STEEL 24 MASTER

XXVI Edizione

RINA

1ª Settimana
RINA
Dalmine (BG)
6 - 10 Maggio 2024

2ª Settimana
Acciaieria Arvedi, c/o ARVEDI CAMPUS
Cremona
10 - 14 Giugno 2024

CO_2 mitigation in integrated plants by injection in the blast furnace of hot H_2-rich syngas produced from Alternative Carbon Materials. RFCS PROSYNTEG

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CRM GROUP

Steelmaster
è una iniziativa sostenuta da

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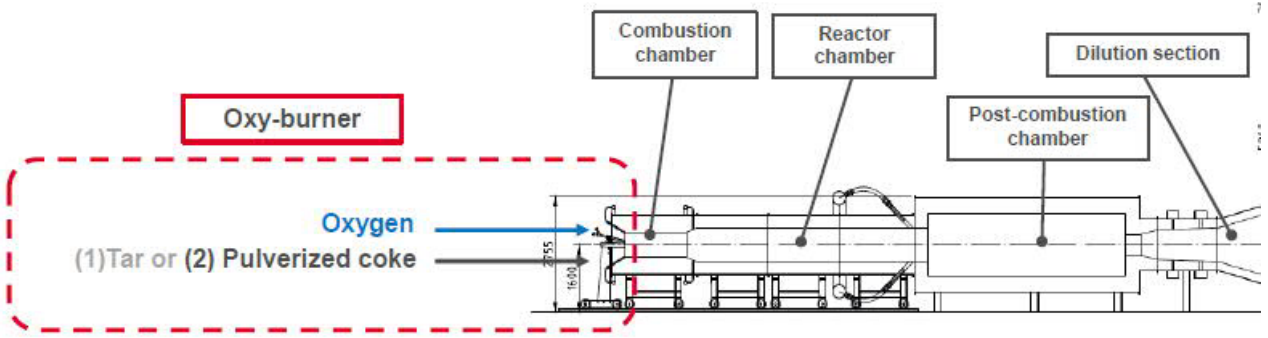
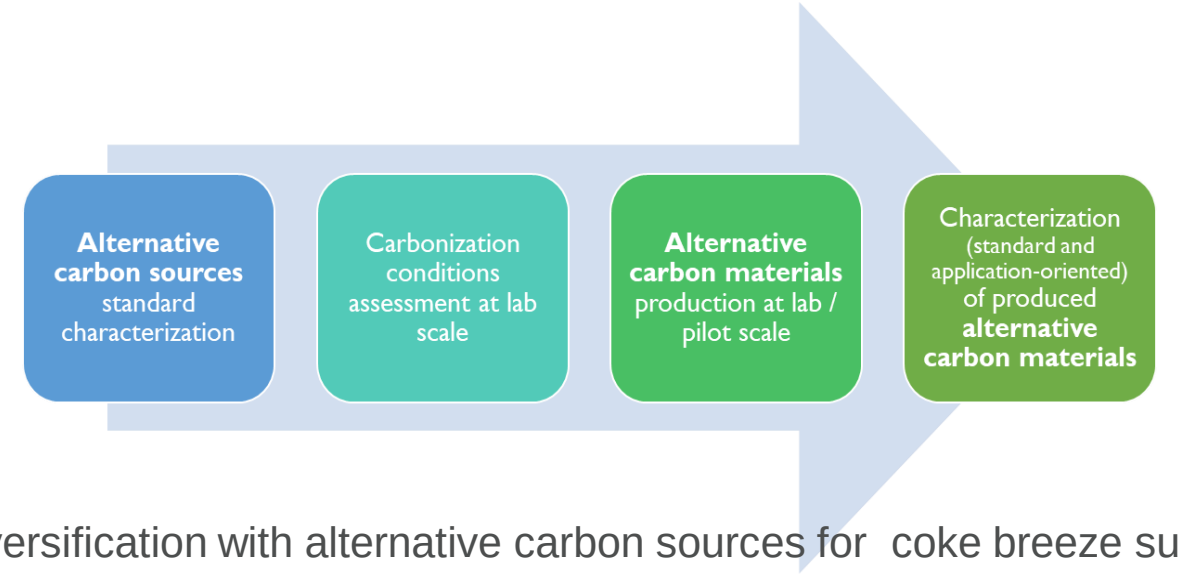
Alternative carbon for oxycombustion combustion



Prosynteg project:

- Production of hot hydrogen-rich syngas in integrated plants for efficient injection in the blast furnace and CO_2 mitigation. Oxycombustion of coke breeze (from Italiana Coke) and dry reforming of coke oven gas.

