



CLARA

Chemical Looping Gasification
for Sustainable Production of
Biofuels

WHAT IS CLARA?

CLARA is a Horizon 2020 project, funded by the EU, involving 13 partners from across Europe, which aims at developing an efficient technology for the production of 2nd generation liquid biofuels based on chemical looping gasification (CLG) of biogenic residues.

H2020 Research and Innovation action
Grant Agreement n° 817841

<https://clara-h2020.eu/>

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ABOUT THE PROJECT

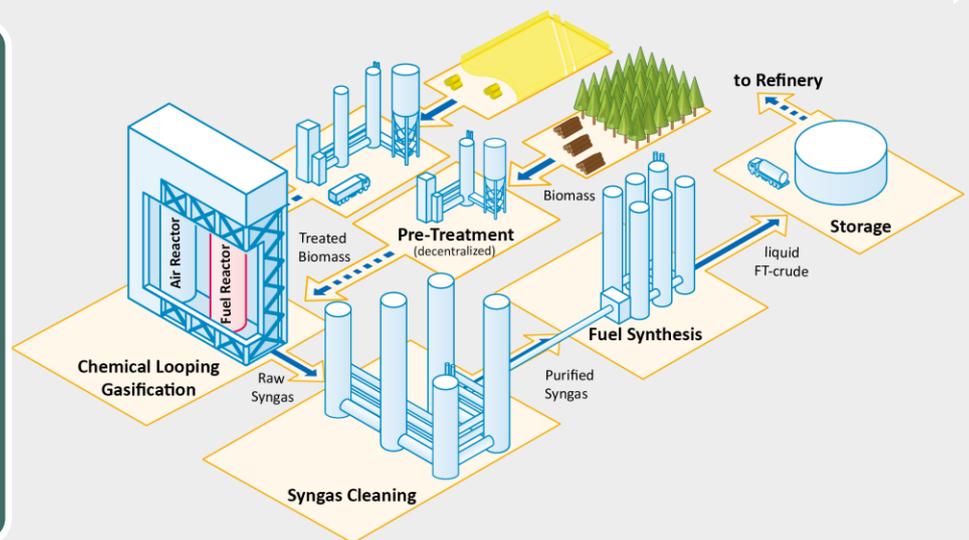
The **de-carbonization of the transport sector** is a key factor for to achieve **significant reductions** in greenhouse gas emissions that are required to **prevent a surge in global average temperatures**, exceeding the 1.5 °C Paris Agreement threshold. To tackle this issue, the **large-scale deployment of biofuels**, in addition to electrification and the increased deployment of rail transport, is necessary. Therefore, **substantial advances in renewable fuel generation**, not affecting food availability and prices, are required. One route to achieve these objectives is **the synthesis of advanced biofuels through thermochemical conversion** of biomass-based residues. Within the scope of CLARA, an efficient technology for the **production of liquid fuels based on chemical looping gasification (CLG) of biogenic residues** is being developed. The major objective is to further investigate and test CLG up to 1 MW_{th} scale in an industrially relevant environment, elevating the process to market maturity. Furthermore, the project aims at devising and optimizing innovative, cost-efficient technologies for biomass pre-treatment and syngas cleaning. These novel process steps will be supplemented by established fuel synthesis technologies (e.g. Fischer-Tropsch process), yielding the full biomass-to-biofuel process chain.

ON THE INSIDE

Project Results

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PROJECT RESULTS

- Researchers from Chalmers University and CSIC have identified natural ores (such as iron ore, manganese ore, ilmenite) and industrial waste (LD slag) as potential **low-cost oxygen carrier materials** for chemical looping gasification.
- A combination of **pre-treatment** methods (torrefaction, washing, additivation) reduces the alkali content of cereal straw, thus qualifying this abundant biogenic resource as feedstock for chemical looping gasification (→ see next page).
- The research team from RWE has demonstrated the basic principle of sulfur recovery by means of H₂O₂, which is the core element of an innovative **syngas cleaning** concept that will significantly reduce the biofuel production costs.

For more information on the project progress visit: <https://clara-h2020.eu/>.

In case you want to receive regular updates on the project, you can [subscribe to the biannual newsletter](#).

GETTING TO KNOW THE PARTNERS – CENER

Being the first sub-unit in the suggested process, pre-treatment is an essential component of the suggested value chain. CENER leads the research efforts in developing a new pre-treatment concept for the preparation of biogenic residues for chemical looping gasification. We had the chance to talk to Ibai Funcia from CENER, learning about their progress.

