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Bio-Flex CLC

PROJECT OVERVIEW

Flexible chemical looping combustion for combined heat and power production from biogenic residues with negative emissions (Bio-FlexCLC)

RI. SE · fortum · CSIC · CERTH Centre for Research & Technology Hellas · Technische Universität Darmstadt · Chalmers · VEAB Växjö Energi · CUBE · repotec · GMAB

Bio-FlexCLC Project

Grant agreement ID: 101147904

Funding Program: HORIZON Europe

Granting Authority: European Union

Call Topic: Development of near zero-emission biomass heat and/or CHP including carbon capture (HORIZON-CL5-2023-D3-02-01)

Starting date: 1st June 2024

Duration: 48 months

Project funding: € 3,948,500.00

Coordinator: RISE Research Institutes of Sweden

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Outline

- Objectives and Concept
- Key Exploitable and Expected Results
- Participants and Consortium Synergies
- Methodology and Execution
- Expected Outcomes

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Objectives and Concepts

- EU has committed to full decarbonization in less than 30 years and Carbon Dioxide Removal(CDR) including Bio-Energy with Carbon Capture and Storage (BECCS) will be instrumental if this is to be achieved.
- However, the high cost and energy penalties of CCS are considered one of the most important barriers to the implementation of CCS and BECCS.
- Moreover, in light of no policy instruments and economic incentives currently in place for BECCS while at the same time needing rapid and substantial BECCS, it poses a dilemma for end users.

➢ Need to minimize the risks of investment in BECCS

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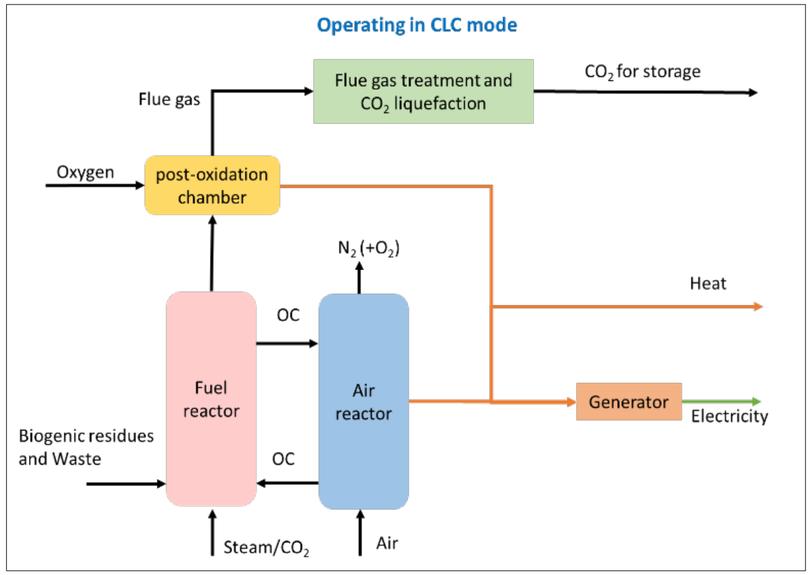
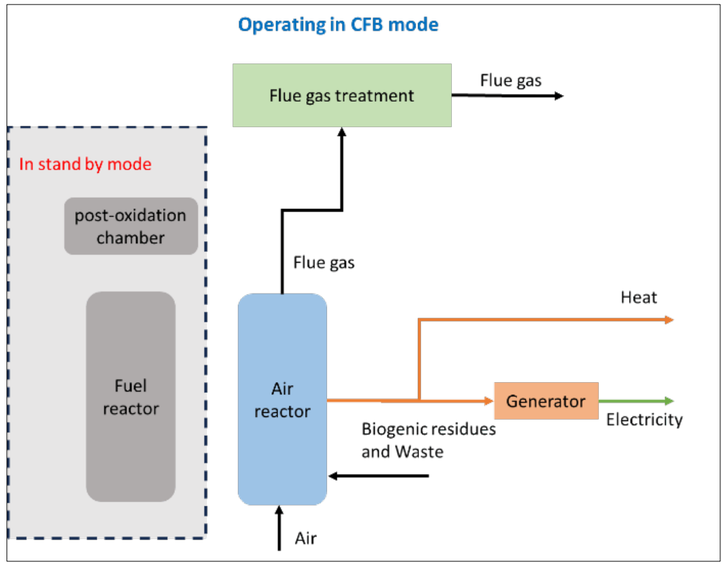
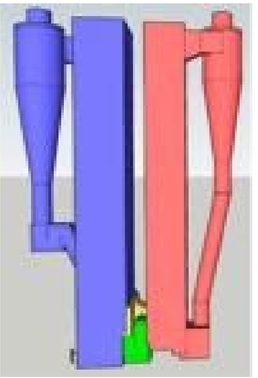
Objectives and Concepts

- The concept is based on dual Circulating Fluidized Bed (CFB) reactors, which can operate in Chemical Looping Combustion (CLC) mode while both reactors are in use or switch to conventional CFB operation when only one reactor is in use.

