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German Power Grids Increasingly Strained

Posted by Euan Mearns on June 1, 2012 - 11:48am
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This is a guest post by Paul-Frederik Bach. Paul-Frederik has more than 40 years experience in power system planning. He worked with grid and generation planning at ELSAM, the coordinating office for west Danish power stations, until 1997. As Planning Director at Eltra, Transmission System Operator in West Denmark, he was in charge of West Denmark's affiliation to the Nordic spot market for electricity, Nord Pool, in 1999. Until retirement in 2005 his main responsibility was the integration of wind power into the power grid in Denmark. He is still active as a consultant with interest in safe and efficient integration of wind power. See here for a previous post on the Oil Drum. This is a link to his website.

With a steep growth of power generation from photovoltaic (PV) and wind power and with 8 GW base load capacity suddenly taken out of service the situation in Germany has developed into a nightmare for system operators.

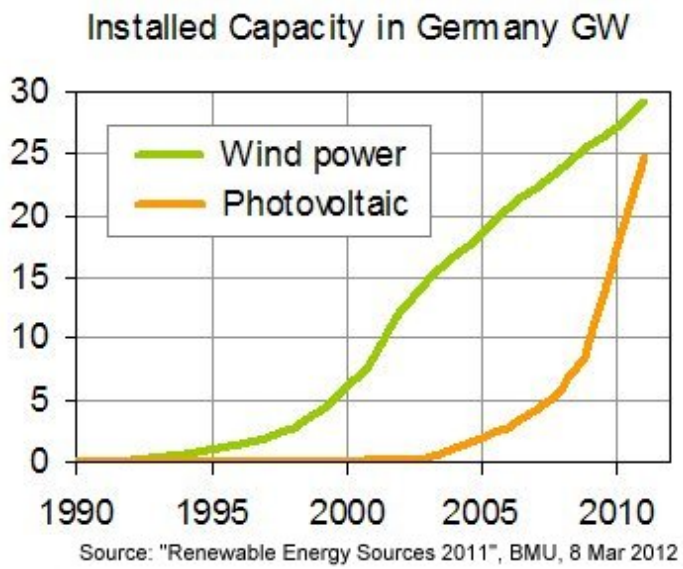

Figure 1

The peak demand in Germany is about 80 GW. The variations of wind and PV generation create situations which require long distance transport of huge amounts of power. The grid capacity is far from sufficient for these transports. The result is a remarkably large number of curtailments of RES (Renewable Energy Sources).

Reports from the European Network of Transmission System Operators for Electricity (ENTSO-E)[1] and the German Grid Agency[2] reflect concern for the operational security of the power system. The risk of a prolonged and widespread power blackout was earlier recognized by the German Bundestag and discussed in an interesting report[3]

This note will present main conclusions from the three reports combined with data, collected from the German system operators.

A New Operating Pattern

Since January 2012 all 4 German system operators have published estimated PV generation based on representative samples. The data will give research environments a new opportunity to analyse the impact of RES in Germany.

