FUELPHORIA Demo 1

Stefano Rebecchi – Bio Base Europe Pilot Plant

FUELPHORIA 2nd Webinar - 4 December 2025

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Overview of the demo

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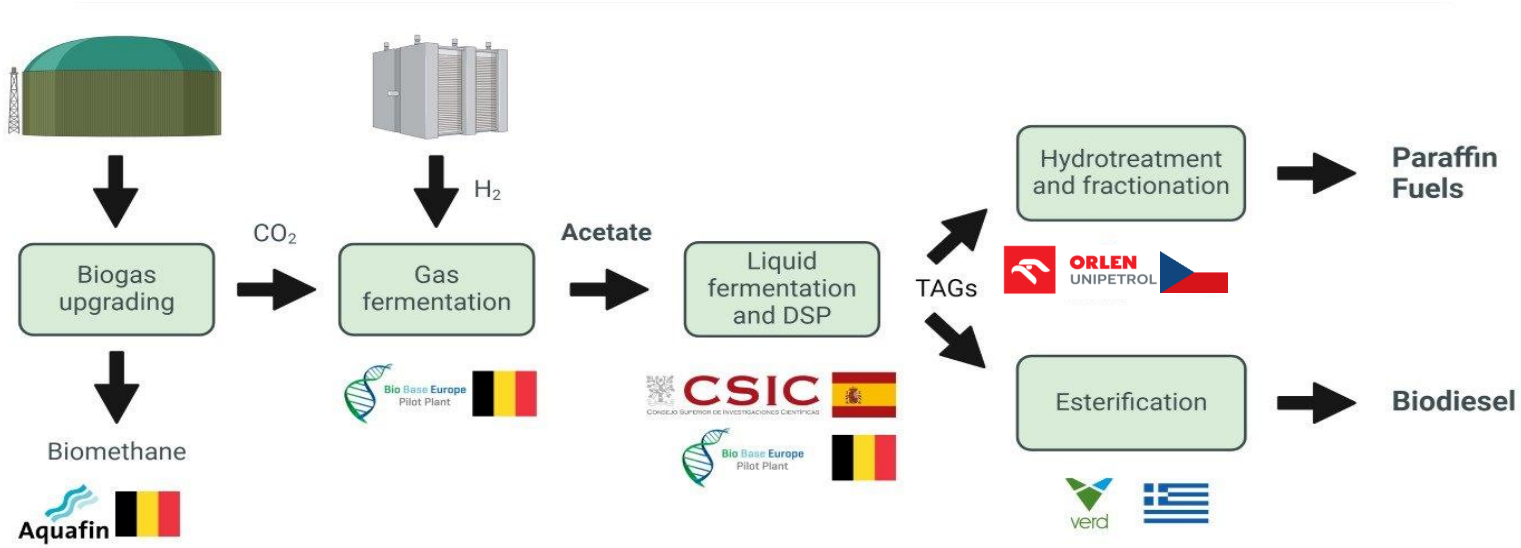
DEMO1 : Hydrotreated and esterified TAGs production from CO2 derived from a biogas upgrading plant via a 2-step fermentation

Location: Belgium
Feedstock: CO_2 from a biogas plant
Involved technologies: gas fermentation, liquid fermentation, strain engineering, hydroprocessing, esterification
End-products: liquid hydrocarbons for transport applications



