TECHNISCHE UNIVERSITÄT WIEN

Energy Economics Group

The transition to a renewable electricity system - the role of electricity storage

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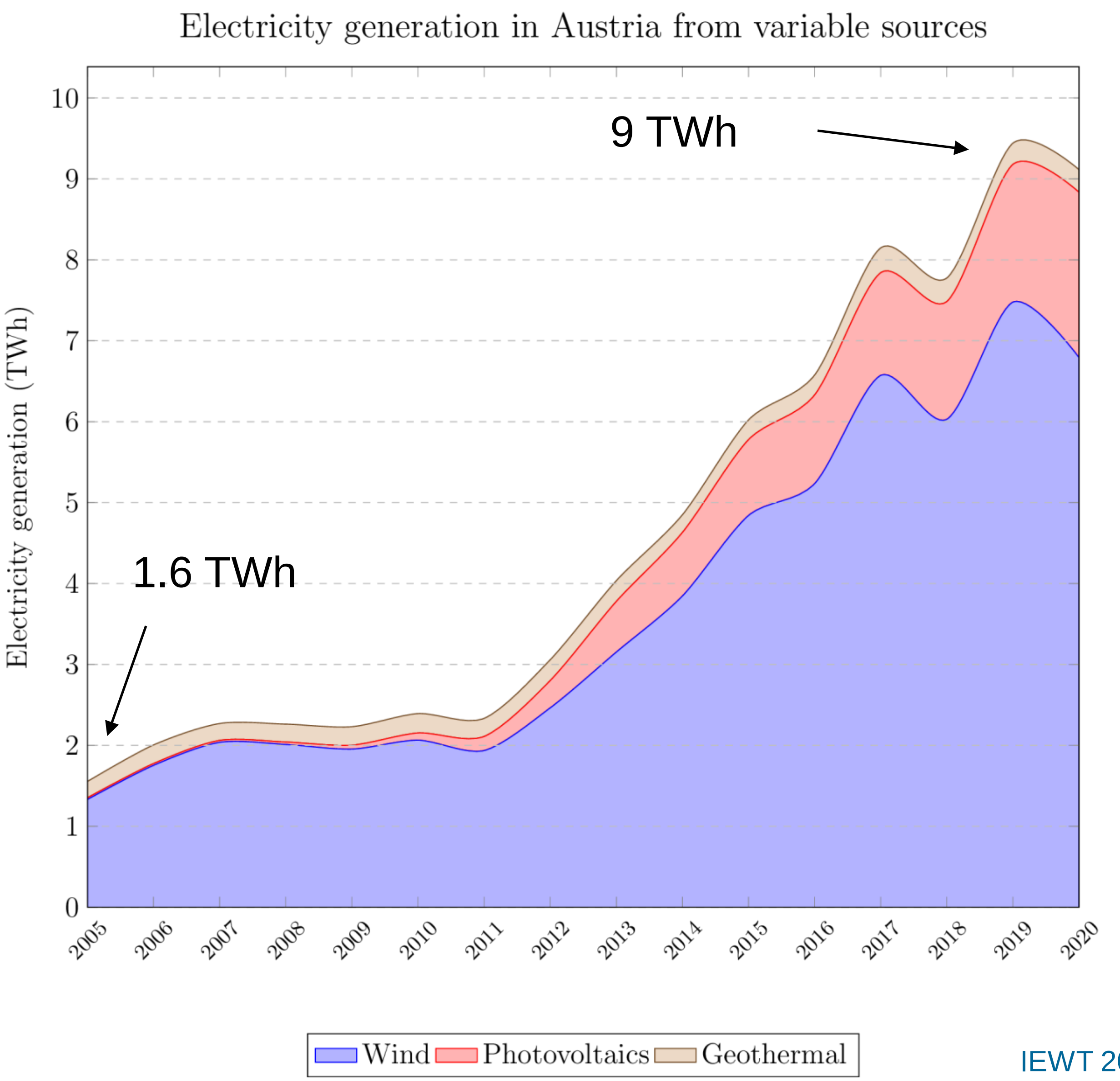
Agenda

- Introduction and overview
- Electricity system with high shares of variable renewables
- Future cost developments with the technological learning approach
- Economic discussion

