DS3 System Services: Portfolio Capability Analysis

External – November 2014

The system services capability provided in this report is based on a single enhanced 2020 portfolio that the TSOs believe can meet the 2020 renewable electricity targets. This is not to say that this is the system services capability required to meet the 2020 renewable electricity targets – for example the 2020 portfolio is likely to be different and therefore the level of capability required may be different.

Additionally volumes detailed in this report are not suitable for auctions or tariff setting.

Contents

1. Introduction

The power system of Ireland and Northern Ireland is in a period of transition driven by national and European policy objectives, particularly with respect to renewable energy. This transition will result in a fundamental change to the power system generation portfolio, the operational characteristics of the system under both steady state and transient conditions and it will significantly transform the requirement for and composition of essential system services.

System Services are those services, aside from energy, that are necessary for the secure operation of the power system. These services are also referred to as Ancillary Services (AS) and System Support Services (SSS). EirGrid and SONI have licence and statutory obligations to ensure sufficient system services are available to enable efficient, reliable and secure power system operation.

To address the challenges of the policy objectives, EirGrid and SONI put in place a multi-year, multi-stakeholder programme of work, "Delivering a Secure Sustainable System" (DS3). The System Services Review, which forms a central component of the DS3 programme, was initiated with the goal of ensuring that system services would be available to meet the needs of the system in line with policy objectives.

The objective of this report is to identify indicative system service capability estimates for the existing portfolio and also for a single enhanced 2020 portfolio that the TSOs believe can meet the 2020 renewable electricity targets. This work involved the following discrete steps:

1. Estimate capability of existing portfolio for all 14 products (sum of all service providers' capability).
2. Derive a single possible 2020 portfolio that could enable operation at 75% SNSP[1]
3. Estimate capability of this enhanced portfolio for all 14 products (sum of all service providers' capability).

[1] SNSP: System Non-Synchronous Penetration

2. Caveats and Limitations of Analysis

This analysis is based on desktop analysis, is indicative in nature and should be considered in the following context:

Limitations

1. Any portfolio must be capable of always meeting realtime system service requirements over the full range of possible system conditions, e.g.
    - Wind ranging from 0 MW to 4600 MW
    - Demand ranging from 2000 MW to 7000 MW
    - Full import to full export on interconnectors
    - Largest single infeed / outfeed: 200 MW to 530 MW
    - Transmission infrastructure build-out and outages
    - Service provider size / location / capability / performance

   The realtime requirements for system services will vary with these system conditions.

2. The realtime system service dispatch will need to take account of the cost of delivering the services. For example, a unit which is capable of providing a significant portion of a realtime product requirement may be very costly to operate in the energy market and thus will present limited realisable value from a realtime system services provision context.

3. There are a range of potential portfolio solutions which would allow the system to be operated at 75% SNSP – the system services capability of these portfolios will likely be different from those detailed in this report.
    - Each individual component of a portfolio solution has its own technical characteristics, i.e. particular system services that it can or cannot provide
    - By setting the volume of individual system services on an assumed portfolio basis a particular technical outcome may be determined and advantage or disadvantage certain technology types.

Caveats

1. The system services capability provided in this report is based on a single enhanced 2020 portfolio that the TSOs believe can meet the 2020 renewable electricity targets. This is not to say that this is the system services capability required to meet the 2020 renewable electricity targets – for example the 2020 portfolio is likely to be different and therefore the level of capability required may be different.

2. The enhanced portfolio detailed here is based on TSO engineering judgement – the TSO expects that the enhanced generation portfolio will evolve based on market forces and is committed to a technology neutral stance.

