BioTheRoS

Collaborative actions to bring novel **BIO**fuels **THE**rmochemical **RO**utes into industrial **S**cale

WORKSHOP: "TOWARDS SUSTAINABLE AVIATION: FROM INNOVATIVE FUEL PATHWAYS TO SCALE-UP"

BioTheRoS Project: Overview of outcomes

Dr. Dimitris Kourkoumpas (CERTH)

6th October 2026, Munich, Germany

The BioTheRoS Project has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement No. 101122212.

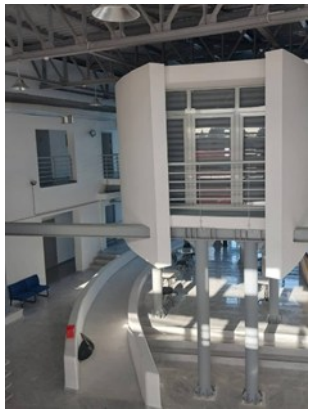
About CERTH

The **Centre for Research and Technology Hellas** (CERTH) is a non-profit organization, established in 2000 with the goal of benefitting society through **innovative research**.

CERTH is a frontrunner in **basic, applied and technological research**.

Research fields:

- Sustainability
- Zero CO_2 Emission Technologies
- Artificial Intelligence
- Internet of Things
- Industry 4.0



CERTH
CENTRE FOR RESEARCH & TECHNOLOGY HELLAS

>1600	5	9
Researchers & Associates	Institutes	Cities

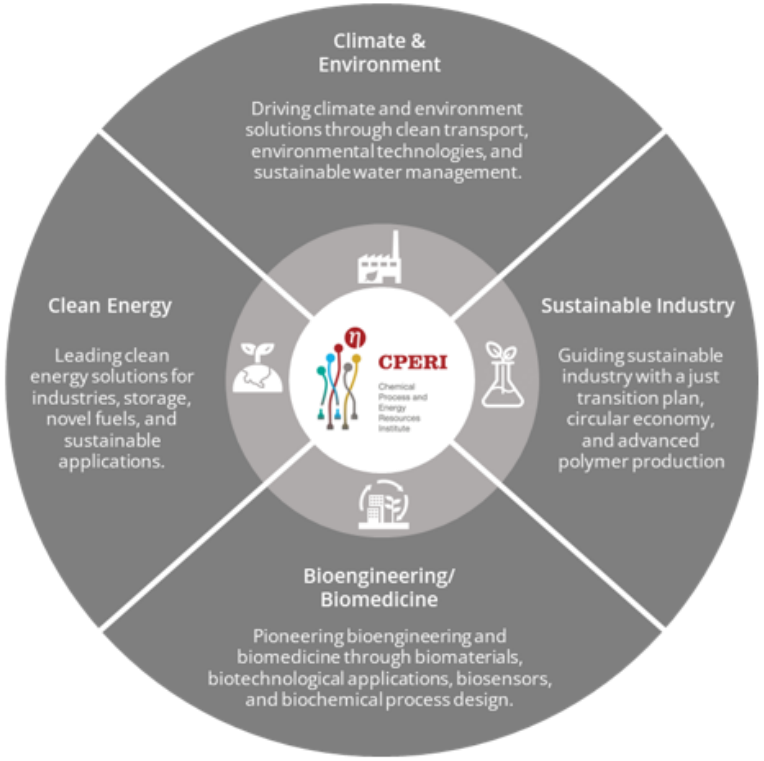
60 M€	80%	13%	7%
Funds Secured Annually	From Research Projects	From Bilateral Contracts with the Industry	From State Funds

15th	1st	23
In H2020 Net EU Contribution in the EU	In H2020 Net EU Contribution in Greece	Spin-offs

About CPERI

Established in 2000 as part of the Centre for Research and Technology-Hellas (CERTH)

CPERI'S RESEARCH DIRECTIONS



TEAM EXPERTISE

Research Fields

- Manufacturing Industries
- Biofuels & Biochemicals
- Bioenergy Retrofits
- Carbon Capture & Utilization
- Waste Management
- Digitalization

Tools Developed

- Life Cycle Assessment
- Predictive Maintenance
- Artificial Intelligence
- Dynamic Web Platforms
- Analytics
- Blockchain Solutions

