Effects of heat demand integration into a European energy systems model

David Huckebrink

RUB

Lehrstuhl
Energiesysteme &
Energiewirtschaft
Prof. Dr. Valentin Bertsch

Outline

- Motivation
- Methods & Data
- Results
- Limitations
- Conclusion & Outlook

Motivation

- Rapid decarbonisation of all energy sectors urgently needed
- Isolated optimisation might distort vision of desirable system
- Interaction between sectors can provide synergy

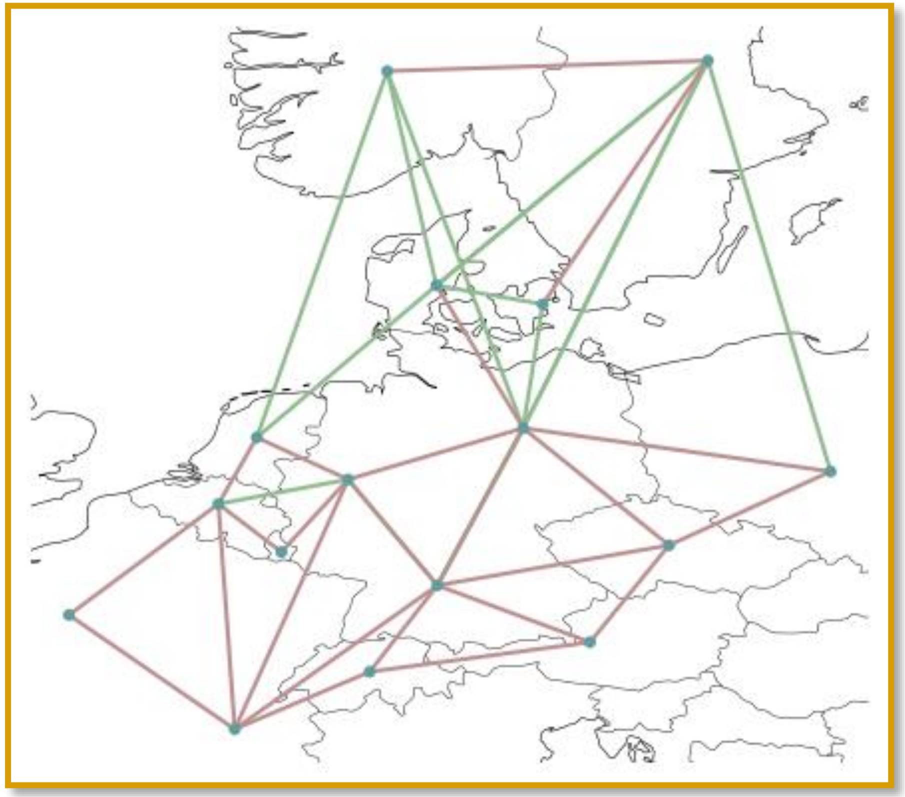
Goal:
Integrated model of
power and heating sector

Integration of heat demand → Modelling thermal inertia → Assessing climate uncertainty

Data

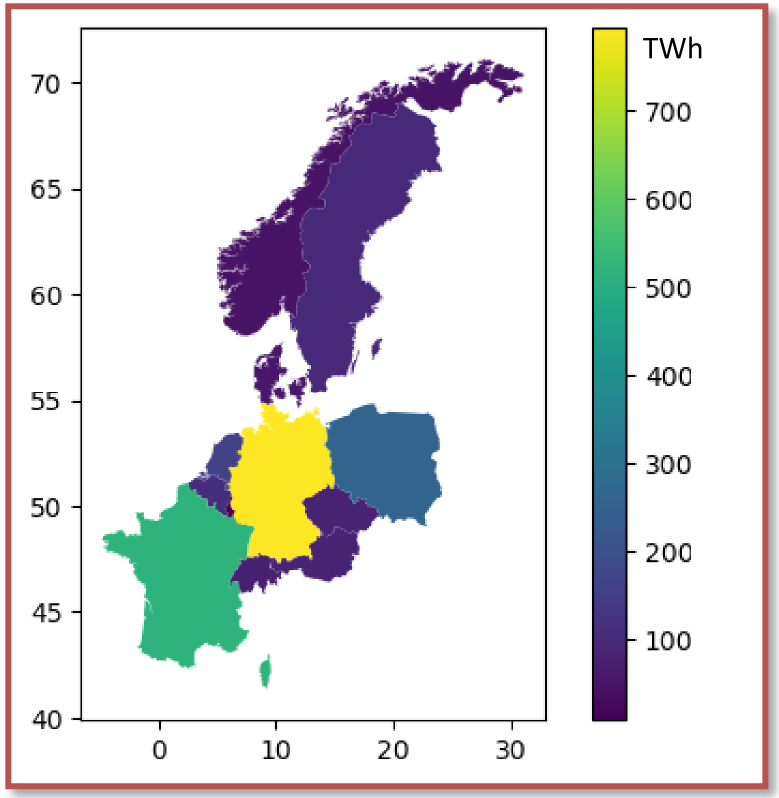
PyPSA-eur[1] (DE + Neighbours)

Electricity: Demand, generation, grid (AC/DC)



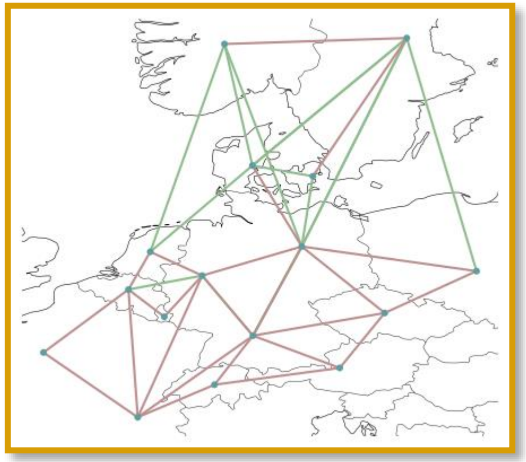
HotMaps[2]