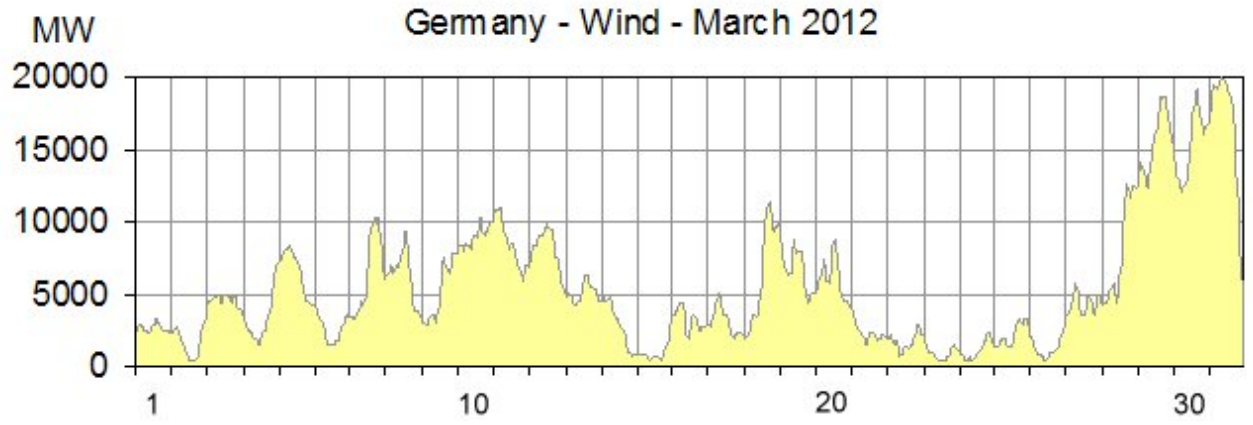

Figure 2

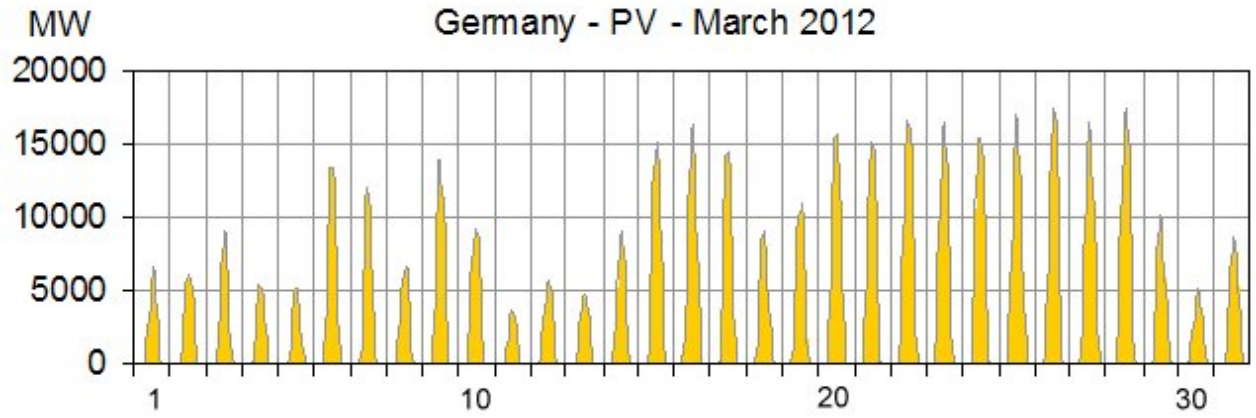

Figure 3

Some observations are possible from the charts above and other evidence:

- Wind power peaks seem not to be simultaneous with PV peaks. This means that PV does not add its full peak capacity to the grid problems during high wind periods.
- The main part of the German wind power is installed in the northern part of the country while the main part of the PV capacity is installed in Bavaria. The nuclear moratorium has created the most serious supply problems in the southern part of Germany. This observation suggests additional PV generation to relieve the supply problems.
- PV generation cannot reduce the need for peak capacity. The reason is that there is no PV generation during the evening peak load.
- The regulating work which must be made by controllable power sources grows considerably with the growth of wind power and PV. TenneT is one of Germany's 4 main grid operators. In the TenneT area a calculation for April 2011 has shown that wind power alone would extend the regulating range by more than 50%, while the actual combination of wind power and PV has doubled the regulating range.

Although PV may be able to give some relief to the grids PV cannot reduce the need for peak

capacity and additional PV will cause a considerable growth in the need for regulating capacity.

The German Grid is a Backbone in Europe

On 4 November 2006 a German 380 kV line had to be temporarily disconnected. Due to insufficient coordination of protection systems a circuit tripped and started cascading outages. The result was that the continental grid in Europe was divided into three islands and about 17 GW load was shed. The case demonstrates how a local event in Germany can turn into a widespread European disturbance.

