nova Institute for Ecology and Innovation

BioRECO2VER

BioRECO2VER: CCU in the context of social acceptance and life cycle assessment

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Center Plock, 07.10.21., PKN Orlen

WP 7 Overview

- Objectives of WP7:
  - Evaluate the **overall environmental sustainability** of the developed products and processes of BioRECO2VER
  - Evaluate the **social acceptance and public perception** of the developed products and processes of BioRECO2VER

Approach & methodology

We wanted to look at two perspectives:

- **Industry**
  - How the **CCU industry** in general thinks about the issue of social acceptance by consumers with regard to converted CO_2 in products.
  - How **companies** that already have CO_2–based products on the market think about acceptance issues
- **Consumers**
  - How **consumers** feel about the issue on converted CO_2 in their products
  - Which **factors** play a major role for the acceptance?

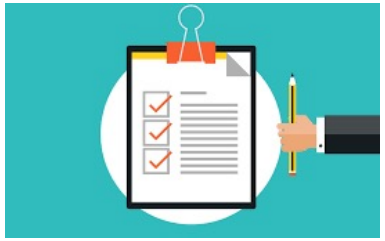
Methodology:

- **Literature research** on consumer perception
- **Online survey** with 11 questions (n=93) circulated via our industry networks
- 4 **expert interviews** with companies who already launched CCU products
- 4 **focus group discussions** with 4-6 consumers each

Previous studies on the Social acceptance & public perception on CCU products

- **Few studies** have investigated the social acceptance of captured CO_2 in consumer products.
- **Little is known about CCU** as a technology among the wider population.
  - Found **positive correlations for people**:
    - with regard to the attitude “environmental awareness”
    - with regard to a more technical background
    - with regard to the age of people
- **Acceptance and trust** in novel technologies like CCU are strongly dependent on the **source of knowledge** (knowledge provider)
  - → e.g. in Germany, the government and NGOs are considered trustworthy
- Difference between general agreement with a technology and having to interact personally → **NIMBY effect** (not-in-my-backyard effect)

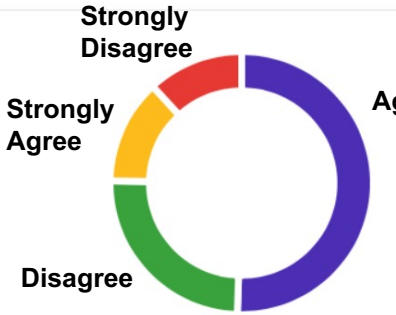
Highlights of the online survey circulated via the chemical & material industry



3. Do you emphazise CCU when marketing your product?

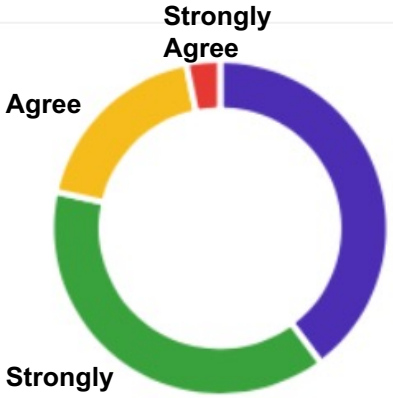
- No : 64 **(68.82%)**
- Yes : 29 **(31.18%)**

5. Do you think that CO2 utilisation for products is perceived as sustainable at... consumer level



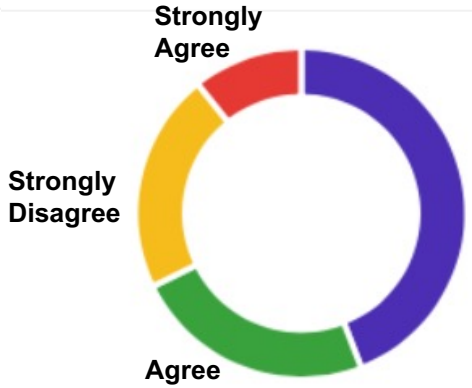
- 3 of 4 : 47 **(50.54%)** **Agree**
- 2 of 4 : 23 **(24.73%)** **Disagree**
- 4 of 4 : 12 **(12.90%)** **Strongly Agree**
- 1 of 4 : 11 **(11.83%)** **Strongly Disagree**

4. Do you think consumers are aware that it is possible to make products from CO_2.



- 2 of 4 : 37 **(39.78%)** **Disagree**
- 1 of 4 : 36 **(38.71%)** **Strongly Disagree**
- 3 of 4 : 17 **(18.28%)** **Agree**
- 4 of 4 : 3 **(3.23%)** **Strongly Agree**

9. Do you think that body-related products made from CO2 are less accepted by consumers



- 2 of 4 : 41 **(44.09%)** **Disagree**
- 3 of 4 : 22 **(23.66%)** **Agree**
- 1 of 4 : 20 **(21.51%)** **Strongly Disagree**
- 4 of 4 : 10 **(10.75%)** **Strongly Agree**

