On-site renewable hydrogen production

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Achievements – Challenges – Future Developments
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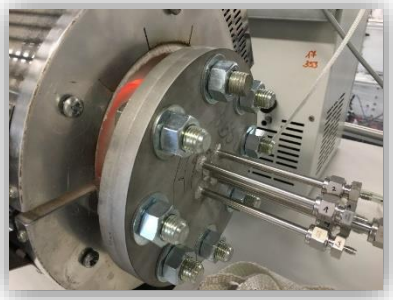
Institute of Chemical Engineering and Environmental Technology (CEET)

WG Fuel Cell and Hydrogen Systems

- **Introduction**
  - Hydrogen production via chemical looping
- Reformer steam iron process
  - High pressure hydrogen production from biogas
  - Prototype scale system at Graz University of Technology



Current Situation – Centralised production

- About 96% of worldwide hydrogen production is based on fossil hydrocarbons.

- In spite of higher productions costs, the decentralised reformation of hydrocarbons can be cost effective.
  - On site reformation of natural gas: 3.0 - 4.0 €/kg
  - Centralised reformation of natural gas: 2.5 - 3.5 €/kg

    (including transport and repressurization)

How can Chemical Looping contribute in this context?

Chemical Looping Processes

Cyclic reduction and oxidation of metal based oxygen carrier

Metal oxide
MeO_x

Reduction

Oxidation

Metal /
Metal oxide
MeO_{x-y}

Chemical Looping Combustion CLC

Heat generation

Carbon dioxide sequestration

Chemical Looping Hydrogen CLH

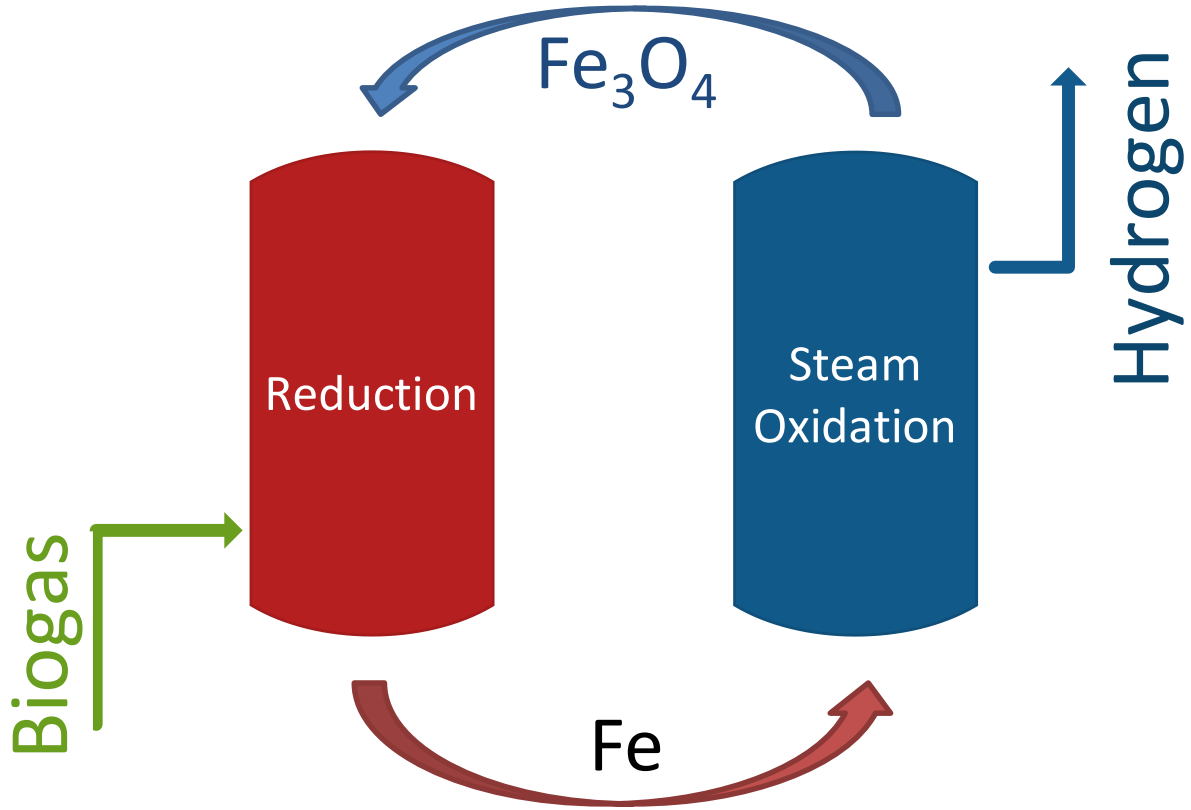
Hydrogen production

(Integrated carbon dioxide sequestration)

How can Chemical Looping contribute in this context?

