CO2CE

HARNESSING THE POTENTIAL OF BIOLOGICAL CO_2 CAPTURE FOR THE CIRCULAR ECONOMY

Department for Energy Security & Net Zero

Co-funded by the European Commission within the Horizon 2020 programme

Accelerating CCS Technologies

7th ACT Knowledge Sharing Workshop
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Paris, France

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CooCE Partners

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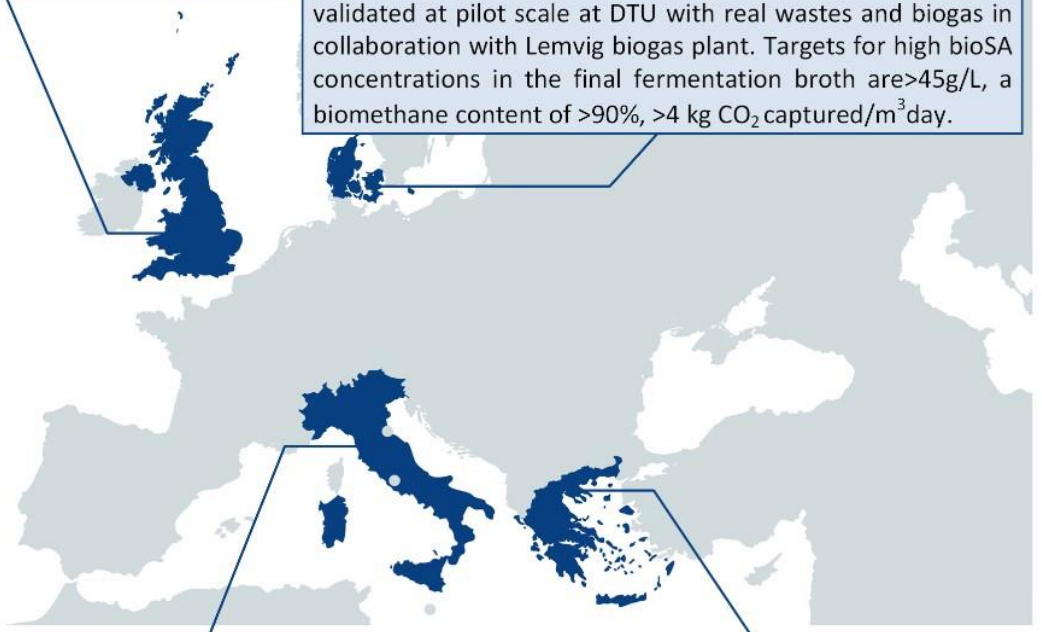
CooCE in UK: Assessment of CO_2 conversion technologies and impacts of **CooCE** on environment and socio-economy through a holistic sustainability analysis, stakeholder engagement.

CooCE in Denmark: Evaluation of CO_2 conversion to bioSA will be performed in Denmark using biogas as the source for CO_2. Selection of high performance succinogenic bacterial will be evaluated for their performance and optimized by evolutionary adaptation. The best fit for using biogas and high strength organic wastes will be chosen. The process will be validated at pilot scale at DTU with real wastes and biogas in collaboration with Lemvig biogas plant. Targets for high bioSA concentrations in the final fermentation broth are>45g/L, a biomethane content of >90%, >4 kg CO_2 captured/m^3day.



CooCE in Italy: Evaluation of CO_2 conversion into PHA will be performed in Italy using emissions from BTS biogas s.r.l. Mainstream and alternative PHA producers will be tested to choose the best fit for the specific gaseous CO_2-rich streams (biogas) ensuring to use the best possible microbial strains. PHA produced will be further evaluated by ENP to pre-commercial phase by producing prototype bioplastic materials.

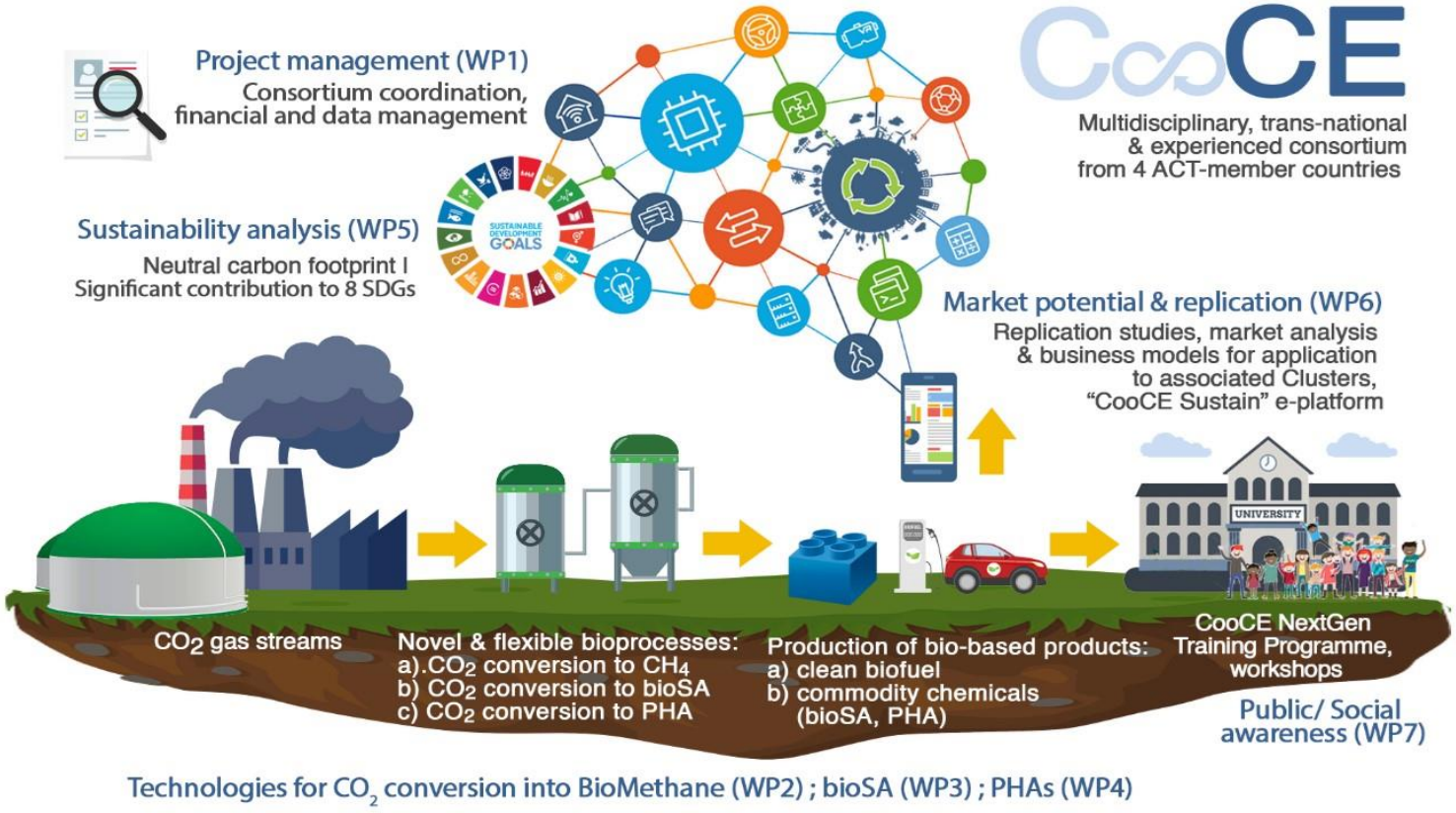
CooCE in Greece: Evaluation of CO_2 hydrogenation will be performed in lab and pilot scale conditions in Greece addressing the needs of the Greek Cluster of Raw Materials (www.grawmat.gr). The GRawMat cluster, led by EcoResources (member of the European Raw Materials Alliance), is comprised by the **top-10 Greek mining industries** (Mytilineos Group, Hellenic Gold, Stonegroup, Grecian Magnesites, North Aegean Slops, Mathios Refractories, GeoHellas, Aegean Perlites, Eco Efficiency, Ellimet.). The overall goal is to **demonstrate for the first time** an optimized bioprocess able to capture and transform **>5 kg CO_2/m^3reactor/day.**