Heat: Demand, generation

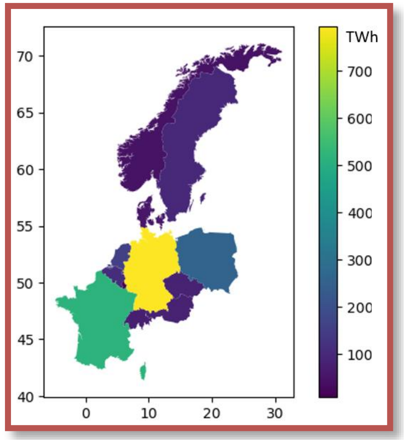


1. Hörsch et al. PyPSA-Eur: An open optimisation model of the European transmission system. Energy Strategy Reviews, 22:207-215, 2018. arXiv:1806.01613, doi:10.1016/j.esr.2018.08.012.
2. Pezzutto et al. Hotmaps, D2.3 WP2 Report – Open Data Set for the EU28, 2019

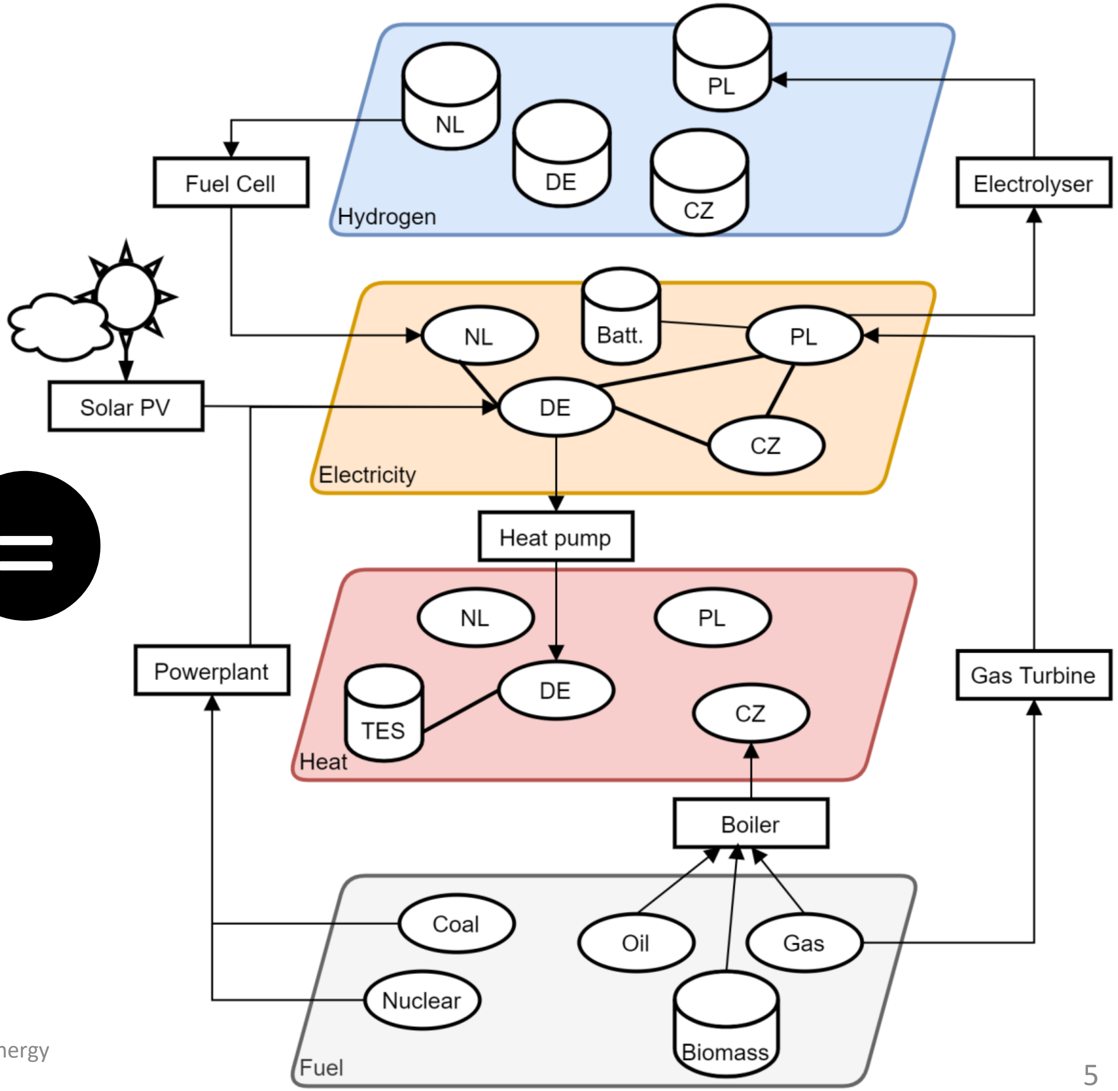
Method – Modelling framework: Backbone[3]



