Fast Pyrolysis Bio-Oil Technology and Production

Your Sustainable Alternative

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Fast Pyrolysis Bio-Oil Technology and Production

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BioWKK conferentie “Groene stoom voor de industrie”

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1. Pyrolysis Technology

1.1: What is pyrolysis?

- **Thermal cracking of organic material in the absence of oxygen**
  - Main Product = Liquid Bio-oil
  - Process conditions:

T = 400 - 600 °C

P = 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	
Composition	$C_2H_5O_2$
Density	1100 - 1200 kg/m^3
Heating value	17 - 20 GJ/m^3
• **Water content**	20 - 30 wt.%
• **Ash**	< 0.1 wt.%
• **Acidity (pH)**	2.5 - 3

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1.2: Why pyrolysis?

- **Decouple biomass resource from location and scale of application**
- **Works with a variety of biomass feedstocks**
- **Yields a homogeneous, 2nd generation liquid, 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 **second generation biofuels**

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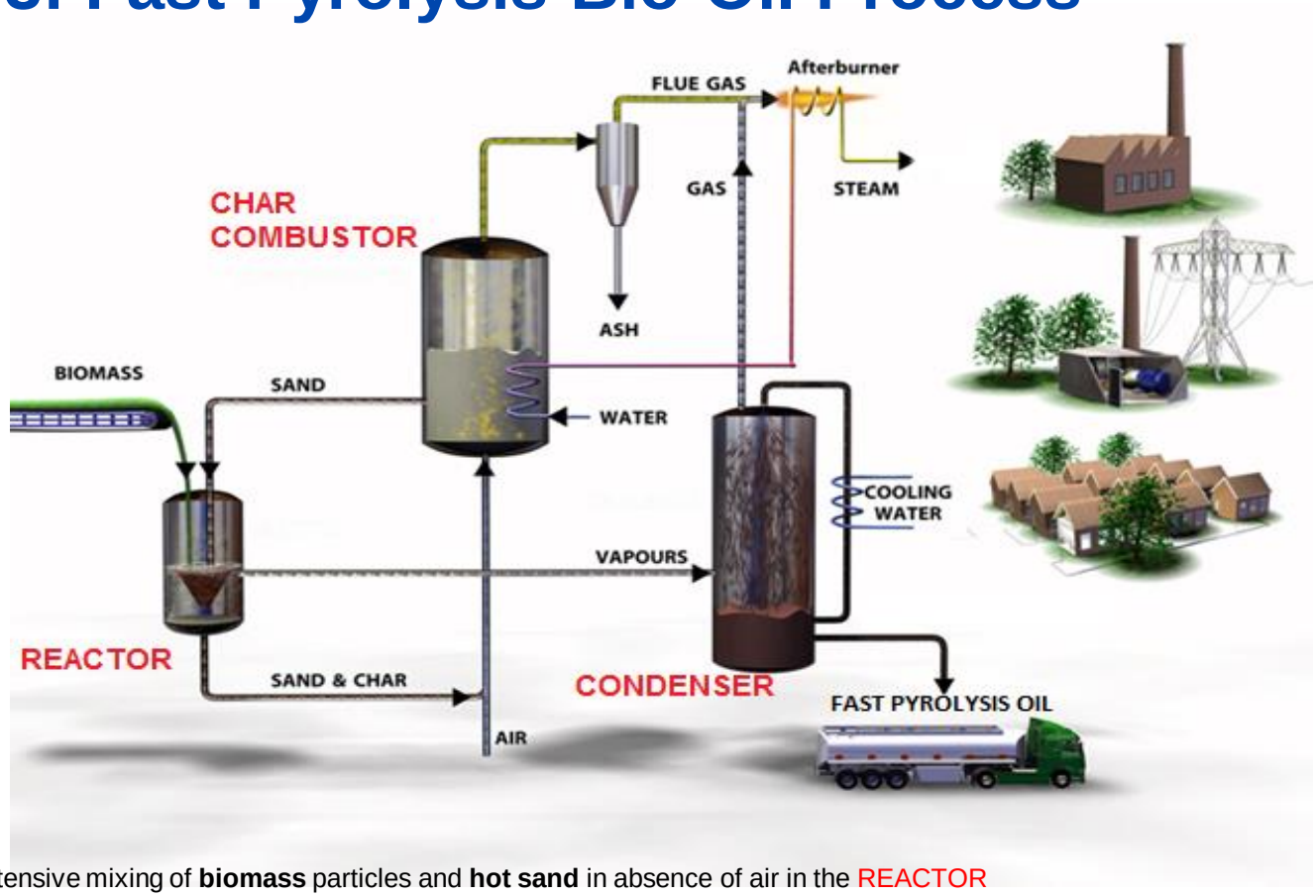
1.3: Fast Pyrolysis Bio-Oil Process



