

The DS3 Programme

Delivering a Secure, Sustainable Electricity System



“Shaping the Power System for the Future”





The EirGrid Group

EirGrid Group is the licensed electricity Transmission System Operator and Market Operator in Ireland and Northern Ireland.

Our mission is to provide quality, efficient, independent transmission and market services for the benefit of communities, farms and businesses across Ireland and Northern Ireland.

We own and operate the East-West Interconnector between Ireland and Great Britain.

DS3 Programme Objective

The aim of the DS3 Programme is to meet the challenges of operating the electricity system in a secure manner while achieving the 2020 renewable electricity targets.



Impetus for DS3

In response to binding National and European targets, EirGrid Group began a multi-year programme, “**Delivering a Secure, Sustainable Electricity System**” (DS3).

Ireland’s target under the EU Renewable Energy Directive (2009/28/EC) is for 16% of the country’s total energy consumption to come from renewable energy sources by 2020¹.

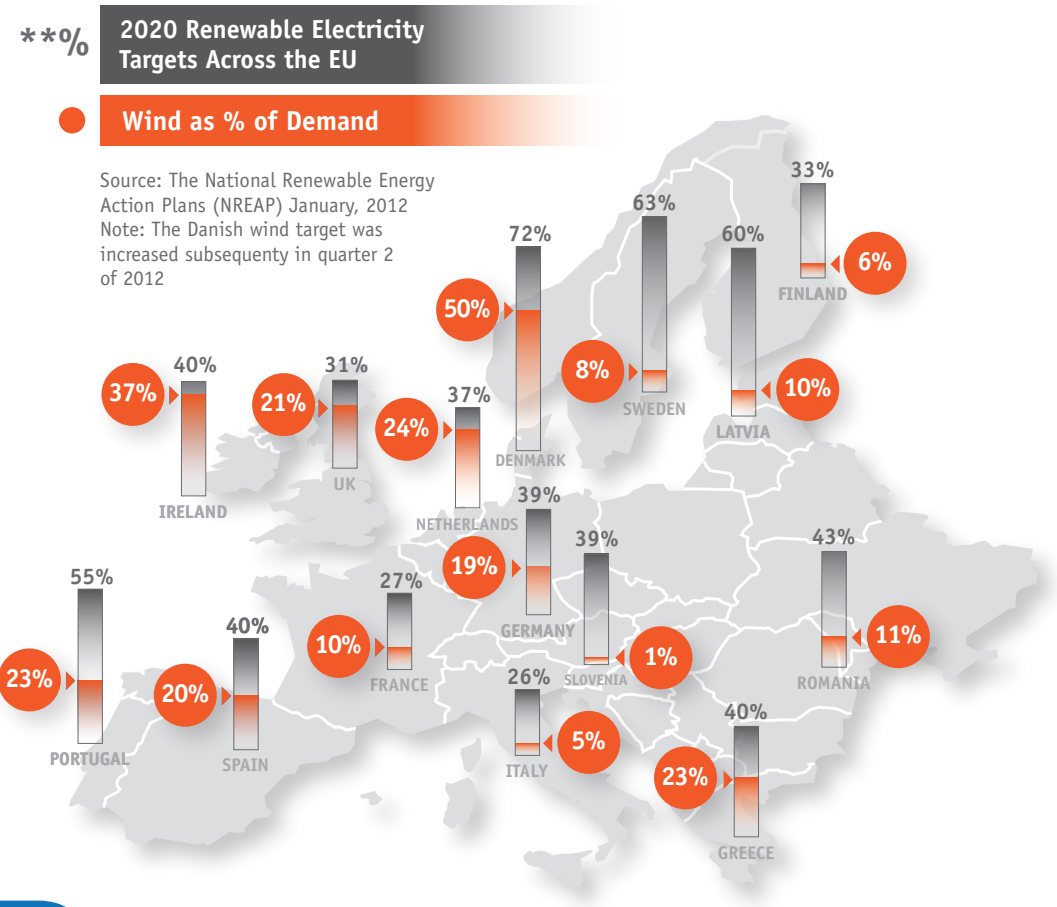
In order to achieve the 16% target the Government set a 10% renewable transport target, a 12% renewable heat target and a 40% renewable electricity target.

Similarly in Northern Ireland, the Department of Enterprise, Trade and Investment (DETI) published the Strategic Energy Framework (SEF) in September 2010, which also set out a 40% renewable electricity target to be reached by 2020.

Achieving this level of renewable integration on a synchronous system is unprecedented and presents significant challenges for the real-time operation of the power system.