In April 2012, the president of ENTSO-E[4], Daniel Dobbeni, states his concern about security of power system operation in Europe in a letter to the European Commissioner for Energy, Günther Oettinger.

> ENTSO-E: "As long as RES generation in certain regions expands faster – partly as a function of national support schemes - than the transmission network can accommodate, the risk of insecure system operation coupled with costly generation curtailments will rise significantly."

An attached briefing paper gives an overview of the current situation. The rapid increase of wind power and other renewable energy sources (RES) without a corresponding reinforcement of the electric grids has caused the problems.

The paper explains: "Heavy 'unplanned' transit flows added to scheduled flows cause severe loading on southern interconnectors (PL/CZ, PL/SK, DE/CZ, and also SK/HU and SK/UA) and lead to non-compliance with fundamental network security criteria. The high level of flows on the interconnectors leads to overloading of the network in Germany and neighbouring countries Poland, Czech Republic, Slovakia and Hungary."

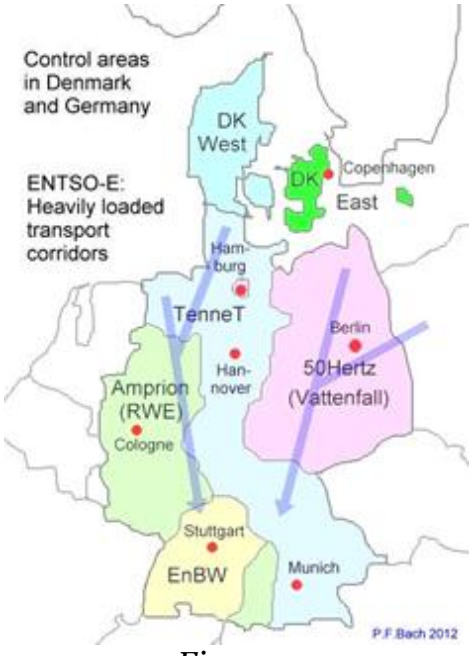

Figure 4

Among the countermeasures of the transmission system operators (TSOs) is the use of the HVDC links across the Baltic Sea for a redistribution of power flows. A common procedure has been developed by German and Polish TSOs and two Nordic TSOs (Energinet.dk and Svenska Kraftnät). However, the remedial actions cannot be guaranteed as they depend on prevailing

system conditions.

The countermeasures have cost implications and cannot be implemented without cost sharing agreements.

ENTSO-E makes reference to its Ten-Year Network Development Plans (TYNDP). The timely implementation of the projects will require the active support of European policy makers.

The paper estimates the necessary investment for reinforcement of the western and the eastern transport corridors in Germany to 30 billion Euros for the next decade. The German reinforcements must be coordinated with investments in neighbouring countries.

Efficient market arrangements are important for efficient congestion management, secure grid operation and overall market efficiency. Therefore the organisation of more consistent markets and redefinition of bidding areas deserve consideration.

The ENTSO-E paper concludes: “If this infrastructure does not materialize in due time then the rate of RES increase should be examined under a more pragmatic prism”.

A German Performance Report for the Winter 2011/12

The Federal German Grid Agency has confirmed the assumption of a strained grid in a 120 page report on the supply situation for electricity and gas in Germany during the winter season 2011/12.

It is useful for the general understanding of the significance of the infrastructure when an authority evaluates actual system conditions and publishes annual reports for better or for worse. Unfortunately that sort of report is rare in the electricity business.

