Annual Renewable Energy Constraint and Curtailment Report 2016

07/04/2017

EIRGRID SONI

Contents

Executive Summary

EirGrid and SONI have prepared this report for the regulatory authorities to outline the levels of dispatch-down of renewable energy in 2016, as required under European[1] and Member State[2] legislation.

The EU Renewable Energy Directive (2009/28/EC) sets a target for Ireland to meet 16% of the country's total energy consumption from renewable energy sources by 2020. To achieve this 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 that set out a 40% renewable electricity target to be reached by 2020. The Transmission System Operators (TSOs) for Ireland and Northern Ireland, EirGrid and SONI respectively, are working towards achieving the governments' renewable electricity targets.

The EU Renewable Energy Directive requires the TSOs to prioritise renewable energy generation. Sometimes measures are taken to turn-off or dispatch-down renewable energy for system security reasons. In these circumstances TSOs must report this to the regulatory authorities. They must also indicate which corrective measures they plan to take to prevent inappropriate dispatching-down. Reducing the level of renewable dispatch-down helps bring both environmental and economic benefits to consumers in Ireland and Northern Ireland.

In Ireland and Northern Ireland, renewable energy is predominately sourced from wind. Other sources include hydroelectricity, solar photovoltaic, biomass and waste. These latter sources of energy are generally maximised in dispatch. Due to their small overall contribution to renewable energy they are excluded from this report.

Dispatch-down of wind energy refers to the amount of wind energy that is available but cannot be produced. This is because of power system limitations, known as curtailments, or network limitations, known as constraints.

In 2016, the total wind energy generated in Ireland and Northern Ireland was 7,620 GWh, while 227GWh of wind energy was dispatched-down. This represents 2.9% of the total available wind energy in 2016, and is a decrease of about 215 GWh on the 2015 figure.

In Ireland, the dispatch-down energy from wind resources was 177 GWh. This is equivalent to 2.8% of the total available wind energy.

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[1] Article 16C of the 2009 Renewable Energy Directive (2009/28/EC) states: "If significant measures are taken to curtail the renewable energy sources in order to guarantee the security of the national electricity system and security of energy supply, Members States shall ensure that the responsible system operators report to the competent regulatory authority on those measures and indicate which corrective measures they intend to take in order to prevent inappropriate curtailments."

[2] Article 4.4 of Statutory Instrument 147 of 2011 states: "If significant measures are taken to curtail the renewable energy sources in order to guarantee the security of the electricity system and security of energy supply, the transmission system operator shall report to CER on those measures and indicate which corrective measures it is intended to take in order to prevent inappropriate curtailments."

In Northern Ireland, the dispatch-down energy from wind resources was 51 GWh. This is equivalent to 3.2% of the total available wind energy.

The level of dispatch-down is affected by a number of factors which vary from year to year. The amount of wind installed on the system and the capacity factor of the wind generation will have an impact on the levels of dispatch-down. The total capacity of wind generation rose by 636 MW in 2016 while the average capacity factor was 27%. In 2015, the average capacity factor was 33%.

The level of demand is another important factor which varies from year to year. Average demand in Ireland in 2016 was 2.3% higher than in 2015 and in Northern Ireland it was just 0.2% lower than in 2015.

There are two interconnectors between the power systems of the island of Ireland and Great Britain. The first is the Moyle Interconnector which is between Northern Ireland and Scotland and the second is the East-West Interconnector (EWIC) which is between Ireland and Wales. The principal benefits of the Moyle and EWIC are:

- reducing the price of electricity in the Single Electricity Market; and
- improving security of supply.

However, they can also facilitate the reduction of wind curtailment. This is done through the use of system operator trades directly with the National Grid Electricity Transmission or through the TSOs' trading partner in Great Britain.

The fundamental issues which give rise to curtailment are being addressed by EirGrid's DS3 programme (Delivering a Secure, Sustainable Electricity System). This programme has been specifically designed to cater for the increased levels of renewable generation which the system now needs to accommodate. This is necessary to ensure that the power system can be operated securely and efficiently and also to address other system-wide limitations. More information on the DS3 programme can be found here:
http://www.eirgridgroup.com/how-the-grid-works/ds3-programme/

The System Non-Synchronous Penetration (SNSP) level, which is an indication of the maximum level of non-synchronous generation (wind and interconnection) which will be allowed on the system, increased from 50% to 55% in March 2016 and a trial of 60% started in November 2016. To address the network limitations which give rise to constraint of wind energy, a Grid Development Strategy for Ireland was published in February 2017. While comprising a grid development strategy for Ireland, it has regard to the all-island network, the issues for grid development in Northern Ireland, with particular reference to the All Island Generation Capacity Statement. The reinforcement of the network will increase the capacity of wind generation which can be accommodated. However, it should be noted that temporary outages of transmission equipment can be required for:

- network improvement works; and
- connections of new wind farms to the network.

These works can lead to reduced network capacity and increased levels of dispatch-down in the short-term.

1 Introduction

1.1 Context

The 2009 European Renewable Energy Directive (2009/28/EC) requires that the TSOs report to the regulatory authorities, CER and URegNI. This report must detail why renewable energy was dispatched-down and what measures are being taken to prevent inappropriate curtailment.

This Directive was put into law in Ireland as S.I. No. 147 of 2011 and in Northern Ireland through the Electricity (Priority Dispatch) Regulations No. 385 of 2012. The Single Electricity Market (SEM) Committee, in its scheduling and dispatch decision paper SEM-11-062, requires that the TSOs report on this as appropriate to CER and URegNI, respectively. This report represents EirGrid and SONI's response to the obligations required through National Law and through the SEM Committee requirement.

1.2 Reasons for Dispatch-Down

Renewable generation has priority dispatch. However, there will be times when it is not possible to accommodate all priority dispatch generation while maintaining the safe, secure operation of the power system. Security-based limits have to be imposed due to both local network and system-wide security issues. It is, therefore, necessary to reduce the output of renewable generators below their maximum available level when these security limits are reached. This reduction is referred to in this report as 'dispatch-down' of renewable generation and is consistent with the principle of priority dispatch.

There are two reasons for the dispatch-down of wind energy: constraint and curtailment. **Constraint** refers to the dispatch-down of wind generation for more localised network reasons (where only a subset of wind generators can contribute to alleviating the problem). **Curtailment** refers to the dispatch-down of wind for system-wide reasons (where the reduction of any or all wind generators would alleviate the problem). The SEM Committee approved in SEM-13-011 the difference between constraint and curtailment.

1.3 Reporting Methodology

In late 2014, a new all-island wind dispatch tool went live in the control centres of both Ireland and Northern Ireland. This tool has resulted in a number of system operation improvements. These include:

- clear categorisation between constraint and curtailment;
- clear reasons for why a curtailment or constraint was applied called a 'reason code';
- easier access to dispatch instructions and wind farm data;
- each instruction is time-stamped with the instruction time.

These improvements led to an investigation of whether a more accurate report could be issued to all controllable wind farms, removing the need to estimate the curtailment and constraint levels applied to wind farms. As a result, a new methodology was developed to

calculate curtailment and constraint levels. It involves making extensive use of one minute SCADA MW signals received from the wind farms and using time-stamped dispatch instructions from the control centres in Ireland and Northern Ireland. The new approach was more accurate than the previous methodology which made use of average half hourly market data for Variable Price Taking Generators (VPTG) wind farms only. The new approach was published for industry to provide feedback to the TSOs.

Feedback from industry was incorporated into the calculation methodology. From 2016 all controllable wind farms were issued with new, detailed constraint and curtailment reports each quarter. A detailed wind aggregate constraint and curtailment report was also published online each quarter to coincide with the individual wind farm reports. This report is accompanied by a separate user guide, which contains a detailed description of the new methodology, worked examples and a Frequently Asked Questions (FAQs) section. Both the aggregate report and the user guide can be found at:
http://www.eirgridgroup.com/how-the-grid-works/renewables/

2 Level of Dispatch-Down Energy in 2016

The following provides a summary of the dispatch-down of wind energy in 2016 for Ireland and Northern Ireland. More details and figures are provided in Appendix A.