The renewable electricity targets for Ireland and Northern Ireland, which will largely be delivered by wind generation, are the highest for any synchronous system in Europe. See figure on page 3: Penetration of Non-Synchronous Renewables

2020 Renewable Electricity Targets Across the EU



¹ Directive 2009/28/EC of the European Parliament and of the Council - <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=Oj:L:2009:140:0016:0062:en:PDF>

Shift in Electricity Supply

The last few years have brought considerable changes to the electricity sector. Most notable have been the drive towards greater environmental sustainability, energy security and economic competitiveness. As a result, there is a commitment to increase the level of renewable generation on the power system.

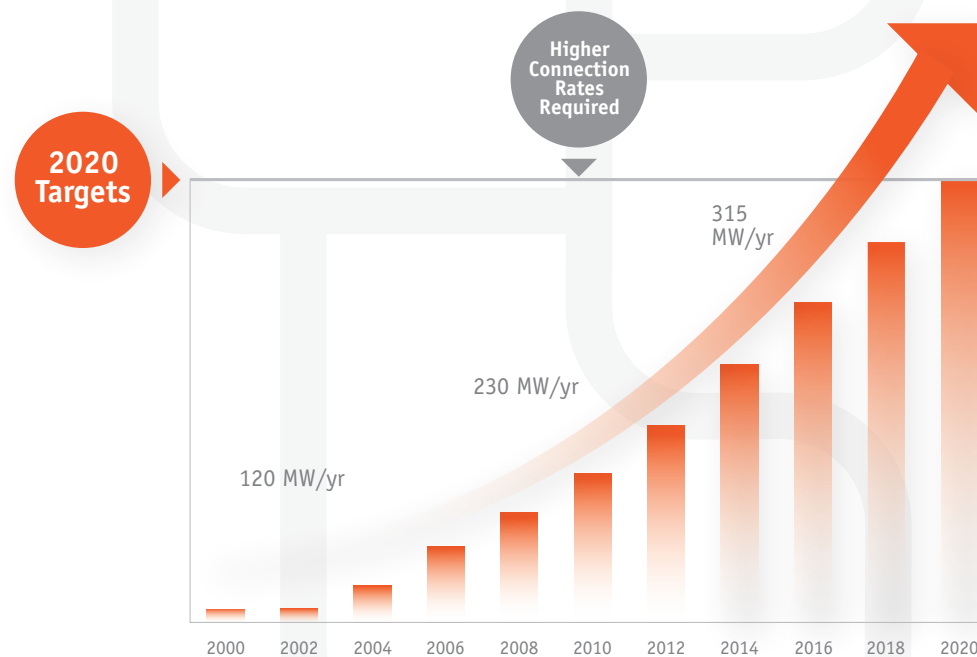
Renewable energy sources, in particular wind generation, are fast becoming a cornerstone of the all-island generation portfolio. Installed wind generation capacity on the island of Ireland has grown from 145 MW at the end of 2002 to 2,825 MW as of December 2014.² This figure is set to increase over the next few years as Ireland and Northern Ireland work to meet their renewable targets by 2020. The actual amount of renewable energy this requires will depend on the demand in future years, the forecast of which

has decreased due to the economic downturn. With these uncertainties in mind, it has been estimated that between 4,400 and 4,900 MW of total installed wind capacity on the island will be required by 2020.³

Renewable energy sources met 21.4% of the island's electricity demand in 2014, 22.6% in Ireland and 17.7% in Northern Ireland.

All-Island Wind Connection Rates

HISTORICAL AND FUTURE CONNECTIONS REQUIRED TO MEET 2020 RES-E TARGETS



Source: EirGrid Group All-Island Renewable Connection Report and 36-Month Forecast (Qtr 4, 2013).

² All Island Wind and Fuel Mix Report (December 2014). http://www.eirgrid.com/media/All-Island_Wind_and_Fuel_Mix_Report_December_2014.pdf

³ All-Island Generation Capacity Statement 2014-2023. <http://www.eirgrid.com/media/Generation%20Capacity%20Statement%202014.pdf>

