Enduring Connection Policy 1

Constraints Report for Area C Solar and Wind

June 2020

Version 1.1

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DOCUMENT HISTORY

Version	Date	Comment
1.0	March 2020	Original release.
1.1	April 2020	Rerun of a number of study scenarios to accommodate the following updates. Note, studies for 2020 and 2021 have not been rerun. Special Protection Scheme included in Mayo. Some revised reinforcement delivery dates (ATR published) Introduce Industry Scenario for North West. Some minor adjustments to generator appendix (generator name changes, some generators whose offer has lapsed) Minor adjustment to reinforcement list (e.g. Athlone Shannonbridge uprate is complete).

TABLE OF CONTENTS

Document Structure

This document contains an Abbreviations and Terms section, an Executive Summary, five main sections, and three Appendices.

The structure of the document is as listed below.

A lot of this document describes study assumptions and methodology. For customers wishing to see the forecast constraints, please proceed to both Chapter 5 and Appendix C.

Additional Introduction to Revised Reports: presents the reasons for the revised reports and restates some future changes which could impact on outturn curtailment and constraint.

Chapter 1: Introduction: presents the purpose of the report and the definitions of curtailment and constraint.

Chapter 2: Study Overview: introduces the study areas, the study years and the generation scenarios. Together, these comprise the study scenarios.

Chapter 3: Study Input Assumptions: describes the study assumptions as they relate to network, demand, interconnection, priority dispatch, generation, system operation and DS3.

Chapter 4: Study Methodology: provides an overview of the software used and how the model is put together. A description of how constraint results are apportioned is also provided.

Chapter 5: Results for Area C: outlines the area covered by this report. The section provides a network diagram of the Area Cnd an overview of the results for Area C.

Appendix A: Network Reinforcements: lists the reinforcements that are included in the study for each study scenario. These reinforcements have a material impact on the resulting constraints.

Appendix B: Generator Details: provides both an overview of the generation, totals by generator category etc. It also provides a comprehensive list of the individual generators included in the study

Appendix C: Area C Node Results: provides a table of results for every node in the area. This table documents the installed MW, available energy, curtailment and constraint for every node in Area C.

The **Abbreviations and Terms** provide a list of the abbreviations and terms used in the document.

Additional Introduction to Revised Areas A, B and C Constraint Reports

Drivers for Update to Constraint Reports in North West

There are two main reasons why EirGrid is now releasing these updated versions of the ECP-1 Constraints Reports for Areas A, B and C. First, EirGrid has been working with a customer on a proposal for a special protection scheme in Mayo. This scheme is expected to help alleviate some local constraints. It is now appropriate to include this in the constraint assessment, and share the findings with other customers in the area.

Second, the original constraints reports for the north west had quite high levels of reported constraints. As a result, EirGrid engaged with industry representatives and it was agreed to perform an additional suite of studies for the north west. The reinforcements in these industry scenarios are selected by industry.

Because the reports in the north west are being reissued, the opportunity is now taken to include a number of additional adjustments.

A recent update on the EirGrid website of the Associated Transmission Reinforcement (ATR) resulted in revised delivery dates of some transmission reinforcements local to the north west. The change to this constraint report is that the Arva - Carrick on Shannon uprate is now introduced in “Future Grid” rather than in 2022, and Binbane – Cathaleen’s Fall uprate is introduced in “Gen Shallow”, rather than in 2021 Both are in the Industry scenario.

The connection arrangement for one ECP-1 generator changed from what was assumed in the original report. It is now to be connected into a new 110kV station, called Firlough, and not connected into the existing Glenree 110kV station. This changes the network arrangement only slightly.

Finally, the ECP-1 connection offers for a small number of generators have lapsed, and these generators are removed from this report. The generators in question are not in the north west. And there are some minor adjustments to the reinforcements listed. For example, the Athlone Shannonbridge uprate is now complete, and this project is removed from the list.

Important Note for Customers

The results presented in this report are based on the simulation and modelling assumptions described. This information is provided to help inform generation developers in decisions that they may make in terms of locating new generation in the future and such decisions are made in the knowledge that there are areas of high constraint currently that may well remain at high levels in the medium to longer term. The findings are indicative only and this report should in no way be read as a guarantee as to future levels of curtailment and constraint.

<u>Valid for these Study Assumptions</u>

EirGrid would like to remind customers that the results presented in these ECP-1 Constraint Reports are only valid for the study assumptions used in the analysis.

As such, there are a number of factors which could result in different levels of curtailment and constraint than are presented here. These include installed generation, reinforcement delivery, intact network, and other issues. While these aspects are covered already in the original constraint reports in Chapter 2 and Chapter 3, it is worth noting the more relevant ones again.

The following is a brief note on each.

<u>Installed Generation</u>

These studies cover the generators that will receive connection offers up to and including ECP-1. Some of these generators may not connect. On the other hand, Ireland has a key target of meeting 70% of electricity demand from renewable sources by 2030. This target is set out in the Government's Climate Action Plan, published in June 2019.

The 70% target means more renewable generators than are studied in this report. This will mean higher curtailment (unless measures to reduce curtailment are found), and depending on the location of the additional generators, higher constraints in some locations for existing and new generation.

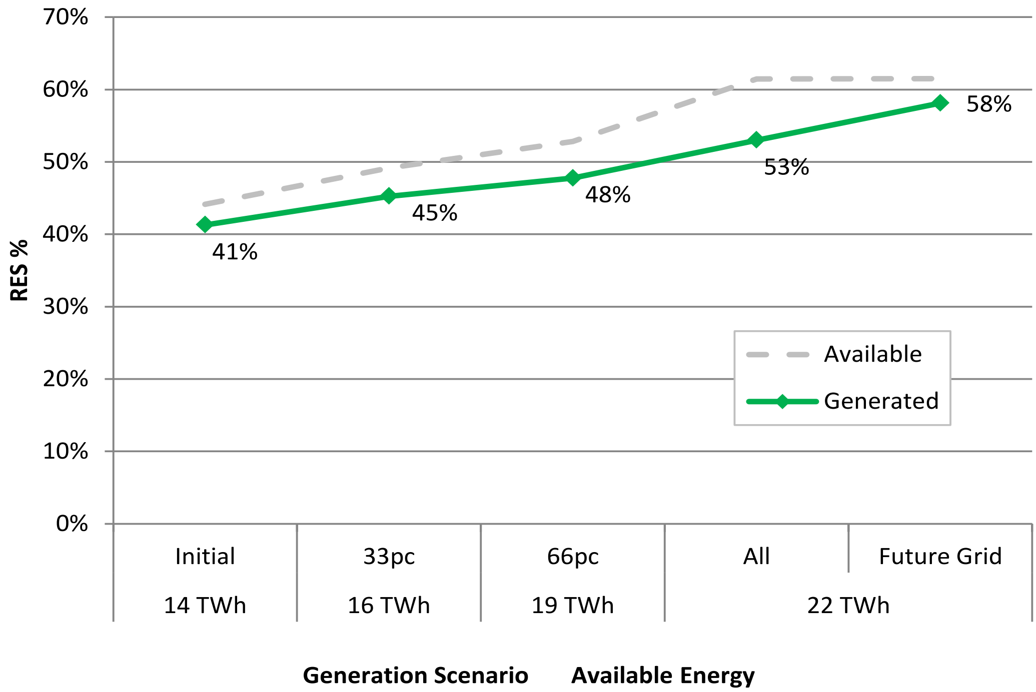


Figure 1 Renewable Percentage in these Constraint Reports

<u>Reinforcement Delivery</u>

The ECP-1 Constraint Reports use a significant number of presumed transmission reinforcements in the different scenarios.

It is important to note that these are not all capitally approved projects. Future reinforcements are subject to comprehensive technical, economic and environmental evaluation before they will be approved. Consequently, some of the reinforcements in this report may not be progressed.

After a project is approved, then a timeline for delivery can be scheduled. Project delivery is subject to a number of considerations including achieving planning permission in a challenging consenting environment, finding an appropriate outage slot to do the work in a congested workplan, challenges gaining access to land, etc.

These reports should not be interpreted as giving a commitment on project delivery dates, especially in the Industry and Future Grid scenarios.

Intact Network

A basic premise of this constraints analysis is that the existing network is available and that all the existing circuits are available to be in service. Given that every item of transmission equipment is expected to be available for the majority of its life, then this assumption is reasonable over the life of a solar or wind generator. However, in any given year, one transmission circuit or another may be unavailable for periods of time. This may be due to scheduled maintenance or a forced outage (e.g. transformer failure), or for reinforcement reasons on circuits (e.g. circuit uprate which requires the conductor and some towers to be replaced) or reinforcement in stations (e.g. outage for busbar upgrade).

As such, for any part of the network, there will be years when constraints may be higher than predicted in this report, due to outages of existing equipment. This is quite likely to happen in the north west where the possible reinforcements include a large number of uprates of existing overhead lines.

Constraints that Move Around

As studied, there are multiple transmission bottlenecks.

When one transmission bottleneck is removed, a generator that was on the right side of that bottleneck, can now find itself on the wrong side of a new bottleneck. In some cases, it can even find itself unlucky to become the most effective generator to constrain to manage the new bottleneck. Therefore, even though overall system wide constraints reduce, the constraints for this generator can increase. These local constraints can remain high until another (or several other) reinforcements are delivered. If and when a number of reinforcements are delivered, the constraints can reduce again.

At this point in time, neither the sequence of future generator connections nor the sequence of future reinforcements is known.

In this report, there are large numbers of reinforcements assumed between the 2022 study year and either the Industry Scenario or the Future Grid scenario. It is possible (though unlikely in most cases), that some unusual sequence of generator connection and reinforcement delivery could cause higher constraints in the middle years for some generators.

Other

EirGrid publish these reports to inform and to provide assistance to generator developers. A large number of study assumptions had to be made to perform these studies, and these assumptions were discussed with industry representatives. However, it is a fact that the power system continues to evolve. As such, it is likely that some of these input assumptions will be updated in the future.

These include, but are not limited to, the following.

As renewable generator technology continues to improve, the capacity factor of some solar and wind generators may be higher than is assumed in this analysis.

These constraint reports make an assumption about what fraction of interconnector capacity can be used to export spare renewable energy. As Britain (and France) continue to develop their own renewable generation, then this fraction may change. Interconnection brings benefits in curtailment, but the quantities assumed in this report will be reviewed for future studies.

In this analysis, the identification of which generators to constrain is not an exact match for the Wind

Dispatch Tool Constraint Groups used in real time system operation. An exact match is not possible because these reports are studying large numbers of future combinations of additional generation and network conditions.

The analysis in this report is based on a DC loadflow analysis. In the future, it is possible that losses, transient stability or voltage will affect constraints apportionment.

The modelling of batteries in this report is on the basis that they are for the provision of system services. It looks likely now that batteries will also be energy trading. This may (or may not) affect the apportionment of local network capacity, and may (or may not) impact on constraints.

The ongoing clarification process in relation to priority dispatch in the Clean Energy Package may (or may not) impact curtailment and constraints.

1 Introduction

1.1 Objective

It is a requirement of CRU's ECP-1 decision, CRU/18/058, that system operators carry out system studies to inform applicants about possible constraint levels. EirGrid has completed this requirement across twelve regional reports. This document collates that information into one single report. The purpose of this report is to provide future generation connection applicants with information on the possible levels of generation output reduction for a range of scenarios so the location of new projects can be made on an informed basis.

It presents the results of studies for a range of generation scenarios and these indicate the levels of transmission curtailment and constraint that solar and wind generation might experience in the future.

The curtailment and constraint results for Area C are included in Chapter 5 and in Appendix C.

1.2 Background

The background to this constraints report covers ongoing changes in generation, demand, network and DS3. All of these have an impact on the constraints evaluation.

More details of the study assumptions are provided in Section 3.

<u>Generation</u>

Since Gate 3, EirGrid has issued an additional 2 GW of connection offers under the Non-GPA (Non-Group Processing Approach) ruleset CER/09/099. In line with government policy and regulator direction, another 2 GW of connection offers have been issued, referred to as the Enduring Connection Policy (ECP).

It is not clear at this stage which of these generators will be successful in future renewable support auctions or may be successful through other funding mechanisms. It is therefore not clear which generators will build or when. This uncertainty has an impact on the approach to this constraint analysis. For this reason, this report uses multiple generation scenarios, so that generators can take a view on the range of curtailment and constraint for different generator build-outs.

<u>Demand</u>

Demand has been growing in Ireland for the past few years and demand has an impact on curtailment. Higher demand means lower curtailment. The system growth forecasts used are the median forecasts from the Generation Capacity Statement 2018.

<u>Network</u>

The analysis concentrates on 2020 to 2022 where the network development is reinforced with existing approved projects and where the predicted network is relatively certain.

<u>DS3</u>

The DS3 programme, led by EirGrid in co-operation with the electricity industry, is expected to continue to successfully deliver improvements in system operation and allow more wind and solar to generate more of the time. This includes improvements to SNSP, ROCOF, inertia and DS3 service provision. DS3 delivery assumptions are part of the study assumptions for this report.

1.3 Definition of Curtailment and Constraint

The terms 'curtailment' and 'constraint' are sometimes used interchangeably to refer to changes in the output of generators in order to maintain the operation of a safe, secure and reliable power system. For the purposes of this report, these terms are used to refer to changes in generator output under different specific circumstances.

EirGrid must dispatch generators in such a way as to provide a range of system services in order to operate a safe and secure electricity system. The types of system services required include the following:

- Frequency control,
- Provision of reserve,
- Voltage control,
- Load following,
- Ability to withstand disturbances,
- Inertia.

As these factors are not accounted for in the SEM, the system operators must deviate from the market schedule and change the output of generators in order to ensure that sufficient quantities of the system services outlined above are made available at all times. The real-time dispatch can change from the market schedule also because of demand and wind forecast errors and unexpected trippings of plant.

Curtailment

Most system services, such as frequency control and reserve, can be located anywhere on the transmission system, whereas services such as voltage control are location specific. Curtailment can arise at times when solar and wind generation levels are a high percentage of system demand as it may be necessary to reduce output from solar and wind powered generators in order to retain the necessary amount of conventional generation online to provide all the required system services. A main component of this is the limit on System Non Synchronous Penetration (SNSP). For the purposes of this report, we classify the changes in generator output which are required by EirGrid for system reasons as 'curtailment'.

Constraint

The output of generators may also need to be changed from the market schedule due to transmission network limitations, specifically the overloading of transmission lines, cables and transformers. This can happen for an intact network but typically occurs for network contingencies. In other words, a line may become overloaded if another line were to trip. In order to avoid this, generation is dispatched so that if the tripping were to occur there would not be any contingency overloads. Changes in generator output for this reason are referred to in this report as 'constraint'. The constraining of generation is location-specific and can be significantly reduced by transmission network reinforcements. The model accounts for N-1 contingencies which is the usual security criteria used for dispatching the power system. In other words the transmission system will be dispatched in such a way that any single contingency will not cause overloads, or will not exceed circuit short term overload capabilities.

Some transmission constraints might only exist temporarily due to transmission lines being taken out of service for maintenance or uprating. Maintenance is not covered in this report. Also, as the focus of this report is on levels of output reduction, the costs associated with constraints and curtailment are not covered here.

2 Overview

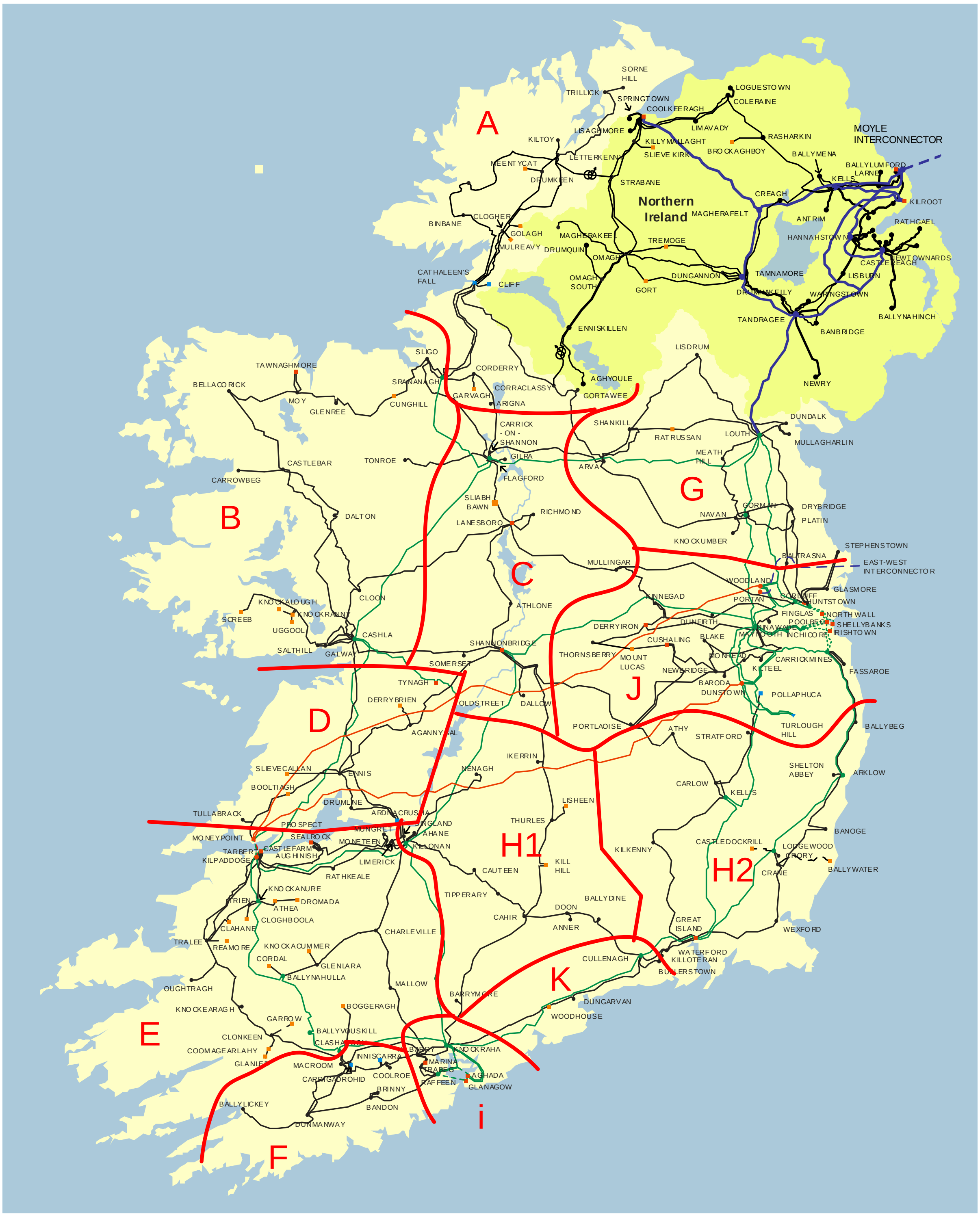


Figure 2-1 Areas Designated for Preparing Wind Energy Profiles, Generation Scenarios and Reporting Results

This chapter presents an overview of the curtailment and constraints assessment. A description is provided of the study scenarios, which in turn are a combination of generation scenarios and study years.

It provides an overview of the study areas. These are fundamental to understanding the contents of the individual area reports. It also provides an overview of the demand, generation and network assumptions that are used in the study. Taken together, this information provides an overview of this constraints analysis.

2.1 Study Areas

The areas shown in Figure 2-1 on the previous page are used for preparing wind energy profiles, for setting up generation scenarios and for reporting results. These areas are similar to those used for the Gate 3 constraints analysis.

2.2 Study Scenarios

The study scenarios are made up of a combination of generation scenarios with scenarios for network and demand. The scenarios cover multiple combinations of generation scenario and network-year scenario.

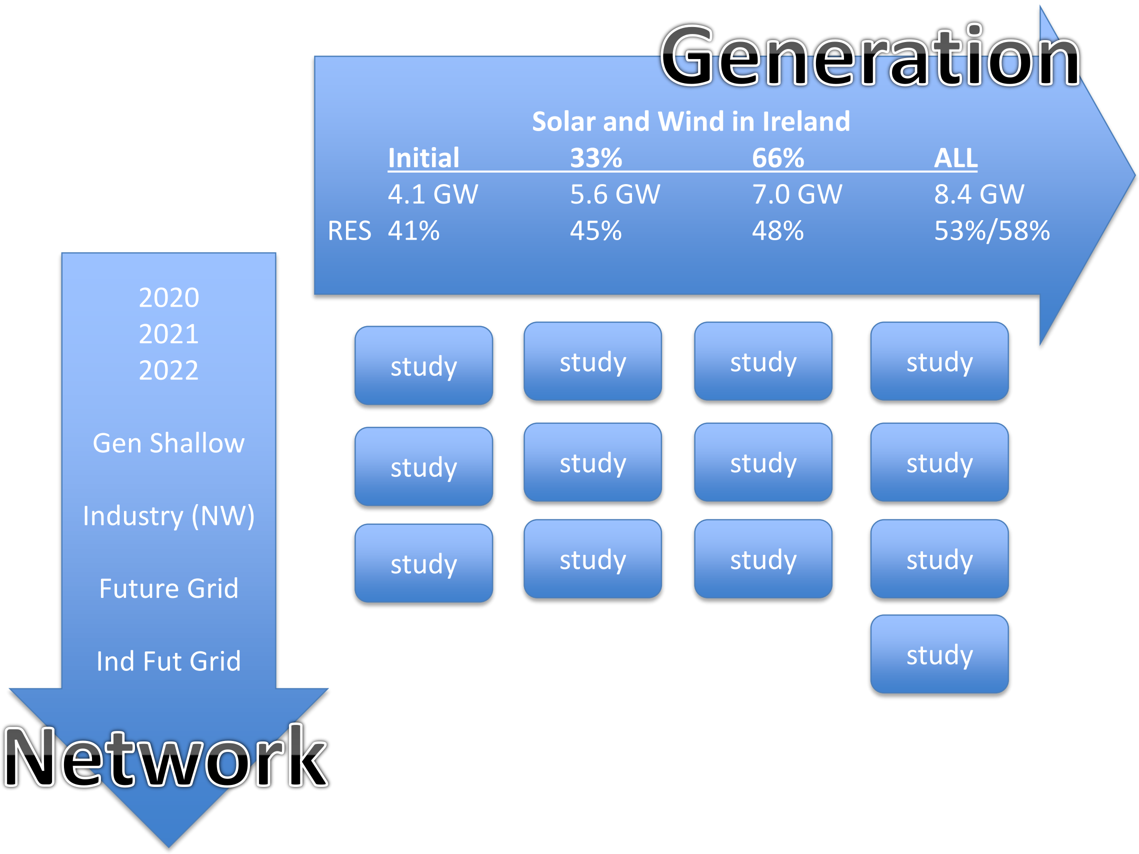


Figure 2-2 Study Scenarios: a Matrix of Generation Scenarios and Network Scenarios

The study scenarios are shown below.

Network and Demand			Generation Scenario					
	2020 March	Initial	North West	South	North East	33%	66%	All
2020	X	X	X	X	X	X	X	X
2021	X	X	X	X	X	X	X	X
2022	X	X	X	X	X	X	X	X
Gen Shallow								X
Industry	X	X	X			X	X	X
Future Grid								X
Industry Future Grid								X

Table 2-1 Study Scenarios (red are updated for this report). South and North East results are not shown in this report.

A description of the generation scenarios and the network and demand scenarios are provided below in Section 0 and Section 2.4 respectively.

Not all of the results from all of the generation scenarios are of interest to generators connecting in Area C. For this reason and in order that the presentation is not unnecessarily confusing, this report provides the results for a subset of the studies. As shown above and for Area C, the study results provided in this report are Initial, North West, 33%, 66% and All.

2.3 Generation Scenarios

The generation study scenarios originally ranged from an Initial scenario which was the generation expected to be in place in the year 2020 to an All Offers scenario which includes all the generators which will have connection offers at the end of ECP-1.

For the north west, at the time of writing, there is an approx. 50 MW difference in installed generation between what is presently installed in the north west and what was originally envisaged for the "initial" scenario. Consequently, for the north west, there is now included a "March 2020" scenario.

There are five middle scenarios. The first three middle scenarios are called North West, South and North East. In each case, these generation scenarios consider the possibility that all the generation with connection offers in their respective regions shown in Figure 2-3 is included in the study.

The other two middle scenarios are called 33% and 66%. The scenario called 33% includes all the generation in the initial scenario and 33% of the remaining generation. Likewise for 66%.

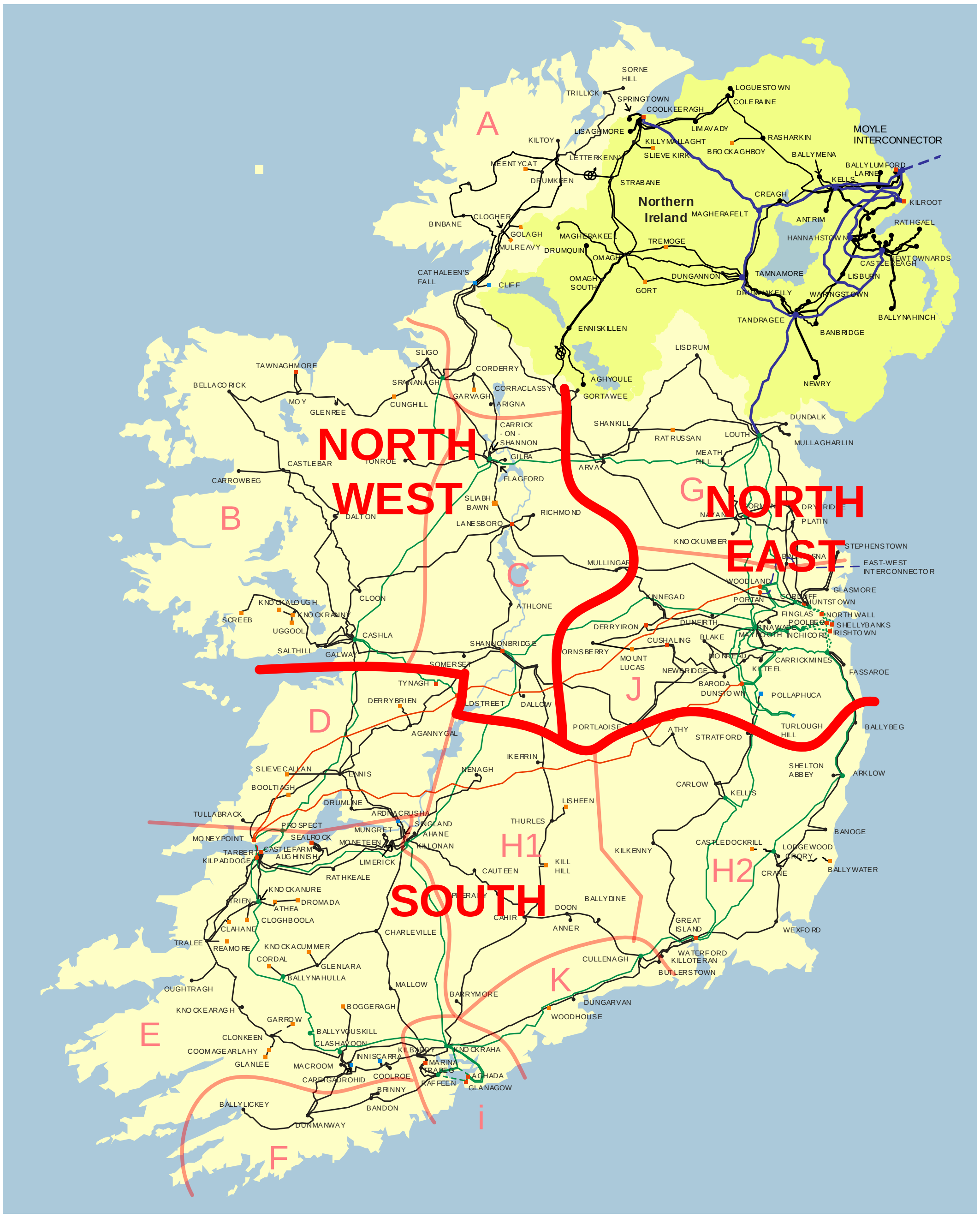


Figure 2-3 Generation Scenarios (North West, South and North East) - Geographic

As Area C is in the North West, there are five relevant generation scenarios for Area C. These are Initial, North West, 33%, 66% and All Offers. The results for these scenarios are provided in this report. For the other two scenarios, North East and South, there is no change in the installed generation in the North West or in Area C, compared to the Initial scenario. Hence, and to avoid unnecessarily complication of the presentation of results, the North East and South generation scenarios are not provided for Area C.

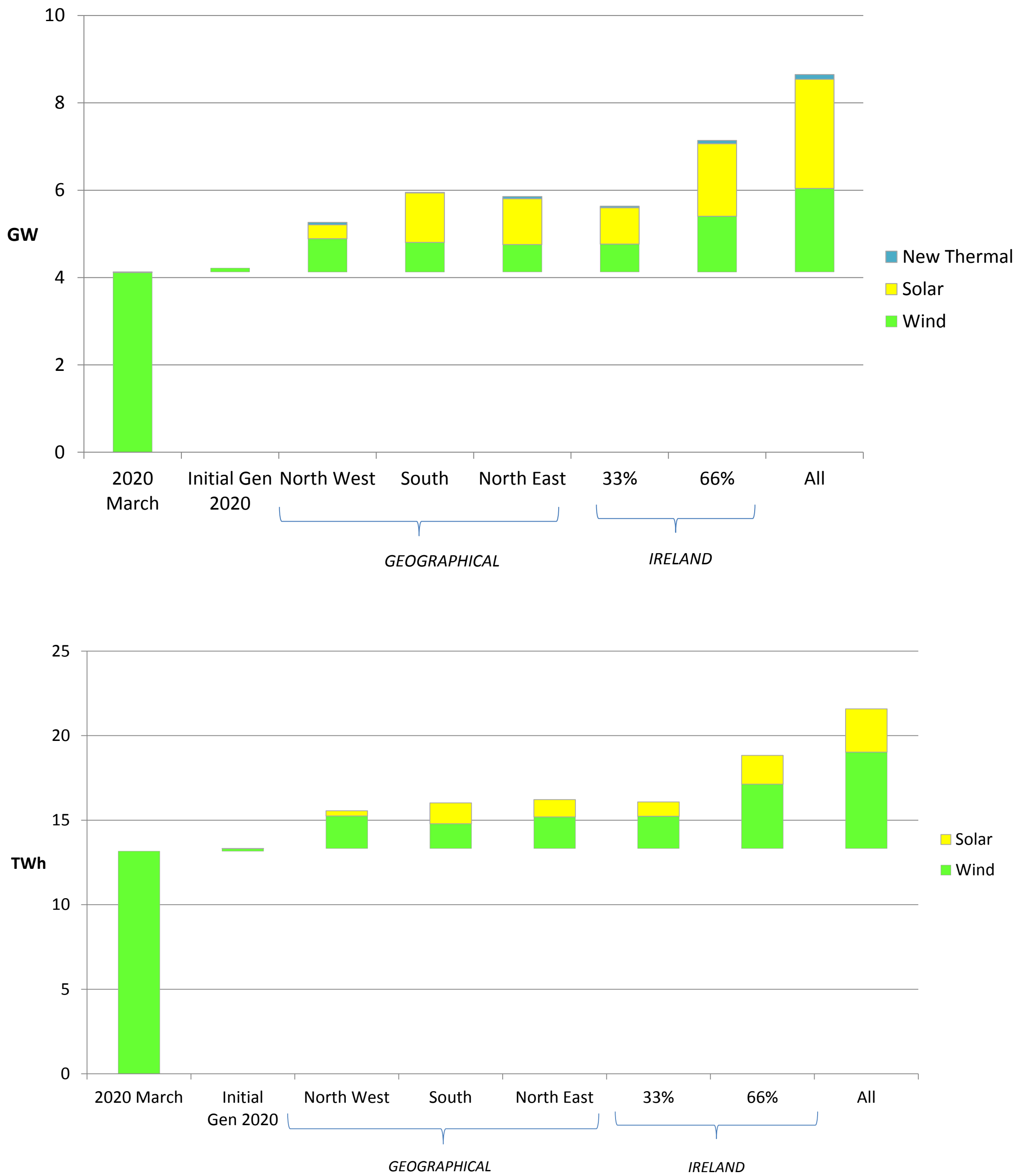


Figure 2-4 Generation Scenarios: Installed GW and Available Energy TWh

To repeat, the generation scenarios are as follows.

- For these revised North West reports, there is a "March 2020" scenario with the generation in the north west aligned with the installed generation.
- The Initial scenario has the generation scheduled predicted to be connected in 2020. There are no ECP-1 generators in this scenario.
- The North West scenario has all the residual Gate 3, the Non GPA and the ECP-1 generation connection applications in the North West in the study in addition to those generators in the Initial scenario.
- The South scenario has all the residual Gate 3, the Non GPA and the ECP-1 generation connection applications in the South in the study in addition to those generators in the Initial scenario.
- The North West scenario has all the residual Gate 3, the Non GPA and the ECP-1 generation connection applications in the North West in the study in addition to those generators in the Initial scenario.
- The 33% scenario is 33% of the way between the Initial scenario and the All scenario.
- The 66% scenario is 66% of the way between the Initial scenario and the All scenario.
- The All scenario has all the Gate 3, the Non GPA and the ECP-1 generation connection applications in the study.

And in this report, the results for Area C are presented for the generation scenarios called Initial, North West, 33%, 66% and All Offers.

The quantities of generation in the generation scenarios are summarised in Figure 2-4 and in Table 2-2.

	Generation Scenario						
	Initial	North West	South	North East	33%	66%	All
Battery	0.0	0.3	0.1	0.2	0.2	0.4	0.6
Solar	0.0	0.3	1.1	1.1	0.8	1.7	2.5
New Thermal	0.02	0.1	0.06	0.1	0.1	0.1	0.2
Wind	4.2	4.7	4.9	4.8	4.8	5.3	6.1
Total	**4.3**	**5.4**	**6.2**	**6.1**	**6.0**	**7.6**	**9.3**

Table 2-2 Generation Scenarios: by Type – Installed GW

2.3.1 Connection Works and Generators

In the north west of the network, there is 220 MW of generation that is not permitted to connect until certain wider system works are complete. These works will not be in place by 2022, and so, the works are not included in the 2022 study. Consequently, the generators that need these works are also not included in the 2022 study. In the connection contract, these are included in the Site Related Connection Equipment, and are sometimes referred to as "shallow reinforcements".

See table below.

Shallow Works	Quantity of Generation
Galway New 110kV Station	30 MW
Uprate Binbane – Cathaleen's Fall 110	30 MW
North Connaught Reinforcement Of which approx. 50 MW must also wait for Uprate of Glenree Moy 110 circuit.	160 MW
	TOTAL: 220 MW

Table 2-3 Shallow Works and Quantities of Generation

Because this generation is not permitted to connect before these works are complete they are not included in the 2020, 2021 and 2022 network studies.

An additional study called Gen Shallow is performed with these works and with the generation that can connect after they are delivered. This study is otherwise similar to study "2022 All".

2.4 Study Year (Demand and Network) and Future Grid

Network and Demand	Demand TWh
2020	32.2
2021	33.8
2022	36.2
Gen Shallow	36.2
Industry	36.2
Future Grid	36.2
Industry Future Grid	36.2

Generation Scenario	Available Energy from Solar and Wind TWh
March 2020	13.2
Initial	13.3
North West	15.1
South	15.9
North East	15.8
33%	14.9
66%	16.5
All	18.1

Table 2-4 Annual Demand (TWh) from Generation Capacity Statement 2018 and, for comparison, the Available Energy (TWh) from Solar and Wind

The study years are chosen to achieve a balance between expected progress in the medium term (predicted DS3 improvements, transmission reinforcements and forecast demand increase) and focusing on the near time to remain realistic and accurate.

This is achieved by studying the years 2020, 2021 and 2022.

In consulting with industry in advance of this review, there was a request for an additional study which could show the combined impact of a moderate number of additional projects that are due to be delivered beyond 2022. Hence, there is a Future Grid scenario. This adds a number of major projects to the 2022 Year. These are North-South 400 kV, Celtic interconnector, Greenlink interconnector, series compensation of the 400 kV network, Project 966, North Connaught 110 kV, major DS3 improvements and several 110 kV uprates. The transmission reinforcements and DS3 initiatives included in the study years are listed in the appendix to this report. The Future Grid scenario uses the 2022 demand.

The demand forecast used is the median forecast from EirGrid's Generation Capacity Statement 2018-2027.

It is worth comparing the annual available energy (TWh) from solar and wind for the different studies with the system demand (TWh). This information is provided above in Table 2-4.

3 Study Input Assumptions

This chapter provides an overview of the input assumptions for the curtailment and constraint modelling. The sections below deal with the assumptions for Network, Study Areas, Demand, Interconnection, Generation, Energy Storage and System Operation.

3.1 Notable Study Assumptions

The following study assumptions are worth noting.

3.1.1 Valid for these Generation Assumptions

The forecast curtailment and constraint in this report is valid for the generation assumptions used in the studies.

3.1.2 Data Freeze

The data freeze for the input assumptions for this analysis was in early 2019. As a result, there may be some developments with the electricity network that are not included here.

3.1.3 Network outages for maintenance and reinforcement

The studies for this report assume an intact network. In other words, there are no network outages in the study. Because transmission equipment is usually in service, this assumption is reasonable when working to provide an average view of expected curtailment and constraint.

However, in order to refurbish or uprate transmission circuits and transmission stations, there is often the need for the circuits or stations to be uprated. This could result in wind and solar generation temporarily seeing higher constraints during these outages.

3.1.4 Network Requirement for Batteries and Conventional Generators

To date, those Batteries are applying for connection to participate in DS3 system services. They have indicated that they typically have an energy storage capacity of less than 30 minutes. Therefore, the expectation is that they will be contracting with DS3 services for reserve provision. As such, these batteries are expected to usually remain at zero output for the majority of the time and only provide energy when required. Hence, the study assumption for this report is that our methodology does not check for N-1 compliance for the battery generating or charging coincident with high levels of wind and solar.

The situation with conventional generation is similar. For conventional generation, the dispatch is primarily economic in nature. As such, the software only runs those relatively expensive conventional generators infrequently in the simulation.

In summary, the model does not assume that batteries and peaker generators are running at the same time as solar and wind is generating.

