November 14th, 2023
Brussels, Belgium

Funded by the European Union

PUBLIC PERCEPTION AND BUSINESS MODELS JOINT EVENT

Organised by the Carbon Capture, Utilisation and Storage (CCUS) & Alternative Fuels Horizon 2020/ Horizon Europe CLUSTER projects

Supported by CINEA - European Climate, Infrastructure and Environment Executive Agency

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Gasification Integrated with CO2 capture and conversion

Case study - GICO

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Gassification Integrated CO2 capture and conversion

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Baseline

WASTE price -33÷100 €/MWh

(-100÷300 €/t, LHV_{wet} 11 MJ/kg=3 MWh/t**, D2.1 BLAZE & D2.1 GICO:**

Intermediate solid bioenergy carriers: 15-5 €/MWh SET plan-GICO)

Legislation gaps for the agroindustrialmunicipal coproducts/waste use for H&P&CCUS&Fuel

Market gaps for solid bioenergy carries (e.g. biochar for Fuel is not as pellet for Heat)

Gasification -> 5-2 €/MWh (1-0.3 k€/MW_{th}, 10% opex)

Conditioning -> 5-2 €/MWh (1-0.3 k€/MW_{th}, 10% opex)

CO_2 capture 90 €/t (GICO 40 €/t), 50%C_{wt}&50%CO2, **5-2 €/MWh**

CO_2 conversion ->CO+½O2, 10 €/MWh_e, 50% efficiency, **5 €/MWh**

(**Intermediate gaseous bioenergy carriers: 30–10 €/MWh** SET plan-GICO)

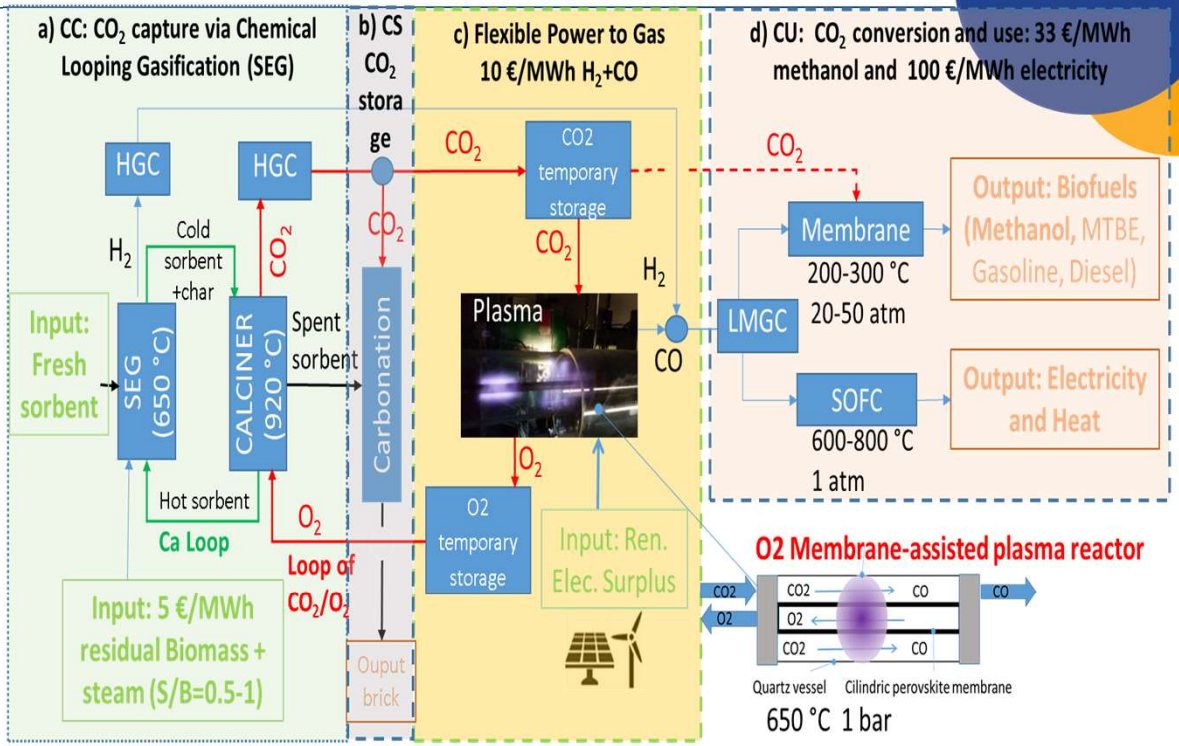
Gap in legislation for gaseous bioenergy carries

Market gaps (e.g. biosyngas is not as H2 in NG grid)

Methanol/biofuel 75 SET plan **35** GICO **€/MWh**

Bioelectricity 200 actual **100** GICO **€/MWh (SOFC<1000€/kWe?)**

Difficulty in use especially in **mix and medium to small scale** (i.e. 2-20 t/day and 500-5,000 kWe, compatible with the standard residual organic waste availability of few thousand tons per year) connected to communities. see public D6.4 GICO deliverable.



