

# Biological **desulfurization** and **methanation** of biogas and CO<sub>2</sub>

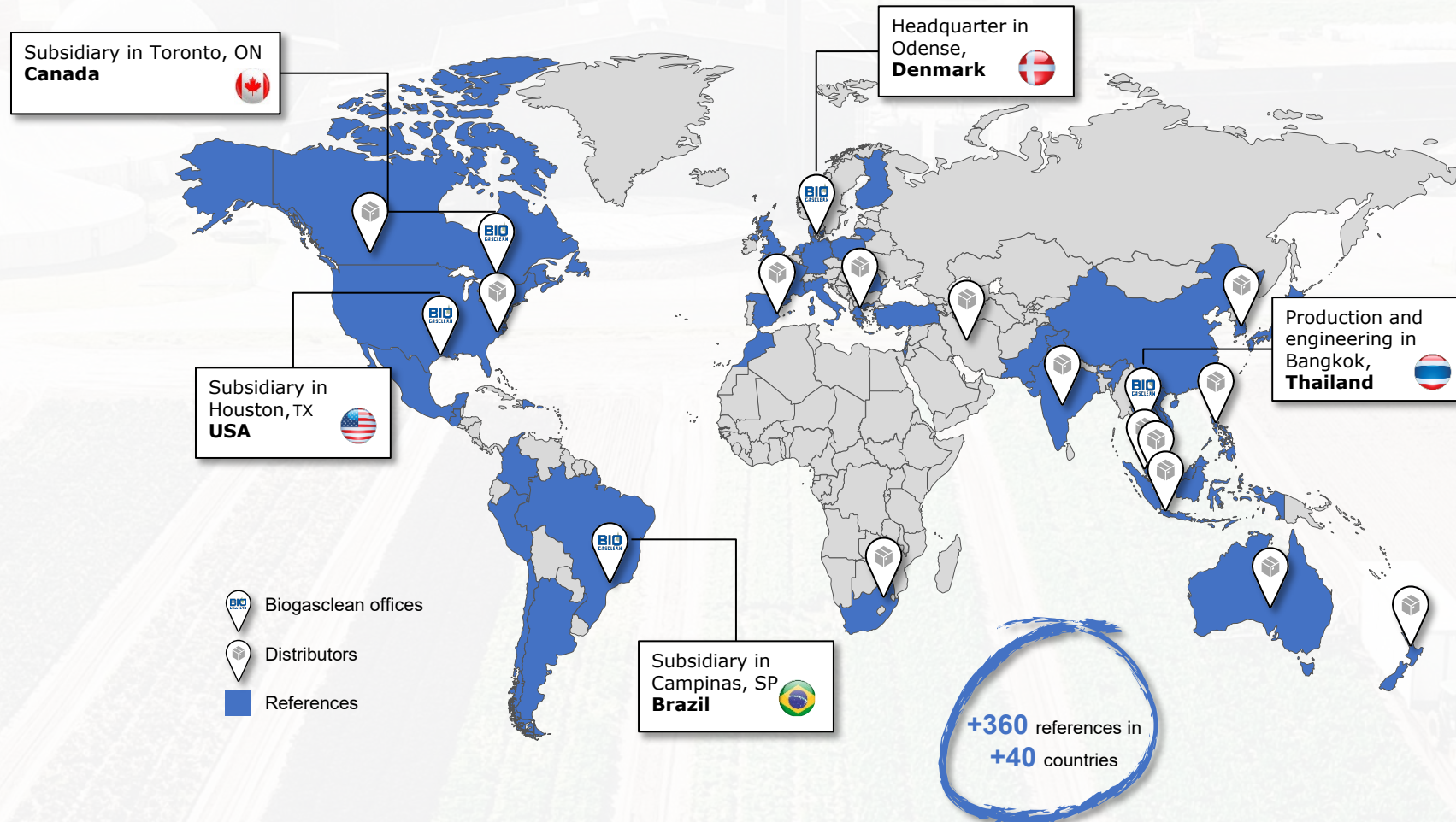
**Hydrogen & P2X 2024**  
June 2024



Innovative solutions for efficient  
production of biogas and e-fuels



# Global footprint





# Question for the audience

**How many of you believe there is currently a viable business case for e-methane? And the technology to produce e-methane is well proven?**





# Bio E-Fuel

## A biological Power-To-G (P2G) technology

- **Bio E-Fuel** is a biological process converting ( $\text{CO}_2$ ) and hydrogen ( $\text{H}_2$ ) to methane ( $\text{CH}_4$ ) in a Bio Trickling Reactor; i.e. biological methanation of  $\text{CO}_2$ .
- **Bio E-Fuel** can be applied everywhere where you have a  $\text{CO}_2$  source. Biogas typically consists of 55-60%  $\text{CH}_4$  and 40-45%  $\text{CO}_2$ . With Bio E-Fuel biogas plants can increase the methane content in biogas to +97-98%, i.e. the efficiency of biogas production increases by up to 78%.
- The process is very robust and **handles untreated biogas and  $\text{CO}_2$**  without prior removal of sulfur and other impurities.





