

Erneuerbaren-Projektfinanzierung in einem System mit null Grenzkosten?

Renewable project finance in a system with zero marginal costs?

FRANCO-GERMAN ENERGY FORUM
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Prof. Dr. Kurt Rohrig

Fraunhofer-Institut für Energiewirtschaft und Energiesystemtechnik

Fraunhofer-Institut for Energy Economics and Energy System Technology



Our service portfolio deals with **current and future challenges** faced by the **energy industry** and **energy system technology** issues.

We explore and develop **solutions** for sustainably transforming **renewable based energy systems**.

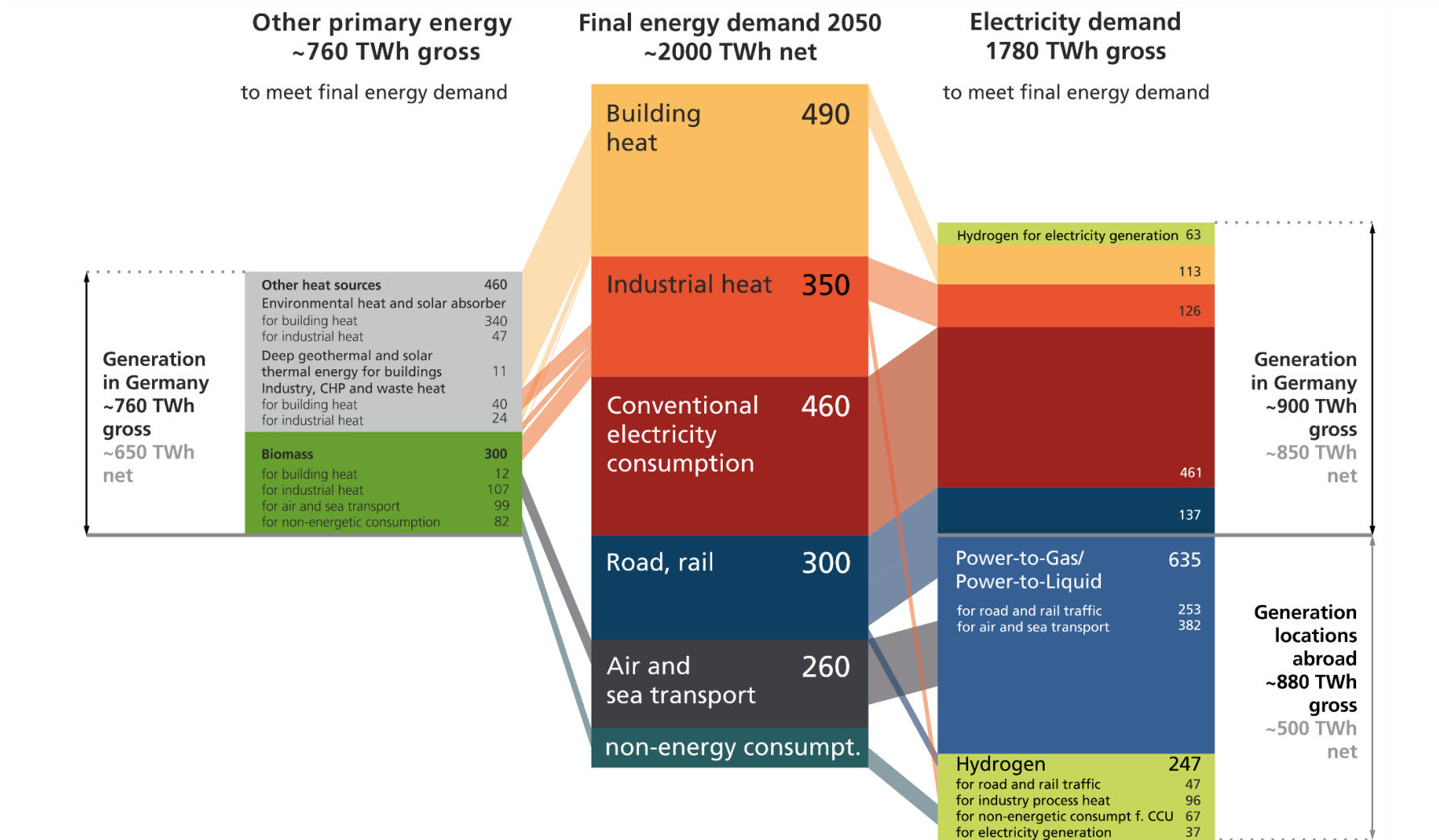


- Personal: about 430
 - Annual budget 28 Mio. EUR
 - Director Prof. Dr. Kurt Rohrig
- www.iee.fraunhofer.de

Agenda

- Introduction
- Energy-only-Market / Merit-Order
- Wholesale Market Clearing Price

Electricity Generation and Demand in Germany 2050

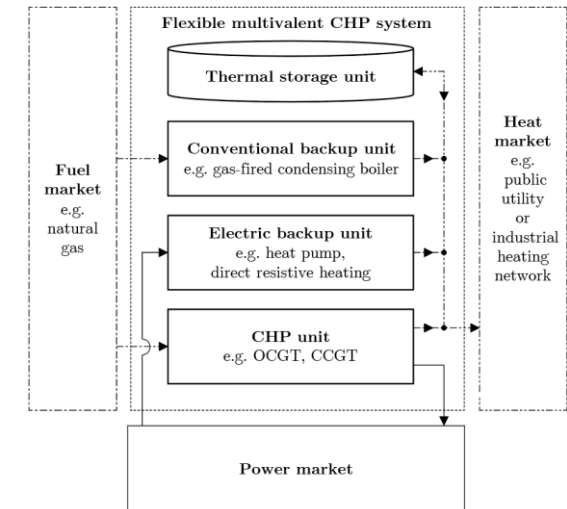
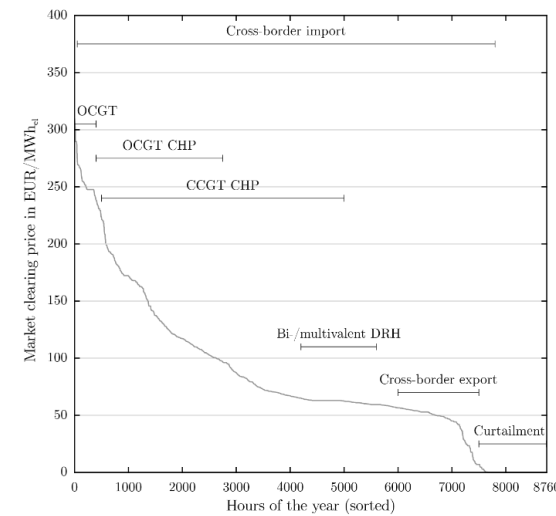
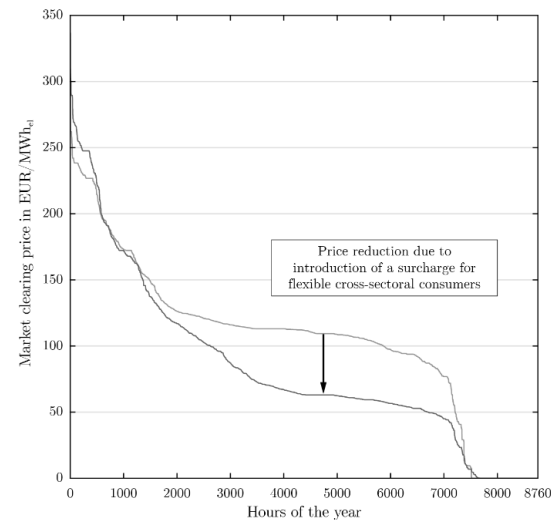


Cross-sectoral demand-bidding for price setting effects in low-carbon power systems

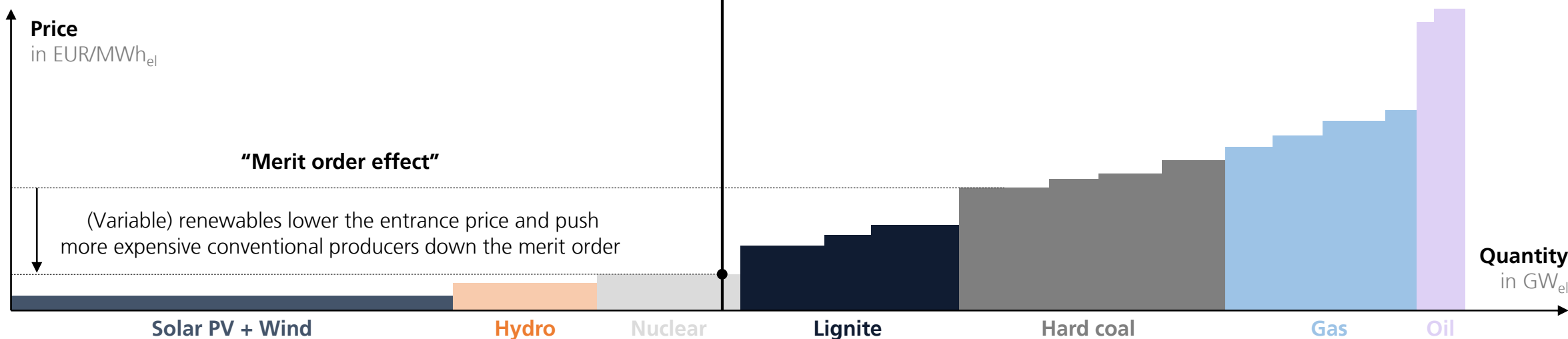
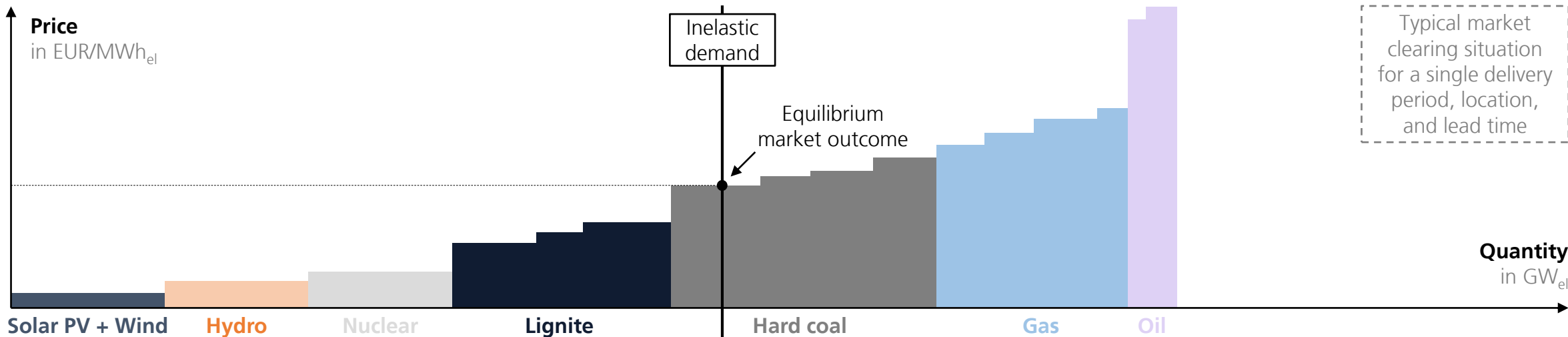


