REVIEW OF MET OFFICE WEATHER FORECAST ACCURACY

Weather Forecasts

National Grid currently procures its main weather forecasts for electricity demand forecasting from the Met Office. National Grid is currently in the middle of a three year contract for these forecasts.

The Met Office won the contract via an open tender process run by National Grid in accordance with all National Grid's standard procurement policies. As part of the tender assessment process, the accuracy of trial forecasts provided by different companies tendering for the contract were assessed. During this process the Met Office was found to be the most accurate of the companies that tendered for the contract.

The Met Office state on their website that "The World Meteorological Organization compares similar statistics among national meteorological services around the world. These show that the Met Office is consistently one of the top two operational services in the world." (http://www.metoffice.gov.uk/about-us/who/accuracy/forecasts)

Use of Weather Forecasts in Electricity Demand Forecasts

Weather forecasts are used in three areas of electricity demand forecasting.

The first area is in forecasting consumer demand. People are more likely to put heating on if it is cold, or turn air conditioning on if it is hot, or turn the lights on earlier if it is dull and overcast.

National Grid derive correlations between demand at different cardinal points of the day and a variety of weather variables, primarily average temperature over last four hours, average temperature at a specific time of day over the last few days, weighted towards most recent temperatures, wind speed and light levels. These correlations are based on a national average weather variables derived as an average of the values in major cities in GB, weighted by demand useage. We receive forecasts for these variables four times a day, each forecast comprising values for the next 14 days at hourly resolution. We also receive measurements from Met Office weather stations every hour.

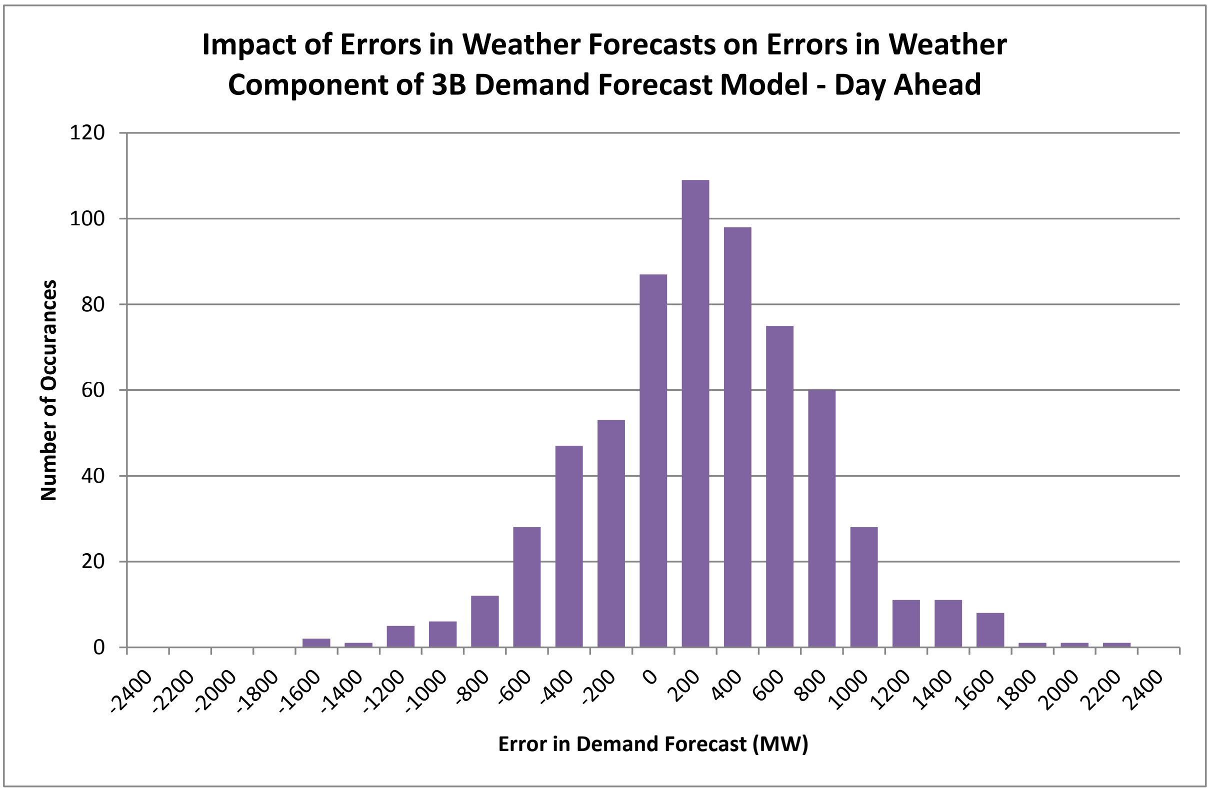
In the following analysis, a number of models currently in use by National Grid to forecast demand at some key cardinal points are used. The forecast weather at 1, 2 and 7 days ahead received in the morning weather forecast each day around 9am is used to calculate demand forecasts. The observed weather from the Met Office Weather stations is then used to calculate what the demand forecast would have been with perfect weather forecasts, and the values compared. This allows us to directly calculate the error in demand forecasts due to errors in weather forecasts.