BioTheRoS Overview

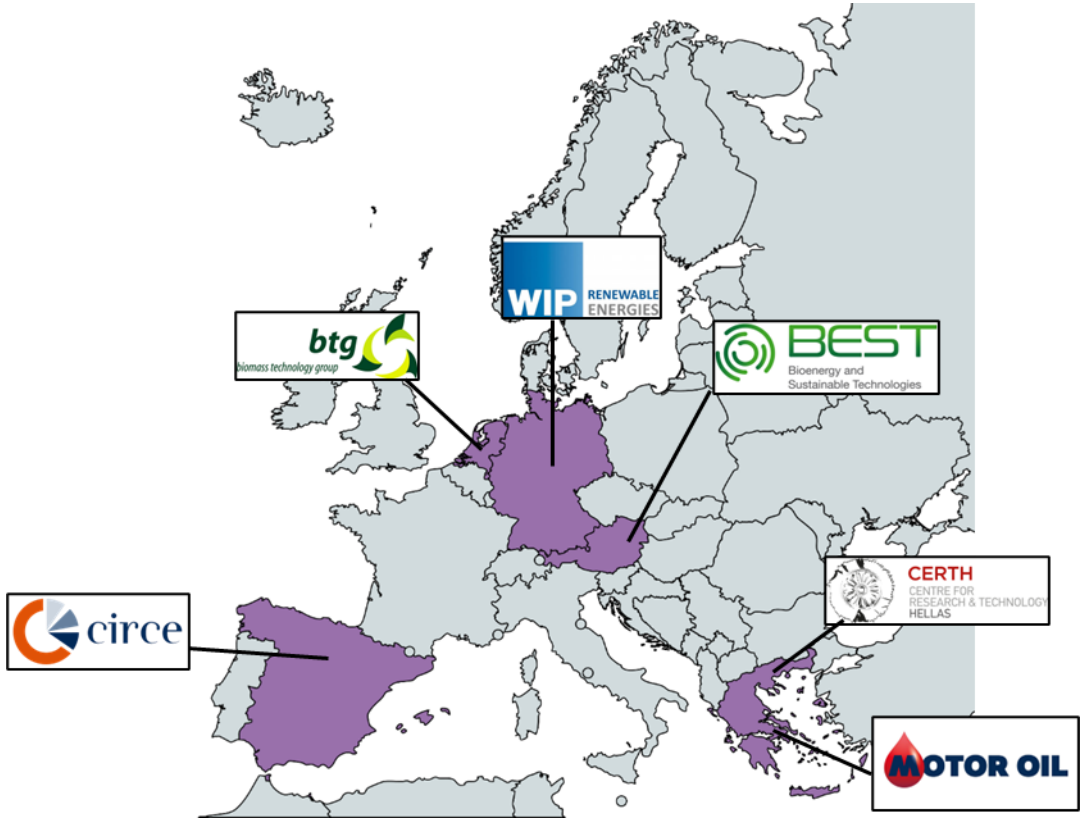
Project Details

BioTheRoS is an EU Horizon Programme under Grant Agreement No 101122212 running from 2023

Demonstration Cases

Application in pyrolysis and upgrading units in Netherlands & gasification unit in Austria

Consortium Members



BioTheRoS Objectives

BioTheRoS develops **innovative** & cost-competitive **Fast Pyrolysis-to-biofuels** and **Gasification-FT-Synthesis value chains**, combining **Carbon Capture Utilization (CCU)** and **fuel upgrading** for accelerating the scale-up of sustainable biofuels.

BioTheRoS Goal: Transfer biomass into an opportunity

1. Development of cost-effective & sustainable technologies for thermochemical conversion of biomass to produce biofuels to TRL5

2. Selection and assessment of several biomass feedstocks suitable for scaled-up sustainable pyrolysis & gasification biofuel value chains employing predictive biomass demand AI models

3. Development of scale-up rules of biofuels production based on advanced modelling techniques and lab/pilot-scale trials.

4. Development of an LCSA framework, integrating technical, environmental, economic & social parameters via multi-criteria decision analysis techniques

5. Identification of concrete measures to improve the sustainability of thermochemical conversion of biomass to biofuels via pyrolysis and gasification

6. Provide clarity into the market dynamics of scaled-up pyrolysis and gasification biofuel value chains

Demo sites & related technologies

The Netherlands – Pyrolysis and Upgrading units

Pyrolysis Units:

- Bench-scale unit: 2–5 kg/h
- Pilot plant: 80–200 kg/h

Upgrading Unit (for pyrolysis oil to fuels):

- Continuous operation
- Capacity: 0.8–1.5 kg/day

Austria – Gasification Unit

Gasification Units:

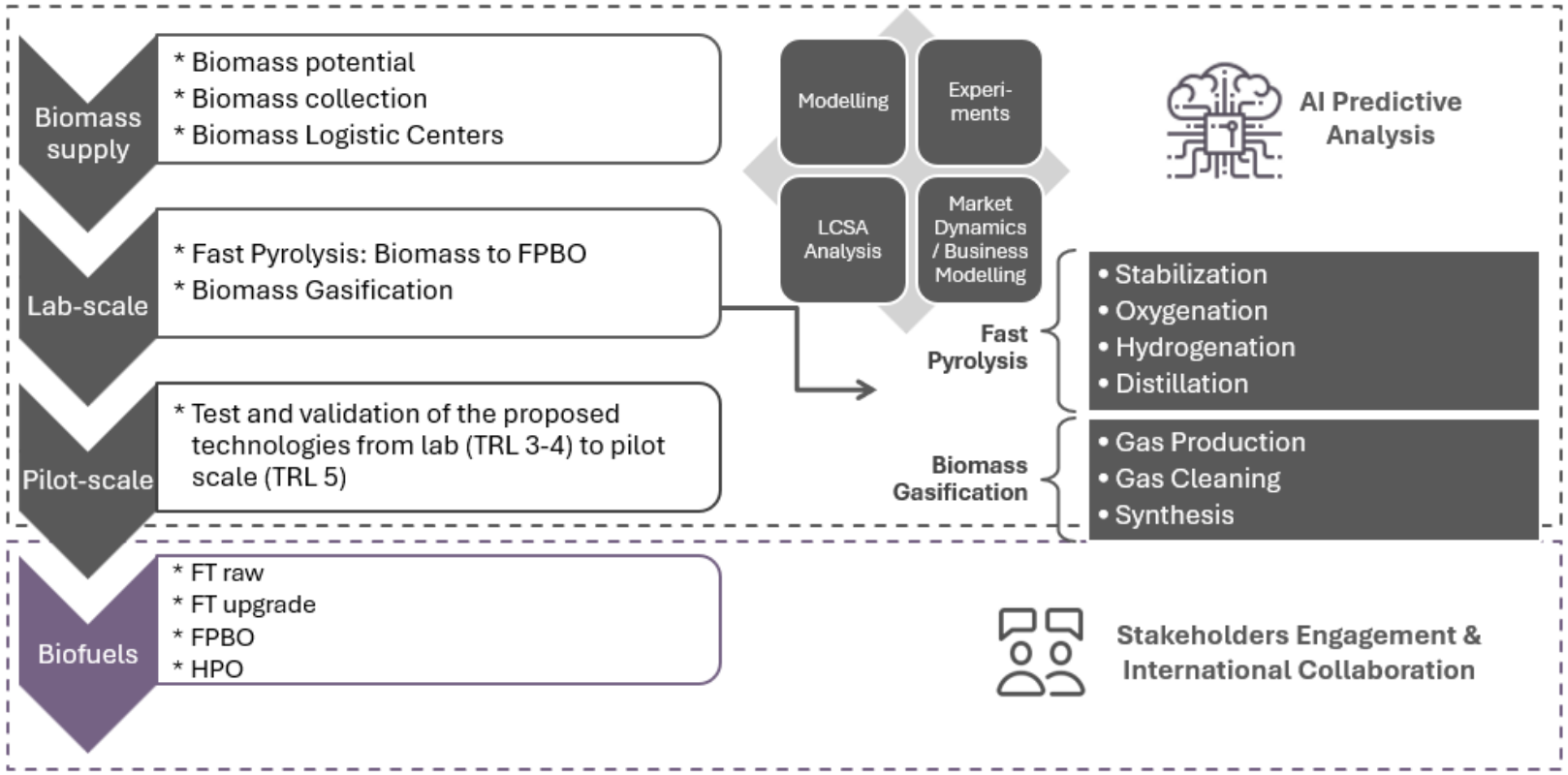
- 1 MW DFB reactor: ~200 kg/h feed rate
- 250 kW Fischer–Tropsch pilot unit: produces 15-20 L of FT raw product

