WAMS: managing emerging stability risks

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GRID RELIABILITY & EFFICIENCY
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New transmission technologies and the growth of renewables are changing the UK's generation profile. These new opportunities also bring new stability risks that VISOR (Visualisation of Real-time System Dynamics using Enhanced Monitoring) will help to mitigate.

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Wind farm in the Scottish Borders - Source: GETTY/ThinkStock

In 2009, the UK government set a legally binding target to obtain 15% of the country's energy consumption from renewable sources by 2020, up from 3% when it adopted the EU Renewable Energy Directive. Planners have already given permission for 35 GW of renewable electricity capacity, enough to meet the required 110 TWh contribution from electricity towards the target, with 1 TWh to spare.

This rapid change in the structure of the energy system is expected to bring environmental benefits and increase energy security. However, it also poses problems for system reliability and resilience. Traditionally, system inertia provided by thermal power plants has been important in achieving frequency stability. But renewable units do not provide inertia. So as the share of renewables increases, the level of system inertia will decrease and become increasingly variable, with frequency behaviour following events becoming more dynamic. Furthermore, renewable generation is located near the best resources, and new power flow patterns and stresses.

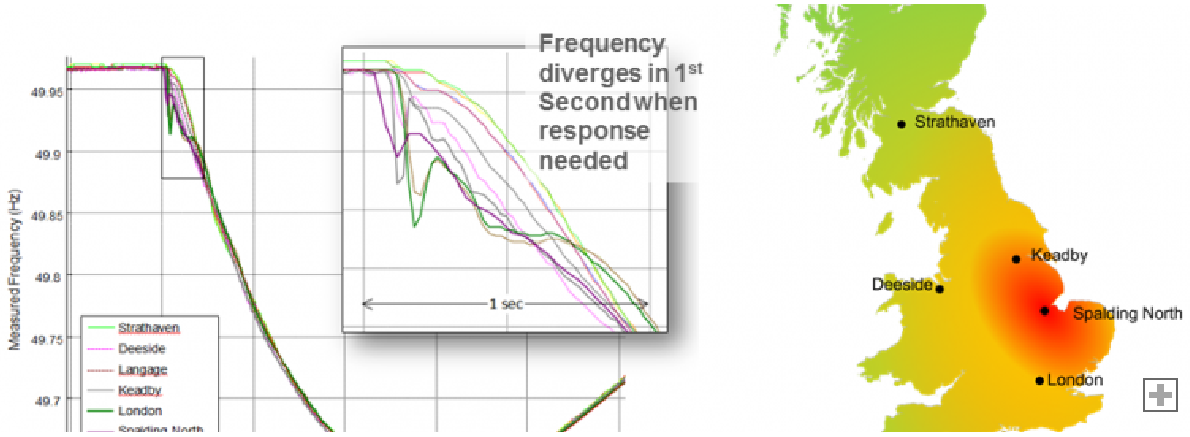
1 __Redefining stability limits

To prevent a system becoming unstable, the conventional practice is to put a MW limit on power flow across a boundary. This is usually based on the total power flow in the most stressed pre-fault condition using power system dynamic simulations. Douglas Wilson, Alstom Grid NMS Chief Scientist, argues for a change of practice in defining the limits. “Increasing penetration of renewable and distributed generation, often connecting at nodes some distance from the centres of inertia, increases the volatility of power transfers. This generation does not contribute to inertia, and breaks the direct relationship between power and angle that underlies the conventional expression of a transient limit in MW.” Phasor measurement expresses voltage or current as a magnitude and phase angle. So, in theory, an angle difference between two centres of inertia is more directly related to the level of system stability.

Wilson and his colleagues developed a suite of tools to manage stability risks and constraints in the GB grid. The tools include a method to define stability limits using angle difference for a boundary of the GB grid, where 1.5 GW of wind generation is connected between the centres of inertia in central Scotland and northern England. The tools also address emerging risks due to oscillations, for example, related to:

- interaction between series compensation and long-shaft thermal generation or fast-acting control (e.g. windfarm voltage control);
- very low frequency governor modes arising from reducing inertia and turbine/governor performance and control tuning;

and local and inter-area electromechanical oscillations involving generators and regions that are different from the historical patterns.



Frequency & RoCoF Behaviour

Analysis results suggest that the new method allows more power to be transferred through interconnections than adopting simply MW as the measure of transient stability limit, and the benefit becomes greater with increasing wind generation. The practical implementation of the new approach will be the result of close cooperation led by Scottish Power Energy Networks (SPEN), including transmission owners, the transmission system operator, Alstom and academic partners, who have secured funding through the UK Office of Gas and Electricity Markets (Ofgem) Network Innovation Competition mechanism. Alstom has been commissioned by SPEN, National Grid and SHE Transmission to provide a flexible, wide-area monitoring solution to strengthen grid stability.

