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MuSeK

Model-Based Analysis to Evaluate the Contribution of the Gas Supply System for the Integration of Fluctuating Renewable Electricity Generation

16th IAEE European Conference
Ljubljana, 26 August 2019

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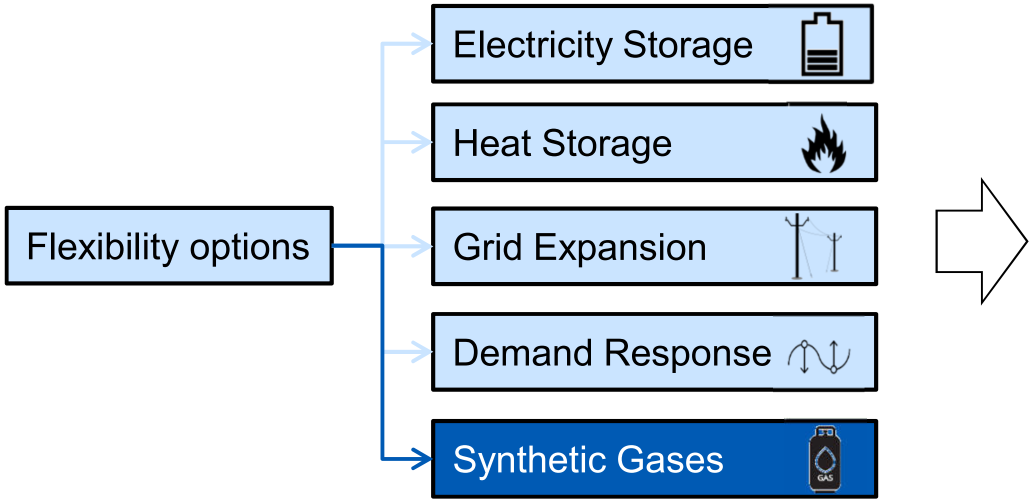
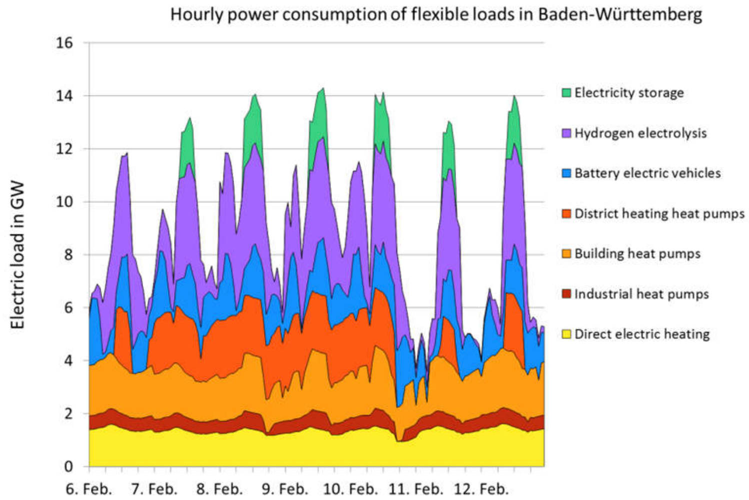
Energy Systems Analysis

DLR

Research topic

- Investigating the flexibility potential of the gas system in comparison with other flexibility options in a future energy system with a high share of RE
- Research project **MuSeKo**: Multi Sector Coupling
  - Examination of flexibility in the production and storage of synthetic gases
  - Interaction with other flexibility options
  - Identification of the least-cost dimensioning of converters and storages





Source: Schick, C. et al. (2018) Energiesystemanalyse Baden-Württemberg. Project report, http://www.strise.de/projekte/

