



# All-Island Ten-Year Transmission Forecast Statement

2021



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This document incorporates the Transmission System Capacity Statement for Northern Ireland and the Transmission Forecast Statement for Ireland.

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# All-Island Ten-Year Transmission Forecast Statement 2021

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# Abbreviations and Terms

## Abbreviations

Abbreviation	Explanation
AC	Alternating Current
ACS	Average Cold Spell
ATR	Associated Transmission Reinforcement
BETTA	The British Electricity Trading and Transmission Arrangements
BSP	Bulk Supply Point
CCGT	Combined Cycle Gas Turbine
CHP	Combined Heat and Power
CRU	Commission for the Regulation of Utilities
DC	Direct Current / Double Circuit
DCCAIE	Department of Communications, Climate Action and Environment
DfE	Department for the Economy
DO	Distillate Oil
DSM	Demand Side Management
DSO	Distribution System Operator
EIDAC	EirGrid Interconnector DAC
ESB	Electricity Supply Board
ESRI	Economic and Social Research Institute
EU	European Union
FAQ	Firm Access Quantity
GCS	Generation Capacity Statement
GIS	Gas Insulated Switchgear
HFO	Heavy Fuel Oil
HVDC	High Voltage Direct Current
IA	Interconnector Administrator
IME	Internal Market for Electricity
IMP	Independent Market Participant
IPP	Independent Power Producer
IRL	Ireland
ITC	Incremental Transfer Capability
kV	Kilo Volts
LFG	Land Fill Gas
MIL	Moyle Interconnector Limited
MCR	Maximum Continuous Rating
MEC	Maximum Export Capacity
MIC	Maximum Import Capacity
MVA	Megavolt-Amperes
MW	Megawatt
NI	Northern Ireland
NIEN	Northern Ireland Electricity Networks

<b>Abbreviation</b>	<b>Explanation</b>
NTC	Net Transfer Capacity
PPB	Power Procurement Business
PU	Per Unit
PST	Phase Shifting Transformer
RES	Renewable Energy Schemes
RIDP	Renewable Integration Development Project
RMS	Root Mean Square
RP	Review Period
SEM	Single Electricity Market
SONI	System Operator for Northern Ireland
SPS	Special Protection Scheme
SVC	Static Var Compensator
SP	Summer Peak
SS	Substation
SV	Summer Valley
TDP	Transmission Development Plan
TDPNI	Transmission Development Plan Northern Ireland
TYTFS	Ten Year Transmission Forecast Statement
TRM	Transfer Reserve Margin
TSO	Transmission System Operator
TTC	Total Transfer Capacity
TX	Transformer
WFPS	Wind Farm Power Station
WP	Winter Peak

## Terms

Abbreviation	Explanation
Active Power	The product of voltage and the in-phase component of alternating current measured in Megawatts (MW). When compounded with the flow of 'reactive power', measured in Megavolt-Amperes Reactive (Mvar), the resultant is measured in Megavolt-Amperes (MVA).
Autumn Peak	This is the maximum Northern Ireland demand in the period September to October inclusive.
Associated Transmission Reinforcement	Associated Transmission Reinforcements (ATRs) are all of the transmission reinforcements that must be completed in order for a generator to be allocated FAQ. ATRs include reinforcements such as line and busbar upratings, new stations and new lines.
Bulk Supply Point	A point at which the Northern Ireland transmission system is connected to the distribution system.
Busbar	The common connection point of two or more circuits.
Capacitor	An item of plant normally utilised on the electrical network to supply reactive power to loads (generally locally) and thereby supporting the local area voltage.
Circuit	An element of the transmission system that carries electrical power.
Combined Cycle Gas Turbine	A collection of gas turbines and steam units; waste heat from the gas turbine(s) is passed through a heat recovery boiler to generate steam for the steam turbine(s).
Combined Heat and Power	A plant designed to produce both heat and electrical power from a single heat source.
Constraint	A transfer limit imposed by finite network capacity.
Contingency	The unexpected failure or outage of a system component, such as a generation unit, transmission line, transformer or other electrical element. A contingency may also include multiple components, which are related by situations leading to simultaneous component outages.
Commission for Regulation of Utilities	The Commission for Regulation of Utilities (CRU) is the regulator for the electricity, natural gas and public water sectors in Ireland.
Data Freeze Date	The dates on which the Transmission Forecast Statement data was effectively "frozen" for both EirGrid and SONI. Changes to transmission system characteristics made after these dates do not feature in the analyses carried out for this Transmission Forecast Statement.
Deep Reinforcement	Refers to transmission system reinforcement additional to the shallow connection that is required to allow a new generator or demand to operate at maximum capacity.
Demand	The peak demand figures in Table 3-1 in the introduction refer to the power that must be transported from transmission system-connected generation stations to meet all customers' electricity requirements. These figures include transmission losses.
Demand-Side Management	The modification of normal demand patterns usually through the use of financial incentives.

EirGrid	EirGrid plc is the state-owned company established to take on the role and responsibilities of Transmission System Operator in Ireland as well as market operator of the wholesale trading system.
EirGrid Interconnector DAC	EIDAC is an organisation that is part of the EirGrid Group. EIDAC owns the East West Interconnector linking the electricity grids in Ireland and Wales. EIDAC sell capacity and services on the East West Interconnector through auctions.
Embedded Generation	Refers to generation that is connected to the distribution system or at a customer's site.
Firm Access Quantity	The level of firm financial access available in the transmission network for a generator is that generator's Firm Access Quantity or 'FAQ'. Firm financial access means that if a generator is constrained on or off, it is eligible for compensation in the manner set out in the Trading & Settlement Code.
Gate 2	The term given to the group-processing scheme that applies to approximately 1,300 MW of renewable generation seeking connection to the transmission and distribution systems.
Gate 3	The term given to the group-processing scheme that applies to approximately 10,000 MW of generation seeking connection to the transmission and distribution systems.
Generation Dispatch	The configuration of outputs from the connected generation units.
Grid Code (EirGrid)	The EirGrid Grid Code is designed to cover all material technical aspects to the operation and use of the transmission system of Ireland. The code was prepared by the TSO (pursuant to Section 33 of the Electricity Regulation Act, 1999) and approved by the CER. The Grid Code is available on <a href="http://www.eirgrid.com">www.eirgrid.com</a> .
Grid Code (SONI)	The SONI Grid Code is designed to permit the development, maintenance and operation of an efficient, co-ordinated and economical transmission system in Northern Ireland. It is prepared by the TSO (SONI) pursuant to condition 16 of SONI's Licence. The SONI Grid Code is available at <a href="http://www.soni.ltd.uk">www.soni.ltd.uk</a>
Interconnector Administrator	An Interconnector Administrator (IA) facilitates the allocation of capacity and energy trading. Trading is carried out using an Interconnector Management Platform (ICMP) for the Moyle and East West Interconnectors.
Incremental Transfer Capability	A measure of the transfer capability remaining in the physical transmission system for further commercial activity over and above anticipated uses.
Interconnector	The tie line, facilities and equipment that connect the transmission system of one independently supplied transmission system to that of another.
Loadflow	Study carried out to simulate the flow of power on the transmission system given a generation dispatch and system load.



Maximum Continuous Rating	<p>The maximum capacity (MVA) modified for ambient temperature conditions that the circuit can sustain indefinitely without degradation of equipment life.</p> <p>The MCR of a generator is the maximum capacity (MW) modified for ambient temperature conditions that the generation unit can sustain indefinitely without degradation of equipment life. All generation capacity figures in this Transmission Forecast Statement are maximum continuous ratings (defined as its MCR at 10°C), expressed in exported terms i.e., generation unit output less the unit's own load.</p>
Maximum Export Capacity	The maximum export value (MW) provided in accordance with the generator's connection agreement. The MECs are contract values which the generator chooses to cater for peaking under certain conditions that are not normally achievable or sustainable e.g., a CCGT plant can produce greater output at lower temperatures.
Net Zero Emissions	Net zero emissions are achieved when anthropogenic emissions of greenhouse gases to the atmosphere are balanced by anthropogenic removals over a specified period.
Node	Connecting point at which several circuits meet. Node and station are used interchangeably in this Transmission Forecast Statement.
Parametric Analysis (P-V) curves	A parametric study involves a series of power flows that monitor the changes in one set of power flow variables with respect to another in a systematic fashion. In this Transmission Forecast Statement the two variables are voltage and ITC.
Per Unit (pu.)	Ratio of the actual electrical quantity to the selected base quantity. The base quantity used here for calculation of per unit impedances is 100 MVA.
Phase Shifting Transformer	An item of plant employed on the electrical network to control the flow of active power.
Power Factor	The power factor of a load is a ratio of the active power requirement to the reactive power requirement of the load.
Reactive Compensation Reactor	<p>The process of supplying reactive power to the network.</p> <p>An item of plant employed on the electrical network to either limit short circuit levels or prevent voltage rise depending on its installation and configuration.</p>
Shallow Connection	Shallow Connection means the local connection assets required to connect a customer to the Transmission System and which are for the specific benefit of that particular customer.
Single Electricity Market	The Single Electricity Market (SEM) is the wholesale electricity market operating in Ireland and Northern Ireland. Further information is available at <a href="http://www.sem-o.com/">http://www.sem-o.com/</a> and <a href="https://www.semcommittee.com/">https://www.semcommittee.com/</a>
SONI	System Operator for Northern Ireland (SONI) Ltd is owned by EirGrid plc. SONI ensures the safe, secure and economic operation of the high-voltage electricity system in Northern Ireland and in cooperation with EirGrid is also responsible for running the all-island wholesale market for electricity.
Split Busbar	Refers to the busbar(s) at a given substation which is operated electrically separated. Busbars are normally split to limit short circuit levels or to maintain security of supply.

Static Var Compensator	Device which provides fast and continuous capacitive and inductive reactive power supply to the power system.
Summer Valley	This is the minimum system demand. It occurs in the period March to September, inclusive in Ireland and May to August, inclusive in Northern Ireland
Summer Peak	This is the maximum system demand in the period March to September, inclusive in Ireland and May to August, inclusive in Northern Ireland.
Tee Connection	Un-switched connection into existing line between two other stations.
Total Transfer Capability	The total capacity available on cross-border circuits between Ireland and Northern Ireland for all flows, including emergency flows that occur after a contingency in either system.
Transformer	An item of equipment connecting busbars at different nominal voltages. (see also Phase Shifting Transformer)
Transmission Interface Station	A station that is a point of connection between the transmission system and the distribution system or directly-connected customers.
Transmission Losses	A small proportion of energy is lost mainly as heat whilst transporting electricity on the transmission system. These are known as transmission losses. As the amount of energy transmitted increases, losses also increase.
Transmission Peak	The peak demand that is transported on the transmission system. The transmission peak includes an estimate of transmission losses.
Transmission Planning Criteria	The set of standards that the transmission system of Ireland is designed to meet.
Transmission System	The transmission system is a meshed network of high-voltage lines and cables (400 kV, 275 kV, 220 kV and 110 kV) for the transmission of bulk electricity supply around Ireland and Northern Ireland. The transmission system and network are used interchangeably in this Transmission Forecast Statement.
Uprating	To increase the rating of a circuit. This is achieved by increasing ground clearances and/or replacing conductor, together with any changes to terminal equipment and support structures.
Utility Regulator (UR)	UR is an independent non-ministerial government department set up to ensure the effective regulation of the Electricity, Gas and Water and Sewerage industries in Northern Ireland.
Winter Peak	This is the maximum annual system demand. It occurs in the period October to February, inclusive in Ireland and in the Period November to February in Northern Ireland.

# Executive Summary

## Introduction

The All-Island Ten-Year Transmission Forecast Statement (TYTFS) 2021 provides the following information:

- Network models and data for the all-island transmission systems;
- Forecast generation capacity and demand growth;
- Maximum and minimum fault levels at transmission system stations;
- Predicted transmission system power flows at different points in time; and
- Demand and generation opportunities on the transmission system.

TYTFS 2021 is prepared in accordance with the statutory and licence obligations outlined in Table S-1.

**Table S-1: Statutory Regulations requiring the TSOs to produce a Transmission Forecast Statement**

Ireland	Northern Ireland
Section 38 of the Electricity Regulation Act 1999 (as amended)	Condition 33 of the Licence to participate in the Transmission of Electricity

TYTFS 2021 describes the transmission system on the island of Ireland, from 2021 to 2030. EirGrid and SONI have jointly prepared TYTFS 2021. This document supersedes the All-Island Ten-Year Transmission Forecast Statement 2020-2029.

This document presents information available for the all-island transmission system at the data freeze date of January 2021. Where applicable we provide information on transmission system projects under development. Where multiple solutions are presented for a transmission system project, no preference is given to one solution<sup>1</sup>.

## Context

In November 2021 the Irish Government launched its Climate Action Plan 2021<sup>2</sup>. The Action Plan sets out an ambitious course of action over the coming years. The plan sets a target that up to 80% of electricity will come from renewable energy sources by 2030.

For Northern Ireland, the United Kingdom's Committee on Climate Change 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 commitment to targeting a challenging ambition in line with the requirements of the Paris Agreement on climate change.

<sup>1</sup> In line with our strategy to consider all practical technology options for network development.

<sup>2</sup> <https://www.gov.ie/en/publication/6223e-climate-action-plan-2021/>

Energy Policy is a devolved matter for Northern Ireland, and in December 2021, the Northern Ireland Executive published its new Energy Strategy<sup>3</sup>. The new strategy sets out a goal of at least 70% of electricity consumed to come from renewable sources by 2030. The Energy Strategy sets out a pathway for energy to 2030 that will mobilise the skills, technologies and behaviours needed to take us towards our vision of net zero carbon and affordable energy by 2050.

In order to meet Ireland's and Northern Ireland's future commitments, investment will be needed in new renewable generation capacity and electricity networks. The transition to low-carbon and renewable energy will have widespread consequences; it will require a significant transformation of the electricity system.

In 2019 EirGrid and SONI launched new corporate Strategies 2020-2025 which are shaped by two factors: climate change and the impending transformation of the electricity sector. Together, EirGrid and SONI are committed to leading the change towards a carbon-free electricity system and achieving the renewable energy ambitions of both jurisdictions.

To realise these ambitions and to enable transformation of the electricity system, EirGrid and SONI launched Shaping Our Electricity Future Roadmap<sup>4</sup> in November 2021. The Roadmap is informed by a comprehensive consultation process with stakeholders across society, policy makers, industry, market participants and electricity consumers. The valued feedback has contributed to our growing body of knowledge on how to decarbonise the electricity system and to support decarbonisation of the broader economy while maintaining a safe and secure supply of electricity for consumers.

The Roadmap provides an outline of the key developments from a networks, engagement, operations and market perspective needed to support a secure transition to at least 70% renewables on the electricity grid by 2030 – an important step on the journey to 80% and to net zero by 2050. Inherent in this is a secure transition to 2030 whereby we continue to operate, develop and maintain a safe, secure, reliable, economical and efficient electricity transmission system with a view to ensuring that all reasonable demands for electricity are met.

## High Level Results

TYTFS 2021 includes maximum and minimum short circuit current levels at transmission system stations. This information is given at each 110 kilovolt (kV), 220 kV, 275 kV and 400 kV transmission system station. Short circuit levels at each transmission system station are provided for the following years: 2021; 2024; and 2027.

Results show that several stations on the island are approaching, or have the potential to exceed, their rated short circuit current level. This can be seen in the maximum short circuit current level analysis, when there are high generation levels on the system. We manage the transmission system to mitigate possible risks while investment plans are in place to resolve these issues. Information on short circuit current levels is presented in Chapter 5.

Ireland and Northern Ireland are currently connected to Great Britain through the Moyle and East-West Interconnector (EWIC) high voltage direct current (HVDC) interconnectors. Interconnection

<sup>3</sup> <https://www.economy-ni.gov.uk/publications/energy-strategy-path-net-zero-energy>

<sup>4</sup> [http://www.eirgridgroup.com/site-files/library/EirGrid/Shaping\\_Our\\_Electricity\\_Future\\_Roadmap.pdf](http://www.eirgridgroup.com/site-files/library/EirGrid/Shaping_Our_Electricity_Future_Roadmap.pdf)

with neighbouring countries offers many benefits, which include:

- Enhancing the security of supply of the transmission system;
- Facilitating the integration of variable renewable generation; and
- Facilitating greater competition and the potential for wholesale electricity prices to be reduced.

Our analyses assumed the planned North South Interconnector is in place in winter 2025 at the time of data freeze. This reinforcement will increase security of supply, support the development of renewable power generation and provide economic benefits to energy citizens in both jurisdictions.

For the purpose of our analysis we assume the planned Greenlink Interconnector is in place in 2024. The connection application for the proposed Celtic Interconnector between Ireland and France was executed in November 2021, after the data freeze date for this forecast statement. This interconnector will be included in future forecast statements' analyses.

TYTFS 2021 includes information on generation and demand opportunities for interested parties. This information is based on assessments and studies carried out on an all-island basis. The methodologies applied to the all-island opportunity analyses are presented in Chapter 6. Information on opportunities is presented in Chapter 7 and Chapter 8.

The generation portfolio assumed in this statement is based on connected generation and generation that had contracts in place, at the data freeze date, to connect to the transmission or distribution system. The all-island generation opportunities assessment in Chapter 7 provides information for generators wishing to connect to the transmission system.

Generator opportunity is assessed at a number of 110 kV, 220 kV, 275 kV and 400 kV nodes across the all-island transmission system. The results show that there are opportunities for new generation of significant scale in the east of the island, in particular in the east of Northern Ireland and in Greater Dublin<sup>5</sup>. The results also show that future generation connections in the North-West, West and South-West regions would require network reinforcements.

Regional changes in locational tariff signals are also described in Chapter 7. This information is provided to help network users make informed decisions when exploring potential transmission network connection locations. Regions with generation capacity in excess of local demand in the South West, West and North West of Ireland have lower Transmission Loss Adjustment Factors and higher Generator Transmission Use of System charges than Eastern regions with higher demand levels and less surplus generation.

The all-island demand opportunity results, based on the 2026 transmission system, are presented in Chapter 8. The demand forecast used in our analysis is the median all-island transmission peak demand forecast which is taken from the All-Island Generation Capacity Statement 2021-2030

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<sup>5</sup> Please refer to Chapter 7 for further details.

(GCS)<sup>6</sup>. The demand forecast represents an average annual increase in all-island winter peak demand of 1.7% over the period of GCS 2021-2030<sup>7</sup>.

The study indicates that there are a number of stations which have the capability to accommodate large demand connections. The planned North South Interconnector improves generation adequacy across the island. It is also an important factor when considering the capacity of the system to connect significant amounts of additional demand in Ireland and Northern Ireland.

Chapter 8 includes a qualitative assessment of the demand capability in the Dublin area and an overview of the CRU's direction on the data centre connections. This has been included as a result of the large volume of connections and enquiries from data centres and other large energy users in the Dublin area.

In late 2021, the CRU issued a direction related to the processing of Data Centre connections to the grid in Ireland<sup>8</sup> to EirGrid, and ESB as DSO. The direction requires EirGrid, and ESB, respectively, to assess future data centre connection applications based on:

- the location of the data centre applicant with respect to whether they are within a constrained or unconstrained region of the electricity system;
- the ability of the data centre applicant to bring onsite dispatchable generation (and/or storage) equivalent to or greater than their demand in order to support security of supply;
- the ability of the data centre applicant to provide flexibility in their demand by reducing consumption when requested to do so by the System Operator at times of system constraint through the use of dispatchable on-site generation (and/or storage) in order to support security of supply; and
- the ability of the data centre applicant to provide flexibility in their demand by reducing consumption when requested to do so by the relevant system operator, during times of system constraint, in order to support security of supply.

In the context of the CRU's direction on the connection of data centres, EirGrid clarified in a December 2021 webinar that the greater Dublin area is considered a constrained region for the purpose of processing of data centre connections.

It is important to note that demand and generation opportunity studies in this TYTFS are based on contracted customer connections and approved transmission reinforcements at the data freeze date. This differs from Shaping Our Electricity Future which assumes connections of demand and generation in addition to those already contracted. For example, Shaping Our Electricity Future assumes that new large energy user demand will connect at Cashla, Coolkeeragh, Killonan and Knockraha; however, there are currently no connection agreements for this demand. Therefore, future iterations of the TYTFS will take the outcome and progress of Shaping Our Electricity Future into account, including new demand and generation customer connections.

<sup>6</sup> <https://www.eirgridgroup.com/site-files/library/EirGrid/208281-All-Island-Generation-Capacity-Statement-LR13A.pdf>

<sup>7</sup> The cumulative forecast increase in demand over the period of GCS 2021-2030 is 16.5%.

<sup>8</sup> <https://www.cru.ie/wp-content/uploads/2021/11/CRU21124-CRU-Direction-to-the-System-Operators-related-to-Data-Centre-grid-connection-processing.pdf>

A significant amount of conventional generation in Ireland and Northern Ireland is expected to close over the period covered by this statement. For the purpose of the TYTFS 2021 analysis, it is assumed that there will be sufficient capacity to ensure that we can meet the defined adequacy standards and operational requirements in each jurisdiction. The Capacity Market is a key market element to facilitate this and the Generation Capacity Statement 2021-2030 outlines some possible challenges in this space. We are currently working with CRU and the Department of the Environment, Climate and Communications (DECC) to address short to medium term generation adequacy concerns in Ireland. Current analysis and projections for Northern Ireland indicate there is sufficient capacity in the short to medium term to meet system needs, however there are risks around low plant availability, plant run hour restrictions, and potential delays to the North-South Interconnector which could impact the adequacy position in the short to medium term. The adequacy position for NI is being monitored on an on-going basis.

The results of demand and generation opportunity analyses are based on high level transmission network assessments. The results provide guidance; the actual connection capacity and possible connection solutions can only be determined following detailed individual connection studies. We will continue to examine innovative solutions and technologies in response to future connection enquiries.

Those who are considering connecting generation or demand to the transmission systems of Ireland or Northern Ireland should contact us. It is advisable to consult us early in the project process. In Ireland customers can contact us at [info@eirgrid.com](mailto:info@eirgrid.com) while in Northern Ireland customers can contact us at [info@soni.ltd.uk](mailto:info@soni.ltd.uk).

# 1. Introduction

All-Island Ten Year

**Transmission Forecast  
Statement**

**2021**



# 1. Introduction

The transmission system is a network of 400 kV, 275 kV, 220 kV and 110 kV high-voltage lines and cables. It is the backbone of the power system, efficiently delivering large amounts of power from where it is generated to where it is needed.

EirGrid is the Transmission System Operator (TSO) in Ireland, while SONI is the TSO in Northern Ireland. As TSOs, we jointly prepare and publish the All-Island Ten Year Transmission Forecast Statement (TYTFS) each year.

EirGrid plans and develops the transmission system in Ireland to ensure it meets forecast transmission system operating conditions. SONI is responsible for planning and operating the transmission system in Northern Ireland within defined security standards.

The TYTFS 2021 provides the following information:

- Network models and data of the all-island transmission system;
- Forecast generation capacity and demand growth;
- Maximum and minimum fault levels at transmission system stations;
- Predicted transmission system power flows at different points in time; and
- Demand and generation opportunities on the transmission system.

The TYTFS is designed to assist users and potential users of the transmission system to identify opportunities to connect to and make use of the transmission system. The appendices provide further information and transmission system data to enable the reader to perform power flow analysis.

When using data provided in the TYTFS 2021, readers should consider other documents we produce, or are involved in producing, including<sup>9</sup>:

- All-Island Generation Capacity Statement (GCS);
- Shaping Our Electricity Future Roadmap;
- EirGrid's Transmission Development Plan for Ireland;
- SONI's Transmission Development Plan for Northern Ireland;
- EirGrid's Tomorrow's Energy Scenarios for Ireland;
- SONI's Tomorrow's Energy Scenarios for Northern Ireland; and
- European Network of Transmission System Operators for Electricity's (ENTSO-E's) Ten Year Network Development Plan for Europe.

Each year EirGrid and SONI jointly prepare the All-Island Generation Capacity Statement. The GCS outlines demand forecasts and assesses the generation adequacy of the island of Ireland over the ten year period covered by the GCS. The TYTFS complements the demand information presented in the GCS.

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<sup>9</sup> Our publications are available at [www.eirgridgroup.com](http://www.eirgridgroup.com) and [www.soni.ltd.uk/](http://www.soni.ltd.uk/)

Each year EirGrid and SONI publish Transmission Development Plans (TDP) for Ireland and Northern Ireland respectively. The TDPs are available on the EirGrid and SONI websites. The TDPs for Ireland and Northern Ireland provide details of the transmission system developments expected to be progressed in Ireland and Northern Ireland in the coming 10 years. These transmission system developments are also included in the data, assumptions and analyses in the TYTFS.

To cater for the increased level of uncertainty over the future usage of the grid EirGrid and SONI have introduced scenario planning for Ireland and Northern Ireland respectively. We call our scenarios Tomorrow's Energy Scenarios (TES). These acknowledge that there is no single pathway to a low carbon future.

The European Network of Transmission System Operators for Electricity (ENTSO-E), of which EirGrid and SONI are members, publishes a Ten Year Network Development Plan (TYNDP) every two years. The TYNDP outlines projects of European significance.

## 1.1 Governing Arrangements

### 1.1.1 Roles and Responsibilities (Governance)

#### Northern Ireland

Under our licence in Northern Ireland, held by SONI, we are required to plan<sup>10</sup> and operate the Northern Ireland transmission system.

In doing so we must comply with both the SONI Transmission System Security and Planning Standards (TSSPS) and the SONI Grid Code.

#### Ireland

Under our licence in Ireland, held by EirGrid, we are required to operate, develop and ensure the maintenance of the Irish transmission system.

In doing so we must comply with both the EirGrid TSSPS and the EirGrid Grid Code.

### 1.1.2 Duty to Prepare a Statement

EirGrid and SONI are each required to publish a Transmission Forecast Statement in line with the Statutory Regulations in Table 1-1. Since 2012 we have jointly prepared and produced an all-island document, following an agreement with the Regulatory Authorities in Ireland<sup>11</sup> and Northern Ireland<sup>12</sup>.

<sup>10</sup> Under the direction of the Utility Regulator (NI), investment planning functions are the responsibility of SONI as of May 2014 (ref: Commission Decisions 12.4.2013 pursuant to Article 3(1) of Regulation (EC) No 714/2009 and Article 10(6) of Directive 2009/72/EC – United Kingdom (Northern Ireland) – SONI / NIE).

<sup>11</sup> The Commission for Regulation of Utilities is the Regulatory Authority in Ireland.

<sup>12</sup> The Utility Regulator is the Regulatory Authority in Northern Ireland.

**Table 1-1: Statutory Regulations requiring the TSOs to produce a Transmission Forecast Statement**

<b>Ireland</b>	<b>Northern Ireland</b>
Section 38 of the Electricity Regulation Act 1999 (as amended)	Condition 33 of the Licence to participate in the Transmission of Electricity

TYTFS 2021 has been prepared in accordance with and in fulfilment of these obligations. The format was approved by the Commission for Regulation of Utilities (CRU) and the Utility Regulator (UR).

### 1.1.3 Single Electricity Market

The Single Electricity Market (SEM) has been operating on the island of Ireland since 2007. The all-island wholesale electricity market allows consumers in both Ireland and Northern Ireland to benefit from increased competition. This in turn allows consumers to benefit from reduced energy costs and improved reliability of supply.

The model of the SEM changed considerably on 1 October 2018 to take account of the requirements of the European Network Codes<sup>13</sup> and the Target Model<sup>14</sup>. The project to develop and realise the new market was called the Integrated - Single Electricity Market (I-SEM). The market remains the Single Electricity Market (SEM<sup>15</sup>).

The transmission systems of Ireland and Northern Ireland are electrically connected by means of a 275 kV tie-line. This tie-line connects Louth station in Co. Louth (Ireland) to Tandragee station, in Co. Armagh (Northern Ireland).

There are also two 110 kV connections between Ireland and Northern Ireland:

- Letterkenny station in Co. Donegal (Ireland) and Strabane station in Co. Tyrone (Northern Ireland); and
- Corraclassy station in Co. Cavan (Ireland) and Enniskillen station in Co. Fermanagh (Northern Ireland).

Generation on the transmission systems of Ireland and Northern Ireland is dispatched on an all-island basis. The TYTFS transmission network models are also dispatched in this manner, to reflect how the all-island transmission system is operated.

## 1.2 Data Management

Transmission system development is continuously evolving. A data freeze date of January 2021 applies to TYTFS 2021. All data for system model files, and sequence data for use with short circuit current level analysis, was collected on this date. A data freeze date enables us to:

- Perform analyses;
- Update system models; and
- Update the appendices of TYTFS 2021.

<sup>13</sup> <https://www.entsoe.eu/major-projects/network-code-development/Pages/default.aspx>

<sup>14</sup> <https://www.entsoe.eu/about-entso-e/market/long-term-market-design/Pages/default.aspx>

<sup>15</sup> Further information on the SEM is available on <https://www.sem-o.com/>

## 1.3 Other Information

Potential users of the transmission system should also be aware of the following key documents:

- SONI Grid Code<sup>16</sup>;
- EirGrid Grid Code<sup>17</sup>;
- SONI Transmission System Security and Planning Standards<sup>18</sup>;
- The Electricity Safety, Quality and Continuity Regulations<sup>19</sup> (Northern Ireland) 2012;
- EirGrid Transmission System Security and Planning Standards<sup>20</sup>;
- EirGrid Operating Security Standards<sup>21</sup>;
- SONI Transmission Connection Charging Methodology Statement<sup>22</sup>;
- EirGrid Transmission Connection Charging Methodology Statement 2008<sup>23</sup>;
- EirGrid Statement of Charges 2021/2022<sup>24</sup>;
- Statement of Charges – For Use of Northern Ireland Electricity Ltd Transmission System<sup>25</sup>;
- EirGrid Transmission Loss Adjustment Factors 2021-2022<sup>26</sup>
- SONI Transmission Loss Adjustment Factors 2021-2022<sup>27</sup>
- All-Island Generation Capacity Statement 2021-2030<sup>28</sup>;
- EirGrid Transmission Development Plan for Ireland 2020-2029<sup>29</sup>; and
- SONI Transmission Development Plan for Northern Ireland 2020-2029<sup>30</sup>.

<sup>16</sup> <http://www.soni.ltd.uk/customer-and-industry/general-customer-information/grid-code/>

<sup>17</sup> <http://www.eirgridgroup.com/customer-and-industry/general-customer-information/grid-code-info/index.xml>

<sup>18</sup> <https://www.soni.ltd.uk/media/Northern-Ireland-TSSPS-September-2015.pdf>

<sup>19</sup> [http://www.legislation.gov.uk/nisr/2012/381/pdfs/nisr\\_20120381\\_en.pdf](http://www.legislation.gov.uk/nisr/2012/381/pdfs/nisr_20120381_en.pdf)

<sup>20</sup> <http://www.eirgridgroup.com/site-files/library/EirGrid/EirGrid-Transmission-System-Security-and-Planning-Standards-TSSPS-Final-May-2016-APPROVED.pdf>

<sup>21</sup> <http://www.eirgridgroup.com/site-files/library/EirGrid/Operating-Security-Standards-December-2011.pdf>

<sup>22</sup> <https://www.soni.ltd.uk/media/SONI-Transmission-Connection-Charging-Methodology-Statement-Effective-1-Sept-2016-Approved-by-UR.pdf>

<sup>23</sup> <http://www.eirgridgroup.com/site-files/library/EirGrid/Connection-Charging-Statement.pdf>

<sup>24</sup> [http://www.eirgridgroup.com/site-files/library/EirGrid/Statement-of-Charges-2021\\_22-\\_final\\_draft-v.1.0.pdf](http://www.eirgridgroup.com/site-files/library/EirGrid/Statement-of-Charges-2021_22-_final_draft-v.1.0.pdf)

<sup>25</sup> [http://www.soni.ltd.uk/customer-and-industry/general-customer-information/transmission-use-of-system-charges%20TUoS/?\\_\\_toolbar=1](http://www.soni.ltd.uk/customer-and-industry/general-customer-information/transmission-use-of-system-charges%20TUoS/?__toolbar=1)

<sup>26</sup> [http://www.eirgridgroup.com/site-files/library/EirGrid/Approved-2021-2022-Transmission-Loss-Adjustment-Factors-\(TLAFs\)-Accompanying-Note-v1.0.pdf](http://www.eirgridgroup.com/site-files/library/EirGrid/Approved-2021-2022-Transmission-Loss-Adjustment-Factors-(TLAFs)-Accompanying-Note-v1.0.pdf)

<sup>27</sup> [https://www.soni.ltd.uk/media/documents/Approved-2021-2022-Transmission-Loss-Adjustment-Factors-\(TLAFs\)-Accompanying-Note-v1.0.pdf](https://www.soni.ltd.uk/media/documents/Approved-2021-2022-Transmission-Loss-Adjustment-Factors-(TLAFs)-Accompanying-Note-v1.0.pdf)

<sup>28</sup> <https://www.eirgridgroup.com/site-files/library/EirGrid/208281-All-Island-Generation-Capacity-Statement-LR13A.pdf>

<sup>29</sup> <https://www.eirgridgroup.com/site-files/library/EirGrid/Transmission-Development-Plan-2020-2029.pdf>

<sup>30</sup> <https://www.soni.ltd.uk/media/documents/SONI-Transmission-Development-Plan-Northern-Ireland-2020-2029.pdf>

## 1.4 Publication

The TYTFS 2021 is available in pdf format on our websites:

- [www.eirgridgroup.com](http://www.eirgridgroup.com); and
- [www.soni.ltd.uk](http://www.soni.ltd.uk)

For a hard-copy version, please send a request to [info@eirgrid.com](mailto:info@eirgrid.com) or [info@soni.ltd.uk](mailto:info@soni.ltd.uk).

Transmission system model files are also available on both websites.



## 2. The Electricity Transmission System

All-Island Ten Year

Transmission Forecast  
Statement

**2021**

## 2. The Electricity Transmission System

### 2.1 Overview of the All-Island Electricity Transmission System

The transmission system in Ireland and Northern Ireland plays a vital role in the supply of electricity. It provides the means to transport energy from generators to demand centres across the island.

The transmission system in Northern Ireland is operated at 275 kV and 110 kV. The transmission system in Ireland is operated at 400 kV, 220 kV and 110 kV. The two transmission systems are connected by means of a 275 kV double circuit from Louth station in Co. Louth (Ireland/IE) to Tandragee station in Co. Armagh (Northern Ireland/NI). There are also two 110 kV connections:

- Letterkenny station in Co. Donegal (IE) to Strabane station in Co. Tyrone (NI); and
- Corraclassy station in Co. Cavan (IE) to Enniskillen station in Co. Fermanagh (NI).

See Section 2.2 below for further information on the existing transmission connections between Ireland and Northern Ireland.

EirGrid and SONI together operate the transmission systems - North and South - on an all-island basis.

The 400 kV, 275 kV and 220 kV networks form the backbone of the transmission system. They have higher power carrying capacity and lower losses than the 110 kV network.

In Ireland, the 400 kV network provides a high capacity link between the Moneypoint generation station on the west coast and Dublin on the east. We are planning a new 400 kV interconnector between Ireland and Northern Ireland called the North South Interconnector.

In Northern Ireland the 275 kV network is comprised of:

- A double circuit ring;
- A double circuit spur to Coolkeeragh Power Station; and
- A double circuit spur southwards into Co. Louth, in Ireland.

In Ireland the transmission network is comprised of single circuit lines which are interconnected to cover the wider geographical distances between stations. Typically large generation stations (greater than 200 MW) are connected to the 220 kV or 400 kV networks.

The 110 kV<sup>31</sup> circuits provide parallel paths to the 220 kV, 275 kV and 400 kV networks and are the most extensive element of the all-island transmission system, reaching into every county on the island of Ireland.

The all island transmission system is generally comprised of overhead lines. There are exceptions

<sup>31</sup> A number of radial 110 kV circuits in Ireland and the 110 kV lines and cables within Dublin City are operated by the Distribution System Operator (DSO). The DSO licence is held by ESB Networks. Details of the distribution network in Dublin are not included in this All-Island Ten Year Transmission Forecast Statement.

to this, such as in the city centres of Belfast, Cork and Dublin, where underground cables are used. Table 2-1 presents the total lengths of overhead lines<sup>32</sup> and cables at the different voltage levels. Revision of individual line lengths may change following completion of network development projects.

**Table 2-1: Total Length of Existing Transmission System Circuits as at the Data Collection Freeze Date (January 2021)**

Voltage Level (kV)	Total Circuit Lengths (km)
400	439
275	825
220	2,004
110	6,777

Transformers are located at substations that link the different voltage networks together, providing paths for power flow between voltage levels. The total transformer capacity between the different voltage levels on the all-island system is presented in Table 2-2.

**Table 2-2 Total Transmission System Transformer MVA Capacity as at the Data Collection Freeze Date<sup>33</sup> (January 2021)**

Voltage Levels (kV)	Capacity (MVA)	Number of transformers
400/220	4,050	8
275/220	1,200	3
275/110	4,280	19
220/110	14,799	70
110/33 <sup>34</sup>	6,190	85

Reactive compensation devices are used to improve transmission system voltages in local areas. Existing reactive compensation devices connected to the transmission system include shunt capacitors, static var compensators (SVCs) and shunt reactors.

Capacitors and SVCs help to support local voltages in areas where low voltages may otherwise occur. Shunt reactors suppress voltages in areas where they would otherwise be too high, most likely during periods of low demand and/or high wind. Table 2-3 displays the reactive compensation on the all-island transmission system.

<sup>32</sup> Some lines may contain short sections of cable.

<sup>33</sup> Transformer details are provided in Tables B-4 and B-5 in Appendix B.

<sup>34</sup> In Northern Ireland, 110/33 kV transformers are formally part of the transmission system. In Ireland, 110/38 kV transformers are part of the distribution system.

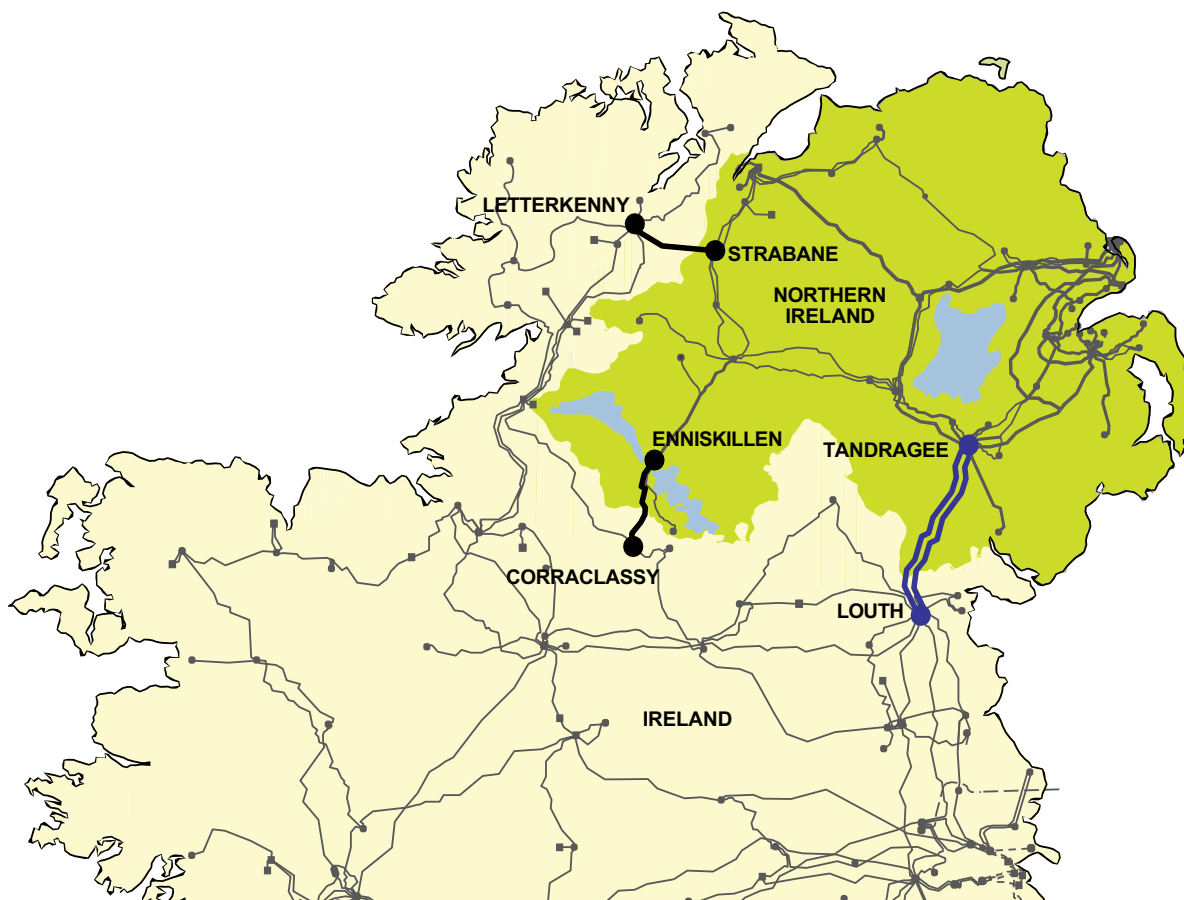


**Table 2-3 Total Reactive Compensation<sup>35</sup> as at the Data Collection Freeze Date (January 2021)**

Voltage Level (kV)	Type	Capacity (Mvar)	Number of Devices
400	Line Shunt Reactor	160	2
	Voltage Source Converter Interconnector	+/- 175	1
275	Shunt Capacitor	236	4
220	Shunt Reactor	200	3
110	Static Var Compensator	90	2
	Shunt Capacitor	961	44
38	Shunt Reactor	100	5
33	Shunt Capacitor	29	5
22	Shunt Reactor	210	7
	Shunt Capacitor	125	5
20	Shunt Capacitor	92	14
	Shunt Reactor	9	1

<sup>35</sup> Details of existing reactive compensation devices are provided in Table B-6 in Appendix B. This table also includes reactive compensation devices at lower voltage levels that are modelled in the TYTFS studies.

## 2.2 Existing Connections between Ireland and Northern Ireland Transmission Systems



**Figure 2-1 Existing Cross-Border Circuits**

As illustrated in Figure 2-1, the transmission systems of Ireland and Northern Ireland are connected via a double circuit 275 kV line. This line connects the Northern Irish transmission system at Tandragee to the Irish transmission system in Louth. There are three 275/220 kV transformers in Louth station, one 600 MVA unit and two ganged<sup>36</sup> 300 MVA units.

The design capacity of each of the 275/220 kV cross-border circuits is 600 MVA. However, the actual capacity of the circuits to accommodate transfers between the two systems at any time depends on the prevailing system conditions on either side of the border. This includes the ability to deal with system separation.

In addition to the main 275/220 kV double circuit, there are two 110 kV connections:

- One between Letterkenny, Co. Donegal and Strabane, Co. Tyrone; and
- One between Corraclassy, Co. Cavan and Enniskillen, Co. Fermanagh.

The purpose of these 110 kV circuits is to provide support to either system in certain system conditions. Phase shifting transformers (PSTs) in Strabane and Enniskillen are used to control the power flow under normal conditions.

<sup>36</sup> Plant connected in parallel through common switchgear.

## 2.3 Interconnection with Great Britain and Europe

Transmission grids are often interconnected so that energy can flow from one country to another. By linking to other transmission systems, we can:

- Increase the diversity and security of energy supplies;
- Facilitate competition in the European market; and
- Aid the transition to a low carbon energy sector by integrating renewable sources.

This helps provide a safe, secure, reliable and affordable energy supply for everybody.

The East West Interconnector links the electricity grids in Ireland and Wales, while the Moyle Interconnector links the electricity grids in Northern Ireland and Scotland. Further interconnectors are planned, see Section 2.3.3 Future European Interconnection.

Power can be either imported or exported on the interconnectors. Interconnector power flows have system impacts that need to be managed operationally. For example, during times of import, conventional generation is displaced by non-synchronous power sources. This reduces the all-island system inertia<sup>37</sup>. Interconnector flows can also have implications for the system frequency and transmission system stability and operation. Frequency changes are faster in transmission systems with low rotational inertia, making frequency control and system operation more challenging.

The Moyle Interconnector also increases the dynamic reactive support required by the transmission system as the link does not have dynamic reactive power export capability<sup>38</sup>.

SONI acts as Interconnector Administrator (IA) for the Moyle interconnector.

Interconnector capacity is auctioned by SEMOpx on behalf of EirGrid Interconnector DAC (EIDAC)<sup>39</sup> and Moyle Interconnector Limited (MIL)<sup>40</sup> in two intra-day ex-ante auctions. The capacity is allocated for use by market participants in the wholesale electricity markets on the islands of Ireland and Great Britain. Figure 2-2 shows the location of the Moyle Interconnector and EirGrid East-West Interconnector.

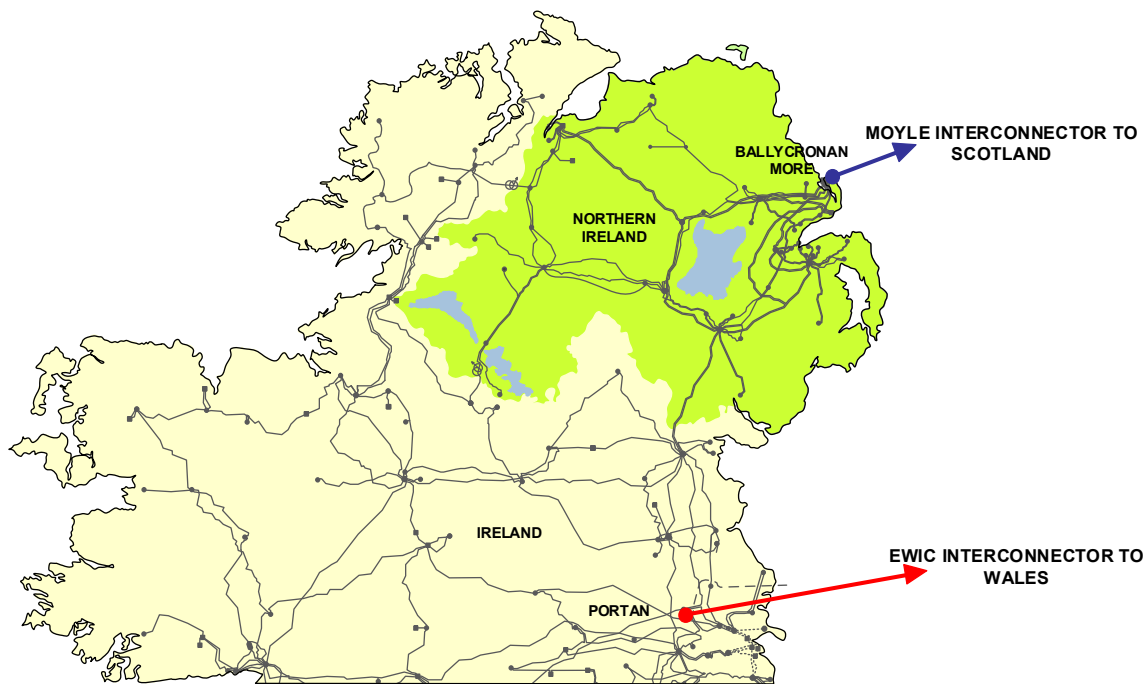
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<sup>37</sup> System inertia is also reduced by the increased wind penetration (another form of non-synchronous generation).

<sup>38</sup> Unlike Moyle the East West Interconnector has dynamic reactive power export capability.

<sup>39</sup> <http://www.eirgridgroup.com/customer-and-industry/interconnection/>

<sup>40</sup> <https://www.mutual-energy.com/electricity/#trading>



**Figure 2-2 Existing Interconnectors**

The amount of power that is permitted to be traded between Ireland and Wales across the East-West Interconnector is detailed in Table 2-4.

The available capacity is measured at the SEM and BETTA market reference point in Deeside 400 kV station in Wales.

**Table 2-4 Contracted Capacity on EWIC Interconnector**

Direction	Summer (MW)	Winter (MW)
Wales to Ireland	500	500
Ireland to Wales	500	500

The amount of power that can be traded between Northern Ireland and Scotland across the Moyle Interconnector is detailed in Table 2-5.

**Table 2-5 Capacity on Moyle Interconnector<sup>41</sup>**

Direction	Dates	Firm capacity available (MW)	Additional Capacity Potentially Available (MW) <sup>42</sup>	Potential Total Capacity Available (MW)
Northern Ireland to Scotland	1 December 2020 – 31 October 2021	250	250	400
	1 November 2021 – 31 March 2022	160	340	400
	1 April 2022 onwards	500 <sup>43</sup>	0	400
Scotland to Northern Ireland	1 April – 31 October	450 <sup>44</sup>	N/A	N/A
	1 November – 31 March	450	N/A	N/A

### 2.3.1 Moyle Interconnector

The Northern Ireland transmission system is currently connected to Scotland via a 500 MW High Voltage Direct Current (HVDC) link, the Moyle Interconnector. It is a Line Commutated Converter (LCC) HVDC link, which commenced full commercial operation in 2002.

It is constructed as a dual monopole HVDC link with two coaxial sub-sea cables from Ballycronan More in Islandmagee, Northern Ireland to Auchencrosh in Ayrshire, Scotland. The link has a physical installed capacity of 500 MW. The link has the capacity to provide reserve of up to 75 MW should the frequency on the island drop below 49.4 Hz.

The converter station at Ballycronan More is looped into one of the 275 kV Ballylumford to Hannahstown circuits. The Moyle link is self-compensating for reactive power losses. There are 4 x 59 Mvar capacitor banks at the Ballycronan More converter station with three of these capacitor banks acting as filters.

Where there are faults on the transmission system, effects are limited to a brief distortion of the HVDC 50 Hz AC synchronous waveform in import mode. The rapid response means that the HVDC link can have a net stabilising effect on the transmission system in the event of generation loss.

### 2.3.2 East-West Interconnector

The East-West Interconnector is a 500 MW HVDC link which runs between Woodland, County Meath in Ireland and Deeside in North Wales. The link comprises approximately 186 km of sub-sea cable and 76 km of land underground cable.

The East-West Interconnector uses Voltage Source Converter (VSC) technology. VSC technology offers independent and rapid control of active and reactive power. It does not suffer from commutation failures, and is capable of offering emergency power control in the event of low or high frequency events.

<sup>41</sup> <https://www.mutual-energy.com/electricity/#moyle-capacity>

<sup>42</sup> This capacity is assessed day-ahead by National Grid based on flows in Scotland.

<sup>43</sup> Maximum Northern Ireland to Scotland flows are limited by constraints on the Northern Ireland network.

<sup>44</sup> May be reduced from 450 MW to 410 MW under certain system outage conditions.

In addition, due to the VSC technology, the East-West Interconnector provides black start capability. The link can operate in either voltage control or reactive power control mode independently in both converter stations. It can supply or absorb up to 175 Mvar at Portan 400 kV station which is connected directly to Woodland 400 kV station. The East-West Interconnector commenced commercial operation in December 2012.

### 2.3.3 Future European Interconnection

Currently, there are two proposed interconnectors that are deemed Projects of Common Interest (PCIs) by the European Commission. PCIs are intended to help the EU achieve its energy policy and climate objectives: affordable, secure and sustainable energy for all citizens. At the TYTFS data freeze date the planned Greenlink Interconnector, connecting Great Island in Co. Wexford to Pembrokeshire in Wales, was expected to be completed in winter 2024. The connection application for the proposed Celtic Interconnector between Ireland and France was executed in November 2021, after the data freeze date for this forecast statement. This interconnector will be included in future forecast statements' analyses.

In Northern Ireland there is potential for new interconnection (LirIC) to Scotland, with one potential operator receiving an interconnector licence from Ofgem. In Ireland, there is a further interconnector project (MARES Connect) from Ireland to GB, part of a wider project that includes a sea water pumped hydro station. Due to the early development status of these projects, they are not included within any studies or tables in this report.

## 2.4 Transmission Development Plans

EirGrid's Transmission Development Plan (TDP)<sup>45</sup> and SONI's Transmission Development Plan Northern Ireland (TDPNI)<sup>46</sup> detail the transmission system development projects that have been initiated by EirGrid and SONI respectively. They also discuss further developments that may arise in the period of the plans. The TDP and TDPNI describe projects that are required to:

- Facilitate demand growth;
- Provide new generation and demand connections<sup>47</sup>;
- Ensure the transmission system is in compliance with the EirGrid Transmission System Security and Planning Standards (TSSPS) and SONI TSSPS;
- Provide interconnection capacity; and
- Refurbish or replace existing assets.

The planned transmission system developments presented in this statement are based on those projects that have received internal approval by the data freeze date<sup>48</sup>. Appendix B outlines these developments. These projects are currently scheduled to be completed at various stages between now and 2030. It should be noted that the information presented in later chapters on transmission system transfer capabilities and opportunities is dependent on the completion of these development projects in the assumed timeframe.

<sup>45</sup> The latest TDP can be found on the EirGrid website <http://www.eirgridgroup.com/how-the-grid-works/tso-regulatory-publicatio/>

<sup>46</sup> The latest TDPNI can be found on the SONI website <http://www.soni.ltd.uk/the-grid/projects/tdpni/the-project/>

<sup>47</sup> For example data centres or large industrial sites.

<sup>48</sup> 01 January 2021

Information presented in the TDP, TDPNI and TYTFS documents represent a snapshot of an evolving transmission system development plan. While we are considering other reinforcements, these are not at the stage of maturity required for inclusion in this statement.

The Transmission Development Plans include details of major transmission system developments planned for the transmission system of Ireland and Northern Ireland. Each planned development is illustrated in the maps and schematics in Appendix A. New generation connections and new transmission interface stations are described in Sections 2.8 and 2.9 respectively.

## 2.5 Ireland Transmission System Developments

This section details the transmission system projects that are planned to take place in Ireland over the period covered by this forecast statement. Project completion dates in the TYTFS are forecasts based on the best project information available at the time of the data freeze date (January 2021).

### 2.5.1 Grid Development Strategy

EirGrid published the updated Grid Development Strategy (GDS) “Your Grid, Your Tomorrow<sup>49</sup>” in 2017. The GDS documents our strategy for the long-term development of the network and includes three strategy statements:

- Inclusive consultation with local communities and stakeholders will be central to our approach;
- We will consider all practical technology options; and
- We will optimise the existing grid to minimise the need for new infrastructure.

The GDS aims to achieve a balance between the costs and impact of new infrastructure, while maximising the capability of the existing network.

### 2.5.2 Our Public Consultation Process

Our approach to developing the grid and how the public can engage with us at each stage of project development is outlined in our Have Your Say<sup>50</sup> brochure.

Our approach comprises a six-step process that provides an “end-to-end” structure for all our grid projects. It ensures an appropriate balance between technical, economic, environmental, social and community considerations, with significant provision for stakeholder engagement at all stages. A general structure of the process is set out in Figure 2-3 below.

<sup>49</sup> <http://www.eirgridgroup.com/the-grid/irelands-strategy/>

<sup>50</sup> [http://www.eirgridgroup.com/site-files/library/EirGrid/EirGrid-Have-Your-Say\\_May-2017.pdf](http://www.eirgridgroup.com/site-files/library/EirGrid/EirGrid-Have-Your-Say_May-2017.pdf)



**Figure 2-3 General structure of the six-step process for our grid projects**

### 2.5.3 Tomorrow's Energy Scenarios

In 2017, to cater for the increased level of uncertainty over the future usage of the grid, we introduced scenario planning into our grid development process. We call our scenarios Tomorrow's Energy Scenarios<sup>51</sup> (TES).

Our scenarios detail credible futures for the electricity sector in Ireland, with specific focus on what this means for the electricity transmission system over the next twenty years and beyond. The underlying assumptions in the scenarios are validated using feedback received from policy makers, industry and the general public as part of an open consultation.

When the scenarios are finalised, we use them to test the performance of the electricity transmission grid and publish the results in the TES System Needs Assessment (SNA)<sup>52</sup>. The TES process occurs every two years.

The needs identified in the TES process are brought through our six-step process for developing the grid. As needs and projects progress through the six-step process they are included in the TDP and TYTFS.

