# Turning $CO_2$ into Biomethane: Driving Scalable Bioenergy Solutions

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ENTRANCE
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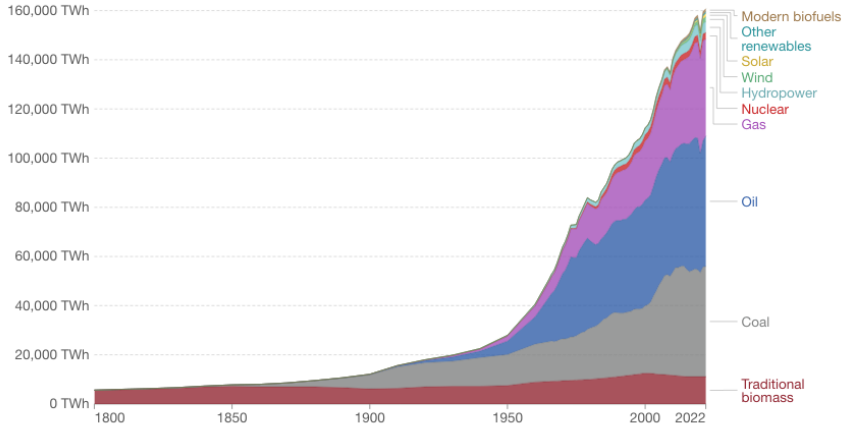
## Global direct primary energy consumption

Our World in Data

Energy consumption is measured in terawatt-hours, in terms of direct primary energy. This means that fossil fuels include the energy lost due to inefficiencies in energy production.




**Data source:** Energy Institute - Statistical Review of World Energy (2023); Smil (2017)
**Note:** In the absence of more recent data, traditional biomass is assumed constant since 2015.
OurWorldInData.org/energy | CC BY

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Council of the EU Press release 20 February 2024 03:10

# Climate action: Council and Parliament agree to establish an EU carbon removals certification framework

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# Climate neutrality

EU countries are committed to making the **EU climate-neutral by 2050**.

Shifting to a zero-emission society and economy is both an urgent challenge – given the increasing number of extreme weather events – and an opportunity to create new jobs and economic opportunities.

The green transition is also a necessary step towards **reducing the EU's energy dependencies**. Replacing fossil fuels with cleaner forms of energy will cut the EU's greenhouse gas emissions and also make the EU's less dependent on Russian gas.