Upgrading Unit (for FT waxes to fuels):

- Hydrocracking pilot plant located in Greece

BioTheRoS Methodology Overview

Core Focus: Pyrolysis & gasification-based advanced biofuel value chains



Multidisciplinary, stepwise methodology

- Feedstock selection
- Pilot-scale validation
- Scale-up simulation & modelling
- Environmental, techno-economic & social assessments

New value chains for biomass valorisation to aviation and maritime biofuels (1/2)

Assessing biomass resource availability

1st step

Selection

- Feedstock
- Geographic Area
- Number of years to be considered
- Production quantity dataset

2nd step

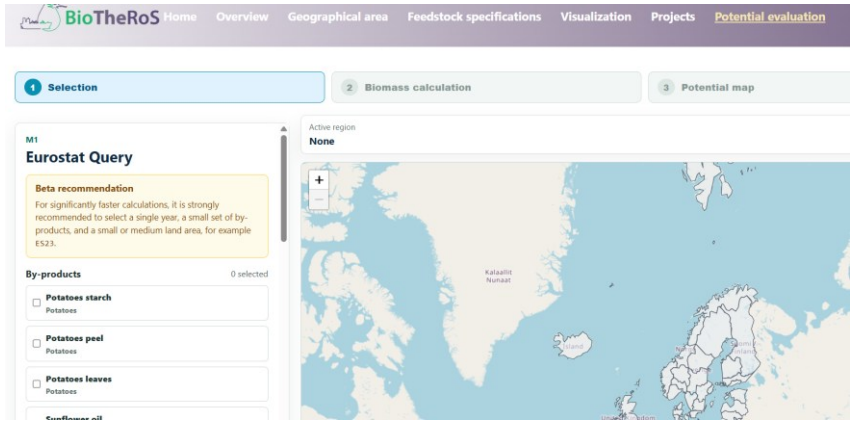
Biomass calculation

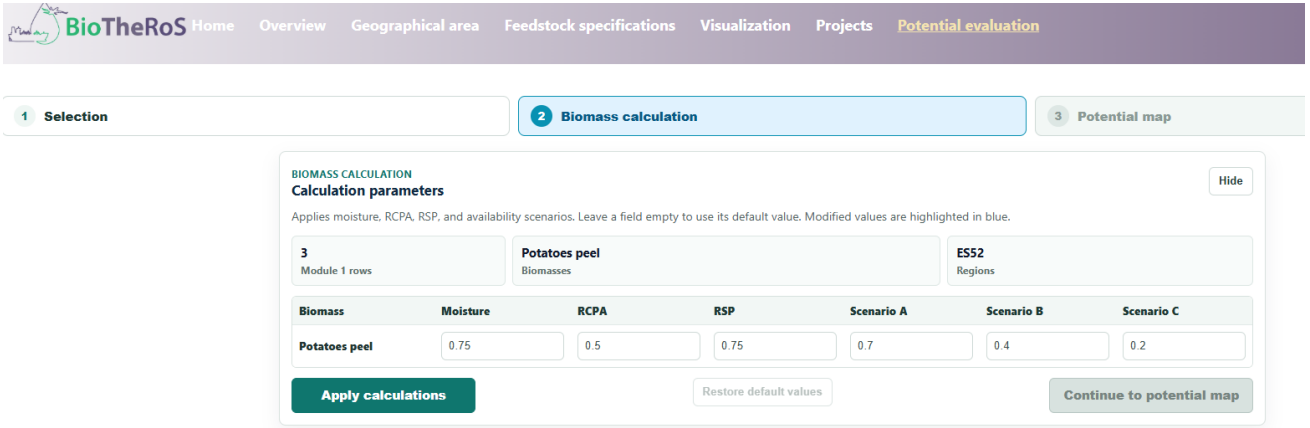
- Biomass using adjustable conversion factors

3rd step

Spatial Resource Assessment

- Spatial biomass availability at 10/100 m resolution
- And within a radius of up to 100 km





New value chains for biomass valorisation to aviation and maritime biofuels (2/2)

Plant siting and logistic optimization – Uses resource availability information to identify the most suitable location for a new processing facility.

