The System-Value of Competing Energy Storage

Parzen et al. (2023), *The Value of Competing Energy Storage in Decarbonized Power Systems*, arXiv, https://doi.org/10.48550/arXiv.2305.09795

THE UNIVERSITY *of* EDINBURGH

Open Energy Transition
from the creators of PyPSA meets Earth

23.07.2023

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(submitted PhD thesis 01.06.23)

Open Energy Transition is a think tank and software company aiming to accelerate the World's transition to sustainable energy with open data and open-source software.

23.07.2023

KEY MESSAGE

- OPTIMIZE ENERGY STORAGE UNDER COMPETITION
- NOT EVERY ENERGY STORAGE IS OPTIMIZATION RELEVANT

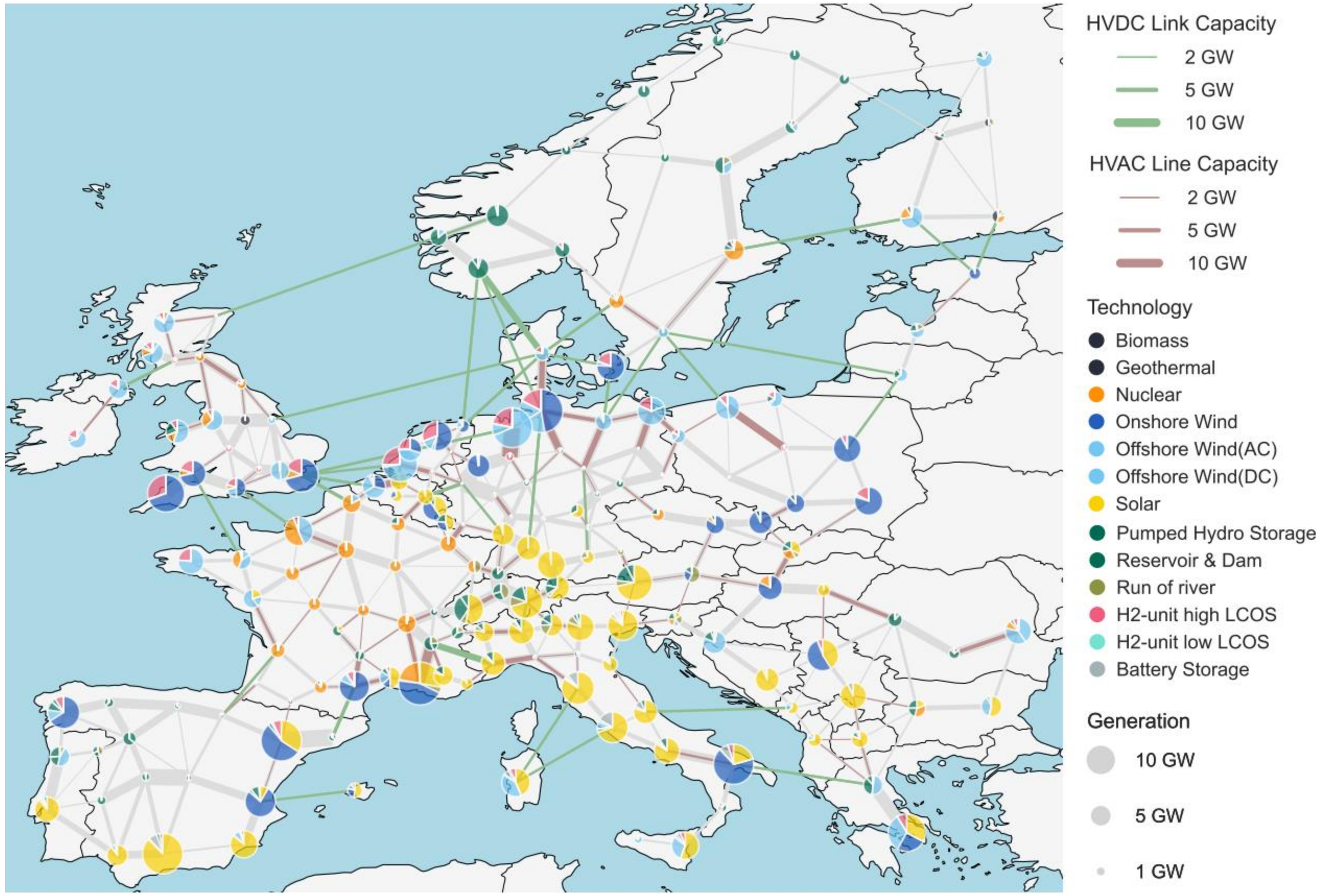
SYSTEM-VALUE DEFINITION

System-value definition:

“ANY ENERGY TECHNOLOGY IS VALUABLE IF IT LOWERS TOTAL SYSTEM COSTS”

- Can be assessed with Energy System Models that minimize costs under constraints
- Learn more in Parzen 2022, "*Beyond cost reduction: improving the value of energy storage in electricity systems*", https://doi.org/10.1007/s43979-022-00027-3

