POLITECNICO MILANO 1863

Group of Energy COnversion Systems

CONVERGE

CarbON Valorisation in Energy-efficient Green fuels

Innovation in Advanced Biofuels Workshop
TNO, Petten, 18th May 2022

The CONVERGE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 818135

CONVERGE overview

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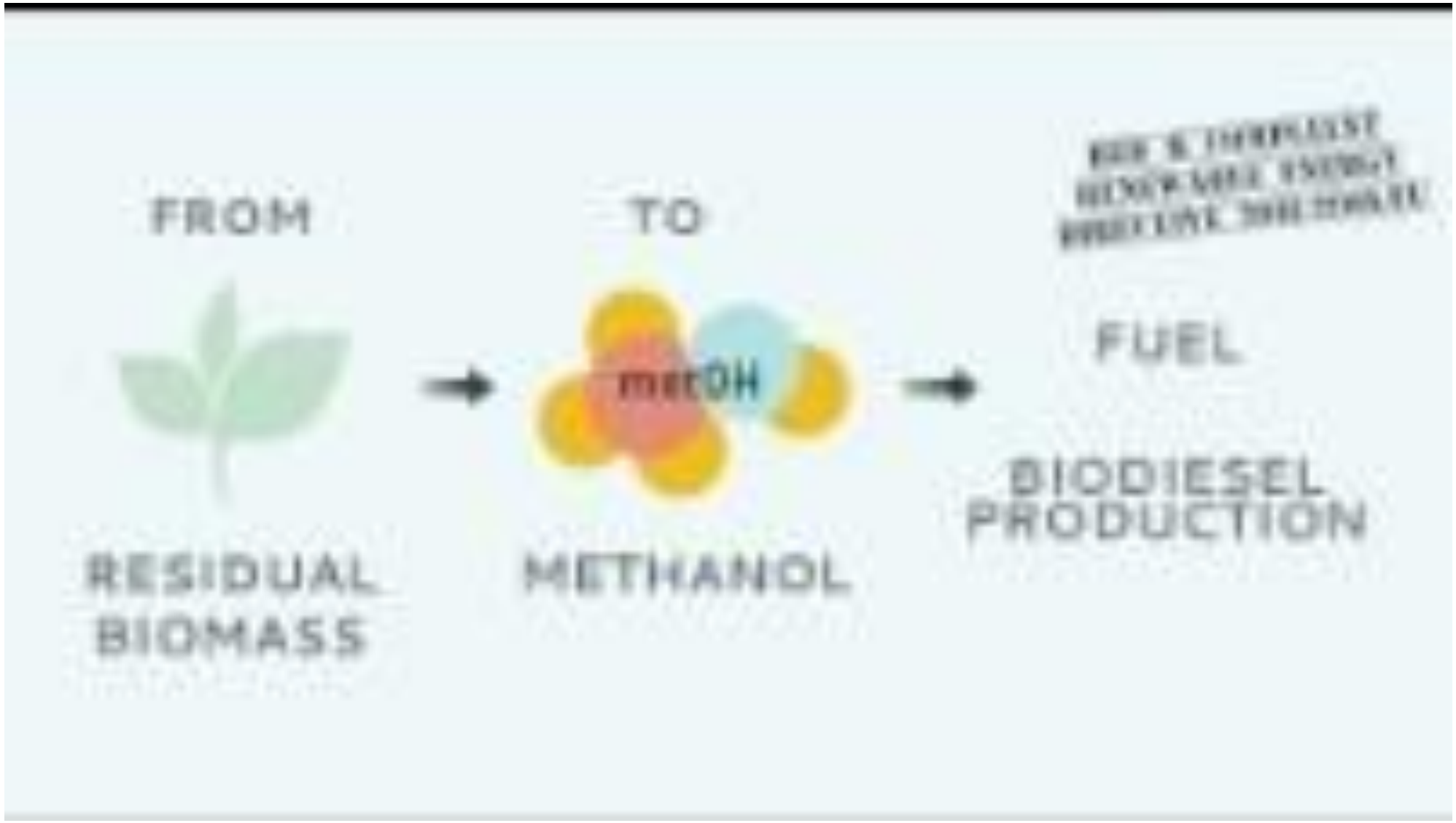

