

Market integration

German wind and PV lower European market electricity price

In countries with a large penetration rate of zero fuel cost renewables (wind power in Denmark and Spain, wind and PV in Germany), the “merit-order effect” (avoiding the most costly means of power production to cover peak loads) is already well documented. In this article, French expert Bernard Chabot shows how the penetration rate of combined wind and PV production in Germany already lowers the European Electricity Index (ELIX) for electricity markets in Germany/Austria, France and Switzerland.

This analysis is a contribution to the ongoing assessment of the impact of zero fuel-cost, variable but predictable renewables such as wind and PV on the market price of electricity in Europe. It will be shown that the largest installed base of wind and PV in Europe, Germany (around 30 GW of wind and 30 GW of PV in mid-2012), already has a direct impact on the European Electricity Index (ELIX). This index is chosen for this analysis as it has since 2010 simulated the future of a truly integrated European power market on a daily basis. It is currently calculated based on national market prices in Germany/Austria, Switzerland and France. Its daily hourly data are publicly available from the EPEX web site (http://www.epexspot.com/fr/donnees_de_marche/elix). The ELIX peak load price is the average of hourly ELIX values from 8 am to 8 pm, and its base load price is the average ELIX value on 24 hours. In order to cover months with both different electricity demand profiles and wind and solar resources, this analysis covers the period from December 2011 to June 2012. The data used for hourly wind and PV power production in Germany are those publicly available every 15 minutes on the EEX web site (<http://www.transparency.eex.com/de/>).

The “merit-order effect” and its present and potential future consequences on electricity markets and electricity systems are described and discussed for example in references [1] and [2]. Simply speaking, it consists in automatically reducing the use of the most costly power plants during peak loads hours, when the corresponding demand can be covered by zero-fuel-cost renewables, such as wind and PV, which benefit from priority access to the grid. The final result is a lower power price on the market, an advantage for market operators, but also a loss of revenue for companies operating conventional peak load fossil-based power plants.

A preliminary analysis suggests that there is a clear correlation between the ELIX hourly values during a month and the hourly German electricity demand covered by conventional power plants larger than 100 MW. Figure 1 shows this correlation during December 2011. The demand covered by those plants vary from 24.7 GW to 57.9 GW and the hourly ELIX prices vary between 0.4 and 80 €/MWh. This correlation is not linear, as there is an acceleration of the electricity price decrease when conventional production is lower than 35 GW; in return, the electricity price rises faster when conventional production is higher than 50 GW.

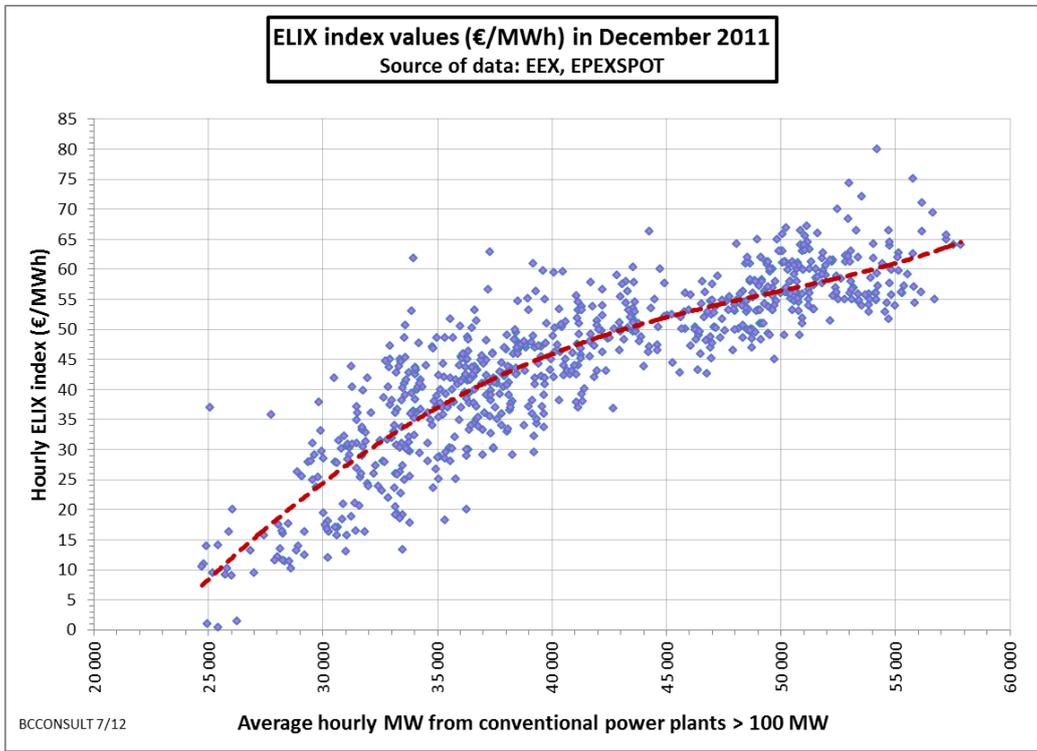


Figure 1: ELIX prices versus demand covered by large conventional power plants in December 2011.

