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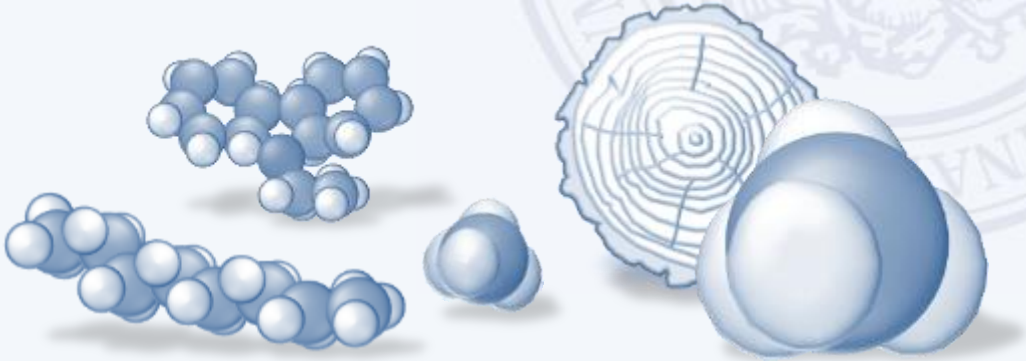
SECOND GENERATION BIOFUELS WORKSHOP:
Exploring technical cooperation among Regional Leaders
Cape Town, Western Cape (ZA), 12 March 2014

Research in Bio-fuels in Bavaria

Jürgen Karl
Lehrstuhl für Energieverfahrenstechnik
Friedrich-Alexander-Universität Erlangen-Nürnberg



1. The Role of Biofuels for Germanys "Energiewende"

- Situation of Europe's gas supply
- Gaps to fill by means of Biofuel

2. State-of-the-art of Biofuels and Second Generation Fuels

- Methanation of Biomass
- Other synthetic Energy Carriers
- Key Technologies for Second Generation Fuels

3. Hydrogen and Second Generation Fuels in Bavaria

- Gasification Research (Biomass Heatpipe Reformer)
- Bavarian Hydrogen Center (BHC)
- Hydrogen and Methanation projects at the Chair of Energy Process Engineering

4. Research Needs and Opportunities

- Outline for a Joint Research program

1. The Role of Biofuels for Germanys "Energiewende"

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- Gaps to fill by means of Biofuel

Upcoming Role of Biofuels in the Energy sector

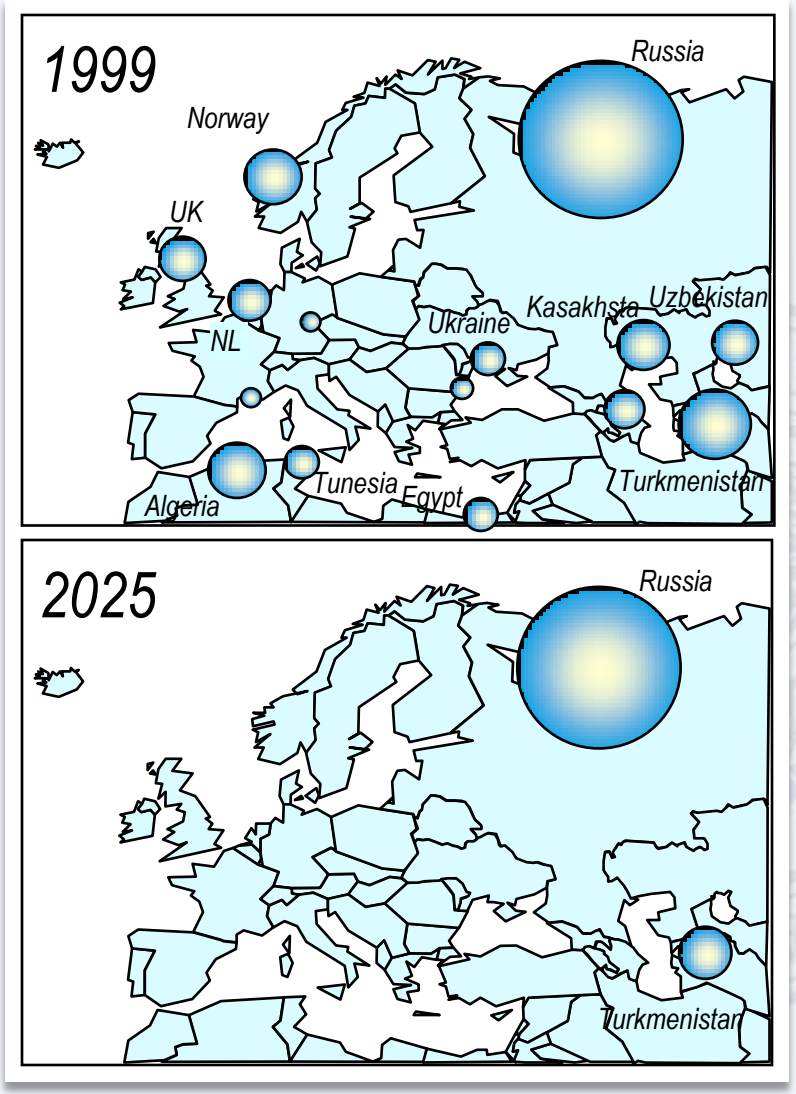
Biofuels…

- …have to substitute fossile fuels in order to improve security-of-supply

Situation of Europe's gas supply

- Reserves-to-production ration is 8 years for Europe and 10 years for the USA (status 2012)
- Europe will depend completely on Russian natural gas supplies

Estimated natural gas reserves



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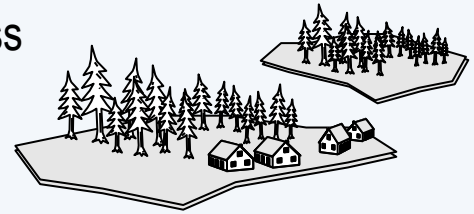
Situation of Europe's gas supply

Possible Solution

- Substitution of natural gas with Biomass
- Methanation makes Biomass transportable
- Biomass may be used in urban areas with high efficiency due to favorable conditions for CHP and without fine dust emissions



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Upcoming Role of Biofuels in the Energy sector

