Annual Renewable Energy Constraint and Curtailment Report 2018

May 2019

EIRGRID SONI

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Version 1.1 Changes:

All-island wind monthly capacity factors bar chart updated on page 11.

Disclaimer

Please note that the historical data contained in this report is indicative and the best available data at the time of writing. 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 2018, 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, the TSOs must report this to the regulatory authorities. They must also indicate the 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 used by the system. This is because of broad power system limitations, known as curtailments, or local network limitations, known as constraints.

In 2018, the total wind energy generated in Ireland and Northern Ireland was 11,076 GWh, while 707 GWh of wind energy was dispatched-down. This represents 6% of the total available wind energy in 2018, and is an increase of 321 GWh on the 2017 value.

In Ireland, the dispatch-down energy from wind resources was 457 GWh. This is equivalent to 5% 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."

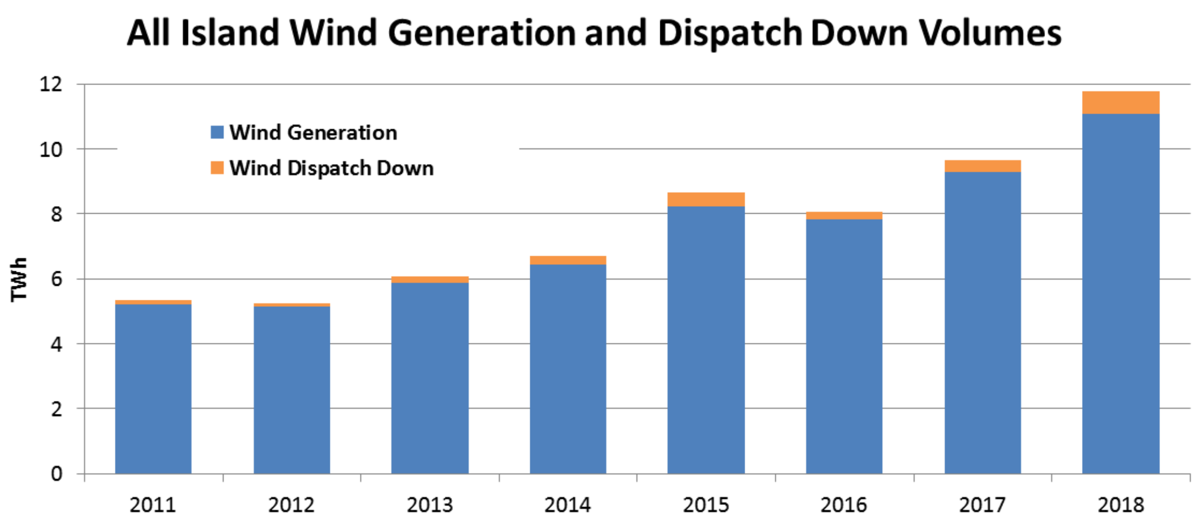
[2] Article 4.4 of Statutory Instrument 147 of 2011 states: "If significant measures are taken to curtail the renewable energy sources in order to guarantee the security of the electricity system and security of energy supply, the transmission system operator shall report to CRU on those measures and 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 250 GWh. This is equivalent to 9.4% of the total available wind energy.

Overall, the dispatch-down of energy from wind resources increased from 4% in 2017 to 6% in 2018. However, during 2018 an additional 1,796 GWh of wind energy was generated compared to 2017. The level of dispatch-down is affected by a number of factors which vary from year to year, such as the amount of wind installed on the system, and the capacity factor of the wind generation. The total capacity of wind generation on the island rose by 475 MW in 2018 while the average wind capacity factor increased by 1% to 27% in 2018.

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, was raised to 65% on a permanent basis in April 2018. The limit is expected to be raised up to 75% in 2020 once any remaining technical obstacles, such as ROCOF capability, are overcome.

The new electricity market (ISEM) went live on October 1st, 2018, integrating the all-island power system with the rest of Europe through the two HVDC interconnectors. The rules around constraints and curtailment did not change under ISEM, and so it is not expected to have an impact on dispatch-down quantities.



The successful implementation of DS3 has enabled better management of significantly higher wind levels on the island year on year without any major increases in dispatch down levels

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 receives priority within the scheduling and dispatch algorithms in the Control Centres. 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 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 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 the difference between constraint and curtailment in their SEM-13-011 paper.

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 controllable 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 2018

The following provides a summary of the dispatch-down of wind energy in 2018 for Ireland and Northern Ireland. (**Note:** The values are based on the best available data at the time of writing.) More details and figures are provided in Appendix A.

2.1 All-Island

In 2018, the share of electricity demand[3] from renewable sources in Ireland and Northern Ireland was 32.9% (Figure 1). This is broken down as follows:

- 29.3% provided by wind;
- 1.9% provided by hydro; and
- 1.7% provided by other[4] renewable energy sources.

The total wind energy generated was 11,076 GWh in Ireland and Northern Ireland. There was an estimated total of 707 GWh of dispatch-down energy from wind farms, which is an increase of about 321 GWh compared to 2017. The level of dispatch-down of wind represents 6% of total available energy from wind resources in Ireland and Northern Ireland.

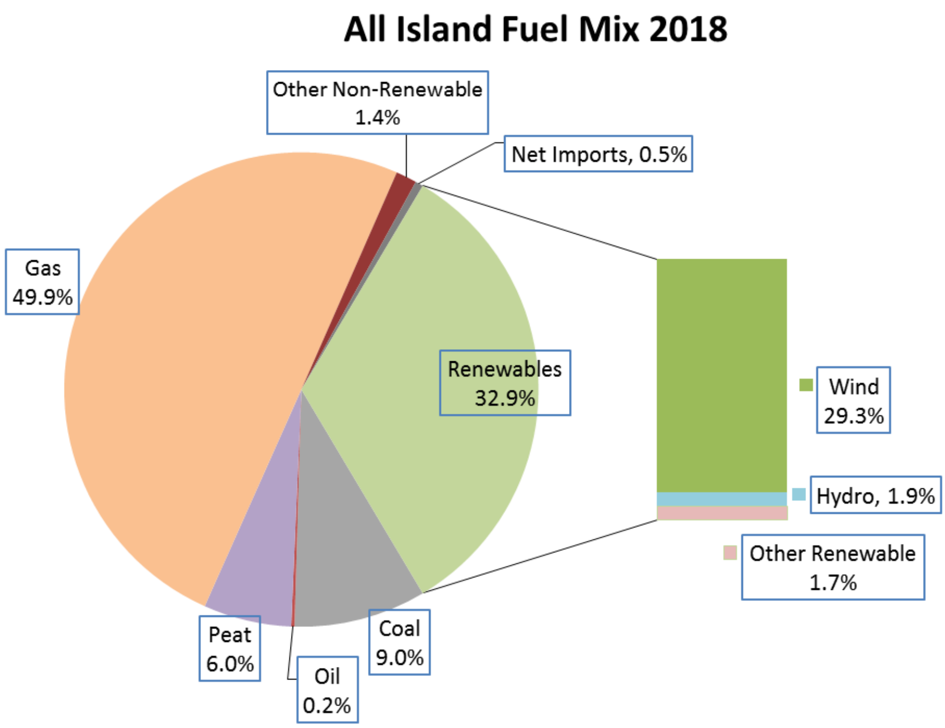


Figure 1: All-Island Fuel Mix for 2018

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[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.

