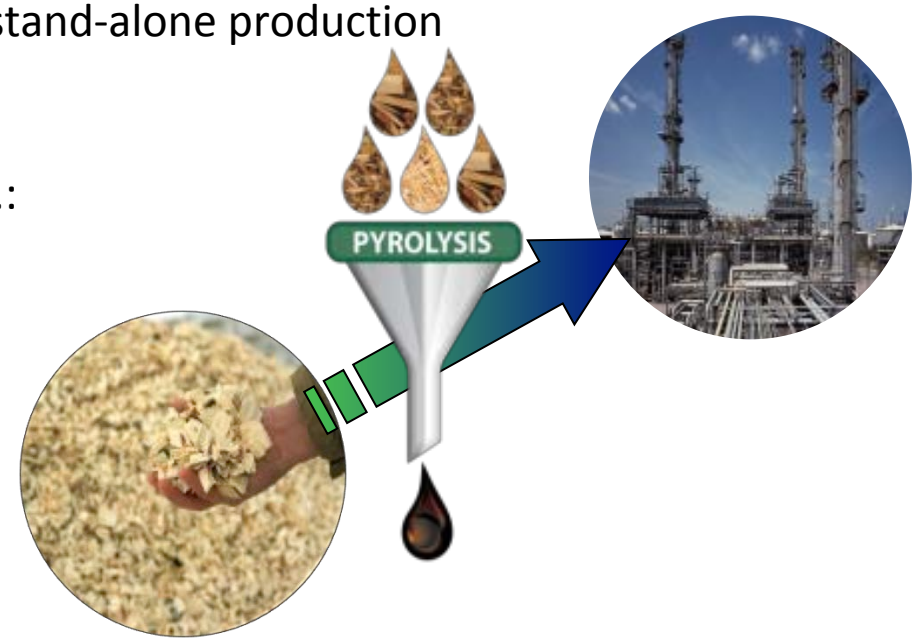
Biobased Paints




Insulation Foam

# Summary

- Fast Pyrolysis is a suitable process to convert a variety of biomasses into a liquid (FPBO);
- The process has been implemented on commercial scale and the liquid product is commercially used for energy application (i.e. replacement natural gas for process steam production)
- Additionally, FPBO can be an excellent raw material for developing a so-called Bioliquids refinery covering Bioenergy, Biofuels and Biobased products:
- FPBO can be used in modified diesel engines for CHP application
- Biofuels can be produced via co-refining in existing refineries or stand-alone production
- FPBO fractionation enables the development of a new range of biobased products. Promising results have been obtained for e.g.:
  - Moulding
  - Insulation foams
  - Paints
  - Wood modification



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# Thanks for your attention !

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