REMix OptiMo: Energy System Model

Input: techno-economic parameters, potentials, scenario data

↓

Model: REMix-OptiMo: Energy System Optimization Model

determining the least-cost composition and hourly operation of the power system

Minimize $C_{system} = \sum c_j x_j$

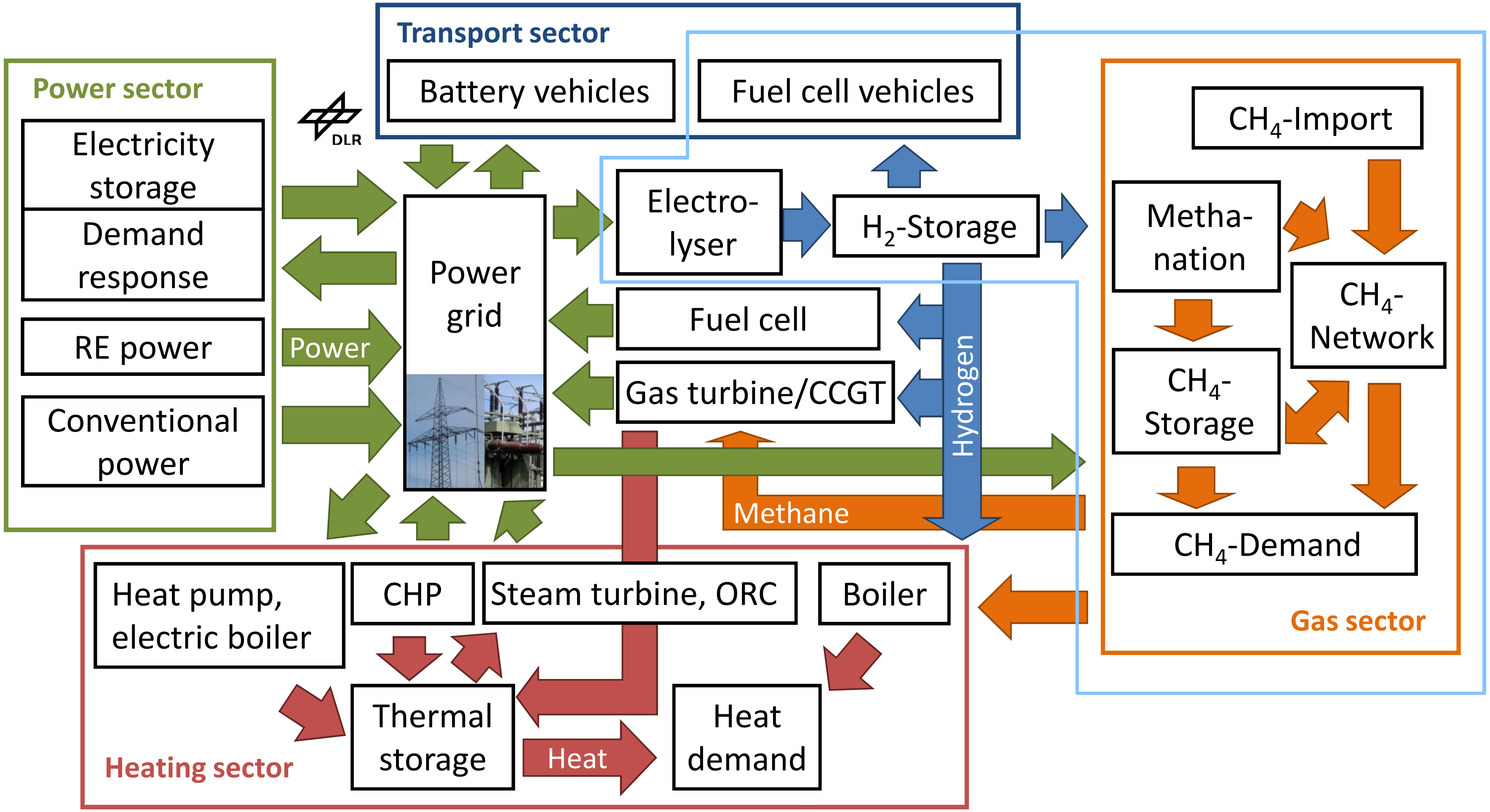
↓

Output: hourly system operation, system costs, emissions, plant expansion

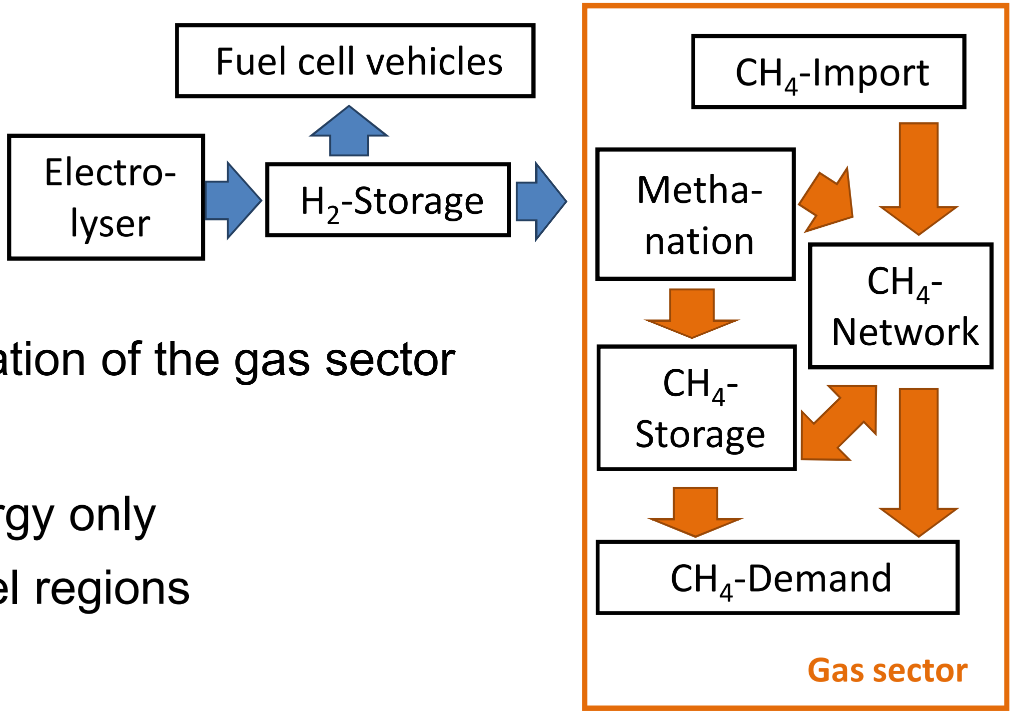
- Cost-minimizing model from an economic planner's perspective, here only LP
- Deterministic optimization realized in GAMS, solved with CPLEX
- Hourly resolution, typically perfect foresight for one year (8760 time steps)
- Simultaneous optimization of plant expansion and operation

Source: Gils, H.C, Scholz, Y., Pregger, T., Luca de Tena, D., Heide, D. (2017) Integrated modelling of variable renewable energy-based power supply in Europe. Energy, 123: 173-188. http://dx.doi.org/10.1016/j.energy.2017.01.115