+



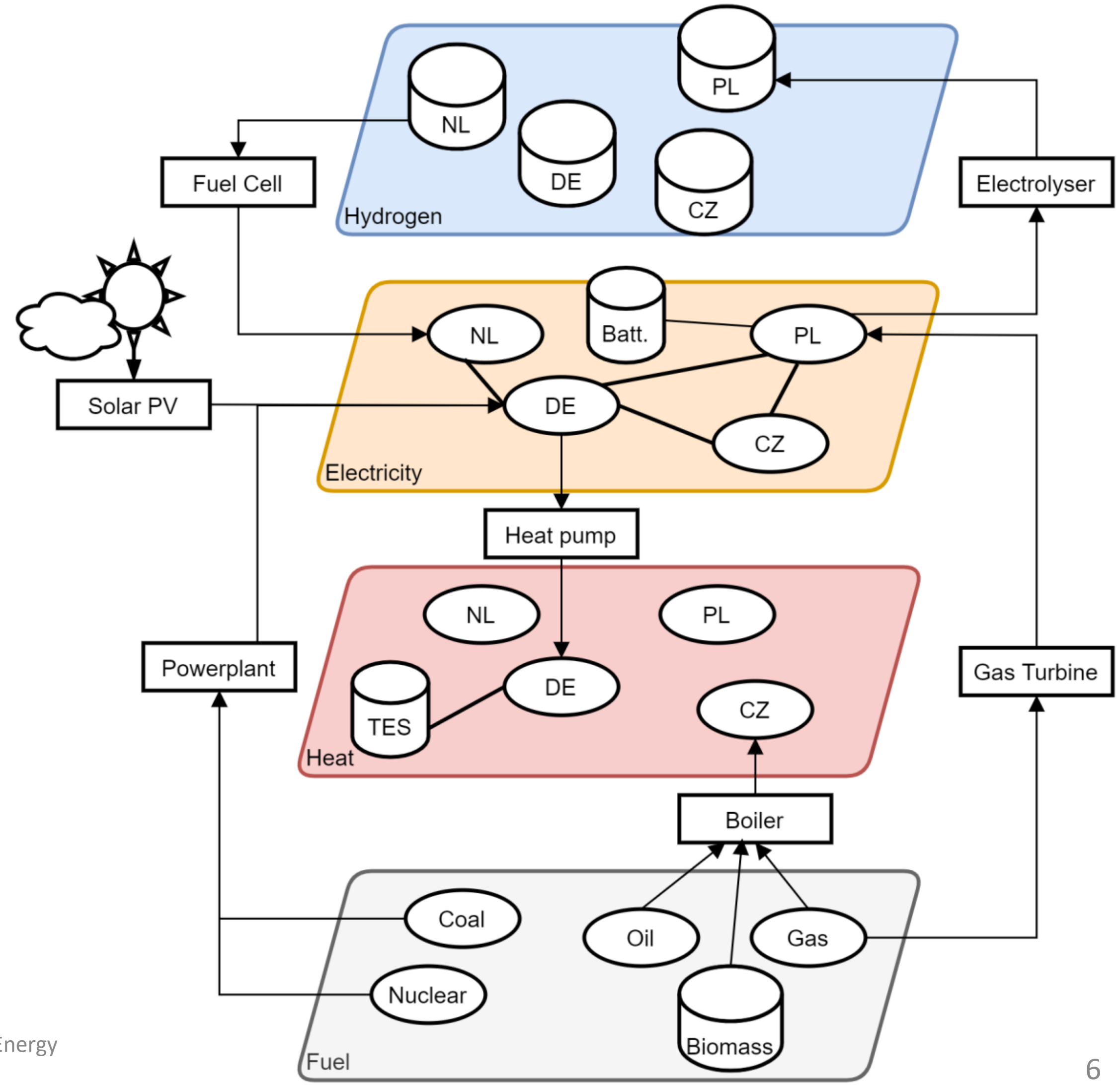
=



3. Helistö N, Kiviluoma J, Ikäheimo J, Rasku T, Rinne E, O'Dwyer C, Li R, Flynn D. Backbone—An Adaptable Energy Systems Modelling Framework. Energies. 2019; 12(17):3388. https://doi.org/10.3390/en12173388

Method – Modelling framework: Backbone[3]

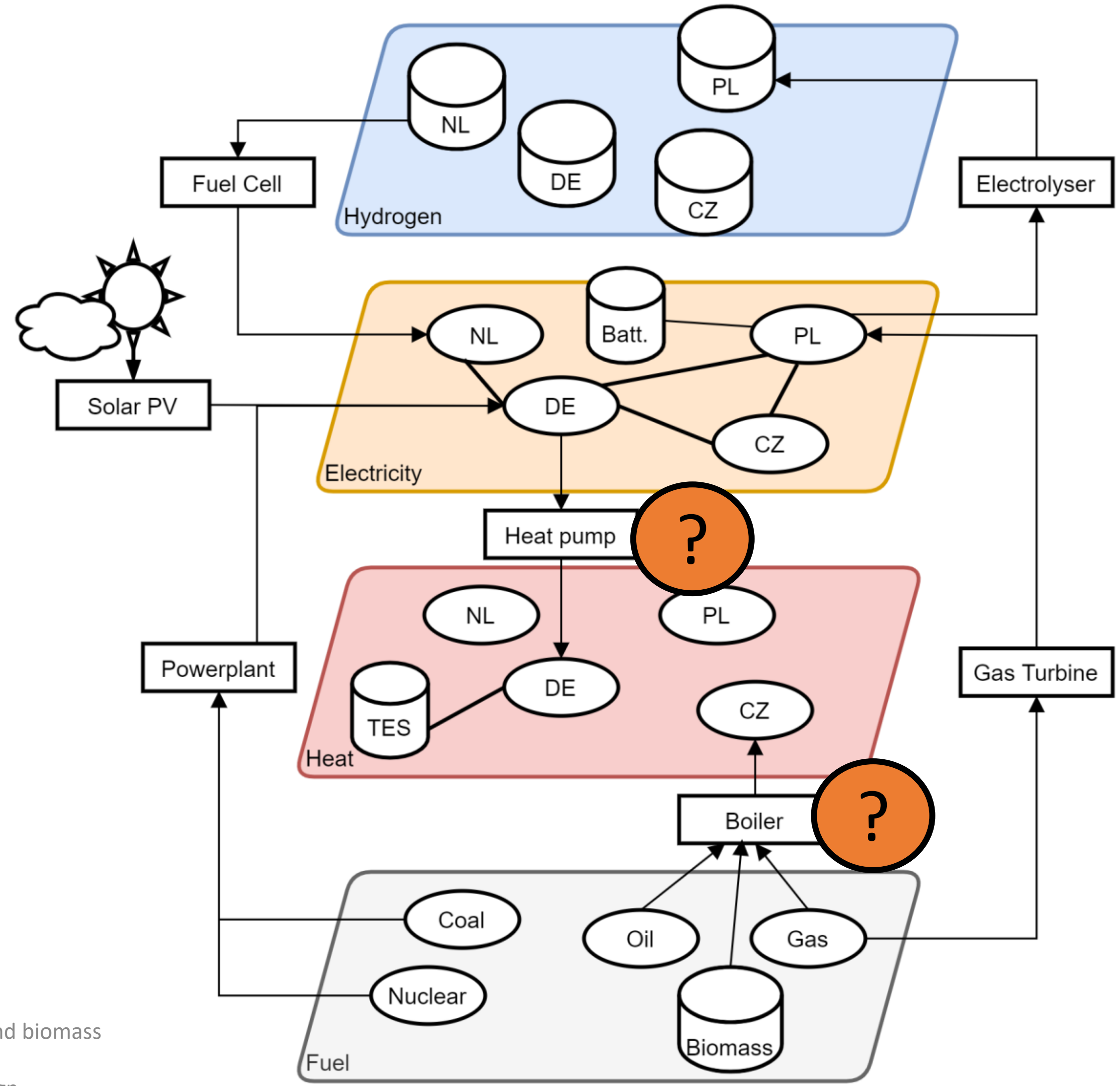
- **Grids** group **nodes** with similar types of energy
- **Nodes** can have a state and introduce demands
- **Units** transform energy between **nodes**



