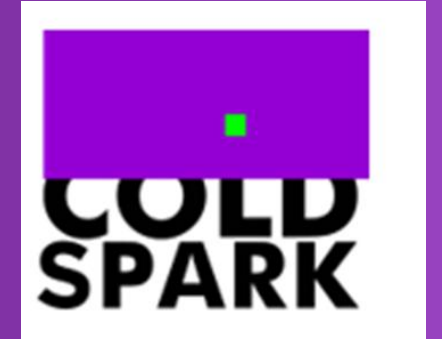


# ColdSpark® Workshop

Progress in Biogas VI

03/09/2024



## Unveiling ColdSpark®: A Life Cycle Assessment Methodological Framework for Evaluating Environmental Performance

Speaker: PhD candidate Isabella Bulfaro  
IREC Catalonia Institute for Energy Research



Funded by  
the European Union



# Outline

1

## Introduction:

- ColdSpark<sup>®</sup> project
- LCA Methodology

2

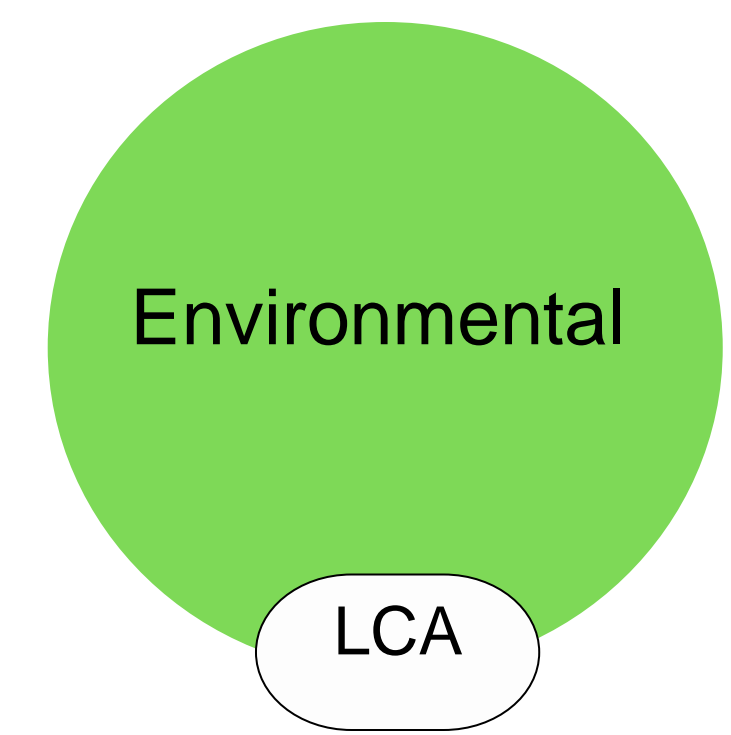
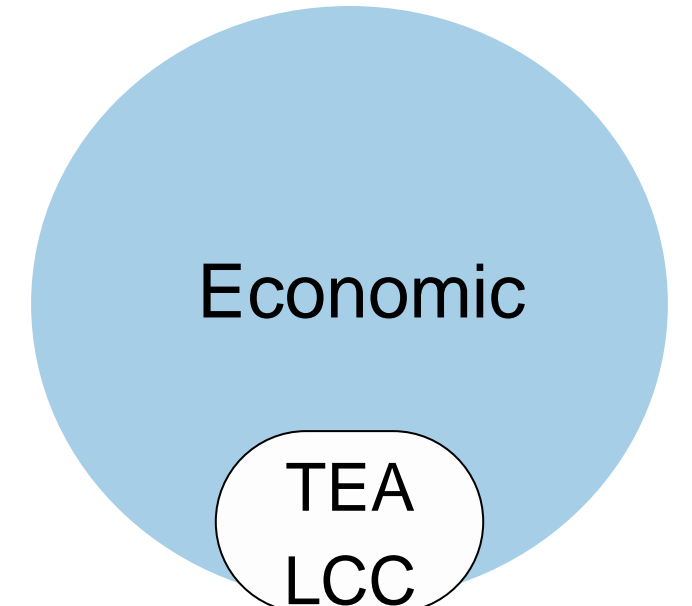
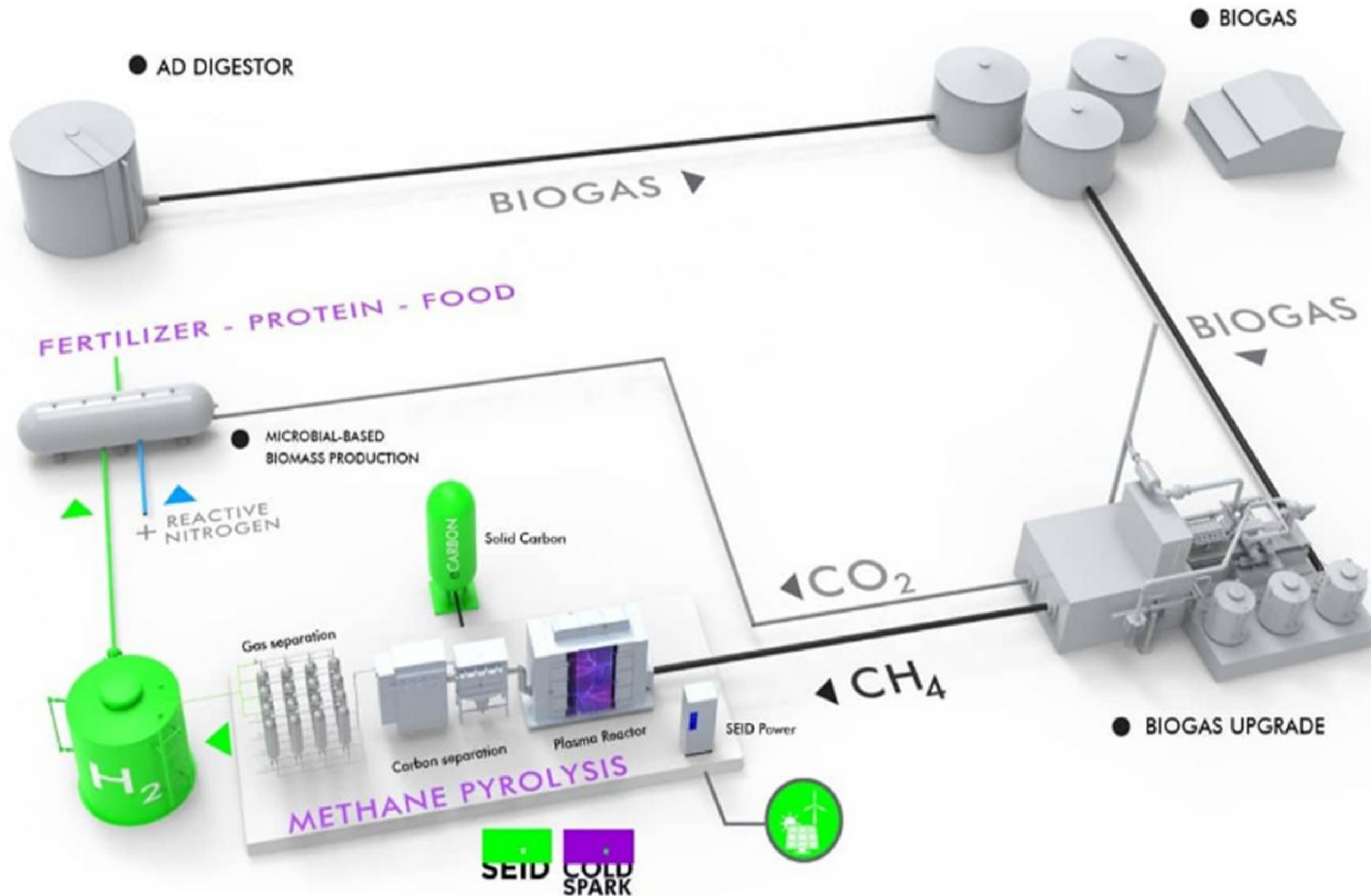
LCA methodological  
approach for ColdSpark<sup>®</sup>  
NTP technology

