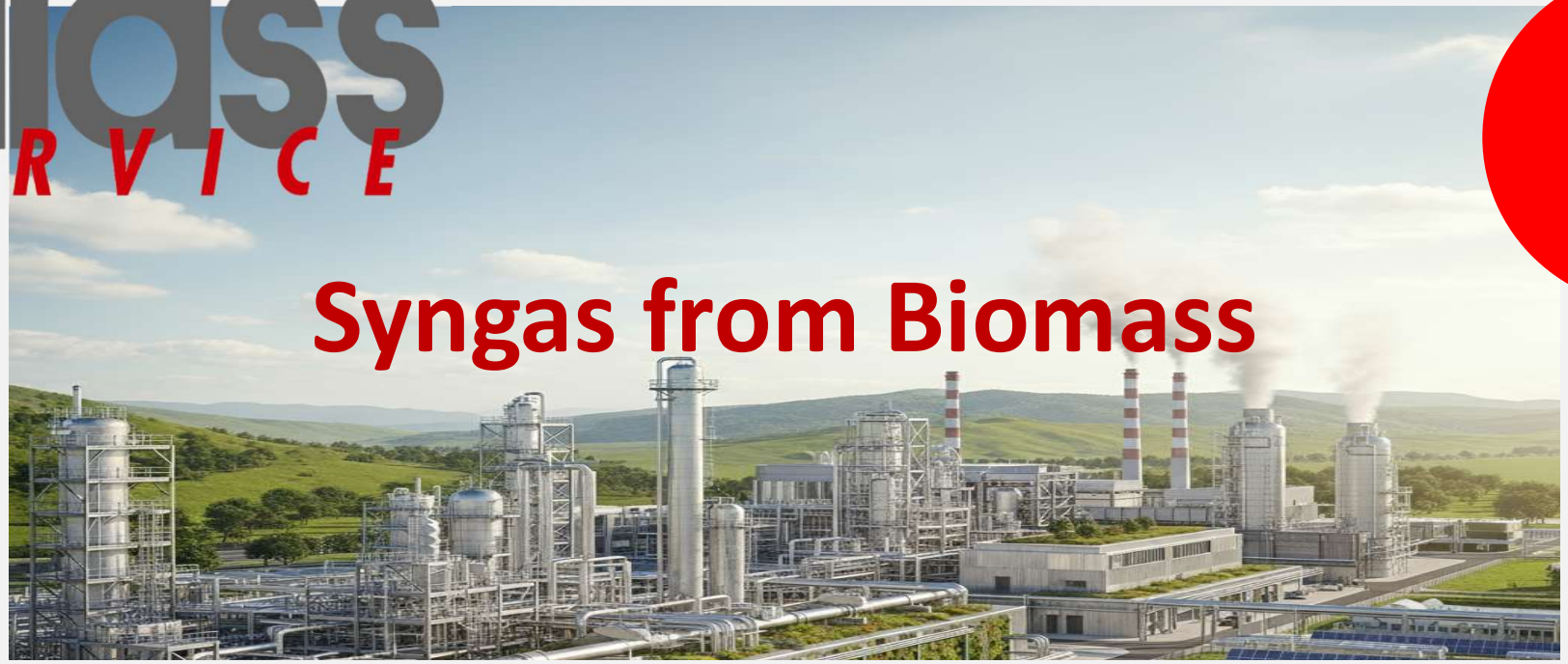
Syngas from Biomass



Effective alternative to achieve the decarbonization

in Glass Industry

Dott. Oliver Bellina – Glass Service S.r.l.

Vitrum - Milan September 17th 2025

Technical and Environmental Context

The growing demand for sustainability in industrial processes has led to the exploration of alternative energy sources. ***(European Target Net to Zero 2030)***

One of the possible alternatives that is still little investigated is syngas (synthesis gas) produced from the gasification of woody biomass.

Syngas, obtained from the gasification of woody biomass, can represent a valid alternative due to its composition rich in hydrogen (H_2), carbon monoxide (CO), and methane (CH_4), making it suitable for high-temperature applications such as glass melting.

THE RAW MATERIAL

Woody biomass, particularly wood chips, is a key resource for renewable energy and syngas production. A benchmark analyzes the availability of wood chips in the Italian and European markets, considering production, consumption, support policies, and growth potential.

The price of wood chips varies according to the water content and the uniformity of the size, which depends on the characteristics of the wood that has been chipped, the type of chipper and the maintenance of the cutting parts and any screening. .