Project objectives

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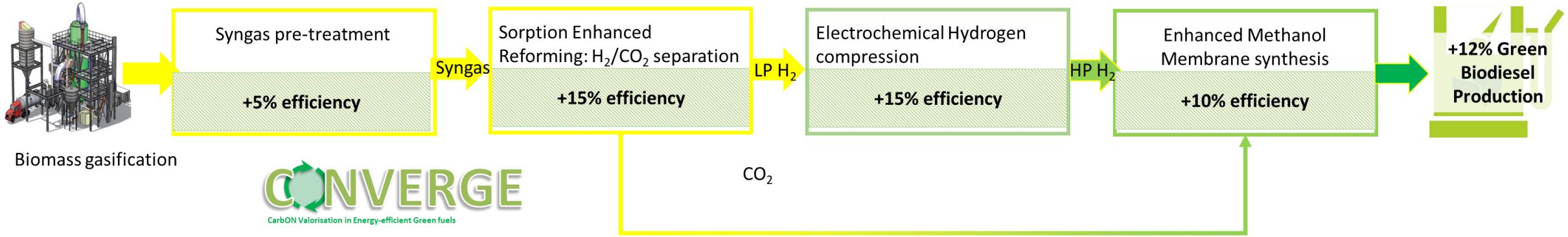

CONVERGE project aims at **supporting biodiesel supply production** from agricultural waste, in particular providing **bio-methanol** to the process.
As byproducts, valuable chemicals (BTX), hydrogen, and CO_2 are made available.

The **CONVERGE project is validating an innovative process** which will **increase the biodiesel production by 12%** per secondary biomass unit used and **reduce the CAPEX by 10%**

The **CONVERGE technologies** moved from discovery stage (TRL3) to development stage (TRL5), due to the development of new catalysts, sorbents and membranes that are tested in pilot scale for several hundred hours.

Consortium

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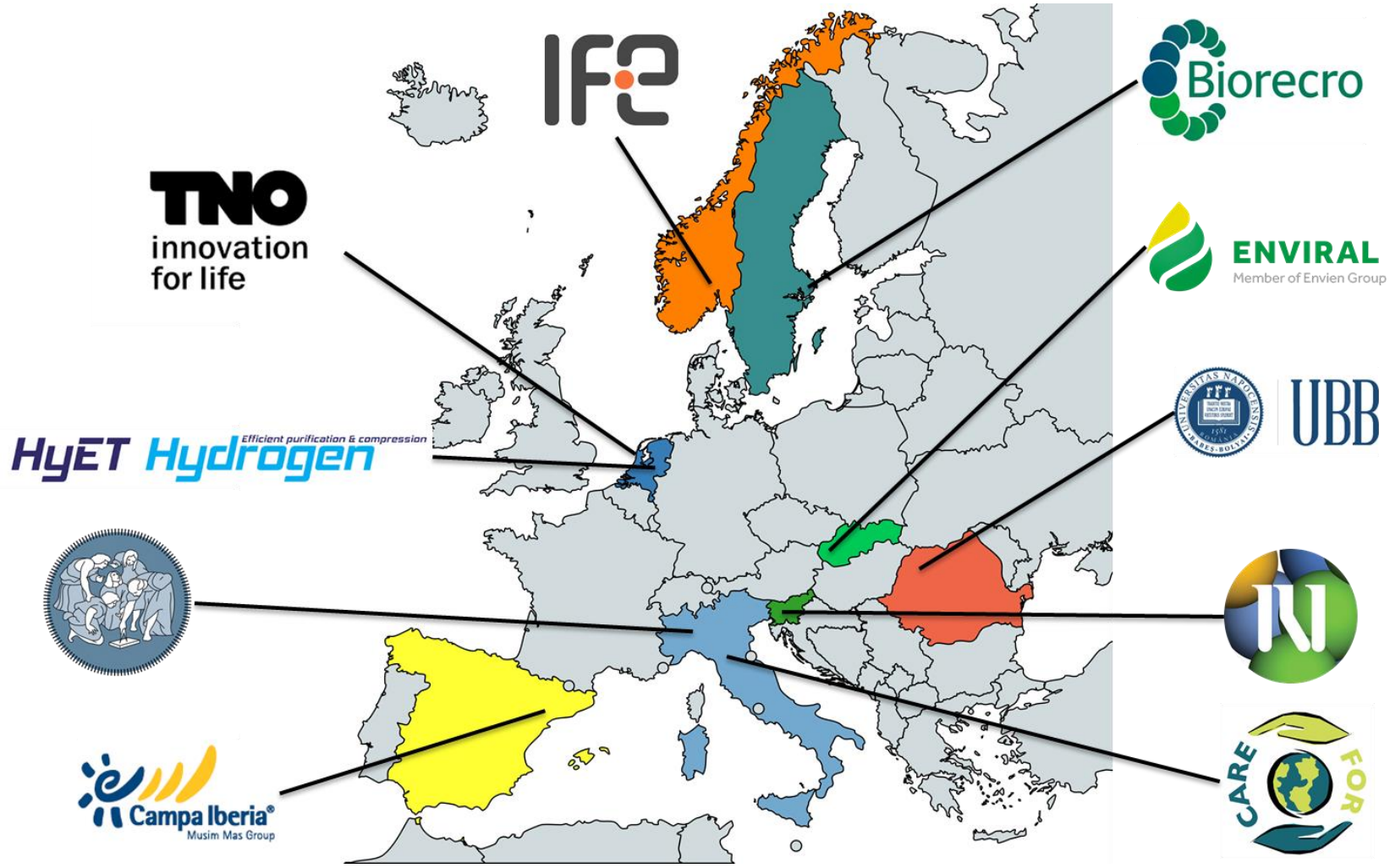