Chemical Looping Hydrogen - CLH

Cyclic reduction and oxidation of metal based oxygen carriers



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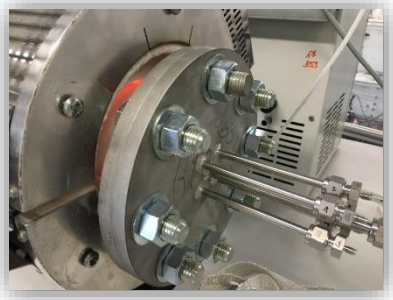
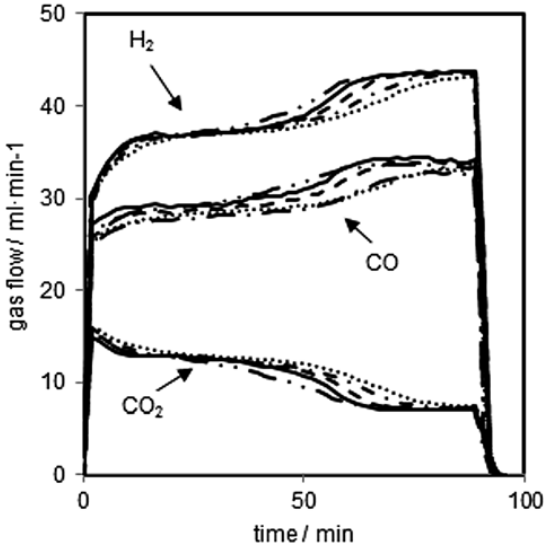
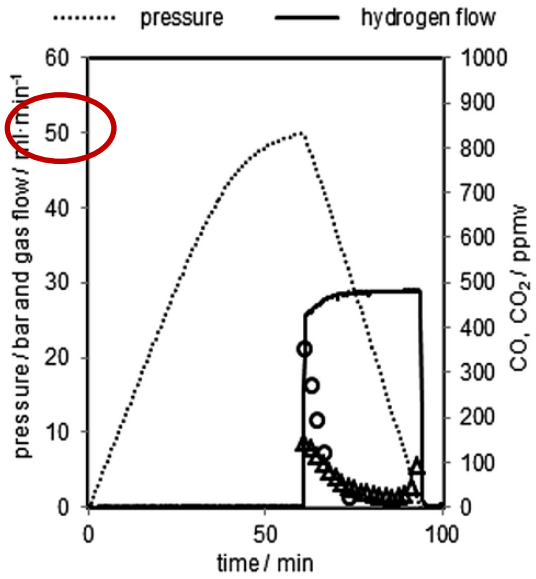


