LIFE Smart Oxy-Boost

Final project performance specific indicators

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

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Trakya Glass Bulgaria EAD Air Liquide	**Final project performance specific indicators** **LIFE Smart Oxy-Boost** **LIFE17 CCM/BG/000069**	Life

Introduction

This document aims to summarize the objectives, technical and global, of the LIFE Smart Oxy-Boost defined before the beginning of the project, the modifications done on these objectives and the results obtained. Explanations will be given to explain why the original objectives have been modified.

Technical results

Initial objectives

Indicators	Air furnace	Oxygen boosting pull rate increase
Pull rate (tpd)	[redacted]	
Improvement expected (%)		
Energy consumption (kWh/Tg)		
Reduction expected (%)		
O2 flow (Nm3/Tg)		
CO2 - Combustion (kg/Tglass)		
CO2 - batch (kg/Tglass)		
CO2 - Oxygen (kg/Tglass)		
Total CO2 process (kg/Tglass)		
Reduction expected (%)		
Total NOx emissions (kg/Tglass)		
Reduction expected (%)		
Total Dust emissions (kg/Tglass)		
Reduction expected (%)		
CAPEX (M€)		

These objectives have been defined based on a furnace nominal pull rate of 650 tons per day and an increase of around 15% of the pull rate before the beginning of the project.

Modified objectives

The smart oxy-boost burners have been installed on a new furnace. Sisecam did not really know the nominal pull rate of this furnace before starting it. That is why a pull rate of 650 tpd has been taken at the beginning for the nominal pull rate. But after a few months of operation, it was noticed that the furnace could easily work with a pull rate of 750 tpd without oxy-boosting. It has been thus decided to take 750 tpd as nominal pull rate for the updated objectives while keeping the 15% increase of the pull rate.

The energy consumption for each ton of glass produced has also been changed since Sisecam recently noticed that there was a mistake in the value given by their NG flowmeters. All the values Sisecam gave at first need to be increased by 8,5% to have the correct value of NG consumed. The energy consumption at 750 tpd is the correct value measured during operation.

It has to be noticed that, at this power, an increase of around 400-500 kWh is needed to increase the pull rate by 10 tpd. It was not possible to only use the oxy-boost burner to reach the 15% pull rate increase because the maximum power of the burners is 1,8MW each. The power of the air burner has also been increased to reach the final 860tpd.

In the first objective table, the CO2 coming from the natural gas transportation and extraction was not taken into account. This CO2 emissions have been added in the objectives table. For each kWh of NG used in the plant 0,04kg of CO2 is produced.

The CO2 emission linked to the O2 production was taken into account in the first objectives. But France's value of CO2 produced per tonne of oxygen used for combustion was used (40,5kgCO2/TO2) which corresponds to one of the lowest values in the world since France is using a lot of nuclear power. It has thus been decided to change this value and take the average value in Europe (284,4 kgCO2/TO2).

The new objectives table with the modification mentioned above is presented below. The value for NOx and Dust reduction have been kept constant compared to the original objectives, -10% and -5% respectively.

Revised objectives (2022)		
Indicators	Air furnace	Smart Oxygen boosting pull rate increase
Pull rate (tpd)	[redacted]	
Energy used (kWh/Tg)		
O2 flow (Nm3/Tg)		
O2 flow (TO2/Tg)		
CO2 - Combustion (kg/Tglass)		
CO2 - batch (kg/Tglass)		
Total direct CO2 (kg/Tglass)		
CO2 - Oxygen (kg/Tglass)		
CO2 from NG (kg/Tg)		
Total indirect CO2 (kg/Tg)		
Total CO2 (kg/Tglass)		
Total CO2 wo batch (kg/Tglass)		
Total NOx emissions (kg/Tglass)		
Total Dust emissions (kg/Tglass)		

In this table, the total direct CO2 emissions reduction has been kept close to the original objectives, -2,7% instead of -2,4% (without the CO2 coming from the O2 production). The addition of indirect emissions coming from the NG and the modification of the CO2 coming from the O2 production led to a reduction of the objectives in terms of global CO2 emissions, -1,6%. But if we do not consider the CO2 coming from the batch where the use of the smart oxy-burner cannot have any impact, the objectives rise to -2,2% close to the initial global CO2 emissions reduction (-2,4%).

