Contributions of Fluidized Bed Technology to CO_2 Reduction

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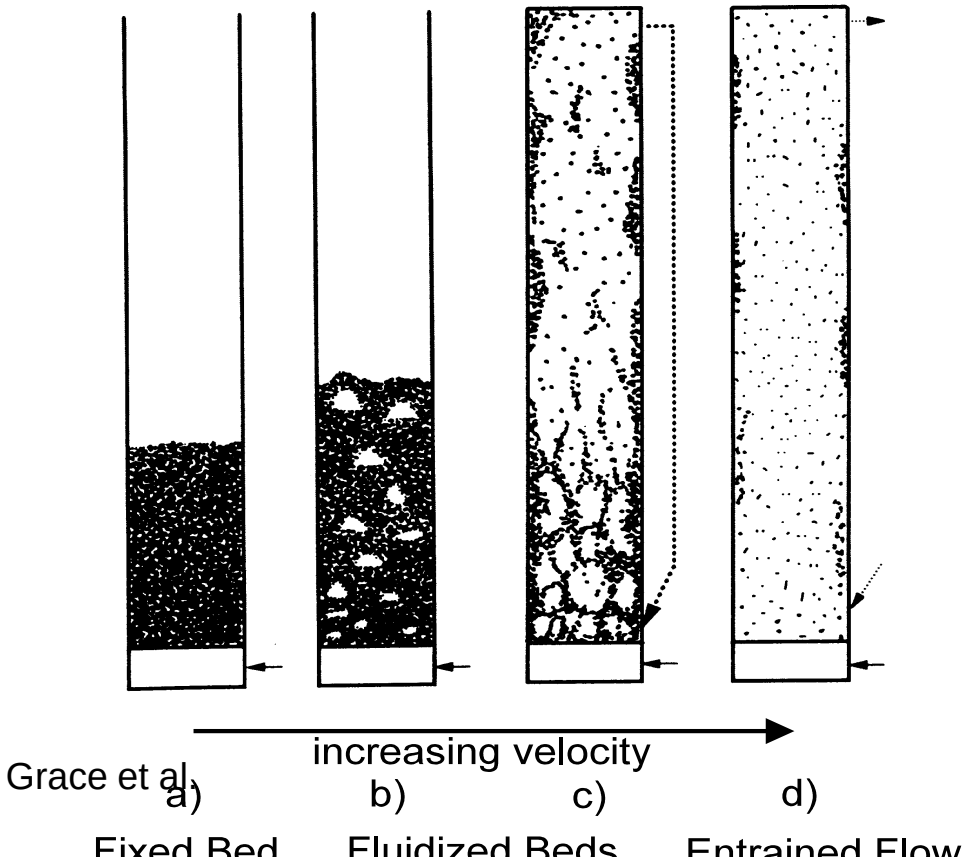
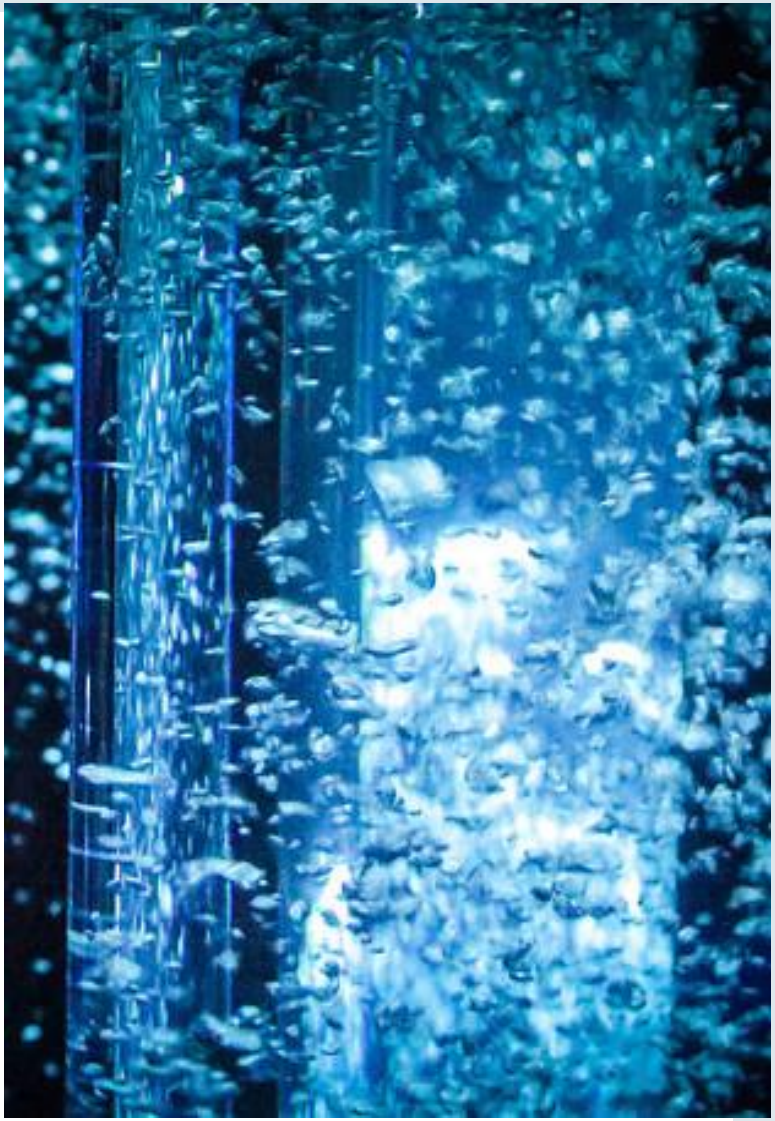
What is a Fluidized Bed?



Grace et al.