3. Volumes detailed in this report are not suitable for auctions or tariff setting.

3. Assumed Generation Portfolios

- The existing portfolio is based on the 2014 portfolio in the Generation Capacity Statement 2014 – 2023, taking account of factors like current DSU capacity
- The enhanced portfolio uses the Generation Capacity Statement 2014-2023 as a foundation, but is augmented based on TSO engineering judgement.
- The key differences between the portfolios (enhanced versus existing) are:
    - Additional ~ 150 MW of DSM (enhanced reserve provision capability)
    - 6 x enhanced capability CCGTs (lower minimum generation level and enhanced reserve capability)
    - 6 x enhanced capability OCGTs (enhanced reserve provision capability)
    - 2 x new OCGTs
    - Additional network devices (STATCOMS and synchronous condensers delivering in aggregate SIR, SSRP and DRR)
    - Additional ~ 2000 MW of installed wind, with just over half with enhanced capability (combination of FFR, FPFAPR and DRR)

Other key assumptions include:

- FFR response was set at 50% of the corresponding POR figure for non-enchanced plant, 60% for enhanced plant.
- The heat status for conventional plant was assumed as cold.
- It has been assumed that windfarms will not contribute to reserve products given its priority status per European RES Directive – however the TSO notes that wind does have the capability of providing these services.
- The enhanced portfolio assumes that the new RoCoF 1 Hz/s standard is in place.

4. Findings

The following tables summarise the system service capability volume estimates for both the existing generation portfolio and a forecasted 2020 portfolio.

Table 1 – System service volume capability estimate for existing generation portfolio

	SIR (MWs^2)	FFR (MW)	POR (MW)	SOR (MW)	TOR1 (MW)	TOR2 (MW)	RR (S) (MW)	RR (D) (MW)	RM1 (MW)	RM3 (MW)	RM8 (MW)	SSRP (Mvar)	DRR (MW)	FPFAPR (MW)
CCGT	65,901	169	338	463	586	655	2,044	0	0	0	996	2,344	4,287	4,287
CHP	0	4	8	8	18	60	169	9	9	171	171	76	171	171
DSM[2]	0	0	0	0	0	0	64	114	215	64	64	0	0	0
Hydro	3,466	3	5	24	51	99	193	148	176	178	178	177	216	216
IC	0	750	750	750	750	750	750	750	750	750	750	350	0	500
OCGT	37,186	93	186	242	265	348	1,096	634	1,080	1,080	1,080	864	1,097	1,097
Storage	55,620	40	80	272	272	292	292	292	292	292	292	309	292	292
Thermal	149,262	98	195	248	269	291	952	0	0	18	126	1,963	3,055	3,055
Wind	0	0	0	0	0	0	0	0	0	0	0	391	0	0
	311,434	**1,281**	**1,562**	**2,007**	**2,211**	**2,495**	**5,560**	**1,947**	**2,522**	**2,553**	**3,657**	**6,474**	**9,118**	**9,618**

[2] Includes distribution connected storage, AGUs etc.

Table 2 – System service volume capability estimates for forecasted enhanced generation portfolio

	SIR (MWs^2)	FFR (MW)	POR (MW)	SOR (MW)	TOR1 (MW)	TOR2 (MW)	RR (S) (MW)	RR (D) (MW)	RM1 (MW)	RM3 (MW)	RM8 (MW)	SSRP (Mvar)	DRR (MW)	FPFAPR (MW)
CCGT	24,876	60	119	170	224	275	836	0	0	0	471	1,050	2,055	2,055
CCGT Enhanced	146,822	173	289	347	385	385	1,208	0	0	0	2,232	1,593	2,232	2,232
CHP	0	4	8	8	18	60	169	9	9	171	171	76	171	171
DSM	0	50	100	100	100	100	314	314	364	214	64	0	0	0
Hydro	3,466	3	5	24	51	99	193	148	176	178	178	177	216	216
IC	0	750	750	750	750	750	750	750	750	750	750	350	0	500
Network Devices	60,000	0	0	0	0	0	0	0	0	0	0	1,400	700	0
OCGT	37,186	80	161	216	236	236	772	310	756	756	756	662	773	773
OCGT Enhanced	0	31	52	52	60	124	324	324	324	324	324	201	324	324
OCGT New	3,081	25	41	41	57	200	200	200	200	200	200	200	200	200
Storage	55,620	40	80	272	272	292	292	292	292	292	292	309	292	292
Thermal	149,262	98	195	248	269	291	952	0	0	18	126	1,963	3,055	3,055
Wind	0	600	0	0	0	0	0	0	0	0	0	1,336	1,100	1,100
	480,312	**2,038**	**1,800**	**2,229**	**2,422**	**2,813**	**6,010**	**2,347**	**2,871**	**2,903**	**5,564**	**9,317**	**11,118**	**10,918**