1st step

Define

- Feedstock demand
- Feedstock cost at plant gate
- Feedstock collection/harvesting cost
- Geographical area or radius

2nd step

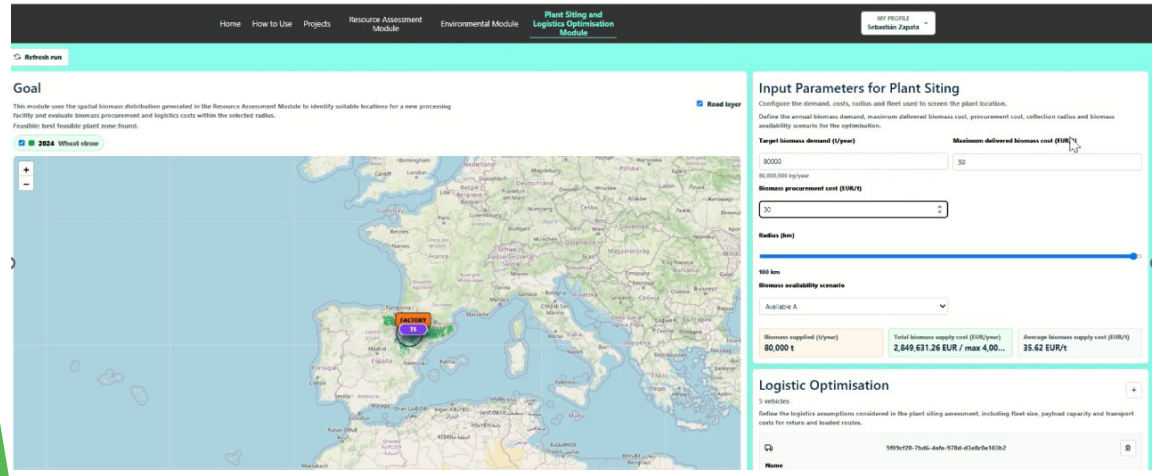
Transportation

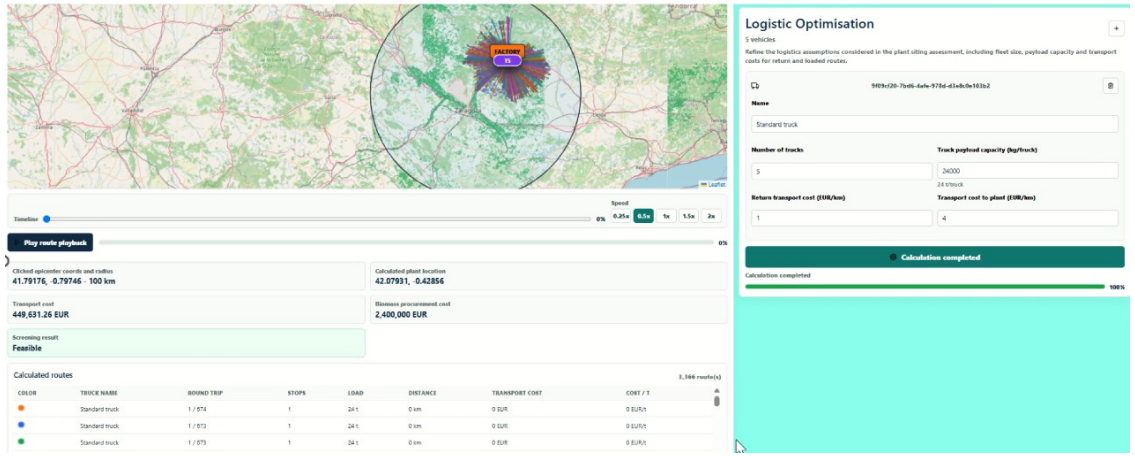
- Number of trucks for collection
- Truck payload capacity
- Transport cost parameters

3rd step

If feasible, tool identifies

- Optimal plant location
- Number of transport operations required
- Transport cost associated with each route
- KPOs: Annual feedstock Acquired, Average feedstock acquisition cost, total annual feedstock supply cost

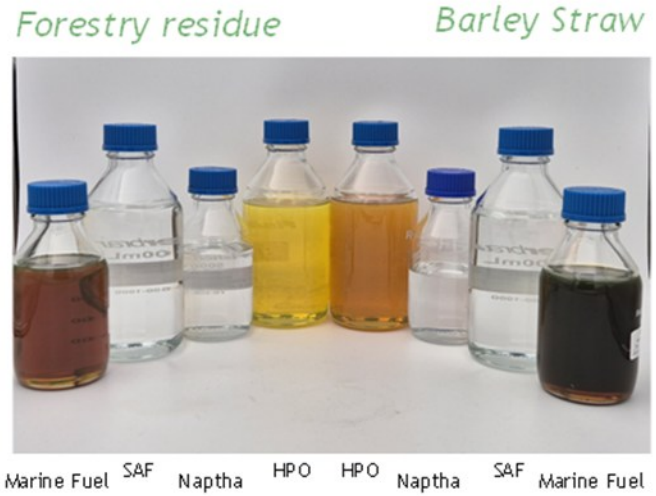




Pyrolysis value chain pilot validation

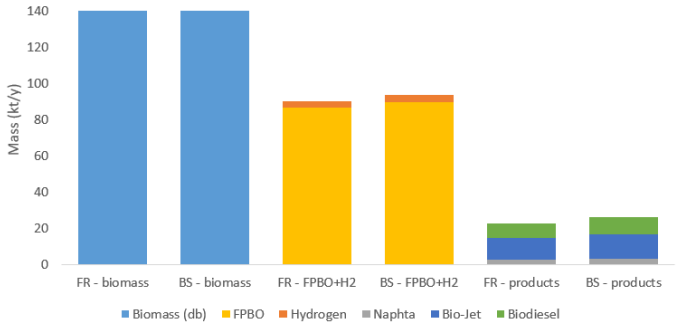
The value chain from biomass via fast pyrolysis to advanced biofuels has been demonstrated for two different biomasses:
Forestry Residue and Barley Straw

Hydrogenation of Pyrolysis Oil yielded HPO – Hydrotreated Pyrolysis oil, which was distillated to yield Naphta, Sustainable Aviation Fuel (SAF) and Renewable Marine Fuel.