# Bio E-fuel video



**Proven technology**

**Is the technology proven?**



# Bio E-Fuel - Development

## Pilot V1

Location: Nature Energy  
Holsted, Denmark  
E-CH<sub>4</sub> flow: 0,8 m<sup>3</sup>/h



## Pilot V2

Location: HOFOR – Avedøre  
Copenhagen, Denmark  
E-CH<sub>4</sub> flow: 0,8 m<sup>3</sup>/h



## Full scale V1

Location: Nature Energy  
Glansager, Denmark  
E-CH<sub>4</sub> flow: 381 m<sup>3</sup>/h



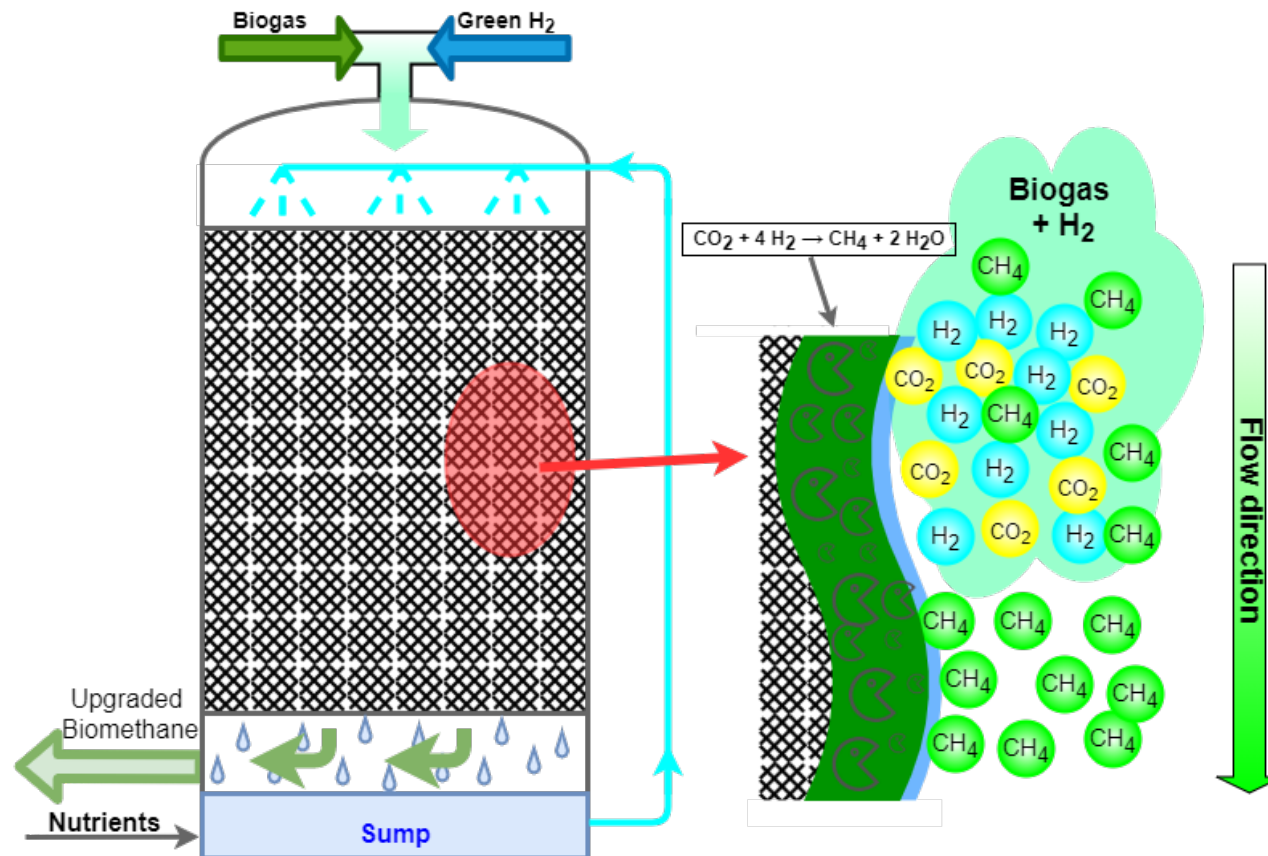
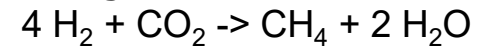
## Biomethanation

