Sensitivities of Power-to-Gas within an Optimised Energy System

100% RE with PtG

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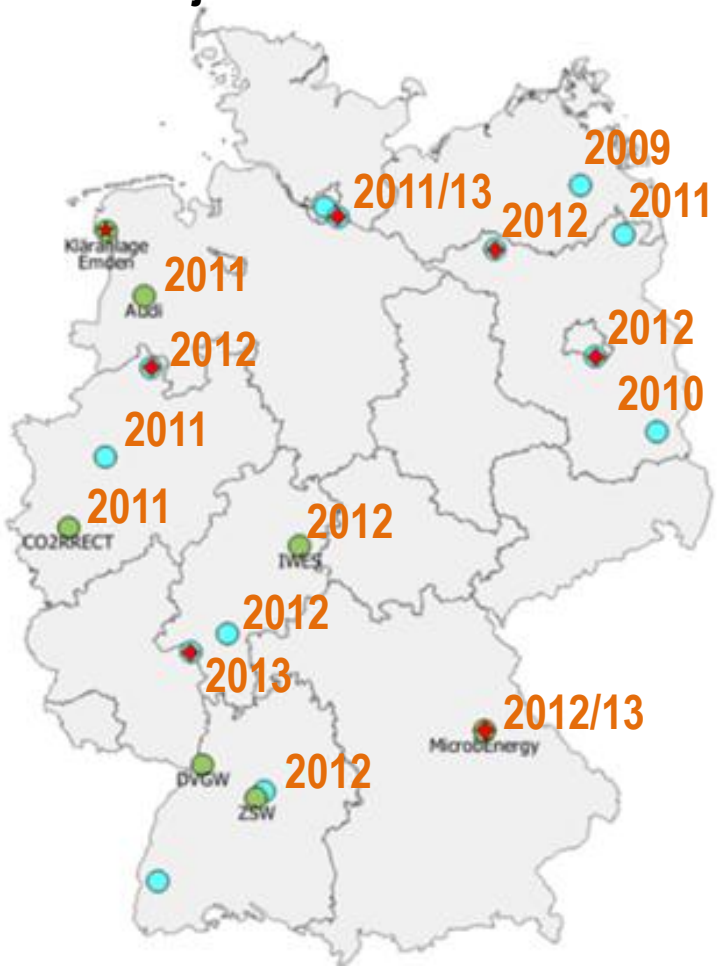
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

REINER LEMOINE INSTITUT

Project partner: juwi, ZSW, ETOGAS smart energy conversion, VORWEG GEHEN

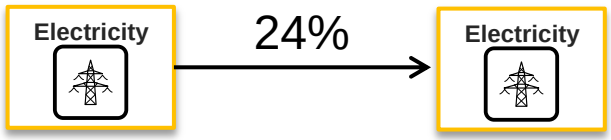
Motivation

Selection of PtG implementation
Projects with start date



Efficiencies

Electricity → Hydrogen = ~75%
Hydrogen → Methane = ~80%
Methane → Electricity = ~40%



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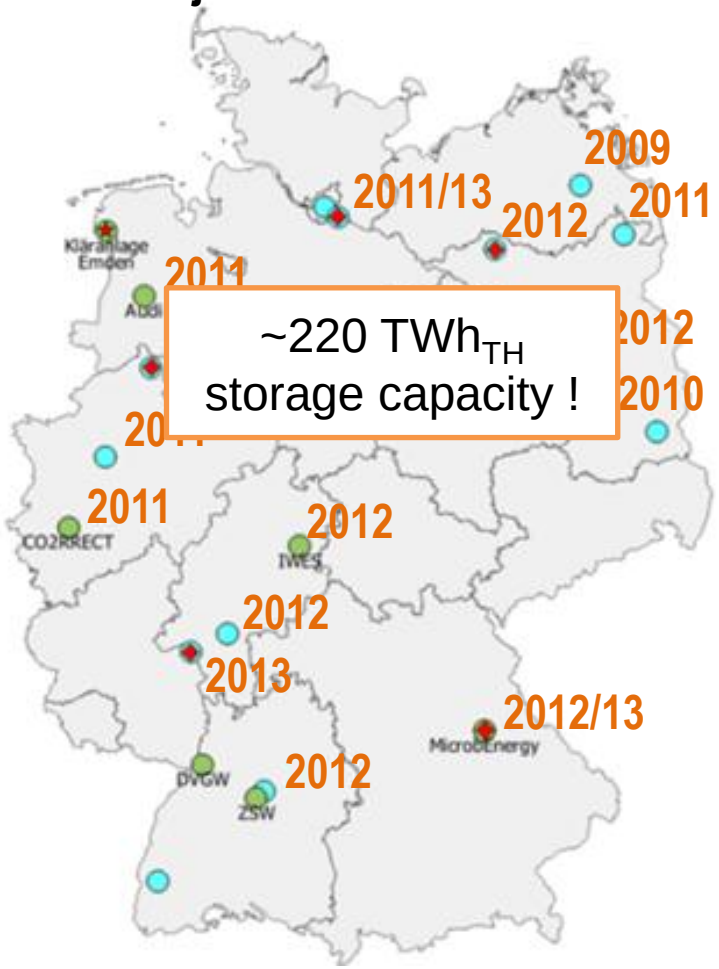
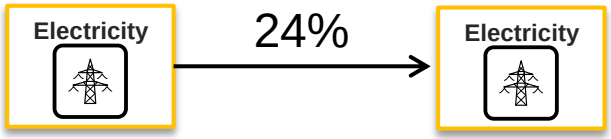
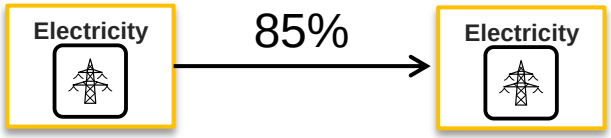


~220 TWh_{TH} storage capacity !

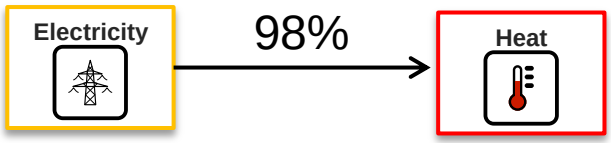
Power to Gas (PtG)

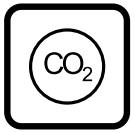


Li-ion – Batteries



Power to Heat (PtH)





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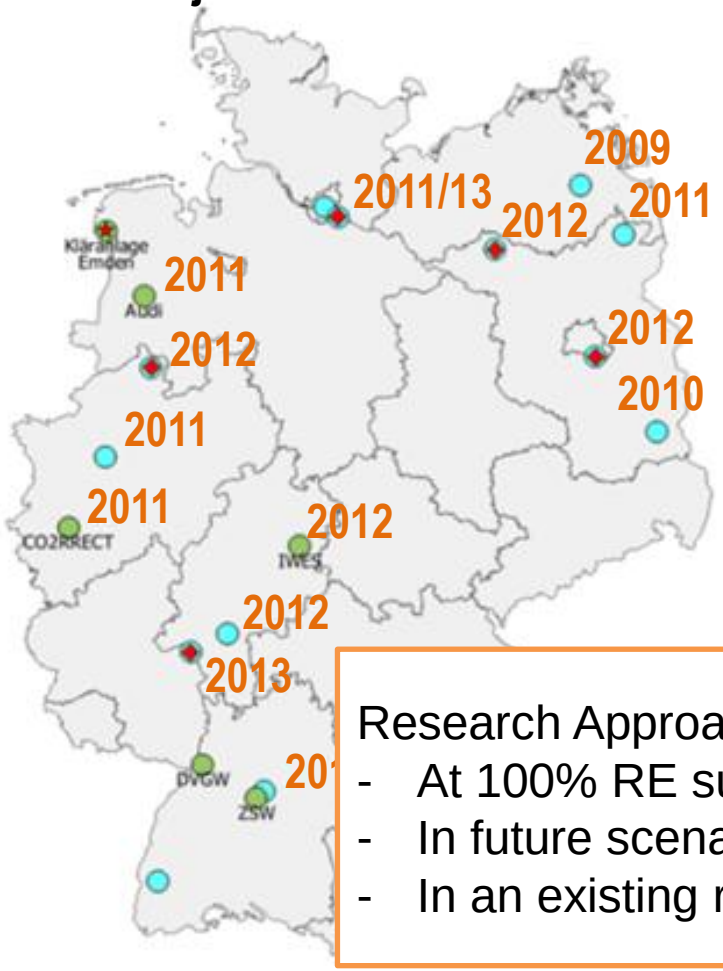

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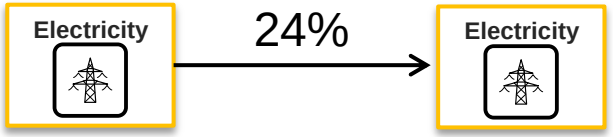

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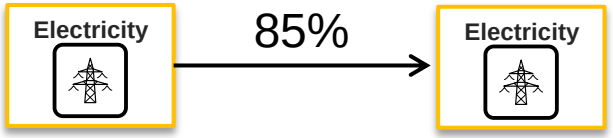

