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Sustainable Glass Industry

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# SUSTAINABLE GLASS INDUSTRY WITH FUEL-FLEXIBLE TECHNOLOGY

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# SUSTAINABLE GLASS INDUSTRY WITH FUEL-FLEXIBLE TECHNOLOGY

**Program**: Horizon Europe

**Project Duration**: 2023.10.01 - 2027.09.30

**Call**: HORIZON-CL5-2022-D3-03-06 Efficient and low-emission technologies for industrial use of combustion and gasification systems from low-value biogenic residues and wastes

**Estimated Project Cost**: 4 478 775.00 EUR.

**Coordinator**: Lithuanian Energy Institute, Lithuania.

**Partners**: CHALMERS TEKNISKA HOGSKOLA AB, Sweden; TECHNISCHE UNIVERSITAET MUENCHEN (TUM), Germany; VYTAUTO DIDZIOJO UNIVERSITETAS (VMU), Lithuania; WIRTSCHAFT UND INFRASTRUKTUR GMBH & CO PLANUNGS KG (WIP), Germany; AB PANEVEZIO STIKLAS, Lithuania; SCHOTT AG, Germany; PLASMAAIR AG OXIDATIVE ABGASBEHANDLUNG UND PLASMASYSTEME (Plasmaair AG), Germany; SHEFFIELD HALLAM UNIVERSITY (SHU), United Kingdom.

# GIFFT context



**$CO_2$ Glass Melting: One of Europe's Most Energy-Intensive and Hard-to-Abate $CO_2$ Sources**

## Production Growth

39.5 mln. tons of glass in the EU in 2022 (+~20 % from 2013)

Photo of AB Panevėžio stiklas

## High Energy Demand

- Glass melting (1200 - 1750°C) accounts for over 75% of the total energy requirements (3 – 8 GJ/t melted glass);

- Final energy consumption ~250 PJ in the EU in 2022;

- Highly dependent on natural gas (NG) 178 PJ (69.2%) or ~5.1 billion. $m^3$ annually;

## High Carbon Footprint

- The $CO_2$ (22 Mt in 2022) emissions are directly linked to the energy used: about 75-85% come from the combustion, while the remaining 15-25% come from the decomposition of carbonates.

# Key problem GIFFT addresses

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**Glass industry is hitting the $CO_2$-reduction limit — new solutions are required.**

## Innovative cross-sectoral solutions are sought:

- ***Green electricity*** **-** limited to <85% $CO_2$***;***
- ***Circularity process*** **-** virgin material replacement, limited to <15-25% $CO_2$**;**
- ***Green alternatives to natural gas*** **–** *carbon-neutral fuels,* limited to <85% $CO_2$***;***
- ***Hybrid fuels scenarios*** **–** *flexibility in extremely challenging situations.*

# GIFFT proposed solution

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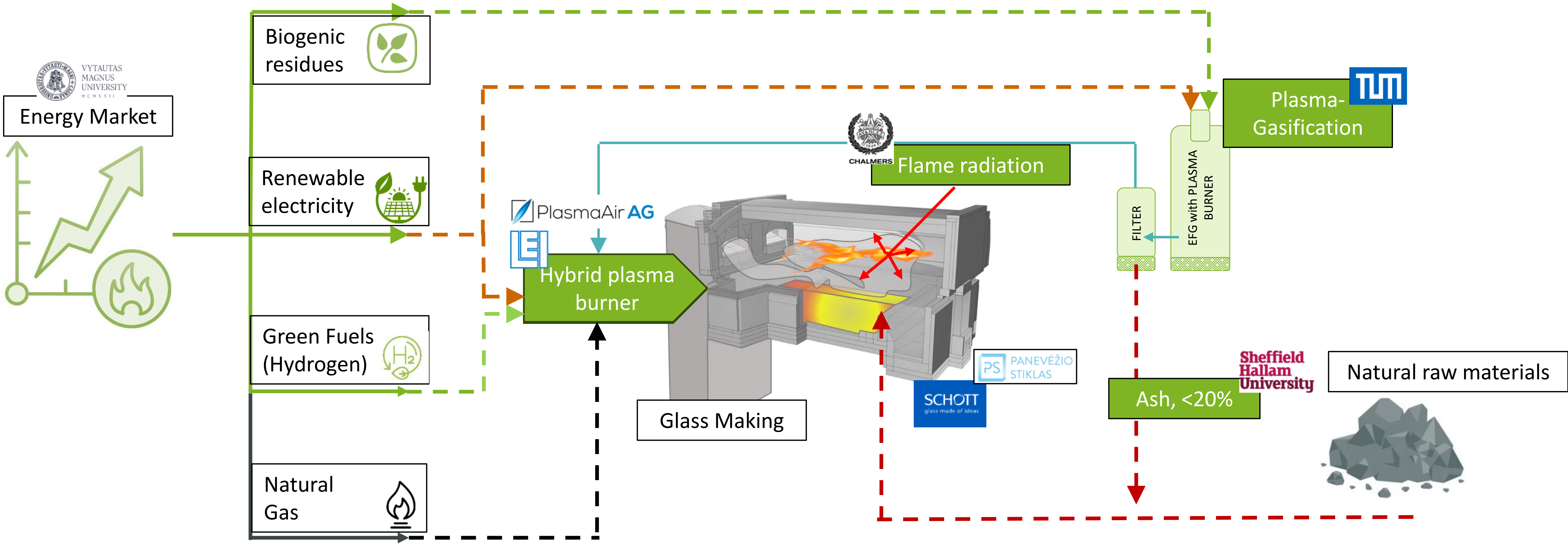
**GIFFT aims to create a flexible hybrid furnace that replaces natural gas with biogenic residues and green electricity, unlocking low-carbon heat production.**