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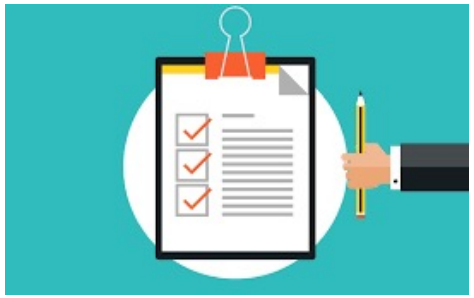
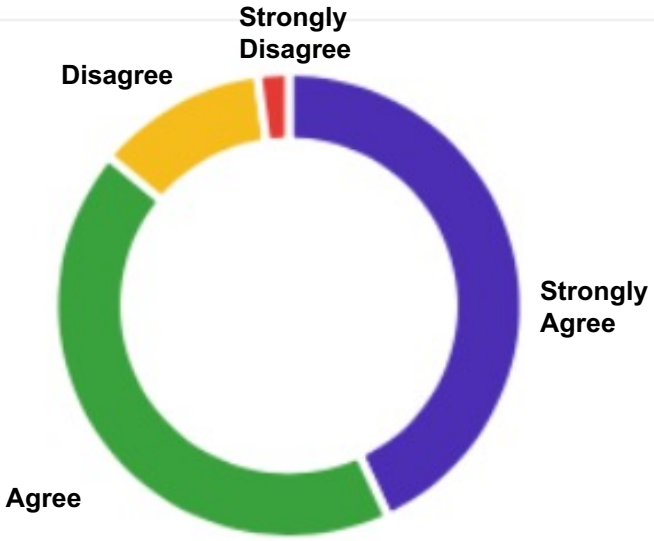


10. Do you think that a CO2 label could help consumers to be more aware of CO2 utilisation



- 4 of 4 : 40 **(43.01%)** — **Strongly Agree**
- 3 of 4 : 40 **(43.01%)** — **Agree**
- 2 of 4 : 11 **(11.83%)** — **Disagree**
- 1 of 4 : 2 **(2.15%)** — **Strongly Disagree**

Insights of the expert interviews

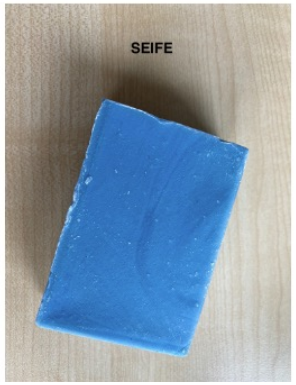
- Rather **positive social acceptance** for CCU
- All **companies have difficulties** in indicating sustainability in a way that it is understandable for consumers → Most companies describe the term **"sustainability" as "fuzzy and imprecise"**
- More specific, CCU and CO_2 utilisation is considered highly difficult to sell due to lack of understanding, so that some producers did **not stress that converted CO_2 is included** at all
  - *"I know that in their marketing, they are not so much highlighting the carbon dioxide, so they try to describe it in a way that usual persons, who are not chemists, can understand it's more sustainable, but I think they do not stress CO_2 as a word or explain what CO_2 is".*
  - Terms like renewable or circular are well-received
- When educating lay-people it is highly important to have "**real applications**" made from converted CO_2 to showcase consumer the value of CO_2 utilisation

Insights of the expert interviews

- Need to have **big brands** on board to introduce a new material at the consumer market → Sustainability as a big selling point with high demands!
- A **CO_2 label** from a trustworthy and well-known certifier with concrete figures on the amount of CO_2 contained **would be very valuable** to give consumers an orientation.
- **Incentives from politics could help** that large industries jump on board
  - For example, a **CO_2 tax on products** in combination with such a label would clearly show consumers by the price which product contain more and which products contain less CO_2 (especially for the European market)

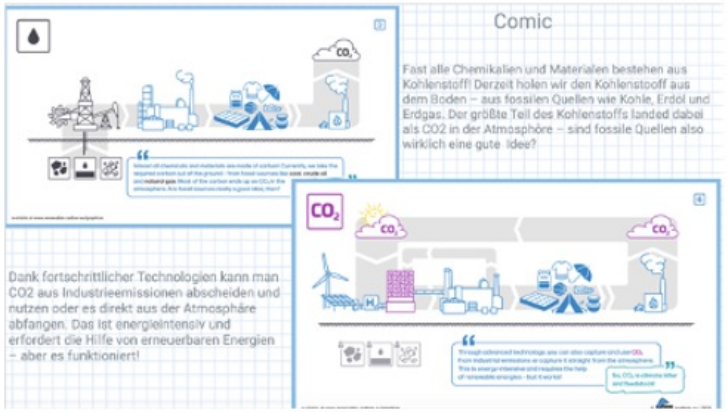
Highlights of the four focus groups

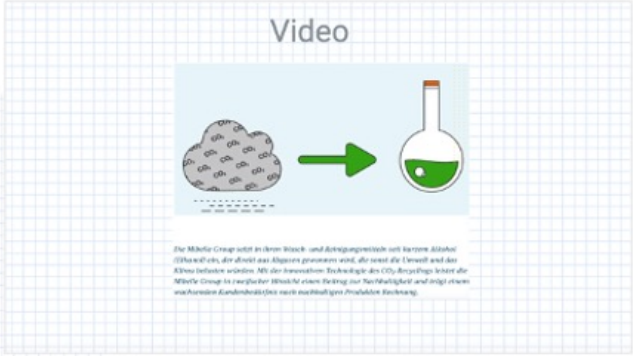
- 2 **focus groups** with the attitude "**high environmental awareness**" → most have been active in environmental NGOs
- 2 **focus groups without** particular strong relation toward the environment
- Participants received **4 different samples in advance** and were instructed to test the products → the participants did not know that the products contain captured CO_2.
  - Wax crayon
  - Soap
  - Piece of foam (used e.g. for mattresses)
  - Household cleaner



Highlights of the four focus groups

- A general explanation of CCU was given in the middle of the focus group discussion
- After that we showed them different information trails about CCU:
  - **Comic**
  - **Label**
  - **Fact sheet**
  - **Tweet** about a CO2 product and
  - **Video**





Statements from the participants

- In general all participants were basically **positively surprised** that such technologies already exists
- They **knew next to nothing** about CO_2 use beforehand

Statements of the participants after they learned that the products we sent them contained captured CO_2:

- In most of the products we tested, the **acceptance of the CO_2 contained was very high**.
  - Some where **concerned** about the mattress foam and the soap **due to health reasons**
- **No real differences between people** with a high environmental awareness and no or less environmental awareness
- Regarding the information trails **most people preferred the video** over the other options
  - However, we would guess that the way of communication is strongly dependent on the environment and the target group.