3

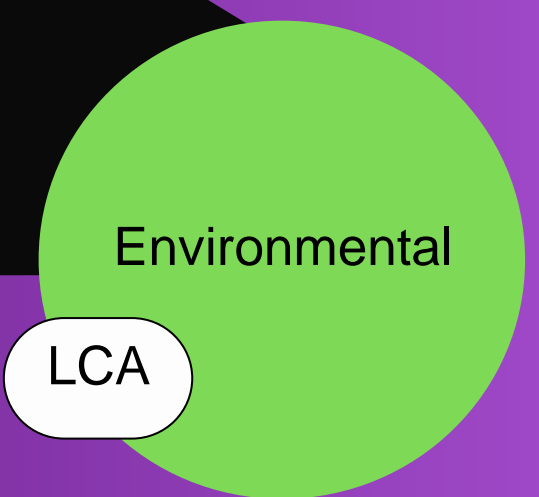
## Preliminary results:

- GHG emissions analysis
- Methodology comparison with Red III

# What is the Role of IREC in ColdSpark®?

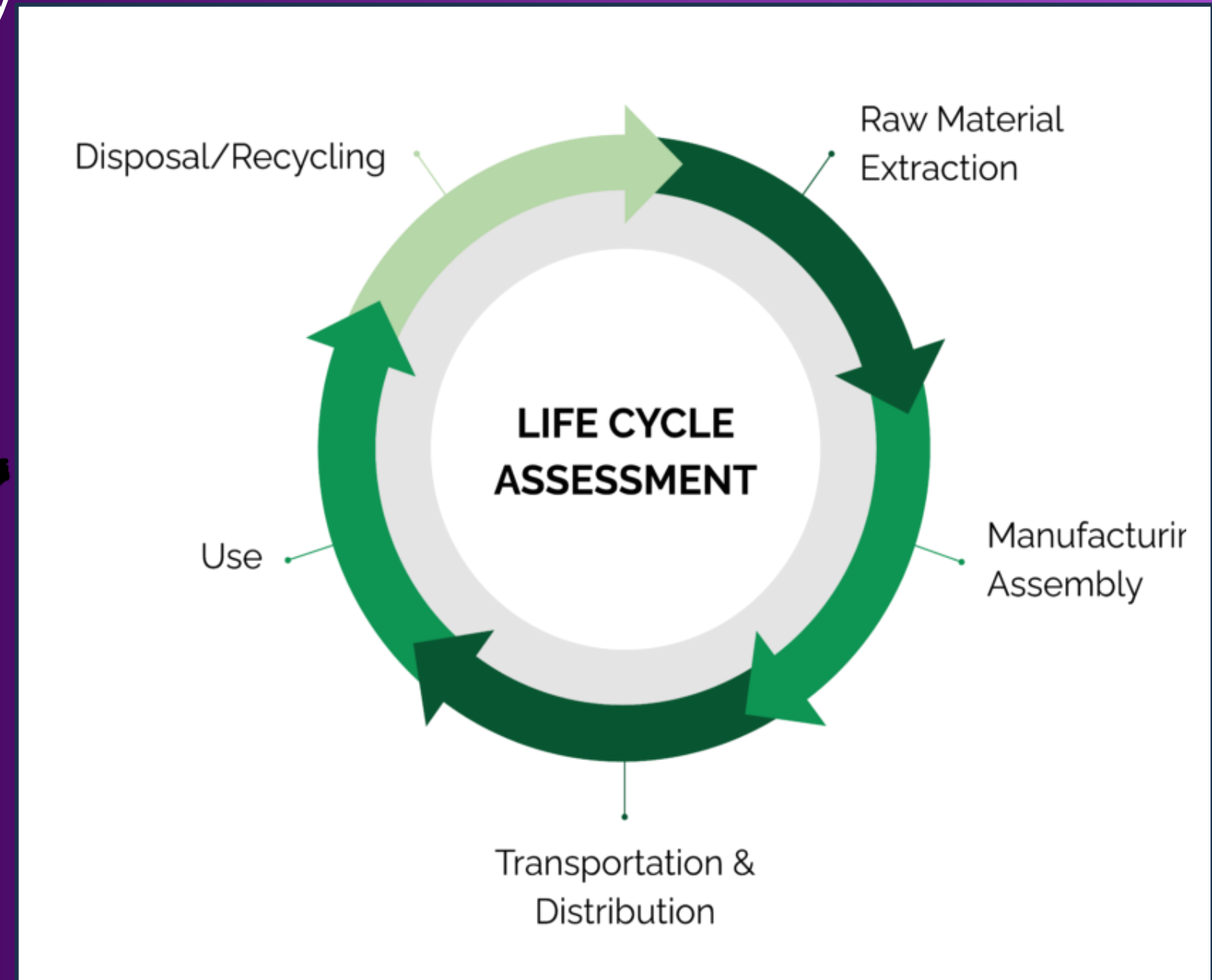


# What is Life Cycle Assessment (LCA)?



LCA is the worldwide recognised methodology for assessing the environmental impacts of a product or activity throughout its entire life cycle. The LCA follows the standards ISO 14040 - 14044:2006

- Life cycle focus
  - Multicriteria
- Quantitative methodology
- Comparative approach