PyPSA-Eur



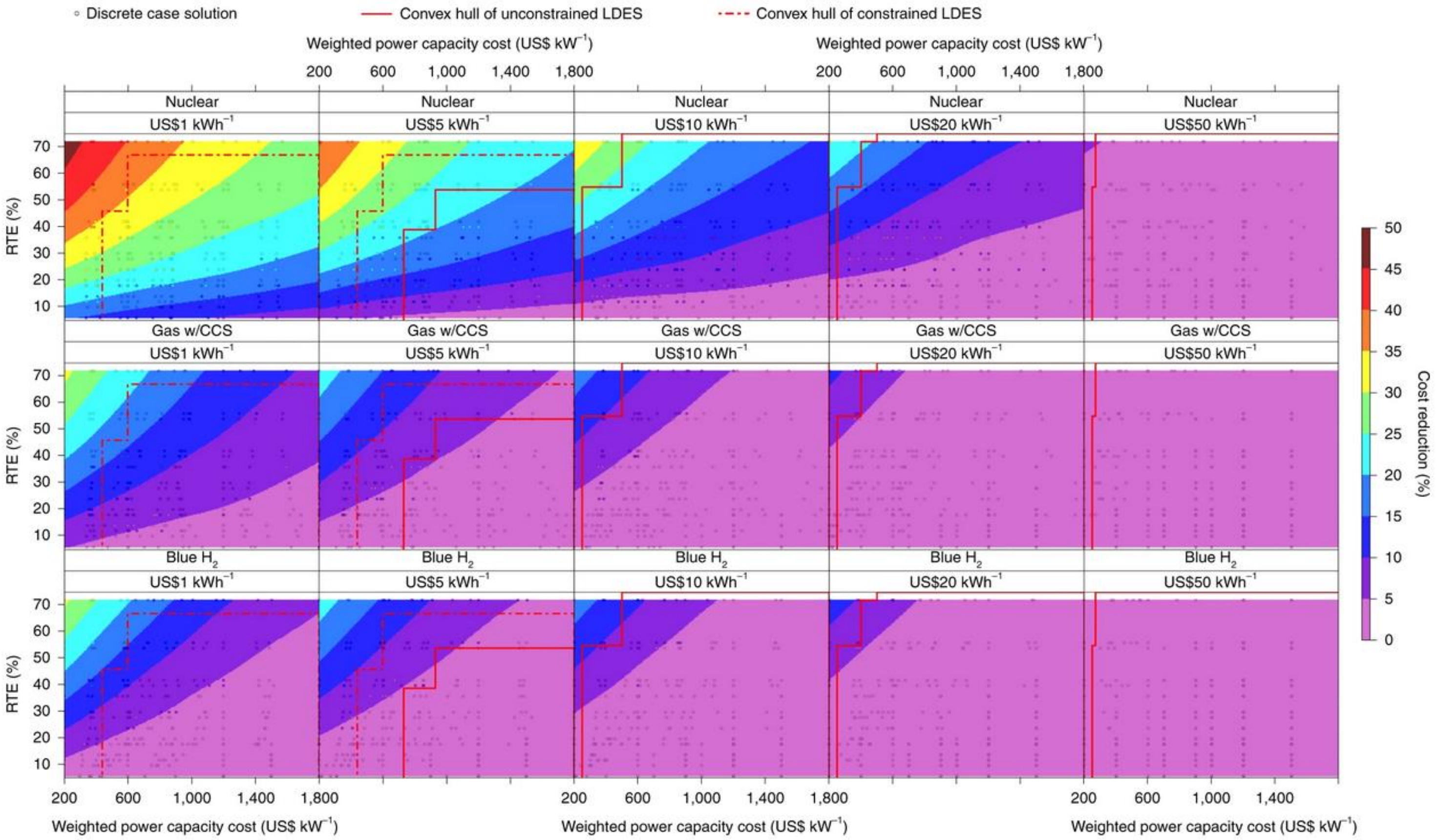
OTHER STUDIES

- Quantify system benefit by **COUNTERFACTUAL SCENARIOS**, meaning comparing system-cost reductions from a scenario with and without storage
- **BUT miss competition aka synergies between energy storage.** Usually only a single generic energy storage is considered, and doing parameter sweeps (costs of each component, efficiency, etc.)
- **PROBLEM.** Conclusion of such studies can mislead energy storage developments and not quantify how much of what technology is required

https://www.nature.com/articles/s41560-021-00796-8/figures/1

Fig. 1: System cost percentage reduction in the Northern System for LDES parameter combination.

From: The design space for long-duration energy storage in decarbonized power systems



Research questions tackled in the preprint

- **Q1.** How significant is the system-benefit from optimizing energy storage with competition compared to without?
- **Q2.** Which energy storage is optimization relevant considering uncertainty?

We included 20 energy storage in this study!