Evaluation of flexible energy sector coupling with REMix

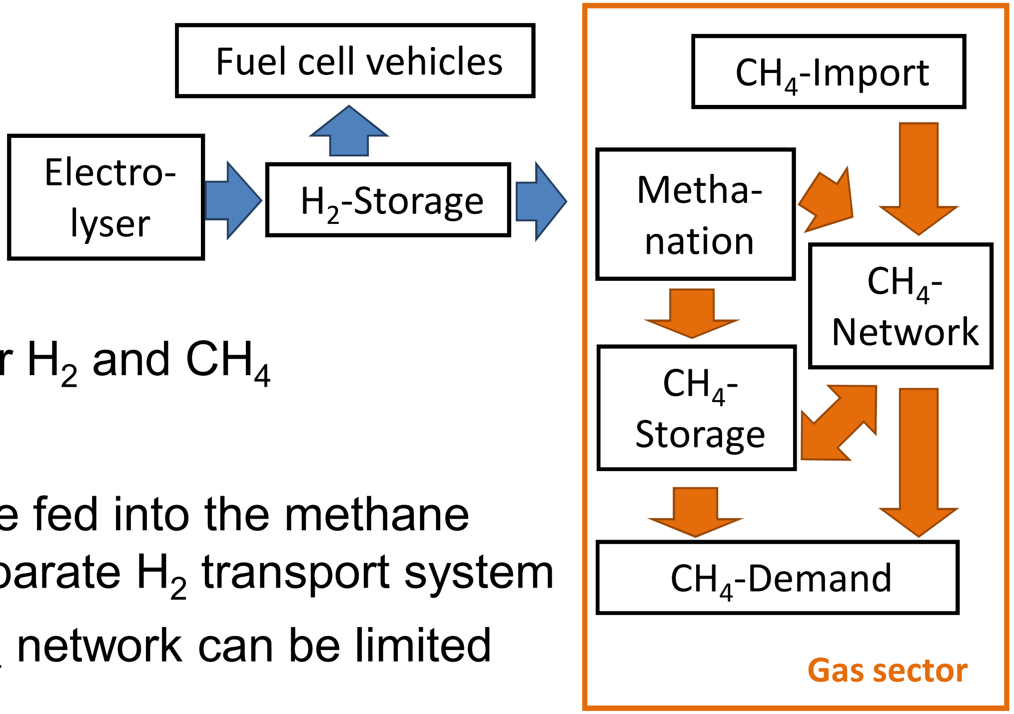


REMix enhancement for the gas sector



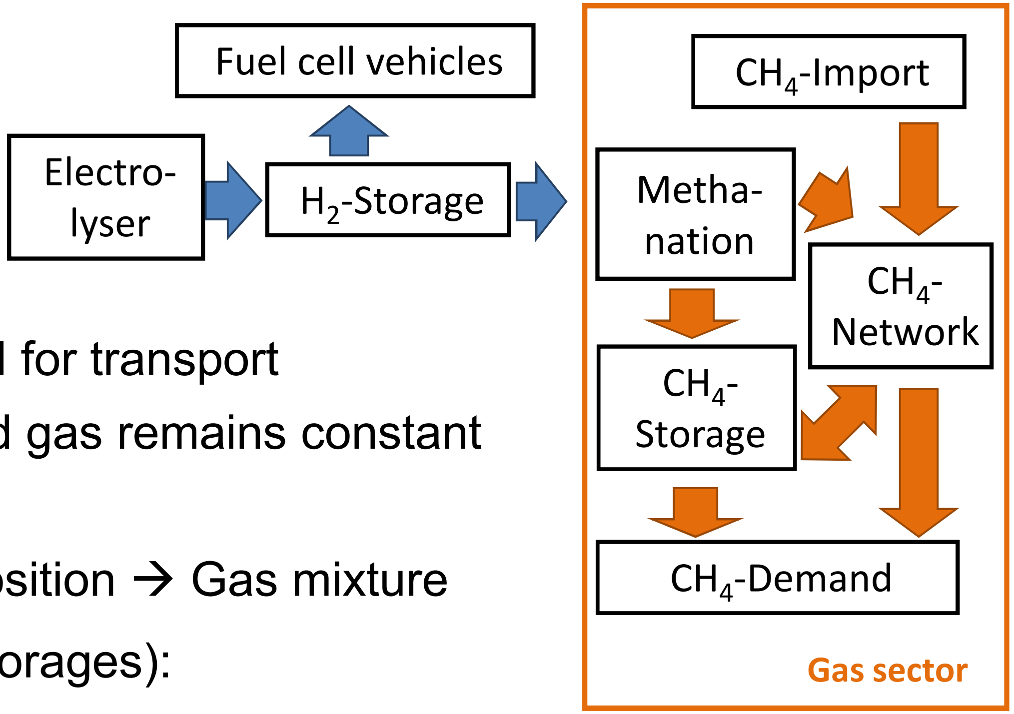
- Goal:
  - Reduced, linearized representation of the gas sector
- Limitations:
  - Consideration of chemical energy only
  - Aggregation according to model regions
- Modules:
  - Modular structure for flexible combination of technologies

REMix gas sector: demand and production



- Gas Demand:
  - Household/Industry demand for H_2 and CH_4
- Elektrolyzer:
  - Produced H_2 and biogas can be fed into the methane transport system as well as separate H_2 transport system
  - Share of H_2 that is fed into CH_4 network can be limited
- Methanation:
  - Generic module to transform input-fuel to output-fuel
  - Considering multiple efficiencies

