Bio Methanol Production via Chemical Looping Gasification Coupled with Membrane Reactors

Public Presentation

Location, dd-mm-year

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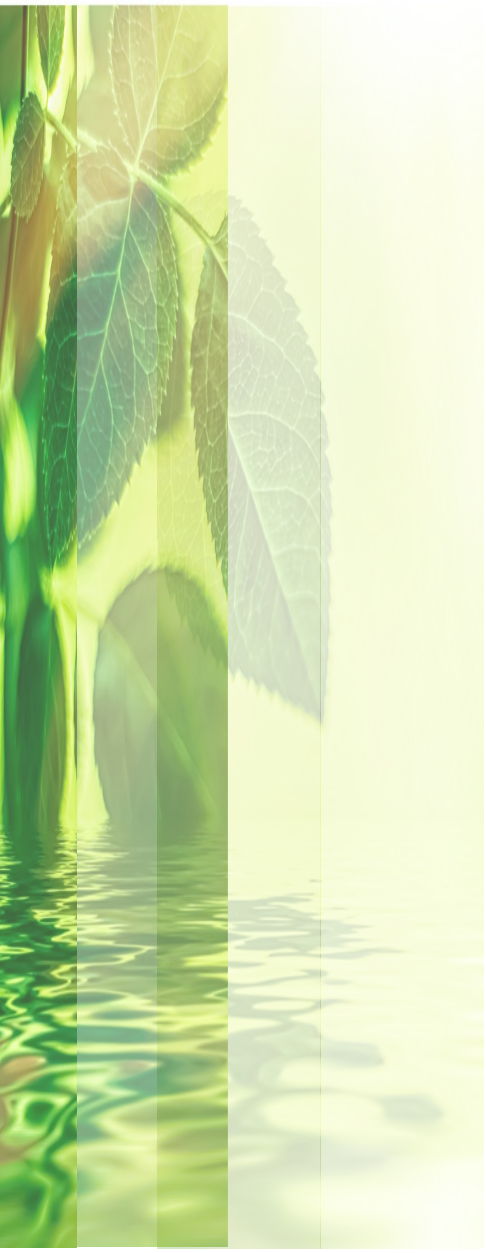

Outline

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Project Overview

- Grant agreement ID: 101147737
- Funding Program: HORIZON Europe
- Granting Authority: European Union
- Call Topic: Development of next generation advanced biofuel technologies (HORIZON-CL5-2023-D3-02-07)
- Starting Date: 1 September 2024
- Duration: 4 years
- Project Funding: € 3,797,326.25
- Coordinator: RISE Research Institutes of Sweden

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Background and Motivation

- Why Biofuels?
  - Critical to decarbonizing hard-to-abate sectors: aviation, shipping, heavy transport.
  - Biofuel demand hit **170B liters in 2022**, projected to rise to **400B liters by 2030 (IEA).**
  - Need for **advanced technologies** to convert low-value biogenic feedstocks.
  - Reduce dependence on fossil fuels.
  - Target: 40% of biofuel from waste, residues, & non-food crops by 2030 (9% in 2021).

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Background and Motivation

- Methanol as a Biofuel and Chemical:
  - Versatile: Used in **combustion engines**, **blended fuels, fuel cells,** and it is also an important **chemical commodity**.
  - High demand: Around 102 million tons of methanol were produced in 2020 with expectations of increasing to 500 Mt/year by 2050
  - Correspond to releasing 1.5 Gt CO_2 per annum if solely sourced from fossil fuels
- Renewable Methanol:
  - Only <1% of global methanol is renewable.
  - **Biomethanol** as a fuel or chemical has a lower CO_2 footprint compared to fossil-based methanol and even e-methanol.

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Background and Motivation

- Methanol as a fuel in Maritime:
  - **Stena Germanica**: world's 1st methanol-powered vessel → SOx & particle emissions cut by 90%.
  - **Maersk**: first methanol-powered vessel launched.

- Methanol in **fuel cells**:
  - Easier storage and transportation vs hydrogen,
  - energy efficiency from feedstock to end-use can be severely increased compared to internal combustion engines.