b) Bubbling fluidized bed BFB

c) Circulating fluidized bed CFB



Lindley Ashline

Fluidized Bed Technology - Communication

Our Popcorn –

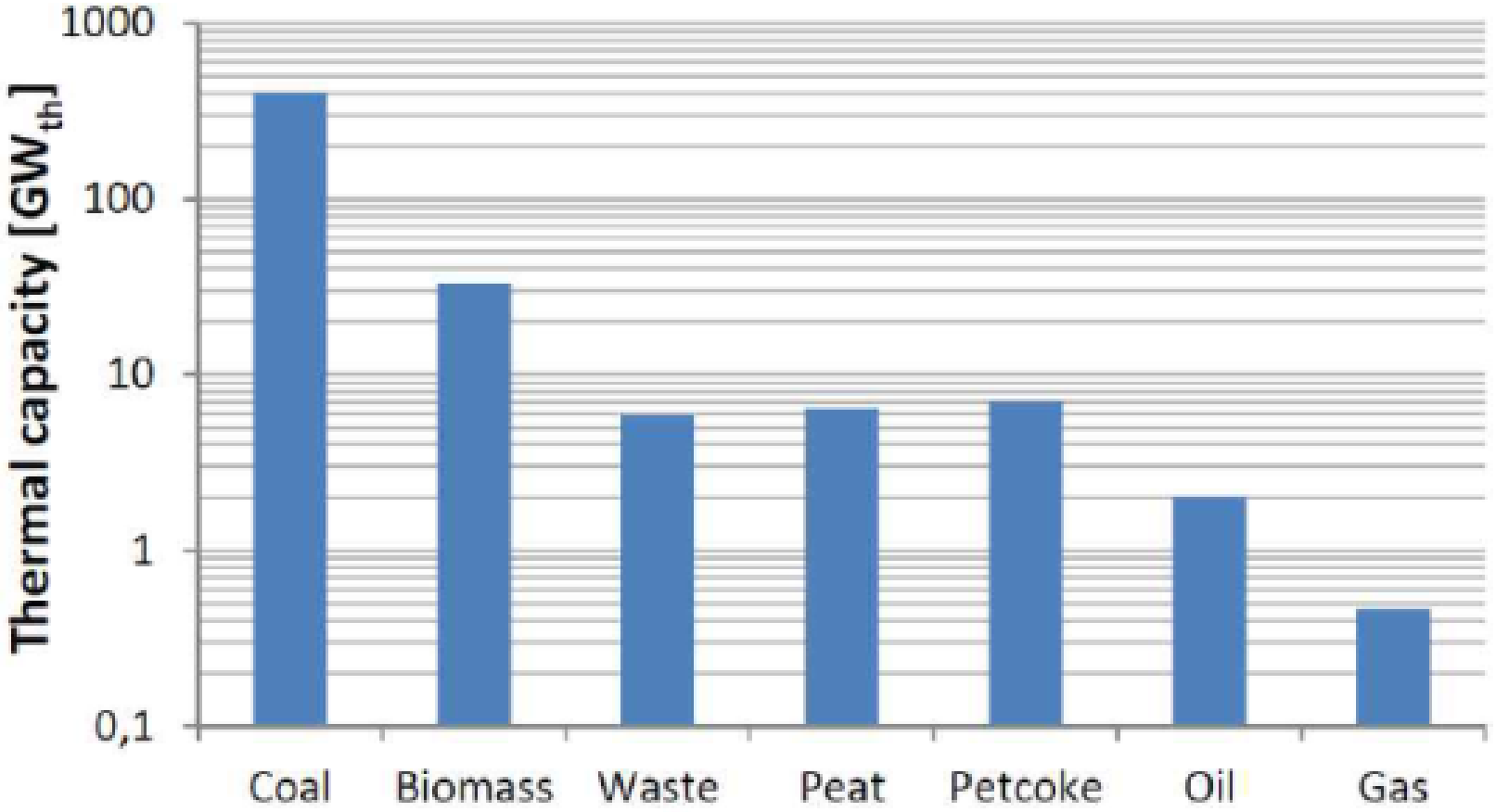
Fluidized Bed

Contents

Contributions and potentials of fluidized bed technology:

- **combustion**
- **gasification**
- **chemical looping combustion CLC**
- **CO2 capture**
- **synthetic biofuels**

Combustion Worldwide

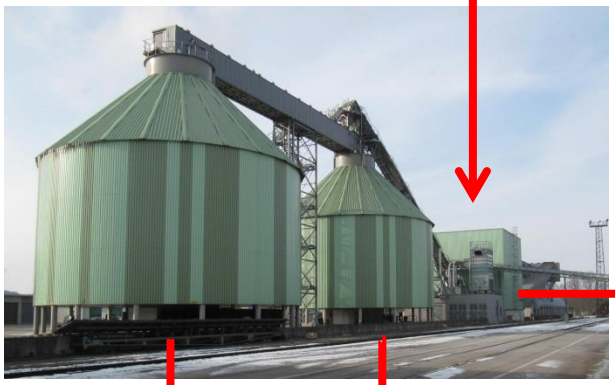


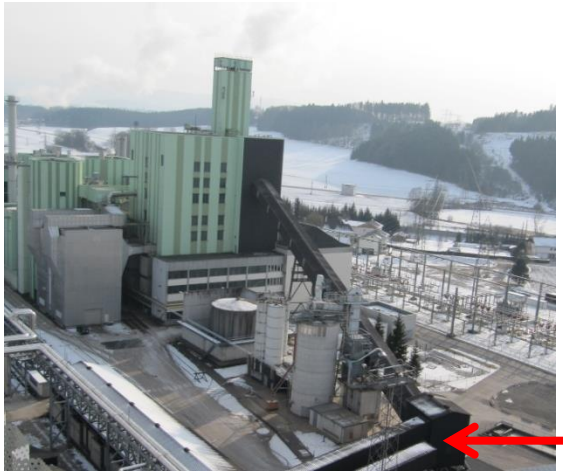
Total thermal capacity of fuels used in fluidized bed boilers worldwide (from IEA-FBC 2017)

Biomass heat- and –power plants

Example

- 49 MW thermal capacity
- 150.000 tons / year
- Provides district heating
- Provides electricity (max. 15 MW)





Urban Mining

Fluidized Bed Units in Austria

Eigentümer/Ort	Jahr	Typ	Leistung	Brennstoffe
Sappi Austria/Gratkorn	1986	CFBC	133 MW	Biogas, Erdgas, Schlamm, Kohle, Öl
ENAGES/Niklasdorf	2004	BFBC	40 MW	Hausmüll, Industrieabfall, Holzabfall, Schlämme
RVL/Lenzing	1998	CFBC	110 MW	Kunststoffe, Abfall, Schlämme, Holzreste
LINZ AG Strom/Linz	2011	BFBC	66 MW	Hausmüll, Abfall, Klärschlamm
UPM Kymmene Austria/ Steyrermuehl	1994	CFBC	48 MW	Rinde, Holz, Holzreste, Schlämme
Energie AG Oberösterreich/ Timelkam	2006	FBC	49 MW	Holz, Altholz, Rinde, Sägespäne
Funder/ St.Veit a.d. Glan	2007	FICFBC	45 MW	Rinde, Holz, Schlämme, Sägespäne, Altholz
Hamburger/ Pitten	1984	BFBC	60 MW	Kohle, Biogas, Schlämme
Fernwärme Wien/ Vienna	1992	FBC	3 x 20 MW	Klärschlamm
Fernwärme Wien/ Vienna	2003	RFBC	40 MW	Hausmüll, Abfälle, Klärschlamm
Wien Energie Bundesforste Biomasse Kraftwerk (WEBBK)/ Biomassekraftwerk Wien-Simmering	2006	CFBC	66 MW	Forstabfälle
Energie Oberwart GmbH/ Oberwart	2008	DFBG	10 MW	Holzhackschnitzel

