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Model-based Analysis of the Contribution of the Gas Supply System to the Integration of Fluctuating Renewable Electricity Generation

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Energy Systems Analysis

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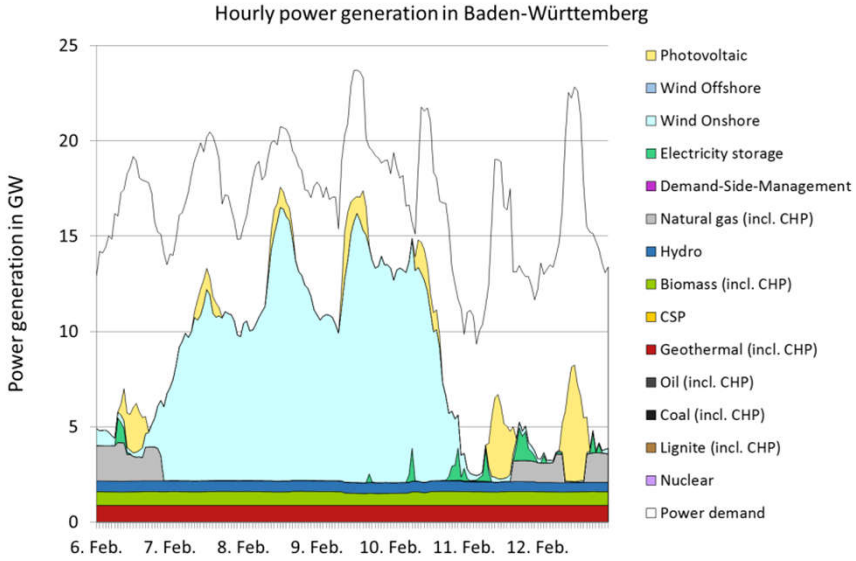
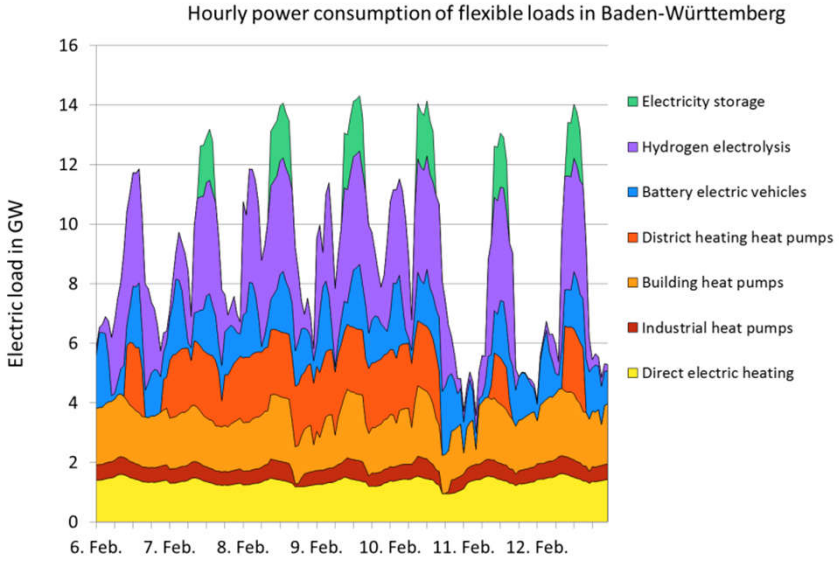
Key messages

- Integrated consideration of all sector coupling options advantageous
- Options of flexible sector coupling interact positively with each other
- Partial conversion of natural gas infrastructure to H_2 appears attractive option