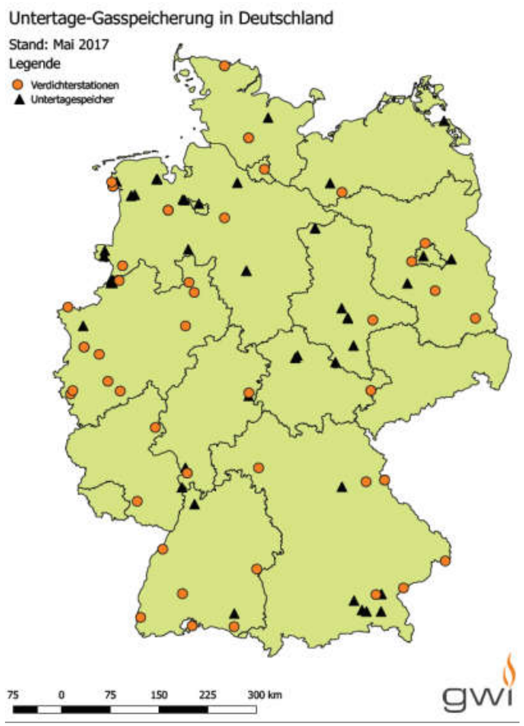
REMix gas sector: transport, storage and import

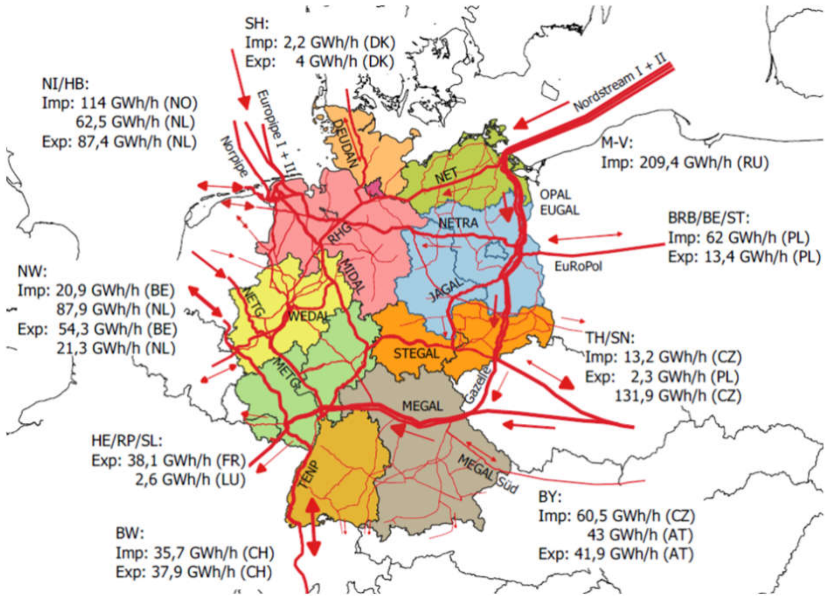


- Gas Network:
  - Compression energy is needed for transport
  - Chemical energy of transported gas remains constant
  - No transport delay
  - No consideration of gas composition → Gas mixture
- Gas Compression (pipelines and storages):
  - Gas- or electricity-powered
- Gas Import:
  - Modelling of import flows
  - Different gases can be imported

Data basis for the gas system modelling in MuSeKo

- Salt domes for CH_4 or H_2 hydrogen storage
- Data on existing assets: storage locations and capacities
- Evaluation of gas transport capacities
- Assumption of reversible flows
- Compressor capacities from literature and inquiries





REMix configuration in MuSeKo

- Regions:
  - Germany divided into states
  - Neighbouring countries
- Myopic application: 2020, 2030, 2040, 2050
  - Decommissioning at end of lifetime
  - No construction time
- Consideration of existing capacities:
  - Power/Gas network and storage
  - Wind/PV capacity w/o decommissioning
  - CHP/conventional capacity w/ decommissioning
- Capacity optimization of RE, gas power plants, CHP, electricity storage and of flexible sector coupling

→ Resulting problem size: **~100 Mio. variables**, **~50 Mio. equations**

Scenarios in MuSeKo

- Exogenously defined demand for electrical power, CH_4, H_2 and heat
- Exogenously defined fuel and CO_2-emission costs

GHG 80

- Base-scenario
- 80% CO_2-reduction

GHG 95

- 95% CO_2-reduction
- Higher CO_2-emission costs
- Increased electrical power and H_2-demand in transport and heating sectors