Vision for gasification technology at TU Wien

RESSOURCES

low grade wood chips

biogenic residues

industrial waste

homogenous municipal waste

sewage sludge manure

rising technological challenges with respect to gasification & gas cleaning

heat

PRODUCTS

electricity

hydrogen

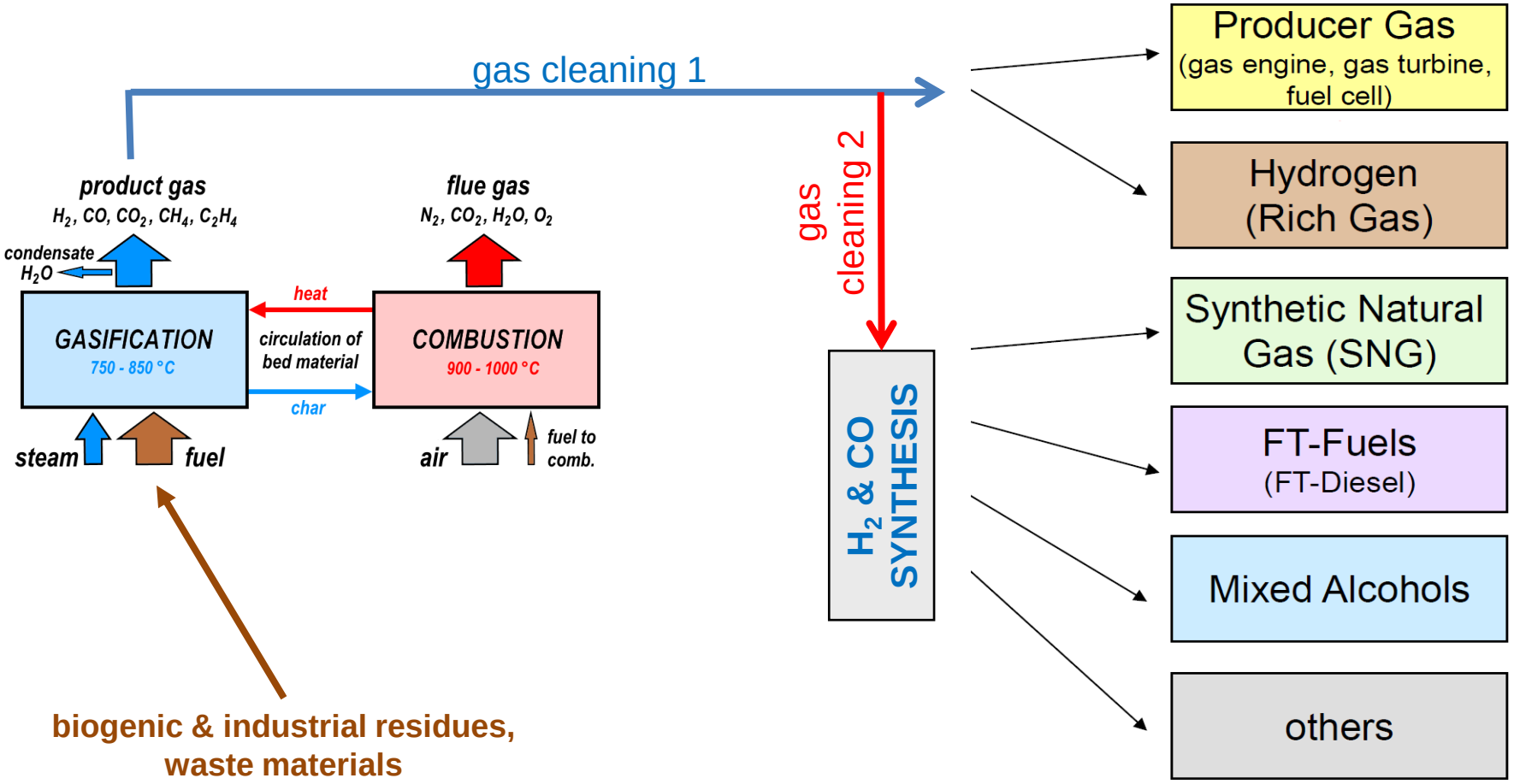
synthetic natural gas

transportation fuels & basic chemicals

Objectives:

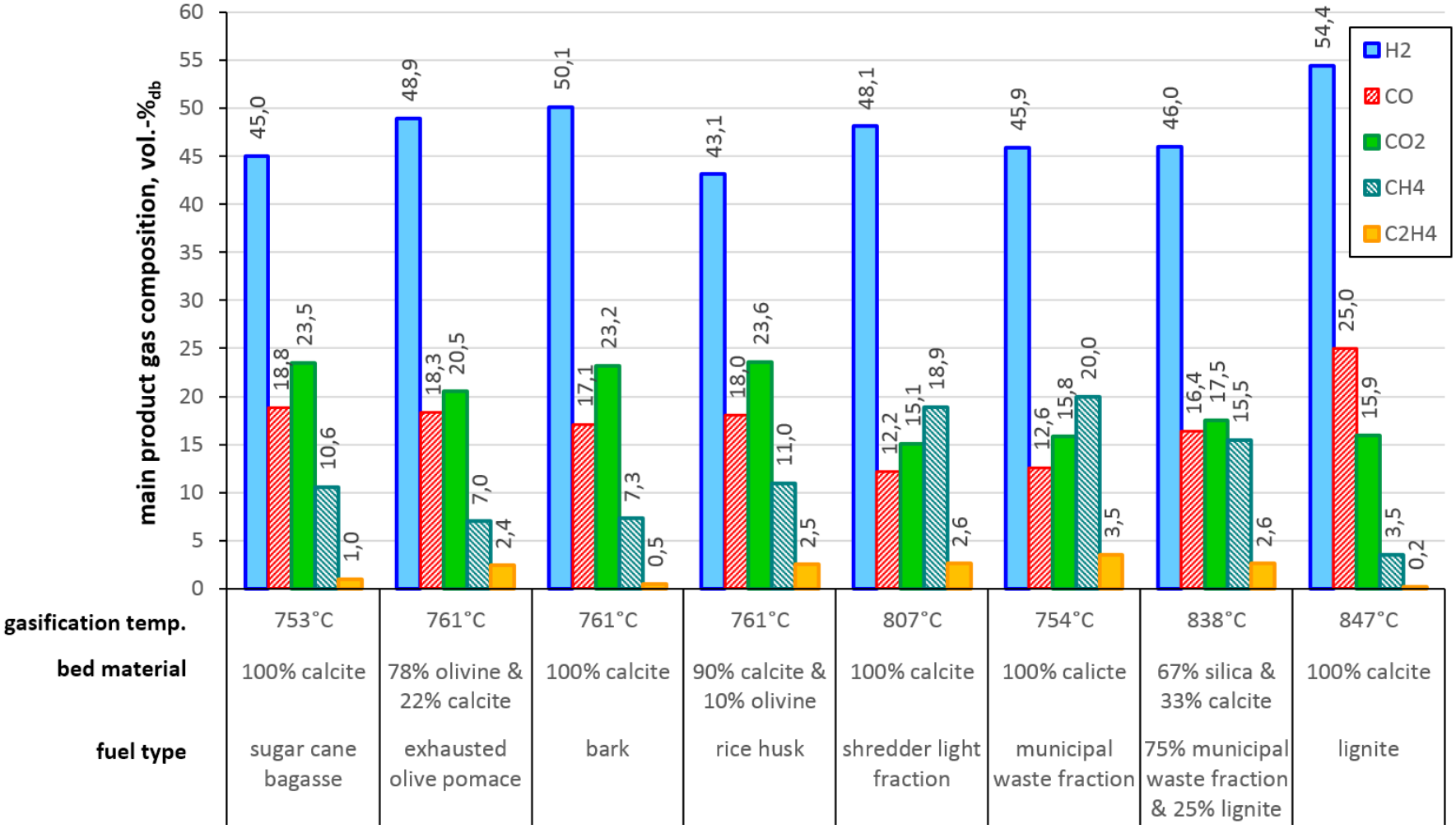
- Increasing the fuel flexibility
- Optimization of gasification (bed materials)

