DS3:
Frequency Control Workstream

CONTEXT

In a synchronous AC power system, such as Ireland and Northern Ireland, all of the conventional generating units are synchronised together, producing electricity at a nominal frequency of 50 Hz. When supply and demand are in balance, the frequency will be static. If there is excess generation, the frequency increases; conversely, if there is insufficient generation, the frequency will decrease. The normal operational frequency range is 49.8 Hz and 50.2 Hz. EirGrid and SONI have a primary duty to manage the frequency in real-time. Frequency excursions outside these limits can occur if there is a sudden change in demand, generation or interconnector flow. This is managed by maintaining operating reserves, both spinning and static, on the system that can be used to correct energy imbalances when they occur.

A power system with a high penetration of variable non-synchronous wind generation poses significant challenges for frequency control over multiple timeframes. These challenges can be categorised as follows:

a) Rate-of-Change-of-Frequency (RoCoF) issues – ensuring that post-event system RoCoF values are managed to avoid excessive rates which come about because of the reduced system inertia in a system with high non-synchronous penetration. This issue is being addressed separately in a dedicated DS3 workstream;
b) Frequency Response to Large Disturbances – ensuring adequate system inertia and fast-acting response to minimize chances of excess frequency deviations from the loss of large in-feeds or large exports;
c) Voltage Dip-Induced Frequency Dips – transmission faults that lead to reduced power output from wind farms, leading to a frequency dip;
d) Frequency Regulation – maintaining system frequency within its normal limits, and coping with fluctuations in demand and generation particularly with increased penetration from wind farms;
e) Ramping Capability – ensuring that the generation and demand side portfolio response is able to cope with changes in demand and wind generation over periods from minutes to hours. This is often referred to as "flexibility" of plant;
f) System Inertia – ensuring the TSOs' unit commitment programme takes account of any system inertia constraints when economically dispatching / committing generation; and
g) Over-Frequency Generation Shedding – developing a schedule of generator/wind-farm shedding which will mitigate high system frequencies caused by, for example, a HVDC trip whilst heavily exporting.

Generation adequacy is not covered explicitly in the DS3 plan. It is assumed that this will be provided by the appropriate market signals to satisfy the required loss-of-load expectation (LOLE). It is noted though that the system services workstream may have an impact on incentivising the provision of certain types of plant in the future. The main facets of frequency control are shown in Figure 1 below.

