ETIP Bioenergy
European Technology and Innovation Platform

Transport fuels via gasification

DEFINITION

Gasification is a thermochemical conversion process at 800-1300°C using a sub-stoichiometric amount of oxygen (typically λ = 0.2-0.5). Under these conditions the biomass is fragmented into raw gas consisting of rather simple molecules, such as: hydrogen (H_2), carbon monoxide (CO), carbon dioxide (CO_2), water (H_2O), methane (CH_4), H_2S, NH_3, HCl, etc. Solid by-products are: tar, char, and inorganic matter. For gasification, any lignocellulosic material is suitable as feedstock. This includes wood from forestry, short rotation coppice, and lignocellulosic energy crops, such as energy grasses and reeds and biomass from dedicated felling of forestry wood.

PROCESS TECHNOLOGY

After size reduction, the raw material is moved into the gasifier. Depending on the desired raw gas composition, typical gasification agents are oxygen and water/steam. The combustible part of the raw gas consists of H_2, CO, CH_4 and short chain hydrocarbons; the non-combustible components are inert gases. A higher process temperature or the use of steam as gasification agent lead to an increased H_2 content. High pressure, on the other hand, decreases the H_2 and CO contents.

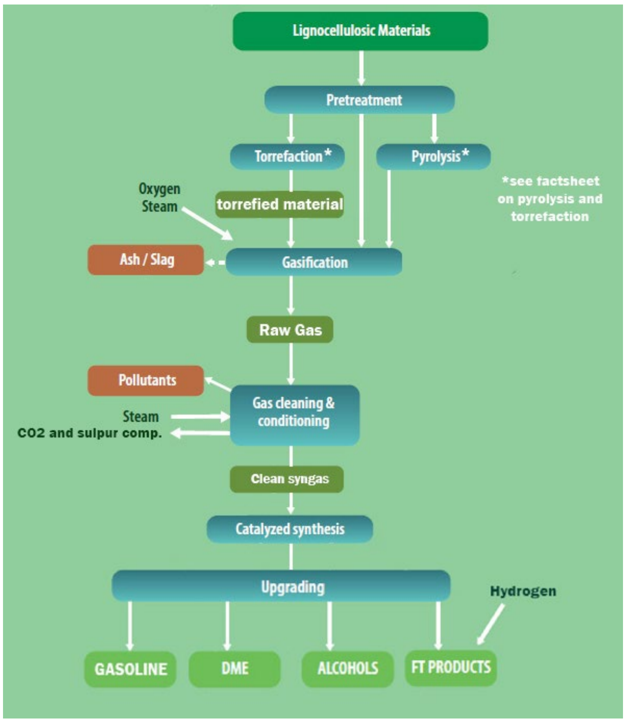

Figure 1: Transport fuels via gasification value chain

Entrained-flow gasifiers operate at high temperatures (1,000-1,300°C) and are suitable when a low CH_4 content is preferred, however feedstocks with very low particle sizes are required. Bubbling and circulating bed gasifiers operate at lower temperatures

(800-1,000°C) and can handle highly heterogeneous materials.

The process heat can either come from an autothermal partial combustion of the processed material in the gasification stage or allothermally via heat exchangers or a heat transferring medium. In the latter case, heat may be generated by combusting the processed material (i.e. combustion and gasification are physically separated) or from external sources. After the gasification process, impurities such as dust, inorganic matter, bed material, tars and alkali compounds are removed through various cleaning steps to obtain a clean fuel gas, which meets the quality requirements of the synthesis unit.

APPLICATIONS

The technology for the use of the synthesis gas intermediate is well-established for fossil-derived synthesis gas and is essential for producing hydrogen in refineries as well as chemicals. Selective catalytic chemical reactions convert the synthesis gas to, by choice, methane, Fischer-Tropsch hydrocarbons, methanol or dimethyl ether (DME), respectively, at temperatures of 200 up to 400°C.

- Methane can be distributed through the natural gas grid and used directly as renewable compressed natural gas (CNG) or liquefied and used in heavy duty vehicles (LNG trucks).
- The Fischer-Tropsch hydrocarbon product is a mixture with a wide range of molecular weights from LPG over naphtha and distillates to waxes. The waxes are typically hydrotreated and then the combined liquid products are fractionated by distillation to gasoline, diesel and jet fuel.

Methanol and DME can be used as such in adapted vehicles or processed further into gasoline.

The typical energy conversion efficiency (biofuel output energy/biomass feedstock energy as received) from feedstock to advanced biofuel products ranges from 40-50% for drop-in hydrocarbon fuels and 60-70% for gases and methanol. The synthesis gas can also be converted to ethanol by micro-organisms at ambient temperature. In addition, hydrogen can be extracted directly from the gas.

EXAMPLES OF DEMOPLANTS

https://www.etipbioenergy.eu/databases/production-facilities

Location: Dunkirk, France

Plant: BioTFuel plant of TotalEnergies, started operation in 2021 (TRL 6-7)

Technology: Gasification, purification and FT synthesis (technologies of TKK and Axens)

Feedstock: Torrefied biomass (straw, forest waste, dedicated energy crops)

Products: 8000 t/y of Fischer-Tropsch liquids, jet fuel component

Link: https://totalenergies.com/energy-expertise/projects/bioenergies/biotfuel-converting-plant-wastes-into-fuel

Location: Eggenstein-Leopoldshafen, Germany

Plant: bioliq® Plant of Karlsruhe Institute of Technology, started operation in 2014 (TRL 6-7)

Technology: High-pressure entrained-flow gasification followed by gasoline synthesis, achieved in two stages via dimethyl ether (DME) as intermediate product

Feedstock: Biomass, pre-treated in a fast pyrolysis step (Biosyncrude® pyrolysis)

Products: either 600 t/y of DME or conversion into 360 t/y gasoline-type fuels

Link: https://onlinelibrary.wiley.com/doi/full/10.1002/cben.202000006
https://www.itc.kit.edu/english/57.php

More information on www.etipbioenergy.eu.

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