Research interest

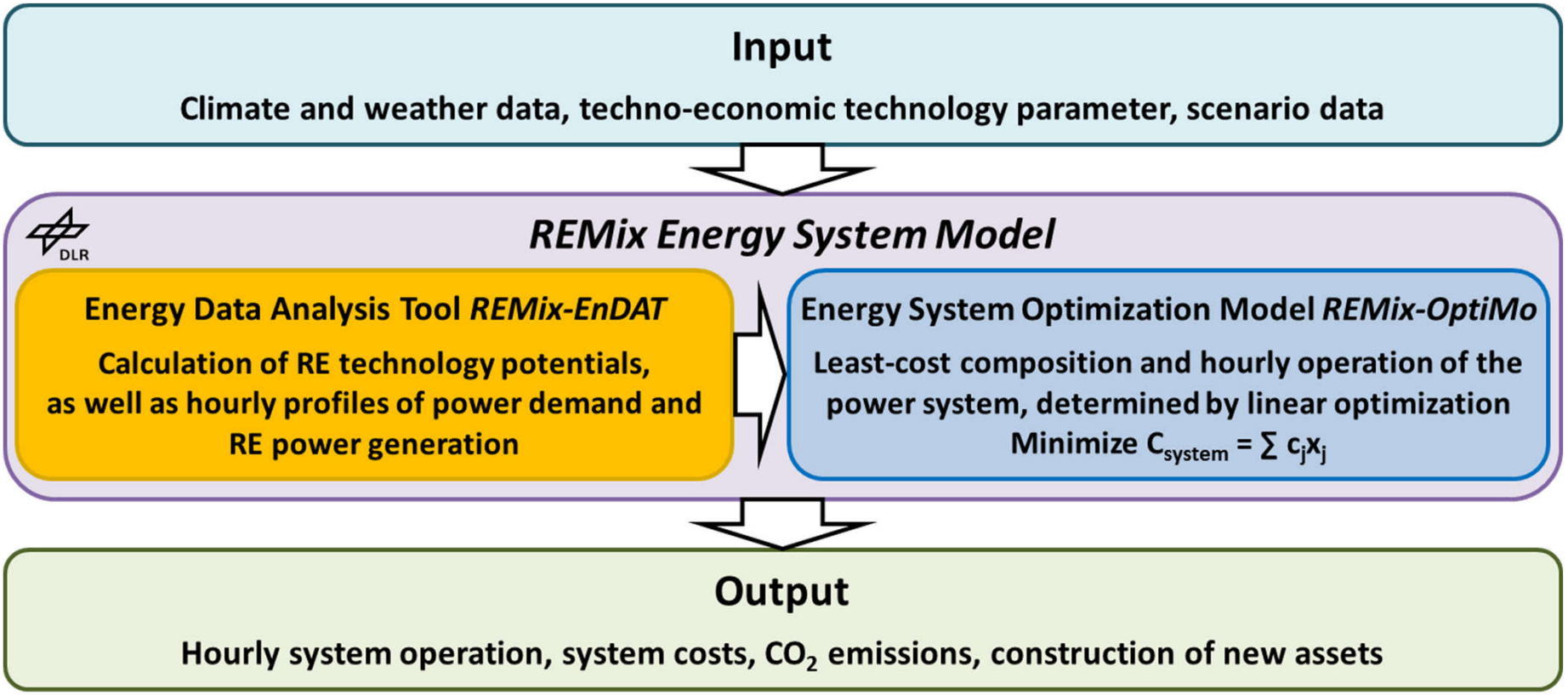
- Evaluation of flexibility in integrated and sustainable energy systems
- In MuSeKo: Contribution of synthetic gases to the system transformation
  - Importance of flexibility in the production of these gases
  - Interaction with other flexibility options
  - Identification of the least-cost dimensioning of converters and storages
  - Analysis of the flexibility of the electrical equipment in the gas network