CooCE Concept & Main Objectives

Industrial sectors currently account for 20% of global CO_2 emissions

CooCE targets to develop and demonstrate a novel biotechnological platform where **CO_2 from biogas or exhaust gasses** is converted into:

- **upgraded biofuels** for flexible on-site hybrid energy storage
- **high market value platform chemicals** forming the building blocks of various biopolymers and bioproducts.



CO_2 sources: biogas & exhaust gasses

BTS

lemvigbiogas.com

WP and Tasks

WP1. Management and Coordination

- T1.1 Project coordination
- T1.2 Financial management
- T1.3 Data management
- T1.4 Coordination with and reporting to ACT

WP2. Biomethane Production

- T2.1 Analysis of CO_2 sources for bioprocesses
- T2.2 Efficiency tests of different H_2 injection regimes and reactor configurations
- T2.3 Validation of the process under intermittent H_2 provision
- T2.4 Process optimization

WP3. BioSA bioproduction

- T3.1 Analysis of biogas plant feedstocks and CO_2 availability for bioSA
- T3.2 Screening and test of alternative bioSA producer strains
- T3.3 Microbial strain improvement
- T3.4 Scale-up operation using second generation feedstocks
- T3.5 Downstream separation, assessment of bioSA purity and bioplastic potential use

WP4. PHA production

- T4.1 CO_2-rich gas and waste streams selection & characterization
- T4.2 Production of PHA from waste CO_2 and sunlight
- T4.3 Bacterial PHA production from carbon streams
- T4.4 PHA recovery, quality assessment and use as bioplastic

WP5. Sustainability analysis and socio-economic impact

- T5.1 Environmental assessment
- T5.2 Socioeconomic and policy assessment
- T5.3 Stakeholder assessment and engagement
- T5.4 Economic assessment
- T5.5 Integrating results

WP6. Market potential and CooCE replication

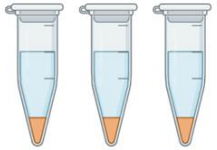
- T6.1 Replication case scenarios
- T6.2 Identify and liaise with related initiatives
- T6.3 Market analysis, development of business models and opportunities for end-users
- T6.4 Development of "CooCE Sustain" e-platform

WP7. Innovation outreach, Impact, Communication and Exploitation

- T7.1 Communication and Dissemination activities
- T7.2 CooCE Training Programme

Platform chemicals evaluation & end users

PHAs mechanical extraction



precipitation using alcohols

optimization evaluated in terms of

- PHAs recovery
- PHAs purity
- productivity of the extraction process

PHAs fractions shipment

Imperial College

applicability as biomaterial assessment

pond

EURONEWPACK
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packaging production

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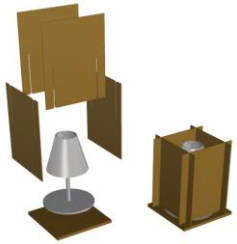
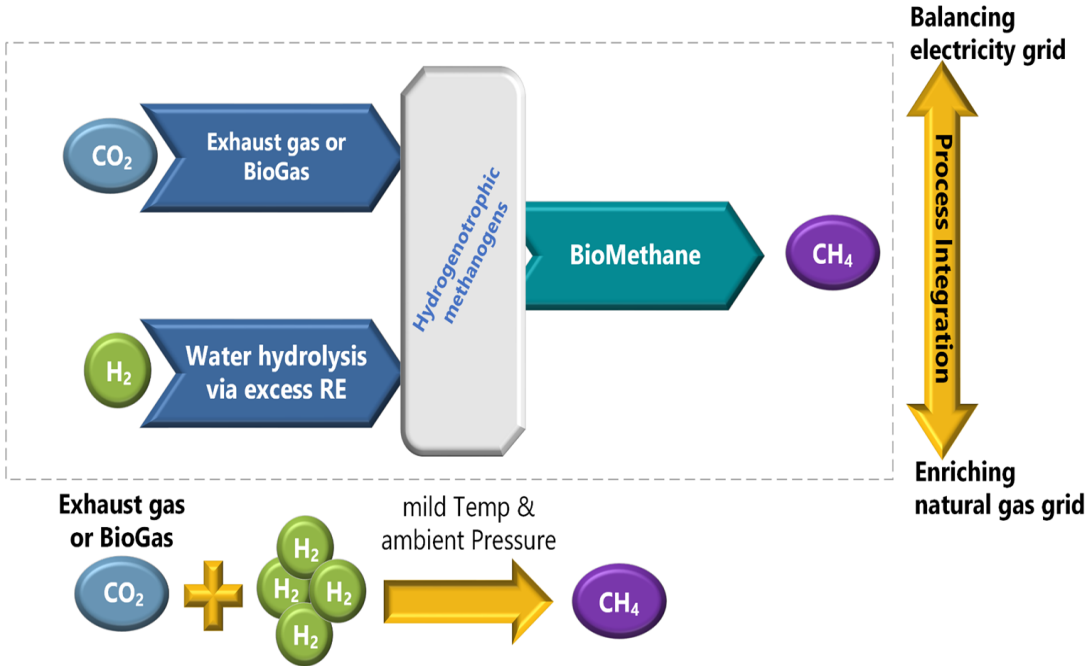
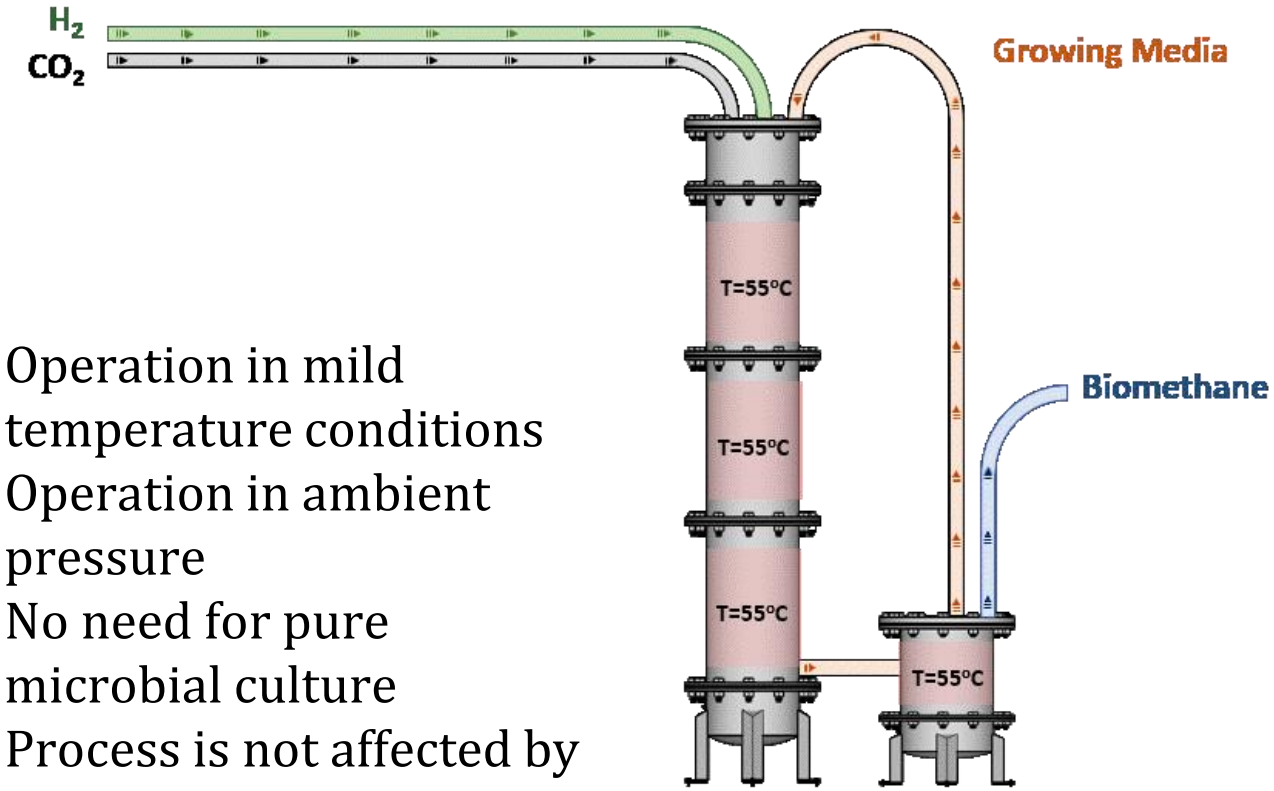


