Biomass gasification as an opportunity for gas companies

Marc Perrin, GDF SUEZ, Research and Innovation Division, CRIGEN, 93211 St Denis, France

Olivier Guerrini, GDF SUEZ, Research and Innovation Division, CRIGEN, 93211 St Denis, France

Guillaume Peureux, GDF SUEZ, Research and Innovation Division, CRIGEN, 93211 St Denis, France

Julien Duclos, GDF SUEZ, Research and Innovation Division, CRIGEN, 93211 St Denis, France

Background

Solid ligneous biomass (fresh wood, forestry bio-products, demolition wood and other woody wastes) is one of the biggest source of renewable energy around the world. Among the 13% of renewable in the primary energy consumption in 2010 in the world, biomass represents the major contributor. When it is valorised in a sustainable way, solid biomass has a high development potential. Unfortunately, a significant share of this usage is not made with high standard of both energy efficiency and low environmental impact. The main difficulty for an efficient use of solid biomass is its transportation to the place of use. In that framework, biomass gasification has a high potential for upgrading and widening biomass energy applications. It represents the so-call thermo-physical pathway to transform solid ligneous biomass into gaseous energy.

Solid biomass cannot be digested through anaerobic digestion that is representing the so-call biological pathway to transform biomass into gaseous energy. In that extend, the two biomass transformation technologies are addressing different resources and are not in competition.

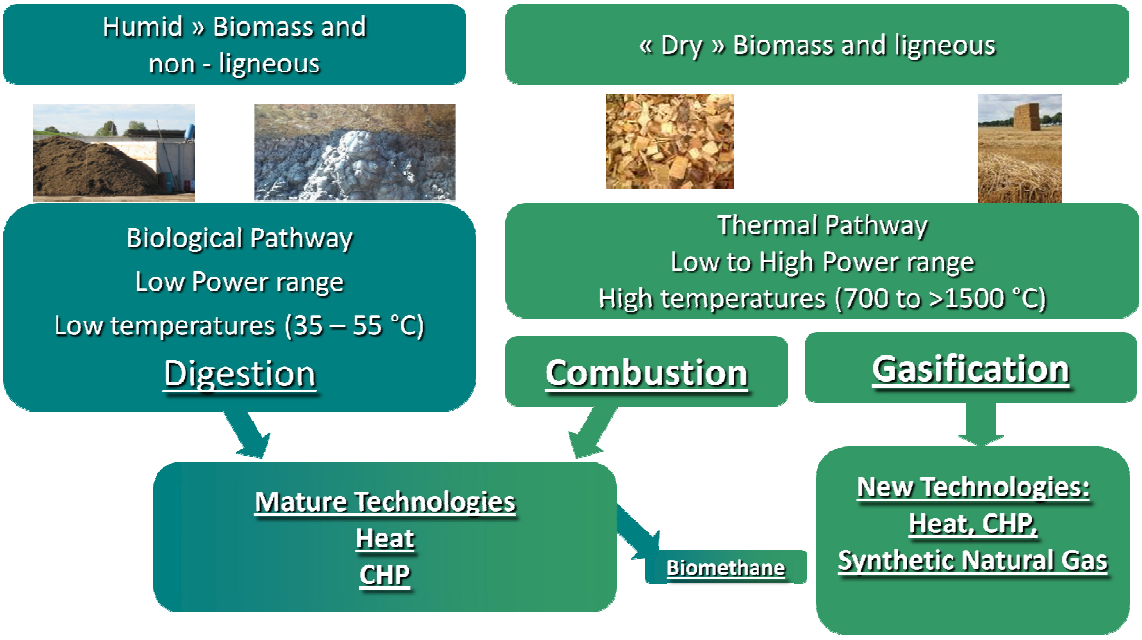

Figure 1: Biological and thermophysical pathways for biomass to energy processes.