### 2.5.4 Descriptions of Ireland Development Projects

#### Aghada 220 kV Redevelopment

The 220 kV busbar in Aghada 220 kV station will be reconfigured from the existing double busbar into a 'C' configuration. The 110 kV busbar will also be updated. The project will increase security of supply, increase operational flexibility and improve maintainability of station equipment. At the TYTFS data freeze date this project was expected to be completed in 2021.

<sup>51</sup> The latest Tomorrow's Energy Scenarios information is available at the following link: <http://www.eirgridgroup.com/customer-and-industry/energy-future/>

<sup>52</sup> TES 2017 System Needs Assessment Report: <http://www.eirgridgroup.com/site-files/library/EirGrid/TES-2017-System-Needs-Assessment-Final.pdf>

TES 2019 System Needs Assessment Report: [http://www.eirgridgroup.com/site-files/library/EirGrid/EirGrid-TES-2019-System-Needs-Assessment-Report\\_Final.pdf](http://www.eirgridgroup.com/site-files/library/EirGrid/EirGrid-TES-2019-System-Needs-Assessment-Report_Final.pdf)



### **Ballynahulla Station STATCOM**

A new  $\pm 100$  Mvar STATCOM will be installed and commissioned on the 110 kV busbar at Ballynahulla. At the TYTFS data freeze date this project was expected to be completed in 2022.

### **Ballyvouskill Temporary Shunt Reactor**

A 50 Mvar shunt reactor will be installed temporarily at Ballyvouskill 220 kV station to address existing voltage support needs before construction of the STATCOM at this site. At the TYTFS data freeze date this project was expected to be completed in 2021.

### **Ballyvouskill Station STATCOM**

A new  $\pm 100$  Mvar STATCOM will be installed and commissioned on the 110 kV busbar at Ballyvouskill. At the TYTFS data freeze date this project was expected to be completed in 2022.

### **Belcamp Phase 2 220/110 kV Development**

A 220 kV cable will connect Shellybanks station to Belcamp station, by utilising the existing Finglas - Shellybanks and Dardistown - Finglas cables, and continuing the cable connection to Belcamp. This will lead to a revision in the feeding arrangements of the underlying Finglas and Belcamp 110 kV network. A new 220 kV indoor ring-type GIS busbar and a second transformer is to be installed at Belcamp. At the TYTFS data freeze date this project was expected to be completed in 2022.

### **Bracklone 110 kV Station**

A new 110 kV substation will be constructed near Portarlington. It will be looped into the existing Newbridge – Portlaoise 110 kV circuit. It will facilitate more demand in the area and also improve security of supply. At the TYTFS data freeze date this project was expected to be completed in 2021.

### **Carrickmines 220/110 kV Redevelopment**

This project involves installation of a fourth 220/110 kV transformer at Carrickmines 220 kV station as well as upgrading to Gas Insulated Switchgear (GIS) and reconfiguration of the existing busbar. At the TYTFS data freeze date this project was expected to be completed in 2023.

### **Castlebagot 220/110 kV Development**

Castlebagot 220/110 kV station<sup>53</sup>, in west Co. Dublin, will be connected into the existing Inchicore-Maynooth No. 1 and No. 2 220 kV lines. A number of the existing 110 kV circuits in the area will be connected to the new Castlebagot station. This development will offload demand from Inchicore 220 kV station. It will also ensure compliance with the distribution system planning standards as new demand connects to the system in the West Dublin area. At the TYTFS data freeze date this project was expected to be completed in 2021.

### **Castlebar 110 kV Busbar Upgrade**

The busbar at Castlebar will be upgraded to accommodate increased power flows arising from an increase in wind generation in the area. At the TYTFS data freeze date this project was expected to be completed in 2021.

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<sup>53</sup> Formerly known as West Dublin 220/110 kV station.

### **Clashavoon – Macroom Second 110 kV Circuit**

A new 110 kV circuit will be constructed between Clashavoon and Macroom substations. The existing 220/110 kV transformer at Clashavoon substation will be replaced with one of higher capacity. At the TYTFS data freeze date this project was expected to be completed in 2021.

### **Clashavoon – Tarbert 220 kV Uprate**

This 220 kV circuit is being uprated to accommodate increased power flows arising from an increase in wind generation. The uprated circuit will enable the export of wind power out of the southwest. Following the connection of four 220 kV stations, the original Clashavoon – Tarbert 220 kV circuit became five circuits: Tarbert – Kilpaddocke, Kilpaddocke – Knockanure, Knockanure – Ballynahulla, Ballynahulla – Ballyvouskil, and Ballyvouskil – Clashavoon. At the TYTFS data freeze date this project was expected to be completed in 2021.

### **Coolnabacky – Portlaoise 110 kV Uprate**

The 110 kV circuit between Coolnabacky and Portlaoise will be uprated due to higher power flows arising once the Coolnabacky 400/110 kV station has been looped into the existing Athy – Portlaoise 110 kV circuit. The higher flows occur during high renewable generation in the south west which flows towards the east. At the TYTFS data freeze date this project was expected to be completed in 2023.

### **Corduff – Ryebrook 110 kV Uprate**

The 110 kV circuit between Corduff and Ryebrook will be uprated due to increases in demand and an increase in flows on the overlying 220 kV network. At the TYTFS data freeze date this project was expected to be completed in 2022.

### **Finglas 220 kV and 110 kV Redevelopment**

The 220 kV and 110 kV busbars in the existing Finglas 220 kV station will be reconfigured and redeveloped into a ring busbar arrangement. This project will address the following issues: ability to accommodate future load growth; security of supply to north Dublin; asset condition of existing equipment; inadequate circuit breaker ratings and the need to upgrade the protection systems. The project will also increase operational flexibility and improve maintainability of station equipment. At the TYTFS data freeze date this project was expected to be completed in 2023.

### **Galway 110 kV Station Redevelopment**

The existing Galway 110 kV station will be replaced with a GIS station in order to accommodate increased power flows due to an increase in wind generation. The project will also increase operational flexibility and improve maintainability of station equipment. At the TYTFS data freeze date this project was expected to be completed in 2023.

### **Greenlink Interconnector**

The Greenlink Interconnector, connecting Great Island in Co. Wexford to Pembrokeshire in Wales, will have an import and export capacity of 500 MW. The project to facilitate the connection of the interconnector to the transmission system will consist of the construction of a new 220 kV GIS station ‘Loughtown’. Loughtown will connect to Great Island 220 kV GIS station via approximately 400m of underground cable. At the TYTFS data freeze date this project was expected to be completed in 2024.

### **Inchicore 220 kV Redevelopment**

The oldest section of the existing Inchicore 220 kV station, in Co. Dublin will be replaced with a new GIS compound. This project will address issues with the condition of existing equipment, inadequate circuit breaker ratings, and the need to upgrade the protection systems. The new GIS compound will increase operational flexibility, improve maintainability of station equipment and allow for future 220 kV expansion. At the TYTFS data freeze date this project was expected to be completed in 2025.

### **Kildare-Meath Grid Upgrade (Capital Project 966)**

This project will involve reinforcement of the network between Dunstown and Woodland 400 kV stations.

We are progressing this project in line with our six-step process for our grid projects. The six-step process is introduced above and outlined in our Have Your Say<sup>54</sup> brochure. In spring 2021 the project completed Step 3 and moved into Step 4. For the most up to date information on the project please visit the project page on the EirGrid website<sup>55</sup>.

### **New 110 kV Station close to Kilbarry 110 kV Station**

A new 110 kV substation will be constructed adjacent to the existing station. This will facilitate more demand in the area and also improve security of supply. Some of the existing circuits connecting into the existing Kilbarry 110 kV station will be transferred into the new station. At the TYTFS data freeze date this project was expected to be completed in 2023.

### **Killonan 220/110 kV Redevelopment**

The existing Killonan 220/110 kV station, in Co. Limerick will be replaced with a new GIS compound. This project will address issues with the condition of existing equipment, inadequate circuit breaker ratings, and the need to upgrade the protection systems as well as to accommodate increased power flows. The new GIS compound will increase operational flexibility and improve maintainability of station equipment. At the TYTFS data freeze date this project was expected to be completed in 2027.

### **Knockanure Station Reactor**

A new 50 Mvar reactor will be installed on the 220 kV busbar at Knockanure. At the TYTFS data freeze date this project was expected to be completed in 2021.

### **Knockraha 220 kV Reconfiguration**

The 220 kV busbar in Knockraha 220 kV station will be reconfigured from the existing double busbar configuration to a ring busbar arrangement. The third Knockraha 220/110 kV transformer will be decommissioned resulting in the station having two 220/110 kV transformers. The project will resolve issues regarding security of supply, operational flexibility and improve maintainability of station equipment. At the TYTFS data freeze date this project was expected to be completed in 2021.

<sup>54</sup> <http://www.eirgridgroup.com/the-grid/>

<sup>55</sup> <http://www.eirgridgroup.com/the-grid/projects/capital-project-966/the-project/>

### **Lanesboro 110 kV Station Redevelopment**

The existing Lanesboro 110 kV station will be replaced with a GIS station in order to accommodate increased power flows due to an increase in wind generation in the north-west. The project will also increase operational flexibility and improve maintainability of station equipment. At the TYTFS data freeze date this project was expected to be completed in 2024.

### **Laois-Kilkenny Reinforcement Project<sup>56</sup>**

This project involves a new 400/110 kV station at Coolnabackey near Portlaoise, Co. Laois, with an associated 110 kV circuit to Kilkenny 110 kV station via a new 110/38 kV station at Ballyragget. The 400/110 kV station will be looped into the existing Dunstown-Moneypoint 400 kV line and the existing Athy-Portlaoise 110 kV line. The proposed infrastructure will improve quality of supply to the south-east and midlands. It will also increase capacity in the region. At the TYTFS data freeze date this project was expected to be completed in 2025.

### **Louth Station Redevelopment**

Louth station comprises three voltage levels, 275 kV, 220 kV and 110 kV. The station will undergo a major refurbishment of assets at all three voltage levels. The 110 kV busbar will be reconfigured from the existing double busbar configuration to ring busbar arrangement. At the TYTFS data freeze date this project was expected to be completed in 2023.

### **Maynooth Station Redevelopment**

This project involves refurbishment and reconfiguration of the entire 220 kV and 110 kV busbars, and an increase in the short circuit rating of both busbars. Series reactors will be incorporated to manage short circuit levels within limits. At the TYTFS data freeze date this project was expected to be completed in 2027.

### **Maynooth – Woodland 220 kV Refurbishment and Upgrade**

The 220 kV circuit between Maynooth and Woodland will be refurbished and upgraded to facilitate increased power flows arising from an increase in demand. At the TYTFS data freeze date this project was expected to be completed in 2022.

### **Moneypoint – Kilpaddoge – Knockanure 220 kV Development**

There is a planned new 220 kV cable from Moneypoint in Co. Clare to Knockanure in north Co. Kerry, via Kilpaddoge also in north Co. Kerry. This will create a new path for power out of the South West to the existing 400 kV network. The project comprises a 220 kV submarine cable under the Shannon between Moneypoint and Kilpaddoge and a 21 km 220 kV land cable between Kilpaddoge and Knockanure. The submarine cable has been completed. At the TYTFS data freeze date the land cable part of the project was expected to be completed in 2021.

### **North Connacht 110 kV Reinforcement**

This project includes a new 110 kV circuit from Moy station in Co. Mayo to Tonroe station in Co. Roscommon. The new circuit will facilitate the connection of renewable generation in Co. Mayo. For the most up to date information on the project please visit the project website on the EirGrid website<sup>57</sup>. At the TYTFS data freeze date this project was expected to be completed in 2024.

<sup>56</sup> <http://www.eirgridgroup.com/the-grid/projects/laois-kilkenny/the-project/>

<sup>57</sup> <http://www.eirgridgroup.com/the-grid/projects/north-connacht/the-project/>

## Regional Solution

The Regional Solution is made up of a number of projects, with the objective of improving security of supply in the south-east and facilitating connection of generation in the south-west.

### (i) Cross-Shannon 400 kV Cable

A 400 kV cable crossing the Shannon estuary will be installed between Kilpaddoge and Moneypoint stations. The cable length is estimated at approximately 6 km consisting of approximately 3 km land cable and approximately 3 km submarine cable. A new 400/220 kV 500 MVA transformer will also be required at Kilpaddoge station. At the TYTFS data freeze date this project was expected to be completed in 2023.

### (ii) Great Island – Kilkenny 110 kV Line Upgrade

At the TYTFS data freeze date this project was expected to be completed in 2021.

### (iii) Wexford 110 kV Busbar Upgrade

At the TYTFS data freeze date this project was expected to be completed in 2021.

### (iv) Dunstown, Moneypoint and Oldstreet Series Compensation

Series compensation will be installed at Dunstown, Moneypoint and Oldstreet 400 kV stations to compensate the Coolnabacky-Moneypoint, Coolnabacky - Dunstown and Oldstreet-Woodland 400 kV lines. At the TYTFS data freeze date these projects were expected to be completed in 2025.

## Thornsberry Busbar Upgrade

The 110 kV busbar at Thornsberry will be upgraded to accommodate increased power flows arising due to increases in demand and generation in the midlands. At the TYTFS data freeze date this project was expected to be completed in 2021.

## Thurles Station STATCOM

One of the existing 15 Mvar capacitor banks on the 110 kV busbar at Thurles will be removed and replaced with a new  $\pm 30$  Mvar STATCOM. At the TYTFS data freeze date this project was expected to be completed in 2022.

## Baroda 110kV station

2 x 20 MVA 110/10 kV transformers to be installed. This is to facilitate the connection of a new customer (MIC = 3 MVA) and the transfer of 7 MVA existing demand from the 110/38 kV transformers at Newbridge 110kV station. The total MIC at Baroda amounts to 10 MVA. For the purpose of TYTFS 2021 analysis, at the TYTFS data freeze date, this project was expected to be completed in 2021.

## Corduff 110 kV Station Development Project

Installation of two additional 110/20 kV 31.5 MVA transformer bays and the construction of an MV switch room within the boundaries of the existing Corduff 220/110 kV Station. Two new 110/20 kV DSO transformers are to be installed to cater for demand growth in the area. For the purpose of TYTFS 2021 analysis, at the TYTFS data freeze date, this project was expected to be completed in 2021.

### Cow cross

1 x 20 MVA 110/10 kV transformers to be installed at the Cow Cross 110 kV busbar. This is to facilitate the retirement of the Cobh 38 kV substation. There will be no new loads or load transfers associated with the retirement of this substation. For the purpose of TYTFS 2021 analysis, at the TYTFS data freeze date, this project was expected to be completed in 2021.

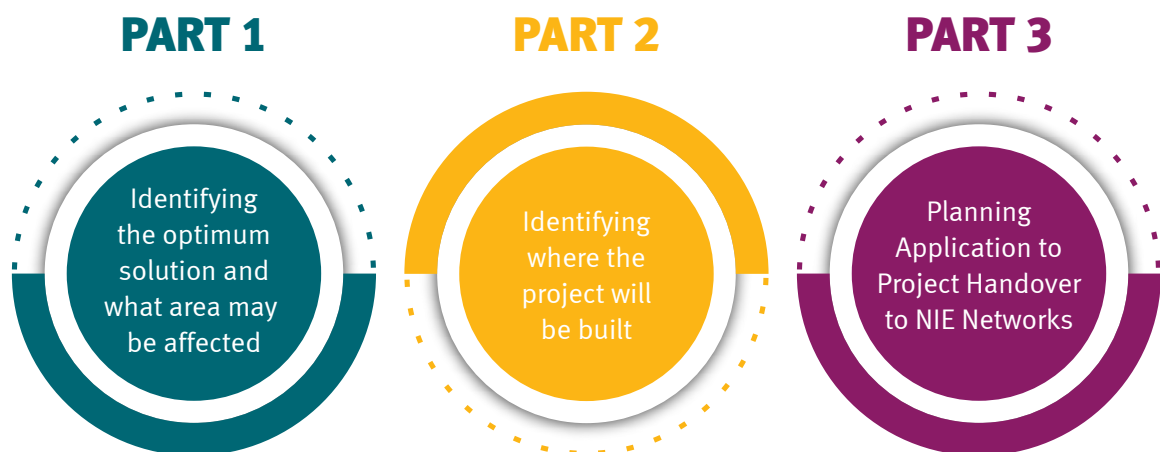
## 2.6 Northern Ireland Transmission System Developments

This section details the transmission system projects that are planned to take place in Northern Ireland over the period covered by this forecast statement. Projects have been included using completion dates assessed to be appropriate at the time of the data freeze (January 2021).

### 2.6.1 Grid Development Process

SONI recently updated the Northern Ireland Grid Development Process<sup>58</sup>. This is a three part process which includes stakeholder and public participation (as appropriate) in the development of projects, see Figure 2-4.

## SONI's Grid Development Process



**Figure 2-4 SONI's Grid Development Process**

The approach taken to developing the grid is described by the following:

- The projects listed here have all progressed through either the SONI approval and governance process or have been identified to SONI by NIE Networks. In cases where the project is at an early stage, i.e. Part 1, this approval may be limited to the investigation of feasibility of several options prior to shortlisting and selection of preferred option and identification of study areas. Therefore, the outline design that progresses to the consents stage may vary from that assumed in the forecast statement study files;
- Developments are based on assumptions relating to the forecast change in demand and generation; and
- Studies have concluded that the following projects are required to address forecast non-

<sup>58</sup> <http://www.soni.ltd.uk/media/SONIs-Powering-The-Future-Grid-Development-Process-brochure.pdf>

compliance with standards, subject to the forecast change in demand and generation. However, further cost benefit analysis may result, in some cases, in the identification of alternative solutions or operational interventions.

Further projects for which a need has been identified but approval has not yet been granted have not been included in the TYTFS analysis. These are discussed in more detail in Transmission Development Plan for Northern Ireland 2020 - 2029<sup>59</sup> (TDPNI) and the draft TDPNI 2021-2030<sup>60</sup>.

SONI published its first ‘Tomorrow’s Energy Scenarios Northern Ireland’ (TESNI) which outlines three possible energy futures<sup>61</sup>. These acknowledge that there is no single pathway to a low carbon future. We also analysed how the existing and planned transmission grid performs under each of the scenarios over a range of timeframes. The results of this analysis, known as TESNI 2020 System Needs Assessment, are also available on the SONI website<sup>62</sup>. To realise an ambition towards a carbon-free electricity system, both EirGrid and SONI launched the Shaping Our Electricity Future Roadmap in November 2021. The Roadmap provides an outline of the key developments from a networks, engagement, operations and market perspective needed to support a secure transition to at least 70% renewables on the electricity grid by 2030 – an important step on the journey to 80% and to net zero by 2050.

## 2.6.2 Descriptions of Northern Ireland Development Projects

### Additional Shunt Reactors

With an increase in small scale generation and increasing energy efficiency, the minimum load seen on the NI transmission system has dropped, leading to an increased need to reduce system voltages during these periods. Shunt reactors suppress system voltages. This project involves installation of two new shunt reactors at Castlereagh, and one at each of Tandragee and Tamnamore, connected to tertiary windings of interbus transformers. At the TYTFS data freeze date this project was expected to be completed by summer 2022.

### Banbridge Transformer Replacement

The 30 MVA 110/33 kV transformers T1 – T4 at Banbridge are to be replaced by two new 90 MVA units. At the TYTFS data freeze date this project was expected to be completed by winter 2026.

### Enniskillen Transformer Replacement

The 45 MVA 110/33 kV transformers T1 and T2 at Enniskillen are to be replaced by new 90 MVA units. At the TYTFS data freeze date this project was expected to be completed by winter 2024.

### Donegall Main (North) Transformer Replacement

The 60 MVA 110/33 kV transformer TxB at Donegall North is to be replaced by a new 90 MVA unit. At the TYTFS data freeze date this project was expected to be completed by summer 2021.

### Glengormley Transformer Replacement

The 60 MVA 110/33 kV transformer TxB at Glengormley is to be replaced by a new 90 MVA unit. At the TYTFS data freeze date this project was expected to be completed by winter 2023.

### Omagh Main – Dromore 110 kV Circuit Uprate

59 <https://www.soni.ltd.uk/media/documents/SONI-Transmission-Development-Plan-Northern-Ireland-2020-2029.pdf>

60 <https://www.soni.ltd.uk/the-grid/projects/tdpni/the-project/>

61 <https://www.soni.ltd.uk/customer-and-industry/energy-future/>

62 <https://www.soni.ltd.uk/media/documents/TESNI-SNA-2020.pdf>

With the connection of Drumquin cluster substation to Dromore it will be necessary to restring the Omagh Main – Dromore tower line with a higher capacity conductor. At the TYTFS data freeze date this project was expected to be completed by 2022.

### **Airport Road Main**

It is planned to construct a new 110/33 kV substation including 2 x 60 MVA transformers and a 33 kV switchboard in the Belfast Harbour Estate, close to Airport Road. The substation will be connected as a teed transformer feeder arrangement from Rosebank Main 110 kV. The substation will supply both Airport Road and Queens Road 33 kV substations which are to be transferred from Cregagh Main. At the TYTFS data freeze date this project was expected to be completed by winter 2023.

### **Ballylumford - Eden 110 kV Circuit Uprate**

The conductor on the existing tower line will be replaced and uprated. At the TYTFS data freeze date this project was expected to be completed by winter 2022.

### **Ballylumford Switchgear**

The existing 110 kV switchgear at Ballylumford is to be replaced with a new 110 kV GIS double busbar and the 110 kV circuits diverted accordingly. At the TYTFS data freeze date this project was expected to be completed by winter 2023. Currently one 275/110 kV interbus transformer at Ballylumford is operated out of service to ensure the fault level is kept within existing switchgear fault rating. After this work is completed, this restriction can be removed.

### **Castlereagh IBTx 1**

The interbus transformer IBTx 1 at Castlereagh is to be replaced. The replacement transformer will have a 240 MVA primary winding and a 60 MVA tertiary winding. At the TYTFS data freeze date this project was expected to be completed by 2027.

### **Castlereagh – Knock 110 kV Cable Uprate**

The cable sealing ends at Castlereagh will be replaced along with a section of cable in order to improve capacity and fault rating. At the TYTFS data freeze date this project was expected to be completed by 2021.

### **Coolkeeragh-Magherafelt 275 kV Circuits**

It is planned to replace the conductor on the existing double circuit tower line. The rating of the replacement conductor will be defined as part of the redesign of the circuit. At the TYTFS data freeze date this project was expected to be completed by winter 2022.

### **Kells-Rasharkin New 110 kV Circuit**

As a result of increasing growth in renewable generation there will be a need to construct a second 110 kV circuit between Kells and Rasharkin 110/33 kV cluster substations. This circuit will be required to have a minimum rating of approximately 190 MVA. At the TYTFS data freeze date this project was expected to be completed by 2026.



## Windfarm Clusters Development

### Garvagh 110 kV Cluster

It is planned to establish a 110/33 kV cluster substation at Agivey, near Garvagh, connected to the Rasharkin cluster via a portal overhead line. At the TYTFS data freeze date this project was expected to be completed by winter 2021.

#### (i) Kells 110/33 kV Cluster

It is planned to establish a 110/33 kV cluster substation near Kells, connected to the existing Kells station via an overhead line. At the TYTFS data freeze date this project was expected to be completed by 2023.

#### (ii) Gort Main 2nd Transformer

It is planned to install a 2<sup>nd</sup> 110/33 kV transformer at Gort Main cluster substation, allowing the transfer of a nearby wind farm from the Omagh distribution system to a more direct connection to the transmission system. At the TYTFS data freeze date this project was expected to be completed by winter 2022.

## Belfast Metropolitan Reinforcement Project: Hannahstown - Castlereagh Reinforcement

The first phase of this project comprises the installation of a fourth transformer at Castlereagh and diverting the Carnmoney to Castlereagh circuit into the Finaghy substation. For the purposes of TYTFS 2021 analysis, this phase of the project is expected to be completed in 2023.

The second phase of this project includes the establishment of new 110 kV double busbar stations at Belfast North Main and Belfast Central Main and installation of new double circuit cables. For the purposes of TYTFS 2021 analysis, this phase of the project is expected to be completed in 2027.

The redundant section between Finaghy and Carnmoney will subsequently be removed.

## Belfast Metropolitan Reinforcement Project: Asset Removal

Once the necessary assets have been installed and the network reconfigured, the Carnmoney to Castlereagh circuit will be removed. The section between Finaghy and Carnmoney will be removed after Phase 1 and the Finaghy to Castlereagh section after Phase 2.

## Projects Not Included in the 2021 TYTFS Analysis

A number of projects have not been included in the TYTFS analysis due to uncertainty at this time over either:

- The case of need; and/or
- Scope; and/or
- Timescales.

These projects are described in more detail in TDPNI which is available on the SONI website<sup>63</sup>.

<sup>63</sup> <http://www.soni.ltd.uk/the-grid/projects/tdpni/the-project/>

## 2.7 Joint Ireland and Northern Ireland Approved Transmission System Developments

This section includes transmission system developments which both EirGrid and SONI have identified the need for.

We are proposing a new 400 kV circuit which will connect Woodland 400/220 kV station in County Meath (Ireland) and Turleenan 400/275 kV station in County Tyrone (Northern Ireland). A new 400 kV station at Turleenan is required.

At present, the transmission transfer capacity between Ireland and Northern Ireland is not sufficient. Due to the risk of a forced outage, we must limit power flows across the border to prevent stress on the grid and risk to security of supply. The North South Interconnector will deliver a more secure and reliable electricity supply throughout the island of Ireland. It will bring about major cost savings and address significant issues around the security of electricity supply.

A key benefit is that it will remove bottlenecks between the two systems. This will enable the two systems to work together as a single network. This will benefit residents and businesses on both sides of the border. Other benefits will include cost savings for consumers, as larger electricity systems operate more efficiently than smaller ones.

The North South Interconnector will also allow for greater connection of renewable generation. This will help Ireland and Northern Ireland achieve future renewable energy targets. At the TYTFS data freeze date this project was expected to be completed by the end of 2025. Once this connection is established, the constraints on the existing Tandragee-Louth 275 kV double circuit will be significantly reduced.

## 2.8 Connection of New Generation Stations

New generators will connect over the period covered by this statement. Table 2-6 lists the transmission system developments associated with future generation. New generators are included in the appropriate network models according to their expected connection date. Details of these generators and their expected connected dates are given in Section B.2 in Appendix B.

**Table 2-6 Transmission System Station Development to Facilitate the Connection of Future Generation**

Generator	Planned Connection Method	Location
Garvagh Cluster <sup>64</sup>	Future Garvagh 110/33 kV cluster substation is planned to be connected via a loop in to the Rasharkin – Brockaghboy 110 kV circuit.	Northern Ireland
Kells Cluster	Future Kells 110/33 kV cluster substation is planned to be tail-connected into Kells 275/110 kV switching station at 110 kV.	Northern Ireland
Ardderoo Wind Farm	New Buffy 110 kV station, connected into Knockranny 110 kV station	Ireland
Ballinknockane Solar Park	New Ballinknockane 110 kV station, connected into the existing Aughinish-Kilpaddoge 110 kV circuit	Ireland
Banemore Solar Farm	New Banemore solar farm, connected into the existing Clahane 110kV station	Ireland
Blundelstown Solar Park	New Blundelstown 110 kV station, connected into the existing Corduff-Mullingar 110 kV circuit	Ireland
Croaghonagh Wind Farm <sup>65</sup>	New Croaghonagh 110 kV station, connected into Clogher 110 kV station	Ireland
Carrigdangan Wind Farm (formerly Barnadivane)	New Carrigdangan 110 kV station, connected into Dunmanway 110 kV station	Ireland
Cloghan Wind Farm	New Cloghan windfarm, connected into the existing Derrycarne 110kV substation east of Cloghan	Ireland
Drombeg Solar Park	New Drombeg 110 kV station, connected into the existing Kilpaddoge-Tralee 110 kV circuit	Ireland
Gallanstown Solar Park	New Gallanstown 110 kV station, connected into the existing Corduff-Platin 110 kV circuit	Ireland
Harristown Solar Park	New Harristown 110 kV station, connected into the existing Kinnegad-Dunfirth/Rinawade 110 kV circuit	Ireland

<sup>64</sup> Formerly known as Agivey

<sup>65</sup> Formed by the merger of Carrickaduff and Carrickalangan windfarms.

Generator	Planned Connection Method	Location
Lumcloon Energy Storage	New Derrycarney 110 kV station, connected into the existing Portlaoise-Dallow/Shannon-bridge 110 kV circuit	Ireland
Monatooreen Solar Park	New Monatooreen 110 kV station, connected into Knockraha 220/110 kV station	Ireland
Oriel Wind Farm	New Oriel 220 kV station, connected into the existing Louth-Woodland 220 kV circuit	Ireland
Oweninny wind farm 3	New Oweninny windfarm 3, connected into existing Bellacorick 110kV substation	Ireland
Rosspile Solar Park	New Rosspile 110 kV station, connected into the existing Great Island-Wexford 110 kV circuit	Ireland
Shantallow Solar Park	New Shantallow 110 kV station, connected into the existing Cashla-Shannonbridge/Somerset 110 kV circuit	Ireland
Timahoe North Solar Park	New Timahoe North 110 kV station, connected into the existing Derryiron-Maynooth 110 kV circuit	Ireland
Tullabeg Solar Park	New Tullabeg 110 kV station, connected into the existing Banoge-Crane 110 kV circuit	Ireland

## 2.9 Connection of New Interface Stations

Transmission interface stations are the points of connection between the transmission system and the distribution system or large energy users connecting directly to the transmission system.

The planned new interface stations, for the period covered by this statement, are listed in Table 2-7. These stations are included in the network models according to their expected connection date. Details of the connections and dates are given in Section B.2, Appendix B. At present, there are emerging needs for additional transformer capacity at transmission interface stations in the Dublin area to accommodate forecasted growth of electricity demand due to large energy users, electrification of heat and transport and growth in commercial connections on the distribution network. The summary of these emerging needs at Transmission interface stations are captured in the ‘Shaping our electricity future – A roadmap to achieve our renewable ambition’ document.

**Table 2-7 Planned Transmission Interface Stations**

Station	Nearest Main Town or Load Centre	County
Airport Road 110 kV station	Belfast	Down
Aungierstown 110 kV station	Transmission connected demand	Kildare
Ballyragget 110 kV station	Ballyragget	Kilkenny
Barnageeragh 110 kV station	Transmission connected demand	Dublin
Baroda 110 kV station	Newbridge	Kildare
Bracetown 220 kV station	Transmission connected demand	Meath
Bracklone 110 kV station	Portarlinton	Laois
Darndale 110 kV station	Transmission connected demand	Dublin
Kellystown 220 kV station	Transmission connected demand	Kildare
New 110 kV station near Kilbarry	Cork	Cork

## 2.10 Detailed Transmission Network Information

Appendix A includes geographical maps and network schematic diagrams of the existing and planned all-island transmission system.

The maps and schematic diagrams show snapshots of the all-island transmission system at January 2021 and the planned transmission system expected by the end of 2030. The diagrams indicate stations, circuits, transformers, generation, reactive devices and phase shifting transformers.

The electrical characteristics and capacity ratings of the existing and planned transmission system are included in Appendix B. Characteristics of existing and planned overhead lines, underground cables, transformers and reactive compensation devices are provided.

# 3. Demand

All-Island Ten Year

Transmission Forecast  
Statement

**2021**

## 3. Demand

This chapter provides information on the all-island, Ireland and Northern Ireland demand forecasts.

The forecasts are taken from the All-Island Generation Capacity Statement 2021-2030 (GCS)<sup>66</sup> which was published by EirGrid and SONI in September 2021. GCS 2021 contains forecasts of future energy consumption and demand levels between 2021 and 2030.

This chapter also provides an introduction to the anticipated large demand increase in the Dublin area. This anticipated demand increase is associated primarily with the connection of new large energy users such as data centres. The impact of these data centres on the future all-island demand forecast is also discussed.

### 3.1 All-Island, Ireland and Northern Ireland Peak Transmission Demand

Table 3-1 presents the median all-island, Ireland and Northern Ireland, winter peak demand forecasts over the period 2021-2030, as published in the GCS.

It is difficult to accurately predict a peak demand figure for a particular year in the future. This is due to a number of factors that can cause fluctuations in the forecast. These factors include weather conditions, economic activity, electricity usage patterns and government policy.

The annual peak demand figures listed in Table 3-1 are expected to occur during the winter period of each year. For example, we would expect that the 2021 peak demand forecast of 7.14 gigawatts (GW) would occur in winter 2021/2022. In Ireland and Northern Ireland, the winter peak demand usually occurs between 17:00 and 19:00 on a weekday evening. However, the peak demand in each jurisdiction generally does not occur on the same day.

The median demand forecast represents an average annual increase in all-island winter peak demand of 1.7% over the period of 2021-2030<sup>67</sup>. This represents a decrease in demand forecast relative to GCS 2020-2029, when the forecast average annual increase in all-island winter peak demand between was 1.8%<sup>68</sup>.

**Table 3-1: All-island, Ireland and Northern Ireland Median Peak Demand Forecast**

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
<b>Northern Ireland (GW)</b>	1.65	1.65	1.65	1.66	1.67	1.68	1.69	1.70	1.711	1.71	1.71
<b>Ireland (GW)</b>	5.36	5.54	5.72	5.85	5.96	6.05	6.14	6.22	6.30	6.37	6.45
<b>All-island (GW)</b>	6.98	7.14	7.33	7.45	7.57	7.67	7.77	7.87	7.97	8.06	8.15

66 <https://www.eirgridgroup.com/site-files/library/EirGrid/208281-All-Island-Generation-Capacity-Statement-LR13A.pdf>

67 The cumulative forecast increase in demand over the period of GCS 2021-2030 is 16.5%.

68 The cumulative forecast increase in demand over the period of GCS 2020-2029 was 19.6%.

As well as winter peak forecasts, we also develop summer peak and summer valley forecasts for Ireland and Northern Ireland. Autumn peak forecasts for Northern Ireland only.

The summer peak refers to the average peak demand levels that are forecast to occur during the summer period of each year. The Ireland and Northern Ireland summer peaks are combined to produce an all-island summer peak.

The overall transmission system power flows are usually lower in summer than in winter. However, this may not be the case for flows on all circuits. The capacity of overhead lines is lower during the summer period because of higher ambient temperatures. Network maintenance is also usually carried out during the summer/autumn period. Both of these factors can restrict the network, reducing its capability to transport power.

The annual minimum expected demand is referred to as the summer valley. It represents the lowest annual demand that is forecast, and is expected to occur during the summer period of each year. The Ireland and Northern Ireland summer valley demands are combined to produce an all-island summer valley demand. The summer valley cases examine the impact of the combination of low demand and low levels of conventional generation on the transmission system.

This minimum condition is of particular interest when assessing the capability of the transmission system to connect new generation. This is because with local demand at a minimum, the connecting generator will export more of its power across the transmission system. The summer peak and valley demands occur between March and August. The autumn peak demand refers to the peak demand value expected in September and October. Summer peak, summer valley and autumn peak demand forecasts can be expressed in terms of percentage of winter peak demand. These are shown in Table 3-2.

**Table 3-2: Ireland and Northern Ireland Seasonal Demand Forecast as a Percentage of Winter Peak Demand**

Season	Ireland Seasonal Demand Forecast as a Percentage of Winter Peak (%)	Northern Ireland Seasonal Demand Forecast as a Percentage of Winter Peak (%)
Winter Peak	100	100
Autumn Peak	N/A	87
Summer Peak	80	79
Summer Valley	35	29

These figures are consistent with historical demand data.



### 3.1.1 Large Demand Increases in the Dublin Area

#### Background

In recent years there has been an increase in the level of connections and enquiries for connection to the transmission system in the Dublin area. This document includes information on both current demand connections and future demand opportunities at the freeze date of January 2021. Our assessment of demand opportunities is presented in Chapter 8 and includes a section focused on the Dublin area.

The level of enquiries in the Dublin area is principally driven by the need for Information, Communications and Technology (ICT) industries and high-tech manufacturing companies to connect to a high quality power supply in the Dublin area.

New Bulk Supply Points (BSPs) with additional transformer capacity may also be required at transmission interface stations in the Dublin area to accommodate forecasted growth of electricity demand due to large energy users.

#### Data Centres

There are currently 12 large data centres connections to the system. These connections are consuming a combined total power demand of approximately 500 MVA. Contracts are in place for a total of 1800 MVA of data centre connections. Applications have been received for a further 2000 MVA of data centre contracts. There continues to be ongoing enquiries regarding further large demand connections in the Dublin region.

#### What is a data centre?

A data centre is a facility used to house computer systems and associated components, such as telecommunications and storage systems. They underpin the operations of companies in the broad ICT sector, particularly those in social media and cloud computing. The size of the individual electricity demand connections depends on the scale of the business operation. These have varied from 20 MW with some possibly extending to 250 MW in the final stages of development. Their use of electricity tends to be constant throughout the year. The modern world increasingly requires the retention and use of vast volumes of data, so this trend is likely to continue for the foreseeable future.

#### Impact on the System Demand Forecast

The potential connection of data centre demand on the scale discussed represents significant demand growth. This is having an impact on the all-island system demand forecast and generation capacity adequacy. Generation adequacy is assessed and discussed in the GCS.

The focus of the majority of the connection enquiries have been in the greater Dublin area. Depending on the number and scale of projects that materialise, new transmission solutions will be required to strengthen the grid to facilitate these connections. These transmission solutions are under investigation and could vary from short lead-time to longer lead-time developments. However, in the webinar on 17<sup>th</sup> December 2021, EirGrid clarified that the greater Dublin area is a constrained region for the purpose of processing of data centre connections. The impact of these Dublin demand connections are described in greater detail in Chapter 8, Section 8.3.

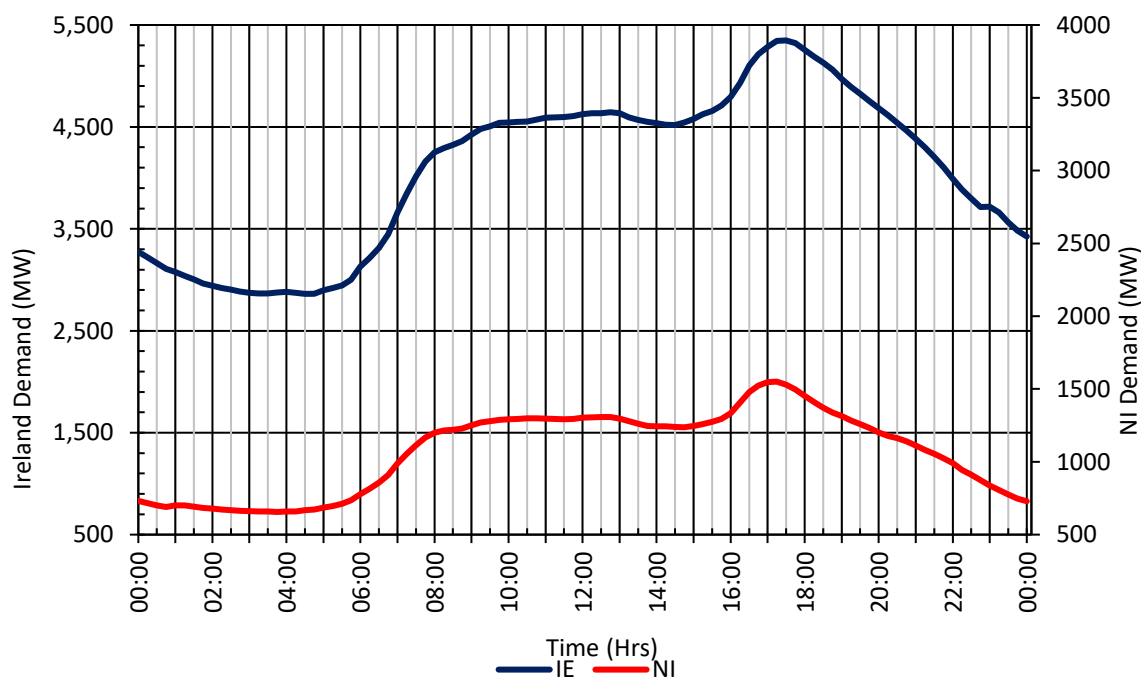
SONI is preparing a connection offer for a data centre in the North West which is expected to connect at Coolkeeragh 110kV. If this offer is accepted, this might have an impact on the generation and demand opportunities in the North West.

### 3.2 Demand Data

Electricity usage follows some generally accepted patterns. For example, annual peak demand occurs between 17:00 - 19:00 hrs on winter weekday evenings. Minimum usage usually occurs during summer weekend night-time hours.

#### 3.2.1 Generated Peak Demand Profiles

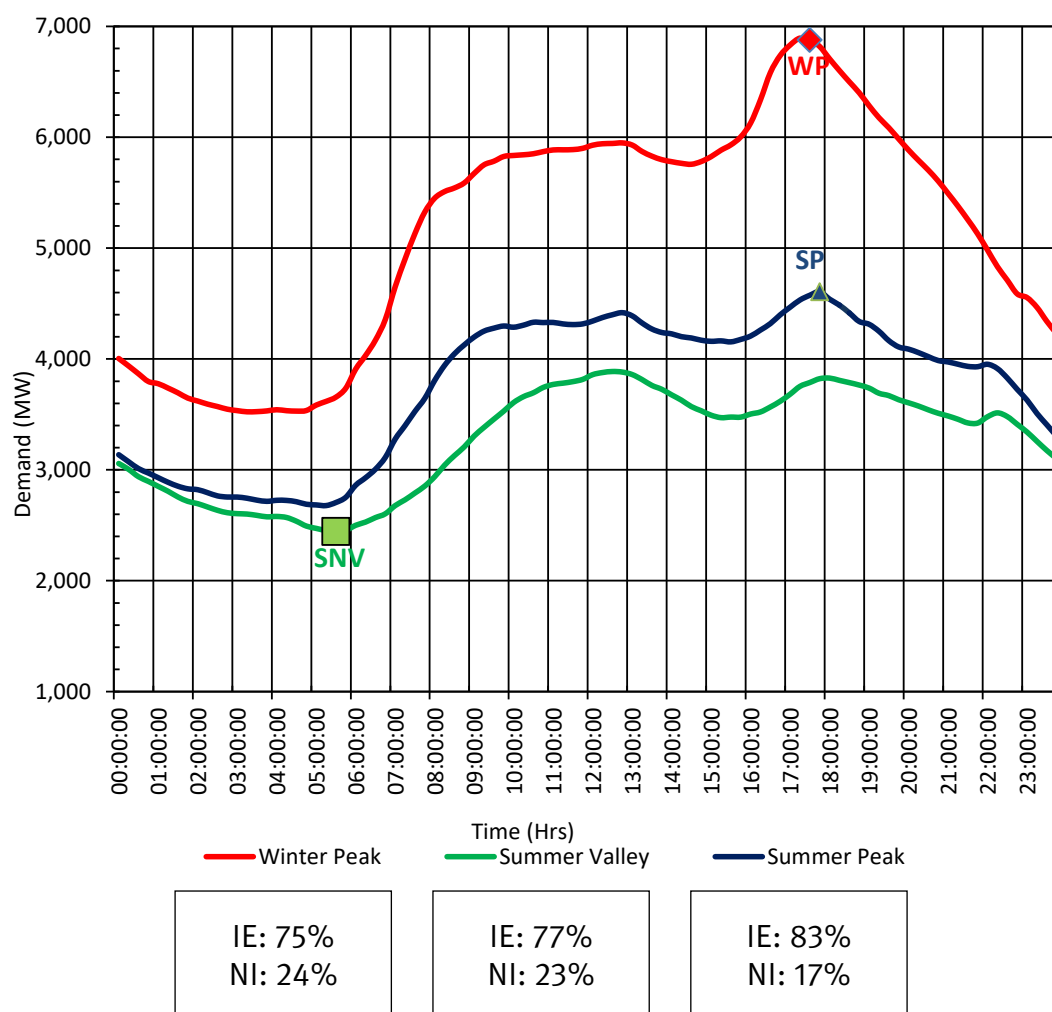
Figure 3-1 shows the generated peak demand profiles of Ireland and Northern Ireland on the day of the 2020 all-island winter peak on 07 December 2020. The individual peaks for Ireland and Northern Ireland occurred on the same day.



**Figure 3-1 Generated Peak Demand Profiles for 2020**

#### 3.2.2 All-Island Demand Profiles

Figure 3-2 shows the profiles of the 2020 all-island winter peak, summer peak and summer valley. The percentage demand attributable to each jurisdiction during the peak and valley scenarios is also shown.



**Figure 3-2 All-Island Daily Demand Profiles for Year 2020**

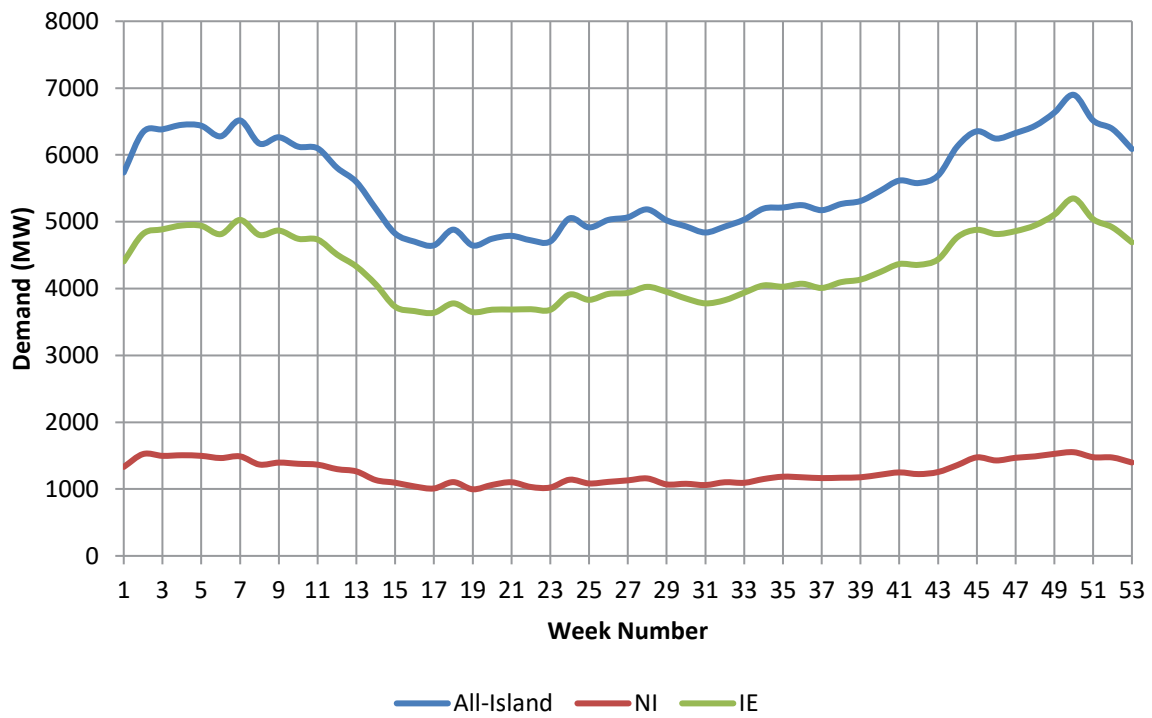
**Table 3-3: Ireland and Northern Ireland Peak and Minimum Demand, 2020**

2020	Ireland		Northern Ireland	
	Date and Time	Demand (MW)	Date and Time	Demand (MW)
Winter Peak	07/12/2020 17:30	5348	07/12/2020 17:15	1551
Summer Peak	02/06/2020 19:00	4219	27/08/2020 17:15	1185
Minimum Demand	31/05/2020 05:30	2006	28/06/2020 05:30	370

Minimum demand is normally seen during the summer. The demand reported here is that which was seen at the transmission system Bulk Supply Points (BSP), which does not count the effect of small scale generation such as rooftop solar panels. These are not metered in the same way as larger sources of generation and serve to reduce the demand observed rather than increasing the generation.

### 3.2.3 All-Island Weekly Demand Peaks

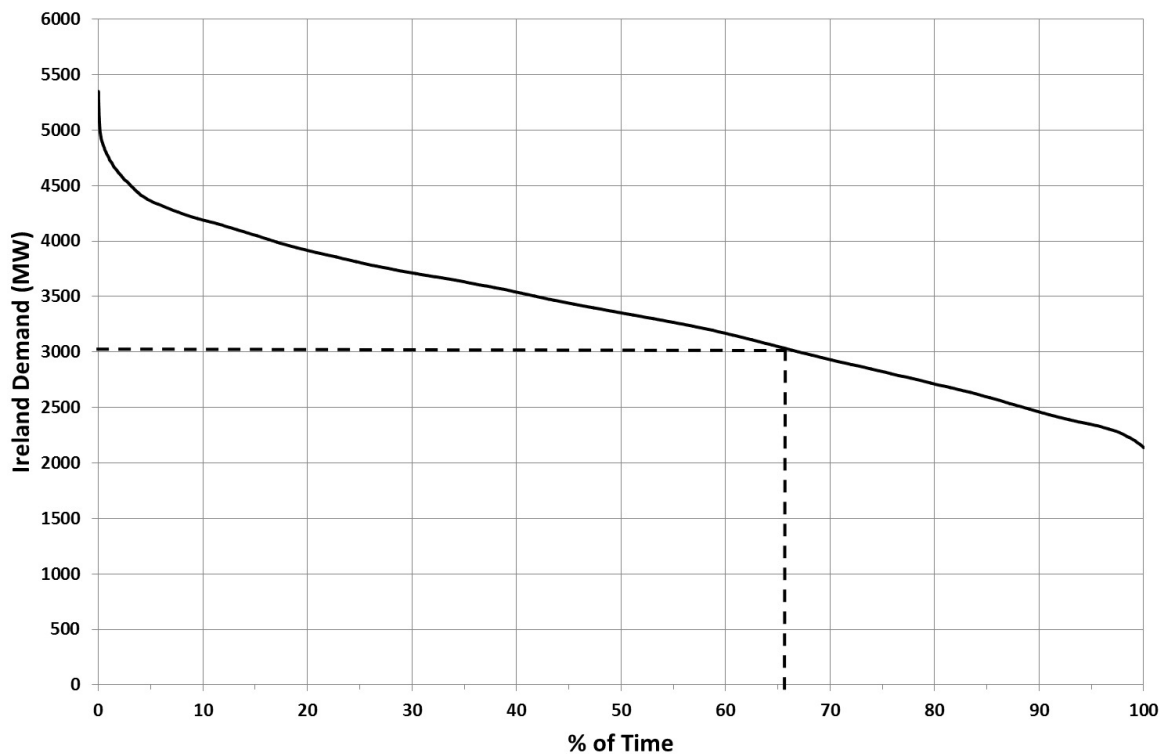
Figure 3-3 shows the profile for the all-island, Northern Ireland and Ireland weekly peaks across the year for 2020.



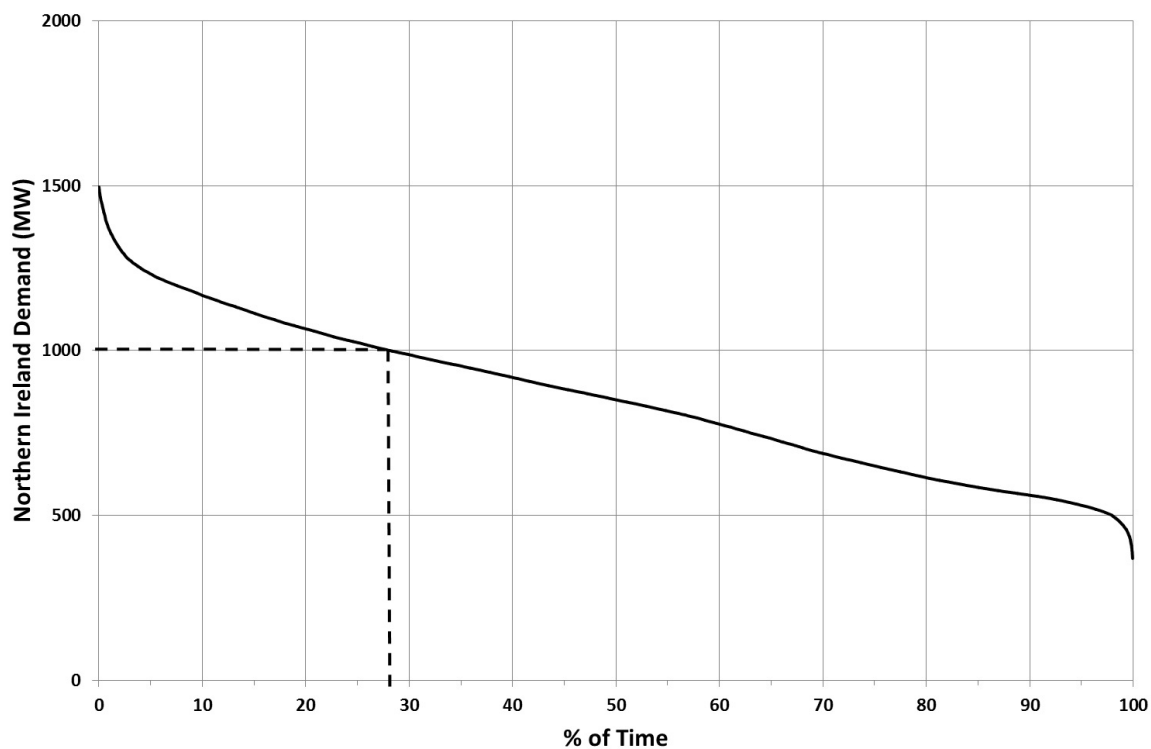
**Figure 3-3 Weekly Demand Peak Values for Year 2020**

### 3.2.4 Load Duration Curves

Figures 3-4 and 3-5 show the Ireland and Northern Ireland 2020 load duration curves, respectively. The curves show the percentage of time in the year that a particular demand value was exceeded. For example, demand exceeded 3,000 MW for 66% of the year in Ireland. Demand in Northern Ireland exceeded 1,000 MW for 28 of the year.



**Figure 3-4 Ireland Load Duration Curve 2020**



**Figure 3-5 Northern Ireland Load Duration Curve 2020**

### 3.3 Forecast Demand at Transmission Interface Stations in Ireland

Transmission interface stations are the points of connection to the transmission system. These interfaces include:

- Connections between the transmission and the distribution systems; and
- Customers connected directly to the transmission system at 220 kV or 110 kV.

The interfaces are mostly 110 kV stations. In Dublin city, where the Distribution System Operator (DSO) operates the 110 kV network, the interface is usually at 220 kV stations. The Transmission System Operator (TSO) and the DSO work collaboratively to ensure that the needs of transmission and distribution connected customers are met through planning the development of these transmission interface stations.

Appendix C lists forecast demands at each transmission interface station. The forecast demands are given for winter peak, summer peak and summer valley for all years from 2021-2030. Demand projections at individual transmission stations are developed from the system demand forecasts on a top-down<sup>69</sup> basis.

The forecasting process includes regular monitoring and review of consumption trends in all parts of the country. The allocation of the system demand forecast to each station is pro-rata. This is based on an up-to-date measurement of actual peak demand at each station. Account is taken

<sup>69</sup> This approach takes the overall demand forecast and breaks it down - using transmission system information, including historical data - to gain better knowledge of the sub-components of the demand forecast.

of planned transfers of demand between stations, as agreed with ESB Networks<sup>70</sup>. In this way, changes in the location of electricity consumption are captured. This process provides a station demand forecast and by extension a regional demand forecast for the short to medium term. The system-wide demand forecasts, presented in Table 3-1, include transmission losses whereas the individual station demand forecasts do not. Transmission losses therefore account for the difference between system-wide demand and the sum of the demand at each interface station. The demand at each interface is given in Appendix C.

Demand forecasts in Appendix C include the small number of directly-connected customers. The values in Appendix C were the best estimates of requirements at the data freeze date and do not reflect contractual status or the level of firm capacity that may be available in the network. In some cases, the estimates may be less than contracted maximum import capacity (MIC) values. These values are chosen to give a better projection of expected demand on a system-wide basis. When analysing the capacity for new demand in a particular area, the MIC values of local directly-connected and contracted customers are used. It is important to note that some contracted MIC are non-firm and subject to flexible demand arrangements.

A demand-side unit (DSU) consists of one or more demand sites that can be instructed by EirGrid and SONI to reduce electricity demand. DSUs are usually medium to large industrial premises. A DSU uses a combination of on-site generation or plant shutdown to deliver a demand reduction. Providing this dispatch availability means that the DSU is eligible for capacity payments in the Single Electricity Market (SEM).

