LIFE CleanOx

Cleanest oxy-fuel combustion technology with radiation based waste heat recovery for glass melting furnaces

Layman's Report

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Project Details

PROJECT TITLE: Cleanest oxy-fuel combustion technology with radiation based waste heat recovery for glass melting furnaces

DURATION: 1st July 2017 – 31st December 2022

EU FINANCIAL CONTRIBUTION: 1,244,869 €

SECTOR: Climate Change Mitigation

PROJECT COORDINATOR: Paşabahçe

Partners

Paşabahçe

Air Liquide

With the contribution of the LIFE Programme of the European Union
LIFE CleanOx - LIFE16 CCM/BG/000059

LIFE CleanOx Project

LIFE CleanOx project is led by Paşabahçe Bulgaria EAD, the tableware's entity of Şişecam Group, in collaboration with Air Liquide. This project, registered as **LIFE16 CCM/BG/000059**, was funded by the European Commission within the LIFE programme. It started on July 1st, 2017 to end in December 31st 2022.

Project Objectives

The project aimed to contribute to the implementation of the Industrial Emissions Directive and the Paris Agreement, as well as the possible implementation of a new industrial policy strategy. Specifically, the project consisted in **demonstrating an innovative radiative heat exchanger (R-HX)** based on HeatOx solution and had three main objectives:

- **Reduction of GHG emissions** linked to tableware glass production (compared to air combustion using a regenerative heat exchanger: 30% less CO2 and 90% less NOx emissions)
- **Increase of thermal efficiency** in tableware glass plants (compared to air combustion using a regenerative heat exchanger: 30% less)
- **Significant CAPEX reduction** (50-75%) compared to LIFE Eco-HeatOx

Context

Observation: As an energy-intensive manufacturing process, it is no surprise that the primary environmental impacts associated to tableware glass manufacturing are the global warming potential (mainly due to CO2 emissions from raw materials and fuels use) and primary energy demand (for which the upstream production of energy, in particular natural gas, is the main contribution). Tableware glass manufacturing is a significant emitter of greenhouse gases (GHG), particularly carbon dioxide (CO2). CO2 in glass manufacturing comes from two sources: the use of fossil fuel to fire furnaces and the carbon contained within and released by raw materials during the melting process. The proposed project aimed at lowering the environmental impact of tableware glass production by preheating O2 and NG for combustion using an innovative radiative heat exchanger. It mainly addresses the major climate issue of industrial CO2 emissions and, at the same time, provides other environmental benefits such as the reduction of NOx emission compared to state-of-the-art air combustion. Unlike previous technologies, affordability of the technology will significantly contribute to the promotion of the technology, leading to greater environmental impact.

Area of improvement: One of the main environmental issue associated with tableware glass production is the high level of NOx emissions due to high-energy consumption. With high temperatures in glass furnaces (up to 1650 °C and up to 2500°C in the flame), the major source of NOx is thermally generated NOx, arising from the oxidation of nitrogen in the combustion atmosphere at temperatures above 1300 °C. The main sources of the nitrogen is combustion air.

Methodology

Project Start
JUL: project start
OCT: KOM in AL's Innovation Campus Paris

Bypass flue gas PO
End of the bypass flue gas engineering & PO issued in Sept

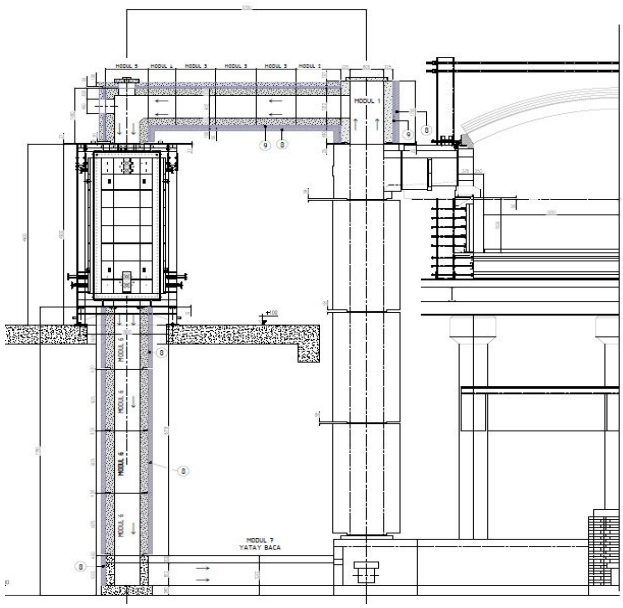
R-HX startup
NOV: start-up
DEC: performances assessment