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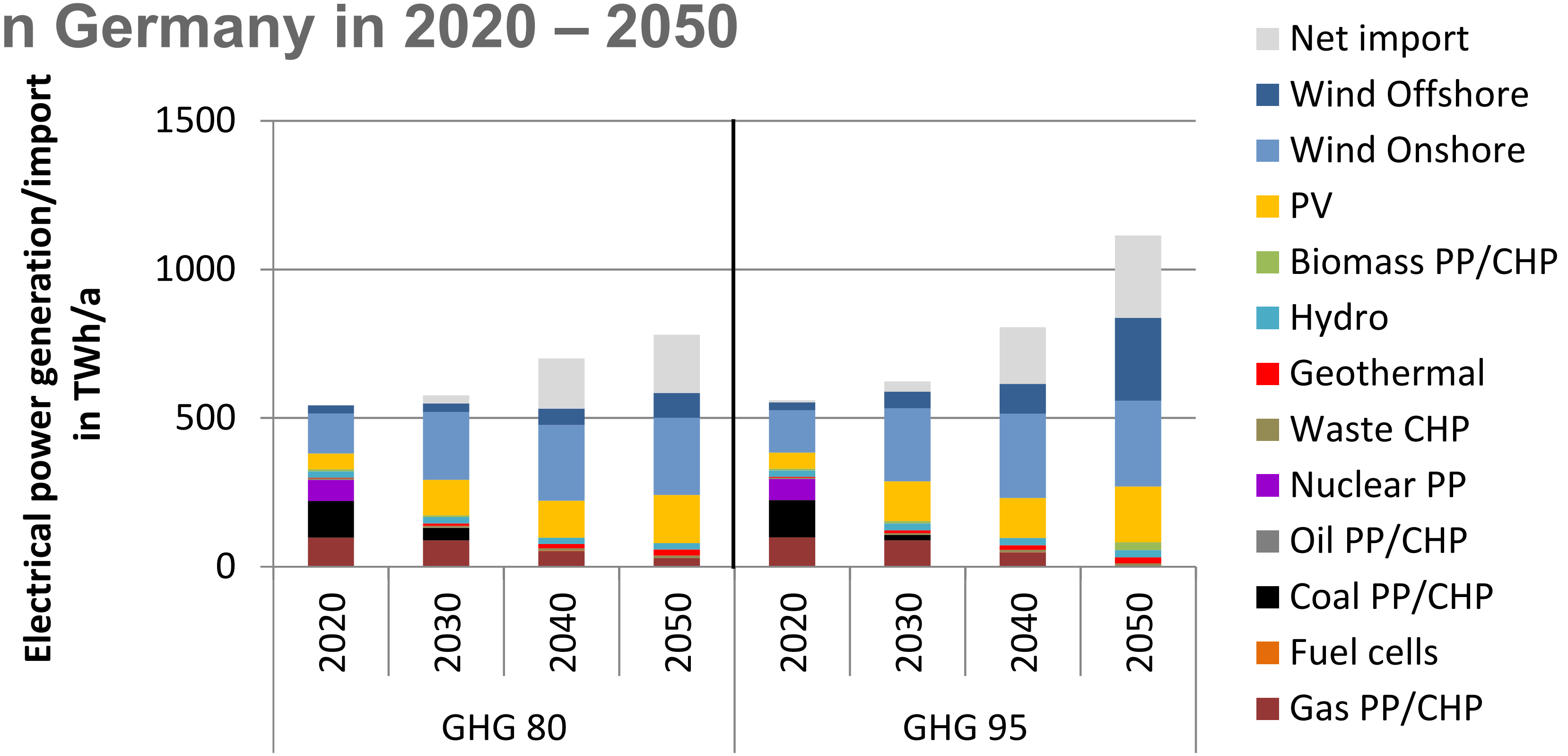
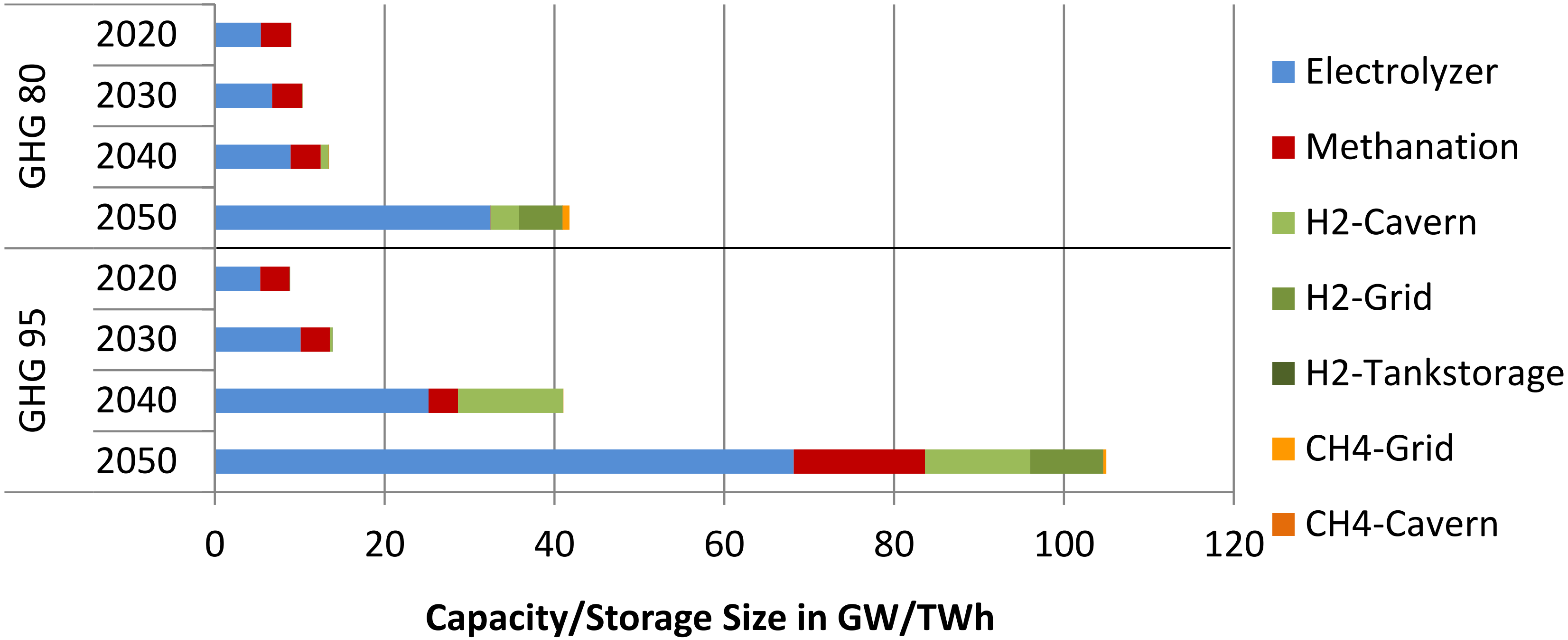
Development of electrical power supply in Germany in 2020 – 2050



