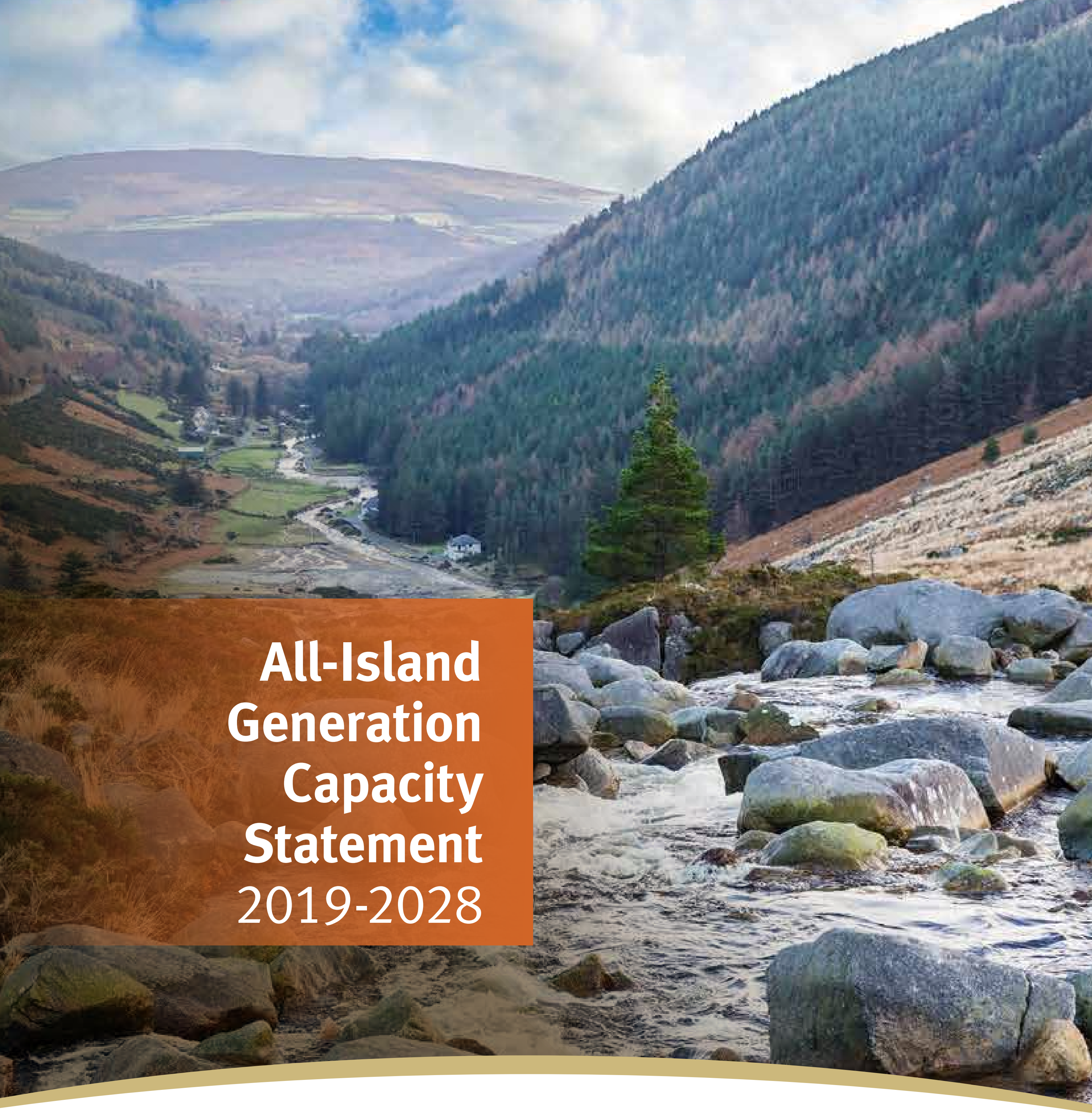

All-Island Generation Capacity Statement 2019-2028

DISCLAIMER

EirGrid and SONI have followed accepted industry practice in the collection and analysis of data available. While all reasonable care has been taken in the preparation of this data, EirGrid and SONI are not responsible for any loss that may be attributed to the use of this information. Prior to taking business decisions, interested parties are advised to seek separate and independent opinion in relation to the matters covered by this report and should not rely solely upon data and information contained herein. Information in this document does not amount to a recommendation in respect of any possible investment. This document does not purport to contain all the information that a prospective investor or participant in the Single Electricity Market may need.

This document incorporates the Generation Capacity Report for Ireland and the Generation Capacity Statement for Northern Ireland.

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Table of Contents

Foreword

EirGrid and SONI, as transmission system operator for Ireland and Northern Ireland respectively, are pleased to present the All-Island Generation Capacity Statement 2019-2028.

In this statement we outline the expected electricity demand and the level of generation capacity that will be required on the island over the next ten years. Eirgrid and SONI carried out generation adequacy studies to assess the balance between supply and demand for a number of realistic scenarios.

The electricity industry continues to undergo change. New market arrangements for the All-Island Single Electricity Market came into operation on 1st October 2018 under the Integrated-Single Electricity Market project. Three capacity market auctions have been successfully held which are central to generation adequacy.

Demand in Ireland is increasing and is forecast to increase significantly, due to the expected expansion of many large energy users. With this increase in demand, and the expected decommissioning of generation plant due to decarbonisation targets and emissions standards, it is expected that new generation will be required. Total Energy Requirement in Northern Ireland has been relatively stable which is expected to continue. However, market demand in Northern Ireland has fallen with the connection of large amounts of small scale and micro generation over the last number of years.

The European Union has set ambitious targets for decarbonisation and for renewable energy for the electricity sector in 2030. It is imperative that each country individually does what it can to limit and reduce its climate impact.

Ireland has produced its draft 2030 National Energy and Climate Plan which envisages a target of at least 55% renewable energy in electricity by 2030. In June 2019, the Minister of Communications, Climate Action and Environment committed to raise the amount of electricity generated from renewable sources to 70% by 2030 with no generation from peat and coal in the Climate Action Plan 2019. This ambition is needed to honour the Paris Agreement. It represents a significant change for the electricity industry and for EirGrid. It is an opportunity to create a sustainable electricity system that will meet the needs for the next generation. EirGrid is committed to doing its part in supporting and delivering on the ambitions of Government energy policy.

To support the development of more renewable generation post 2020, the Irish Government announced a new “Renewable Electricity Support Scheme” (RESS). It is envisioned that there will be a series of auctions to deliver the 12GW Renewable Energy Source (RES) target over the next decade. Eirgrid is delighted to be hosting the RESS auction platform. Eirgrid is working with the Department of Communications, Climate Action and Environment (DCCAE), the Commission for Regulation of Utilities (CRU) and industry participants to complete the inaugural RESS auction within the next 12 months to enable the early delivery of renewable generation projects in order to meet our RES-E trajectory to 2030.

For Northern Ireland, the United Kingdom’s Committee on Climate Change recently advised that it is necessary, feasible and cost-effective for the UK to set a target of net-zero Green House Gas (GHG) emissions by 2050. The Climate Change Act 2008 (2050 Target Amendment) Order 2019 came into effect on the 27 June 2019. The revised legally binding target towards net zero emissions covers all sectors of the economy. This update to the Order demonstrates the UK’s and Northern Ireland’s commitment to targeting a challenging ambition in line with the requirements of the Paris Agreement.

Energy Policy is a devolved matter for Northern Ireland and the Department for the Economy (DfE) are currently working with stakeholders to develop the next Strategic Energy Framework for Northern

Ireland. SONI are providing input to this important work which will inform future renewable targets and the approach to facilitating growth in renewable electricity generation. In acknowledging that there is no single pathway to a low carbon economy SONI has used scenario planning as a means to create a range of possible energy futures and will shortly publish its 'Tomorrow's Energy Scenarios'. This document provides a range of plausible scenarios on how the Northern Ireland energy system might develop.

A challenge to the industry is the decommissioning of generation plant due to decarbonisation targets. SONI have been informed that coal-fired generation at Kilroot in Northern Ireland will not be available from 2025.

The North South Interconnector project will provide a vital link between the two grids on the island. All planning and legal hurdles have been dismissed in Ireland. SONI are working to resolve the planning challenges in Northern Ireland and will be endeavouring to bring this critical project to fruition as quickly as possible. Together with the new SEM, this will enable the Group to realise our ambition of maximising the considerable benefits of an all-island electricity system and market.

We hope you find this document informative. This is your grid and energy market. We very much welcome feedback from you on how we can improve this document and make it more useful.

Mark Foley
EirGrid Group
Chief Executive

Jo Aston
SONI
Managing Director

Document Structure

This document contains a Glossary of Terms section, an Executive Summary, four main sections and four appendices. The structure of the document is as follows:

The **Glossary of Terms** explains some technical terms used in the document.

The **Executive Summary** gives an overview of the main highlights of the document and presents the statement in summary terms.

Section 1 introduces our statutory and legal obligations. The purpose and context of the report is outlined.

Section 2 outlines the demand forecast methodology, and presents estimates of demand over the next ten years.

Section 3 describes the assumptions in relation to electricity generation.

Adequacy assessments are presented in **Section 4**.

Four **Appendices** are included at the end of this report. They provide further detail on the data and methodology used in this study.

Glossary of Terms

Acronym/ Abbreviation	Term	Explanation
AGU	Aggregated Generator Unit	A number of individual diesel generators grouping together to make available their combined capacity.
ALF	Annual Load Factor	The ALF is the average load divided by the peak load. E.g. TER=42,000 GWh, Peak = 7.3 GW (Median forecast for All-Island system in 2020) $$ALF = \frac{42,000/8760}{7.33} = 66\%$$ where 8760 = number of hours per year = 24*365
CF	Capacity Factor	$$\text{Capacity Factor} = \frac{\text{Energy Output}}{\text{Hours per year*Installed Capacity}}$$
CEP	Clean Energy Package	EU Commission package of measures to facilitate the clean energy transition. The EU has committed to cut CO2 emissions by at least 40% by 2030 while modernising the EU's economy.
CCGT	Combined Cycle Gas Turbine	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.
CHP	Combined Heat and Power	A highly efficient process that captures and utilises the heat that is a by-product of the electricity generation process.
	Demand	The amount of electrical power that is consumed by a customer and 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. This includes any losses (line or transformer).
DS3	Delivering a Secure Sustainable Electricity System	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 the challenges of operating the electricity system in a secure manner while achieving these 2020 renewable electricity targets.
DSU	Demand Side Unit	A Demand Side Unit (DSU) consists of one or more Individual Demand Sites that can be dispatched by the Transmission System Operator (TSO) as if it was a generator.

Acronym/ Abbreviation	Term	Explanation
	Dispatchable Generation	Sources of electricity that can be used on demand and dispatched at the request of power grid operators, according to market needs. Does not include wind and solar generation which are non-dispatchable generation.
	EU-SysFlex	Aiming to achieve a pan-European system with an efficient coordinated use of flexibilities for the integration of a large share of renewable energy sources. EU-SysFlex will come up with new types of services that will meet the needs of the system with more than 50% of renewable energy sources.
ECP-1	Enduring Connection Policy	A process to provide connection offers to facilitate 2GW of renewable generation in Ireland.
ENTSO-e	European Network of Transmission System Operators – Electricity	ENTSO-E, the European Network of Transmission System Operators, represents 43 electricity transmission system operators from 36 countries across Europe.
ESB Networks	Electricity Supply Board: Networks	A subsidiary within ESB Group, ESB Networks is the licensed operator of the electricity distribution system in the Republic of Ireland and owner of all transmission and distribution network infrastructure.
	FlexTech Initiative	Industry wide consortium to better understand the perspectives and key challenges of players in the electricity sector that if resolved, will deliver significant benefits in terms of meeting Ireland and Northern Ireland's renewable obligations.
FOP	Forced Outage Probability	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 Adequacy	The ability of all the generation units connected to the electrical power system to meet the total demand imposed on them at all times. The demand includes transmission and distribution losses in addition to customer demand.
	Gate 3	Generation Connection Policy managing connection of 4000MW of renewable energy to the Irish power system.
GWh	Gigawatt Hour	Unit of energy 1 gigawatt hour = 1,000,000 kilowatt hours = 3.6 x 1012 joules
GNP	Gross National Product	The total value of goods produced and services provided by a country during one year, equal to the gross domestic product plus the net income from foreign investments.

Acronym/ Abbreviation	Term	Explanation
GVA	Gross Value Added	In economics, GVA is the measure of the value of goods and services produced in an area, industry or sector of an economy. In national accounts GVA is output minus intermediate consumption; it is a balancing item of the national accounts' production account.
IC	Interconnector	The electrical link, facilities and equipment that connect the transmission network of one country to another.
HVDC	High Voltage, Direct Current	A HVDC electric power transmission system uses direct current for the bulk transmission of electrical power.
IED	Industrial Emissions Directive	Directive 2010/75/EU of the European Parliament and the Council on industrial emissions (the Industrial Emissions Directive or IED) is the main EU instrument regulating pollutant emissions from industrial installations.
LOLE	Loss of Load Expectation	The LOLE is the mathematical expectation of the number of hours in the year during which the available generation plant will be inadequate to meet the instantaneous demand.
MEC	Maximum Export Capacity	The maximum export value (MW) provided in accordance with a generator's connection agreement. The MEC is a contract value which the generator chooses as its maximum output and is used in the design of the Transmission System.
MVA	Mega Volt Ampere	Unit of apparent power. MVA ratings are often used for transformers, e.g. for customer connections.
MW	Megawatt	Unit of power.
	Non-GPA	Non-Group Processing Approach.
NECP	National Energy and Climate Plan	Regulation on the governance of the energy union and climate action to meet the EU's 2030 energy and climate targets.
NIRO	Northern Ireland Renewables Obligation	NIRO is the main policy measure for supporting the development of renewable electricity in Northern Ireland.
REFIT 3	Renewable Energy Feed-in Tariff 3	REFIT 3 is a support scheme for renewable energy from the Department of Communications, Climate Action and Environment in Ireland. It is designed to incentivise the addition of 310 MW of renewable electricity capacity to the Irish grid. Of this, 185 MW will be High Efficiency CHP, using both Anaerobic Digestion and the thermo-chemical conversion of solid biomass, while 125 MW will be reserved for biomass combustion and biomass co-firing[1].
RES	Renewable Energy Source	

1 http://www.dccae.gov.ie/energy/en-ie/Renewable-Energy/Pages/Refit-3-landing-page.aspx

Acronym/ Abbreviation	Term	Explanation
RES	Renewable Energy Source	
RES-E		Renewable Electricity.
RESS	Renewable Energy Support Scheme	Scheme will provide for a renewable electricity (RES-E) ambition of up to a maximum of 70% by 2030, initially announced via the Government Climate Action Plan 2019. Subject to determining the cost effective level which will be set out in the National Energy and Climate Plan (NECP) expected by the end of 2019.
SEAI		Sustainable Energy Authority of Ireland.
SEM	Single Electricity Market	This is the wholesale market for the island of Ireland. It has changed considerably to take account of the requirements of the European Network Codes and the Target Model through the Integrated-Single Electricity Market project. The new market arrangements went live on 1 October 2018.
SONI		System Operator Northern Ireland.
ENTSO-E TYNDP		European Network of Transmission System Operators – Electricity Ten Year National Development Plan.
TWh	Terawatt Hour	Unit of energy 1 terawatt hour = 1,000,000,000 kilowatt hours = 3.6 x 1015 joules
TER	Total Electricity Requirement	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 Losses	A small proportion of energy is lost as heat or light whilst transporting electricity on the transmission network. These losses are known as transmission losses.
	Transmission Peak	The peak demand that is transported on the transmission network. The transmission peak includes an estimate of transmission losses.
TSO	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.

Executive Summary

Executive Summary

In this Generation Capacity Statement (GCS), the likely balance between electricity demand and supply during the years 2019 to 2028 is examined. This GCS covers both Northern Ireland and Ireland, and is produced jointly between SONI and EirGrid[2].

EirGrid, the transmission system operator (TSO) in Ireland, has a regulatory requirement to publish forecast information about the power system, including an assessment of the balance between supply and demand. SONI, the TSO in Northern Ireland, is required by licence to produce an annual Generation Capacity Statement.

To obtain the most relevant information, EirGrid and SONI consulted widely with industry participants and have used the most up-to-date information at the time of publication.

A range of scenarios was prepared to forecast electricity demand over the time horizon of the report.

In our adequacy assessment studies, the generation portfolio is modelled against the demand forecast, using the accepted standard risk. These studies were carried out separately for Ireland and Northern Ireland, and jointly on an all-island basis.

The findings, in terms of the overall demand and supply balance, should be useful to market participants, regulatory agencies and policy makers.

Key Messages

The All-Island demand is increasing and is forecast to increase significantly, largely due to the expected expansion of large energy users such as data centres.

The SEM capacity market is designed to procure sufficient capacity to meet the adequacy standard. The recent SEM T-1 2019/2020[3] and T-4 2022/2023[4] were successfully held and secured 8.3 GW and 7.4 GW of de-rated capacity respectively for the All-Island system. The amount of generation required in the All-Island Capacity market is set by the capacity requirement, as calculated by EirGrid/SONI in accordance with the methodology as set out within the Capacity Requirement and De-Rating Factor Methodology Detailed Design Decision Paper[5] and subsequently approved by the regulatory authorities. The demand scenarios outlined in the report influence the calculation of the capacity requirement.

EirGrid and SONI are working towards the delivery of the second North South interconnector in 2023. Planning permission for this interconnector has been granted in Ireland and all legal challenges have been dismissed. This means the project has now cleared all planning related legal hurdles in Ireland. The project has encountered delays in Northern Ireland to date however SONI are working to resolve the planning challenges in Northern Ireland and will be endeavouring to bring this critical project to fruition as quickly as possible. In line with planning legislation, the Department for Infrastructure recently hosted a four week public consultation on further environmental information submitted in July 2019 by SONI[6].

2 Where 'we' is used, it refers to both companies, unless otherwise stated.
3 https://www.sem-o.com/documents/general-publications/T-1-2019-2020-Final-Capacity-Auction-Results-Report.pdf
4 https://www.sem-o.com/documents/general-publications/T-4-2022-2023-Final-Capacity-Auction-Results-Report.pdf
5 SEM-16-082
6 http://epicpublic.planningni.gov.uk/publicaccess/, application reference numbers O/2009/0792/F and O/2013/0214/F

Much progress has been made towards meeting our targets for renewable energy, and this is set to continue. EirGrid and SONI are supporting the integration of more intermittent generation sources with initiatives that encourage flexibility such as EU-SysFlex, FlexTech initiative and DS3[7].

The UK's exit from the EU (Brexit) is an uncertainty for the future, but at this point, it is not clear what impact it will have and as such we have not made changes to our adequacy methodology associated with Brexit.

Kilroot has indicated that the coal-fired generators ST1 and ST2 will not be available from 2025 inline with UK policy. EirGrid has also assumed that Moneypoint coal-fired generation will not be available from July 2025 as a result of the European Union Clean Energy Package decision to exclude generation emitting more than 550g/kWh from capacity markets such as SEM and as set out in the Irish Government Climate Action Plan 2019. An additional scenario has also been included to show the effects of the peat units not reaching the required 50% biomass burning target by 2025 and requiring approximately two units to close.

Considering the All-Island system, there is a significant surplus of plant currently. This surplus is expected to be eroded by the growth in demand and expected plant closures (e.g. due to emissions restrictions) over the next ten years. At a Median demand level there is not adequate generation capacity to meet demand from 2026 on an All-Island basis once Moneypoint closes at the end of 2025. Should any other plant close then this could give rise to earlier deficits. Also, poor availability of the generation fleet, as seen in 2018, could give rise to deficits.

On a combined, all-island basis, the growth in energy demand for the next ten years varies between 18% in the low demand scenario, to 41% in the high scenario.

The all-island studies presented here are based on an 8 hour adequacy standard.

Northern Ireland

The Total Electricity Requirement in Northern Ireland has been relatively flat in the last number of years. There is an expectation that electricity demand will remain fairly stable in the near future. There have been some enquiries and a connection application related to possible new Data Centre demand.

On the supply-side, we have included all capacity unless providers have notified us that they will not be available. Based on this, in the median demand scenario, Northern Ireland is within the adequacy standard until 2025 when it drops below standard. This is due to the closure of the Kilroot coal units.

On completion of the second North South interconnector we can consider the all-island system to be capable as operating electrically as one, i.e. with all the generation capacity from both jurisdictions to meet the combined load. One of the advantages of considering an all-island system is a capacity benefit, i.e. in general, you need less capacity for the combined all-island system than for the sum of two single-jurisdiction studies. In the Median demand scenario, the Northern Ireland system does not have sufficient capacity from 2025.

The studies presented here are based on the 4.9 hour adequacy standard used in Northern Ireland.

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

Ireland

Demand in Ireland is increasing and is forecast to increase significantly, due to the expected expansion of many large energy users.

At a Median demand level there is not adequate generation capacity to meet demand from 2026 for Ireland once Moneypoint closes. However, should any other plant close then this could give rise to earlier deficits. Also, poor availability of the generation fleet, as seen in 2018, could give rise to deficits.

EirGrid is progressing plans for the proposed Celtic Interconnector between Ireland and France and has completed an Investment Request with the Commission for Regulation of Utilities (CRU). A public consultation took place and CRU responded in support of the project in April 2019 The Celtic Interconnector project proposal has received approval to apply for EU financial assistance and has submitted their application to the EU Commission for funding in June 2019[8].

