FlexSNG NEWSLETTER

Flexible Production of Synthetic Natural Gas and Biochar via Gasification of Biomass and Waste

Issue 1 / December 2021

We are pleased to share the first issue of the FlexSNG e-newsletter, keeping you up to date with all the latest news and developments from the project.

Contents

1. Introduction to FlexSNG

The transition towards climate neutrality by 2050 is one of the main themes in the agenda of the European Union and its member states. To reach this target, the European Union aims at increasing the share of renewable energy sources in both heat, electricity and transport use. Bioenergy will play an ever increasingly role in this transition but further improvements in conversion technologies and biomass supply chain management are required to reduce the bioenergy/biofuel production costs and boost the market uptake of advanced biofuels and bioenergy in replacement of fossil fuel alternatives.

The **H2020 project FlexSNG** aims at solving this issue by developing a cost-effective gasification-based process for flexible production of pipeline-quality biomethane, high-value biochar and renewable heat from a wide variety of low-quality biomass residues and biogenic waste feedstocks (Figure 1).

The combination of feedstock supply chain optimization and new technology innovations leads to significant cost reductions that allow lowering biomethane production costs by more than 30% compared to state-of-the-art biomass-to-SNG technologies. The medium-scale conversion units of 50-150 MW biomass/waste input facilitate the use of local biomass residues and biogenic waste fractions without heavy transport logistics.

Figure 1. Schematic diagram of the FlexSNG process.

The key innovative technology at the core of the FlexSNG concept is the flexible gasification process that can switch between two operation modes according to market signals or feedstock availability and price:

1. Co-production of biomethane, biochar and heat

2. Maximised production of biomethane and heat

The biomethane product, with a methane content of 96-98%, can be readily injected into the existing gas infrastructure for distribution to various end-consumers in the transport sector, heat/power production, industries and households. The co-produced biochar is a solid and therefore easily storable bioenergy carrier that can be used to displace fossil feedstocks in energy production and industry (e.g., iron and steel making) but also has wide markets in material use (e.g. soil amendment, activated carbon). The by-product heat that is recovered from the gasification/synthesis process is either used for renewable district heating or supplied to industries as process steam.

FlexSNG is an **EU-Canada jointly funded action** that brings together a well-balanced mix of leading universities, research institutes, SMEs and technology providers/engineering companies from seven European countries and Canada. The technical development and validation activities of the project focus on the three key enabling technologies that form the backbone of the FlexSNG process: low-cost oxygen supply via oxygen transport membranes (OTMs), flexible gasification process and simplified gas clean-up. The experimental work culminates to week-long test campaigns, where the process is validated to TRL5 at VTT's Piloting Centre in Bioruukki, Finland. Another central activity in the project is feedstock supply chain optimization that, using sophisticated modelling tools and systems analysis approach, aims at improving feedstock supply chain management and logistics to reach 20% reduction in feedstock supply costs. Towards the end of the project, techno-economic assessments and case studies will be carried out to identify the most promising locations and conditions for successful industrial deployment of the FlexSNG concept in Europe and Canada.

FlexSNG is an **EU-Canada jointly funded action**

2. First successful gasification experiments conducted in November 2021 and samples of biochar delivered for further characterization

The **Bubbling Circulating Fluidised-Bed (BCFB) gasifier** developed by VTT essentially forms the foundation for the flexible FlexSNG process. The BCFB gasifier design makes possible to respond to changes in market conditions and/or feedstock availability by switching operation mode. The coupling of a bubbling fluidised-bed bottom and a circulating fluidised-bed top enables the production of good-quality biochar, while maintaining the tar concentration at an acceptable level for downstream processing.

One of the key benefits of the BCFB gasification technology is its feedstock-flexibility, which is enabled by the two novel features: 1) in co-production mode, the gasifier is operated at lower temperature (700-800 °C), which reduces the risk for ash melting, and 2) when maximising biomethane production, the gasification performance of particularly challenging waste feeds can be improved by co-feeding of biochar. This approach makes possible to convert a much wider range of lower quality, low-cost biomass residues and biogenic waste feedstocks into added-value products than achieved with state-of-the-art gasification technologies.

Figure 2. VTT's gasification pilot plant.

The commissioning of the BCFB gasification pilot (Figure 2 and Figure 4) and the first gasification test campaign was successfully realised at VTT's Bioruukki Pilot Centre in November 2021 using crushed bark as gasifier feedstock. The pilot-scale experiments focused on testing different feed gas ratios and gasification temperatures to identify optimal conditions for co-production of synthesis gas and biochar and to enable trouble-free filtration and subsequent reforming of the produced gas.

