Methodological recommendations for the LCA of e-fuels and preliminary calculations

ScoreLCA seminar – March 19, 2026

Consulting | Tools | Training

Our mission

We help organisations enhance their environmental and social performance, from product level to overall strategy

Independent consultancy founded in 2005, worker-owned co-operative since 2017

- A team of 145 employee-partners
- 3 offices in Nantes, Lyon and Troyes
- Local ambassadors across France

Our activities

From objective assessment to the implementation of practical solutions
— including R&D, training, tools and software —
tailored to each sector’s specific needs and real-world challenges.

7 areas of expertise with strong cross-team interaction

AGRO-RESOURCES & GREEN CHEMISTRY
(agri-food, detergence, textile, bio-based materials, fuels, formulation)

GOODS & SERVICES
(daily, technical & technological, innovative, essential)

CONSTRUCTION
(products and materials for construction, EEE)

SOCIAL FOOTPRINTS/ CLIMATE / BIODIVERSITY

IT DEVELOPMENT
distribution and development of custom software

TRAINING
for skills transfer (*Qualiopi* accredited)

R&D
for sustainable development professions

Software we develop

ASKOR designed by EVEA

evdec designed by evea

Software we distribute

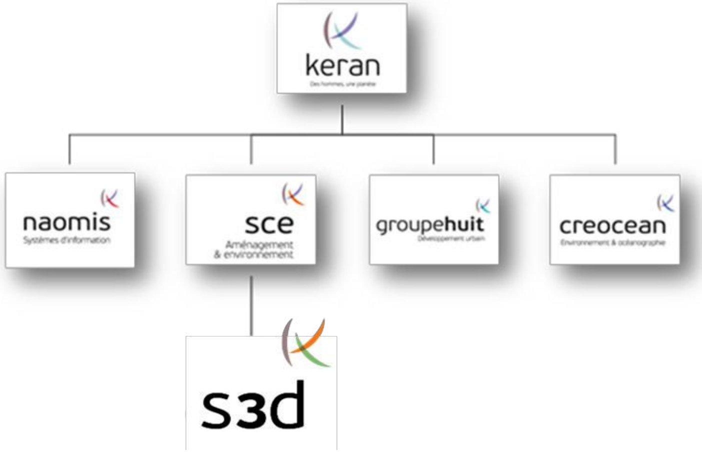
Toovalu

shdb

BC 2025 PRO BILAN CARBONE® | Planet Tech'Care | Mouvement IMPACT FRANCE | ACT ACCELERATE® CLIMATE TRANSITION

S3d Ingénierie

- Consulting and engineering company specialized in energy recovery from biomass & waste
- Funded in 2007
- 30 coworkers, based in Nantes, Lyon, Paris, Toulouse, and Barcelona
- Subsidiary of the KERAN group



ANAEROBIC DIGESTION

Fermentable waste

GASIFICATION & PYROLYSIS

Lignocellulosic materials, Solid Recovered Fuel (SRF), plastics…

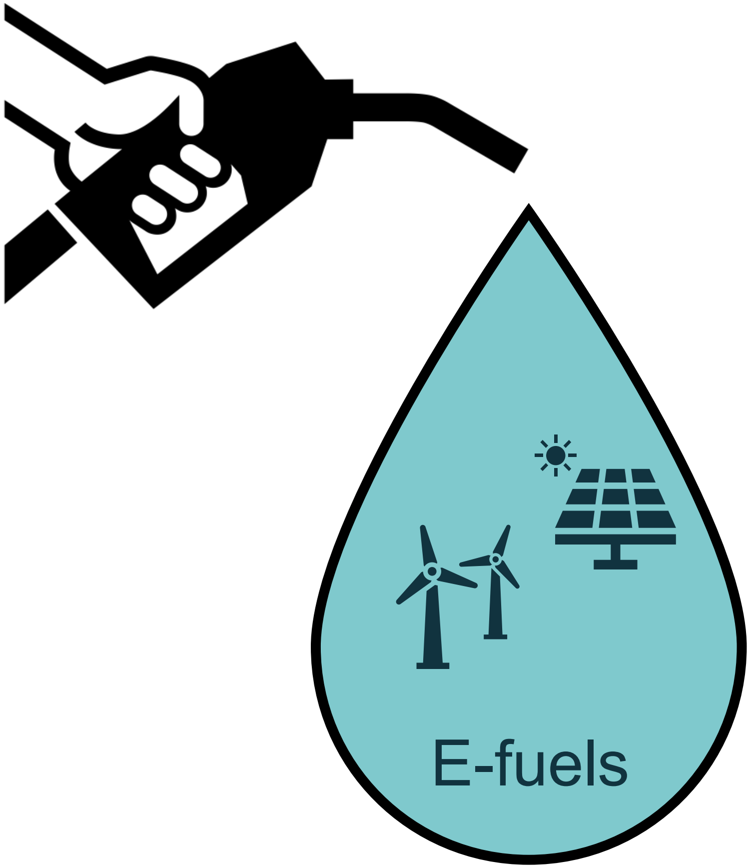
ALTERNATIVE FUELS

NGV and bioNGV, hydrogen, liquid biofuels

STRATEGY & PERFORMANCE

Industrial and territorial ecology, environmental assessments, territorial waste management planification

Summary



Background and objective of the study

Context:

Numerous LCAs

- On Google Scholar, a search for "LCA e-fuel" yields nearly **1,000 results**, and a search for "LCA Power-to-X" yields more than **23,000 results**.
- Some articles **summarize several LCAs that have been carried out.**

In the absence of common methodologies, the conclusions of these e-fuel LCAs vary greatly

- For example, for e-methanol, the LCAs reported in the literature show cradle-to-gate carbon footprints ranging from **-1.7 to +9.7 kgCO_2 eq** per kg of methanol (Müller et al. 2020).