High pressure hydrogen production from biogas

High pressure reactor system

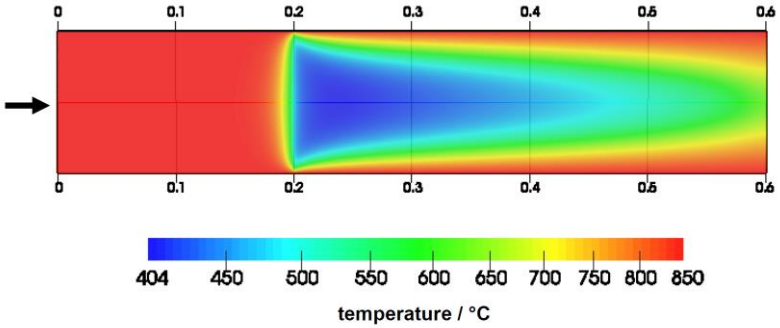


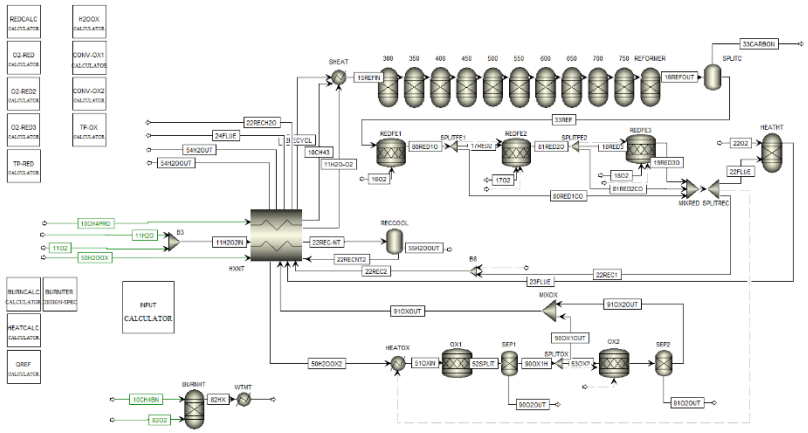


- **Pressurized hydrogen release** up to **50 bar** from different user-defined synthetic biogas mixtures in lab scale reactor
- **High hydrogen purity** up to **99.999%**

High pressure hydrogen production from biogas

Process development and simulation

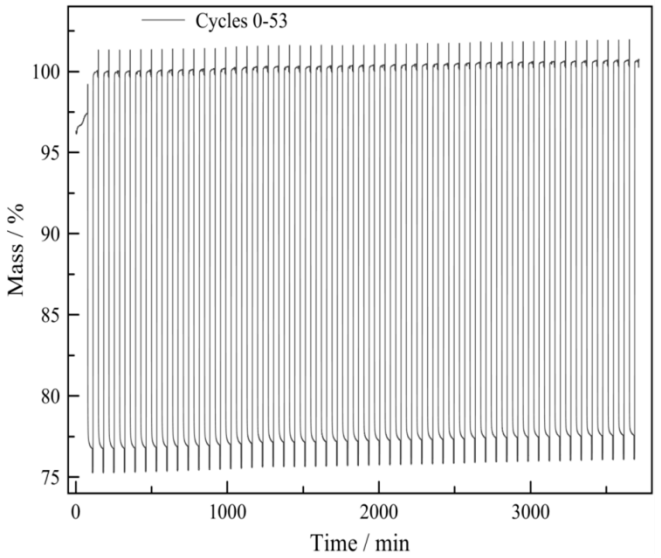




- Fit of **CFD models** to experimental data for scale-up and design aspects of steam reformer applications
- Optimization of system efficiency and heat recovery via **thermodynamic process design** for different biobased and fossil feedstock

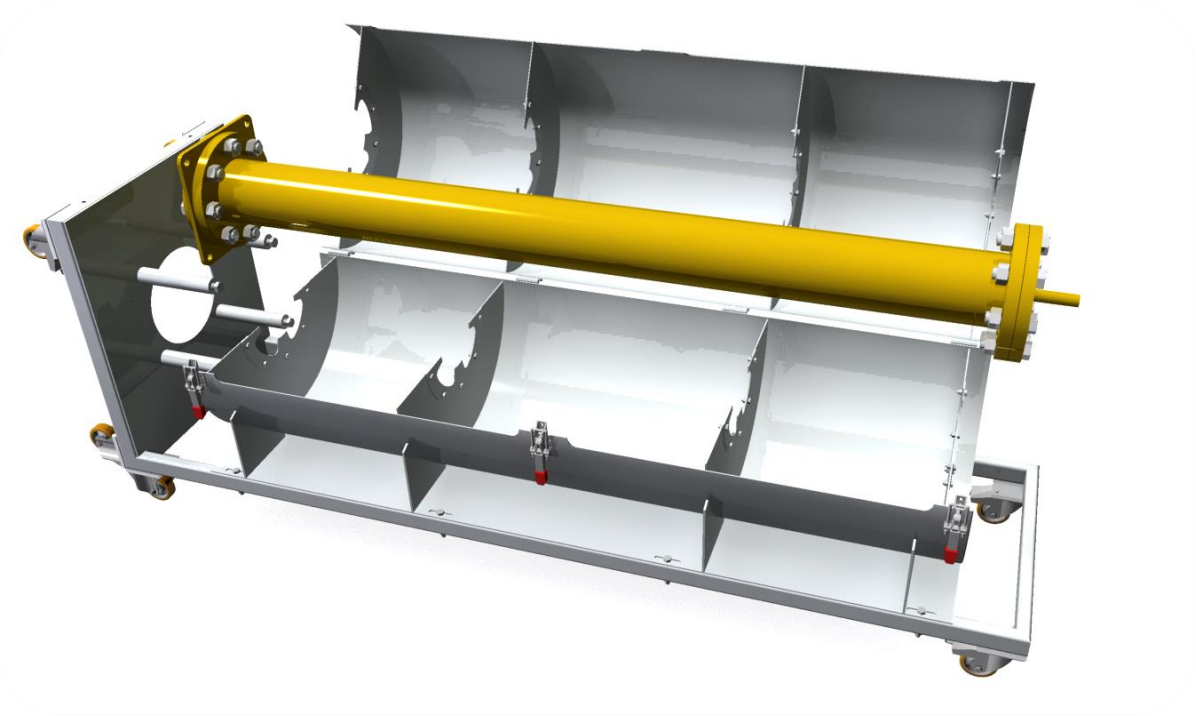
High pressure hydrogen production from biogas