Main take-aways social acceptance of CCU

- Companies
  - **Difficult to market** the concept of CCU
  - Similar to bio-based, it might be feasible to use **simpler terminology** to get the message across → a good example: Circular carbon
  - Currently, **brands are a stronger driver than regulation** & policy for CCU
  - Companies are largely convinced that a **reliable label** would be a strong tool for marketing

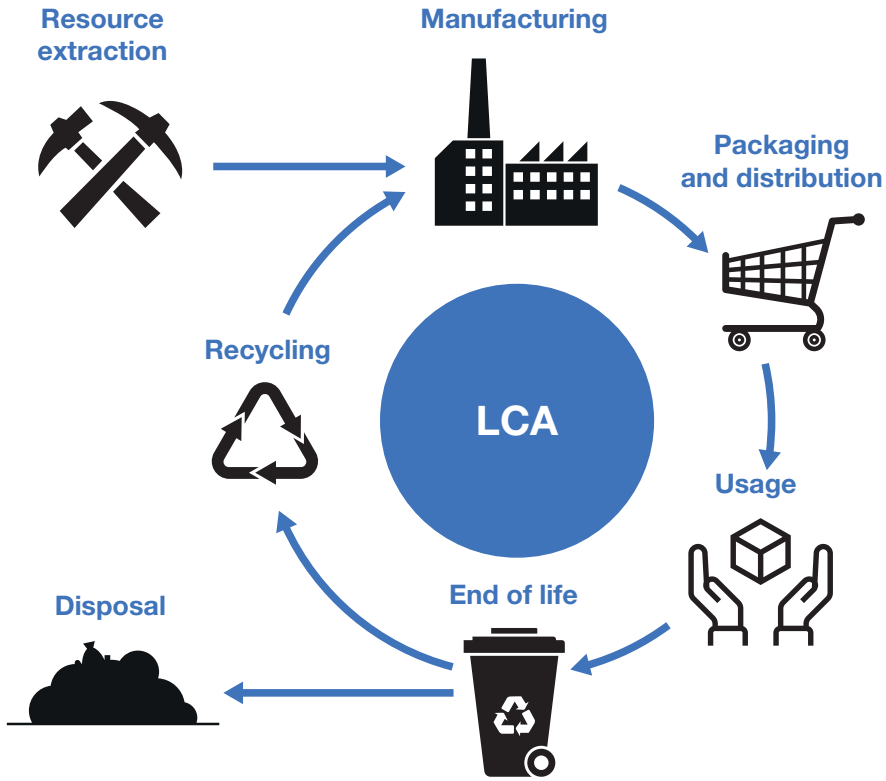
- Consumers
  - **No knowledge of CCU**
  - In principle, consumers are **positively surprised about CCU when they understand** the concept
  - **Trust is strongly dependent** on the source of information
  - Issues can arise via the **NIMBY-effect**: If people perceive issue to their personal health or other personal limitations (e.g. a CCU plant in the neighbourhood), they might oppose
  - Transferring information via video was received best, but this is likely dependent on the circumstances (e.g. videos not feasible in supermarkets)

What is Life Cycle Assessment?

- Method to **assess** the **potential environmental impact** of a product or service throughout its entire life cycle. That is, from the supply of raw materials and production, to use, disposal or end-of-life waste management (cradle-to-grave)

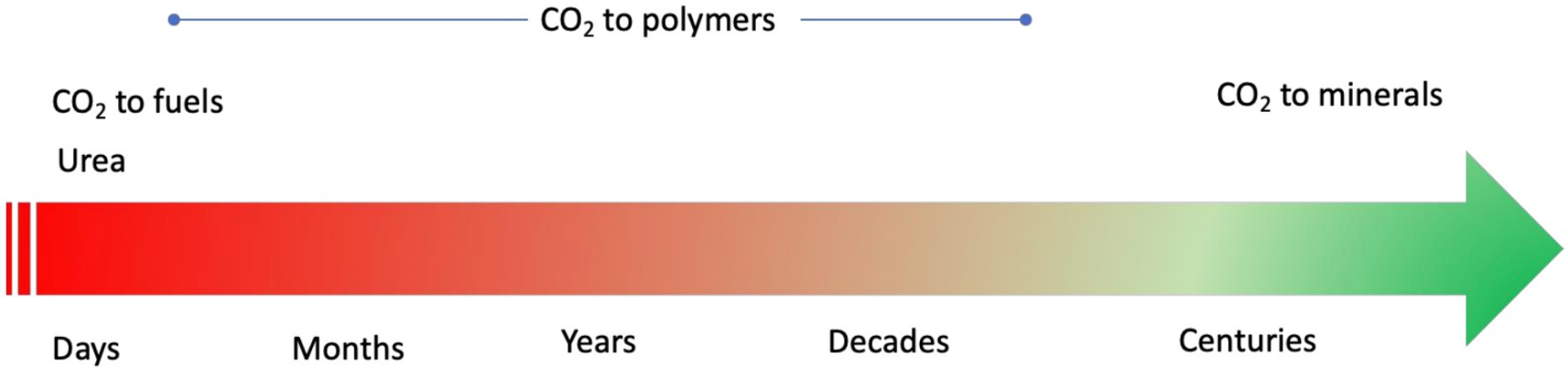
- It is an internationally standardised method under ISO 14040 and ISO 14044

