Gasification integrated with CO2 capture and conversion

GICO H2020 project

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The projects have received funding from the European Union's Horizon 2020 research and innovation programme

OUTLINE

Co-funded by the Horizon 2020 programme of the European Union

- Concept and SoA of gasification integrated with CO2 capture and conversion
- GICO activities and collaboration points!
- Residual biomass and Hydro Thermal Cracking
- Steam Indirectly Heated Gasification with inbed sorbents/catalysts
- Hot Gas conditioning: tar catalyst reforming and plasma craking
- Power to gas: PLASMA for CO2 conversion and SOFC/SOEC
- Overall techno-economic analysis and auxiliary component development

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CONCEPT

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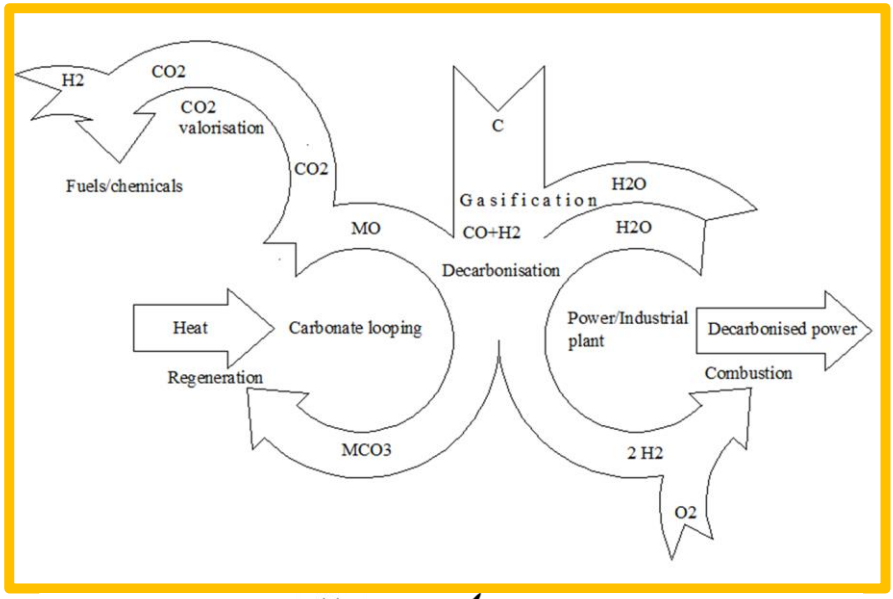
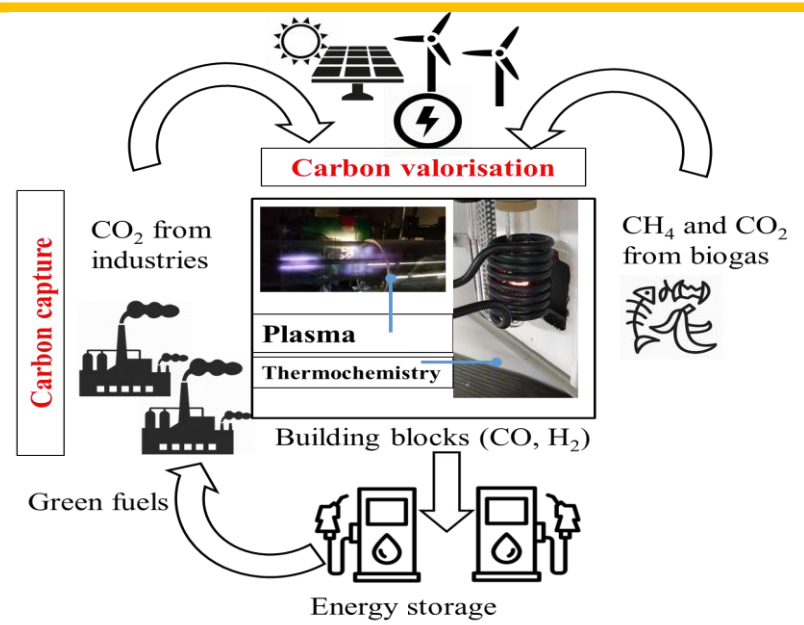
- Steam Gasification (SG), Carbon Capture Storage and Use (CCSU) and renewable Power To Gas (P2G) integration can be the basis of the RES next generation
- SG has the ability to convert with high efficiency the large biomass and waste potential in high Heating Value (HV) gas that can be converted in the main energy vectors (i.e. electricity and fuels) with high efficiency and low environmental impacts but the feedstock ashes melting point must be higher than 1200 or 800 °C (respectively, fixed or fluidised bed SG), the gas produced is still too rich of CO2 to be efficiently converted especially in fuels and the process requires heat and so needs for pure oxygen or air to promote exothermal/combustion reactions, producing flue gas;
- CCSU has the ability to further decrease the CO2 emissions but it requires additional reactors;
- P2G has the ability to convert surplus renewable electricity into gaseous fuels but the actual electrolysis process are not integrated to produce a liquid biofuel and cannot be quickly turned on/off.
- Combining advanced SG, CCSU and P2G, instead, it is possible to convert renewable energy sources into energy vectors with the highest efficiency and lowest greenhouse gases emission and cost.





