Annual Renewable Energy Constraint and Curtailment Report 2017

01/06/2018

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Disclaimer

Please note that the historical data contained in this report is indicative. While every effort has been made in the compilation of this report to ensure that the information herein is correct, the TSOs do not accept liability for any loss or damage arising from the use of this document or any reliance on the information it contains. Use of this document and the information it contains is at the user's sole risk.

Executive Summary

EirGrid and SONI have prepared this report for the regulatory authorities to outline the levels of dispatch-down of renewable energy in 2017, 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 for the Economy 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.

In Ireland and Northern Ireland, renewable energy is predominantly 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 2017, the total wind energy generated in Ireland and Northern Ireland was 9,280 GWh, while 386 GWh of wind energy was dispatched-down. This represents 4% of the total available wind energy in 2017, and is an increase of about 159 GWh on the 2016 figure.

In Ireland, the dispatch-down energy from wind resources was 277 GWh. This is equivalent to 3.7% of the total available wind energy.

[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 CRU 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 109 GWh. This is equivalent to 5% of the total available wind energy.

Overall, the dispatch-down of energy from wind resources increased from 2.9% in 2016 to 4% in 2017. However, during 2017 an additional 1,440 GWh of wind energy was generated compared to 2016. The level of dispatch-down is affected by a number of factors which vary from year to year.

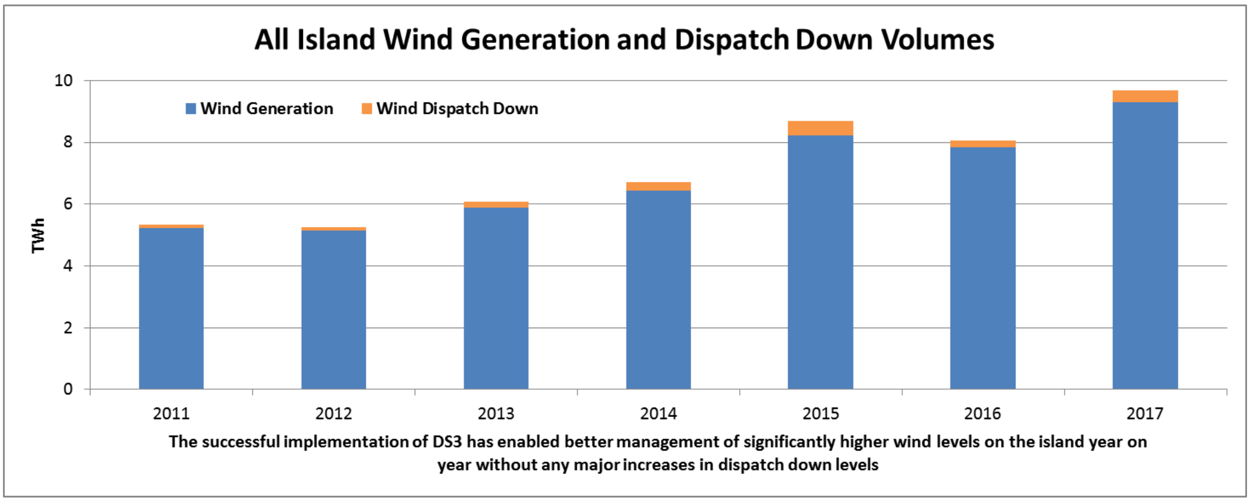
The amount of wind installed on the system and the capacity factor of the wind generation will have a significant impact on the levels of dispatch-down. The total capacity of wind generation on the island rose by 744 MW in 2017 while the average wind capacity factor remained the same at 26%.

A number of operational issues which give rise to curtailment are being addressed by the DS3 programme (Delivering a Secure, Sustainable Electricity System). 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 55% to 60% on a trial basis in November 2016 and permanently in March 2017. This limit was raised again to 65% on a trial basis in November 2017.

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 export limit on EWIC Interconnector increased to 500 MW on a permanent basis following a trial in November 2017.



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 generation and demand 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, Commission for Regulation of Utilities (CRU) in Ireland and the Utility Regulator (UR) in Northern Ireland. 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 CRU and the UR, 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 as per SEM-11-062.

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/

Any reduction in the output of renewable generators whilst responding to system frequency is not assessed in these reports. When operating in frequency response mode the wind farm output varies in real time based on the current system conditions and not in response to a dispatch instruction from the wind dispatch tool.

2 Level of Dispatch-Down Energy in 2017

The following provides a summary of the dispatch-down of wind energy in 2017 for Ireland and Northern Ireland. More details and figures are provided in Appendix A.

2.1 All-Island

In 2017, the share of electricity demand[3] from renewable sources in Ireland and Northern Ireland was 29.7%. This is broken down as follows:

- 26.4% provided by wind;
- 1.9% provided by hydro; and
- 1.4% provided by other[4] renewable energy sources.

The total wind energy generated was 9,280 GWh in Ireland and Northern Ireland. There was an estimated total of 386 GWh of dispatch-down energy from wind farms, which is an increase of about 159 GWh compared to 2016. The level of dispatch-down of wind represents 4% 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 metered 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.