For this constraints report, this assumption is reasonable. However, in the future, if batteries were to require more running, and / or if a future operation of the system was to require prolonged running of peaker generators, or that some network capacity be explicitly reserved for peaker generators, then this constraints analysis would need to be revised.

3.1.5 Priority Dispatch for Renewable Generation Connecting After July 2019

A recent regulation has issued from the EU in relation to the treatment of priority dispatch of renewable generation over 400 kW connecting post 4th July 2019.

The relevant clause is as follows:

> *REGULATION (EU) 2019/943 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 June 2019 on the internal market for electricity*
>
> https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0943&from=EN
>
> *Article 12 (6)*
>
> *Without prejudice to contracts concluded before 4 July 2019, power-generating facilities that use renewable energy sources or high-efficiency cogeneration and were commissioned before 4 July 2019 and, when commissioned, were subject to priority dispatch under Article 15(5) of Directive 2012/27/EU or Article 16(2) of Directive 2009/28/EC of the European Parliament and of the Council (20) shall continue to benefit from priority dispatch. Priority dispatch shall no longer apply to such power-generating facilities from the date on which the power-generating facility becomes subject to significant modifications, which shall be deemed to be the case at least where a new connection agreement is required or where the generation capacity of the power-generating facility is increased.*

At the time of writing, the consequences, and exact details of implementation of this decision, have yet to be fully understood.

For this report, there is no differentiation made in the studies between renewable generation connecting pre-July 2019 and post-July 2019.

3.2 Network

3.2.1 Transmission Network

This section details the modelling assumptions used in this study for the transmission network. A list of the network reinforcements used in the model is provided in Appendix A.

The Irish transmission system is a meshed network with voltage levels at 400 kV, 275 kV, 220 kV and 110 kV. The distribution system typically has a radial topography with voltage levels at 110 kV in the Dublin region, and 38 kV, 20 kV, 10 kV and low voltage nationwide. The network is necessary to allow bulk power flows to be transported over long distances from power stations and renewable generation sites to the towns and cities in Ireland.

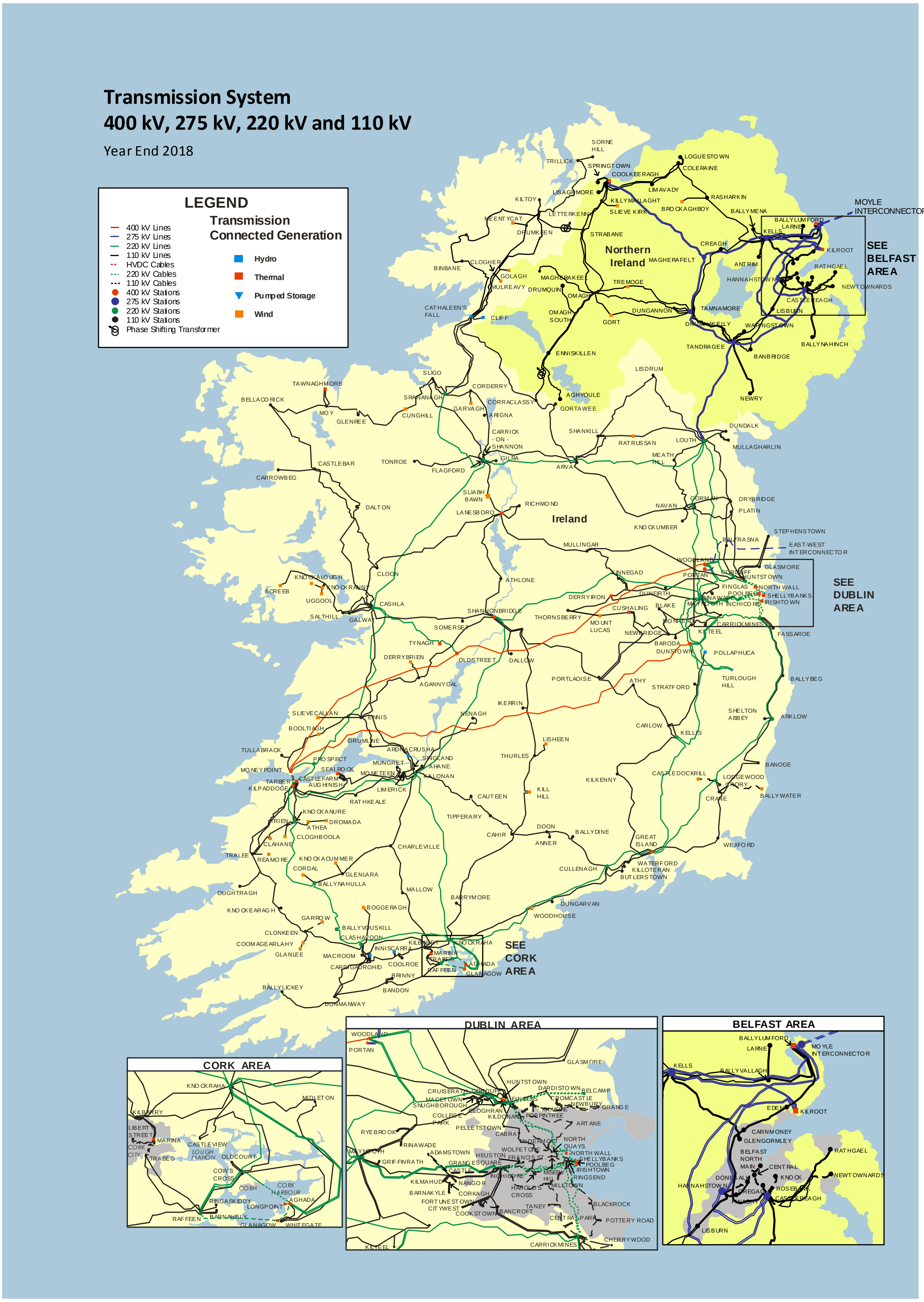


Figure 3-1 Ireland transmission network (2019)

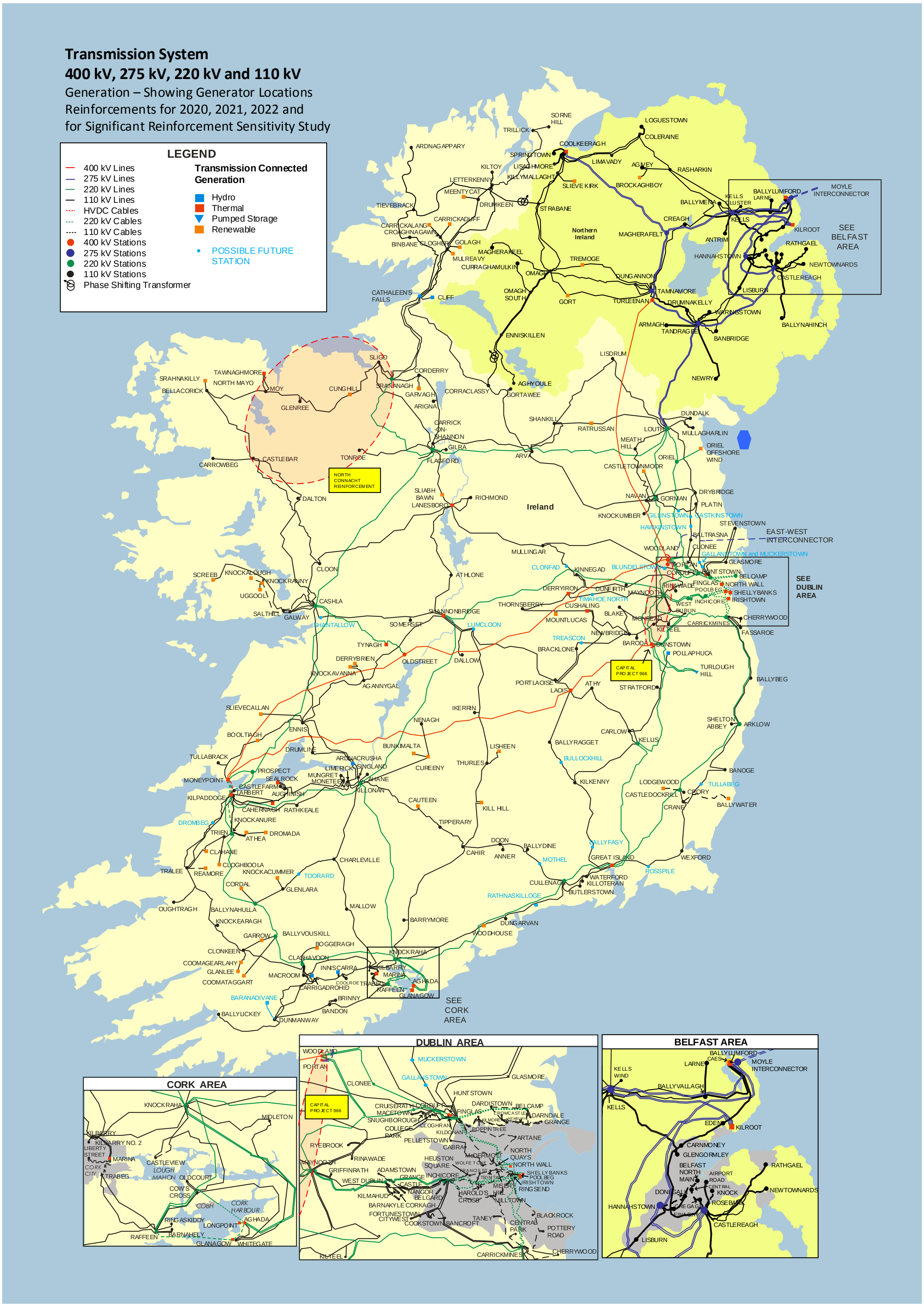


Figure 3-2 Ireland transmission network, showing assumed future generator locations and future projects.

As the transmission system operator (TSO), EirGrid is tasked with operating the transmission system in a safe, secure, economic, efficient and reliable manner. EirGrid are also responsible for planning the network of the future.

Currently, there are new renewable generation connections being planned to enable the increase in electrical power consumption to be derived from renewable energy sources, i.e. wind power and solar power whilst reducing the dependence on conventional generation.

The purpose of this technical study is to provide the probable levels of transmission network constraint across the study period 2020-2022. The level of network constraint will be due to a number of reasons:

- Scenarios of varying levels of installed generation, ranging from the installed generation connected in 2020 up to the installed generation including all connection offers.
- The climatic year, i.e. the level of sunshine or wind speed for that year.
- The expected network development plans.
- The network contingencies that cause other lines to overload in the event of the fault on a section of the network.

Figure 3-1 shows the existing Ireland transmission network. Figure 3-2 shows the location of the future generator connections and shows a number of the future large projects that are included in the Future Grid scenario.

3.2.2 Distribution System

For the purposes of the constraints modelling, a simplified representation of the distribution system is used whereby all load and generation is assumed to be aggregated to the nearest transmission node.

Hence, this report does not account for the impact of constraints (if any) on the distribution network.

3.2.3 Ratings and Overload Ratings

In formulating an optimum dispatch system operation takes account of potential overloads that could be caused as a result of certain N-1 contingencies on the transmission system. When determining if the post-contingency flows are within limits, the system operator uses the overload rating of the apparatus or plant (for N-1) as well as the normal rating (for N flows). Where available, the overload rating is typically higher than the normal rating but is only allowed in emergency conditions and for short periods of time. The overload rating is plant specific.

This rating and overload rating is handled in Plexos.

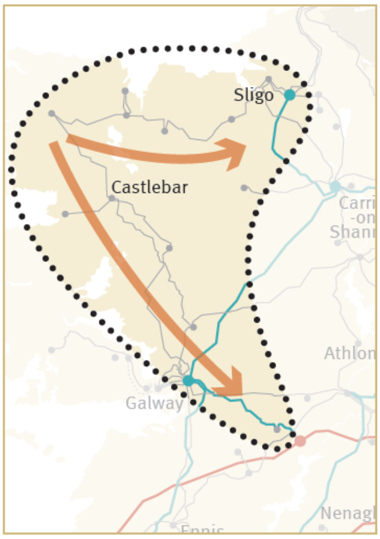
3.2.4 Transmission Reinforcements

For each study year from 2020 through 2022, a number of transmission reinforcements are added to the model. These additional transmission reinforcements include Overhead Line (OHL) and cable uprating as well as new build OHLs, cables and transformers.

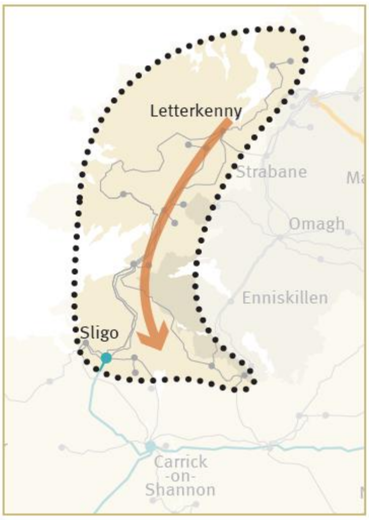
A full list of the transmission reinforcements (new build and uprates) assumed in the constraints modelling is included in Appendix A.

Area 1 – Dublin

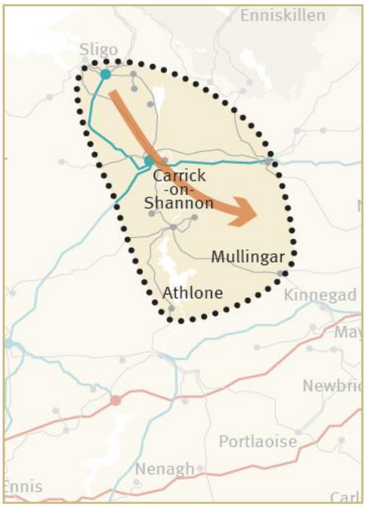
Area 2 – West



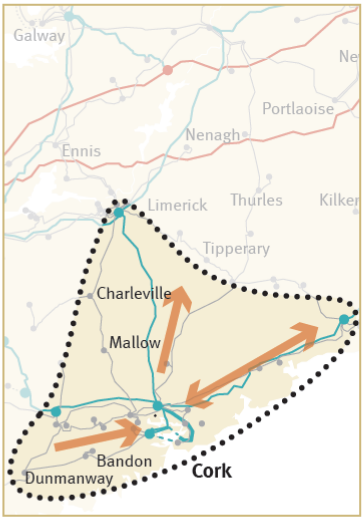
Area 3 – North-West Border



Area 4 – Midlands



Area 5 – South-West to South-East



Area 6 – South-East

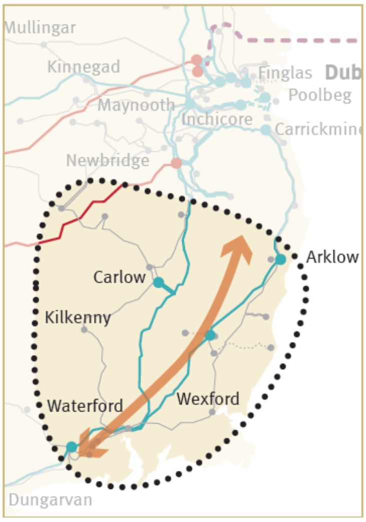


Figure 3-3 Tomorrow's Energy Scenarios (TES) System Needs Assessment"

Customers should recognise that the reinforcements listed will be subject to a full economic analysis and optimisation process before a decision is made to proceed with them. This analysis takes into account the latest demand forecasts and the level of acceptance and subsequent progress of generator connection offers. Inclusion of transmission reinforcement projects in this report is not confirmation that they will proceed and other projects may be selected in their place. For the avoidance of doubt, any party making a decision based on this list should recognise that these are modelling assumptions only and should not be considered as a basis in fact.

Additional information about these reinforcements is available on the EirGrid website.

3.2.5 Network Capability

In 2018, EirGrid published "Tomorrow's Energy Scenarios (TES) System Needs Assessment".

That report looks at the future network in the study years 2025, 2030 and 2040. This report identifies six areas of the network where there is a potential need for Grid Reinforcement. These areas are shown in Figure 3-3.

This ECP constraint report encounters transmission constraints in similar locations as those that are listed in the TES report.

This ECP constraint report has constraints in other locations as well. These arise in two ways. The first is where a forthcoming reinforcement is included in the TES but is not included here. This happens when the reinforcement is due for completion after 2022 (the cut off for this report) but before 2025 (TES Study Year). There are several examples of this but a notable one is the Galway 110 kV busbar reinforcement. The second is where there are new ECP generator connection applications that were not in the TES.

It is a feature of power flows in Ireland, after local demand is met, that the extra power needs to be transported to the East. This is to meet the Dublin load and to supply export markets via EWIC.

From a constraints point of view, some generator locations are relatively disadvantaged because their power has to cross several of the areas shown in Figure 3-3. The impact of this will be seen on the constraint levels in some study areas.

3.3 Demand

An introduction to the demand used in this report is provided in Chapter 2.

	TER (TWh)			Transmission Winter Peak (GW)		
Year	Ireland	Northern Ireland	All-Island	Ireland	Northern Ireland	All-Island
2020	32.2	9.2	41.4	5.5	1.7	7.2
2021	33.8	9.2	43.0	5.7	1.7	7.3
2022	36.2	9.3	45.5	6.0	1.8	7.7

Table 3-1 Forecast Demand and Peak for study years 2020-2022

The demand profiles for both Ireland and Northern Ireland are based on their actual 2015 demand profiles. This is the same year as used for the wind profiles. These are then adjusted to get an annual winter peak and energy value as per the median demand in the Generation Capacity Statement 2018-2027. The values used are shown in Table 3-1.

The nodal distribution of the load used in the constraints modelling is consistent with the "All Island Transmission Forecast Statement 2017".

3.4 Interconnection

Existing Interconnection on the island consists of a tie line between Ireland and Northern Ireland plus two High Voltage Direct Current (HVDC) interconnectors to Great Britain (GB) referred to as the Moyle Interconnector and the East-West Interconnector (EWIC). This section describes the assumptions and modelling methodology used for interconnection in these studies.

For all the model scenarios, the interconnectors are set up to export wind that would otherwise be curtailed, subject to the provisions of the SNSP rule and available interconnector capacity.

3.4.1 North–South Tie Line

The connection of Ireland's power system to Northern Ireland is achieved via a double circuit 275 kV line running from Louth to Tandragee. In addition to the main 275 kV double circuit; there are two 110 kV connections, one between Letterkenny in Co. Donegal and Strabane in Co. Tyrone, and the other between Corraclassy in Co. Cavan and Enniskillen in Co. Fermanagh.

The purpose of these 110 kV circuits is to provide support to either transmission system for certain conditions or in the event of an unexpected circuit outage. Phase shifting transformers in Strabane and Enniskillen are used to control the power flow under normal conditions.

It is assumed that the Letterkenny-Strabane and Corraclassy-Enniskillen 110 kV connections are not used to transfer power between the two control areas for the purposes of this constraint modelling exercise.

EirGrid is currently developing a 400 kV North-South Interconnector between Woodland and Turleenan, which for the purposes of these studies is assumed to connect in 2023.

Prior to the 400 kV North-South Interconnector being built, the existing Louth-Tandragee Interconnector is assumed to be limited. The assumption in this study is that flow are limited to 300 MW from South to North and 300 MW from North to South. When the 400 kV North-South Interconnector is in place, this limitation will be effectively removed.

3.4.2 Moyle Interconnector

The Moyle Interconnector, which went into commercial operation in 2002, connects the electricity grids of Northern Ireland and Great Britain between Ballylumford and Auchencrosh in Scotland. It has a capacity of 500 MW however; it can be limited to 83 MW export at present.

At present, National Grid is carrying out work to increase the ability to receive power in Scotland. There is also a limit on the Northern Ireland side to the amount of power that can be exported. The projected increases in export capability (power to Scotland) for this study are set out in the Table 3-2. The Future Grid assumption that Moyle will be able to export 500 MW is a study assumption for the future. There is no immediate plan to increase the export capacity to this level until after the North South interconnector is built, the ability to export power to Scotland will then be reviewed.

The import capacity remains at 450 MW.

3.4.3 East West Interconnector (EWIC)

It is assumed that the EWIC is modelled for all study years with a maximum export capacity of 530 MW. The extra 30 MW is to account for losses in the converter stations and on the cable.

3.4.4 Additional Interconnection

For the Future Grid scenario, a Celtic interconnector with a 700 MW export capacity and a Greenlink interconnector with a 500 MW export capacity is modelled.

	2019	2020	2021	2022	Future Grid
Moyle Export Capacity	83	255 / 210	210 / 138	138 / 295	500
EWIC Export Capacity	530	530	530	530	530
Celtic Export Capacity					700
Greenlink					500

Table 3-2 Interconnection capacities

3.4.5 Interconnector Capacities

The interconnector capacities used in the model are shown in Table 3-2.

It is a study assumption that interconnectors can be used to export renewable energy, with the proviso that, when calculating an annual average behaviour, it would be optimistic to assume that maximum interconnection will always be available when required.

For various reasons, there will be times when the international market schedule will sometimes provide less export than could theoretically be possible. For example, the receiving country may not be in a position to accept large trades, the position of renewable energy in the day ahead market may be impacted by forecast error, etc., etc.

Hence, for modelling purposes in this report, it is assumed that the export capacity of each interconnector is de-rated by 20% to account for this. For example with Celtic, the export rating is 568 MW is in the model.

3.5 Priority Dispatch and Fuel Prices

3.5.1 Priority Dispatch for Wind and Solar Generation

In Ireland and Northern Ireland, wind and solar generation is given priority dispatch and this is implemented in the model.

This is achieved in the model by treating both controllable wind and controllable solar as if it had an offer price of zero. As Plexos seeks to provide the most economical solution while satisfying all transmission system constraints, it consequently will run as much wind and solar as it can.

3.5.2 Priority Dispatch for Thermal Generation

The generators shown in Table 3-3 are in the model as priority dispatch thermal plant that can be dispatched down to minimum generation levels during curtailment or constraint.

For this study, it is assumed that the peat power plants at least partially convert to renewable energy (biomass) and so remain with priority dispatch, albeit a lower priority than wind and solar.

3.5.3 Small-Scale Generation

Generating Unit	Existing (MW)	Maximum Export Capacity (MW)	Minimum Export Capacity (MW)
Edenderry	118	118	42
Lough Ree	91	91	31
West Offaly	137	137	48
Dublin Waste-to-Energy	61.5	61.5	21.5
Indaver Waste	17	17	10
Seal Rock 3&4	166	166	80
Tawnaghmore (Mayo Renewable)	0	49	20
Bandon (GP Wood)	0	17	6
Derryiron (Rhode Biomass)	0	18	6
Navan (Farrelly Brothers)	0	13	5
Thornsberry (Derryclure)	0	10	4

Table 3-3 Priority Dispatch – Thermal – Large Generators

Small-scale generation in constraints modelling refers to small uncontrollable, generation typically less than 5MW such as:

- Wind turbine e.g. a 250kW wind turbine supplying a farm or factory
- Solar PV e.g. a 4kW PV system installed on a home
- Hydro e.g. a 100kW run of river hydro scheme
- Tidal generator e.g. a 1.2MW Turbine
- Combined Heat and Power Generation, e.g. a 1MW natural gas CHP supplying a leisure centre
- An anaerobic digester, e.g. a 500kW AD plant converting electricity from waste food
- A diesel generator, e.g. a standby generation for a factory or commercial building.

Generating Unit	Existing (MW)	Minimum Export Capacity (MW)	Maximum Export Capacity (MW)
Butlerstown			2
Castleview			4
Charleville			2
Drybridge			3
Finglas			4
Macroom			1
Meath Hill			4
Richmond			5
Tonroe			2

Table 3-4 Future Thermal Small Scale Generators

It is assumed that the future small generators listed in Table 3-4 are not re-dispatched to allow wind generation to be dispatched. These generators are modelled in their respective Generator Scenarios, depending on North West, South, North East, etc. These small generators, should they connect, are modelled as competing for access to the transmission network.

3.5.4 Fuel and Carbon Prices

Fuel Type	IE	NI
Gas €/GJ	€ 6.40	€ 6.40
Coal €/GJ	€ 2.47	€ 2.85
LSFO €/GJ	€ 6.35	
DO €/GJ	€ 11.85	€ 11.85
CO2 €/tCO2	€ 22.49	€22.49

Table 3-5 Fuel and Carbon prices based on DBC 2019-20 Forecast

Since Plexos operates with a commitment and dispatch strategy to provide the most economical solution while satisfying all transmission system constraints, the fuel and carbon prices employed in the model are therefore relevant as to which generators are committed and dispatched. To an extent, this can influence both curtailment and transmission constraint levels experienced by renewable generators.

The prices used in the model are listed can be found in Table 3-5. The fuel and carbon prices are kept constant through the study period. The monthly differences in gas and oil prices are accounted for by using historical fuel profiles, but ensuring that the annual average is equal to the values shown above.

The cost of carbon is included in the commitment and dispatch decisions for each generating unit that emits carbon. The gas units in Ireland are also subject to a gas transportation charge that is included in the model.

Dublin Bay has a long-term fuel contract and is allowed to bid lower costs to the market based on this. It has recently been notified to the market that this long-term fuel contract will end in 2019. Hence, for this constraints analysis, it is assumed that Dublin Bay's gas price will be the same as other gas units.

3.6 Generation

An introduction and overview of the generation in this report is provided in Chapter 2. Additional detail is now provided in this section.

3.6.1 Conventional Generation

The model includes a portfolio of the thermal conventional generation in both Ireland and Northern Ireland. The operating characteristics of the existing conventional generation employed in the modelling are principally based on the SEM Generator Dataset. In some instances, minor changes to the dataset are made due to additional information becoming available to the TSOs.

The technical dataset includes the following information:

1. Fuel type (e.g. gas, wind, coal etc.)
2. Maximum and minimum operating output (MW)
3. Capacity state and heat rates (used to determine how much fuel is burnt to produce 1MW of output power)
4. Ramp rates (important to determine how quickly a machine can change its power output)
5. Minimum up-time and downtime

This technical data allows the Plexos software to calculate the cost of generating a megawatt of electrical energy for each generator in the model. Note that each generator has a different cost.

Other factors that influence the generation dispatch over an extended study horizon are:

- Generation Commissioning & Decommissioning
- Generation Outages
- Generation Emissions restrictions

3.6.1.1 Conventional Generation Commissioning and Decommissioning

With the introduction of SEM Capacity Auctions, the future of conventional generator commissioning and decommissioning is more dynamic than would previously have been the case. That being the case, a number of generator units retired from service in 2018 and, for the Generation Capacity Statement, some generators have indicated that their units may retire beyond the time frame of this study (e.g. 2023).

Hence, over the study period, it is assumed that there is no additional commissioning or decommissioning of large system generators.

3.6.1.2 Conventional Generation Outages

Scheduled and forced conventional generator outages are modelled in Plexos using Scheduled Outage Durations (SODs) and Forced Outage Probabilities (FOPs).

For this study, the Forced Outage Probabilities are used. The FOPs employed are those used for the DBC 2019-20 Forecast. Plexos will generate forced outage patterns from the FOP and mean time to repair data, which will provide a deterministic outage pattern against which the model will dispatch generation against demand.

3.6.1.3 Conventional Generation Emissions Limits

The European Union has set ambitious targets for decarbonisation and for renewable energy for the electricity sector by 2030. To date the Industrial Emissions Directive (IED) and Clean Energy For All Package are the two main instruments which will aim to transform the electricity sector, amongst other sectors, to a cleaner and more sustainable future for all.

The Clean Energy Package targets all generation to be under 550g/kWh by 2025 and this limit will affect certain generation plants in Ireland.

In Ireland, some plants are affected by the IED, and have entered into the Ireland Transitional National Plan (TNP). However, it is not anticipated that their running regimes will be curtailed. For example, under the TNP, Moneypoint's availability will be closely linked to the performance of its abatement equipment.

Hence, over the study period, explicit emission limits for conventional generation are not included in the model.

3.6.2 Renewable Generation

The amount of electrical energy output from renewable generation is generally described in terms of capacity factor. The capacity factor relates to the amount of energy that may be achieved from a renewable technology over the period of one calendar year. One factor in the energy yield difference is that solar PV does not produce electrical energy at night, but the wind can blow at any time of the day or night.

The values used in this study for solar and wind are listed below.

3.6.2.1 Renewable Generation – Installed Capacity

In the model, the generation portfolio to be employed for each study year is specified explicitly. The lists of the renewable generators assumed in each study is contained in Appendix B.

In previous constraint reports, predicted generator build out rates were used to place generators in the different study years. This is not the case in this report because there is uncertainty as to which generators will be successful in future support auctions and which generators will proceed to construction. Hence, this report uses regional generation scenarios, which are described in Chapter 2.

	Northern Ireland in model (MW)
Wind	1345 MW
Large Scale Solar	157 MW
Small Scale Solar	116 MW

Table 3-6 Installed Solar and Wind in Northern Ireland

3.6.2.2 Solar

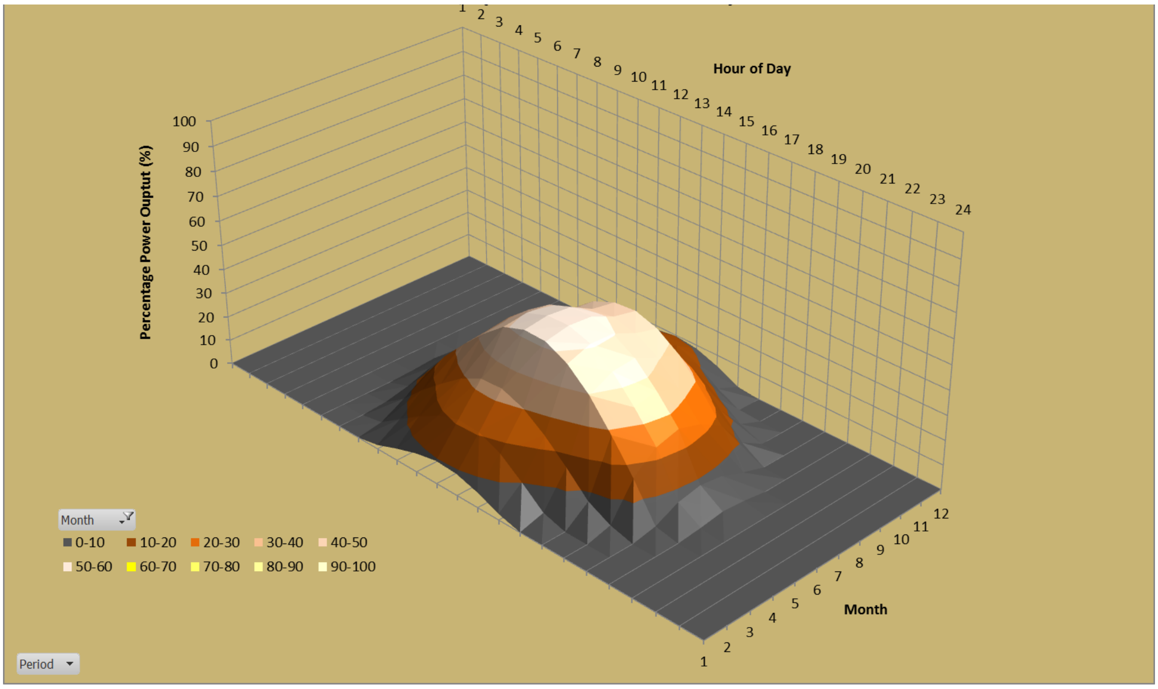


Figure 3-4 Solar Energy Profile (monthly average – hour of day)

On average, solar profiles tend to have a fairly predictable shape. Figure 3-4 shows the average hourly energy output from solar PV over a one year period. The capacity factor for solar PV is largely dependent on latitude - the closer to the equator the higher the annual capacity factor. The solar capacity factor for a country like Spain will have a value of around 20%, i.e. double the output of Ireland.

The surface plot of Figure 3-4 highlights the expected Ireland solar profile characteristic. The lowest intensity of solar electrical output is in the 4 winter months November through to February with hourly values on average not exceeding 20%. As expected the solar electrical energy output is highest in the summer months with average hourly solar electrical output peaking in the 50-60% range.

The main point is that the solar electrical available energy is fairly predictable, and is typically there during times of increasing electrical demand i.e. the morning rise. However, the winter peak demand will not be met by solar.

Solar energy output may be reduced if it is located on a part of the network that has constraint issues.

3.6.2.2.1 Solar Profiles

Solar generation is modelled in the analysis using an hourly solar power series at every transmission node where solar generation is connected.

To provide a representative solar series for Ireland, three solar profiles are used. The groupings used are shown in Figure 3-5. The capacity factors of the different profiles are shown in Table 3-7.

This approach captures the variation in solar energy when comparing solar farms in the south and solar farms in the north. Clearly, this approach does not take into account hourly variations in solar power within each group, due to local cloud in that individual hour, etc. Since this study is focused on the curtailment and constraint on the transmission system, it is reasonable to assume that these solar profiles capture the average behaviour of solar on the island.

EirGrid is grateful for the assistance of the solar industry in providing these profiles for use in this study.

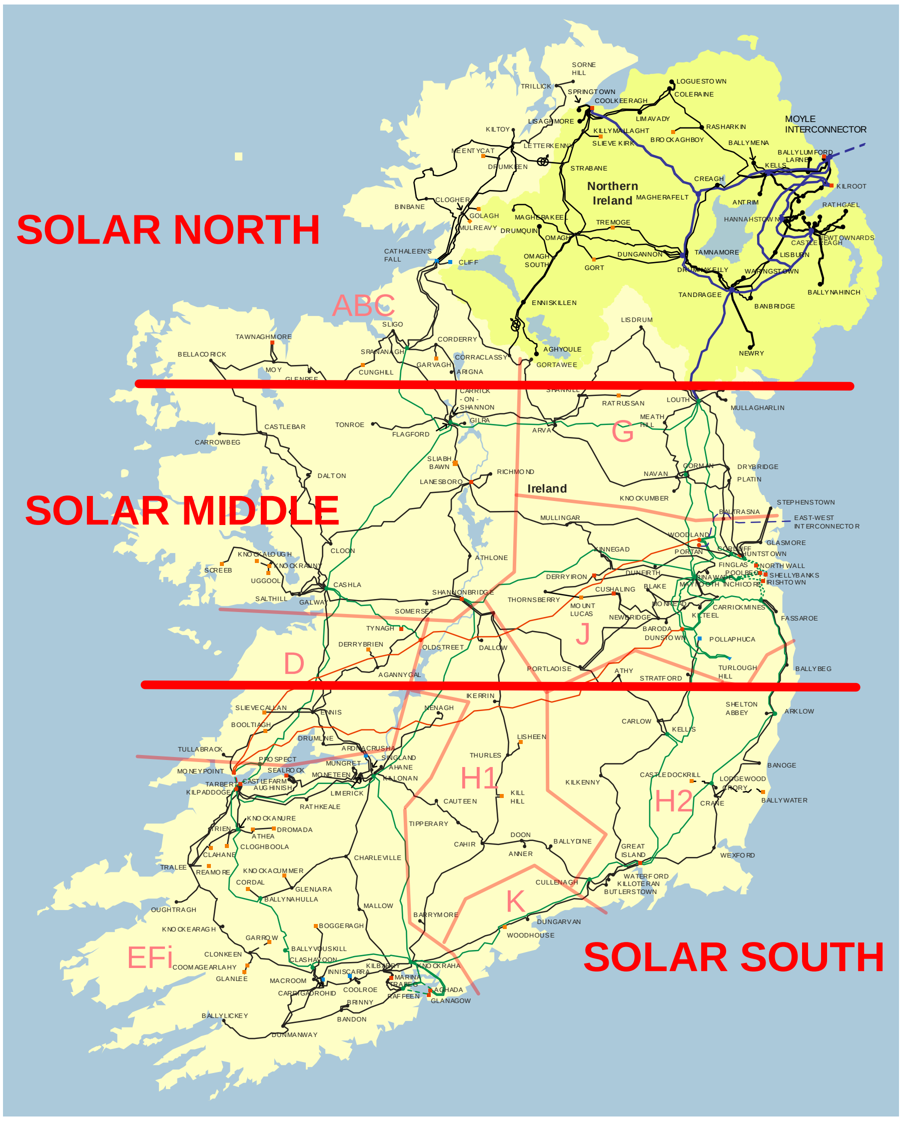


Figure 3-5 Groupings used for Solar Profiles in Model

Solar	Capacity Factor
Solar North	10%
Solar Middle	11%
Solar South	12%

Table 3-7 Capacity Factor of Solar Profiles

It should be noted that if the capacity factor of actual solar farms turns out to be higher than modelled here, then solar farms may experience higher levels of curtailment and constraint than are predicted by this report.

3.6.2.3 Wind

This section details how wind generation on the island of Ireland is modelled in Plexos.

Wind generation is modelled in the analysis using an hourly wind power series at every transmission node where wind generation is connected. To provide a representative wind series, wind profiles are used. Where area wind profiles are used, the areas are the same as were used for Gate 3.

By using historical wind profiles it is possible to account for the geographical variation of wind power across the island. The wind profiles for the study year for both Ireland and Northern Ireland are created using 2015 wind data. 2015 was a comparatively high wind year.