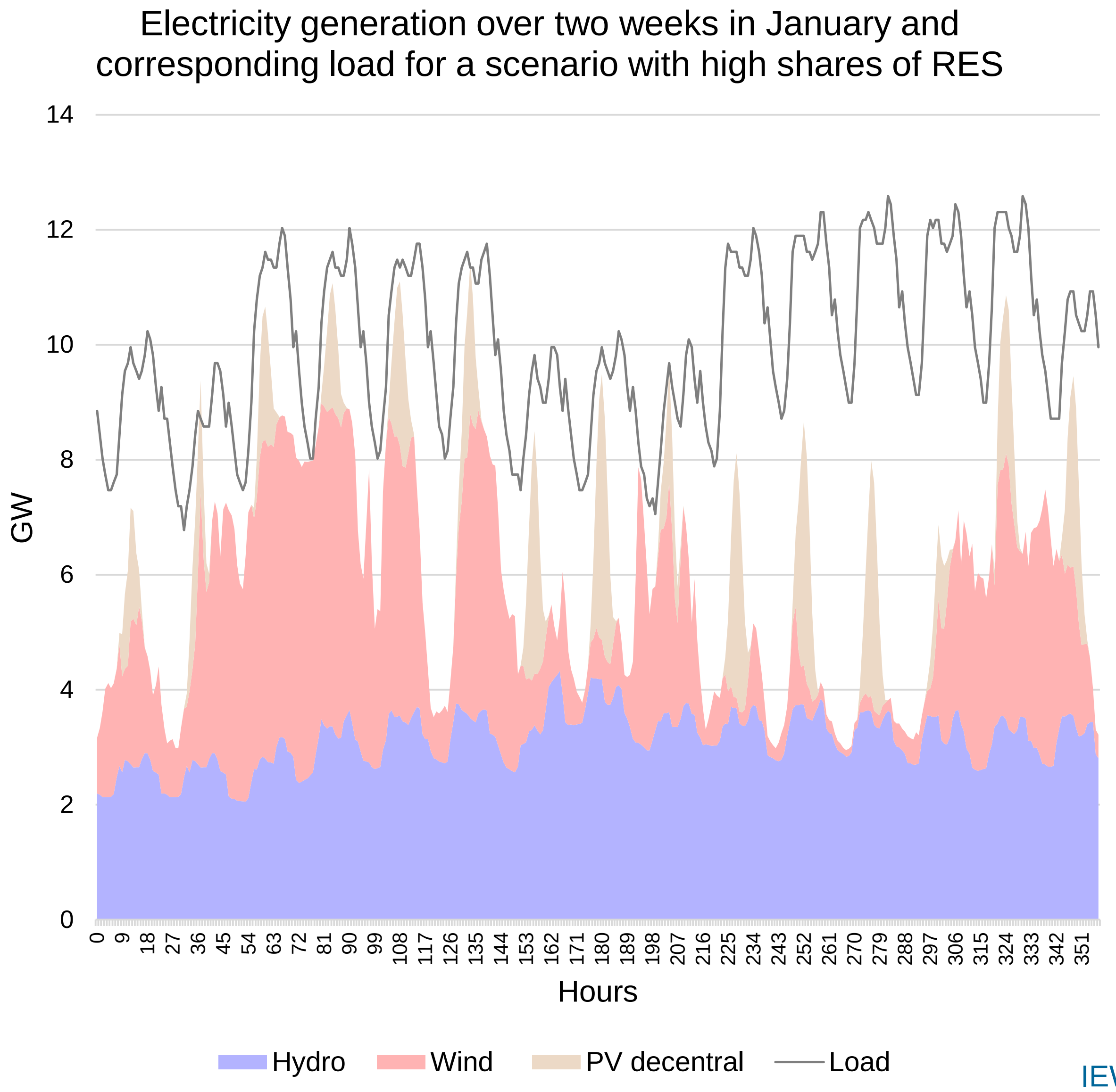
Increasing importance of storage

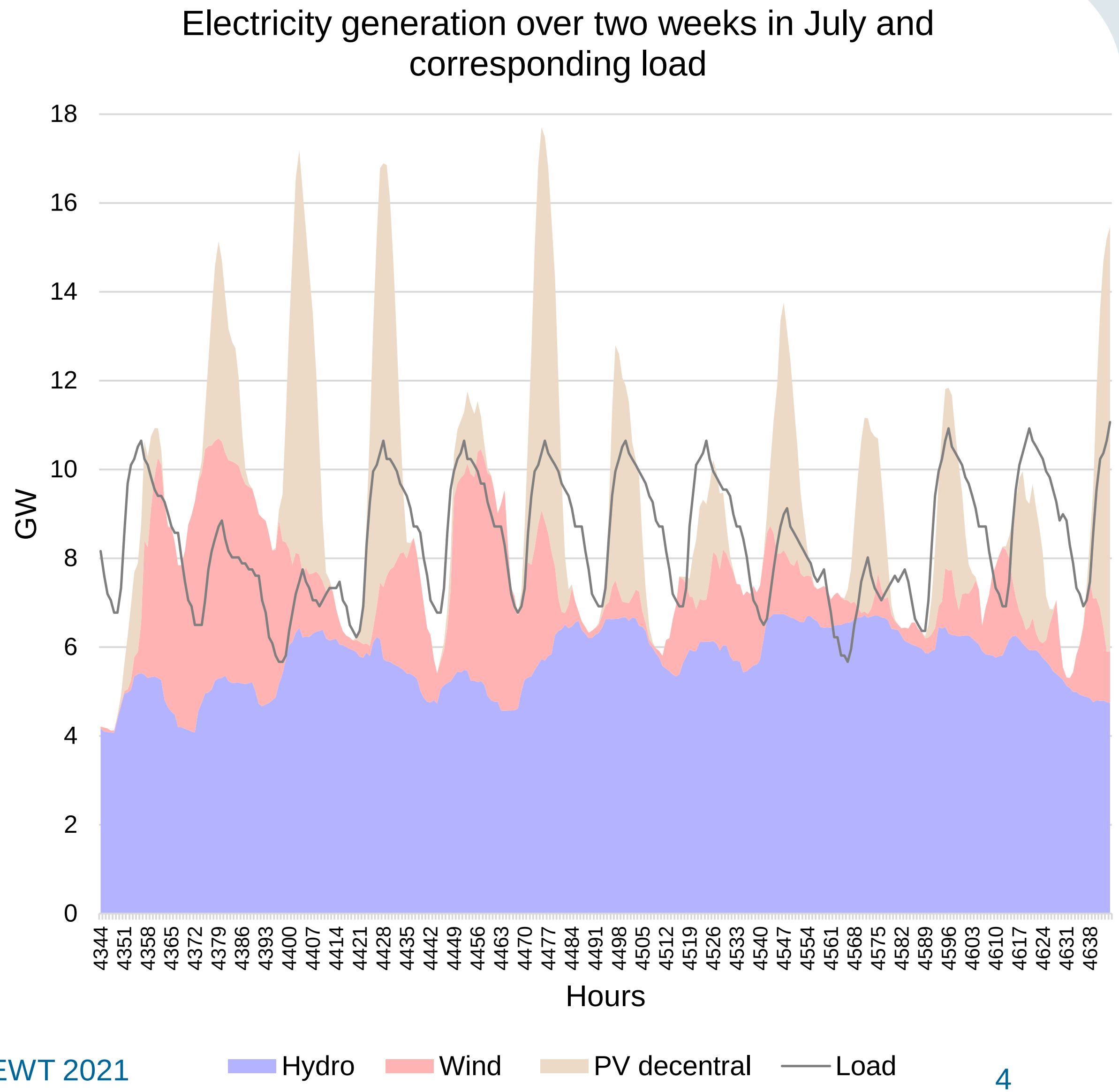


- Continuation of this trend in view of EU/Austrian emission targets