Main outcomes

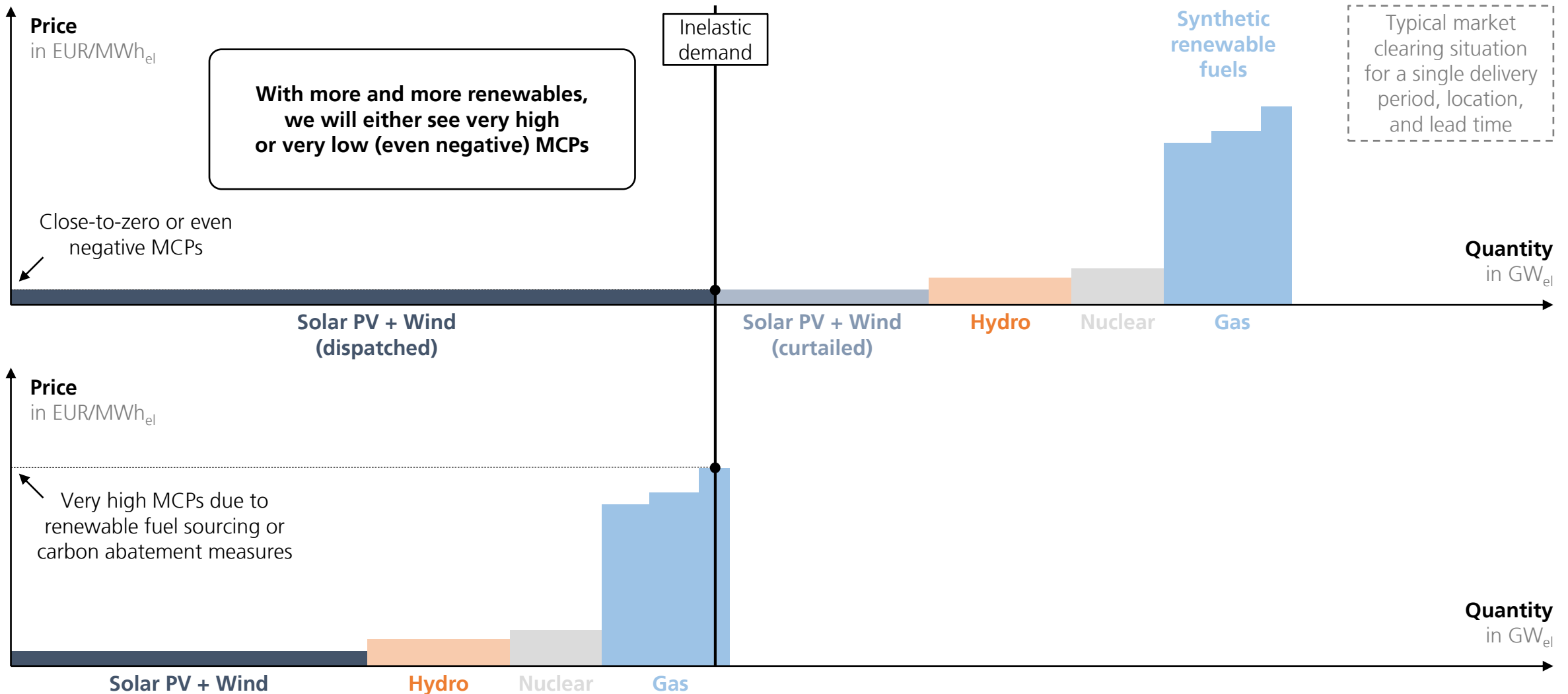
- Explicit modelling of **cross-sectoral demand bidding crucial for electricity price formation** in low-carbon power markets
- Hybrid **cross-sectoral consumers limit the role of zero or even negative prices** in integrated systems dominated by renewables
- Future electricity market clearing requires **capturing of sector interactions** and a variety of **technology combinations**



"Merit order effect"

