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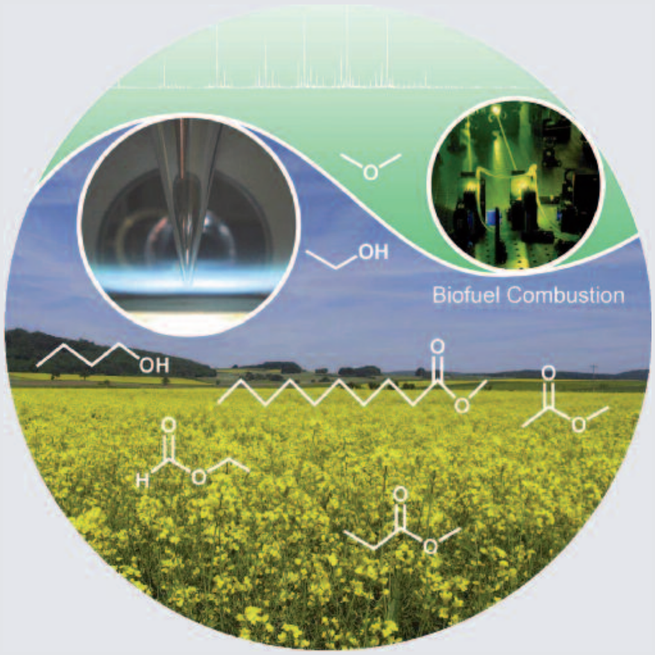



# ADVANCED CLEANING DEVICES FOR PRODUCTION OF GREEN SYNGAS

*In this note the objectives of a project financed from European Community in the FP7 to realize a cleaning system for a syngas obtained from the gassification of biomass will be reported. In order to us the obtained syngas can be transformed with further catalytic processes previously eliminating sulphur chlorine, COS, HCN, $NH_3$ and tars.*

The transport sector represents a growing share of the total fossil fuel usage in the world. In order to fulfill the commitment to the Kyoto Protocol, the world usage of fossil oil in transport sectors must be reduced. One important approach to achieving this goal is to increase the share of renewable sources as feedstocks in conversion routes. These biomass conversion routes involve a number of difficulties that should be attended to first by a suitable process configuration to avoid catalyst poisoning in production of syngas. Second, a major problem in the production of syngas derived fuel from renewable sources is the presence of contaminates in the product gas from a biomass gasifier. These impurities that cause catalytic poisoning should be completely removed prior to the entry in catalytic systems that utilize in upgrading steps.

With the evolution of these advanced uses of biomass derived syngas, it becomes necessary to develop progressively more stringent gas cleaning systems. In this note the goal of a project which has been founded within FP7 of European Community in the area of energy (Second Generation Fuel from Biomass) will be reported. The project has title "High purity syngas cleaning technologies for biofuel" and the program is the development of a novel gas cleanup in order to reduce impurities from gasifier's product gas to limits required for upgrading to syngas using as a feedstock in production of vehicle fuels. To accomplish this target that biomass conversion should preserve high energy efficiency in the subsequent synthesis steps and preventing catalytic poisoning, an alternative product route and more efficient gas cleaning systems are required. Nevertheless, biomass conversion processes offer many economical and environmental benefits, but it is clear that conversion technology should be able to compete with other conversion routes, for example via methane. Therefore, this RTD program combines European expertise in the field of gasification, different proficiencies in cleaning technologies, high ranking catalyst expertise, Catalyst Company, and one research companies with R&D activities in the fields to expedite the development and commercialization of research outcomes.