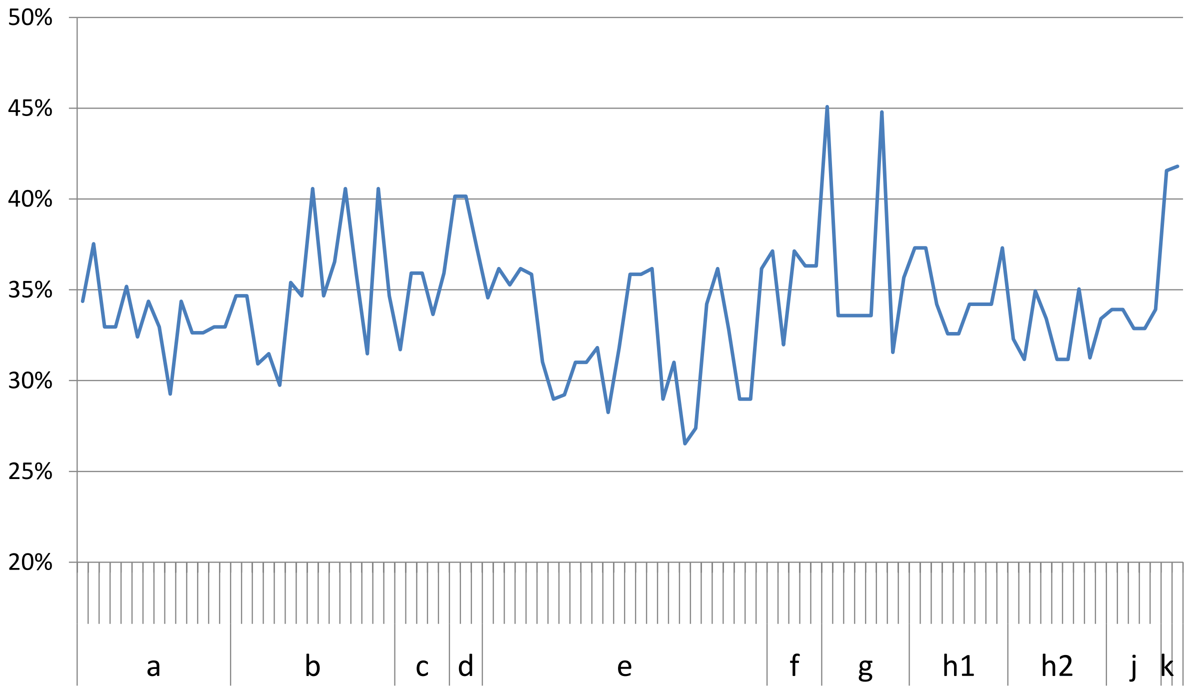


Figure 3-6 Capacity Factor by Node, grouped by Area, for Existing Wind

Wind Profiles

A different treatment is applied to existing windfarms as to the future windfarms. The existing windfarms are considered to be the windfarms in the Initial generation scenario.

In so far as is possible, existing windfarms are given wind profile information on a node basis. In other words, each 110 kV station has a different wind profile. These 110 kV node profiles are created from the historical 2015 profile information. The capacity factors of these node profiles are shown in Figure 3-6.

Future windfarms are provided with the 2015 profile of a representative windfarm in the area. For this study, this is referred to as a "sample". A benefit of the different treatment for the future windfarms is that the capacity factors of the input profile are considered to be a better fit. The capacity factor of these sample profiles is provided in Table 3-8.

Wind Regions	2015 Capacity Factors for Future Windfarms
Ireland	
A	33%
B	34%
C	35%
D	40%
E	35%
F	36%
G	33%
G Offshore	45%
H1	34%
H2	33%
I	36%
J	34%
K	43%
Northern Ireland	
NI	31%

Table 3-8 Capacity factors for Future Wind

Capacity Factor

The overall wind generation capacity factor for Ireland using these sample 2015 wind profiles and for generation scenario All is 34%. This gives a capacity factor that is higher as a system average than has been achieved in recent years. However, this value is probably representative for a wind fleet that will include new technology windfarms and some excellent wind sites and some offshore wind. Hence, it is believed that it is a suitable 'wind year' to use for an assessment of future curtailment and constraints.

3.6.2.4 Generation Controllability

Traditionally, smaller (and some older) wind farms and solar generators do not have to be controllable. The study methodology takes into account all uncontrollable wind and solar generation and does not include these generators in any output reductions calculations.

Generally, apart from some older windfarms, it is assumed that all wind farms are controllable if their MEC is greater than or equal to 5 MW (for generators which received a connection offer before 2015) or if their MEC is greater than or equal to 1 MW (after 2015). All solar farms with an MEC greater than or equal to 1 MW are assumed to be controllable.

3.6.2.5 Perfect Foresight – Wind Forecast

Building an economic power market model will always require input assumptions. One such assumption is that the climatic year will be from historical data. The use of historical data means that the power market model will create generation commitment and dispatch decisions based on the perfect foresight of wind and solar output. In real-time operation of the power system, this is not the case. There will inevitably be an error between the forecast and the out-turn wind. This can mean that the model may show lower levels of curtailment since with perfect foresight it may choose to de-commit units based on what it knows will happen in. In reality differences and uncertainties in wind or demand forecasts mean that a different schedule of generators may be required than that modelled with perfect foresight.

3.7 System Operation

3.7.1 Safe Operation (Security Constrained N-1)

The basic principle of N-1 security in network planning states that if a component – e.g. a transformer or circuit – should fail or be shut down in a network, then the network security must still be guaranteed. Furthermore, the voltage must remain within the permitted limits and the remaining resources must not be overloaded or must not exceed the short term overload capability of the equipment.

EirGrid operates the Ireland transmission network to be N-1 secure.

3.7.2 Operational Constraint Rules

This section presents the all-island operational constraints, which are used to develop the 'constraint rules' for the Plexos economic dispatch tool. This section outlines the operational rules employed in the constraints modelling. The operational rules cover System Non-Synchronous Penetration (SNSP), operational reserve requirements and minimum synchronous generation levels.

The purpose of this section is to define the set of 'Operational Constraints', and how these constraints may evolve over the proposed study period. Operational constraints are important since they will help to define system issues that may cause a reduction in renewable generation.

The curtailment is an all-island issue. This report will present the generation curtailment on a jurisdictional and nodal basis. The way in which operational constraint rules change over time is a very important factor when trying to model expected levels of wind curtailment. Operational constraint rules that are said to be 'binding' will tend to turn down renewable generators that are then reported as curtailment.

3.7.2.1 Operational Constraint Rules Post 2020

The DS3 work-stream has been established to enable the connection of enough renewable generation to meet government 2020 targets. The horizon for these studies extends past the year 2020. There are no additional operational constraints modifications assumed since there are no specific studies that can be used to support any additional rule changes.

Active System Wide Constraints		
Limit	Operational Constraint rule	NI Constraint/Curtailment report
Non-Synchronous Generation	There is a requirement to limit the instantaneous penetration of asynchronous generation connected to the All Island system.	The limits vary across the years of the report: 65% (2018), 70% (2019), 75% (2020-2024).
Operational Limit For RoCoF	There is a requirement to limit the RoCoF on the All-Island system.	The limits vary across the years of the report: 0.5Hz/Sec (2018-2019), 1Hz/Sec (2020-2024)
Operational Limit For Inertia	There is a requirement to have a minimum level of inertia on the All-Island system.	The limits vary across the years of the report: 23,000 MWs (2018-2019), 17,500 MWs (2020-2022)

Table 3-9 Active System Wide Operational Constraints

3.7.2.2 System-Wide Operational Constraint

There are several operational constraints associated with the DS3 programme. These operational rules make sure that the system operators can run the system within frequency stability limits. Changes to system rules require capital investment to be made, at both TSO and generator levels.

This study uses the operational constraints listed in Table 3-9.

3.7.2.3 System Non-Synchronous Penetration

Indicative Date	SNSP Limit	Inertia from Conventional Generators
	65%	23,000
Oct 2019	70%	23,000
Jan 2020	70%	17,500
Apr 2020	75%	17,500
Future Grid scenario	80%	17,500

Table 3-10 Indicative DS3 Dates for SNSP and Inertia Floor

There is a system need to limit the amount of 'non-synchronous' generation at any point in time. The limit makes sure that the power system operates within a stable zone.

A mathematical expression describing the SNSP rule is as follows:

$$\frac{Non\ Synchronous\ Generation}{Total\ Generation} \leq SNSP\ Limit$$

$$\frac{All\ Island\ Wind\ Generation + Interconnector\ Imports}{All\ Island\ Demand + Interconnector\ Exports} \leq SNSP\ Limit$$

An increase in the SNSP limit will allow more 'non-synchronous' generation to be accepted onto the system. The DS3 work stream is responsible for determining the SNSP outlook. The timeline for increases in SNSP is shown in Table 3-10.

3.7.2.4 Inertia Floor

The current operational limit for the system inertia floor is 23,000 MWs. In 2019, a trial will take place on the system to decrease the inertia floor to 20,000 MWs. This will allow the power system to operate with less synchronous machines online for frequency stability.

The DS3 programme predicts that the system inertia floor will reduce to 17,500 MWs in 2020.

Operational Reserve Requirements	
Limit	Operational Constraint rule
<u>Primary Reserve</u> **All Island - 75% of the Largest In-Feed** **A Minimum of 115MW** **Ireland Min – 110/75** **NI Min – 50**	All Island primary reserve must be 75% of the largest infeed with jurisdictional limits of **Jurisdictional Requirement** Ireland At night 75MW / Daytime 110 MW Northern Ireland 50 MW
<u>Negative Reserve</u> **Ireland Min – 100 MW** **NI Min – 50 MW**	Negative reserve must be held on the system. When a Generators output is above its minimum generation threshold, it is said to carry negative reserve. There will only be a cost associated when lower cost generation is curtailed to allow ramping of generation above its minimum generation level to cover the negative reserve service Ireland Requirement 100 MW Northern Ireland Requirement 50 MW

Table 3-11 Active System Wide Operational Constraints

3.7.2.5 Operational Reserve

Operating reserve is surplus operating capacity that can instantly respond to a sudden increase in the electric load or a sudden decrease in the renewable power output. Operating reserve provides a safety margin that helps ensure reliable electricity supply despite variability in the electric load and the renewable power supply. The operating reserve is equal to the operating capacity minus the electric load. To provide reserve, some generators are part-loaded i.e. are operated below their maximum output capacity to provide a quick-acting source of reserve.

The working assumption is that enough Primary Operating Reserve (POR) will be provided to cover 75% of the loss of the largest infeed. The largest infeed is either the largest generation infeed or if larger, the import from an interconnector. In practice, this varies in proportion to the largest infeed by output. The model also includes Secondary Operating Reserve (SOR) and Tertiary Operating Reserve (TOR).

Operating Reserve Assumptions
The total All Island reserve requirement is assumed to be equal to 75% of the capacity of the largest unit on the system. It is assumed that wind is not curtailed to provide reserve or governing. A total static reserve figure of 100 MW is assumed to be provided by the Moyle and East-West Interconnectors. It is assumed that in pumping mode, pumped storage units provide reserve equal to 100% of their MW pumping value.

Table 3-12 Reserve Assumptions Employed

Minimum Conventional Generation Assumptions
Ireland
Ensure that at least two large thermal units in the Dublin region are synchronised at all times. Ensure at least 5 large units are synchronised at all times (proxy for inertia constraints). Thermal Priority Dispatch units as set out in **Table 3-3**. Assume that at least 3 pump sets are on during the night
Northern Ireland
A minimum of 3 conventional units must be synchronised at all times.

Table 3-13 Summary of Minimum Generation Requirements

Negative Operating Reserve is also modelled. This keeps some conventional generators above their minimum generation level and allows these generators reduce their output in response to a high frequency event.

3.7.2.6 Minimum Number of Synchronous Generators at any time

There is a requirement to have a minimum number of conventional generators synchronised at all times to provide inertia to the power system, ensure voltage stability and to ensure that network limitations (line loading and system voltages) are respected.

Changes to the rules are guided by operational and/or planning assumptions.

Table 3-13 details the assumptions employed with respect to the minimum conventional generation requirements for the constraints modelling.

Operational Constraints for Ireland	
Limit	Operational Constraint rule
<u>System Stability:</u> **5 Units from AD2, DB1, HNC, HN2, MP1, MP2, MP3, PBC, TB3, TB4, TYC, WG1**	There are a minimum number of high-inertia machines that must be on-load at all times in Ireland. Five of these units are required to be on line for dynamic stability.
<u>Dublin Generation :</u> **2 Units from DB1, HNC, HN2, PBC**	There are a minimum number of large generators that must be on-load at all times in the Dublin area. Required for voltage control. This assumes EWIC is operational
<u>Dublin North Gen:</u> **1 Unit from PBC, HNC, HN2**	Requirement for generation in North/South Dublin (for load flow and voltage control).
<u>Dublin South Gen:</u> **1 Unit from PBC, DB1**	
<u>Southwest Gen :</u> **2 by night 3 by day**	There must be at least 2/3 generators on-load at all times in the South West area. Required for voltage stability. AD2, AT11, AT12, AT14, SK3, SK4, WG1

Table 3-14 Ireland Must Run Rules

3.8 DS3 Programme

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

The aim of the DS3 programme is to meet Ireland's 2020 electricity targets and beyond by increasing the amount of renewable energy on the Irish power system in a safe and secure manner.

<u>Synchronous v non-synchronous generation</u>

There are two types of electricity generation: synchronous generation and non-synchronous generation. Synchronous generation produces the same amount of electricity all the time. It is reliable and predictable and, therefore, easy to bring onto the grid. Fossil fuels such as coal, oil and gas are a type of synchronous generation.

Non-synchronous generation produces a variable amount of electricity depending on the renewable energy source. It does not produce the same amount of electricity all of the time. This makes it less reliable, and more difficult to bring onto the grid. Most renewable forms of energy, such as wind and solar, are types of non-synchronous generation. This is because the amount of wind and solar radiation is always changing and therefore they cannot produce power predictably.

<u>Meeting renewable electricity targets</u>

The 2020 renewable electricity target and future targets mean that we will have to increase the amount of non-synchronous generation on the Irish power system in a safe and secure manner. The aim of the DS3 Programme is to meet this challenge.

So far the DS3 programme has enabled EirGrid to increase levels of renewable generation on the system from 50% to 65%. This is a world-first. We aim to increase this gradually to 75% over the coming years.

The DS3 programme assumptions in this study are included in Table 3-10.

3.9 SEM Constraint Groups

SEM Constraint Groups were proposed in SEM-13-012 and "Proposed Constraint Groups arising from SEM-11-105". There is one active SEM Constraint Group in Ireland, one future group in Ireland, and none in Northern Ireland.

The Donegal Constraint Group is presently active. In 2015, after the delivery of a number of transmission reinforcements, both the membership and the boundary of the Donegal Constraint Group were reduced. This SEM Constraint Group is now effective only for the transmission constraint at the group boundary and even that is mitigated by the introduction of a Special Protection Scheme at Clogher.

With the Clogher SPS included in the Constraint studies, the transmission constraint that invokes the Donegal Constraint Group binds very rarely in the simulations. The simulations are dominated by transmission constraints that overlap with other areas and which are not being driven by the members of the Donegal Constraint Group. Hence, the Donegal Constraint Group is not included in this study.

The Southwest Constraint Group in not presently active and is not modelled.

4 Study Methodology

4.1 Introduction

This section provides an overview of the modelling methodology employed to determine the likely curtailment and constraint levels for generators in this study.

The methodology of production cost modelling is utilised to conduct the studies for this report. This section includes a detailed description of production cost modelling is presented and an overview of Plexos, the modelling tool employed, is also provided. In addition, there is a description of curtailment and constraint modelling,

4.2 Production Cost Modelling

In general terms, production cost models utilise optimisation algorithms with the objective of minimising the cost of generating power to meet demand in a region while satisfying operational, security and environmental constraints. A production cost model minimises the combined fuel cost, CO2 cost, and variable operation and maintenance cost. Wind-powered generation has essentially zero production cost but is a variable energy source. Hydro generation also has zero cost but is energy limited. Chronological production cost models optimise generator commitment and dispatch scheduling for every hour of a study period (typically one-year duration).

Production cost models require:

- Specification of individual generator capabilities including capacity, start-up energy, annual forced outage rate, annual scheduled outage duration, reserve provision capabilities, emission rates and heat rates (fuel input requirement per unit output generation).
- Specification of the hourly demand profile for the region.
- Specification of the fuel price for each type of fuel.
- Specification of the transmission network (required for studies where transmission constraint information is the desired output).
- Specification of contingencies.
- System security constraints such as the requirement for reserve.
- Generator operational constraints such as maximum and minimum operational levels, ramp rates, minimum runtimes and downtimes etc.
- Environmental considerations such as the cost of CO_2.

The production cost modelling tool employed in this study is Plexos.

4.3 The Software: Plexos Integrated Energy Model

Plexos is a detailed generation and transmission analysis program that has been widely used in the electricity industry for many years. EirGrid has extensive experience in using this simulation tool to model the Irish power system. Plexos is supplied and supported by Energy Exemplar and is continually being upgraded and improved. It is a production cost modelling simulation program, used to determine power system performance and cost. It is a complex and very powerful tool for power system analysis, with separate commitment and dispatch algorithms.

Commitment and Dispatch

The commitment process refers to the selection of a number of generators, from the total generation portfolio, which is to be used to meet customer demand. The decision as to when these generators should come on or off-line is also part of the commitment process. So, for example, additional generation is committed on Monday mornings in order to meet higher weekday (than weekend) demand.

The dispatch process refers to the decisions taken on the loading of individual generation units. Thus the contribution from each online, or committed, unit towards meeting customer demand is determined by the dispatch decision.

Generator, Demand and Network

Full technical performance characteristics and operational cost details of each generation unit on the system is specified. An hourly system demand profile is also required. In this case, the transmission system is also modelled in detail.

The program output provides complete details of the operation of each generation unit. These are aggregated into system totals. Flows on transmission lines can be monitored and potential constraints on the system can be identified. A wide range of output reports is available, from system summaries to hour by hour information on individual generators.

DC Loadflow

Plexos is a DC loadflow simulation tool. Therefore, it only models real power flows and does not consider voltage. Transmission plant and line ratings are MVA rated and ratings vary with voltage. For the purposes of modelling the DC load flow MW ratings for the circuits, the model assumes a conversion factor of 0.9.

The conversion factor allows the necessary spare capacity for reactive power on the circuits and it allows for post-contingency low voltage. This 0.9 conversion factor gives a good performance for a wide range of pre-contingency and post-contingency conditions.

The model, as constructed, does not account for losses.

4.4 System Model

For this study, the system is modelled at generator level i.e. every single conventional generator is modelled in detail. Characteristics such as heat rates, ramp rates, minimum runtime and downtime, start-up energy, reserve provision capabilities, annual forced outage rate, annual scheduled outage duration and emission rates of each individual generator are specified.

Solar and wind-powered generators are modelled at 110 kV node level. In other words, if several windfarms are fed from a 110 kV node, the model represents them as a single windfarm at that node. The same is true for solar farms. These generators use hourly generation profiles series. More detail on the modelling of solar and wind-powered generation is provided in Section 3.6.2.

Ireland and Northern Ireland are treated as a single dispatch system in the production cost model for the purposes of producing an optimal minimum cost commitment and dispatch. Generators are dispatched based on their short-run marginal costs (which include the costs of fuel and CO2 emissions) and in accordance with the dispatch assumptions outlined below.

4.5 Software Determination of Curtailment and Constraint

For this report, the wind and solar generators are assumed to be Grid Code compliant and that controllable wind and solar generators can be instructed to reduce their output if required.

The Plexos model is used to calculate curtailment and constraint. A number of supplemental studies are also needed to properly apportion constraints.

In the simulation, generators are committed and dispatched in the most economical manner while satisfying operational and security constraints such as limitations on the instantaneous wind penetration, operating reserve requirements, the requirement for a minimum number of synchronised conventional generators as well as the limitations of the transmission network.

The simulation is a security constrained N-1 study. This means that the network flows are constantly monitored to be safe against the possible loss of any item of transmission equipment.

The total reduction in wind energy for each wind generator is calculated by comparing the wind energy output from the simulation with the available wind energy.

4.6 Apportioning of Curtailment and Constraint

Constraint

When a transmission constraint occurs, Plexos will attempt to alleviate the constraint in the most cost-effective manner.

If a transmission constraint causes wind or solar generation to be constrained down, Plexos' internal dispatch logic may choose one generator to constrain down out of several that have the same flow impact on the constraint (due to the fact that, in the constraints model, all these renewable generators are modelled with the same cost of production).

This report studies the connection of very large amounts of generation to the transmission network in the years 2020 to 2022. As such, there are some areas where the levels of transmission constraints are both large and frequent. There are also areas where there are, at times, several overlapping transmission constraints. This makes it more difficult to apportion curtailment and constraints to individual nodes.

Post-processing of the results is required. This ensures that generators, which have a similar impact on the constraint, will share proportionally in the effect of the constraint in the study results.

Curtailment

At hours when it is necessary to curtail wind and solar generation output, a decision has to be made as to which should have their output reduced. It is assumed in this study that, where possible, all controllable wind and solar generators share the reduction in output energy arising from curtailment in proportion to their available energy in that hour i.e. on a pro-rata basis.

5 Results for Area C

5.1 Introduction

This chapter provides the curtailment and constraint results for Area C that are predicted by these constraint studies. An overview and discussion of the results is provided in this chapter. The curtailment and constraint results for each node are provided in Appendix C.

The Area C results are evaluated together with Area A and Area B.

5.2 Study Scenarios – Revised Report

5.2.1 Introduction to Revised Network Scenarios (Study Years)

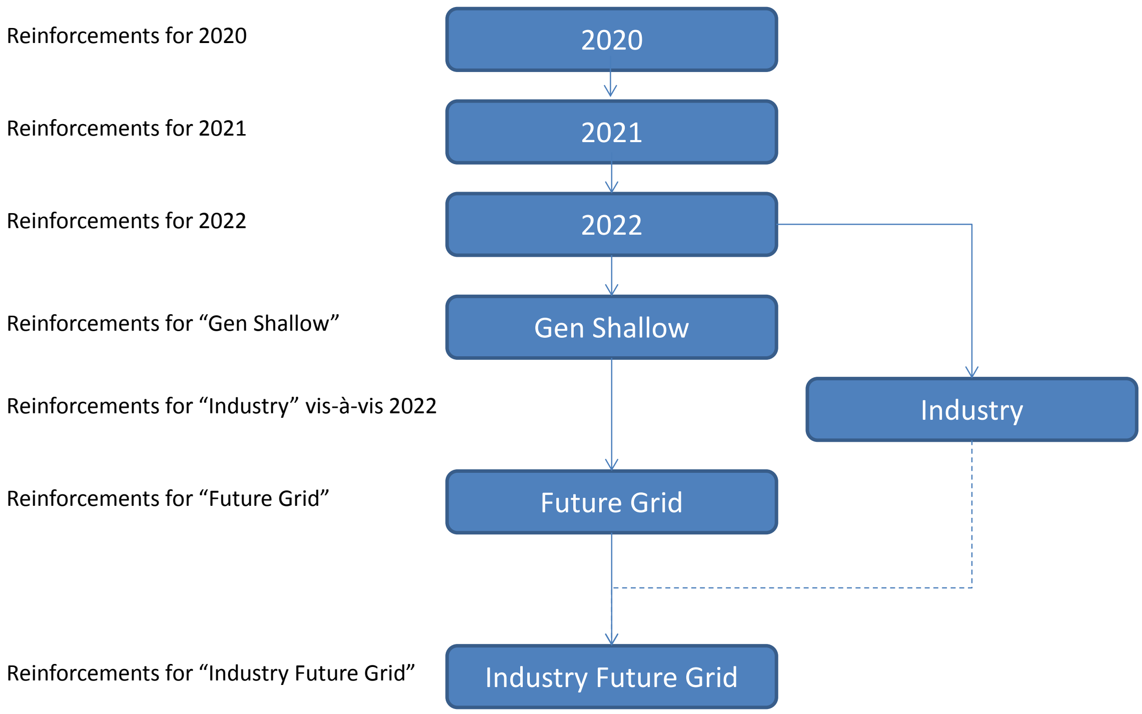


Figure 5-1 Network Scenarios (Study Years) in the Revised Report

There are several reasons why this revised version of the report is now being released. The first reason is that the 2022 study year now includes a proposed special protection scheme in Mayo.

Second, the expected delivery dates of some reinforcements have been adjusted in the recent ATR publication on the EirGrid website. The change to this constraint report is that the Arva - Carrick on Shannon uprate is now introduced in “Future Grid” rather than in 2022, and Binbane – Cathaleen’s Fall uprate is introduced in “Gen Shallow”, rather than in 2021 Both are in the Industry scenario.

Thirdly, EirGrid offered industry representatives an additional study for the north west. As a result there is now the Industry scenario.

Finally, the industry representatives asked for a revised version of the Future Grid scenario which includes any existing Association Transmission Reinforcements (ATR). This is the Industry Future Grid scenario.

An overview of the revised network scenarios is shown in Figure 5-1.

Please note that the 2020 and 2021 results have not been recalculated for this report.

5.2.2 Generation Scenarios

Normally, there are sixteen study scenarios presented in each area report. There is one future grid scenario. The next fifteen are combinations of three study years (2020, 2021 and 2022) and five generation scenarios (Initial, North West, 33%, 66% and All).

The Generation Scenarios are as follows:

- For the Area A, B and C reports, feedback on the initial report indicated that there is approx. 50 MW less generation installed in the north west at the time of writing than is in Generation Scenario Initial. Consequently, an extra generator scenario **March 2020** was performed for the north west.
- Generation Scenario **Initial** is the generation that was expected to be in place by 2020. It is assumed that there is no large scale solar generation in Ireland in Initial.
- Generation Scenario **North West** takes Generation Scenario Initial and adds all the other generators in the North West who will have connection offers up to ECP-1. The difference between North West and Initial is that all the generators in Areas A, B, and C are in Generation Scenario North West.
- The **33%** scenario is 33% of the way between the Initial scenario and the All scenario.
- The **66%** scenario is 66% of the way between the Initial scenario and the All scenario.
- Finally, Generation Scenario **All** contains all the generators up to ECP-1 who will have connection offers.

For the Area A, B and C constraint reports, and for the study years 2020, 2021 and 2022, the generation scenarios are reduced by their share of 220 MW of generation in Areas A and B. These are generators which must wait for shallow reinforcements before they can connect. See section 5.4.1. There is an extra study, Generators with Shallows, that includes this extra 220 MW of generation.

5.3 Study Notes

A list of the major study assumptions is provided in Section 3. For Area C, it is worth mentioning the following again.

5.3.1 Intact Network

The scenarios in this Constraint Report are intended to give a view of average long term levels of curtailment and constraint, subject to installed generation, demand, interconnection, DS3 delivery and reinforcement delivery.

The studies for this Constraint Report are modelled on the assumption of an intact network. This assumption is reasonable over the life of generation projects because transmission circuits are expected to normally be in service.

However, in any given year, there can be outages of local transmission circuits, or of interconnector circuits, and in some instances the duration of these outages can be several weeks, several months or, in exceptional cases, longer than a year. These outages can be to facilitate reinforcement, or can be as the result of equipment failure.

Therefore, in any given year, for short term reasons, the average transmission constraints in an area can be higher than is presented in this report.

5.3.2 Peaking Generation and Batteries

As set out in Section 3.1.4, this analysis does not assume that batteries and peaker generators are running at the same time as solar and wind is generating, or that network capacity would be explicitly reserved for peaker generators or batteries.

For this constraints report, this assumption is reasonable. However, in the future, if batteries were to require more running, and / or if a future operation of the system was to require prolonged running of peaker generators, or that some network capacity be explicitly reserved for either, then this constraints analysis would need to be revised.

5.3.3 Benefit of Capacity Factor

In the real world and within Area C, a windfarm may have a better site, better turbines, etc., and may have a better capacity factor than neighbouring windfarms. This report doesn't differentiate on this, but a windfarm with a higher capacity factor will probably see less percentage curtailment and less percentage constraint than an adjacent windfarm with lower capacity factor. This is because at times of medium or low wind, the high capacity windfarm has power when the low capacity windfarm doesn't.

5.3.4 Notes on Curtailment and Constraint Modelling

<u>Curtailment</u>

In this report, in each hour of the study, the curtailment is shared pro-rata on a system wide basis. This means that both curtailment reductions (as demand increases, as interconnection increases, or with the DS3 programme) and curtailment increases (when new generators connect) are shared system-wide.

Solar sees different reported levels of curtailment than wind. This is because the generator types have different capacity factors and they generate at different times.

The forecast curtailment is broadly constant within each area. To be precise, curtailment is calculated as an average for each subgroup within an area. There can be small variations in curtailment within an area, due to the use of node wind profiles. Comparing between areas, if there is a large quantity of wind generation in a given area, then that area can see relatively high curtailment.

<u>Constraints in 2020, 2021 and 2022</u>

In most study years, there is a tendency for renewable power to flow toward the demand at Dublin and toward the interconnector at EWIC. These flow patterns are relevant when seeking to understand constraint apportionment in the simulation.

When presented as percentage values, the constraint results look different for solar and for wind, but that is because the solar and wind have different forecast energy profiles.

5.4 Generation Overview

Areas, A, B and C are in the north west of the country and there is a mix of existing wind, future wind and future solar locating here.

Node	SO	Status	Battery	Solar	Thermal	Wind
Athlone	DSO	ECP-1 Offer		4		
Athlone	DSO	Existing Offer		8		
Carrick on Shannon	DSO	Existing Offer		8		4
Dallow	DSO	Initial				21
Dallow	DSO	Existing Offer		4		
Dallow	DSO	ECP-1 Offer		4		3
Lanesboro	DSO	Initial				5
Lanesboro	DSO	Existing Offer		4		
Lanesboro	DSO	ECP-1 Offer				5
Lanesboro	TSO	Initial			94	
Lumcloon	TSO	Existing Offer	100			
Lumcloon	TSO	ECP-1 Offer				34
Mount Dillon	TSO	ECP-1 Offer		90		
Mullingar	DSO	Existing Offer		8		
Mullingar	DSO	ECP-1 Offer		4		
Richmond	DSO	Existing Offer		4		
Richmond	DSO	ECP-1 Offer		8	5	
Shannonbridge	TSO	Initial			141	
Shannonbridge	TSO	ECP-1 Offer		65		
Shannonbridge 220	TSO	Existing Offer	163			
Sliabh Bawn	TSO	Initial				58
Somerset	DSO	Initial				8
Somerset	DSO	Existing Offer		4		12
SUBTOTAL			**263 MW**	**215 MW**	**240 MW**	**150 MW**

Table 5-1 Generation Summary in Area C for Generation Scenario "All"

A list of the generators in Area C is provided in Table 5-1. For installed MW of solar and wind, Area C makes up 365 MW.

A summary of the total generation in Areas A, B and C is provided in Table 5-2. There is an increase of almost 1000 MW of renewable generation in these three areas. This is important for Area C because these three areas share the same circuits for exporting power to the rest of the system.

	Generation Scenario	
	Initial	**All**
Solar	0	340
Wave	0	10
Wind	1,400	2000
TOTAL IN AREAS A, B AND C	**1,400 MW**	**2,350 MW**

Table 5-2 Increase in Generation in Combined Areas A, B and C for these Studies

It can be seen that Area C makes up a relatively small fraction of the 2350 MW in the three areas. This means that constraints in Area C are impacted by the generation connecting in Areas A and B.

Installed Generation (Ireland and Area C)

For Ireland, it is assumed that there is no solar in Generation Scenario Initial. The installed solar in Ireland in Generation Scenario North West is 0.3 GW (all in the North West) and in Generation Scenario All is 2.5 GW. The 33% and 66% scenarios have 0.8 GW of solar and 1.7 GW of solar respectively.

The installed wind is 4.2 GW in Generation Scenario Initial and this increases to 4.7 GW in Generation Scenario North West and to 6.1 GW in Generation Scenario All. The 33% and 66% scenarios have 4.8 GW of wind and 5.3 GW of wind respectively.

SOLAR	Generation Scenario					
	Initial	***NW*** 2020 – 2022	***33%*** 2020 – 2022	***66%*** 2020 – 2022	***All*** 2020 – 2022	**All**
Installed Ireland (GW)	0	0.3	0.8	1.7	2.5	2.5
Installed Area C (MW)	0	215	72	143	215	215
Installed Controllable Area C (MW)	0	215	72	143	215	215
Available Controllable Area C (GWh)	0	210	69	139	210	210

Table 5-3 Installed MW and GWh for Area C – Solar

There is no solar in Area C assumed in Generation Scenario Initial and this increases to 215 MW in scenario North West and scenario All. Generation Scenario 33% has 72 MW of solar in Area C and Generation Scenario 66% has 143 MW.

The controllable wind in Area C increases from 68 MW in Generation Scenario Initial to 122 MW in Generation Scenario North West and Generation Scenario All. Generation Scenario 33% has 86 MW of controllable wind in Area C and Generation Scenario 66% has 104 MW.

WIND	Generation Scenario					
	Initial	*NW* 2020 – 2022	*33%* 2020 – 2022	*66%* 2020 – 2022	*All* 2020 – 2022	All
Installed Ireland (GW)	4.2	4.7	4.8	5.3	5.9	6.1
Installed Area C (MW)	92	150	111	131	150	150
Installed Controllable Area C (MW)	68	122	86	104	122	122
Available Controllable Area C (GWh)	198	367	253	309	367	367

Table 5-4 Installed MW and GWh for Area C - Wind

5.4.1 Shallow Works and Generators

In the north west of the network, there is 220 MW of generation that is not permitted to connect until certain wider system works are complete. These works will not be in place by 2022, and so, the works are not included in the 2022 study. Consequently, the generators that need these works are also not included in the 2022 study. In the connection contract, these are included in the Site Related Connection Equipment, and are sometimes referred to as "shallow reinforcements".

See table below.

Shallow Works	Quantity of Generation
Galway New 110kV Station	30 MW
Uprate Binbane – Cathaleen's Fall 110	30 MW
North Connaught Reinforcement Of which approx. 50 MW must also wait for Uprate of Glenree Moy 110 circuit.	160 MW
	TOTAL: 220 MW

Table 5-5 Shallow Works and Quantities of Generation

Because this generation is not permitted to connect before these works are complete they are not included in the 2020, 2021 and 2022 network studies.

An additional study called Gen Shallow is performed with these works and with the generation that can connect after they are delivered. This study is otherwise similar to study "2022 All".

5.5 Network Overview

The transmission network in Areas A, B and C, and surrounding areas, is shown in Figure 5-2. The 400 kV circuits are shown in red, the 220 kV circuits in green and the 110 kV circuits in black. Possible future transmission stations for new generation are shown in blue.

At times of high renewable generation, there is a tendency for power from Areas A, B and C to flow toward the demand at Dublin and toward the EWIC interconnector.

For this report, constraints in the model are optimised on a system basis. This means that the constraints in Area C are caused both by local and by wider system considerations. So, in theory, an increase in the installed generation in another area can increase constraints in Area C.

The meshed electricity transmission system is operated to be safe, at all times, against the loss of any circuit. For large power flows out of an area, this means that power transfer capability depends on the network capacity after the outage of any large circuit.

Figure 5-2 Network showing Areas A, B and C and Surrounding Network

It is found that the simulated constraint levels for the north west are noticeably higher than for other study areas.

For the generation scenarios studied, there are several transmission boundaries that limit the power export from Areas A, B and C. Some of the relevant overload and contingency pairs are as follows:

- Lanesboro Mullingar for loss of Oldstreet Woodland 400
- Arva Navan 110 for loss of Gorman Louth 220
- Louth Ratrussan 110 for loss of Flagford Louth 220
- Arva – Carrick on Shannon for loss of Flagford Louth 220
- Sliabh Bawn – Mount Dillon – Lanesboro for loss of Flagford Srananagh 220
- Flagford Sligo for loss of Flagford Srananagh 220
  For Area A
- Cathaleen's Fall – Srananagh circuit 1 for the loss of circuit 2
- Cathaleen's Fall – Clogher circuit 1 for the loss of circuit 2
- Clogher Golagh for the loss of Clogher Drumkeen
  For Area B
- Glenree Moy for the loss of Bellacorick Castlebar
- Bellacorick Castlebar for the loss of Cunghill Sligo
- Castlebar Cloon for the loss of Cashla Dalton
- Intact network flows on Galway busbar

5.6 Results by Node (Subgroups)

There is a post-processing step between the Plexos simulation and this report and it involves the identification of subgroups. Subgroups are those groups of stations, where the expected constraints are likely to be similar and are presented as such in the reports.

For Area C, the respective subgroups for solar and wind are set out in Table 5-6.

Subgroup **ABC SOLAR North**	**Subgroup** **ABC SOLAR South**	**Subgroup** **A and C north for WIND**	**Subgroup** **C South for WIND**
Mount Dillon	Athlone	Lanesboro	Dallow
Carrick on Shannon	Dallow	Sliabh Bawn	Lumcloon
Corderry in Area A	Lanesboro	**All Wind in Area A**	Somerset
Dalton in Area B	Mullingar	Sligo in Area B	
Moy in Area B	Richmond		
	Shannonbridge		
	Somerset		
	Cloon in Area B		
	Shantallow in Area B		

Table 5-6 Subgroups in Area C for Solar and Wind

The results for Area C are provided in Table 5-7. The breakdown between curtailment and constraint are shown in the figures on the following pages.

		SOLAR		WIND	
Gen Scenario	**Study Year**	**Subgroup ABC Solar North**	**Subgroup ABC Solar South**	**Subgroup C north**	**Subgroup C south for Wind**
March 2020	2020			10%	3%
	2021			10%	2%
	2022			9%	2%
	Industry			1%	3%
Initial	2020			11%	3%
	2021			11%	3%
	2022			11%	2%
	Industry			1%	4%
North West	2020	24%	6%	25%	6%
	2021	25%	6%	26%	5%
	2022	22%	5%	24%	4%
	Industry	4%	2%	4%	5%
33%	2020	15%	4%	16%	7%
	2021	16%	5%	17%	7%
	2022	13%	4%	16%	4%
	Industry	2%	2%	3%	7%
66%	2020	18%	7%	21%	12%
	2021	19%	8%	22%	11%
	2022	18%	6%	21%	8%
	Industry	4%	6%	7%	12%
All	2020	24%	11%	26%	17%
	2021	24%	11%	26%	17%
	2022	24%	10%	25%	13%
	Industry	33%	11%	32%	13%
Gen Shallow		8%	11%	12%	17%
Future Grid		8%	2%	3%	2%
Industry Future Grid		7%	2%	3%	2%

Table 5-7 Combined Curtailment and Constraint by Subgroup in Area C

Subgroups: Solar

There is a 90 MW solar park at Mount Dillon looping into the Sliabh Bawn – Lanesboro 110kV circuit. The rating of this circuit is 99/110/121 MVA for summer / autumn / winter ratings. The combination of the circuit rating, the local contingencies and the size of the solar generation means that solar generation north of Mount Dillon sees different levels of constraints than solar generation in the rest of Area C.

Subgroups: Wind

The combined wind power output of Areas A, B and C tends to hit a transmission boundary at Lanesboro Mullingar. However, wind generators located in the south of Area C can export their power on different circuits. Hence, these generators see different levels of constraint and are in a separate subgroup.

Results for Area C - Solar

There are two subgroups for solar in Area C. Solar in the north of Area C gets higher "curtailment and constraint". This is because a 90 MW park is connecting into the Lanesboro – Sliabh Bawn circuit, which has a relatively low rating. Consequently, generators north of Mount Dillon see higher constraints than the other solar in Area C.