THE RAW MATERIAL

Wood chip quality is defined by the international technical standard UNI EN ISO 177225-4, which defines three quality classes and their corresponding characteristics.
The quality classes provided by the standard are A1, A2, and B1; while the Biomass plus certification scheme also includes the "A1plus" and "A1plus Cippatino" classes, which improve on the A1 class of the technical standard.

Quality Classification by ISO 17255-4	A1plus A1plus Cippatino	A1	A2	B
Originated by	Full trees without roots Tree trunks Forestal residuals Wood's residuals not chemically treated			Forest full trees or other virgin wood Wood's residuals not chemically treated
Moisture (%)	M10 < 10	M25 < 25	M35 < 35	Maximum value must be declared
Ashes	A1.0 < 1,0	A1.0 < 1,0	A1.5 < 1,5	A3.0 < 3,0
Calorific Power	Q > 16 MJ/kg Q > 4.5 kWh/kg	Specify	Specify	Specify
Density (kg/m3)	> 150	> 150	> 150	> 150
Chemical Analysis	Non prevista	Non prevista	Non prevista	Chemical Analysis as per ISO 17225-4

THE RAW MATERIAL

For the highest quality class, with low water content, defined as class A1, the price of wood chips, including VAT per ton, is €146/t, while per MWh it is €40; the price of wood chips in class B1 is €49/t, while per MWh it is approximately €20. In this regard, it is important to remember that the use of wood chips in different quality classes is closely linked to the technology that maximizes their energy efficiency.

Since transport costs can range from €20 to €50 per ton, depending on the transport and the distance, the prices of wood chips for the final consumer in January 2025 shown in Table below are expressed ex-works and include VAT.

Quality Class	Average (€/ton)	%Δ	Average (€/MWh)
A1	146,9 €	7.6%	39,8 €
A2	103,4 €	9.5%	33,2 €
B1	49,2 €	-20.2%	20,3 €

Source: Energy from Wood magazine «Price of wood chips in January 2025» and AIEL (Italian Association of Agroforestry Energies))

THE RAW MATERIAL

Availability of Wood Chips in Italy

Production and Sources

- Primary source: Forest waste (60%), agricultural residues (20%), dedicated crops (20%).
- Annual production: ~8-10 million tons (Mt), of which ~3-4 Mt used for bioenergy.
- Most active regions: Trentino-Alto Adige, Piedmont, Lombardy, Veneto, Tuscany.

Market and Prices

- Average price: € 50/ton (depending on moisture and quality).
- Main consumption: District heating, cogeneration, and industry.

Challenges:

- Fragmentation of the supply chain.
- Competition with other uses (panels, pellets).

THE RAW MATERIAL

Availability of Wood Chips in Europe

Production and Consumption

- Main producing countries:
- Sweden, Finland, Germany, Austria, France.
- EU production: ~150 Mt/year (of which ~50 Mt for bioenergy).
- Major consumption: Thermal (heating) and cogeneration sectors.

Prices and Market Dynamics

- Average price: €50–100/ton (Northern Europe) vs. €50–130/ton (Southern Europe).
- Growing market thanks to EU policies on renewables (RED III).

EU Policies

- RED III Directive (32% renewables by 2030).
- Sustainability criteria for biomass (zero deforestation).

THE RAW MATERIAL

The average price of wood chips in Europe varies depending on the quality class and quantity purchased, but generally ranges between €20 and €40/MWh for class A1 wood chips and between €15 and €25/MWh for class B1 wood chips. The cost per ton can range from approximately €50 to €140 depending on the class and quality, according to market research data.

Region	Annual Production (Mt)	Average Price (€/ton)	Main Uses	Future Trends
Italiy	8–10	50 (Cat B1)	District heating, industry	Moderate growth
Europe	~150	50 (Cat B1)	Heating, energy	Sustainability RED III

Key Trends: Greater focus on sustainable certifications.

PROCESS

Gasification is a thermochemical process that converts biomass into syngas through partially oxidative reactions under controlled conditions (700–1100 °C).

Wood biomass (sawdust, pellets, wood chips) is dried, pyrolyzed, and then gasified in the presence of a sub-stoichiometric percentage of an oxidizing agent (air, oxygen, or steam). The resulting gas mixture constitutes what is known as synthesis gas (syngas) and itself represents a fuel.