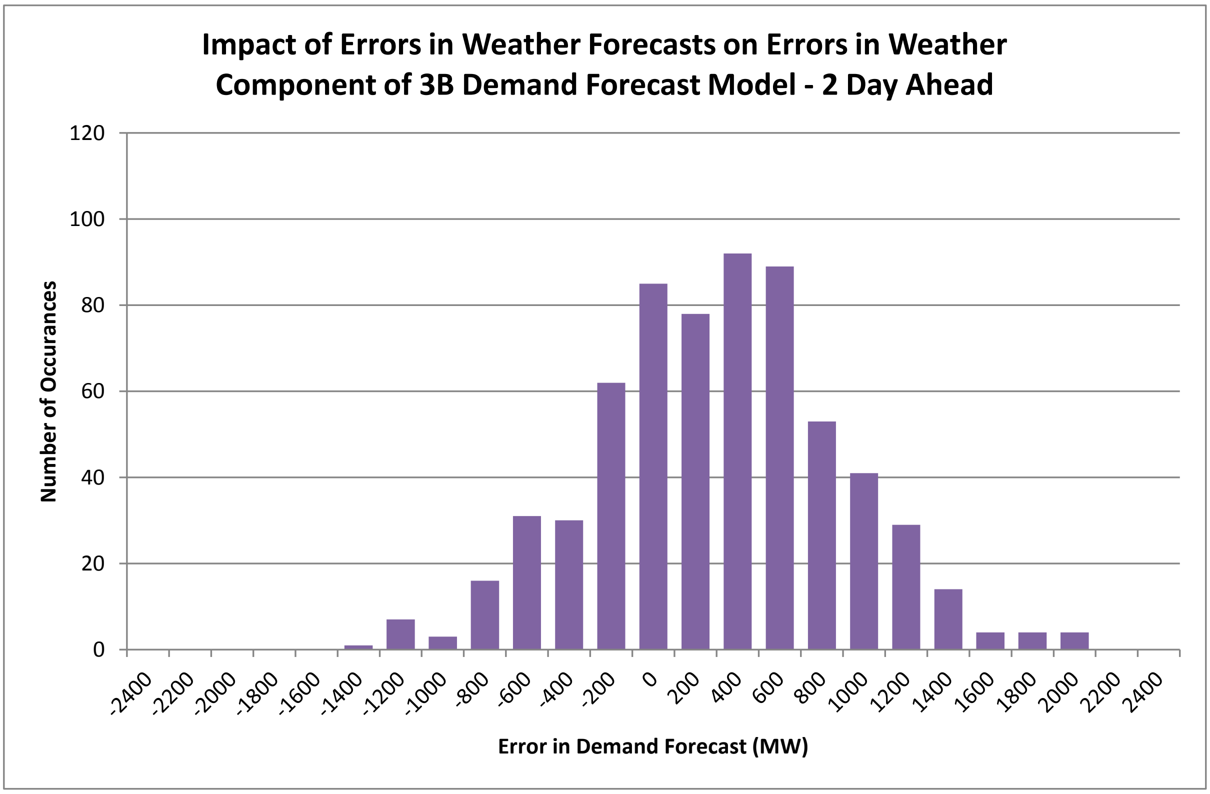
The main results are:

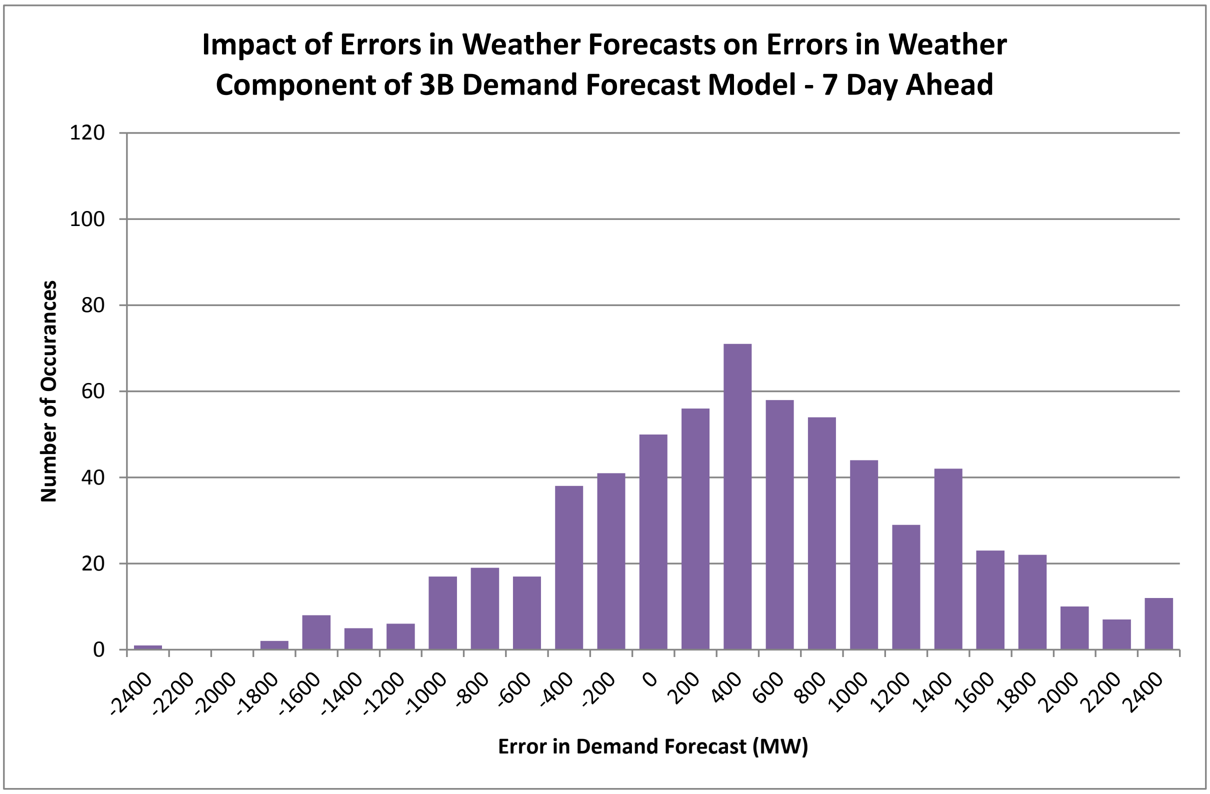
		Errors in MW					
		1B Error	**2A Error**	**2B Error**	**3B Error**	**4B Error**	**DP Error**
Day Ahead	Mean Error	-32.9	141.3	214.2	144.1	87.8	164.7
	Mean Absolute Error	265.6	361.9	447.6	438.0	279.2	328.6
	Standard Deviation	374.1	462.5	535.1	541.8	347.5	388.4
2 Day Ahead	Mean Error	-28.7	175.5	273.4	203.8	139.1	225.3
	Mean Absolute Error	288.6	387.8	493.9	484.8	307.3	366.5
	Standard Deviation	378.0	467.1	556.3	576.2	368.4	410.5
7 Day Ahead	Mean Error	-18.8	174.4	453.7	390.1	351.0	616.4
	Mean Absolute Error	506.0	633.7	792.2	764.6	635.7	786.3
	Standard Deviation	638.7	801.9	937.0	884.9	765.2	805.6

