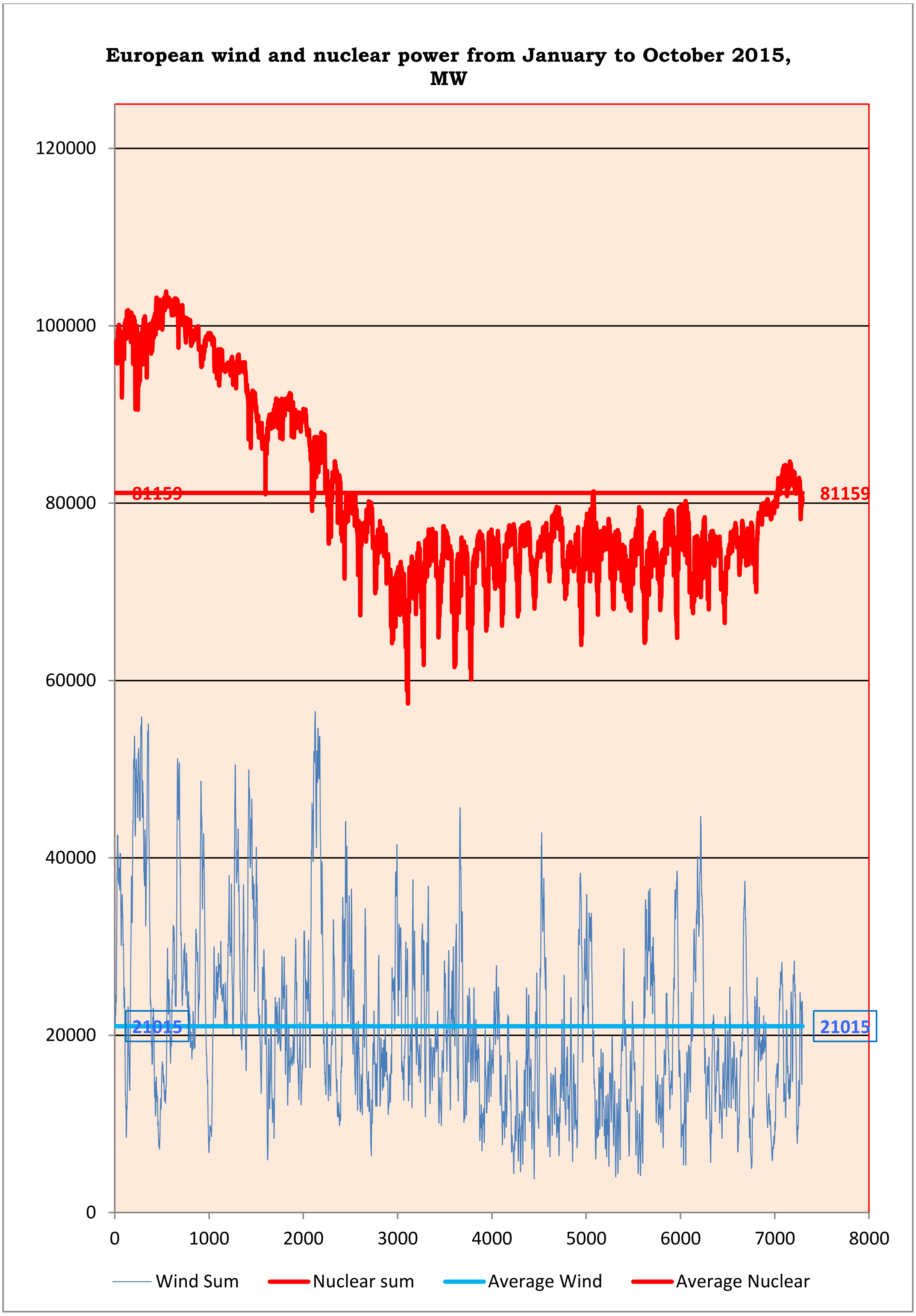
Danish and European Energy 2015



Contents

Sources:

Official statistics from Norway, Sweden, Germany and France.
Energistyrelsen, Denmark
Energinet.dk
Paul Frederik Bach, Denmark
Rolf Schuster, Aachen, Germany.

The author has neither received any instructions nor discussed the contents with anybody, so every possible mistake or false conclusion is the author's own responsibility.

Note to the front page:
The graph is made by data from Austria, Belgium, The Czech Rep, Denmark, Spain, France, Finland, Hungary, Poland, Sweden and Germany.
It should be remarked, that all the minima for nuclear power occur in week-ends, i.e. nuclear power is controllable,

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Introduction

The author is chemical engineer, M.Sc, from another time, i.e. 1960. I have worked with research, production and projects in detergents, fine organic chemicals for the pharmaceutical industry, oil and gas production in the North Sea and with production and developing new production methods for cellulose to the paper industry.

Late in my career I was asked to take over responsibility for the energy sector in a plant using 20.000 tons of oil and 15.000 MWh per year. In reality more a job for a tax specialist, rather than a job for a widely experienced chemical engineer. But some body had to do the job to fight against the absurdities following the World's first carbon dioxide law effective from January 1. 1992.

Thanks to Boolean Algebra I could get an overview of the taxation rules and earn my salary by stretching the law to the limit. Not a worthy occupation for Denmark's probably most all round experienced chemical engineer. Alas in vain. Eventually the production moved to Asia. And some politicians could rejoice by saying "We do something to reduce the carbon dioxide emission."

I had the luck to be engaged in a large Engineering and consulting company, Cowi, where I could continue my occupation of fighting the worse consequences of the Danish Energy policy. And in a British American Company, Perry Videx, dealing with used equipment for the chemical industry where I in 17 years among other assisted them in exporting abandoned chemical plants mainly to Asia.

In October 2015 I visited Munich together with two of my grandchildren. We visited **Deutsches Museum,** one of the largest technical museums in the world.

It was establishing an exhibition about the pharmaceutical industry. I.e. they showed an extraction apparatus for extraction of some "natural medicine" from plants. In the country who invented the organic chemical industry!!

It must be said, however, that there was a very fine energy exhibition demonstrating both wind power, PV, and amazingly an excellent exhibition about nuclear power.

Afterwards I wrote to the person responsible for that exhibition that I missed two things:

1. An indication of the problems arising from the variation of wind and sun power.
2. An A4 page showing the costs of producing nuclear power, preferably from a German nuclear plant.

To the first point came the answer that you can't show everything, and to the second came a reference to some article from Green Peace.

I sent a thought to George Orwell's "1984" and his description of the poor Winston Smith working with the "Ministry for Truth".

Soeren Kjaersgaard, April 2016

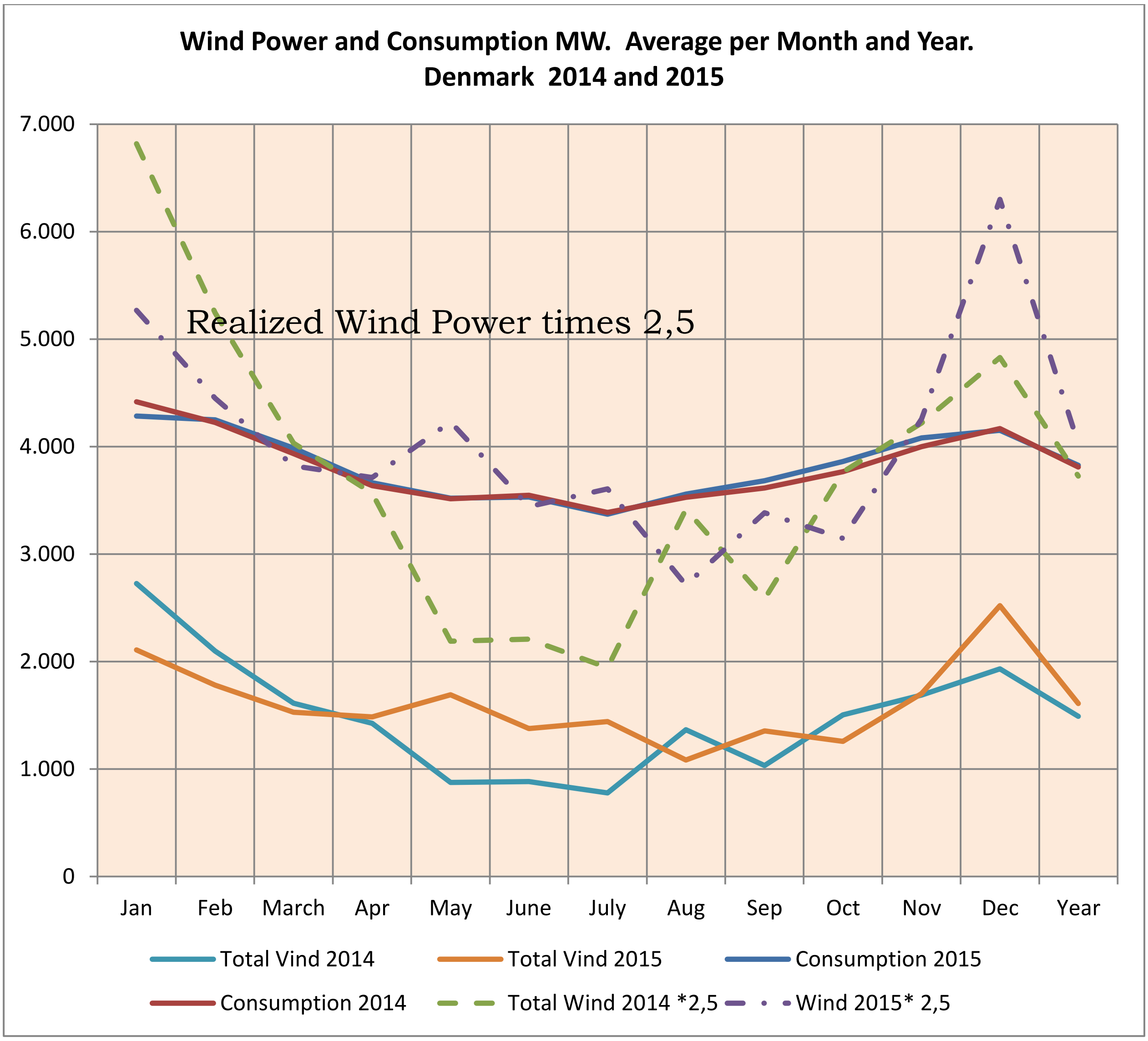
Conclusions

1. Denmark is a special case because our consumption of electricity on average is less than 4 GW. We are closely connected with our neighbours who in total consume on average about 85 GW. Therefor our high proportion of fluctuating wind power has been possible. So a large part of this report deals with German conditions.
2. *Page 6-11.* Denmark is deeply dependent of electricity exchange with our neighbours Norway, Sweden and Germany. The high proportion of wind power in our system is only possible because our neighbours consume about 80 GW and Denmark less than 4 GW.
3. *Page 12* Off shore wind power is just as unreliable as on shore wind. It is not always blowing off shore.
4. *Page 15.* **Imported bio mass** is the fastest growing energy supply. Already in 2007 it surpassed wind+sun. In 2014 the import corresponded to **1726** MW against the wind power, **1496** MW. Hardly sustainable in the long run.
5. *Page 15.* Denmark experiences a fast decline in domestic energy production, and in 2013 the consumption was higher than the production.
6. *Page 16.* Energy intensive industries are fleeing. Their energy consumption fell from 5249 MW in 2000 to 3837 MW in 2014.
7. *Page 17.* The Danish wind power production in 2015 was 42,7% of the load. A graph shows that this figure varies violently. Sometimes the wind power is higher than the load, and very often zero or close to zero. So back-up is a must.
8. *Page 18.* It is shown that there is a clear correlation between wind power and import and export. I.e. the Danish wind power has made us deeply dependent of our neighbours.
9. *Page 20.* When it blows the export to Norway and Sweden goes up and the export to Germany goes down. Illustrating some of the problems with "Die Energiewende"
10. *Page 21.* It is shown that the domestic use of produced wind power falls when the production surpasses abt. 2000 MW. And a formula is given for this. So it seems meaningless to build new wind parks.
11. *Page 22-24.* Data are given for wind power and nuclear power in Austria, Belgium, The Czech Rep, Denmark, Spain, France, Finland, Hungary, Poland, Sweden and Germany from January to October 2015 It is remarked that the nuclear power amounts to 81 GW against the wind power 21 GW, and that the standard deviation is 48% for wind and 13 % for nuclear.
12. *Page 24.* Considerations to the French wind power.
13. *Page 25-*27. British and Danish wind power are compared, and it is shown, that there is a high degree of simultaneousness. It is simply not true that it blows in UK when there is wind still in Denmark and vice versa. The reliability of British nuclear power contrary to the wind power is shown.

14. *Page 28-30*. The wind power in the named countries is compared, and it is shown that an European super grid will not help much to even the wind power since the weather does not change much from country to country.
15. *Page 31-33*. The size of a battery to secure an even output from Danish Wind and PV production is calculated. And it is shown that the idea of large scale electrochemical storage is pure nonsense.
16. *Page 34-35*. The German Energiewende and hydropower + pumped storage are analyzed. The problems are enormous.
17. *Page 36*-38. Detailed data for the German production of Photo Voltaics and Wind Power in 2015 are given.
18. *Page 39*-40. Calculations of the demands to a storage system to fulfill the "Energiewende."
19. *Page 41-45*. A power point presentation from the Fraunhofer Institute advocating an 8 fold increase in German wind power and PV is analyzed.
20. *Page 46*. Data from Swedish nuclear power plant Forsmark are presented + a calculation of the cost of electricity from a new nuclear power plant.

Danish Wind Statistics.

Data per month
The graph shows monthly averages for power consumption and wind power in 2014 and 2015. And since the Danish wind power on average is very close to 40% of the consumption two of the curves show the wind power if the generating capacity was increased by a factor 2,5.



It is easily seen that the estimated expansion of the wind power would present a gigantic transfer or storage problem. Norway and Sweden might be able and willing to store our wind power by storing the water behind the dams and substitute their hydropower with Danish wind power. But they are in the happy situation that they can demand the price they want for this service since they can do very well without Danish wind power.
Wind export to the continent is no option either, because when it blows in Denmark it blows in Germany too and their transmission lines are completely congested.

The key data for Danish electricity production, consumption and im- and export are shown in table hereunder.

Danish electricity supply and consumption 2015. MW								
	Sun	Wind	Thermal	Load	Export	Import	Import net	Wind/ Load
	MW							W/kW
Average	69	1612	1470	3826	218	893	675	427
Max	496	4450	4769	5729	2631	2974	-2631	1431
Min	0	1	254	2272	0	0	2974	0
Stddev	112	1171	815	776	464	798	1114	308
Observations	8760	8760	8760	8760	8760	8760	8760	8760
Gwh	604	14119	12878	33513	1908	7819	5912	
PJ	2,2	50,8	46,4	120,6	6,9	28,1	21,3	

It is seen:

1. The sun power is until now of no great importance.
2. The Wind Power varies between 1 and 4450 MW.
3. The output from thermal power stations varies between 254 and 4769 MW
4. On average we imported 675 MW corresponding to 18% of the consumption.
5. The maximum export was 2631 MW i.e. 69% of our average consumption.
6. The maximum import was 2974 MW i.e. 77% of our average consumption.
7. The wind power delivered on average 427 W/kW consumption or 42,7%, but this figure varies between 0 and 1431 W/kW.

So the Danish electricity system is deeply dependent on benevolent – and much bigger neighbours. And that we have. Norway and Sweden consumes roughly 30 GW and Germany abt. 55 GW, more than 20 times the Danish consumption. This fact has made the high Danish wind power production possible.

The key data for the Danish Wind Power in 2014 and 2015 are shown hereunder.

Wind turbines numbers and capacities				Performance		
	End of year	2014	2015	Average	2014	2015
Offshore	Installed capacity MW	1271	1271	MW	592	552
	Number of Wind turbines	519	516	kW/installed MW	466	434
Onshore	Installed capacity MW	3634	3799	MW	899	1.060
	Number of Wind turbines	4753	5260	kW/installed MW	252	285
Denmark total	Installed capacity MW	4906	5070	MW	1.491	1.611
	Number of Wind turbines	5272	5776	kW/installed MW	308	325

The number of onshore Wind-turbines contains a number of very small and irrelevant turbines. So the number of on shore wind turbines is not an exact figure. The figure for installed capacity too is not an exact figure but close to be correct, albeit it changes from month to month. But an increase of installed generating capacity of about 170 MW is a good estimate. Very often the public protests vigorously against building of new on shore turbines.

No new off shore turbines were installed in 2015.

Aalborg University has a large department working with green energy. So in May 2014 the internationally renown professor in noise measuring and control Henrik Møller was fired. “He does not bring value to the university” it was declared. You might in justice ask: ”Who brings value to the university?” The answer is easily formulated: “The tax payers and institutes working for the wind industry”

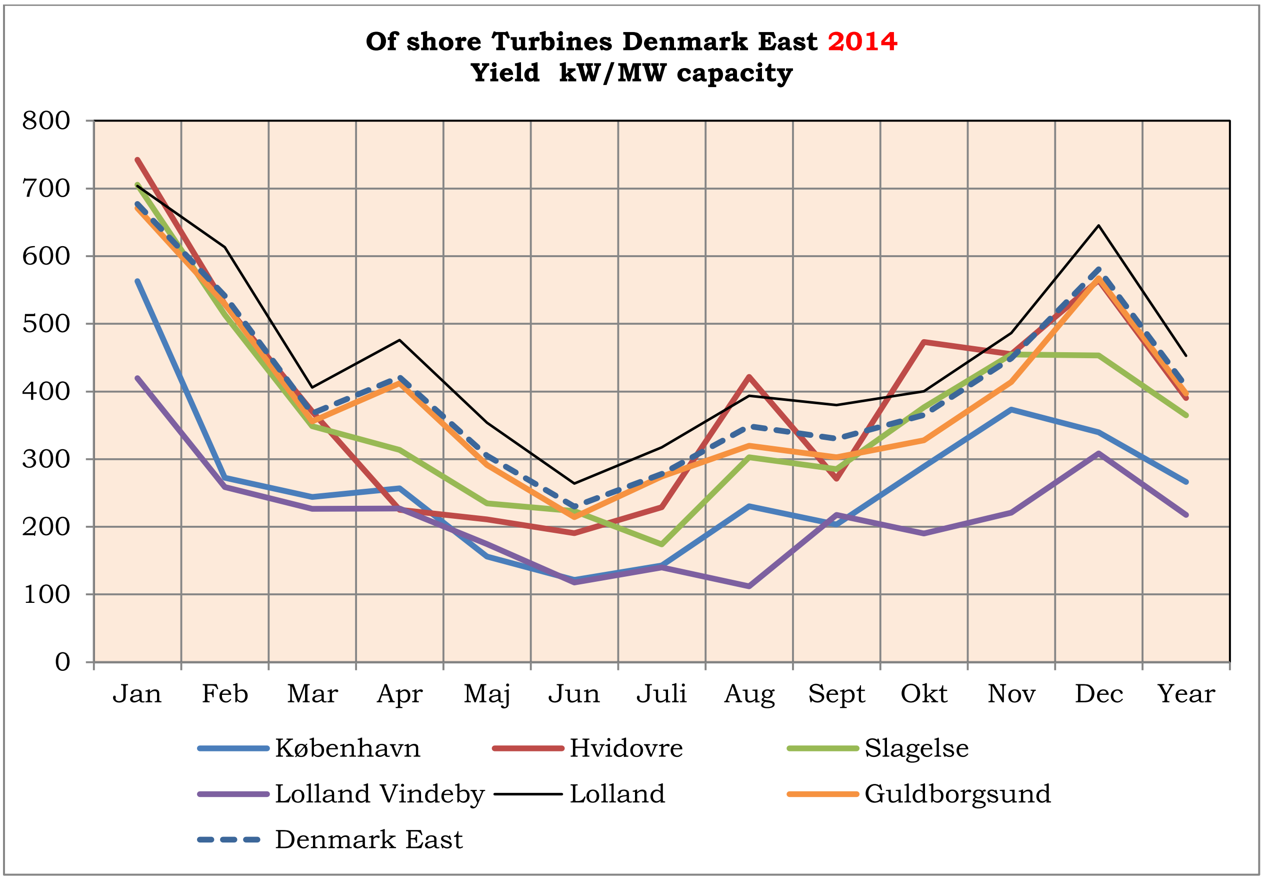
There has been a slight increase in generating capacity of about 160 MW in 2015. The output has increased in total 120 MW.

2015 was a very windy year, but the offshore turbines have yielded only **434** kW/installed MW in 2015 against **466** kW/installed MW in 2014. There were serious problems with the Windparks Norddjurs and Hornsrev 2.

The onshore turbines yielded 252 kW/Installed MW in 2014 and 285 kW/installed MW in 2015.

Offshore Wind turbines.