Aims

Once transformed into a gas (syngas) the gasified biomass could be valorised through 3 paths:

- Combustion of the syngas into engines for Combined Heat and Power (CHP) application with a *high biomass to power conversion ratio*,
- Direct firing of the syngas into an industrial furnace for direct heating of the final product (glass, brick, ceramics,…),
- Transformation into a bio Synthetic Natural Gas (SNG or biomethane) that is injected into the gas grid in middle scale plants (10-50 MW) to keep as low as possible the impact of biomass transportation from crop zone to transformation zone,

The last two applications has the advantage to respectively,

- allow an industrial gas customer to keep fossil Natural Gas as its fuel for heat production while having a significant part of his energy mix being renewable,
- decoupled the biomass transformation location to the place of use by using existing natural grid to transport the "wood" natural gas, while keeping the wide range of natural gas applications (heat, cooling, electricity, vehicles)

For gas companies also active in business of Services to Energy, such business activities are giving a wide perspectives through local production of green gases and sales of renewable heat, power or fuel gas.

Methods

GDF SUEZ with other partners (industrial gas consumers, gasification technology developers, professional and academic organizations) steers or participates in several projects to develop such applications as :

- BioVive with Saint Gobain Emballage (Verralia) as coordinator for direct firing application in the glass melting industry, supported by the French Research Agency (ANR)
- VeGaz supported by ANR, ended in April 2011,
- GAYA for 2nd Generation biomethane production, supported by Ademe, the French Agency for Energy and Environment

Results

Industrial green gas

The trade organisation of the champagne wine industry (CIVC) targets to contribute to fight global warming by reducing its greenhouse gas emissions by 25% in 2020 and 75 to 80% up to 2050. Champagne bottles account for 15% of the emissions (according to a footprint study in 2003).

As part of this strategy, CIVC contributed to launch the BioViVe project. In addition to CIVC, the partners of this project are Verallia, second worldwide producer of glass bottles and jars, GDF SUEZ, leader in Energy and Energy Services, XYLOWATT, originally a spin-off from Université Catholique de Louvain and now a fast growing Belgian SME specialising in the design, construction and operation of biomass gasification units, and CIRAD, a French agricultural research centre for development. The BioViVe Research & Development project aims at substituting fossil fuel with synthetic gas produced from vineyard by-products for direct use in a glass furnace. The champagne vineyard possesses

biomass resources that are not yet valorised, such as dug-out stumps or recently cut branches that are burnt on site (Figure 2). The BioViVe project consists in adapting the existing Xylowatt gasifier technology to the characteristics of vineyard waste wood and in optimising the synthetic gas produced to the requirement of a glass furnace. In this way, the vine, which produces the champagne wine, will also provide part of the energy needed for the production of the bottles in which the wine will be commercialised.

Figure 2: Open air burning of vineyard cuts

Figure 3: Verallia Oiry Champagne bottles production plant

Over the last ten years, XYLOWATT, a spinoff company of the Catholic University of Louvain, has developed a “fixed bed” and “downdraft”-type gasification reactor ideally suited to small-scale cogeneration (the NOTAR® reactor, two standard models available for 0.3 and 1.5 MWe). The biomass, which is fed in through the upper section of the reactor, undergoes various gas conversion reactions (pyrolysis, combustion, reduction) during the course of its journey to the base of the reactor.