WP2 concept





- ✓ Operation in mild temperature conditions
- ✓ Operation in ambient pressure
- ✓ No need for pure microbial culture
- ✓ Process is not affected by the CO2 purity
- ✓ Transformation of CO_2 to 3-gen biofuel (biomethane)

Biomethane production

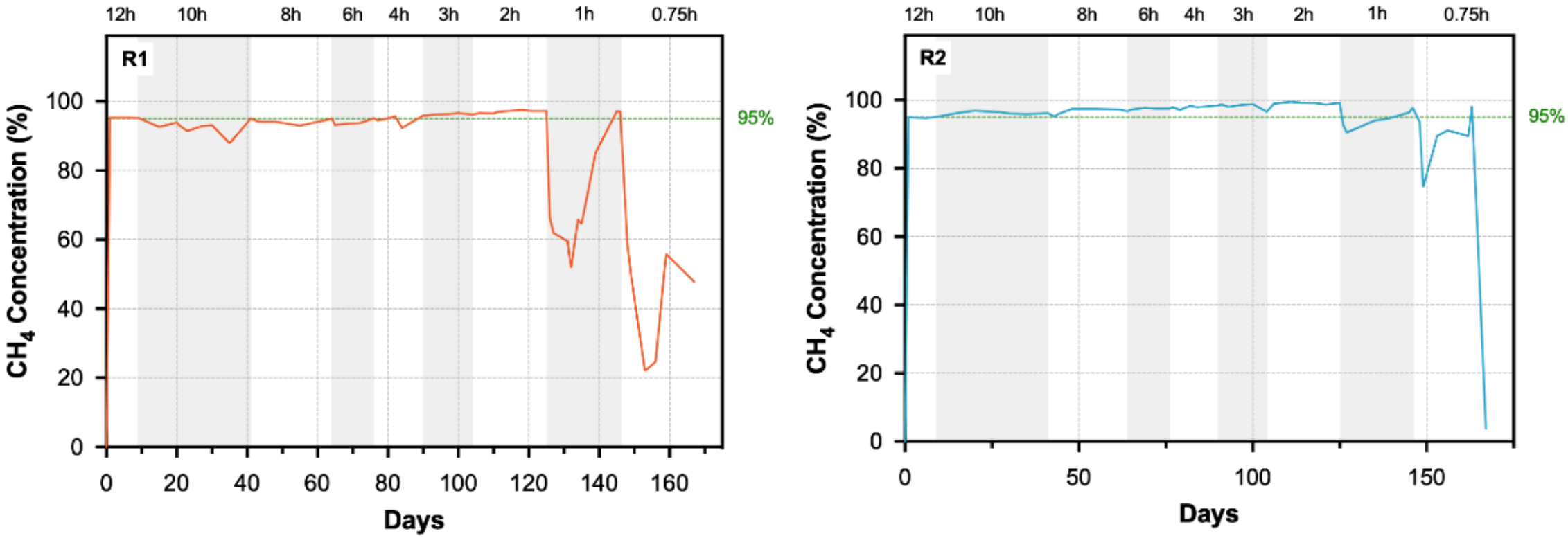
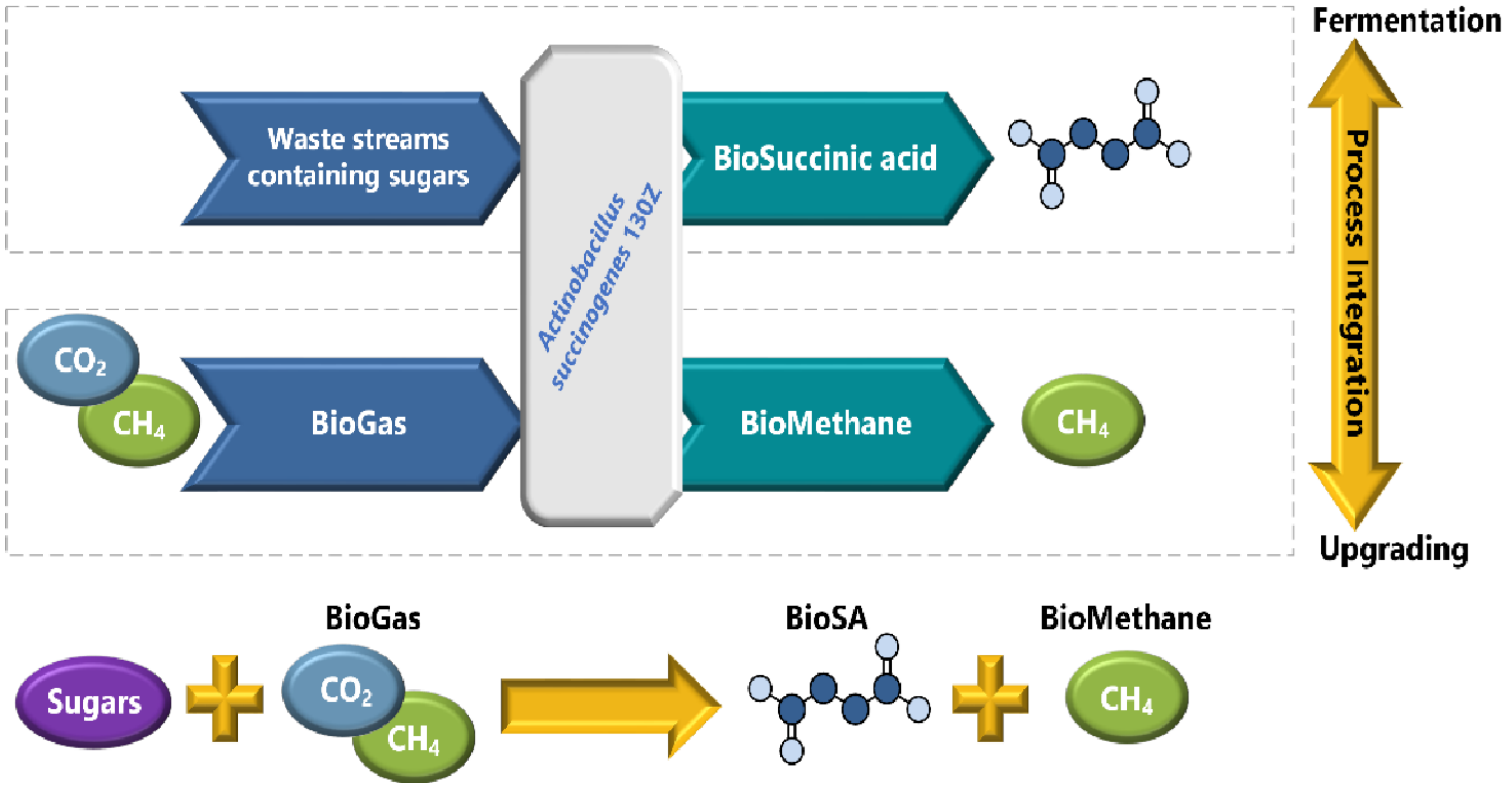