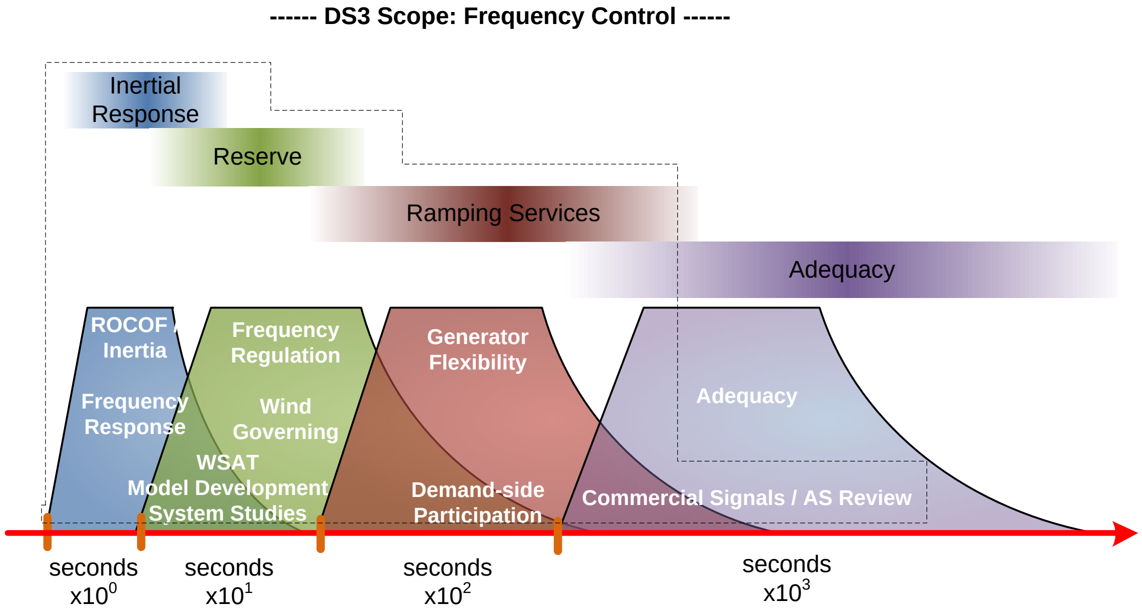


Figure 1: Frequency Control Overview

The purpose of the DS3 programme is to address the various challenges with operating the power system as wind penetration increases. Frequency control is a central pillar of the programme, along with voltage control, as it gets to the very heart of how a power system is operated.

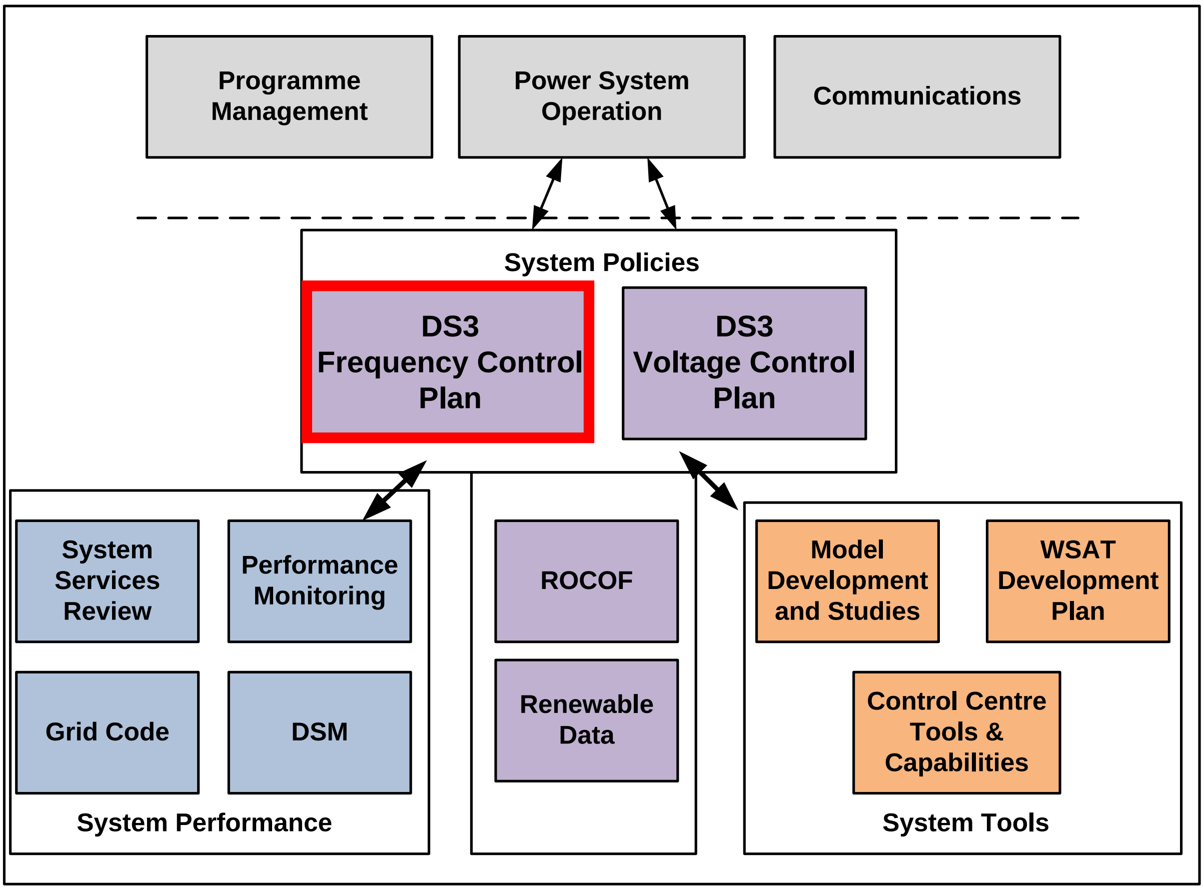
Objectives

The objectives of the Frequency Control workstream are to develop:

1. Operational Policy on necessary operating reserves to meet loss of the largest in-feed and loss of the largest export in a system with increasing penetration of wind;
2. Operational Policy on voltage dip-induced frequency dips, i.e. a fault on the system that leads to a frequency excursion due to slow active power recovery of wind farms causing an energy imbalance after the fault has been cleared;
3. Operational Policy on ramping duties and requirements over timeframes from minutes to hours;
4. Operational Policy on frequency regulation for high penetrations of variable renewables;
5. Incorporating system inertia constraint formulation into TSOs' unit commitment programme; and
6. Development of an over-frequency generation shedding settings schedule.

Dependencies

The DS3 Frequency Control workstream is dependent on the results of other parts of the DS3 programme, as well as its own internal elements. The starting point for the plan is the Facilitation of Renewables study results, which showed that at times of high wind penetrations, frequency control could prove to be challenging and was a key factor that could limit the amount of wind allowed on the system. Specifically the Model Development and Studies, System Services, WSAT and RoCoF workstreams will provide key inputs into the Frequency Control workstream. However, other workstreams will also play a role as depicted graphically below.



Additionally, the frequency control workstream is dependent on continued cooperation with ESBN and NIE through the TSO-DSO Engagement Plan – this reflects the fact that frequency control has implications for both the transmission and distribution networks as the levels of renewable penetration increases. In particular there is a need to ensure that frequency settings are known and co-ordinated across distribution and transmission generator plant and system protection equipment.

HIGH LEVEL PLAN

TASK NO.	TASK / DELIVERABLE	RESPONSIBLE	ORIGINAL DUE DATE	DUE DATE
Operational Policy: Voltage-dip induced frequency dips				
FC.1.0	Derive a working all-island system model	TSOs	Q2 2012	Complete
FC.1.1 (MDS.2.1)	Obtain dynamic models for wind governing / emulated inertia	TSOs	Q1 2013	Complete
FC.1.2.1 (MDS.3.5.1)	Pilot study to investigate voltage dip-induced frequency dips	TSOs	Q2 2013	Complete
FC.1.2.2 (MDS.3.5.2)	Full study to investigate voltage dip-induced frequency dips	TSOs	Q3 2013	Q3 2014
FC.1.3	Development of operational policy to take account of voltage dip-induced frequency dips	TSOs	Q2 2013	Q1 2015
Operational Policy: Frequency Regulation & Reserve				
FC.2.1	Study the frequency regulation issue / historical data / likely issues	TSOs	Q2 2012	Complete
FC.2.2	Study the frequency response to large disturbances based on historical data	TSOs	Q2 2012	Complete
FC.2.3	Look at long-term System Services implications for inertia provision	TSOs	Q2 2012	Complete
FC.2.4	Derive a working all-island system model	TSOs	Q2 2012	Complete
FC.2.5	Look at long-term System Services implications for frequency regulation provision	TSOs	Q2 2012	Complete
FC.2.6	Reserve study based on existing operational policies	TSOs	New Task	Q3 2014
FC.2.7	Report on system frequency regulation analysis	TSOs	Q2 2012	Q4 2014
FC.2.8	Begin reserve / regulation pilot test on wind farms	TSOs	Q1 2013	Q4 2014
FC.2.9 (MDS.3.6.1)	Pilot FFR/POR/SOR study based on existing operational policies	TSOs	New Task	Q1 2015
FC.2.10	Review of reserve / regulation pilot test on wind farms	TSOs	Q3 2013	Q2 2015
FC.2.11	Develop interim reserve / regulation operational policy	TSOs	New Task	Q4 2015
FC.2.12	Deliver final reserve / regulation operational policy (taking account of non-conventional providers)	TSOs	Q3 2014	Q2 2016
Operational Policy: Ramping				
FC.3.1	Analysis of historical data and studies on expected ramping duty in the future	TSOs	Q2 2012	Complete
FC.3.2	Look at long-term System Services for ramping services provision	TSOs	Q2 2012	Complete
FC.3.3 (MDS.3.4.2)	Agree terms of full Ramping Policy study	TSOs	New Task	Q4 2014
FC.3.4	Determine forecast accuracy of demand	TSOs	New Task	Q4 2014
FC.3.5	Determine forecast accuracy of interconnector	TSOs	New Task	Q4 2014
FC.3.6	Determine forecast accuracy of wind	TSOs	New Task	Q4 2014