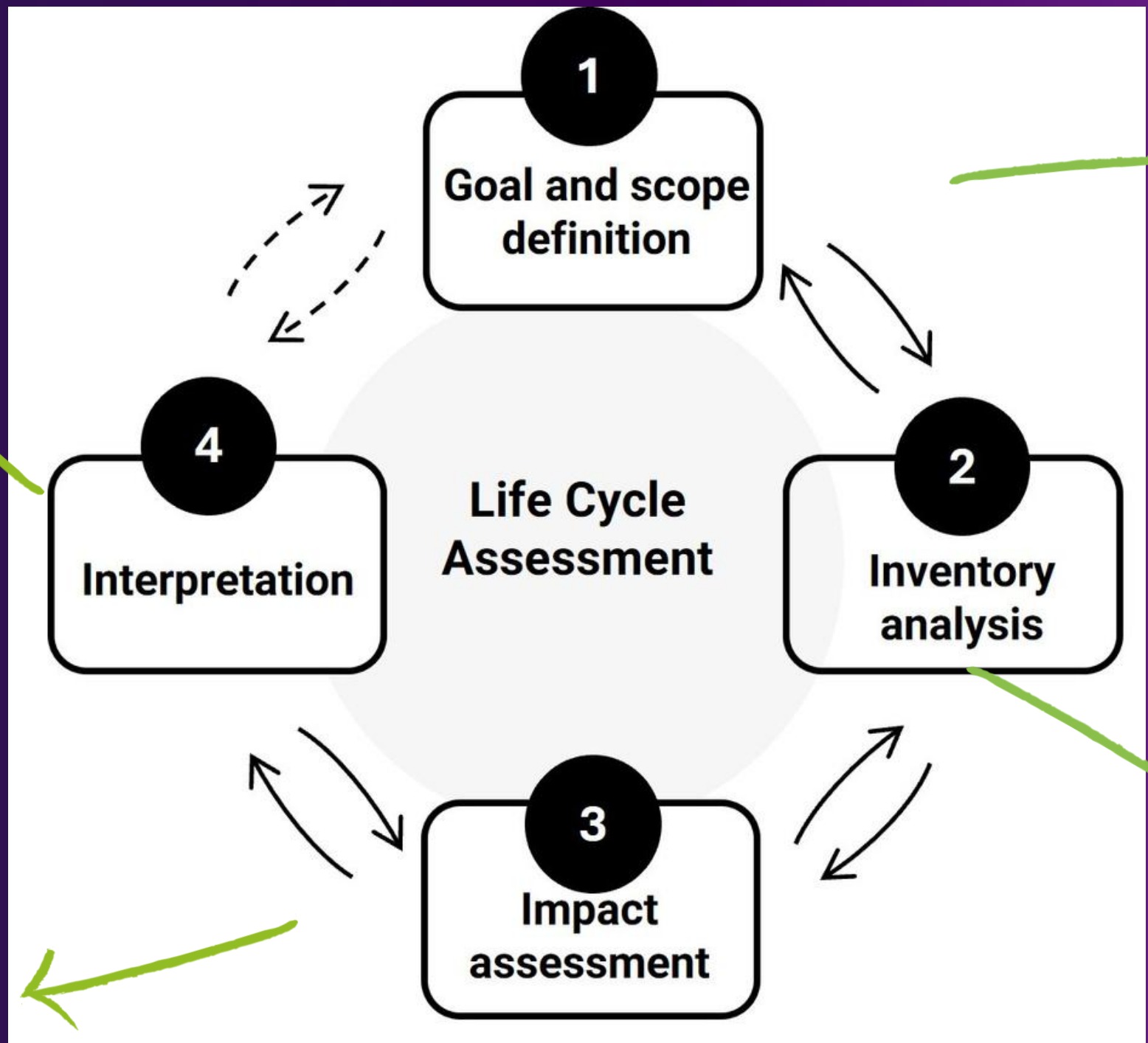
# What is Life Cycle Assessment (LCA)?

Environmental

LCA

Results and Interpretation:  
Analysing of results in terms of impact categories to identify environmental hotspots along the life cycle to provide recommendations and decision-making support

Life Cycle Impact Assessment (LCIA):  
converting the inputs and outputs to potential impacts along the categories analysis



Goal and scope: Definition of the study's final objective, intended application, purpose, and intended audience as well as:

- system boundaries
- functional unit
- impact categories

Life Cycle Inventory (LCI):  
determination and quantification of relevant inputs and outputs

# How are we applying the LCA on ColdSpark<sup>®</sup>?

Environmental

LCA

Guidelines  
and  
regulations  
reviews

## LCA Regulation

LCA ISO 14040-14044  
European Environmental Footprint methods (EF)

## H<sub>2</sub> LCA Guideline

Guidance Document for Performing LCA on Hydrogen Production Systems

### FC-HyGuide

Harmonised multi-dimensional framework for the LCSA and prospective benchmarking of FCH systems

SH2E- European Project

## H<sub>2</sub> Carbon Footprint Guideline

Methodology for Determining the Greenhouse Gas Emissions Associated with the Production of Hydrogen- (IPHE)

## H<sub>2</sub> impact categories harmonisation Guideline

Harmonised Carbon and Energy Footprints of Fossil Hydrogen.”  
Harmonising Methodological Choices in Life Cycle Assessment of Hydrogen.”  
Valente, Iribarren, and Dufour- IMDEA Energy, Juan Carlos University

## European regulation Red II -III and Annexes

Directive (EU) 2018/2001 of 11 December 2018 on the promotion of the use of energy from renewable sources and Commission Delegated Regulation (EU) 2023/1185

