NEW ENERGY

FORUM

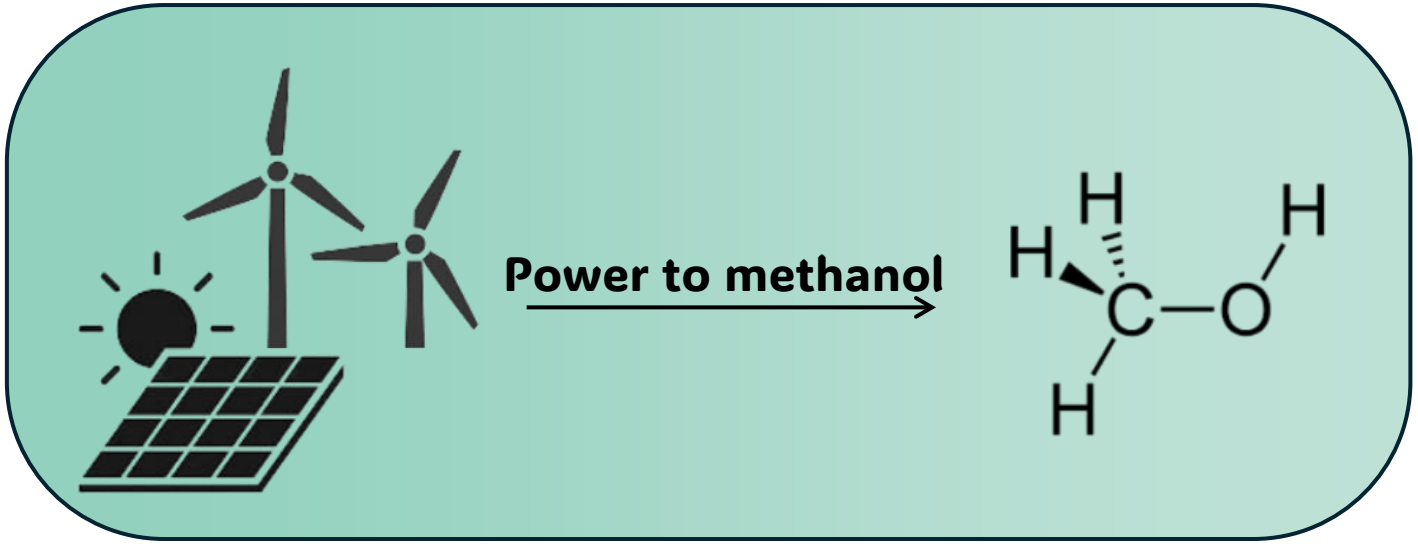
19 juni 2025 | Groningen

Breaking Barriers

NEW ENERGY FORUM

SAXION

Impact of Power to Methanol systems



19/06/2025

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Hanze

Two Power to Methanol (PtM) pathways

Green hydrogen is made from the **electrolysis of water**.

Captured CO_2 is a waste-stream that is **captured instead of emitted** into the atmosphere.

- Direct synthesis of green **hydrogen** and captured **carbon dioxide**
- **Syngas** production from **Dry Methane Reforming** react extra hydrogen to create **methanol**

$$3H_2 + CO_2 \rightleftharpoons CH_3OH + H_2O$$

RWGS reaction: $H_2 + CO_2 \rightleftharpoons CO + H_2O$

$$2H_2 + CO \rightleftharpoons CH_3OH$$

DMR reaction: $CH_4 + CO_2 \rightleftharpoons \underbrace{2CO + 2H_2}_{\text{Syngas}}$

Method

This LCA is used to **evaluate the environmental impact** of a process from **cradle to gate.**