What appealed to you in the CLARA project, sparking the interest to get involved in it?

The Biomass Department of CENER has several strategic research lines based on the future perspective of renewable energy market evolution. New resources to create energy vectors such as biomass wastes and advanced biofuels production are a strategic priority. In this sense, CLARA project offers the opportunity of combining both of them.

What is your role in the project and what expertise do you bring to the consortium?

CENER develops concepts for pre-treatment of biogenic residues that will improve the efficiency, operability, and economics of the overall gasification process as well as enlarge the biomass feedstock basis suitable for it. On the one hand, CENER has a long experience and the required facilities for handling solid biofuels at semi-industrial pilot scale as demonstrated in the frame of SECTOR project. On the other hand, CENER has also a vast experience in the environmental evaluation of biofuel production processes via Life Cycle Analysis as Biorescue or Ambition. Some of these projects can be consulted at: <https://www.bio2c.es/projects/>

Why do you think CLARA is an important project for society, academia, and industry?

From the point of using biogenic residues as feedstock in the bioenergy sector there is no conflict with food production or other kind of land use. Besides marketing of biogenic residues and operation of decentralized supply plants to centralized CLG plants may also strengthen the economy of rural areas. The CLG technology facilitates the combination of biofuel production with no or even negative CO₂ emissions if the captured CO₂ is stored permanently. If not, the other option is to use the separated CO₂ for further biofuel production, but in this case, renewable electricity or hydrogen must be available. At the same time that we carry out this interesting project, I think it is a very enriching experience to work in collaboration with the other partners of the project, and to share information and experiences.

What are the biggest challenges in your work within CLARA?

Cereal straw has been selected as a representative agricultural residue as an attractive lignocellulosic material, since it is one of the most abundant renewable resources. However, biogenic residues such as straw, have undesired properties with respect to gasification in fluidized beds: low energy density, low ash melting point and high content of volatile inorganics like alkali and chlorine. The challenge is to develop a pre-treatment concept by means of heat treatment, washing and use of additives to avoid operational problems with focus on optimizing fuel properties to improve conversion efficiency during CLG in a sustainable way. →



Wheat Straw Pellets



CENER

NATIONAL RENEWABLE
ENERGY CENTRE

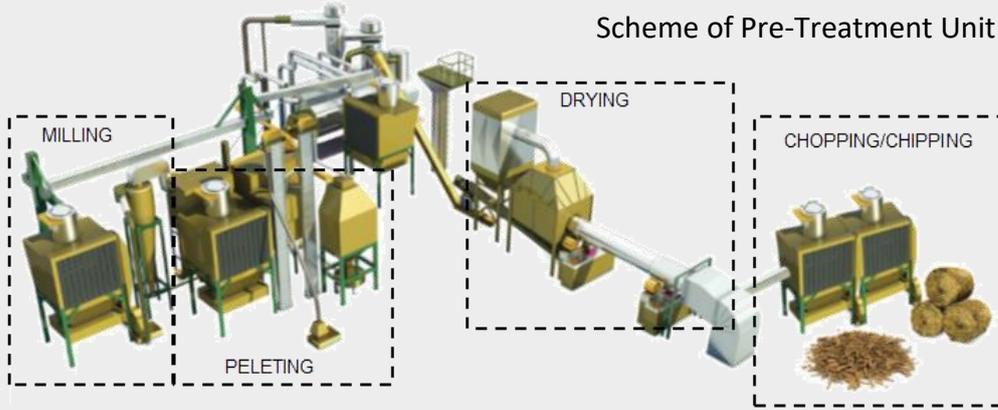
ADIttech

The National Renewable Energy Centre of Spain (CENER) develops applied research in renewable energies, and provides technological support to companies and energy institutions in six areas: wind, solar thermal and photovoltaic solar energy, biomass, smart and efficient buildings and districts, and grid integration of energy. CENER is a technology centre with worldwide recognized prestige, activity and experience.

CENER Biomass Department performs applied research activities in the field of biomass, providing R&D services and technical assistance to all agents of the sector. The area is focused on the development & optimization of production processes of bioproducts, solid biofuels, advanced liquid or gaseous biofuels, as well as biorefinery concepts. Indeed, the main pillars are focused on solid biofuels, bioprocesses and comprehensive sustainability assessment.

