Improved hourly shaping using renewable production information

KYOS Analysis Report

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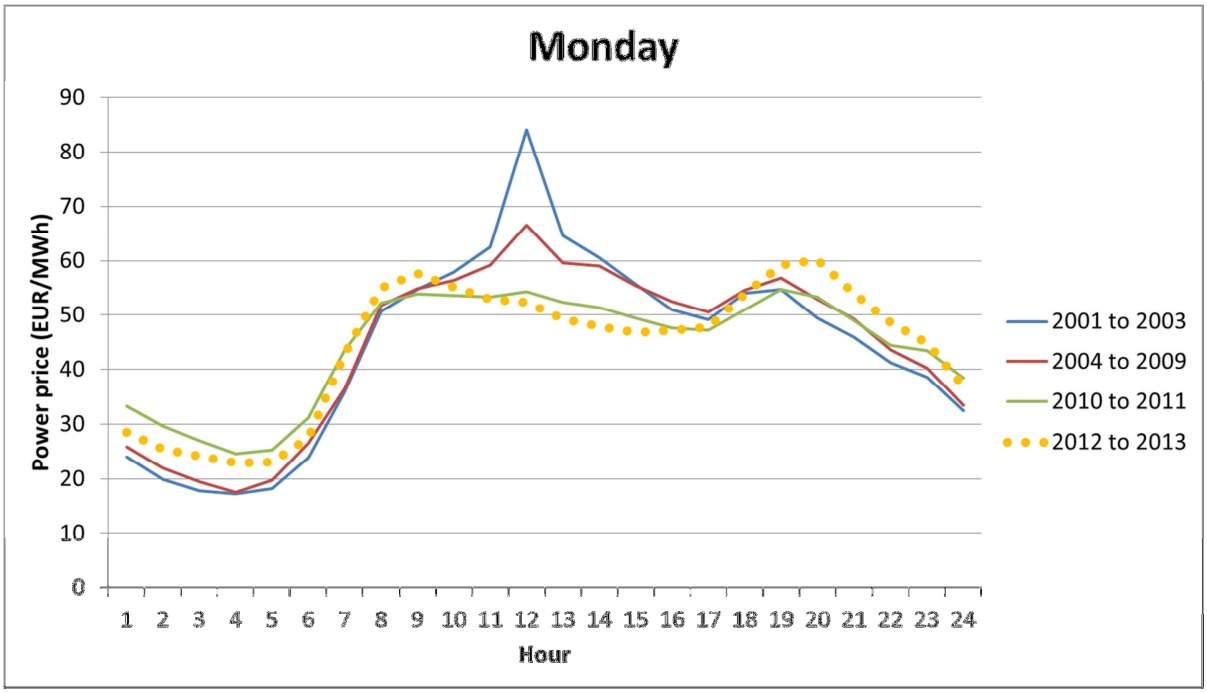
1 Introduction

In this report we analyze the German hourly power prices. In particular, we study the effect of renewable power production on the intra-day shapes. The forward curve builder of KYOS (KyCurve), has a special module to take the renewable production into account when creating hourly price forward curves. Part of the model is a sensitivity estimation of how hourly power prices respond to changes in renewable production. Our analysis shows that this is an important component, even more so for longer term forward curves. Furthermore, we show that the sensitivity varies per hour and weekday.