Elsewhere, EirGrid is also working with Element Power on its Greenlink 500 MW interconnector linking the power markets of Great Britain and Ireland[9].

Demand Forecast

The demand forecast in Ireland continues to be heavily influenced by the expected growth of large energy users, primarily Data Centres. These need a lot of power and can require the same amount of energy as a large town. Our analysis shows that demand from data centres could account for 29% of all demand in Ireland by 2028 in our Median demand scenario.

In Ireland, the growth in energy demand for the next ten years varies between 23% in the low demand scenario, to 47% in the high scenario as shown below in Figure 1.

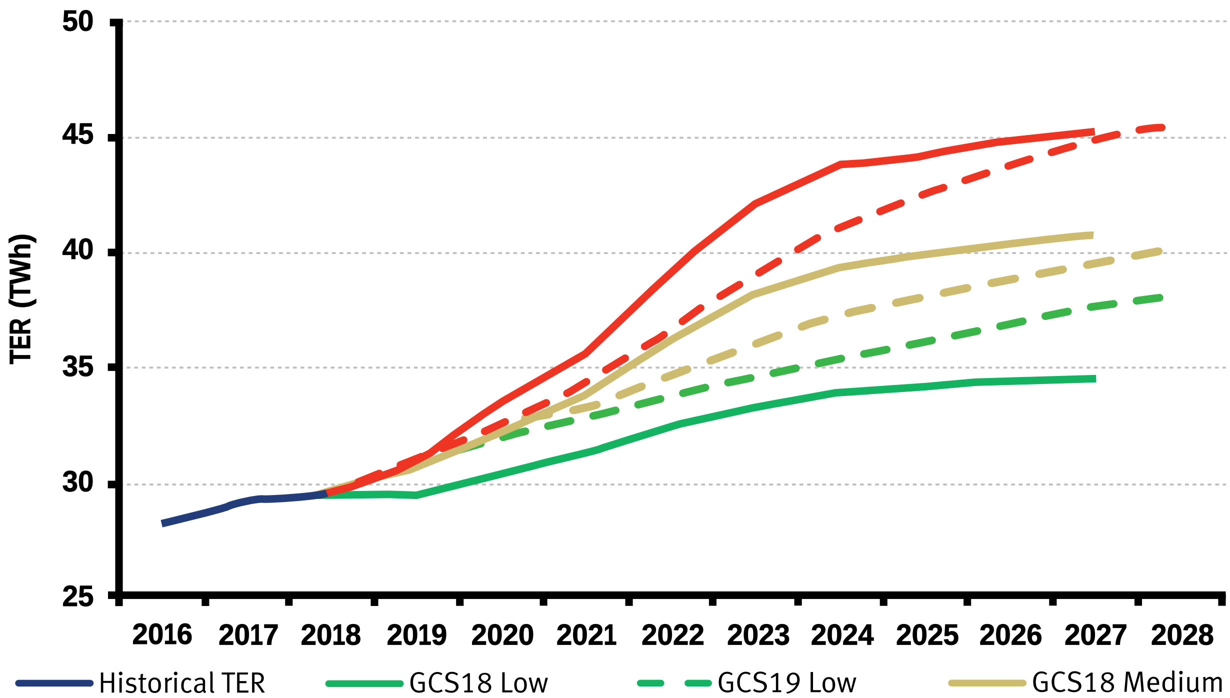

Figure 1 - Ireland Total Energy Forecast GCS 2019 - 2028

8 More information is available at http://www.eirgridgroup.com/the-grid/projects/celtic-interconnector/the-project/
9 More information is available at https://www.greenlink.ie/

The Median Forecast is generally aligned with EirGrid's Tomorrow Energy Scenarios which predict an overall Energy Requirement for Ireland of approximately 41TWh by 2030. This is also in line with the ENTSO-E TYNDP[10] 2020 National Trends Scenario forecast. The Northern Ireland overall energy requirement is also in line with ENTSO-E TYNDP 2020 forecasts.

Total Electricity Requirement in Northern Ireland is relatively flat, and is expected to continue in this manner in the median scenario up until 2023 when the connection of some data centre load drives some demand growth. The median scenario shows demand rising by 10% over the next 10 years. Low demand scenario shows demand falling by 1%, while in the high demand scenario demand would rise by 20%.

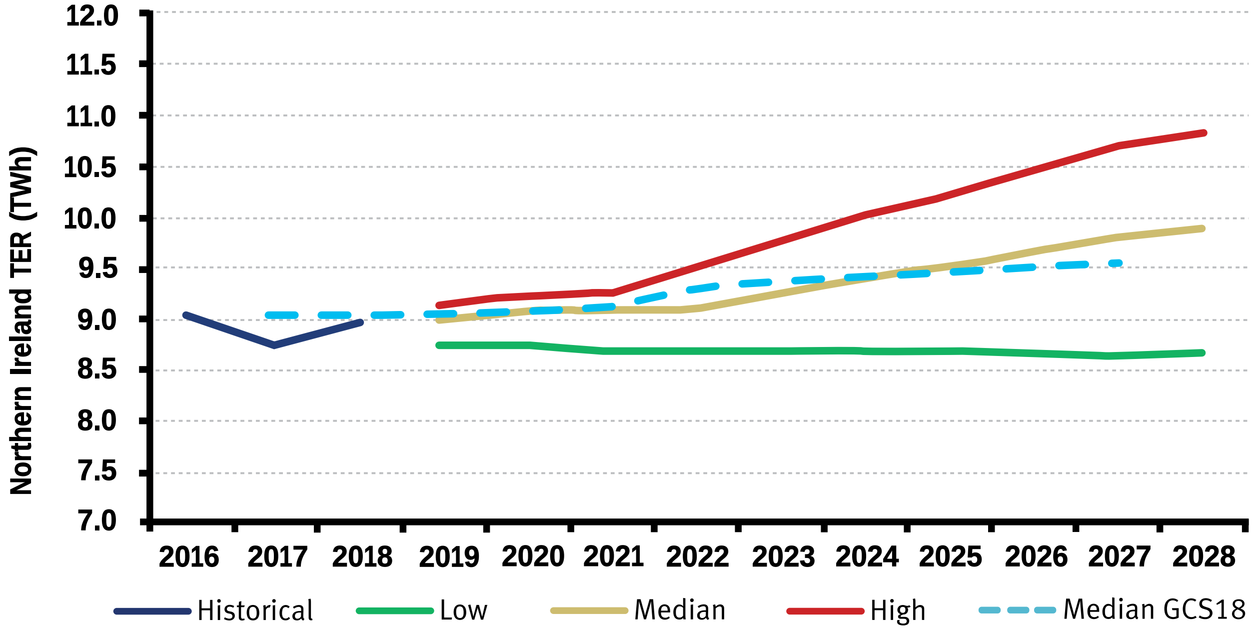

Figure 2 - Demand forecast for Northern Ireland, showing the spread from low to high scenarios

Dispatchable Generation and Interconnection

Figure 3 shows the dispatchable generation contracted and connected on the island from the start of 2019. This information was gathered from interested parties in the industry. Some generators have indicated that they will be unavailable in the latter half of the decade. In addition, we have assumed that Moneypoint coal-fired generation will not be available from 1st July 2025 as a result of the European Union Clean Energy Package decision to exclude generation emitting more than 550g/kWh from capacity markets such as SEM.

We have included in the models the new Dublin generation that was successful in the recent CY2022/23 T-4 capacity auction from the start of 2023. It should be noted that, at time of publication, these units do not have signed connection agreements in place.

10 ENTSO-E Ten Year National Development Plan 2020: https://consultations.entsoe.eu/tyndp/2020-scenario-storylines/

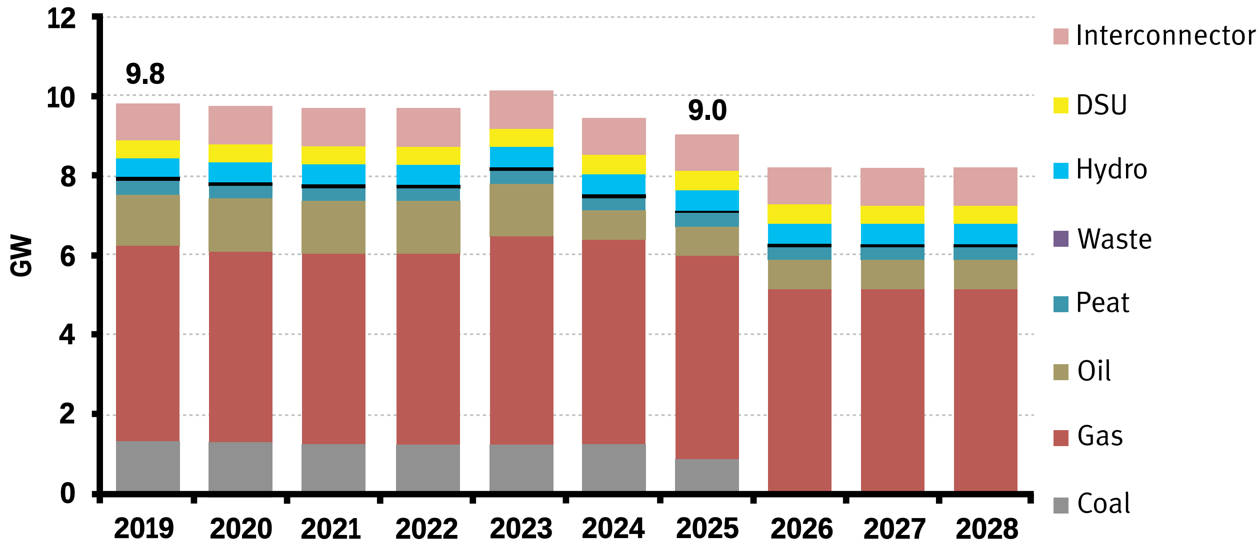

Figure 3 - All-Island portfolio of de-rated dispatchable generation and interconnection capacity, as assumed in our reference scenario

In Ireland and Northern Ireland there has been a deterioration of unit availability over the past year. In particular, the deterioration of the conventional plant unit availability in both Ireland and Northern Ireland was observed across 2018 as highlighted in Figure 4. This highlights the possibility of a low availability year occurring and we have analysed this in one of our adequacy scenarios.

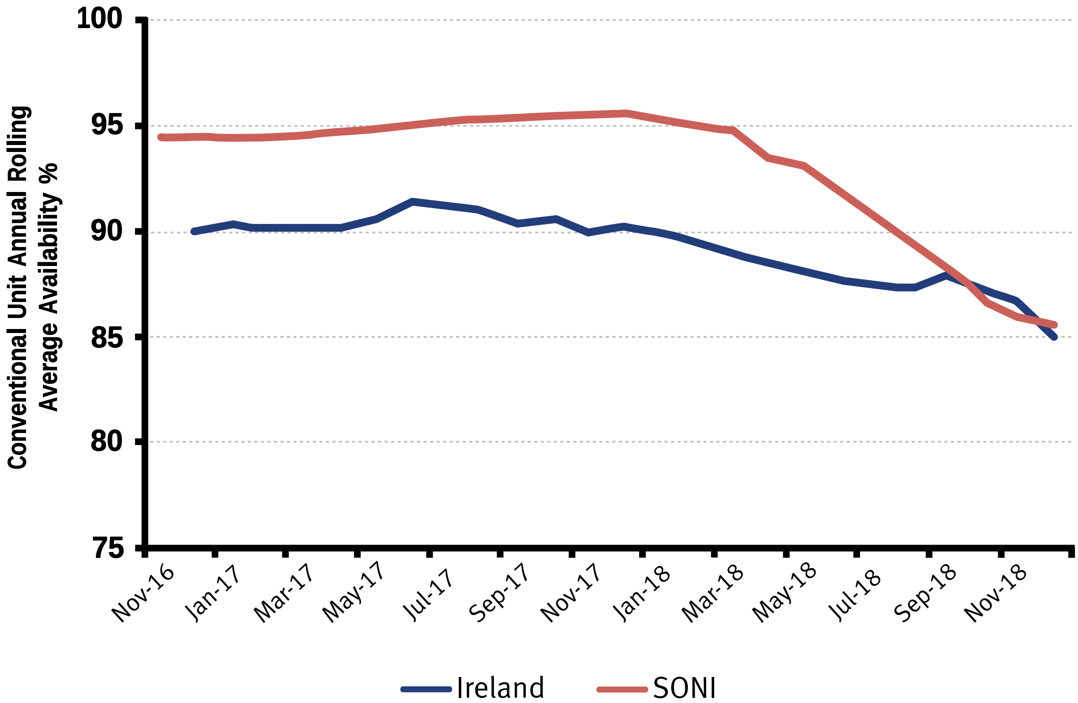

Figure 4 - Ireland and Northern Ireland Conventional Unit Availability

Renewable Energy Sources (RES)

Ireland

New wind farms commissioned in Ireland in 2018 brought the total wind capacity to over 3666 MW[11], contributing to the increase in overall RES percentage to 32.5%. Other sources of RES include biomass, hydro, solar PV and renewable waste. In the coming years, many new wind farms are due to connect, which are required in order to meet our 40% RES target in 2020 which Eirgrid are currently on track to achieve only if the peat plants achieve a minimum of 30% biomass generation.

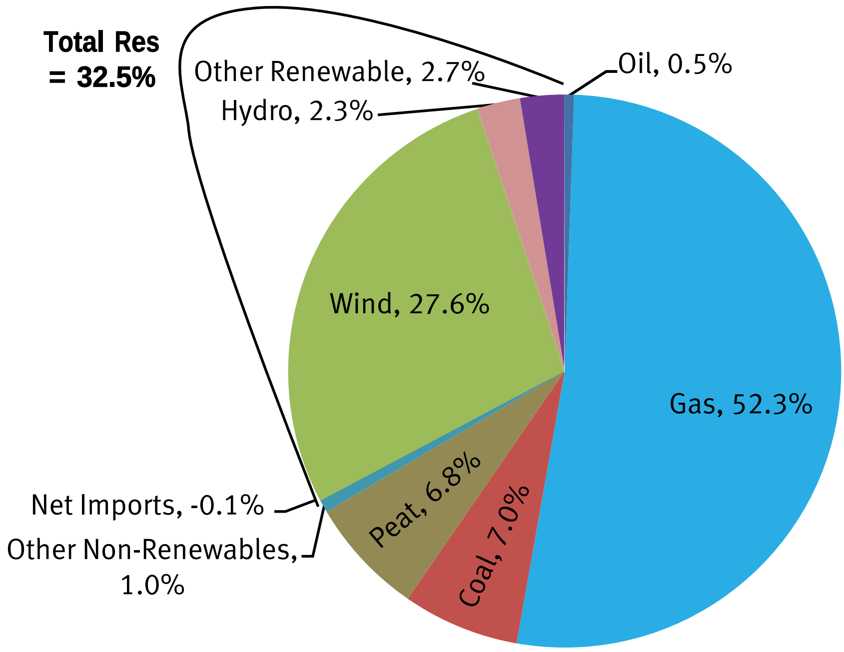

Figure 5 - Fuel mix in Ireland in 2018

Northern Ireland

The 2010-20 Strategic Energy Framework includes a target to achieve 40% of electricity consumption from renewable sources by 2020. There are over 1250 MW of wind currently installed in Northern Ireland, and this is set to grow to almost 1300 MW by 2020. Solar Photovoltaic generation has seen rapid growth in Northern Ireland in recent years. A number of large-scale projects commissioned in 2017 and 2018 brought the total capacity of solar PV to around 250 MW. These levels of wind and solar PV generation along with contribution from other renewable technologies should be sufficient to meet the renewable sources target in 2020.

The Department for the Economy (DfE) appointed external consultants in February 2019 to carry out research on the future of renewables in Northern Ireland including consideration of the potential for a new renewable electricity target. SONI are providing input to this work due to be completed in the near future and will be an important step for the DfE in considering its approach to facilitating growth in renewable electricity generation going forward.

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

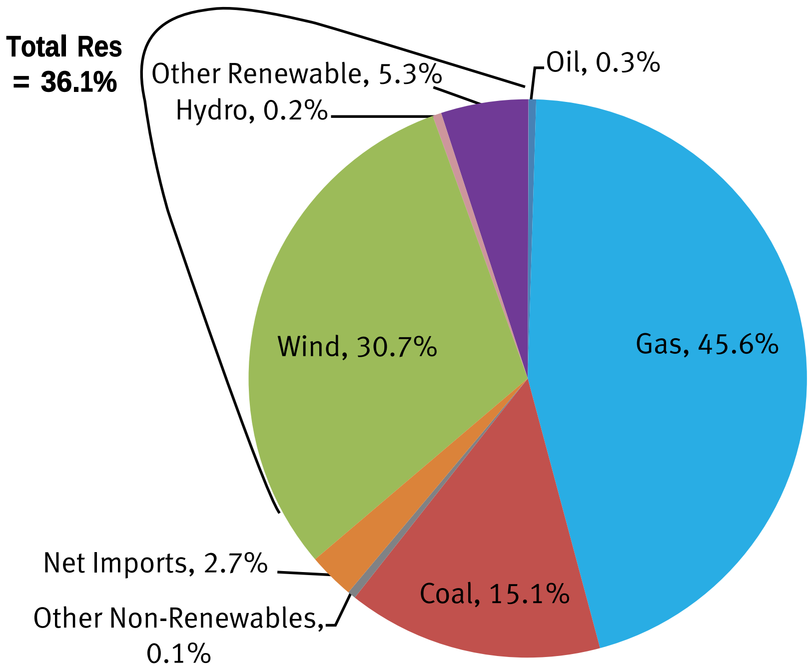

Figure 6 - Fuel mix in Northern Ireland in 2018

Adequacy Analysis

We can use the information gathered and the assumptions made in order to model the balance between supply and demand of electricity. Here we present a summary of our generation adequacy studies. We expect the second North-South Interconnector to be available in 2023, and therefore studies were carried out on an all-island basis in the years 2024 to 2028.

Single-jurisdictional studies beyond 2023 have been completed, in the event that the second North South Interconnector is delayed.

Ireland, without the second North South Interconnector

In the absence of the second North-South Interconnector, Ireland is assumed to continue to be able to rely on Northern Ireland for 100 MW, across the current limited interconnection.

In the Capacity Requirement calculations for the T-1 2019/2020 Capacity Auction, 10 different demand levels were examined, equally spaced from Low to High demand. Then, a Least Worst Regrets analysis was carried out to choose the optimal case. This has resulted in the Capacity Requirement being chosen for demand level 7 or 8, i.e. between the Median and the High demands. We have a scenario for Ireland which uses the 8th level demand forecast. Ireland starts in a position of significant generation surplus in 2019. Thereafter, some generation plant is assumed to shut down because of emissions restrictions and the EU Commissions Clean Energy Package. By 2026, a deficit of capacity is forecast in all scenarios except the Low Demand forecast. Adequacy studies results for Ireland are listed in Table 1.

With a low availability scenario (worst year in 5 years), there would be a deficit of plant by 2026.

If base-load high-carbon plant were unavailable from 2026 (e.g. two out of three peat units), this capacity would need to be replaced.

Scenario	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
High Demand	1380	1130	940	740	940	110	10	-830	-960	-1040
Demand Level 8	1440	1210	1080	860	1100	320	240	-570	-690	-750
Median Demand	1510	1250	1080	940	1240	520	490	-300	-380	-440
Low Demand	1650	1480	1380	1290	1660	1010	1020	290	240	190
Low Availability, Median Demand	1200	930	810	620	970	160	130	-770	-850	-920
Reduced Peats Capacity, Median Demand	1510	1250	1080	940	1240	520	490	-490	-570	-640

Table 1 - Results of adequacy studies for Ireland, given in MW of surplus plant (+) or deficit (-)

Northern Ireland, without the second North South Interconnector

When Northern Ireland is assessed on its own, we assume a continued ability to rely on 200 MW from Ireland.

The median demand scenario is shown to be in surplus of around 300 MW for most years. Northern Ireland goes into deficit in the Median and High scenarios in 2025, caused by the assumed closure of the Kilroot coal units.

Scenario	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Median Demand	360	350	310	300	280	270	-70	-90	-100	-110
Low Demand	390	390	360	360	360	360	50	50	50	50
High Demand	310	310	260	230	220	190	-160	-180	-220	-230

Table 2 - Results of adequacy studies for Northern Ireland, given in MW of surplus plant (+) or deficit (-)

All-Island, with the second North South Interconnector

The second North-South Interconnector is planned to be commissioned in 2023. Thereafter, we can consider the all-island system to be capable of operating electrically as one, i.e. with all the generation capacity from both jurisdictions to meet the combined load.

One of the advantages of considering an all-island system is a capacity benefit, i.e. in general, you need less capacity for the combined all-island system than for the sum of two single-jurisdiction studies. Adequacy studies results for the All-Island system are listed in Table 3.

The All-Island system does not have sufficient capacity from 2026 for all scenarios except the Low Demand forecast.

Scenario	2024	2025	2026	2027	2028
High Demand	510	30	-870	-1040	-1130
Demand Level 8	730	270	-600	-750	-830
Median Demand	990	610	-230	-330	-410
Low Demand	1630	1310	560	500	460
Low Availability, Median Demand	470	70	-860	-970	-1040
Reduced Peats Capacity, Median Demand	990	610	-430	-540	-610

Table 3 - Results of adequacy studies for the All-Island system

Introduction

1

1. Introduction

This report seeks to inform market participants, regulatory agencies and policy makers of the likely generation capacity required to achieve an adequate supply and demand balance for electricity for the period up to 2028[12].

