

9

- 🖄 🔼 🖿 📮

24.10.2017

The impact of PV penetration levels on price volatility and resulting revenues for storage plants Michael HARTNER⁽¹⁾, Andreas Permoser⁽²⁾

⁽¹⁾ Energy Economics Group, Institut für Energiesysteme und Elektrische Antriebe, TU

Wien

Motivation und zentrale Fragestellung

This study analyzes the effect of electricity generation from photovoltaic on electricity prices and revenues for storage plants. Within the literature the effect of renewables on price variance and as a result on the income of storage plants on the spot market is not clear. A recent study by Wozabel et al. (2014) [1] shows that the effect also depends on the penetration level of renewables on the market. In this study we proved and quantified that hypothesis focusing on the effect of photovoltaic on the Austrian and German electricity market.

Methodische Vorgangsweise

We apply an electricity dispatch model to derive hourly prices for the market region of Austria and Germany for increasing installed capacity of photovoltaic. Those prices are used to calculate potential revenues for storage systems using a storage optimization model based on linear optimization. In addition we also estimated historic revenues for storage plants on the spot markets using EEX prices from 2002 to 2014.

Ergebnisse und Schlussfolgerungen

Figure 1 shows calculated annual revenues in €/kW from the storage model for historical spot market prices (EEX stock exchange) from 2002 to 2014 and storage capacity vs. power output ratios of 4h, 8h, 200h and 2000h. Revenues increased until 2008 where rising electricity demand in combination with high prices for primary energy carriers led to high average electricity prices in combination with frequent price peaks. After 2008 modelled storage revenues declined sharply. Both, average prices and price variance declined which leads to lower revenues for storage plants on the spot market. One reason for this decline is assumed to be declining primary energy carrier prices. The impact of feed in from PV however cannot be directly derived from this development because direct effects are partly offset by primary energy price changes and other factors.



Figure 1: Development of historic revenues for storage plants based on EEX spot market prices

The following results are based on modelled prices derived from the electricity dispatch model. All parameters have been kept constant except for the share of PV in the system. Results clearly show that the effect of increased feed in from photovoltaic depends on the penetration level. There is a nonlinear relationship between PV and storage revenues. For low shares of photovoltaic in total electricity generation, decreasing revenues and price variances are observed because of high correlations between demand peaks and solar radiation. The minimum of revenues for storage plants is reached at around 5% penetration level. For higher shares revenues start to increase significantly and are expected to be higher than initial revenues for penetration levels >10%. The shape of the curve is similar for all 4 capacity vs. power output ratios of the storage plants which reflect daily, monthly and seasonal storage facilities.



Figure 2: Development of revenues for storage plants at various shares of PV in the system

The explanation for this development lies within the modelled prices which can be seen in Figure 3: Modelled average prices in each hour for various PV shares (average over 365 days for each hour). The average price curve is flattened out for a 5% PV share before a price valley starts to form at higher shares.

From these observations we conclude that although of course additional storage capacity (or other flexibility options) will be a valuable features for electricity systems in the long term if



high shares of PV are introduced to the system, initial incentives from spot market prices might be low or even negative for low penetration rates. For the market region of Austria and Germany it was found that PV penetration is currently (in the year 2016) close to the minimum of the revenue curve derived from model results concluding that in the future additional PV capacities should have a positive effect on revenues for storage systems operating on spot market price arbitrage within this market region.

For other regions where PV penetration levels are still significantly lower than 5% model results suggest that revenues for storage operators on the spot market might decline with increasing PV shares until reaching the tipping point where revenues start to increase again.

For investors and policy making in terms of integration PV into the electricity system we conclude that: - PV can lead to lower incentives to invest in storage plants for low PV penetration level and it might therefore not pay off to invest now even if additional storage is valuable in the long term.

- With respect to this observation an approach where first PV feed in is supported and additional incentives for storage systems are added at a later stage when the value of storage for the system starts to rise again is more cost effective than supporting PV and storage simultaneously at low PV penetration levels.

- From a methodological point of view we conclude that econometric models might not be suitable to estimate the long term effect of VRs on price variance if historical data on VR feed-in and prices only cover a certain range of VR penetration. The derived curves shown in the result sections can only be reproduced if the available data covers the historical period of at least more than 5% PV penetration and must either allow for structural breaks or include a nonlinear relationship between PV penetration and prices to reproduce the change in the direction of the effect on price variances.

Literatur

[1] Wozabal, D., Graf, C., Hirschmann, D., 2014. The Effect of Intermittent Renewables on the Electricity Price Variance (SSRN Scholarly Paper No. ID 2402233). Social Science Research Network, Rochester, NY.