REFOLUTION
Unlocking the potential of biofuels

REFOLUTION Project newsletter
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Refinery integration, scale-up and certification for aviation and marine biofuels production

Content

1. Introduction

The first two years of the REFOLUTION project have come to an end.
Since the launch of the website, the initial social media campaigns, and the first presentations at both national and international conferences, the REFOLUTION project has continued to progress and strengthen its impact. REFOLUTION aims to demonstrate the transformation of bio-oils, produced through fast pyrolysis, into advanced biofuels.

By leveraging intermediate processing steps combined with downstream co-processing technologies, REFOLUTION targets two distinct applications: Fluid Catalytic Cracking (FCC) co-processing for the aviation and marine sectors, at TRL 7; Hydrotreating for the marine sector, at TRL 6.
As we move through these development stages, we are excited to showcase some of the work we have done to date.

2. Second Year Project Meeting

On 28-29 November 2024, the REFOLUTION consortium met for two days of meetings in Worms, Germany, marking a significant milestone in the project journey. This meeting brought together all project partners, to evaluate the remarkable progress made in the first two years of research. During the meeting, the consortium had the opportunity to reflect on the progress achieved so far, acknowledge the challenges faced along the way, and engage in in-depth discussions to address any ongoing concerns.

The meeting also provided an opportunity to visit the FCC catalyst manufacturing plant at Grace, the market leader in the supply of FCC catalysts in Europe. As a project partner, Grace plays a key role in supporting and enabling the energy transition at our clients' FCC plants.

Figure 1. Project meeting in Worms, Germany.
Credit: ETA Florence.

In conclusion, the consortium members worked together to define strategies and set key priorities for the next phase of the project. This meeting was a crucial opportunity to foster collaboration, improve communication, and reinforce the commitment to the project's long-term objectives.

Figure 2. Project meeting in Worms, Germany.
Credit: ETA Florence.

Key Highlights from the Meeting:

Review of Project Progress: The consortium conducted an in-depth review of the project's achievements to date, celebrating key milestones and reflecting on the significant progress made across the various work packages and activities. This session allowed the team to highlight successes and assess the impact of their collective efforts so far.

Discussion of Future Directions: In a series of focused discussions, participants worked together to shape the strategic roadmap for the project's next steps. The assembly were crucial in aligning the team's vision and ensuring that the project's goals remain ambitious and achievable in the years to come.

Collaboration and Knowledge Sharing: The meeting proved to be an excellent occasion for strengthening collaboration among partners. Participants exchanged valuable insights, shared best practices, and brainstormed innovative solutions, reinforcing the collective expertise within the consortium.

Through cutting-edge technologies and ongoing scientific research, the project seeks to unlock the full potential of biofuels, contributing to the development of greener, more sustainable solutions for the aviation and marine industries. Through these efforts, the consortium is determined to contribute and pave the way for a greener future in transportation.

Figure 3. Project meeting in Worms, Germany.
Credit: ETA Florence.

3. REFOLUTION webinar

The first webinar of the REFOLUTION project took place on November 8, 2024, offering an in-depth analysis of the role that social awareness plays in promoting social acceptance of biofuels. Moderated by Silje Fosse Håkonsen, a Research Scientist at SINTEF, and organized in collaboration with ETIP Bioenergy and the Bio4Fuels Centre—represented by Judit Sandquist, a Research Scientist at SINTEF—the webinar aimed to deepen the understanding of how societal engagement can support the successful integration of biofuels into both public discourse and practical application.

The event included the presentation of Nina Wessberg, Principal Scientist at VTT, and Remina Aleksieva, an Analyst at the Center for the Study of Democracy (CSD). Nina Wessberg introduced the Responsible Research and Innovation approach (RRI), that is also part of the REFOLUTION research. This methodology promotes research and development processes that integrate both environmental and social considerations, ensuring that the broader impacts of biofuels, both on ecosystems and communities, are carefully examined.

On the other hand, Remina Aleksieva shared the results from citizen panels conducted in Bulgaria, Italy, Sweden, and Austria, highlighting the different levels of public awareness and trust in biofuels across different countries.

Both studies highlighted the critical importance of social acceptance in the widespread adoption and implementation of biofuels. The production and use of biofuels have far-reaching consequences, not only for the environment but also for local communities. The public's perception of biofuels as a sustainable solution is essential in shaping their future success. For this reason, both studies highlighted the urgent need for transparent communication, which goes beyond the misleading greenwashing claims that often obscure the true sustainability of bioenergy solutions.

Credit: Canva.

