DANISH WIND POWER - HOW MUCH IS EXPORTED?

A note on the dispute between CEPOS and CEESA

Reel Energi Oplysning (Reliable Energy Information) -REO

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Statistics is like a streetlamp: not very illuminating - but good to lean against. Robert Storm Petersen

"I think the same people are travelling around, meeting each other and telling each other the same things all the time. I was waiting for someone to challenge their views, but this does not happen."
(Young participant in Workshop on Future Energy Systems, DTU-Risø, 2008, in talk with the author)

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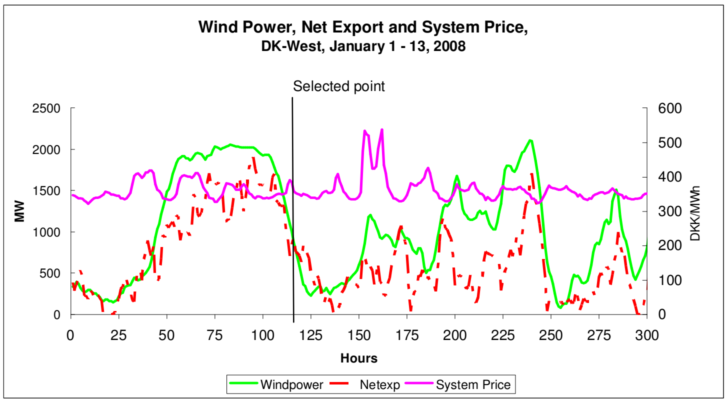
Summary

Why does Denmark export electricity?
This is the central point in the dispute between CEPOS and CEESA.
CEPOS says: Because we occasionally have overproduction of electricity, due to an excess of wind energy.
CEESA says: Because it is profitable.

In this note, REO shows that CEESA's arguments are based on selected data and are not valid.
An example:

CEESA argues as follows: On 5. January 2008 at 19.00 and on 10. March 2008 at 19.00, West Denmark produced approx. 1000 MW windpower. On 5. January there was export, and on 10. March there was no export. According to CEESA, the explanation is that the system price on 5.January was 386 kr/MWh, whereas the price on 10. March was only 234 kr/MWh. In the authors' own words :
Therefore, we infer that the reason for the difference between the two hours is the financial incentive for mainly the large power stations to produce (or not produce).

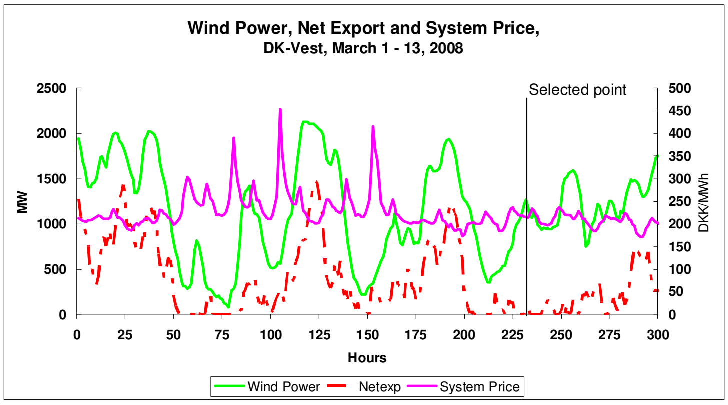
If one considers an interval around each of the two selected times, one arrives at a different result. The first Figure shows the situation in the period 1 - 13. January 2008. The chosen point is marked by a vertical line.



CEESA attributes the export at the point under consideration to the high system price. But this price is practically constant in the entire interval 0 to 150 hours. If CEESA's explanation was correct, there would have been export in the whole period. This is not the case. Export increased from 0 to approx. 1500 MW and fell to 0 in the interval 25 to 130 hours. In the same interval, windpower increased from 0 to 2000 MW and fell again to 0.

CEESA's view is not supported by data.

The next Figure shows the situation around 13. March. Here the chosen point is located in a relatively long interval practically without export. The system price varies in the first 200 hours. If CEESA's conclusion were correct, this should have affected export. This does not happen: the three maxima of the violet price curve do not coincide with export changes (red curve). On the other hand, the increased wind-power (green curve) before 50 hours and around 125 and 190 hours are accompanied by increased export. The data shown in the Figure therefore show a correlation between windpower and export and show no correlation between system price and export.



CEESA's argument is based on selected data and is incorrect. The data indicate that it is windpower that is exported.

Introduction

There is a lively debate between the think-tank CEPOS (CEnter for POlitical Studies) on the one hand and 14 researchers from Danish universities and research institutes on the other. The latter cooperate in the project: Coherent Energy and Environmental System Analysis, CEESA, and this acronym will be used in the following. CEPOS holds that about half the electricity produced by Danish wind turbines is exported. CEESA holds that only one percent is exported and the rest is consumed within the country.

This note looks more closely at CEESA's arguments. This will be done by an independent analysis of the same data. The data consist of statistics for the production of electricity from central and decentral power plants, wind turbines, exchanges with neighbouring countries and domestic consumption. All data are on a time axis and the power unit is MW. Data are available for the two independent grids – Denmark West and Denmark East. The most rational treatment is to consider the grids separately, as they are not connected electrically. (A HVDC-cable under The Great Belt will be ready in the course of 2010).

This note considers only Denmark West. All data are from Energinet.dk.

What is the disagreement about?

CEPOS argues that there is a correlation between the net export of electricity and the production of windpower. This means that when the production of windpower increases, export of electricity also increases. This leads CEPOS to conclude that it is windpower that is exported.[1]

The CEESA report rejects this conclusion by arguing as follows:[2]

1. CEESA accepts that net electricity and windpower are correlated. But CEESA finds that there is a similar correlation between net export and production from central power plants. Therefore one can just as well say that it is the power from central power plants that is exported. CEESA holds that the argument is wrong in both cases, as a statistical relation between two sets of values does not imply a causal relation.
2. CEESA holds that electricity is exported when it is economically attractive to do so.
3. CEESA points out that one can only speak about export of windpower when windpower production exceeds domestic electricity consumption. When windpower production exceeds the net export, both CEESA and CEPOS agree that the difference is consumed in Denmark. When the net export exceeds the windpower, CEESA holds that one cannot, by any statistical or physical method, determine whether it is windpower that is exported.
4. CEESA states that only experts with a deep knowledge of the intricacies of the market can evaluate how much power from a given source is exported. CEESA estimates that about 1% of wind turbine production is exported.

[1] http://www.cepos.dk/fileadmin/user_upload/Arkiv/PDF/Wind_energy_-_the_case_of_Denmark.pdf
[2] http://www.energyplanning.aau.dk/Publications/DanishWindPower.pdf

1. Statistical analyses

CEESA bases the first argument on the analysis of data for Denmark West in 2008. This means that 8784 data points are included in the analysis. The result is shown in Figures 1 and 2 in the report, reproduced here. All other Figures in this note have been prepared by REO.

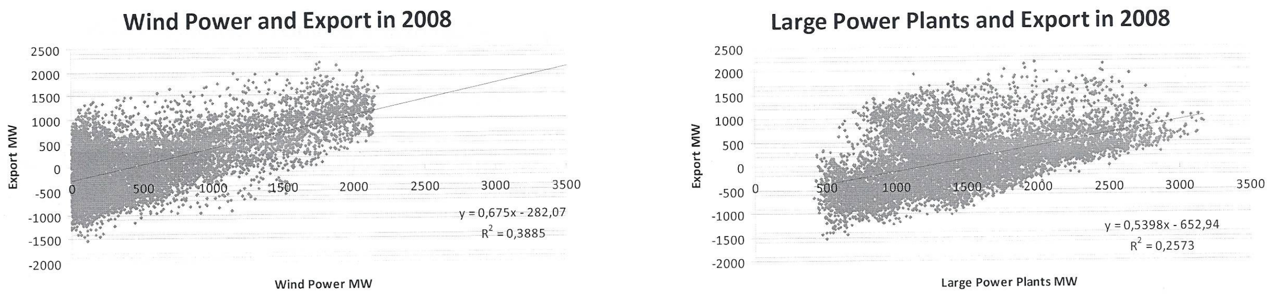


Figure 1. The two central graphs from CEESA's report.

Both Figures show a number of points and their regression line. Increasing production from both types of power plant are correlated with increasing export. Therefore – according to CEESA – one cannot determine which ”type” of electricity is exported.

In the CEESA report, the appendix gives the equations for the two regression lines : y = 0,675x - 282, R^2 = 0,3885 for windpower, and y = 0,5398x - 653, R^2 = 0,2573 for central power plants. The number preceding x is the slope of the line: the higher the number, the higher the correlation. R^2 is a measure of how well the data points follow the regression line. It is a number between 0 and 1; a high value means a good agreement between data and line.

If, instead of a whole year, one looks at a single month and uses the same method that CEPOS and CEESA have used, one sees Figures 2 and 3, which are for January 2008.

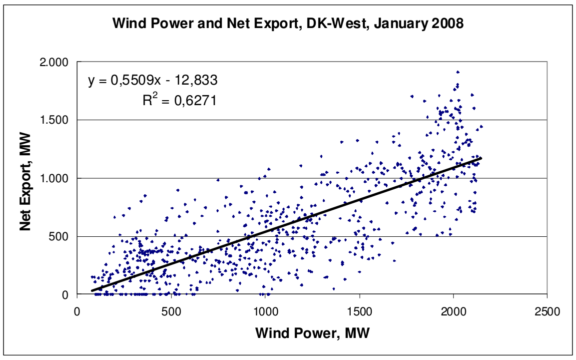


Figure 2: Plot of Windpower production and net export, January 2008

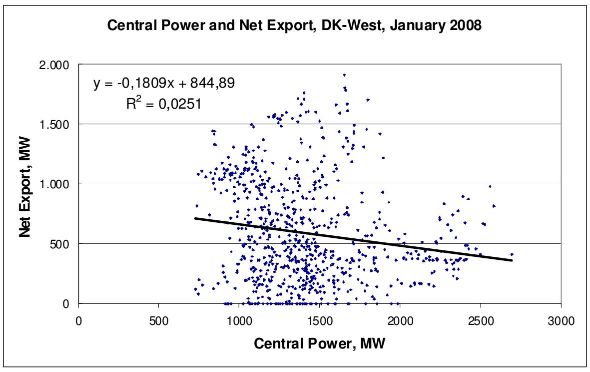


Figure 3: Plot af net export against production at central plants, January 2008.