➢ operating in CLC mode enables CHP production with negative emissions at low-cost while the concept is flexible to switch to CFB boiler mode to produce CHP with net-zero emissions







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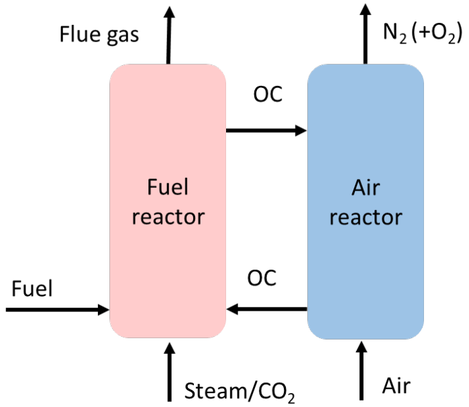
Objectives and Concepts

J. Guo et.al. Forests 2024, 15(8), 1372

Biogenic waste as feedstock



Chemical Looping Combustion

Combined heat and power (CHP) plants

Chemical Looping Combustion (CLC)

- CO_2 capture at exceptionally low cost (roughly 20 €/ton$_{CO2}$)
- no energy penalty for gas separation and close to 100% CO_2 capture
- reduced cost for flue gas cleaning as ash and emissions will be concentrated to the fuel reactor, where the gas flow is reduced to a quarter compared to conventional combustion
- scalability to larger dimensions
- eliminating the cost penalties associated for post-combustion capture or oxy-fuel infrastructure
- minimal or negligible emissions of NOx and reactive impurities

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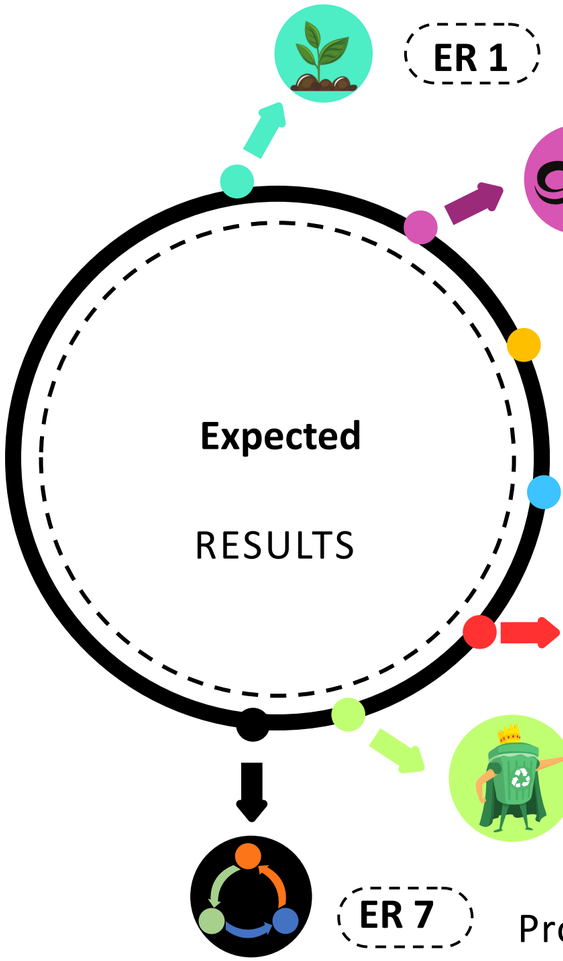
Key Exploitable and Expected Results



ER 1 Reducing the energy penalty and cost of CO_2 capture for CHP plants

ER 2 Efficient and scalable process concept for CHP plants based on CLC-CFB operation

ER 3 Utilizing biogenic residues and wastes for heat and power generation with negative emission

ER 4 Socio-economic analysis of adopting Bio-FlexCLC for converting biogenic residues and wastes to CHP

ER 5 Process of flue gas treatment to lower emission of particles and harmful gases, e.g. SOx, NOx and aromatics

ER 6 Improving conversion of the biogenic residues to heat and power

ER 7 Process and life cycle analysis of full value chain of Bio-FlexCLC

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Key Exploitable and Expected Results

