# Biomethane and Power-to-Gas: Teaming up for the energy transition

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Ramona Schröer


Foto: Fraunhofer IWES | Volker Beushausen



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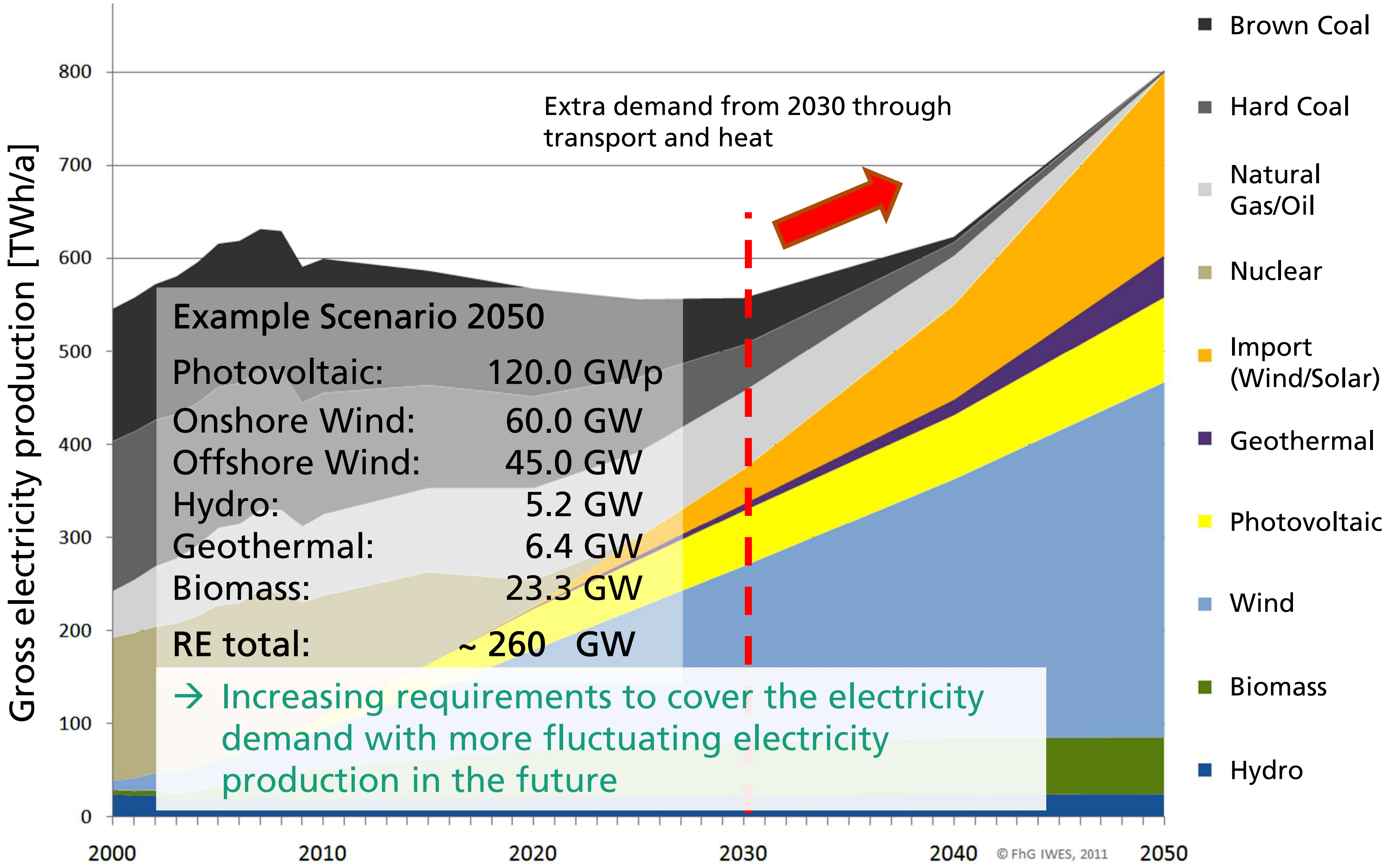
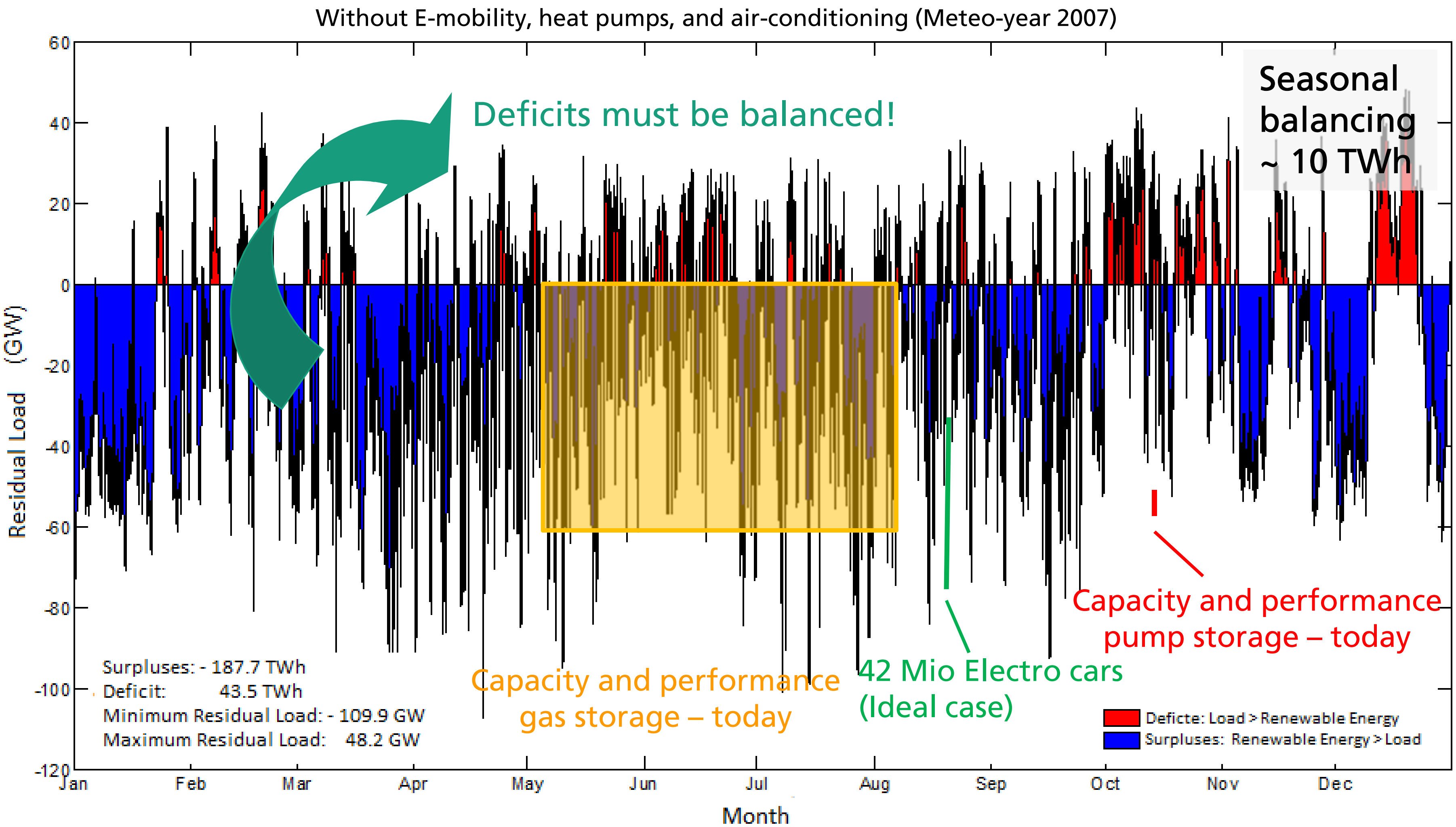
# The role of Power-to-Gas in the future energy system