The project, known as VISOR (Visualisation of Real-time System Dynamics using Enhanced Monitoring) will improve transmission operation through enhanced risk mitigation and boundary transfer management, using real-time synchrophasor and waveform data with advanced analysis and presentation. The VISOR technology addresses a bandwidth of 0.005 Hz to 46 Hz, using phasor measurements, and a new form of fast streaming data, named Synchronised Waveform Measurements, to capture the higher frequencies. Apart from oscillation identification, the processes use a new technique to extract the location of sources of oscillation problems. Real-time response guidelines are being developed based on measurements, without requiring model-based replication of the problem. An application for managing islanding will also be trialled. Wilson describes one major advantage of this approach. "This is like navigating a route using a GPS, showing your position in real time based on an up-to-date map compared to using charts from before the area was fully explored and having to periodically calculate position from observation of the sun or stars (clouds permitting).

2__Reactive, proactive, resilient

Alstom's centre of excellence for WAMS in Edinburgh, Scotland, is designing and implementing the overall monitoring and detection system. This includes **e-terra***phasorpoint* software and server hardware, system training and workshops. Multifunction phasor measurement and digital fault recording units provided by the Alstom site located in Florianópolis, Brazil are being installed at substation locations, including series capacitor and power plant sites. The units deliver the precisely timed power system measurements required for grid stability applications.

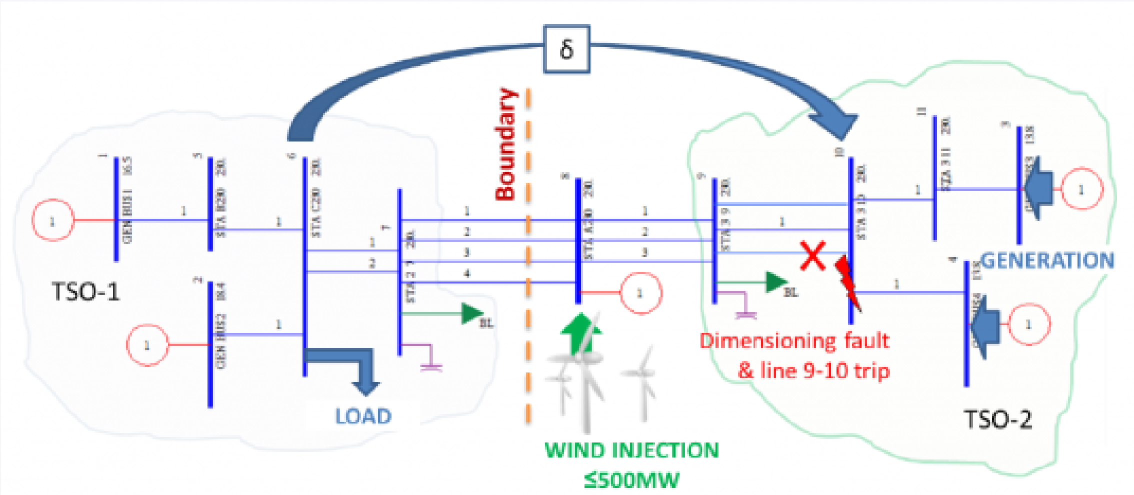
VISOR will mitigate the risk of unwanted interactions between generation plants by improving the knowledge of SSO behaviour. It will produce early warning signs suitable for control-room alarming, before plants are at risk of outage. Since the power plants most exposed to SSO are large nuclear and thermal units, the potential benefit is significant. Wilson summarises the team's goal as reactivity and pro-activity: "Reactivity based on real-time monitoring to instantaneously mitigate and fix the effects of a local or regional disturbance. Pro-activity, using statistical analysis to characterise the grid’s resilience, now and in the future."

3 __Saving millions on frequency stability

The UK Network Innovation Competition funds projects like VISOR, which could deliver carbon or environmental benefits. Following the VISOR project, a team led by Vandad Hamidi, National Grid SMARTer System Performance Manager, has been awarded nearly €13 million (£10 million) to look at enhanced frequency control capability (EFCC).

Why is enhanced frequency control so important?

Vandad Hamidi: Traditionally, frequency stability relies on a large volume of high-inertia equipment, mainly thermal generation units. Meeting UK carbon reduction targets will result in a significant increase in the volume of renewables, which have little or no inertia. At times when these replace the thermal units, this reduces system inertia and increases the volume and speed of frequency response requirements. Under existing arrangements the cost of controlling frequency will increase to £200-£250 million a year by 2020. EFCC could save £150-£200 million of this.



Dynamic model including synchronous generation, a transiently constrained corridor, and wind generation injection.

What is the new approach?

V.H.: Our system will obtain fast, accurate frequency and voltage angle data at locations around the system, and distribute the information to locations where it is used in controlled responses to disturbances. The target is to counter a loss of power infeed or load as quickly as possible, close to the source of the disturbance. The monitoring and control system being developed by Alstom will initiate a fast power response proportional to the rate of change of frequency, and directed towards areas of the grid where it is effective at controlling frequency without adding to power flow stresses in the grid. This wide area monitoring and control system is designed to coordinate with local frequency control schemes.

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