CONCEPT

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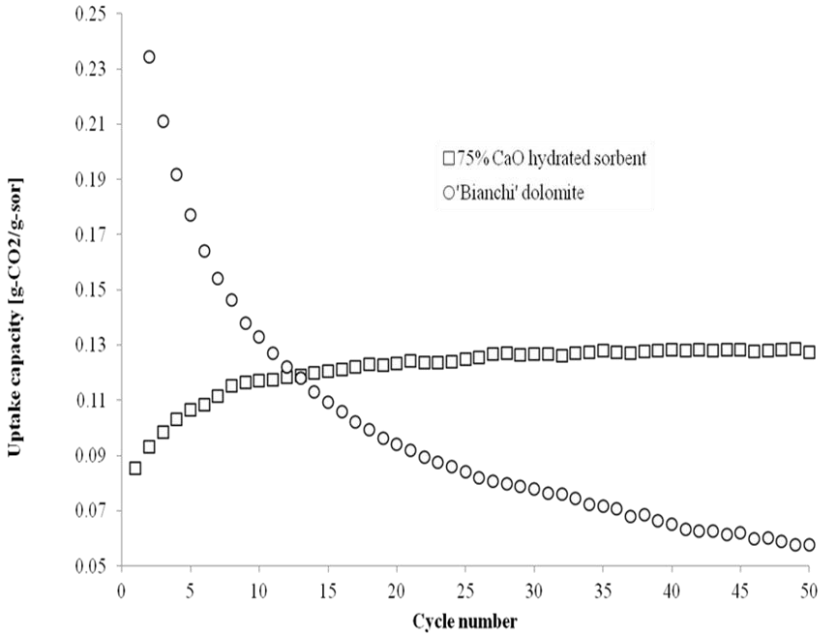
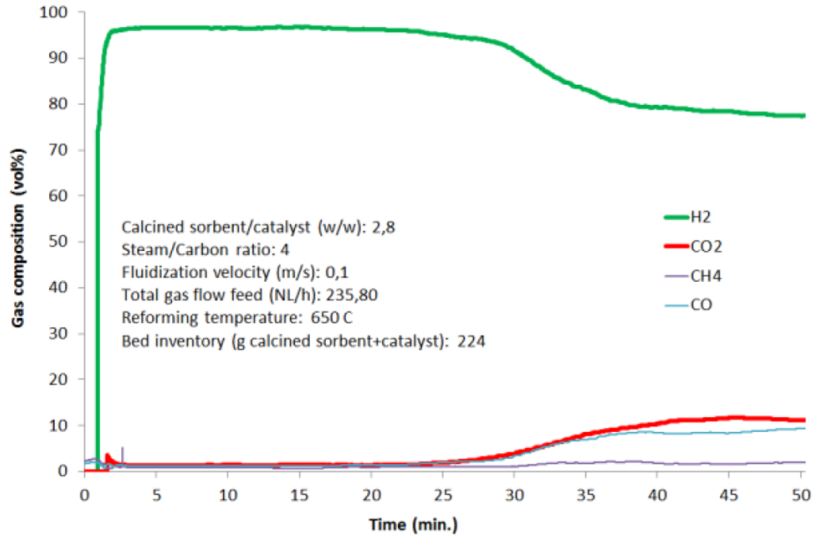
- In fact, using e.g. CaO sorbents instead of the inert material in an indirectly heated fluidised bed steam gasification (so CLG: Chemical Looping Gasification, and in particular SEG: Sorption Enhanced Gasification), will not only shift the thermodynamic equilibrium towards more H2 (from around 40% H2, 23% CO and CO2 and 13% CH4, the volume fraction dry syngas composition become 90% H2, 5% CO, 3% CH4 and 2% CO2) but also will decrease the gasifier temperature (allowing the use of biomass with low ashes melting point) and the energy to be transferred to the gasifier. Moreover, the gasifier will be also a carbonator and the combustor also a calcinatory, thus avoiding the necessity of multiple reactors and decreasing the bed to be recirculated owing to the exothermic carbonation and endothermic calcination reactions.