Generation adequacy is a measure of the capability of the electricity supply to meet the electricity demand on the system. The development, planning and connection of new generation capacity to the transmission or distribution systems can involve long lead times and high capital investment. Consequently, this report provides information covering a ten-year timeframe.

EirGrid, the transmission system operator (TSO) in Ireland, is required to publish forecast information about the power system, as set out in Section 38 of the Electricity Regulation Act 1999 and Part 10 of S.I. No. 60 of 2005 European Communities (Internal Market in Electricity) Regulations.

Similarly, SONI, the TSO in Northern Ireland, is required to produce an annual Generation Capacity Statement, in accordance with Condition 35 of the Licence to participate in the Transmission of Electricity granted to SONI Ltd by the Department for the Economy.

This Generation Capacity Statement covers the years 2019-2028 for both Northern Ireland and Ireland, and is produced jointly between SONI and EirGrid. Where 'we' is used, it refers to both companies, unless otherwise stated.

This report supersedes the joint EirGrid and SONI All-Island Generation Capacity Statement 2018-2027, published in October 2018.

Input data assumptions have been reviewed and updated.

The Generation Capacity Statement is evolving to support the SEM Capacity Market and other requirements of a changing electricity system. These changes will also be reflected across a longer horizon by the energy scenarios being produced by SONI and EirGrid. We will continue to work with Regulators and other stakeholders to ensure that both the document and the underlying methodologies remain relevant and useful.

12 EirGrid and SONI also publish a Winter Outlook Report which is focused on the following winter period, thus concentrating on the known, short-term plant position rather than the long-term outlook presented in the Generation Capacity Statement. http://www.eirgridgroup.com/site-files/library/EirGrid/Winter-Outlook-2018-19.pdf

Demand Forecast

2

2. Demand Forecast

2.1. Introduction

Making a prediction of what the electricity demand will be in the future is a multi-layered task. The demand forecast is developed for each jurisdiction separately, then added together for all-island studies.

For each jurisdiction, we initially analyse the historical demand data to provide a suitable starting point. Part of this process involves the exploration of weather effects on demand, e.g. the correction of a high peak demand on a particularly cold day to what it would have been had the weather been average.

Another aspect of historical analysis is the calculation of the amount of self-consumption, i.e. energy that is created and used on-site, without being transmitted to the grid or metered. Examples would be a self-consuming CHP unit, or a domestic solar PV panel. As this sector is growing, it is necessary to track it and the influence that it has on the total metered demand.

We also examine other factors affecting demand, such as economic activity and any particular sectors that are experiencing strong growth. When forecasting demand, we need to take into account the expected growth in these areas.

In line with ENTSO-E TYNDP modelling for the National Trends Scenario, the GCS has included a forecast for electric vehicle and heat pumps growth in Ireland over the next ten years. The draft Irish Government NECP has targets of 20% of the vehicle fleet to be Electric Vehicles by 2030 which is approximately 500,000 cars and 400,000 homes with heat pumps and Solar PV. The GCS 2020 – 2029 will be updated to reflect the relevant targets from the Irish Governments Climate Action Plan 2019.

This GCS demand forecast is used in the calculation of the Capacity Requirement in the SEM Capacity Market auctions. In order to cover a range of possible futures, the GCS demand forecast is provided as three scenarios; Low, Median and High demand.

2.2. Demand Forecast for Ireland

2.2.1. Methodology

The electricity forecast model for Ireland is a multiple linear regression model which predicts electricity demand based on changes in economic parameters. Particular attention is paid to the effects of energy efficiency measures and large, new industrial users. A spread of electricity forecasts is produced covering the next ten years.

EirGrid has sought the advice of the Economic and Social Research Institute (ESRI) which has expertise in modelling the Irish economy[13]. They advised us to focus on the economic parameters of GVA[14], Personal Consumption[15] and GNP[16].

13 http://www.esri.ie/irish-economy/
14 Gross Value Added at basic prices of non-foreign owned Multinational Enterprises
15 Personal Consumption of Goods and Services (PCGS) measures consumer spending on goods and services, including such items as food, drink, cars, holidays, etc.
16 Gross National Product (GNP) is the total value of goods and services produced in a country, discounting the net amount of incomes sent to or received from abroad. It is modified for the effect of re-domiciled companies, i.e. foreign companies which hold substantial investments overseas but have established a legal presence in Ireland.

The demand forecast incorporates some reduction due to energy efficiency measures, in line with the EU energy efficiency targets for 2030. This includes the effect of the installation of smart meters, which could reduce peak demand from domestic users by up to 8%[17].

2.2.2. Historical Data

Historical records of electricity generated and electricity sales are gathered from various sources such as the ESB Networks, SEAI (Sustainable Energy Authority of Ireland) and EirGrid. Transporting electricity from the generator to the customer invariably leads to losses. Based on the comparison of historical sales to exported energy over 2008 - 2017, we have estimated that between 7 and 8% of power produced is lost as it passes through the electricity transmission and distribution systems.

Past economic data is sourced from the most recent Quarterly National Accounts of the Central Statistics Office[18]. We analyse the data to capture the most recent trends relating the economic parameters to demand patterns.

Historical weather data is obtained from Met Éireann, Ireland's National Meteorological Service.

2.2.3. Forecasting Causal Inputs

In order for the energy model to make future predictions, we require forecasts of Gross Value Added (GVA), Gross National Product (GNP) and Personal Consumption. GVA and GNP are combined to influence the forecast of Commercial and Industrial electricity demand. Personal Consumption figures influence the forecast of residential electricity demand. These forecasts are provided by the ESRI in their Quarterly Economic Commentary. Longer-term trends arise out of the ESRI's Median Term Review.

As a cross-check, the ESRI forecasts were compared with predictions from other institutions such as the Central Bank of Ireland and the figures listed in Table 4 were used for GCS studies.

	2018-2021	2022-2028
GVA / GNP	3.8%	3.4%
Personal Consumption	2.5%	2.6%

Table 4 - Average annual growths for macroeconomic parameters, as provided by the ESRI

2.2.4. Forecast Scenarios and Large Energy Users in Ireland

A key driver for electricity demand in Ireland for the next number of years is the connection of new large energy users, such as data centres.

In Ireland, there is presently approximately 1000 MVA of demand capacity that is contracted to data centres and other large energy users. These customers are connected to the transmission system or to the distribution system. The typical load currently drawn by these customers is approximately 35% of their contracted Maximum Input Capacity. This is expected to rise as these customers build out to their full potential.

Large industrial connections normally do not dominate a country's energy demand forecast but this is the case for Ireland at the moment. A significant proportion of this extra load will materialise in the Dublin region.

17 https://www.cru.ie/wp-content/uploads/2011/07/cer11080ai.pdf
18 https://www.esri.ie/publications/quarterly-economic-commentary-spring-2019

There are many projects for large energy users in the connection process, or that have made material enquiries. Eirgrid have examined the status of these proposed projects and have made assumptions concerning the demand load expected from these customers in the future. Eirgrid have taken into account various different factors including the existence of other completed projects by the same company, financial close, planning permission, etc. This has formed the differences between our low, median and high scenarios.

For all scenarios, there have been assumptions covering long-term energy efficiency annual savings, 500000 EV cars and 400000 heat pumps by 2030 in the residential demand forecast as was set out in the draft NECP. All scenarios have the same assumptions for the projects already built. The GCS 2020 – 2029 will be updated to reflect the relevant targets from the Governments Climate Action Plan 2019.

In forecasting future demand, Eirgrid also take account that data centres normally have a flat demand profile.

Since the GCS 2018-2027, EirGrid have received more detailed demand build out estimates from the data centres and large energy users across the country. When compared to GCS18, this has resulted in a reduction of the overall level of peak demand to be reduced by c. 200MW 2022-2024.

From the result of this process, Table 5 gives the breakdown of Data Centre and Large Industrial Users demand forecasted by 2028, Fi gure 7 shows to forecasted build out per scenario out to 2028, Figure 8 shows Ireland's total energy requirement forecast and Figure 9 shows, for the Median scenario, the energy breakdown forecast per sector.

Forecast Scenario	Addition to 400 MVA of currently built Data Centres and large energy users	Overall 2028 Demand in MVA
Low	700	1100
Median	1000	1400
High	1600	1900

Table 5 - Forecasted Data Centre and Large Industrial User Demand by 2028

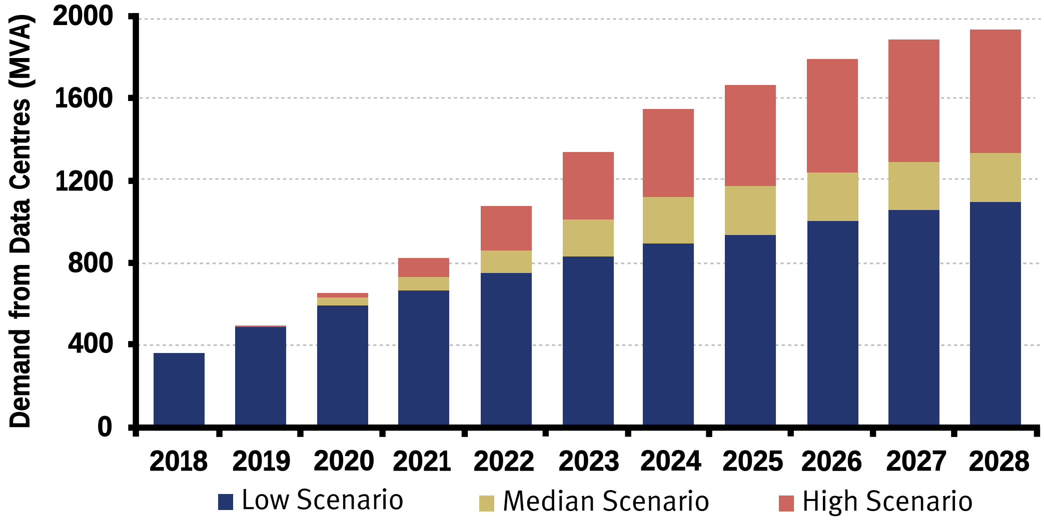

Figure 7 - Ireland demand expected from assumed build-out of large energy users, divided into 3 different categories. Also illustrated is how Eirgrid assume to divide out this demand into the Low, Median and High Demand forecast scenarios for 2028

These three scenarios give an appropriate view of the range of possible demand growths facing Ireland. Though the high demand forecast is, for a time, slower to grow than that for GCS18, it is forecasted to reach the same level by 2028.

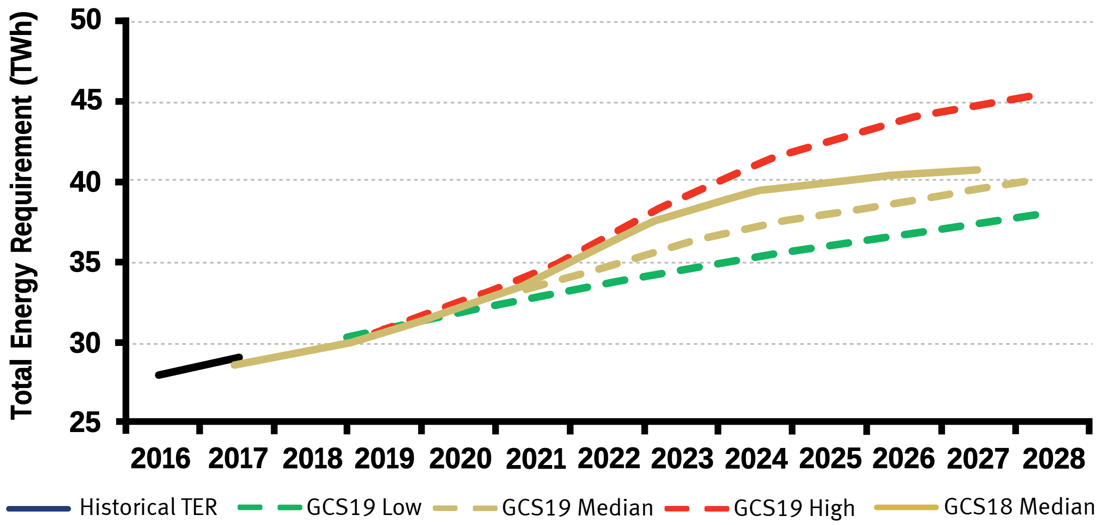

Figure 8 - Total Electricity Requirement forecast for Ireland 2019 - 2028

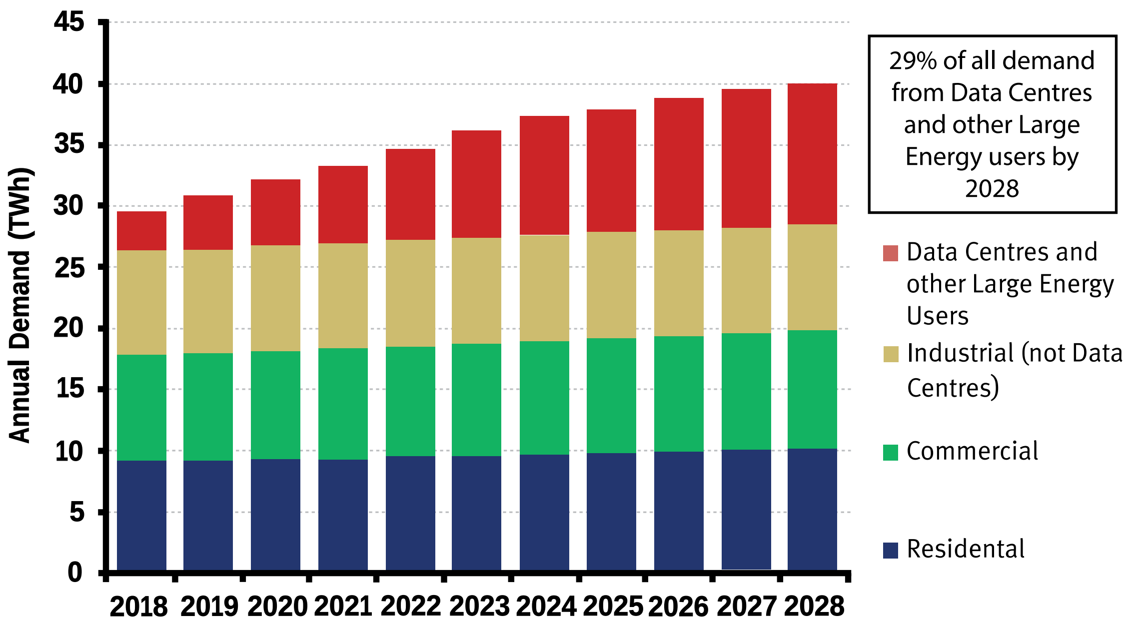

Figure 9 - For the Ireland Median Demand scenario, this illustrates the approximate split into different sectors. Eirgrid estimate that 29% of total demand will come from data centres by 2028

2.2.5. Peak Demand Forecasting

The peak demand model is based on the historical relationship between the annual electricity consumption and winter peak demand. This relationship is defined by the Annual Load Factor (ALF), which is simply the average load divided by the peak load.

Temperature has a significant effect on electricity demand, particularly on the peak demand. This was particularly evident over the two severe winters of 2010 and 2011, when temperatures decreased dramatically and demand increased to record levels. Average Cold Spell (ACS) correction has the effect of 'smoothing out' the demand curve so that economic factors are the predominant remaining influences, see Figure 10. The temperature-corrected peak curve is used in the ALF model, which can then be modelled for the future using the previously-determined energy forecasts.

To reflect different segments of demand, additional forecasts of industrial and data-centre type demand is grown separately using a profile appropriate to its expected usage i.e. flat demand profile. Remaining additional demand is grown proportionally using historical demand profiles.

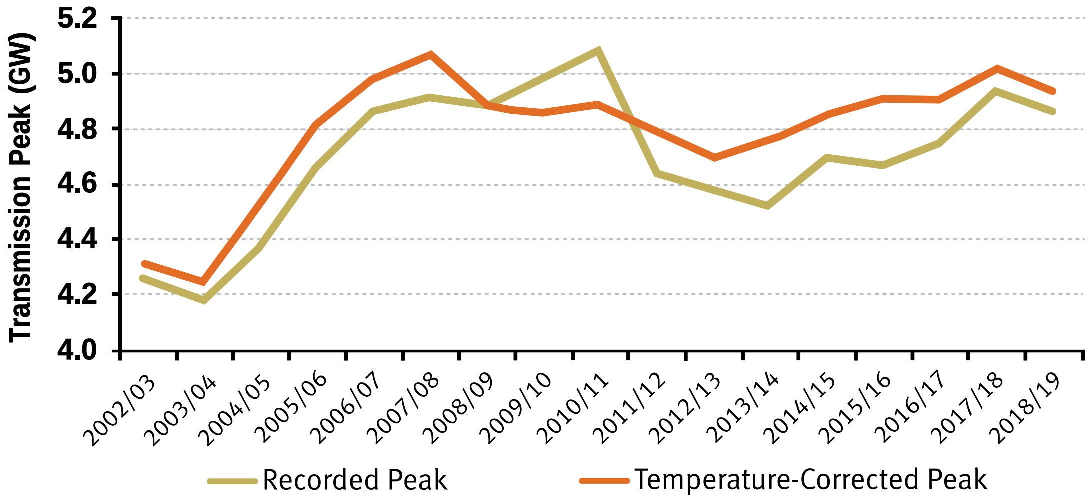

Figure 10 - Past values of recorded maximum demand in Ireland, and the ACS temperature-corrected values

This forecast is then tempered with estimates of energy efficiency savings, particularly to allow for the effect of smart meters. Eirgrid assume that smart meters could cause the peak to decrease by up to 4% for domestic users, from the start of their roll-out in 2019/2020.

In the early years of the forecast, Eirgrid have allowed for more variation, i.e. for the low peak forecast, and considered that there might be a slower than forecasted roll-out of smart meters. For the high scenario, Eirgrid have considered the possibility that the winter might be severely cold and thus result in higher peaks. This effect is swamped by the larger effects of data centre load variation in the later years of the forecast.

While Eirgrid do not expect an extremely warm or extremely cold winter every year, this range of scenarios is within the bounds of probability for the immediate winter. Therefore, it is included in our forecast to be provided for the Least Worst Regret analysis of the Capacity Requirement in the Capacity Market.

The main difference between the forecasts of low, median and high peaks is the differing amounts of load assumed from data centres and other large energy users. While the growth patterns are slightly different from GCS18, the overall trend is quite similar, reflecting the steady progress of the demand projects.

The GCS19 forecasted peaks have changed since GCS18 due to a different ramp out rate of demand of data centres and large energy users across Ireland. This has been informed by information directly from the specific demand customers.

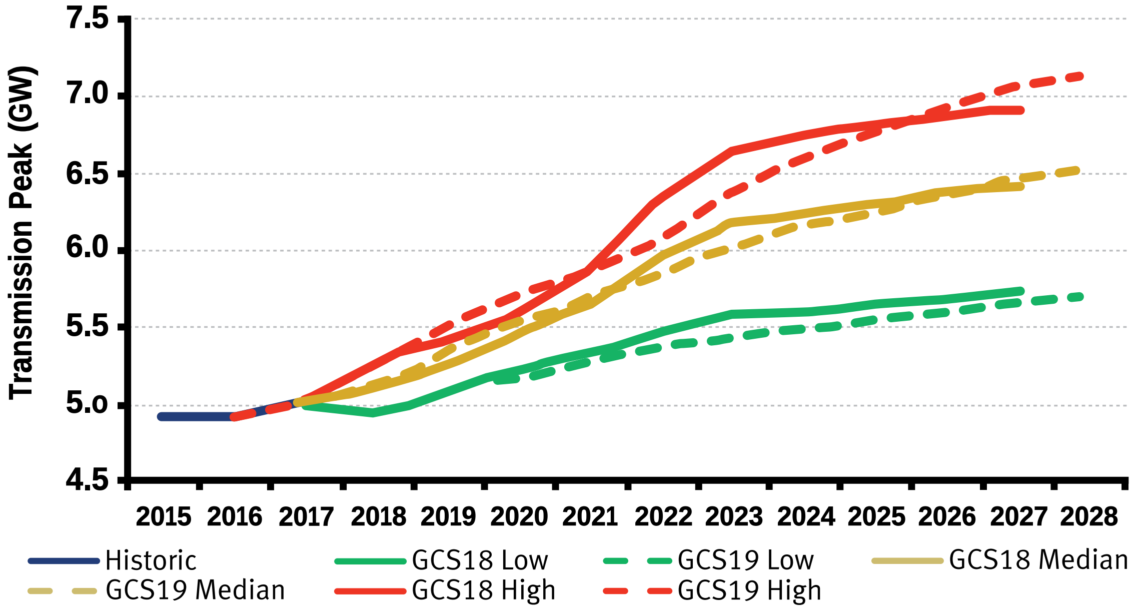

Figure 11 - Transmission peak forecast for Ireland

2.3. Demand Forecast for Northern Ireland

2.3.1. Methodology

The electricity forecast model is a multiple linear regression model which predicts electricity demand based on changes in economic parameters. Particular attention is paid to the effects of energy efficiency measures and large, new industrial users. A spread of electricity forecasts is produced, covering the next ten years.

The Total Energy Requirement (TER) forecast is carried out with reference to economic parameters, primarily Gross Value Added (GVA). The consensus amongst economists is that there will be growth in Northern Ireland's economy, although some uncertainty surrounds the pace of growth. For the purposes of the studies we have assumed a steady economic growth of between one and two percent annually.