- Integration of a large share of variable renewables
- Crucial role of storage in the long run

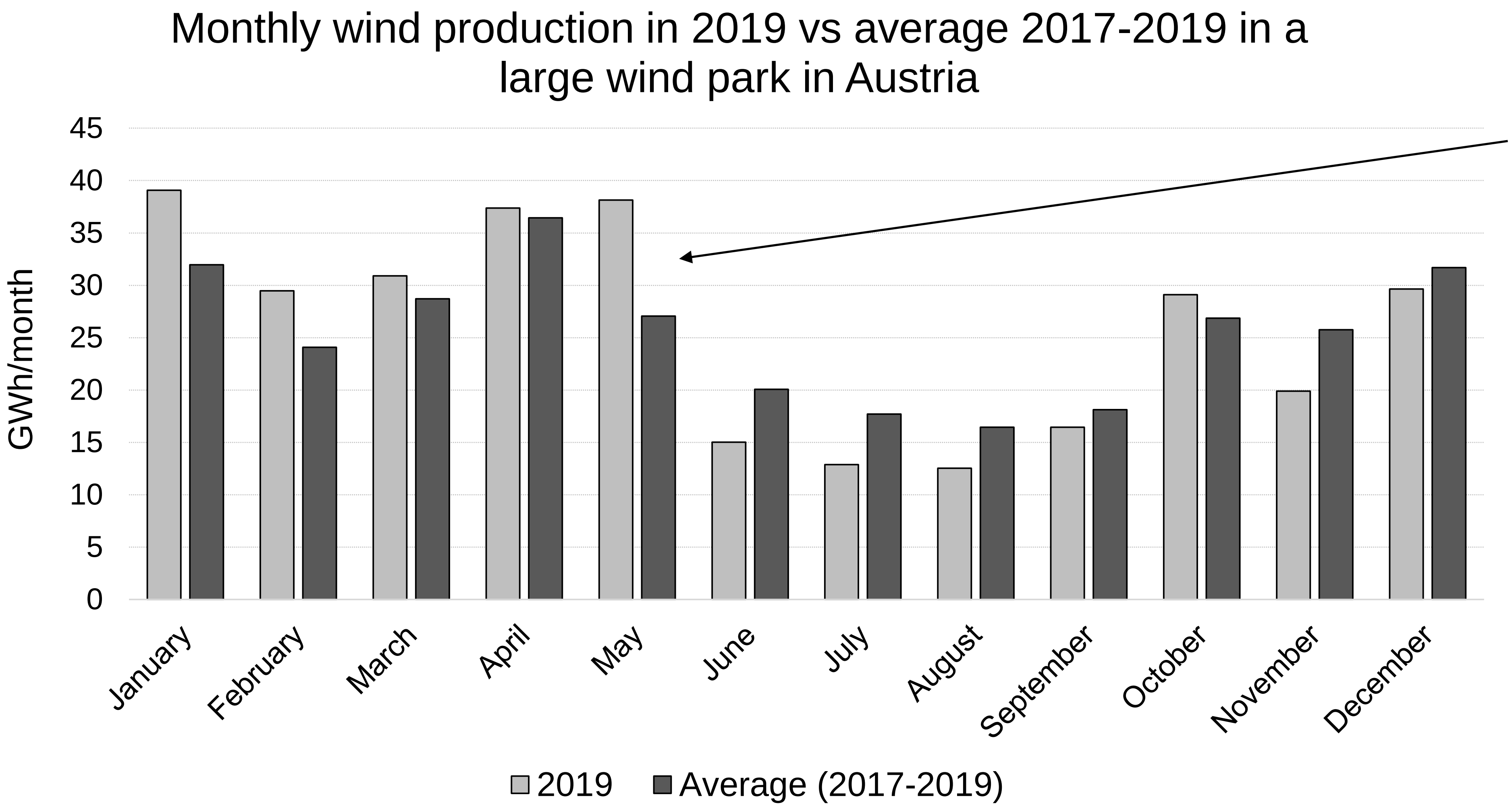
Source: Statistics Austria (2021): Data for 2020 is preliminary

