Danish Wind Power January to June 2015

It is often claimed that Denmark is a forerunner in green energy and wind power. This may be true. But it is not an example to follow.

In the first half of 2015 the Danish wind power was on average 1663 MW and the electric load was 3942 MW.
The wind power thus corresponded on average to 433 W/kW load.
It can be seen form the following diagrams and tables that
1. We imported roughly 10 % of our electricity.
2. The net export varied between -3187 MW and 2633 MW.
3. The net export follows the wind power.

Denmark lies between Norway with an average load of ca. 15 GW, Sweden with an average load of ca. 15 GW, and about 75% of these 30 GW are easily controllable hydro power, and Germany with an average load on ca. 50 GW, so the average Danish load is about 5% of our neighbours'.

It is shown in the following diagrams that the
(***production of wind power/electricity consumption in Denmark***
varies between **2 and 1431 kW/MW**. (p. 10). The average figure for January to June 2015 is 432 kW/MW and the standard deviation is 310 kW/MW. So full back up is a must.

It is shown too, that there is a close relationship between wind power and export/import.

Until now our neighbours have supplied a large part of the back up, and have absorbed a large part of the wind power, which could not be used in the Danish system.
This fact has made the high proportion of wind power in the Danish system possible, but it may change as Germany goes on with the ENERGIEWENDE.

The reader must study the diagrams and tables himself. I just want to remark, that it is shown that off-shore wind comes down to zero just as often as on-shore wind power.
My allegation is:
It will be impossible for any other country to obtain the same proportion of wind power in their power system as Denmark.

I hereby permit everybody to use my diagrams and tables as you might wish.

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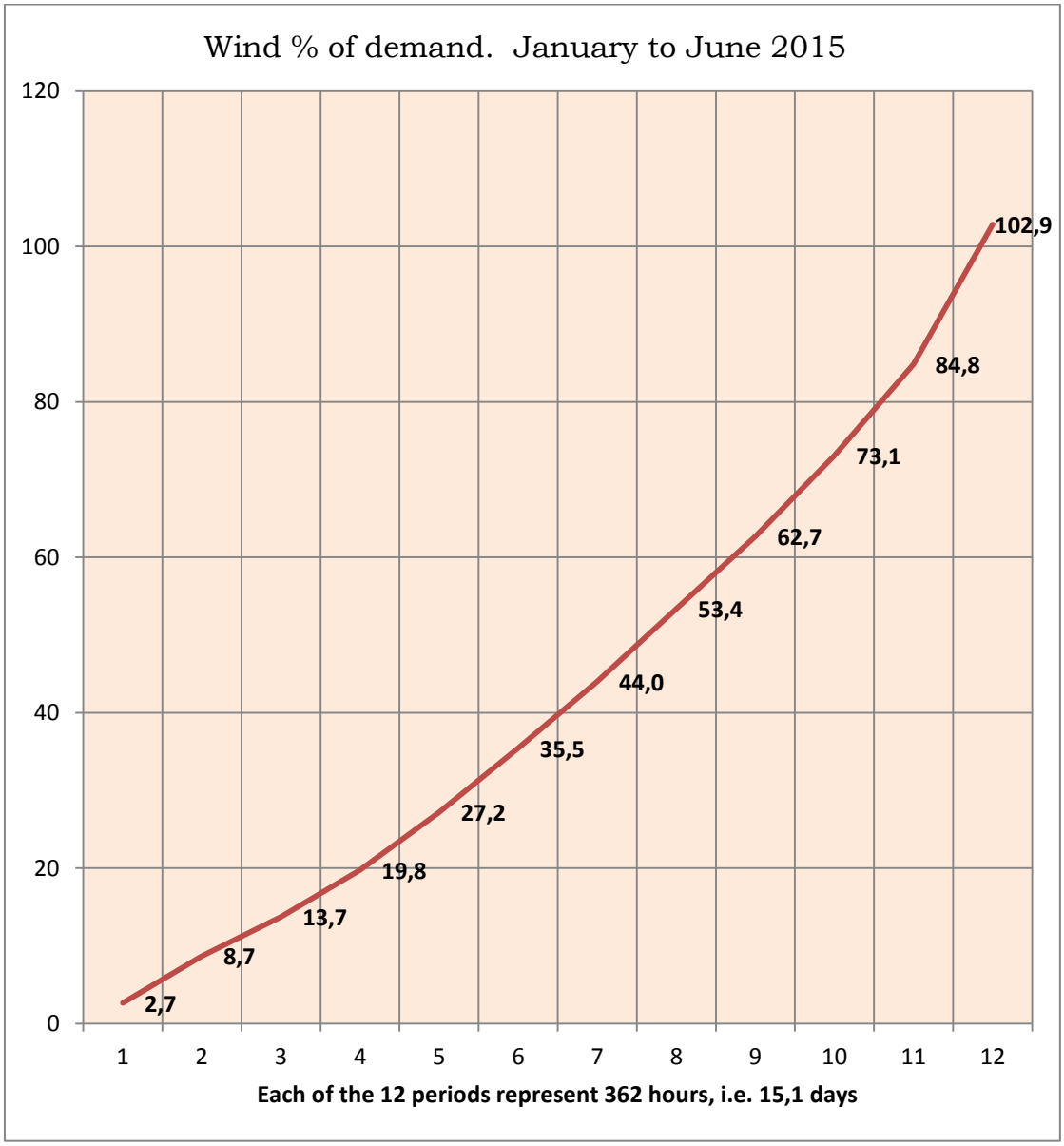
The main data source for the Danish Figures is:
http://www.energinet.dk/DA/El/Engrosmarked/Udtraek-af-markedsdata/Sider/default.aspx.
The data for Germany and France is supplied by P.F. Bach: http://pfbach.dk/

The diagram hereunder illustrates the already well known fact, that wind energy isn't always available when you need it.

The period January to June 2015 is divided in twelve parts, and you see that in the 362 hours with the least wind production an average of only 3% of the electricity demand is produced by wind turbines.

In the next 362 hours the average is 9% and so on.

This proves that full back-up is needed no matter how much wind power we build.

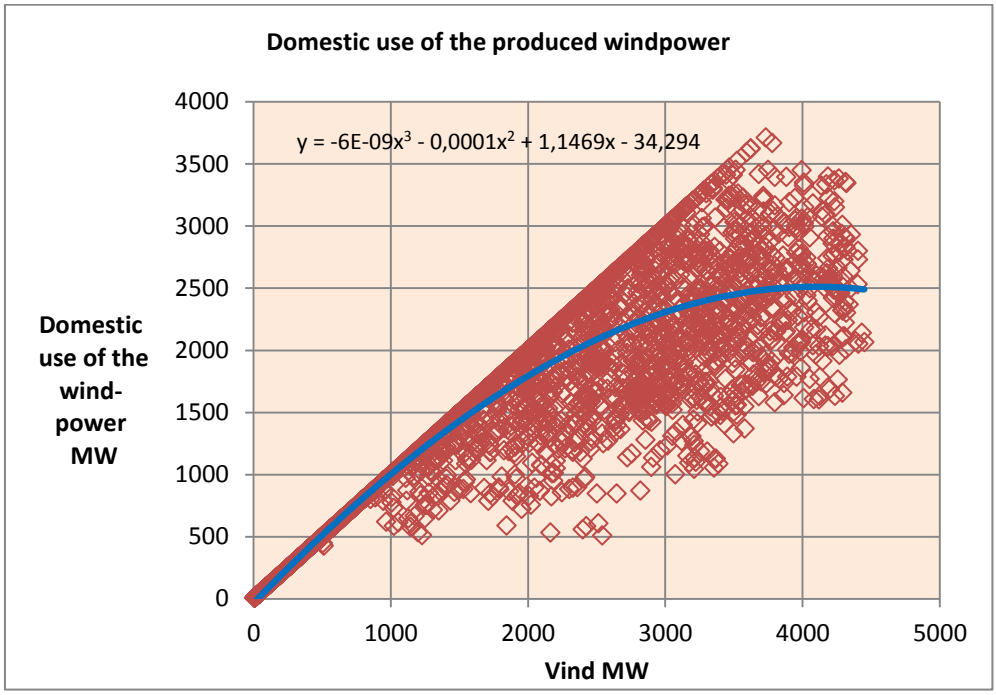


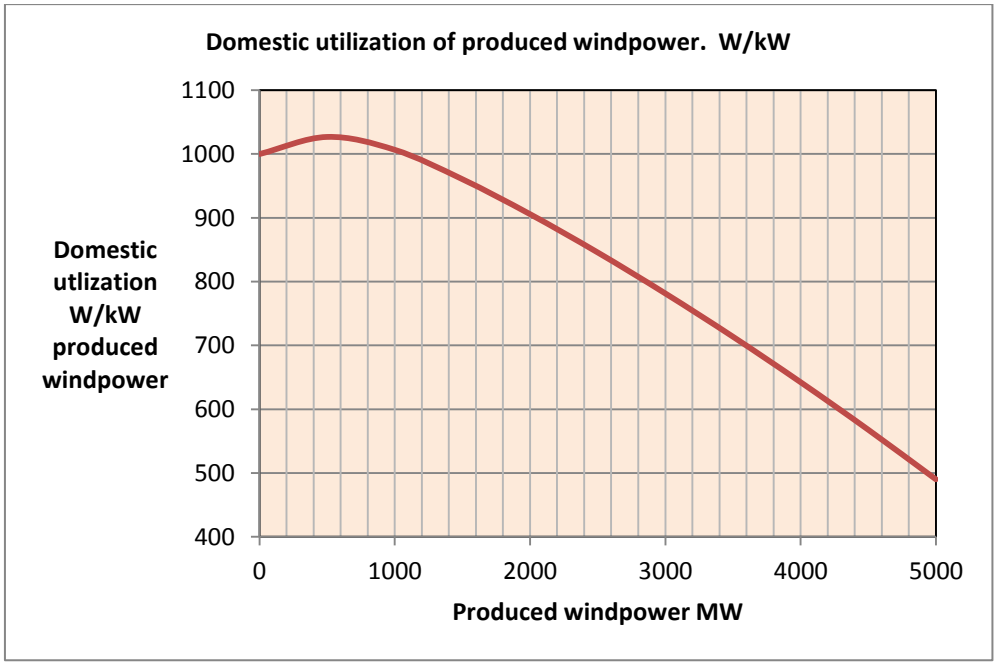
Domestic utilization of the Danish windpower.

It is a well known fact, that only a part of the Danish wind power is utilized in Denmark. But because we have 5 different electric connections to Norway, Sweden and Germany, it is impossible to calculate how much without using Boolean algebra.