It is noted that DSUs may reduce some customers' demands from time to time over winter peak hours. However, normal demand levels are included in the winter peak demand forecasts shown in Table C-1 in Appendix C. Normal demand levels are also used in the power flow tables in Appendix H. These normal demand levels are used since they are more indicative of general power flows.

It is identified that there are emerging needs for additional transformer capacity at transmission interface stations in the Dublin area to accommodate forecasted growth of electricity demand due to large energy users, electrification of heat and transport and growth in commercial connections in the distribution network. The summary of these emerging needs at Transmission interface stations are captured in the 'Shaping our electricity future – A roadmap to achieve our renewable ambition' document.

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<sup>70</sup> ESB Networks is the Distribution System Operator (DSO) in Ireland.

### 3.4 Forecast Demand at Northern Ireland Bulk Supply Points (BSP)

The 110/33 kV BSP demand forecasts are provided by NIE Networks<sup>71</sup>. These forecasts are based on demand trends at an individual nodal level and adjusted to align with system average cold spell (ACS<sup>72</sup>) forecasts. Consideration is also given to future block load transfers from one BSP to another. Tables and information relating to demand forecasts are contained in Appendix C.

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<sup>71</sup> NIE Networks is the DSO in Northern Ireland.

<sup>72</sup> Demand trends are based on historical information. ACS analysis produces a peak demand which would have occurred had conditions been averagely cold for the time of year. This ACS adjustment to each winter peak seeks to remove any sudden changes caused by extremely cold or unusually mild weather conditions.

# 4. Generation

All-Island Ten Year

**Transmission Forecast  
Statement**

**2021**



## 4. Generation

This chapter gives information about existing generation capacity. This chapter also defines future projections for the next ten years from 2021 to 2030. All generation capacity and dispatch figures given in this statement are expressed in exported or net terms. This is the generation unit output less the unit's own auxiliary load.

In November 2021 the Irish Government launched its Climate Action Plan 2021. The Action Plan sets out an ambitious course of action over the coming years. The plan sets a target that up to 80% of electricity will come from renewable energy sources by 2030. In order to meet this target, investment will be needed in new renewable generation capacity, system service infrastructure and electricity networks.

In Northern Ireland, the United Kingdom's Committee on Climate Change 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 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 commitment to targeting a challenging ambition in line with the requirements of the Paris Agreement on climate change.

Energy Policy is a devolved matter for Northern Ireland, and the DfE has worked with stakeholders, including SONI and developed the Future Energy Strategy<sup>73</sup> for Northern Ireland. This strategy was published in December 2021. The new strategy sets out a goal of at least 70% of electricity consumed to come from renewable sources by 2030. We believe this is achievable if industry, government, communities and landowners collaborate to make it happen. The Energy Strategy sets out a pathway for energy to 2030 that will mobilise the skills, technologies and behaviours needed to take us towards our vision of net zero carbon and affordable energy by 2050.

A freeze date for data was applied when compiling this TYTFS. A freeze date enables transmission system analyses to be carried out for inclusion in the document. The data freeze date for TYTFS 2021 is January 2021.

### 4.1 Generation in Ireland

At the data freeze date 11,834 MW of generation capacity was installed in Ireland, as detailed in Table 4-1.

**Table 4-1 Installed Generation Capacity in Ireland**

Transmission System Connected (MW)	Distribution System Connected (MW)	Total Generation Capacity (MW)
9,316 <sup>74</sup>	2,518	11,834

<sup>73</sup> <https://www.economy-ni.gov.uk/publications/energy-strategy-path-net-zero-energy>

<sup>74</sup> Please note this figure does not include the East West Interconnector.

#### 4.1.1 Existing and Planned Transmission Connected Generation

Table 4-2 lists planned generators that have signed transmission connection agreements in place, along with their expected energisation dates if available, at the data freeze date. It should be noted that this position has changed somewhat since the data freeze date and a number of projects have decided not to proceed – a more up to date picture is presented in the Generation Capacity Statement 2021 to 2030.

**Table 4-2 Contracted Transmission Generation at data freeze date**

Generator	Generation Type	Generation Capacity (MW)	Expected Energisation Date
Ardderoo (formerly Buffy)	Wind	91.20	2021
Aghada BESS 01	Battery	19	2024 & beyond
Aghada BESS 02	Battery	159	2024 & beyond
Ballinknockane	Solar	50	2022
Banemore	Solar	34	2024 & beyond
Blackwater Bog Solar 1	Solar	65	Date unavailable
Blundlestown	Solar	60	2021
Cloghan	Wind	34	2024 & beyond
Cloncreen	Wind	100	2024 & beyond
Clonfad	Solar	100	2022/23
Croaghonagh <sup>75</sup>	Wind	138.10	2022/23
Drombeg	Solar	50	2022/23
Gallanstown	Solar	119	2022/23
Gaskinstown	Solar	85	2022/23
Gillinstown	Solar	95	2022/23
Glen Solar	Solar	40	2022/23
Gorman Energy Storage	Battery	50	Date unavailable
Harristown	Solar	42.3	2022
Hiltown	Solar	9.99	2024 & beyond
Firlough	Wind	48.30	2022/23
Killala Wind Farm (Phase 2)	Wind	10.80	2022/23
Knocknamona (Prev. Crohaun)	Wind	34	2021
Lenalea	Wind	30.5	2024 & beyond
Lisheen 3	Wind	28.8	2023/24
Loughteague	Solar	55	2024 & beyond
Maas Windfarm (Loughderryduff 2)	Wind	9.35	2022/23
Monatooreen	Solar	25.7	2024 & beyond

<sup>75</sup> Formed by the merger of Carrickaduff and Carrickalangan wind farms.

Generator	Generation Type	Generation Capacity (MW)	Expected Energisation Date
Mully Graffy Windfarm (Kilgorman)	Wind	29.9	2022/23
North Wall 5	OCGT	120	Date unavailable
Oriel (1)	Wind	210	2022/23
Oweninny 3	Wind	50	2022/23
Poolbeg Energy Storage	Battery	75	2022/23
Poolbeg Flexgen	OCGT	70	2022/23
Porterstown	Battery	30	2021
Rosspile	Solar	95	2022/23
Shannonbridge A	Battery	100	2021
Shannonbridge B	Battery	63.2	2021
Shantallow	Solar	35	2022/23
Sheskin Windfarm (formerly Ederglen Windfarm)	Wind	32.9	2022/23
SouthWall	Battery	30	2022/23
Timahoe North	Solar	70	2022/23
Tullabeg	Solar	50	2022/23

#### 4.1.2 Planned Closure of Generation Plant

The closure of generation plant could have a significant impact on the ability of the transmission system to comply with standards. The EirGrid Grid Code specifies the minimum length of notice a generator must give the TSO before retirement or divestiture. The closure of a generator with capacity less than or equal to 50 MW requires at least 24 months' notice. Generators with larger capacity than this must give at least 36 months' notice.

Some older generators will come to the end of their lifetimes over the next ten years. Some generators are also assumed to close as they don't comply with the carbon limits imposed by the Clean Energy Package. These generators are noted in the All-Island Generation Capacity Statement 2021-2030 (GCS) and are listed in Table 4-3.

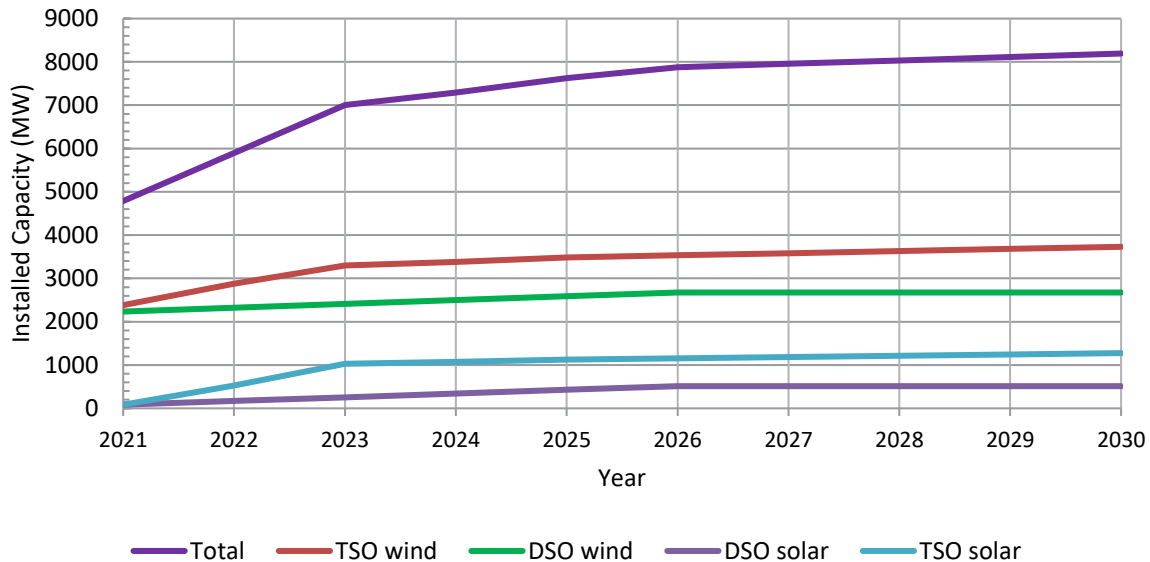
**Table 4-3 Closure of Conventional Generation**

Generator	Generation Capacity (MW)	Expected to close by end of year
Lough Ree	91	Closed
West Offaly	137	Closed
Aghada (AT1)	90	2023
Edenderry (ED1)	118	2023
Tarbert 1, 2, 3, 4	590	2023
Moneypoint 1,2,3	885	2025

### 4.1.3 Wind and Solar Generation

Over the past two decades wind power generation in Ireland has increased significantly. The level of wind generation in Ireland is expected to continue to grow over the period of this TYTFS.

While there is currently no grid scale solar generation connected, solar connections are expected to increase significantly over the course of this TYTFS. The information presented in Figure 4-1 is a combination of connected and contracted wind and solar generation as of data freeze date<sup>76</sup>.



**Figure 4-1 Connected and Contracted Wind and Solar Capacity, 2021 to 2030**

Table 4-4 shows the existing and committed wind and solar generation capacity totals expected to be connected by the end of each year<sup>77</sup>. These generators have signed connection agreements and are committed to connecting to either the transmission or distribution system over the next few years. Generators with no estimated connection dates were assumed to connect at a steady rate from 2022 onwards.

**Table 4-4 Existing and Committed Wind and Solar Capacity Totals (MW)**

Connection	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Wind (Transmission)	2383	2874	3302	3378	3483	3532	3581	3631	3680	3730
Wind (Distribution)	2235	2323	22411	2499	2587	2675	2675	2675	2675	2675
Solar (Transmission)	84	529	1031	1071	1126	1156	1185	1215	1245	1275
Solar (Distribution)	85	171	256	341	426	512	512	512	512	512
Total	4787	5897	7000	7289	7623	7875	7954	8034	8113	8192

<sup>76</sup> Detailed information on these figures is presented in Tables D-2 and D-3 in Appendix D.

<sup>77</sup> The individual wind farm details are included in Tables D-2 and D-3 of Appendix D.

#### 4.1.4 Offshore Generation

In November 2021, the Irish Government launched the Climate Action Plan 2021 which includes an action to develop a new version of Offshore Renewable Energy Development Plan (OREDPP)

The Climate Action Plan 2021 sets out an ambitious course of action over the coming years. Specifically, it sets a target that up to 80% of electricity will come from renewable energy sources by 2030.

In order to meet the Climate Action Plan target, investment will be needed in new renewable generation capacity. Offshore wind will be a significant part of the renewable generation mix in the future. Currently there is one 25 MW offshore wind farm in Ireland. The Action Plan outlines that at least 5 GW of offshore wind will be connected to the grid by 2030. As connection agreements are put in place to meet this level of capacity, we will include them in future TYTFS analyses.

#### 4.1.5 Demand Side Units

In 2021, demand side units (DSUs) in Ireland had a combined dispatchable capacity of 620 MW.

#### 4.1.6 Distribution-Connected Generation

Table 4-5 details the existing distribution-connected generation capacity by generation type. This generation plant comprises of small conventional and renewable units. Conventional units include CHP schemes and small industrial thermal units. Renewable generation consists of:

- Wind;
- Small Hydro;
- Land-fill gas (LFG);
- Biogas; and
- Biomass.

**Table 4-5 Existing Distribution-Connected Generation in Ireland**

	Wind <sup>78</sup>	Small Hydro	Biomass/ LFG	CHP	Diesel	Solar	Total
Net Capacity (MW)	2360	27	101	125	18	<1	2,631

Distribution-connected generators reduce the demand supplied through Transmission Interface Stations. Forecasts of demand levels at individual Transmission Interface Stations are presented in Appendix C. These forecasts take account of the contribution of the existing non-wind distribution-connected generators<sup>79</sup>.

## 4.2 Generation in Northern Ireland

At the data freeze date 3,971MW of generation capacity was installed in Northern Ireland, as detailed in Table 4-6.

<sup>78</sup> Table D-3 in Appendix D provides details of the existing distribution-connected wind farms and their capacities.

<sup>79</sup> Because of the variability of wind, a fixed contribution from distribution-connected wind farms is not taken into account in the calculation of the peak transmission flow forecasts. Rather a number of wind scenarios are considered in the TYTFS analyses.

**Table 4-6 Northern Ireland Installed Generation Capacity**

Transmission System Connected (MW)	Distribution System Connected (MW)	Total Generation Capacity (MW)
2,247 <sup>80</sup>	1,724	3,971

The 2,247MW connected to the transmission system consists of:

- Conventional generation;
- Brockaghboy Wind Farm; and
- Slieve Kirk Wind Farm.

**4.2.1 Existing and Planned Transmission Connected Generation**

**Existing Conventional Generation**

In Northern Ireland, conventional thermal generation plant was split into two contractual categories:

- Plant contracted to Power NI Energy Limited via their Power Procurement Business (PPB) (Contracted Plant); and
- Independent Market Participants (IMP) (Non-Contracted Plant).

The PPB contracts will expire in 2023. More up to date information on the existing conventional Generation are presented in the Generation Capacity Statement 2021 to 2030.

**4.2.2 Planned Closure of Generation Plant**

The generation output of Kilroot ST1 and ST2 is anticipated to be restricted. The restriction is due to the Industrial Emissions Directive (IED). The restriction includes limited emissions each year from 2016-2020, followed by severely restricted running hours in subsequent years. From July 2020, emissions restrictions became tighter with the end of Transitional National Plan and in 2021, emissions limits have been tightened much further as noted in GCS 2021 Kilroot ST1 and ST2 are assumed unavailable after 2023.

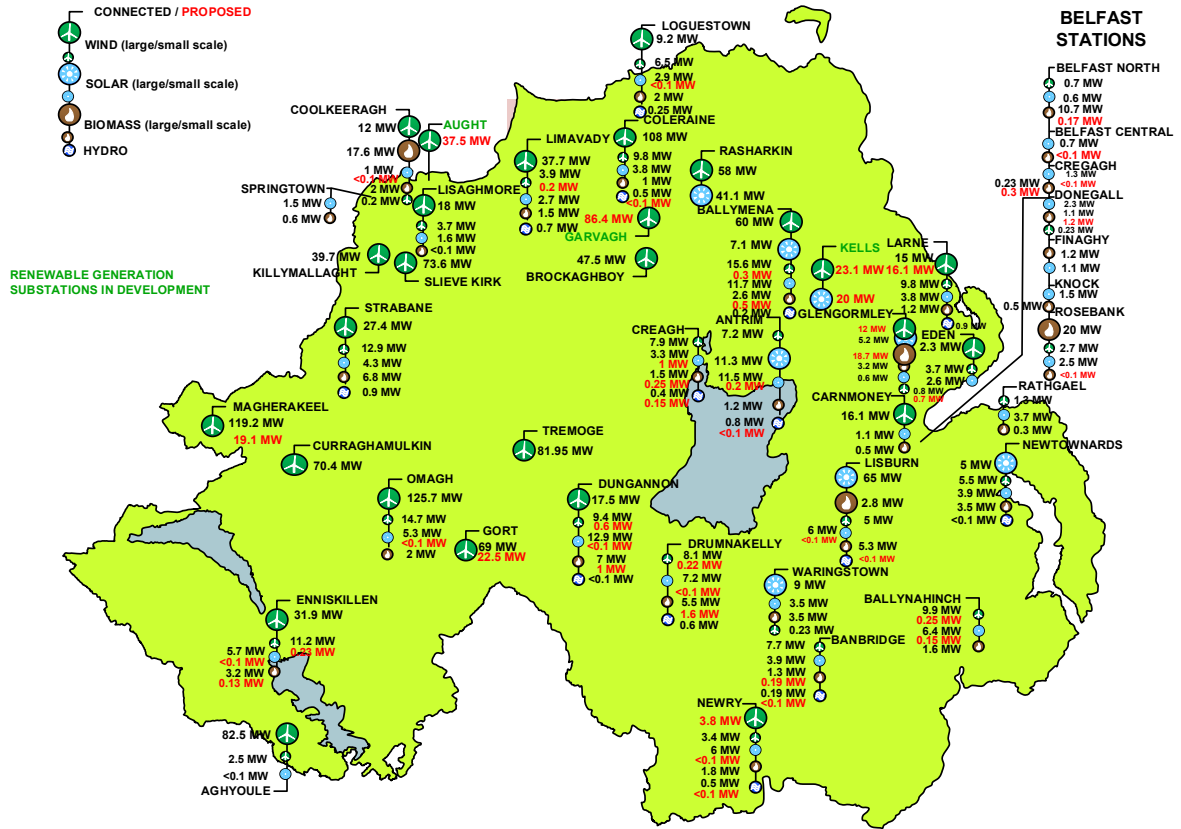
**4.2.3 Northern Ireland Renewable Generation**

**Existing/Approved Renewable Generation**

Existing and approved renewable generation in NI is shown geographically in Figure 4-2. The totals are derived from locational and capacity information on:

- Large scale renewable generation schemes that are connected to the Northern Ireland network;
- Small scale renewable generation schemes with installed capacity at each Bulk Supply Point (BSP) greater than 0.5 MW;
- Large scale schemes that are currently in construction; and
- Schemes approved by the planning service.

<sup>80</sup> Please note this figure does not include the Moyle Interconnector capacity.

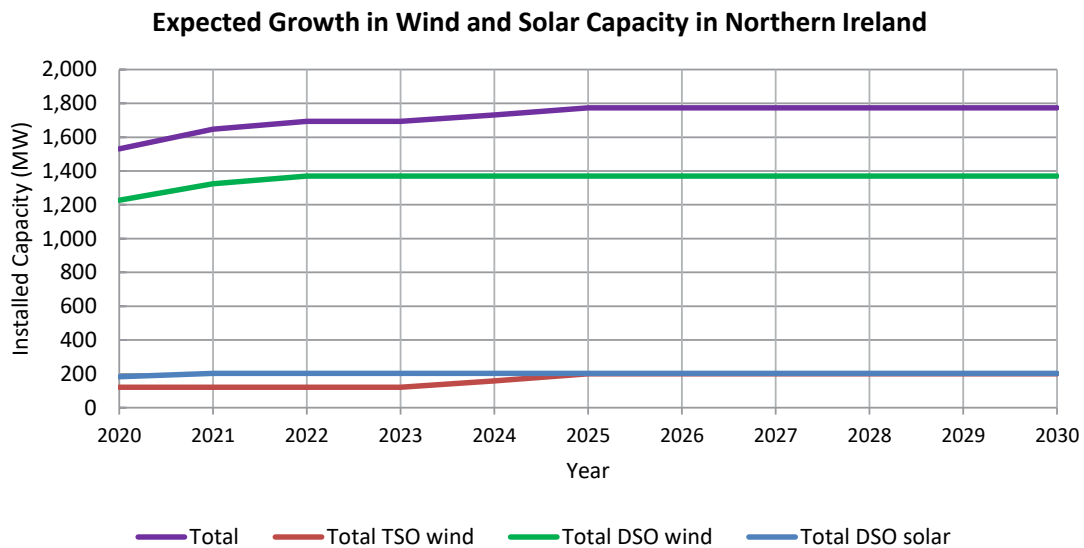


**Figure 4-2 Existing and Committed Northern Ireland Renewable Generation**

The map indicates points at which renewable generation is connected to or is assumed to connect to. These points include 110/33 kV Bulk Supply Points and 110/33 kV Cluster substations<sup>81</sup>.

Figure 4-3 shows the expected change in wind and solar generation in Northern Ireland. Only committed generators are included.

<sup>81</sup> A Cluster substation is a 110/33 kV substation in the vicinity of a number of wind farms. It acts as a local hub to group or “cluster” the wind farms. The wind farms are connected by short individual 33 kV lines to the Cluster substation. Cluster substations already exist at Magherakeel, Tremoge, Gort, Rasharkin and Curraghmulkin, with a further two planned at Agivey and Kells (see Chapter 2). SONI is responsible for the delivery of the transmission elements of the Cluster substation, in line with the criteria set out in ‘Statement of Charges for Connection to the Northern Ireland Electricity Networks’ Distribution System’: <https://www.nienetworks.co.uk/statementof-charges>



**Figure 4-3 Connected and Contracted Wind and Solar Capacity in Northern Ireland, 2021 to 2030**

Table 4-7 shows the existing and committed wind and solar generation capacity totals expected to be connected by the end of each year<sup>82</sup>. These wind and solar farms have signed connection agreements and are committed to connecting to either the transmission or distribution system over the next few years.

**Table 4-7 Existing and Committed Wind and Solar Capacity Totals (MW)**

Connection	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Wind (Transmission)	121	121	121	159	201	201	201	201	201	201
Wind (Distribution)	1324	1370	1370	1370	1370	1370	1370	1370	1370	1370
Solar (Distribution)	183	203	203	203	203	203	203	203	203	203
Total	1628	1694	1694	1732	1774	1774	1774	1774	1774	1774

### Offshore Renewable Generation

Our assumptions regarding the level and location of offshore renewable generation connected to the NI transmission system are based on best information available at the data freeze date.

For the purpose of this TYTFS analyses we assumed that there will not be any offshore renewable generation connected as at present there are no connection agreements in place. We will continue to monitor the progress with a view to incorporating offshore renewable generation if available in future TYTFS analyses.

<sup>82</sup> The individual wind farm details are included in Tables D-2 and D-3 of Appendix D.



#### 4.2.4 Demand Side Units

In 2021, demand side units (DSUs) in Northern Ireland had a combined dispatchable capacity of 135 MW.

#### 4.2.5 Distribution-Connected Generation

##### Existing Distribution-Connected Generation

Table 4-8 shows a breakdown of the existing Northern Ireland distribution-connected generation. In Northern Ireland there are more small Scale Generation compared to Ireland.

**Table 4-8 Northern Ireland Distribution-Connected Generation**

Generation	Net Capacity (MW)
Large Scale Wind	996
Small Scale Wind	163
Large Scale Biomass	23
Small Scale Biomass, CHP and Landfill Gas	69
Large Scale Solar	144
Small Scale Solar	124
Small Scale Hydro	6
Large Scale Landfill Gas	3
CHP	27
AGU	71 (83) <sup>83</sup>
<b>Total</b>	<b>1,626</b>

There is a total of 83 MW of Aggregated Generating Units (AGUs) in Northern Ireland registered in the SEM by three parties. Two of these AGUs, iPower and EmPower, consist of mostly distribution connected diesel generator sets located around Northern Ireland. The third, ContourGlobal, consists of CHP gas generation. These units currently participate in the SEM.

There is currently 6 MW of small-scale hydro generation installed on the waterways of Northern Ireland. This is a mature technology. Due to the lack of suitable new locations, limited increase in the small-scale hydro is expected in the foreseeable future.

<sup>83</sup> There is 83 MW of AGU capacity in Northern Ireland. However, this includes 12 MW at Contour Global in Lisburn, which is a CHP plant. To avoid double counting of generation, only 71 MW of AGU capacity is included in the total figure.

# 5. Transmission System Performance

All-Island Ten Year

Transmission Forecast Statement

**2021**

## 5. Transmission System Performance

This chapter describes the future performance of the transmission system in terms of compliance with planning standards<sup>84</sup>. System performance levels are assessed using:

- Forecast power flows; and
- Short circuit<sup>85</sup> current levels.

The power flow and short circuit analyses results presented in this document are based on updated information, which includes changes to:

- The existing and planned transmission system;
- Demand projections; and
- Generation connections.

This updated information is based on the best information available at the data freeze date, January 2021.

### 5.1 Forecast Power Flows

The power flows on the all-island transmission system, at any given time, depend on a number of factors, such as:

- The transmission system configuration;
- The level of demand; and
- The power output from each generator.

There are many possible combinations of generator dispatches that can meet the demand requirements. There are also many demand scenarios that may occur on the transmission system. Renewable generation connected to the all-island transmission and distribution system has the effect of altering power flows. The increase in renewable generation<sup>86</sup> is one of the main factors behind recent changes to power flows on the transmission system.

When examining transmission system performance a range of economic generation dispatches are considered. The generation dispatches used in our power flow analysis are prepared on an all-island basis<sup>87</sup>. Power flows across the existing 275 kV and planned 400 kV internal<sup>88</sup> interconnectors are modelled to operate within transfer limits. The dispatch scenarios also consider imports and exports of power across the existing Moyle and East-West interconnectors. Transmission system power flows are described in Appendix H. The power flow tables show the flow of real power on the transmission system under normal conditions.

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<sup>84</sup> Please note that different planning standards are applied in Ireland and Northern Ireland.

<sup>85</sup> Short circuit analysis was carried out on both the Ireland and Northern Ireland transmission systems.

<sup>86</sup> Projected levels of renewable generation connections are detailed in Tables D-2 and D-3 in Appendix D.

<sup>87</sup> This is reflective of how generation is dispatched in the Single Electricity Market.

<sup>88</sup> Internal to the all-island transmission system. These are the interconnectors between Ireland and Northern Ireland. This type of interconnector is also known as a tie line.

As can be seen in Appendix H, the level of renewable generation increases over the ten year period. As renewable generation increases, power flows from the West of the island to the East can be seen to increase. This is because renewable power generated in the Western regions is supplying the larger demand levels in the East (Belfast and Dublin). These increased power flows are more significant at times of minimum demand and high renewable generation output.

Another effect that can be seen in Appendix H is the effect of increased renewable generation levels on reactive power requirements on the transmission system. At high levels of renewable generation, reactive power support is needed to keep voltages within planning standard limits.

## 5.2 Compliance with Planning Standards

The transmission system is planned and operated to technical requirements and standards in Ireland and Northern Ireland. These requirements are laid out in the Transmission System Security and Planning Standards (TSSPS<sup>89</sup>) documents. These standards are in line with international standards.

The standards are deterministic<sup>90</sup> – as are those generally used throughout the world in transmission planning. They set out an objective standard which delivers an acceptable compromise between the cost of development and service delivered. Rather than conducting subjective benefit analysis in each case, it is preferable to plan to meet an objective standard and carry out analysis of the options available to meet the standard.

The need for transmission system development is identified when the simulation of future conditions indicates that the TSSPS would be breached.

### 5.2.1 Ireland

Our view of future transmission needs and our plan to develop the Irish network through specific projects to meet these needs over the next ten years is presented in our Transmission Development Plan (TDP<sup>91</sup>). The TDP presents the projects which are currently being advanced to solve the needs of the transmission network. In addition, future needs that drive future potential projects are also discussed. We issue the TDP annually.

It is possible that changes will occur in the need for; scope of; and timing of the developments in the TDP. Similarly, it is likely, given the continuously changing nature of electricity requirements, that new developments will emerge that could impact the plan as presented. The long-term development of the network is under review on an on-going basis.

TYTFS 2021 includes transmission system development projects that have received capital approval.

<sup>89</sup> The Irish transmission system is developed in accordance with the TSSPS Ireland: <http://www.eirgridgroup.com/site-files/library/EirGrid/EirGrid-Transmission-System-Security-and-Planning-Standards-TSSPS-Final-May-2016-APPROVED.pdf>

The Northern Irish transmission system is developed in accordance with the TSSPS Northern Ireland: <http://www.soni.ltd.uk/media/Northern-Ireland-TSSPS-September-2015.pdf>

<sup>90</sup> The deterministic methodology is often referred to as the N-1 criterion. The system must have sufficient capacity so that in the eventuality of a probable system outage, there are no resulting system problems such as overloading, under-voltage, over-voltage or instability.

<sup>91</sup> The latest version of the Transmission Development Plan for Ireland is available at [www.eirgridgroup.com](http://www.eirgridgroup.com).

## 5.2.2 Northern Ireland

The Northern Ireland transmission projects included in TYTFS 2021 are based on the Transmission Development Plan Northern Ireland (TDPNI<sup>92</sup>). The TDPNI is issued annually. Capital projects are mainly driven by increases in Northern Ireland demand levels and renewable generation connections. Planned developments also include load related and asset replacement projects. These projects mainly impact on the rating of switchgear<sup>93</sup> and circuits.

It is possible that changes will occur in the need for; scope of; and timing of the developments in the TDPNI. Similarly, it is likely, given the continuously changing nature of electricity requirements, that new developments will emerge that could impact the plan as presented. The long-term development of the network is under review on an on-going basis.

TYTFS 2021 includes transmission system development projects that have received capital approval.

## 5.3 Short Circuit Current Levels<sup>94</sup>

Short circuit currents<sup>95</sup> occur during a fault condition on the transmission system. Depending on the type of fault, these short circuit currents can be very high. All transmission system equipment must be capable of carrying these very high currents.

Protection devices, in particular circuit breakers, must be capable of closing onto high currents created by a fault on the transmission system. They must also be capable of interrupting high currents to isolate a fault. Correct operation is essential for minimising risk to personnel and preventing damage to transmission equipment. Correct operation of protection devices is also necessary for maintaining system stability, security and quality of supply.

Short circuit current levels must be considered as the transmission system is developed and as new generation or demand is connected. In Ireland the EirGrid Grid Code specifies short circuit current levels; these values are shown in Table 5-1. Users connecting to the transmission system are required to design their plant and apparatus to these specified levels. Equipment at lower voltage levels must also be designed to withstand short circuit current levels.

**Table 5-1: Short Circuit Current Levels**

Voltage Level (kV)	Short Circuit Current Levels (kA)	
	Ireland	Northern Ireland
400	50	50
275	n/a	40
220	40	n/a
110	Countrywide	25
	Designated sites	31.5

<sup>92</sup> The latest version of TDPNI is available at [www.soni.ltd.uk](http://www.soni.ltd.uk).

<sup>93</sup> Devices used to control, protect and isolate electrical equipment.

<sup>94</sup> Short circuit currents are also known as “fault levels”.

<sup>95</sup> A short circuit current is an abnormal current that flows along an unintended, low resistance path. Short circuit currents can be extremely high and may cause harm to personnel or damage equipment.

Table 5-1 also includes short circuit requirements for new users connecting to the Northern Ireland transmission system. Northern Ireland system users are recommended to design their plant and apparatus to withstand short circuit current levels set out in Table 5-1, as a minimum. The design of a user's plant is also subject to detailed short circuit current level assessment.

Changes to the transmission system or the addition of generation can increase the short circuit current levels at nearby<sup>96</sup> stations. Forecast increases in short circuit current levels can indicate transmission system equipment at risk of having its rating exceeded. Should this be the case, it may be necessary to replace this equipment with higher rated plant. Risk mitigation measures may also be implemented to reduce short circuit current levels. Short circuit current levels are calculated for all transmission system nodes in accordance with engineering recommendation G74<sup>97</sup>. Engineering recommendation G74 is based on international standards.

The analysis was carried out for single and three phase faults, for winter peak and summer valley studies. Short circuit current levels were assessed for the years 2021, 2024 and 2027, and the results are presented in Section 5.3.1. A description of the calculation methods used are given in Appendix E. Appendix E also provides the results of the short circuit analysis alongside an explanation of the terms used in short circuit discussions in this document.

Winter peak analysis is carried out to represent the most onerous transmission system conditions, where maximum short circuit currents on the transmission system are most likely to occur. During winter peak analysis, generators that are not providing real or reactive power are switched on in the study and dispatched at 0 MW. This measure ensures short circuit current contributions from all generator sources are considered in the studies. This ensures the most onerous, but credible conditions are used for the calculation of short circuit current levels at each bus.

Analysis of summer valley is carried out to indicate minimum short circuit currents on the transmission system based on intact network conditions. The minimum short circuit current at each bus is dependent on generation dispatch and transmission system conditions. Those requiring the expected minimum short circuit current level at a particular bus are advised to contact us directly. During summer valley analysis, generators that were not dispatched were not connected to the system.

Both the maximum and minimum short circuit current level studies assume that the transmission system is in the normal intact condition. The economic generation dispatches for the winter peak and summer valley studies are presented in Appendix D.

The results presented in Section 5.3.1 are the total busbar short circuit current levels. Short circuit current that could flow through each individual circuit breaker may be less than the total busbar short circuit current. This is dependent on network configuration and conditions.

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<sup>96</sup> This means stations that are electrically nearby, which does not necessarily mean those geographically closest.

<sup>97</sup> IEC 60909 was an international standard issued in 1988 which provided guidance on the manual calculation of short circuit currents in a three phase AC system. The conservative results produced by this method could result in over investment and Engineering Recommendation G74 was introduced by Electricity Networks Association (ENA) as an outline procedure for computer-based derivation of short circuit currents.

### 5.3.1 Assessment of Short Circuit Current Levels in Ireland

The transmission system in Ireland is designed and operated to maintain short circuit current levels below the levels in Table 5-1. In planning the system a 10% margin is applied (for example 220 kV short circuit currents will be kept below 36 kA). This is done for security reasons.

As Table 5-1 indicates, while most 110 kV stations in Ireland are designated as 25 kA, the EirGrid Grid Code stipulates that certain 110 kV stations may be designated as 31.5 kA. A new station could be designated as 31.5 kA from the start, or an existing 25 kA station may be changed to 31.5 kA. When a station changes from 25 kA to 31.5 kA, the equipment at that station may need to be modified. Station equipment at lower voltages also needs to be replaced in order to comply with this design rating.

Short circuit current results are presented in Appendix E. The results for Ireland include X/R ratios, transient AC ( $I_k'$ ) and subtransient AC ( $I_k''$ ) currents. These results provide an indication of the strength of the transmission system.

### 5.3.2 Assessment of Short Circuit Current Levels in Northern Ireland

The Northern Ireland transmission system is designed and operated to maintain short circuit current levels below equipment ratings. These ratings are listed in the tables in Appendix E, Section E.6.3. The individual substation ratings are based on the lowest rated equipment at each substation.

The Northern Ireland results in Appendix E include transmission substation ratings for:

- AC & DC X/R Ratios;
- Initial Short Circuit Current ( $I''$ );
- Peak Make Current ( $i_p$ ); and
- RMS Break Current ( $I_B$ ).

The  $I''$  and  $i_p$  values are used to assess the necessary rating of electrical equipment required to close onto short circuit currents.

The  $I_B$  values are used to assess the capability of electrical equipment required to open and break short circuit current.

### 5.3.3 Maximum Short Circuit Current Results

Short circuit current results show that a number of Ireland and Northern Ireland transmission nodes have short circuit current levels with the potential to be close to or exceed acceptable levels. Careful management of these issues is needed to ensure short circuit currents remain within acceptable levels.

Figure 5-1 indicates the locations where short circuit current levels are high in 2027. In Ireland the short circuit current level results are represented as a percentage of the levels specified in the Grid Code which are outlined in Table 5.1.

In Northern Ireland the short circuit level results are represented as a percentage of actual equipment ratings.

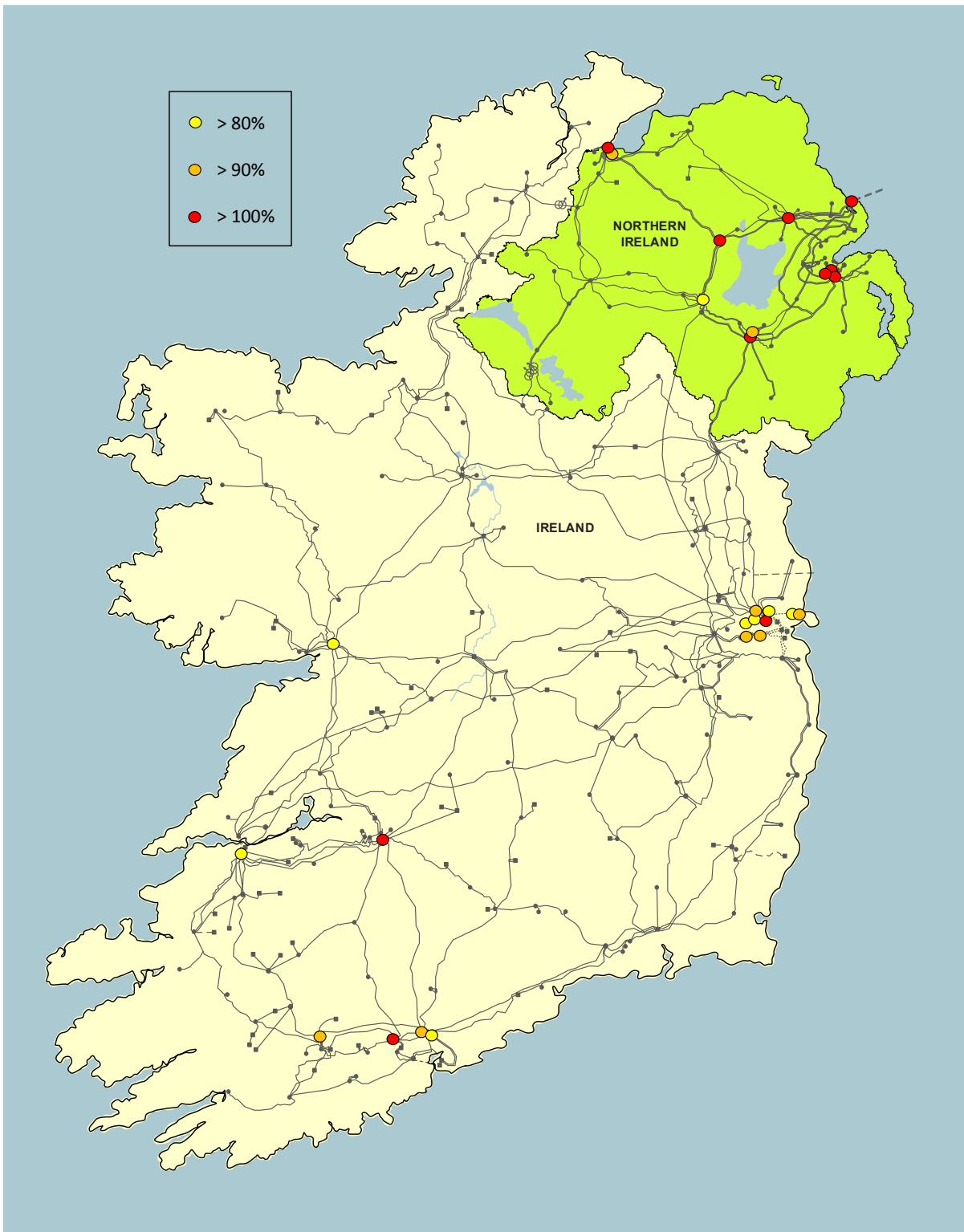
Three short circuit level ranges are represented in Figure 5-1:

- Yellow dots represent substations where short circuit current results are between 80% and 90% of the ratings;
- Orange dots represent substations where short circuit current results are between 90% and 100% of the ratings; and
- Red dots indicate substations where the short circuit current results exceed ratings.

There are a number of stations where short circuit current levels are anticipated to be above 80% of standard levels and these are indicated in Figure 5-1. We continue to monitor short circuit current levels at all stations and if required we will put mitigation plans and measures in place to ensure that they remain within safety standards. Mitigations include operational measures such as sectionalising parts of the network and investing in new equipment.

The short circuit ratings of Castlereagh, Kells, Magherafelt, Tandragee and Coolkeeragh 275 kV substations in Northern Ireland have been reduced to 10 kA following a review by NIE Networks of the ability of concrete structures at these substations to withstand mechanical forces arising from fault conditions. SONI and NIE Networks will be bringing forward projects to address this issue.





**Figure 5-1: Short Circuit Current Levels for Winter Peak 2027**

Table 5-2 below provides information on the transmission nodes for 2021; 2024; and 2027 where the short circuit current level is above 90% of the relevant level<sup>98</sup>.

<sup>98</sup> In Ireland these results are presented as a percentage of the short circuit current levels specified in the Grid Code which are outlined in Table 5.1, with the exception of KLN/Killonan 110 kV which is presented as a percentage of actual equipment ratings. In Northern Ireland they are a percentage of actual equipment ratings. Please note the Northern Ireland results in 2022 and 2025 take account of planned switchgear upratings in deriving this percentage.

**Table 5-2: Nodes Approaching or Exceeding Short Circuit Current Levels**

Rating (%)	2021	2024	2027
>100	BPS 110 kV	KLN 110 kV	KLN 110 kV
	KLN 110 kV	CAS 275 kV	CAS 275 kV
	CAS 275 kV	CPS 275 kV	CPS 275 kV
	CPS 275 kV	KEL 275 kV	KEL 275 kV
	KEL 275 kV	MAG 275 kV	MAG 275 kV
	MAG 275 kV	TAN 275 kV	TAN 275 kV
	TAN 275 kV	KRA 110 kV	KLM 110kV
			KRA 110 kV
			CAS 110 kV
		CRE 110 kV	
>90	CLA 110 kV	CLA 110 kV	CLA 110 kV
	KBY 110 kV	CDU 110 kV	CDU 110 kV
	KRA 110 kV	CPS 110 kV	CPS 110 kV
	STR 110 kV	CBT 110 kV	TAN 110 kV
		MEN 110 kV	BKY 110kV
		TAN 110 kV	CBT 110kV
		DTN 110 kV	CRM 110kV
		DRN 110 kV	DRN 110kV
		KLM 110 kV	INC 110kV
		GRA 110 kV	KUD 110kV
			MEN 110 kV
			NBY 110kV
			CKG 110kV

**Stations Where the Rating Has Been Exceeded**

Ireland Transmission Stations Where the Rating Has been Exceeded

- i. Killonan 110 kV (KLN 110 kV), Kilmore 110 kV (KLM 110 kV), Knockraha 110 kV (KRA 110 kV)

Studies indicate that the short circuit current level at Killonan, Kilmore and Knockraha 110 kV station has the potential to exceed 100% of the existing substation ratings.

The existing Killonan 110 kV substation is being refurbished to a 220 kV and 110 kV GIS station. The existing AIS station will be decommissioned. This work is due to be completed in 2027.

In the interim, we will continue to monitor and manage this risk. If required we will put mitigation plans and measures in place to ensure that the short circuit current levels at these stations remain within safety standards.

## Northern Ireland Stations Where the Rating Has Been Exceeded

### i. Castlereagh, Coolkeeragh, Kells, Magherafelt and Tandragee 275 kV

The short circuit rating of these stations have been reduced to 10 kA following a review by NIE Networks of the ability of concrete structures at these stations to withstand mechanical forces arising from fault currents. SONI and NIE Networks will bring forward projects to address these issues, and will continue to monitor the risk on-site in the meantime.

### ii. Ballylumford 110 kV

Short circuit current level at the Ballylumford 110 kV node exceed the existing substation ratings. This occurs under maximum generation conditions when both of the 275/110 kV interbus transformers are in service.

The existing substation is programmed to be replaced with a substation incorporating a new 110 kV GIS switchboard. This work is planned to be completed by 2023. In the interim, we manage this risk by operating with one interbus transformer out of service. This reduces the short circuit current level below the equipment rating.

## 5.3.4 Minimum Short Circuit Current Results

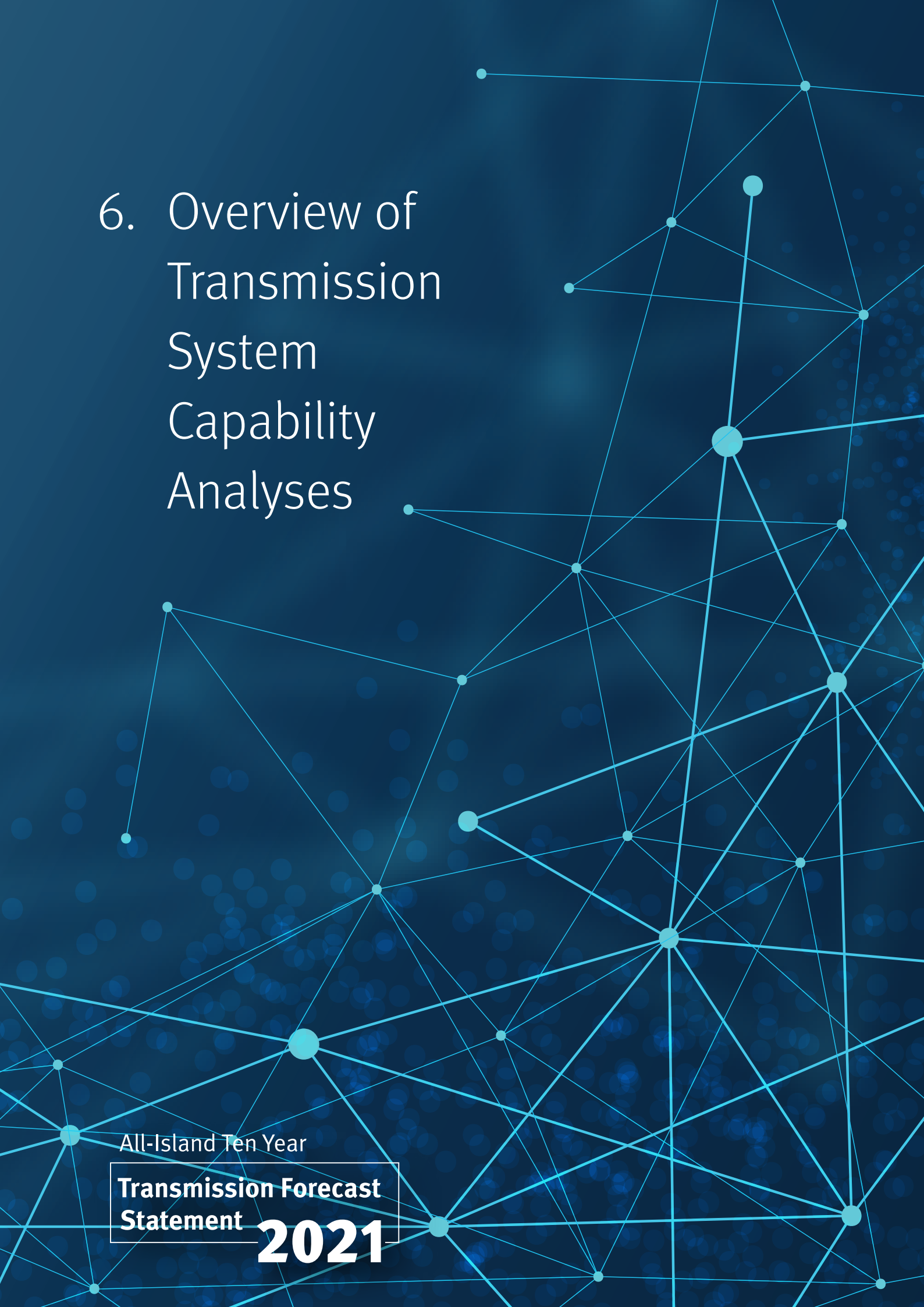
The minimum short circuit current results are presented in Appendix E. These results indicate minimum short circuit currents on the transmission system based on intact network conditions. These results are representative of the assumed generation dispatch and transmission system conditions.

Any parties requiring the expected minimum short circuit current level at a particular bus are advised to contact us directly.

The Moyle Interconnector has a minimum operating requirement of 1,500 MVA. This is equivalent to a short circuit current level of 3.15 kA. Below this short circuit current level the high voltage direct current (HVDC) interconnector fails to commute<sup>99</sup>. However, as shown in Appendix E, this is not an issue over the period covered by this TYTFS.

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<sup>99</sup> Commutation is the process of reversing the direction of electric current. It is commonly used when turning alternating current to a direct current.

A network diagram consisting of numerous light blue nodes connected by thin lines, set against a dark blue background with a bokeh effect. The nodes are of varying sizes, with some being significantly larger than others, and they are interconnected in a complex, web-like structure.

# 6. Overview of Transmission System Capability Analyses

All-Island Ten Year

**Transmission Forecast  
Statement**

**2021**

# 6. Overview of Transmission System Capability Analyses

This chapter describes analyses carried out to determine the capability of the transmission system to accommodate additional demand and generation. The results of these analyses<sup>100</sup> provide the basis for the statements of opportunity<sup>101</sup> discussed in Chapter 7 and Chapter 8.

## 6.1 All-Island Demand Opportunity Analysis

This section describes the demand opportunity analysis performed on the Ireland and Northern Ireland power systems. This analysis is used to determine the capability of the transmission system to accommodate additional demand connections at the defined areas. The statements of opportunity presented in Chapter 8 are a result of this demand opportunity analysis.

The all-island demand opportunity analysis is carried out for a single year, 2026. This year gives developers a useful indication as to the demand opportunities that exist in the medium-term on the transmission system. Studies are carried out for the summer period and the winter period of 2026/2027.

In Northern Ireland the demand opportunity analysis provides an indication of capability of the backbone<sup>102</sup> transmission network to accommodate additional demand. In Ireland, the locations analysed for new demand have been carefully chosen based on feedback from industry sources. The chosen stations have been tailored to align with potential areas that are of interest to customers seeking connection to the transmission system.

It should be noted that the results of these studies are dependent on:

- Generation assumptions;
- Demand assumptions; and
- Completion dates of transmission system development projects.
- Factors that may influence the results are discussed in Section 6.3.

### 6.1.1 Approach for Calculation of Demand Opportunity

The transmission system is planned to meet forecast demand levels at all stations in Ireland and Northern Ireland. The demand forecast for each 110 kV station is a proportion of the overall system demand forecast. This forecast is based on historical demand distributions. Future demand customers that have signed connection agreements are also included in station demand forecasts as presented in Chapter 3.

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<sup>100</sup> It is important to note that the statements of opportunity are not only based on these analyses, but also on information presented in other chapters of this document.

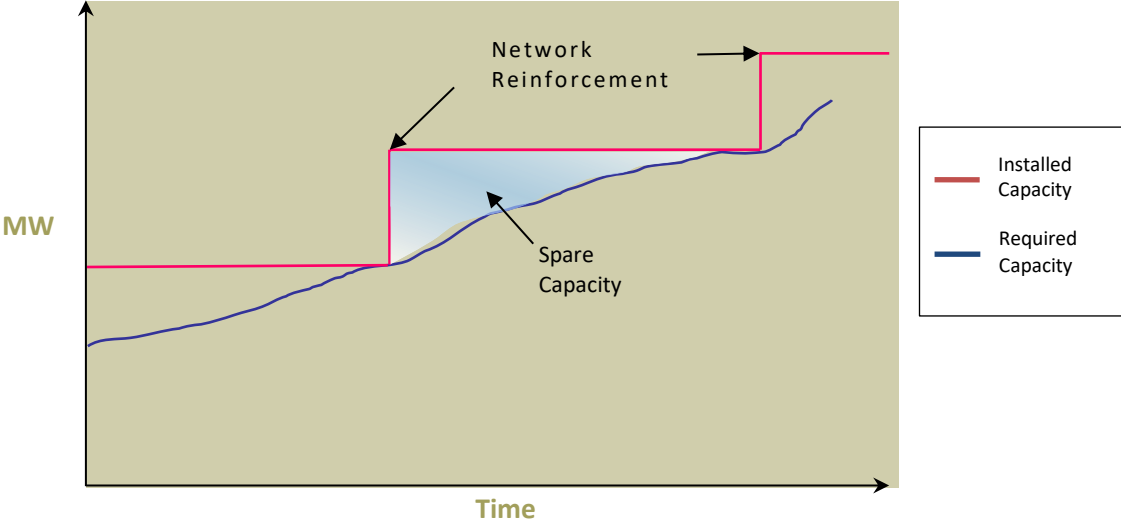
<sup>101</sup> Information on how to become a customer can be accessed at the EirGrid and SONI websites as follows

<http://www.eirgridgroup.com/customer-and-industry/becoming-a-customer/>

<http://www.soni.ltd.uk/customer-and-industry/becoming-a-customer/>

<sup>102</sup> The backbone transmission system connects local area networks together, enabling the efficient bulk transfer of electricity around the country and beyond.

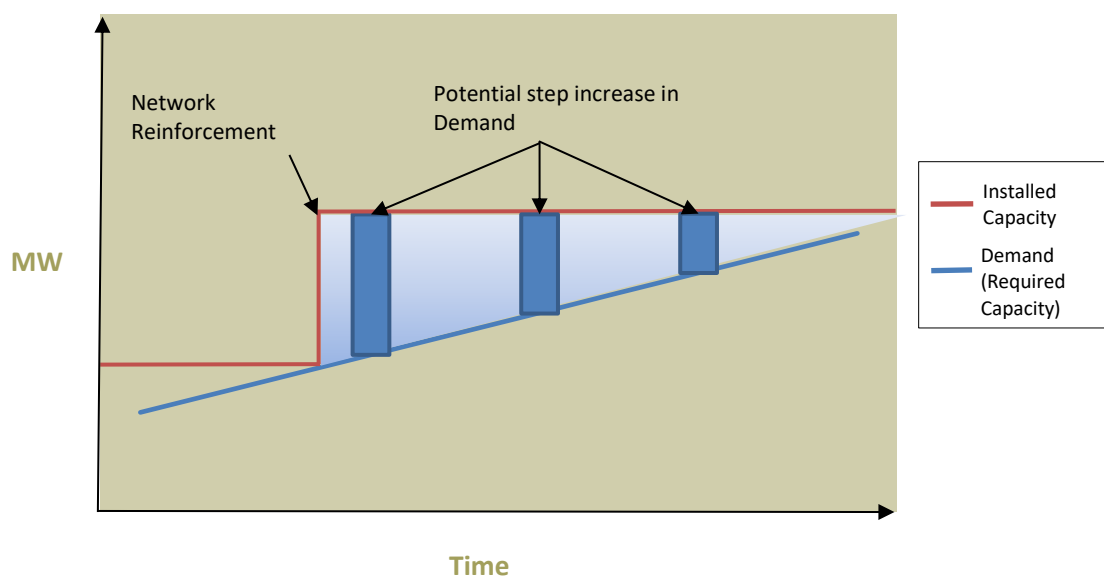
Additional demand connections above the forecast levels are not explicitly catered for in transmission system development plans. However, capacity for additional demand on the transmission system may exist at certain locations. For example, the addition of transmission system infrastructure generally provides a step increase in transmission system capacity. This addition may permit demand connections higher than forecast levels, as illustrated in Figure 6-1.



**Figure 6-1: Illustration of Typical Step Change in System Capacity Due to the Addition of Transmission System Infrastructure**

In Figure 6-1 the blue line represents the required MW capacity at a particular location on the transmission system. The red line represents the installed transmission system capacity. As Figure 6-1 shows, changes in installed capacity generally appear as a step increase following completion of a network reinforcement project. Therefore, following a network reinforcement project there is spare capacity available on the transmission system for a period of time.

In general, demand for electricity increases over time. Figure 6-2 below displays the typical demand growth profile of a typical station. The blue line represents the demand forecast at the station. The blue bars represent potential new step increases in demand that could potentially be accommodated at this typical station.



**Figure 6-2: Forecast Demand Profile of a Typical Station and Station Potential to Accommodate Additional Step Increase in Demand**

The analysis examines the transmission system’s capability to accept such increased demand above forecast levels. Capability to accept additional demand is examined at a number of 110 kV, 220 kV and 275 kV stations. The stations analysed are distributed throughout Ireland and Northern Ireland, as shown in Figure 8-1 in Chapter 8. The results of this analysis are useful in identifying opportunities for the connection of new or increased demand.

The opportunity value calculated is a measure of the transfer capability remaining in the physical transmission system. It provides an indication of the flexibility of the transmission system to accommodate future demand increases before additional reinforcements are required.

