ON THE ECONOMICS OF STORAGE FOR INTEGRATING LARGER SHARES OF VARIABLE RENEWABLES IN THE ELECTRICITY SYSTEM

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Overview.

Larger shares of renewable energy sources (RES) are considered as a precondition for heading towards sustainable electricity systems. In recent years electricity generation from variable sources like wind and solar has rised. Typically, variable RES have profiles different from customers load profiles, see Fig. 1. Also in this case to balance electricity supply over time calls for storages has been launched. Hence the relevance of balancing is necessary and in first line are currently storage technologies. Storage has played an important role for balancing generation and demand at least to some extent since the beginning of electricity systems with pump storage having played the by far most relevant role. About 99% of all electricity storage is pumped storage (REF). This balance has to be done over short – e.g. hours, days – and longer periods e.g. months and year.

The core objective of this paper is to investigate the future market prospects of long-term – as hydro pump storages, and power-to-gas (PtG) technologies like hydrogen (H2) and methane (CH4) – and short-term – battery – electricity storages from an economic point-of-view. In this context it is very important to analyze especially the long-term Learning effects regarding the investment costs of all relevant technologies.

Method

Our method of approach is based on levelized cost calculation of electricity storages, see Haas and Ajanovic (2013). A very important parameter in this context are fullloadhours (FLH), see Ajanovic and Haas (2014).

The most crucial parameter in this context are full-load hours T.

$$C_{Sp} = \frac{I\,\alpha}{T\,\eta} + C_{BW} + p \qquad \text{[cent/kWh]} \qquad (1)$$

with:

C_{Sp} Total storage costs per kWh in storage [cent per kWh]
C_{OM} Operation & maintenance costs [cent per kWh]
I Total investment costs [EUR/kW)
T Fulllloadhours (h/a)
Efficiency

E.g at FLH of 500 h/yr the costs are four times higher than at 2000 h/yr, see Fig. 2. To answer the core question we use a dynamic framework to model supply from various quantities of variable RES- E and the load profiles based on Western European conditions, see Fig.1. The analysis of future prospects is based on technological learning (TL) regarding the future development of investment costs of long-term storages. Quantities for the single technologies are modeled based on IEA (2011). Note, that for hydro storages we do not consider further TL.
On the electricity market side we use a fundamental approach where the intersection of supply and demand at every point-of-time gives the corresponding electricity market price. It is important to note that the quantity of storage has a feedback on the market price for charging storages as well as discharging and, hence, on the price spread..

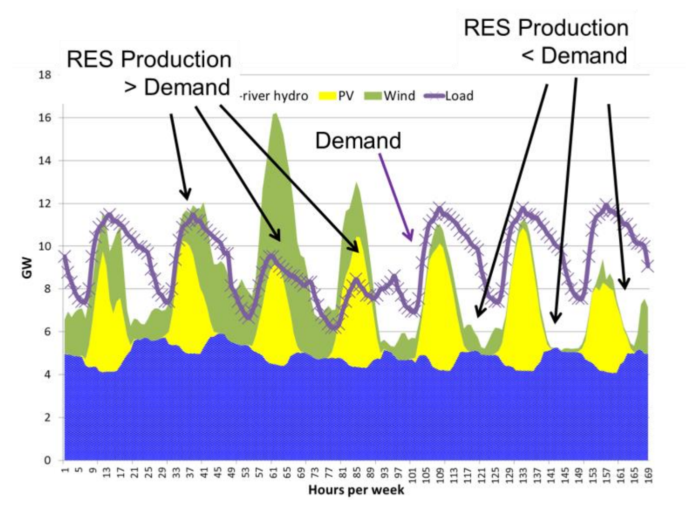


Figure 1. Electricitygeneration from variable RES and Load over a week (modelling example)

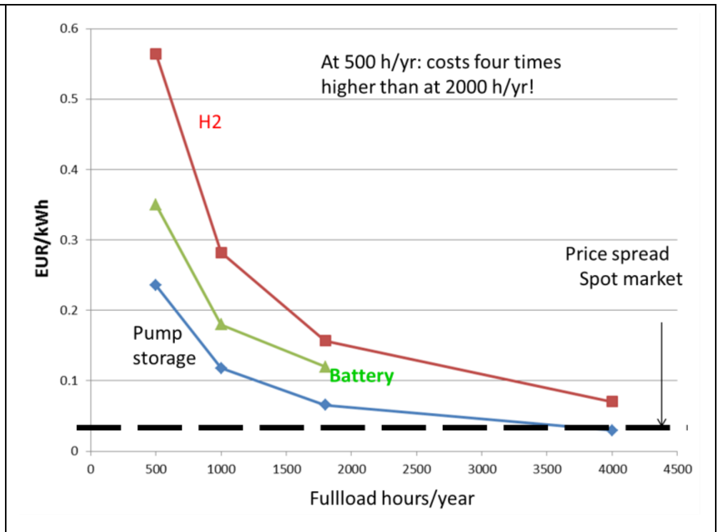


Figure 2. Costs of storing electricity for different technologies depending on the fullload hours per year