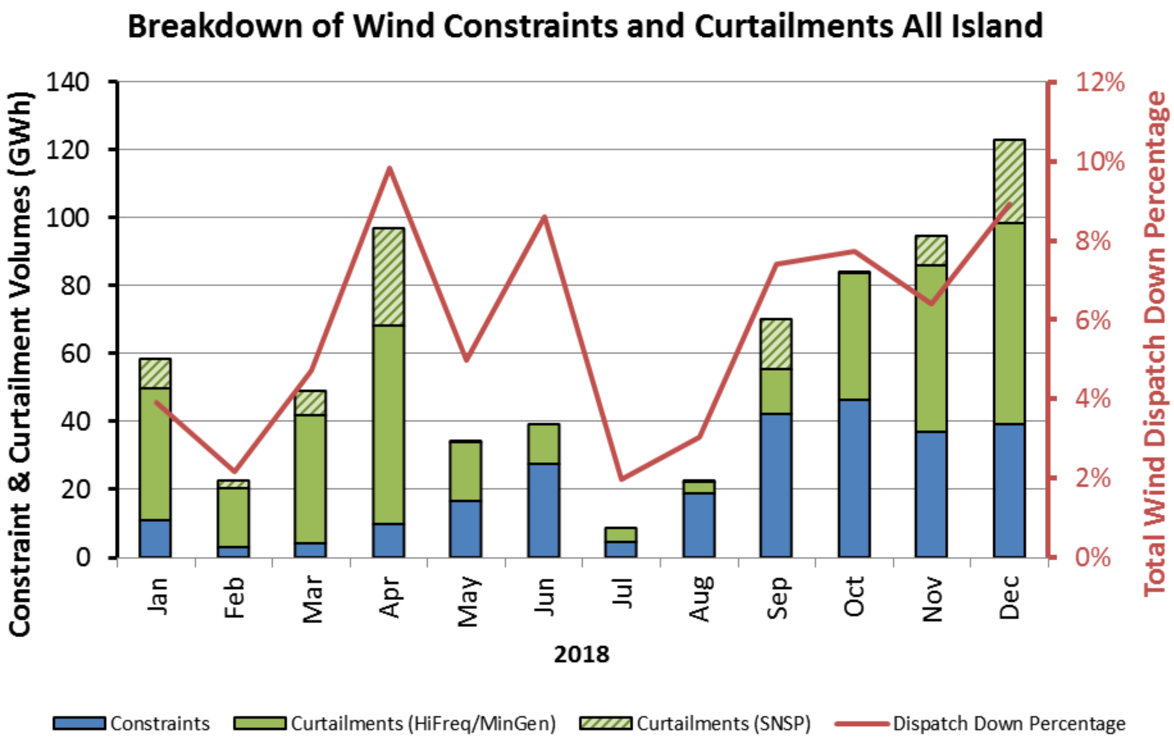

Figure 2: Monthly breakdown of the main wind dispatch-down categories on the island in 2018

2.2 Northern Ireland

In 2018, the total dispatch-down energy from wind generation in Northern Ireland was 250 GWh. This is equivalent to 9.4% of total available wind energy in that jurisdiction. This is a total overall increase of about 141 GWh in dispatch-down energy from wind generation compared to 2017.

2.3 Ireland

In 2018, the total dispatch-down energy from wind generation in Ireland was 457 GWh. This is equivalent to 5% of total available wind energy in Ireland. This is a total overall increase of about 180 GWh in dispatch-down energy from wind generation compared to 2017.

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: the amount of wind generation installed on the system; and the capacity factor of the wind generation.

At the beginning of January 2018, the total installed capacity of wind generation on the island was 4,467 MW. By year-end, the figure had risen to 4,942 MW (3,666 MW in Ireland and 1,276 MW in Northern Ireland). Table 1 shows the end of year wind capacities on the island from 2008 to 2018.

In 2018, 475 MW was added to the wind installed capacity on the island, down from 746MW in the previous year. Almost 2GW of wind generation has been added to the all-island system in the past five years. This rate of build is expected to continue until the year 2020 at least, to help work towards the nationally set targets of 40% renewable electricity as a percentage of demand.

	Wind Installed Capacities (MW)								
	Ireland			Northern Ireland			All Island		
Year End	TSO	DSO	Total	TSO	DSO	Total	TSO	DSO	Total
2008	417.8	524.5	**942.3**	0.0	267.7	**267.7**	417.8	792.2	**1,209.9**
2009	668.8	582.6	**1,251.3**	0.0	348.7	**348.7**	668.8	931.3	**1,600.0**
2010	727.8	662.6	**1,390.4**	0.0	392.2	**392.2**	727.8	1,054.8	**1,782.6**
2011	769.2	815.4	**1,584.6**	73.6	438.8	**512.4**	842.8	1,254.2	**2,097.0**
2012	769.2	934.3	**1,703.5**	73.6	526.0	**599.6**	842.8	1,460.3	**2,303.1**
2013	845.2	1,078.1	**1,923.3**	73.6	566.4	**640.0**	918.8	1,644.4	**2,563.2**
2014	1,046.6	1,219.9	**2,266.4**	73.6	655.5	**729.1**	1,120.2	1,875.4	**2,995.6**
2015	1,152.6	1,294.7	**2,447.3**	73.6	677.4	**751.0**	1,226.2	1,972.1	**3,198.3**
2016	1,371.3	1,407.8	**2,779.1**	73.6	869.0	**942.6**	1,444.9	2,276.8	**3,721.7**
2017	1,591.5	1,722.1	**3,313.6**	121.1	1,032.6	**1,153.7**	1,712.6	2,754.7	**4,467.3**
2018	1,774.5	1,891.8	**3,666.2**	121.1	1,155.2	**1,276.3**	1,895.6	3,046.9	**4,942.5**

Table 1: Installed wind capacities on the island from 2008 to 2018

This extra 475 MW also represents an 11% 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.