3. Helistö N, Kiviluoma J, Ikäheimo J, Rasku T, Rinne E, O'Dwyer C, Li R, Flynn D. Backbone—An Adaptable Energy Systems Modelling Framework. Energies. 2019; 12(17):3388. https://doi.org/10.3390/en12173388

Method – Models & Assumptions

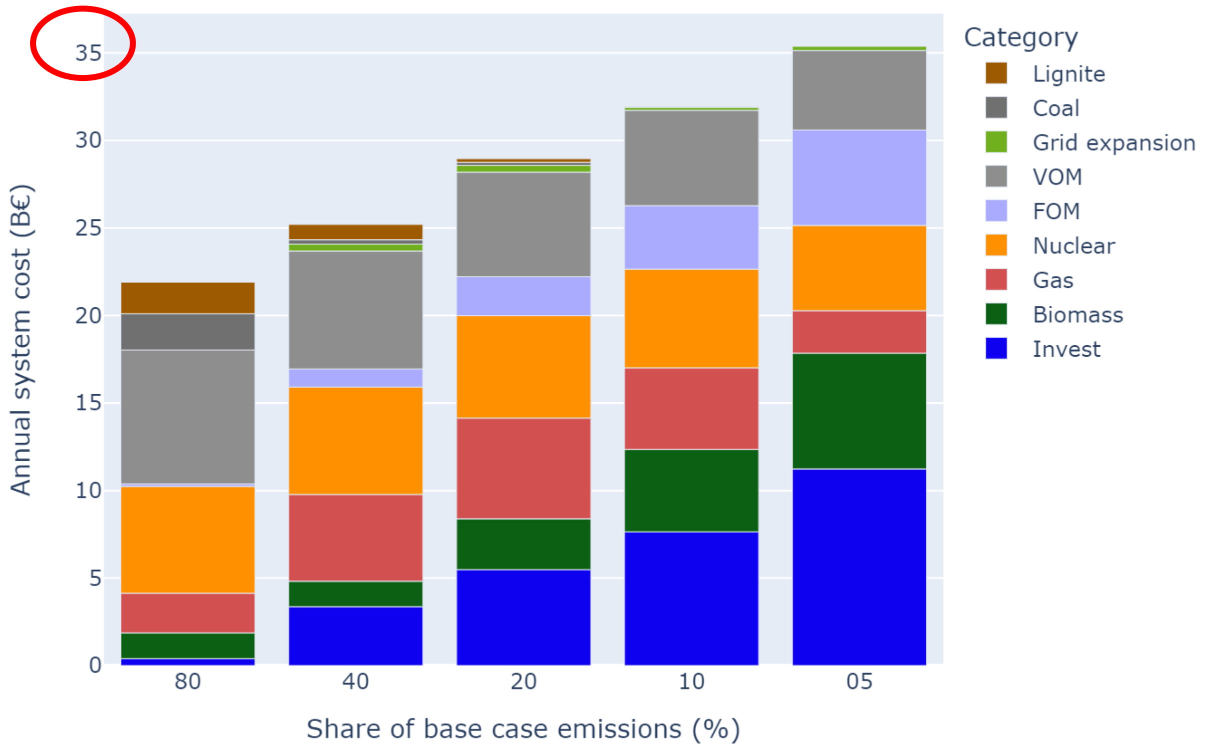
- Two models: **electricity only** and **integrated heating**
- Heating capacities determined through pre-solve
- Fuels are limitless, biomass is limited to "sustainable" origin[4]
- Time-series are aggregated to three typical weeks[5]
- Emissions are constrained down to 5% of base case



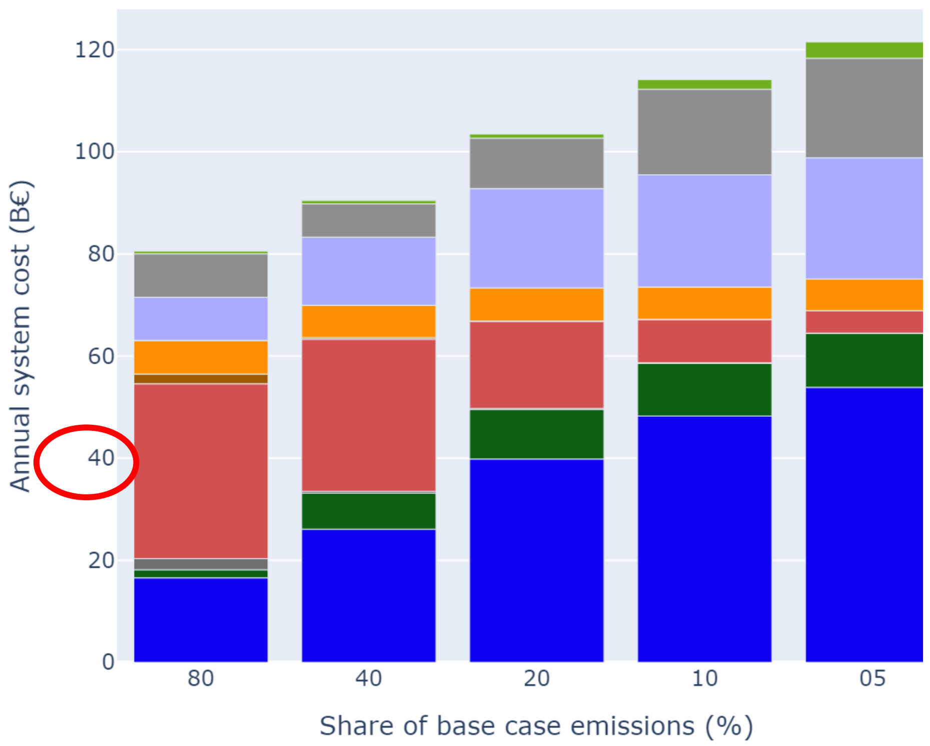
4. Ruiz et al. (2019): ENSPRESO - an open, EU-28 wide, transparent and coherent database of wind, solar and biomass energy potentials, Energy Strategy Reviews, 26, https://doi.org/10.1016/j.esr.2019.100379.
5. Kotzur et al. (2018): Impact of different time series aggregation methods on optimal energy system design