Objective:

Recommend methodological rules for environmental assessment work such as LCA of e-fuels

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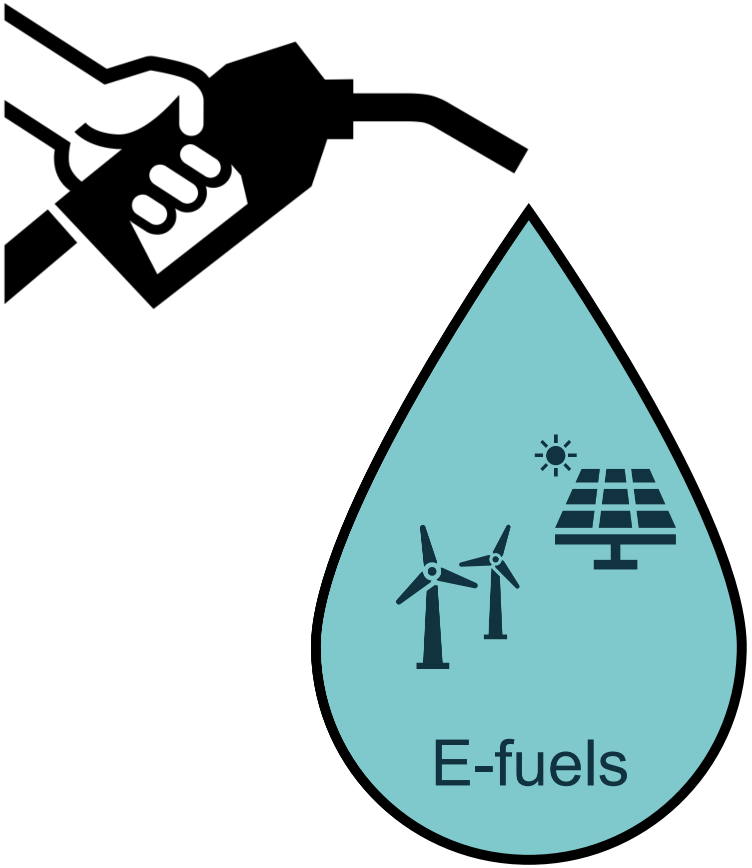
Summary



1. **Context & objective of the study**
2. **What is e-fuel? State of the art technology**
3. **Methodological challenges for e-fuel LCAs**
   - Introduction
   - Conducting an LCA of e-fuel
   - Impact assessment – Case study results
4. **Questions**

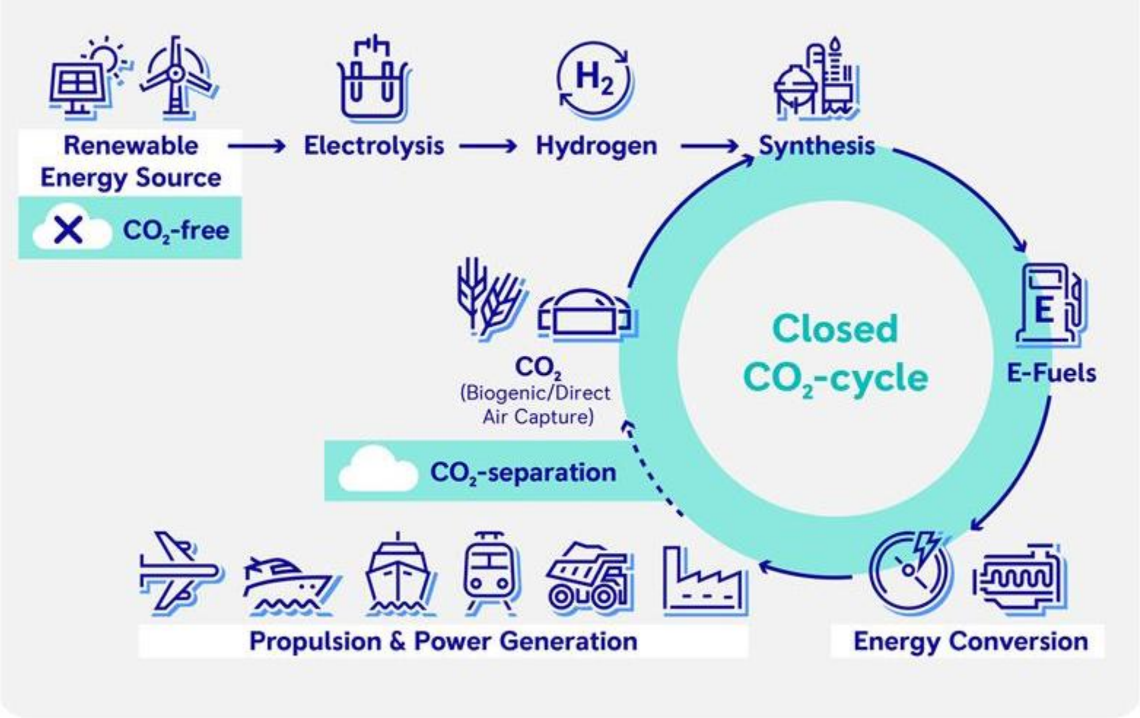
What is e-fuel?

- E-fuels, or electrofuels, are a category of **synthetic fuels** that can be used in **drop-in** mode.

- E-fuels are synthesized from **H_2 , and CO_2 , or $N._2$**

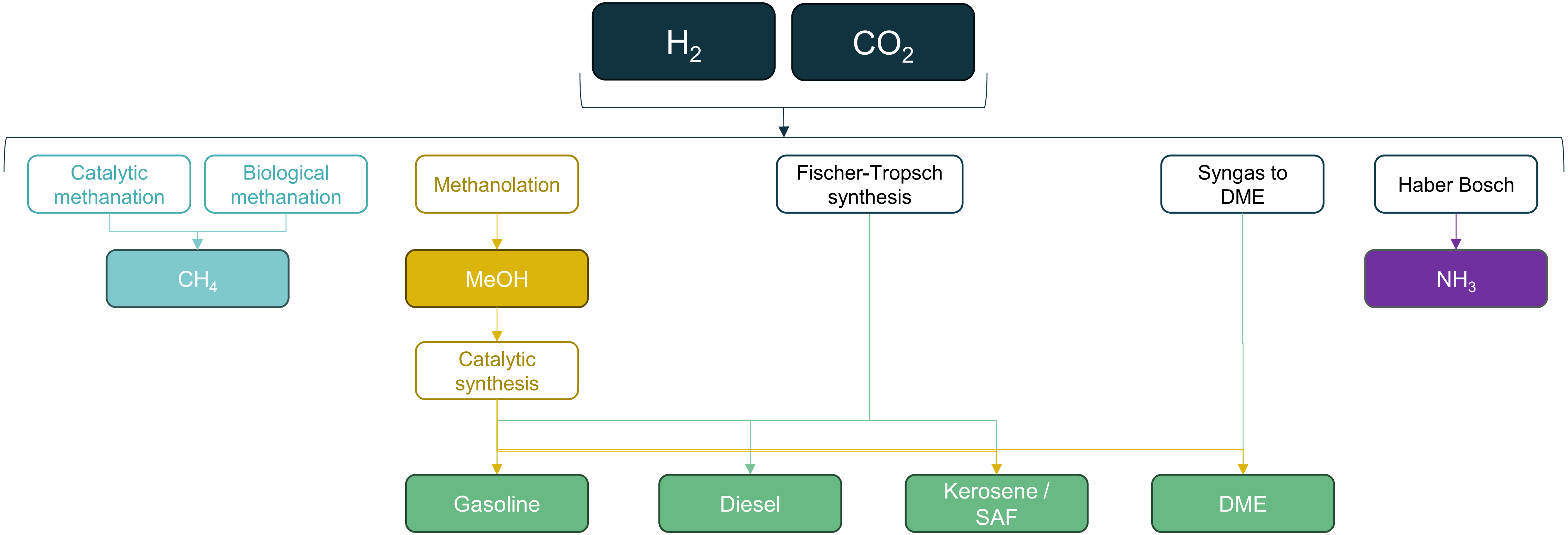
- H_2 e is produced by **electrolysis of water** using **low-carbon electricity** sources