The Strategic Energy Framework for Northern Ireland sets out the Northern Ireland contribution to the 1% year-on-year energy efficiency target for the UK. Energy efficiency has also been incorporated in the demand forecast. The Department for the Economy is currently reviewing and refreshing the Strategic Energy Framework.

2.3.2. Demand Scenarios

Given the degree of economic uncertainty into the future, SONI believes it prudent to consider three alternative scenarios for the economy, each of which can then be factored in to derive an estimate of energy production. Combining both temperature and economic scenarios as well as energy efficiency allows for median, high and low demand forecasts to be formulated.

The median demand forecast is based on an average temperature year, including energy efficiency with the central economic factor being applied and this is our best estimate of what might happen in the future.

The low demand forecast is based on a relatively high temperature year, higher energy efficiency with the pessimistic economic factor being applied. Conversely, the high demand forecast is based on a relatively low temperature year, lower energy efficiency with the more optimistic economic factor being applied. The optimistic and pessimistic economic factors are based on the central economic factor plus and minus one percent.

There have been some enquiries from new large industrial users including data centres seeking to connect in Northern Ireland. In order to capture the impact of new large industrial users SONI have based the demand forecast scenarios on different build-out scenarios. The low demand scenario assumes no new large industrial load. The median demand scenario includes a project with a connection offer in place, modified by an estimated connection probability, from 2023. In addition to this, the high demand contains a potential load that has made a material enquiry, modified by an estimated connection probability, from 2022. These three scenarios give an appropriate view of the range of possible demand growths.

2.3.3. Self-Consumption

SONI has been working with Northern Ireland Electricity Networks (NIE Networks) and referencing the Renewable Obligation Certificate Register (ROC Register[19]) to establish the amount of embedded generation that is currently connected on the system and what amounts will be connecting in the future.

This has enabled us to make an informed estimate of the amount of energy contributed to the total demand by self-consumption, which is then added to the energy which must be exported by generators to meet all demand, resulting in the Total Electricity Requirement (TER)[20].

2.3.4. TER Forecast

It can be seen that the new TER forecast (Figure 12) is similar to the previous forecast published in the Generation Capacity Statement 2018-2027. The main difference is that caused by the addition and timing of potential new large industrial load. The range difference between median and high demand is primarily based on new large industrial load build-out scenarios.

19 https://www.renewablesandchp.ofgem.gov.uk/
20 Self-consumption in Northern Ireland currently represents approximately 3% of TER

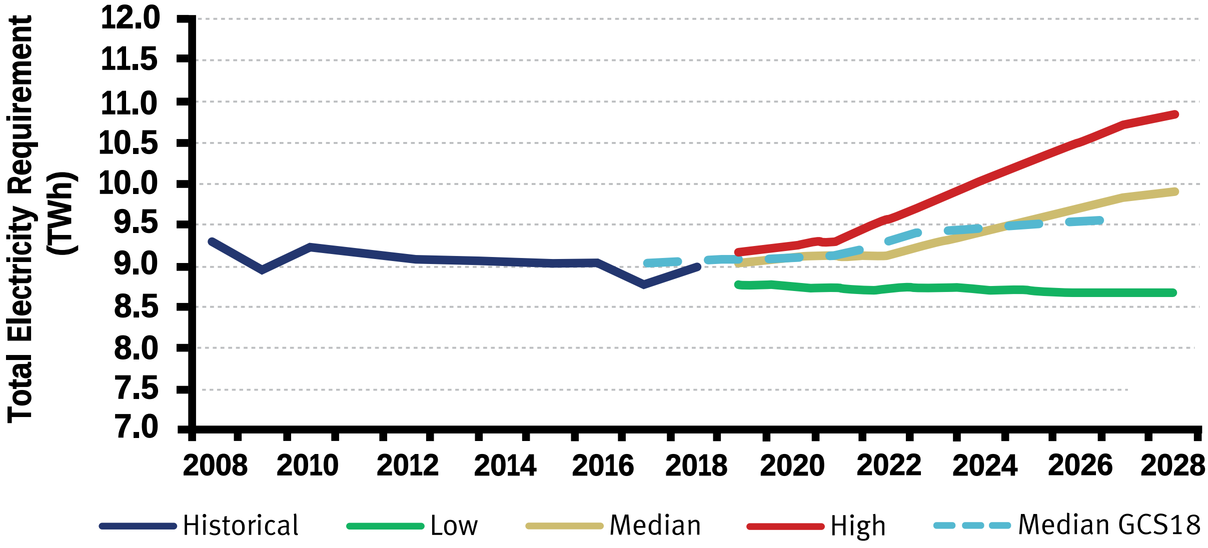

Figure 12 - Northern Ireland TER Forecast

2.3.5. Peak Demand Forecasting

The peak demand model is based on the historical relationship between the annual electricity consumption and winter peak demand. This relationship is defined by the Annual Load Factor (ALF), which is simply the average load divided by the peak load.

Temperature has a significant effect on electricity demand, particularly on Peak demand. This was particularly evident over the two severe winters of 2010 and 2011, when temperatures decreased dramatically and demand increased to record levels. Average Cold Spell (ACS) correction has the effect of 'smoothing out' the demand curve so that economic factors are the predominant remaining influences. The temperature-corrected peak curve is used in the ALF model, which can then be modelled for the future using the previously-determined energy forecasts.

The Northern Ireland 2017/18 generated winter peak of 1819 MW occurred on Tuesday 13 February 2018 at 18:30.

SONI has applied the ACS temperature correction, to update Figure 13.

As with the annual electricity demand forecast outlined in section 2.2(d), three peak forecast scenarios have been built. These consist of a pessimistic, realistic and optimistic view with adjustments that take account of current economic outlook predictions.

In the early years of the forecast SONI used temperature variation to give a plausible range between the low and high peak forecast, i.e. the low peak forecast is based on a mild winter, and the high scenario is based on a very cold winter. This has been based on historical records over the last 10 years. While SONI do not expect an extremely warm or extremely cold winter every year, this range of scenarios is within the bounds of probability for the immediate years.

In later years, variations caused by economic projections and new demand types are more significant and are used instead.

The main difference between the forecasts of low, median and high peaks is the differing amounts of load assumed from new large industrial load users. This forecast employs a similar methodology as that used in the Total Energy Requirement forecast.

Figure 12 shows the TER peak forecast for Northern Ireland. It can be seen that the resulting forecast is similar to the previous forecast.

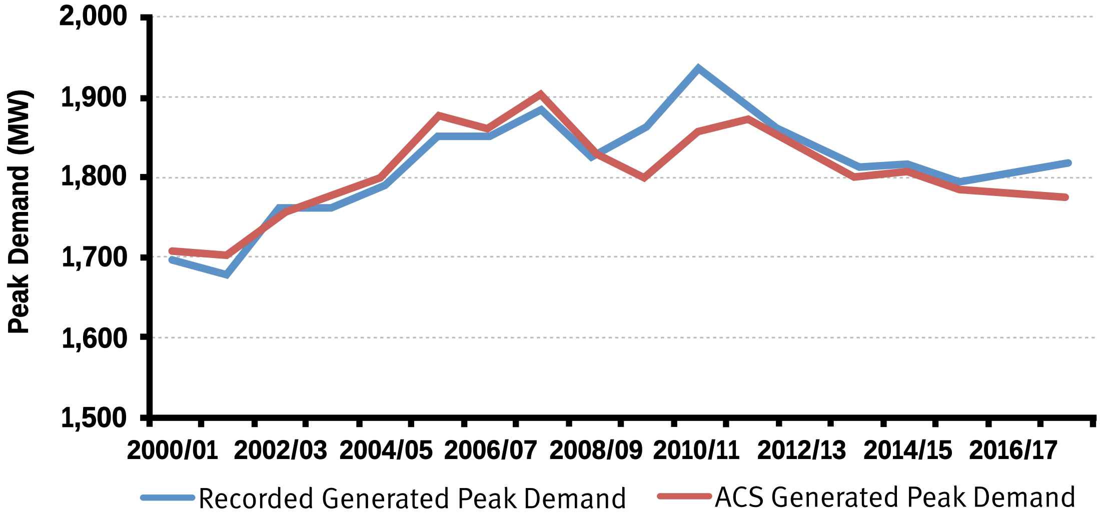

Figure 13 - Recorded and ACS-corrected peaks (generated level) for Northern Ireland. The most significant corrections are for 2009/10 and 2010/11, when the temperature deviated most from normal

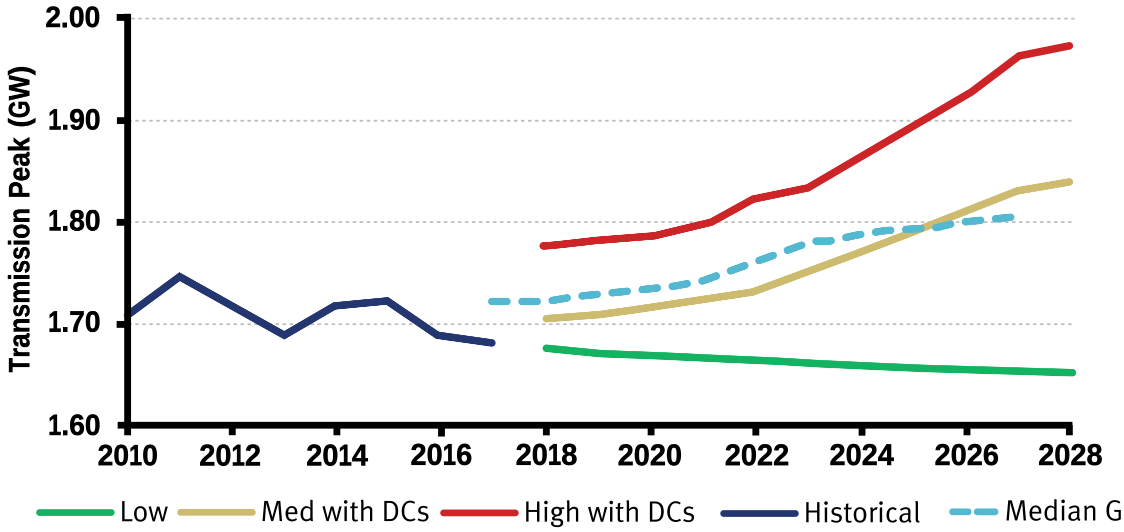

Figure 14 - ACS Transmission Peak forecasts for Northern Ireland

Appendix 1 lists the detailed energy and peak data out to 2028 including growth rates. It also includes the all island demand. While demand growth in Northern Ireland is subdued the demand growth in Ireland is significant which can be seen in the all island demand growth.

2.4. The Combined All-Island Forecast

In order to carry out combined studies for the all-island system, we simply add the two jurisdictional forecasts together for the total energy requirement, see Figure 15. The All-Island peak forecast is shown in Figure 16.

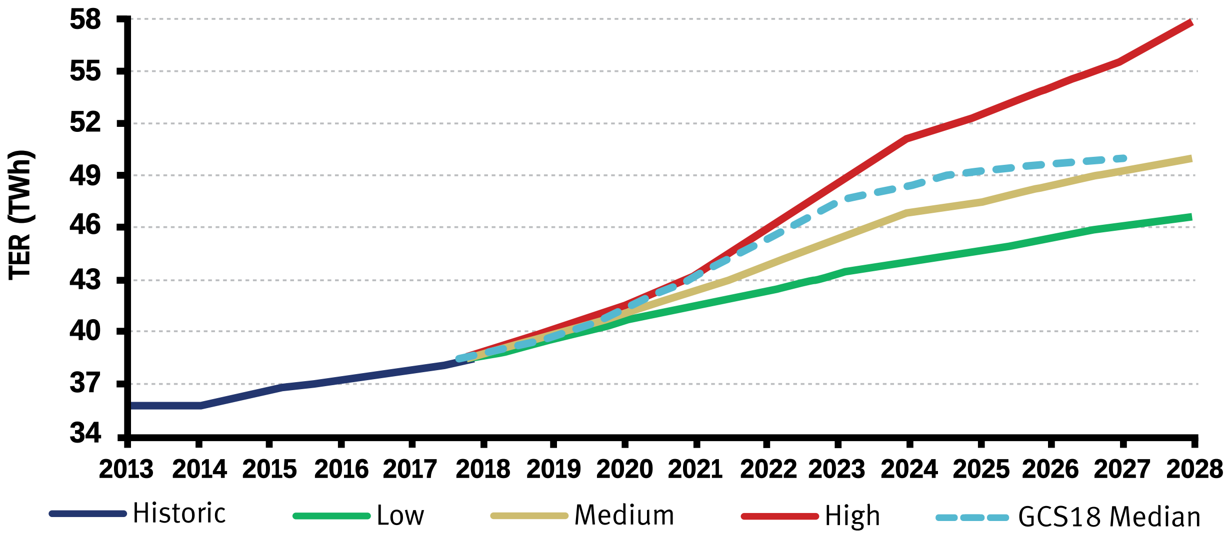

Figure 15 - The combined TER forecast for the All-Island system

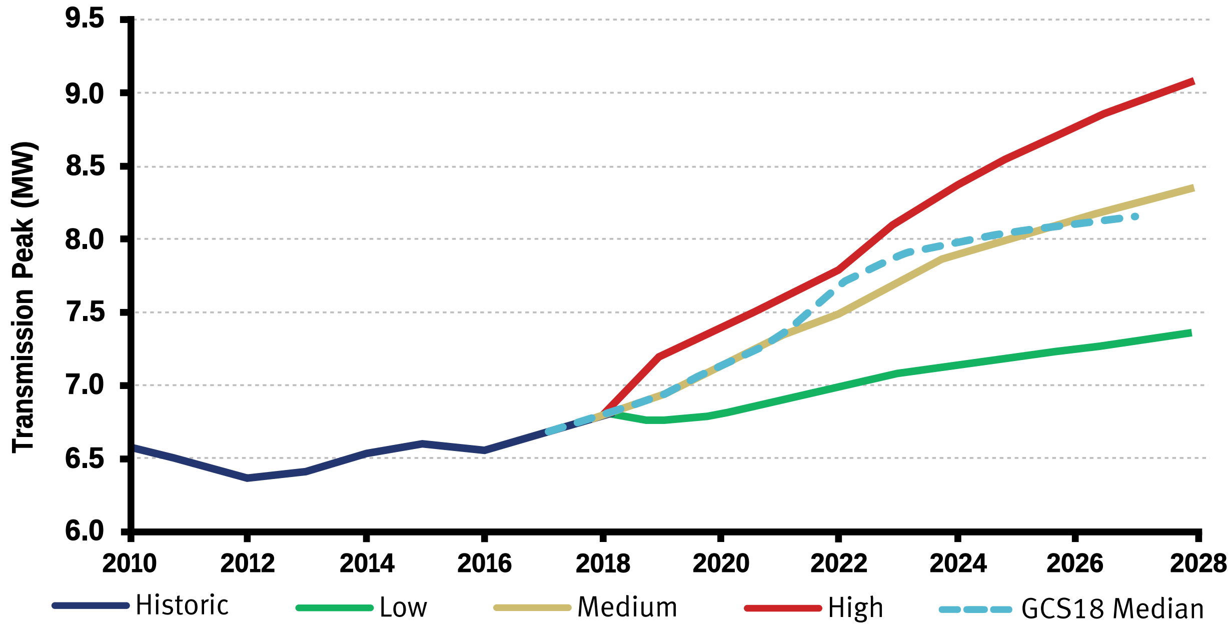

Figure 16 - The Transmission Peak forecast for the combined All-Island forecast

2.5. Annual Load Shape and Demand Profiles

To create future demand profiles for the adequacy studies, it is necessary to use an appropriate base year profile which provides a representative demand profile. This profile is then progressively scaled up using forecasts of energy peak and demand. Similar to the methodology employed in the Capacity Market auction calculations, we have used a number of base year profiles, carried out a number of adequacy studies separately, then taken an average of the results. The profile year that gave the closest result to this average was then used for subsequent adequacy studies. This avoids any bias that might ensue if only one, atypical year were used.

To reflect different segments of demand, additional forecast industrial and data-centre type demand is grown separately using a profile appropriate to its expected usage i.e. flat demand profile. Remaining additional demand is grown proportionally using historical demand profiles.

Electricity usage generally follows some predictable patterns. For example, the peak demand occurs during winter weekday evenings while minimum usage occurs during summer weekend night-time hours. Peak demand during summer months occurs much earlier in the day than it does in the winter period.

Many factors impact on this electricity usage pattern throughout the year. Examples include weather, sporting or social events, holidays, and customer demand management.

Generation 3

3. Generation

3.1. Introduction

This section describes the significant sources of electricity generation connected to the systems in Ireland and Northern Ireland known to the system operators. The portfolio may change due to the Capacity Market in the SEM. This is because only plant that are successful in the capacity auctions for the relevant years will receive capacity payments and therefore be liable for Reliability Options. Plant that does not receive capacity payments may seek to exit the market.

A total of 8.3 GW of de-rated capacity cleared in the T-1 2019/2020 All-Island capacity auction[21] held in December 2018, as shown in Figure 17. For the purposes of adequacy studies, we continue to include unsuccessful plant unless formal closure notices have been received.

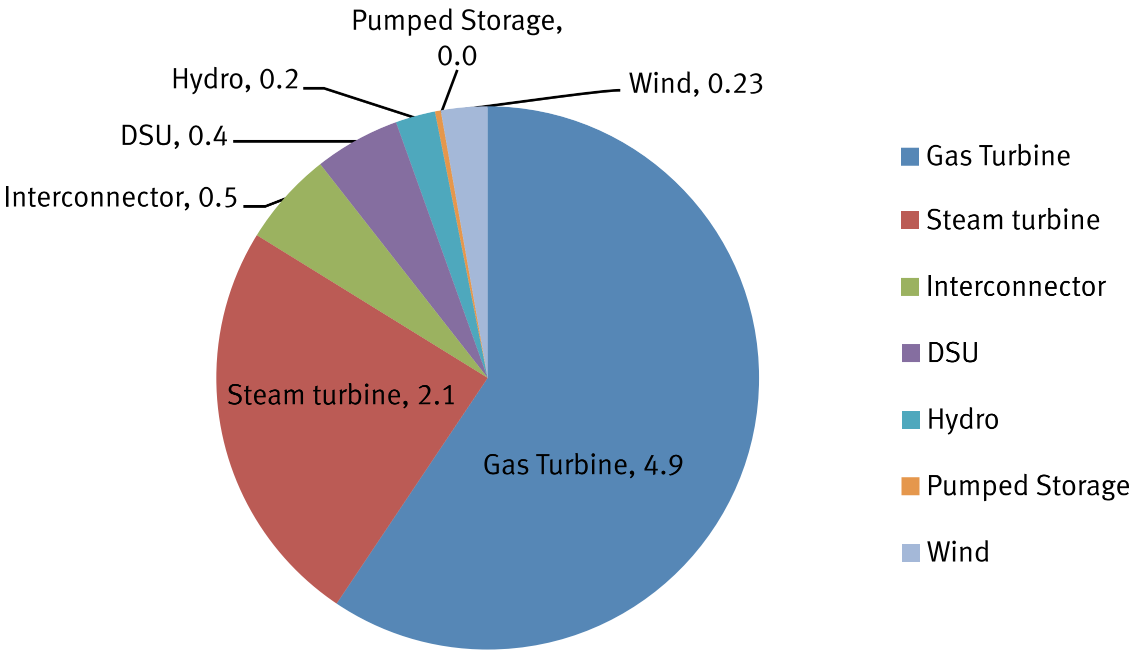

Figure 17 - The total amount of de-rated capacity (GW) that cleared the T-1 2019/2020 All-Island Capacity Market auction in December 2018 was 8.3 GW. Here it is divided into the technology categories used in the Capacity Market

3.2. Changes to Conventional Generation in Ireland

This section describes changes in fully dispatchable plant capacities in Ireland. Information on known plant additions and closures are documented.

Some of the older generators have informed Eirgrid of their intention to decommission, as detailed below in Table 6. The main reason for decommissioning is because of emissions restrictions.

21 https://www.sem-o.com/documents/general-publications/T-1-2019-2020-Final-Capacity-Auction-Results-Report.pdf

Plant	Export Capacity (MW)	Expected to close by the end of year:	Comment
Aghada (AT1)	90	2023	IED Limited Life-time Derogation.
North Wall 5	104	2019	Closing in September 2019 to be repowered.
Tabert 1,2,3,4	590	2023	Notified by SSE.
Moneypoint	885	2025	Assumed on the basis of Moneypoint not being compliant of the Clean Energy Package of 550gCO2/kWh ESB has not provided a closure notice for these units. MP2 was not successful in the CY2022/2023 T-4 SEM auction

Table 6 - Assumptions for Plant closures in Ireland

For the purposes of compliance with the IED, the ESB Aghada plant has been designated a 'Limited Life-time Derogation'. This plant will have limited running hours and are expected to shut by the end of 2023, see Table 6.

For the purposes of adequacy studies, Eirgrid have included all existing plant that entered the T-4 2022/23 auction, not just the capacity that was successful in the auction. This amounts to 7.5 GW of de-rated dispatchable plant in Ireland for 2019.

Eirgrid have included in the models the new Dublin generation that was successful in the recent CY2022/23 T-4 capacity auction from the start of 2023. It should be noted that, at time of publication, these units did not have signed connection agreements in place. Table 7 lists the successful Dublin generation units in the T-4 auction at their de-rated capacities.