Results – System cost

Electricity only

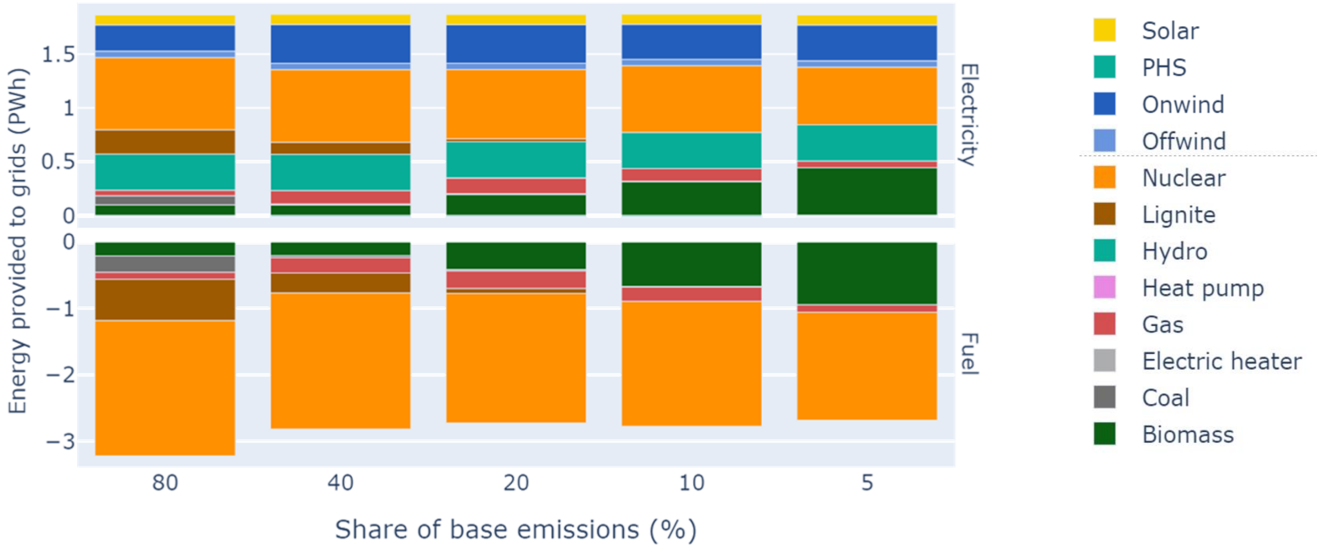


Integrated heating

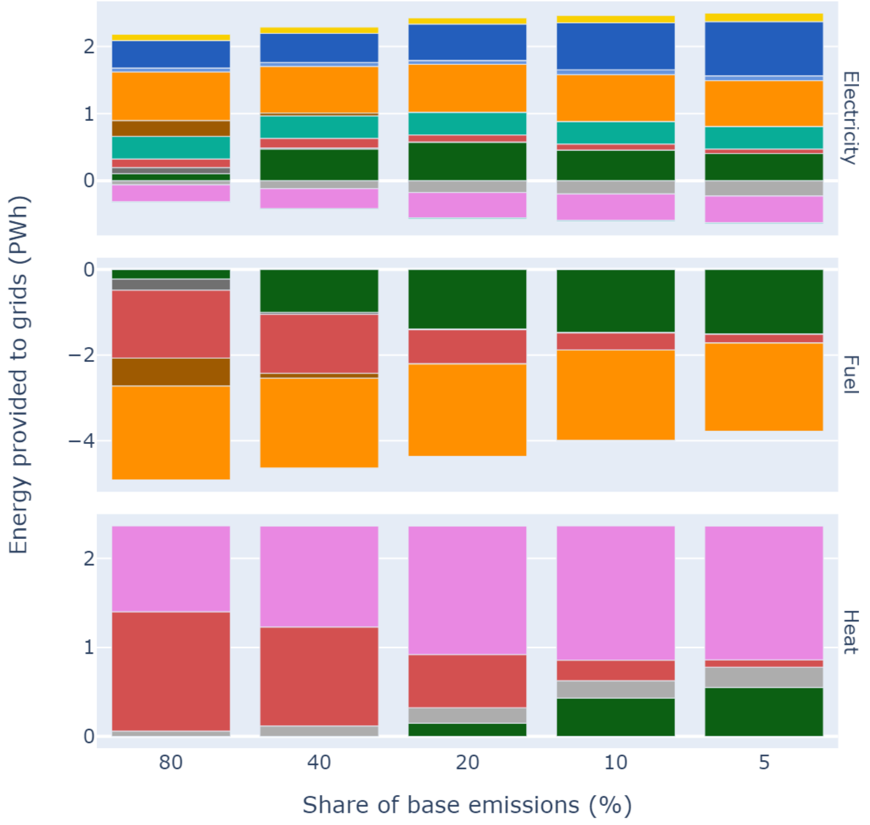


Results – Energy provision

Electricity only



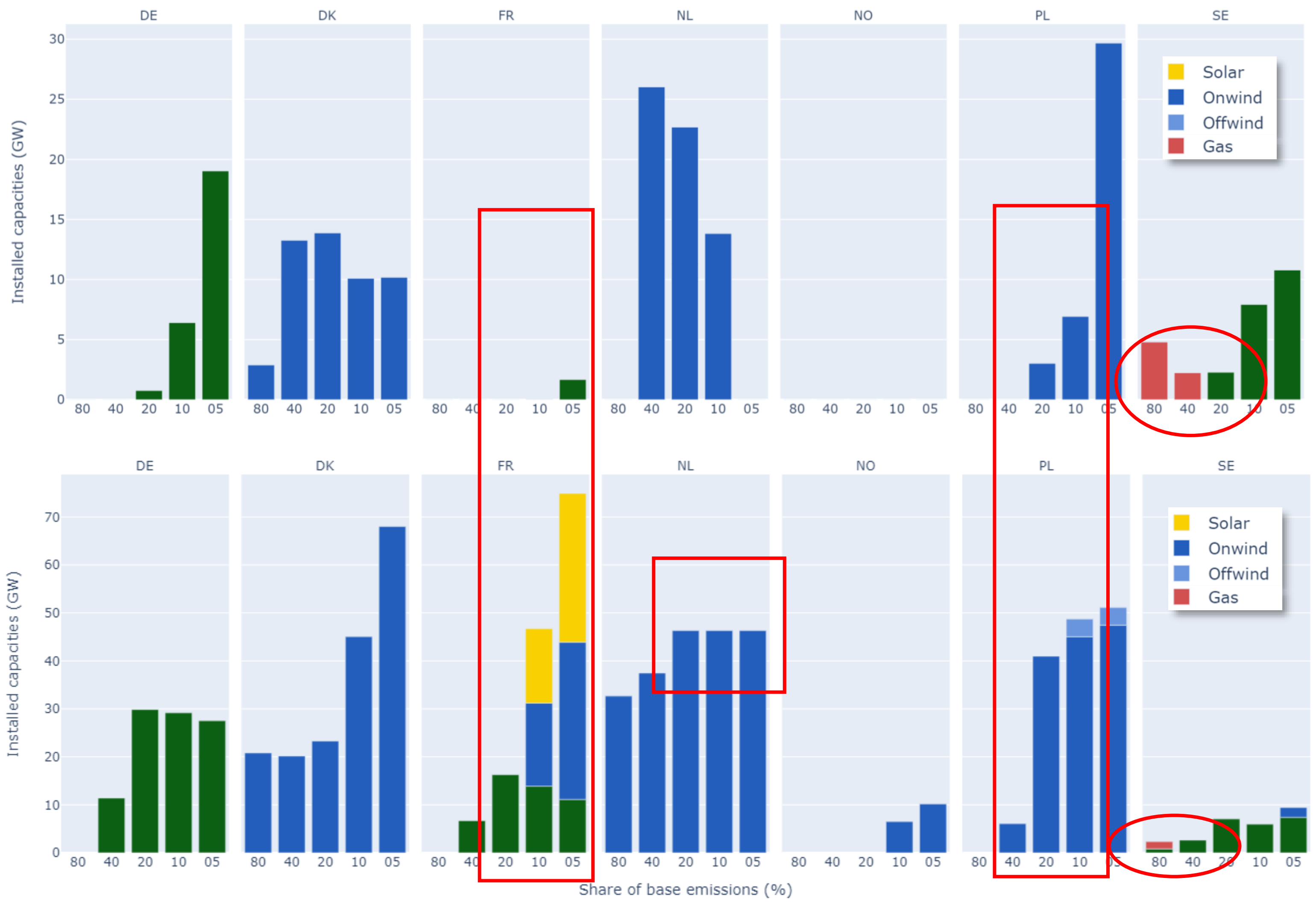
Integrated heating



Results – Installed capacities (for electricity)