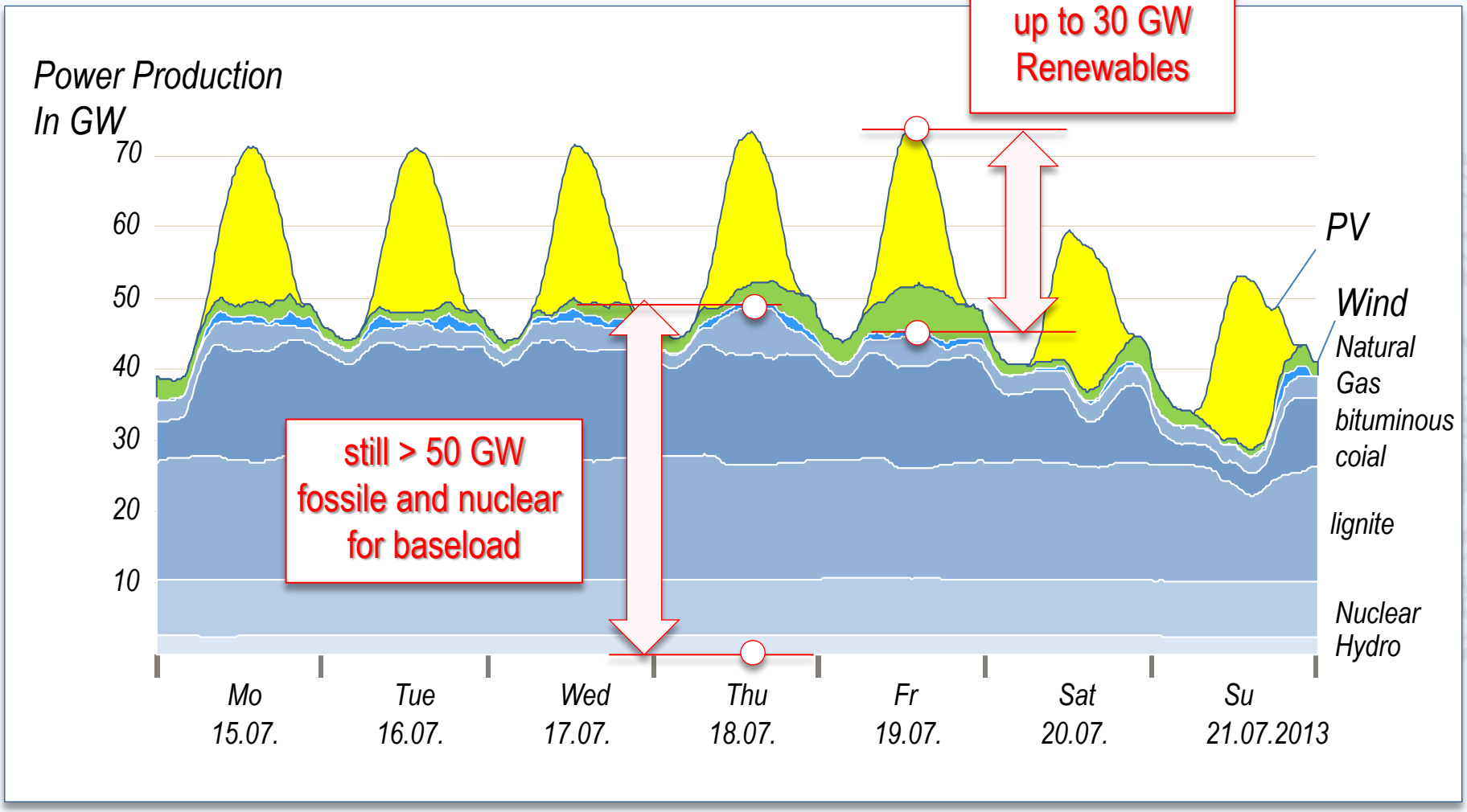
Biofuels…

- …have to substitute fossil fuels in order to improve security-of-supply
- … shall back-up increasing shares of wind and photovoltaics (PV) with highest flexibility

A Summer Week in Germany…

Feed-in tariff for PV:
9 ct/kWh / 1.5 R/kWh

- Renewables cover 25% of Germanys power production
- Increasing the share of wind and PV requires affordable and most flexible back-up capacities…



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Upcoming Role of Biofuels in the Energy sector

Biofuels…

- …have to substitute fossil fuels in order to improve security-of-supply
- … shall back-up increasing shares of wind and photovoltaics (PV) with highest flexibility
- … have to use existing infrastructures and storage capacities

1 Mio. electrical vehicles
10 GWh

Reference: pumped storage hydro power stations in Germany
40 GWh

Natural gas grid
2170 GWh

Liquid fuel
2500 GWh

Quelle: M.Specht, Kraft-Wärme-Kopplung mit Biomasse, Augsburg, 10.03.2010

2. State-of-the-art of Biofuels and Second Generation Fuels

- Methanation of Biomass
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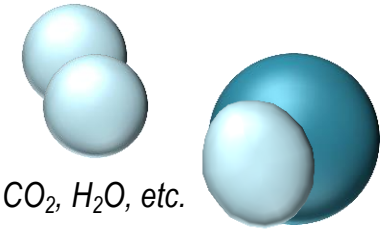
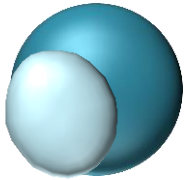
Examples for Second Generation Fuels: Substitute Natural Gas (SNG)

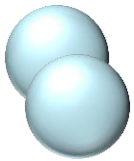
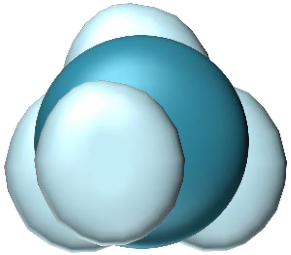
- Production of synthetic „natural gas" from biomass ("Methanation")

1. Step:
Thermal gasification

$$\underset{\text{(Biomass)}}{CH_xO_y} + H_2O \xrightarrow{\text{gasification}} CO + 3\,H_2 + CO_2,\ H_2O,\ \text{etc.}$$





CO + 3  $\xrightarrow{\text{hydrogenation}}$  + H_2O, CO_2, … *heat*

CH_4

hydrogen

2. Step:
Methanation

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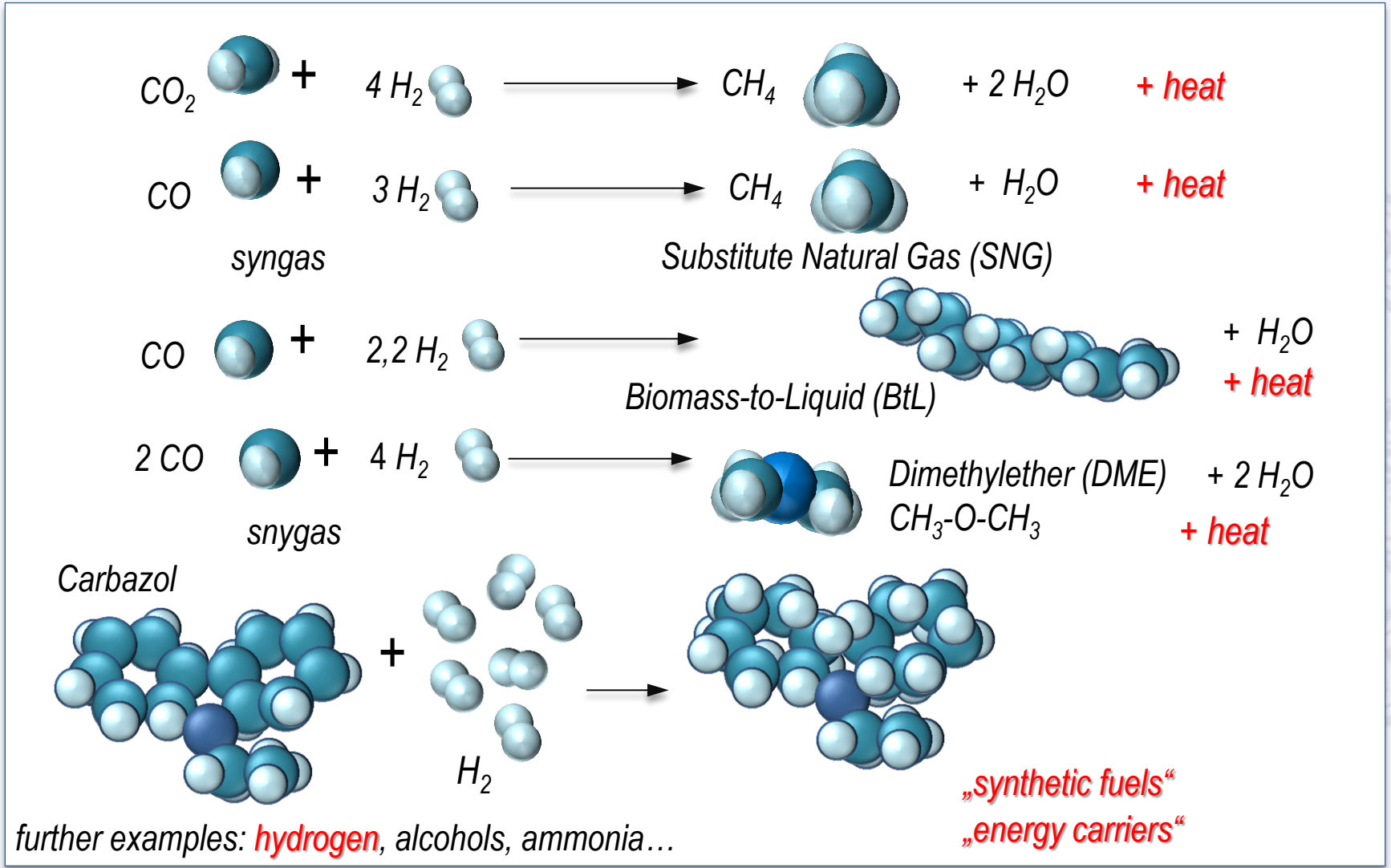
Examples for Second Generation Fuels:

- „Polygeneration“ is particularly interesting…



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Key Technologies for Second Generation Fuels:

1. Gasification

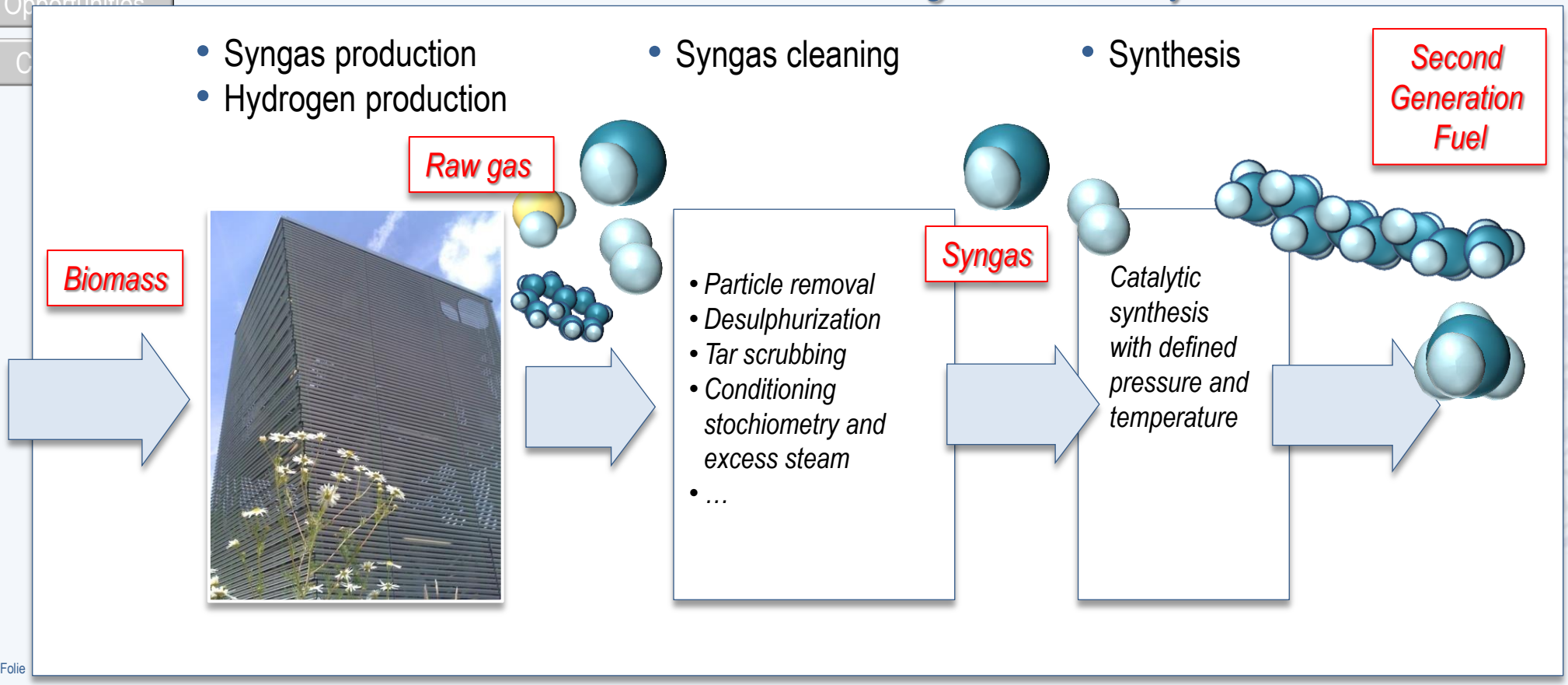
- Syngas production
- Hydrogen production

2. Gas cleaning

- Syngas cleaning

3. Synthesis

- Synthesis



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Process chain for Second Generation Fuels

Reaction equation for the methanation of biomass: ($CH_{1,37}O_{0,61}$)

with autothermal oxygen gasification

with allothermal steam gasification

1. Option: oxygen

$$CH_{1,37}O_{0,61} + 0{,}3525\ O_2 \longrightarrow 0{,}3425\ CH_4 + 0{,}6575\ CO_2$$

$$CH_{1,37}O_{0,61} + 0{,}3525\ H_2O \longrightarrow 0{,}51875\ CH_4 + 0{,}48125\ CO_2$$

2. Option: steam

Thermal gasification (Reforming) → Gas cleaning → Synthesis → CO_2 Sequestration

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Gasification Technologies

Agnion Heatpipe-Reformer, Pfaffenhofen, D

Biomass HKW Güssing, AT

Sasolburg factury
Quelle: www.sasol.com

steam gasification

- Dual Fluidized Bed gasification
- Applied for biomass only
- Small- and medium-scale plants

- Entrained flow, fixed bed-, fluidized bed gasification
- Large-scale plants

SNG-Anlage, CPI Xinjiang Energy Co. Ltd, Yili City Xingjiang, China, 8 x 500 MW Siemens SFG-500 coal gasifier, comissioning 2014