2017 — 2018 — 2019 — 2020 — 2021 — 2022

R-HX delivery
+ Flue gas bypass channel engineering
+ AL's small test unit

Eqpt delivery
SEPT: start of the site activities
OCT: R-HX installation

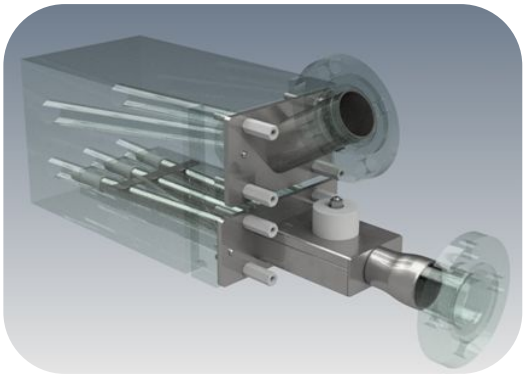
B furnace rebuild



By-pass flue gas channel on the left side and on the right side the radiative heat-exchanger

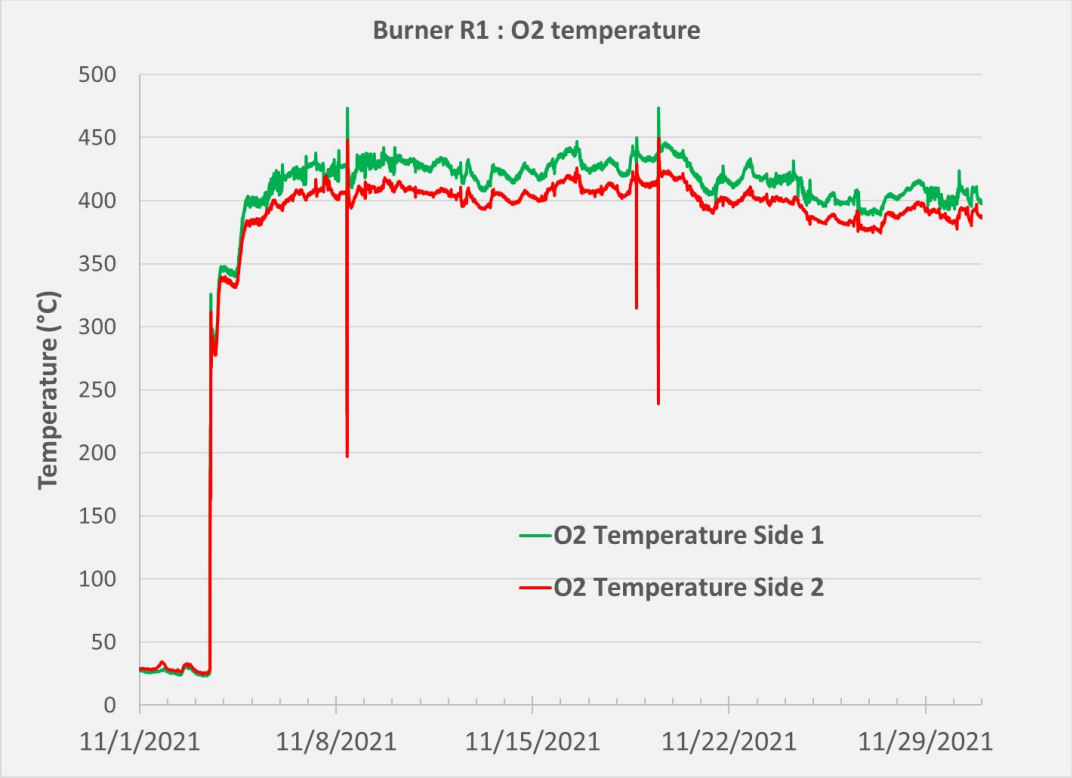
Technology

LIFE CleanOx is composed of the following two main technology bricks: heat exchanger and burners. Oxygen and natural gas are preheated directly by hot flue gas in CleanOx without intermediate fluid. The main technological breakthrough is a novel radiative heat exchanger that enables to avoid the intermediate step of heating air without compromising on safety.



Results

Energy Efficiency: The radiative heat exchanger was unable to improve upon the energy savings and CO2 emission reduction achieved by LIFE Eco-HeatOx, already implemented at the plant, but is expected to deliver similar performance on scale-up.



Emissions Reduction: Based on the test results, CO2 emissions reductions of 23% and NOx emissions reductions of 90% (relative to air combustion with a regenerative heat exchanger) are expected, equivalent to LIFE Eco-HeatOx, already implemented at the plant.

Results

CAPEX and Footprint reduction: The radiative heat exchanger was confirmed to provide significant reduction in overall system complexity, physical footprint and CAPEX. These benefits will support more widespread implementation of oxy-combustion and heat recovery in the glass industry (and other industries) leading to significant improvements in energy efficiency and reductions in emissions compared to air combustion.

Productivity and Quality: The glass production and quality was the same as the base case.

Results

Environmental impact: The main objective of the project, and the LIFE programme, is to reduce the human impact on nature. All the environmental indicators results are in the following table :

Environmental indicators results			
	Baseline (air combustion)	**Performance Test**	**Expected at Scale**
Pull (Tons/day)	**220**	**NA**	**220**
Energy Consumption (GJ/Ton of glass)	**5.3**	**4.4**	**4.1**
CO2 - Combustion (kg/Ton of glass)	**335**	**277**	**259**
CO2 - raw materials (kg/Ton of glass)	**112**	**112**	**112**