Of course, the hourly MWs from conventional power plants larger than 100 MW are determined both by demand and by the production from other power plants, including wind and PV. Figure 2 shows that both base-load and peak-load ELIX daily prices correlate with the combined [wind + PV] daily penetration rate: the higher this penetration rate, the lower base load and peak load ELIX values.

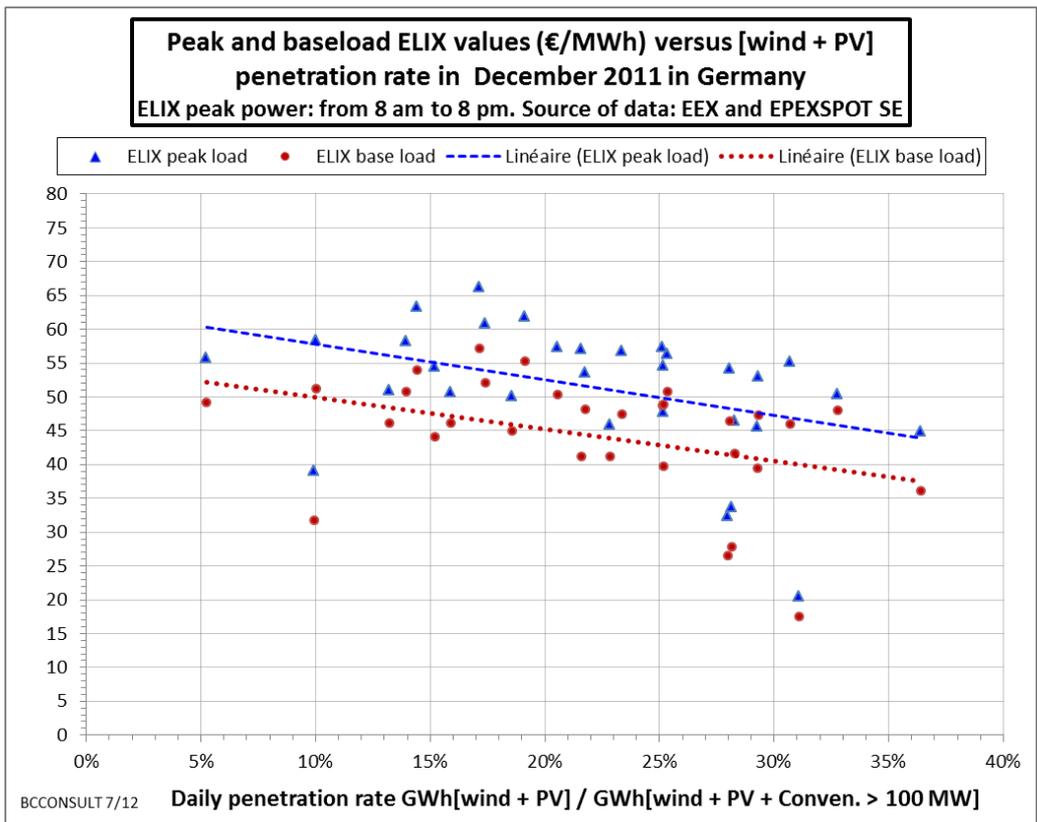


Figure 2: Daily base load and peak load ELIX prices in December 2012 versus daily combined [wind + PV] penetration rate (%)

Figure 3 shows the ratio between the ELIX daily peak load and base load. In December 2011, this ratio is always higher than one, as experienced before wind and PV large scale installations: “rationally”, peak hours prices are supposed to be higher than base load prices!

