Bio-Flex CLC

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

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Innovations in Near-Zero-Emission Biomass Heat and Power, Including Carbon Capture

November 2026



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Advancing Low-Risk, Flexible BECCS Technologies to Utilize Biogenic Residues and Wastes in CHP

De-Risking Investment

Low-risk and low-cost BECCS tech overcomes missing policy incentives.

Biogenic Residue Feedstock

Promote the circular economy with the advantage of no additional land use

Dynamic Grid Flexibility

Adjustable heat-to-power ratios balance intermittent renewables.

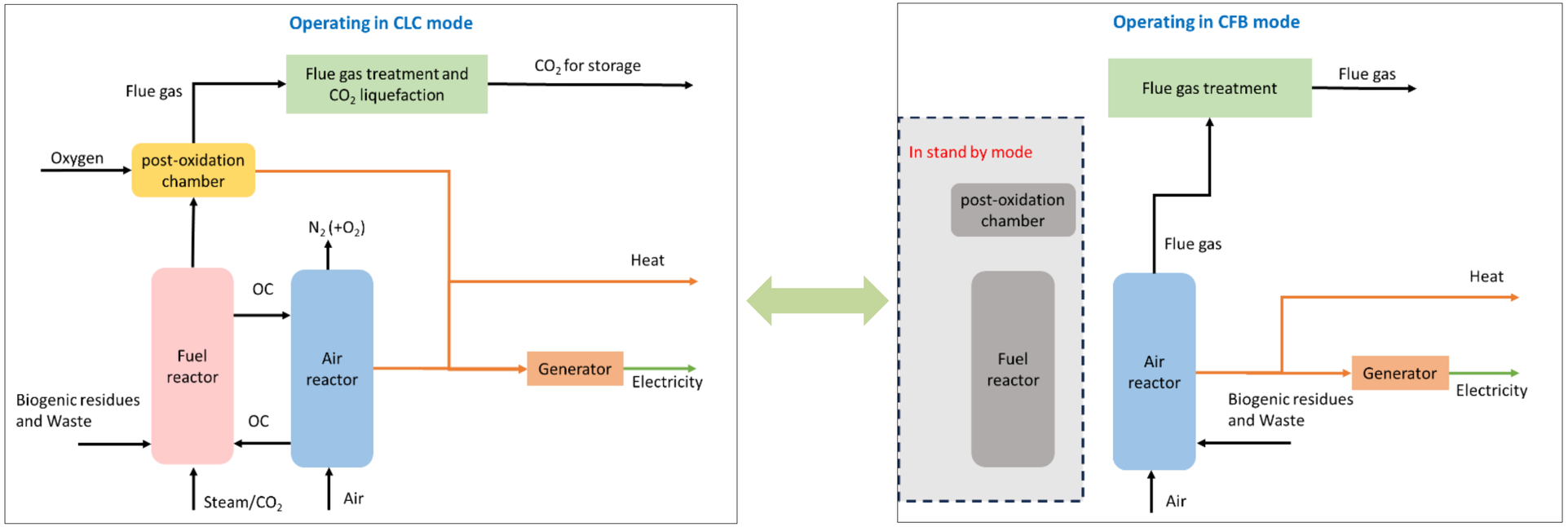
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Bio-FlexCLC Idea