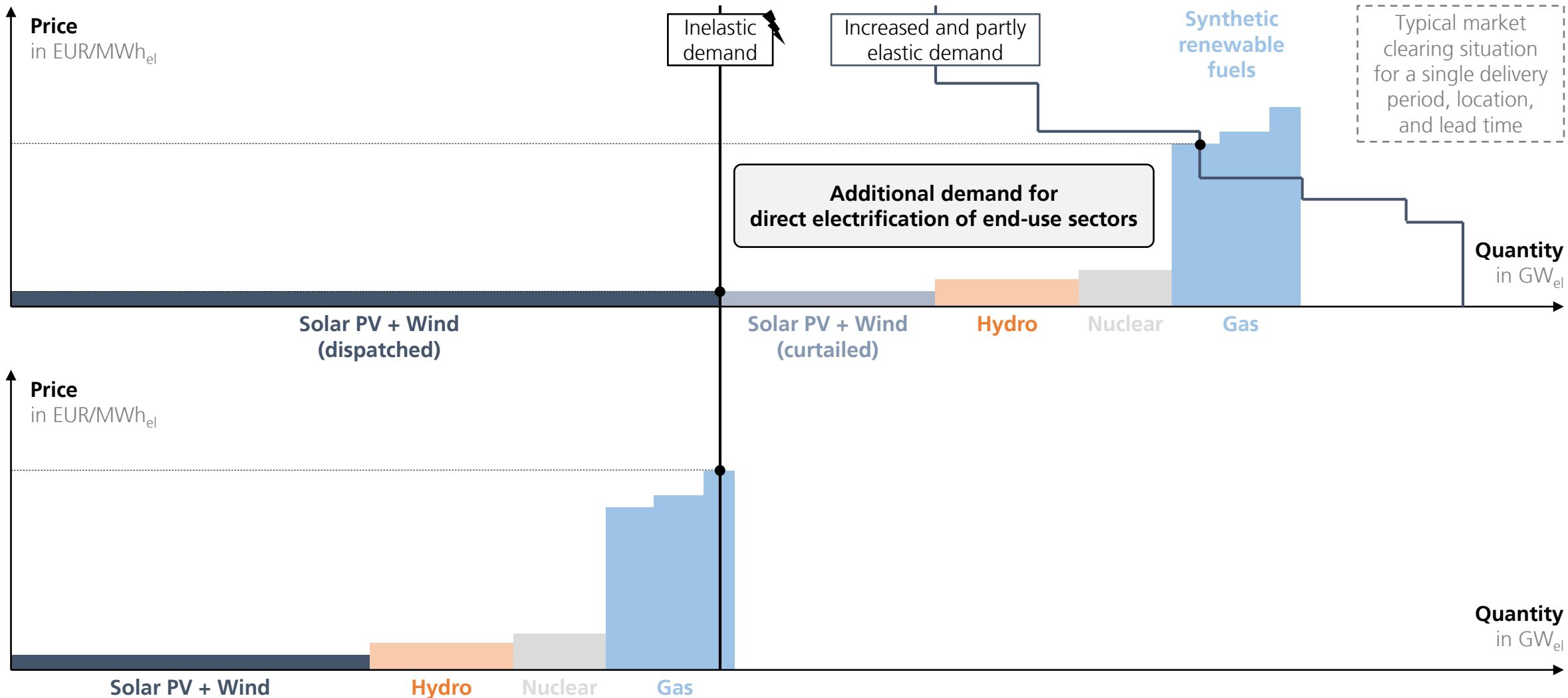


High and low clearing prices

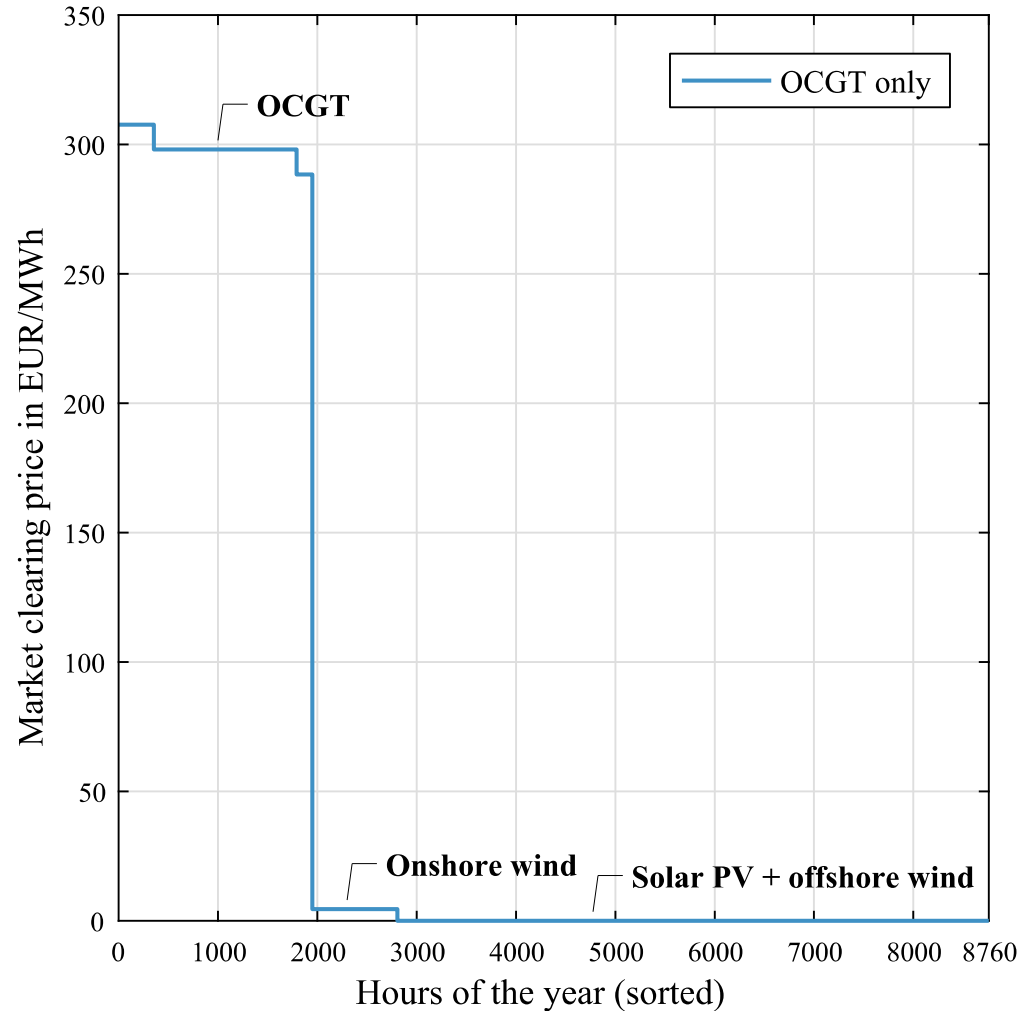


MO effect

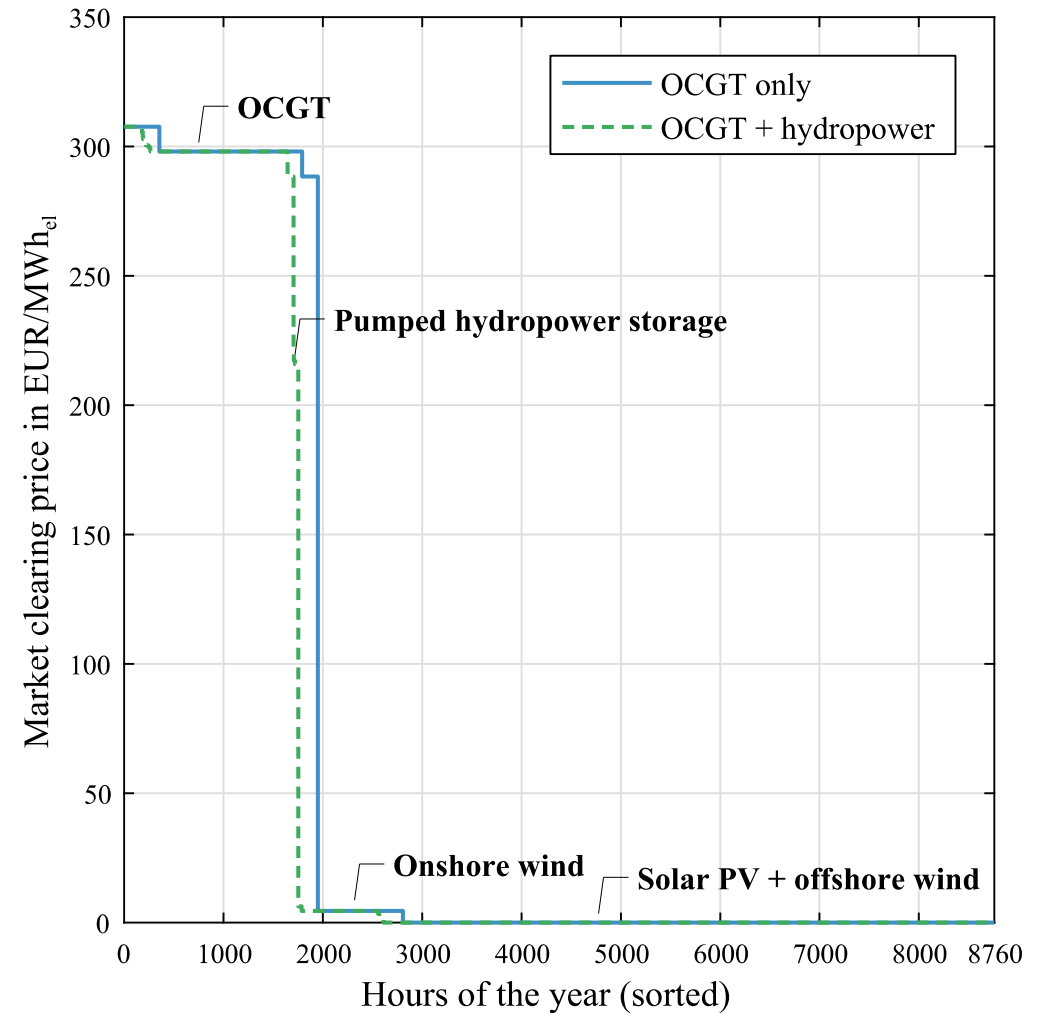
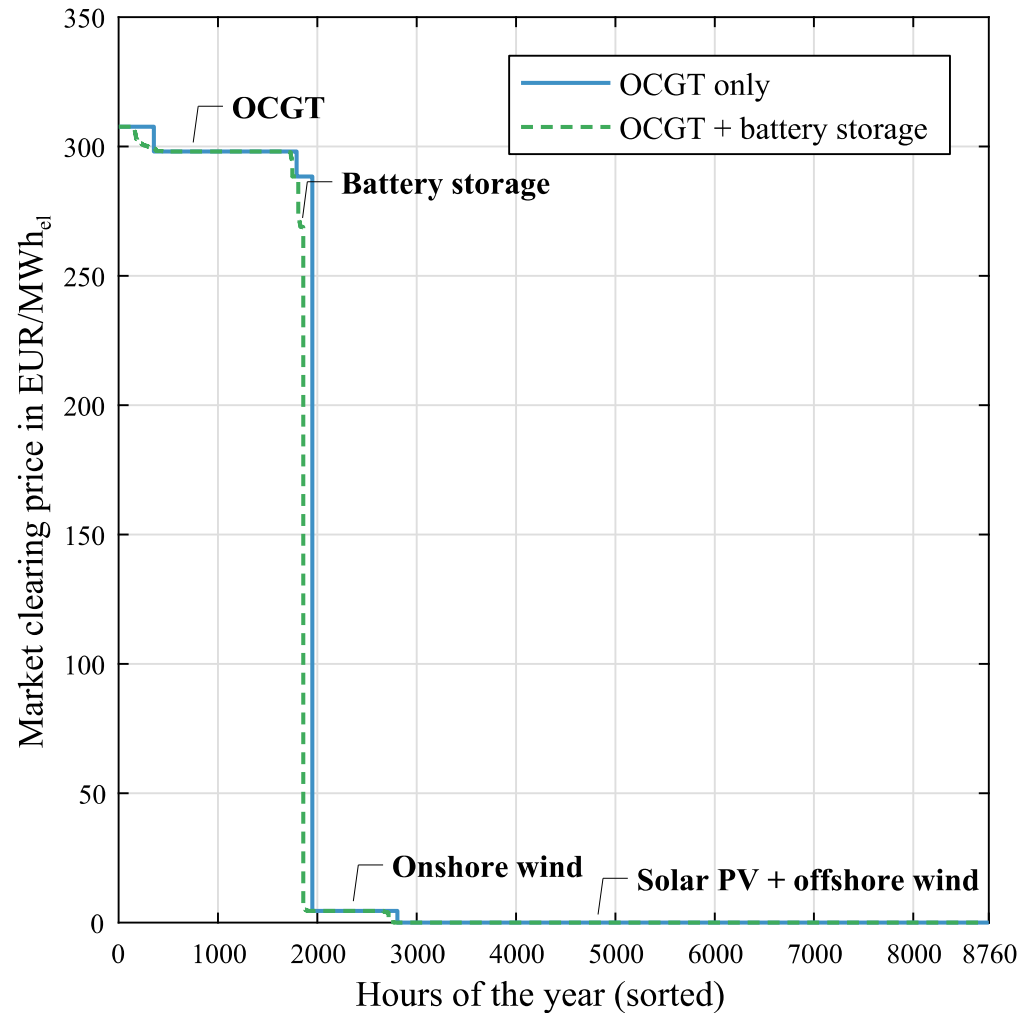
Inelastic demand versus increasing sector integration