# Transformation of the energy system till 2050




Source: Nitsch, Sterner et al. 2010; UBA Energy goal 100% electricity from RE

# 100% Renewable electricity in 2050




→ Gas storage = 1500 to 3000 x the capacity of all pump storages ( $\eta_{GT,GuD}$ = 28-55%)

Source: IWES-calculation for UBA Energy goal 100% electricity from RE



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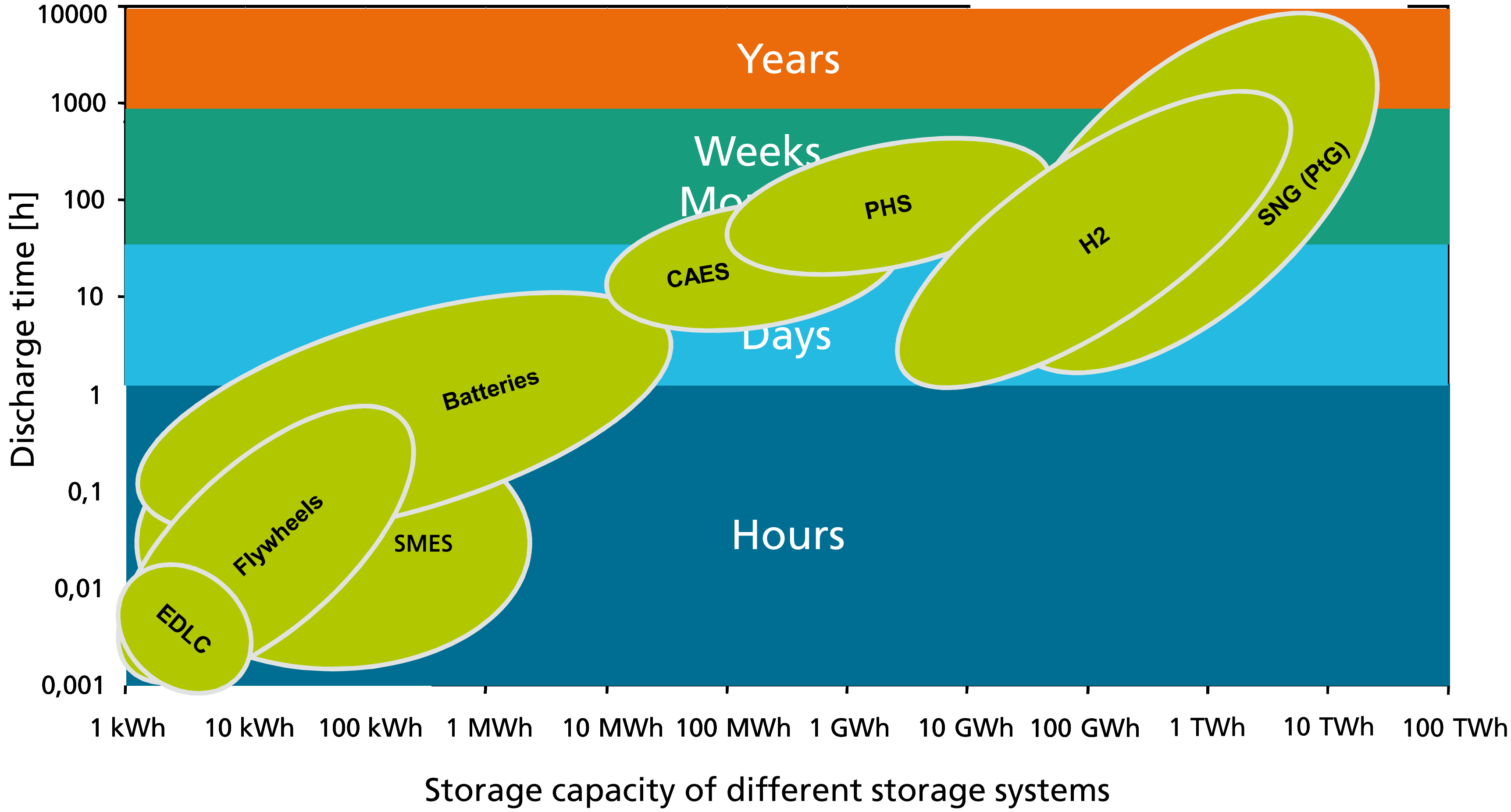
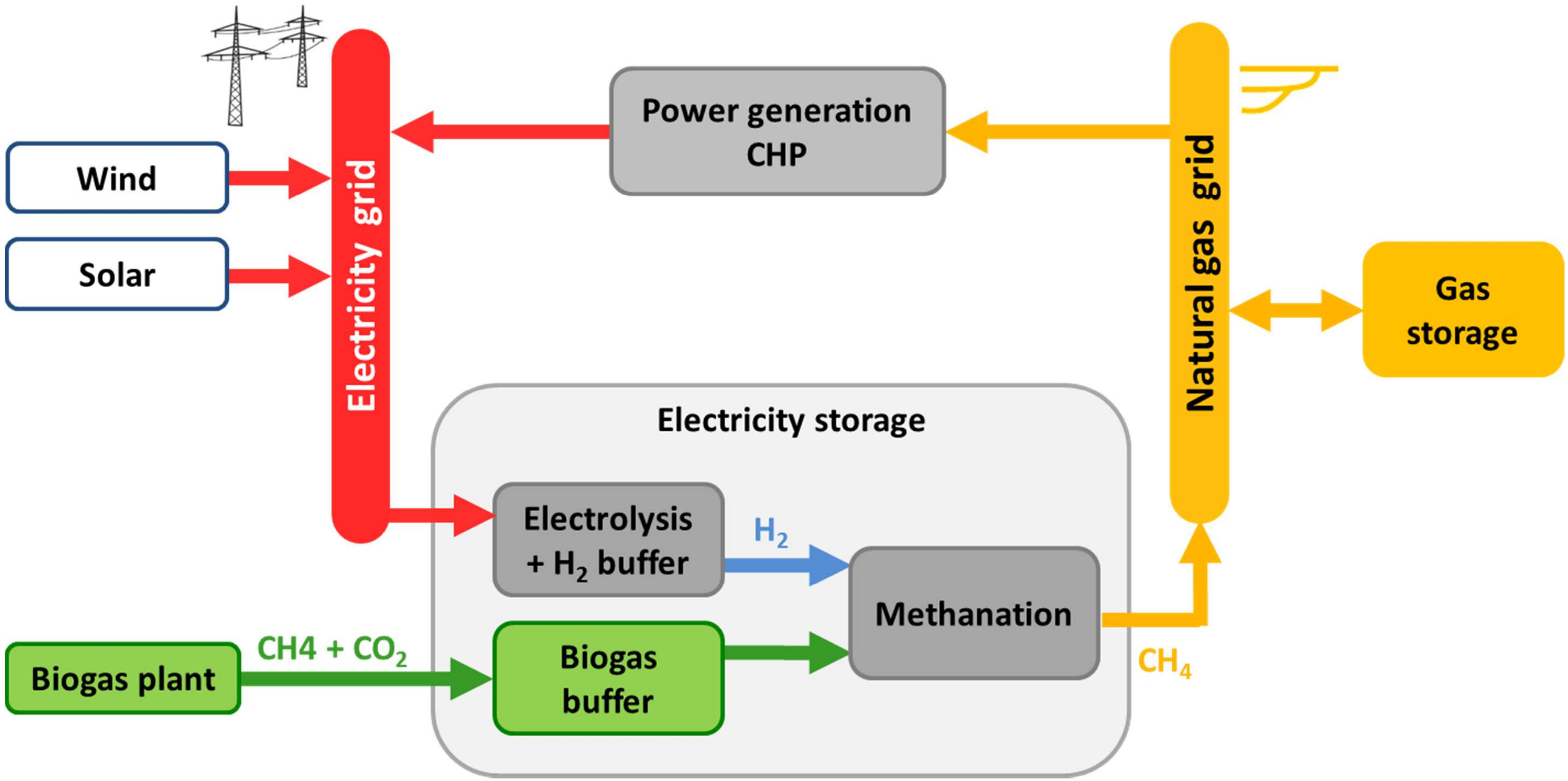
# Capacity and discharge time of different storage technologies




