SUSTAINABLE GLASS PRODUCTION WITH HYBRID PLASMA-ASSISTED COMBUSTION TECHNOLOGY

N. Striūgas[1], R. Skvorčinskienė[1], A. Tamošiūnas[2]

[1]Laboratory of Combustion Processes, Lithuanian Energy Institute, Kaunas, LT-44403, Lithuania
[2]Plasma Processing Laboratory, Lithuanian Energy Institute, Kaunas, LT-44403, Lithuania

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Presenting author email: nerijus.striugas@lei.lt

Over nearly 100 years, the glass manufacturing process has been improved by redesigning or adapting a range of innovative low-carbon technologies that are much more energy efficient: waste heat recovery technologies, ORC cycles, the use of new insulating materials, energy management, automation and other innovative technologies. Improvements in energy efficiency contribute directly to the reduction of CO_2 emissions: over the last century, specific energy consumption and energy-related CO_2 emissions have fallen by more than 75%. However, these improvements have almost reached their thermodynamic limit; it is no longer possible to significantly reduce CO_2 emissions with current methods and the combustion of natural gas or other fossil fuels. Needs to move towards energy and even greater circularity in glass production where there is potential.

The "Flexible Hybrid Furnace of the Future" is the European glass industry's vision to meet the European Green Deal's objective of reducing Europe's carbon emissions and contributing to EU climate neutrality. Effective decarbonisation of the entire glass sector as soon as possible requires the development of new methods and technologies and the search for environmentally friendly alternatives to natural gas as a carbon-neutral alternative fuel.

This paper presents the vision and latest results of the Horizon Europe project GIFFT (Sustainable Glass Industry with Fuel-Flexible Technology), whose overall objective is to develop a sustainable, hybrid and biofuel-flexible heat generation technology and process that can be integrated into industrial glass production through the efficient use of plasma combustion and gasification systems.

The GIFFT concept is to develop and validate a flexible hybrid furnace that makes optimal use of freely available low-cost green electricity and low-cost biofuels to facilitate the transition from natural gas to a new low-carbon and more dynamic heat generation. By combining plasma gasification of biomass and flexible combustion of hybrid fuels, the GIFFT process can offer high fuel flexibility and more dynamic operation in response to changes in energy and fuel markets. The process is designed to allow continuous operation of the glassmaking plant throughout the year, with a high number of operating hours. The flexibility of the hybrid operation and fuels is analysed using standard flow diagrams to calculate the energy and mass balances when changing the four main regimes: the Bace case, the Biomass case, the Green electricity case and the Green hydrogen case. Hybrid operational and fuel flexibility is analysed using standard flow diagrams to calculate energy and mass balances by varying the four main regimes: the Bace case, the Biomass case, the Breen electricity case and the Green hydrogen case. Preliminary results of combustion tests will also be made available during the conference to demonstrate the validity of the theoretical assessment.

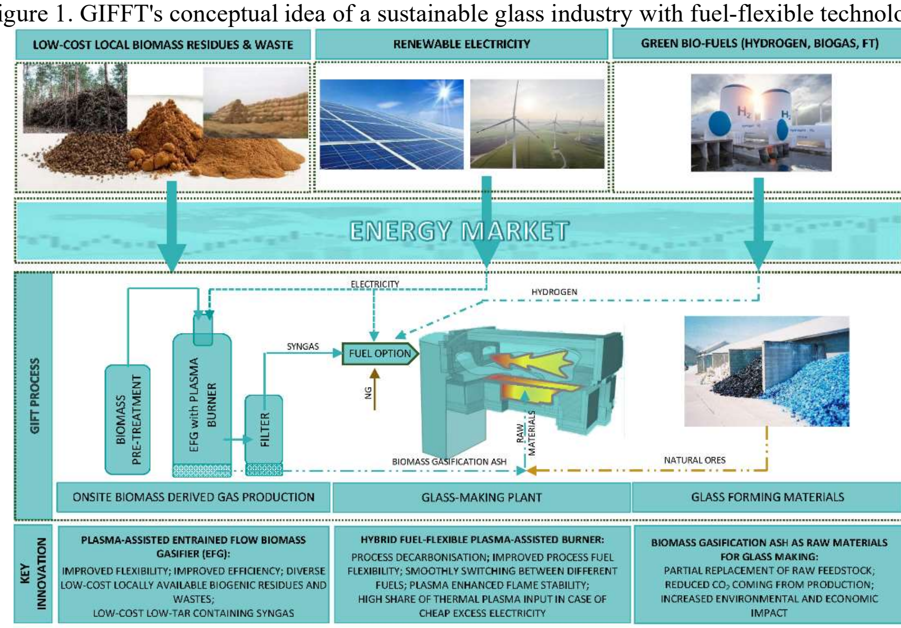
"Base Case" - The core of the glass-making plant is the melting unit, where raw feedstocks are converted into glass and byproduct heat. As the melting process is very energy-intensive, the NG is commonly used as a main energy source. To become less dependent on fossil energy sources and concurrently contribute to decarbonisation, the concept could be integrated, allowing the diversification of the energy sources by choosing the cheapest available option on the green energy market and dynamically switching between them accordingly (see three next cases below).