Oxygen gasification

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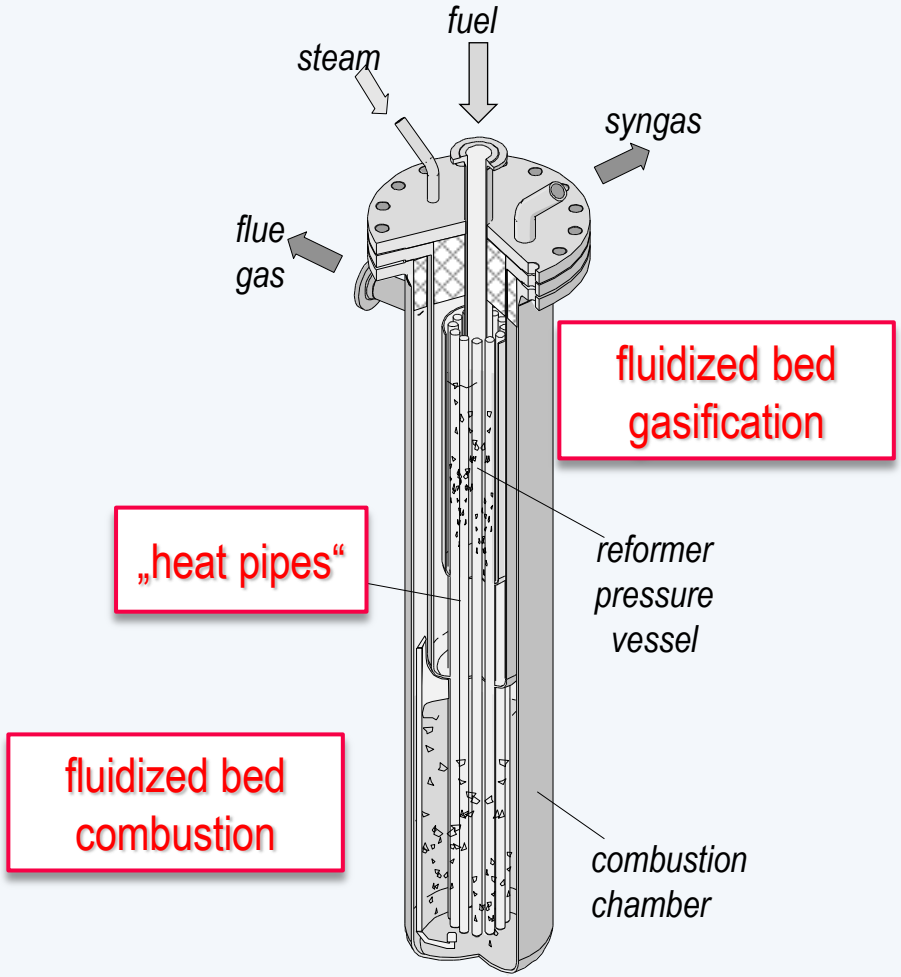
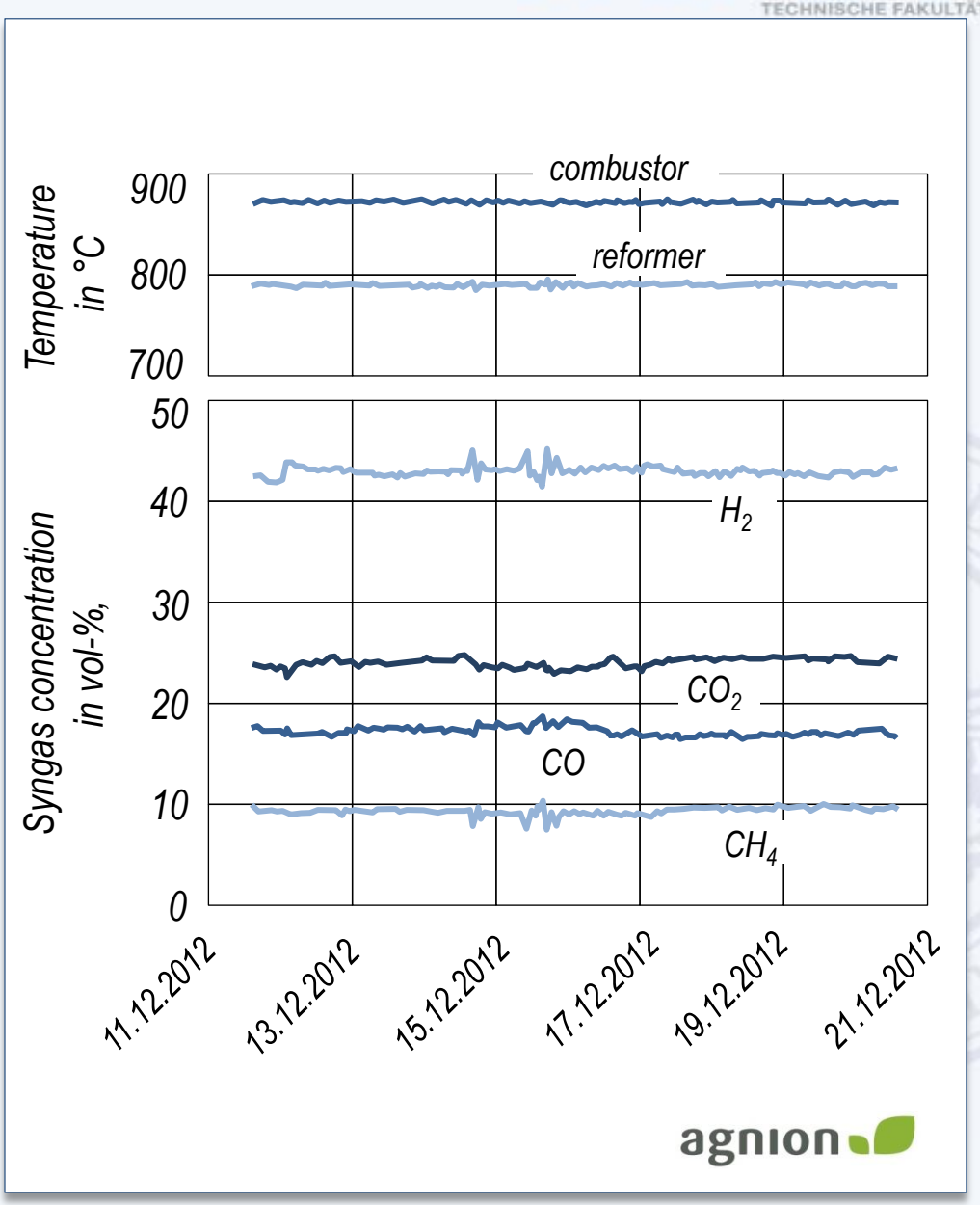
500 kW agnion Heatpipe-Reformer pilot





Karl, J., Biomass heat pipe reformer—design and performance of an indirectly heated steam gasifier Biomass Conversion and Biorefinery: Volume 4, Issue 1 (2014), P 1-14

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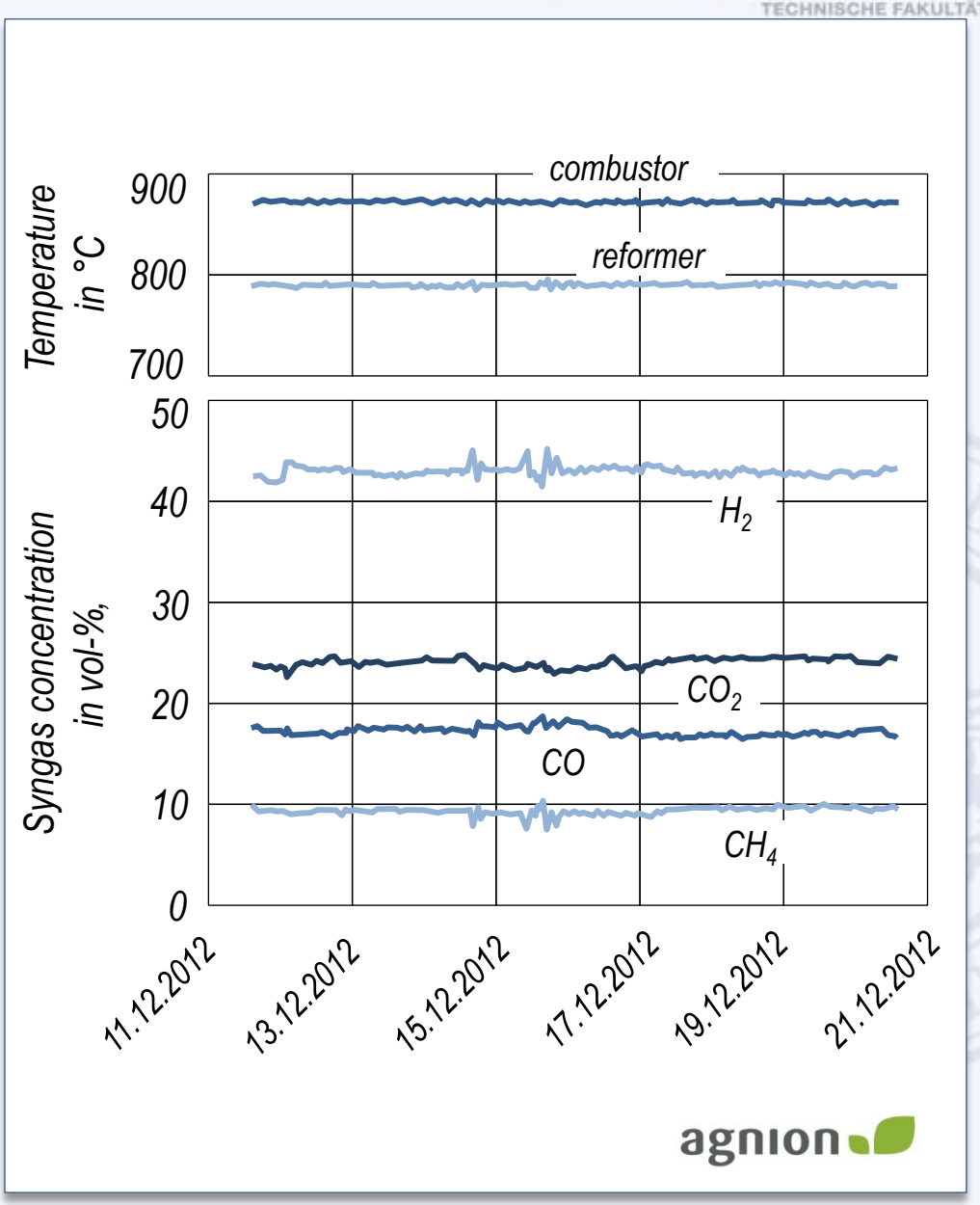
Performance of the 500 kW agnion Heatpipe-Reformer pilot