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Challenges in Biomethanol Production from Biomass

- Key Limitations
  - **Sustainable biomass supply is limited** → cannot fully meet future demand and must be used efficiently.
  - **Low conversion efficiency** in conventional gasification & methanol synthesis technologies
  - **Significant loss of biogenic carbon:** a significant part of biogenic carbon from the feedstock converts to CO_2 during conventional gasification & syngas conditioning.
- Technical Challenges
  - Inability to process **low-value, contaminated biogenic residues** without pretreatment.
  - Heterogeneous feedstocks (e.g., MSW, waste wood) require complex handling.
- Economic Barriers
  - Biomethanol cost can jump from $43/ton to $660/ton (Biomass cost ↑, Conversion efficiency ↓)
  - **Fossil-based methanol cost**: $100–250/ton → currently more competitive price.

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Overall aim of this project:

Develop a novel, **efficient, and scalable process** to convert **low-value biogenic residues** and organic waste to **biomethanol** through **chemical looping gasification** coupled with **membrane reactors**

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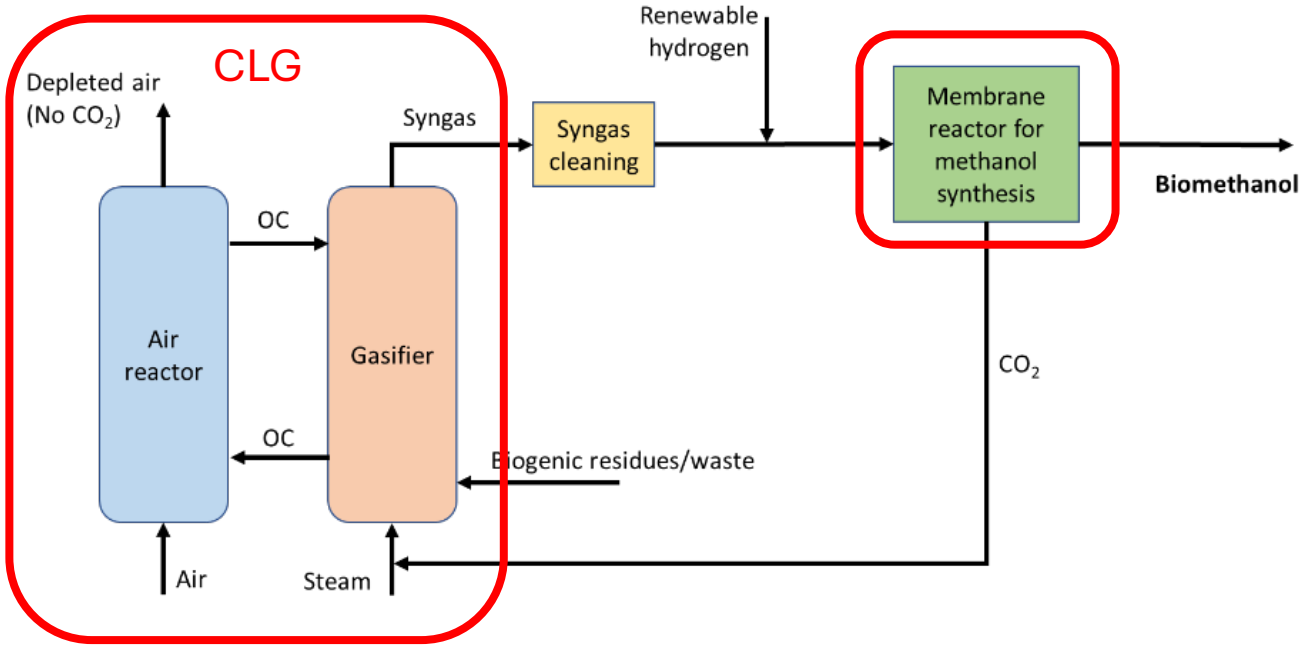
Bio-MeGaFuel Concepts

Advantageous:

- Flexible toward feedstocks and can utilize various biogenic residues and wastes.
- Higher conversion efficiencies and yields compared to conventional gasification and methanol synthesis methods
- Full Value Chain Process intensification and Integration
- Boosts the production yield by using green hydrogen for syngas conditioning (vs water-gas shift)



- Cost-Effective Design: Fewer process units with integrated heat and power.
- The process is less energy-intensive and is self-sufficient in terms of heat.
- **Lower production cost** with **potential net zero emission** (significantly reducing greenhouse gas emissions)

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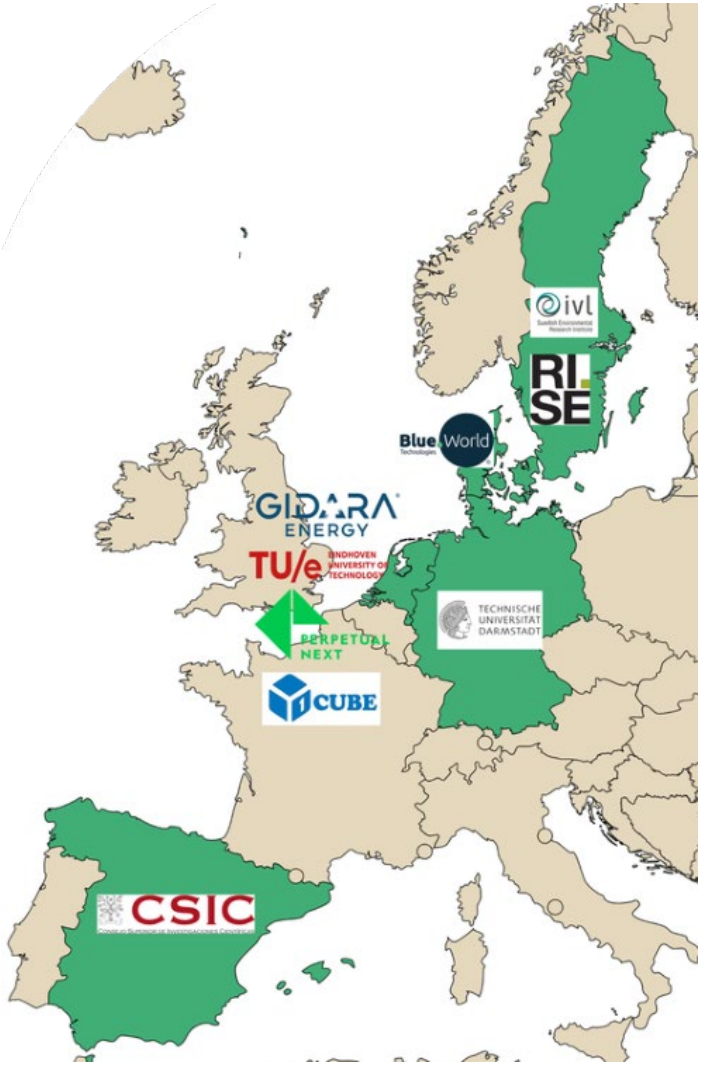
Participants and Consortium Synergies

- The Bio-MeGaFuel project has an expert consortium. It consists of **9 partners from 5 countries** and includes:
  - Four Companies: GIDARA Energy, Perpetual Next, 1Cube and Blue World Technologies.
  - Three Research Institutes: RISE Research Institutes of Sweden, The Spanish National Research Council, and IVL Swedish Environmental Research Institute.
  - Two Universities: The Technical University of Darmstadt and Eindhoven University of Technology.