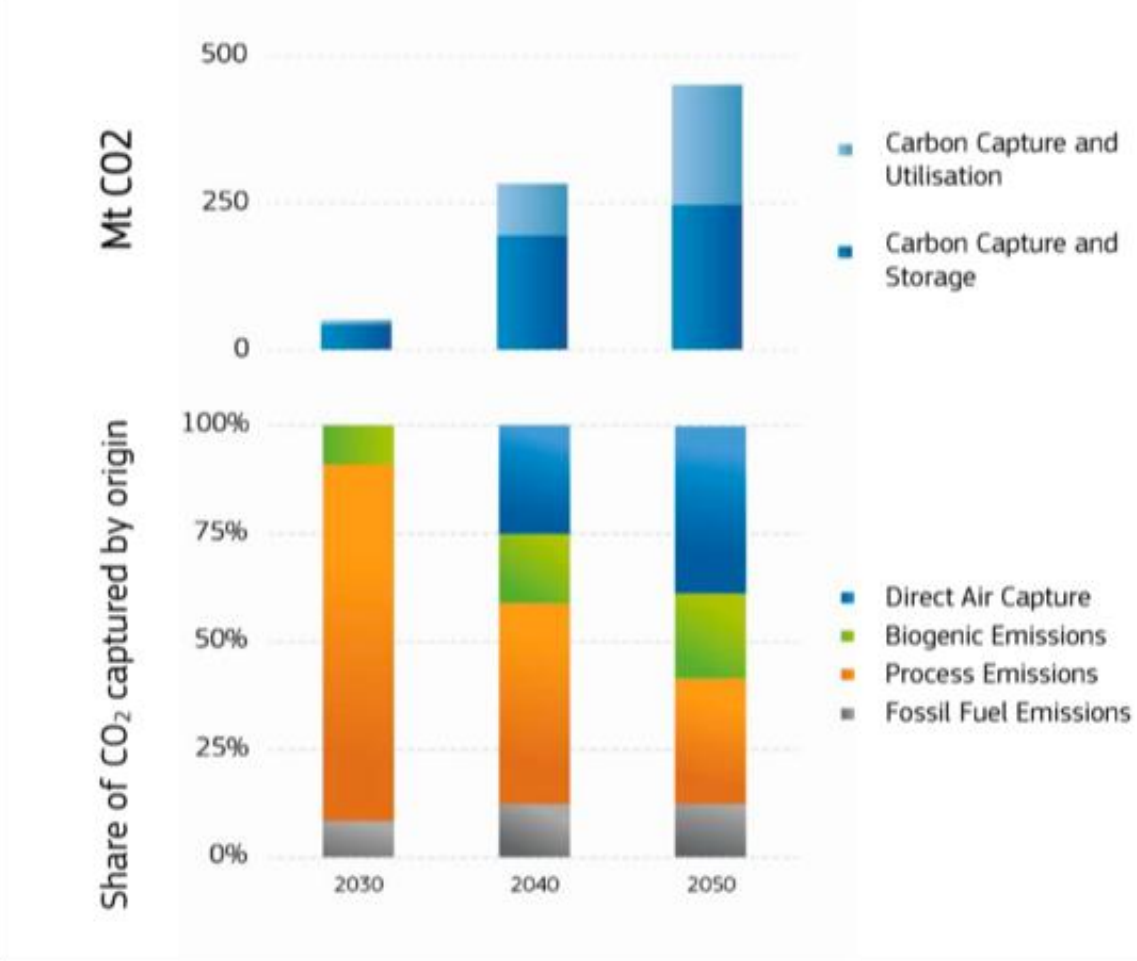
The Council is currently working on new rules which aim to reduce the EU's emissions **by at least 55% by 2030** (compared to 1990), with the so-called 'Fit for 55' package.

This page gives an overview of the latest and upcoming meetings, press releases and policies related to the work of the Council and the European Council on the EU's goal to become climate-neutral by 2050.

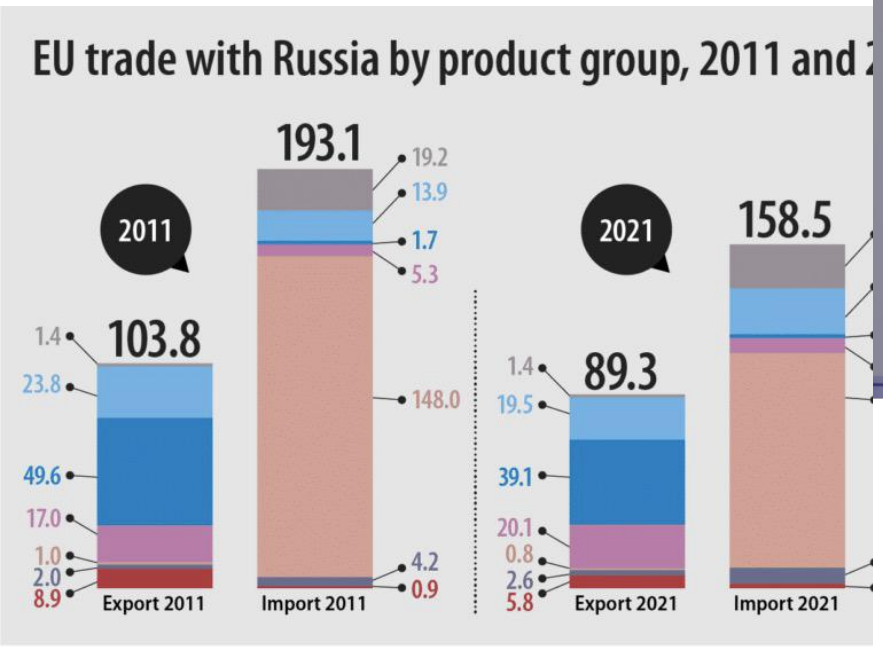
**Seventeen years ago the European Council made a commitment to construct up to twelve carbon capture and storage (CCS) demonstration plants by 2015. Yet today there is still no CO2 being stored within the EU on anything other than a pilot basis.**
*Chris Davies is Director of CCS Europe*

