LIFE Smart Oxy-Boost

After-LIFE Plan

With the contribution of the LIFE financial instrument of the European Community

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Table of Contents

1. Summary

After-LIFE plan includes the activities envisaged by the partners after the LIFE Smart Oxy-Boost project. These activities have many different purposes; two of them are to bring the technology to the market and to disseminate the achievements and the technology potentials amongst target groups.

Both the main and the communication activities selected for the continuation were found to be effective and successful in terms of implementation throughout the LIFE Smart Oxy-Boost project.

2. Project objectives and key achievement

The LIFE Smart Oxy-Boost project has aimed at demonstrating partial oxy-fuel conversion of side-fired regenerative (air-fuel) float glass furnace and has based on 4 main objectives:

- Reducing specific CO_2 emissions from combustion by 4,1 % and total specific CO_2 emissions by 1,5% in an air-fuel float glass furnace by only using approximately 10 % of the amount of O_2 and less than 10 % of the CAPEX required for a typical full oxy-fuel furnace conversion. Once validated, Smart Oxy-Boost is projected to pay back in less than 2-3 years depending on the asset/furnace utilization factor.
- Reducing specific energy consumption by 4,1 % while increasing production by 15 %
- Reducing NO_X emissions by 10 %
- Reducing particulate emissions by 5 %

The three first objectives have been achieved and even exceed during the first trials:

- The specific CO2 emissions have been reduced by 4,5% and the total specific emissions by 2,5% with only addition of the smart oxy-burners
- The specific energy consumption has been reduced by 4,5% while the production was increased by 14,7%
- The NOx have been reduced by 17,2%

The objective for dust emissions reduction has not been proved. The measurement done could not show the interest of using the smart oxy-burner to reduce the dust emissions, further measurements have to be done.

The balance (partial conversion) between air-fuel and full oxy-combustion has allowed decreasing GHG emissions (compared to air-fuel) while ensuring the replication of the Smart Oxy-Boost technology thanks to its financial viability (compared to full oxy-combustion).

3. Replicability and transferability plan

The aim of this plan is to analyze the potential of the project to be replicated and transferred during and after its implementation by other stakeholders such as industries in the glass sector.

Smart oxy-boost technology has achieved 15 % capacity increase with 4.3 % decrease in energy consumption in TGB. Considering the results of LIFE Smart Oxy-Boost project and the high replicability potential of the process, Smart Oxy-Boost technology can be implemented to other glass furnaces conveniently so that energy consumption and thereby GHG emissions of furnaces would be decreased.

Figure.1 Stakeholders and target groups

Communication and dissemination activities have an important role in enhancing the replicability and transferability strategy by enabling to reach a wider audience and by providing long-term dissemination tools. To achieve these objectives, Şişecam has defined several dissemination tools

such as the participation in seminars and conferences, and the creation of a website. Şişecam also will publicize articles in specialized journals, elaborate and print information materials, such as brochures and flyers and organize meetings and events with potential clients and users to reach a large audience.

Results of the project have been disseminated in reputable industrial conferences and magazines via oral presentations and papers. In this scope, both partners Air Liquide and Şişecam have attended specialized conferences and seminars defined in the Strategic dissemination plan. Such events are dedicated to professionals, academicians, researchers, and other stakeholders from the glass sector mainly.

After the technology was validated, a plan for the transfer of the technology to other float glass furnaces and sectors has been prepared within the deliverable “replicability and transferability plan”.

Main steps of the replicability and transferability plan are listed below.

1. Market and competition analysis
2. Business models definition including in case of replicability of transferability
3. Technical and business activities aiming at validating the transferability of the solution to applications/sectors

3.1 Market analysis

The objective within this step will be to carefully analyze the size of the markets that will be addressed in case of transfer of the project results but also to analyze the competition in order to further estimate the potential breakthrough.

It is estimated that 628 furnaces are operating in Europe with 43 M tons production capacity per year for every kind of glass. 490 furnaces of them are regenerative or recuperative, which uses liquid or gaseous fossil fuel for combustion. Today, about 35 furnaces are operating with oxy-combustion in the EU, for fiberglass and technical glass production mainly.