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

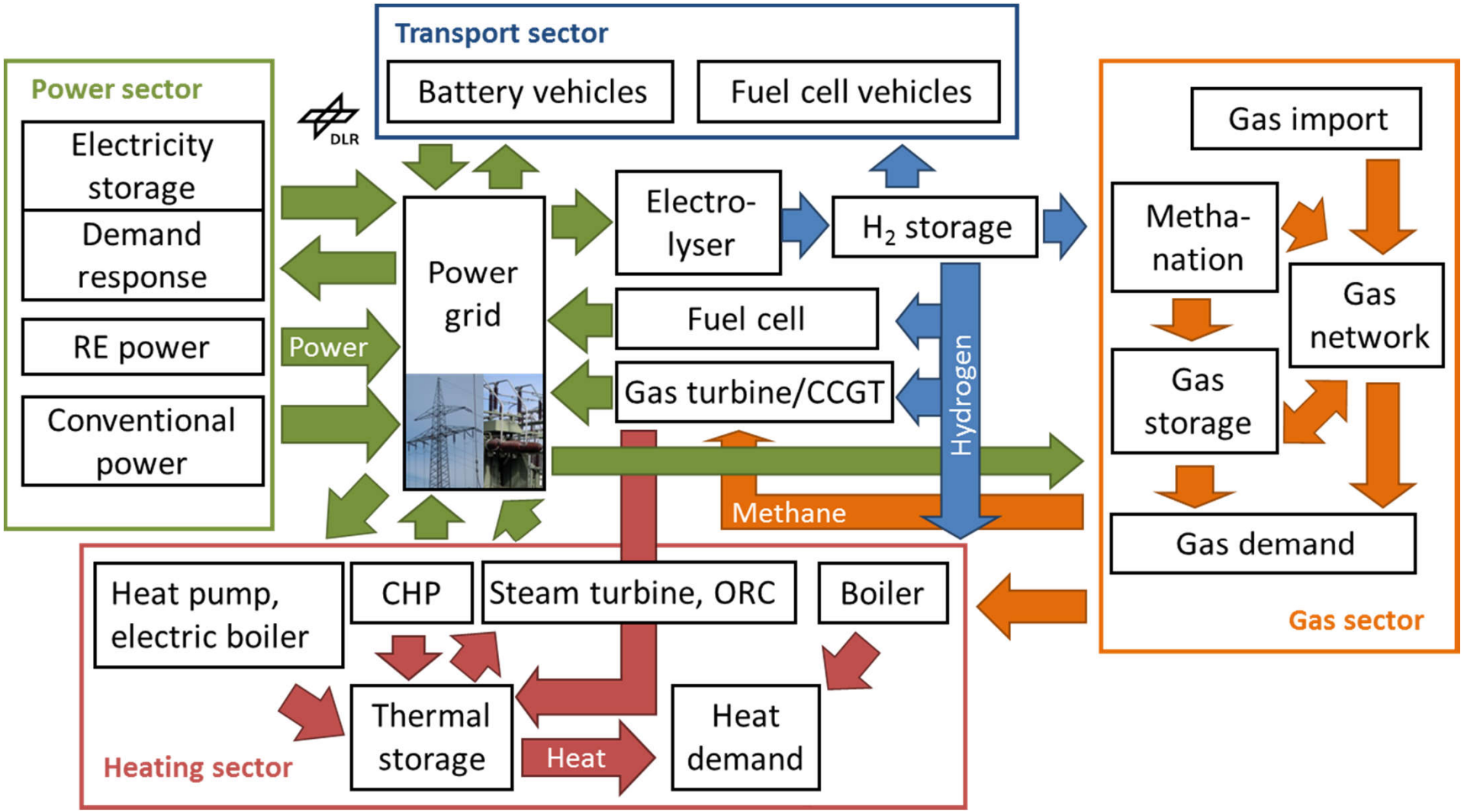
REMix energy system model



- Cost-minimizing model from an economic planner's perspective
- Deterministic linear optimization realized in GAMS
- Hourly resolution, typically perfect foresight for one year

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



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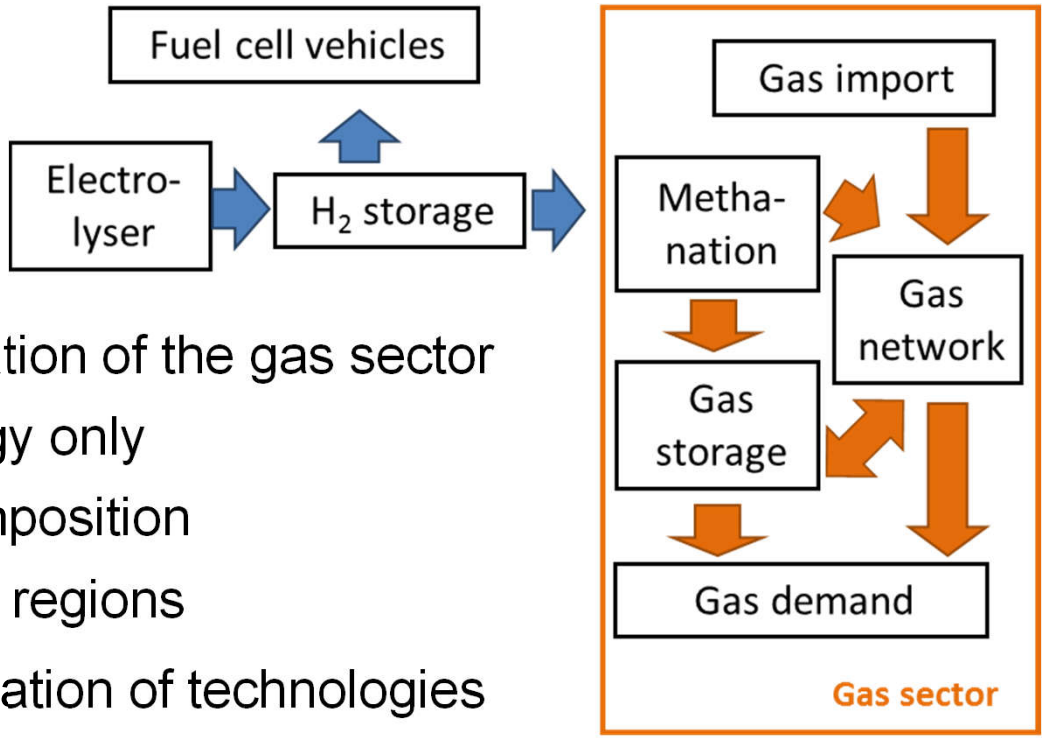
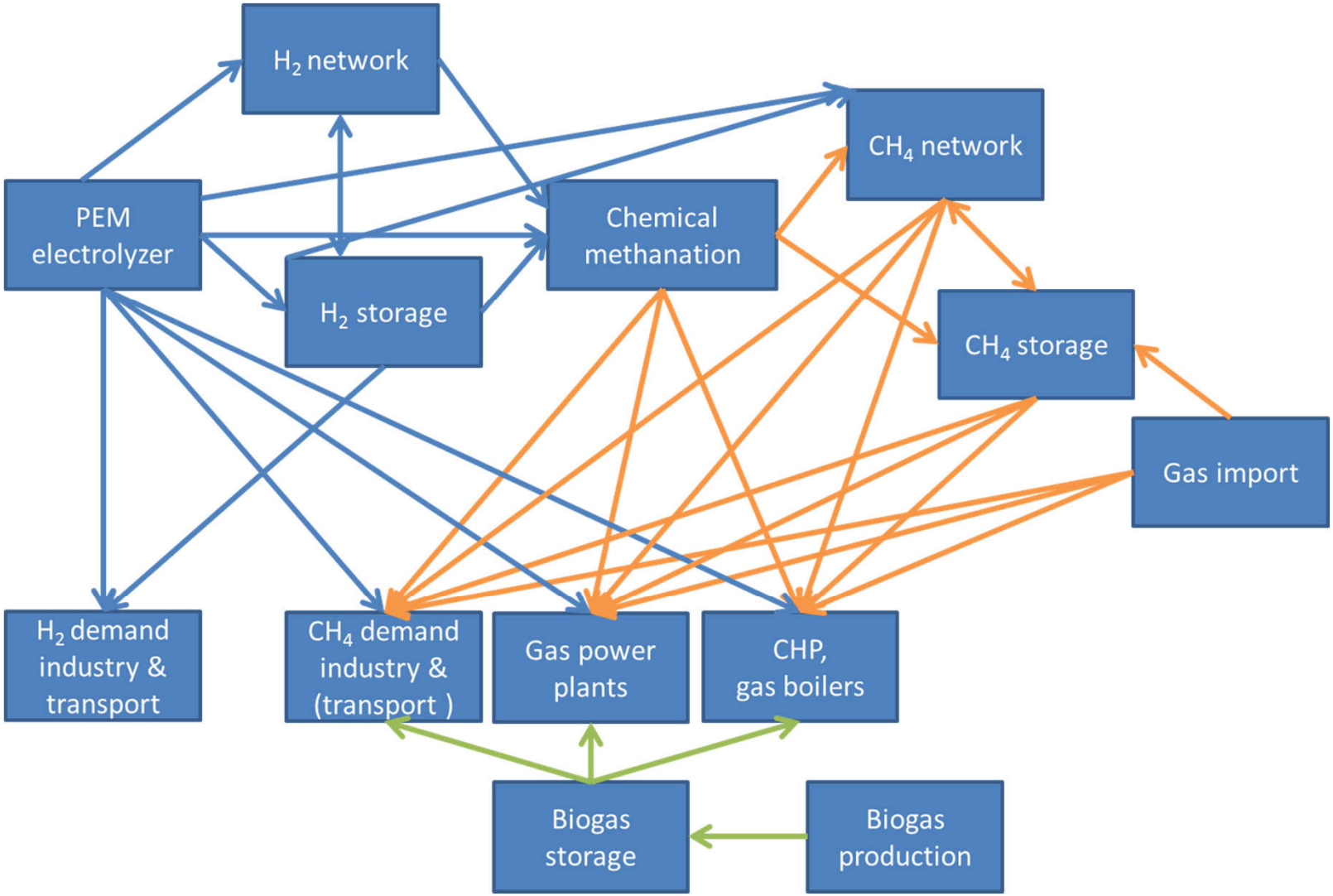
REMix enhancement for the gas sector