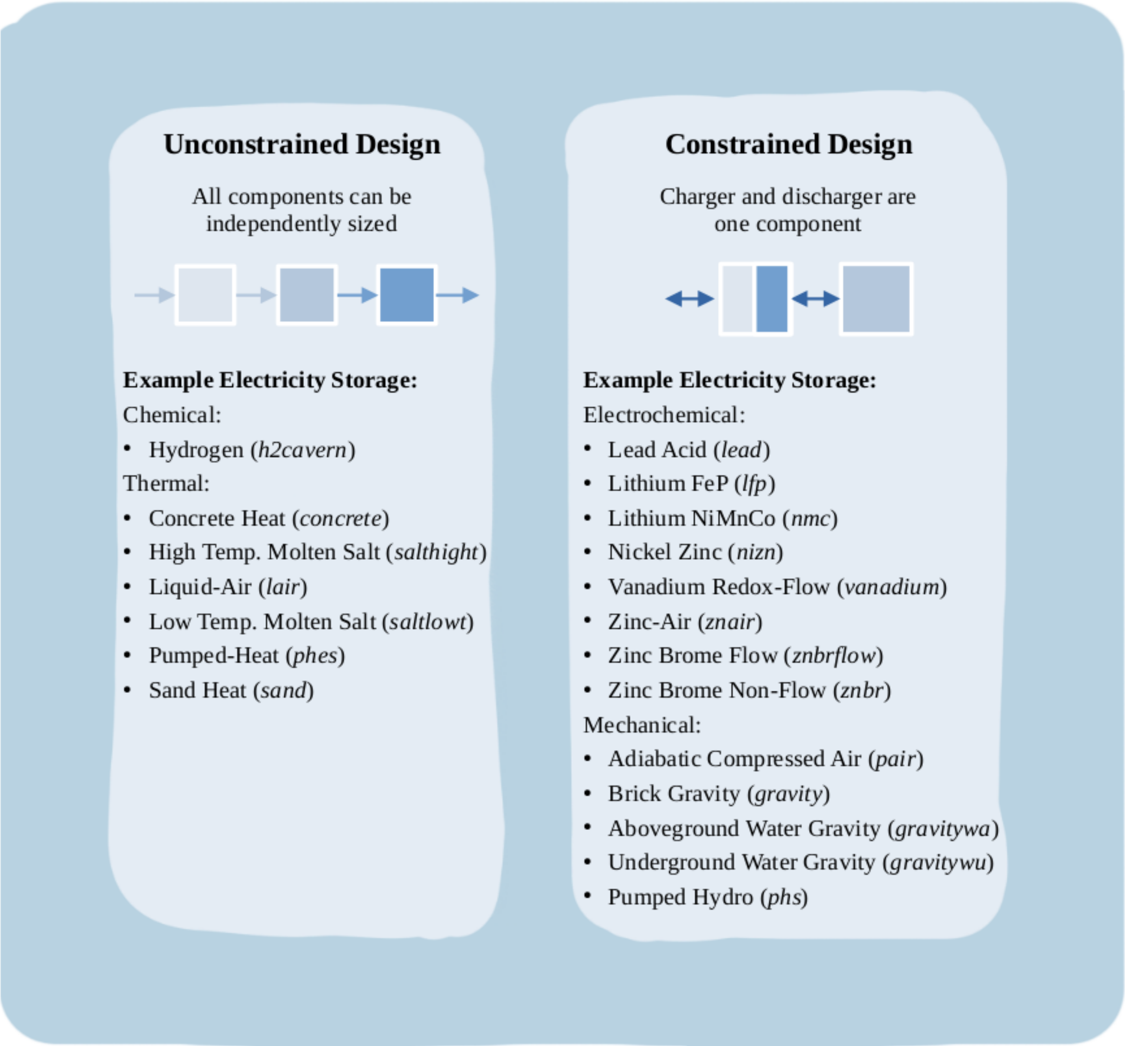
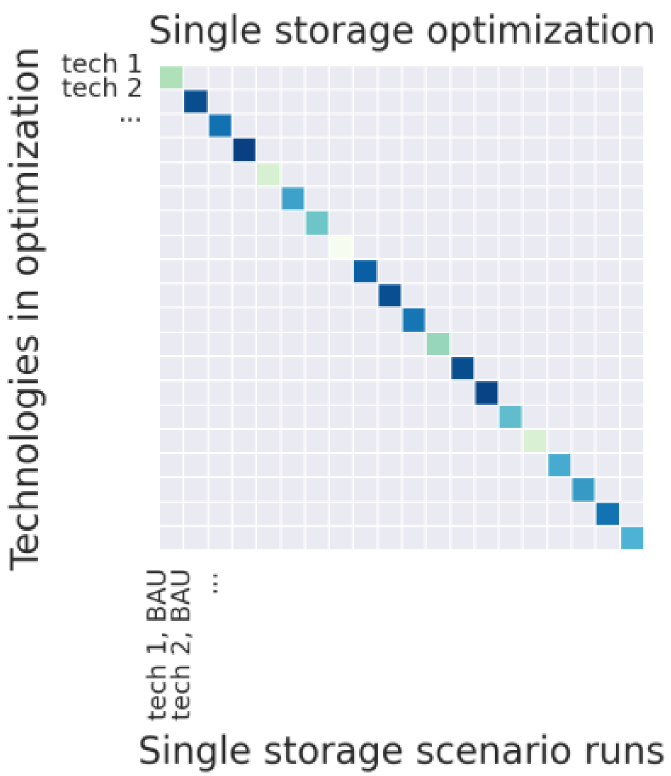