The syngas produced varies depending on the technology, operating conditions and gasifying agent. When air is used, the syngas typically contains:

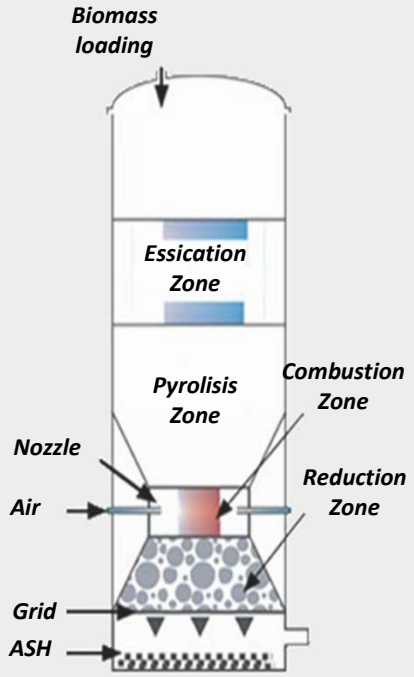
- **CO (15-25%) – Main fuel**
- **H_2 (10-20%) – High calorific power**
- **CH_4 (1-3%) – Contributes to the energy value**
- **CO_2 (8-12%) – Inert, to be separated if necessary**
- **N_2 (45-55%)**
- **Tar (long chain hydrocarbons)**
- **Dust (particulate matter)**

To be removed to avoid system problems like cloggins an stiking material along the distribution piping