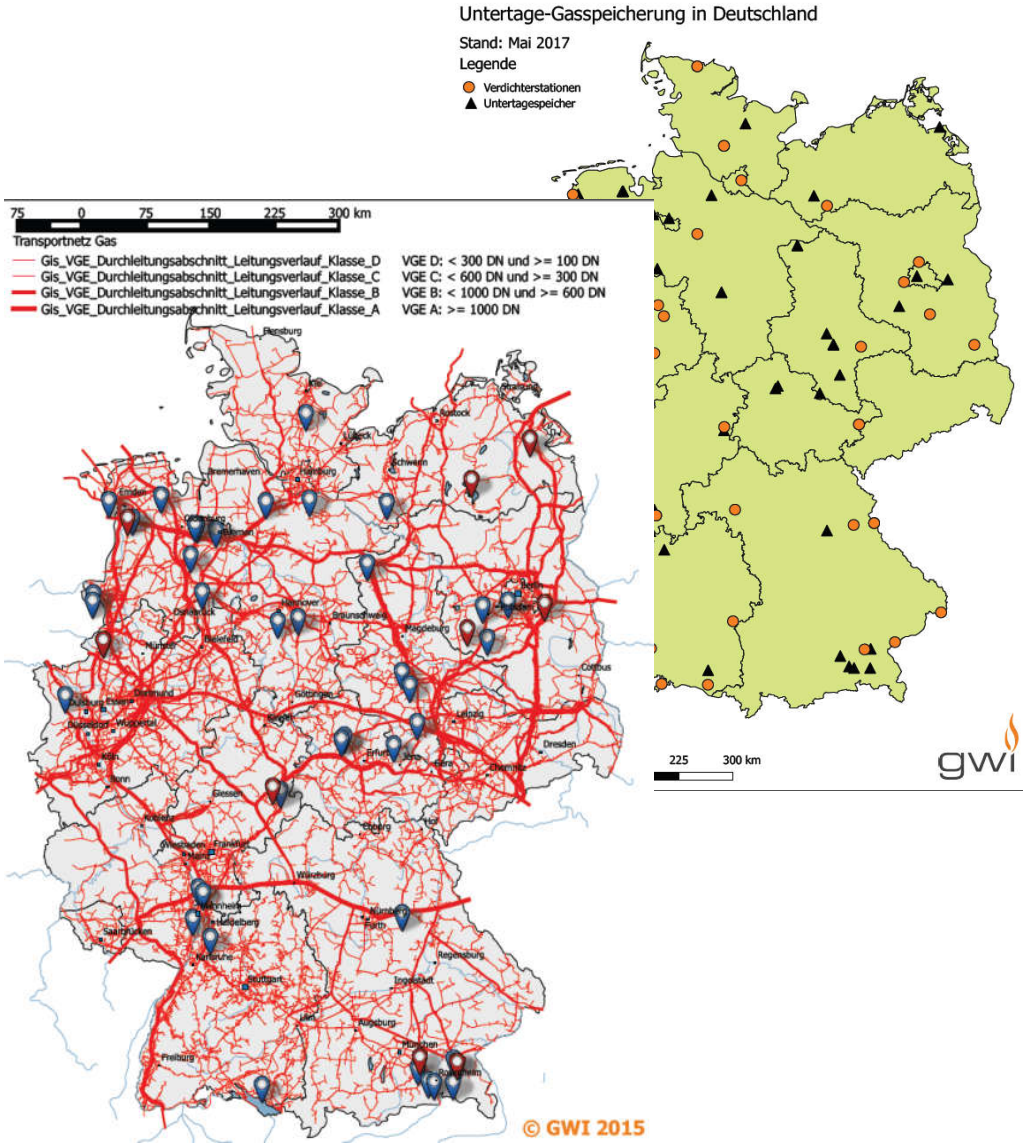
- Goal: reduced, linearized representation of the gas sector
  - Consideration of chemical energy only
  - No consideration of the gas composition
  - Aggregation according to model regions
- Modular structure for flexible combination of technologies
- Generic modules representing similar technologies
- Simplified modelling of gas transport between the model regions
- Compression in pipelines and storages with gas or electricity (endogenous)
- Optional feeding of hydrogen and biogas into the natural gas system