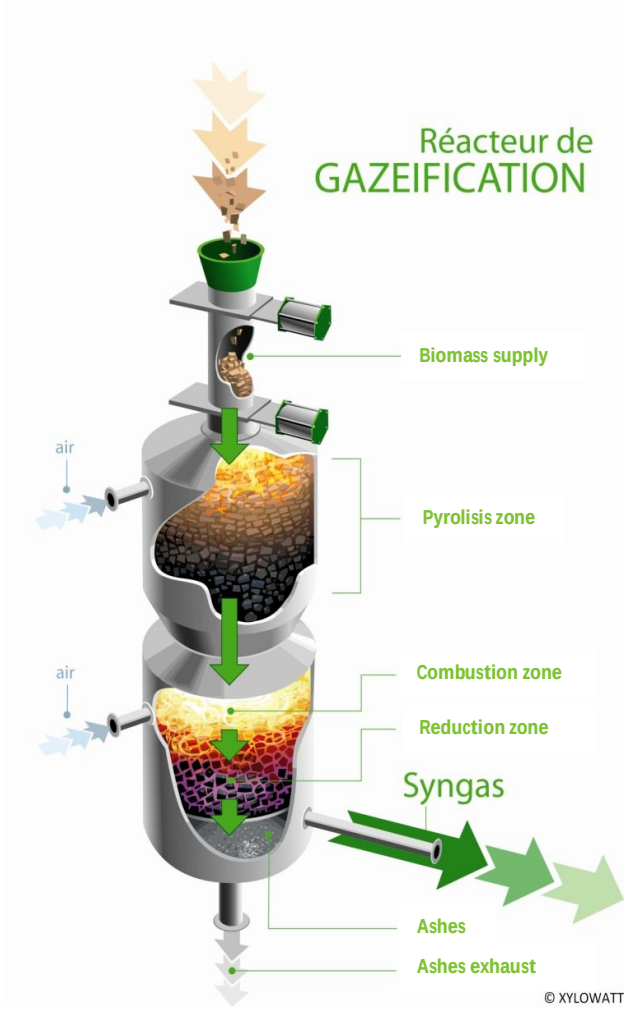

Figure 4: Xylowatt Gasification Technology

A 1 MW wood gasifier has been customized by Xylowatt, to best suit the specific needs of syngas combustion into a glass melting furnace.

It has been installed and tested successfully at GDF SUEZ Research Centre (Figure 5). It produces a clean syngas that is injected into a 2 MW laboratory combustion test cell representative of a slice of a glass melting furnace with high temperature air preheating. This test cell is a unique facility in Europe able to reproduce combustion environment of a industrial glass melting furnace.

Different mixtures of NG and syngas are under intense testing with different injections modes into the combustion test cell. Enhancing the power output and combustion qualities of the syngas are also addressed. Detailed measurements are being made to find the best combustion adjustments.

Once the combustion test is completed at GDF Suez Research Centre in May 2012, the gasifier will be transported to Verallia plant in Oiry, near the city of Epernay (Figure 3), where champagne wine bottles are produced. There it will be tested in real industrial conditions.

In addition to the developments on synthetic gas, the BioViVe partners wish to create a sustainable and local biomass collection supply chain involving the champagne wine producers.

Upon completion of the R & D project, the BioViVe partners wish to have tested substitution levels of biomass energy of about 7% in industrial conditions, and to have acquired the knowledge for substitution levels up to 50%.

This renewable biosyngas, in addition with NG, will in a close future, be a helper for energy companies to support their customers in lowering their dependencies on fossil fuels.

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Figure 5 : Biomass gasifier and combustion test cell for BioVive Project

2nd Generation Biomethane or Bio-SNG with a local vision

Biomass is today the main renewable primary energy used in the world. In a lot of both developed and emerging countries, biomass is the renewable primary energy that has the highest development potential. Indeed to remain an renewable energy, biomass has to be collected in an sustainable way and converted to energy with the highest energy efficiency.

The VeGaz project, supported by ANR and completed in early 2011, has demonstrated the potential of development of Biomethane 2G in Europe.

For the assessment of the resource, a study made for GDF SUEZ by Deutsches Biomasseforschungszentrum (DBFZ) has identified a high potential for Synthetic Natural Gas (SNG) made out of solid biomass as shown in Figure 6. This represents 25 TWh in 2020 and a set of 150 to 200 production plants for France only. Furthermore, for France where as in other European countries the Natural Gas (NG) transmission grid is dense, if the supply radius is limited to 50 km, still 98% of the available solid biomass could be converted into biomethane, as green NG.