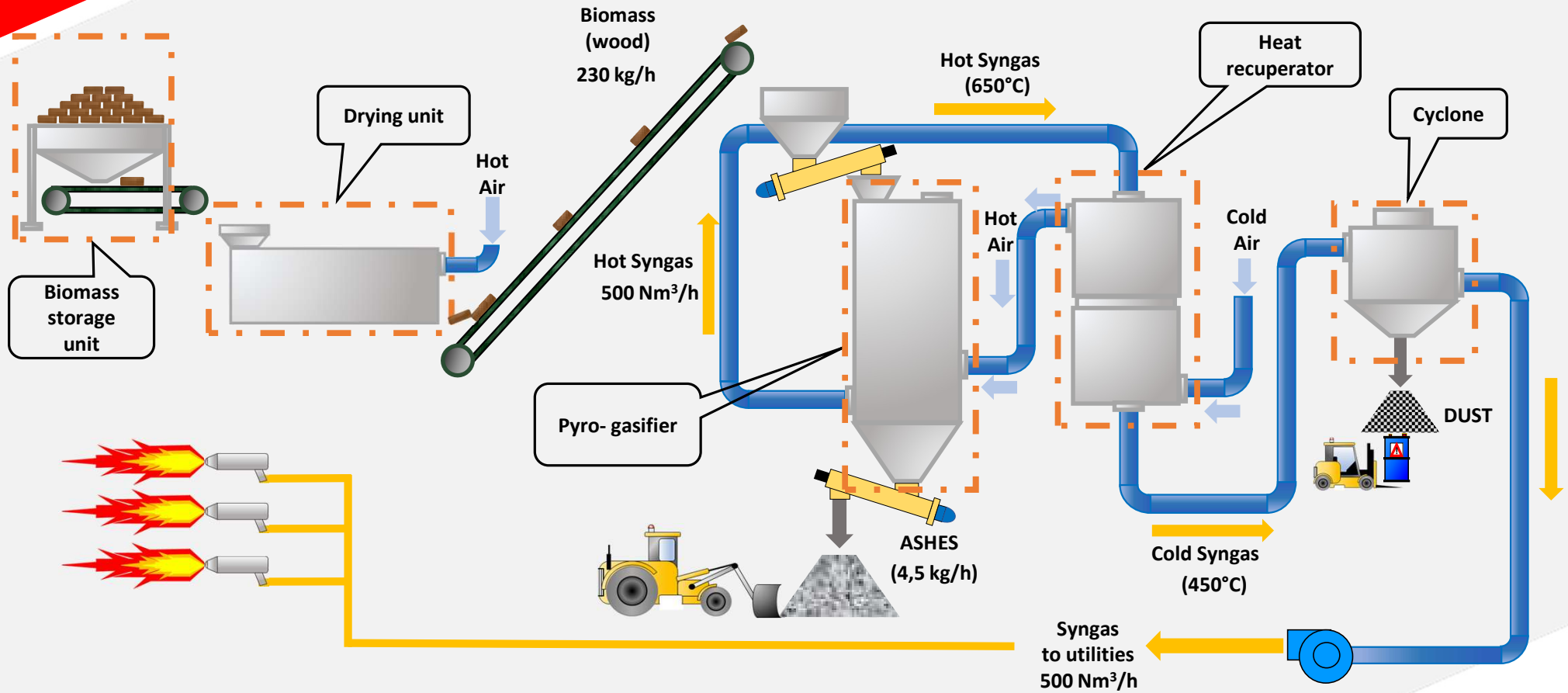
PROCESS

System Components

1) Container for wood chip storage, with a moving floor and extraction screw. With a capacity of 50 m^3, it would provide approximately two days of autonomy. Ground space must be considered for unloading the wood chips before loading. A mechanical shovel is required for loading.
2) Conveyor belt for loading wood chips to the gasifier.
3) Heat exchanger of approximately 15 kW for heating gasification air from 20°C to approximately 200°C.
4) Cyclone for separating dust from syngas.
5) High-temperature exhaust fan for syngas.

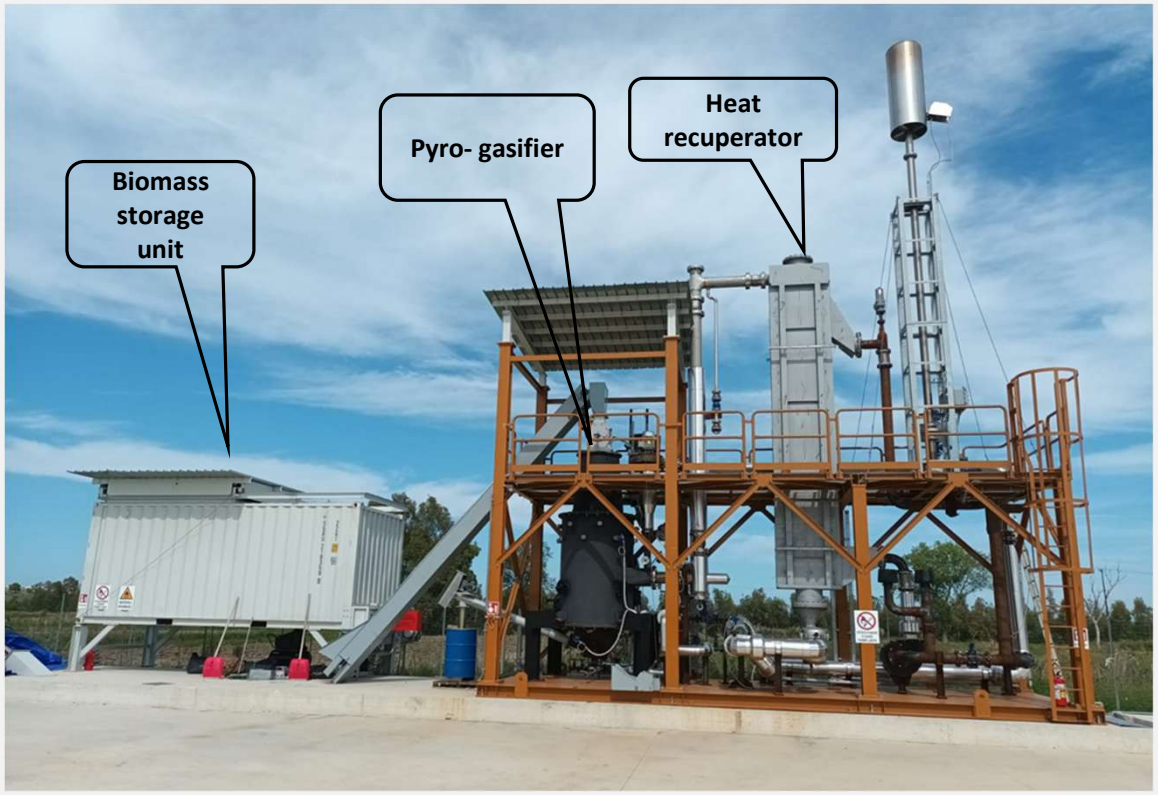


PROCESS


Biomass
(wood)
230 kg/h
Drying unit
Hot
Air
Biomass
storage
unit
Hot Syngas
(650°C)
Heat
recuperator
Cyclone
Hot Syngas
500 Nm³/h
Hot
Air
Cold
Air
Pyro- gasifier
DUST
ASHES
(4,5 kg/h)
Cold Syngas
(450°C)
Syngas
to utilities
500 Nm³/h

