



Online workshop „The role of energy storage
in power sectors with fossil fuel phase-out“

Electricity storage and the renewable energy transition

Wolf-Peter Schill
9 October 2020



Future of
Fossil Fuels

Recent commentary published in *Joule*

- Three strands of storage research literature
- Illustration how storage use changes with increasing renewables and sector coupling
- Some policy and research conclusions

Commentary Electricity Storage and the Renewable Energy Transition

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Introduction

The transition to renewable energy sources is a main strategy for deep decarbonization. In many countries, the potentials of dispatchable renewables—such as hydro power, geothermal, or biomass—are limited. The renewable energy transition is thus often driven by wind power and solar

photovoltaics (PV). Wind and PV have characteristic features that become increasingly relevant with growing penetration. In particular, their generation patterns are temporally variable, and the spatial distribution of good wind and solar resources does not necessarily coincide with the historical grid layout. Different technological options are available for integrating increasing shares of variable renewable energy sources, often referred to as flexibility options. These include, but are not limited to, various electricity storage technologies.

So what is the role of electricity storage in the renewable energy transition? In this Commentary, I discuss how three different strands of the literature address this question, summarize a few well-established findings, and provide some intuition on how the role of electricity storage changes with increasing shares of renewables and sector coupling. Using residual load duration curves (RLDCs), which are generated with a stylized open-source model, I illustrate that the main driver for electricity storage deployment shifts when the renewable penetration increases toward 100%, from taking up renewable surplus generation to meeting positive residual load. Flexible sector coupling interacts with the former, but hardly with the latter. Based on this, I suggest promising fields for future research and draw a few high-level policy conclusions.

Electricity Storage Technologies, Applications, and Competing Flexibility Options

Many different electricity storage technologies are available. Electricity storage is broadly defined as any technology that allows taking up electrical energy at one point in time and releasing electrical energy again at a later point in time ("Power-to-Power"). Technologies are available at various

scales and can widely differ in round-trip efficiency as well as energy and power-related costs. This leads to varying energy-to-power (E/P) ratios. These typically do not exceed a few hours for short-term storage, e.g., lithium-ion batteries or pumped hydro storage, but may range from days to weeks for long-term storage, e.g., hydrogen-based electricity storage.

There are many different applications for electricity storage. A major grid-scale application is bulk electricity storage, also referred to as energy arbitrage. It allows increasing the use of generators with low variable costs by shifting their production from periods with low electricity demand (and low priced) to such with higher demand (and higher priced), which becomes increasingly relevant with growing renewable penetration.

Aside from energy arbitrage, there are many other uses of electricity storage, which storage facilities may also be able to combine to some extent. These include, but are not limited to, reduced ramping of other generators, the provision of different types of ancillary services, in particular balancing power; the deferral of transmission or distribution infrastructure investments; and various end-user applications, including power quality and PV self-consumption. Many of these storage applications also become increasingly relevant in the context of variable renewable energy integration.

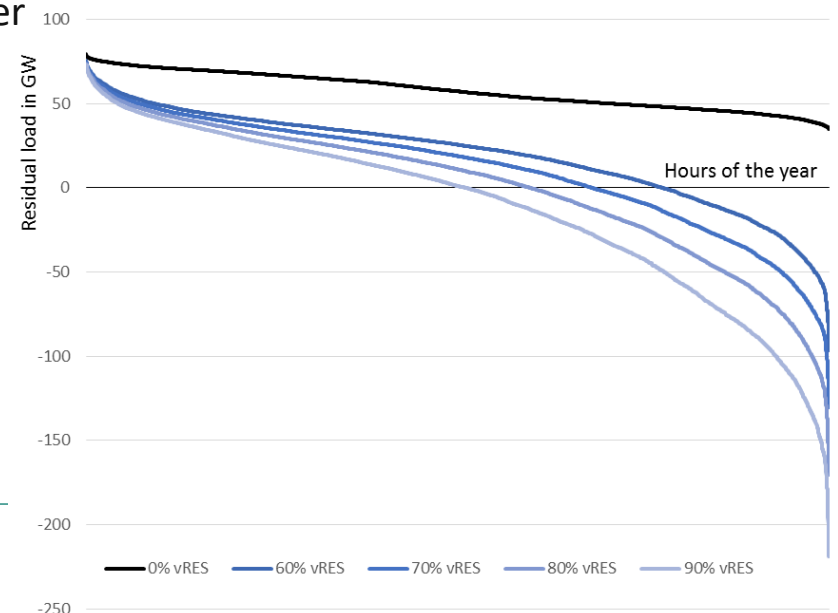
Electricity storage, especially short-term storage, competes with many other flexibility options on both the supply and demand side that can also contribute to renewable integration.¹