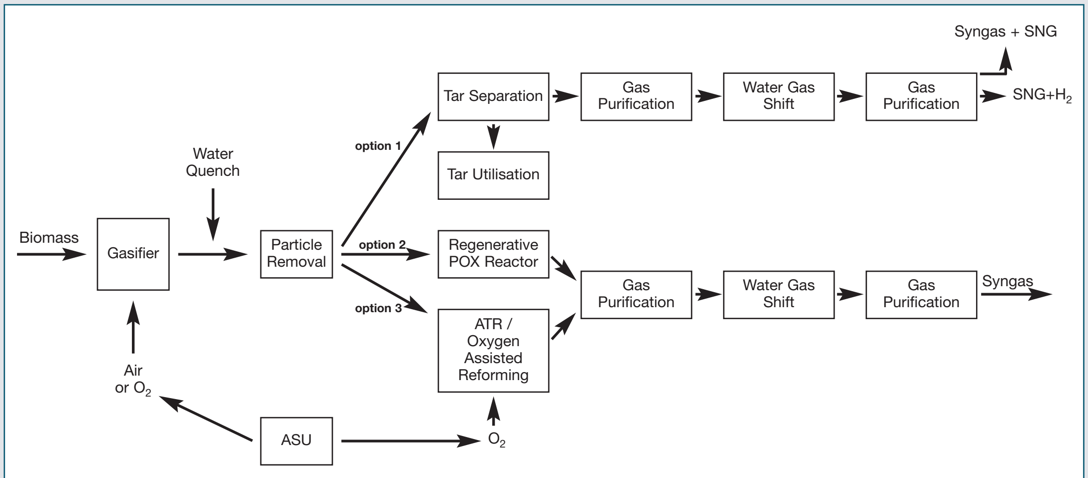



**Fig. 1 - Three configurations of production routes; option 1: Non-reforming configuration; option 2: Regenerative partial oxidation configuration; option 3: Catalytic reforming configuration**

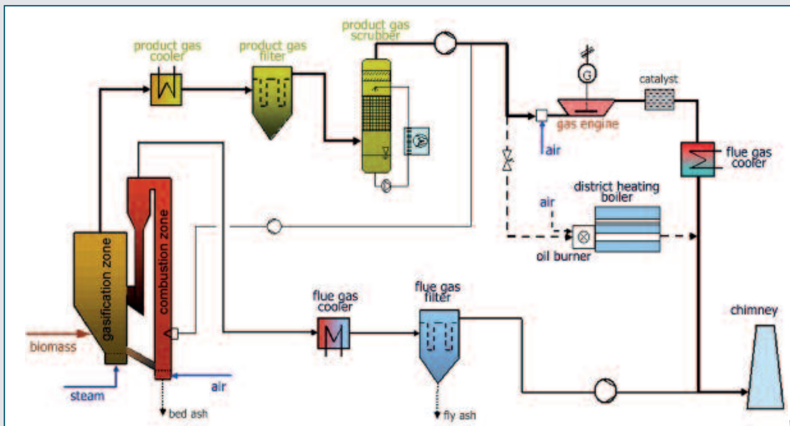
The gas produced could be a synthetic natural gas (SNG) + synthesis gas mixture. This could be methanated into SNG (synthetic natural gas) or separated into SNG and synthesis gas that after further purification could be used for production of liquid fuels, such as methanol, DME or FT diesel. The gas could also be shifted towards hydrogen, forming a SNG + $H_2$ mixture also known as Hythane. All of these products, SNG, liquid fuels and Hythane, are transport fuels.

In the second configuration, Fig. 1 (option 2), a non-catalytic reforming step is assumed. Partial oxidation (POX) can be used to reform the tars and low hydrocarbons of the gas; however, a rather large part of the low heat value (LHV) of the gas is consumed to increase the temperature so that the reaction can occur. The released heat can of course be used in various ways, but it will be withdrawn from the fuel production. On the positive side, there is no catalyst that can be destroyed; this guarantees the function of the process. However, if the partial oxidation is used in conjunction with an efficient heat recovery system, only the heat consumed by the reforming step (endothermic process) has to be released. This opens the use of energy-efficient reforming processes such as regenerative or recuperative partial oxidation (RPO). Regenerative Partial Oxidation Configuration is a non-

## Methodology and associated work plan

The work is included on the evaluation of different units in three suggested configurations (Fig. 1) and resulting in a novel production route for pure syngas from biomass. The key issue is energy conservation in the formed gas; the smallest possible part of the lower heating value (LHV) should be used for processing and cleaning of the gas. In this suggested process scheme (Fig. 1, option 1) a non-reforming configuration is chosen. The advantage of this is that the drain of chemically stored heat in the reforming step-SREF (Steam Reforming), ATR (Auto Reformer), POX (Partial Oxidation) is avoided. The disadvantage is that the gas will contain tars and those must be separated from or used in the gas stream. Tars could be reduced in an on-stream tar cracker or by separation from the gas stream and then used separately. This could, for instance, be done in an air- or oxygen-blown tar cracker or by a wet absorption step. It is however, important that the tars somehow be integrated in the process so the heat value is not lost.

Since there is no reforming step, the gas temperature can be decreased, making the downstream gas purification steps easier to perform. It might be necessary to perform some steps before the HT shift reactor; others, such as desulphurisation, could be done afterwards if a sour shift catalyst is used. Apart from the usual steps, such as removal of chlorine, COS, HCN and sulphur, removals step for ammonia will also be of importance. The ammonia can be removed from the gas by water scrubbing, but this will just move the problem from the gas phase to the water phase. Depending on how the gas is going to be used, a high-temperature (HT) shift step or high-temperature/low-temperature (HT/LT) shift steps will be needed to tune the $CO/H_2$ ratio for producing syngas for different applications, including synthetic biofuels for vehicles. If the sulphur content of the gas is sufficient to keep sulphide-based shift catalysts in active form, there is no need to remove the sulphur prior to the shift steps.