Appendix I – Product Description

The TSOs have developed a number of new System Services products and have proposed refinement of the definitions of some of the existing ancillary services.

New products

- Synchronous Inertial Response (SIR)
- Fast Post-fault Active Power Recovery (FPFAPR)
- Dynamic Reactive Response (DR)
- Fast Frequency Response (FFR)
- Ramping Margin (RM)

Existing products

- Operating Reserves: POR, SOR, TOR1 &TOR2
- Replacement Reserve – minor modification proposed
- Steady-state reactive power – modification proposed

The details of these proposals are provided in this appendix.

New product: Synchronous Inertial Response

Synchronous Inertial Response (SIR) is the response in terms of active power output and synchronising torque that a unit can provide following disturbances. It is a response that is immediately available from synchronous generators, synchronous condensers and some synchronous demand loads (when synchronised) because of the nature of synchronous machines and is a key determinant of the strength and stability of the power system. It has significant implications for rate of change of frequency (RoCoF) during power imbalances and for transmission protection devices and philosophy. With increasing non-synchronous generation this response becomes scarce and there is therefore a need to incentivise it. In particular, if synchronous inertial response can be provided at low MW outputs, the system can accommodate higher levels of non-synchronous generation.

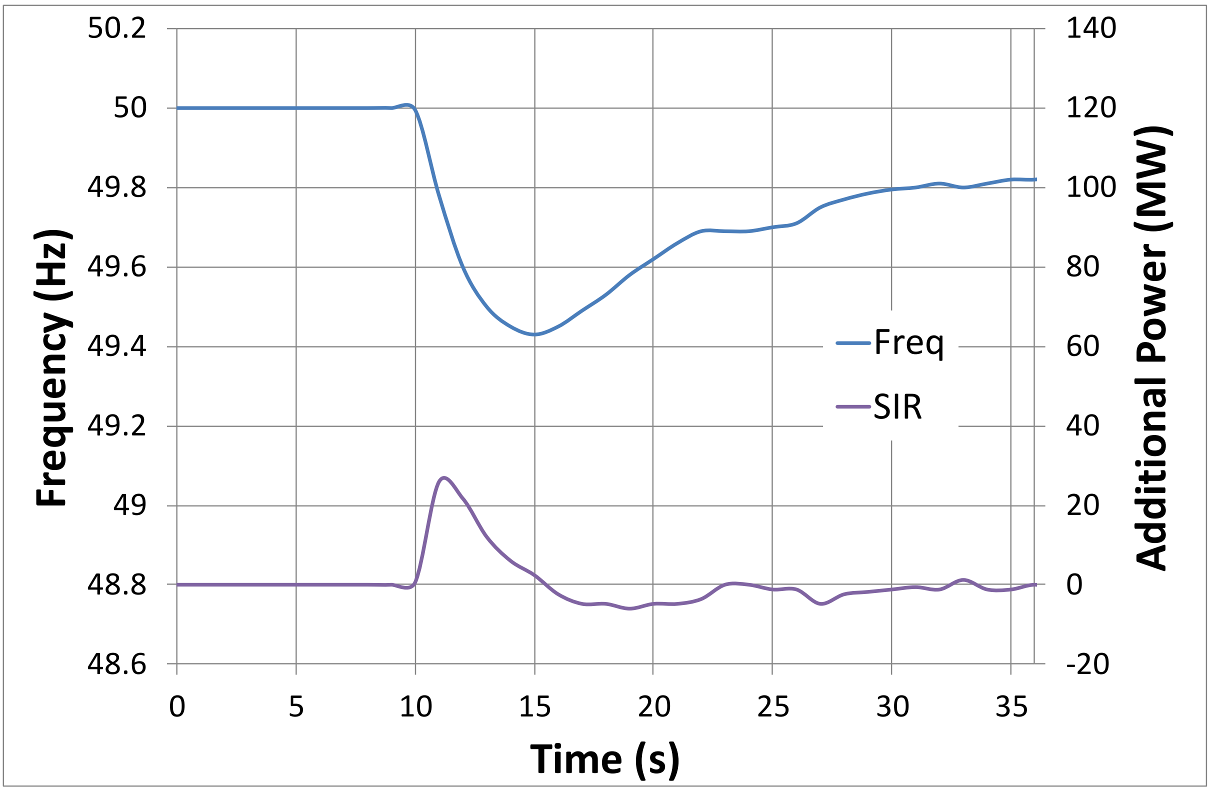

Figure 1: Illustration of typical inertial response