REFERENCE MARKET	Market Size	KER	Market	Trend
Biomass[i]	$91.3 billion in - $105.7 billion by 2028	Hydro-Thermal Carbonization (HTC)	Biomass gasification	$91.3 billion in - $105.7 billion by 2028 CAGR of 3.0 % from 2023 to 2028
Syngas[ii]	$ 48.89 billion in 2022 - $73.71 billion by 2030	Sorption Enhanced Gasifier (SEG)[v]	Cement & Steel mill	Cement market: 340.61 billion in 2022 - $481.73 billion by 2029. CAGR of 5.1% in 2022-2029 Iron and steel market: $1,538.72 billion in 2021. CAGR of 5.1% from 2022 to 2030.
Hydrogen[iii]	$170.14 billion in 2023 - $317.39 billion in 2030	Hot gas filtration and conditioning (HGC)[vi]	Catalytic converter	$49.25 billion in 2021 - $76.7 billion by 2030. CAGR 9.3% between 2022 and 2030.
Carbon capture, storage, and utilization CCSU[iv]	$1.9 billion in 2020- $7.0 billion by 2030	Membranes for oxygen separation (MOS)[vii]	Gas separation membrane	$1,856.78 million in 2023 - $2,469.59 million by 2028. CAGR of 5.87% during 2023-2028.

Methodology

Threat of New Entrants - MEDIUM

High initial capital intensity

Complex and different authorization rules between states

Presence of many supports scheme offered by the government.

Low market maturity

Supplier Power - LOW

Large number of small biomass suppliers

Dependence on a low number of suppliers of consumables products (membranes, catalyst materials)

The fast advancement in technology has helped in reducing the cost of manufacturing (SOFC) and increased competition

Competitive Rivalry - HIGH

High due to the presence of new emerging companies globally specialized in alternative RES (CHP, SOFC, biofuels plants).

Very small number of competitors already on the market able to combine all the technologies present in GICO

High competition of electric vehicle with biofuels

Buyer Power - LOW

High switching costs

Low market maturity

Complex installation and authorization procedures

Incentives more reward decentralized and continuous production over time, this lowers the risk of exchange of the source of production

Threat of Substitutes - MEDIUM

High number of low costs fossil substitutes

High number of alternative traditional RES for electricity (solar, wind, biomass CHP) and transport (electric vehicles)

Reduced number of substitutes capable of producing bio-methanol from residual CO2

The presence of incentives and subsidies focused on RES has given it a boom for new companies to enter into the market.

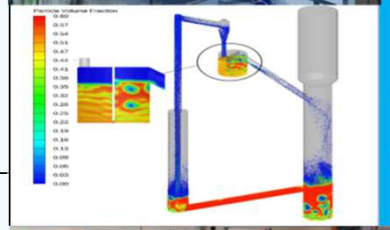
The global warming legislation has also increased the companies to focus on clean energy. These factors create a high level of competitiveness on the market both in relation to the existing company (Competitive Rivalry) and for the possible entry of new companies (Threat of New Entrants).
The products have high initial costs and low sales numbers compared to traditional and fossil plants.

