

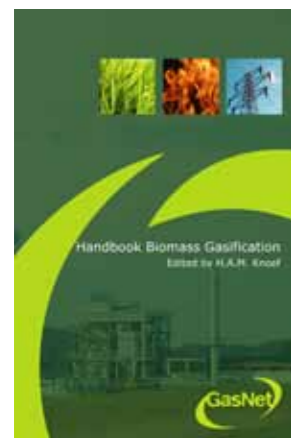
BTG offers

The development of bioenergy and biomass gasification in particular requires specific know-how, skills and experience. With more than twenty years of focused dedication to the furtherance of biomass gasification, BTG offers all that is needed to facilitate the successful implementation of these projects worldwide.

The BTG activities are environmentally, technologically and financially sound, reduce the emission of greenhouse gases, contribute to local socio-economic development and are true showcases and incubators for further commercial take-off. Projects are always co-developed and implemented in close-cooperation with partners. BTG is facilitating and promoting biomass gasification projects and portfolios worldwide and can offer the following:

- > Biomass gasification technology **expertise** on fixed bed, fluid bed, entrained flow, waste and plasma gasification
- > **Information** through several websites prepared and maintained by BTG, it's dedicated library and the published Handbook on Biomass Gasification in 2007
- > Laboratory **facilities** are available for gasification, and upgrading
- > **Technical assistance** in project development, permitting, design, commissioning, tendering, training in operation and maintenance
- > Technical **services** and implementation support
- > Perform **studies** like market, feasibility, scenario & policy, quick scan studies and carbon consultancy
- > Process **engineering** and project **management** of complete plants, including legislation aspects (in co-operation with partners)
- > **Due Diligence** for specific clients

Additional activities BTG covers are business development, project development, finance and other commercial services related to flash pyrolysis and bioenergy in general.



BTG Biomass Technology Group BV

BTG is an independent private firm specialised in the conversion of biomass into biofuels and bioenergy. Since its privatisation in 1987, BTG has carried out more than 1500 assignments worldwide. Field experience has been gained in more than 80 countries and more than 60 bioenergy systems and factories have been implemented. The company's longstanding focus on and dedication to bioenergy has resulted in the establishment of more than 20 subsidiaries and spin-off companies in the bioenergy sector.



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Spin-offs

BTG BioLiquids BV
BTG BioHeat International BV
BTG-PTZ Power Systems BV
BTG-Central Europe s.r.o.
BTG-BioEnergy Investment BV



BTG's Biomass Gasification Expertise

Gaseous Biofuel from Biomass & Waste

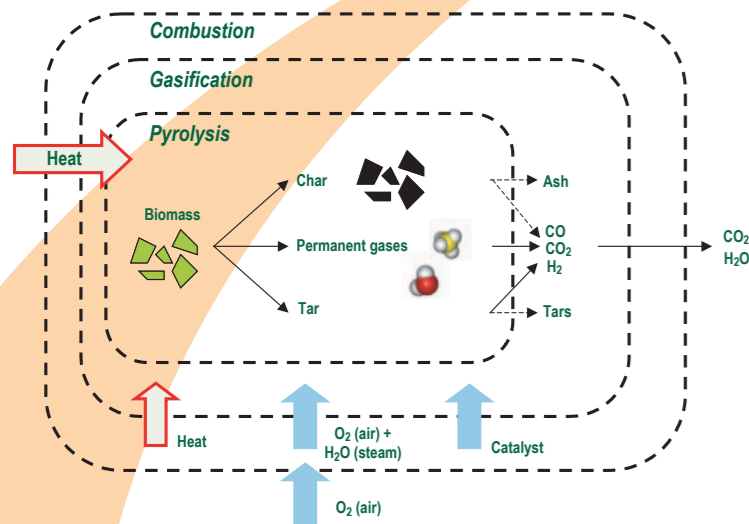


Gasification of Biomass & Waste

BTG established its reputation as a world-leading expert in the field of biomass gasification

Gasification

The importance of gasification can be derived from the history; the existence of fuel gas was a 'catalyst' for the development of the gas engine. All over the world, we use the term gas pedal, even in diesel cars.



Biomass gasification is an endothermic thermal conversion technology where a solid fuel composed of the main elements carbon, hydrogen and oxygen, is converted into a combustible gas. A limited supply of oxygen, air, steam or a combination serves as the oxidizing agent. The heat can be generated internal by partial combustion of the biomass (autothermal gasification) or external by a heat carrier like hot sand (allothermal gasification).