		Turbines		**Output kw/Installed MW 2015**						
		MW	**Number**	Jan	Feb	Mar	April	May	June	
Copenhagen	27-12-2000	2	**20**	370	256	277	237	251	197	
Hvidovre	23-11-2009	3,6	**3**	562	455	415	385	441	317	
Slagelse	28-10-2009	3	**7**	516	439	376	491	525	390	
Lolland Vindeby	01-09-1991	0,45	**11**	289	242	251	169	170	133	
Lolland	21-04-2010	2,3	**90**	616	488	517	399	416	339	
Guldborgsund	17-06-2003	2,3	**72**	566	433	392	303	349	242	
Hornsrev 1	10-12-2002	2	**80**	555	543	499	396	471	369	
Hornsrev 2	14-05-2009	2,3	**91**	611	544	517	463	553	467	
Lemvig	09-01-2003	2,15	**8**	472	478	439	390	504	424	
Norddjurs	16-11-2012	3,6	**111**	654	428	171	483	551	480	
Odder	30-05-1995	0,5	**5**	476	397	355	140	176	121	
Samsø	08-02-2003	2,3	**23**	440	453	466	378	440	356	
Frederikshavn	28-05-2003	2,53	**8**	435	441	288	299	379	328	
Denmark East	**MW installed**	**449**	**206**	566	458	452	343	371	284	
Denmark West		**822**	**313**	611	505	321	454	530	448	
				July	Aug	Sep	Oct	Nov	Dec	**Year**
Copenhagen	27-12-2000	2	**20**	229	204	246	267	343	425	**276**
Hvidovre	23-11-2009	3,6	**3**	380	330	412	313	520	635	**430**
Slagelse	28-10-2009	3	**7**	383	374	436	385	666	718	**530**
Lolland Vindeby	01-09-1991	0,45	**11**	105	84	106	79	104	130	**155**
Lolland	21-04-2010	2,3	**90**	410	319	399	336	587	754	**469**
Guldborgsund	17-06-2003	2,3	**72**	363	291	343	293	552	689	**403**
Hornsrev 1	10-12-2002	2	**80**	326	278	368	355	534	562	**438**
Hornsrev 2	14-05-2009	2,3	**91**	441	334	486	275	0	169	**411**
Lemvig	09-01-2003	2,15	**8**	387	292	371	347	439	558	**415**
Norddjurs	16-11-2012	3,6	**111**	474	413	524	506	180	748	**466**
Odder	30-05-1995	0,5	**5**	135	107	139	308	376	482	**336**
Samsø	08-02-2003	2,3	**23**	387	289	368	436	469	600	**424**
Frederikshavn	28-05-2003	2,53	**8**	214	245	381	364	238	464	**336**
Denmark East	**MW installed**	**449**	**206**	366	293	357	307	539	678	**418**
Denmark West		**822**	**313**	430	359	474	411	219	553	**443**


Of shore Turbines Denmark East 2014
Yield kW/MW capacity
800
700
600
500
400
300
200
100
0
Jan
Feb
Mar
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Jun
Juli
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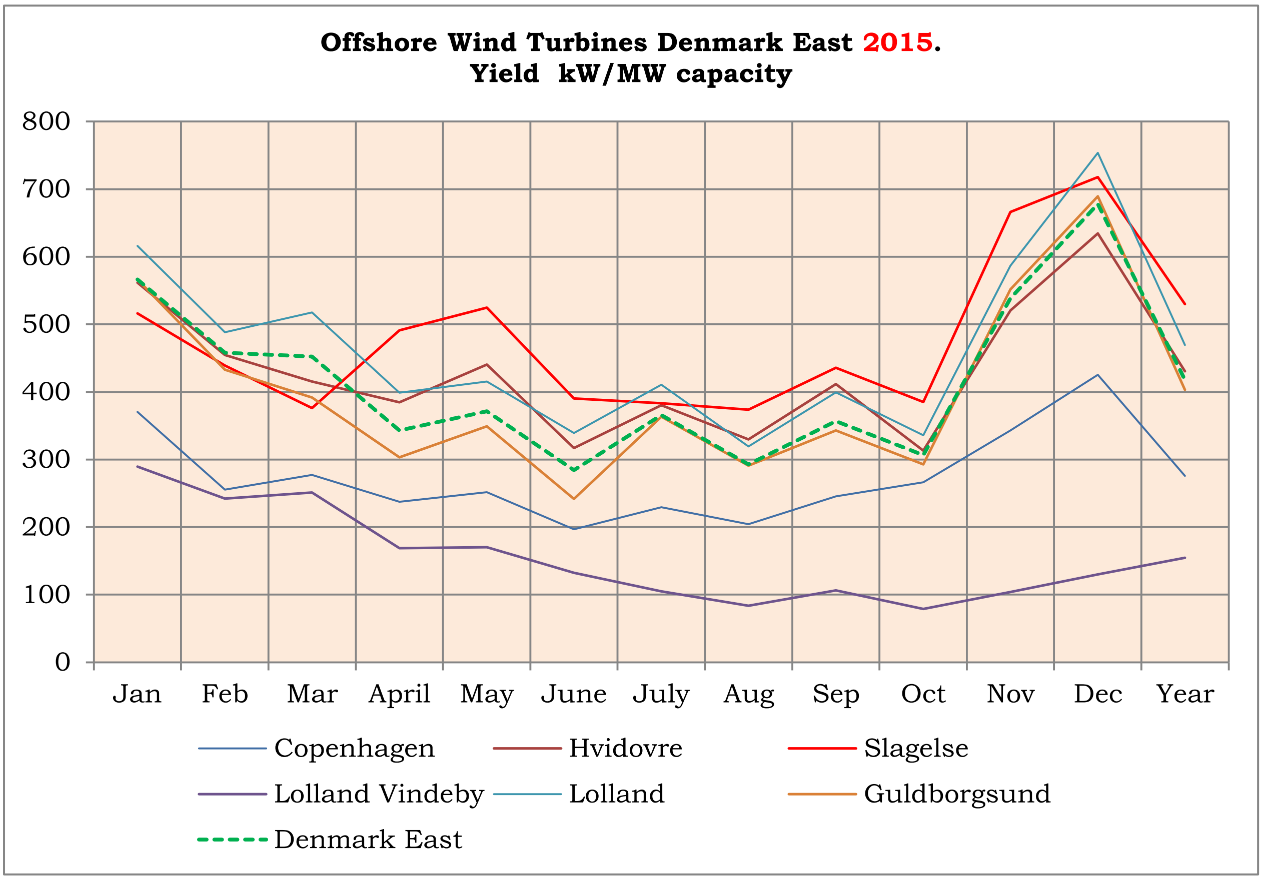
Year
København
Hvidovre
Slagelse
Lolland Vindeby
Lolland
Guldborgsund
Denmark East


Offshore Wind Turbines Denmark East 2015.
Yield kW/MW capacity
800
700
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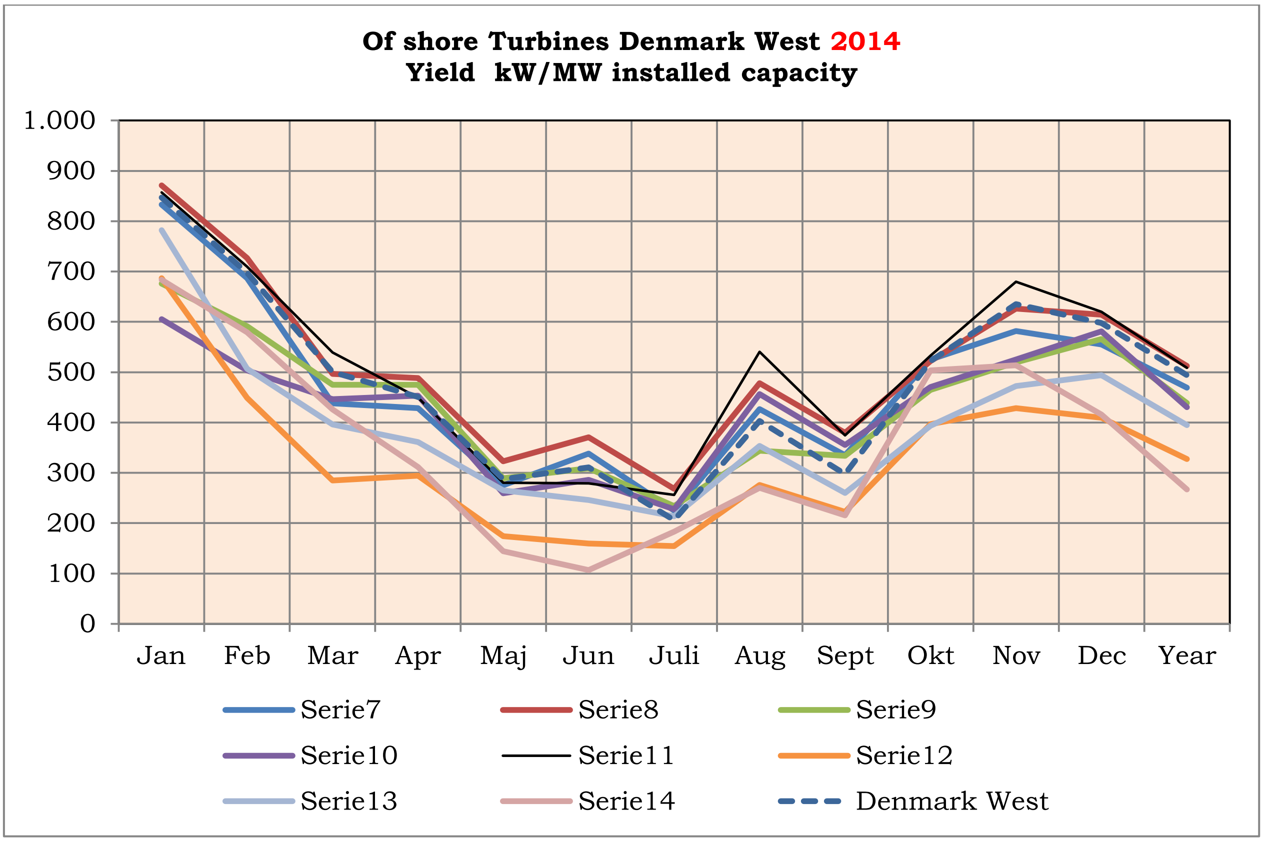
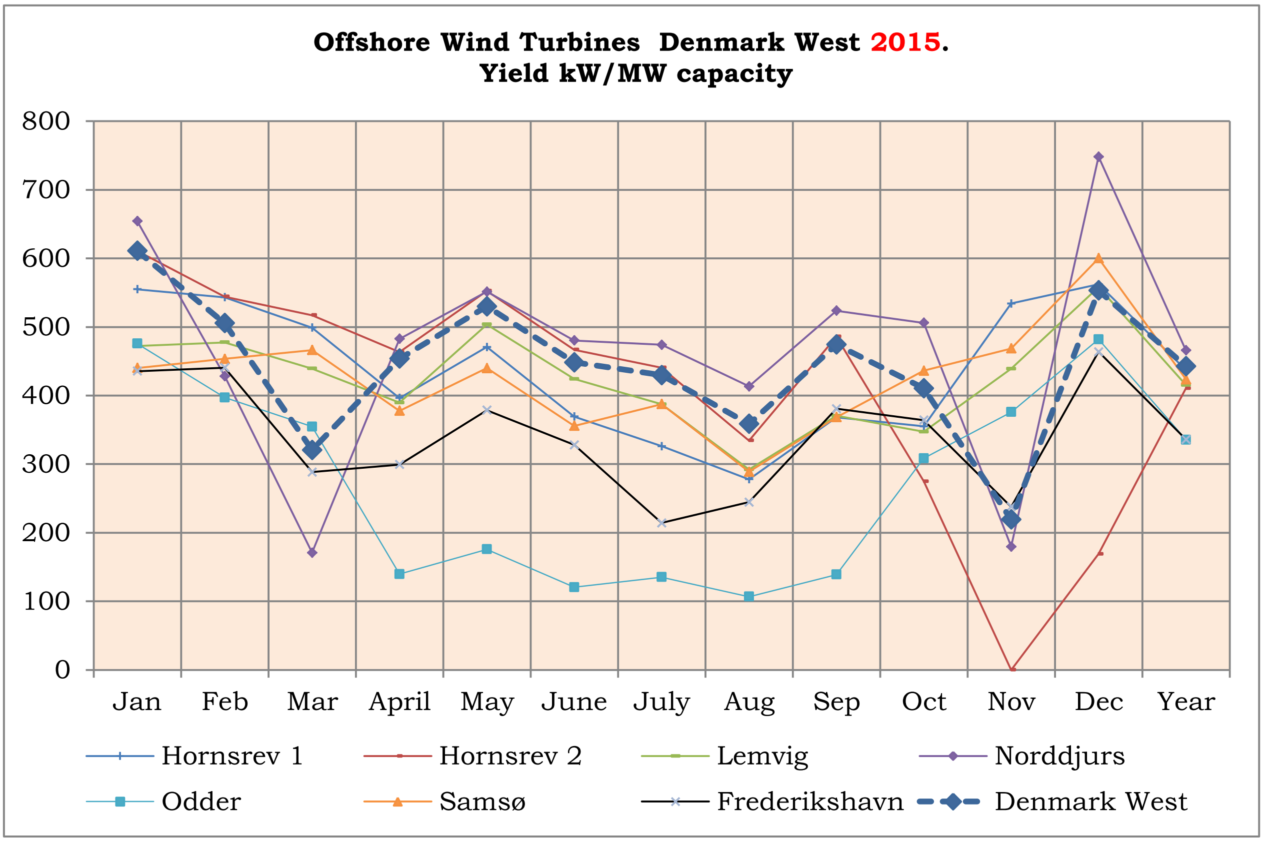
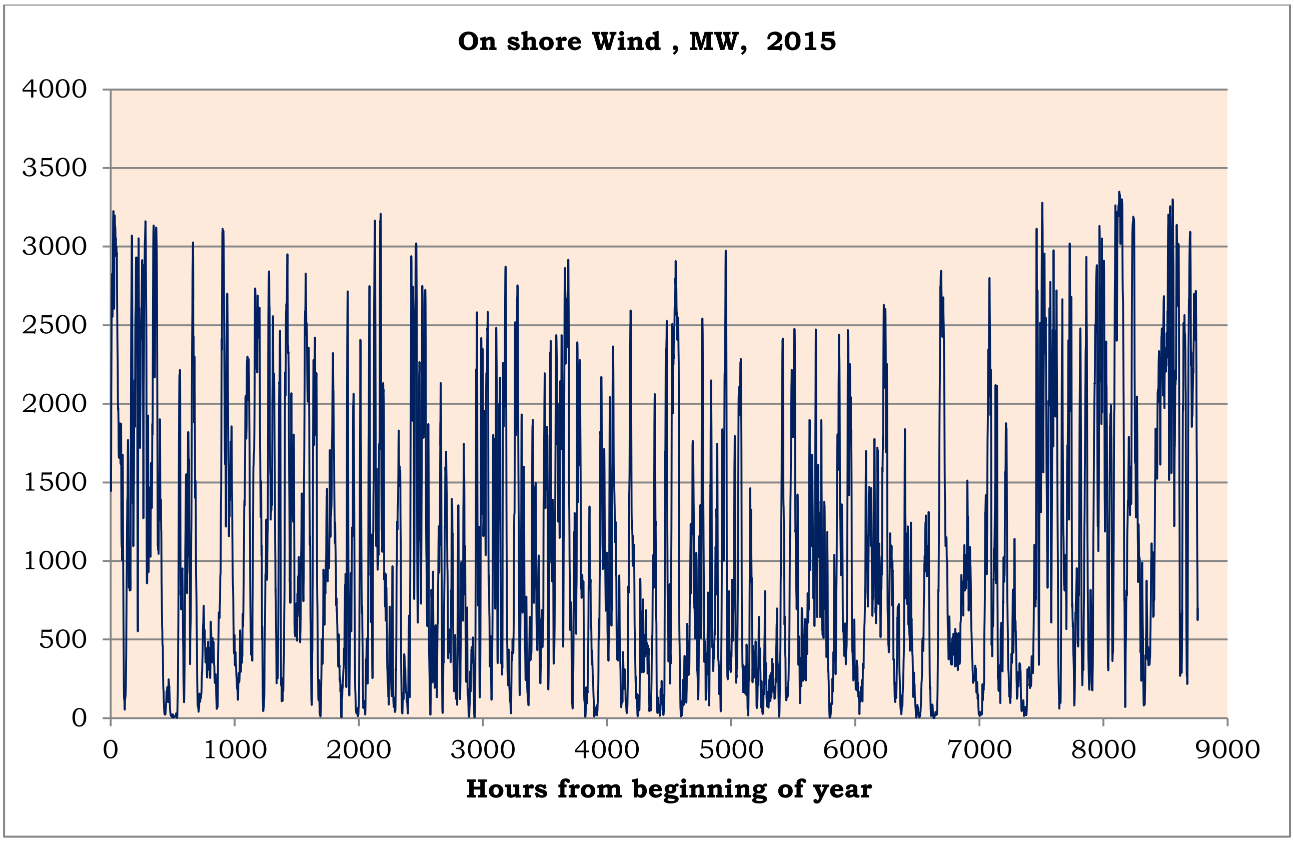
Denmark East

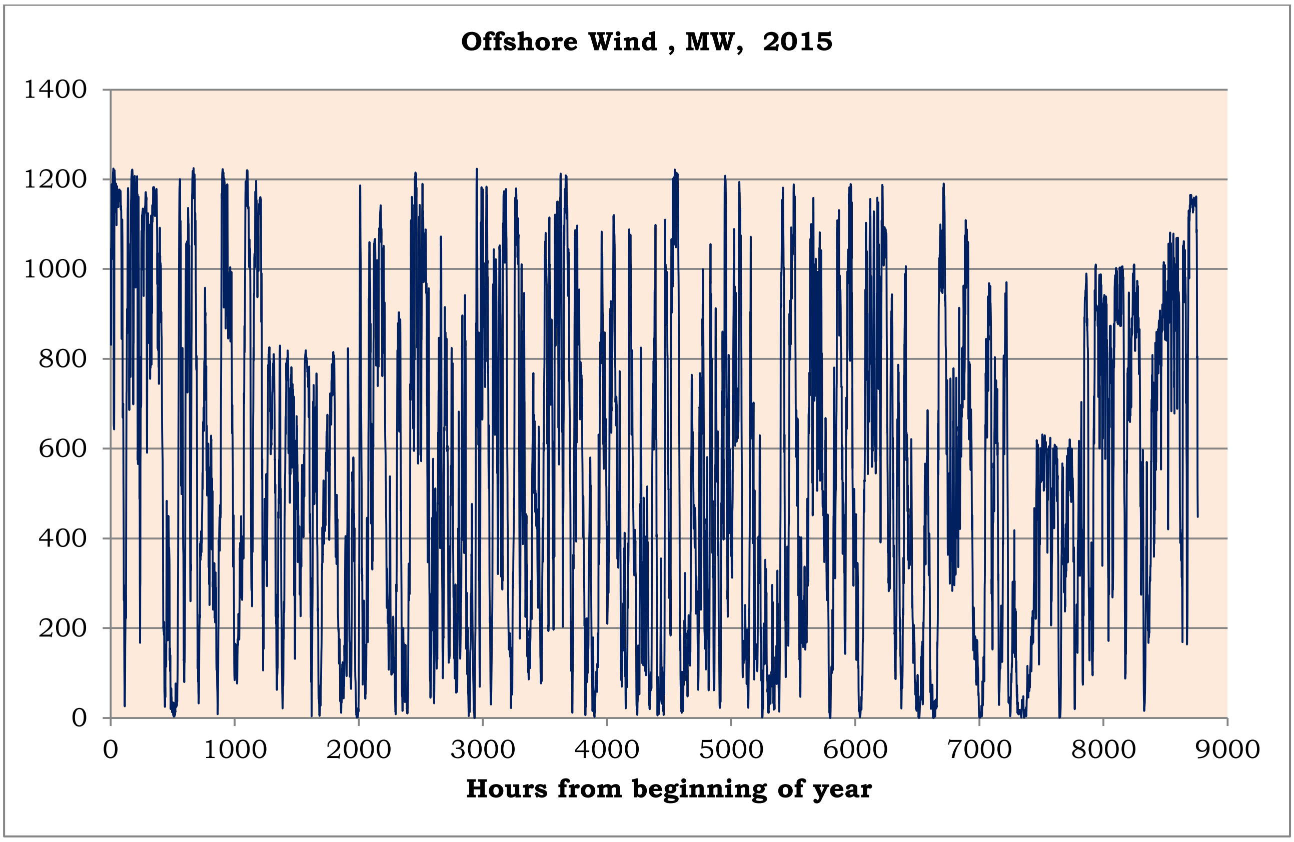


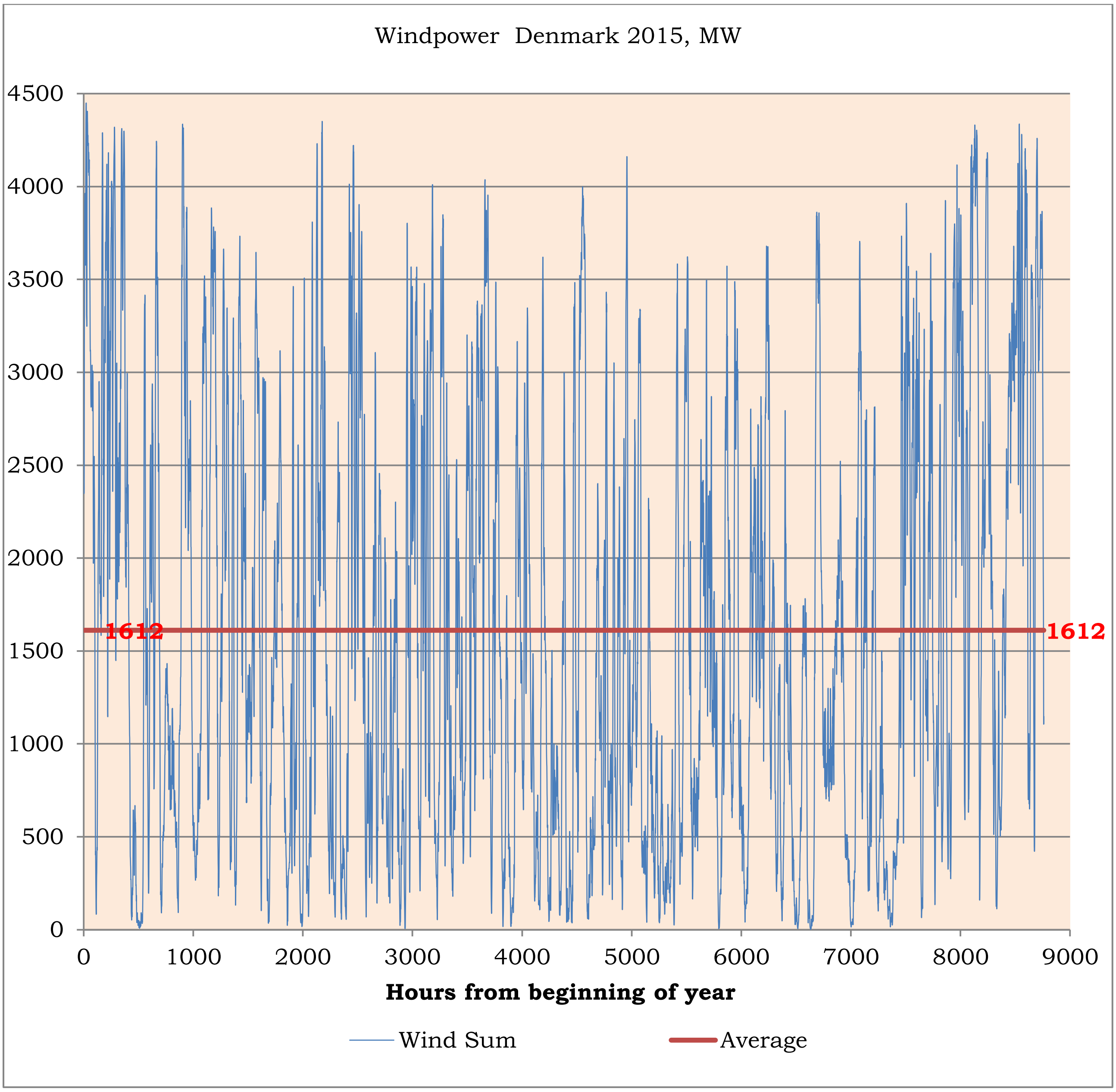


It is easily seen that even off shore wind turbines don't deliver a stable electricity supply.

This becomes even more evident, if you instead of demonstrating averages per month show variations from hour to hour.







Danish Wind, MW, 2015			
	Onshore	Offshore	Sum
Average	1060	552	1612
Max	3349	1225	4450
Min	0	0	1
Stddev	857	361	1171
Hours	8760	8760	8760
GWh	9286	4833	14119

If you don't consider capital and maintenance costs it is of course very cheap to produce wind power. But both the above graph and the table illustrates clearly that you always need a fully operational stand by system.

This costs something. Nobody seems to know how much. Since Gro Harlem Brundtland with her report in 1987 stated that the energy supply is too important to be entrusted to private business the political system has made a Soviet system out of the energy supply characterized by waste, inefficiency, corruption and impenetrable accounting.

Danish Energy statistics. Energy production.