Using the methodology from ISO14040:2006

Software: **OpenLCA**

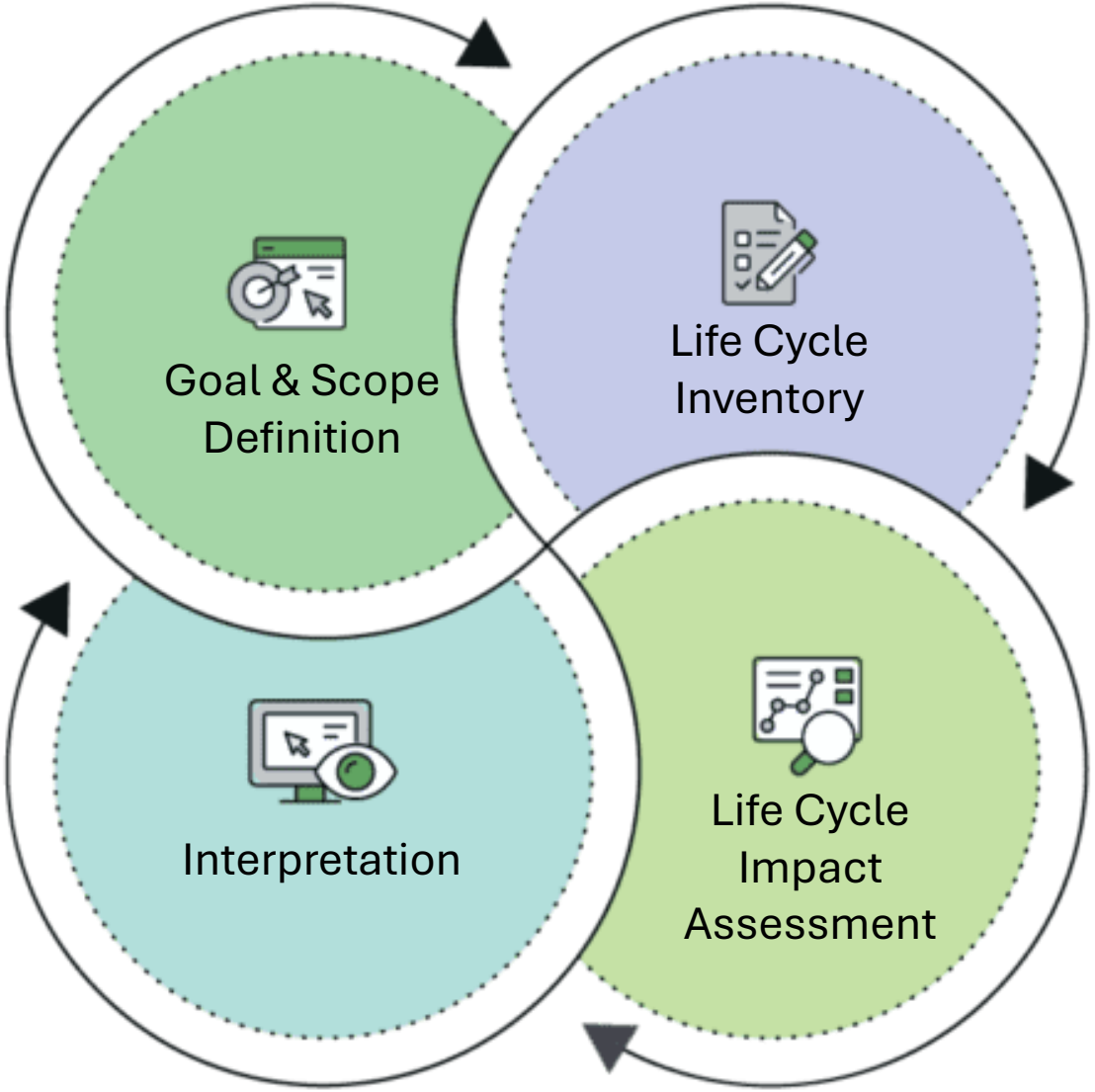
Database: **EcoInvent**

Impact assessment method:

European Footprint (EF3.0)

1) *https://www.openlca.org/*
2) *https://ecoinvent.org/*
3) *https://eplca.jrc.ec.europa.eu*