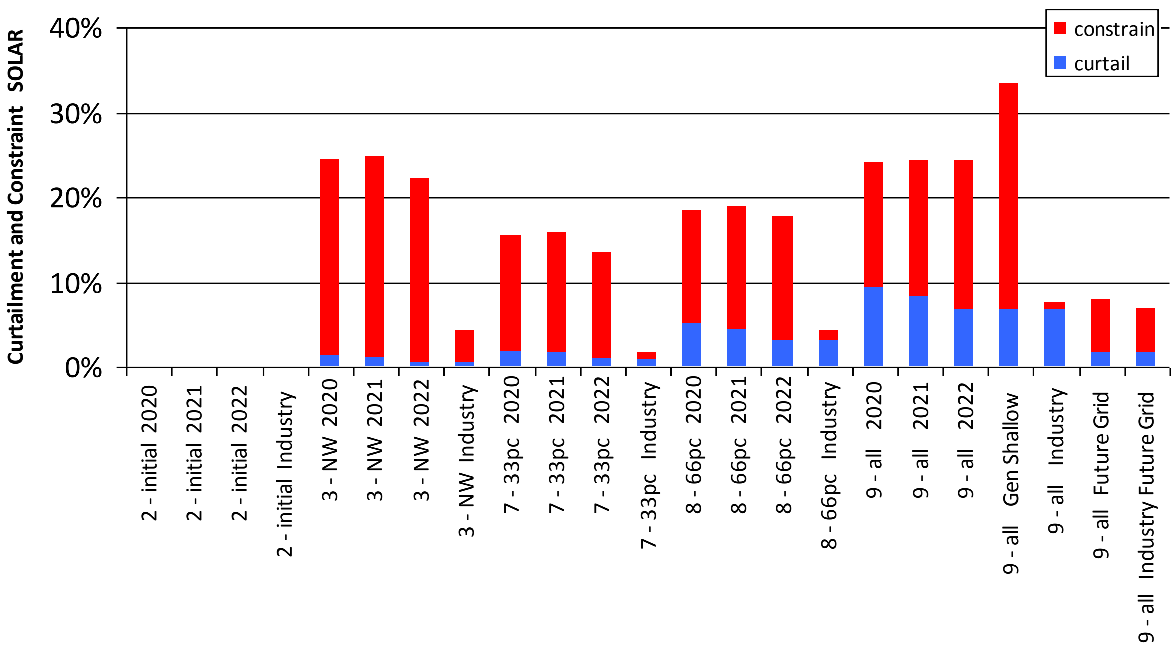


Figure 5-3 Results SOLAR – subgroup C north

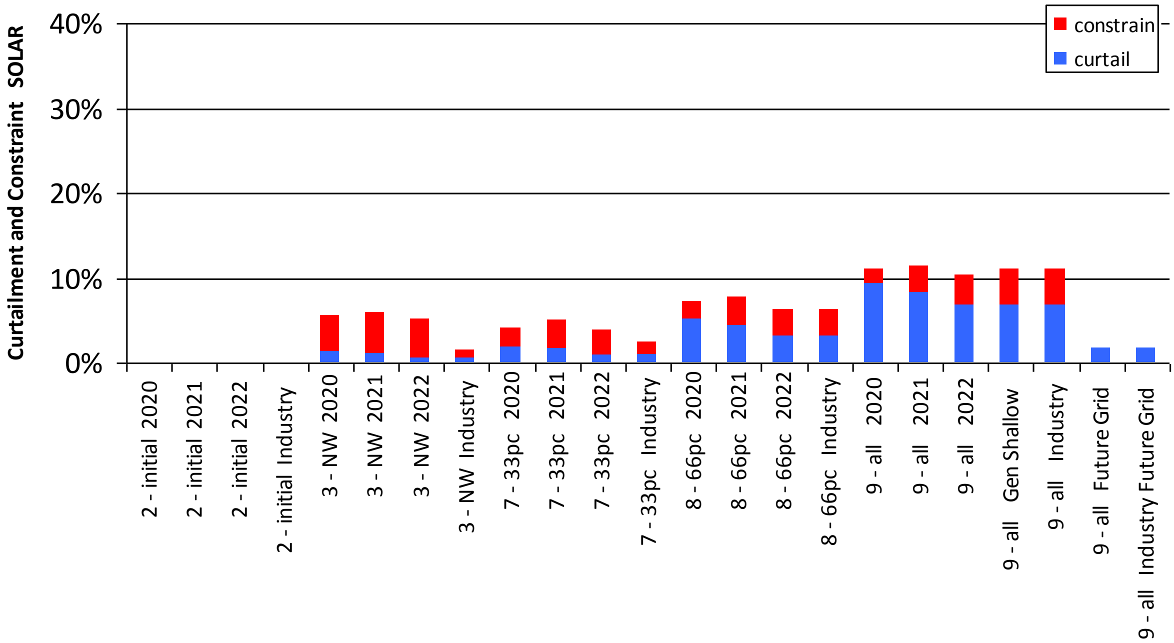


Figure 5-4 Results SOLAR – subgroup C south

<u>Results for Area C - Wind</u>

In the south of the area, wind sees "curtailment and constraint" that is similar to what was achieved in Area H1 and Area J. This is because electrically, these locations are connected to Area H1 and Area J.

Wind in the north of Area C gets noticeably higher "curtailment and constraint". This is because most of the combined generation from Areas A, B and C meets the most frequently binding transmission boundary at Lanesboro and Mullingar in Area C.

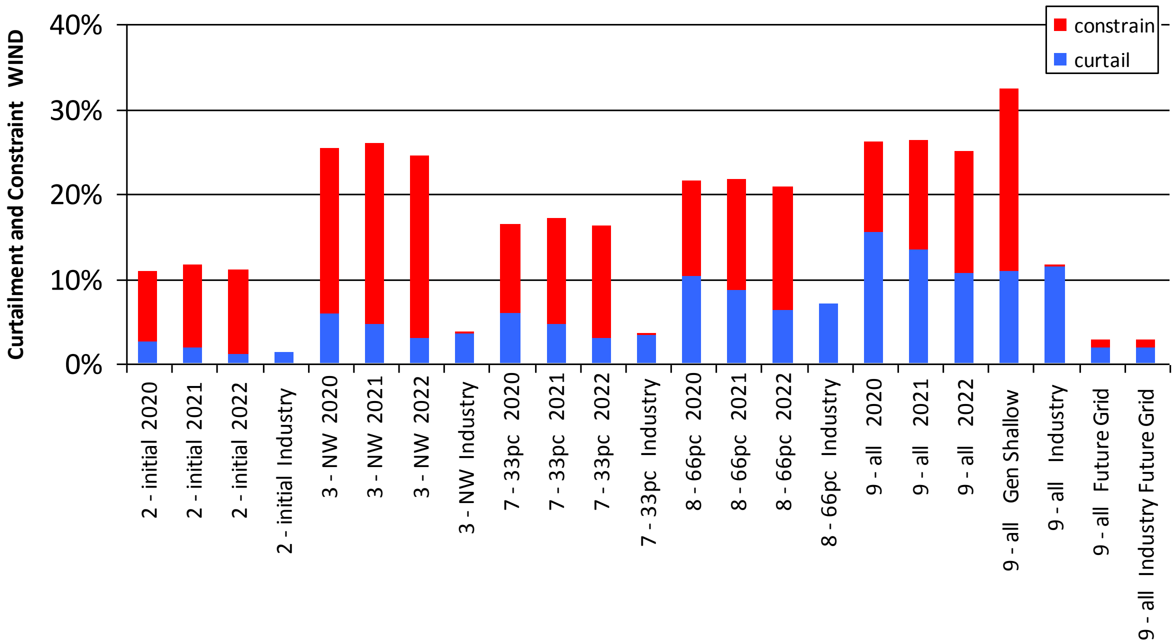


Figure 5-5 Results WIND – subgroup A and C north

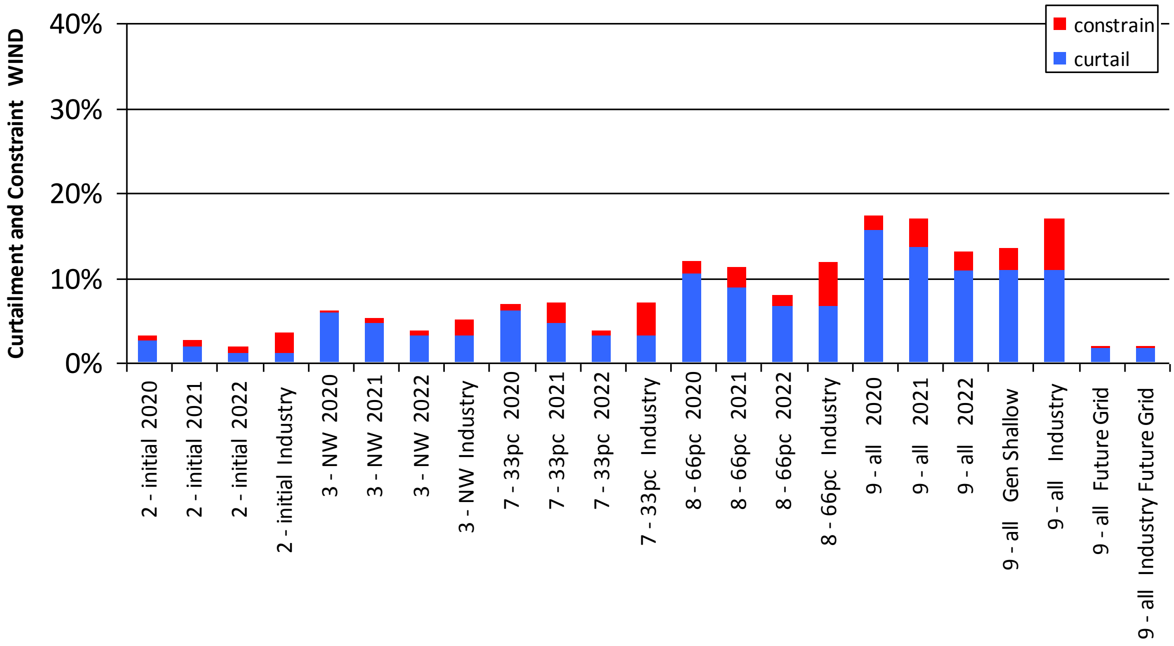


Figure 5-6 Results WIND – subgroup C south

5.7 Future Grid

While preparing for this report, the wind and solar developers requested the inclusion of a study including a number of projects beyond the time horizon of this report. For this reason, a Future Grid scenario is performed which includes a variety of projects that are well beyond the timeframe of this report. The study uses Generation Scenario All and takes the 2022 year as a starting point before adding additional reinforcements and future DS3 assumptions.

This study is not intended as an indication to individual generators that their curtailment and constraints will change to the indicated levels. Rather, it is a signal of the types and variety of projects which would be required to reduce curtailment and constraints for the Generation portfolio in this report. In addition, this study is not intended to be exhaustive and it is not intended to remove all transmission constraints. The reinforcements used, in addition to those in study year 2022, are listed in Appendix A.

The reference case and the Future Grid scenario have the same generation and have the same demand so the difference between the two curves is due to the added projects.

Results – Future Grid

The study finds that the cumulative impact of these projects is a noticeable reduction in the curtailment and constraint. It should be noted that this Future Grid scenario has not studied each project individually, so it is not possible to comment on the individual impact of each project.

A lot of the improvement is due to the interconnector projects; Celtic, Greenlink, and the forecast capacity increase on Moyle. The interconnectors reduce curtailment. As modelled in this report, it is assumed that the countries on the other side of the interconnectors will normally be able to take the surplus renewable power from Ireland. Curtailment is also reduced by the expected DS3 improvements. The line uprates, the series compensations, the new circuits and the forecast system demand also contribute to reducing curtailment and constraint.

The following possible reinforcements, or some equivalent, are also important for Areas A, B and C. These are the North Connaught project, the Lanesboro Mullingar uprate, the Lanesboro station uprate and the Lanesboro – Mount Dillon – Sliabh Bawn uprate.

5.7.1 Industry Future Grid - Revised Report

EirGrid received feedback from industry on the original report that the Future Grid scenario did not include four reinforcements that are Associated Transmission Reinforcements (ATRs) for existing generators.

These are

- Uprate Castlebar Dalton 110
- Uprate Castlebar Cloon 110
- Uprate Cashla Dalton 110
- Uprate Flagford – Sliabh Bawn 110

So, an extra scenario is now presented with these additional four reinforcements, and with uprate Louth Ratrussan 110 and with a second Srananagh 220/110 transformer. This is the Industry Future Grid scenario.

Overall, the constraints in the North West reduce with these extra reinforcements. This shows the benefit of these reinforcements.

5.8 Conclusion - Results for Area C

This chapter provides an overview of the curtailment and constraint forecast values for Area C for a range of scenarios based on a number of installed generation assumptions (generation scenarios) and on the study year (network and demand assumptions).

The forecast values in this report are an indication of constraints based on a given set of assumptions and inputs, rather than any form of assurance or guarantee. The report is useful in comparing the expected performance in different locations and informing developers in locating future projects.

The results depend on the study assumptions which are described in this report.

Appendix C contains the detailed results consisting of energy (GWh) and percentage curtailment and constraint values for each node for both solar and wind in Area C.

5.8.1 Tables of Results for parts of Subgroups in Area C

The installed MW, available energy GWh, and percentage results for each subgroup are provided in the tables below.

ABC Solar North	Year	2020	Initial	Generation Scenarios NW	33%	66%	All
Total (MW)		0	0	146	48	96	146
of which is Controllable (MW)		0	0	146	48	96	146
Available Energy Controllable (GWh)		0	0	139	46	92	139
Curtailment (GWh)	2020			2	1	5	13
	2021			1	1	4	12
	2022			1	0	3	9
Constraint (GWh)	2020			32	6	12	20
	2021			33	7	13	22
	2022			30	6	13	24
Curtailment and Constraint (GWh)	2020			34	7	17	34
	2021			34	7	17	34
	2022			31	6	16	34
Curtailment	2020			1%	2%	5%	9%
	2021			1%	2%	4%	8%
	2022			1%	1%	3%	7%
	Gen Shallow						7%
	Industry			1%	1%	3%	7%
Constraint	2020			23%	14%	13%	15%
	2021			24%	14%	15%	16%
	2022			22%	12%	14%	17%
	Gen Shallow						27%
	Industry			4%	1%	1%	1%
Curtailment and Constraint	2020			24%	15%	18%	24%
	2021			25%	16%	19%	24%
	2022			22%	13%	18%	24%
	Gen Shallow						33%
	Industry			4%	2%	4%	8%
	Future Grid						8%
	Industry Fut Grid						7%

Table 5-8 Results for Subgroup Solar North (Carrick on Shannon and Mount Dillon in Area C)

ABC Solar South	Year	Generation Scenarios					
		2020	Initial	NW	33%	66%	All
Total (MW)	2020 to 2022	0	0	176	58	116	176
of which is Controllable (MW)	2020 to 2022	0	0	176	58	116	176
Available Energy Controllable (GWh)	2020 to 2022	0	0	172	57	113	172
Curtailment (GWh)	2020			2	1	6	16
	2021			2	1	5	14
	2022			1	1	4	12
Constraint (GWh)	2020			7	1	2	3
	2021			8	2	4	5
	2022			8	2	3	6
Curtailment and Constraint (GWh)	2020			9	2	8	19
	2021			10	3	9	20
	2022			9	2	7	18
Curtailment	2020			1%	2%	5%	9%
	2021			1%	2%	4%	8%
	2022			1%	1%	3%	7%
	Gen Shallow						7%
	Industry			1%	1%	3%	7%
Constraint	2020			4%	2%	2%	2%
	2021			5%	3%	3%	3%
	2022			4%	3%	3%	4%
	Gen Shallow						4%
	Industry			1%	1%	3%	4%
Curtailment and Constraint	2020			6%	4%	7%	11%
	2021			6%	5%	8%	11%
	2022			5%	4%	6%	10%
	Gen Shallow						11%
	Industry			2%	2%	6%	11%
	Future Grid						2%
	Industry Fut Grid						2%

Table 5-9 Results for Subgroup Solar C South

WIND AREA C NORTH Many studies, with Area A, and Sligo in Area B	Year	Generation Scenarios 2020	Initial	NW	33%	66%	All
Total (MW)	2020 to 2022	701	726	949	800	873	949
	with Shallow Reinforce			979	810	895	979
of which is Controllable (MW)	2020 to 2022	565	583	796	653	723	796
	with Shallow Reinforce			826	664	745	826
Available Energy Controllable (GWh)	2020 to 2022	1,649	1,709	2,314	1,908	2,108	2,314
	with Shallow Reinforce			2,401	1,940	2,170	2,401
Curtailment (GWh)	2020	43	45	141	114	225	373
	2021	31	32	110	88	188	323
	2022	19	20	70	57	133	246
Constraint (GWh)	2020	115	142	468	203	241	257
	2021	136	164	512	242	281	308
	2022	135	169	497	252	304	332
Curtailment and Constraint (GWh)	2020	158	187	609	318	467	630
	2021	167	196	622	331	469	631
	2022	154	188	567	310	437	578
Curtailment	2020	3%	3%	6%	6%	10%	15%
	2021	2%	2%	5%	5%	9%	13%
	2022	1%	1%	3%	3%	6%	11%
	Gen Shallow						11%
	Industry	1%	1%	3%	3%	7%	11%
Constraint	2020	7%	8%	19%	10%	11%	11%
	2021	8%	10%	21%	13%	13%	13%
	2022	8%	10%	21%	13%	14%	14%
	Gen Shallow						22%
	Industry	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
Curtailment and Constraint	2020	10%	11%	25%	16%	21%	26%
	2021	10%	11%	26%	17%	22%	26%
	2022	9%	11%	24%	16%	21%	25%
	Gen Shallow						32%
	Industry	1%	1%	4%	3%	7%	12%
	Future Grid						3%
	Industry Fut Grid						3%

Table 5-10 Results for A and C North Wind (Lanesboro and Sliabh Bawn in Area C)

WIND AREA C SOUTH	Year	Generation Scenarios 2020	Initial	NW	33%	66%	All
Total (MW)		29	29	78	45	60	78
of which is Controllable (MW)		10	10	59	26	42	59
Available Energy Controllable (GWh)		28	28	181	78	129	181
Curtailment (GWh)	2020	0.7	0.7	10.8	4.7	13.7	28.5
	2021	0.5	0.5	8.4	3.7	11.4	24.8
	2022	0.3	0.3	5.8	2.5	8.4	19.8
Constraint (GWh)	2020	0.1	0.2	0.3	0.6	1.7	3.1
	2021	0.2	0.2	0.8	1.8	3.2	5.8
	2022	0.2	0.2	0.7	0.5	1.8	3.9
Curtailment and Constraint (GWh)	2020	0.9	0.9	11.1	5.4	15.4	31.6
	2021	0.7	0.7	9.2	5.4	14.6	30.6
	2022	0.5	0.5	6.5	2.9	10.3	23.7
Curtailment	2020	3%	3%	6%	6%	11%	16%
	2021	2%	2%	5%	5%	9%	14%
	2022	1%	1%	3%	3%	7%	11%
	Gen Shallow						11%
	Industry	1%	1%	3%	3%	7%	11%
Constraint	2020	1%	1%	0%	1%	1%	2%
	2021	1%	1%	0%	2%	2%	3%
	2022	1%	1%	0%	1%	1%	2%
	Gen Shallow						3%
	Industry	2%	2%	2%	4%	5%	6%
Curtailment and Constraint	2020	3%	3%	6%	7%	12%	17%
	2021	2%	3%	5%	7%	11%	17%
	2022	2%	2%	4%	4%	8%	13%
	Gen Shallow						13%
	Industry	3%	4%	5%	7%	12%	17%
	Future Grid						2%
	Industry Future Grid						2%

Table 5-11 Results for Subgroup C South for Wind

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Appendix A Network Reinforcement

A.1 Introduction to Revised Reinforcement List

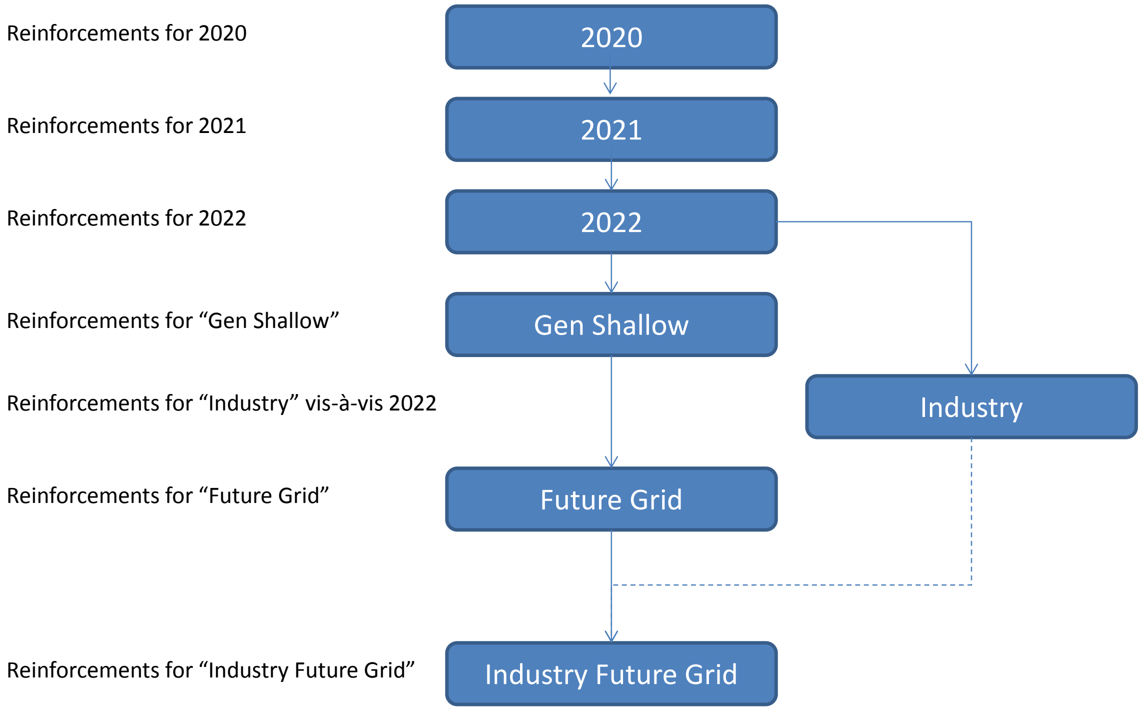

Figure 7 Reinforcement Overview

There are three reasons why this revised version of the report is now being released. The first reason is that the 2022 study year now includes a proposed special protection scheme in Mayo.

Second, the expected delivery dates of some reinforcements have been adjusted in the recent ATR publication on the EirGrid website. The only change to this constraint report is that the Arva - Carrick on Shannon uprate is now introduced in "Future Grid" rather than in 2022.

Thirdly, EirGrid offered industry representatives an additional study for the north west. As a result there are now some additional scenarios.

An overview of the reinforcements is shown in Figure 7.

Please note that the 2020 and 2021 results have not been recalculated for this report.

A.2 Reinforcements in 2020

Project Type	Project
	Included in Model from 2020
DS3 Programme	SNSP 75% 65% at present.
DS3 Programme	Inertia 17500 23000 at present
New Build	Belcamp 220 kV station
New Build	Castlebaggot 220 kV station
New Build	Clashavoon Macroom 110 circuit 2
New Build	Mount Lucas – Thornsberry 110
New Build	Loop Kilpaddoge into Tarbert Tralee 110 circuit 1
Uprate	Dunstown T4202 to 528 MVA
Uprate	Clashavoon T2101 to 278 MVA
Uprate now complete	Great Island – Wexford 110 to 178 / 194 / 209 MVA
Uprate	Corduff Ryebrook 110 to 184 / 198/ 198 MVA
Station	Thornsberry busbar and bay conductor uprate To give Derryiron Thornsberry uprate to 104 / 113 / 122 MVA

Table A-0-1 Reinforcements for 2020

A.3 Reinforcements in 2021

Project Type	Project
	Included in Model from 2021
New Build	Kilpaddoge Knockanure 220 circuit 2
New Build	Belcamp Shellybanks 220
New Build	Loop Kilpaddoge into Killonan Tarbert 220
New Build	Clashavoon Dunmanway 110
Uprate	Ballynahulla Knockanure 220 to 513 / 643 / 716 MVA
Uprate	Ballynahulla Ballyvouskil 220 to 519 / 643 / 716 MVA
Uprate	Bellacorick Moy 110 to 178 / 197 / 197 MVA
Uprate	Corderry Srananagh 110 to 178 / 197 / 197 MVA
Uprate	Laois Portlaoise 110 to 178 / 197 / 197 MVA
Uprate	Ardnacrusha Singland to 110 178 / 193 / 210 MVA *uprate in Ardnacrusha station*
Uprate	Arklow Ballybeg 110 to 133 / 148 / 159 MVA *uprate in Arklow station*
Uprate	Cloon Lanesboro 110 to 99 / 111 / 122 MVA *restore rating on this circuit*
Uprate	Flagford Louth 220 to 433 / 473 / 513 MVA *restore rating on this circuit*
Station	Castlebar busbar uprate
Station	Moy busbar uprate For uprate Glenree Moy to 104/113/122 MVA
Station	Wexford busbar uprate
Reactive Support	Thurles STATCOM
Special Protection Scheme	Galway temporary SPS until new Galway 110 station
Transformer	Retire Knockraha T2103

Table A-0-2 Additional Reinforcements for 2021

A.4 Reinforcements in 2022

Project Type	Project
	Included in Model from 2022
New Build	Laois 400 kV station (Coolnabacky)
New Build	Ballyragget Kilkenny 110
New Build	Ballyragget Laois 110
Uprate	Great Island – Kilkenny 110 to 178 / 197 / 197 MVA
Uprate	In Maynooth station, uprate the Derryiron bay conductor, dropper, etc. To give Derryiron Maynooth uprate to 103 / 132 / 156 MVA Timahoe North new station will loop into this circuit.
Station	Knockraha station reconfiguration and short circuit mitigation
Station	Kilkenny busbar uprate
Special Protection Scheme	Bellacorick SPS

Table A-0-3 Additional Reinforcements for 2022

A.5 Reinforcements in Gen Shallow

Project Type	Project
	Included in "Generation Shallow"
New Build	North Connaught
New Build	New 110 kV station at Galway
Uprate	In Maynooth station, uprate the Derryiron bay conductor, dropper, etc. To give Derryiron Maynooth uprate to 103 / 132 / 156 MVA Timahoe North new station will loop into this circuit.
Uprate	Glenree Moy 110 to 178 / 197 / 197 MVA
Uprate	Binbane – Cathaleen's Fall 110 to 178 / 197 / 197 MVA
Uprate	Uprate the overhead line portion of Cashla Salthill 110 to give A line rating for Cashla Salthill of 97 / 97 / 97 MVA And a significant overload capability as per the cable overload capability

Table A-0-4 Additional Reinforcements for Gen Shallow

A.6 Reinforcements in Future Grid

Project Type	Project
	Included in Future Grid scenario
Demand	2022 Demand used for this study
DS3 Programme	Reserve provided from alternative sources (batteries, etc.)
DS3 Programme	SNSP 80%
DS3 Programme	Large Generator Must Run (4 in Ireland, 2 in Northern Ireland) Before this (5 in Ireland, 3 in Northern Ireland)
New Build	North-South 400 kV interconnector
New Build	Project 966 For this study, modelled as a Dunstown Woodland 400 kV circuit.
New Build	Srananagh T2101
Station	Sectionalise Knockranny 110 station
Interconnector	Celtic 700 MW to France
Interconnector	Moyle export capability of 500 MW
Interconnector	Greenlink 500 MW to Britain
Series Compensation	Dunstown Laois 400
Series Compensation	Moneypoint Laois 400
Series Compensation	Oldstreet Woodland 400
Uprate	Flagford Sligo 110 to 178 / 197 / 197 MVA
Uprate	Lanesboro – Sliabh Bawn 110 to 178 / 197 / 197 MVA
Uprate	Gorman Platin 110 to 178 / 197 / 197 MVA
Uprate	Lisheen Thurles 110 to 178 / 197 / 197 MVA
Uprate	Dunmanway Bandon 110 to 178 / 197 / 197 MVA
Uprate	Bandon Raffeen 110 to 178 / 197 / 197 MVA
Station	Bandon busbar uprate
Station	Maynooth station reconfiguration

Project Type	Project
Station	Letterkenny busbar uprate For Drumkeen Letterkenny, no change For Letterkenny – Golagh T uprate to 103/113/122
Station	Lanesboro busbar uprate
Reactive Support	Ballynahulla STATCOM
Reactive Support	Ballyvouskil STATCOM
Reactive Support	Knockanure reactor
Uprate	Arklow Ballybeg 110 to 178 / 197 / 197 MVA
Uprate	Ballybeg Carrickmines 110 to 178 / 197 / 197 MVA
Uprate	Aghada Knockraha 220 circuit 1 to 433/ 472 / 512 MVA
Uprate	Aghada Knockraha 220 circuit 2 to 433/ 472 / 512 MVA
Uprate	Gorman Maynooth 220 to 433/ 472 / 512 MVA
Uprate	Maynooth – Blake T to 134 / 148 / 159 MVA
Uprate	Maynooth Woodland 220 to 434 / 472 / 472 MVA
Uprate	Arva – Carrick on Shannon 110 to 178 / 197 / 197 MVA
Uprate	Lanesboro Mullingar 110 to 178 / 197 / 197 MVA
Uprate	Derryiron Maynooth 110 to 178 / 197 / 197 MVA

Table A-0-5 Additional Reinforcements for Future Grid scenario

There are projects beyond the time frame for this study that will reduce curtailment and constraints. The more significant of these projects are already being progressed (DS3 Programme, Celtic Interconnector, North South Interconnector, Series Compensation of 400 kV network, new Galway 110 kV station, North Connaught, etc.) and others are in preparation. Information about approved reinforcements is available on the EirGrid website.

For the Future Grid scenario, there are three types of project included for a future well beyond the timeframe of this report. These include DS3 projects, interconnection and transmission reinforcement.

SNSP, Conventional Must Run, Etc.

For this study, SNSP was increased to 80%, it is assumed that reserve was provided from alternative sources the number of must run large conventional units was reduced. These modelling assumptions go beyond the present programme for DS3.

Interconnection

There are three interconnector projects assumed. The first is that the export capacity of Moyle would increase to 500 MW. The second is an assumption of a Celtic interconnector to France and the third is the assumption of a Greenlink interconnector to Britain.

Transmission Reinforcement

There are twenty nine extra transmission reinforcements included in the Future Grid scenario compared with the 2022 Year. The study uses a mix of approved projects (albeit due beyond 2022) and a limited number of other projects which, from the constraint analysis only, appear to warrant inclusion.

As a simplification for the modelling in this scenario only, it is assumed that where a 110 kV circuit rating is the constraint, that the project to resolve it is to uprate the existing circuit. The uprate of a 110 kV circuit is frequently a major and expensive undertaking and these projects may not be implemented in this way. Customers should recognise that the reinforcements listed will be subject to a full economic analysis and optimisation process before a decision is made to proceed with them.

Also, this Future Grid scenario is not intended to be a plan to identify all the reinforcements necessary to solve all the transmission constraints in an area. Consequently, even with the reinforcements selected, there are still some new transmission constraints and these are visible in the findings.

A.7 Reinforcements in Industry

Project Type	Project
	Included in "Industry" scenario
	These are in addition to the reinforcements in 2022. **A lot (but not all) the reinforcements from Gen Shallow and from Future Grid are included here.** **In addition, some reinforcements here are not in Gen Shallow or Future Grid.**
Uprate	Arva - Carrick on Shannon 110 to 178 / 197 / 197 MVA
Uprate	Flagford Sligo 110 to 178 / 197 / 197 MVA
Uprate	Lanesboro - Sliabh Bawn 110 to 178 / 197 / 197 MVA
Uprate	Lanesboro Mullingar 110 to 178 / 197 / 197 MVA
Uprate	Glenree Moy 110 to 178 / 197 / 197 MVA
Uprate	Uprate the overhead line portion of Cashla Salthill 110 to give A line rating for Cashla Salthill of 97 / 97 / 97 MVA And a significant overload capability as per the cable overload capability
Uprate	Castlebar Cloon 110 to 178 / 197 / 197 MVA
Uprate	Castlebar Dalton 110 to 178 / 197 / 197 MVA
Uprate	Cashla Dalton 110 to 178 / 197 / 197 MVA
Uprate	Flagford - Sliabh Bawn 110 to 178 / 197 / 197 MVA
Uprate	Binbane – Cathaleen's Fall 110 to 178 / 197 / 197 MVA
Uprate	Louth Ratrussan 110 to 178 / 197 / 197 MVA
New Build	New 110 kV station at Galway
New Build	Srananagh T2101
Station	Letterkenny busbar uprate For Drumkeen Letterkenny, no change For Letterkenny – Golagh T uprate to 103/113/122
Station	Lanesboro busbar uprate For Lanesboro Mullingar (see above) For Lanesboro – Sliabh Bawn (see above)
Station	Sectionalise Knockranny 110 station

Table A-0-6 Additional Reinforcements for Industry Scenario

A.8 Reinforcements in Industry Future Grid

Project Type	Project
	Included in "Industry Future Grid" scenario
	These are in addition to the reinforcements in "Future Grid".
Uprate	Castlebar Cloon 110 to 178 / 197 / 197 MVA
Uprate	Castlebar Dalton 110 to 178 / 197 / 197 MVA
Uprate	Cashla Dalton 110 to 178 / 197 / 197 MVA
Uprate	Flagford Sliabh Bawn 110 to 178 / 197 / 197 MVA
Uprate	Louth Ratrussan 110 to 178 / 197 / 197 MVA
New Build	Srananagh T2101

Table A-0-7 Additional Reinforcements for "Industry Future Grid" scenario

Appendix B Generator

Generator information is in this Appendix as follows.