The transfer analysis is intended as a pre-feasibility indication of opportunity for increased demands. The method for determining capacity closely aligns with pre-feasibility study techniques.

In Ireland, the Ireland Transmission System Security and Planning Standards (TSSPS)<sup>103</sup> have been applied in the analyses of demand opportunities. The transmission system is assessed for the loss of any single item of plant (N-1). Unlike generators, demand stations are typically not dispatchable. It is therefore necessary to assess the transmission system performance against standards for maintenance-trip contingencies (N-1-1) in the analysis of increased demand in Ireland.

In Northern Ireland, the Northern Ireland Transmission System Security and Planning Standards (TSSPS)<sup>104</sup> have been applied for analyses of demand opportunities. The transmission system is assessed for loss of any single item of transmission plant (N-1) and loss of a double circuit (N-DCT) all year round. During the summer season the Northern Ireland transmission system is also assessed for maintenance-trip (N-1-1) contingencies for specific cases.

<sup>103</sup> <http://www.eirgridgroup.com/site-files/library/EirGrid/EirGrid-Transmission-System-Security-and-Planning-Standards-TSSPS-Final-May-2016-APPROVED.pdf>

<sup>104</sup> <http://www.soni.ltd.uk/media/Northern-Ireland-TSSPS-September-2015.pdf>

Voltage analysis is performed as part of the demand capacity studies in both Ireland and Northern Ireland. This is because the addition of demand is likely to impact on local voltage levels.

**6.1.2 Method for Calculating Limits for Increased Demand Connections**

An AC load flow linear algorithm is used to screen critical contingencies for thermal overloads or voltage limitations.

<b>What is a load flow?</b>
A load flow is a numerical analysis of the flow of electric power in an interconnected system. Load flow analysis is performed on a power system model to determine steady-state (normal operation) values such as voltages, voltage angles, real power and reactive power.

<b>What is a linear algorithm?</b>
A linear algorithm uses an interactive approach to find the solution to a numerical problem, such as determining voltages on the power system. A linear algorithm is a simple and robust method of finding a solution.

Power transfers are considered using dispatch scenarios typically experienced on the transmission system. While these dispatches are typical, we choose them for our analysis to stress the network in terms of power transfers.

By analysing different scenarios that stress the transmission system, we can reasonably ensure that the demand opportunities reported in our analysis will not breach our Transmission System Security and Planning Standards.

The conventional units selected for each dispatch scenario align with market projections for the study year 2026.

**Modelling Details**

**For single (N-1) and double circuit (N-DC) contingency studies**

- Generators are modelled with their maximum output equivalent to their Maximum Export Capacity (MEC); and
- Local wind generation is switched out in the vicinity of the test station<sup>105</sup>.

**For maintenance-trip studies (N-1-1)**

- Generators are modelled with their maximum output equivalent to their Maximum Export Capacity (MEC); and
- Some centrally-dispatchable generation local to the test station is maximised to its MEC value<sup>106</sup>.

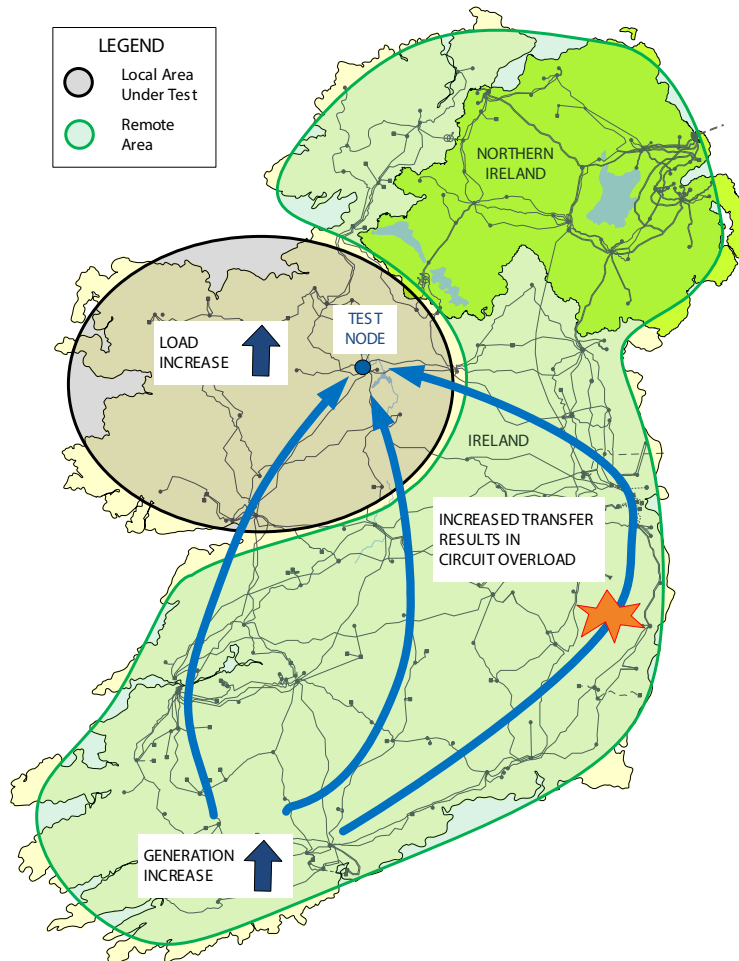
To calculate the opportunity, demand at 0.95 power factor is added to a test station in increasing amounts. This is balanced by an increase in generation<sup>107</sup> outside the local test area. This is illustrated in Figure 6-3 below.

<sup>105</sup> As renewable generation is classified as an intermittent energy source, it cannot be relied upon to serve demand.

<sup>106</sup> This is implemented to create a more favourable dispatch for the maintenance case.

<sup>107</sup> Generation increased as per merit order.





**Figure 6-3: Illustration of Incremental Transfer Capability Study Method for Demand**

The limit for increased transfers to the test station is then established. This is achieved by checking the post-contingency performance of the transmission system against thermal and voltage standards. This process is carried out for each dispatch scenario studied. Issues on the transmission system are not considered limiting unless they are sensitive to the incremental transfers under examination.

### Calculation of Results

As noted above we undertake a range of contingency studies (N-1, N-1-1, N-DCT) to calculate the capability for increased demand at each station studied.

For the maintenance-trip studies (N-1-1) in Ireland, less onerous generation dispatches can be scheduled to accommodate maintenance outages.

The results of this analysis are reported in Chapter 8. The demand opportunity reported is the lowest demand increase achieved from the range of studies undertaken. It is important to note that results of the demand opportunity analysis are indicative only. Demand opportunity is tested at each station on an individual basis. As such, the opportunities presented are not cumulative. If new demand connects in an area that is currently shown to have capacity, this will then use up some or all of the available capacity in that area.

Potential demand customers should not be discouraged by choosing a site in which there appears to be a lack of transmission system capacity. The actual transmission capacity can only be determined during the connection offer process. Early consultation with us is encouraged so that we can work jointly to explore options relating to any potential proposals and enable timely decision making. Customers considering connecting demand to the transmission system are advised to contact us as early in the project as possible.

### **6.1.3 Calculation of Capability for Demand in Dublin**

The Dublin region is the largest demand centre on the all-island transmission system. Dublin has been and remains the focus of continued interest for the connection of new large demand.

There has been a significant increase in the number of enquiries and applications for new demand connections in the Dublin region and its environs in recent years. Many of these requests are for data centres. Data centres present relatively flat load profiles that impact on both the minimum and maximum demand requirements in the region.

The Dublin 220 kV transmission network is operated by EirGrid, the transmission system operator (TSO). The radial 110 kV circuits are operated by ESB Networks, the distribution system operator (DSO). System development and operation in the area requires both system operators to work closely together. This is to ensure power flows are optimised and to facilitate new connections.

Due to the volume of demand enquiries and applications received for the Dublin area, and their potential impact, Section 8.3 of this document focuses on the demand opportunities in the Dublin region.

The Dublin region has been divided into three geographic zones (see Figure 8-3 in Chapter 8), namely the North, West and South. This is aimed at providing a more detailed insight into the available connection capacity. This takes into account the three main corridors servicing the main bulk supply points<sup>108</sup>.

The methodology used to consider demand opportunities in the Dublin region is based on the existing transmission system. It also includes criteria, such as:

- How each zone is expected to develop; and
- The associated lead times for project delivery.

### **6.1.4 Calculation of Capability for Demand at Any Station Outside Dublin**

This section provides a general example of the analysis of the capability of any station studied in Chapter 8 to accept additional new demand.

The assessment is carried out by simulating the transmission system for summer peak and winter peak 2026. The station is tested to accommodate increased demand. The relevant demand forecasts and generator dispatches are used.

Due to its variable nature, wind generation cannot be relied on to meet the demand at all times.

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<sup>108</sup> These main bulk supply points act as the transmission to distribution interfaces in the region.

Therefore, all wind generation in the vicinity of the test station is switched off. Studies are carried out according to the dispatch scenario assumed. The extra demand in each study is met by increasing generation according to the merit order. For each study in turn, a test demand (for example 100 MW) is added to the station under study. The power system is then analysed using an AC load flow linear algorithm.

The analysis tests an exhaustive range of N-1 contingencies (individual circuit/transformer or generator outages) to identify any resultant TSSPS violations. Thus TSSPS violations identify a capacity limit. Some contingencies cause violations of thermal overload or voltage standards at the maximum capacity. In these cases, the analysis reverts to 0 MW and performs the test in increasing steps, 10 MW in size. The test runs in increasing steps until a violation of thermal overload or voltage standards occurs. The preceding step value is then the calculated capacity value.

In assessing opportunities for new demand, the TYTFS considers the capability of the transmission system only. The capability of the distribution system is not addressed in Ireland or Northern Ireland. The implications for generation adequacy of demand growth above the median forecast levels are dealt with separately in the All-Island Generation Capacity Statement 2021-2030 (GCS) which is available on the EirGrid and SONI websites.

## 6.2 All-Island Generator Opportunity Analysis

This section describes the generation opportunity analysis performed on the Ireland and Northern Ireland power systems. This analysis is used to determine the capability of the transmission system to accommodate additional generation connections at the defined areas. The statements of opportunity presented in Chapter 7 are a result of this generation opportunity analysis.

The generation opportunity for a selection of nodes across the all-island transmission network is presented in Chapter 7. The final year of this forecast statement, 2030, is used in the analysis. The analysis is performed using an AC load flow linear algorithm, the same approach used in the demand opportunity analysis.

In Chapter 7 we also include information on the harmonised all-island Transmission Use of System (TUoS) tariffs and Transmission Loss Adjustment Factor (TLAF) arrangements in the SEM. The all-island TUoS and TLAF arrangements have an objective to provide locational signals to generators that reflect the costs they impose on the transmission system<sup>109</sup>.

This information is provided to help generators make informed decisions when exploring potential transmission network connection locations.

All information relating to generation opportunity presented in Chapter 7 is indicative only. The actual transmission system capacity can only be determined during the connection offer process.

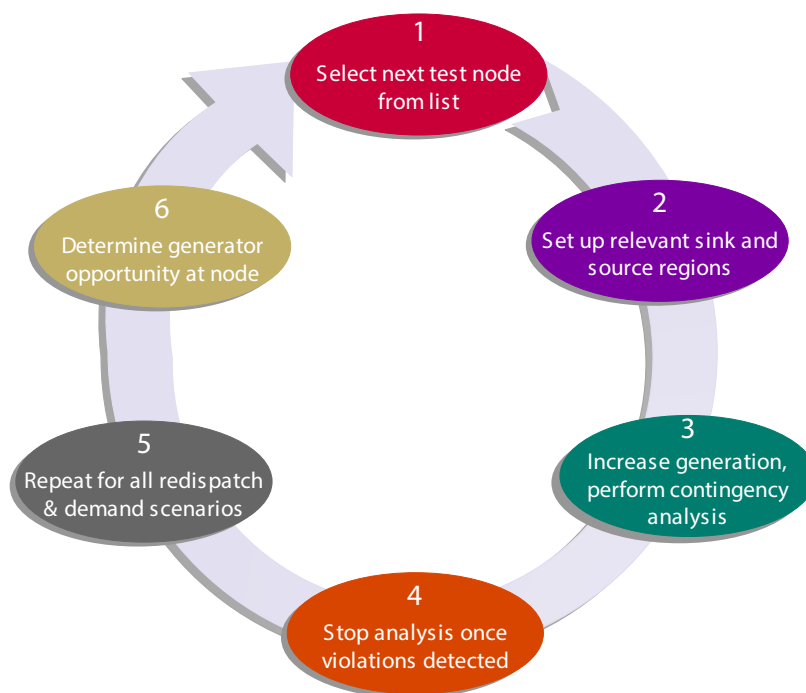
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<sup>109</sup> This is not the only objective of the charges and losses arrangements in SEM.

### 6.2.1 Approach for Calculation of Generation Opportunity

Generation opportunity at a node is assessed via the use of an AC load flow linear algorithm. It is based on the premise that new generation at a particular point on the network will displace generation at a different point on the network. Figure 6-4 presents a simple illustration of the calculation methodology used for the generator opportunity analysis.

All existing generation, and all generation planned to connect in Ireland and Northern Ireland during the period covered by the TYTFS, is considered for dispatch before assessing any further generation opportunity on the all-island transmission network.



**Figure 6-4: Generator Opportunities Analysis Methodology**

We compiled a list of 110 kV, 220 kV, 275 kV and 400 kV nodes for generation opportunity analysis. These nodes are distributed across the all-island network so that potential users can understand how opportunities vary across the network.

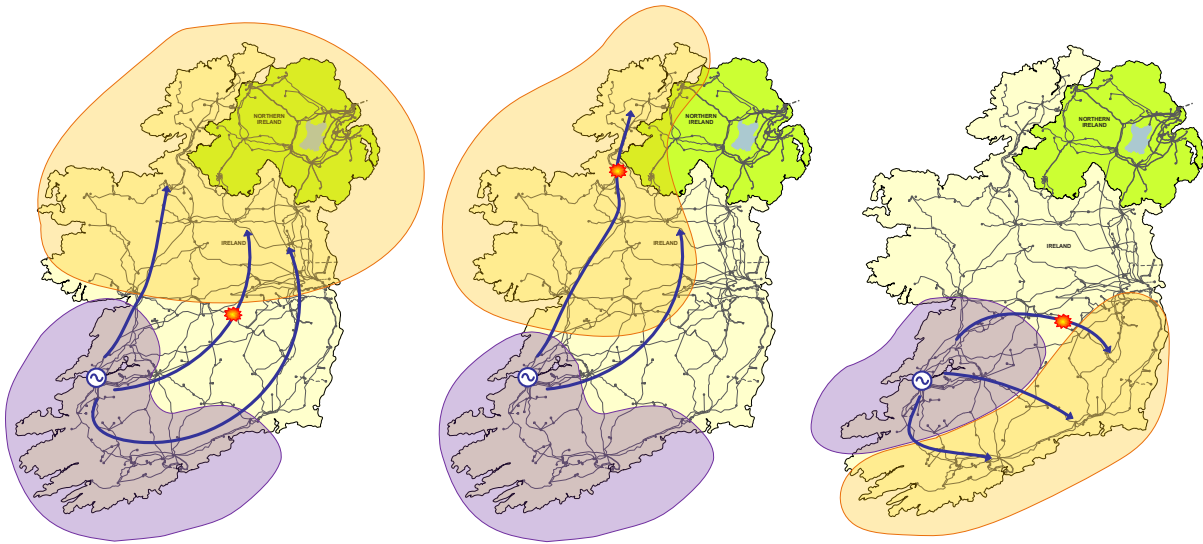
When testing a node, existing generation in the area around the node is maximised; this group of generators is referred to as the source region. The remaining generation required to meet the demand is dispatched based on a merit order. Finally, the test generator is then dispatched.

As the output of the test generator increases, the output from other generation in a separate area of the network - the sink area - is reduced. This forces power flows along specific corridors of the transmission network.

For each incremental increase in new generation capacity at the test node, an AC load flow linear algorithm is used to test the network for compliance with the TSSPS. The generation opportunity is determined once overloads are detected on the network.

For the generation opportunity analysis, single (N-1) and double circuit (N-DCT) contingency studies only are considered.

For each node assessed, three different analyses are performed. Figure 6-5 demonstrates an example of this approach.



**Figure 6-5: Illustration of Incremental Transfer Capability Study Method for Generation**

For each scenario in the illustration, the purple area represents the source region where generation is maximised. The test generator is then increased, and generation in the orange area - the sink region - is reduced. The blue arrows represent the resulting power flows. These three scenarios are then repeated for the following network demand scenarios:

- Winter peak;
- Autumn peak (Northern Ireland only);
- Summer peak; and
- Summer valley.

The lowest result from all of the scenarios analysed is used to determine the capacity of the node under test. By analysing several scenarios across different demand scenarios that stress the transmission system, we can reasonably ensure that the generation opportunities reported in our analysis will not breach our Transmission System Security and Planning Standards.

It is important to note that results of the generation opportunity analysis are indicative only. The results of the analysis are not cumulative, as the capability of a node to accept new generation capacity is tested individually.

The transmission system is planned to meet forecast generation levels at all stations in Ireland and Northern Ireland. Additional generation connections above the forecast levels are not explicitly catered for in transmission system development plans. However, capacity for additional generation on the transmission system may exist at certain locations.

Because of the relative size of individual generators, changes in generation installations, whether new additions or closures can have a more significant impact on power flows than demand. New generation capacity will inevitably alter the power flows across the network, which has the potential to create overload problems deep into the network. Problems deep into the network are resolved by network reinforcements known as deep reinforcements.

The generation opportunity analysis presents the level of generation that can be accommodated on the planned transmission system without the need for deep reinforcements to allow full network access.

### 6.3 Factors Impacting On Results

The results of the analyses<sup>110</sup> described in this chapter are based on a set of assumptions. These assumptions are associated with:

- Future demand growth;
- Generation connections; and
- Transmission system developments.

The key forecast factors on which the results depend are dynamic. Therefore, the reality that emerges will not exactly match the forecasts. Consequently, the results, while reasonably indicative, should not be interpreted as definitive projections.

The factors likely to have an impact on the outcomes include:

- The signing of a connection agreement by a new generator;
- Delays in connection of committed new generation stations;
- Closure of existing generation stations;
- Changes in the economy which give rise to consequential changes in the overall demand for electricity;
- Changes in demand in a particular region or area, arising from new industry developments or closures;
- Delays in the provision of transmission system reinforcements; and
- Selection and construction of new transmission system reinforcement developments which may significantly increase transmission system capacity.

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<sup>110</sup> The results are presented in Chapter 7 and Chapter 8.

# 7. Transmission System Capability for New Generation

All-Island Ten Year

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# 7. Transmission System Capability for New Generation

## 7.1 Summary of analysis

The results of the Generation opportunity analysis for this statement show that there are opportunities for new generation of significant scale in the east of the island, in particular in the east of Northern Ireland, Greater Dublin area and in the North east. Generation opportunities in other areas will rely on delivery of network reinforcements including those identified in ‘Shaping Our Electricity Future’ analysis. With significant quantities of renewable generation connected across the island, future generation connections in the North-West, West and South-West regions would require network reinforcements.

The areas with the greatest opportunity for additional generation are at nodes on the 275 kV ring in Northern Ireland, and 220 kV stations in the Dublin area. While an area may have capacity for new generation connections, it should be noted that development of substantial levels of generation in a concentrated area of the network could create a range of complex issues, in particular breaches of short circuit levels.

## 7.2 Background

In this chapter we provide the results of the detailed generation capacity opportunity analysis, of which the calculation methodology is described in Chapter 6.

The analysis considers the final year of this statement (2030) and details the opportunity for connecting further generation beyond the assumed installed generation portfolio. The results provide potential network users with an indication of the capacity of the all-island transmission system to accept new generation. It must be emphasised that this analysis is purely indicative. The actual transmission network capacity can only be determined during the connection offer process. This process requires detailed network assessments in order to determine the optimal connection arrangement that complies with the Transmission System Security and Planning Standards (TSSPS) in Ireland and Northern Ireland.

Changes to generation dispatch patterns and the geographical location of generation can have an impact on all-island transmission network power flows. As a result, Generator Transmission Use of System (GTUoS) tariffs and Transmission Loss Adjustment Factors (TLAFs) can change, resulting in an impact on the economics of power generation. Resulting regional changes in GTUoS and TLAFs are described to help participants make informed decisions when exploring potential transmission network connection locations.

It is important to note that generation opportunity studies in this TYTFS are based on contracted customer connections and approved transmission reinforcements at the data freeze date. This differs from Shaping Our Electricity Future which assumes generation connections in addition to those already contracted. Shaping Our Electricity Future assumes that aggregated renewable generation capacities in 2030 exceed those assumed in the TYTFS. Future iterations of the TYTFS will take the outcome and progress of Shaping Our Electricity Future into account, including new generation customer connections.



## 7.3 New Generation Capacity

The level of generation expected to connect to the all-island transmission system is described in detail in Chapter 4 of this statement.

The largest recent generation capacity increase has been wind generation. At the freeze date of January 2021 there was approximately 5700 MW connected to the all-island transmission system.

This generation is mainly connected in remote locations in the South-West, West and North-West of the island of Ireland. At times of high wind generation, this can result in very high power flows on transmission circuits supplying power to the large demand centres on the East coast of Ireland and Northern Ireland.

Currently there is a relatively small amount of solar generation capacity connected to the all-island transmission system.

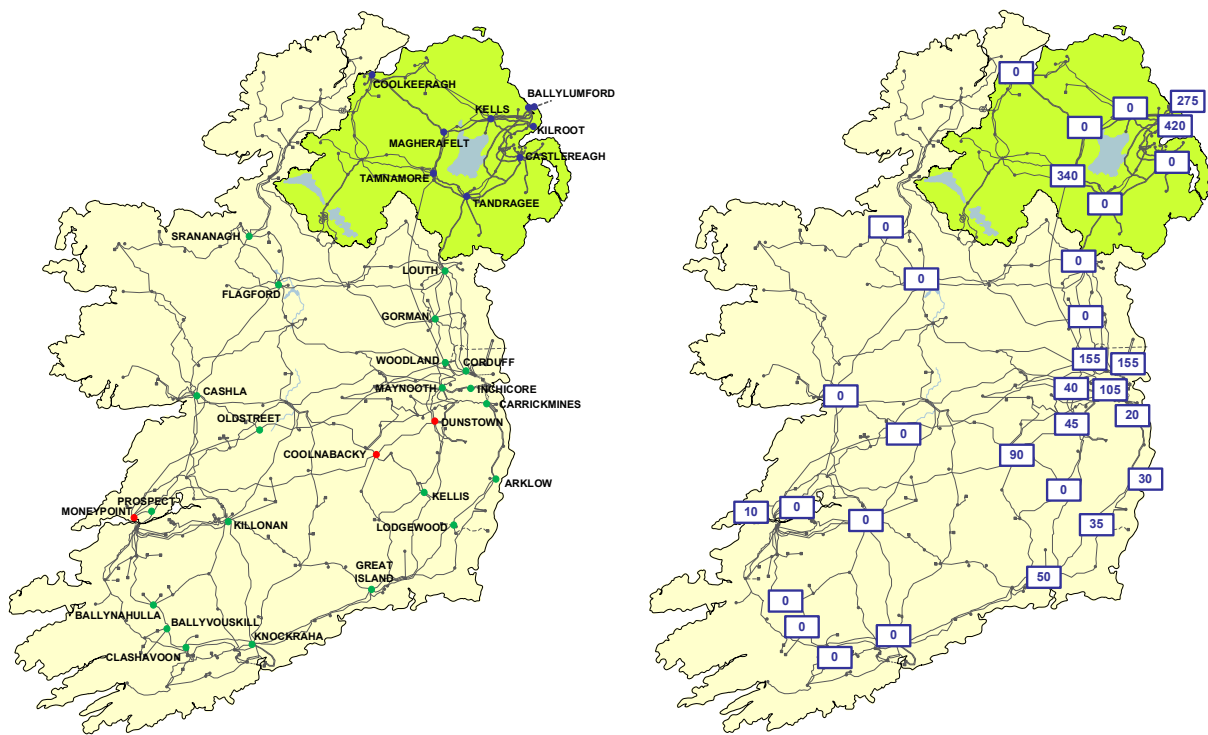
In contrast, there are several large conventional power stations due to retire, or to have restricted output, due to the EU Industrial Emissions Directive. These are detailed in All-Island Generation Capacity Statement 2021-2030 and are noted in Chapter 4 of this document. For the purpose of the TYTFS 2021 analysis, it is assumed that sufficient generation capacity will be delivered in appropriate locations to ensure generation adequacy and security of supply are maintained.

It is important to note that we are currently working with CRU and the Department of the Environment, Climate and Communications (DECC) to address short to medium term generation adequacy concerns in Ireland. Current analysis and projections for Northern Ireland indicate there is sufficient capacity in the short to medium term to meet system needs, however there are risks around low plant availability, plant run hour restrictions, delays to North-South Interconnector which would impact the adequacy position in the short to medium term. The adequacy position for Northern Ireland is being monitored on an on-going basis.

## 7.4 Generation Opportunity

### 7.4.1 Assessment of Selected 220 kV, 275 kV and 400 kV Stations

This section provides the opportunities for additional generation on the 220 kV, 275 kV and 400 kV networks in 2030. For these high voltage stations, new generation of up to 600 MW in size was considered for assessment. Figure 7-1 illustrates the stations selected across the all-island network, as well as their associated generation opportunity. It is important to note that the results are not cumulative, as the opportunity at each station is assessed individually. The capacities shown are relevant to the station tested, but also provide an indication of the opportunities available at neighbouring stations.



**Figure 7-1 Generation opportunity at 220 kV, 275 kV and 400 kV stations in 2030**

In general, there is no opportunity for new generation in the North, West and South of Ireland. The transmission network in these areas has significant levels of connected and planned renewable generation. Moreover, the southern region contains efficient conventional gas generators and plans for further interconnection. In the East, and to a lesser extent South-Eastern region, there are opportunities for new generation connections near the large demand centres.

With the potential development of large data centres in the Dublin area, there will be increased generation opportunities at stations around Dublin beyond that indicated in this analysis.

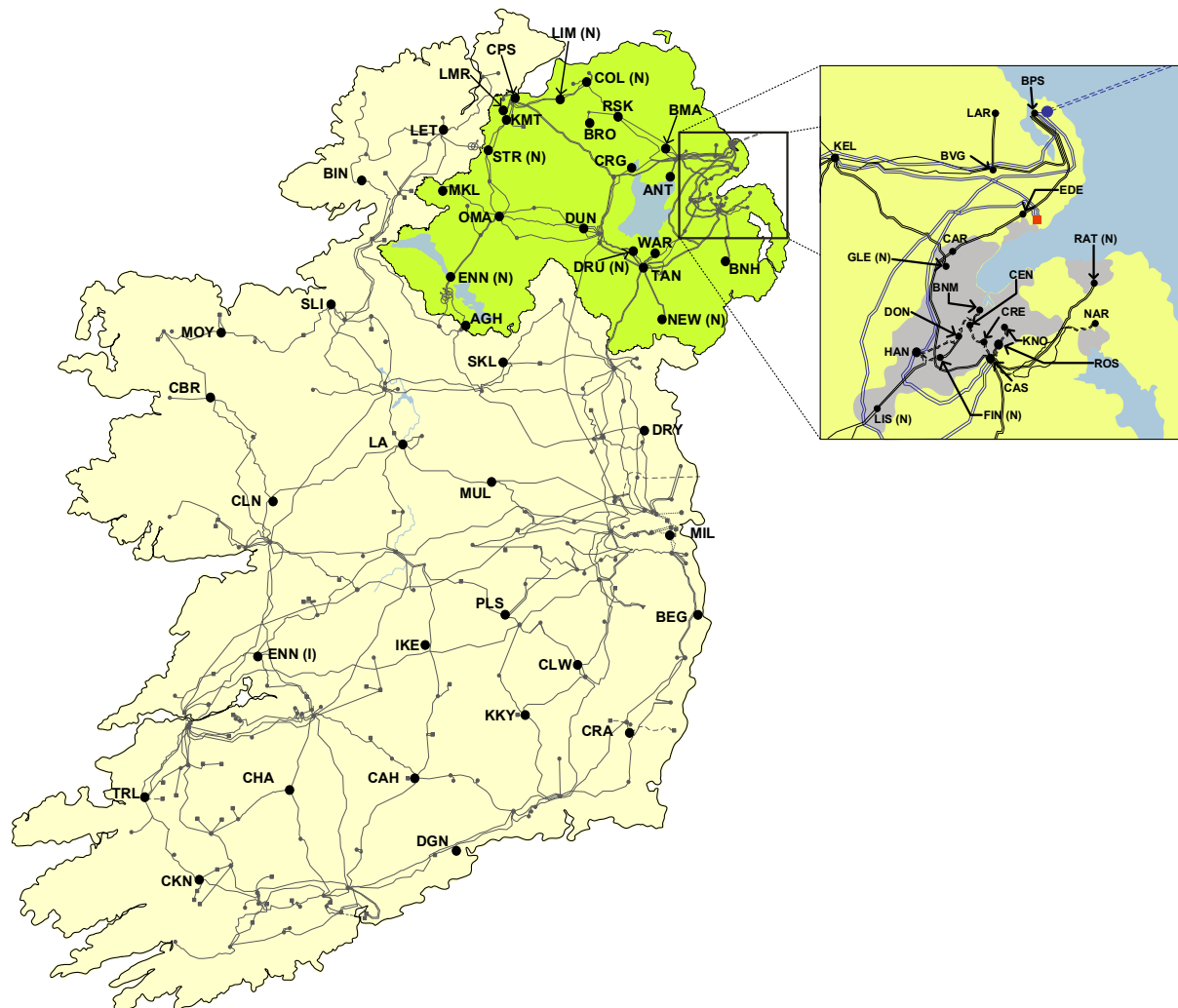
In Northern Ireland, there is currently very little opportunity for new generation in the North-West region, although this may change in future. This area has significant levels of renewable generation, both connected and planned, and the transmission network consists almost entirely of 110 kV circuits. There is currently no capacity for new synchronous generation to be directly connected at Coolkeeragh, Magherafelt, Tandragee, Castlereagh and Kells 275 kV stations. This is because the mechanical forces created by the additional fault current of directly connected generation would exceed the original design specification. SONI and NIE Networks will be bringing forward projects to address this issue, however these are at an early stage. The fault contribution from non-synchronous connections such as wind farms and data centres tend to be significantly smaller, particularly those likely to connect at 110 kV. Any potential connection at these nodes would therefore be assessed based on its fault current contribution.

### 7.4.2 Assessment of Selected 110 kV Stations

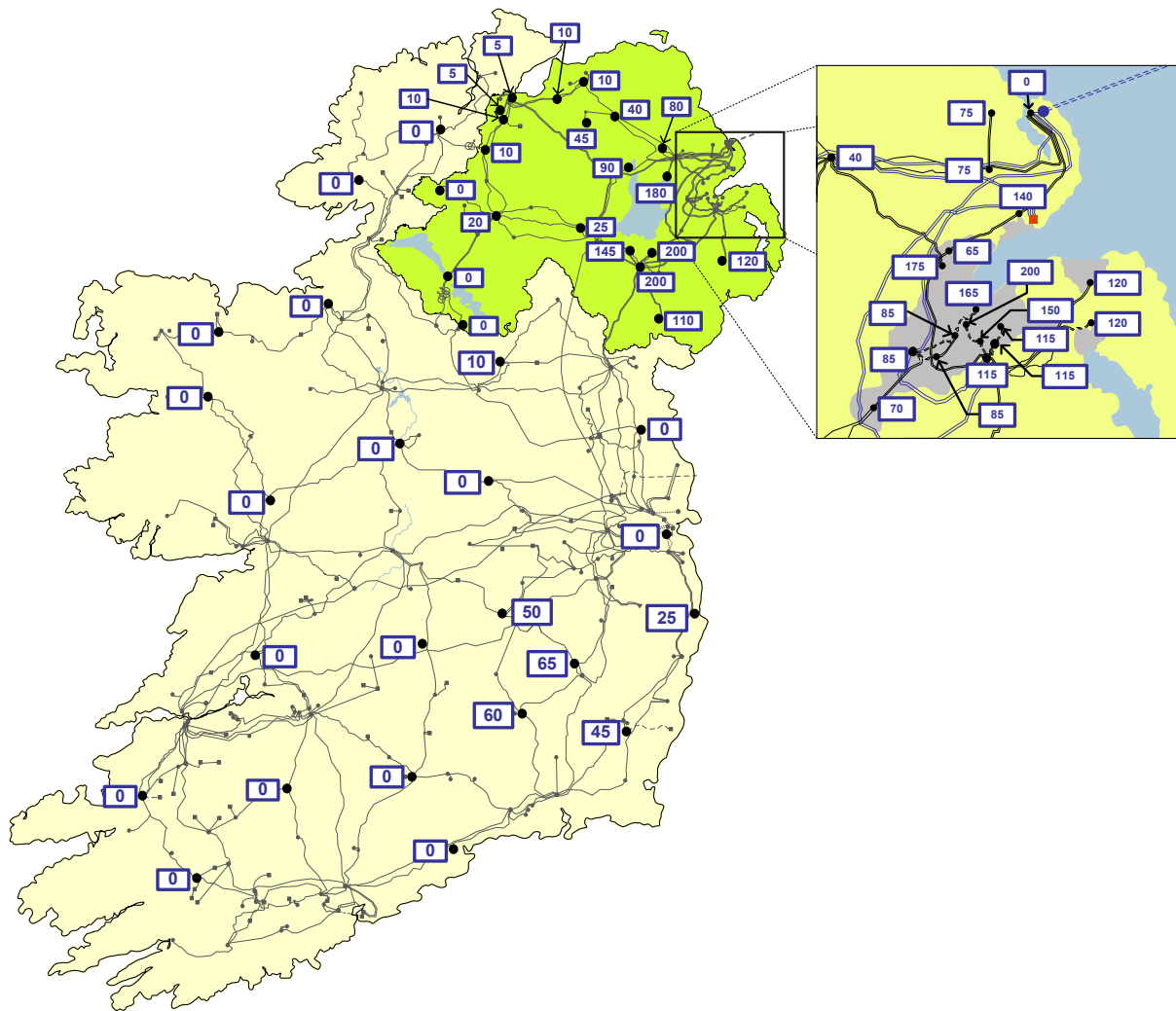
Numerous 110 kV stations were analysed to complement the higher voltage stations analysed in Section 7.4.1. For these stations, new generation of up to 200 MW in size was considered in the assessment for all 110 kV nodes. Selected stations are displayed in Figure 7-2, and the associated generation opportunity for each of the stations is displayed in Figure 7-3.

As in the previous section, the results are not cumulative, as the opportunity at each station is assessed individually. The capacities shown are relevant to the station tested, but also provide an indication of the opportunities available at neighbouring stations.

The results show that there is little opportunity for generation connections at 110 kV. By 2030, there is a high level of renewable generation connected to both the transmission and distribution systems in Ireland. The renewable connections are concentrated in the North-West, West and South-West. The installed capacities will exceed the demand in these areas, resulting in limited opportunities for new connections without additional reinforcements.



**Figure 7-2: Selected 110 kV stations for the generation opportunity studies**



**Figure 7-3: Generation opportunity at the selected 110 kV stations in 2030**

Some capacity for additional generation is available within the 110 kV network at some nodes in the South-East and Midlands of Ireland. This is due to the presence of large demand centres, the lower penetration of renewable generation, as well as the strength of the transmission network in this region. Detailed connection studies are required to determine more accurate quantities of available capacity and connection arrangements.

High levels of additional renewable generation are expected to connect to the distribution and transmission systems in Northern Ireland by 2030. This generation in the North and West of Northern Ireland is greater than local demand and causes congestion in the transmission network. Consequently, these regions have a low potential for additional connections.

Opportunities for generation connections are possible in the East of Northern Ireland. This is due to lower congestion within the transmission network, and higher demand density. Similarly, with the assessment of the generator opportunities for the high voltage network, these results are only indicative of the potential for connection in the network. These figures are, furthermore, not cumulative as the nodes are assessed in isolation.

## 7.5 Generation Locational Tariff Signals and Their Impact on Transmission Network Capacity

Harmonised transmission arrangements provide locational signals to users reflecting the costs they impose on the transmission system. TLAFs and GTUoS tariffs, as part of harmonised transmission arrangements, can provide generators with locational signals informing their decision on where to connect to the grid and incentivise efficient generation dispatch.

Electrical losses, which occur as electricity is transported along transmission circuits, are accounted for in the settlement process with the application of TLAFs. Some units are responsible for proportionally more transmission losses than others, depending on their point of connection to the grid and use of transmission network capacity.

The methodology used by the transmission system operators (TSOs) to calculate the TLAFs has been approved by the regulatory authorities.

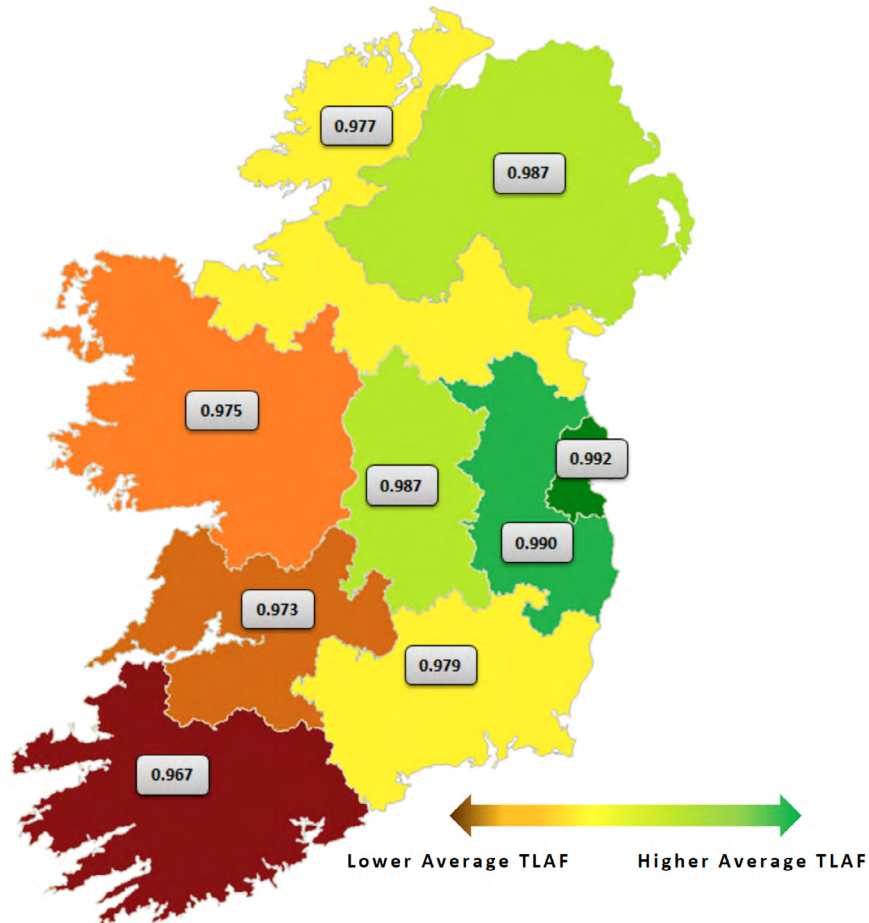
The most efficient way to transfer power in terms of losses is to minimise the distance between generation and demand, and not to heavily load lines. Due to the location and amount of demand and generation, power can be transmitted over sizeable distances. If the power generated in a region is in excess of the demand in that region, the excess generation will be utilised some distance away from the source.

The transmission network consists of high voltage overhead lines and cables ranging from 110 kV to 400 kV. When current flows across these circuits, some energy is lost as heat. The higher the power transmitted on a line, the higher the current. Current has a squared relationship to power losses, therefore if the power on a line is doubled, the losses will increase by a factor of four. In general, transmitting power on a higher voltage level will lower the associated current. The associated losses will be dependent on how congested the line is; increasing power on an already congested line will result in greater losses than increasing power on a similar less congested line. The Transmission Use of System (TUoS) tariff is the main tariff for transporting power in bulk, across the power system. Generator Transmission Use of System (GTUoS) tariffs contains a locational component, which provides a signal of the costs associated with a generator's use of the transmission network.

Such signals provide a commercial incentive for generators to make informed decisions (both siting/entry and exit decisions) concerning their use of the transmission system. This is intended to improve efficiency in respect of both the use of, and investment in, the transmission system.

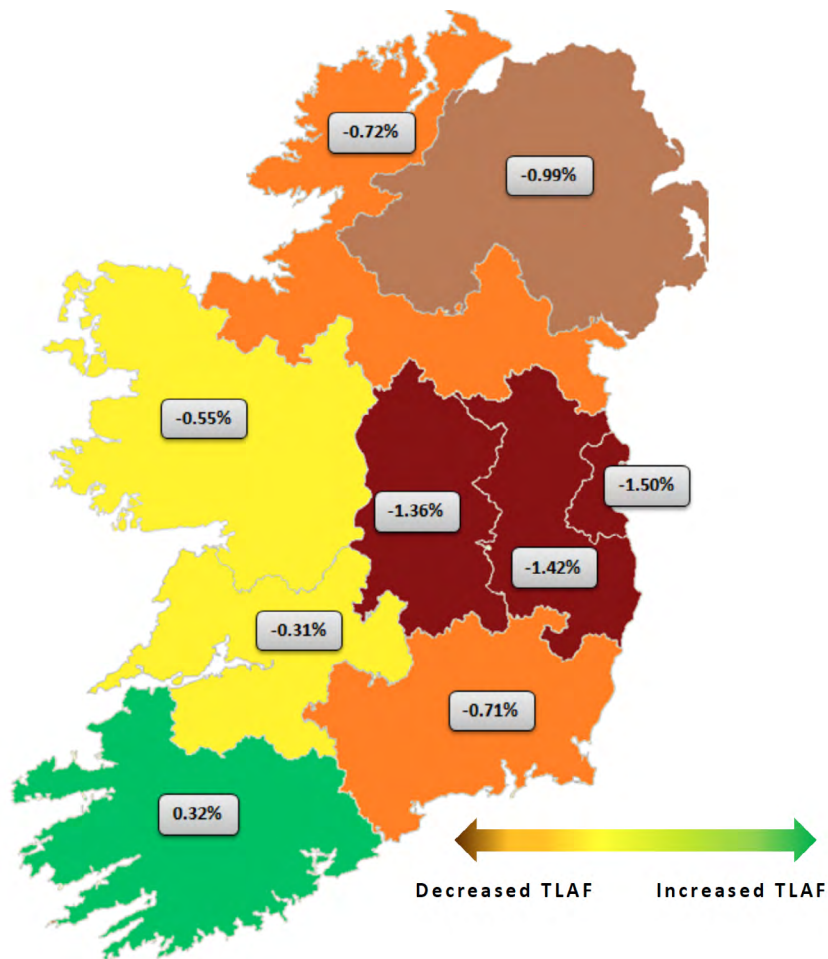
### 7.5.1 TLAFs

Generator TLAFs are reflective of their contribution to transmission losses. The principle is that market participants that contribute more to transmission losses, due to their location, should have a lower TLAF, than those generators who contribute less to transmission losses. The regional average 2021/22 TLAF values are shown in Figure 7-4 and are based on the published approved 2021/22 TLAF values.



**Figure 7-4: All-island 2021/22 regional average TLAF values**

Figure 7-5 shows the change in TLAFs between 2020/21 and 2021/22. These changes are influenced by yearly dispatch, demand and topology changes.



**Figure 7-5: % TLA Change between 2020/21 & 2021/22**

The information presented in Figures 7-4 and 7-5 should be used as regional indicators. For the 2021/22 tariff year, the average all-island TLA has decreased by 0.52%. The average TLAs for the Dublin and Northern Ireland areas have seen the largest decrease between 2020/21 and 2021/22, however, as shown in Figure 7-4, their average TLAs remain high and above average when considering all-island TLAs. TLAs for the Dublin region are relatively high as there tends to be local use of generation, with an increasing demand. Local use of generation also typically supports the relatively high Northern Ireland TLAs. Further information on the 2021/22 TLAs can be found on the EirGrid and SONI websites.

# 7.6 GTUoS

The regional average 2021/22 GTUoS tariffs are shown in Figure 7-6, and are based on the approved 2021/22 GTUoS tariffs. Higher GTUoS tariffs are reflective of transmission investment costs linked to a generator’s use of the system. This promotes efficient use of the transmission system by generators, which should, in turn, facilitate efficient investment in the transmission system.

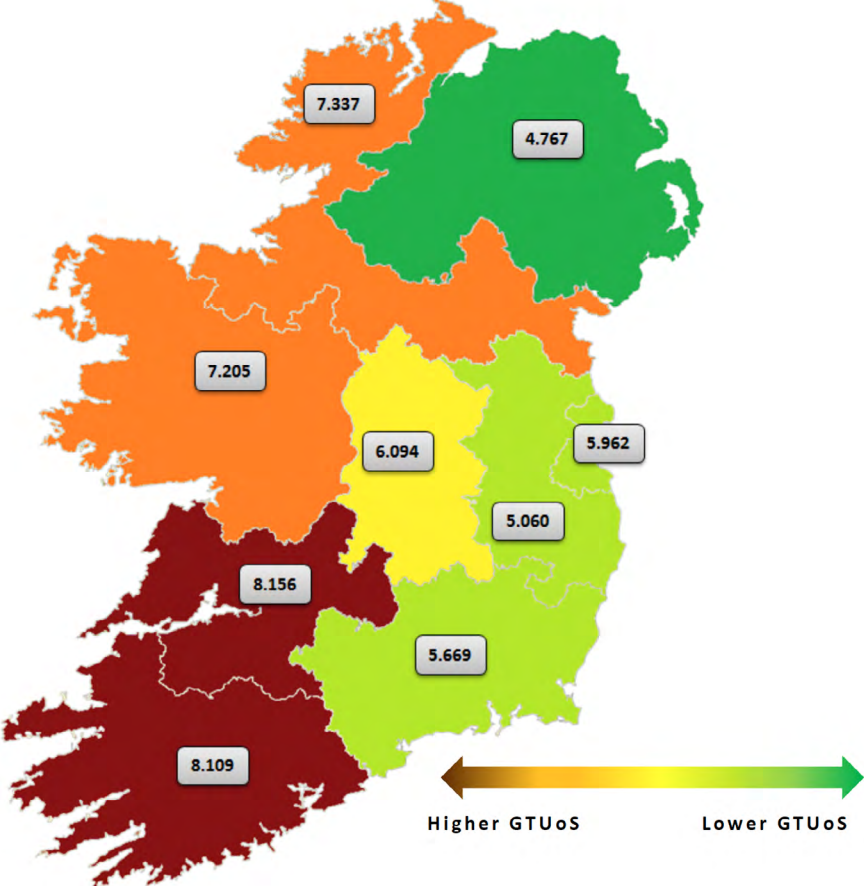
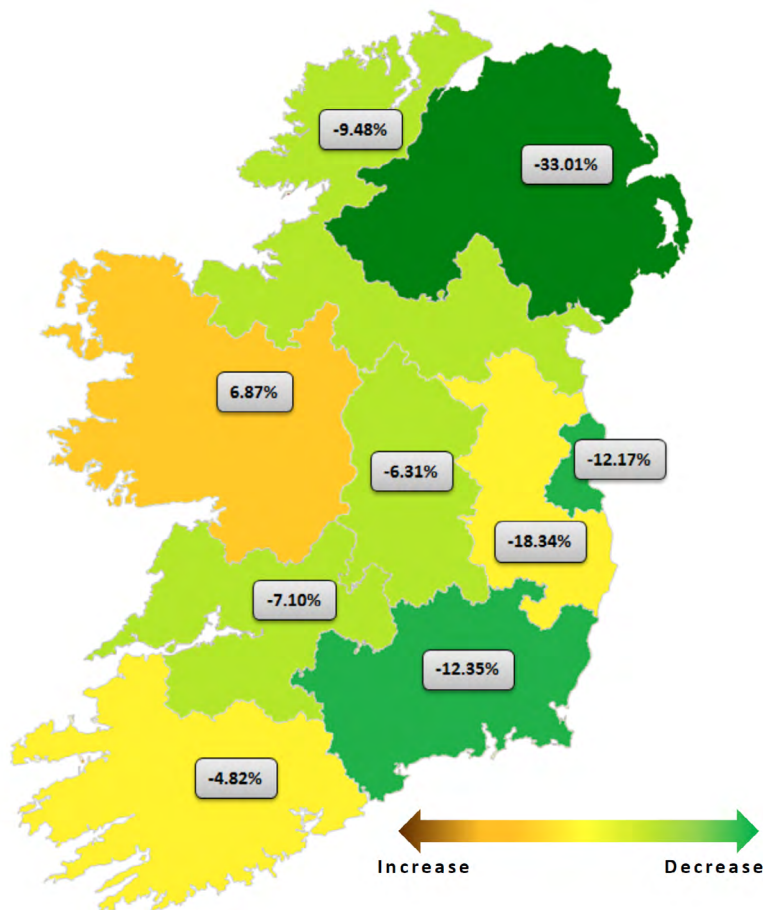


Figure 7-6: All-Island 2021/22 regional average GTUoS values



Figure 7-7 shows the change in GTUoS tariffs between 2020/21 and 2021/22.



**Figure 7-7: % GTUoS change between 2020/21 & 2021/22**

For 2021/22, there is an overall decrease in tariffs due to a 9.7% decrease in the all-island revenue. Regional changes are attributed to changes in network flows and local reinforcements. The annual revenue is the amount allowed to build, operate and maintain the transmission network, and this has decreased in Ireland and increased in Northern Ireland for 2021/22.

GTUoS tariffs for 2021/22 have decreased, on average, by 12% from those for 2020/21, which is higher than the revenue change. This is driven by the 9.7% decrease in approved revenue to be recovered by GTUoS and 1.9% increase in MWs (MEC) in the model.

No significant changes were observed due to reinforcements joining or leaving the 12 year cost window, however, the easing of the Moyle Export constraint led to the reversal of base flows on the planned Turleenan-Woodland circuit, which in turn meant significant reductions in NI tariffs. As shown in Figure 7-7, GTUoS tariffs for Northern Ireland in 2021/22 are 33% lower than those of 2020/21 and are also around 33% lower than the average Ireland GTUoS tariff for 2021/22<sup>111</sup>. The base flows in 2021/22 are otherwise relatively similar to those of 2020/21, and as a result there are similar trends to those of 2020/21. Further information on the 2021/22 GTUoS can be found on the EirGrid and SONI websites.<sup>112</sup>

<sup>111</sup> <http://www.eirgridgroup.com/site-files/library/EirGrid/2122-Approved-GTUoS-Tariffs-v1.pdf>  
<https://www.soni.ltd.uk/media/documents/2122-Approved-GTUoS-Tariffs-v1.pdf>

<sup>112</sup> <http://www.eirgridgroup.com/site-files/library/EirGrid/2122-Approved-GTUoS-Tariffs-Accompanying-Note-v1.o.pdf>  
<https://www.soni.ltd.uk/media/documents/2122-Approved-GTUoS-Tariffs-Accompanying-Note-v1.o.pdf>

## 7.7 Assumptions behind the TLAf and GTUoS models

### 7.7.1 TLAfs

The assumptions used to determine TLAfs are from the Imperfections Forecast model, and essentially are a snapshot of a particular study year, comprised of complex and detailed data. This data is collected up to a data freeze point just before the calculation process. This ensures they are as reflective as reasonably practicable for the study year.

For the level of detail involved specifically for calculating TLAfs, the assumptions are only valid for the study year.

Due to the complexity and variability of these assumptions, their collective impact on TLAfs is neither predictable nor forecastable. Looking beyond the study year, assumption data becomes increasingly speculative and could not be considered as reasonable data for the TLAf model.

### 7.7.2 GTUoS

The GTUoS model includes an element of ‘looking to the future’ by adopting the principle of incorporating the future network. Looking at the future network involves including the next five years of network files in the model. The network files are consistent with the information published in the latest version of this document available at the time of calculation. Indicative asset costs for a 12 year window are also included in the GTUoS model (looking five years forward and seven years back). Under normal circumstances this starts when the asset first appears in the ‘Year+5’ network file, until seven years post-commissioning. GTUoS tariffs are calculated on an all-island basis, but assumptions or network changes from one jurisdiction can have an impact on the other. For example, if the revenue to be recovered in Ireland significantly increased, but the revenue to be recovered in Northern Ireland remained the same as the previous year, the average all-island tariff would increase as there is a greater all-island pot to recover. Local variations would then be related to changes in network flows. Another example could be when looking at interconnector flows, where an assumption for Moyle impacts flows in Ireland, and an assumption for EWIC impacts flows in Northern Ireland.

Although there is an element of forecasting in the GTUoS model by looking at the future network and associated costs, alongside this are many assumptions and variables that only apply for the study year.

## 7.8 How to Use the Information for Generation

Generation developers wishing to use the information contained within this section when considering where to connect should follow these steps:

- Consult the maps in Appendix A to find the nearest transmission station to the proposed development. Also, consider the regions and nodes identified in Section 7.4 which are indicating opportunity for generation connections.
- Consult the forecast increase and retirement of generation within a region. Consider the impact of changes to the transmission system since the analysis was carried out. Consider short circuit current levels at the nearest transmission station.
- Discuss your project with EirGrid or SONI as early as possible.
- If seeking to apply for a connection, refer to the EirGrid connection application process<sup>113</sup> or the SONI connection application process<sup>114</sup>.

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<sup>113</sup> <http://www.eirgridgroup.com/customer-and-industry/becoming-a-customer/>

<sup>114</sup> <https://www.soni.ltd.uk/Customers/howconnected/>

# 8. Transmission System Capability for New Demand

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## 8. Transmission System Capability for New Demand<sup>115</sup>

This chapter presents the demand opportunity analysis which assesses the capability of the existing and planned transmission system to accommodate increased demand, based on information available at the data freeze date of January 2021. Opportunities for further demand connections in Ireland and Northern Ireland are also discussed.

A significant amount of conventional generation in Ireland and Northern Ireland is expected to close down over the period covered by this statement. However, for the purpose of the TYTFS 2021 analysis, it is assumed that there will be sufficient capacity to ensure that we can meet the defined adequacy standards and operational requirements in each jurisdiction. The Capacity Market is a key market element to facilitate this and the Generation Capacity Statement 2021-2030 outlines some possible challenges in this space. EirGrid is currently working with CRU and the Department of the Environment, Climate and Communications (DECC) to address short to medium term generation adequacy concerns in Ireland. Current analysis and projections for Northern Ireland indicate there is sufficient capacity in the short to medium term to meet system needs, However, there are risks relating to low plant availability, plant run-hour restrictions, and delays to North-South Interconnector which could impact the adequacy position in the short to medium term. The adequacy position for Northern Ireland is being monitored on an on-going basis.

There continues to be a significant volume of enquiries and applications for the connection of large energy users such as data centres in the Dublin region (see Chapter 3). This is addressed in Section 8.3, in which a qualitative approach to describe demand opportunities in the Dublin area is presented. The CRU has recently published CRU21124<sup>116</sup>, CRU's direction to the System Operators relating to data centre grid connection processing. The CRU assessed three mitigation options for managing challenges associated with growth of data centre connection demand. The CRU has directed the System Operator to assess future data centre connection applications based on:

- the location of the data centre applicant with respect to whether they are within a constrained or unconstrained region of the electricity system;
- the ability of the data centre applicant to bring onsite dispatchable generation (and/or storage) equivalent to or greater than their demand in order to support security of supply;
- the ability of the data centre applicant to provide flexibility in their demand by reducing consumption when requested to do so by the System Operator at times of system constraint through the use of dispatchable on-site generation (and/or storage) in order to support security of supply; and
- the ability of the data centre applicant to provide flexibility in their demand by reducing consumption when requested to do so by the relevant system operator, during times of system constraint, in order to support security of supply.