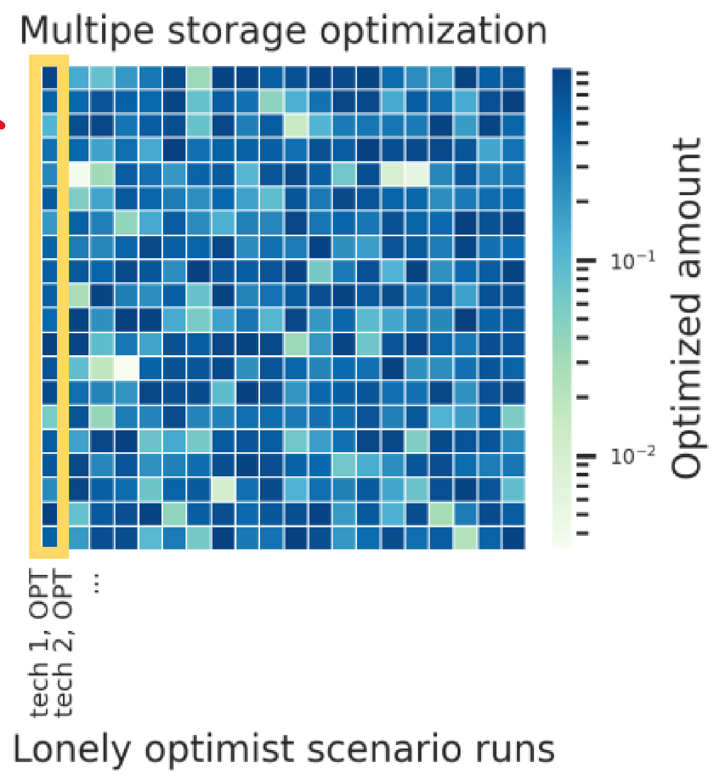