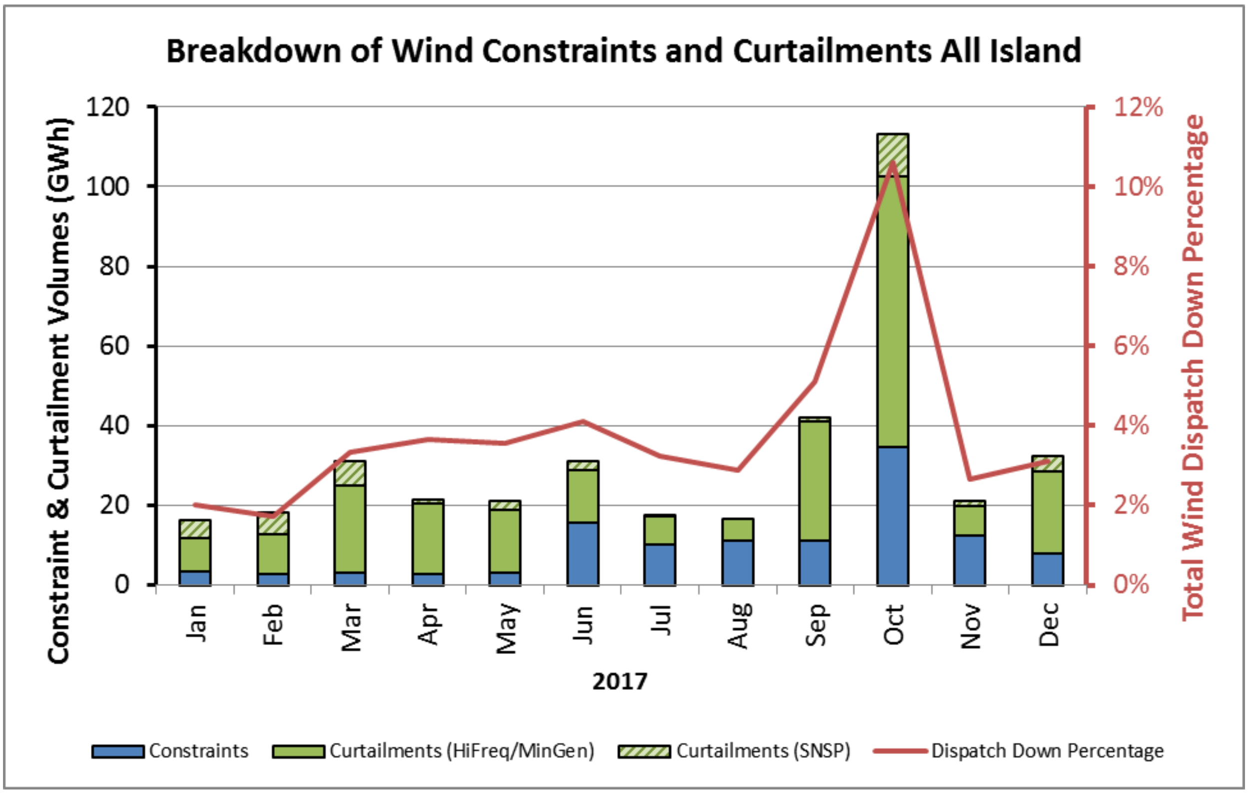


Figure 1: Monthly breakdown of the main wind dispatch-down categories on the island in 2017

2.2 Northern Ireland

In 2017, the total dispatch-down energy from wind generation in Northern Ireland was 109 GWh. This is equivalent to 5% of total available wind energy in that jurisdiction. This is a total overall increase of about 58 GWh in dispatch-down energy from wind generation compared to 2016.

2.3 Ireland

In 2017, the total dispatch-down energy from wind generation in Ireland was 277 GWh. This is equivalent to 3.7% of total available wind energy in Ireland. This is a total overall increase of about 100 GWh in dispatch-down energy from wind generation compared to 2016.

2.4 October 2017

October 2017 stands out due to the high levels of wind dispatch-down across all categories in this month compared to the rest of the year.

A number of factors contributed to the overall increase in this month. These include system constraints due to Rate of Change of Frequency (RoCoF) settings on wind farms in Northern Ireland before changes were implemented. Local transmission constraints to facilitate capital works are scheduled to conclude at the end of October which is also discussed in more detail in Section 4.2.

The all-island wind capacity factor for October 2017 was 30% which was an increase over the summer months which would have led to higher levels of curtailment.

The System Non Synchronous Penetration (SNSP) level increased on a trial basis in November 2016 by 5% which would have brought a reduction in SNSP curtailments from this month onwards.

During October 2017, a number of weather incidents occurred including ex-Hurricane Ophelia, and Storm Brian, both of which led to significant amounts of constraints and curtailments. The power system was operated in a defensive mode during these storms to counteract high wind-speed shutdown and maintain system security.

3. Contributory Factors for Dispatch-Down of Wind

3.1 Installed Wind and Capacity Factor

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 2017, the total installed capacity of wind generation on the island was 3,727 MW. By year-end, the figure had risen to 4,471 MW (3,311 MW in Ireland and 1,160 MW in Northern Ireland). Table 1 shows the end of year wind capacities on the island from 2007 to 2017.

In 2017, 744 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 325 MW over the previous 5 years. This rate of build is expected to continue until the year 2020 at least to achieve the nationally set targets of 40% renewable electricity as a percentage of demand.

This added 744 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

	Ireland Wind Installed Capacities (MW)			Northern Ireland Wind Installed Capacities (MW)			All Island Wind Installed Capacities (MW)		
Year	TSO	DSO	Total	TSO	DSO	Total	TSO	DSO	Total
2007	310.9	429.6	740.5	0.0	252.9	252.9	310.9	682.5	993.4
2008	417.8	524.5	942.3	0.0	269.3	269.3	417.8	793.8	1,211.6
2009	668.8	582.6	1,251.3	0.0	350.9	350.9	668.8	933.5	1,602.2
2010	727.8	662.6	1,390.4	0.0	394.6	394.6	727.8	1,057.3	1,785.1
2011	769.2	815.4	1,584.6	73.6	441.6	515.2	842.8	1,257.0	2,099.8
2012	769.2	934.3	1,703.5	73.6	529.4	603.0	842.8	1,463.6	2,306.4
2013	830.2	1,178.1	2,008.3	73.6	569.9	643.5	903.8	1,748.0	2,651.8
2014	959.6	1,319.9	2,279.4	73.6	659.6	733.2	1,033.2	1,979.5	3,012.7
2015	1,052.6	1,394.7	2,447.3	73.6	681.7	755.3	1,126.2	2,076.4	3,202.5
2016	1,271.3	1,507.8	2,779.1	73.6	874.5	948.1	1,344.9	2,382.3	3,727.1
2017	1,491.5	1,819.6	3,311.1	121.1	1,039.1	1,160.2	1,612.6	2,858.7	4,471.3

Data Sources:
Ireland TSO Connected Wind: EirGrid
Ireland DSO Connected Wind: ESB Networks
Northern Ireland Connected Wind: SONI

Table 1: Installed wind capacities on the island from 2007 to 2017

Over the year, the capacity factor[4] of wind farms was 26% which was the same as in 2016. In 2015 it was 31%. The seasonal variation in the capacity factor is evident in Figure 2.

[4] 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.