Bio e-fuel as a commercially  
available product in Europa  
and North America



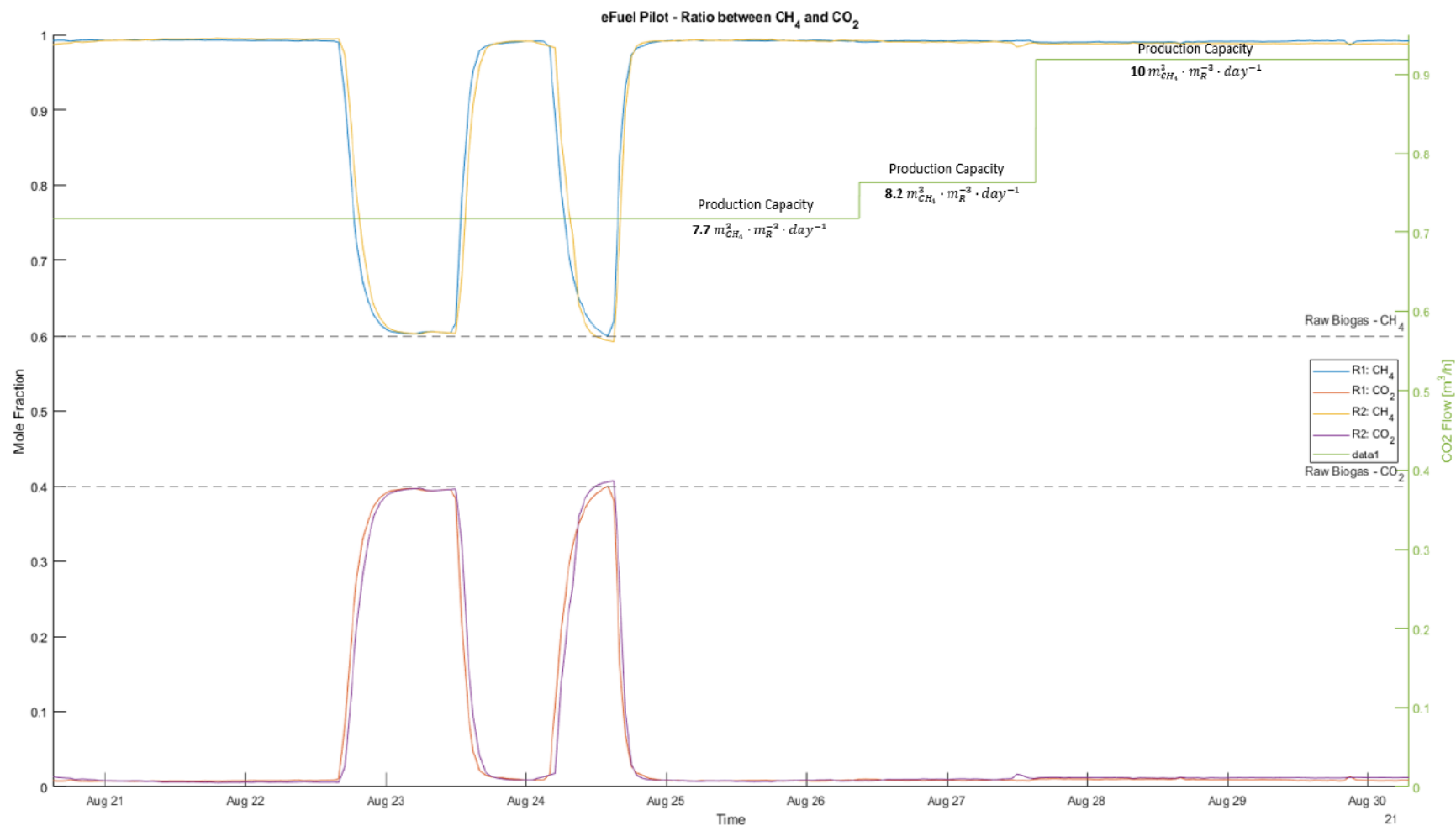
# Process in Bio E-Fuel Reactor

Biological Methanation





# Bio E-Fuel efficiency and performance





PROBES - TANK 3-2-1

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BG-fm user logged in

Addition H2 decentral

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MAIN

ALARM

COUNT

SECURITY

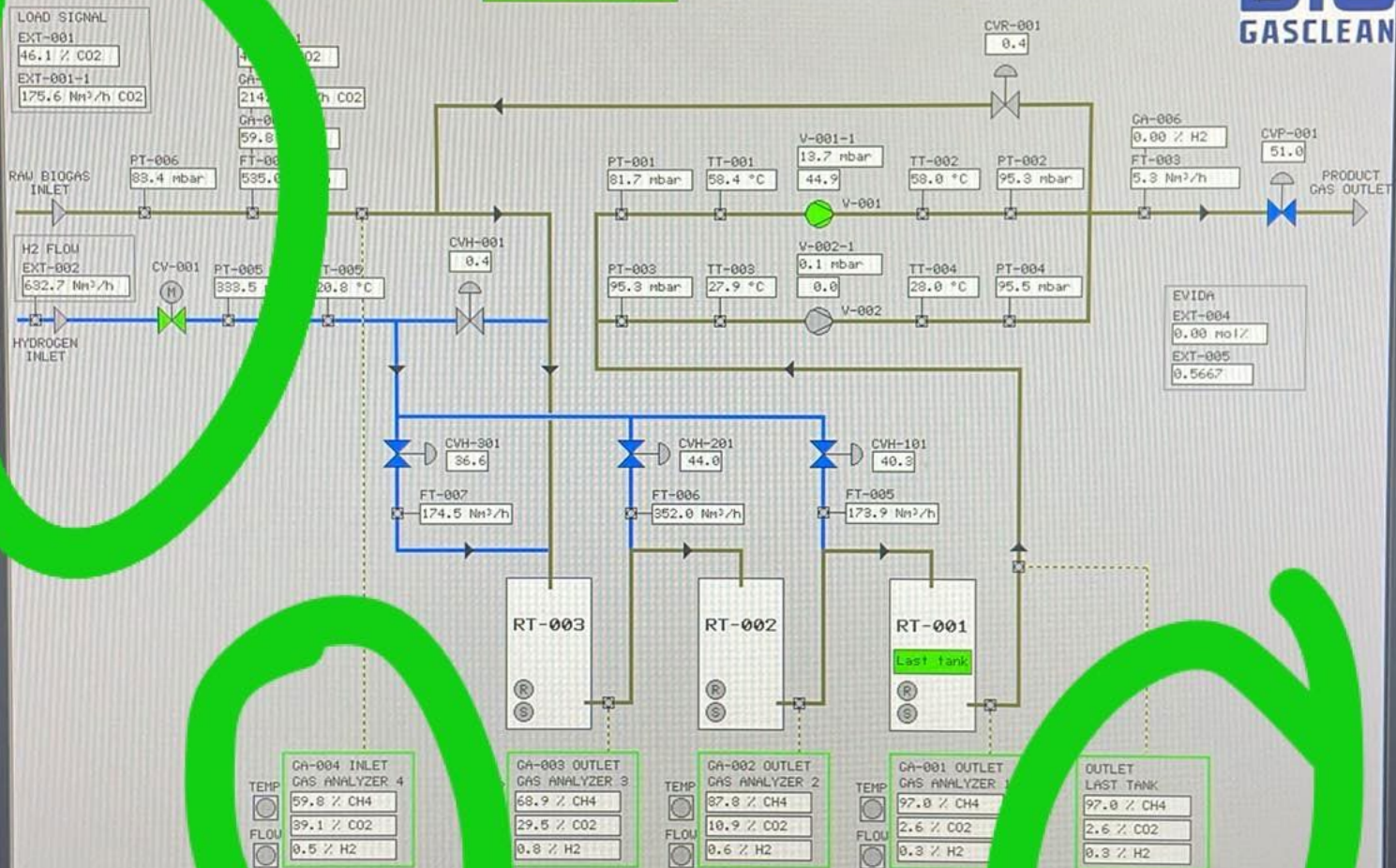
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SETUP  
COMMON