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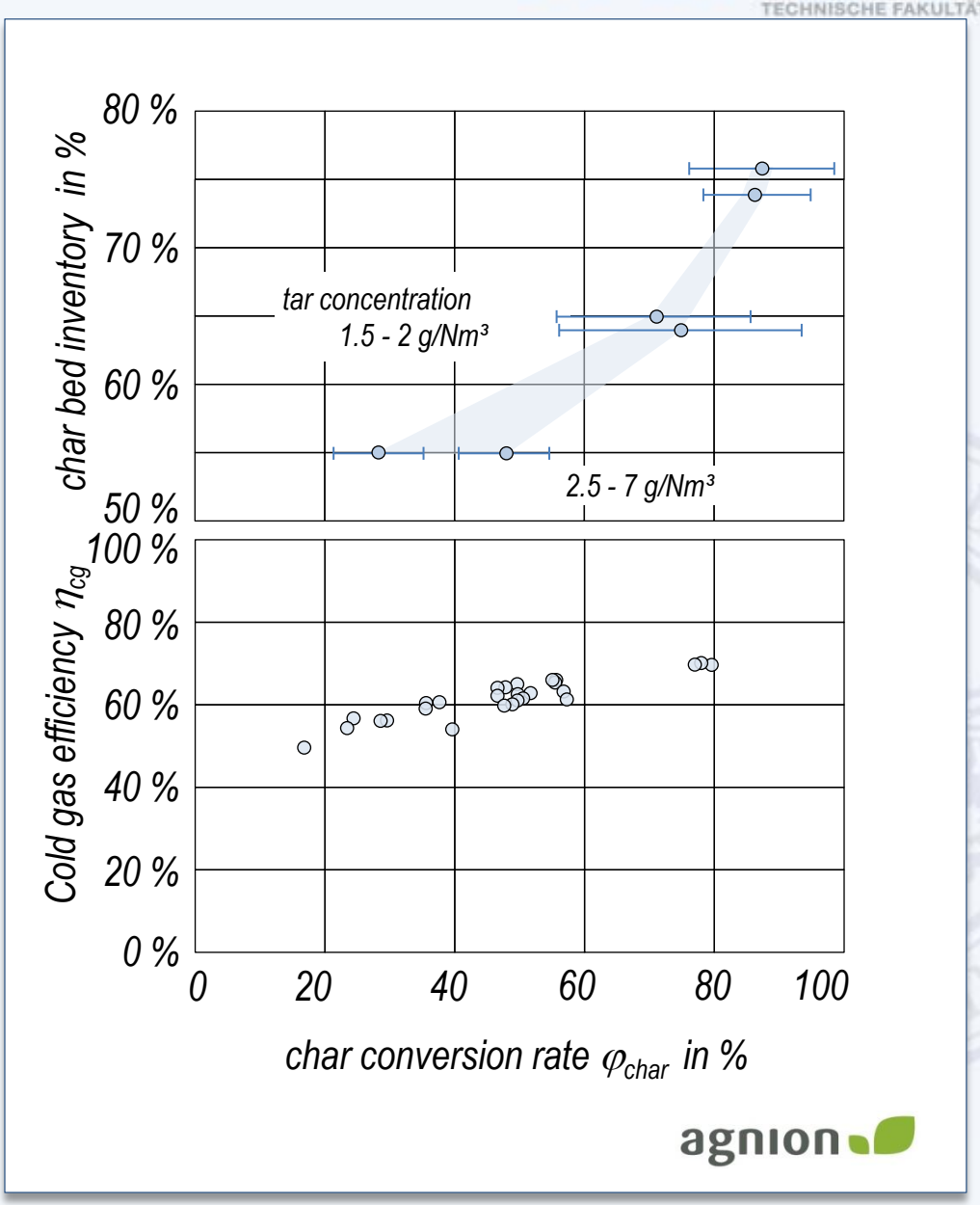

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Process chain for Second Generation Fuels

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(Factor 2,5!)

… 2,25 CO_2 per CH_4

with allothermal steam gasification

$$CH_{1,37}O_{0,61} + 0{,}3525\ H_2O \longrightarrow 0{,}51875\ CH_4 + 0{,}48125\ CO_2$$

… 0,92 CO_2 per CH_4

Thermal gasification (Reforming) → Gas cleaning → Synthesis → CO_2 Sequestration

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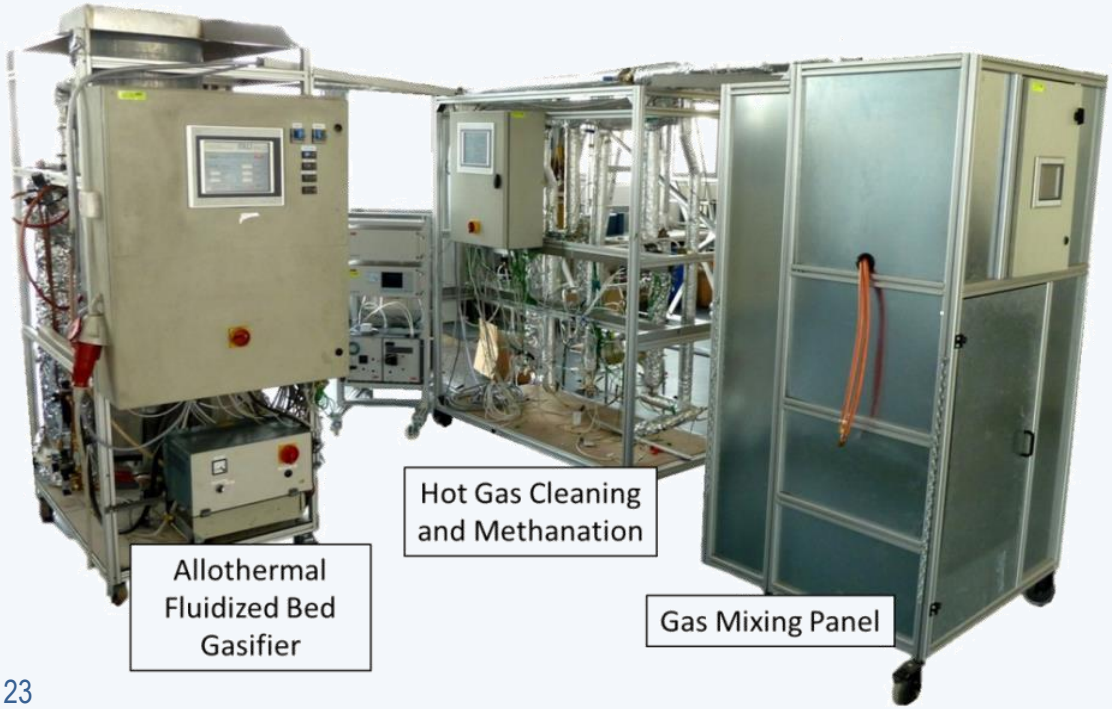
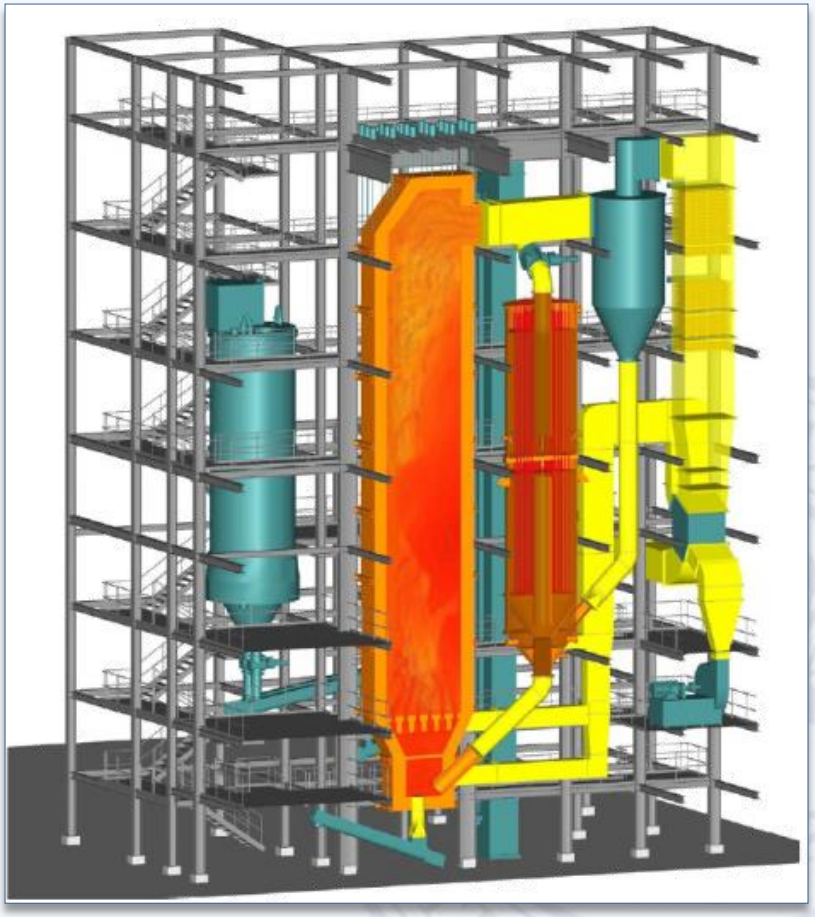
EU Project