Figure 2 shows that net export increases when windpower increases.

Data for January 2008 give a better linear correlation than for the whole year 2008 (R^2 = 0,627 instead of 0,3885), although it is less strong (slope 0,551 for January instead of 0,675 for the year).

Figure 3 shows that when production at central power plants increases, net export falls; the regression line is falling.

This is the opposite tendency to that claimed by CEESA for the whole year.

Conclusion 1

The result of the statistical analysis depends on the time interval used. CEESA has chosen to use a whole year. If one uses a month, one can obtain a different result!

Can one find a month in which the result supports CEESA´s argument?
The answer is yes. In Appendix 1 the analysis is shown for all the months of 2008. The 24 graphs show net export plotted against windpower production (on the left) and against central power plant production (on the right). The strongest support for CEESA’s argument appears in the graphs for April 2008, which are therefore reproduced here.

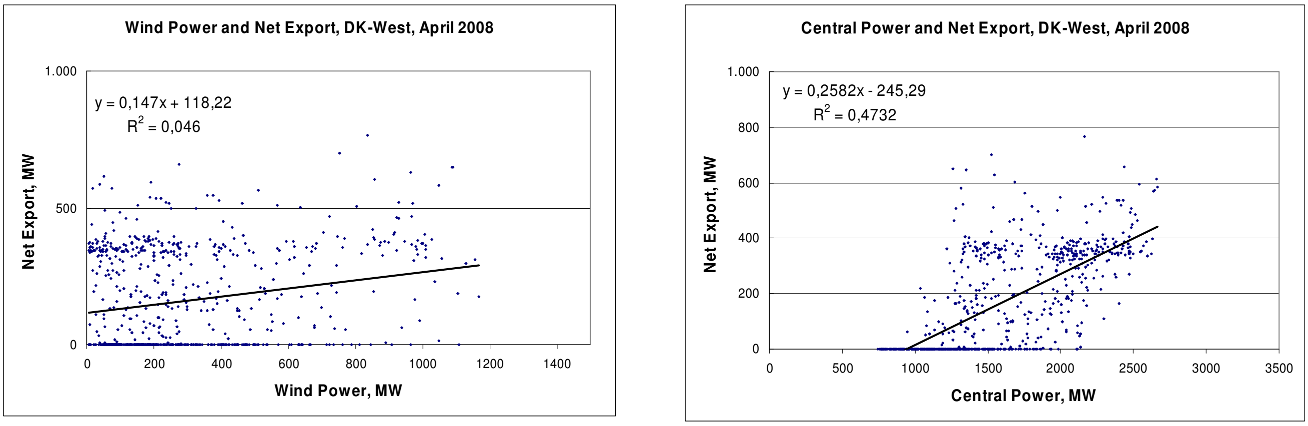


Figure 4. Analysis results for April 2008.

The regression line on the left-hand graph has a very weak slope, whereas the line on the right-hand graph is very steep. This shows a strong correlation between export and the production from central power plants.

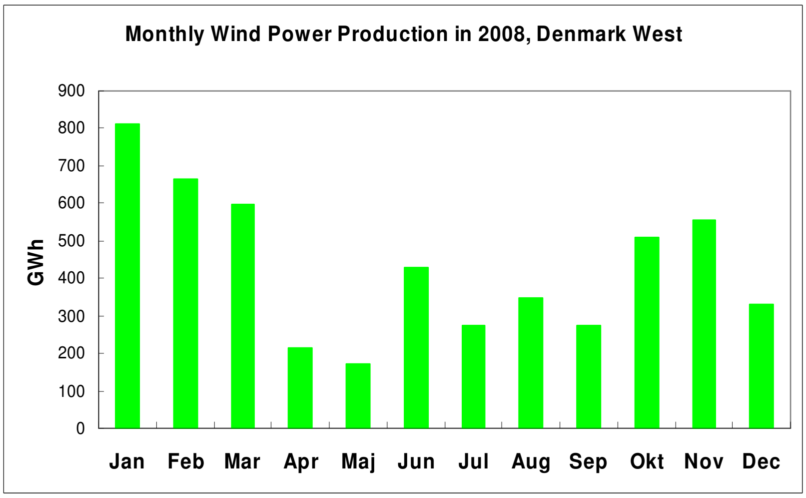


Figure 5. Monthly windpower production in 2008

Why this difference between months? A pointer to the answer is shown in Figure 5, which shows the monthly production of windpower for Denmark West. It can be seen that in the period April to September, windpower was weak, especially in April and May. The explanation of the weak correlation of windpower and net export in April is therefore that there was little wind-power to export. When our neighbours buy electricity in those months, it has to come from the central power plants.

What is the correct time-interval to use in the statistical analysis?

To answer this question, we first look at data for a single month.

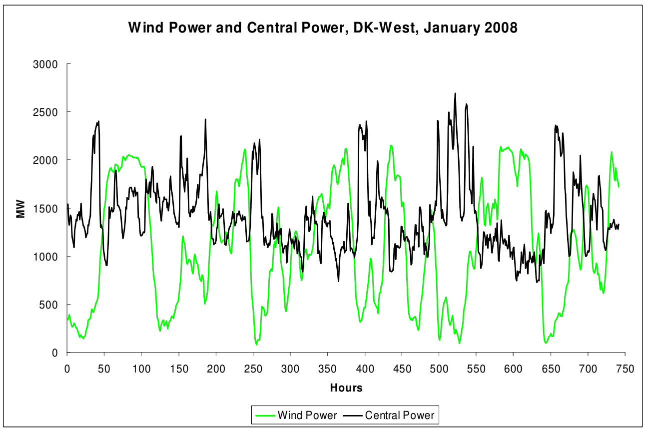


Figure 6. Production of windpower and central power, DK-West, January 2008

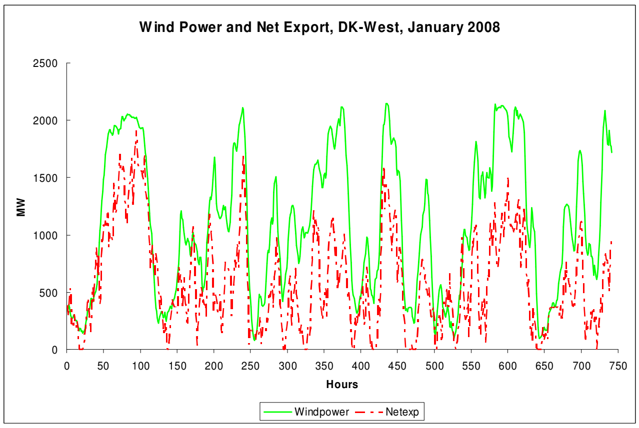


Figure 7. Production of windpower and net export, DK-West, January 2008

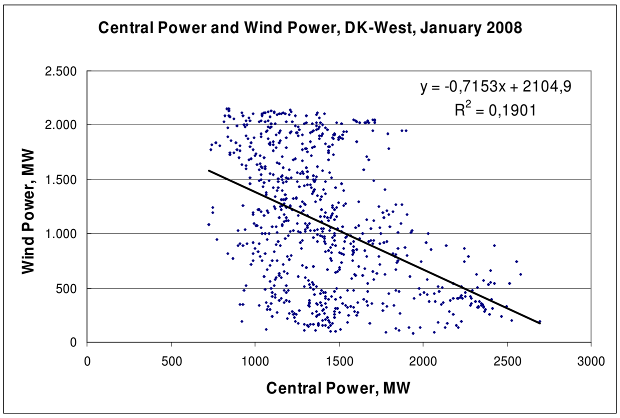


Figure 8. Windpower and central power.

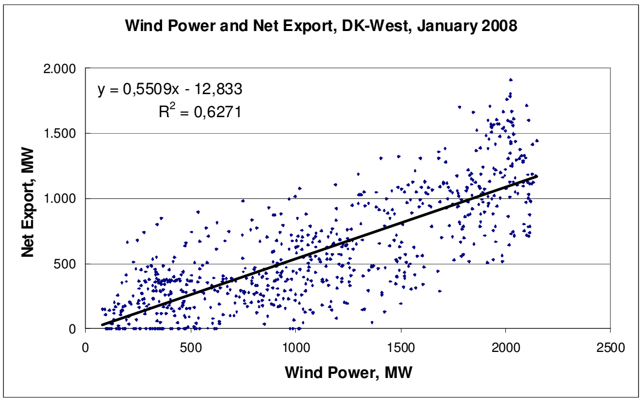


Figure 9. Windpower and net export (repeat of Fig. 2)

Figure 6 shows the production of windpower (green) and power from large power plants (black) for Denmark West in January 2008. It can be seen that peaks in the black curve frequently correspond to valleys in the green, and that green and black peaks are not simultaneous. Around 250 and 660 hours this is very clear. A statistical analysis (as above) of data on Figure 6 is shown in Figure 8.
The falling regression line reflects that the two curves in Figure 6 oscillate out of phase.

Figure 7 shows the production of windpower and the net export of electricity (red). Here it can be seen that the green and red curves have a tendency to coincide, even though they do not always oscillate in phase: high production of windpower often coincides with high export. The corresponding point diagram can be seen in Figure 9.
The rising regression line reflects that the two curves in Figure 7 oscillate in phase.

In the course of the month there are seven periods of 50 to 150 hours in which windpower increases from almost zero to a high level and back again (Figure 7). A statistical analysis must cover several of these variations to be meaningful: data values for a single hour or for a 24-hour period are generally meaningless. This indicates that a month is appropriate.

As there can be many irregularities in the electric system in the course of a year (Figure 5), an analysis that covers a whole year will not be of interest; many different phenomena (seasonal variation, abnormal weather, technical breakdowns, etc.) would be mixed together.

If two curves oscillate in phase (Figure 8) – or out of phase (Figure 7) – this does not necessarily prove a causal relation. But if this tendency appears year after year, there is good reason to suspect a causal relation.