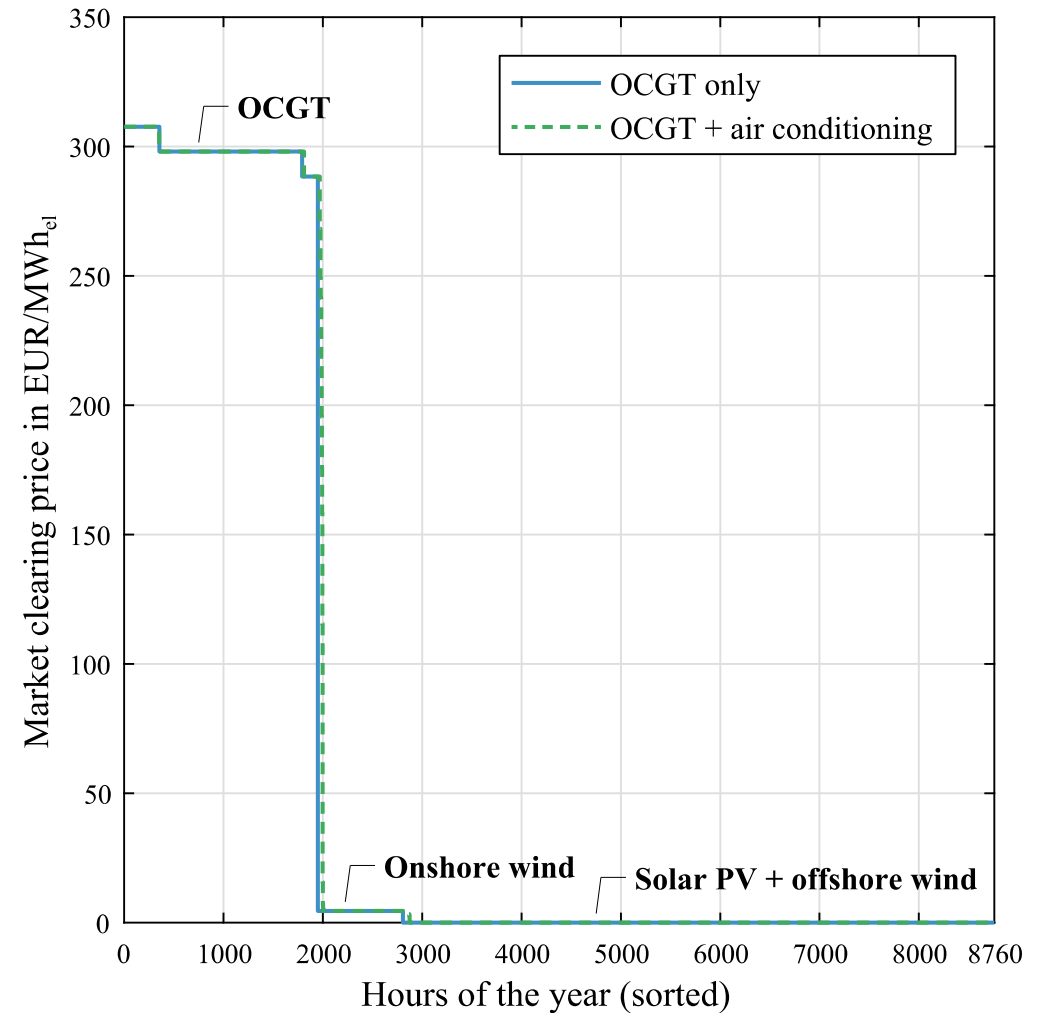
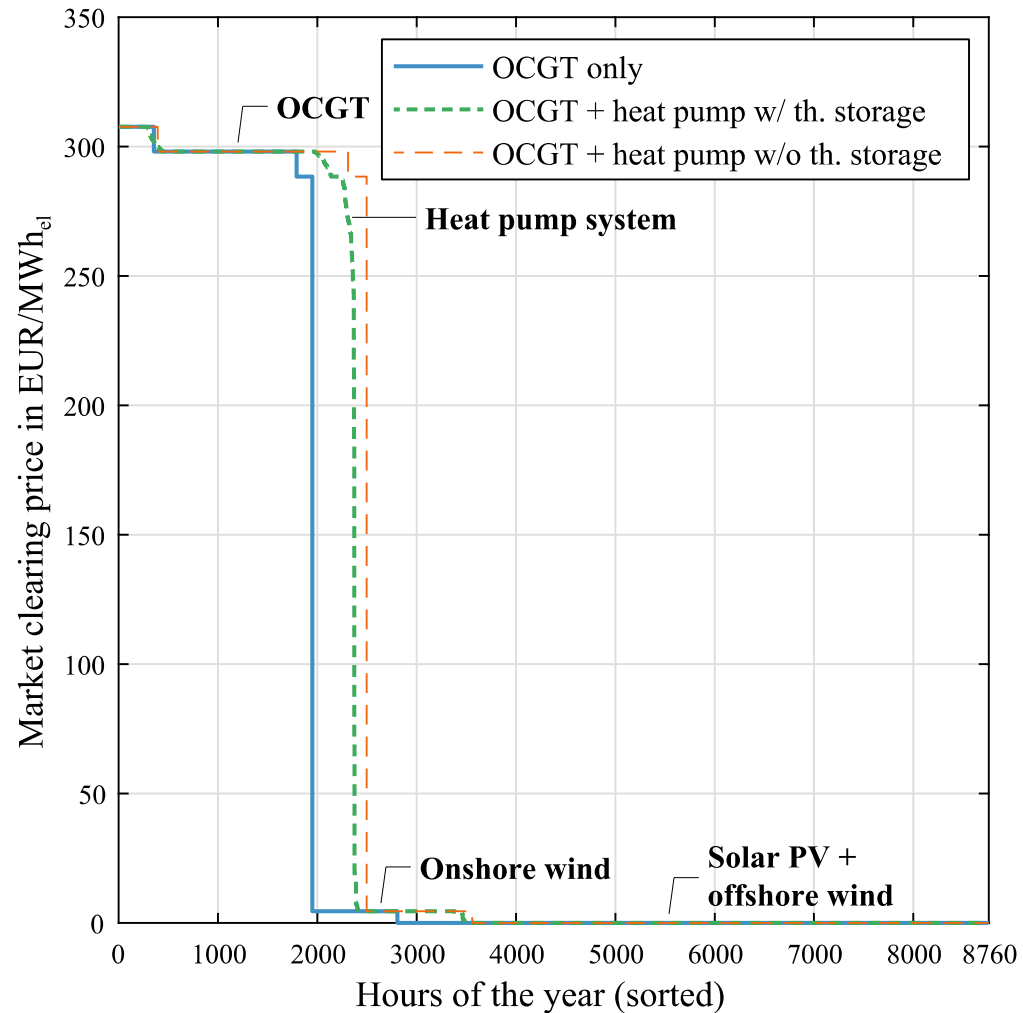
Wholesale market clearing prices in a stylised German market arrangement - RES and OCGTs (Base Case)



Wholesale market price impact of additional power sector flexibility options

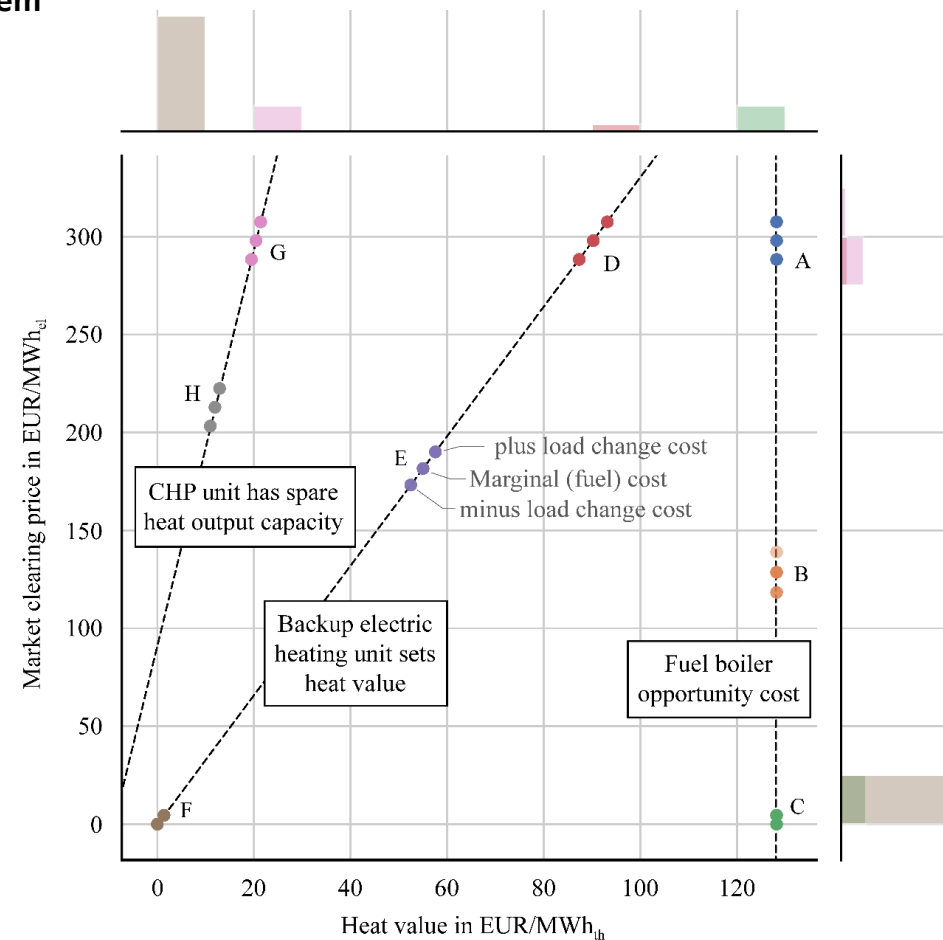
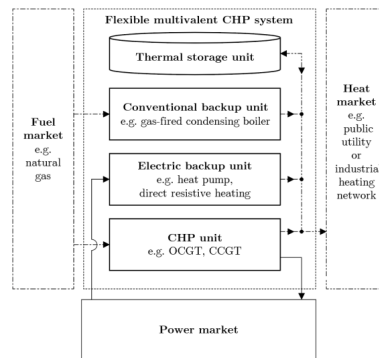
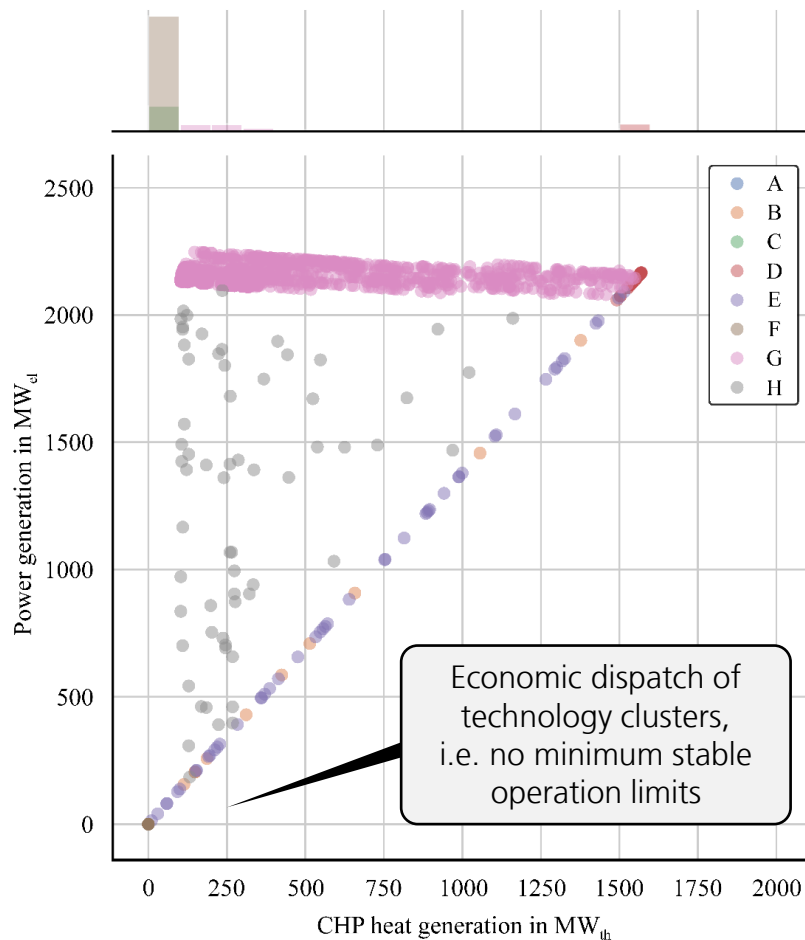