CO_2freeSNG 2.0

Objectives

- Substitute Natural Gas from Lignite (catalyst screenings, raw gas cleaning, process integration)
- Basic design 50 MW Heatpipe-Reformer
- with integrated sequestration of CO_2





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with **allothermal** steam gasification

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Thermal gasification (Reforming) → Gas cleaning → Hydrogen production

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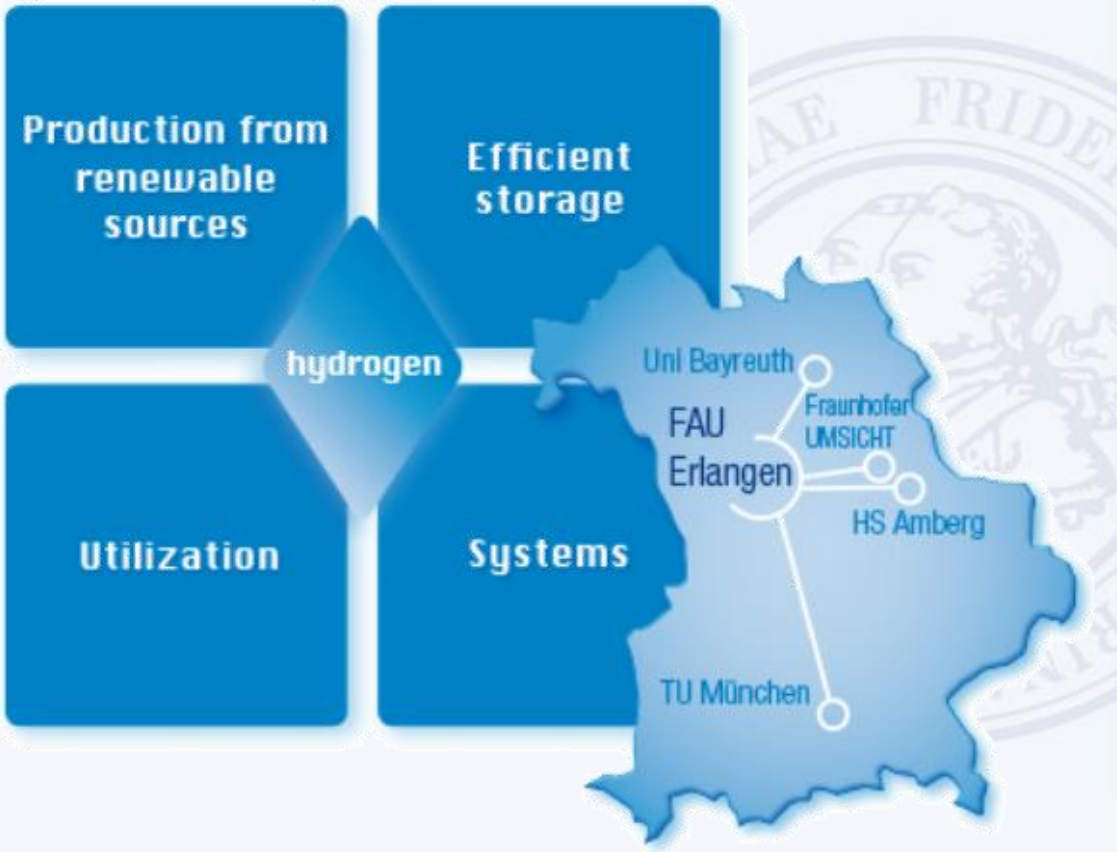
Bavarian Hydrogen Center

- BHC focuses on the efficient production, storage and utilization of renewable hydrogen
- so-called "liquid hydrogen carriers" (liquid organic hydrogen carrier – LOHC , i.e. Carbazol) store large amounts of hydrogen without losses at ambient conditions.



Bavarian Hydrogen Center

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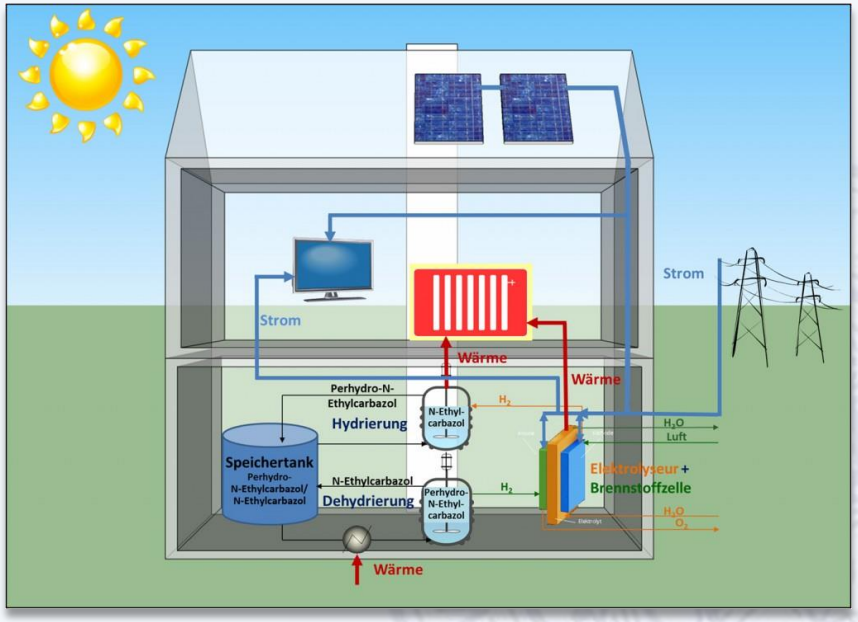
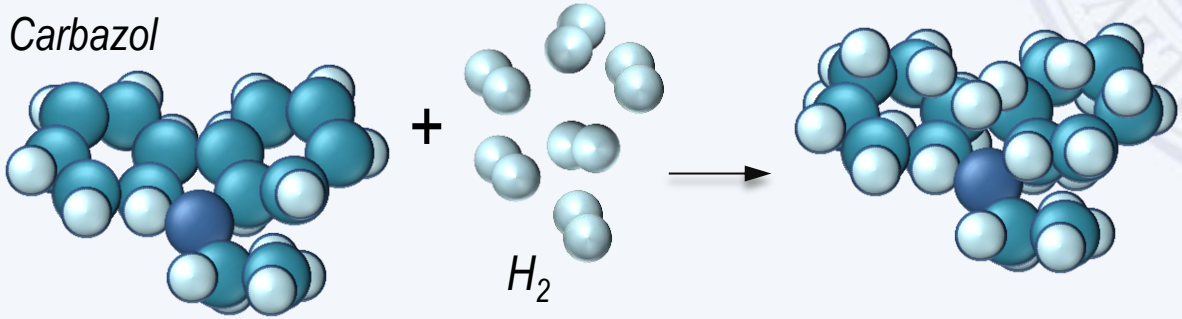
Bavarian Hydrogen Center