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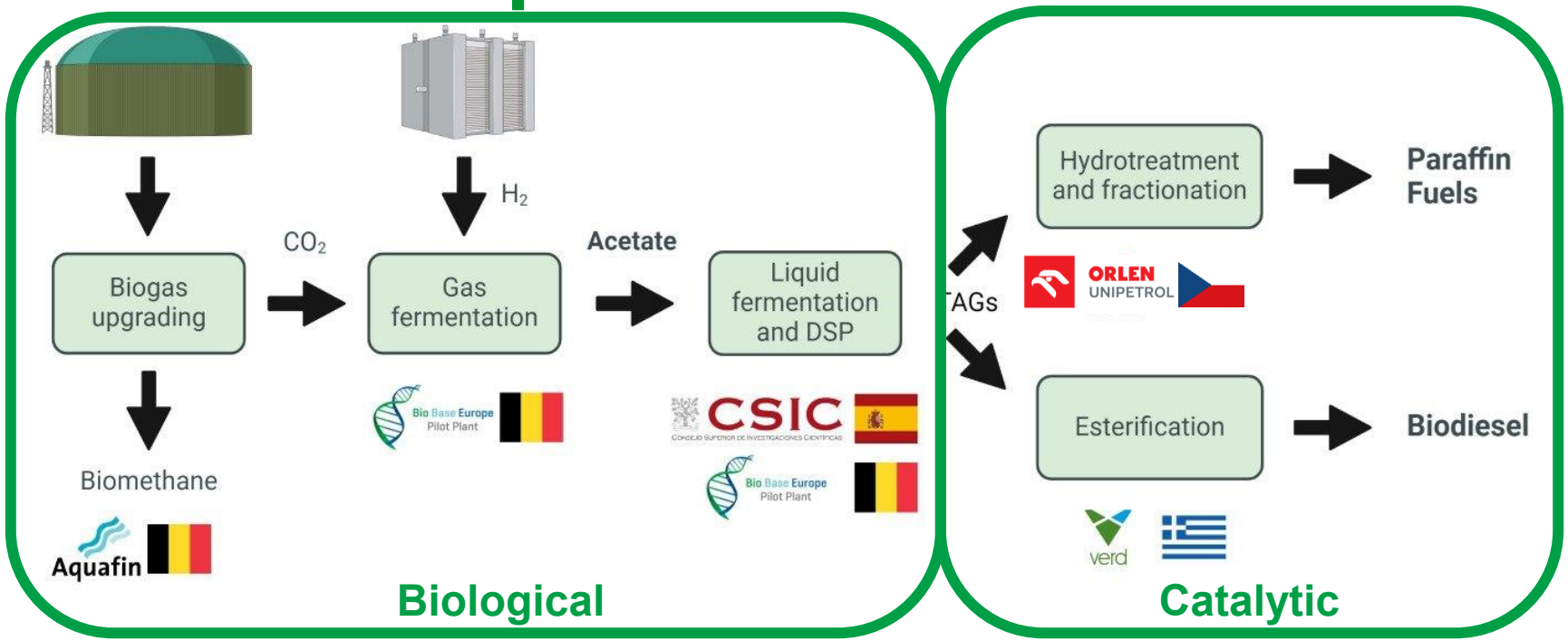
Conversion processes and Innovations



2-step fermentation process

- Gas fermentation of Biogenic CO_2 to acetate
- Liquid fermentation to produce TAGs from bio-acetate

Upgrading

- Hydrotreatment
- Esterification

Innovations

(i)
The development of an integrated scheme for the valorisation of biogenic CO_2 into advanced biofuels;

(ii)
Long and/or medium chain TAGs production from CO_2 via acetate will be demonstrated;

(iii)
The metabolic engineering strategies on oleaginous strains

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Laboratory scale tests

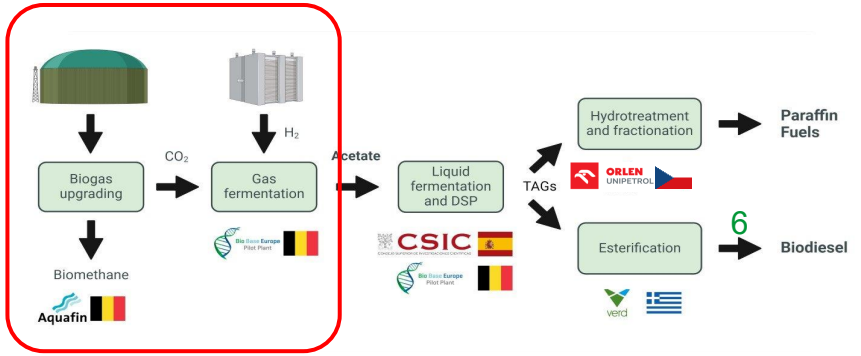
Optimization of the Gas-substrate fermentation