The main infrastructures in this department include the Biomass Laboratory (biomass & biofuels characterization and process development at lab scale), as well as the Biorefinery and Bioenergy Centre (BIO2C, www.bio2c.es). The BIO2C is a semi-industrial pilot scale test facility able to develop production processes for bioproducts, solid biofuels, advanced liquid or gaseous biofuels, as well as biorefinery concepts integrating different valorization routes, as an intermediate step between laboratory and the industrial scale-up of these technologies. The center constitutes an integrated trial and demonstration platform designed to develop processes, equipment and specific components, new bio-products or biofuels and bio-refinery concepts.

Scheme of Pre-Treatment Unit



→ Currently, CENER is developing new pre-treatment methods for biogenic residues. Why is “pre-treatment” important for biomass-to-biofuel process chains? In which way can it influence the product quality and the process efficiency?

Due to above mentioned characteristics of wheat straw several operational problems can arise during gasification in fluidized beds such as agglomeration, slagging, corrosion and fouling. Besides, its low energy content makes it difficult to handle, transport and store efficiently thus limiting its commercial use.

The suggested pre-treatment step aims to improve not only the feedstock quality in terms of its energy content (density and NCV) and its inorganic matter melting behavior, but also in terms of the associated pre-treatment process efficiency and fuel delivery cost.

How can the newly developed pre-treatment methods help other projects or industrial processes?

Biomass demand is increasing and therefore the pressure on the procurement prices for the higher quality feedstock. As consequence, the consumption of lower quality and cheaper feedstocks for biopower and advanced biofuels will increase drastically in next years.

What was your biggest success in the project so far?

CENER has proven the feasibility of modifying and improving wheat straw properties by means of combining torrefaction, washing and the use of additives at laboratory scale. Nevertheless, some challenges remain opened and should be completed in frame of the CLARA project, particularly it must be point out that results should be also confirmed and verified during the pilot plant trials.



Mr. Ibai Funcia has a Degree in Chemistry and an Interuniversity Master's degree in Project Management. Since July 2003 he has been working in CENER's Biomass Department as a Biomass Senior researcher. Besides working at CENER, he is finishing his PhD in the field of Biomass Inorganic Modelling during Combustion at Public University of Navarre.

The main areas in which he has developed his work at CENER in the last 17 years have been:

- Thermochemical route: biomass torrefaction, biomass combustion (ash behavior at high temperature) and biomass gasification (tar cleaning, sampling and analysis).
- Biochemical route: biomass pre-treatments and downstream processing.
- Biomass and Bio-fuel characterization. Laboratory quality and assurance procedures.
- He has participated in RTD projects like: SECTOR (European – 7^o FP) and INNPACTO MULTIBIOM (MINECO-Spain) for the development of multi-fuel biomass combustion technology for high power electricity.



Biomass Pre-Treatment Unit at CENER facilities (BIO2C)

DISSEMINATION ACTIVITIES

Scientific publications

- K. Atsonios, A. Nesiadis, N. Detsios, K. Koutita, N. Nikolopoulos, and P. Grammelis, "Review on dynamic process modeling of gasification based biorefineries and bio-based heat & power plants," *Fuel Processing Technology*, vol. 197, p. 106188, Jan. 2020.

Conference Contributions

- CLARA - Chemical Looping Gasification for Sustainable Production of Biofuels, *Paving the Way Towards Clean Energy and Fuels in Europe*, EUBCE Lisbon, 29.05.19
- Chemical Looping Gasification for Sustainable Production of Biofuels, 2. *German Doctoral Colloquium Bioenergy*, Nuremberg, 30/09-01/10/19
- Chemical Looping Gasification for Sustainable Production of Biofuels, *Bio4Fuels*, Gothenburg, 04/11/19
- Improving ash melting behavior of challenging biomass fuels, *European Biomass to Power 2019*, 07/11/19
- Chemical Looping Gasification – A Novel Process for the Sustainable Production of Biofuels, *6th CEBC*, Graz, 22/01/20
- Biomass Chemical Looping Gasification (BCGL) Using Ilmenite as Oxygen Carrier, *6th CEBC*, Graz, 22/01/20
- Novel concept for the pre-treatment of cereal straw, *European Pellet Conference 2020*, 04/03/2020

Other publications

- *European Energy Innovation*, Spring 2020 Edition, "Chemical Looping Gasification – A Novel Process for the Production of Biofuels Allowing for Net Negative CO₂ Emissions"
- *Open Access Government*, The CLARA project – Chemical Looping Gasification for Sustainable Production of Biofuels

CONSORTIUM



For more information on the project progress visit: <https://clara-h2020.eu/>.

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