*Flow sheet of Güssing plant for long term testing at large scale in GREENSYNGAS*

Biomass is gasified in a duel fluidised-bed (steam blown) reactor and the resulting gas is used to produce heat and power. Some basic information on this plant is as follows:

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|---|---|
| Start up of gasifier | November 2001 |
| Start up of gas engine | April 2002 |
| Fuel | wood chips |
| Fuel Power | 8000-9500 kW |
| Electrical output | 2000 kW |
| Thermal output | 4500 kW |

catalytic reforming which eliminates the poisoning troubles and at the same time preserves energy to re-use in other process units. The analytical characterization and gas cleaning are performed at more moderate temperatures interval for which there is conventional procedure. There is no up-to-date literature information available concerning application of the "Regenerative Partial Oxidation" in combination with the biomass gasification and is unique to this proposal. Since the Partial Oxidation (POX) process does not require any catalyst, no gas purification (except removal of dust) is required before this step. The gas will probably also contain ammonia, entailing the need for gas purification; the shift reaction is somewhat the same as in Fig. 1 (option 2), above.

The gas produced is synthesis gas and it has to be used in a further catalytic upgrading step for production of liquid fuel or be shifted towards hydrogen.

In the Fig. 1 (option 3) deals with the third process configuration, a catalytic reforming step is fitted. In a catalytic reforming process, the tars and low hydrocarbons should be converted in the catalytic bed. The reformer is most probably an Autothermal Reforming (ATR) type.

The call highlighted the R&D need for gas cleaning and minimization of catalytic poisoning in upgrading step in order to meet the call objective to produce pure syngas from biomass by thermo-chemical conversion. The troublesome step is catalytic steam reforming, therefore three configurations of the catalytic and non-catalytic reforming including "Regenerative Partial Oxidation Configuration" have been suggested in the Greensyngas.

The objective of this project is very hot topic and success of this project provides a valuable and decision making tool for future use of sustainable biofuel in transport sector. The project is close to the final phase and the dissemination of final report to the public access will help and reduce the gap between the applied research and the commercialization phase.

The coordinator on behalf of the involved partners of Greensyngas will also acknowledge the financially supported by the European Commission (EC) 7th Framework Programme (Greensyngas Project, Contract number 213628).

## Role of each contractor in the project

The several participants to the project and their role in order to give an idea of the competences necessary to address all the problems which arise using catalysts for transforming syngas produced from biomass Lund University (Sweden): coordinator & management; research of downstream processing, particle phase characterisation for performance measurement of cleaning, catalytic system, demonstration. TU Munich (Germany): development of sophisticated techniques (Laser diagnostics, Optical) for characterisation of tar & alkali in gasifier.

Technische Universiteit Delft (The Netherlands): on-line tar measurements and gasification with different biomass supply by Lantmännen (Sweden), the gasifier was also used for field test of reforming catalyst (gas supply to the reactor system), and calibrating of the developed methodology for high temperature fine particle in produced gas (gas supply). Porvair (United Kingdom): filter system that responds to the requirement of clean gas for downstream processing in Greensyngas, multi-cyclone and sintered metal. Forschungszentrum Jülich (Germany): chemical hot gas cleaning and thermodynamic modelling, small gasification system, Biomass characterisation supply by Lantmännen.

Bologna University (Italy): downstream catalytic system; steam reforming, WGS reaction, catalytic tar cracking. Johnson Matthey (United Kingdom): scientific aspect of the catalytic system, catalysts supply, process flow-sheeting. Norwegian University of Science and Technology (Norway): Downstream catalytic system; steam reforming, WGS reaction. Kraftwerk Güssing GmbH & Co KG (Austria): gasification, demo of cleaning device, experimental concerning catalyst exposure, supply of product gas from the gasifier to the partners laboratory. Lantmännen (Sweden): biomass quality, accessibility and supply to different laboratories. Bil Sweden (Sweden): science in Society www.e-at.lth.se/greensyngas/

RIASSUNTO

**_Dispositivi di purificazione avanzati per la produzione di syngas verde_**

*In questa nota vengono descritti gli obiettivi di un progetto finanziato dall'Unione Europea nell'ambito del 7° Programma Quadro per realizzare un sistema per purificare il syngas ottenuto da gassificazione di biomassa. Per trasformare il syngas ottenuto mediante ulteriori processi catalitici è infatti necessario, secondo il coordinatore del progetto, eliminare preventivamente cloruro di zolfo, COS, HCN, $NH_3$ e altre impurità eventualmente presenti.*