Modelling results for the EU's 2040 climate target Communication indicate that approximately
280 million tonnes would have to be captured by 2040 and around 450 million tonnes by 2050
(see Figure).

(Ref: "COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS", EN ENEUROPEAN COMMISSION
Strasbourg, 6.2.2024)



# Importance of Groningen





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## The dash away from gas: how the Netherlands kicked a big fossil fuel habit

Posted on 2 June 2021

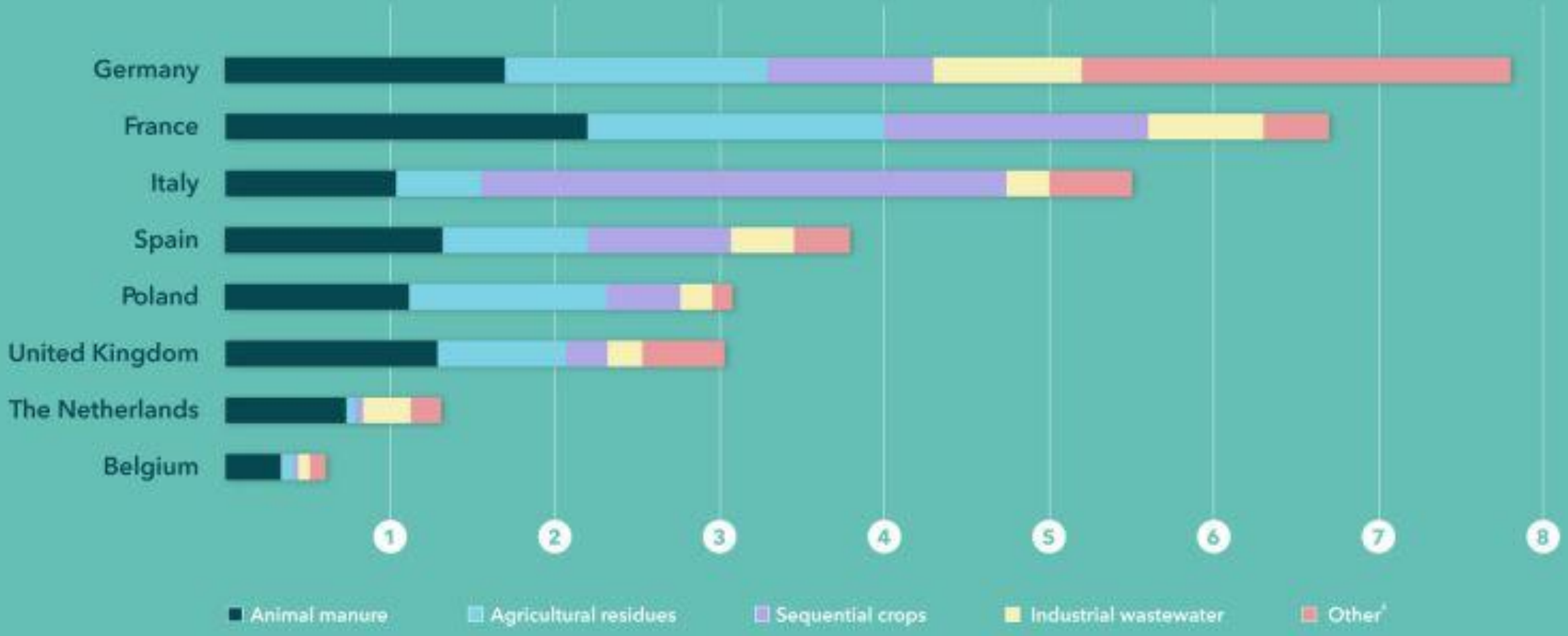
See lessons

There is no energy security = more sustainable energy  is needed
Alternative energy production is essential