• Power-to-Power: Demand-side management, in particular temporal shifting of conventional electric

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Residual load duration curves (RLDC)

- RL: electric load – potential renewable generation
- RLDC: Hourly RL values, sorted in decreasing order
- Generated with stylized version of DIETER, calibrated to Germany



Different technologies

- Always: „Power-to-Power“
- Differences in roundtrip efficiency and costs related to energy and power
→ different typical E/P ratios

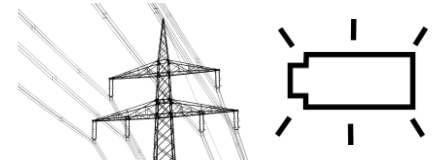
Many different applications

- Focus here: bulk electricity storage (energy arbitrage)
- Other applications: ancillary services, transmission or distribution grid relief, ...

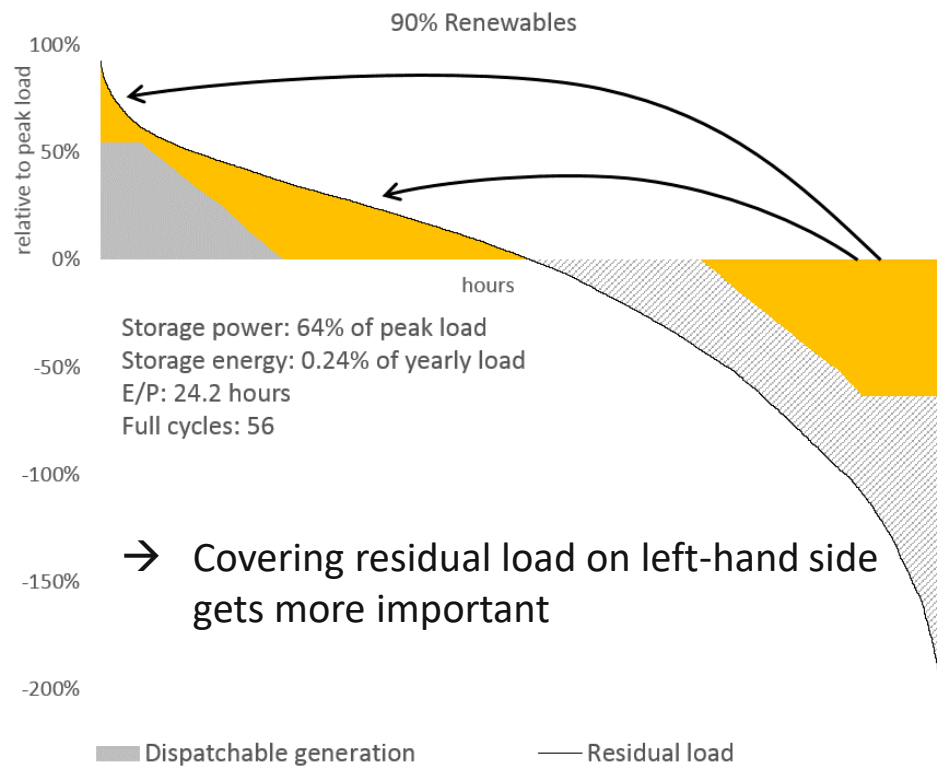
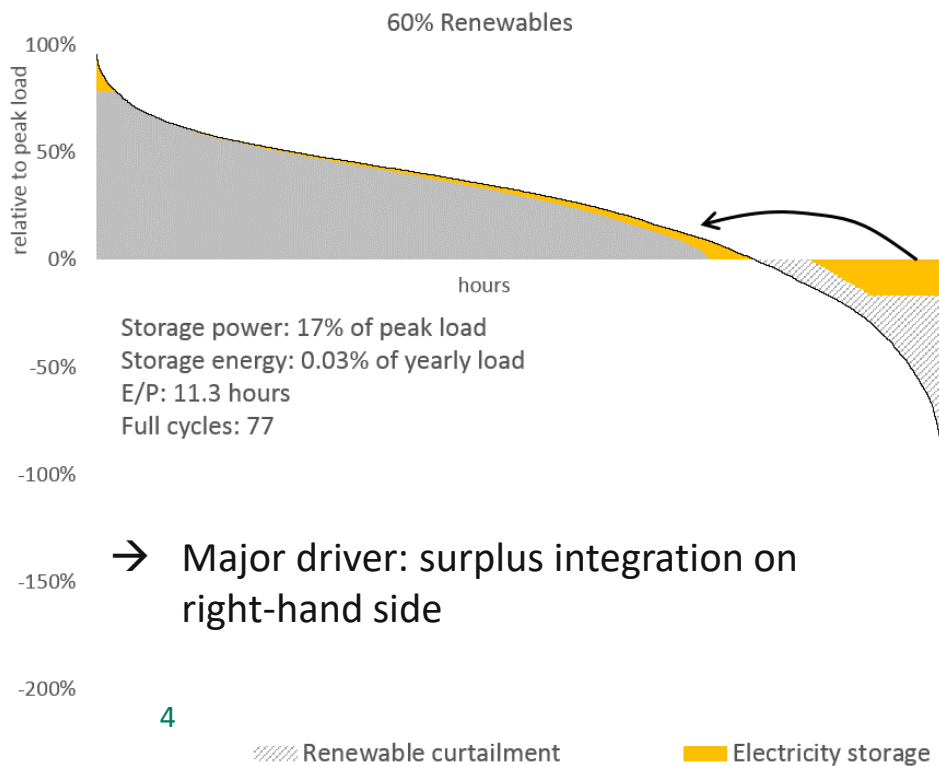
Competing flexibility options

