NAME : Sean Ritson	GROUP REF. : C2
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While the control systems of power electronic interfaced resources can be highly flexible they may not be able to be adjusted to meet all of the power system technical performance requirements. In what circumstances are supporting technologies, such as battery energy storage systems or synchronous condensers, needed to complement the capabilities of the power electronic interfaced resources? How are control interactions between these technologies being managed to improve power system technical performance?

On the island of Ireland, following a successful trial it has been demonstrated the system can manage up to 75% of generation needs from non-synchronous sources at any time i.e. 75% System Non-Synchronous Penetration (SNSP). As the Irish system is not synchronously supported by neighbouring regions, world leading SNSP levels are required to transition to a system predominantly powered by renewables. Transitioning to higher levels of SNSP requires appropriate support from the technologies available to the system at any time and with growing diversity among the technology mix the capabilities of the various technology types need to be appropriately understood.

One important supporting technology is Battery Energy Storage Systems (BESS). The capacity of BESS connected to the Irish system has increased significantly in the past couple of years, and there is significant capacity in development for the coming years as depicted in Figure 1. With BESS contributing significantly to the capacity mix across the island, maximising the contribution from these units will become increasingly important. The potential value contribution from BESS is multi-dimensional with the units connected to the Irish power system providing a range of system (ancillary) services including:

- Fast Frequency Response (FFR): 2-10 seconds
- Primary Operating Reserve (POR): 5-15 seconds
- Secondary Operating Reserve (SOR): 15-90 seconds
- Tertiary Operating Reserve 1 (TOR1): 90-300 seconds
- Tertiary Operating Reserve 2 (TOR2): 5-20 minutes

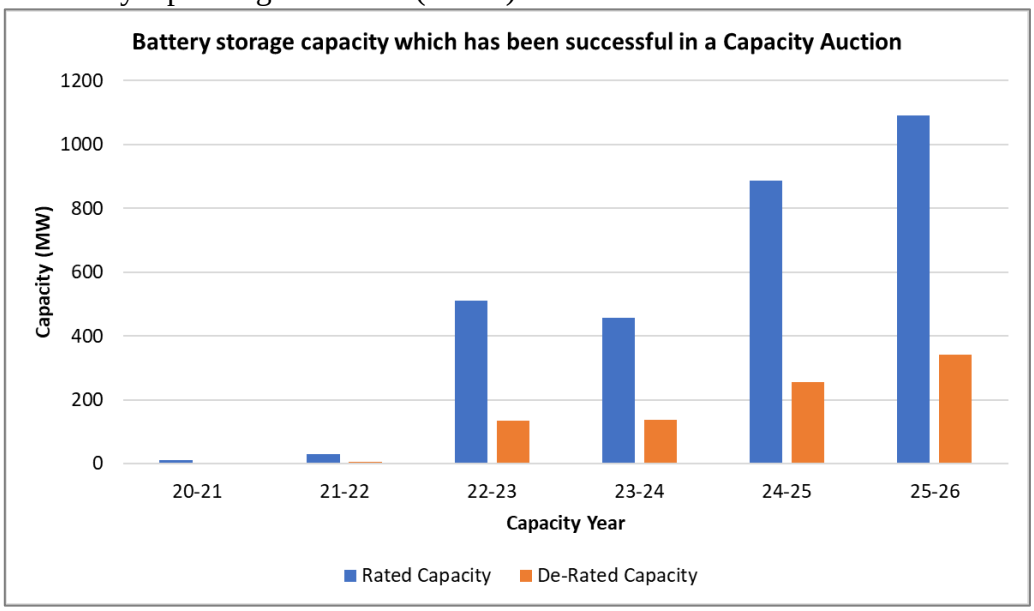

Figure 1 - Growth of battery technology in the Irish Capacity Market

The BESS units connected to the Irish power system can respond in fractions of a second to frequency fluctuations. Typically, there needs to be some degree of tolerance for fluctuations given the frequency will naturally vary as supply is actively managed to be balanced against the demand on the system at any time. The variations in system frequency are becoming more pronounced as the system becomes increasingly driven by intermittent renewables (primarily wind on the Irish system today however this will start to include solar in the next 2-3 years as the results from recent renewable energy auctions materialise). Additionally, as the share of renewables increases the system must adapt to operate with less inertia, which will naturally result in a system that is more prone to frequency fluctuations. In this respect, EirGrid and SONI (the TSOs on the island of Ireland) have deployed a range of frequency response modes across the BESS units on the system. The frequency response modes are a combination of thresholds and trajectory settings that effectively govern a unit's response to frequency derivations. Such settings are depicted in Figure 2 below.