The proposed SIR product is defined as the kinetic energy (at nominal frequency) of a dispatchable synchronous generator, dispatchable synchronous condenser or dispatchable synchronous demand load multiplied by the SIR Factor (SIRF). The SIRF of a synchronous generator is the ratio of the kinetic energy (at nominal frequency) to the lowest sustainable MW output at which the unit can operate at while providing reactive power control. It will be based on the commissioned design capability of the plant as determined through appropriate testing procedures. The SIRF will need to exceed a threshold of 15 s for the provider to be eligible for payment and payment will be capped at a SIRF of 45 s. The SIRF for a synchronous condenser or a synchronous demand load that can provide reactive power control is 45 s. Payments for SIR will be based on the SIR Volume:

SIR Volume = Stored Kinetic Energy × (SIRF – 15) × Unit Status

New product: Fast Post-fault Active Power Recovery

Units that can recover their MW output quickly following a voltage disturbance (including transmission faults) can mitigate the impact of such disturbances on the system frequency. If a large number of generators do not recover their MW output following a transmission fault, a significant power imbalance can occur, giving rise to a severe frequency transient. It is proposed to introduce a service that rewards generators that make a positive contribution to system security.

Fast Post-fault Active Power Recovery is defined as having been provided when, for any fault disturbance that is cleared within 900 ms, a plant that is exporting active power to the system recovers its active power to at least 90% of its pre-fault value within 250 ms of the voltage recovering to at least 90% of its pre-fault value. The generator must remain connected to the system for at least 15 minutes following the fault.