- LCA assesses environmental impacts, such as global warming potential or eutrophication over the life cycle of a product or service, as well as the impacts on natural resources and/or human health



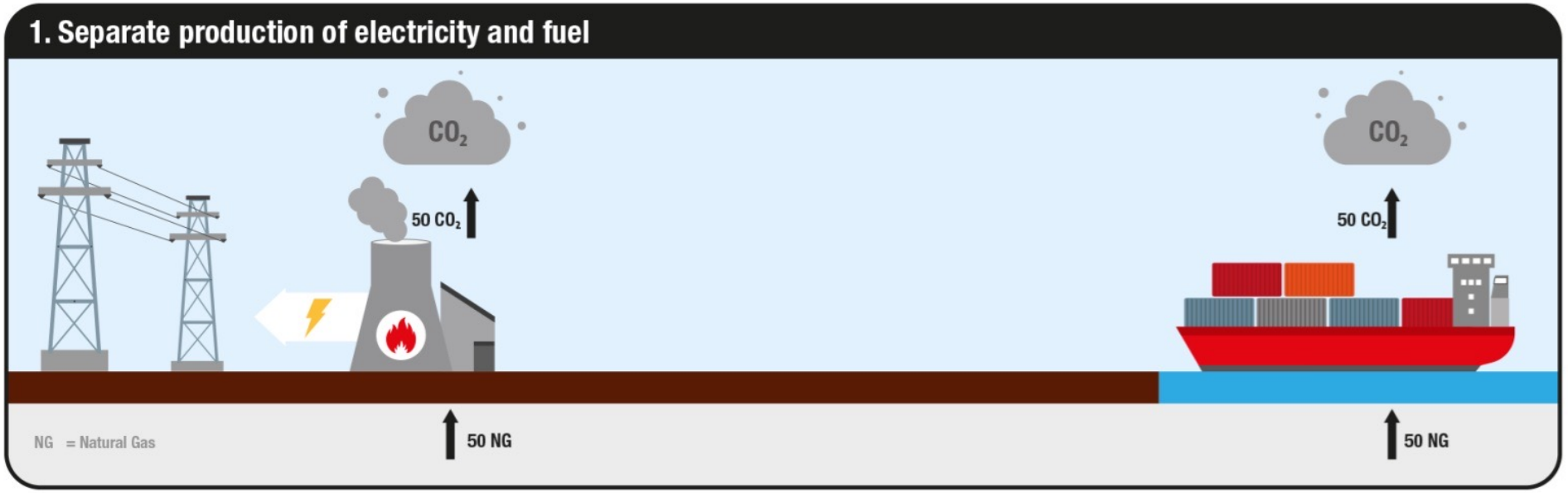
CCU: Delayed emissions

- Delayed emissions of high relevance for CCU → **CO_2 is used instead of released**, but how long is the delay? For fuels, only a few months? For plastics, 20-30 or more years?
- Different ways to consider delayed emissions → **recommendations differ from complex scientific calculations to 500-year horizons** as a minimum threshold
  - Few to none CCU applications bind carbon for >500 years
- Other way of thinking: If the CCU product replaces a product derived from fossil resources, we have a **substitution**



System expansion:
Production of electricity and fuel

(The figures model ideal conditions without losses (100% efficiency))



Separate fossil electricity and fossil fuel production result in maximum GHG emissions (50 + 50 CO_2 = 100 CO_2)