Differences between summer and winter



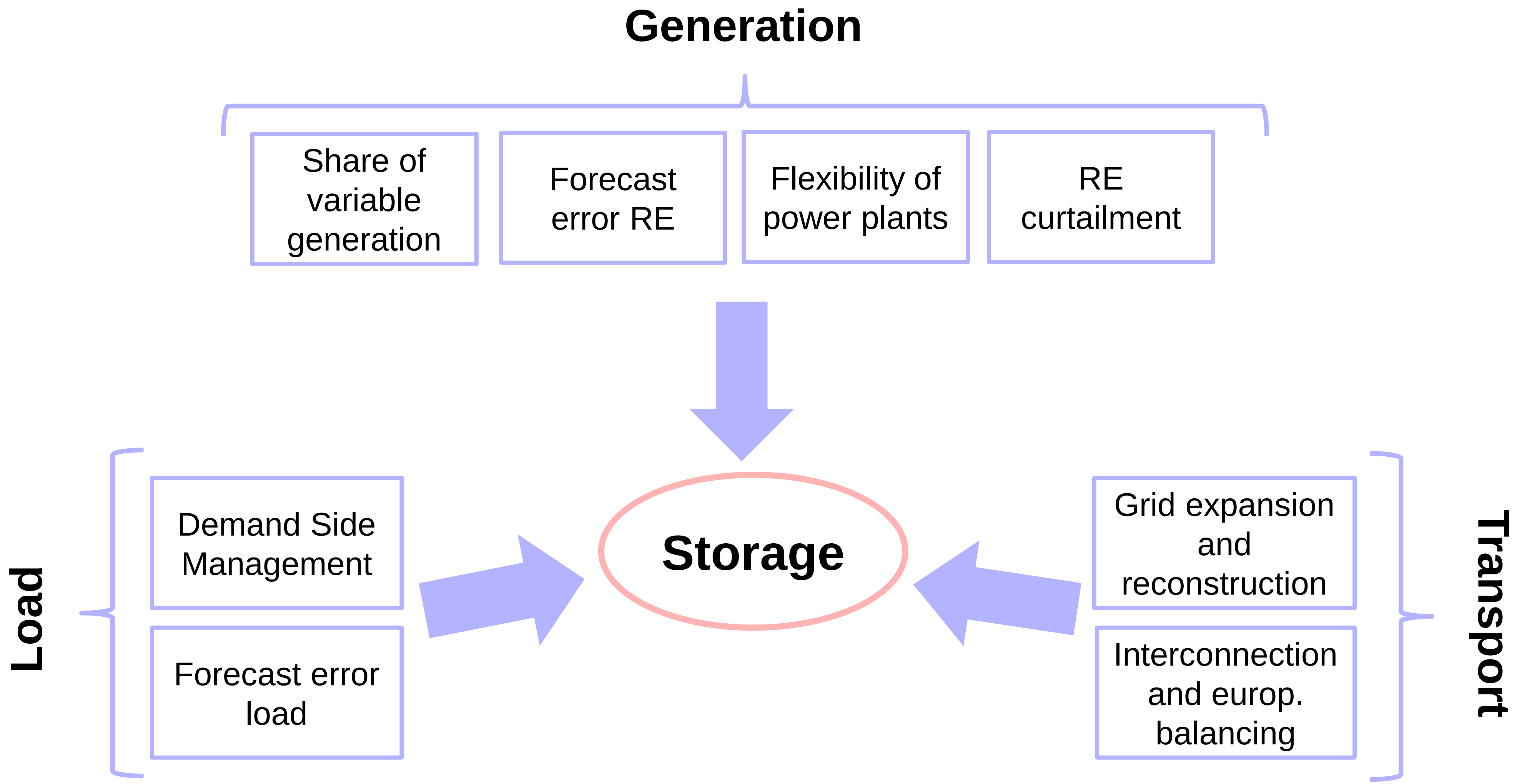


Wind production is fluctuating over the years



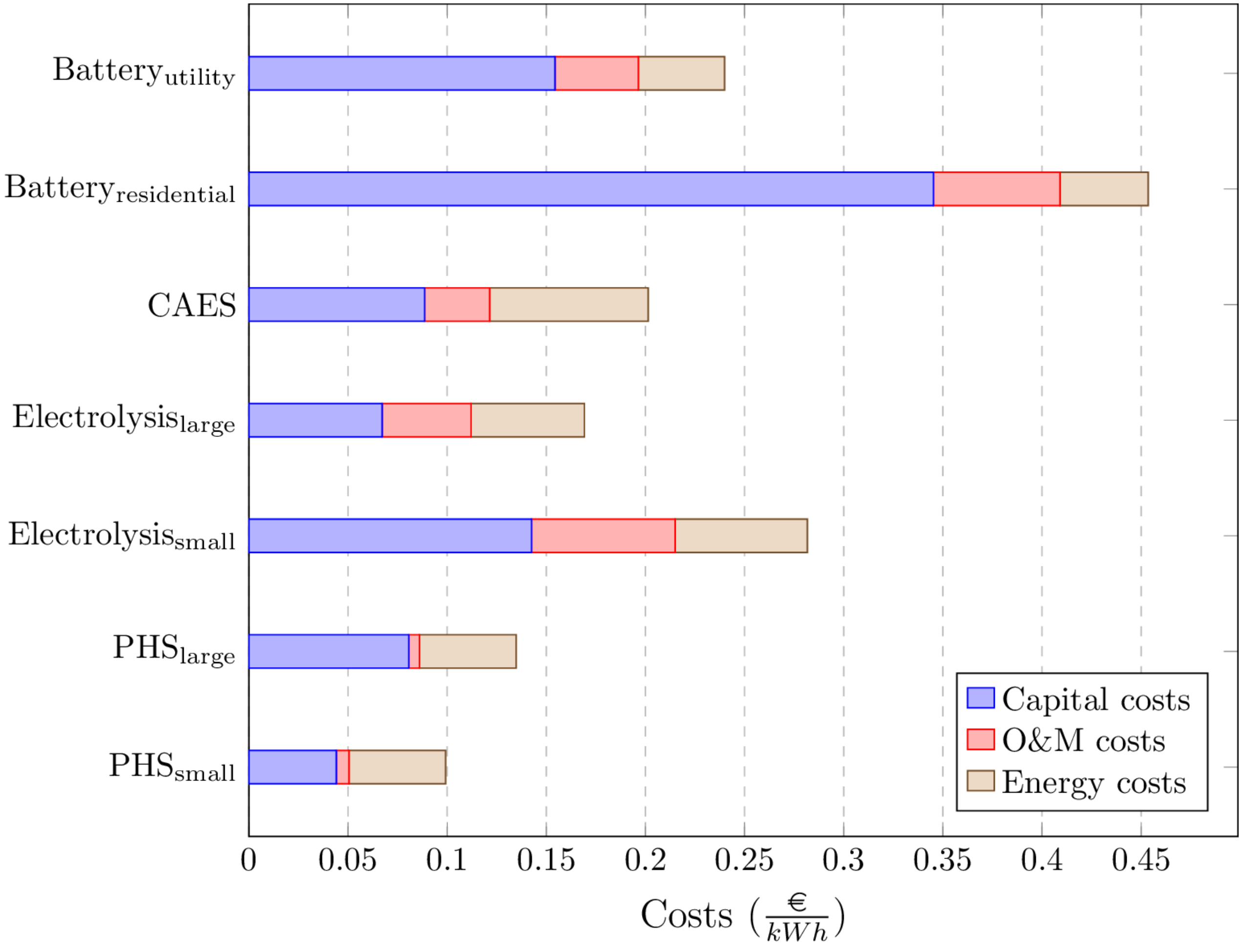
Also substantial difference among different years depending on the wind

Factors influencing the required storage capacities



Source: Sterner et al. (2019)

Storage costs



Calculations:

$$C_{STO} = \frac{\frac{IC * C.R.F + C_{O\&M}}{T} + C_E}{\eta_{STO}} \quad (1)$$

IC … Investment costs of a storage (EUR/kW)

C.R.F…Capital recovery factor (1/year)