Results

The results obtained are summarized in the following tables. The first table shows the results obtained during the measurement campaign of November 2020 and the second table the results of the measurement campaign of December 2021. The first measurement campaign has been realized by Air Liquide team and the second by Sisecam team.

For all the results a LHV of 10,1kWh/Nm3 for the NG has been taken.

First test campaign 11/2020					
Indicators	Air furnace (2019) Base	Smart Oxygen boosting (2020) pull rate increase 1	Smart Oxygen boosting (2020) pull rate increase 2	Smart Oxygen boosting (2020) pull rate increase 2	Smart Oxygen boosting (2020) pull rate increase 3
Pull rate (tpd)	[redacted]				
Energy used (kWh/Tg)					
O2 flow (Nm3/Tg)					
O2 flow (TO2/Tg)					
CO2 - Combustion (kg/Tglass)					
CO2 - batch (kg/Tglass)					
Total direct CO2 (kg/Tglass)					
CO2 - Oxygen (kg/Tglass)					
CO2 from NG (kg/Tg)					
Total indirect CO2 (kg/Tg)					
Total CO2 (kg/Tglass)					
Total CO2 wo batch (kg/Tglass)					
Total NOx (NO + NO2) emissions (kg/Tglass)					
Total Dust emissions (kg/Tglass)					

Second test campaign 12/2021 Based on global flowrate			
Indicators	Air furnace 12/2021 Base	Smart Oxygen boosting 12/2021 1	Smart Oxygen boosting 12/2021 2
Pull rate (tpd)	[redacted]		
Energy used (kWh/Tg)			
O2 flow (Nm3/Tg)			
O2 flow (TO2/Tg)			
CO2 - Combustion (kg/Tglass)			
CO2 - batch (kg/Tglass)			
Total direct CO2 (kg/Tglass)			
CO2 - Oxygen (kg/Tglass)			
CO2 from NG (kg/Tg)			
Total indirect CO2 (kg/Tg)			
Total CO2 (kg/Tglass)			
Total CO2 wo batch (kg/Tglass)			
Total NO emissions (kg/Tglass)			

As presented in the tables, with the use of the smart oxy-burner, Sisecam managed to increase the furnace pull rate up to 860tpd without any issue for the furnace. As explained before to reach this pull rate starting from 750tpd, Sisecam used the smart oxy-burner at their full power and also increased the power of their air burner since the smart oxy-burners only allow to increase the pull rate by around 80tpd.

Energy consumption

For the two measurement campaigns a reduction of the energy consumption per ton of glass is observed. With a pull rate of 860tpd, the energy consumption was decreased by 5,8% during the first campaign and by 4,3% during the second one. An error on Sisecam NG flowmeters was found between the two campaigns, corrections have been applied for the first campaign data but the

correction might have not been perfect and it can explain the difference between the two campaigns. Anyway, in both campaigns the results are better than the objectives defined at the beginning of the project. For pull rates between 750 and 860tpd, the energy used reduction is still present but lower. the higher the pull rate is, the lower the specific consumption of the furnace is.

CO2 emissions

The CO2 emissions could be calculated for different pull rates. At the highest pull rate 860tpd, the CO2 emissions have been reduced by 2,8% compared to the base case in the first campaign and by 1,7%. When the CO2 coming from the batch is not taken into account the reduction reaches 3,9% and 2,3% for the first and second measurement campaign respectively. It shows that the objective in terms of CO2 reduction have been achieved and even exceeded during the first campaign.

As it can be expected, for lower pull rate the CO2 reduction is lower. During the first campaign almost no reduction of the CO2 emissions at 790tpd has been noticed and reductions of 0,5% and 2,2% have been measured for pull rates of 810 and 840tpd respectively. These results can be explained by the fact that a lower pull rate increase will result in lower CO2 reduction and that at this pull rates the furnace was not stabilized, it was still in the ramp up phase meaning that the temperature in the furnace (and thus the natural gas flow rate) was a higher than the targeted temperature in stabilized phase. The temperatures were kept high to allow Sisecam to easier increase the pull rate further. At these points (790tpd, 810tpd and 840tpd) the natural gas consumption could have been lower than the figures presented in the table above and the results in terms of CO2 emissions avoided could have been much better.