PROCESS

Installed prototype in collaboration with Biosyn and UNIPI

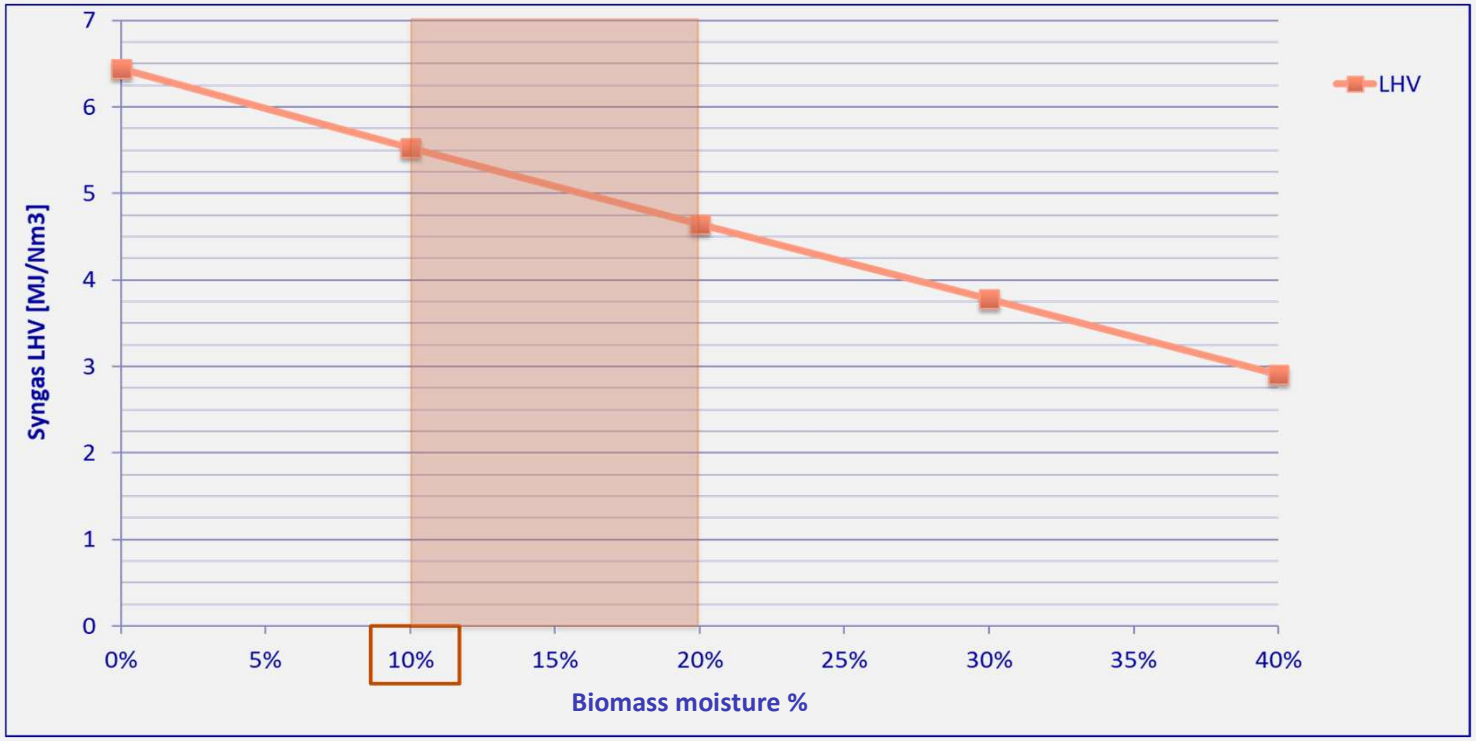


Syngas Characteristics Volumetric Composition:

- CO ≈ 22%
- CO_2 ≈ 9%
- H_2 ≈ 18%
- CH_4 ≈ 2%
- N_2 ≈ 49%
- PCI: 5 - 6 MJ/Nm^3

PROCESS

As the humidity of the wood chips increases: The calorific value of the syngas decreases