- CO_2 is captured from various sources:
  - Direct capture from the air
  - Separation from industrial fumes
  - Biomass (biogas)



Source and credits: www.mtu-solutions.com

The e-fuels studied



For the in-depth case study, the **MeOH to kerosene** pathway has been selected: maturity, available distribution and storage infrastructure, existing vehicles → best representativeness in 2025

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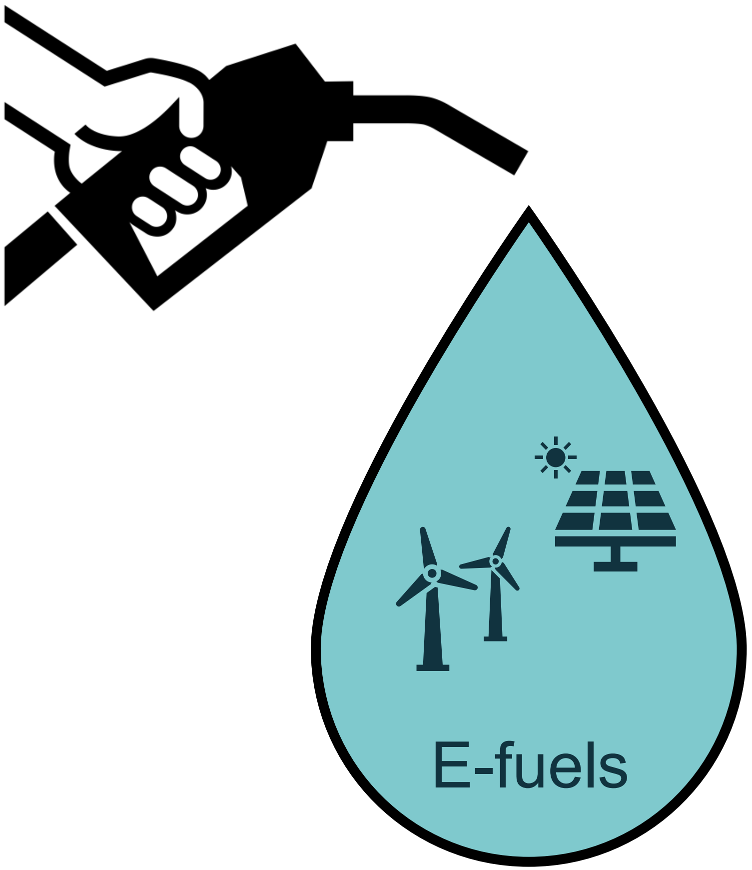
Summary



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Introduction

According to articles by **Koj et al.**, **Ince et al.**, and **Ballal et al.**,

the main factors **that most influence** the results of a Power-to-X system LCA are:

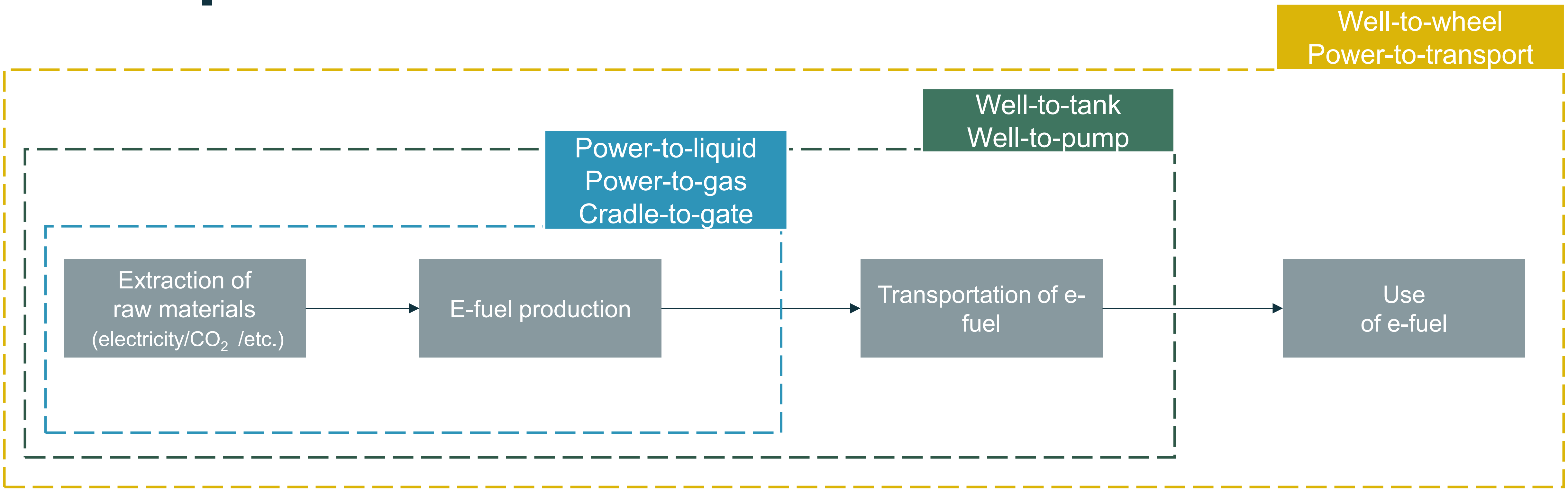
The **source of electricity** used for hydrogen production

The **LCA methodology** used to take into account **the source of CO_2**, and **the use of CO_2**

*Ballal et al. also specifies the **type and efficiency of the electrolyzer** in 3ème factor*

- *Koj, Wulf, and Zapp 2019: a meta-analysis of 32 Power-to-X LCAs*
- *Ince et al. 2021: a meta-analysis of 24 Power-to-X LCAs*
- *Ballal et al. 2023: Analysis of the carbon footprint of an e-SAF by varying the source of CO_2 (DAC, biorefinery, and gas power plant) and the type of electrolyzer (AEL, PEM, and SOEC).*