- P2G technology to convert the CO2 from the combustor, will not only avoid flue gas emissions but overall will produce oxygen for the combustor and CO in order to produce carbon fuels (e.g. methanol, DME, methane, kerosene, diesel). In particular, combination of membranes with plasma technologies not only will allow better turnkey process (because it can be quicker activated/deactivated with higher efficiency than actual electrolysis process) but overall will synergistically increase the conversion of CO2 into CO (reducing the optimal membrane process temperature respect the actual 850 °C).



CONCEPT

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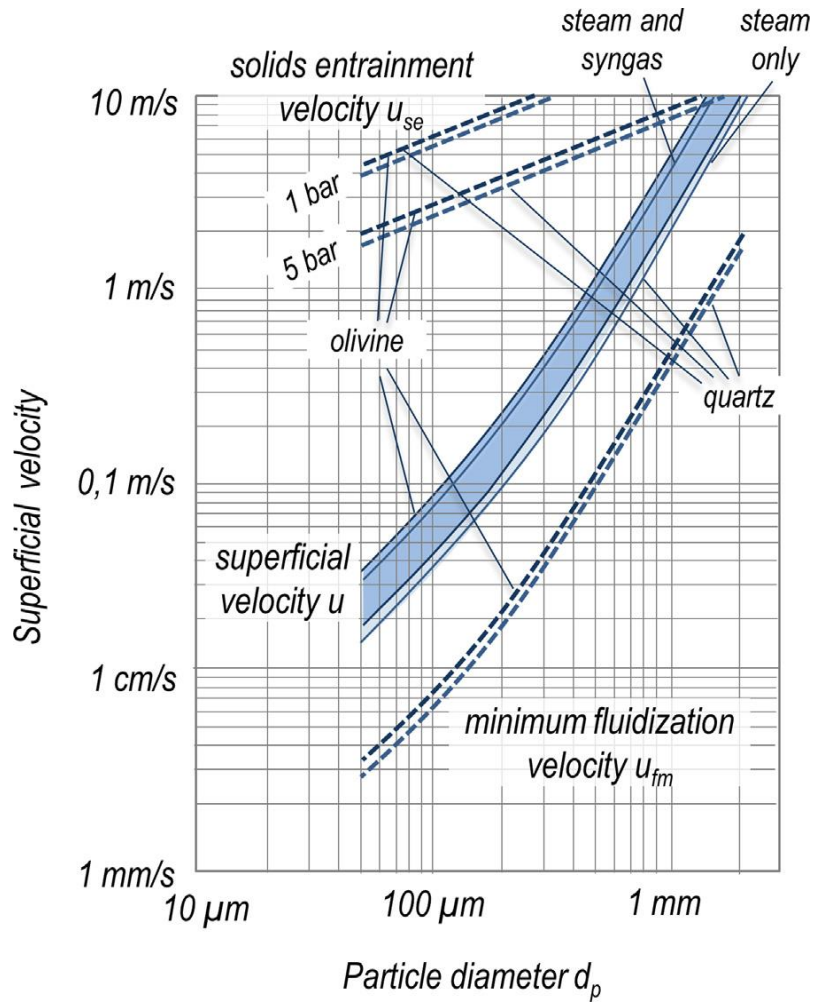
- Finally, mixing the high hydrogen content syngas with the high CO content gas from the CO2 conversion the final products is a gas with high H2 to CO ratio that can be used to produce carbon fuels or electricity and heat via fuel cells, so producing biofuels, electricity and heat with very high efficiency and very low emissions and cost (considering the low cost primary feedstock used, the combustor emissions avoided and the process integration).
- Overall, the main issues that undermine the development of these technologies are: (i) effect of the main and trace poisoning elements on the durability of plant components (ii) development of sorbents, catalysts, and membranes and (iii) development of integrated processes.