# GIFFT operational flexibility (1)

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**Operation example of GIFFT for container glass production for container glass production**

## Base case

Production 140 $t_{Glass}$/d

***Energy for glass melting***:

*NG combustion - 922 kWh/$t_{Glass}$*
*Electricity - 103 kWh/$t_{Glass}$*
**Total: ~ 1025 kWh/$t_{Glass}$**

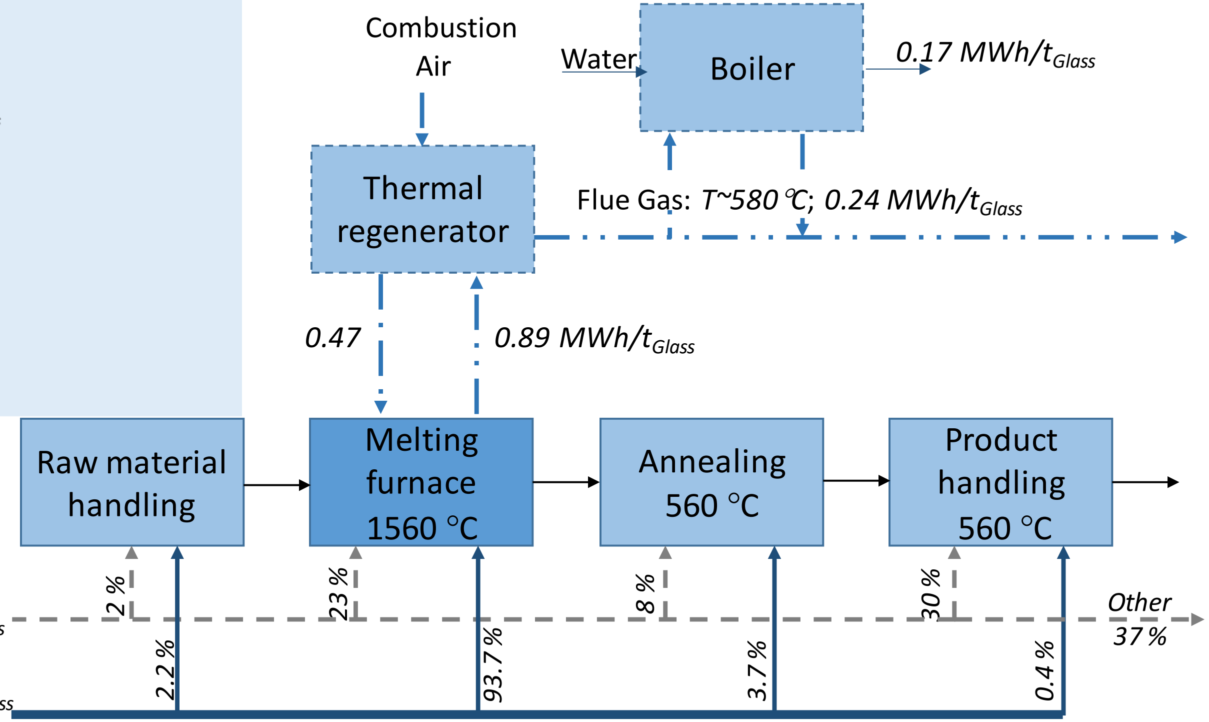
***$CO_2$ from glass melting***:

*NG combustion - 0.20 $t_{CO2}/t_{Glass}$*
*Process - 0.09 $t_{CO2}/t_{Glass}$*
**Total: ~ 0.29 $t_{CO2}/t_{Glass}$**