Dual fluidized bed steam gasification



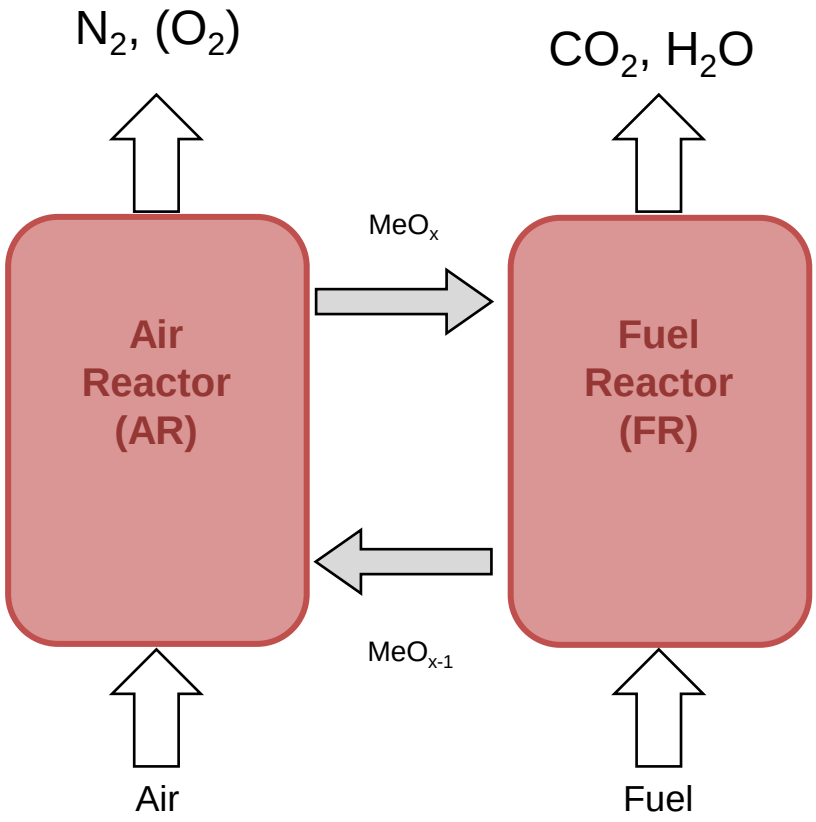
Gasification

Gasification of different fuels:



Main product gas components

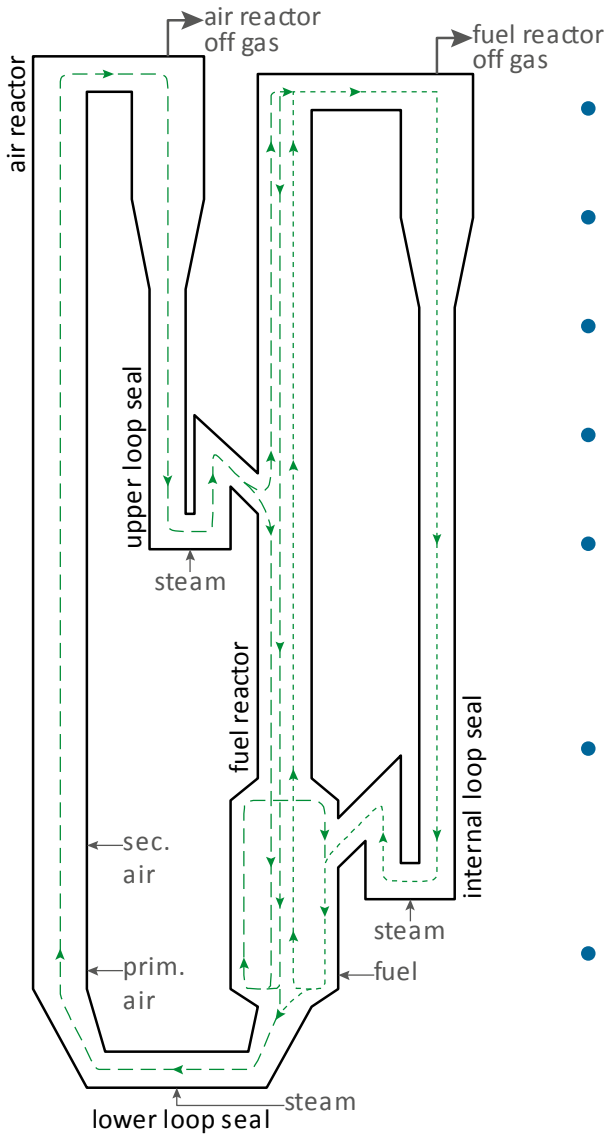
Chemical looping combustion (CLC)