10 partners from 8 EU countries are contributing to CONVERGE development:

- 2 universities (POLIMI and UBB)
- 3 research organizations (TNO, IFE, and NIC)
- 2 SMEs (BioRecro and HyET)
- 2 large companies (Enviral and Campa Iberia)
- a professional association (CFE)

The project started in November 2018, and its duration was extended to December 2022.

CONVERGE Process

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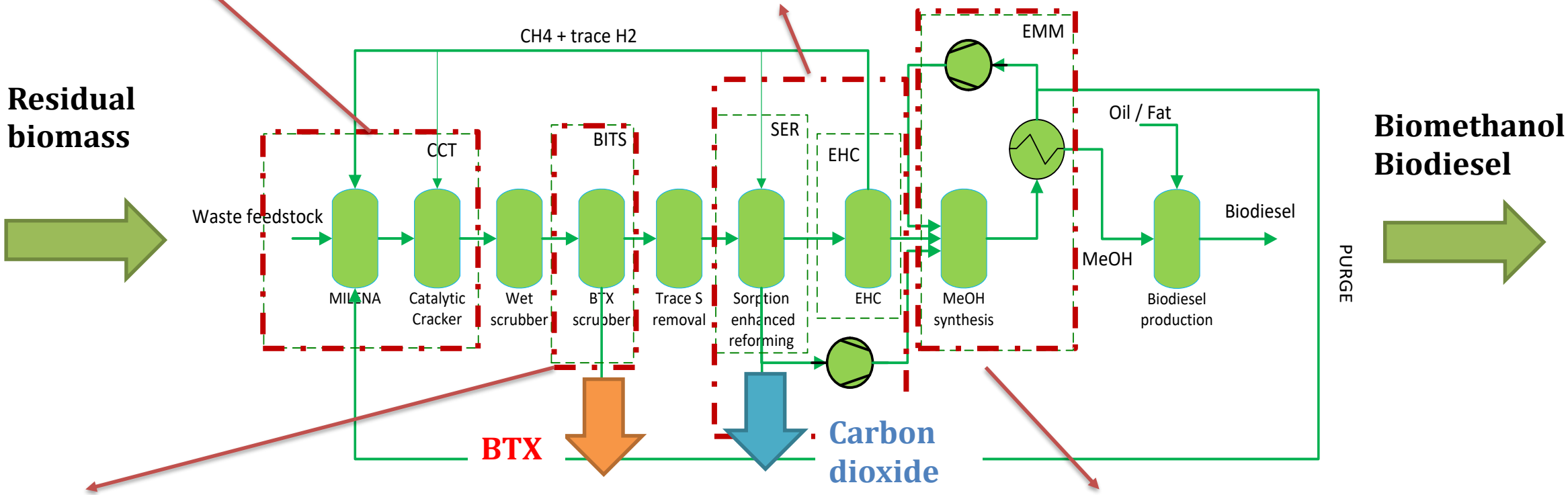
1. **CCT**: **Catalytic cracking of tars** from an indirectly heated gasifier to below green C_8
2. **AREA**: **Recovery of refinery products** including aromatics for green C_6-C_8 fraction (BTX)
3. **SER**: **Sorption-Enhanced Reforming** of C_1-C_6 for excess-carbon removal, and H_2 production
4. **EHC**: Highly efficient **electrochemical compression** of green H_2 with by-product fuel
5. **EMM**: **Enhanced Methanol Membrane** to ensure efficient green biodiesel production