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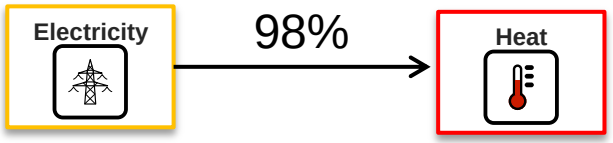
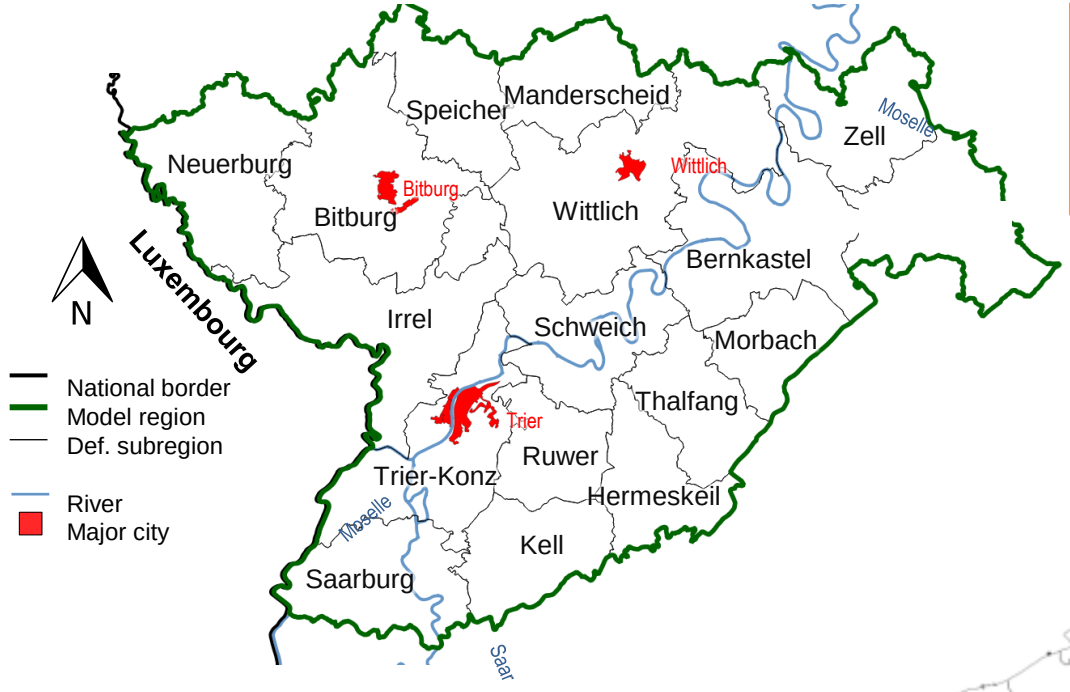


Research Approach: What is the most economic storage solution?
- At 100% RE supply
- In future scenarios
- In an existing region

Agenda

- Methods: model region and model
- Results
  - Optimised Scenario (Base)
  - Variation of CAPEX
  - Technology and supply
- Conclusion