This is my translation of the 10 points of the summary:

1. The situation of the power grid was very strained during the winter 2011/12.
2. Besides the scenarios described in the Grid Agency report of 31 August 2011 the shortage of natural gas in February 2012 was followed by an unexpected event which added to the load on the electric grids, respectively required additional measures from the transmissions system operators for maintaining system security.
3. In addition to that also unusual high forecast errors caused an exhaustion of the regulating reserves. Therefore the transmissions system operators had to resort to additional measures. The Grid Agency will create incentives for improvements of the forecasts by adaptation of the price system for balancing power.
4. The synchronous compensator Biblis was commissioned in February 2012 and provided the expected relief of the voltage problems.
5. German and Austrian power plant reserves were used in several cases for the relief of power lines and as a supplement to already exhausted regulating capacity. About the same magnitude of power reserves will be needed next winter.
6. The power plant capacity has developed unfavourably. Planned extensions have been delayed. Further decommissioning of conventional power plants cannot be defended in Germany for the time being. The prevention of decommissioning of power plants for conventional production will require regulating and legal measures. If more power stations nevertheless should be decommissioned in Southern Germany the needed reserve capacity would increase correspondingly. Besides, the need for capacity mechanisms should be intensively investigated in the medium term.
7. The supply of more power from renewable sources than can actually be transferred by the grid would add to overloading of the grid because the price signals would displace conventional power plants in the merit order and the electricity export from Germany in

the internal market would increase. It is the understanding of the grid agency that the existing legal framework allows the transmission system operators to use measures which can reduce the supply to a level which can be transferred by the grid. Nevertheless, a normative clarification seems to be expedient.

8. The cooperation between grid operators for electricity and gas must be improved in order to take account of the growing significance of gas power plants and gas supply to the security of supply of the electric grids. Even here changes of the legal framework are recommended.
9. No technical valid measures can replace grid extensions. A consistent use of the established instruments for acceleration of the reinforcement of the grids is required.
10. The reduced supply of gas in February 2012 has revealed the weak points of the gas grids. Action is needed for the gas grids. Fortunately this need is clearly inferior to the need for action in the electricity grids.

The general view seems to be concern for the future capacity of power plants, regulating power and reserves. The rigid point 9 seems surprising, but it may reflect a typical view of a grid agency. A strong grid is important, but several other integration measures deserve careful consideration.

The increasing trend in the use of §13.1 of the German Energy Industry Act (EnWG) for redispatch and in the use of §11 of the RES Act (EEG) and §13.2 of EnWG for reduction of feed-in of power is demonstrated in report. The data is valid for the transmission grid.

Redispatch is used for the relief of highly loaded grid components..

Winter season	2010/11	2011/12
Number of relieved components	5	9
Redispatched energy GWh	120	2.295

For both years most redispatch concerned the line Remptendorf-Redwitz between Germany and Austria.

Feed-in reduction was initiated 197 times during the winter season 2011/12 compared to 39 times the previous year.

In 184 cases wind power caused high feed-in from distribution grids into the transmission grids. 5 cases were remarkable and affected the entire grid:

Winter season 2011/12	Facility	Consequence
3 Dec 2011	Rörsdorf-Hradec	> 1000 MW
29 Dec 2011	Remptendorf-Redwitz Vierraden-Kreinik	>1000 MW
15 Feb 2012	Remptendorf-Redwitz Bärwalde-Schmölln	1200 MW

22-23 Feb 2012	Remptendorf-Redwitz	4000 MW n-1 problem
28-29 Mar 2012	Remptendorf-Redwitz Eisenach-Mecklar Vieselbach-Mecklar	4800 MW n-1 problem

This information confirms that German electricity supply had narrow margins during the winter 2011/12 without room for additional heroic political decisions. Hopefully the messages of the Grid Agency will be understood, so a better harmony between the transition of the production facilities towards green solutions and the necessary adaptation of the infrastructure.

A Critical Case

"Welt Online" has reported on "alarm level yellow" for German power grids on 28 and 29 March 2012[5].

German grid operators are obliged to report all operational interventions aimed at avoiding overloads or power failures. The grid operator for the eastern Germany, 50hertz, has published a very brief report on the event in German. More details are given in the Grid Agency report.

