



**FLEXIBLE AND ADVANCED
BIOFUEL TECHNOLOGY THROUGH
AN INNOVATIVE MICROWAVE
PYROLYSIS & HYDROGEN-FREE
HYDRODEOXYGENATION PROCESS**



**Funded by
the European Union**

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THE PROJECT

The European Union funded **Flexby project** aims to produce efficient and sustainable advanced liquid and gaseous biofuels from microalgae cultivated in domestic wastewater and from industrial waste streams, integrating a cost-efficient and groundbreaking microwave-assisted pyrolysis process. Flexby's overall objective is to significantly advance the development of cost-effective solutions to minimise carbon waste and inhibit biogenic effluent gas emissions in sustainable biofuel production pro-

cesses.

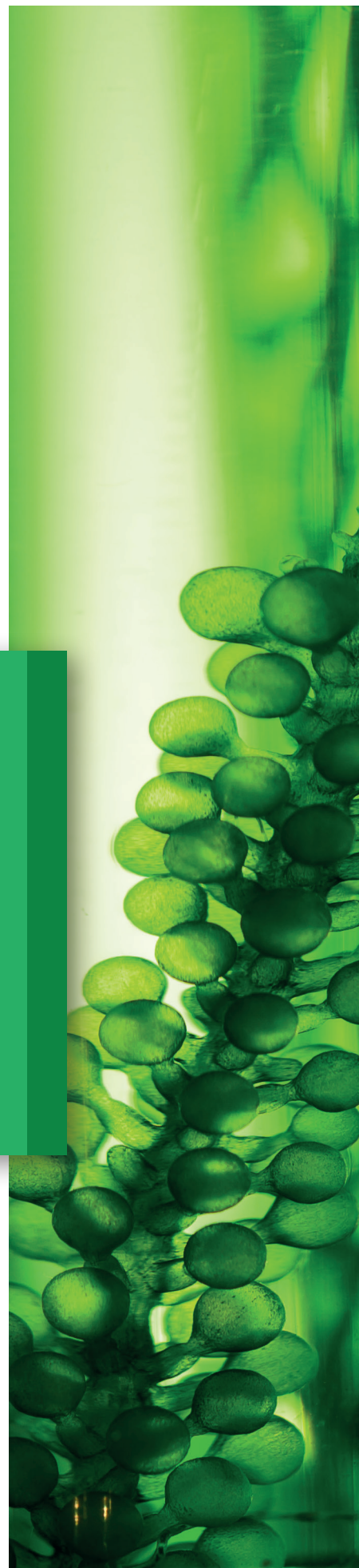
Flexby addresses the critical need for sustainable energy solutions by **converting waste materials into valuable biofuels**. The feedstock, derived from microalgae and industrial waste, undergoes microwave-assisted pyrolysis to produce three distinct fractions: **solid, liquid, and gas**. These fractions are then valorised through non-carbon emitting technologies to produce advanced biofuels which will then be utilised to generate electricity in fuel cells.

- The hydrogen-free **hydrodeoxygenation** (HDO) process will convert the liquid fraction into heavy transport biofuels without the use of hydrogen, leveraging water from the feedstock for significant process advantages.
- The gaseous fraction will be directly valorised to produce **bio-hydrogen**, contributing to the project's commitment to circular economy principles and low-carbon emissions.
- The solid fraction will be transformed into **biochar fertiliser**, proven to reduce soil biogenic emissions, and used as activated carbon to support the catalysis process.

Aligned with the European Commission's Digital Strategy, **Flexby includes a strong digitalisation component to enhance cost-efficiency**. Artificial intelligence will be employed in data processing to improve efficiency, reduce costs, and move closer to a near-zero carbon emission process.

By promoting a circular economy, recycling biomass residues,

and utilising photovoltaic renewable energy, **Flexby aims to achieve a comprehensive sustainability assessment**. A series of LCA analyses will be conducted to establish an inventory of Flexby flows and their impacts, considering environmental and socioeconomic factors and scrutinising the carbon neutrality of the process.



INNOVATION

The Flexby project will develop several innovative concepts to advance the technology level of advanced biofuel production.

1. Microalgae Cultivation

Flexby will develop and test new operational procedures for process intensification to advance microalgae cultivation in wastewater, ultimately enabling better control and replicability of cultivation processes, leading to higher biomass yields.

2. Microwave Fast / Flash Pyrolysis

Pyrolysis is the thermal decomposition of biomass in the absence of oxygen, and microwave pyrolysis has emerged as a technology with substantial advantages over conventional pyrolysis. Flexby will surpass current methodologies by producing the first microwave pyrolysis demonstrator at technology

readiness level (TRL) 5 to use cultivated microalgae and industrial waste feedstocks.

3. Hydrogen-Free Hydrodeoxygenation

Catalytic Hydrodeoxygenation (HDO) is the state-of-the-art process for oxygen removal to produce high energy hydrocarbons with low emissions, but the use of high-pressure hydrogen, which is expensive and difficult to manage, is a barrier to upscaling. Flexby will develop a novel hydrogen-free hydrodeoxygenation approach which eliminates the dewatering step and uses carbon-based multifunctional catalysts which could pave the way for a safer, more energy efficient and cost-effective production of bio-oil.