Plant	De-Rated Capacity (MW)	Available
Dublin Region		
ESB North Wall 5 GT	108	2023
ESB North Wall 4 GT	108	2023
Statkraft Ireland	45	2023
ESB Ringsend Gas Flexgen	64	2023
ESB Poolbeg Gas Flexgen	64	2023
ESB Corduff Gas Flexgen	64	2023
ESB Poolbeg 2hr Battery Storage	39	2023
ESB Southwall 2hr Battery Storage	17	2023
ESB Inchicore 2hr Battery Storage	17	2023
Non-Dublin Region		
ESB Aghada 1hr Battery Storage	7	2023

Table 7 - Assumptions for new plant capacities for adequacy studies from 2023[22]

22 https://www.sem-o.com/documents/general-publications/T-4-2022-2023-Final-Capacity-Auction-Results-Report.pdf

3.3. Changes to Conventional Generation in Northern Ireland

This section describes changes in fully dispatchable plant capacities in Northern Ireland. Information on known plant additions and closures are documented.

For the purposes of adequacy studies, all existing plant that entered the T-4 2022/23 auction are included, not just the capacity that was successful in the auction. This amounts to 2.4 GW of de-rated dispatchable plant in Northern Ireland.

Ballylumford (units B4 and B5) closed at the end of 2018, having received a Grid Code derogation from the Utility Regulator to close earlier than required as per the Grid Code.

Plant	Export Capacity (MW)	Expected to close by the end of year:	Comment
Kilroot ST1	238	2024	AES has indicated that it will reduce to 199 MW from mid-2020. It is assumed not available after 2024 due to restrictions on coal-firing.
Kilroot ST2	238	2024	AES has indicated that it will reduce to 199 MW from mid-2020. It is assumed not available after 2024 due to restrictions on coal-firing.

Table 8 - Assumptions for plant changes in Northern Ireland

AES has invested in a Selective Non-Catalytic Reduction system at ST1 and ST2 to reduce emissions. They have been fully available in 2016, 2017 and 2018 and have an ability to purchase some additional emission allowances in the UK NOx trading scheme. They believe they can be fully available under this arrangement until the end of June 2020.

Emission restrictions become tighter in July 2020 when the Transitional National Plan ends and the units on oil firing could be limited to a rolling annual average of 1500 stack hours. In 2021 revised Best Available Techniques Reference Document restrictions will apply, so limits will further tighten. However, AES has been working with a supplier that has developed a solution to further reduce NOx emissions and is reasonably confident that with this in place, they could be fully available until the end of 2024. This solution would only apply to the coal rating of 398 MW. Note that AES have indicated that the solution is new technology so there is uncertainty - no investment decision has been made, and the business case is uncertain. However, in the absence of a formal notification of closure, SONI have modelled the units at the reduced capacity of 398 MW without run-hour or emissions restrictions for the purposes of the adequacy studies.

Current UK policy is to end coal-fired generation in Great Britain by 2025. While SONI is awaiting proposals for a devolved policy for Northern Ireland, it is seen as prudent not to incorporate these coal units in the adequacy studies from 2025.

These assumptions are based on information provided by AES. SONI note that since the data freeze point AES have sold all generation located at the Ballylumford and Kilroot sites to EP UK Investments Ltd, which is part of Energetický a Průmyslový Holding (EPH) company.

Belfast Power Limited (Evermore Energy) is proposing a 480 MW gas fired power station in the Belfast Harbour Estate. The proposed power station will use combined cycle gas turbine (CCGT) technology.

Belfast Power has submitted an application for Planning Permission to the Northern Ireland Planning Service. On 25th March 2019 the Department for Infrastructure issued a ‘notice of opinion’ to approve the proposed power station which has a grid connection offer from SONI. For the purposes of this report, this project is not included in the adequacy studies. SONI will continue to monitor the status of this project with a view to incorporating it in future studies if appropriate.

3.4. Impact of the Industrial Emissions Directive, Climate Action Plan and Clean Energy Package

The European Union has set ambitious targets for decarbonisation and for renewable energy for the electricity sector by 2030. To date the IED, CEP and the Irish Government Climate Action Plan 2019 are the three main instruments which aim to transform the electricity sector, amongst other sectors, to a cleaner and more sustainable future for all.

Ireland has produced a draft 2030 National Energy and Climate Plan which envisages a target of at least 55% renewable energy in electricity by 2030 with a finalised version expected by the end of 2019. In June 2019, the Minister of Communications, Climate Action and Environment published the Climate Action Plan 2019 which has committed to raising the amount of electricity generated from renewable sources to 70% by 2030 with no generation from peat and coal. This ambition is needed to honour the Paris Agreement. It represents a significant change for the electricity industry and for EirGrid. It is an opportunity to create a sustainable electricity system that will meet the needs for the next generation.

Directive 2010/75/EU of the European Parliament and the Council on industrial emissions (the Industrial Emissions Directive or IED) is the main EU instrument regulating pollutant emissions from industrial installations. The IED replaces seven existing directives including the Integrated Pollution Prevention and Control Directive 2008/1/EC (IPPC) and the Large Combustion Plant Directive 2001/80/EC (LCPD).

In 2017, the European Commission published a final decision on the Best Available Techniques[23] (BAT) for large combustion plants, which will apply new standards on emissions from August 2021. For combustion plants, Emission Limit Values (ELVs) for Nitrous Oxide (NOx), Sulphur Dioxide (SO2) and particulate levels have been tightened.

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 TNP (Transitional National Plan). 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.

To support the development of more renewable generation post 2020, the Irish Government announced a new Renewable Electricity Support Scheme (RESS). It is envisioned that there will be a series of auctions to deliver our targets over the next decade. Eirgrid is working with DCCAE, CRU and industry participants to complete the inaugural RESS auction within the next 12 months to enable the early delivery of renewable generation projects in order to meet our RES-E trajectory to 2030.

23 http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1502972300769&uri=CELEX:32017D1442

3.5. Interconnection

Interconnection allows the transport of electrical power between two transmission systems. Interconnection with Great Britain over the East-West and Moyle interconnectors provides significant capacity benefit. It also allows opportunities for direct trading between the system operators, known as counter-trading. Further transmission links between Ireland and Northern Ireland would significantly enhance generation adequacy in both jurisdictions.

3.5.1 North-South Interconnector

As the second high capacity transmission link between Ireland and Northern Ireland is assumed to be commissioned in 2023, an all-island generation adequacy assessment can be carried out from 2024 onwards. This all-island assessment shows an increase in the security of supply for both jurisdictions, as the demand and generation portfolios for Northern Ireland and Ireland are aggregated to meet to combined demand.

Prior to the completion of this second North-South Interconnector project, the existing interconnector arrangement between the two regions creates a physical constraint that affects the level of support that can be provided by each system to the other. On this basis each TSO is obliged to help the other in times of shortfall.

With this joint operational approach to capacity shortfalls, the TSOs agreed that the level of capacity reliance would be maintained by modifying interconnector flows. Reductions in reserve would be followed by load shedding by both parties as a final step to maintaining system integrity[24 25].

Generation adequacy assessments for each region are carried out with an assumed degree of capacity interdependence from the other region. This is an interim arrangement until the additional interconnector removes this physical constraint. The capacity reliance values used for the adequacy studies are shown in Table 9.

	North to South	South to North
Capacity Reliance	100 MW	200 MW

Table 9 - Capacity reliance at present on the existing North South Interconnector

During real time operations, flows in excess of the capacity reliance can sometimes take place if required.

As it is within the all-island market, the interconnection between Ireland and Northern Ireland is treated as an element of the transmission system, rather than an interconnector to facilitate cross-border trading. As such, it is a different case compared to how the East-West (EWIC) and Moyle interconnectors are considered.

3.5.2 Generation Available in Great Britain

When assessing the contribution of an interconnector to generation adequacy, we need to consider the availability of generation at the other side, as well as the availability of the interconnector itself.

24 https://www.sem-o.com/documents/general-publications/Information_Note_on_Inter-Area_Flow_Constraints.pdf
25 http://www.eirgridgroup.com/site-files/library/EirGrid/OperationalConstraintsUpdateVersion1_82_May_2019.pdf

In order to improve our understanding of how interconnection can provide benefit, we look to our European neighbours. ENTSO-E, in collaboration with EirGrid, SONI and other TSOs, has recently improved its adequacy assessment methodology with a special emphasis on harmonised inputs, system flexibility and interconnection assessments. The Mid-Term Adequacy Forecast (MAF[26]) uses probabilistic methods to take into account the intermittency of the growing renewable generation sector.

3.5.3 East-West HVDC Interconnection between Ireland and Wales

The East-West interconnector connects the transmission systems of Ireland and Wales with a capacity of 500 MW in either direction. However, it is difficult to predict whether or not imports for the full 500 MW will be available at all times. Informed by the SEM Capacity Market decision, we used a 60% External market derating factor, i.e. 300 MW, and appropriate availability statistics.

3.5.4 Moyle Interconnector between Northern Ireland and Scotland

The Moyle Interconnector is a dual monopole HVDC link with two coaxial undersea cables from Ballycronanmore (Islandmagee) to Auchencrosh (Ayrshire). The transfer capacity of the Moyle Interconnector for the trading of electricity between the electricity markets of Ireland and Great Britain varies[27] as shown in Table 10.

Direction	Dates	Contracted Capacity (MW)	Additional Capacity Potentially Available (MW)	Potential Total Capacity Available (MW)
West to East	10 November 2017 to 30 November 2019	80	420	500
	1 December 2019 to 31 May 2020	307	193	500
	1 June 2020 to 31 October 2021	250	250	500
	1 November 2021 to 31 March 2022	160	340	500
	1 April 2022 Onwards	500	0	500
East to West	November to March Each Year	450	-	450

Table 10 - Transfer capacity of the Moyle Interconnector

It is difficult to predict whether or not imports for the full capacity will be available at all times.

For the purposes of adequacy studies, we treat the Moyle interconnector with a 60% External market derating factor (270 MW) used in the SEM Capacity Market, and appropriate availability statistics.

26 https://www.entsoe.eu/outlooks/maf/Pages/default.aspx
27 http://www.mutual-energy.com/electricity-business/moyle-interconnector/trading-across-the-moyle-interconnector/

3.5.5 Further Interconnection

There are many proposed interconnector projects involving Ireland. Table 11 below contains a list of projects that has been assessed as part of the next European Ten Year Network Development Plan[28] Projects of Common Interest. As these projects are at a preliminary stage, Eirgrid have not included them in the adequacy assessments in this report. It is expected that once an interconnector project reaches financial close and has an EPC contract it will be included in GCS adequacy studies.

Project	Description
Celtic	Interconnector between Ireland and France (with PCI status[29])
Gallant	Project providing interconnection to Great Britain
Greenconnect	Project providing interconnection to Great Britain
Greenlink	Project providing interconnection to Great Britain (with PCI status[29])
Greenwire North	Project providing interconnection to Great Britain
Greenwire South	Project providing interconnection to Great Britain
Irish-Scottish Links on Energy Study (ISLES)	Offshore wind hub potentially providing interconnection to Scotland
Marex	Project providing interconnection to Great Britain

Table 11 - Proposed interconnection projects

3.6. Wind Capacity and Renewable Targets

In both Ireland and Northern Ireland, government policies are in place which set targets for the amount of electricity sourced from renewables. The integration of more variable renewable forms of generation on the power system means we must consider an additional complex range of demand and supply issues. Our 'Delivering a Secure Sustainable Electricity System' (DS3) programme aims to meet the challenges of operating the electricity system in a secure manner while achieving the 2020 renewable electricity targets[30].

In Ireland, DCCAE has launched a set of auctions called the Renewable Electricity Support Scheme (RESS). The RESS scheme is underpinned by the agreement between the EU Commission, EU Parliament and EU Council to set an EU-wide, binding renewable energy target of 32% out to 2030[31]. Ireland is due to publish its National Energy Climate Plan (NECP) by the end of 2019. This will set out how Ireland plans to achieve the target of at least 70% RES-E by 2030. Until the NECP is published it is hard to provide definitive elements of the renewable generation fleet expected.

28 TYNDP 2016 is produced by the European Network of Transmission System Operators – Electricity (ENTSO-e), see http://tyndp.entsoe.eu/
29 EC Project of Common Interest, see: https://ec.europa.eu/energy/sites/ener/files/documents/memberstatespci_list_2017.pdf
30 http://www.eirgridgroup.com/how-the-grid-works/ds3-programme/
31 https://www.dccae.gov.ie/documents/RESS%20Design%20Paper.pdf

However, it can be assumed that these renewable targets will be achieved largely through the deployment of additional wind powered generation in Ireland. There have been a number of grid access connection schemes to develop renewable generation; Gate 3, Non-GPA and ECP-1. Figure shows the breakdown of connected, contracted and in-process grid connections including ECP-1 wind, solar and battery projects. The graph represents the capacity of connection offers which have been issued however it is not clear yet what level of installed capacity will result from the total capacity offered. EirGrid publishes a list of all Transmission Connected wind generation in Ireland[32], while ESB Networks publishes that which is Distribution Connected[33].

As intermittent RES generation is deployed, challenges related to mismatch between energy generation and consumption become more critical. Battery Energy Storage is included in the graph below. It is important to note that while Battery Energy Storage does not contribute directly to Ireland's RES-E target, it will facilitate the integration of increased renewable energy capacity. Sufficiently flexible energy storage systems, particularly those connected through fast-response electronic interfaces would ideally complement a varied and disperse generation portfolio. In particular, various energy storage technologies are expected to provide a wide range of advanced services (mostly related to system integrity and stability, for instance synthetic/virtual inertia, frequency containment, frequency restoration and restoration reserves, ramping support, and energy balance; but also energy arbitrage over different time scales, from intra-daily to seasonal).

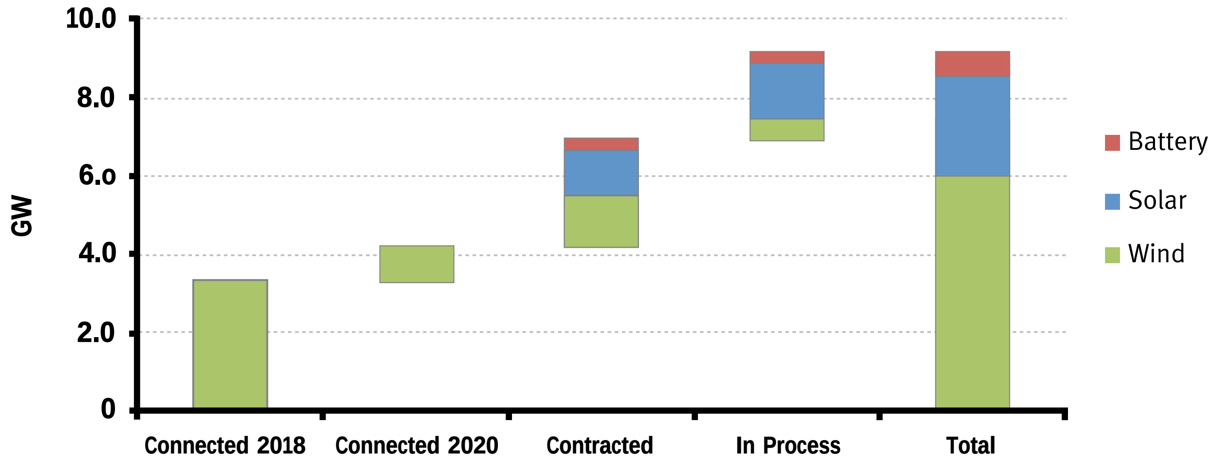

Figure 18 - Connected, contracted and in-process grid connections including ECP-1 wind, solar and battery projects

Table 12 shows the totals for existing and planned wind generation in Northern Ireland. The figures for Northern Ireland are based on volumes of applications to SONI and NIE Networks which have accepted a grid connection offer and do not include small scale generation.

	Existing (MW)	Planned (MW)
Northern Ireland TSO	121	0
Northern Ireland DSO	974	129
Total	**1095**	**129**

Table 12 - Existing (connected or energised) and planned (contracted or applied) wind farms for Northern Ireland

32 http://www.eirgridgroup.com/customer-and-industry/general-customer-information/connected-and-contracted-generators/
33 https://www.esbnetworks.ie/new-connections/generator-connections/generator-connection-statistics

3.6.1 Pathways to achieving the 2030 EU RES-E targets of up to 70%

In June 2019, the Irish Government published the Climate Action Plan 2019[34]. In it the Government set out guidelines for how, at a high level, the 70% renewable energy target is reached. This includes:

- Delivering an early and complete phase-out of coal and peat fired electricity generation:
    - Moneypoint closure by 2025,
    - Bord na Mona transition away from peat by 2028.
- An increase of electricity from renewable sources to 70% via:
    - At least 3.5 GW of offshore renewable energy,
    - Up to 1.5 GW of grid-scale solar PV energy,
    - Up to 8.2 GW total of increased onshore wind capacity.
- Meeting 15% of electricity demand by renewable sources contracted under Corporate PPAs[35].
- Enhanced interconnection is planned, including the Celtic Interconnector to France and further interconnection to the UK.
- Facilitation of small and micro scale generation at a residential and community level to sell excess generation back to the grid.
- Smart meters installation for all homes by 2024.
- Revised market structures and grid connection processes to best facilitate the above developments

The RESS Auction Scheme will support delivery of Ireland's renewable electricity (RES-E) targets by 2030 subject to determining the cost effective level which will be set out in the draft National Energy and Climate Plan (NECP). There will be a series of auctions throughout the lifetime of the scheme.

Renewable electricity deployment takes a centralized pathway. The diversity of the renewables mix increases due to reducing levelised costs and auction designs: large scale onshore wind, offshore wind and solar PV are expected to be most prevalent. Carbon capture and storage could be developed to further decarbonize fossil fuel generation.

For an example of the renewable mix which could achieve the 70% RES-E target based on this year's GCS ten-year median demand forecast, Ireland would be on track to achieve the 70% RES-E by 2030 with the following renewable generation portfolio in Figure 19.

34 https://assets.gov.ie/10206/d042e174c1654c6ca14f39242fb07d22.pdf
35 A corporate PPA refers to a contractual arrangement whereby independent generators (typically renewable) and corporates that are large energy consumers, contract for the sale of power to that consumer.

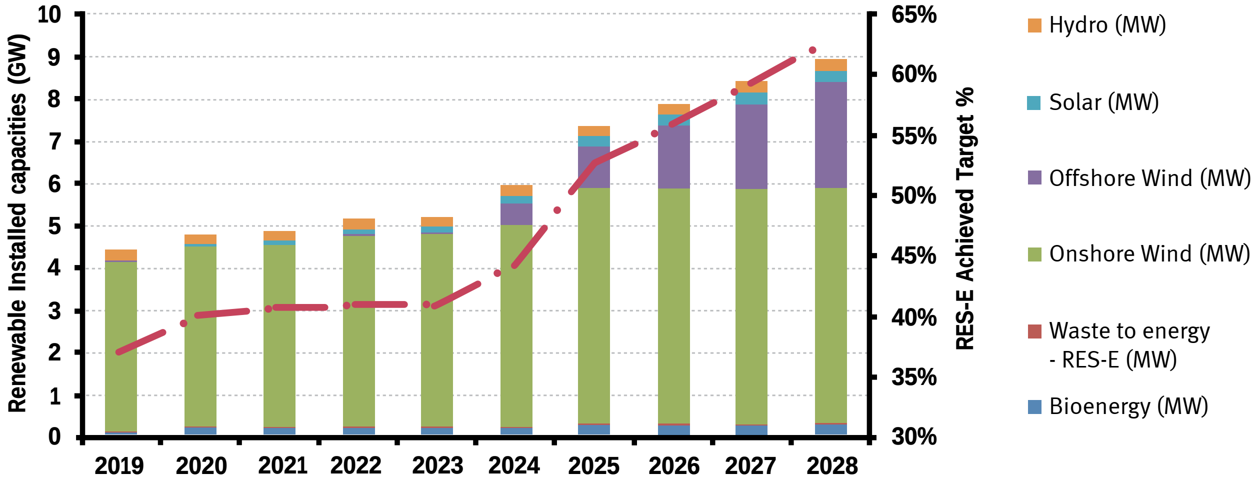

Figure 19 - Example renewable energy generation portfolio which could achieve the 70% RES-E target

3.6.2 Wind Power in Ireland

The Irish Government has a target of 40% of electricity to be generated from renewable sources by 2020, as was restated in the 2015 White Paper on Energy[36]. The 40% RES-E target is part of the Government's strategy to meet the overall Irish target to achieve 16% of all energy consumed to come from renewable sources by 2020.

Installed capacity of wind generation has increased from 135 MW at the end of 2002 to over 3666 MW at the end of 2018. This value is set to increase over the next two years as Ireland endeavours to meet its renewable target in 2020.

In order to comply with the RES Directive (2009/28/EC) guidelines for the 2020 RES target in Ireland, we normalise the annual energy from wind power[37]. This is done by applying an average of the past 5 year's capacity factor. This normalised annual energy has grown from 4200 GWh in 2011 to 8600 GWh in 2018, which accounts for 28% of total electricity demand in 2018. The variation in wind capacity factors is displayed in Figure 20.