J. Karla, T. Prollb, Steam gasification of biomass in dual fluidized bed gasifiers: A review, Renewable and Sustainable Energy Reviews 98 (2018) 64–78

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Indirectly heated steam gasifiers

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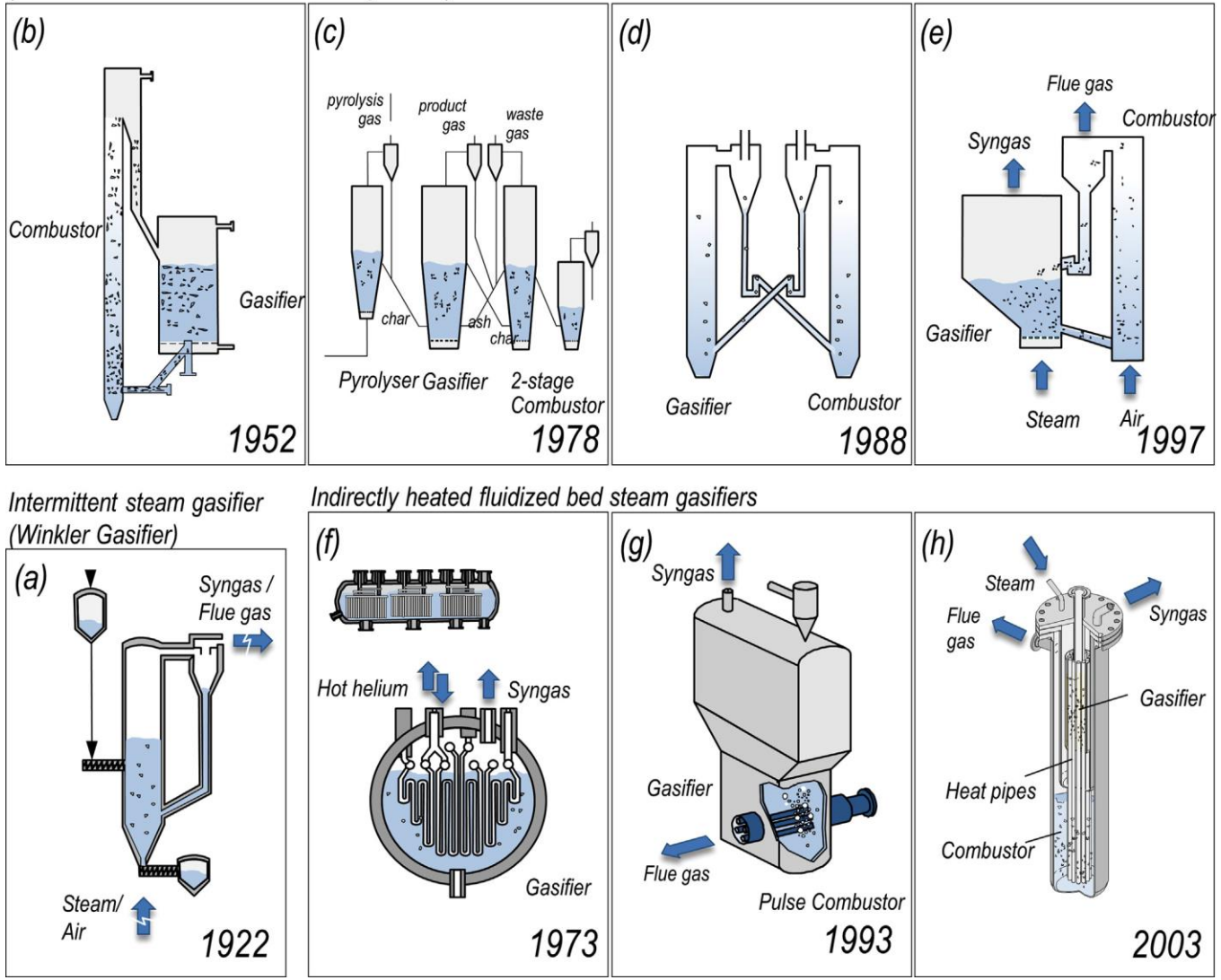