This data shows the expected result that errors get larger the further ahead the forecasts. The less expected result is the level of variation of this error across the day. Mean Absolute Errors at 7 days ahead range between 506 and 792 MW, falling to 265 to 448 MW at day ahead.

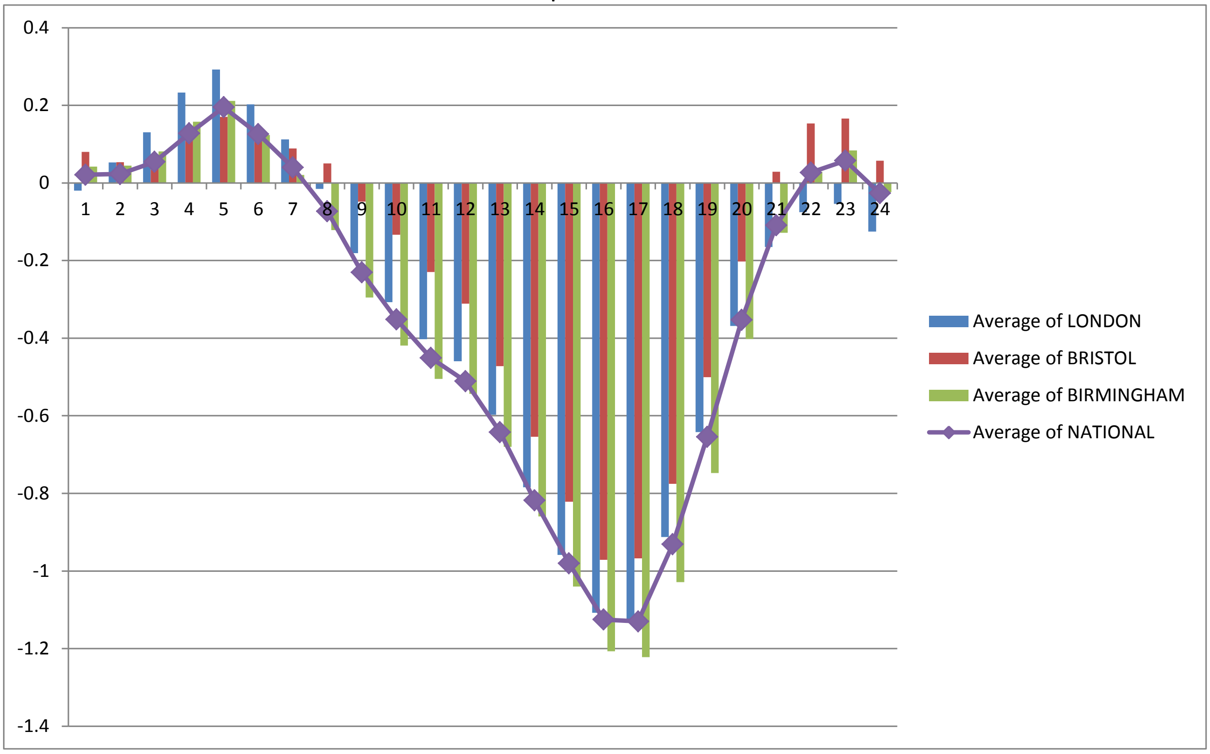
The following graphs show a breakdown of variation in error, looking at the 3B cardinal point which is one of the most weather dependent models. It can be seen that at day ahead most weather forecasts introduce a demand forecast error in the range -400 to +800 MW. By 7 days ahead the spread is much wider, approaching -1000 to +1800 MW.