Flat glass industry has a turnover of 15 billion with 60 installations in 12 countries in Europe. Annual growth in flat glass output is in the order of 2-3 % on average because of growth in the automotive and construction industries. There is a great potential in the flat glass sector to apply this technology to other furnaces. Considering float furnaces in Europe, it is possible to increase production capacity to 2* M tons per year with existing furnaces with 4 % decrease in energy consumption.

Also, container and float glass division is 82 % of glass production in tonnage. Smart Oxy-boost technology can be implemented to nearly 293 units. Dissemination of this technology to other glass furnaces will provide a significant contribution to reducing energy consumption and emissions.

Şişecam Group has 50 furnaces operating in Turkey and abroad with total 4.9 M tons production per year in 2020. 46 of 50 furnaces are regenerative and 4 of them are oxy-fuel. 28 furnaces are operating in Turkey, others in foreign countries namely Russia, Bulgaria, Italy, India and Egypt.

Table.1 Number of Şişecam Glass Furnaces

	Float	Packaging	Tableware	E-Glass
Turkey	9	12	6	1
Abroad	6	12	4	-

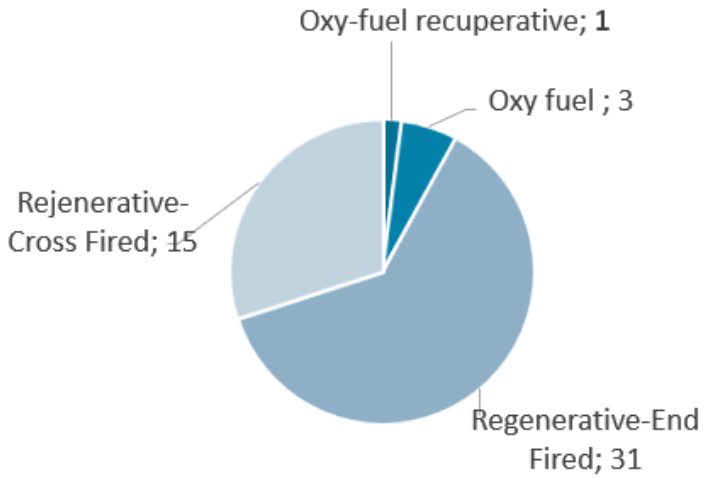

Figure.1 Şişecam furnaces' types

Firstly, the main objective of the project is to reduce greenhouse gas emissions (4,2 % CO_2 savings from combustion and 10 % NO_x savings) compared to the air combustion process which will ensure a low-carbon economy in the glass industry. Secondly, another main project objective is to increase thermal efficiency in glass plants by reducing natural gas (NG) use for the glass melting process by 4,2 % which highly contributes to a resource efficient economy. The Smart oxy-boost technology has achieved 15 % capacity increase with 4 % decrease in energy consumption in TGB and 4 % reduction in CO_2 emissions from combustion and 2.8 % reduction in total specific CO_2 emissions in an air-fuel float glass furnace. In Europe, CO_2 emission of the glass industry is around 21.7MT per year. After implementation of Smart oxy-boost to air-fired furnaces, the potential yearly CO_2 saving will be about 0.146 MT per year.

3.2 Business plan

Stakeholders are defined as Şişecam Group, public authorities and glass industry. Şişecam Group is charged to validate the technology in the pilot furnace and transfer and replicate the technology to its other furnaces worldwide. Stakeholders should agree with environmental regulations

implemented by public authorities. Other glass producers are pressured to carry out similar technologies to coordinate with the new environmental norms set by the project. They should get involved through targeted dissemination and replication actions.

Glass industry and other industries using combustion in their processes (steel, cement manufacturers, etc.) can be considered as target groups for replication and transfer of results in order to keep pace with innovation of the process for environmental reasons.

Şişecam aims to replicate and transfer this technology to the following furnaces, respectively.

- Application of this technology in other Şişecam flat glass furnaces
- Application of this technology in other companies' flat glass furnaces in Europe and worldwide
- Application of this technology in other types of glass furnaces (container etc.)
- Application of this technology in other sectors (steel, cement etc.)

Based on the business plan and the dissemination activities performed by the partners during and after the project, Şişecam would replicate the process in other float furnaces of the Şişecam Group.