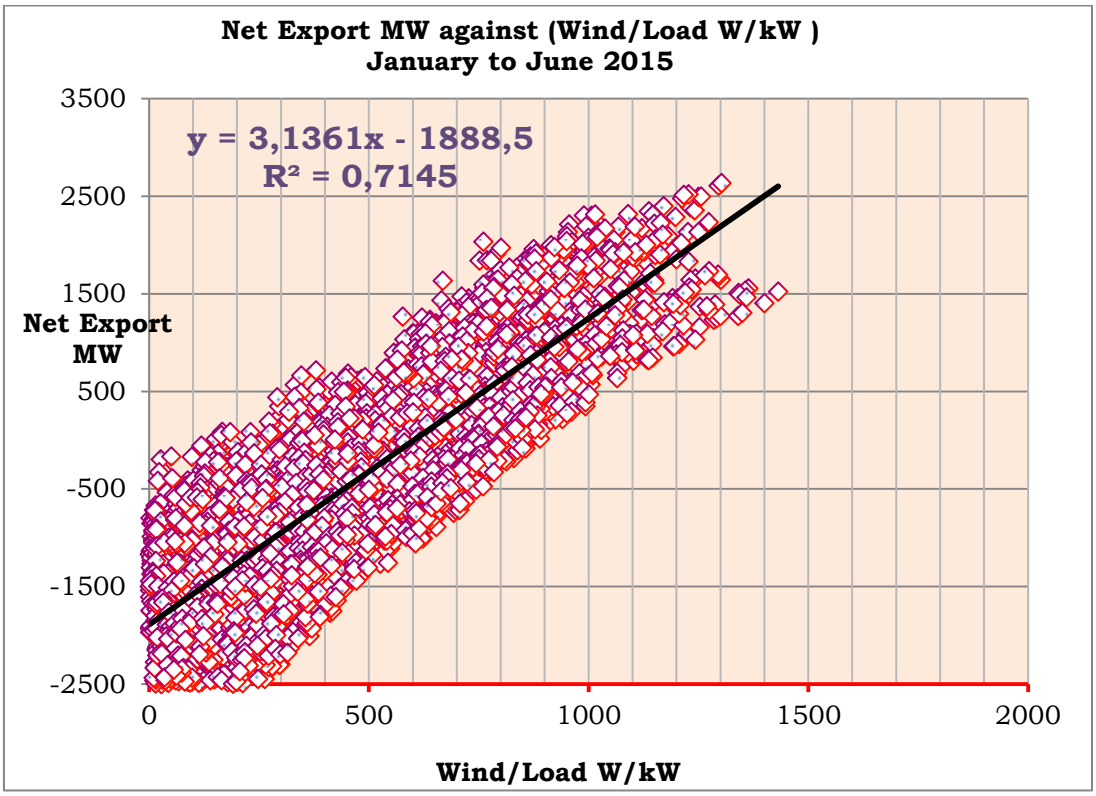
So when I calculate the utilization of the wind current I subtract the power export, from the Danish wind power and let Boolean algebra prevent me from getting meaningless results. A lot of data must be considered. The wind power is given for Denmark East and Denmark West. And import/export too. So the input data amounts to 7 per hour.

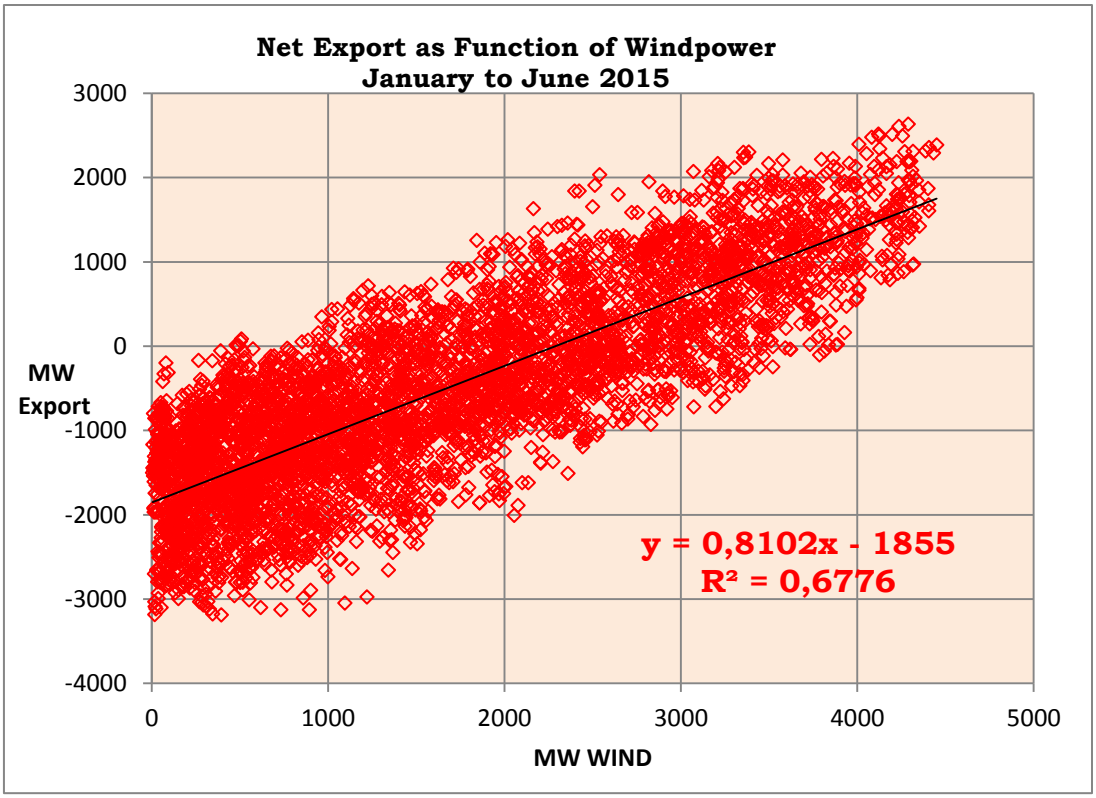
This proves how important it is to know how to use the "If" function in your computer. And I doubt it that this is generally known.





This diagram shows that the met export increases with wind power. The correlation formula tells that when the wind power is higher than 1888,5/3,176 = 595 W Wind power per kW load then it becomes necessary to export the wind power beyond this figure.