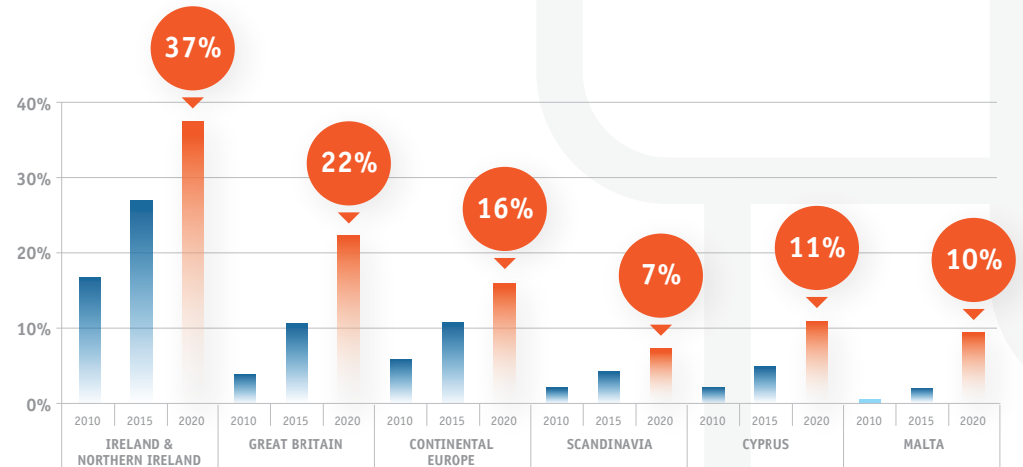
The growth of wind generation presents a range of operational challenges for the power system. The technological characteristics of wind generation are different to traditional generation sources. Wind generation, which is dependent on weather conditions, is inherently variable. This variability must be managed to ensure demand for electricity is met at all times. Additionally, wind generation is a non-synchronous technology, which poses challenges when integrating into a lightly interconnected synchronous system.

What is a 'synchronous system'?

A synchronous system is a power grid where electricity is generated at a single synchronised AC frequency. Ireland and Northern Ireland form such a system – all of the conventional generators on the island run in synchronism, producing electricity at 50Hz. Synchronous systems can operate in relatively small regions, such as Ireland and Northern Ireland, or span vast areas, such as Continental Europe.

Penetration of Non-Synchronous Renewables

IN EACH EUROPEAN SYNCHRONOUS SYSTEM 2010-2020



Source: The National Renewable Energy Action Plans (NREAP 2010)

DS3 - Delivering a Secure, Sustainable Electricity System

The DS3 Programme is designed to ensure that we can securely operate the power system with increasing amounts of variable non-synchronous renewable generation over the coming years. Together with the on-going grid infrastructure development (Grid25 in Ireland and a similar programme which is under development in Northern Ireland) and the addition of renewable generation capacity, the DS3 programme is critical to meeting the renewable electricity targets by 2020.

As operators of an island power system, the TSOs (Transmission System Operators) are facing unique challenges with regard to managing the variability of wind generation while maintaining power system stability and security. As these challenges will not be encountered in larger systems for many years, Ireland and Northern Ireland have the opportunity to lead the way in the integration of non synchronous renewable generation.

The DS3 Programme is made up of 11 workstreams, which fall under the three pillars of System Performance, System Policies and System Tools. Each pillar is fundamental to the success of the programme and to achieving the 40% renewable electricity target. The programme brings together many different strands, including development of financial incentives for better plant performance, and the development of new operational policies and system tools to use the portfolio to the best of its capabilities. Standards for wind farms and conventional plant are also being reviewed to give enhanced operational flexibility for the future. The programme involves many different stakeholders, including the Distribution System Operators (DSOs), Regulatory Authorities, Conventional Generators and Renewable Generators, as well as Government Departments.

DS3 Programme Objectives

The DS3 Programme has been created to meet the challenges of operating the electricity system in a secure manner while achieving 2020 renewable electricity targets.



Programme Establishment and Planning

Since 2011 the focus has been on creating the correct technical and commercial mechanisms to incentivise and improve system performance and capability. Some of the work completed within the DS3 Programme includes:

- A multi-stage consultation process for **System Services**, including consultations on the approach used, the products required and the financial arrangements;
- The approval of a number of **Grid Code** modifications in Ireland and Northern Ireland;
- The implementation of the Wind Security Assessment Tool (**WSAT**) in both Dublin and Belfast Control Centres;
- The decisions on **RoCoF (Rate of Change of Frequency)** from the Regulators in both jurisdictions.

Implementation Phase

Since 2014 the main focus has moved towards the implementation of increased performance capability for the generation portfolio, and developing the required system policies and tools needed to meet the 2020 targets. Future work to be accomplished by the DS3 Programme will include:

- Adapting and refining system operational policies to assist in securely managing the **voltage** and **frequency** on the Irish and Northern Irish power system;
- Design, development and implementation of enhanced **system tools** in order to manage the increased organisational complexity. For example, the inclusion of a ramping tool and a voltage trajectory tool;
- The development of a long-term Operational Policy for large-scale **Demand Side Management** penetration;
- The implementation of an enhanced **Performance Monitoring** system.

Stakeholder Engagement

Given the scale, extent and impact of the DS3 Programme, there is a role for all stakeholders in ensuring its success. EirGrid Group is committed to engaging with all our customers and stakeholders in this regard.

A DS3 Advisory Council was established to provide a forum to discuss issues which may impact on the success of the programme. The Council is comprised of experts from academia and industry across Ireland, Northern Ireland and Europe. It meets approximately every four months and has met 11 times since October 2011.

The wider power industry is updated on recent findings and developments in the DS3 Programme through Industry Forums. These are held roughly every six months. Attendance has been consistently high at the 10 Forums that have been held to date.