Biochar has several potential applications that will be explored during the project, e.g. replacement of fossil carbon in energy production and material use in soil amendment, wastewater treatment or as activated carbon. The goal is to identify the most attractive utilisation pathways both in the European and Canadian context taking into consideration country-specific legislation and markets. First samples of biochar (Figure 3) generated in the gasification experiments have now been delivered to EIFER (Germany) for characterisation.

Figure 3. Biochar sample produced in the first gasification test campaign.

These samples will be analysed with respect to chemical composition, combustion properties, storability and other characteristics relevant for energetic or material use of biochar.

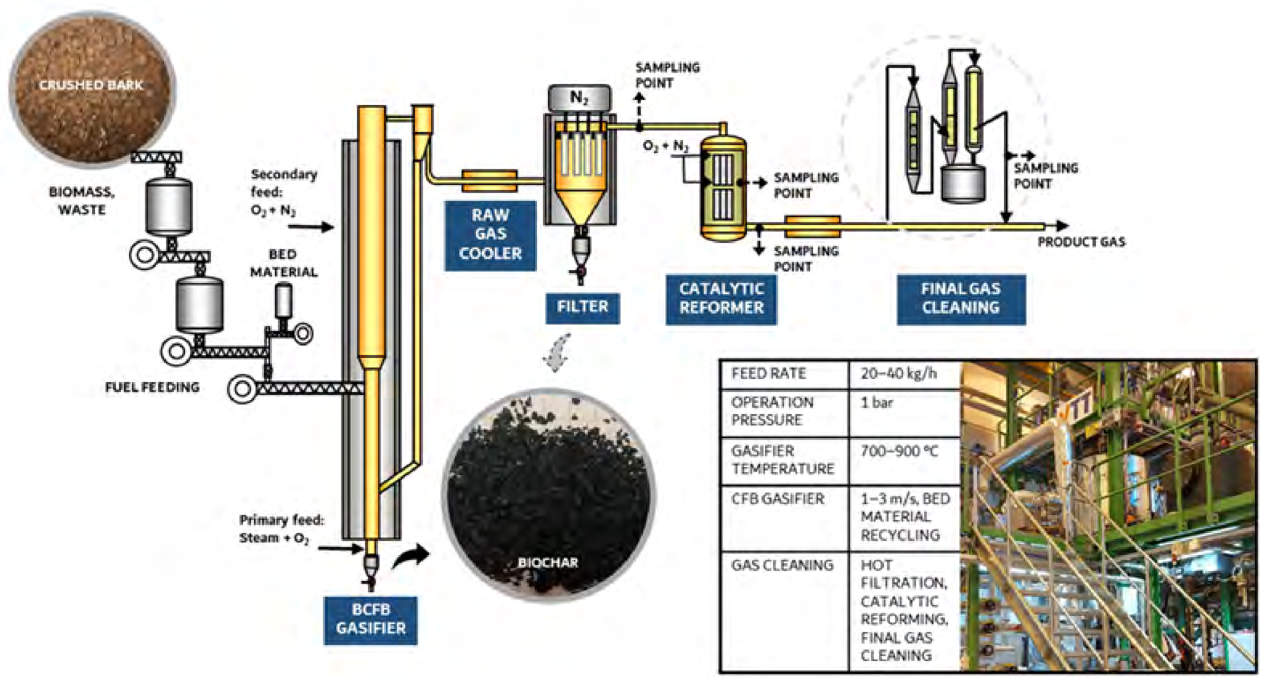

Figure 4. BCFB gasification pilot at VTT's Piloting Centre Bioruukki, Finland.

The gasification and gas clean-up development work is currently ongoing and the next test campaigns are scheduled for January 2022. The pilot-scale tests will serve as a starting point for the extended-time validation experiments where the whole process (up to final gas clean-up) will be validated at VTT's pilot plant with an overall target of more than 200 hours of operation. Several different feedstocks, e.g. forest residues, bark, straw, demolition wood and other waste-derived feedstocks, as well as co-feeding of biochar with waste feedstocks will be tested in the upcoming tests to highlight the feedstock-flexibility of the process.

