# THE FUTURE OF HYDROGEN SUPPLY

## Dezentrale Wasserstoffherstellung mit dem "On-Site On-Demand"-System OSOD

Rouge H2 Engineering GmbH
www.rgh2.com

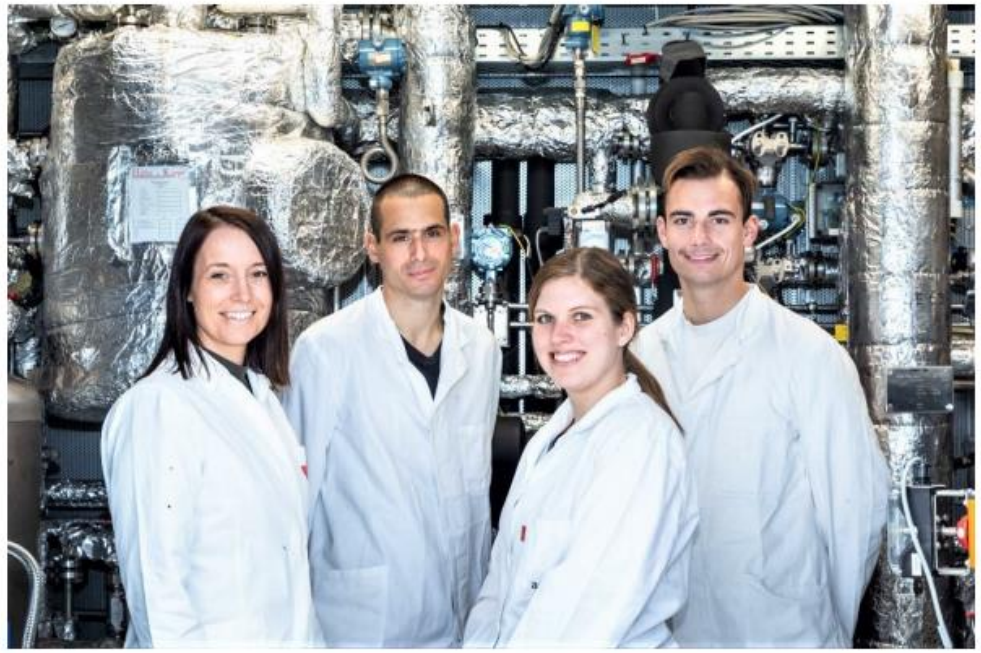
# MEET THE TEAM

## Female entrepreneur and owner of RGH2 Chi-En (Sable) Huang is the driver, backed by a committed and experienced team

- Austrian Company, headquarters in Graz
- Expertise in green technologies
- Operation of 1st fixed bed chemical looping hydrogen prototype plant
- National and international R&D projects
- Commercialization of groundbreaking chemical looping technology