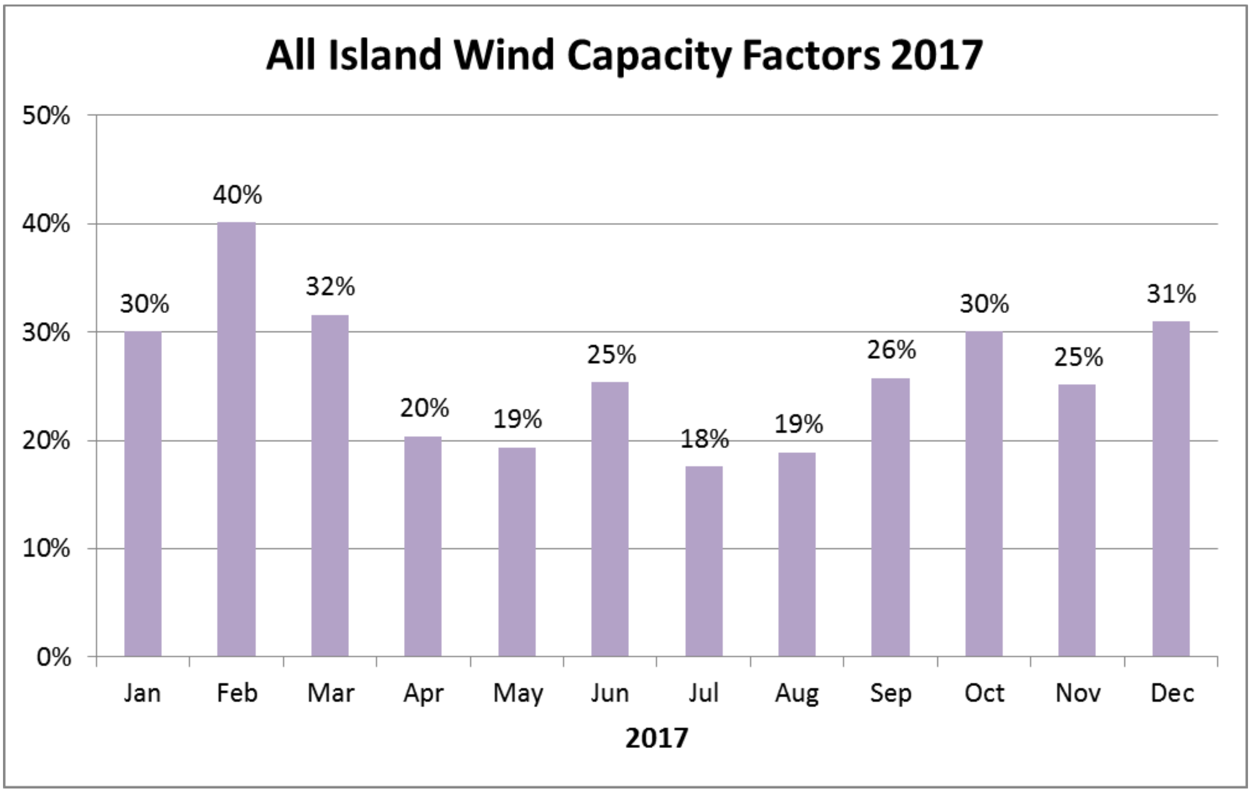


Figure 2: All-Island Monthly Wind Capacity Factors in 2017

The level of installed wind increased from 2016 to 2017. The capacity factor was 26% in both years, however the increased wind installed capacity resulted in higher generation in 2017.

3.2 Generation Portfolio

In 2017, there were changes to the generation portfolio in Ireland and Northern Ireland that may have contributed to the levels of dispatch down.

Turlough Hill pumped storage station was unavailable due to scheduled and forced outages from mid-July until the end of October 2017. The station typically pumps at night time, increasing the system load. Increasing system load during periods of high wind generation at night can reduce wind curtailment.

During 2017 outages of the Moyle and EWIC interconnectors and changes to capacity of the interconnectors resulted in higher wind curtailment at times due to them being unavailable for exports. EWIC interconnector was unavailable for 1 week in March 2017 and then from mid-April until the end of May. A second pole of Moyle interconnector became available from the end of September 2017 which increased the capacity of the interconnector.

In November 2017, the firm export limit reduced on Moyle from 295 MW to 80 MW due to transmission constraints on the system in Great Britain. National Grid (the Transmission System Operator in Great Britain) has put in place a process where this export capacity may be increased at times and during these periods additional exports can be accommodated.

Throughout 2017 a number of trials were conducted on EWIC to facilitate higher levels of exports. Following successful completion of these trials the export limit was increased to 500 MW on EWIC from November 2017 on a permanent basis.

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. In 2016, the all island demand based on metered data was 36.36 TWh. In 2017 the all island demand marginally increased by 0.7% to 36.63 TWh so it would not be expected to impact significantly on dispatch-down levels.

3.5 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[5] before Autonomous Price Taker Generation[6] 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"[7] and the associated addendum. To meet the controllability definition, the operational policy[8] 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.

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

In Northern Ireland, the breakdown of wind dispatch-down volumes in 2017 between constraints and curtailments was 37% and 63% respectively.

In Ireland, the breakdown of wind dispatch-down volumes in 2016 between constraints and curtailments was 28% and 72% respectively.

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[5] 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.

[6] 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

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

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

Table 2 shows the aggregate estimated[9] breakdown of wind dispatch-down on the island over the last 7 years.

Estimated Breakdown of Dispatch-down of Wind on the Island	2011	2012	2013	2014	2015	2016	2017
Constraints	20%	38%	28%	35%	36%	48%	31%
Curtailments	80%	62%	72%	65%	64%	52%	69%

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

4.1 Curtailment

Curtailment refers to the dispatch-down of wind for system-wide reasons. There are different 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. System Non-Synchronous Penetration (SNSP[10]) limit

In order to securely operate the system these limits result in minimum generation requirements on the conventional (synchronous) generation portfolio. The implementation of these security limits is described in detail in the Operational Constraints Update paper. This document is published[11] on the EirGrid Group website.

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 55% to 60% in November 2016 and a trial of 65% commenced in November 2017. The ultimate aim of the DS3 programme is to increase this limit towards 75%.

The above limits can reduce the ability to accommodate wind generation, particularly overnight during the lower demand hours.

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.

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[9] A more accurate methodology for calculating wind dispatch down was implemented from 2016. Figures from previous years are best estimates.
[10] SNSP is the ratio of non-synchronous generation (wind and HVDC imports) to demand plus HVDC exports
[11] http://www.eirgridgroup.com/library/index.xml