P	E	S	T	L	E
Political	Economic	Social	Technological	Legal	Environment
Directive 2018/2001 on renewable energy (REDII)	Cogeneration and Biomass subsidies	Biomass acceptance	Electrification	National procedure for installation	Circular economy: Residues from the process: ash, char, exhausted catalysts
European Green Deal (EGD)	SOFC cost trend roadmap	Biofuel acceptance	Distributed RES generation (DG)	Electricity market rules	CO_2 emissions and European Emissions Trading System (EU ETS)
Transport policies	Trend of price of energy: biomethanol and electricity	Renewable energy community (REC)	SOFC and membrane technological evolution	Certification of supply chain sustainability	Sustainability of the residual biomass
Fit for 55	Energy taxation	Carbon Capture and Storage (CCS) Social Acceptance			The Industrial Emissions Directive (IED) 2010/75/EU

Value proposition	Biofuels, electricity, heat production and carbon capture with high efficiency and low emissions from organic waste
Target stakeholders 1: Industries	Manufacturing and Engineering companies, Fuels and energy utility companies, Fuels and energy end users with organic waste: Industries can benefit from GICO plant making production more sustainable, reducing carbon emissions and reusing existing sources
Target stakeholders 2: Researcher and Academia	Universities and research centres with models and test rigs on organic waste conversions, CO2 capture and conversion, biofuel and electricity production: GICO models and test rigs can be replicated or integrated/improved for specific applications
Target stakeholders 3: Civil Society	Citizens, associations, NGOs, Municipalities, Regions, States, EU: concerns and legislation on organic waste, solid and gaseous bioenergy carriers, CCUS, biofuels and bioelectricity
Customer needs	Reduce consumption of fossil fuels, electricity and heat. Reduction of CO_2 emissions.
Product developed to meet the needs	Fully operational system to produce biofuel, electricity, heat with CO_2 capture
Customers pains and related GICO pain relievers:	High prices for fossil fuels, electricity and heat from the gas/power/heat distribution network ↔ Electricity and heat production at lower prices
	Exceeding of CO2 emission limits ↔ CO_2 capture will allow to reduce emissions with equal consumptions
Gain creators	Direct selling biofuels, electricity and heat to the customers, not the plant. For the customer the gain is do not care about operation and maintenance of complex plants.
	Realize high efficiency plants by matching consumptions of fuels, electricity and heat
	The CO_2 capture will allow to reduce customers CO_2 footprint

Results

KER	TECHNOLOGY	REFERENCE MARKET	Target end users	Partner	Exploitation strategy
1	**GICO integrated system**	WASTE treatment Solid and Gaseous energy carriers CCSU P2G CHP Biofuel	Industries (wood,paper, food, beverage, cement, steel) and Waste management companies	ICI (Europen leader in industrial steam generation systems)	Business models of application of GICO technologies to the portfolio of ICI costumers
2	**Hydro Thermal Carbonization** (HTC)	Bio-syngas Gasifier and CHP	Manufacturing companies (e.g. ICI)	CSIC	Integration and scale up of HTC test rig and pilot plant
3	CO_2 sorbents	Carbon Capture	Industries and Waste management companies	MTEC	Scale up of manufacturing
4	**Sorption Enhanced Gasifier (SEG)**	Carbon Capture	Manufacturing companies (e.g. ICI)	ENEA	Integration and scale up of SEG test rig and pilot plant
5	High temperature inorganic removal sorbents	Gas conditioning	Manufacturing companies (e.g. ICI, CALIDA)	FZJ	Integration and scale up of HGC pilot plant
6	Plasma enhanced catalytic oxidation PECO	Gas conditioning	Industries,Waste management and Engineering companies	IRIS	Plant integration test + Patent + direct sale
7	**Hot Gas Conditioning (HGC)**	Fossil and renewable fuels HT treatments	Manufacturing (e.g. ICI) and Engineering companies	CALIDA	Plant integration tests + direct sale
8	Plasma-assisted catalyst system for **CO_2 conversion to CO**	Carbon Use	Manufacturing companies (e.g. ICI)	TUE	Integration and scale up of Plasma test rigs
9	**Oxygen separation membranes**	Gas separation membranes	Manufacturing companies	TECNALIA	Patent and licensing
10	**SOFC** fed by biosyngas	CHP	SOFC integration companies (e.g. ICI)	USGM	Patent and licensing