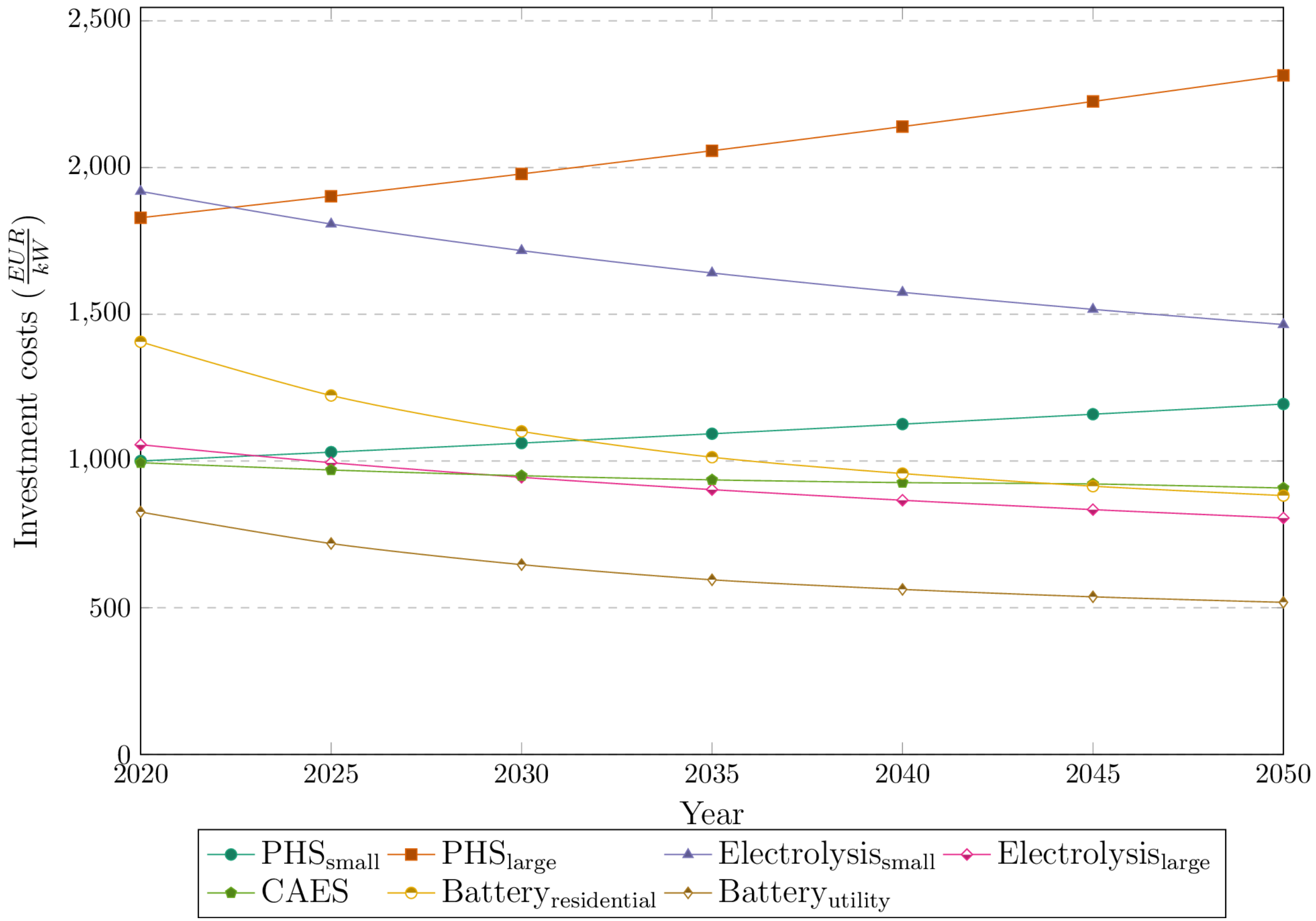
$C_{O\&M}$ … Operation and maintenance costs of the storage (EUR/year)

C_E … Costs of electricity (EUR/kWh)

T … FLH (hours per year)

η_{STO}… Storage efficiency

Development of investment costs of different storage technologies



Technological learning concept:

$$IC_t(x) = IC_{Con_t}(\mathrm{x}) + IC_{New_t}(\mathrm{x}) \quad (3)$$

$$IC_{New_t}(x) = IC_{New_t}(x_{Nat_t}) + IC_{New_t}(x_{Int_t}) \quad (4)$$

$$IC_{New}(x_t) = IC(x_{t_0}) * \left(\frac{x_t}{x_{t_0}}\right)^{-b} \quad (5)$$