biogas

# Abundant feedstock throughout Europe in 2030

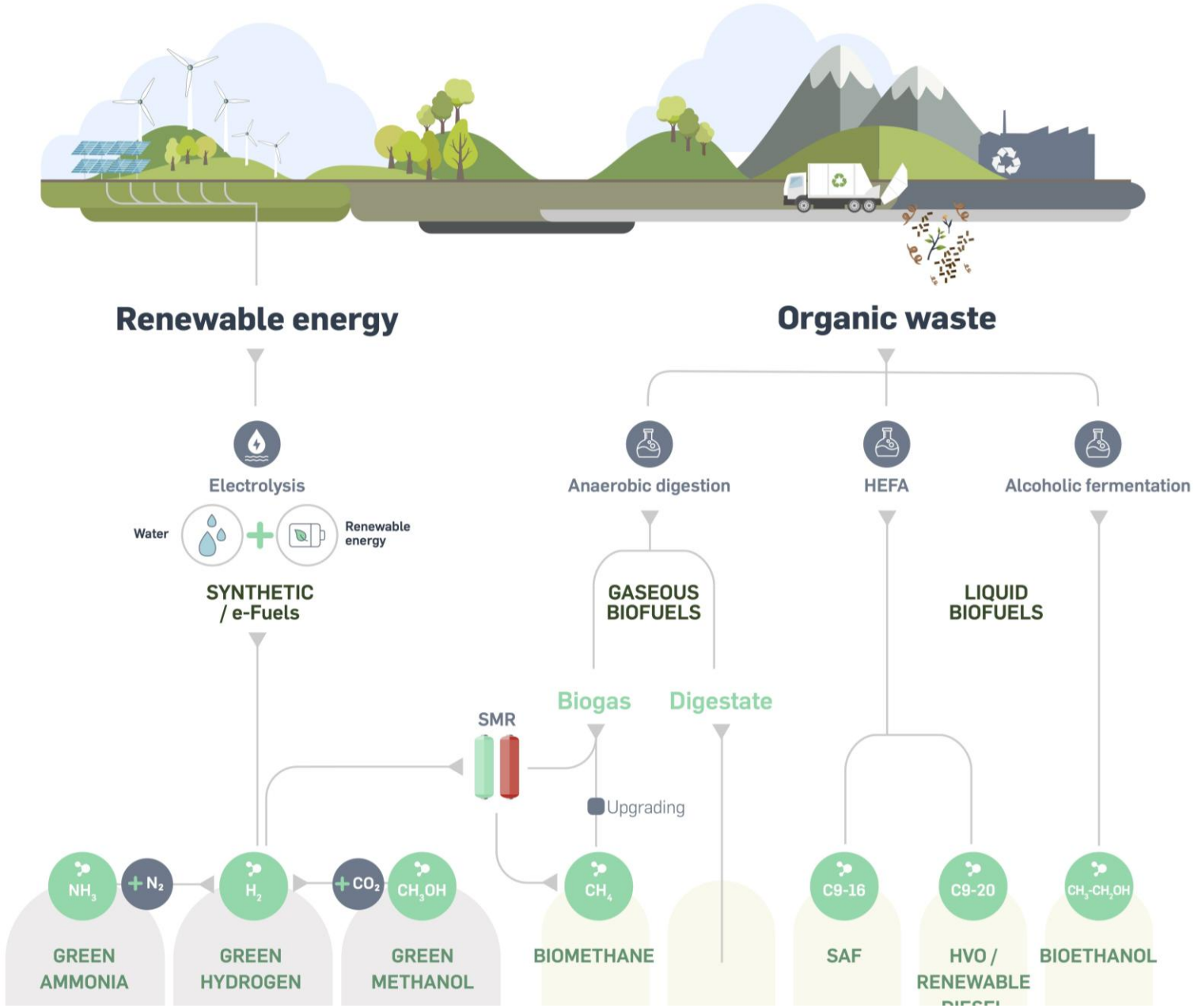
BIOMETHANE POTENTIAL PER FEEDSTOCK AND COUNTRY (BCM PER YEAR)[1]