- Phasing out of nuclear energy by 2022 and coal energy by 2038
- Biomass only in GHG 95-scenario considered
- No back-up capacity of gas turbines in GHG 95
- GHG 95: 30 % more generation in 2050

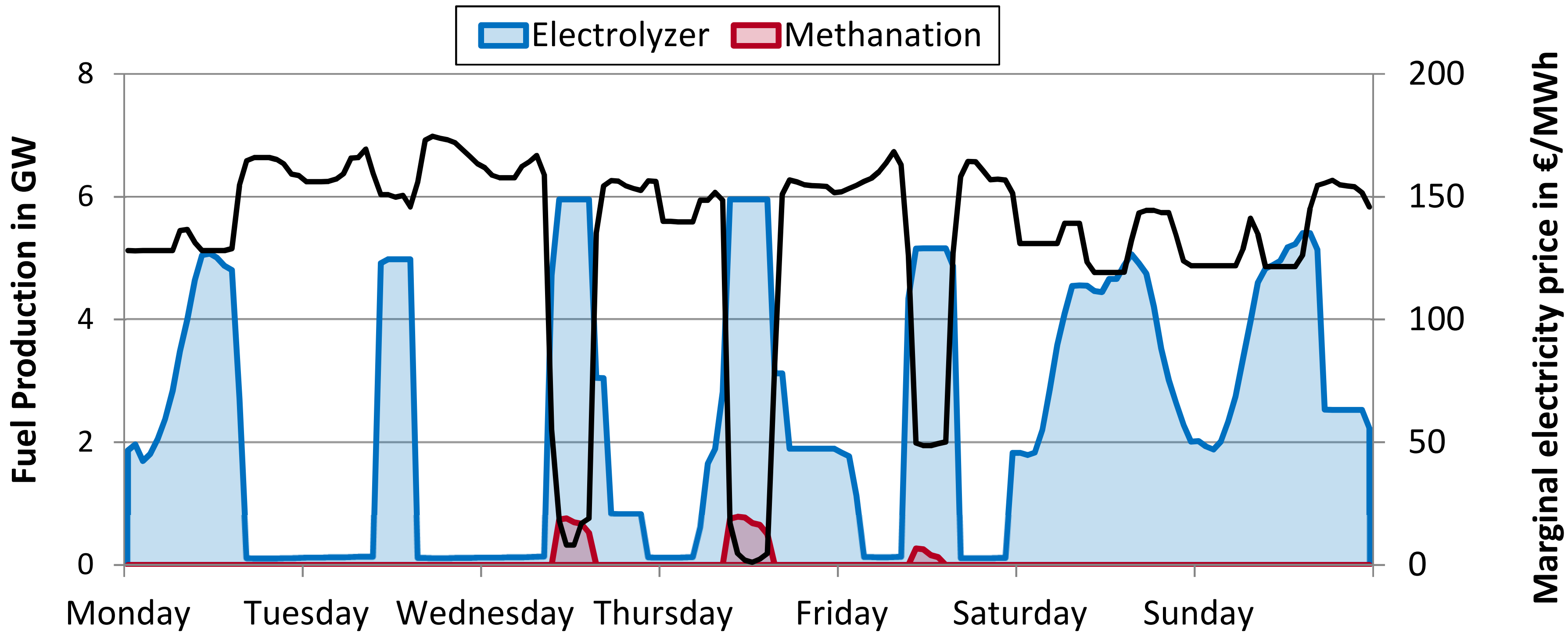
Preliminary results

Development of the gas sector in Germany



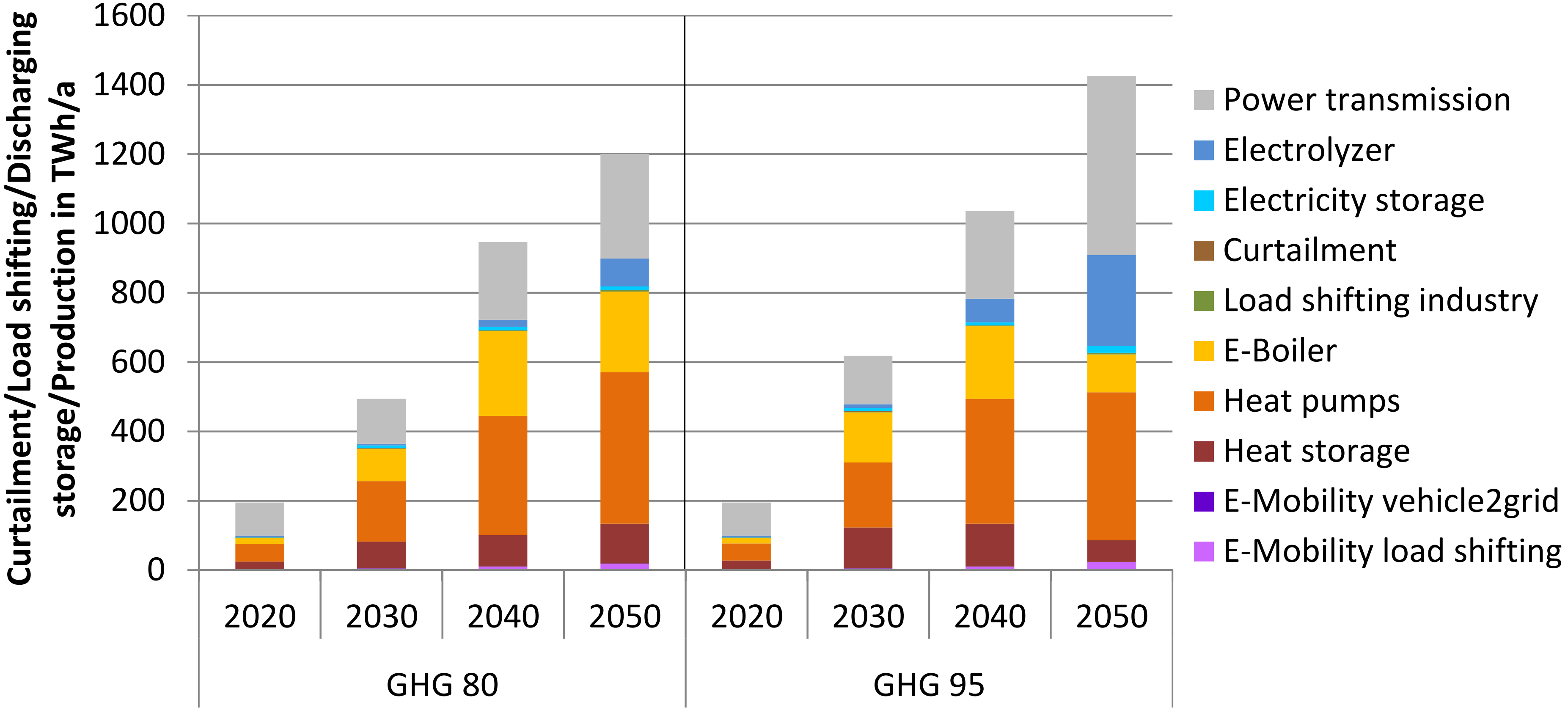
- Expansion of H_2-infrastructure
- Increase in methanation plant capacity only to fullfil CH_4-demand