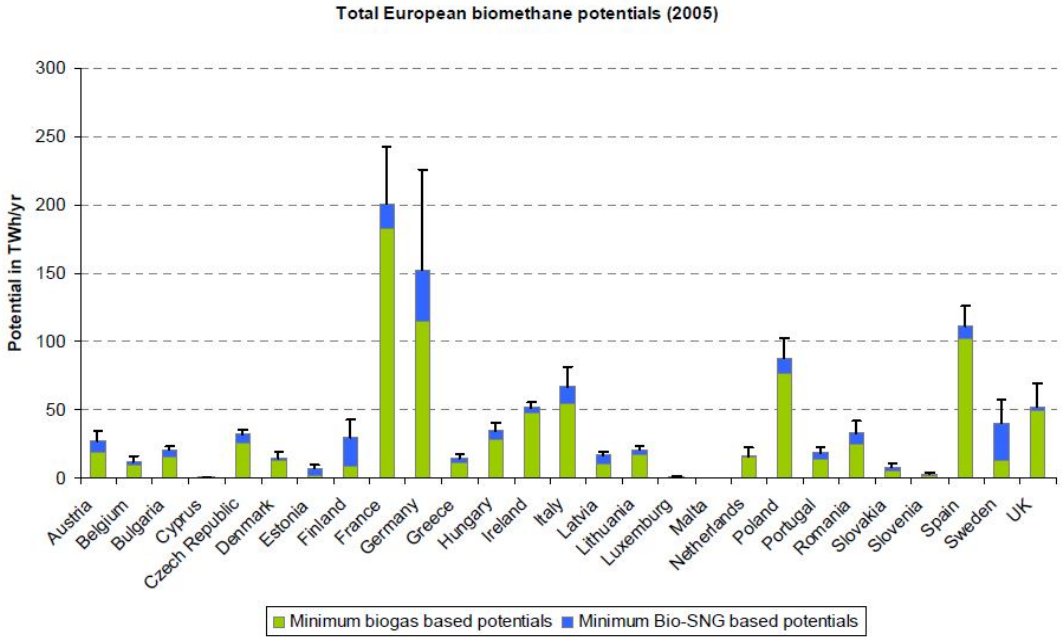

Figure 6 : Biomethane potential for grid injection in European countries – Source : DBFZ – GDF SUEZ - 2009

For the possibility to potentially achieved high efficiency conversion of solid biomass to renewable natural gas (70%) while keeping environmental impact at minimum, studies made in VeGaz project has shown the potential to reach more than 70% of net energy efficiency if the excess heat in valorised. Valorisation of this excess heat is likely only if the size of the plant stays in a small to medium range. Otherwise it is difficult to usage for large quantities of heat locally.

In addition a comparison has been made with 2nd Generation Liquid Biofuels for both Energy Efficiency and Environmental Impact. On both criteria, biomethane has shown higher benefits than 2nd generation biodiesel.

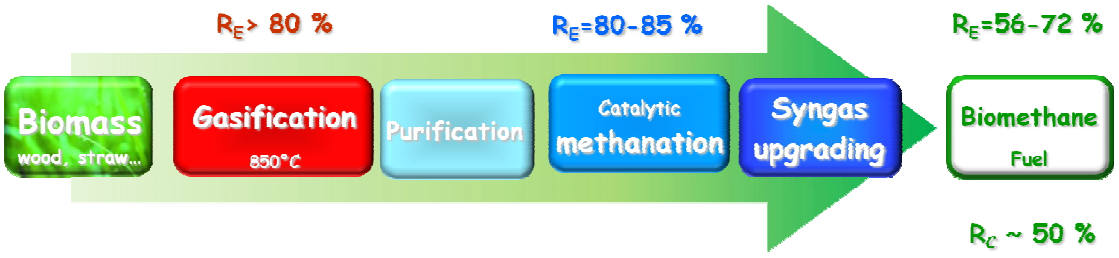

Figure 7: 2G Biomethane key figures

Furthermore the VeGaz project has shown that medium size methane production plants (20-50 MW) avoid long supply chain which, combined with high conversion efficiency, is leading to lower or similar production costs than large BtL[1] plants (400 MW) for biodiesel production.

Then the first stage of validation of the local scheme that is illustrated in Figure 8 was passed.