Objectives:

- wild type anaerobic acetogenic bacteria
- development of a continuous fermentation process (lab scale)
- maximize productivity and acetate concentration (gas pressures and flow rates, CO_2/H_2 ratio, medium composition, …)

Results:

- **60 days** of continuous fermentation
- CO_2 consumption rate **>50%**
- Robust process over long periods of time
- The process developed is ready to be scaled up to 150 L



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Development of oleaginous strains for TAG production

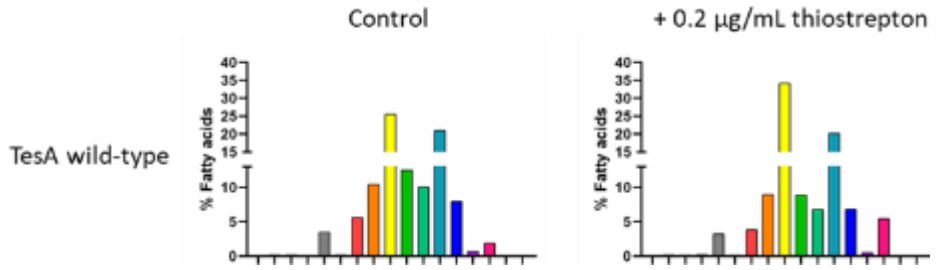
Objectives:

- use lipid producing strains: bacteria (*Rhodococcus*) and yeasts (*Yarrowia*)
- improve the production of lipids by increasing the transport and flux of carbon from acetate to TAGs

Results:

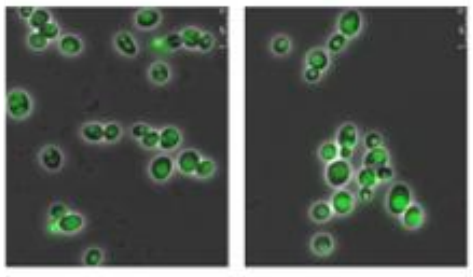
Yarrowia lipolytica

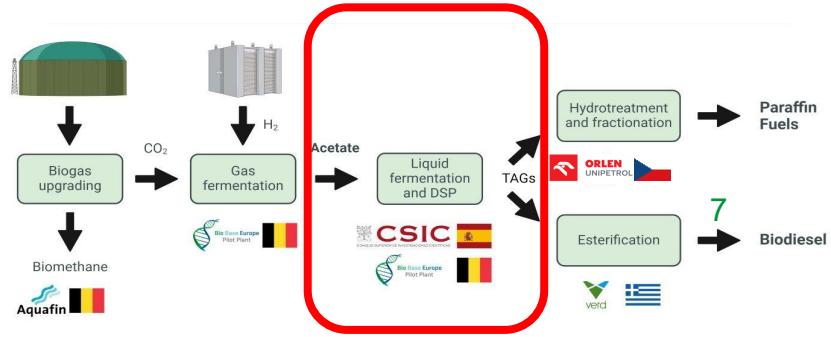
- 3 *Yarrowia lipolytica* strains have been produced and tested
- Increased consumption of acetate and production of TAGs