CO2 - O2 production (kg/Ton of glass)	**NA**	**17**	**16**
Total CO2 (kg/Ton of glass)	**447**	**406**	**387**
Total NOx (NO + NO2) (kg/Ton of glass)	**5.2**	**0.52**	**0.52**

Summary of results

Production

Consumption

Quality

CO2 emissions

NOx emissions

Replicability

CleanOx enables the glass industry to comply with and go further current climate regulations thanks to the reduction in fuel and oxygen and in CO2 compared to widespread air combustion. It is in line with the EU climate policy on energy and greenhouse gas intensive industrial production and can lead to the development of stricter Union policy and legislation.

Consequently, besides GHG savings, economic viability of the proposed innovative technology is key to contribute to EU climate objectives through wide replication after demonstration. Hence the contribution of the project to the development and demonstration of an innovative climate change mitigation technology suitable for being replicated and transferred to other energy intensive industries.

Today, about 35 furnaces are operating with oxy-combustion in EU, for fiberglass and technical glass production mainly. Tank capacity in container and float glass production, represent both nearly 82% of glass production in tonnage. Those account for 293 units and can be potentially converted to CleanOx technology. This technology could be implemented with all of these furnaces when rebuilt, since it could work with any type of glass and every fuel type.

Transferability

At the end of a furnace's usual lifetime (7 to 12 years), when investment decision is made to renovate, oxy-combustion with CleanOx technology can possibly be implemented. Then, in 15 years, major part of air glass furnaces could be converted to oxy-combustion with CleanOx technology. With further development to adapt the CleanOx design, it will be extended to other manufacturing «high temperatures» processes such as melting and heat treatment, for steel and non-ferrous metals, foundries and non-ferrous recycling processes as well, but also for cement and other 'Basic mineral non-metallic Materials'. On this industry, potential CO_2 and energy savings will depend on fumes temperature and process characteristics resulted in an average estimated reduction about 50% of CO_2 coming from direct combustion in the process.