Source: Specht et al, 2010

# The principles of Power-to-Gas

# Power-to-Gas




Source: Specht, Sterner 2008 diversified

# Methanation must be a part of the Power-to-Gas concept

- Injection of hydrogen in natural gas grid is limited up to 5 Vol.-% (partially 2 Vol.-% e.g. filling station)

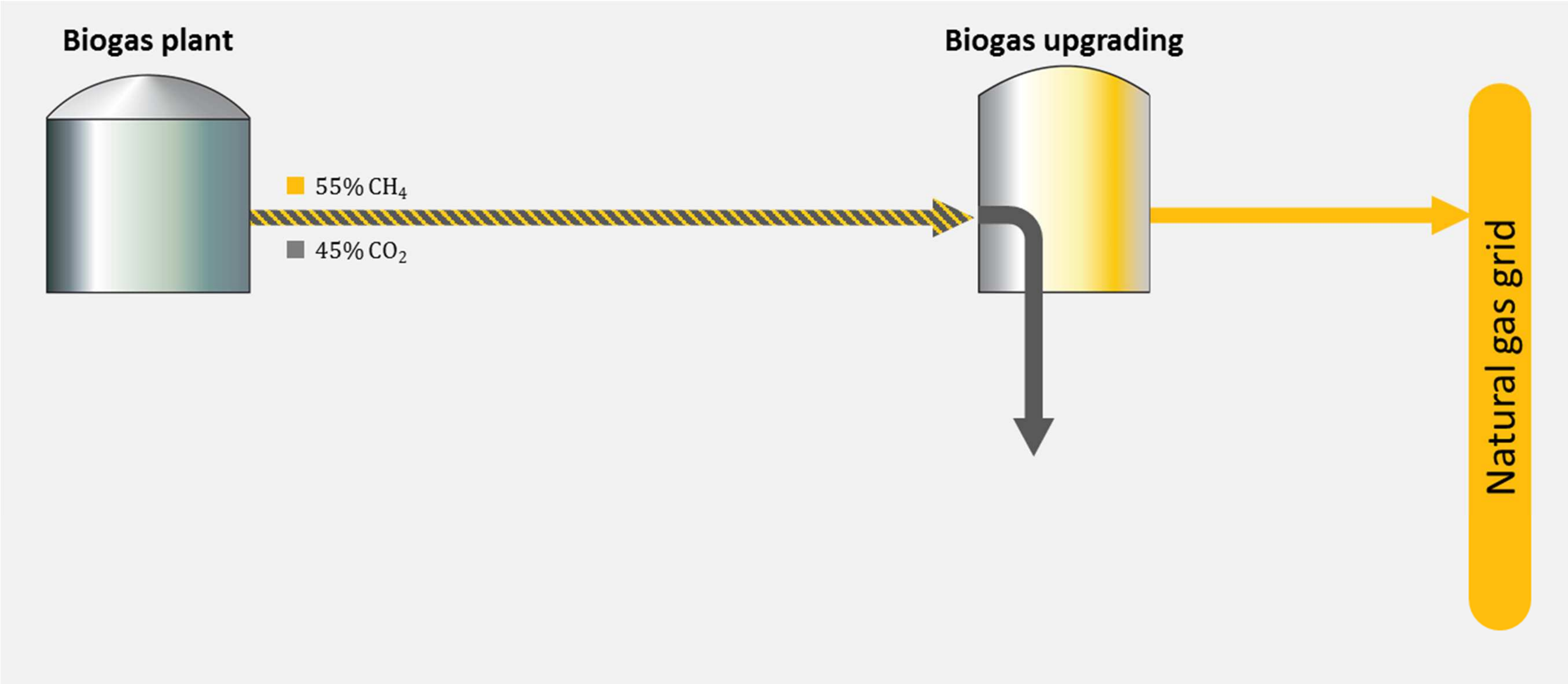
  → It's not possible to store enough energy in the form of hydrogen and to ensure the future demand of chemical energy sources as long-term storages
- Biologic and catalytic methanation to convert hydrogen into methane
- Injection of methane into the existing natural gas network or direct use
- Almost no limit for injection of methane into the natural gas infrastructure
- Gas use for electricity, mobility, heat, or industrial usage
- $CO_2$ sources are needed for methanation
- Biogas is a suitable $CO_2$ source
- The biogas plants in Germany provide enough $CO_2$ for the production of about 60 TWh methane

  → it is possible to provide large amounts of renewable $CO_2$ by biogas

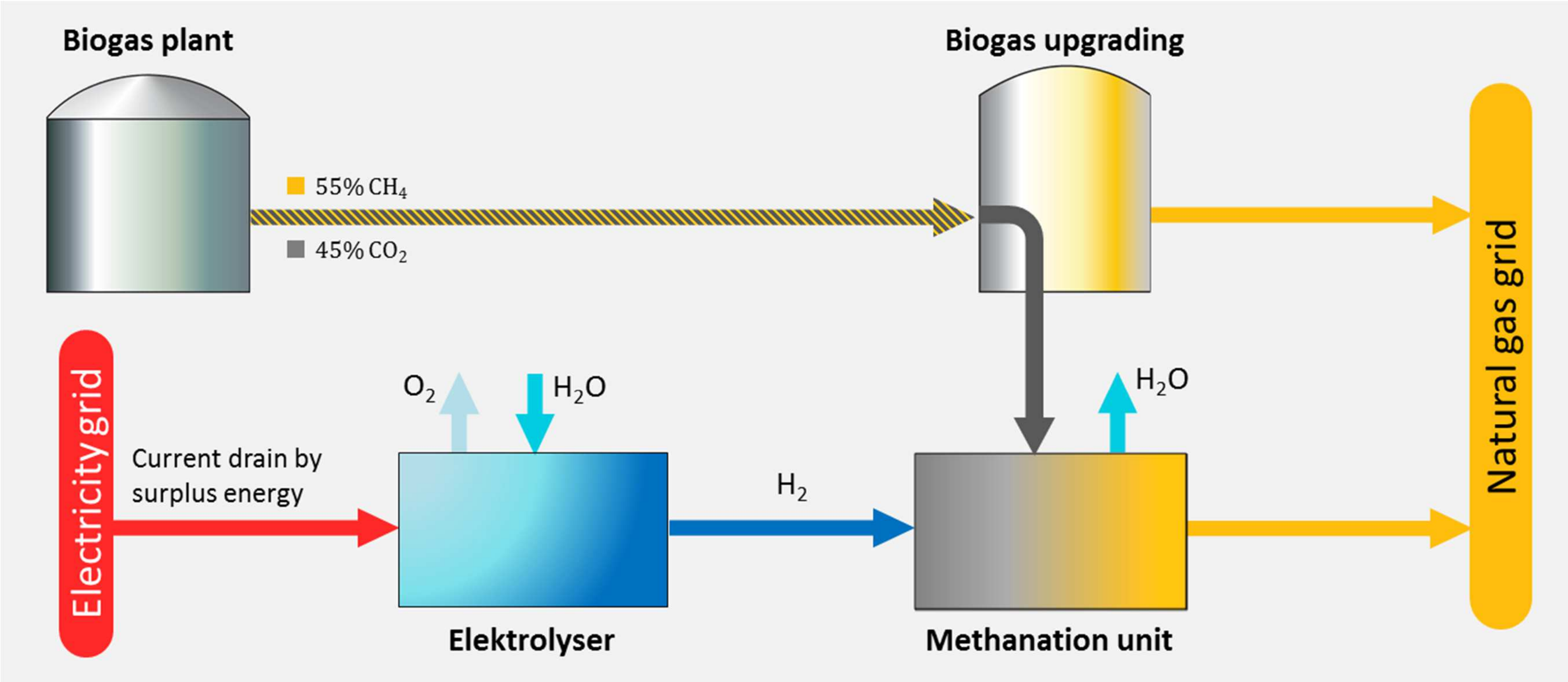
  → Biogas is essential for the future energy system and as an inexpensive $CO_2$ source for PtG