Figure 2: Illustration of energy storage technologies with abbreviations used in this study.

THE MOST ENERGY STORAGE TECHNOLOGIES EVER THROWN INTO AN ENREGY SYSTEM MODEL (Thanks PNNL for the data that was just released 2022/23)

Methodology: We optimize every storage alone & under competition





LONELY OPTIMIST SCENARIO means,

- 1 TECHNOLOGY IS ASSUMED **30% CHEAPER THAN BAU**
- 19 TECHNOLOGIES ARE ASSUMED TO BE **30% MORE EXPENSIVE THAN BAU**

--> Goal. Find which technology is not relevant even after the best possible conditions

What happens if we optimize every storage alone?

- Heterogenous energy to power ratios depending on technology
- More extreme especially when there is design-freedom (no constraint)

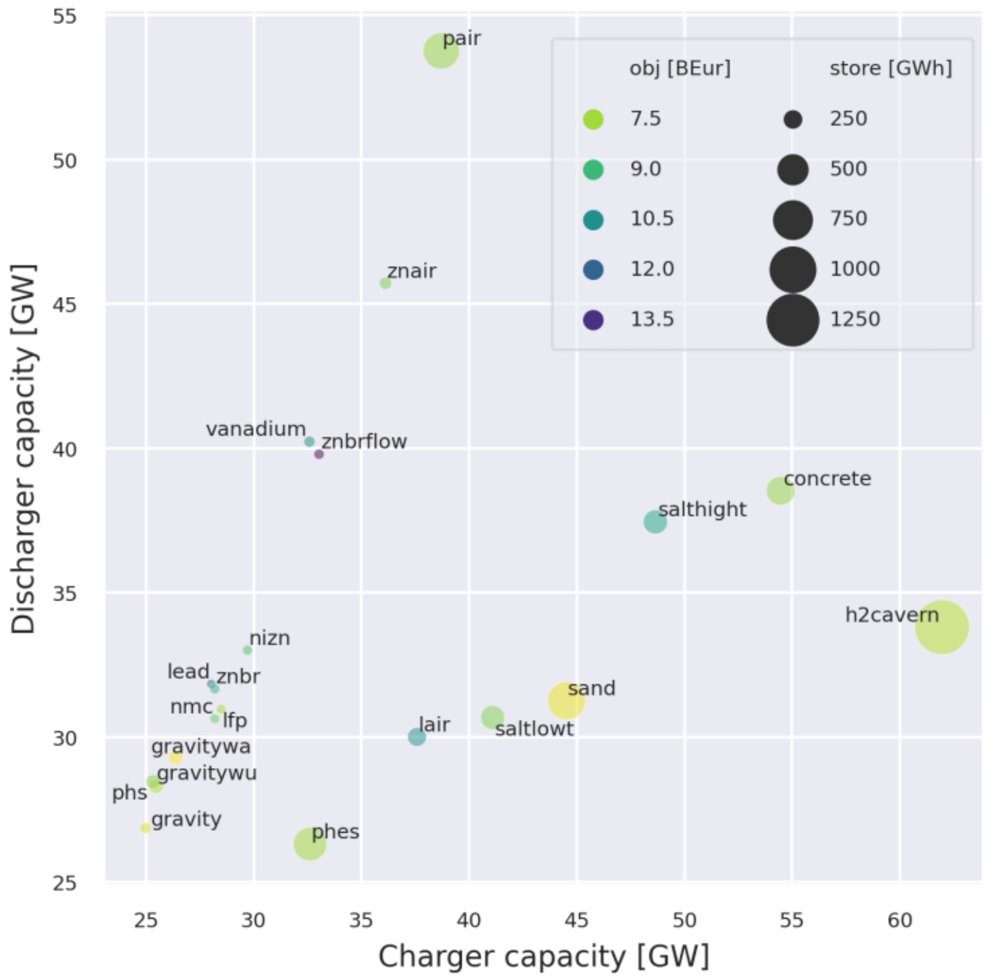


Figure 3: Optimization results for single energy storage scenarios. The y-axis, x-axis, and marker size show the deployment required for a least-cost 2050 power system in Nigeria. The colour indicates the total system costs.

Total system costs comparison of scenarios. High savings under competition.