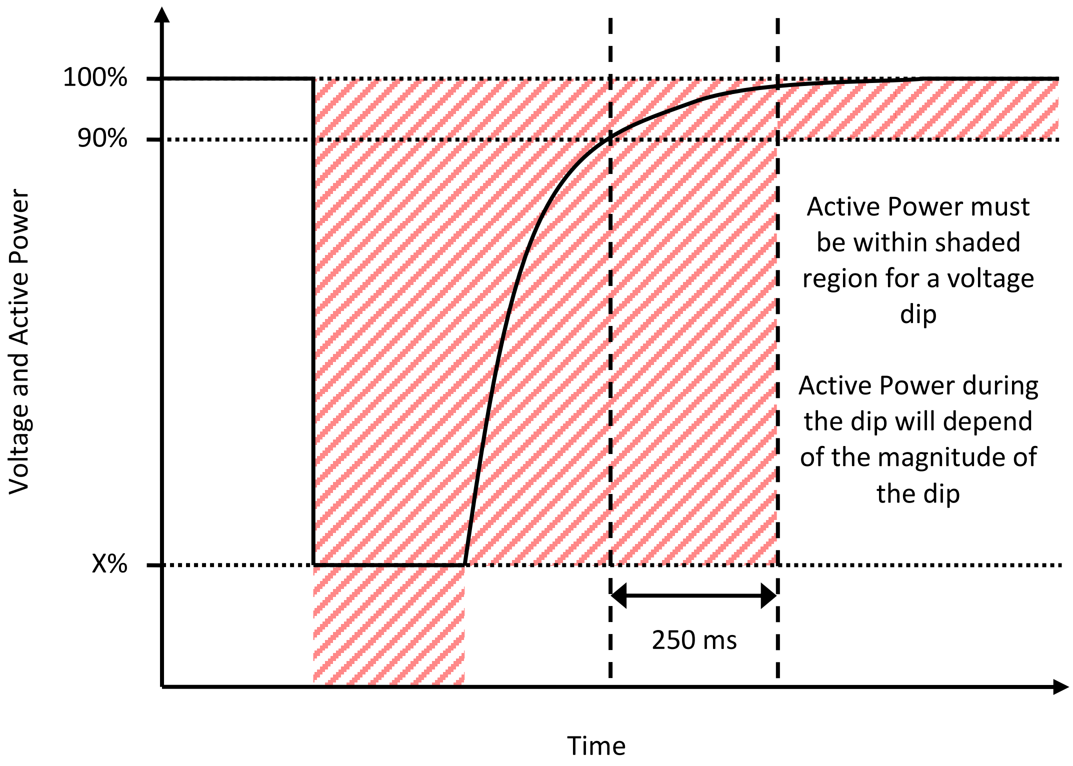

Figure 2: Fast Post-Fault Active Power Recovery Product

New product: Dynamic Reactive Response

At high levels of instantaneous penetration of non-synchronous generation there are relatively few conventional (synchronous) units left on the system and the electrical distance between these units is increased. The synchronous torque holding these units together as a single system is therefore weakened. This can be mitigated by an increase in the dynamic reactive response of wind farms during disturbances. Therefore, a new service is proposed to incentivise this type of response, which is particularly important at high levels of renewable non-synchronous generation. In line with the proposed changes to the Grid Codes, a Dynamic Reactive Response product is proposed.

The Dynamic Reactive Response product is defined as the ability of a unit when connected to deliver a Reactive Current response for voltage dips in excess of 30% that would achieve at least a Reactive Power in Mvar of 31% of the registered capacity at nominal voltage. The Reactive Current response shall be supplied with a Rise Time no greater than 40 ms and a Settling Time no greater than 300 ms.