2.1 All-Island

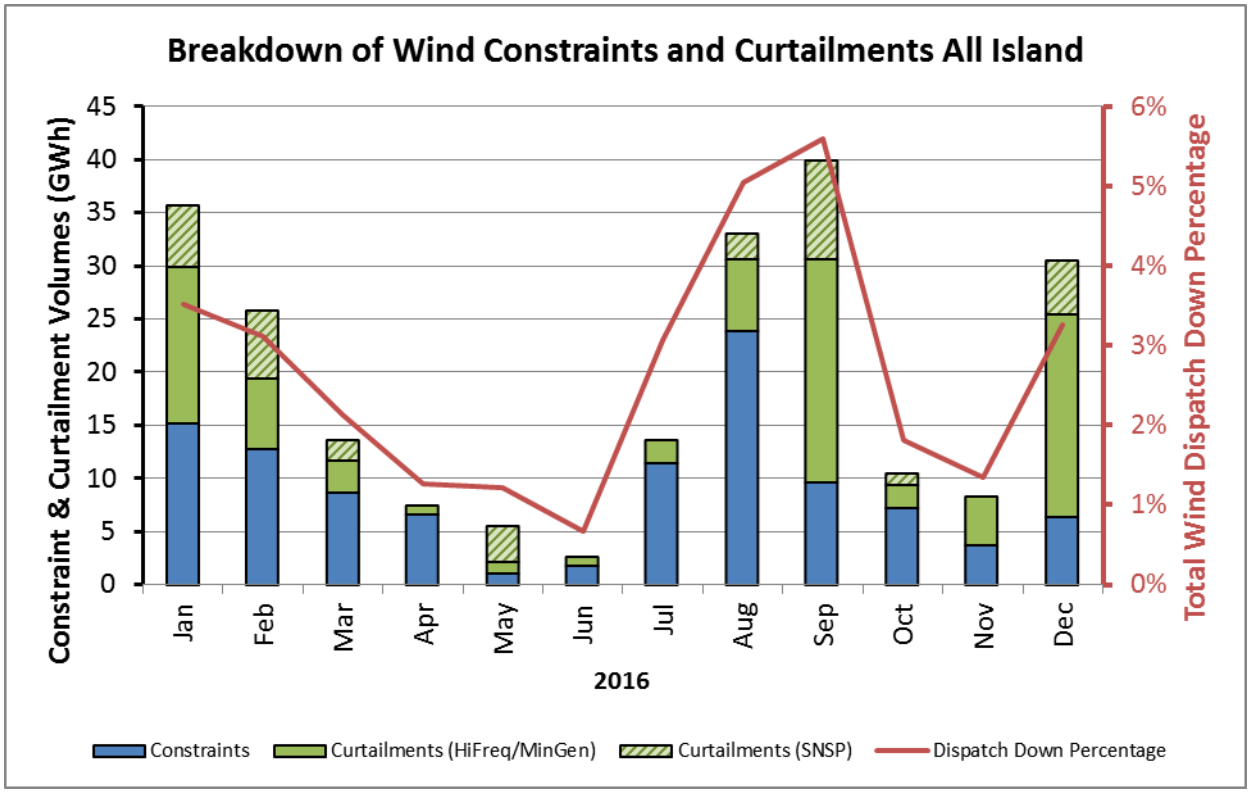
In 2016, the share of centrally dispatched generation[3] from renewable sources in Ireland and Northern Ireland was 24.5%. This is broken down as follows:

- 21.3% provided by wind;
- 1.9% provided by hydro; and
- 1.4% provided by other[4] renewable energy sources.

The total wind energy generated was 7,620 GWh in Ireland and Northern Ireland. There was an estimated total of 227 GWh of dispatch-down energy from wind farms, which is a decrease of about 215 GWh compared to 2015. The level of dispatch-down of wind represents 2.9% of total available energy from wind resources in Ireland and Northern Ireland.

[3] Note that since the percentage figures are presented for centrally dispatched generation (based on SCADA data), they do not account for non-dispatchable embedded renewable generation, which includes biomass, land-fill gas and small-scale hydro.
[4] Other renewable energy sources include CHP, bioenergy, solar and ocean energy.

Figure 1: Monthly breakdown of the main wind dispatch-down categories on the island in 2016



2.2 Northern Ireland

In 2016, the total dispatch-down energy from wind generation in Northern Ireland was 51 GWh. This is equivalent to 3.2% of total available wind energy in that jurisdiction. This is a total overall decrease of about 44 GWh in dispatch-down energy from wind generation compared to 2015.

2.3 Ireland

In 2016, the total dispatch-down energy from wind generation in Ireland was 177 GWh. This is equivalent to 2.8% of total available wind energy in Ireland. This is a total overall decrease of about 171 GWh in dispatch-down energy from wind generation compared to 2015.

3 Contributory Factors for Dispatch-Down of Wind

3.1 Changes to Operational Dispatch Policy

Before the SEM-11-062 decision paper, the operational policy in use was to dispatch-down Variable Price Taking Generation[4] before Autonomous Price Taker Generation[5] units. This policy was implemented in 2008. Its purpose was to:

- provide clarity on operational practice; and
- reflect the more onerous commercial implications of dispatch-down for autonomous units.

Since the introduction of SEM-11-062, there is a requirement to dispatch-down wind generators based on their controllability. This is defined under the Grid Codes and is verified through performance monitoring and testing. The implementation of this is described in the policy document "Policy for Implementing Scheduling and Dispatch Decisions SEM-11-062"[6] and the associated addendum. To meet the controllability definition, the operational policy[7] requires a wind farm to achieve operational certificate status 12 months after energisation. This process was implemented in December 2014 and a number of wind farms were moved to category 1 for this reason. If a wind farm is in category 1, it means that it will be dispatched down ahead of other wind farms.

3.2 Level of Wind

As explained in section 1.2, it is sometimes necessary to limit the maximum level of wind generation on the system for security or safety reasons. The impact of these limits on the level of dispatch-down will depend on two factors. These are the amount of wind generation installed **and** the capacity factor of the wind generation.

At the beginning of January 2016, the total installed capacity of wind generation on the island was 2990 MW. By year-end, the figure had risen to 3626 MW (2827 MW in Ireland and 799 MW in Northern Ireland). Table 1 shows the end of year wind capacities on the island from 2000 to 2016.

Over the year, the capacity factor[8] of wind farms was 27%. For comparison, the annual capacity factor in 2015 was 33% and in 2014 was 29%. The seasonal variation in the capacity factor is evident in Figure 3.

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[4] Variable Price Taker Generators (VPTGs) which:
- when not constrained/curtailed are scheduled and paid based on their actual output;
- when constrained/curtailed are scheduled based on their actual availability.

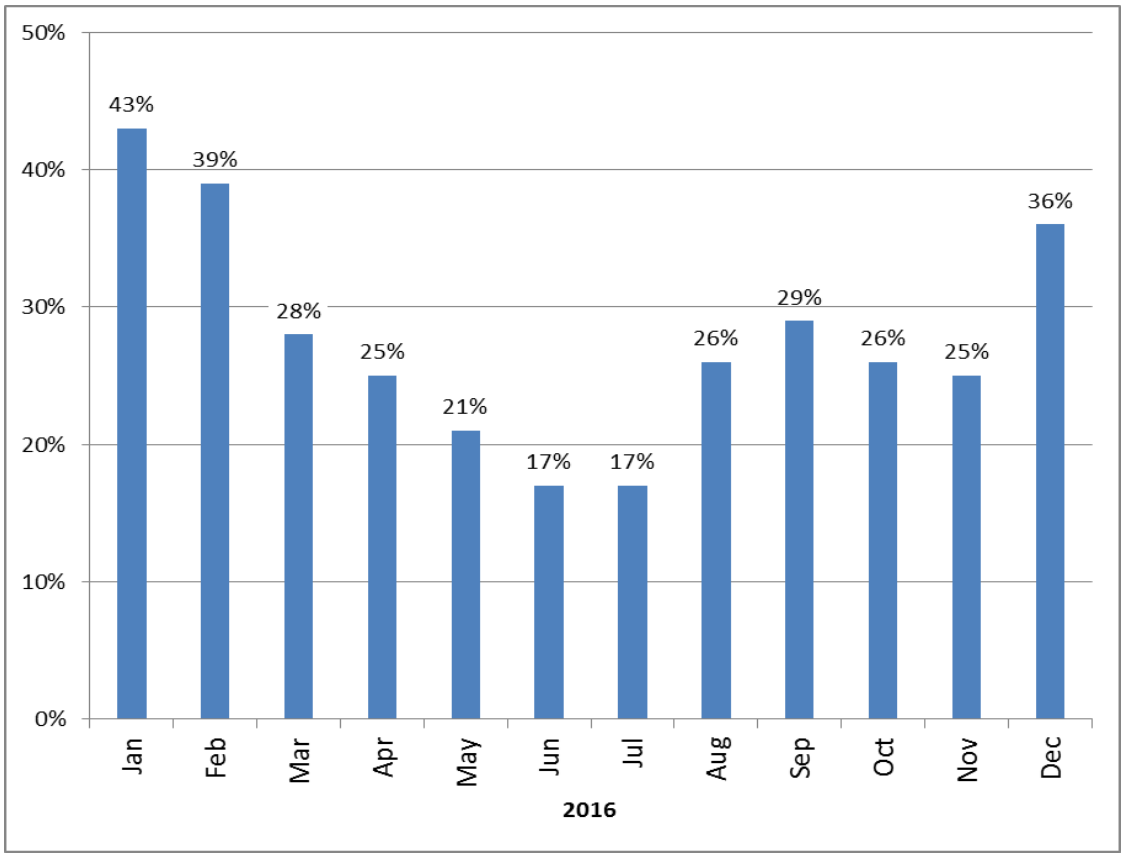
[5] Autonomous Price Taker Generators (APTGs) which are paid based on their actual output at all times as outlined in Table 5.1 of the Trading & Settlement Code found at www.sem-o.com

[6] http://www.eirgridgroup.com/library/index.xml

[7] Wind Farm Controllability Categorisation Policy, 5 March 2012

[8] The capacity factor is the amount of energy produced (MW output) relative to the theoretical maximum that could have been produced if the wind generation operated at full capacity. Therefore, it represents the average output of the wind generation. This capacity factor is based on SCADA data.