Rhodococcus jostii

- different acetate concentrations have been tested in fed-batch





Optimization of the TAGs fermentation

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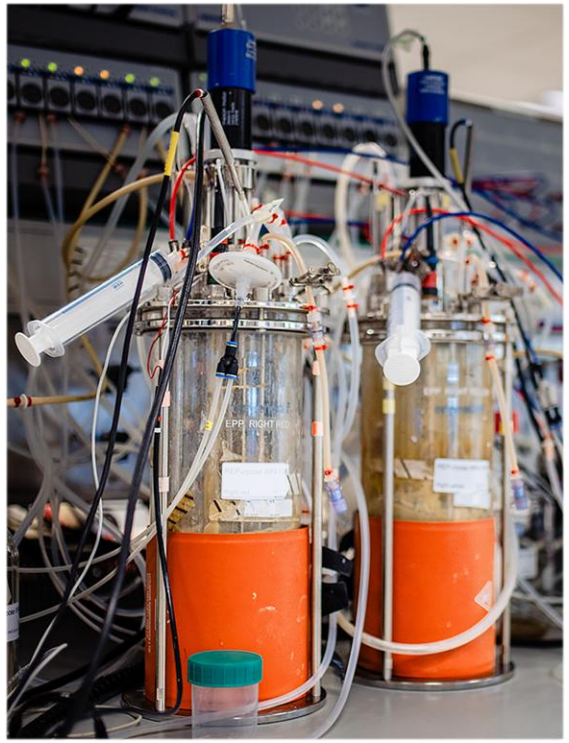
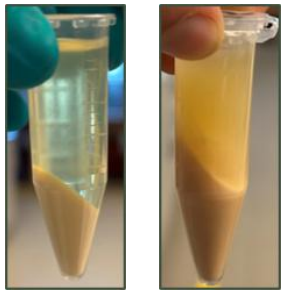
Objectives:

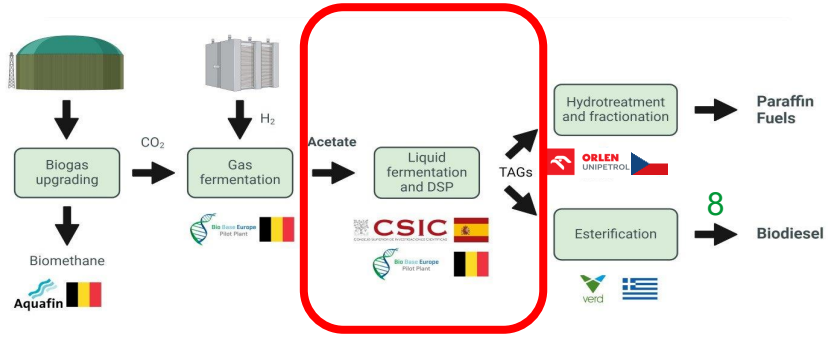
- Use of an optimized strains to produce triaglycerides (TAGs)
- maximize titer (g/L) and productivity (g/L/h) by finetuning parameters such as pH, pO2, oxygen transfer rates, feed regimes, agitation, etc.
- optimization of the recovery and purification of the TAGs

Results:

- *Yarrowia lipolytica* and *Rhodococcus jostii* have been tested at 4L and 30L scale bioreactor
- Increased TAGs productivity and concentration
- Screening of various pretreatment and solvents resulted in an optimized DSP protocol (>80% yield)







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TAGs Oils Esterification

Initial Oil Characterization

1. H2O = 9.83% wt.
2. FFA = 2.89% wt.
3. Water, solids & water-soluble materials= 10% V/V

Biodiesel Synthesis – Initial Experiments

1. Pretreatment: Acid wash with H3PO4 solution
2. Acid Esterification: 70-80o C reflux reaction, 0.5% m/m H2SO4, 30% m/m CH3OH, 30 min.
3. Trans Esterification: 2-step reflux reaction at 60o C, 2.5% m/m CH3OK, 15% m/m CH3OH, 3hrs.
4. Final product washes: 3 simultaneous washes with (1) water, (2) acid water and (3) water, Centrifugal Separations

Results – Need Improving

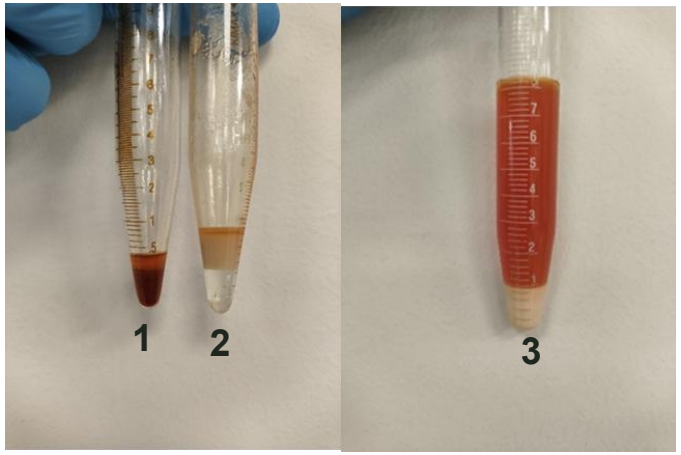
1. Reaction Conversion= ~58%
2. Iodine Value= 15.11 – Strong indication of high amounts of saturated methyl esters