TRENDS

SETUP  
LEVEL 8

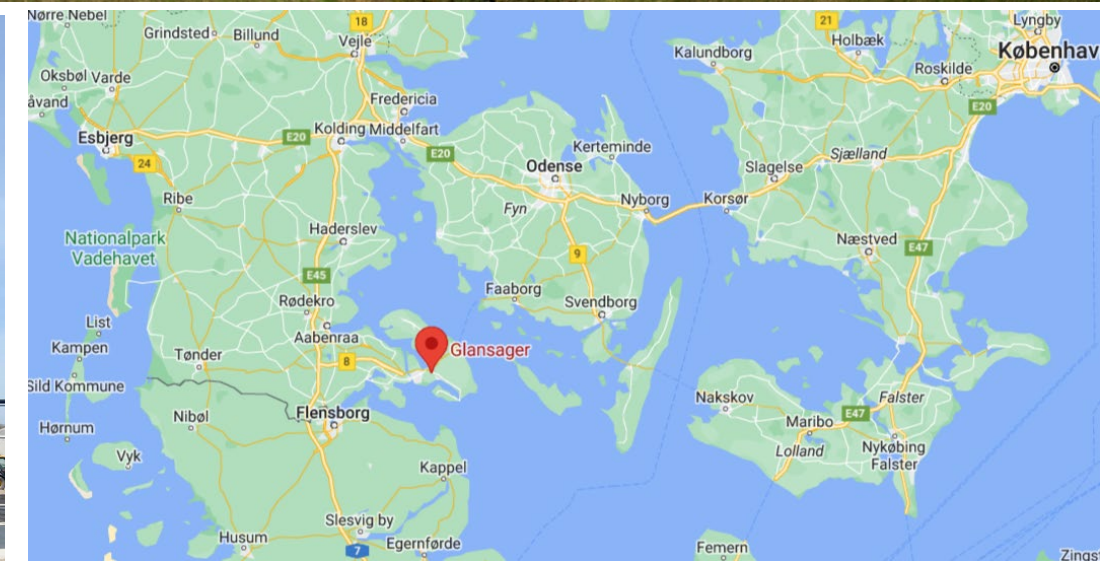
SETUP  
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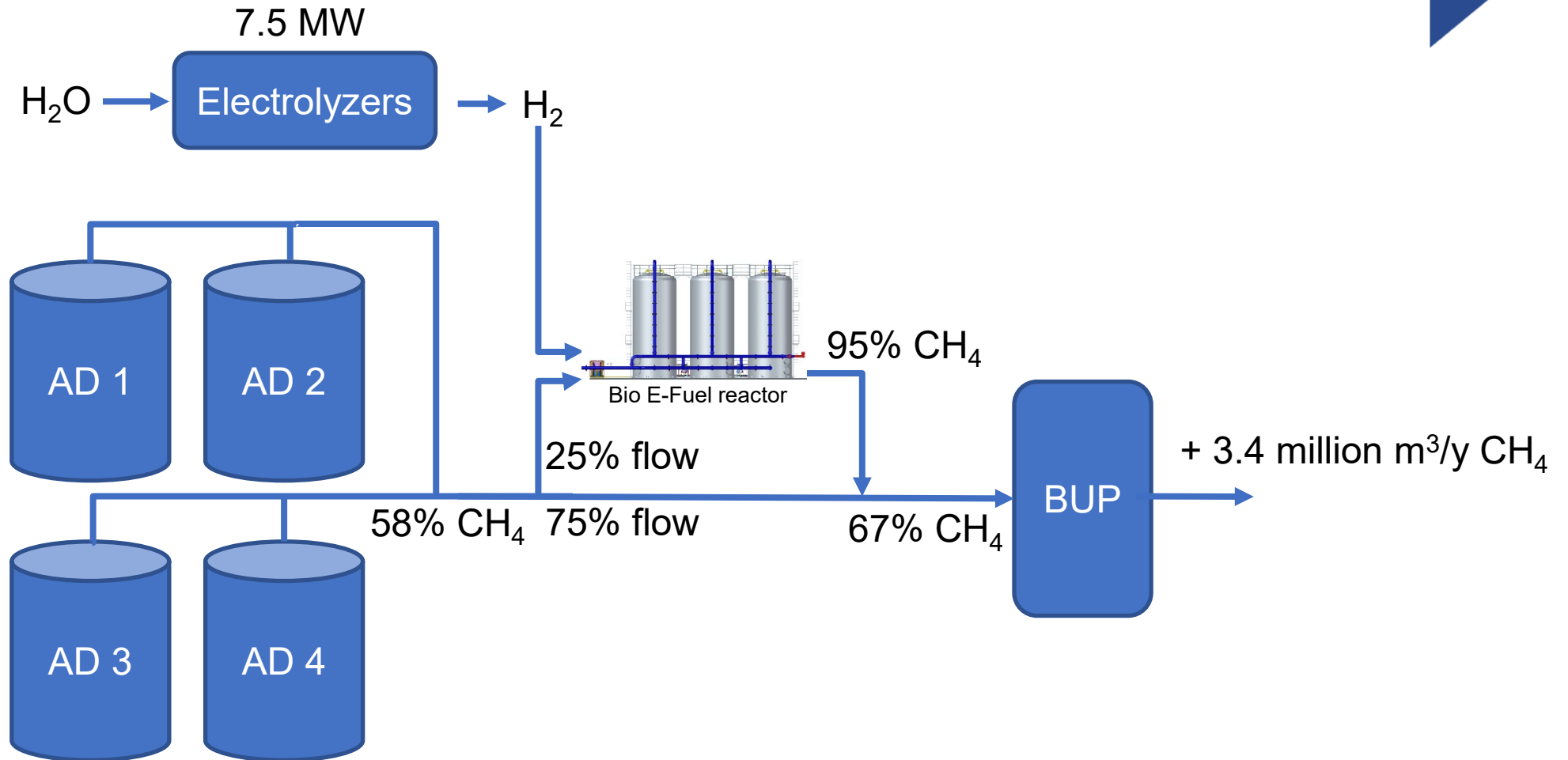
# P2G Plant at Nature Energy, Glansager - Overview