The TSO-DSO interaction is an important element of the successful implementation of the DS3 Programme.

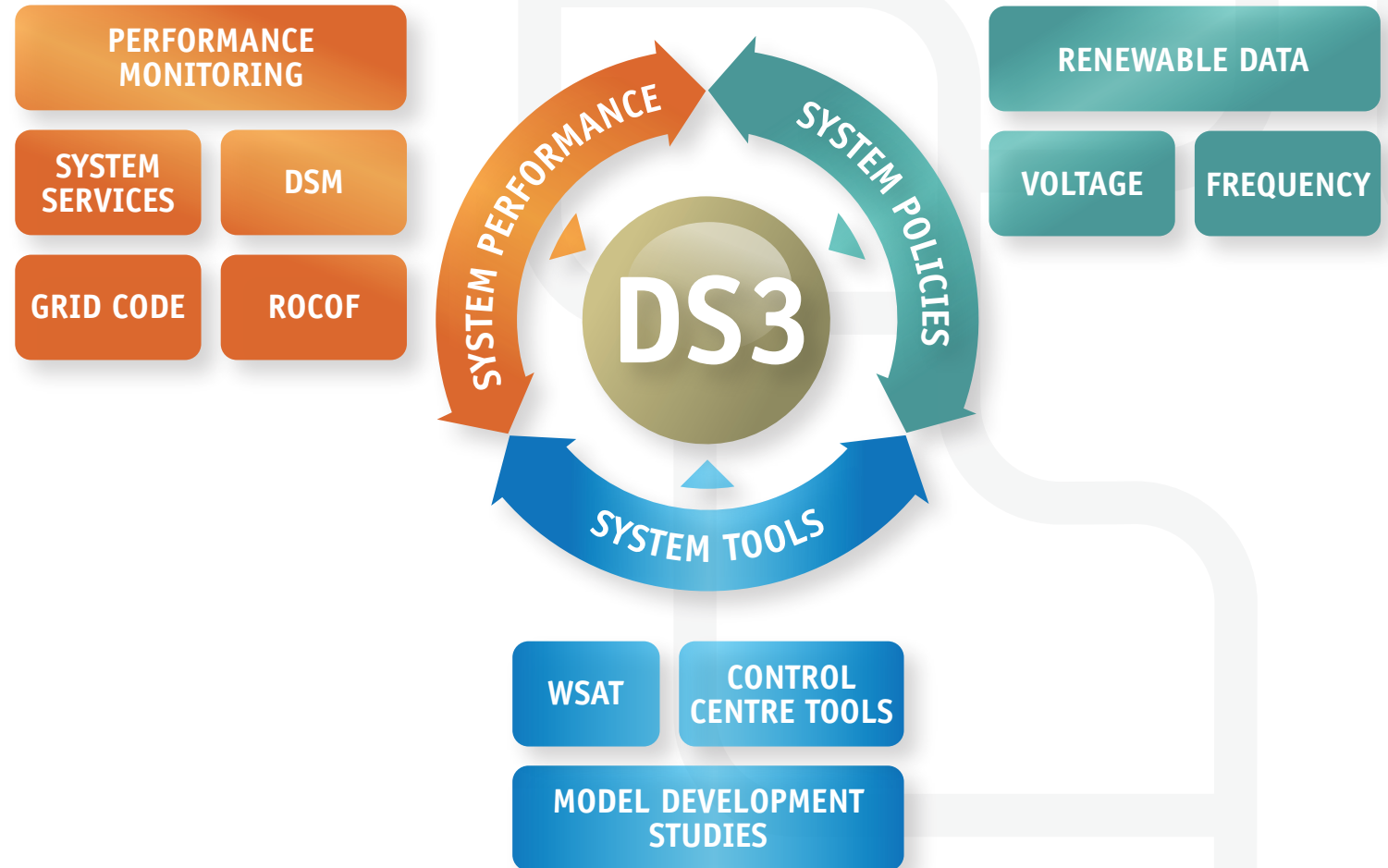
The relationship with the DSOs is critical for the overall safe, secure and efficient operation and development of the power system. A high degree of TSO-DSO co-operation is required to allow each party to fulfil their obligations. A Joint Working Group and an Operational Oversight Committee were established with both ESBN (ESB Networks) and NIE (Northern Ireland Electricity) to ensure a considered and co-ordinated approach across the island.

To ensure the successful delivery of the DS3 Programme, the system operators are also working closely with the regulators, government departments and all relevant industry stakeholders. The objective of all parties is to ensure that the 2020 40% renewable policy targets are delivered in a cost-efficient manner without adversely affecting security of supply of the all-island power system.