(1) *Biomethane potential determined using the anaerobic digestion process*
(2) **Other** *includes permanent grassland, biowaste, sewage sludge and roadside verge grass*
*Source: European Biogas Association (Guidehouse report)*

Green Giraffe Advisory

# BIOFUEL PRODUCTION INFOGRAPHICS




Source: CEPSA

# European biogas sector

## 2000-2020

- Electricity production
- Energy crops

## 2020-2050

- Biomethane production
- Waste/Sequential crops
- $CO_2$ valorization

**Main trends**

$CH_4$

- Sector industrialization

**Main challenges**

- Increase sustainability and reduce production costs

Brémond, Ulysse, et al. "A vision of European biogas sector development towards 2030: Trends and challenges." *Journal of Cleaner Production* 287 (2021): 125065.

# Challenges of Upscaling Biogas Technologies

- **Feedstock Variability and Supply Chain**:

Inconsistent feedstock supply and quality can affect biogas yields.

- **Reactor Design and Process Optimization**:

Scaling up digesters introduces challenges in maintaining optimal digestion conditions.

- **Methane Yield Optimization**:

Achieving high methane yields is crucial but can be difficult at larger scales.

# Challenges of Upscaling Biogas Technologies

- **Gas Upgrading**:

Upgrading biogas at scale is challenging.

- **Waste Management and Digestate Utilization**:

Managing large quantities of digestate is a challenge for large-scale operations.

- **Biological Stability and Process Resilience**:

Upscaling can introduce biological instability in digestion processes.

# HOW TO VALORIZE BIOGAS?

Our living lab facility: available to learn with application


# Biogas upgrading in a pilot-scale trickle bed reactor

## Target

**Reactor upscaling**
0.8 $m^3$ reaction volume

**Integration**
into industrial infrastructure

**Operation**
at real conditions

**Identification**
of operational strategies for high performance


## Key findings

**High performance**
6 $m^3/(m^3_{RV} \cdot d)$ $CH_4$ production at synthetic natural gas quality

**Propionic acid accumulation**
probably due to high $H_2$ partial pressure

**Reduced $H_2S$**
but too low to serve as sulfur source

**Stabilized pH level**
by $Na_2S$ addition and increasing $NH_4^+$

**Reduced trace element addition**

REFERENCE: Fenske, C. F., Kirzeder, F., Strübing, D., & Koch, K. (2023). Biogas upgrading in a pilot-scale trickle bed reactor–Long-term biological methanation under real application conditions. Bioresource Technology, 376, 128868.

# Early findings

- **Pressure swings**

Production of methane decreases pressure in the system causing imbalanced pressure distribution in the system lines

- **Challenge in solubility differences of gases**

Solubility difference between methane and carbondioxide is very high causing gas solubility imbalance leading pressure gas accumulation or swings in pressure

- **High initial and operational costs**

High cost of installing the equipment and high cost of the hydrogen makes it challenging to have a business case

# More can be achieved with upgrading

Carbondioxide to methane

Carbondioxide to platform chemicals (formate, ethanol, methanol)

Carbondioxide to syngas for further green chemical production

Methane to methanol and or other green molecules

# WHAT ABOUT BIO HYDROGEN OR OTHER ALTERNATIVES?


©AdobeStock (from left to right ) scharfsinn86/AA+W

Renewable hydrogen is produced through the process of electrolysis, using renewable electricity to split water into hydrogen and oxygen and is therefore a ‘renewable fuel of non-biological origin’ (RFNBO).

# Thank you!

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