Wholesale market price impact of additional heating/cooling flexibility options

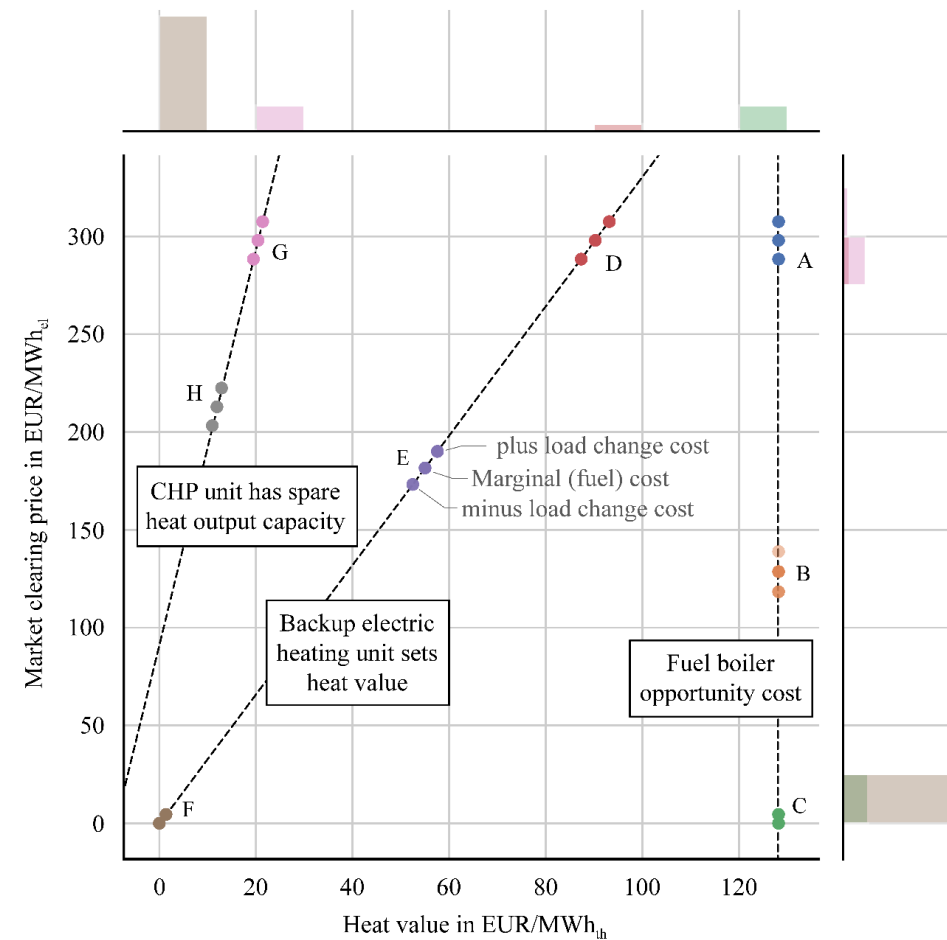
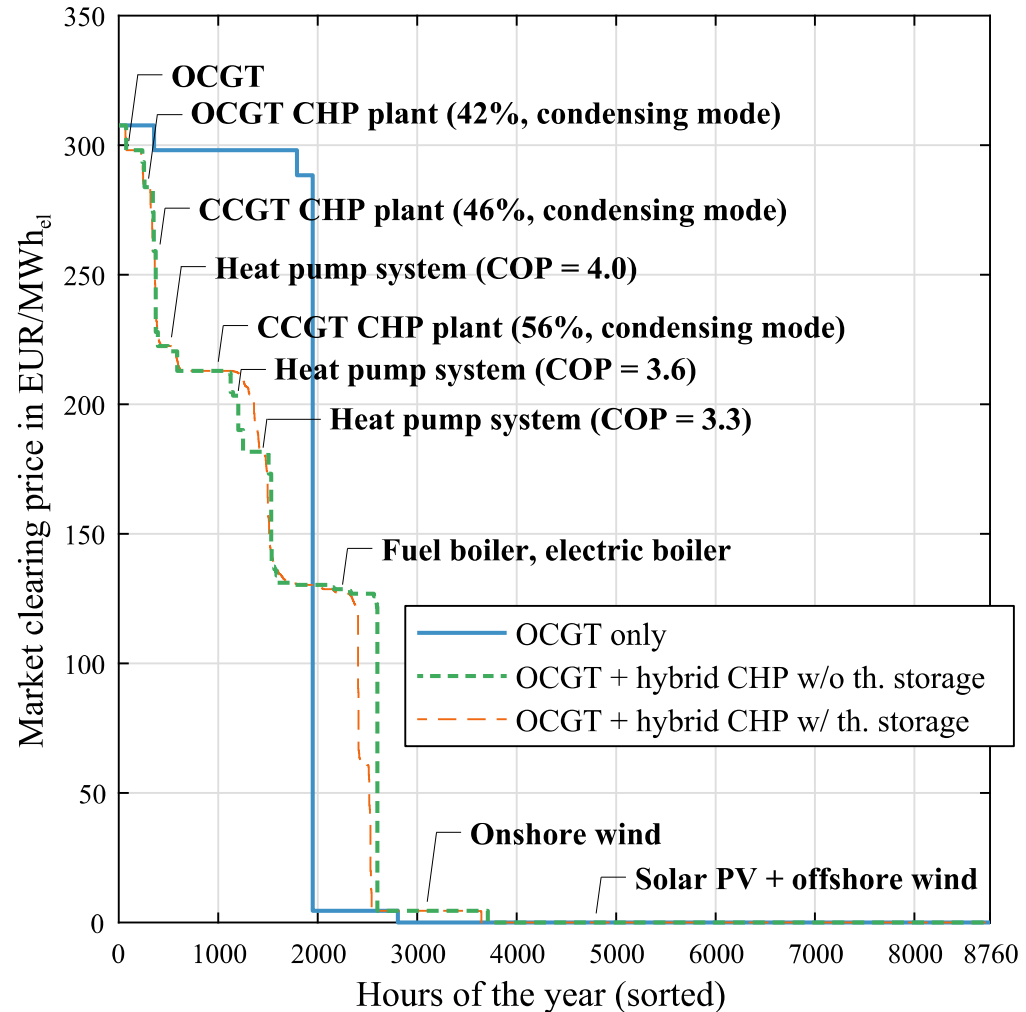