Sable Huang

CEO
Florian von Hofen

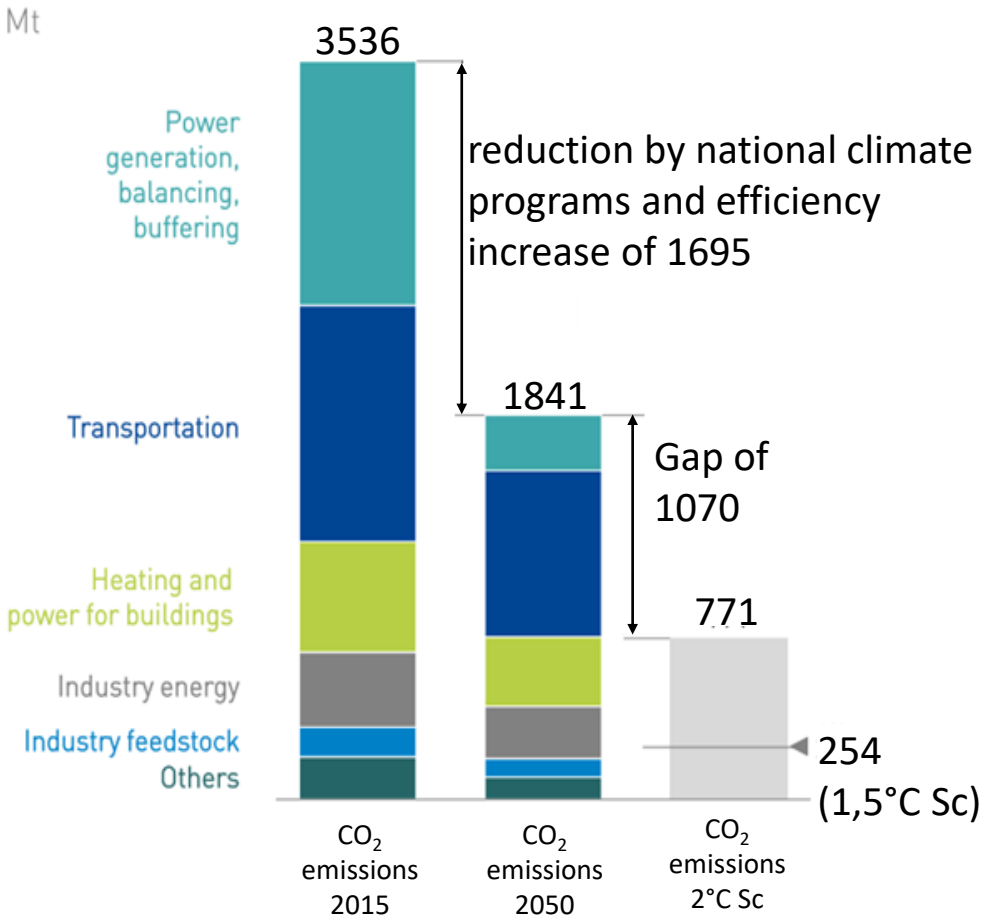


the R&D team

# THE GREATER ISSUE

## Decisive actions are necessary to confront the challenges of global climate change
## Notably the reduction of fossil $CO_2$ emissions

- To mitigate the effects of global warming a reduction of anthropogenic non-renewable $CO_2$ emissions is key
- Current actions leave a reduction-gap of 1070 Mt $CO_2$ in the EU
- The implementation of additional green technologies is necessary to reach the 2°C goal




IEA (2017), *Energy Technology Perspectives 2017*, IEA, Paris https://www.iea.org/reports/energy-technology-perspectives-2017
Fuell Cells and Hydrogen Joint undertaking, Hydrogen Roadmap Europe 2019

# GREEN $H_2$ AS KEY TECHNOLOGY

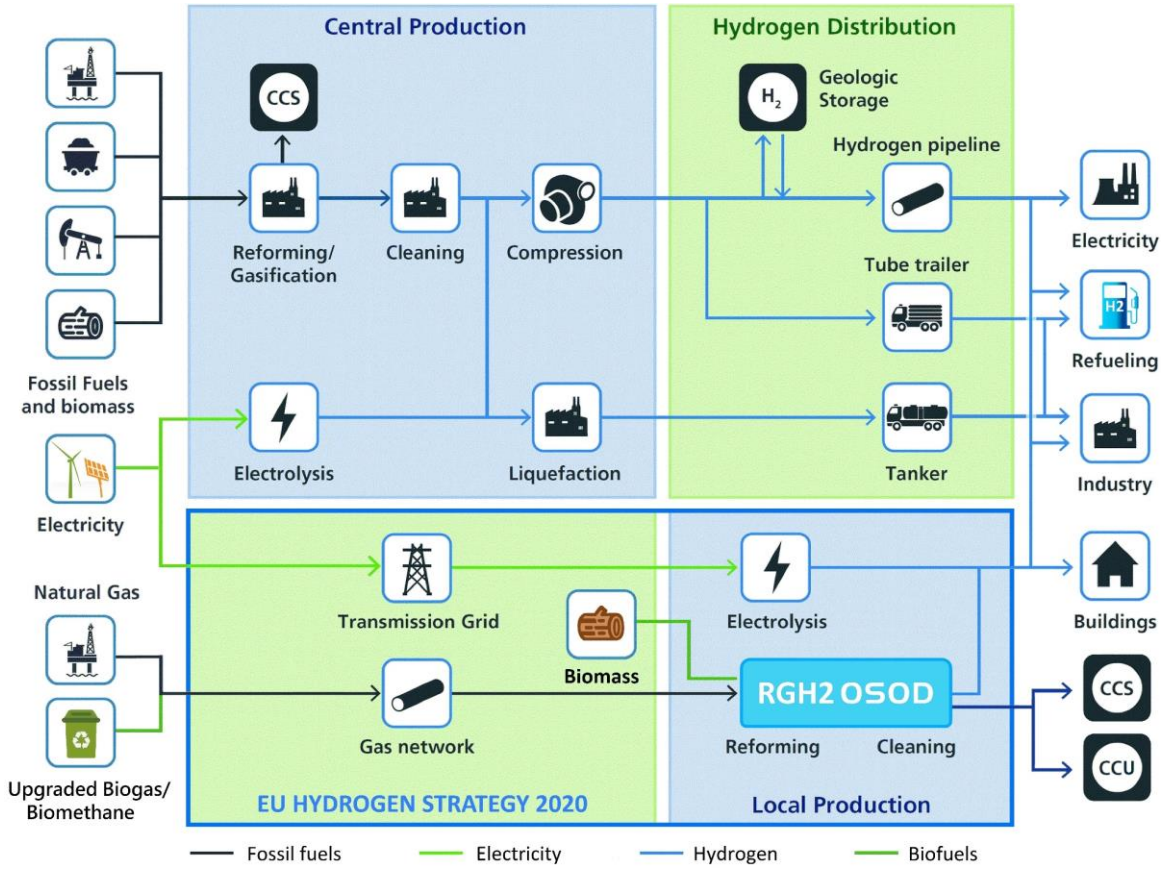
## Green Hydrogen from renewable electricity or biogenic feedstock is a promising pathway to reduce fossil $CO_2$ emissions

