ON THE GROWING IMPACT OF RENEWABLE ENERGY IN EUROPEAN ELECTRICITY MARKETS

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Overview

Despite the high costs, generating electricity from renewable energy sources is considered as environmentally benign. In recent years due to generous support schemes in a number of countries, electricity generation from renewables is growing at a remarkable rates. The growth of "new" renewables excluding hydro is even more impressive over the same period from less than 1% to about 9%, mainly from wind and biomass. This paper examines the historical growth, the current situation and the future prospects of renewables for electricity generation in Europe. Similar arguments, of course, apply to other regions of the world with ambitious renewable targets. The main objective is to examine the possible effects of further uptake of renewables on prices in European electricity markets including:

- The impact of renewables at specific times of the year when they shift the supply curve of conventional generators in wholesale markets leading to low or even negative prices;
- The impact of intermittent renewables on the cost of fossil fueled plants, mainly natural gas, and
- Change of spreads between high and low price levels.

Method

Our method of approach is based on the fundamental principle that prices equal marginal costs. One of the major features of the liberalized electricity markets was that the pricing regimes changed. In former regulated markets, prices were established by setting a regulated tariff, which was calculated by dividing the total costs of supplying service by the number of kWhs sold – with some differences between different groups of customers. The major change that took place after the liberalization was that prices were now expected to reflect the marginal costs of electricity generation. At the time when liberalization started considerable excess capacities existed in Europe. This led to the expectation that prices will (always) reflect the short-term marginal costs (STMC).

Results

PV generation during mid-day hours not only displaces virtually all hydro generation but results in lower spot prices during a period when they tend to be high. This is an example of how the rise of renewables will impact spot prices, trading patterns and dispatching of conventional generation. Similar patterns are experienced in other sunny regions such as Italy and Spain where solar generation has a significant impact on mid-day prices.
The explanation is simple. On a sunny day with ample solar generation, the supply curve is shifted to the right as schematically shown in Fig 1, which essentially pushes nuclear and fossil fueled generation "out of the market."

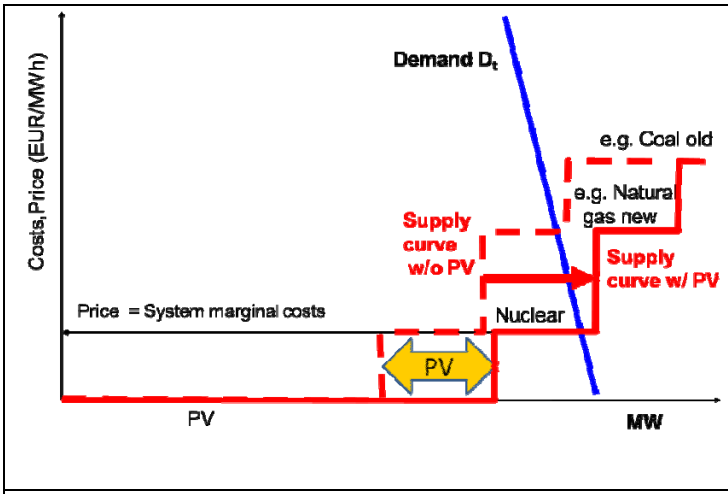

Figure 1. Merit order supply curve with and without additional PV capacities at on-peak time of a bright summer day with short term marginal costs for conventional capacities

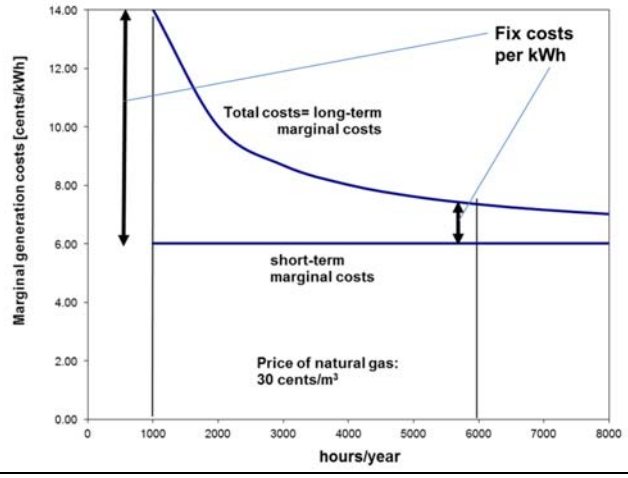

Figure 2. Short term (variable) and long term (total) marginal costs of electricity generation in a CCGT plant depending on yearly full-load hours