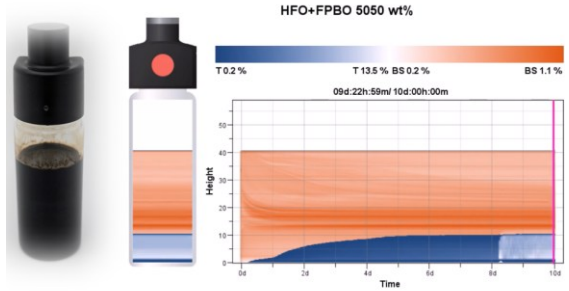


Key results

- Guidelines for scaling-up were developed
- Fuel synergies & blending were assessed



Main mass flows for a 4-FPBO plant pyrolysis upgrading value chain based on forestry residue (FR) or barley straw (BS)



Gasification value chain pilot validation

- Stable operation of full process chain overall several days with waste feedstock

  Biogenic waste materials can effectively serve as feedstock for gasification with minor effect on syngas quality

- Assessment of gas impurities and gas cleaning performance

  Higher amounts of impurities sufficiently reduced to necessary levels for synthesis

- Production of FT-syncrude for further processing

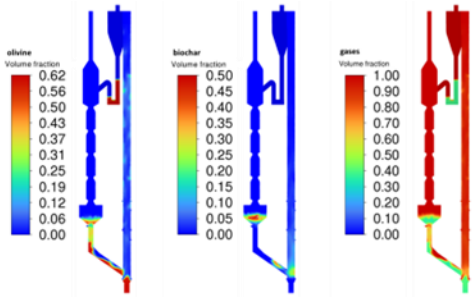
  Overall CO conversion of 70–85 % during FTS; chain growth probability α = 0.87 (close to the optimum of 0.9)

  Upgrading to SAF

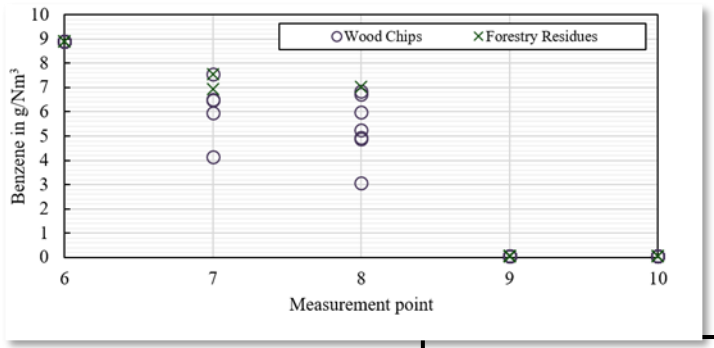
- Integration of carbon capture technology into thermochemical processes

  Carbon capture was enhanced up to 2.5 times by using CA as biocatalyst, reaching more than 50% efficiency

- Validation of gasifier performance

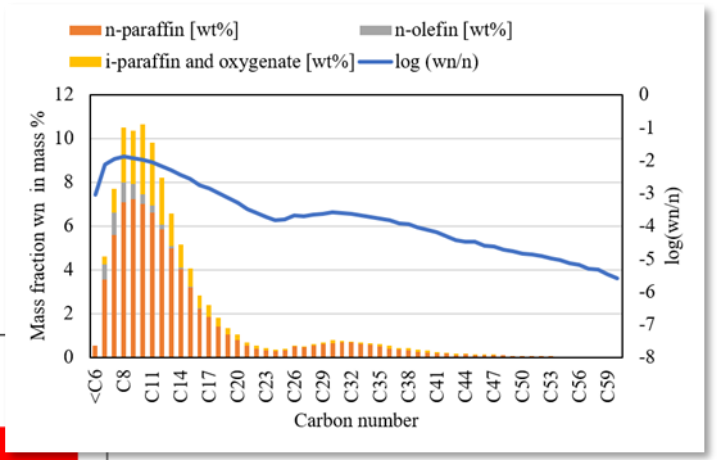


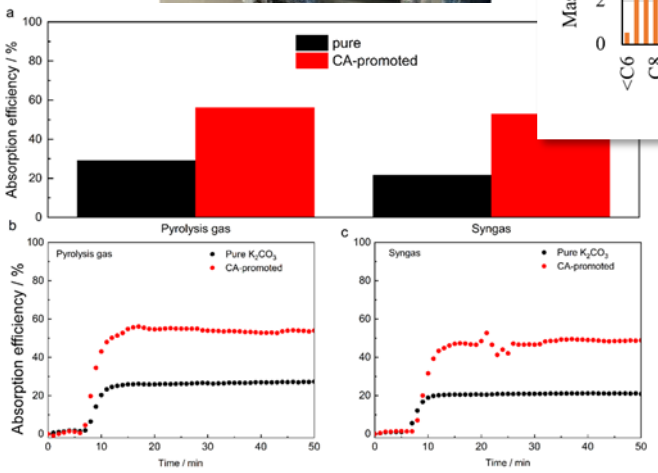
Gas cleaning performance



Prior to FT-synthesis

Chain growth probability





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Impact assessment and Replication (1/4)

TEC

Fast Pyrolysis

Gasification with F-T synthesis

Process Stages

Shared Upstream: biomass feedstock → transport → pre-treatment

Pyrolysis → FPBO + biochar → Stabilization → SPBO → Hydrogenation + H_2 → Distillation → Naphtha, Jet, Marine

Gasification → syngas + biochar → Syngas Cleaning → Clean Syngas → F-T Synthesis + Syncrude → Upgrading → Jet & Marine Fractions