Fig. 1 Concentration of methane at the output gas of R1 and R2 during the different Gas Retention Times.

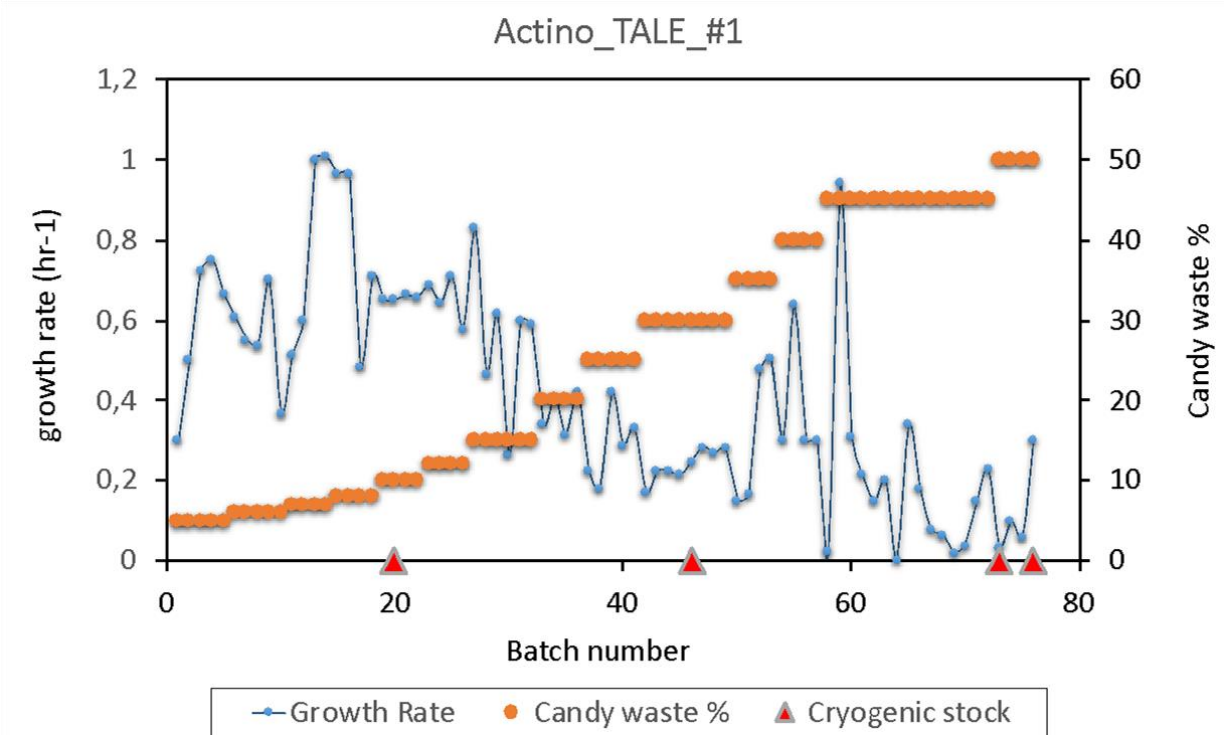
WP 3 Succinic acid production

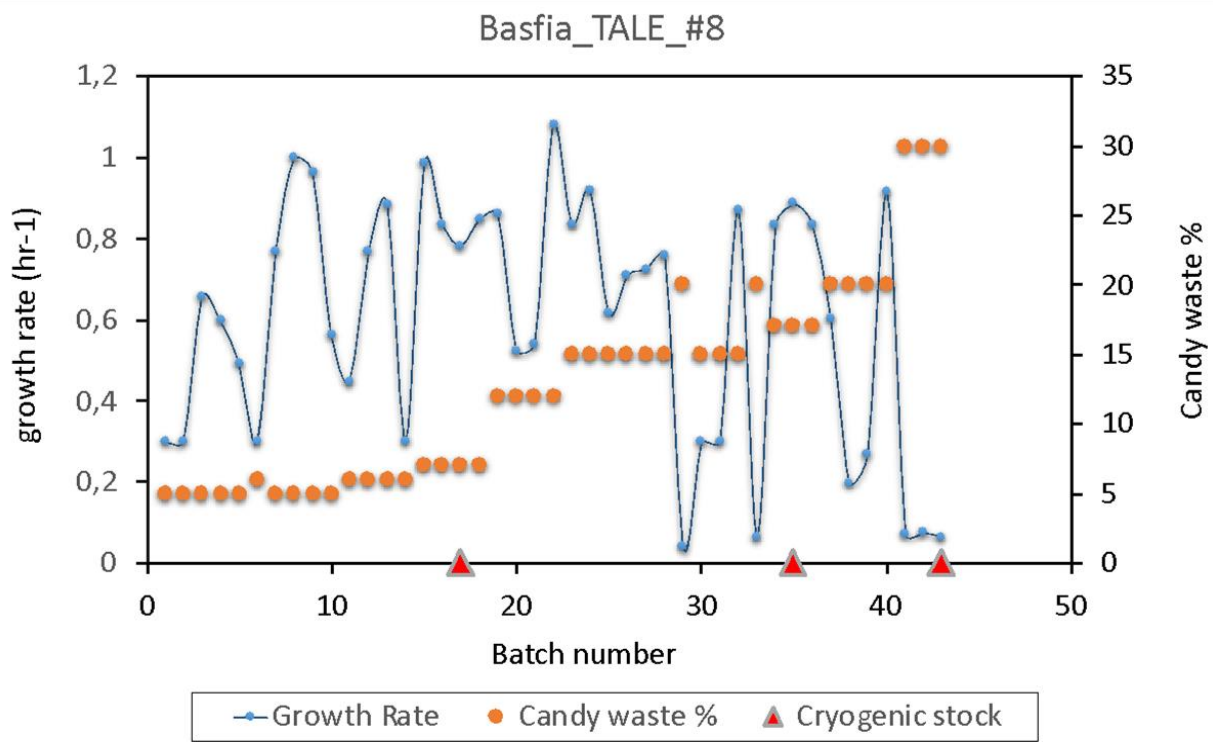


Screening of bioSA-producing strains
Microbial strain selection and improvement

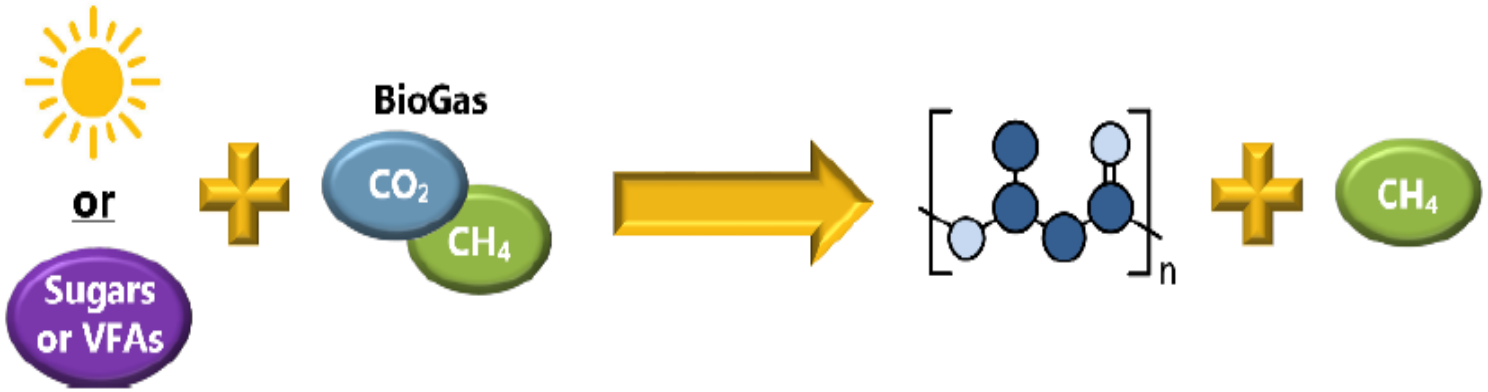