Gas grid decarbonization

Mobility: heavy duty & long distances

$H_2$ as feedstock and process heat

$H_2$ as seasonal and regional energy storage/carrier




The role of hydrogen and fuel cells in the global energy system, Iain Staffell, et al., Energy Environ. Sci.,2019,12,463
Fuell Cells and Hydrogen Joint undertaking, Hydrogen Roadmap Europe 2019

Fuell Cells and Hydrogen Joint undertaking, Hydrogen Roadmap Europe 2019

# COMPANY PURPOSE

## We will bring to market the world's first hydrogen generator that can produce and store hydrogen in one unit




## VISION

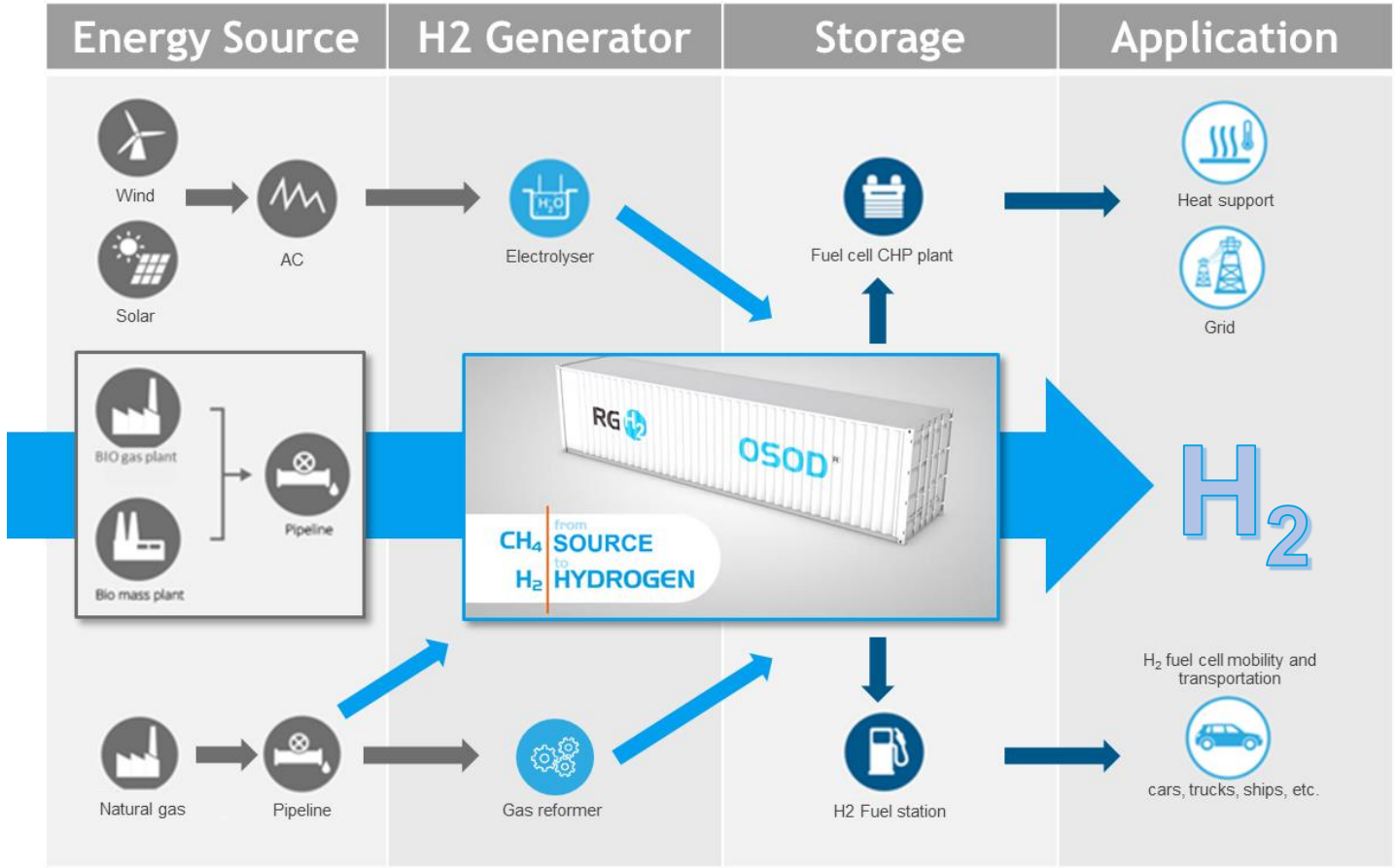
We enhance hydrogen uptake by introducing a hydrogen generator that makes it easier to produce and access hydrogen - **for a sustainably powered future.**