# Combination of Biogas and Power-to-Gas plants

# Biogas upgrading process and injection into natural gas grid



# $CO_2$ from biogas upgrading process reacts with hydrogen to methane




- Surplus electricity can be used instead of wasting
- Unused $CO_2$ becomes energy source
- Energy carrier can be stored over long time within existing infrastructure



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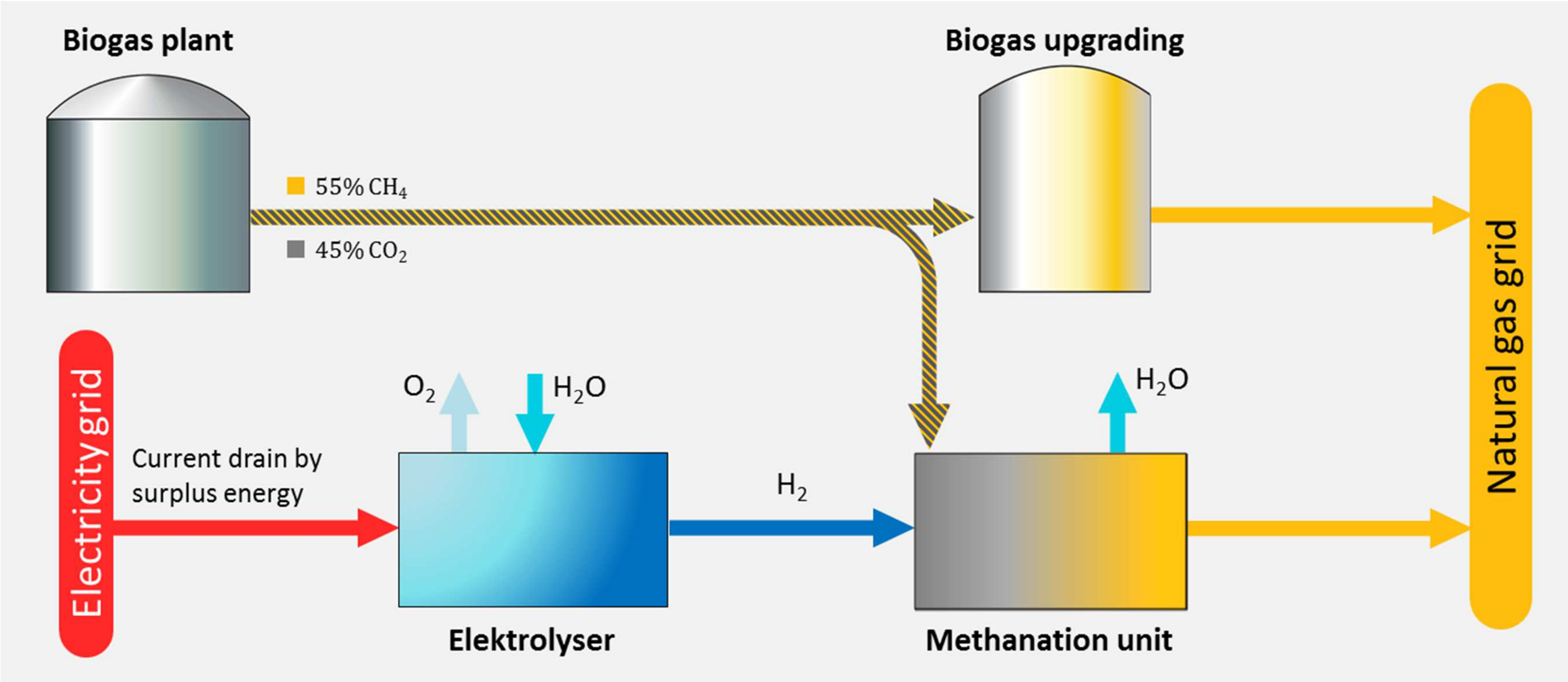
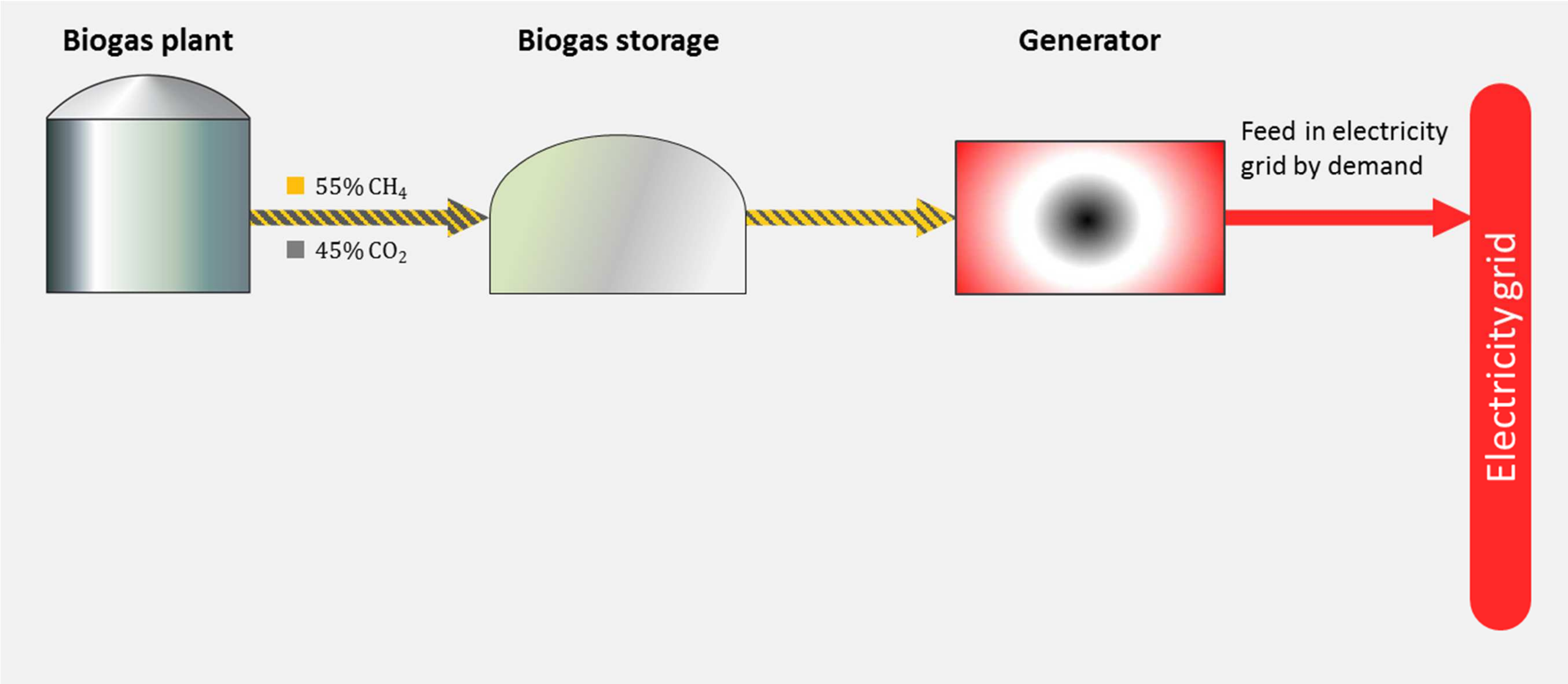
# New biogas upgrading process by direct methanation of the biogas with hydrogen to methane