In particular, the research presented by the Center for the Study of Democracy revealed that after a session where experts explained the science behind bioenergy and its potential to address sustainability challenges, trust in bioenergy as a viable and environmentally responsible solution increased moderately.
This demonstrates how providing accessible science information to citizens with diverse backgrounds can significantly improve public trust in bioenergy and new energy technologies. Ultimately, the RRI framework, as presented by Nina Wessberg, offers a holistic approach to research and innovation in biofuels.

It underlines the importance of not just considering technological advancements but also how these innovations impact society at large.
Ensuring that the development and adoption of biofuels are aligned with societal needs and values is crucial for creating sustainable and publicly supported energy solutions. This webinar, with its focus on social awareness and public engagement, highlighted the path forward for integrating biofuels into a more sustainable and socially accepted energy future.

Figure 4. Webinar webcard and presentations.
Credit: ETA Florence.

PRESENTATIONS:

Sustainability and Responsibility in Refolution biofuel research project context

Sustainable Biofuels in a Norwegian context

Social Acceptance of Bioenergy: Key Lessons and Insights from Bulgaria, Italy, Sweden and Austria

Refolution project presentation

4. Digital carbon tracking model

As part of the EU Horizon REFOLUTION project, a cutting-edge digital carbon tracking model is being developed to optimize the integration of fast pyrolysis bio-oil (FPBO) into fluid catalytic cracking (FCC) units. This innovative model harnesses data from experimental setups and results, employing advanced carbon tracking methodologies and product characterization techniques to accurately monitor and predict the behavior of renewable carbon in the process. By integrating real-time data with sophisticated analytical tools, the model enables precise tracking of carbon flows and product yields, significantly enhancing the efficiency and sustainability of co-feeding operations. This approach not only simplifies processes but also provides a reliable, cost-effective alternative to traditional, resource-intensive analytical methods.

The digital carbon tracking model is a sophisticated tool designed to accurately predict product yields and the renewable carbon content in each fraction generated during the co-feeding of Fast Pyrolysis Bio-Oil (FPBO) in a Fluidized Catalytic Cracking (FCC) process.

This innovative model leverages advanced data analytics and computational techniques to provide real-time monitoring and precise forecasting of renewable carbon content, enabling a more efficient and reliable assessment of the product stream.

By offering this level of accuracy in tracking renewable products, the digital carbon tracking model significantly reduces the need for costly, labor-intensive, and time-consuming analytical methods traditionally used in the industry.

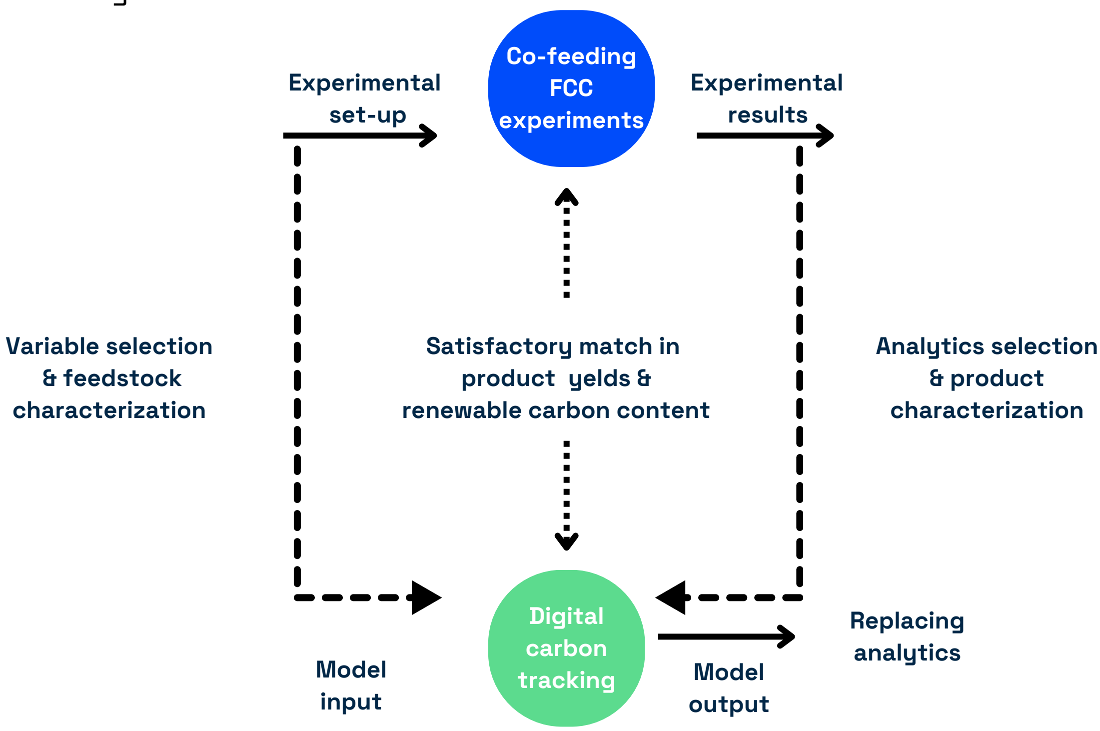

Figure 5. interconnections between an actual co-feeding set-up and a digital carbon tracking model. Credit: BTG in collaboration with SINTEF.