36 http://www.dccae.gov.ie/energy/en-ie/Energy-Initiatives/Pages/White-Paper-on-Energy-Policy-in-Ireland-.aspx
37 http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32009L0028&from=EN

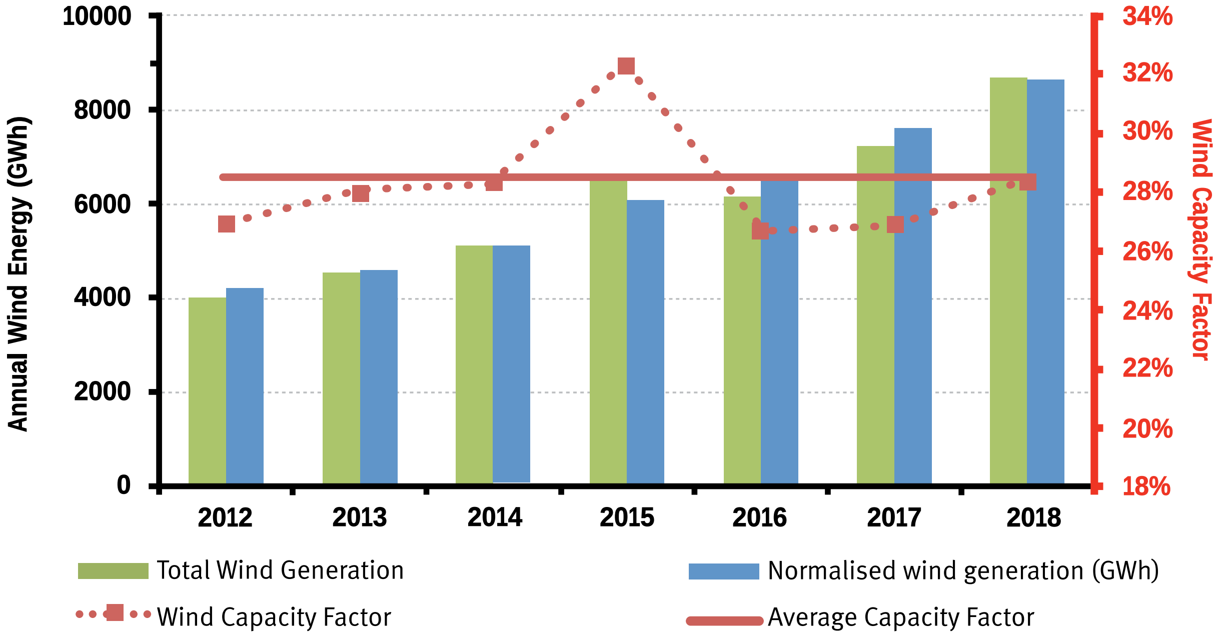

Figure 20 - The actual and normalised annual energy produced from wind power in Ireland over the last six years. In red are the figures for annual wind capacity factor, and their average

The actual amount of renewable energy that will be required will depend on the demand in 2019/2020. Also, the assumptions made for other renewable generation will have a bearing on how much wind energy will need to be generated to reach the 40% target. Lastly, a small amount of available energy from wind cannot be used due to transmission constraints or system curtailment. We estimated this to be approximately 5.0% in 2018[38]. This has varied between 2.8% and 5.1% over the past seven years.

With these uncertainties in mind, we estimate that a band of 3900 – 4400 MW of on-shore wind capacity is required to meet the 2020 RES-E targets for Ireland, depending on the demand level scenario and assuming that the peat units reach 30-35% biomass burning. The most likely scenario for installed wind capacity in 2020 is expected to be 4200 MW. This would imply an average build-out of approximately 330 MW per year until the end of 2020, see Figure 21.

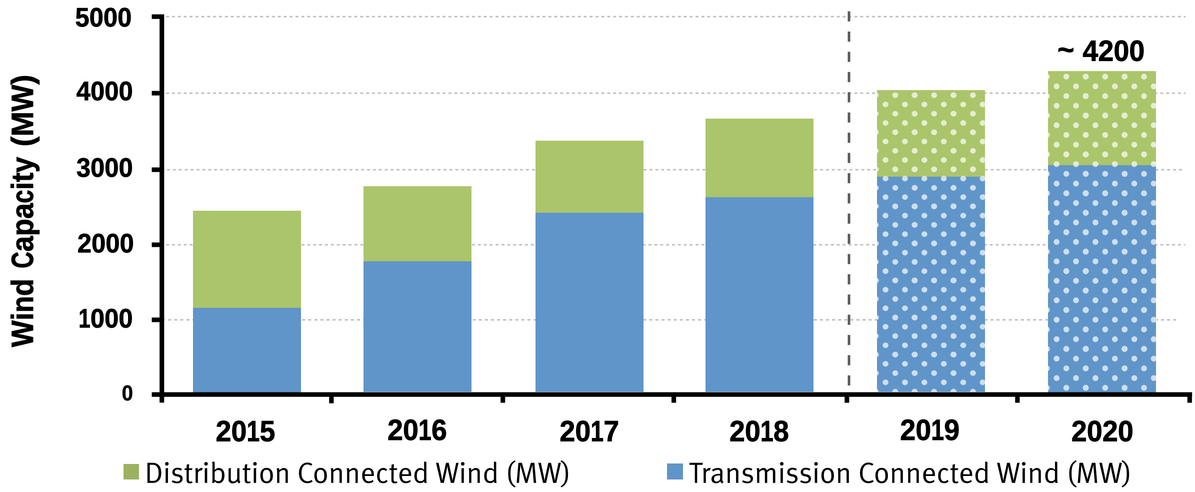

Figure 21 - Historical and assumed growth of wind capacity in Ireland. The target of 40% RES is met by 2020

38 http://www.eirgridgroup.com/site-files/library/EirGrid/2017-Qtr4-Wind-Dispatch-Down-Report.pdf

Assumptions for wind capacity development post-2020 were developed using the draft NECP in this Generation Capacity Statement. Future versions of this document will be informed by the Government Climate Action Plan 2019 and publication of the finalised NECP by the end of 2019.

3.6.3 Wind Power in Northern Ireland

The Strategic Energy Framework for Northern Ireland restated the target of 12% of electricity consumption from renewable resources by 2012 with a new additional target of 40% of electricity consumption from renewable resources by 2020. The Department for the Economy is currently reviewing its Strategic Energy Framework. For 2018, 36% of electricity consumption came from renewable sources in Northern Ireland, most of which was from wind power.

The Northern Ireland Renewables Obligation (NIRO) is the main policy measure for supporting the development of renewable electricity in Northern Ireland. It works alongside the Renewables Obligation (RO) for England and Wales and the Renewables Obligation Scotland (ROS). As part of UK-wide Electricity Market Reform, all three Renewables Obligations closed to new generation from 1st April 2017.

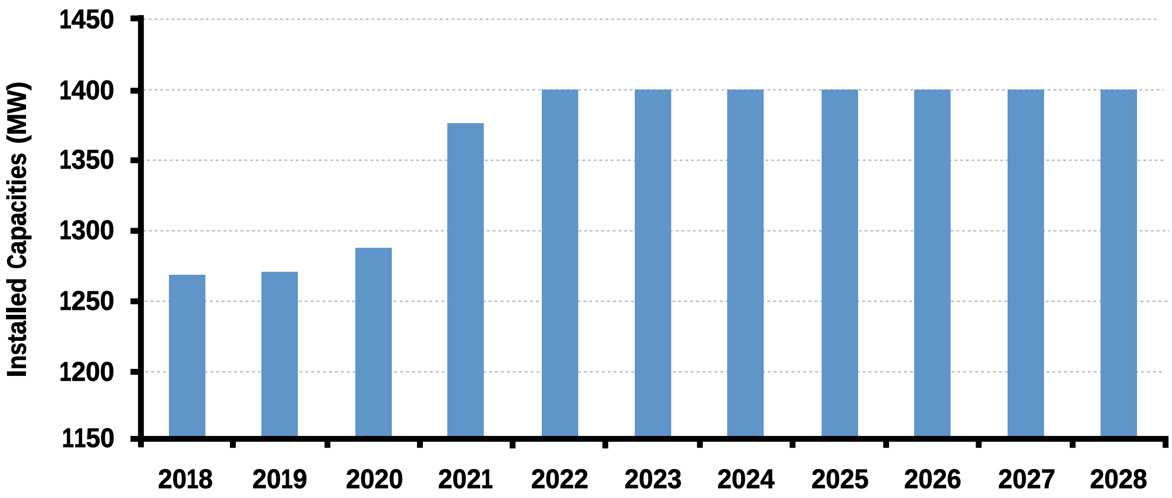

Figure 22 - The expected growth of wind capacity installed in Northern Ireland, reaching almost 1300 MW by 2020 with a further 100MW to connect by 2022. These assumptions are based on volumes of applications to SONI and NIE Networks which have accepted a grid connection offer and includes both large scale and small scale wind. Projected capacity growth of wind is slower than GCS18 with almost 1400MW forecast to be installed by 2022 compared to 1400 MW by 2020 in GCS18.

The Department for the Economy (DfE) appointed external consultants in February 2019 to carry out research on the future of renewables in Northern Ireland including consideration of the potential for a new renewable electricity target. SONI are providing input to this work due to be completed during the summer and will be an important step for the Department in considering its approach to facilitating growth in renewable electricity generation going forward.

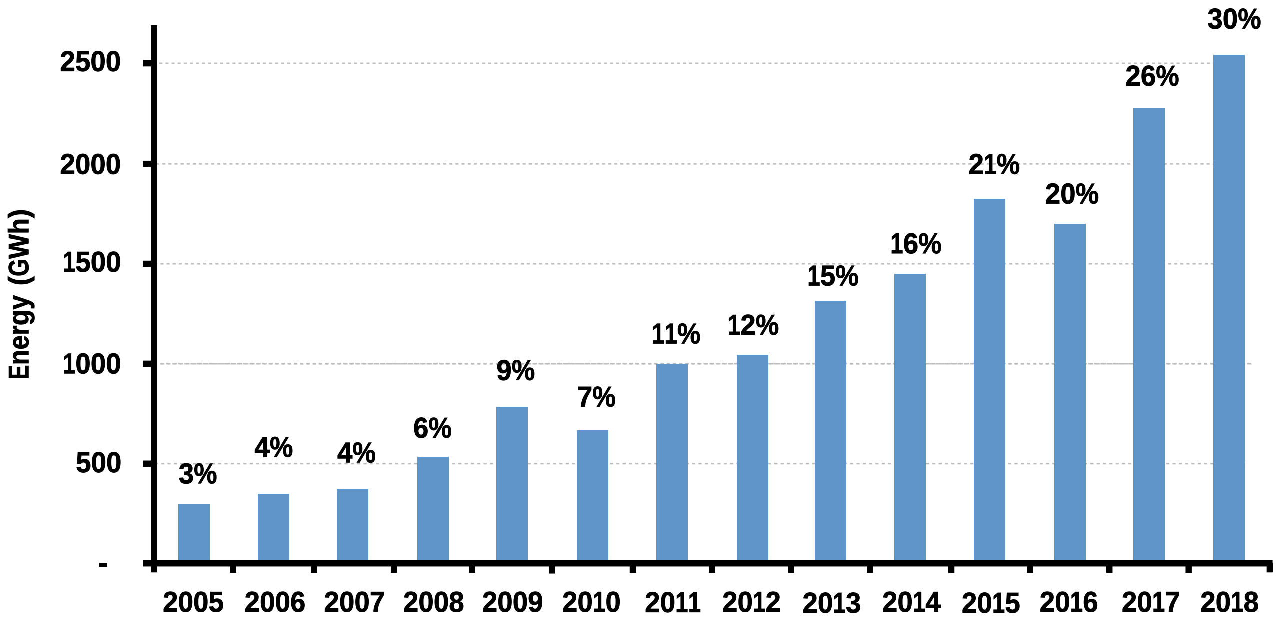

Figure 23 - Historical wind generation for Northern Ireland in annual electricity terms, also given as a percentage of total electricity produced that year. Figures are based on sent-out metering available to SONI

SONI estimate the expected growth of wind capacity, along with contributions from other renewables such as solar photo-voltaic and biomass (see Table A-5), will achieve 40% of electricity consumption from renewables generation sources in 2020. We have assumed that large scale onshore wind has a capacity factor of 30%, PV 10% and large scale biomass 80%.

The analysis assumes that new wind farms in Northern Ireland will be connected to the grid and that the necessary reinforcements will be completed in a timely manner. No sensitivities around this assumption are considered. For the purposes of the studies for this report, as there are no grid connection offers in place, SONI assume that by 2028 there will not be any offshore wind or tidal connected.

Figure 23 shows the increase in energy supplied from wind generation in recent years. In 2005, just 3% of Northern Ireland's electricity needs came from wind generation. This share had increased to 30% by 2018.

3.6.4 Modelling of Wind Power in Adequacy Studies

The modelling of wind power in our adequacy studies matches the treatment of wind in the Capacity Market calculations.

For the Capacity Market, a number of historical wind profiles are grown to match the installed capacity of wind expected in future years. These profiles are then used separately to modify the future demand forecast, where each historical year's profile for wind is matched with the same historical year's demand profile. It is these modified demand forecasts that are subsequently used in the adequacy calculations to obtain the Capacity Requirement for the Capacity Market.

3.7. Other Non-Conventional Generation

The assumed build-out of non-conventional generators is summarised in APPENDIX 2 (Table A-5 and Table A-8).

3.7.1 Demand Side Units

A Demand Side Unit (DSU) consists of one or more individual demand sites that we can dispatch as if it was a generator. An individual demand site is typically a medium to large industrial premises. A DSU Aggregator may contract with the individual demand sites and aggregate them together to operate as a single DSU.

In Ireland, 540 MW of DSU capacity cleared the 2019/2020 T-1 Capacity Market auction held in December 2018 and 620MW successfully cleared the 2022/2023 T-4 Capacity Auction held in March 2019. Eirgrid will continue to monitor this relatively new capacity in order to assess its contribution to system adequacy appropriately.

Industrial generation refers to generation, usually powered by diesel engines, located on industrial or commercial premises, which acts as on-site supply during peak demand and emergency periods. The condition and mode of operation of this plant is uncertain, as some of these units would fall outside the control of the TSOs. Industrial generation has been ascribed a capacity of 9 MW in Ireland for the purposes of this report.

Dispatchable Aggregated Generating Units (AGU) operate in Northern Ireland, which consist of a number of individual diesel generators grouping together to make available their combined capacity to the market. An AGU capacity of 76 MW and a DSU capacity of 98 MW were successful in the T-1 Capacity Market auction held in December 2018.

3.7.2 Small scale CHP

Combined Heat and Power utilises generation plant to simultaneously create both electricity and useful heat. Due to the high overall efficiency of CHP plant, often in excess of 80%, its operation provides benefits in terms of reducing fossil fuel consumption and CO2 emissions.

There are approximately 159 MW of CHP units noted in Ireland which are included in the GCS, mostly gas-fired. This is the same as the GCS18. This does not include the 161 MW centrally dispatched CHP plant operated by Aughinish Alumina.

In Northern Ireland, there is currently an estimated 9 MW of small scale CHP connected to the distribution system (3 MW of which is renewable and 6 MW non-renewable). With little further information, an assumption has been made that, for the purposes of this statement, this will not change.

3.7.3 Biofuel

There are a number of different types of biofuel-powered generation plant on the island.

For the previous GCS, EirGrid estimated there to be 54 MW of generation capacity powered by biofuel, biogas or landfill gas in Ireland. This amount has now been lessened by an amount of biofuel units that have registered as a DSU.

Eirgrid have assumed that the peat plant at Edenderry, Lough Ree and West Offaly will be approximately 30-35% powered by biomass by 2020. By 2025, Eirgrid would expect the peat units to be 50% biomass and by 2030, 100% biomass.

REFIT 3[39] provides an incentive for biomass-fuelled CHP plant. This will likely result in up to 100 MW of plant, including Dublin Waste Energy. These plant will make a significant contribution to the 40% RES target.

Currently in Northern Ireland, there is an estimated 46 MW of small scale generation powered by biofuels, including biomass, biogas and landfill gas. For the purposes of this report, and in the absence of more detailed information, it has been assumed that this capacity will not change.

Lisahally Waste Project became operational in 2015 in Northern Ireland. It is a wood-fueled energy-from-waste/biomass combined heat and power plant with a capacity of approximately 18 MW. The plant is dispatchable and has been granted priority dispatch.

3.7.4 Small-scale Hydro

It is estimated that there is currently 22 MW of small-scale hydro capacity installed in rivers and streams across Ireland. Such plant generates approximately 43 GWh per year, making up 0.2% of total annual generation. While this is a mature technology, the lack of suitable new locations limits increased contribution from this source. It is assumed that there are no further increases in small hydro capacity over the remaining years of the study.

The capacity in Northern Ireland is approximately 6 MW and consists primarily of a large number of small run-of-the-river projects. For the purposes of this report it has been assumed that this capacity will not change.

3.7.5 Waste-to-energy

Ireland has two waste-to-energy plants. The 61 MW Dublin waste-to-energy plant which was commissioned in 2017 and Indaver (17 MW). The GCS assumes a 50% renewable content, thus contributing to our RES targets.

In early 2018, approximately 15 MW of energy from waste generation was installed at the Bombardier site in Belfast.

3.7.6 Solar PV

In Ireland, the uptake of government support in this sector is unclear, and so Eirgrid have assumed modest growth, reaching 100 MW by 2024.

In Northern Ireland, the capacity of small scale solar PV has increased rapidly in recent years. Connected capacity is approximately 112 MW. SONI expects this capacity will continue to grow, reaching 117 MW by the end of 2019.

In Northern Ireland a number of large scale PV projects have connected in recent years. Capacity is approximately 134 MW. SONI expects capacity to grow to 179 MW by the end of 2022.

Similar to the treatment of wind power, solar PV capacity is de-rated in our adequacy studies to the de-rating factor used in the 2019/2020 T-1 Capacity Market auction, i.e. 0.055[40].

39 http://www.dccae.gov.ie/energy/en-ie/Renewable-Energy/Pages/Refit-3-landing-page.aspx
40 https://www.sem-o.com/documents/general-publications/Final-Auction-Information-Pack_FAIP1920T-1.pdf

3.7.7 Marine Energy

In Ireland, due the large amount of uncertainty associated with this new technology, Eirgrid have taken the prudent approach that there will be no commercial marine developments available for adequacy purposes in Ireland before 2028.

In Northern Ireland, The Crown Estate has awarded development rights for sites off the North Coast of Northern Ireland close to Torr Head and Fair Head. At present there are no connection offers in place for tidal projects. Therefore, for the purposes of this report, SONI have not included any capacity within our reference scenario adequacy studies. SONI will continue to monitor its status with a view to incorporating it into future studies.

3.7.8 Kilroot Energy Storage

AES completed the Kilroot Energy Storage Array located in Kilroot Power Station in 2016. This pilot scheme provides 10 MW of interconnected energy storage, as well as system services including frequency regulation as part of the system operators' DS3 System Services arrangements. While providing DS3 System Services is desirable, this type of capacity is not included in our models for adequacy calculation purposes.

3.8. Plant Availability

In 2018, there were significant rolling outages at Great Island and Moneypoint which negatively affected availability statistics for Ireland.

Figure 24 shows Ireland system wide availability which has been decreasing for the past number of years. This affects generation plant ability to provide maximum adequacy support to demand.

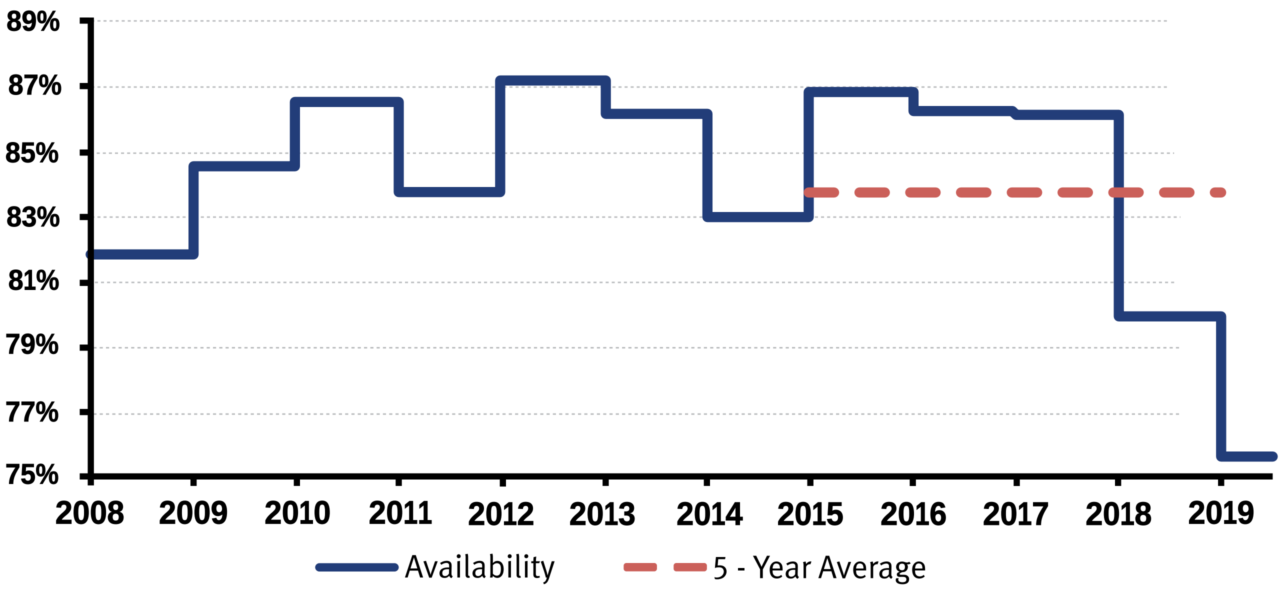

Figure 24 - The average 365-day annual system-wide availability in Ireland

Ireland Forced Outage Rates have been increasing over the past number of years, linked to the system availability falling. This is displayed in Figure 25.