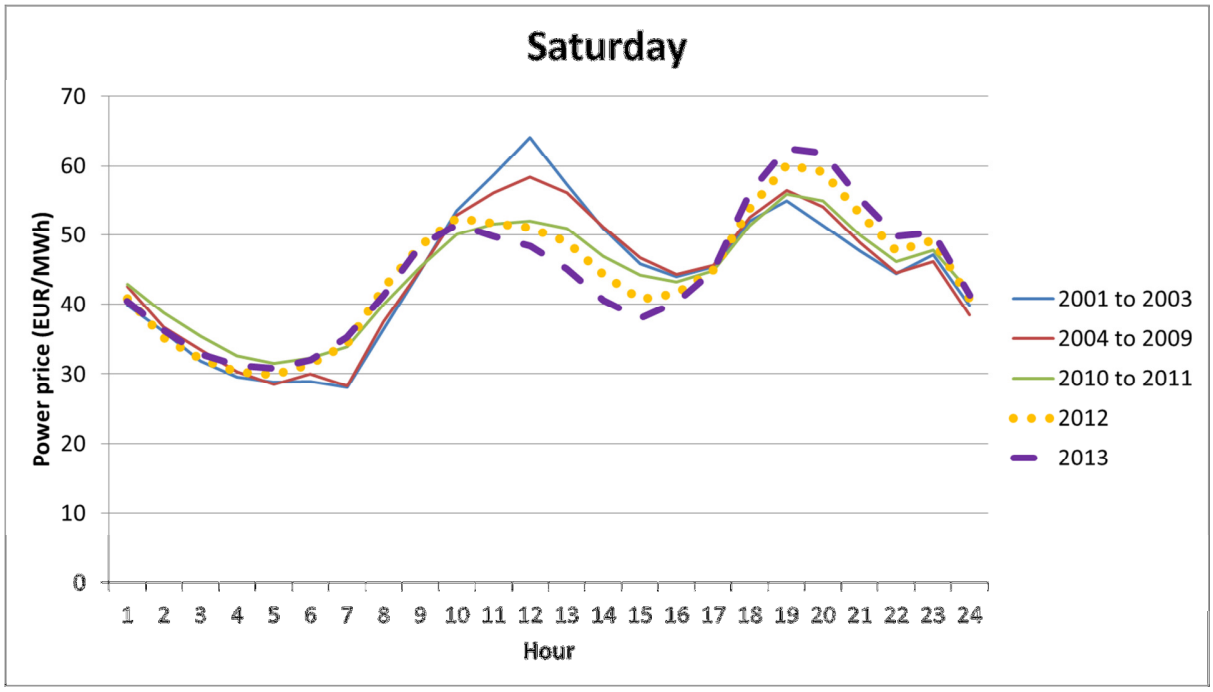
This analysis report is a follow-up on the paper which describes the renewable regression approach as published in German in “Energiewirtschaftliche Tagesfragen” and in English in “ZE Datawatch” (January 2013), with the English title “How renewables shape the future”. It is available on the KYOS website from the following link: http://www.kyos.com/power-markets/power-publications.

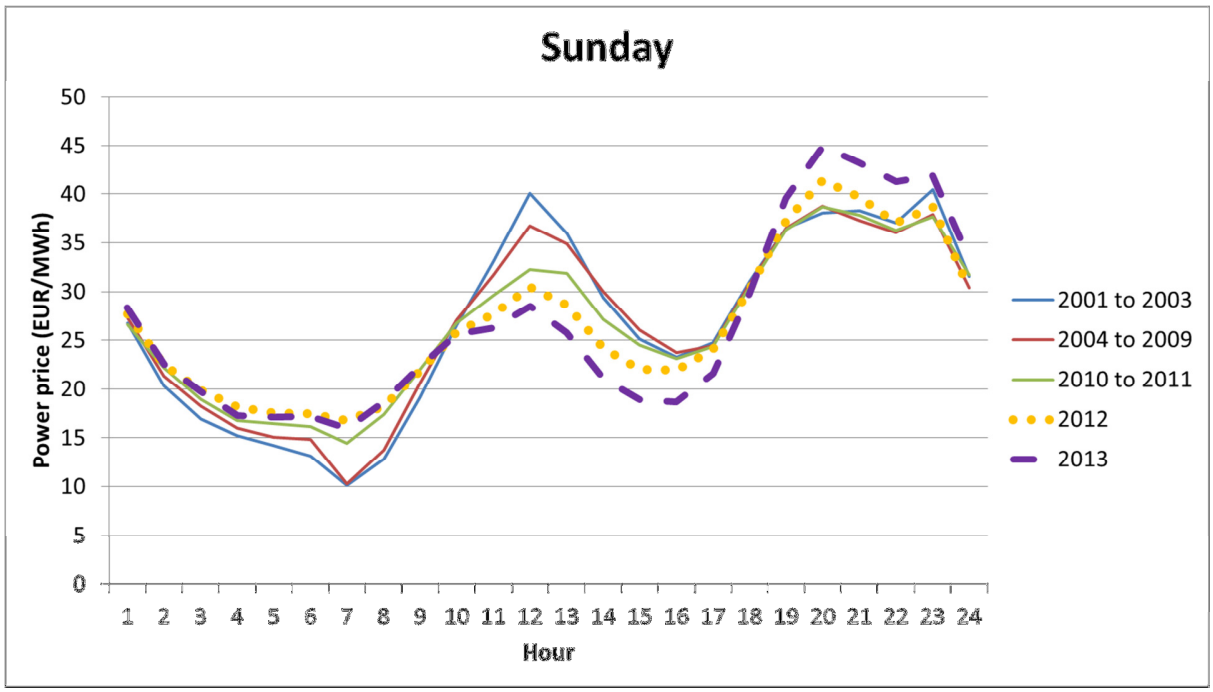
2 Historical hourly spot price patterns in Germany