- Location in **Sonderborg, Denmark.**
- The first full scale Bio E-Fuel Plant is under commissioning and received the first hydrogen in early **October 2023.**
- Production capacity: **381 Nm<sup>3</sup>/h E-Methane** or 3,400,000 Nm<sup>3</sup>/y or 33 GWh/y E-Methane.
- Biogasclean's Bio E-Fuel plants are based on a **scalable and modular design** with one or more tanks in stainless steel or reinforced fiberglass.
- The Bio E-Fuel plant **comprises 3 pcs. insulated tanks** in stainless steel filled with a random packed packing material.



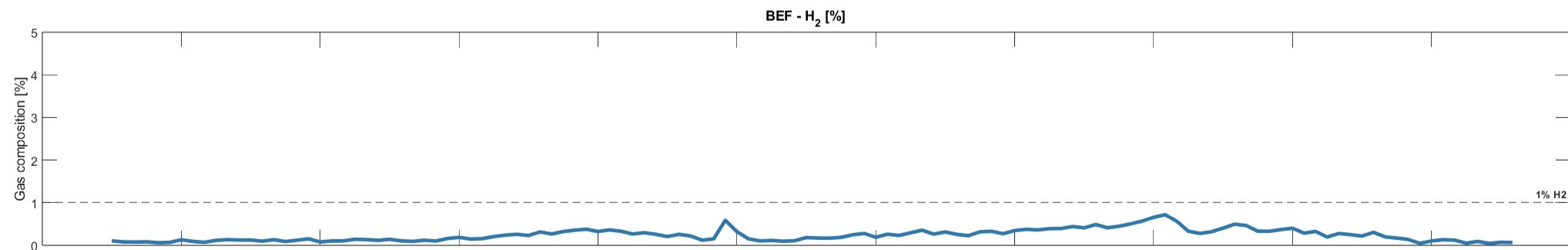
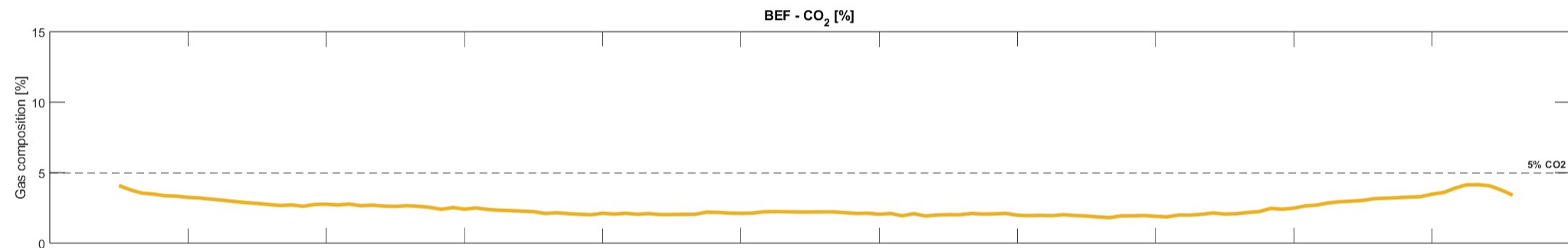
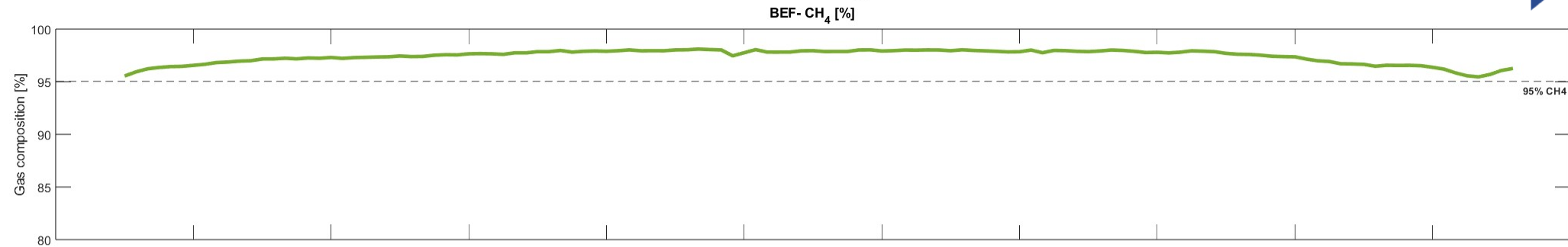