Different operating states of flexible hybrid CHP systems

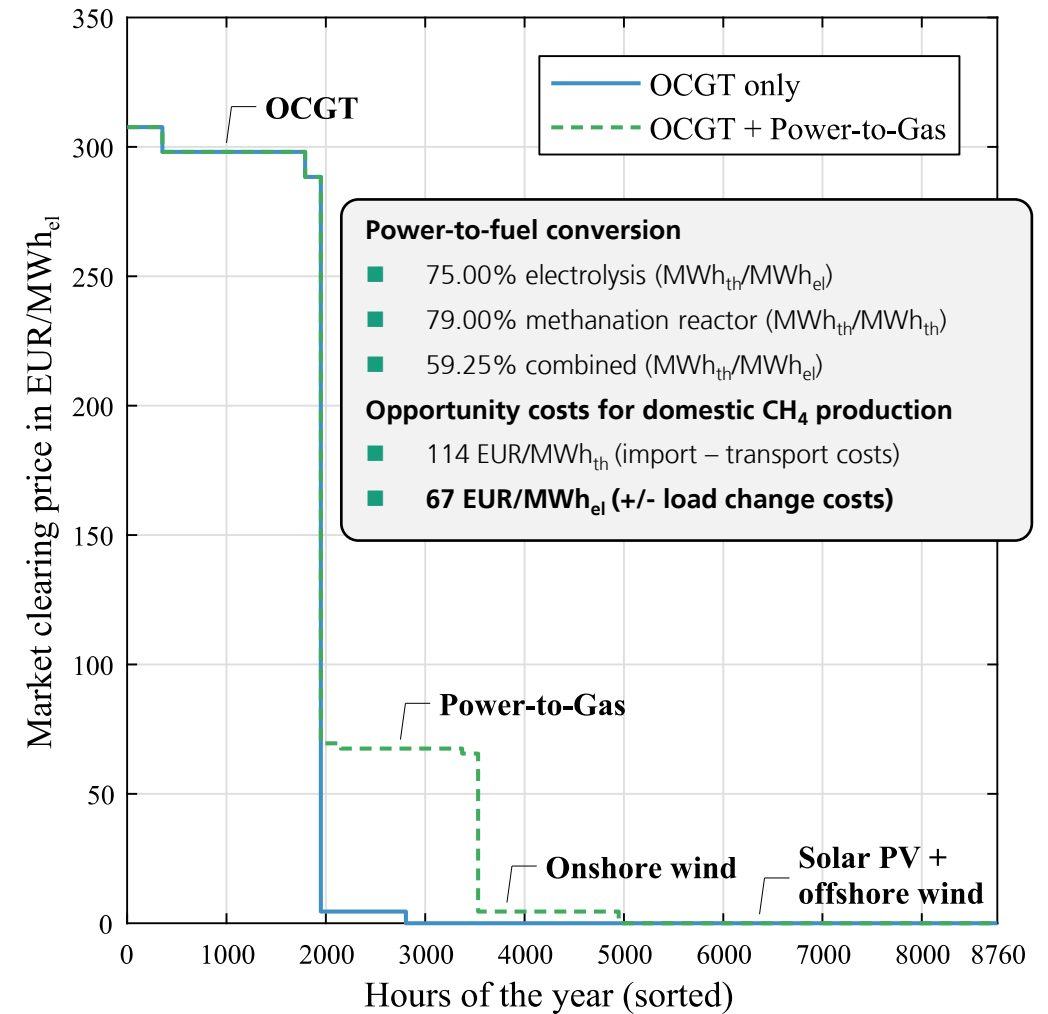
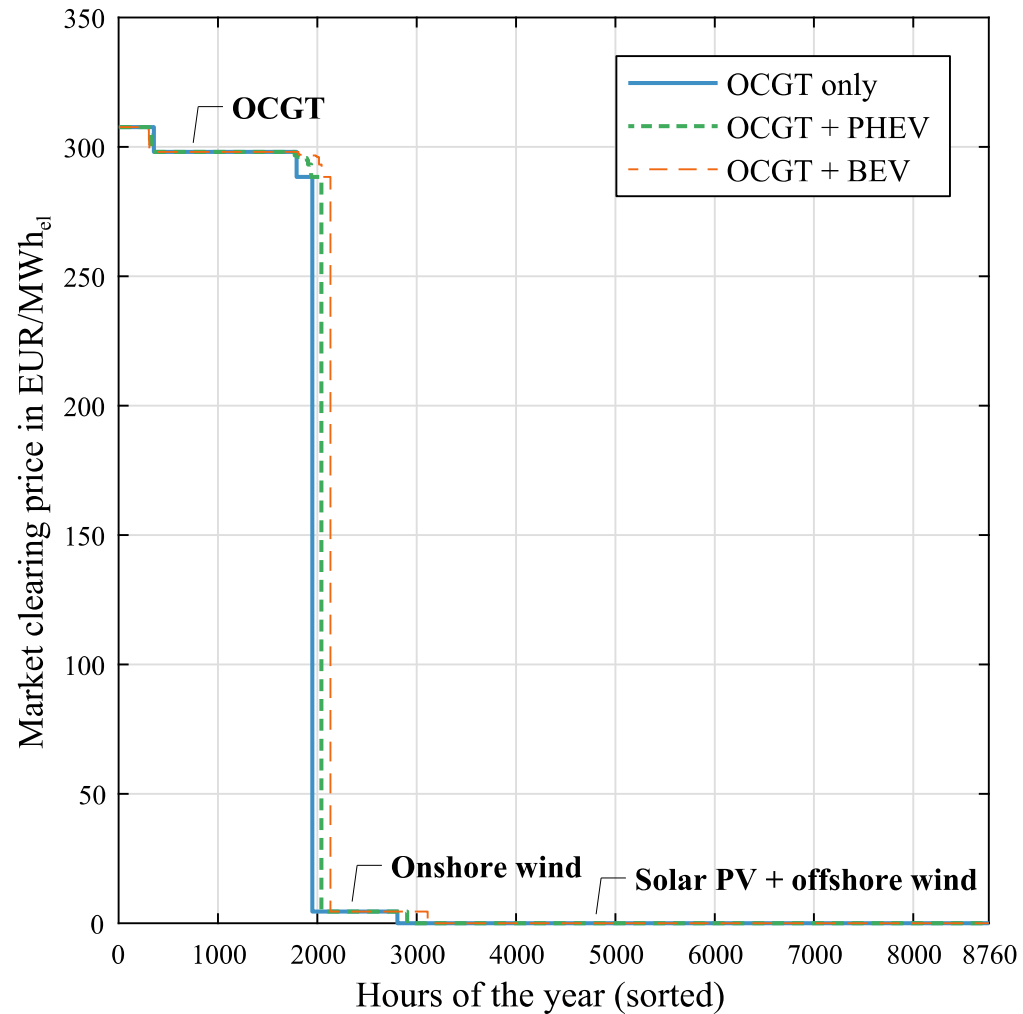
Exemplary multivalent CHP system



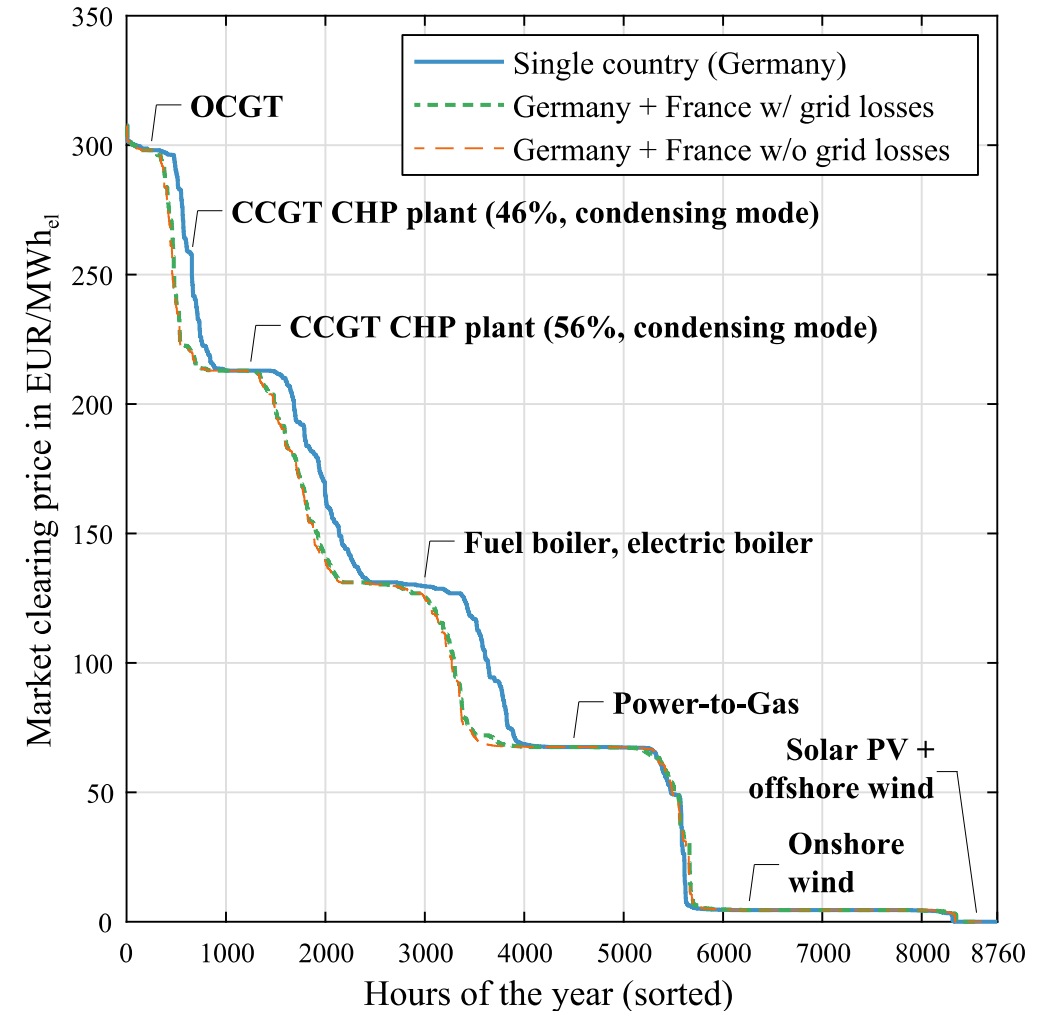
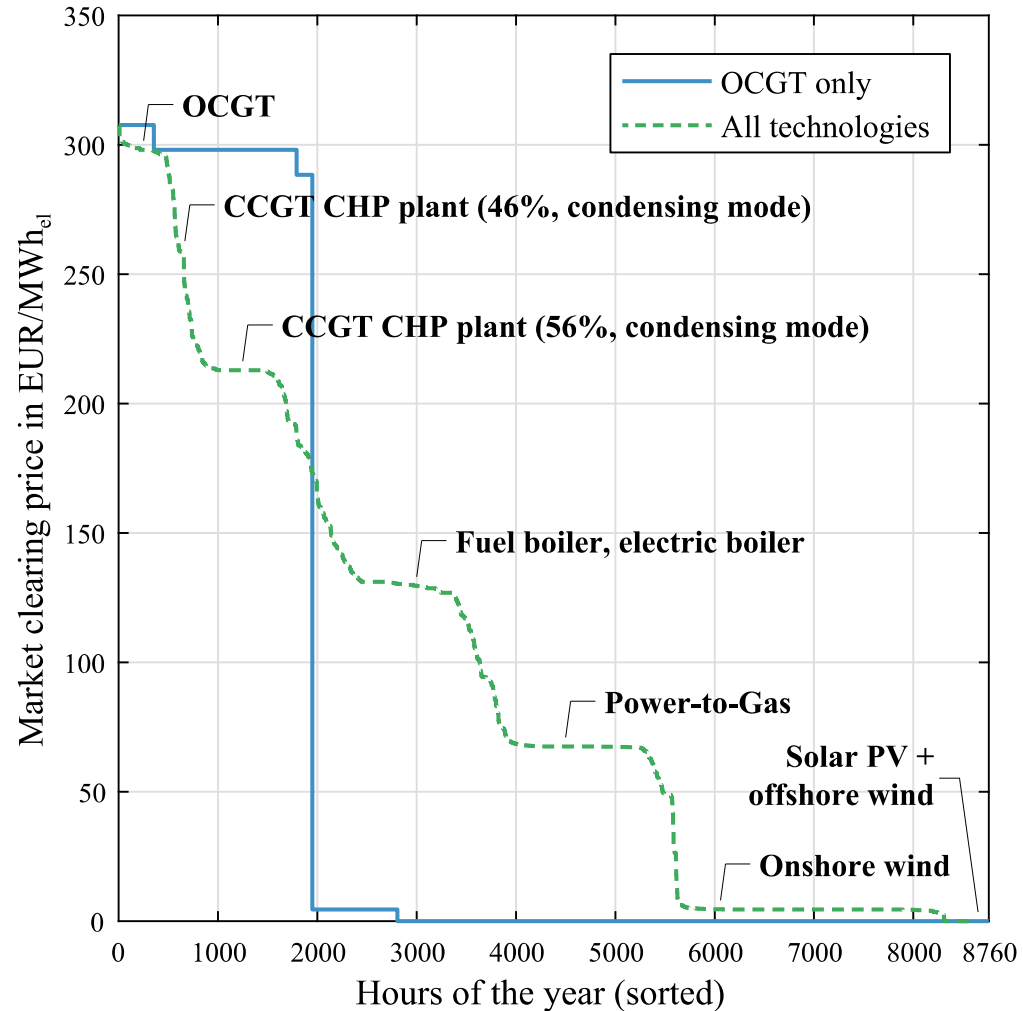
Wholesale market price impact of additional heating/cooling flexibility options



