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The merit order effect of wind and photovoltaic electricity generation in Germany 2008–2016 estimation and distributional implications

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ABSTRACT

Generation from renewable energy sources in Germany has experienced a considerable uptake in recent years. Mainly responsible for this development is the German Renewable Energy Sources Act (Erneuerbare Energien Gesetz, EEG). This paper considers redistributive implications of the EEG for different electricity consumers. Using time-series regression analysis, we show that electricity generation by wind and PV has reduced spot market prices considerably by 6 €/MWh in 2010 rising to 10 €/MWh in 2012. We use these results to build a near-term forecasting tool for merit order effects, projected to reach 14-16 €/MWh in 2016. On the other hand, the costs of the EEG are passed forward to consumers in the form of a surcharge. Our findings highlight significant redistributive transfers under the current design of the EEG. In particular, some energy-intensive industries are benefiting from lower wholesale electricity prices whilst being largely exempted from contributing to the costs of the scheme. We also highlight implications of our results for other areas for reform of the EEG, such as adequate renumeration mechanisms that ensure efficient operation and investment decisions are made under the scheme. More generally, these findings suggest that policy makers need to integrate distributional assessments into policy design and implementation.

1. Introduction

Electricity generation from renewable energy sources in Germany has expanded rapidly over the past decades, rising from 20 TWh in 1990 to 142 TWh in 2012, of which wind provided 51 TWh and photovoltaics (PV) 26 TWh. Biomass was responsible for 39 TWh (AG Energiebilanzen, 2013). The main reason for this expansion is the key support instrument for renewables in Germany, the German Renewable Energy Sources Act (Erneuerbare Energien Gesetz, EEG). The EEG consists of priority feed-in, a purchase guarantee and a fixed feed-in tariff for electricity generated by renewable energy sources. The electricity from renewables fed into the grid via the EEG is mainly sold by network operators on the day-ahead (spot) market. The differential between the guaranteed price and the revenues achieved by renewables on the electricity market are paid for by power consumers.

To this end, power consumers are divided into a privileged and a non-privileged group. The privileged consumers mainly consist of energy-intensive companies, who pay 0.05 ct/kWh for the EEG surcharge, whilst for non-privileged consumers (mainly households), the surcharge is calculated on a yearly basis based on not only the quantities of renewables fed into the grid, but also other parameters, such as revenues attainable on the spot market, the level of total final consumption, the scope of privileged consumers and forecasting errors of earlier years (see Öko-Institut, 2012a for an analysis of the different components).

In October 2013 the transmission network operators published the surcharge for non-privileged consumers for 2014 at 6.24 ct/kWh rising from 5.28 ct/kWh in 2013 and 3.59 ct/kWh in 2012. The surcharge for non-privileged consumers is considerably (100 times) higher than the surcharge for the privileged consumers at 0.05 ct/kWh. This led to discussions about the appropriateness of the privilege rules. In their coalition agreement signed in December 2013, the coalition parties of the German government announced their plan to check the viability of the basis for the reduced surcharge (CDU/CSU and SPD, 2013). A paper by the Federal Ministry for Economic Affairs and Energy (BMWi, 2014) laying out reform options for the EEG further states the need for the privilege rules to conform to EU law, in light of infringement procedures opened against Germany by the European Union in December 2013.

A review of the scope and extent of the surcharge seems reasonable, not least because renewables have a depressing effect on the wholesale price of electricity through the so-called merit order effect. On a competitive electricity market, the higher the feed-in of renewables, the lower the wholesale price (at least in the short run). Therefore, companies that buy electricity on the wholesale market and are privileged

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under the EEG enjoy lower prices. This likely overcompensates for the amount they pay for the surcharge. As the International Energy Agency notes in their report on energy policies in Germany: "Recent increases in electricity costs have placed low-income households under pressure, whilst large consumers who buy power on the wholesale market have been shielded from the surcharge whilst benefitting from the renewables-induced reduction of wholesale prices" (IEA, 2013; p.131).

On liberalised power markets electricity prices and the deployment of power plants on the day-ahead (spot) market are determined on an exchange. The EPEX Spot, a merger of the German EEX and the French Powernext, is responsible for the electricity spot markets in Germany, Austria, France and Switzerland. At 12 noon each day an auction for each of the 24 hours of the following day takes place. Power producers offer their electricity at short-term marginal costs, which consist mainly of fuel costs and CO_2-costs. The offers are then lined up from lowest to highest resulting in the merit order curve. Fig. 1 shows a stylized merit order curve for Germany. Renewables have close to zero marginal costs, followed by nuclear energy, lignite, hard coal, gas and fuel oil plants. The spot market price for each hour is then determined by the marginal plant that is needed to satisfy electricity demand in the respective hour.

As more renewable energy sources are added to the generation mix, the merit order curve is shifted to the right and lower prices on the day-ahead market result. In their first monitoring report on the EEG, the Federal Environment Ministry gives an overview of the results of studies carried out on the merit order effect in Germany to date (BMWi / BMU, 2012; p.40). The results range from 2 to 13 €/MWh and are generally higher in recent years, as more energy generated by renewable sources is fed into the grid. Previous research has shown that the merit order effect of renewables is greater on the spot market than on the forward market (Öko-Institut, 2012b). However, a close interaction between the spot and the forward market exists. If this was not the case, arbitrage between the two markets would be possible (cf. Sensfuß, 2011).