The Smart Oxy-Boost process has been specifically designed for flat glass furnaces. Besides Şişecam Group, the other glass companies may benefit from the know-how generated in this project. For instance, companies such as Saint Gobain (60 production sites), O+I (37 production sites), Vetropack Group (7 production sites in Europe), Vidrala (6 production sites in Europe) Wiegan Glas (5 production sites in Europe) and Arc International (4 production sites) may be interested. In addition, the knowledge and data acquired during the LIFE Smart Oxy-Boost project has been very valuable for other types of glass furnaces.

Besides the glass sector, the developed technology can be transferred to other sectors having high temperature processes (such as steel, cement, non-ferrous metals etc.) with similar or slightly different configurations in terms of burner layout. They should be interested in implementing the technology in order to reduce their activities' environmental impact.

These replication and transfer projects will be ensured by financial viability of the technology demonstrated through the LIFE Smart Oxy-Boost project due to the low CAPEX.

3.3 Swot analysis

Considering the current situation and future expectations of the glass industry, a SWOT analysis has been done to introduce this technology to the market.

Strengths	• Providing capacity increase • Decreasing specific energy consumption • Decreasing carbon emissions

	• Applicability to different type of glass (float, container etc.) • Applicability to different sectors (cement, steel etc.)
Weaknesses	• Requirement of initial investment
Opportunities	• Growing sector
Threats	• Global financial crises • Uncertainty of energy prices • High oxygen prices

3.4 Technical activities

The pilot smart oxy-boost technology has been implemented to a flat glass furnace but, the LIFE Smart Oxy-Boost project could be very beneficial to other glass furnaces. Also, the technology is convenient for other industries having high temperature processes.

e.Burner could work with any type of glass and fuel so it could be implemented to glass furnaces with ease. At the end of a furnace's lifetime, whenthe investment decision is made to rebuild the furnace, Smart Oxy-Boost technology with e.Burner can possibly be implemented thanks to its financial viability. Then, in 15 years, oxy-boost technology could be applied to a major part of air-fuel furnaces.

In line with the Şişecam's needs, Şişecam Flat Glass Russia has been chosen to implement Smart Oxy-Boost technology in accordance with the business plan to reduce environmental impact. Similar to the TGB furnace, 4 % reduction in energy and CO_2 emissions from combustion are expected. In this scope, simulation and design change studies are carried out. After investment decision is made, next steps that will apply are defined in below:

- Application for the required permits for oxygen production and use in float glass furnace
- Determination of upstream and downstream process limitations to eliminate the imposing effects of unrelated technical limitations on the environmental benefits of the projects.
- Measuring and validating an accurate baseline level of process functionality prior to the implementation of an oxygen boosting system to monitor all of the indicators including thermal, mechanical, and environmental.
- Investigation of the furnace capacity increase, glass quality improvement, production and energy efficiency improvement to better understand and predict the furnace's behavior.
- Implementation of burners, piping and O2 generator into furnace to set up Oxy-Boost system.

- Definition of optimum operating conditions and operation of different production cases to establish transitional and steady state operating practices for changing operating and product requirements.

3.5 After-LIFE actions

Timetable of the After-LIFE actions per beneficiary is summarized below.

After-LIFE Actions	Responsible Beneficiary	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Continuation of Şişecam operation	Şişecam											
Contacts with stakeholders and target groups- for improvement of developed technology	Şişecam & Air Liquide											
Elaboration of dissemination materials	Şişecam											
Creation and update of a website presenting the project's results	Şişecam											
Presentation of the project's benefits in national and international conferences and seminars	Şişecam&Air Liquide											
Organization of meetings with stakeholders and target groups interested to replicate the developed technology	Şişecam&Air Liquide											

All the next actions described in this table will be carried out with the partners' own resources. As present in the project performance indicators, there will be no external input from grants or

subsidies. The partners are confident that the cost-effectiveness of the project will be used to deploy it effectively.

4. Conclusions

The Smart Oxy-Boost project was designed, developed and implemented with the purpose of contributing to the environment for a low energy and low carbon economy. This after-LIFE plan outlined next steps to carry out this mission by bringing the developed technology to the market and disseminating its achievements.

There is a great potential in the glass and other sectors like cement and steel to apply this technology. Dissemination of this technology to other furnaces will provide a significant contribution to reducing energy consumption and emissions.