Optimal moisture level between 10 and 15%

PROCESS

GASIFIER PERFORMANCES

PARAMETER	OPERATIVE RESULS AFTER 2 YEARS OF TESTS
Inlet power of gasifier	1000 kW
Wood chips consumption	225 kg/h
SynGas flow	520 Nm^3/h
Calorific Power	**5.5 MJ/Nm^3**
Gas saving flow	**80 Std m^3/h**
Energy efficency	**80%**
Ash flows	5 kg/h (dust from Cyclone included)
Cost of Ash treatment	90 €/t
Operativity	Tested for 7,500 h/year (expandable to 8,200 by continous maintenace)

Considering the cost and dimensions of pyro-gasifire unit, it possible to installa second unit to improve the Syngas production up to 1000 Nm^3/h

GLASS INDUSTRY EQUIREMENTS

Glass furnaces operate at high temperatures (1400–1600 °C) and require:

- High calorific value
- Combustion stability (optimized H_2/CO ratio)
- Low contaminant content (sulfur, alkalis, chlorine)

Advantages of Using Syngas

- *Reduction of CO_2 emissions (biomass carbon neutrality)*
- Greater energy efficiency compared to direct biomass combustion
- *Possibility of integrating with green hydrogen to improve sustainability*

Challenges and Limitations

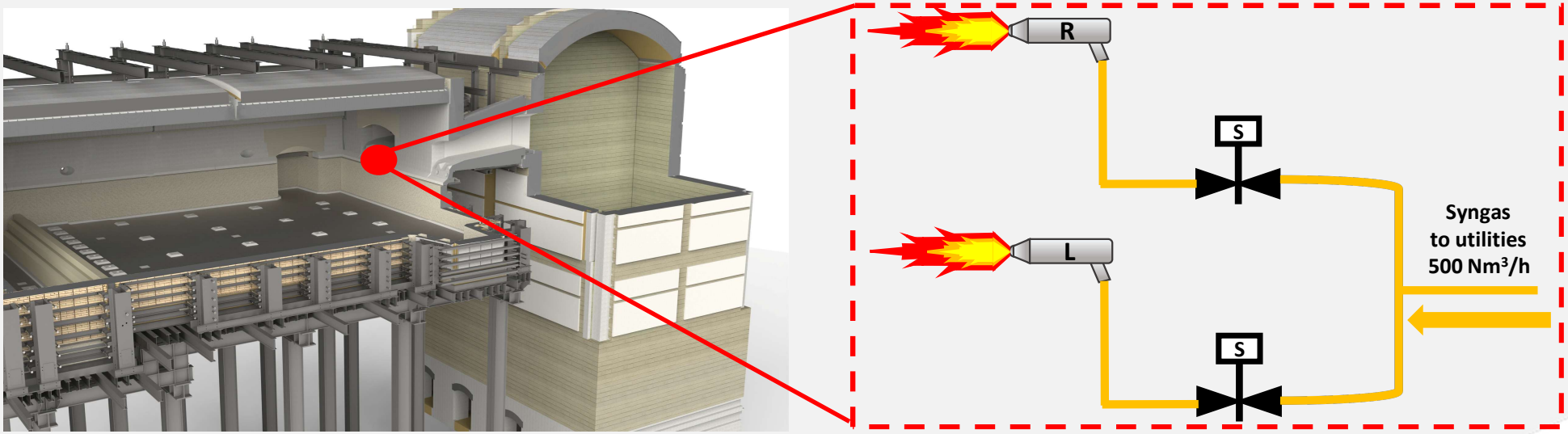
- *Variability in syngas quality (depending on biomass and process)*
- *Need to adapt burners (due to different combustion behavior)*
- *Purification and storage costs*

IMPLEMENTATION OPTIONS

One implementation solution involves the use of a tower burner.