Data  
availability

Partners feedback



Literature review  
Database analysis



# The LCA methodological framework for ColdSpark<sup>®</sup>

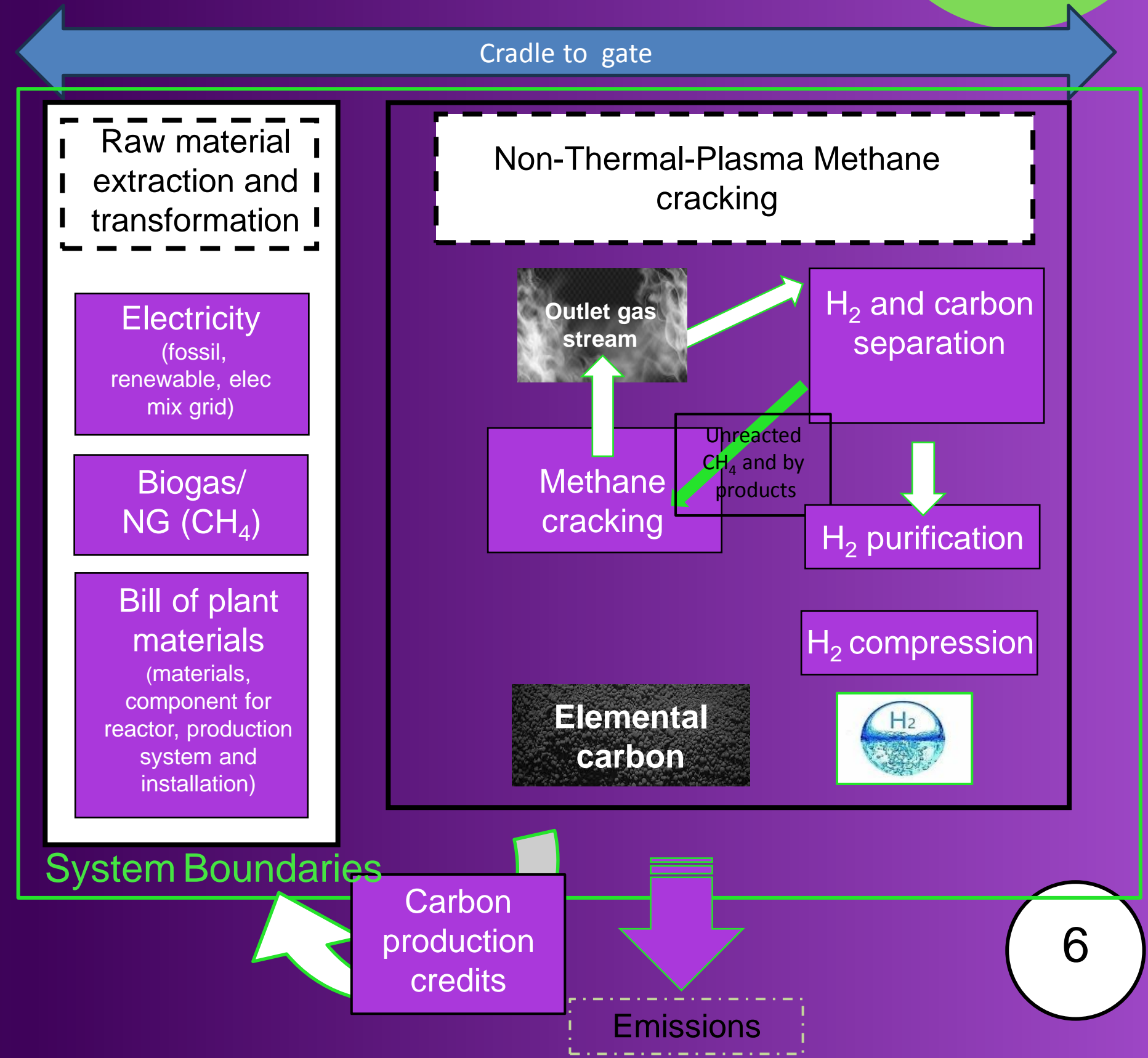


**Goal:**  
Evaluate the environmental impact of the ColdSpark<sup>®</sup> NTP methane cracking process for H<sub>2</sub> and elemental carbon production.

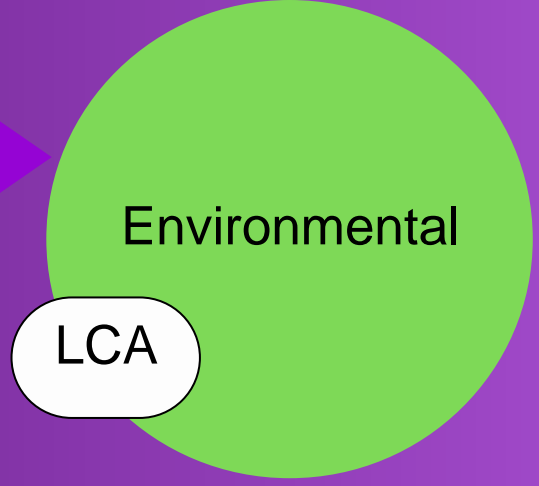
- FU: 1 kg H<sub>2</sub>; (purity, temperature and pressure will be defined along with the technological development)

- Scope: Cradle to gate and system boundaries









- Multifunctional system: System expansion











# The LCA methodological framework for ColdSpark®



- Impact categories and calculation method:  
Environmental footprint 3.1, IPCC AR6 for Global Warming Potential including biogenic carbon

 Resource use, minerals and metals	 Ozone depletion	 Human toxicity, cancer	 Human Toxicity, non-cancer
 Particulate matter	 Ionising radiation	 Photochemical ozone formation	 Acidification

 Eutrophication, marine	 Eutrophication, terrestrial	 Eutrophication, freshwater	 Ecotoxicity, freshwater
 Land use	 Water use	 Resource use, fossils	 Resource use, minerals and metals

# ColdSpark® preliminary GHG emissions analysis

2

ColdSpark®  
LCA  
methodological  
framework

RED III EU  
Directive GHG  
emissions  
methodology

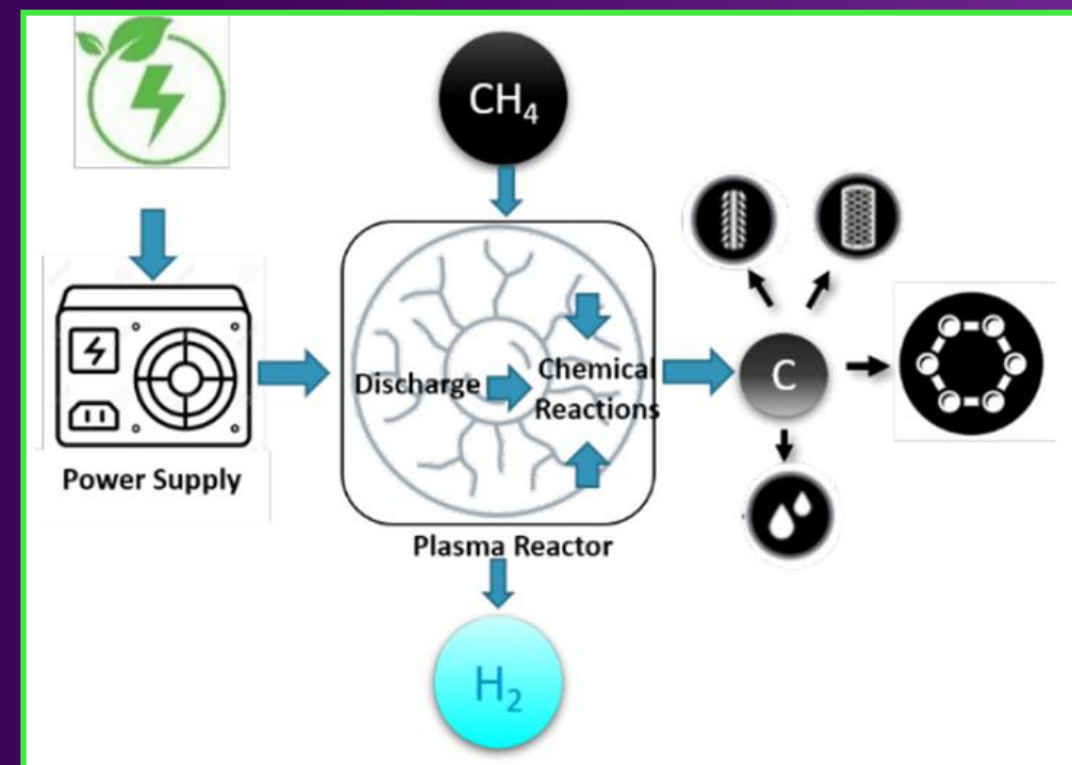
RED III EU  
Directive GHG  
emissions  
methodology  
with solid  
carbon CCS