Impact of Errors in Weather Forecasts on Errors in Weather Component of 3B Demand Forecast Model - Day Ahead
Number of Occurances
0
20
40
60
80
100
120
-2400 -2200 -2000 -1800 -1600 -1400 -1200 -1000 -800 -600 -400 -200 0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400
Error in Demand Forecast (MW)


Impact of Errors in Weather Forecasts on Errors in Weather Component of 3B Demand Forecast Model - 2 Day Ahead
Number of Occurances
0
20
40
60
80
100
120
-2400 -2200 -2000 -1800 -1600 -1400 -1200 -1000 -800 -600 -400 -200 0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400
Error in Demand Forecast (MW)



It is also interesting to note the variation in error across the day. For example, looking at the error in 7 day ahead temperature forecasts for the cities contributing the most to the national average calculation, we see average errors in temperature of less than 0.2 C overnight, but an average under-forecast of well over 1 C around the darkness peak at 1700 to 1800.



The second area of impact of weather forecast errors is in PV forecasts. There are around 11.5 GW of embedded solar generation. This generation has the effect of meeting local demand within the distribution network, and so reducing the demand on the Transmission system which is forecast by National Grid. For this reason, we forecast embedded PV and wind generation, and subtract these forecasts from the demand to produce a net demand forecast.

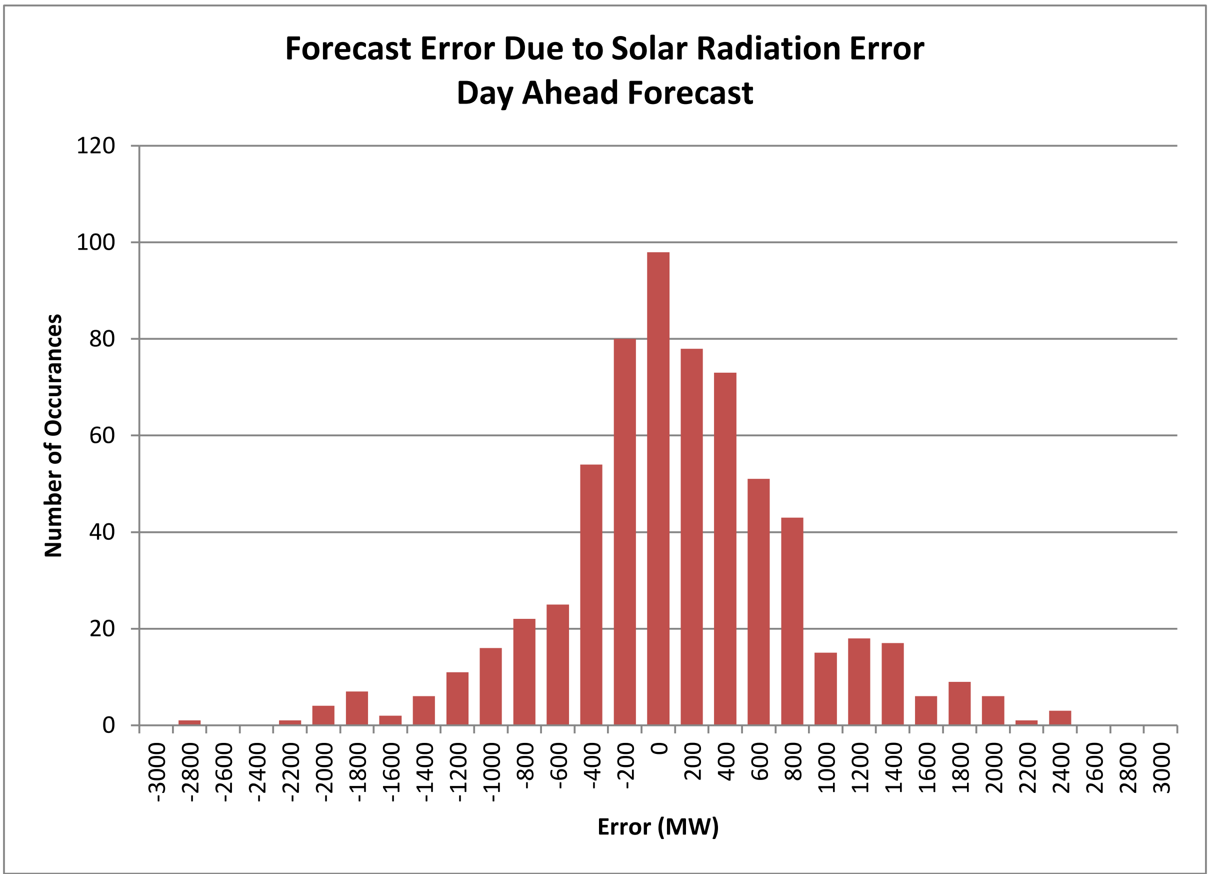
National Grid receives solar radiation forecasts for around 60 weather stations round the country. All PV is allocated to the closest weather station, and a forecast PV output calculated from the forecast solar radiation at that site. The forecasts for each weather station are then combined to produce a national total PV forecast.

In this analysis, the same process has been followed as above, comparing the forecast solar radiation at the 60 sites at 7, 2 and 1 day ahead with the observed values, and calculating the forecast that would have been made with perfect weather forecasts.