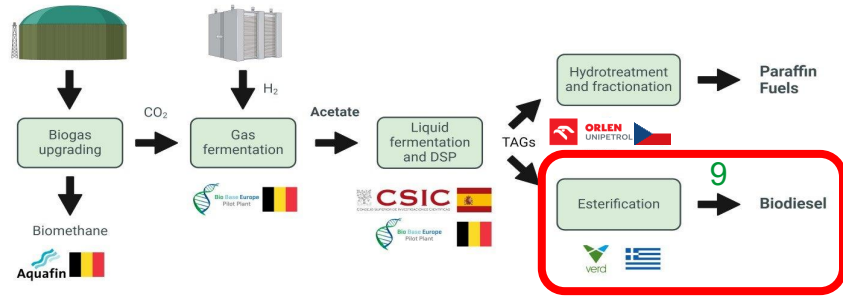
Trans Esterification Results

Glycerol: 0,015%
Monoglycerides: 4,81%
Diglycerides : 12,06%
Triglycerides : 41,86%

According to EN 14105

Biodiesel Washes





Upscale and challenges

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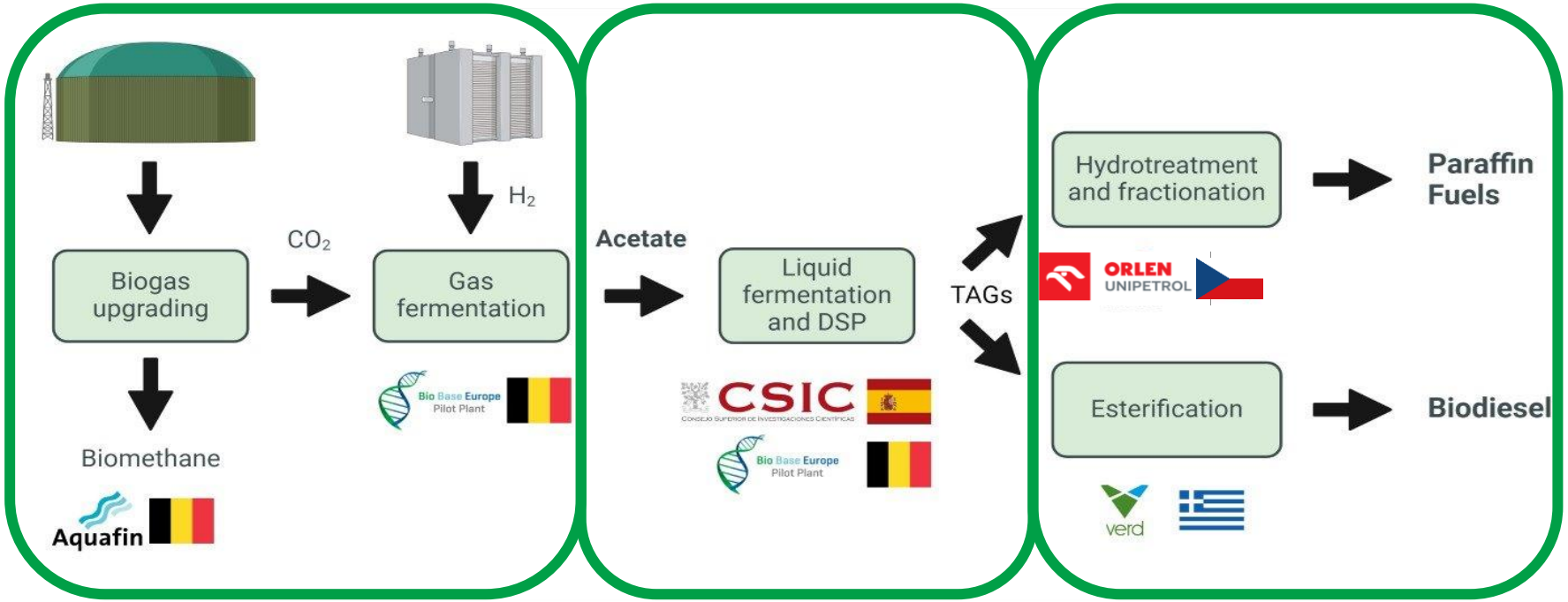
Scale-up and real demonstration of DEMO 1