Possible interpretations of the correlations shown in Figures 6 and 8, and in Figures 7 and 9:

a) Figure 6/8: When the wind blows up, the central plants reduce their output, and when the wind drops, the central plants increase their output.

b) Figure 7/9: The central plants cannot reduce their output to a low level for technical reasons. If the production of windpower exceeds the possible reduction of central plant output, export of electricity is necessary.

These two interpretations are parallel. If one of them is correct, then the other is also.

But CEESA rejects interpretation b); as the report, in its reference to the graphs reproduced in Figure 1 states:

Accordingly, one could use more or less the same argument for large power plants as for wind power. In both cases, however, the argument would be wrong. The causal relation behind export is more complex and involves understanding market mechanisms and cost implications of the various power suppliers on the Nordic grid.

This means that interpretation a) of the statistical analysis of Figure 8 is also rejected. This is unfortunate, as this interpretation explains why Danish wind turbines save coal in the central plants.

Conclusion 2

CEESA does not accept that a statistical analysis of grid data can show a causal relation between windpower production and export!
A parallel analysis shows that central power plant production is cut back when the wind blows up. This results in a saving of coal in Denmark.
Is this analysis also wrong?

Electricity price and export

CEESA has a completely different explanation of the cause of electricity export.

To establish a causal relation, one has to examine WHY the Danish energy system ends up exporting or importing electricity. Such causal relation has to do with the functionality of international (Nordic) electricity markets and how the independent power generators respond to price incentives. Most export is generated in power plants for the simple reason that it is financially attractive for the Danish power producers to generate power and sell it on the international power market. (p. 11-12)

CEESA bases this explanation on the comparison of two data points in two different months. One is 5. January 2008, 1900 hrs., the other is 10. March, 1900 hrs. Figure 3 in the CEESA report shows el-system data for the two points, together with the system prices. This was 386 dkkr/MWh on 5. January and 234 dkkr/MWh on 10. March. In both cases windpower production was approx. 1000 MW, but in January – and not in March – there is export. The whole argument is as follows:

However, if we look at Fig. 3 and examine the contribution of the different generators, it is clear that large power stations generated much more electricity in the January situation than in the March situation. In both situations, wind power production was about 1000 MW as mentioned. Therefore, we infer that the reason for the difference between the two hours is the financial incentive for mainly the large power stations to produce (or not produce). The price on the Nord Pool international electricity market was only 234 DKK/MWh on March 10th and substantially higher on January 5th, namely 386 DKK/MWh. Consequently, the power stations make a profit on exporting in January but not in March. (p. 12-13)

Let us consider the situation in an interval around the two chosen points.

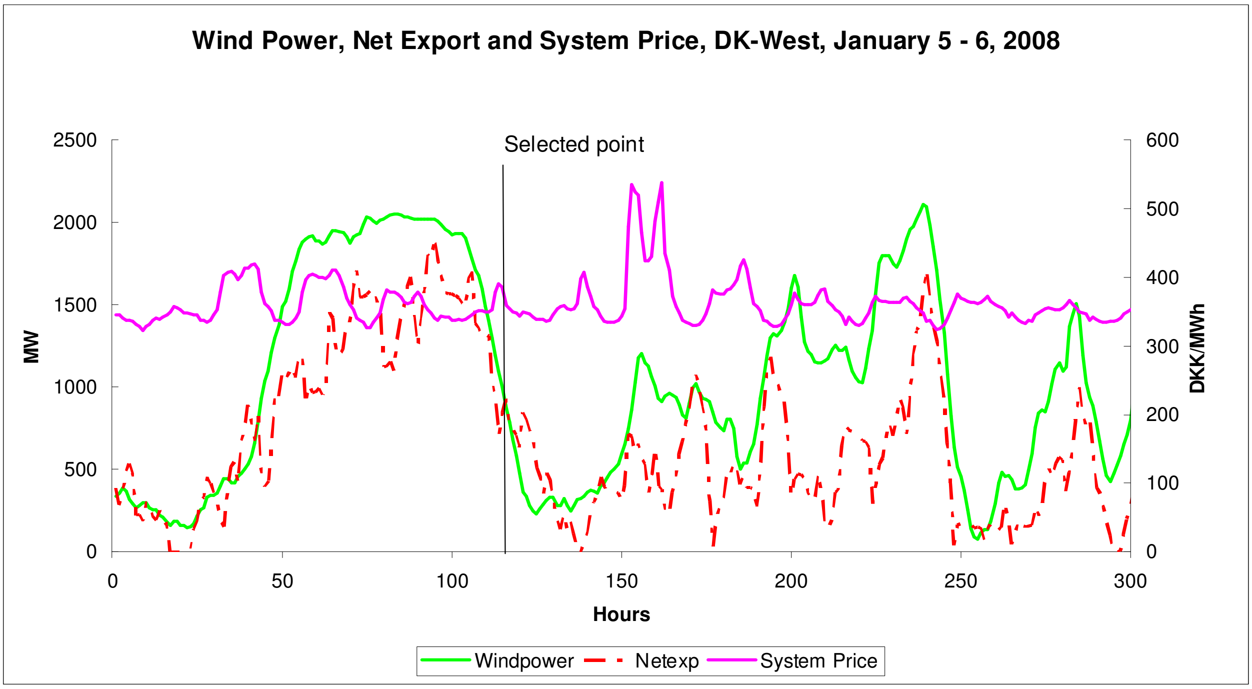


Figure 10. The region around the point in January 2008 that CEESA chose to consider.

Figure 10 shows the situation around the first point. According to CEESA, the export at the chosen point is due to the high system price (compared to March). This view is incompatible with the fact that export fell in the following 20 hours, even though the system price was unchanged.

In the 70 hours prior to the point, export increased from zero, **simultaneously with the wind-power, but at the chosen point it is declining, simultaneously with the windpower.** This strongly indicates that it is the windpower that is exported.

The interval around the next chosen point is shown in Figure 11.

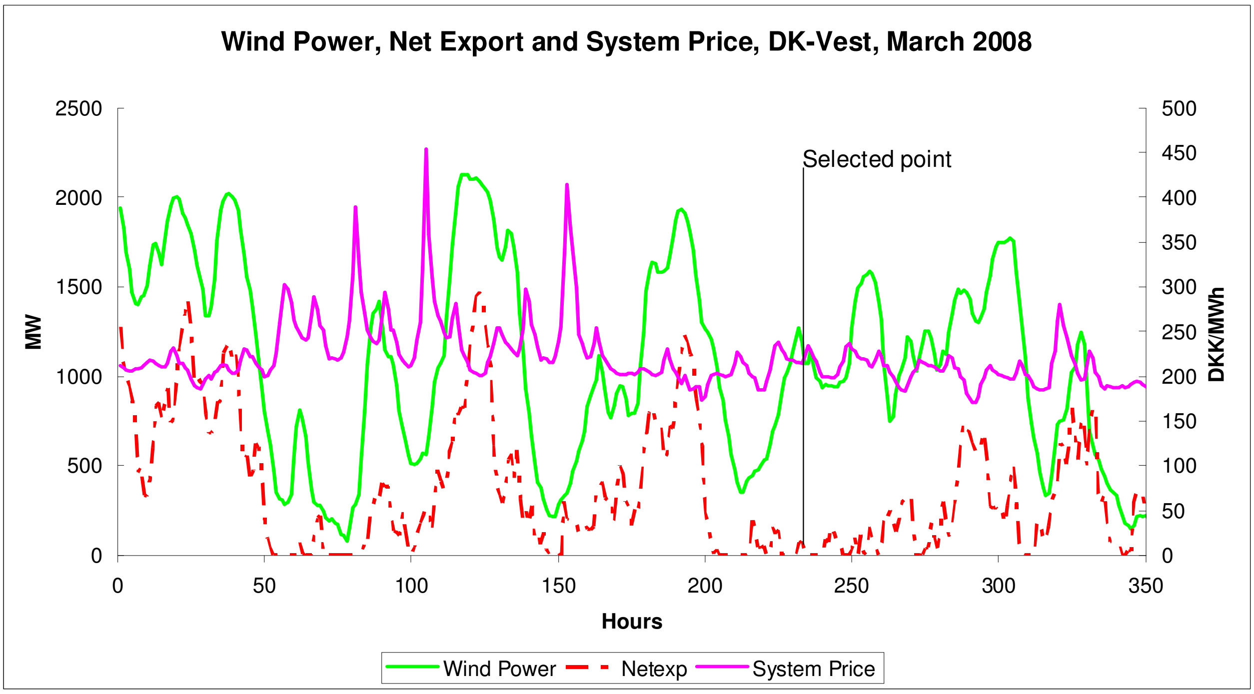


Figure 11. The region around the point in March 2008, that CEESA chose to consider.

It can be seen that the chosen point is located in a lengthy interval (70 hours) with little or no export, and in which the windpower produced was undoubtedly used in Denmark. However, Figure 11 shows a variation in the system price, not found in Figure 10. It will therefore be investigated whether there is a correlation between the system price and the net export.
Figure 12 plots data from Figure 11.

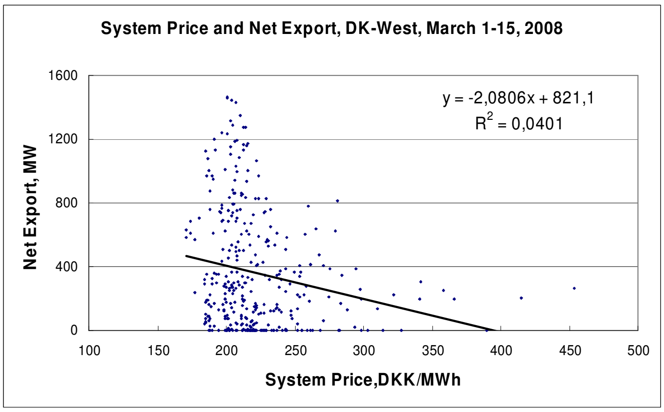


Figure 12. Price and net export corresponding to Figure 11.