Alternative carbon for pulverised combustion

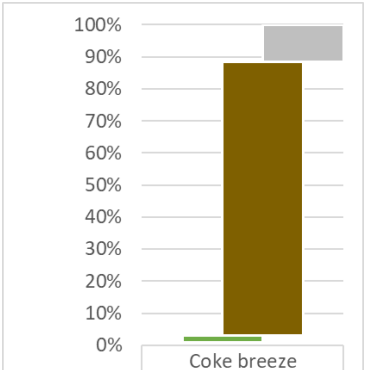


Raw materials diversification with alternative carbon sources for coke breeze substitution.

Alternative carbon materials produced by carbonisation of various types of feedstock.

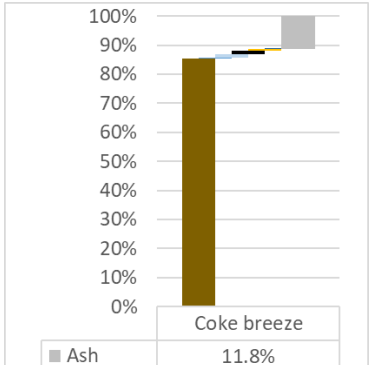
Description of coke breeze from Italiana Coke

Coke breeze samples from Italiana Coke as reference material.
Standard characterization achieved at CRM.



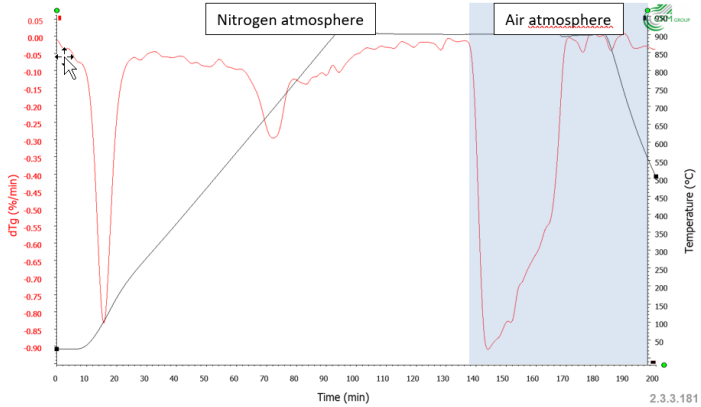
	Coke breeze
Ash	11.7%
Fixed carbon	85.4%
Volatile matter	2.2%
Moisture	0.8%

Proximate analysis (ar)

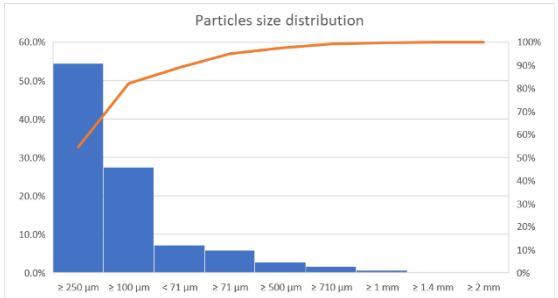


	Coke breeze
Ash	11.8%
Chlorine	0.06%
Sulphur	0.5%
Nitrogen	1.3%
Other	1.1%
Hydrogen	0.3%
Carbon	85.5%

Elemental analysis (db)