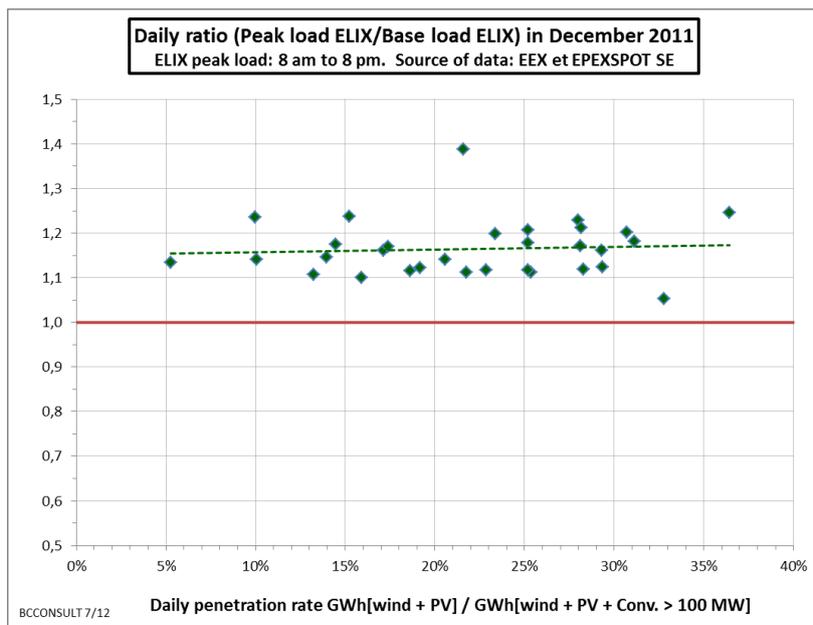


Figure 3: Daily ratio between daily peak load and base load ELIX prices versus [wind + PV] daily penetration rate (%) in December 2011

Figure 4 shows how the hourly ELIX prices are impacted both by the demand and by the combined [wind + PV] hourly production, here for example from December 22nd to 28th, 2011. Low demand around Christmas (December 24 to 26) and large wind production (PV production being minimal in December in Germany) leads to very low ELIX prices, including nearly zero prices at the end of the night. On the contrary, on evening of December 27, low wind production and zero PV production created a spike on ELIX price around 6 pm, as experienced before the creation of a large wind and PV installation base in Germany.

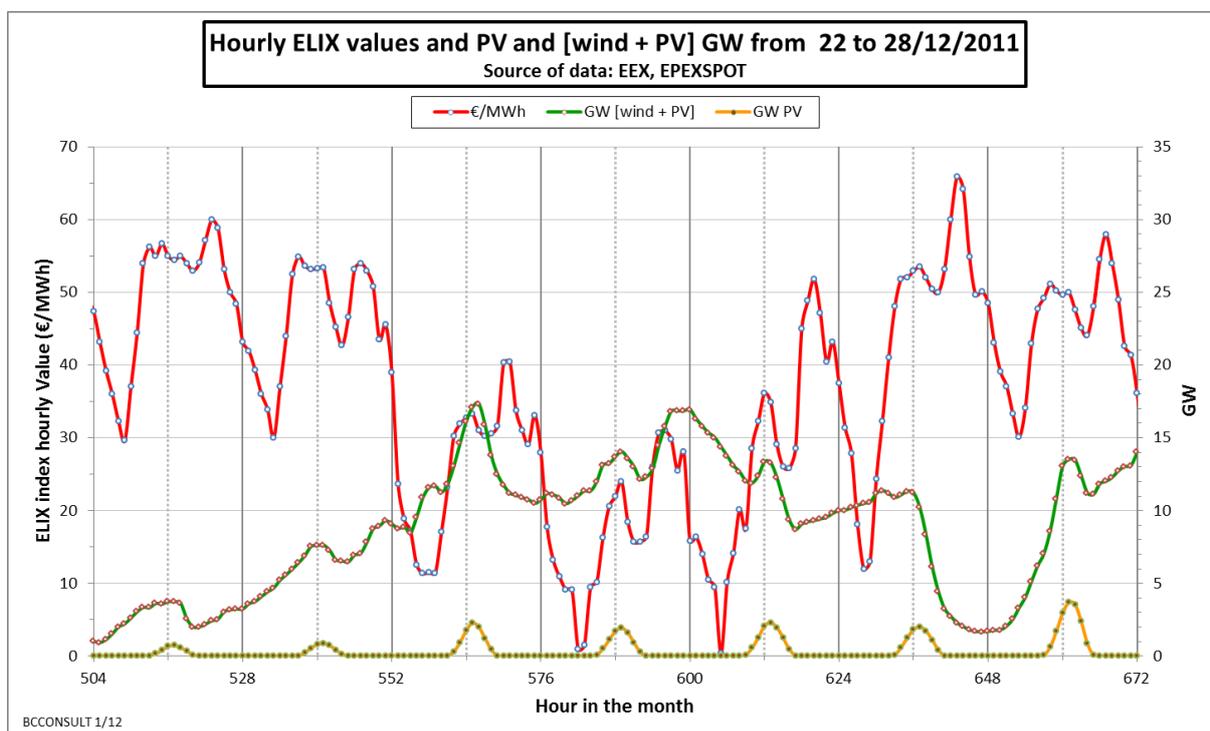


Figure 4: Hourly ELIX values from December 22 to 28, 2011

Results for January 2012 are qualitatively the same, even if the combined [wind + PV] penetration rate was lower (from 3 to 27.5 % only, due to exceptionally low winds). But on one day, the ELIX peak load/base load ratio was slightly lower than 1.

