

Bioenergy value chain 3: power and heat via gasification

Lab scale

Bench scale

Pilot Plant

Demonstration

Production

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

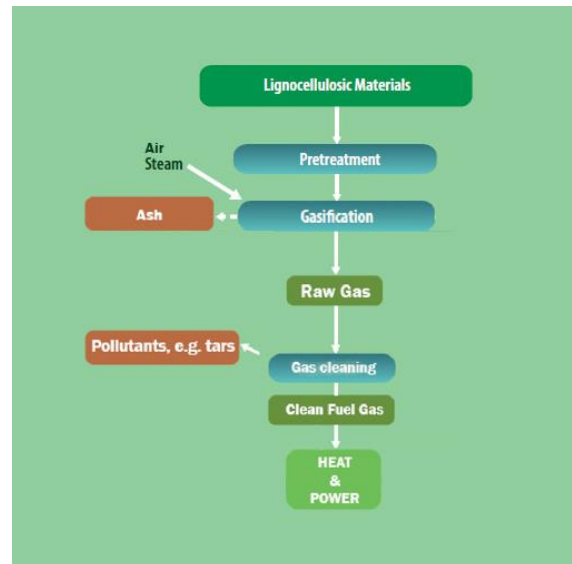
Gasification is a thermochemical process at 800-1300°C and under shortage of oxygen (typically $\lambda = 0.2-0.5$). Under these conditions the biomass is fragmented into raw gas consisting of rather simple molecules such as: hydrogen, carbon monoxide, carbon dioxide, water, methane, etc. Solid by-products 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 (H₂), carbon monoxide (CO), methane (CH₄) and short chain hydrocarbons; the non-combustible components are inert gases. A higher process temperature or using steam as gasification agent leads to increased H₂ content. High pressure, on the other hand, decreases the H₂ 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).

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.

Figure 1: Power-to-heat-via-gasification value chain



End products

Power

Heat

The excess heat of the power production can be used for district heating, district hot water or industrial process heating.

Cooling

An alternative way to use the excess heat is to produce cooling from heat-driven heat pumps.

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.

The cleaned raw gas, now a clean fuel gas, must meet the quality requirement of the power (and heat) generating unit which normally would be a gas engine or a gas turbine.

Application

Use as engine fuel

The fuel gas can be used in spark-ignited (Otto) engines and in compression (Diesel) engines and for gas turbines for power and heat production. Engines are applied for power generation in the range of 500 kW up to 40 MW. Biomass-to-electricity efficiency in practice lies between 25 and 31 %, and the overall performance between 80 and 92 %

As heat is not always a desired output of a CHP plant, some plants use an organic Rankine cycle to further convert heat into electricity, increasing the electric output by 20 to 30 %.

Another point of attention is that the exact composition of the producer gas will vary with each batch of biomass feedstock. This requires advanced automatic engine controls to adapt engine operations to maintain load and avoid excessive amounts of hazardous emissions.

One way to limit too brisk changes in engine operation is to use sufficiently large buffer tanks.

Use for co-firing

The idea of co-firing is to use existing large scale power plants and replace part of the fossil fuels (coal, oil, natural gas) by biomass.

Example of gasification CHP plants

Pilot

Fundacion Cidaut Spanish project producing 100-150 kW_{el}

Commercial

Skive plant Capacity of 6 MW_{el} and 20 MW_{th}; run by city of Skive (Denmark); operational since 2008

Güssing plant Capacity of 2 MW_{el} and 4,5 MW_{th}; run by a public-private consortium (Austria); operational since 2002

CFB Geertruidenberg 9600 MW_{el} coal power plant, 30 MW_{el} of co-firing product gas; run by the Dutch energy company Essent; operational since 2005

The previous gasification of the biomass offers a number of advantages compared to direct co-firing when solid biomass is fed into the boiler:

- Higher fuel flexibility
- No significant impact on the performance of the boiler
- Less strict requirements in the producer gas quality as compared to other applications
- Possibility of keeping the biomass ash separated from coal ash.

Further information

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