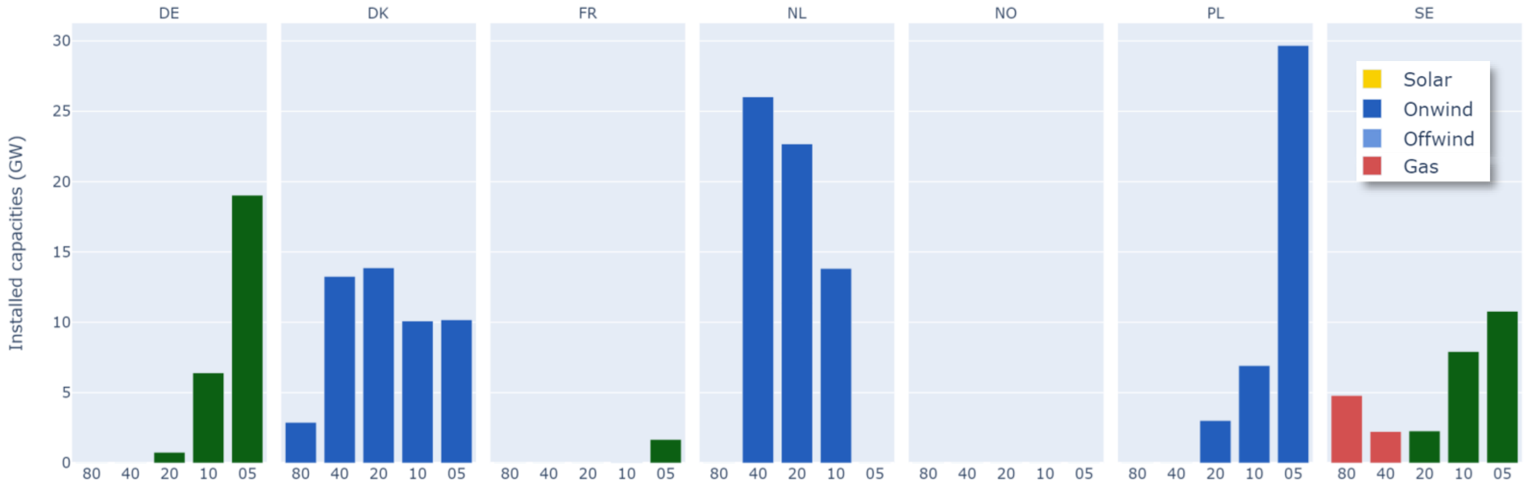
Electricity only

Integrated heating

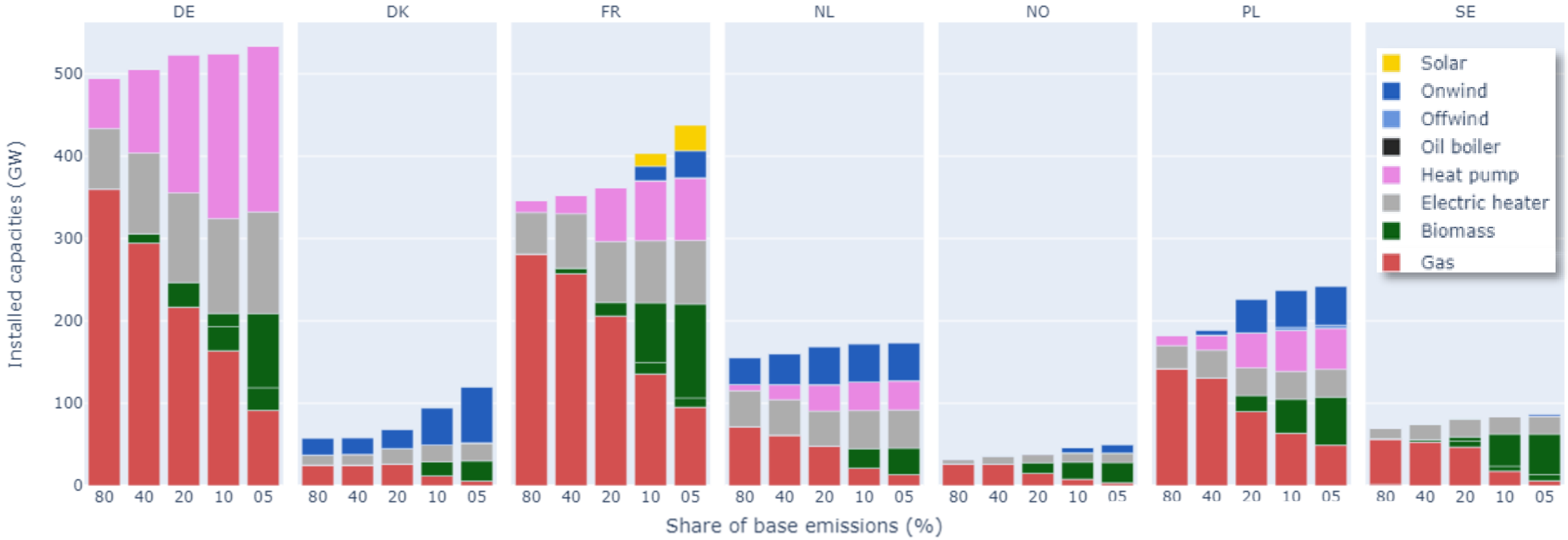


Results – Installed capacities (incl. heating)