Danish Energy production **TJ**	***1 975***	***1 985***	***1 995***	***2 000***	***2 005***
Oil and natural gas	7 430	169 851	589 451	1 075 434	1 189 396
Solar	-	58	213	335	419
Wind, Hydro, Geothermal	76	292	4 394	15 435	24 063
Wood and straw	6 227	24 900	34 662	37 275	51 996
Biogas	154	294	1 758	2 912	3 830
Garbage	9 240	13 834	22 906	30 392	37 792
Biooil and heat pumps	10	2 049	2 946	3 344	4 491
Sum Biofuel and garbage	15 631	41 077	62 273	73 923	98 109
Sum non fossil	15 707	41 426	66 879	89 693	122 591
Sum	**23 137**	**211 277**	**656 330**	**1 165 127**	**1 311 987**
Imported biomass	**-**	**-**	**233**	**2 466**	**18 918**
Consumption	**708 619**	**790 972**	**806 061**	**774 686**	**785 685**

Danish Energy production **TJ**	***2 010***	***2 011***	***2 012***	***2 013***	***2 014***
Oil and natural gas	830 196	717 080	645 180	552 681	523 295
Solar	657	789	1 254	2 890	3 371
Wind, Hydro, Geothermal	28 401	35 413	37 322	40 321	47 303
Wood and straw	69 361	62 324	59 131	59 091	53 890
Biogas	4 337	4 107	4 399	4 604	5 143
Garbage	38 107	38 427	37 344	37 466	38 720
Biooil and heat pumps	7 592	6 857	7 421	7 733	7 970
Sum Biofuel and garbage	119 396	111 715	108 296	108 895	105 723
Sum non fossil	148 454	147 918	146 872	152 106	156 396
Sum	**978 650**	**864 998**	**792 051**	**704 786**	**679 691**
Imported biomass	**39 483**	**45 503**	**51 825**	**52 800**	**54 577**
Consumption	**802 513**	**747 417**	**713 368**	**721 320**	**683 024**

2011 was the last year where the Danish Energy production was larger than the consumption.

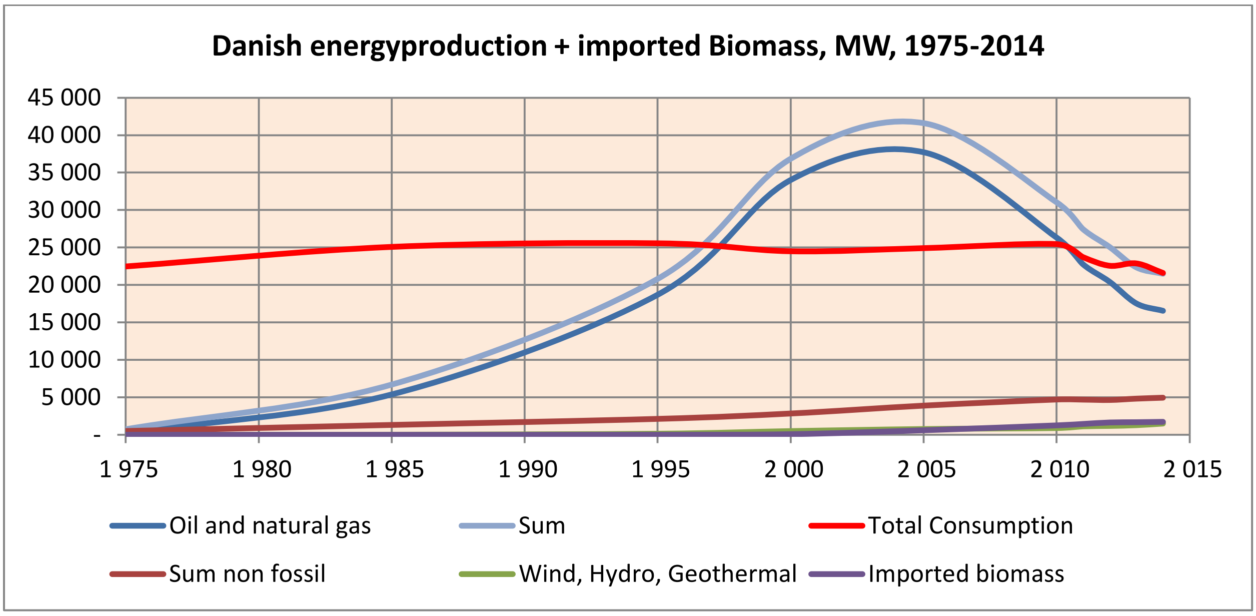
The tables hereunder show the consumption in Joule/second i.e. **watt.** This unit is chosen because all kinds of power plants use this unit.

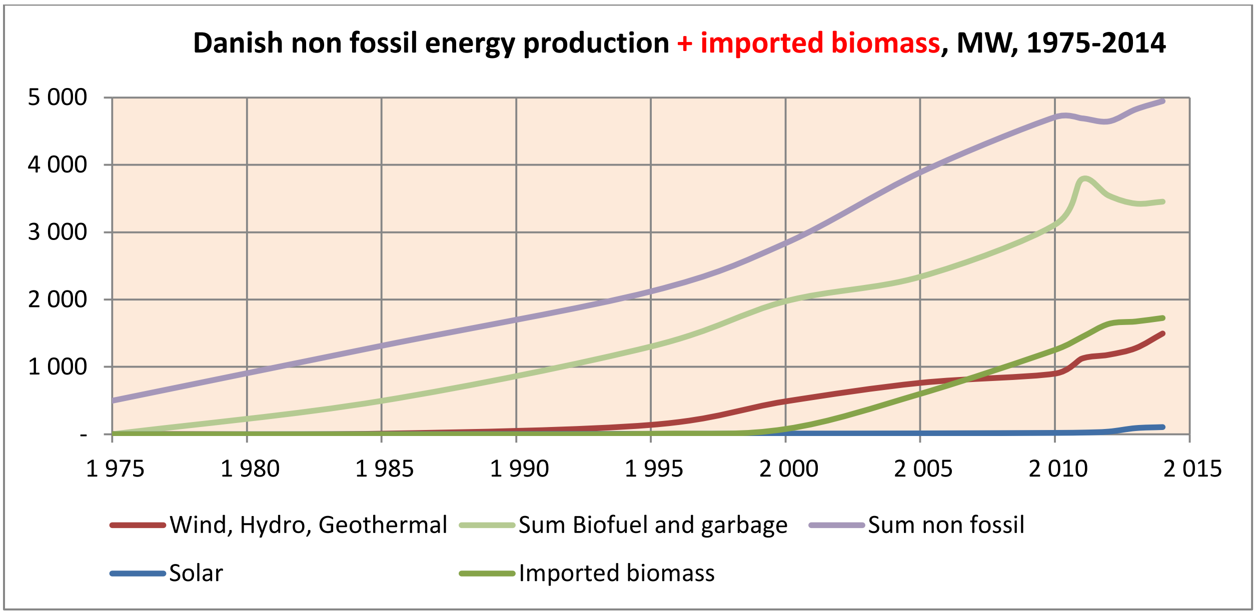
Danish Energy production **MW**	***1 975***	***1 985***	***1 995***	***2 000***	***2 005***
Oil and natural gas	236	5 386	18 691	34 009	37 715
Solar	-	2	7	11	13
Wind, Hydro, Geothermal	2	9	139	488	763
Wood and straw	197	790	1 099	1 179	1 649
Biogas	5	9	56	92	121
Garbage	293	439	726	961	1 198
Biooil and heat pumps	0	65	93	106	142
Sum Biofuel and garbage	496	1 303	1 975	2 338	3 111
Sum non fossil	498	1 314	2 121	2 836	3 887
Sum	**734**	**6 700**	**20 812**	**36 845**	**41 603**
Imported biomass	**-**	**-**	**7**	**78**	**600**
Total Consumption	22 470	25 082	25 560	24 498	24 914

Danish Energy production **MW**	***2 010***	***2 011***	***2 012***	***2 013***	***2 014***
Oil and natural gas	26 325	22 738	20 403	17 525	16 548
Solar	21	25	40	92	107
Wind, Hydro, Geothermal	901	1 123	1 180	1 279	1 496
Wood and straw	2 199	1 976	1 870	1 874	1 704
Biogas	138	130	139	146	163
Garbage	1 208	1 219	1 181	1 188	1 224
Biooil and heat pumps	241	217	235	245	252
Sum Biofuel and garbage	3 786	3 542	3 425	3 453	3 343
Sum non fossil	4 707	4 690	4 645	4 823	4 946
Sum	**31 033**	**27 429**	**25 047**	**22 349**	**21 494**
Imported biomass	**1 252**	**1 443**	**1 639**	**1 674**	**1 726**
Total Consumption	25 448	23 700	22 559	22 873	21 599

Non fossil + imported biomass amounts to 5069 MW in 2014, and the wind power amounts to 1496 MW in 2014 i.e. 30% of the “sustainable energy.”

Sustainable Energy in Denmark





November the 6th in 2008 at 11.52 o'clock the Danish prime minister Anders Fogh Rasmussen promised a "Fossil Free Denmark in 2050." It seems that he should in stead have promised eternal occupation for a huge number of mediocre professors and their staffs. And smart business men.

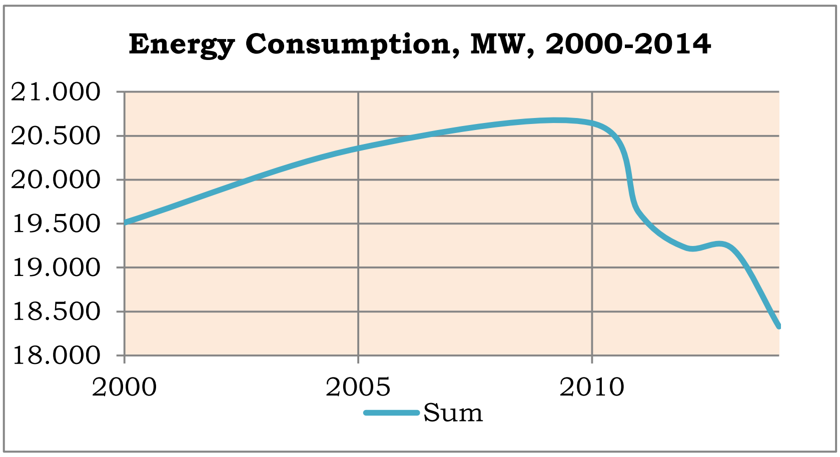
It should be remarked too, that ***the fastest growing non fossil energy supply is imported biomass. It has even surpassed wind+solar+hydro+geothermal, 1503 MW in 2014.***
Imported biomass 1736 MW in 2014.

For instance the small community in which the author is living is partly kept warm by burning household waste imported from London. We even get paid to burn it. Smart of course until the British begin to build incineration ovens and district heating systems. It is a question, however, if this is a "sustainable" and long lasting solution.

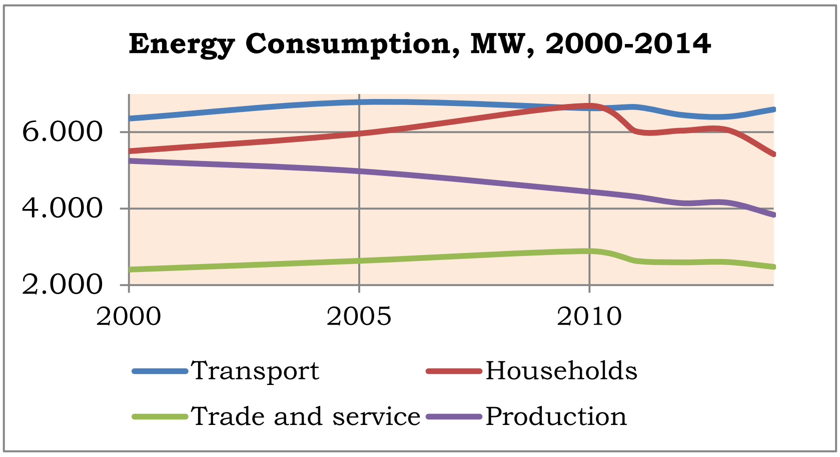
Danish energy consumption 2000-2014.

Energycon-sumption, PJ	**2000 -2014**							**Diffe-rence**
Year	***2000***	***2005***	***2010***	***2011***	***2012***	***2013***	***2014***	***2000-2014***
Transport	201	214	209	210	204	202	208	7
Households	174	188	211	190	191	191	171	-3
Trade and service	76	83	91	83	82	82	78	2
Production	166	157	140	136	131	131	121	-45
Sum	**617**	**642**	**651**	**619**	**608**	**606**	**578**	**-39**

Energycon-sumption, MW	**2000-2014**							**Diffe-rence**
Year	***2000***	***2005***	***2010***	***2011***	***2012***	***2013***	***2014***	***2000-2014***
Transport	6.356	6.786	6.627	6.659	6.451	6.405	6.596	239
Households	5.502	5.961	6.691	6.025	6.040	6.057	5.422	-80
Trade and service	2.403	2.632	2.886	2.632	2.593	2.600	2.473	70
Production	5.249	4.978	4.439	4.313	4.143	4.154	3.837	-1.413
Sum	**19.511**	**20.358**	**20.643**	**19.628**	**19.227**	**19.216**	**18.328**	**-1.183**



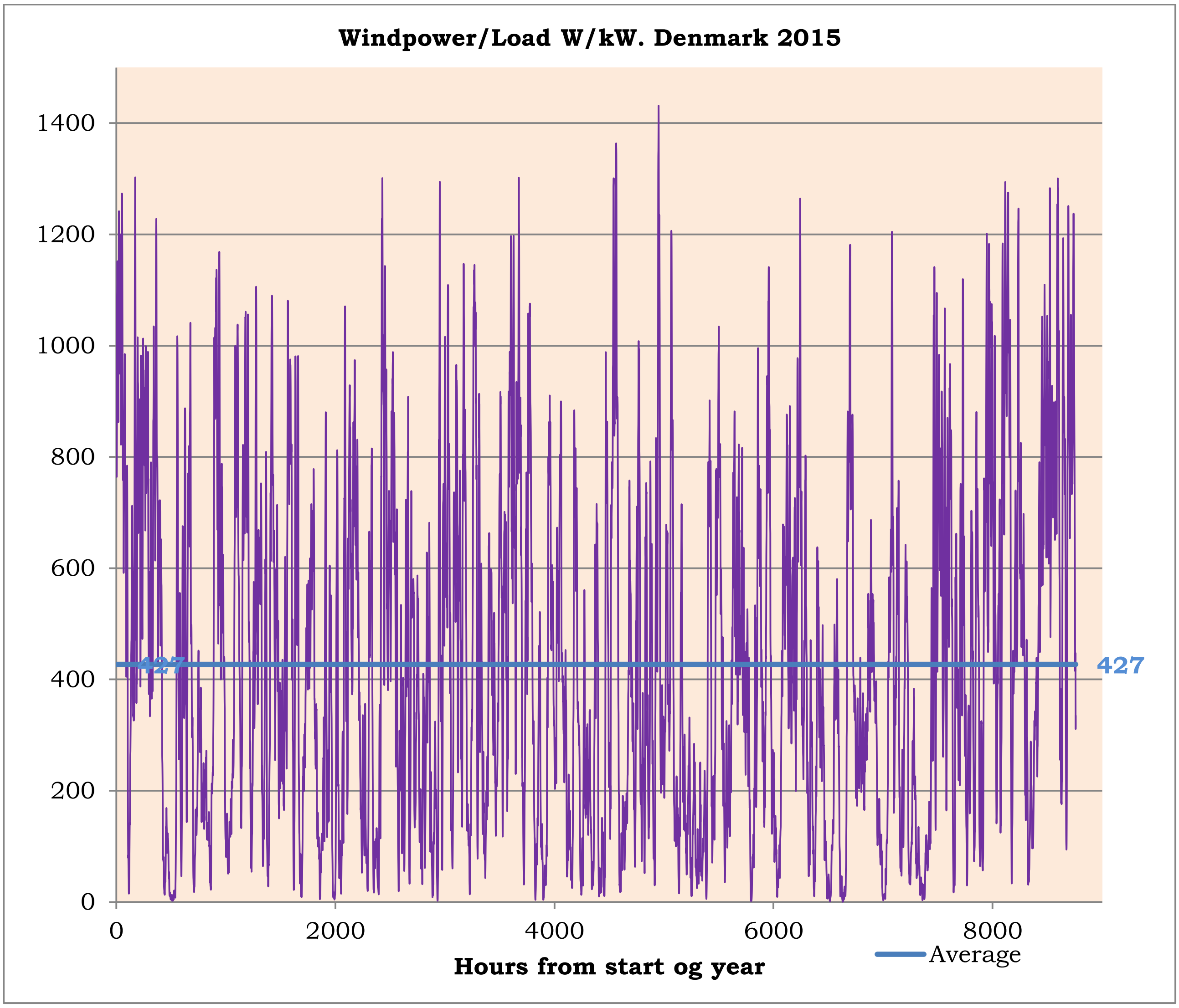
There has been some decrease in the energy consumption.
Mainly in households and industry.
The political system is very satisfied with the decline in the industrial consumption.
They have been succesful in their effort to expel heavy industry to China, India and so on, and feel they have done something good to the climate. And forget that the energy consumption per produced entity is much higher in China than in Europe.



Tom Lehrer sang many years ago: ”It feels nice to be good”.

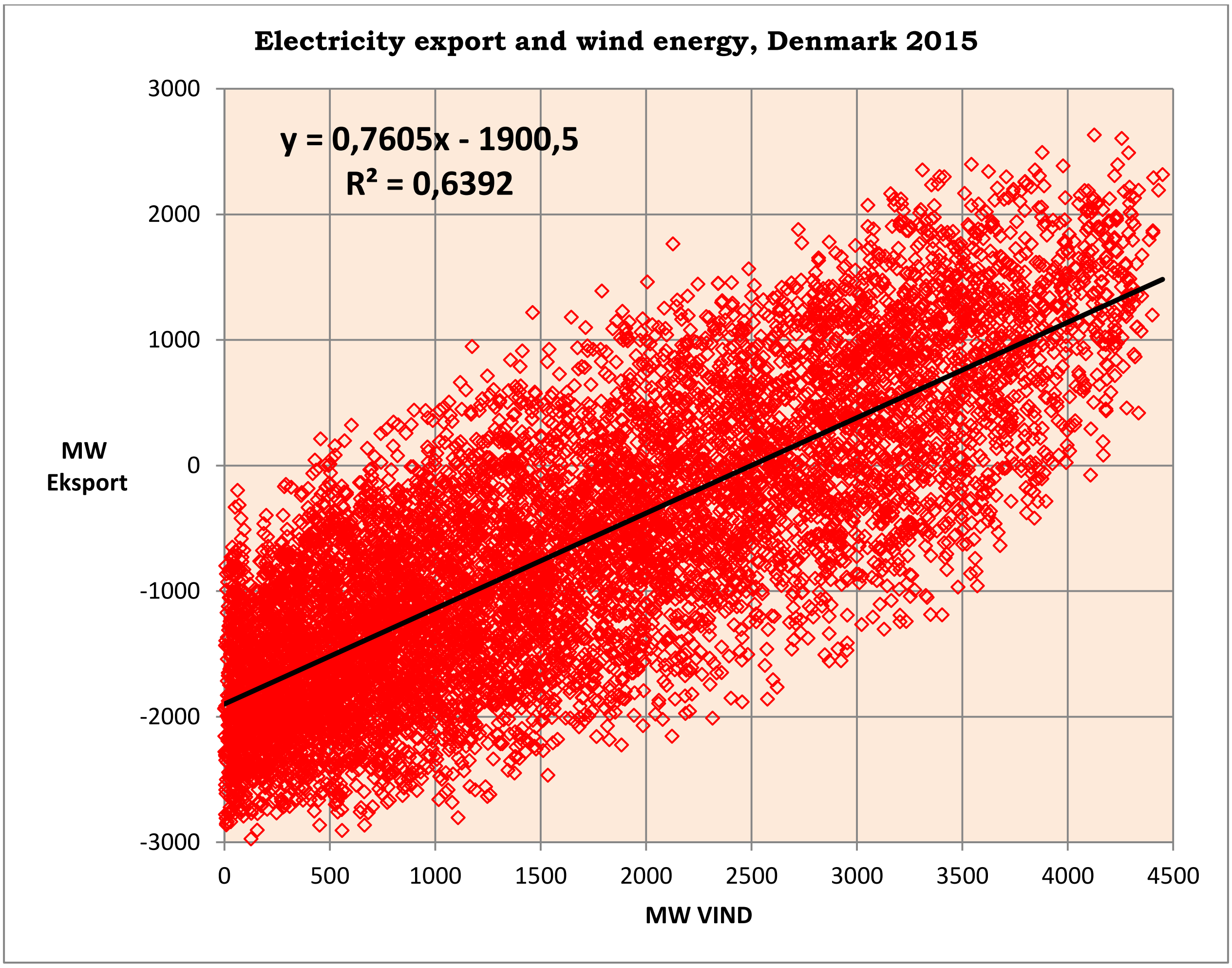
Wind energy and consumption

It is generally acknowledged that wind energy isn't necessarily available when needed.
The graph hereunder illustrates this fact.
The graph shows hour for hour in 2015 the wind effect relative to the electric load. The used unit is W/kW. The ideal would be that this figure would always be 1000 W/kW so that the wind power would at any time equal the load. As can be seen the reality deviates considerably from the ideal.
The maximum wind power/load was 1431 kW/MW, i.e. the wind power was 1,431 times the consumption. More often the wind power is close to zero.



Average	427
Max	1431
Min	0
Stddev	308

The average **427 W wind power/kW load** is probably the highest in the World, and probably possible only because Denmark is situated between neighbours with much higher loads than Denmark. Norway + Sweden about 30 GW and Germany about 55 GW against the Danish average load of about 4 GW. It is seen, that the proportion of wind power relative to the load varies between 1,431 times the load and 0. **So full back up is a must.**
The graph below illustrates the dependency of import and export of electricity when you choose to let the wind power correspond to more than 40 % of the electricity load **on average!**



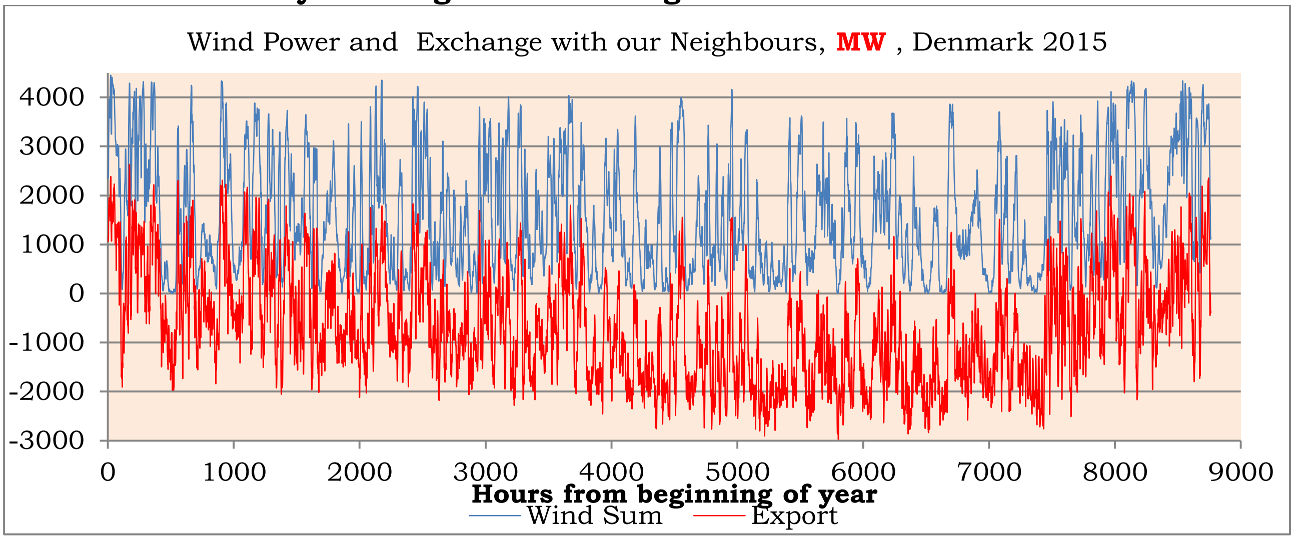
Denmark 2015					
	Load	Wind Sum	Net-Export	Export	Import
Average	3826	1612	-675	218	-893
Maks	5729	4450	2631	2631	0
Min	2272	1	-2974	0	-2974
Stdafv	776	1171	1114	464	798

The graph illustrates Denmark's deep dependency of international electricity trade. In principle there is nothing wrong with that. However the German market is mainly closed when it blows because Germany gets her own wind power too when it blows in Denmark.