Catalytic Cracking and BTX scrubber

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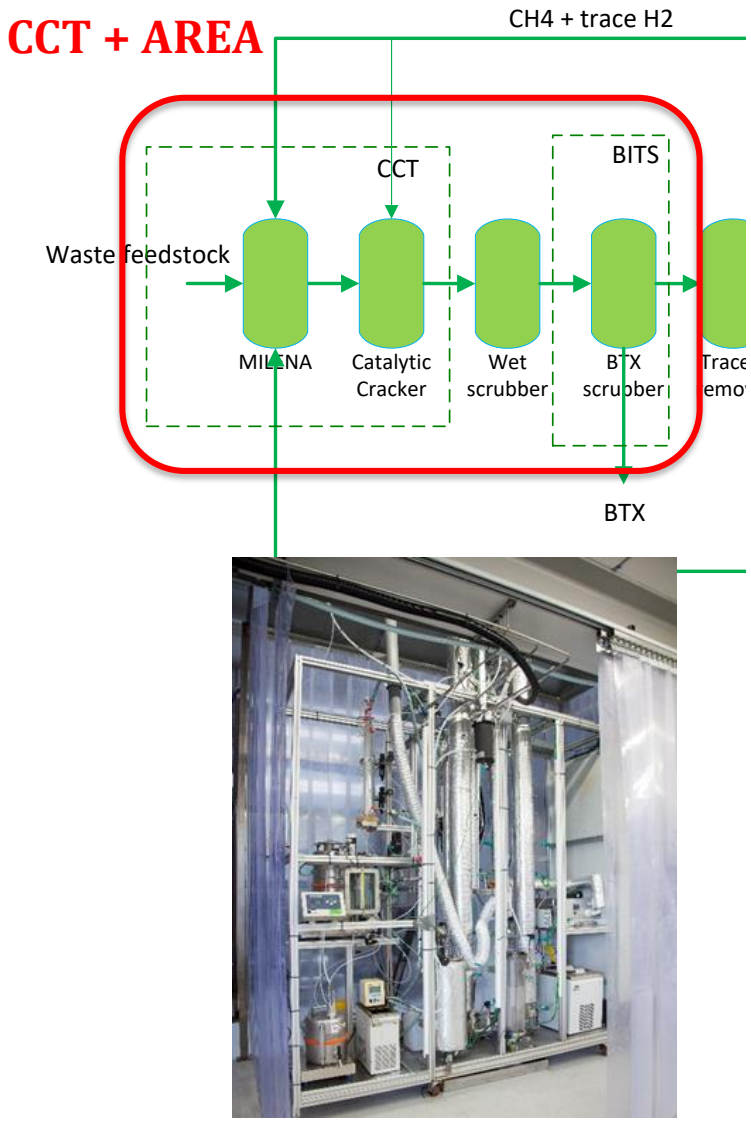

- Conversion of C_{9+} species from the producer gas at similar temperature to the gasification
- **Development of a catalyst** that cracks tars to molecules **smaller than C_8,** maximizing the BTX productivity
- **Design and build a system for the conversion of tar compounds**, without cracking the BTX fraction
- Mini pilot unit able to process 5 Nm^3/h dry product gas

  BTX removal > 95 vol%

  Quantitative removal of higher aromatic compounds

A new catalyst selective to BTX at ambient pressure has been identified and the CCT reactor setup is complete.