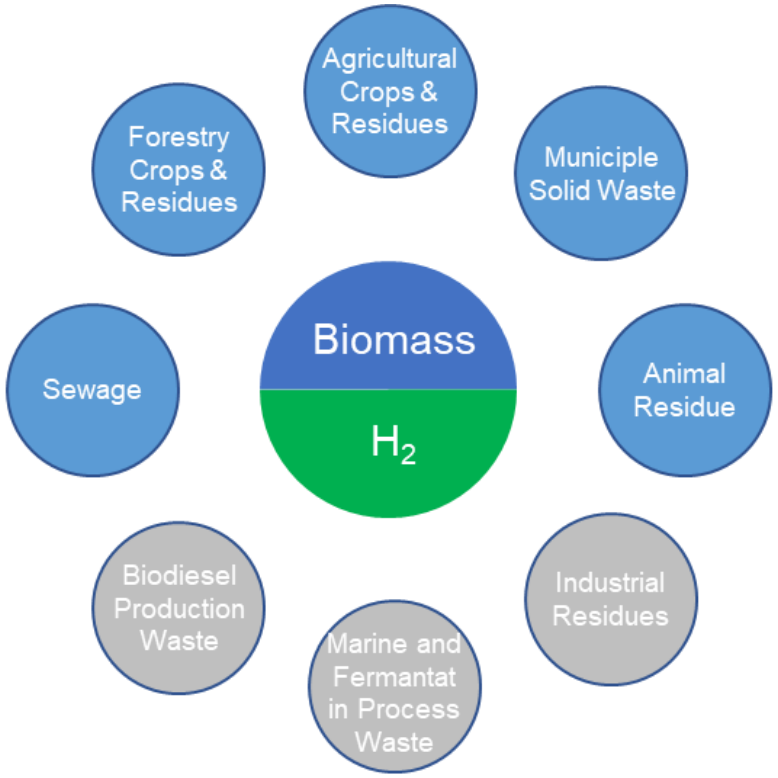
## MISSION

We offer an **all-in-one hydrogen production and storage** that is safe, lossless and low in maintainance. We can achieve this by commercialising our groundbreaking chemical looping technology.

# APPLICATIONS

The chemical looping process with its high process flexibility enables the operation of the OSOD system with various feedstock and hydrogen applications



# PROBLEM AND SOLUTION

Hydrogen uptake is restrained by high costs, logistic and safety concerns for suppliers and users
We can transfer hydrogen supply to a viable business model for our customers

## Main problems:

The main problems hydrogen suppliers and users face are

- safety concerns and problematic storage of hydrogen,
- centralized production and complex logistics,
- need for heavy-duty transportation,
- high operating and investment costs,
- non-sustainable dependence on fossil gas.

## Our Solution:

We are able to tackle all the mentioned problems by introducing a

- safe,
- decentralised,
- on-site on-demand (OSOD),
- all-in-one hydrogen generator AND storage unit,
- running on biogas/biomass and with low operating costs.