<u>Reactor design:</u>

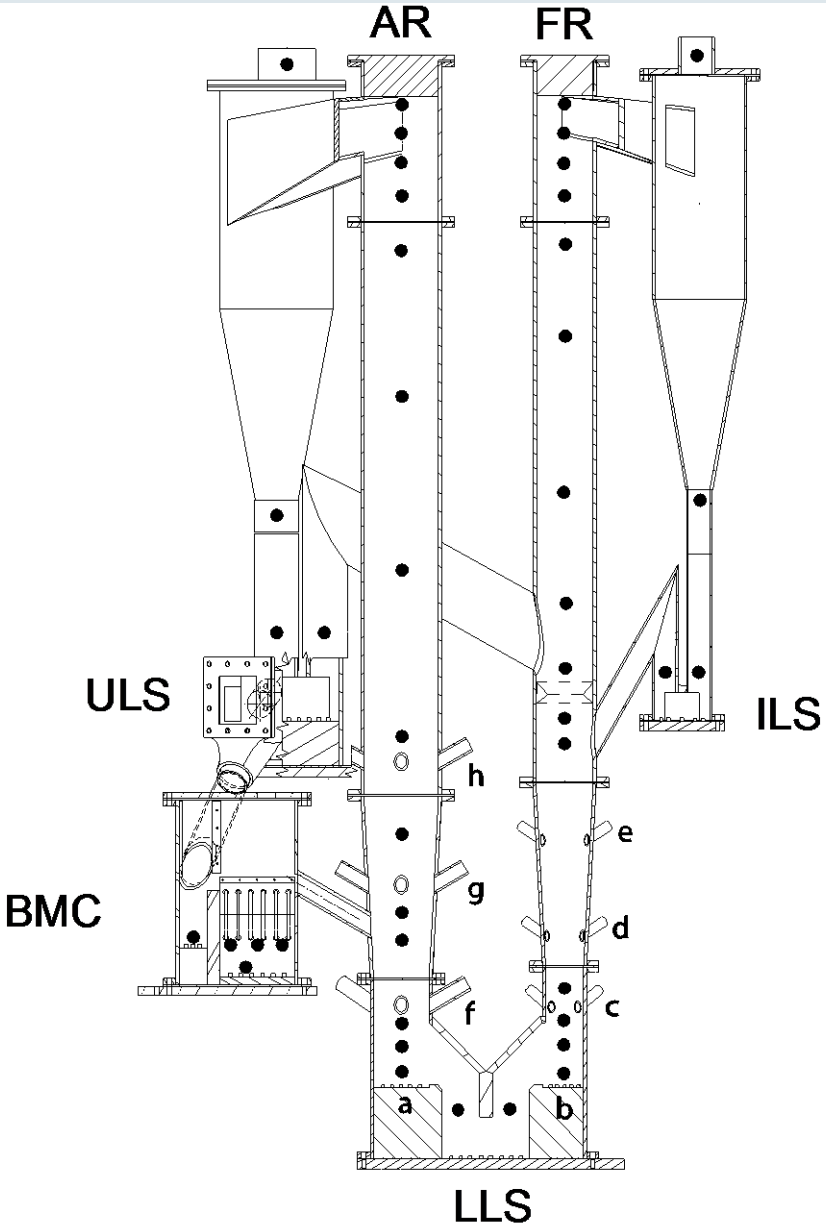
- Fluidized bed systems
- Excellent gas-solid-contact
- High solids circulation
- Broad operating range
- Small reactor foot print

120kW pilot unit



- Dual Circulation Fluidized Bed concept
- Scale-up ready design
- 120kW design fuel power
- High solids circulation (up to 5000 kg/h)
- Several 100 hours of fuel operation with gaseous fuels (natural gas, syngas)
- More than 10 oxygen carrier materials tested (Cu, Fe, Mn and Ni based)
- Full fuel conversion with several materials achieved

Cold Flow Model of 10 MW reactor



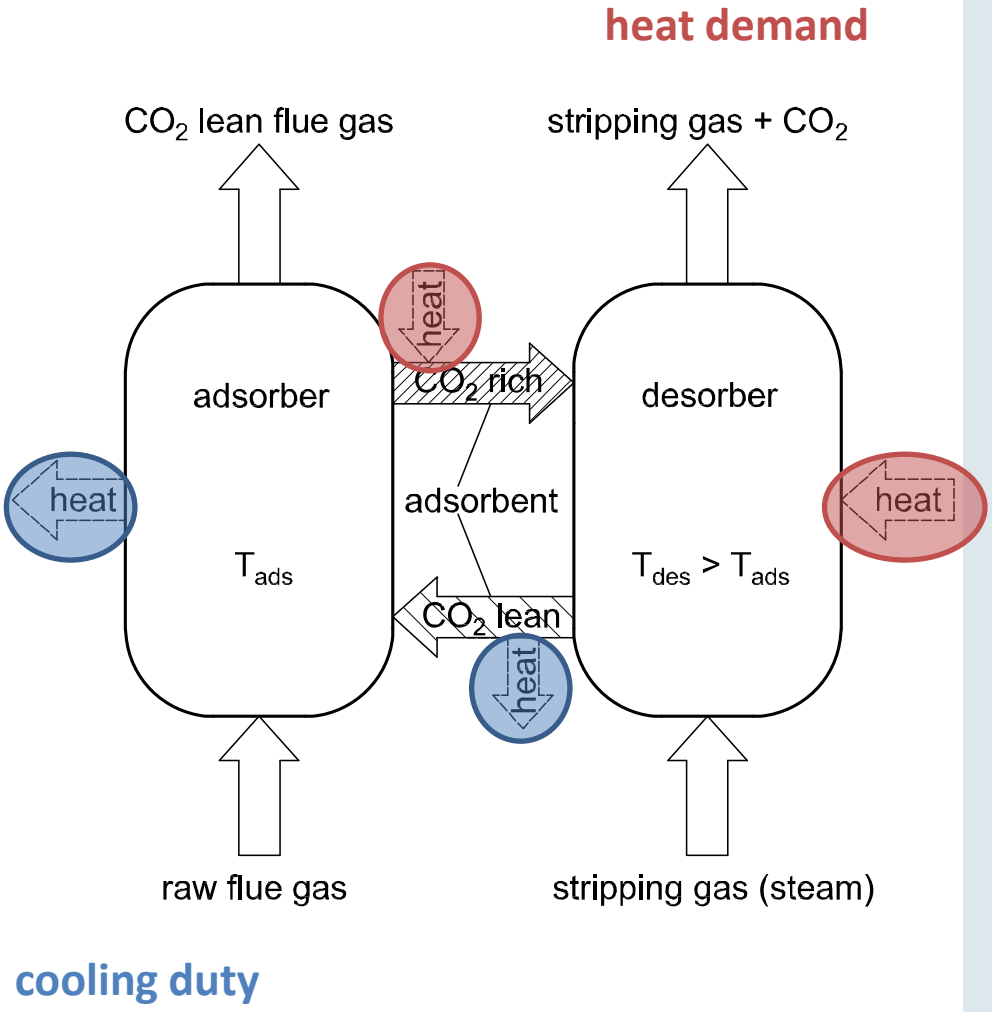
AR … Air Reactor
FR … Fuel Reactor
BMC … Bed Material Cooler
ILS … Internal Loop Seal
ULS … Upper Loop Seal
LLS … Lower Loop Seal