CO_2- H_2 separation

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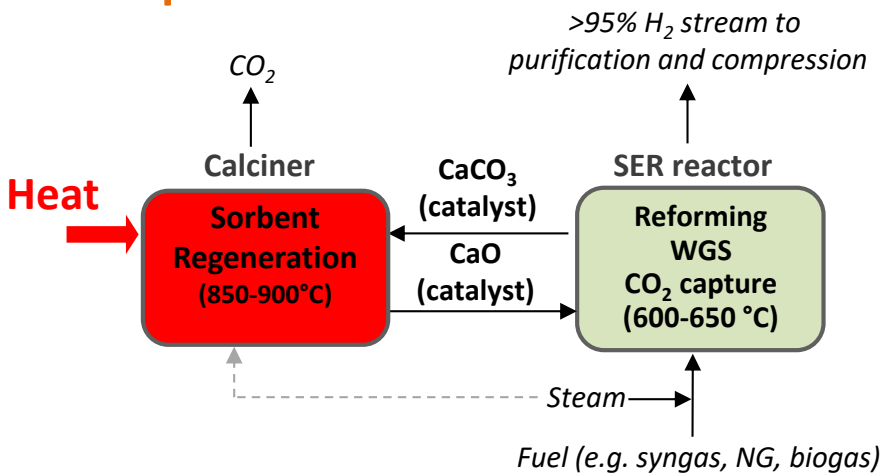
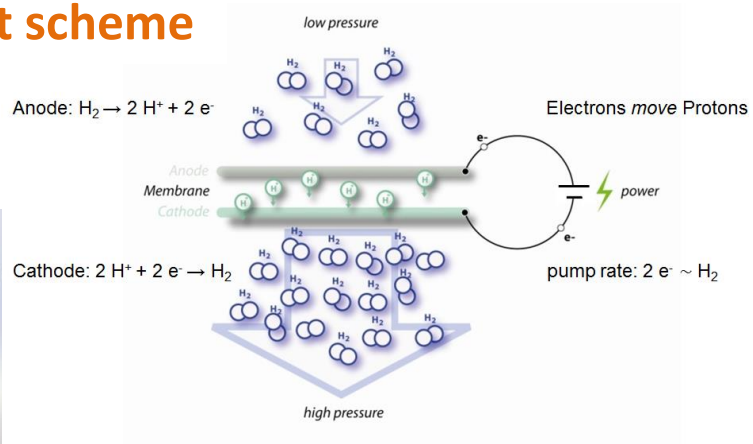
SER Concept scheme



Sorption-Enhanced Reforming

- Lower temperature of reforming (about 650°C)
- Offgas from synthesis section or syngas from gasifier provide the high temperature heat for sorbent regeneration (900 °C)
- A partial CO_2 removal step can improve the integrated system performance, resulting in a high CO_2 removed fraction

EHC Concept scheme



Electrochemical Hydrogen compression

- Combined hydrogen separation and compression in a modular system
- The complete system extracts and compresses H_2 at >99.5% purity to 50 bar in a single step
- Primary energy consumption is expected to be reduced down to 12 MJ/kg H2, at a 10 Nm^3/hr H_2 (20 kg H_2/day) output.

CO_2- H_2 separation

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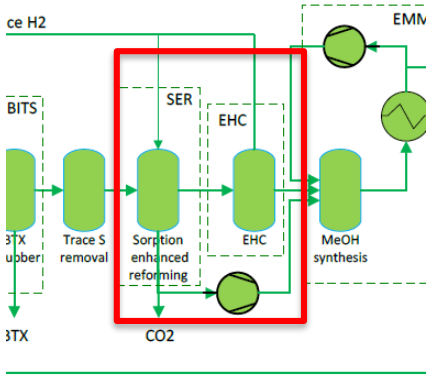
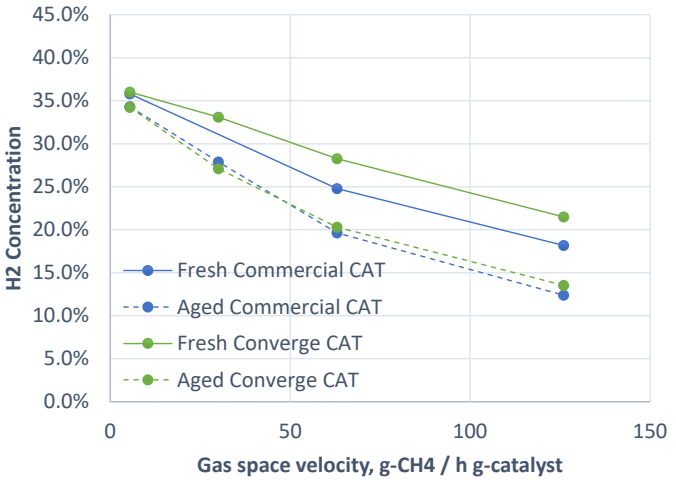
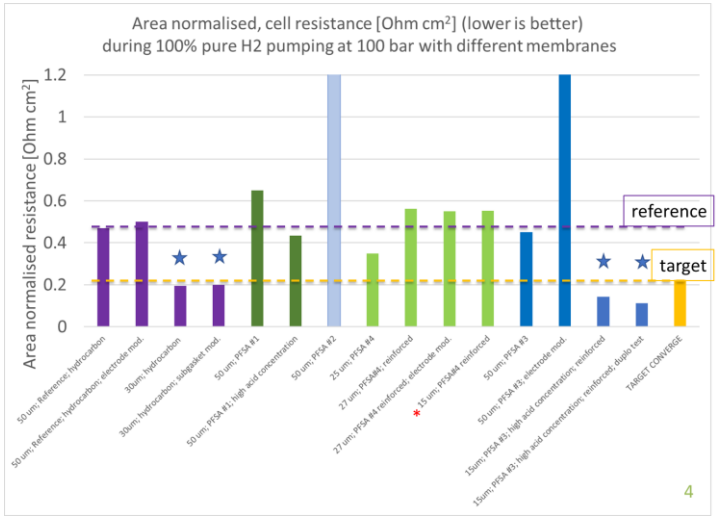
Development of the **Sorption Enhanced Reforming (SER)** and **Electrochemical Hydrogen Compressor (EHC)** technologies at TRL5 :