February 2012 was exceptional for peak power demand and related ELIX prices. Figure 5 shows the correlation between hourly ELIX prices and the hourly production from conventional power plants larger than 100 MW.

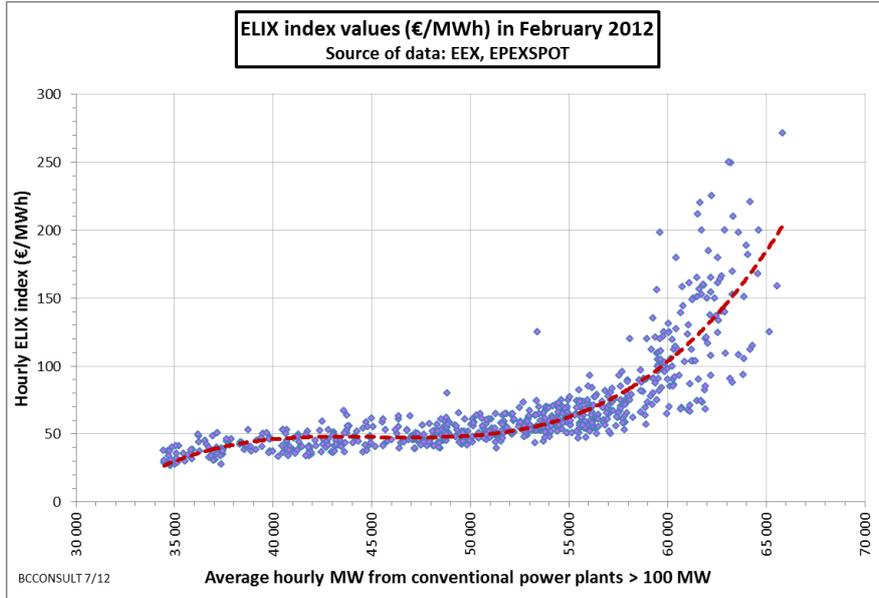


Figure 5: ELIX values versus demand covered by conventional large power plants in February 2012

Beyond 60 GW of demand covered by large conventional power plants, there is clearly a fast increase of ELIX prices, up to 275 €/MWh.

Figure 6 shows the correlation between daily [wind + PV] penetration rate and the daily peak and base load ELIX prices.

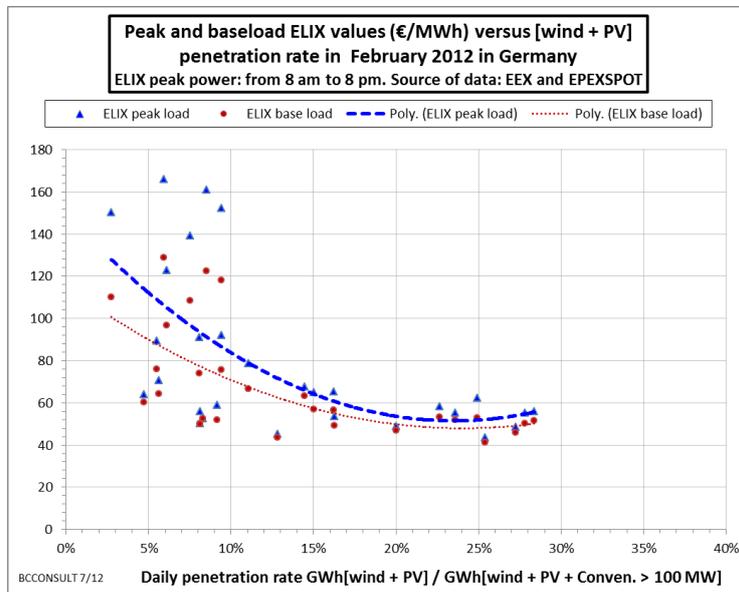


Figure 6: Daily peak and base load ELIX prices versus daily [wind + PV] penetration rate in February 2012

Clearly, weak [wind + PV] daily penetration rates (lower than 10 %) lead to both high peak and base load prices of electricity.