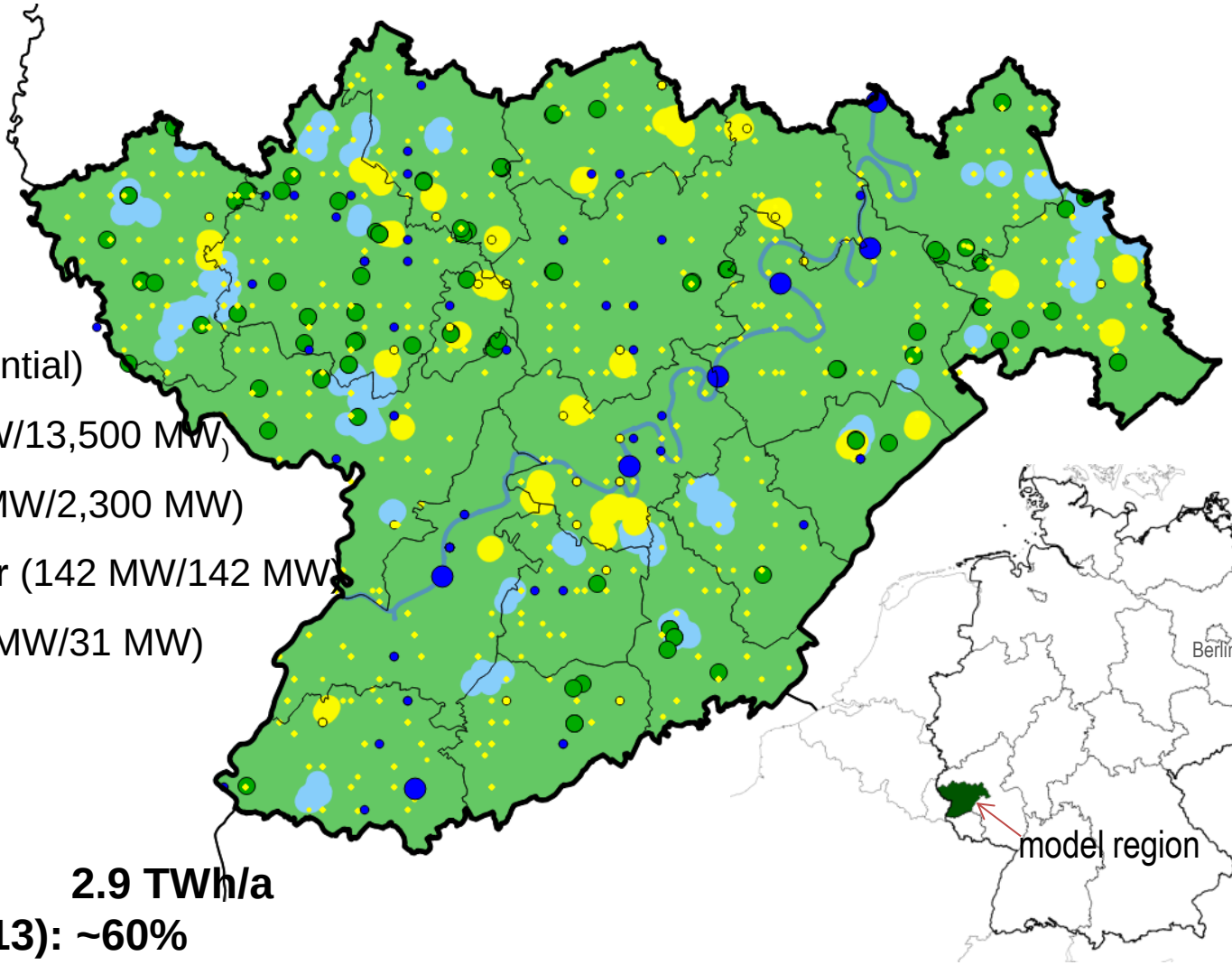
Model Region: Trier Amprion 5



Model region corresponds to the existing electricity grid Amprion 5

Geographical size: 1% of GER
Rural area;
Biggest city Trier ~100,000 inhabitants

Model Region: Power Supply

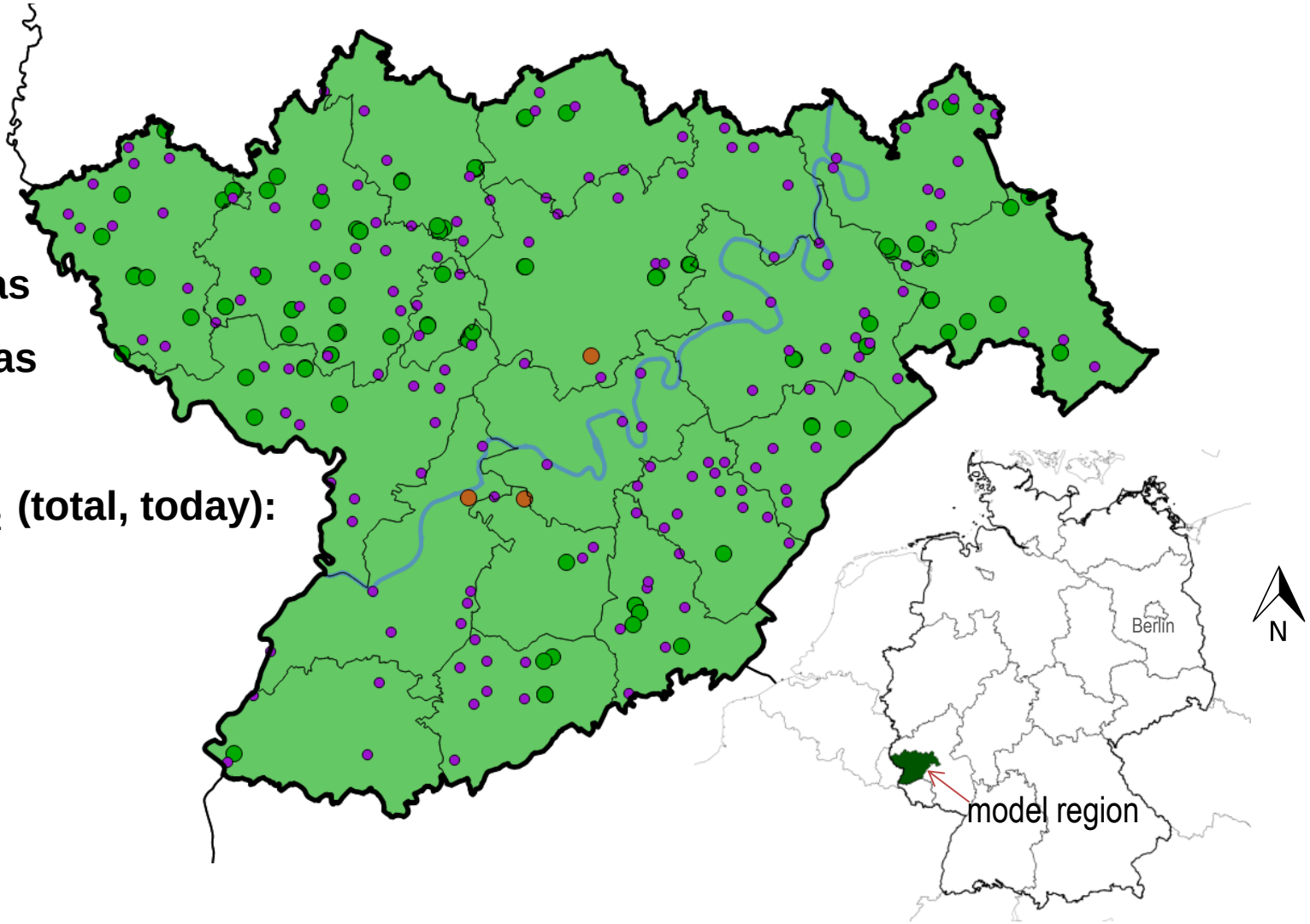


El. Demand: 2.9 TWh/a
RE share (2013): ~60%

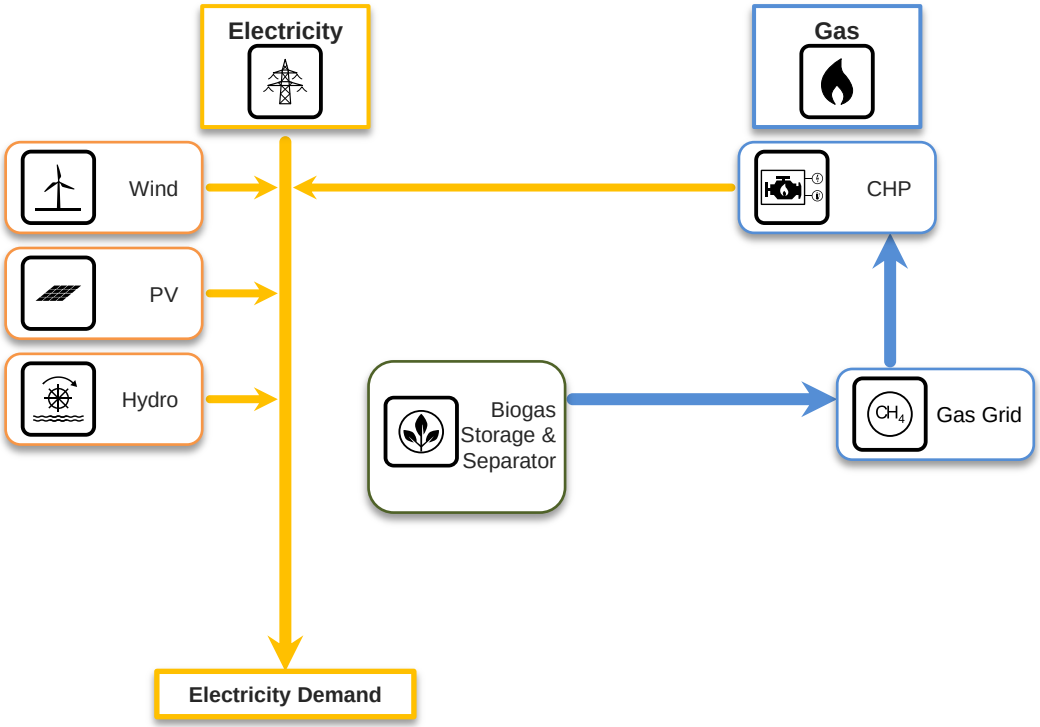
Model Region: CO_2 Sources

- Biogas
- Landfill gas
- Sewage gas

Biogas, CO_2 (total, today):
104 kt/a



Optimisation Model - Structure



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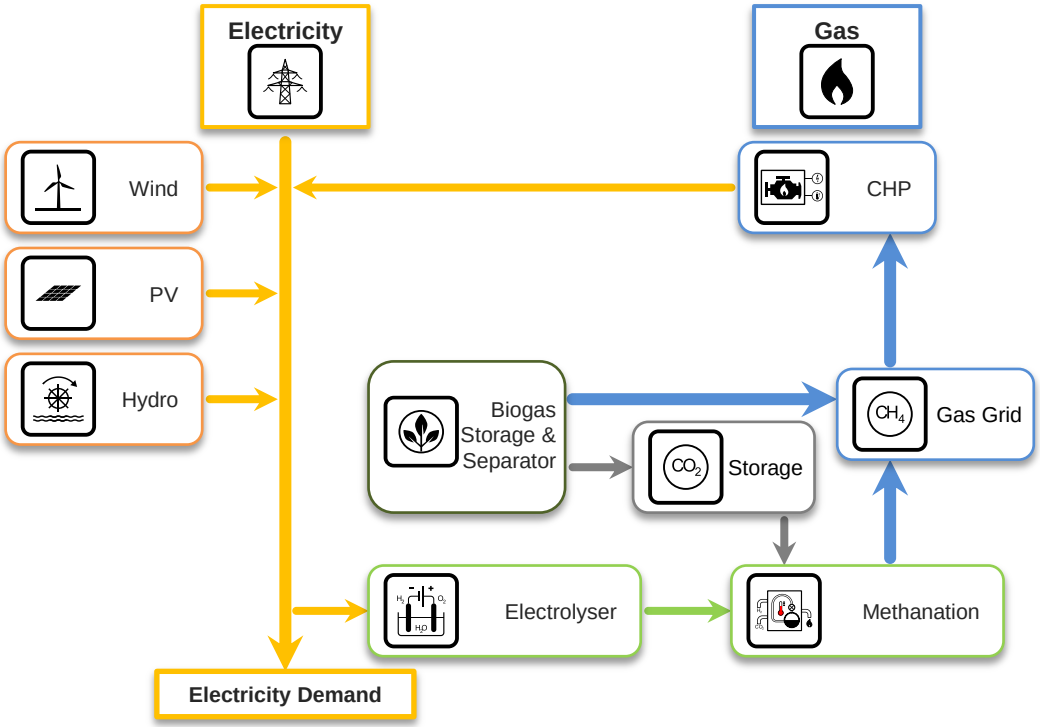

- PtG incl. methanation
- PtG incl. CO_2 sources

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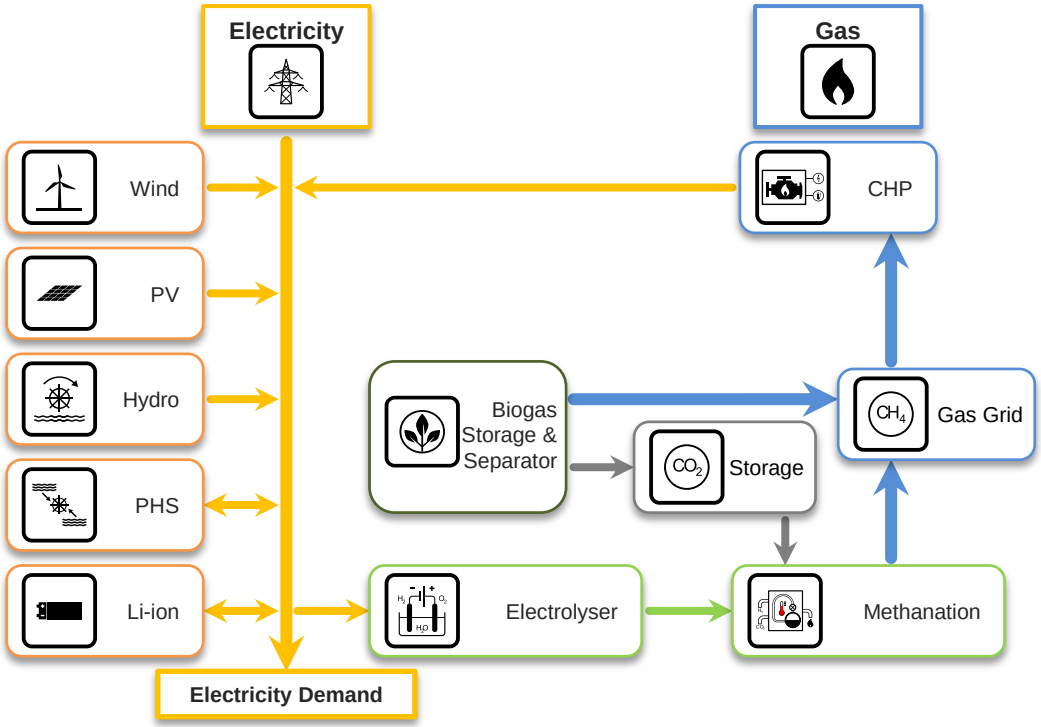

- PtG incl. methanation
- PtG incl. CO_2 sources

- PHS & Li-Ion

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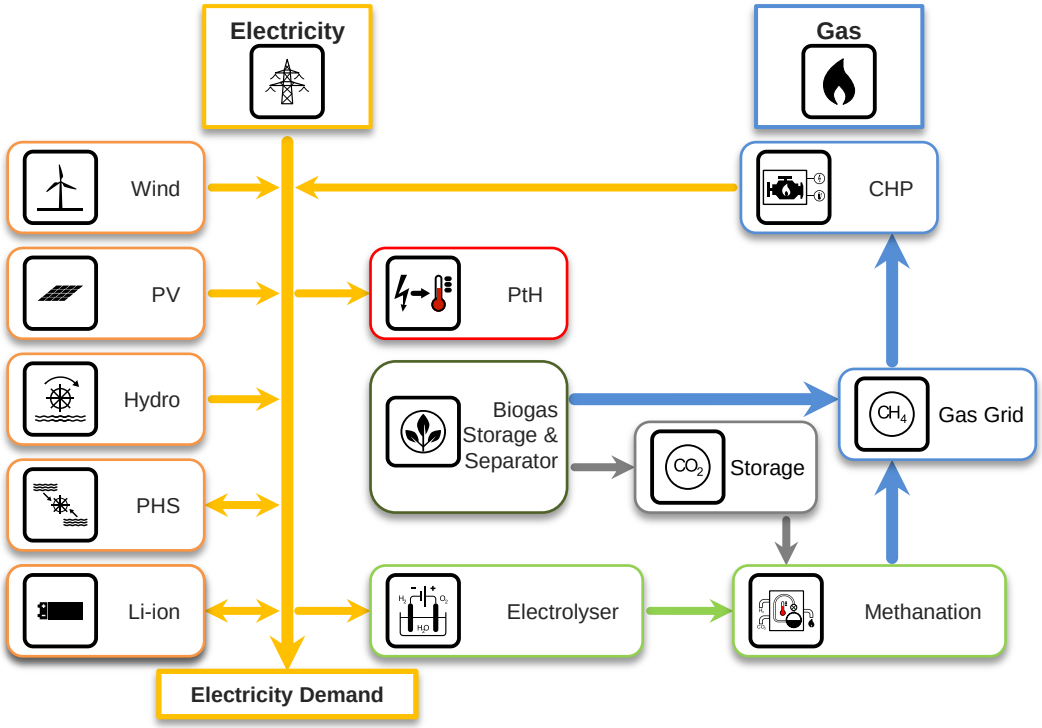