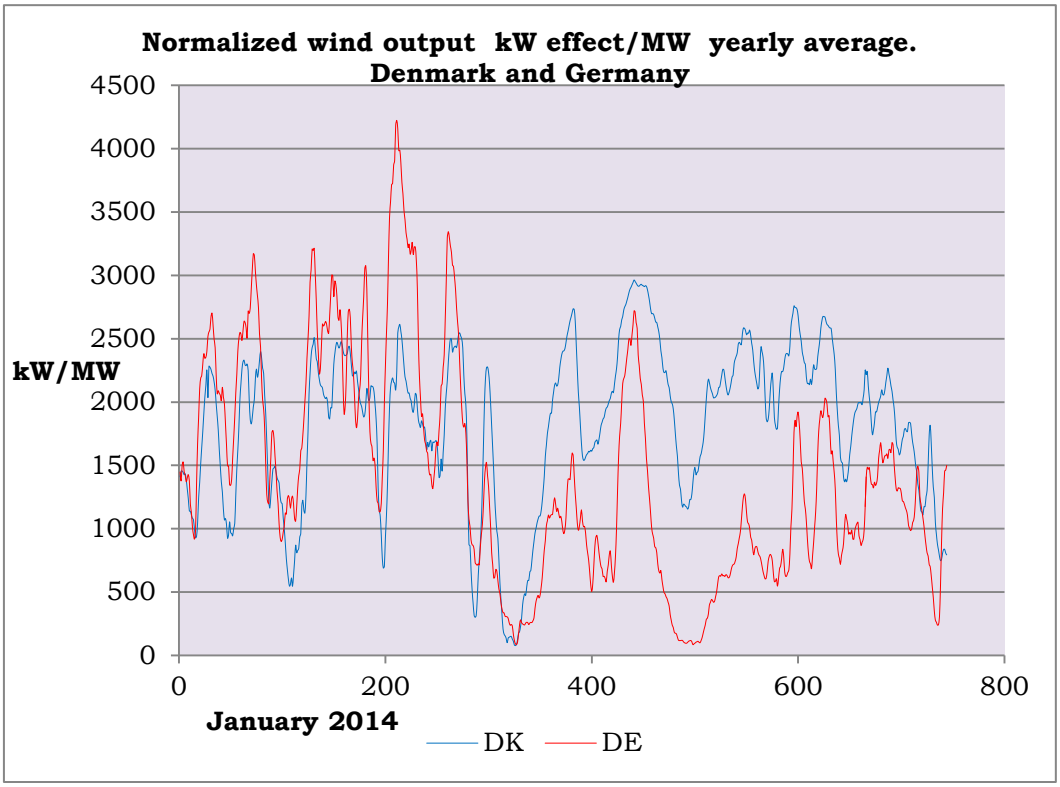


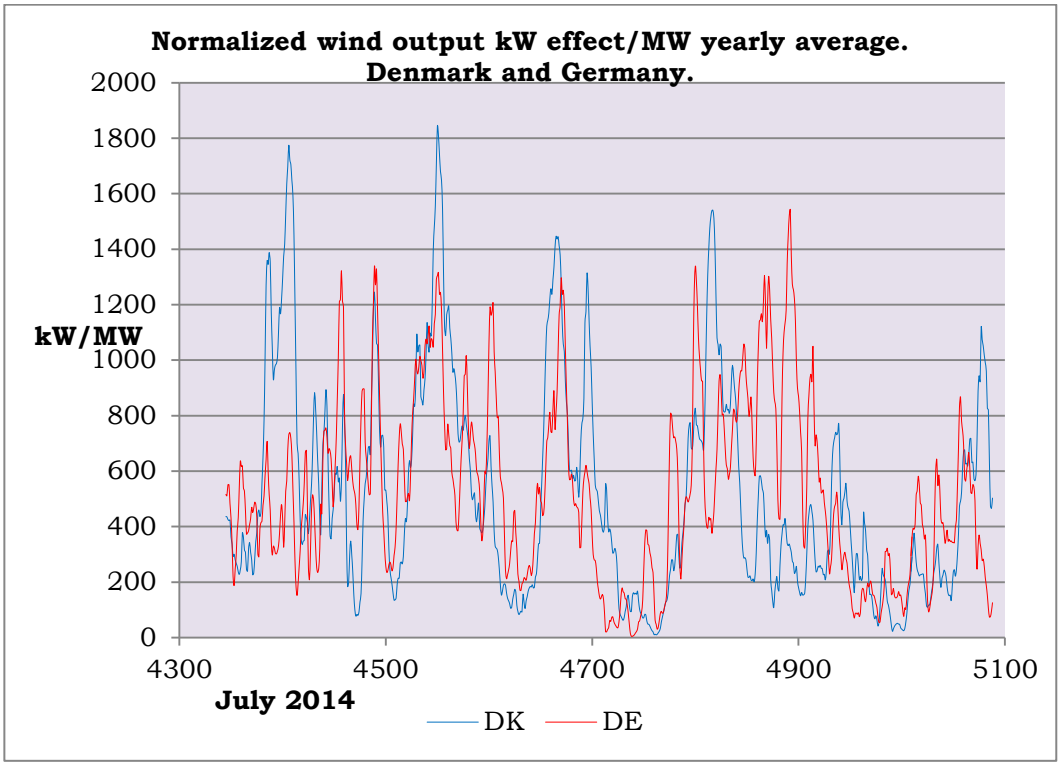


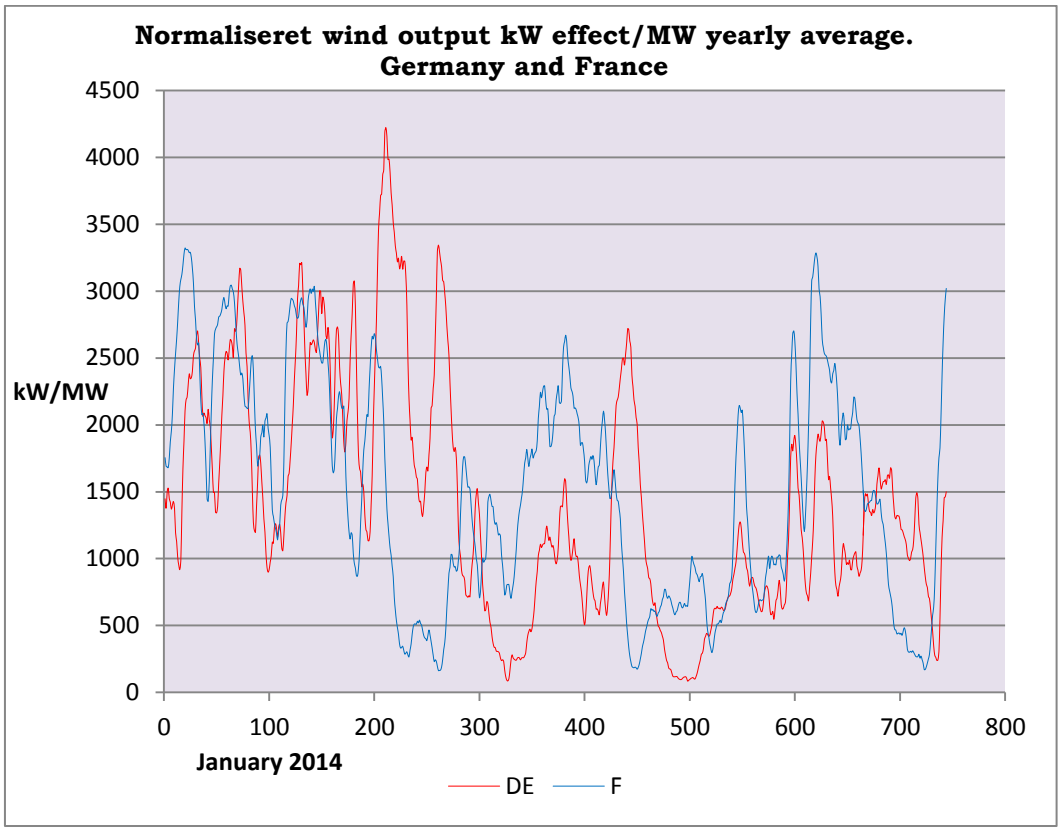
In all the following diagrams the abcissae indicate hours since beginning of the year 2015.

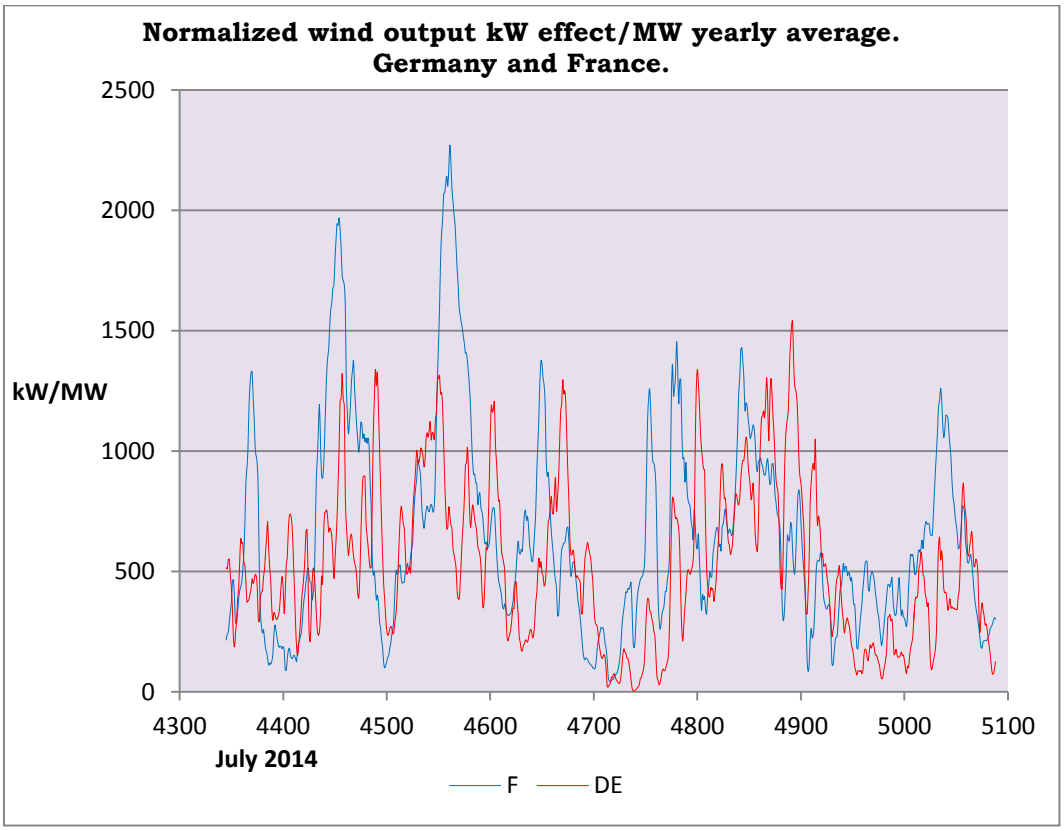
It is generally assumed, that it always blows somewhere. So we just need to build an inter European smart grid to transport the fluctuating wind power from place to place, and thus obtain a secure supply.This is not true either, but to prove it you must use mathematical tricks, because you cannot directly compare Danish, German and French wind power output because the installed capacities are of a very different magnitude. So, to obtain comparable figures I normalize the data by dividing the output for each country and hour by the average per year and then multiply by 1000.

Then we get the dimensionless number kW/MW in the following graphs showing the normalized curves for Denmark and Germany, and Germany and France.






Normaliseret wind output kW effect/MW yearly average.
Germany and France
4500
4000
3500
3000
2500
kW/MW
2000
1500
1000
500
0
0
100
200
300
400
500
600
700
800
January 2014
DE
F