The knowledge and data acquired during the LIFE CleanOx project is very valuable for other glass furnaces as well as steel, cement, enamel, frit or any other industry requiring the use of high quantities of energy for melting purposes in small or medium size furnaces. Therefore, some R&D activities (pilot scale) would be necessary in a first step in order to adapt the technology brick (radiative heat-exchanger) to the particularities of other targeted furnaces (batch cycle, special pollutant in fumes, etc.). Then an industrial demonstration would be implemented with partners to validate the transferability and launch the deployment.

Dissemination and networking actions

The project improves the knowledge base for the implementation of effective climate change mitigation actions. This knowledge will be disseminated in ordered to be applied in practice.

In the frame of networking and dissemination activities Project partners made contact with other LIFE projects, presented LIFE CleanOx project at different seminars and conferences.

1st action: Şişecam and Air Liquide attended the 2017 ICG (International Commission on Glass) Annual Meeting in Istanbul (Turkey). This ICG Annual Meeting was held in conjunction with 32nd Şişecam Glass Symposium where Şişecam invited glass world stakeholders to share and discuss knowledge about the latest developments on glass science and manufacturing technology. At the occasion of this ICG, Air Liquide made a presentation of Life Eco-HeatOx project results and introduced the new Life CleanOx project.

2nd action: At the occasion of the Glass Trend (Glass Technology Research & New Developments) Seminar on "How to face the technological challenges of the Paris climate agreement?" in Marktheidenfeld (Germany) in 2018, both Partners were present and attended the session "Low carbon raw materials" where Şişecam presented the Melting properties of fiberglass batch with low gas content and the session "Low carbon combustion technologies and heat recovery" where Air Liquide presented the Combustion technologies and models helping carbon neutrality developed by Air Liquide.

3rd action: Air Liquide attended the Asia Green Glassmaking Plant Summit 2018 which was held at the Pullman Shanghai Skyway. The conference was dedicated to Build Energy Efficient Digitalised,HE-ULE Glassmaking Plant.

4th action: ICG (International Commission on Glass) Annual Meeting 2018 was held in Yokohama (Japan). The main issue of ICG 2018 was "Innovations in Glass and Glass Technologies: Contributions to a Sustainable Society". Over 500 Glass Industry professionals attended the event.
Air Liquide made a presentation on "HeatOx to Glass industry for Low Carbon & Circular Economy".

5th action: The LIFE Platform Meeting on Climate Change Mitigation in Energy Intensive Industries held in Utrecht (Netherlands) in 2018 brought together beneficiaries of the LIFE Programme and other EU funding mechanisms, policy makers and stakeholders with the aim to discuss how Energy Intensive Industries (EII) can contribute to implementing the European Union's roadmap to decarbonisation. LIFE CleanOx project beneficiary was invited to participate in the platform meeting due to its contribution to making European industry more climate-friendly and less energy-consuming.

6th action: Both project's partners attended the Glasstec fair (international trade fair for glass production, processing and products) in 2018 and in 2022 in Düsseldorf (Germany).