Hydroprocessing tests of TAGs targeting to produce up to 250L of advanced paraffinic biofuels with potential use in transport.

Esterification tests aiming to produce up to 150L of advanced biofuel through

Gas fermentation

scale up to 150 L scale using the **real Biogenic-CO_2** coming from biogas upgrading plant and real industrial conditions (AQUAFIN site).

TAGs fermentation

Scale-up of the TAGs fermentation and recovery, overall goal is to produce **hundreds of kg (up to tonne) scale of purified microbial oil**

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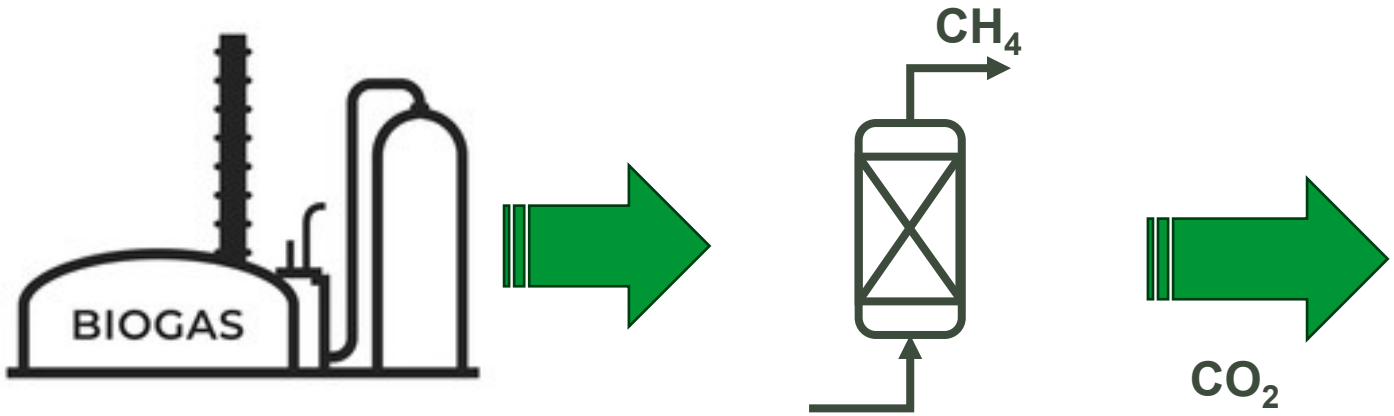
Bio Base Europe Pilot Plant

Scale-up Gas fermentation



Biogas plant

Upgrading plant

Mobile gas fermentation unit

Bio Base Mobile Pilot Plant (BBMPP)

Location:
AQUAFIN's WWTP
(Antwerp, Belgium)

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Aquafin

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Pilot Plant

Scale-up Gas fermentation

- Transportation
- Integration
- Commissioning

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- Permits from the authorities
- Construction works