The product gas consists of carbon monoxide, carbon dioxide, hydrogen, methane, trace amounts of higher hydrocarbons, water, nitrogen (with air as oxidant) and various contaminants, such as small char particles, ash, tars, higher hydrocarbons, alkalies, ammonia, acids, and the like.

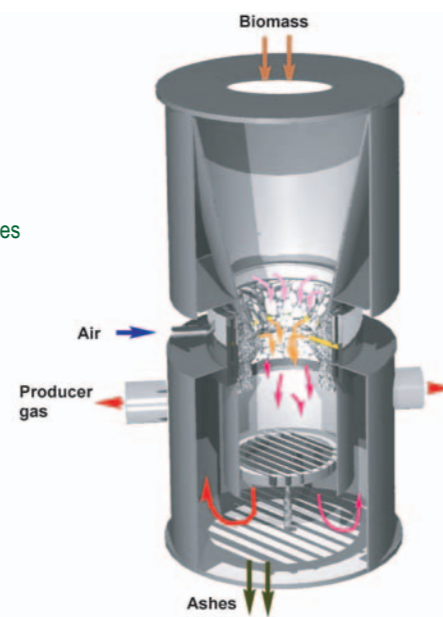
Different type of gasifier design can be distinguished:

- > fixed bed: downdraft, updraft, crossdraft
- > fluid bed: bubbling, circulating, twin-bed
- > entrained flow
- > stage gasification with physical separation of pyrolysis, oxidation and/or pyrolysis zones
- > slagging bed gasification
- > plasma gasification

From a chemical point of view, the process of biomass gasification is quite complex.

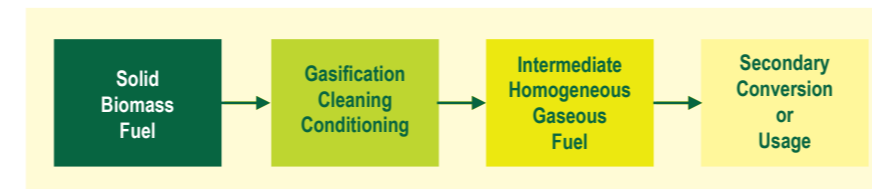
It includes a number of steps like:

- > thermal decomposition to non-condensable gas, vapors and char (pyrolysis);
- > subsequent thermal cracking of vapors to gas and char;
- > gasification of char by steam or carbon dioxide;
- > partial oxidation of combustible gas, vapors and char.



Advantages

Gasification has the potential to produce a clean homogeneous fuel from an contaminated and inhomogeneous solid fuel. The clean gas is derived from the intermediate raw gas after sufficient cleaning and conditioning. This offers significant advantages during the secondary conversion process or usage of the gas:



- > The gas volumes to be conditioned after gasification (producer gas) are much smaller than those after combustion (flue gas)
- > Producer gas can be used in multiple ways (see applications)
- > The different steps in fixed bed gasification offers the possibility to physically separate the different steps (pyrolysis, partial oxidation, reduction) involved in the gasification process
- > Biomass gasification can be efficiently applied at very small scale (fixed bed), to medium scale (fluid bed), to extremely large scale (entrained flow)
- > It is possible to remove the CO₂ in the producer gas before subsequent usage
- > Potential for de-centralized medium scale Waste-to-Energy applications, for instance as an alternative for large scale waste incineration plants.

These advantages means that biomass gasification:

- > Can be characterized as an efficient and eco-friendly technology for energy production from biomass and waste
- > Fits perfectly into the EU Renewable Energy Policy, Climate Change, Sustainability and other upcoming Directives and policy measures.



Applications

Gasification of biomass converts a solid renewable fuel to a gas that can be used in a modern conversion device, such as a gas turbine or engine, for electricity and heat production. This opens the possibility of moving from the traditional, small-scale, low-efficiency steam cycle to the efficient gas turbine. Recently, other applications became of interest like syngas production, methane, hydrogen (for fuel cells), etc.

The following applications can be distinguished:

- > Gasification for heat production
- > Fixed bed gasifiers for power or CHP production from biomass
- > Fluid bed gasification for co-firing gas from biomass in existing power plants
- > Fluid bed gasification for large scale advanced power production (IGCC)
- > Entrained flow gasification for syngas production for liquid (transportation) fuels like methanol, FT-diesel, as well as chemicals as purely syngas containing only CO and H₂ is the chemical building block for the organic chemistry.