- Overview by Type
- Generator Type by Node for All Offers
- Generator List by Name
- Generation Type by Node for each Study Scenario

B.1 Generator Type for each Generation Scenario

	Initial	north west	south	north east	33%	66%	All
battery		278	141	210	210	420	629
inertia				4	1	3	4
solar		322	1023	1049	798	1597	2395
new thermal	20	76	63	68	68	119	167
wave	10	10	15	10	12	14	15
wind	4212	4891	4805	4761	4820	5424	6035
Total	**4242**	**5577**	**6047**	**6102**	**5909**	**7577**	**9245**

B.2 Generator Type by Area for each Generation Scenario

	Initial	north west	south	north east	33%	66%	All
battery		**278**	**141**	**210**	**210**	**419**	**629**
B		15			5	10	15
C		263			88	175	263
E			46		15	31	46
G				143	48	95	143
H2			95		32	63	95
J				67	22	45	67
inertia				**4**	**1**	**3**	**4**
J				4	1	3	4
solar		**322**	**1023**	**1049**	**798**	**1597**	**2395**
A		40			13	26	40
B		67			22	44	67
C		215			71	142	215
D			24		8	16	24
E			221		74	147	221
F			24		8	16	24
G				290	96	192	290
H1			167		55	110	167
H2			399		133	266	399
I			66		22	44	66
J				759	250	506	759
K			122		40	80	122

	Initial	north west	south	north east	33%	66%	All
new thermal	**20**	**76**	**63**	**68**	**68**	**119**	**167**
B		51			17	34	51
C		5			2	3	5
E			2		1	1	2
F	16	16	18	16	16	18	18
G				20	7	13	20
H2			33		11	22	33
I			4		1	3	4
J	4	4	4	32	13	23	32
K			2		1	1	2
wave	**10**	**10**	**15**	**10**	**12**	**14**	**15**
B	10	10	10	10	10	10	10
D			5		2	4	5
wind	**4212**	**4891**	**4805**	**4761**	**4820**	**5424**	**6035**
A	638	882	638	638	718	799	882
B	616	992	616	616	743	869	992
C	91	150	91	91	111	130	150
D	262	262	309	262	278	293	309
E	1400	1400	1550	1400	1452	1500	1552
F	147	147	250	147	181	215	250
G	174	174	174	578	308	444	578
H1	441	441	680	441	520	599	680
H2	322	322	342	322	329	336	342
I	6	6	6	6	6	6	6
J	88	88	88	233	136	184	233
K	27	27	61	27	38	49	61

B.3 Generator Type by Node for All Offers

	battery	inertia	solar	Thermal new	wave	Wind	Total
A			**40**			**882**	**922**
Ardnagappary						18	18
Arigna						16	16
Binbane						81	81
Carrickaduff and Carrickalangan						138	138
Cathaleen's Fall						23	23
Corderry			40			63	103
Garvagh						82	82
Golagh						15	15
Gortawee						3	3
Lenalea						31	31
Letterkenny						90	90
Meentycat						85	85
Mulreavy						95	95
Sorne Hill						67	67
Tievebrack						30	30
Trillick						45	45
B	**15**	**0**	**67**	**51**	**10**	**994**	**1137**
Bellacorick	3				10	310	323
Castlebar						44	44
Cloon			24			4	28
Cunghill						35	35
Dalton	12		4			43	59
Firlough (was Carrowleagh-Kilbride)						48	48
Glenree						78	78
Knockranny						156	156
Moy			4			6	10
Salthill						44	44
Shantallow into Cashla Somerset T			35				35
Sligo						14	14
Tawnaghmore				49		30	79
Tonroe				2		12	14
Uggool						170	170
C	**263**		**215**	**5**		**150**	**633**
Athlone			12				12
Carrick on Shannon			8			4	12
Dallow			8			24	32
Lanesboro			4			10	14
Lumcloon	100					34	134
Mount Dillon into Lanesboro Sliabh Bawn			90				90
Mullingar			12				12

	battery	inertia	solar	Thermal new	wave	Wind	Total
Richmond			12	5			17
Shannonbridge			65				65
Shannonbridge 220	163						163
Sliabh Bawn						58	58
Somerset			4			20	24
D			**24**		**5**	**309**	**338**
Ardnacrusha			8			8	16
Booltiagh						140	140
Derrybrien						60	60
Drumline			12				12
Ennis			4				4
Slievecallan						71	71
Tullabrack					5	31	36
E	**46**		**221**	**2**		**1552**	**1821**
Athea						102	102
Aughinish			50				50
Boggeragh						169	169
Charleville			30	2		70	102
Clahane			34			52	86
Cloghboola						101	101
Coomagearlahy						81	81
Coomataggart						178	178
Cordal						148	148
Dromada						29	29
Drombeg loop into Kilpaddoge Tralee 2			50				50
Garrow						74	74
Glanlee						30	30
Glenlara			5			26	31
Glenlara_wind connected via Ballynahulla 220						41	41
Kilpaddoge	30					60	90
Knockacummer						100	100
Knockearagh			9			14	23
Limerick			4				4
Mallow			19				19
Moneypoint	8					17	25
Oughtragh			4			9	13
Rathkeale			4			32	36
Reamore	8					98	106
Tralee			8			48	56
Trien			4			27	31
Trien_wind connected via Knockanure 220						46	46
F			**24**	**18**		**250**	**292**

	battery	inertia	solar	Thermal new	wave	Wind	Total
Ballylickey						60	60
Bandon			20	17		13	50
Dunmanway						153	153
Macroom			4	1		24	29
G	**143**		**290**	**20**		**578**	**1028**
Baltrasna			20				20
Drybridge			19	3		6	28
Dundalk			4			34	35
Gaskinstown into Drybridge Hawkinstown			85				85
Gillinstown into Gorman Platin			95				95
Gorman	50					120	170
Hawkinstown into Baltrasna-Dry			50				50
Lisdrum	60					33	93
Meath Hill	33			4		69	106
Navan			13	13			26
Oriel						210	210
Ratrussan						79	79
Shankill			4			28	32
H1			**167**			**680**	**847**
Ahane			8				8
Ballydine			7				7
Barrymore			10			32	42
Cahir			36				36
Cauteen						182	182
Doon			8			17	25
Ikerrin			30			36	66
Kill Hill						36	36
Killonan						141	141
Lisheen						127	127
Mothel into Ballydine Cullenagh			60				60
Nenagh			4			62	66
Thurles						42	42
Tipperary			4			5	9
H2	**95**		**399**	**33**		**342**	**869**
Arklow			14			80	94
Ballybeg			8				8
Ballywater						42	42
Banoge	9		8				17
Bullockhill into Ballyragget-KK			50				50
Carlow			8			55	63
Castledockrell						41	41
Crane	16		13			7	36
Crory			16			60	76
Great Island	30		17	33			80

	battery	inertia	solar	Thermal new	wave	Wind	Total
Kilkenny	40		24				64
Rosspile into GI-Wex			95				95
Stratford			4				4
Tullabeg into Banoge Crane			50				50
Waterford			4			19	23
Wexford			88			39	127
I			**65**	**4**		**6**	**75**
Barnahely			5			5	10
Castleview				4			4
Coolroe			20				20
Cow Cross			5				5
Kilbarry			10				10
Midleton			17			2	19
Trabeg			9				9
J	**67**	**4**	**759**	**32**		**233**	**1095**
Athy	8		9				17
BLAKE			86				86
Blundelstown into Cdu-Mul			80				80
Clonfad into Kinn-Mul			100				100
College Park		4					4
Coolnabacky			55				55
Cushaling						100	100
Derryiron	20			18			38
Dunfirth			18				18
Finglas			20	4			24
Gallanstown Muckerstown into Corduff Platin			119				119
Glasmore			4				4
Grange Castle			16				16
Griffinrath			45				45
Harristown			42				42
Kilteel	30		15				45
Monread			8				8
Mount Lucas						79	79
Newbridge			16				16
Portlaoise			8			54	62
Stephenstown	9		5				14
Thornsberry			8	10			18
Timahoe North into Maynooth Derryiron			70				70
Treascon into Bracklone Portlaoise			40				40
K			**122**	**2**		**61**	**185**
Butlerstown			4	2		2	8
Dungarvan			23			5	28
Rathnaskilloge into Cullenagh			95				95

	battery	inertia	solar	Thermal new	wave	Wind	Total
Dungarvan							
Woodhouse						54	54

B.4 Generator Type by Node for each Generation Scenario

			Gen Installed Scenarios						
node	type	area	Initial	north west	south	north east	33%	66%	ALL offers
Ahane	solar	H1			8		3	5	8
Ardnacrusha	solar	D			8		3	5	8
Ardnacrusha	wind	D	8	8	8	8	8	8	8
Ardnagappary	wind	A	18	18	18	18	18	18	18
Arigna	wind	A	16	16	16	16	16	16	16
Arklow	solar	H2			14		5	9	14
Arklow	wind	H2	80	80	80	80	80	80	80
Athea	wind	E	34	34	102	34	57	79	102
Athlone	solar	C		12			4	8	12
Athy	battery	J				8	3	5	8
Athy	solar	J				9	3	6	9
Aughinish	solar	E			50		17	33	50
Ballybeg	solar	H2			8		3	5	8
Ballydine	solar	H1			7		2	5	7
Ballylickey	wind	F	60	60	60	60	60	60	60
Ballywater	wind	H2	42	42	42	42	42	42	42
Baltrasna	solar	G				20	7	13	20
Bandon	solar	F			20		7	13	20
Bandon	thermal	F	16	16	17	16	16	17	17
Bandon	wind	F	13	13	13	13	13	13	13
Banoge	battery	H2			9		3	6	9
Banoge	solar	H2			8		3	5	8
Barnahely	solar	I			5		2	3	5
Barnahely	wind	I	5	5	5	5	5	5	5
Barrymore	solar	H1			10		3	7	10
Barrymore	wind	H1	32	32	32	32	32	32	32
Bellacorick	battery	B		3			1	2	3
Bellacorick	wave	B	10	10	10	10	10	10	10
Bellacorick	wind	B	115	310	115	115	180	245	310
Binbane	wind	A	79	81	79	79	79	80	81
Blake	solar	J				86	29	56	86
Blundelstown into Cdu-Mul	solar	J				80	27	53	80
Boggeragh	wind	E	143	143	169	143	152	160	169
Booltiagh	wind	D	93	93	140	93	109	124	140
Bullockhill into Ballyragget-KK	solar	H2			50		17	33	50
Butlerstown	solar	K			4		1	3	4
Butlerstown	thermal	K			2		1	1	2
Butlerstown	wind	K	2	2	2	2	2	2	2
Cahir	solar	H1			36		12	24	36
Carlow	solar	H2			8		3	5	8
Carlow	wind	H2	35	35	55	35	42	48	55

node	type	area	Gen Installed Scenarios						
			Initial	north west	south	north east	33%	66%	ALL offers
Carrick on Shannon	solar	C		8			3	5	8
Carrick on Shannon	wind	C		4			1	3	4
Carrickaduff and Carrickalangan	wind	A		138			46	92	138
Castlebar	wind	B	44	44	44	44	44	44	44
Castledockrell	wind	H2	41	41	41	41	41	41	41
Castleview	thermal	I			4		1	3	4
Cathaleen's Fall	wind	A	23	23	23	23	23	23	23
Cauteen	wind	H1	178	178	182	178	179	181	182
Charleville	solar	E			30		10	20	30
Charleville	thermal	E			2		1	1	2
Charleville	wind	E	70	70	70	70	70	70	70
Clahane	solar	E			34		11	23	34
Clahane	wind	E	52	52	52	52	52	52	52
Cloghboola	wind	E	101	101	101	101	101	101	101
Clonfad into Kinn-Mul	solar	J				100	33	67	100
Cloon	solar	B		24			8	16	24
Cloon	wind	B	4	4	4	4	4	4	4
College Park	inertia	J				4	1	3	4
Coolnabacky	solar	J				55	18	37	55
Coolroe	solar	I			20		7	13	20
Coomagearlahy	wind	E	81	81	81	81	81	81	81
Coomataggart	wind	E	178	178	178	178	178	178	178
Cordal	wind	E	148	148	148	148	148	148	148
Corderry	solar	A		40			13	27	40
Corderry	wind	A	63	63	63	63	63	63	63
Cow Cross	solar	I			5		2	3	5
Crane	battery	H2			16		5	11	16
Crane	solar	H2			13		4	9	13
Crane	wind	H2	7	7	7	7	7	7	7
Crory	solar	H2			16		5	11	16
Crory	wind	H2	60	60	60	60	60	60	60
Cunghill	wind	B	35	35	35	35	35	35	35
Cushaling	wind	J				100	33	67	100
Dallow	solar	C		8			3	5	8
Dallow	wind	C	21	24	21	21	22	23	24
Dalton	battery	B		12			4	8	12
Dalton	solar	B		4			1	3	4
Dalton	wind	B	43	43	43	43	43	43	43
Derrybrien	wind	D	60	60	60	60	60	60	60
Derryiron	battery	J				20	7	13	20
Derryiron	thermal	J				18	6	12	18
Doon	solar	H1			8		3	5	8
Doon	wind	H1			17		6	11	17
Dromada	wind	E	29	29	29	29	29	29	29

node	type	area	Gen Installed Scenarios						
			Initial	north west	south	north east	33%	66%	ALL offers
Drombeg loop into Kilpaddoge Tralee 2	solar	E			50		17	33	50
Drumline	solar	D			12		4	8	12
Drybridge	solar	G				19	6	13	19
Drybridge	thermal	G				3	1	2	3
Drybridge	wind	G	6	6	6	6	6	6	6
Dundalk	solar	G				4	1	3	4
Dundalk	wind	G	16	16	16	34	22	28	34
Dunfirth	solar	J				18	6	12	18
Dungarvan	solar	K			23		8	15	23
Dungarvan	wind	K	5	5	5	5	5	5	5
Dunmanway	wind	F	50	50	153	50	84	119	153
Ennis	solar	D			4		1	3	4
Finglas	solar	J				20	7	13	20
Finglas	thermal	J	4	4	4	4	4	4	4
Firlough	wind	B		48			16	32	48
Gallanstown Muckerstown into Corduff Platin	solar	J				119	40	79	119
Garrow	wind	E	74	74	74	74	74	74	74
Garvagh	wind	A	82	82	82	82	82	82	82
Gaskinstown into Drybridge Hawkinstown	solar	G				85	28	57	85
Gillinstown into Gorman Platin	solar	G				95	32	63	95
Glanlee	wind	E	30	30	30	30	30	30	30
Glasmore	solar	J				4	1	3	4
Glenlara	solar	E			5		2	3	5
Glenlara	wind	E	26	26	26	26	26	26	26
Glenlara_wind	wind	E	27	27	41	27	32	36	41
Glenree	wind	B	65	78	65	65	69	74	78
Golagh	wind	A	15	15	15	15	15	15	15
Gorman	battery	G				50	17	33	50
Gorman	wind	G				120	40	80	120
Gortawee	wind	A	3	3	3	3	3	3	3
Grange Castle	solar	J				16	5	11	16
Great Island	battery	H2			30		10	20	30
Great Island	solar	H2			17		6	11	17
Great Island	thermal	H2			33		11	22	33
Griffinrath	solar	J				45	15	30	45
Harristown	solar	J				42	14	28	42
Hawkinstown into Baltrasna-Dry	solar	G				50	17	33	50
Ikerrin	solar	H1			30		10	20	30
Ikerrin	wind	H1	36	36	36	36	36	36	36
Kilbarry	solar	I			10		3	7	10

node	type	area	Gen Installed Scenarios						
			Initial	north west	south	north east	33%	66%	ALL offers
Kilkenny	battery	H2			40		13	27	40
Kilkenny	solar	H2			24		8	16	24
Kill Hill	wind	H1	36	36	36	36	36	36	36
Killonan	wind	H1			141		47	94	141
Kilpaddoge	battery	E			30		10	20	30
Kilpaddoge	wind	E	60	60	60	60	60	60	60
Kilteel	battery	J				30	10	20	30
Kilteel	solar	J				15	5	10	15
Knockacummer	wind	E	100	100	100	100	100	100	100
Knockearagh	solar	E			9		3	6	9
Knockearagh	wind	E	14	14	14	14	14	14	14
Knockranny	wind	B	37	156	37	37	76	116	156
Lanesboro	solar	C		4			1	3	4
Lanesboro	wind	C	5	10	5	5	7	8	10
Lenalea	wind	A		31			10	20	31
Letterkenny	wind	A	52	90	52	52	65	77	90
Limerick	solar	E			4		1	3	4
Lisdrum	battery	G				60	20	40	60
Lisdrum	wind	G				33	11	22	33
Lisheen	wind	H1	99	99	127	99	108	118	127
Lumcloon	battery	C		100			33	67	100
Lumcloon	wind	C		34			11	23	34
Macroom	solar	F			4		1	3	4
Macroom	thermal	F			1		0	1	1
Macroom	wind	F	24	24	24	24	24	24	24
Mallow	solar	E			19		6	13	19
Meath Hill	battery	G				33	11	22	33
Meath Hill	thermal	G				4	1	3	4
Meath Hill	wind	G	46	46	46	69	54	61	69
Meentycat	wind	A	85	85	85	85	85	85	85
Midleton	solar	I			17		6	12	17
Midleton	wind	I	2	2	2	2	2	2	2
Moneypoint	battery	E			8		3	5	8
Moneypoint	wind	E	17	17	17	17	17	17	17
Monread	solar	J				8	3	5	8
Mothel into Ballydine Cullenagh	solar	H1			60		20	40	60
Mount Dillon into Lanesboro Sliabh Bawn	solar	C	0	90	0	0	30	60	90
Mount Lucas	wind	J	79	79	79	79	79	79	79
Moy	solar	B		4			1	3	4
Moy	wind	B	6	6	6	6	6	6	6
Mullingar	solar	C		12			4	8	12
Mulreavy	wind	A	95	95	95	95	95	95	95
Navan	solar	G				13	4	9	13
Navan	thermal	G				13	4	9	13

node	type	area	Gen Installed Scenarios						
			Initial	north west	south	north east	33%	66%	ALL offers
Nenagh	solar	H1			4		1	3	4
Nenagh	wind	H1	14	14	62	14	30	46	62
Newbridge	solar	J				16	5	11	16
Oriel	wind	G				210	70	140	210
Oughtragh	solar	E			4		1	3	4
Oughtragh	wind	E	9	9	9	9	9	9	9
Portlaoise	solar	J				8	3	5	8
Portlaoise	wind	J	9	9	9	54	24	39	54
Rathkeale	solar	E			4		1	3	4
Rathkeale	wind	E	32	32	32	32	32	32	32
Rathnaskilloge into Cullenagh Dungarvan	solar	K			95		32	63	95
Ratrussan	wind	G	79	79	79	79	79	79	79
Reamore	battery	E			8		3	5	8
Reamore	wind	E	60	60	98	60	73	85	98
Richmond	solar	C		12			4	8	12
Richmond	thermal	C		5			2	3	5
Rosspile into GI-Wex	solar	H2			95		32	63	95
Salthill	wind	B	44	44	44	44	44	44	44
Shankill	solar	G				4	1	3	4
Shankill	wind	G	28	28	28	28	28	28	28
Shannonbridge	solar	C		65			22	43	65
Shannonbridge 220	battery	C		163			54	109	163
Shantallow into Cashla Somerset T	solar	B		35			12	23	35
Sliabh Bawn	wind	C	58	58	58	58	58	58	58
Slievecallan	wind	D	71	71	71	71	71	71	71
Sligo	wind	B	14	14	14	14	14	14	14
Somerset	solar	C		4			1	3	4
Somerset	wind	C	8	20	8	8	12	16	20
Sorne Hill	wind	A	62	67	62	62	64	65	67
Stephenstown	battery	J				9	3	6	9
Stephenstown	solar	J				5	2	3	5
Stratford	solar	H2			4		1	3	4
Tawnaghmore	thermal	B		49			16	33	49
Tawnaghmore	wind	B	30	30	30	30	30	30	30
Thornsberry	solar	J				8	3	5	8
Thornsberry	thermal	J				10	3	7	10
Thurles	wind	H1	42	42	42	42	42	42	42
Tievebrack	wind	A		30			10	20	30
Timahoe North into Maynooth Derryiron	solar	J				70	23	47	70
Tipperary	solar	H1			4		1	3	4

node	type	area	Gen Installed Scenarios						
			Initial	north west	south	north east	33%	66%	ALL offers
Tipperary	wind	H1	5	5	5	5	5	5	5
Tonroe	thermal	B		2			1	1	2
Tonroe	wind	B	12	12	12	12	12	12	12
Trabeg	solar	I			9		3	6	9
Tralee	solar	E			8		3	5	8
Tralee	wind	E	48	48	48	48	48	48	48
Treascon into Bracklone Portlaoise	solar	J				40	13	27	40
Trien	solar	E			4		1	3	4
Trien	wind	E	27	27	27	27	27	27	27
Trien_wind	wind	E	40	40	46	40	42	44	46
Trillick	wind	A	45	45	45	45	45	45	45
Tullabeg into Banoge Crane	solar	H2			50		17	33	50
Tullabrack	wave	D			5		2	3	5
Tullabrack	wind	D	31	31	31	31	31	31	31
Uggool	wind	B	169	169	169	169	169	169	169
Waterford	solar	H2			4		1	3	4
Waterford	wind	H2	19	19	19	19	19	19	19
Wexford	solar	H2			88		29	59	88
Wexford	wind	H2	39	39	39	39	39	39	39
Woodhouse	wind	K	20	20	54	20	31	43	54

B.5 Generator List by Name

Area	Node	Type	Name	SO	Status	MEC
H1	Ahane	solar	Clyduff Solar Park	DSO	offer	4
H1	Ahane	solar	Laghtane Solar Farm	DSO	offer	4
D	Ardnacrusha	solar	Ballymorris Solar Park	DSO	offer	4
D	Ardnacrusha	solar	Clooncarhy Solar Farm	DSO	offer	4
D	Ardnacrusha	wind	Knockastanna (1)	DSO	connected	7.5
A	Ardnagappary	wind	Cronalaght (2)	DSO	offer	17.96
A	Arigna	wind	Corrie Mountain (1)	DSO	connected	4.8
A	Arigna	wind	Kilronan (1)	DSO	connected	5
A	Arigna	wind	Seltanaveeny (1)	DSO	connected	4.6
A	Arigna	wind	Spion Kop (1)	DSO	connected	1.2
H2	Arklow	solar	Templerainey East Solar Farm	DSO	ECP	4
H2	Arklow	solar	Tiglin Solar	DSO	ECP	4
H2	Arklow	wind	Arklow Bank (1)	DSO	connected	25.2
H2	Arklow	wind	Ballycumber (1)	DSO	offer	18
H2	Arklow	solar	Knockadosan Solar (formerly Springfarm Wind Farm)	DSO	offer	6
H2	Arklow	wind	Raheenleagh (1)	DSO	connected	36.5
E	Athea	wind	Athea (1)a	TSO	connected	34.35
E	Athea	wind	Beenanaspock and Tobertooreen Wind Farm	TSO	offer	34.15
E	Athea	wind	Knockathea	DSO	offer	33.9
C	Athlone	solar	Ballinamudda Solar Farm	DSO	offer	4
C	Athlone	solar	Rooaun Solar Farm	DSO	ECP	4
C	Athlone	solar	Shannagh Beg Solar Farm	DSO	offer	4
J	Athy	battery	Moatstown Battery Energy Storage	DSO	ECP	8
J	Athy	solar	Moatstown Solar	DSO	offer	4
J	Athy	solar	Woodstock North Solar Farm	DSO	offer	4.99
E	Aughinish	solar	Ballinknockane Solar Farm	TSO	offer	50
H2	Ballybeg	solar	Ballymerrigan PV	DSO	offer	4
H2	Ballybeg	solar	Millvale PV	DSO	offer	4
H1	Ballydine	solar	Ballyrichard Solar Park	DSO	offer	3
H1	Ballydine	solar	Carrick Solar	DSO	offer	4
F	Ballylickey	wind	Ballybane (2a)	DSO	connected	11.5
F	Ballylickey	wind	Ballybane (Glanta Commons) Wind Farm	DSO	connected	19.55
F	Ballylickey	wind	Ballybane 2 (Glanta Commons) Wind Farm	DSO	connected	8.4
F	Ballylickey	wind	Ballybane 2A (Glanta Commons) Wind Farm Extension	DSO	connected	1.55
F	Ballylickey	wind	Ballybane 3 (Glanta Commons) Wind Farm	DSO	connected	4.45
F	Ballylickey	wind	Derreenacrinnig West (prev Kilvinane 2 WF)	DSO	offer	5.82
F	Ballylickey	wind	Kealkil (Curraglass) (1)	DSO	connected	8.5
H2	Ballywater	wind	Ballywater (1)	TSO	connected	31.5
H2	Ballywater	wind	Ballywater (2)	TSO	connected	10.5

Area	Node	Type	Name	SO	Status	MEC
G	Baltrasna	solar	Hilltown PV	DSO	offer	10
G	Baltrasna	solar	Painestown Hill Solar Farm	DSO	offer	9.99
F	Bandon	solar	Callatrim South Solar PV Farm	DSO	ECP	5.95
F	Bandon	solar	Currabeha	DSO	ECP	4.95
F	Bandon	solar	Enniskeane PV	DSO	ECP	3.99
F	Bandon	solar	Garryndruig	DSO	ECP	4.95
F	Bandon	thermal	GP Wood CHP	DSO	offer	16.3
F	Bandon	thermal	Timoleague Agri Gen	DSO	offer	1.1
F	Bandon	wind	Garranereagh (1)	DSO	connected	8.75
F	Bandon	wind	Kilvinane (1)	DSO	connected	4.5
H2	Banoge	battery	Gorey Battery Energy Storage	DSO	ECP	9
H2	Banoge	solar	Courtown Solar Farm (previously Coolnastudd)	DSO	offer	4
H2	Banoge	solar	Gorey Solar	DSO	ECP	4
I	Barnahely	solar	Leacht Cross Solar	DSO	offer	4.95
I	Barnahely	wind	DePuy	DSO	connected	2.5
I	Barnahely	wind	Wind Energy Project (Janssen)	DSO	connected	2
H1	Barrymore	solar	Farran South	DSO	ECP	9.9
H1	Barrymore	wind	Barranafaddock (1)	DSO	connected	32.4
B	Bellacorick	battery	Shranakilla Energy Park	DSO	ECP	3
B	Bellacorick	wave	AMETS Belmullet (1)	DSO	offer	10
B	Bellacorick	wind	Bellacorick (1)	DSO	connected	6.45
B	Bellacorick	wind	Bunaveala (Keenagh) (1)	DSO	offer	9.2
B	Bellacorick	wind	Bunnahowen (1)	DSO	offer	2.55
B	Bellacorick	wind	Dooleeg More (1)	DSO	ECP	2.5
B	Bellacorick	wind	Corvoderry (was Gortnahurra (1))	DSO	offer	33.9
B	Bellacorick	wind	Oweninny (5)**	TSO	offer	50
B	Bellacorick	wind	Oweninny Power (1)	TSO	offer	89
B	Bellacorick	wind	Oweninny Power (2)	TSO	offer	83
B	Bellacorick	wind	Sheskin Windfarm (formerly Ederglen Windfarm)	DSO	offer	16.8
B	Bellacorick	wind	Tawnaghmore 1 2 and 3 Merge	DSO	offer	16.1
A	Binbane	wind	Clogheravaddy (1)	DSO	offer	20
A	Binbane	wind	Corkermore (1)	DSO	connected	9.99
A	Binbane	wind	Corkermore (2)	DSO	offer	9.4
A	Binbane	wind	Killin Hill (1)	DSO	connected	6
A	Binbane	wind	Killybegs (1)	DSO	connected	2.55
A	Binbane	wind	Loughderryduff (1)	DSO	connected	7.65
A	Binbane	wind	Maas Wind Farm (Loughderryduff 2)	DSO	offer	9.35
A	Binbane	wind	Meenachullalan (1)	DSO	connected	11.9
A	Binbane	wind	Meenachullalan (2)	DSO	offer	1.9
A	Binbane	wind	Shannagh (1) previously Kilcar	DSO	connected	2.55
J	Blake	solar	Timahoe South	TSO	ECP	81
J	Blake	Solar	Kishavanna	DSO	ECP	5
J	Blundelstown into Cdu-Mul	solar	Blundlestown	TSO	offer	80
E	Boggeragh	wind	Boggeragh (1)	TSO	connected	57

Area	Node	Type	Name	SO	Status	MEC
E	Boggeragh	wind	Boggeragh 2	TSO	connected	47.7
E	Boggeragh	wind	Boggeragh 2 (Killavoy (1))	TSO	connected	18
E	Boggeragh	wind	Carrigcannon (1)	DSO	connected	20
E	Boggeragh	wind	Carrigcannon (2)	DSO	ECP	3
E	Boggeragh	wind	Esk (1)	DSO	offer	5.4
E	Boggeragh	wind	Esk Wind Farm (sub metered Gneeves 2 Merge)	DSO	offer	5.4
E	Boggeragh	wind	ESK Wind Farm Phase 2	DSO	ECP	12
D	Booltiagh	wind	Booltiagh (1)	TSO	connected	19.45
D	Booltiagh	wind	Booltiagh (2)	TSO	connected	3
D	Booltiagh	wind	Booltiagh (3)	TSO	connected	9
D	Booltiagh	wind	Boolynagleragh (1)	DSO	offer	36.98
D	Booltiagh	wind	Cahermurphy (1)	DSO	offer	6
D	Booltiagh	wind	Crossmore (1)	DSO	ECP	15
D	Booltiagh	wind	Glenmore (1)	DSO	offer	24
D	Booltiagh	wind	Kiltumper	DSO	offer	4.99
D	Booltiagh	wind	Lissycasey (1)	DSO	offer	13.399
D	Booltiagh	wind	Sorrell Island (Glenmore) Wind Farm Extension	DSO	ECP	8
H2	Bullockhill into Ballyragget-KK	solar	Bullockhill Solar Park	TSO	ECP	50
K	Butlerstown	solar	Coolnagapogue Solar Farm Phase 1	DSO	ECP	3.95
K	Butlerstown	thermal	Ormonde Organics	DSO	ECP	1.9
K	Butlerstown	wind	Beallough (1)	DSO	connected	1.7
H1	Cahir	solar	Ballyfowloo Solar Farm	DSO	ECP	4
H1	Cahir	solar	Ballymacadam Solar	DSO	ECP	24
H1	Cahir	solar	Clonmel Road Solar	DSO	offer	4
H1	Cahir	solar	Lawclon Solar Farm	DSO	ECP	4
H2	Carlow	solar	Kilcarrig Solar PV Farm	DSO	ECP	4
H2	Carlow	solar	Loan PV	DSO	ECP	3.99
H2	Carlow	wind	Ballyshonog (1)	DSO	offer	5
H2	Carlow	wind	Bilboa (1)	DSO	ECP	15
H2	Carlow	wind	Cronelea (1)	DSO	connected	4.99
H2	Carlow	wind	Cronelea (2)	DSO	connected	4.5
H2	Carlow	wind	Cronelea Upper (1)	DSO	connected	2.55
H2	Carlow	wind	Cronelea Upper (2)	DSO	connected	1.7
H2	Carlow	wind	Gortahile (1)	DSO	connected	21
C	Carrick on Shannon	solar	Lisdadnan Solar Farm	DSO	offer	4
C	Carrick on Shannon	solar	Rathleg Solar Farm	DSO	offer	4
C	Carrick on Shannon	wind	Derryknockeran (1)	DSO	offer	4.25
A	Carrickaduff and Carrickalangan	wind	Carrickaduff Wind Farm (1)	TSO	offer	33
A	Carrickaduff and Carrickalangan	wind	Carrickaduff Wind Farm (2)	TSO	offer	33.1
A	Carrickaduff and Carrickalangan	wind	Croaghonagh 1	TSO	ECP	72

Area	Node	Type	Name	SO	Status	MEC
B	Castlebar	wind	Cuillalea (1)	DSO	connected	3.4
B	Castlebar	wind	Cuillalea (2)	DSO	connected	1.59
B	Castlebar	wind	Lenanavea (2) - Lenanavea Burren	DSO	connected	4.65
B	Castlebar	wind	Raheen Barr (1)	DSO	connected	18.7
B	Castlebar	wind	Raheen Barr (2)	DSO	connected	8.5
B	Castlebar	wind	Raheen barr Extension (formally Lenanavea (3))	DSO	offer	6.8
H2	Castledockrell	wind	Castledockrell (1)	TSO	connected	20
H2	Castledockrell	wind	Castledockrell (2)	TSO	connected	2
H2	Castledockrell	wind	Castledockrell (3)	TSO	connected	3.3
H2	Castledockrell	wind	Castledockrell (4)	TSO	connected	16.1
I	Castleview	thermal	Hoffman Renewable Bioenery Plant	DSO	offer	4
A	Cathaleen's Fall	wind	Anarget (1)	DSO	connected	1.98
A	Cathaleen's Fall	wind	Meenadreen (1)	DSO	connected	3.4
A	Cathaleen's Fall	wind	Spaddan (1)	DSO	connected	17.5
H1	Cauteen	wind	Cappagh White (1)	DSO	connected	13.2
H1	Cauteen	wind	Cappagh White 2 & 3 & 4 Merge	DSO	connected	49.08
H1	Cauteen	wind	Cappawhite A (merger of Cappagh White 3, 2 & 4)	DSO	connected	2.92
H1	Cauteen	wind	Garracummer (1)	DSO	connected	36.9
H1	Cauteen	wind	Garracummer (2)	DSO	connected	1
H1	Cauteen	wind	Glencarbry (1)	DSO	connected	33
H1	Cauteen	wind	Glenough (1)	DSO	connected	33
H1	Cauteen	wind	Holyford (1)	DSO	connected	9
H1	Cauteen	wind	Ring Hill Wind Farm	DSO	offer	4
E	Charleville	solar	Fiddane Solar	DSO	offer	29.9
E	Charleville	thermal	Evaporator Upgrade	DSO	offer	1.5
E	Charleville	wind	Boolard Wind Farm (Charlevile)	DSO	offer	4.45
E	Charleville	wind	Castlepook (1)	DSO	connected	33.1
E	Charleville	wind	Kilberehert (1)	DSO	connected	4.799
E	Charleville	wind	Kilmeedy (1)	DSO	connected	4.7
E	Charleville	wind	Knocknatallig	DSO	connected	18.3
E	Charleville	wind	Rathnacally (1)	DSO	connected	4.45
E	Clahane	solar	Banemore Solar Farm	TSO	offer	34
E	Clahane	wind	Clahane (1)	TSO	connected	37.8
E	Clahane	wind	Clahane (2)	TSO	connected	13.8
E	Cloghboola	wind	Cloghanaleskirt (1)	DSO	connected	12.55
E	Cloghboola	wind	Glanaruddery 1 (formerly Dromadda More Wind Farm)	DSO	connected	20
E	Cloghboola	wind	Glanaruddery 2 (formerly Dromadda More 2)	DSO	connected	12
E	Cloghboola	wind	Glantaunyalkeen Windfarm(Cloghboola (2) Ext)	DSO	offer	10
E	Cloghboola	wind	Knocknagashel Wind (Cloghboola (1))	TSO	connected	46
J	Clonfad into Kinn-Mul	solar	Clonfad Solar	TSO	ECP	100
B	Cloon	solar	Barnderg Solar Farm	DSO	offer	4

Area	Node	Type	Name	SO	Status	MEC
B	Cloon	solar	Cloonascragh Solar	DSO	ECP	20
B	Cloon	wind	Cloonlusk (1)	DSO	connected	4.25
J	College Park	inertia	Data Electronics Services Ltd	DSO	offer	4
J	Coolnabacky	solar	Loughteague	TSO	offer	55
I	Coolroe	solar	Carrigyknaveen Solar Park	DSO	offer	10
I	Coolroe	solar	Garravagh 1 Solar Park	DSO	offer	10
E	Coomagearlahy	wind	Coomagearlahy (1)	TSO	connected	42.5
E	Coomagearlahy	wind	Coomagearlahy (2)	TSO	connected	8.5
E	Coomagearlahy	wind	Coomagearlahy (3)	TSO	connected	30
E	Coomataggart	wind	Cleanrath (1)	DSO	offer	42.64
E	Coomataggart	wind	Grousemount WF	TSO	offer	114.2
E	Coomataggart	wind	Lettercannon (1)	DSO	offer	21.6
E	Cordal	wind	Coollegrean (1)	DSO	connected	18.5
E	Cordal	wind	Cordal (1)	TSO	connected	35.85
E	Cordal	wind	Cordal (2)	TSO	connected	54
E	Cordal	wind	Scartaglen (1)	DSO	connected	35.45
E	Cordal	wind	Scartaglen (2)	DSO	connected	3.8
A	Corderry	solar	Glen Solar	TSO	ECP	40
A	Corderry	wind	Altagowlan (1)	DSO	connected	7.65
A	Corderry	wind	Black Banks (1)	DSO	connected	3.4
A	Corderry	wind	Black Banks (2)	DSO	connected	6.8
A	Corderry	wind	Carrane Hill (1)	DSO	connected	3.4
A	Corderry	wind	Carrane Hill (2)	DSO	connected	1.598
A	Corderry	wind	Geevagh (1)	DSO	connected	4.95
A	Corderry	wind	Moneenatieve (1)	DSO	connected	3.96
A	Corderry	wind	Tullynamoyle (1)	DSO	connected	9
A	Corderry	wind	Tullynamoyle 2 Wind Farm	DSO	connected	10.225
A	Corderry	wind	Tullynamoyle 3	DSO	connected	11.98
I	Cow Cross	solar	Ballynacrusha	DSO	ECP	4.95
H2	Crane	battery	Avonbeg BESS	DSO	ECP	16
H2	Crane	solar	Cherryorchard Solar Farm	DSO	ECP	4
H2	Crane	solar	Macallian Solar	DSO	ECP	9
H2	Crane	wind	Greenoge (1)	DSO	connected	4.99
H2	Crane	wind	Kilbranish (1)	DSO	offer	2.5
H2	Crory	solar	Ballycarney PV	DSO	ECP	3.99
H2	Crory	solar	Ballylough	DSO	ECP	3.999
H2	Crory	solar	Ballymacsimon Solar Farm	DSO	offer	3.99
H2	Crory	wind	Ballaman formerly (Kennystown) (1)	DSO	connected	3.6
H2	Crory	wind	Ballycadden (1)	DSO	connected	14.45
H2	Crory	wind	Ballycadden (2)	DSO	connected	9.762
H2	Crory	wind	Ballyduff (1)	DSO	connected	4
H2	Crory	wind	Ballynancoran (1)	DSO	connected	4
H2	Crory	wind	Gibbet Hill (1)	DSO	connected	14.8
H2	Crory	wind	Knocknalour (1)	DSO	connected	5
H2	Crory	wind	Knocknalour (2)	DSO	connected	3.95
H2	Crory	solar	The Dell Solar Farm	DSO	ECP	3.99

Area	Node	Type	Name	SO	Status	MEC
B	Cunghill	wind	Kingsmountain (1)	TSO	connected	23.75
B	Cunghill	wind	Kingsmountain (2)	TSO	connected	11.05
J	Cushaling	wind	Cloncreen Wind farm	TSO	ECP	100
C	Dallow	solar	Clonoghill Solar Farm	DSO	offer	4
C	Dallow	solar	Lacka Solar Park	DSO	ECP	3.99
C	Dallow	wind	Carrig (1)	DSO	connected	2.55
C	Dallow	wind	Leabeg (1)	DSO	connected	4.25
C	Dallow	wind	Meenwaun WF	DSO	connected	9.99
C	Dallow	wind	Meenwaun Windfarm Ext.	DSO	ECP	3.3
C	Dallow	wind	Skehanagh (1)	DSO	connected	4.25
B	Dalton	battery	MCB Battery Storage	DSO	ECP	12
B	Dalton	solar	Lisduff Solar Park (Claremorris)	DSO	offer	4
B	Dalton	wind	Mace Upper (1)	DSO	connected	2.55
B	Dalton	wind	Magheramore (1)	DSO	connected	40.8
D	Derrybrien	wind	Derrybrien (1)	TSO	connected	59.5
J	Derryiron	battery	Rhode 20 MW ESS	TSO	ECP	20
J	Derryiron	thermal	Rhode Biomass Extension	DSO	offer	1.74
J	Derryiron	thermal	Rhode Biomass Plant (1)	DSO	offer	14.56
J	Derryiron	thermal	Rhode Biomass Plant (2nd Ext of DG793)	DSO	offer	1.2
H1	Doon	solar	Horsepasture Solar Farm (Grian PV)	DSO	ECP	8
H1	Doon	wind	Boolabrien Upper (1)	DSO	offer	17
E	Dromada	wind	Dromada (1)	TSO	connected	28.5
E	Drombeg loop into Kilpaddoge Tralee 2	solar	Drombeg Solar Park	TSO	offer	50
D	Drumline	solar	Clonloghan 2 Solar Park	DSO	offer	4
D	Drumline	solar	Clonloghan Solar Park	DSO	offer	4
D	Drumline	solar	Firgrove Solar Park	DSO	ECP	4
G	Drybridge	solar	Cluide Solar	DSO	ECP	4
G	Drybridge	solar	Balgeen Solar formerly Dardistown	DSO	ECP	3.5
G	Drybridge	solar	Grangegeeth Solar	DSO	offer	4
G	Drybridge	solar	Newtown PV	DSO	offer	3.99
G	Drybridge	solar	Stamullen Solar Park	DSO	ECP	3.99
G	Drybridge	thermal	Rathdrinagh Biogas	DSO	offer	3
G	Drybridge	wind	Collon Wind Power	DSO	connected	2.3
G	Drybridge	wind	Dunmore (1)	DSO	connected	1.7
G	Drybridge	wind	Dunmore (2)	DSO	connected	1.8
G	Dundalk	solar	Willville Solar Park	DSO	ECP	3.99
G	Dundalk	wind	Old Mill was Grove Hill (1) formerly Tullynageer	DSO	connected	16.1
G	Dundalk	wind	Old Mill extension	DSO	ECP	3
G	Dundalk	wind	Slievenaglogh (1)	DSO	offer	15
J	Dunfirth	solar	Hortland PV	DSO	offer	4
J	Dunfirth	solar	Knockanally Solar Park	DSO	offer	10
J	Dunfirth	solar	Ovidstown Solar	DSO	offer	4
K	Dungarvan	solar	Clashnagoneen Solar Farm	DSO	ECP	4
K	Dungarvan	solar	Drumroe East Solar Farm	DSO	ECP	15