(a) Winkler gasifier. Interconnected fluidized bed gasifiers
(b) Rayners moving burden gasifier
(c) FLUGA process
(d) Battelle's FERCO gasifier
(e) Gussing gasifier. Indirectly heated fluidized bed gasifiers
(f) MGB gasifier
(g) MTCI gasifier
(h) Biomass Heatpipe Reformer.

J. Karla, T. Prollb, Steam gasification of biomass in dual fluidized bed gasifiers: A review, Renewable and Sustainable Energy Reviews 98 (2018) 64–78.

GICO gasifieris as Battelle gasifier of 1988 or Gussding of 1997 but with two bubbling and not 2 circulating or 1 circulating and 1 bubblimng fluidised bed gasifiers thus simplicity, realeability and compatcness.

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CONCEPT

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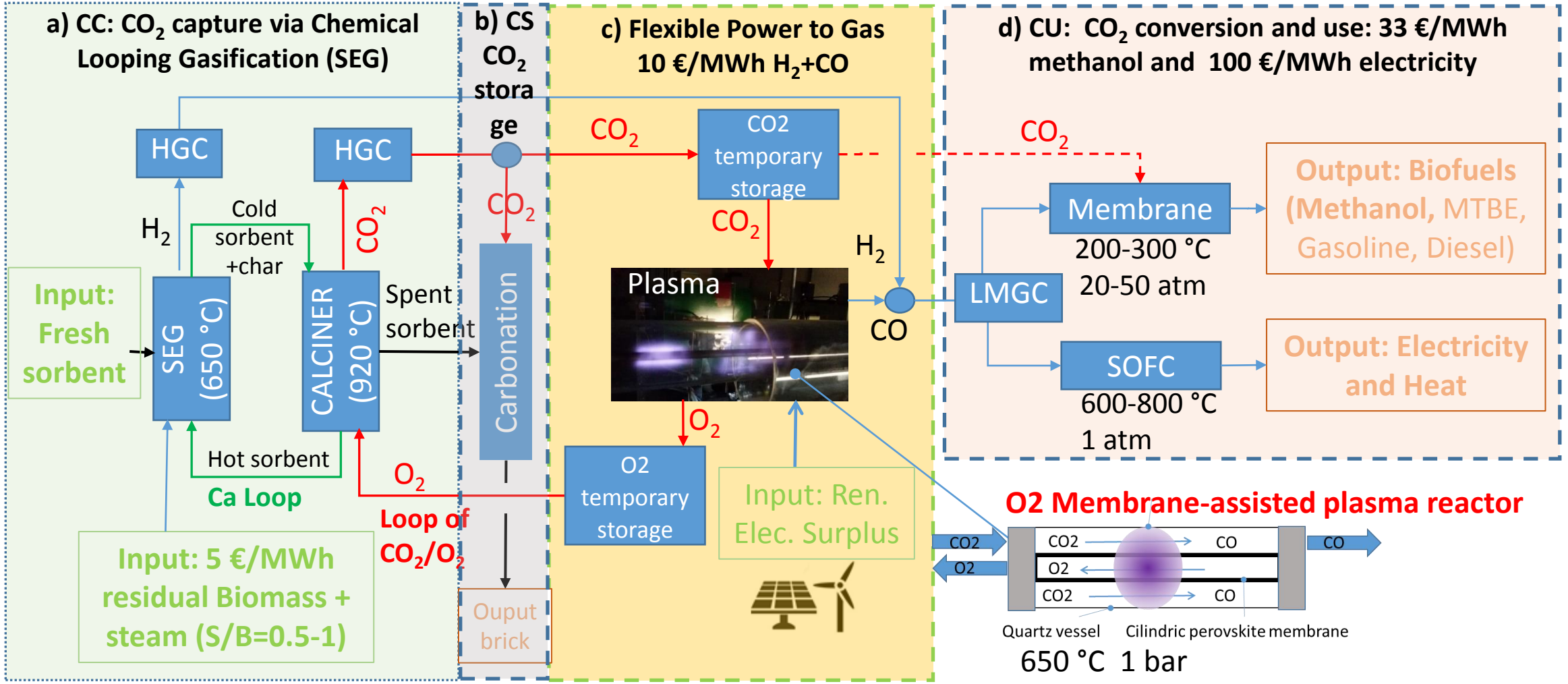

