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Defining green hydrogen: Does simultaneity benefit big players?

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Index

Introduction

Hydrogen

- At the center of **indirect electrification**
  - → Support of the integration of variable renewables in the power sector
  - → Decarbonization of hard-to-abate sectors

Definition of "green" hydrogen

- Necessary to prioritize direct electrification
- Three requisites after **RED II**:

Additionality

Proximity

Temporal correlation (simultaneity)

Literature review

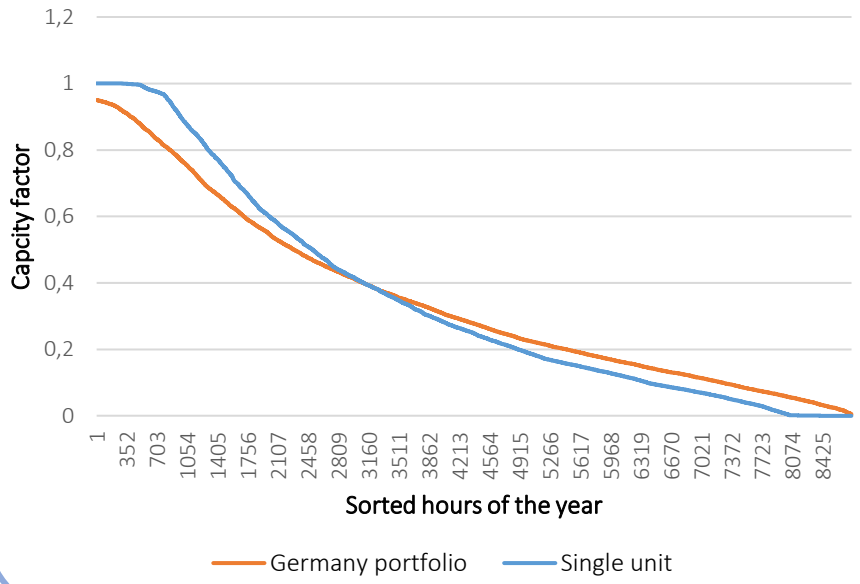
Arguments when discussing simultaneity

- Levelized **cost** of hydrogen (LCOH)
- **CO2-intensity** of the produced hydrogen

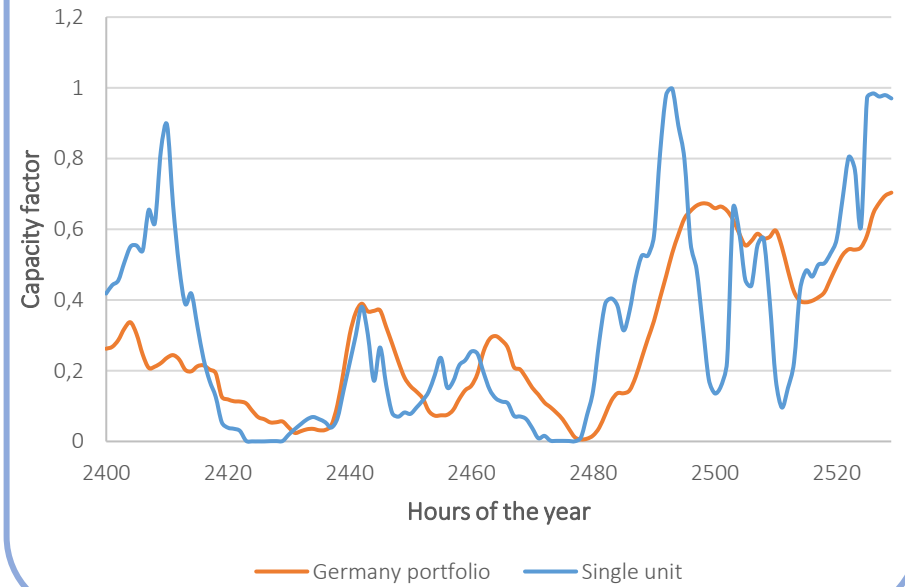
Work	Investigation of a unit or portfolio	
	Unit	Portfolio
Schlund and Theile 2021. *Simultaneity of green energy and hydrogen production*	**X**	
Ruhnau and Schiele 2022. *Flexible green hydrogen*	**X**	
Zeyen, et al. 2022. *Hourly versus annually matched renewable supply for electrolytic hydrogen*		**X**
Brauer, et al. 2022. *Green hydrogen – How grey can it be?*		**X**

Wind profiles

Lower **steepness** of the "Germany portfolio curve



Higher **smoothness** of the "Germany portfolio curve



Portfolio effects: Lower variance in energy production (not a higher average)

Research question

Assumptions

- **Volatility reduction** of variable renewables through geographic and technological smoothing
- Relevant only when **hourly simultaneity** is enforced

Research question

- Can owners of a geographically diverse portfolio of variable renewable energy achieve a **lower LCOH** than smaller players? ?