# OSOD SYSTEM LAYOUT

## THE FUTURE OF HYDROGEN SUPPLY – the OSOD prototype system

# OSOD PROCESS DESCRIPTION

## THE FUTURE OF HYDROGEN SUPPLY –
## The application of a fixed bed chemical looping hydrogen process

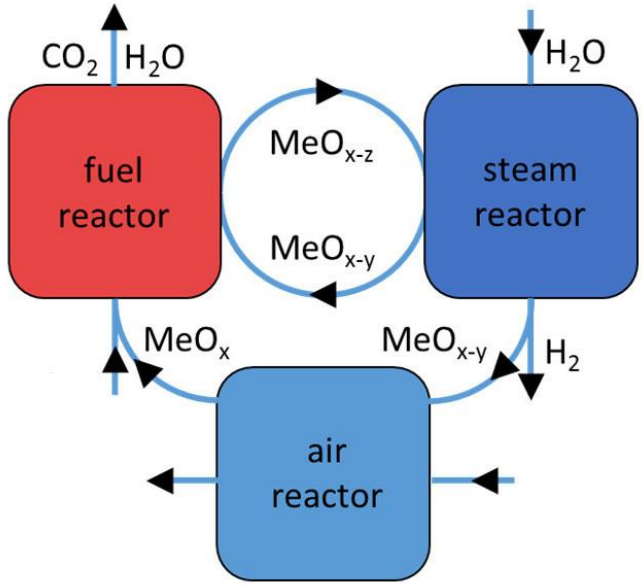
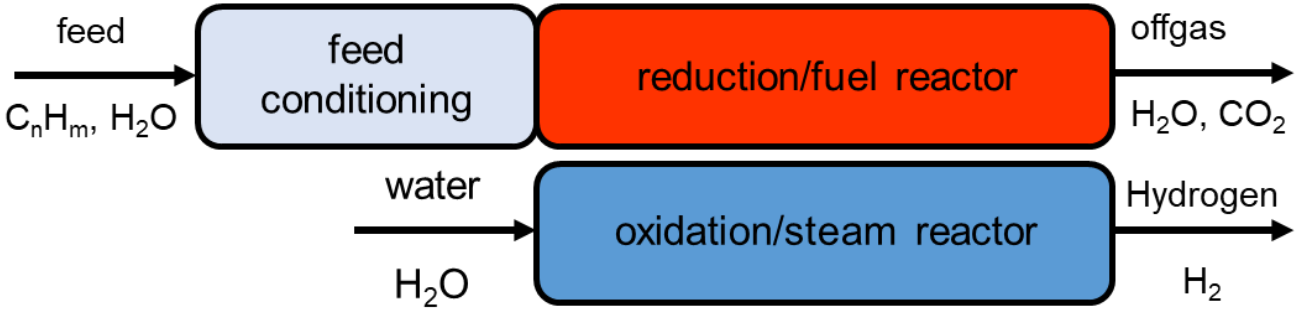



Fig.: process schematic of the process with an air oxidation as third step.

- OSOD system produces **pressurized pure hydrogen** out of different carbon based feedstock utilizing the **chemical looping process**.
- In combination with state of the art reforming or gasification systems for feed gas conditioning any **hydrocarbon** can be converted to hydrogen.
- Feed gas conditioning generates a $H_2$ and CO rich syn-gas.
- **Syn-gas** is used for the **reduction** of an iron based **oxygen carrier** and process heat generation
- The subsequent **oxidation** with steam provides high purity pressurized **hydrogen**.



# OSOD ENVIRONMENTAL BENEFITS

## Green hydrogen production from biogas has a significant $CO_2$ emission reduction potential compared to state of the art hydrogen supply

| **Scenario 1** | **RGH2 OSOD from Biogas [1]** | **Fossil gas conventional reforming [2]** | **Electrolysis with 100% wind energy [3]** | **Electrolysis with 100% solar power [3]** |
|---|---|---|---|---|
| **$H_2$ Production [$kgCO_2/kgH_2$]** | 1,82 | 9,84 | 0,65 | 2,82 |
| **Reduction potential** | 82% | - | 93% | 71% |
| | | | | |
| **Scenario 2** | **RGH2 OSOD powered Fuel cell car 1 $kg_{H2}$/100 km** | **Electric car with grid power [4,5] 21 kWh/100 km** | **Diesel car [5] 4,8 L/100 km** | |
| **Propulsion system [$kgCO_2$/100km]** | 2,94 | 5,6 | 15,2 | |
| **Reduction potential** | 81% | 63% | - | |


[1] https://www.ifeu.de/fileadmin/uploads/oekobilanzen/pdf/THG_Bilanzen_Bio_Erdgas.pdf
[2] https://ieaghg.org/exco_docs/2017-02.pdf
[3] https://www.nrel.gov/analysis/life-cycle-assessment.html
[4] https://secure.umweltbundesamt.at/co2mon/co2mon.html
[5] https://www.quarks.de/umwelt/klimawandel/co2-rechner-fuer-auto-flugzeug-und-co/