ALE (**Adaptive Laboratory Evolution)** protocol for increased tolerance to high Candy Waste concentration (>250 g/l sugars)

- *4 replicate lineages for each wild-type strain*





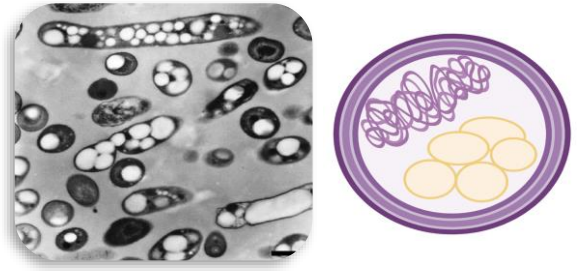
WP4: PHA production

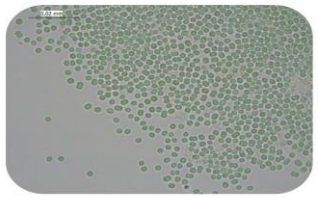


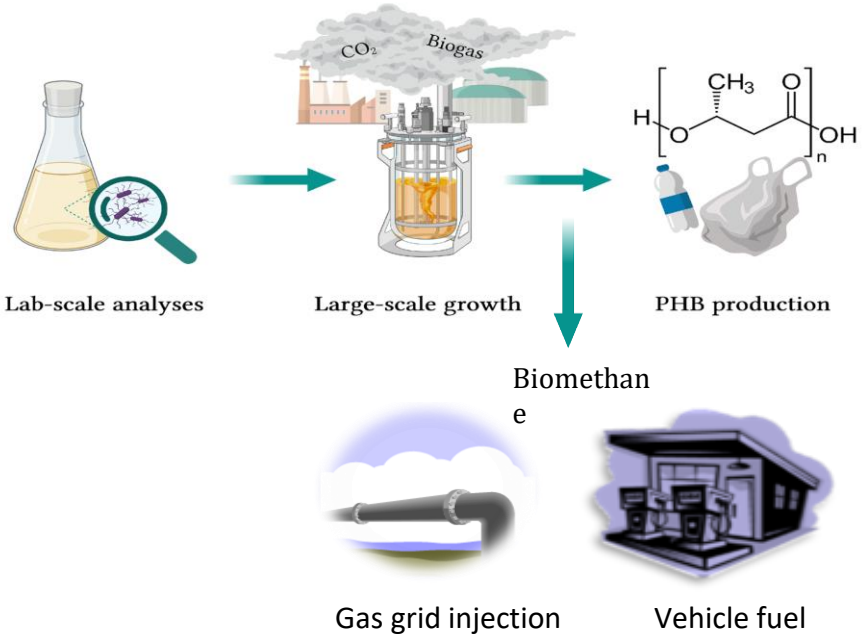
Biological PHAs production at lab-scale using real gas stream from biogas plant