Figure 2: All-Island Monthly Wind Capacity Factors in 2016



3.3 Demand Level

The level of demand is another important factor which affects the dispatch-down of wind. Increased demand generally enables greater levels of wind to be accommodated on the system. Average demand in Ireland in 2016 was 2.3% higher than in 2015 and in Northern Ireland it was just 0.2% lower than in 2015.

3.4 Generation Portfolio

In 2016, there were changes to the generation portfolio in Ireland. A number of generating units reduced their minimum generation levels (that is, the minimum stable MW level at which the generating unit can operate continuously). Another generating unit split from one large Combined Cycle Gas Turbine into two smaller market units. These changes allowed more wind to be facilitated on the system at times while still maintaining system security.

3.5 Wind Installed Capacity

In 2016, 636 MW was added to the wind installed capacity on the island. This represents a significant increase on the average annual wind connection level of about 250 MW over the previous 5 years. This rate of build is expected to continue or possibly increase until the year 2020 at least to achieve the nationally set targets of 40% renewable electricity as a percentage of demand.

This added 636 MW also represents a 20% increase in the installed capacity of wind which, when compared to the small changes in demand and the same interconnection capacity, could result in higher levels of wind dispatch-down.

However, the levels of wind in 2016 were much lower than 2015. This lower wind capacity factor resulted in less wind generation and dispatch-down in 2016, but the increased wind installed capacity should result in higher generation on average in the future. Table 1 shows the wind capacities in Ireland and Northern Ireland since 2000.

Table 1: Wind capacities on the island from 2000 to 2016

Wind Capacities on the Island (MW)			
Year	**Northern Ireland**	**Ireland**	**All Island**
2000	36.8	119.4	156.2
2001	36.8	125.8	162.6
2002	36.8	138.5	175.3
2003	76.0	214.0	290.0
2004	89.1	341.6	430.7
2005	108.6	517.2	625.8
2006	131.6	749.0	880.6
2007	214.0	797.6	1,011.6
2008	230.7	1,030.4	1,261.1
2009	301.1	1,265.5	1,566.6
2010	340.9	1,373.8	1,714.7
2011	405.1	1,631.0	2,036.1
2012	488.5	1,763.5	2,252.0
2013	554.3	1,896.2	2,450.5
2014	614.0	2,173.0	2,787.0
2015	627.0	2,363.0	2,990.0
2016	799.0	2,827.0	3,626.0

3.6 Wind farms in Controllability Category 3

From January to December 2016 the number of wind farms in controllability category 3 increased from 65 MW to 399 MW on an all-island basis. Wind farms in this controllability category are in their commissioning phase and, as in the policy set out in SEM-11-062, these wind farms are dispatched down after category 1 and category 2 wind farms. Due to the increase in capacity of the wind farms in category 3, this would have increased the dispatch-down of category 1 and category 2 wind farms at times.

3.7 Breakdown of Wind Dispatch-Down – Curtailment vs. Constraint

In Northern Ireland, the breakdown of wind dispatch-down volumes in 2016 between constraints and curtailments was 40% and 60% respectively.

In Ireland, the breakdown of wind dispatch-down volumes in 2016 between constraints and curtailments was 50% and 50% respectively.

All-Island: Table 2 shows the aggregate estimated breakdown of wind dispatch-down on the island over the last 6 years.

Table 2: All-Island Yearly Breakdown of Dispatch-Down Energy into Constraints and Curtailments

Estimated Breakdown of Dispatch-down of Wind on the Island	2011	2012	2013	2014	2015	2016
Constraints	20%	38%	28%	35%	36%	48%
Curtailments	80%	62%	72%	65%	64%	52%

3.8 Curtailment

Curtailment refers to the dispatch-down of wind for system-wide reasons. There are five types of system security limits that necessitate curtailment:

1. System stability requirements (synchronous inertia, dynamic and transient stability);
2. Operating reserve requirements, including negative reserve;
3. Voltage control requirements;
4. Morning load rise requirements;
5. System Non-Synchronous Penetration (SNSP[9]) limit, (The SNSP limit was raised from 50% to 55% in October 2015 and a trial of 60% commenced in November 2016).

The first four of these limits tend to impose minimum generation requirements on the conventional (synchronous) generation portfolio. This in turn can limit the 'room' for wind generation, particularly overnight during the lower demand hours. The implementation of these security limits is described in the Operational Constraints Update paper. This paper replaces the Transmission Constraint Groups document. Both documents are published[10] on the EirGrid website.

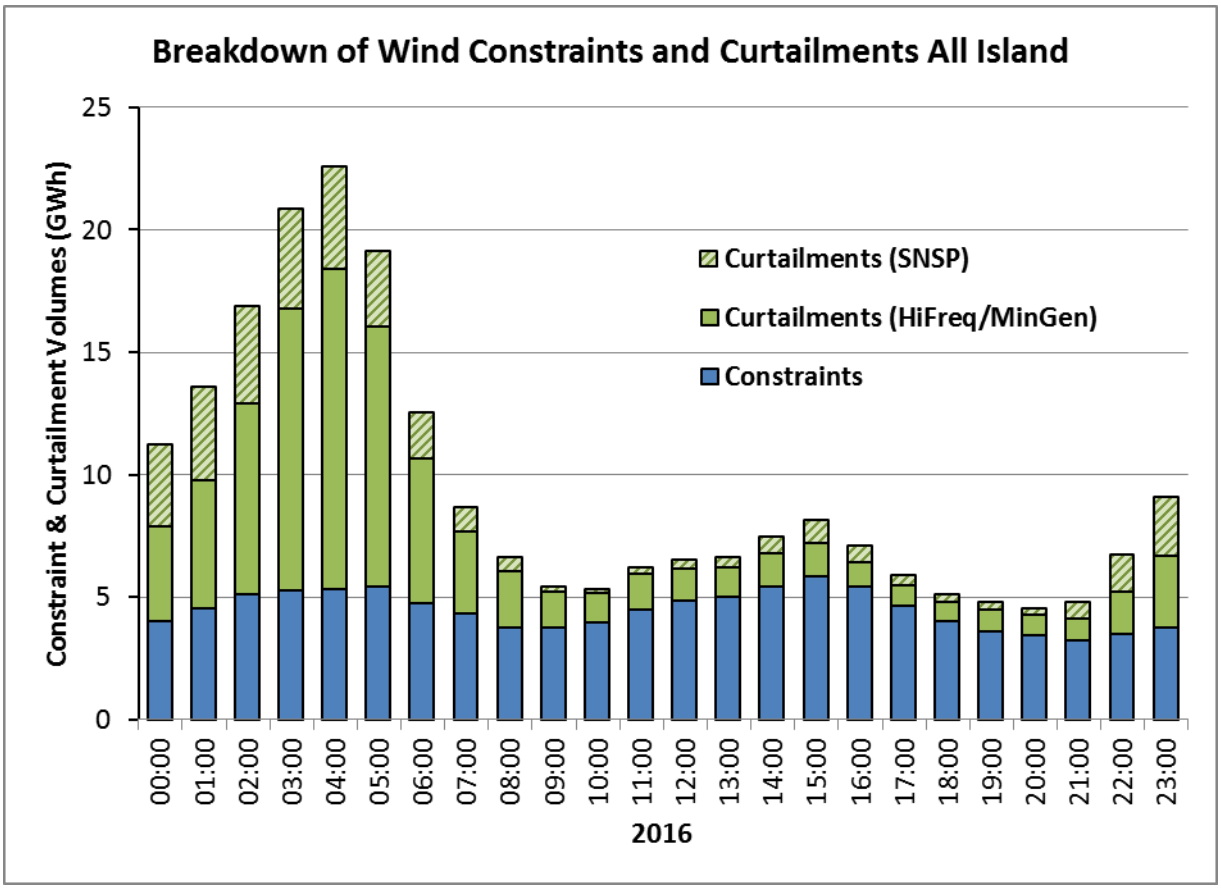
The fifth limit, SNSP, is a system security metric that has been established from the results of the DS3 programme. These studies initially identified 50% as the maximum permissible level. Due to works undertaken by the TSOs under the DS3 programme, the SNSP level was reassessed and the limit was raised from 50% to 55% in October 2015 and a trial of 60%

[9] SNSP is the ratio of non-synchronous generation (wind and HVDC imports) to demand plus HVDC exports
[10] http://www.eirgridgroup.com/library/index.xml

commenced in November 2016. The ultimate aim of the DS3 programme is to increase this limit towards 75%.

The impact of curtailment can be seen in Figure 3, which shows the total annual all-island dispatch-down of energy by hour of day. There are more curtailments in the night hours (11pm to 8am) when compared to constraints.