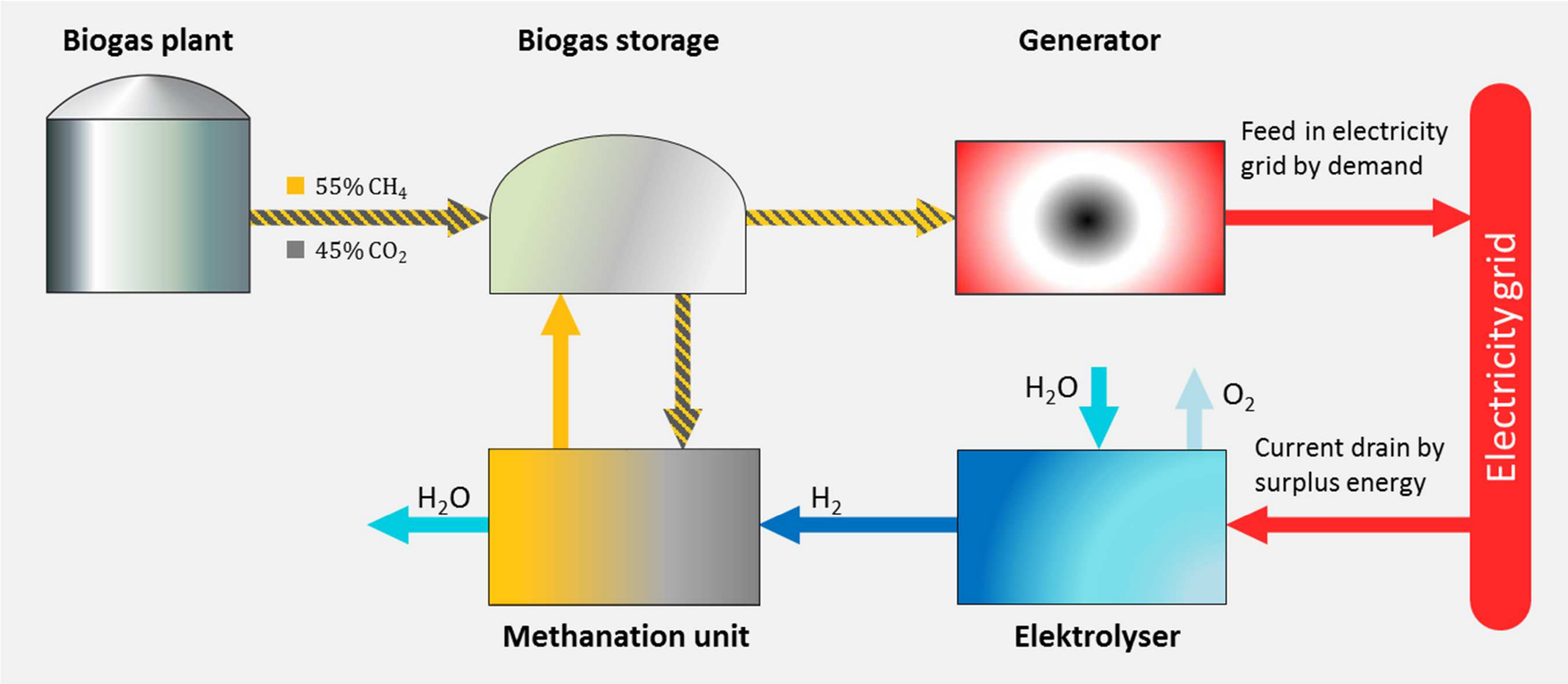



- Bypassing the upgrading process is possible
- Power-to-Gas plant can replace the conventional upgrading process

# Conventional biogas plant with electicity production

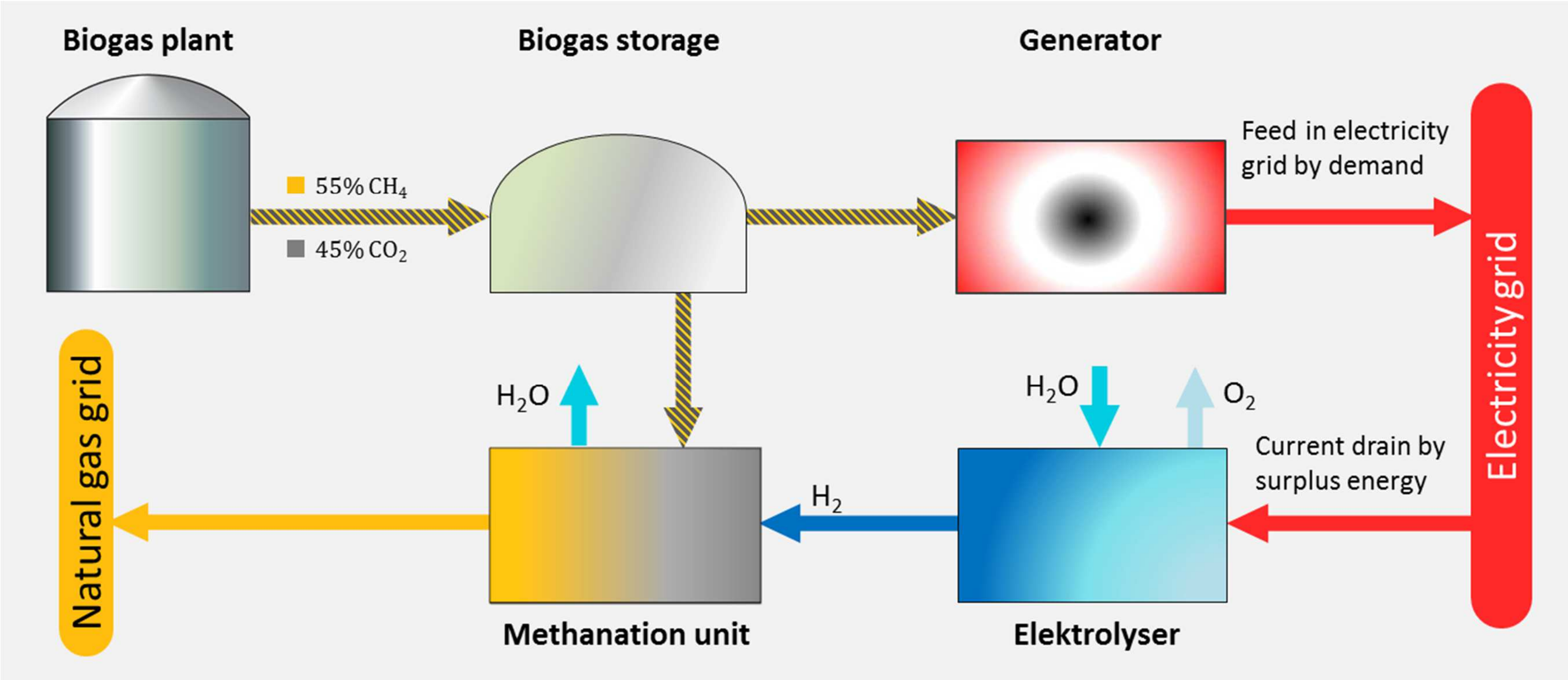


# Direct methanation of biogas, storage of the methane and electricity production




- PtG increases the methane concentration in biogas
- Storage of the methane at site
- Biogas plants are developed to energy storages