# ColdSpark® preliminary GHG emissions analysis and general assumptions

- 85% methane conversion efficiency, electricity consumption: 15 kWh/kg H<sub>2</sub>.
- Cradle to gate without Plant Bill of materials. The carbon and H<sub>2</sub> separation, purification and compression steps are excluded
- Electricity mix taken from LCA Sphera professional database.
- Geographical context: Norway and Germany

Electricity

BioCH<sub>4</sub> from  
organic waste



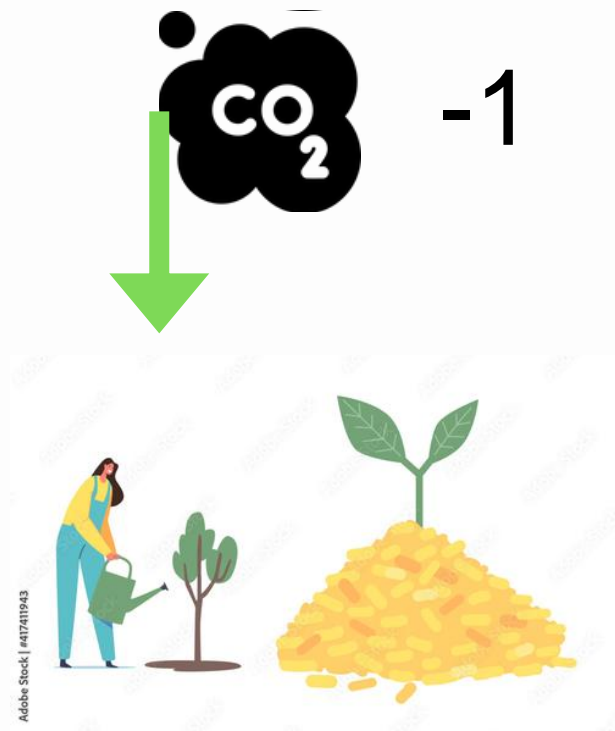
# ColdSpark<sup>®</sup> preliminary results: ColdSpark<sup>®</sup> LCA methodological framework

- All emissions are allocated to H<sub>2</sub> (no system expansion)
- Biogenic CO<sub>2</sub> is included (embedded and emitted biogenic CO<sub>2</sub> is included)
- Biomethane from organic waste by using LCA Sphera professional database

-8.33  
kg CO<sub>2</sub> eq/kg  
H<sub>2</sub>  
Norway

-2.25  
kg CO<sub>2</sub>eq/kg H<sub>2</sub>  
Germany

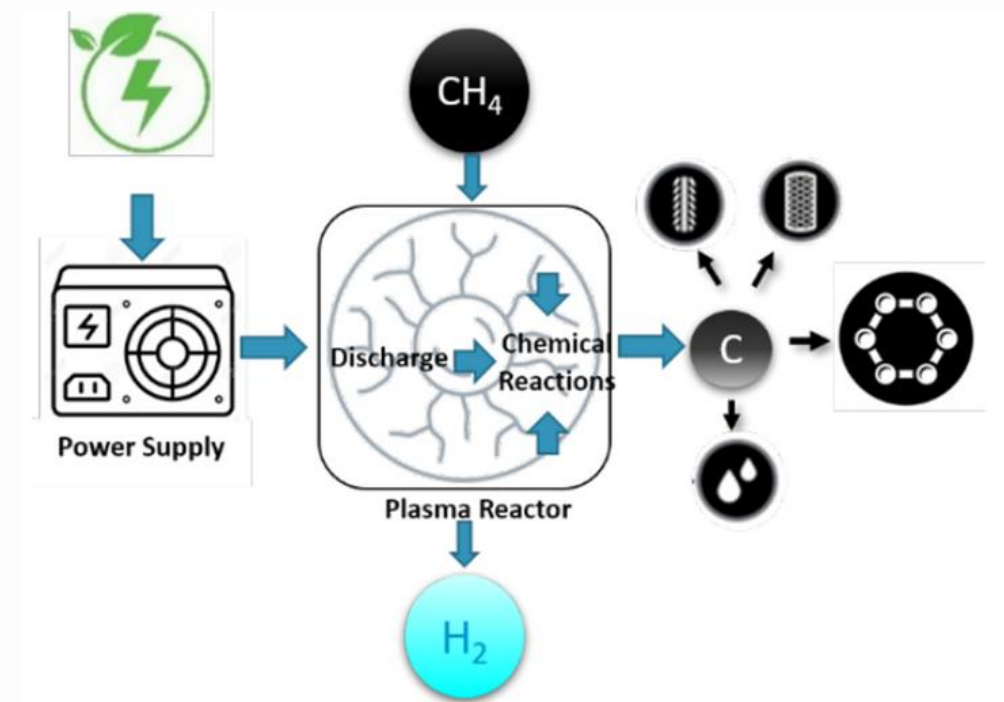
# ColdSpark<sup>®</sup> preliminary results: including biogenic CO<sub>2</sub>



Biomass



Biomethane production



ColdSpark<sup>®</sup> Biomethane NTP cracking

The biogenic CO<sub>2</sub> balance is negative

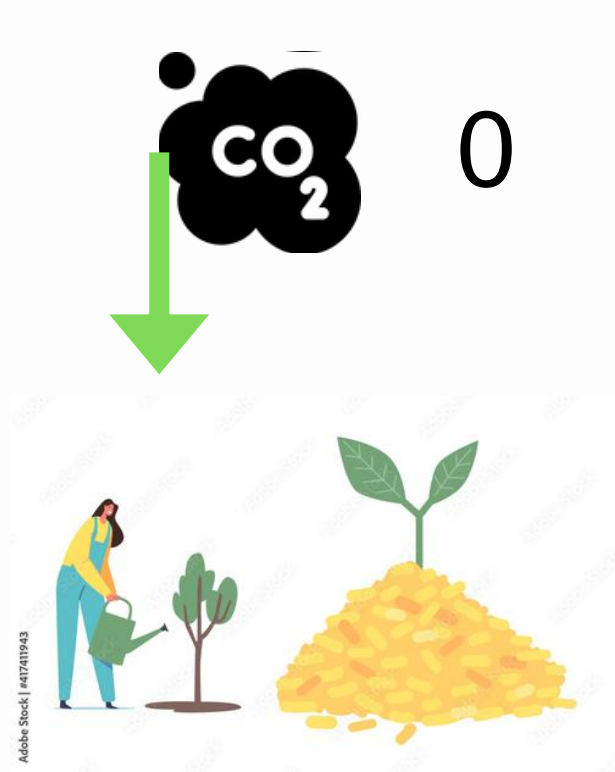
# ColdSpark® preliminary results under Red III