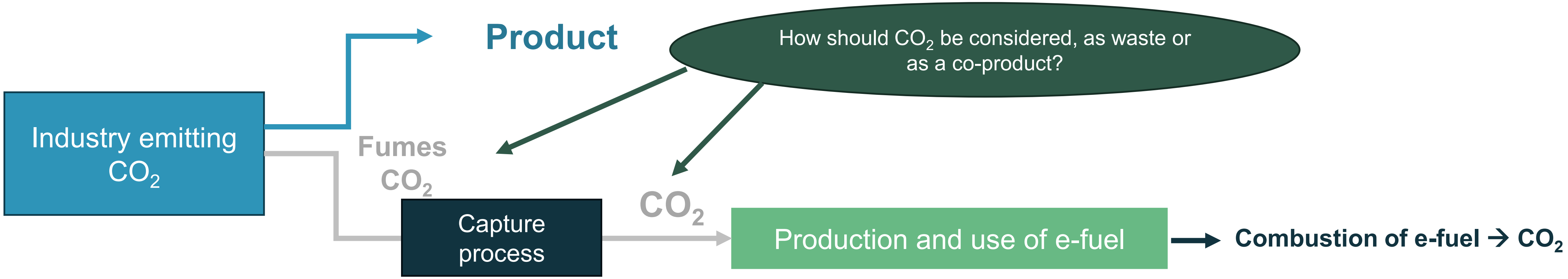
Scope



Power-to-X = Power-to-Liquid + Power-to-Gas + Power-to-Chemicals

For any comparison with conventional fuel, it is recommended to take into account the use of e-fuel (due to its different chemical composition).
It is recommended to take infrastructure into account if wind or solar power is used.

Multifunctionality management



For industries that emit CO_2 fumes, e-fuel is a **CCU** (Carbon Capture and Utilization) product, and the **captured** CO_2 has **value**.

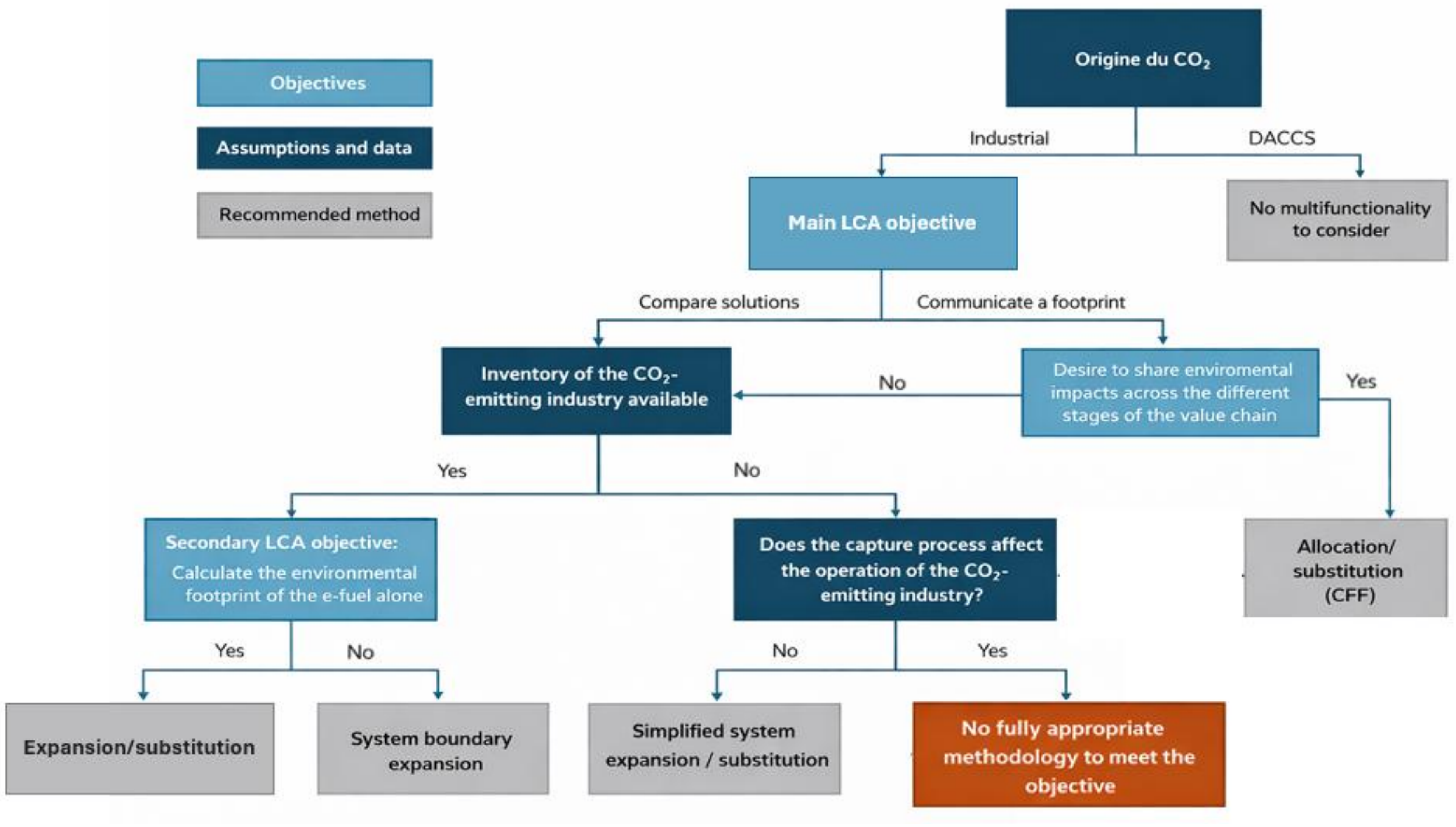
It is not waste that needs to be treated, but a raw material. Concentrated CO_2 is a co-product.

This implies that the "CO-emitting industry$_2$ " system is a multifunctional system: production of the main product **AND** CO_2 .

The central methodological question therefore boils down to:

How to manage the multifunctionality of the system?

Recommendations: Management of multifunctionality



Life cycle inventory: electricity

The LCA results for e-fuels are particularly sensitive to **the electrolyzer's electricity consumption** data.
It is advisable to refer to SCORE LCA study no. 2022-01.

Data	Recommendation
Amount of electricity consumed by the electrolyzer	1. Use specific data where possible. 2. Otherwise, use bibliographic data, paying particular attention to the technological representativeness of the data used.
Electricity mix used	1. Use specific data where possible (dedicated electricity production, contract with a supplier that guarantees a certain mix). 2. When using electricity from the grid, use the most up-to-date data possible. In France, RTE provides the most up-to-date electricity mix. 3. Avoid using secondary data from databases, which may be less up-to-date than data from other sources.
Inventory of electricity generation and transmission facilities	1. If possible, use specific data (dedicated production). 2. Where applicable, the Ecoinvent LCA database provides secondary data with excellent geographical representativeness and good technological representativeness, but limited temporal representation.

Life cycle inventory: CO_2 capture process

The recommendations are as follows:

1. Ideally, use a **specific inventory**
2. If this is not possible, use representative bibliographic data, particularly from a **technological** point of view**.**
3. If this is not possible, the Ecoinvent database provides liquid CO_2 data, which must be adapted as best as possible.

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Life cycle inventory: capture process

Depending on the origin of the CO fumes$_2$, pre-treatment is not always necessary (e.g., ammonia plant, bioethanol plant).