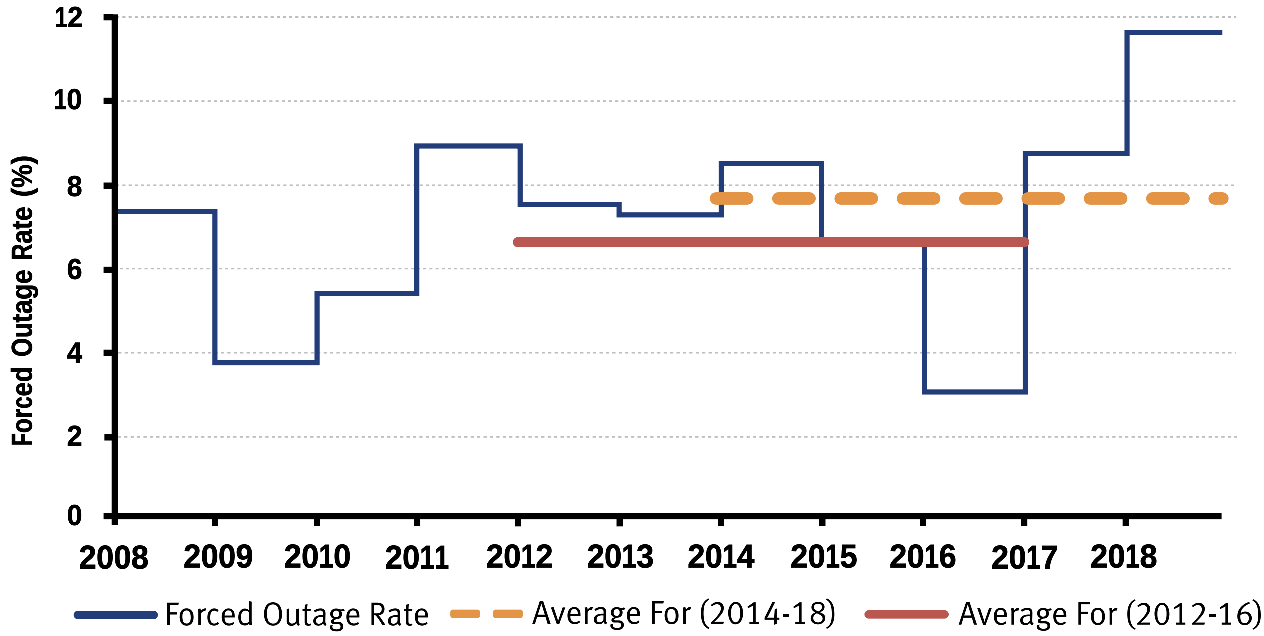

Figure 25 - Average annual system-wide Forced Outage Rates in Ireland for each of the past 10 years (solid lines in navy blue), and also across 2014-2018 (Dashed Orange) and 2012-2016 (Solid Red)

For comparison, see the system-wide average FOR in Northern Ireland in Figure 26.

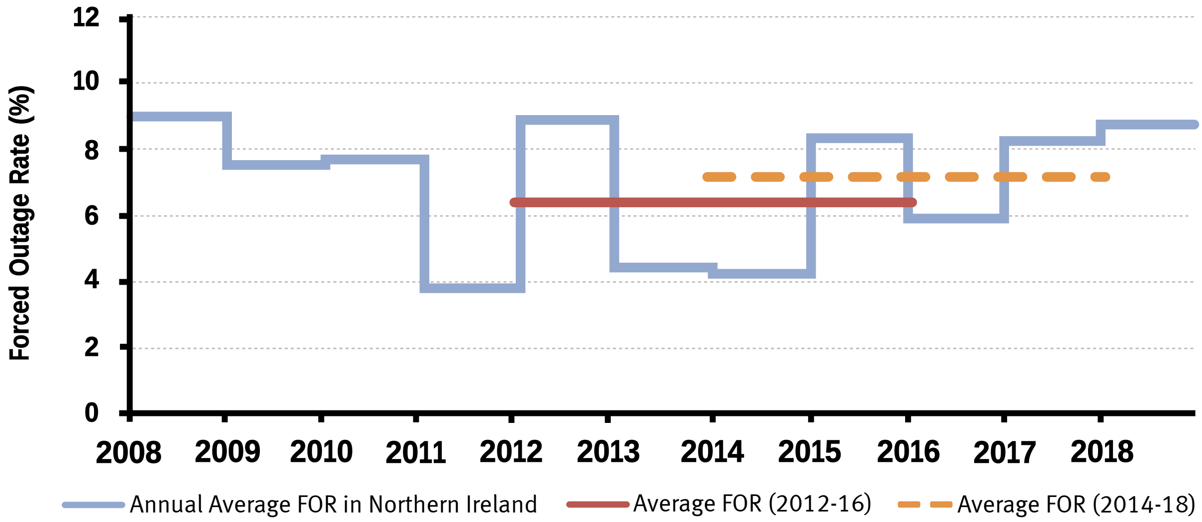

Figure 26 - Average annual system-wide FOR in Northern Ireland for each of the past 10 years (solid lines in light blue). Also shown (in dashed lines) are the 5-year average values of FOR for each technology type, as assumed in the T-1 Capacity Market auction for 2019/20

In Ireland and Northern Ireland there has been a deterioration of unit availability over the past year. In particular, the deterioration of the conventional plant unit availability in both Ireland and Northern Ireland was observed across 2018 as highlighted in Figure 27. This highlights the possibility of a low availability year occurring and we have analysed this in one of our adequacy scenarios.

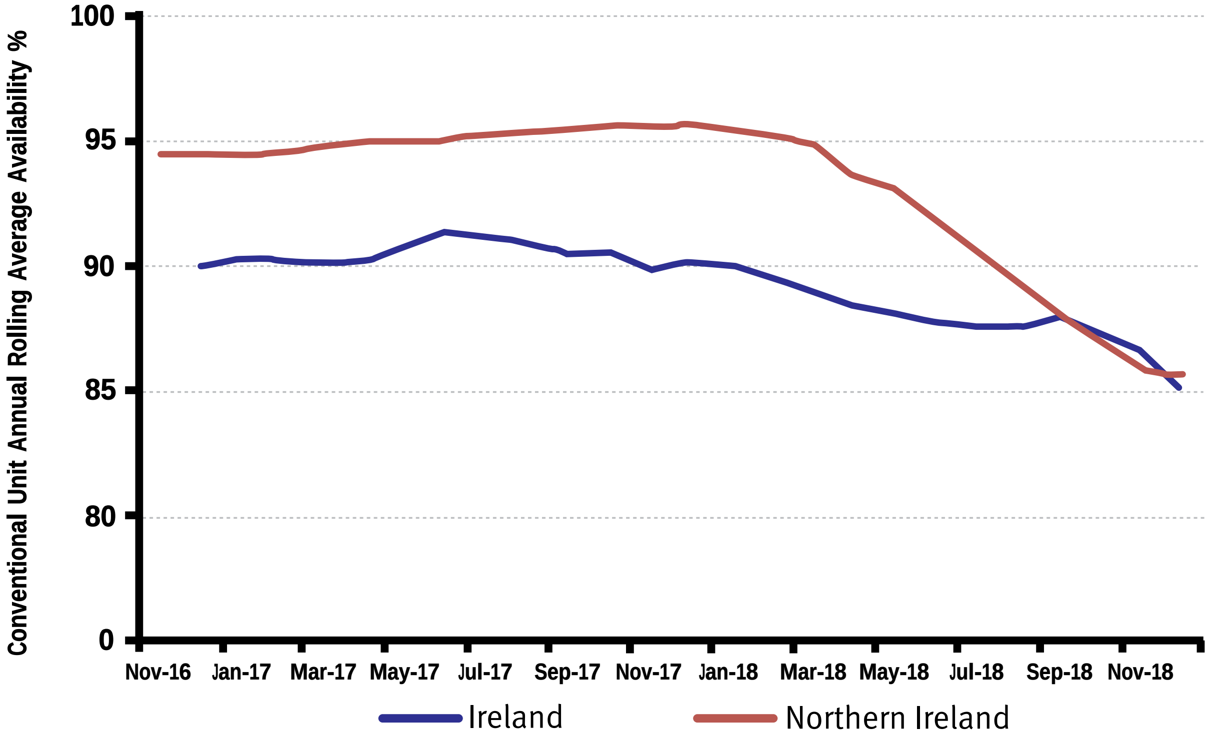

Figure 27 Ireland and Northern Ireland Conventional Unit Availability

For the purpose of adequacy studies in the GCS, EirGrid and SONI uses the plant availability averages from the SEM Capacity Market Requirement. These use the 5-year averages per technology class. There are five different technology classes in the Capacity Market, and a system-wide class, see Table 13.

Technology Category	Weighted Forced Outage Probability (%)	Weighted Scheduled Outage Rate (weeks)
DSU	5.8%	4
Gas Turbine	3.4%	3
Hydro	5.0%	9
Steam Turbine	9.2%	3
Storage	10.6%	3
System Wide	5.8%	4

Table 13 - Availability parameters that were used in the T-1 2019/2020 Capacity Market auction in December 2018

Adequacy Assessments

4

4. Adequacy Assessments

4.1. Introduction

We study generation adequacy in order to assess the balance of supply and demand in the future. The assumptions made in the last two chapters for supply and demand are now brought together in our adequacy assessments. Detail on the methodology we employ is given in APPENDIX 3.

Studies are carried out in three different ways:

- for Northern Ireland alone,
- for Ireland alone,
- and for both jurisdictions combined, i.e. on an all-island basis.

In this section, we describe the setup of each scenario and present the results of the adequacy studies in graphical format. Tables of the results are to be found in APPENDIX 4.

4.2. Assumptions

In our adequacy studies, we assume the following:

- The assessments were carried out for low, median and high demand scenarios. We also include a scenario at the 8th level demand forecast[41] for Ireland (this matches the level of demand chosen by the Least Worst Regrets methodology for the calculation of the Capacity Requirement in the 2019/20 T-1 Capacity Market auction).
- The portfolio excludes generation capacity that has notified us that they will be not available.
- The availability statistics match those used in the Capacity Market auction, i.e. 5-year average values for each technology category.
- The derating factor for the undersea interconnectors EWIC was approximately 50%, as determined by the Regulatory Authorities.
- Typical profiles of demand and wind were used in the studies.
- The adequacy standard is set at 8 hours Loss of Load Expectation (LOLE) per year for Ireland and in the all-island case.
- For Northern Ireland, the standard is 4.9 hours Loss of Load Expectation (LOLE) and assumes a 200 MW capacity reliance on Ireland.
- Ireland assumes a 100 MW capacity reliance on Northern Ireland.

The adequacy results are given in MW as a surplus (+) or deficit (-) of perfect plant (plant that is 100% available).

41 Demand Level 8 was selected in the 2018/19 T-1 Capacity Market auction. It is recalculated for each Capacity Market auction, which could result in different demand levels being selected in future.

4.3. Adequacy Results for Ireland

The Ireland system starts in a position of significant surplus, as shown in Figure 19. This is eroded as the demand forecast increases with each passing year and some generation plant is assumed to shut. If the 8th demand level is assumed, significant deficits are expected from 2026. If capacity is unsuccessful in the December 2018 T-1 auction close sooner than currently expected, then deficits may occur earlier also.

To meet Dublin specific security of supply issues, the SEM T-4 2022/2023 auction included a Dublin regional location requirement. This is to meet the expected demand growth specific to the Dublin region. Without this location requirement, EirGrid would see operational constraints and issues on the network due to generation being further away from the concentrated demand.

Eirgrid also look at the effects of the generators having low availability, i.e. five years' of availability data was assessed and the worst availability year identified - the availability of each unit in this year is used for the low availability scenario. 2018 proved to be the year with the lowest availability statistics. This applies to all generation units, except for the DSUs –due to an insufficient level of historical data available to analyse for DSUs. The adequacy situation deteriorates when using these low availability statistics.

The final scenario that we looked at is one in which if the ESB peat units are not able to comply with the Clean Energy Package requirement of 550gCO2/kWh by 2025. For this, Eirgrid started with the Median demand scenario and then removed two peat plants. This is a study scenario only and Eirgrid have not received a notice of closure from ESB. As ESB is testing biomass co-firing at its peat stations, Eirgrid will continue to monitor the percentage of renewable generation occurring at these plants.

You can see below how the adequacy situation dis-improves in this scenario in Figure 28. This shows how there is need for new low-carbon plant to be commissioned should the high-carbon plant shut.

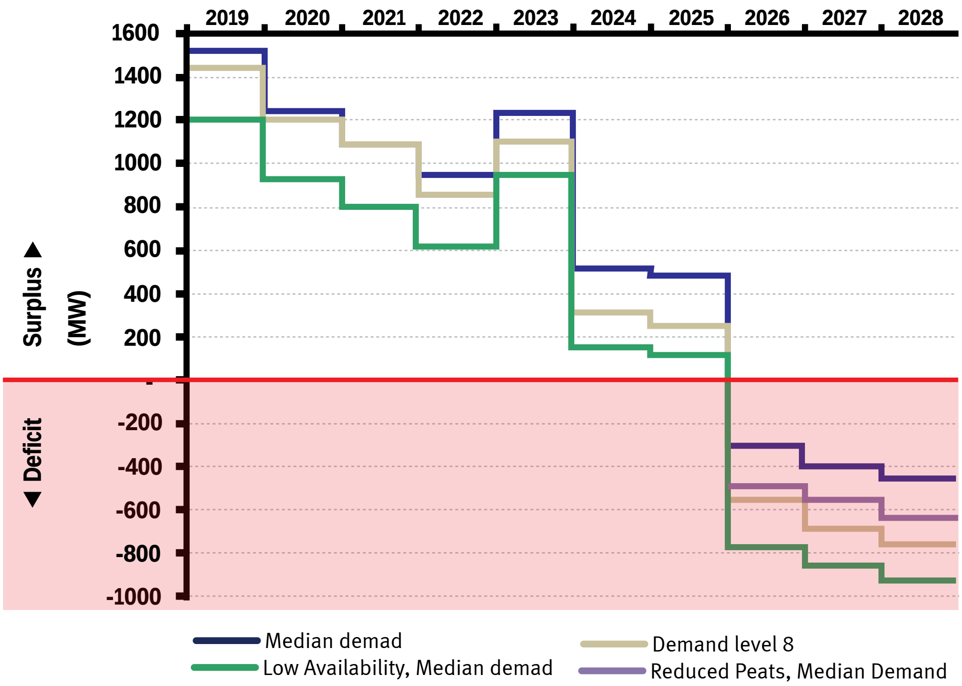

Figure 28 - Adequacy results for Ireland, in terms of surplus or deficit of plant. Results are given for the Median and 8th level demand scenarios. Also shown are the scenarios of Low Availability and Reduced Peats

4.4. Adequacy Results for Northern Ireland

Figure 29 shows a graphical representation of the adequacy studies' results for Northern Ireland over the ten years of the study.

There are separate traces for the low, median and high demand scenarios. The median demand scenario is shown to be in surplus of around 300 MW for most years. This reflects the fact that there is not much change expected in the median demand forecast, or in the plant portfolio. Northern Ireland goes into deficit in the Median and High scenarios in 2025, caused by the assumed unavailability of the Kilroot coal units.

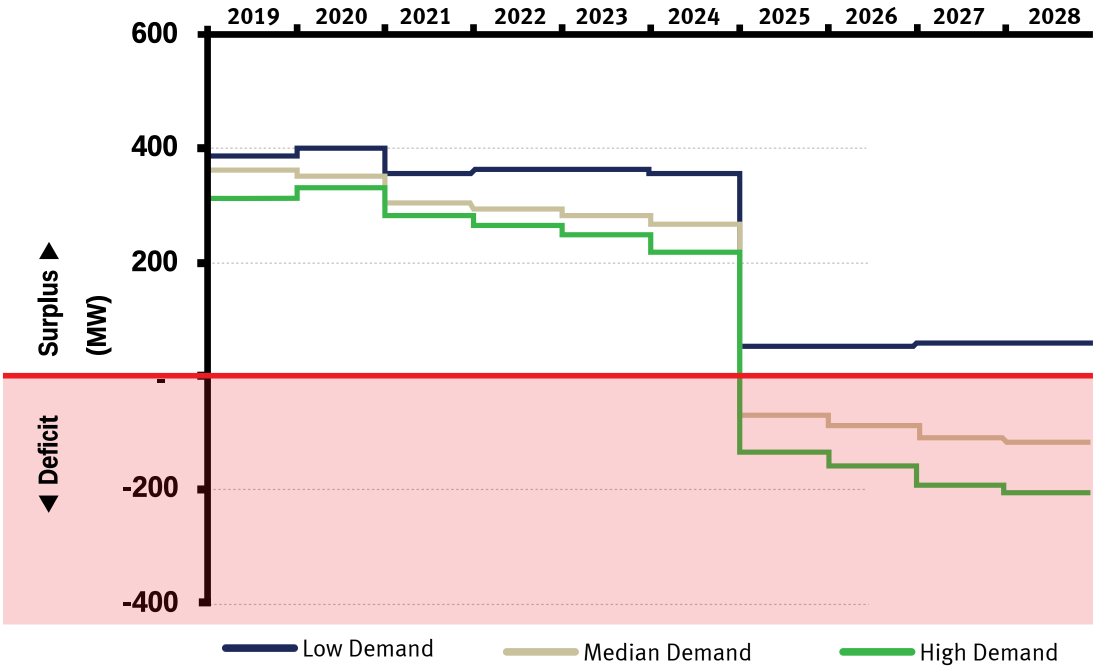

Figure 29 - Adequacy results for Northern Ireland, in terms of surplus or deficit of plant. Results are given for the low, median and high demand scenarios

4.5. Adequacy Results for the All-Island System

There are also studies carried out on an all-island basis, which assume that the second North-South Interconnector is available. The second North-South Interconnector is assumed to be commissioned in 2023.

In the all-island case, the surplus for any particular year is greater than the sum of the two separate jurisdictional studies. This capacity benefit demonstrates some of the advantages of the second North South Interconnector.

Figure 30 shows the all-island adequacy results for different scenarios, all of which are initially in surplus. This surplus drops over time, due to demand increasing and the assumed plant closures. If capacity unsuccessful in the future SEM capacity auctions, or any other plant becomes unavailable then further deficits could occur.

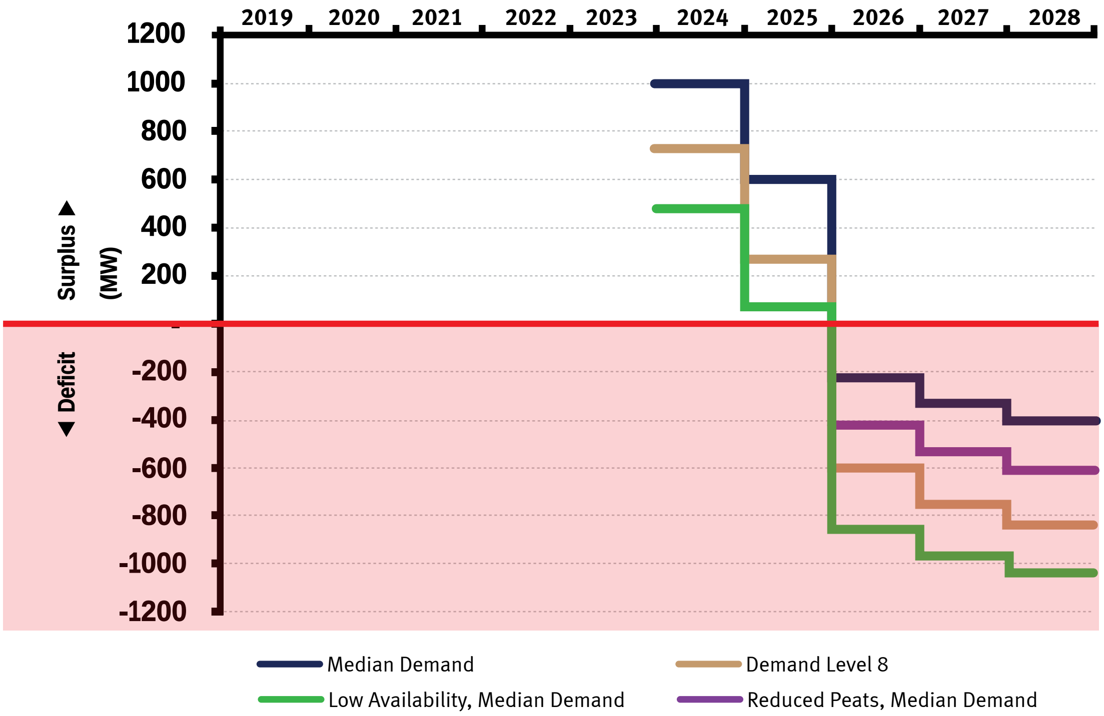

Figure 30 - Adequacy results for the All-Island system

Appendices

Appendix 1 Demand Scenarios

Median	Calendar year TER (TWh)						TER Peak (GW)			Transmission Peak (GW)		
Year	Ireland		Northern Ireland		All-island		Ireland	Northern Ireland	All-island	Ireland	Northern Ireland	All-island
2018	29.8		8.97	8.97	38.8		5.06	1.74*	6.70	4.94	1.71*	6.58
2019	30.9	3.7%	9.02	0.5%	39.9	2.9%	5.48	1.74	7.09	5.35	1.71	6.96
2020	32.3	4.7%	9.10	0.9%	41.5	3.9%	5.68	1.75	7.30	5.54	1.72	7.16
2021	33.3	3.1%	9.09	-0.2%	42.4	2.4%	5.84	1.76	7.48	5.71	1.73	7.34
2022	34.7	4.0%	9.13	0.4%	43.8	3.2%	6.00	1.77	7.65	5.86	1.73	7.51
2023	36.2	4.3%	9.26	1.4%	45.4	3.7%	6.18	1.79	7.84	6.05	1.75	7.71
2024	37.4	3.5%	9.45	2.0%	46.9	3.2%	6.31	1.81	8.02	6.17	1.77	7.88
2025	38.0	1.5%	9.53	0.9%	47.5	1.4%	6.39	1.83	8.15	6.26	1.79	8.01
2026	38.9	2.3%	9.67	1.5%	48.5	2.1%	6.51	1.85	8.26	6.37	1.81	8.13
2027	39.6	1.8%	9.82	1.6%	49.4	1.8%	6.60	1.87	8.39	6.47	1.83	8.26
2028	40.2	1.7%	9.92	1.0%	50.2	1.6%	6.67	1.88	8.49	6.54	1.84	8.35