Cupriavidus necator DSM 545

Synechocystis sp. B12

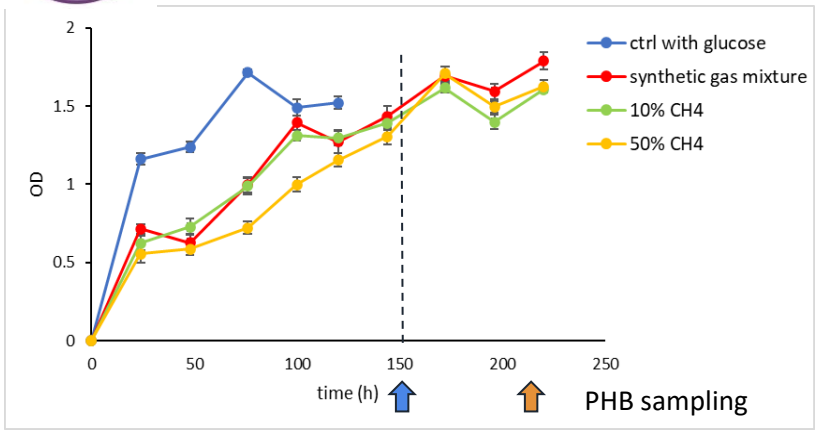


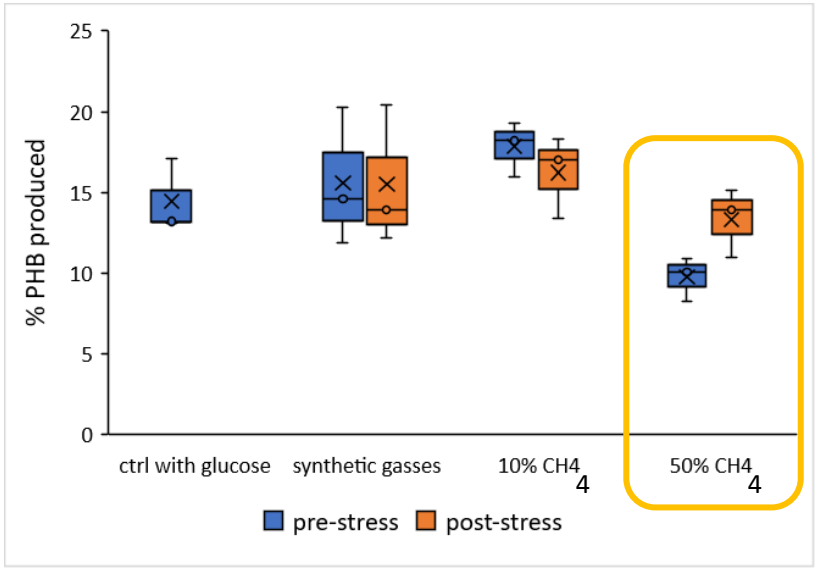




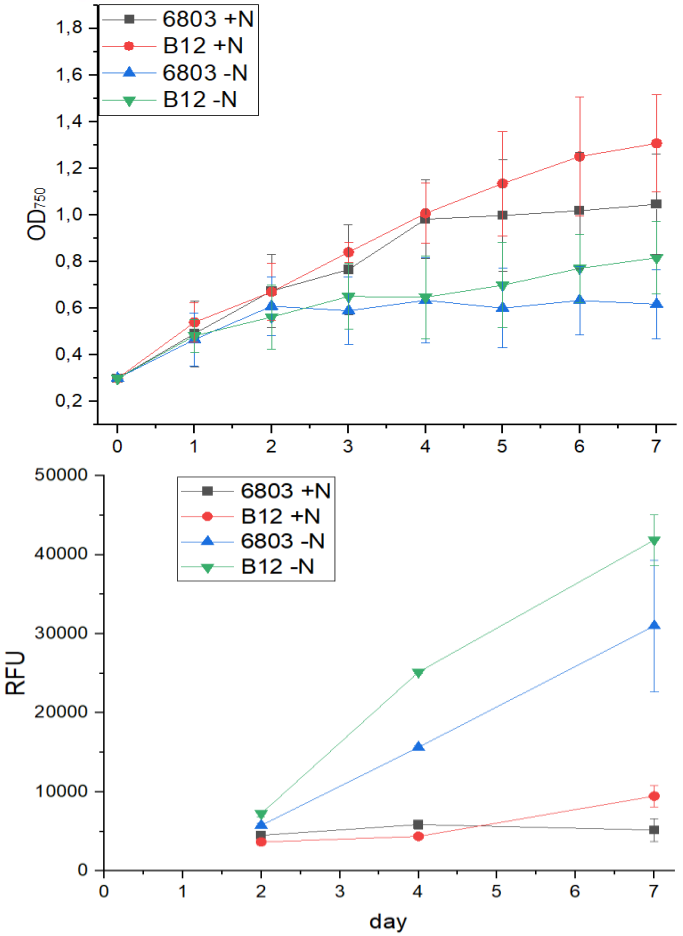
C. necator growing in CH_4 synthetic mixture

Cupriavidus necator DSM 545





Synechocystis sp. B12



- Both organisms are highly tolerant to methane and real biogas
- High PHB accumulation achieved in *Synechocystis* sp. B12

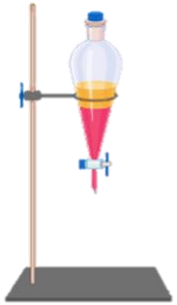
PHB extraction

Traditional toxic methods (Benchmark)

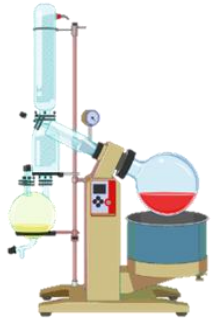
cell separation

lyophilization

PHB extraction



distillation



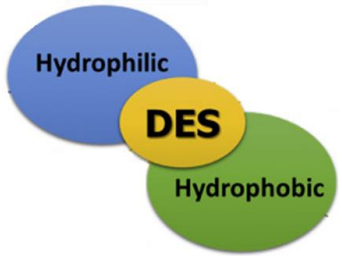
PHB extracted

culture

Green Solvents for future PHB extraction:

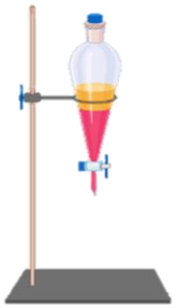
Solvents	Anti-solvents
•Ethyl acetate	•Ethanol
•Methyl ethyl ketone	•Methanol
	•Acetone

Deep Eutectic Solvents (DES)