This not only lowers operational costs but also enhances the overall sustainability and efficiency of the process, making it a vital tool for optimizing the integration of renewable feedstocks into conventional refining operations.
This innovation supports the commercialization of the co-feeding process for marine and sustainable aviation fuel production, advancing decarbonization efforts.

5. CO-FCC Unit

Within REFOLUTION, a yield-based model of the FCC unit was developed, incorporating both fossil and biological compounds and modelling the cracking reactions resulting from the FCC co-processing.
The lab-co-FCC unit was constructed at BTG's premises and the aim is to develop a virtual representation of the entire system based on real-time measurements from the process unit, providing insights and the potential to optimise the unit in real-time, predicting system efficiency.
The model will be based on high-resolution C14 analysis of the bio-derived component, along with online spectroscopic measurements (Raman/FT-IR) and sampling for GC-MS analysis. These measurements will first be used to calibrate spectroscopic data for real-time monitoring of product streams from the FCC unit. Simultaneously, they will support reaction modeling for the FCC unit. Integrating this into a flowsheet simulator with online data updates from GC-MS/C14 analysis will enable real-time tracking of green bioderived carbon.

A detailed understanding of biogenic carbon distribution in FCC product streams enables stakeholders to optimize operations, enhance biofuel production yields, and reduce costs effectively. This critical deliverable will empower industrial partners with actionable insights to better manage commercial FCC co-feeding operations.

Figure 5. The lab-co-FCC unit built at the premises of BTG. The images show parts of the unit.

In REFOLUTION, we are developing an advanced modelling tool designed to track both inlet and outlet carbon flows throughout the process.

The current version of the model has been fine-tuned to accurately represent experimental data collected within the scope of our project, as well as data from previous projects.

The flexible structure of this model allows for the seamless integration of new data provided by our partners, ensuring continuous improvement and enhancing its overall applicability.

One of the key objectives is to predict how variations in feedstock composition, particularly the proportion of pyrolysis oil blended with VGO (Vacuum Gas Oil), influence the yields of gasoline, kerosene, and diesel.

Additionally, the model is being developed to track biogenic carbon, enabling a more comprehensive analysis of the environmental impact of the processes involved. This will provide valuable insights into optimizing feedstock usage and improving sustainability outcomes across the entire biofuel production chain.

6. Influence of Feedstock Composition on Conversion, Product Yields, and Catalyst Performance

The increasing demand for sustainable fuels has accelerated research into co-processing bio-based feedstocks with conventional petroleum-derived feedstocks in Fluid Catalytic Cracking (FCC) units.

Within the REFOLUTION project, the co-processing of three fast pyrolysis bio-oils (FPBOs) was tested.

Experiments involving hydrotreated pyrolysis oil (HPO), stabilized deoxygenated pyrolysis oil (SDPO) and stabilized pyrolysis oil (SPO) with vacuum gas oil (VGO) were conducted in a MAT unit, using an 80:20 VGO:Biocrude oil ratio with equilibrium catalyst (Ecat). From the experiments it emerged that HPO offers superior performance due to its low oxygen content and high hydrogen-to-carbon (H/C) ratio, which enhances conversion and limits coke formation.

In contrast, SPO and SDPO show reduced performance due to higher oxygen levels and water content, which deactivates catalysts via competitive adsorption. HPO also promotes higher yields of light products like LPG and light olefins, while SPO and SDPO yield lower conversions and increased coke deposition.

The results of this research, conducted by colleagues at MOEVE with the contribution of the partner GRACE, are important because they highlight the potential of HPO as a high-quality feedstock for the production of FCC biofuels.

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The REFOLUTION project started in January 2023 and will end in December 2026. Coordinated by SINTEF, the project brings together 14 partners from 8 European countries, driven by strong industrial leadership, the consortium includes key market players across the resource-process (upstream/reactor/catalyst/downstream) product spectrum. This ensures a powerful driving force for technology development throughout the entire production chain, addressing challenges in critical EU sectors related to energy and transportation.

Partners

Keep in touch

info@refolution.eu

refolution.eu

REFOLUTION Project

@REFOLUTION_HEU

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