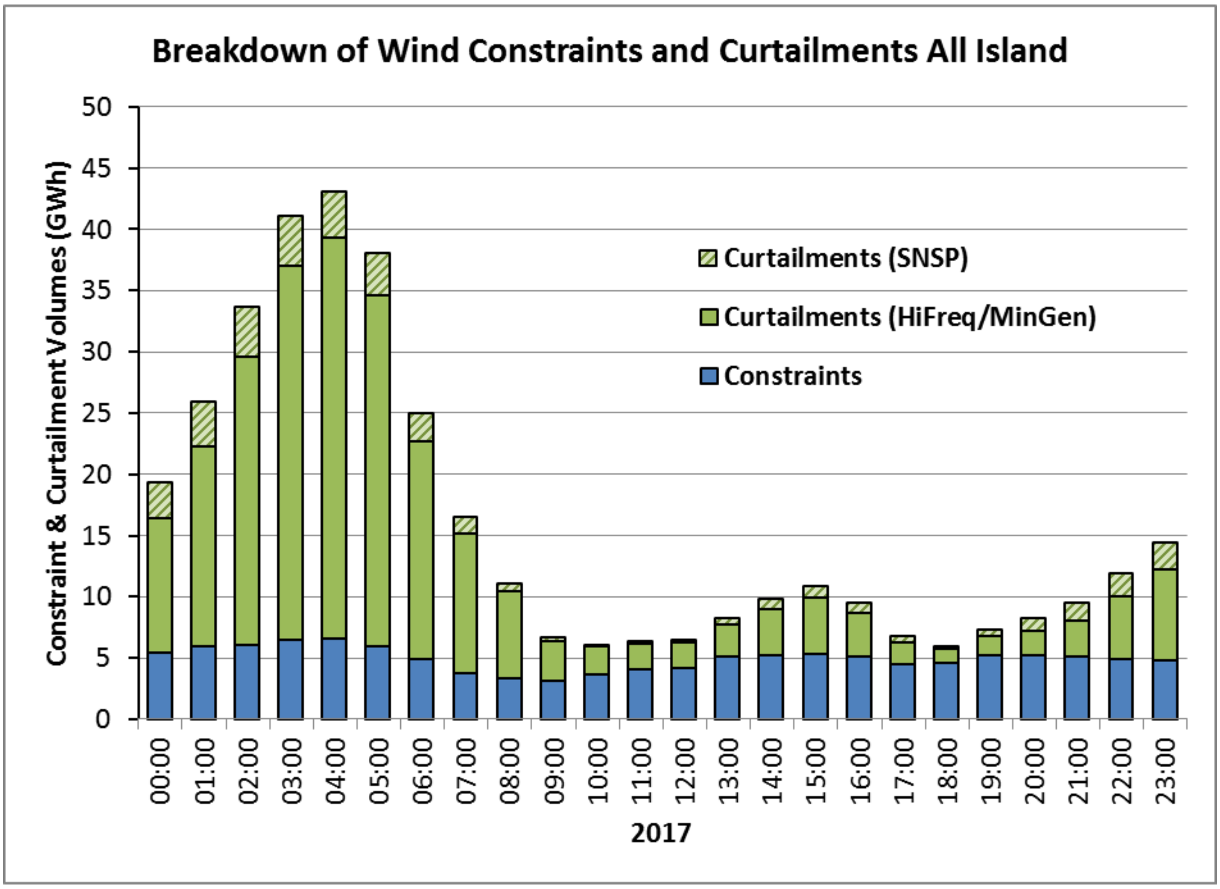


Figure 3: All-Island breakdown of wind constraints and curtailments in 2017 by hour of day

4.2 Constraints

The dispatch-down of wind for network reasons is referred to as a constraint.

Constraint of wind can occur for two main reasons:

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

In order to reinforce the network to facilitate more wind generation, a number of major capital works projects are scheduled during the transmission outage season each year. These outages may reduce the wind generation capacity of the network for the duration of any works. 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.

The proportion of all-island dispatch-down attributable to constraints (rather than curtailment) was 31% in 2017. This was due partly to an increase in installed wind generation but more significantly due to the transmission outages in 2017. Many of these outages were to facilitate the upgrading and uprating of the transmission system.

4.3 Wind Dispatch-Down by Region

The greatest percentage of wind dispatch-down (constraints and curtailment) in 2017 was observed in Northern Ireland, the North West, and West regions, as shown in Figure 4. The latest version of the transmission system map is included in Appendix C. The following are the main factors for higher than average wind dispatch-down in these regions:

Northern Ireland:

In order to operate the power system at higher levels of SNSP (65% from November 2017) certain wind farms must be constrained during these periods. Whilst operating at high levels of SNSP the Rate of Change of Frequency (RoCoF) following a large tripping increases. To manage this RoCoF settings are increased on wind farms so they do not trip also. A Wind Security Assessment Tool (WSAT) is used in real time operation of the power system to indicate times when wind farms with lower RoCoF settings need to be constrained.

A number of wind farms in Northern Ireland were impacted by this issue. In November 2017 work commenced to update these settings. The majority of wind farm settings have now been changed which should result in a reduction in constraints for RoCoF reasons in Northern Ireland in the future.

Ireland:

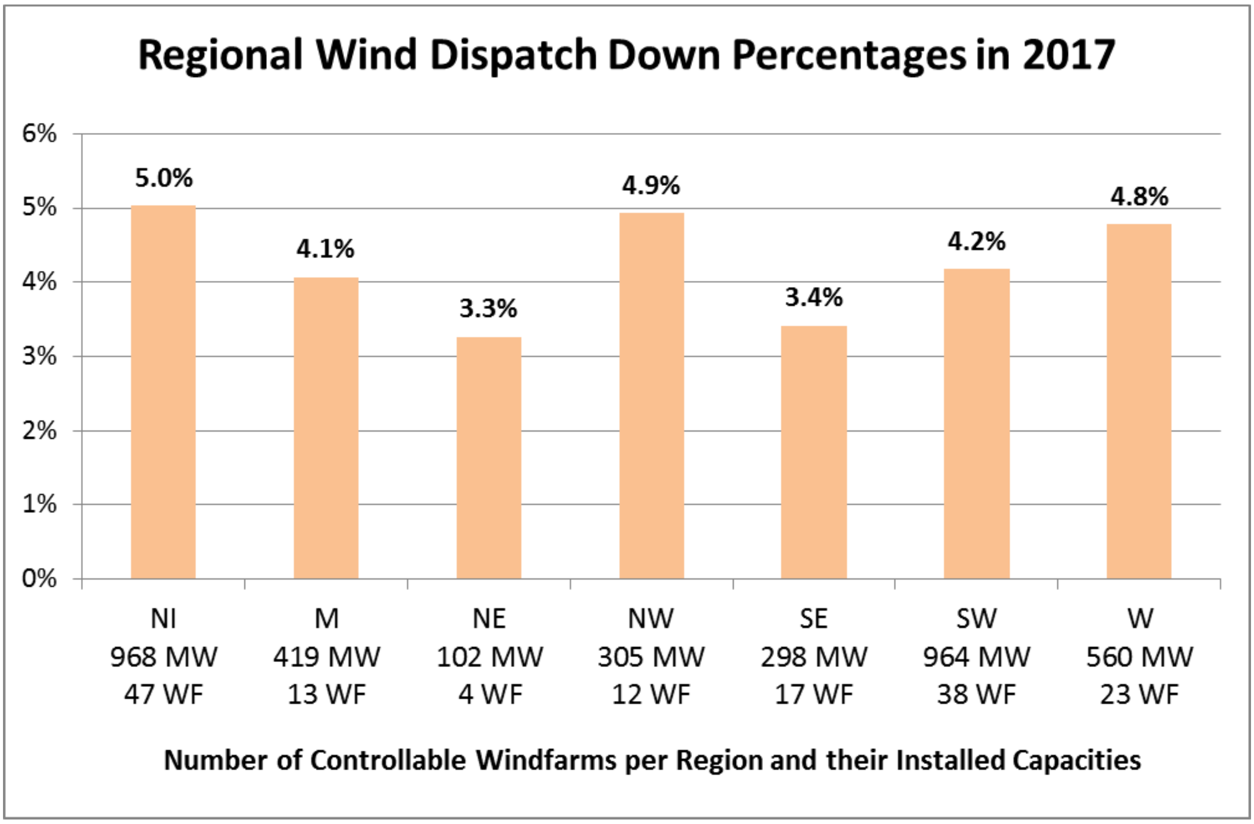
In recent years significant capital works have been undertaken to upgrade the transmission system to allow more wind generation to be exported from wind farms on the system particularly in the West, South West and North West regions of Ireland. These areas have previously experienced the greatest level of restrictions for the export of wind.

West (W) and South West (SW)

During 2017 the programme of works in the West and South West involved the completion of a number of capital projects to facilitate the export of wind between Tarbert and Clashavoon 220 kV stations. These included the connection of a new 220 kV station called Kilpaddoge, the energisation of a 220 kV subsea cable linking Kilpaddoge with Moneypoint 220 kV station and the uprate of the Ballyvouskill – Ballynahulla 220 kV circuit. The addition of these circuits facilitates greater levels of wind generation to be exported from this region via the 220 kV network which has a higher capacity than the 110 kV network.