Shared downstream: SAF and marine diesel → aviation and shipping

Evaluation

01 LCA, LCC and MCDA
Combined assessment of scale-up performance

02 Scale-up guidelines
For commercial pyrolysis and gasification

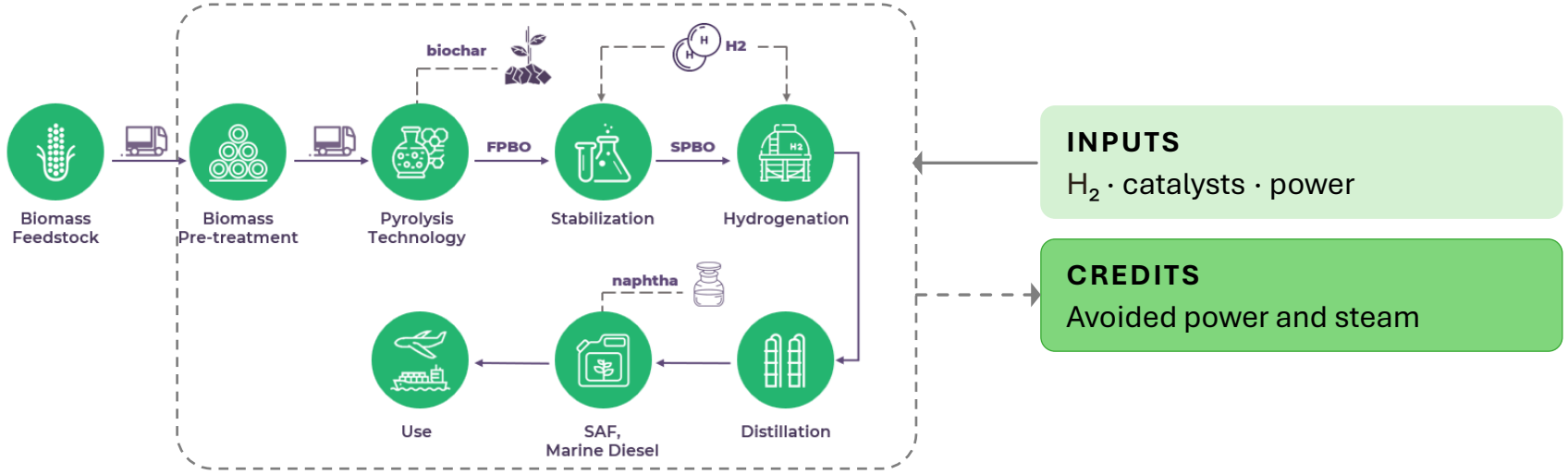
03 Use cases
Biomass capacity, geography and end-use, with feasibility studies

04 Risks and barriers
Scenario modelling with analytical calculations

Digital Platform :
Brings together the BioTheRoS technologies, process stages and evaluation results

Impact assessment and Replication (2/4)

LCA Results: **Fast Pyrolysis | Barley Straw as Feedstock**



INPUTS
H_2 · catalysts · power

CREDITS
Avoided power and steam

PER GJ OF FUEL	Unit	HPO jet	HPO marine	HPO naphtha
Climate change	kg CO_2 eq	−4.48	−3.23	−1.05
Fossil and nuclear energy	MJ	−130.85	−88.45	−30.77
Mineral resources	g	−15.92	−10.76	−3.75
Particulate matter	g $PM_{2.5}$ eq	−1.33	−0.90	−0.31
Water scarcity	m^3 world eq	−0.72	−0.49	−0.17

Key insight: every pyrolysis fuel shows a net benefit on all five indicators, with jet the largest.

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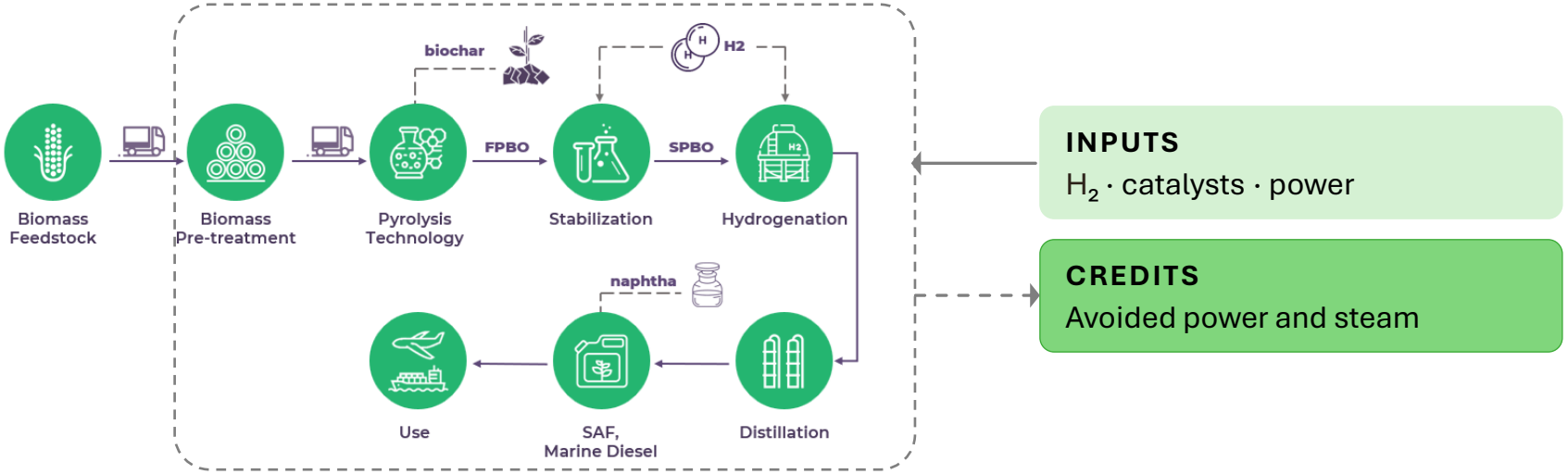
Impact assessment and Replication (3/4)

LCA Results: **Fast Pyrolysis | Forestry Residues as Feedstock**



INPUTS
H_2 · catalysts · power

CREDITS
Avoided power and steam

PER GJ OF FUEL	Unit	HPO jet	HPO marine	HPO naphtha
Climate change	kg CO_2 eq	−5.32	−3.77	−1.24
Fossil and nuclear energy	MJ	−145.26	−96.84	−33.95
Mineral resources	g	−17.71	−11.81	−4.14
Particulate matter	g $PM_{2.5}$ eq	−1.48	−0.99	−0.35
Water scarcity	m^3 world eq	−0.89	−0.56	−0.21

Key insight: every pyrolysis fuel shows a net benefit on all five indicators, with jet the largest.