It is clear that there is a negative correlation: when the system price rises, export falls.
This **is contrary to CEESA's conclusion:**

Therefore, we infer that the reason for the difference between the two hours is the financial incentive for mainly the large power stations to produce (or not produce).(p. 12-13)

Conclusion 3

CEESA selects two data points and draws wide-ranging conclusions from them. A consideration of an interval around the selected points gives a different result.

CEESA then considers (Figure 4 in the report) the situation on 14. June 2008, when around midday there was export for a few hours when the system price passed a maximum. This export occured simultaneously with an increase in the production at central and decentral power plants when the wind was impudent enough not to begin to increase until several hours later. The report states:

Fig. 4 is even more effective at illustrating the 'causality' of energy production causing export from wind power and power plants.(p. 13).

This is a wide-ranging conclusion, based on a special situation of limited duration. In the course of the morning of 14. June, export to Germany increased from 350 MW to almost 1300 MW, then declined to approx.800 MW and disappeared before midnight. It was this extraordinary demand that caused the system price to rise for a few hours. (On this day the Brokdorf nuclear power plant on the Elbe was closed down due to the annual inspection).

3. CEESA's remaining considerations on the export of electricity

The CEESA report has this to say on the year 2008:

During a few hours, the wind power production exceeded the demand and the excess production was exported. However, this happened in only 43 hours and the total excess production being exported was as low as 5 GWh, equal to less than 0.1 percent of the wind power production (or less than 0.02 percent of the demand). (p. 14)

It continues:

In other hours, there were either no export at all or the wind production exceeded the export. In such hours, the share of wind production which exceeded the export would have to be used domestically – no other outlet for this wind power exists. In 2008, this domestically used production was as high as 4,398 GWh equal to 63 percent of the wind power production (or approx. 12 percent of the demand). It should be noted that this number only includes the share that exceeds the export.(p. 15)

This refers to the situation dominant in Figure 7: the production of windpower exceeds the net export (green curve above red). CEESA claims that the difference was used in Denmark and that this was the case for 63% of of the windpower produced in Denmark in 2008.

Tabel 1 Vestdanmark	
"Januar 2008	
	GWh
Vindkraft	814
Netto eksport	431
Differens	383

This can be illustrated by data for January 2008, shown in Table 1. If one imagines a situation in which all connections to other countries were broken and all wind turbines stopped, the other Danish power plants would have to produce an additional 383 GWh if consumption in Denmark is to be unchanged. Similarly, power plants in other countries would have to produce an additional 431 GWh for their customers. It is therefore reasonable to say that 383 GWh of the total of 814 GWh wind energy was consumed in Denmark. This corresponds to 47%, so that 53% was consumed abroad.

This does not agree with the CEESA report, which evaluates the export of wind energy for the whole year at 61 GWh (p. 19). CEESA states in the citation above that when the green curve is above the red (Figure 7), the difference is consumed in Denmark. This amounts to 383 GWh. But according to CEESA, one can say nothing about the rest of the 814 GWh produced, except to assume that it is consumed in Denmark. Otherwise one cannot come down to the value of 61 GWh for the exported wind energy for the whole year.

Furthermore, the CEESA report states:

Consequently, one can say for a fact that a minimum of 0.1 percent of the Danish wind power production in 2008 was exported and a minimum of 63 percent was used in Denmark.
With regard to the remaining 36.9 percent, one cannot conclude anything from a purely technical, physical or statistical point of view as illustrated before.

If 63 % of the produced wind energy is used in Denmark, what happens to the other 37%? CEESA concludes that nothing can be said about it. They support this by their statistical analysis of data for the entire year 2008, which has been shown above to be implausible (see conclusions 1 and 2). When the net export exceeds the wind energy production, one cannot – according to CEESA –say anything at all. Here is an example. Figure 13 shows for December 2008 a graph corresponding to Figure 7. Here the situation is somewhat different, as there is a substantial export from the beginning of the month (the red curve is above the green). So here it must be the central plants that produce for export. It is this situation that is not covered by CEESA. According to CEESA, one cannot say anything about what is exported in this situation: *(one cannot conclude anything from a purely technical, physical or statistical point of view as illustrated before.)*

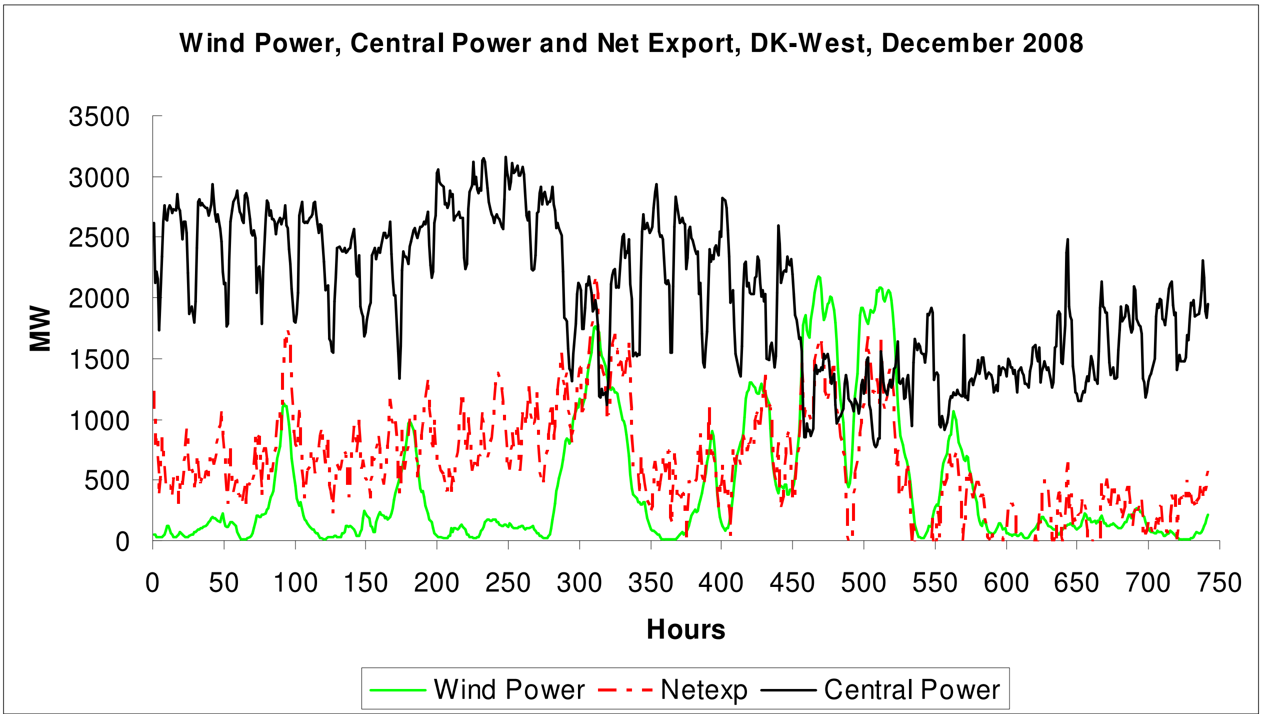


Figure 13. Windpower, central power, and net export, Denmark West, December 2008.

We first consider the interval 3.-5. December (49 to 120 hours from the beginning of the month.). In this period the wind blows up, and then subsides. A non-statistical analysis (look at the first green peak on the graph) shows that the export, already begun, increases further simultaneously with the increasing production of windpower. A plot of the relevant points can be seen in Figure 14.

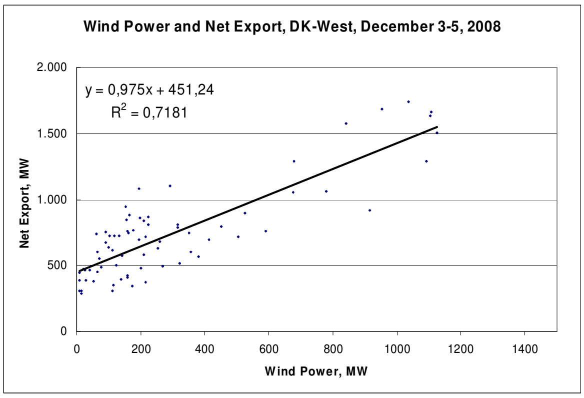


Figure 14: Plot of net export and windpower, based on 3 days in December 2008.

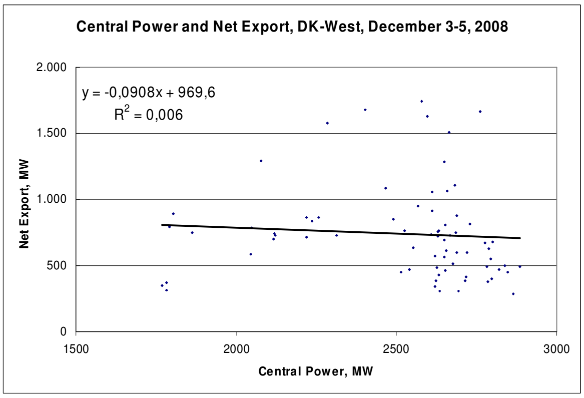


Figure 15: Plot of net export and central power, based on 3 days in December 2008.

Figure 14 shows a high correlation between net export and windpower. This means that the red and the green peaks at about 100 hours on Figure 7 coincide, which is obvious at a glance.

Figure 15 shows that when power production at central plants increases, net export declines. Here the correlation is very low (R^2 close to zero).

This analysis shows that it is possible to analyse data even though the net export exceeds wind-power production – contrary to CEESA's view. Figure 14 provides strong evidence for the conclusion that it is windpower which is exported. If anyone is skeptical about statistical methods, look at Figure 13 just before 100 hours – and use common sense.