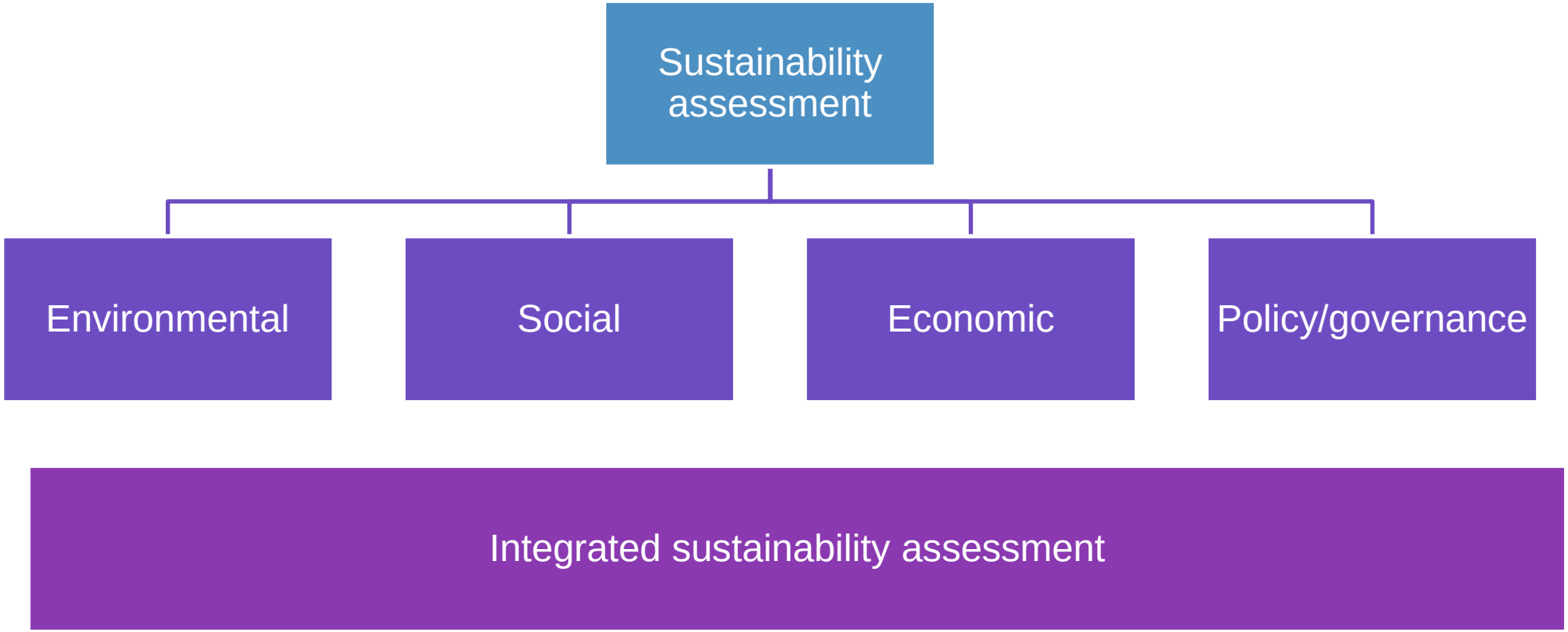
Novel alternatives for future experiments

cell separation



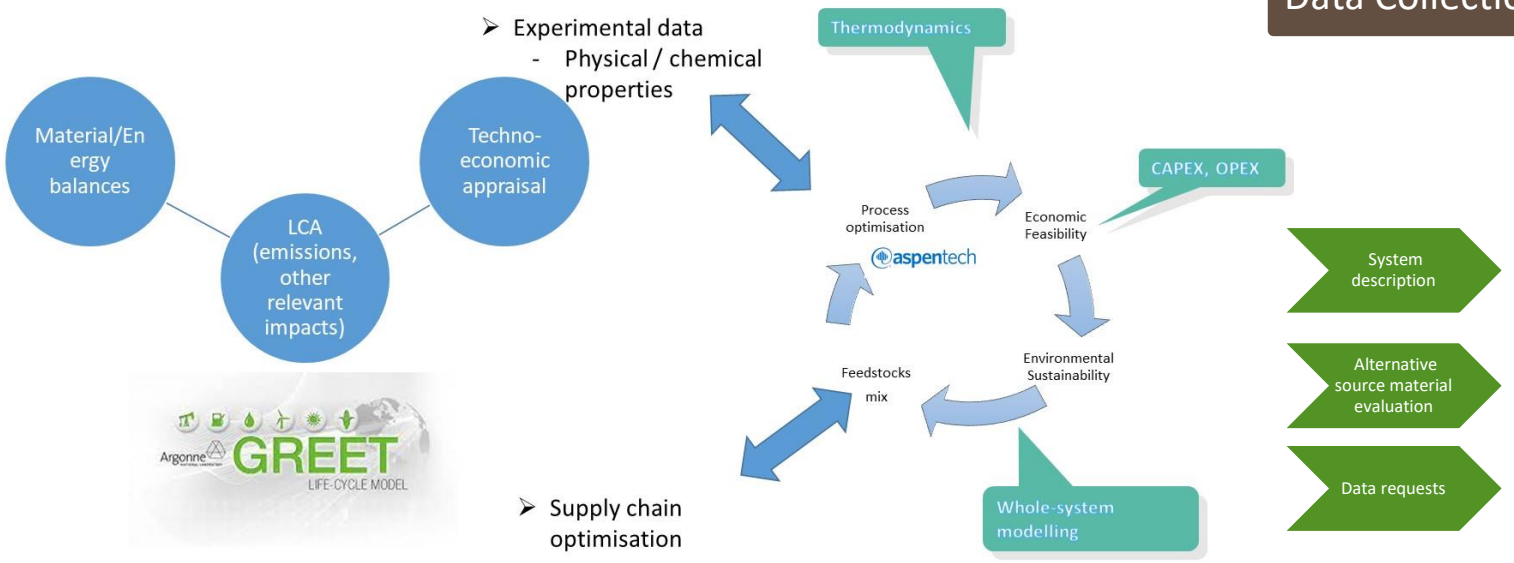
PHB extraction using DES+chemical cell disruption

