Two Hurricanes stressed Danish Grids in 2013

A burning platform?

Energinet.dk's CEO, Peder Østermark Andreasen, has said that maintaining security of electricity supply in Denmark is like working on a burning platform. Energinet.dk's director of system development and electricity market, Søren Dupont Kristensen, has subsequently confirmed the challenges[1] while outlining how Energinet.dk will maintain security of supply at the present level, even when further thermal power plants have closed down.

Due to such mixed signals, technical reports on critical incidents could help the public to understand the magnitude of the challenges and the risk of electricity curtailments.

Critical incidents occur in all grids. They are useful. Analyses of critical incidents can help to understand the operational limits of the grid and to improve emergency procedures.

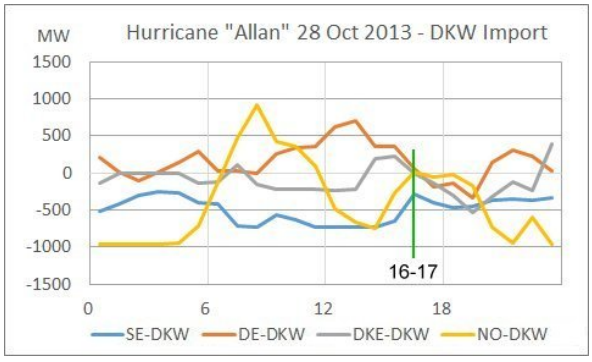
Generally, the Danish TSO does not publish such information, but as an exception, Energinet.dk told the story about the hurricane Allan exactly one year after the incident[2] (in Danish).

The hurricane Allan 28 October 2013

On 28 October 2013, the hurricane Allan swept across the southern parts of Denmark. Allan was a regional storm from southwest with 10 minutes average wind speeds exceeding 28.5 m/s. The strongest gust of wind was 53.5 m/s which is the highest value observed in Denmark so far.

At 13:57, the storm caused the first faults in the transmission system. In West Denmark (DKW) a central 400 kV line (Kassø-Revsing) disconnected. Energinet.dk reports "alert condition".

At 14:41 one of two 400 kV lines to Germany disconnected due to a fault in Germany and Energinet.dk activates additional local reserves

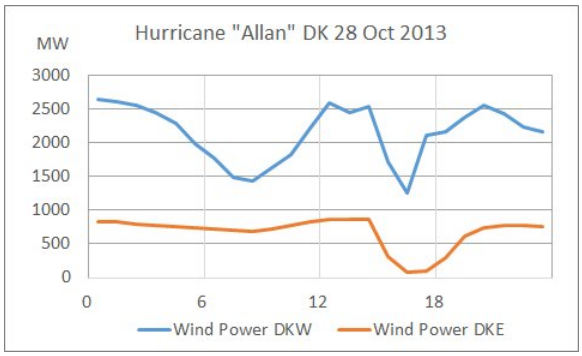


West Denmark (DKW) has interconnections with Norway (NO), Sweden (SE), Germany (DE) and East Denmark (DKE).

The hurricane moved eastwards. The HVDC link between west and east Denmark was unavailable from 15:42 due to a transformer fault. Reduced export to Norway replaced the supplies from east to west in Denmark. During the hour 16 to 17, West Denmark only exchanged power with Sweden.

[1] http://ing.dk/artikel/energinetdk-vi-skal-sikre-elforsyningen-ikke-redde-kraftvaerker-172366
[2] http://energinet.dk/DA/El/Nyheder/Sider/Stormen-Allan-Hvad-var-det,-der-skete.aspx

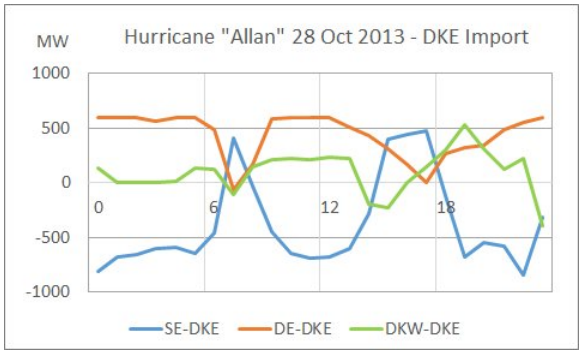
From 16:21, several faults hit the transmission system in East Denmark (DKE). The faults prevented operation of the Kontek HVDC link to Germany and the Kyndby backup power plant.



Wind turbines are designed to stop production when wind speed exceeds a certain level. Wind power output in the eastern part of Denmark dropped from 870 MW (or MWh/h) 14:00-15:00 to less than 100 MW 16:00-17:00[3].

The drop was less dramatic in the western part of Denmark. The reason was that the full force of the hurricane did not reach the northern part of Jutland.

After the loss of both more than 800 MW wind power and the Kyndby power plant (664 MW) and with two of three interconnections out of service, the East Danish power system was vulnerable and Energinet.dk prepared to shed load for 500,000 consumers. The planned load shedding also included parts of the Copenhagen area.