This type of case is treated in an analysis of windpower in Denmark's electricity supply, carried out by REO in 2007[3], but it did not attract much attention. In this analysis an advanced method is used: windpower consumed in Denmark is equal to windpower production minus the net export (when the result is positive). In other cases (such as in December 2008, considered above), the correlation between the two variables is investigated at 12-hour intervals. On the basis of the correlation coefficient it is decided whether the windpower can be considered as consumed in Denmark in whole or part, or whether it was exported. Figure 16 shows the result of the analysis applied to December 2008. It can be seen that around 300 hours, half the windpower is consumed in Denmark, even though windpower and export are practically equal. This is due to the absence of correlation of the two variables over a period of 12 hours. It is clear that even when wind turbine power is exported, wind turbines replace coal in the other power plants. This is why wind turbine energy is used in Denmark. (See also: Bertel Lohmann Andersen. Analysis of wind power in Danish electricity supply, 2005-2007, *Int. J. Nuclear Governance, Economy and Ecology*, Vol. 3, No. 2, 2010, www.inderscience.com)

[3] http://www.reo.dk/ Click on REO's publications/reports

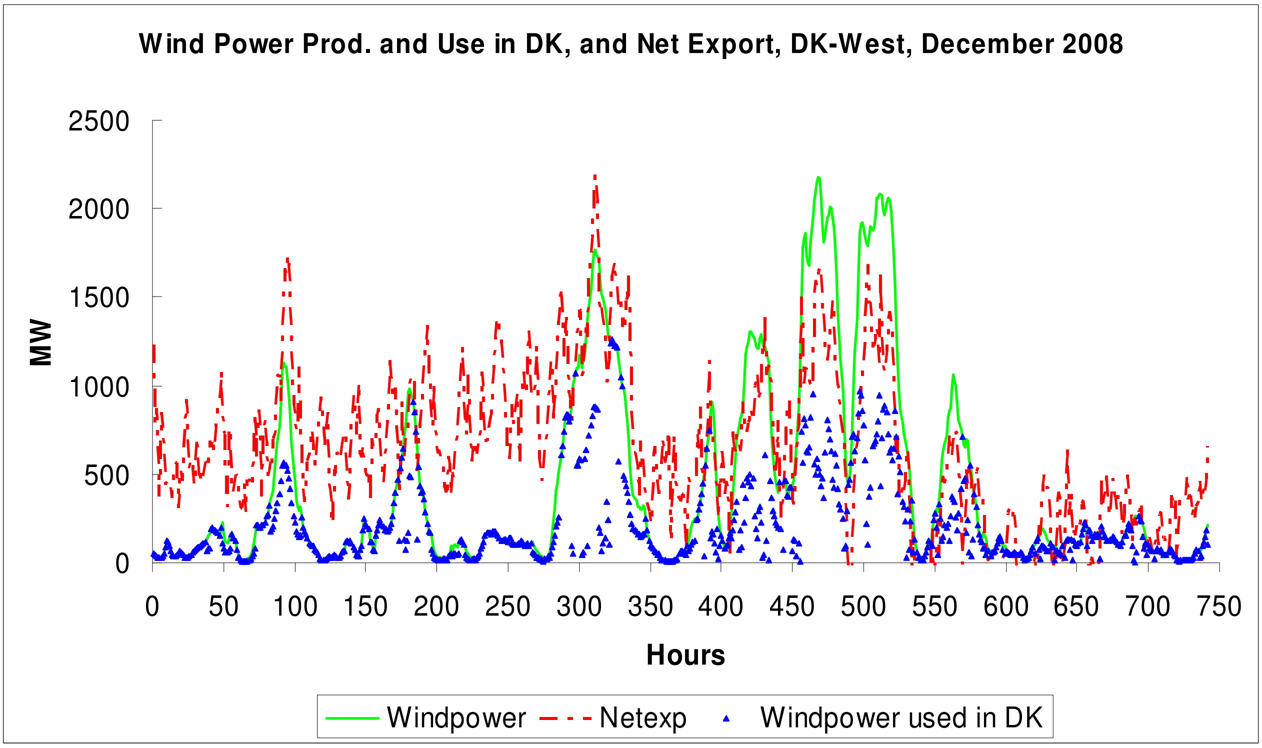


Figure 16. Production and internal consumption of windpower, and electricity export, DK-West, December 2008

CEESA's evaluation of how much wind energy is exported is based on a consideration of the Nordic electricity system that is incomprehensible to the layman.

The CEESA report states:

One has to establish a causal relation, which can be found by observing the market mechanisms of international electricity markets. Such observation leads to the conclusion that the production of the last unit of electricity comes from the units with the highest short-term marginal production costs, and consequently the wind export in 2008 was only 61 GWh equal to approx. 1 percent of the wind power production (or less than 0.2 percent of the demand).(p. 20-21)

It is remarkable that one can base the export of electricity from sources that vary greatly within a few hours on marginal costs (*short-term marginal production costs)* alone. Is it the marginal costs that determine production, or is it the uncontrollable production (windpower) that determines the marginal costs? What role do they play under the above-mentioned technical conditions a) and b) ? At all events, the stated figure of **61 GWh is not the result of an analysis comprehensible to the reader.**

We are thus in a situation that what ordinary people can see with their own eyes in Figure 7 and similar Figures:

That electricity is often exported when windpower production is high, and that there is a causal relation between windpower and export,

is incorrect according to CEESA. Apparently it is only experts with a profound knowledge of the electricity market who can explain electricity exports.

4. Results for Denmark-West, 2008

Using the method described above (footnote 3), the fraction of the generated wind energy consumed in Denmark can be calculated. Table 2 shows the result for each month in 2008. The figures in column 4 are those shown in Figure 5.

Column 10 shows the fraction of wind energy in the total consumption in West Denmark. The lowest was 8.4% in December, and the highest 21% in February. Wind energy production in January corresponded to 40% of consumption, and the lowest was in May with 10%.

The result for the whole year was that wind energy production accounted for 24% of consumption and wind energy consumption for 15.4%.

All data apply to West Denmark, which has more windpower capacity than East Denmark.

Tabel 2. Vestdanmark 2008										
								Vindkraft		
	Cen	Decen	Vind	Imp	Input total	Export	Elorbrug	forbrugt i DK		produk-tion
	GWh	GWh	GWh	GWh	GWh	GWh	GWh	GWh	% af elforbug	
1	2	3	4	5	6	7	8	9	10	11
Jan	1053,1	598,8	813,6	390,2	2855,7	821,0	2034,7	403,7	19,8	40,0
Feb	964,4	520,3	665,3	522,5	2672,5	800,5	1872,0	393,7	21,0	35,5
Mar	999,9	497,1	598,9	574,3	2670,1	784,8	1885,2	390,4	20,7	31,8
Apr	1136,1	433,4	215,4	795,0	2580,0	831,2	1748,8	164,6	9,4	12,3
Maj	948,8	319,5	173,4	724,2	2165,9	452,3	1713,2	165,3	9,6	10,1
Jun	920,5	267,6	430,6	613,9	2232,6	546,7	1685,9	339,3	20,1	25,5
Jul	735,4	274,0	274,2	877,0	2160,6	562,6	1598,0	253,5	15,9	17,2
Aug	694,2	240,0	348,9	743,1	2026,2	319,9	1706,3	341,6	20,0	20,4
Sep	963,4	311,0	274,6	790,4	2339,4	618,6	1720,8	228,8	13,3	16,0
Okt	1237,4	399,4	509,6	656,1	2802,6	954,9	1847,7	249,0	13,5	27,6
Nov	1379,8	488,5	556,7	495,7	2920,8	1035,5	1885,2	236,7	12,6	29,5
Dec	1495,8	578,7	331,5	541,4	2947,4	1023,2	1924,2	162,2	8,4	17,2
Year	12528,7	4928,2	5192,8	7723,9	30373,7	8751,1	21622,1	3328,8	15,4	24,0
Resultat for Vestdanmark 2008. Kolonne 10 viser vindkraftens andel af elforbruget.										

The higher the production of wind energy, the more difficult it becomes to integrate it into the Danish grid. This is clearly shown by plotting production (column 11) on the x-axis and internal consumption on the y-axis (Figure 17).

This is consistent with the results for 2005, 2006 and 2007, shown in Figure 18.

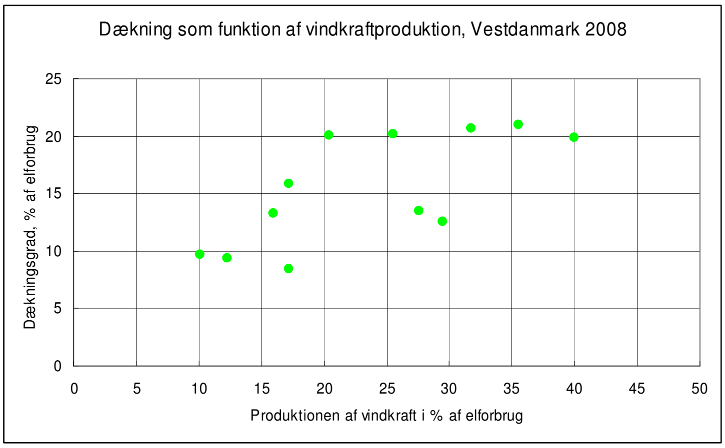


Figure 17. Consumption and production, Denmark-West, 2008

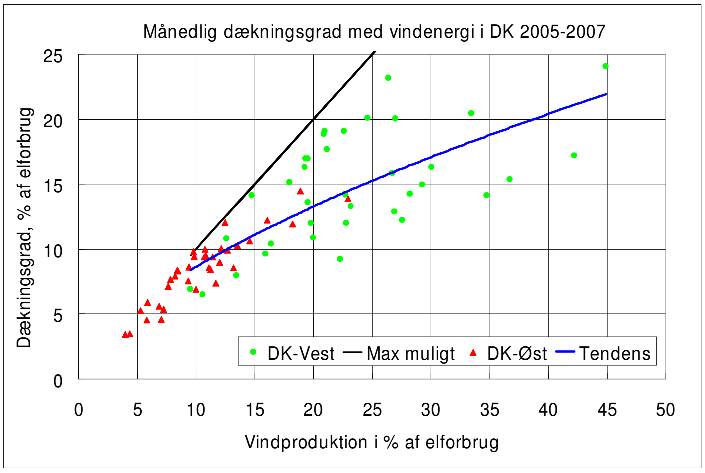


Figure 18. Consumption increases more slowly than production.

In January 2008 the production of wind energy in West Denmark corresponded to 40% of total electricity consumption.

If CEESA is correct in concluding that max. 1% of the wind energy produced in 2008 was exported, it follows that the wind energy consumed in January in Denmark-West amounted to 40% of total consumption. A colossal achieve- ment!