Material development



- **Oxygen carrier stability** is crucial in cyclic reduction and oxidation reaction
- Stabilisation with **high-melting metal oxide additives (Al_2O_3, SiO_2, …)**
- **Long-term stability tests** with single pellets and in bulk

RESC prototype system

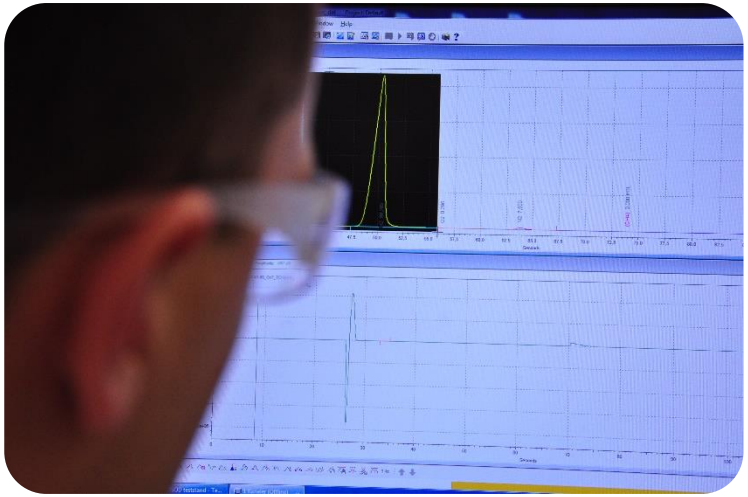


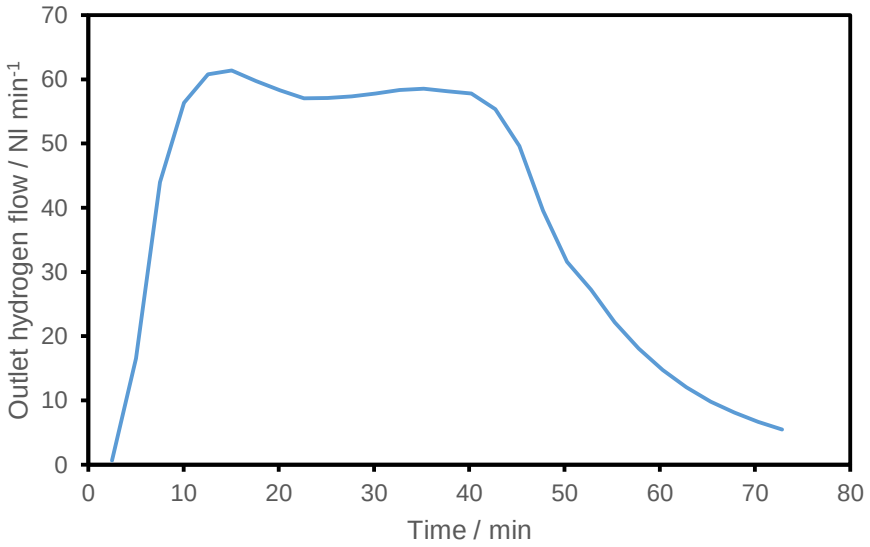
- **Reformer Sponge Iron Cycle System** as **semi-industrial prototype** in TU Graz research lab developed at Institute of Chemical Engineering and Environmental Technology

RESC prototype system

- **Hydrogen production up to 5 Nm^3 h^{-1}** in TU Graz research lab from methane feedstock
- Process evaluation in a **combined single reactor system** with integrated thermal and gas analysis
- Integrated steam reforming and gas purification via chemical looping