**Energy to Melter:**

Electricity *0.10 MWh/$t_{Glass}$*

Natural Gas *0.92 MWh/$t_{Glass}$*




# GIFFT operational flexibility (2)

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## Biomass (Solo) Case

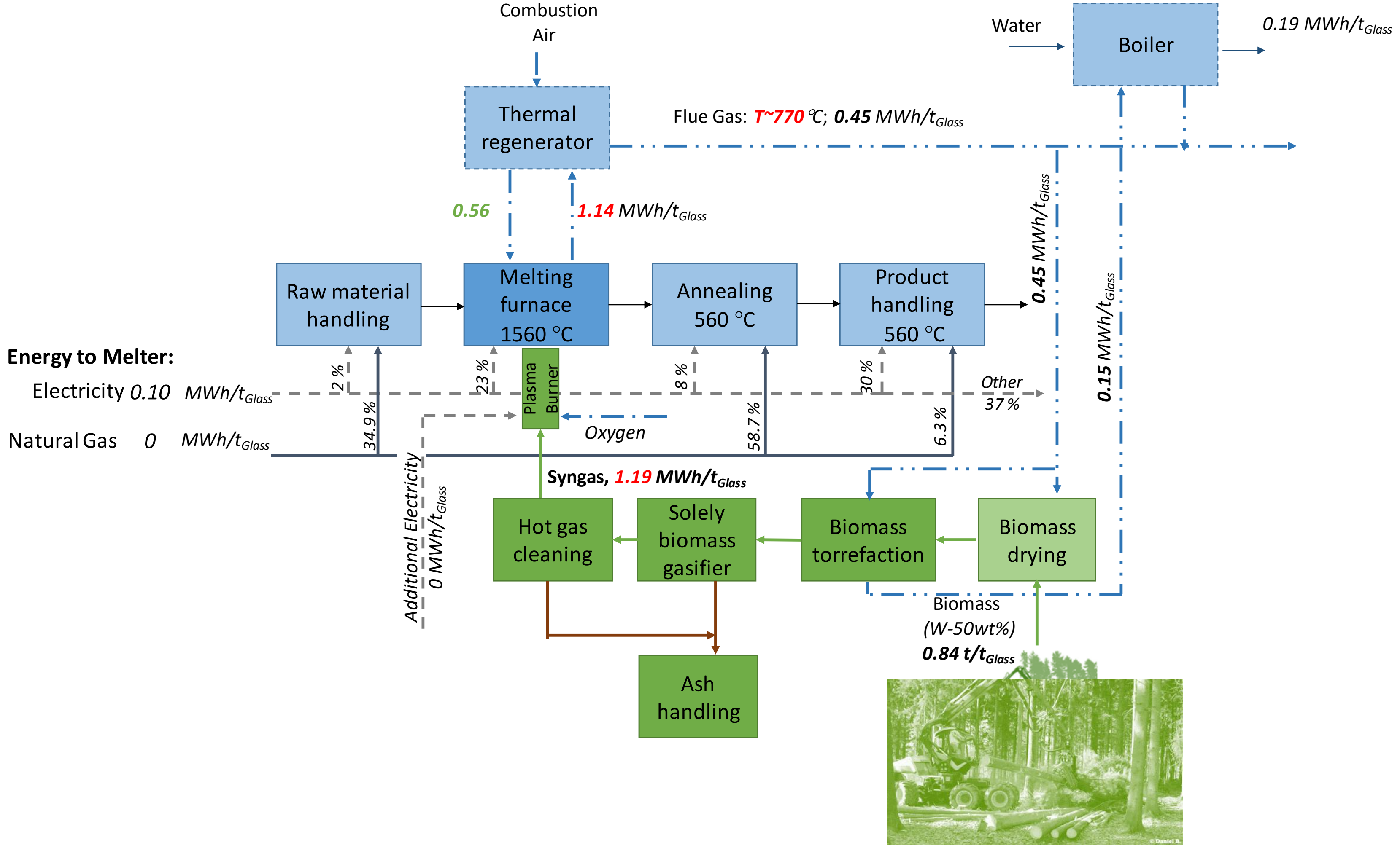
**Production** ***140*** $\boldsymbol{t_{Glass}/d}$

***Energy for glass melting***:

*NG combustion - 0 kWh/*$t_{Glass}$
*SynGas combustion - 533 kWh/*$t_{Glass}$
*Electricity (plazma+tenai) - 507 kWh/*$t_{Glass}$
**Total: ~ 1040 kWh/**$\boldsymbol{t_{Glass}}$

***$\boldsymbol{CO_2}$ from glass melting***:

*NG combustion - 0* $t_{CO2}/t_{Glass}$
*SynGas combustion - 0.30* $t_{CO2}/t_{Glass}$
*Process - 0.05* $t_{CO2}/t_{Glass}$
**Total: ~ 0.35** $\boldsymbol{t_{CO2}/t_{Glass}}$