<sup>115</sup> Information for potential demand connections can be accessed at the following addresses: [http://www.eirgridgroup.com/\\_\\_uuid/463e7512-d115-4d94-b1ab-79b8cb366f73/index.xml](http://www.eirgridgroup.com/__uuid/463e7512-d115-4d94-b1ab-79b8cb366f73/index.xml) and [http://www.soni.ltd.uk/\\_\\_uuid/463e7512-d115-4d94-b1ab-79b8cb366f73/index.xml](http://www.soni.ltd.uk/__uuid/463e7512-d115-4d94-b1ab-79b8cb366f73/index.xml)

<sup>116</sup> <https://www.cru.ie/wp-content/uploads/2021/11/CRU21124-CRU-Direction-to-the-System-Operators-related-to-Data-Centre-grid-connection-processing.pdf>

EirGrid is working with the CRU, and all other relevant parties, to implement the measures outlined in the CRU's direction paper.

It should be noted that results relating to demand opportunities in this forecast statement are indicative only and are based on information available at the data freeze date of January 2021. It is advised that any potential new demand consumers contact EirGrid in the first instance so that the available connection options can be considered. In particular, data centres need to consider the status of Dublin as a constrained area in the context of the CRU's direction to System Operators relating to data centre grid connection processing.

## 8.1 Transmission System Demand Capability Obligations

This chapter of the TYTFS is published in order to meet the requirements of EirGrid's Section 38 of the 1999 Electricity Act and Condition 33 of SONI's TSO licence.

The analysis illustrated in Chapter 8 is presented to provide a high-level indication of transmission network capacity for developers. Results from demand capability studies are based on a specific set of assumptions (see Chapter 6) which may be subject to change. Developers wishing to connect to the transmission system will require further detailed studies.

The TYTFS is not intended to have any legal effect on the negotiation of contractual terms for transmission system connections. Before making any commercial decisions, developers should contact us and engage in a formal application/offer process for their proposed developments.

## 8.2 All-Island Transmission System Capability for New Demand

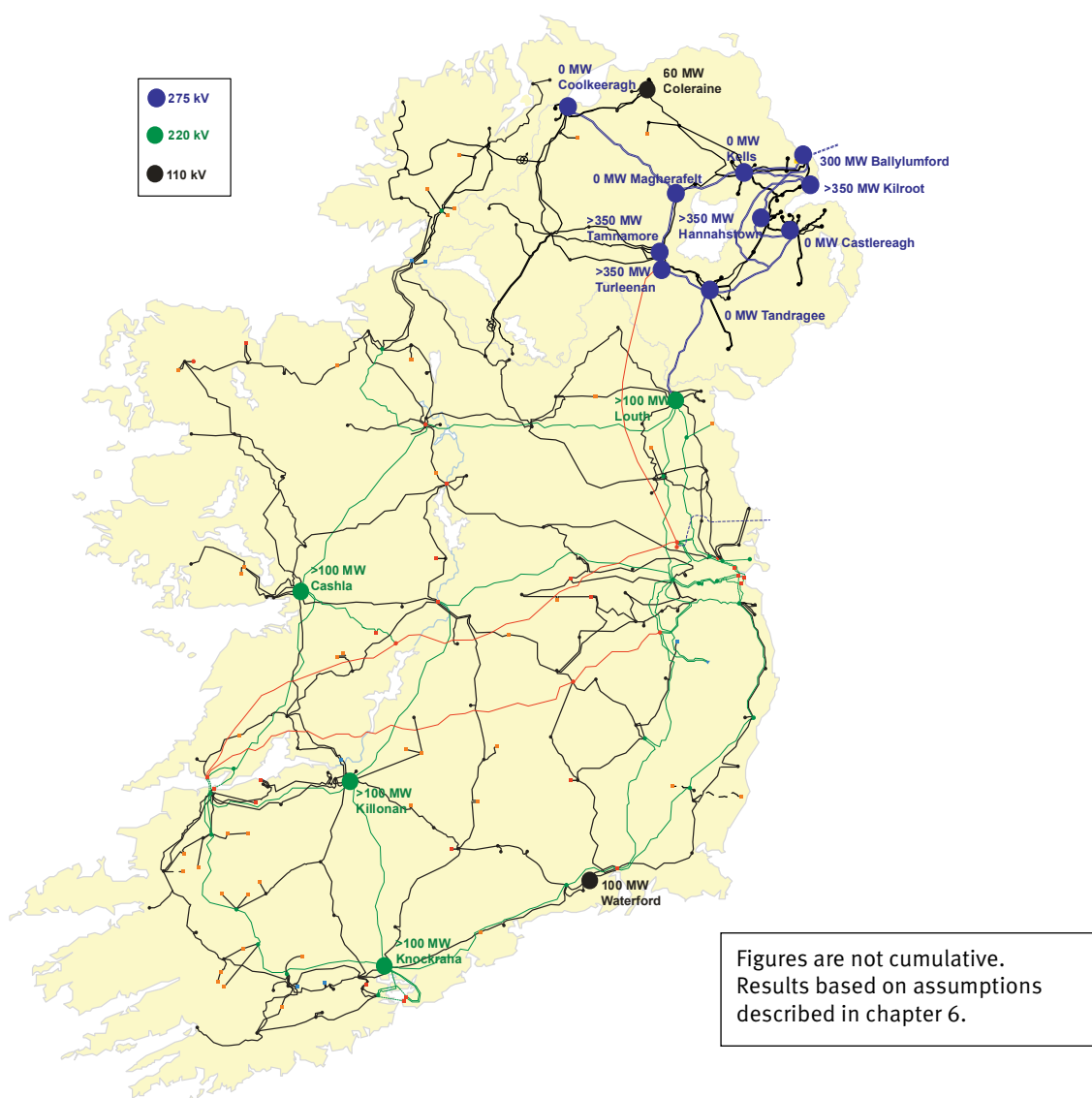
As detailed in Chapter 6, the transmission system's capacity to accommodate new demand is assessed using demand opportunity analysis. The study was performed for 2026 winter and summer peaks.

Data used for the demand opportunity analysis is based on the best available information at the January 2021 data freeze date. The results of the demand opportunity analysis presented in this chapter are based on the following assumptions:

- Year 2026 demand forecast was used (see Appendix C);
- Only transmission reinforcements with capital approval which were planned to be completed by 2026 at the data freeze date were included in the analysis;
- Planned generation up until 2026 at the data freeze date was included in the analysis;
- Variable generation cannot be relied upon to serve demand. As such, variable generation local to the test station was switched out; and
- The 2026 transmission system was assessed for the following contingencies: the loss of a single transmission asset (N-1); a maintenance-trip (N-1-1); and loss of a double transmission circuit (N-DC, Northern Ireland).

We analysed 42 transmission stations throughout Ireland (excluding Dublin) and Northern Ireland for Demand Opportunities. These consisted of twenty-six 110 kV stations, six 220 kV stations and ten 275 kV stations. These stations were analysed to help identify locations that are potentially suitable for major industrial load centres with large power requirements. The stations examined and their accompanying results are shown in Figure 8-1. The stations with the capacity to accommodate at least 100MW additional demand are reported for Ireland. There may be some limited opportunities for demand increase at other nodes but these should be discussed with EirGrid on a case by case basis. Opportunities in Dublin are discussed separately in Section 8.3.

It should be noted that demand opportunity is tested at each station on an individual basis. As such, the opportunities presented are not cumulative. If new demand connects in an area that is currently shown to have capacity, it will consume some, or all of, the available capacity in that area.



**Figure 8-1 Capability for Additional Demand at 275 kV, 220 kV and 110 kV Stations in 2026**

As a general rule, demand opportunity at a particular station would tend to reduce over time. This is due to normal demand growth using up available capacity. Yet, in some cases demand opportunities can improve as a result of planned transmission system or generation developments.

The results of the analysis are presented on a regional basis below. The results provide a high-level indication that in 2026 there will be opportunities at all the stations examined based on the data assumptions applied in the analysis. It should be noted that the analysis does not reflect changes that have occurred since the data freeze such as changes to contracted demand connections.

## 8.3 Opportunities for New Demand in the Dublin Area

### 8.3.1 Context

Dublin is the largest load centre on the island of Ireland. We include this section due to the considerable interest and number of enquiries for connection to the grid around Dublin (see Chapter 3 Demand). The volume of enquiries and the uncertainty of their final power requirements require us to make a qualitative assessment of demand opportunities for the future.

The scale of individual demand connection enquiries to the transmission system vary from 20 MW to over 250 MW. The enquiries mainly comprise data centres supporting the information, communications, and technology (ICT) infrastructure of large multi-national companies.

### 8.3.2 Dublin Transmission Development Plans

The demand connections in Dublin fall into three zones: North, West and South Dublin. Each zone is described below with consideration given to existing transmission infrastructure, transmission network projects and lead times.

Should the reader require more detailed transmission network project information please read our latest Transmission Development Plan and Associated Transmission Reinforcement<sup>117</sup> (ATR) update, both of which are available on the EirGrid website.

### 8.3.3 North Dublin

North Dublin has three 220/110 kV interface stations at Corduff, Finglas, and Belcamp. In addition, there is a 220 kV directly connected customer interface station at Clonee. The level of interest for connection in North Dublin is the highest of all Dublin areas.

A number of transmission projects are in place to increase the network capacity and security of supply in this area. They are summarised in Table 8-1 below.

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<sup>117</sup> <https://www.eirgridgroup.com/customer-and-industry/general-customer-information/operational-constraints/>



**Table 8-1: North Dublin Projects**

<b>North Dublin</b>		
Project Name / Number	Project Description	Estimated Delivery Date at Data Freeze
Belcamp Phase 2 (CPo984)	Additional 220/110 kV transformer and second circuit	2022
Finglas (CPo646)	110 kV station redevelopment	2023
Finglas (CPo792)	220 kV station redevelopment	2023

As noted in our Transmission Development Plan we have confirmed the need for further investment in North Dublin. In response, we are progressing the East Meath-North Dublin Network Reinforcement (CP1021). This will increase network connectivity between Woodland 400 kV station and a transmission station in North Dublin. Typically, such major projects delivering additional network capacity have significant lead times (five to ten years or more), and are dependent on the chosen technology.

#### 8.3.4 West Dublin

West Dublin has an existing 220/110 kV interface station at Inchicore, with another 220/110 kV station recently developed at Castlebagot<sup>118</sup>. These stations are supported by the Maynooth 220/110 kV station in Kildare, just outside Dublin.

A number of transmission projects are in place to increase the network capacity and security of supply in this area. They are summarised in Table 8-2 below.

**Table 8-2: West Dublin Projects**

<b>West Dublin</b>		
Project Name / Number	Project Description	Estimated Delivery Date at Data Freeze
Castlebagot (CPo872)	New 220/110 kV station	2021
Barnageeragh (CP1093)	New 110kV station	2022
Maynooth-Woodland (CPo869)	Uprate 220 kV line	2022
Ryebrook-Corduff (CPo668)	Uprate 110 kV line	2022
Inchicore (CPo692)	220 kV station upgrade	2025
Maynooth (CPo8o8)	220/110 kV station redevelopment	2027

<sup>118</sup> Formerly known as West Dublin 220/110 kV station.

As noted in our Transmission Development Plan we have confirmed the need for further investment in this area. In response, we are progressing the Kildare-Meath Grid Upgrade (also known as Capital Project 966) which seeks to increase the strength of the link between two existing 400 kV stations at Dunstown and Woodland.

**8.3.5 South Dublin**

South Dublin has one main 220/110 kV interface station at Carrickmines. Carrickmines is connected at 220 kV to Dunstown 400/220 kV station and Arklow 220/110 kV station.

A transmission project was being progressed, at the data freeze date, to increase the network capacity and ensure continued security of supply in this area. It is summarised in Table 8-3 below.

**Table 8-3: South Dublin Projects**

South Dublin		
Project Name / Number	Project Description	Estimated Delivery Date at Data Freeze
Carrickmines (CP0580)	New 220/110 kV 250 MVA transformer & GIS development	2023

**8.3.6 Additional transmission capacity required in the Dublin Area**

EirGrid recently published *Shaping Our Electricity Future*. This report and the associated study identifies the need for further transmission capacity in the Dublin area in addition to the Dublin network reinforcements described above.

The study indicates that a new 220 kV circuit is required in South Dublin along with replacement of five 220 kV underground circuits in the Dublin area. There are a number of drivers for these reinforcements including growth of demand in the area due to data centres and electrification of heat and transport, as well as connections of new offshore wind capacity.

**8.3.7 CRU direction on data centre connections**

The greater Dublin area has experienced high levels of data centre growth in recent years. This demand growth is expected to continue over the coming years as existing data centres utilise their full contracted MIC.

Connecting more data centres to the greater Dublin area will exacerbate the constraint issues that have developed in this area and present risks associated with security of the transmission system.

In light of these issues and the CRU’s direction on the connection of data centres, EirGrid clarified in the webinar on 17<sup>th</sup> December 2021 that the greater Dublin area is considered a constrained region for the purpose of processing of data centre connections. The CRU direction requires that the constrained areas are reassessed biennially.

### 8.3.8 Looking Forward

In January 2017 we published an updated grid development strategy for the long-term development of the network. In the strategy paper<sup>119</sup>, we explain the role of electricity transmission infrastructure in supporting new investments and jobs as well as ensuring competitiveness by offering cost-effective power capacity.

The strategy puts forward a number of major projects to upgrade the transmission network. The Regional Solution (see Chapter 2) and the Kildare-Meath Grid Upgrade (Capital Project 966) have many system benefits, which include providing additional network capacity and improving security of supply for the eastern side of Ireland.

The Regional Solution involves a new circuit across the Shannon Estuary and the installation of series compensation equipment on the 400 kV circuits that extend from Moneypoint 400 kV power station in the West of Ireland towards Woodland and Dunstown 400 kV stations located on the western outskirts of Dublin.

This project will greatly enhance the capability of the existing 400 kV circuits to transfer bulk power generated in the South-West and West to Dublin and other demand centres in the East, as illustrated in Figure 8-2.

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<sup>119</sup> <http://www.eirgridgroup.com/the-grid/irelands-strategy/>

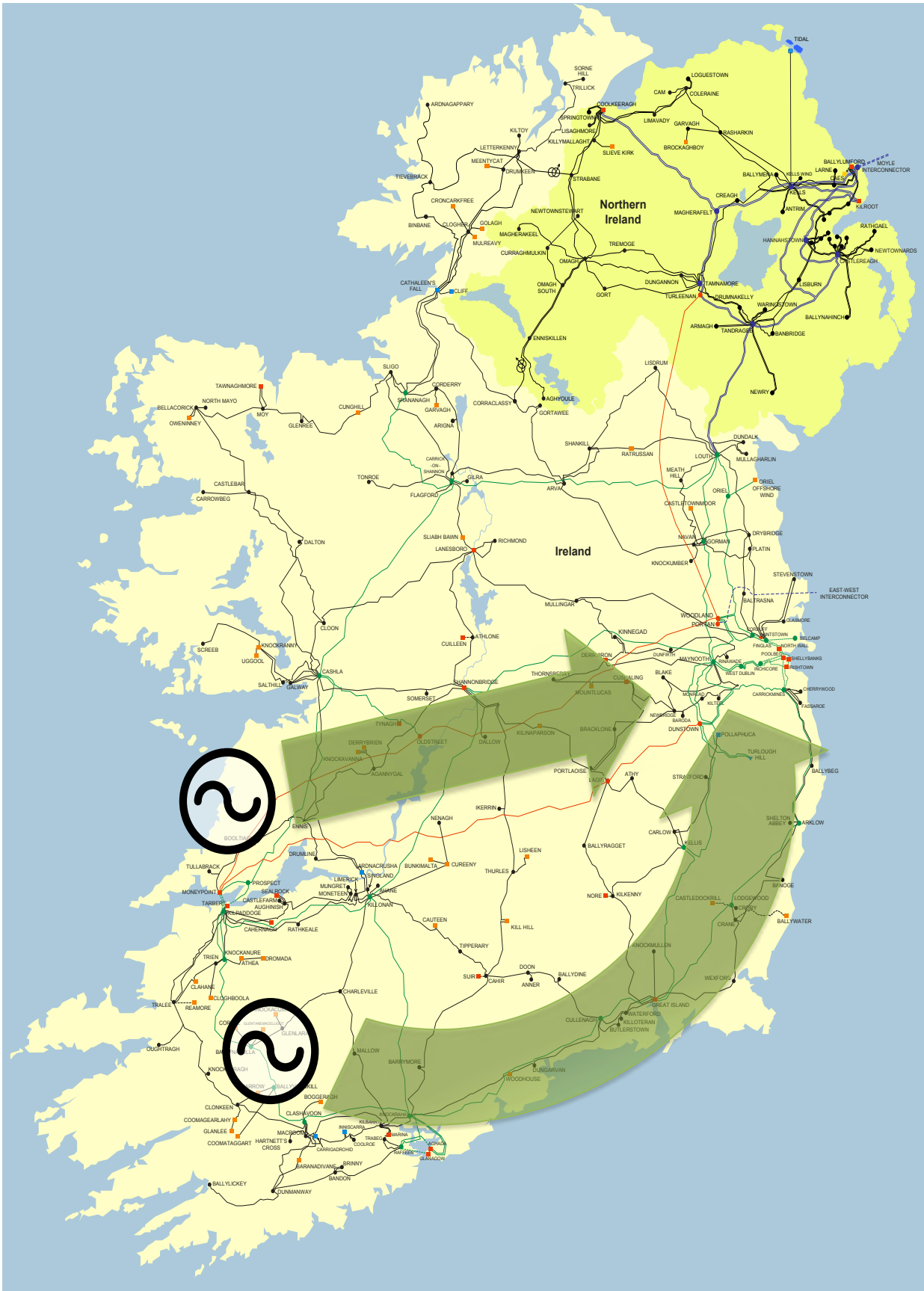


Figure 8-2: Transfer of Power Generated in the West and South-West Regions to the East

The Kildare-Meath Grid Upgrade is at an early point in the project life-cycle. This project will provide a high capacity link between two 400 kV stations at Dunstown and Woodland. This will provide benefits by reducing power flows that pass through the Dublin 220 kV transmission network.

To maintain system stability and facilitate significant inter-regional power flows we are also developing a number of voltage support solutions across Ireland.

In addition, as noted in our Transmission Development Plan, we have confirmed the need for investment in North Dublin. The future project is called the East Meath-North Dublin Network Reinforcement (CP1021).

EirGrid's *Shaping Our Electricity Future* report identifies the need for a new 220 kV circuit in South Dublin along with replacement of five 220 kV underground circuits in the Dublin area. There are a number of drivers for these reinforcements including growth of demand in the area due to data centres and electrification of heat and transport, as well as connections of new offshore wind capacity. However, despite these additional reinforcements, Dublin will still have to be treated as a constraint region and adhere to CRU's direction for connection of additional data centers as per Section 8.3.7.

### 8.3.9 Summary

New transmission solutions will be required to strengthen the grid and to maintain security of supply. These solutions are being progressed.

We continue to apply a strategic approach to network development and we are continuously considering the approach to the level of demand enquiries. Our strategic approach takes account of the following:

- Companies developing data centres operate in a rapid and dynamic environment. Their business requires connection timescales that are short relative to time taken for transmission reinforcement. Most are considering being operational within two to three years and growing their power usage rapidly thereafter.
- We are working to understand the needs of these developers and their impact in terms of our grid development strategy and *Shaping Our Electricity Future*. We are publishing information on the system adequacy, grid needs and opportunities to ensure transparency so that the impacts of this sector and its developments are known.
- We will continue to examine innovative solutions and technologies in response to future requests.
- As interest in connecting additional demand has developed into contracted connections, the available capacity on the existing transmission network for further large scale demand connections has been depleted. As such, the Dublin region is considered a constrained region in the context of additional demand.

It is advised that any potential new demand consumers contact EirGrid early so that the available connection options can be considered. In particular, data centres need to consider the status of

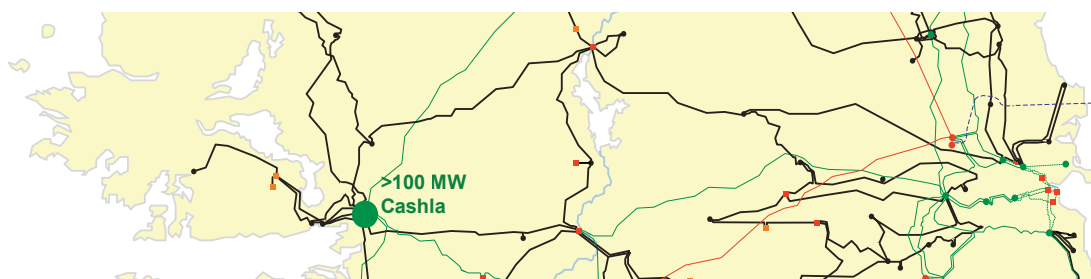
Dublin as a constrained area for demand and follow the latest mitigation options published by the CRU in [CRU21124](#), CRU's Direction to the System Operators relating to Data Centre grid connection processing.

## 8.4 Transmission System Capability for New Demand in Ireland

Demand opportunities available on an Ireland regional basis are discussed below. Results presented in this section are based on the assumptions detailed in Chapter 6.

### 8.4.1 Opportunities for New Demand in the Midlands and West

The indicative demand opportunities available in the Midlands and West are shown in Figure 8-3. It is shown that there is potential demand opportunities available for new customers in the region<sup>120</sup>. Cashla 220 kV station would be suitable connection point for major industrial load centres. This station is capable of accommodating additional demand without additional network reinforcements.

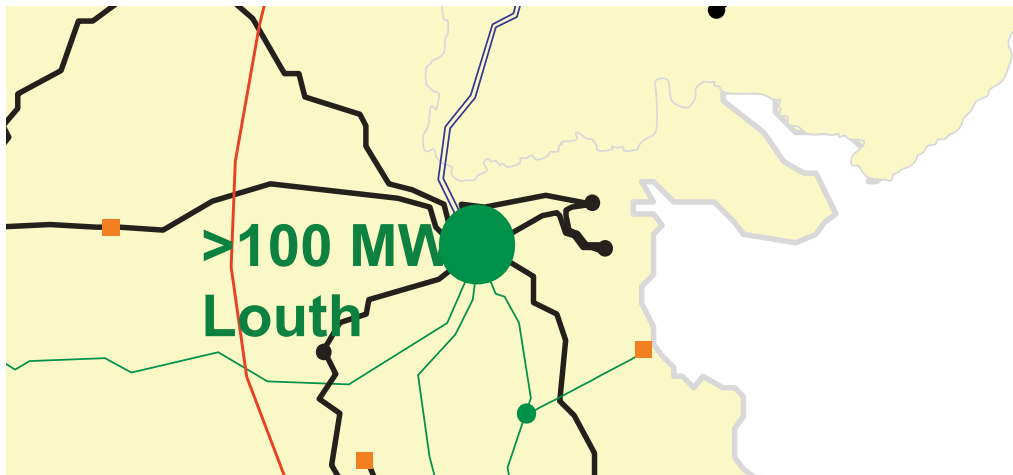


**Figure 8-3: Capability for Additional Demand in Midlands and West Regions**

### 8.4.2 Opportunities for New Demand in the North-East

The demand opportunity available for the North-East region is shown in Figure 8-4. Demand opportunity studies were performed at Louth 220/110 kV station in this region. From the study it is observed that Louth is capable of accommodating significant additional demand without additional network reinforcements in the North-East region.

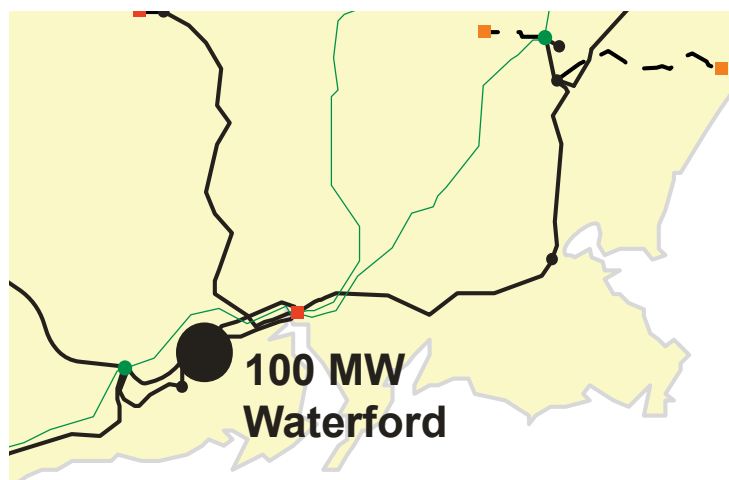
<sup>120</sup> Please note that the demand opportunities results are not cumulative. Each station is assessed individually, taking account of forecast demand growth only at stations outside of the test node. These figures are indicative only, with further detailed assessment of each station required. Customers considering connecting demand to the Irish transmission system are advised to contact EirGrid as early in the project as possible.



**Figure 8-4: Capability for Additional Demand in North-East Region**

### 8.4.3 Opportunities for New Demand in the South-East

The demand opportunity available for the South-East region is shown in Figure 8-5. Demand opportunity studies were performed at Waterford 110 kV station in this region. In our studies we identified an opportunity for 100 MW at Waterford 110kV station in the South-East region.

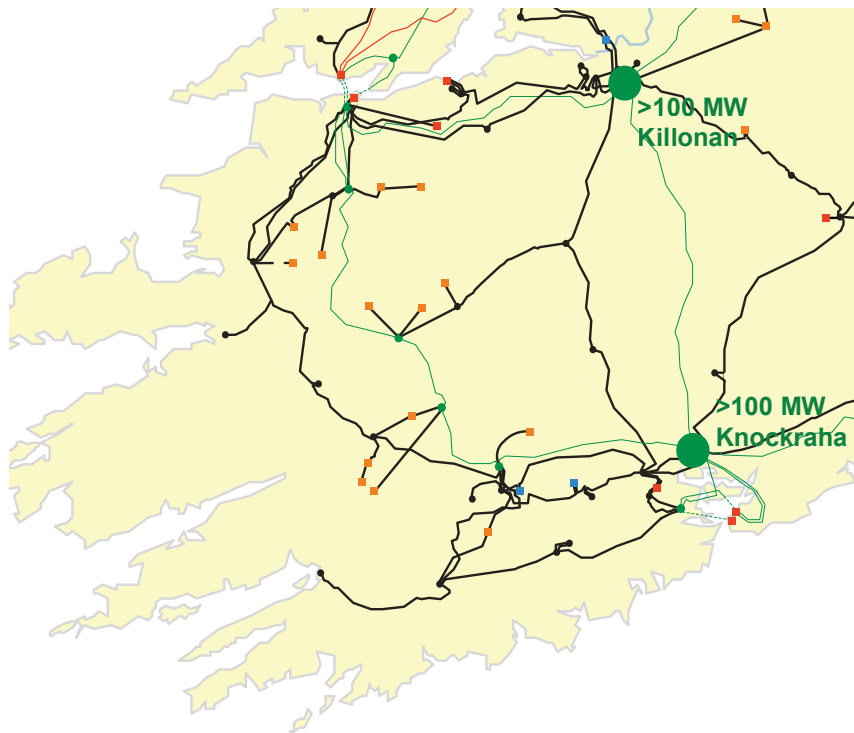


**Figure 8-5 Capability for Additional Demand in the South-East Region**

### 8.4.4 Opportunities for New Demand in the South-West

The demand opportunities available for the South-West region are shown in Figure 8-6. It can be seen that there are potential opportunities available for industrial customers in this region.

In particular the Killonan and Knockraha 220 kV stations would be suitable connection points for major industrial load centres, with the capability of accommodating in excess of 200 MW at each station without additional network reinforcements.



**Figure 8-6: Capability for Additional Demand in South-West Region**

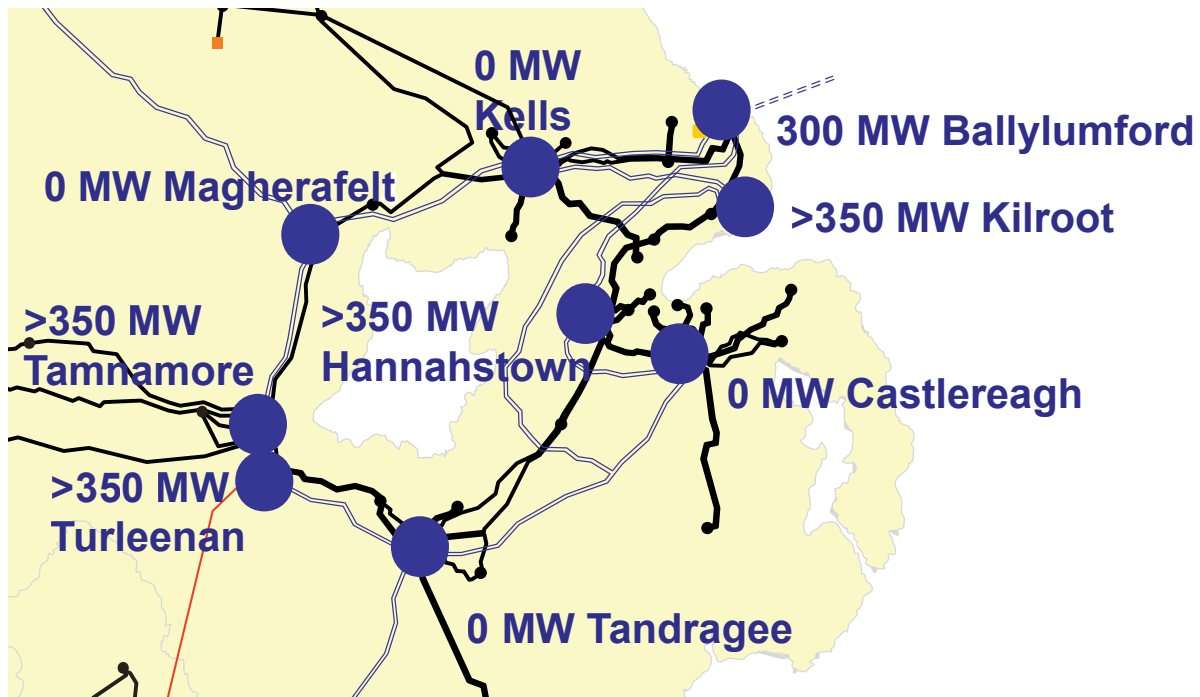
## 8.5 Transmission System Capability for New Demand in Northern Ireland

Section 8.5.1 discusses the demand opportunities available in the South-Eastern region of Northern Ireland. Section 8.5.2 discusses the demand opportunities available in the Northern and Western region. These results are based on the assumptions detailed in Chapter 6.

### 8.5.1 Opportunities for New Demand in South-East of Northern Ireland

The demand opportunities available in the South-Eastern region are shown in Figure 8-7.





**Figure 8-7 Capability for Additional Demand (MW) in the East of Northern Ireland**

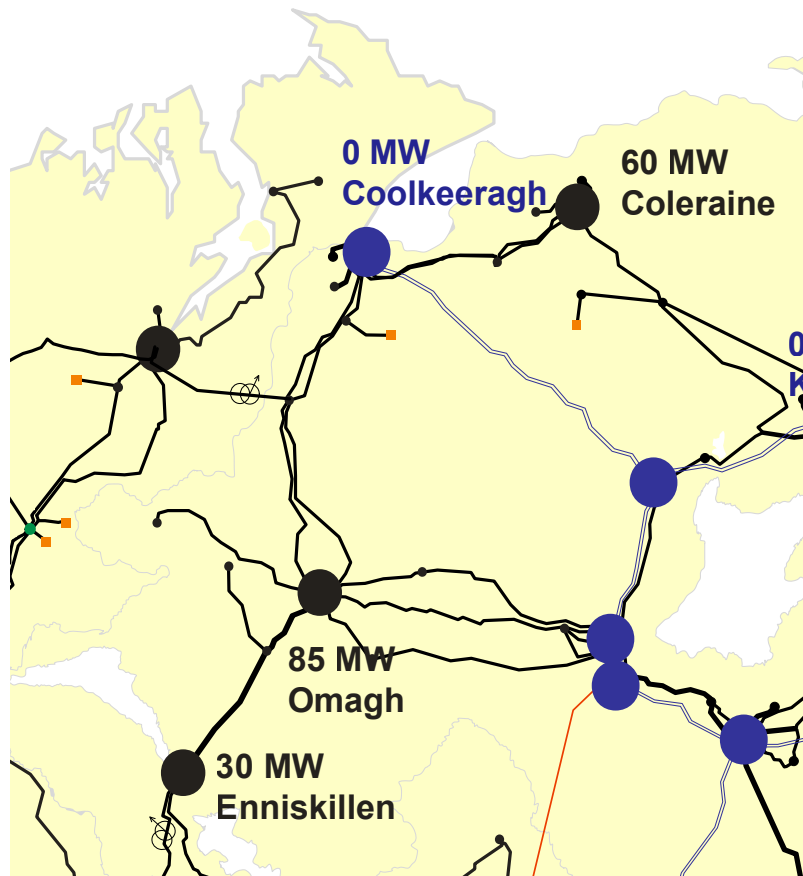
It can be seen that there are potential opportunities available for industrial customers at most stations examined in the region. Those stations with capacity are capable of accommodating approximately 350 MW<sup>121</sup> of additional demand without additional network reinforcements.

Those 275 kV stations with an identified capacity of 0 MW are restricted by the ability of the structures and busbars to withstand mechanical forces arising from potential faults. SONI and NIEN will be bringing forward projects to address this issue, however, these are at an early stage and no additional capacity can as yet be identified with sufficient certainty. The fault contributions from non-synchronous connections such as data centres tend to be significantly smaller, particularly those likely to connect at 110 kV. Any such potential connection at these nodes would be assessed based on its fault current contribution.

### 8.5.2 Opportunities for New Demand in North and West of Northern Ireland

The demand opportunities available for the North and West of Northern Ireland are shown in Figure 8-8.

<sup>121</sup> Please note that the demand opportunities results are not cumulative. Each station is assessed individually, taking account of forecast demand growth only at stations outside of the test node. These figures are indicative only, with further detailed assessment of each station required. Customers considering connecting demand to the NI transmission system are advised to contact SONI as early in the project as possible.



**Figure 8-8: Capability for Additional Demand in the North and West of Northern Ireland**

It can be seen that there are potential opportunities available for industrial customers at all stations examined in the region except Coolkeeragh. It should be noted that the North-West of Northern Ireland requires specific assessment in line with the TSSPS (see Chapter 6). As the North-West is connected by a single double circuit 275 kV spur, an N-1-1 contingency is performed as a credible contingency:

- The loss of the Coolkeeragh-Magherafelt 275 kV double circuit; and
- Coolkeeragh steam and gas units are out on maintenance.

However, the capacity at Coolkeeragh is limited by the ability of the 275 kV structures to withstand mechanical loading from potential faults. SONI and NIEN will be bringing forward projects to address this issue, however, these are at an early stage.

Enniskillen station represents the second lowest capability of the 110 kV nodes assessed. Enniskillen 110 kV is connected to Dromore 110 kV station via two 110 kV circuits. The loss of one of these circuits creates a thermal overload on the other. This limits demand connection capability.

## 8.6 How to Use the Information for Demand

Although not every station was considered, the results presented can be regarded as a guide to opportunities at other stations in the same area.

Customers wishing to use the demand opportunity results described in this chapter when considering where to connect should follow these steps:

- (1) Consult the maps in Appendix A to find the nearest transmission station to the proposed development. Also, the nearest station for which opportunity has been assessed should be identified, where it differs from the nearest transmission station.
- (2) The anticipated demand growth at the relevant station can be obtained from the demand forecasts presented in Appendix C. The transmission system is being planned to meet this level of demand increase.
- (3) Consider the impact of changes to the transmission system since the analysis was carried out.
- (4) Consult with EirGrid or SONI on the proposed location as early as possible as well as consulting the EirGrid application process<sup>122</sup> or SONI application process<sup>123</sup>.

Early consultation with us is encouraged so that we can work jointly to explore options relating to any potential proposals and enable timely decision making.

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<sup>122</sup> <http://www.eirgridgroup.com/customer-and-industry/becoming-a-customer/>

<sup>123</sup> <http://www.soni.ltd.uk/Customers/howconnected/>

# Appendix A

All-Island Ten Year

Transmission Forecast  
Statement

**2021**

# Appendix A Maps and Schematic Diagrams

Appendix A contains geographical maps of the All-Island Transmission System and short bus codes for every transmission voltage node on the island. Geographical maps are presented illustrating the All-Island Transmission System in 2021 and as planned for in 2030 as at data freeze date of 1<sup>st</sup> January 2021.

## A.1 Network Maps

This section includes two network maps:

- Figure A-1 is a map of the All-Island Transmission System as at January 2021; and
- Figure A-2 is a map of the planned All-Island Transmission System in 2030.

Note: There are a number of network reinforcement projects that do not have a finalised reinforcement solution. They are shown on the Transmission System Map as a transparent bubble in Figure A-2. The solutions that will be used for these projects have not yet been finalised.

**Figure A - 1**

**Transmission System  
400 kV, 275 kV, 220 kV and 110 kV  
January 2021**

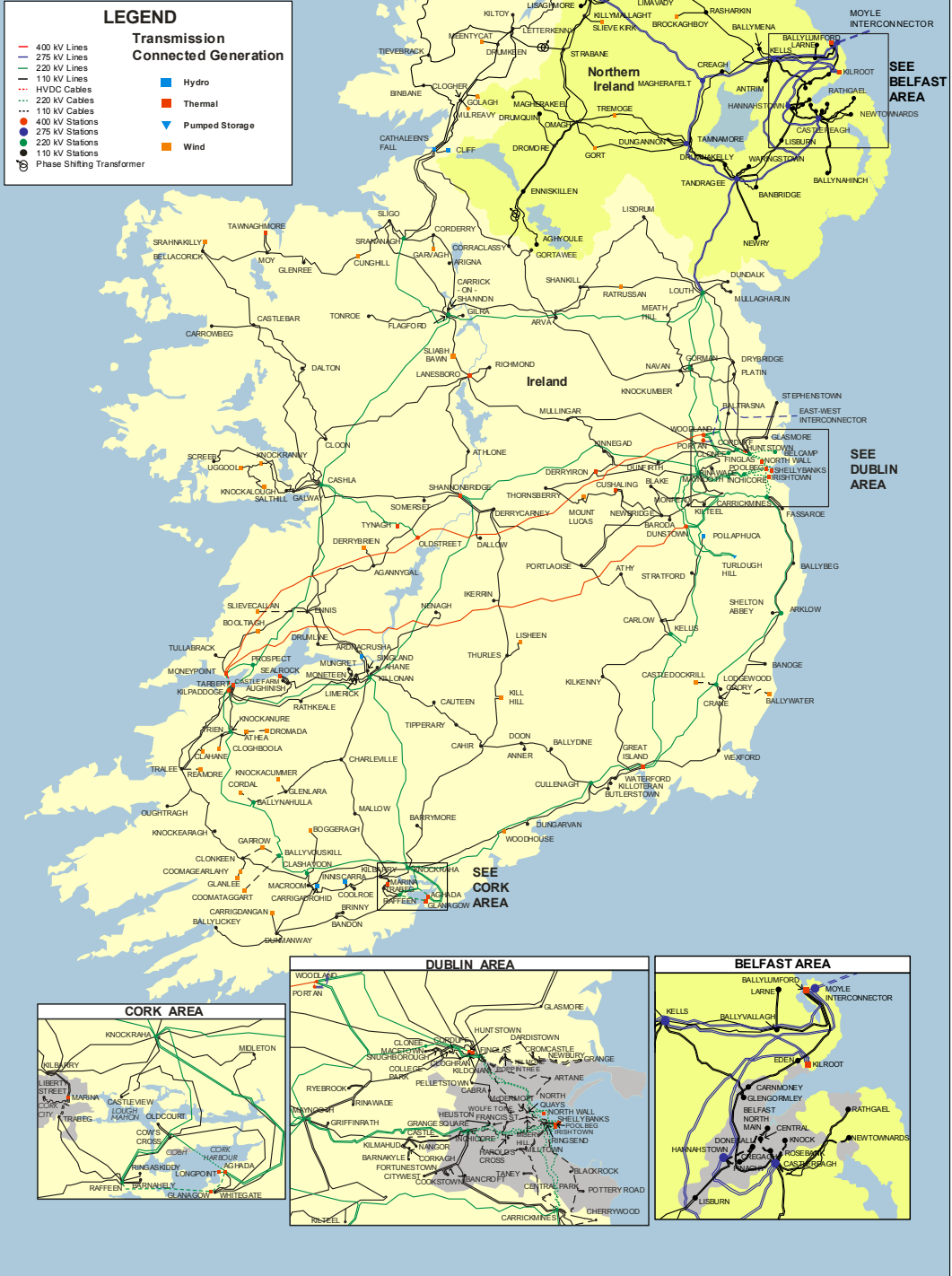


Figure A - 2

Planned Transmission System  
400 kV, 275 kV, 220 kV and 110 kV  
December 2030

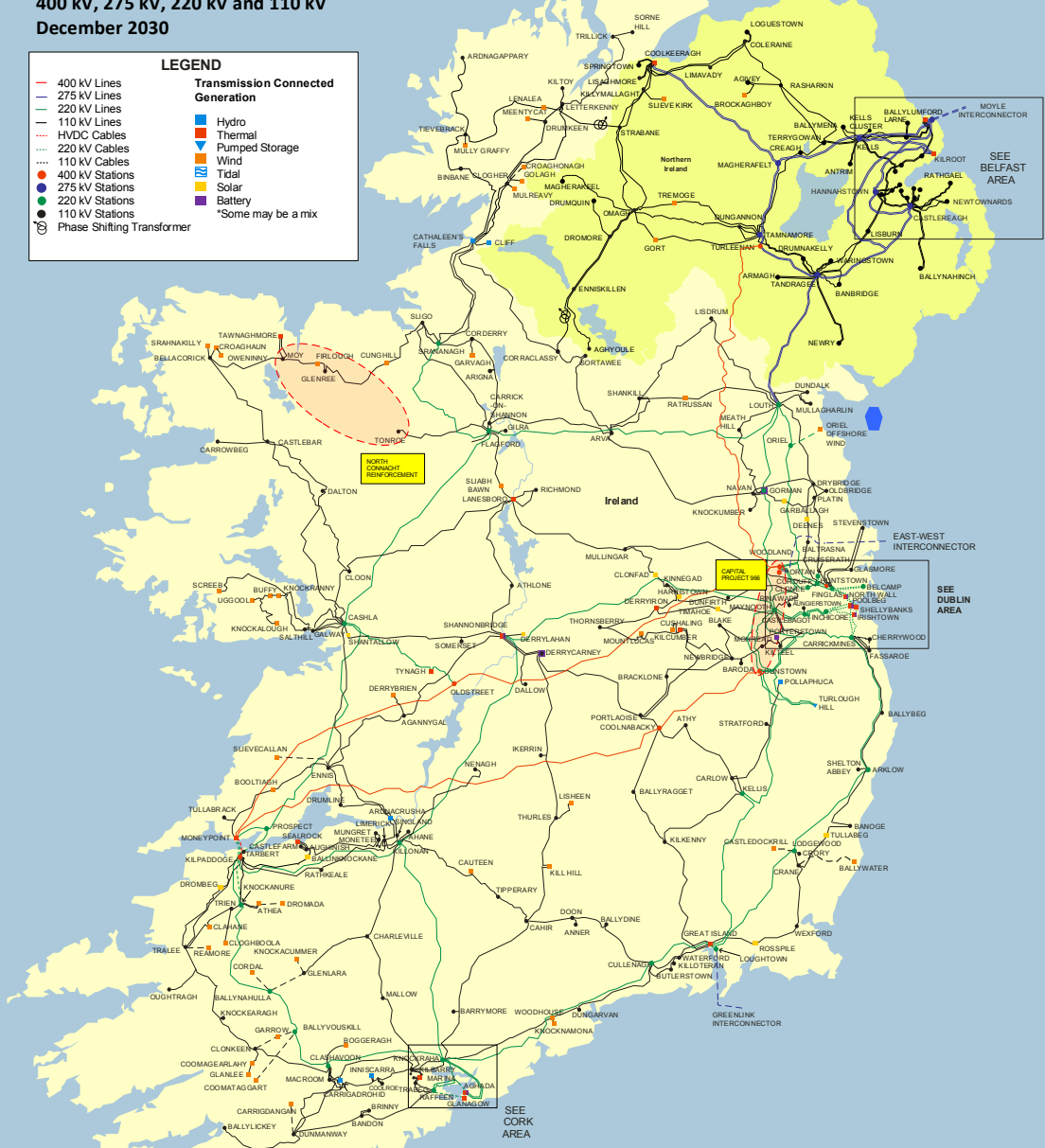
**LEGEND**

- 400 kV Lines
- 275 kV Lines
- 220 kV Lines
- 110 kV Lines
- HVDC Cables
- 220 kV Cables
- 110 kV Cables
- 400 kV Stations
- 275 kV Stations
- 220 kV Stations
- 110 kV Stations
- ⊗ Phase Shifting Transformer

**Transmission Connected Generation**

- Hydro
- Thermal
- Pumped Storage
- Wind
- Tidal
- Solar
- Battery

\*Some may be a mix



## A.2 Short Bus Codes

The following table associates full station names with the two or three letter codes used in the schematic diagrams in Section A.3, in the tables in Appendices B and C, and the power flow tables in Appendix H. Stations in Northern Ireland and Ireland with the same three letter bus code are distinguished with (N) for Northern Ireland and (I) for Ireland.

**Table A-1 Short Bus Codes**

Short Bus Code	Full Name	Short Bus Code	Full Name	Short Bus Code	Full Name
AA	Ardnacrusha	BGH	Boggeragh	CAR	Carnmoney
AD	Aghada	BGT	Ballyragget	CAS	Castlereagh
ADM	Adamstown	BIN	Binbane	CBG	Carrowbeg
AGH	Aghyoule	BK	Bellacorick	CBL	Cloghboola
AGL	Agannygal	BKM	Bunkimalta	CBR	Castlebar
AGN	Aungierstown	BKY	Barnakyle	CBT	Castlebagot
AGI	Agivey Cluster	BLA	Blackrock	CCN	Cloncreen
AGT	Aught	BLC	Belcamp	CD	Carrigadrohid
AGY	Ardnagappary	BLE	Ballinknockane	CDN	Carrigdangan
AHA	Ahane	BLI	Ballylickey	CDF	Carrickaduff
AIR	Airport Road	BLK	Blake	CDK	Castledockrill
ANR	Anner	BLU	Blundelstown	CDL	Cordal
ANT	Antrim	BMA	Ballymena	CDU	Corduff
ARI	Arigna	BNH	Ballynahinch	CDY	Corderry
ARK	Arklow	BNM	Belfast North	CEN	Belfast Central
ARM	Armagh	BOG	Banoge	CF	Cathleen's Fall
ART	Artane	BOL	Booltiagh	CFD	Clonfad
ARV	Arva	BPS	Ballylumford Power Station	CFM	Castlefarm
ATE	Athea	BRA	Bracklone	CGL	Coomagearlahy
ATH	Athlone	BRI	Brinny	CH	Cahernagh
ATY	Athy	BRO	Brockaghboy	CHA	Charleville
AUG	Aughinish	BRT	Bracetown	CHE	Cherrywood
BAG	Barnageeragh	BRY	Barnahely	CHR	Cahernagh
BAL	Baltrasna	BUF	Buffy	CKG	Corkagh
BAN (I)	Bandon	BUT	Butlerstown	CKM	Carrickmines
BAN (N)	Banbridge	BVG	Ballyvallagh	CKN	Clonkeen
BAR	Barrymore	BVK	Ballyvouskill	CL	Cliff
BCM	Ballycummin	BWR	Ballywater	CLA	Clashavoon
BCT	Bancroft	BYC	Ballycronan More (Moyle)	CLD	Coolderrig
BDA	Baroda	BYH	Ballynahulla	CLE	Clonee
BDM	Ballydam	CAB	Cabra	CLG	Cloghran
BDN	Ballydine	CAE	CAES	CLH	Clahane
BDV	Barnadivane	CAG	Carrickalangan	CLM	Culmore_RD
BEG	Ballybeg	CAH	Cahir	CLN	Cloon
BFP	Belfast Power Station	CAM	Cam Cluster	CLO	Clogher
BGD	Belgard Road			CLS	Clonshaugh
				CLW	Carlow



Short Bus Code	Full Name
CNB	Coolnabacky
CNG	Coolnagoonag
CNF	Caraunduff
CNN	Croaghmagawna
COL (I)	College Park
COL (N)	Coleraine
COO	Cookstown
COR	Corraclassy
COS	Carrick-on-Shannon
COW	Cow Cross
CPK	Central Park
CPS	Coolkeeragh Power Station
CRA	Crane
CRD	Croaghonagh
CRE	Cregagh
CRG	Creagh
CRH	Cruiserath
CRM	Cromcastle
CRN	Croaghaun
CRO	Coolroe
CRR	Curragha
CRY	Crory
CSH	Cashla
CTG	Coomataggart
CTN	Cauteen
CTY	City West
CUL	Cullenagh
CUN	Cunghill
CUR	Cureeny
CUS	Cushaling
CVW	Castleview
DAL	Dallow
DRN	Darndale
DDK	Dundalk
DEE	Deenes
DER	Derryiron
DEY	Derrycarney
DFR	Dunfirth
DGN	Dungarvan
DHN	Derrylahan
DJG	Drombeg
DLN	Derrylyn
DLT	Dalton

Short Bus Code	Full Name
DMY	Dunmanway
DON	Donegall
DOO	Doon
DRM	Drumkeen
DRN	Darndale
DRO	Dromada
DRO (N)	Dromore
DRQ	Drumquin Cluster
DRU (I)	Drumline
DRU (N)	Drumnakelly
DRY	Drybridge
DSN	Dunstown
DTN	Dardistown
DUN	Dungannon
DYN	Derrybrien
EDE	Eden
ENN (I)	Ennis
ENN (N)	Enniskillen
FAS	Fassaroe
FAS E	Fassaroe East
FGH	Firlough
FIN (I)	Finglas
FIN (N)	Finaghy
FLA	Flagford
FNT	Finnstown
FRN	Francis Street
GAE	Glanlee
GAL	Galway
GRV	Garvagh
GCA	Grange Castle
GGO	Glanagow
GI	Great Island
GIL	Gilra
GLA	Glasmore
GLE (I)	Glenlara
GLE (N)	Glengormley
GLN	Glen
GAN	Gallanstown
GLR	Glenree
GOL	Golagh
GOR (I)	Gorman
GOR (N)	Gort Cluster
GRA	Grange
GRH	Garballagh
GRI	Griffinrath

Short Bus Code	Full Name
GRO	Garrow
GWE	Gortawee
HAN	Hannastown
HAR	Harolds Cross
HEU	Heuston Square
HN	Huntstown
HRR	Harristown
IA	Inniscarra
IKE	Ikerrin
INC	Inchicore
ISH	Irishtown
KBY	Kilbarry
KBY2	Kilbarry No. 2
KCR	Knockacummer
KCY	Kilcarbery
KDN	Kildonan
KEL	Kells
KLC	Kells Cluster
KER	Knockearagh
KHL	Kill Hill
KIN	Kinnegad
KKY	Kilkenny
KLH	Knockalough
KLM	Kilmore
KLN	Killonan
KLS	Kellis
KMA	Knocknamona
KMT	Killymallaght
KNO	Knock
KNR	Knockanure
KNV	Knockavanna
KNY	Knockranny
KPG	Kilpaddoge
KPN	Killinaperson
KPS	Kilroot Power Station
KRA	Knockraha
KSE	Kishoge
KTL	Kilteel
KTN	Killoteran
KUD	Kilmahud
KUR	Knockumber
KYT	Kellystown
LA	Lanesboro
LAR	Larne

Short Bus Code	Full Name
LET	Letterkenny
LIB	Liberty Street
LIM (I)	Limerick
LIM (N)	Limavady
LIS (I)	Lisdrum
LIS (N)	Lisburn
LMR	Lisaghmore
LNA	Lenalea
LOG	Loguestown
LOU	Louth
LPT	Longpoint
LSN	Lisheen
LUM	Lumcloon
LWD	Lodgewood
MAC	Macroom
MAG	Magherafelt
MAL	Mallow
MAY	Maynooth
MCD	McDermott
MCE	Macetown
MEE	Meentycat
MEN	Monatooreen
MHL	Misery Hill
MID	Midleton
MIL	Milltown
MKL	Magherakeel Cluster
MLC	Mountlucas
MLG	Mully Graffy
MLN	Mullagharlin
MON	Monread
MOY	Moy
MP	Moneypoint
MR	Marina
MRY	Mulreavy
MTH	Meath Hill
MTN	Moneteen
MUC	Muckerstown
MUL	Mullingar
MUN	Mungret
NAN (I)	Nangor
NAR	Newtownards
NAV	Navan
NBY	Newbury
NEN	Nenagh

Short Bus Code	Full Name
NEW (I)	Newbridge
NEW (N)	Newry
NQS	North Quays
NW	North Wall
OLD	Oldcourt
OMA	Omagh
ORL	Oriel
OST	Oldstreet
OUG	Oughtragh
PA	Pollaphuca
PB	Poolbeg
PGN	Pigeon Top
PLA	Platin
PLS	Portlaoise
POP	Poppintree
POT	Pottery Road
PRO	Prospect
PRT	Portan
PTN	Pelletstown
RAF	Raffeen
RAT (I)	Rathkeale
RAT (N)	Rathgael
RE	Ringsend
REM	Reamore
RIC	Richmond
RNW	Rinawade
ROP	Rosspile
ROS	Rosebank
RRU	Ratrussan
RSK	Rasharkin Cluster
RSY	Ringaskiddy
RTO	Rathnaskillo
RYB	Ryebrook
SAL	Salthill
SBH	Snughborough
SCR	Screeb
SH	Shannonbridge
SHE	Shelton Abbey
SHL	Shellybanks
SK	Sealrock
SKL	Shankill
SKY	Srahnakilly
SLB	Sliabh Bawn
SLC	Slievecallan
SLI	Sligo

Short Bus Code	Full Name
SLK	Slieve Kirk
SNG	Singland
SOM	Somerset
SOR	Sorne Hill
SPR	Springtown
SRA	Srananagh
STR (I)	Stratford
STR (N)	Strabane
SVN	Stevenstown
SXH	Shantallow
TAN	Tandragee
TAW	Tawnaghmore
TB	Tarbert
TBG	Trabeg
TBK	Tullabrack
TEN	Timahoe
TGW	Terrygowan
TH	Turlough Hill
THU	Thurles
TIP	Tipperary
TIV	Tievebrack
TLK	Trillick
TLY	Tanley
TMN	Tamnamore
TON	Tonroe
TRE	Tremoge Cluster
TRI	Trien
TRL	Tralee
TRN	Trinity
TSB	Thornsberry
TTU	Tullabeg
TUR	Turleenan
TYN	Tynagh
UGL	Uggool
WAR	Waringstown
WAT	Waterford
WEX	Wexford
WH	Woodhouse
WHI	Whitegate
WOL	Wolfe Tone
YLW	Yellowmeadow

## A.3 Schematic Diagrams of the All Island Transmission System

Schematic diagrams of the All-Island Transmission System are included to assist users in understanding the transmission system and in the identification of the changes outlined in Appendix B. Lines, cables, transformers, station busbars and reactive compensation devices are illustrated in the diagrams. The type of generation (thermal, wind, hydro or solar) at a station is also displayed. Table A-2 indicates the diagram conventions.

The schematic diagram for 2021 shows the transmission system as of January 2021. The schematic diagram for 2030 shows the planned transmission system due to be completed by the end of 2030.