4. Pyrogas Processing for Bio-hydrogen Production

The gaseous fraction will be used

to produce bio-hydrogen facilitated by investigating more realistic gaseous blends appropriate for microwave-assisted pyrolysis and employing optimal catalytic formulations.

Flexby also incorporates an **innovative approach to biogenic carbon storage and utilisation**. CO₂ will be utilised as a carbon pool for syngas, and a gas-phase CO₂ utilisation process will convert CO₂ into added value products. The produced **biochar will be used as a soil amendment to enhance organic carbon content, soil functionality, and carbon sequestration**. Additionally, a physical carbon activation process will catalyse liquid biofuel production, with **microalgae cultivation acting as a carbon capture source** to reduce global CO₂ emissions.





IMPACTS

1) More cost-efficient process

In combination with artificial intelligence, the project integrates advanced technologies such as hydrogen-free hydrodeoxygenation, which completely avoids fossil hydrogen production, fast pyrolysis, supported by advanced optimisation techniques, and recycling of by-products will be used to achieve a highly integrated and near-zero discharge process.

2) Flexible and versatile technology

The technology allows flexible biofuel production for different end uses including heavy transport and fuel cell-powered devices. Such versatility is achieved via the custom designed catalytic processes for hydrogen-free hydrodeoxygenation and pyro-gas processing.

3) Negative carbon emissions

Flexby removes emissions related to hydrogen production, uses renewable energy to power the process, utilises microalgae biomass with the capability to sequester CO₂, and produces biochar which can be used in agriculture to increase crop efficiency along with sequestering the soil-related CO₂.

4) Net-zero by-product uses

All the pyrolysis solid, liquid and gaseous fractions will be reused as biofuels, or as a catalytic support material to be used within the process. The bio-char product can also be used as fertiliser and soil carbon sequestrator, minimising landfill biogenic emissions.



THE CONSORTIUM

Flexby brings together a diverse consortium of experts, including one large enterprise, four SMEs, two universities, two research and technology organisations, and one non-profit association from five different countries.

idener.ai

IDENER is an interdisciplinary company developing intricate AI applications for engineering and science. They are the Flexby Project Coordinators and will lead the development of the digital tools that will enhance the technical and cost efficiency of the process.



Algae for Future is a biotechnology company based in Portugal with over 20 years of accumulated experience in algae research and development, and production up to industrial scale. A4f will lead the research directed at the identification and characterisation of the microalgae, its cultivation in wastewater, and the wastewater treatment and microalgae production at TRL5.



CSIC-INCAR is the Carbon Science and Technology Institute which forms part of the Spanish Council for Scientific Research. Their main task in the Flexby project is to test the microwave pyrolysis technology, compare the results with conventional pyrolysis heating, and test and validate the bio-char produced from the process.



Universidad de Sevilla, founded in the 16th century, is a prestigious educational institution with over 70,000 students. They will lead the research focused on the production of advanced biofuels through catalysis design and testing, advanced liquid biofuel and bio-hydrogen production, and the testing of the produced biofuels in fuel cells.



Fricke and Mallah are a leading developer of modern and sustainable solutions in microwave technology. In Flexby, they will be working closely with CSIC-INCAR on the design of the microwave pyrolysis system.



Politecnico di Milano, founded in 1863 with over 45,000 students, is a scientific and technological university specialising in training engineers, architects, and industrial designers. Politecnico di Milano will lead the research into the optimisation and up-scaling of the Flexby technologies, primarily by performing detailed process simulations.

GreenDelta

GREENDELTA are sustainability consultants and advisors who develop their own open-source software, databases and methods, and apply these to perform sustainability, lifecycle, environmental, lifecycle costing and social lifecycle assessments. GREENDELTA will be leading the sustainability assessment for the Flexby project.



GALP are a Portuguese based supplier of oil, natural gas, electricity, biofuels, and environmental products. Their primary role in the project will be to perform a suitability assessment of the produced biofuel.



CO2 Value Europe are a non-profit association representing the Carbon Capture and Utilisation community in Europe. The Association cultivates an extensive network of organisations and individuals who collectively endorse the vision that Carbon Capture and Utilisation (CCU) technologies are essential for the European Union to achieve its climate objectives. CVE will lead the clustering activities of the project.



KNEIA are experts in scientific communication, research results valorisation and open science and will lead Flexby's communication, dissemination and exploitation actions.

The collaboration between the diverse range of expertise within the Flexby consortium will lead to significant strides being made in increasing the use of advanced biofuels in the heavy transport sector, thereby mitigating climate impact and contributing to the reduction of global annual CO₂ emissions by up to 120 million tonnes by 2050.



Grant Agreement Number 101144144

Call: HORIZON-CL5-2023-D3-02

Topic: HORIZON-CL5-2023-D3-02-07

Type of action: HORIZON Research and Innovation Actions

Granting authority: European Climate, Infrastructure and Environment Executive Agency - CINEA

Project starting date: 1 May 2024

Project end date: 30 April 2028

Project duration: 48 months

Grant amount: 3,993,682.50

Partners: 10

Countries: 5



www.flexby.eu/

For more information, please contact:

Dr Nuria Ferrera Lorenzo - Flexby Project Coordinator
nuria.ferrera@idener.ai

Mike Hepworth – Communications and media
mike@kneia.com



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