- Reduce the **energy consumption** for hydrogen production, CO_2 removal and compression to 1.2 MJ/kg CO_2
- **Extract and compress** H_2 at >99.5% purity, 50 bar and at a primary energy consumption of 12 MJ/kg H_2



New reforming catalyst outperforms HTCAT commercial catalyst after long term tests – **Gycerol** can be reformed with syngas.





New membranes for the EHC has been identified with performance and costs aligned with the project energy targets.

TRL 5 test are the next step.

Enhanced Methanol Membrane Reactor

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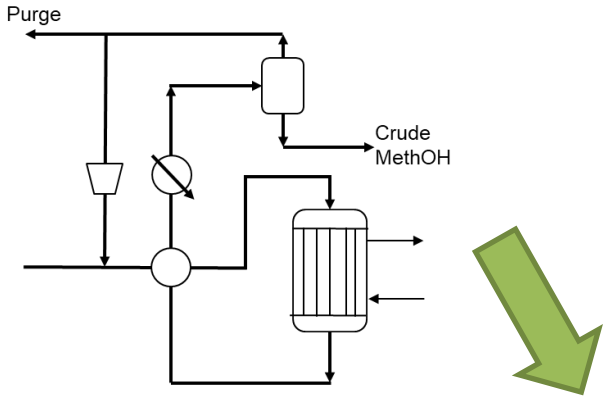
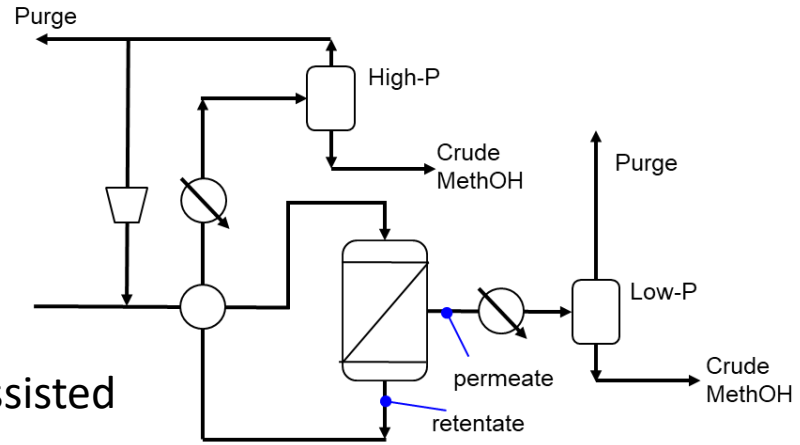
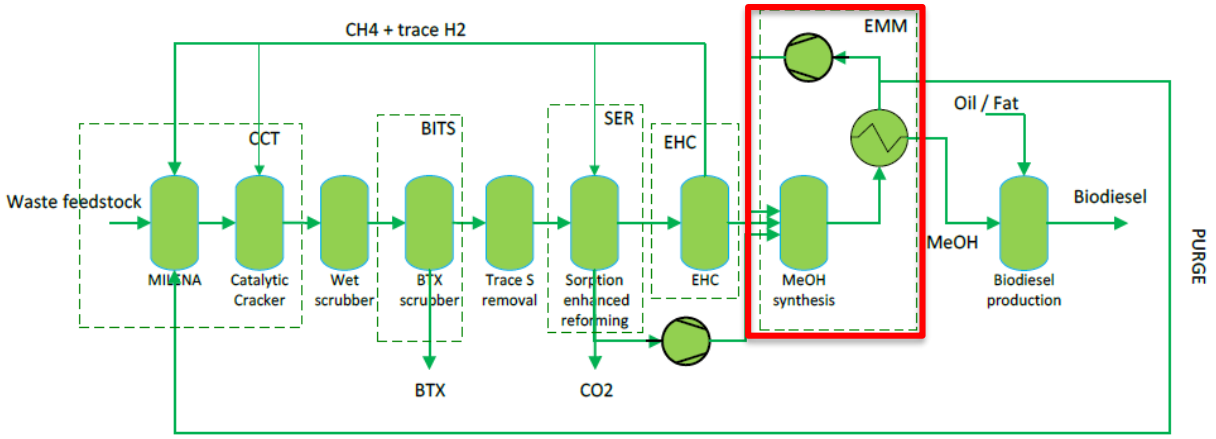
Conventional