Role of Biofuels
Technologies
Bavarian Projects
Opportunities
Conclusion

- BHC focuses on the efficient production, storage and utilization of renewable hydrogen
- so-called "liquid hydrogen carriers" (liquid organic hydrogen carrier – LOHC , i.e. Carbazol) store large amounts of hydrogen without losses at ambient conditions.
- a functional storage facility will be revealed as part of a demonstration system





Bavarian Hydrogen Center

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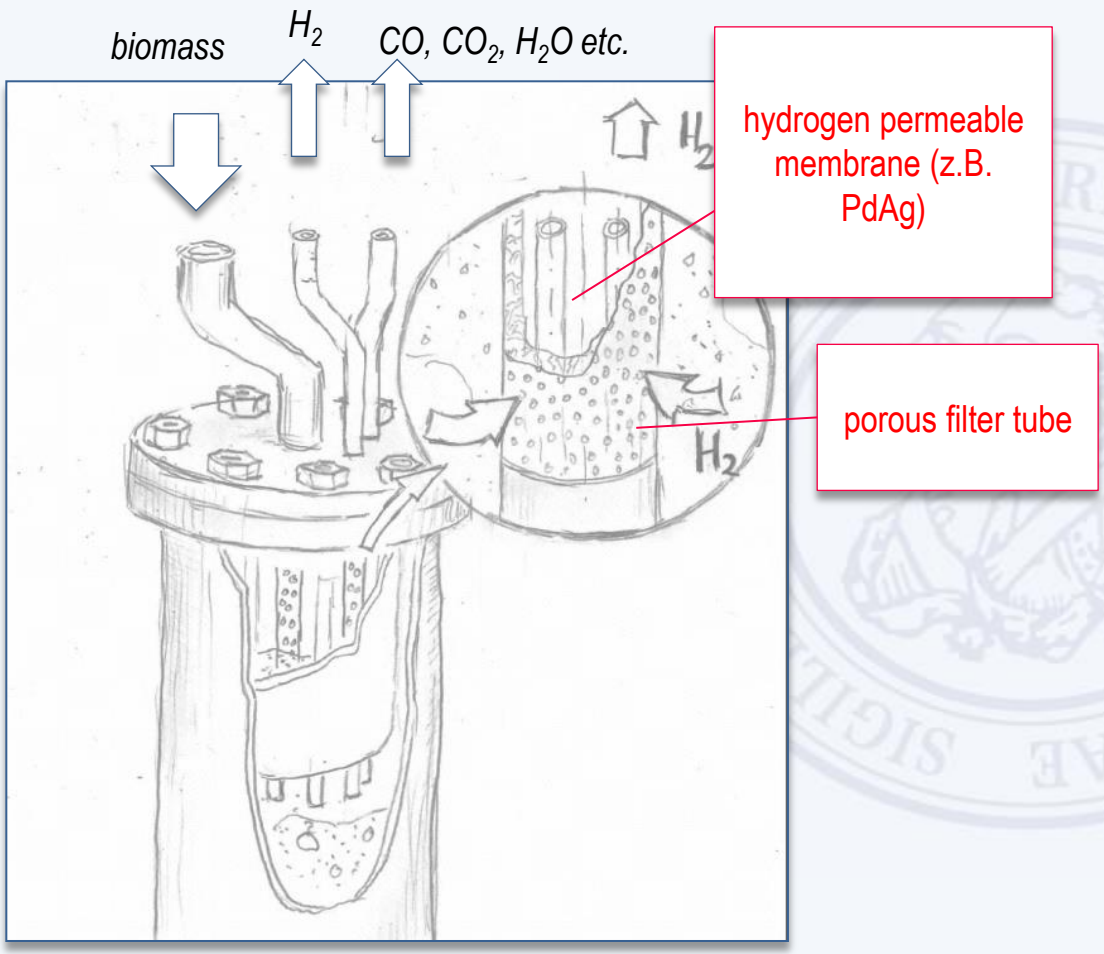
Bavarian Hydrogen Center

- Heatpipe-Reformer 2.0 @ EVT with in-situ hydrogen separation

Work package
„Production of Hydrogen“



4. Research Needs and Opportunities

- Outline for a Joint Research program

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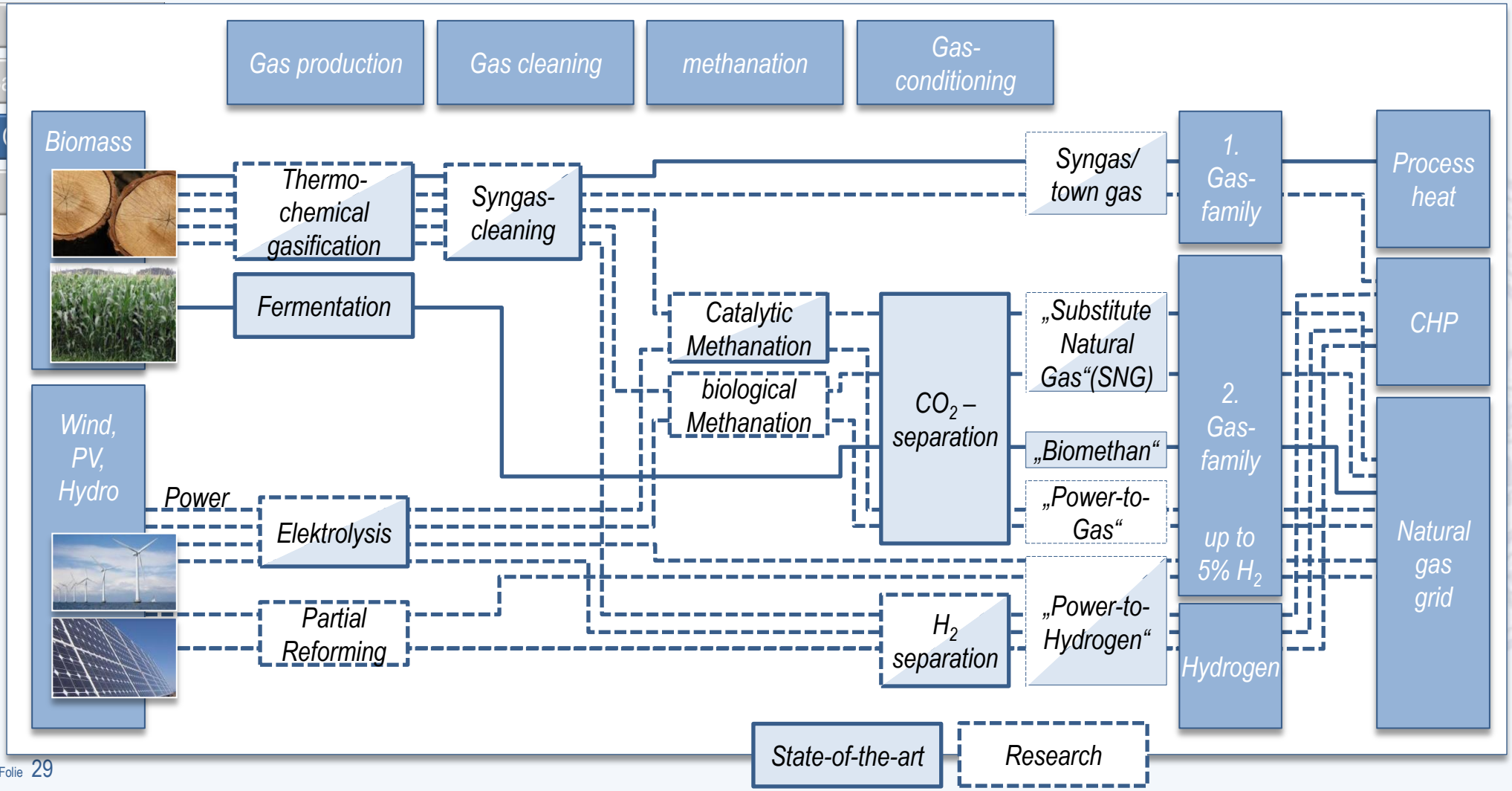
Research needs for Biofuels in the Energy sector
(example: methanation)

Role of Biofuels

- there are many technologies and route options still to be developed



Do we need another joint research program?