- 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

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2. Technip – BTL Collaboration

- **Rolling out fast pyrolysis bio-oil (FPBO) technology & commercial production**

2.1: Technip – A World Leader in the Energy Industry

- Global footprint with ~32, 500 people in 45 Countries
- Global expertise in Engineering, Procurement and Construction (EPC)
- Technology leader in Hydrogen, Ethylene, Refining & Petrochemical
- Advancing innovative, green solutions to meet the world's energy challenges

Technip's mission is to deliver safe, sustainable, quality and successful projects

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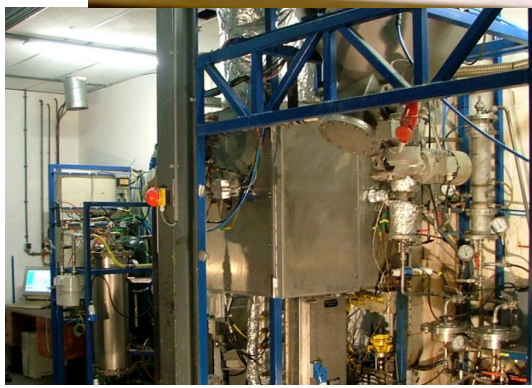
2.2: BTG Bioliquids

- Active in research and development of biomass technology
- Patented fast pyrolysis oil technology
- Reference commercial production plant with operational know-how



BTG Bioliquids contributes towards a sustainable society by providing a renewable alternative to fossil fuels

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2.3: Technip – BTL Collaboration

- Green technology
- Complete turnkey (EPC) delivery of the Fast Pyrolysis Bio-Oil (FPBO) units
- Operational support for commercial production of pyrolysis oil
- The link between biomass (agricultural) and petrochemical Industries

We offer **proven technology** and **EPC expertise** for **modular** pyrolysis oil units.

2.4: Benefits of Technip – BTL FPO Plants

- Plant functions **autonomously** (stand-alone installation)
- **High operating plant efficiency** (~ 85%) as no external fuel or power is consumed during normal operation
- Plant can produce enough LP **steam** to dry biomass from 55%.wt moisture content down to 5%.wt moisture
- At lower biomass moisture content, plant can:
  - Export **excess steam** to an external local user and/or,
  - **Electricity generation** via steam turbine, enough for the plant and export excess to an external grid.
- Absence of inert carrier gas recycle, results in minimum downstream equipment size and thus a small plant with **low CAPEX**.
- **Modular** approach for turnkey delivery of pyrolysis oil plant
  - Shorter delivery time and safer construction
- Plant can be operated and controlled by **one operator**

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3. Commercial Production

Empyro Plant in Hengelo, the Netherlands

Plant Data

Plant Capacity 120 tonnes of dry wood residue /day

Plant Feedstock Wood Residue

Plant Output per year

- **Oil** 20 million litres
- **Electricity** 2,200 MWh
- **Steam** 80, 000 tonnes
- **CO2- eq. reduction** 24,000 tonnes