The Three Pillars of DS3

The DS3 Programme is built around three main pillars: System Performance, System Policies and System Tools. Each pillar is vital to the success of the programme and the delivery of the renewable electricity targets. Together with the on-going grid infrastructure development (Grid25 in Ireland and a similar programme which is under development in Northern Ireland) and the addition of renewable generation capacity, the DS3 Programme is critical to meeting those targets by 2020.





System Performance

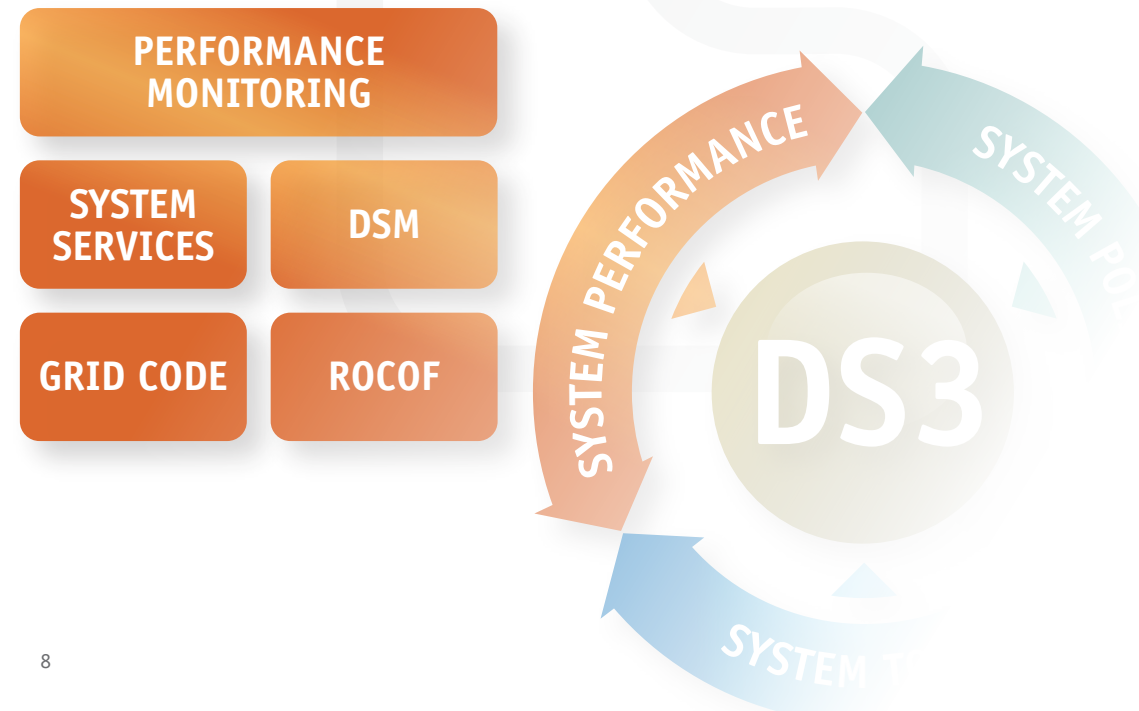
System performance refers to the performance of all plant connected to the power system. In order to ensure the system performance required to meet the 2020 targets, considerable work is needed in the areas of Grid Code modifications, Rate of Change of Frequency (RoCoF) modification and the provision of System Services. This will require greater participation from demand connected loads and enhanced performance monitoring capabilities. The main aims of this pillar are:

- To provide certainty around current and future plant performance capability, and to ensure the continued reliable performance of all plant connected to the power system;
- To ensure the development of a portfolio of plant aligned with the long-term operational needs of the power system;

- To identify and incentivise the necessary System Services required to operate a secure power system with a significant level of renewables.

The **Grid Code** sets out the performance standards for all plant connecting to the power system. Compliance with it is essential to the security of the network. The Grid Code reflects the dynamic nature of the power system, where technology is continuously evolving and, in tandem, operating practices and procedures are constantly updated. In February 2013, Ireland Grid Code modifications regarding wind farm power stations were approved by the Commission for Energy Regulation (CER). In Northern Ireland the Wind Farm Power Station Setting Schedule was approved by the Regulator, URegNI, in November 2013. In Ireland the Distribution Code modifications for these wind farm standards have been agreed by the Distribution Code Review Panel.

Demand Side Management (DSM) will play a key role in facilitating the management of more renewables due to its inherent flexibility. Demand Side Units (DSU) and Aggregated Generator Units (AGU) currently operate commercially within the SEM and are centrally dispatched. The wider DSM space is also evolving rapidly with significant work being carried out in developing storage solutions, integrating electric vehicles, etc.