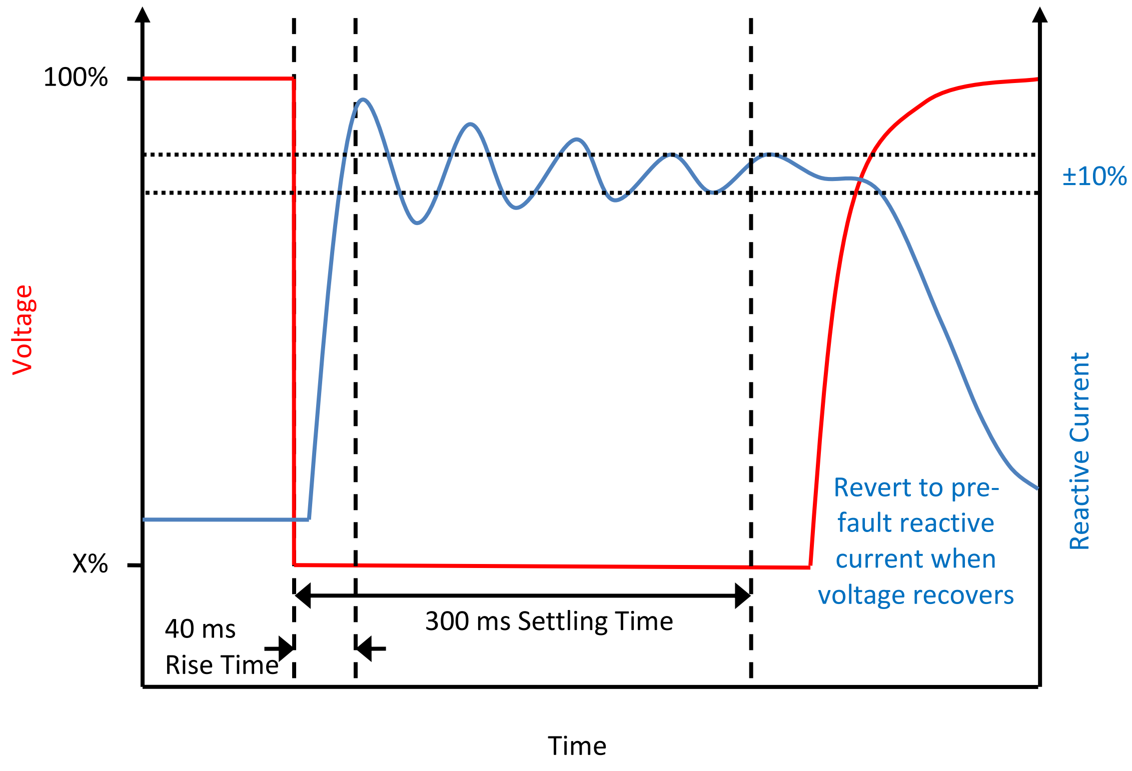

Figure 3: Dynamic Reactive Response product

New product: Fast Frequency Response

With appropriate control systems, both synchronous and non-synchronous generators can provide fast-acting response to changes in frequency that supplements any inherent inertial response. In particular, Fast Frequency Response (FFR) as defined below (MW response faster than the existing Primary Operating Reserve times) may, in the event of a sudden power imbalance, increase the time to reach the frequency nadir and mitigate the RoCoF in the same period, thus lessening the extent of the frequency transient. This product runs in conjunction with SIR so providers who can maintain or increase their outputs in these timeframes are eligible for both services.

Fast Frequency Response is defined as the additional increase in MW output from a generator or reduction in demand following a frequency event that is available within 2 seconds of the start of the event and is sustained for at least 8 seconds. The extra energy provided in the 2 to 10 second timeframe by the increase in MW output must be greater than any loss of energy in the 10 to 20 second timeframe due to a reduction in MW output below the initial MW output (i.e. the hatched blue area must be greater than the hatched green area in Figure 1).