Figure 3: All-Island breakdown of wind constraints and curtailments in 2016 by hour of day



3.9 Constraints

The dispatch-down of wind for network reasons is referred to as a constraint. Constraint of wind can occur for intact network conditions. This can be for two main reasons:

- more wind generation than the localised carrying capacity of the network; or
- during outages for maintenance, upgrade works or faults.

The grid development strategy and associated technical report directly address these issues in Ireland. The strategy allows for strengthening the network in critical and constrained areas. As noted previously, the new strategy identifies issues for grid development in Northern Ireland, with particular reference to the All Island Generation Capacity Statement.

The major capital works associated with these types of projects may reduce the capacity of the network for the duration of the work. In the short term, this leads to a rise in the levels

of constraint in these areas. However, in the long term, this reinforcement of the network increases its capacity. This enables the accommodation of more generation in that area. During 2016, several circuits were upgraded. This allowed for more wind generation to be exported from the region and thus reduced wind constraints.

From a network perspective, the west, north-west and south-west of the Irish system have the greatest level of restrictions for the export of wind. There is also evidence that other areas on the system have seen restrictions, but these are generally associated with transmission outages.

The proportion of dispatch-down attributable to constraints (rather than curtailment) is 48% in 2016. This was due partly to an increase in installed wind generation but more significantly to the transmission outages in 2016. Many of these outages were to facilitate the upgrading and uprating of the transmission system.

South West:

During 2016 there were significant capital works undertaken to upgrade the transmission system to allow more wind generation to be exported from wind farms between Tarbert and Clashavoon 220 kV stations in the South West.

During 2016 the programme of works in the South West involved the connection of two new 220 kV stations called Ballynahulla and Knockanure. These new stations were in addition to Ballyvouskill station which was connected in 2015. A final 220 kV station called Kilpaddoge is due to connect in 2017. These works will facilitate the connection and export of wind in the region.

While the network in the region is being developed, there will be a transitionary period when the extent of the work will lead to an increased number of longer network outages which can lead to local constraints. With limited demand for electricity in the region compared to the wind capacity, a loss of transmission export capacity from the region required dispatch-down of wind in this area to maintain the security and safety of the network.

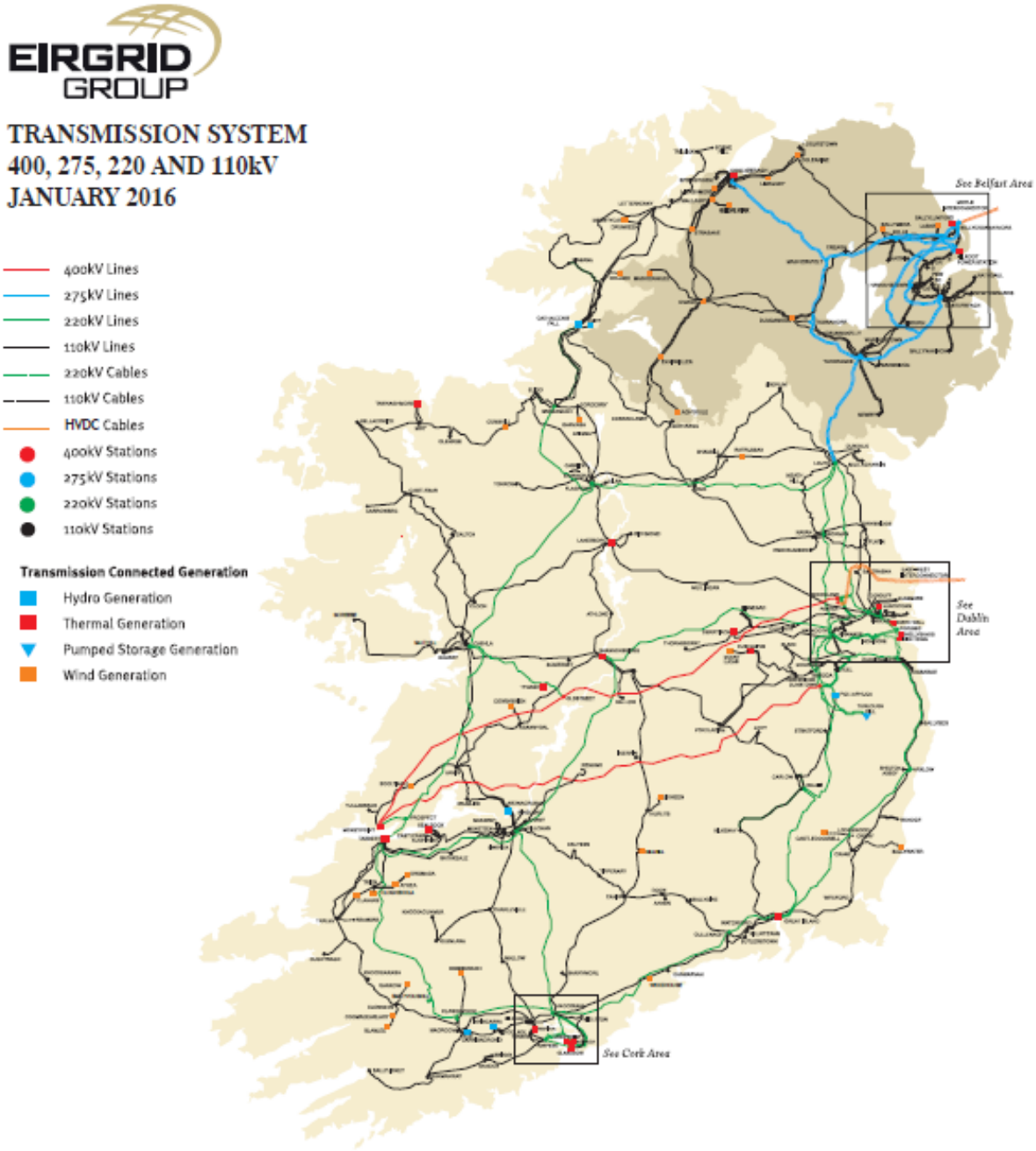
Table 3 outlines the main outages which affected wind farms in the South West region in 2016.

Table 3: Main transmission outages in the South West in 2016

Circuit	Nature of Outage	Start Date	End Date
Tarbert – Trien 110 kV Line	Scheduled loop in to Knockanure	29 March	2 June
Ballyvouskill – Tarbert 220 kV Line[11]	Facilitating the energisation of Knockanure and Ballynahulla 220 kV stations	29 March	1 September
Knockanure – Trien No. 1 and No. 2 110 kV Lines	Energisation works in Knockanure and Trien	2 June	14 June
Knockanure – Trien No. 2 110 kV Line	Forced outage (issues with equipment)	17 June	9 September
Tarbert – Tralee No. 1 110 kV Line	High priority maintenance	10 August	30 August
Ballyvouskill – Clashavoon 220 kV Line	Scheduled uprate	22 September	30 November

[11] The Ballyvouskill – Tarbert 220 kV Line ceased to exist in 2016 as it became the Tarbert – Knockanure, Knockanure – Ballynahulla and Ballynahulla – Ballyvouskill 220 kV circuits with the integration of Knockanure and Ballynahulla 220 kV stations. The resulting circuits returned to service in a sequence over a number of days at the end of August and start of September.