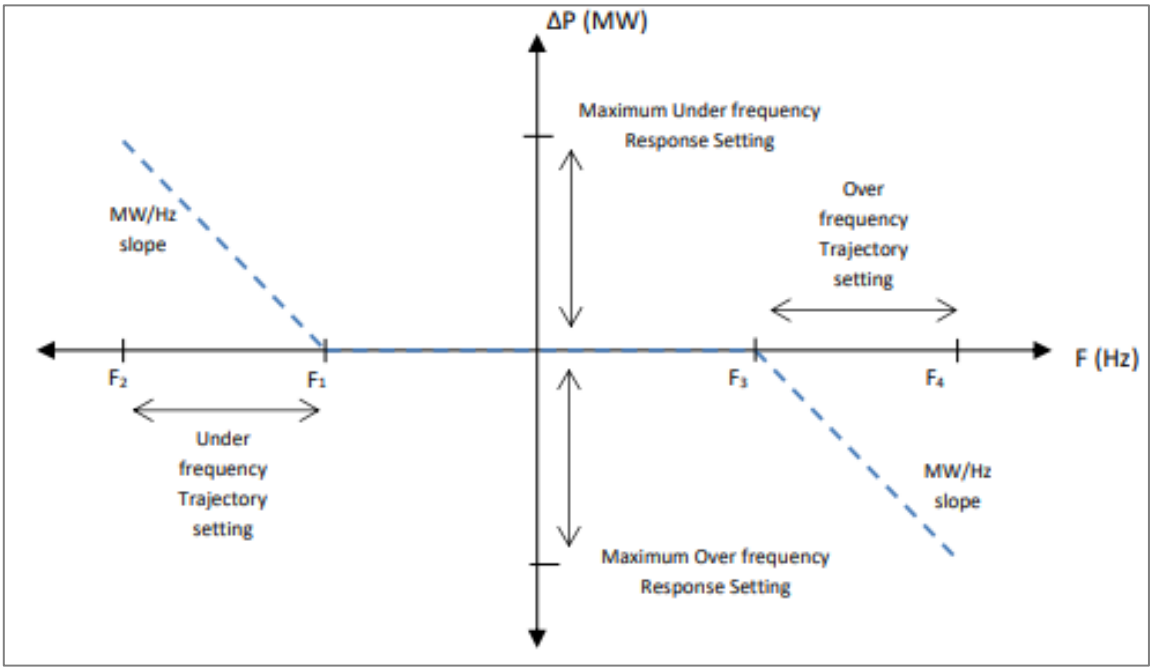

Figure 2 – BESS frequency response setting configuration

As the importance of energy storage grows, one such benefit as shown in Figure 3 below is in response to frequency events, specifically in this case a double trip under frequency event.

Through comparing the theoretical Rate of Change of Frequency (RoCoF) with the calculated RoCoF, it is shown that batteries effectively contributed to reducing the RoCoF during the 2nd generator trip, thus limiting the potential cascading effects of multiple loss of generators. Currently, across the system a range of settings are deployed as the need for BESS response develops, with under frequency response settings between 49.985 Hz and 49.8 Hz. Therefore, regardless of the under-frequency setting, all batteries would have surpassed their under-frequency trajectory setting following the first generator trip and actively outputting power. It is for this reason that the RoCoF in response to the 2nd generator trip was much less the original trip. Managing these settings across the range of responses required from BESS units given the developing system conditions is under continued review.