Results

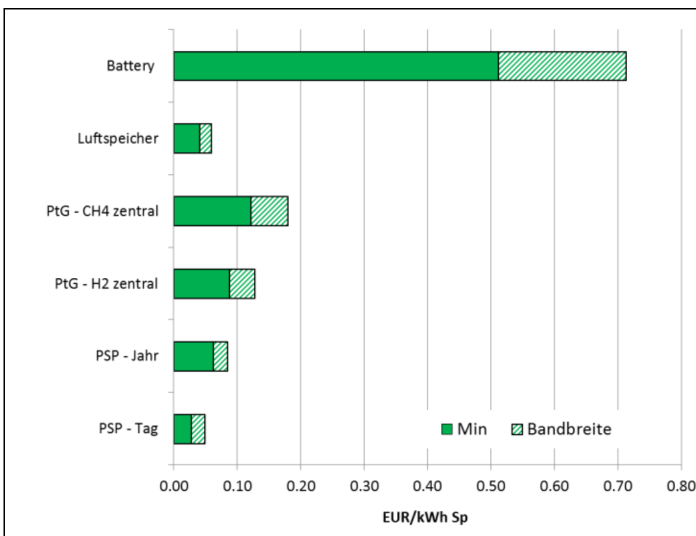
The major results of our Investigations are:

The first major problem of the economics of storages are their low fullloadhours (FLH), see Fig.2. Currently, a figure of about 2000 hours per year is considered to be the minimum. As Fig. 3 shows costs that at current price spreads of about 3 to 5 cents/kWh in the German/French market no type of storage is economically attractive at FLH below 4000 h/yr. Also in the long run the economic prospects of storages do not look much brighter.

Over the period up to 2050 decreases in the prices of PtG- technologies will take place mainly due to learning effects. For long-term hydro pump storages (over a year) further prices will rather increase mainly due to a lack of sites with reasonable costs and lack of acceptance, see Fig. 8. In a dynamic market framework the costs of all centralized long-term storage technologies will finally be too high to become competitive. By 2030 under most favourable learning conditions the costs of hydrogen and methane for 2000 fullload hours per year will be between 0.15 EUR/kWh and 0.20 EUR/kWh. For the same FLH the price spread will be at the utmost about 0.08 EUR/kWh.

Other reasons for limited attractiveness of long-term storages are competition with demand response options, demand–side management, and grid extention, see Fig. 4. Moreover, decentralized storages might also compete. The costs of the latter will not decline significantly faster but they will compete on end-user price level which is (and will remain) remarkably higher

An additional reason for the unfavorable economic conditions of long-term storages is the self-cannibalism of storages in electricity markets. This means that every additional storage has lower FLH then the one before, see Fig. 7 and, in addition reduces the price spread and, hence, its own economic performance, Ehlers (2011).



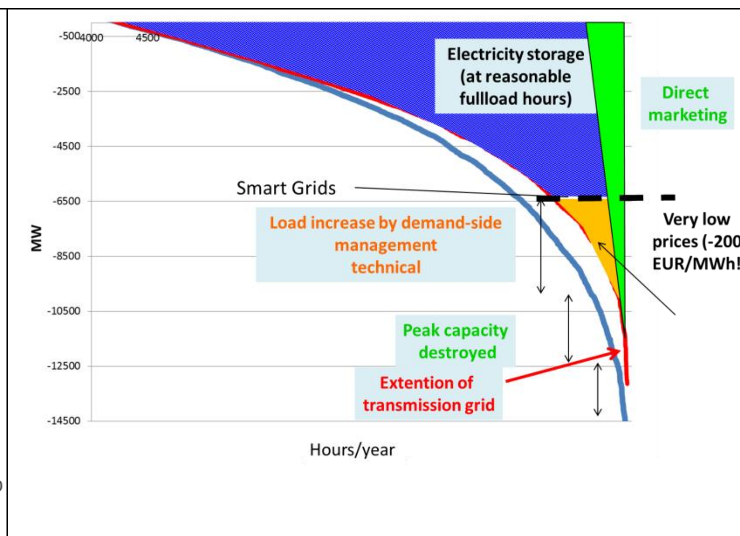


Figure 3. Costs of storing electricity for different technologies in comparison to electricity prices (as of 2014)

Figure 4. Competing options with storage for flexible use of excess electricity competing with long-term storages

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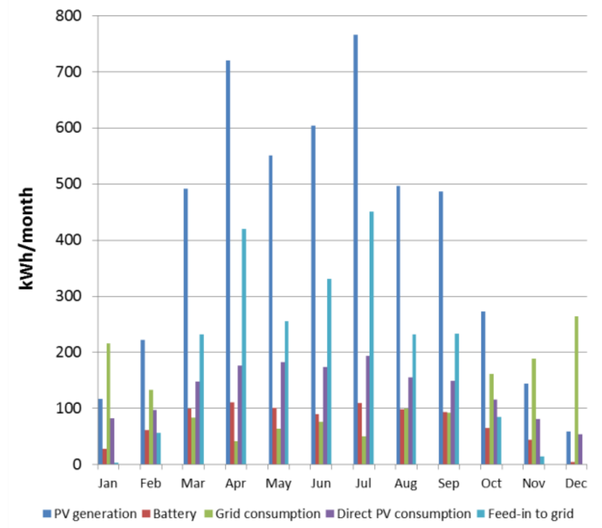