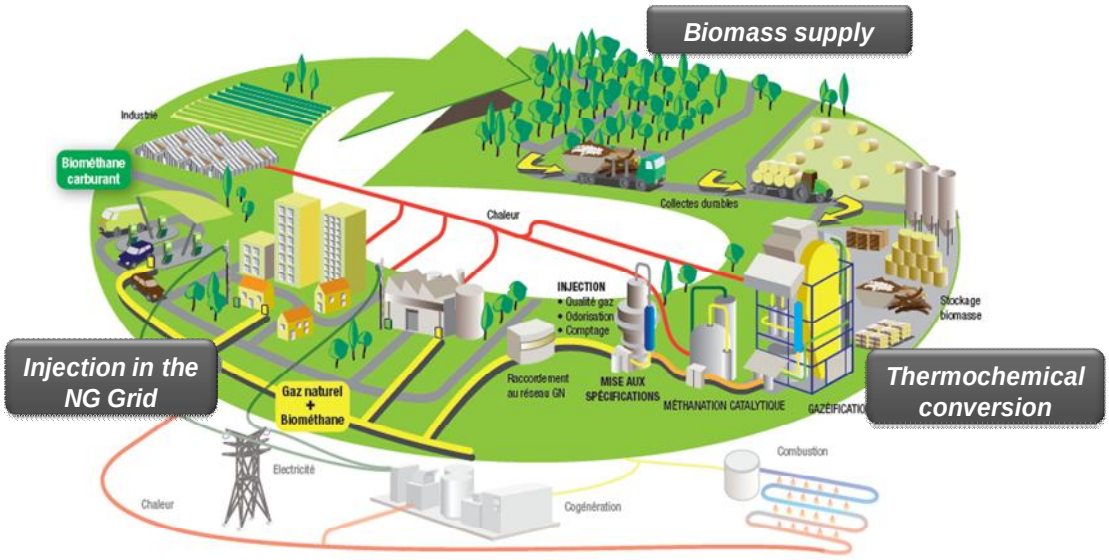

Figure 8: 2G Biomethane production scheme

Nevertheless, current production cost for 2G biomethane is too high for being competitive with NG even if present support mechanism for renewable energies, as it exists in most of European countries would be applied to 2G biomethane. This promising technology needs development and innovation efforts to improve global energy efficiency of production plants and lower production costs by better reactors and component integration and optimisation.

The GAYA project aims to demonstrate *« from vegetal to reel »* at a pre-industrial scale the technical, economic, environmental and societal validity of gaseous biofuels by thermochemical production.

It has been officially launched in June 2010 for 7 years with 11 partners from upstream to downstream chain, coordinated by GDF SUEZ and with an overall budget of 47 M€. It associates GDF SUEZ, as industrial integrator with partners from all the technology chain.

From the upstream (biomass evaluation and sourcing, logistics, markets):

- The Technology Institute of the Forest, Cellulose, Construction Wood and Furnishing Industries (FCBA)
- The Federation of the French Private Forest Owners (UCFF)
- The Technical Centre of the Paper Industry (CTP)

For Academic Research on chemistry, thermodynamics and :

- Catalysis and Solid Chemistry Unit (UCSS) in Lille,

[1] Biomass to Liquids : thermochemical conversion of biomass with Fisher-Tropsch synthesis

- A French research centre working with developing countries to tackle international agricultural and development issues (CIRAD) in Montpellier,
- Reactions and Process Engineering Laboratory (LRGP) in Nancy,
- Chemical Engineering Laboratory (LGC) at Toulouse,
- An Engineering School, “Ecole des Mines d’Albi”

For industrial research:

- The Laboratory for Innovation in New Energy Technologies and Nanomaterials (LITEN) of the French Alternative Energies and Atomic Energy Commission (CEA)
- REPOTEC, an Austrian company, which has developed and industrialised a biomass gasification technology based on a circulating fluidised bed, successfully applied for Combine Heat and Power plants (ie: at Güssing, Austria).