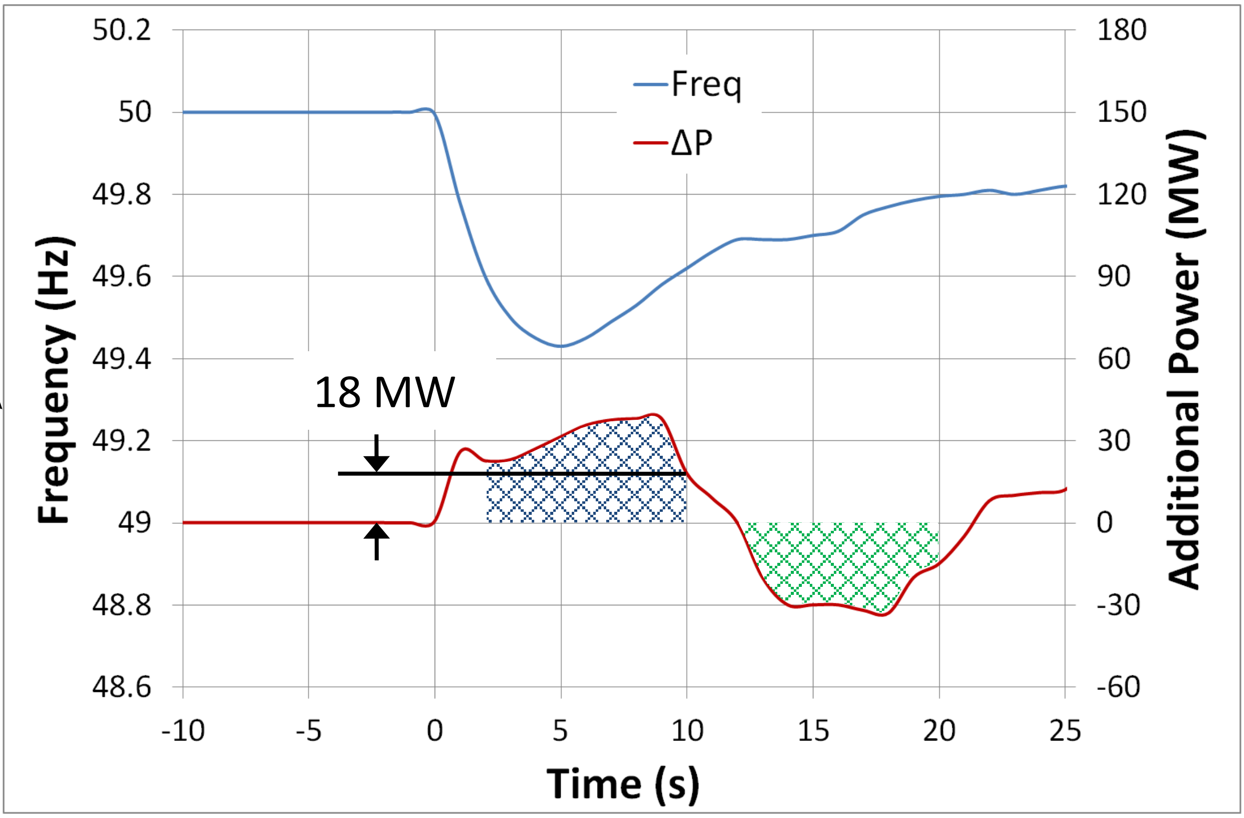

Figure 4: Fast Frequency Response Product

New product: Ramping Margin

The management of variability and uncertainty is critical to a power system with high levels of wind penetration. Detailed analysis has shown that portfolios that are capacity adequate are unlikely to be adequate in terms of ramping over all the necessary timeframes to efficiently and effectively manage the variable renewable sources and changes in interconnector flows while maintaining system security. The analysis has also indicated that a ramping-down product is not currently required.

To incentivise the portfolio to provide the necessary margins to securely operate the power system a new ramping-up product is being proposed over three distinct product time horizons.

*Ramping Margin is defined as the guaranteed margin that a unit provides to the system operator at a point in time for a specific horizon and duration. The TSOs are proposing horizons of one, three and eight hours with associated durations of two, five and eight hours respectively. The Ramping Margin products are called RM1, RM3 and RM8 respectively. The Ramping Margin for a unit at the starting point is the ramp-up capability of the unit in the horizon time limited by the lowest availability in **both** the horizon and duration window (e.g. from 0 to 8 hours for RM3). Thus the Ramping Margin represents the increased MW output that can be delivered with a good degree of certainty by the product horizon time and sustained for the product duration window.*

Please note the following points in relation to the Ramping Margin Product:

- The ramping-up capability of the plant will be based on Technical Offer Data submitted and will include ramp rates, dwell times, break points, etc. as applicable.
- The measurement of this product will be based on half hour figures of MW output and availability.

- The three proposed products are not mutually exclusive. Plant capable of providing all three products are eligible to receive payment for all three, similarly for two.
- Both synchronised and non-synchronised plant is eligible for payment.
- The TSOs do not currently propose to weight payments at times of scarcity.
- The TSOs acknowledge that further discussions will take place regarding plant constrained on/off in the implementation stage.