Life Cycle Assessment (LCA) method

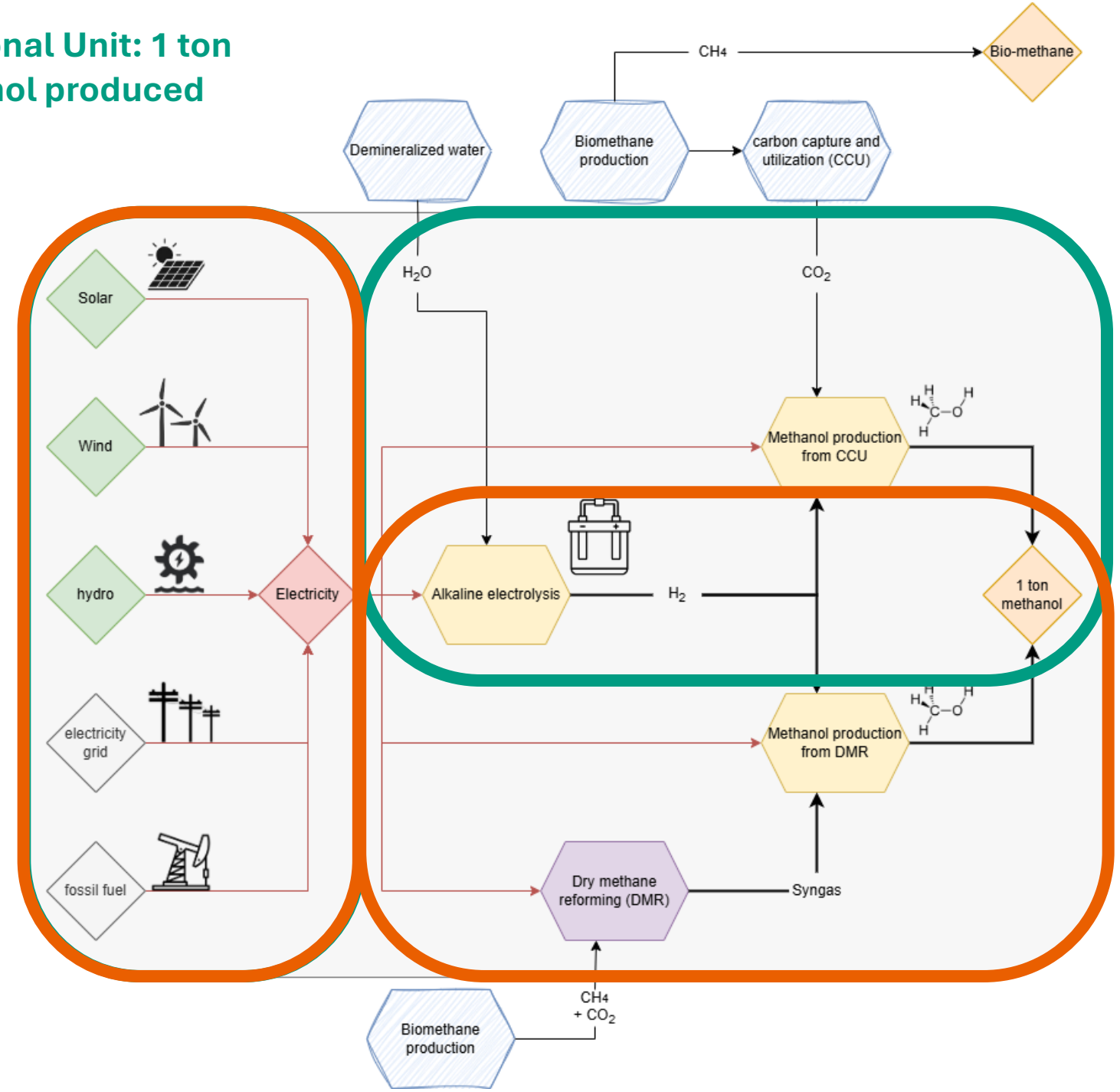


https://p6technologies.com/lca/

Goal, scope & system boundaries