# PTG Plant at Nature Energy, Glansager – Flow diagram



# Product gas after the bio methanation system

## BEF - Glansager





# P2G Plant at Nature Energy, HOFOR WWTP





# Trend for e-methane production at municipal WWTPs

“The most important thing is that with this facility, we would be able to ensure that **all the gas we produce is 100% CO2-neutral**. So, if everything goes well, and all our test trials proceed in the right direction, then this facility **will be replaced by a full-scale plant in 2027**, says gas manager Morten Stanley”

Source: <https://www.tv2kosmopol.dk/koebenhavn/koebenhavnerne-tis-lort-og-opvaskevand-skal-blive-til-klimavenlig-bygas>

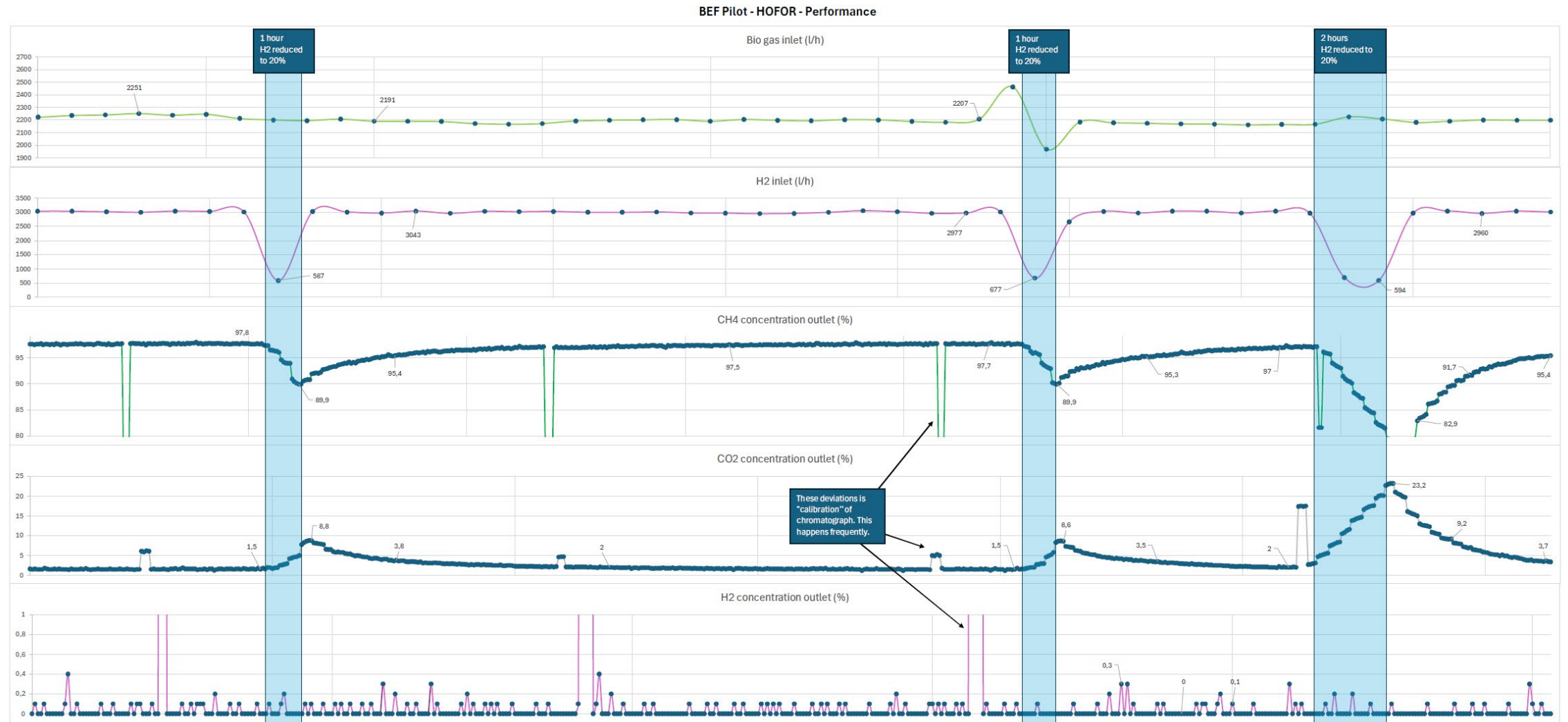
Københavnerne tis, lort og opvaskevand skal blive til klimavenlig bygas

Hovedstadsområdetets forsyningselskab, Hofo, har som de første i landet investeret i et Power-to-Gas-testanlæg. Det skal sætte turbo på udviklingen af klimavenlig bygas. Lort og tis er ingredienserne.