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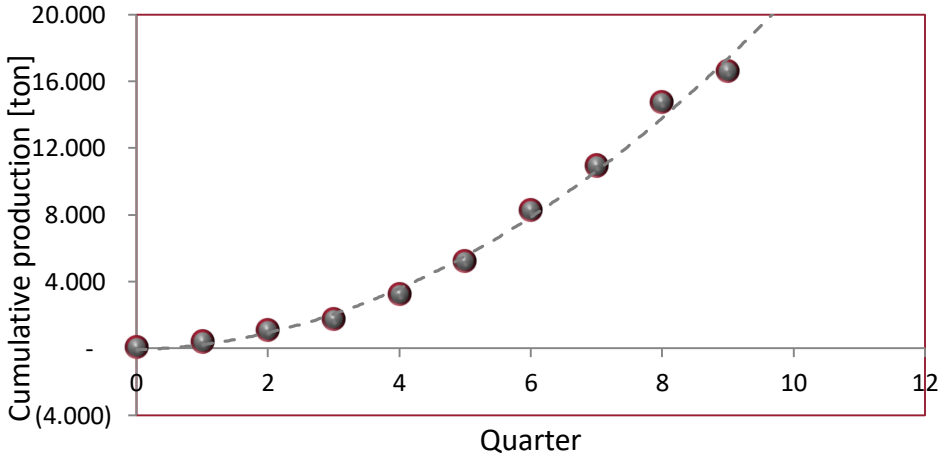
Update Empyro after 2 years of operation

- Scale up successful, our modified RCR (Rotating Cone Reactor) performs very well
- Some start-up challenges (‘teething troubles’) as was expected but Empyro uptime gradually increasing
- Process is stable and easy to control (only one operator during the night shift)
- Oil quality has been excellent from the first batch and remained highly constant since
- September 2017: 18 million liters of oil produced at Empyro!
- Running at 3.3 tons of oil per hour (design capacity) at the moment