Over the years, the dynamics of the power market have changed considerably. In the early years of liberalization of the German electricity sector, there could be periods of low supply and correspondingly high spot prices ('spikes'). In the last few years market prices have dropped significantly and in particular during times of strong wind or intensive sunshine, because then there is a large power production from solar and wind installations at low or even negative marginal costs. Since most solar production is during midday, the midday prices have particularly suffered from the growth in solar capacity. If we compare the shape over the day on a Monday (see Figure), we clearly see how prices midday have dropped. The graph is based on EEX/EPEX day-ahead spot prices, normalized to an average of around 44 €/MWh (the overall average spot price).



The graph shows the development of the Monday shape over time; the other working days show a very similar pattern. Prices used to be highest around noon, but now the early morning and early evening (around 20:00) are the peak prices. Saturday and Sunday shapes have undergone a strong change too, though are quite different. The graphs for those days show the years 2012 and 2013 separately (not as one group), because the differences are remarkable. Important to know as well is that in the Saturday and Sunday graphs we replaced negative prices by 0. This is obviously a bit arbitrary, but a few days would otherwise have such a big impact that they would blur the overall development. Also noteworthy is that Sundays include German public holidays, while Saturdays include bridge days. In comparison to working days, the prices are relatively lower in the morning, and the midday impact of solar production is stronger.


Saturday
Power price (EUR/MWh)
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
2001 to 2003
2004 to 2009
2010 to 2011
2012
2013


Sunday
Power price (EUR/MWh)
50
45
40
35
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
2001 to 2003
2004 to 2009
2010 to 2011
2012
2013

3 Input settings

Growth in wind and solar production are a major explanation for the changing intraday pattern in German power prices. The KyCurve forward curve building software, including the renewables module, takes this development into account when creating hourly price forward curves (HPFC's). The model creates arbitrage-free forward curves, i.e. curves whose average prices over a certain period match with the corresponding forward price.

The model filters out representative shapes in historical spot prices and applies those to the current forward prices in the market. The renewables module ensures that the changing shape due to the growth in renewables is (more) accurately taken into account. We can select one of the following regressions to estimate the sensitivity of spot prices to renewables (wind/solar) production:

- Regression 1: Single regression for all renewable data.
- Regression 2: Split up the regression between peak and offpeak hours.
- Regression 24: Hourly regression.
- Regression 24 & Daytype: Split up the regression per hour and daytype.

The model requires the following fundamental input data:

- Historical Renewable Production: the historical hourly total, solar and wind production should be provided and cover the same period as the historical spot price data.
- Renewable capacities: the renewable capacities (in MW), both historically and for the future horizon over which a forward curve needs to be generated.

4 Results

4.1 Renewable coefficients

In this section, we show the renewable coefficients for the regression from January 2011 to December 2013. We take the most flexible regression setting, with parameters estimated separately per hour and per day type.

The results show that a 1% rise in wind generation (from one day to the following day) tends to provoke a 1-5% fall in the power price. This very fluctuating impact is directly related to the position in the merit order and therefore to the spot price. For instance, a 1% rise on Sundays tends to have a sharper impact on prices than on working days. We can conclude the same for offpeak hours compared to peak hours.