System expansion:
Production of electricity and fuel

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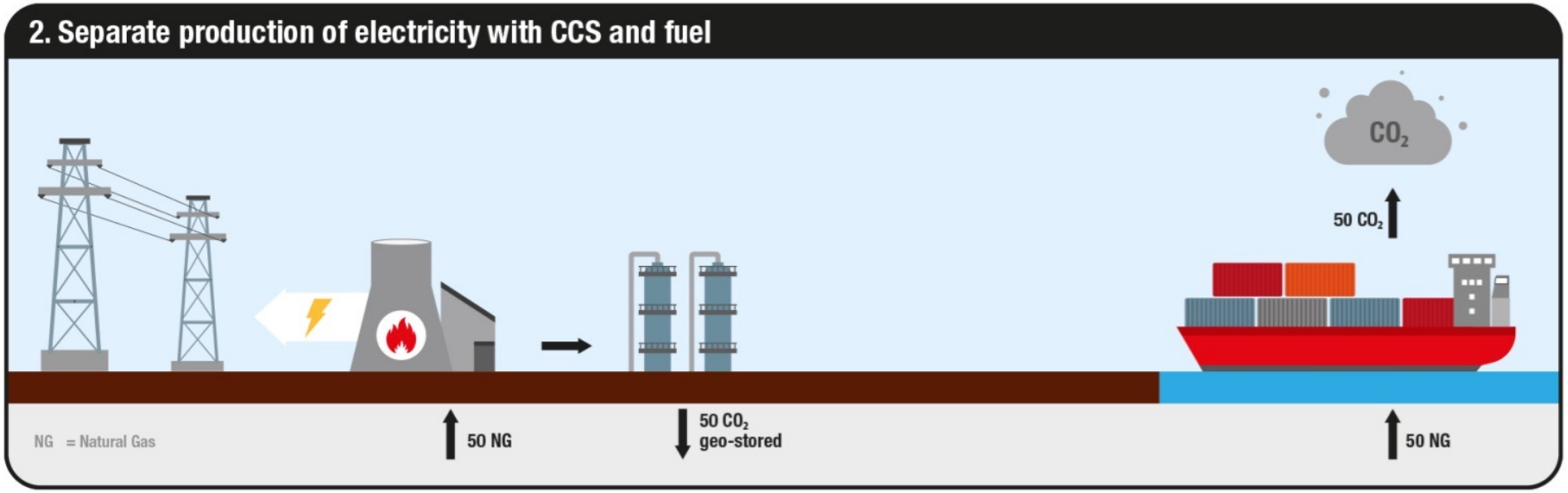
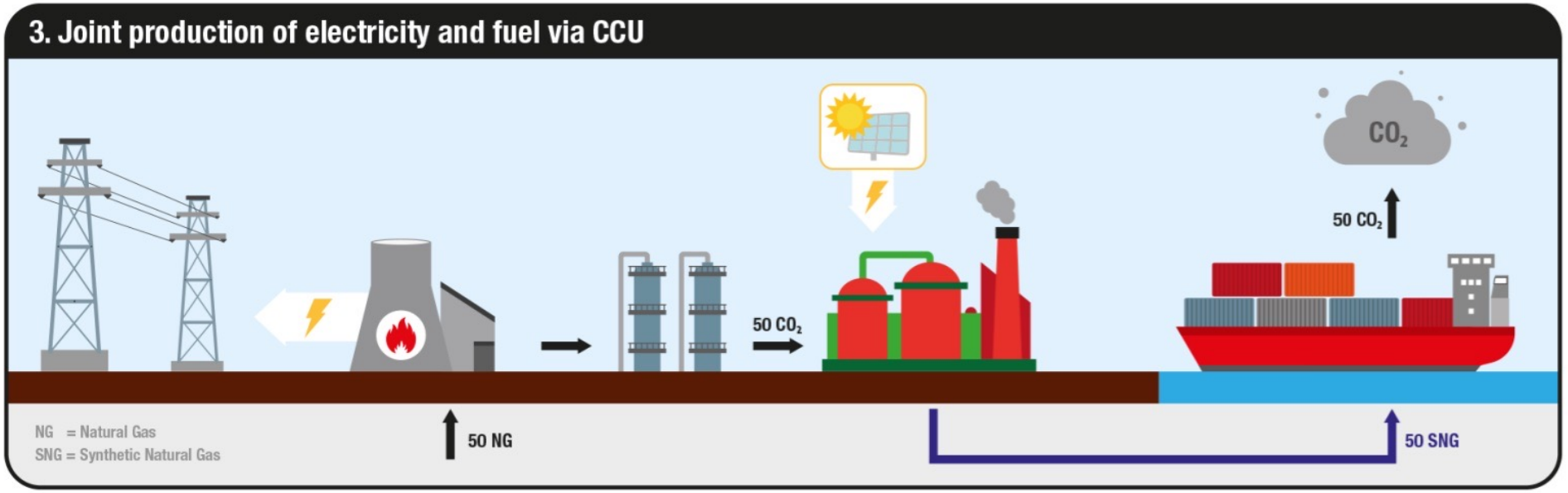


Carbon Capture and Sequestration (CCS) reduces the total CO_2 emissions by 50%.

System expansion:
Production of electricity and fuel

(The figures model ideal conditions without losses (100% efficiency))



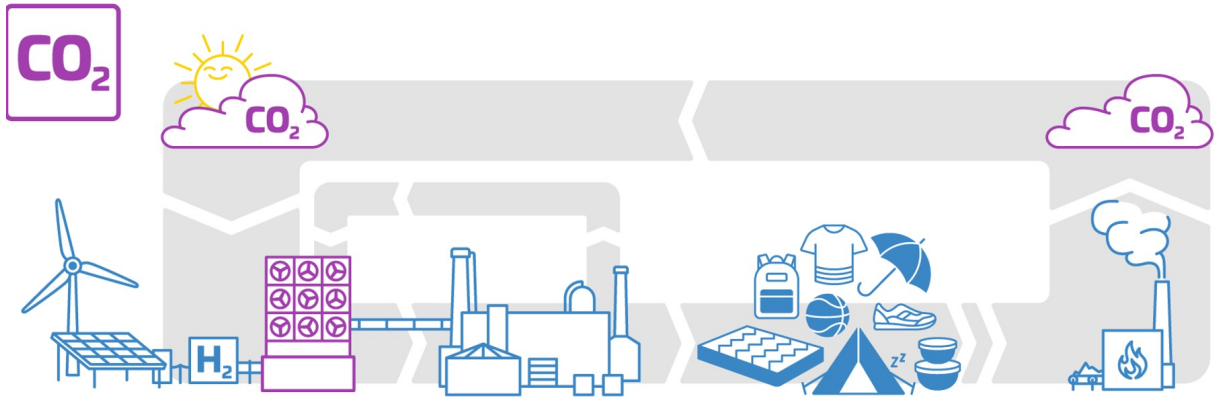
Carbon Capture and Utilization (CCU) also reduces total CO_2 emissions by 50% by using emissions from electricity production to produce fuels and substituting fossil natural gas (NG).