Data on "carbon dioxide, liquid" from ecoinvent

Pre-treatment of fumes → CO capture$_2$ → CO purification$_2$ + liquefaction

Bibliographic data from the ScoreLCA CCU CCS study

Recommendation: choose impact indicators

Choose indicators that represent 80% of the single score (PEF method)

- Method recommended by the European Commission

In all cases, choose the following indicators:

- Climate change
- Depletion of fossil resources
- Depletion of mineral and metal resources

Use at least one **additional flow indicator** that characterizes the energy efficiency of e-fuel

- For example:

$$\textit{Energy efficiency} = \frac{\textit{LHV energy content of the e-fuel}}{\textit{Total energy consumed at all stages of the e-fuel life cycle}}$$

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The report also discusses:

Biogenic carbon:
How can we take into account that the CO_2 capted is biogenic (i.e., not derived from fossil resources)?
For example, CO_2 captured from a biorefinery.

$_2$Transport of CO_2 capture:
Which ICV should be used for the different types of CO_2 transport?

The case of DAC, Direct Air Capture:
How can we perform an LCA on an e-fuel produced by DAC?

And many other topics covered!

Dynamic LCA of e-fuel:
How can we take into account the temporal variation in e-fuel production?

Focus on the CFF applied to e-fuels:
Is CFF applicable to e-fuels? How should it be applied?

Prospective LCA of e-fuel:
How to perform an LCA of an e-fuel from 2050?

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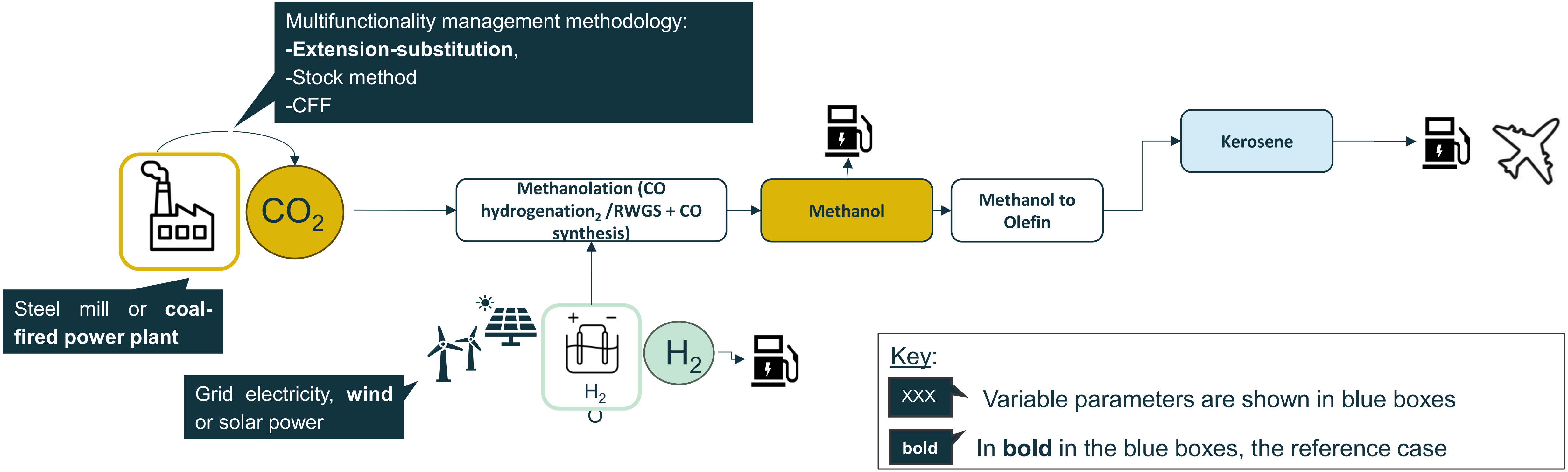
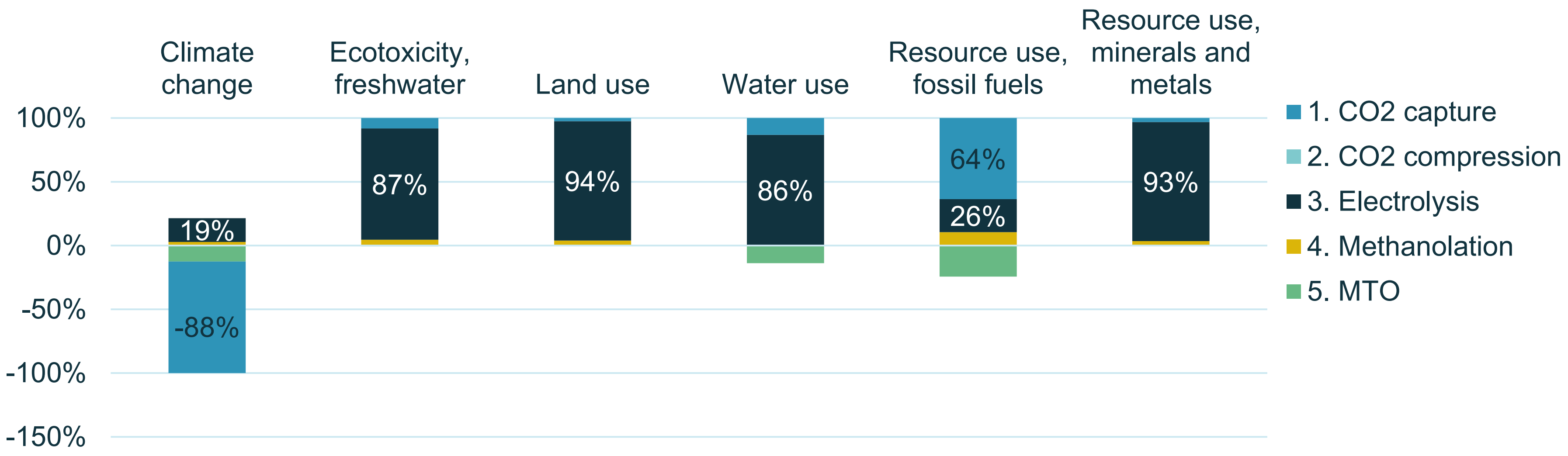
Presentation of the case study

Study of an e-SAF (= e-kerosene).
Scope: Power-to-liquid = cradle-to-gate (distribution and use excluded from scope)
Functional unit: Produce 1 MJ of e-SAF