Synthetic fuel production (GHG 95)



- H_2-production corresponds to electricity price and thus electricity production
- Methanation only comes into system at extremely low electricity costs

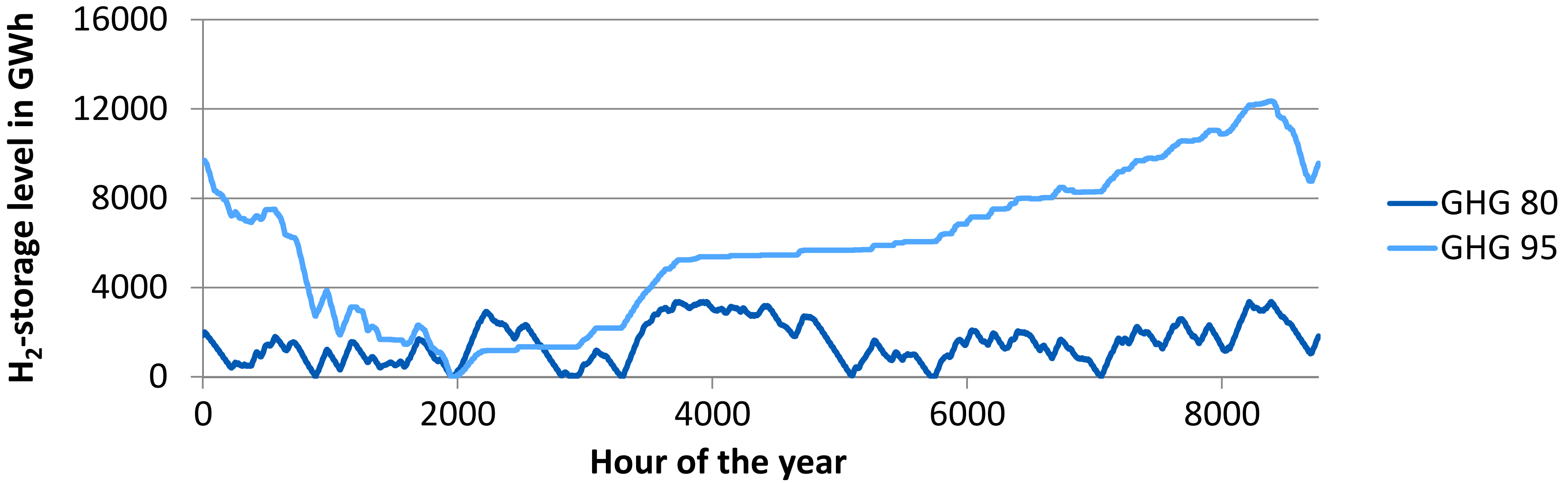
Load balancing through various flexibility options