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GICO

GICO develops new materials (CO2 capture sorbents; high temperature inorganic removal sorbents; catalytic filter candles; membranes for oxygen separation and methanol production) and technologies (Hydro Thermal Carbonisation; Sorption Enhanced Gasification; Hot Gas Conditioning; Carbon Capture, Storage and Use; Power To Gas via Plasma conversion) to:

1. produce intermediate solid (5 vs 15 €/MWh) and gaseous (10 vs 30 €/MWh with zero particulate and ppb contaminants level) bioenergy carriers;
2. capture CO2 (40 €/t vs 90 €/t) receiving waste high alkali content and producing bricks;
3. convert CO2 to CO and O2 (90 vs 10% efficiency) storing renewable electricity excess;
4. produce methanol (35 vs 75 €/MWh) and electricity (100 vs 200 €/MWh).

Aim: to develop small to medium scale residual biomass plants (i.e. 2-20 t/day and 500-5,000 kWe, compatible with the standard residual biomass availability of few thousand tons per year) connected to communities.

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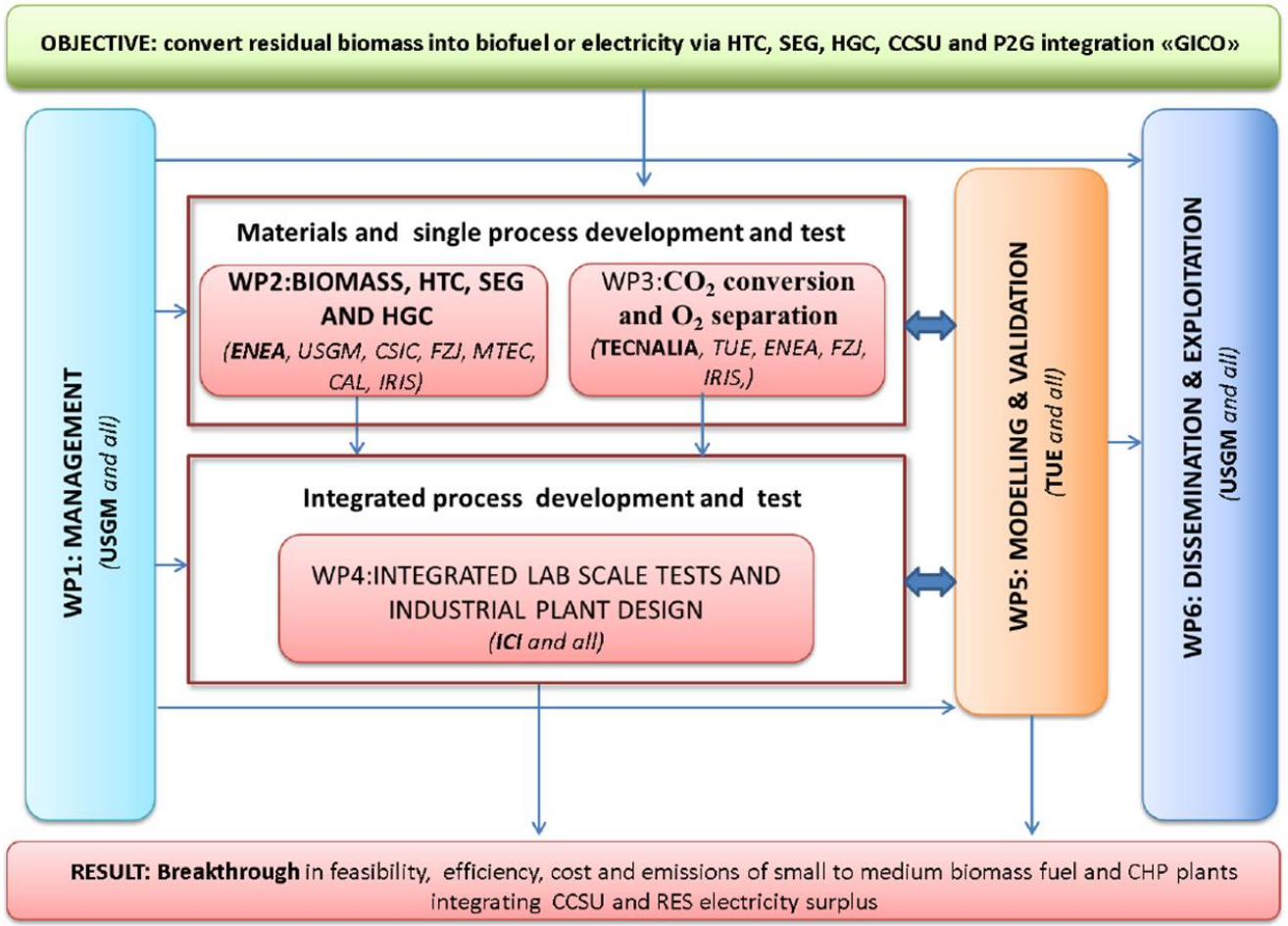

-6 WPs
-4 years project
-4.000.000,00 € funded
-11 partners

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GICO PARTNERS

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TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

ICI CALDAIE

IRIS PLAYGROUND FOR NEW IDEAS

CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

UNIVERSITÀ DEGLI STUDI GUGLIELMO MARCONI

JÜLICH FORSCHUNGSZENTRUM

ENEA

CALIDA CLEANTECH

tecnalia MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE

Marion Technologie Nanomatériaux Matériaux Nanostructurés & Poudres Céramiques

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MAIN RESULTS

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Since the project has started recently (December 1st 2020), only one deliverable has been completed:

- D 2.1: Selection of feedstocks and their characterization (CSIC), that is focused on:
  - Selection and characterization of multiple biomasses
  - Understanding which type of biomass is optimal for this project
  - Possible usage of multiple biomasses as feedstock.