Conclusion

In the past few years, the contribution of wind energy to electricity consumption in Denmark has been the subject of controversy. Officially, wind energy covers 20% of domestic consumption. In 2007, REO published an analysis of windpower in Denmark's electricity supply for 2005 and 2006. It showed that windpower in the two years covered 13.6% and 10.3% respectively of domestic consumption. In 2009 a report from CEPOS came to a similar conclusion. This report also covered the economic aspects. A group of 14 Danish researchers contributed to a CEESA report in 2010, in which the above-mentioned conclusions were rejected. The CEESA report was presented on the TV News on 25.February, 21.00.

In the present note it is shown that the conclusions of CEESA on a number of points are erroneous.

- CEESA's results are based on a statistical analysis of all data in 2008. Due to the great variation in windpower in the course of a year, this gives a significantly different result from an analysis of a single month.
- CEESA bases a conclusion on data for a certain hour on two dates. Analysis of data for an interval around the chosen points gives a greatly different result.
- CEESA states that a thorough analysis of the electricity market leads to the conclusion that approx. 1% of the wind energy produced is exported.

The different interpretations of Denmark's electricity supply is illustrated by the following two Figures, which apply to the case in which windpower exceeds the net export.

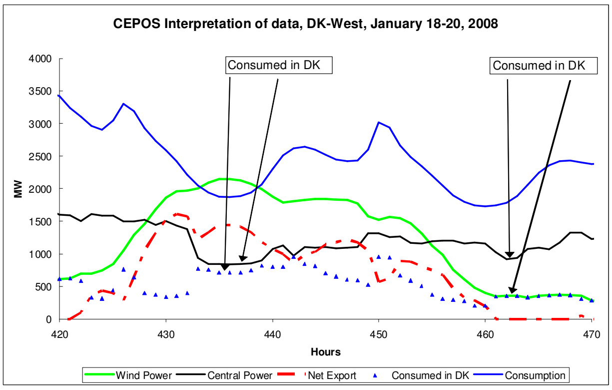


Figure19. CEPOS's interpretation of electricity supply.

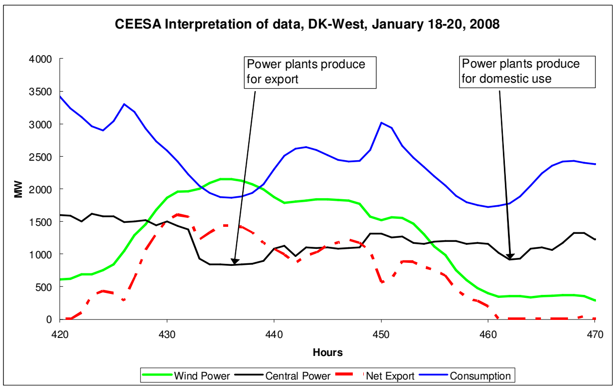


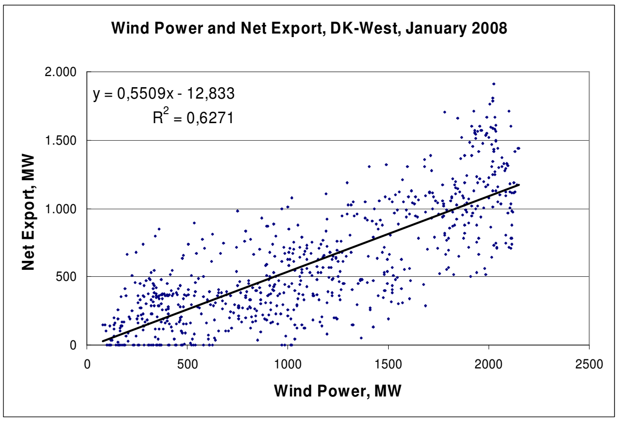
Figure 20. CEESA's interpretation of electricity supply.

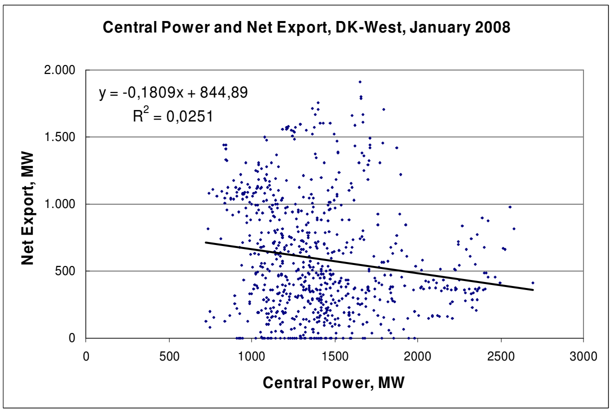
REO and CEPOS take the view that Denmark's electricity supply is covered by the production from central and decentral plants plus windpower minus net export. The exported electricity, according to this view, is in many cases produced by wind turbines, as net export and windpower are strongly correlated.

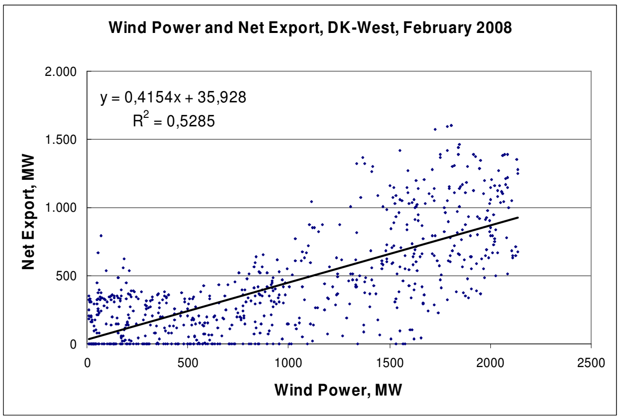
CEESA takes the view that windpower is primarily produced for the domestic market. The interpretation of the central plants' production can therefore change from day to day, as shown in the right-hand Figure: for about 435 timer the central plants produce for export, as domestic consumption is fully covered by wind-power. About 30 hours later the central plants have the same output – but now it is entirely for dome-stic consumption. The consequences this can have for the operators at the central power plants are unknown.

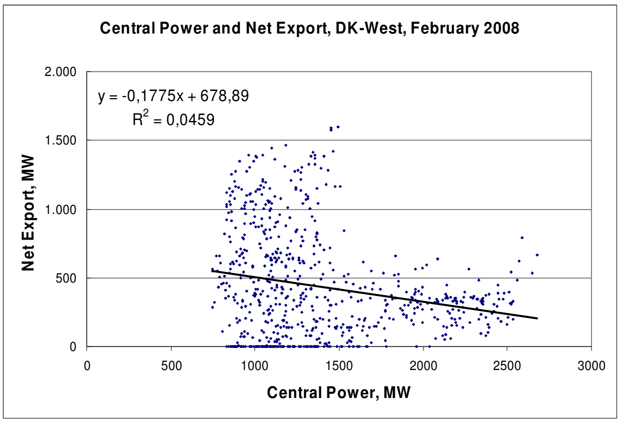
Regardless of whether 12% or 20% of domestic consumption in Denmark is covered by windpower, Denmark is a leading country in the windpower sector. This is something we can all be proud of. But with regard to future development it is important that public opinion be based on reality.

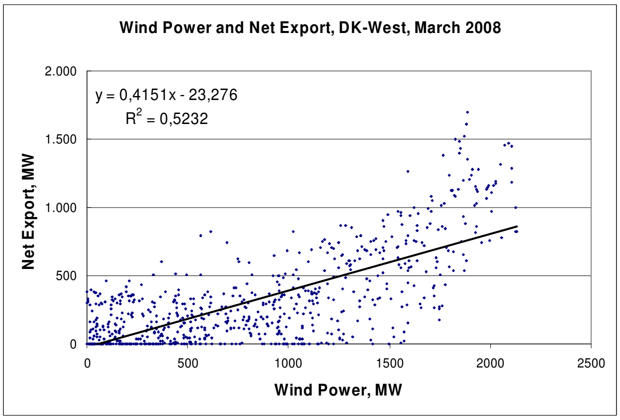
Appendix 1

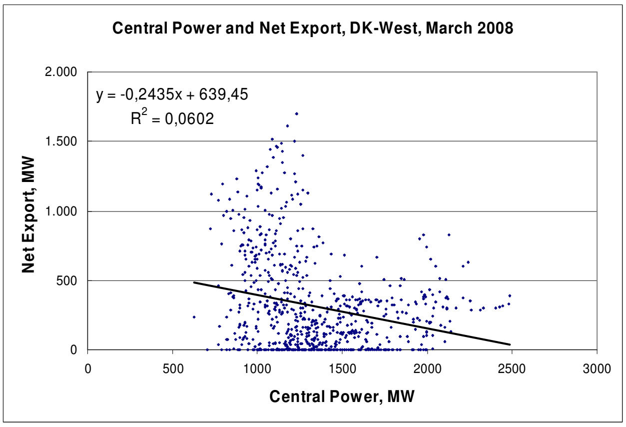

Wind Power and Net Export, DK-West, January 2008
y = 0,5509x - 12,833
R^2 = 0,6271
Net Export, MW
Wind Power, MW
2.000
1.500
1.000
500
0
0
500
1000
1500
2000
2500

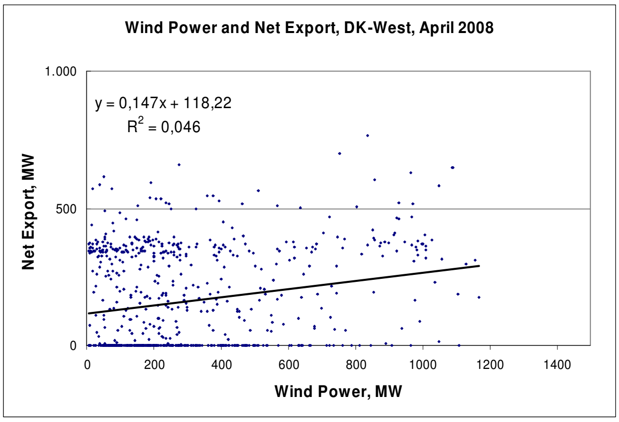

Central Power and Net Export, DK-West, January 2008
y = -0,1809x + 844,89
R^2 = 0,0251
Net Export, MW
Central Power, MW
2.000
1.500
1.000
500
0
0
500
1000
1500
2000
2500
3000