CCU: Electricity

- **CO_2 from industrial sources** is rarely a pure stream, but rather a mixture
- CO_2 is a naturally **stable** chemical, which often requires further processing steps.

- This usually requires **additional energy/electricity** for purification and utilisation
- The additional electricity will be **allocated to the process** and causes additional environmental impacts
- Dependent on the **grid mix this can lead to higher emissions** than what was avoided by CCU
- Running process on **additional** (produced on-site or purchased additionally) **renewable energy** is therefore often necessary
- **Purchased additionally**
  - RE currently limited, where to use it for maximum efficiency?
  - Purchased green electricity lowers RE in the grid mix
- **Producing on site**
  - Constructing required RE plants to cover energy needs are a good, but expensive solution

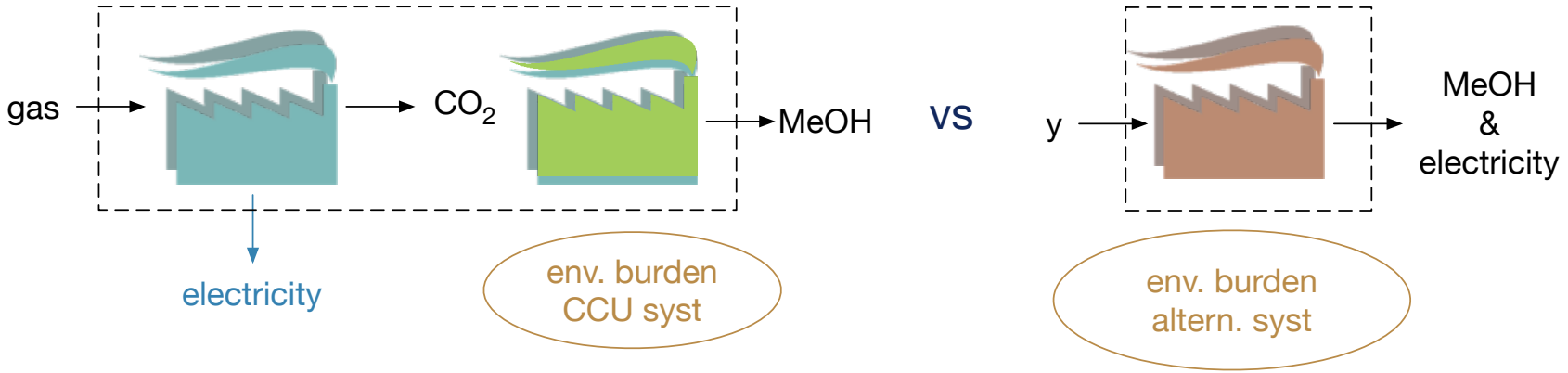
CCU: Credit and Burden



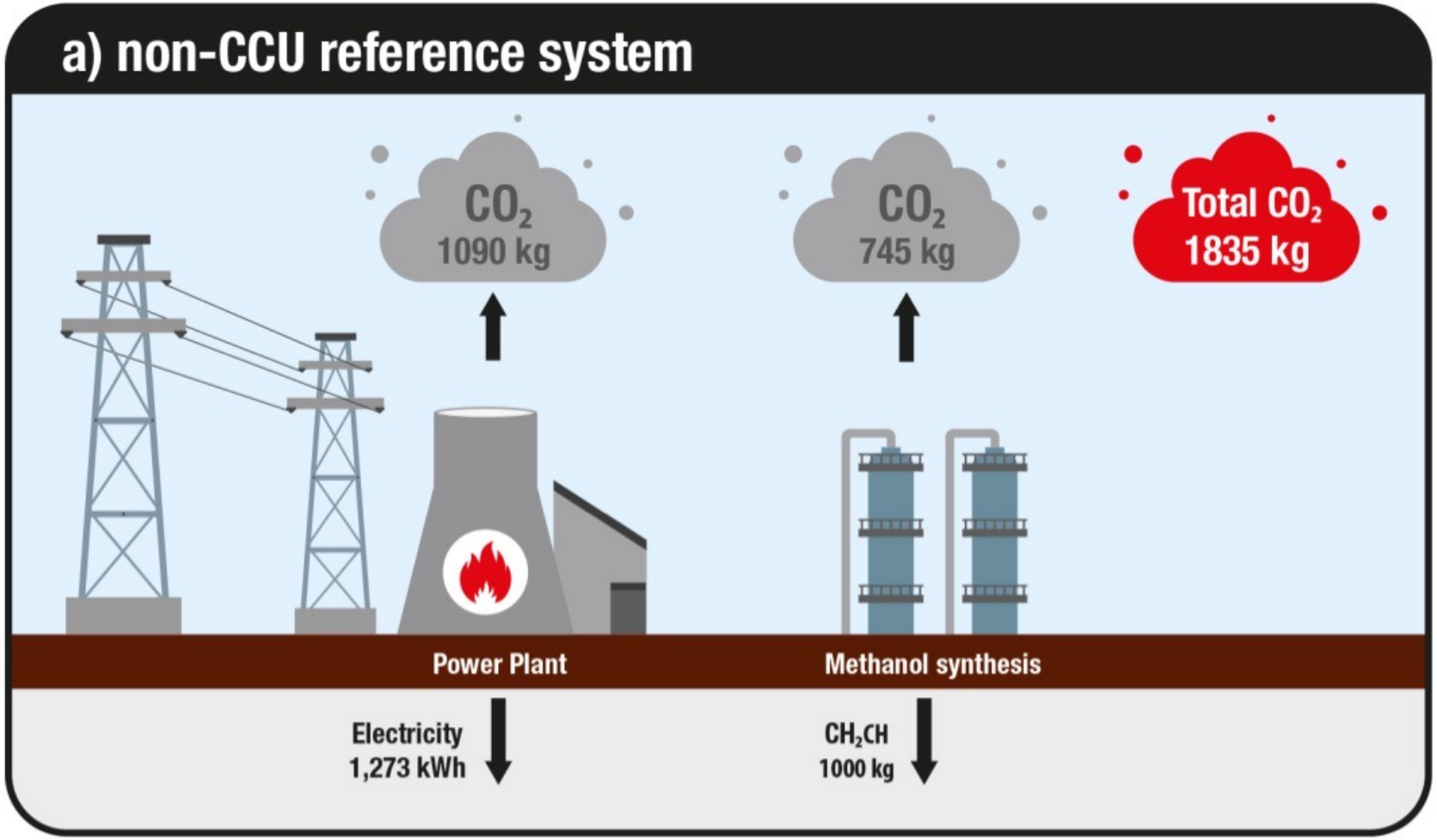
- Utilizing CO_2 has some peculiarities that have to be considered within the context of BioRECO$_2$VER:
  - By definition, **CO_2 is an elementary feedstock** for CCU plants. At the same time, it **also contributes to a fundamental impact category** (global warming potential, GWP)
  - For the emitting plant, **CO_2** is typically not the main product, often rather an **undesired side product**.
  - Upon utilisation of the CO_2 instead of emitting it to the atmosphere, it is of relevance **who gets the credit for reduction in CO_2 emission** or, in LCA terms words, how to allocate the CO_2 emission reduction between emitter and receiver of CO_2.
  - Because the CO_2 is usually a side product / waste from another process, **multi-functionality** occurs → **More than one product** (e.g. product from the original process and CCU product)

