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The merit-order effect: A detailed analysis of the price effect of renewable electricity generation on spot market prices in Germany

Frank Sensfuß [a,*], Mario Ragwitz [a], Massimo Genoese [b,1]

[a] Fraunhofer Institute for Systems and Innovation Research, Breslauer Str. 48, 76139 Karlsruhe, Germany
[b] Institute for Industrial Production, Universität Karlsruhe (TH), Hertzstr. 16, 76187 Karlsruhe, Germany

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ABSTRACT

The German feed-in support of electricity generation from renewable energy sources has led to high growth rates of the supported technologies. Critics state that the costs for consumers are too high. An important aspect to be considered in the discussion is the price effect created by renewable electricity generation. This paper seeks to analyse the impact of privileged renewable electricity generation on the electricity market in Germany. The central aspect to be analysed is the impact of renewable electricity generation on spot market prices. The results generated by an agent-based simulation platform indicate that the financial volume of the price reduction is considerable. In the short run, this gives rise to a distributional effect which creates savings for the demand side by reducing generator profits. In the case of the year 2006, the volume of the merit-order effect exceeds the volume of the net support payments for renewable electricity generation which have to be paid by consumers.

1. Introduction

The development of renewable electricity generation in Germany has been characterized by considerable growth rates throughout the past 15 years. This development is mainly driven by a guaranteed feed-in-tariff which has been in place since 1991. The actual conditions of the German support scheme were revised in 1998, 2000 and 2004 (see also Lauber and Metz, 2004; Wüstenhagen and Bilharz, 2006). Since 2000 the Renewable Energy Sources Act is in place. According to the law the German grid operators have to buy electricity generated by specified renewable energy sources at a guaranteed feed-in-tariff. In a second step the electricity is sold to the electricity suppliers according to their market-share. The additional cost for the feed-in-tariff has to be paid by the consumers in the end. There is a considerable debate on the efficiency and the cost of the renewable support scheme. Publications on international level on the analysis of cost and efficiency of different support schemes on the European level (Ragwitz et al., 2007; Huber et al., 2004) and the United States (Palmer and Burtraw, 2005) show that this discussion is not only a German phenomenon. As a consequence of the continuous growth of supported renewable electricity generation in Germany from 18.1 TWh to ca. 52 TWh per year in the period of 2001–2006 the payments for the feed-in-tariff rose according to the association of German grid operators from 1.6 billion € to 5.6 billion per year (Verband der Netzbetreiber [VDN], 2007). Additional aspects are necessary extensions of the grid and the increased demand for system services. However, recent studies show that the additional cost for these aspects are within the range of 1–10 €/MWh of renewable electricity generation which equals ca. 52–520 million € in the year 2006 (Auer et al., 2006; Klobasa and Ragwitz, 2006). But the electricity generated by renewable energy sources also has a value which has to be taken into account in the current discussion. Leaving minor aspects like necessary grid extensions and the increased demand for system services (see also Deutsche Energie-Agentur [DENA], 2005) aside the additional costs of the support from a consumer perspective could be defined by the feed-in-tariff minus the market value of the renewable electricity. An estimation of the market value of the renewable electricity generation can be calculated by multiplying the electricity production by the spot market price. Based on the market prices and the volume of the renewable electricity generation the market value of the generated renewable electricity can be estimated to ca. 2.5 billion €, almost 45% of the support payments. In another recent study which takes electricity trades on future markets into account the market value of renewable electricity generation is estimated at 44 €/MWh (Wenzel and Diekmann, 2006) or 2.3 billion €. The rising fuel prices and the introduction of the European emission trading system have led to a heavy increase of electricity prices

* Corresponding author. Tel.: +49 721 6809 133.
E-mail addresses: frank.sensfuss@isi.fraunhofer.de (F. Sensfuß), massimo.genoese@wiwi.uni-karlsruhe.de (M. Genoese).
[1] Tel.: +49 721 608 4417.

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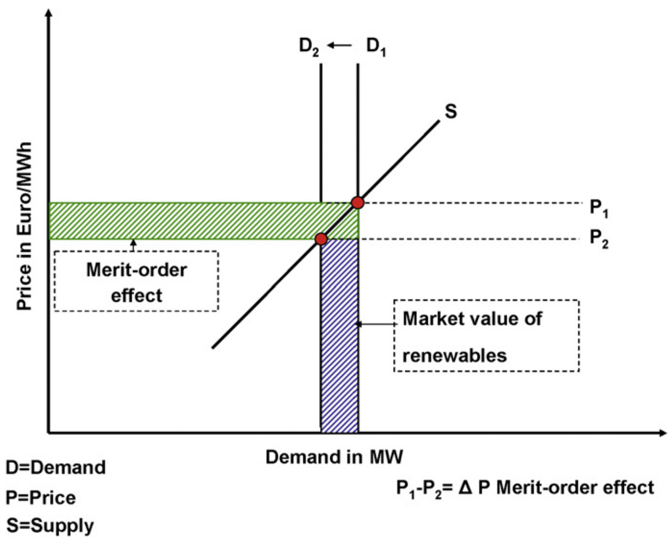

Fig. 1. Merit-order effect of renewable electricity generation. *Source*: own illustration.

which was not foreseen in the futures markets (European Energy Exchange [EEX], 2007a). This aspect leads to slight differences regarding the estimation of the market value.