TGA on coke breeze, under nitrogen until 900°C and then air



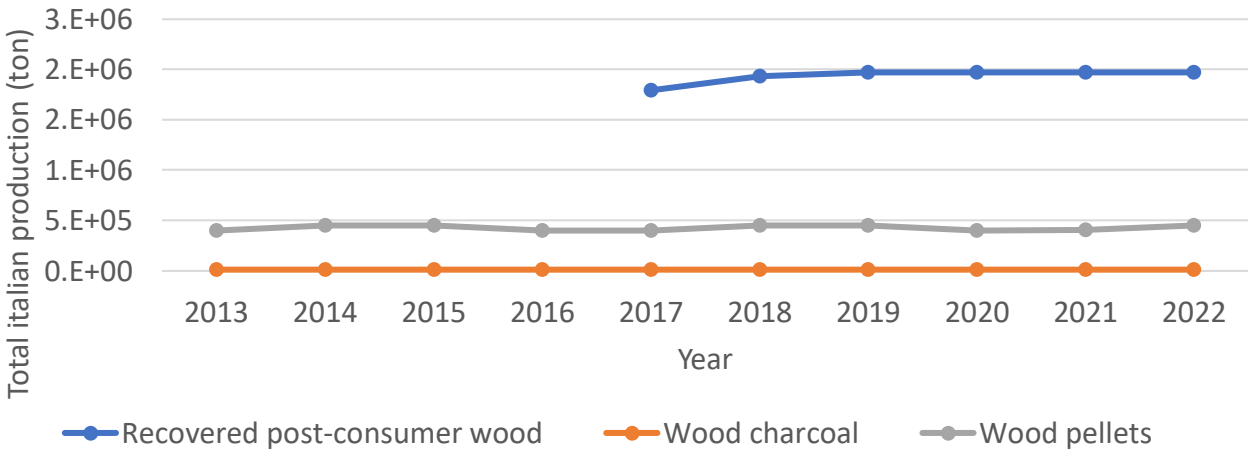
ICP measurement on Coke breeze (main elements)					
Al	Fe	Ca	K	Mg	Na
6444	3922	4785	1041	1158	875
mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg

Alternative carbon sources selection




Selection of Alternative carbon sources

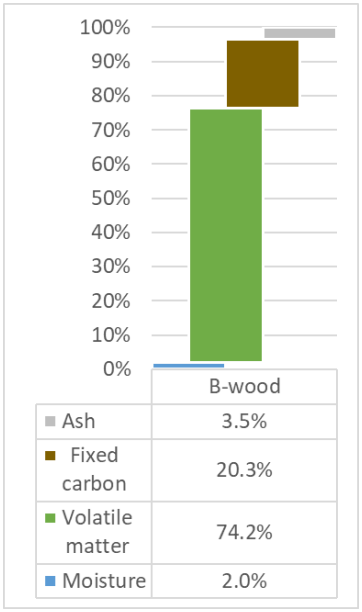
Waste wood from construction and furniture (B-wood)



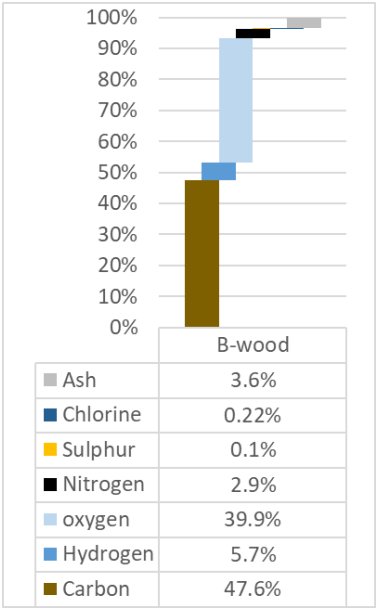
Source: FAOSTAT 2024

Selection of Alternative carbon sources

Waste wood from construction and furniture (B-wood).



Proximate analysis (ar)



Elemental analysis (db)

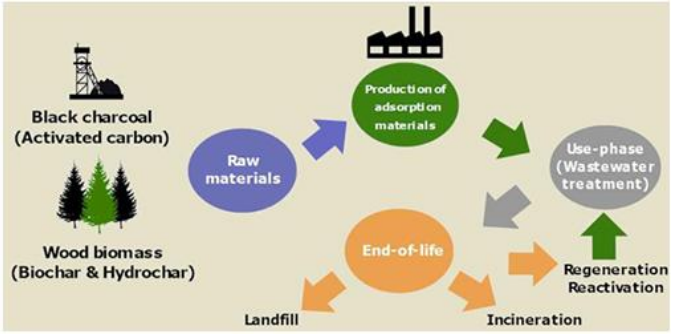
ICP measurement on B-wood (main elements)						
Al	Fe	Ca	K	Mg	Na	Zn
mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
864	717	7213	827	553	1008	4169

Selection of Alternative carbon sources

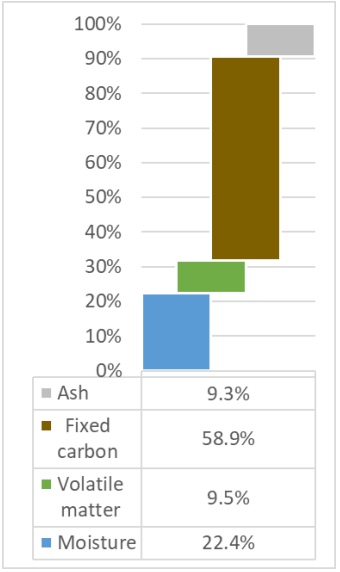
Spent activated carbon

Already high Carbon content but have pollutants as a function of their use.