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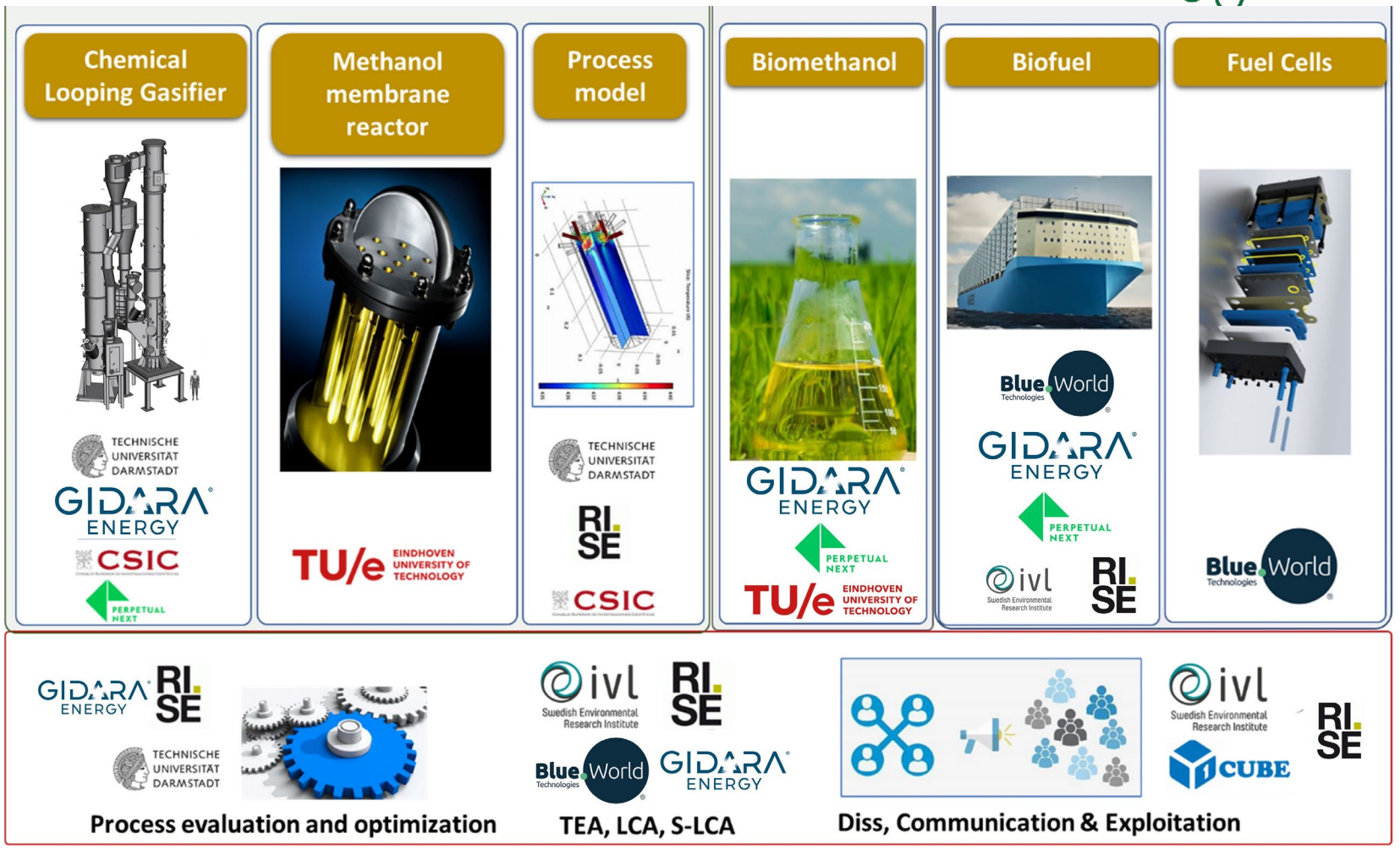
The Bio-MeGaFuel project value chain