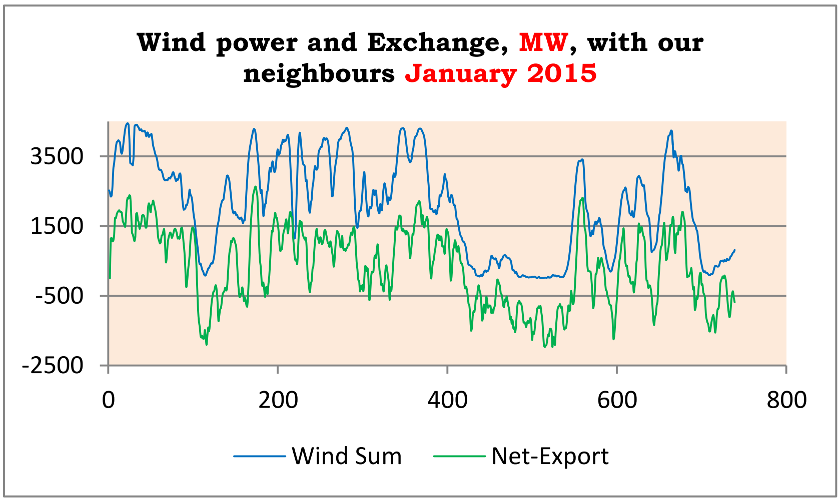
And Norway and Sweden do under no circumstances need Danish wind power. They can however make money when they reduce the hydropower production when it blows in Denmark and increase this production to export electricity to Denmark when the there is no or little wind in Denmark – and Germany. The author is not able to give any figures for the cost of this Swedish and Norwegian service. But probably the Swedes and Norwegians exploit their monopoly for storing of wind power.

It is seen, that Denmark in2015 had a net import of 675 MW, 18% of our consumption, with a maximum of 2631 MW.

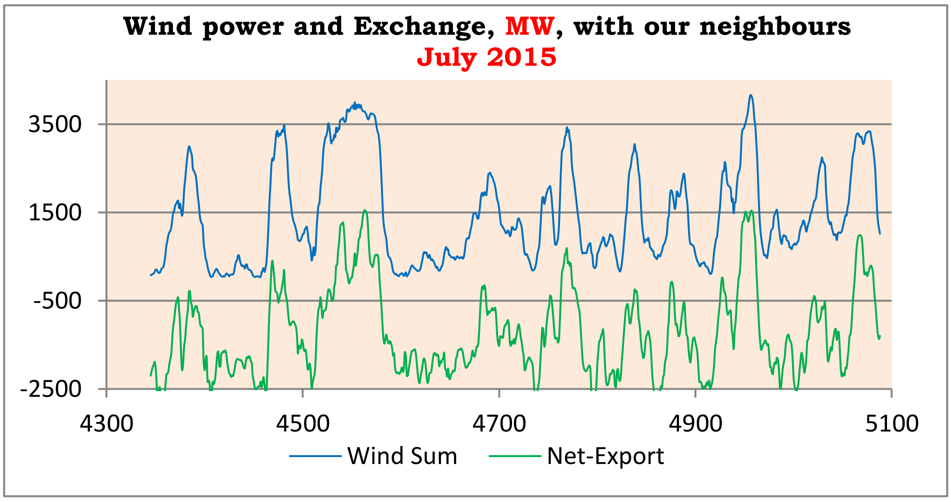
Wind and electricity exchange with our neighbours.



Denmark 2015, MW		
	Wind Sum	Net Export
Average	1612	-675
Max	4450	2631
Min	1	-2974
Stddev	1171	1114

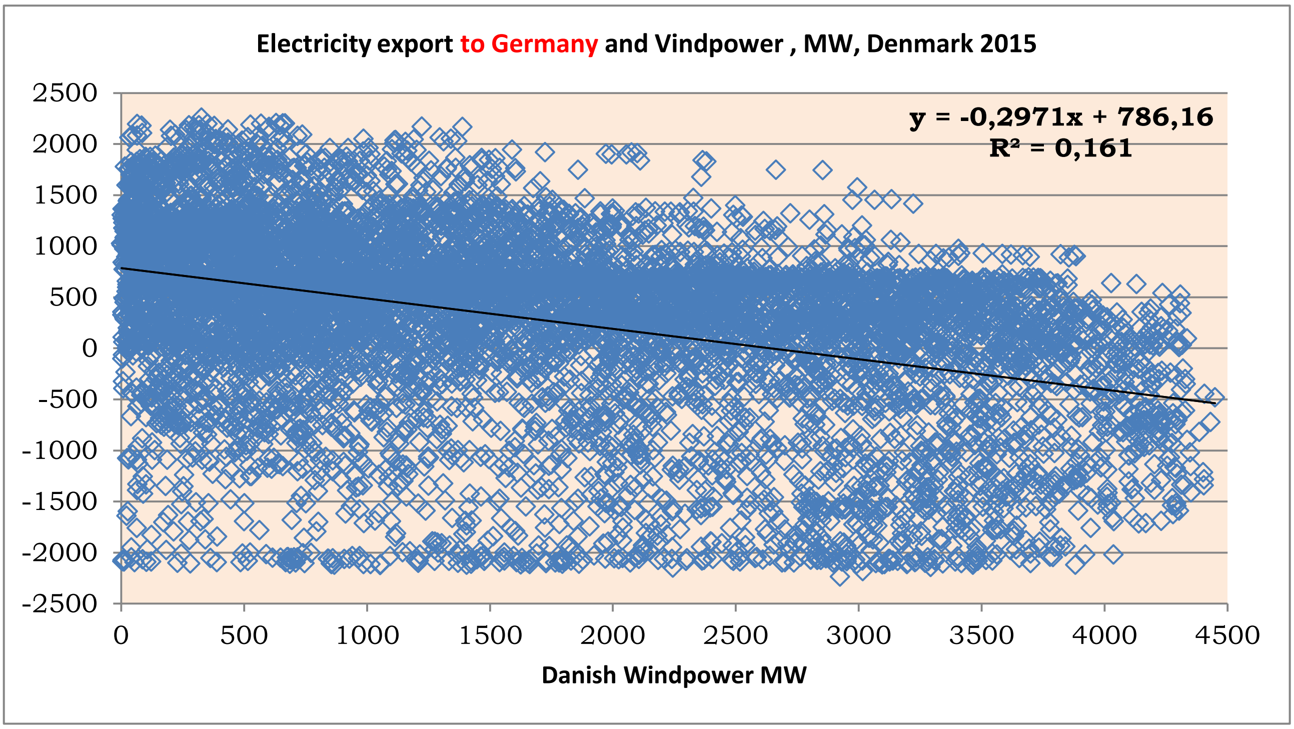


It is difficult to read the above figure so the graphs for January and July are shown.
Here it can easily be seen, that the Danish wind power system is deeply dependent of the close cooperation with Norway, Sweden and Germany.
It is seen, that there is no difference in the dependency of foreign exchange from summer to winter.

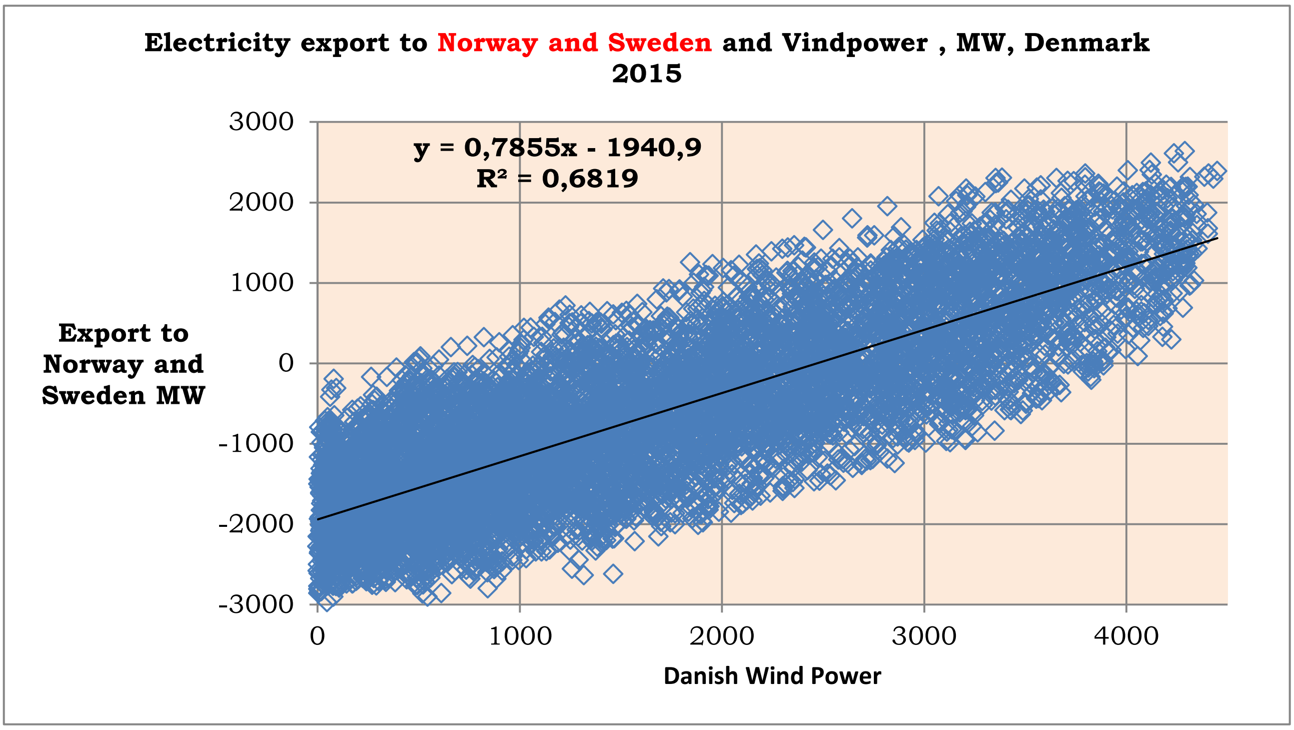


It is shown above, that the export increases when the wind increa-ses.

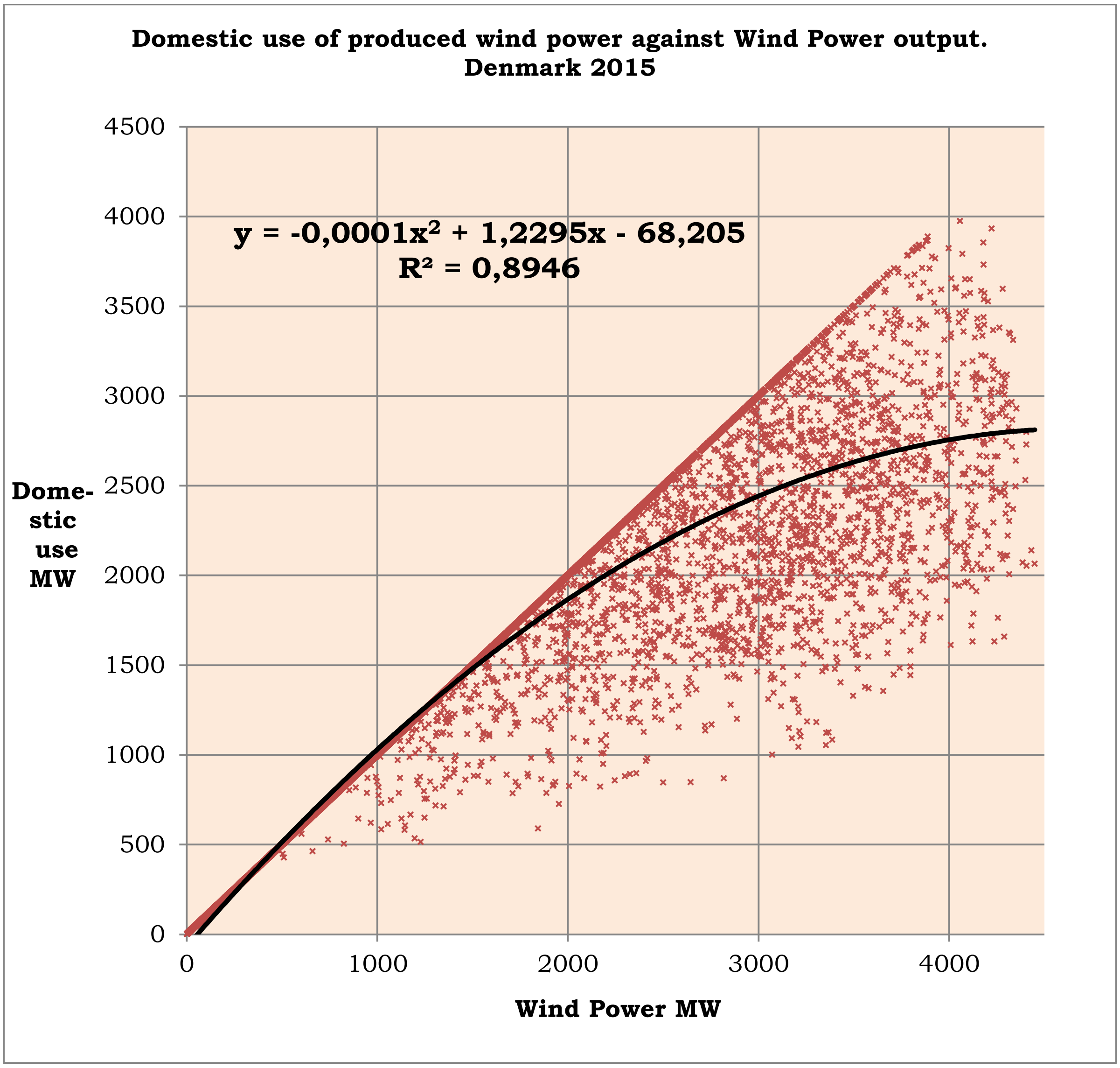
You might expect too, that the large German market with practical no hydropower and a decreasing nu-clear power would be the most inter-esting. This is, however not the case as is shown hereunder.



So it is very fortunate, that we can export our surplus to Norway and Sweden when the wind is blowing, as is shown hereunder.



Germany may need our electricity because of the "Energiewende". Norway and Sweden doesn't need our electricity at all. So the Danish wind industry must be lucky that Europe has adopted Gro Harlem Brundtland's statement in her report "Our common future" that: "The energy supply is too important to be entrusted to private business". However, the Danish tax payers and consumers have no reason at all to be lucky.



This graph shows the not surprising fact, that when the wind power surpases about 2000 MW the domestic use of that wind power falls.
Therefor it seem meaningless to build new wind parks. At least until we have learned to use the produced wind power.
Not an easy project if we should pay the price the owners of the wind turbine parks are paid for their wind power.

European Supergrid.

It is evident, that when you have said Wind Power you have said back-up too. Could this back up consist of European Wind Power connected by a super grid?

We have the data for the below mentioned countries for every hour from January to October 2015. (Rolf Schuster)

Wind, MW, January to October 2015												
	Austria	Bel-gium	Czech Rep.	Den-mark	Spain	France	Fin-land	Hun-gary	Polan d	Swed en	Germ any	Total Wind
Average	556	493	64	1465	5586	2052	206	78	1060	1704	7745	**21015**
Max	2036	1669	280	4845	17436	7324	763	305	3818	4790	31033	**56512**
Min	0	0	0	7	255	262	4	0	0	75	174	**3801**
Stddev	521	428	55	1090	3238	1425	138	80	854	963	6307	**10047**
Obser-vations	*7296*	*7296*	*7296*	*7296*	*7296*	*7296*	*7296*	*7296*	*7296*	*7296*	*7296*	***7296***
Stddev % of average	**94**	**87**	**85**	**74**	**58**	**69**	**67**	**102**	**81**	**56**	**81**	**48**
Wind capacity	**2335**	**2178**	**323**	**5267**	**23323**	**11401**	**1104**	**512**	**3834**	**6033**	**44000**	**100310**
Efficiency kW/MW	**238**	**226**	**200**	**278**	**240**	**180**	**186**	**152**	**276**	**283**	**176**	**210**

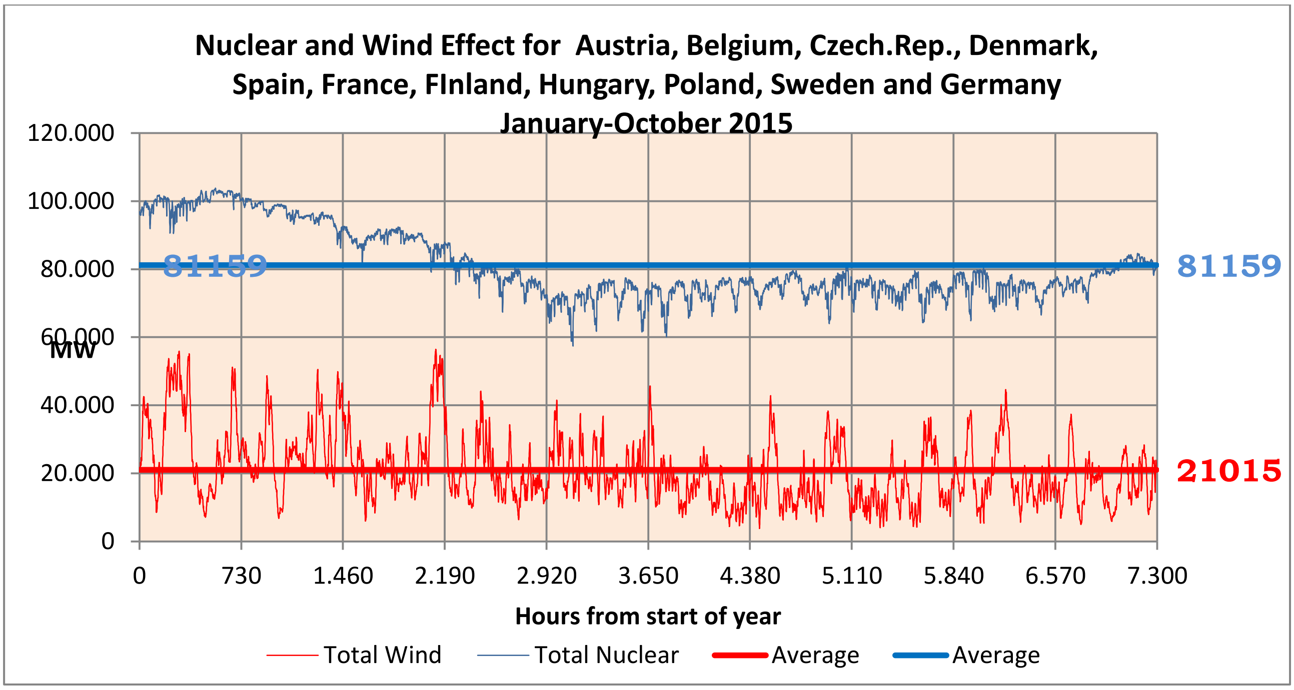
Over this huge area the Wind Power fluctuates between 3801 and 56512 MW and with an average of 21015 MW. The standard deviation for the sum is 48% of the average sum.

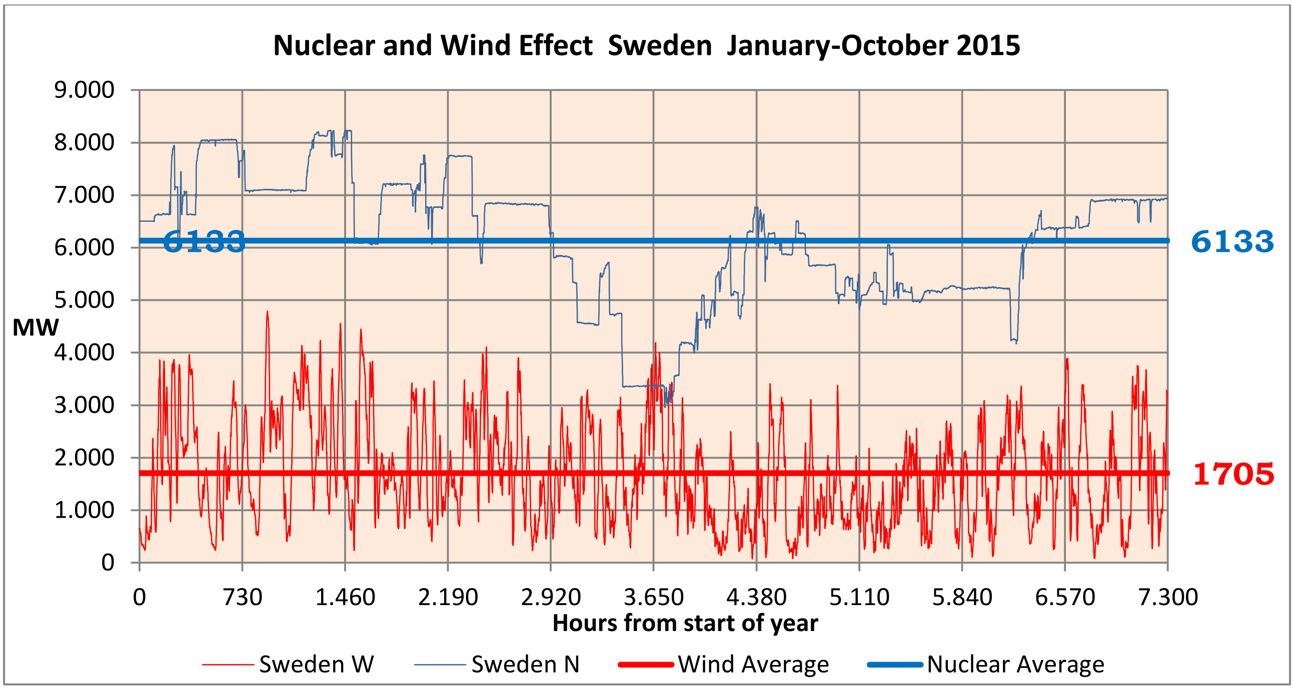
For comparison the generation of nuclear power is shown hereunder

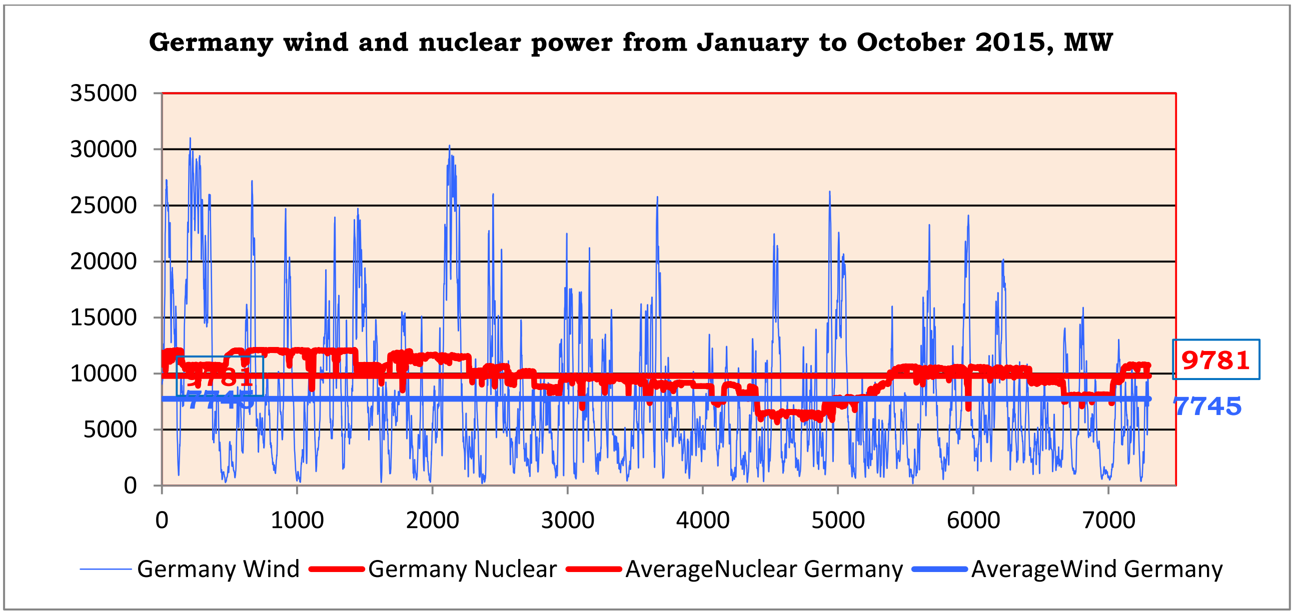
Nuclear, MW, January to October 2015										
	Bel gium	Czech Rep	Swizer-land	Ger-many	Spain	France	Finland	Hungary	Sweden	Total Nuclear
Average	**2740**	**2958**	**2480**	**9781**	**6292**	**46561**	**2510**	**1704**	**6133**	**81159**
Max	**3913**	**3951**	**3356**	**12116**	**7115**	**61490**	**2780**	**1941**	**8235**	**103880**
Min	**417**	**1380**	**0**	**5637**	**3712**	**29881**	**1643**	**1139**	**2952**	**57394**
Stddev	**775**	**680**	**800**	**1593**	**880**	**6312**	**347**	**248**	**1200**	**10201**
Observations	*7296*	*7296*	*7296*	*7296*	*7296*	*7296*	*7296*	*7296*	*7296*	*7296*
Stddev % of average	**28**	**23**	**32**	**16**	**14**	**14**	**14**	**15**	**20**	**13**

Nuclear Power is produced with a **standard deviation of 13%** of the average, whereas the **wind power** is produced with a standard deviation of **48%** of the average. The nuclear power deviation is a result of control and demand. The wind power is not controllable at all.