Gas sector technologies modelled in the MuSeKo project



Data basis for the gas system modelling in MuSeKo

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



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gwi Gas- und Wärme-Institut Essen e.V.

REMix configuration in MuSeKo

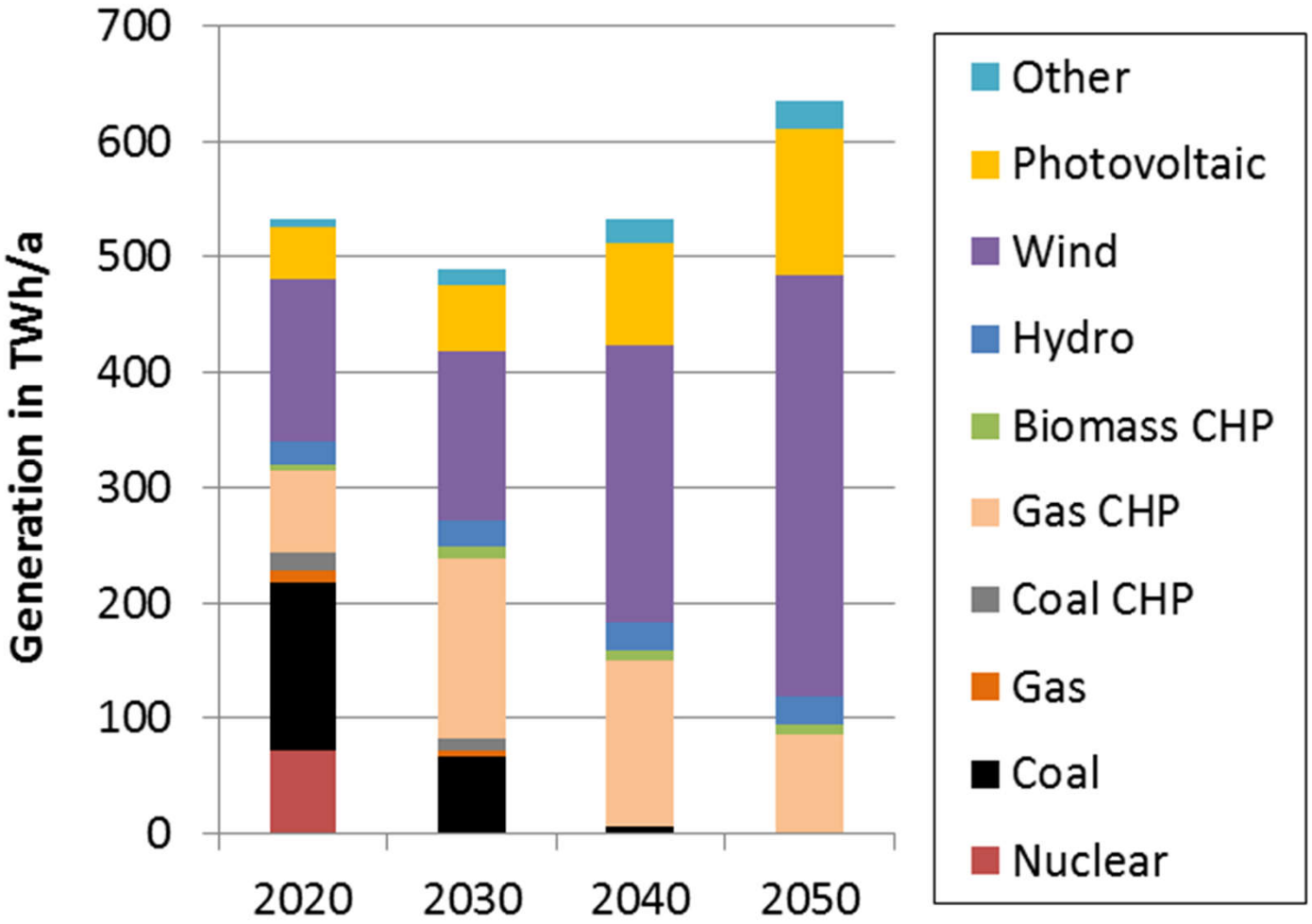
- Myopic application: 2020, 2030, 2040, 2050
  - Capacity installation transferred to subsequent years
  - Decommissioning at end of lifetime
  - No construction time
- Consideration of existing capacities:
  - Power transmission and storage
  - Gas network and storage
  - Wind/PV capacity w/o decommissioning
  - CHP/conventional capacity w/ decommissioning
- Capacity optimisation of RE, gas power plants, CHP and electricity storage
- Capacity optimisation of flexible sector coupling
- Power grid expansion only from 2040 on, limited to 3 GW per line and decade
- Base scenario with ~80% emission reduction until 2050 (rel. to 1990)