CCU: Credit and Burden
System expansion

- **System expansion**: comparison between CCU system (end-products) & a system with the same functions
  - Clearly determines environmental impact reductions
  - Strictly reflects physical relations ships
  - Can be complex
  - No product-specific assessment of the CO_2

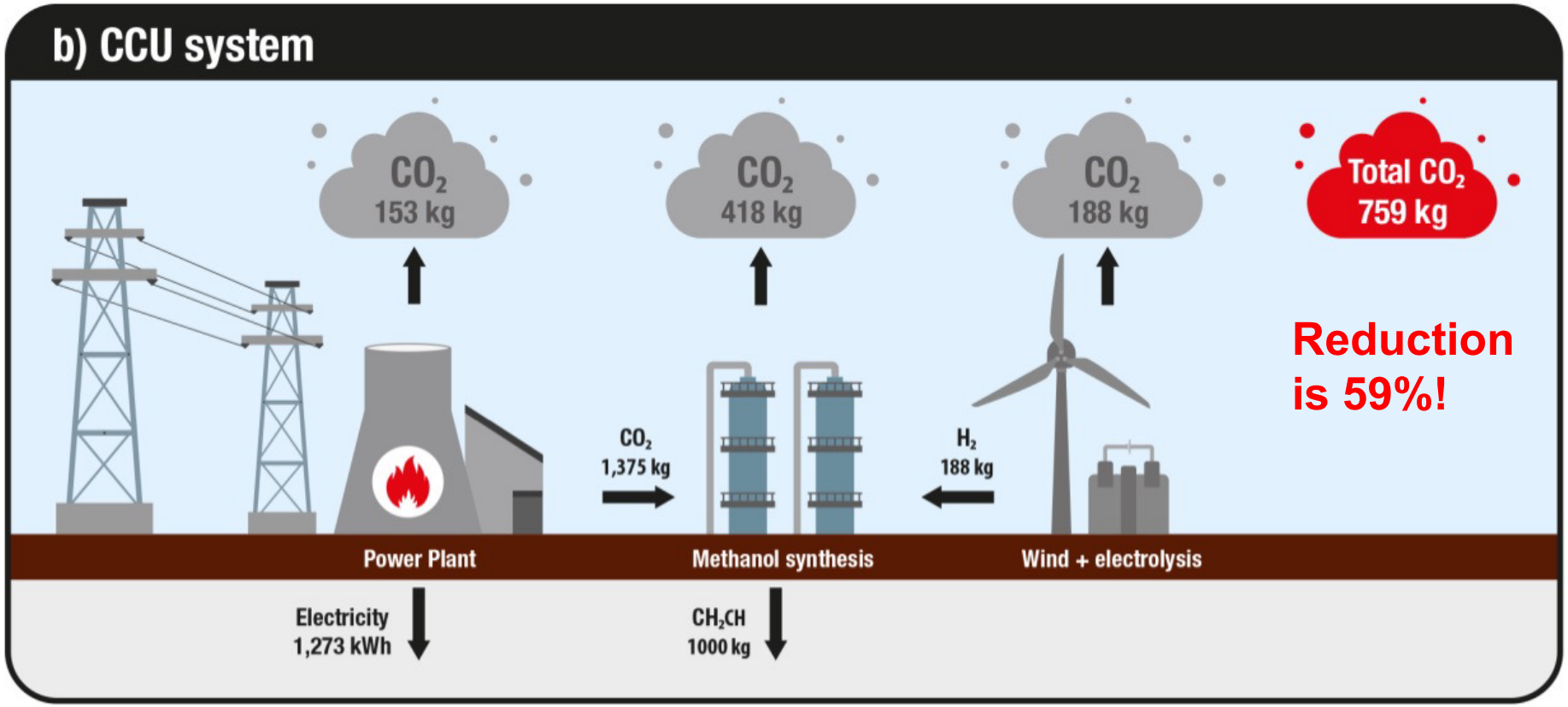


Example: Seperate production of electricity and methanol



Source: Von der Assen, N., Voll, P., Peters, M. and Andre´ Bardow, A.: LCAof CO_2 capture and utilization: a tutorial review. Chem. Soc. Rev. 2014-01-20.