Over the year, the capacity factor[4] of wind farms was 27% which is slightly higher than 2016 & 2017 (26%). In 2015 it was 31%. The seasonal variation in the capacity factor is evident in Figure 3.

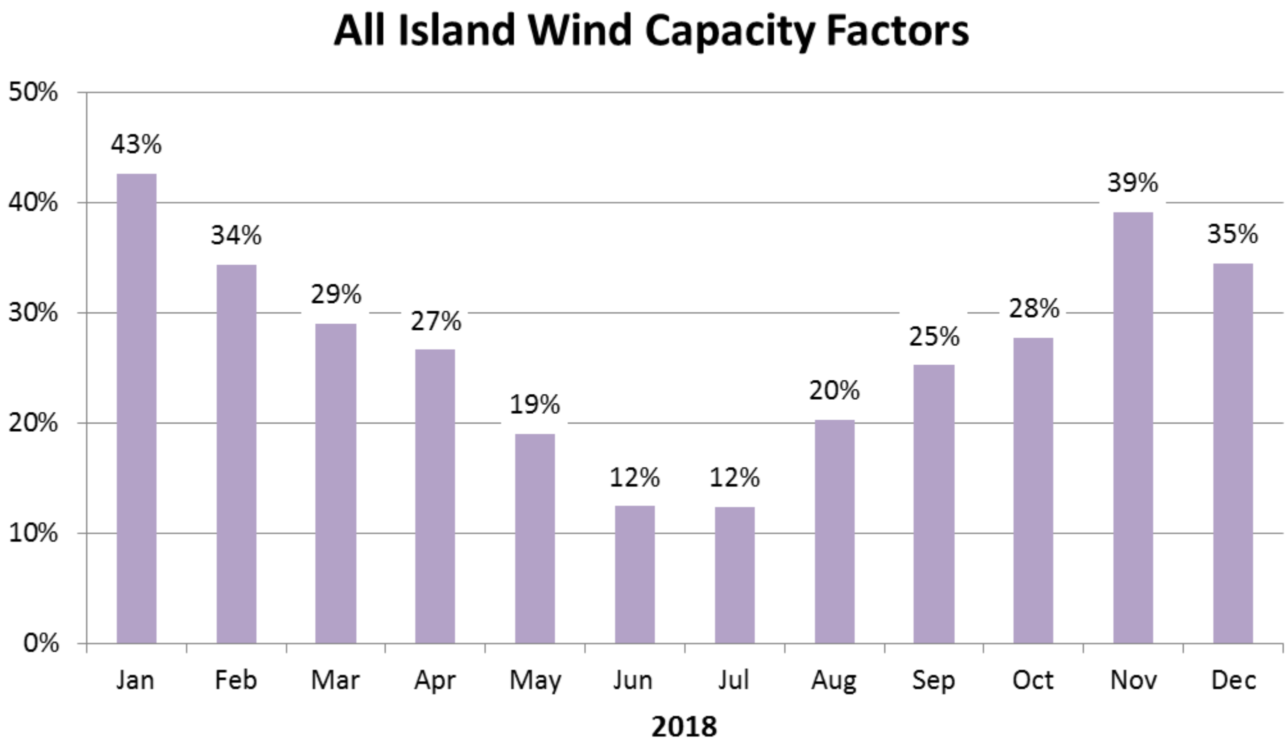

Figure 3: All-Island Monthly Wind Capacity Factors in 2018

3.2 Generation Portfolio and Outages in 2018

The main generator outages that may have affected dispatch-down are summarised below:

- TH2, TH3 and TH4 were all **unavailable for pumping** for approximately 3 weeks in June. This would have reduced system demand at night, potentially leading to extra wind curtailment, although wind was only high for a few days in the middle of the month.
- EWIC was on outage on a number of occasions in 2018, including most of March and the first two weeks of May. There were some periods of high wind during March, but the overall capacity factor was only 23%, so the outage should not have added significantly to dispatch down levels.

[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 indicative and based on real-time SCADA data.

There were a number of forced outages towards the end of the year, leading to tight generation margins in November and December, but this should not have had any impact on dispatch-down values.

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 2017, the all island demand based on metered data was 36.86 TWh. In 2018 the all island demand increased by 1% to 37.2 TWh, and so it would not be expected to impact significantly on dispatch-down levels.

3.4 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.

There have been no changes to Operational Policies related to wind dispatch-down since ISEM go-live in October 2018.

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[5] Variable Price Taker Generators (now called Controllable WindFarms in ISEM) 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

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

In Northern Ireland, the breakdown of wind dispatch-down volumes in 2018 between constraints and curtailments was 43% and 57% respectively.

In Ireland, the breakdown of wind dispatch-down volumes in 2018 between constraints and curtailments was 34% and 66% respectively.

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

Estimated Breakdown of Dispatch-down of Wind on the Island	2011	2012	2013	2014	2015	2016	2017	2018
Constraints	20%	38%	28%	35%	36%	48%	31%	37%
Curtailments	80%	62%	72%	65%	64%	52%	69%	63%

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 to 65% in

[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

April 2018. The ultimate aim of the DS3 programme is to increase this limit to 75% by 2020.

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 4, 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 7am) when compared to constraints because the demand is lower (Figure 4 is essentially the mirror image of the demand curve).