# GIFFT operational flexibility (3)

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## Green Electricity Case

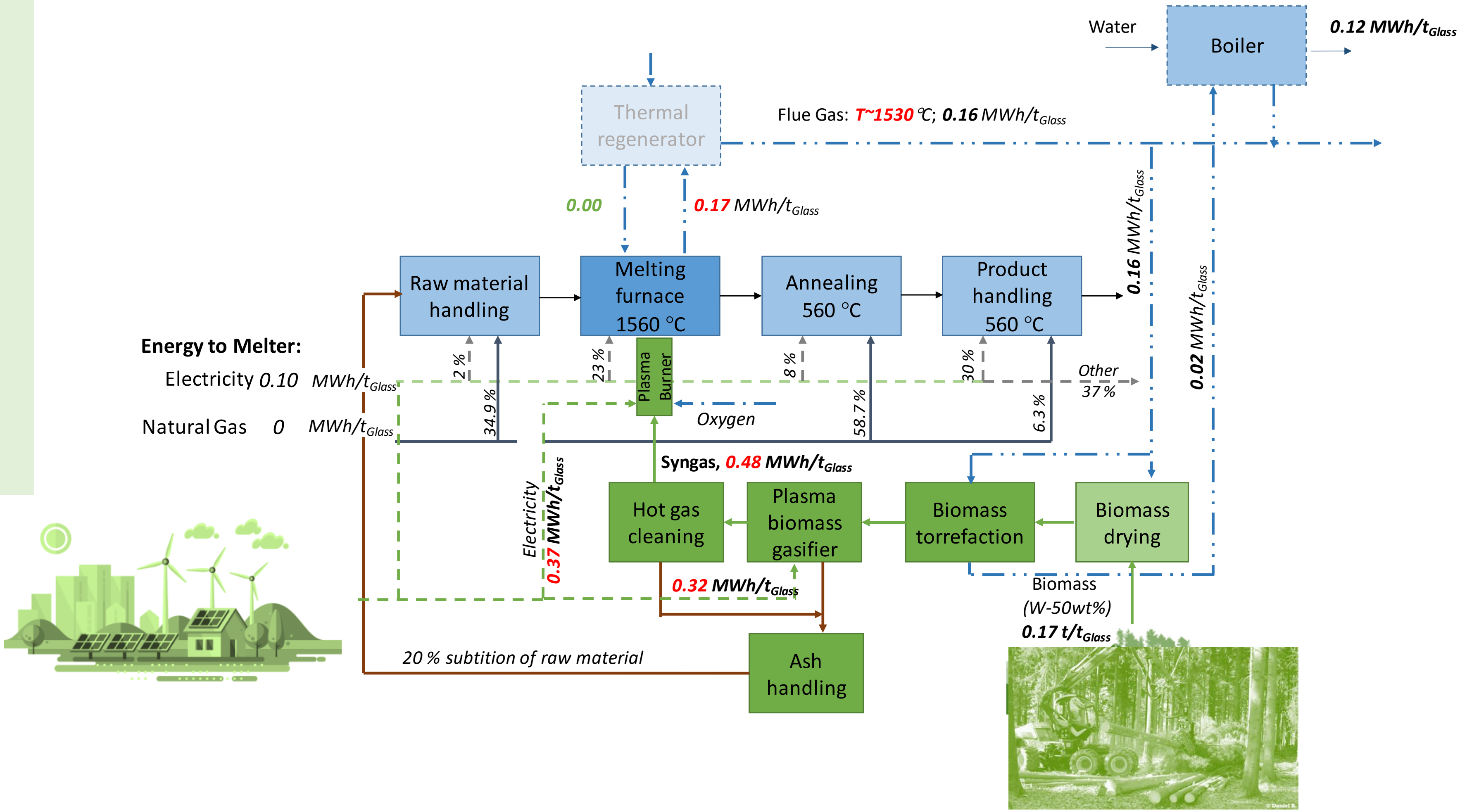
**Production *140 $t_{Glass}$/d***

***Energy for glass melting*:**

*NG combustion - 0 kWh/$t_{Glass}$*
*SynGas combustion - 493 kWh/$t_{Glass}$*
*Electricity (plazma+tenai) - 480 kWh/$t_{Glass}$*
**Total: ~ 973 kWh/$t_{Glass}$**

***$CO_2$ from glass melting*:**

*NG combustion - 0 $t_{CO2}/t_{Glass}$*
*SynGas combustion - 0.12 $t_{CO2}/t_{Glass}$*
*Process - 0.05 $t_{CO2}/t_{Glass}$*
**Total: ~ 0.17 $t_{CO2}/t_{Glass}$**