At 8:48 pm one of two circuits of the 380 kV line Wolmirsted-Helmstedt tripped. The other followed 12 minutes later. The reason was a technical defect in TennetT's substation Helmstedt. Wolmirsted-Helmstedt is the northernmost link between the 50Hertz area (the former DDR) and the other German system operators.

The wind power peak level was not extreme. Nevertheless the remaining links had to be relieved and 50Hertz had to activate comprehensive measures. This is probably the reason why this event caught the attention of the media.

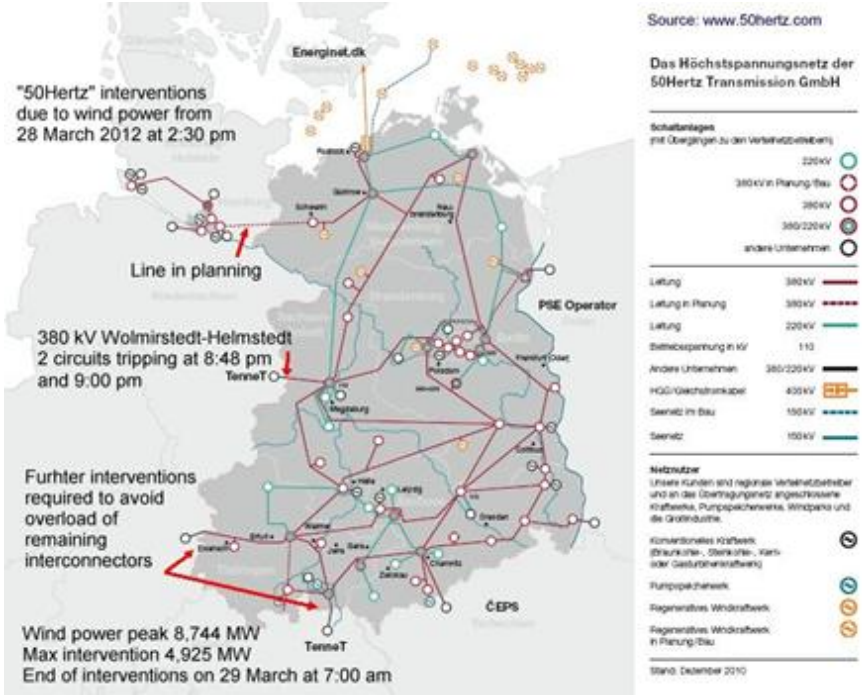

Figure 5

The interventions included about 2000 MW redispatch and about 4000 MW feed-in reductions.