- Power-to-Power: e.g. demand-side management of existing load
- X-to-Power: Flexible operation of dispatchable plants
- Power-to-X: New and flexible loads related to sector coupling, e.g. Power-to-Heat
 - Without reconversion to electricity, incl. other forms of energy storage
- Geographical balancing

Common findings in the literature and some intuition

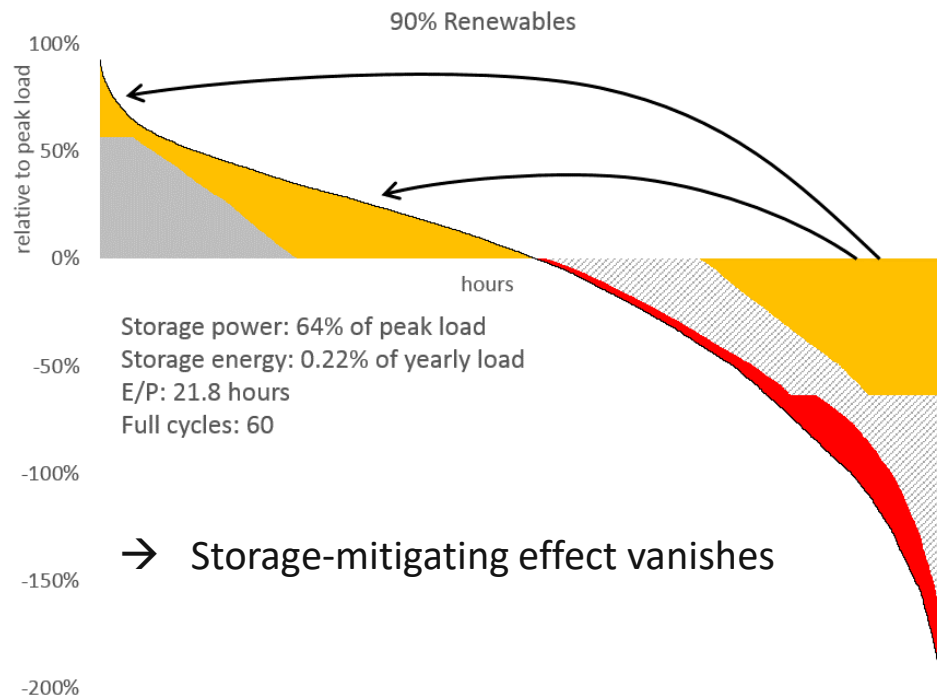
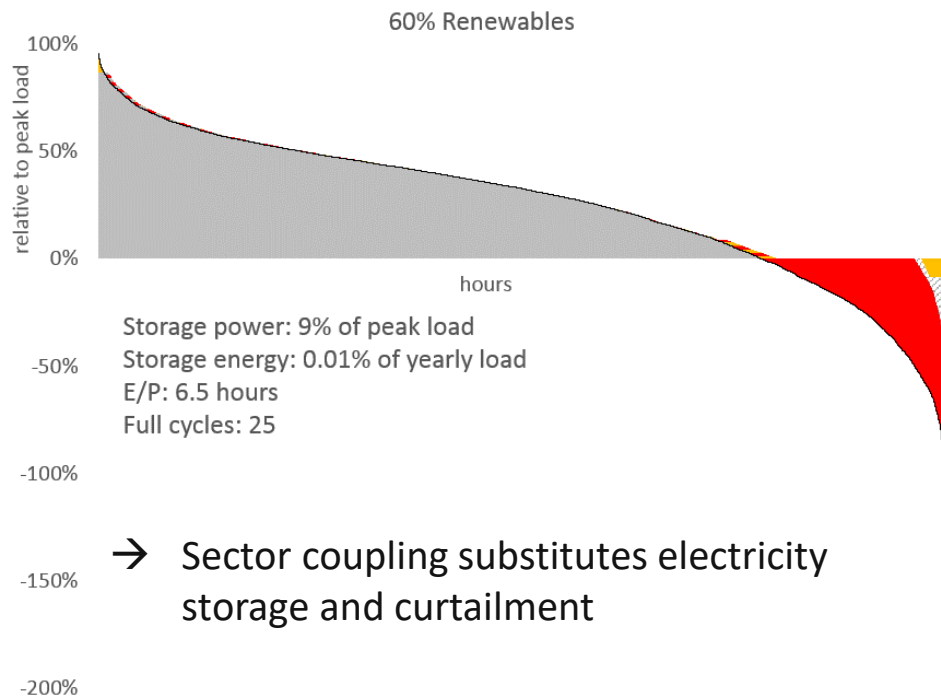
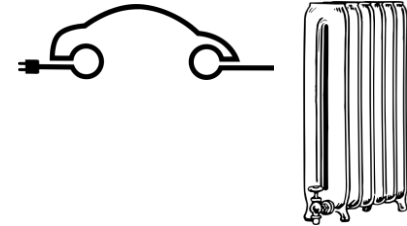