Area	Node	Type	Name	SO	Status	MEC
K	Dungarvan	solar	Foxhall PV	DSO	ECP	3.99
K	Dungarvan	wind	Ballycurreen (1)	DSO	connected	4.99
F	Dunmanway	wind	Carrigdangan (formerly Barnadivine)	TSO	offer	60
F	Dunmanway	wind	Carrigdangan Wind Farm Ext.	TSO	ECP	7.95
F	Dunmanway	wind	Coomatallin (1)	DSO	connected	5.95
F	Dunmanway	wind	Coomatallin (2)	DSO	offer	3.05
F	Dunmanway	wind	Coomleagh (1)	DSO	offer	5.95
F	Dunmanway	wind	Coomleagh Wind Farm (extension)	DSO	offer	2
F	Dunmanway	wind	Currabwee (1)	DSO	connected	4.62
F	Dunmanway	wind	Derryvacorneen (1)	DSO	connected	17
F	Dunmanway	wind	Dromleena (1)	DSO	ECP	9.9
F	Dunmanway	wind	Killaveenoge (formerly Barrboy (1))	DSO	connected	7.8
F	Dunmanway	wind	Knockeenbui Wind Farm	DSO	ECP	13.8
F	Dunmanway	wind	Lahanaght Hill (1)	DSO	connected	4.25
F	Dunmanway	wind	Milane Hill (1)	DSO	connected	5.94
F	Dunmanway	wind	Reenascreena (1)	DSO	connected	4.5
D	Ennis	solar	Spancil Hill Solar Farm	DSO	offer	4
J	Finglas	solar	Bullstown Solar Extension	DSO	offer	3.96
J	Finglas	solar	Bullstown Solar Farm	DSO	offer	3.96
J	Finglas	solar	Darthogue Solar	DSO	ECP	12
J	Finglas	thermal	Huntstown Renewable Bioenergy Plant	DSO	offer	4
B	Firlough	wind	Firlough (was Carrowleagh Kilbride)	DSO	ECP	48.3
J	Gallanstown Muckerstown into Corduff Platin	solar	Gallanstown Solar	TSO	offer	85
J	Gallanstown Muckerstown into Corduff Platin	solar	Muckerstown Solar Park	TSO	offer	34
E	Garrow	wind	Caherdowney (1)	DSO	connected	10
E	Garrow	wind	Clydaghroe (1)	DSO	connected	4.99
E	Garrow	wind	Coomacheo (1)	TSO	connected	41.225
E	Garrow	wind	Coomacheo (2)	TSO	connected	18
A	Garvagh	wind	Derrysallagh Wind Farm (Formerly Kilronan 2)	DSO	offer	34
A	Garvagh	wind	Garvagh - Glebe (1a)	TSO	connected	26
A	Garvagh	wind	Garvagh - Tullynahaw (1c)	TSO	connected	22
G	Gastkinstown into Gorman Platin	solar	Gaskinstown Solar Farm	TSO	ECP	85
G	Gillinstown into Gorman Platin	solar	Gillinstown Solar	TSO	ECP	95
E	Glanlee	wind	Glanlee (1)	TSO	connected	29.8
J	Glasmore	solar	Featherbed Lane Solar	DSO	offer	4
E	Glenlara	solar	Dromalour	DSO	offer	4.95
E	Glenlara	wind	Taurbeg (1)	DSO	connected	26

Area	Node	Type	Name	SO	Status	MEC
E	Glenlara_wind	wind	Dromdeeveen (1)	DSO	connected	10.5
E	Glenlara_wind	wind	Dromdeeveen (2)	DSO	connected	16.5
E	Glenlara_wind	wind	Mauricetown (Glenduff) Wind Farm	DSO	offer	13.8
B	Glenree	wind	Black Lough (1)	DSO	ECP	12.5
B	Glenree	wind	Bunnyconnellan (1)	DSO	offer	28
B	Glenree	wind	Carrowleagh (1)	DSO	connected	34.15
B	Glenree	wind	Carrowleagh (2)	DSO	offer	2.65
A	Golagh	wind	Golagh (1)	TSO	connected	15
G	Gorman	battery	Gorman (Graigs) Energy Storage Station	TSO	ECP	30
G	Gorman	battery	Gorman Energy Storage Station - Extension	TSO	ECP	20
G	Gorman	wind	Castletownmoor	TSO	offer	120
A	Gortawee	wind	Coreen (1)	DSO	connected	3
J	Grange Castle	solar	Furryhill Solar	DSO	ECP	16
H2	Great Island	battery	Kilmannock Battery Storage Facility	TSO	ECP	30
H2	Great Island	solar	Ballycullane Solar Park	DSO	offer	4.99
H2	Great Island	solar	Ballygowny Solar Farm	DSO	ECP	12
H2	Great Island	Thermal	Great Island CCGT in ECP-1	TSO	ECP	33
J	Griffinrath	solar	Confey Solar Park	DSO	ECP	9.5
J	Griffinrath	solar	Dollanstown Stud Solar Farm	DSO	offer	4
J	Griffinrath	solar	Taghadoe Solar Farm	DSO	offer	25
J	Griffinrath	solar	Tower Hill Solar Farm	DSO	ECP	6
G	Hawkinstown into Baltrasna-Dry	solar	Hawkinstown Solar Park re-submission	TSO	offer	50
H1	Ikerrin	solar	Doonane Solar	DSO	offer	29.9
H1	Ikerrin	wind	Monaincha Bog (1)	DSO	connected	35.95
I	Kilbarry	solar	Coolyduff	DSO	offer	4.95
I	Kilbarry	solar	Drumgarriff South	DSO	offer	4.95
H2	Kilkenny	battery	Nore Power G&S	TSO	ECP	40
H2	Kilkenny	solar	Ballytobin Solar PV	DSO	offer	4
H2	Kilkenny	solar	Castlekelly Solar PV Farm	DSO	offer	4
H2	Kilkenny	solar	Clashmagrath PV	DSO	ECP	3.99
H2	Kilkenny	solar	Derrynahinch Solar Farm	DSO	ECP	4
H2	Kilkenny	solar	Keatingstown Solar Farm	DSO	ECP	4
H2	Kilkenny	solar	Kiltorcan Solar Farm	DSO	ECP	4
H1	Kill Hill	wind	Kill Hill (1) - phase 1	TSO	connected	36
H1	Killonan	wind	Bunkimalta (1)	DSO	offer	46.5
H1	Killonan	wind	Cureeny (1)	DSO	offer	94
E	Kilpaddoge	battery	Glencloosagh Phase 3	TSO	ECP	30
E	Kilpaddoge	wind	Kelwin Power Plant	TSO	connected	41.6
E	Kilpaddoge	wind	Leanamore (1) (formerly Tarbert (1))	DSO	connected	18
J	Kilteel	battery	Porterstown Battery Storage Facility	TSO	ECP	30
J	Kilteel	solar	Threecastles Solar Farm	DSO	offer	15

Area	Node	Type	Name	SO	Status	MEC
J	Kinnegad	solar	Harristown Solar PV	TSO	offer	42.3
E	Knockacummer	wind	Knockacummer (1)	TSO	connected	100
E	Knockearagh	solar	Ballynamaunagh Solar Park	DSO	ECP	4.99
E	Knockearagh	solar	Madam's Hill Solar Park	DSO	offer	4
E	Knockearagh	wind	Gneeves (1)	DSO	connected	9.35
E	Knockearagh	wind	WEDcross (1)	DSO	connected	4.5
B	Knockranny	wind	Ardderoo 2 (Formerly Buffy)	TSO	offer	64.2
B	Knockranny	wind	Ardderoo Wind Farm	TSO	offer	27
B	Knockranny	wind	Knockalough (1)	TSO	offer	33.6
B	Knockranny	wind	Rossaveel Wind	DSO	offer	3
B	Knockranny	wind	Galway Ph3	TSO	ECP	28.8
C	Lanesboro	solar	Creevy Solar	DSO	offer	4
C	Mount Dillon into Lanesboro Sliabh Bawn	solar	Mountdillon Solar	TSO	ECP	90
C	Lanesboro	wind	Roxborough	DSO	ECP	4.95
C	Lanesboro	wind	Skrine (1)	DSO	connected	4.6
A	Lenalea	wind	Lenalea WF	TSO	ECP	31
A	Letterkenny	wind	Cark (1)	DSO	connected	15
A	Letterkenny	wind	Carrick Wind Farm (Garrymore)	DSO	offer	4.3
A	Letterkenny	wind	Cronalaght (1)	DSO	connected	4.98
A	Letterkenny	wind	Culliagh (1)	DSO	connected	11.88
A	Letterkenny	wind	Garrymore WF	DSO	offer	4.4
A	Letterkenny	wind	Glenalla (Garrymore)	DSO	offer	2.1
A	Letterkenny	wind	Lettergull (1)	DSO	offer	20
A	Letterkenny	wind	Lurganboy (1)	DSO	connected	4.99
A	Letterkenny	wind	Meenanilta (1)	DSO	connected	2.55
A	Letterkenny	wind	Meenanilta (2)	DSO	connected	2.45
A	Letterkenny	wind	Meenanilta (3)	DSO	connected	3.4
A	Letterkenny	wind	Newtownfore (1)	DSO	offer	14.4
E	Limerick	solar	Kilcolman Solar Farm	DSO	offer	4
G	Lisdrum	battery	Lisdrumdoagh Energy Storage Facility	TSO	ECP	60
G	Lisdrum	wind	Coolberrin Wind Farm (formerly Bragan Wind Farm)	DSO	offer	33.1
H1	Lisheen	wind	Bruckana (1)	DSO	connected	39.6
H1	Lisheen	wind	Lisheen (1)	TSO	connected	36
H1	Lisheen	wind	Lisheen (1a)	TSO	connected	23
H1	Lisheen	wind	Lisheen 3	TSO	ECP	28.8
C	Lumcloon	battery	Lumcloon ESS (Derrycarney)	TSO	offer	100
C	Lumcloon	wind	Cloghan	TSO	ECP	34
F	Macroom	solar	Knockglass Solar Farm	DSO	offer	4
F	Macroom	thermal	Cork Green Energy Biomass CHP Plant	DSO	offer	1.2
F	Macroom	wind	Bawnmore (1) formerly Burren (Cork)	DSO	connected	24
E	Mallow	solar	Carrigoon Solar Farm	DSO	offer	4
E	Mallow	solar	Crossfield	DSO	offer	4.95

Area	Node	Type	Name	SO	Status	MEC
E	Mallow	solar	Kilcummer Upper Solar Farm	DSO	ECP	10
G	Meath Hill	battery	Ardagh South Energy Storage Facility	DSO	ECP	33
G	Meath Hill	thermal	College Proteins CHP	DSO	ECP	3.99
G	Meath Hill	wind	Gartnaneane (1)	DSO	connected	10.5
G	Meath Hill	wind	Gartnaneane (2)	DSO	connected	4.5
G	Meath Hill	wind	Mullananalt (1)	DSO	connected	7.5
G	Meath Hill	wind	Raragh (2)	DSO	offer	11.5
G	Meath Hill	wind	Taghart (1)	DSO	ECP	23.06
G	Meath Hill	wind	Teevurcher	DSO	connected	9
G	Meath Hill	wind	Tullynamalra (1)	DSO	offer	2.638
A	Meentycat	wind	Meentycat (1)	TSO	connected	70.96
A	Meentycat	wind	Meentycat (2)	TSO	connected	14
I	Midleton	solar	Gortacrue Solar Park	DSO	offer	3.99
I	Midleton	solar	IQ Solar Farm	DSO	ECP	4
I	Midleton	solar	Malapardas	DSO	ECP	4.95
I	Midleton	solar	Tead More Solar (Meelshane)	DSO	ECP	3.95
I	Midleton	wind	Crocane (1)	DSO	connected	1.7
E	Moneypoint	battery	Moneypoint Battery Storage	TSO	offer	7.5
E	Moneypoint	wind	Moneypoint WF	TSO	connected	17.25
J	Monread	solar	Bodenstown Solar Farm	DSO	offer	4
J	Monread	solar	Kerdiffstown PV	DSO	offer	4
H1	Mothel into Ballydine Cullenagh	solar	Mothel PV	TSO	offer	60
J	Mount Lucas	wind	Mount Lucas (1)	TSO	connected	79.2
B	Moy	solar	Carrowgarve Solar	DSO	offer	4
B	Moy	wind	Lackan (1)	DSO	connected	6
C	Mullingar	solar	Liss Solar Farm (prev Lands at Liss)	DSO	offer	4
C	Mullingar	solar	Marlinstown Solar Farm (prev Russellstown)	DSO	offer	4
C	Mullingar	solar	Tullynally Estate	DSO	ECP	4
A	Mulreavy	wind	Mulreavy (Mulreavy (1))	TSO	connected	82
A	Mulreavy	wind	Mulreavy Ext (Croaghnameal (1))	TSO	connected	4.25
A	Mulreavy	wind	Mulreavy Ext (Meenadreen South (1))	TSO	connected	3.6
A	Mulreavy	wind	Mulreavy Ext (Meenadreen South (2))	TSO	connected	5.4
G	Navan	solar	Friarspark Solar	DSO	ECP	4
G	Navan	solar	Kilkeelan Solar Farm	DSO	offer	4
G	Navan	thermal	Shamrock Renewable Fuels formerly Farelly Brothers	DSO	offer	13
G	Navan	solar	Martinstown Solar formerly Crowinstown Great wind	DSO	offer	4.999
H1	Nenagh	solar	Lisbrien Solar Farm	DSO	offer	4
H1	Nenagh	wind	Ballinlough (1)	DSO	connected	2.55
H1	Nenagh	wind	Ballinveny (1)	DSO	connected	2.55
H1	Nenagh / Freagh	wind	Castlewaller (1)	TSO	ECP	48
H1	Nenagh	wind	Curraghgraigue (1)	DSO	connected	2.55

Area	Node	Type	Name	SO	Status	MEC
H1	Nenagh	wind	Curraghgraigue (2)	DSO	connected	2.44
H1	Nenagh	wind	Templederry (1)	DSO	connected	3.9
J	Newbridge	solar	Dunmurry Springs PV	DSO	offer	12
J	Newbridge	solar	Pollardstown PV	DSO	offer	3.99
G	Oriel	wind	Oriel (1)	TSO	offer	210
E	Oughtragh	solar	Maine Solar	DSO	offer	4
E	Oughtragh	wind	Knockaneden (1)	DSO	connected	9
J	Portlaoise	solar	Acragar Solar Farm	DSO	ECP	4
J	Portlaoise	solar	Shanderry Solar Farm	DSO	offer	4
J	Portlaoise	wind	Dooray WF	DSO	offer	45.001
J	Portlaoise	wind	Lisdowney (1)	DSO	connected	9.2
E	Rathkeale	solar	Dungeeha Solar	DSO	ECP	4
E	Rathkeale	wind	Carrons (1)	DSO	connected	4.99
E	Rathkeale	wind	Grouse Lodge (1)	DSO	connected	15
E	Rathkeale	wind	Rathcahill (1)	DSO	connected	12.5
K	Rathnaskilloge into Cullenagh Dungarvan	solar	Rathnaskilloge	TSO	ECP	95
G	Ratrussan	wind	Mountain Lodge (1)	TSO	connected	24.8
G	Ratrussan	wind	Mountain Lodge (3)	TSO	connected	5.82
G	Ratrussan	wind	Ratrussan (1a)	TSO	connected	48
E	Reamore	battery	Knocknagoum Battery Storage	DSO	ECP	8
E	Reamore	wind	Knocknagoum (1)	DSO	connected	42.55
E	Reamore	wind	Knocknagoum (2) formerly Muingnatee (3)	DSO	connected	1.8
E	Reamore	wind	Muingnaminnane (1)	DSO	connected	15.3
E	Reamore	wind	Muingnaminnane (2)	DSO	offer	13.5
E	Reamore	wind	Stack's Mountain	DSO	offer	25.3
C	Richmond	solar	Cleggil Solar	DSO	ECP	8
C	Richmond	solar	Lisnageeragh Solar Farm	DSO	offer	4
C	Richmond	thermal	Camlin CHP	DSO	ECP	5
H2	Rosspile into GI-Wex	solar	Rosspile Solar Farm	TSO	offer	95
B	Salthill	wind	Inverin (Knock South) (1)	DSO	connected	2.64
B	Salthill	wind	Leitir Guingaid & Doire Chrith1 & 2 Merge	DSO	connected	40.9
G	Shankill	solar	Carrickabane Solar Farm	DSO	offer	4
G	Shankill	wind	Carrickallen Wind Farm	DSO	offer	22
G	Shankill	wind	Liffey Autoproduction Project	DSO	connected	1.6
G	Shankill	wind	Liffey Autoproduction Project (extension)	DSO	connected	1.417
G	Shankill	wind	Mountain Lodge (2)	DSO	connected	3
C	Shannonbridge	solar	Blackwater Bog Solar 1	TSO	ECP	65
C	Shannonbridge 220	battery	Shannonbridge B ESS	TSO	offer	97.2
C	Shannonbridge 220	battery	Shannonbridge ESS	TSO	offer	66

Area	Node	Type	Name	SO	Status	MEC
B	Shantallow into Cashla Somerset T	solar	Shantallow Solar	TSO	offer	35
C	Sliabh Bawn	wind	Sliabh Bawn (1)	TSO	connected	58
D	Slievecallan	wind	Boolinrudda (formerly Boolynagleragh & Glenmore)	TSO	connected	17.64
D	Slievecallan	wind	Boolinrudda (formerly Loughaun North)	TSO	connected	26.87
D	Slievecallan	wind	Knockalassa (formerly Keelderry)	TSO	connected	26.875
B	Sligo	wind	Carrickeeney (1)	DSO	connected	7.65
B	Sligo	wind	Faughary (1)	DSO	connected	6
C	Somerset	solar	Ballycrissane Solar Farm	DSO	offer	4
C	Somerset	wind	Lisbeg Windfarm (formerly Sonnagh Old 2 & 3)	DSO	offer	11.89
C	Somerset	wind	Sonnagh Old (1)	DSO	connected	7.65
A	Sorne Hill	wind	Corvin Wind Turbine	DSO	offer	2.1
A	Sorne Hill	wind	Fahan Wind Farm	DSO	ECP	5
A	Sorne Hill	wind	Flughland (1)	DSO	connected	9.2
A	Sorne Hill	wind	Glackmore Hill (2)	DSO	connected	1.4
A	Sorne Hill	wind	Meenkeeragh (1)	DSO	connected	4.2
A	Sorne Hill	wind	Sorne Hill (1)	DSO	connected	31.5
A	Sorne Hill	wind	Sorne Hill (2)	DSO	connected	7.4
A	Sorne Hill	wind	Sorne Hill Single Turbine (Enros)	DSO	offer	2.3
A	Sorne Hill	wind	Three Trees (1)	DSO	offer	4.25
J	Stephenstown	battery	Gardnershill FGS	DSO	ECP	9
J	Stephenstown	solar	Matt Solar Farm	DSO	offer	4.95
H2	Stratford	solar	Newtownsaunders	DSO	offer	4
B	Tawnaghmore	thermal	Mayo Renewable Power Biomass CHP	DSO	offer	49
B	Tawnaghmore	wind	Killala (1)	DSO	offer	30
J	Thornsberry	solar	Lehinch Solar Farm	DSO	offer	4
J	Thornsberry	solar	Muinagh Solar Farm	DSO	offer	4
J	Thornsberry	thermal	Derryclure (1)	DSO	offer	9.9
H1	Thurles	wind	An Cnoc	DSO	connected	11.5
H1	Thurles	wind	Ballinacurry WF	DSO	offer	4.6
H1	Thurles	wind	Ballybay Wind Farm (Tullaroan)	DSO	connected	13.8
H1	Thurles	wind	Foyle Windfarm	DSO	connected	9.6
H1	Thurles	wind	Gurteen (1)	DSO	connected	2.3
A	Tievebrack	wind	Mully Graffy Windfarm (Kilgorman)	TSO	ECP	29.9
J	Timahoe North into Maynooth Derryiron	solar	Timahoe North	TSO	offer	70
H1	Tipperary	solar	Ballinalard Solar Farm	DSO	offer	4
H1	Tipperary	wind	Slievereagh (1)	DSO	connected	4.6
B	Tonroe	thermal	Biocore Enviromental AD	DSO	offer	1.5
B	Tonroe	wind	Grady Joinery	DSO	connected	2.5
B	Tonroe	wind	Largan Hill (1)	DSO	connected	5.94
B	Tonroe	wind	Roosky (1)	DSO	connected	3.6

Area	Node	Type	Name	SO	Status	MEC
I	Trabeg	solar	Piercestown (formerly Jackeens) SPV	DSO	ECP	4
I	Trabeg	solar	Shanagraigue	DSO	offer	4.95
E	Tralee	solar	Bawnboy Solar Park	DSO	offer	4
E	Tralee	solar	Drummartin Solar Farm	DSO	ECP	4
E	Tralee	wind	Ballincollig Hill (1)	DSO	connected	15
E	Tralee	wind	Beenageeha (1)	DSO	connected	3.96
E	Tralee	wind	Mount Eagle (1)	DSO	connected	5.1
E	Tralee	wind	Mount Eagle (2)	DSO	connected	1.7
E	Tralee	wind	Tursillagh (1)	DSO	connected	15
E	Tralee	wind	Tursillagh (2)	DSO	connected	6.8
J	Treascon into Bracklone Portlaoise	solar	Treascon Solar	TSO	offer	40
E	Trien	solar	Shanacool (Trienearagh) Solar Park	DSO	offer	4
E	Trien	wind	Ballagh (1)	DSO	connected	4.6
E	Trien	wind	Beale Hill (1)	DSO	connected	1.65
E	Trien	wind	Beale Hill (2)	DSO	connected	2.55
E	Trien	wind	Beale Hill (3)	DSO	connected	1.3
E	Trien	wind	Curraghderrig (1)	DSO	connected	4.5
E	Trien	wind	Gortnacloghy Wiind Farm	DSO	connected	4.4
E	Trien	wind	Tournafulla (1)	DSO	connected	7.5
E	Trien_wind	wind	Knockawarriga (1)	DSO	connected	22.5
E	Trien_wind	wind	Knockawarriga Extension (Glenduff & Caherlevoy)	DSO	offer	6.6
E	Trien_wind	wind	Tournafulla (2)	DSO	connected	17.2
A	Trillick	wind	Beam Hill (1)	DSO	connected	14
A	Trillick	wind	Cooly (1)	DSO	connected	4
A	Trillick	wind	Crockahenny (1)	DSO	connected	5
A	Trillick	wind	Drumlough Hill (1)	DSO	connected	4.8
A	Trillick	wind	Drumlough Hill (2)	DSO	connected	9.99
A	Trillick	wind	Meenaward	DSO	connected	6.9
H2	Tullabeg into Banoge Crane	solar	Tullabeg Solar Park	TSO	offer	50
D	Tullabrack	wave	WestWave Killard	DSO	offer	5.4
D	Tullabrack	wind	Carrownawelaun (1)	DSO	connected	4.6
D	Tullabrack	wind	Moanmore (1)	DSO	connected	12.6
D	Tullabrack	wind	Tullabrack (1)	DSO	connected	13.8
B	Uggool	wind	Seecon (1)	TSO	connected	105
B	Uggool	wind	Uggool (1)	TSO	connected	64
H2	Waterford	solar	Curraghmartin Solar Park	DSO	offer	3.99
H2	Waterford	wind	Ballymartin (1)	DSO	connected	6
H2	Waterford	wind	Ballymartin (2)	DSO	connected	8.28
H2	Waterford	wind	Rahora (1)	DSO	connected	4.25
H2	Wexford	solar	Ballycarran Solar Park	DSO	ECP	3.999
H2	Wexford	solar	Ballykereen Solar	DSO	ECP	11
H2	Wexford	solar	Ballymackesy East Solar Farm	DSO	ECP	4
H2	Wexford	solar	Blusheens 2 Solar Park	DSO	offer	3.99

Area	Node	Type	Name	SO	Status	MEC
H2	Wexford	solar	Blusheens Solar Park	DSO	offer	3.99
H2	Wexford	solar	Davidstown Solar	DSO	ECP	5
H2	Wexford	solar	Dennistown Solar	DSO	ECP	26
H2	Wexford	solar	Mackmine Solar	DSO	ECP	10
H2	Wexford	solar	St Johns Solar Farm	DSO	ECP	4
H2	Wexford	solar	Sweetfarm Solar Farm	DSO	ECP	4
H2	Wexford	solar	Tomfarney North Solar Farm	DSO	ECP	8
H2	Wexford	solar	Tomnalossett Solar Farm (Assaly)	DSO	ECP	4
H2	Wexford	wind	Carnsore (1)	DSO	connected	11.9
H2	Wexford	wind	Richfield (1)	DSO	connected	20.25
H2	Wexford	wind	Richfield (2)	DSO	connected	6.75
K	Woodhouse	wind	Knocknamona Wind Farm (Prev. Crohaun)	TSO	offer	34
K	Woodhouse	wind	Woodhouse (1)	TSO	connected	20

Table B-15: Generation in the model

Note that the year of connection is rounded from the build-out rate date or target connection date.

These are in addition to the large generators which are listed in EirGrid's Generation Capacity Statement 2018.

C Area C Node Results

This appendix presents the results of the modelling analysis for Area C. The levels of curtailment and constraint that controllable solar and wind generators in Area C might expect to experience are reported on a nodal basis for the study scenarios. Details on the generation capacity at each node are provided along with the assumed amount of controllable wind generation.

This appendix also presents a list for each node of those generators that are included in the study.

The table of results for each node provides information for each scenario of the curtailment, the constraint and the combined curtailment and constraint. Where there is both solar and wind at a node, the solar and wind results are provided separately. The curtailment and constraint results are also provided as a graph. These graphs show how the combined curtailment and constraint increase as additional generation is added and show how it decreases in later years.

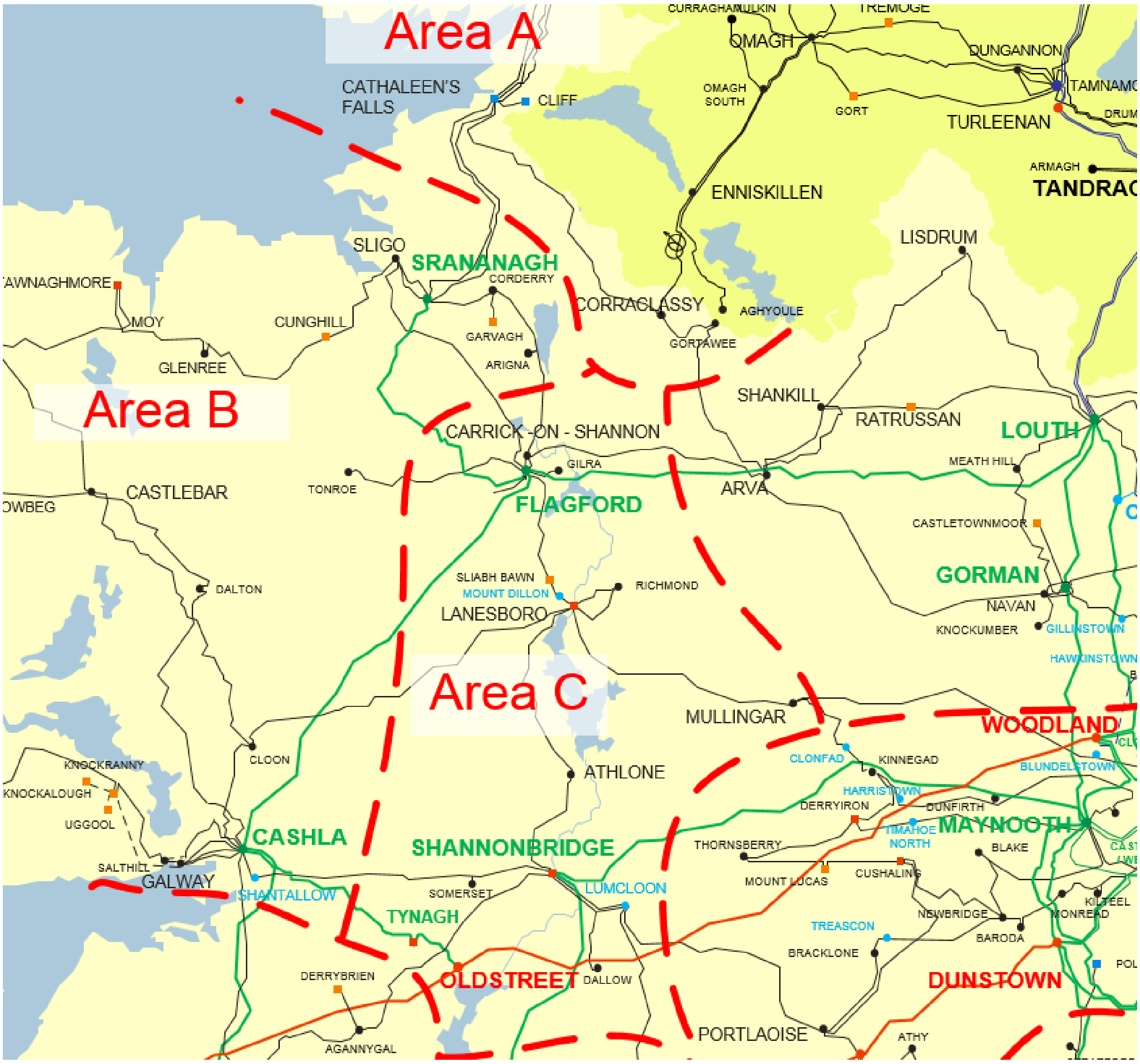

Figure 0-1 – Network Map of Area C

Node	SO	Status	Battery	Solar	Thermal	Wind
Athlone	DSO	ECP-1 Offer		4		
Athlone	DSO	Existing Offer		8		
Carrick on Shannon	DSO	Existing Offer		8		4
Dallow	DSO	Initial				21
Dallow	DSO	Existing Offer		4		
Dallow	DSO	ECP-1 Offer		4		3
Lanesboro	DSO	Initial				5
Lanesboro	DSO	Existing Offer		4		
Lanesboro	DSO	ECP-1 Offer				5
Lanesboro	TSO	Thermal			94	
Lumcloon	TSO	Existing Offer	100			
Lumcloon	TSO	ECP-1 Offer				34
Mount Dillon	TSO	ECP-1 Offer		90		
Mullingar	DSO	Existing Offer		8		
Mullingar	DSO	ECP-1 Offer		4		
Richmond	DSO	Existing Offer		4		
Richmond	DSO	ECP-1 Offer		8	5	
Shannonbridge	TSO	Initial			141	
Shannonbridge	TSO	ECP-1 Offer		65		
Shannonbridge 220	TSO	Existing Offer	163			
Sliabh Bawn	TSO	Initial				58
Somerset	DSO	Initial				8
Somerset	DSO	Existing Offer		4		12
SUBTOTAL			263	215	240	150

Table 0-1 Generation Summary in Area C

C.0 Generation Scenario "March 2020" versus Generation Scenario "Initial"

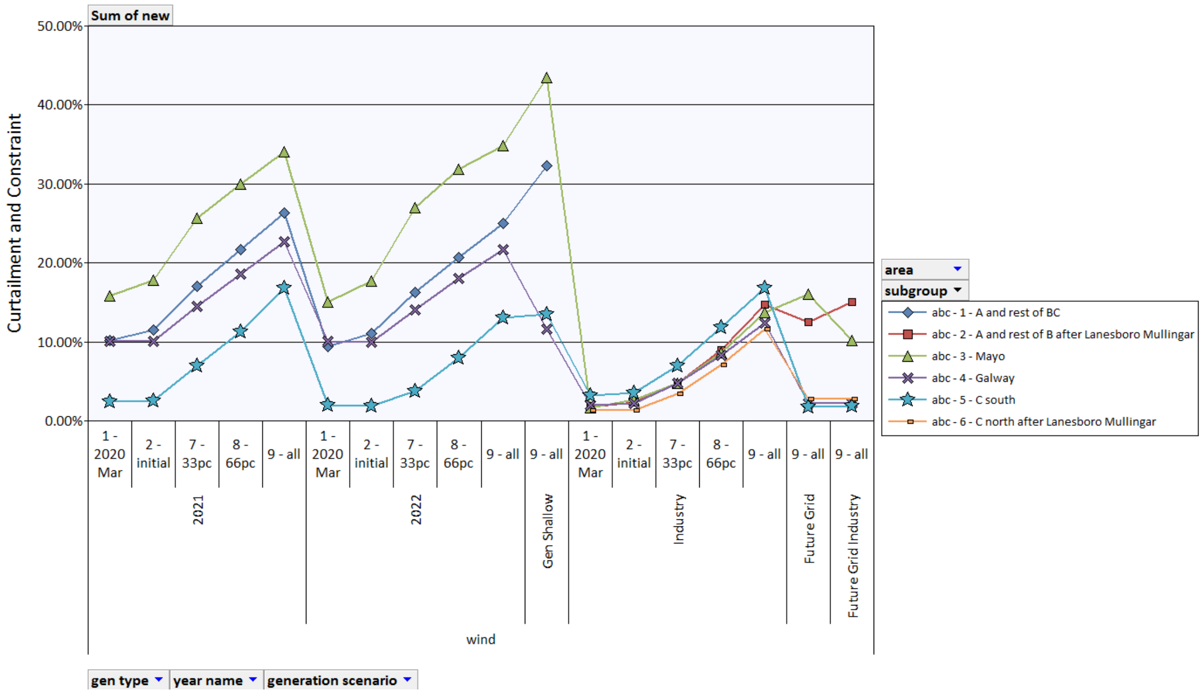

Figure 0-2 Curtailment and Constraint results with a March 2020 scenario that has 50 MW less wind generation in Area A, B and C

The analysis for these ECP-1 Constraint Reports was begun at the end of 2018. As such, the generator scenario "initial" is an estimate at the time of what generation would be installed by 2020.

At the time of preparing these revised reports, for the north west there is approx. 50 MW less generation installed than was predicted for generation scenario Initial. For this reason, an extra generation scenario, called "March 2020" was run to show the impact of the as installed generation.

The results for this scenario are provided in Section 5.6. The results for this scenario are not included in Appendix C.

C.1 Athlone

The location of this node is shown in the figure.

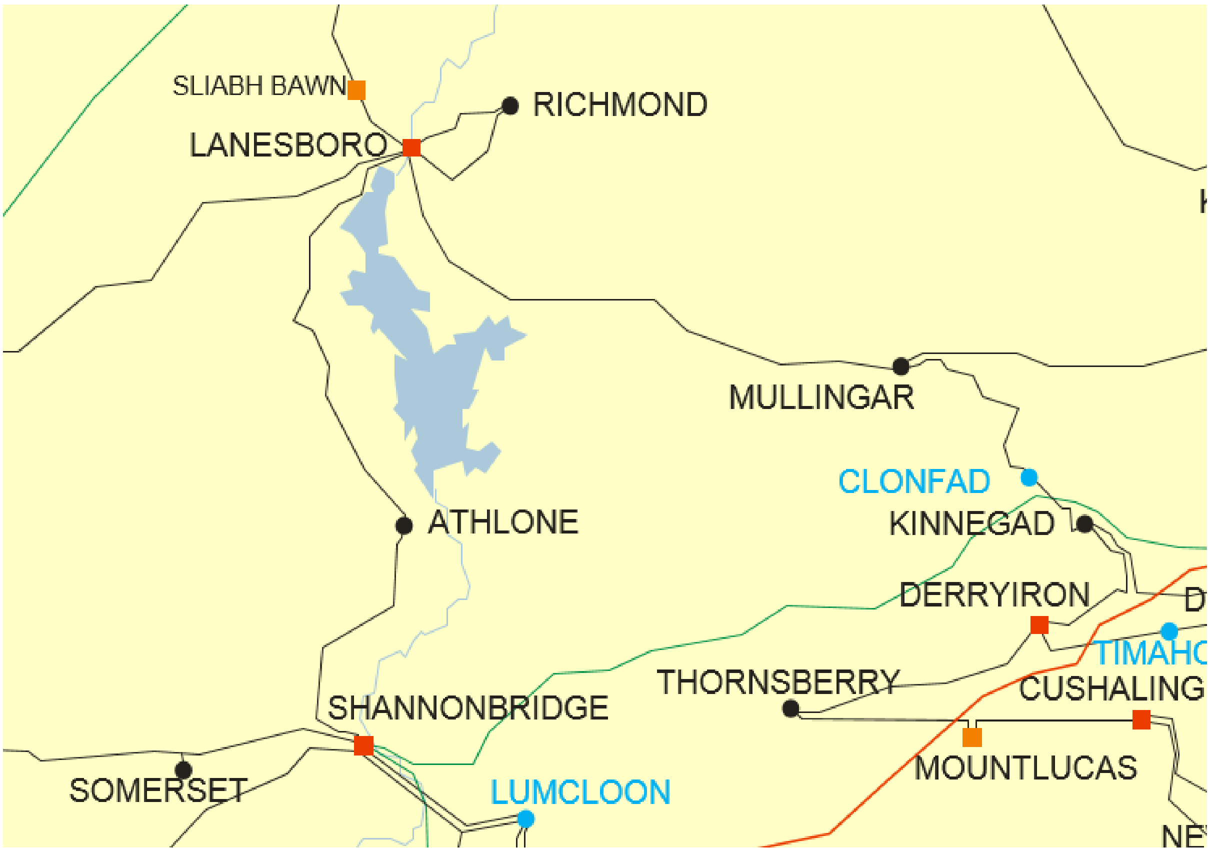

Figure 0-3 Location of Athlone Node

The generators, which are modelled at this node, are listed as follows.

