Over Frequency Generation Shedding Schedule

Summary Report

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EIRGRID SONI

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1. Introduction

The power system of Ireland and Northern Ireland is undergoing significant change. Conventional fossil fuel synchronous generators are increasingly being displaced by renewable non-synchronous generators. This transition fundamentally alters the dynamic characteristics of the power system of Ireland and Northern Ireland.

Traditionally, the sudden loss of the Largest Single Infeed (LSI) – a generator or HVDC interconnector[1] import – has been the focus when assessing the stability of the system. However in recent years, electricity exports from Ireland and Northern Ireland to Great Britain, via the interconnectors, are more frequent than before. The trip of a Largest Single Outfeed (LSO), such as an interconnector exporting, could result in an over frequency event as illustrated in Figure 1. Therefore, the TSO must increasingly consider the sudden loss of an interconnector while exporting when assessing the stability of the system.

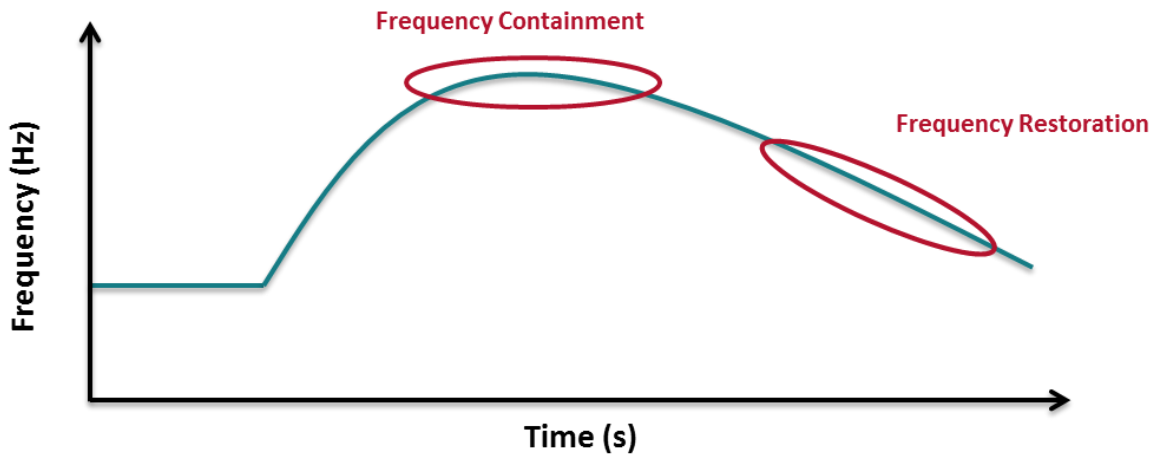

Figure 1: Example of an over frequency event

At times of high wind generation, conventional generators may be offline or near their minimum generation level. This reduces the level of online synchronous inertia[2] and the availability of conventional generators to reduce their power output. Furthermore, as the size and occurrence of interconnector exports increase, the risk of over frequency events from an interconnector export trip also increases.

To maintain the security of the power system following an over frequency event, the TSOs have developed an over frequency generation shedding schedule (OFGSS). The OFGSS involves the deliberate

[1] Interconnectors are HVDC subsea cables which allow for the transfer of power between the island of Ireland and Great Britain.

[2] A characteristic of conventional synchronous generators which helps maintain the stability of the system.

disconnection or reduction in output of generation in a staggered approach at different frequency triggers. The objective of the OFGSS is to contain the system frequency rise during an over frequency event. Additional action may then be needed to restore the system frequency to its nominal value of 50 Hz. This report provides a summary of the approach taken to develop the OFGSS and an illustration of it's impact following implementation.

2. Methodology

2.1. Study objectives

The objective of the study was to produce an OFGSS for the Ireland and Northern Ireland power system taking account of two contingencies:

1. The loss of a 500 MW interconnector export; and
2. System separation (separation of the Ireland and Northern Ireland system – currently connected through a dual 275 kV tie-line).

As stated, the objective of the OFGSS is to contain the system frequency rise following an over frequency event. The OFGSS involves the deliberate disconnection or reduction in output of generation in a staggered approach at different frequency triggers to contain the system frequency. Additional action may be needed to restore the system frequency to its nominal value of 50 Hz.