Normalized wind output kW effect/MW yearly average.
Germany and France.
2500
2000
1500
kW/MW
1000
500
0
4300
4400
4500
4600
4700
4800
4900
5000
5100
July 2014
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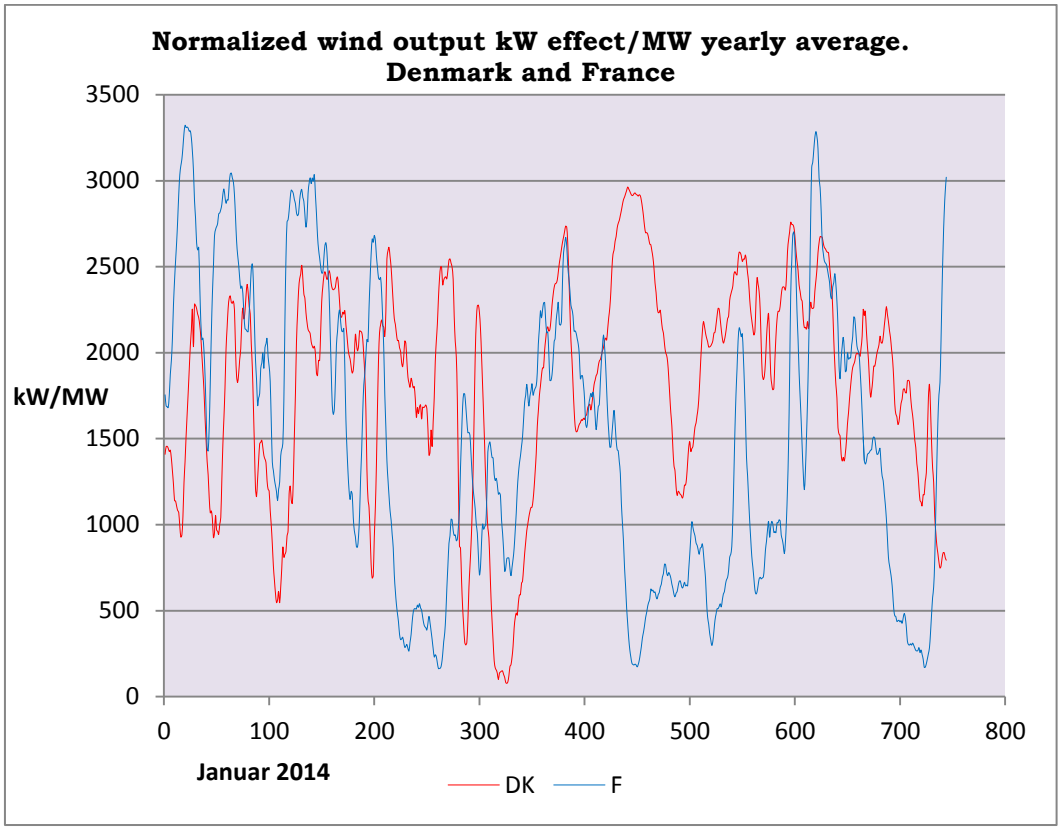
Normalized wind output kW effect/MW yearly average.
Denmark and France
3500
3000
2500
2000
kW/MW
1500
1000
500
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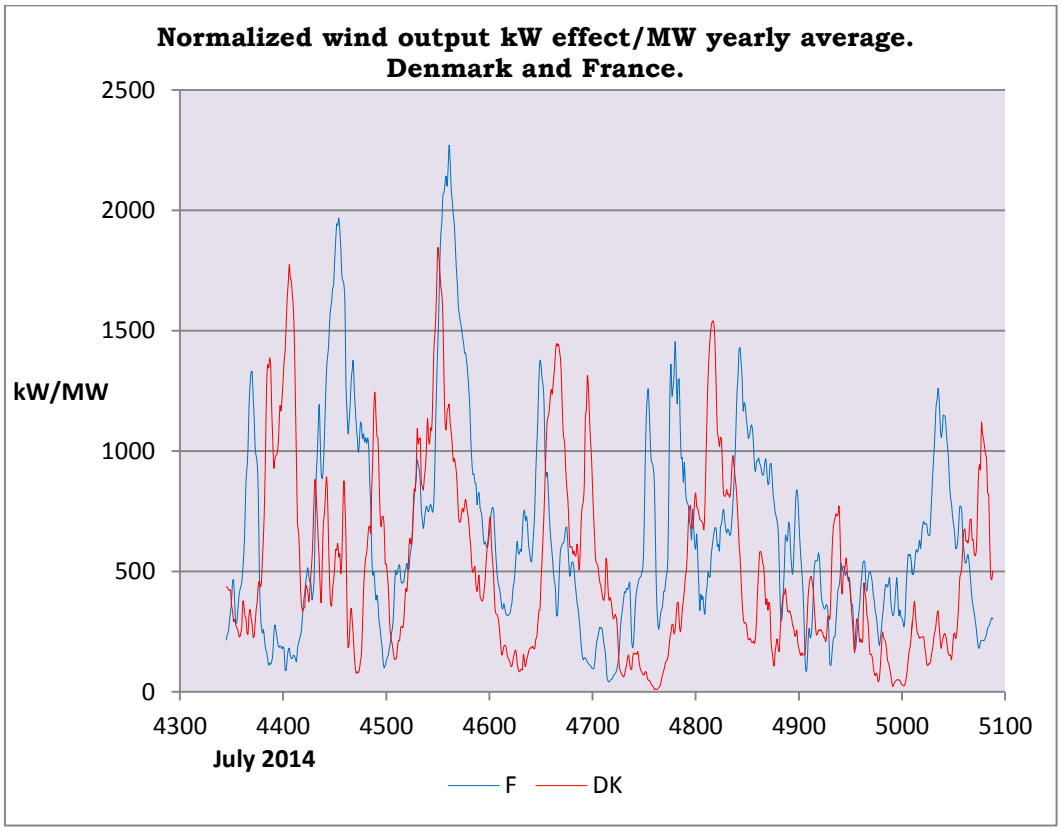
Normalized wind output kW effect/MW yearly average.
Denmark and France.
2500
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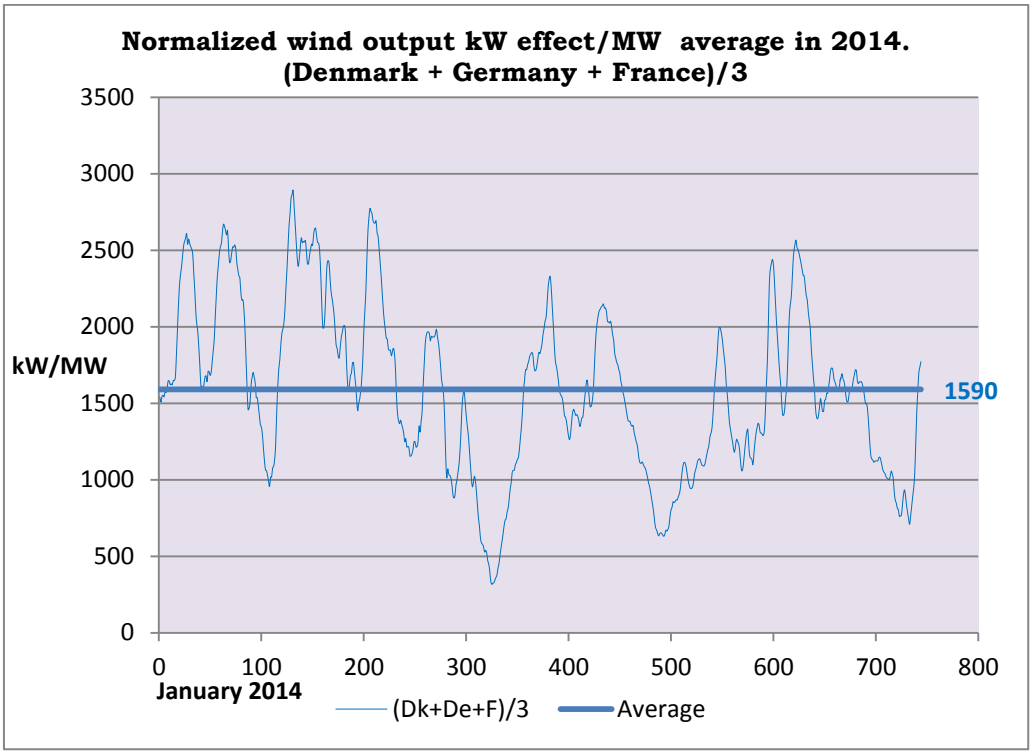
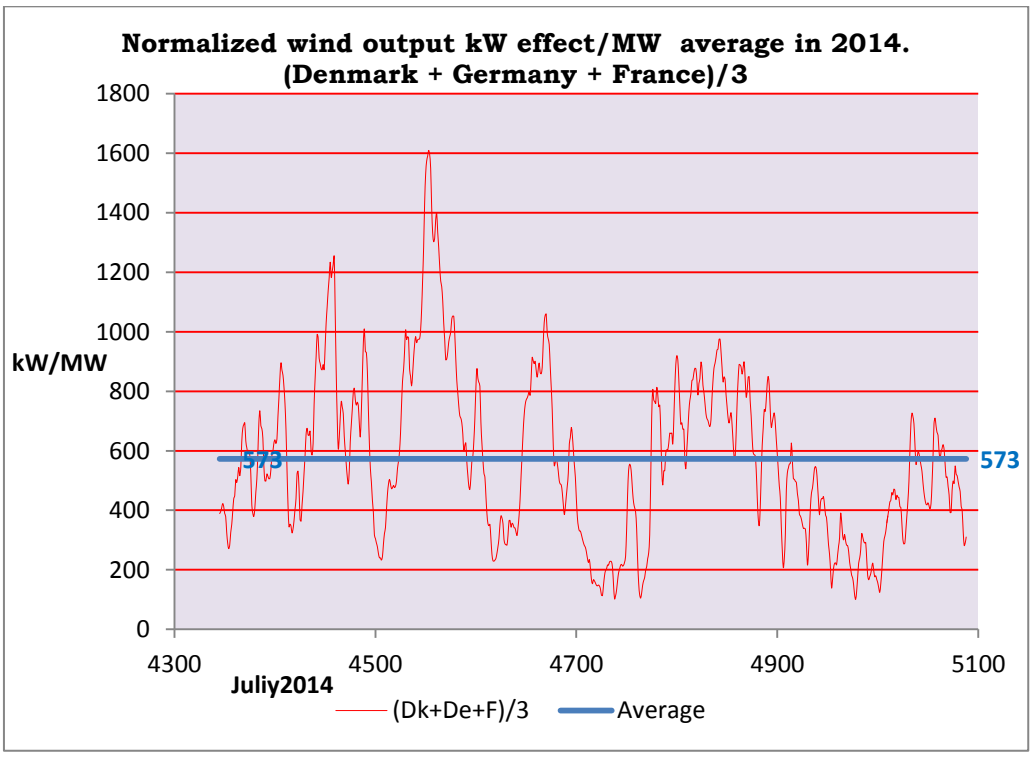
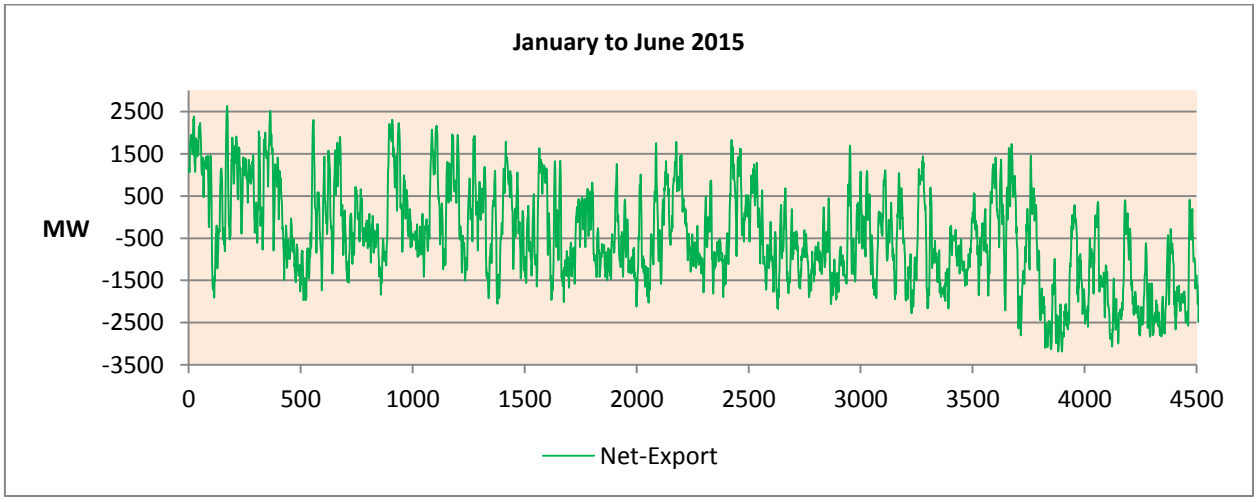