North West (NW)

The constraint of wind in the region is predominately associated with transmission outages during the summer. The level of constraints has, however, reduced significantly due to new circuits being energised in this region in previous years.



Note: Installed capacities are indicative end of year figures and do not reflect capacity changes throughout the year.

Figure 4: Regional Wind Dispatch-Down Percentages in 2017

5 Mitigation Measures

5.1 Operational Policy and the DS3 Programme

The fundamental issues that give rise to curtailment have been identified in Section 4.1. 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 4.1.

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.

SNSP (System Non-Synchronous Penetration) is the sum of non-synchronous generation (such as wind, solar and HVDC imports) as a percentage of total demand and exports. When the SNSP limit is raised, a trial period takes place before it becomes permanent. During the trial period, the system is operated at this increased SNSP limit except during adverse system events or during system testing.

The SNSP level was increased from 55% to 60% on a trial basis in November 2016 and permanently in March 2017. This limit was raised again to 65% on a trial basis in November 2017.

Separately, a series of trials took place to increase exports on EWIC to 500 MW for various levels of wind generation. The trials were completed and the EWIC export limit was permanently increased to 500 MW in November 2017. These two measures facilitate higher levels of wind generation.

5.2 Operational Policy – Interconnector Countertrading[13]

Following gate closure in the SEM, the TSOs may seek to initiate changes to the interconnector flows of Moyle and the East West Interconnectors. The reasons for this

[12] http://www.eirgridgroup.com/how-the-grid-works/ds3-programme/
[13] http://www.eirgridgroup.com/site-files/library/EirGrid/InformationNoteExtensionofTSOcounter-tradingfacilitiesforDBCmanagement.pdf

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[14] 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
- relevant system limitations
- availability of a counter party to give effect to any potential trade

Throughout 2017, 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 after the fact whether the countertrading was for priority dispatch or for economic reasons.

5.3 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.

[14] 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 2017. 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/

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

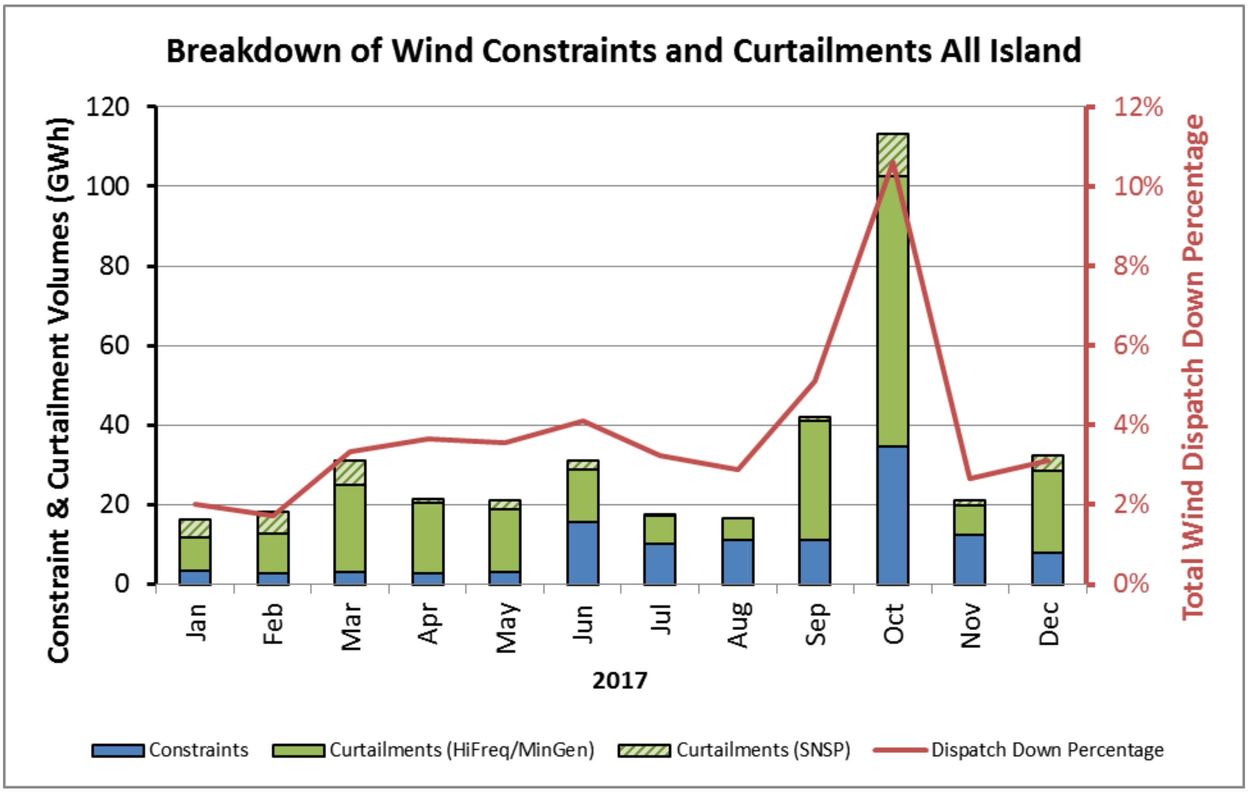
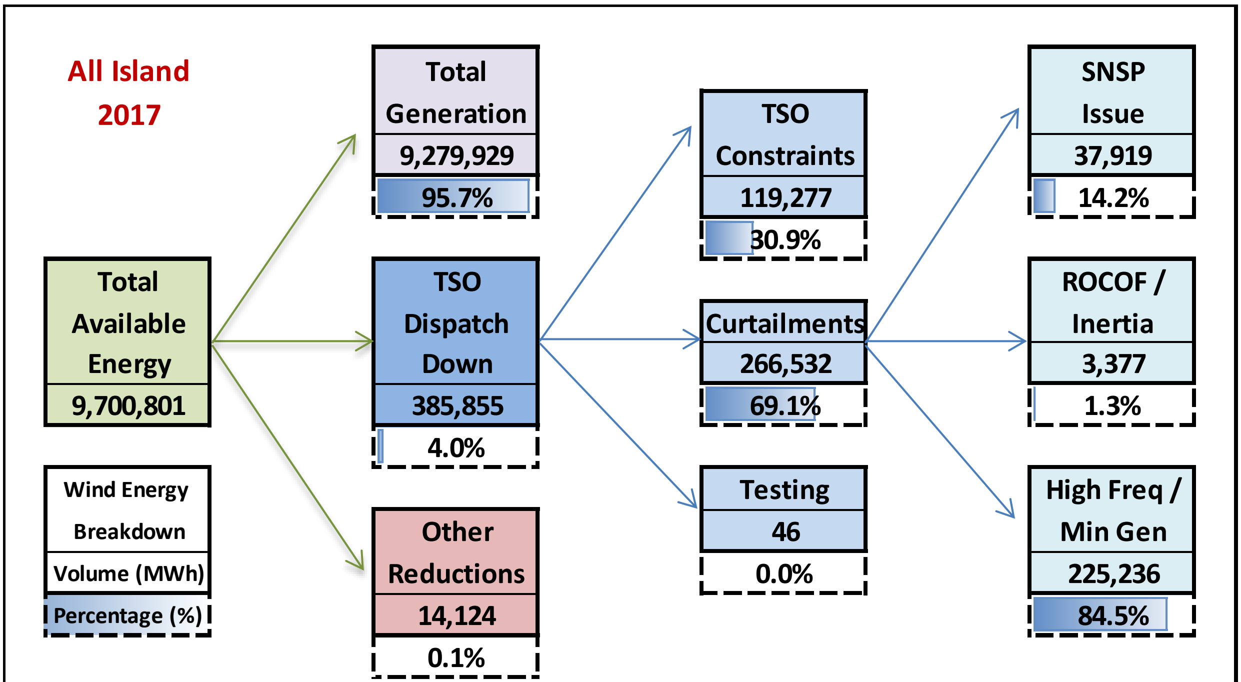