# OSOD COST COMPARISON

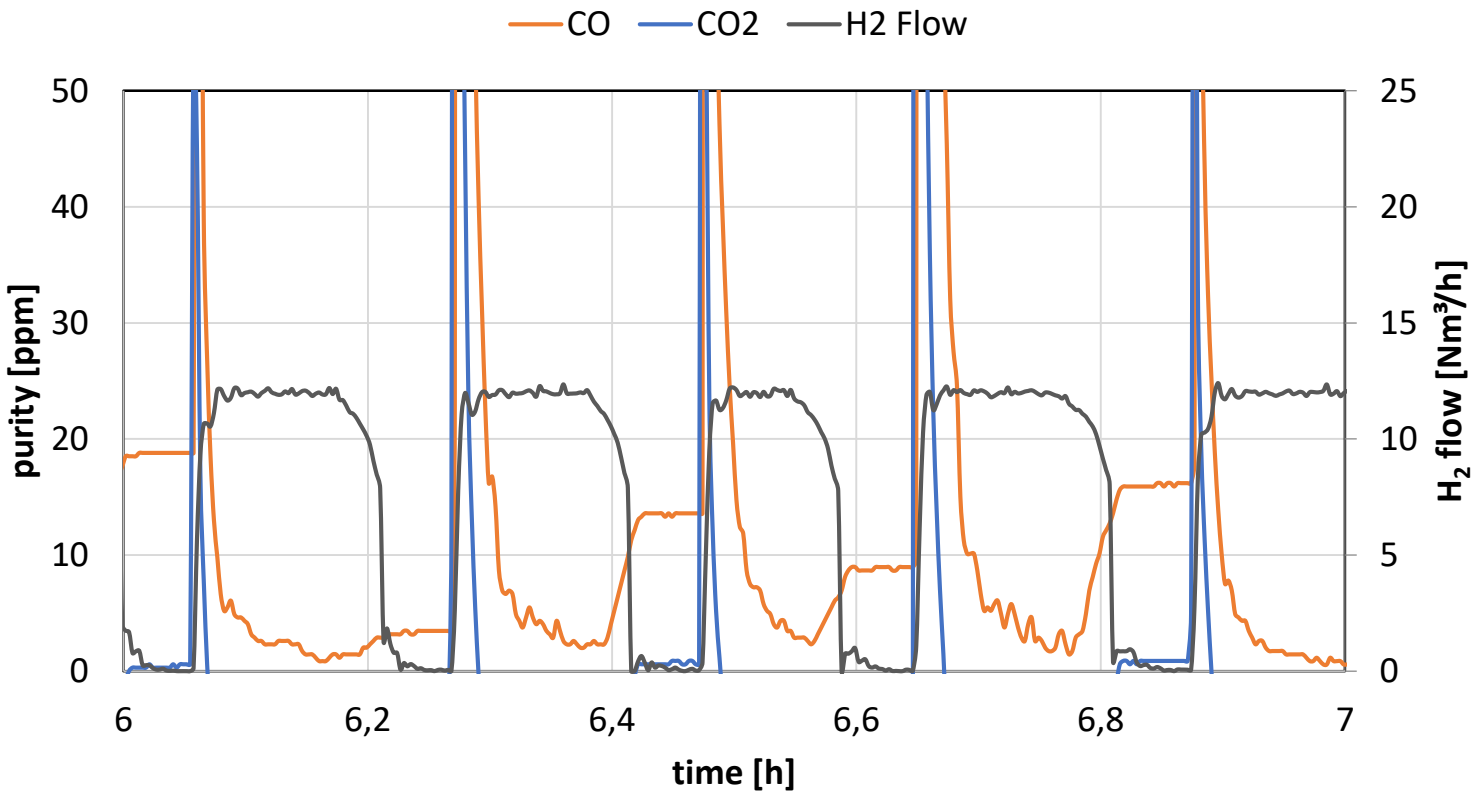
## Green hydrogen production with the OSOD system enables costs reduction compared to other decentralized production methods

| | RGH2 OSOD from biogas | PEM-Electrolysis 100% grid electricity | PEM-Electrolysis with 100% wind energy (no energy costs) |
|---|---|---|---|
| **H2 Production costs [€/kg]** | 4,6 – 6,2 | 6,3 [1] | 9,1 [1] |
| **Sustainability [$kg_{CO2}/kg_{H2}$]** | 1,82 | 13,0 [2] | 0,65 [3] |
| **Energy security** | 100% | 100% | 20% [1] |


[1] A. Christensen, “Assessment of Hydrogen Production Costs from Electrolysis: United States and Europe,” 2020. [Online].
Available: https://theicct.org/publications/assessment-hydrogen-production-costs-electrolysis-united-states-and-europe.
[2] Umweltbundesamt, “Treibhausgasrechner Umweltbundesamt,” 2021. https://secure.umweltbundesamt.at/co2mon/co2mon.html.
[3] NREL, “Life Cycle Assessment Harmonization - Harmonized Results,” 2021. https://www.nrel.gov/analysis/life-cycle-assessment.html. https://www.nrel.gov/docs/fy13osti/57187.pdf