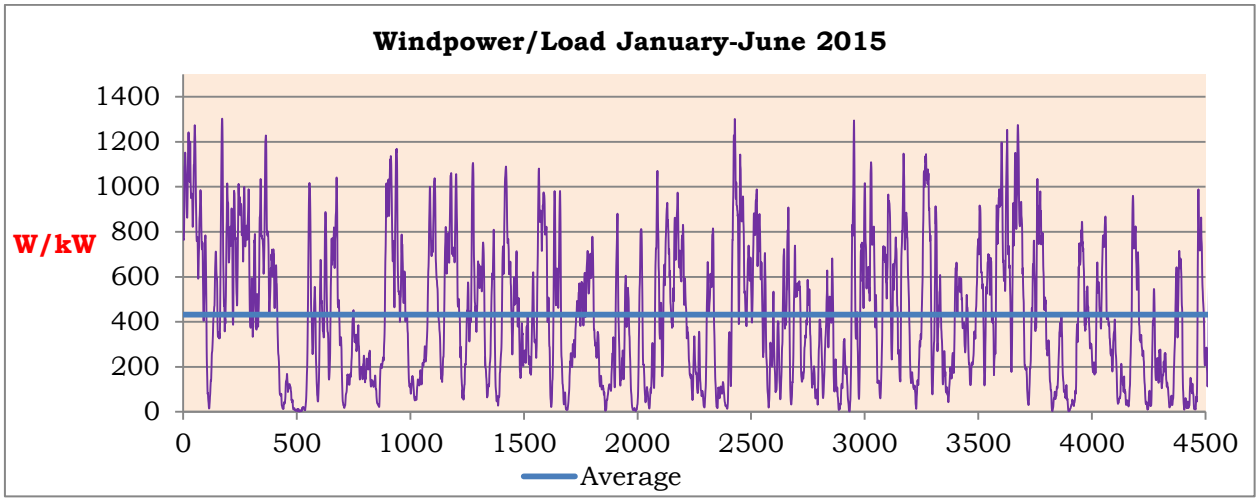


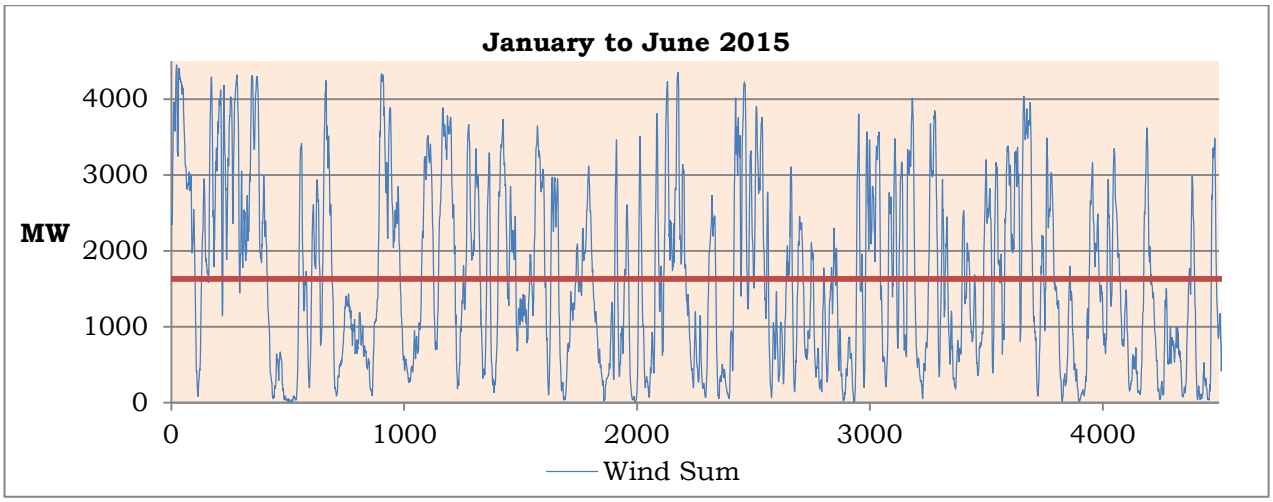
Please observe that the wind output in July is only a third of the output in January. A circumstance worth to remember, if you want an electrified car park.

All the following diagrams and tables show Danish figures only

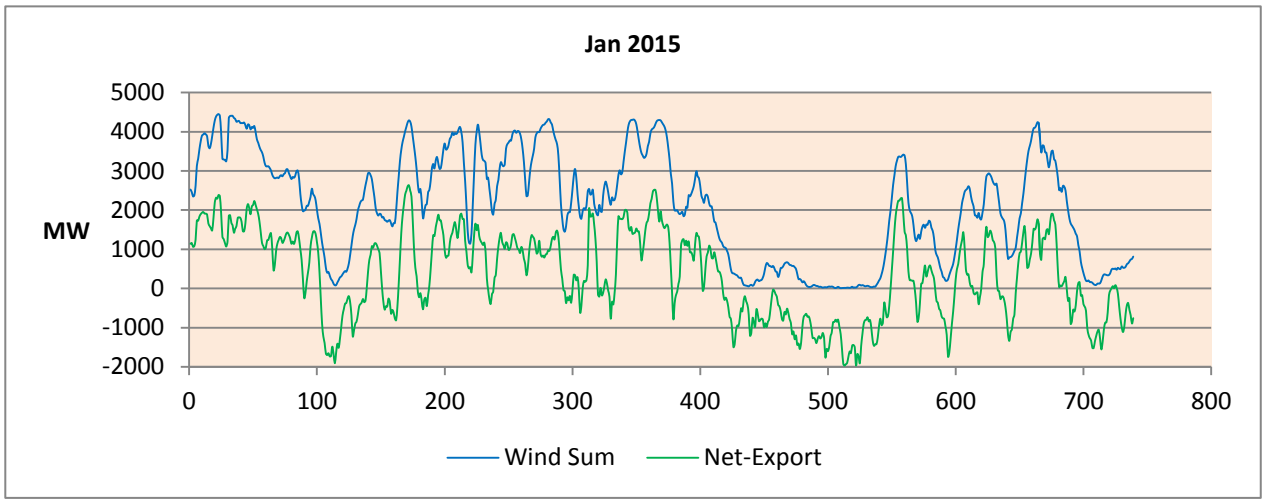
Jan-June 2015	Solar MW	Wind On-shore MW	Wind Off-shore MW	Wind Sum MW	Thermal Prod. MW	Load MW	Wind/ Load W/kW	Net Export MW
Average	82	1061	570	1631	1610	3859	432	-534
Max	496	3226	1225	4450	4769	5844	1431	2633
Min	0	2	0	6	330	2276	2	-3187
Stddev	121	839	369	1169	854	779	310	1151
GWh	**415**	**5401**	**2898**	**8299**	**8193**	**19633**		**-2715**

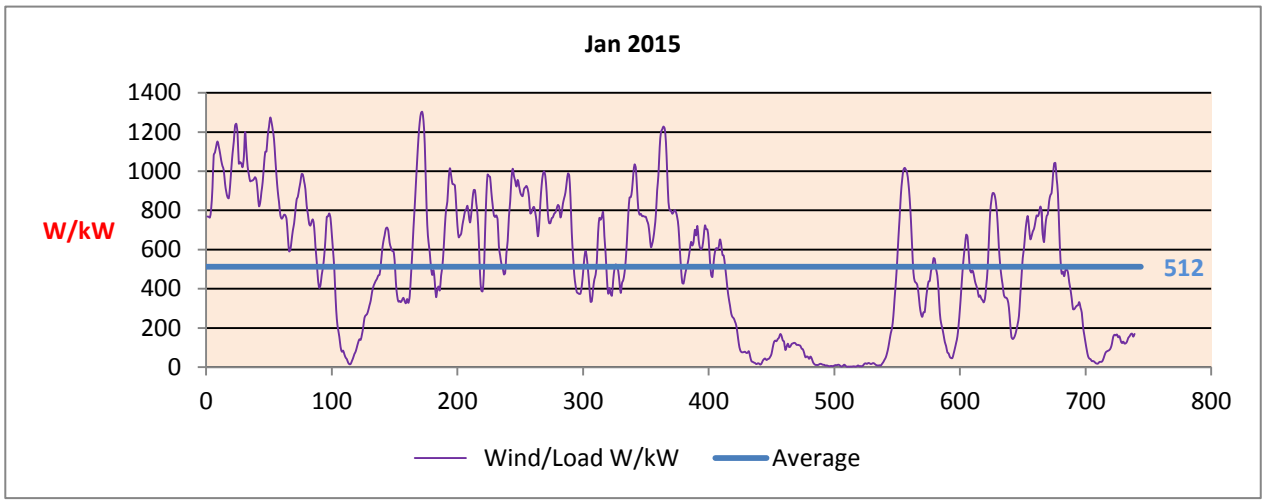


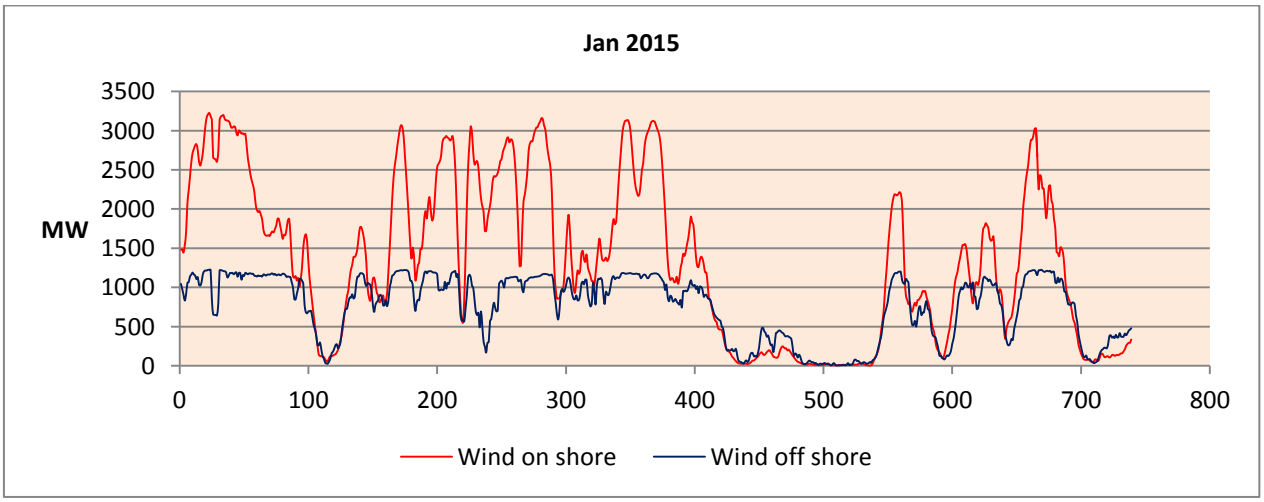




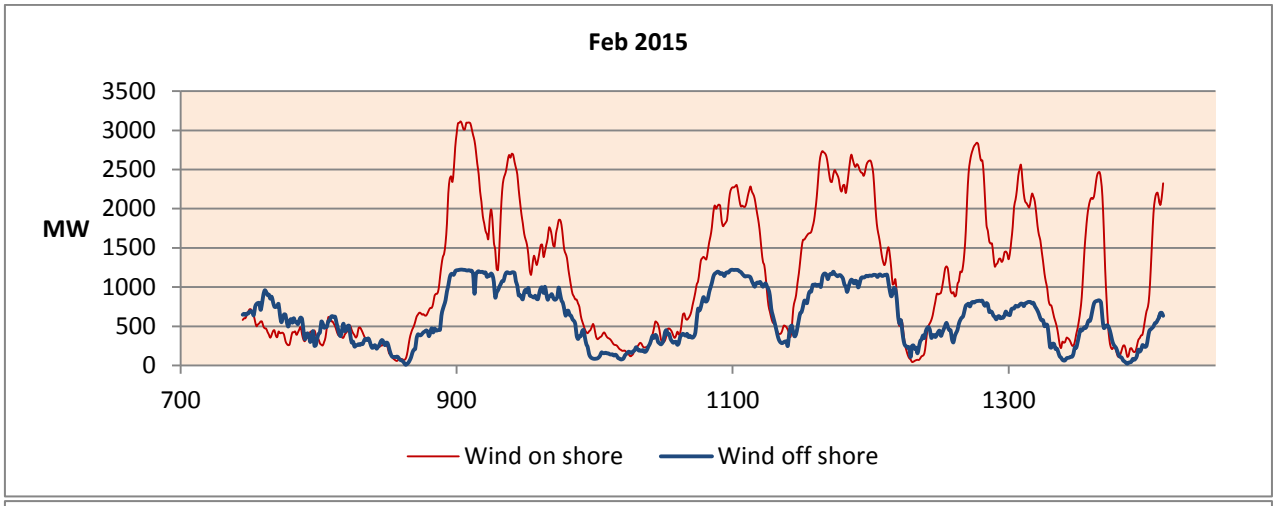
January 2015	Solar MW	Wind On-shore MW	Wind Off-shore MW	Wind Sum MW	Thermal Prod. MW	Load MW	Wind/ Load W/kW	Net Export MW
Average	11	1349	756	2106	2494	4283	512	343
Max	197	3226	1225	4450	4502	5729	1303	2633
Min	0	2	3	8	958	2868	2	-1970
Stddev	27	1016	410	1382	652	811	348	1103
GWh	**58**	**6864**	**3849**	**10713**	**12691**	**21792**		**1747**