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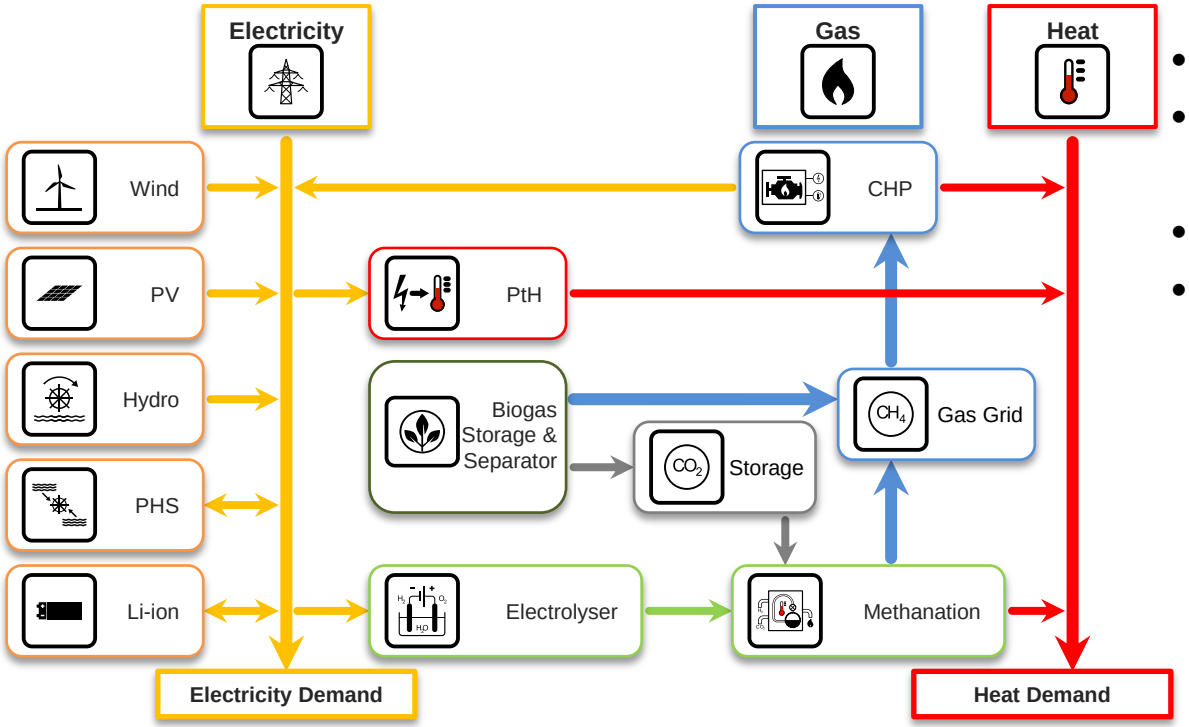

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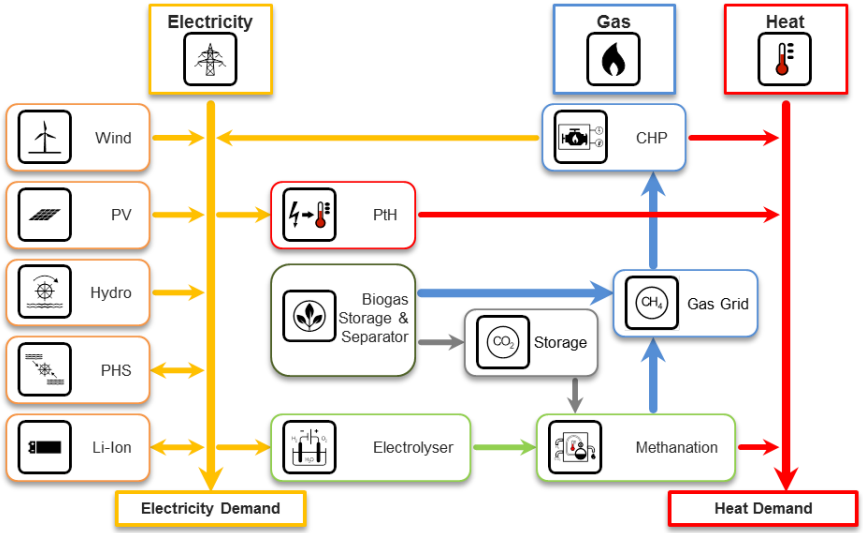
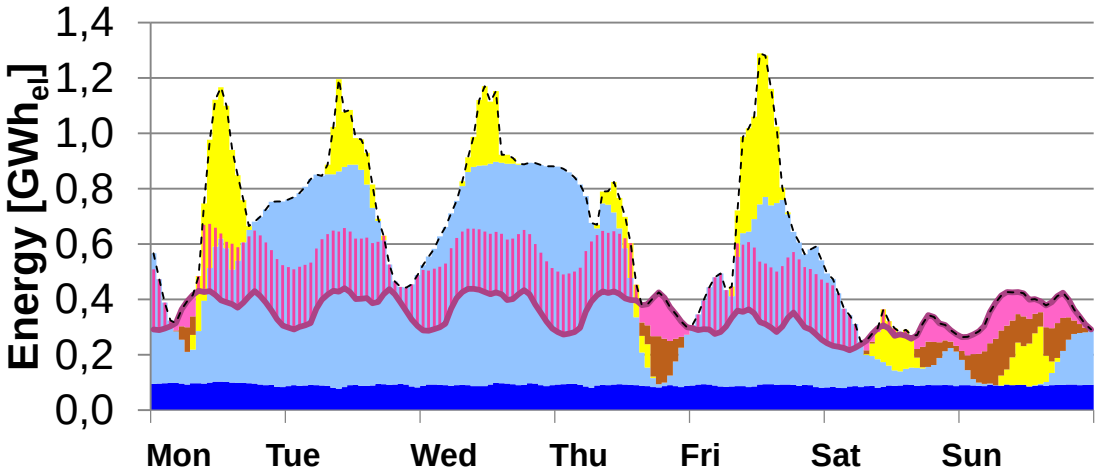
Optimisation Model - Approach



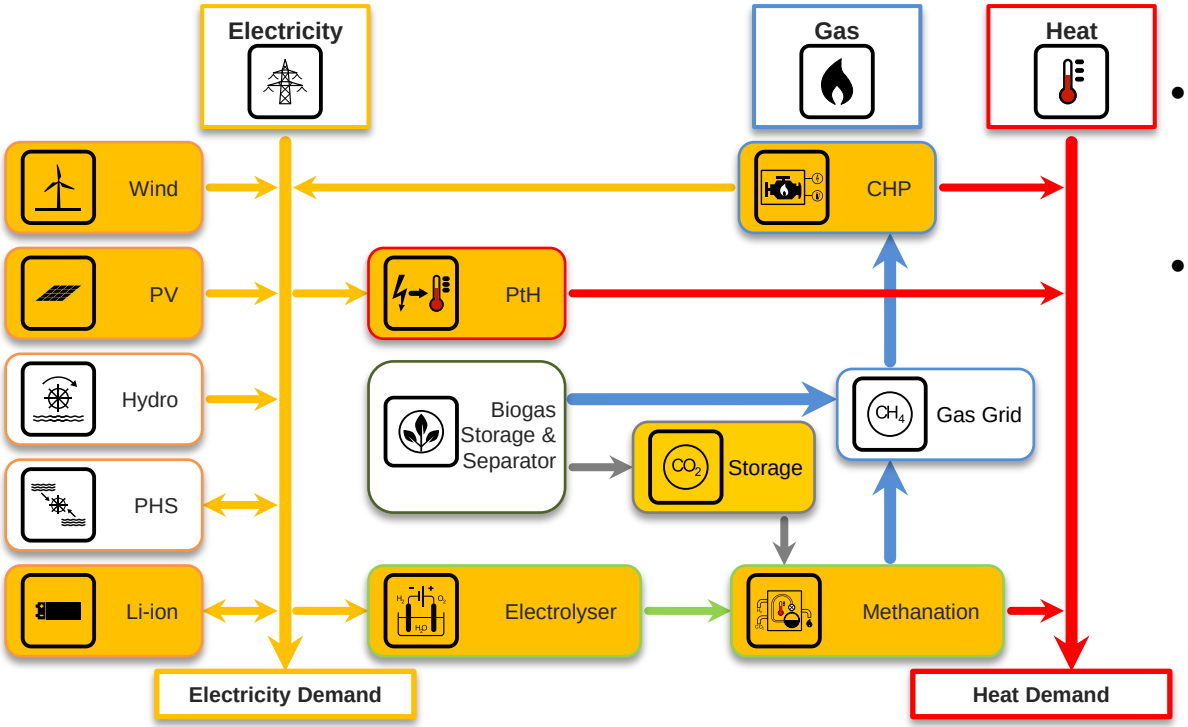


- PtG incl. methanation
- PtG incl. CO_2 sources

- PHS & Li-Ion
- PtH incl. heat demand

- Step size: 15 min
- Reference years: 2
  → weather data
- Optimisation parameter: Installed capacities
- Optimisation target: minimal LCOE
- Optimisation:
- Non-Linear Solver
- Merit order
- Reinforcement learning (RL)

Optimisation Model - Approach



- Optimisation parameter: Installed capacities
- Optimisation target: minimal LCOE

Assumptions (Future Scenario)

(Weak) Wind Power:	1,600	€/kW	
(High) Wind Power:	1,000	€/kW	
PV Rooftop:	875	€/kW	
PV Ground-Mounted:	700	€/kW	
Hydropower:	2,700	€/kW	
Biogas:	1,350	€/kW	
CHP:	900	€/kW	Eff.:40%
PtG:	900	€/kW	Eff.:60%
Li-ion:	350	€/kW	Eff.:85%
PHS:	160	€/kW	Eff.:81%
PtH:	100	€/kW	Eff.:98%