While only one deliverable has been completed as of now, multiple activities are ongoing, and by December 2021 multiple deliverables will be ready, regarding the following arguments:

- D2.2: Characterisation and production of large-scale pretreated feedstock (CSIC)
- D2.3: CO_2 sorbent and reforming catalyst agent (ENEA)
- D2.7: SEG (Sorption Enhanced Gasification) experiments: measurement of process parameters and syngas quality (ENEA)
- D3.4: Oxygen separation membranes: First generation and Second generation (TECNALIA)
- D6.4: Market monitoring and analysis (IRIS)

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COLLABORATIONS

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- Data exchange regarding the following topics:
  - Biomass characteristics
  - HydroThermal Carbonization (HTC)
  - Indirectly heated steam gasification with or without Sorption Enhanced Gasification (high temperature solid-sorbents for CO_2 capture)
  - Hot Gas Conditioning (particulates, tar, Sulphur and Chlorine compounds)
  - Solid Oxide Fuel Cells (SOFC/SOEC)
  - Plasma processes (for tar and electrochemical-catalytic reduction of CO_2)
  - Membranes (from high temperature particulate filters to perovskite membranes for oxygen separation)
  - Biofuel production (with a focus on Methanol)
  - Info on the lab scale testing rigs
  - LCA exchange and overall Techno-Economic analysis

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DISSEMINATION

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Dissemination/communication activities are and will be made by using the following:

- Events and conferences: the partners of the project will take part in local and international conferences and meetings (both online and physically) outside the project to disseminate results and raise awareness around its activities and achievements.

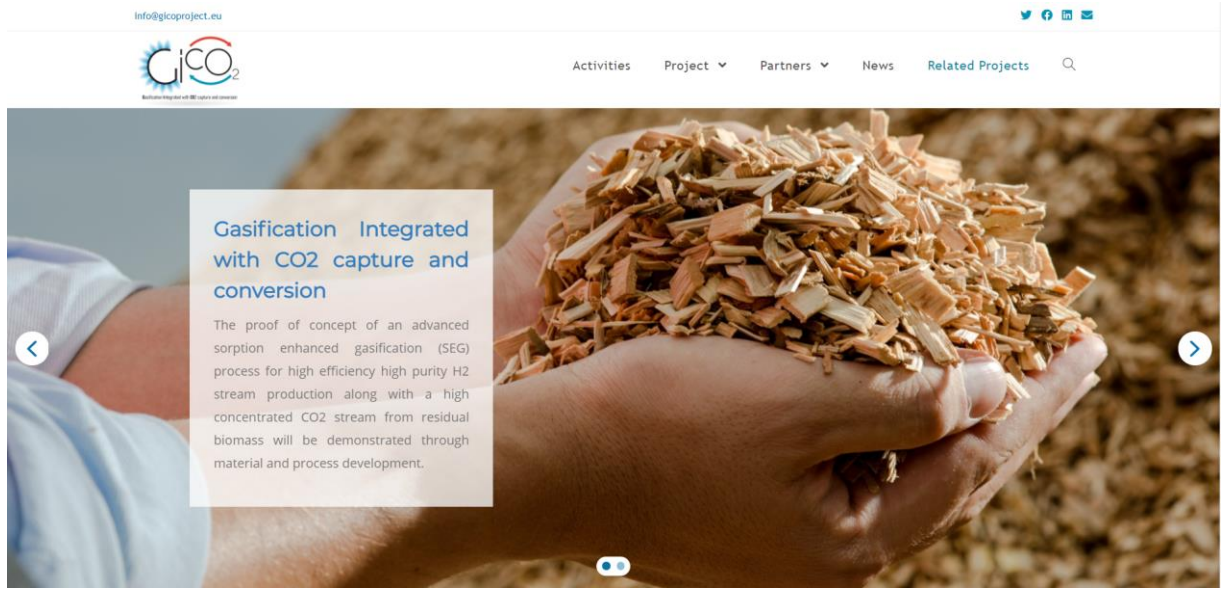
- Publications in scientific journals: the first submissions will come when substantial scientific results will arise from the project.

- The official BLAZE website https://www.blazeproject.eu:

- The official GICO website https://www.gicoproject.eu:

- Platform: www.blazeproject.eu/biocogen-2030/

- GICO social media (Twitter, Linkedin and Facebook):
  - Gico Project (@GicoProject) / Twitter
  - Gico Project: Overview | LinkedIn
  - GICO project | Facebook



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