Electricity only

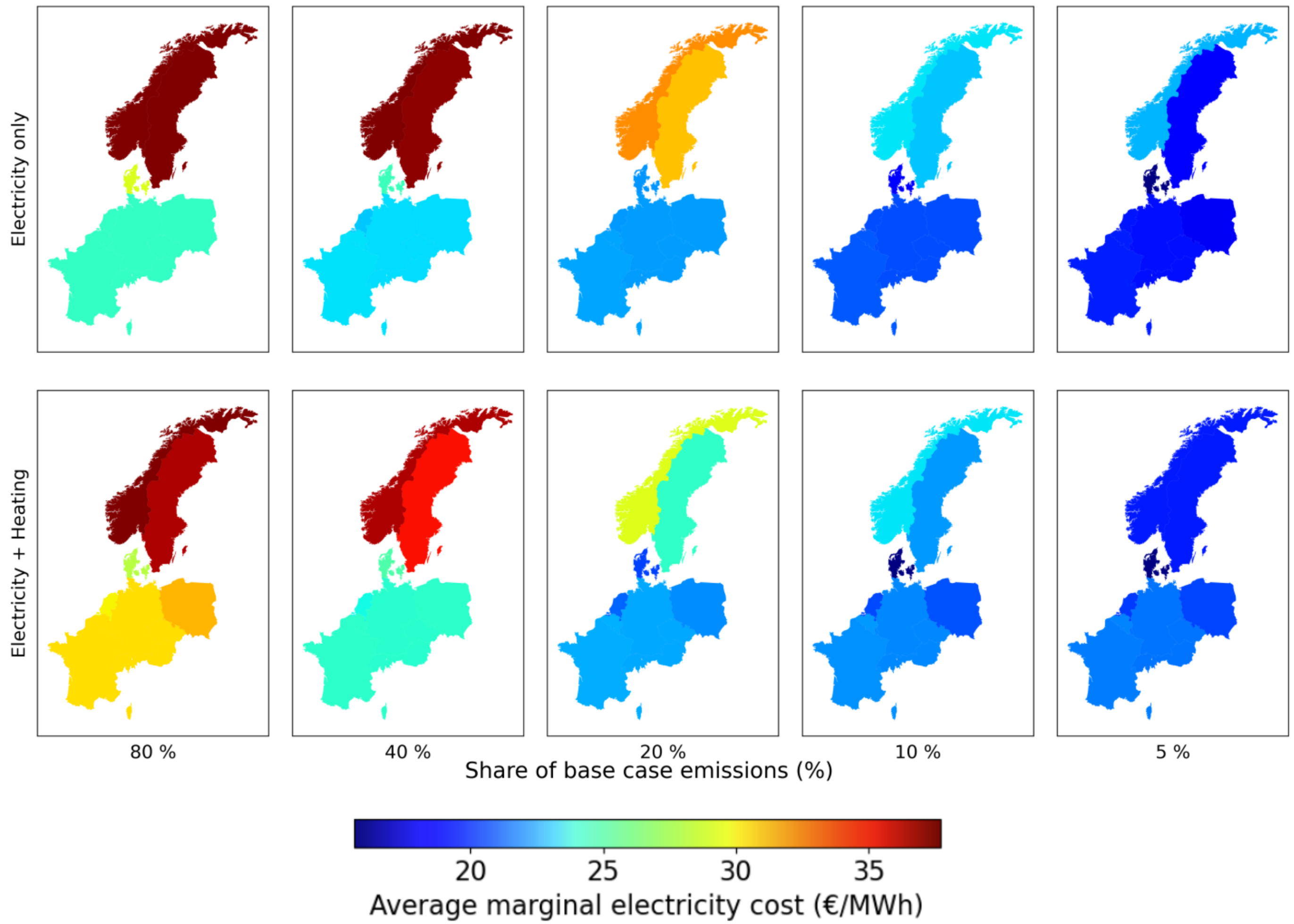


Integrated heating



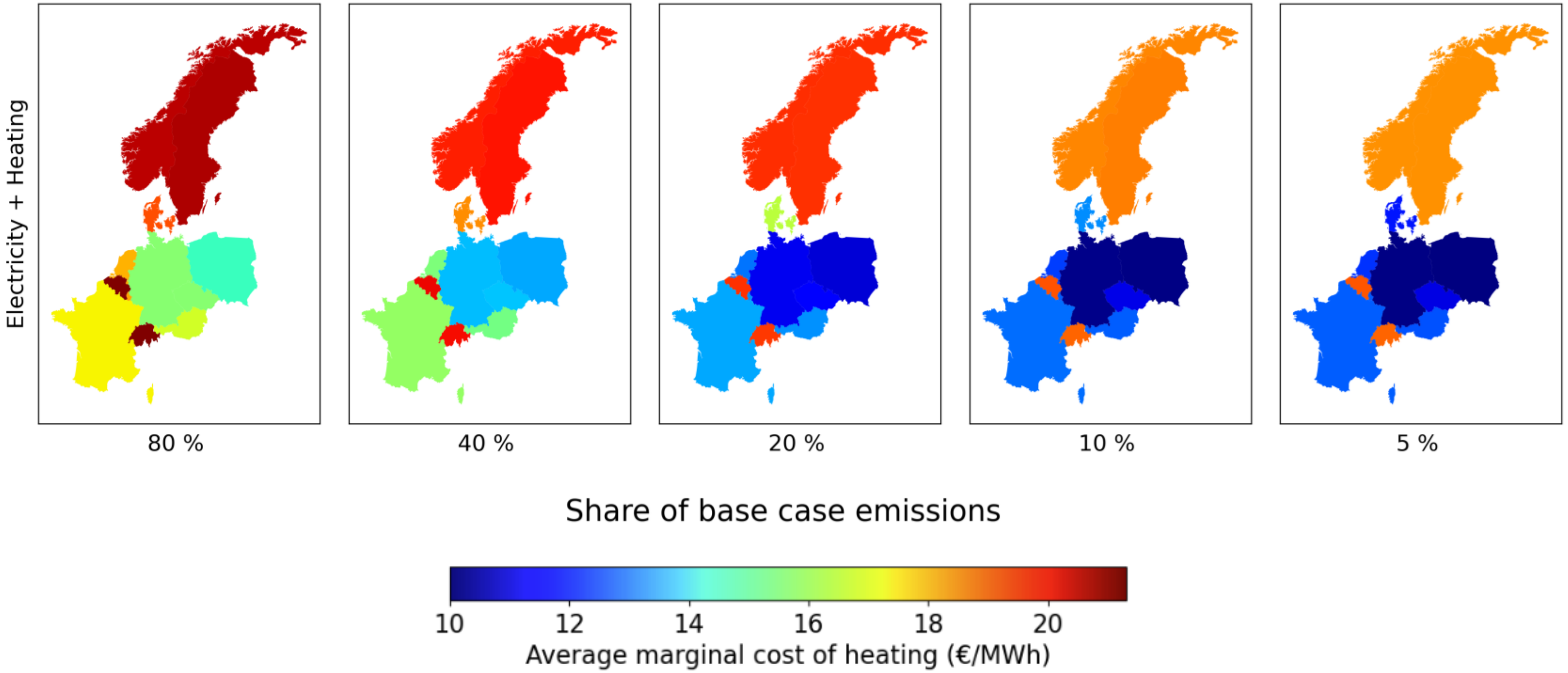
Results – Marginal cost of electricity

- Costs decrease with decreasing emissions
  - Faster in northern than in central EU
- Costs start higher with added heating demand
  - But drop below the electricity only scenario
- Difference reduces with decreasing emissions



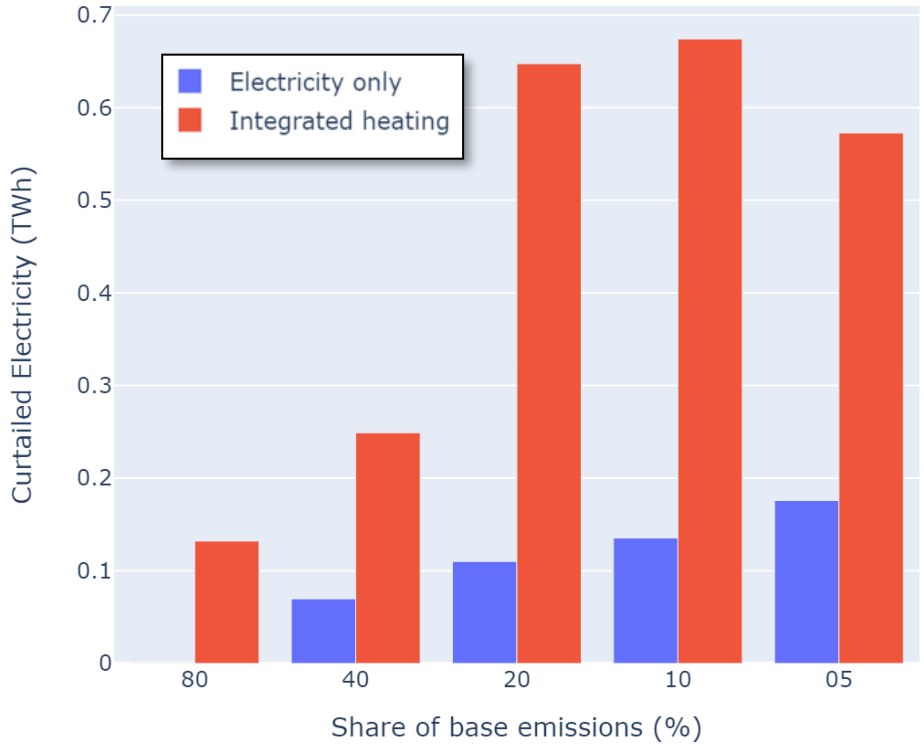
Results – Marginal cost of heating

- Cost decrease with decreasing emissions
- But stagnate from 10% to 5%



Results - Curtailments

- Integration of heating displays more curtailment in general
- Reduction visible at low emissions
- Does not match expectation: More flexibility should reduce curtailment



Limitations