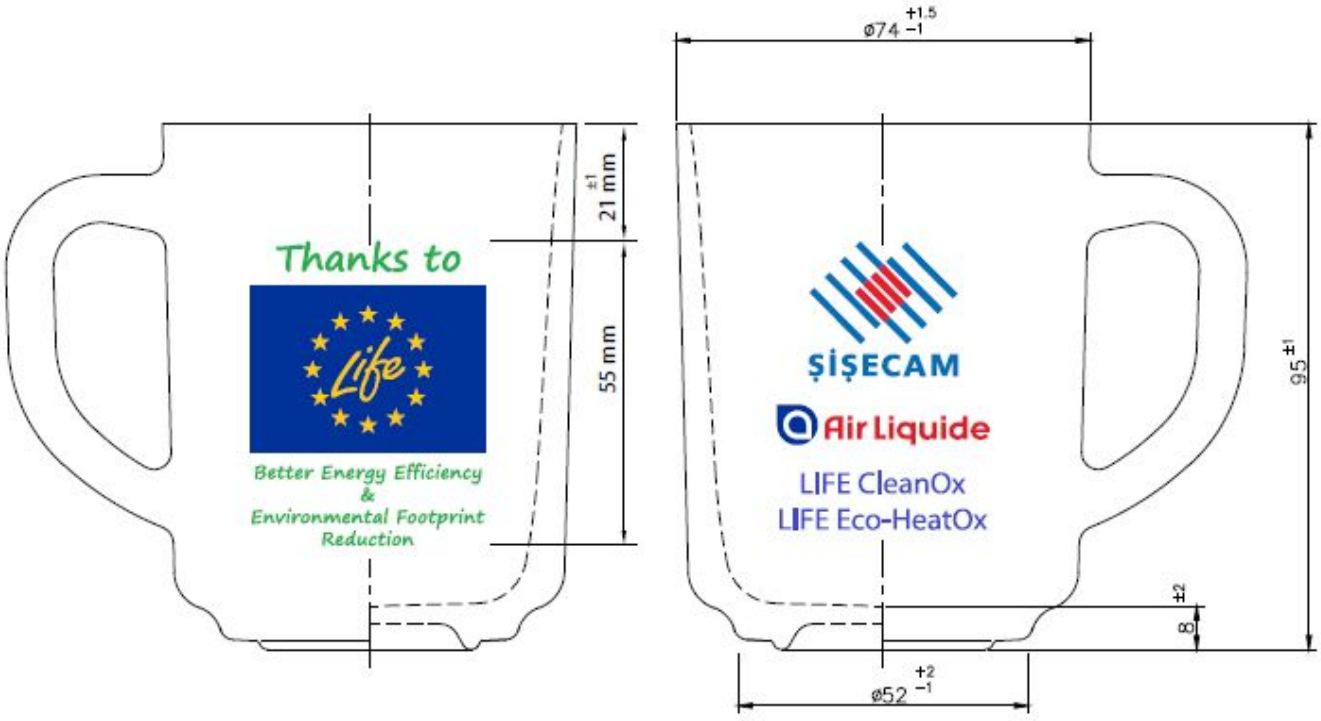
At Glasstec 2018, Air Liquide featured solutions that ensure "CLEAR EFFICIENCY" for the glass production and processing. Among the technologies showcased by Air Liquide, HeatOx technology was the flagship!

Thanks to connected glasses, live-streaming sessions were organized between project's partners in order to allow the Glasstec attendees to visit the HeatOx technology for Glass implemented at Paşabahçe in Bulgaria. It was a first of its kind: the visitors of the Air Liquide stand were taken in this way to the plant in Bulgaria to see virtually the Heatox process in a real environment, while sitting in Düsseldorf. These live-streaming sessions of HeatOx installation in Bulgaria have attracted about hundred attendees and customers for a unique live journey.
A 3D model of HeatOx technology was also made available by Air Liquide on its booth.

During Glasstec 2022, Air Liquide's trade show motto was "Growing Clean with Air Liquide". With Oxy-combustion, Heat Recovery & Hydrogen Combustion solutions in its technologies portfolio, Air Liquide was able to present low-carbon energy solutions to glassmakers and interested parties.
At GLASSTEC, Air Liquide also showed a new oxygen on-site plant to reduce the CO2 footprint at customer sites.

7th action: Air Liquide, Paşabahçe and Şişecam have jointly presented HeatOx technology and the LIFE CleanOx project at the Glass Problem Conference in Columbus, Ohio (USA) multiple times, so that participants are aware of the continuous development of the technology, notably including a paper presented by Şişecam in 2016 and a presentation of Four Major Levers for Contribution of Glass Industry Decarbonization in 2019. In 2022, the partners presented the latest Radiative Heat Exchanger results from the Life CleanOx project at the 83rd GPC.

In the framework of the CleanOx project, Paşabahçe, Şişecam and Air Liquide also worked on the following glass which was manufactured in the Paşabahçe's plant in Bulgaria. The purpose was to communicate on the LIFE+ project:



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