Pilot-scale tests are the starting point for technology validation

3. Development of Oxygen Transport Membranes (OTMs) for cost-effective oxygen production for the gasification process

Another key development topic during the first six months of the project is the **oxygen transport membrane (OTM) technology.** The OTM technology developed by DTU enables the production of high purity oxygen (> 99.5%) from air at low cost utilising the heat available in the gasification process. This technology achieves 50% reduction in energy consumption compared to state-of-the-art solutions based on cryogenic air separation.

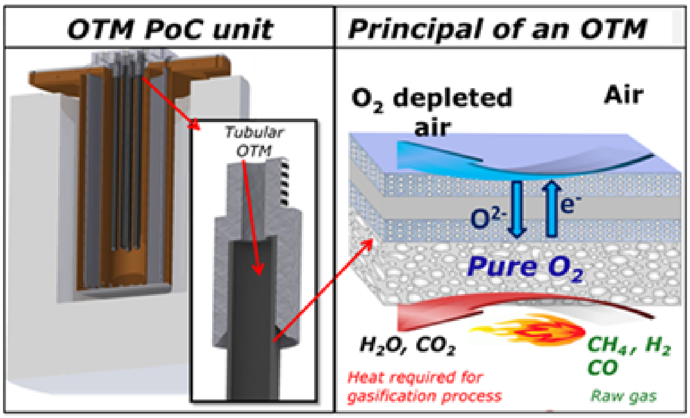

Figure 5. Operating principle of an oxygen transport membrane.

The key feature of an oxygen transport membrane is a gas-tight layer of a ceramic material, which can selectively conduct oxide ions (O^{2-}) at temperatures above 700 °C. The difference in oxygen concentration between the two sides of the membrane provides the driving force for the process. Since high temperature heat sources are available in the gasification process and the required oxygen gradient can be achieved by flowing e.g. raw synthesis gas on one side of the membrane (direct integration), oxygen can be separated from air at a very low energy penalty. This makes it possible to realise oxygen-blown gasification processes also on a smaller scale than is economically feasible with conventional oxygen plants. The advantages of OTMs over conventional oxygen production methods like PSA (pressure swing absorption) and cryogenic air distillation are: 1) OTMs deliver oxygen at a purity close to a 100 % (as only oxygen ions can pass through the membrane), 2) OTM modules can easily be scaled to process needs, and 3) they can be integrated into gasification processes.

Figure 6. U-shaped oxygen transport membrane.

During the first six months, the work at DTU focused on developing the first generation of OTM tubes and designing the core of the OTM module. Already now, the first test results of the tubes (in idealized gases like hydrogen and methane) are available, and they look promising. Researchers at DTU believe that these results are an important step to reach the first milestone in this project, and experiments to verify the performance under relevant conditions are already scheduled in the next weeks. In these experiments, gas compositions found in the Bubbling Circulating Fluidised-Bed gasifier will be "mimed", which will allow estimating the performance of the OTMs tubes in the planned field tests at VTT.

Progress has also been made on the design of the actual OTM module. A first version of the core unit of the OTM reactor consisting of ten tubes (Figure 7) has been made, and calculations of heat flow and energy balance (under adiabatic conditions) are currently running. As a next step, the auxiliary components of the OTM reactor (heating elements, heat exchangers, gas analysis, etc.) will be designed.

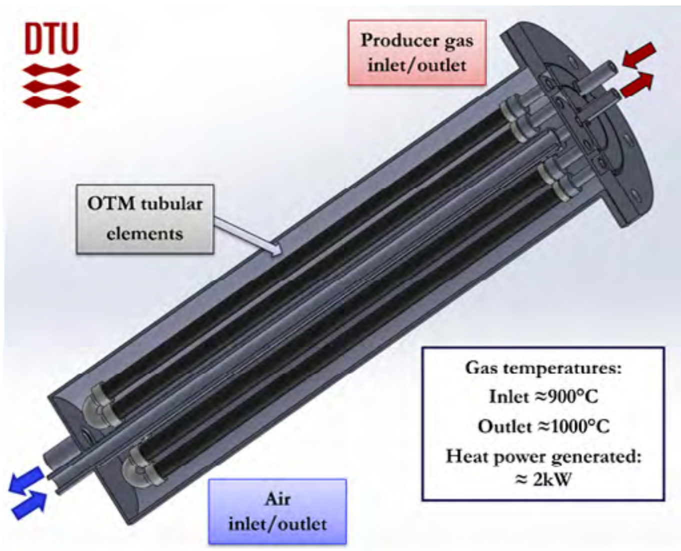

Figure 7. The core unit of the OTM reactor.

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