- Energy allocation
- Biogenic CO<sub>2</sub> is excluded
- Biomethane from biowaste close digestate, off-gas combustion data from RED III default value

1.71  
kg CO<sub>2</sub>eq/kg H<sub>2</sub>  
Norway

4.90  
kg CO<sub>2</sub> eq/kg H<sub>2</sub>  
Germany

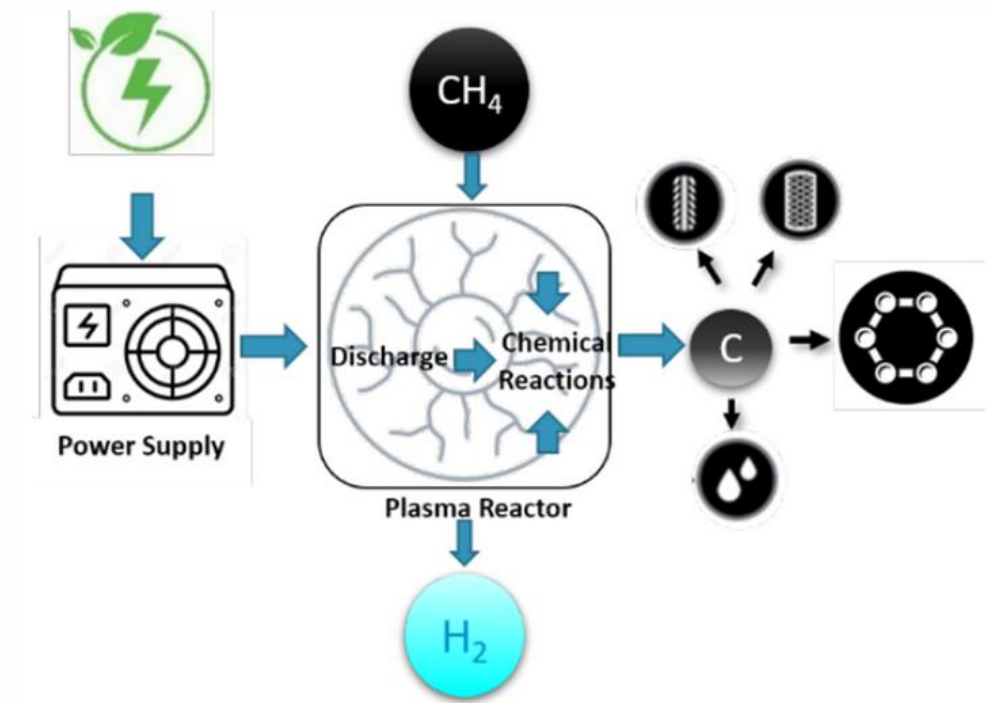
# ColdSpark<sup>®</sup> preliminary results: excluding biogenic CO<sub>2</sub>



Biomass



Biomethane production



ColdSpark<sup>®</sup> Biomethane NTP cracking

The biogenic CO<sub>2</sub> balance is 0

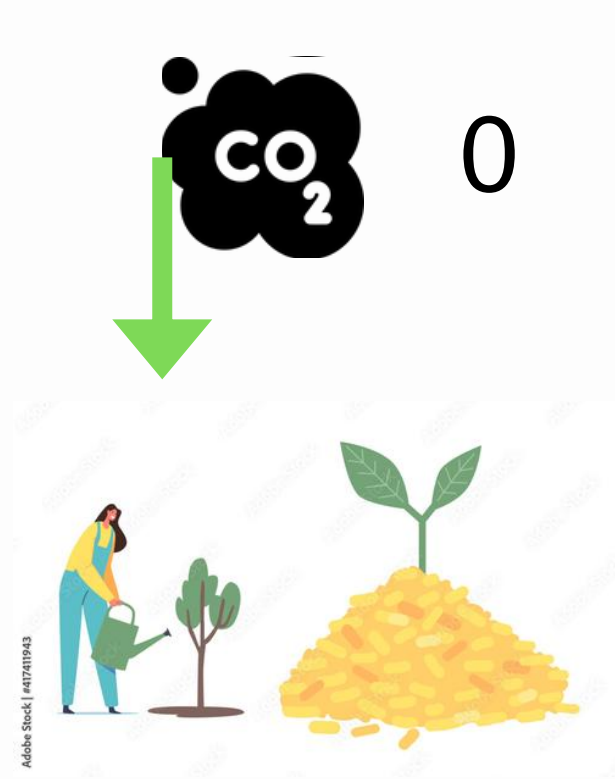
# ColdSpark<sup>®</sup> preliminary results under Red III with solid carbon as CCS

- Energy allocation
- Biogenic CO<sub>2</sub> is excluded, solid carbon is included as CCS strategy
- Biomethane from biowaste close digestate, off-gas combustion data from RED III default value

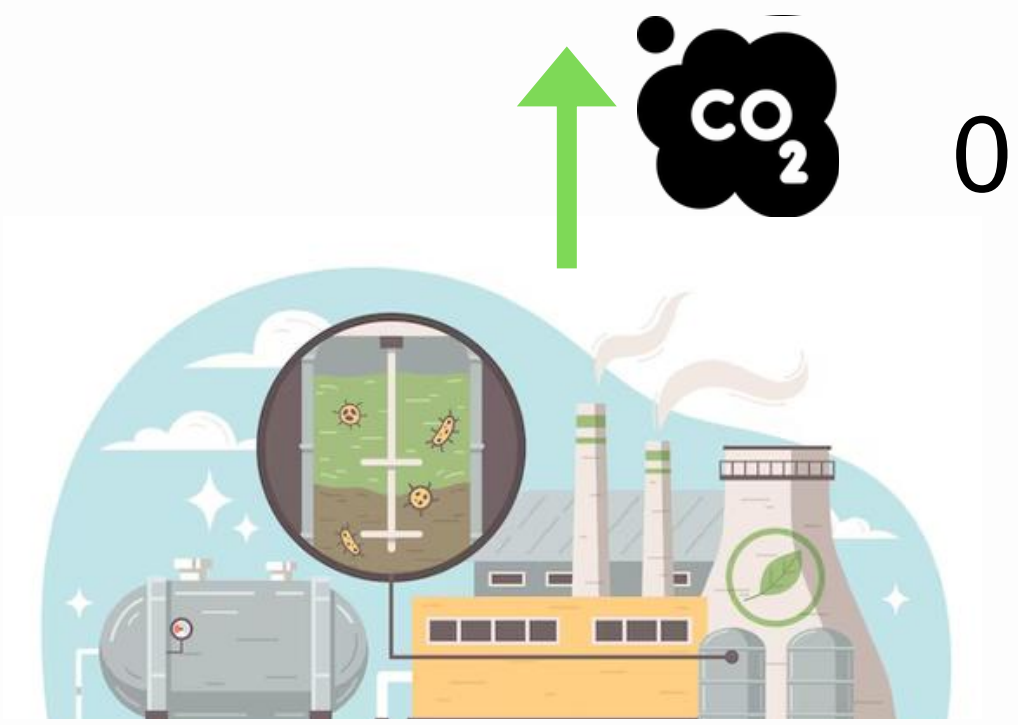
-4.32  
kg CO<sub>2</sub> eq/kg  
H<sub>2</sub>  
Norway