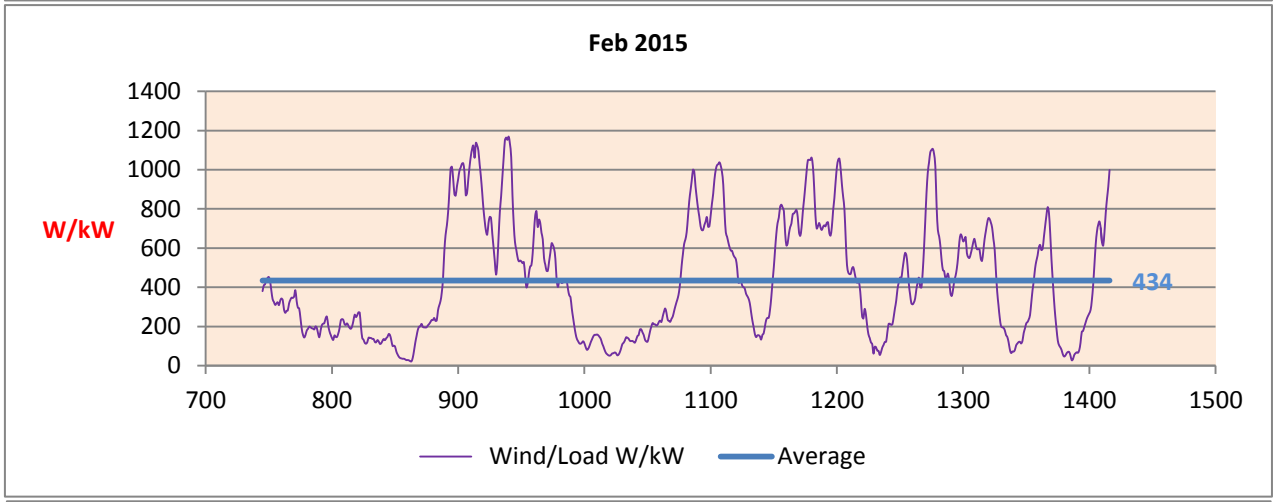


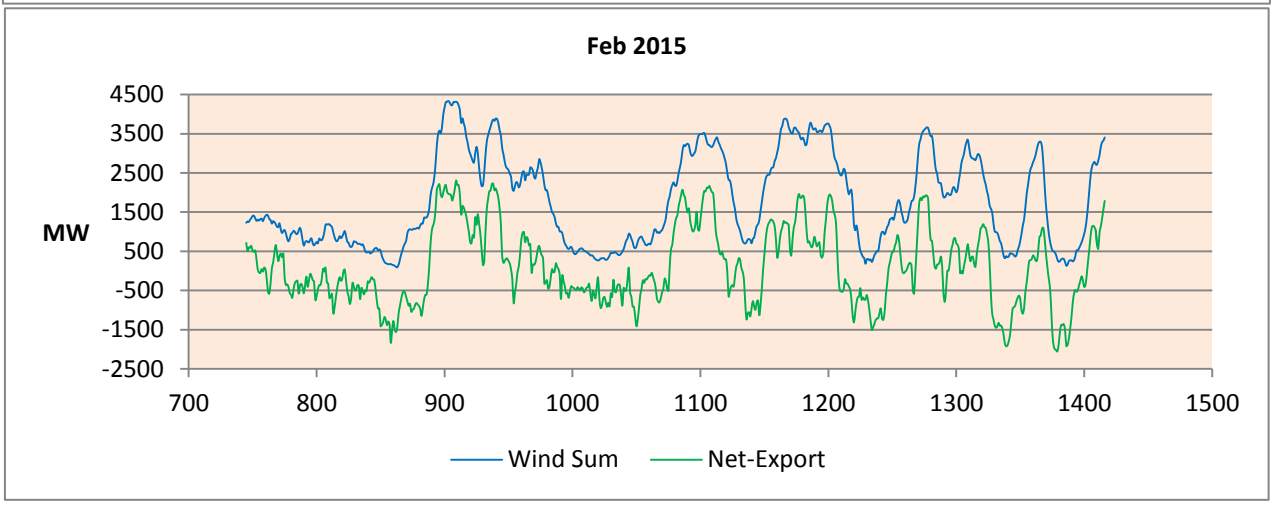




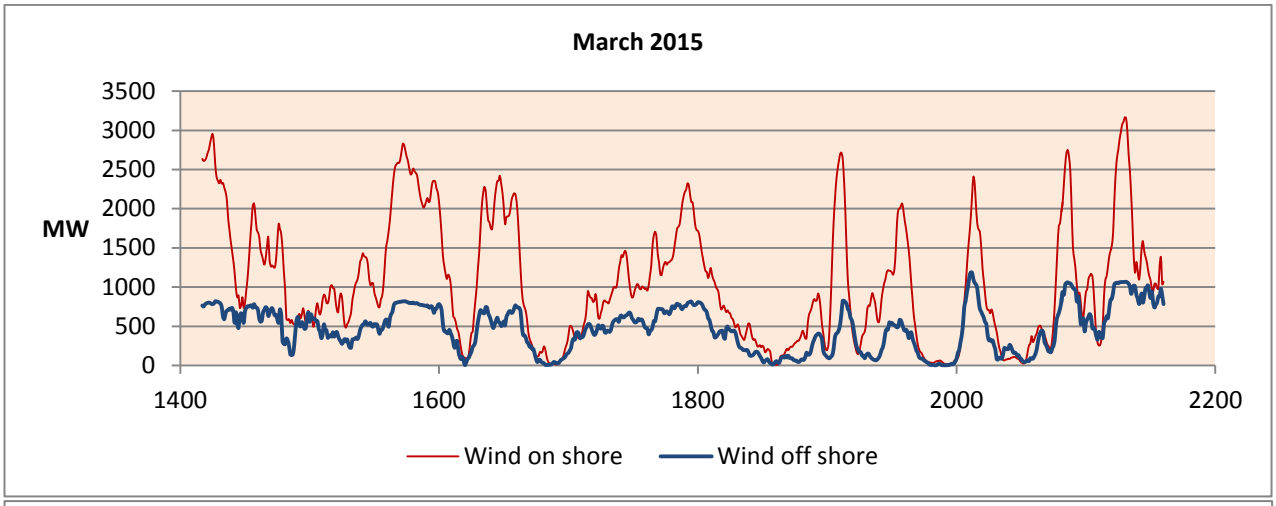
February 2015	Solar MW	Wind On-shore MW	Wind Off-shore MW	Wind Sum MW	Thermal Prod. MW	Load MW	Wind/ Load W/kW	Net Export MW
Average	22	1159	621	1780	2541	4250	434	93
Max	255	3114	1223	4336	4769	5655	1169	2310
Min	0	45	8	92	1184	2919	22	-2054
Stddev	46	865	356	1179	643	767	301	984
GWh	**15**	**779**	**417**	**1196**	**1708**	**2856**		**63**