During all of February 2012, the daily ELIX peak load was higher or equal than the ELIX base load as shown in figure 7. But clearly, the ratio between the two values is decreasing with increasing [wind + PV] penetration rate.

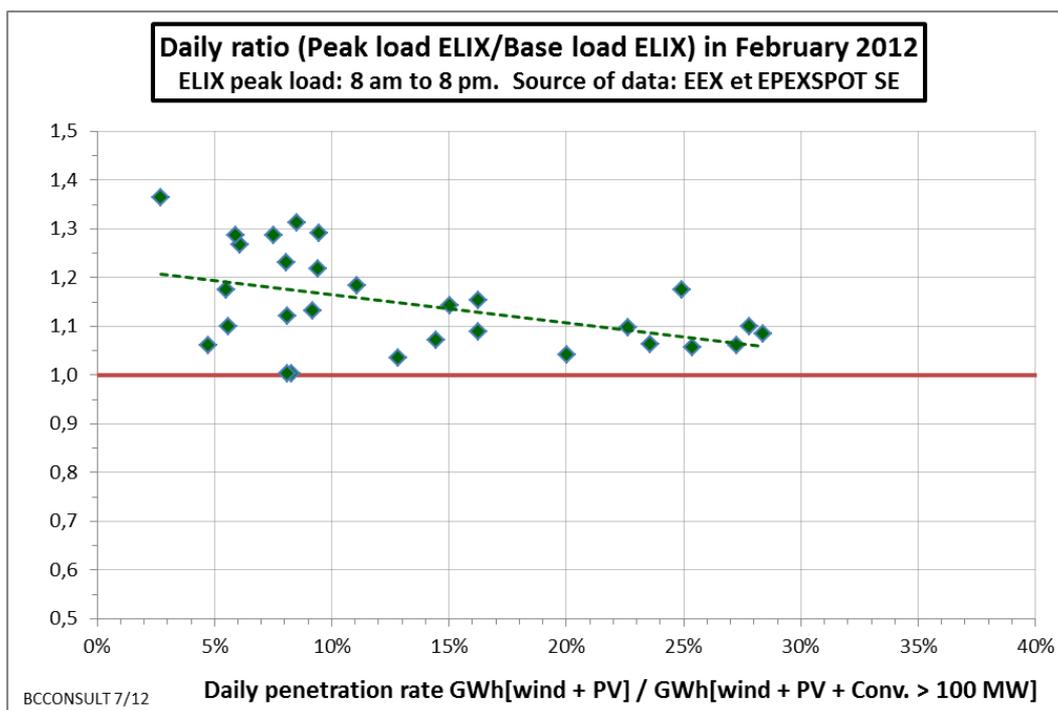


Figure 7: Daily ratio between peak load and base load ELIX versus [wind + PV] daily penetration rate (%) in February 2012

From March to June 2012, there is a slight evolution of parameters and correlations already analyzed for December 2011 and February 2012. As an example, June 2012 results are shown in figures 8, 9 and 10.