Figure 4: Transmission System Map



3.10 Wind Dispatch-Down by Region

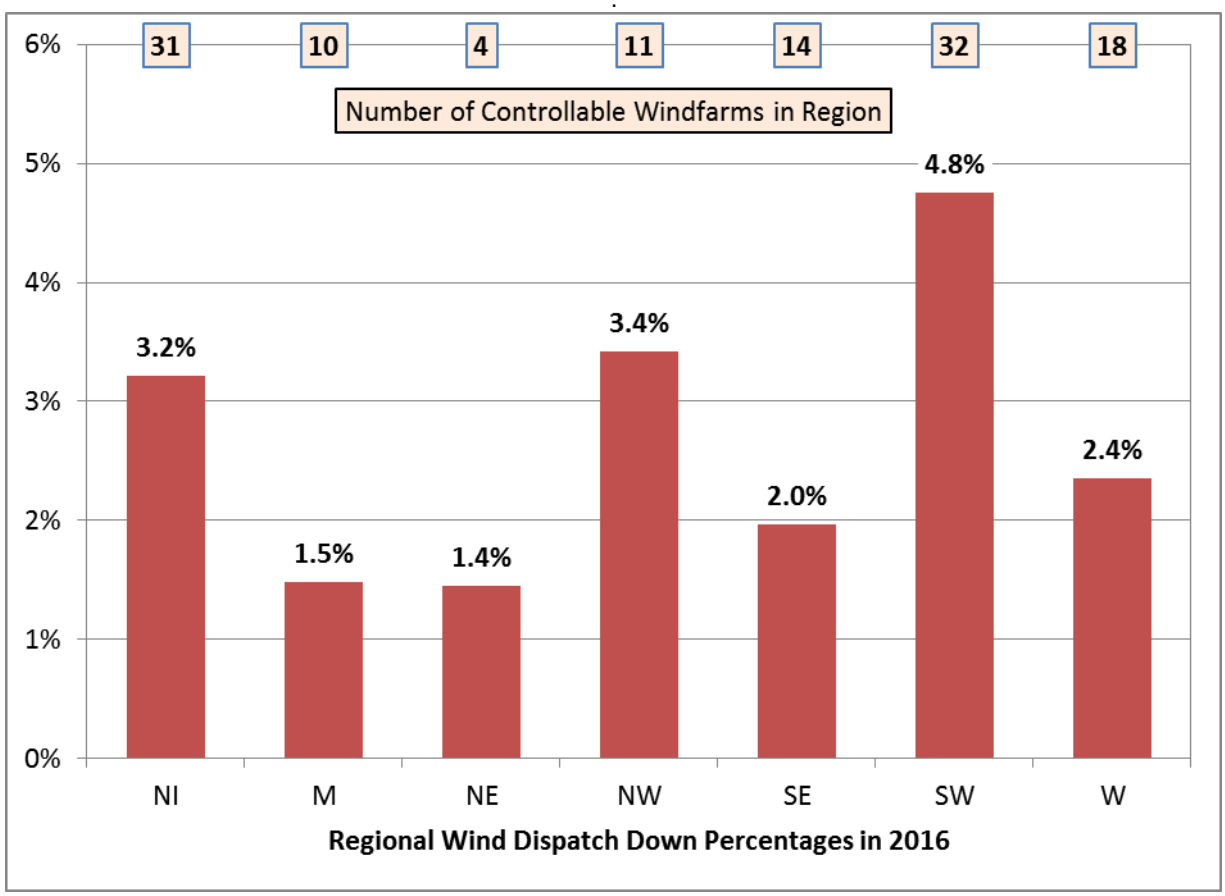
The greatest percentage of wind dispatch-down was observed in the South West and North West regions and in Northern Ireland, as shown in Figure 5. The following are the main factors for higher than average wind dispatch-down in these regions:

South West (SW) – The dispatch-down of wind in the region is predominately due to transmission constraints associated with capital works as described in Section 3.9.

North West (NW) – The dispatch-down of wind in the region is predominately due to transmission constraints associated with transmission outages during the summer. The level of constraints in the NW has, however, reduced significantly due to new circuits being energised in this region in previous years.

Northern Ireland (NI) – This is mainly due to a number of wind farms in this region being in category 1. As required by SEM-11-062, these wind farms need to be dispatched down ahead of category 2 wind farms. An additional factor is constraints on the distribution system.

Figure 5: Regional Wind Dispatch-Down Percentages in 2016



4 Mitigation Measures

4.1 Network Reinforcements

The recently published Grid Development Strategy and associated plans will be the primary methods of addressing network capacity issues. SONI is also developing project specific solutions to address network capacity issues in Northern Ireland. The outages necessary to deliver the network upgrades may result in additional constraints in the short term. However, in the long run constraints on wind generation will be reduced. In addition, consideration will be given to the use of new technologies including dynamic line rating and special protection schemes.

4.2 Operational Policy and the DS3 Programme

The fundamental issues that give rise to curtailment have been identified in section 2.5. These issues are being addressed by EirGrid and SONI's Delivering a Secure Sustainable Electricity System (DS3) programme[12]. This is a multi-stakeholder, multi-year programme of work designed specifically to securely and efficiently increase the capability of the power system. It will cover operation from a maximum of 50% System Non-Synchronous Penetration (SNSP) level to a maximum of 75%. It will also address the other limits identified in section 2.5.

The DS3 programme was formally launched in August 2011 and is designed to facilitate increased levels of renewables penetration in order to meet public policy objectives. However, the success of the programme depends on appropriate and positive engagement from all industry stakeholders. This includes conventional and renewable generators, the regulatory authorities, transmission system operators and distribution system operators in both Ireland and Northern Ireland.

There are operational policy studies which have been completed with the aim to minimise curtailment. These studies were followed by trials, which are either ongoing or have been completed. A trial on the power system operating at a 60% limit of System Non-Synchronous Penetration (SNSP) began in late 2016. Separately, another trial is in place to increase exports on EWIC to 500 MW when wind generation is below 1000 MW. These two measures facilitate higher levels of wind penetration.

The new interim System Services arrangements have gone live for 11of the 14 System Services in October 2016. In November 2016, a procurement exercise was undertaken to select participants in a System Services Qualification Trial Process. The aim of this process is to allow new and existing technologies the chance to prove themselves capable of providing new and existing System Services. As an outcome of these trials, it is expected that the range of System Service providers can be expanded in future central procurement processes. This will enhance the flexibility of the power system when operating at high levels of wind penetration and will aid reduced levels of curtailment.

[12] http://www.eirgridgroup.com/how-the-grid-works/ds3-programme/

4.3 Operational Policy – Interconnection

Interconnector Status Updates

The East West Interconnector (EWIC) went into partial commercial operation in December 2012 and full commercial operation in May 2013. EWIC was on forced outage between September and December 2016.

The Moyle Interconnector was operating with only one pole[13] between April and June 2016 and was on full scheduled outage between June and September 2016.

System Operator Interconnector Countertrading[14]

Following gate closure in the SEM, the TSOs may seek to initiate changes to the interconnector flows. The reasons for this would be for system security or to facilitate priority dispatch generation (as directed in SEM Committee Decision paper SEM-11-062). These changes would be through countertrading[15] between system operators or through a third party in the wholesale electricity market in Great Britain.
Countertrading is carried out in line with:

- commercial parameters approved by the regulatory authorities;
- any relevant system limitations; and
- the availability of a counter party to give effect to any potential trade.

Throughout 2016, countertrading arrangements were regularly used to alleviate curtailment of priority dispatch generation and also for reserve co-optimisation. This countertrading is predominately carried out using the services of a third party trading partner. As the tool used by the TSOs optimises the generation schedule based on numerous variables, it is not possible to differentiate between whether the countertrading was for priority dispatch or for economic reasons.

4.4 Controllability of Wind Generators

Wind farm controllability is the ability of the TSO control centres to dispatch a wind farm's output to a specific level. Uncontrollable wind farms are dispatched directly by opening circuit breakers. This results in full disconnection rather than a gradual dispatch-down. Controllability enables fairness of dispatch-down between wind farms on a pro-rata basis. To ensure increasing and appropriate levels of controllability, EirGrid and SONI have sought, where possible, to standardise testing procedures and rigorously enforce controllability requirements on all wind farms.

[13] When operating on one pole the capability of Moyle is reduced to ±250 MW.
[14] http://www.eirgridgroup.com/site-files/library/EirGrid/InformationNoteExtensionofTSOcounter-tradingfacilitiesforDBCmanagement.pdf
[15] Once the SEM market has closed, the TSOs may initiate changes to the interconnector schedules via SO countertrading for reasons of system security or to facilitate priority dispatch generation (as directed in SEM Committee Decision paper SEM-11-062).

Appendix A – Detailed Results

The following charts provide a breakdown of the wind dispatch-down categories both in volumes and in percentage of available energy.

More detailed monthly and regional figures are available in our final quarterly wind dispatch-down report for 2016. Our quarterly report user guide provides a detailed description of the dispatch-down categories and the methodology used. Both the quarterly report and the user guide are available on our website:
http://www.eirgridgroup.com/how-the-grid-works/renewables/

The bar charts show the breakdown of dispatch-down energy by category (reason code), but only the three main constraint and curtailment categories are represented.
The remaining categories are too small to display in these charts, but are fully included in volume and percentage format in the flowcharts directly below them.

Reason Codes

This is a list of all the reason codes used when constraining and curtailing wind:

- Transmission (TSO) Constraints: Used to resolve a local network issue.
- Testing (TSO): Used when wind farm testing is carried out by the TSO, e.g. for commissioning and monitoring.
- Curtailments:
    - High Frequency/Mingen: Used when attempting to alleviate an emergency high frequency event or in order to facilitate the minimum level of conventional generation on the system to satisfy reserve requirements, priority dispatch or to provide ramping capabilities.
    - SNSP Issue: Used to reduce the System Non-Synchronous Penetration.
    - ROCOF/Inertia: Used when the Rate of Change of Frequency (ROCOF) value for the loss of the largest single infeed is unacceptably high and wind must be dispatched down as a result or when the system inertia is too low.
- Other Reductions:
    - DSO/DNO Constraints: Used when a dispatch is carried out as a result of a request from the Distribution System Operator or the Distribution Network Operator.
    - Developer Outage: Used when a wind farm must reduce output mainly to carry out software upgrades.
    - Developer Testing: Used when testing is carried out by a wind farm developer.

