Newsletter IV, October 2020

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

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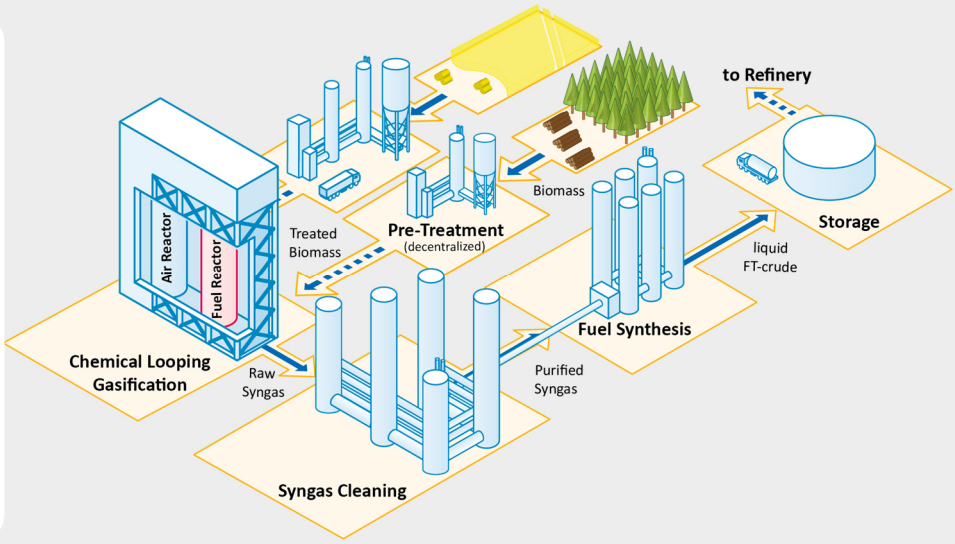
About the Project

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

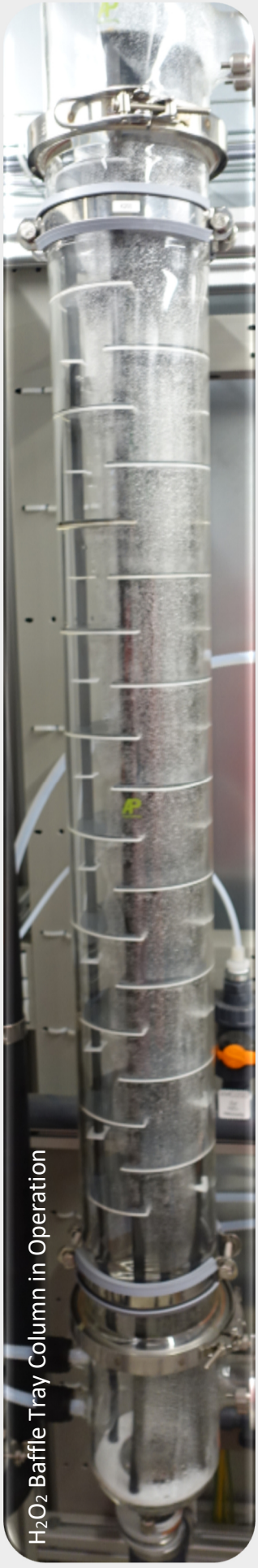
- More than **350 hours of continuous CLG operation have been completed** in bench in lab scale units, providing insights on process control strategies, process efficiency, and the merit of different oxygen carrier materials for large-scale CLG operation.
- A pre-treatment concept, allowing for the efficient utilization of wheat straw in CLG, which is being developed under the lead of CENER, is on the verge of finalization. First **feedstock samples** produced by this concept **will be tested in small-scale CLG units shortly**.
- Research at RWE yielded a more **detailed understanding of the basic principle of sulfur recovery from sour gases by means of H_2O_2**, which is the core element of the novel syngas cleaning concept, substantially reducing biofuel production costs (⬊ see next page).
- The TUDA **pilot plant has been extended by a syngas-treatment unit**, allowing for downstream processing of up to 200 Nm^3/h raw syngas produced in the pilot scale gasifier.

A detailed summary of all projects results can be found in the second public report!

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.

RWE Power, with headquarters in Essen and Cologne, Germany, is a company of the RWE Group. Its business is lignite-based and nuclear power generation. The Company employs about 10,300 people and operates three opencast lignite mines in the Rhineland area. Lignite production is predominantly used for electricity generation in the Company's own power stations, but is also processed to make solid fuels and filter materials. In addition, RWE Power manages the operation, decommissioning and dismantling of RWE Power's nuclear facilities. The Company's power stations supply the grid with an overall capacity of more than 14 gigawatts. Since the 1980's, RWE Power has also developed technologies for alternative utilization of coal via gasification and synthesis of hydrocarbons, thus contributing to the CLARA project with its practical experience in the field of coal gasification, coal gas cleaning, and synthesis of hydrocarbons.
RWE Power will provide an existing container-based synthesis test setup available for investigations within the project. Currently, this test setup is capable of studying the synthesis reactions of synthesis gas to methane, methanol, and Fischer-Tropsch crude oil mix.
Furthermore, RWE Power operates a mobile gas cleaning test rig to investigate innovative process steps for synthesis gas desulphuration and recovery of pure sulphur. In case of success, this innovative concept has the ability to become significantly more economic than the currently applied technologies.