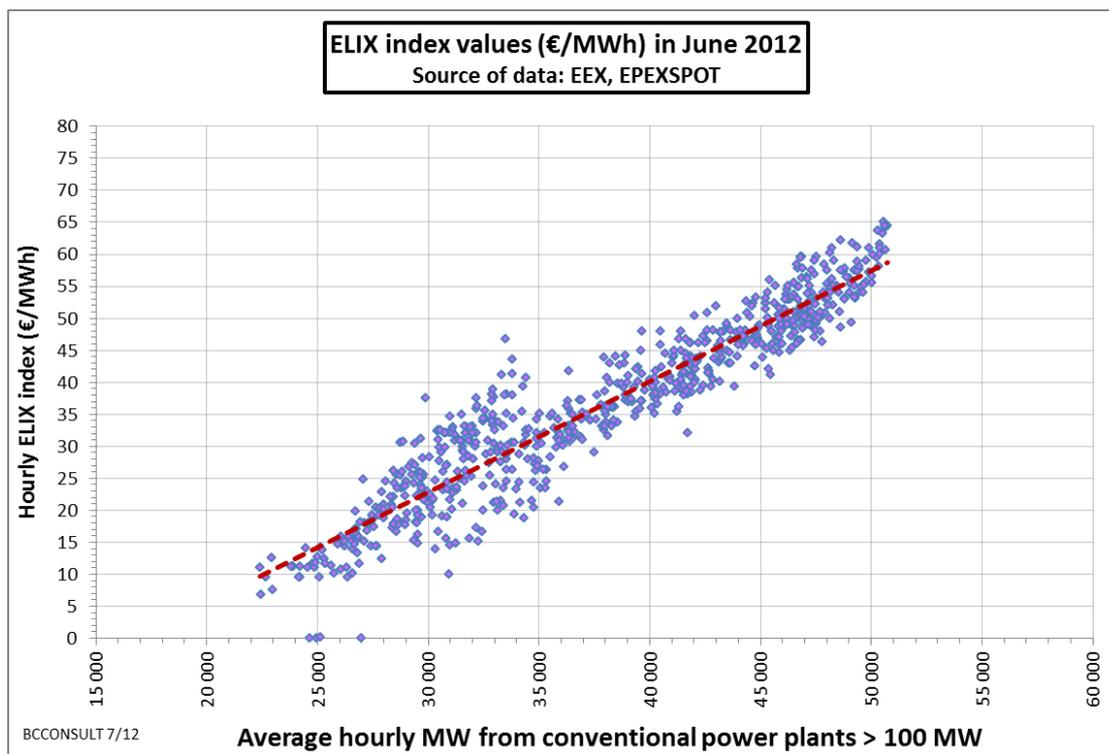


Figure 8: ELIX values versus demand covered by conventional large power plants in June 2012

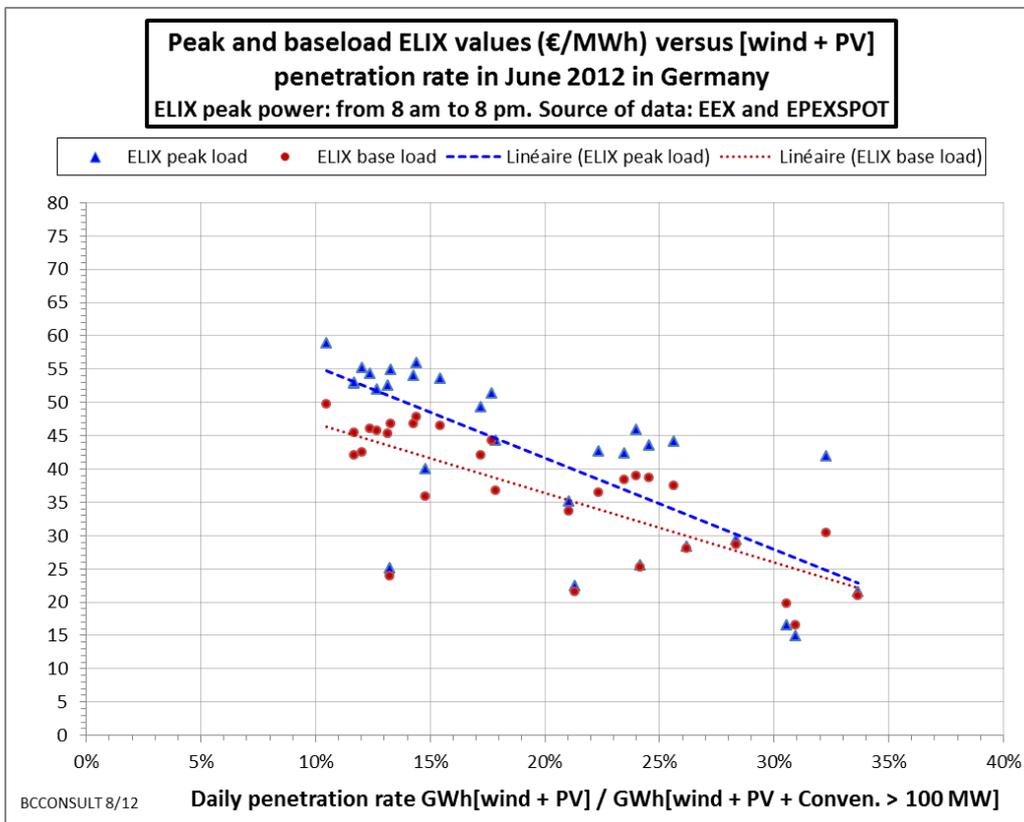


Figure 9: Daily peak and base load daily ELIX prices versus daily [wind + PV] penetration rate in June 2012