NOx and dust emissions

To obtain these results on-site measurements of NOx and dust were necessary. But due to the COVID crisis, it has not been possible to do these measurements at a pull rate of 860tpd yet. The NOx and dust measurements were done at 790 tpd, increase of 5,3% of the pull rate during the first measurement campaign and at 850tpd, increase of 13,3% of the pull rate during the second one.

First one can observe that the NOx measured at 750tpd for the two campaigns are different 4,181 and 3,517 kgNOX/Tglass. It can be explained by the fact that during the first campaign both NO and NO2 were measured whereas during the second campaign only NO have been measured. In the literature one can find that NO2 represent around 20% of the NOx, and if we apply a 20% correction, the figures obtained are very close (3,517*1,2=4,22). In the tables we let the real values measured.

The first measurements show a decrease of 7% of the NOx emissions for around ⅓ of the final pull rate aimed. With a simple projection, we can think that the NOx reduction will exceed the initial objectives.

The second measurements show that for an increase of 13,3% of the pull rate, the NO production has been reduced by 22,2%.

Concerning the dust emissions, one can observe that in the first campaign the dust emissions measurements increased with the use of oxy-boosting and the pull rate increases. It is difficult to say if the use of the smart oxy-burner had an impact on the dust emissions. Indeed, these results are hard to analyze since the measurements have not been done the right way. It is not possible in such a furnace to compare the results with or without oxy-boosting at two different pull rates to assess the efficiency of the oxy-boosting to reduce the dust emissions (conclusion coming from discussions with experts from the Celsian company). It is indeed very difficult to predict how the dust emissions will behave with the increase of the pull rate without previous measurements, the dust emissions don't increase linearly with the increase of the pull rate. The results of the measurements show an increase of 12% of the dust measured in the regenerators when the pull rate is increased by 5,3% with the usage of the smart oxy-boost burners but it is not possible to assess the effect of the oxy-boost burner on the dust emissions. New measurements need to be done at the same pull, in similar pressure and temperature conditions with and without the oxy-boost burner to show the efficiency of the oxy-boost burner to reduce the dust emissions.

Due to the restriction linked to the COVID crisis, it has not been possible to realize such measurements during the period of the project. Measurements are still planned but after the end of the project. Thus, we will not be able to conclude on the effect of the oxy-boost burner on the dust production. Dust measurements were also done during the second measurement campaign. The sample are currently analyzed by Sisecam team, they should be ready soon. But, again, the baseline was done at 750tpd without the use of the smart oxy-burner and at 850tpd with the use of the smart oxy-burner. It will be again difficult to see the impact of the smart oxy-burner on the dust emissions.

Global results

Indicator	Unité plateforme KPI	State-of-play at the beginning of the project period at project level	State-of-play at the end of the project period at project level	State-of-play 3 years after the project end at project continuation, replication and/or transfer level
Partial reduction of specific pressures/threats affecting the spatial extent of the project in comparison to the present level	m2	0	453 000	953 000
Persons who may have been influenced via dissemination or awareness raising project-actions (reaching)	Number of other persons influenced /impacted independently of the project area	0	1336	5500
Persons who changed their behaviour or practices due to the project actions	Number of non-resident persons regularly present within or near the project area (e.g. employees)	0	150	2000
Private for profit	number of stakeholders involved due to the project	0	1	1
No. of unique visits	number	0	936	1500
Professionals - experts in the field	No. of individuals	0	830	1000
Jobs	No. of FTE	0	3,28	9,87
Running cost/operating costs during the project and expected in case of continuation/replication/transfer after the project period	€	0	120 067	120 067
Grants, subsidies	€	/	/	0

Project area

Sisecam has a plan to implement Smart Oxyburners at its Russia plant. Russia plant is 500.000m2. This will be in addition of the 453.000m2 used in the context of the LIFE Smart Oxy-Boost project.