Preliminary REMix results from the MuSeKo project

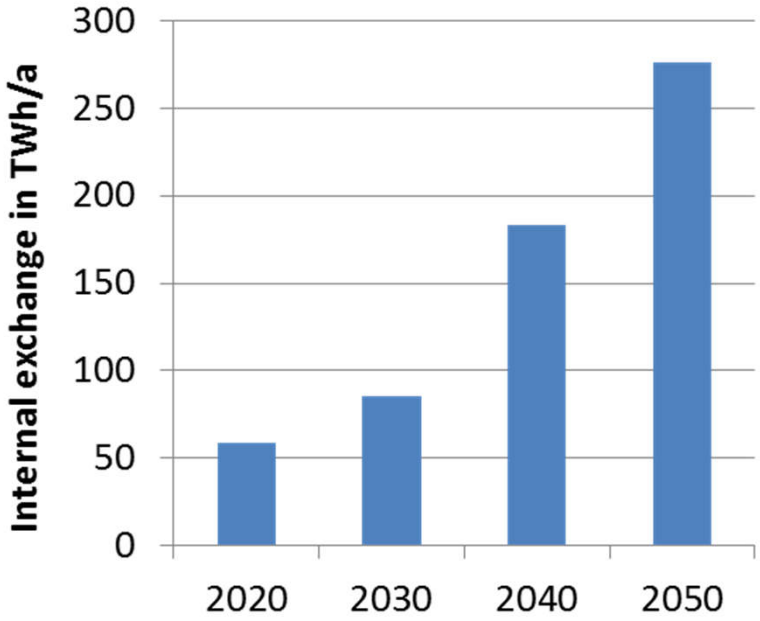
Focus:

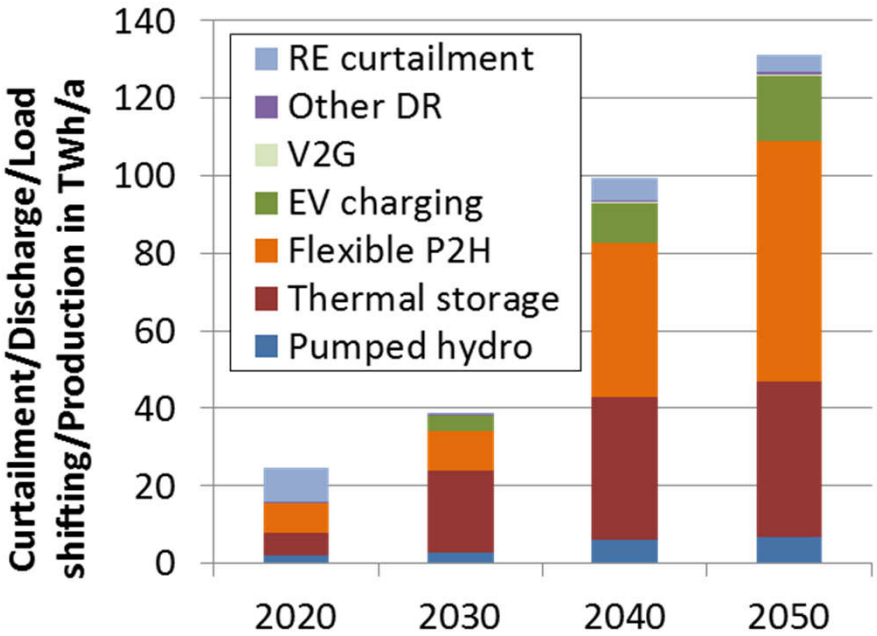
- Power generation
- Load balancing through power transmission, electricity storage, flexible heat production and battery vehicles
- Load balancing through flexible H_2 production

Development of power generation 2020 – 2050



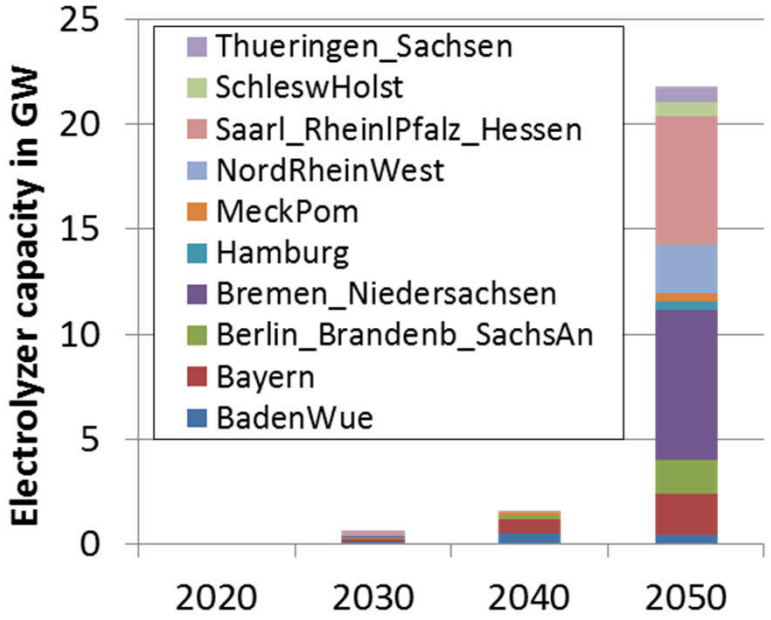
Load balancing through power transmission, electricity storage, flexible heat production and battery vehicles