The dependency of power prices on solar production is very comparable to wind. However, since solar production is only available during the day, there are no parameter estimates for the evening/night hours. Again, we observe that the sensitivity to solar production tends to be larger during lower load hours.

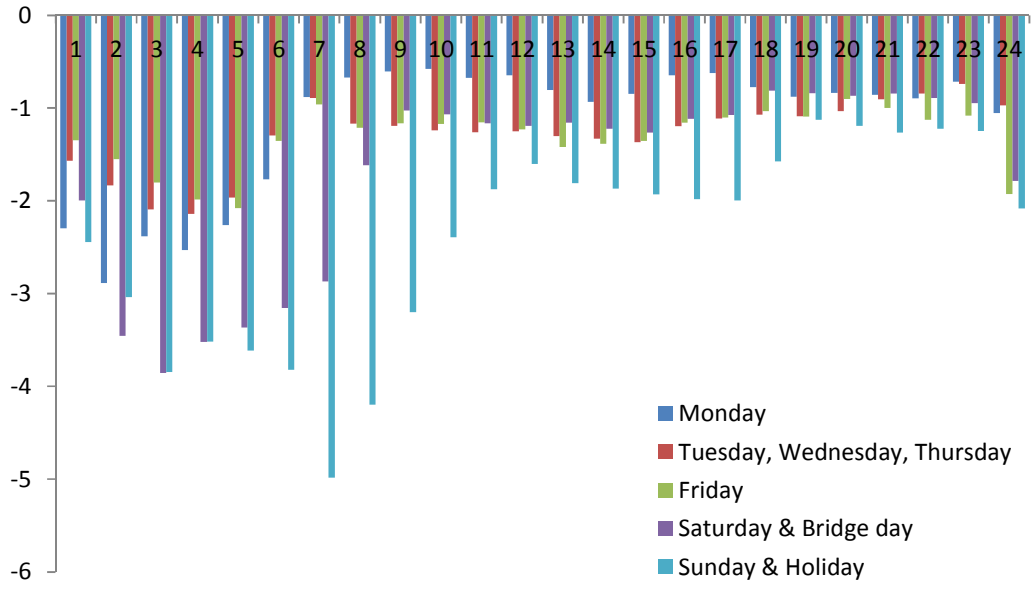


Figure: Wind coefficients for a day type-hourly regression.

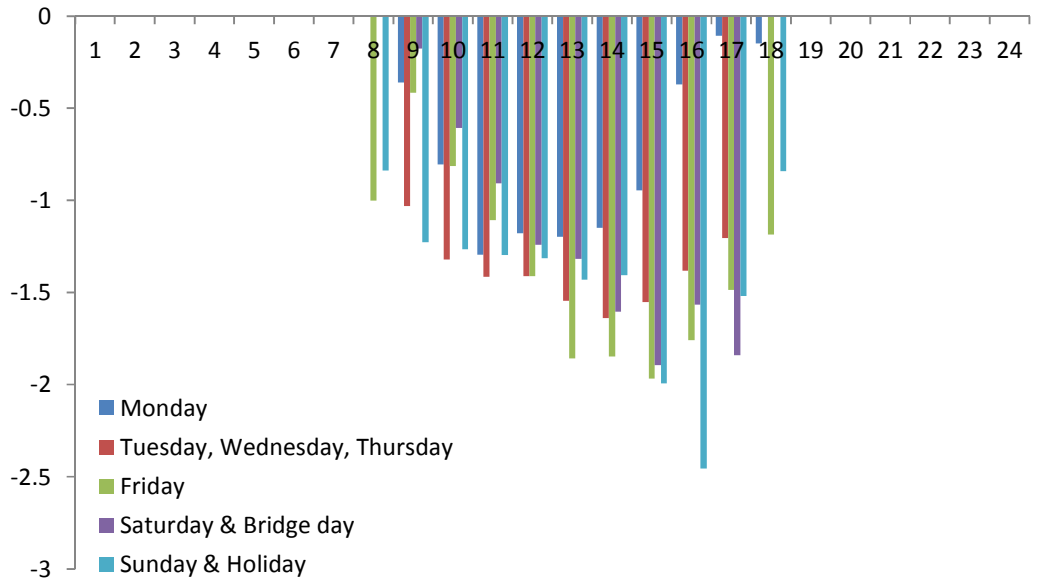


Figure: Solar coefficients for a day type -hourly regression.