4. Fast Pyrolysis Bio-Oil Applications

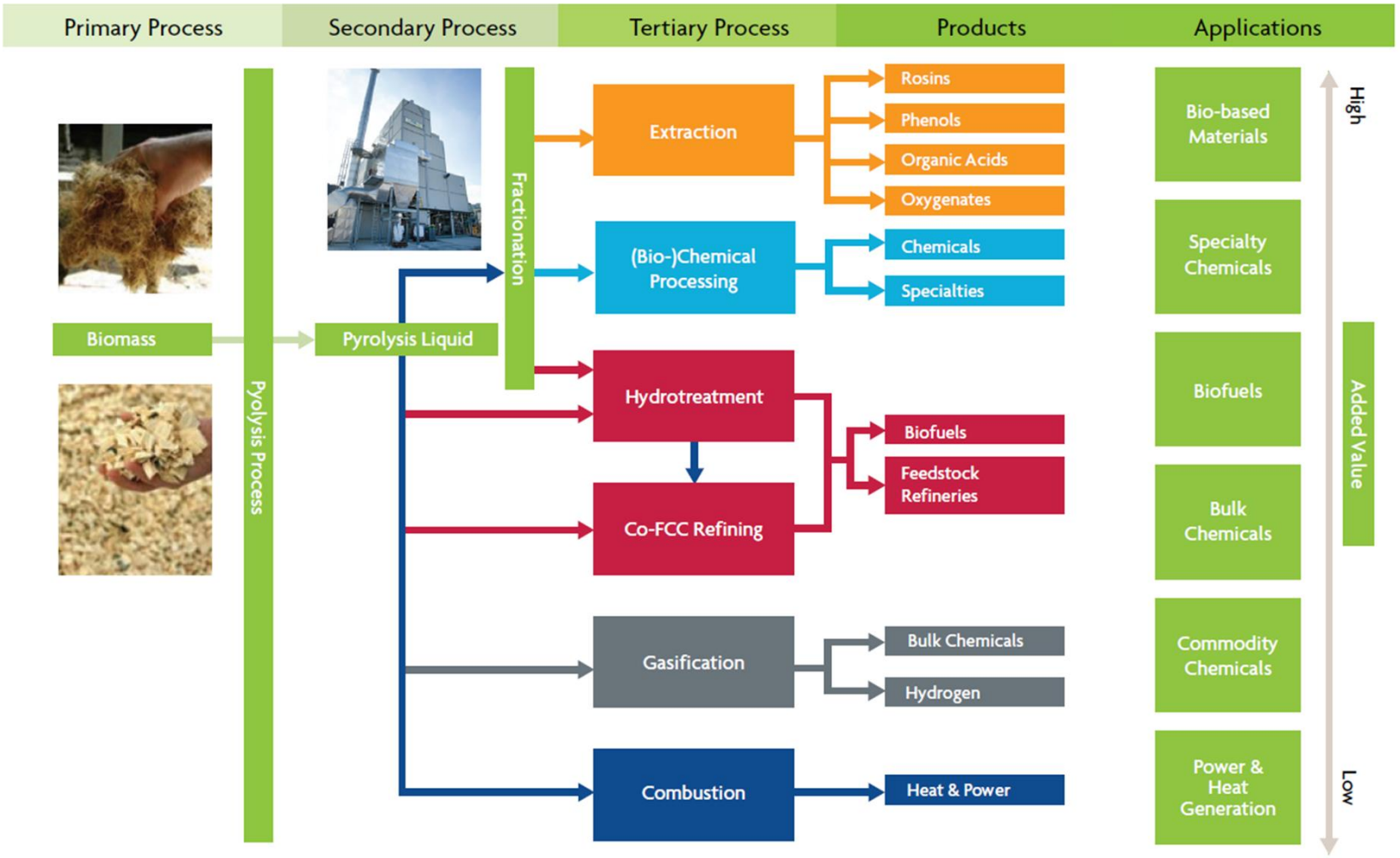
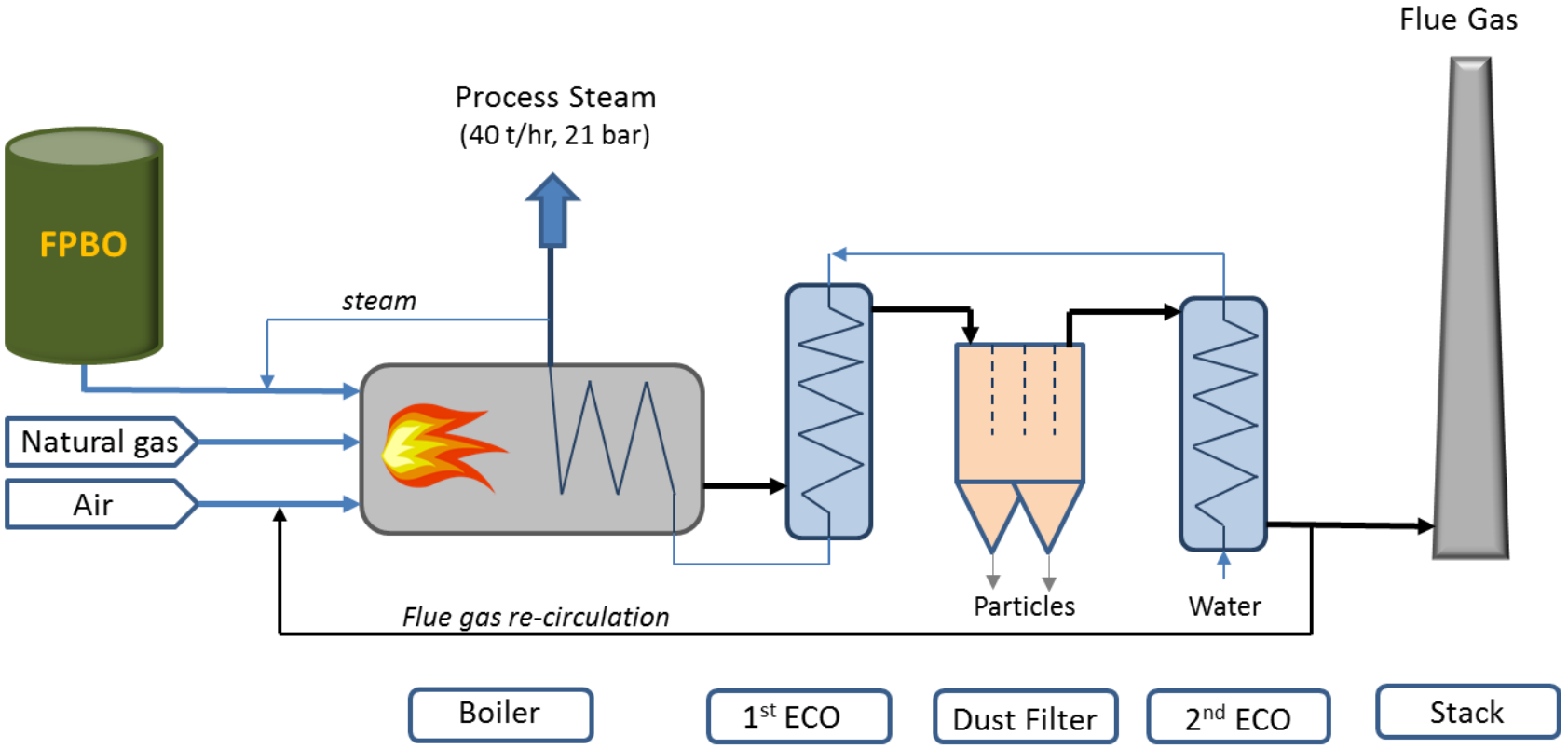