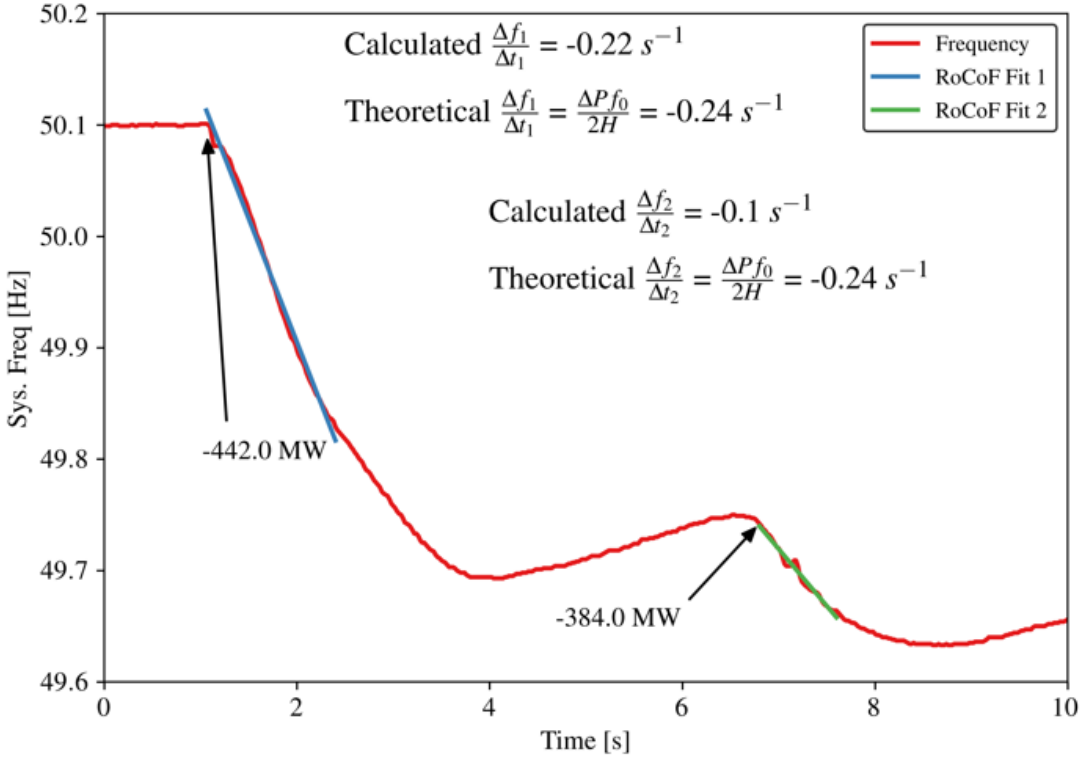

Figure 3 - Double trip event of large conventional plant and associated trip ROCOFs

In 2030 the Irish power system is expected to be required to operate up to and beyond 95% SNSP. Whilst BESS may not represent the full replacement for the reduction in system inertia, the effectiveness of the technology has been demonstrated to make an effective contribution and operating alongside other technologies such as synchronous condensers will reduce dependence on conventional generation for system needs.

Both Northern Ireland and Ireland achieved their respective targets of 40% of their electricity needs coming from renewable resources in 2020. The 2021 Climate Action Plan in Ireland and the Northern Ireland Energy Strategy both set a target for this to increase to 80% by 2030. As we embark on this transition the role and demand for dynamic, flexible energy storage will become ever more prevalent and therefore wider contributions from BESS units as well as limitations need to be considered. These are briefly outlined below.

Future opportunity:

- Energy arbitrage / peak shaving. Currently on the Irish power system BESS units are typically short duration (approx. 30 minutes of output at max capacity) and provide ancillary services. Therefore, these units are commercially designed to provide system services ranging from FFR (2 second response time) to TOR2 (up to 20 minutes response). EirGrid and SONI have conducted trials to evaluate the scope of system changes and/or considerations that are needed to enable BESS units to move from System Services to more dynamic and regular operation.
- Storage duration: As mentioned above the majority of units active on the Irish power system today are shorter duration units. However, this year the first 2-hour unit was energised and furthermore in recent capacity auctions a number of 3+ hour units have been successfully awarded capacity for future capacity years. It is expected a more diverse range of services will be on offer from these longer duration units for example, longer duration storage units can contribute to System Service Ramping products.

- Blackstart provision: Longer term it is anticipated that BESS may contribute to reinforce and support the Blackstart provision in the event of system restoration

Limitations:

- It has been indicated to EirGrid and SONI that a number of units have limited number of charge/discharge cycles permitted on per annum based on their OEM warranty agreements. This has the potential to limit the scope for which these units can be dispatched by the system operator.