**Table A-2 Schematic Legend**
























Symbol	Network Element Represented
	110 kV circuit
	220 kV circuit
	275 kV circuit
	400 kV circuit
	System Link
	110 kV Busbar
	220 kV Busbar
	275 kV Busbar
	400 kV Busbar
	Busbar with Thermal Generation
	Busbar with Wind Generation (>5 MW)
	Busbar with Hydro Generation
	Busbar with Solar Generation (>5 MW)
	Busbar with Wind and Thermal Generation
	Busbar with Wind and Hydro Generation
	Busbar with Wind and Solar Generation
	Capacitor
	Static Var Compensator/STATCOM
	Reactor
	Phase Shifting Transformer
	Transformer
	Normally Open Point
	Series Compensation

Figure A-3  
 Schematic Diagram of the All-Island  
 Transmission System as of January 2021

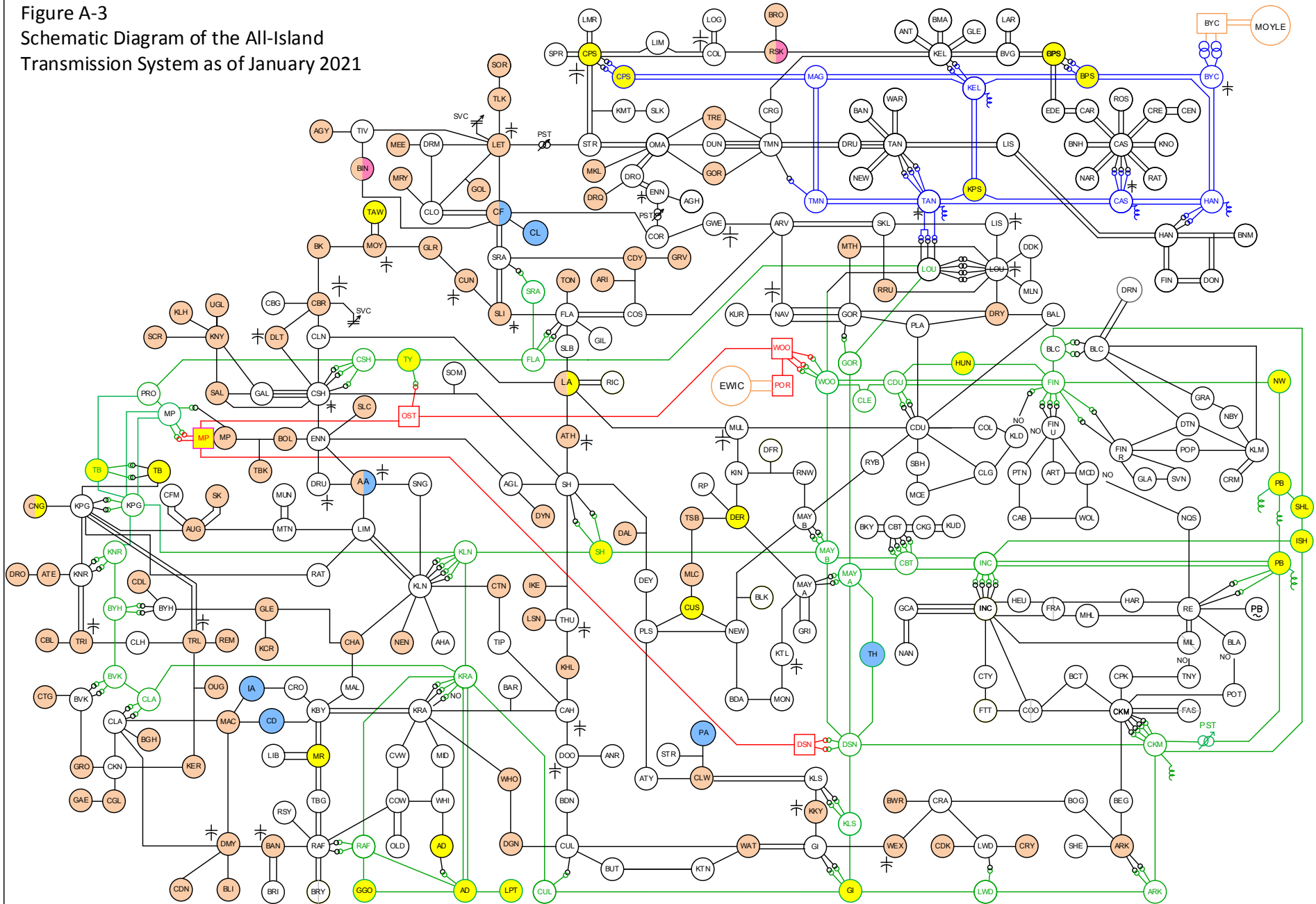
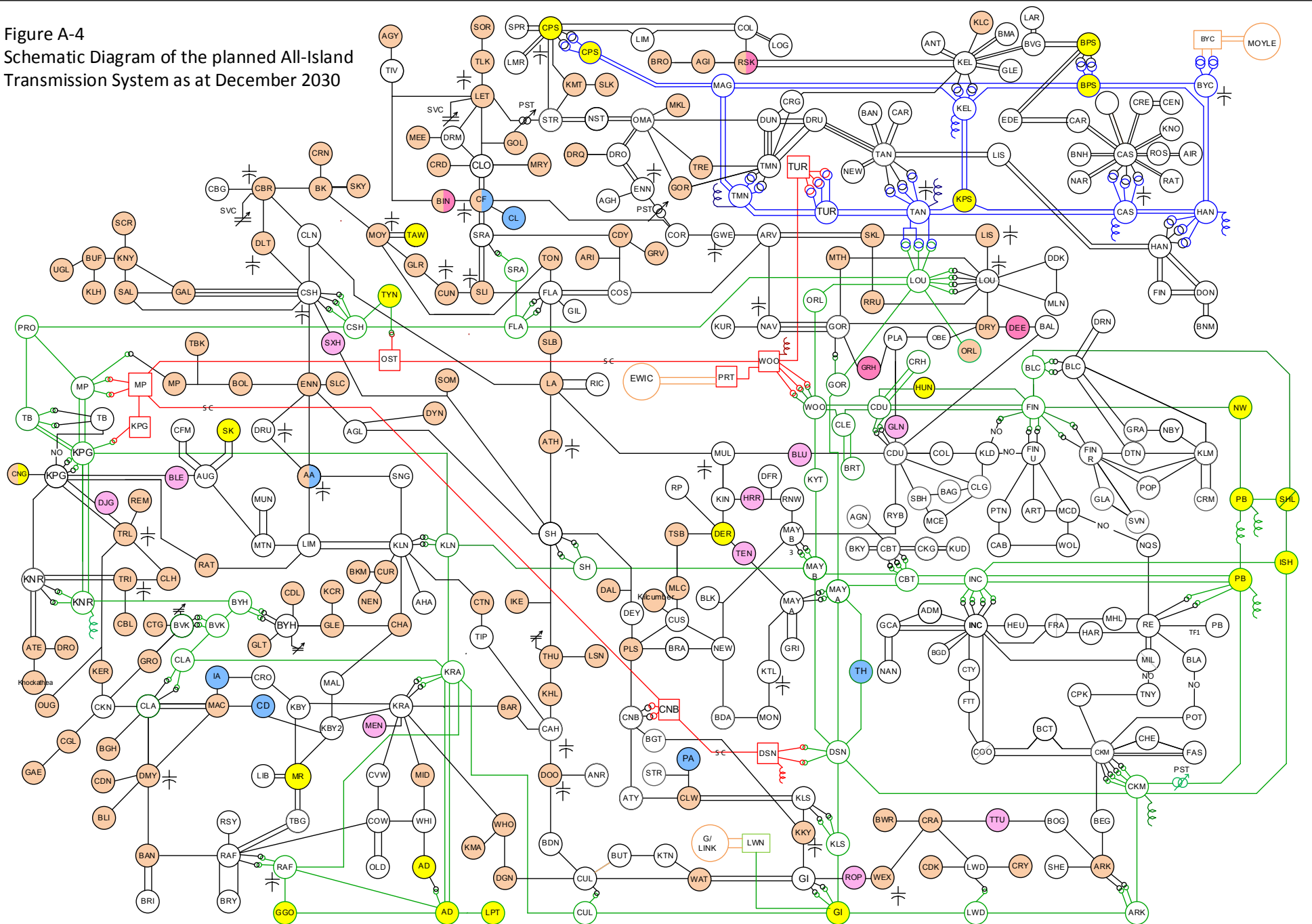


Figure A-4  
 Schematic Diagram of the planned All-Island  
 Transmission System as at December 2030



# Appendix B

All-Island Ten Year

Transmission Forecast  
Statement

**2021**

# Appendix B Transmission System Characteristics

This appendix presents details of the physical and electrical characteristics of the all-island transmission system in tabular form:

- Section B.1 details the data for the existing<sup>124</sup> transmission system; and
- Section B.2 details the data for planned transmission system developments<sup>125</sup>.

The following is a list of tables in Section B.1:

- Table B-2 Characteristics of Existing Transmission Circuits;
- Table B-3 Characteristics of Existing Transformers in Ireland;
- Table B-4 Characteristics of Existing 3 Winding Transformers in Northern Ireland;
- Table B-5 Characteristics of Existing 2 Winding Transformers in Northern Ireland;
- Table B-6 Characteristics of Existing Power Flow Controllers; and
- Table B-7 Characteristics of Existing Reactive Compensation.

The following is a list of tables in Section B.2:

- Table B-8 Expected Changes in Transmission Circuits;
- Table B-9 Expected Changes in Transformers in Ireland;
- Table B-10 Expected Changes in 3 Winding Transformers in Northern Ireland;
- Table B-11 Expected Changes in 2 Winding Transformers in Northern Ireland; and
- Table B-12 Expected Changes in Reactive Compensation.

Tables B-2 and B-8 include the ratings for lines and cables in MVA for winter and summer reference temperature conditions at 1 per unit (pu) voltage. The higher ambient temperature in summer dictates a reduced thermal rating for overhead lines. The rating is the maximum permissible power that the circuit can transport on a continuous basis.

Reference ambient temperatures are:

- winter: 11°C<sup>126</sup>; and
- summer: 25°C.

The electrical characteristics of the all-island transmission system at the four nominal voltage

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<sup>124</sup> As at January 2021.

<sup>125</sup> Includes transmission system reinforcement projects and developments necessary to connect new generation and demand.

<sup>126</sup> ESB Networks previously calculated winter ratings based on an assumed winter temperature of 5°C. In 2018 this was changed to 11°C.

levels are documented. They are represented in per unit values, with a 100 MVA base, and the applicable reference voltage. Table B-1 below displays the four nominal and reference voltage levels on the all-island transmission system.

**Table B-1 Nominal and Reference Voltage Levels**

<b>Nominal Voltage Level (kV)</b>	<b>Reference Voltage (kV)</b>
400	400
275	275
220	220
110	110

In some cases equipment associated with a line or cable may be lower rated than the circuit or line. However, this equipment<sup>127</sup> is easier to upgrade than lines and cables and is therefore not expected to restrict access to the transmission system.

A small number of 110 kV stations are connected to the transmission system via a tee. A tee is an un-switched connection into an existing line between two other stations. For the purposes of describing the various sections of lines in the following tables, tee points are identified by the name of the tee'd 110 kV station with a suffix "T" added.

<sup>127</sup> For example, current transformers.



## B-1 Characteristics of the Existing Transmission System (January 2021)

**Table B-2 Characteristics of Existing Transmission Circuits**

Voltage (kV)	From	To	No.	Length (km)	Impedance on			Rating (MVA)		
					100 MVA Base (pu)			Summer	Autumn	Winter
					R	X	B			
400	DSN	MP	1	208.5	0	0.04	1.14	1283	1331	1454
400	MP	OST	1	104.14	0	0.03	0.49	1283	1331	1454
400	OST	WOO	1	126	0	0.03	0.57	1577	1749	1944
400	WOO	WOO	1	0.5	0	0	0.04	685	685	685
275	BPS	HAN	2	45.5	0	0.02	0.11	710	820	881
275	BPS	KEL	1	34.5	0	0.01	0.09	710	820	881
275	BPS	MAG	1	65.5	0	0.03	0.17	710	820	881
275	BPS	BYC	1	0.8	0	0	0	710	820	881
275	CAS	HAN	1	18.4	0	0.01	0.05	710	820	881
275	CAS	HAN	2	18.4	0	0.01	0.05	710	820	881
275	CAS	KPS	1	66.8	0	0.03	0.17	710	820	881
275	CAS	TAN	1	45.6	0	0.02	0.11	710	820	881
275	CPS	MAG	1	56.2	0.01	0.03	0.15	412	477	513
275	CPS	MAG	2	56.2	0.01	0.03	0.15	412	477	513
275	HAN	BYC	1	44.7	0	0.02	0.11	710	820	881
275	KEL	KPS	1	29	0	0.01	0.08	710	820	881
275	KEL	KPS	2	29	0	0.01	0.08	710	820	881
275	KEL	MAG	1	31.1	0	0.01	0.08	710	820	881
275	KPS	TAN	1	80.8	0	0.03	0.21	710	820	881
275	LOU	TAN	1	50	0	0.02	0.13	710	820	881
275	LOU	TAN	2	50	0	0.02	0.13	710	820	881
275	MAG	TMN	1	25.68	0	0.01	0.07	710	820	881
275	MAG	TMN	2	25.68	0	0.01	0.07	710	820	881
275	TAN	TMN	1	25.74	0	0.01	0.07	710	820	881
275	TAN	TMN	2	25.74	0	0.01	0.07	710	820	881
220	AD	AD	1	1.4	0	0	0.04	593	593	593
220	AD	GGO	1	3.78	0	0	0.1	573	536	573
220	AD	KRA	1	25.6	0	0.02	0.03	393	429	468
220	AD	KRA	2	25.6	0	0.02	0.03	393	429	468
220	AD	LPT	1	0.97	0	0	0.03	593	593	593
220	AD	RAF	1	14.4	0	0.01	0.25	434	481	513
220	ARK	CKM	1	53.61	0.01	0.05	0.08	434	481	513
220	ARK	LWD	1	39.02	0.01	0.03	0.05	434	481	513
220	BLC	FIN (I)	1	10	0	0	0.33	570	570	570
220	BVK	BYH	1	28.57	0	0.03	0.05	434	473	513
220	BVK	CLA	1	16.78	0	0.01	0.03	740	769	792
220	CBT	INC	1	14.3	0	0.01	0.01	761	780	794
220	CBT	INC	2	14.32	0	0.01	0.02	761	780	794
220	CBT	MAY	1	11.72	0	0.01	0.02	761	780	794
220	CBT	MAY	2	11.7	0	0.01	0.02	761	780	794

**Table B-2 Characteristics of Existing Transmission Circuits**

Voltage (kV)	From	To	No.	Length (km)	Impedance on			Rating (MVA)		
					100 MVA Base (pu)			Summer	Autumn	Winter
				R	X	B				
220	CDU	FIN (I)	1	3.73	0	0	0.01	434	481	513
220	CDU	FIN (I)	2	3.73	0	0	0.01	434	481	513
220	CDU	HN	1	3.73	0	0	0.13	555	555	555
220	CDU	WOO	2	17.84	0	0.02	0.02	434	481	513
220	CKM	DSN	1	41.61	0.01	0.04	0.11	434	481	513
220	CKM	ISH	1	11.89	0	0.01	0.33	593	593	593
220	CLA	KRA	1	42.93	0.01	0.04	0.06	646	704	751
220	CLE	CDU	1	5.06	0	0	0.01	434	481	513
220	CLE	WOO	1	13.5	0	0.01	0.02	434	473	513
220	CSH	FLA	1	88.09	0.01	0.08	0.12	350	393	436
220	CSH	PRO	1	88.54	0.01	0.08	0.12	392	429	468
220	CSH	TYN	1	39.89	0.01	0.03	0.06	761	777	792
220	CUL	GI	1	23.34	0	0.02	0.04	746	746	793
220	CUL	KRA	1	86	0.01	0.07	0.12	646	704	765
220	DSN	KLS	1	59.3	0.01	0.05	0.08	393	429	468
220	DSN	MAY	1	36.29	0	0.03	0.05	350	393	436
220	DSN	MAY	2	30.55	0	0.03	0.04	350	393	436
220	DSN	TH	1	26.62	0	0.02	0.14	351	351	351
220	FIN (I)	HN	1	1.4	0	0	0.04	593	593	593
220	FIN (I)	NW	1	11.85	0	0	0.67	332	332	332
220	FIN (I)	SHL	1	13.4	0	0.01	0.37	536	557	557
220	FLA	LOU	1	110.08	0.01	0.1	0.15	384	430	475
220	FLA	SRA	1	56.01	0.01	0.05	0.08	434	481	513
220	GGO	RAF	1	9.5	0	0.01	0.41	570	570	570
220	GI	KLS	1	70.43	0.01	0.06	0.1	393	429	468
220	GI	LWD	1	48.08	0.01	0.04	0.07	434	481	513
220	GOR	LOU	1	32.41	0	0.03	0.04	434	473	476
220	GOR	MAY	1	42.19	0.01	0.04	0.06	350	393	436
220	INC	ISH	1	12.06	0	0.01	0.33	562	582	634
220	INC	PB	1	12.5	0	0	0.5	267	267	267
220	INC	PB	2	11.3	0	0	0.72	351	351	351
220	ISH	SHL	1	1.31	0	0	0.04	593	593	593
220	KLN	KPG	1	70.57	0.01	0.06	0.11	434	481	513
220	KLN	KRA	1	82.16	0.01	0.07	0.11	512	536	564
220	KLN	SH	1	89.7	0.01	0.08	0.12	269	322	354
220	KPG	KNR	1	21.4	0	0.02	0.05	731	750	762
220	KPG	KNR	2	20	0	0.01	0.97	731	750	762
220	KPG	MP	1	5.4	0	0	0.24	660	660	660
220	KPG	MP	2	5.4	0	0	0.24	660	660	660
220	KPG	TB	1	2.8	0	0	0.03	350	393	436
220	KPG	TB	2	2.8	0	0	0.03	350	393	436
220	KNR	BYH	1	37.79	0.01	0.03	0.06	434	473	513
220	KRA	RAF	1	19.25	0	0.02	0.03	353	405	454

**Table B-2 Characteristics of Existing Transmission Circuits**

Voltage (kV)	From	To	No.	Length (km)	Impedance on			Rating (MVA)		
					100 MVA Base (pu)			Summer	Autumn	Winter
					R	X	B			
220	LOU	WOO	1	61.2	0.01	0.05	0.08	350	393	436
220	MAY	SH	1	105.6	0.02	0.09	0.14	269	322	354
220	MAY	TH	1	53.1	0.01	0.04	0.18	325	351	351
220	MAY	WOO	1	22.3	0	0.02	0.03	350	393	436
220	MP	PRO	1	12.7	0	0.01	0.02	537	600	663
220	NW	PB	1	4.5	0	0	0.26	332	332	332
220	OST	TYN	1	10.04	0	0.01	0.01	434	481	513
220	PB	CKM	1	14.5	0	0.01	0.58	267	267	267
220	PB	PB	1	1	0	0.04	0	450	450	450
220	PB	SHL	1	0.12	0	0	0	593	593	593
220	PRO	TB	1	10.16	0	0.01	0.17	467	467	467
110	AA	DRU	1	18.15	0.03	0.06	0.01	99	110	121
110	AA	ENN (I)	1	32.33	0.05	0.11	0.01	99	110	121
110	AA	LIM (I)	1	11.7	0.01	0.04	0.01	178	194	209
110	AA	SNG	1	5.46	0	0.02	0.01	145	161	177
110	AD	WHI	1	3.1	0.01	0.01	0	99	110	121
110	ADM	INC	1	10.5	0.01	0.03	0.02	103	123	134
110	AGH	ENN (N)	1	31.1	0.04	0.1	0.02	109	114	124
110	AGL	DYN	1	8	0.01	0.03	0	105	116	123
110	AGL	ENN (I)	1	38.2	0.06	0.13	0.01	99	110	121
110	AGL	SH	1	45.88	0.07	0.16	0.02	104	113	119
110	AHA	KLN	1	3.77	0	0.01	0	112	112	112
110	ANR	DOO	1	2	0	0.01	0	105	116	123
110	ANT	KEL	1	8.93	0.01	0.03	0	82	95	103
110	ANT	KEL	2	8.93	0.01	0.03	0	82	95	103
110	AGY	TIV	1	35	0.05	0.12	0.01	105	116	123
110	ARI	ARI T	1	0.21	0	0	0	105	116	123
110	ARK	BEG	1	21.94	0.01	0.08	0.01	99	111	122
110	ARK	BOG	1	29	0.02	0.1	0.01	178	197	210
110	ARK	SHE	2	2.2	0	0.01	0	34	46	57
110	ART	FIN (I)	1	9	0.01	0.01	0.06	120	120	131
110	ART	MCD	1	4.9	0	0.01	0.03	120	120	131
110	ARV	COS	1	43.04	0.07	0.15	0.01	104	113	123
110	ARV	GWE	1	30.6	0.02	0.1	0.01	178	197	210
110	ARV	NAV	1	65.5	0.04	0.21	0.02	178	197	210
110	ARV	SKL	1	18.52	0.01	0.06	0.01	178	197	210
110	ARV	SKL	2	23.56	0.02	0.08	0.01	178	197	210
110	ATE	DRO	1	5.47	0	0.01	0.06	120	124	140
110	ATE	KNR	1	6.71	0	0.02	0.01	178	197	210
110	ATH	LA	1	35.78	0.05	0.12	0.01	99	110	121
110	ATH	SH	1	21.63	0.01	0.07	0.01	178	190	190
110	BGD	INC	1	6.5	0.01	0.01	0.07	140	140	140
110	BGD	INC	2	6.5	0.01	0.01	0.07	140	140	140

**Table B-2 Characteristics of Existing Transmission Circuits**

Voltage (kV)	From	To	No.	Length (km)	Impedance on			Rating (MVA)		
					100 MVA Base (pu)			Summer	Autumn	Winter
				R	X	B				
110	ATY	CLW	1	24.23	0.04	0.08	0.01	99	110	121
110	ATY	PLS	1	25.48	0.04	0.09	0.01	99	110	121
110	AUG	CFM	1	0.65	0	0	0	96	96	96
110	AUG	CFM	2	0.67	0	0	0	96	96	96
110	AUG	KPG	1	32.83	0.02	0.11	0.01	178	197	210
110	AUG	MTN	1	27.5	0.02	0.09	0.01	178	197	210
110	AUG	SK	3	1	0	0	0.01	120	120	120
110	AUG	SK	4	1	0	0	0.01	120	120	120
110	BAL	CDU	1	15.93	0.01	0.06	0.01	178	194	209
110	BAL	DRY	1	20	0.01	0.07	0.01	178	197	210
110	BAN	BRI	1	2.6	0	0.01	0	105	116	123
110	BAN	BRI	2	2.5	0	0.01	0	99	110	121
110	BAN	DMY	1	25.9	0.04	0.09	0.01	99	110	121
110	BAN	RAF	1	26.89	0.04	0.09	0.01	99	110	121
110	BAN	TAN	1	18.4	0.02	0.06	0.01	82	95	103
110	BAN	TAN	2	18.4	0.02	0.05	0.01	82	95	103
110	BAR	BAR	1	0.31	0	0	0	136	150	159
110	BCT	CKM	1	3.1	0	0.01	0.03	140	140	140
110	BCT	COO	1	15.1	0.01	0.05	0.03	130	130	130
110	BDA	MON	1	11.2	0.01	0.03	0.03	99	110	121
110	BDA	NEW (I)	1	7.2	0.01	0.02	0.03	122	122	122
110	BDN	CUL	1	21.8	0.03	0.08	0.01	196	216	217
110	BDN	DOO	1	11.3	0.01	0.04	0	178	197	210
110	BEG	CKM	1	32.3	0.02	0.12	0.01	136	150	159
110	BIN	CF	1	34.26	0.05	0.12	0.01	99	110	121
110	BIN	TIV	1	23.2	0.02	0.08	0.01	136	150	159
110	BK	CBR	1	37.39	0.05	0.13	0.01	195	202	221
110	BK	MOY	1	27	0.02	0.09	0.01	178	197	210
110	BK	SKY	1	4	0	0	0.04	192	192	192
110	BK	CRN	1	3.3	0	0.01	0	178	197	210
110	BK	SKY	1	4	0	0	0.04	187	206	223
110	BKM	CUR	1	7.3	0	0.01	0.07	120	120	120
110	BLA	RE	1	7.7	0	0.01	0.14	119	119	119
110	BLI	DMY	1	27.57	0.04	0.09	0.01	105	116	123
110	BLK	BLK	1	0.5	0	0	0	136	150	159
110	BMA	KEL	1	10	0.01	0.04	0	109	119	124
110	BMA	KEL	2	11.5	0.02	0.04	0	109	119	124
110	BNH	CAS	1	21.2	0.03	0.07	0.01	82	95	103
110	BNH	CAS	2	21.2	0.03	0.07	0.01	82	95	103
110	BNK	CKG	1	3	0	0	0.03	187	206	223
110	BNK	INC	1	10	0	0.01	0.11	187	206	223
110	BNM	DON	1	6.02	0.01	0.01	0.05	75	75	82
110	BNM	DON	2	5.81	0.01	0.01	0.05	75	75	82

**Table B-2 Characteristics of Existing Transmission Circuits**

Voltage (kV)	From	To	No.	Length (km)	Impedance on			Rating (MVA)		
					100 MVA Base (pu)			Summer	Autumn	Winter
					R	X	B			
110	BGH	CLA	1	13.5	0.01	0.04	0.03	178	197	210
110	BOG	CRA	1	24.67	0.02	0.08	0.01	178	197	210
110	BOL	ENN	1	24.69	0.02	0.08	0.01	178	197	210
110	BOL	TBKT	1	18.28	0.01	0.06	0.01	178	197	210
110	BPS	BVG	1	17.3	0.02	0.06	0.01	82	95	103
110	BPS	BVG	2	17.3	0.02	0.06	0.01	82	95	103
110	BPS	EDE	1	15.1	0.02	0.05	0.01	69	80	86
110	BPS	EDE	2	15.1	0.02	0.05	0.01	70	81	87
110	BRO	RSK	1	17.44	0.01	0.06	0.02	144	144	144
110	BRY	RAF	1	1.7	0	0.01	0	63	82	92
110	BRY	RAF	2	1.8	0	0.01	0	99	110	121
110	BUT	CUL	1	12.32	0.01	0.04	0.01	178	192	192
110	BUT	KTN	1	2.72	0	0.01	0	200	209	216
110	BVG	KEL	1	21.2	0.03	0.07	0.01	109	119	124
110	BVG	KEL	2	20.3	0.03	0.07	0.01	109	119	124
110	BVG	LAR	1	7.1	0.01	0.02	0	79	79	113
110	BVG	LAR	2	7.1	0.01	0.02	0	79	79	113
110	BVK	CTG	1	31.7	0.01	0.04	0.39	228	228	228
110	BWR	CRA	1	22.4	0.01	0.02	0.14	115	115	115
110	BYH	CDL	1	9.54	0	0.01	0.11	195	201	220
110	BYH	Gle	1	19.1	0.01	0.02	0.19	124	124	124
110	CAB	PTN	1	2.66	0	0.01	0.01	80	105	119
110	CAB	WOL	1	4.7	0	0.01	0.03	120	120	131
110	CAH	BAR	1	43.69	0.07	0.15	0.01	105	116	123
110	CAH	DOO	1	15.73	0.01	0.05	0.01	178	197	210
110	CAH	KHL	1	17.95	0.01	0.06	0.01	178	197	210
110	CAH	TIP	1	18.06	0.01	0.06	0.01	178	197	210
110	CAR	CAS	1	24.7	0.04	0.09	0.01	69	80	86
110	CAR	CAS	2	24.7	0.04	0.09	0.01	70	81	87
110	CAR	EDE	1	12.4	0.02	0.04	0	69	80	86
110	CAR	EDE	2	12.4	0.02	0.04	0	69	80	86
110	CAS	CRE	1	2.96	0	0	0.06	132	132	145
110	CAS	CRE	2	2.96	0	0	0.06	132	132	145
110	CAS	KNO	1	4.59	0.01	0	0.04	66	66	73
110	CAS	KNO	2	4.52	0.01	0	0.04	66	66	73
110	CAS	NAR	1	18	0.02	0.04	0.07	109	109	124
110	CAS	NAR	2	19.8	0.02	0.05	0.07	109	124	124
110	CAS	RAT (N)	1	18.9	0.03	0.06	0.01	82	95	103
110	CAS	RAT (N)	2	18.9	0.03	0.06	0.01	82	95	103
110	CAS	ROS	1	1.83	0	0	0.02	144	144	152
110	CAS	ROS	2	1.83	0	0	0.02	144	144	152
110	CAU	KLN	1	29.24	0.02	0.1	0.01	178	197	210
110	KNG	TRI	1	13.62	0.01	0.02	0.1	124	124	124

**Table B-2 Characteristics of Existing Transmission Circuits**

Voltage (kV)	From	To	No.	Length (km)	Impedance on			Rating (MVA)		
					100 MVA Base (pu)			Summer	Autumn	Winter
					R	X	B			
110	CBG	CBR	1	26.71	0.04	0.08	0.06	99	110	121
110	CBR	CLN	1	57.52	0.09	0.2	0.02	99	110	121
110	CBR	DLT	1	27.77	0.04	0.1	0.01	99	110	121
110	CCF	CAD	1	5.5	0	0.01	0.06	140	140	140
110	CCF	CKL	1	7	0	0.01	0.08	140	140	140
110	CD	KBY	1	32.33	0.02	0.1	0.03	178	194	209
110	CD	MAC	1	2.41	0	0.01	0	178	197	210
110	CDK	LWD	1	8.4	0	0.01	0.05	115	115	115
110	CDU	MUL	1	73.26	0.09	0.24	0.04	104	113	122
110	CDU	PLA	1	37	0.02	0.12	0.01	178	197	210
110	CDU	RYB	1	13	0.01	0.04	0	178	197	219
110	CDU	SBH	1	1.77	0	0	0.02	238	238	238
110	CDY	ARI T	1	13.68	0.01	0.04	0.01	178	197	210
110	CDY	GRV	1	5.83	0	0.02	0	132	137	150
110	CDY	SRA	1	12.7	0.02	0.04	0	178	197	210
110	CEN	CRE	1	3.22	0	0	0.03	144	144	144
110	CEN	CRE	2	3.22	0	0	0.03	144	144	144
110	CF	CL	1	5.5	0.01	0.02	0	136	150	159
110	CF	CLO	2	25.74	0.04	0.09	0.01	178	194	209
110	CF	COR	1	61.3	0.04	0.2	0.02	178	194	209
110	CF	SRA	1	52.98	0.07	0.18	0.02	196	214	234
110	CF	CLO	1	26.07	0.02	0.09	0.02	178	194	209
110	CF	SRA	2	49.2	0.03	0.16	0.02	178	197	210
110	CGL	GAE	1	2	0	0	0.01	130	130	130
110	CHA	GLE	1	28.06	0.04	0.1	0.01	99	110	121
110	CHA	KLN	1	36.9	0.04	0.12	0.01	136	150	159
110	CHA	MAL	1	22.5	0.01	0.07	0.01	178	197	210
110	CHE	FAS	1	2.2	0	0.01	0	105	116	123
110	CKG	CBT	1	0.75	0	0	0.01	187	206	223
110	CKG	KUD	1	0.75	0	0	0.01	187	206	223
110	CKM	CHE	1	4	0	0.01	0.03	105	116	123
110	CKM	COO	2	16	0.01	0.04	0.06	130	130	130
110	CKM	FAS	1	2.9	0.01	0.01	0	105	116	123
110	CKM	FAS	1	7.5	0.01	0.03	0	105	116	123
110	CKM	POT	1	3.2	0	0	0.06	119	119	119
110	CKN	CGL	1	6.3	0	0.02	0	178	190	190
110	CKN	GRO	1	15.17	0.01	0.01	0.14	120	120	120
110	CKN	KER	1	20.3	0.01	0.07	0.01	178	197	210
110	CLA	CKN	1	29.97	0.02	0.1	0.02	178	190	190
110	CLA	DMY	1	38.83	0.02	0.13	0.02	178	197	210
110	CLA	MAC	1	5.66	0	0.02	0	161	176	191
110	CLA	MAC	2	5.66	0	0.01	0.1	161	176	192
110	CLG	CDU	1	2.5	0	0	0.03	187	206	219

**Table B-2 Characteristics of Existing Transmission Circuits**

Voltage (kV)	From	To	No.	Length (km)	Impedance on			Rating (MVA)		
					100 MVA Base (pu)			Summer	Autumn	Winter
					R	X	B			
110	CLG	FIN (I)	1	3.64	0	0.01	0.01	124	124	124
110	CLH	TRI	1	9	0.01	0.03	0	99	110	121
110	CLH	TRL	1	13.5	0.02	0.05	0.01	105	114	123
110	CLN	LA	1	64.76	0.1	0.22	0.02	99	110	121
110	CLO	CCF	1	18	0.01	0.06	0.01	178	197	210
110	CLO	GLT	1	0.25	0	0	0	187	206	217
110	CLO	MRY	1	7.68	0	0.01	0.09	136	136	136
110	CLW	KLS	1	5.4	0.01	0.02	0	99	110	121
110	CLW	KLS	2	5.28	0.01	0.02	0	99	110	121
110	CLW	STR	1	17.6	0.03	0.06	0.01	105	116	123
110	GRO	BVK	1	4.91	0	0	0.05	195	201	220
110	COL (I)	CDU	1	2.66	0	0	0.02	143	143	143
110	COL (N)	CPS	1	46.7	0.06	0.16	0.02	82	95	103
110	COL (I)	FIN (I)	1	5.02	0	0.01	0.04	104	124	124
110	COL (N)	LIM (N)	1	18.63	0.02	0.06	0.01	82	95	103
110	COL (N)	LOG	1	8.1	0.01	0.03	0	82	95	103
110	COL (N)	LOG	2	8.1	0.01	0.03	0	82	95	103
110	COL (N)	RSK	1	20.01	0.02	0.07	0.01	186	191	193
110	COO	FTT	1	4.4	0	0.01	0.02	124	124	132
110	COO	INC	1	6.17	0.01	0.02	0.03	136	140	140
110	COR	ENN (N)	1	27.5	0.04	0.1	0.01	99	110	121
110	COR	GWE	1	10.9	0.01	0.04	0	178	197	210
110	COS	ARI T	1	20.7	0.01	0.07	0.01	178	197	210
110	COS	FLA	1	3.4	0.01	0.01	0	99	110	121
110	COS	FLA	2	3.3	0.01	0.01	0	99	110	121
110	COW	OLD	1	2.3	0	0.01	0	105	116	123
110	COW	OLD	2	2.2	0	0.01	0	105	116	123
110	COW	RAF	1	6.9	0.01	0.02	0	99	110	121
110	COW	WHI	1	17.79	0.03	0.06	0.01	99	110	121
110	CPK	CPK	1	3.38	0	0	0.03	100	100	100
110	CPK	TNY	1	5.59	0	0.01	0.07	100	100	100
110	CPS	KMT	1	14.5	0.01	0.05	0.01	143	158	166
110	CPS	LIM (N)	1	29.5	0.04	0.1	0.01	82	95	103
110	CPS	LMR	1	9	0.01	0.03	0	82	95	103
110	CPS	LMR	2	9	0.01	0.03	0	82	95	103
110	CPS	STR (N)	1	27	0.02	0.05	0.02	109	119	124
110	CPS	SPR	1	9.23	0.01	0.03	0.01	82	95	103
110	CPS	SPR	2	9.38	0.01	0.03	0.01	82	95	103
110	CRA	LWD	1	6.69	0	0.02	0	178	197	210
110	CRA	WEX	1	22.82	0.02	0.08	0.01	99	110	113
110	CRG	KEL	1	23.1	0.03	0.08	0.01	82	95	103
110	CRG	TMN	1	36.24	0.05	0.12	0.02	109	114	124
110	CRM	KLM	1	1.35	0	0	0.01	140	140	140

**Table B-2 Characteristics of Existing Transmission Circuits**

Voltage (kV)	From	To	No.	Length (km)	Impedance on			Rating (MVA)		
					100 MVA Base (pu)			Summer	Autumn	Winter
				R	X	B				
110	CRM	KLM	2	1.35	0	0	0.01	140	140	140
110	CRO	IA	1	2.74	0	0.01	0	196	216	217
110	CRO	KBY	1	14.35	0.02	0.05	0.02	178	194	200
110	CSH	CLN	1	22.8	0.01	0.07	0.01	178	197	210
110	CSH	DLT	1	60.76	0.07	0.21	0.02	99	110	121
110	CSH	ENN	1	53.47	0.03	0.17	0.02	178	197	210
110	CSH	GAL	1	13.8	0.02	0.05	0	99	110	121
110	CSH	GAL	2	11.3	0.02	0.04	0	99	110	121
110	CSH	GAL	3	11.3	0.02	0.04	0	99	110	121
110	CSH	SAL	1	24.85	0.02	0.07	0.07	97	97	97
110	CSH	SOM	1	50.02	0.08	0.17	0.02	99	110	121
110	CTN	TIP	1	13.15	0.01	0.04	0.01	178	197	210
110	CTY	FTT	1	1.5	0	0	0.02	124	124	132
110	CTY	INC	1	8.9	0.01	0.03	0	103	116	123
110	CUL	DGN	1	34.24	0.02	0.11	0.02	178	192	192
110	CUL	WAT	1	13.14	0.01	0.03	0.06	178	194	200
110	CUN	GLR	1	26.29	0.04	0.09	0.01	178	194	209
110	CUN	SLI	1	21.1	0.03	0.07	0.01	178	194	209
110	CUR	BKM	1	17.3	0	0.02	0.19	190	190	190
110	CUR	NEN	1	18.83	0.03	0.07	0.01	105	116	123
110	CUS	MLC	1	13.67	0.02	0.05	0.01	136	150	159
110	CUS	NEW (I)	1	24.61	0.03	0.08	0.01	134	147	152
110	CUS	PLS	1	42.14	0.04	0.14	0.01	136	150	159
110	CVW	COW	1	17.22	0.02	0.05	0.02	99	110	121
110	CVW	DKL	1	0.36	0	0	0	105	116	123
110	CVW	KRA	1	7.59	0.01	0.03	0	99	110	121
110	DAL	DAL	1	12.2	0.02	0.04	0	105	116	123
110	DDK	LOU	1	16.81	0.03	0.06	0.01	99	110	121
110	DDK	MLN	1	7.5	0.01	0.03	0	99	110	121
110	DER	KIN	1	15.11	0.01	0.05	0.01	99	110	121
110	DER	MAY	1	43.45	0.03	0.15	0.02	74	84	93
110	DER	TSB	1	19.67	0.03	0.07	0.01	99	110	121
110	DEY	DAL	1	6.35	0	0.02	0	178	197	210
110	DEY	PLS	1	48.45	0.03	0.16	0.02	178	197	210
110	DGN	WHE	1	8.65	0.01	0.03	0	178	197	210
110	DMY	CDN	1	10.88	0.02	0.04	0	211	216	217
110	DMY	MAC	1	26.22	0.04	0.09	0.01	196	213	217
110	DON	FIN (N)	1	3.67	0	0.01	0.01	69	81	86
110	DON	FIN (N)	2	3.74	0	0.01	0.01	69	80	86
110	DON	HAN	1	6.07	0	0.01	0.14	144	144	158
110	DON	HAN	2	5.89	0	0.01	0.14	144	144	158
110	DRM	CLO	1	27	0.04	0.09	0.02	103	116	123
110	DRM	LET	1	8.35	0.01	0.03	0	99	110	123



**Table B-2 Characteristics of Existing Transmission Circuits**

Voltage (kV)	From	To	No.	Length (km)	Impedance on			Rating (MVA)		
					100 MVA Base (pu)			Summer	Autumn	Winter
				R	X	B				
110	DRM	MEE	1	5	0.01	0.02	0	99	110	121
110	DRO	EKN	1	24.59	0.03	0.07	0.01	82	95	103
110	DRO	EKN	2	24.59	0.03	0.07	0.01	82	95	103
110	DRO	OMA	1	9.23	0.02	0.05	0.01	82	95	103
110	DRO	OMA	2	9.23	0.02	0.05	0.01	82	95	103
110	DRU	ENN	1	17.44	0.03	0.06	0.01	99	110	121
110	DRU (N)	TAN	1	4.4	0	0.01	0	79	96	113
110	DRU (N)	TAN	2	4.4	0	0.01	0	79	96	113
110	DRU (N)	TAN	3	4.1	0.01	0.01	0	108	119	126
110	DRU (N)	TMN	1	22.69	0.03	0.08	0.01	109	119	124
110	DRU (N)	TMN	2	21.53	0.03	0.07	0.01	109	119	124
110	DRY	GOR	1	19.39	0.03	0.07	0.01	99	110	121
110	DRY	LOU	1	31.9	0.02	0.1	0.01	99	110	121
110	DRY	PLA	1	5.3	0.01	0.02	0	99	110	121
110	DTN	FIN (I)	1	9.25	0	0.01	0.11	140	140	140
110	DTN	KLM	1	3.2	0	0.01	0.03	140	140	140
110	DUN	OMA	1	36.1	0.04	0.12	0.01	186	191	193
110	DUN	TMN	1	6.53	0	0.02	0.01	157	171	178
110	DUN	TMN	2	5.82	0.01	0.02	0	144	144	144
110	DUN	TMN	3	6.01	0	0.02	0.02	186	191	193
110	ENN (I)	SLC	1	31	0	0.05	0.27	195	201	220
110	FAS	FAS	1	5	0.01	0.02	0	105	116	123
110	FIN	GLA	1	14.02	0.02	0.05	0.01	105	116	123
110	FIN	GRA	1	13.2	0.01	0.01	0.24	119	119	119
110	FIN (N)	HAN	1	3.03	0	0	0.02	144	144	144
110	FIN (N)	HAN	2	3.21	0	0	0.02	144	144	144
110	FIN	MCD	1	7.9	0	0.01	0.14	119	119	119
110	FIN	POP	1	4.3	0	0.01	0.03	120	120	131
110	FIN	PTN	1	3.52	0	0.01	0.01	80	105	119
110	FIN	SVN	1	32.22	0.04	0.1	0.06	105	115	115
110	FLA	GIL	1	10.6	0.02	0.04	0	105	116	123
110	FLA	SLB	1	21.7	0.03	0.08	0.01	99	110	123
110	FLA	SLI	1	50.5	0.08	0.17	0.02	99	110	121
110	FLA	TON	1	32.31	0.05	0.11	0.01	98	111	126
110	FRA	HAR	1	2.28	0	0	0.03	107	107	107
110	FRA	HEU	1	2.4	0	0	0.02	140	140	140
110	FRA	INC	1	5.6	0	0.01	0.07	107	107	107
110	FRA	TRN	1	2.8	0	0	0.03	140	140	140
110	GAL	SEE	1	25.53	0.01	0.03	0.14	99	110	121
110	GAL	SAL	1	6.12	0	0	0.07	99	106	106
110	GCA	GRI	1	8.87	0.01	0.03	0.01	103	120	131
110	GCA	INC	1	8.1	0.01	0.03	0.01	103	123	134
110	GCA	INC	2	8.1	0.01	0.03	0.01	103	123	134

**Table B-2 Characteristics of Existing Transmission Circuits**

Voltage (kV)	From	To	No.	Length (km)	Impedance on			Rating (MVA)		
					100 MVA Base (pu)			Summer	Autumn	Winter
					R	X	B			
110	GCA	KUD	2	2.1	0	0	0.02	140	140	140
110	GCA	NAN	1	1.82	0	0	0.01	120	120	131
110	GCA	NAN	2	1.74	0	0	0.01	120	120	131
110	GI	KKY	1	49.2	0.08	0.17	0.02	99	110	121
110	GI	WAT	1	11.7	0.01	0.04	0	178	197	210
110	GI	WAT	2	12.92	0.01	0.04	0.01	178	197	210
110	GI	WEX	1	34.5	0.02	0.11	0.01	178	197	210
110	GLA	SVN	1	18	0.02	0.06	0.05	136	150	154
110	GLE (N)	KEL	1	21.4	0.03	0.07	0.03	82	82	90
110	GLE (N)	KEL	2	21.4	0.03	0.07	0.03	82	82	90
110	GLE	KCR	1	11.32	0	0.01	0.12	122	122	122
110	GOL	GL T	1	3.9	0.01	0.01	0	105	116	123
110	GOR	MTH	1	26.39	0.03	0.09	0.01	99	110	121
110	GOR	NAV	1	5.33	0.01	0.02	0	99	110	121
110	GOR	NAV	2	6.3	0.01	0.02	0	99	110	121
110	GOR	NAV	3	5.49	0.01	0.02	0.01	99	110	121
110	GOR	PLA	1	19.74	0.03	0.07	0.01	99	110	121
110	GRA	NBY	1	5.05	0	0.01	0.09	119	119	119
110	GRI	GRI	1	1	0	0	0	105	116	123
110	GRI	MAY	1	2.2	0	0.01	0	105	116	123
110	GOR (N)	OMA	1	17.12	0.01	0.07	0.01	200	200	200
110	GOR (N)	TMN	1	34.83	0.02	0.13	0.01	200	200	200
110	HAN	LIS (N)	1	9.2	0.01	0.03	0.02	82	95	103
110	HAN	LIS (N)	2	9.2	0.01	0.03	0.02	80	93	100
110	HAR	RE	1	5.63	0	0.01	0.07	107	107	107
110	HEU	INC	1	3.6	0	0.01	0.04	140	140	140
110	IA	MAC	1	18.16	0.03	0.06	0.01	196	213	217
110	IKE	IKE T	1	0.15	0	0	0	80	105	119
110	INC	MIL	1	8.4	0	0.01	0.05	120	120	131
110	KBY	KRA	1	11.9	0.01	0.04	0	178	197	210
110	KBY	KRA	2	12.5	0.02	0.04	0	99	110	121
110	KBY	MAL	1	29.2	0.02	0.1	0.01	134	147	159
110	KBY	MR	1	4.44	0	0.02	0	103	119	130
110	KBY	MR	2	4.65	0.01	0.02	0	103	119	130
110	KEL	RSK	1	25.9	0.04	0.13	0.01	185	190	193
110	KER	OUG T	1	22.6	0.01	0.07	0.01	178	197	210
110	KMT	STR (N)	1	11.2	0.01	0.04	0	143	158	166
110	KMT	SLK	1	6.2	0.01	0.02	0.01	109	119	124
110	KIN	DFR	1	29.25	0.02	0.1	0.01	99	110	121
110	KIN	MUL	1	24.92	0.02	0.08	0.02	178	197	210
110	KHL	THU	1	21.24	0.01	0.07	0.01	178	197	210
110	KLM	NBY	1	1.2	0	0	0.02	119	119	119
110	KLM	POP	1	6	0	0.01	0.04	120	120	131

**Table B-2 Characteristics of Existing Transmission Circuits**

Voltage (kV)	From	To	No.	Length (km)	Impedance on			Rating (MVA)		
					100 MVA Base (pu)			Summer	Autumn	Winter
					R	X	B			
110	KLN	CUR	1	14.77	0.01	0.05	0.01	136	150	159
110	KLN	LIM (I)	1	9	0.01	0.03	0	99	110	121
110	KLN	LIM (I)	2	11.7	0.02	0.04	0.01	80	95	110
110	KLN	SNG	1	4.05	0	0.01	0	178	194	209
110	KPG	CNG	1	0.3	0	0	0	140	140	140
110	KPG	KNR	1	14.95	0.02	0.05	0.01	136	150	159
110	KPG	RAT (I)	1	32.42	0.03	0.11	0.02	136	150	159
110	KPG	TB	1	1.61	0	0.01	0	99	110	121
110	KPG	TB	2	1.61	0	0.01	0	99	110	121
110	KPG	TRL	1	39.38	0.06	0.14	0.01	99	110	121
110	KPG	TRL	2	43.58	0.03	0.14	0.02	178	190	190
110	KLS	KKY	1	34.3	0.05	0.12	0.01	99	110	121
110	KNR	TRI	1	4.29	0	0.01	0.01	178	194	209
110	KNR	TRI	2	4.21	0	0.01	0	99	110	121
110	KRA	BAR	1	19.45	0.02	0.07	0.01	136	150	159
110	KRA	MID	1	10.7	0.02	0.04	0	99	110	121
110	KRA	WHO	1	41.46	0.03	0.14	0.02	178	197	210
110	KTL	MAY	1	21.39	0.02	0.07	0.01	99	110	121
110	KTL	MON	1	8.88	0.01	0.03	0	136	150	159
110	KTN	WAT	1	3.3	0	0	0.04	99	110	121
110	KUR	NAV	1	6.1	0.01	0.02	0	99	110	123
110	LA	MUL	1	46.27	0.07	0.16	0.02	99	110	121
110	LA	RIC	1	15.74	0.02	0.05	0.01	99	110	123
110	LA	RIC	2	12.55	0.02	0.04	0.01	99	110	123
110	LA	SLB	1	9.1	0.01	0.03	0	99	110	123
110	LET	GL T	1	38.4	0.06	0.13	0.01	99	110	121
110	LET	STR (N)	1	22.25	0.04	0.08	0.01	99	110	123
110	LET	TIV	1	45.2	0.05	0.15	0.02	136	150	159
110	LET	TLK	1	34.05	0.05	0.12	0.01	105	116	123
110	LIB	MR	1	2.7	0	0	0.02	100	100	100
110	LIB	MR	2	2.74	0	0	0.02	99	110	119
110	LIM (I)	MTN	1	6.47	0.01	0.02	0	178	197	210
110	LIM (I)	RAT	1	28.35	0.04	0.1	0.01	99	110	121
110	LIS	LOU	1	40.4	0.06	0.14	0.01	99	110	123
110	LIS	SKL	1	39.3	0.06	0.14	0.01	99	110	123
110	LIS (N)	TAN	1	31	0.04	0.11	0.01	82	95	103
110	LIS (N)	TAN	2	29.2	0.03	0.1	0.01	80	93	100
110	LOU	MLN	1	13	0.02	0.05	0	99	110	121
110	LOU	MTH	1	15.1	0.02	0.05	0.01	99	110	121
110	LOU	RRU	1	38.82	0.06	0.13	0.01	95	103	112
110	LSN	THU	1	10.4	0.02	0.04	0	104	113	122
110	MKL	OMA	1	37.5	0.03	0.11	0.02	139	150	157
110	MAY	BLK	1	30.9	0.03	0.1	0.01	99	110	121

**Table B-2 Characteristics of Existing Transmission Circuits**

Voltage (kV)	From	To	No.	Length (km)	Impedance on			Rating (MVA)		
					100 MVA Base (pu)			Summer	Autumn	Winter
				R	X	B				
110	MAY	GRI	1	2.2	0	0.01	0	99	110	120
110	MAY	RNW	1	7.1	0.01	0.02	0	80	92	103
110	MAY	RYB	1	9.02	0.01	0.03	0.01	178	197	219
110	MCD	NQS	1	2	0	0	0.04	119	119	119
110	MCD	WOL	1	1.4	0	0	0.01	120	120	131
110	MHL	RE	1	3	0	0	0.03	140	140	140
110	MHL	TRN	1	1.4	0	0	0.01	140	140	140
110	MID	WHI	1	20.02	0.03	0.07	0.01	99	110	121
110	MIL	RE	1	4.9	0	0.01	0.08	100	100	100
110	MIL	RE	2	5.55	0	0.01	0.03	120	120	131
110	MIL	TNY	1	5.55	0	0.01	0.07	100	100	100
110	MLC	TSB	1	18.29	0.02	0.06	0.03	135	147	159
110	MOY	TAW	1	8.39	0.01	0.03	0	99	110	123
110	MOY	TAW	2	8.3	0.01	0.03	0	99	110	121
110	MP	TBK T	1	7.29	0.01	0.02	0	178	197	210
110	MR	TBG	1	3.25	0	0	0.04	178	198	219
110	MR	TBG	2	2.8	0	0	0.03	178	206	219
110	MTN	MUN	1	0.7	0	0	0	105	116	123
110	MTN	MUN	2	0.7	0	0	0	105	116	123
110	NEW (I)	BLK	1	12.2	0.01	0.04	0	136	150	159
110	NEW (N)	TAN	1	24.1	0.03	0.08	0.01	82	95	103
110	NEW (N)	TAN	2	24	0.03	0.08	0.01	82	95	103
110	NQS	RE	1	2.1	0	0	0.04	119	119	119
110	OMA	STR (N)	1	35.5	0.05	0.12	0.01	109	119	124
110	OMA	STR (N)	2	35.5	0.05	0.13	0.01	82	95	103
110	OMA	TRE	1	21.45	0.03	0.07	0.01	186	191	193
110	GLR	MOY	1	13.96	0.02	0.05	0	105	116	123
110	OUG	OUG T	1	11	0.02	0.04	0	105	116	123
110	PA	STR	1	22.4	0.04	0.08	0.01	105	116	123
110	PB	RE	3	1.4	0	0	0.05	269	269	269
110	PB	RE	4	1.4	0	0	0.05	269	269	269
110	RAF	RSY	1	2.1	0	0.01	0	63	82	92
110	RAF	TBG	1	11.03	0.02	0.04	0.01	195	201	2200
110	RAF	TBG	2	9.5	0.01	0.03	0.01	178	194	209
110	RE	WBK	1	0.62	0	0	0.02	125	130	141
110	REM	TRL	1	11.99	0.01	0	0.11	125	130	141
110	RNW	DFR	1	25.9	0.02	0.09	0.01	99	110	121
110	RRU	SKL	1	12.67	0.02	0.04	0	95	103	112
110	KNY	KLH	1	11.7	0	0.02	0.11	190	190	190
110	KNY	SCR	1	33.33	0.03	0.11	0.04	135	147	159
110	KNY	SHL	1	22.71	0.02	0.06	0.08	195	201	220
110	KNY	UGL	1	3.42	0	0	0.04	195	201	220
110	BRA	NEW (I)	1	22.7	0.02	0.08	0.01	136	150	159

**Table B-2 Characteristics of Existing Transmission Circuits**

Voltage (kV)	From	To	No.	Length (km)	Impedance on			Rating (MVA)		
					100 MVA Base (pu)			Summer	Autumn	Winter
				R	X	B				
110	BRA	PLS	1	19.26	0.03	0.07	0.01	99	110	121
110	SH	DAL	1	12	0.01	0.04	0.01	178	197	210
110	SH	IKE T	1	53.94	0.03	0.18	0.02	178	197	210
110	SH	SOM	1	13.8	0.02	0.05	0.01	105	116	123
110	SLI	SRA	1	11.1	0.02	0.04	0	99	110	121
110	SLI	SRA	2	12	0.02	0.04	0	99	110	121
110	SBH	MCE	1	4.72	0.01	0.02	0.01	99	110	121
110	SOM	SOM	1	2	0	0.01	0	105	116	123
110	SOR	TLK	1	4.4	0.01	0.02	0	105	116	123
110	STR	STR	1	2	0	0.01	0	105	116	123
110	TAN	WAR	1	12.9	0.01	0.04	0.01	79	96	113
110	TAN	WAR	2	12.9	0.01	0.04	0.01	79	96	113
110	TBK	TBK T	1	2.9	0.01	0.01	0	105	116	123
110	THU	IKE T	1	25.68	0.02	0.08	0.01	178	197	210
110	TRE	TMN	1	42.93	0.03	0.08	0.03	186	191	193
110	TRL	OUG T	1	11.3	0.01	0.04	0	178	197	210
110	WHE	WHE	1	1.5	0	0	0.02	124	124	124