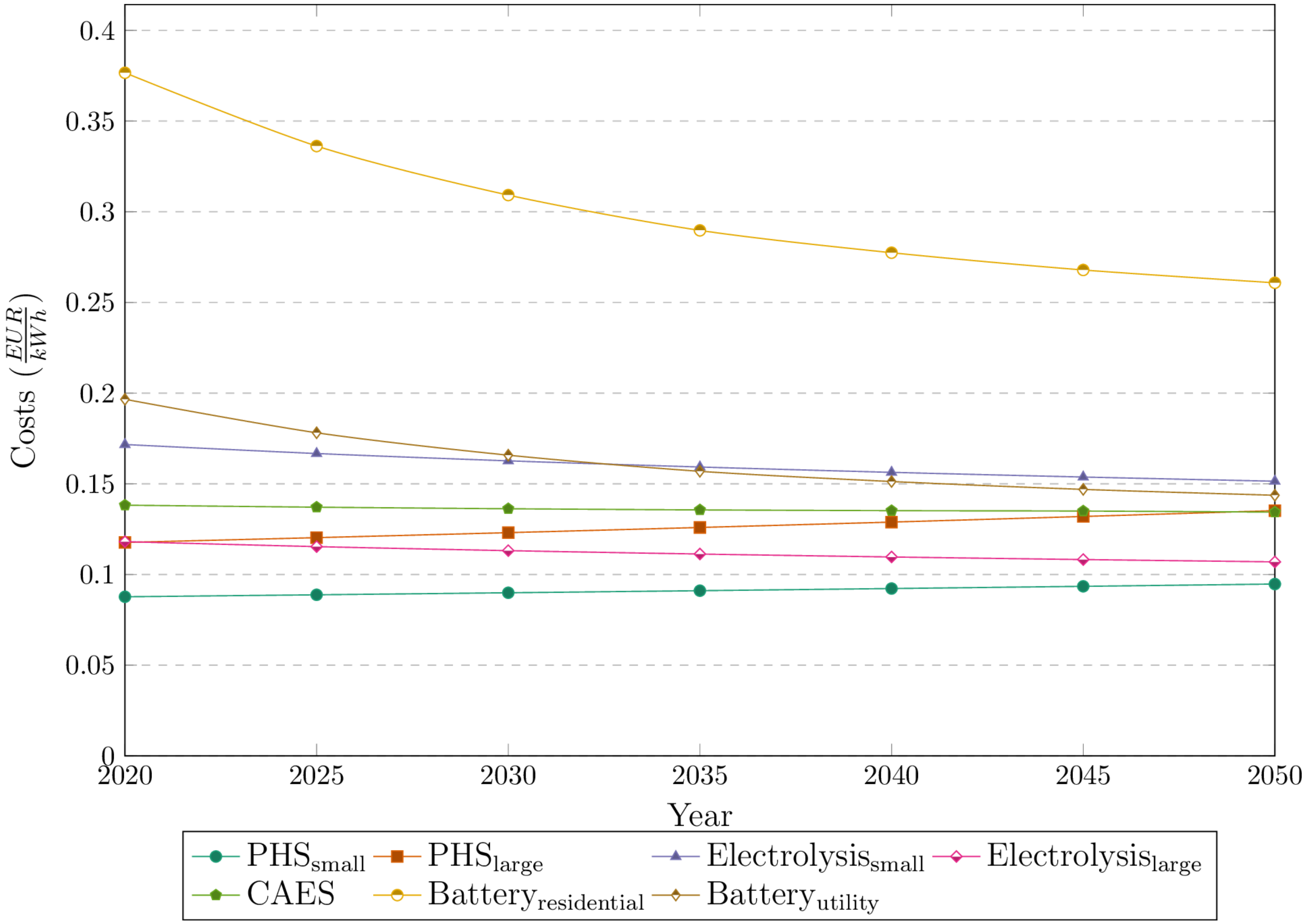
x… Cumulative amount manufactured

b… Learning index

- Learning rates (LR) of 20% Batteries, 18% of Electrolysis
- PHS no LR → fully mature technology
- Rise of cost (lack of sites and acceptance)

Source: Haas et al. (2021), Junginger (2020), IEA (2020), Tsiropoulous (2018)