H_2O_2 Baffle Tray Column in Operation

Getting to Know the Partners – RWE

Supplying syngas of sufficient quality is an important prerequisite for virtually all synthesis routes. Here, the Fischer-Tropsch-synthesis, being employed within the scope of CLARA to produce gasoline and diesel from syngas, is no exception. RWE leads research efforts in developing a novel syngas treatment concept for the efficient and reliable removal of side-products and contaminants from the syngas produced via CLG prior to fuel synthesis. We had the chance to talk to Thorsten Liese and Frank Buschsieweke from RWE, to learn about the advantages and promises of this novel technology and how it is being further developed within the CLARA project.

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

As we have been working on process chains based on gasification, either for power production including carbon storage or for production of base chemicals like methanol or transport fuels, for decades, a participation in the CLARA project, further promoting such process chains, was and is of great interest to us. We have seen that gas cleaning holds a large portion of investment and operation costs of such processes. Besides our focus on the new idea of gas cleaning, we saw further economic potentials in the field of gasification. So does TU Darmstadt, e.g. by avoiding air separation via Chemical Looping Gasification. Our idea of innovative gas cleaning aims for avoiding costly refrigeration of process media, too.

Many processes have been developed for lignite applications, which form our background. Now, in the phase of energy transition, we are looking to apply these processes to alternative biogenic resources. We believe that our experience can help in this transition.

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

RWE conducted numerous feasibility studies for IGCC-CCS (Integrated Gasification Combined Cycle for heat and power production), including Carbon Capture and Storage. Within these studies, different technologies for the complete process chain have been evaluated together with technology licensors, engineering companies, and own experts. Based on that, we now have strong knowledge to do in-house concept development and evaluation for new applications, be it the use of regenerative fuels (biomass) or the application of new technologies or innovative combinations of already established technologies.

As a special topic, we developed a new concept for syngas desulphurization in combination with sulphur recovery, using agents that are commonly known, but not applied in this field, yet. To confirm the expected performance of such a concept, we operate a mobile gas cleaning test rig within this project, partly at our own site, partly at the site of the coordinator, where it is integrated into the full process chain, to evaluate its merit in a representative environment. ⇘

Test Module with Glass Column

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

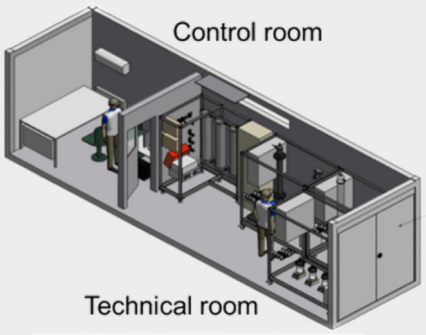
First of all, CLARA deals with the sustainable application of regenerative and residual fuels, which is a major aspect for our society. Furthermore, there are few but major technical and economic issues to be solved for such applications in large scale. Both academia and industry can learn a lot more and can broaden its knowledge basis. If the project is successful, this could lead to new business and/or guarantee competitiveness of industrial players in these markets, especially those located in Europe.

What are the biggest challenges in your work within CLARA?

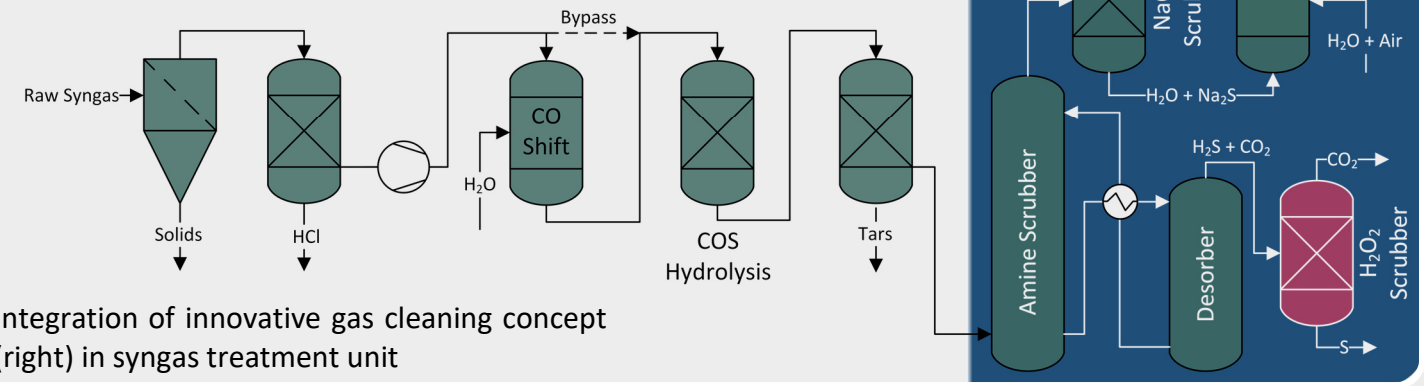
One basic challenges, just like in every experimental work, was to get all pieces working in the correct mode and manner. Be it simple hand valves or highly complicated parts like the Gas Chromatograph, problems can and already did occur– despite good engineering standards and correct design. On top of this, COVID19 led to an extra challenge to fulfil the time schedule for our work.