Implications if true

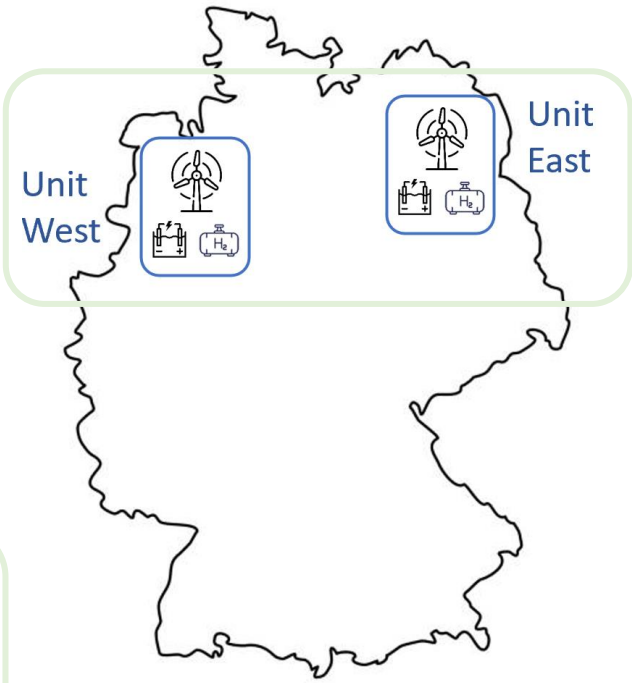
- Compromise of the **non-discriminatory principle** of the European energy market
- High market **entry barriers**

Index

Method: Units and portfolio

Unit

- **Components** of a unit:
  - Renewable energy generator
  - Hydrogen storage
  - Electrolyzer
- Defined by choice of
  - **Location** (East and West)
  - **Technology** (Wind and solar)



Portfolio

- Two units assumed to belong to a single investor
- Simultaneity criterion applies on a portfolio level

Method: Optimization Model

Objective function

- **Minimization of the LCOH**, composed of
  - Investment costs
  - Variable costs (electricity and H2 production)
  - Difference of selling and buying electricity from the grid

Contraints

- **Constant hydrogen supply** for each hour of the year
- Additionality
- Simultaneity: electricity exchange between units for portfolio owners

Optimized sizes

- Size of all unit **components**
- **Electricity** produced and traded at each hour

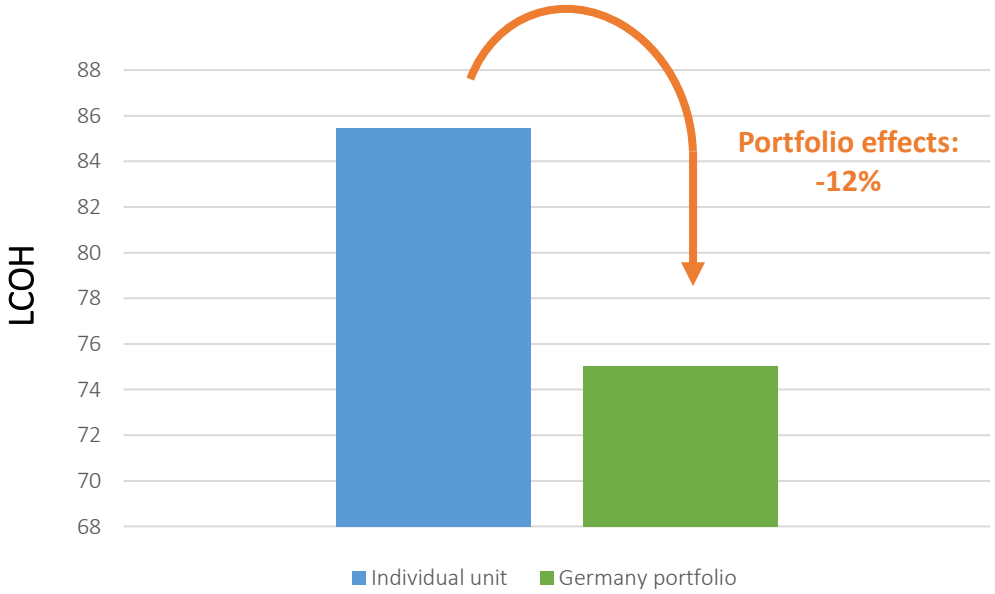
Index

Results: Benchmark

Two runs with single time series

- **Germany** portfolio, 3069 full load hours (FLH)
  - Source: ENTSO-E's ERAA-5
- Single **location**, 3100 FLH
  - Source: atlite