# OSOD HIGH PURITY $H_2$ PRODUCTION

## At scale pure hydrogen production in continuous operation from natural gas or biogas



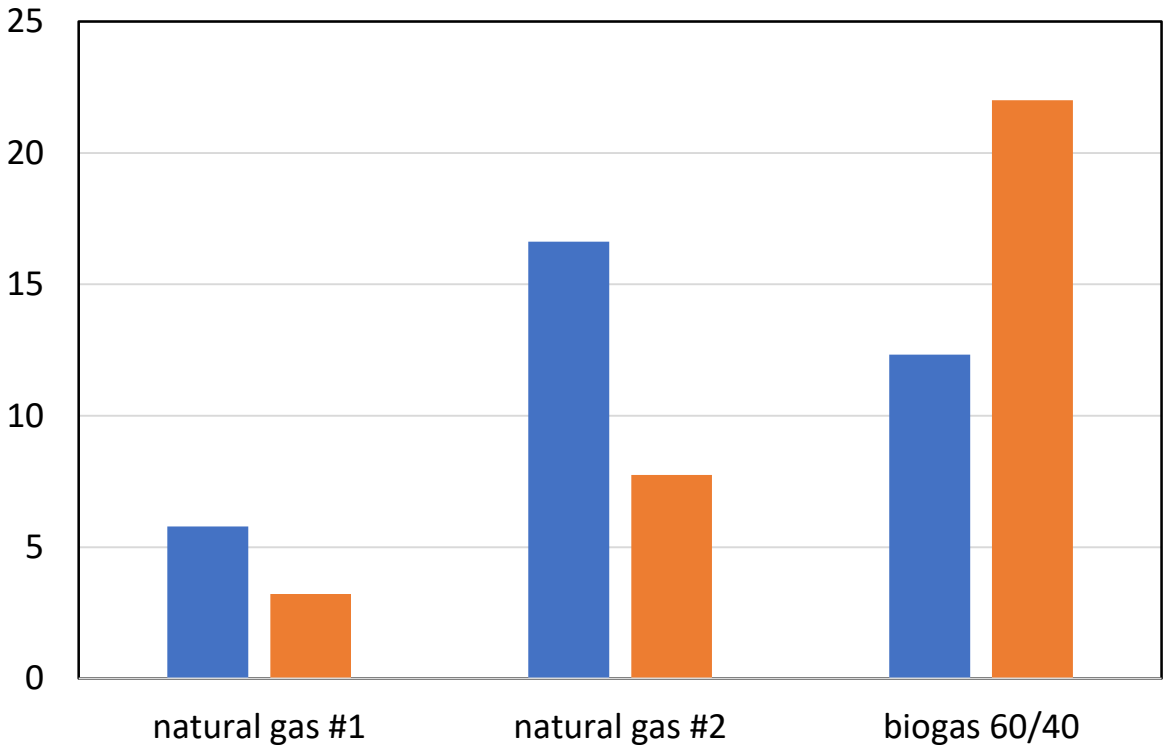

- Feedstock: natural gas
- steam reforming at S/C = 1,6
- $H_2$ production up to 20 m³/h at 10 barg
- Hydrogen purity >99,999%