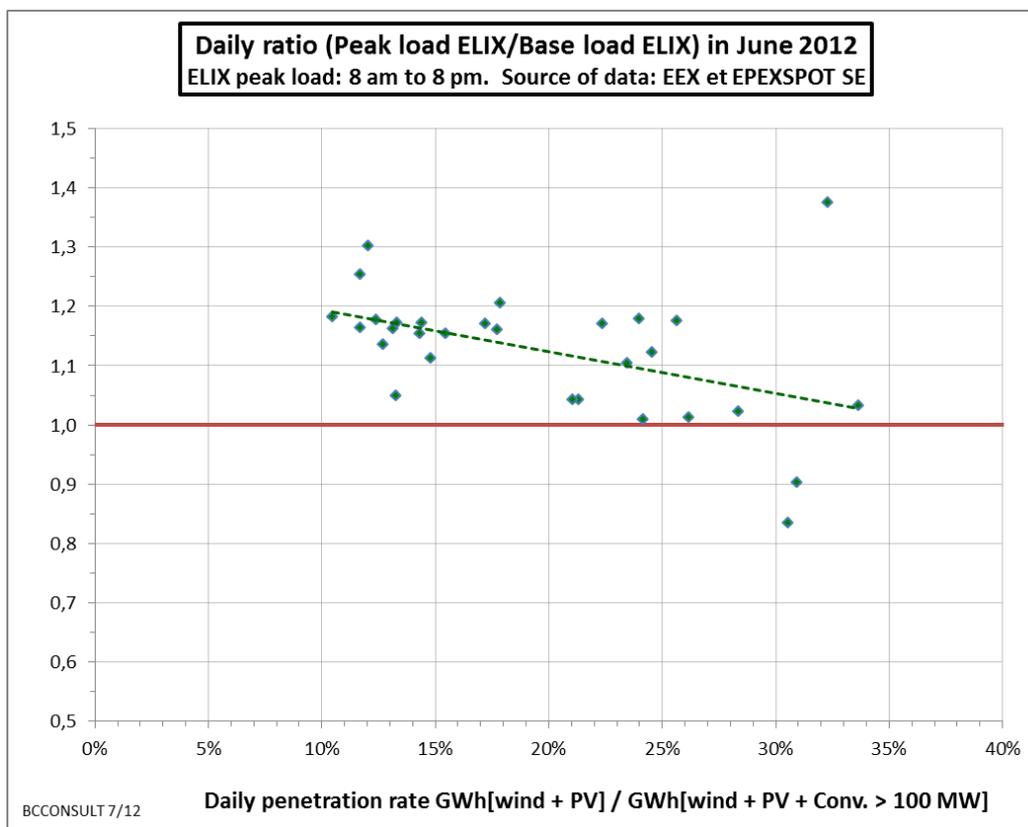


Figure 10: Daily ratio between peak load and base load ELIX prices versus [wind + PV] daily penetration rate (%) in June 2012

One can see that on two days in June the peak to base daily ELIX ratio is lower than one: on those days, the average daily peak power price is lower than the base load price!

Figure 11 shows an example of the effect of [wind + PV] production (mainly PV production in mid-day in sunny months like in June 2012): the contribution from large conventional power plants is lowered, in some cases at a very low level such as during week-ends when power demand is weak, and so the ELIX price is also decreasing at a very low level. The peak load and related high electricity prices experienced in Germany from around 9 am to 6 pm before this “peak load shaving” from [wind + PV] production is now often replaced by a “price valley” from noon to mid-afternoon !