Two broad methods to analyse the merit order effect of renewables have been employed: first, regression analysis of historical time-series data and second, electricity market modelling. The former analyses historical price and generation data, whilst the latter compares different scenarios within an electricity market model. There are merits and challenges concerning either of the methods. Using an electricity market model requires careful calibration and especially the definition of a reasonable counterfactual scenario. Regression analysis, on the other hand, can employ actual historical data and does not have to make assumptions about alternative developments. At the same time, only rather short-term merit order effects, based on the current electricity market and power generation structure are calculated. Moreover, issues such as the costs for new power plants or network development are not considered (Würzburg et al., 2013).

Regressing the German spot market price of electricity on the residual load, von Roon and Huck (2010) conclude that an extra GW of renewables or cogeneration decreases the spot price by 2.4 €/MWh (on average) and that the total merit order effect of renewables is 11 €/MWh in 2008. Since day-ahead wind forecasts are used as a basis by bidders in the spot market auctions, Neubarth et al. (2006) use those forecasts to determine the impact of an additional GW of wind on the hourly spot market price in Germany and conclude that it is equal to 1.9 €/MWh. This is equivalent to an average total merit order effect of 7.6 €/MWh in 2004–2005. Würzburg et al. (2013, p.3) note the "very limited empirical evidence" on merit order effects in Germany and carry out an analysis of the merit order effect on the joint German and Austrian market using daily averaged data on electricity prices, renewable feed-in, load, the price of gas and import and export flows. They estimate an overall reduction in the electricity spot price of 7.6 €/MWh between mid-2010 and mid-2012.

Time-series regression analysis has also been used to determine the impact of renewables and cogeneration on electricity prices in other countries. Gelabert et al. (2011) conclude that between 2005 and 2010 an additional GW of energy from renewables or cogeneration in Spain led to a decrease in the spot electricity price of 1.9 €/MWh on average. Jónsson et al. (2010) employ non-parametric parameter estimates to model the spot price dynamics on the Danish electricity market. They also find a significant price effect of wind, especially at the high demand end. Studies also exist for the Australian (Cludius et al., 2014; Forrest and MacGill, 2013) and Texan (Woo et al., 2011) markets, which both model the electricity price using an AR(1) process. Additionally, Cludius et al. (2014) and Forrest and MacGill (2013) employ a logarithmic transformation to account for specific impacts at the very low and high demand end.

Although electricity market models take a different approach, researchers have generated results in the same range. Using an agent-based electricity market model, Sensfuß (2011) and Sensfuß et al. (2008) calculate average merit order effects for Germany of 1.7 €/MWh in 2001, rising to 7.83 €/MWh in 2006 and between 5.82 €/MWh in 2007 and 6.09 €/MWh in 2009. Weigt (2009) uses a market equilibrium

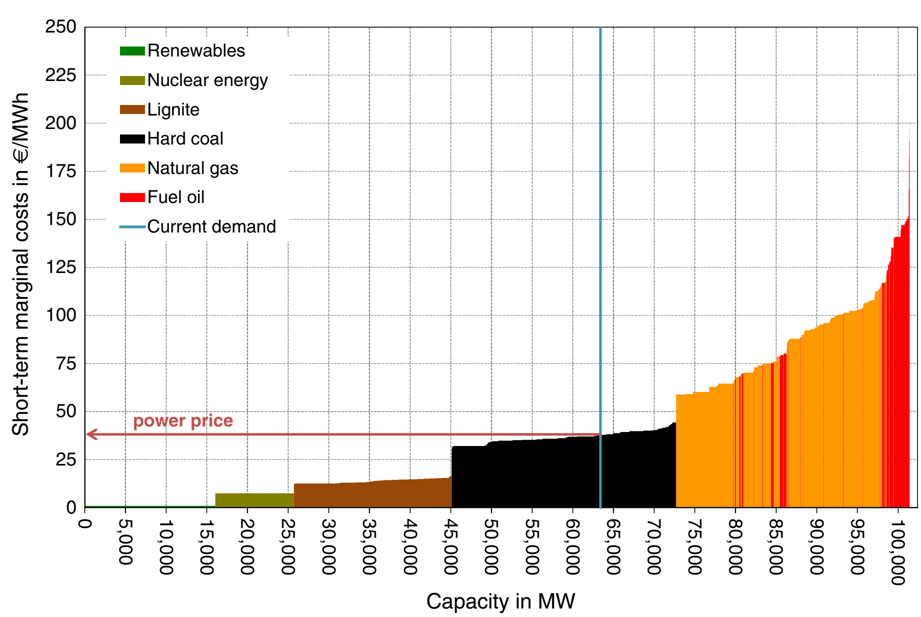

Fig. 1. Stylized German merit order curve.
Source: Own illustration.