Humans influenced by the project

We considered that the project influenced 1336 people at the end and will continue after. For the website, 936 people visited it at least once. 1500 number of visitors is expected beyond three years. But also, at the end of the project, we considered: the participation to several conferences, fairs, and exhibitions related to the glass industry, articles in specialized publications, information along usual business contacts, 1300 leaflets, posters and brochures. Beyond 3 years: a successful project would entail further promotion activities than those scheduled in the current project, further participation to conferences, fairs, exhibitions, related to the other countries, in particular in Asia, with articles, posters and brochures translated in the language of the country.

We considered that that the project not only influenced people but also had and will have an impact. To estimate these indicators, we considered:

At the end of the project: Organisation of meetings with the authorities and any interested groups (industries, researchers, policy makers...) , meetings with stakeholders EC, training, TGB plant visits. And beyond 3 years, organisation of meetings with the authorities and any interested groups (industries, researchers, policy makers...), development of a web WW community. Visits of plants with several references in different segments, collaboration with local engineering companies, Program of training.

Governance

During the project we had 1 subcontractor involved in the project for the construction of the equipment.

Information and awareness raising to the general public

We launched the Smart Oxy-Boost Website at the beginning of the project, 438 visitors visited it in the last year. 427 of these are unique people. The total number of page views since the beginning of the project is 936. 1500 number of visitors is expected beyond three years.

Capacity building

LIFE Smart Oxy-boost project is represented by TGB at operational excellence session of 36th Glass Symposium. More than 750 participants from 40 countries participated in this on-line symposium and the LIFE Smart Oxy-boost project was presented at this on-line meeting.

In the frame of Smart Oxy-Boost project AL made a presentation called Clear Efficiency. ICG international Congress in Boston, USA in 2019. (50-60 participants)

The LIFE Smart Oxy-Boost project was presented in 07 April 2021 Video Conference to the ICG-TC9 Energy Efficiency committee members. (30 participants)

Jobs

The LIFE Smart Oxy-Boost project strengthens employment by making highly qualified staffs. It broadens and deepen the knowledge and skills of the team members, enabling the career development and insertion of workers, including young workers.

Employees involved in the project (20 people) spent an average of 16.4% of their time on this project throughout the project period (is equal to 3,28 FTE). Employees working in the furnace department and auxiliary facilities will continue their responsibilities after the project. To successfully roll out this new technology in Europe and worldwide, TGB and AL will train local people and capitalize on first industrial references. All workers will be trained on specifics standards and codes of the new technology. addition, the inexperienced staff working for glass industry insofar with only air-combustion knowledge would be trained for oxy-fuel combustion

Beyond three years FTE will be three times as Şişecam has a plan to implement Smart Oxy-boost system at its Russia and Turkey plant.

Contribution to economic growth

It is complicated to estimate the costs, because the running costs is based on energy consumption reduction. We estimated it at 120 067€, because of the energy (natural gas) consumption is decreased by 4.3% with the help of smart oxyboost system. But this is depending on the rising energy prices, the amount of savings will probably be higher in the coming years.

We do not expect any further grants, the project is in its final stages and there are no technical milestones to be achieved. The next steps will not be technical improvements, Şişecam will implement the Smart Oxyboost application in other furnaces with its own contributions.

Conclusion

Concerning the technical results, they have been modified compared to the original objectives to take into account the fact that the furnace baseline is a pull rate of 750tpd and not 650tpd, the right value of CO2 emitted by tonne of O2 produced and the CO2 emissions coming from the natural gas extraction and transportation. It has reduced a bit the objective in term of CO2 emissions but the other indicators (NOx, dust, specific consumption) have been kept constant.

The objective for dust emissions reduction have 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.

Otherwise, the results of the measurement campaign show that the objectives have been achieved. The pull rate has been increased by 15%, while the power consumption has been reduced by 5,8%, the CO2 emissions by 2,8% and the NOx emissions by 22% in the best case. It represents a reduction of around 4900T of CO2 and 274T of NOx per year.

Concerning the global results, they have been modified during the course of the project according to the evolution of the project. Some have had to cope with the covid crisis while others are in line with what we had hoped for. These results are found in different parts of the project as they complement the technical objectives, and it is through the development of these indicators that the project will be sustainable over time.