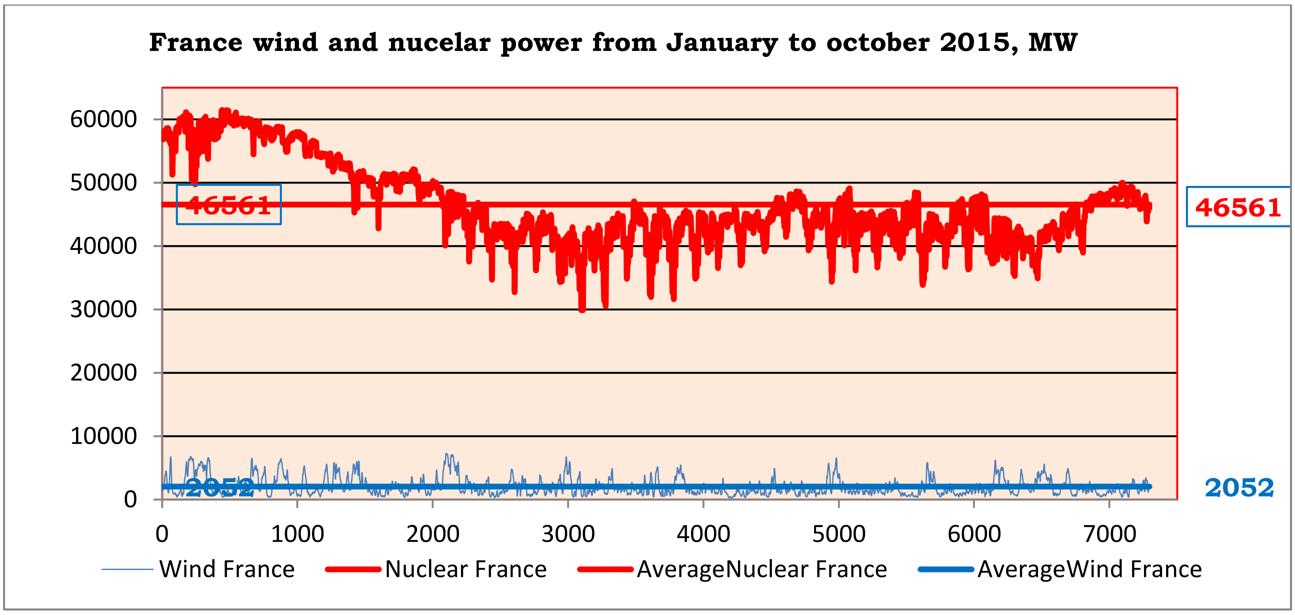
It should be noted too, that the wind power is only 21 GW about 4 times less than the nuclear power 81 GW.







When the last German nuclear reactor is closed in 2022 Germany will need double as much wind power as to day. Quite a task.



The minimum wind power in France in the period was 262 MW. That is the stand by capacity France has saved by building a wind power capacity of 10 GW (March 2015). If we estimate a price for wind power capacity of 1,32 Mio €/MW France has paid 13,2 Billion € for these 262 MW.

The nuclear fuel price is according to Swedish accounts 5€/MWh. Maintenance and operation for a nuclear power plant can be considered to be fixed costs. 2052 MW would thus cost 5*2052*8760/1000000=90 Mio €/year. Maintenance for wind power is according to Danish figures about 7€/MWh. So the windpower has cost France 36 Mio € net + interest and depreciation for 13,2 billion €!

Wind, Denmark + United Kingdom , Nuclear United Kingdom.

The production of British and Danish wind power is comparable as is shown by the table hereunder. I.e, the British output in 2015 was on average 2669 MW against the Danish 1613 MW. So the British is a factor 1,65 higher than the Danish.

	Danish and British Wind, Nuclear and Load, MW, 2015					
	GB	DK	GB+DK	GB	GB	DK
	Wind			Nuclear	Load	
Average	2669	1613	4282	7501	33022	3826
Max	6584	4455	10373	9006	77897	5729
Min	70	1	83	6046	19614	2272
Stddev	1641	1172	2355	600	6807	776
Stddev % of average	**61,5**	**72,7**	**55,0**	**8,0**	**20,6**	**20,3**
Observations	8760	8760	8760	8760	8760	8760

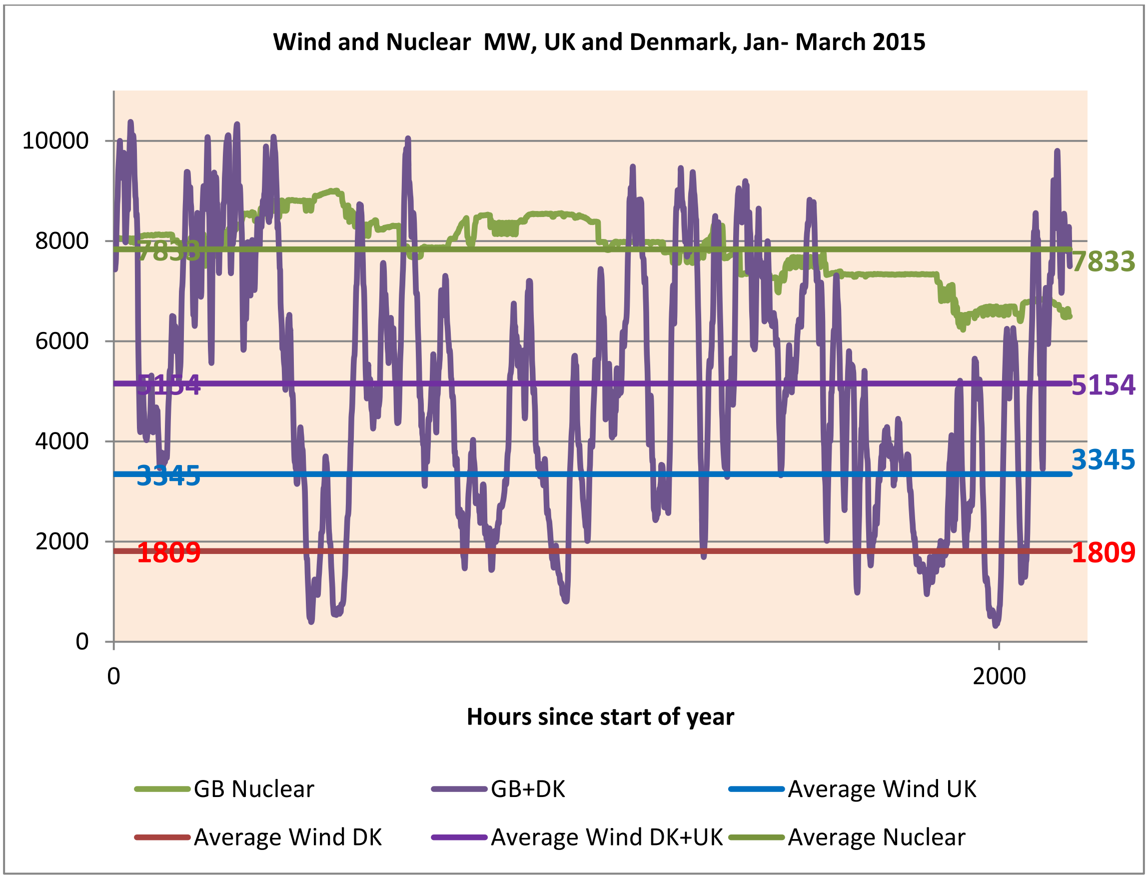
The Danish wind output is 42% of the load and the British is 8% of the load.

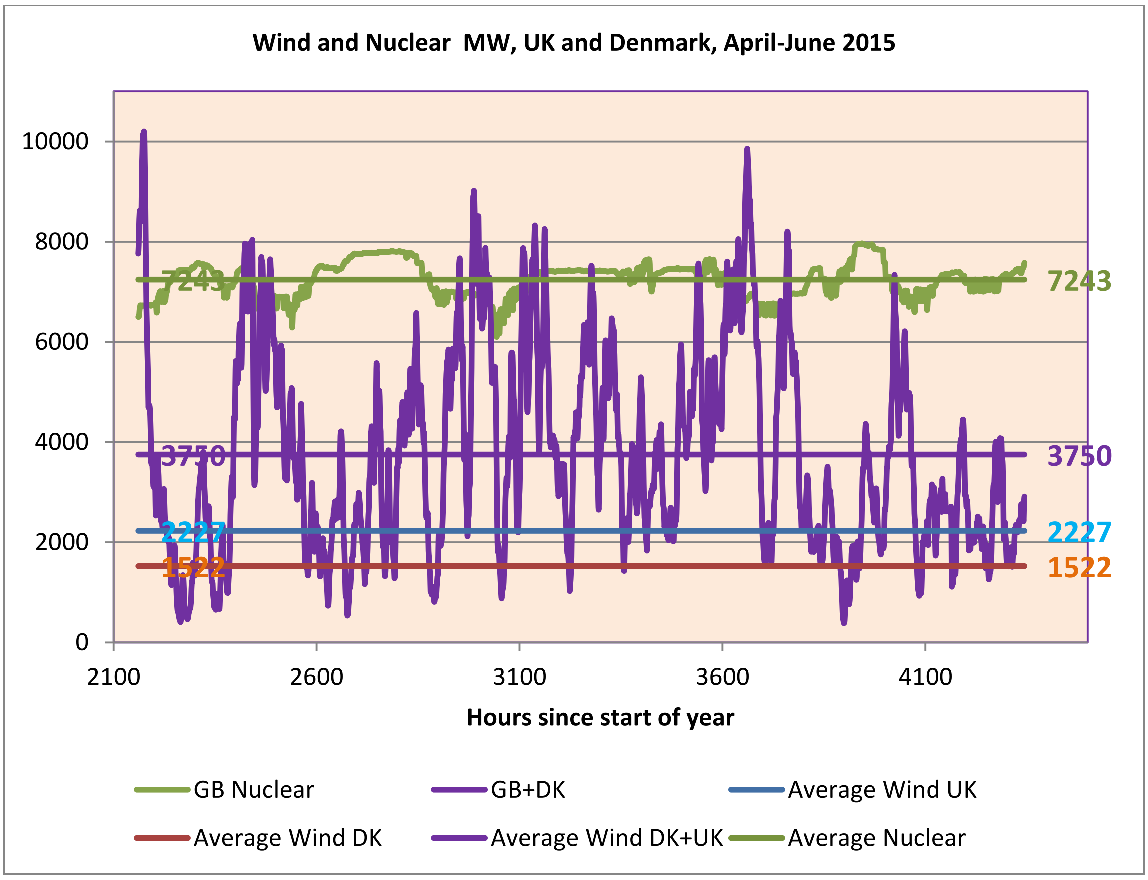
So if Great Britain would have the same proportion of wind power as Denmark the wind power would have a variation between 34 GW and 0,35 GW.

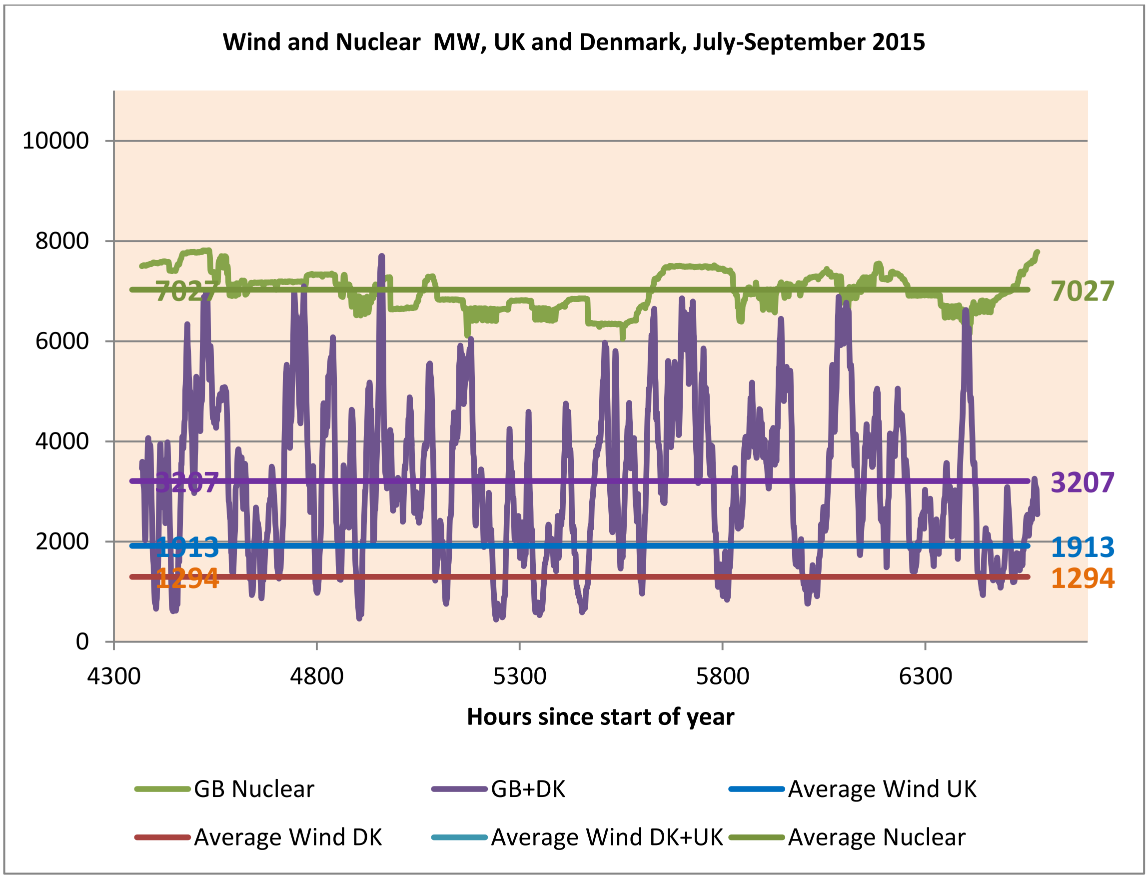
Denmark is in a unique situation since our consumption is only about 4 GW against the Norwegian + Swedish about 30 GW of which about 75% is easily controllable hydropower. So when it blows we can sell the wind power to Norway and Sweden albeit at very low prices and when it doesn't blow we can buy it back at somewhat higher prices. But after all it is physically possible. The western part of Denmark, Jutland, has been electrically connected to Norway, Sweden and Germany for more than 50 years and the eastern part, Sealand, has been connected to Sweden for more than 100 years and to Germany too for 20-30 years, whereas the eastern and western part of Denmark has been electrically connected since 2010 only.

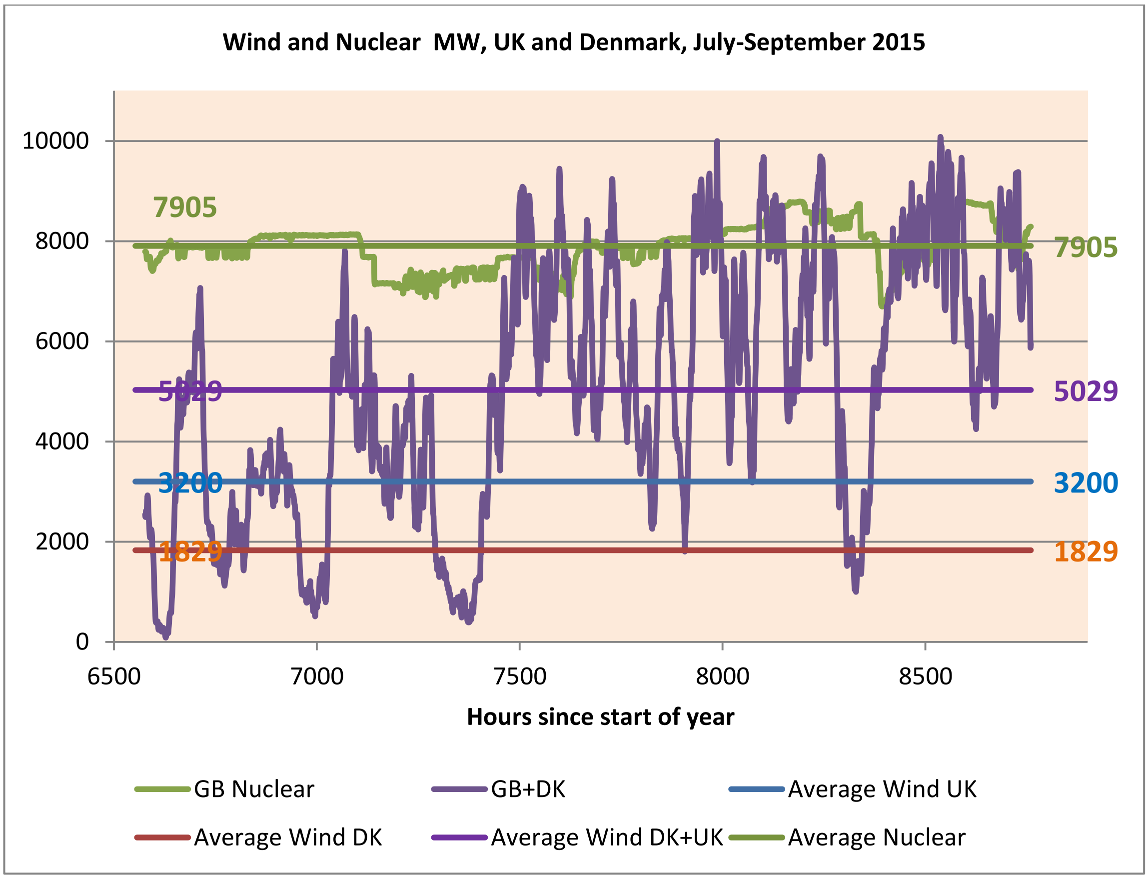
Now it is proposed to connect Denmark and Great Britain by a cable across the North Sea. We don't know to which degree the Scandinavian hydropower can even out the fluctuations in the British wind power too – and the German. But surely far from what would be needed if UK had the same proportion of wind power in her system as Denmark.

In the following some graphs are illustrating the variation in Danish and British wind power. It can easily be seen, that a cable between UK and Denmark would not do much to even out the wind power in Denmark and UK since Danish and British wind power to a very large degree are simultaneous. It is generally assumed, that the wind arrives in Denmark 24 hours later than in England. That is simply not true.


Wind and Nuclear MW, UK and Denmark, Jan- March 2015
10000
8000
6000
4000
2000
0
0
2000
Hours since start of year
7833
5154
3345
1809
GB Nuclear
GB+DK
Average Wind UK
Average Wind DK
Average Wind DK+UK
Average Nuclear


Wind and Nuclear MW, UK and Denmark, April-June 2015
10000
8000
6000
4000
2000
0
2100
2600
3100
3600
4100
Hours since start of year
7243
3750
2227
1522
GB Nuclear
GB+DK
Average Wind UK
Average Wind DK
Average Wind DK+UK
Average Nuclear


Wind and Nuclear MW, UK and Denmark, July-September 2015
10000
8000
6000
4000
2000
0
4300
4800
5300
5800
6300
Hours since start of year
7027
3207
1913
1294
GB Nuclear
GB+DK
Average Wind UK
Average Wind DK
Average Wind DK+UK
Average Nuclear


Wind and Nuclear MW, UK and Denmark, July-September 2015
10000
8000
6000
4000
2000
0
6500
7000
7500
8000
8500
Hours since start of year
7905
5029
3200
1829
GB Nuclear
GB+DK
Average Wind UK
Average Wind DK
Average Wind DK+UK
Average Nuclear

Comparison of different wind power systems.

It is not very meaningful to show for instance Finnish and German wind power since Germany had an average production 7745 MW and Finland 206 MW in January to October 2016.

But if you divide the single measurements for the different countries with the average production and multiply by 1000 you get production/(average production) expressed in kW/MW, and then you can compare. And you get better data to give an idea of the benefits of a trans European super grid.

And you get an idea about what we could obtain by extending the wind power to comparable levels in all the countries considered.

The average figures for the period January to October 2015 are shown in the table hereunder.

