A Challenging Operating Situation

On 3 December 2019, Energinet launched a story with the following headline on its Danish homepage: “Challenging operating situation in Eastern Denmark in October”. It was not Energinet’s intention to mention this event publicly because it was not considered critical.

However, the Swedish TSO, Svenska Kraftnät, had a different view. They issued the story on 3 December, and Energinet had to follow suit. Svenska Kraftnät’s introduction (my translation):

> *On 8 October, a number of events happened in the Danish transmission grid, which had serious consequences for the Swedish power system, though no electricity users were affected. One of the conclusions is that it is decisive that all connecting parties meet the connection requirements in order to have a robust grid.*

Events in Denmark

The substation Bjæverskov in Eastern Denmark (DK 2) is the Danish terminal of the HVDC link to Germany. A circuit breaker in the substation failed and caused a busbar short circuit. The HVDC-link tripped and 600 MW import from Germany was lost. The short circuit also cause tripping of the Avedøre power station and downregulation of the Rødsand offshore wind farm (fig. 1).

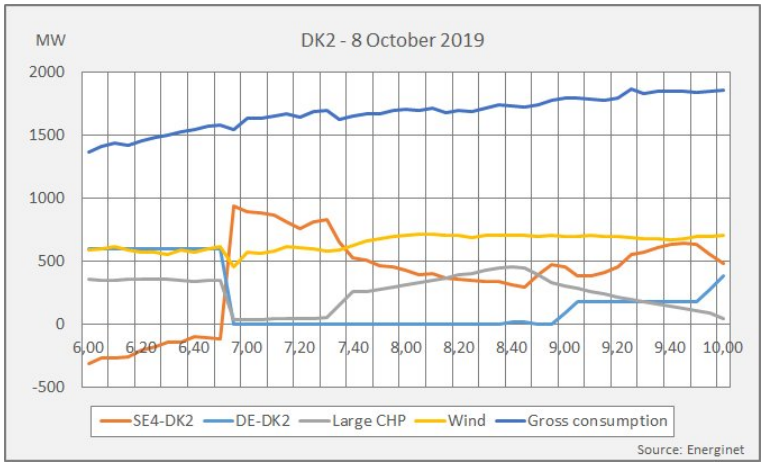

Fig. 1 – Selected 5 minutes data for DK 2 from 6:00 am to 10:00 am

The total loss of supply to DK 2 was about 1100 MW. The HVDC-link between west and east in Denmark was out of service. The loss was replaced by import from Sweden. Production from Rødsand windfarm was restored within minutes, while it took more than 30 minutes before upregulation on the Avedøre power station could begin. The Kontek HVDC-link began upregulation after two hours.

The operational planning had prepared DK2 for the loss of 600 MW. All available reserves were activated. The import was within the technical limits of the AC interconnection to Sweden, but if the Svenska Kraftnät had demanded reduction of the exchange, manual load shedding would have been the only option left to Energinet.

Consequences in Sweden

The post from Svenska Kraftnät explains that the events in Denmark caused voltage reductions even in Sweden and increased transfer of power from north to south in Sweden.

The calculated total transfer capacities were exceeded in the so-called cuts (or cross-sections) of the Swedish primary grid, particularly from SE 2 to SE 3 and from SE 3 to SE 4 (fig. 2).

The lowest frequency was 49.71 Hz.

Svenska Kraftnät activated all available regulating bids, made to the regulating power market in SE 4, and the fast active disturbance reserves in the southern parts of Sweden.

Voltage and frequency were normal within 15 minutes. Transfer from SE 3 to SE 4 was within limitation after 22 minutes. The transfer from SE 2 to SE 3 varied above and below the limit for a longer time.

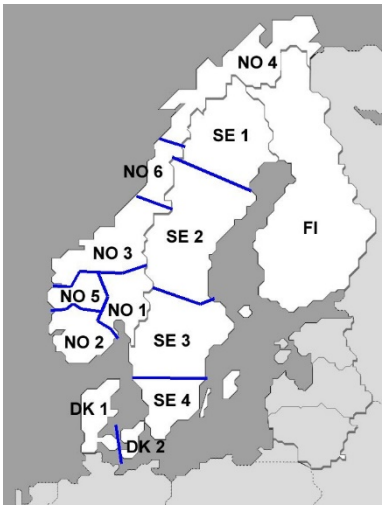

Fig. 2 - Nordic price zones

After a disturbance, normal security should be restored within 15 minutes. During the restoration period, reserves may be insufficient for maintaining the full supply in case of an additional disturbance, and the TSO must be ready to initiate a manual load shedding in order to prevent system collapse.

The TSOs face large changes and challenges. The posts from both TSOs stress the importance of compliance with the connection requirements for operators and suppliers of components in the power systems.

The question is if reserves for possible non-compliance of new components should be considered.

Increasing probability of 'unlikely events'?

After a stroke of lightning in England on 9 August 2019, power production dropped by nearly 2000 MW, which is about twice the planned reserve capacity. National Grid explained in its first messages that the three simultaneous loss of power were very unlikely. However, the voltage drop after the lightning seems to have been a common cause of the full loss of power. Advanced control systems in new plants seem to have been too sensitive to fast voltage or frequency variations.

The events in Denmark also included the unexpected loss of a wind park and a thermal power plant.

Details on all losses exceeding the N-1 criteria are interesting

The new control systems have probably been planned to meet all requirements, but it is difficult to test all properties at the testbed.

The power systems will need smarter protection, when more wind power, more solar power and more high voltage AC cables have replaced traditional power plants and reduced the system robustness. Therefore, a systematic collection and international sharing of experiences from all disturbances with more loss of power than considered in the traditional N-1 criteria would be useful for a fast removal of teething problems in new control systems.

It is not helpful to hide incidents, only because disruptions have been avoided.