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PREF. SUBJECT : **PS3**
QUESTION N° : **14**

PS3 Question 14

What are the worldwide experiences in situations where the overall power system model failed to predict an actual system event or ongoing occurrences of abnormal responses, and were the causes could be deterministically identified and rectified?

Response :

This contribution aims to illustrate both, the need to represent Large Energy Users protection systems in planning and operations studies as well as the need to validate those models on a regular basis against recorded data during system incidents.

Ireland has experienced a surge of large-scale Data Centre (DC) connections over the recent years, attracted by a cold climate and high level of renewable generation providing green credentials to their services. The IT equipment they contain is relied upon for important functions including communication, entertainment, navigation, finances and security. They are mission critical facilities and are equipped with Uninterrupted Power Supplies (UPS) and back-up generation. Given the potential significance of any power supply interruption to DCs they have highly sensitive protection schemes that can quickly transfer critical load from the main supply to internal UPS for the period it takes to start-up the back-up generation. This is seen by the power system as a sudden load reduction and presents a number of challenges for system operations, including rebalancing load with generation and reconnection of large loads. For an under-frequency event which requires an increase in generation or a reduction in demand to restore system frequency, a reduction in DC demand could be beneficial. However, should an over frequency event occur which requires increased demand\reduced generation; system operation could be compromised by the sudden reduction in DC demand.

While currently the aggregate DC demand in Ireland amounts to slightly over 500 MW (similar in size to the largest infeed/outfeed to the system), it is expected that by 2030 it could represent 30% of the peak demand in the Irish power system (well in excess of the largest infeed/outfeed). It is, therefore, critical that the operation of these protection relays is accurately captured in planning and operational dynamic stability studies.

The experience to date has been that many transmission disturbances result in a large loss of load within milliseconds, which on investigation has been attributable to large DCs switching to their own power supply. The dramatic effect of this behaviour on the system frequency is illustrated in Figure 1, showing the load reduction at one DC site immediately after a SLG fault in the 220kV system. Based on early experiences, EirGrid developed detailed phasor-domain dynamic models of the DCs protection systems using the information provided by the DC owners. These include under and over voltage, under and over frequency and Rate of Change of Frequency (RoCoF) protection relays. However, these models do not always predict the correct level of DC demand reduction when compared against recorded PMU data. An example is shown in Figure 2, where the protection models predicted higher load disconnection than observed during the incident, leading to a false sense of security. The graph on the left shows the model response with the original parameters as provided by DC owners whereas the graph

on the right shows the correct response after parameter tuning to match the PMU data for this particular incident. These tuned parameters, however, do not necessarily match the response to other incidents. The lack of visibility of DC's internal load distribution and potential changes to protection settings without notification to TSO represent ongoing challenges for the upkeeping of the models. EirGrid is currently engaging with DC owners to better understand the protection systems and improve modelling for planning and operational studies.

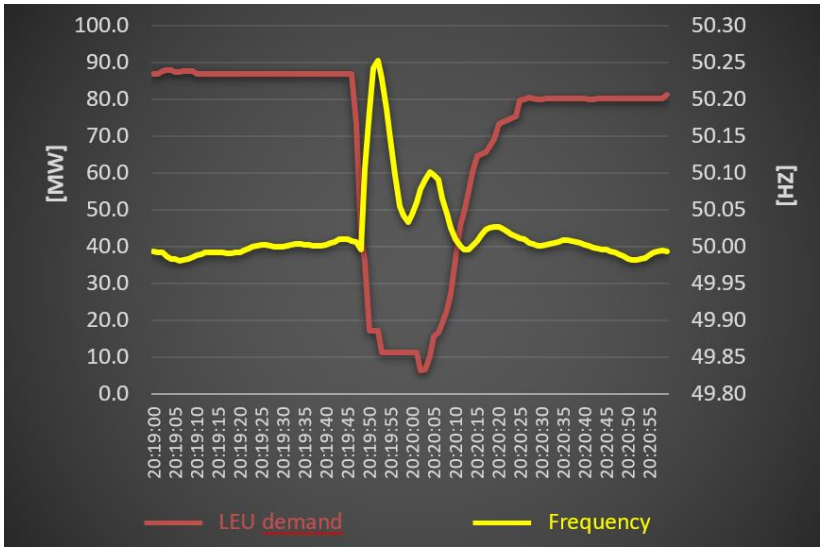

Figure 1 – LEU demand reduction in response to nearby system fault – effect on system frequency

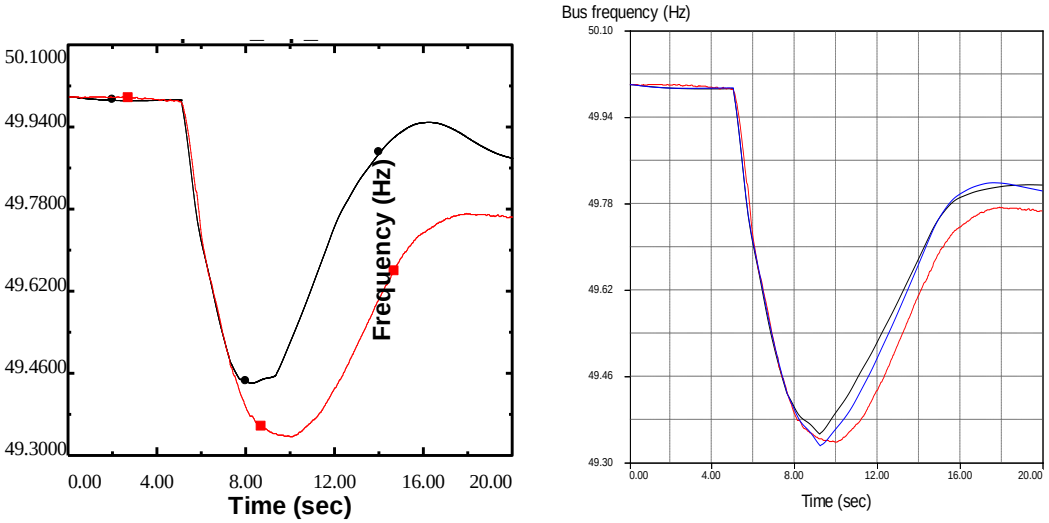

*Figure 2 – System frequency following trip of large generator: **Red** is PMU data; **Black** is simulation result based on DC load disconnection by protection models. Left graph shows original model parameters and Right graph shows updated model parameters*