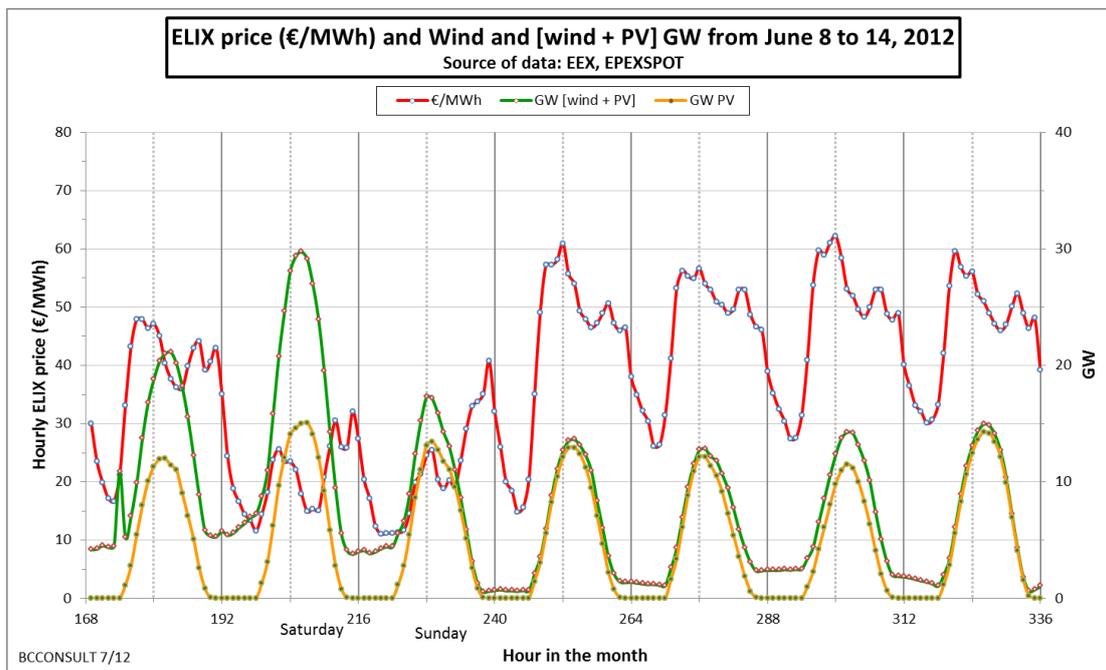


Figure 11: Hourly ELIX values from June 8 to 14, 2012

As a consequence, the number of days when the daily peak load ELIX price is lower than the base load ELIX price is rapidly increasing. As shown in figure 12, on the 213 days from December 2011 to June 2012, this “irrational electricity pricing” (according to conventional market rules) appeared on 19 days, or around 9 % of the days during the period.

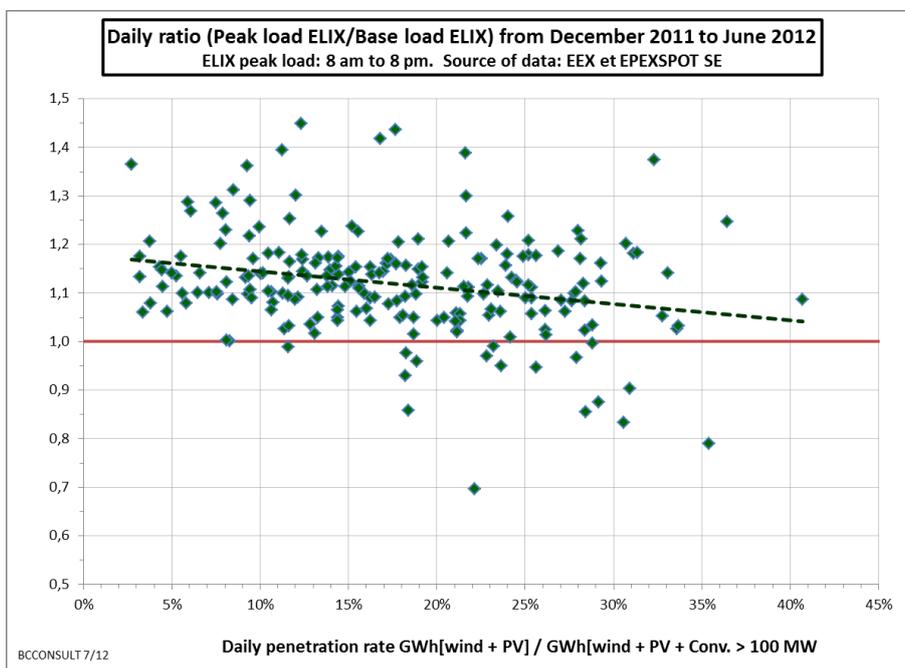


Figure 12: Daily ratio between peak load and base load ELIX prices versus [wind + PV] daily penetration rate (%) from December 1st 2011 to the end of June 2012

This analysis is only a preliminary one, and it should be extended to a whole year, always taking into account the [wind + PV] production and not PV or wind power alone. But its results are in accordance with the qualitative results and conclusions of other studies on the “hot topic” of actual impacts of large wind and PV penetration rates on electricity markets and on “business models”, requiring changes for companies operating conventional fossil based power plants put in operation during peak demand hours.

Using the ELIX price index demonstrates that those impacts are not limited to countries with large wind and PV penetration rates: other European countries will more and more benefit from lower market prices of electricity resulting from large wind and PV penetration rates in leader countries. (Bernard Chabot/Craig Morris).

References:

[1] Sven Bode and Helmuth-M. Groscurth, Arrhenius Institute for Energy and Climate Policy, “Elements of a Sustainable Design for Electricity Markets”, 2011,
http://arrhenius.de/uploads/media/arrhenius_DP_6_E_Final.pdf

[2] Craig Morris “Capacity premiums for conventional power”, June 1st, 2012,
<http://www.renewablesinternational.net/capacity-premiums-for-conventional-power/150/537/38715/>