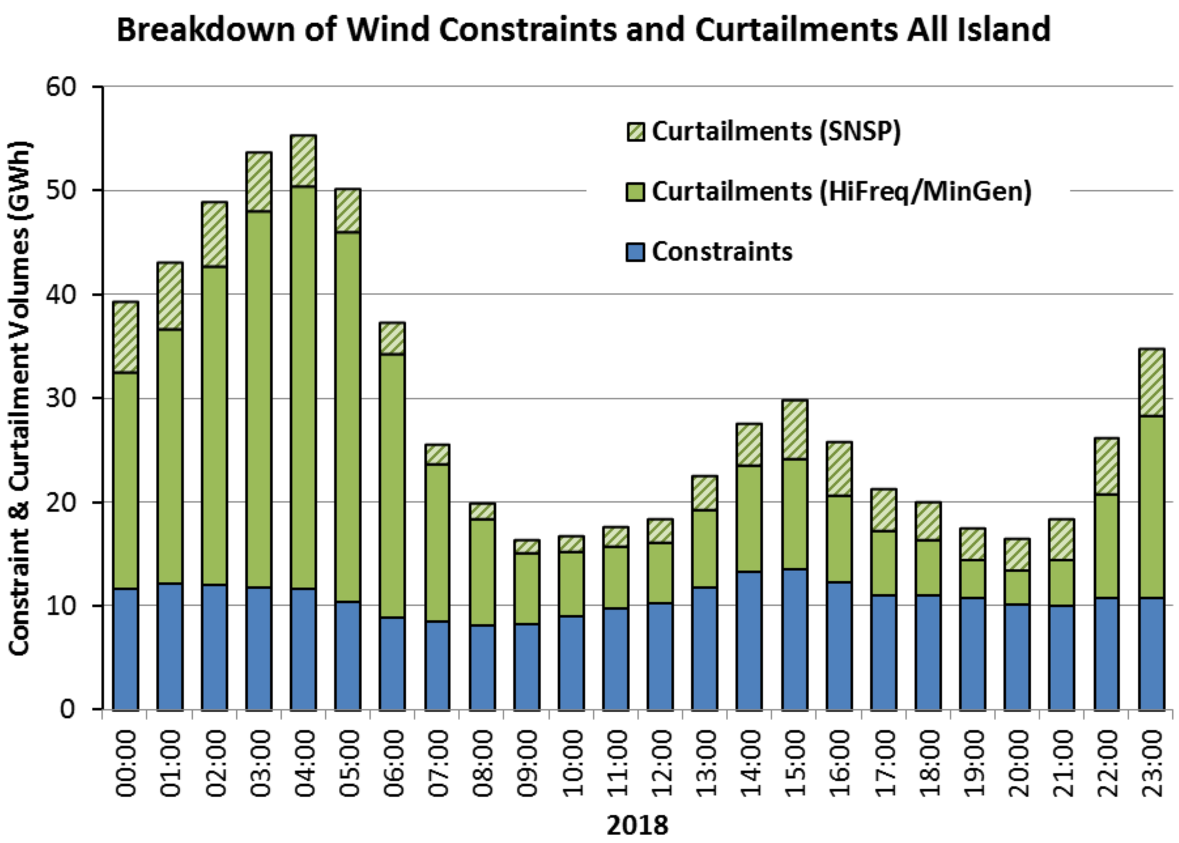


Figure 4: All-Island breakdown of wind constraints and curtailments in 2018 by hour of day

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 37% in 2018. This was due partly to an increase in installed wind generation but more significantly due to the transmission outages in 2018. Many of these outages were to facilitate the upgrading and uprating of the transmission system.

4.3 Wind Dispatch-Down by Region

The areas with the highest levels of wind dispatch-down (constraints and curtailment) in 2018 were Northern Ireland, the North West and South West of Ireland (Figure 5). The following are the main factors for high wind dispatch-down in these regions:

Northern Ireland:

In general, wind constraints are trending upwards in Northern Ireland due to the amount of wind on the Northern Ireland system relative to its size. At times there is no option but to constrain wind if all of the online conventional units are at minimum generation, while also managing the potential loss of the tie-line. The loss of the tie-line is flagged as a Northern Ireland constraint as opposed to curtailment, as it does not affect wind in Ireland, i.e. it's a local Northern Ireland issue.

In 2018, there were high transmission constraints in Northern Ireland for a combination of reasons. Quarter 3 saw high wind availability, particularly in September, but the loads in Northern Ireland remained low until after the clock change in October which resulted in increased constraints to protect against system separation (loss of the North-South Tie Line). There were also several significant transmission outages during Q3 which resulted in transmission constraints. This is to be expected during the outage season. There were outages of Magherakeel transformers, Tamnamore transformer and the Coolkeeragh-Magherafelt A circuit that all had an impact on transmission constraints.

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 North West and South West regions of Ireland. These areas have previously experienced the greatest level of restrictions for the export of wind.

North West(NW)

There is limited connectivity between Donegal / North West and the rest of the system, and any outages for maintenance or uprates can lead to significant constraints. In the Donegal region in 2018, there was significant works in Letterkenny 110kV station to help system security in the area. There were also works in Castlebar and Carrick-on-Shannon. The outage of Carrick-on-Shannon to Corderry / Arigna-T 110kV circuit, and the Arva to Carrick-on-Shannon 110kV circuit would have led to additional constraints of wind in the North West. In Donegal, the Binbane-Letterkenny 110kV circuit was out for several weeks, which would have led to increased constraints. In Mayo, the Bellacorick-Castlebar 110kV circuit was on outage from April to July, leading to increased constraints on the path out of Castlebar (to Sligo).

South West (SW)

During 2018, the programme of works in the South West involved the continuation of a number of capital projects to facilitate the export of wind from the area. These included the uprate of Kilpaddoge Knockanure 220 kV circuit, rerouting a number of 110 kV circuits into Kilpaddoge 110 kV station, and the transfer of Moneypoint – Oldstreet 400 kV circuit into a new 400 kV GIS station in Moneypoint. These outages may have driven some additional dispatch down of windfarms (of the order of 1%) in the South West, based on a comparison of the regions in Figure 5.

