Where energies make tomorrow

Fast pyrolysis bio-oil technology and production

Sustainable, bio-based solutions for the heat, power, biofuels and chemicals industries

T.EN TECHNIP ENERGIES

Delivering safe, sustainable, quality projects

With more than 50 years of experience gained through involvement in 30 grassroots refineries and more than 100 expansion projects, Technip Energies is a leader in the refining industry. The company's portfolio of technologies includes proprietary refining technologies and equipment for catalytic cracking, and the recovery of refinery offgas and propylene, among others. Technip Energies also collaborates with other international licensors to optimize third-party schemes.

Fast pyrolysis bio-oil technology

As part of its commitment to meet the world's energy challenges, Technip Energies leverages its refining experience to provide alternative "green" energy and bio-based products through the delivery of fast pyrolysis bio-oil (FPBO) technology which converts biomass to pyrolysis oil.

Next generation bio-liquids

Pyrolysis oil is a renewable, second-generation bioliquid that can be used as a sustainable alternative to fossil fuels to produce renewable energy and chemicals.

FPBO technology transforms non-food lignocellulosic biomass into liquid. All kinds of biomass residue not competing with the food chain can be used. This bio-oil is easy to store and transport, and can be conveniently used in versatile applications in a bio-based economy, including heat, power, transportation fuels and in bio-refineries.

Licensed technology installations

Technip Energies delivers complete turnkey FPBO units, including engineering, procurement and construction (EPC), with core components of the plant based exclusively on BTG Bioliquids patented FPBO licensed technology. The pyrolysis plant is based on modular design which allows for quick installation.

BTG Bioliquids' experience in the design and commercial operation of one of the world's first FPBO production facilities (Empyro), combined with Technip Energies's global EPC strength, fosters our joint commitment to provide our customers with proven technology, EPC expertise and commercial pyrolysis oil production facilities.

About BTG Bioliquids

BTG Bioliquids is a pyrolysis technology provider. Within two seconds, BTG Bioliquids' technology efficiently converts most types of non-food biomass into a second generation bio-oil.

BTG Bioliquids B.V. was established by BTG Biomass Technology Group in 2007 to commercialize its biomass pyrolysis technology.

Over the years, BTG Bioliquids has constantly improved its pyrolysis technology, developed innovative solutions and registered several patents. BTG Bioliquids fully enjoys BTG's experience and know-how in building high-quality pyrolysis plants.

For more information, visit www.btg-Bioliquids.com.

btg bioliquids

Commercial plant demonstrates FPBO benefits

Empyro BV's pyrolysis oil production facility began operations in early 2015. The plant converts five tons of wood residues per hour into pyrolysis oil, process steam and electricity.

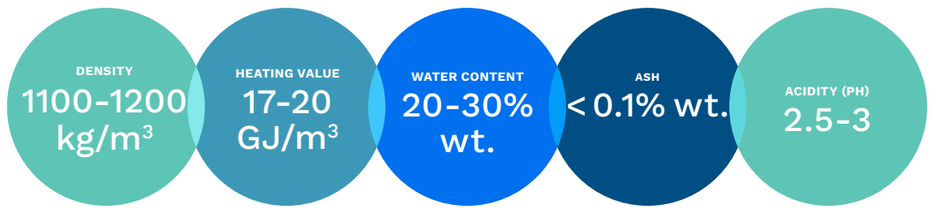
Plant data

- Capacity: 120 tons of dry biomass/ day
- Up to 4,500 MWh gross power production
- Feedstock: Wood residue
- Plant output per year:
  - 20 million liters oil
  - 80,000 tons steam
  - CO_2- eq. reduction - 24,000 tons
  - Overall conversion efficiency is 85% (biomass to pyrolysis oil and by-products of the process)

Benefits of BTG Bioliquids' patented FPBO technology

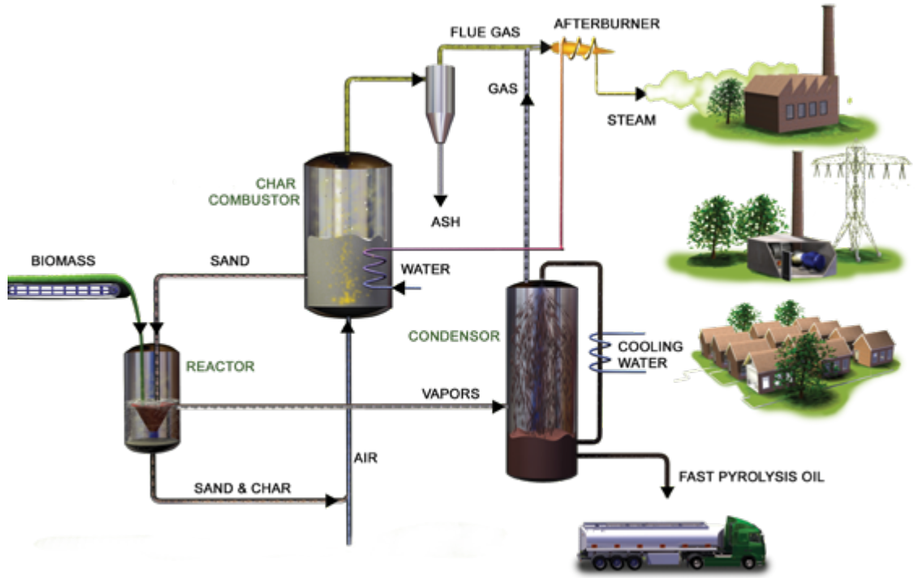
- High efficiency operating plant as no external fuel (e.g. natural gas) or power is consumed during normal operation.
- Plant can produce enough low pressure steam to dry biomass of 55% wt moisture content, down to 3% wt.
- At lower biomass moisture content, the plant can export excess steam to a local user.
- Using a steam turbine, our installation also can produce enough power to support the FPBO unit and export excess to an external grid.
- Absence of inert carrier gas results in minimum downstream equipment and lower CAPEX.
- Pyrolysis plant can be equipped with an optional patented pyrolysis oil post-treatment equipment. This facilitates the production of clean, homogeneous single-phase pyrolysis oil from more challenging biomass.
- Modular approach for turnkey delivery of pyrolysis oil plants, resulting in shorter delivery time and safer construction.