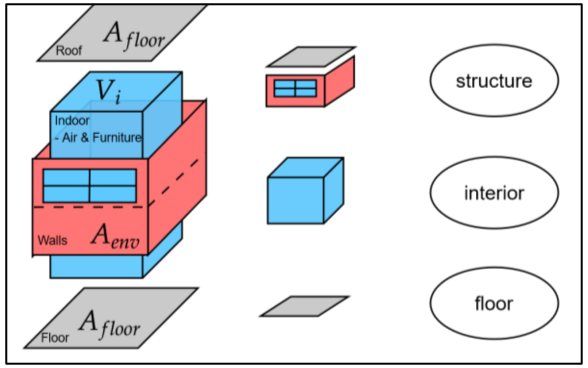
- No thermal energy storages
- Lossless transmission underestimates costs
- Three “typical weeks” might be very optimistic (no storage)
- District heating, CHP (& other heat sources) not yet implemented

Conclusion

- Gas and biomass move from electricity to heating
- Hydrogen and battery storages available but not used
- Integrated analysis calls for even larger RES investments
  - These lead to lower prices → Might have adverse effects on profitability

Outlook

- Implementation of missing technologies



Integration of heat demand → Modelling thermal inertia → Assessing climate uncertainty

Thank you for your attention!

huckebrink@ee.rub.de

RUB

EE Lehrstuhl Energiesysteme & Energiewirtschaft
Prof. Dr. Valentin Bertsch