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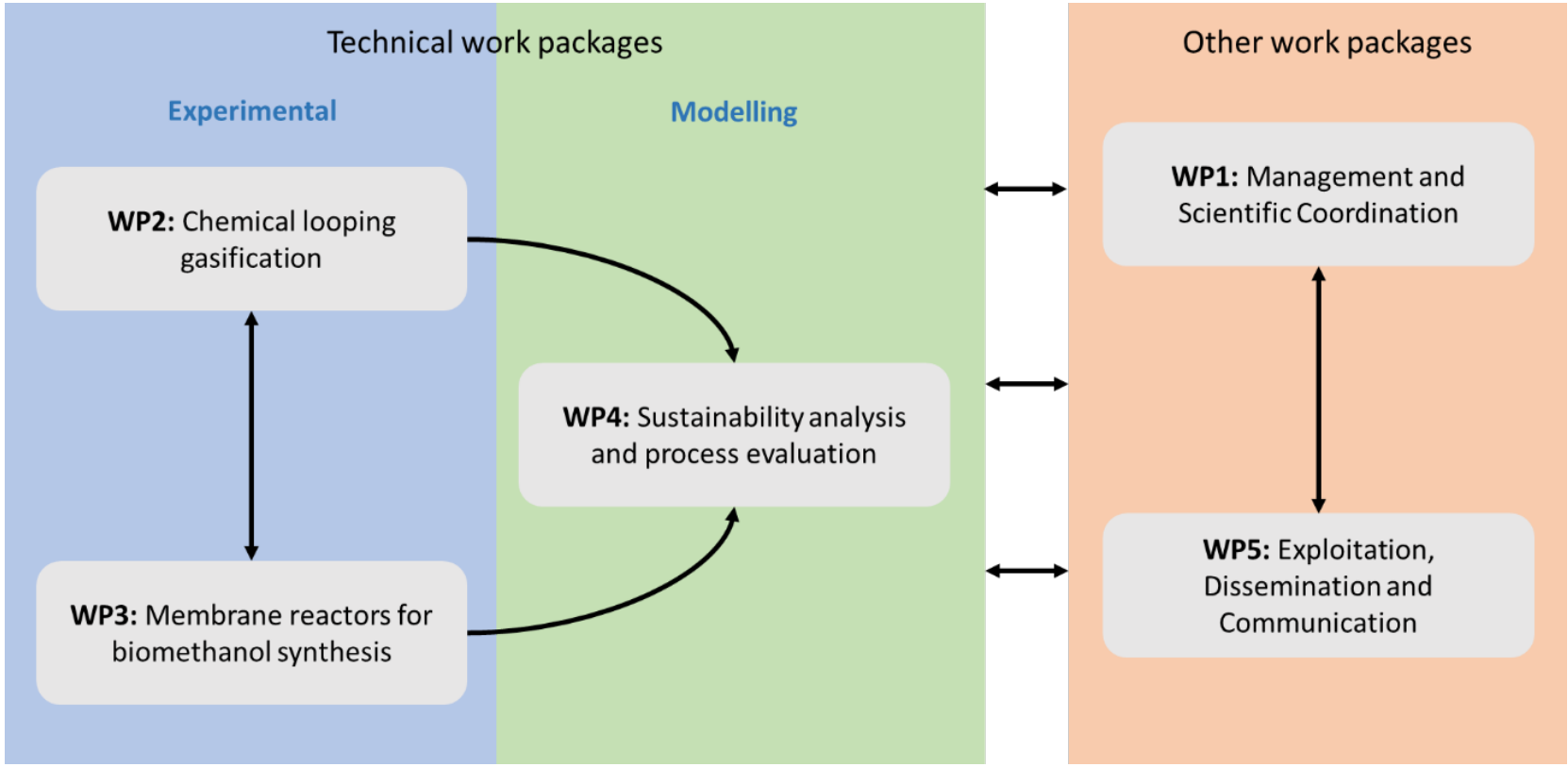
The overall structure of the work plan



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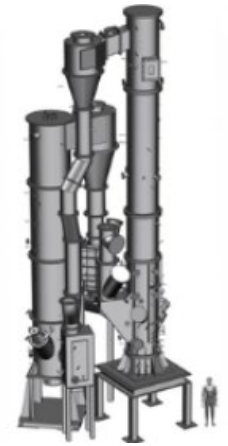
Methodology and key performance indicators (KPIs)

- 1: Developing biogenic resides and wastes gasification with oxygen carriers to maximize the conversion of biogenic residues and wastes to syngas
  - Testing at least five different biogenic fuels including microalgae
  - Operate the 1 MW CLG pilot plant at TUDA in auto-thermal modes to gasify 50-70 tons of biogenic residues (TRL 5)
  - 80% gasifier cold gas efficiency
  - 98% carbon conversion in gasifier
  - <10% of reactive ash species released in air reactor