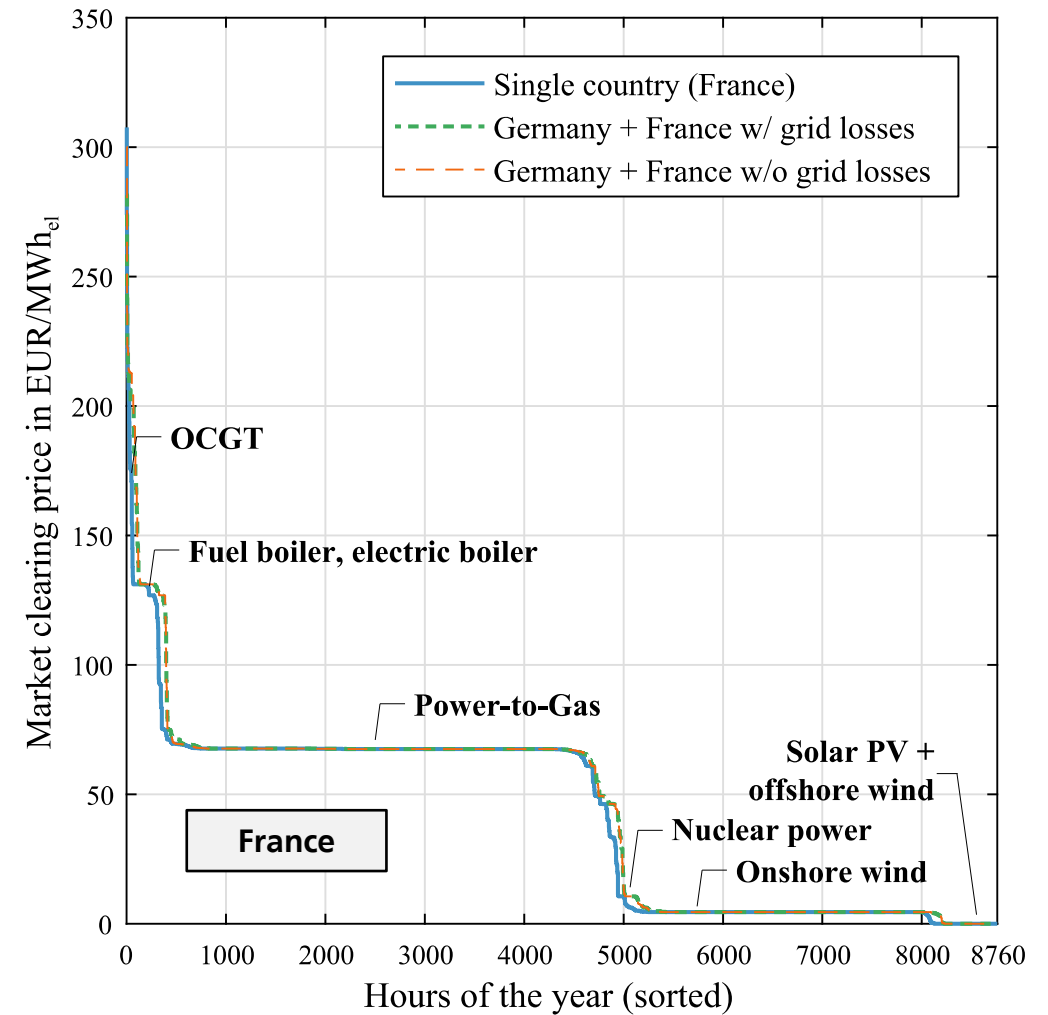
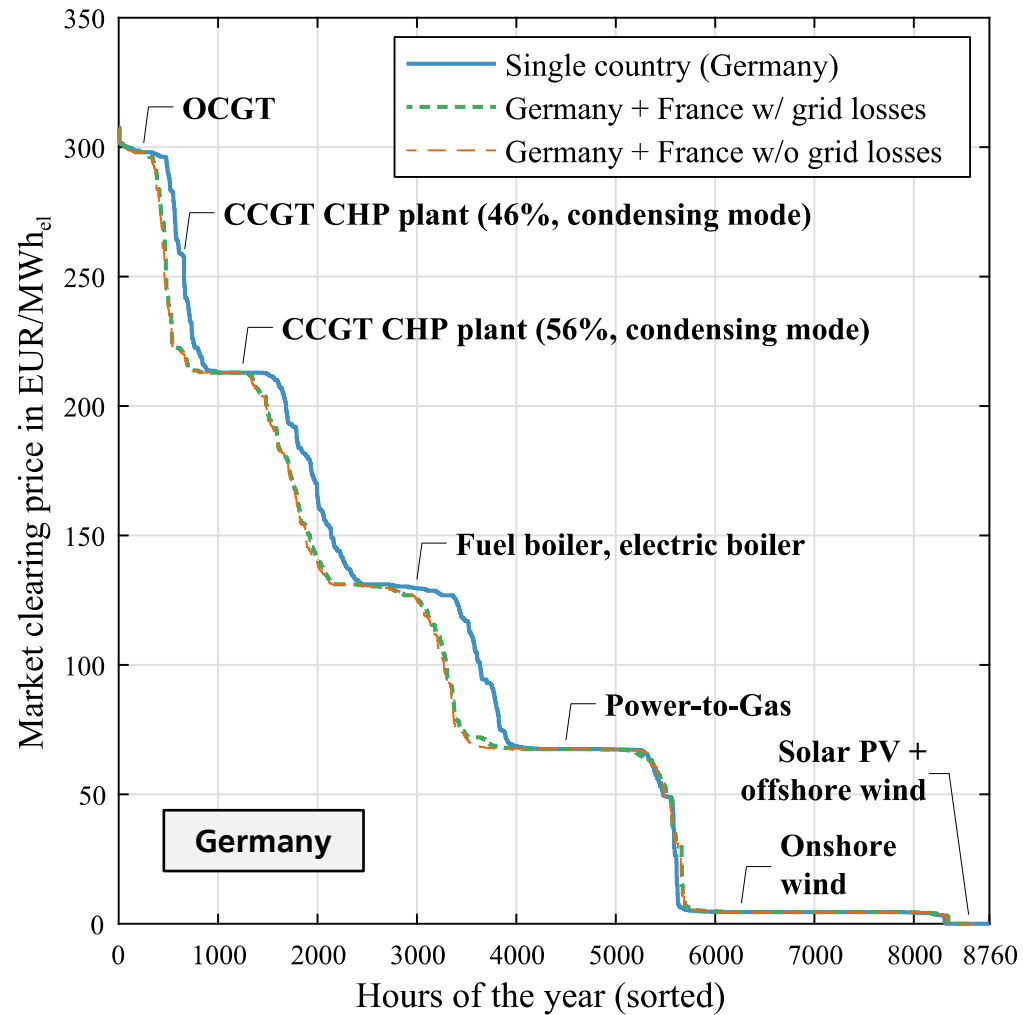
Wholesale market price impact of transport sector and power-to-gas units