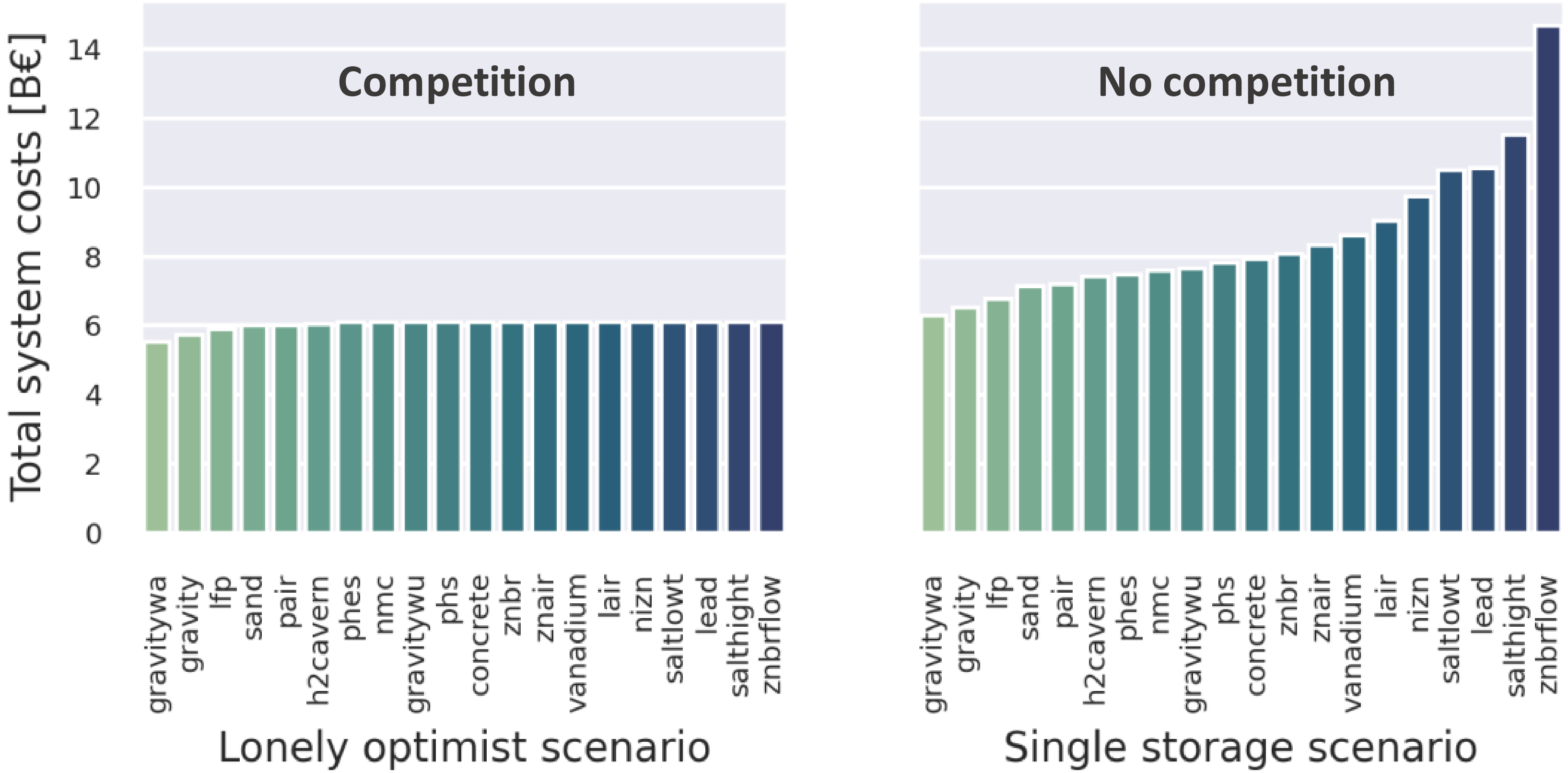


Figure 4: Total system cost for energy storage scenario with (left) and without (right) competition. Scenarios are sorted according to the total system costs.

Analysing which technologies compete and how much they are optimized

- **Reminder.** Technologies provide only system-value if they are optimized!
- Not all energy storage technologies are optimization relevant (rows that are blank)
- Li-Ion battery surprisingly under strong competition and not always relevant (in the given system)
- Surprise candidates:
    - Thermal Sand Storage
    - Gravity storage