All-Island:

Figure 6: Monthly breakdown of all-island wind constraints and curtailments in 2016

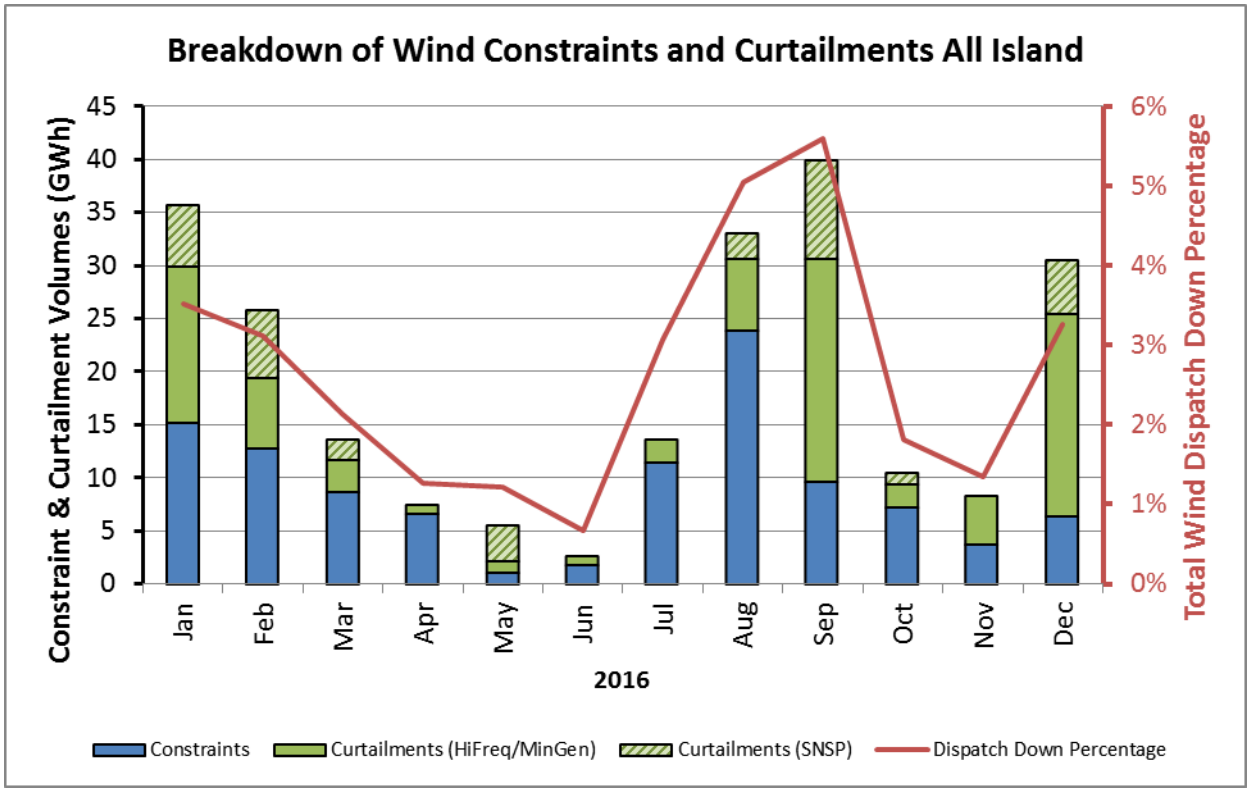
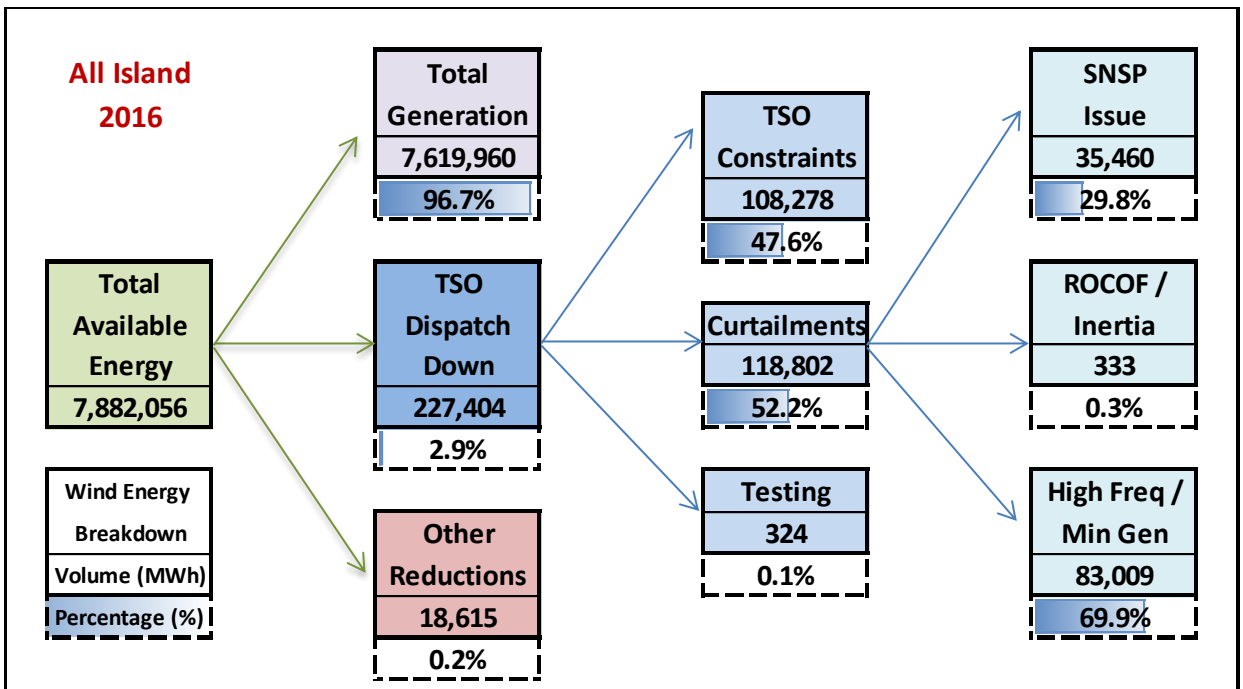


Figure 7: Graphical representation of all-island wind dispatch-down categories in 2016



Other reductions include DSO constraints, developer outage and developer testing.
Certain types of reductions are outside of the control of the TSO and are not logged.
Therefore, Available Energy ≠ Generation + TSO Dispatch Down + Other Reductions

Ireland:

Figure 8: Monthly breakdown of the main wind dispatch-down categories in Ireland in 2016