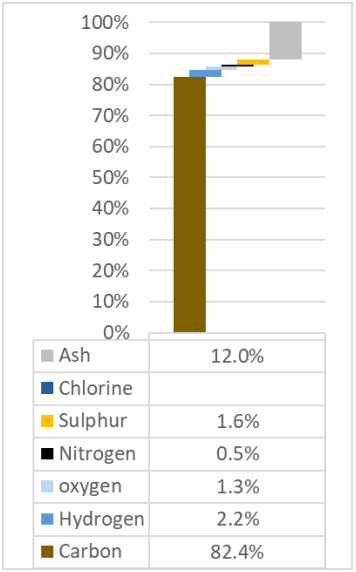
Here, Spent AC used in industrial air treatment, main pollutant : C10-C16 hydrocarbon



(Kozyatnyk, et al., 2020)



Proximate analysis (ar)

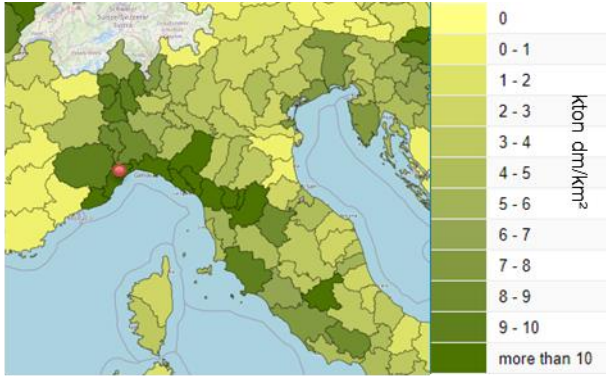


Elemental analysis (db)

Selection of Alternative carbon sources

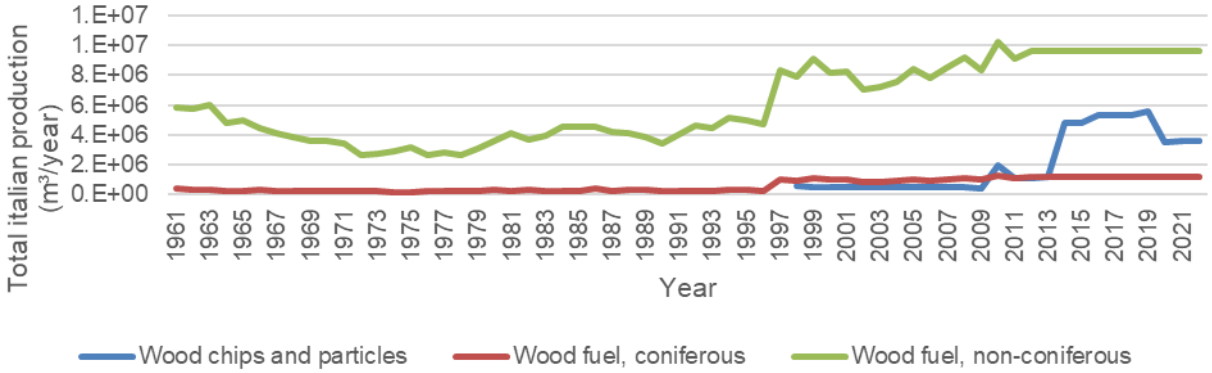
Natural wood waste from coppice woodland forestry :