The core of the GAYA project is the Demonstration Platform. The goal of that unique facility is to offer the capacity of testing a very wide range of biomasses suitable for gasification for transformation into a gas meeting all grid specifications and the suitable for injection. It will allow to change the reactors and components (gas treatments as cleaning and separation) for optimisation and enhancement of performances.

The GAYA platform has been engineered and will be build in 2012 at St Fons near the city of Lyon in France. A 5 year experimental test program has been set up to optimized the all chain for performance and costs while minimizing environmental impact.

Simulation tools are being developed accordingly to be able to design future plants adapted to local available biomass and grid injection conditions. Among them, CFD tool is a must to test different configurations without running into a costly “cut and try” process. Thanks to a team of experts at the Research and Innovation Division of GDF SUEZ, real-time simulation of a gasification reactor (REPOTEC Technology) has been realised. It is the first step of a larger study and associated developments to built a CFD tool to assist design of such reactors.

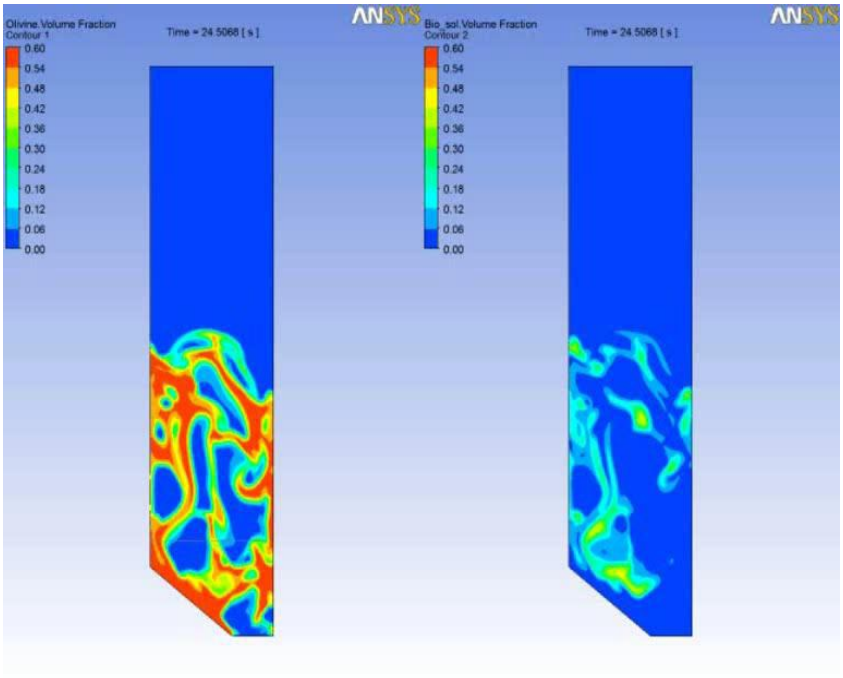

Figure 9: CFD simulation of a fluidised bad gasification reactor - sand (left) and biomass (right) concentration maps

Summary/Conclusions

Transformation of solid biomass into a renewable and combustible gas could be made into 2 different forms: as a syngas to be burnt directly into industrial furnaces or processes or by transforming the syngas into a bio Synthetic Natural Gas (biomethane) that is injected into the gas grid. This gas could called 2G Biomethane.

Both applications use biomass gasification technology and represents an opportunity for gas companies to green their supply while giving to their customer the opportunity to have a significant part of renewable gas in their energy mix.

Biosyngas combustion is technologically available, except when a specific combustion process as in the glass industry imposes dedicated technical developments before going to the market, like those addressed in the BioViVe project.

2G Biomethane is a new grid gas, fully compatible with Natural Gas, that represents a very high potential for converting a significant part of grid gas into a renewable energy. Once improvements and innovations will outcome from present development made in GAYA project and similar actions undertaken in different countries over the world, the Gas Industry would be able to green a significant part of its production. GDF SUEZ is acting in that direction with an objective to develop a new market based on a new technology by 2017.