Bioenergy value chain 2: biomass to gas

Feedstock

For gasification, any lignocellulosic material is suitable as feedstock. The term lignocellulosic covers a range of plant molecules/biomass containing cellulose, with varying amounts of lignin, chain length, and degrees of polymerization. This includes wood from forestry, short rotation coppice (SRC), and lignocellulosic energy crops, such as energy grasses and reeds. Biomass from dedicated felling of forestry wood is also lignocellulosic but is not considered sustainable.

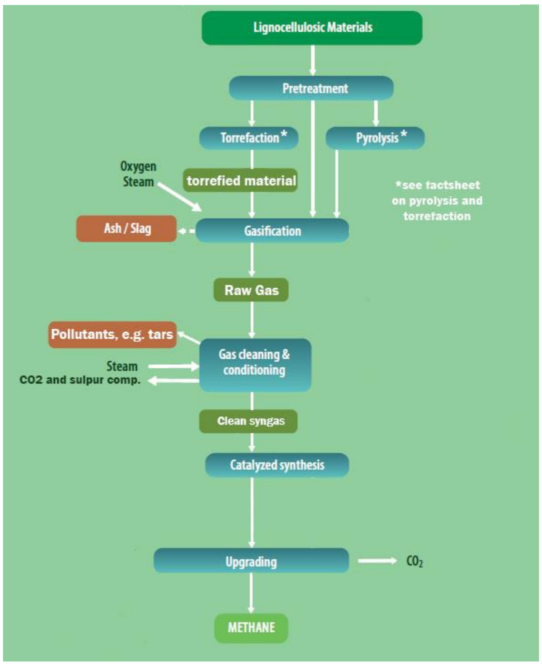
Gasification

Gasification is a thermochemical process at 800-1300°C and under shortage 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, carbon monoxide, carbon dioxide, water, methane, etc. Solid by-products are: char, ashes and impurities. The gaseous molecules are then chemically re-synthesized to biofuels.

After size reduction of the raw material, it is moved into the gasifier. Typical gasification agents are: oxygen and water/steam. The choice of the gasification agent depends on the desired raw gas composition. The combustible part of the raw gas consists of hydrogen (H_2), carbon monoxide (CO), methane (CH_4) and short chain hydrocarbons; the non-combustible components are inert gases. A higher process temperature or using steam as gasification agent leads to increased H_2 content. High pressure, on the other hand, decreases the H_2 and CO.

Entrained-flow gasifiers operate at high temperatures (1000-1300 °C) and are therefore suitable when a low methane content is preferred. Bubbling and circulating bed gasifiers in contrast are operated at lower temperatures (800-1000 °C).

Figure 1: Biomass-to-gas value chain



End products

Synthetic natural gas (SNG)

For application as car fuels, SNG is either compressed at around 200 bar or liquefied at -161.7°C at atmospheric pressure.

By-products

Carbon monoxide (CO)

Carbon monoxide is not suitable for the use in vehicle engines.

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 heat transferring medium. In the latter case the heat may be generated by the combustion of the processed material (i.e., combustion and gasification are physically separated) or from external sources.

Impurities of the raw gas depend on the gasification condition and used biomass and can cause corrosion, erosion, deposits and poisoning of catalysts. It is therefore necessary to clean the raw gas. Depending on technology impurities such as dust, ashes, bed material, tars and alkali compounds are removed through various cleaning steps. Components having mainly poisonous effects are sulphur compounds, nitrogen and chloride. The sulphur compounds can be withdrawn by commercially available processes; to get rid of nitrogen and chloride wet washing is required.

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The cleaned raw gas will then be upgraded to clean synthesis gas (syngas).

- An optimal H_2/CO ratio of 3,0 is obtained by the Water-gas-shift reaction: $CO + H_2O \leftrightarrow CO_2 + H2$.
- CO_2 removal can be performed by physical (absorption to water or other solvents) or chemical (absorption to chemical compounds) methods. Other absorption methods are based on pressure or temperature variations.

Product formation

Synthetic natural gas or Bio-SNG

The upgrading to SNG (synthetic natural gas) requires methanation of the cleaned syngas, followed by a final CO_2 removal. In the methanation step (catalyzed by nickel oxide) at 20-30 bar pressure and high temperature carbon monoxide reacts with hydrogen forming methane and water

Example projects on biomass-to-gas production

Pilot

ECN	Dutch project producing synthetic natural gas; operational in 2008 ; currently idle
GAYA	producing synthetic natural gas; run by French consortium; start-up planned in 2017

Demo

GoBiGas I	producing synthetic natural gas; run by Goteborg Energi (Sweden); operational since 2014

The withdrawal of CO_2 can be performed by water scrubbing (a counter-current physical absorption into a packed column) and Pressure Swing Adsorption (an absorption into a column of zeolites or activated carbon molecular sieves followed by a hydrogen sulphide removing step) technologies. Natural gas quality is reached at 98% methane content. The final step is the gas compression (up to 20 bar for injection into the natural gas grid, up to 200 bar for storage or for use as vehicle fuel).

Further information

Read up-to-date information about the thermochemical conversion technology at www.biofuelstp.eu