- Oak
- Beech



Availability of non-coniferous forest residue in mass,

Source: s2biom

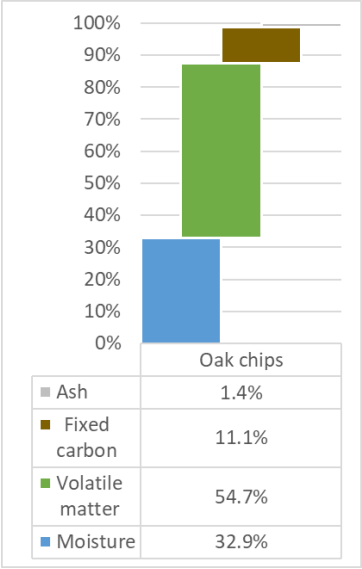


Source: FAOSTAT 2024

Selection of Alternative carbon sources

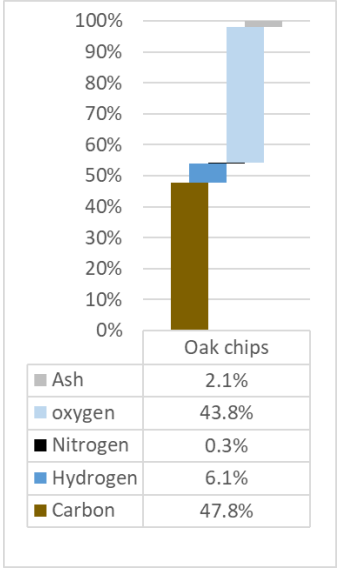
Natural wood waste from coppice woodland forestry :

- Characterisation of Oak



	Oak chips
Ash	1.4%
Fixed carbon	11.1%
Volatile matter	54.7%
Moisture	32.9%

Proximate analysis (ar)



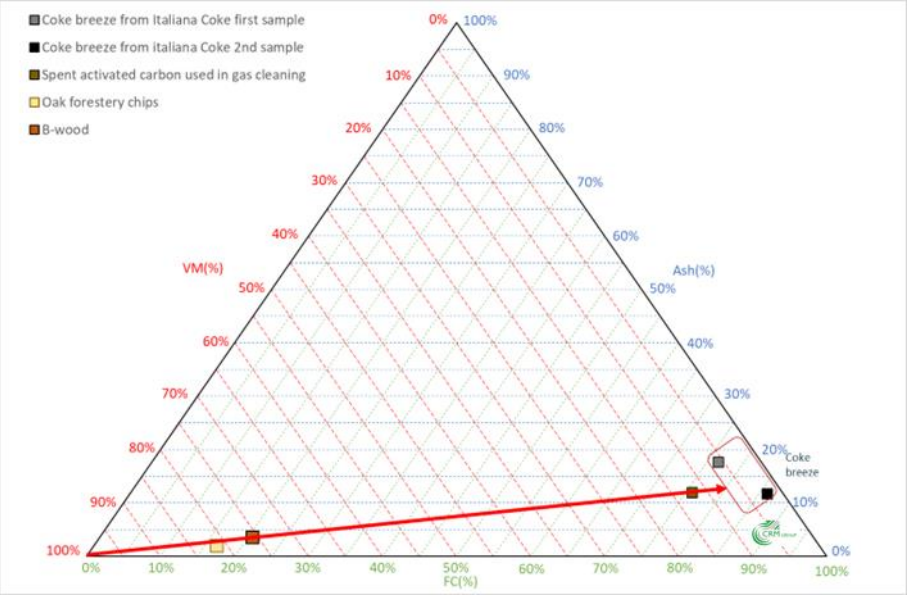
	Oak chips
Ash	2.1%
oxygen	43.8%
Nitrogen	0.3%
Hydrogen	6.1%
Carbon	47.8%

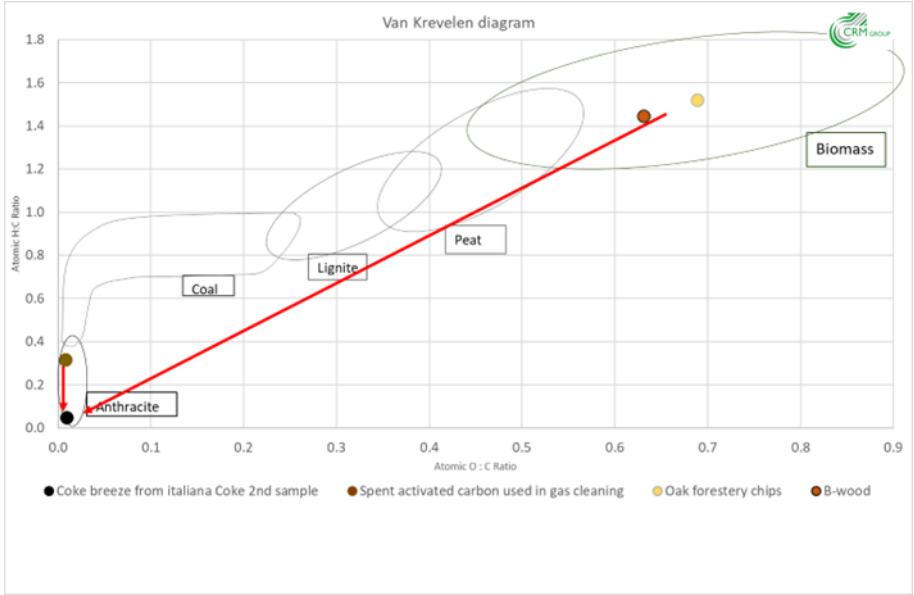
Elemental analysis (db)

