Wind and load variability in the Nordic countries

This publication analysed the variability of wind production and load in Denmark, Finland, Sweden, and the Nordic region as a whole, based on real data measured from large-scale wind power during 2009–2011. The Nordic-wide wind power time series was scaled up such that Sweden had same amount of wind power production than Denmark, and Finland and Norway only 50% of the wind power production in Denmark. Wind power production in Denmark and Sweden is somewhat correlated (coefficient 0.7) but less correlation is found between the other countries. The variations from one hour to the next are only weakly correlated between all countries, even between Denmark and Sweden. Largest variations occur when the production is approximately 30–70% of installed capacity and variability is low during periods of light winds. The variability in shorter time scales was less than the hourly variations. During the three years analysed in this publication there were few storm incidents and they did not produce dramatic wind power ramps in the Nordic region. Wind and load variations are not correlated between the countries, which is beneficial from the viewpoint of wind integration. The smoothing effect is shown as reduction of variability from a single country to Nordic-wide wind power. The impact of wind power on the variability that the system experiences is evaluated by analysing the variability of net load with different wind power penetration levels. The Nordic-wide wind power production increases the highest hourly ramps by 2.4% (up) and -3.6% (down) of installed wind power capacity when there is 20% wind power penetration and by 2.7% (up) and -4.7% (down) for 30% wind penetration. These results assess the impacts of variability only. The next step will be assessing the uncertainty from forecast errors. The timing of ramp events, and occurrence of high-wind and low-load are studied. With current wind penetration, low production levels (2–5% of installed wind power) can occur in a single country during peak loads, but in the Nordic region the production during peak loads does not fall to such low levels (minimum 14% during 10 highest peaks). The low wind periods occur primarily in the summertime. The longest period with wind generation below 5% of installed capacity in the wintertime for three years of data was 30 hours. The maximum penetration level, during one hour, can reach high levels already with a 20% (yearly) penetration level. At 30% penetration on yearly level the maximum hourly wind share was 160% in Denmark, 130–140% in Finland and Sweden and 110% in Nordic region.

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