Height: ca. 1.7 m
Scale: 1:11

Continuous TSA solid sorbent CO_2 capture

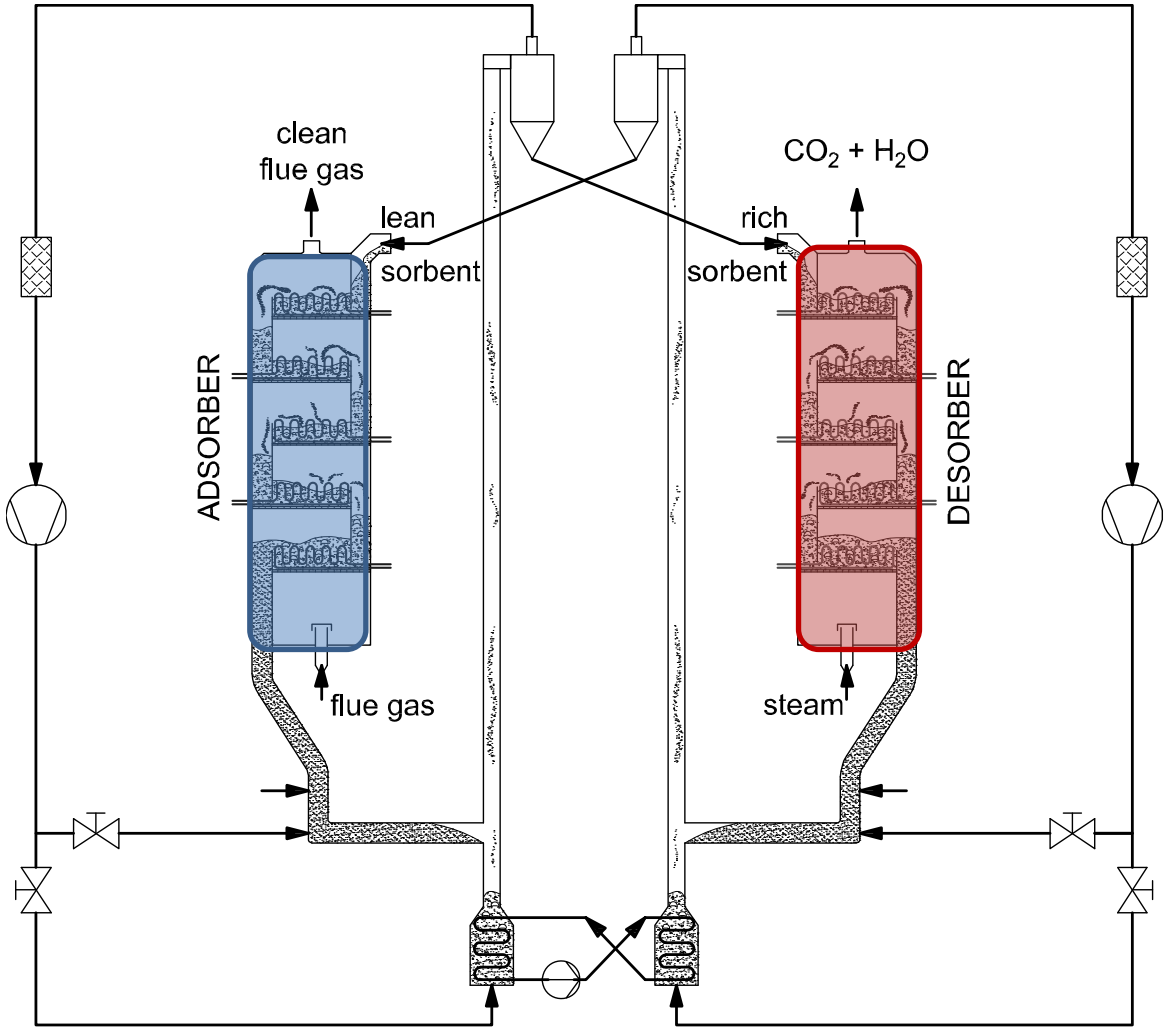
Reactor design aspects

- separate adsorber and desorber
- heat management is crucial
- process heat demand ➔ Min.
- Flue gas throughput ➔ Max.
- pressure drop ADS➔ Min.

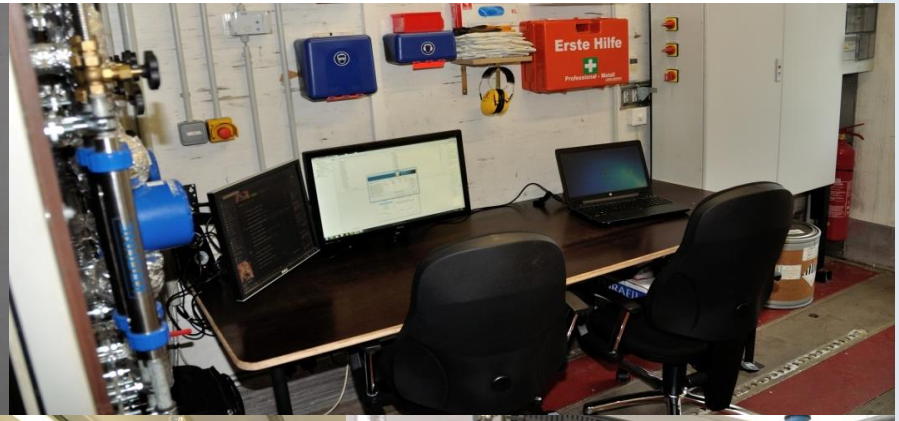


Continuous TSA solid sorbent CO_2 capture

Joint invention:



TSA bench scale unit – mobile lab

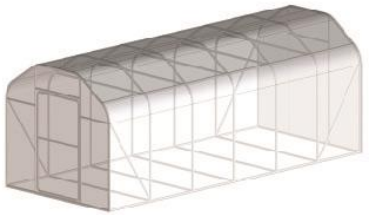


ViennaGreenCO_2 – Pilot project

Existing infrastructure:

Wien Energie Biomass CHP Plant

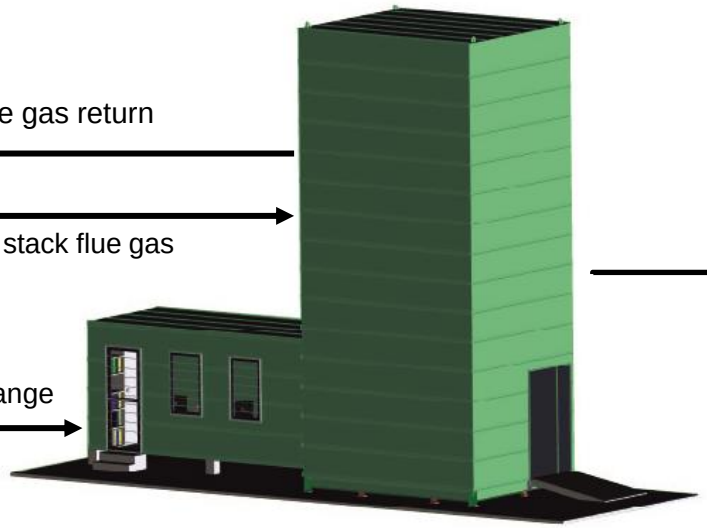
Test Greenhouse



lkprojekt

LGV Frischgemüse

TSA Pilot Unit



Pilot unit flue gas return

Slip stream- stack flue gas

Signal exchange

Utilities

Discontinous CO_2 supply

BERTSCH

M-TEC ENERGIE.INNOVATIV

FT-Synthesis
FT slurry Reactor and catalysts

Slurry reactors was selected

Development of FT technology

- Lab scale plant (5Nm³/h of synthesis gas) in operation since 2005
- ~ 2000 hours of operation per year
- Till 2008 optimisation of gas treatment
- Afterwards testing of catalysts and development
- In 2010 scaling up of the gas treatment
- **In 2015 scaling up of the slurry reactor**