Beech and Oak chips

Carbonisation conditions, assessment at lab scale

Carbonisation conditions, assessment at lab scale





Necessity of carbonisation to reduce the volatile and hydrogen to optimise the yield of CO2 by oxy-combustion.

Charcoal grindability is better compared to biomass.

Carbonisation conditions, assessment at lab scale

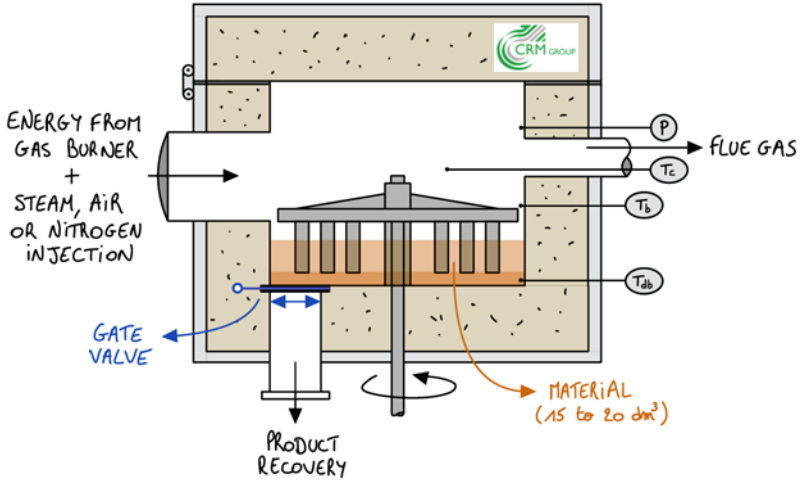
- Carbonisation characterisation with TGA
- Pyrolysis tests in crucibles
    - On a selected temperature
    - For various residence time
    - Analysis of the product and mass balance on the solid phase
- Validation of the temperature and residence time with a trial in BATCH18’’ furnace
- Production of alternative carbon materials samples in rotary kiln

Alternatives carbon materials, production at lab / pilot scale

BATCH18” presentation

Thermal processing of granular solids, sludge, etc.

- 18’’ reactor with rabble arms
- Atmospheric pressure, Max temperature 1100°C
- Work under oxygen-free atmosphere and controlled temperature,
- Stirring of materials
- Defined treatment time
- Batch of 15 liters of materials
- Heating power:
    - 80 kW gas burner
    - 17 kW electrical radiative top heating



Alternatives carbon materials, production at lab / pilot scale

Larger supply of ACM: Pilot rotary kiln

Thermal processing of granular solids, sludge, etc.

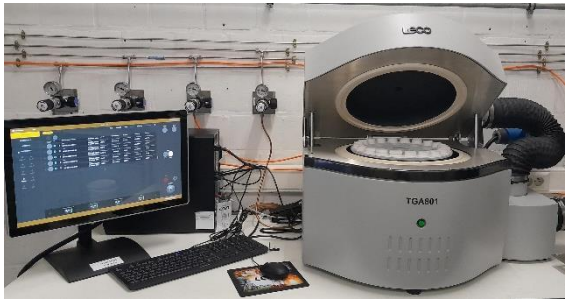
- Atmospheric pressure
- 400 to 1300°C
- Charging: conveyor through lock hopper
- Discharging: water-cooled screw
- Heating power:
  - 50 to 500 kW natural gas burner
  - 100 kW indirect electrical heating

Characterisation of produced alternative carbon material

Standard characterisation

The produced alternative carbon by pyrolysis will be characterised at CRM:

- Proximate analysis (Moisture, volatille matter, ash)
- Ultimate analysis (C, H, N)
- Halogens (Cl, I, Br, F)
- ICP
- HHV