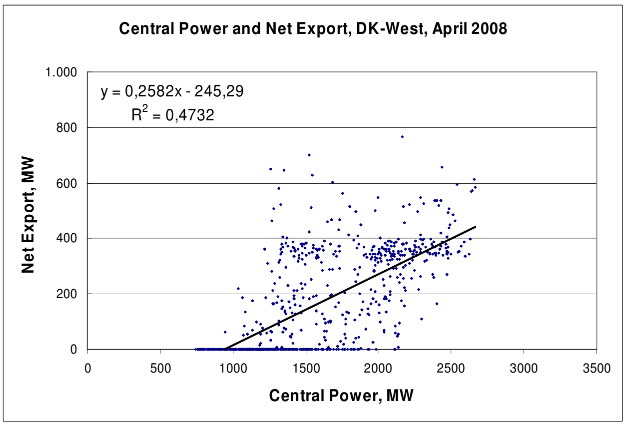

Wind Power and Net Export, DK-West, February 2008
y = 0,4154x + 35,928
R^2 = 0,5285
Net Export, MW
Wind Power, MW
2.000
1.500
1.000
500
0
0
500
1000
1500
2000
2500

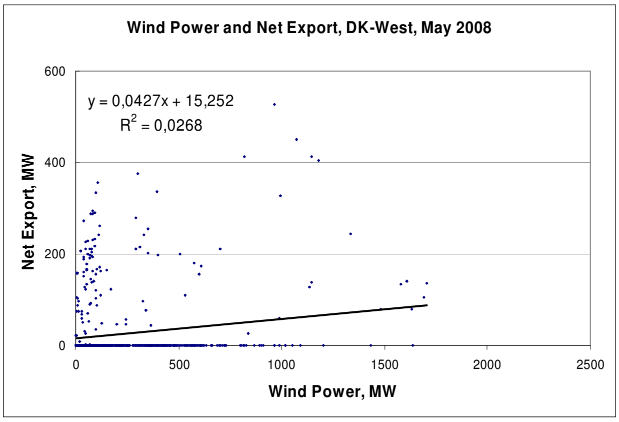

Central Power and Net Export, DK-West, February 2008
y = -0,1775x + 678,89
R^2 = 0,0459
Net Export, MW
Central Power, MW
2.000
1.500
1.000
500
0
0
500
1000
1500
2000
2500
3000

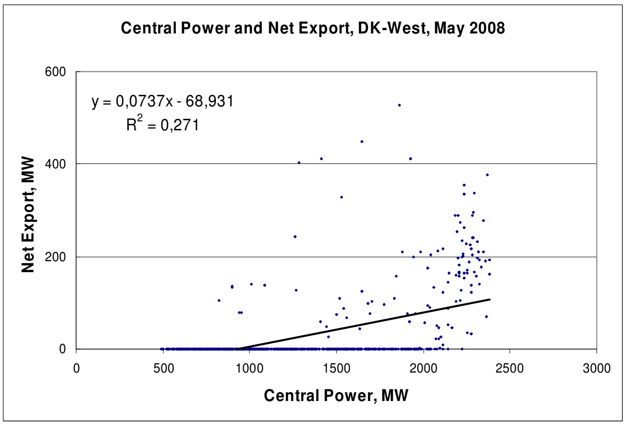

Wind Power and Net Export, DK-West, March 2008
y = 0,4151x - 23,276
R^2 = 0,5232
Net Export, MW
Wind Power, MW
2.000
1.500
1.000
500
0
0
500
1000
1500
2000
2500

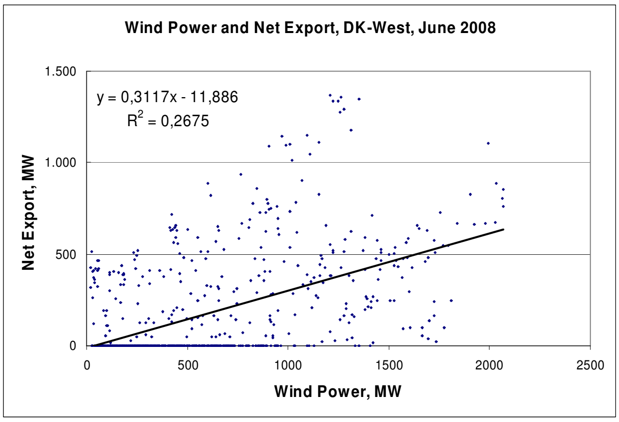

Central Power and Net Export, DK-West, March 2008
y = -0,2435x + 639,45
R^2 = 0,0602
Net Export, MW
Central Power, MW
2.000
1.500
1.000
500
0
0
500
1000
1500
2000
2500
3000

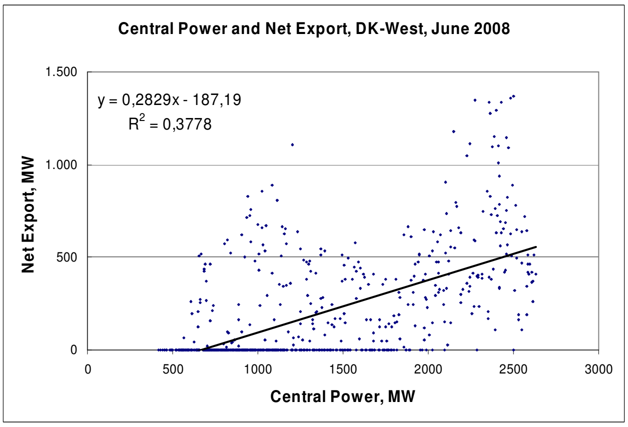

Wind Power and Net Export, DK-West, April 2008
y = 0,147x + 118,22
R^2 = 0,046
Net Export, MW
Wind Power, MW
1.000
500
0
0
200
400
600
800
1000
1200
1400

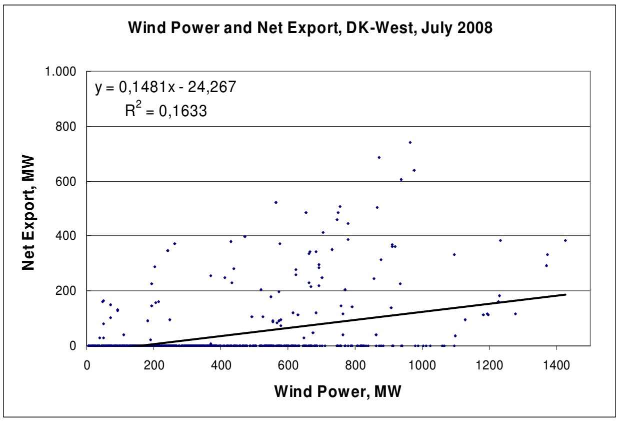

Central Power and Net Export, DK-West, April 2008
y = 0,2582x - 245,29
R^2 = 0,4732
Net Export, MW
Central Power, MW
1.000
800
600
400
200
0
0
500
1000
1500
2000
2500
3000
3500

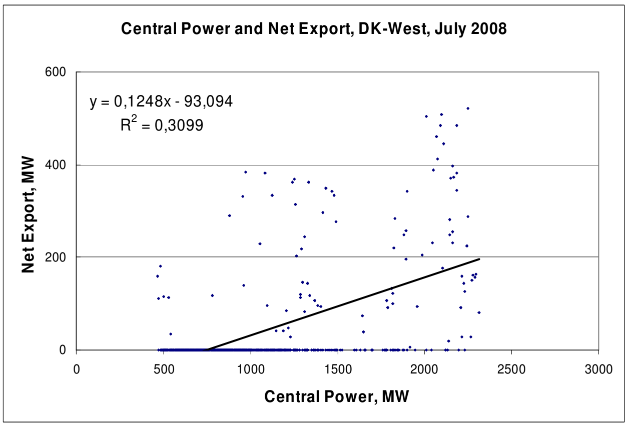

Wind Power and Net Export, DK-West, May 2008
y = 0,0427x + 15,252
R^2 = 0,0268
Net Export, MW
0
200
400
600
Wind Power, MW
0
500
1000
1500
2000
2500

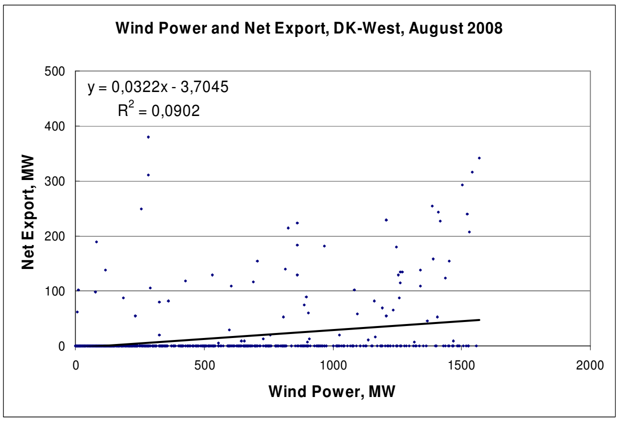

Central Power and Net Export, DK-West, May 2008
y = 0,0737x - 68,931
R^2 = 0,271
Net Export, MW
0
200
400
600
Central Power, MW
0
500
1000
1500
2000
2500
3000

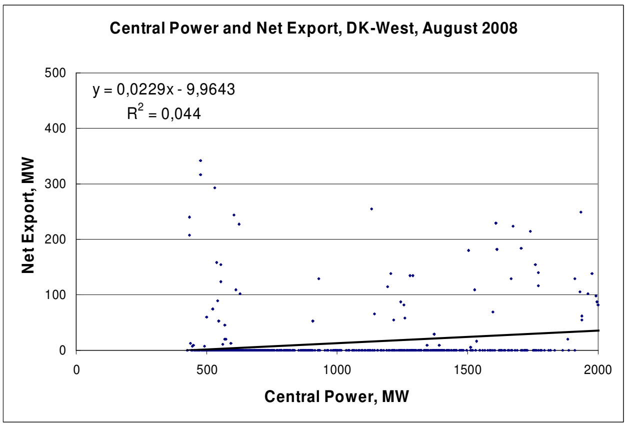

Wind Power and Net Export, DK-West, June 2008
y = 0,3117x - 11,886
R^2 = 0,2675
Net Export, MW
0
500
1.000
1.500
Wind Power, MW
0
500
1000
1500
2000
2500