Key Exploitable Results
KER 1: Design and develop operating strategies of a flexible CLC-CFB boiler Partners: AE, GMAB, RISE, TUDA, CTH, CSIC, and CERTH
KER 2: Demonstration of Bio-FlexCLC at TRL 5 for CHP production from biogenic residues and wastes with negative emissions at a lower cost and energy penalty for CO2 capture Partners: AE, FORT, VEAB, RISE, TUDA, CTH, CSIC, and CERTH
KER 3: Process for flue gas treatment and CO2 liquefaction of a Bio-FlexCLC plant Partners: RISE, GMAB, AE, TUDA, CTH, CSIC, and CERTH
KER 4: CFD models for fuel reactor with packings and post-oxidation chamber Partners: CERTH, CTH, TUDA, CSIC
KER 5: Socio-economic and environmental impact of a Bio-FlexCLC plant Partners: RISE, FORT, VEAB
KER 6: Process design and techno-economic evaluation of a Bio-FlexCLC plant Partners: RISE, AE, BE, FORT, VEAB, TUDA, CTH, and CSIC
KER 7: Exploitation Roadmap for Bio-FlexCLC process Partners: AE, FORT, GMAB, VEAB, RISE, TUDA, CTH, CSIC, and CERTH

Main end-user: Manufacturers of dual fluidized bed plants (combustion, incineration, and fuels conversion), Utility (heat and power) producers.

Value proposition: Compared to current CFB boilers, Bio-FlexCLC will reduce the risk of implementation by developing and demonstrating CLC-CFB concept, decreasing cost and energy penalty of CO2 capture, utilizing the biogenic residues and wastes as a fuel, and developing the gas cleaning and CO2 liquefaction.

Time to market: 4-6 years after the project ends

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Participants and Consortium Synergies

10 consortium partners from 7 EU countries

Partner	Role
RISE	Project coordination, process design and technoeconomic assessment, LCA and sLCA, developing gas cleaning and liquefaction processes
Repotec	Designing the process and operating strategies
GMAB	Designing gas treatment technologies
CTH	Improving process performance of flexible Bio-FlexCLC
CSIC	Chemical looping and fluidized bed combustion
CERTH	CFD modelling of post-oxidation chamber and fuel reactors with packings
TUDa	Demonstration of Bio-FlexCLC at MW scale; process evaluation and optimization of flexible Bio-FlexCLC
1Cube	Exploitation, Dissemination and Communication
FORTUM	Providing feedback and data for process and environmental analysis. Utility producer in Poland. Potential end user of the process.
VEAB	Providing feedback and data for process and environmental analysis. Utility producer in Sweden. Potential end user of the process.

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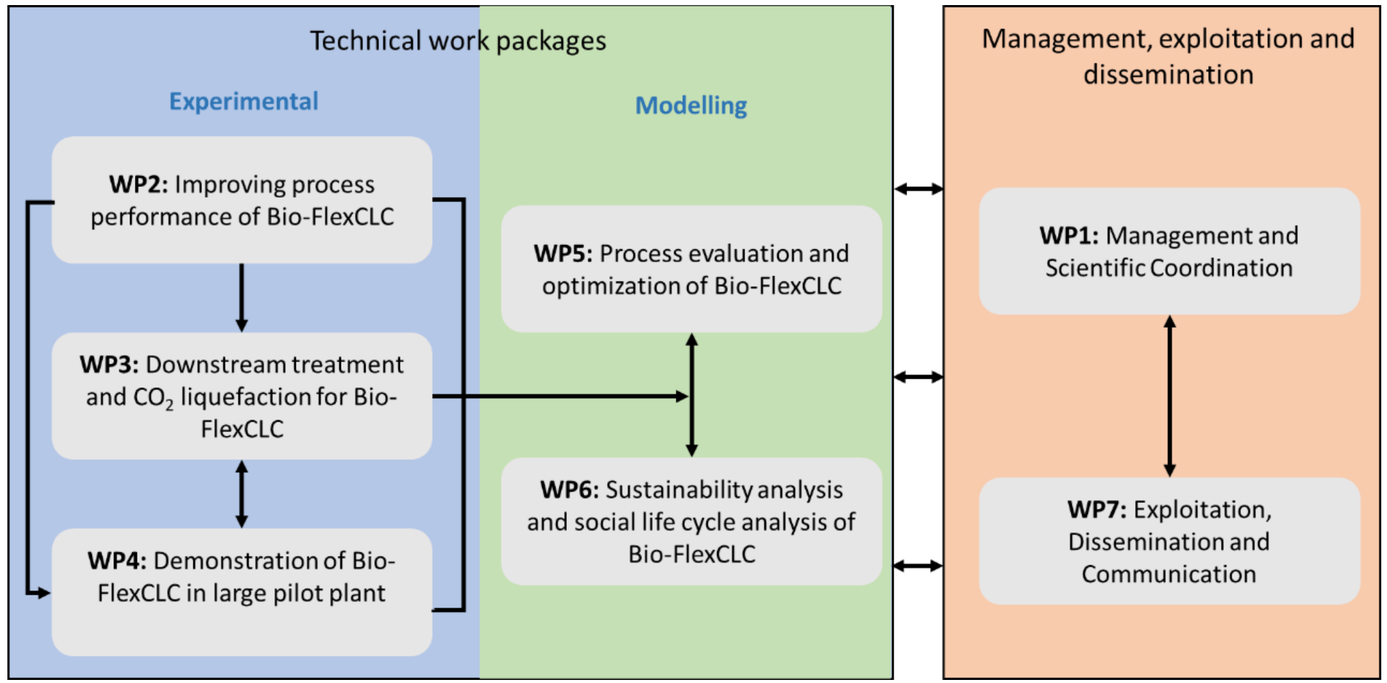
The overall structure of the work plan