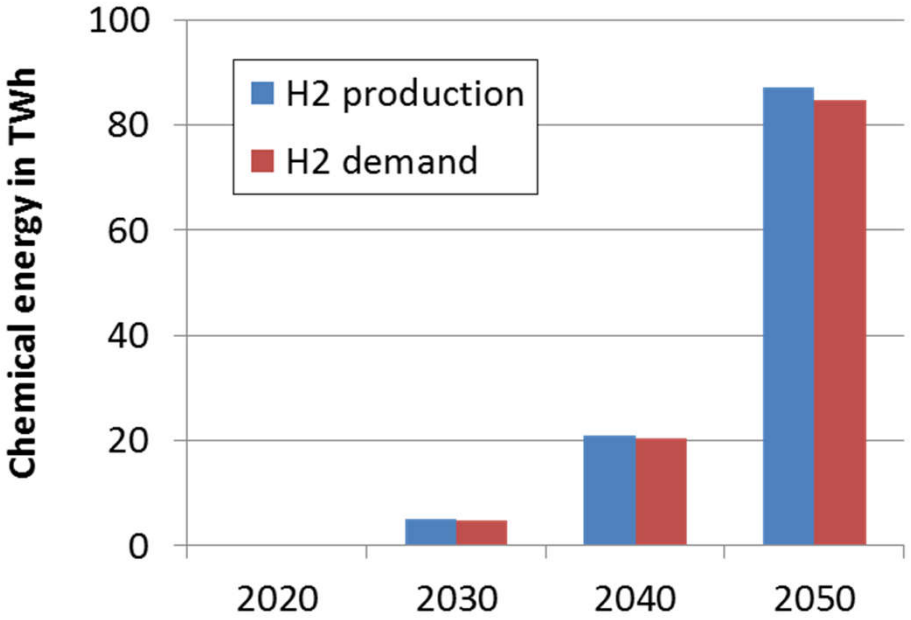




- Endogenous battery storage installation only outside Germany
- Grid capacity expansion within Germany by ~30 GW
- Thermal storage application mostly in district heating
- About 35% of the battery vehicle charging demand is shifted

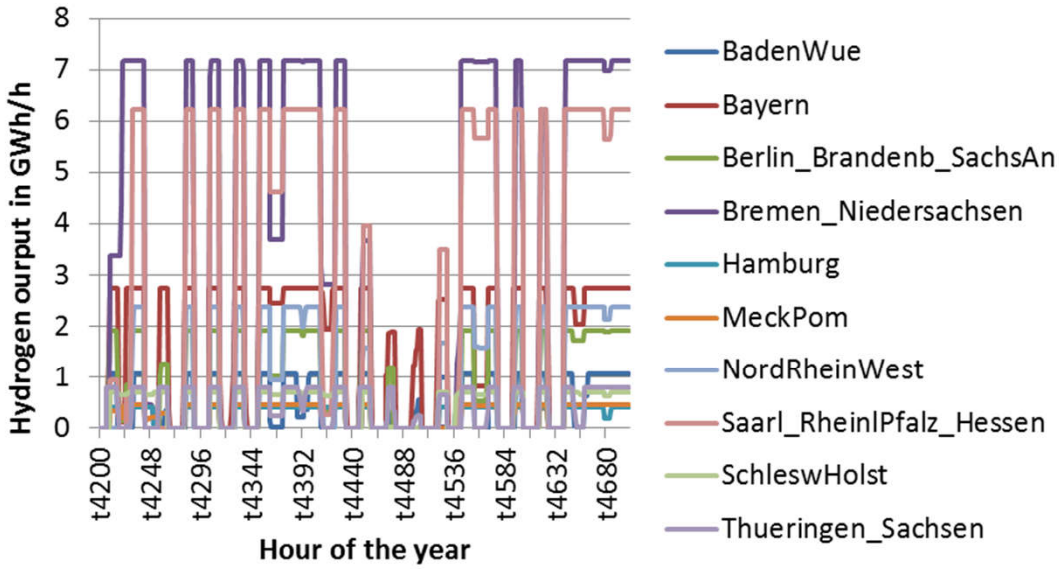
Load balancing through flexible H_2 production