"Biomass case"- the process gets the biomass derived gas production process and gasification unit. Various biomass residues and organic waste fractions are gasified using plasma-assisted gasification. The hot raw gas is then cleaned and led into a hybrid fuel flexible plasma-assisted burner. Here, distinct from the gasifier, the plasma torch operates continuously. In addition, the gasification biomass ash is generated, which is used as a substitute for natural ores in the glass-making process. This case allows minimising the use of NG and switching to biomass-derived gas operation; a reduction of up to 30% of total CO_2 emissions, or up to 73% of fossil CO_2 per ton of glass produced, is expected.

"Green Electricity Case" - the plant is operated to maximise the use of green electricity. Therefore, the biomass feeding and syngas production is reduced and optimised for plasma-assisted gasification operation. Simultaneously, the plasma-assisted burner increases the thermal energy output from the plasma torch up to 25-50% of the total heat energy demand. In this case, it is very likely that cheap hydrogen will become available on the market. Therefore, depending on its price and availability, syngas production is minimised or stopped and the plant is switching to an electric-hydrogen mode of operation. In certain cases of gasification, biomass ash is also produced and sent to the production of raw feedstock. In this case, the use of NG is minimal, and a reduction of up to 55% of total CO_2 emissions, or up to 70% of fossil CO_2 per ton of glass produced, is expected.

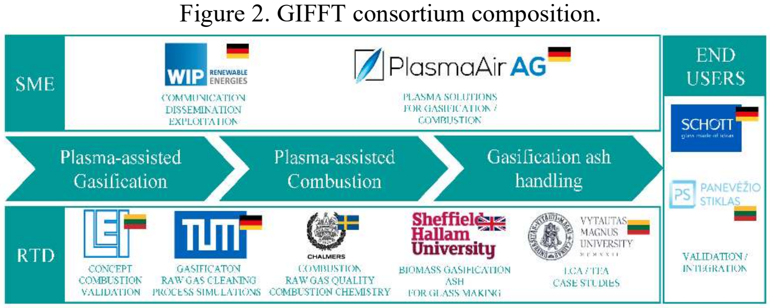
"Green Hydrogen Case"- the plant is switched to maximum hydrogen fuel operation, i.e. biomass-derived gas production is stopped, and the plasma torch output of the hybrid burner is minimised. However, in this hydrogen base case, no biomass gasification ash is produced. In order to reduce the CO_2 emissions coming from the process, additional biomass ash has to be acquired from biomass combustion or gasification plants in the region. In relation to this scenario, the use of NG is minimal and a reduction of both total and fossil CO_2 emissions up to 67% per ton of glass produced is expected.

Figure 1. GIFFT's conceptual idea of a sustainable glass industry with fuel-flexible technology.



The GIFFT consortium is led by the Lithuanian energy institute (LEI) and gathers renowned universities from four different European countries with complementary types of expertise and four companies, including two SMEs. Each partner brings specific knowledge required to develop all technological aspects of the project as well as experts in economic assessment and stakeholder engagement to ensure the process validity and uptake (see Figure 2).

Figure 2. GIFFT consortium composition.



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