**Table B-3 Characteristics of Existing Transformers in Ireland**

Station	Transformer	Rating (MVA)	HV/LV (kV)	Impedance on		Voltage Ratio Tapping Range	
				100 MVA Base (pu)		+	-
				R	X		
DSN	T4201	500	400/220	0.0002	0.0317	0.013	0.156
DSN	T4202	500	400/220	0.0003	0.027	0.105	0.079
MP	T4201	500	400/220	0.0003	0.027	0.105	0.079
MP	T4202	500	400/220	0.0002	0.0329	0.013	0.156
OST	T4201	500	400/220	0.0003	0.027	0.105	0.079
WOO	T4201	500	400/220	0.0002	0.0316	0.014	0.155
WOO	T4202	550	400/220	0.0002	0.027	N/A	N/A
WOO	T4204	500	400/220	0.0002	0.0316	0.014	0.155
LOU	AT1	300	275/220	0.0008	0.0303	0.154	0.154
LOU	AT2	600	220/275	0.0008	0.03	0.154	0.154
LOU	AT3	300	220/275	0.0008	0.015	0.154	0.154
AD	T2101	125	220/110	0.001	0.124	0.1	0.18
ARK	T2101	63	220/110	0.007	0.18	0.23	0.19
ARK	T2102	125	220/110	0.0021	0.1237	0.097	0.182
BVK	T2101	250	220/110	0.001	0.064	0.097	0.178
BVK	T2102	250	220/110	0.001	0.064	0.097	0.178
BLC	T2101	250	220/110	0.001	0.0646	0.097	0.179
CLA	T2102	250	220/110	0.0013	0.0647	0.097	0.179
CLA	T2101	250	220/110	0.0013	0.0647	0.1	0.1
CSH	T2101	238	220/110	0.0004	0.0631	0.096	0.182
CSH	T2102	250	220/110	0.0004	0.0631	0.096	0.182
CSH	T2104	175	220/110	0.0021	0.1332	0.227	0.182
CKM	T2101	250	220/110	0.001	0.0646	0.097	0.179
CKM	T2102	250	220/110	0.001	0.0646	0.097	0.179
CKM	T2103	250	220/110	0.001	0.0646	0.097	0.179
CKM	T2104	250	220/110	0.0004	0.0631	0.096	0.182
CUL	T2101	250	220/110	0.0005	0.064	0.09	0.182
CDU	T2101	250	220/110	0.00093	0.06152	0.097	0.178
CDU	T2102	250	220/110	0.00066	0.061	0.099	0.177
FLA	T2101	125	220/110	0.0027	0.128	0.097	0.182
FLA	T2102	125	220/110	0.0008	0.1331	0.097	0.182
FIN	T2101	250	220/110	0.0013	0.0651	0.098	0.18
FIN	T2102	250	220/110	0.0013	0.0648	0.099	0.18
FIN	T2103	250	220/110	0.001	0.064	0.099	0.177
FIN	T2104	250	220/110	0.001	0.0638	0.099	0.177
FIN	T2105	250	220/110	0.001	0.064	0.099	0.177
GI	T2101	125	220/110	0.0026	0.1331	0.097	0.182
GI	T2102	125	220/110	0.0023	0.1237	0.229	0.182
GOR	T2101	250	220/110	0.001	0.064	0.097	0.182
INC	T2101	250	220/110	0.001	0.0564	0.095	0.178
INC	T2102	250	220/110	0.001	0.0564	0.095	0.178
INC	T2103	250	220/110	0.0001	0.06	0.09	0.182
INC	T2104	250	220/110	0.0001	0.06	0.09	0.182

**Table B-3 Characteristics of Existing Transformers in Ireland**

Station	Transformer	Rating (MVA)	HV/LV (kV)	Impedance on		Voltage Ratio Tapping Range	
				100 MVA Base (pu)		+	-
				R	X		
KNR	T2101	250	220/110	0.001	0.064	0.097	0.178
KNR	T2102	250	220/110	0.001	0.064	0.097	0.178
KRA	T2101	250	220/110	0.0013	0.0647	0.097	0.179
KRA	T2102	250	220/110	0.0013	0.0652	0.097	0.179
KRA	T2103	250	220/110	0.0013	0.0652	0.097	0.179
KLN	T2101	63	220/110	0.0065	0.2453	0.229	0.182
KLN	T2102	63	220/110	0.0095	0.2473	0.229	0.182
KLN	T2103	250	220/110	0.0004	0.0631	0.096	0.182
KLN	T2104	120	220/110	0.001	0.123	0.097	0.182
BYH	T2101	250	220/110	0.001	0.064	0.097	0.178
BYH	T2102	250	220/110	0.001	0.064	0.097	0.178
KLS	T2101	125	220/110	0.00132	0.1237	0.097	0.182
KLS	T2102	125	220/110	0.0008	0.1237	0.097	0.182
KPG	T2101	250	220/110	0.0004	0.0631	0.096	0.182
KPG	T2102	250	220/110	0.0004	0.0631	0.096	0.182
CBT	T2101	250	220/110	0.001	0.0646	0.097	0.179
CBT	T2102	250	220/110	0.001	0.0646	0.097	0.179
CBT	T2103	250	220/110	0.001	0.0646	0.097	0.179
CBT	T2104	250	220/110	0.001	0.0646	0.097	0.179
LOU	T2101	125	220/110	0.0022	0.1331	0.229	0.182
LOU	T2103	125	220/110	0.0023	0.1324	0.229	0.182
LOU	T2102	125	220/110	0.0022	0.1324	0.23	0.182
LOU	T2104	250	220/110	0.001	0.064	0.097	0.178
LWD	T2101	250	220/110	0.001	0.064	0.099	0.18
MAY	T2101	125	220/110	0.0021	0.1339	0.227	0.182
MAY	T2102	238	220/110	0.001	0.064	0.097	0.178
MAY	T2103	125	220/110	0.0021	0.1324	0.227	0.182
MAY	T2104	250	220/110	0.001	0.064	0.099	0.177
MP	T2101	250	220/110	0.001	0.064	0.097	0.178
PB	T2103	250	220/110	0.0013	0.059	0.089	0.173
PB	T2104	250	220/110	0.0013	0.0609	0.089	0.173
RAF	T2101	238	220/110	0.001	0.064	0.097	0.178
RAF	T2102	250	220/110	0.000446	0.0558	0.097	0.178
SH	T2101	125	220/110	0.00574	0.1237	0.097	0.182
SH	T2102	125	220/110	0.00131	0.1237	0.097	0.182
SRA	T2101	250	220/110	0.001	0.064	0.097	0.182
TB	T2101	238	220/110	0.00099	0.0554	0.097	0.179
TB	T2102	238	220/110	0.00099	0.0554	0.097	0.179

**Table B-4 Characteristics of Existing 3 Winding Transformers in Northern Ireland**

Substation/ Transformer	HV/LV (kV)	Impedance pu on 100 MVA base						Rating (MVA)			Off Nominal Ratio (pu)		No. of Taps
		W1-2		W2-3		W3-1		W1	W2	W3	Upper	Lower	
		R	X	R	X	R	X						
BPS IBTx 1	275/110	0.002	0.064	0.002	0.209	0	0.133	240	240	30	1.15	0.85	19
BPS IBTx 2	275/110	0.002	0.064	0.002	0.206	0	0.128	240	240	30	1.15	0.85	19
CAS IBTx 1	275/110	0.001	0.064	0.001	0.224	0	0.145	240	240	30	1.15	0.85	19
CAS IBTx 2	275/110	0.002	0.064	0.002	0.209	0	0.133	240	240	30	1.15	0.85	19
CAS IBTx 3	275/110	0.002	0.066	0.002	0.238	0	0.159	240	240	30	1.15	0.85	19
CPS IBTx 1	275/110	0.002	0.064	0.002	0.224	0	0.145	240	240	60	1.15	0.85	19
CPS IBTx 2	275/110	0.001	0.064	0.001	0.224	0	0.145	240	240	30	1.15	0.85	19
HAN IBTx 1	275/110	0.002	0.059	0.002	0.126	0	0.056	240	240	45	1.15	0.85	19
HAN IBTx 2	275/110	0.002	0.059	0.002	0.126	0	0.056	240	240	45	1.15	0.85	19
HAN IBTx 3	275/110	0.001	0.064	0.001	0.224	0	0.145	240	240	60	1.15	0.85	19
KEL IBTx 1	275/110	0.002	0.061	0.002	0.127	0	0.057	240	240	45	1.15	0.85	19
KEL IBTx 2	275/110	0.002	0.061	0.002	0.132	0	0.057	240	240	45	1.15	0.85	19
TAN IBTx 1	275/110	0.002	0.064	0.002	0.209	0	0.133	240	240	30	1.15	0.85	19
TAN IBTx 2	275/110	0.002	0.064	0.002	0.209	0	0.133	240	240	30	1.15	0.85	19
TAN IBTx 3	275/110	0.001	0.064	0.001	0.224	0	0.145	240	240	60	1.15	0.85	19
TMN IBTx 1	275/110	0.001	0.064	0.004	0.232	0	0.151	240	240	60	1.15	0.85	19
TMN IBTx 2	275/110	0.001	0.064	0.004	0.23	0	0.15	240	240	60	1.15	0.85	19
KPS IBTx 1	275/11.5	0.006	0.307	0.009	0.574	0.06	0.304	110	55	55	1.15	0.938	33



**Table B-5 Characteristics of Existing 2 Winding Transformers in Northern Ireland<sup>128</sup>**

Station	HV/LV (kV)	Rating (MVA)	Impedance pu on rating base		Off nominal ratio		No. of Taps
			R	X	Upper	Lower	
AGH	110/33	90	0.0039	0.2464	1.1	0.8	19
ANT	110/33	90	0.0039	0.2464	1.1	0.8	19
ANT	110/33	90	0.0039	0.2473	1.1	0.8	19
BMA	110/33	90	0.0039	0.2447	1.1	0.8	19
BMA	110/33	90	0.0039	0.2463	1.1	0.8	19
BMA	110/33	90	0.0065	0.2893	1.1	0.8	19
BMA	110/33	60	0.0065	0.2867	1.1	0.8	19
BAN (N)	110/33	30	0.0171	0.4133	1.1	0.8	15
BAN (N)	110/33	30	0.019	0.414	1.1	0.8	15
BAN (N)	110/33	30	0.019	0.4167	1.1	0.8	15
BAN (N)	110/33	30	0.019	0.415	1.1	0.8	15
BNH	110/33	90	0.0037	0.2419	1.1	0.8	19
BNH	110/33	90	0.0038	0.2413	1.1	0.8	19
BNM	110/33	90	0.0039	0.2461	1.1	0.8	19
BNM	110/33	90	0.0039	0.2461	1.1	0.8	19
BRO	110/33	100	0.0035	0.16	1.1	0.9	33
CAR	110/33	90	0.0039	0.248	1.1	0.8	19
CAR	110/33	90	0.0039	0.248	1.1	0.8	19
CEN	110/33	90	0.0037	0.2422	1.1	0.8	19
CEN	110/33	90	0.0038	0.2419	1.1	0.8	19
COL (N)	110/33	60	0.0074	0.2512	1.1	0.8	19
COL (N)	110/33	60	0.0075	0.2508	1.1	0.8	19
CPS	110/33	90	0.0087	0.2559	1.1	0.8	19
CPS	110/33	90	0.0087	0.2573	1.1	0.8	19
CRG	110/33	60	0.0074	0.2515	1.1	0.8	19
CRG	110/33	60	0.0074	0.2508	1.1	0.8	19
CRE	110/33	75	0.0091	0.1953	1.1	0.8	19
CRE	110/33	75	0.0091	0.1967	1.1	0.8	19
DON	110/33	60	0.0119	0.3607	1.1	0.8	19
DON	110/33	60	0.0119	0.3658	1.1	0.8	19
DON	110/33	90	0.004	0.2403	1.1	0.8	19
DON	110/33	60	0.0119	0.3658	1.1	0.8	19
DRU (N)	110/33	90	0.0061	0.2423	1.1	0.8	19
DRU (N)	110/33	90	0.0061	0.2426	1.1	0.8	19
DRQ	110/33	90	0.0039	0.2461	1.1	0.8	19
DUN	110/33	90	0.0087	0.2566	1.1	0.8	19
DUN	110/33	90	0.0087	0.2599	1.1	0.8	19
EDE	110/33	45	0.0125	0.2733	1.1	0.8	19
EDE	110/33	45	0.0123	0.2738	1.1	0.8	19
ENN (N)	110/33	45	0.0126	0.272	1.1	0.8	19

<sup>128</sup> 110/33 kV transformers in Northern Ireland are included here as these are controlled by SONI. 110/38 kV transformers in Ireland are not included here as these are controlled by ESB Networks.

**Table B-5 Characteristics of Existing 2 Winding Transformers in Northern Ireland**

Station	HV/LV (kV)	Rating (MVA)	Impedance pu on rating base		Off nominal ratio		No. of Taps
			R	X	Upper	Lower	
ENN (N)	110/33	45	0.0126	0.2733	1.1	0.8	19
ENN (N)	110/33	60	0.0078	0.2512	1.1	0.8	19
FIN (N)	110/33	45	0.0076	0.2533	1.1	0.8	19
FIN (N)	110/33	45	0.0076	0.2549	1.1	0.8	19
GLE (N)	110/33	60	0.0119	0.2692	1.1	0.8	19
GOR (N)	110/33	90	0.0039	0.2461	1.1	0.8	19
KMT	110/33	90	0.0039	0.2461	1.1	0.8	19
KNO	110/33	90	0.0039	0.2461	1.1	0.8	19
KNO	110/33	90	0.0039	0.2461	1.1	0.8	19
LAR	110/33	45	0.0116	0.2778	1.1	0.8	15
LAR	110/33	45	0.0116	0.2771	1.1	0.8	15
LIM (N)	110/33	45	0.0125	0.2809	1.1	0.8	15
LIM (N)	110/33	45	0.0122	0.2764	1.1	0.8	15
LIS (N)	110/33	90	0.0087	0.254	1.1	0.8	19
LIS (N)	110/33	90	0.0086	0.2569	1.1	0.8	19
LMR	110/33	45	0.0076	0.254	1.1	0.8	19
LMR	110/33	45	0.0076	0.2533	1.1	0.8	19
LOG	110/33	45	0.0126	0.2738	1.1	0.8	19
LOG	110/33	45	0.0128	0.28	1.1	0.8	19
MKL	110/33	90	0.0039	0.2502	1.1	0.8	19
MKL	110/33	90	0.0039	0.2502	1.1	0.8	19
NAR	110/33	60	0.0075	0.2505	1.1	0.8	19
NAR	110/33	60	0.0073	0.25	1.1	0.8	19
NEW (N)	110/33	90	0.0038	0.2427	1.1	0.8	19
NEW (N)	110/33	90	0.0038	0.2419	1.1	0.8	19
OMA	110/33	90	0.0039	0.2481	1.1	0.8	19
OMA	110/33	90	0.0039	0.249	1.1	0.8	19
RSK	110/33	90	0.0039	0.2461	1.1	0.8	19
RAT (N)	110/33	90	0.0087	0.2549	1.1	0.8	19
RAT (N)	110/33	90	0.0046	0.2402	1.1	0.8	19
ROS	110/33	90	0.0087	0.2576	1.1	0.8	19
ROS	110/33	90	0.0087	0.2533	1.1	0.8	19
SPR	110/33	90	0.0039	0.247	1.1	0.8	19
SPR	110/33	90	0.0039	0.2471	1.1	0.8	19
STR (N)	110/33	45	0.0076	0.2522	1.1	0.8	19
STR (N)	110/33	45	0.0076	0.2516	1.1	0.8	19
TRE	110/33	90	0.0039	0.2461	1.1	0.8	19
WAR	110/33	90	0.0039	0.2481	1.1	0.8	19
WAR	110/33	90	0.0039	0.2488	1.1	0.8	19

**Table B-6 Characteristics of Existing Power Flow Controllers**

Station	Voltage (kV)	Circuit	Rating (MVA)	Impedance on 100 MVA Base (pu)		Phase Angle Range (electrical degrees)	
				R	X	+	-
CKM	220	CKM – PB	350	0.000	0.029	15.3	15.3
ENN (N)	110	ENN (N) – COR	125	0.000	0.0213	45	45
STR (N)	110	STR (N) – LET	125	0.000	0.0213	45	45

**Table B-7 Characteristics of Existing Reactive Compensation**

Station	Voltage (kV)	Plant	Capability (Mvar)	
			Generate	Absorb
AA	110	1 Capacitor	30	
ATH	110	3 Capacitors (1 Mobile)	90	
BAN (I)	110	1 Capacitor	15	
BYC	275	4 Capacitors (4 x 59)	236	
CAH	110	4 Capacitors (4 x 15)	60	
CAS	22	1 Shunt Reactor (30)		30
CAS	22	3 Capacitors (3 x 25)	75	
CBR	110	1 Capacitor	30	
CBR	110	1 Static Var Compensator	10	60
CF	110	1 Capacitor	15	
CGL	20	3 Capacitors (3 x 1)	3	
CKM	220	1 Shunt Reactor		100
CKM	38	1 Shunt Reactor		20
COL (N)	110	1 Capacitor	36	
CPS	110	1 Capacitor	40	
CSH	110	2 Capacitors (2 x 40)	80	
CUN	20	2 Capacitors (2 x 4)	8	
DLN	33	1 Capacitor	5	
DLT	110	1 Capacitor	15	
DMY	110	1 Capacitor	15	
DOO	110	1 Capacitor	15	
DRU (I)	110	1 Capacitor	15	
DYN	20	2 Capacitors (2 x 6.5)	13	
ENN (N)	33	4 Capacitors (4 x 6)	24	
FIN (I)	38	1 Shunt Reactor		20
GRV	20	1 Static Var Compensator	7.5	7.5
GRV	20	2 Capacitors (1 x 12.38, 1 x 1.5)	13.9	
GRV	20	1 Shunt Reactor		9
GIL	20	1 Capacitor	12	
GWE	110	1 Capacitor	15	
HAN	22	2 Shunt Reactors (2 x 30)		60
INC	38	2 Shunt Reactors (2 x 20)		40
KEL	22	2 Shunt Reactors (2 x 30)		60
KKY	110	2 Capacitor (2 x 15)	30	
KNR	220	1 Shunt Reactor		50
KNY	110	1 Capacitor	30	
KTL	110	1 Capacitor	30	
LET	110	2 Capacitor (1 Mobile)	45	
LET	110	1 Static Var Compensator	30	
LIS (I)	110	2 Capacitors (2 x 15)	30	
LOU	110	1 Capacitor	30	
LSN	20	1 Capacitor	4	
MOY	110	2 Capacitors (2 x 15)	30	

**Table B-7 Characteristics of Existing Reactive Compensation**

Station	Voltage (kV)	Plant	Capability (Mvar)	
			Generate	Absorb
MP	6.6	1 Capacitor	1	
MRY	20	1 Capacitor	4	
MUL	110	2 Capacitors (2 x 15)	30	
NAV	110	1 Capacitor (1 Mobile)	30	
PB	220	2 Shunt Reactors (2 x 50)		100
POR	400	EWIC HVDC	175	175
RAF	110	1 Capacitor	60	
RE	38	1 Shunt Reactor		20
SKL	110	1 Capacitor (1 Mobile)	30	
SLB	20	1 Capacitor	15	
SLI	110	1 Capacitor	15	
SLK	20	1 Capacitor	13	
TAN	22	2 Capacitors (2 x 25)	50	
TAN	22	2 Shunt Reactors (2 x 30)		60
THU	110	1 Capacitor	15	
THU	110	1 Static Var Compensator	30	30
TRI	110	1 Capacitor	30	
TRL	110	1 Capacitor	30	
WEX	110	2 Capacitors (2 x 15)	30	

## B.2 Transmission System Developments

Future developments of the transmission system are listed in this section according to the year in which they are expected to be completed. The physical and electrical characteristics of future transmission plant or changes to the characteristics brought about by planned developments are listed in the tables. These characteristics are indicative at this stage and will be reviewed when the item of plant is commissioned.

**Table B-8 Expected Changes in Transmission Circuits**

Action	Voltage (kV)	From	To	No.	Length (km)	Impedance on 100 MVA Base (pu)			Rating (MVA)		Year
						R	X	B	Summer	Winter	
Add	220	BTN	CLE	2	2.5	0.0001	0.0004	0.083	570	570	2021
Add	220	CDU	CRH	2		4.8E-05	0.00018	0.0415	570	570	2021
Add	220	CDU	CRH	1		4.8E-05	0.00018	0.0415	570	570	2021
Add	220	BRT	CLE	1	2.5	0.0001	0.0004	0.083	570	570	2021
Add	110	KUD	CBT	1	0.75	0.0002	0.0009	0.0083	187	223	2021
Add	110	DTN	BLC	2	8	0.0041	0.00893	0.04864	140	143	2021
Add	110	CKG	CBT	2	0.75	0.0002	0.0009	0.0083	187	223	2021
Amend	110	GCA	INC	3	7.71	0.0047	0.0044	0.0939	124	124	2021
Remove	110	GCA	KUD	2	2.1	0.0015	0.0032	0.0211	140	140	2021
Add	110	ADM	GCA	1	2.5	0.0018	0.0038	0.0251	140	140	2021
Remove	110	KIN	DFR	1	29.25	0.0213	0.0957	0.0103	99	121	2021
Add	110	KNY	BUF	1	0.5	0.0002	0.0007	0.0056	140	140	2021
Remove	110	KPG	TRL	2	43.578	0.0271	0.1405	0.0231	178	190	2021
Add	110	LIS	LIS	1	0.25	0.0001	0.0003	0.0028	187	223	2021
Remove	110	BKY	CKG	1	3	0.0007	0.0033	0.033	187	223	2021
Remove	110	BNK	INC	1	10	0.0023	0.011	0.11	187	223	2021
Amend	110	BNK	CBT	1	1	0.0003	0.0011	0.011	187	223	2021
Add	110	BKY	CBT	2	0.6	0.0003	0.0011	0.011	187	223	2021
Add	110	SXH	SOM	1	45.45	0.0707	0.1563	0.0146	105	123	2021
Remove	110	KRA	KRA	1		0	0.0001	0	178	210	2021
Remove	110	BOG	CRA	1	24.677	0.0179	0.0811	0.0087	178	210	2021
Remove	110	ADM	KUD	1		0.00075	0.0016	0.01055	140	140	2021
Add	110	BLE	KPG	1	28.23	0.0178	0.0917	0.01	178	210	2021
Add	110	AUG	BLE	1	4.56	0.0029	0.0149	0.0017	178	210	2021
Remove	110	AUG	KPG	1	32.83	0.0207	0.1067	0.0116	178	210	2021
Add	110	BLU	CDU	1	18.33	0.0168	0.0557	0.0308	130	130	2021
Add	110	BLU	MUL	1	56.18	0.079	0.1906	0.025	105	123	2021
Add	110	DJG	TRL	1	32.333	0.0203	0.1047	0.0138	178	210	2021
Add	110	BLC	KLM	1	4	0.0023	0.005	0.0291	140	140	2021
Add	110	DJG	KPG	1	13.895	0.0081	0.0452	0.0104	178	210	2021
Add	110	BOG	TTU	1	11.15	0.007	0.0362	0.0045	178	210	2021
Add	110	CSH	SXH	1	4.65	0.0073	0.016	0.0015	105	123	2021
Remove	110	CSH	SOM	1	50.019	0.0778	0.172	0.0161	99	121	2021
Add	110	CRA	TTU	1	13.653	0.011	0.0452	0.0054	178	210	2021
Remove	110	CDU	MUL	1	73.255	0.09326	0.24155	0.03764	104	122	2021

**Table B-8 Expected Changes in Transmission Circuits**

Action	Voltage (kV)	From	To	No.	Length (km)	Impedance on 100 MVA Base (pu)			Rating (MVA)		Year
						R	X	B	Summer	Winter	
Add	110	KRA	MEN	1	2.8	0.0017	0.0016	0.0341	124	124	2021
Add	110	BLC	GRA	1	4.3	0.0025	0.0053	0.0309	140	140	2021
Add	400	KPG	MP	1	6	0.00084	0.00023	0.54891	1210	1210	2022
Add	220	ORL	ORL	1	20.1	0.0007	0.0079	0.5502	593	593	2022
Add	220	KYT	WOO	1	13.8	0.003	0.0109	0.1124	761	746	2022
Add	220	KYT	MAY	1	13.5	0.003	0.0106	0.112	761	746	2022
Remove	220	LOU	WOO	1	61.2	0.0071	0.053	0.08	350	436	2022
Add	220	LOU	ORL	1	14.5	0.0017	0.0126	0.019	434	513	2022
Add	220	WOO	ORL	1	49.2	0.0058	0.0427	0.0644	434	513	2022
Add	220	ORL	ORL	1	15.9	0.0007	0.0023	0.5279	570	570	2022
Remove	220	FIN	SHL	1	13.4	0.0005	0.0053	0.3668	536	557	2022
Remove	220	MAY	WOO	1	22.3	0.0027	0.0195	0.0295	350	436	2022
Add	220	BLC	SHL	1	23.4	0.001	0.0034	0.7769	570	570	2022
Add	110	INC	YMW	1	3.18	0.0008	0.0035	0.035	187	223	2022
Add	110	BAL	DEE	1	10.75	0.0068	0.0349	0.0044	178	210	2022
Remove	110	BAL	DRY	1	20	0.0126	0.065	0.0071	178	210	2022
Add	110	BAG	CLG	1	0.85	0.0002	0.001	0.0094	192	192	2022
Remove	110	BRO	RSK	1		0.01	0.062	0.02	144	144	2022
Add	110	GRV	RSK	1		0.0098	0.059	0.0167	187	200	2022
Add	110	BAG	SBH	1	1.2	0.0003	0.0014	0.0133	192	192	2022
Remove	110	CLG	FIN	1	3.64	0.0035	0.0111	0.0073	124	124	2022
Add	110	HRR	KIN	1	5.825	0.006	0.0193	0.0034	136	159	2022
Add	110	GCA	YMW	1	5.09	0.0012	0.0056	0.056	187	223	2022
Add	110	GOR	GOR	1	0.5	0.0002	0.0006	0.0056	187	223	2022
Amend	110	GLN	PLA	1	26.55	0.0167	0.0863	0.0094	178	210	2022
Add	110	HRR	DFR	1	9.414	0.0064	0.0307	0.0034	104	157	2022
Add	110	GI	ROP	1	19.7	0.0123	0.0635	0.0103	178	210	2022
Add	110	CKN	CUS	1	0.5	0.0002	0.0007	0.0056	140	140	2022
Add	110	FIN	MCE	1	8.37	0.0081	0.0262	0.0127	124	124	2022
Remove	110	KIN	MUL	1	24.919	0.0155	0.07731	0.02271	178	210	2022
Add	110	CFN	KIN	1	6.59	0.0042	0.0215	0.0024	178	210	2022
Add	110	CFN	MUL	1	18.97	0.012	0.0617	0.0067	178	210	2022
Remove	110	CKG	KUD	1	0.75	0.0002	0.0009	0.0083	187	223	2022
Add	110	DRY	DEE	1	9.55	0.006	0.031	0.004	178	210	2022
Remove	110	CDU	PLA	1	37	0.0233	0.1202	0.0131	178	210	2022
Add	110	CDU	GLN	1	11.05	0.007	0.0359	0.0039	178	210	2022
Add	110	CLU	CBT	1	0.1	0.0001	0.0002	0.0012	187	223	2022
Add	110	CLU	KUD	1	0.9	0.0003	0.001	0.01	187	223	2022
Remove	110	GI	WEX	1	34.5	0.0217	0.1121	0.0122	178	210	2022
Amend	110	AGN	CBT	2	0.2	0.0001	0.0003	0.0022	187	223	2022
Remove	110	SNU	MCE	1	4.7271	0.0047	0.0151	0.0054	99	121	2022
Add	110	BRO	AGI	1		0.0027	0.0164	0.0047	144	144	2022
Add	110	AGN	CBT	1	0.2	0.0001	0.0003	0.0022	187	223	2022

**Table B-8 Expected Changes in Transmission Circuits**

Action	Voltage (kV)	From	To	No.	Length (km)	Impedance on 100 MVA Base (pu)			Rating (MVA)		Year
						R	X	B	Summer	Winter	
Add	110	ROP	WEX	1	15.2	0.0095	0.0489	0.0087	178	210	2022
Add	110	THU	THU	1	0.001	0.0001	0.0001	0.0001	218	232	2022
Remove	275	TAN	TMN	1		0.00116	0.01085	0.0647	710	881	2025
Add	275	TMN	TUR	1		0.00024	0.00227	0.01354	710	881	2023
Add	275	TAN	TUR	2		0.00092	0.00862	0.05139	710	881	2023
Remove	275	TAN	TMN	2		0.00116	0.01085	0.0647	710	881	2023
Add	275	TMN	TUR	2		0.00024	0.00227	0.01354	710	881	2023
Add	275	TAN	TUR	1		0.00092	0.00862	0.05139	710	881	2023
Add	220	GI	LWN	1	0.4	0.0001	0.0002	0.011	593	593	2023
Add	110	AGT	CLM	1	8	0.0084	0.0223	0.0502	200	200	2023
Add	110	PLA	OBE	1	2.955	0.0043	0.0096	0.0038	105	123	2023
Add	110	DGN	RTO	1	15.475	0.0098	0.0502	0.006	178	210	2023
Remove	110	DRY	PLA	1	5.3	0.0082	0.0182	0.0017	99	121	2023
Add	110	DRY	OBE	1	2.875	0.0042	0.0093	0.0038	105	123	2023
Add	110	KLC	KLC	1		0.005	0.0312	0.00298	126	156	2023
Add	110	FGH	MOY	1	15.87	0.0197	0.0472	0.048	105	123	2023
Add	110	CRR	CRR	1	2	0.00059	0.00224	0.0156	80	50	2023
Amend	110	CAS	FIN (N)	1	9.1	0.01369	0.03189	0.003	70	87	2023
Remove	110	CUL	DGN	1	34.239	0.0215	0.1093	0.0203	178	192	2023
Add	110	DLN	SH	1	3.5	0.0009	0.0043	0.0386	140	140	2023
Add	110	CRR	PGN	1	2.4	0.0017	0.00269	0.01872	60	60	2023
Add	110	MAY	TEN	1	18.71	0.0118	0.0605	0.0093	112	112	2023
Add	110	CD	KLP	1	32.091	0.0202	0.1043	0.0113	178	210	2023
Remove	110	CD	KBY	1	32.338	0.01988	0.1043	0.02497	178	209	2023
Add	110	GLE (N)	KEL	1		0.02726	0.06833	0.02722	82	90	2023
Add	110	KEL	KEL	1		0.00033	0.00131	0.00798	144	144	2023
Remove	110	GLR	MOY	1	13.956	0.0216	0.048	0.0045	105	123	2023
Add	110	CLD	GCA	2	2.02	0.0005	0.0025	0.0223	140	140	2023
Add	110	CUL	RTO	1	19.175	0.0121	0.0622	0.0074	178	210	2023
Add	110	LET	LNA	1	12.23	0.0128	0.0408	0.0042	136	159	2023
Remove	110	KBY	MAL	1	29.2	0.0184	0.0949	0.0103	134	159	2023
Remove	110	KBY	MR	1	4.438	0.00448	0.01466	0.004	103	130	2023
Remove	110	KBY	KRA	2	12.5	0.0183	0.0428	0.0041	99	121	2023
Add	110	TIV	MLG	1	6.1	0.0044	0.0091	0.0612	140	140	2023
Remove	110	CAR	CAS	1		0.03714	0.0875	0.00798	69	86	2023
Remove	110	CAR	CAS	2		0.03695	0.08641	0.00803	70	87	2023
Add	110	KLP	KRA	2	12.5	0.0183	0.0428	0.0041	99	121	2023
Remove	110	GOR	PLA	1	19.732	0.0302	0.0681	0.0064	99	121	2023
Add	110	GOR	GRH	1	14.125	0.0214	0.0484	0.0051	105	123	2023
Remove	110	DER	MAY	1	43.448	0.0277	0.14567	0.0177	74	93	2023
Add	110	AIR	ROS	1		0.01312	0.03406	0.00338	82	103	2023



**Table B-8 Expected Changes in Transmission Circuits**

Action	Voltage (kV)	From	To	No.	Length (km)	Impedance on 100 MVA Base (pu)			Rating (MVA)		Year
						R	X	B	Summer	Winter	
Add	110	CLD	GCA	1	1.87	0.0005	0.0023	0.0207	140	140	2023
Add	110	DER	TEN	1	25.125	0.0158	0.0817	0.0089	178	210	2023
Add	110	CPS	CLM	1	3.6	0.00101	0.0028	0.0867	200	200	2023
Add	110	BGT	KKY	1	22	0.0139	0.0715	0.0078	178	210	2023
Amend	110	CAS	FIN (N)	1	9.1	0.01376	0.0323	0.003	69	86	2023
Add	110	LNA	TIV	1	33.13	0.0345	0.1106	0.0113	136	159	2023
Add	110	FGH	GLR	1	5.701	0.0038	0.0122	0.0448	105	123	2023
Add	110	GRH	PLA	1	6.05	0.0094	0.0208	0.0025	105	123	2023
Remove	110	LET	TIV	1	45.2	0.0471	0.1508	0.0154	136	159	2023
Add	110	KLP	MAL	1	29.2	0.0184	0.0949	0.0103	134	159	2023
Add	220	DSN	MAY	2	30.55	0.0036	0.0265	0.04	434	513	2024
Remove	220	DSN	MAY	2	30.55	0.0036	0.0265	0.04	350	436	2024
Add	110	BDM	MID	1	3.516	0.0047	0.0122	0.0012	99	121	2024
Add	110	BDM	WHI	1	18.306	0.0268	0.0628	0.006	99	121	2024
Add	110	BGT	CNB	1	28	0.0176	0.091	0.0099	178	210	2024
Add	110	KEL	RSK	2	25.903	0.02167	0.1344	0.0129	188	213	2024
Remove	110	ATY	PLS	1	25.482	0.03822	0.08764	0.00848	99	121	2024
Add	110	ARK	PHY	2	2.38	0.0015	0.0078	0.0009	178	210	2024
Add	110	MOY	TON	1	58	0.0365	0.1884	0.0205	178	210	2024
Remove	110	MID	WHI	1	20.022	0.0303	0.0691	0.0065	99	121	2024
Add	110	ATY	CNB	1	21.94	0.0138	0.0713	0.0078	178	210	2024
Add	110	AGN	KSE	1	1.7	0.0004	0.0019	0.0188	187	223	2024
Add	110	ARK	PHY	1	2.25	0.0015	0.0074	0.0008	178	210	2024
Add	110	BKY	KCY	1	0.75	0.0002	0.0009	0.0083	187	223	2024
Add	110	GAR	GLN	1	0.1	0.0001	0.0002	0.0012	140	140	2024
Add	110	PHY	SHE	1	0.375	0.0003	0.0013	0.0002	178	210	2024
Remove	110	ARK	SHE	2	2.2	0.0035	0.0077	0.0008	34	57	2024
Add	110	CNB	PLS	1	8.36	0.0051	0.0261	0.0083	178	210	2024
Add	110	CBT	KCY	1	0.75	0.0002	0.0009	0.0083	187	223	2024
Add	110	CBT	KSE	1	1.9	0.0005	0.0021	0.021	187	223	2024
Add	400	TUR	WOO	1		0.0027	0.0311	0.7066	1424	1731	2025
Add	400	CNB	MP	1		0.0033	0.01134	0.858	1577	1944	2025
Remove	400	DSN	MP	1	208.5	0.00405	0.04359	1.13973	1283	1454	2025
Add	400	CNB	DSN	1		0.0009	0.003	0.226	1577	1944	2025
Add	110	CNB	CNB	1		0	0.0001	0	178	210	2025
Add	110	RSK	TGW	1		0.01264	0.07231	0.03087	200	200	2026
Add	110	KEL	TGW	1		0.0097	0.04125	0.00443	200	200	2026
Remove	110	CRG	KEL	1		0.02933	0.07667	0.01292	82	103	2026
Add	110	CEN	CEN	1	0.001	0.0001	0.0001	0.0001	187	223	2026
Add	110	BNM	CEN	1		0.00024	0.00093	0.00647			2026
Add	110	CRG	TGW	1		0.01276	0.034	0.00896	109	124	2026
Add	110	GI	WAT	2	12.901	0.0082	0.042	0.0046	178	210	2027

**Table B-9 Expected Changes in Transformers in Ireland**

Action	Station	Transformer	Rating (MVA)	HV/ LV	Impedance on 100 MVA Base (pu)		Voltage Ratio Tapping Range		Year
				(kV)	R	X	+	-	
Remove	KRA	T2103	250	220/110	0.0013	0.0652	0.1	0.18	2021
Add	KPG	T4101	500	400/220	0.0003	0.027	0.1	0.08	2022
Add	BLC	T2102	250	220/110	0.001	0.0646	0.1	0.1	2022
Add	CNB	T4101	500	400/110	0.00048	0.072	0.16	0.16	2025
Add	CNB	T4102	500	400/110	0.00048	0.072	0.16	0.16	2025
Add	KLN	T2104	250	220/110	0.0004	0.0631	0.1	0.18	2027
Amend	KLN	T2104	250	220/110	0.0004	0.0631	0.1	0.18	2027
Remove	KLN	T2102	63	220/110	0.0095	0.2473	0.23	0.18	2027
Remove	KLN	T2101	63	220/110	0.0065	0.2453	0.23	0.18	2027

**Table B-10 Expected Changes in 3 Winding Transformers in Northern Ireland**

Action	Substation/ Transformer	Voltage (kV)	Impedance on 100 MVA Base (pu)						Rating (MVA)			Off Nominal Ratio (pu)		No. of Taps	Year
			W1-2		W2-3		W3-1		W1	W2	W3	Upper	Lower		
			R	X	R	X	R	X							
Add	TUR IBTx 1	400/275	0.0003	0.026	0.0001	0.18	0.0001	0.2	500	500	60	1.1	0.9	15	2023
Add	TUR IBTx 2	400/275	0.0003	0.026	0.0001	0.18	0.0001	0.2	500	500	60	1.1	0.9	15	2023
Add	TUR IBTx 3	400/275	0.0003	0.026	0.0001	0.18	0.0001	0.2	500	500	60	1.1	0.9	15	2023
Add	CAST4	110/275	0.0008	0.03	0.0008	0.02	0.0003	0.025	240	240	240	1.1	0.9	23	2023
Add	HNNHAT2	110/275	0.0014	0.0639	0.0014	0.2236	0	0.1449	240	240	60	1.15	0.85	19	2024
Remove	HNNHAT1	110/275	0.0018	0.0591	0.0018	0.1261	0	0.056	240	240	45	1.15	0.85	19	2024

**Table B-11 Expected Changes in 2 Winding Transformers in Northern Ireland**

Action	Station	HV/LV (kV)	Rating (MVA)	Impedance pu on rating base		Off nominal ratio		No. of taps	Year
				R	X	Upper	Lower		
Add	DON	110/33	90	0.0039	0.2461	1.1	0.8	19	2022
Amend	BMA	110/33	90	0.0065	0.2867	1.1	0.9	33	2022
Add	GOR (N)	110/33	90	0.0039	0.2461	1.1	0.9	33	2022
Add	GRV	110/33	90	0.0039	0.2461	1.1	0.8	19	2022
Add	AIR	110/33	60	0.0073	0.25	1.1	0.8	19	2023
Add	CAS	110/33	60	0.0159	0.2292	1.1625	0.9125	21	2023
Add	AIR	110/33	60	0.0073	0.25	1.1	0.8	19	2023
Add	AIR	110/33	60	0.0073	0.25	1.1	0.8	19	2023
Add	CRR	110/33	50	0.0071	0.4126	1.1	0.9	33	2023
Add	PGN	110/33	60	0.0228	0.3201	1.1	0.9	33	2023
Add	GLE (N)	110/33	90	0.0119	0.2692	1.1	0.8	19	2023
Add	GLE (N)	110/33	90	0.0119	0.2692	1.1	0.8	19	2023
Add	KEL	110/33	90	0.0039	0.2461	1.1	0.8	19	2023
Add	KEL	110/33	60	0.0265	0.3076	1.1	0.8	19	2023
Add	AGT	110/33	80	0.0266	0.335	1.1	0.9	33	2023
Amend	ENN (N)	110/33	90	0.0126	0.272	1.1	0.9	33	2024
Amend	ENN (N)	110/33	90	0.0126	0.2733	1.1	0.9	33	2024
Add	BAN	110/33	90	0.0039	0.2461	1.1	0.9	33	2026
Add	BAN	110/33	90	0.0039	0.2461	1.1	0.9	33	2026

**Table B-12 Expected Changes in Reactive Compensation**

Action	Station	Voltage	Plant	Mvar Capability		Year
				Generate	Absorb	
Add	KNR	110	Reactor		50	2021
Remove	THU	110	Capacitor	15		2022
Add	THU	110	STATCOM	30	30	2022
Add	BYH	110	STATCOM	100	100	2022
Add	BVK	110	STATCOM	100	100	2022
Add	CAS	22	Reactor		30	2022
Add	CAS	22	Reactor		30	2022
Add	TMN	22	Reactor		30	2022
Add	TAN	22	Reactor		30	2022

# Appendix C

All-Island Ten Year

Transmission Forecast  
Statement

**2021**

# Appendix C Demand forecasts at individual transmission interface stations

Transmission Interface Stations and Bulk Supply Points are connection points to the transmission system. These connection points include transmission system connections to the distribution system or directly-connected customers. Table C-1 to Table C-4 list the demand forecasts at each Transmission Interface Station and Bulk Supply Point. The forecasts are noted for each node between 2021 and 2030 at the winter peak, summer peak, and summer valley. The autumn peak forecasts are also given for Northern Ireland.

The station demand values do not include transmission losses. Demand values at stations that interface with the distribution system do include distribution losses.

Transmission Interface Stations are generally 110 kV stations. The exceptions to this are six 220/110 kV interface stations that supply the Dublin network. These interface stations are Belcamp, Carrickmines, Castlebagot, Finglas, Inchicore and Poolbeg.

Only stations feeding demand are included in the tables below, generation stations are not included.

**Table C-1 Demand Forecasts at Time of Winter Peak**

Bus Code	Bus Name	Power Factor	Demand Forecast (MW)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
AA	Ardnacrusha	0.992	63.2	64.6	64.2	64.4	64.5	64.7	65.1	65.6	66.4	66.8
AGH	Aghyoule	0.99	17.1	17.5	17.4	17.9	18.1	18.3	18.4	18.5	18.6	18.7
AGN	Aungierstown	0.95	-	7.6	15.2	22.8	25.2	27.6	29.9	32.3	34.7	37.1
AGY	Ardnagappary	1	16.1	16.41	16.31	16.36	16.38	16.44	16.54	16.67	16.86	16.97
AHA	Ahane	0.999	5.0	5.1	5.1	5.1	5.1	5.1	5.2	5.2	5.3	5.3
AIR	Airport Road	0.99	-	-	28.2	30.5	31.9	33.5	37.4	37.6	37.8	38.0
ANR	Anner	0.95	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
ANT	Antrim	0.98	41.8	42.6	42.2	43.1	43.4	43.7	43.9	44.1	44.4	44.6
ARI	Arigna	1	5.5	5.6	5.6	5.6	5.6	5.7	5.7	5.7	5.8	5.8
ARK	Arklow	1	41.7	42.6	42.3	42.4	42.5	42.6	42.9	43.2	43.7	44.0
ATH	Athlone	0.997	82.1	83.9	83.3	83.6	83.7	84.0	84.5	85.2	86.2	86.7
ATY	Athy	0.966	19.4	19.8	19.7	19.7	19.8	19.8	19.9	20.1	20.3	20.5
BAG	Barnageeragh	0.95	-	-	2.4	4.8	7.1	9.5	11.9	14.3	16.6	19.0
BAL	Baltrasna	0.999	16.5	16.8	16.7	16.8	16.8	16.9	17.0	17.1	17.3	17.4
BAN	Bandon	0.989	48.8	49.9	49.6	49.7	49.8	50.0	50.3	50.7	51.3	51.6
BAN (N)	Banbridge	0.99	39.2	40.0	39.6	40.4	40.7	40.9	41.1	41.3	41.6	41.8
BAR	Barrymore	0.998	31.6	32.3	32.1	32.2	32.2	32.3	32.5	32.8	33.2	33.4
BDA	Baroda	0.95	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
BDN	Ballydine	0.95	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
BDN	Ballydine	0.984	15.2	15.5	15.4	15.5	15.5	15.5	15.6	15.8	16.0	16.0
BEG	Ballybeg	1	15.5	15.9	15.8	15.8	15.8	15.9	16.0	16.1	16.3	16.4
BIN	Binbane	1	4.67	4.77	4.74	4.76	4.76	4.78	4.81	4.85	4.9	4.93
BK	Bellacorick	0.999	6.0	6.1	6.1	6.1	6.1	6.1	6.2	6.2	6.3	6.3
BLC	Belcamp	0.951	58.9	68.4	77.9	87.4	96.9	106.4	108.3	108.3	108.3	108.3
BLI	Ballylickey	0.999	14.1	14.4	14.3	14.4	14.4	14.5	14.5	14.7	14.8	14.9
BLK	Blake	0.994	28.0	28.6	28.4	28.5	28.5	28.6	28.8	29.0	29.4	29.5
BMA	Ballymena	0.984	83.6	85.2	84.4	86.2	86.8	87.3	87.6	88.1	88.6	89.1
BNH	Ballynahinch	0.99	57.0	58.0	57.4	58.7	59.0	59.3	59.6	59.9	60.3	60.6
BNM	Belfast North	0.99	50.1	51.0	50.6	51.7	52.0	52.3	52.5	52.8	53.1	53.4
BOG	Banoge	0.997	8.6	8.8	8.8	8.8	8.8	8.8	8.9	9.0	9.1	9.1
BR	Ringsend/Francis St	0.999	49.5	50.6	50.3	50.5	50.5	50.7	51.0	51.4	52.0	52.3
BRI	Brinny	0.95	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
BRY	Barnahely	0.977	35.3	36.1	35.9	36.0	36.0	36.1	36.4	36.7	37.1	37.3
BUT	Butlerstown	0.989	41.7	42.6	42.3	42.5	42.5	42.7	42.9	43.3	43.8	44.0
BVG	Ballyvallagh	0.99	15.1	15.4	15.3	15.6	15.7	15.8	15.8	15.9	16.0	16.1
CAH	Cahir	0.989	27.3	27.8	27.7	27.8	27.8	27.9	28.1	28.3	28.6	28.8
CAR	Carnmoney	0.99	25.1	25.2	24.6	24.7	24.5	24.3	24.0	24.2	24.3	24.4
CBG	Carrowbeg	0.991	18.6	19.0	18.9	18.9	19.0	19.0	19.1	19.3	19.5	19.6
CBR	Castlebar	0.993	34.3	35.0	34.8	35.0	35.0	35.1	35.3	35.6	36.0	36.2
CEN	Belfast Central	0.99	53.2	54.2	53.8	55.1	55.5	55.9	56.3	56.6	56.9	57.2
CF	Cathleen's Fall	0.998	21.4	21.8	21.7	21.8	21.8	21.9	22.0	22.2	22.4	22.6
CFM	Castlefarm	0.95	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.8
CHA	Charleville	0.988	20.8	21.3	21.2	21.2	21.3	21.3	21.4	21.6	21.9	22.0
CKM	Carrickmines	0.998	362.6	369.3	367.3	368.4	368.8	369.8	371.7	374.3	378.1	380.0
CLE	Clonee	0.95	86.5	105.5	124.5	142.5	142.5	142.5	142.5	142.5	142.5	142.5
CLG	Cloghran	0.95	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7



**Table C-1 Demand Forecasts at Time of Winter Peak**

Bus Code	Bus Name	Power Factor	Demand Forecast (MW)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
CLN	Cloon	1	27.4	28.0	27.8	27.9	27.9	28.0	28.2	28.4	28.8	28.9
CLU	Clutterland	0.95	0.0	3.8	3.8	9.5	14.3	20.0	24.7	30.4	35.2	40.9
CLW	Carlow	0.992	71.6	73.2	72.7	72.9	73.0	73.3	73.7	74.3	75.2	75.6
COL	College Park	0.994	34.3	35.0	34.8	35.0	35.0	35.1	35.3	35.6	36.0	36.2
COL (N)	Coleraine	0.99	42.8	43.5	43.1	44.0	44.3	44.5	44.7	45.0	45.2	45.5
COS	Carrick-On-Shanon	0.996	29.7	30.4	30.2	30.3	30.3	30.4	30.6	30.9	31.2	31.4
COW	Cow Cross	1	17.3	17.7	17.6	17.7	17.7	17.7	17.9	18.0	18.2	18.3
CPS	Coolkeeragh	0.99	25.4	25.8	25.6	26.1	26.3	26.4	26.6	26.7	26.9	27.0
CRA	Crane	0.992	32.6	33.3	33.1	33.2	33.2	33.3	33.5	33.8	34.2	34.4
CRE	Cregagh	0.99	86.2	72.5	71.9	73.6	74.2	74.7	75.2	75.6	76.0	76.5
CRG	Creagh	0.99	24.9	25.3	25.1	25.6	25.8	25.9	26.1	26.2	26.3	26.5
CRH	Cruiserath	0.95	3.8	9.0	14.3	19.5	24.7	29.9	35.2	40.4	45.6	50.8
CRO	Coolroe	1	10.9	11.2	11.1	11.1	11.2	11.2	11.3	11.3	11.5	11.5
CVW	Castleview	0.95	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8
CVW	Castleview	0.989	33.5	34.2	34.0	34.1	34.2	34.3	34.5	34.8	35.2	35.4
DAL	Dallow	0.981	19.2	19.6	19.5	19.6	19.6	19.7	19.8	19.9	20.2	20.3
DDK	Dundalk	0.99	68.1	69.6	69.1	69.4	69.5	69.7	70.1	70.7	71.5	72.0
DFR	Dunfirth	0.96	11.1	11.4	11.3	11.3	11.3	11.4	11.4	11.5	11.7	11.7
DGN	Dungarvan	0.991	50.5	51.6	51.3	51.5	51.5	51.7	52.0	52.4	53.1	53.4
DLT	Dalton	0.99	29.3	29.9	29.7	29.9	29.9	30.0	30.2	30.4	30.8	31.0
DMY	Dunmanway	0.991	35.7	36.5	36.2	36.4	36.4	36.5	36.8	37.0	37.5	37.7
DON	Donegall	0.99	91.4	91.5	89.1	89.5	88.6	87.7	86.7	87.2	87.6	88.1
DOO	Doon	0.991	28.4	29.0	28.8	28.9	29.0	29.1	29.2	29.5	29.8	30.0
DRU	Drumline	0.952	31.6	32.3	32.1	32.2	32.3	32.4	32.6	32.8	33.2	33.4
DRU (N)	Drumnakelly	0.98	91.7	93.4	92.5	94.6	95.2	95.9	96.4	97.0	97.5	98.1
DRY	Drybridge	0.994	92.5	94.5	93.9	94.2	94.3	94.6	95.2	96.0	97.1	97.7
DUN	Dungannon	0.99	97.0	98.8	97.9	100.0	100.6	101.2	101.7	102.2	102.8	103.4
EDE	Eden	0.98	34.6	35.2	34.9	35.7	35.9	36.1	36.2	36.4	36.6	36.9
ENN	Ennis	0.986	63.6	65.0	64.6	64.8	64.9	65.1	65.5	66.0	66.8	67.2
ENN (N)	Enniskillen	0.99	56.8	57.8	57.3	58.6	58.9	59.2	59.5	59.8	60.2	60.5
FIN (I)	Finglas	0.984	480.8	490.5	487.6	489.2	489.8	491.3	494.0	497.7	503.2	506.1
FIN (N)	Finaghy	0.99	31.0	31.5	31.2	31.9	32.1	32.3	32.4	32.6	32.8	33.0
FTT	Fortunestown	0.998	14.4	14.7	14.6	14.6	14.6	14.7	14.8	14.9	15.1	15.2
GAL	Galway	0.994	97.9	100.0	99.3	99.7	99.8	100.1	100.7	101.5	102.7	103.4
GI	Great Island	0.964	16.5	16.9	16.8	16.8	16.9	16.9	17.0	17.1	17.3	17.5
GIL	Gilra	0.95	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4
GLE	Glenlara	0.994	17.7	18.1	18.0	18.1	18.1	18.2	18.3	18.4	18.6	18.7
GLE (N)	Glengormley	0.98	31.4	31.8	31.4	32.0	32.1	32.1	32.2	32.3	32.5	32.7
GRI	Griffinrath	0.994	66.8	68.3	67.8	68.1	68.1	68.4	68.8	69.3	70.1	70.6
GWE	Gortawee	0.991	11.0	11.3	11.2	11.2	11.3	11.3	11.4	11.4	11.6	11.7
GWE	Gortawee	0.95	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1
IKE	Ikerrin	0.981	31.8	32.5	32.3	32.4	32.4	32.5	32.7	33.0	33.4	33.6
INC	Inchicor	0.999	489.0	520.5	546.6	575.2	593.9	612.0	631.9	650.3	671.8	689.0
KBY	Kilbarry	0.991	88.0	89.9	89.4	89.7	89.8	90.1	90.6	91.3	92.4	93.0
KCY	Kilcarbery	0.95	0.0	0.0	0.0	4.8	9.5	14.3	19.0	23.8	23.8	23.8
KER	Knockearagh	0.981	41.3	42.2	41.9	42.0	42.1	42.2	42.5	42.8	43.3	43.6

**Table C-1 Demand Forecasts at Time of Winter Peak**

Bus Code	Bus Name	Power Factor	Demand Forecast (MW)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
KGE	Kishoge	0.95	0.0	0.0	0.0	4.8	9.5	14.3	19.0	23.8	23.8	23.8
KIL	Kilteel	0.97	36.3	37.0	36.8	36.9	37.0	37.1	37.3	37.6	38.1	38.3
KIN	Kinnegad	0.95	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2
KKY	Kilkenny	0.988	61.7	63.0	62.6	62.9	62.9	63.1	63.5	64.0	64.8	65.2
KLM	Kilmore	0.99	20.1	20.5	20.4	20.5	20.5	20.5	20.7	20.8	21.1	21.2
KNO	Knock	0.99	51.3	45.6	45.2	46.2	46.6	46.9	47.1	47.4	47.6	47.9
KTN	Killoteran	0.982	14.6	14.9	14.8	14.8	14.9	14.9	15.0	15.1	15.3	15.4
KUR	Knockumber	0.95	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7
KYT	Kellystown	0.95	28.5	59.9	114.0	116.9	116.9	116.9	116.9	116.9	116.9	116.9
LA	Lanesborough	0.989	17.1	17.5	17.4	17.5	17.5	17.5	17.7	17.8	18.0	18.1
LAR	Larne	0.99	28.7	29.2	28.9	29.5	29.7	29.8	30.0	30.1	30.3	30.5
LET	Letterkenny	0.991	65.6	67	66.58	66.81	66.9	67.12	67.52	68.06	68.86	69.28
LIB	Liberty Street	0.994	25.8	26.3	26.1	26.2	26.3	26.4	26.5	26.7	27.0	27.2
LIM	Limerick	0.995	86.5	88.4	87.9	88.2	88.3	88.6	89.1	89.8	90.9	91.4
LIM (N)	Limavady	0.99	24.8	25.2	25.0	25.5	25.6	25.8	25.9	26.0	26.2	26.3
LIS	Lisdrum	0.975	32.2	32.8	32.6	32.8	32.8	32.9	33.1	33.4	33.8	34.0
LIS (N)	Lisburn	0.99	74.0	75.4	74.7	76.3	76.8	77.2	77.6	78.0	78.5	78.9
LMR	Lisaghmore	0.98	32.9	33.5	33.2	33.9	34.1	34.3	34.4	34.6	34.8	35.0
LOG	Loguestown	0.98	39.0	39.7	39.4	40.2	40.4	40.7	40.8	41.1	41.3	41.5
MAC	Macroom	0.994	18.0	18.4	18.2	18.3	18.3	18.4	18.5	18.7	18.9	19.0
MAL	Mallow	0.989	24.7	25.2	25.1	25.2	25.2	25.3	25.4	25.6	25.9	26.1
MCE	Mace	0.95	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
MCE	Macetown	0.997	31.4	32.1	31.9	32.0	32.0	32.1	32.3	32.6	32.9	33.1
MID	Midleton	0.985	44.6	45.6	45.3	45.5	45.5	45.7	45.9	46.3	46.9	47.1
MLN	Mullagharlin	0.95	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
MON	Monread	0.992	14.4	14.7	14.6	14.6	14.6	14.7	14.8	14.9	15.1	15.2
MOY	Moy	0.993	31.3	32.0	31.8	31.9	31.9	32.0	32.2	32.5	32.9	33.1
MR	Marina	0.996	17.5	17.9	17.7	17.8	17.8	17.9	18.0	18.1	18.4	18.5
MTH	Meath Hill	0.96	58.5	59.8	59.4	59.6	59.7	59.9	60.2	60.7	61.4	61.8
MUL	Mullingar	0.989	46.3	47.3	47.0	47.1	47.2	47.4	47.6	48.0	48.6	48.9
MUN	Mungret	0.95	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5
NAR	Newtownards	0.99	45.4	46.2	45.8	46.7	47.0	47.3	47.5	47.7	48.0	48.3
NAV	Navan	0.987	64.3	65.7	65.3	65.5	65.6	65.8	66.2	66.7	67.5	67.9
NEW	Newbridge	0.991	43.4	44.4	44.1	44.2	44.3	44.4	44.7	45.1	45.6	45.9
NEW (N)	Newry	0.99	80.0	81.5	80.7	82.5	83.0	83.5	83.9	84.3	84.8	85.3
NNA	Nenagh	0.947	23.0	23.5	23.4	23.5	23.5	23.6	23.7	23.9	24.2	24.3
ODE	Oldbridge	0.95	0.0	0.0	3.8	9.5	14.3	20.0	24.7	30.4	35.2	40.9
OLD	Oldcourt	0.95	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
OMA	Omagh	0.99	60.7	61.8	61.2	62.5	62.8	63.2	63.5	63.8	64.2	64.5
OUG	Oughtragh	0.998	27.6	28.2	28.0	28.1	28.1	28.2	28.4	28.6	28.9	29.1
PB	Poolbeg	0.989	186.2	190.2	189.1	189.7	190.0	190.6	191.7	193.2	195.5	196.7
PLA	Platin	0.95	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
PLS	Portlaoise	0.984	55.9	57.1	56.8	57.0	57.1	57.2	57.6	58.0	58.7	59.1
RAT	Rathkeale	0.996	43.3	44.2	43.9	44.1	44.1	44.3	44.6	44.9	45.4	45.7
RAT (N)	Rathgael	0.99	57.9	58.9	58.4	59.6	60.0	60.3	60.6	60.9	61.2	61.6
RIC	Richmond	0.98	37.7	38.5	38.3	38.4	38.5	38.6	38.8	39.1	39.6	39.8