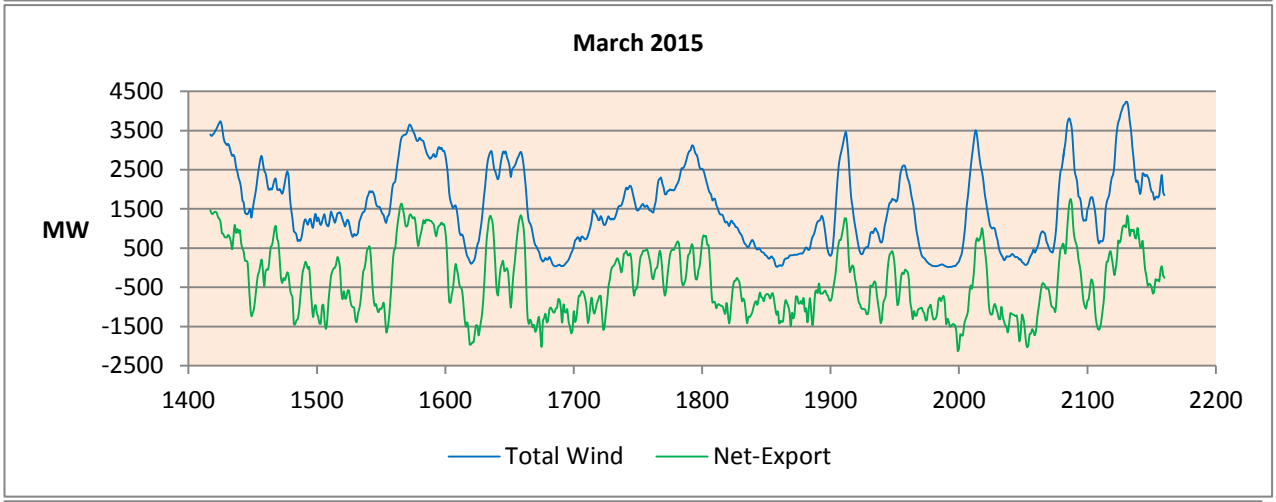


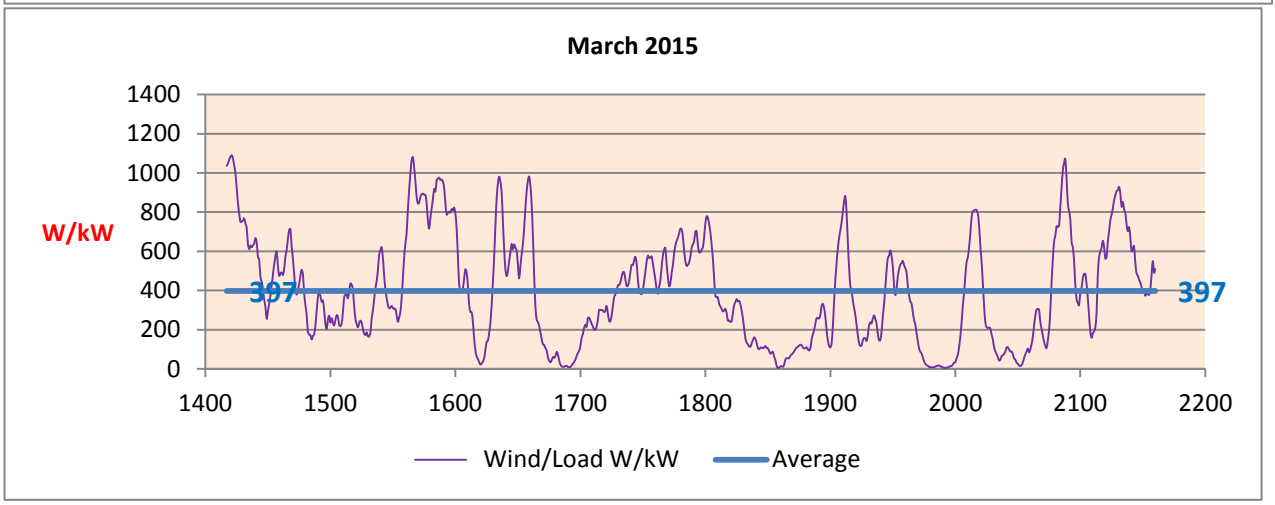




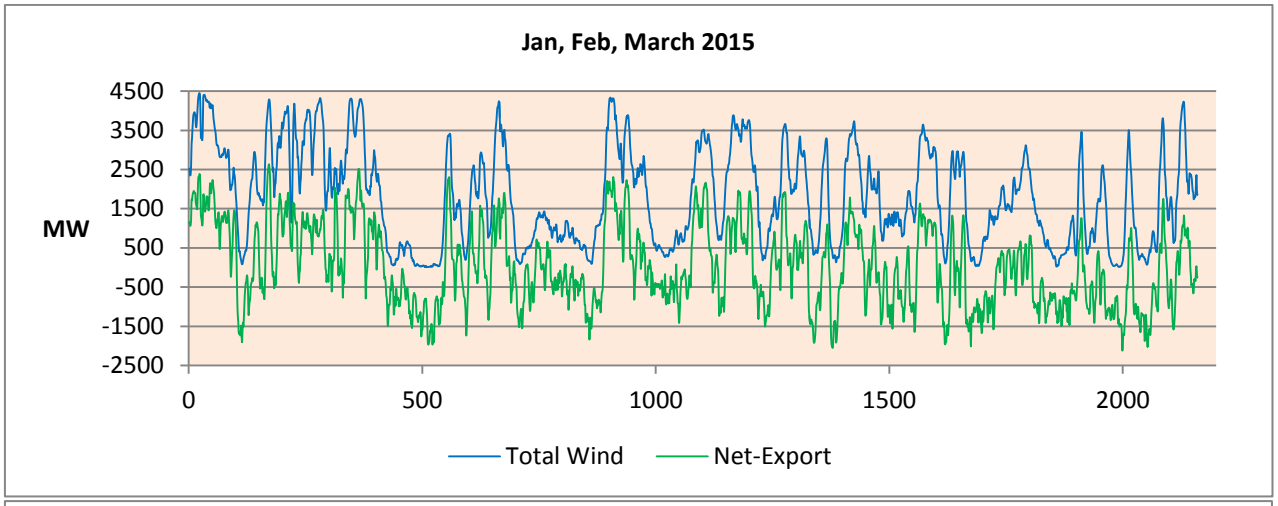
March 2015	Solar MW	Wind On-shore MW	Wind Off-shore MW	Wind Sum MW	Thermal Prod. MW	Load MW	Wind/ Load W/kW	Net Export MW
Average	63	1065	468	1533	2008	3985	397	-379
Max	399	3166	1187	4231	3983	5208	1090	1753
Min	0	6	1	17	1123	2745	4	-2120
Stddev	98	780	287	1029	529	697	275	863
GWh	**47**	**792**	**348**	**1141**	**1494**	**2965**		**-282**

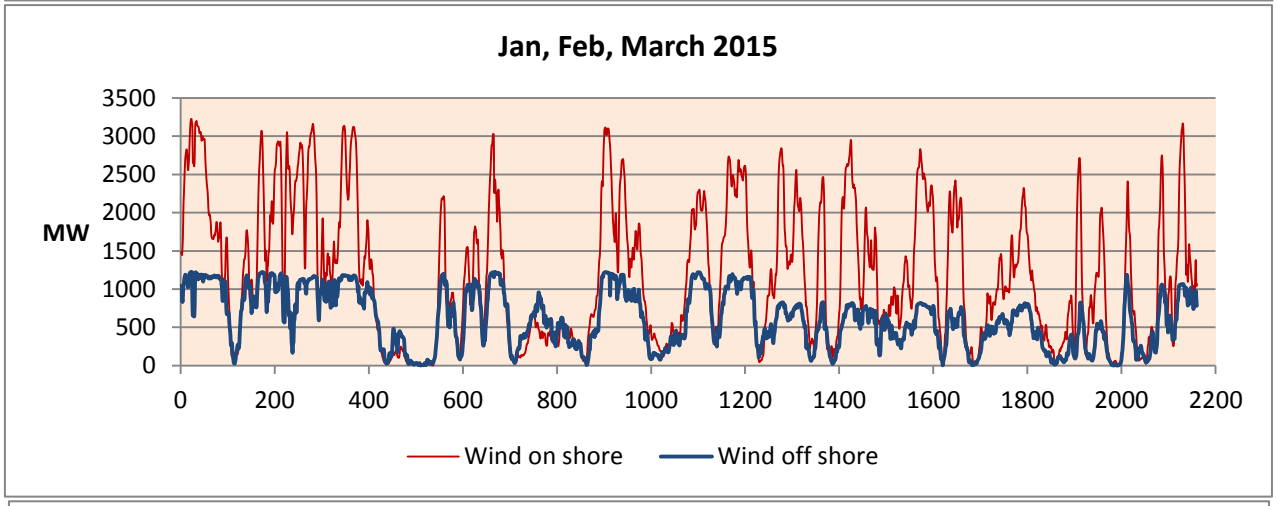


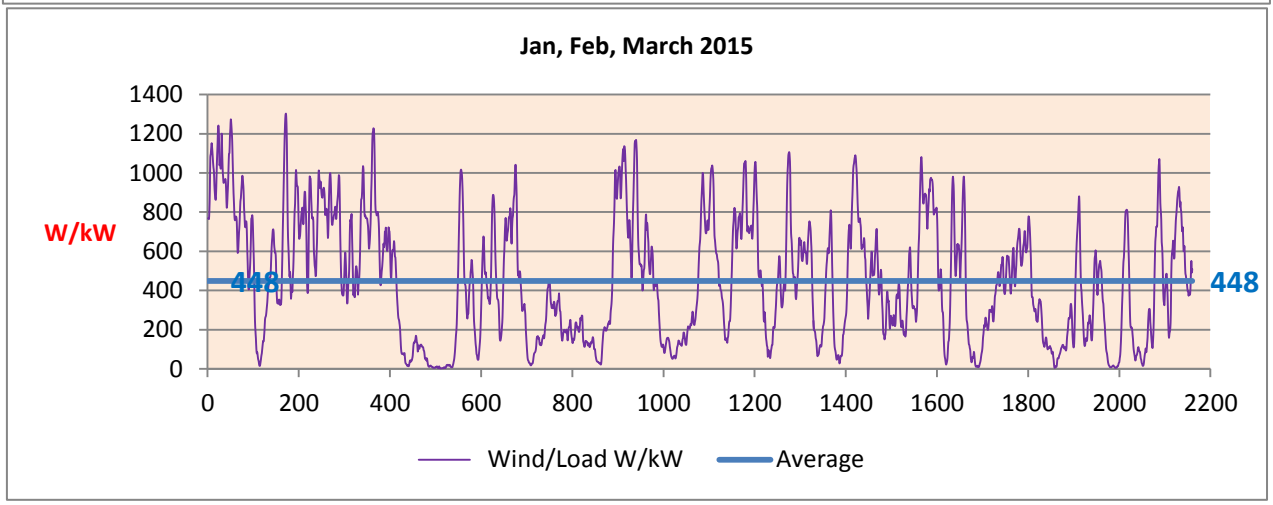




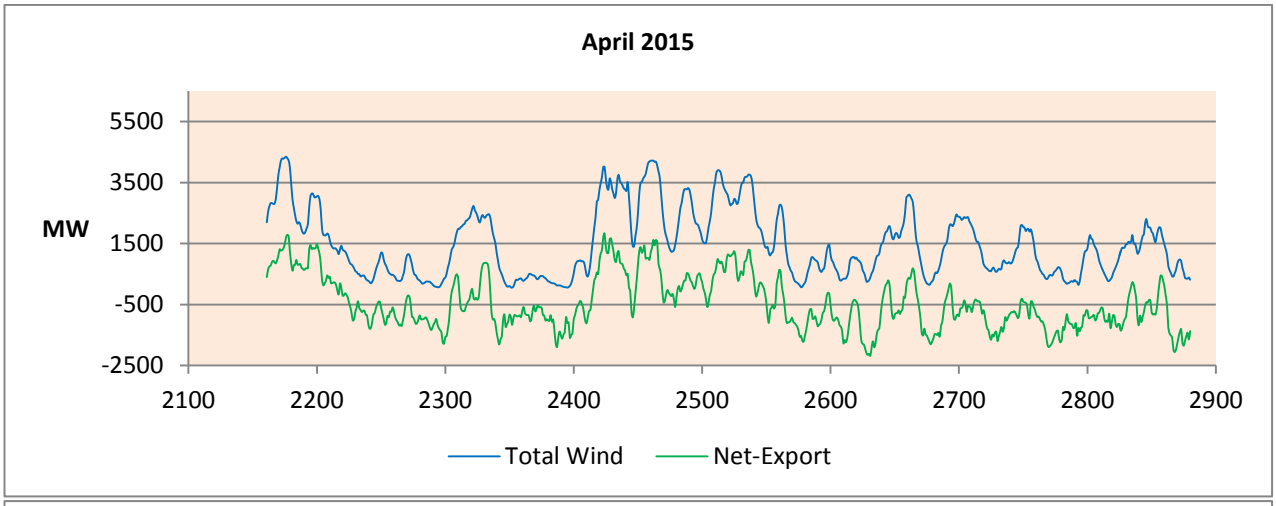
Jan, Feb, March 2015	Solar MW	Wind On-shore MW	Wind Off-shore MW	Wind Sum MW	Thermal Prod. MW	Load MW	Wind/ Load W/kW	Net Export MW
Average	33	1192	615	1807	2341	4170	448	17
Max	399	3226	1225	4450	4769	5729	1303	2633
Min	0	2	1	8	958	2745	2	-2120
Stddev	69	901	374	1229	655	771	313	1034
GWh	70	2575	1328	3903	5058	9008		36