Reference scenario - Main contributors to impacts



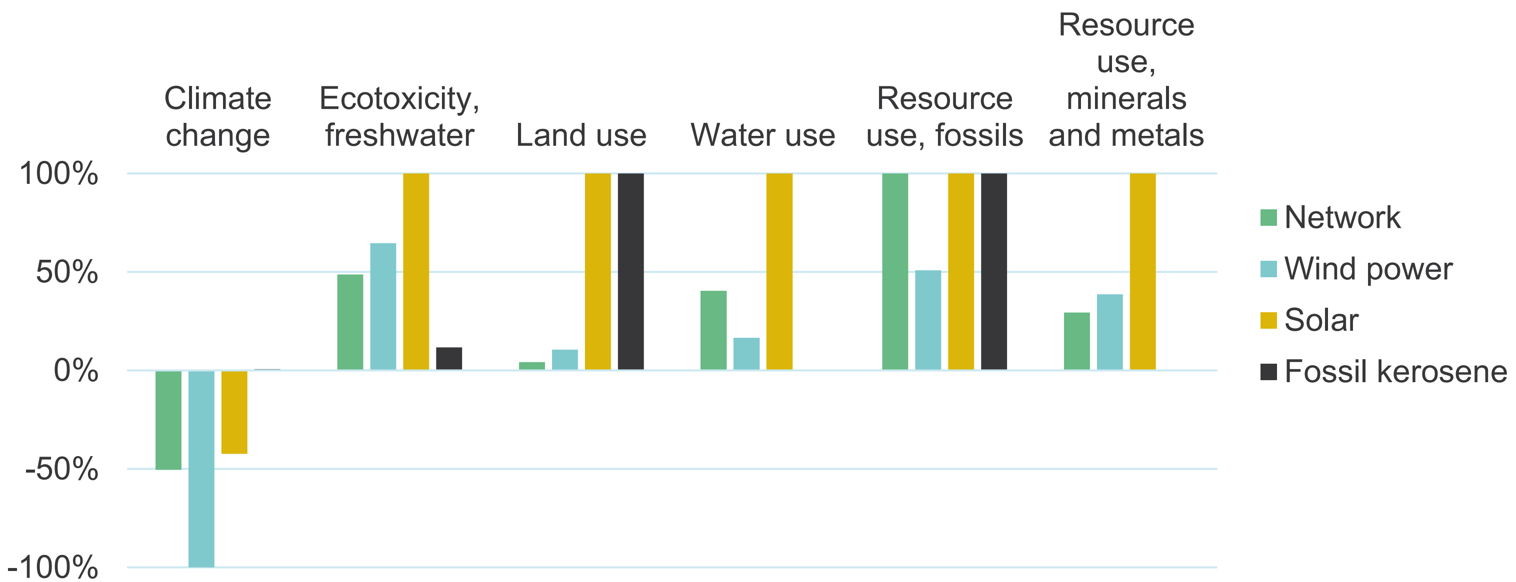
The main contributor to impacts is **electrolysis,** and more specifically **wind power**, across almost all indicators.

Except:

- $_2$ **climate change**, where the main contributor is **CO2 capture** (negative CO2 emissions$_2$)
- and **fossil fuel use**, where the main contributor is **grid electricity from the CO2 capture stage.**

In terms of fossil fuel use, the MTO stage is negative thanks to the heat avoided.

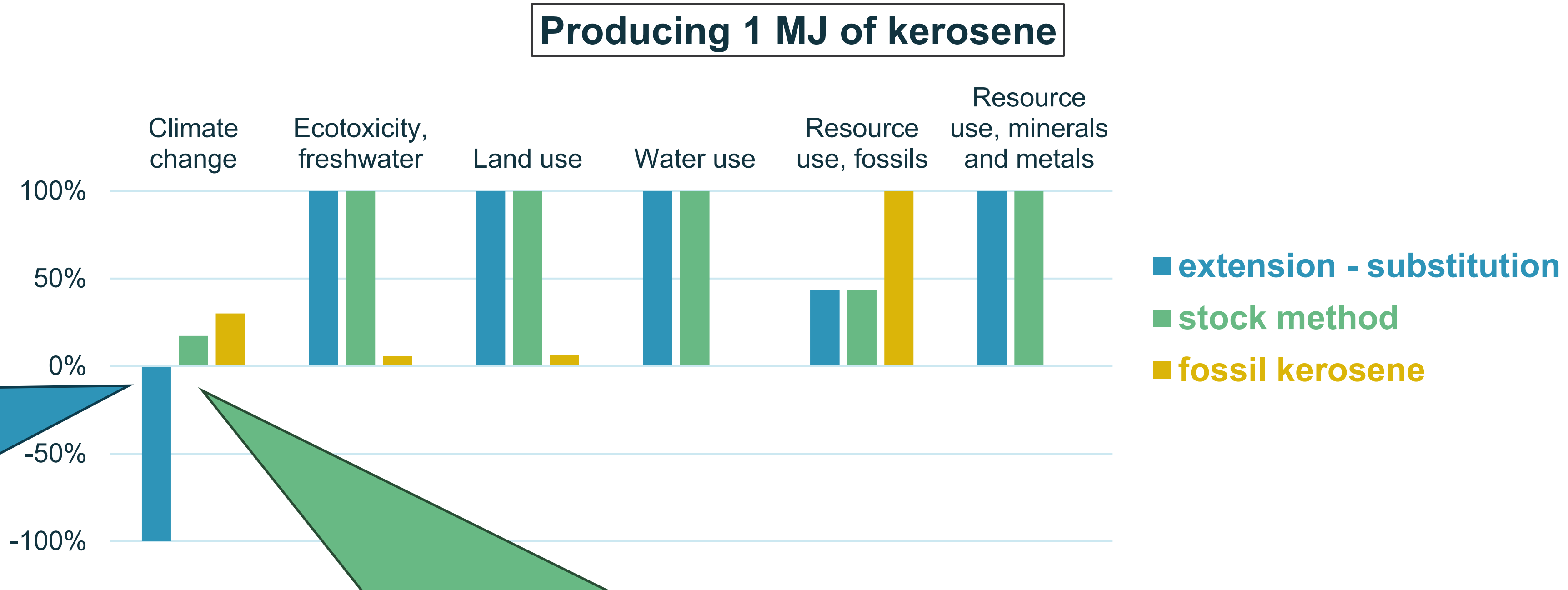
Reference scenario - Impact of electricity used in electrolysis



- **Fossil kerosene** has **less** overall **impact** than **e-kerosene,** except in terms of **climate change** and **land use**.

-The **type of electricity has a huge impact on the environmental footprint**: for example, there is a difference of more than 80% between **solar** and **wind power** in terms of land use.