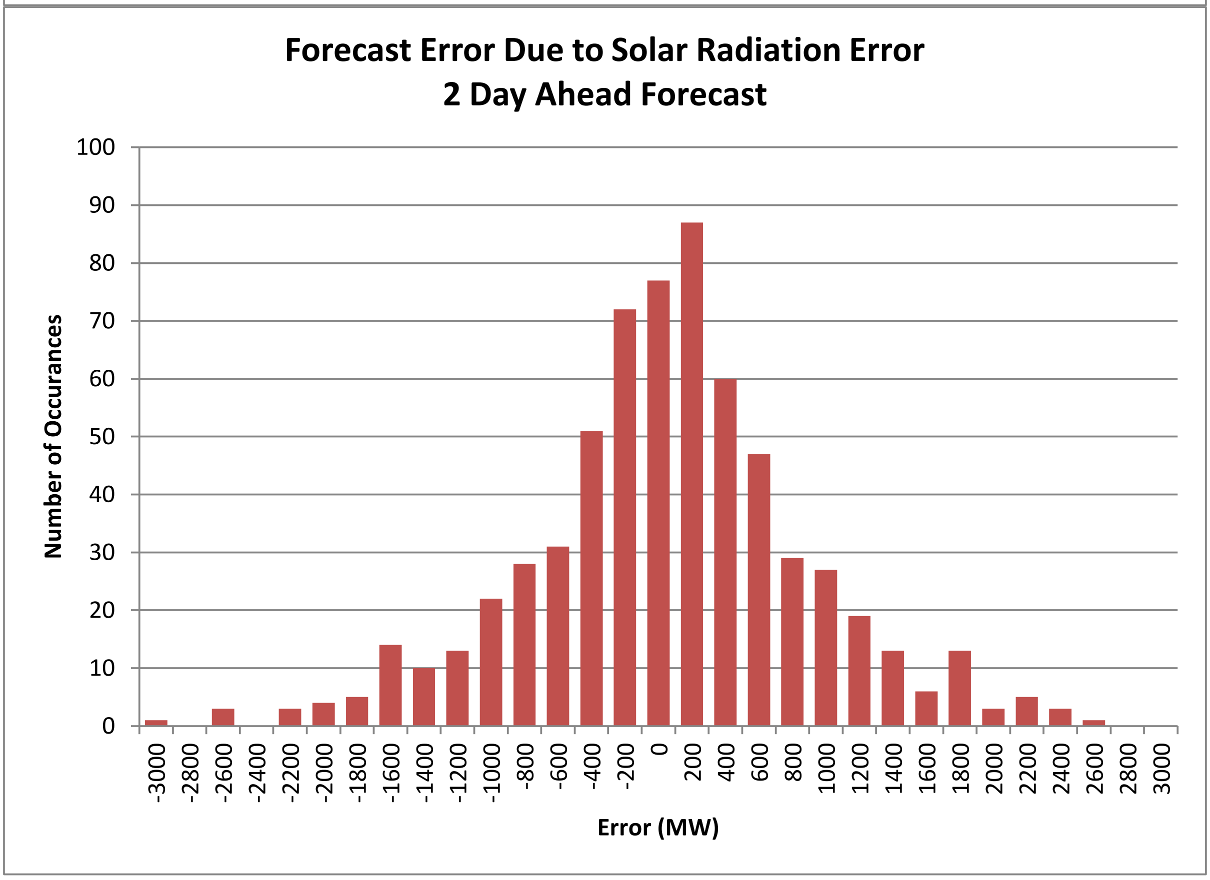
The forecast accuracy in MW is shown below for 1300 each day, based on the 0900 weather forecasts. There is relatively little bias until 7 days ahead. The mean absolute error rises from 548 MW at day ahead to 928 MW at 7 days ahead.

		MW
Day Ahead	Mean Error	31.5
	Mean Absolute Error	548.3
	Standard Deviation	744.1
2 Day Ahead	Mean Error	-47.9
	Mean Absolute Error	623.5
	Standard Deviation	841.8
7 Day Ahead	Mean Error	-189.0
	Mean Absolute Error	928.4
	Standard Deviation	1186.9