# GIFFT operational flexibility (4)

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## Hydrogen Case

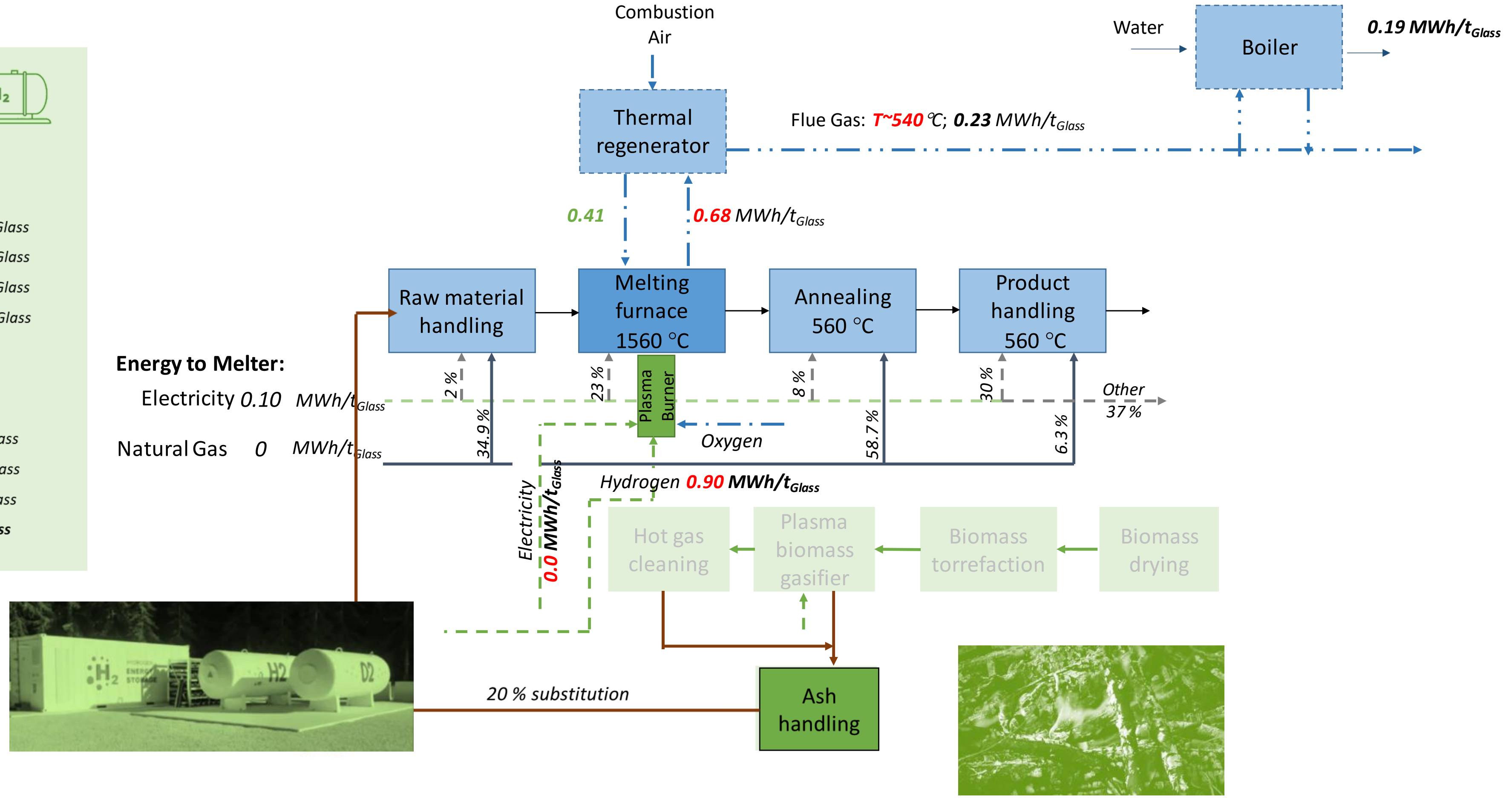
**Production *140* $t_{Glass}$*/d***

***Energy for glass melting*:**

*NG combustion - 0 kWh/$t_{Glass}$*
*$H_2$ combustion - 478 kWh/$t_{Glass}$*
*Electricity (plasma+rods) - 473 kWh/$t_{Glass}$*
**Total: ~ 951 kWh/$t_{Glass}$**

***$CO_2$ from glass melting*:**

*NG combustion - 0 $t_{CO2}/t_{Glass}$*
*$H_2$ combustion - 0.12 $t_{CO2}/t_{Glass}$*
*Process - 0.05 $t_{CO2}/t_{Glass}$*
**Total: ~ 0.05 $t_{CO2}/t_{Glass}$**