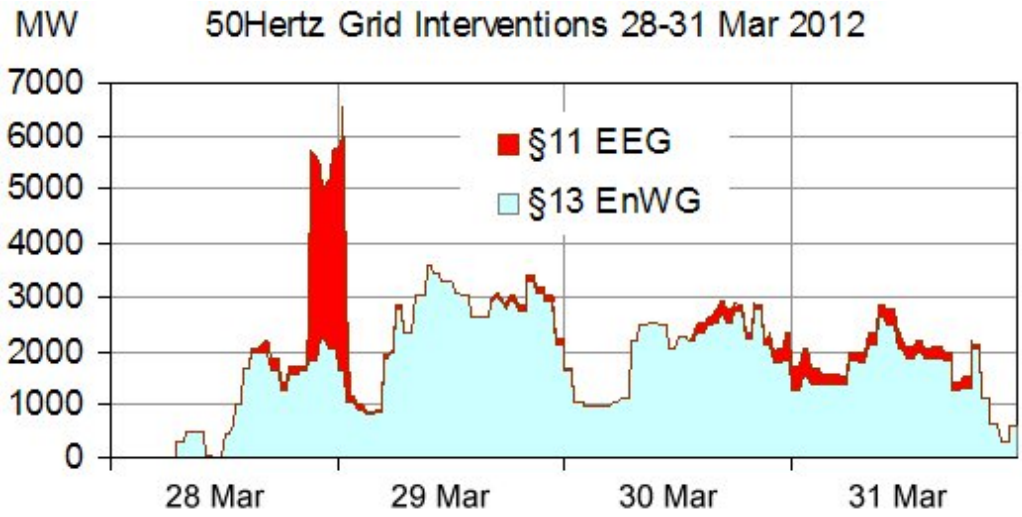

Figure 6

The case reveals the vulnerability of the German power system. Until 9 April 50hertz has issued 23 similar reports on strained grid conditions in 2012.

23% of the Hours in Q1 2012 Affected by Interventions

The number of interventions has increased dramatically in Germany from 2010/11 to 2011/12. In spite of the obligation to publish information on all interventions it is difficult to form an overview.

The practical administration of the rules and the compensation is quite complex. There are 4 grid operators for the primary level (380 kV) and a number of grid operators at lower voltage levels. Bottlenecks are often detected in local grids. It makes no difference to the owner of a wind turbine if local or national grids are congested.

In an attempt to establish an impression of the extent of interventions in Germany EON Netz will be used as an example. EON Netz is operating the largest secondary grid in Germany. The primary grid in the same area is operated by TenneT.

The control area is divided into a number of local areas (Landkreise). An intervention concerning EEG § 11 is valid for electricity production in one local area. The severity is indicated in steps between 0% and 100%.

Each intervention record specifies start time and duration. Interventions for different local areas are usually overlapping. It is a main purpose of the lists of interventions to support the calculation of economic compensations for the owners of the affected power plants.

During first quarter of 2012 EON Netz has issued 257 interventions. The average length was 5.7 hours. Up to 10 interventions have been issued for the same hour. 504 hours had one or more interventions.

Thus there have been interventions active for 23.1% of the hours during the first quarter of 2012.

The total amount of curtailed energy from wind and CHP is probably modest, but the observations seem to indicate that German grids are frequently loaded to the capacity limits. Strained grids have a higher risk of cascading outages caused by single events.

What Happens During a Blackout?

The Federal political system in Germany has for some time been conscious of the risk of a large blackout.

In 2011 the Office of Technology Assessment at the German Bundestag (TAB) published an interesting report on the consequences of blackouts lasting up to two weeks.

The following infrastructure sectors are considered:

- Information technology and telecommunications
- Transport and traffic
- Water supply and wastewater disposal
- Food supply
- Health care system
- Financial services
- Public institutes – case study on "prisons"

The conclusion is that an interruption of the power supply will be tantamount to a national disaster already after a few days. Though the probability of this event is very low the report recommends further efforts at all levels in order to “increase the resilience of critical infrastructure sectors in both the short and medium-term and also to further optimise the capacities of the national system for disaster control”.

Planning for blackouts is often neglected. One reason is the optimistic assumption that blackouts can be avoided. Another reason is the high cost of measures which are supposed to be superfluous.

However, large blackouts do occur. They cannot be completely avoided, but the restoration process can be more or less well prepared. Therefore vital infrastructure sectors should be prepared for power failures and the necessary facilities for a black start of the power system should be installed and ready for action.

[1] Interconnected system operation conditions in Continental Central Europe - A briefing paper to the European Commission, EMTSO-E, 13 Mar 2012.

[2] Bericht zum Zustand der leitungsgebundenen Energieversorgung im Winter 2011/12 Bundesnetzagentur, 3 May 2012 (in German)

[3] What happens during a blackout?, Office of Technology Assessment by the German Bundestag, 7 Apr 2011,translated from: “Was bei einem Blackout geschieht”.

[4] The European Network of Transmission System Operators for Electricity

[5] http://www.welt.de/dieweltbewegen/article106143921/Stromnetz-geht-ploetzlich-auf-Alarmstufe-gelb.html