# Bio E-Fuel HOFOR Performance





**Viable business case for e-methane?**

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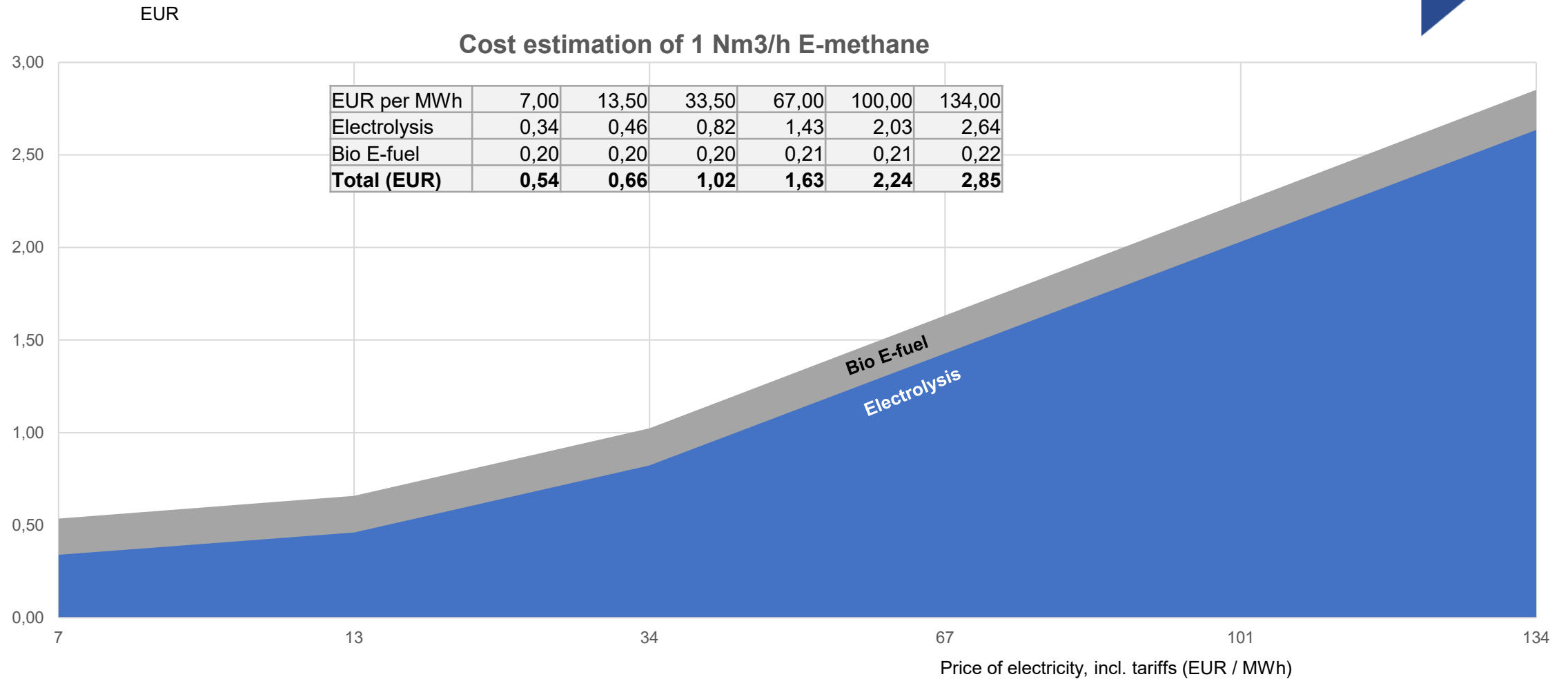


# Production price of 1 m<sup>3</sup> e-methane

## Assumptions

- Efficiency of electrolysis (73%) = 54 kWh pr. Kg H<sub>2</sub>
- Depreciation of **10 years** (Electrolysis and bio methanation)
- Yearly uptime = 75 %
- Average price of electricity = 0.3 DKK pr. kWh = 40.3 EUR pr. MWh
- Total production price (CAPEX, OPEX and Depreciation) per Nm<sup>3</sup> E-methane = **1.15 EUR**

# Cost estimation electrolysis and Bio E-Fuel (EUR)





# Offtake price and economy for e-methane June 2024

- Initial estimated offtake price for e-methane certificates: **150 EUR/MWh**
- Costs associated with trading of certificates and other associated costs still not determined
- This e-methane does not yet comply with RFNBO, yet. But is expected to be compliant soon.

The CO<sub>2</sub> is **biogenic**.

The energy used for hydrogen production is **renewable** (GOO).

- Requirements for e-methane certification according to **RFNBO** are still not completely clear.

We expect the **e-methane easily to qualify for RFNBO**.

Qualification is expected to **trigger higher e-methane certificate prices**.