Results – Optimised Scenario: Base

Base assumptions with 80% RE
LCOE: 9.3 ct/kWh
PtG inst.: 0 MW

Base assumptions with 100% RE
LCOE: 11.0 ct/kWh
PtG inst.: 218 MW

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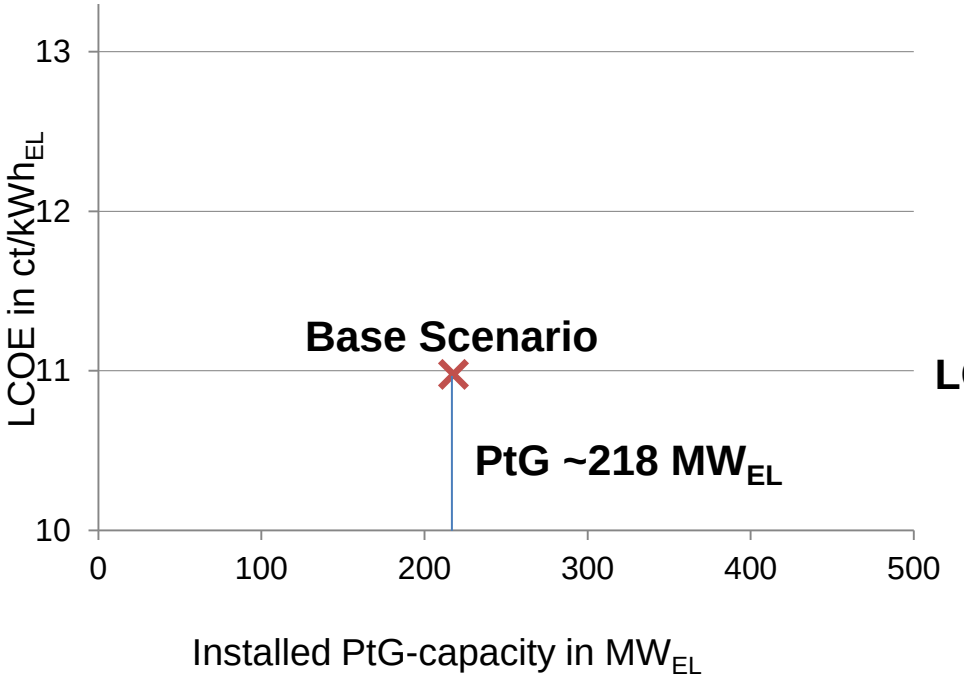
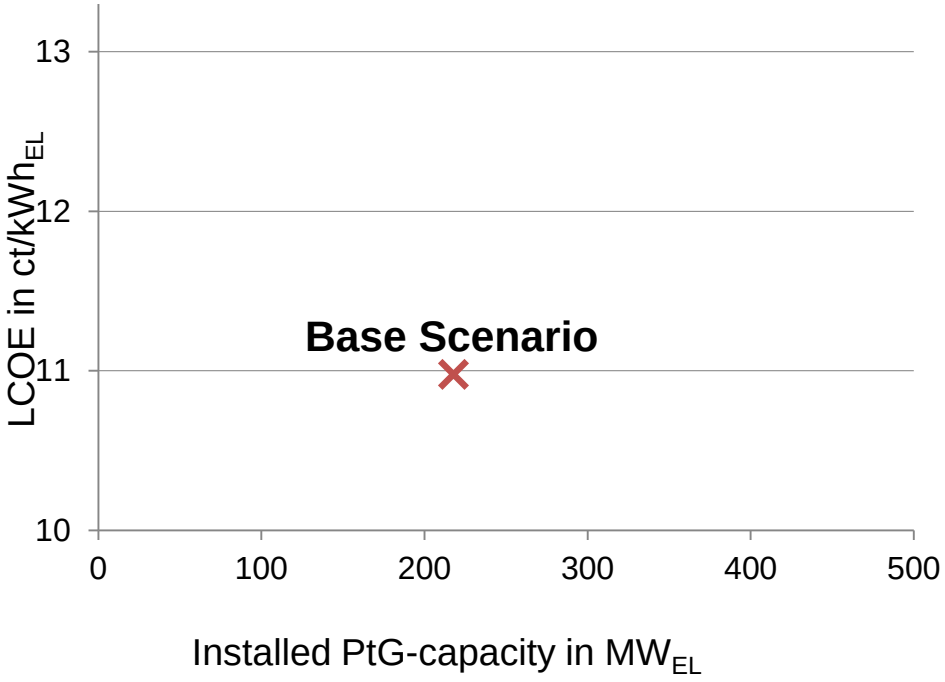
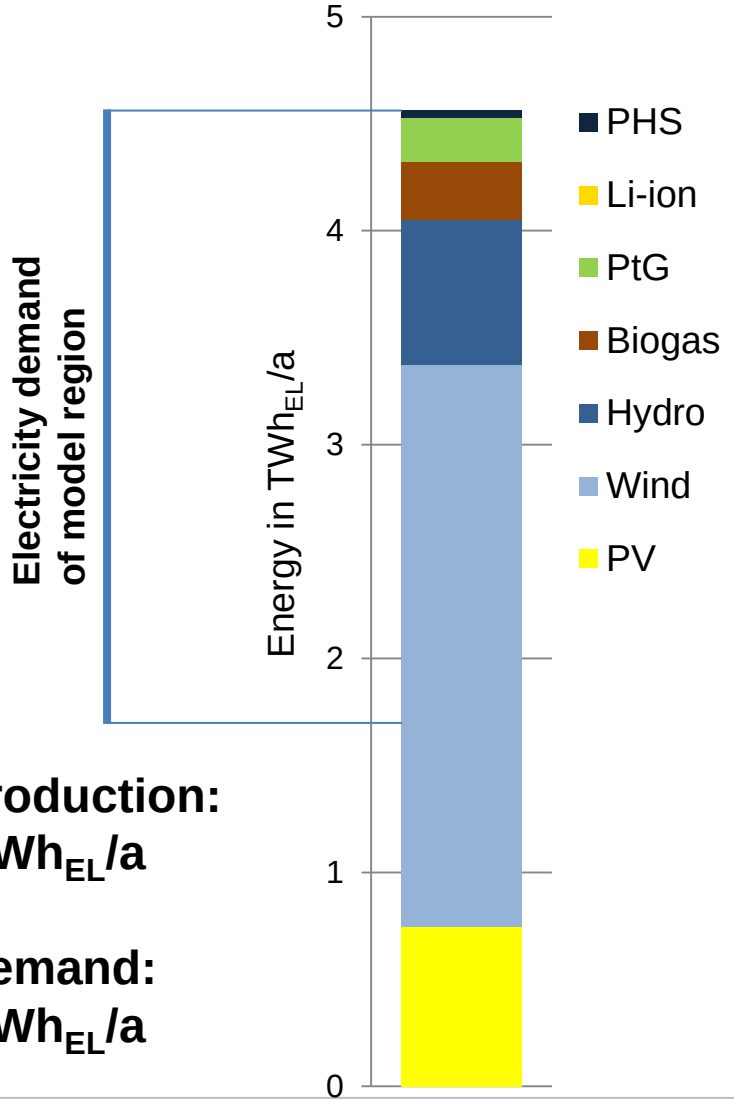