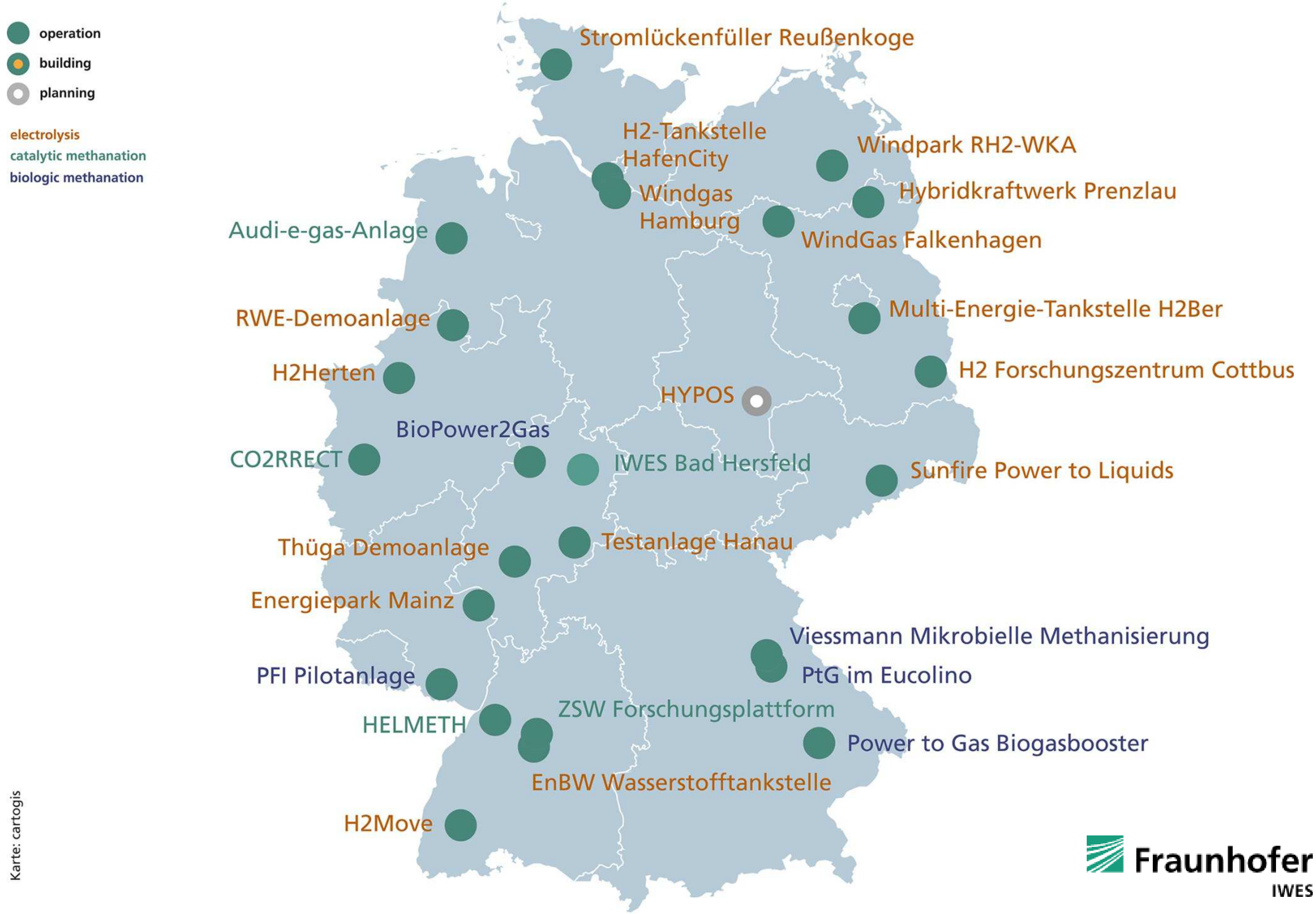
# Direct methanation of biogas, injection of the methane into natural gas grid




- Construction of gas grid connection possible for large biogas plants

# Demonstration and research projects

# Power-to-Gas plants in Germany (excerpt)

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# International projects (examples)

## Denmark / Electrochaea

- Pre-commercial field trial in Foulum with 50kW system with biological methanation reactor with biogas input; running time until 2013
- Commercial-scale field trial planned with 1 $MW_{el}$ plant in Copenhagen to demonstrate process at commercial scale using optimized reactor, 2014-2016

## Switzerland:

- First pilot and demonstration plant with 25 kW in Rapperswil, operation since 2015
- PostBus Project in Brugg with 5 FC busses; hydrogen filling station with alcaline electrolyser with 300 kW

## Horizon 2020: STORE&GO (2016-2020):

- 1 MW catalytic methanation plant in Falkenhagen, Germany
- 700 kW biologic methanation plant in Soluthurn, Switzerland
- 200 kW catalytic methanation plant in Puglia, Italy

Sources: Haferbrandl/Electrochaea 2015, Frank/EET 2016

# IWES technology R&D Roadmap for Power-to-Gas

- IWES focuses on direct methanation of biogas
  - Concept has been demonstrated in a first attempt
  - Technological development of an innovative methanation reactor
  - Laboratory scale testing of the new dynamic reactor
- The following steps are necessary for testing and further development of the technology
  - Scaling of the system from laboratory in a pilot plant system with 50 $kW_{el}$
  - Integration at a biogas plant and use of real biogas

Systematic, step by step development and scaling from lab to demonstration

# IWES 50 kW pilot plant

- Scaling from laboratory to a technically relevant scale
  → Investigation of the innovative reactor concept
- PtG plant consists of
  - PEM electrolysis (commercial electrolyser), capacity 50 $kW_{el}$
  - Methanation of hydrogen in a innovative reactor by means of the direct methanation of biogas $CO_2$
  - components and interfaces within the system such as gas supply, measurement and control technology, and the coupling with the electrolysis.
- Integration into the experimental biogas plant of IWES
  → Investigation of the combined operation of the biogas plant and PtG plant
- Development of plant-specific details and investigation of operation
- Investigation of the coupling behavior of electrolysis and methanation
- Proof of the dynamic operation mode of the PtG plant