2.2. Study Approach

An OFGSS comprising solely of wind generation was developed and assessed. Wind generation was chosen due to:

1. The relatively smaller size of windfarms in comparison to large conventional generators;
2. There is no synchronous inertia lost following their disconnection;
3. They are geographically dispersed; and
4. There is a Grid Code requirement for wind generation to have the facility to reduce their output to 0 MW at a specified frequency.

Therefore the use of wind generation allows for an accurate and prudent OFGSS to be developed. Furthermore, it avoids any potential local voltage issues which may be experienced if too much generation is tripped in one area. The windfarms for each frequency trip band were carefully selected based on their geographical location to avoid these voltage issues.

PLEXOS[3] was used to create dispatch scenarios which allowed for the assessment of the two contingencies over a full year. This allowed the assessment of varying levels of demand, wind generation, and conventional generation dispatch. Frequency and voltage stability analysis was carried out for 8760 hours for both contingencies. An iterative process of testing the dispatch schedule, analysing the results to ensure no frequency or voltage issues were present, modifying the OFGSS and retesting was undertaken. This process was repeated until an optimal OFGSS was developed to cover the wide range of system conditions which were being investigated. Details of the results are given in the next section.

[3] PLEXOS for Power Systems - https://energyexemplar.com/software/plexos-desktop-edition/.

3. Results

This section illustrates frequency traces for the two contingencies assessed; presenting results for both pre- and post-implementation of the new OFGSS. Each charts presents 8760 results, i.e. a result for every hour of the year analysed.

3.1. Pre-Implementation of the OFGSS – Interconnector Export Trip

Figure 2 illustrates the frequency traces for the loss of an interconnector on full export pre-implementation of the OFGSS. This demonstrates that the current over frequency settings are not sufficient as it can clearly be seen a number of hours result in the system collapsing.

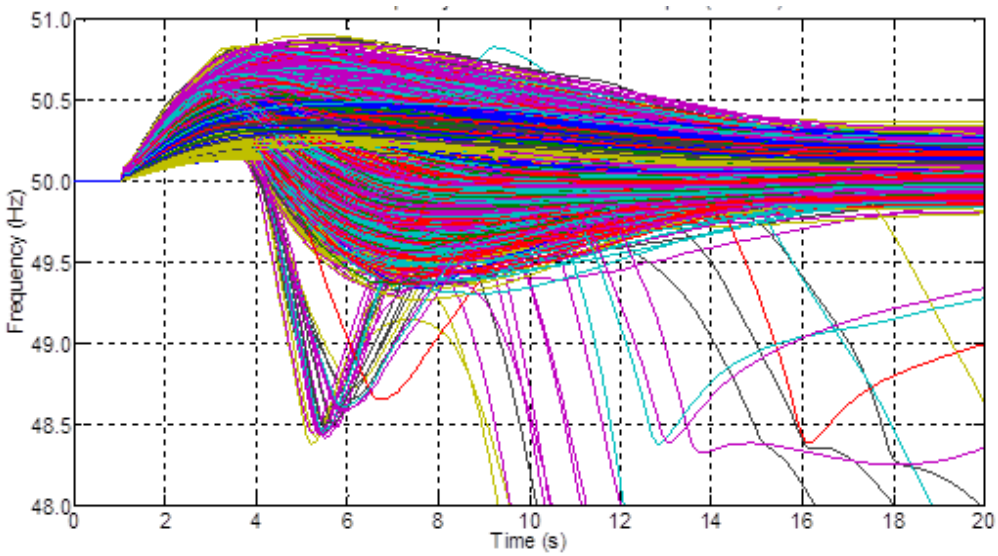

Figure 2: Loss of exporting interconnector pre-implementation of the OFGSS

3.2. Post-Implementation of the OFGSS – Interconnector Export Trip

Figure 3 illustrates the frequency traces for the loss of an exporting interconnector post-implementation of the OFGSS. No frequency issues are observed once the sceheme is in place. As the frequency rises above 50.5 Hz, generation is tripped in a co-ordinated manner which arrests the frequency rise.

In a number of dispatches the frequency remains above 50.35 Hz at the end of the simulation. In these dispatches wind generation is high, resulting in a number of conventional units operating at, or close to, their minimum generation levels. While the frequency rise is contained, further action is required to

restore the frequency to pre-contingency levels close to 50 Hz. This could be achieved by frequency regulation from WFPS or manual action via the control centres.