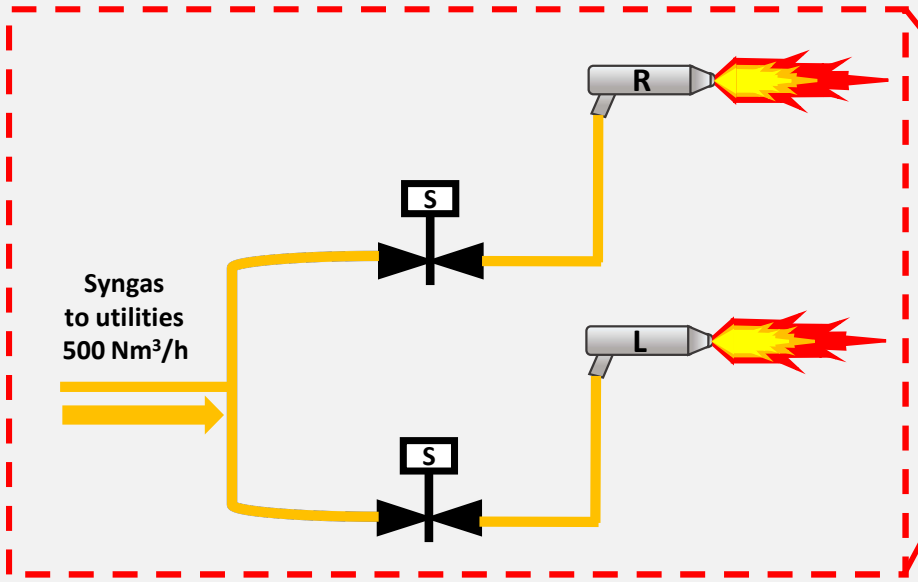
In many cases, the number of burners per tower is overdimensioned and, under normal operating conditions, the furnace runs with 1 or 2 burners less than designed.

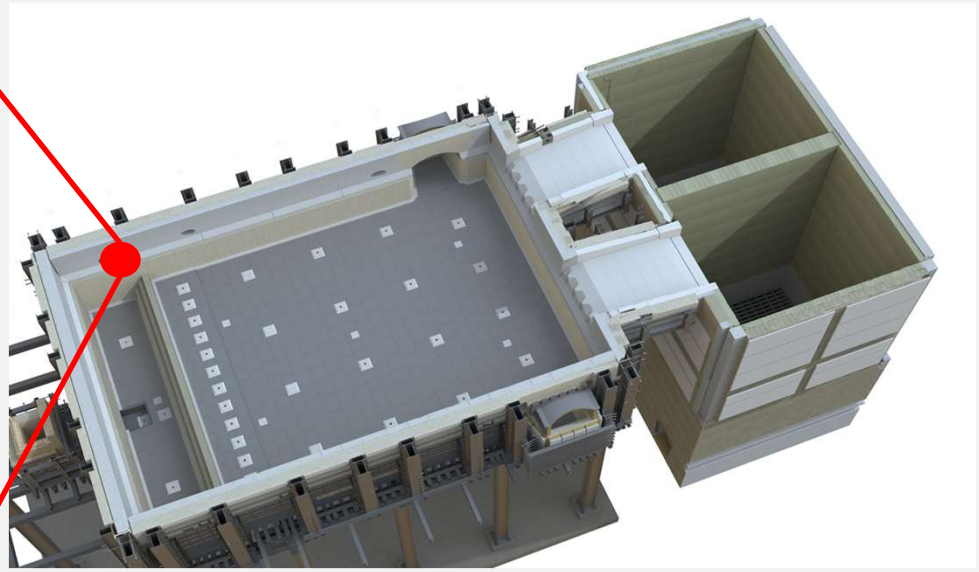
In that situation, it is possible to use these stations to install syngas burners.



IMPLEMENTATION OPTIONS

A potential alternative is to install syngas staging burners in specific areas of the furnace.
For an end-port furnace, the front area is also the preferred location for burning off excess air supply.





TECHNICAL ECONOMICAL ANALYSIS

Natural Gas

Detail for Italy (industrial use)

- Average price 2024: **€0.35-0.45/Stdm3**
- The price of gas for industrial use in Italy, set by ARERA, varies monthly and can be consulted on the authority's website or through energy suppliers. ***For the month of July, the price for the vulnerability protection service has been set at €0.42/Stdm3***. This price refers to the cost of gas per cubic meter and includes the CMEM (gas raw material) component and other charges. For industrial users, the actual price may vary depending on the supplier and the type of contract chosen, but is always based on ARERA's recommendations.

Additional costs:

- National network transport: **+€0.01-0.03/Stdm3.**
- Excise duties/charges: Depend on consumption (often subsidized for industry).

TECHNICAL ECONOMICAL ANALYSIS

Natural Gas
Europe Detail (industrial use)

- Average price per Stdm³ (net of taxes): **€0.30 - €0.40/Stdm³**

Countries with the lowest prices:

- Norway: ~€0.15/Stdm³ (local production).
- Netherlands: ~€0.20/Stdm³ (Groningen gas).

Countries with the highest prices:

- Germany: ~0.30 - 0.40 €/Stdm³ (dependence on Russian gas).
- Spain/Portugal: ~0.25 - 0.35 €/Stdm³ (high LNG costs).