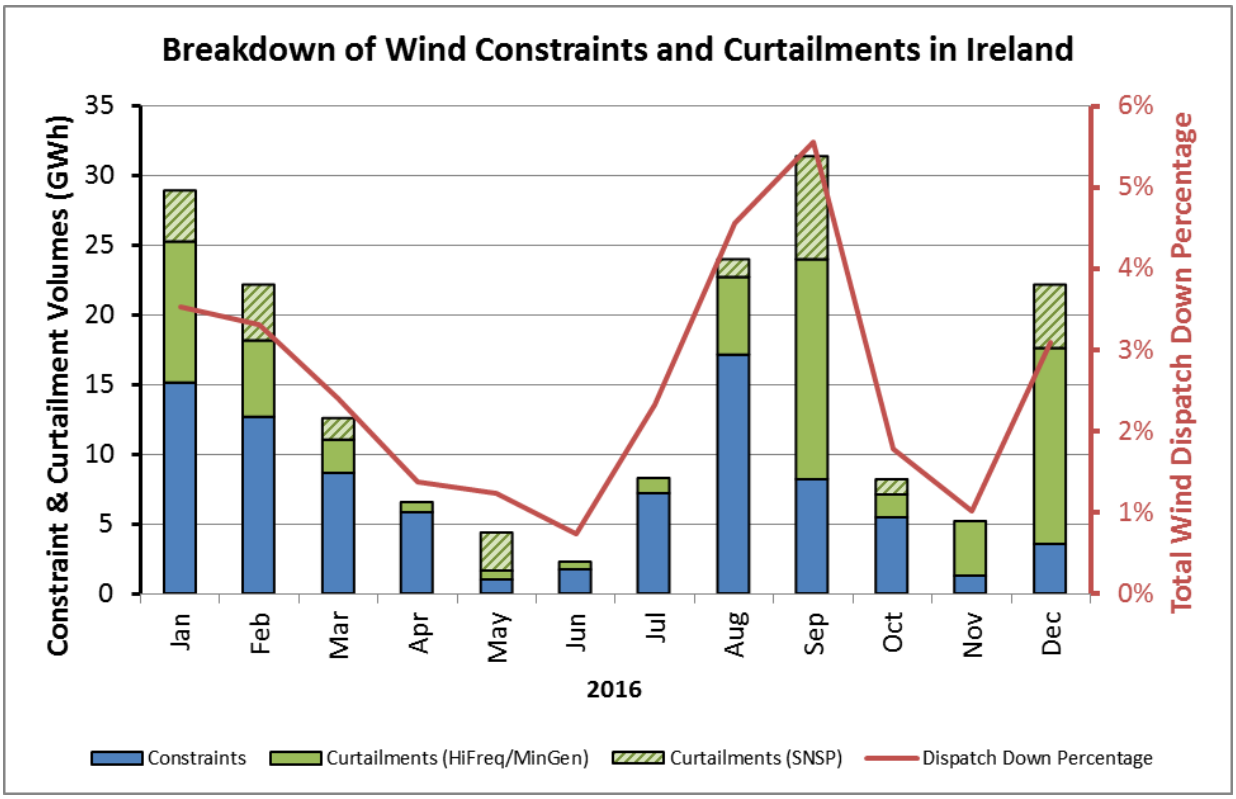
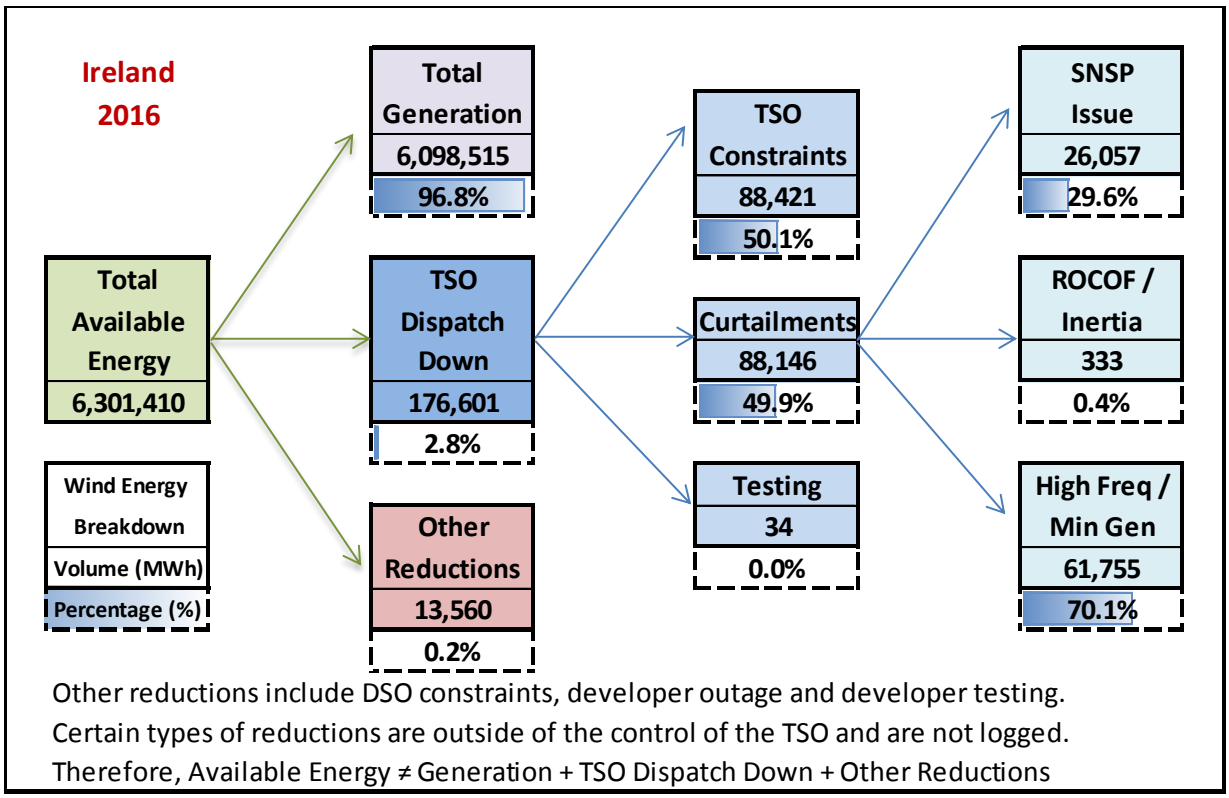


Figure 9: Graphical representation of wind dispatch-down categories in Ireland in 2016



Northern Ireland:

Figure 10: Monthly breakdown of wind dispatch-down categories in Northern Ireland in 2016

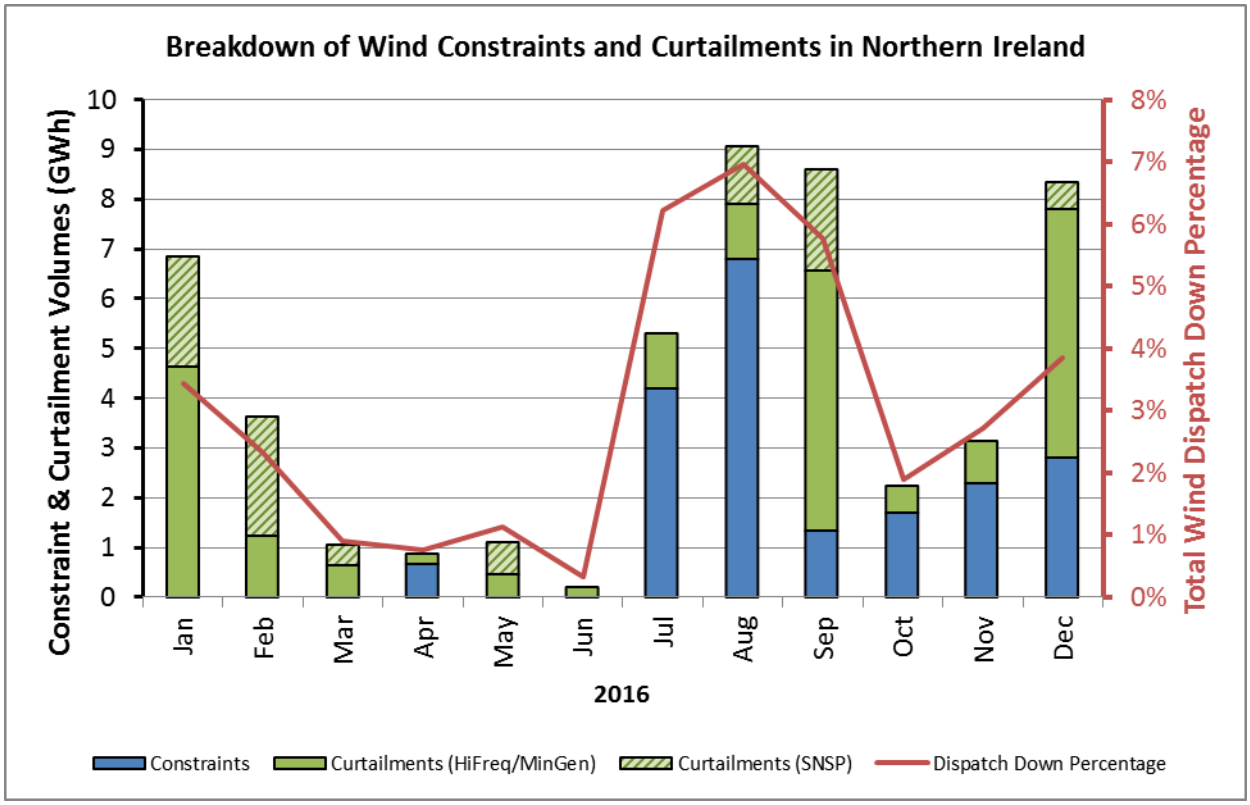
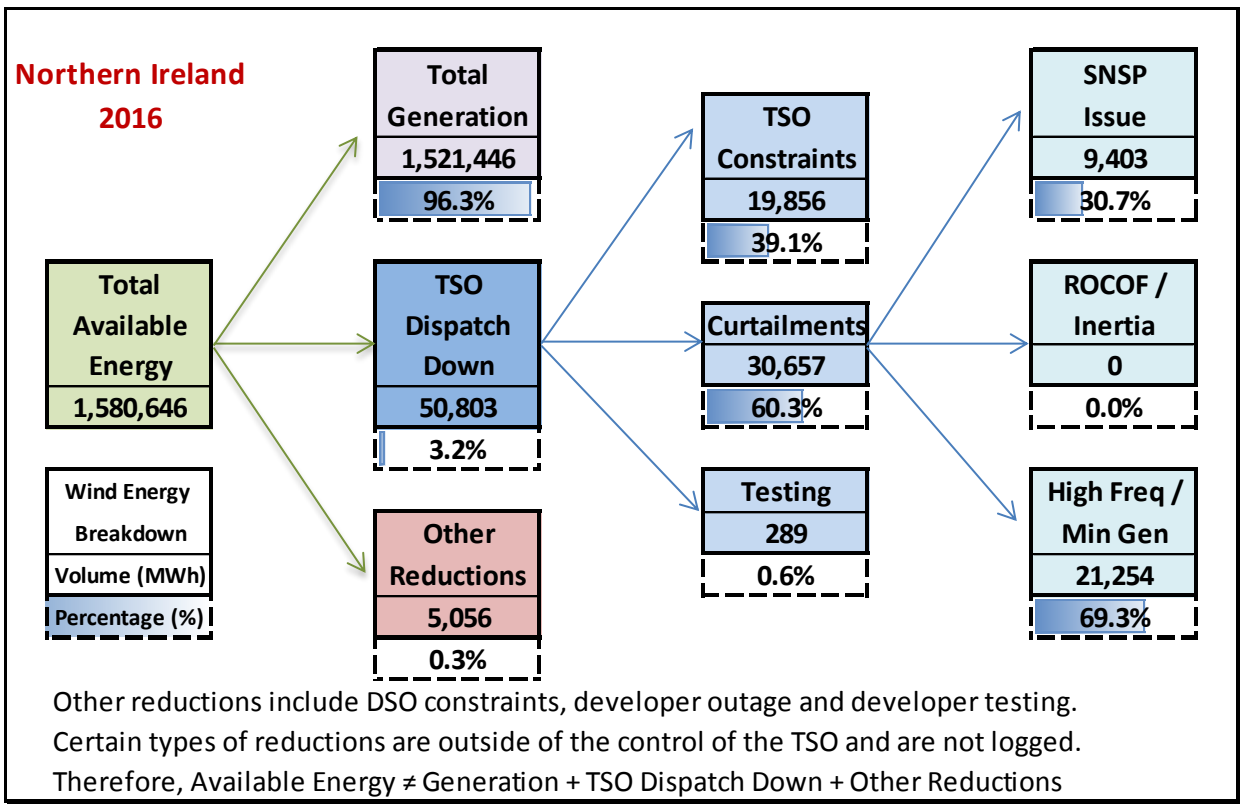