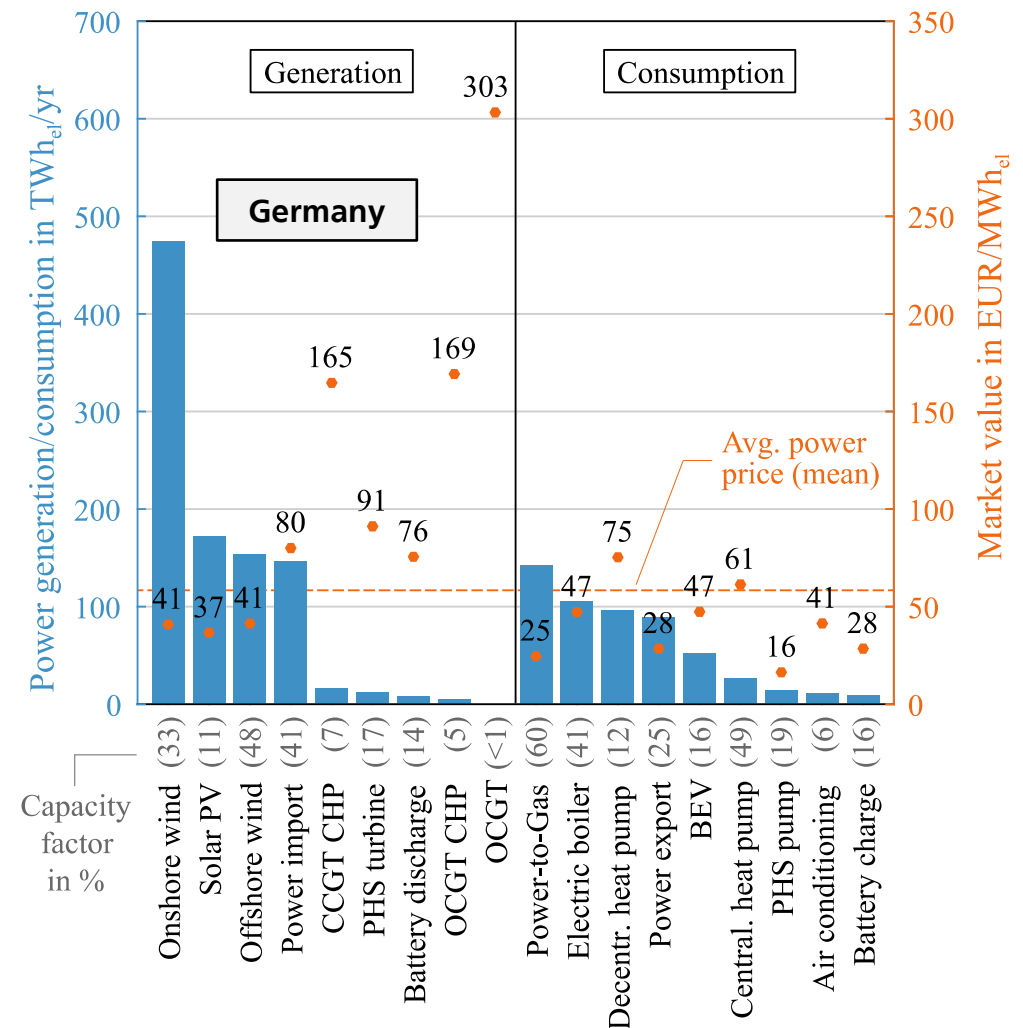
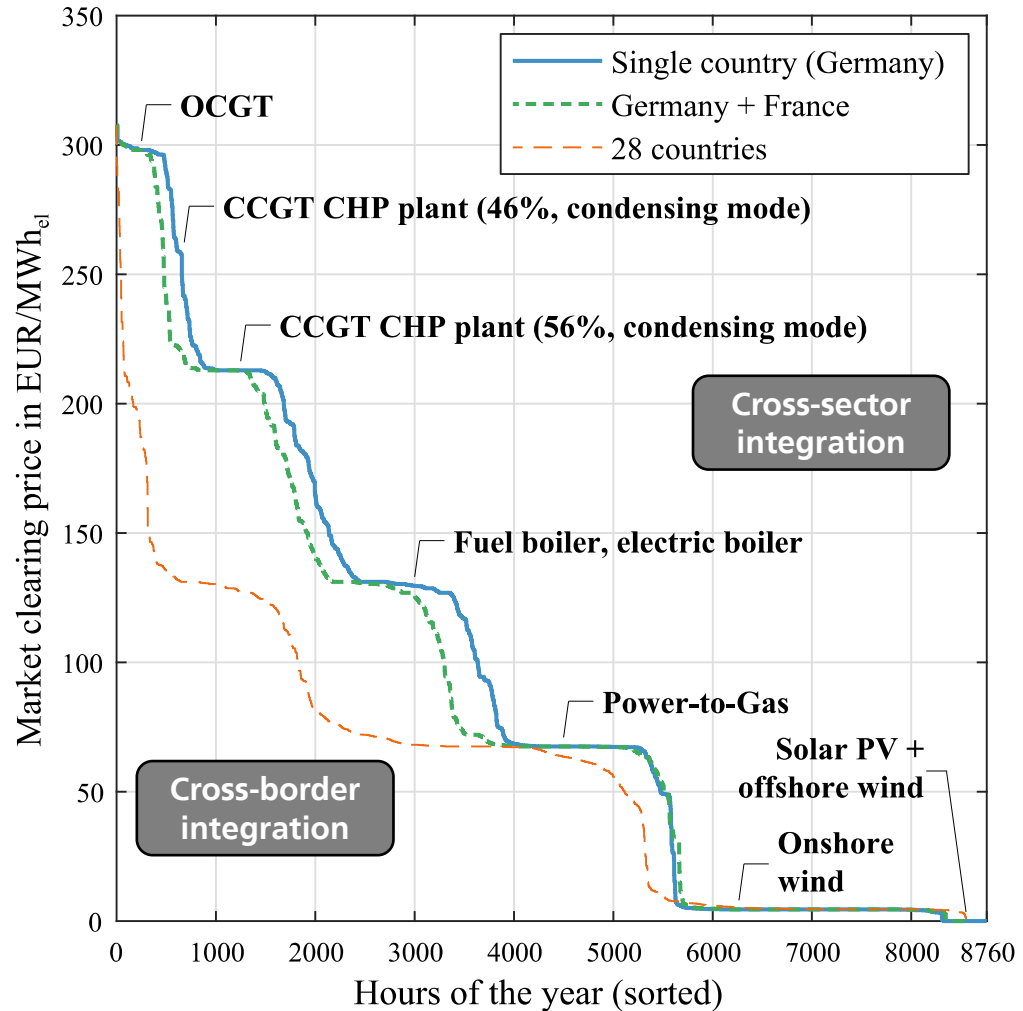
Wholesale market price impact of cross-border integration with France



Wholesale market price impact of additional heating/cooling flexibility options in Germany and France:



New market clearing effects in future wholesale power markets of net-zero systems – hybrid technology combinations and electrolysers may set the price



Main takeaways

Opportunity costs of **hybrid cross-sectoral electricity consumers** can **avoid penny switching effects of very high and low prices** in systems primarily based on renewable electricity (multi-fuel and temporal flexibility)

High power prices still occur when **open-cycle** or **combined-cycle gas turbines**, partly as **combined heat and power plants**, set the price

Few situations in which **market-based curtailment** of renewable energy sources **is unavoidable**, leading to situations with **very low power prices**

All units that can shift energy demand within a limited number of hours, e.g. thermal storage, battery storage, pumped hydro storage, **lead to a smoothing of the price step levels**

Power-to-gas plants exhibit a **certain willingness-to-pay** for electricity **as long as they** can **compete with synthetic fuel imports**

Variable renewable energy sources' **market values can be stabilized by** the power demand of various **direct or indirect electrification applications**

Main takeaways

Opportunity costs of **hybrid cross-sectoral electricity consumers** can **avoid penny switching effects of very high and low prices** in systems primarily based on renewable electricity (multi-fuel and temporal flexibility)

Cross-sectoral demand-bidding for price setting effects in low-carbon power systems will lead to stable energy prices and finance renewable energy projects

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Power-to-gas plants exhibit a **certain willingness-to-pay** for electricity **as long as they** can **compete with synthetic fuel imports**

Variable renewable energy sources' **market values can be stabilized by** the power demand of various **direct or indirect electrification applications**

References

P. Härtel, M. Korpås, “Demystifying market clearing and price-setting effects in low-carbon energy systems,” Energy Economics, 105051, 2020. doi: [10.1016/j.eneco.2020.105051](https://doi.org/10.1016/j.eneco.2020.105051).

D. Böttger, P. Härtel, “On Wholesale Electricity Prices and Market Values in a Carbon-Neutral Energy System,” Preprint under review in Energy Economics, <http://arxiv.org/abs/2105.01127>.

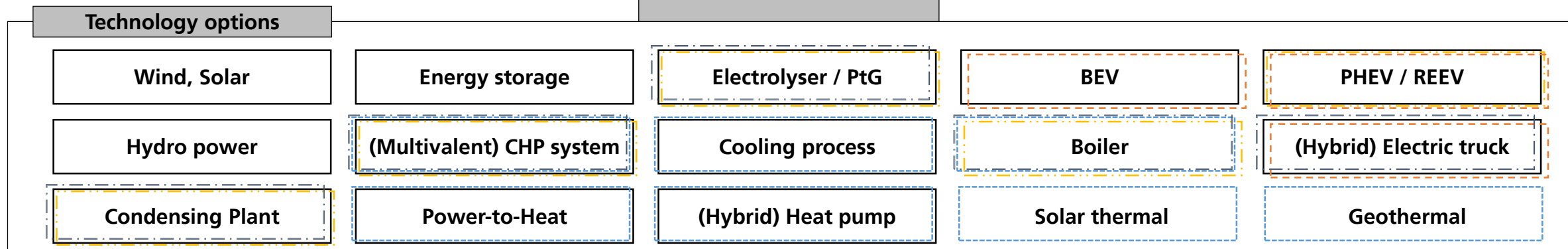
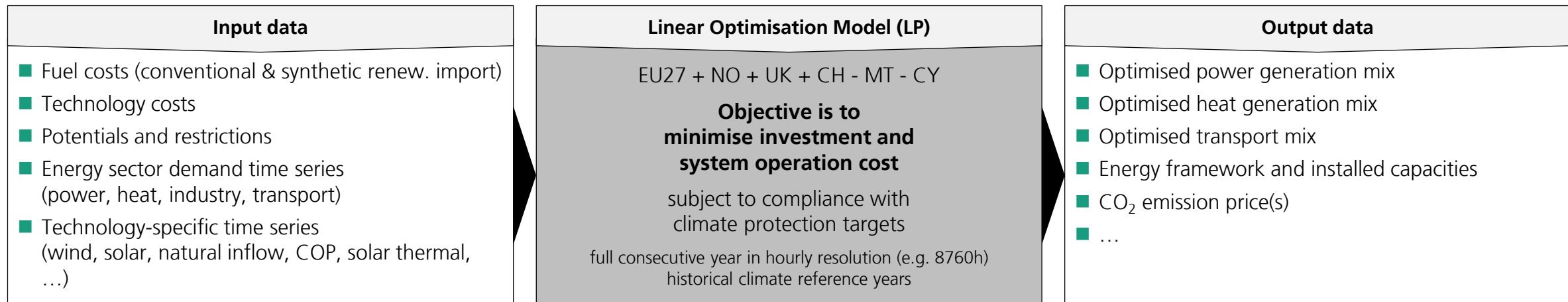
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Merci pour votre attention
Danke für Ihre Aufmerksamkeit
Thank You for your attention

SCOPE Scenario Development (SCOPE SD) ^{IEE}



Case study setup