- By incorporating a membrane into the methanol reactor, the selective removal of methanol and water boosts the driving force for methanol synthesis
- **Validate the Enhanced Membrane Methanol** synthesis with improved **single pass conversion** reducing the size of the methanol reactor
- Pilot TRL 5 reactor has been successfully tested, with an improvement in conversion performance

Membrane assisted





Economic and environmental targets

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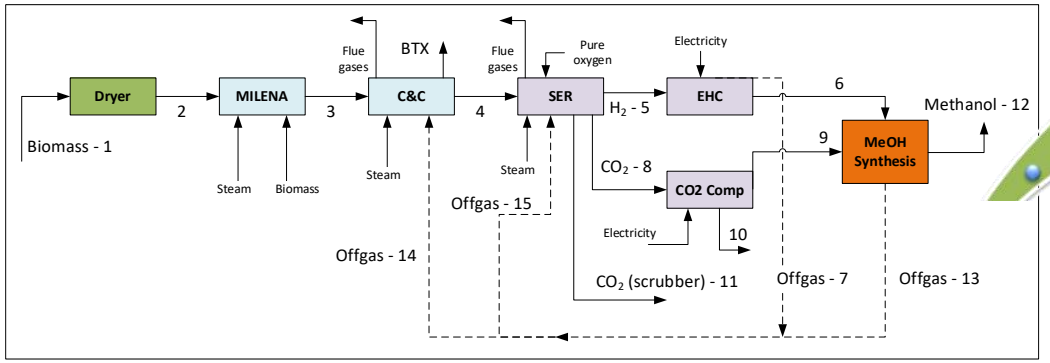
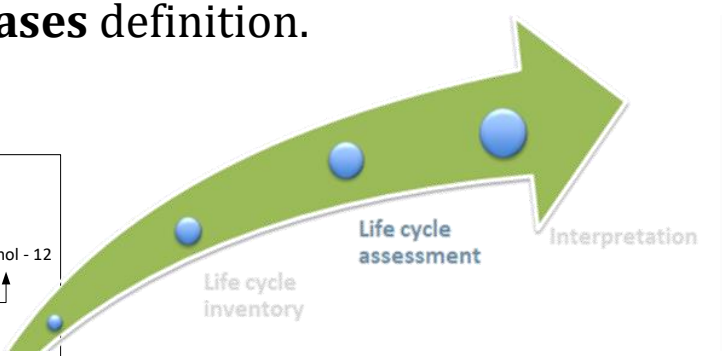
Complementary to the technologies' development, **techno-economic** evaluation of the complete process is ongoing together with **life cycle assessment** and **business cases** definition.





- **Reduce the cost of methanol production** from biomass to methanol with respect to benchmark cases
- Evaluation of **environmental and social impacts**
- Evaluation of the use of developed technologies (CCT, AREA, SER, EHC and EMM) in **other possible spin-off sectors**
- **Valorisation of the highly purified CO_2** produced from the SER unit either in BeCCS and CCU type applications