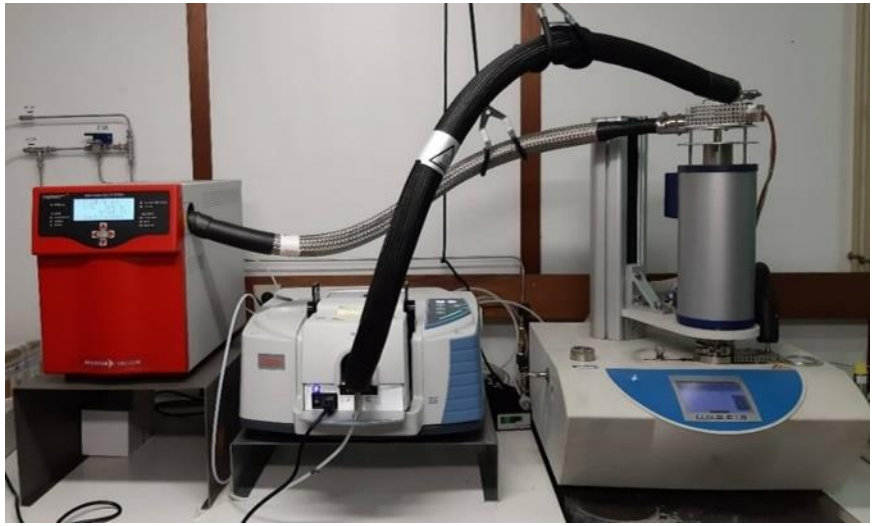
The results will feed the models of oxy-combustion to confirm that the characteristics are reached before pilot testing.

Selection of the best products for larger sample production

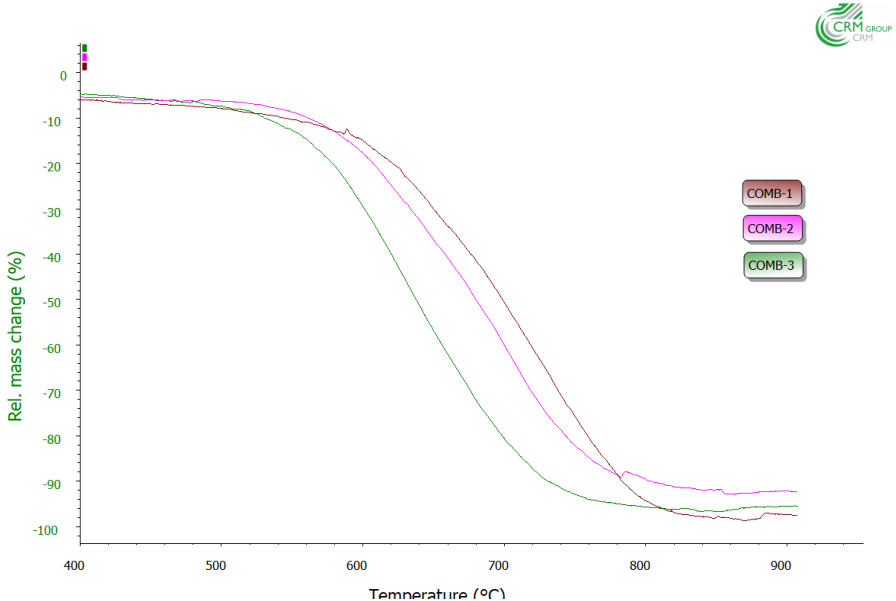
Characterisation of produced alternative carbon materials: Reactivity experiments

Thermogravimetric analysis at CRM:

- Development of a methods for oxycombustion
- Possibility to do gas analysis for in-depth investigation of the conversion
- Non-isotherm method inspired from Russell, et al., 1998



Characterisation of produced alternative carbon materials: Reactivity experiments



TGA results on coke breeze combustion at three oxygen level

$$Arrhenius\ law: -\frac{dW}{w}dt = A_0 e^{-\frac{E}{RT}}$$

Table of results from Arrhenius law applied on the mass loss for three combustions conditions

Protocol	O2 %	A0	E (kJ/mol)	Reactivity: Log(A_0) with E=100kJ/mol at 50% of relative mass loss
COMB-1	11%	105.6	89	2.00
COMB-2	21%	1041.7	105.9	3.05
COMB-3	50%	1097.2	101.7	3.13

The coke breeze is the reference for comparison with produced alternative carbon materials

Measurements planned until 61% of oxygen in nitrogen.

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Thanks for your attention

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