# Expected Impact

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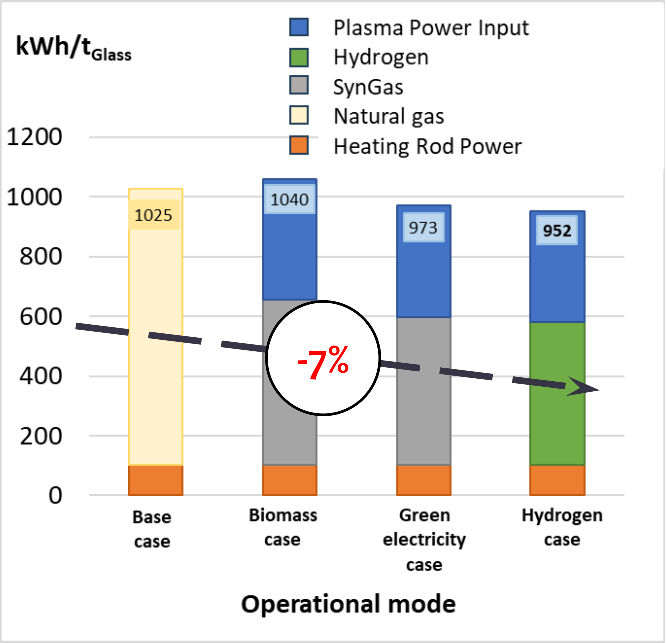
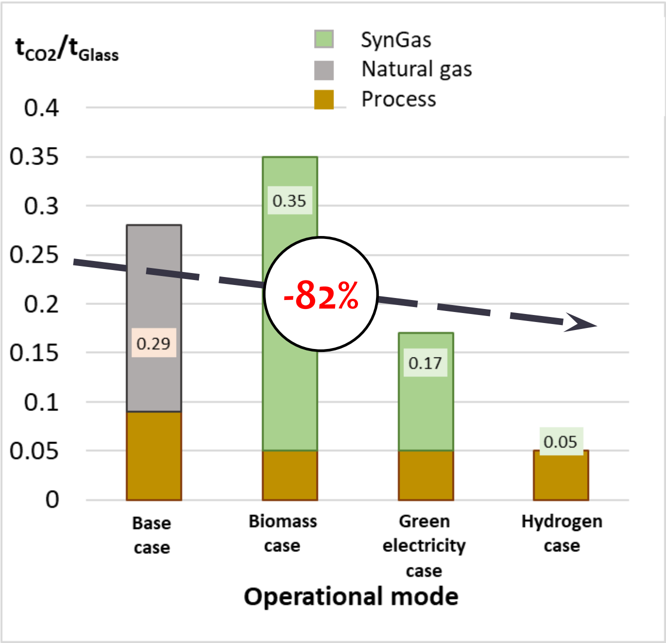
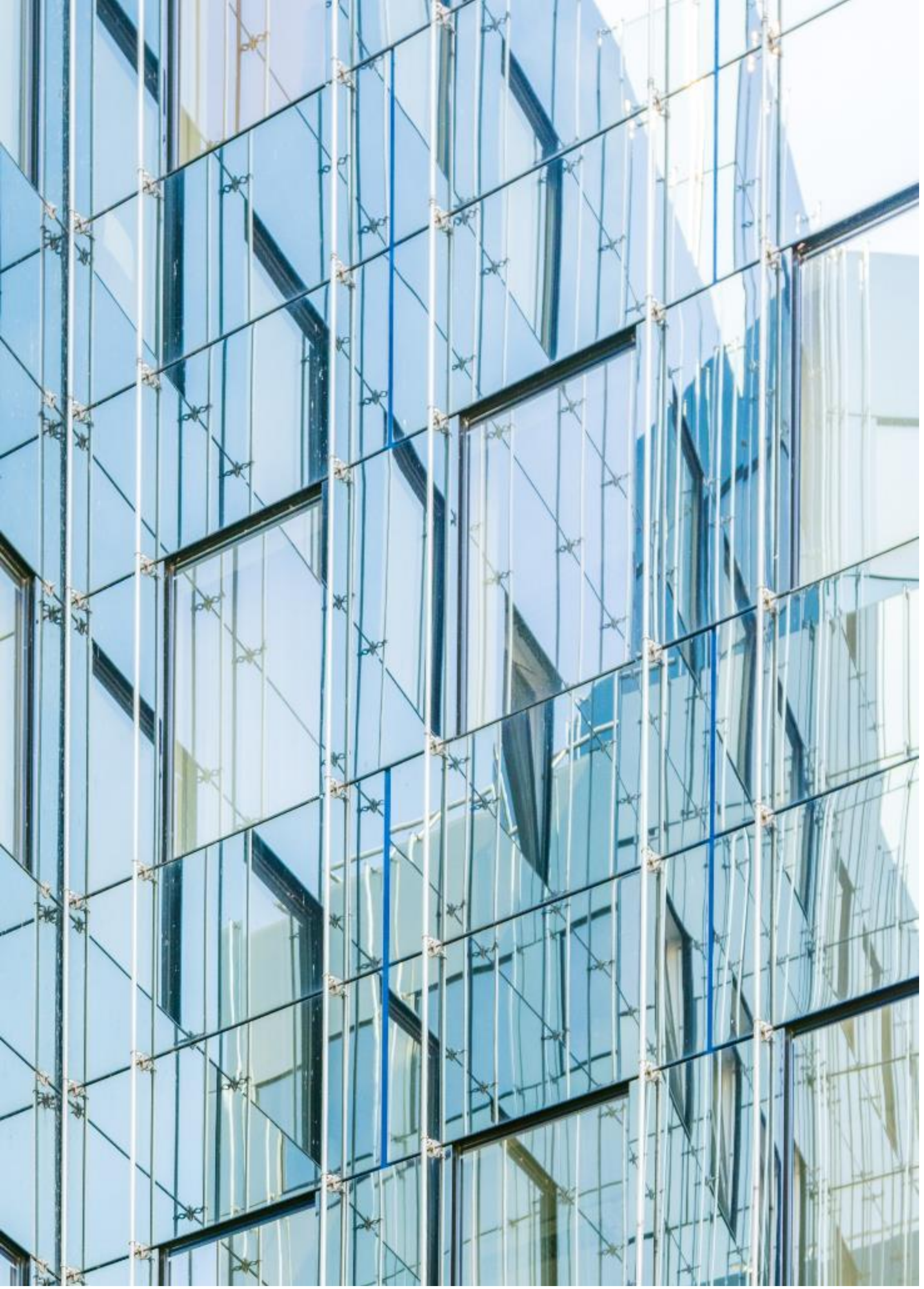
## Energy consumption




## $CO_2$ emissions




## Fuel consumption



# Key Innovations

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- Plasma-assisted biomass gasification (EFG) (TUM, PlasmaAir);
- Hybrid fuel flexible plasma burner (LEI, PlasmaAir, CTH);
- Flame heat radiation parameters (CTH, LEI);
- Biomass gasification ash as feedstock for glass production (SHU).

# Visual Comparison of Conventional and Hybrid Burner Flames

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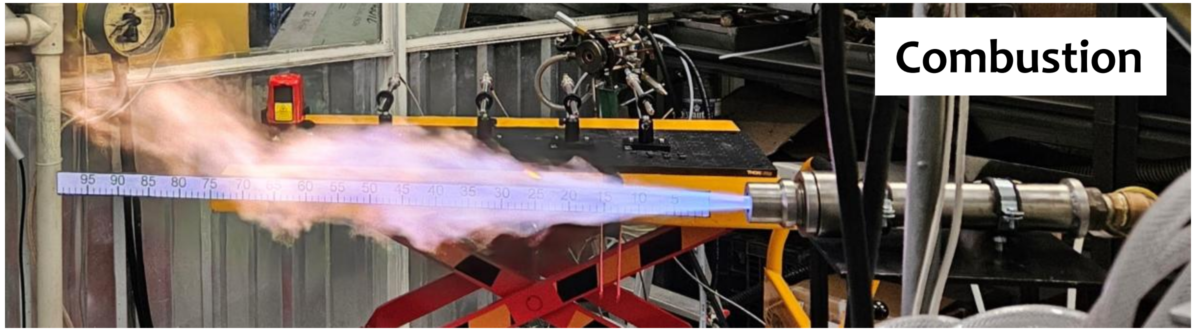
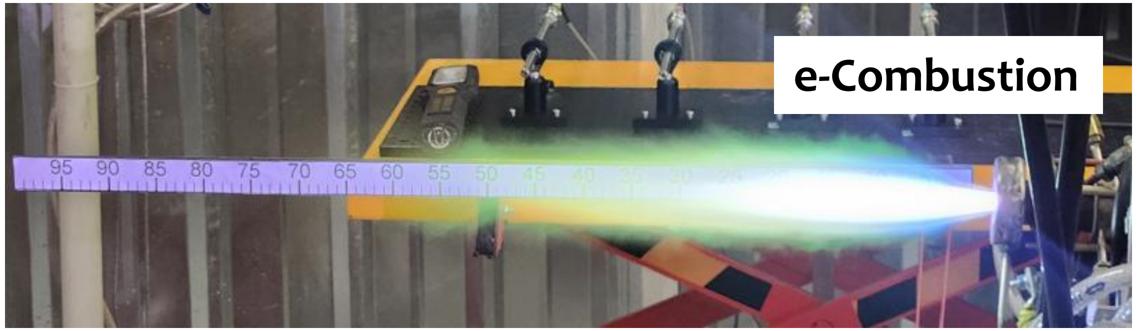
**$CH_4/O_2$**