LCOE ~11 ct/kWh$_{EL}$

Results – Optimised Scenario: Base

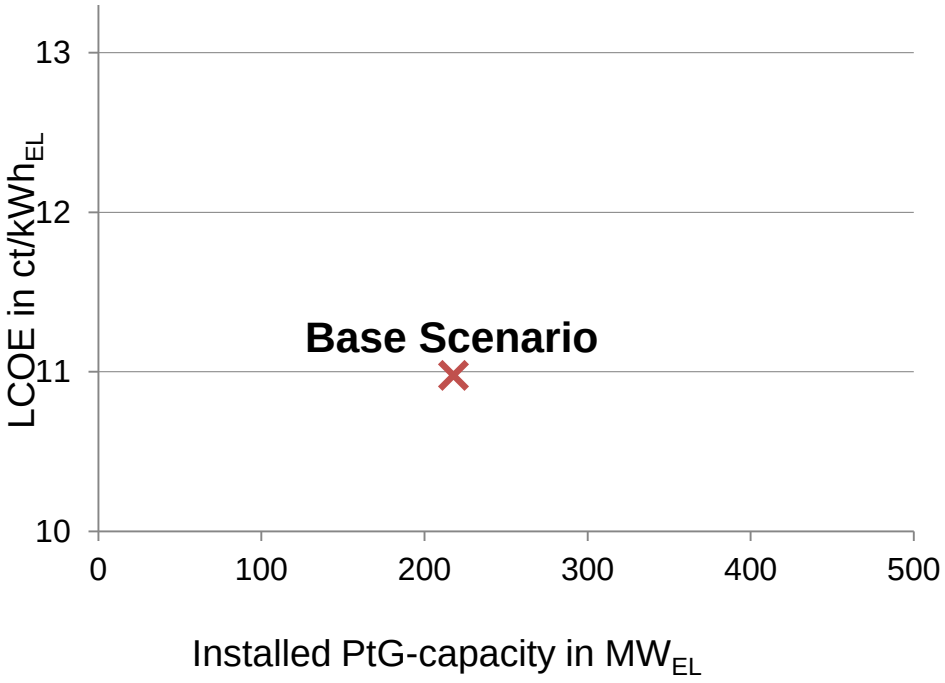


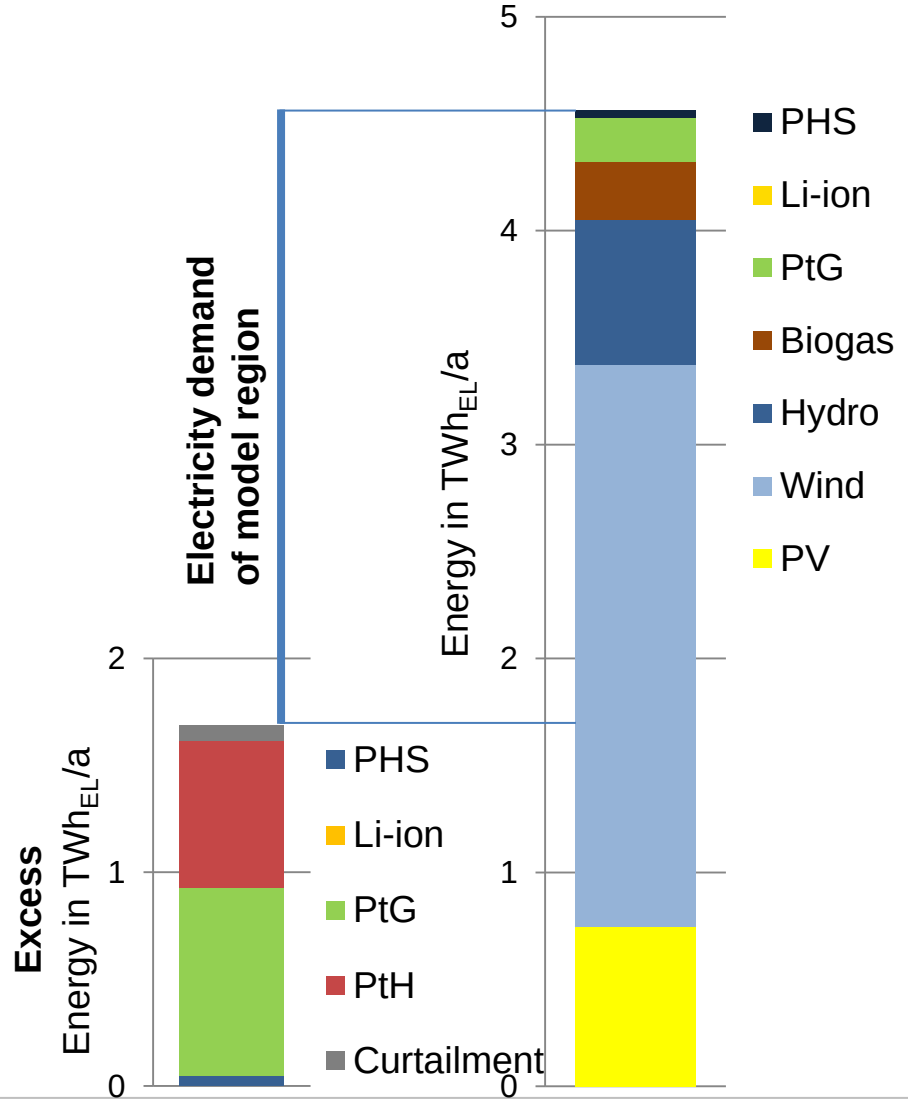


El. Production: 4.6 TWh$_{EL}$/a

El. Demand: 2.9 TWh$_{EL}$/a

Results – Optimised Scenario: Base





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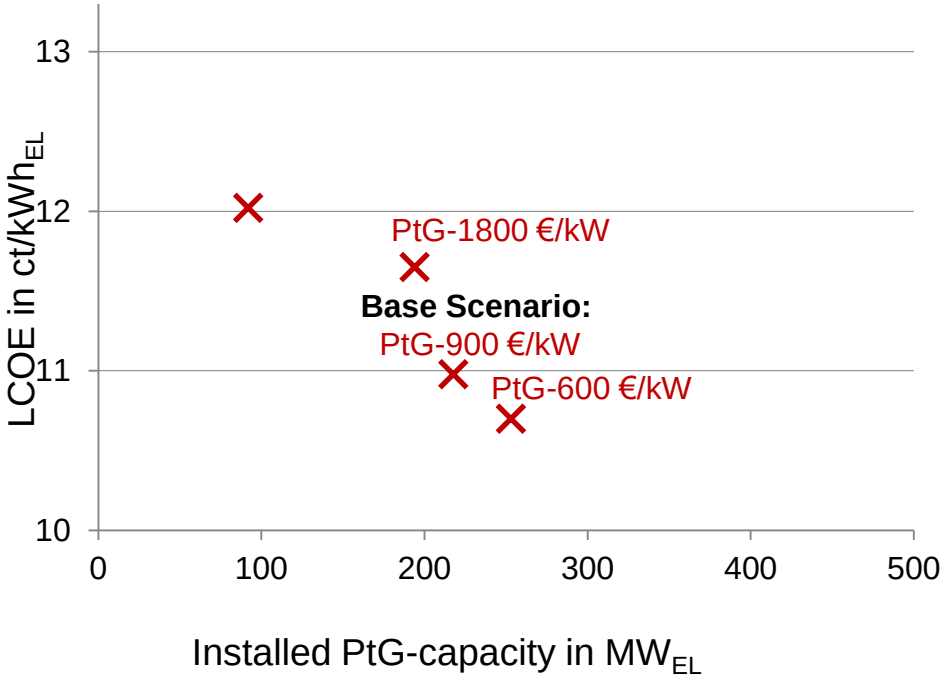
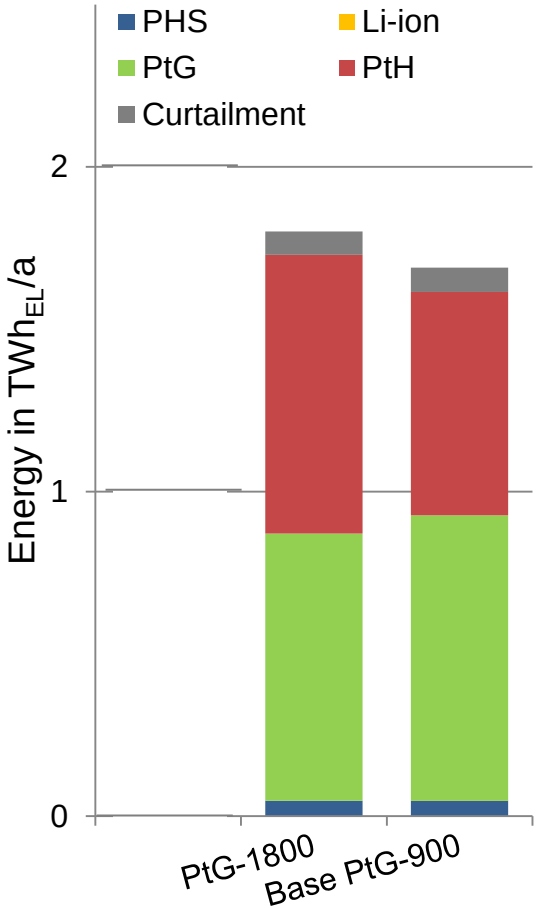
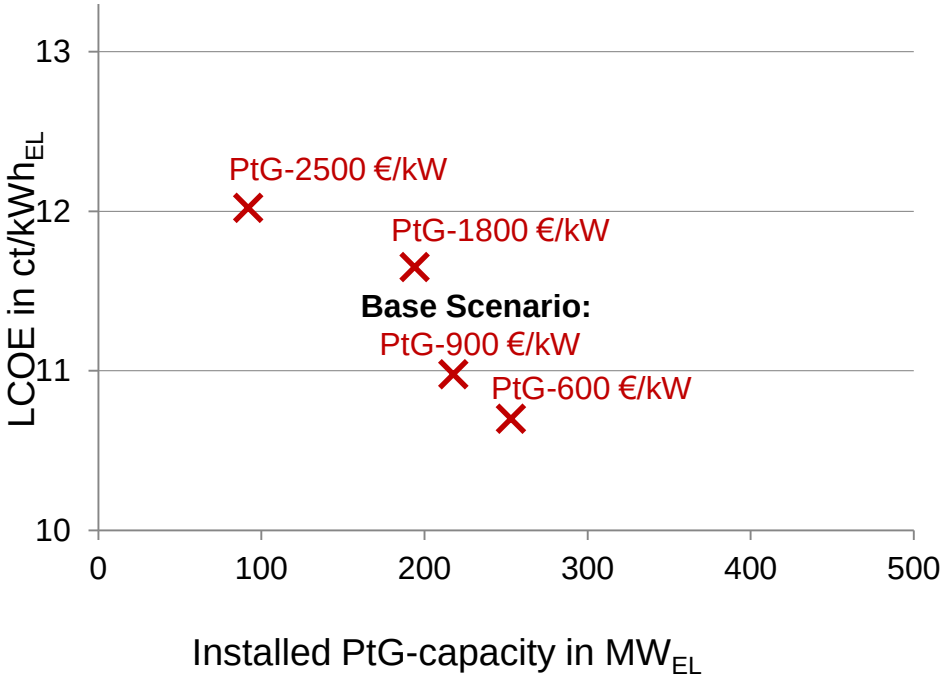
Results – Variation of PtG-CAPEX