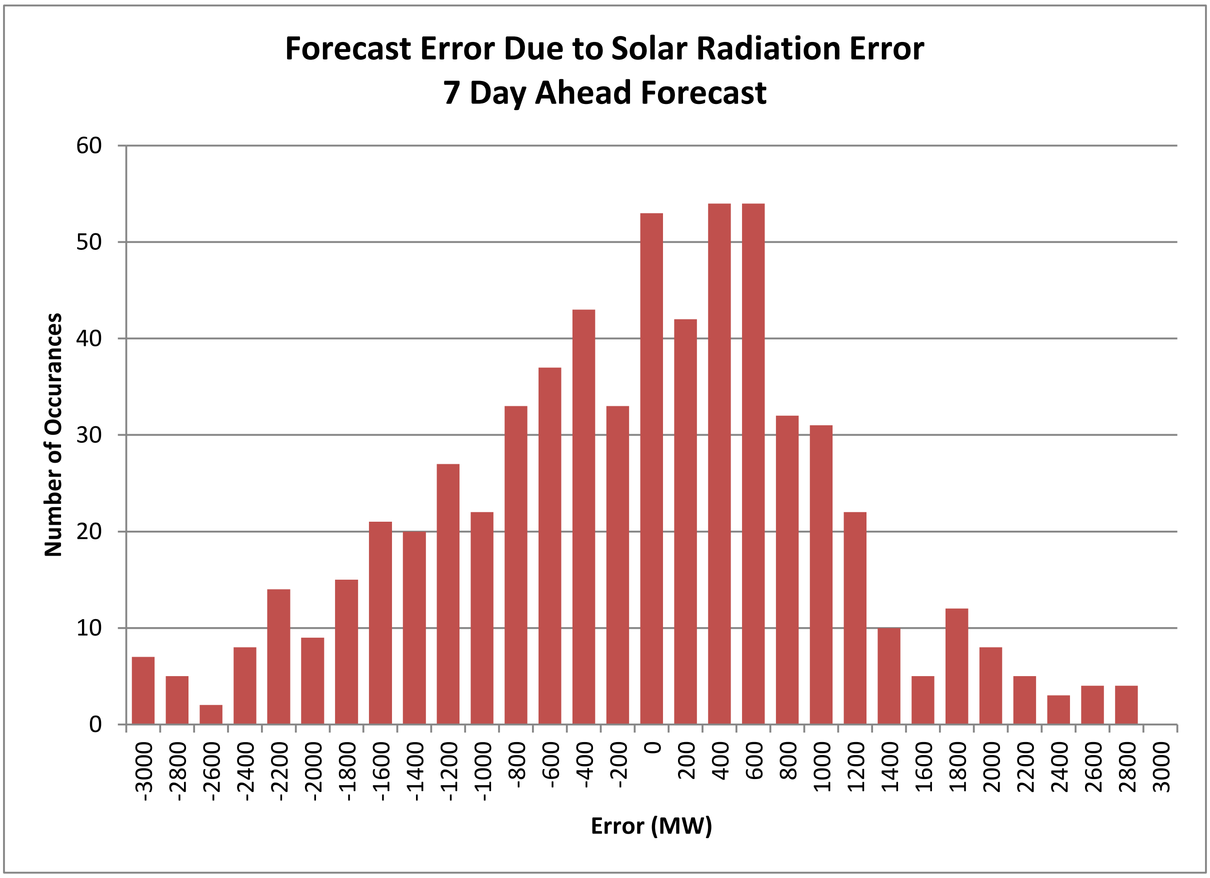
As with the weather models, there is a significant day on day variation in the error. At day ahead the error is mostly in the -400 to +800 rang, but by 7 days ahead the error is widely distributed, with many days having a solar radiation forecast error leading to a MW error of over 2000 MW over or under forecast.



Forecast Error Due to Solar Radiation Error
Day Ahead Forecast
Number of Occurances
Error (MW)



Forecast Error Due to Solar Radiation Error
2 Day Ahead Forecast
Number of Occurances
Error (MW)