At high instantaneous non-synchronous renewable penetration levels, frequency control becomes more challenging, due in part to the presence of **Rate of Change of Frequency (RoCoF)** protection relays and the potential for large amounts of wind farms to shut down during a fault scenario⁴. A RoCoF decision paper was published by both the Irish and Northern Irish Regulators in the first half of 2014. Both approved, in principle, the TSOs' proposed modification to move to a RoCoF standard of 1Hz/s over 500ms. However, the decisions outline the need for the implementation of the new RoCoF standard to be linked to the completion of generator studies over a period of 18 to 36 months.

A central aspect of the DS3 Programme is the **System Services** review. System services are products, other than energy, that are required for the continuous, secure operation of the power system. For example, reactive power is required to enable the system operators to manage voltages across the system. The System Services

Review was carried out to identify the new products that are needed to complement the transition towards a power system with high levels of wind generation.

In December 2014, the Regulatory Authorities in Ireland and Northern Ireland published a decision paper endorsing DS3's ground breaking approach to solving this issue known as System Services. The decision changes the commercial focus of generation towards better performance and greater flexibility, essential for a system like ours with increasing wind penetration. This solution will shape the evolution of market policy in Europe, the US and further afield.

The significant elements of the decision are:

- An increase in the annual budget cap from €60m to €235m;
- Doubling the number of System Service products from 7 to 14;
- Movement to a hybrid regulated tariff / auction procurement mechanism;

The detailed design and implementation phase of this project is now underway.

Performance Monitoring, including both commissioning and on-going testing of generators, needs to evolve to meet the changing nature of the system. It is essential for the TSOs to understand the capability and compliance of the generation portfolio with respect to the Grid Codes, their registered technical operating characteristics and their capability to provide the contracted levels of System Service provision. Performance monitoring in turn helps to flag non-compliances, so that the generating units can remedy these issues, submit derogations or revise their contracted values.

Work completed to date includes:

- Standardisation and documentation of existing processes on an all-island basis;
- Development of a detailed design specification for the enhanced performance monitoring IT system;

- Engagement with industry through workshops presenting proposed business processes and working examples;
- Publication of draft test procedures for industry comment;
- Development of the business case and scope for the roll out of high speed data recorders.



⁴ RoCoF protection relays are an islanding detection method for embedded generation units

System Policies

As the level of renewable generation increases, the TSOs will be required to update and develop new system operational policies.

This is needed to manage the increasing complexity associated with integrating large amounts of variable non-synchronous renewable generation.

In particular, operational policies will need to be developed to support **frequency control** and **voltage control**. Renewable generation displaces traditional generation sources and also tends to be located far from load centres. Thus, the power system can experience a wide variety of different power-flows and voltage profiles over the course of a day. This needs to be carefully managed while “keeping the lights on” for all electricity consumers.

EirGrid Group currently has a maximum System Non-Synchronous Penetration (SNSP) level of 50%. This level is based on the results of detailed technical studies, and

represents a secure operational level given the current plant portfolio and system capability.

The DS3 Programme aims to address the various factors that influence the SNSP limit, with the ultimate aim of increasing the limit from 50% to 75%. This target will be reviewed as the DS3 Programme progresses, depending on the progress of various workstreams. Each year the TSOs publish the Operational Capability Outlook – this briefing paper sets out their view of how operational capability metrics for the Irish and Northern Irish power system are expected to change between now and 2020.

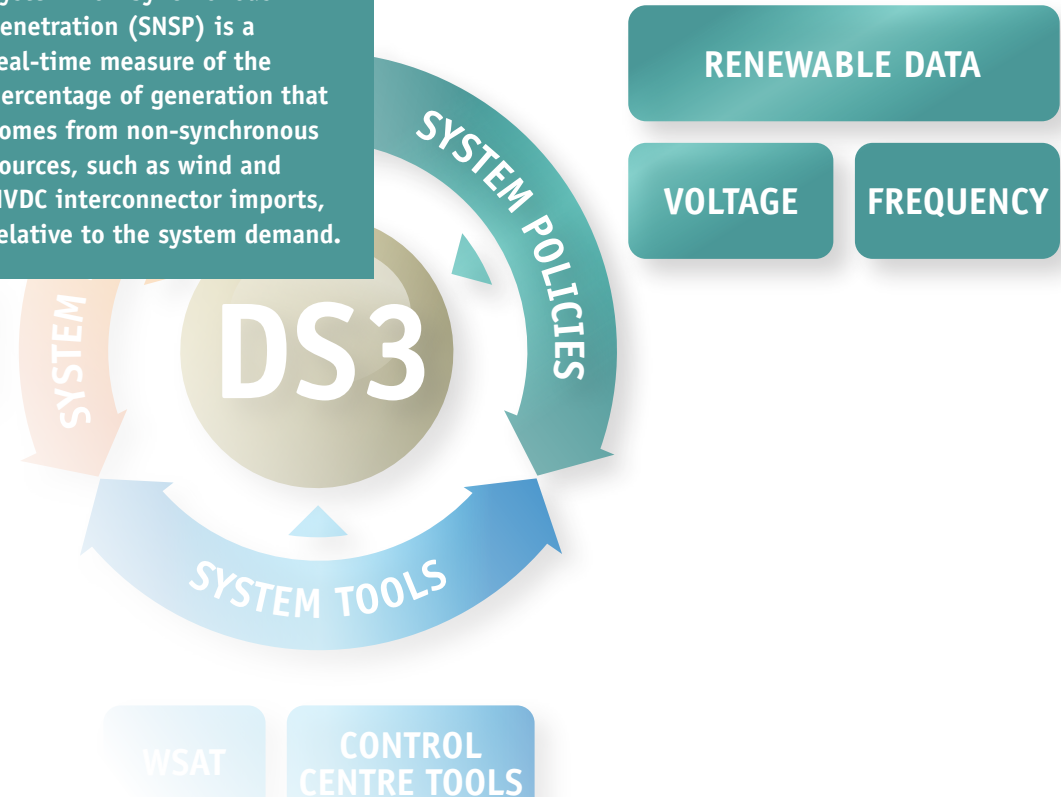
The DS3 Programme collates various system statistics and regular reports on key system indices. This provides clear information to the industry and to the general public on the progress being made in integrating renewables into the power system. It also allows broad trends to be identified and