Example: Joint production of electricity and methanol via CCU & wind energy)



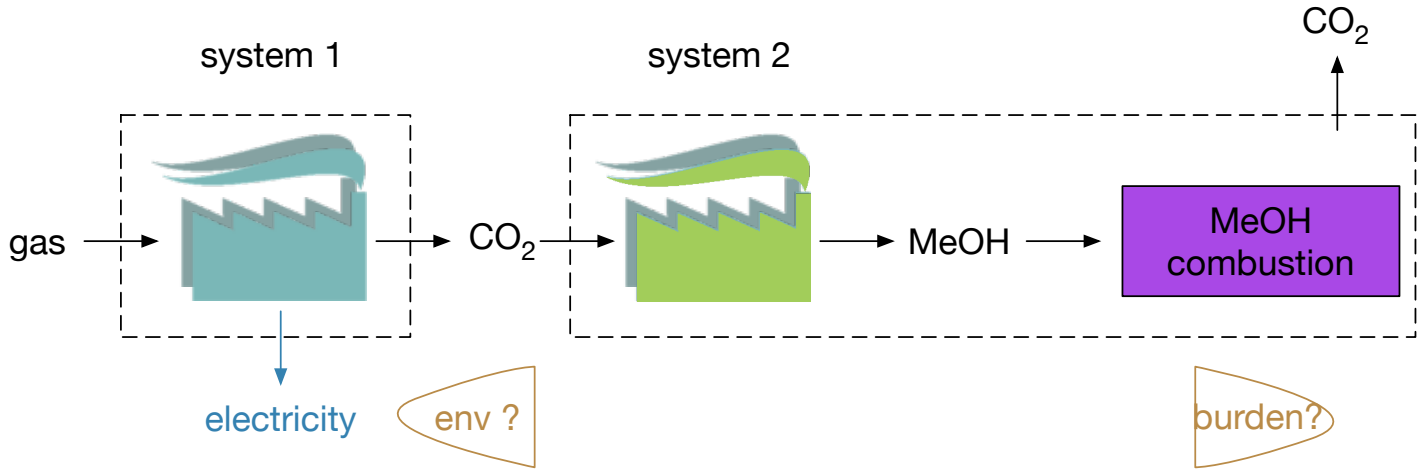
Source: Von der Assen, N., Voll, P., Peters, M. and Andre´ Bardow, A.: LCAof CO_2 capture and utilization: a tutorial review. Chem. Soc. Rev. 2014-01-20.

CCU: Credit and Burden Crediting

- **Substitution** (Avoided burden / credits)
  - Assigns all environmental burdens to a defined main function.
  - CCU would receive full burden of the process, but at the same time also receive credits for avoided production of the other product (here electricity) that would otherwise be provided through an alternative route

Credit and Burden of CCU: Allocation

- **Allocation**
- Environmental burden of is split between system 1 (electricity) & system 2 (MeOH)
- How to split? Most common suggestions are
  - **100:0** (giving merit to the CCU plant)
  - **50:50** (even split to provide incentives to both parties)
  - **0:100** (could be meaningful in an increasingly defossilised system (CO_2 valuable)



Comparison of different jet fuel feedstocks and pathways – CCU jet fuel is the best

	Jet fuel yield (GJ/ha*y)	GHG emissions without LUC ($g\ CO_2$ eq/MJ fuel)	GHG emissions with dLUC ($g\ CO_2$ eq/MJ fuel)	Green + blue water demand (m^3/GJ)
Crude oil		87.5		
Natural gas		101		
Rapeseed oil (HEFA)		55	98	
Jatropha oil (HEFA)	15 - 50	39		574
Palm oil (HEFA)	162	30	40 - 700	150
Algae oil (HEFA)	156 - 402	51		14 - 53
SRC (short rotation coppice)	47 - 171	18	- 2	112
PtL (solar)	580 - 1070			
PtL (wind)	470 - 1040	1 – 28 (*)		0.04 – 0.08

Summary, based on: Schmidt, P. et al. 2018: Power-to-Liquids as Renewable Fuel Option for Aviation: A Review. In: Chem. Ing. Tech. 2018, 90, No. 1-2, 127-140. / (*): In a today's mainly fossil energy landscape in material sourcing and construction.

Main take-aways LCA of CCU

- **CCU can be a relevant option for climate change mitigation**
  - through **substituting** fossil C or circulating atmospheric/bio-based C
- A critical issue to consider are the (usually **large**) **required amounts of energy** to transform the CO_2
- There is **no** standardised **agreement on** who receives **credit** for avoided emissions via CCU
- There are **different methods to allocate environmental burdens** between multiple functions/products
  - can lead to quite different results, **careful with comparisons!**

Thank you for your attention!

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