The following catalysts were used:

- Haber Bosch catalyst (mainly for start up)
- Research catalyst (based on cobalt ruthenium, produced from University of Strasbourg)
- Pre-commercial cobalt catalyst
- Pre-commercial iron catalyst

Upscaling of FT slurry reactor

- **Efficiency of bubble column slurry reactor (BCSR) is strongly depended on the hydrodynamic regime of the bubble movement**

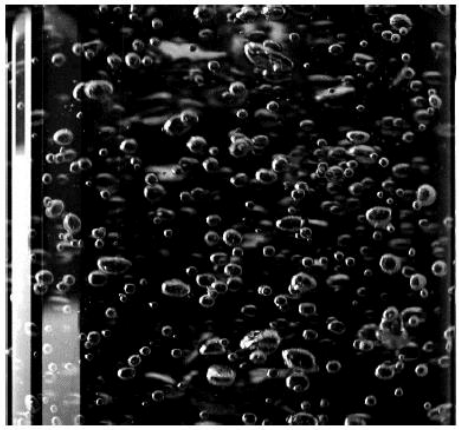


Figure 5: Gas velocity U_{gas} = 0,0053 m/s

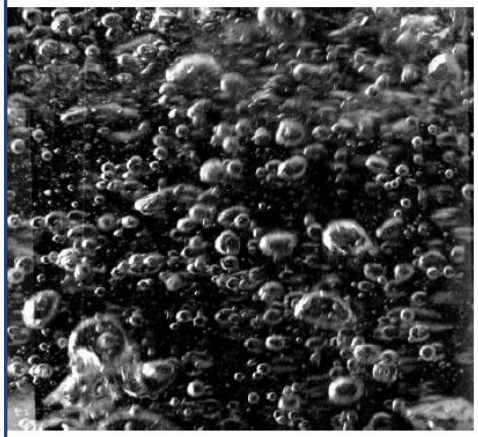
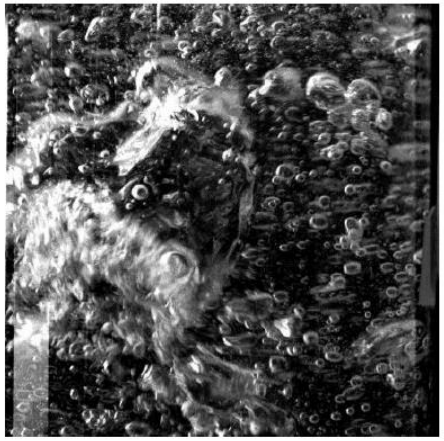