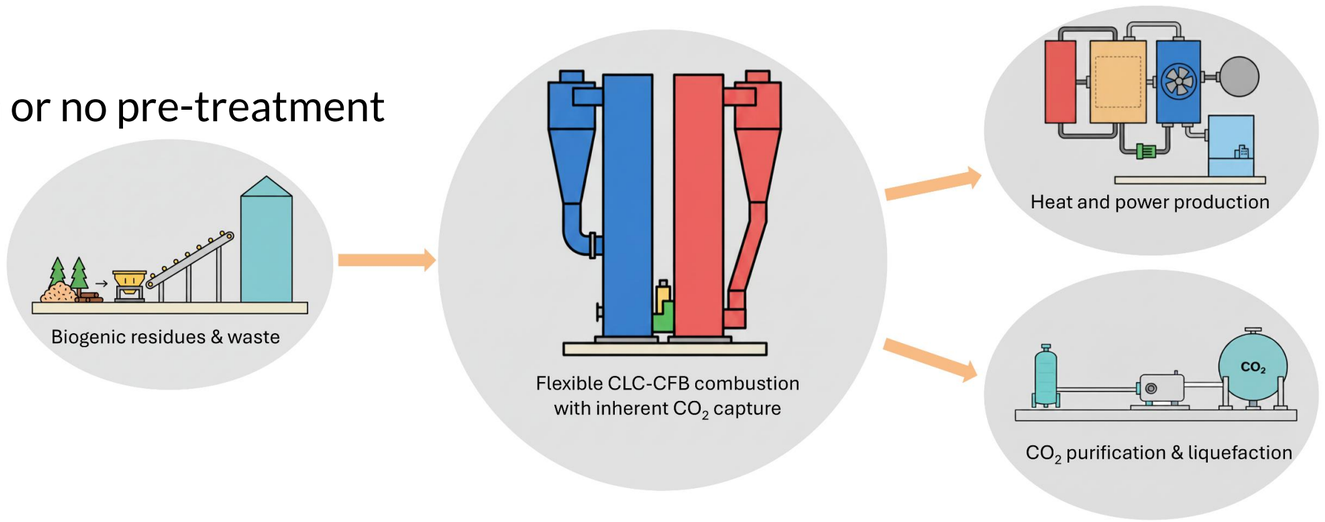
- The concept is based on dual circulating fluidized bed reactors which can operate in CLC mode while both reactors are in use or switch to conventional CFB operation when only one reactor is in use.
  - operating in CLC mode enables CHP production with negative emissions at low-cost while the concept is flexible to switch to CFB boiler mode to produce CHP with net-zero emissions



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Bio-FlexCLC Advantageous

1. Strong compatibility with existing infrastructure, as the technology is based on fluidized bed combustion, a common technology for heat and power production,
2. Have the flexibility to switch to conventional Circulating Fluidized Bed (CFB) combustion if market conditions are not amiable for carbon capture,
3. Since CLC offers inherent CO_2 capture, the CO_2 capture process automatically adapts to load variations
4. Have higher efficiency and lower cost and energy penalty and for CO_2 capture (close to 100%),
    - Negative emission (CDR) at low cost
5. Can utilize biogenic residues and wastes with minimum or no pre-treatment
5. Have flexibility towards load fluctuations,
6. Have low corrosion with improved steam data for improved electrical efficiency,
7. Reduce SOx and NOx emissions



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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

Black pellets | Olive stones | Branches & treetops | RDF



To reduce the emissions of harmful gases and particles

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



portable gas cleaning pilot plant

To improve the conversion of fuel by adding packings in the fuel reactor and post oxidation chamber

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%

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

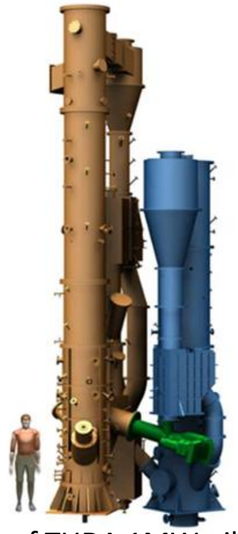
To demonstrate Bio-FlexCLC at MW-scale with downstream treatment and liquefaction

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% CO_2 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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Bio-FlexCLC