Figure 5: Monthly breakdown of all-island wind constraints and curtailments in 2017



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

Figure 6: Graphical representation of all-island wind dispatch-down categories in 2017

Ireland

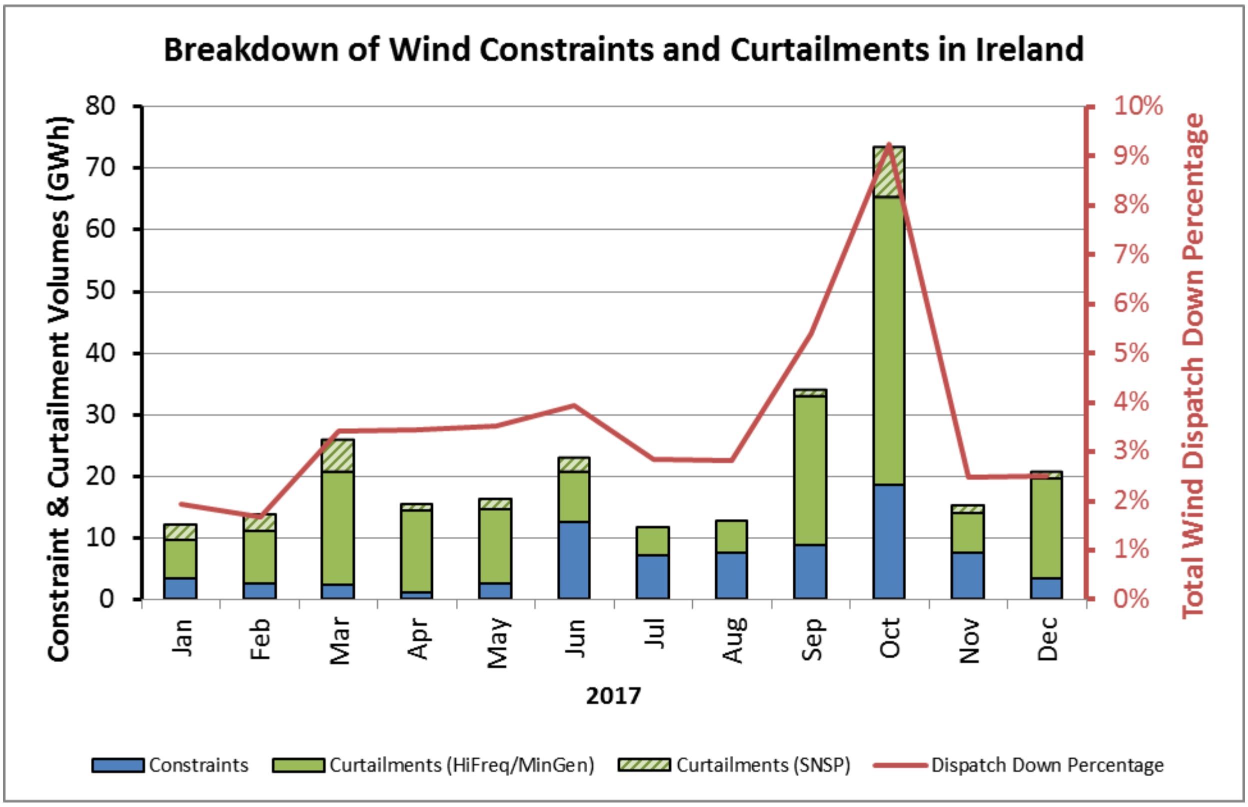


Figure 7: Monthly breakdown of the main wind dispatch-down categories in Ireland in 2017

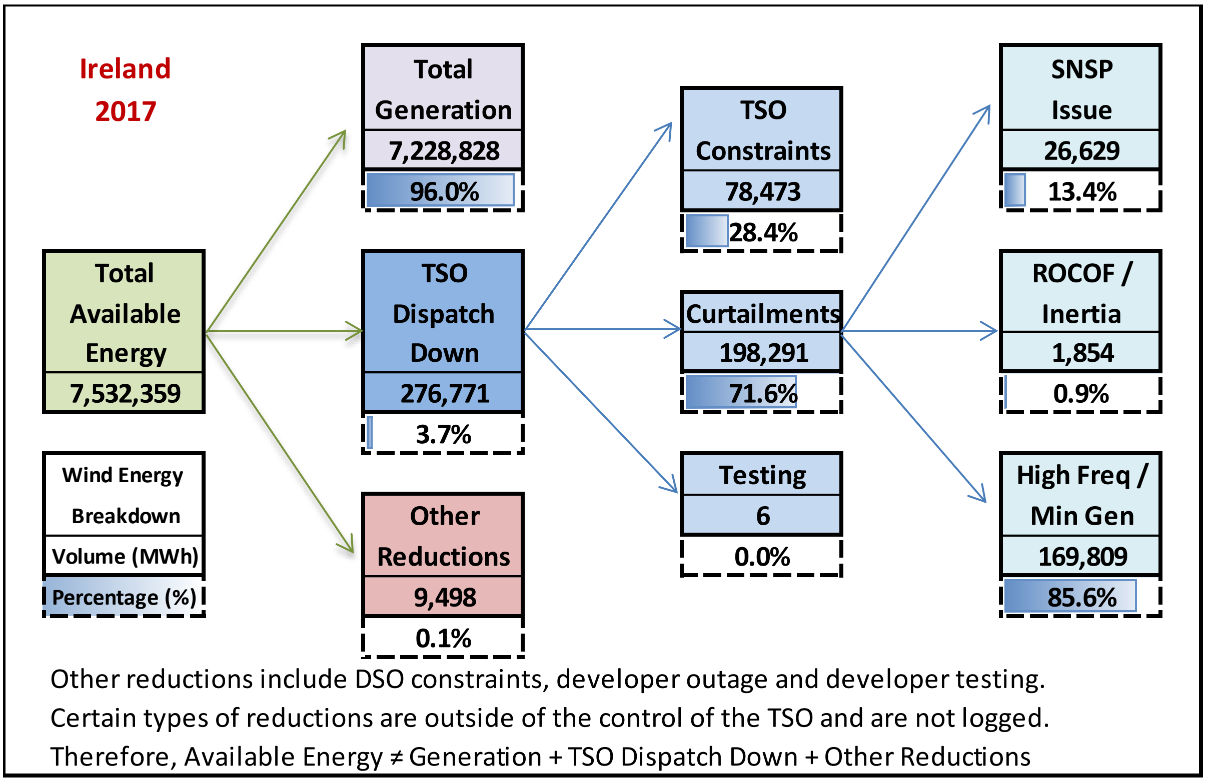


Figure 8: Graphical representation of wind dispatch-down categories in Ireland in 2017