BioTheRoS

Impact assessment and Replication (4/4)

Digital Platform

One site. **Four powers.**

Information

Tools

Input Clarity	Clear input data, with suggested value scenarios based on AACE
Common Method	All LCC tools in one workspace; every user follows the same approach
Results	Saved and available always, with all information in one place
Easy to Use	Clear steps, little training needed
User Management	Control who sees, edits and deletes what
Safety	Protected data and connections

Collaboration

Persistence

Save time on guessing and fixing. From day one.

Market dynamics and techno-economic feasibility

Global policy & market status of Advanced biofuels

Policy frameworks and advanced biofuel markets assessed across major regions

Market Dynamics

Advanced Biofuel demand drivers identified, showing the influence of HEFA availability

Technology integration

A Techno-economic assessment of carbon capture and hydrogen production was carried out and add-in of these technologies in the gasification and pyrolysis value chain is being studied

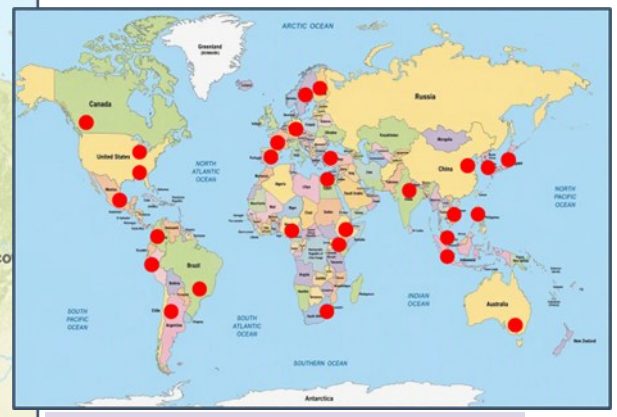
Business potential

Business cases are being developed for selected locations for thermochemical advanced biofuel production

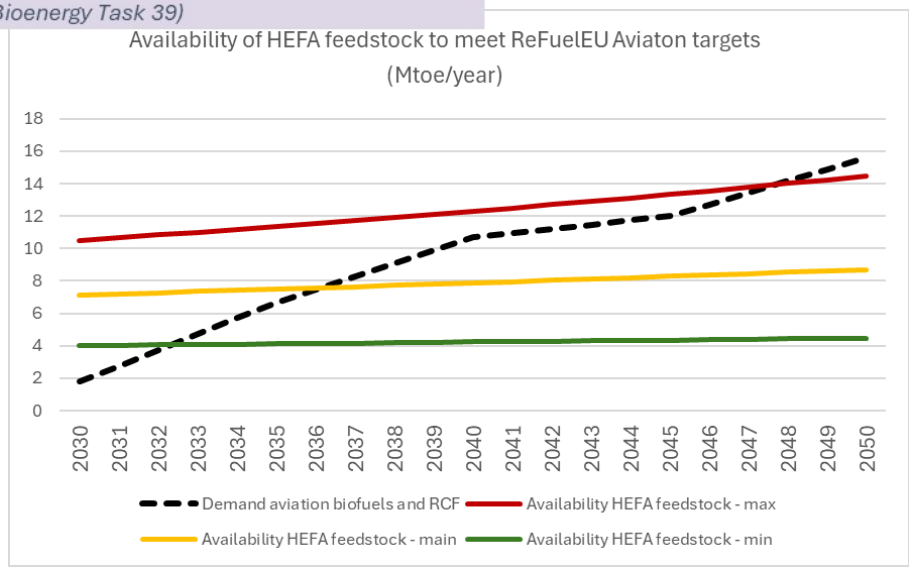
Market uptake

Recommendations are being formulated for increased market uptake of thermochemical advanced biofuels.

SAF production facilities in Europe (Source: IEA Bioenergy Task 39)



Potential biofuel production locations



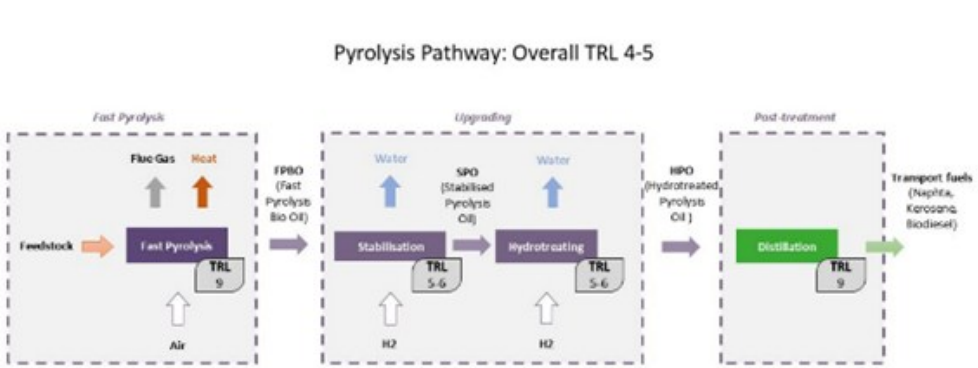
International cooperation and network development

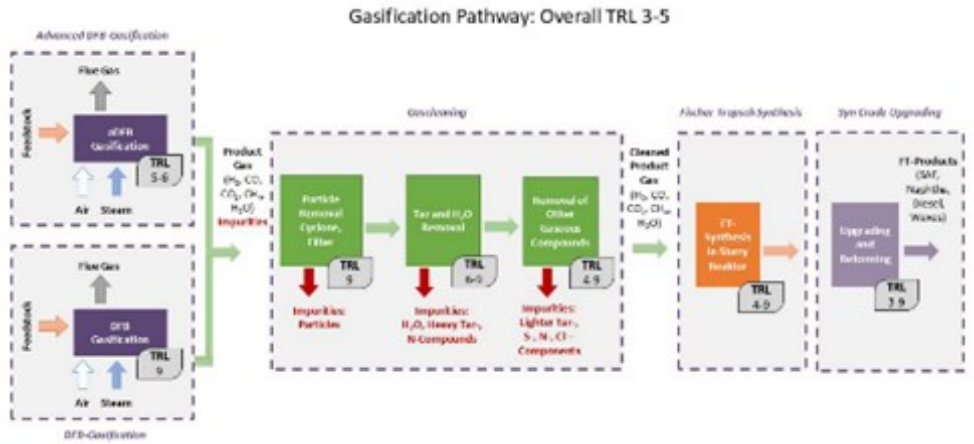
Synergies with EU funded and international projects and cooperation with international networks