Plant integration in biomass supply chain

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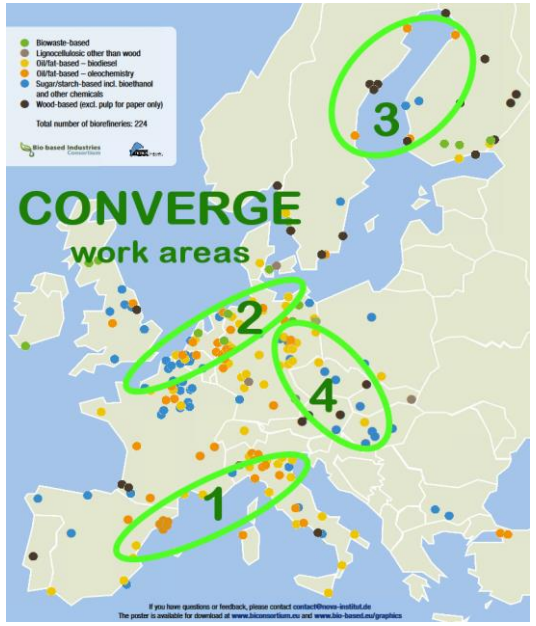
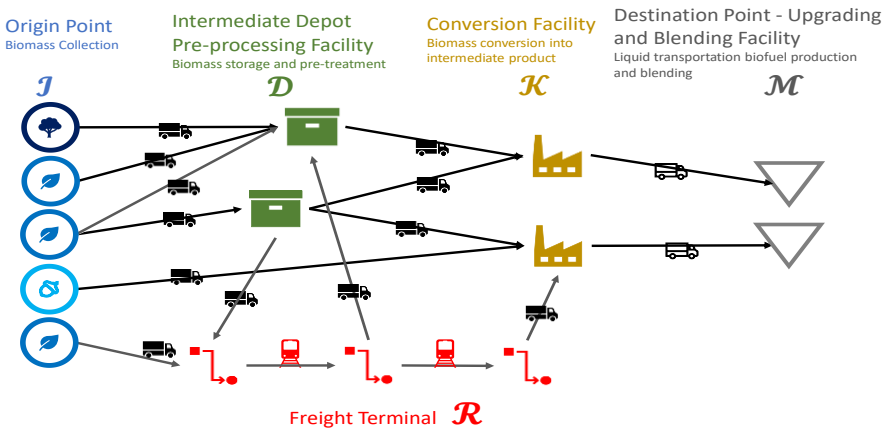
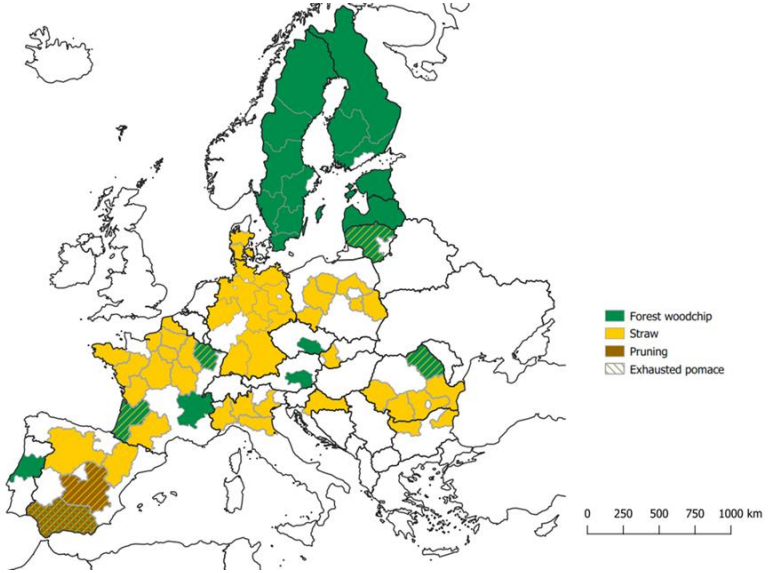
Methodology to assess the Bioeconomic Potential of the Residual Biomasses (Annex IX, Part A, RED II) and the European Regions Suitability (NUTS2) for hosting the CONVERGE technology.

Examples of results: Biomass supply regional clusters suitable for CONVERGE concept at commercial scale for a capacity plant above 200MW$_{th}$.







Tool for the **optimization of the supply chain** in four different regional areas has been developed.

Conclusions

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- Experimental and demonstration activities supported **new catalysts and sorbents development** with promising performances applied to tar conversion to useful products, sorption-enhanced reforming and pure CO_2 separation.
- **Improved design solutions and membranes** are now available for electrochemical hydrogen compression and for methanol synthesis steps.
- Preliminary system techno-economic and environmental performance assessment has indicated the way to further develop the different components, but final assessments are ongoing
- Very interesting results for the **supply chain** of secondary biomass have been found.

There is still work to be done…

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Get in touch with us

Website: www.converge-h2020.eu
Researchgate: **CONVERGE: CarbON Valorisation in Energy-efficient Green fuels**
Linkedin: **showcase/converge-horizon2020**

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