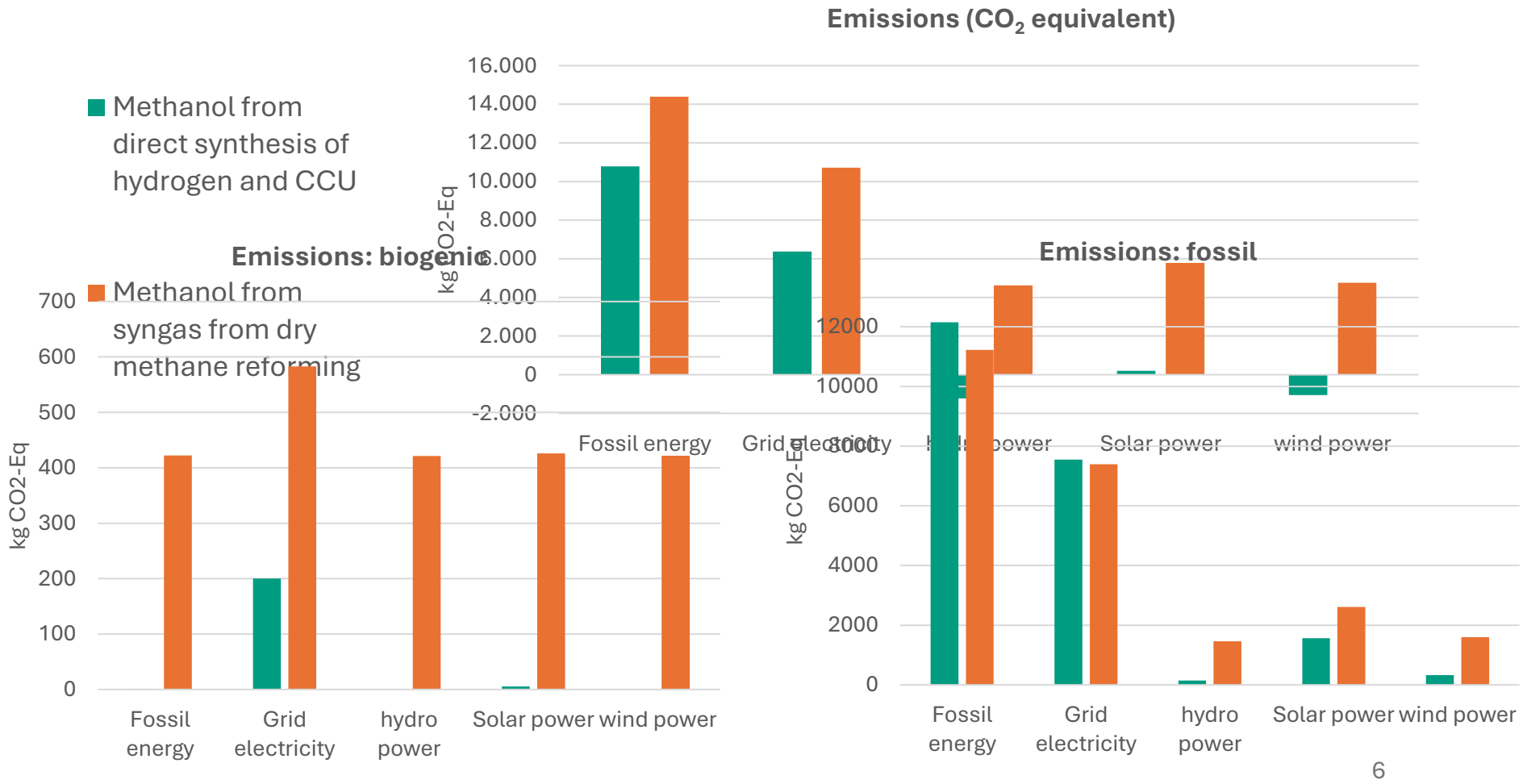
- Energy sources
- **Electrolysis**
- Carbon capture + DMR
- **Methanol production**