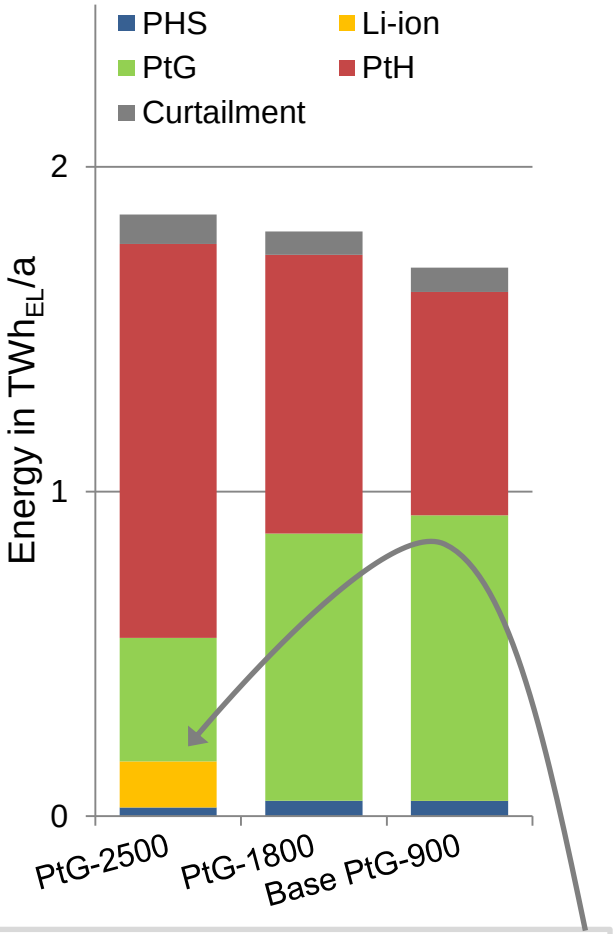




2 * Inv. costs PtG =
~ slight changes in the energy mix

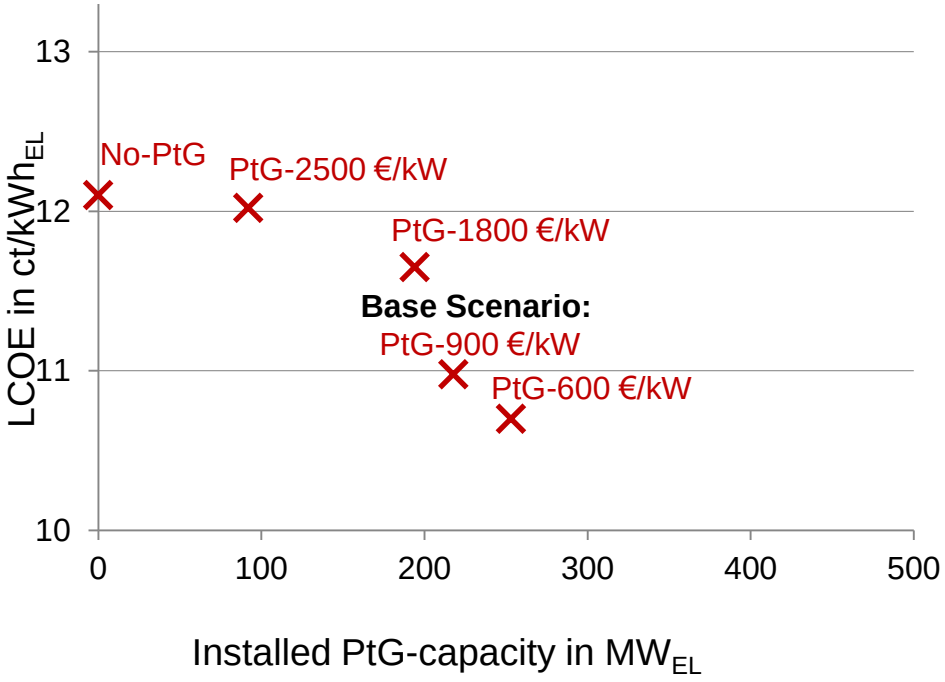
Results – Variation of PtG-CAPEX

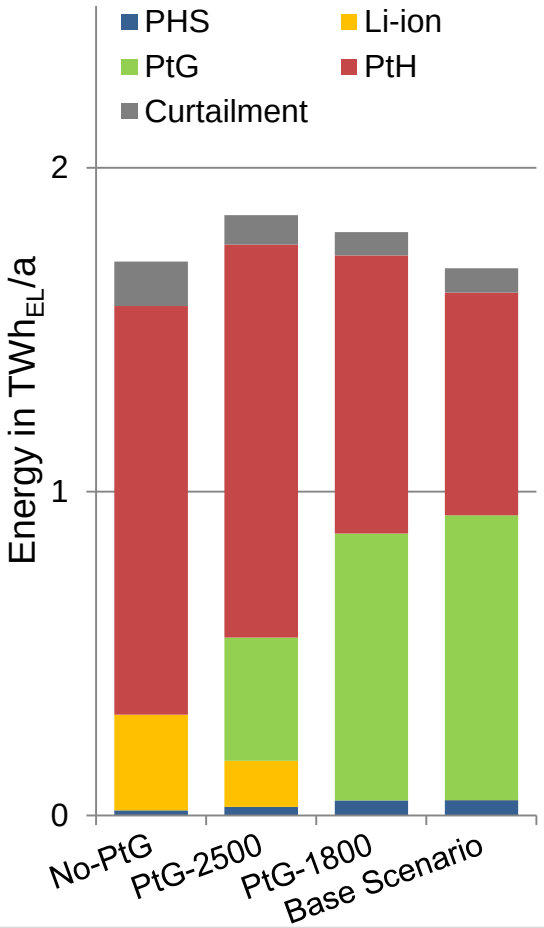




At 2.500 €/kW batteries are competitive to Li-ion at a CAPEX of 350 €/kWh

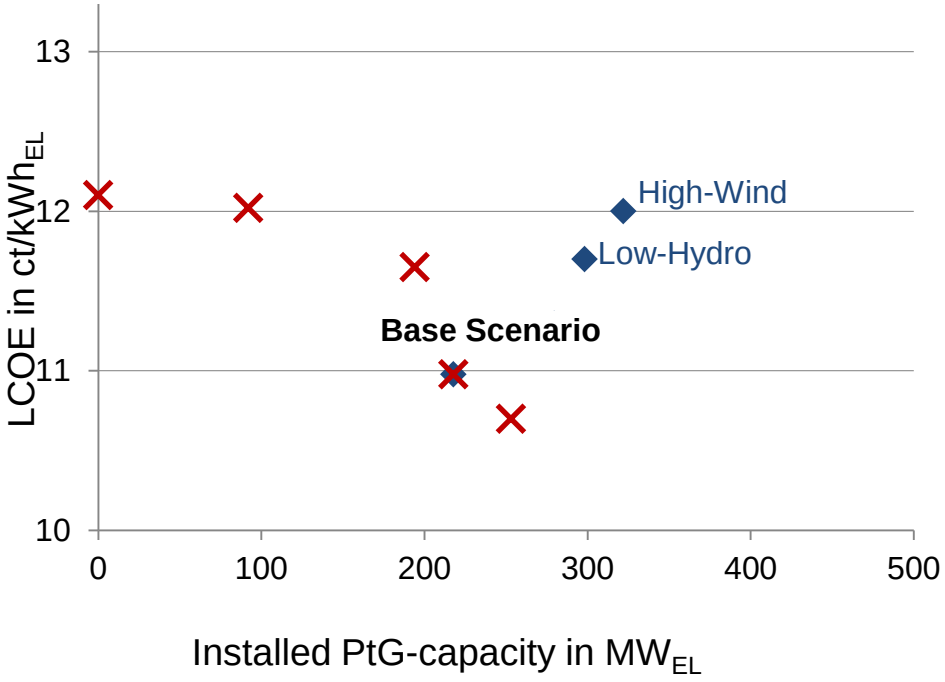
Results – Variation of PtG-CAPEX

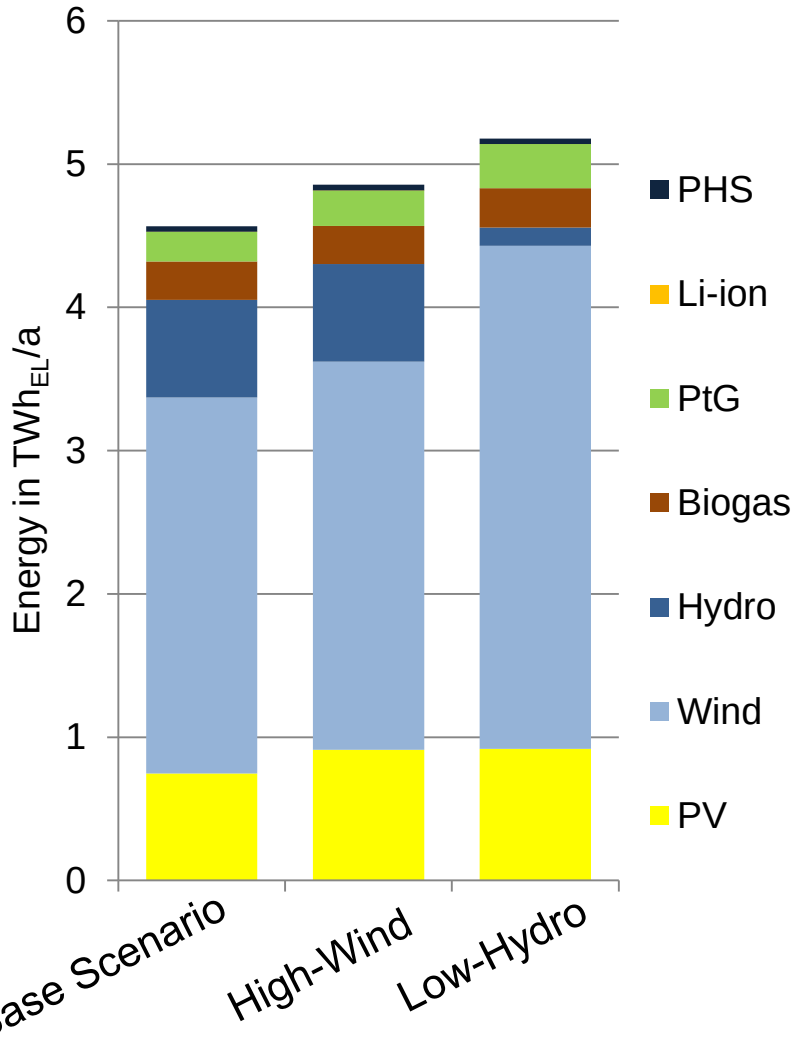




No-PtG: System without PtG
- Higher LCOE
- Higher need for regulation

Sensitivities: Technology and Supply





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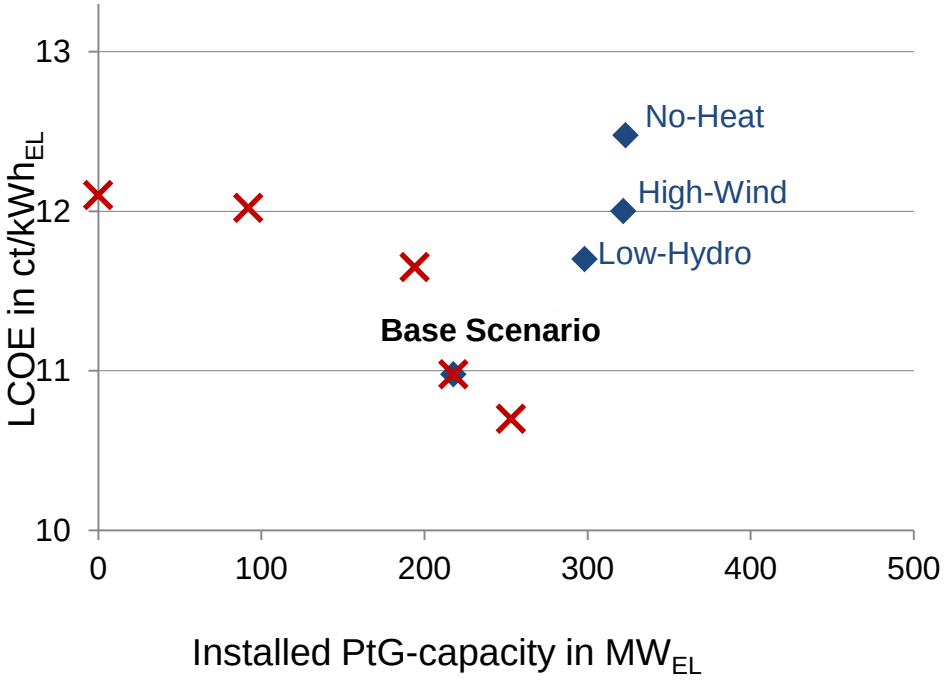
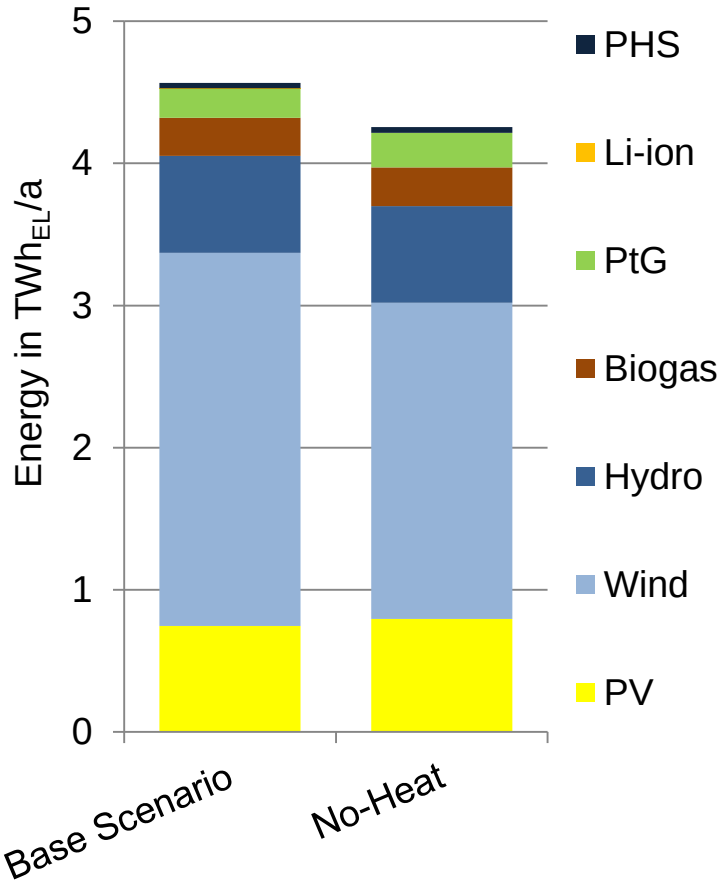
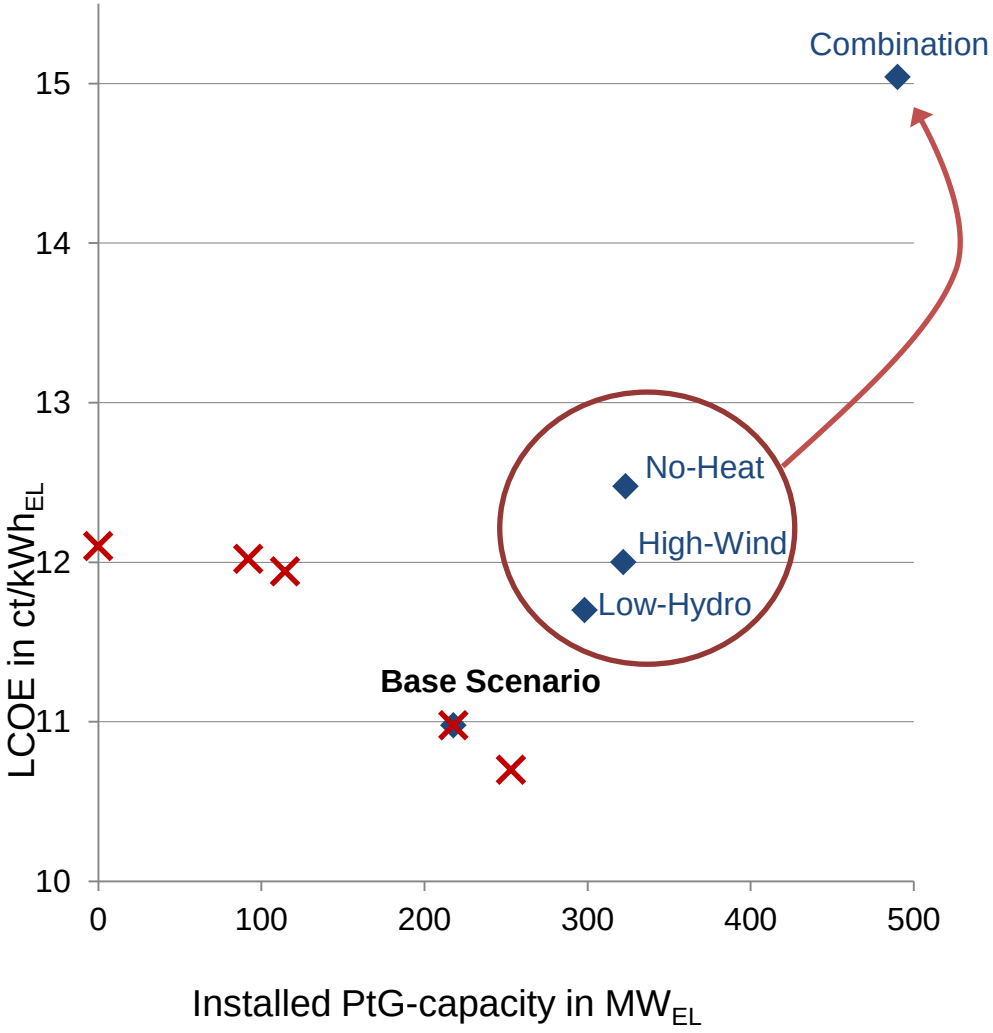




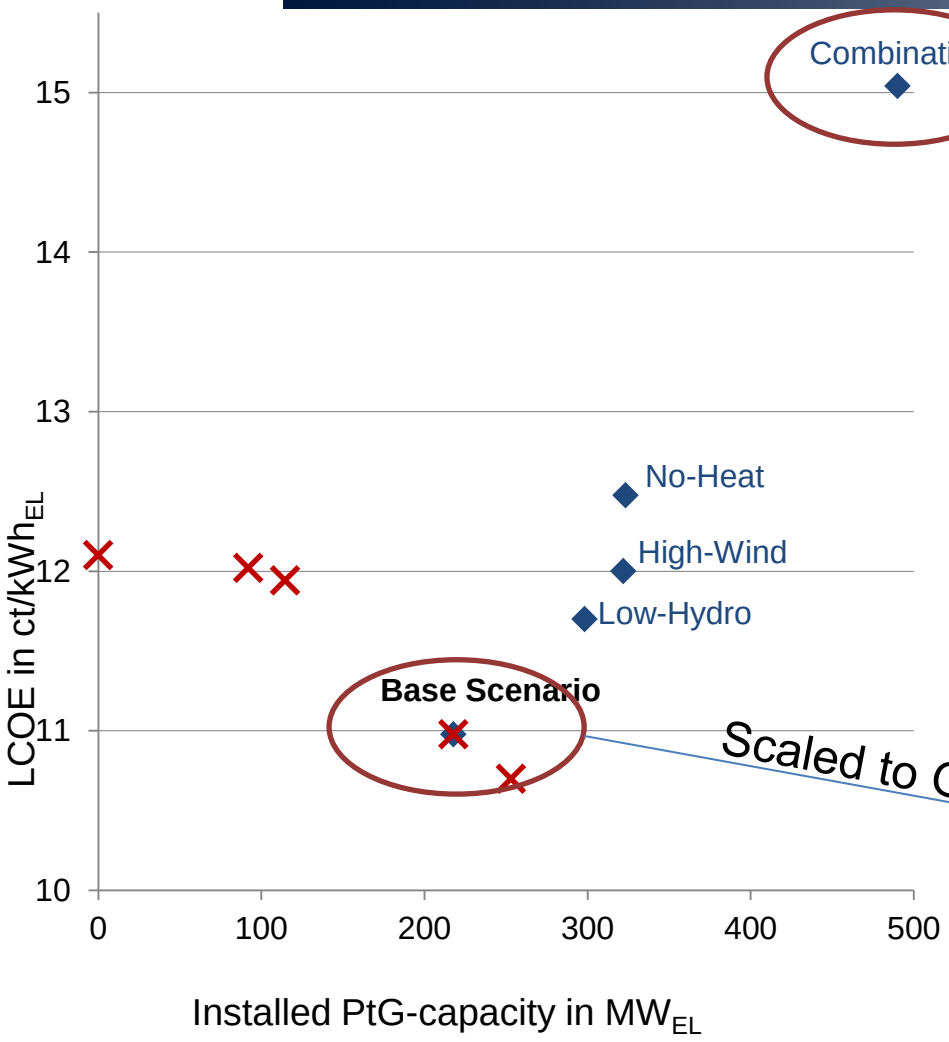
Results: Combination of the influences



Scenario closer to German state of the art:

Significantly higher need of storage!

Results: Combination of the influences



PHS inst. today:
~ 7 GW

Conclusion

A 100% RE energy supply is possible without PtG, but …

PtG is a key technology for a **cost efficient** energy supply

PtG will be needed at ~80% RE share

Thank you!

Gefördert durch:

Bundesministerium für Wirtschaft und Energie

aufgrund eines Beschlusses des Deutschen Bundestages

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Kurzporträt RLI

Zielsetzung des RLI: Anwendungsnahe Forschung zur optimalen Integration Erneuerbarer Energien in unser Energiesystem

Thematische Schwerpunkte am RLI

Mobilität und Erneuerbare Energien

Optimierte Energiesysteme

Technologie Erneuerbarer Energiesysteme

Off-Grid Inselsysteme

Querschnittsthema

- Konzeption und Begleitung von Transformationsprozessen