If there's a gap between academic research and public policies…

- … do academics fail to comply with public needs?
- … do policy makers fail to comply with scientific insights realizations?

→ Purpose of this section: bridging the gap between academic research and public policies and drafting of a joint research program for the partner regions

What is needed to gap bridges? ⇨ Communication

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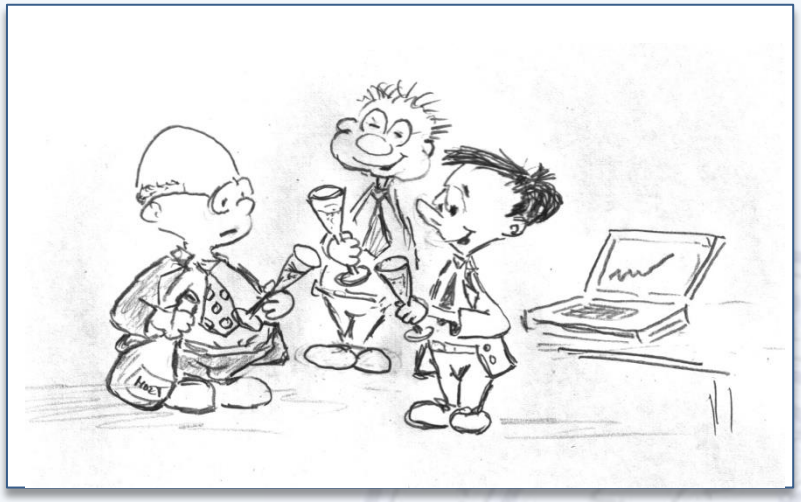
„We have to faciliate the dating process…“

Scientists favorite type of communication



Policy makers favorite type of communication

What is needed to gap bridges? ⇨ Communication

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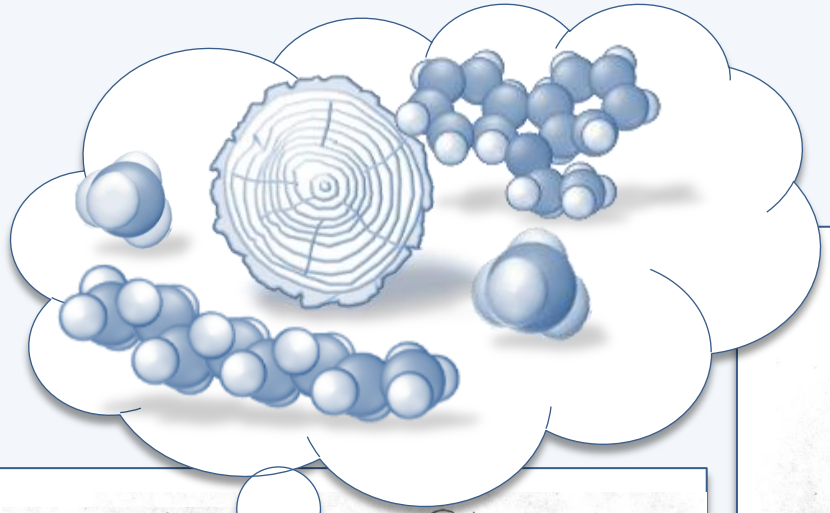
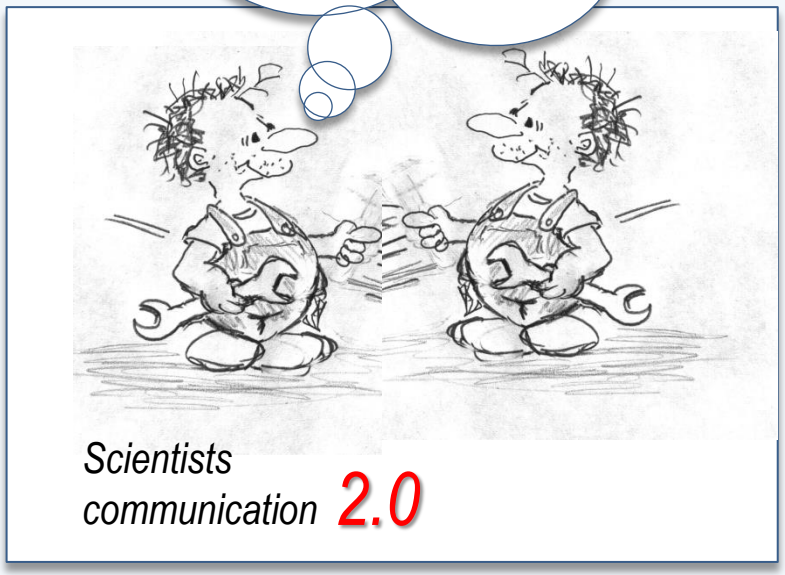
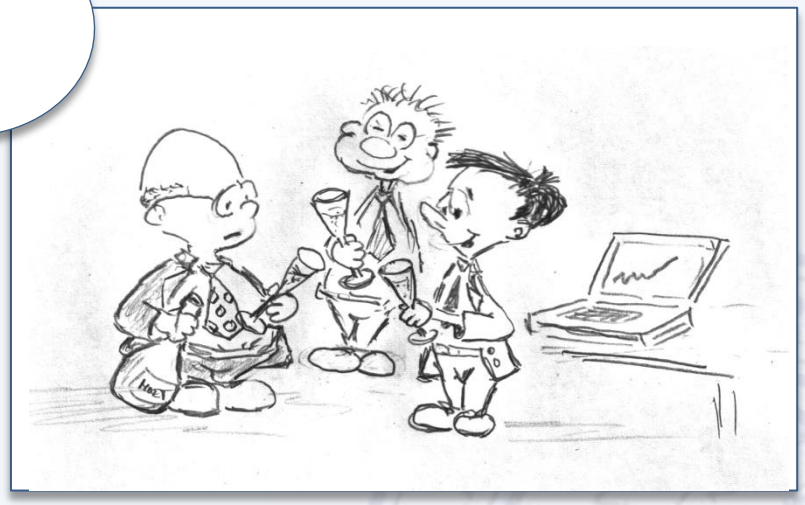




Scientists communication 2.0

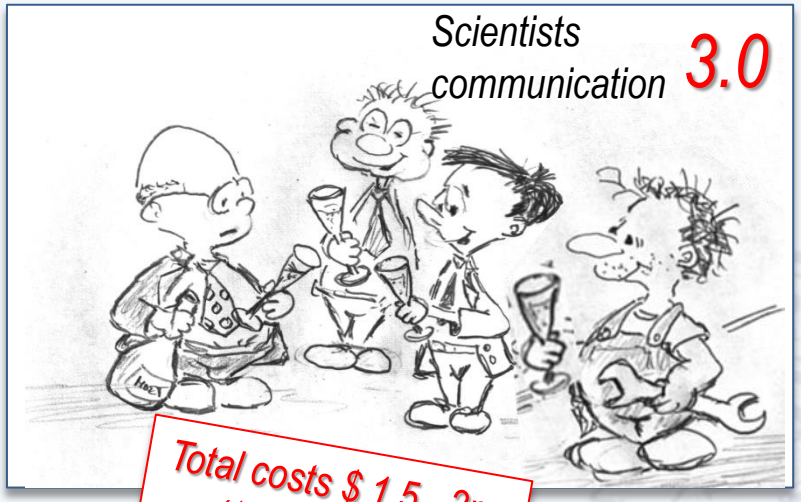


Policy makers favorite type of communication

What is needed to gap bridges? ⇨ Communication

Proposal for a Joint Research Program:

- each partner region should finance 1-2 PhD student for three years
- each PhD student shall stay 36 month at his own university and 2 x 3 months at an University of a partner region
- all students/instructors should meet once a year in order to communicate…



Total costs $ 1.5 - 2m
($ 70-100k p.a.
per partner region)

Expected outcome:

- Scientific exchange and gain of knowledge
- Lasting personal links between scientists and regions
- Sustainable ond ongoing communication
- New concepts and arguments for policy makers …

What is needed to gap bridges? ⇨ Communication