acted upon. For example, EirGrid analyses the High Wind Speed Shutdown of wind turbines (see facing page) to help determine operational policy for high wind situations.

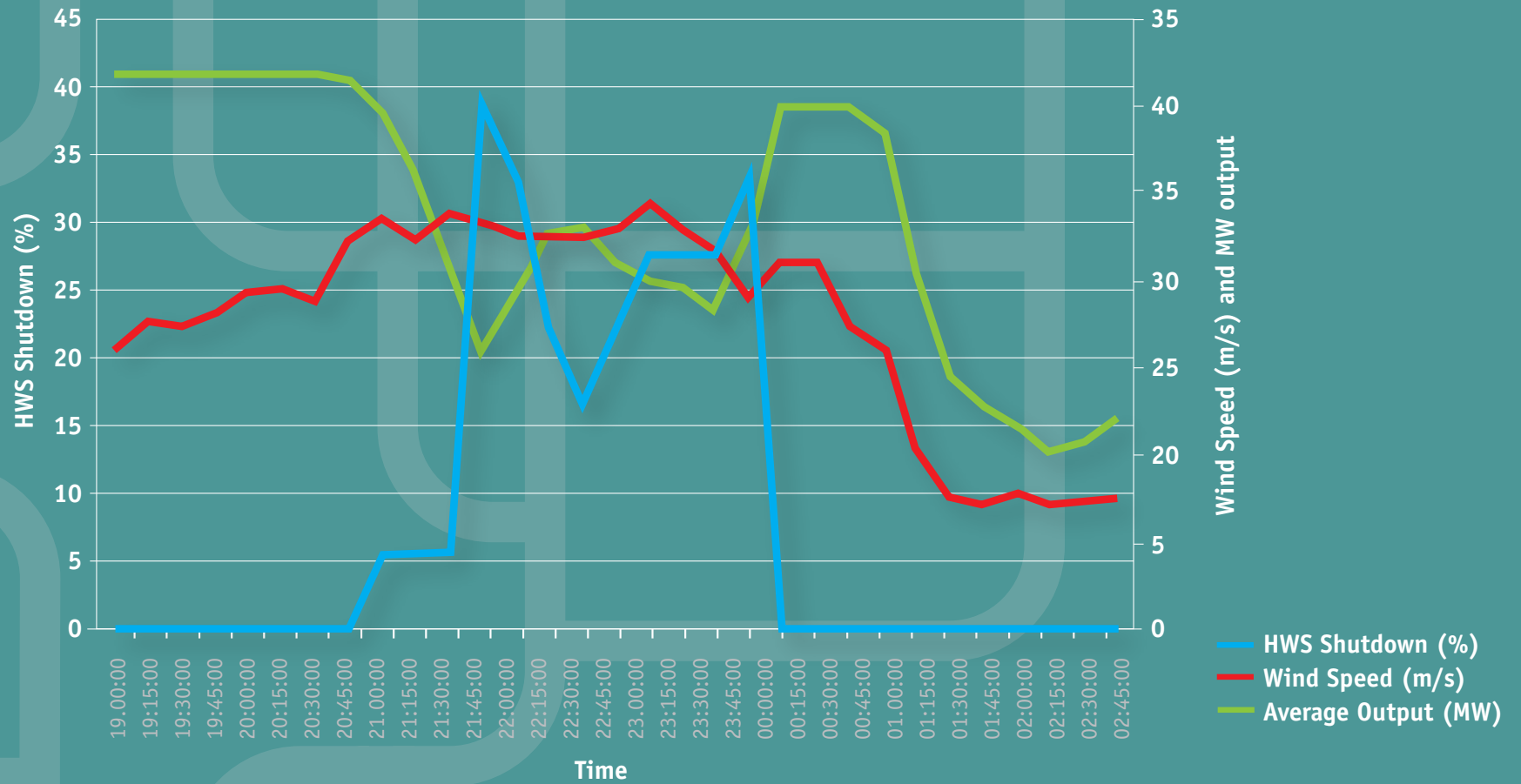


What is SNSP?