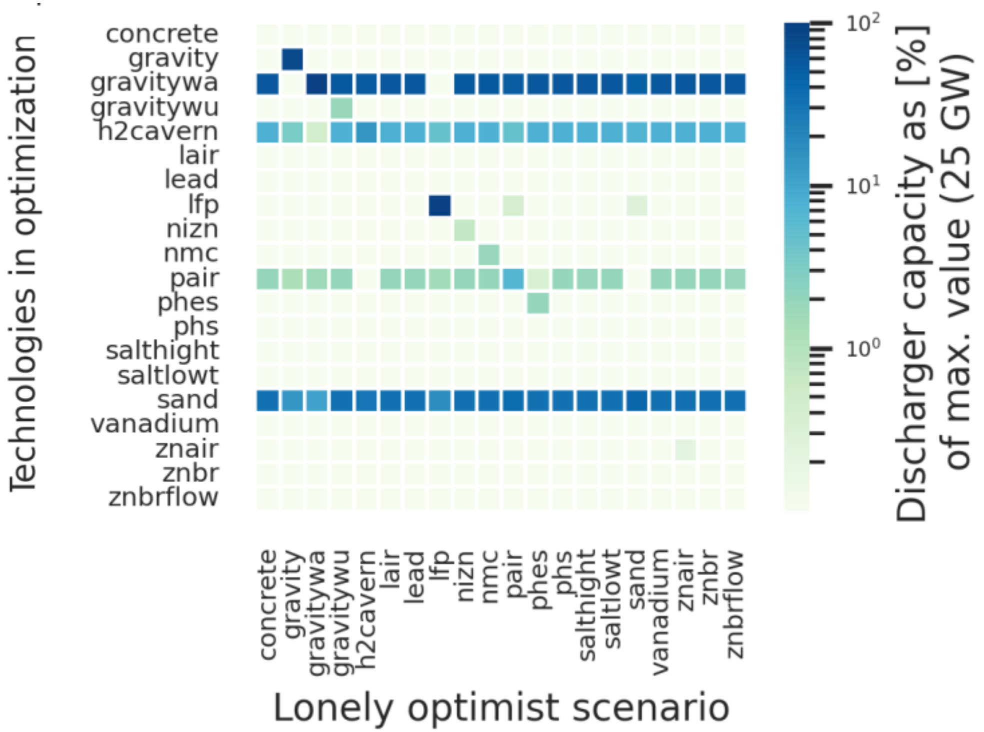


Figure 5: Optimized charger, store, and discharger capacity for the lonely optimist scenario in Nigeria. All technologies on the y-axis are available for the optimization scenario in each run. One column refers thereby to one scenario run. The x-axis shows the lonely optimist scenarios, which assume optimistic capital costs assumptions (-30%) for the mentioned technology while the others technologies on the y-axis are assumed to have pessimistic capital cost assumptions (+30%).

Future work

- **Spatial relevancy.** Every energy system is unique (demand, supply, grid configuration). The system-value of energy storage will change depending on which reaching we are looking at. Our new **PyPSA-Earth developments** allow to explore the value globally (join our open community?)