To promote the technology in general and to contribute to the Kyoto protocol, BTG participates in several Networks on Biomass Gasification. Due to more than 20 years active in the field of biomass gasification, BTG has the knowledge of almost all available technologies and its suppliers.

BTG's Test facilities

BTG has several test facilities available, which are used in combination with BTG's major other core business, pyrolysis.



Two stage gasification

Two-stage gasification unit for production of a clean fuel gas.

Capacity:	1 - 5 kg biomass/hour
Product:	producer gas – clean fuel gas
Feedstock examples:	wood, energy crops, agricultural residues, waste, dried manure, etc.
Particle size:	up to 10 mm
Moisture content:	up to 25 wt%
Typical runtime:	1 - 4 hrs
Basic results:	gas yield, gas composition, tar content & composition, mass- & energy balance



(Catalytic) gasification of liquids

Gasification of liquids to produce clean fuel gas - Syngas.

Capacity:	1 kg liquids /hour
Product:	producer gas – clean fuel gas - syngas
Feedstock examples:	pyrolysis oil, vegetable oil, waste oil,.....
Gasifying medium:	steam/air
Temperature:	< 1000 C
Pressure:	atmospheric
Typical runtime:	1 - 4 hrs
Basic results:	gas yield, gas composition, tar content, mass- & energy balance



Reforming in supercritical gasification

Pilot-plant installation for the conversion of wet biomass and residues in supercritical water to produce Substitute Natural Gas (SNG) or Hydrogen.

Capacity:	5 – 30 L/hr
Product:	(Compressed) Substitute Natural Gas – (C)SNG, / Hydrogen / SynGas
Feedstock examples:	wet biomass and residues, glycerine, vinnasse, wine residues, etc.
Moisture content:	up to 95 wt%
Typical runtime:	2 – 5 hrs
Basic results:	gas yields, gas compositions, mass- and energy balance



Tar Measurement Standardisation

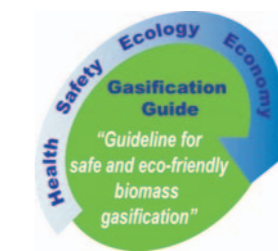
Since its early existence, BTG has been actively involved in Standardization of measuring tar concentration in producer gas. Most methods are based on condensation in a liquid or adsorption on a solid material. Off-line methods used by BTG are the SPA method and Gravimetric analysis:

- > The Solid Phase Adsorption (SPA) technique developed at KTH, Sweden. A gas sample is sucked through an amino-sorbent collecting all tar compounds. Afterwards, by using different solvents the aromatic and phenolic compounds are collected separately and analysed by using a GC. Although the sampling is quite easy and fast, the total analysis may take a few hours. (Reference: Brage, Qizhuang, Guanxing Chen and K Sjostrom, Use of amino phase adsorbent for biomass tar sampling and separation, Fuel 76 (2), pp 137-142 (1997)).
- > The International CEN/BT/TF143 Standard "Biomass Gasification — Tar and Particles in Product Gases — Sampling and Analysis" published in 2005, information can be found at www.tarweb.net.

More recently, BTG and KTH started the development of a real on-line tar measurement method based on Photo-Ionization Detection (PID). This method should in particular be suitable for measuring low tar concentrations, which enables to use such device as a process control instrument and as a safeguard for expensive downstream equipment like compressor, gas engine, gas turbine, etc.

Links:

www.gasnet.uk.net
www.gasification-guide.eu
www.gasifiers.org
www.tarweb.net
www.gasification.eu (Dutch)
www.thermalnet.co.uk



biomass technology group

Due Dilligence

BTG has substantial experience with conducting independent appraisals of companies and gasification technologies for due diligence purposes. BTG's core expertise lies in the analysis of the company's technical and business competence. A wide range of studies is conducted to meet specific client requirements.

Typical clients include:

- > Banks for project finance
- > Venture capital funds, venture capitalists and private equity funds for equity stakes,
- > Strategic investors for joint ventures and acquisitions
- > Project developers & public authorities to confirm that a process is 'fit for purpose'.

Recent examples:

- > Due diligence assessment of new innovative technologies for the production of biofuels, which included a review and comparison of three companies in the USA developing and commercializing new gasification process for conversion of biomass into liquid biofuels.
- > Due diligence assessment of innovative large-scale technologies for the production of syngas and synthetic liquid biofuels.
- > Due diligence assessment of a waste to energy gasification process for clean energy production and syngas production