East Denmark (DKE) has interconnections with Sweden (SE), Germany (DE) and West Denmark (DKW).

The exchanges on 28 October can support the evaluation of what happened.

There were no capacity limitations on the three interconnectors. In the morning imports from Germany and West Denmark decreased by 800 MW. At the same time, the gross consumption increased by 500 MW. Sweden replaced 1,050 MW of the missing 1,300 MW.

Energinet.dk called the alert condition off at 18:15 for West Denmark and at 20:00 for East Denmark.

The story at the Energinet.dk web site is far from a complete technical report on the incident. For instance, it does not say anything about the planned operation for the day and the deviations from actual operation. Did Energinet.dk anticipate the wind power drops?

Allan was a violent storm. Flying objects can cause damage randomly. It is impossible to predict lost grid elements under such conditions. Efficient load shedding procedures can be vital. The case also demonstrated the vulnerability of interconnectors. Therefore, it can be decisive to have a certain capacity of local dispatchable production.

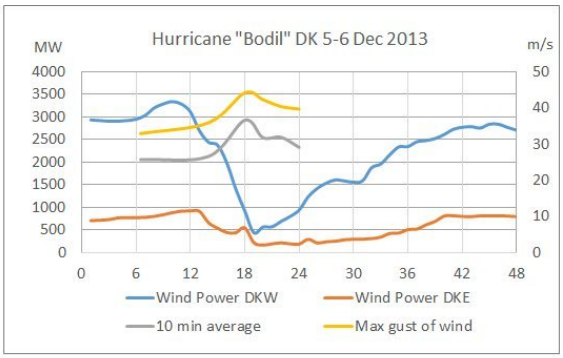
Energinet.dk did not yet publish the details on its emergency strategy.

[3] Hourly time series from http://energinet.dk/EN/El/Engrosmarked/Udtraek-af-markedsdata/Sider/default.aspx

The hurricane Bodil 5-6 December 2013

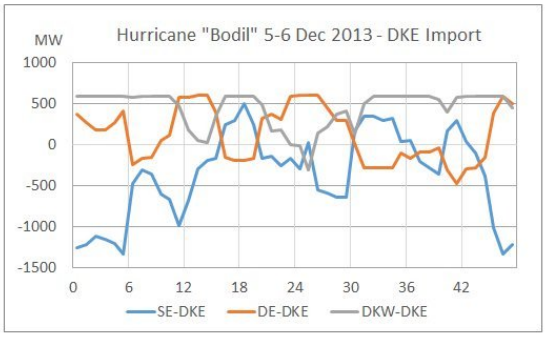
Some media have mentioned another critical incident in December 2013. It was probably during the hurricane Bodil on 5-6 December. Bodil was a regional storm from northwest. It was different from Allan in the sense that the duration was longer and it affected larger parts of the country. The maximum observed wind gust was 44.2 m/s.

The description on the DMI web site has made it possible to make a rough estimate of the course of the wind speed. It demonstrates how increasing wind above 25 m/s causes decreasing wind power output.



The loss of wind power from noon (11-12) to evening (18-19) was 2,670 MW in West Denmark and 700 MW in East Denmark.

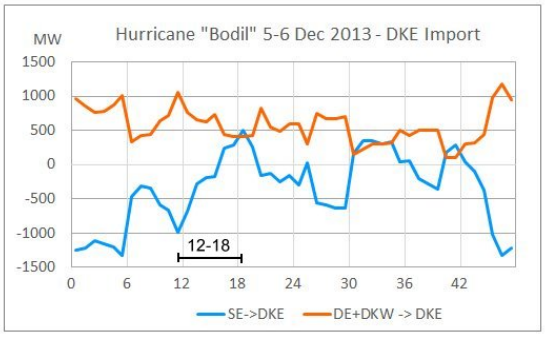
The total loss of wind power was larger than for the hurricane Allan, but there is no information on lost grid elements.



Again, exchanges can indicate a supply pattern, in this case for East Denmark.

During the afternoon, Germany and West Denmark maintained a supply for East Denmark alternately.

In order to clarify the roles we add imports from West Denmark and Germany together in the next chart. During the afternoon supplies from Germany and West Denmark decreased by 600 MW while Sweden during the same hours (12-18) was able to adjust exchange with East Denmark by 1.500 MW.



In my interpretation, security of supply in East Denmark depends decisively on Sweden because Denmark and the northern part of Germany seem to have shortages at the same time.

A local interruption of supply is not the end of the world. If it is possible to avoid local interruptions completely it is an indication of too expensive grids. Usually it is possible to restore supply very quickly after a local curtailment.

It is much more important to avoid a total system collapse. After a complete blackout, the restoration of normal supply may take hours or days.

More wind power and less thermal power will inevitably add to the operational challenges. This will make the study of grid performance during emergencies even more interesting and more important within the next few years.