- Optimal storage deployment moderate until ~80% RES
- Increases substantially towards 100% renewables
- Depends on other sources of power sector flexibility

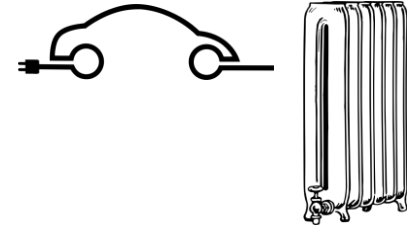


More intuition

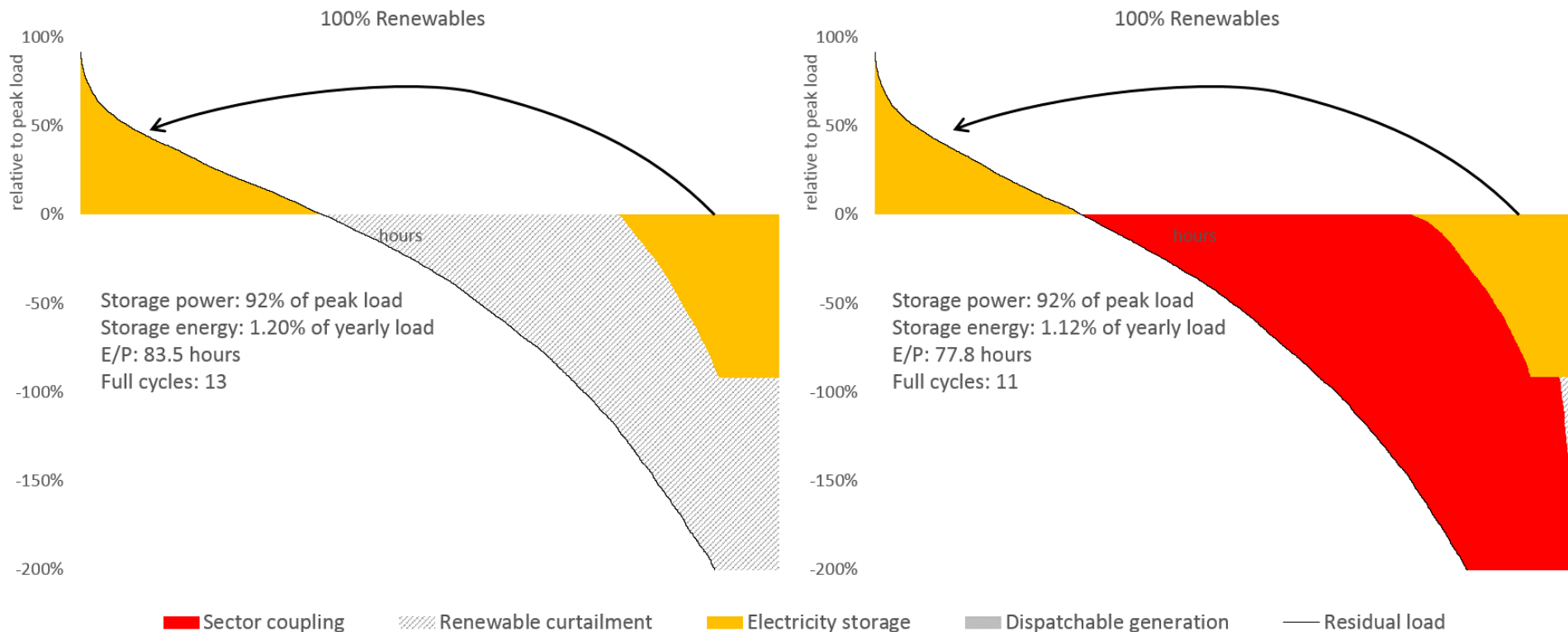
- New loads can increase the demand-side flexibility of the system
- E.g. Power-to-heat, electric vehicle batteries, green hydrogen
- This can mitigate storage needs for lower RES shares