# Opportunities and challenges

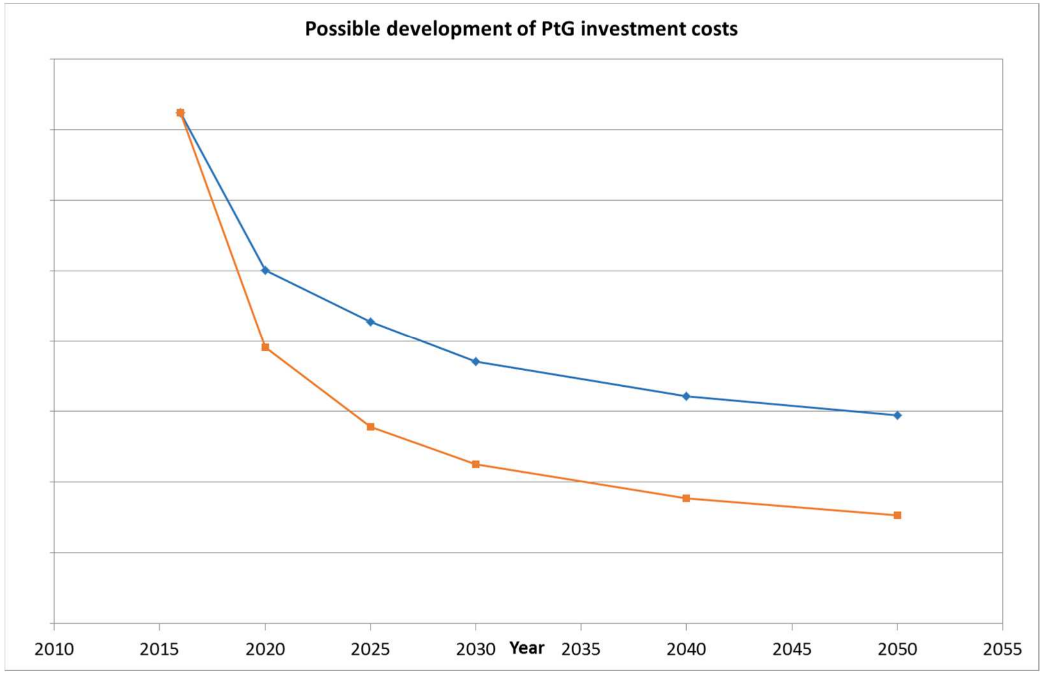
# Advantages of PtG for the entire power supply system

- Increase the flexibility of the energy system
- Use of existing infrastructure
- Potential for temporal and spatial balancing
- Supports to achieve high climate change policy targets
- Key role as long-term storage within the future energy system

# Challenges for PtG
## Currently, there is no business model for PtG plants

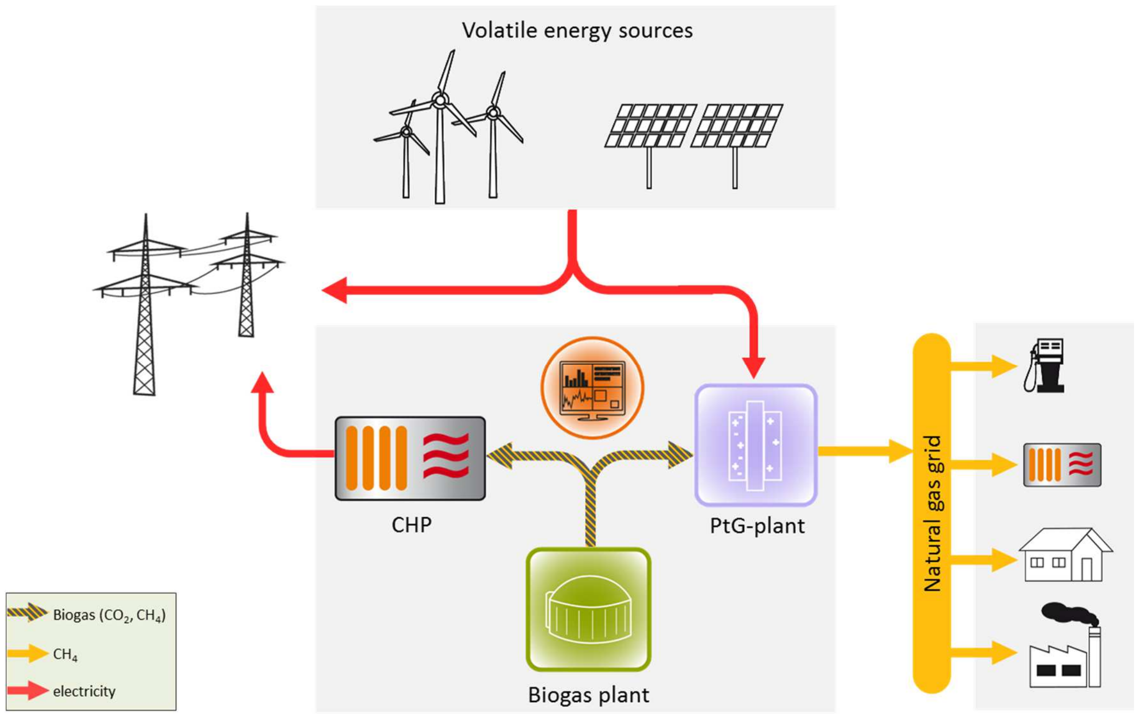
Reasons

- High investment costs
- Low full-load hours
- Electricity purchase



# Challenges for PtG
## Business model development

- Optimization of the electricity procurement
- Network load management and system service
- Combined operation of PtG and biogas plants



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# Summary

- PtG necessary as long-term storage
- High storage capacity of natural gas grid
- Methanation must be a part of the PtG concept
- Biogas plants are suitable $CO_2$ sources
- Large amounts of renewable $CO_2$ by biogas
- Direct methanation allows the use of all biogas plants
- Combination of biogas and PtG plants has advantages
- Flexibility of biogas plants in connection with Power-to-Gas possible

→ Biogas and PtG are required for the implementation of the energy transition

# Thank you for your attention!

Dr.-Ing. Ramona Schröer

*Project leader Power-to-Gas*

*Division Energy Process Engineering*

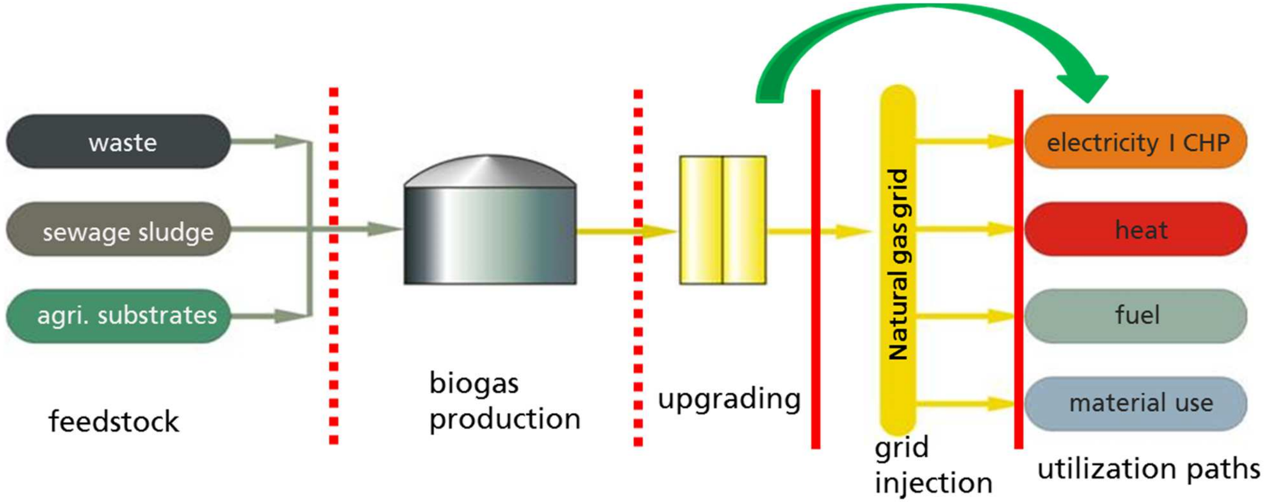
*Fraunhofer Institute for Windenergy and Energy System Technology*