- 2: Developing membrane reactors for methanol synthesis
  - Demonstrate membranes at TRL5 in a standalone setup to produce biomethanol
  - Significantly increase the yield of biomethanol production from syngas by two-fold.
  - Separating unconverted biogenic CO2

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Methodology and key performance indicators (KPIs)

- 3: Process evaluation and sustainability analysis
  - Design of a full chain process for the production of biomethanol from residual biomass via CLG
  - Compare different process configurations to identify the optimal operation of the production plant.
  - Estimate CAPEX and OPEX of the production plant and identify how the production cost is affected by the plant capacity and other process parameters (i.e., sensitivity analysis)
  - Estimate the carbon footprint from the production of bio-methanol via the Bio-MeGaFuel concept.
  - Assess the social and socio-economic impacts of the Bio-MeGaFuel concept throughout the entire life cycle

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Methodology and key performance indicators (KPIs)

- 4: Exploitation and whole Value Chain analysis
  - Market, production, and end-user uptake analysis of biomethanol (production potential, cost analysis, etc.)
  - Current and conceptual value chains and business models

- 5: Dissemination and communication of the project's results
  - To identify target groups, communication tools and distribution channels.
  - To promote Bio-MeGaFuel concept as a reliable technology to the market,
  - To engage relevant technology providers and end users n Bio-MeGaFuel
  - To disseminate the results from the project and coordinate that research infrastructure will be open and accessible for knowledge transfer.
  - To create recognition by graphically coherent communications.
  - To interact with a wide audience through the internet, promotional material and events.

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Key Exploitable and Expected Results

Key Exploitable Results	Bio-MeGaFuel Key Exploitable Results Preliminary Plan
KER 1: Operating strategies of a chemical looping gasifier for high syngas yield by conversion of bio residue Partners: TUDA, CSIC, GID	Main end-user: Manufacturers of dual fluidized bed plants Value proposition: lower costs and higher efficiency due to less corrosion and higher syngas yield (>50%) Time to market: 5-10 years
KER 2: steam/CO2 gasification of waste biomass for syngas production with maximized bio-carbon utilization Partners: TUDA, CSIC	Main end-user: Manufacturers of dual fluidized bed plants, biomass incinerators, carbon capture and utilization technology providers. Value proposition: Compared to state of art gasification technologies, this would lead to lower costs Time to market: 5-10 years
KER 3: Membrane and membrane reactors for methanol synthesis Partners: TUE	Main end-user: Methanol producers Value proposition: Integrated reactors including membranes allow two fold higher yield for methanol synthesis Time to market: 3 years after the project finishes
KER 4: Process model for CLG and whole process chain Partners: RISE, TUDA	Main end-user: Manufacturers and operators of dual fluidized bed plants, methanol producers, energy and CHP plants, chemical industries with separation processes involved Value proposition: Increased carbon utilization and reduced effort for gas purification, leading to cost reduction Time to market: 2 years after the project ends

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QUESTIONS/COMMENTS

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Backup Slides

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Expected Results

ER 1: Novel and efficient process route for the synthesis of biomethanol

ER 2: Clean syngas via CLG of low-value biogenic residues and waste streams.

ER 3: Methanol synthesis from syngas in novel membrane reactors

ER 4: Maximum conversion of biogenic carbon from biomass to biomethanol.

ER 5: Market analysis and full value chain analysis of biomethanol production from biogenic residues and wastes and its application in hard-to-decarbonize sectors.

ER 6: Process analysis of Bio-MeGaFuel

ER 7: Techno-economic assessment of a Bio-MeGaFuel plant at a commercial scale

ER 8: Life cycle analysis of the full value chain of Bio-MeGaFuel

ER 9: Social impacts of the Bio-MeGaFuel concept throughout the entire life cycle

ER 10: Exploitation road map for Bio-MeGaFuel

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