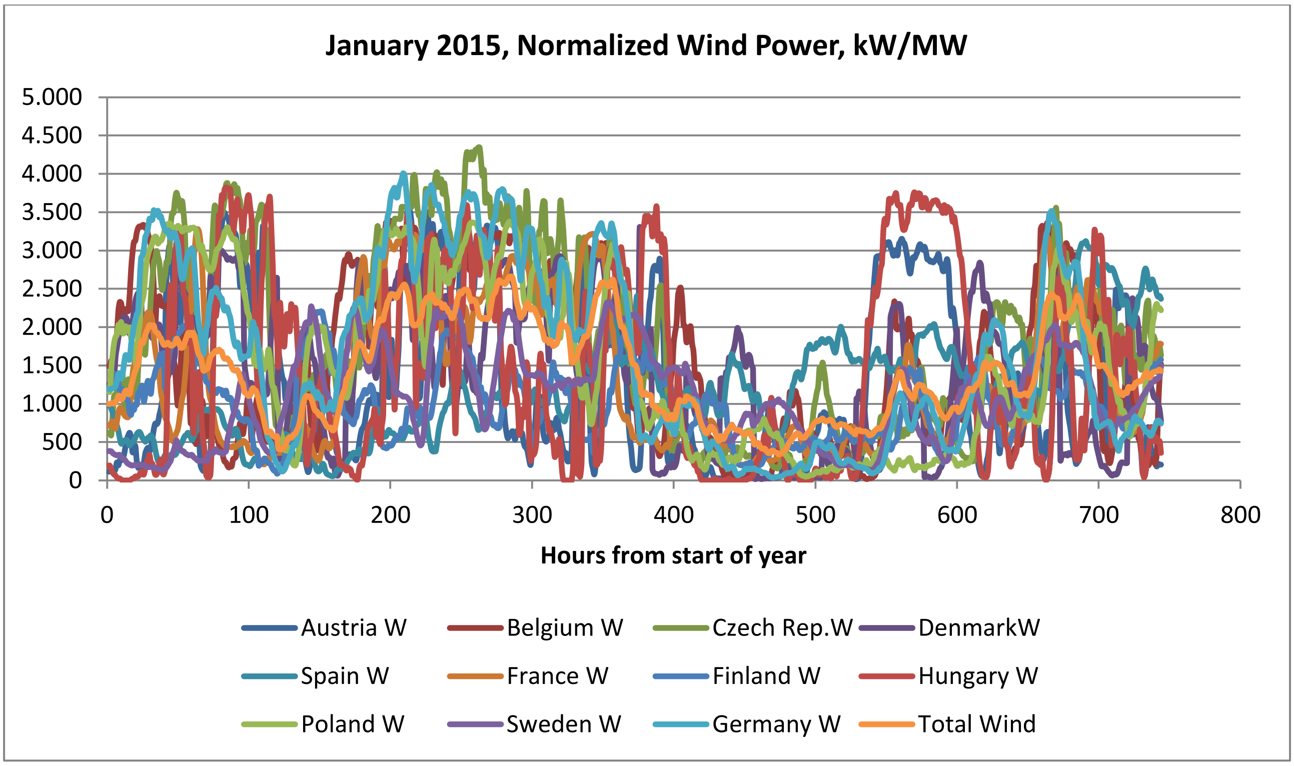
	January - October 2015. Normalized Wind Power. kW/MW											
	Au-stria	Bel-gium	Czech Rep.	Den-mark	Spain	Fran-ce	Fin-land	Hun-gary	Po-land	Swe-den	Ger-many	**Total Wind**
Average	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	**1000**
Max	3659	3387	4344	3308	3121	3569	3711	3913	3602	2810	4007	**2689**
Min	0	0	0	5	46	128	19	0	0	44	22	**181**
Stddev	936	869	851	744	580	694	670	1022	805	565	814	**478**
Obser-vations	7295	7295	7295	7295	7295	7295	7295	7295	7295	7295	7295	**7295**
Stddev % of average	**94**	**87**	**85**	**74**	**58**	**69**	**67**	**102**	**81**	**56**	**81**	**48**

Spain and Sweden have the lowest standard deviations and remarkably France has the highest minimum value. All other countires have a minimum value close to zero. The normalized minimum value for all countries combined is 181 kw/MW average production.

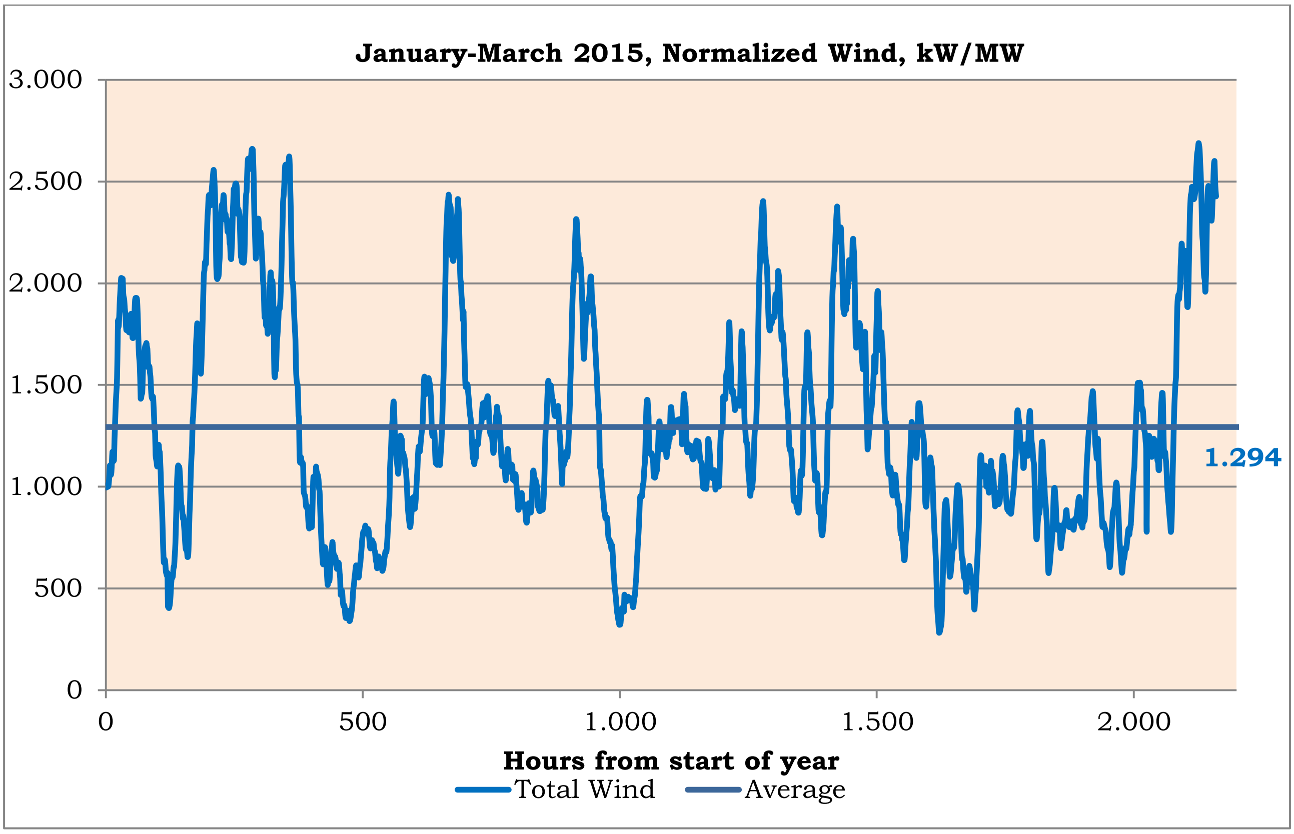
This means that the necessary back up for the wind turbines must be 82% of the average wind production. After the building of a transeuropean super grid.

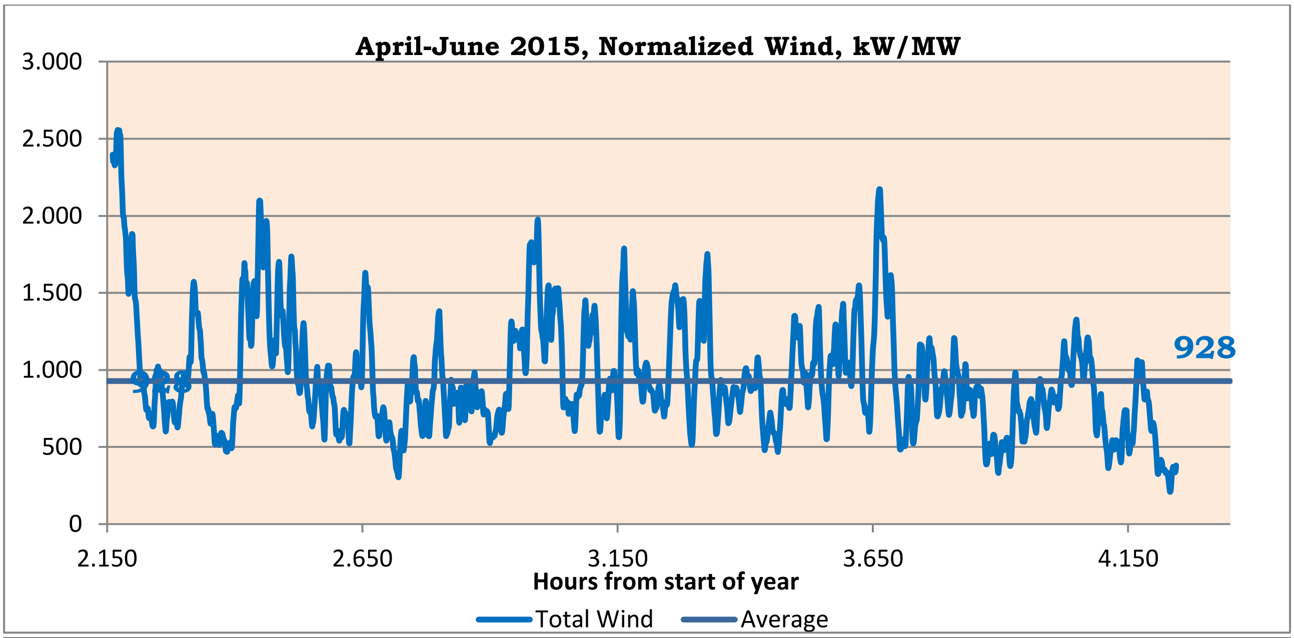
This should be taken into account, when you speak of the cost for wind energy.

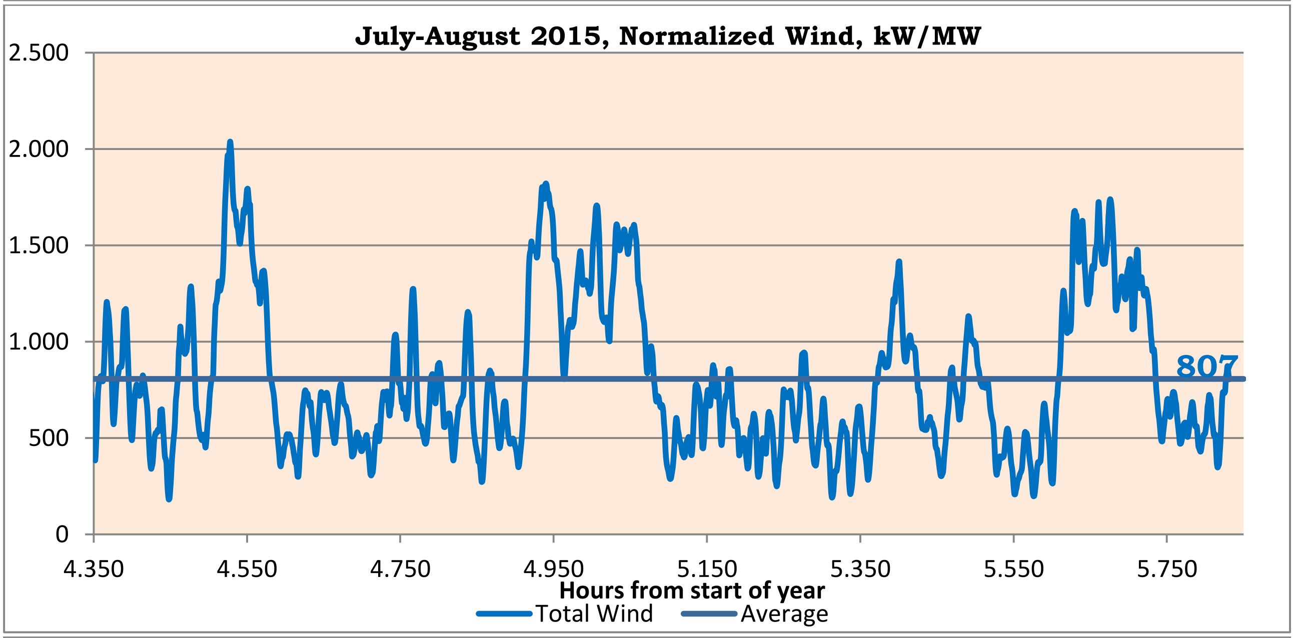
The graph hereunder shows the normalized values for all the mentioned countries plus the sum

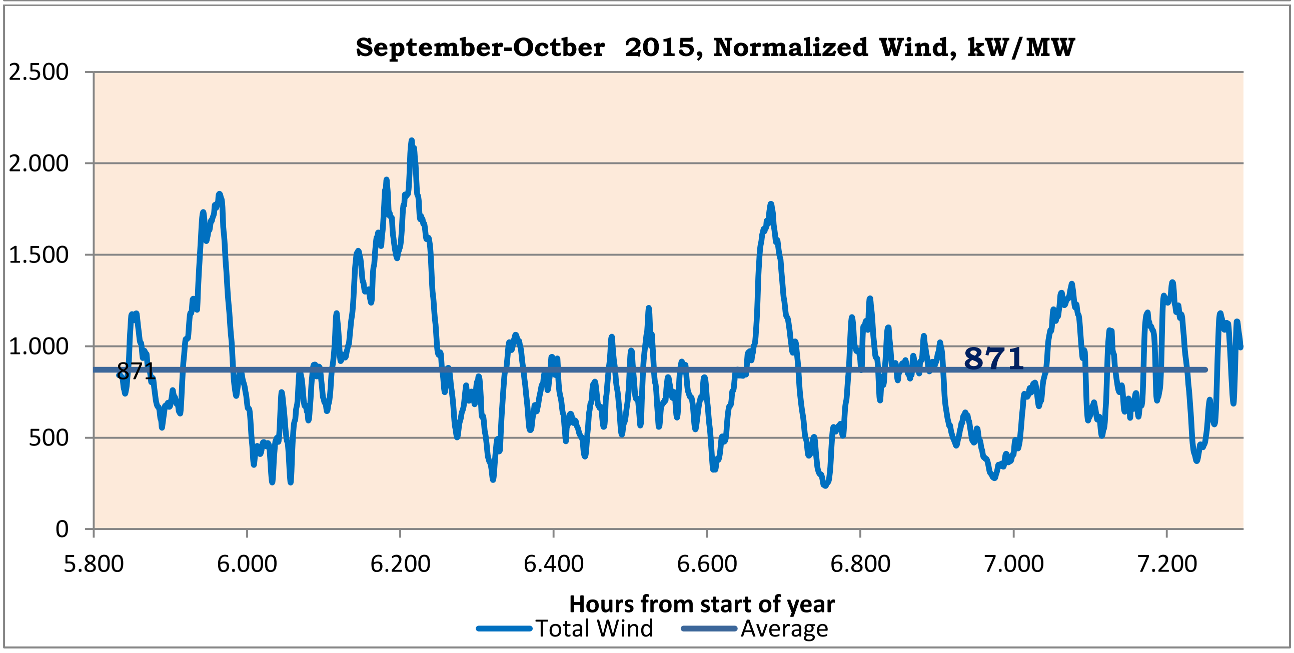


Obviously it does not make much sense to look at a graph like the graph above. Therefore the sum is shown hereunder for the months January-March, April-June, July-August and September-October.




April-June 2015, Normalized Wind, kW/MW
3.000
2.500
2.000
1.500
1.000
500
0
928
2.150
2.650
3.150
3.650
4.150
Hours from start of year
Total Wind
Average


July-August 2015, Normalized Wind, kW/MW
2.500
2.000
1.500
1.000
500
0
807
4.350
4.550
4.750
4.950
5.150
5.350
5.550
5.750
Hours from start of year
Total Wind
Average


September-Octber 2015, Normalized Wind, kW/MW
2.500
2.000
1.500
1.000
500
0
871
871
5.800
6.000
6.200
6.400
6.600
6.800
7.000
7.200
Hours from start of year
Total Wind
Average

Storage of wind power.

“Sie werden schon was finden” (They will soon invent something), said a German doctor to me. My answer was: ”You have worked with lung cancer in your entire career. How much have you been able to increase the life expectancy for your patients in 40 years, days, weeks, months or years?” He was an honest man and answered:” May be weeks.” “How can you be so convinced that the natural laws are not valid for the energy supply” was my answer.

Until this day the only serious way to store wind power is to keep the water behind the hydro power dams when it blows, and to open for the ports by wind still. And may be pumped storage.

It is impossible to give objective values for the needed storage capacity and effect, but if we really want a “sustainable” energy supply we will have to produce much more electrical energy by means of sun and wind.

For instance Sweden has an electricity consumption of about 14 MWh/inhabitant/year against Germany’s about 8 MWh/year, or 1,94 kW and 0,9 kW respectively. Since nearly the entire electricity production in Sweden and France is by nuclear and hydro power, it follows that Sweden and France have a much lower carbon dioxide emission than comparable countries.

The carbon dioxide emission is **5,5** tons per capita per year in Sweden and **8,9** in Germany. And Sweden is much colder than Germany. So a lot of carbon dioxide free electricity production will be needed, provided that the green house hypothesis is true.

In the following we will try to calculate the demand to a storing system.

Electrochemical storage.
It is possible to use the electricity to produce hydrogen and store it in the form of $LiBH_4$. And it should be possible to obtain an accessible storage capacity of 22,2 GJ/ton corresponding to 6,17 MWh per ton.
In the following the loss by producing hydrogen, reacting it to $LiBH_4$ and releasing the hydrogen again is estimated to 20%.
The loss by burning the hydrogen in a gas turbine to produce electricity is estimated to 50%, so the overall efficiency of the process is estimated to 40% or 0,4.

Denmark has in more than 100 years benefitted from access to Norwegian and Swedish Hydro Power, and we consider this access as a precondition for the high percentage of wind power in the Danish electricity system.

So in the following we will try to calculate the demands for a back-up system for wind power based on hydro power or a $LiBH_4$ storage, provided that the output from the wind system + back up is kept constant. Of course we know very well that the demand for electricity changes all the time, so the calculations do not present the truth, but hopefully they will be a good approximation to the truth, and at least give an idea of the dimension for a back-up system.

Denmark Wind, Lithium Boron Hydride Storage, January -December 2015							
	Wind DK	**To Reservoir MW**	**To reservoir after losses MW**	**From Reservoir MW**	**Resulting Wind Power MW**	**Storage content GWh**	**Loss**
	MW	MW	MW	MW	MW	GWh	MW
Average	1624	717	573	287	1194	1004	**430**
Max	4450	3256	2605	1192	1194	1617	GWh
Min	2	0	0	0	1194	0	**3767**
Stddev	1170	899	719	388	0	455	MW/GW
Observations	8760	8760	8760	8760	8760	8760	**265**

Lithium Boron Hydride Storage				
Storing capacity	GJ/ton	22,2	Storing efficiency	0,8
	MWh/ton	6,17	Regenerating efficiency	0,5
Max storage capacity	GWh	1617	Efficiency total	0,4
		262185		
Required LiBH4	Ton			
Required LiBH4 per MW average Wind	Ton	161		

.

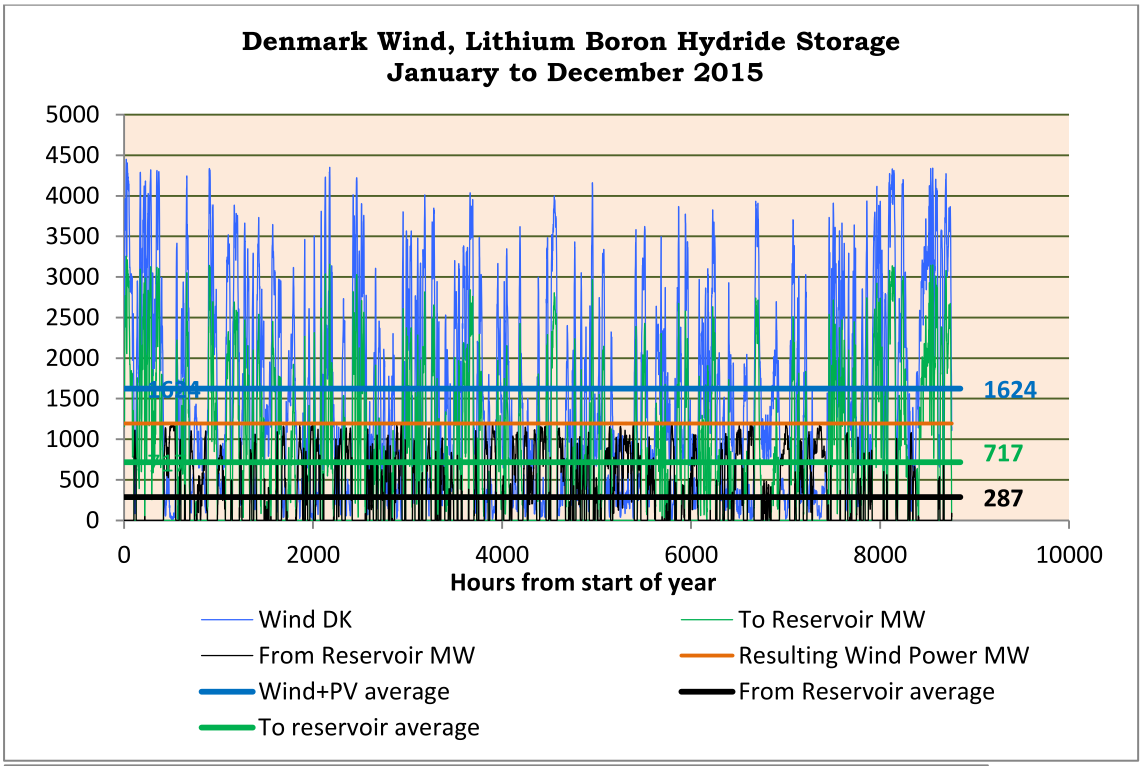
The average wind power in Denmark in 2015 was 1624 MW varying between 2 and 4450 MW.

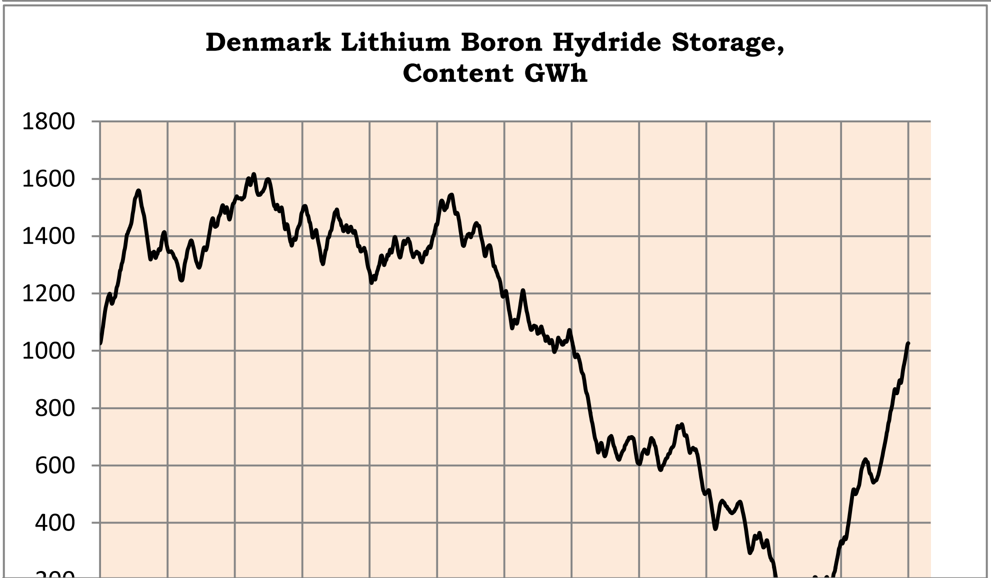
The average output to the back-up system is calculated to 717 MW and the return from the storage would be 287 MW.