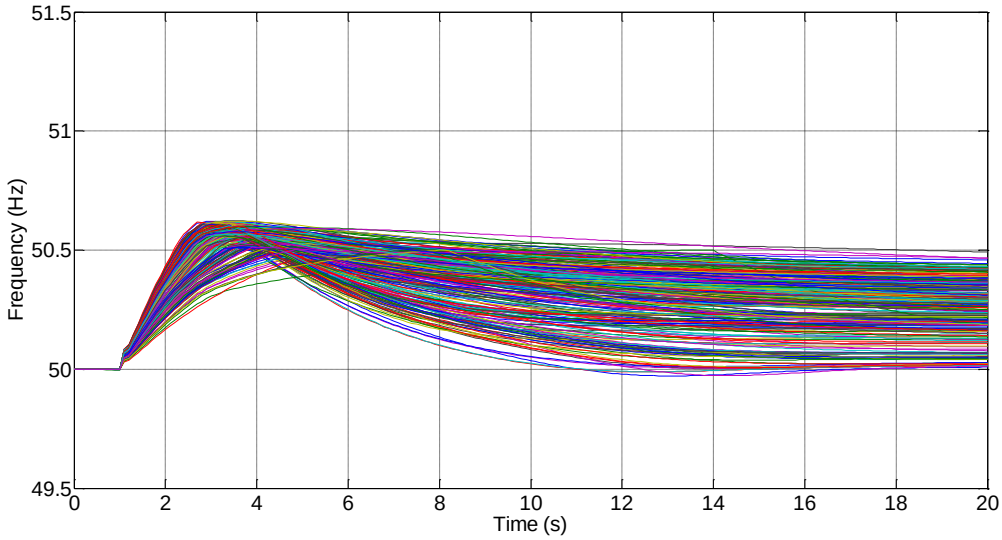

Figure 3: Loss of exporting interconnector post-implementation of the OFGSS

3.3. Post-Implementation of the OFGSS – System Seperation

3.3.1. System Separation – Ireland exporting to Northern Ireland

Figure 4 illustrates the frequency traces in Ireland following a system separation event post-implementation of the OFGSS when Ireland is exporting to Northern Ireland. No frequency issues are observed once the sceheme is in place. As the frequency rises above 50.5 Hz, generation is tripped in a co-ordinated manner which arrests the frequency rise.

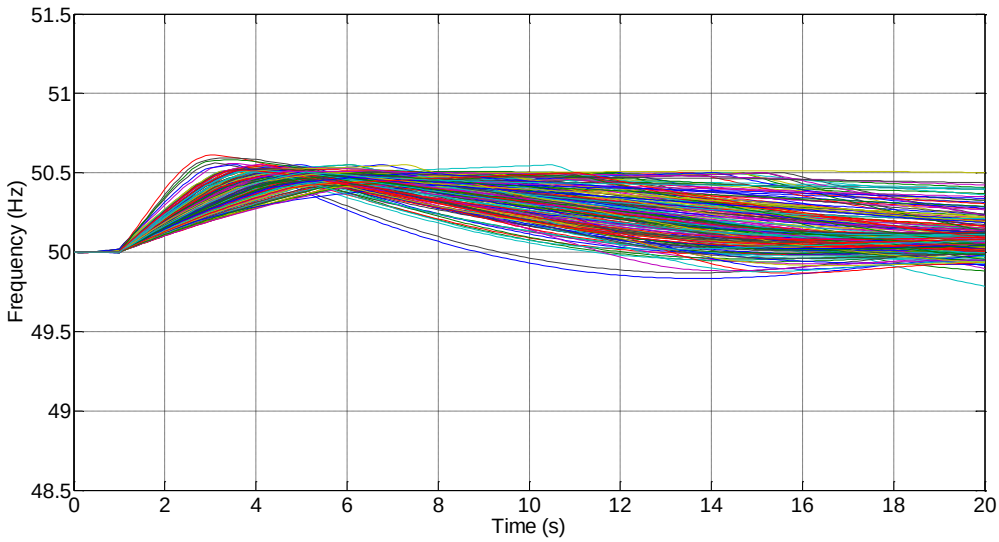

Figure 4: Frequency traces for Ireland following a system separation event post-implementation of the OFGSS