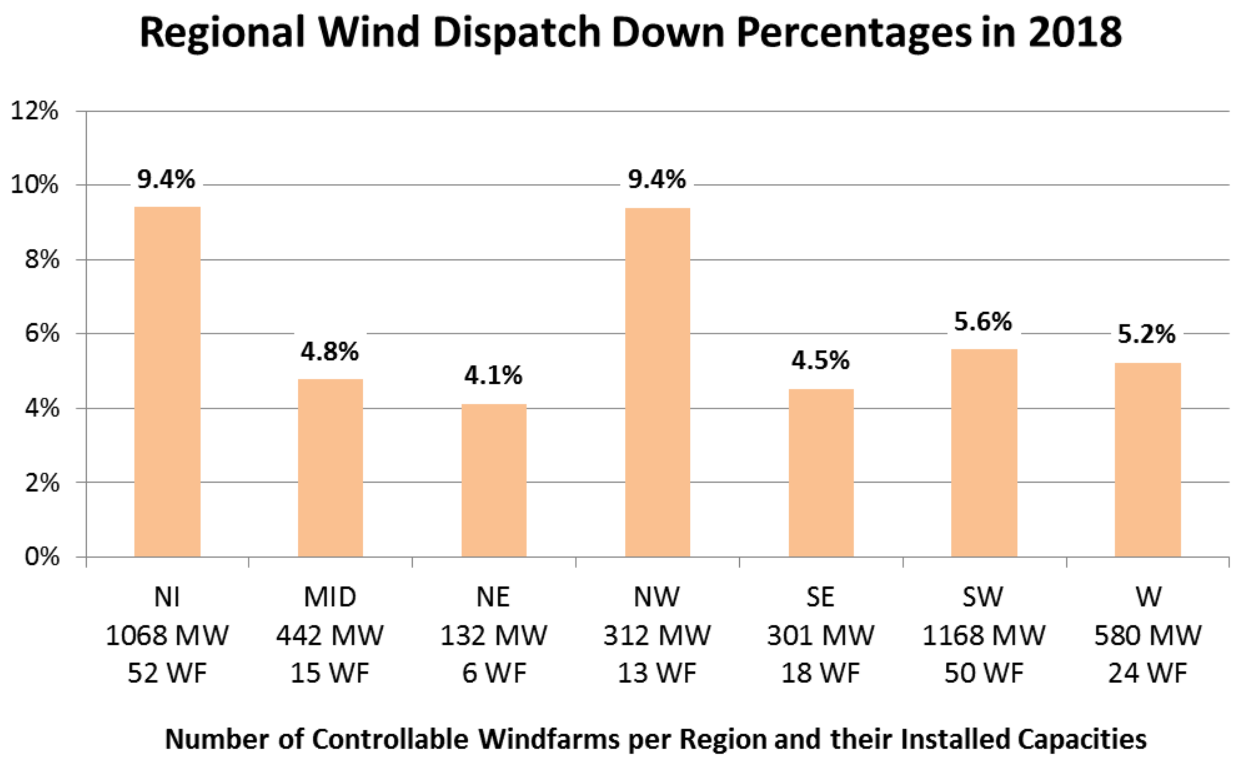


Figure 5: Regional Wind Dispatch-Down Percentages in 2018

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

5 Mitigation Measures

5.1 Operational Policy and the DS3 Programme

The fundamental issues that give rise to curtailment are outlined 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, and to 65% on a permanent basis in April 2018.

The EWIC export limit is 500 MW, but the Moyle export limit is dependent on system conditions in Scotland and can change daily. The firm export capacity on Moyle is 80MW, but this can be increased to 300MW in day-ahead market runs, depending on system conditions in Scotland.

5.2 Operational Policy – Interconnector Countertrading[13]

Following gate closure in the old SEM market (prior to October 2018), the TSOs could seek to change the flows on the Moyle and the East West Interconnectors for system security

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

reasons, or to facilitate priority dispatch generation (as directed in SEM Committee Decision paper SEM-11-062). These changes were made by countertrading 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 2018 up until the start of ISEM, 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 was not possible to differentiate after the fact whether the countertrading was for priority dispatch or for economic reasons.

Post-ISEM (October 2018 onwards), countertrading has not been used by the Control Centres, as it was decided it would be better to allow the new market bed-in without TSO interference. The flows on EWIC and Moyle are driven by price differentials between GB and the all-island system, and the consensus is that the market is getting the flows correct – high wind conditions (with corresponding low market prices in ISEM) generally lead to high exports on the Interconnectors, and vice-versa. In the future, countertrading will only be used to resolve system security issues, and thus is not expected to be used often.

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.

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 2018. 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/Minimum generation: 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

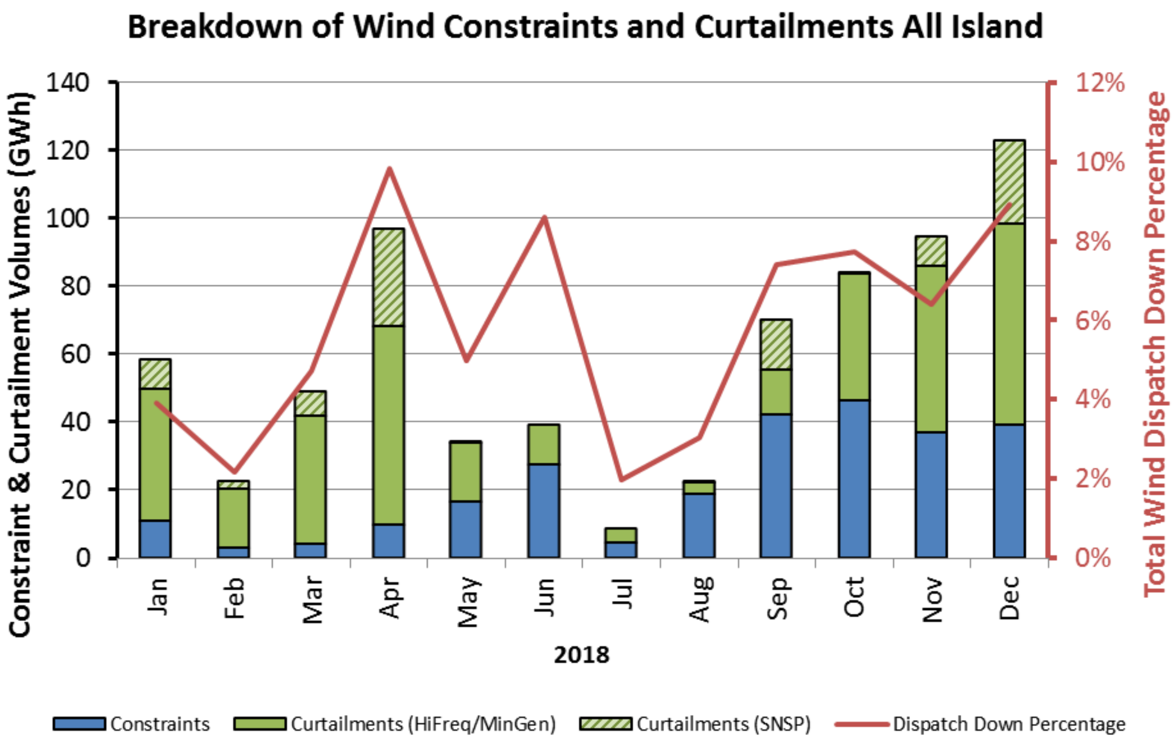
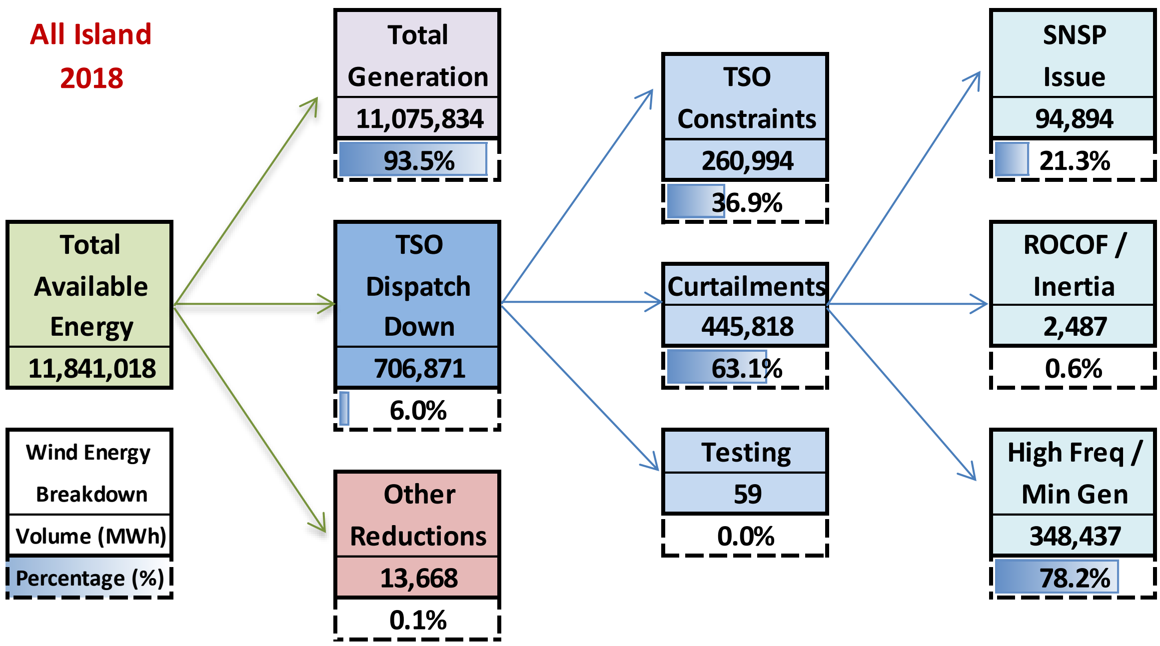