Functional Unit: 1 ton methanol produced



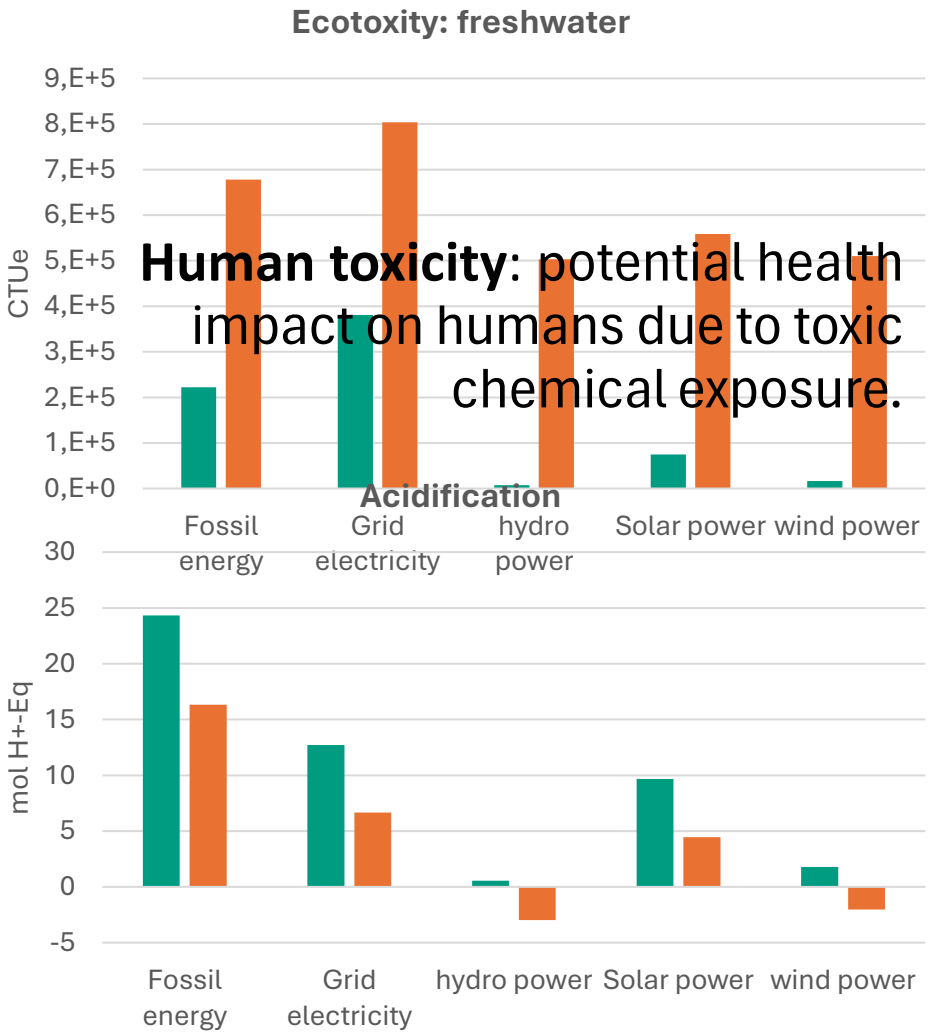
Results

Note: the **biomethane** is **allocated outside** the system boundary for the direct synthesis pathway

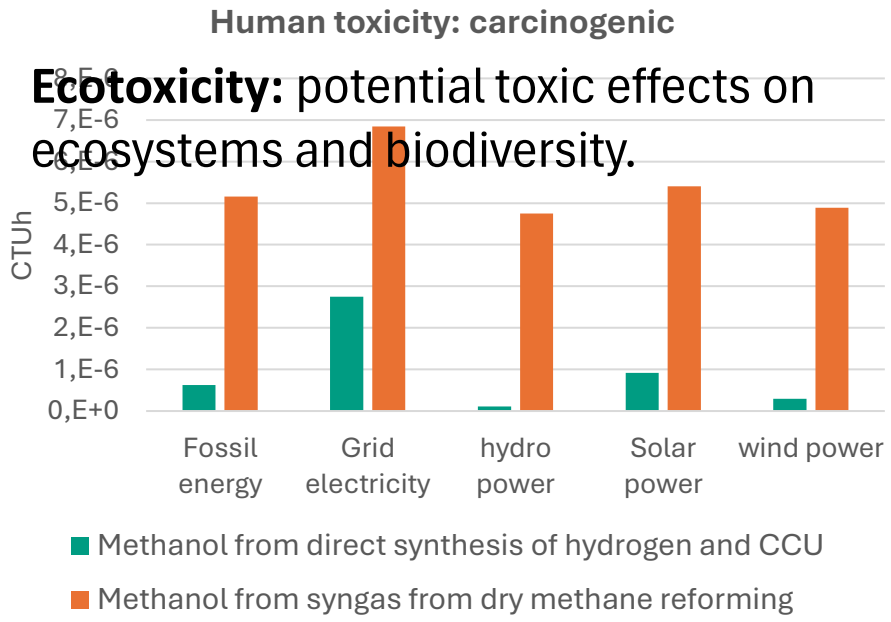


Results

The **DMR process** has more environmental impact due to the **biomethane input.**



Human toxicity: potential health impact on humans due to toxic chemical exposure.