The over-all loss is calculated to 430 MW or 265 MW per produced GW wind power.

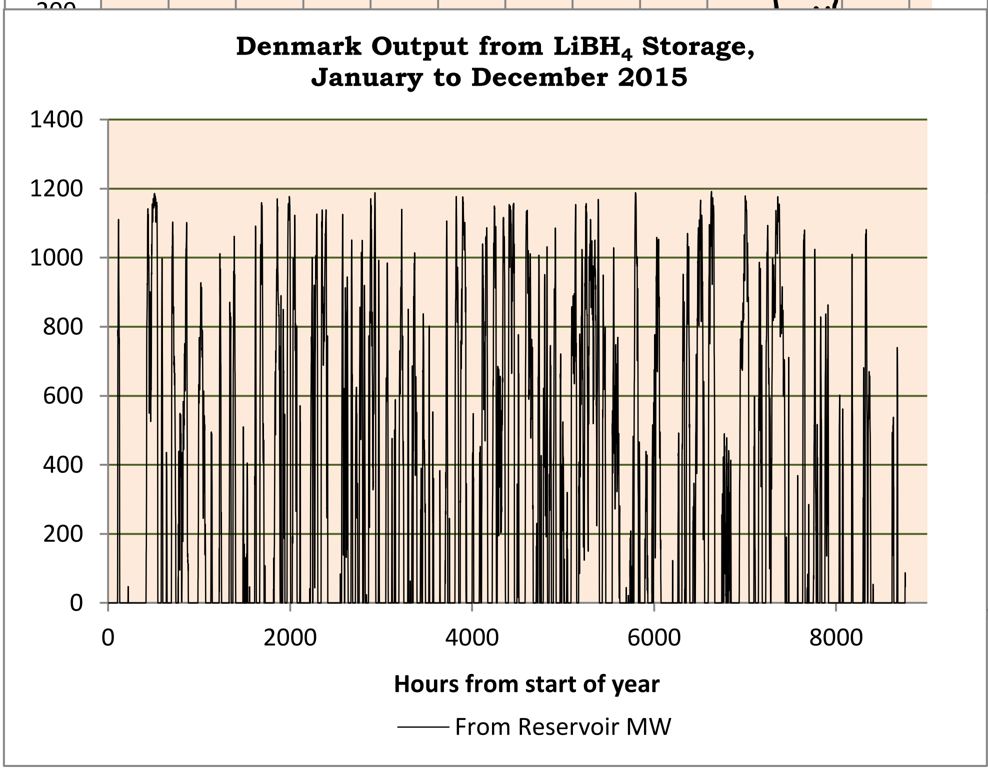
But then you would get a stable output of **1194** MW instead of a very unstable average of 1624 MW.

A short glance at the calculated need for $LIBH_4$, 161 ton per produced MW, makes it clear that large scale electrochemical storage of wind power is impossible, and it is justified to ask if universities should waste money and scientific talent to occupy themselves with the matter.





This graph shows how much power would be stored in the reser- voir any time during the year.



This graph shows how much electri- city should be delivered from the reservoir any time during the year.

uropean Energy

It is obvious that electro-chemical storage is of no interest at all when the small Danish system would need a battery containing 262.000 tons of $LiBH_4$.

So in the following we will consider a pumped storage.

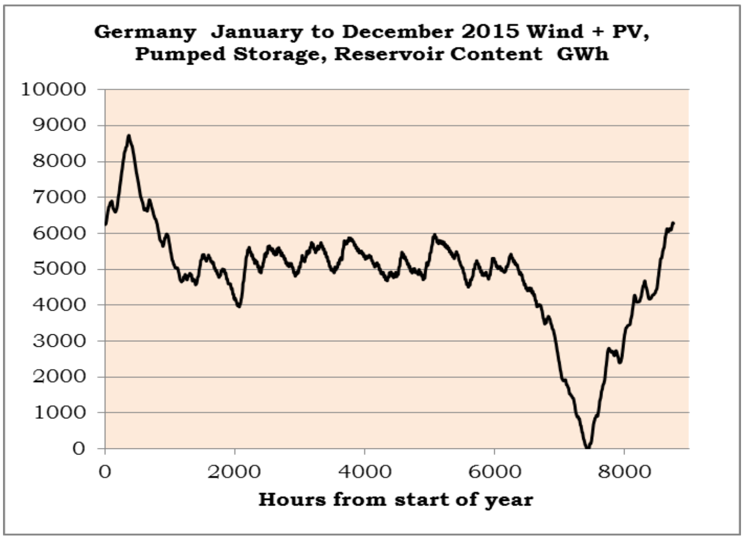
Pumped Storage for German Wind and PV power.

We presume again that the output from wind turbines + solar cells + the storage system should be constant. Not because we expect that this can or should reflect the reality, but because this can be calculated, and because we think that the reality will be more demanding.
We presume that the loss by pumping water to the reservoir will be 10% and that the turbines afterwards will have an efficiency of 90%, so that the total loss will be 19%.

German Wind + PV. January -December 2015							
	Wind +PV DE	**To Reservoir MW**	**To reservoir after losses MW**	**From Reservoir MW**	**Resulting Wind +PV Power MW**	**Reservoir content GWh**	**Loss**
	MW	MW	MW	MW	MW	GWh	MW
Average	12832	3879	3491	3142	12095	**4814**	737
Max	42266	30171	27154	11757	12095	**8730**	GWh
Min	338	0	0	0	12095	0	6457
Stddev	8512	5850	5265	3721	0	1491	MW/GW
Observations	8760	8760	8760	8760	8760	8760	**57**

Pumped storage	
Storing efficiency	0,9
Regenerating efficiency	0,9
Efficiency total	0,81

The result is seen in the table above and in the graph hereunder.



The calculation shows, that if you wish to keep the output from wind + PV power constant then you need a storage system with a storing capacity 8730 GWh, or **8,73 TWh** and a production capacity of **11,7 GW**. And it should be possible to fill the reservoir with a capacity of **27 GW**. Or otherwise expressed when the wind blows and the sun shines the pumps to fill the reservoirs should have a capacity large enough to use **27 GW**. ***This corresponds to 50 % of the German average load.***

Comparison with Europe's largest pumped storage system, Vianden in Luxembourg.

	Input Capacity MW	Output Capacity MW	Reservoir Capa-city GWh	Overall effi-ciency W/kW
Calculated demand	27000	11700	8730	
Vianden	1040	1290	5	800
Geetshacht Hamburg	96	120	0,53	

These figures speak for them selves.

Hydro power

Hydropower in Europe					
	Generation 2013		Generation Capacity	Reservoir Capacity	Peak Consumption
	TWh	GW	GW	TWh	GW
Austria	41	4,7			
Finland	13	1,5			
France	**75**	**8,6**	**25,2**		
Germany	24	2,7			
Italy	52	5,9			
Norway	**129**	**14,7**	**29,6**	**83,4**	**24,2**
Portugal	15	1,7			
Romania	15	1,7			
Spain	41	4,7			
Sweden	**60**	**6,8**	**16,2**	**33,7**	
Switzerland	40	4,6			
Sum	**505**	**57,6**		**220**	

Germany would need a maximum reservoir capacity of 8,73 TWh to keep output from the today existent Wind and Solar Power Constant. There is no reason to believe that this extra capacity could be found in existent hydropower systems. When it blows and the sun shines in Germany electricity could be exported to for instance Sweden and imported from Sweden when needed.

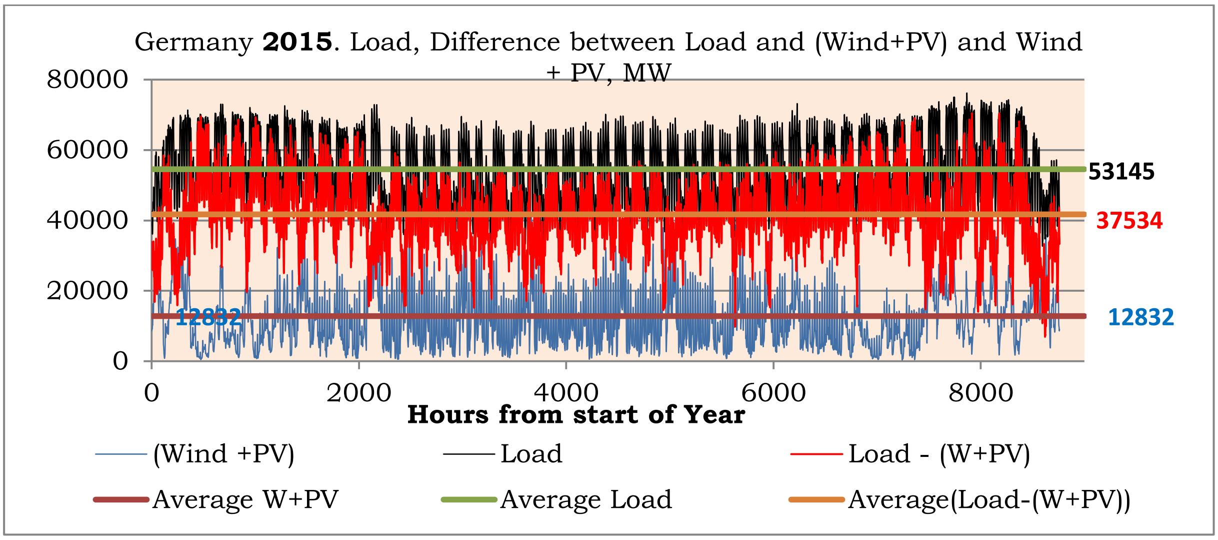
Germany 2015	
Average load	**54 GW**
The difference between load and (Wind+PV):	
Average	**42 GW**
Maximum	**70 GW**
Minimum	**7 GW**

Swedish data 2015			
	Total produk-tion	**Import / export**	**Load = Production + import**
Average	17470	-2752	15534
Max	24979	1549	22862
Min	10093	-7093	8805
Swedish im- and export of electricity 2015			
	Import	**Export**	**Sum**
	MW average 2015		
Denmark	218	-636	-397
Finland	0	-1978	-1977
Norway	827	-413	414
Poland	2	-402	-400
Germany	16	-224	-208

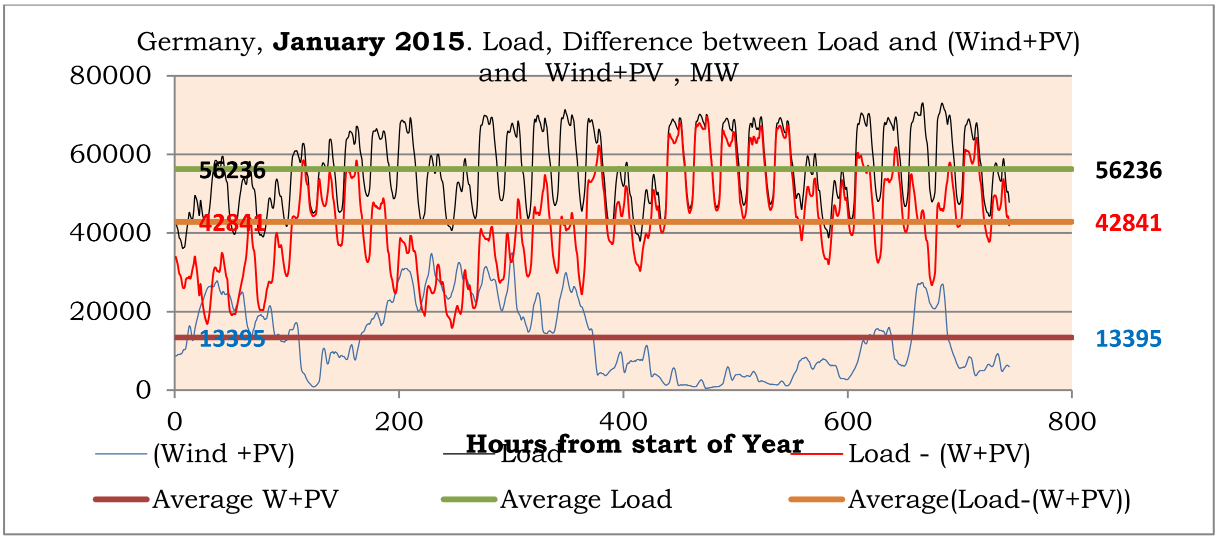
The German difference between load and (Wind + PV) varies between 7 and 70 GW. The Swedish data shows a maximal Swedish export at 7,09 GW. Norway may be able to supply a little more, but **it would demand enormous and probably impossible investments to enable Norway and Sweden to secure a stable electricity supply in Germany.**

German data 2015

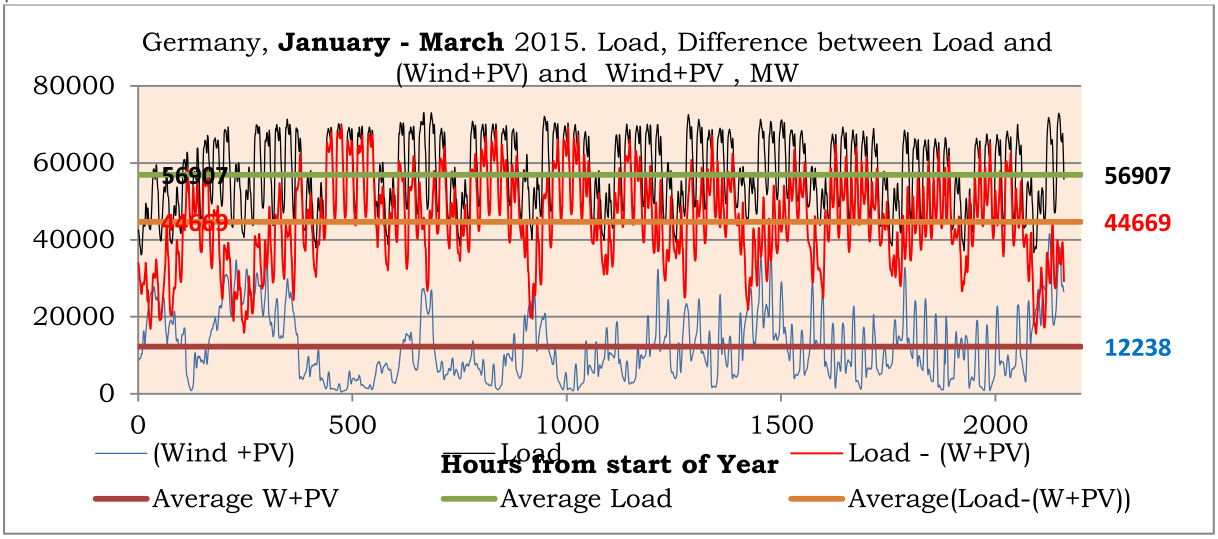
2015 Jan-Dec	Wind	PV	(Wind +PV)	Load	Load - (W+PV)
Average MW	8848	3984	12832	54554	41722
Max MW	32605	25540	42266	76212	70439
Min MW	151	0	338	31671	6932
Stddev MW	7165	6011	8512	9930	10738
Observations	8760	8760	8760	8760	8760



2015 Jan	Wind	PV	(Wind +PV)	Load	Load - (W+PV)
Average	12647	752	13395	56236	42841
Max	30286	10621	34866	73057	69594
Min	336	0	465	36115	15886
Stddev	9171	1488	9330	9385	12675
Observations	744	744	744	744	744



2015 Jan -Mar	Wind	PV	(Wind +PV)	Load	Load - (W+PV)
Average	10008	2229	12238	56907	44669
Max	30286	21661	41634	73057	69594
Min	281	0	465	36115	15609
Stddev	7782	4112	8380	9084	11299
Observations	2160	2160	2160	2160	2160



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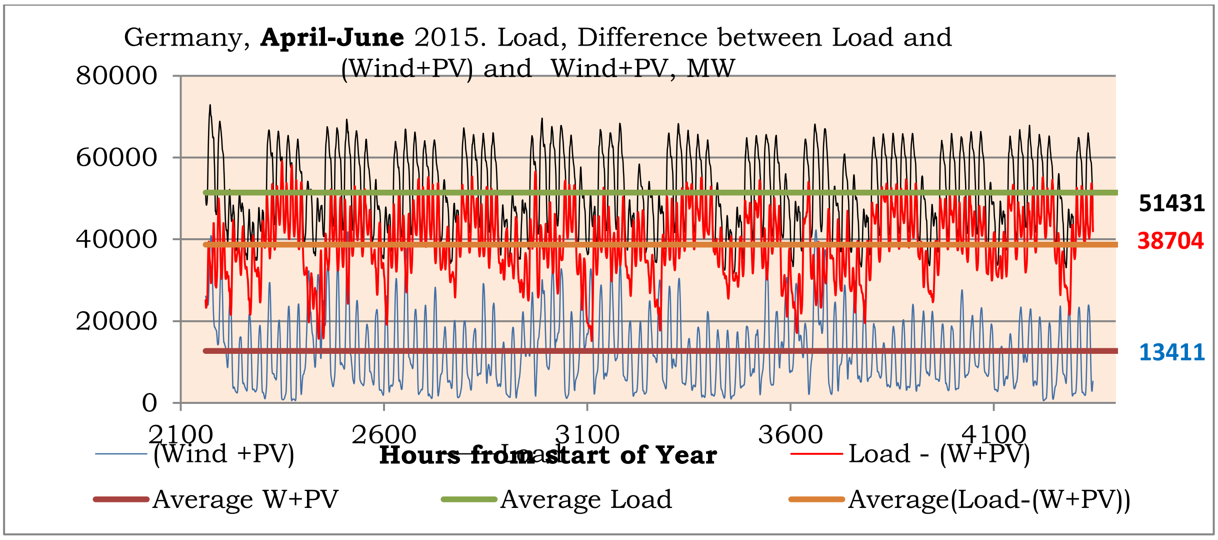
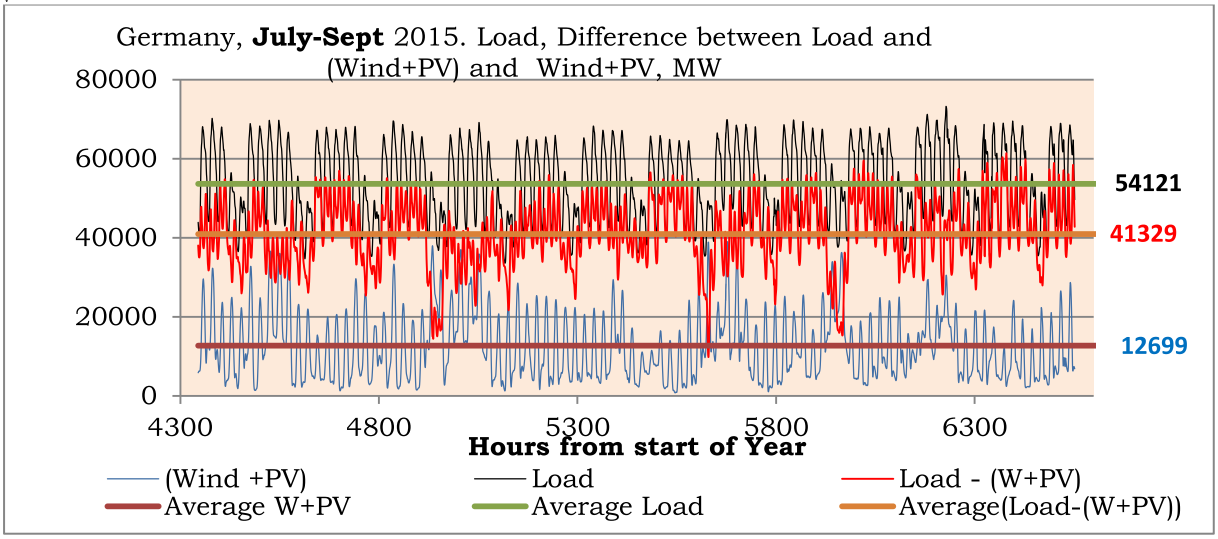
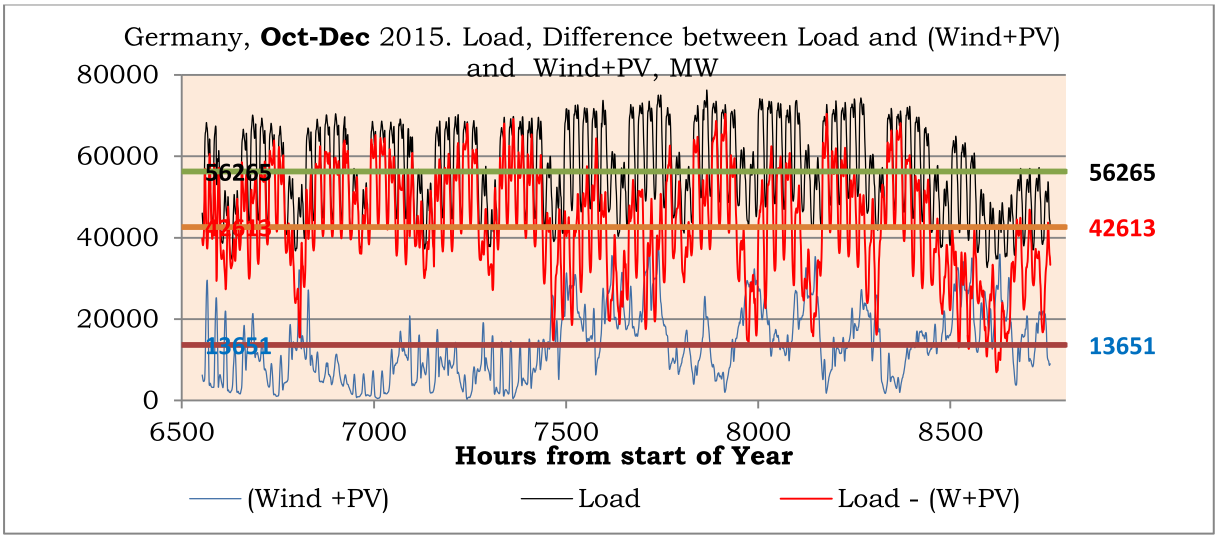
2015 Apr-June	Wind	PV	(Wind +PV)	Load	Load - (W+PV)
Average	6592	6134	12727	51431	38704
Max	27513	25540	42266	72894	59158
Min	188	0	565	31671	15184
Stddev	5166	7089	8715	9562	8358
Observations	2184	2184	2184	2184	2184



2015 July-Sep	Wind	PV	(Wind +PV)	Load	Load - (W+PV)
Average	6922	5777	12699	53630	40931
Max	25782	24433	38983	73200	61382
Min	176	0	756	33585	9819
Stddev	5327	7046	8404	9523	8679
Observations	2208	2208	2208	2208	2208



2015 Oct-Dec	Wind	PV	(Wind +PV)	Load	Load - (W+PV)
Average	11871	1781	13651	56265	**42613**
Max	32605	24455	37662	76212	**70439**
Min	151	0	338	32685	**6932**
Stddev	8397	3445	8488	10519	**13014**
Observations	2208	2208	2208	2208	**2208**



Energiwende by expanding Wind and Solar Power

It is evident, that you can't build an electricity system on wind and photovoltaics without caring about back up. It is evident too from the data calculated for Denmark, that large scale electrochemical storage may be interesting for universities looking for funds for futile research and for nobody else.