-1.13  
kg CO<sub>2</sub> eq/kg  
H<sub>2</sub>  
Germany

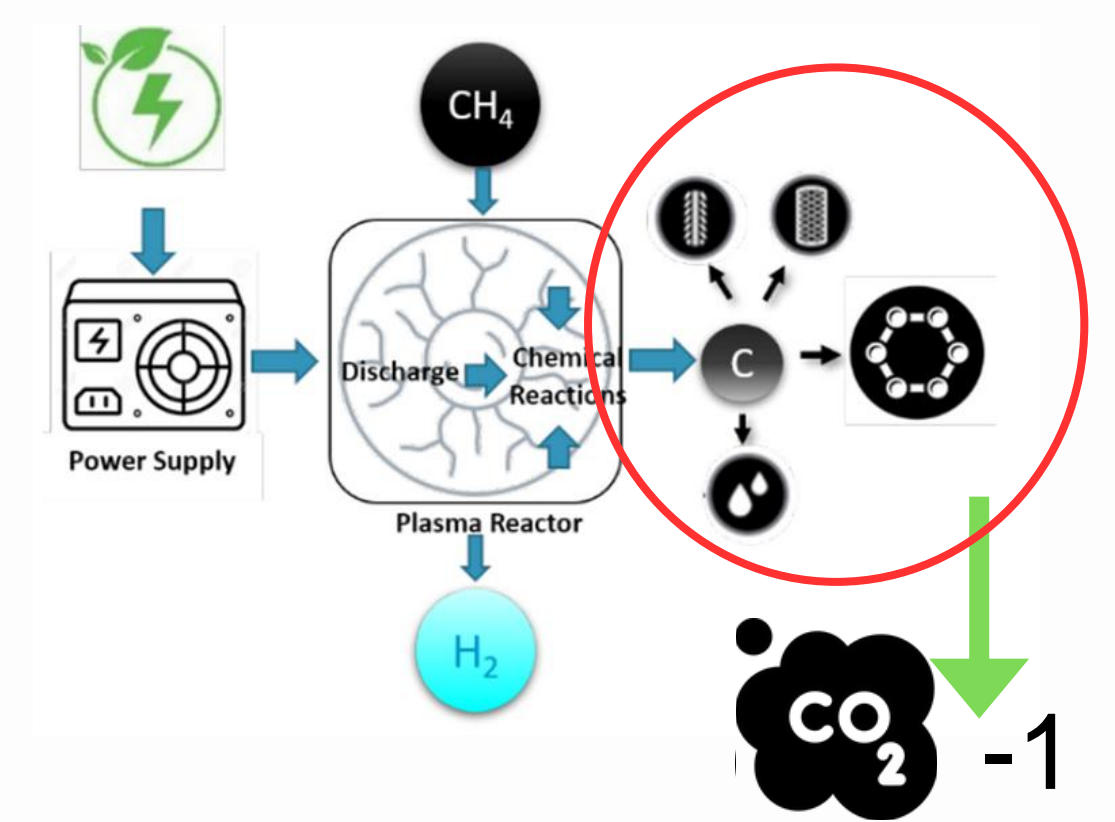
# ColdSpark<sup>®</sup> preliminary results: excluding biogenic CO<sub>2</sub> with solid carbon as CCS strategy