Figure 6: Monthly breakdown of all-island wind constraints and curtailments in 2018



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 7: Graphical representation of all-island wind dispatch-down categories in 2018

Ireland

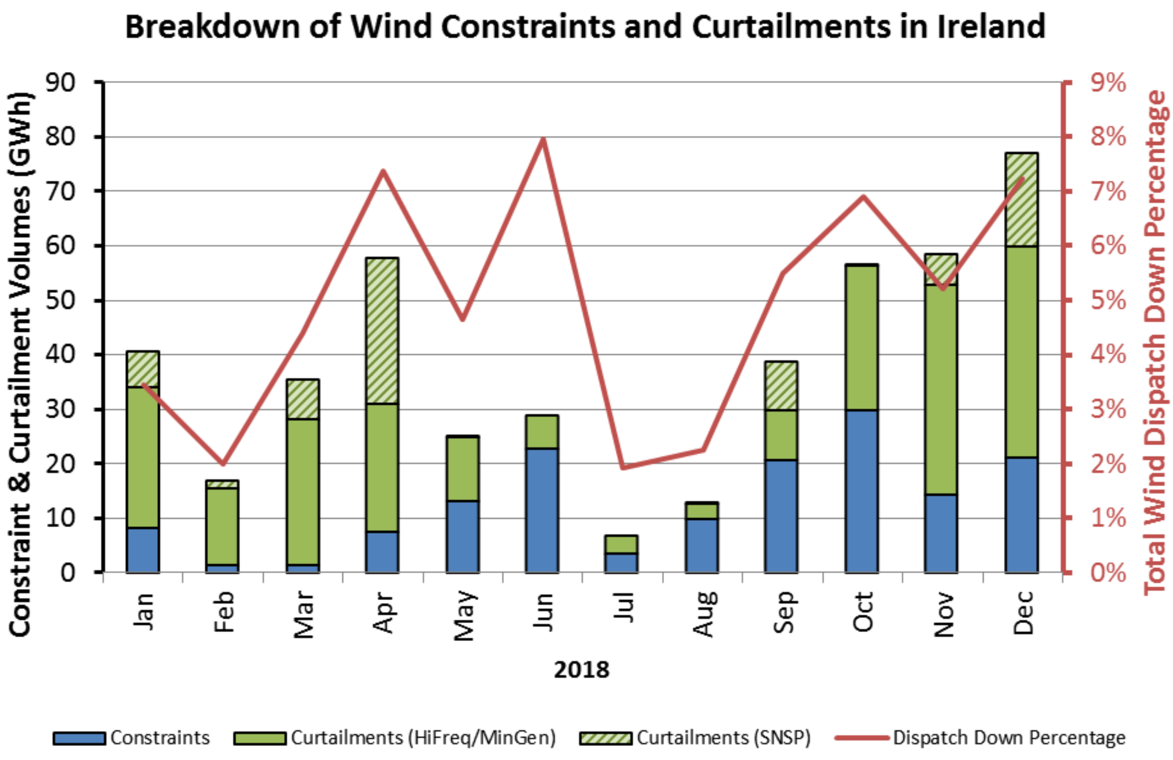
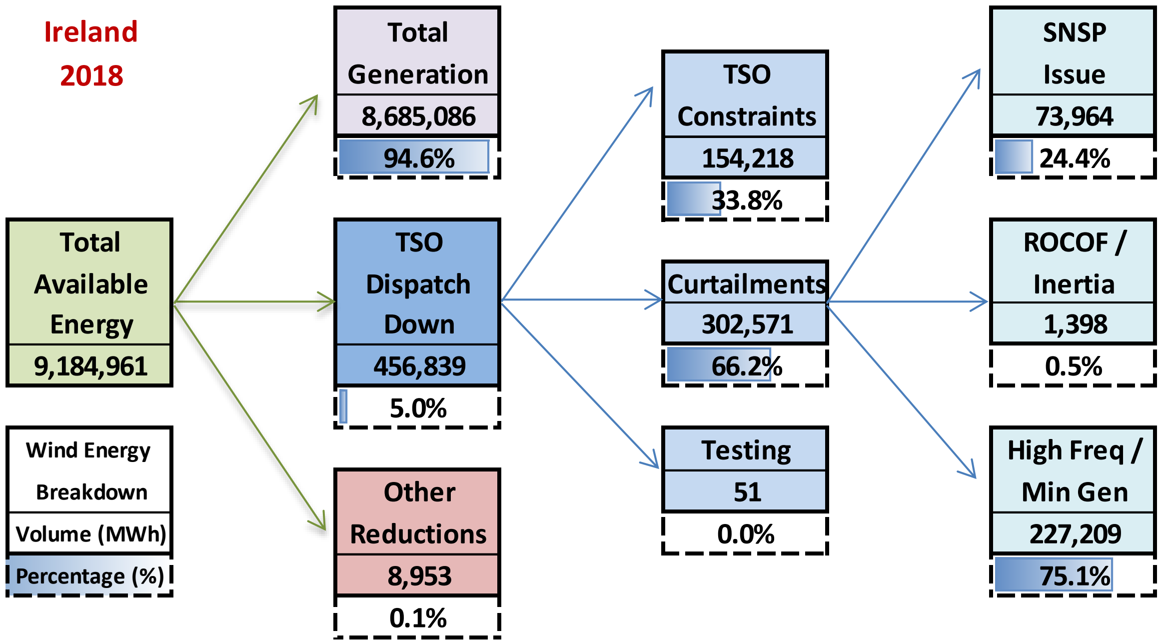