Figure based on BTG Biomass Technology Group B.V. intellectual property

4.1 Pyrolysis Oil Application

Industrial Steam Generation at FrieslandCampina



Schematic drawing of Process Steam Boiler at FrieslandCampina

FrieslandCampina

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4.1 Pyrolysis Oil Application

Industrial Steam Generation at FrieslandCampina

Picture taken of the inside of the FCD boiler when firing both pyrolysis oil and natural gas

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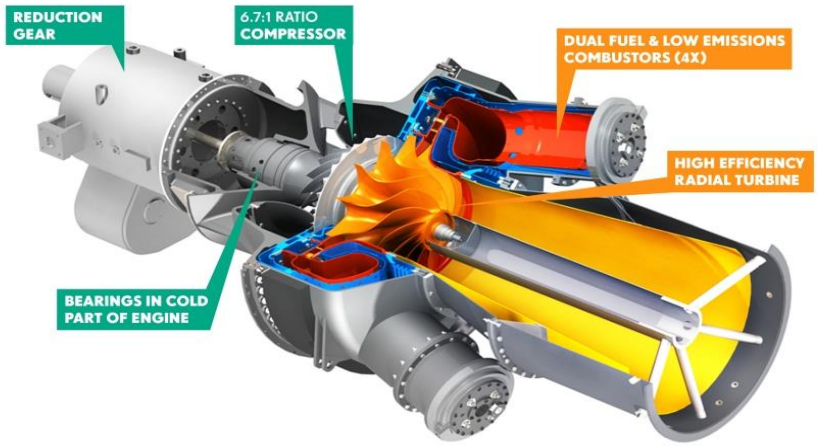
4.2: Heat & Power Generation

Gas Turbines can be used to produce electricity and heat in a combined heat and power plant

- Generation sets can be adapted to run on pyrolysis oil e.g. Opra Turbines
- Heat and power applications in oil & gas, industrial, commercial and marine sectors.



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4.3: Co-FCC Route
Based on Technip FCC Technology

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Fast Pyrolysis
Bio-Oil Plant

Conventional Oil Refinery

Hydrotreater

Gasoline

Diesel

LPG

Fast Pyrolysis Oil

Vacuum
Gas Oil

Distillation

Crude Oil

Co-refining FPBO in FCC enables production of **2nd generation bio-fuels** while utilizing existing refining infrastructure.

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4.4: Technip 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**

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4.5: Transition Towards a Bio-based Economy

Technip and **BTL** are developing the **Co-FCC Route** to facilitate:

- Bio-based feedstock (FPBO) for the petrochemical industry
- Refining industry production of second generation biofuels and bio-based products while utilizing existing infrastructure
- A viable and cost effective development of a bio-based economy in order to meet renewable energy and sustainability targets

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