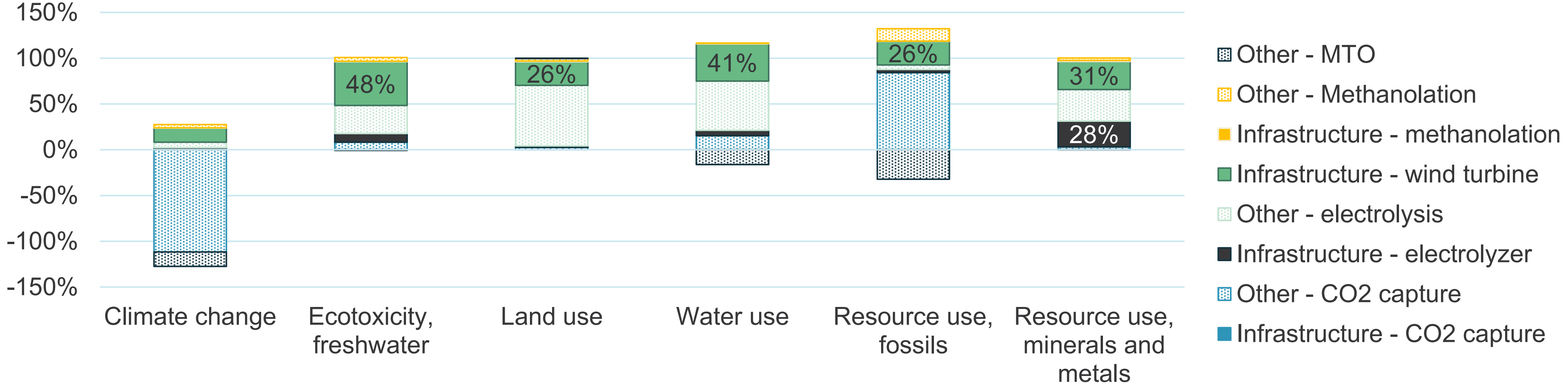
Influence of the multifunctionality management method



Extension – substitution: The extension-substitution method accounts for the entire CO_2 capture process$_2$, but has one trade-off: the substitution of emissions. This has negative impacts on climate change.

Stock method: the stock method has a greater impact than the extension-substitution method because it attributes the entire CO_2 capture process without compensation.

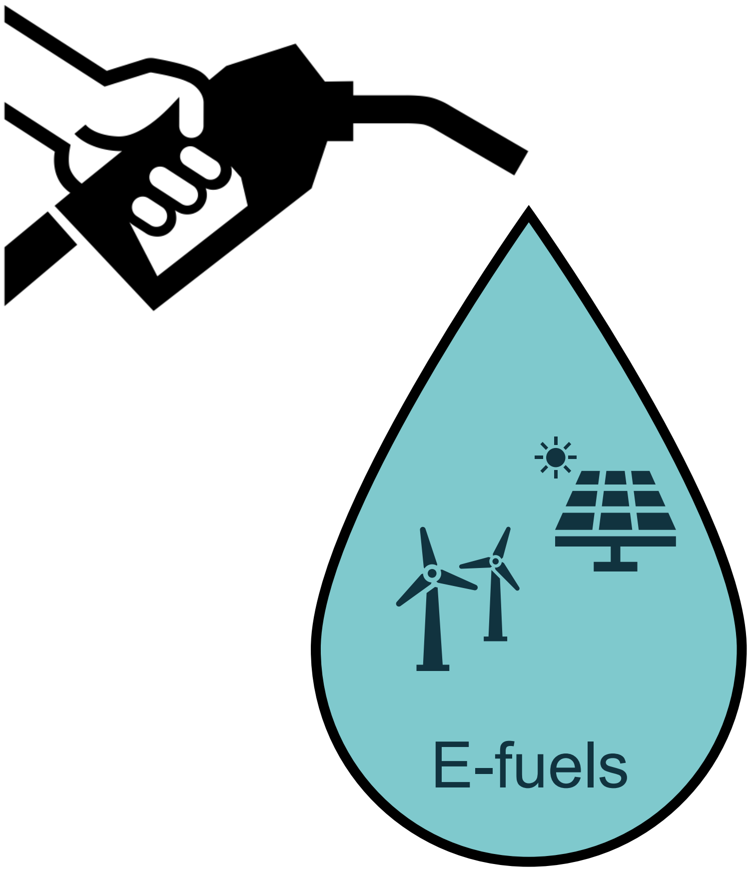
Contribution of infrastructure



Infrastructure: in solid colors.
The rest: dotted lines.

The infrastructure for **methanol production** and **CO_2 capture$_2$** is negligible.
Wind turbines have a particularly significant impact.
Electrolyzer infrastructure has a significant impact, particularly on the use of mineral resources (28%) due to the copper used.

Summary



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Do you have any questions?