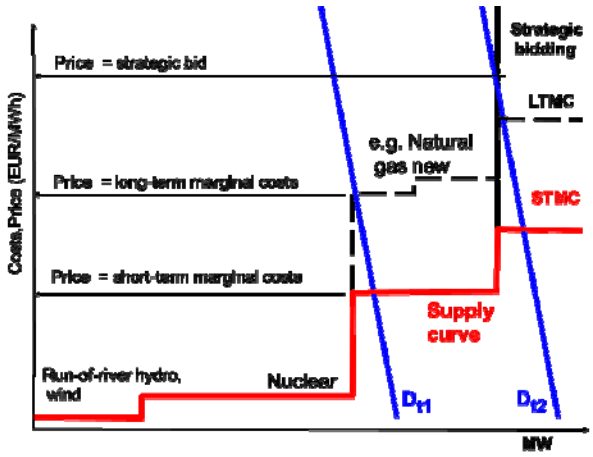

Figure 3. Merit order supply curve for STMC vs LTMC of CCGT plants or strategic bidding at times with low intermittent renewables

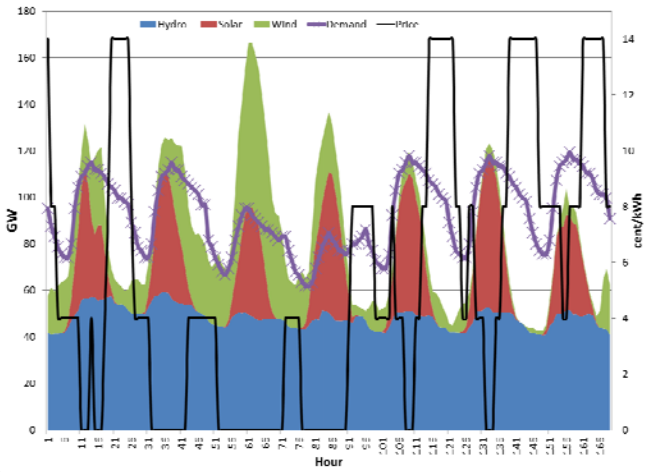

Figure 4. Development of intermittent renewables from wind, PV and run-of-river hydro plants over a week in summer on an hourly base in comparison to demand and resulting electricity market prices with total costs charged for conventional capacities

Aside from the above-described effects, intermittent renewables will also influence the costs at which fossil generation – especially natural gas – are offered. The illustration in Fig. 2 is based on the right hand-side at 6,000 full-load hours per year[1]. The revenues derived from these hours must cover both the fixed and variable costs, as illustrated in Fig. 2. The graph schematically shows the total and variable (short term) electricity generation costs of a new combined-cycled gas turbine (CCGT) based on its annual full-load generation hours. As can be seen, the share of fixed costs is considerably higher when the plant operates at full load for a minimal number of hours, say, 1,000 h/yr[2] as opposed to a high number of hours, say 6,000 h/yr.

How the growth of renewables might impact future pricing strategies of fossil or biomass power plants over time is a subject of speculation. As schematically shown in Fig. 3, the merit order supply curve and the high and low demand curves are affected based on the availability of renewables, which tend to be intermittent and not entirely predictable. The illustration shows three examples for supply curves: merit order supply curves for STMC vs. LTMC of CCGT plants and a supply curve for strategic bidding, which is shown as a vertical line.

How will the price spread in European markets evolve in the future as larger amounts of PV, solar thermal and wind generation are added to the network? The consequence for electricity prices are shown in Fig. 4 where a hypothetical scenario with high levels of generation from wind, PV and run-of-river hydro plants over a week in summer are depicted using synthetic hourly data for an average year in Germany. The graph shows significant volatilities in electricity market prices with total costs charged for conventional capacities – black solid line – ranging from zero to 14 cents/kWh[3] within very short-term time intervals. In practice, of course, the prices may not go to zero but would be rather low.

Conclusions

The major conclusion of this chapter is that the electricity market and the electricity supply system of the future will look quite different than today while many of the fundamentals will remain. By and large, most of the effects of renewables are already known, what is new is that the variability of their generation will further increase if much higher quantities of wind and PV are fed into the grid, as appear to be the case for the EU.The effects of these developments on the prices in electricity markets will be:

- Much more price volatility from hour-to-hour and day-to-day;
- Increasing relevance of intra-day markets;
- Higher prices for fossil capacities and storage technologies for balancing the intermittent renewable generation; and
- Growth of balancing markets and intensified competition at the level of decentralized balancing organizations.
- In this context, a key question is whether and when an electricity market fully or mostly supplied by renewables can be brought about? While this issue has not been part of the analysis in this chapter, it is not difficult to predict that an electricity market fully supplied or mostly by renewables can only be achieved at an abnormally high cost. The simple explanation is that such a system will need large amounts of flexible generation and/or storage or equally large demand-side resources.

[1] That assumes roughly 70% capacity factor.
[2] Of course, full-load hours vary year-by-year depending on demand, hydro power and other factors.
[3] The 14 cents/kWh in this example results from Fig. 15 with full load hours of about 1,000 h/yr