# Offtake and projected economy for e-methane

- Expected long-term projection of electricity price (excluding the 10-20% most expensive periods):  
Price per kWh: **0.3 DKK**  
Equivalent to **300 DKK per MWh** or **40 EUR per MWh**
- Implications for e-methane pricing:  
40 EUR per MWh translates to an e-methane price of approximately **1.15 EUR per m<sup>3</sup>**  
1 MWh requires approximately 100 Nm<sup>3</sup> of methane, **resulting in a cost of 115 EUR per MWh**
- Comparison:  
Current estimated price: **150 EUR/MWh + price of methane** (and without trading costs)



# Uncertainty for e-Methane projects

- **Technological Uncertainty:**

Emerging technologies yet to reach full commercial maturity? – **We have proved the technologies on several setups and the technologies are ready**

Challenges in scaling up production efficiently – **Glansager has proved the scalability of biological methanation**

- **Pricing Uncertainty:**

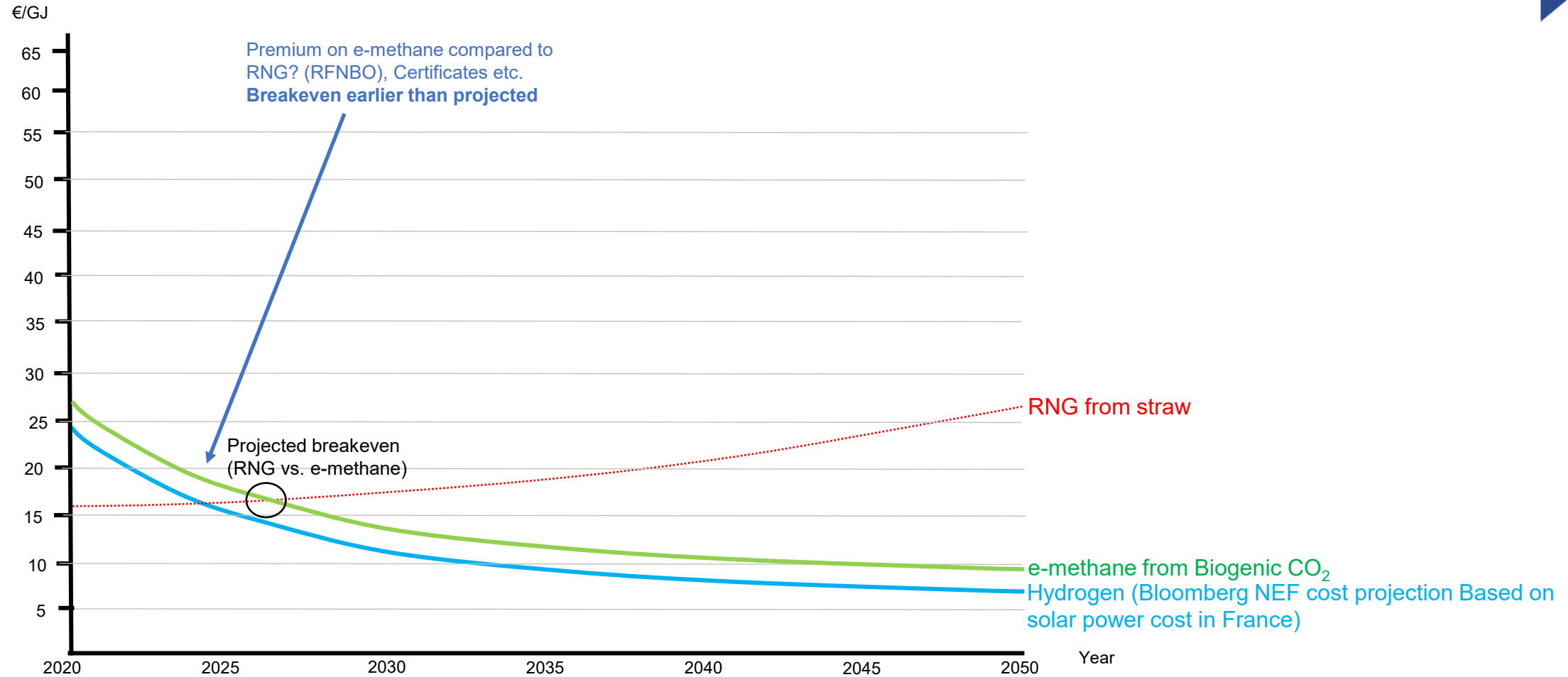
Lack of established pricing frameworks and benchmarks – **Yet the first valuation at 150 EUR/MWh is very positive for the case**

- **Future Market Dynamics:**

Uncertain regulatory landscape affecting long-term investment decisions

Potential competition with other uses for biogenic CO<sub>2</sub> or H<sub>2</sub>

# Expected cost break-even between bio-methane and e-methane





# Biogasclean methanation key takeaways

- **Bio E-Fuel can be applied everywhere where you have a CO<sub>2</sub> source**; however, it is a **perfect fit for biogas plants** as the CO<sub>2</sub> and the infrastructure for methane production are already available.
- Bio E-Fuel increases the output on biogas plants from 55-60% to **+97-98% CH<sub>4</sub>**; i.e., up to **78% more biomethane produced** from the same amount of organic substrate.
- Bio E-Fuel can process the **raw biogas or CO<sub>2</sub>** flow without any prior removal sulfur or other impurities.
- **Operation at low pressure** (<200 mBar) and **low temperature** (<60°C) gives low OPEX.
- There is a **huge potential** of e-methane production
- Currently we are **already seeing viability** in e-methane production and **promising business cases**
- **We need more investments in the e-methane market**



# Thank you

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