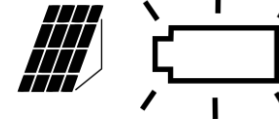
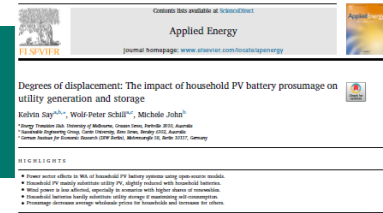
100% renewables



- Storage needs strongly increase vs. 90%
- Even massive sector coupling hardly changes optimal storage deployment
→ Storage driven by left-hand side
- If sector coupling is less flexible, additional electricity storage may be required...



Literature strand 3: PV-batteries for solar prosumage



Prosumage

- Production, consumption, and storage
- PV-battery systems, operated to optimize self-consumption
- Major growth in several markets, e.g. some US regions and Australia
- Neither investments nor operations usually guided by energy system considerations

Highlights

- Three sector effects in WA of household PV battery systems using open-access models.
- Wind power is less affected, especially in scenarios with higher shares of renewables.
- Household batteries modify electricity supply patterns, including those not requiring its generation.
- Percentage decrease energy withdrawn from the grid varies with increase in solar.

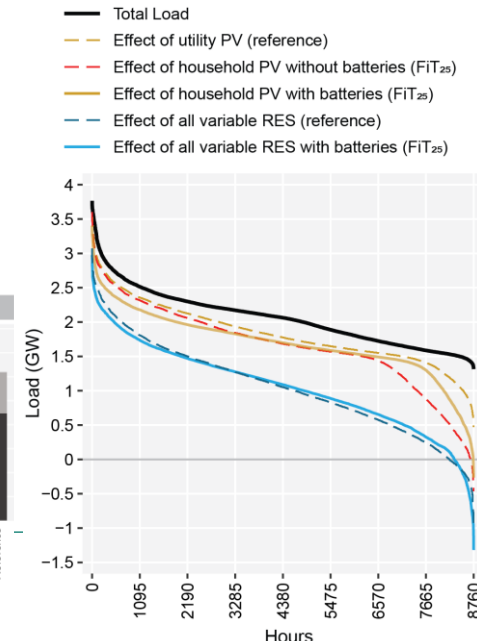
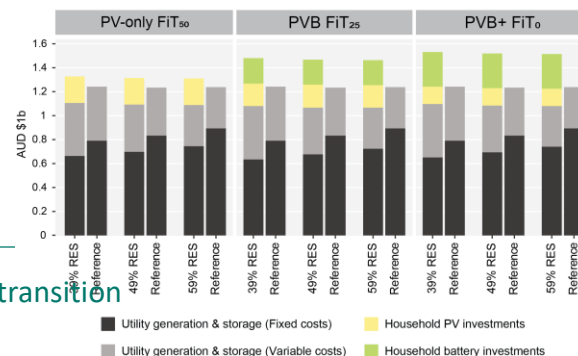
ARTICLE INFO

Article Reductions in the use of PV and battery storage households to meet in PV battery prosumage...
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Glimpse on another recent paper: prosumage in Western Australia

- Residual load smoothing comparable to grid-scale batteries, but more costly
- Desirable: make additional (system-oriented) use of PV-batteries



Policy conclusions

- Electricity storage concerns currently no reason to slow down renewable deployment
- In highly renewable systems, longer-term storage becomes key
 - Focus for R&D
 - Incentives for market uptake to scale up, foster technological learning, and develop supply chains
 - But avoid unintended path dependencies and excessive hydrogen use vs. direct electrification
- Enable sector coupling to become temporally flexible
 - Sufficient investment in heat or hydrogen storage
 - Non-distortive charges and tariffs

Conclusions for energy system research

- Research strand 1 is done
- Put flexibility aspects of sector coupling in the focus

Thank you for listening



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Backup: less flexible storage

Inflexible sector coupling increases electricity storage needs