Development of storage costs



Economics - Example for the case of PHS

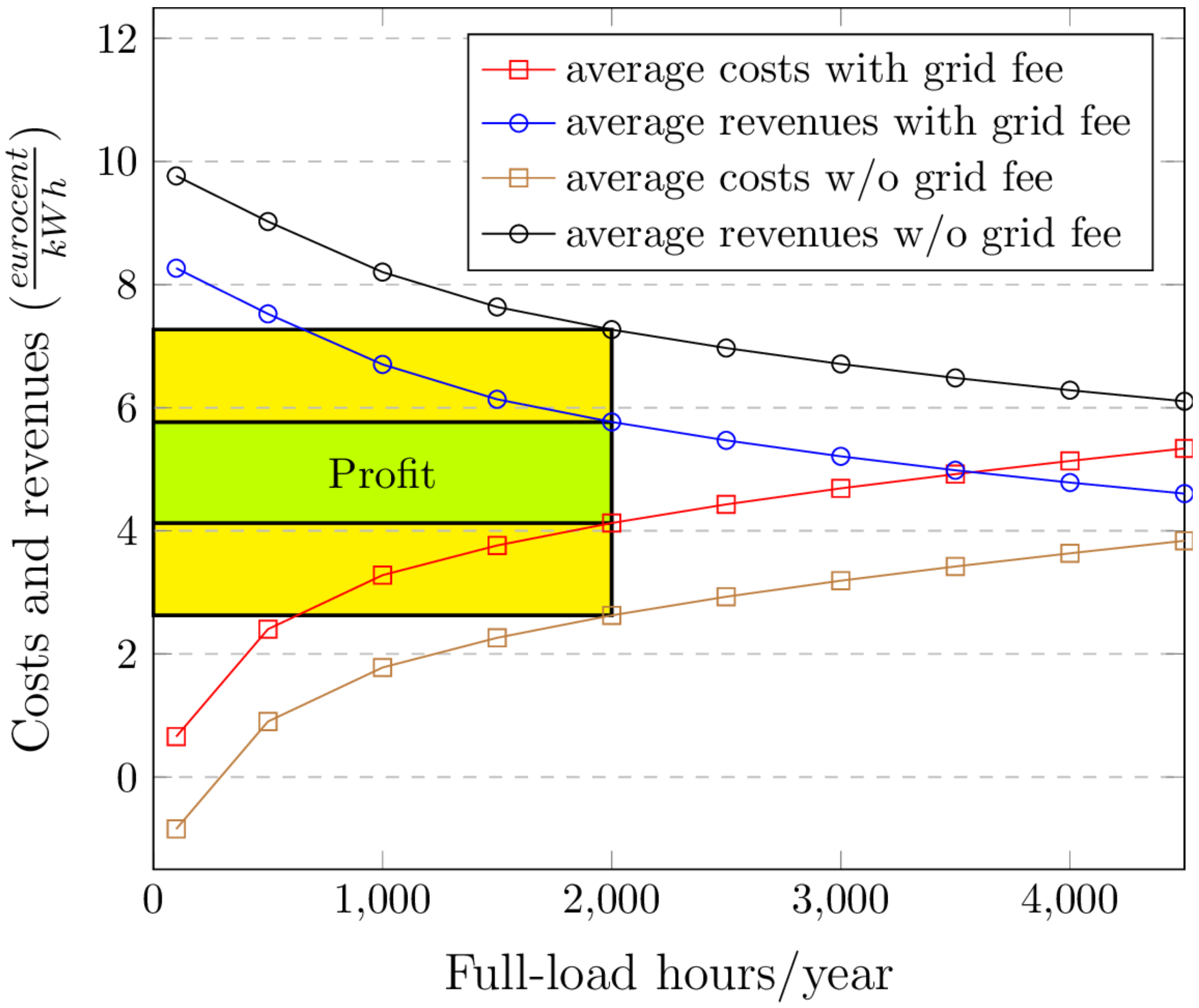
- Profit maximization as the goal of the storage operator competing on the market
- Defined as revenuse minus costs (only consider arbitrage value here)

$$\max \Pi_t = \sum R_t - C_t = \sum (P_{H_t} - C_{gf_t}) \cdot D_t - (P_{L_t} + C_{gf_t}) \cdot \frac{D_t}{\eta_t} - IC_0 \cdot C.R.F. - C_{OM_t} = 0 \qquad (2)$$

P_H… High price of electricity on the market (EUR/kWh)
P_L… Low price of electricity on the market (EUR/kWh)
C_{gf}… Costs of grid fee
D_t … Demand of energy (kWh)
η… Storage efficiency
IC …. Investment costs of a storage (EUR)
C.R.F….Capital recovery factor (1/year)
C_{OM} … Costs of operation & maintenance of the storage (EUR/year)

- Introduction of a grid fee at 1.5 cent/kWh

Example for the case of PHS



- Production costs and revenues are largely depending on the full-load hours (FLH) per year
- Overall profit at 2,000 FLH

Data used is the classified frequency of the average electricity costs as well as revenues for the example of the wholesale exchange in AT for 2020, considering storage losses

Source: EXAA (2020)

Problems

- Each additional installed storage capacity reduces the FLH hence the profit
- Arbitrage profits are also reduced as with each additional installed storage capacity the required peak load is reduced and also the price difference
- (unless RES capacities are added to the same extent, or supply curve is not convex – s-shaped by marked design with high negative prices, might increase the price level)
- PHS: Potential is limited by the availability of sites; most topographical optimal sites are already taken (higher construction costs and permission processes); use of exhaust coal/lignite mines as water reservoirs (high costs)

Source: Brücker und Preuße (2020)

Conclusions

- Seasonal storage will be required in an energy system with high shares of fluctuating renewables
- Storage will be included in the RES model to define scenarios with different storage amounts
- FLH have the biggest impact on storage costs
- The issue of grid fees has to be dealt with also in view of lower possible arbitrage profit

Thank you for your attention!

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