In addition the electricity generated by renewable energy sources also has an impact on the market prices itself. The central contribution of this paper to the current discussion of renewable support schemes is the analysis of this interaction. A stylized overview of the discussed effects of renewable electricity generation for a single hour is given in Fig. 1. It is assumed that the electricity demand is inelastic in the short-term perspective of a day-ahead market. Since the electricity generated by renewable energy sources has to be bought by supply companies in advance the remaining demand load that has to be purchased on the electricity markets is reduced correspondingly. Therefore the guaranteed feed-in of electricity generated by renewable energy sources has the effect of a reduction in the electricity demand. In the picture the German merit-order-curve, which is a step function of single plant units in the real world, is simplified as a linear supply curve. As long as this supply curve has a positive slope the reduced demand on the markets leads to lower prices. As this effect shifts market prices along the German merit-order of power plants this effect is called merit-order-effect in this paper. A central goal of this paper is to assess the actual value of the merit-order effect of German renewable electricity generation in the period 2001–2006. Another important interaction of renewable electricity generation is the interaction with the European emission trading system. A discussion of the interrelation of the German feed-in-support for renewable electricity generation and the European emission trading system can be found in recent publications (Rathmann, 2007; Walz, 2005). Future work will have to take this aspect into account.

Since electricity demand and renewable electricity generation vary on an hourly basis, an estimation of the actual value of the merit-order effect is far more complex than the estimation of the market value. Therefore the analysis is carried out using the PowerACE Cluster System which is able to simulate hourly spot market prices.

2. Methodology

In order to determine the impact of renewable electricity generation the calibrated PowerACE model is used to simulate electricity market prices in the years 2001 and 2004–2006. A detailed description of the PowerACE model can be found in Sensfuß (2007) and Genoese et al. (2007). The model provides a detailed representation of the German electricity sector. The model simulates reserve markets and the spot market. The spot market prices are calculated on an hourly level for an entire year. Based on a price prognosis power plants and pumped storage plants are bid into reserve markets[2] and the spot market. For the given simulation the bid price for power plants is based on variable cost and start up cost. Demand and renewable load are bid with price inelastic bids into the market. It is assumed that the entire electricity demand is traded at the simulated spot market. This assumption deviates from the real world situation in two ways:

1. In the real world situation only ca. 89 TWh or 16.5% of the electricity demand were traded on the spot market in 2006 (European Energy Exchange [EEX], 2007b). It can be assumed that an important amount of electricity is traded in bilateral contracts which are likely to be less volatile than the spot market.
2. The simulated spot market prices are based on fundamental data. Therefore prices are less volatile than real world market prices. It is not likely that peak prices of several hundred €/MWh at the real spot market represent a good price signal for the entire electricity demand in a given hour. Under the given assumption that the entire electricity demand is traded at the resulting market prices it seems to be adequate to base the analysis on the more conservative price development of the simulated market prices.

The cost of renewable electricity generation is calculated based on given hourly load profiles. The resulting electricity production may differ from published production data due to the fact that the capacity available at the end of the year is assumed to be producing for the entire year according to the technology specific utilization.

All other parameters are held constant. In order to determine the impact of renewable electricity generation on the electricity market the simulation is run 50 times. The resulting time series is calculated as average of the simulation runs in order to level out variations caused by the random generator used to simulate power plant outages. In a second step the same procedure is applied to 50 simulation runs without renewable electricity production supported by the feed-in tariff. Since the development of large hydro plants has not yet been affected by the renewable support scheme, electricity from large hydro plants is taken into account in both simulation settings. The following analysis compares both time series.

3. Results

A comparison of a selected day in October 2006 is given in Fig. 3. The figure shows the impact of renewable electricity generation supported by the EEG on the remaining system load that has to be covered by conventional power plants. The load of renewable electricity generation in the selected period varies between 4.4 and 14.7 GW. But its impact on prices varies even more. During hours of low load the reduction of the market price is 0 €/MWh while it reaches up to 36 €/MWh in hours of peak

[2] In order to keep the frequency of the electricity grid at a constant level electricity demand and supply have to be balanced continuously. In order to ensure the stability of the electricity grid in case of unforeseen events such as plant outages the grid operators have to use balancing capacity. The purchase of balancing capacity can take place on separate reserve markets.