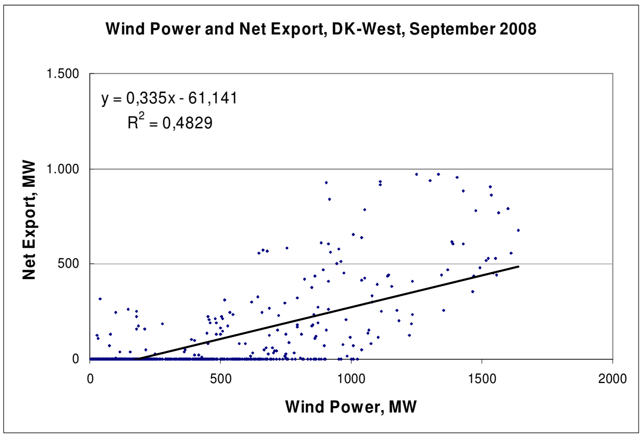

Central Power and Net Export, DK-West, June 2008
y = 0,2829x - 187,19
R^2 = 0,3778
Net Export, MW
0
500
1.000
1.500
Central Power, MW
0
500
1000
1500
2000
2500
3000

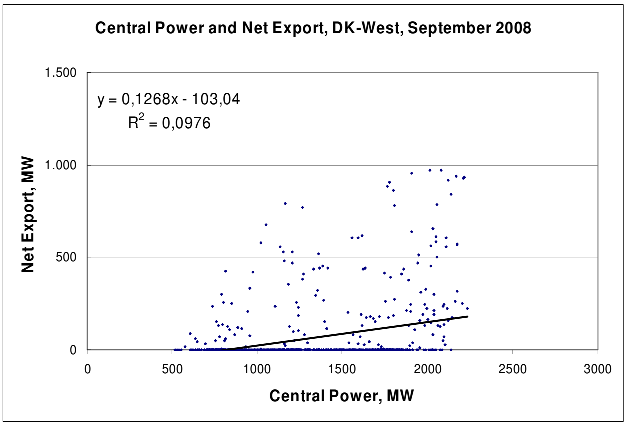

Wind Power and Net Export, DK-West, July 2008
y = 0,1481x - 24,267
R^2 = 0,1633
Net Export, MW
0
200
400
600
800
1.000
Wind Power, MW
0
200
400
600
800
1000
1200
1400

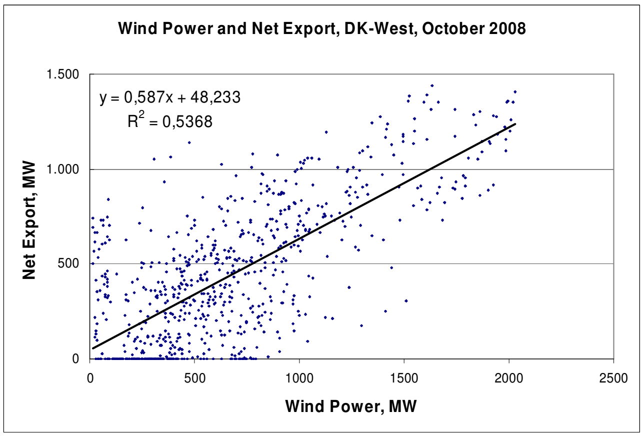

Central Power and Net Export, DK-West, July 2008
y = 0,1248x - 93,094
R^2 = 0,3099
Net Export, MW
0
200
400
600
Central Power, MW
0
500
1000
1500
2000
2500
3000

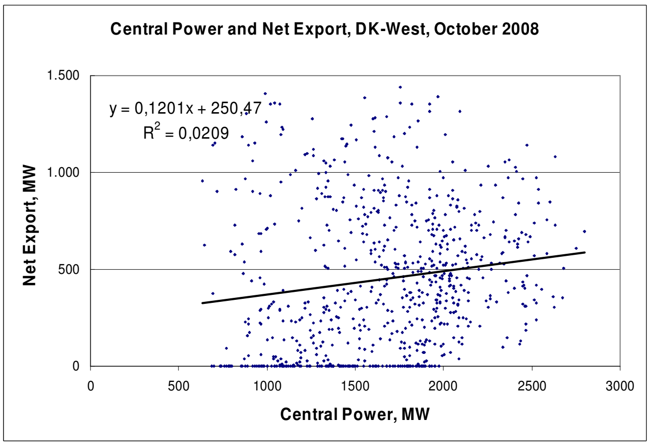

Wind Power and Net Export, DK-West, August 2008
y = 0,0322x - 3,7045
R^2 = 0,0902
Net Export, MW
0
100
200
300
400
500
Wind Power, MW
0
500
1000
1500
2000

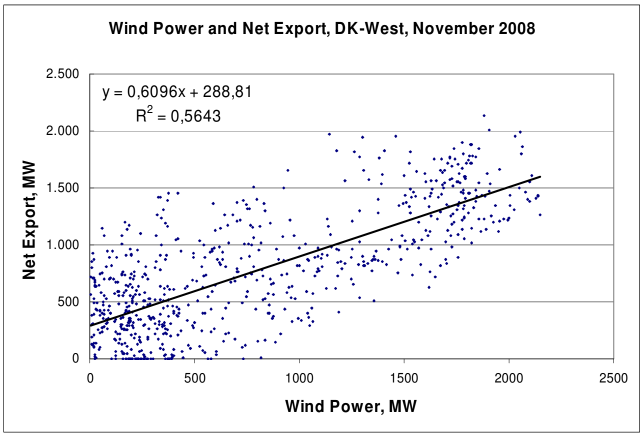

Central Power and Net Export, DK-West, August 2008
y = 0,0229x - 9,9643
R^2 = 0,044
Net Export, MW
0
100
200
300
400
500
Central Power, MW
0
500
1000
1500
2000

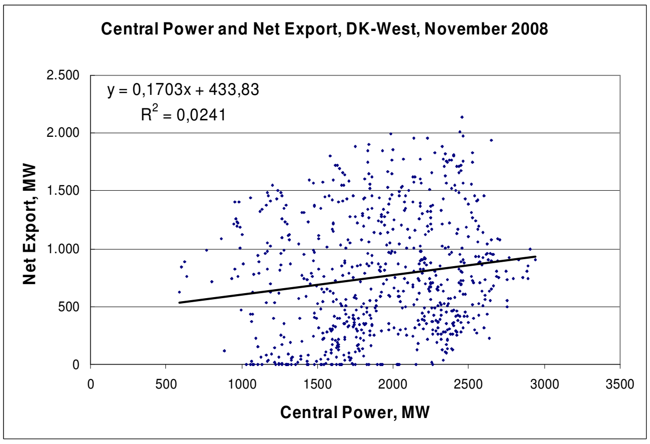

Wind Power and Net Export, DK-West, September 2008
y = 0,335x - 61,141
R2 = 0,4829
Net Export, MW
Wind Power, MW

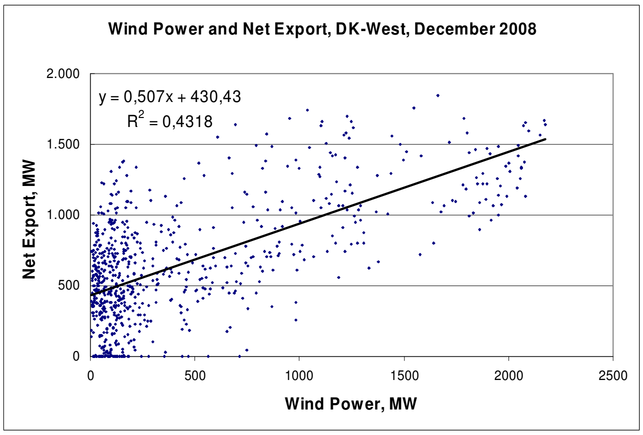

Central Power and Net Export, DK-West, September 2008
y = 0,1268x - 103,04
R2 = 0,0976
Net Export, MW
Central Power, MW

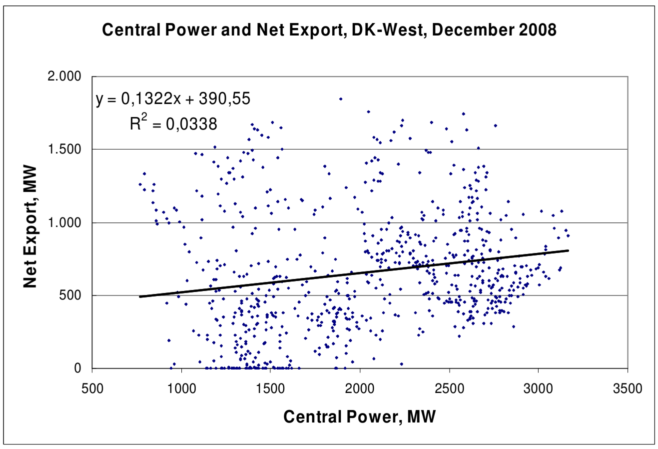

Wind Power and Net Export, DK-West, October 2008
y = 0,587x + 48,233
R2 = 0,5368
Net Export, MW
Wind Power, MW


Central Power and Net Export, DK-West, October 2008
y = 0,1201x + 250,47
R2 = 0,0209
Net Export, MW
Central Power, MW


Wind Power and Net Export, DK-West, November 2008
y = 0,6096x + 288,81
R2 = 0,5643
Net Export, MW
Wind Power, MW


Central Power and Net Export, DK-West, November 2008
y = 0,1703x + 433,83
R2 = 0,0241
Net Export, MW
Central Power, MW


Wind Power and Net Export, DK-West, December 2008
y = 0,507x + 430,43
R2 = 0,4318
Net Export, MW
Wind Power, MW


Central Power and Net Export, DK-West, December 2008
y = 0,1322x + 390,55
R2 = 0,0338
Net Export, MW
Central Power, MW