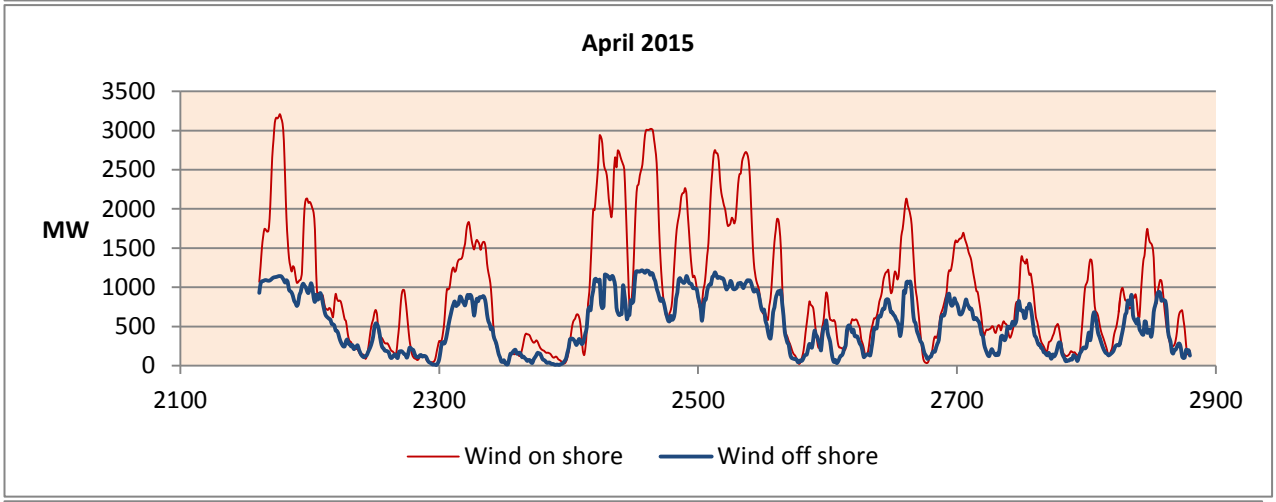


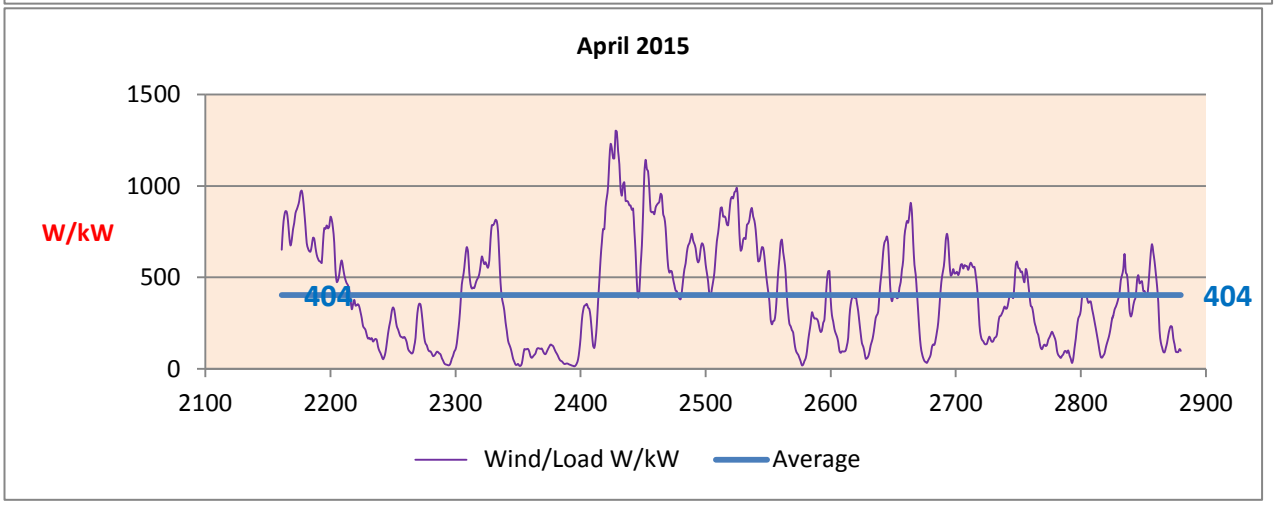




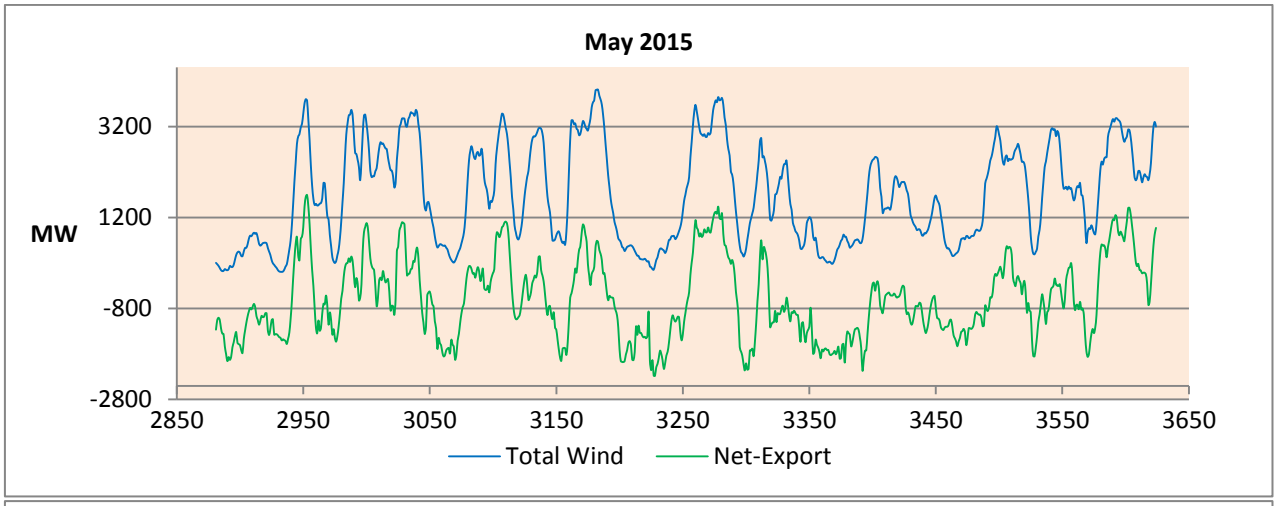
April 2015	Solar MW	Wind On-shore MW	Wind Off-shore MW	Wind Sum MW	Thermal Prod. MW	Load MW	Wind/ Load W/kW	Net Export MW
Average	117	959	527	1486	1599	3663	404	-461
Max	485	3209	1215	4351	3651	5007	1301	1830
Min	0	22	8	55	751	2516	14	-2180
Stddev	146	784	361	1112	476	649	285	877
GWh	85	700	385	1085	1168	2674		-337

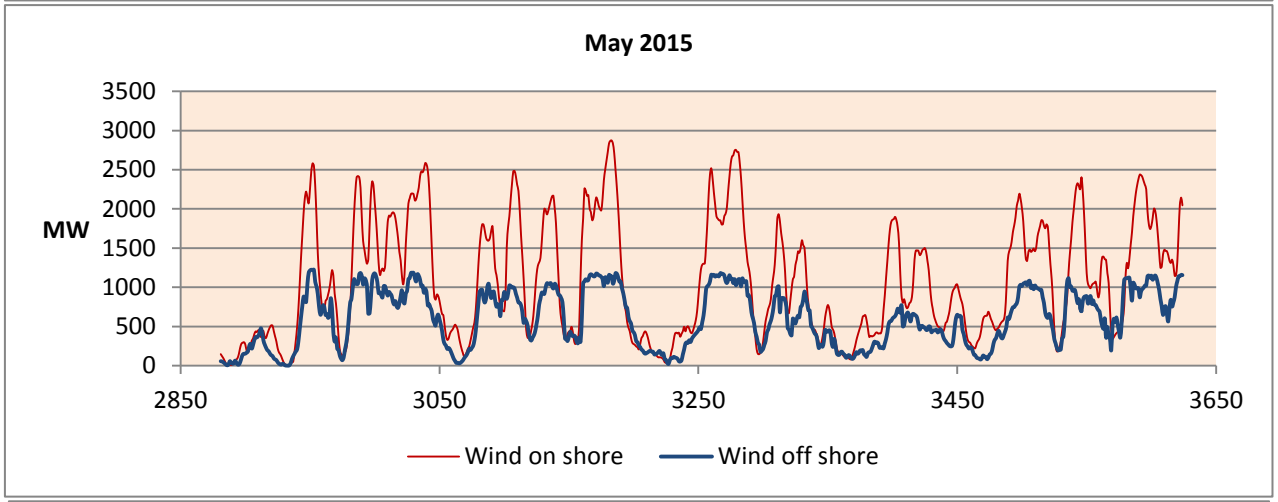


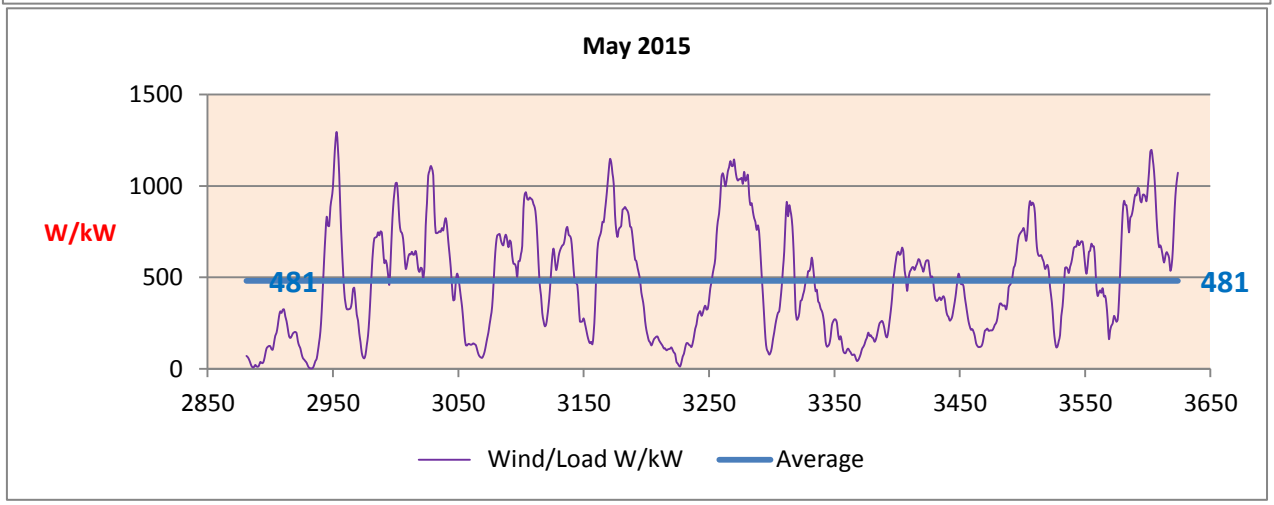




May 2015	Solar MW	Wind On-shore MW	Wind Off-shore MW	Wind Sum MW	Thermal Prod. MW	Load MW	Wind/ Load W/kW	Net Export MW
Average	112	1091	602	1693	1102	3519	481	-612
Max	481	2873	1224	4011	2568	4831	1295	1693
Min	0	6	0	6	534	2358	2	-2280
Stddev	130			1088	347	652	304	876
GWh	83	812	448	1260	820	2618		-455







June 2015	Solar MW	Wind On-shore MW	Wind Off-shore MW	Wind Sum MW	Thermal Prod. MW	Load MW	Wind/ Load W/kW	Net Export MW
Average	123	882	496	1379	1015	3974	366	-1458
Max	491	2917	1213	4037	2113	5844	1274	1732
Min	0	9	2	17	497	2417	3	-3187
Stddev	136	750	349	1068	369	761	298	1147
GWh	90	644	362	1006	741	2901		-1064