Generator	SO	Type	Status	Capacity
Ballinamudda Solar Farm	DSO	solar	Existing Offer	4 MW
Rooaun Solar Farm	DSO	solar	ECP-1 Offer	4 MW
Shannagh Beg Solar Farm	DSO	solar	Existing Offer	4 MW

Table 0-2 Generation Included in Study for Athlone Node

ATHLONE SOLAR	Year	Initial	NW	33%	66%	All
Total (MW)		0	12	4	8	12
of which is Controllable (MW)		0	12	4	8	12
Available Energy Controllable (GWh)		0	12	4	8	12
Curtailment (GWh)	2020		0.2	0.1	0.4	1.1
	2021		0.1	0.1	0.3	1.0
	2022		0.1	0.0	0.2	0.8
Constraint (GWh)	2020		0.5	0.1	0.2	0.2
	2021		0.6	0.1	0.3	0.4
	2022		0.5	0.1	0.2	0.4
Curtailment and Constraint (GWh)	2020		0.6	0.2	0.6	1.3
	2021		0.7	0.2	0.6	1.3
	2022		0.6	0.1	0.5	1.2
Curtailment	2020		1%	2%	5%	9%
	2021		1%	2%	4%	8%
	2022		1%	1%	3%	7%
	Gen Shallow					7%
	Industry		1%	1%	3%	7%
Constraint	2020		4%	2%	2%	2%
	2021		5%	3%	3%	3%
	2022		4%	3%	3%	4%
	Gen Shallow					4%
	Industry		1%	1%	3%	4%
Curtailment and Constraint	2020		6%	4%	7%	11%
	2021		6%	5%	8%	11%
	2022		5%	4%	6%	10%
	Gen Shallow					11%
	Industry		2%	2%	6%	11%
	Future Grid					2%
	Industry Future Grid					2%

Table 0-3 Results for Athlone Solar

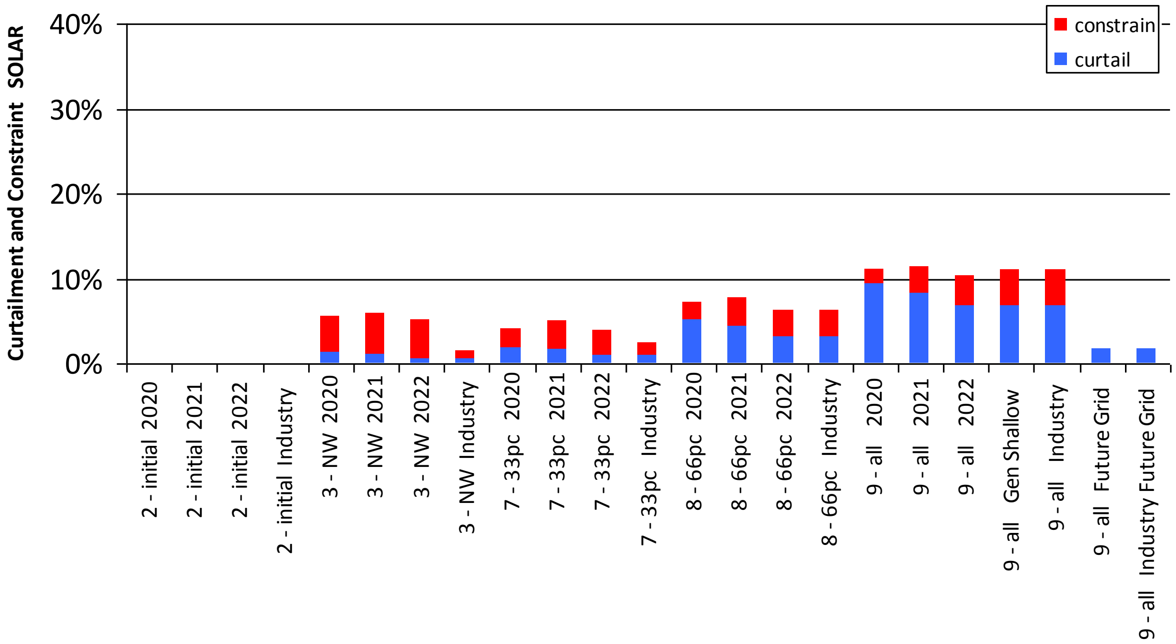

Figure 0-4 Curtailment and Constraint for Athlone Solar

C.2 Carrick on Shannon

The location of this node is shown in the figure.

Figure 0-5 Location of Carrick on Shannon Node

The generators, which are modelled at this node, are listed as follows.

Generator	SO	Type	Status	Capacity
Derryknockeran (1)	DSO	wind	Existing Offer	4 MW
Lisdadnan Solar Farm	DSO	solar	Existing Offer	4 MW
Rathleg Solar Farm	DSO	solar	Existing Offer	4 MW

Table 0-4 Generation Included in Study for Carrick on Shannon Node

The Gate 3 windfarm for Derryknockeran is not considered to be controllable for this study.

CARRICK ON SHANNON SOLAR	Year	Initial	NW	33%	66%	All
Total (MW)		0	8	3	5	8
of which is Controllable (MW)		0	8	3	5	8
Available Energy Controllable (GWh)		0	8	3	5	8
Curtailment (GWh)	2020		0.1	0.0	0.3	0.7
	2021		0.1	0.0	0.2	0.7
	2022		0.0	0.0	0.2	0.5
Constraint (GWh)	2020		1.8	0.3	0.7	1.1
	2021		1.8	0.4	0.7	1.2
	2022		1.7	0.3	0.7	1.4
Curtailment and Constraint (GWh)	2020		1.9	0.4	0.9	1.9
	2021		1.9	0.4	1.0	1.9
	2022		1.7	0.3	0.9	1.9
Curtailment	2020		1%	2%	5%	9%
	2021		1%	2%	4%	8%
	2022		1%	1%	3%	7%
	Gen Shallow					7%
	Industry		1%	1%	3%	7%
Constraint	2020		23%	14%	13%	15%
	2021		24%	14%	15%	16%
	2022		22%	12%	14%	17%
	Gen Shallow					27%
	Industry		4%	1%	1%	1%
Curtailment and Constraint	2020		24%	15%	18%	24%
	2021		25%	16%	19%	24%
	2022		22%	13%	18%	24%
	Gen Shallow					33%
	Industry		4%	2%	4%	8%
	Future Grid					8%
	Industry Future Grid					7%

Table 0-5 Results for Carrick on Shannon Solar

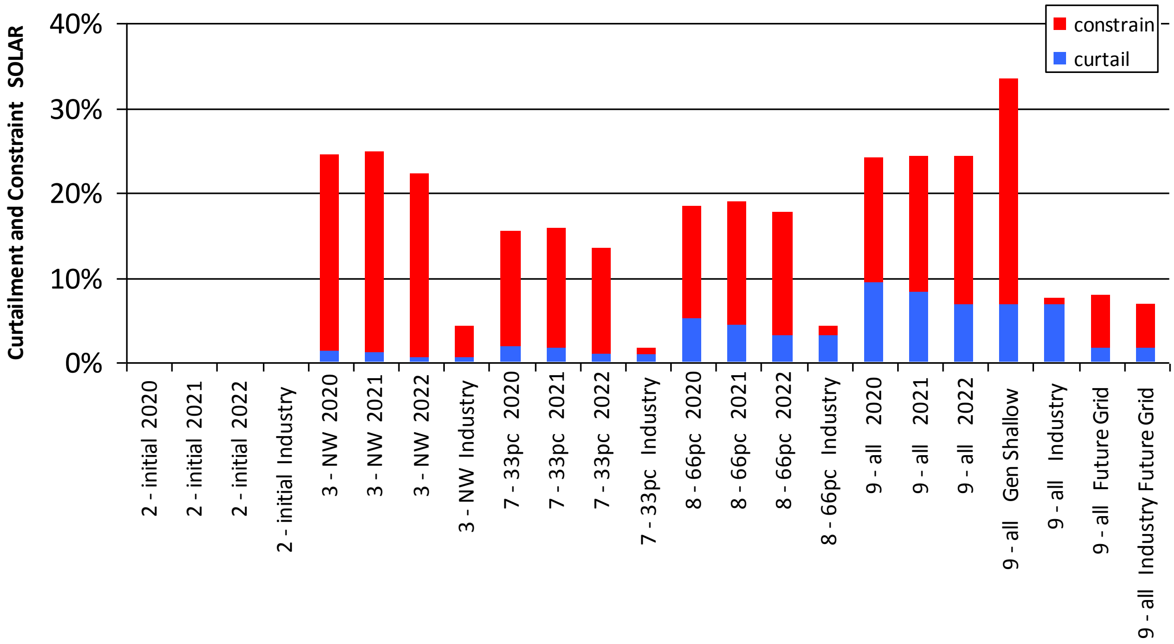

Figure 0-6 Curtailment and Constraint for Carrick on Shannon Solar

C.3 Dallow

The location of this node is shown in the figure.

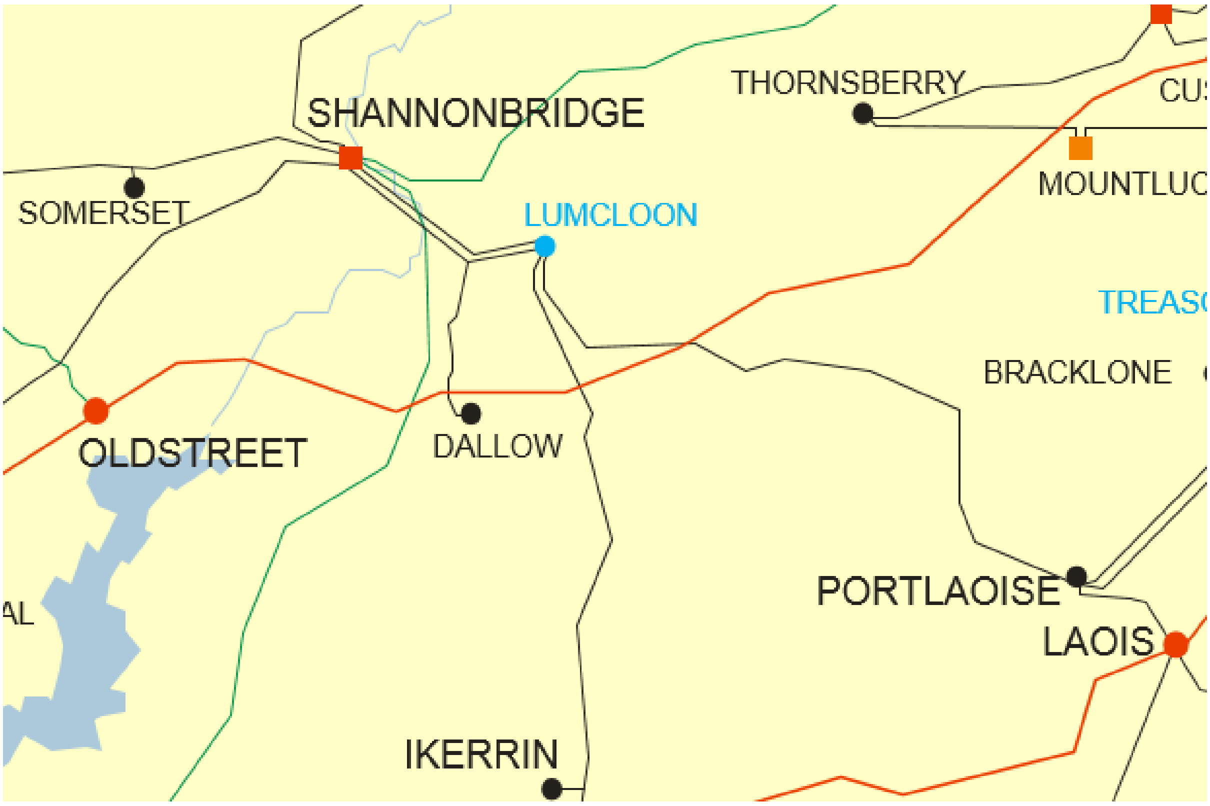

Figure 0-7 Location of Dallow Node

The generators, which are modelled at this node, are listed as follows.

Generator	SO	Type	Status	Capacity
Carrig (1)	DSO	wind	Initial	3 MW
Clonoghill Solar Farm	DSO	solar	Existing Offer	4 MW
Lacka Solar Park	DSO	solar	ECP-1 Offer	4 MW
Leabeg (1)	DSO	wind	Initial	4 MW
Meenwaun WF	DSO	wind	Initial	10 MW
Meenwaun Windfarm Ext.	DSO	wind	ECP-1 Offer	3 MW
Skehanagh (1)	DSO	wind	Initial	4 MW

Table 0-6 Generation Included in Study for Dallow Node

DALLOW SOLAR	Year	Initial	NW	33%	66%	All
Total (MW)		0	8	3	5	8
of which is Controllable (MW)		0	8	3	5	8
Available Energy Controllable (GWh)		0	8	3	5	8
Curtailment (GWh)	2020		0.1	0.0	0.3	0.7
	2021		0.1	0.0	0.2	0.6
	2022		0.0	0.0	0.2	0.5
Constraint (GWh)	2020		0.3	0.1	0.1	0.1
	2021		0.4	0.1	0.2	0.2
	2022		0.3	0.1	0.2	0.3
Curtailment and Constraint (GWh)	2020		0.4	0.1	0.4	0.9
	2021		0.5	0.1	0.4	0.9
	2022		0.4	0.1	0.3	0.8
Curtailment	2020		1%	2%	5%	9%
	2021		1%	2%	4%	8%
	2022		1%	1%	3%	7%
	Gen Shallow					7%
	Industry		1%	1%	3%	7%
Constraint	2020		4%	2%	2%	2%
	2021		5%	3%	3%	3%
	2022		4%	3%	3%	4%
	Gen Shallow					4%
	Industry		1%	1%	3%	4%
Curtailment and Constraint	2020		6%	4%	7%	11%
	2021		6%	5%	8%	11%
	2022		5%	4%	6%	10%
	Gen Shallow					11%
	Industry		2%	2%	6%	11%
	Future Grid					2%
	Industry Future Grid					2%

Table 0-7 Results for Dallow Solar

DALLOW WIND	Year	Initial	NW	33%	66%	All
Total (MW)		21	24	22	23	24
of which is Controllable (MW)		10	13	11	12	13
Available Energy Controllable (GWh)		28	38	31	34	38
Curtailment (GWh)	2020	0.7	2.3	1.9	3.6	6.0
	2021	0.5	1.8	1.4	3.0	5.2
	2022	0.3	1.2	1.0	2.2	4.1
Constraint (GWh)	2020	0.2	0.1	0.2	0.5	0.6
	2021	0.2	0.2	0.7	0.8	1.2
	2022	0.2	0.2	0.2	0.5	0.8
Curtailment and Constraint (GWh)	2020	0.9	2.3	2.1	4.1	6.6
	2021	0.7	1.9	2.1	3.9	6.4
	2022	0.5	1.4	1.2	2.7	4.9
Curtailment	2020	3%	6%	6%	11%	16%
	2021	2%	5%	5%	9%	14%
	2022	1%	3%	3%	7%	11%
	Gen Shallow					11%
	Industry	1%	3%	3%	7%	11%
Constraint	2020	1%	0%	1%	1%	2%
	2021	1%	0%	2%	2%	3%
	2022	1%	0%	1%	1%	2%
	Gen Shallow					3%
	Industry	2%	2%	4%	5%	6%
Curtailment and Constraint	2020	3%	6%	7%	12%	17%
	2021	3%	5%	7%	11%	17%
	2022	2%	4%	4%	8%	13%
	Gen Shallow					13%
	Industry	4%	5%	7%	12%	17%
	Future Grid					2%
	Industry Future Grid					2%

Table 0-8 Results for Dallow Wind

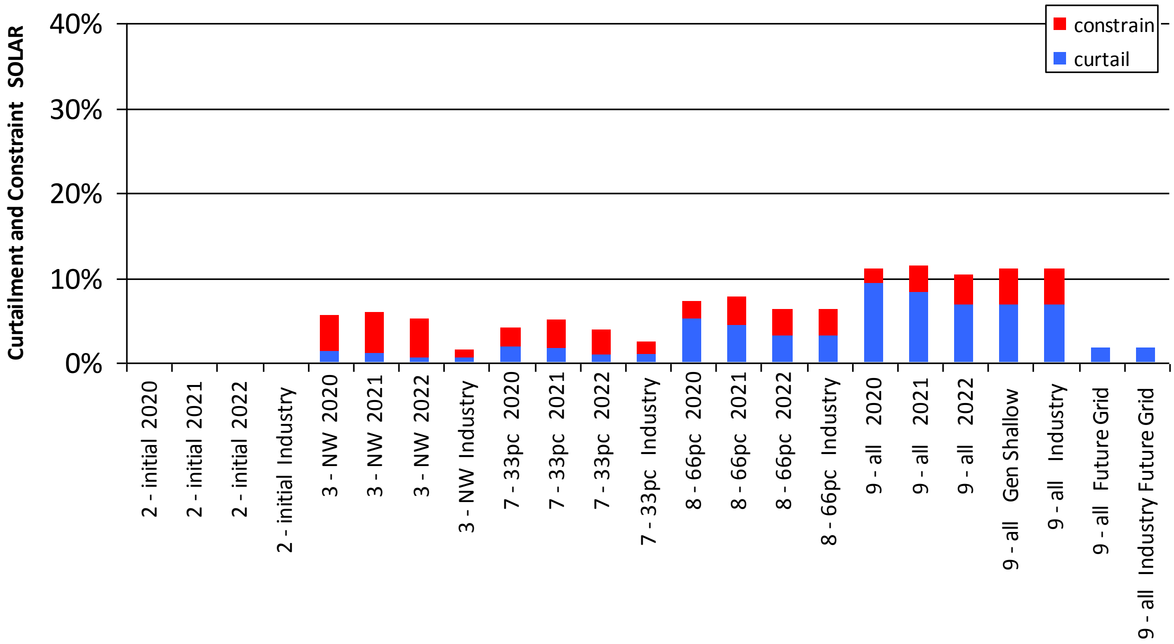

Figure 0-8 Curtailment and Constraint for Dallow Solar

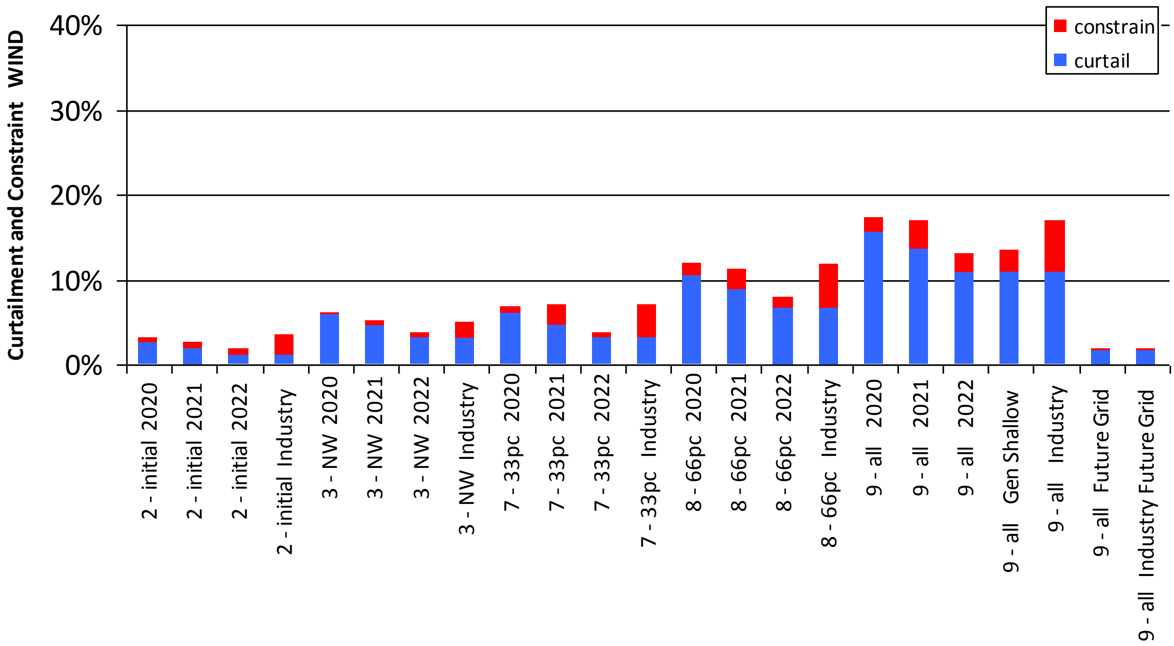

Figure 0-9 Curtailment and Constraint for Dallow Wind

C.4 Lanesboro

The location of this node is shown in the figure.

Figure 0-10 Location of Lanesboro Node

The generators, which are modelled at this node, are listed as follows.

Generator	SO	Type	Status	Capacity
Creevy Solar	DSO	solar	Existing Offer	4 MW
Lough Ree Power	TSO	thermal	Initial	94 MW
Roxborough	DSO	wind	ECP-1 Offer	5 MW
Skrine (1)	DSO	wind	Initial	5 MW

Table 0-9 Generation Included in Study for Lanesboro Node

LANESBORO SOLAR	Year	Initial	NW	33%	66%	All
Total (MW)		0	4	1	3	4
of which is Controllable (MW)		0	4	1	3	4
Available Energy Controllable (GWh)		0	4	1	3	4
Curtailment (GWh)	2020		0.1	0.0	0.1	0.4
	2021		0.0	0.0	0.1	0.3
	2022		0.0	0.0	0.1	0.3
Constraint (GWh)	2020		0.2	0.0	0.1	0.1
	2021		0.2	0.0	0.1	0.1
	2022		0.2	0.0	0.1	0.1
Curtailment and Constraint (GWh)	2020		0.2	0.1	0.2	0.4
	2021		0.2	0.1	0.2	0.4
	2022		0.2	0.0	0.2	0.4
Curtailment	2020		1%	2%	5%	9%
	2021		1%	2%	4%	8%
	2022		1%	1%	3%	7%
	Gen Shallow					7%
	Industry		1%	1%	3%	7%
Constraint	2020		4%	2%	2%	2%
	2021		5%	3%	3%	3%
	2022		4%	3%	3%	4%
	Gen Shallow					4%
	Industry		1%	1%	3%	4%
Curtailment and Constraint	2020		6%	4%	7%	11%
	2021		6%	5%	8%	11%
	2022		5%	4%	6%	10%
	Gen Shallow					11%
	Industry		2%	2%	6%	11%
	Future Grid					2%
	Industry Future Grid					2%

Table 0-10 Results for Lanesboro Solar

LANESBORO WIND	Year	Initial	NW	33%	66%	All
Total (MW)		0	10	6	8	10
of which is Controllable (MW)		0	5	2	3	5
Available Energy Controllable (GWh)		0	15	5	10	15
Curtailment (GWh)	2020		0.9	0.3	1.1	2.4
	2021		0.7	0.2	0.9	2.1
	2022		0.5	0.2	0.6	1.6
Constraint (GWh)	2020		3.0	0.5	1.1	1.7
	2021		3.3	0.6	1.3	2.0
	2022		3.3	0.7	1.5	2.2
Curtailment and Constraint (GWh)	2020		3.9	0.8	2.2	4.1
	2021		4.0	0.9	2.2	4.1
	2022		3.8	0.8	2.1	3.9
Curtailment	2020		6%	6%	10%	15%
	2021		5%	5%	9%	13%
	2022		3%	3%	6%	11%
	Gen Shallow					11%
	Industry		3%	3%	7%	11%
Constraint	2020		19%	10%	11%	11%
	2021		21%	13%	13%	13%
	2022		21%	13%	14%	14%
	Gen Shallow					22%
	Industry		0%	0%	0%	0%
Curtailment and Constraint	2020		25%	16%	21%	26%
	2021		26%	17%	22%	26%
	2022		24%	16%	21%	25%
	Gen Shallow					32%
	Industry		4%	3%	7%	12%
	Future Grid					3%
	Industry Future Grid					3%

Table 0-11 Results for Lanesboro Wind

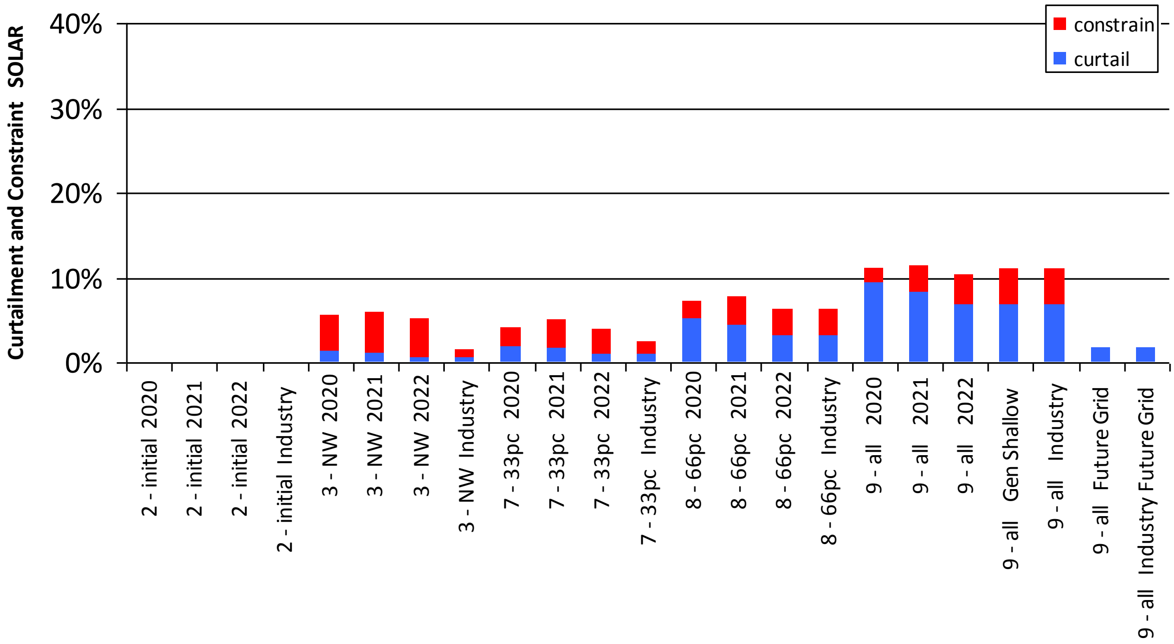

Figure 0-11 Curtailment and Constraint for Lanesboro Solar

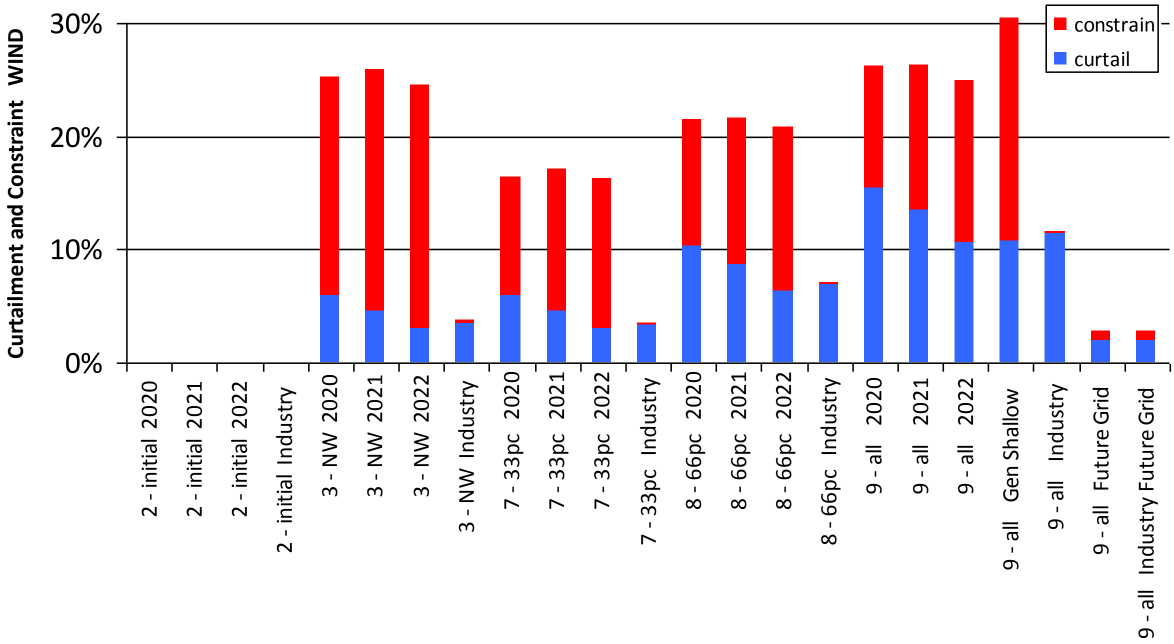

Figure 0-12 Curtailment and Constraint for Lanesboro Wind

C.5 Lumcloon

The location of this node is shown in the figure.

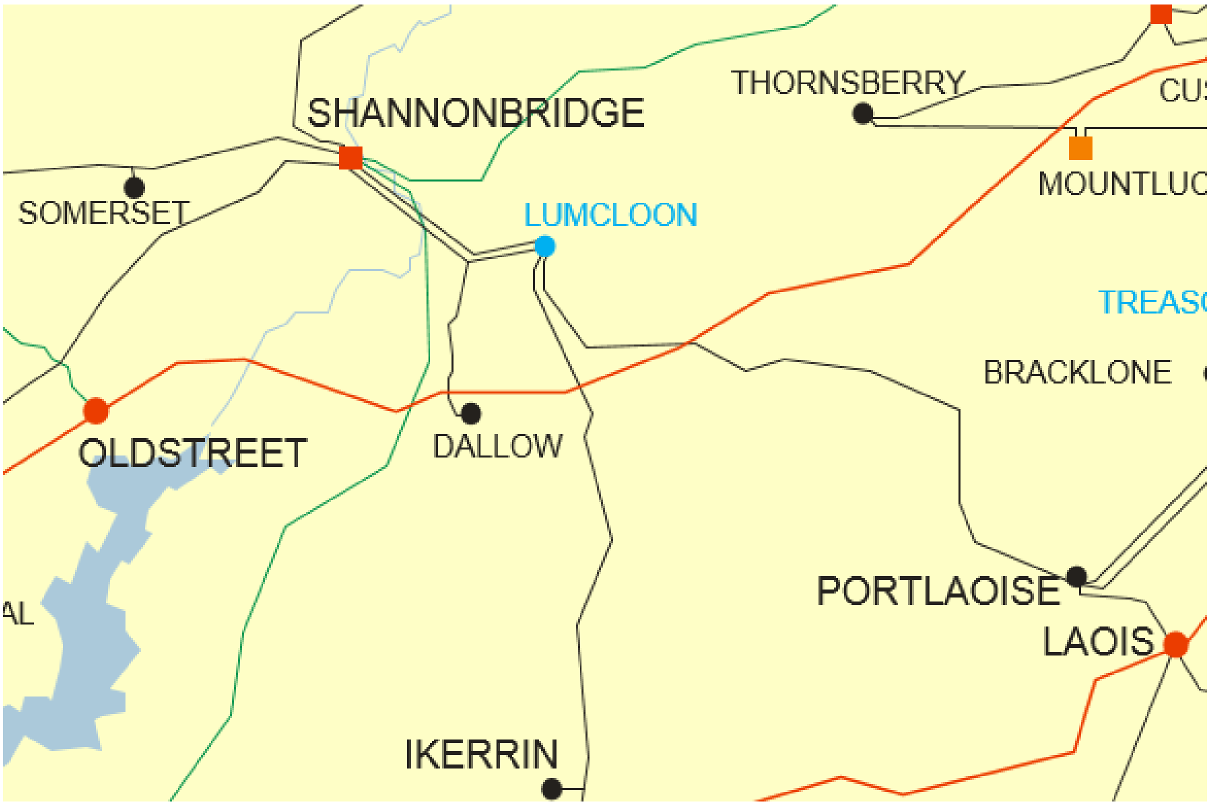

Figure 0-13 Location of Lumcloon Node

The generators, which are modelled at this node, are listed as follows.

Generator	SO	Type	Status	Capacity
Cloghan Wind Farm	TSO	wind	ECP-1 Offer	34 MW
Lumcloon ESS (Derrycarney)	TSO	battery	Existing Offer	100 MW

Table 0-12 Generation Included in Study for Lumcloon Node

LUMCLOON WIND	Year	Initial	NW	33%	66%	All
Total (MW)		0	34	11	22	34
of which is Controllable (MW)		0	34	11	22	34
Available Energy Controllable (GWh)		0	106	35	70	106
Curtailment (GWh)	2020		6.3	2.1	7.4	16.7
	2021		4.9	1.6	6.2	14.5
	2022		3.4	1.1	4.6	11.6
Constraint (GWh)	2020		0.1	0.3	0.9	1.8
	2021		0.4	0.8	1.7	3.4
	2022		0.4	0.2	1.0	2.3
Curtailment and Constraint (GWh)	2020		6.5	2.4	8.4	18.5
	2021		5.4	2.4	7.9	17.9
	2022		3.8	1.3	5.6	13.9
Curtailment	2020		6%	6%	11%	16%
	2021		5%	5%	9%	14%
	2022		3%	3%	7%	11%
	Gen Shallow					11%
	Industry		3%	3%	7%	11%
Constraint	2020		0%	1%	1%	2%
	2021		0%	2%	2%	3%
	2022		0%	1%	1%	2%
	Gen Shallow					3%
	Industry		2%	4%	5%	6%
Curtailment and Constraint	2020		6%	7%	12%	17%
	2021		5%	7%	11%	17%
	2022		4%	4%	8%	13%
	Gen Shallow					13%
	Industry		5%	7%	12%	17%
	Future Grid					2%
	Industry Future Grid					2%

Table 0-13 Results for Lumcloon Wind

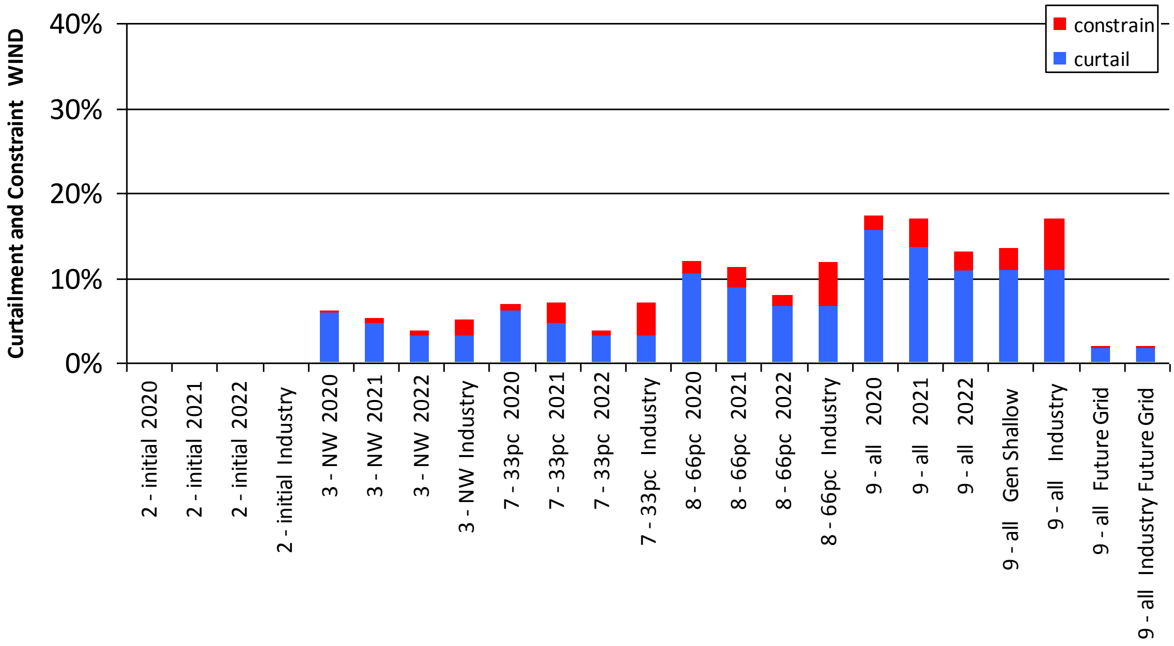

Figure 0-14 Curtailment and Constraint for Lumcloon Wind

C.6 Mount Dillon

The location of this node is shown in the figure.

Figure 0-15 Location of Mount Dillon Node

The generators, which are modelled at this node, are listed as follows.

Generator	SO	Type	Status	Capacity
Mountdillon Solar	TSO	solar	ECP-1 Offer	90 MW

Table 0-14 Generation Included in Study for Mount Dillon Node

MOUNT DILLON SOLAR	Year	Initial	NW	33%	66%	All
Total (MW)		0	90	30	59	90
of which is Controllable (MW)		0	90	30	59	90
Available Energy Controllable (GWh)		0	88	29	58	88
Curtailment (GWh)	2020		1.2	0.5	3.0	8.2
	2021		0.9	0.5	2.5	7.3
	2022		0.6	0.3	1.9	5.9
Constraint (GWh)	2020		20.3	3.9	7.6	12.9
	2021		20.8	4.1	8.4	14.0
	2022		18.9	3.6	8.4	15.3
Curtailment and Constraint (GWh)	2020		21.5	4.5	10.6	21.2
	2021		21.8	4.6	11.0	21.3
	2022		19.5	3.9	10.2	21.3
Curtailment	2020		1%	2%	5%	9%
	2021		1%	2%	4%	8%
	2022		1%	1%	3%	7%
	Gen Shallow					7%
	Industry		1%	1%	3%	7%
Constraint	2020		23%	14%	13%	15%
	2021		24%	14%	15%	16%
	2022		22%	12%	14%	17%
	Gen Shallow					27%
	Industry		4%	1%	1%	1%
Curtailment and Constraint	2020		24%	15%	18%	24%
	2021		25%	16%	19%	24%
	2022		22%	13%	18%	24%
	Gen Shallow					33%
	Industry		4%	2%	4%	8%
	Future Grid					8%
	Industry Future Grid					7%

Table 0-15 Results for Mount Dillon Solar

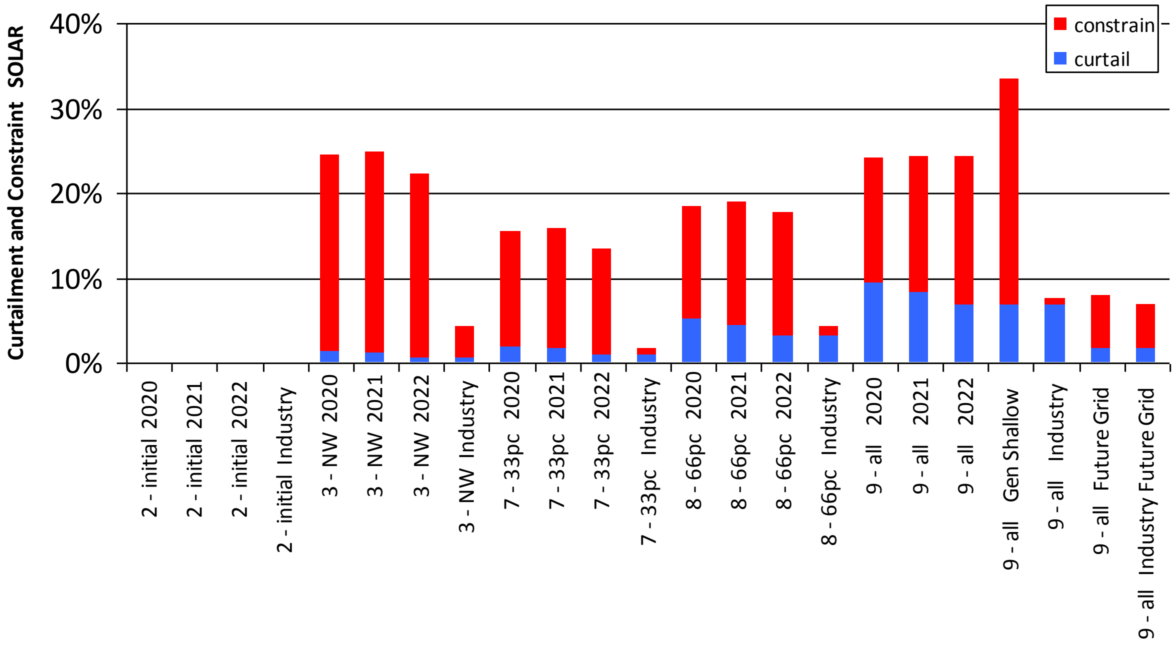

Figure 0-16 Curtailment and Constraint for Mount Dillon Solar

C.7 Mullingar

The location of this node is shown in the figure.