Potential providers of these services include conventional generators that are not dispatched to their maximum output, storage devices, demand side providers and wind farms that have been dispatched down. In the future with the potential for implicit continuous gate closures, interconnector participants with excess capacity for importing may also be able to provide this service.

Existing product: Operating Reserve

As per current definitions – no changes to the definitions of the POR, SOR, TOR1 and TOR2 services are proposed.

Existing product: Replacement Reserve

It is proposed that, to avoid overlap with the 1 hour ramping product described below, the timings associated with the Replacement Reserve product are redefined.

Replacement Reserve is the additional MW output (and/or reduction in demand) provided compared to the pre-incident output (or demand) which is fully available and sustainable over the period from 20 minutes to 1 hour following an Event.

Existing product: Steady-state reactive power

The need for reliable steady state reactive power control is important for the control of system voltages and for the efficient transmission of power around the system. Both synchronous and non-synchronous sources can contribute to this requirement.

The need for reactive power varies as demand varies and as the sources of generation vary. Since reactive power is difficult to transmit over long distances (unlike active power), reactive sources are required to be distributed across the system. Thus there is not necessarily a strong link between the need for active power and reactive power from the same sources. It is therefore proposed that the reactive power product is re-structured in a way that incentivises reactive capability across the widest possible active power range (P_{range}).

The Reactive Power Capability product is defined for conventional generators as the dispatchable reactive power range in Mvar (Q_{range}) that can be provided across the full range of active power output (i.e. from minimum generation to maximum generation). For wind farms the Reactive Power Capability product is defined as the dispatchable reactive power range in Mvar (Q_{range}) that can be provided across the active power range from Registered Capacity down to at least 12% Registered Capacity.

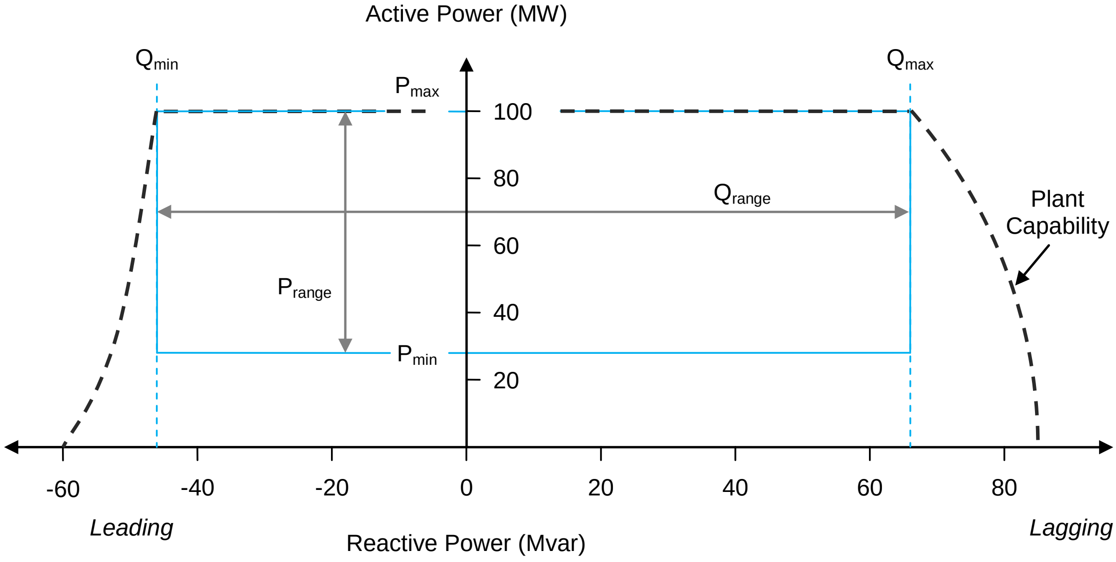

Figure 5: Illustration of Q_{range} and P_{range} for the Steady-State Reactive Power product