  Mean CO: 3 ppm

  Mean $CO_2$: 2 ppm

# HYDROGEN PRODUCTION FROM BIOGAS

## The fixed bed chemical looping system enables an efficient conversion of **biogas mixtures to hydrogen**



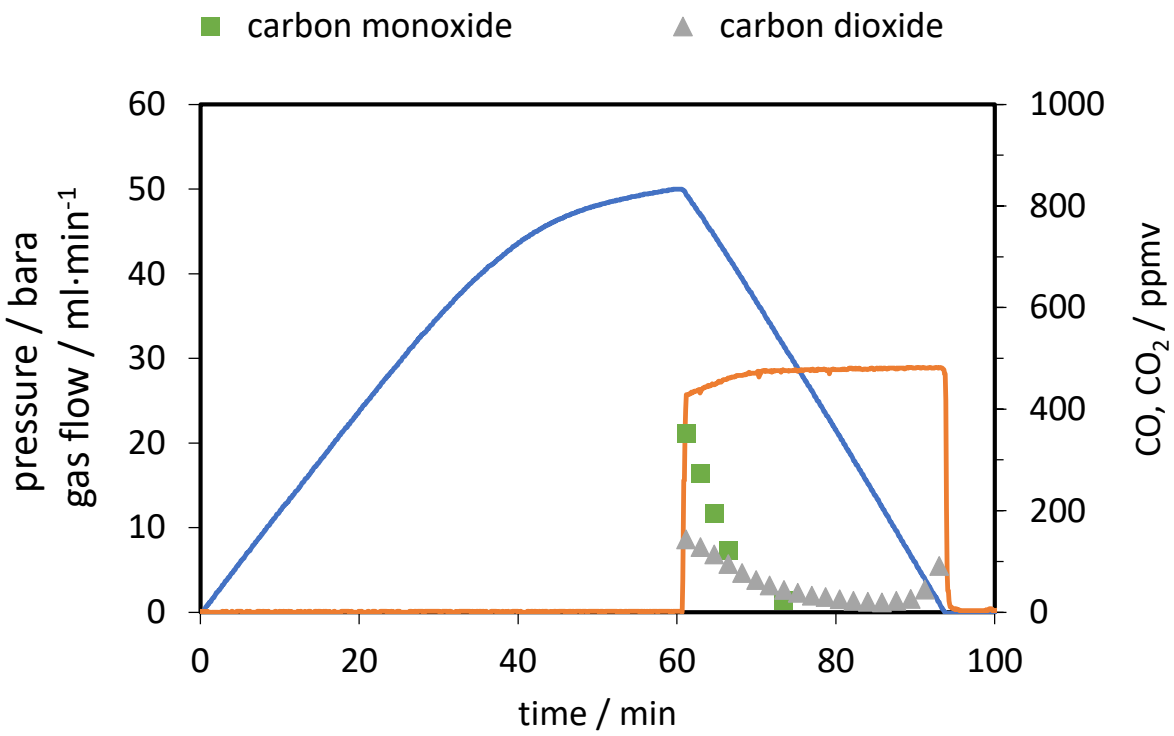

| | CO ppm | $CO_2$ ppm | S/C, O/C |
|---|---|---|---|
| **natural gas #1** | 6 | 3 | 1,6 |
| **natural gas #2** | 17 | 8 | 1,4 |
| **biogas 60/40 vol%** | 12 | 22 | 1,4 |

Process parameters:

- $CH_4$ feed: 6 – 8 $Nm^3/h$
- Temperature: 850 – 900 °C
- Hydrogen production: 10-15 $Nm^3/h$, 3 - 5 barg

# HIGH PRESSURE $H_2$ PRODUCTION

The fixed bed chemical looping system enables the direct production of **pressurized hydrogen**



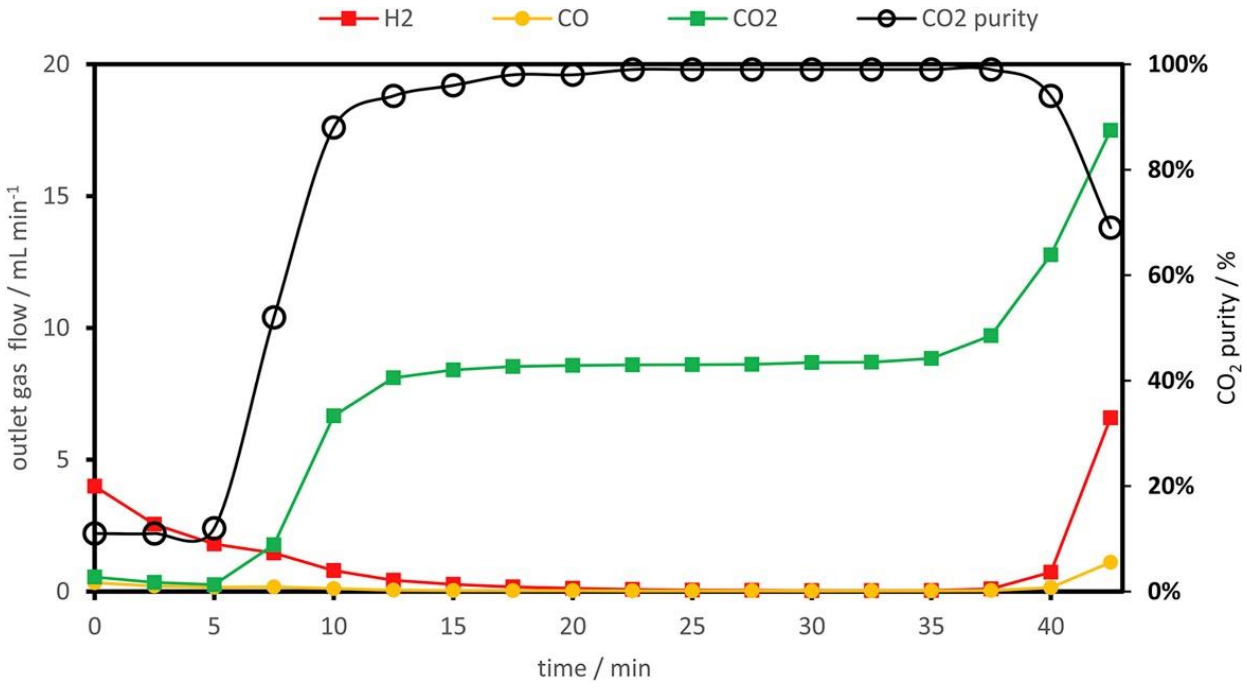

- Oxidation cycles at elevated pressure
- Pressurized hydrogen up to 100 bar
- Hydrogen purity

  99,958% - 99,999%
- Impurities CO und $CO_2$

Experimental setup

# OSOD $CO_2$ CARBON CAPTURE CAPABILITIES

## The implementation of an additional air oxidation enables the generation of a **pure $CO_2$ stream**




- Carbon capture capabilities enabled by process variation
- A second oxidation step with air is integrated
- Average $CO_2$ purity 95%
- Product gas pressurized up to 30 bara in carbon capture mode
- Average $H_2$ purity 95%


Zacharias, R., et al., High-pressure hydrogen production with inherent sequestration of a pure carbon dioxide stream via fixed bed chemical looping. *International Journal of Hydrogen Energy*, *44*(16), 7943–7957. https://doi.org/10.1016/j.ijhydene.2019.01.257

# Engineering for Change

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