WP 5 Sustainability assessment

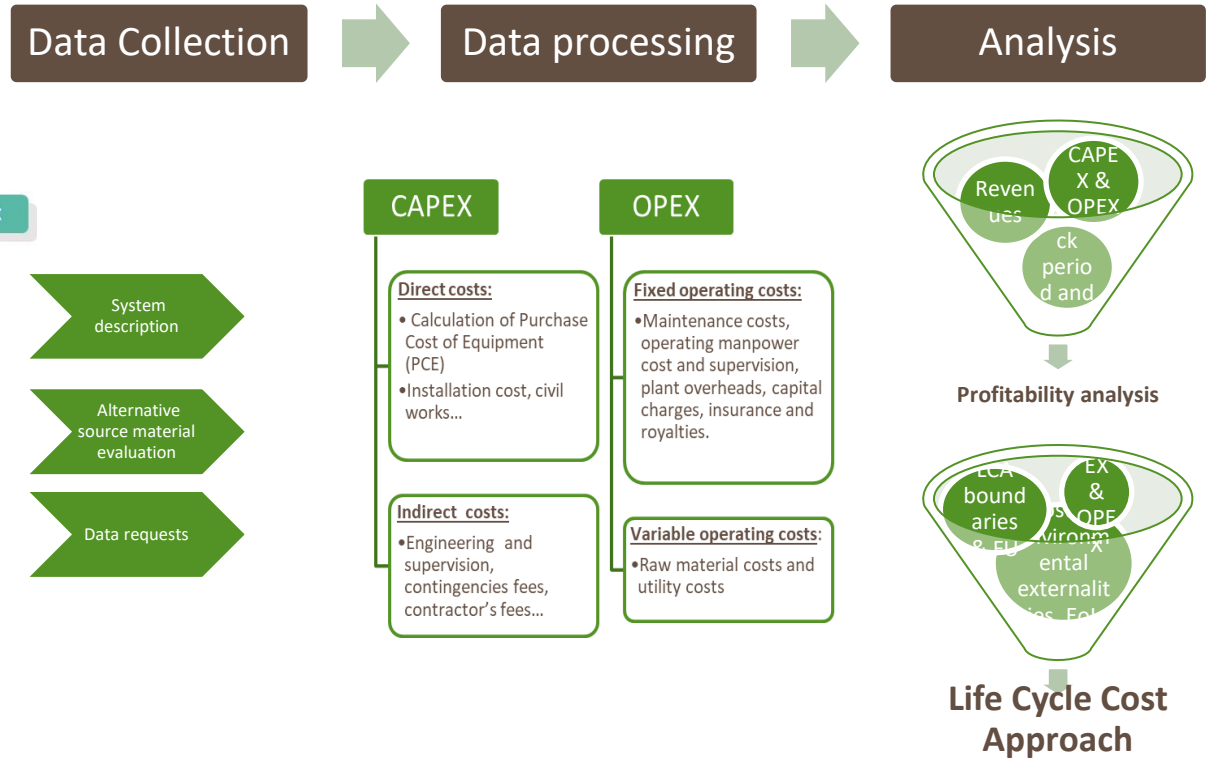


Environmental Assessment Life cycle analysis

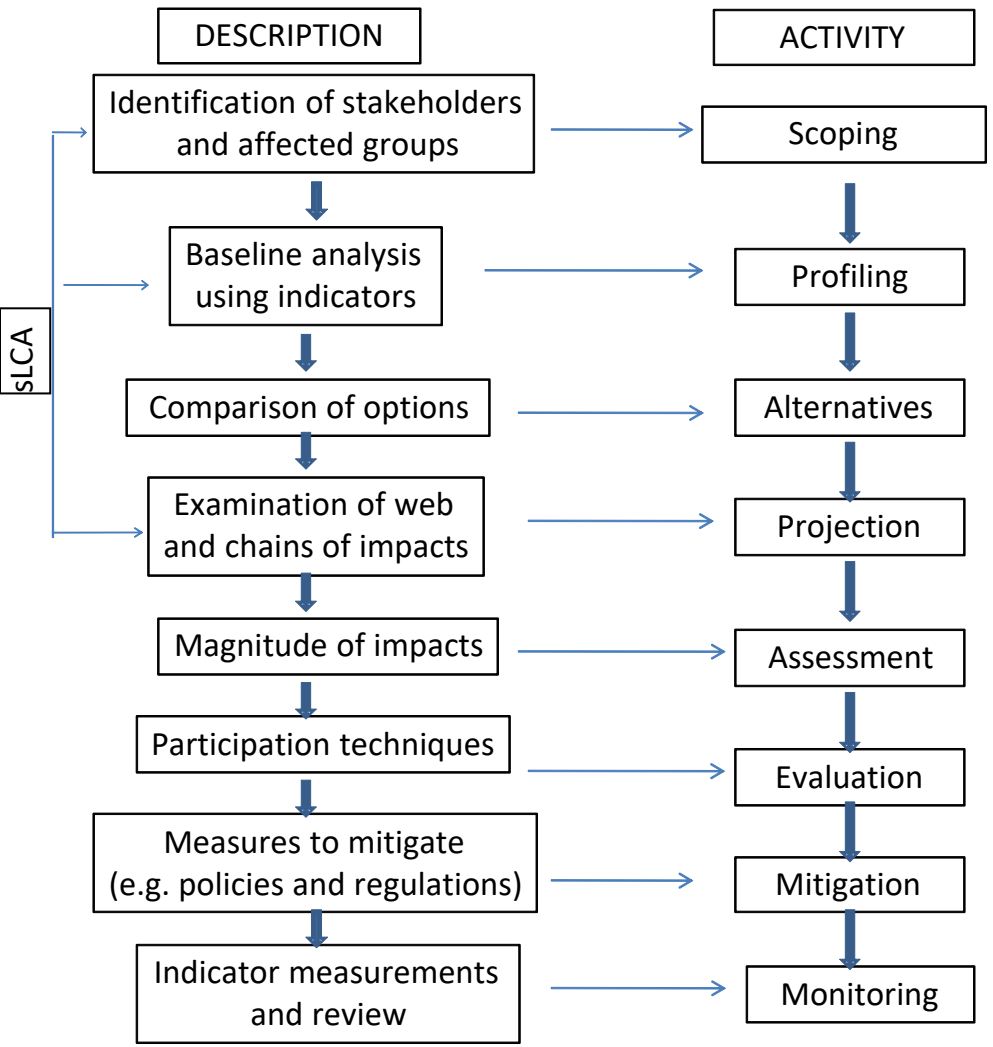
Circular Economy



Micro-Economic Assessment



Adapted social impact assessment to sLCA



(Diaz-Chavez, 2012)

Workshop in Bologna with stakeholders EUBCE, June 2023

Advantages	Challenges
CooCE Concept	***Concept/CCUS***
Addresses policy agendas for lowering emissions	Competing uses for renewable energy
Carbon negative	Complex market for biogas producers
CO_2 as feedstock	Costly investment
Circularity	Energy requirements
Decentralised approach	Lack of funding mechanisms
Diversified applications	Little known yet
Favoured by net zero emissions mandates	Multitude of stakeholders
Suitable across industries/sectors	Own CO_2 emissions
Potentially profitable	Potential shortage of CO_2
Revenue pathway for biogas producers	Public perception
Techno-process	Scalability
Biodigestion	Slow market expansion in EU
Bioreaction	***Techno-process***
Biomethane upgrade	Bacteria use/storage/platform purification
Gases purification	Biogas transportation
Integrated System	H_2 production
System easy to operate	Large-scale growth of microorganisms
Product	Potential CO_2 leakage
Biogas from CO_2 upgrade	Reactor configuration
Chemicals platform	***Product***
Diversified range of outputs	Quality standards for commercial use
Fuels from CO_2 with H_2	***Policy/Regulation***
High Purity bio-CH_4	Lack of consistency in EU regulations
Bioplastics (rising demand)	Lack of policies for CCUS/its bioproducts

(Diaz-Chavez, 2012)

Organisers
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Dr Diaz-Chavez, Dr Evans and Dr Giarola
Coordinator CooCe:
Dr Tomas Morisoto

Imperial College London

Accelerating CCS Technologies

Next steps

- WP2 – 4 Move from Lab to pilot scale
- WP2 Biomethane finishing in September 2023
- WP4 to produce PHP to be analysed at Imperial College
- WP5 include pilot data and move to sustainability assessment
- WP6 Market potential
- WP7 training programme in 2024

Please complete the CooCE survey!

Could you please take part in an online survey on Carbon Capture Use and Storage (CCUS)? The aim is to understand how stakeholders view CCU/S, its potential, possibilities and challenges.

The survey is for CooCE project (https://cooce.eu/), which is jointly funded by ACT-ERANET, under the European Union's Horizon 2020, No 327331 and UK BEIS.

Your can access it through this link https://imperial.eu.qualtrics.com/jfe/form/SV_3CqtT0XqwYSvpVI and also the QR code.

Please participate and share the link.

The survey will close on the 30th August. Thank you so much!

Thank you for your kind attention