FC.3.7	Determine process for estimating forecast accuracy	TSOs	New Task	Q4 2014
FC.3.8 (MDS.3.4.4)	Carry out Ramping Policy study	TSOs	New Task	Q2 2015
FC.3.9	Interim Ramping Operational Policy developed	TSOs	Q1 2014	Q3 2015
FC.3.10	Specification for Grid Ramping Tool	TSOs	New Task	Q4 2015
Operational Tools: Inertia				
FC.4.1	Scope system inertia constraint formulation for RCUC	TSOs	New Task	Complete
FC.4.2 (CCTC1.9)	Implementation of inertia constraint formulation in RCUC	TSOs	New Task	Q4 2014
Static Reserve Review				
TDF1	Development and assessment of requirements			
TDF1.1	Develop over frequency generation shedding requirements	TSOs	New Task	Q2 2014
TDF1.2	Develop over frequency interface protection setting requirements	TSOs	New Task	Q2 2014
TDF1.3	Assessment of TSOs' over frequency generation shedding requirements	ESBN	New Task	Q3 2014
TDF1.4	Assessment of TSOs' over frequency generation shedding requirements w.r.t. interface protection	ESBN	New Task	Q3 2014
TDF1.5	Assessment of TSOs' over frequency generation shedding requirements	NIE	New Task	Q3 2014
TDF1.6	Assessment of TSOs' over frequency generation shedding requirements w.r.t. interface protection	NIE	New Task	Q3 2014
TDF1.7	Assessment of TSOs' requirements including impact on LoM and User protection settings	ESBN	New Task	Q3 2014
TDF1.8	Agree next steps regarding implementation	NIE / TSO	New Task	Q3 2014
TDF1.9	Agree next steps regarding implementation	ESBN / TSO	New Task	Q3 2014
TDF2	Implementation Project (subject to outcome of considerations/approvals above)			
TDF2.1	Develop high frequency shedding schedule and implementation plan	NIE / TSO	New Task	Q3 2014
TDF2.2	Develop high frequency shedding schedule and implementation plan	ESBN / TSO	New Task	Q3 2014
TDF2.3	Commence implementation project	NIE	New Task	Q4 2014
TDF2.4	Commence implementation project	ESBN	New Task	Q4 2014
TDF3	Enduring Arrangements			
TDF3.1	Agree enduring policy/process for DSO and User frequency settings	NIE / TSO	New Task	Q4 2014
TDF3.2	Agree enduring policy/process for all DSO and User frequency settings	ESBN / TSO	New Task	Q4 2014
Data Gathering				
FC.5.1 (TDL2.1)	Survey and compile database of existing RoCoF and frequency settings	NIE	New Task	Q3 2014
FC.5.2 (TDL2.2)	Compile database of existing RoCoF and frequency settings	ESBN	New Task	Q3 2014
FC.5.3	Survey and compile database of frequency and voltage sensitive protection device settings	TSOs	Q2 2013	Q1 2015