Figure 8: Monthly breakdown of the main wind dispatch-down categories in Ireland in 2018



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 9: Graphical representation of wind dispatch-down categories in Ireland in 2018

Northern Ireland

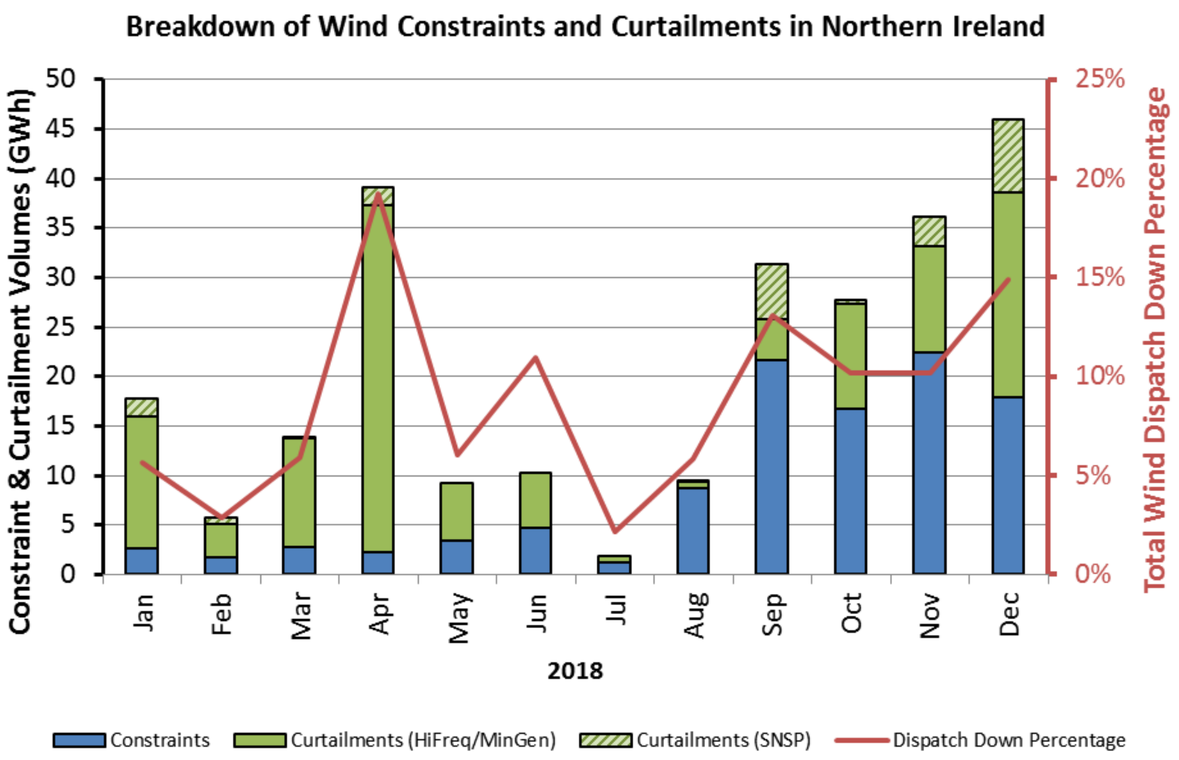
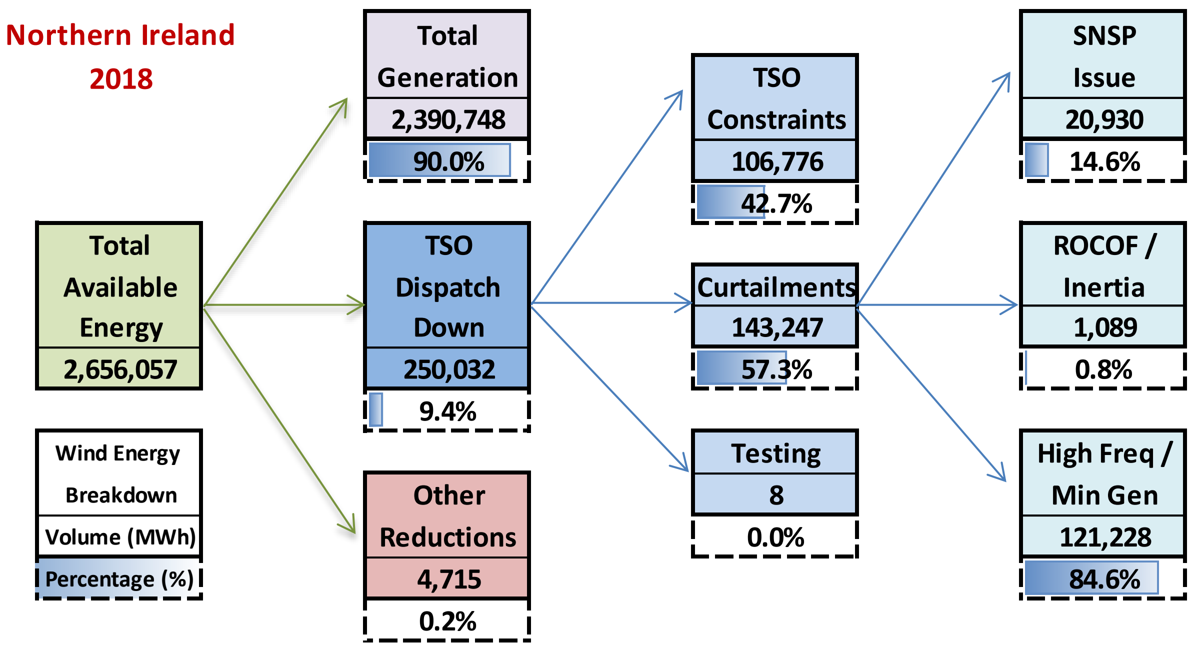


Figure 10: Monthly breakdown of wind dispatch-down categories in Northern Ireland in 2018



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 11: Graphical representation of Northern Ireland dispatch-down categories in 2018

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%
2018	9.4%	5.0%	6.0%

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
2018	250	457	707

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
2018	1,276	3,666	4,942

Year	All Island Estimated Wind Dispatch Breakdown	
	Constraints	Curtailment
2011	20%	80%
2012	38%	62%
2013	28%	72%
2014	35%	65%
2015	36%	64%
2016	48%	52%
2017	31%	69%
2018	37%	63%