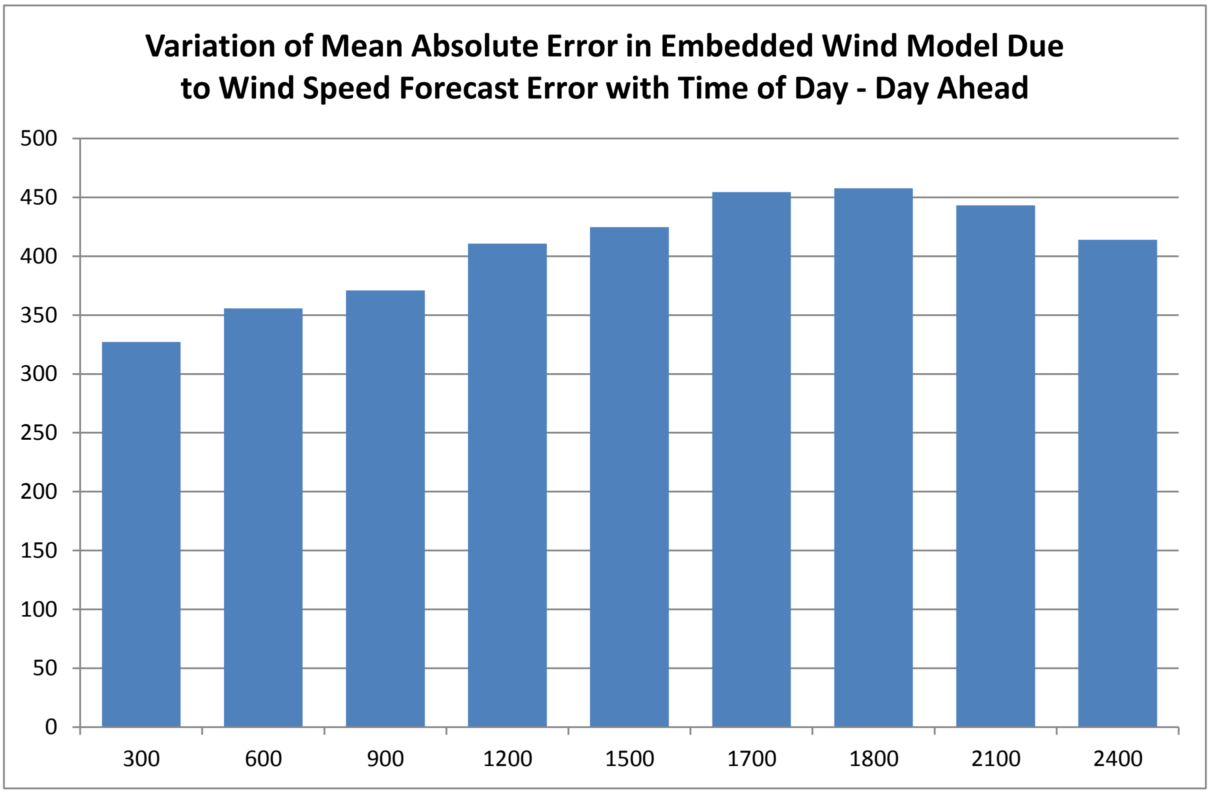


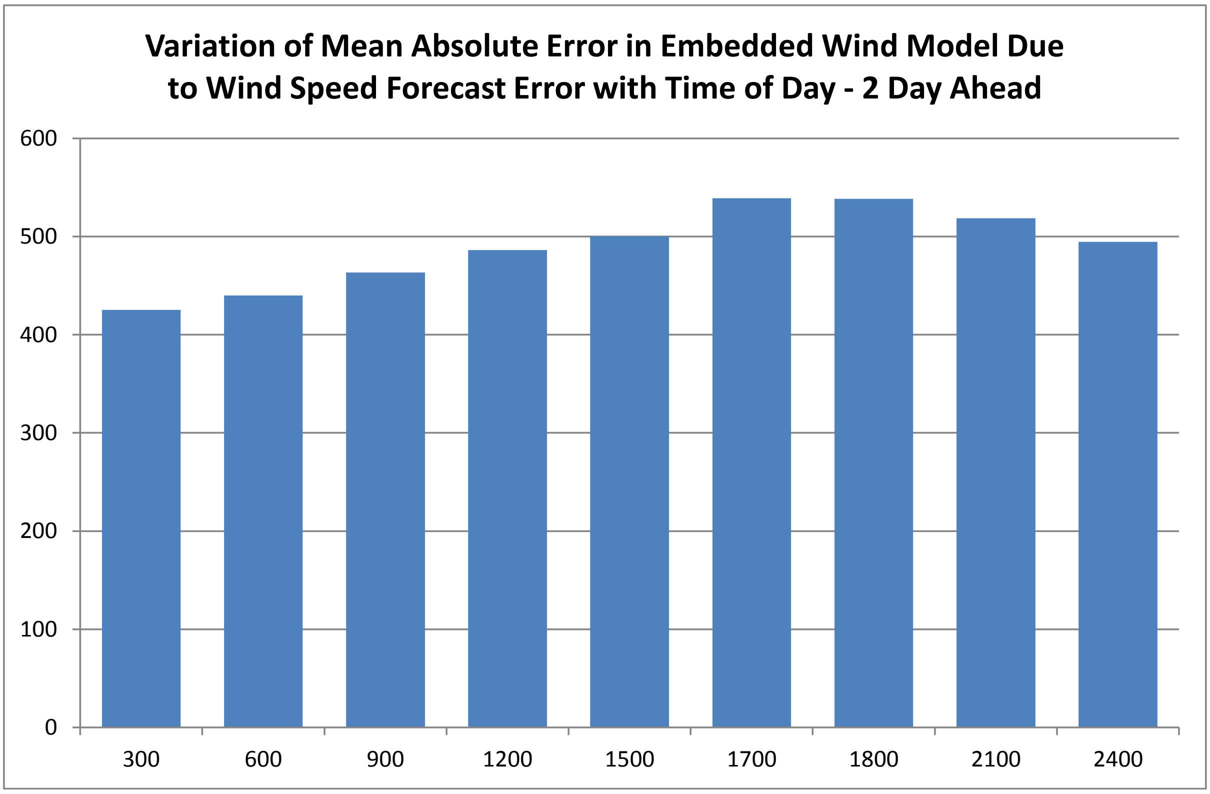
The final component is the effect of wind speed forecast on the embedded wind generation forecast. Embedded wind acts in the same way as PV to reduce the demand on the transmission system.