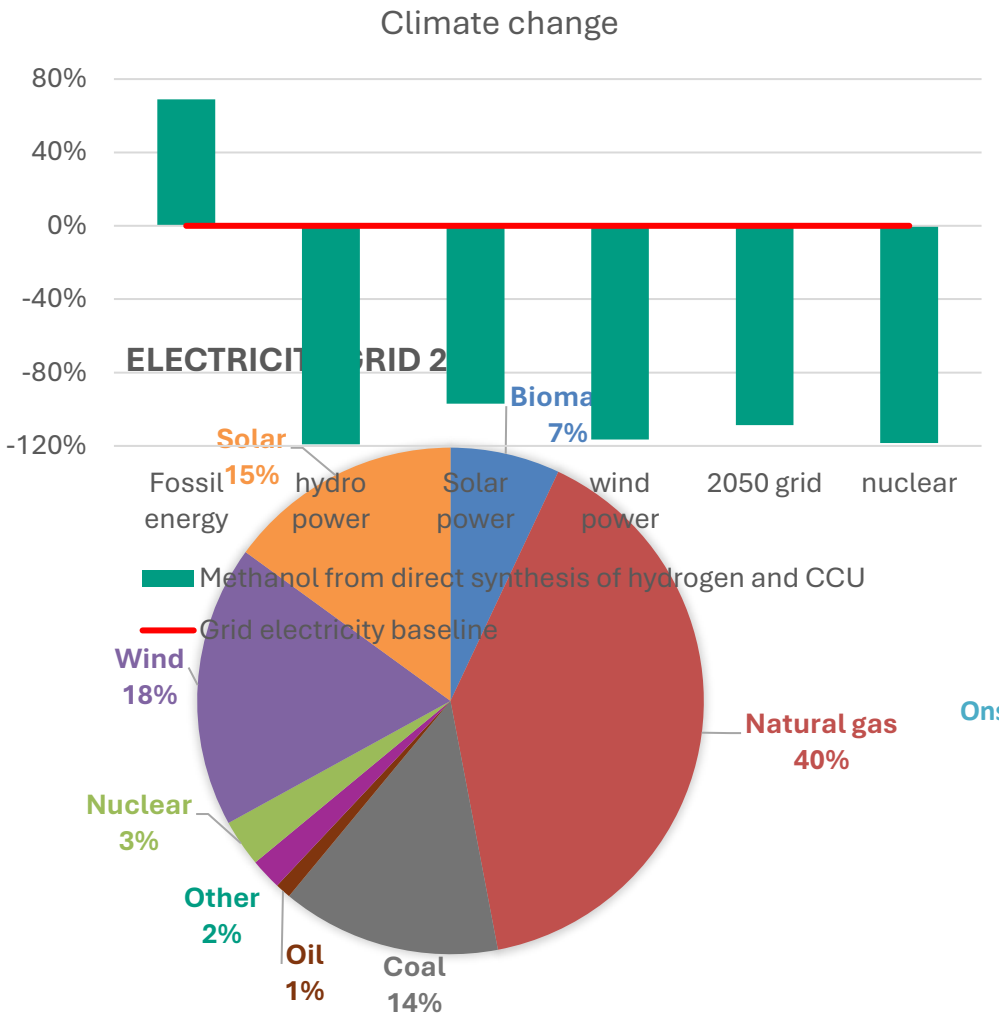
Ecotoxicity: potential toxic effects on ecosystems and biodiversity.

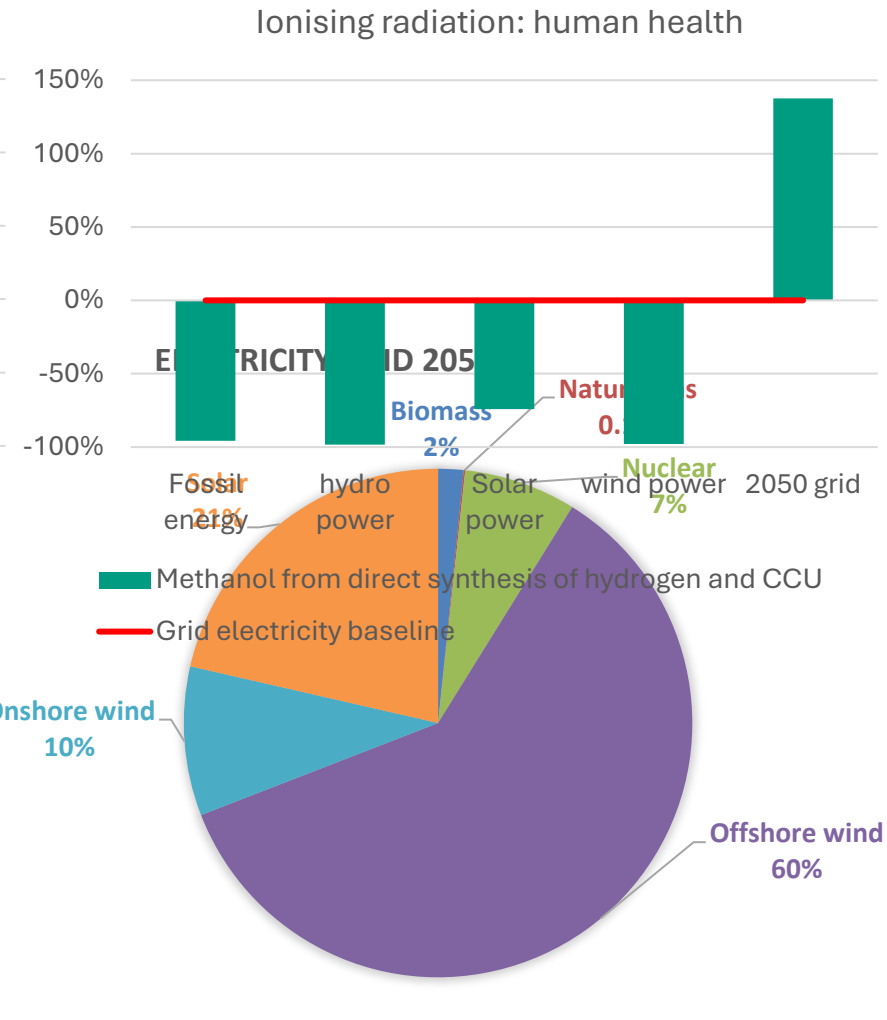
Acidification: potential to release acidifying substances that harm soil and water. Mainly caused by air emissions of NH_3, NO_2 and SO_x.