Table A-1 - The Median Demand Forecast, given in Calendar year format (including a correction to 366 days in each Leap year), for Total Electricity Requirement (TER). TER is the total electricity required by the region, i.e. it includes all electricity produced by large-scale, dispatchable generators, all small-scale exporting generators, and an estimate of electricity produced by self-consuming generators. *Figure is provisional

Low	Calendar year TER (TWh)						TER Peak (GW)			Transmission Peak (GW)		
Year	Ireland		Northern Ireland		All-island		Ireland	Northern Ireland	All-island	Ireland	Northern Ireland	All-island
2018	29.8		8.97		38.8		5.06	1.74*	6.70	4.94	1.71*	6.58
2019	30.9	3.7%	8.74	-2.6%	39.6	2.1%	5.21	1.71	6.80	5.08	1.67	6.68
2020	32.0	3.7%	8.76	0.3%	40.8	3.0%	5.32	1.70	6.93	5.18	1.67	6.79
2021	32.8	2.3%	8.71	-0.6%	41.5	1.7%	5.40	1.70	7.03	5.26	1.67	6.89
2022	33.7	2.9%	8.70	-0.1%	42.4	2.3%	5.51	1.70	7.12	5.38	1.67	6.98
2023	34.6	2.5%	8.69	-0.1%	43.3	2.0%	5.57	1.70	7.22	5.44	1.66	7.08
2024	35.4	2.5%	8.72	0.4%	44.2	2.0%	5.62	1.70	7.27	5.49	1.66	7.14
2025	36.0	1.5%	8.68	-0.5%	44.6	1.1%	5.68	1.69	7.32	5.54	1.66	7.18
2026	36.8	2.3%	8.67	-0.1%	45.5	1.9%	5.74	1.69	7.37	5.60	1.66	7.24
2027	37.5	1.8%	8.66	-0.1%	46.2	1.5%	5.80	1.69	7.43	5.67	1.65	7.30
2028	38.1	1.7%	8.70	0.5%	46.8	1.5%	5.85	1.69	7.49	5.71	1.65	7.36

Table A-2 - Low Demand Forecast

High	Calendar year TER (TWh)						TER Peak (GW)			Transmission Peak (GW)		
Year	Ireland		Northern Ireland		All-island		Ireland	Northern Ireland	All-island	Ireland	Northern Ireland	All-island
2018	29.8		8.97		38.8		5.06	1.74*	6.70	4.94	1.71*	6.58
2019	31.0	3.9%	9.14	1.9%	40.1	3.1%	5.65	1.81	7.32	5.52	1.78	7.20
2020	32.5	5.1%	9.27	1.4%	41.8	4.2%	5.85	1.82	7.53	5.71	1.79	7.40
2021	34.1	4.9%	9.27	0.1%	43.4	3.9%	6.01	1.83	7.71	5.88	1.8	7.58
2022	36.6	7.2%	9.51	2.6%	46.1	6.2%	6.21	1.86	7.94	6.08	1.82	7.80
2023	39.1	6.8%	9.76	2.6%	48.8	6.0%	6.52	1.87	8.25	6.38	1.84	8.12
2024	41.2	5.4%	10.07	3.2%	51.3	5.0%	6.74	1.90	8.50	6.60	1.87	8.37
2025	42.4	2.9%	10.23	1.6%	52.6	2.6%	6.90	1.94	8.71	6.76	1.90	8.58
2026	43.7	3.1%	10.47	2.3%	54.2	3.0%	7.06	1.96	8.89	6.93	1.93	8.76
2027	44.8	2.4%	10.71	2.3%	55.5	2.4%	7.20	2.00	9.09	7.06	1.96	8.95
2028	45.5	1.7%	10.86	1.4%	56.4	1.7%	7.27	2.01	9.21	7.14	1.97	9.08

Table A-3 - High Demand Forecast

Appendix 2 Generation Plant Information

	ID	Fuel Type	Technology Category	2019	Comment
Aghada	AT1	Gas/DO	Gas Turbine	90	To be shut before end of 2023
	AT2	Gas/DO	Gas Turbine	90	
	AT4	Gas/DO	Gas Turbine	90	
	AD2	Gas/DO	Gas Turbine	431	
All DSU	DSU	DSU	DSU	540	
Ardnacrusha	AA1-4	Hydro	Hydro	86	
Dublin Bay	DB1	Gas/DO	Gas Turbine	405	
Dublin Waste	DW1	Waste	Steam Turbine	61	
Edenderry	ED1	Milled peat/ biomass	Steam Turbine	118	Planning Permission extended
	ED3	DO	Gas Turbine	58	
	ED5	DO	Gas Turbine	58	
Erne	ER1	Hydro	Hydro	65	
EWIC	EW1	DC Interconnector		500	
Great Island CCGT	GI4	Gas/DO	Gas Turbine	431	
Huntstown	HNC	Gas/DO	Gas Turbine	342	
	HN2	Gas/DO	Gas Turbine	408	
Indaver Waste	IW1	Waste	Steam Turbine	17	
Lee	LE1-4	Hydro	Hydro	27	
Liffey	LI1-4	Hydro	Hydro	38	
Lough Ree	LR4	Peat	Steam Turbine	91	PSO levy runs out in 2019
Moneypoint	MP1	Coal/HFO	Steam Turbine	285	To close by 1st July 2025 due to CEP
	MP2	Coal/HFO	Steam Turbine	285	To close by 1st July 2025 due to CEP
	MP3	Coal/HFO	Steam Turbine	285	To close by 1st July 2025 due to CEP
North Wall CT	NW5	Gas/DO	Gas Turbine	104	3 Year outage. To return in 2023 at a similar size
Poolbeg CC	PBA	Gas/DO	Gas Turbine	230	
	PBB		Gas Turbine	230	
Rhode	RP1	DO	Gas Turbine	52	
	RP2	DO	Gas Turbine	52	

	ID	Fuel Type	Technology Category	2018	Comment
Sealrock	SK3	Gas/DO	Gas Turbine	81	
	SK4	Gas/DO	Gas Turbine	81	
Tarbert	TB1	HFO	Steam Turbine	54	To be shut by end of 2023
	TB2	HFO	Steam Turbine	54	To be shut by end of 2023
	TB3	HFO	Steam Turbine	241	To be shut by end of 2023
	TB4	HFO	Steam Turbine	241	To be shut by end of 2023
Tawnaghmore	TP1	DO	Gas Turbine	52	
	TP3	DO	Gas Turbine	52	
Turlough Hill	TH1	Pumped storage	Storage	292	
Tynagh	TYC	Gas/DO	Gas Turbine	400	
West Offaly	WO4	Peat	Steam Turbine	137	PSO levy runs out in 2019
Whitegate	WG1	Gas/DO	Gas Turbine	444	
Total Dispatchable including DSU				**7598**	

Table A-4 - Registered Capacity of dispatchable generation and interconnectors in Ireland in 2019 (MW)
DSU: Demand Side Unit; HFO: Heavy Fuel Oil; DO: Distillate Oil

***Some CHP, Biomass and LFG units have registered as Demand Side units in the Capacity Market, and are therefore included in the previous**

at year end:	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Wind	4015	4250	4131	4366	4247	4482	5305	5489	5673	5857
Hydro	22	22	22	22	22	22	22	22	22	22
Biomass and LFG*	24	24	24	24	24	24	24	24	24	24
Biomass CHP	30	60	60	60	60	60	60	60	60	60
Industrial	9	9	9	9	9	9	9	9	10	11
Conventional CHP*	129	129	129	129	129	129	129	129	129	129
Solar PV	20	50	101	152	203	254	305	324	343	362
Total	**4249**	**4544**	**4476**	**4762**	**4694**	**4980**	**5854**	**6057**	**6261**	**6465**

Table A-5 - Partially/Non-Dispatchable plant in Ireland (MW)

at year end:	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
All Wind*	4015	4250	4131	4366	4247	4482	5305	5489	5673	5857
All Hydro	238	238	238	238	238	238	238	238	238	238
Biomass/LFG (including those units registered in the Capacity Market and Biomass CHP)	54	84	84	84	84	84	84	84	84	84
Waste (Assume 50% renewable)	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5
Peat Stations on Biomass	35	121	121	121	121	121	121	121	121	121
Solar PV	20	50	101	152	203	254	305	324	343	362
Total RES	**4401**	**4782**	**4714**	**5000**	**4932**	**5218**	**6092**	**6295**	**6498**	**6701**

Table A-6 - All Renewable energy sources in Ireland (MW). We have assumed that the peat plant at Edenderry, Lough Ree and West Offaly will be approximately 30-35% powered by biomass by 2020

***The wind forecasts past 2020 are not based on exact projects. When more detailed information of exact wind developments occur, this will be included in the forecast.**

	ID	Fuel Type	Technology Category	2019	Comment
Ballylumford	B31	Gas*/Heavy Fuel Oil	Gas Turbine	246	
	B32	Gas*/Heavy Fuel Oil	Gas Turbine	246	
	B10	Gas*/Heavy Fuel Oil	Gas Turbine	101	
	GT7(GT1)	Distillate Oil	Gas Turbine	58	
	GT8(GT2)	Distillate Oil	Gas Turbine	58	
Kilroot	ST1	Heavy Fuel Oil*/ Coal	Steam Turbine	238	Reduces to 199 MW from mid-2020. Assumed unavailable after 2024.
	ST2	Heavy Fuel Oil*/ Coal	Steam Turbine	238	Reduces to 199 MW from mid-2020. Assumed unavailable after 2024.
	KGT1	Distillate Oil	Gas Turbine	29	
	KGT2	Distillate Oil	Gas Turbine	29	
	KGT3	Distillate Oil	Gas Turbine	42	
	KGT4	Distillate Oil	Gas Turbine	42	

	ID	Fuel Type	Technology Category	2019	Comment

Coolkeeragh	GT8	Distillate Oil	Gas Turbine	53	
	C30	Gas*/Distillate Oil	Gas Turbine	408	
AGU	AGU	Distillate Oil	Gas Turbine	76	
DSU	DSU	Various	DSU	98	
Lisahally		Biomass		18	Not in Capacity Market, but assumed available for capacity requirement
Contour Global	CGA	Gas	Gas Turbine	12	
Moyle		DC Interconnector		450	
			Total Dispatchable plant	**2442**	

Table A-7 - Registered Capacity of dispatchable generation and interconnectors in Northern Ireland in 2019 (MW)

at year end:	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Large Scale Wind	1095	1095	1111	1201	1224	1224	1224	1224	1224	1224	1224
Small Scale Wind	173	176	176	176	176	176	176	176	176	176	176
Large Scale Solar	134	134	134	134	179	179	179	179	179	179	179
Small Scale Solar	112	117	117	117	117	117	117	117	117	117	117
Small Scale Biogas	24	24	24	24	24	24	24	24	24	24	24
Landfill Gas	16	16	16	16	16	16	16	16	16	16	16
Small Scale Bio-mass	6	6	6	6	6	6	6	6	6	6	6
Renewable CHP	3	3	3	3	3	3	3	3	3	3	3
Other CHP	6	6	6	6	6	6	6	6	6	6	6
Small Scale Hydro	6	6	6	6	6	6	6	6	6	6	6
Waste-to-energy*	15	15	15	15	15	15	15	15	15	15	15
Total	**1590**	**1598**	**1614**	**1704**	**1772**	**1772**	**1772**	**1772**	**1772**	**1772**	**1772**

Table A-8 - Partially/Non-Dispatchable plant in Northern Ireland (MW). *Bombardier and Full Circle

at year end:	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
All Wind	1268	1271	1287	1377	1400	1400	1400	1400	1400	1400	1400

All Solar PV	246	251	251	251	296	296	296	296	296	296	296
All Biomass/Bio-gas/LFGas/WTE	79	79	79	79	79	79	79	79	79	79	79
Renewable CHP	3	3	3	3	3	3	3	3	3	3	3
Hydro	6	6	6	6	6	6	6	6	6	6	6
Total RES	**1602**	**1610**	**1626**	**1716**	**1784**	**1784**	**1784**	**1784**	**1784**	**1784**	**1784**

Table A-9 - All Renewable energy sources in Northern Ireland (MW)

Appendix 3 Methodology

Generation Adequacy Standard

Generation adequacy is assessed by determining the likelihood of there being sufficient generation to meet customer demand. It does not take into account any limitations imposed by the transmission system, reserve requirements or the energy markets.

In practice, when there is not enough supply to meet load, the load must be reduced. This is achieved by cutting off electricity from customers. In adequacy calculations, if there is predicted to be a supply shortage at any time, there is a Loss of Load Expectation (LOLE) for that period. In reality, load shedding due to generation shortages is a very rare event.

LOLE can be used to set an adequacy standard. In Ireland the adequacy standard is 8 hours LOLE per annum. If this is exceeded in either jurisdiction, it indicates the system has a higher than acceptable level of risk. The adequacy standard used for all-island calculations is 8 hours.

With any generator, there is always a risk that it may suddenly and unexpectedly be unable to generate electricity (due to equipment failure, for example). Such events are called forced outages, and the proportion of time a generator is out of action due to such an event gives its forced outage rate (FOR).

Forced outages mean that the available generation in a system at any future period is never certain. At any particular time, several units may fail simultaneously, or there may be no such failures at all. There is therefore a probabilistic aspect to supply, and to the LOLE. The model used for these studies works out the probability of load loss for each half-hour period – it is these that are then summed to get the yearly LOLE, which is then compared to the adequacy standard.

It is assumed that forced outages of generators are independent events, and that one generator failing does not influence the failure of another.

Loss of Load Expectation

AdCal software is used to calculate LOLE. The probability of supply not meeting demand is calculated for each hour of each study year. The annual LOLE is the sum of the contributions from each hour.

Consider now the simplest case of a single-system study, with a deterministic load model (that is, with only one value used for each load), and no scheduled maintenance, so that there is one generation availability distribution for the entire year.

If

Lh,d =load at hour h on day d

G =generation plant available

H =number loads/day to be examined (i.e. 1, 24 or 48)

D =total number of days in year to be examined

then the annual LOLE is given by

$$LOLE = \sum_{d=1,D} \sum_{h=1,H} Prob. (G < L_{h,d})$$

This equation is used in the following practical example.

Simplified Example of LOLE Calculation

Consider a system consisting of just three generation units, as in Table A-10.

	Capacity (MW)	Forced outage probability	Probability of being available
Unit A	10	0.05	0.95
Unit B	20	0.08	0.92
Unit C	50	0.10	0.90
Total	**80**		

Table A-10 - System for LOLE example

If the load to be served in a particular hour is 55 MW, what is the probability of this load being met in this hour? To calculate this, the following steps are followed, see Table A-11:

1) How many different states can the system be in, i.e. if all units are available, if one is forced out, if two are forced out, or all three?

2) How many megawatts are in service for each of these states?

3) What is the probability of each of these states occurring?

4) Add up the probabilities for the states where the load cannot be met.

5)≠ Calculate expectation.

Only states 1, 2 and 3 are providing enough generation to meet the demand of 55 MW. The probabilities for the other five failing states are added up to give a total probability of 0.1036. So in this particular hour, there is a chance of approximately 10% that there will not be enough generation to meet the load.

It can be said that this hour is contributing about 6 minutes (10% of 1 hour) to the total LOLE for the year. This is then summed for each hour of the year.

1)	1)	2)	3)	3)	4)	4)
State	**Units in service**	**Capacity in service (MW)**	**Probability for (A*B*C)**	**Probability**	**Ability to meet 55 MW demand**	**Expectation of Failure (LOLE)**
1	A, B, C	80	0.95*0.92*0.90 =	0.7866	Pass	0
2	B, C	70	0.05*0.92*0.90 =	0.0414	Pass	0
3	A, C	60	0.95*0.08*0.90 =	0.0684	Pass	0
4	C	50	0.05*0.08*0.90 =	0.0036	Fail	0.0036
5	A, B	30	0.95*0.92*0.10 =	0.0874	Fail	0.0874
6	B	20	0.05*0.92*0.10 =	0.0046	Fail	0.0046
7	A	10	0.95*0.08*0.10 =	0.0076	Fail	0.0076
8	none	0	0.05*0.08*0.10 =	0.0004	Fail	0.0004
Total				**1.0000**		**0.1036**

Table A-11 - Probability table

Interpretation of Results

While the use of LOLE allows a sophisticated, repeatable and technically accurate assessment of generation adequacy to be undertaken, understanding and interpreting the results may not be completely intuitive. If, for example, in a sample year, the analysis shows that there is a loss of load expectation of 16 hours, this does not mean that all customers will be without supply for 16 hours or that, if there is a supply shortage, it will last for 16 consecutive hours.

It does mean that if the sample year could be replayed many times and each unique outcome averaged, that demand could be expected to exceed supply for an annual average duration of 16 hours. If such circumstances arose, typically only a small number of customers would be affected for a short period. Normal practice would be to maintain supply to industry, and to use a rolling process to ensure that any burden is spread.

In addition, results expressed in LOLE terms do not give an intuitive feel for the scale of the plant shortage or surplus. This effect is accentuated by the fact that the relationship between LOLE and plant shortage/surplus is highly non-linear. In other words, it does not take twice as much plant to return a system to the 8 hour standard from 24 hours LOLE as it would from 16 hours.

The adequacy calculation assumes that forced outages are independent, and that if one generator trips it does not affect the likelihood of another generator tripping. In some situations, it is possible that a generator tripping can cause a system voltage disturbance that in turn could cause another generator to trip. Any such occurrences are a matter for system security, and therefore are outside the scope of these system adequacy studies.

As for common-mode failures, it is possible that more than one generating unit is affected at the same time by, for example, a computer virus or by extreme weather, etc. However, it could be considered the responsibility of each generator to put in place measures to mitigate against such known risks for their own units.

Surplus & Deficit

In order to assist understanding and interpretation of results, a further calculation is made which indicates the amount of plant required to return the system to standard. This effectively translates the gap between the LOLE projected for a given year and the standard into an equivalent plant capacity (in MW). If the system is in surplus, this value indicates how much plant can be removed from the system without breaching the LOLE standard. Conversely, if the system is in breach of the LOLE standard, the calculation indicates how much plant should be added to the system to maintain security.

The exact amount of plant that could be added or removed would depend on the particular size and availability of any new plant to be added. The amount of surplus or deficit plant is therefore given in terms of Perfect Plant. Perfect Plant may be thought of as a conventional generator with no outages. In reality, no plant is perfect, and the amount of real plant in surplus or deficit will always be higher.

It should be noted that actual loss of load as a result of a supply shortage does not represent a catastrophic failure of the power system[42]. In all probability such shortages, or loss of load, would not result in widespread interruptions to customers. Rather, it would likely take the form of supply outages to a small number of customers for a period in the order of an hour or two. This would be done in a controlled fashion, to ensure that critical services are not affected.

42 In line with international practice, some risk of such supply shortages are accepted to avoid the unreasonably high cost associated with reducing this risk to a negligible level.

Appendix 4 Adequacy Results

Scenario	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
High Demand	1380	1130	940	740	940	110	10	**-830**	**-960**	**-1040**
Demand level 8	1440	1210	1080	860	1100	320	240	**-570**	**-690**	**-750**
Median Demand	1510	1250	1080	940	1240	520	490	**-300**	**-380**	**-440**
Low Demand	1650	1480	1380	1290	1660	1010	1020	290	240	190
Low availability, Median Demand	1200	930	810	620	970	160	130	**-770**	**-850**	**-920**
Reduced Peats Capacity, Median Demand	1510	1250	1080	940	1240	520	490	**-490**	**-570**	**-640**

Table A-12 - Results of adequacy studies for Ireland, given in MW of surplus plant (+) or deficit (-)

Scenario	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Median Demand	360	350	310	300	280	270	**-70**	**-90**	**-100**	**-110**
Low Demand	390	390	360	360	360	360	50	50	50	50
High Demand	310	310	260	230	220	190	**-160**	**-180**	**-220**	**-230**

Table A-13 - Results of adequacy studies for Northern Ireland, given in MW of surplus plant (+) or deficit (-)

Scenario	2024	2025	2026	2027	2028
High Demand	510	30	**-870**	**-1040**	**-1130**
Demand level 8	730	270	**-600**	**-750**	**-830**
Median Demand	990	610	**-230**	**-330**	**-410**
Low Demand	1630	1310	560	500	460
Low Availability, Median Demand	470	70	**-860**	**-970**	**-1040**
Reduced Peats Capacity, Median Demand	990	610	**-430**	**-540**	**-610**

Table A-14 - Results of adequacy studies for the All-Island system

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