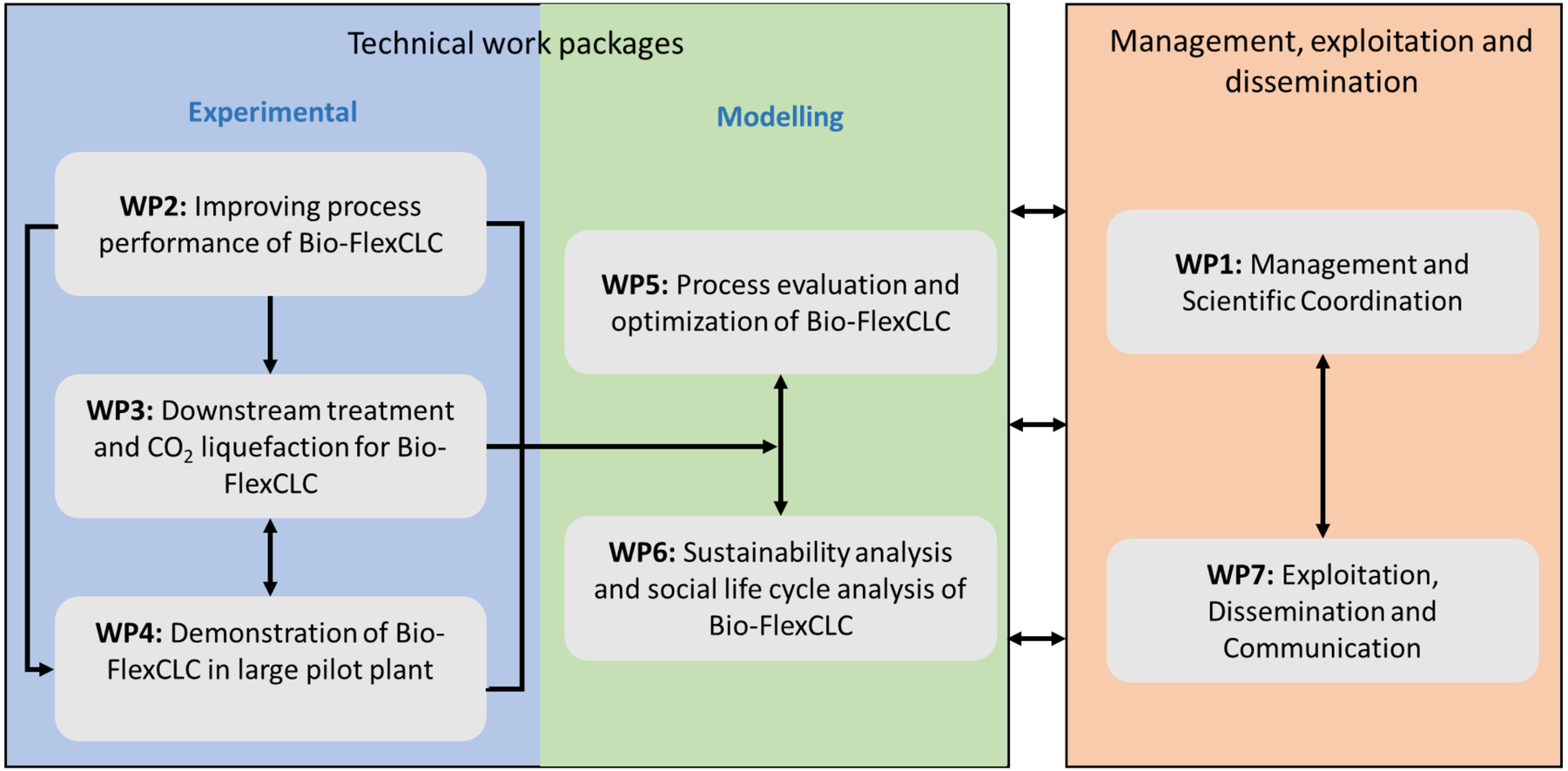
Duration: 48 months
Start Date: June 2024
Funding: Approximately €3.9 million, funded by the European Union (EU).

	Participant organisation name
1	RISE RESEARCH INSTITUTE OF SWEDEN
2	AICHERNIG ENGINEERING
3	GÖTAVERKEN MILJÖ AB
4	TECHNISCHE UNIVERSITAT DARMSTADT
5	CHALMERS TEKNISKA HOGSKOLA
6	SPANISH NATIONAL RESEARCH COUNCIL
7	NATIONAL CENTER FOR RESEARCH AND TECHNOLOGICAL DEVELOPMENT
8	1CUBE
9	FORTUM POWER AND HEAT POLSKA
10	VÄXJÖ ENERGI AB



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The overall structure of the work plan in Bio-FlexCLC



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Thank you for your attention

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