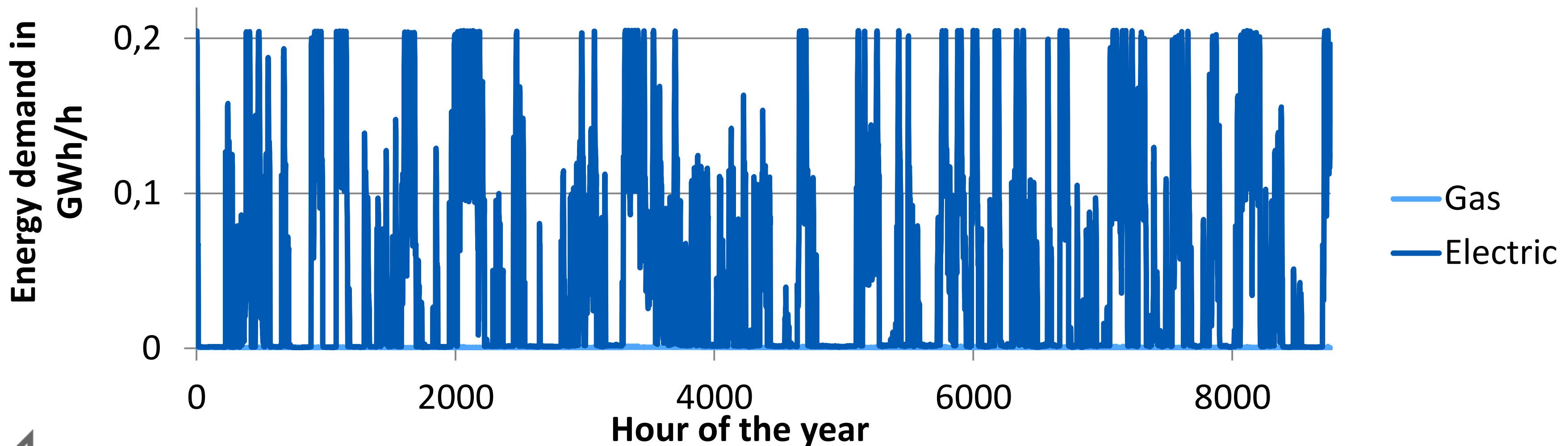


- About 30% of the battery vehicle charging demand is shifted
- Thermal energy storage buffers wind generation peaks
- Endogenous battery storage installation only outside Germany
- Power transmission is the most import balancing technology

Preliminary results

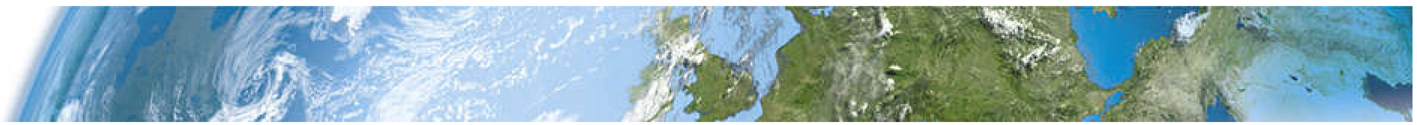
Behaviour of gas sector components



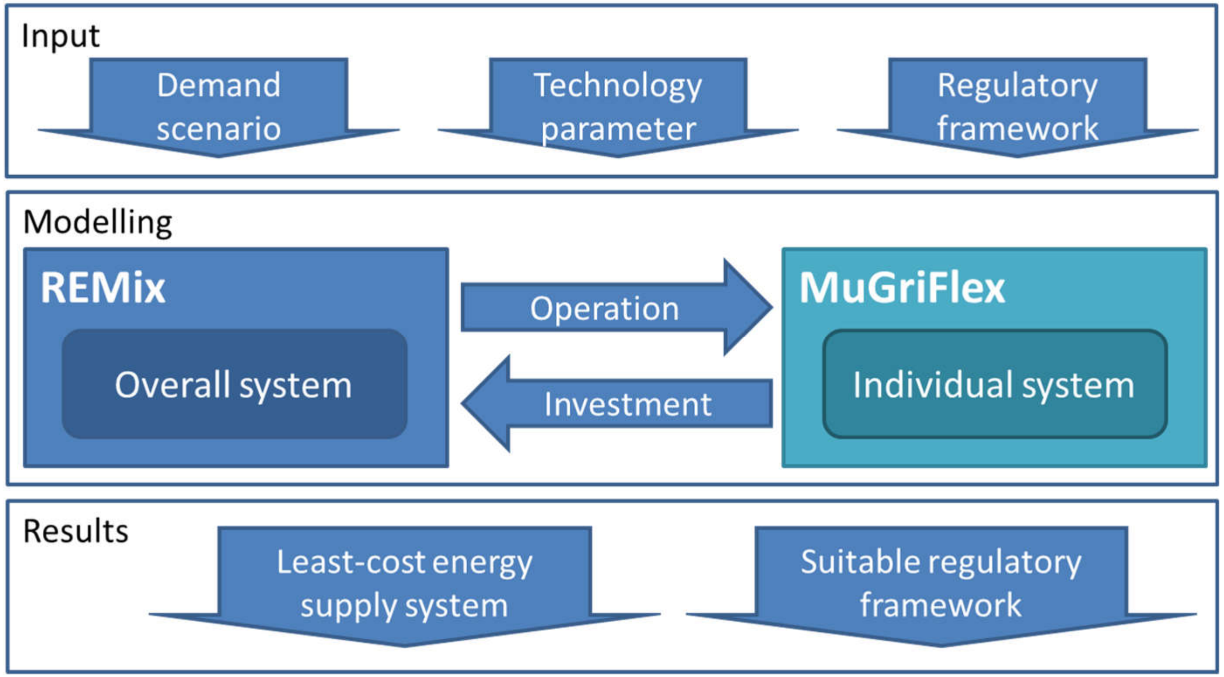


Summary

- Integrated consideration of all sector coupling options desirable
- Options of flexible sector coupling interact positively with each other
- Simplified representation of the gas sector improves analysis capabilities
- Flexible H_2-production can make a significant contribution to RE balancing
- Partial conversion of natural gas infrastructure to H_2 is an attractive option
- Methanation and seasonal storage become relevant in GHG 95 scenario



Outlook



- Comparison to business perspective
- Further analysis of interactions within the overall system
- Further scenarios and sensitivity analysis

Kontakt

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This presentation is based on results of the project “Modellbasierte Analyse der Integration erneuerbarer Stromerzeugung durch die Kopplung der Stromversorgung mit dem Wärme-, Gas- und Verkehrssektor“ (MuSeKo) funded by the German Federal Ministry of Economic Affairs and Energy (BMWi) under grant number FKZ: 03ET4038B.

Fraunhofer IFAM

Deutsches Zentrum für Luft- und Raumfahrt

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