Aquafin

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Scale-up Gas fermentation

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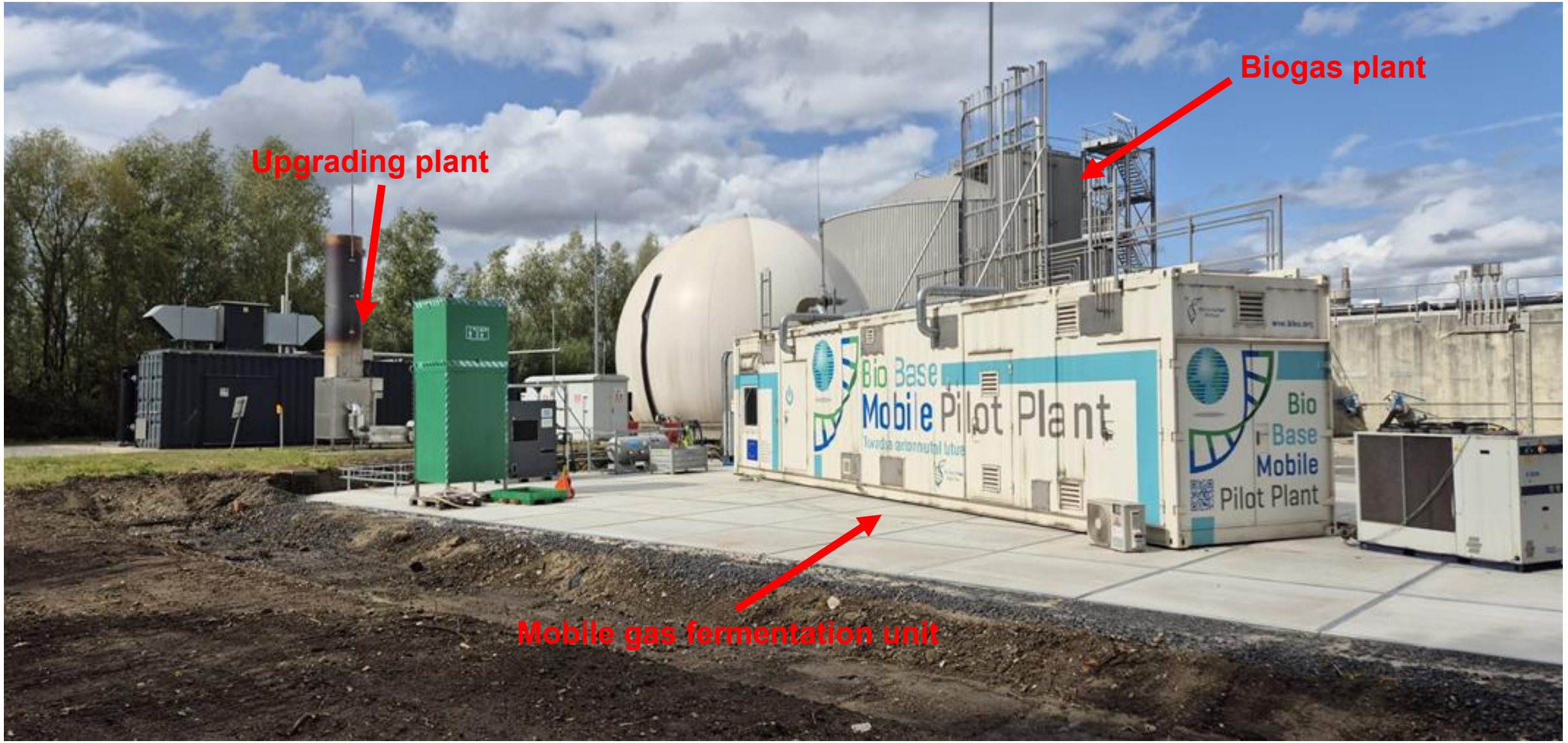
Pilot Plant



Future activities

Microbial oil (TAGs) production

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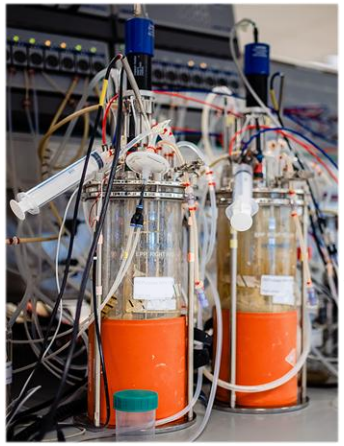
Scale-up of:

- TAGs fermentation
- Recovery and purification of the TAGs (DSP)

Production hundreds of kg (up to tonne) scale of purified microbial oil



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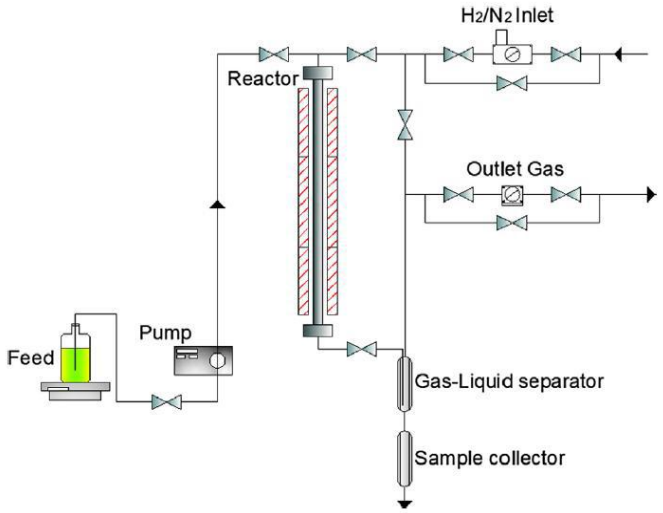
TAGs upgrading

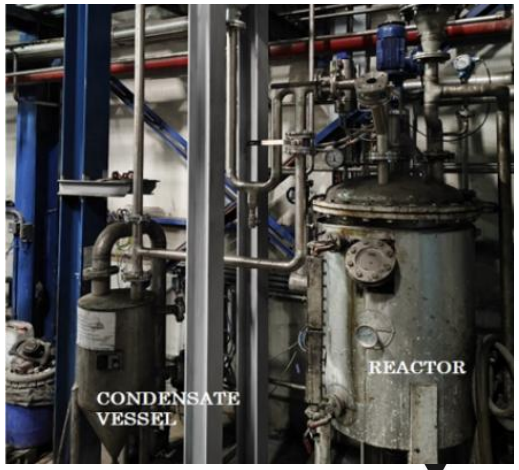
Hydrotreatment

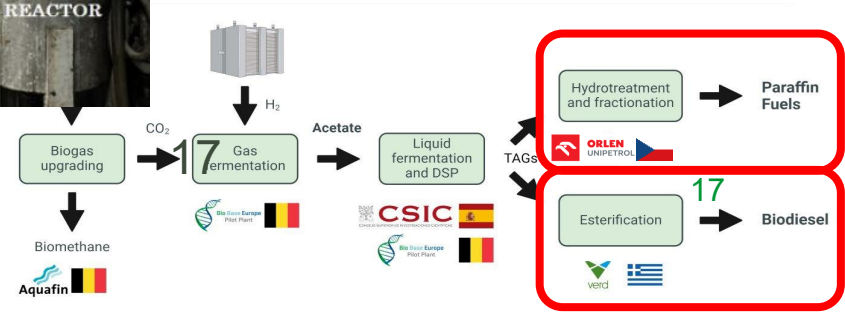
- selection of a catalyst; based on catalyst properties and activity during the reaction
- scaling up of the process into bigger reactor
- Challenge will be also suitability of commercial catalyst for Fuelphoria Oil



Esterification

- Improve Conversion: Increase temperature, catalyst loading, retention time and Methanol/Oil
- Measure Non-Saponifiable Matter during initial Oil Characterization
- Scale up of the process to 250L scale pilot unit





About FUELPHORIA

FUELPHORIA is an EU-funded Innovation Action project working to establish sustainable, competitive, and secure value chains for advanced biofuels and renewable fuels of non-biological origin.

Coordinated by CERTH, the project will set up and test a portfolio of 9 complete value chains in Belgium, Greece, and Spain.

Project partners will also evaluate the environmental performance of the FUELPHORIA renewable fuels, design innovative business models to prepare their market entry, and explore their export potential through collaboration with Africa

Get in touch

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