TECHNICAL ECONOMICAL ANALYSIS

Historical Comparison (2022-2024)

Year	Italy (€/Stdm³)	Europe (€/Stdm³)	Critical Event
2022	0,80 - 1,20	0,70 - 1,10	Russia-Ukraine war
2023	0,40 - 0,60	0,30 - 0,50	Falling demand, full inventories
2024	**0,35 - 0,45**	**0,30 - 0,40**	Market normalization

Region	Price (USD/MMBtu)	Price (€/MWh)	Price (€/Stdm3)	Notes
Italy (Europe)	$10-12	€30-35	**€0,35-0,45**	PSV price + transport
Germany	$10-12	€32-38	**€0,31-0,36**	LNG addiction

Spot prices: TTF (Europe)

Key factors in price differences:

- Dependence on LNG (Asia and Europe pay premiums for transportation).
- Infrastructure: Who has gas pipelines (Europe with Algeria)
- Geopolitical crises: Sanctions against Russia have increased costs in Europe.

TECHNICAL ECONOMICAL ANALYSIS

TREND IN CO_2 TITLES COSTS ETS 2024-2025

2023-2024: Prices fluctuated between €60 and €90/ton, with a decline in 2023 due to the energy crisis and a recovery in 2024.
End of 2024: A range of €75-90/ton is expected due to Reduction in allowances in circulation (-4.3% annually from 2024 due to the Market Stability Reserve). Increased demand (recovering industrial sectors).
2025-2030: Prices rise due to Fit for 55 (EU targets -62% ETS emissions by 2030) and Phasing of free allowances for some sectors.

Types of CO_2 Securities in the ETS Market

Title	Description	Price (May 2024)
EUA (Phase 4)	EU primary quotas (1 EUA = 1 tonne of CO_2 equivalent)	**~€70-80/ton**
EUAA	Aviation Allowances (similar to EUAs but for the airline industry)	**~€70-80/ton**
CER/ERU	Credits from CDM/JI projects (limited in use after 2020)	**Not used**

(Source: ICE, EEX, Bloomberg Carbon)

PROCESS

With a system producing up to 500 Nm^3/h of Syngas, you can save up to 80 $Stdm^3/h$ of natural gas.

Dry wood chip yield: 2.3 Nm^3/kg equivalent to Wood chip consumption: 225 kg/h

Annual gas savings for approximately 7,500 hours: approximately 600,000 $Stdm^3$ equivalent to approximately 1,200 tons of CO_2 eq.

Translated into euros, this becomes approximately €210,000 in gas and €90,000 in CO_2 in the ETS.

Wood Chip Consumption	Syngas	Natural Gas Savings	CO_2 savings *
225 kg/h	520 Nm^3/h	~80 $Stdm^3/h$	158 kg/h
~ 1690 tons/year	3,900,000 Nm^3/year	600,000 $Stdm^3$/year	1,200 ton/year

**** Conversion factor 2 t CO2 eq/1000 Std m3 Natural Gas – Source ISPRA National Standard Coefficients Table***

TECHNICAL ECONOMICAL ANALYSIS

PREVISIONAL PAYBACK

INVESTMENT	€	PARAMETERS	€
Turnkey system cost including design, construction and commissioning	- 400,000	Cost of wood chips (B1)	- 101,000
		Ash disposal cost	- 3,000
		Electricity Cost	- 5,000
Cost of system adaptation including syngas burners and drying unit	- 100,000	Maintenance Cost	- 20,000
		Saving Natural Gas	+ 210,000
Total	- 500,000	Saving ETS	+ 90,000
		Total budget	+ 170,000
INVESTMENT RECOVERY			***<4 years***

SHELF LIFE OF GASIFIER 15 YEARS

CONCLUSIONS

- Pyrogasification of biomass could give an effective contribution to cost saving and decarbonazation in a sector (Glass manufacturing) classified as **Hard to Habate**
- Considering the present context of glass furnace production, implementation of pyrogasifier unit which supply up to 500 Nm^3/h of Syngas from biomass, gives a total saving of about 8% of the natural gas needed for melting process. (16% reduction if installed 2 pyrogasifier modules)
- ***Combining the pyrogasifier contributes with improvement of electrical boosting and/or oxy combustion, the saving in terms of natural gas can easily reach values of 30 – 40% of the request.***
- Implementation of Drying unit, feeded with thermal waste, easily recovered in Glass plant, can improve the pyrogasification, reducing cost of wood chips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