Northern Ireland

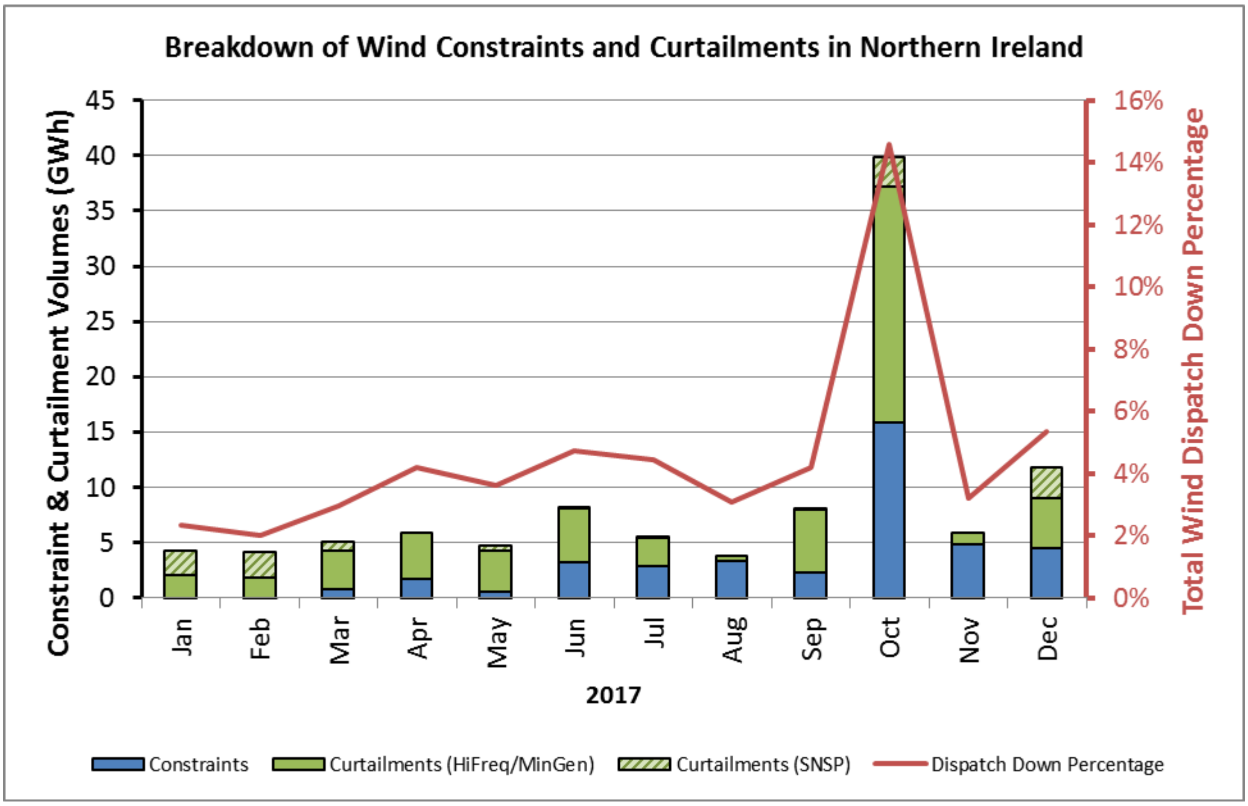


Figure 9: Monthly breakdown of wind dispatch-down categories in Northern Ireland in 2017

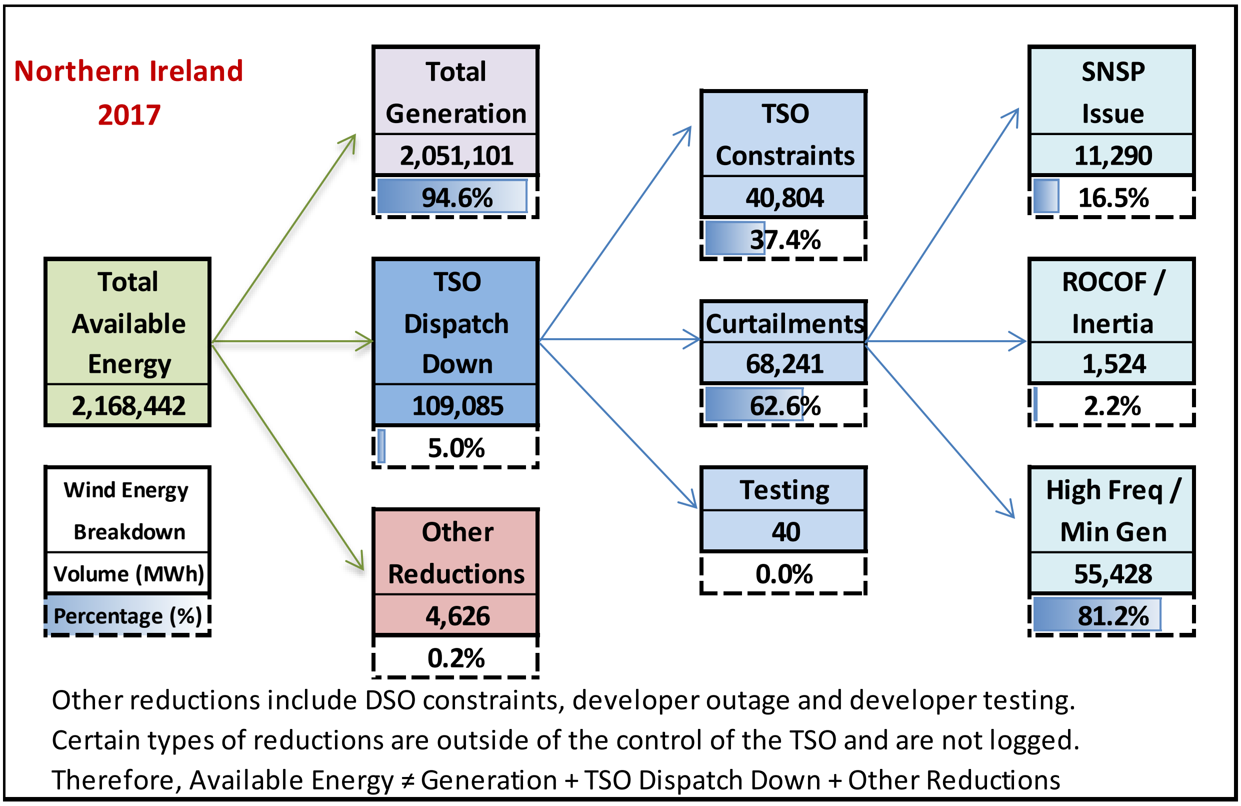


Figure 10: Graphical representation of Northern Ireland dispatch-down categories in 2017