System Non-Synchronous Penetration (SNSP) is a real-time measure of the percentage of generation that comes from non-synchronous sources, such as wind and HVDC interconnector imports, relative to the system demand.



Example of High Wind Speed Shutdown of a Wind Turbine



System Tools

The evolving power system requires new principles and operational practices. This, in turn, means we must develop and implement new and updated system tools.

An important tool used in the Control Centres is the Wind Forecast tool. This estimates the level of wind power production over the coming hours and days. At present, forecasts are supplied by two external providers while a project has been completed to improve forecast accuracy and Grid Controller user interface.

The development of online SNSP, system inertia and RoCoF monitoring within the existing Energy Management System (EMS) is complete. Furthermore, an EMS Integration project for Ireland and Northern Ireland is underway. This will deliver enhanced operational flexibility to the Control Centres.

When there is high wind generation, especially during times of low demand, wind generation may need to

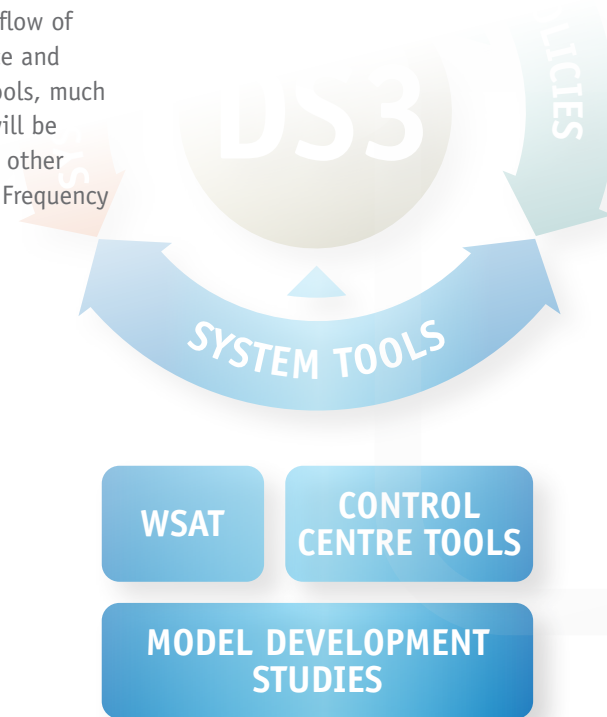
be dispatched down (e.g. to maintain system security). This is done using the wind dispatch tool, which sends out instructions electronically to wind farms. To aid tracking of dispatch instructions, the tool will also provide downstream reporting systems with reasons for each wind dispatch.

The stability of the power system is affected by wind generation. To study this in real-time, an online Wind Security Assessment Tool (WSAT) was introduced into the Dublin and Belfast Control Centres. WSAT provides a real-time assessment of the transient and voltage stability of the power system, allowing Grid Controllers to take appropriate actions if necessary. Further extensions of WSAT may include assessment of frequency stability, calculation of security based regional wind curtailment amounts and enhanced look-ahead capability.

Other work areas will include: 1) the continued development of the Reserve Constrained Unit Commitment

(RCUC) tool, which will take account of new operational metrics; 2) the development of a tool to present power system data recorded by Phasor Monitoring Units (PMUs); 3) the provision of the necessary training for Control Centre staff on any new tools or policies.

In keeping with the natural flow of DS3 from System Performance and System Policies to System Tools, much of the activity in this area will be driven by the outputs of the other DS3 workstreams, especially Frequency Control and Voltage Control.



Further information on the DS3 Programme can be found at eirgrid.com/operations/ds3/ or soni.ltd.uk/Operations/DS3/

The DS3 Programme is focused on developing the Irish and Northern Irish power system for the future. The current 40% renewable electricity target for 2020 presents very challenging future operational scenarios for the System Operators. Many different aspects of system operation are being reviewed and revamped under the auspices of DS3. In tandem with this, the electricity industry as a whole is addressing the major changes to standards, practices and financial rewards which will be required to meet the targets. By working together to overcome these challenges, Ireland and Northern Ireland can lead the world in the integration of renewable energy.



Further information on the DS3 Programme can be found at
eirgrid.com/operations/ds3/
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