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			2018		
Month	**NI**	**IE**	**AI**	**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%	5.7%	3.5%	3.9%
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%	2.9%	2.0%	2.2%
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%	5.9%	4.4%	4.7%
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%**	**4.9%**	**3.3%**	**3.6%**
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%	19.2%	7.4%	9.8%
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%	6.1%	4.7%	5.0%
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%	11.0%	8.0%	8.6%
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%**	**13.0%**	**6.6%**	**8.0%**
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%	2.1%	1.9%	2.0%
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%	5.8%	2.2%	3.0%
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%	4.2%	5.4%	5.1%	13.1%	5.5%	7.4%
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%**	**8.7%**	**3.6%**	**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%	14.6%	9.2%	10.6%	10.2%	6.9%	7.7%
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%	10.2%	5.2%	6.4%
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%	14.9%	7.2%	8.9%
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%**	**11.7%**	**6.4%**	**7.7%**
Year Total DD	**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%**	**9.4%**	**5.0%**	**6.0%**
Constraints	0.3%	0.5%	0.4%	0.3%	0.9%	0.8%	0.5%	1.0%	0.9%	1.0%	1.5%	1.4%	1.9%	1.8%	1.8%	1.3%	1.4%	1.4%	1.9%	1.0%	1.2%	4.0%	1.7%	2.2%
Curtailments	1.1%	2.0%	1.8%	0.4%	1.5%	1.3%	1.3%	2.5%	2.3%	1.8%	2.9%	2.6%	3.4%	3.3%	3.3%	1.9%	1.4%	1.5%	3.1%	2.6%	2.7%	5.4%	3.3%	3.8%
Wind Installed Capacity (MW)	512	1,585	2,097	600	1,703	2,303	640	1,923	2,563	729	2,266	2,996	751	2,447	3,198	943	2,779	3,722	1,154	3,314	4,467	1,276	3,666	4,942
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	2,391	8,685	11,076
Wind Capacity Factors	21%	31%	28%	21%	28%	27%	23%	29%	28%	24%	28%	27%	28%	32%	31%	23%	27%	26%	22%	27%	26%	22%	28%	27%
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			65% Perm from Apr		

Notes:

"Dispatch Down" consists of TSO constraints, curtailments 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 from 2016. Figures from previous years are best estimates.

Wind installed capacities, generation and capacity factors are indicative and based on the latest available information.

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 in times of extreme system events or during system testing.

For more infomration see annual and quarterly dispatch down reports.

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

Appendix C – Transmission System Map

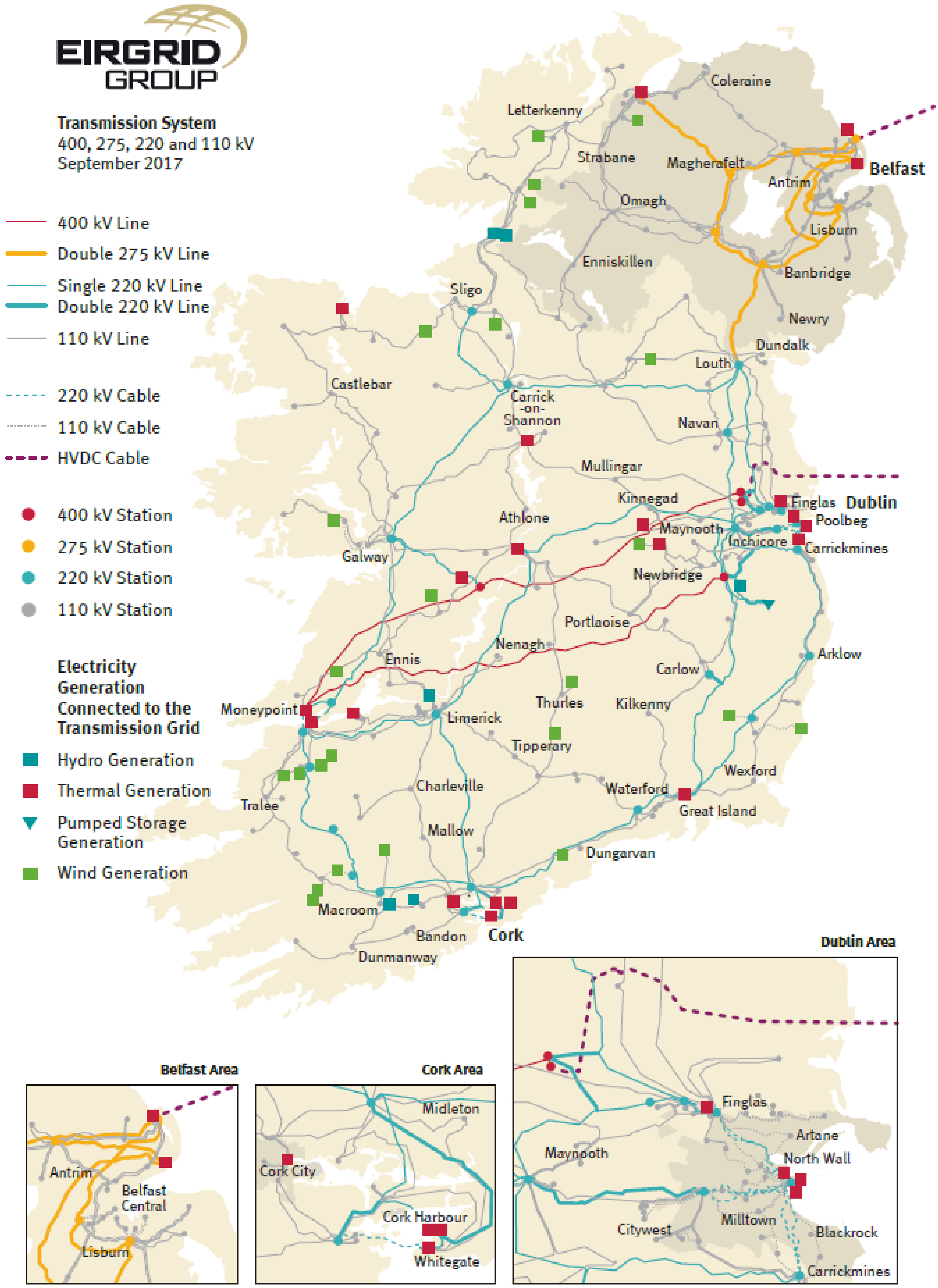


Figure 11: Transmission System Map

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
MID	Midlands (region)
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