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%
2017	5.0%	3.7%	4.0%

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
2017	109	277	386

Year	Wind Capacity (MW) at Year End		
	Northern Ireland	Ireland	All Island
2011	515	1,585	2,100
2012	603	1,703	2,306
2013	644	2,008	2,652
2014	733	2,279	3,013
2015	755	2,447	3,203
2016	948	2,779	3,727
2017	1,160	3,311	4,471

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%
2017	31%	69%

* Percentages prior to 2016 are estimated

Historical Wind Dispatch Down (Constraint and Curtailment) Percentages for Ireland (IE), Northern Ireland (NI) and All Island (AI)

	2011			2012			2013			2014			2015			2016			2017		
Month	**NI**	**IE**	**AI**	**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%	2.4%	1.9%	2.0%
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%	2.0%	1.7%	1.7%
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%	3.0%	3.4%	3.3%
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%**	**2.4%**	**2.3%**	**2.4%**
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%	4.2%	3.5%	3.6%
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%	3.6%	3.5%	3.5%
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%	4.7%	3.9%	4.1%
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%**	**4.2%**	**3.7%**	**3.8%**
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%	4.4%	2.8%	3.2%
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%	3.1%	2.8%	2.9%
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%	4.2%	5.4%	5.1%
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%**	**3.9%**	**3.9%**	**3.9%**
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%	14.6%	9.2%	10.6%
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%	3.2%	2.5%	2.6%
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%	5.3%	2.5%	3.1%
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%**	**8.5%**	**4.9%**	**5.7%**
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%**	**5.0%**	**3.7%**	**4.0%**
Wind Installed Capacity (MW)	515	1,585	2,100	603	1,703	2,306	644	2,008	2,652	733	2,279	3,013	755	2,447	3,203	948	2,779	3,727	1,160	3,311	4,471
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	2,051	7,229	9,280
Wind Capacity Factors	21%	31%	28%	21%	28%	27%	23%	29%	27%	24%	27%	26%	28%	32%	31%	23%	27%	26%	22%	27%	26%
SNSP Limit	50%			50%			50%			50%			55% Trial from Oct			55% Perm from Mar 60% Trial from Nov			60% Perm from Mar 65% Trial from Nov		

Notes:

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

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

Appendix C – Transmission System Map

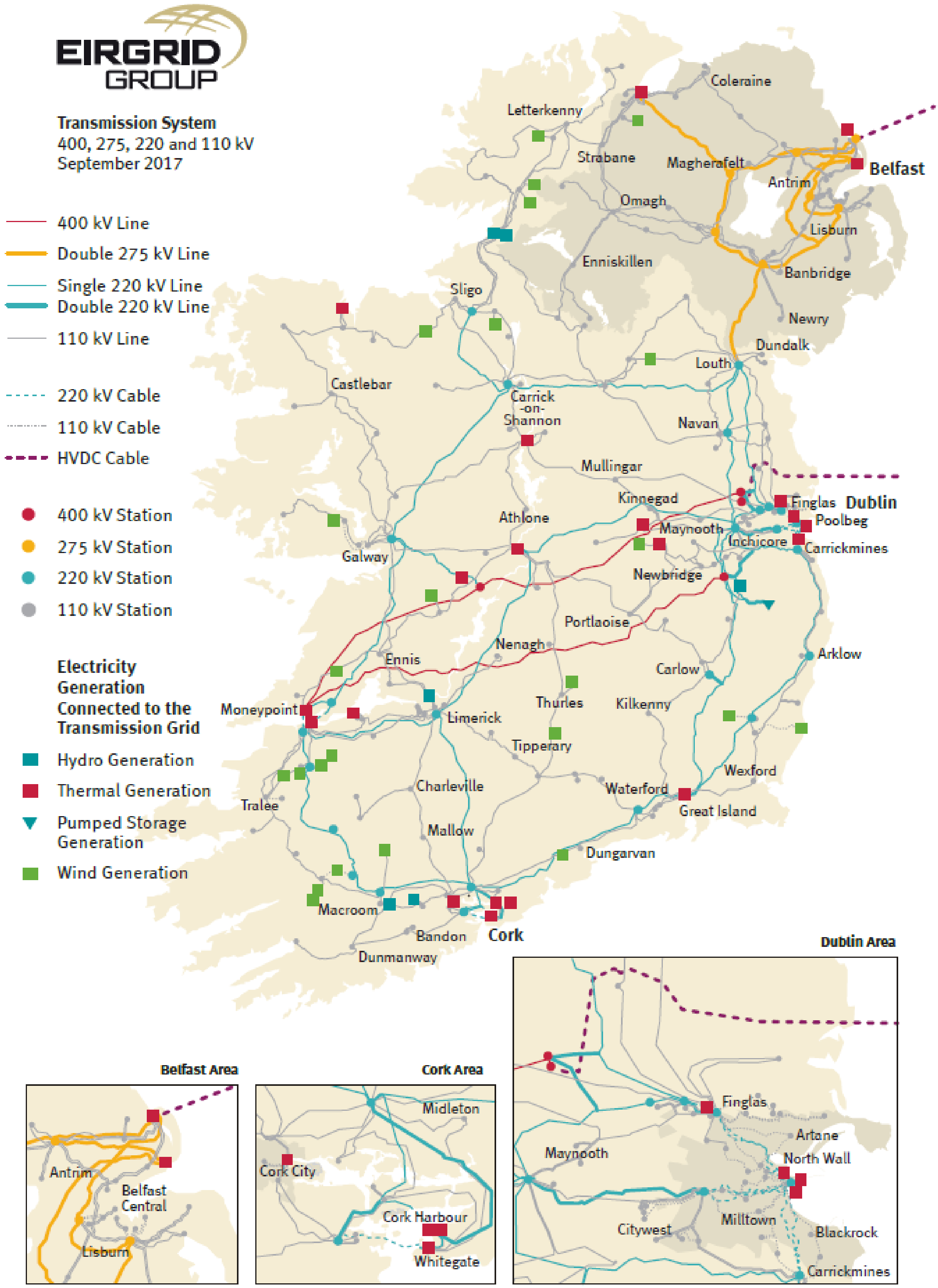


Figure 11: Transmission System Map

Appendix D – Abbreviations

CHP	Combined Heat and Power
CRU	Commission for Regulation of Utilities
DfE	Department for Economy, Northern Ireland
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
UR	Utility Regulator Northern Ireland
VPTG	Variable Price Taking Generator
W	West