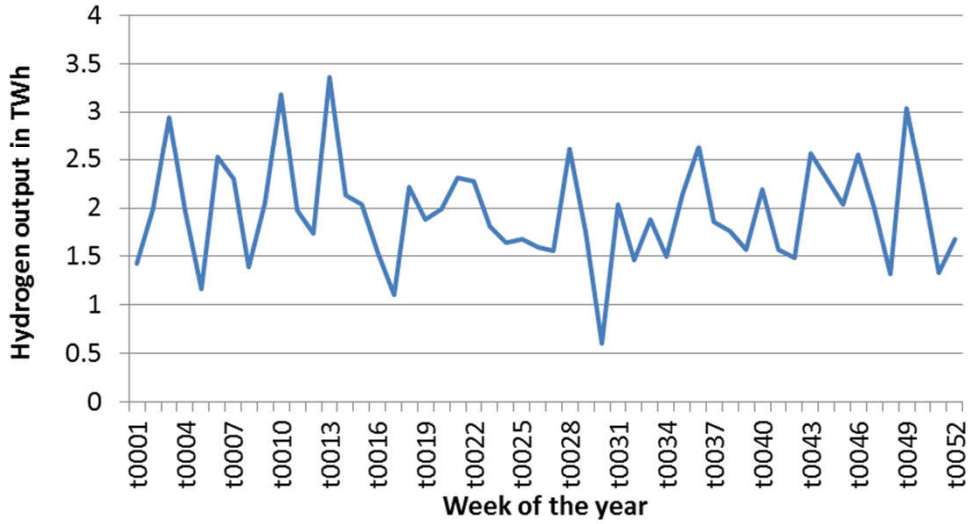




- No usage of methanation
- H_2 network with total capacity of 10 GW built, mostly in North-South direction
- H_2 underground storage with capacity of 1.3 TWh (chem) built
- 2/3 of H_2 production goes through the network, 1/3 is stored

Flexible hydrogen production in 2050

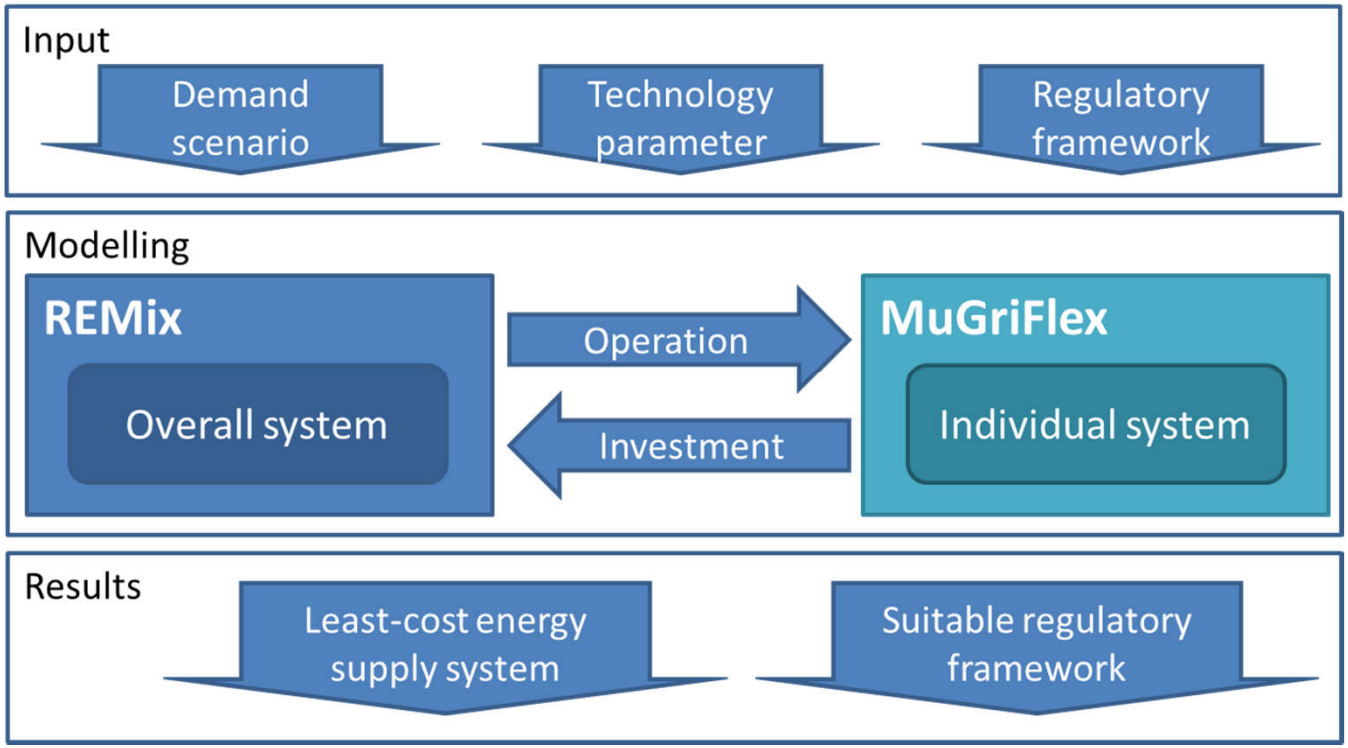




Summary

- Integrated consideration of all sector coupling options desirable
- There is still much room for improvement in modelling
- Options of flexible sector coupling interact positively with each other
- Flexible H_2 generation can make a significant contribution to RE balancing
- Partial conversion of natural gas infrastructure to H_2 is an attractive option
- Methanation does not come into play in the 80% CO_2 reduction scenario

Outlook



- Comparison to business perspective
- Further analysis of interactions within the overall system
- Evaluation of the operation of the electric equipment in the gas system
- Further scenarios and sensitivity analysis

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