**$H_2/O_2$**


50% chemical energy + 50% electrical energy




# LEI plasma-assisted burner prototype

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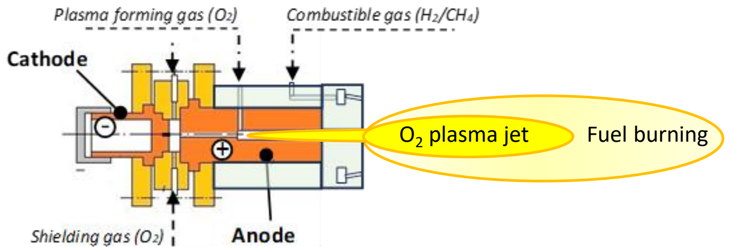
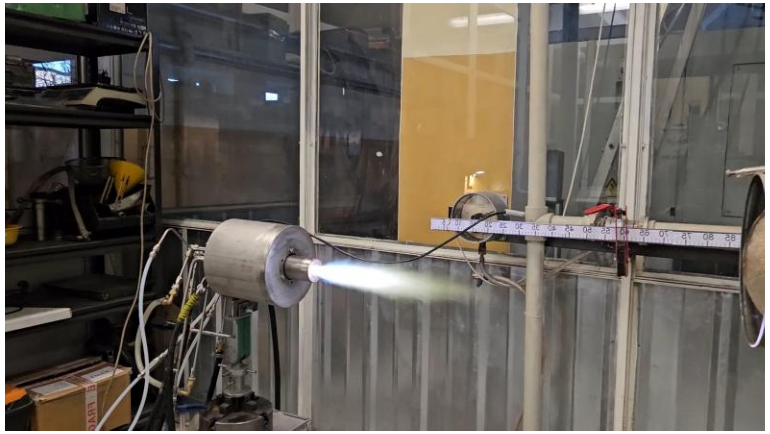
**Operation modes allow to switch in a short time from 100% combustion to 50% electric heat and 50% combustion**




**LEI Plasma burner in test operation**

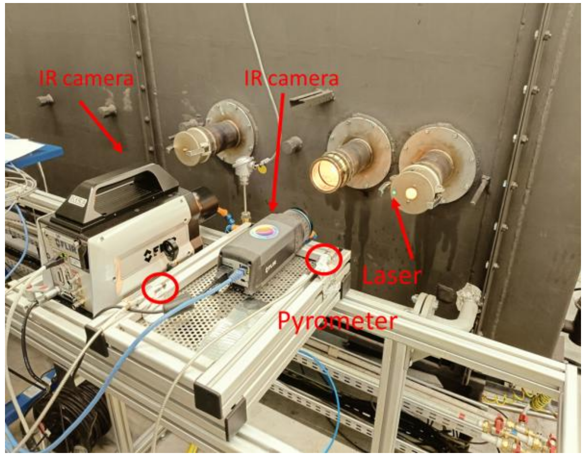


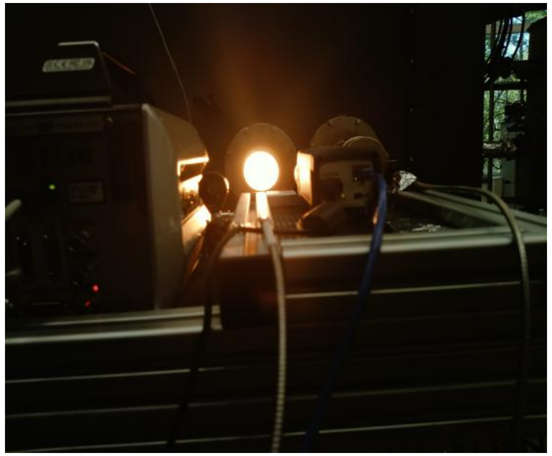
**The main parameters of the burner**

| Parameter | Value | Comment |
|---|---|---|
| Shielding gas | Oxygen | Constant |
| $O_2$ , Nm$^3$/h | 1,2 | |
| Plasma-forming gas | Oxygen | Variable depending on operating mode |
| $O_2$ , Nm$^3$/h | 3,8–14,5 | |
| Combustible gas | $H_2$ or $CH_4$ | |
| $H_2$ , Nm$^3$/h | 10,0–21,6 | Variable depending on operating mode |
| $CH_4$ , Nm$^3$/h | 3,0–8,0 | |
| Plasma torch power, kW | 25–52 | |
| Arc current, A | 120–220 | |
| Plasma voltage, V | 150–250 | |
| Total burner capacity, kW | 70–116 | |