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Methodology and Execution

To further understand CLC of biogenic residues

CLC operation mode with four different biogenic residues, e.g. agricultural and forestry residues, and investigate fate of ash species

To reduce the emissions of harmful gases and particles

Developing the gas cleaning procedure to reduce SOx, NOx, aromatics, and particle emissions including CO2 capture and CO2-Liquifaction unit

portable gas cleaning pilot plant

To improve the conversion of fuel by lab experiments and modelling

Reduce the fraction of unconverted fuel in the fuel reactor (below 10% oxygen demand, or above 90% gas conversion);
Reach >99% conversion in the fuel reactor and post post-oxidation step

10 kW CLC pilot reactor (left) and 20 kW CLC pilot plant (right)

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Methodology and Execution

To evaluate the flexibility of Bio-FlexCLC operation

Changing the thermal input in the Bio-FlexCLC operation from 100% to 75%, 60% and 50% with a ramp-up/down speed of the boiler load of at least 5 % MCR/min

Develop strategies for optimized operation at heat-to-power ratio of 1:1, 2:1, and 3:1

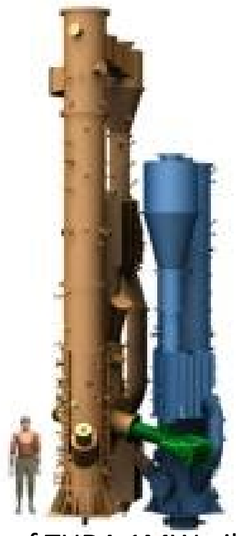
To demonstrate Bio-FlexCLC at MW-scale with downstream treatment and liquefaction

Operate the 1 MW bio-FlexCLC plant in CLC-CFB modes with downstream gas treatment and liquefaction for at least 200 hours and reach >95% CO2 capture

To design a full chain 100 MW commercial scale Bio-FlexCLC plant for CHP production from biogenic residues

To evaluate the economic and environmental performance of the process concept

Evaluate the environmental and economic performance for at least two locations for adopting Bio-FlexCLC in the regions in transition from fossil fuels



Drawing of TUDA 1MW pilot plant

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Impact of Bio-FlexCLC

- A fuel combustion facility which can achieve negative emissions with CO_2 capture.
- Possibility to run as a conventional CFB unit without CO_2 capture when market conditions are not viable for CO_2 capture.
- Facilitating the utilization of challenging-to-exploit or low-value bio resources like organic wastes.
- Creating new employment opportunities, particularly in biomass or residue-rich regions, such as rural areas.
- Reducing reliance on fossil fuels and mitigating the need for oil imports.
- Enhancing local and regional production autonomy and supply security.
- Boosting the economy in regions where waste generation or agriculture significantly contributes to GDP (Gross Domestic Product).
- Diminishing greenhouse gas emissions linked to the natural decomposition of low-value biomass.
- Contributing to the principles of the circular economy, particularly when resources like agricultural residues are effectively harnessed

European Green Deal

Reduce the carbon footprint & make the CHP plants more resilient and sustainable

An Economy that works for people

The exploitation of Bio-FlexCLC could generate direct and indirect jobs as the demand for the production of CHP with zero emissions and not from fossil fuel is increasing.

A stronger Europe in the world

Production of CHP from low value biogenic residue will play a key role when considering Europe´s security of energy.

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Questions / Comments

Please follow our project website and our LinkedIn page for the latest news and developments.
Website: https://www.bioflexclcproject.eu/
LinkedIn: https://www.linkedin.com/company/bio-flexclc/

Website

LinkedIn

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