3.3.2. System Separation – Northern Ireland exporting to Ireland

Figure 5 illustrates the frequency traces in Northern Ireland following a system separation event post-implementation of the OFGSS when Northern Ireland is exporting to Ireland. As the Northern Ireland system is relatively light, the frequency can quickly rise above 50.5 Hz. In a small number of dispatches this results in the activation of under-frequency load shedding protection to maintain the system security. This is deemed to be a very low probability event. The construction of the North South Interconnector will further reduce the likelihood of this event occurring as it increases security of supply to Northern Ireland. In the vast majority of dispatches, the frequency remains within the acceptable limits.

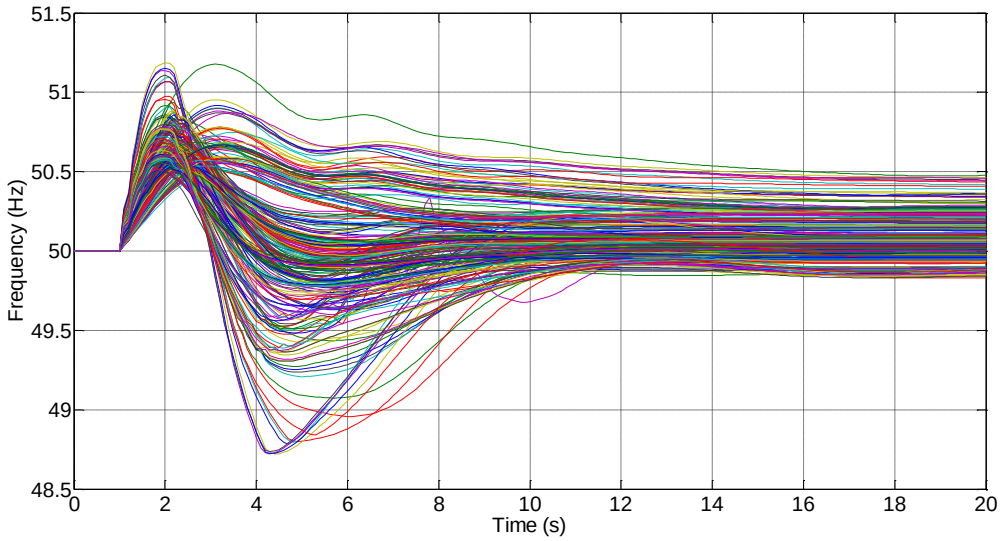

Figure 5: Frequency traces for Northern Ireland following a system separation event post-implementation of the OFGSS

4. Conclusions and Next Steps

The OFGSS, detailed in Appendix A, is effective in mitigating against high frequency events for the wide range of scenarios studied, provided that sufficient wind generation is present on the power system.

No significant frequency issues present themselves when applying the proposed OFGSS, with the exception of load shedding in Northern Ireland following a system separation event where Northern Ireland is exporting to Ireland. System separation is a rare event and will become increasingly unlikely to occur following the energisation of the North South Interconnector.

In all of the generation dispatches studied, the OFGSS was successful in arresting the frequency rise. For the majority of the dispatches studied, the frequency returned to within normal operating limits. Additional actions may be necessary to restore the frequency to the pre-contingency conditions but this is outside the remit of the OFGSS.

The TSOs will initate the transition to the OFGSS scheme outlined in Appendix A in close co-ordination with the Distribution System Operators and the wind farm generators included within the scheme.

Appendix A. Anonymised OFGSS

The following table sets out the frequency setpoints at which the OFGSS will activate for various windfarms in Ireland and Northern Ireland.

Frequency Set-point	All-Island (MW)	IE (MW)	NI (MW)
50.5	129	109	21
50.55	106	106	
50.6	172	154	19
50.65	156	156	
50.7	174	156	18
50.75	152	152	
50.8	186	160	26
50.85	72	72	
50.9	21		21
51	21		21
51.1	18		18
51.2	30		30
51.3	31		31
51.4	27		27
51.5	30		30
Total	**1322**	**1063**	**260**

Table 1: Frequency setpoints for activation of the OFGSS for various windfarms in Ireland and Northern Ireland