4.2 Hourly shapes and realizations in 2013

Using forward data of 30 January 2013, we created an hourly price forward curve until November 2013. The hourly forward prices are compared with the realized prices over the period February to November 2013. The 'Spot' line (red) is the average realized price; the 'Without' line (blue) is the hourly KyCurve shape using no renewable regression; the 'Reg24 daytype' line (green) shows the KyCurve shape using the renewable regression approach per hour and day-type.

Both KyCurve approaches are relatively close to the realized average shape. However, using the renewable regression approach the fit becomes a bit better in most cases. On average, the renewable regression approach creates higher prices in the early evening (begin of offpeak) and lower prices in the middle of the day.

Comparing the approach with renewables to the one without:

- Mondays: better fit midday, worse in early evening (small differences)
- Tuesdays-Thursdays: better fit midday and early evening (small differences)
- Fridays: worse fit midday and early evening (small differences)
- Saturdays and bridge days: better fit overall (larger differences)
- Sundays and holidays: better fit overall (larger differences)

Overall, the improvement in fit is most noticeable on Saturdays and Sundays. Those are also the days where a small increase in renewable production might push prices down quite considerably. Therefore, incorporating the growth in renewables on those days is most important.

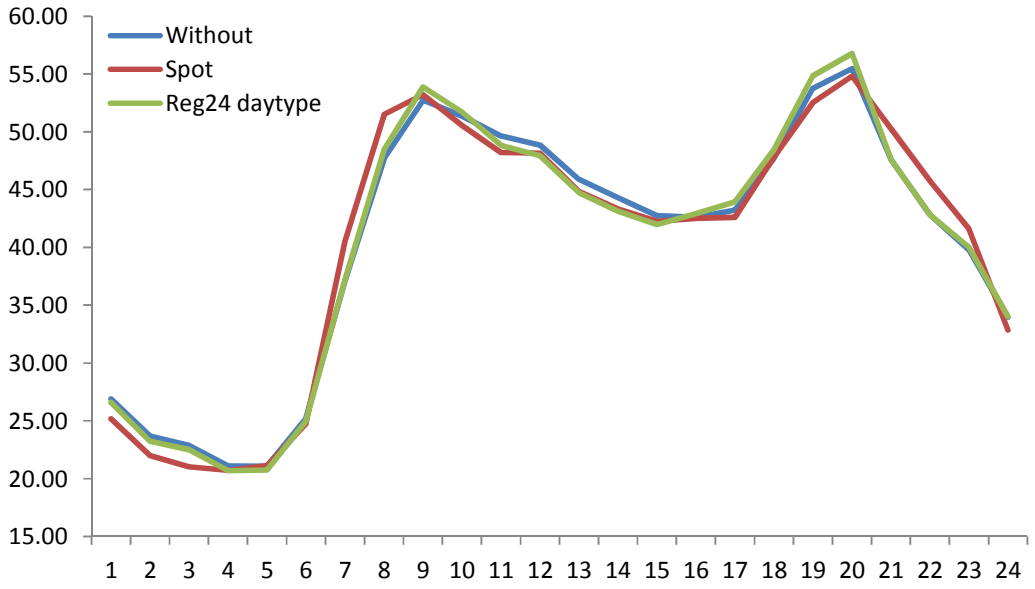


Figure: Hourly mean shape of Mondays.