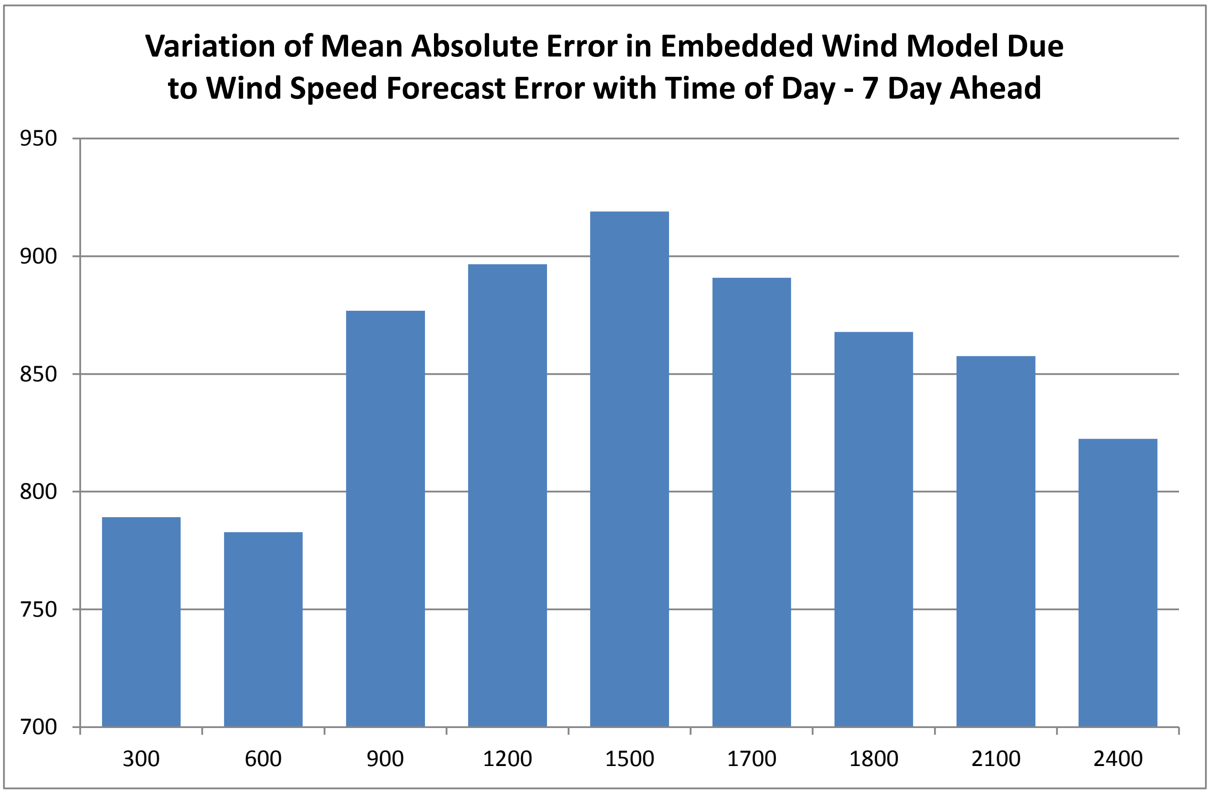
We forecast embedded wind by allocating all wind generators above 1 MW to one of around 80 weather locations, and using generic power curves to convert the wind speed forecasts to MW. In this analysis this has been simplified to use only the national average wind speed, and a simplified linear power curve. While this will introduce some error into the analysis is does enable a view of the impact of wind speed error to be calculated.

		Errors in MW									
		0300	**0600**	**0900**	**1200**	**1500**	**1700**	**1800**	**2100**	**2400**	**Daily Average**
Day Ahead	Mean Error	44.4	75.5	66.6	46.9	34.2	37.4	13.9	119.8	59.0	55.3
	Mean Absolute Error	327.2	355.7	370.9	410.9	424.8	454.6	457.8	443.2	414.0	406.6
	Standard Deviation	464.6	510.5	515.8	560.0	582.7	617.3	626.8	599.4	558.7	562.2
2 Day Ahead	Mean Error	83.8	108.6	86.4	82.6	49.5	40.0	7.6	112.4	87.0	73.1
	Mean Absolute Error	425.5	440.1	463.6	486.4	500.4	539.2	538.5	518.8	494.7	489.7
	Standard Deviation	584.4	589.8	610.5	666.0	672.3	708.9	717.8	682.6	660.5	656.7
7 Day Ahead	Mean Error	100.5	97.9	80.6	27.5	-184.3	-165.1	-101.1	199.7	110.7	18.5
	Mean Absolute Error	789.1	782.7	876.8	896.7	919.1	890.9	867.9	857.6	822.4	855.9
	Standard Deviation	996.1	992.9	1100.8	1127.9	1136.0	1118.1	1097.6	1041.7	1022.7	1078.6

Again we see that there is little bias, but errors in increase at longer range. We also see a similar pattern of variation of errors across the day, with peak errors occurring again around the darkness peak in early evening.


Variation of Mean Absolute Error in Embedded Wind Model Due to Wind Speed Forecast Error with Time of Day - Day Ahead
500
450
400
350
300
250
200
150
100
50
0
300
600
900
1200
1500
1700
1800
2100
2400


Variation of Mean Absolute Error in Embedded Wind Model Due to Wind Speed Forecast Error with Time of Day - 2 Day Ahead
600
500
400
300
200
100
0
300
600
900
1200
1500
1700
1800
2100
2400



Summary

Weather forecast errors impact demand forecasts in three areas, consumer response to weather, PV generation and embedded wind generation.

At day ahead the mean absolute error in MW introduced by these three factors is 350, 548 and 406 MW respectively. While it is not statistically valid to just add the three errors together to get an overall effect, the errors will be correlated to some extent, so it is reasonable to say that weather errors can introduce a mean absolute demand forecast error of around 1000 MW during daylight hours in summer.

By 7 days ahead, the MAEs are 686, 928 and 855 MW respectively, pointing to an overall MAE in the 1500 – 2000 MW range. There are also a significant number of days when the error in one or more components can introduce a demand forecast error well in excess of 2000 MW.

While National Grid is working with the Met Office to reduce these errors, particularly in the solar radiation forecasts, there is still a very large irreducible error due to weather forecasts which makes it unreasonable to assume that National Grid can move from mean to lower quartile errors in a short timescale.