Add to this that the Swedish electricity consumption is about 1,9 kW per person against the German about 0,65 kW/person.

	Average MW		
2015	(Wind +PV)	Load	Load - (W+PV)
Jan-Mar	12238	56907	44669
Apr-Jun	12727	51431	38704
Jul-Aug	12699	53630	40931
Oct-Dec	13651	56265	42613
Jan-Dec	**12832**	**54544**	**41722**

If you look at the averages for Wind+ PW, Load and the difference Load-(Wind+PV) you find surprisingly small differences from period to period. So you might conclude, that we just multiply (Wind +PW) with, then you don't need to care very much about back-up.

This exercise has been made in the table below.

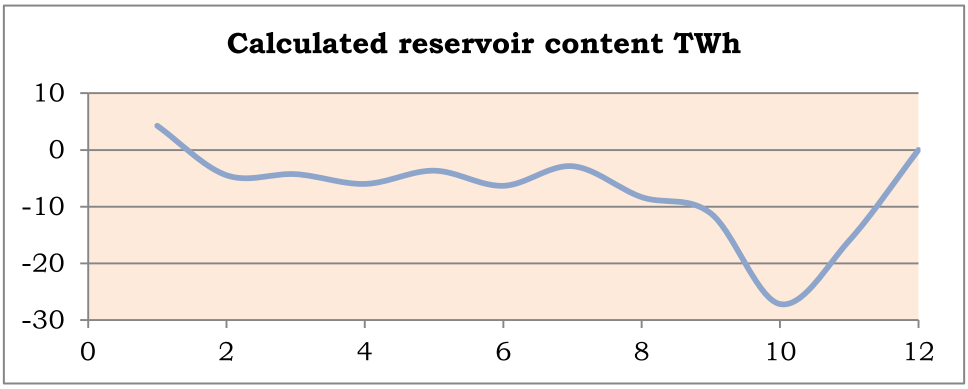
Period	Wind	PV	Wind + PVL	Load	Load-(W+PV)	Accumulated Load-(W+PV)
	GW					TWh
1	59,6	2,5	62,1	56,3	-5,8	4,3
2	39,0	6,9	45,9	57,8	11,9	-4,5
3	43,9	13,1	57,0	56,7	-0,3	-4,3
4	28,1	20,8	49,0	51,3	2,4	-6,0
5	34,4	19,7	54,2	51,0	-3,2	-3,7
6	26,7	21,6	48,3	51,9	3,7	-6,3
7	36,3	21,8	58,1	53,4	-4,7	-2,9
8	24,7	20,4	45,0	52,5	7,5	-8,3
9	35,5	15,5	51,0	55,0	3,9	-11,2
10	25,0	8,1	33,1	55,0	21,9	-27,2
11	69,0	5,3	74,3	58,9	-15,3	-16,0
12	72,8	3,8	76,7	54,8	-21,9	**0,0**
Average	**41,3**	**13,3**	**54,6**	**54,6**	**0,0**	
Mulipli-cator	**4,66**	**3,44**				

In this table the measured data are divided in 12 even long periods of 730 hours, and the average for each period is calculated.

And the figures for wind power have been multiplied by **4,66** and the data for PV power have been multiplied by **3,44**. These numbers are chosen because Load-(W+PV) arrive at zero by year's end.

The numbers are found by means of the marvelous excel program's ability to perform iterations.

In the first period, 30 days and 10 hours, more power is produced by wind and sun than is used so you could fill 4,3 TWh into the reservoir. In the following months the reservoir contents goes up and down, and the figures show, that you by the end of period 10 (October) must have been able to draw 27,2 TWh from the reservoir, and that it is filled up again in period 11 and 12 to reach zero at years end.



So in period 10 you would need to draw on average 21,9 GW from the reservoir – he peaks will be much higher and you would need to draw 16 TWh from the reservoir. The Vianden pumped storage system has a storing capacity of 5 GWh or 1/3000 of the calculated need.

So to make the Energiewende to a success, Germany needs either formidable back-up capacity power stations operated by biofuel or benevolent neighbours or control over the European Union. But then Germany can not have benevolent neighbours.

Add to this, that the Fraunhofer proposal described next operates with a doubling of the German electricity consumption.

A German Dream

FRAUNHOFER-INSTITUT FÜR SOLARE ENERGIESYSTEME, ISE
100 % ERNEUERBARE ENERGIEN FÜR STROM UND WÄRME IN DEUTSCHLAND

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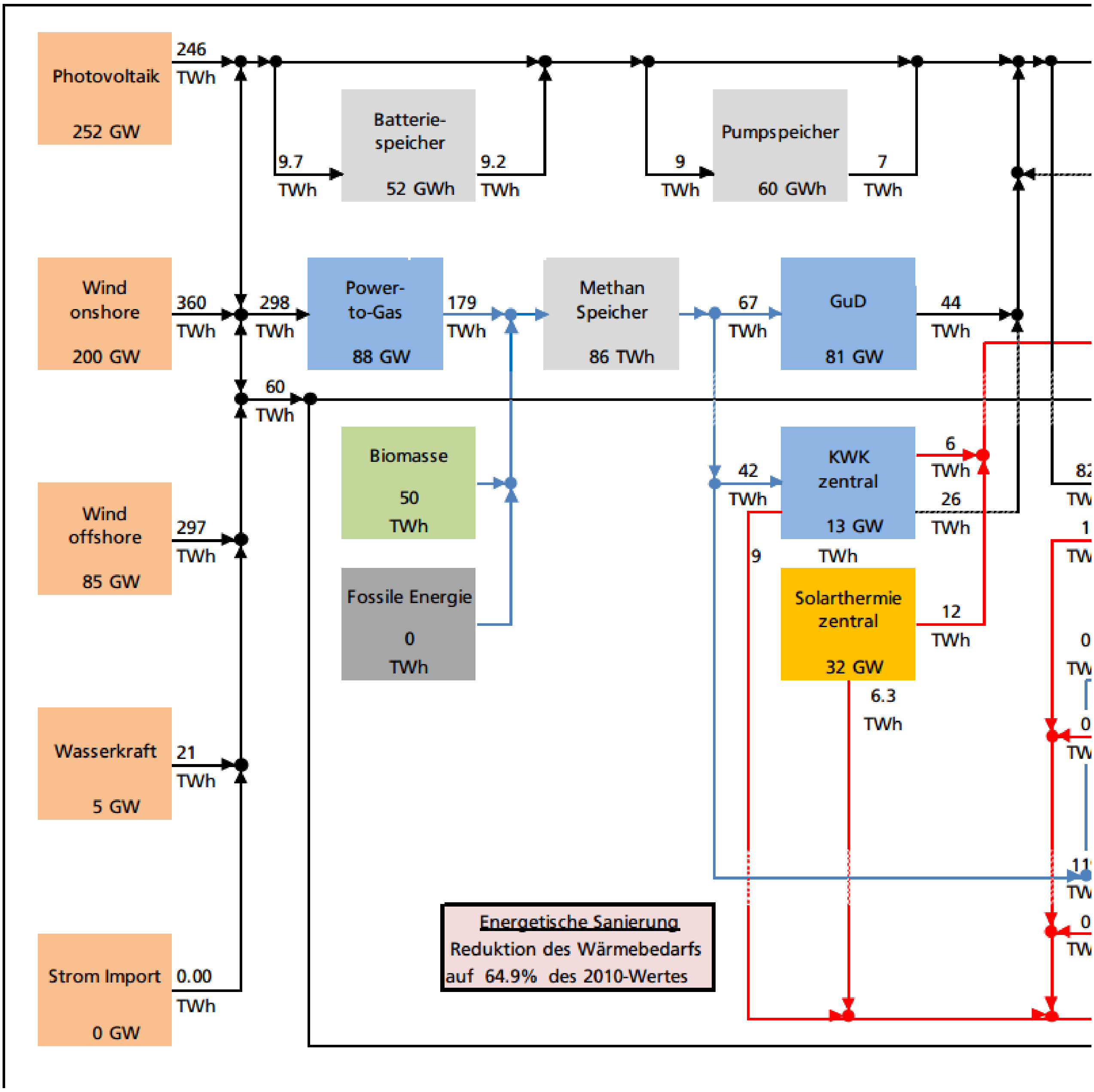
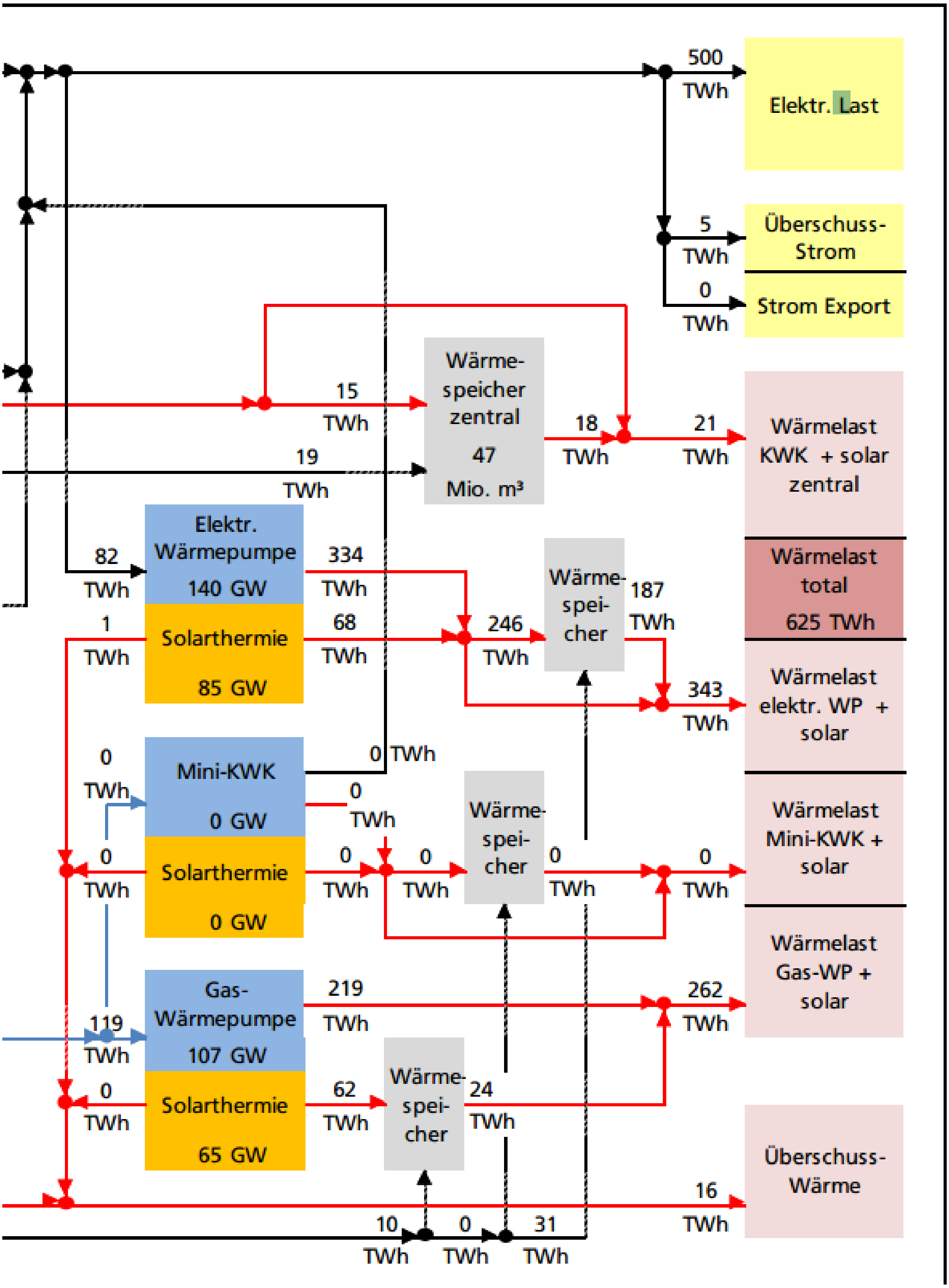




This author (Soeren Kjaersgaard) some years ago in the American Magazine "Power" saw the remark:
"There is a long way from power point to power plant".

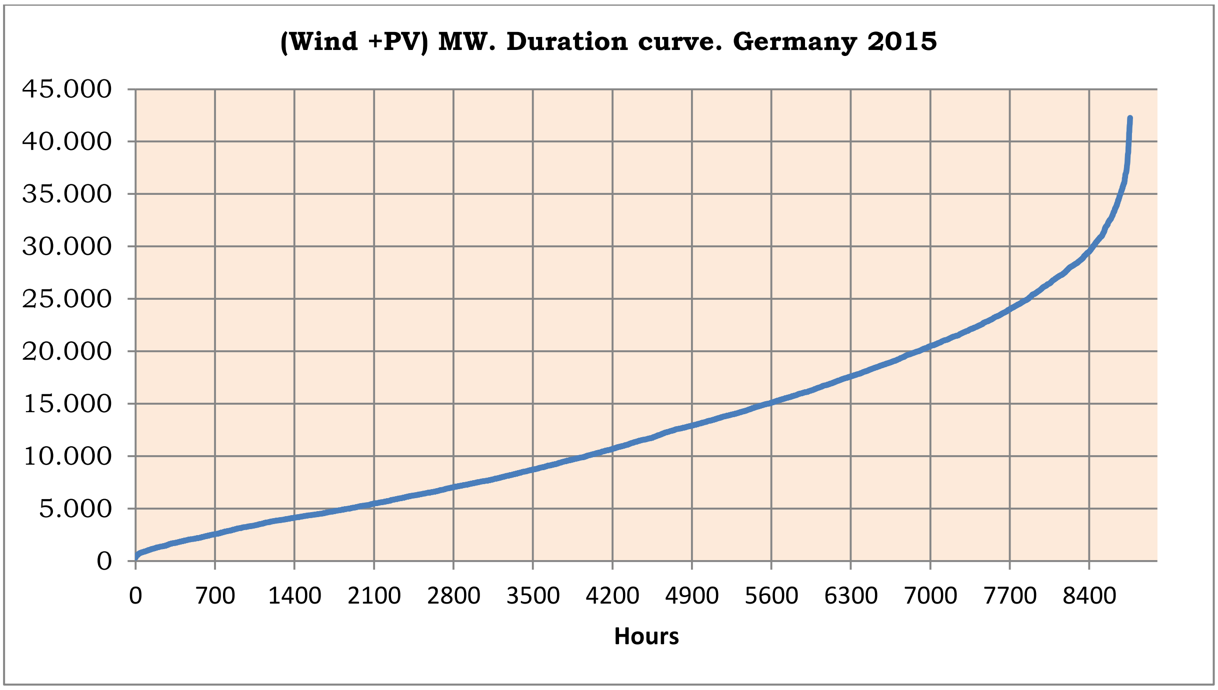
		Comparison Fraunhofer Estimate with Germany 2015						
		Fraunhofer Project/Estimate			Germany 2015			
		Wind	PV	Wind + PV	Wind	PV	Wind + PV	Load
Average	GW	75,1	28,1	103,2	8,8	4,0	12,8	54,6
Max	GW	*250*	*202*	*452,4*	32,6	25,5	42,3	76,2
Min	GW	*1,3*	*0,0*	*2,7*	0,2	0,0	0,3	31,7
Production per year	TWh	657	246	903	78	35	112	478
Production per year	PJ	2365	886	3251	279	126	405	1720
Installed capacity	GW	285	252	537,0	43,0	39,1	82,1	
Efficiency	W/kW installed	263	112	192	206	102	156	
Relation between Max and average		*3,7*	*6,4*	*3,3*	3,7	6,41	3,29	1,40
Relation between Min and average		*0,017*	*0,000*	*0,026*	0,017	0,000	0,026	0,6

In the table above The Fraunhofer estimate is compared with the German figures from 2015. (It should be remarked that the capacities for Wind and PV change all the time. The capacity data for Germany are from August 2015.)
The data written with red are extrapolated from the German data for 2015.

It is remarked that the estimate for wind efficiency is **263 W** output/kW installed, against 206 for Germany in 2015. The corresponding Danish figures for wind turbine efficiency is ca. **450 W/kW** for offshore turbines and **270 W/kW** for onshore turbines, so the Fraunhofer estimate is not unreasonable, considering that it operates with 200 GW onshore and 85 GW offshore capacity. With Danish efficiencies that would give an overall efficiency of ca. **325 W/kW** installed capacity.

But you may conclude that Germany is not very well suited for wind power, because the weather is much more pleasant than the always windy Danish.

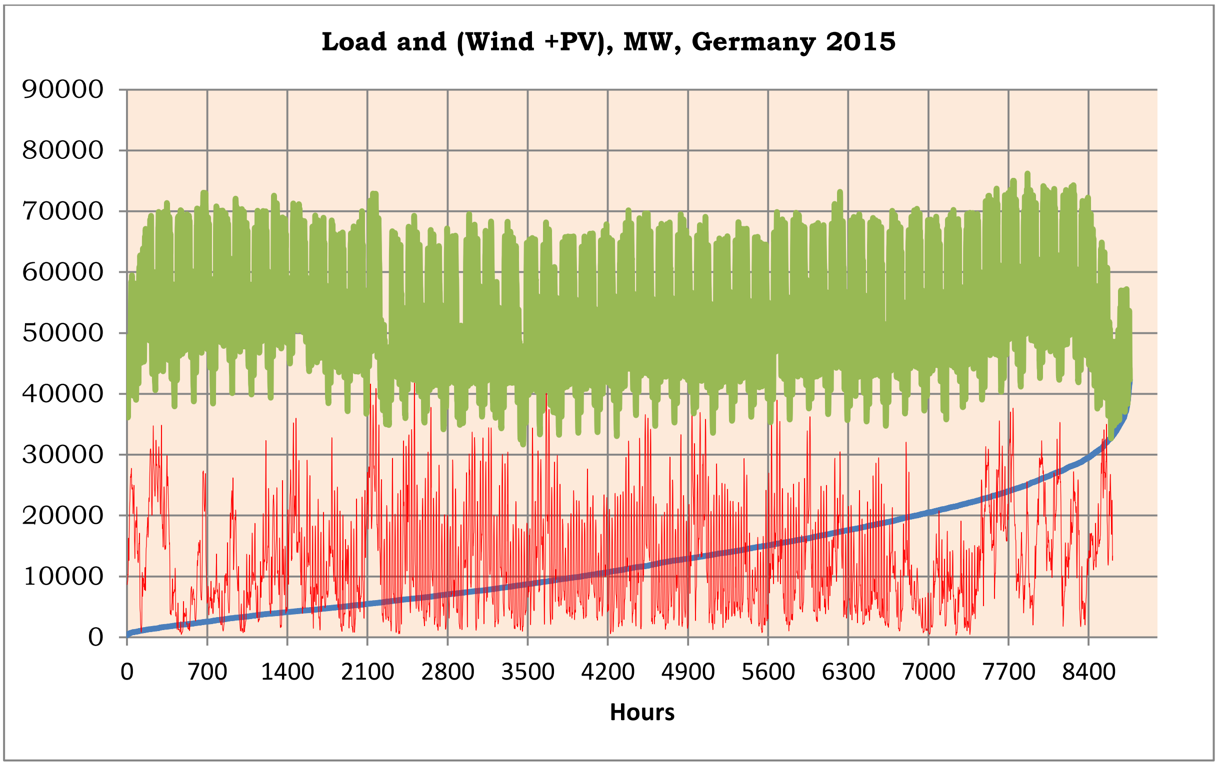
The Fraunhofer plan operates with a **pumped storage of 60 GWh**. The Vianden storage- the biggest in Europe- has a capacity of **5 GWh**. The German dam builders can look forward to golden times. And the lawyers and the courts too.



The graph above shows the distribution and Wind + PV power in Germany in 2015. It shows that in the first 2100 hours the power is less than 5000 MW and in 4900 hours less than the average of 12.800 MW.

There are 8760 hours in a year. In the last 360 hours the output is larger than 30.000 MW.

If you would skip the production larger than 30.000 MW you would loose about 1% of the produced power so in principle you don't need to care about the highest peaks in the production.



The Fraunhofer Institute proposes to double the green curve, load, and to multiply the red curve (Wind+PV) with 8, and let the red and the green curve fit together. A tremendous task.

This is illustrated by the table hereunder.

			Fraunhofer Estimate			Germany 2015	Denmark 2015		
			On shore	Off shore	Sum	Sum	On shore	Off Shore	Sum
Installed	Wind	GW	200	85	285	43,1	3,799	1,271	5,07
Production		GW	41	34	75	9	1,06	0,552	1,612
Efficiency		**W/kW**	**205**	**399**	**263**	**205**	**279**	**434**	**318**
Installed	PV	GW			252	39,1			
Production		GW			28	4,0			0,069
Efficiency		**W/kW**			**111**	**102**			
Sum PV+Wind		GW			103	13			1,681
		PJ			3251	405			53
Total Con-sumption		PJ			13335	13335			723
PV+Wind		**% of total**			**24,4**	**3,03**			**7,33**

The Fraunhofer Institute proposes to increase Wind + PV power by a factor 8. That would give Germany 24% of her present energy consumption, against the present value of 3 %.

The Danish PV and Wind represents 7 % of our energy consumption.

The author hopes to have shown that the Danish figure which is the highest in the World, at least among developed countries, has been possible only, because Denmark is a small country placed between neighbours with electricity systems about 20 times larger than the Danish system.
Germany can impossibly hope to be in the same situation. So the German “Energiewende” is according to our opinion doomed to remain a dream.

Nuclear Power.

Below is shown the capital cost for a new nuclear power plant in Turkey according to "World Nuclear News" April 15, 2015.

New Turkish Nclear Power Plant		
Investment	Mio €	20.000
Capacity	MW	4800
Efficiency		0,9
Real capacity	MW	4320
Production	GWh/year	37.152
Inerest rate	% p.a.	4,00%
Depreciation time	years	30
Capital cost	Mio €/year	1.157
Capital cost	**€/MWh**	**31,13**

And hereunder is shown the account for the nuclear power plant Forsmark in Sweden for 2015:

Forsmark Sweden 2015							
Production	GWh	21.100					
	MW	2.409					
Nominal capacity	MW	3.294					
Efficiency	**kW/MW**	**731**					
	%	SEK/ MWh	Mio SEK	DKK/ MWh	Mio DKK	€/M Wh	Mio €
Total cost 2015		**308**	**6499**	**247**	**5212**	**33**	**701**
Reactor fuel	15	46	975	37	782	5	105
Interest + depreciation	11	34	715	27	573	4	77
Funding future costs	14	43	910	35	730	5	98
Operation	33	102	2145	82	1720	11	231
Other	4	12	260	10	208	1	28
Effect tax	23	71	1495	57	1199	8	161
Sum	**100**	**308**	**6499**	**247**	**5212**	**33**	**701**
Minus effekttax		237	5004	190	4013	26	539
Minus Effecttax and capital		203	4289	163	3440	22	462
Capital cost for new nuclear plant		289		232		31	
Electricity price from new nuclear plant		**492**		**395**		**53**	

Forsmark had a capital cost in 2015 of 34 SEK/MWh and an effect tax of 71 SEK/MWh. If we withdraw those two costs and add the calculated capital cost 31€/MWh for a new power plant we get the shown prices for prices for a new power plant. However, the operation costs for a new plant ought to be lower than for an old plant.

Nuclear power does not present the back up problems we know from wind and PV. And nobody has ever heard of serious nuclear accidents from any of the countries referred to in this report. Even the old VVER reactors of Soviet origin are functioning well.