	Success factors	Failure factors
	STRENGTHS	**WEAKNESSES**
Internal	**Modularity**: The system consists of modules that can be marketed integrated or individually.	**Level of development**: Immature (TRL4-5) technology for commercialization. Large-scale production could present other drawbacks compared to those found in laboratory and pilot developed environment.
Internal	**Residual Biomass**: Use of low-cost residual biomass with constant production and currently considered as waste	
Internal	**Circular economy**: reuse of CO_2 sorbent in other industrial sectors	**O&M**: presence of consumable materials, such as catalysts and membranes to be replaced periodically to ensure the correct functioning of the system, with high costs due to a still restricted market.
Internal	**Biomethanol flexibility**: used in transport sector in alternative to fossil fuels and electric mobility	
Internal	**Near zero GHG Emission**: by combining the CO_2 plasma conversion system and SOFCs to produce electric and thermal energy and biomethanol	**Technical installation requirements**: GICO requires significant space for waste storage and treatment, gasifier, GCU, SOFC, methanol reactor.
	OPPORTUNITIES	**THREATS**
External	**Rural regeneration**: creation of additional income for agroindustrialmuncipal companies with organic waste, creation of a series of high skill green jobs in the area	**Market competition**: lower prices of conventional fossil energy technologies and presence of new renewable competitors
External	**Green retrofitting**: the installation of individual technologies can be integrated into existing CHP and fuel plants: expanding treatable waste (HTC, SEG); reducing emissions (CO_2 Capture and Conversion, HGC), improving efficiency (HGC/SOFC vs CGC/ICE, Membrane reactors).	**RES Competitor incentives**: presence of incentives on competing RES technologies (solar/wind, batteries)
External	**Energy community**: increase the local green prosumers, increase stability of electric grid and reduce energy costs (self-consumption incentives)	**Complex and instable Subsidy schemes**: in the future may pose a risk if the technology cannot decrease the investment costs.
External	**Electrification**: The trend to electrification in the future will be an opportunity for fuel cells which can achieve higher power-to-heat ratios than other CHP technologies.	**Installation rules**: unclear national installation regulations could slow down the spread of the system
External	**Green Electric storage and grid flexibility**: stability in electricity production, storage of discontinuous RES via CO2 conversion	**Biomass acceptance and supply chain**: the use of biomass to produce biofuels and biochemicals is a relatively new activity and meets the resistance. The supply chain is not organized like that of fossil fuels.

Stakeholder impact

Wide **spectrum of organic waste** from local and certified supply chain. A certified and local supply chain allows to secure supply and logistic, to certify emissions reduction and to have a high level of social acceptance.

Decentralized energy production in renewable energy communities. The GICO plant stands as a fulcrum in the nascent RES energy communities. The members of the energy community thus become prosumers, supplying the raw material (organic waste, CaO, CO_2) and selling thermal and electrical energy and biofuels and residual materials (spent CaCO3). The electricity produced and self-consumed within the community is also subject to OPEX incentives (119 €/MWh in Italy) which allow for a reduction in the investment payback time.

The presence of regulations that require prosumers to be equipped with a smart meter and a dynamic price contract allows them to be rewarded for moving consumption / production in times when energy is widely available and cheap. The configuration of GICO allows to "store" the surplus of discontinuous RES through the **conversion of CO_2** and therefore to obtain economic rewards on contract at a dynamic price.

The **production of electricity, heating, and biomethanol** at the same time from natural and anthropogenic sources, including residual biomass and the conversion with plasma technologies (powered by a discontinuous renewable source) of CO_2 from fumes, could be the first step towards an anthropogenic carbon cycle.

The **electrification**, in particular with Distributed RES generation, of the energy market plays a key role in the energy policies of the European Union, but also of developing countries: electricity meets 21% of global final energy consumption by 2030. The Increasing rural electrification rate, particularly in developing countries, has escalated the demand for decentralized electricity generation, which is majorly driving the global biomass gasification market toward growth but sustainablke solutions as GICO have to be applied!

By analyzing the state of the art, actors in the field, the Project Goals (PG), the market positioning diagram and the SWOT analysis, we reach the following **conclusions**:

- The PG can have strong technological impacts in different sectors but regulations and markets have to be developed!
- The PG can become the core of a larger one also involving other initiatives, in Horizon Results Booster activities and beyond.
- The rich diversity represented in the PG can be exploited for the creation of a joint document, containing a brief set of key recommendations for target stakeholders – e.g. large enterprises (wood, paper, food, beverage, cement, steel, waste management) or the general public – on waste, CCUS, P2G, CHP, Biofuel!
- This document can work as the basis for further joint activities, which can consolidate the PG position as a leading and inspirational force in the field.
- Integration of GICO technologies within these industries via scale up and business models is the leading exploitation way!

https://www.gicoproject.eu

Platforms:

https://zeroemissionsplatform.eu/
www.ccusnetwork.eu/knowledge-platform
https://ccushub.ogci.com/ www.blazeproject.eu/biocogen-2030/

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Thank You

For Your Attention

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