Another challenge - upfront to the project - was to define and design a highly flexible installation, facilitating the test of different parts of a gas cleaning process. This led to the use of different modules, which can be moved and connected individually to the fixed parts like gas inlet & outlet, online gas analyzer, and control system.

Thorsten Liese joined RWE Power in 2010. Apart from his deep understanding of chemical processes, he has 10 years of experience in R&D project management within RWE. His main topics of expertise are carbon capture/utilization, syngas cleaning, and synthesis gas based processes. Furthermore, Thorsten has over 10 years process engineering experience in the area of polymers, olefins, and refining technologies. He gained his PhD in technical chemistry in 1999.



Front View of Syngas Treatment Unit of RWE



Integration of innovative gas cleaning concept (right) in syngas treatment unit

Currently, RWE is developing a novel syngas treatment system. Why is "syngas treatment" essential for biomass-to-biofuel process chains? In which way can it influence the product quality or the process efficiency?

For both, IGCC or BtX processes based on fossil fuels or biomasses, gas cleaning is an essential but expensive part. Gas cleaning is mandatory to avoid poisoning of synthesis catalyst leading to sufficient lifetime of such, high synthesis efficiency, and finally a perfect quality of the final products. With the novel gas cleaning system, the product quality will not be changed - it has to fulfil the same product specifications as existing mature applications. However, the required gas cleaning can be done at lower internal energy use and hence at lower costs compared to mature or state-of-the-art technologies like Rectisol® and Claus®. Additionally, in comparison to well-established solvents (e.g. Methanol), less hazardous solvents like H_2O_2 and amines will be applied.

How can the newly developed syngas treatment method help other projects or industrial processes?

As syngas cleaning is essential/necessary for any kind of technology using synthesis gas, e.g. from gasification processes and applications based on it, they can be brought to a more efficient and economic level through the novel gas cleaning concept.

What was your biggest success in the project so far?

As we had a lot of trouble with different parts in the mobile test rig, we are now happy to have a complete set of basic data on the conversion rate in the chemical system. As this data has been collected in single step lab scale reactors, we now can go on to validate it in a more technical surrounding inside a multi-step reactor (i.e. a tray column). This is an important step for further scale-up of the required equipment to industrial size and finally to confirm our expectations regarding process economics. ♦

Mobile Syngas Treatment Unit of RWE

Frank Buschsieweke is working for RWE power and other subsidiaries within the RWE group since 1991, mainly in R&D related topics. Beside his work at RWE Power, he gained a PhD in Chemical Engineering for his works on lignite drying in a pressurized steam fluidized bed in 2006.

His main topics of expertise are air separation, lignite drying and mechanical treatment, lignite gasification, and syngas cleaning. In between, he worked in the business development of large-scale fuel cells including field tests at customers' sites for several years. He was involved in feasibility studies as well as in operation of small and large-scale test plants for the individual technologies.

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.
- Dieringer, P.; Marx, F.; Alobaid, F.; Ströhle, J.; Epple, B. "*Process Control Strategies in Chemical Looping Gasification—A Novel Process for the Production of Biofuels Allowing for Net Negative CO2 Emissions*", Applied Sciences 2020, 10 (12), 4271.
- Condori, O.; García-Labiano, F.; de Diego, L. F.; Izquierdo, M. T.; Abad, A.; Adánez, J. "*Biomass Chemical Looping Gasification for Syngas Production Using Ilmenite as Oxygen Carrier in a 1.5 KWth Unit*", Chemical Engineering Journal 2021, 405, 126679.
- Andrea Di Giuliano, Ibai Funcia, Raúl Pérez-Vega, Javier Gil and Katia Gallucci, *"Novel Application of Pretreatment and Diagnostic Method Using Dynamic Pressure Fluctuations to Resolve and Detect Issues Related to Biogenic Residue Ash in Chemical Looping Gasification"*, Processes 2020, 8 (9), 1137

Conference Contributions

- 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
- Advanced Fischer-Tropsch biofuels production from syngas derived from Chemical Looping Gasification: A preliminary process simulation study, *eEUBCE2020*, 06/07/2020

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
- *Open Access Government, July Edition*, "Production of Biofuels exhibiting a net-negative CO2 Footprint"

Consortium

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