- **Quantifying better drivers and uncertainty.** There is a need to better understand why do we see what we see. Requires Monte-Carlo and thousands of scenarios for statistical relevancy. Combination with Modelling-to-Generate-Alternative (MGA) might be good

- **Improving data & TRL consideration.** What would be nice to have uncertainty ranges for the technologies as well as some feeling of Technology Readiness Level.

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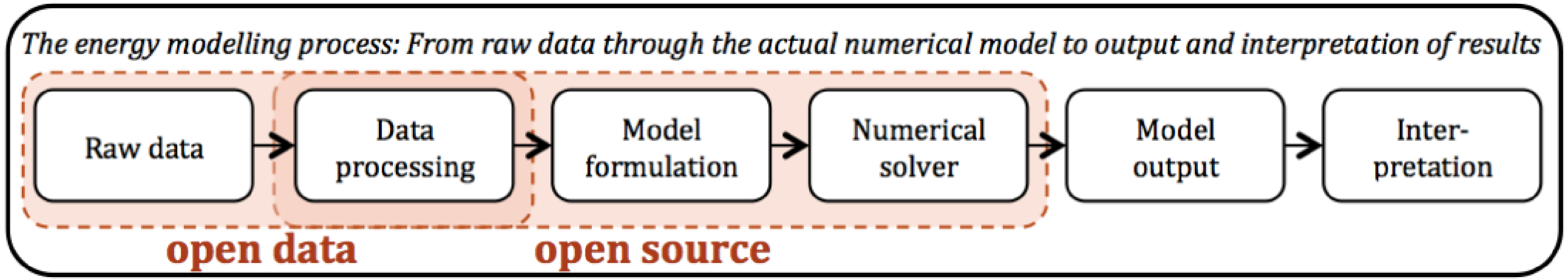
Back-up – AWESOME OPENMOD COMMUNITY

The whole chain from raw data to modelling results should be open:



Open data + free software ⇒ Transparency + Reproducibility

There's an initiative for that! Sign up for the mailing list / come to the next workshop:

openmod open energy modelling initiative

openmod-initiative.org