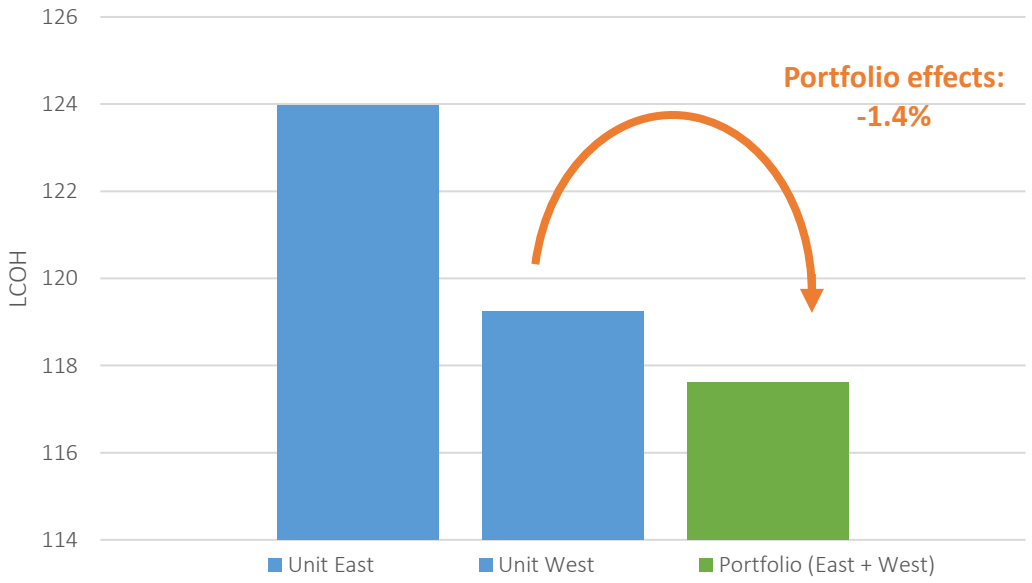
→ Similar FLH: guarantee **comparability** in terms of LCOE



Results: Main case

- Two time series (same turbine type, different heights)
  - **East**: 2543 FLH
  - **West**: 2547 FLH

- **Hourly simultaneity**:
  - Not enforced: same LCOH for all three scenarios
  - Enforced: Portfolio effects



Results: Sensitivity analyses

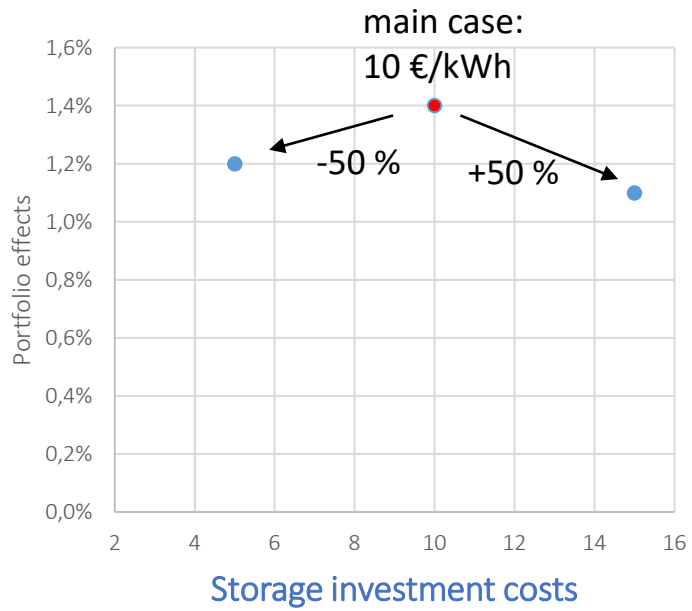
Grid fees

Main case: 27.5 €/kWh → **+/- 50% change**

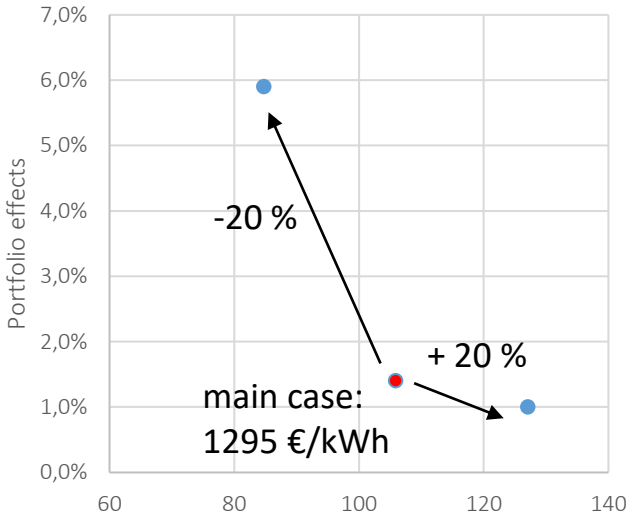
→ Does not affect single units

→ Portfolio effects **decrease** with increasing grid fees **(-/+ 0.1% change)**

Investment costs



Storage investment costs



Wind investment costs

Index

Conclusion

Preliminary results: indicative evidence of the existence of portfolio effects

Next steps

- Further sensitivity analysis
- Effects of increasing the number of locations in a portfolio
- Including PV as a generation technology

Relevance for policy

- Argument against hourly simultaneity
- Disadvantage for smaller players, the scale of which depends on the discussed parameters