Biomass



Biomethane production

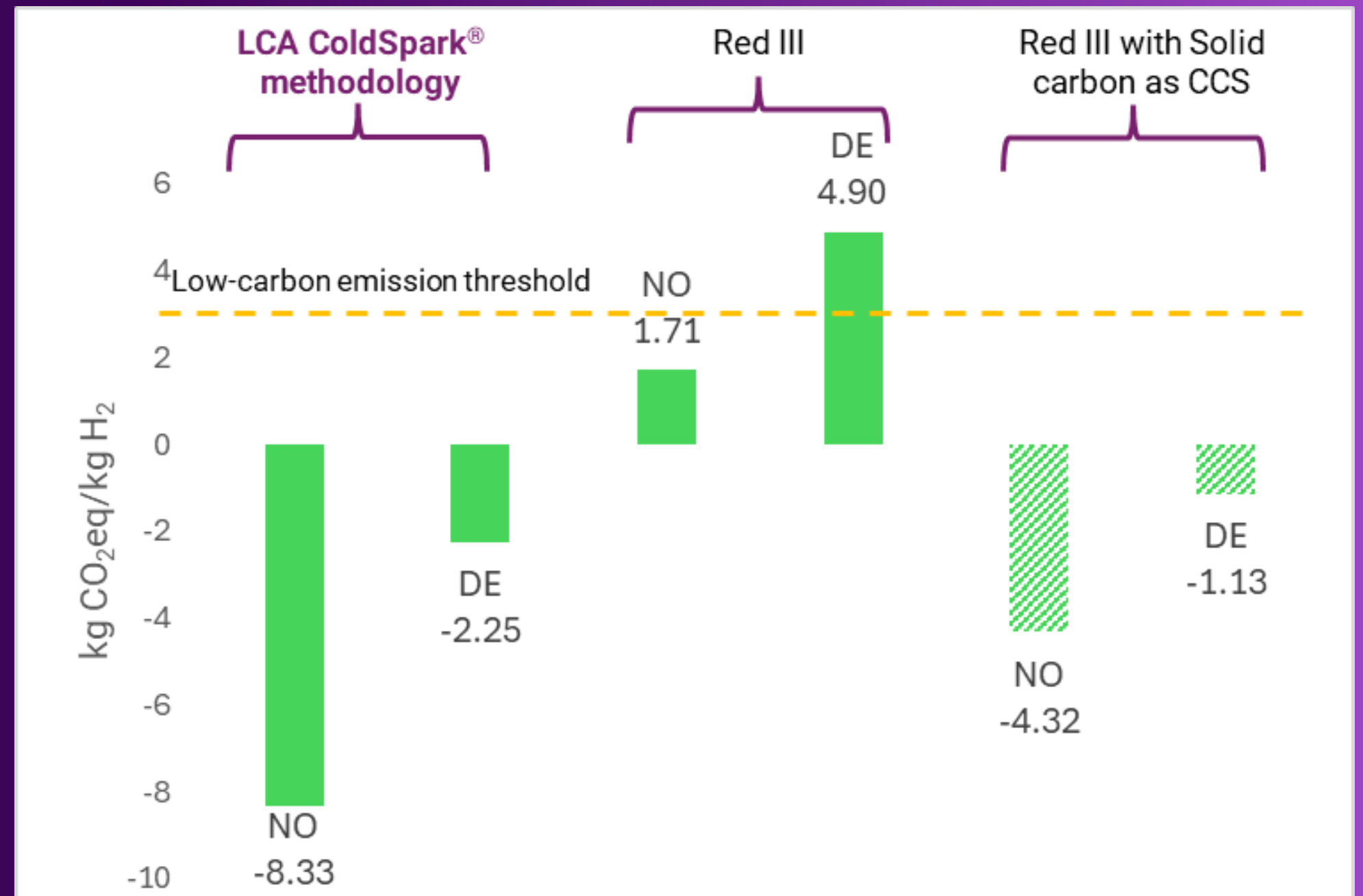


ColdSpark<sup>®</sup> Biomethane NTP cracking

Biogenic CO<sub>2</sub> is stored as solid carbon

# ColdSpark® preliminary GHG emissions results comparison

- Both methodologies of including biogenic CO<sub>2</sub> and Red III solid carbon as CCS unveil the removal carbon potential of the ColdSpark® technology.
- The inclusion of solid carbon as CCS is fundamental to promoting technology development and its environmental opportunity for carbon removal.
- Following Red III methodology, the process placed in Norway falls below the hydrogen low carbon emission threshold.



# ColdSpark<sup>®</sup> carbon removal: potential advantages

## Advantages compared to traditional CO<sub>2</sub> carbon sequestration and storage

High value by  
byproduct

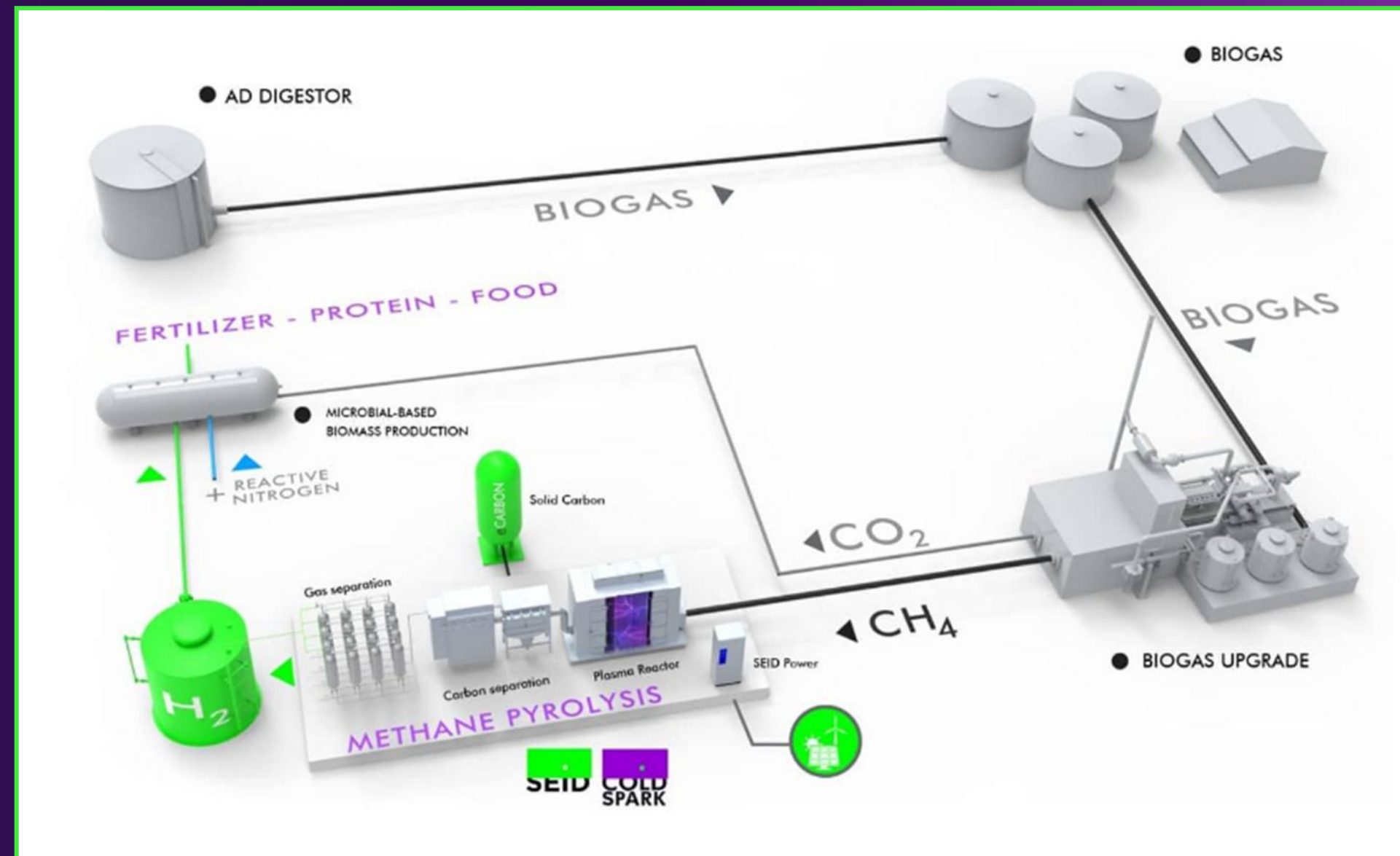
Low-complexity  
transport and  
storage

Simplified  
infrastructure

Reduced  
construction  
time

Mitigated risks  
concerning  
social  
acceptability

# Conclusion

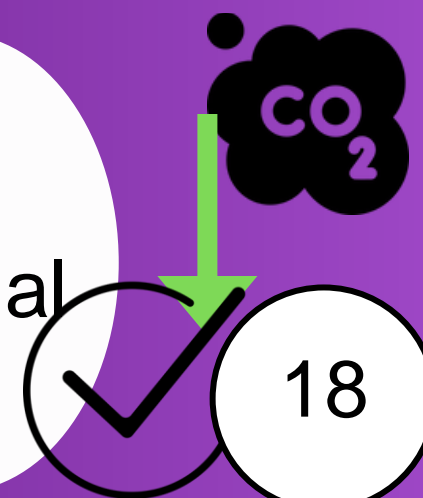


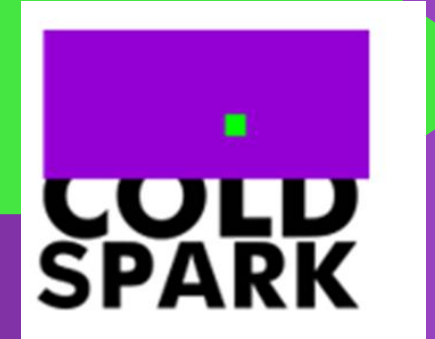
LCA for NTP  
Methane  
cracking

Definition of the LCA methodological  
framework for ColdSpark®



Preliminary GHG emissions  
analysis: carbon removal potential





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## Follow ColdSpark® project



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