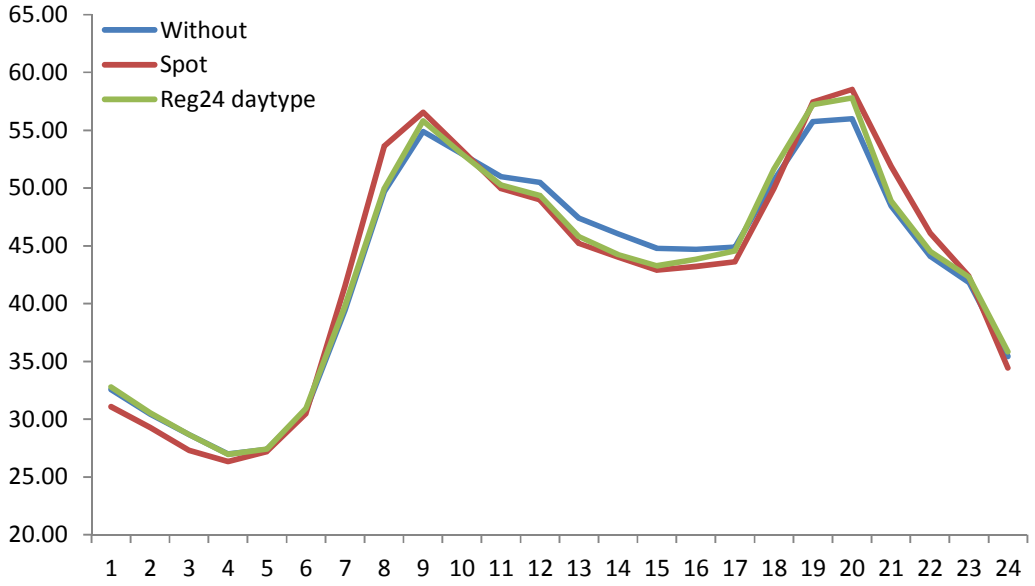


Figure: Hourly mean shape of Tuesdays, Wednesdays and Thursdays.

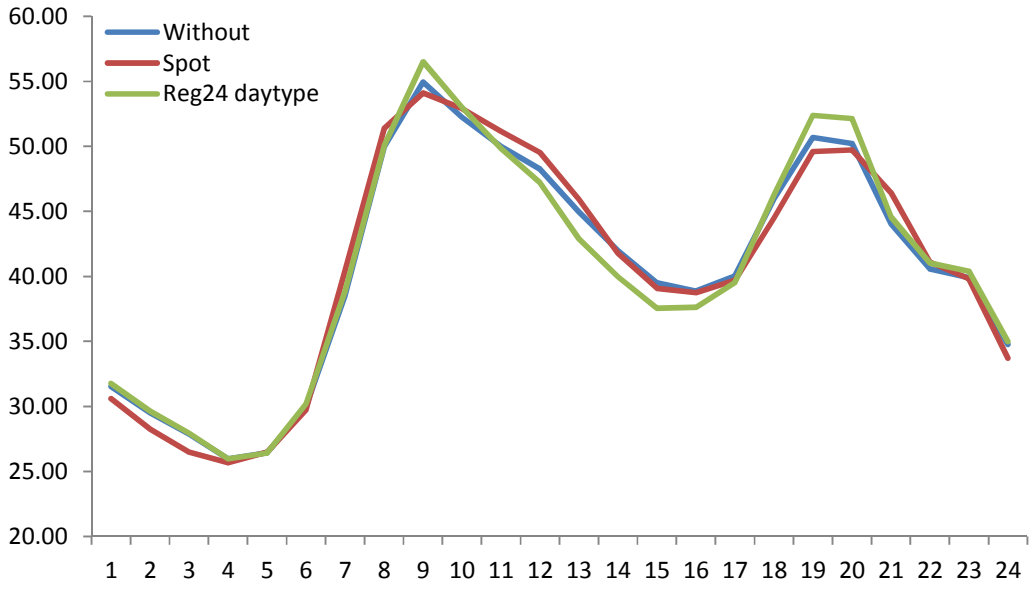


Figure: Hourly mean shape of Fridays.