Figure 5. Monthly data for own consumption, grid supply, battery charge, battery discharge and grid feed-in

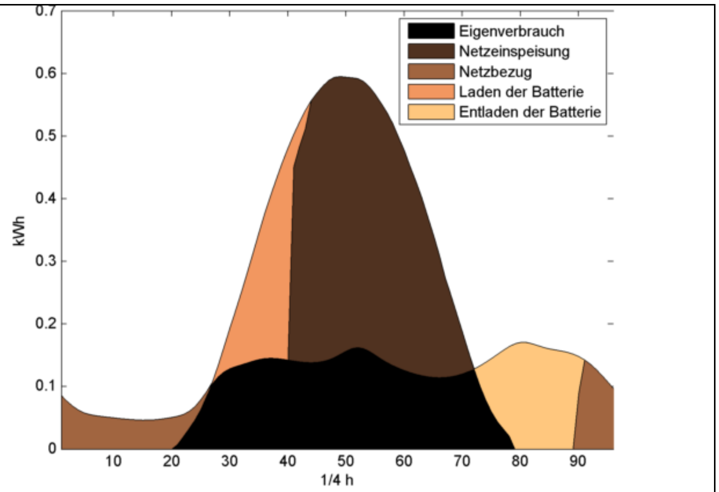

Figure 6. Comparison of own consumption, grid supply, battery charge, battery discharge and grid feed-in on a summer day

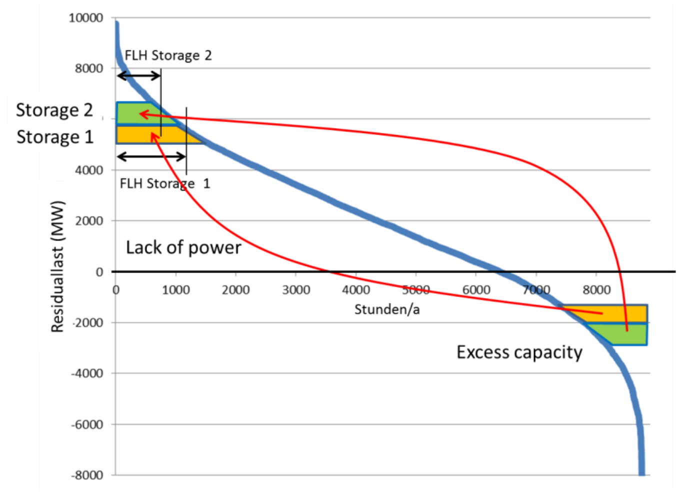

Figure 7. Fullloadhours of additional storages within a load duration curve with large shares of RES-E

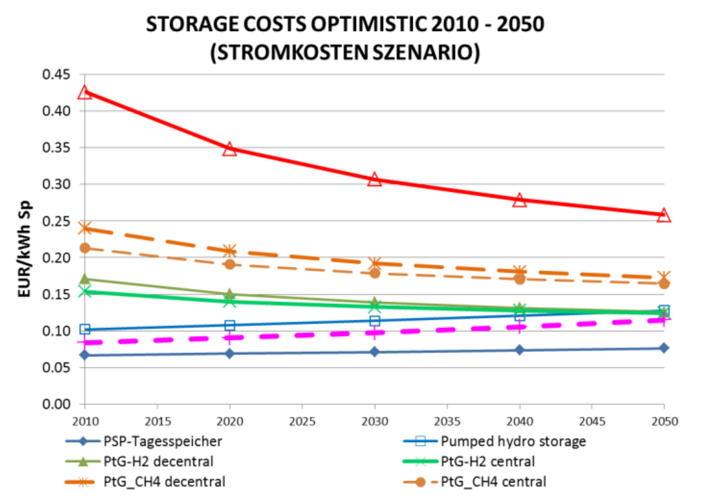

Figure 8. Development of costs of several technologies for long-term storage of electricity depending on Technological Learning over time up to 2050

Conclusions

The major conclusions are: (i) Despite many calls for a prophylactic construction of new storage capacities with respect to all centralized long-term storage technologies the future perspectives will be much less promising than currently indicated in several papers and discussions; (ii) new long term hydro storages will not become economically attractive in general in the next decades; however, daily storages will remain the cheapest option and the most likely to be competitive; (iii) batteries has the advantage that they do no compete with the low price spreads in the wholesale

markets but with the considerably higher retail prices for electricity (between 20 and 30 cent/kWh in Western Europe); (iv) For PtG-technologies it will also become very hard to compete in the electricity markets despite a high technological learning potential. Yet, for hydrogen and methane there are prospects for use in the transport sector. Fuel prices in transport in recent years have rather increased compared to stagnation or decreases in electricity spot markets. Consequently, and given in addition the lack of environmentally benign fuels for mobility hydrogen and methane from renewable electricity might become an economically alternative for fueling passenger cars.
However, in any case new storages should be constructed only in a coordinated way and if there is a clear sign for new excess production, in this case of RES.

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