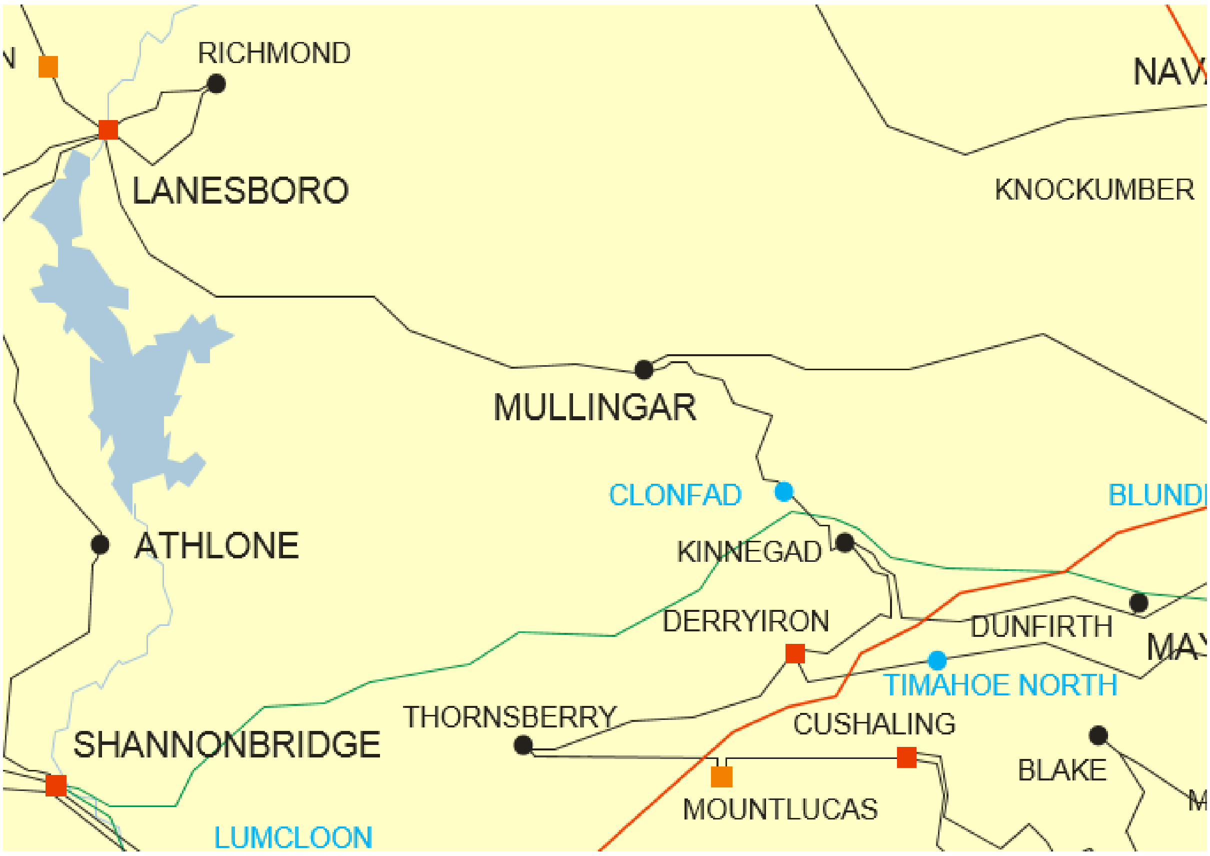

Figure 0-17 Location of Mullingar Node

The generators, which are modelled at this node, are listed as follows.

Generator	SO	Type	Status	Capacity
Liss Solar Farm (prev Lands at Liss)	DSO	solar	Existing Offer	4 MW
Marlinstown Solar Farm (prev Russellstown)	DSO	solar	Existing Offer	4 MW
Tullynally Estate	DSO	solar	ECP-1 Offer	4 MW

Table 0-16 Generation Included in Study for Mullingar Node

MULLINGAR SOLAR	Year	Initial	NW	33%	66%	All
Total (MW)		0	12	4	8	12
of which is Controllable (MW)		0	12	4	8	12
Available Energy Controllable (GWh)		0	12	4	8	12
Curtailment (GWh)	2020		0.2	0.1	0.4	1.1
	2021		0.1	0.1	0.3	1.0
	2022		0.1	0.0	0.2	0.8
Constraint (GWh)	2020		0.5	0.1	0.2	0.2
	2021		0.6	0.1	0.3	0.4
	2022		0.5	0.1	0.2	0.4
Curtailment and Constraint (GWh)	2020		0.6	0.2	0.6	1.3
	2021		0.7	0.2	0.6	1.3
	2022		0.6	0.1	0.5	1.2
Curtailment	2020		1%	2%	5%	9%
	2021		1%	2%	4%	8%
	2022		1%	1%	3%	7%
	Gen Shallow					7%
	Industry		1%	1%	3%	7%
Constraint	2020		4%	2%	2%	2%
	2021		5%	3%	3%	3%
	2022		4%	3%	3%	4%
	Gen Shallow					4%
	Industry		1%	1%	3%	4%
Curtailment and Constraint	2020		6%	4%	7%	11%
	2021		6%	5%	8%	11%
	2022		5%	4%	6%	10%
	Gen Shallow					11%
	Industry		2%	2%	6%	11%
	Future Grid					2%
	Industry Future Grid					2%

Table 0-17 Results for Mullingar Solar

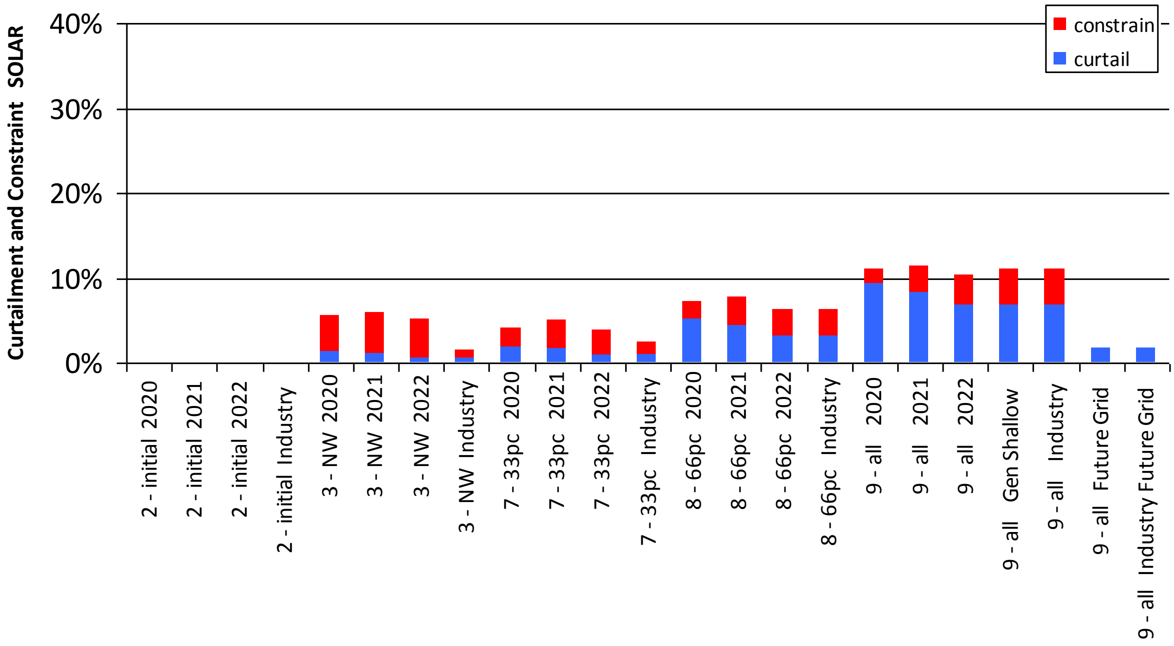

Figure 0-18 Curtailment and Constraint for Mullingar Solar

C.8 Richmond

The location of this node is shown in the figure.

Figure 0-19 Location of Richmond Node

The generators, which are modelled at this node, are listed as follows.

Generator	SO	Type	Status	Capacity
Camlin CHP	DSO	thermal	ECP-1 Offer	5 MW
Cleggil Solar	DSO	solar	ECP-1 Offer	8 MW
Lisnageeragh Solar Farm	DSO	solar	Existing Offer	4 MW

Table 0-18 Generation Included in Study for Richmond Node

RICHMOND SOLAR	Year	Initial	NW	33%	66%	All
Total (MW)	2020 to 2022	0	12	4	8	12
of which is Controllable (MW)	2020 to 2022	0	12	4	8	12
Available Energy Controllable (GWh)	2020 to 2022	0	12	4	8	12
Curtailment (GWh)	2020		0.2	0.1	0.4	1.1
	2021		0.1	0.1	0.3	1.0
	2022		0.1	0.0	0.2	0.8
Constraint (GWh)	2020		0.5	0.1	0.2	0.2
	2021		0.6	0.1	0.3	0.4
	2022		0.5	0.1	0.2	0.4
Curtailment and Constraint (GWh)	2020		0.6	0.2	0.6	1.3
	2021		0.7	0.2	0.6	1.3
	2022		0.6	0.1	0.5	1.2
Curtailment	2020		1%	2%	5%	9%
	2021		1%	2%	4%	8%
	2022		1%	1%	3%	7%
	Gen Shallow					7%
	Industry		1%	1%	3%	7%
Constraint	2020		4%	2%	2%	2%
	2021		5%	3%	3%	3%
	2022		4%	3%	3%	4%
	Gen Shallow					4%
	Industry		1%	1%	3%	4%
Curtailment and Constraint	2020		6%	4%	7%	11%
	2021		6%	5%	8%	11%
	2022		5%	4%	6%	10%
	Gen Shallow					11%
	Industry		2%	2%	6%	11%
	Future Grid					2%
	Industry Future Grid					2%

Table 0-19 Results for Richmond Solar

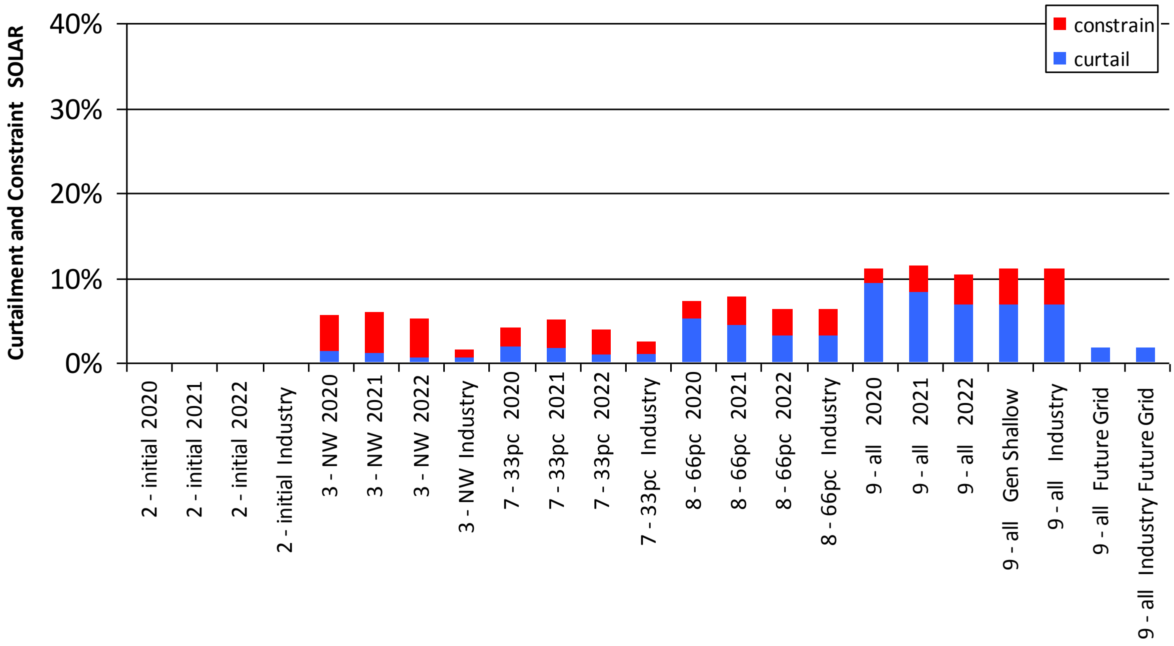

Figure 0-20 Curtailment and Constraint for Richmond Solar

C.9 Shannonbridge

The location of this node is shown in the figure.

Figure 0-21 Location of Shannonbridge Node

The generators, which are modelled at this node, are listed as follows.

Generator	SO	Type	Status	Capacity
Blackwater Bog Solar 1	TSO	solar	ECP-1 Offer	65 MW
West Offaly Power	TSO	thermal	Initial	141 MW

Table 0-20 Generation Included in Study for Shannonbridge Node

SHANNONBRIDGE SOLAR	Year	Initial	NW	33%	66%	All
Total (MW)		0	65	21	43	65
of which is Controllable (MW)		0	65	21	43	65
Available Energy Controllable (GWh)		0	63	21	42	63
Curtailment (GWh)	2020		0.8	0.4	2.2	5.9
	2021		0.7	0.3	1.8	5.3
	2022		0.4	0.2	1.3	4.3
Constraint (GWh)	2020		2.7	0.5	0.8	1.1
	2021		3.1	0.7	1.4	1.9
	2022		2.8	0.6	1.3	2.2
Curtailment and Constraint (GWh)	2020		3.5	0.9	3.0	7.1
	2021		3.8	1.0	3.2	7.2
	2022		3.2	0.8	2.6	6.5
Curtailment	2020		1%	2%	5%	9%
	2021		1%	2%	4%	8%
	2022		1%	1%	3%	7%
	Gen Shallow					7%
	Industry		1%	1%	3%	7%
Constraint	2020		4%	2%	2%	2%
	2021		5%	3%	3%	3%
	2022		4%	3%	3%	4%
	Gen Shallow					4%
	Industry		1%	1%	3%	4%
Curtailment and Constraint	2020		6%	4%	7%	11%
	2021		6%	5%	8%	11%
	2022		5%	4%	6%	10%
	Gen Shallow					11%
	Industry		2%	2%	6%	11%
	Future Grid					2%
	Industry Future Grid					2%

Table 0-21 Results for Shannonbridge Solar

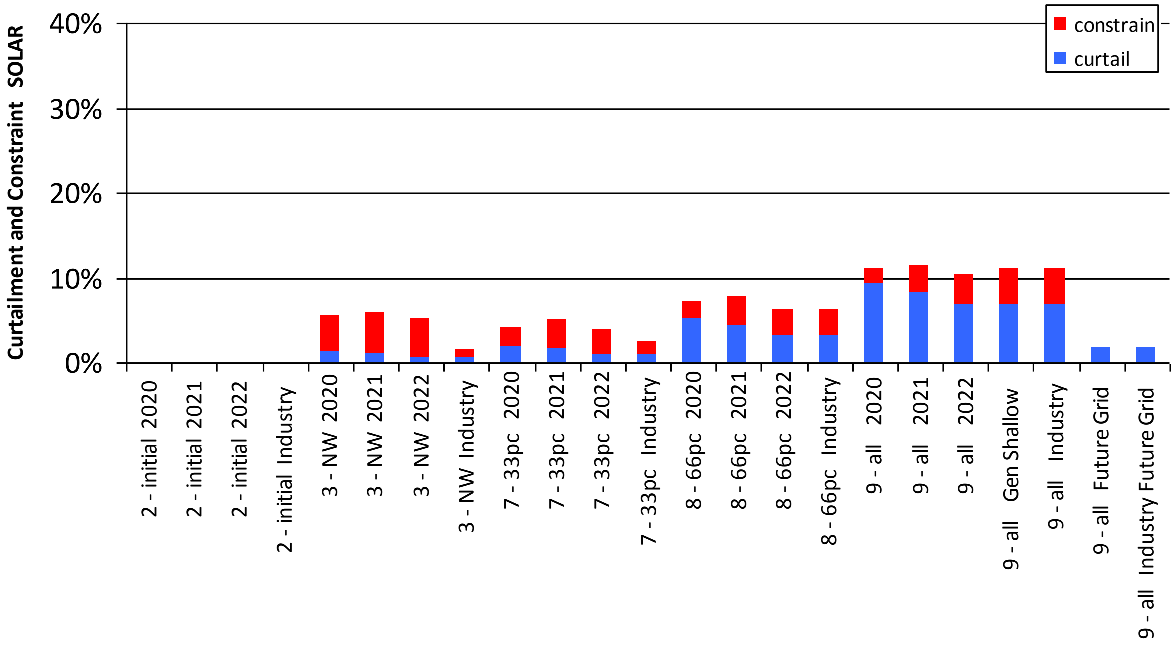

Figure 0-22 Curtailment and Constraint for Shannonbridge solar

C.10 Sliabh Bawn

The location of this node is shown in the figure.

Figure 0-23 Location of Sliabh Bawn Node

The generators, which are modelled at this node, are listed as follows.

Generator	SO	Type	Status	Capacity
Sliabh Bawn (1)	TSO	wind	Initial	58 MW

Table 0-22 Generation Included in Study for Sliabh Bawn Node

SLIABH BAWN WIND	Year	Initial	NW	33%	66%	All
Total (MW)	2020 to 2022	58	58	58	58	58
of which is Controllable (MW)	2020 to 2022	58	58	58	58	58
Available Energy Controllable (GWh)	2020 to 2022	170	170	170	170	170
Curtailment (GWh)	2020	4.4	10.0	10.0	17.7	26.5
	2021	3.2	7.8	7.8	14.7	22.9
	2022	1.9	5.1	5.1	10.7	18.1
Constraint (GWh)	2020	14.1	33.2	17.9	19.0	18.2
	2021	16.4	36.3	21.3	22.0	21.8
	2022	16.8	36.5	22.5	24.5	24.4
Curtailment and Constraint (GWh)	2020	18.6	43.2	27.9	36.7	44.6
	2021	19.5	44.1	29.0	36.8	44.7
	2022	18.7	41.6	27.6	35.2	42.4
Curtailment	2020	3%	6%	6%	10%	15%
	2021	2%	5%	5%	9%	13%
	2022	1%	3%	3%	6%	11%
	Gen Shallow					11%
	Industry	1%	3%	3%	7%	11%
Constraint	2020	8%	19%	10%	11%	11%
	2021	10%	21%	13%	13%	13%
	2022	10%	21%	13%	14%	14%
	Gen Shallow					22%
	Industry	0%	0%	0%	0%	0%
Curtailment and Constraint	2020	11%	25%	16%	21%	26%
	2021	11%	26%	17%	22%	26%
	2022	11%	24%	16%	21%	25%
	Gen Shallow					32%
	Industry	1%	4%	3%	7%	12%
	Future Grid					3%
	Industry Future Grid					3%

Table 0-23 Results for Sliabh Bawn Wind

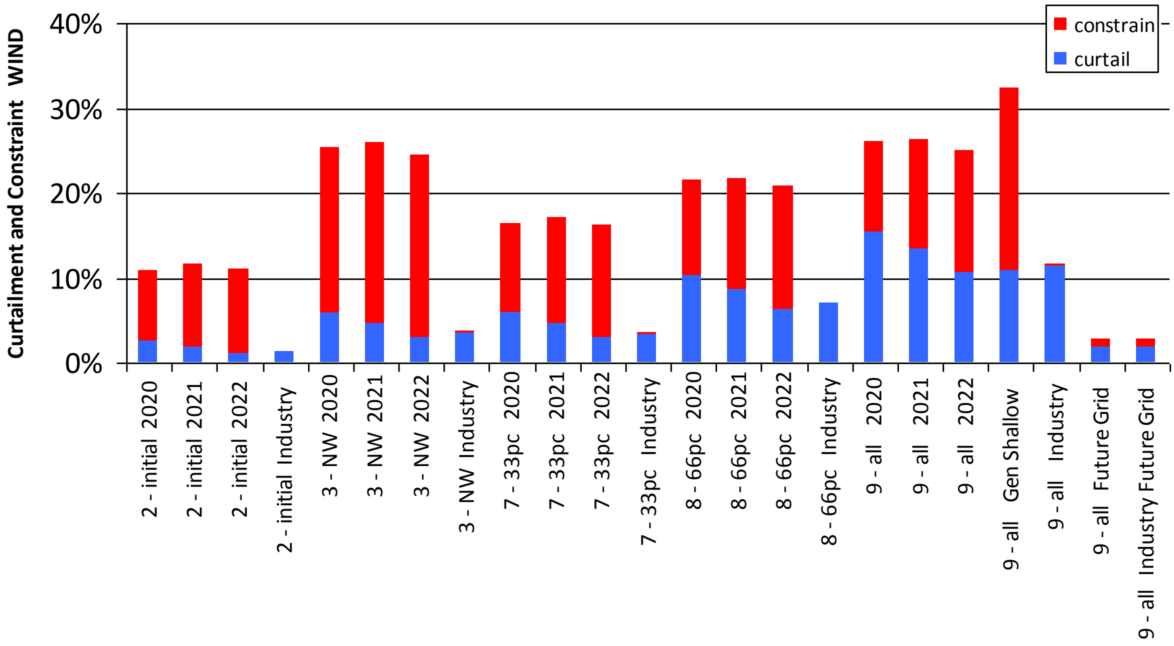

Figure 0-24 Curtailment and Constraint for Sliabh Bawn Wind

C.11 Somerset

The location of this node is shown in the figure.

Figure 0-25 Location of Somerset Node

The generators, which are modelled at this node, are listed as follows.

Generator	SO	Type	Status	Capacity
Ballycrissane Solar Farm	DSO	solar	Existing Offer	4 MW
Lisbeg Windfarm (formerly Sonnagh Old 2 & 3)	DSO	wind	Existing Offer	12 MW
Sonnagh Old (1)	DSO	wind	Initial	8 MW

Table 0-24 Generation Included in Study for Somerset Node

SOMERSET SOLAR	Year	Initial	NW	33%	66%	All
Total (MW)		0	4	1	3	4
of which is Controllable (MW)		0	4	1	3	4
Available Energy Controllable (GWh)		0	4	1	3	4
Curtailment (GWh)	2020		0.1	0.0	0.1	0.4
	2021		0.0	0.0	0.1	0.3
	2022		0.0	0.0	0.1	0.3
Constraint (GWh)	2020		0.2	0.0	0.1	0.1
	2021		0.2	0.0	0.1	0.1
	2022		0.2	0.0	0.1	0.1
Curtailment and Constraint (GWh)	2020		0.2	0.1	0.2	0.4
	2021		0.2	0.1	0.2	0.4
	2022		0.2	0.0	0.2	0.4
Curtailment	2020		1%	2%	5%	9%
	2021		1%	2%	4%	8%
	2022		1%	1%	3%	7%
	Gen Shallow					7%
	Industry		1%	1%	3%	7%
Constraint	2020		4%	2%	2%	2%
	2021		5%	3%	3%	3%
	2022		4%	3%	3%	4%
	Gen Shallow					4%
	Industry		1%	1%	3%	4%
Curtailment and Constraint	2020		6%	4%	7%	11%
	2021		6%	5%	8%	11%
	2022		5%	4%	6%	10%
	Gen Shallow					11%
	Industry		2%	2%	6%	11%
	Future Grid					2%
	Industry Future Grid					2%

Table 0-25 Results for Somerset Solar

SOMERSET WIND	Year	Initial	NW	33%	66%	All
Total (MW)	2020 to 2022	0	20	12	15	20
of which is Controllable (MW)	2020 to 2022	0	12	4	8	12
Available Energy Controllable (GWh)	2020 to 2022	0	37	12	25	37
Curtailment (GWh)	2020		2.2	0.7	2.6	5.8
	2021		1.7	0.6	2.2	5.1
	2022		1.2	0.4	1.6	4.1
Constraint (GWh)	2020		0.1	0.1	0.3	0.6
	2021		0.2	0.3	0.6	1.2
	2022		0.1	0.1	0.3	0.8
Curtailment and Constraint (GWh)	2020		2.3	0.8	2.9	6.5
	2021		1.9	0.9	2.8	6.3
	2022		1.3	0.5	1.9	4.8
Curtailment	2020		6%	6%	11%	16%
	2021		5%	5%	9%	14%
	2022		3%	3%	7%	11%
	Gen Shallow					11%
	Industry		3%	3%	7%	11%
Constraint	2020		0%	1%	1%	2%
	2021		0%	2%	2%	3%
	2022		0%	1%	1%	2%
	Gen Shallow					3%
	Industry		2%	4%	5%	6%
Curtailment and Constraint	2020		6%	7%	12%	17%
	2021		5%	7%	11%	17%
	2022		4%	4%	8%	13%
	Gen Shallow					13%
	Industry		5%	7%	12%	17%
	Future Grid					2%
	Industry Future Grid					2%

Table 0-26 Results for Somerset Wind

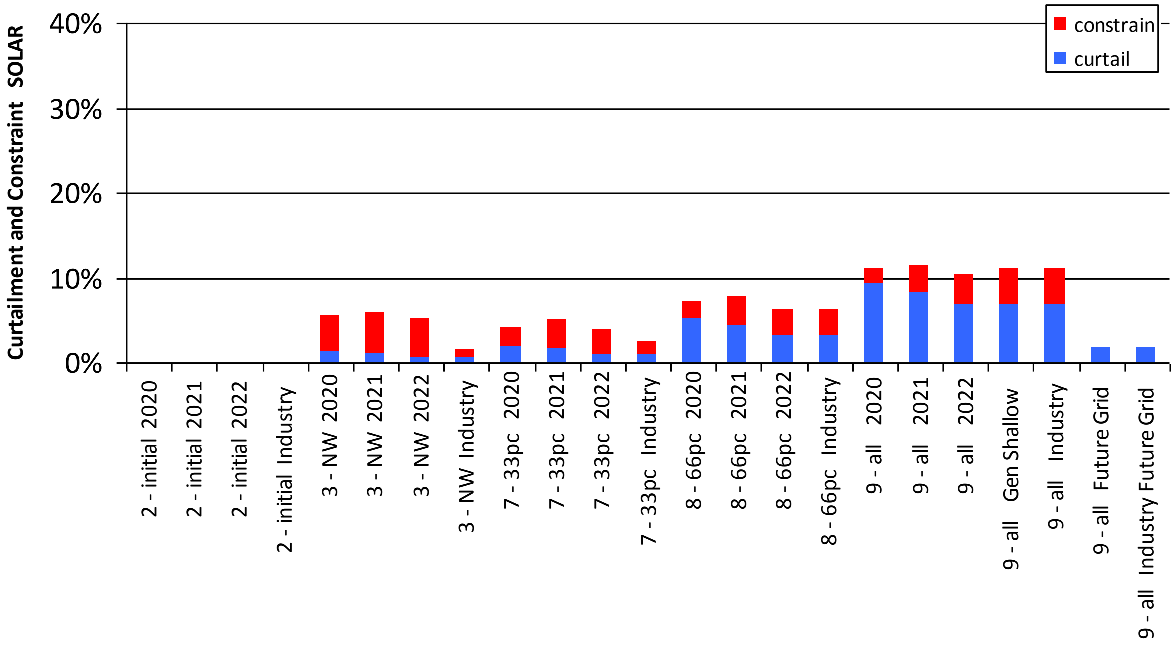

Figure 0-26 Curtailment and Constraint for Somerset Solar

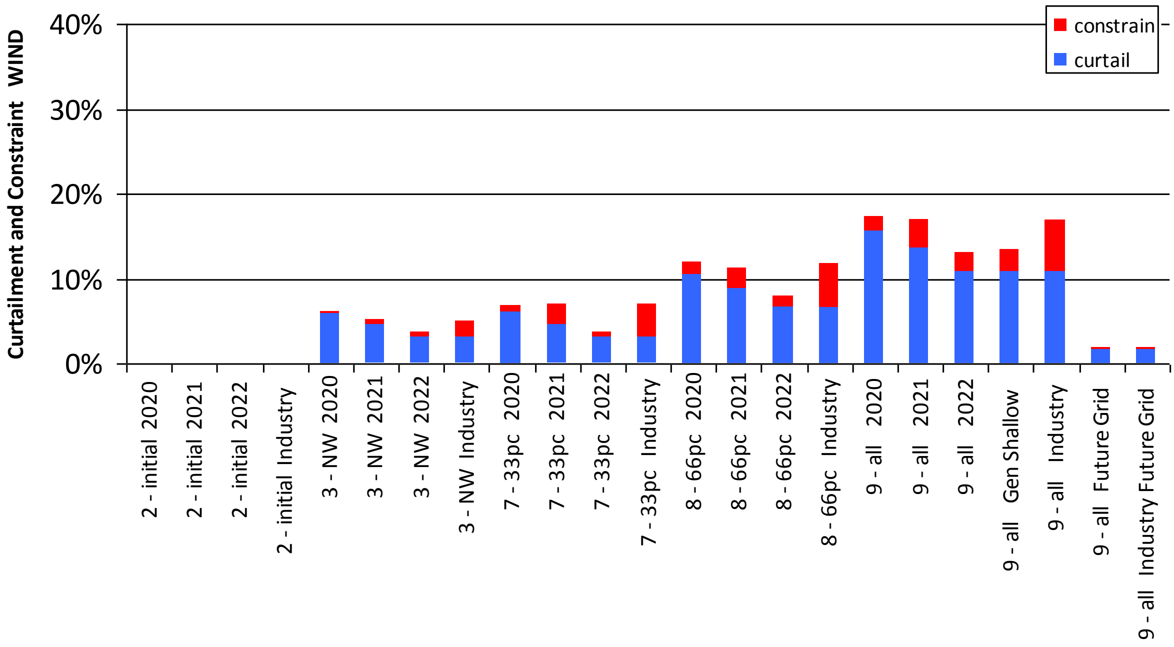

Figure 0-27 Curtailment and Constraint for Somerset Wind

Abbreviation and Terms

Active Power

The product of voltage and the in-phase component of alternating current measured in Megawatts (MW). When compounded with the flow of 'reactive power', measured in Megavolt-Amperes Reactive (Mvar), the resultant is measured in Megavolt-Amperes (MVA).

Busbar

The common connection point of two or more circuits.

Capacity Factor

$$Capacity\ Factor = \frac{Energy\ Output}{Hours\ per\ year * Installed\ Capacity}$$

Combined Cycle Gas Turbine (CCGT)

This is a type of thermal generator that typically uses natural gas as a fuel source. It is a collection of gas turbines and steam units; where waste heat from the gas turbines(s) is passed through a heat recovery boiler to generate steam for the steam turbines.

Commission for Regulation of Utilities (CRU)

The CRU is the regulator for the electricity, natural gas and public water sectors in Ireland.

Constraint

The reduction in output of a generator due to network limits. Usually, constraints are local to a transmission bottleneck.

Contingency

The unexpected failure or outage of a system component, such as a generation unit, transmission line, transformer or other electrical element. The transmission network is operated safe against the possible failure or outage of any system component. Hence, contingency usually refers to the possible loss of any system component. A contingency may also include multiple components, when these are subject to common cause outages.

Curtailment

Curtailment is when the transmission system operators EirGrid and SONI ask generation to reduce their output to ensure system security is maintained. Usually, curtailment is shared across the whole system.

Demand

The amount of electrical power that customers consume and which is measured in Megawatts (MW). In a general sense, the amount of power that must be transported from transmission network connected generation stations to meet all customers' electricity requirements.

Enduring Connection Policy (ECP)

The Commission for Regulation of Utilities (CRU) has put in place a revised approach to issuing connection offers to generators. This approach is called the Enduring Connection Policy (ECP). With ECP, it is envisaged that batches of generator connection offers will issue on a periodic basis.

Enduring Connection Policy - 1 (ECP-1)
Under the ECP arrangements, the processing of the first batch, called Enduring Connection Policy – 1 (ECP-1), began in 2018 and is expected to conclude in early 2020. A second batch, called ECP-2, will begin processing shortly thereafter. For ECP-1, EirGrid and ESB will issue 2 GW of generator connection offers. It is a feature of ECP-1 that these offers are made on a non-firm basis. Also, it is a requirement of ECP-1 that EirGrid provide a constraints report for the generators.

Forced Outage Probability (FOP)
This is the statistical probability that a generation unit will be unable to produce electricity for non-scheduled reasons due to the failure of either the generation plant or supporting systems. Periods, when the unit is on scheduled outage, are not included in the determination of forced outage probability.

Generation Dispatch
This is the configuration of outputs from the connected generation units.

Interconnector
The electrical link, facilities and equipment that connect the transmission network of one EU member state to another.

Loadflow
Study carried out to simulate the flow of power on the transmission system given a generation dispatch and system load.

A DC loadflow is a study, which uses simplifying assumptions in relation to voltage and reactive power. DC loadflow studies are used as part of a complicated overarching study. For example, Plexos uses DC loadflow because it is performing studies for every hour of every study year and is performing a large optimisation calculation for each of these.

Maximum Export Capacity (MEC)
The maximum export value (MW) provided in accordance with a generator's connection agreement. The MEC is a contract value that the generator chooses as its maximum output.

Megawatt (MW) and Gigawatt (GW)
Unit of power: 1 megawatt = 1,000 kilowatts = 106 joules / second
1 gigawatt = 1,000 megawatts

Megawatt Hour (MWh), Gigawatt Hour (GWh) and Terawatt Hour (TWh)
Unit of energy: 1 megawatt hour = 1,000 kilowatt hours = 3.6×10^9 joules
1 gigawatt hour = 1,000 megawatt hours
1 terawatt hour = 1,000 gigawatt hours

Plexos
Plexos is the power system simulation tool used in this study to evaluate curtailment and constraint. Plexos is a detailed generation and transmission analysis program that has been widely used in the electricity industry for many years.

Rate of Change of Frequency (ROCOF)
As low inertia non-synchronous generators displace high inertia synchronous generators in system dispatch, then the system gets lighter. Then, for the loss of a large infeed (e.g. trip of an interconnector or generator), the system frequency will change more quickly.

ROCOF is the agreed limit to which the system is agreed to be operated and which generators, demand and system protection schemes are expected to manage. In Ireland, the TSOs are proposing to increase the ROCOF value. This will allow more renewable generation and may require confirmation by participants that they can meet the proposed ROCOF.

Short Run Marginal Cost (SRMC)
The instantaneous variable cost for a power plant to provide an additional unit of electricity, i.e. the cost of each extra MW it could produce excluding its fixed costs. The SRMC reflects the opportunity

cost of the electricity produced, which is the economic activity that the generator forgoes to produce electricity. For example, in the case of a generator fueled by gas, the opportunity cost includes the price of gas on the day that it is bidding in because if the generator is not producing electricity it could sell its gas in the open market.

System Non-Synchronous Penetration (SNSP)
The introduction of large quantities of non-synchronous generators such as solar and wind poses challenges to a synchronous power system. For Ireland, a system non-synchronous penetration (SNSP) ratio is defined to help identify the system operational limits. The present allowable ratio is 65% but the proposed procurement of system services other than energy and proposed amendments to system operation are expected to allow SNSP to increase in future years.

Total Electricity Requirement (TER)
TER is the total amount of electricity required by a country. It includes all electricity exported by generating units, as well as that consumed on-site by self-consuming electricity producers, e.g. CHP.

Transmission Peak
The peak demand that is transported on the transmission network. The transmission peak includes an estimate of transmission losses.

Transmission System
The transmission system is a meshed network of high-voltage lines and cables (400 kV, 275 kV, 220 kV and 110 kV) for the transmission of bulk electricity supply around Ireland and Northern Ireland.

Transmission System Operator
In the electrical power business, a transmission system operator is the licensed entity that is responsible for transmitting electrical power from generation plants to regional or local electricity distribution operators.

Uprating
To increase the rating of a circuit. This is achieved by increasing ground clearances and/or replacing conductor, together with any changes to terminal equipment, support structures and foundations.

Winter Peak
This is the maximum annual system demand. It occurs in the period October to February, inclusive in Ireland and in the Period November to February in Northern Ireland.

References

Enduring Connection Policy

http://www.eirgridgroup.com/customer-and-industry/becoming-a-customer/generator-connections/enduring-connection-polic/

Generation Capacity Statement

http://www.eirgridgroup.com/site-files/library/EirGrid/EirGrid-Group-All-Island-Generation-Capacity-Statement-2019-2028.pdf

Reinforcement Projects

http://www.eirgridgroup.com/the-grid/projects/

http://www.soni.ltd.uk/the-grid/projects/

All Island Ten Year Transmission Forecast Statement

http://www.eirgridgroup.com/site-files/library/EirGrid/TYTFS-2018-FINAL-HI-RES.pdf

Transmission Development Plan for Northern Ireland 2018-2027

http://www.soni.ltd.uk/the-grid/projects/tdpni-2018-27/related-documents/

Tomorrows Energy Scenarios

http://www.eirgridgroup.com/site-files/library/EirGrid/TES-2017-System-Needs-Assessment-Final.pdf

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http://www.eirgridgroup.com/how-the-grid-works/renewables/

https://www.esbnetworks.ie/new-connections/generator-connections/generator-connection-statistics

DS3 Programme

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