Figure 5: Gas velocity U_{gas} = 0,0106 m/s



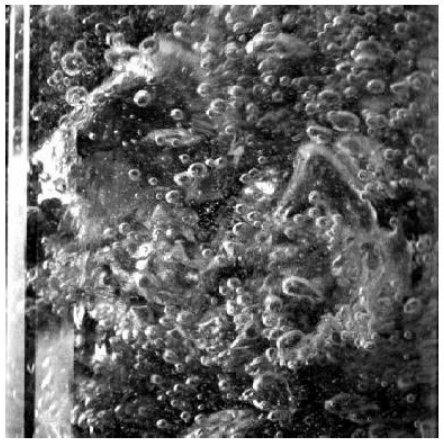


Figure 5: Gas velocities 0,0212 and 0,0371 m/s, respectively

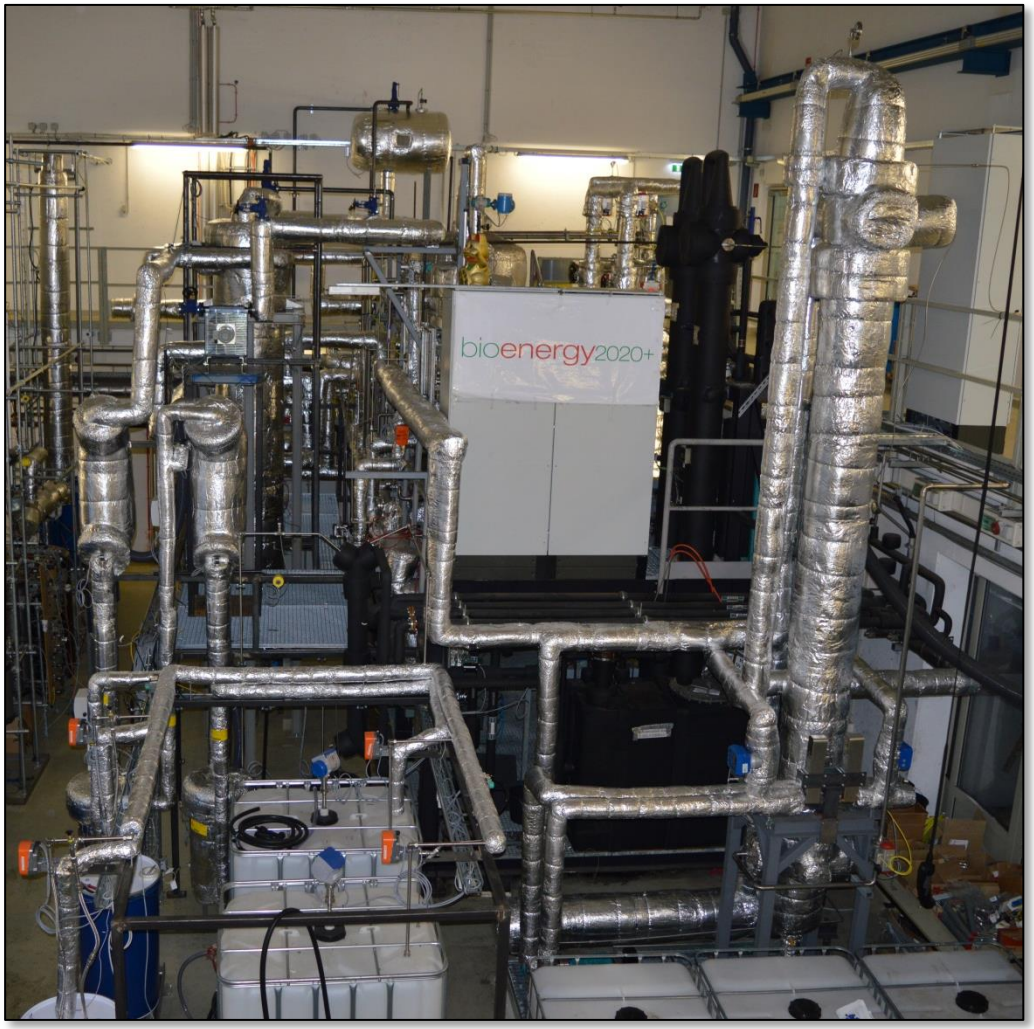
Homogenous Regime

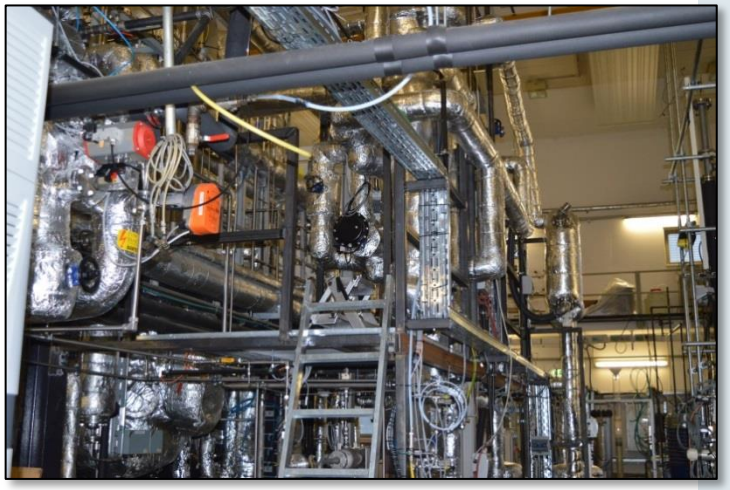
Transition Regime

Heterogeneous Regime

Churn up turbulence increase hold – up of small bubbles 4 times more efficient than homogenous regime

Overview “Barrel per Day” FT pilot plant

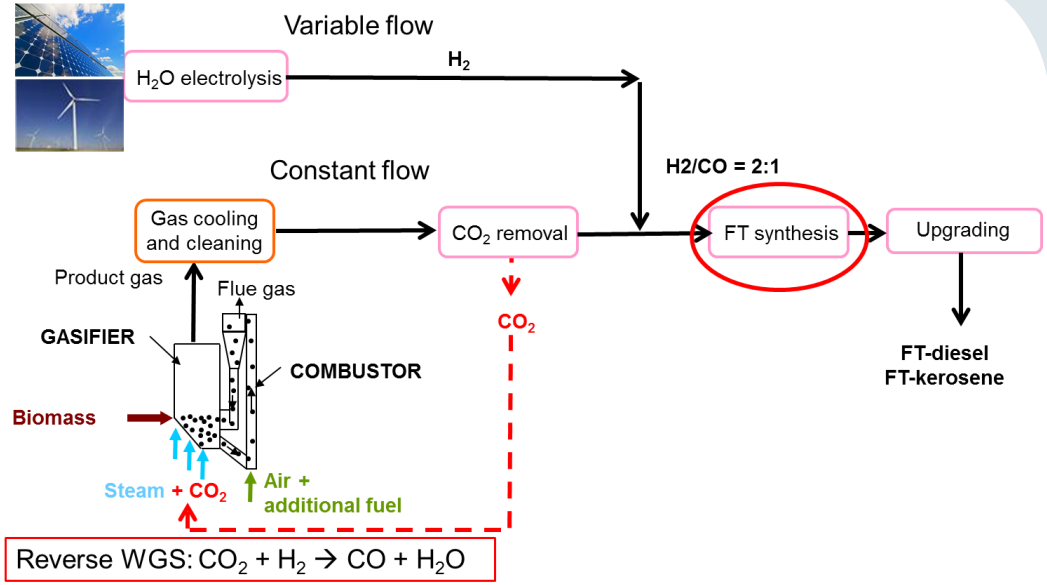


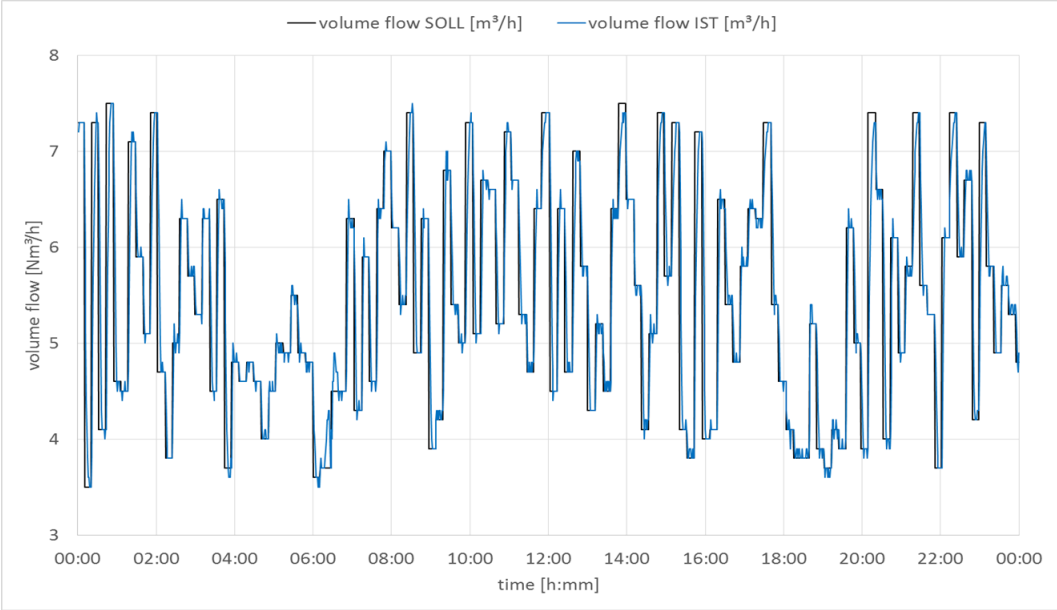


Biomass combined with Power to Liquids: Winddiesel

Hybrid system between Biomass2Liquid and Power2Liquid:

- Baseload is done by biomass
- Excess electricity is feed into synthesis gas
- Gasifier is used as reverse WGS
- Causes a fluctuating mass flow through FT reactor, which was experimentally investigated





Conclusions

- This presentation shows **contributions and potentials of the fluidized bed technology to reduce CO_2** as it is applied in:

- **combustion (biomass, waste, co-combustion)**
- **gasification (biomass, waste)**
- **CO_2 capture (chemical looping combustion, CLC)**
- **CO_2 capture (TSA fluidized bed)**
- **synthetic biofuels (FT)**

Thank you for your attention!

https://nachhaltigwirtschaften.at/de/iea/technologieprogramme/fbc/iea-fbc-arbeitsperiode-2017-2020.php

www.ieafbc.org

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