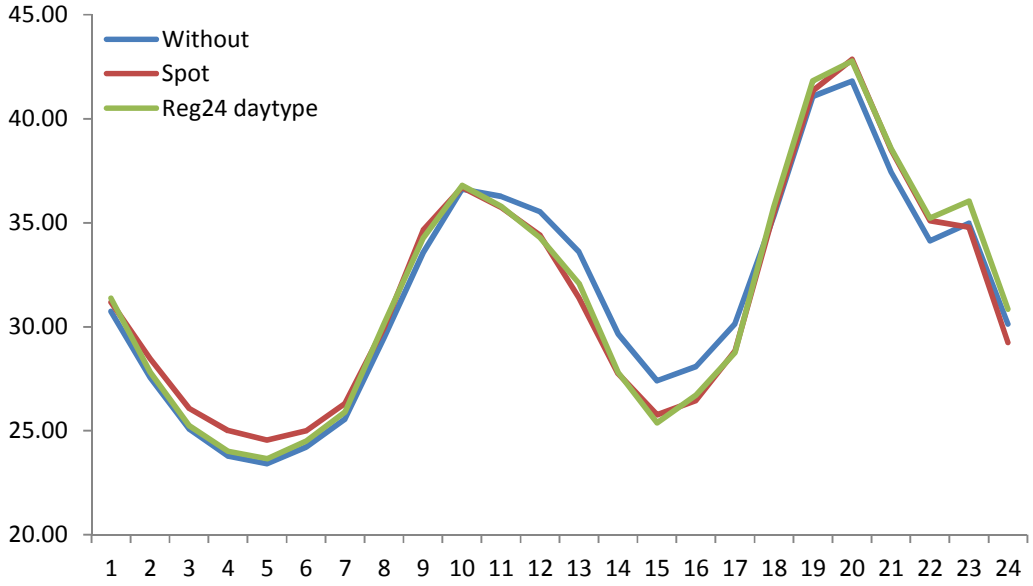


Figure: Hourly mean shape of the Saturdays and bridge days.

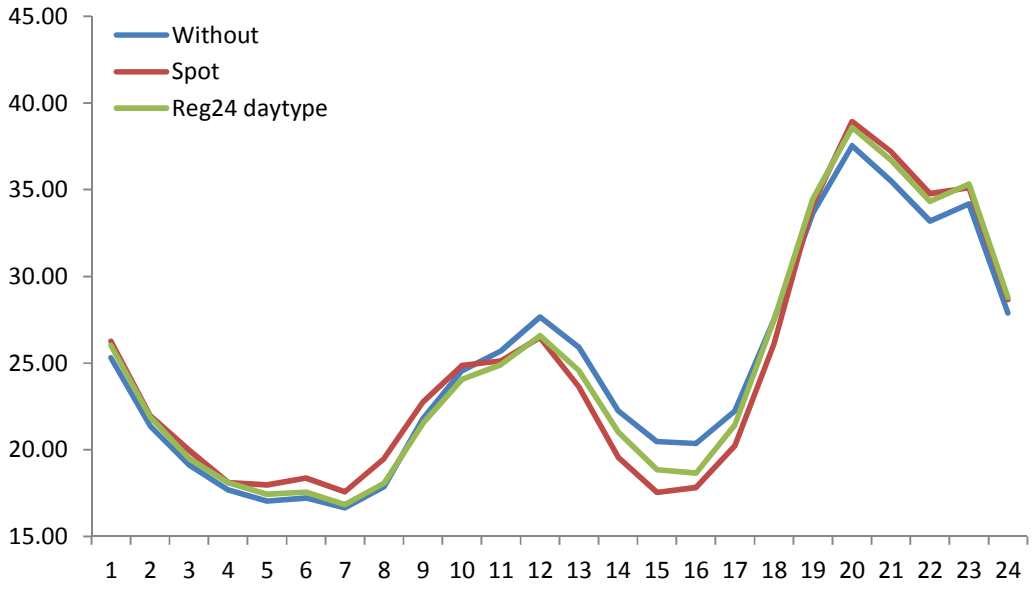


Figure: Hourly mean shape of the Sundays (except June 2013 because of very negative Spot prices) and holidays.

4.3 Hourly shapes for later years

The model always uses at most two years of historical spot prices for forecasting the future hourly shapes. In our case the historical data run from February 2011 to January 2013, and then the forward curve is created till November 2013. This means that the growth in renewables is more limited than if we had generated forward curves over longer horizons. It explains why the difference between the results with and without the renewables regression are relatively small. Actually, the renewables component has a bigger impact for longer-term curves, because the renewable capacities are expected to grow further. This is shown in the next graphs, for a Sunday.