RESC prototype system





- **Determination of** critical process parameters for **carbon formation** and **process restrictions in large scale reactors**
- Latest Micro GC gas analysis to detect gas impurities down to 1ppm

Summary

- Development of a new hydrogen production system
  - Based on chemical looping hydrogen system
  - Reformer steam iron process for hydrogen production
  - Utilization of renewable resources as feedstock

- On-site hydrogen release
  - Prototype reactor for combined hydrogen production and purification
  - Thermodynamic system design for operation of a combined reformer and purification unit
  - Material research for long-term cycle stability

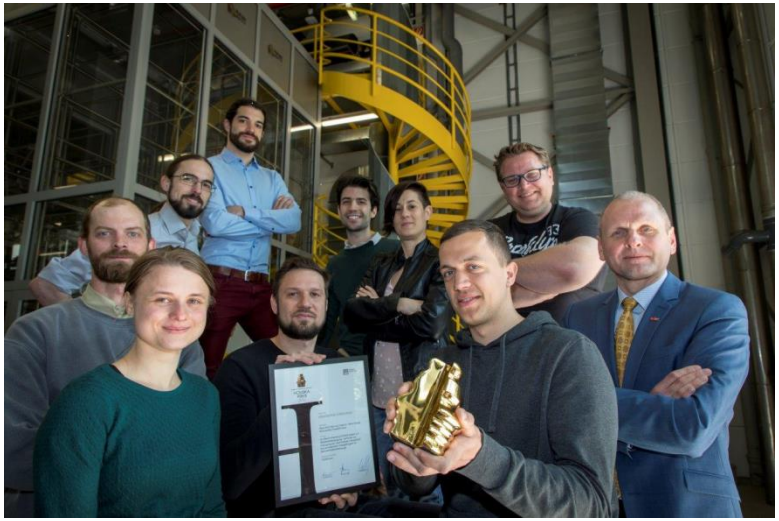
Hydrogen production by chemical looping

The reformer steam iron process (RESC)

On May, 4th 2017 the **RESC-Team** at **TU Graz** was awarded with the **prestigious HOUSKA award 2017** for industry-related research projects.

HOUSKA PREIS 2017

Awards show Houska 2017, Vienna



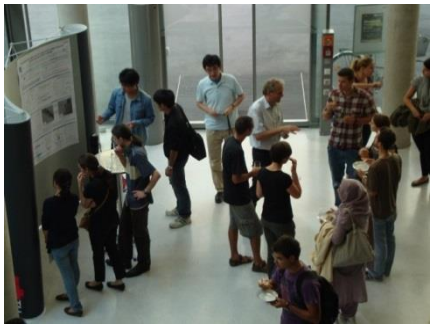
RESC Team at TU Graz

Fotos: Lunghammer / TU Graz
B&C/APA-Fotoservice/Schedl

Events - Dissemination

Highlights of International Fuel Cell Research 2017 (IEA Workshop)

TU Graz, May 15th, 2017.

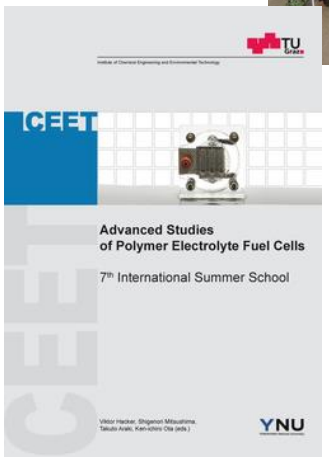


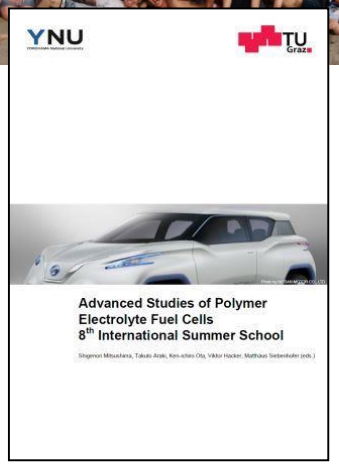
10th FC Summer School 2017

Yokohama National University and TU Graz, Yokohama, Japan.
August 20th – 26th, 2017

3nd International Workshop on Hydrogen and Fuel Cells

Yokohama National University and TU Graz, Yokohama, Japan
August 23rd, 2017





www.ceet.tugraz.at/fuelcells

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Acknowledgements