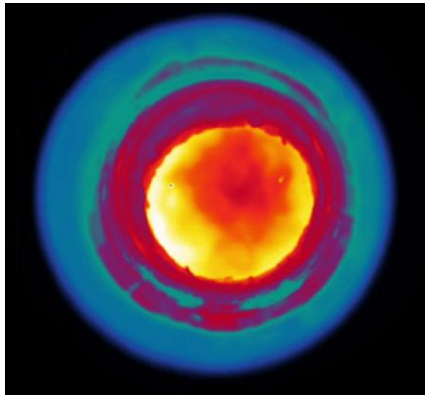
# LEI plasma-assisted burner prototype testing

- Stable burner operation with both $CH_4$ and $H_2$ fuels during a full shift, maintaining 1560 °C furnace temperature;
- Achieved radiative and temperature conditions comparable to conventional combustion;
- Hybrid plasma burner has the potential for a robust technological solution to bring electricity into crown heating of glass melting furnaces.

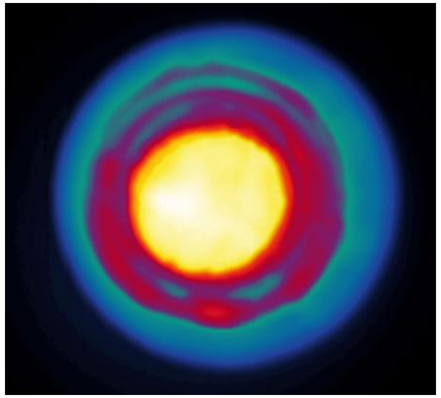


$CO_2$ spectrum



IR intensity



# Biomass gasification ash as feedstock for glass production

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Biomass ash can partially replace up to 20% of raw materials such as high-value soda ash, limestone, and dolomite.

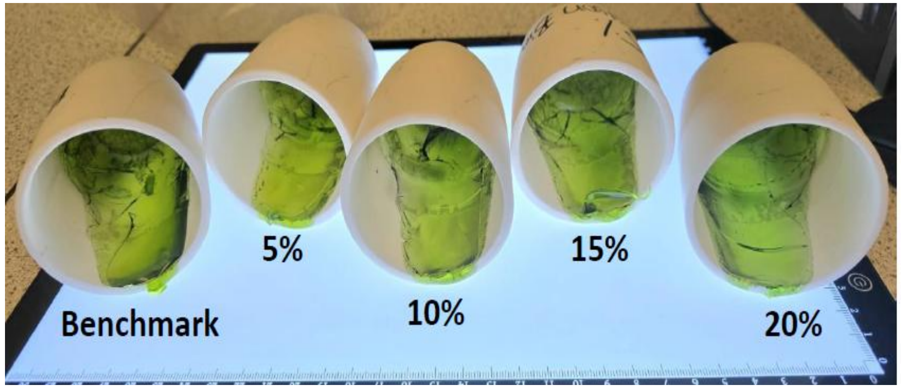
Biomass ash enables up to 20% $CO_2$ reduction from the avoided production of these raw materials. Ash-derived glass batches allow further $CO_2$ saving.

Our collaboration with glass artists Lulu Harrison and Elliot Walker has led to production of glass pieces and exhibitions of biomass ash-glasses at QEST 35 Johnnie Walker (Edinburgh) and the Bank of England (London).

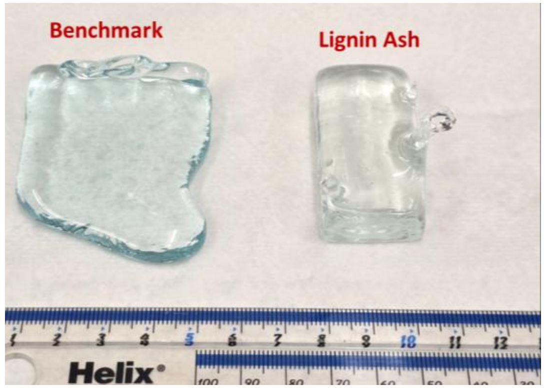

Post processing of ash via different separation techniques improves the quality of the ash.

Utilising ash from gasification process minimises landfill disposal, promotes waste-to-resource strategies, supporting industrial circularity.

## Green glass (different ash additions)




## Colorless glass (5% ash addition)




## Amber glass (5% ash addition)

# So what's next?

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- Plasma-assisted biomass gasification experiments;
- Radiative heat-transfer modelling of plasma flames;
- Integration and TRL-5 testing of a plasma burner in SCHOTT’s simulated glass-melting furnace (Germany);
- TEA–LCA assessment of selected GIFFT scenarios;
- Optimisation of glass batches and compositions with ash additions.

*Start* October, 2023 — October, 2024 — **December, 2025** — October, 2026 — October, 2027 *End*

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# Project partners

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Sheffield Hallam University Knowledge Applied

PANEVĖŽIO STIKLAS

PlasmaAir AG

SCHOTT glass made of ideas

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