Figure 11: Graphical representation of Northern Ireland dispatch-down categories in 2016



Appendix B – Summary Results

Year	Wind Dispatch-Down (%)		
	Northern Ireland	Ireland	All Island
2011	1.3%	2.4%	2.2%
2012	0.7%	2.5%	2.1%
2013	1.9%	3.5%	3.2%
2014	2.8%	4.4%	4.1%
2015	5.3%	5.1%	5.1%
2016	3.2%	2.8%	2.9%

Year	Wind Dispatch-Down Volume (GWh)		
	Northern Ireland	Ireland	All Island
2011	13	106	119
2012	7	103	110
2013	24	171	196
2014	41	236	277
2015	95	348	442
2016	51	177	227

Year	Wind Capacity (MW) at Year End		
	Northern Ireland	Ireland	All Island
2011	405	1,631	2,036
2012	488	1,763	2,252
2013	554	1,896	2,450
2014	614	2,173	2,787
2015	627	2,363	2,990
2016	799	2,827	3,626

Year	All Island Estimated Wind Dispatch Breakdown	
	Constraints	Curtailment
2011	20%	80%
2012	38%	62%
2013	28%	72%
2014	35%	65%
2015	36%	66%
2016	48%	52%

Table 3: Historical Wind Dispatch-Down Summary in Ireland, Northern Ireland and All-Island

	2011			2012			2013			2014			2015			2016		
Month	**NI**	**IE**	**AI**	**NI**	**IE**	**AI**	**NI**	**IE**	**AI**	**NI**	**IE**	**AI**	**NI**	**IE**	**AI**	**NI**	**IE**	**AI**
Jan	0.0%	0.8%	0.6%	0.5%	2.2%	1.9%	0.7%	0.4%	0.5%	2.9%	4.9%	4.5%	4.3%	4.3%	4.3%	3.4%	3.5%	3.5%
Feb	0.0%	0.6%	0.5%	0.2%	2.8%	2.2%	0.3%	0.7%	0.6%	3.2%	3.7%	3.6%	4.6%	4.1%	4.2%	2.3%	3.3%	3.1%
Mar	2.7%	1.8%	2.0%	0.8%	2.4%	2.0%	0.6%	0.3%	0.3%	1.8%	4.0%	3.5%	11.4%	8.0%	8.8%	0.9%	2.4%	2.1%
Qtr1	**0.7%**	**1.0%**	**0.9%**	**0.5%**	**2.4%**	**2.0%**	**0.6%**	**0.4%**	**0.5%**	**2.7%**	**4.2%**	**3.9%**	**6.9%**	**5.4%**	**5.8%**	**2.4%**	**3.2%**	**3.0%**
Apr	1.3%	1.2%	1.3%	0.2%	1.4%	1.2%	2.6%	4.7%	4.3%	1.8%	4.2%	3.7%	2.8%	1.8%	2.0%	0.8%	1.4%	1.3%
May	2.2%	3.5%	3.2%	0.6%	1.6%	1.4%	3.7%	6.1%	5.6%	1.5%	2.8%	2.5%	3.8%	4.5%	4.3%	1.1%	1.2%	1.2%
Jun	0.4%	0.8%	0.7%	0.4%	4.0%	3.3%	1.9%	3.7%	3.4%	0.6%	3.3%	2.7%	4.2%	5.0%	4.8%	0.3%	0.7%	0.7%
Qtr2	**1.6%**	**2.3%**	**2.2%**	**0.4%**	**2.2%**	**1.9%**	**2.9%**	**5.0%**	**4.6%**	**1.5%**	**3.4%**	**3.0%**	**3.7%**	**3.9%**	**3.8%**	**0.8%**	**1.2%**	**1.1%**
Jul	0.2%	3.3%	2.8%	0.5%	1.9%	1.6%	0.8%	4.2%	3.4%	1.6%	3.9%	3.4%	2.8%	3.8%	3.7%	6.2%	2.3%	3.1%
Aug	0.0%	0.7%	0.5%	4.0%	4.2%	4.1%	2.4%	5.4%	4.7%	3.8%	3.5%	3.6%	5.0%	5.8%	5.6%	7.0%	4.6%	5.0%
Sep	2.4%	3.9%	3.7%	0.4%	4.8%	3.7%	0.5%	4.2%	3.3%	0.1%	2.2%	1.8%	1.5%	2.7%	2.5%	5.8%	5.6%	5.6%
Qtr3	**1.5%**	**3.1%**	**2.8%**	**1.5%**	**3.8%**	**3.3%**	**1.3%**	**4.6%**	**3.9%**	**2.4%**	**3.3%**	**3.1%**	**3.1%**	**4.1%**	**3.9%**	**6.3%**	**4.4%**	**4.8%**
Oct	2.4%	4.7%	4.3%	0.0%	0.3%	0.2%	1.6%	5.9%	5.0%	4.5%	8.2%	7.4%	4.2%	3.8%	3.9%	1.9%	1.8%	1.8%
Nov	1.2%	2.3%	2.1%	0.1%	1.0%	0.8%	4.0%	3.0%	3.2%	2.0%	3.2%	3.0%	6.9%	6.8%	6.9%	2.7%	1.0%	1.3%
Dec	0.7%	2.2%	1.9%	0.8%	2.8%	2.5%	2.0%	4.4%	3.8%	4.5%	5.0%	4.9%	6.2%	6.3%	6.3%	3.8%	3.1%	3.3%
Qtr4	**1.4%**	**2.9%**	**2.6%**	**0.4%**	**1.6%**	**1.4%**	**2.4%**	**4.5%**	**4.0%**	**3.9%**	**5.7%**	**5.3%**	**6.1%**	**6.0%**	**6.0%**	**3.0%**	**2.1%**	**2.3%**
Year Total	**1.3%**	**2.4%**	**2.2%**	**0.7%**	**2.5%**	**2.1%**	**1.9%**	**3.5%**	**3.2%**	**2.8%**	**4.4%**	**4.1%**	**5.3%**	**5.1%**	**5.1%**	**3.2%**	**2.8%**	**2.9%**
Wind Installed Capacity (MW)	405	1,631	2,036	488	1,763	2,252	554	1,896	2,451	614	2,173	2,787	627	2,363	2,990	799	2,827	3,626
Wind Generation (GWh)	943	4,256	5,198	1,020	4,102	5,122	1,259	4,642	5,901	1,453	5,116	6,568	1,803	6,537	8,339	1,725	6,115	7,840
Wind Capacity Factors	29%	32%	32%	26%	28%	27%	28%	29%	29%	28%	29%	29%	33%	33%	33%	28%	27%	27%

Notes:

'Dispatch-down' consists of TSO curtailments, constraints and wind testing.

The darker shaded cells indicate higher dispatch down percentages in order to produce a graphical representation similar to a heat map.

A more accurate methodology for calculating wind dispatch-down was implemented in 2016. Figures from previous years are best estimates.

Appendix C – Abbreviations

CER	Commission for Energy Regulation
CHP	Combined Heat and Power
DETI	Department of Enterprise, Trade and Investment
DNO	Distribution Network Operator
DSO	Distribution System Operator
E	East
EWIC	East West Interconnector
GW	Gigawatt
GWh	Gigawatt-hour
HVDC	High Voltage Direct Current
IRE	Ireland
IT	Information Technology
km	Kilometre
kV	kilovolt
M	Midlands
MW	Megawatt
MWh	Megawatt-hour
NE	North East
NI	Northern Ireland
NW	North West
S	South
S.I.	Statutory Instrument
SCADA	Supervisory Control And Data Acquisition
SE	South East
SEF	Strategic Energy Framework
SEM	Single Electricity Market
SNSP	System Non-Synchronous Penetration
SO	System Operator
SONI	System Operator Northern Ireland
SW	South West
TSO	Transmission System Operator
URegNI	Utility Regulator Northern Ireland
VPTG	Variable Price Taking Generator
W	West