Highlights and key results

- Creation of BioTheRoS Knowledge Hub. This is a database established in the course of the project and provides links to relevant publications and research groups
- Tech State Navigator with Pyrolysis and Gasification Pathway Selector as interactive tool giving TRLs of the pathways and process steps

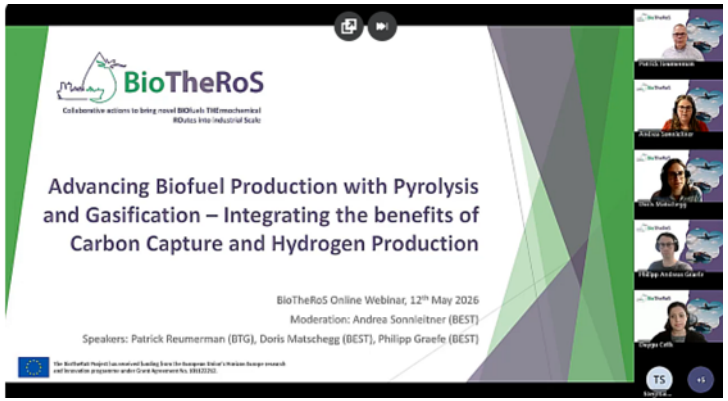
Publication Database | Research Network | Tech State Navigator



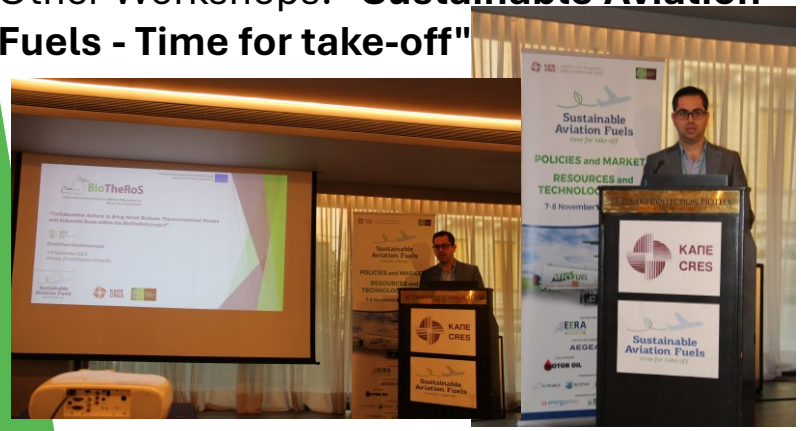


Dissemination and Communication – Last highlights

Webinar: **"Advanced Biofuel Production With Pyrolysis And Gasification – Integrating The Benefits Of Carbon Capture And Hydrogen Production"**

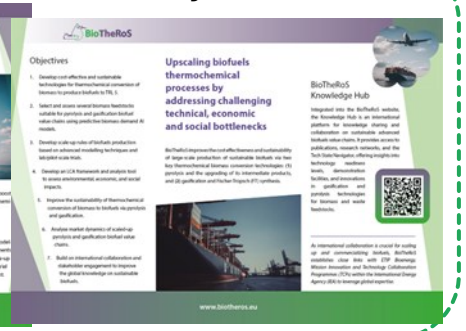


Other Workshops: **"Sustainable Aviation Fuels - Time for take-off"**



Workshop At CEBC 2026:
"Biofuels for Transport: BioTheRoS Project Insights Into Technology, Markets, and Sustainability"

New flyer



EUBCE representation 2026

- Presentation: **Market Readiness for Advanced Aviation and Shipping Fuels in Europe**
- Workshop contribution: **"Advanced Biofuels: Industry, Market & Policy Perspectives"**

Project's website
https://www.biotheros.eu/en/home/

BioTheRoS

Potential Synergies

Government & Regulatory Bodies	BioTheRoS shares lessons learned and regulatory insights at EU and regional levels
Fuel Producers and Suppliers	BioTheRoS highlights the environmental and economic benefits of biofuel production & use
Biomass Providers	BioTheRoS provides economic benefits for engaging in the biofuel supply chain
Research Stakeholders	BioTheRoS shares technical results, innovations, progress, and project challenges
Airlines & Shipping Companies	BioTheRoS raises awareness of the potential for biofuel use
General Public / Citizens	BioTheRoS shares insights on EU competitiveness, external dependency, environmental and societal impacts

Take-Home Messages

Feedstock Supply & Cost Competitiveness:

Ensuring a **sustainable, cost-effective feedstock supply** is essential for the growth of future biorefineries. Investment incentives are needed to offset biomass's price disadvantage relative to fossil fuels.

Supply Chain Risk Management:

Effective biomass supply chain management is critical to securing long-term sustainability and consistent fuel availability.

Circular Economy Integration:

Holistic, circular economy-driven guidelines are required across the entire advanced biofuel supply chain to stimulate aviation and maritime fuel markets.

Technology Pathways & Scale-Up:

Constraints and opportunities for scaling up pyrolysis and gasification pathways must be clearly identified.

Sustainability & LCA Focus:

Growing attention to GHG impacts in aviation and maritime sectors underscores the need for **LCSA** and integration of **economic, environmental, and social dimensions** for a balanced sustainability approach.

Thank you!

Dr. Dimitrios Kourkoumpas

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