Thank you

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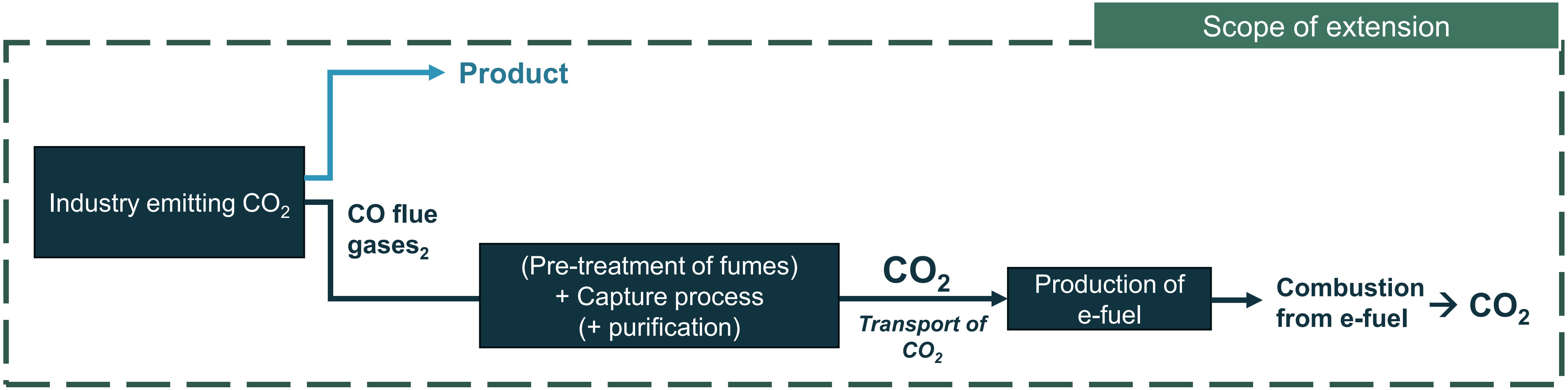
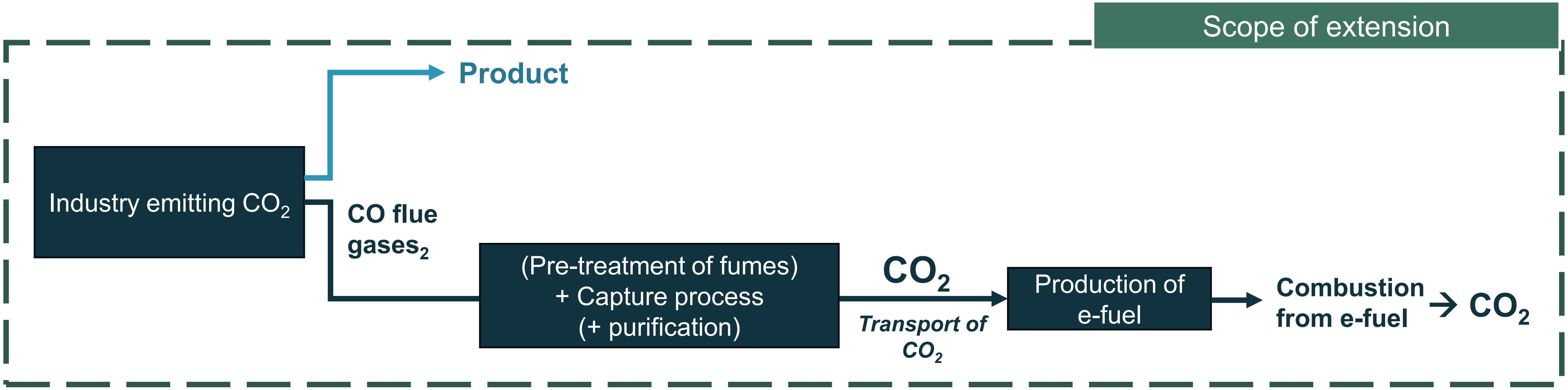
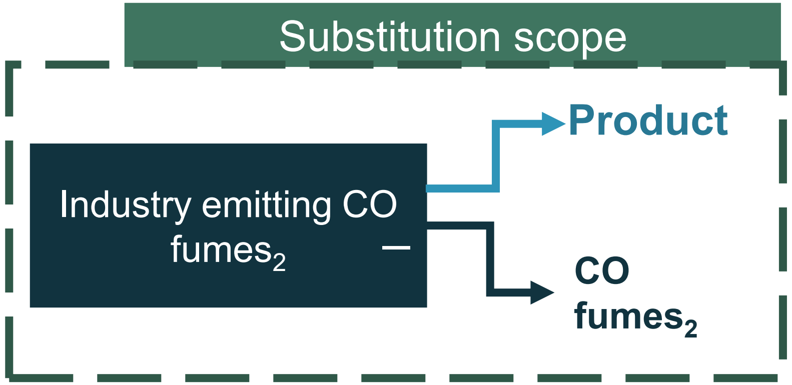
Extension



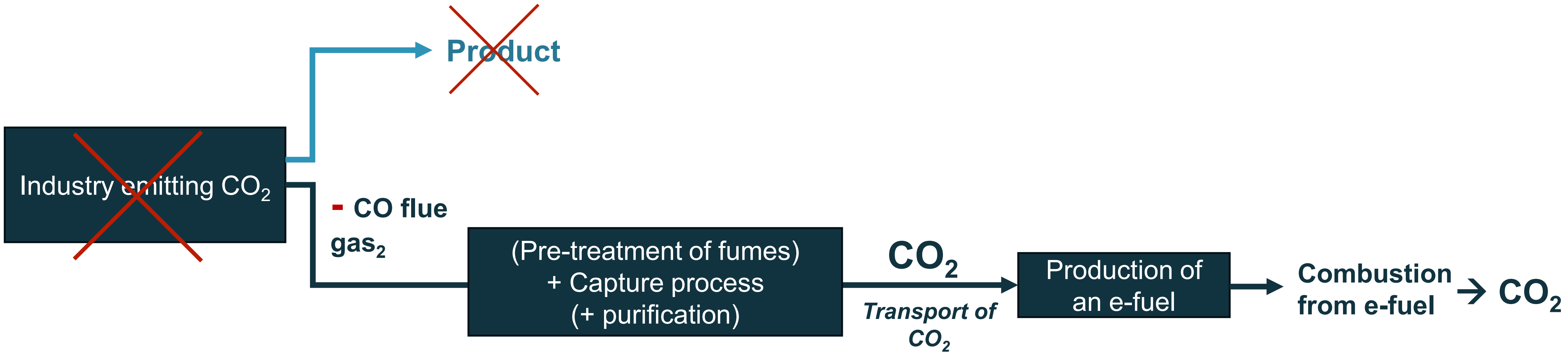
Scope of extension
Product
Industry emitting CO_2
CO flue
gases$_2$
(Pre-treatment of fumes)
+ Capture process
(+ purification)
CO_2
Transport of
CO_2
Production of
e-fuel
Combustion
from e-fuel
→ CO_2

Extension-substitution

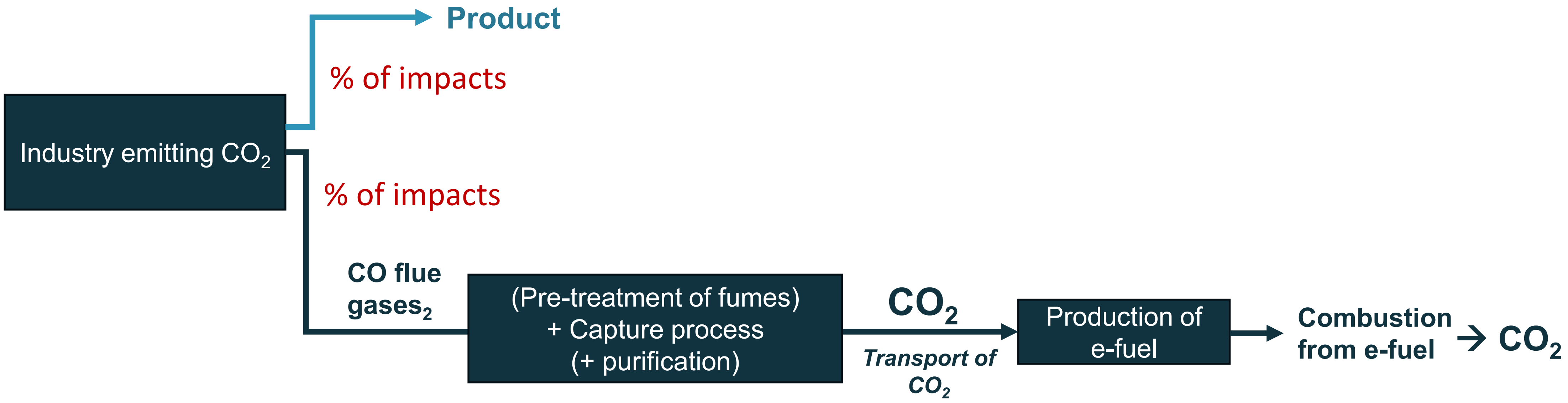




Simplified extension-substitution



Allocation


Product
% of impacts
Industry emitting CO_2
% of impacts
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