Phone: +49-561-7294-1744

E-Mail: ramona.schroeer@iwes.fraunhofer.de

Hessian Biogas Research Center HBFZ, Bad Hersfeld

# eMikroBGAA – Efficient micro biogas upgrading plants

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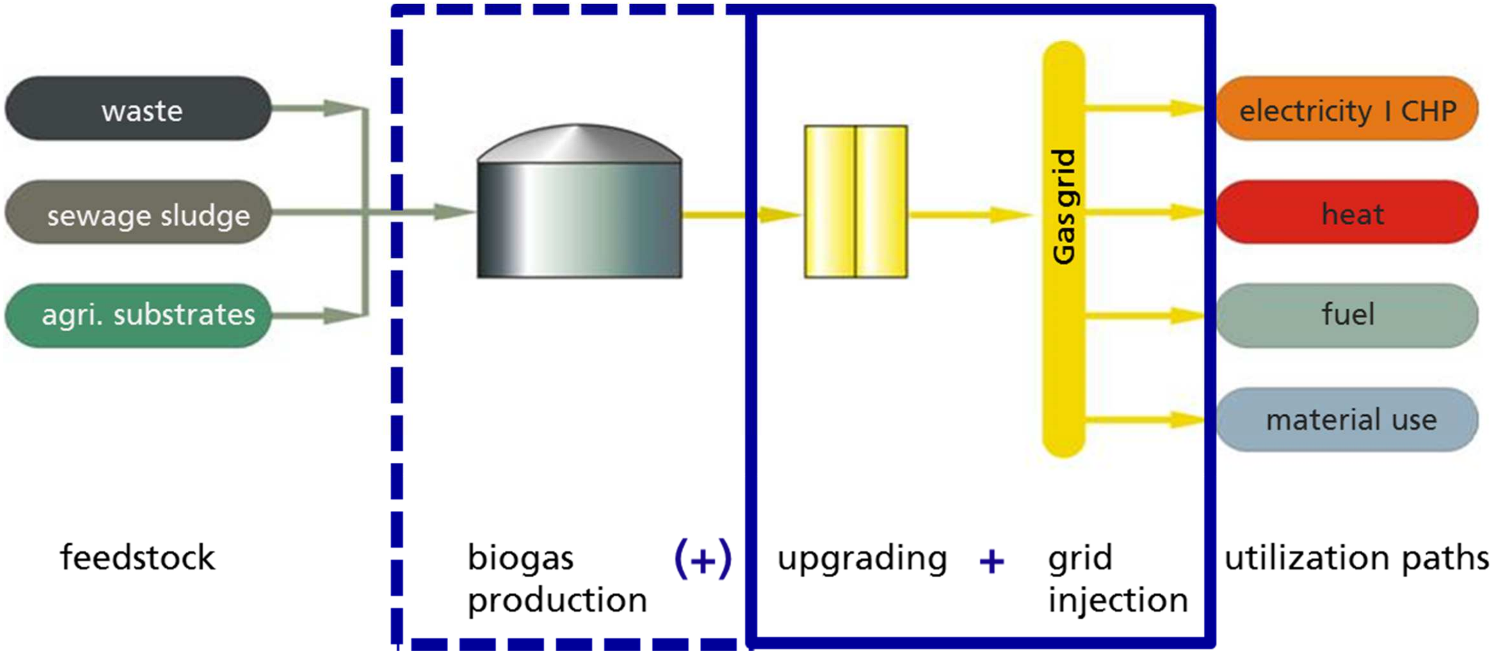
## Background

- High costs for biomethane injection in Germany: In average ca. 2-3 cents/kWh
- By now not recognized (by policy and society) because of allocation mechanism – at least not noticeably discussed
- Problem:
  - Too low (economic) incentives to reduce full costs of biomethane grid injection
  - Potentially wrong incentives due to allocation mechanism
- The German Gras Grid Access ordinance (GasNZV) has successfully decreased obstacles for grid injection but caused in parallel (unwanted) increased costs for grid injection.

# Project system boundaries: costs

→ Evaluation of full cost optimized variations: upgrading - grid inj. - grid

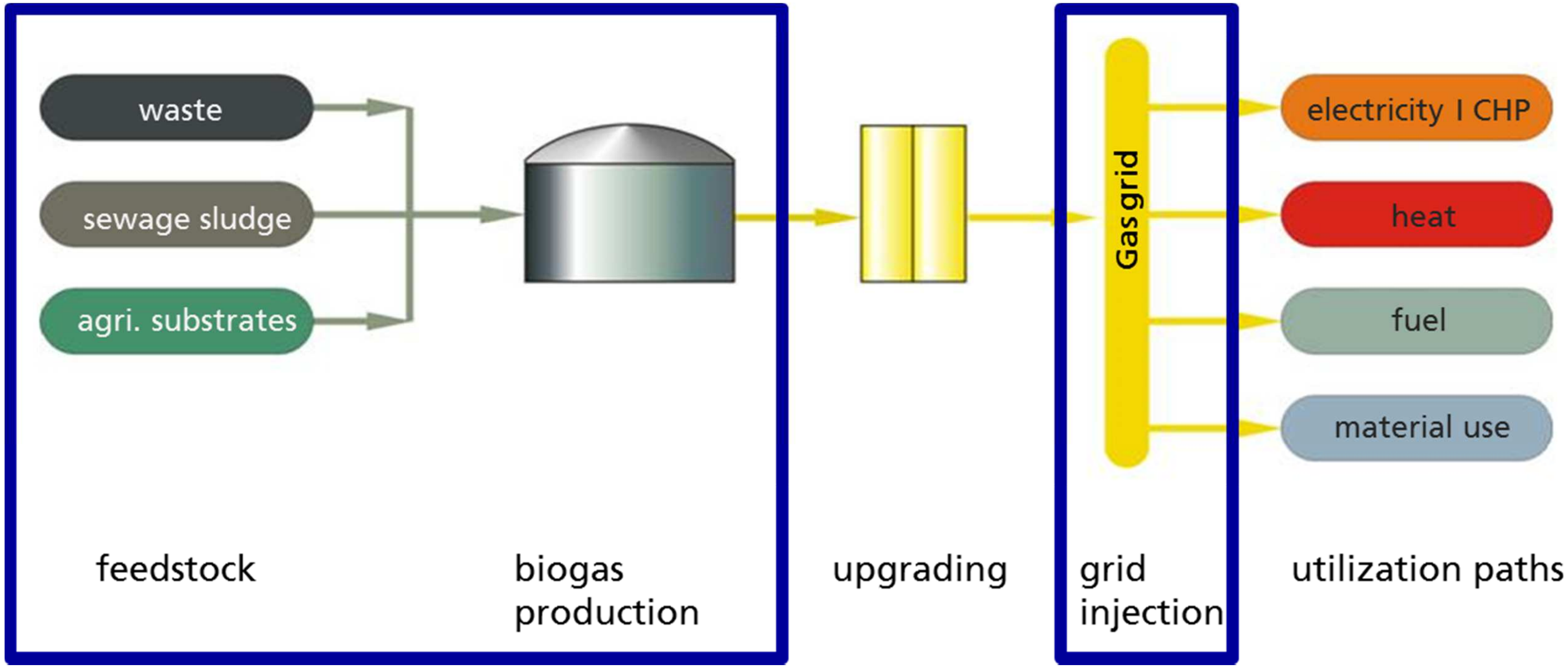



**Objective 1:**

Under which framework conditions will upgrading and grid-injection of comparatively small biogas amounts - especially by repowering of already existing biogas plants using CHP with low heat utilization factors - from an economic perspective (regarding full costs of upgrading and grid-injection) make sense?

# Project system boundaries: costs

→ Evaluation of biogas- und natural gas grid potentials for identified full cost optimized injection variations




**Objective 2:**

What will be the potential of sites with this constellation in Germany?