Typical FPBO characteristics



How is FPBO produced?

The graph below depicts an overview of the pyrolysis process that converts second-generation biomass to fast pyrolysis bio-oil.



- The technology is based on intensive mixing of biomass particles and hot sand in a reactor without air. Pyrolysis oil, char and gas are the primary products from the process.
- The char and sand are recycled to a combustor where the char is burned to reheat the sand.
- The vapors leaving the reactor are rapidly cooled in the condenser yielding pyrolysis oil and some gases.
- The gases and 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, avoiding mineral depletion.

Sustainable alternatives

Pyrolysis oil can be applied in the generation of heat and power, transportation fuels and bio-based chemicals.

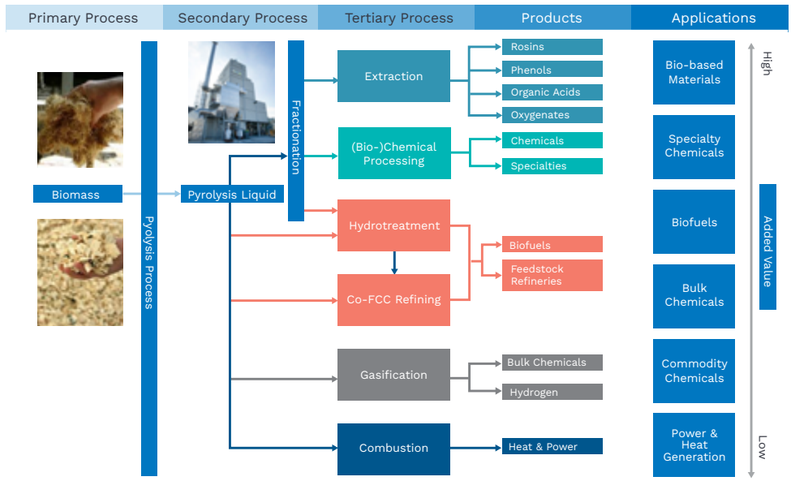


Figure based on BTG Biomass Technology Group B.V. intellectual property

Cleaner energy source: heat and power

Substituting pyrolysis oil for fossil fuel can be done today by (co-)combustion of natural gas, coal- or oil-fired boilers, furnaces and turbines. Pyrolysis oil combustion in a boiler or furnace for heat and/or electricity generation is the simplest and straightforward application. Retrofitting these systems requires limited investments and due to its greenhouse gas reduction of around 90 percent, pyrolysis oil offers a unique opportunity to make energy supply cleaner and sustainable.

Advancing bio-based economy

Technip Energies owns Fluid Catalytic Cracking (FCC) technology and is developing a route to co-feed FPBO into an FCC unit. This approach will enable the refining industry to produce biofuels and high-value bio-based chemicals in an increasingly renewable way without changing the entire existing infrastructure of the plant.

Feedstock for the petrochemical industry

Pyrolysis oil is an important step in the transition towards a sustainable economy. It makes maximum use of the agricultural sector biomass residues and provides a link to the petrochemical industry by providing a potential feedstock, facilitating a comprehensive, cost-effective approach to a bio-based economy.

What we offer

Technip Energies offers licensed pyrolysis technology delivered as a turnkey project that includes:

- Permission to use one fast pyrolysis installation based on BTG Bioliquids' pyrolysis technology
- Full scope of services for engineering, procurement and construction (EPC) of the plant, including;
  - Core modular pyrolysis units preassembled on skids
  - Supporting equipment systems such as biomass pre-treatment, steam system, oil storage facilities and other utilities
  - Commissioning of the pyrolysis installation
  - Performance guarantee

We also offer customized supporting services that employ BTG Bioliquids' advanced research facilities in the biomass section and Technip Energies's technical capabilities in the refining industry. Examples include:

- Feasibility studies with cost estimation
- Project management
- Engineering services including Front-End Engineering and Design (FEED) studies for co-feeding pyrolysis oil in FCC systems
- Storage tank parks for pyrolysis oil
- Feedstock (biomass) testing
- Testing pyrolysis oil in energy systems
- Assistance with implementation of pyrolysis technology and set-up of pyrolysis supply chain
- After-sales services including spare parts
- Pyrolysis oil sales

Hydrogen plant in The Netherlands depicting Technip Energies' technical capabilities in the refining industry.

Technip Energies

The Netherlands
Zain Abdin
+31 79 3293625
zainul.abdin@technipenergies.com

Jacco Kroeze
+31 79 3293745
jacco.kroeze@technipenergies.com

technipenergies.com

BTG Bioliquids BV

The Netherlands
Gerhard Muggen
+31 53 486 2287
gerhard.muggen@btg-bioliquids.com

btg-bioliquids.com