Results

The sensitivity analysis has been done for the grid electricity, adding a predicted **grid for 2050** and a **100% nuclear** grid.

The results are **normalized** over the grid electricity





1) Https://www.energie-nederland.nl/feiten-cijfers/duurzaam-energiesysteem/

2) https://energyscenarios.tno.nl/data/electricity_supply

1)

2)

Conclusion

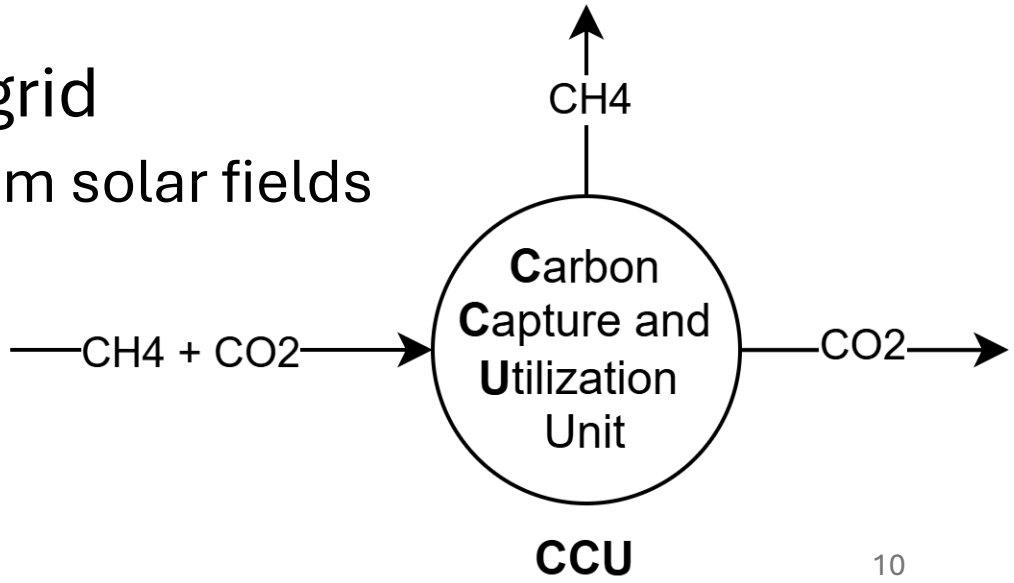
- **Wind and hydro** electricity often show the **lowest** impact
- **Grid and fossil-based** electricity often has the **highest** impact

- The **DMR** pathway often has a **higher** environmental impact
  - This is often due to the allocation of the **biomethane**

- The **sensitivity analysis** shows the impact of **future** and **nuclear** electricity usage on the environment.

Future research

- Add **CCU unit** in the direct synthesis pathway and **allocate the biomethane production** accordingly
  - This would increase the validity of the comparison between the two methanol production processes
- Compare different **electrolyser types**
  - Now only alkaline water electrolysis is considered
- **Solar electricity** in the grid
  - Currently comes only from solar fields



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Thank you for your attention and interest.

I am happy to answer any questions you might have!

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