**Table C-1 Demand Forecasts at Time of Winter Peak**

Bus Code	Bus Name	Power Factor	Demand Forecast (MW)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
RNW	Rinawade	0.95	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1
ROS	Rosebank	0.99	30.4	27.8	27.6	28.2	28.4	28.5	28.7	28.8	29.0	29.1
RYB	Ryebrook	0.95	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5
SBH	Snughborough	0.95	14.3	14.3	17.1	19.0	21.9	23.8	14.3	28.5	31.4	33.3
SCR	Screebe	0.992	17.3	17.7	17.6	17.7	17.7	17.7	17.9	18.0	18.2	18.3
SHE	Shelton Abbey	0.95	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
SHL	Salthill	1	45.4	46.4	46.1	46.2	46.3	46.4	46.7	47.1	47.7	47.9
SKL	Shankill	0.995	59.3	60.6	60.2	60.4	60.5	60.7	61.1	61.6	62.3	62.7
SLI	Sligo	0.997	56.7	58.0	57.6	57.8	57.9	58.1	58.4	58.9	59.6	59.9
SNG	Singland	0.995	18.2	18.6	18.5	18.6	18.6	18.6	18.8	18.9	19.1	19.2
SOM	Somerset	0.989	23.7	24.2	24.1	24.2	24.2	24.3	24.4	24.6	24.9	25.1
SPR	Springtown	0.98	47.6	48.4	48.0	49.0	49.3	49.5	49.7	50.0	50.3	50.6
STR	Stratford	0.989	24.2	24.7	24.6	24.7	24.7	24.8	24.9	25.1	25.4	25.6
STR (N)	Strabane	0.99	42.3	43.1	42.7	43.6	43.8	44.1	44.3	44.5	44.8	45.0
TBG	Trabeg	0.997	73.8	75.4	74.9	75.2	75.3	75.5	76.0	76.6	77.5	78.0
TBK	Tullabrack	0.961	12.9	13.2	13.1	13.2	13.2	13.2	13.3	13.4	13.6	13.7
THU	Thurles	0.982	30.3	31.0	30.8	30.9	30.9	31.0	31.2	31.5	31.9	32.0
TIP	Tipperary	0.984	21.5	22.0	21.8	21.9	21.9	22.0	22.1	22.3	22.6	22.7
TLK	Trillick	0.987	22.9	23.3	23.2	23.3	23.3	23.4	23.5	23.7	24.0	24.1
TON	Tonroe	0.988	15.3	15.7	15.6	15.6	15.7	15.7	15.8	15.9	16.1	16.2
TRI	Trien	0.992	18.3	18.7	18.5	18.6	18.6	18.7	18.8	19.0	19.2	19.3
TRL	Tralee	0.992	58.3	59.5	59.2	59.4	59.4	59.6	60.0	60.5	61.2	61.5
TSB	Thornsberry	0.986	36.1	36.9	36.6	36.8	36.8	36.9	37.2	37.4	37.9	38.1
WAR	Waringstown	0.99	66.2	67.4	66.8	68.2	68.6	69.0	69.2	69.6	70.0	70.4
WAT	Waterford	0.996	56.1	57.3	56.9	57.1	57.2	57.4	57.7	58.2	58.9	59.2
WEX	Wexford	0.985	61.1	62.4	62.0	62.2	62.3	62.5	62.8	63.4	64.1	64.5
WHI	Whitegate	0.95	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0

**Table C-2 Demand Forecasts at Time of Summer Peak**

Bus Code	Bus Name	Power Factor	Demand Forecast (MW)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
AA	Ardnacrusha	0.993	48.8	49.7	49.3	48.6	48.5	48.4	48.6	48.9	49.3	49.5
AGH	Aghyoule	0.99	5.0	5.1	5.1	5.2	5.3	5.4	5.4	5.4	5.5	5.5
AGN	Aungierstown	0.95	0.0	7.6	15.2	22.8	25.2	27.6	29.9	32.3	34.7	37.1
AGY	Ardnagappary	0.989	11	11.2	11.1	10.9	10.9	10.9	10.9	11	11.1	11.1
AHA	Ahane	0.998	3.9	3.9	3.9	3.9	3.9	3.8	3.9	3.9	3.9	3.9
AIR	Airport Road	0.99			8.3	8.9	9.4	9.8	11.0	11.0	11.1	11.1
ANR	Anner	0.95	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
ANT	Antrim	0.98	12.3	12.5	12.4	12.6	12.7	12.8	12.9	12.9	13.0	13.1
ARI	Arigna	0.998	4.3	4.3	4.3	4.3	4.2	4.2	4.3	4.3	4.3	4.3
ARK	Arklow	0.997	32.2	32.7	32.5	32.1	31.9	31.9	32.0	32.2	32.5	32.6
ATH	Athlone	0.998	63.4	64.5	64.0	63.2	62.9	62.9	63.1	63.5	64.0	64.2
ATY	Athy	0.968	15.0	15.2	15.1	14.9	14.9	14.8	14.9	15.0	15.1	15.2
BAG	Barnageeragh	0.95	0.0	0.0	2.4	4.8	7.1	9.5	11.9	14.3	16.6	19.0
BAL	Baltrasna	1	12.7	12.9	12.8	12.7	12.6	12.6	12.7	12.7	12.8	12.9
BAN	Bandon	0.987	37.7	38.4	38.1	37.6	37.4	37.4	37.5	37.7	38.0	38.2
BAN (N)	Banbridge	0.99	11.5	11.7	11.6	11.8	11.9	12.0	12.0	12.1	12.2	12.2
BAR	Barrymore	1	24.4	24.8	24.6	24.3	24.2	24.2	24.3	24.4	24.6	24.7
BDA	Baroda	0.95	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
BDN	Ballydine	0.95	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
BDN	Ballydine	0.96	11.7	11.9	11.8	11.7	11.6	11.6	11.7	11.7	11.8	11.9
BEG	Ballybeg	1	12.0	12.2	12.1	11.9	11.9	11.9	11.9	12.0	12.1	12.2
BIN	Binbane	0.969	3.7	3.8	3.7	3.67	3.7	3.7	3.7	3.7	3.7	3.7
BK	Bellacorick	0.996	4.6	4.7	4.7	4.6	4.6	4.6	4.6	4.6	4.7	4.7
BLC	Belcamp	0.95	58.9	68.4	77.9	87.4	96.9	106.4	108.3	108.3	108.3	108.3
BLI	Ballylickey	0.991	10.9	11.1	11.0	10.9	10.8	10.8	10.9	10.9	11.0	11.1
BLK	Blake	0.99	21.6	22.0	21.8	21.5	21.4	21.4	21.5	21.6	21.8	21.9
BMA	Ballymena	0.96	24.5	25.0	24.7	25.3	25.4	25.6	25.7	25.8	26.0	26.1
BNH	Ballynahinch	0.99	16.7	17.0	16.8	17.2	17.3	17.4	17.5	17.6	17.7	17.8
BNM	Belfast North	0.99	14.7	15.0	14.8	15.1	15.2	15.3	15.4	15.5	15.6	15.6
BOG	Banoge	0.97	6.7	6.8	6.7	6.6	6.6	6.6	6.6	6.7	6.7	6.8
BRI	Brinny	0.95	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
BRY	Barnahely	0.976	27.3	27.8	27.5	27.2	27.1	27.1	27.2	27.3	27.5	27.6
BUT	Butlerstown	0.989	32.2	32.8	32.5	32.1	32.0	31.9	32.0	32.2	32.5	32.6
BVG	Larne	0.99	4.4	4.5	4.5	4.6	4.6	4.6	4.6	4.7	4.7	4.7
CAH	Cahir	0.981	21.0	21.4	21.2	21.0	20.9	20.9	21.0	21.1	21.2	21.3
CAR	Carnmoney	0.99	7.4	7.4	7.2	7.3	7.2	7.1	7.0	7.1	7.1	7.2
CBG	Carrowbeg	0.984	14.4	14.6	14.5	14.3	14.3	14.2	14.3	14.4	14.5	14.5
CBR	Castlebar	0.988	26.5	27.0	26.7	26.4	26.3	26.3	26.4	26.5	26.7	26.8
CEN	Belfast Central	0.99	15.6	15.9	15.8	16.1	16.3	16.4	16.5	16.6	16.7	16.8
CF	Cathleen's Fall	0.964	16.5	16.8	16.6	16.4	16.4	16.4	16.4	16.5	16.6	16.7
CFM	Castlefarm	0.95	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.8
CHA	Charleville	0.96	16.1	16.4	16.2	16.0	16.0	16.0	16.0	16.1	16.2	16.3
CKM	Carrickmines	0.998	291.8	296.1	294.2	291.0	290.2	290.1	290.8	292.2	294.1	295.1
CLE	Clonee	0.95	71.8	83.2	94.6	106.0	117.4	128.8	135.4	135.4	135.4	135.4
CLG	Cloghran	0.95	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7
CLN	Cloon	0.925	21.1	21.5	21.4	21.1	21.0	21.0	21.1	21.2	21.3	21.4

**Table C-2 Demand Forecasts at Time of Summer Peak**

Bus Code	Bus Name	Power Factor	Demand Forecast (MW)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
CLU	Clutterland	0.95	0.0	3.8	3.8	9.5	14.3	20.0	24.7	30.4	35.2	40.9
CLW	Carlow	0.991	55.3	56.3	55.8	55.1	54.9	54.9	55.0	55.4	55.8	56.0
COL	College Park	0.986	26.5	27.0	26.7	26.4	26.3	26.3	26.4	26.5	26.7	26.8
COL (N)	Coleraine	0.99	12.5	12.8	12.6	12.9	13.0	13.0	13.1	13.2	13.3	13.3
COS	Carrick on Shannon	0.989	23.0	23.4	23.2	22.9	22.8	22.8	22.9	23.0	23.2	23.3
COW	Cow Cross	0.997	13.4	13.6	13.5	13.3	13.3	13.3	13.3	13.4	13.5	13.6
CPS	Coolkeeragh	0.99	7.4	7.6	7.5	7.7	7.7	7.8	7.8	7.8	7.9	7.9
CRA	Crane	0.979	25.1	25.6	25.4	25.1	25.0	25.0	25.0	25.2	25.4	25.5
CRE	Cregagh	0.99	25.2	21.2	21.1	21.6	21.7	21.9	22.0	22.1	22.3	22.4
CRG	Creagh	0.99	7.3	7.4	7.4	7.5	7.6	7.6	7.6	7.7	7.7	7.8
CRH	Cruiserath	0.95	3.8	9.0	14.3	19.5	24.7	29.9	35.2	40.4	45.6	50.8
CRO	Coolroe	1	8.4	8.6	8.5	8.4	8.4	8.4	8.4	8.5	8.5	8.6
CVW	Castleview	0.95	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8
CVW	Castleview	0.982	25.9	26.3	26.1	25.8	25.7	25.7	25.8	25.9	26.1	26.2
DAL	Dallow	0.987	14.8	15.1	15.0	14.8	14.7	14.7	14.8	14.9	15.0	15.0
DDK	Dundalk	0.986	52.6	53.5	53.1	52.4	52.2	52.2	52.4	52.7	53.1	53.3
DFR	Dunfirth	0.991	8.6	8.7	8.7	8.6	8.5	8.5	8.5	8.6	8.7	8.7
DGN	Dungarvan	0.984	39.0	39.7	39.4	38.9	38.7	38.7	38.8	39.1	39.4	39.5
DLT	Dalton	0.981	22.6	23.0	22.8	22.5	22.5	22.5	22.5	22.7	22.8	22.9
DMY	Dunmanway	0.976	27.6	28.1	27.8	27.5	27.4	27.4	27.4	27.6	27.8	27.9
DON	Donegall	0.99	26.8	26.8	26.1	26.2	26.0	25.7	25.4	25.5	25.7	25.8
DOO	Doon	0.984	21.9	22.3	22.1	21.9	21.8	21.8	21.8	22.0	22.1	22.2
DRU	Drumline	0.945	24.4	24.9	24.7	24.3	24.2	24.2	24.3	24.5	24.6	24.7
DRU (N)	Drumnakelly	0.98	26.8	27.4	27.1	27.7	27.9	28.1	28.3	28.4	28.6	28.7
DRY	Drybridge	0.985	71.4	72.7	72.1	71.1	70.9	70.9	71.1	71.5	72.1	72.4
DUN	Dungannon	0.99	28.4	28.9	28.7	29.3	29.5	29.7	29.8	29.9	30.1	30.3
EDE	Eden	0.98	10.1	10.3	10.2	10.4	10.5	10.6	10.6	10.7	10.7	10.8
ENN	Ennis	0.981	49.1	50.0	49.6	48.9	48.8	48.7	48.9	49.2	49.6	49.8
ENN (N)	Enniskillen	0.99	16.6	16.9	16.8	17.2	17.2	17.4	17.4	17.5	17.6	17.7
FIN (I)	Finglas	0.994	378.5	384.8	381.9	377.4	376.2	375.9	377.1	379.1	381.8	383.2
FIN (N)	Finaghy	0.99	9.1	9.2	9.2	9.4	9.4	9.5	9.5	9.6	9.6	9.7
FTT	Fortunestown	0.997	11.1	11.3	11.2	11.0	11.0	11.0	11.0	11.1	11.2	11.2
GAL	Galway	0.988	75.5	76.9	76.3	75.3	75.0	75.0	75.2	75.7	76.3	76.6
GI	Great Island	0.952	12.8	13.0	12.9	12.7	12.7	12.7	12.7	12.8	12.9	12.9
GIL	Gilra	0.95	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4
GLE	Glenlara	0.998	13.7	13.9	13.8	13.6	13.6	13.6	13.6	13.7	13.8	13.9
GLE (N)	Glengormley	0.97	9.2	9.3	9.2	9.4	9.4	9.4	9.4	9.5	9.5	9.6
GRI	Griffinrath	0.997	51.6	52.5	52.1	51.4	51.2	51.2	51.4	51.7	52.1	52.3
GWE	Gortawee	0.98	8.5	8.7	8.6	8.5	8.5	8.5	8.5	8.5	8.6	8.6
GWE	Gortawee	0.95	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1
IKE	Ikerrin	0.967	24.5	25.0	24.8	24.4	24.4	24.3	24.4	24.6	24.8	24.9
INC	Inchicore	0.995	420.6	449.8	475.9	500.4	517.6	534.9	553.7	571.0	590.7	606.9
KBY	Kilbarry	0.993	67.9	69.2	68.6	67.7	67.5	67.5	67.7	68.1	68.6	68.9
KCY	Kilcarbery	0.95	0.0	0.0	0.0	4.8	9.5	14.3	19.0	23.8	23.8	23.8
KER	Knockearagh	0.971	31.9	32.4	32.2	31.8	31.6	31.6	31.7	31.9	32.2	32.3
KGE	Kishoge	0.95	0.0	0.0	0.0	4.8	9.5	14.3	19.0	23.8	23.8	23.8

**Table C-2 Demand Forecasts at Time of Summer Peak**

Bus Code	Bus Name	Power Factor	Demand Forecast (MW)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
KIL	Kilteel	0.988	28.0	28.5	28.3	27.9	27.8	27.8	27.9	28.0	28.3	28.4
KIN	Kinnegad	0.95	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2
KKY	Kilkenny	0.978	47.6	48.5	48.1	47.5	47.3	47.3	47.4	47.7	48.1	48.3
KLM	Kilmore	0.989	15.5	15.8	15.7	15.4	15.4	15.4	15.4	15.5	15.6	15.7
KNO	Knock	0.99	15.0	13.4	13.3	13.5	13.6	13.7	13.8	13.9	14.0	14.0
KTN	Killoteran	0.976	11.2	11.5	11.4	11.2	11.2	11.2	11.2	11.3	11.4	11.4
KUR	Knockumber	0.95	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7
KYT	Kellystown	0.95	28.5	59.9	114.0	116.9	116.9	116.9	116.9	116.9	116.9	116.9
LA	Lanesborough	0.984	13.2	13.5	13.4	13.2	13.1	13.1	13.2	13.3	13.4	13.4
LAR	Larne	0.99	8.4	8.6	8.5	8.6	8.7	8.7	8.8	8.8	8.9	8.9
LET	Letterkenny	0.985	50.6	51.5	51.1	50.4	50.3	50.2	50.4	50.7	51.1	51.3
LIB	Liberty Street	0.986	19.9	20.2	20.1	19.8	19.7	19.7	19.8	19.9	20.1	20.2
LIM	Limerick	0.993	66.8	68.0	67.5	66.6	66.4	66.3	66.5	66.9	67.4	67.7
LIM (N)	Limavady	0.99	7.3	7.4	7.3	7.5	7.5	7.6	7.6	7.6	7.7	7.7
LIS	Lisdrum	0.952	24.8	25.3	25.1	24.7	24.7	24.6	24.7	24.9	25.1	25.2
LIS (N)	Lisburn	0.99	21.7	22.1	21.9	22.4	22.5	22.6	22.7	22.9	23.0	23.1
LMR	Lisaghmore	0.98	9.6	9.8	9.7	9.9	10.0	10.0	10.1	10.1	10.2	10.3
LOG	Loguestown	0.98	11.4	11.6	11.5	11.8	11.8	11.9	12.0	12.0	12.1	12.2
MAC	Macroom	0.973	13.9	14.1	14.0	13.8	13.8	13.8	13.8	13.9	14.0	14.1
MAL	Mallow	0.981	19.1	19.4	19.3	19.0	18.9	18.9	19.0	19.1	19.3	19.3
MCE	Mace IBM	0.95	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
MCE	Macetown	0.995	24.2	24.7	24.5	24.1	24.1	24.0	24.1	24.3	24.5	24.5
MID	Midleton	0.98	34.4	35.1	34.8	34.3	34.2	34.2	34.3	34.5	34.8	34.9
MLN	Mullagharlin	0.95	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
MON	Monread	0.975	11.1	11.3	11.2	11.0	11.0	11.0	11.0	11.1	11.2	11.2
MOY	Moy	0.989	24.2	24.6	24.4	24.1	24.0	24.0	24.1	24.2	24.4	24.5
MR	Marina	0.992	13.5	13.7	13.6	13.4	13.4	13.4	13.4	13.5	13.6	13.7
MTH	Meath Hill	0.938	45.2	46.0	45.6	45.0	44.8	44.8	45.0	45.2	45.6	45.8
MUL	Mullingar	0.985	35.7	36.4	36.1	35.6	35.5	35.5	35.6	35.8	36.1	36.2
MUN	Mungret	0.95	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5
NAR	Newtownards	0.99	13.3	13.5	13.4	13.7	13.8	13.8	13.9	14.0	14.1	14.1
NAV	Navan	0.98	49.6	50.5	50.1	49.5	49.3	49.3	49.4	49.7	50.1	50.3
NEW	Newbridge	0.981	33.5	34.1	33.9	33.4	33.3	33.3	33.4	33.6	33.8	34.0
NEW (N)	Newry	0.99	23.4	23.9	23.7	24.2	24.3	24.5	24.6	24.7	24.8	25.0
NNA	Nenagh	0.954	17.8	18.1	18.0	17.7	17.7	17.7	17.7	17.8	18.0	18.0
ODE	Oldbridge	0.95	0.0	0.0	3.8	9.5	14.3	20.0	24.7	30.4	35.2	40.9
OLD	Oldcourt	0.95	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
OMA	Omagh	0.99	17.8	18.1	17.9	18.3	18.4	18.5	18.6	18.7	18.8	18.9
OUG	Oughtragh	0.992	21.3	21.7	21.5	21.2	21.1	21.1	21.2	21.3	21.5	21.6
PB	Poolbeg	0.989	143.8	146.4	145.2	143.3	142.8	142.7	143.1	144.0	145.1	145.7
PLA	Platin	0.95	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
PLS	Portlaoise 110kV	0.979	43.2	44.0	43.6	43.0	42.9	42.9	43.0	43.3	43.6	43.8
RAT	Rathkeale	0.993	33.4	34.0	33.7	33.3	33.2	33.2	33.3	33.5	33.7	33.9
RAT (N)	Rathgael	0.99	16.9	17.3	17.1	17.5	17.6	17.7	17.7	17.8	17.9	18.0
RIC	Richmond	0.972	29.1	29.6	29.4	29.0	28.9	28.9	29.0	29.2	29.4	29.5
RNW	Rinawade	0.95	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1

**Table C-2 Demand Forecasts at Time of Summer Peak**

Bus Code	Bus Name	Power Factor	Demand Forecast (MW)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ROS	Rosebank	0.99	8.9	8.2	8.1	8.3	8.3	8.4	8.4	8.4	8.5	8.5
RYB	Ryebrook	0.95	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5
SBH	Snughborough	0.95	14.3	14.3	17.1	19.0	21.9	23.8	14.3	28.5	31.4	33.3
SCR	Screebe	0.999	13.4	13.6	13.5	13.3	13.3	13.3	13.3	13.4	13.5	13.6
SHE	Shelton Abbey	0.95	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
SHL	Salthill	0.997	35.0	35.7	35.4	34.9	34.8	34.8	34.9	35.1	35.4	35.5
SKL	Shankill	0.993	45.8	46.6	46.3	45.7	45.5	45.5	45.6	45.9	46.2	46.4
SLI	Sligo	0.996	43.8	44.6	44.2	43.7	43.5	43.5	43.6	43.9	44.2	44.4
SNG	Singland	0.992	14.1	14.3	14.2	14.0	14.0	14.0	14.0	14.1	14.2	14.3
SOM	Somerset	0.974	18.3	18.7	18.5	18.3	18.2	18.2	18.2	18.4	18.5	18.6
SPR	Springtown	0.98	13.9	14.2	14.0	14.3	14.4	14.5	14.6	14.6	14.7	14.8
STR	Stratford	0.958	18.7	19.0	18.9	18.6	18.6	18.5	18.6	18.7	18.9	18.9
STR (N)	Strabane	0.99	12.4	12.6	12.5	12.8	12.8	12.9	13.0	13.0	13.1	13.2
TBG	Trabeg	0.994	57.0	58.0	57.5	56.8	56.6	56.6	56.7	57.1	57.5	57.8
TBK	Tullabrack	0.931	10.0	10.2	10.1	9.9	9.9	9.9	9.9	10.0	10.1	10.1
THU	Thurles	0.983	23.4	23.8	23.7	23.3	23.3	23.3	23.3	23.5	23.6	23.7
TIP	Tipperary	0.986	16.6	16.9	16.8	16.5	16.5	16.5	16.5	16.6	16.8	16.8
TLK	Trillick	0.968	17.6	18.0	17.8	17.6	17.5	17.5	17.6	17.7	17.8	17.9
TON	Tonroe	0.925	11.8	12.1	12.0	11.8	11.8	11.8	11.8	11.9	12.0	12.0
TRI	Trien	1	14.1	14.4	14.2	14.1	14.0	14.0	14.0	14.1	14.2	14.3
TRL	Tralee	0.99	45.0	45.8	45.4	44.8	44.7	44.7	44.8	45.1	45.4	45.6
TSB	Thornsberrry	0.977	27.9	28.4	28.1	27.8	27.7	27.7	27.7	27.9	28.1	28.2
WAR	Waringstown	0.99	19.4	19.8	19.6	20.0	20.1	20.2	20.3	20.4	20.5	20.6
WAT	Waterford	0.986	43.3	44.1	43.7	43.1	43.0	43.0	43.1	43.4	43.7	43.9
WEX	Wexford	0.979	47.1	48.0	47.6	47.0	46.8	46.8	46.9	47.2	47.6	47.8
WHI	Whitegate	0.95	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0

**Table C-3 Demand Forecasts at Time of Summer Valley**

Bus Code	Bus Name	Power Factor	Demand Forecast (MW)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
AA	Ardnacrusha	1	28.7	28.7	28.6	28.5	28.5	28.5	28.4	28.4	28.4	28.4
AGH (N)	Aghyoule	0.99	5.0	5.1	5.1	5.2	5.3	5.4	5.4	5.4	5.5	5.5
AGN	Aungierstown	0.95	0.0	7.6	15.2	22.8	25.2	27.6	29.9	32.3	34.7	37.1
AGY	Ardnagappary	0.98	4.8	4.8	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
AHA	Ahane	0.965	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
AIR	Airport Road	0.99	-	-	8.3	8.9	9.4	9.8	11.0	11.0	11.1	11.1
ANR	Anner	0.95	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
ANT	Antrim	0.98	12.3	12.5	12.4	12.6	12.7	12.8	12.9	12.9	13.0	13.1
ARI	Arigna	0.911	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
ARK	Arklow	0.967	15.4	15.4	15.4	15.4	15.3	15.3	15.3	15.3	15.3	15.3
ATH	Athlone	0.995	26.8	26.7	26.7	26.6	26.6	26.6	26.5	26.5	26.5	26.5
ATY	Athy	0.971	6.1	6.1	6.1	6.1	6.0	6.0	6.0	6.0	6.0	6.0
BAG	Barnageeragh	0.95	0.0	0.0	2.4	4.8	7.1	9.5	11.9	14.3	16.6	19.0
BAL	Baltrasna	0.998	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
BAN	Bandon	0.993	16.6	16.6	16.6	16.5	16.5	16.5	16.5	16.5	16.5	16.4
BAN (N)	Banbridge	0.99	11.5	11.7	11.6	11.8	11.9	12.0	12.0	12.1	12.2	12.2
BAR	Barrymore	0.958	11.5	11.5	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.3
BDA	Baroda	0.95	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
BDN	Ballydine	0.982	3.8	3.8	3.8	3.8	3.7	3.7	3.7	3.7	3.7	3.7
BDN	Ballydine	0.95	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
BEG	Ballybeg	0.992	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
BIN	Binbane	0.982	6.2	6.2	6.2	6.2	6.2	6.2	6.1	6.1	6.1	6.1
BK	Bellacorick	0.998	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
BLI	Ballylickey	0.925	6.0	6.0	6.0	6.0	5.9	5.9	5.9	5.9	5.9	5.9
BLC	Belcamp	0.950	58.9	68.4	77.9	87.4	96.9	106.4	108.3	108.3	108.3	108.3
BLK	Blake	0.999	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.2	8.2	8.2
BMA	Ballymena	0.96	24.5	25.0	24.7	25.3	25.4	25.6	25.7	25.8	26.0	26.1
BNH	Ballynahinch	0.99	16.7	17.0	16.8	17.2	17.3	17.4	17.5	17.6	17.7	17.8
BNM	Belfast North	0.99	14.7	15.0	14.8	15.1	15.2	15.3	15.4	15.5	15.6	15.6
BOG	Banoge	0.989	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
BRI	Brinny	0.95	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
BRY	Barnahely	0.982	26.6	26.6	26.5	26.5	26.4	26.4	26.4	26.3	26.3	26.3
BUT	Butlerstown	0.999	12.9	12.9	12.9	12.8	12.8	12.8	12.8	12.8	12.8	12.7
BVG	Ballyvallyagh	0.99	4.4	4.5	4.5	4.6	4.6	4.6	4.6	4.7	4.7	4.7
CAH	Cahir	1	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.2
CAR	Carnmoney	0.99	7.4	7.4	7.2	7.3	7.2	7.1	7.0	7.1	7.1	7.2
CBG	Carrowbeg	0.996	8.4	8.4	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
CBR	Castlebar	0.984	10.7	10.7	10.7	10.7	10.7	10.7	10.6	10.6	10.6	10.6
CEN	Belfast Central	0.99	15.6	15.9	15.8	16.1	16.3	16.4	16.5	16.6	16.7	16.8
CF	Cathaleens Fall	0.999	6.4	6.4	6.4	6.4	6.3	6.3	6.3	6.3	6.3	6.3
CFM	Castlefarm	0.95	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.8
CHA	Charleville	0.999	6.7	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6
CKM	Carrickmines	0.998	144.3	144.2	143.9	143.8	143.6	143.5	143.4	143.3	143.2	143.2
CLE	Clonee	0.95	86.5	105.5	124.5	142.5	142.5	142.5	142.5	142.5	142.5	142.5
CLG	Cloghran	0.95	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7
CLN	Cloon	1	7.1	7.1	7.1	7.0	7.0	7.0	7.0	7.0	7.0	7.0



**Table C-3 Demand Forecasts at Time of Summer Valley**

Bus Code	Bus Name	Power Factor	Demand Forecast (MW)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
CLU	Clutterland	0.95	0.0	3.8	3.8	9.5	14.3	20.0	24.7	30.4	35.2	40.9
CLW	Carlow	0.982	18.2	18.2	18.2	18.1	18.1	18.1	18.1	18.0	18.0	18.0
COL	College Park	0.993	21.1	21.1	21.1	21.0	21.0	20.9	20.9	20.9	20.9	20.9
COL (N)	Coleraine	0.99	12.5	12.8	12.6	12.9	13.0	13.0	13.1	13.2	13.3	13.3
COS	Carrick on Shannon	1	8.0	8.0	8.0	8.0	7.9	7.9	7.9	7.9	7.9	7.9
COW	Cow Cross	1	8.2	8.2	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
CPS	Coolkeeragh	0.99	7.4	7.6	7.5	7.7	7.7	7.8	7.8	7.8	7.9	7.9
CRA	Crane	0.999	12.0	12.0	11.9	11.9	11.9	11.9	11.9	11.9	11.8	11.8
CRE	Cregagh	0.99	25.2	21.2	21.1	21.6	21.7	21.9	22.0	22.1	22.3	22.4
CRG	Creagh	0.99	7.3	7.4	7.4	7.5	7.6	7.6	7.6	7.7	7.7	7.8
CRH	Cruiserath	0.95	3.8	9.0	14.3	19.5	24.7	29.9	35.2	40.4	45.6	50.8
CRO	Coolroe	1	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.6
CVW	Castleview	0.95	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8
CVW	Castleview	0.992	14.9	14.9	14.9	14.8	14.8	14.8	14.8	14.8	14.8	14.8
DAL	Dallow	0.993	4.8	4.8	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
DDK	Dundalk	1	18.3	18.3	18.3	18.2	18.2	18.2	18.1	18.1	18.1	18.1
DFR	Dunfirth	1	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.2
DGN	Dungarvan	1	15.1	15.1	15.1	15.0	15.0	15.0	15.0	15.0	14.9	14.9
DLT	Dalton	0.999	10.7	10.7	10.7	10.6	10.6	10.6	10.6	10.6	10.6	10.6
DMY	Dunmanway	0.983	10.1	10.1	10.1	10.0	10.0	10.0	10.0	10.0	10.0	10.0
DON	Donegall	0.99	26.8	26.8	26.1	26.2	26.0	25.7	25.4	25.5	25.7	25.8
DOO	Doon	1	8.9	8.9	8.9	8.9	8.9	8.8	8.8	8.8	8.8	8.8
DRU	Drumline	0.873	12.9	12.9	12.8	12.8	12.8	12.8	12.8	12.8	12.7	12.7
DRU (N)	Drumnakelly	0.98	26.8	27.4	27.1	27.7	27.9	28.1	28.3	28.4	28.6	28.7
DRY	Drybridge	1	24.3	24.3	24.2	24.2	24.1	24.1	24.1	24.1	24.0	24.0
DUN	Dungannon	0.99	28.4	28.9	28.7	29.3	29.5	29.7	29.8	29.9	30.1	30.3
EDE	Eden	0.98	10.1	10.3	10.2	10.4	10.5	10.6	10.6	10.7	10.7	10.8
ENN	Ennis	0.996	22.0	22.0	21.9	21.9	21.9	21.8	21.8	21.8	21.8	21.8
ENN (N)	Enniskillen	0.99	16.6	16.9	16.8	17.2	17.2	17.4	17.4	17.5	17.6	17.7
FIN (I)	Finglas	0.993	184.9	184.7	184.4	184.1	183.9	183.7	183.5	183.4	183.2	183.1
FIN (N)	Finaghy	0.99	9.1	9.2	9.2	9.4	9.4	9.5	9.5	9.6	9.6	9.7
FTT	Fortunestown	1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
GAL	Galway	1	34.2	34.1	34.1	34.0	33.9	33.9	33.9	33.8	33.8	33.8
GI	Great Island	0.979	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
GIL	Gilra	0.95	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4
GLE	Glenlara	0.956	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
GLE (N)	Glengormley	0.97	9.2	9.3	9.2	9.4	9.4	9.4	9.4	9.5	9.5	9.6
GRI	Griffinrath	1	23.1	23.0	23.0	22.9	22.9	22.9	22.8	22.8	22.8	22.8
GWE	Gortawee	0.981	6.5	6.5	6.5	6.4	6.4	6.4	6.4	6.4	6.4	6.4
GWE	Gortawee	0.95	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1
IKE	Ikerrin	0.996	9.7	9.7	9.7	9.7	9.7	9.6	9.6	9.6	9.6	9.6
INC	Inchicore	0.984	307.5	332.3	360.1	387.3	405.2	422.5	440.5	456.2	473.9	489.2
KBY	Kilbarry	1	20.3	20.3	20.2	20.2	20.2	20.1	20.1	20.1	20.1	20.1
KCY	Kilcarbery	0.95	0.0	0.0	0.0	4.8	9.5	14.3	19.0	23.8	23.8	23.8
KER	Knockearagh	0.99	15.3	15.3	15.3	15.2	15.2	15.2	15.2	15.2	15.1	15.1
KGE	Kishoge	0.95	0.0	0.0	0.0	4.8	9.5	14.3	19.0	23.8	23.8	23.8

**Table C-3 Demand Forecasts at Time of Summer Valley**

Bus Code	Bus Name	Power Factor	Demand Forecast (MW)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
KIL	Kilteel	0.998	9.8	9.8	9.8	9.8	9.7	9.7	9.7	9.7	9.7	9.7
KIN	Kinnegad	0.95	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2
KKY	Kilkenny	1	19.0	18.9	18.9	18.9	18.8	18.8	18.8	18.8	18.8	18.7
KLM	Kilmore	0.992	9.4	9.4	9.4	9.4	9.4	9.4	9.3	9.3	9.3	9.3
KNO	Knock	0.99	15.0	13.4	13.3	13.5	13.6	13.7	13.8	13.9	14.0	14.0
KTN	Killoteran	0.993	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
KUR	Knockumber	0.95	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7
KYT	Kellystown	0.95	28.5	59.9	114.0	116.9	116.9	116.9	116.9	116.9	116.9	116.9
LA	Lanesborough	1	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
LAR	Larne	0.99	8.4	8.6	8.5	8.6	8.7	8.7	8.8	8.8	8.9	8.9
LET	Letterkenny	0.996	17.8	17.8	17.8	17.7	17.7	17.7	17.7	17.6	17.6	17.6
LIB	Liberty Street	0.989	7.9	7.9	7.9	7.8	7.8	7.8	7.8	7.8	7.8	7.8
LIM	Limerick	1	30.2	30.1	30.1	30.0	30.0	29.9	29.9	29.9	29.9	29.8
LIM (N)	Limavady	0.99	7.3	7.4	7.3	7.5	7.5	7.6	7.6	7.6	7.7	7.7
LIS	Lisdrum	0.992	9.8	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.6
LIS (N)	Lisburn	0.99	21.7	22.1	21.9	22.4	22.5	22.6	22.7	22.9	23.0	23.1
LMR	Lisaghmore	0.98	9.6	9.8	9.7	9.9	10.0	10.0	10.1	10.1	10.2	10.3
LOG	Loguestown	0.98	11.4	11.6	11.5	11.8	11.8	11.9	12.0	12.0	12.1	12.2
MAC	Macroom	0.96	7.1	7.1	7.1	7.1	7.1	7.0	7.0	7.0	7.0	7.0
MAL	Mallow	0.988	12.9	12.9	12.8	12.8	12.8	12.8	12.8	12.8	12.7	12.7
MCE	Mace	0.95	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
MCE	Macetown	0.95	10.2	10.2	10.2	10.2	10.2	10.1	10.1	10.1	10.1	10.1
MID	Midleton	0.99	21.2	21.1	21.1	21.0	21.0	21.0	21.0	20.9	20.9	20.9
MLN	Mullagharlin	0.95	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
MON	Monread	0.999	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
MOY	Moy	1	10.1	10.1	10.1	10.1	10.1	10.1	10.0	10.0	10.0	10.0
MR	Marina	0.999	4.8	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
MTH	Meath Hill	0.984	13.5	13.5	13.5	13.5	13.4	13.4	13.4	13.4	13.4	13.4
MUL	Mullingar	0.998	13.1	13.1	13.1	13.0	13.0	13.0	13.0	13.0	13.0	13.0
MUN	Mungret	0.95	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5
NAR	Newtownards	0.99	13.3	13.5	13.4	13.7	13.8	13.8	13.9	14.0	14.1	14.1
NAV	Navan	0.969	17.7	17.7	17.6	17.6	17.6	17.6	17.5	17.5	17.5	17.5
NEW	Newbridge	1	13.2	13.2	13.2	13.2	13.1	13.1	13.1	13.1	13.1	13.1
NEW (N)	Newry	0.99	23.4	23.9	23.7	24.2	24.3	24.5	24.6	24.7	24.8	25.0
NNA	Nenagh	0.977	8.2	8.2	8.2	8.2	8.2	8.1	8.1	8.1	8.1	8.1
ODE	Oldbridge	0.95	0.0	0.0	3.8	9.5	14.3	20.0	24.7	30.4	35.2	40.9
OLD	Oldcourt	0.95	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
OMA	Omagh	0.99	17.8	18.1	17.9	18.3	18.4	18.5	18.6	18.7	18.8	18.9
OUG	Oughtragh	0.989	10.6	10.6	10.6	10.5	10.5	10.5	10.5	10.5	10.5	10.5
PB	Poolbeg	0.995	73.7	73.6	73.5	73.3	73.2	73.1	73.0	72.9	72.9	72.8
PLA	Platin	0.95	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
PLS	Portlaoise 110kv	0.996	17.7	17.6	17.6	17.6	17.5	17.5	17.5	17.5	17.5	17.4
RAT	Rathkeale	0.997	9.8	9.7	9.7	9.7	9.7	9.7	9.7	9.6	9.6	9.6
RAT (N)	Rathgael	0.99	16.9	17.3	17.1	17.5	17.6	17.7	17.7	17.8	17.9	18.0
RIC	Richmond	0.997	11.9	11.9	11.9	11.9	11.8	11.8	11.8	11.8	11.8	11.8
RNW	Rinawade	0.95	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1

**Table C-3 Demand Forecasts at Time of Summer Valley**

Bus Code	Bus Name	Power Factor	Demand Forecast (MW)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ROS	Rosebank	0.99	8.9	8.2	8.1	8.3	8.3	8.4	8.4	8.4	8.5	8.5
RYB	Ryebrook	0.95	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5
SBH	Snughborough	0.95	14.3	14.3	17.1	19.0	21.9	23.8	14.3	28.5	31.4	33.3
SCR	Screebe	0.976	7.7	7.7	7.7	7.6	7.6	7.6	7.6	7.6	7.6	7.6
SHE	Shelton Abbey	0.95	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
SHL	Salthill	0.997	14.1	14.0	14.0	14.0	14.0	13.9	13.9	13.9	13.9	13.9
SKL	Shankill	0.997	11.6	11.5	11.5	11.5	11.5	11.5	11.5	11.4	11.4	11.4
SLI	Sligo	1	16.6	16.6	16.5	16.5	16.5	16.5	16.4	16.4	16.4	16.4
SNG	Singland	1	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.4	5.4
SOM	Somerset	0.998	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
SPR	Springtown	0.98	13.9	14.2	14.0	14.3	14.4	14.5	14.6	14.6	14.7	14.8
STR	Stratford	1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.0
STR (N)	Strabane	0.99	12.4	12.6	12.5	12.8	12.8	12.9	13.0	13.0	13.1	13.2
TBG	Trabeg	1	27.0	26.9	26.9	26.8	26.8	26.8	26.7	26.7	26.7	26.6
TBK	Tullabrack	0.992	1.9	1.9	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
THU	Thurles	0.99	10.6	10.6	10.6	10.6	10.6	10.6	10.5	10.5	10.5	10.5
TIP	Tipperary	0.992	7.3	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
TLK	Trillick	0.994	5.9	5.9	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8
TON	Tonroe	0.987	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
TRI	Trien	0.962	9.2	9.2	9.2	9.2	9.2	9.1	9.1	9.1	9.1	9.1
TRL	Tralee	0.997	15.1	15.1	15.1	15.0	15.0	15.0	15.0	15.0	15.0	14.9
TSB	Thornsberrry	0.996	11.0	10.9	10.9	10.9	10.9	10.9	10.9	10.8	10.8	10.8
WAR	Waringstown	0.99	19.4	19.8	19.6	20.0	20.1	20.2	20.3	20.4	20.5	20.6
WAT	Waterford	1	29.0	28.9	28.9	28.8	28.8	28.7	28.7	28.7	28.6	28.6
WEX	Wexford	1	20.9	20.8	20.8	20.8	20.7	20.7	20.7	20.7	20.6	20.6
WHI	Whitegate	0.95	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0

**Table C-4 Demand Forecasts at Time of Autumn Peak – Northern Ireland only**

Bus Code	Bus Name	Power Factor	Demand Forecast (MW)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
AGH	Aghyoule	0.99	14.9	15.2	15.1	15.5	15.7	15.9	16.0	16.1	16.2	16.3
AIR	Airport Road	0.99	-	-	24.5	26.5	27.7	29.1	32.5	32.7	32.9	33.0
ANT	Antrim	0.98	36.4	37.0	36.7	37.5	37.7	37.9	38.1	38.3	38.5	38.8
BAN (N)	Banbridge	0.99	34.1	34.7	34.4	35.1	35.3	35.6	35.7	35.9	36.1	36.3
BMA	Ballymena	0.96	72.7	74.0	73.3	74.9	75.4	75.8	76.1	76.6	77.0	77.4
BNH	Ballynahinch	0.99	49.5	50.4	49.9	51.0	51.3	51.6	51.8	52.1	52.4	52.7
BNM	Belfast North	0.99	43.5	44.4	43.9	44.9	45.2	45.4	45.6	45.9	46.1	46.4
BVG	Ballyvallyagh	0.99	13.2	13.4	13.3	13.6	13.6	13.7	13.8	13.8	13.9	14.0
CAR	Carnmoney	0.99	21.8	21.9	21.4	21.5	21.3	21.1	20.9	21.0	21.1	21.2
CEN	Belfast Central	0.99	46.2	47.1	46.8	47.9	48.2	48.6	48.9	49.2	49.4	49.7
COL (N)	Coleraine	0.99	37.1	37.8	37.5	38.3	38.5	38.7	38.8	39.1	39.3	39.5
CPS	Coolkeeragh	0.99	22.0	22.4	22.2	22.7	22.9	23.0	23.1	23.2	23.3	23.5
CRE	Cregagh	0.99	74.9	63.0	62.5	64.0	64.5	64.9	65.3	65.7	66.1	66.5
CRG	Creagh	0.99	21.6	22.0	21.8	22.3	22.4	22.5	22.6	22.8	22.9	23.0
DON	Donegall	0.99	79.4	79.5	77.4	77.8	77.0	76.2	75.3	75.7	76.2	76.6
DRU (N)	Drumnakelly	0.98	79.6	81.2	80.4	82.2	82.7	83.3	83.8	84.3	84.8	85.2
DUN	Dungannon	0.99	84.3	85.9	85.1	86.9	87.4	88.0	88.3	88.8	89.3	89.8
EDE	Eden	0.98	30.1	30.6	30.3	31.0	31.2	31.4	31.5	31.7	31.8	32.0
ENN (N)	Enniskillen	0.99	49.3	50.3	49.8	50.9	51.2	51.5	51.7	52.0	52.3	52.6
FIN (N)	Finaghy	0.99	26.9	27.4	27.2	27.7	27.9	28.1	28.2	28.3	28.5	28.7
GLE (N)	Glengormley	0.97	27.3	27.7	27.3	27.8	27.9	27.9	27.9	28.1	28.3	28.4
KNO	Knock	0.99	44.5	39.7	39.3	40.2	40.5	40.7	40.9	41.2	41.4	41.6
LAR	Larne	0.99	24.9	25.4	25.1	25.6	25.8	25.9	26.0	26.2	26.3	26.5
LIM (N)	Limavady	0.99	21.5	21.9	21.7	22.2	22.3	22.4	22.5	22.6	22.7	22.9
LIS (N)	Lisburn	0.99	64.3	65.5	64.9	66.3	66.7	67.1	67.4	67.8	68.2	68.6
LMR	Lisaghmore	0.98	28.6	29.1	28.8	29.4	29.6	29.8	29.9	30.1	30.3	30.4
LOG	Loguestown	0.98	33.9	34.5	34.2	34.9	35.1	35.3	35.5	35.7	35.9	36.1
NAR	Newtownards	0.99	39.4	40.2	39.8	40.6	40.9	41.1	41.2	41.5	41.7	41.9
NEW (N)	Newry	0.99	69.5	70.8	70.2	71.7	72.1	72.6	72.9	73.3	73.7	74.1
OMA	Omagh	0.99	52.7	53.7	53.2	54.3	54.6	54.9	55.1	55.5	55.8	56.1
RAT (N)	Rathgael	0.99	50.3	51.2	50.7	51.8	52.1	52.4	52.6	52.9	53.2	53.5
ROS	Rosebank	0.99	26.4	24.2	24.0	24.5	24.6	24.8	24.9	25.0	25.2	25.3
SPR	Springtown	0.98	41.3	42.1	41.7	42.6	42.8	43.0	43.2	43.5	43.7	43.9
STR (N)	Strabane	0.99	36.8	37.5	37.1	37.9	38.1	38.3	38.5	38.7	38.9	39.1
WAR	Waringstown	0.99	57.5	58.6	58.0	59.3	59.6	59.9	60.1	60.5	60.9	61.2

# Appendix D

All-Island Ten Year

Transmission Forecast  
Statement

**2021**

# Appendix D Generation Capacity Details

## D.1 Generation Capacity Details

Table D-1 lists existing and committed future transmission connected generation, their connection details and the Registered Capacity<sup>129</sup> of each unit as at the data freeze date.

All generation capacity figures in Table D-1 are expressed in exported terms. Exported terms are given by the generation unit output less than the unit's own auxiliary load. The units are grouped in these tables on a geographical basis. Generation capacity figures are rounded to the nearest MW.

Table D-2 lists the existing and committed future wind generation. The wind generation included in this table is wind generation that feeds into each 110 kV transmission station, from the distribution system. The respective MW capacity over the period of the statement is included. Table D-2 is based on the wind farms that had connection agreements with the DSO at the data freeze date.

Table D-3 lists the existing and committed distribution connected generation, excluding wind generation, as at the data freeze date. Their respective MW capacity over the period of the statement is included.

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<sup>129</sup> The Registered Capacity of future units will not be known until the unit enters the Integrated Single Electricity Market. Therefore, for future units the Maximum Export Capacity of the unit appears in Table D-1.

**Table D-1 MEC of Existing and Committed Transmission-Connected Generation**

Area	Generation Station	Unit ID	Connected At		Fuel Type	Connection Year (if future)	Maximum Export Capacity (MW)
Border	Carrickaduff		Croaghmagawna	110 kV	Wind	2023	66
	Carrickalangan		Croaghmagawna	110 kV	Wind	2023	72
	Erne Cathleens Fall Hydro (3)		Cath_Fall	110 kV	Hydro		22
	Erne Cathleens Fall Hydro (4)	ER3	Cath_Fall	110 kV	Hydro		23
	Erne Cliff Hydro (1)	ER4	Cliff	110 kV	Hydro		10
	Erne Cliff Hydro (2)	ER1	Cliff	110 kV	Hydro		10
	Firlough WF		Firlough	110 kV	Wind		48.3
	Garvagh - Glebe (1a)	ER2	Garvagh	110 kV	Wind		26
	Garvagh - Tullynahaw (1c)		Garvagh	110 kV	Wind		22
	Golagh (1)		Golagh	110 kV	Wind		15
	Lenalea		Lenalea	110 kV	Wind	2025	30.5
	Kingsmountain (1)		Cunghill	110 kV	Wind		24
	Kingsmountain (2)		Cunghill	110 kV	Wind		11
	Lisdrumdoagh Energy Storage Facility		Lisdrum	110 kV	Battery		60
	Meentycat (1)		Meentycat	110 kV	Wind		71
	Meentycat (2)		Meentycat	110 kV	Wind		14
	Mountain Lodge (1)		Ratrussan	110 kV	Wind		31
	Mullygaffy		Tievebrack	110 kV	Wind		29.9
	Mulreavy (1)		Mulreavy	110 kV	wind		82
	Mulreavy Ext		Mulreavy	110 kV	Wind		13
Oriel (1)		Oriel	0.69 kV	Wind	2022	210	
Ratrussan (1a)		Ratrussan	110 kV	Wind		48	
<b>Border Area Total</b>							<b>938.7</b>
Dublin	Corduff		Corduff	220 kV	Battery	2022	70
	Dublin Bay Power		Irishtown	220 kV	Gas/Oil		422
	Gallanstown Solar		Gallanstown	110 kV	Solar	2023	119
	Harristown Solar PV		Harristown	110 kV	Solar	2023	42
	Huntstown (1)	HNC	Huntstown	220 kV	Gas/Oil		236
	Huntstown (1)	HNC	Huntstown	220 kV	Gas/Oil		123
	Huntstown (2)	HN2	Huntstown	220 kV	Gas		412
	Shellybanks Combined Cycle	PBC	Shellybanks	220 kV	Gas/Oil		150
	Shellybanks Combined Cycle	PBC	Shellybanks	220 kV	Gas/Oil		150
	Shellybanks Combined Cycle	PBC	Shellybanks	220 kV	Gas/Oil		173
	<b>Dublin Area Total</b>						

**Table D-1 MEC of Existing and Committed Transmission-Connected Generation**

Area	Generation Station	Unit ID	Connected At		Fuel Type	Connection Year (if future)	Maximum Export Capacity (MW)
Mid-East	Blundlestown		Blundelstown	110 kV	Solar		60
	Cloncreen Wind farm		Cloncreen	110 kV	Wind	2025	75
	Gaskinstown		Deenes	110 kV	Solar	2022	85
	Gillinstown Solar		Garballagh	110 kV	Solar	2023	95
	Gorman BES		Gorman	110 kV	Battery	2023	50
	Liffey Hydro (1)	LI1	Pollaphuca	110 kV	Hydro		15
	Liffey Hydro (2)	LI2	Pollaphuca	110 kV	Hydro		15
	Liffey Hydro (4)	LI4	Pollaphuca	110 kV	Hydro		4
	Porterstown BES		Kilteel	110 kV	Battery		30
	Timahoe North		Timahoe	110 kV	Solar	2023	70
	Turlough Hill (1)	TH1	Turlough Hill	220 kV	Pumped Storage		73
	Turlough Hill (2)	TH2	Turlough Hill	220 kV	Pumped Storage		73
	Turlough Hill (3)	TH3	Turlough Hill	220 kV	Pumped Storage		73
	Turlough Hill (4)	TH4	Turlough Hill	220 kV	Pumped Storage		73
	<b>Mid-East Area Total</b>						
Midlands	Blackwater Bog Solar 1		Derrylahan	110 kV	solar	2023	65
	Clonfad Solar		Clonfad	110 kV	solar	2022	100
	Cloghan Wind Farm		Derrycarney	110 kV	Wind	2024	34
	Edenderry Peaking	ED3	Cushaling	110 kV	Conventional		117
	Edenderry Power	ED1	Cushaling	110 kV	Peat		134
	Lanesboro (2)		Lanesboro	110 kV	Peat		40
	Lanesboro (3)		Lanesboro	110 kV	Peat		45
	Loughteague		Coolnabacky	110 kV	solar	2025	55
	Lumcloon Batt		Derrycarney	110 kV	Battery		100
	Mountlucas (1)		Mountlucas	110 kV	Wind		79
	Rhode PCP (1)	RP1	Derryiron	110 kV	Distillate		52
	Rhode PCP (2)	RP2	Derryiron	110 kV	Distillate		52
<b>Midlands Area Total</b>							<b>873</b>



**Table D-1 MEC of Existing and Committed Transmission-Connected Generation**

Area	Generation Station	Unit ID	Connected At		Fuel Type	Connection Year (if future)	Maximum Export Capacity (MW)
Mid-West	Alumina CHP (1)	SK3	Aughinish	110 kV	Gas		86
	Alumina CHP (1)	SK4	Aughinish	110 kV	Gas		86
	Ardnacrusha Hydro (1)	AA1	Ardnacrusha	110 kV	Hydro		21
	Ardnacrusha Hydro (2)	AA2	Ardnacrusha	110 kV	Hydro		22
	Ardnacrusha Hydro (3)	AA3	Ardnacrusha	110 kV	Hydro		19
	Ardnacrusha Hydro (4)	AA4	Ardnacrusha	110 kV	Hydro		24
	Boolinrudda		Ennis	110 kV	Wind		46
	Booltiagh (1)		Booltiagh	110 kV	Wind		19
	Booltiagh (2)		Booltiagh	110 kV	Wind		12
	Dromada (1)		Dromada	110 kV	Wind		29
	Kill Hill (1)		Kill Hill	110 kV	Wind		36
	Knockalassa		Ennis	110 kV	Wind		27
	Lisheen (1)		Lisheen	110 kV	Wind		36
	Lisheen (1a)		Lisheen	110 kV	Wind		19
	Lisheen 3		Lisheen	110 kV	Wind	2022	29
	Moneypoint (1)	MP1	MNYPG3	380 kV	Coal		302
	Moneypoint (2)	MP2	MNYPG3	380 kV	Coal		305
	Moneypoint (3)	MP3	MNYPG3	380 kV	Coal		302
Moneypoint WF		MNYPG3	380 kV	Wind		18	
<b>Mid-West Area Total</b>							<b>1438</b>
Northern Ireland	Ballylumford	BGT20	Ballylumford	275 kV	Gas		500
	Ballylumford 10	B10	Ballylumford	110 kV	Gas		100
	Ballylumford GT1		Ballylumford	110 kV	Gas		58
	Ballylumford GT2		Ballylumford	110 kV	Gas		58
	Castlereagh BES		CASTLEREAGH	110 kV	Battery	2023	50
	Coolkeeragh GT	C30 GT	COOLKEERAGH	275 kV	Gas		260
	Coolkeeragh GT8	CGT8	COOLKEERAGH	110 kV	Oil		53
	Coolkeeragh ST	C30 GS	COOLKEERAGH	110 kV	Gas		170
	Kilroot GT3	KGT3	KILROOT	275 kV	Distillate		42
	Kilroot GT4	KGT4	KILROOT	275 kV	Distillate		42
	KELLS_BES		KELLS	110 kV	Battery	2023	50
	Kilroot OCGT6		KILROOT	275 kV	Gas	2023	406
	Kilroot OCGT7		KILROOT	275 kV	Gas	2023	302
	Kilroot ST1	K1	KILROOT	275 kV	Coal/Oil		195
	Kilroot ST2	K2	KILROOT	275 kV	Coal/Oil		195
	Tamnamore BES		TAMNAMORE	110 kV	Battery		50
Tandragee BES		TANDRAGEE	110 kV	Battery		50	
<b>Northern Ireland Total</b>							<b>2581</b>
South-East	Ballywater		Ballywater	110 kV	Wind		42
	Castledockrell		Castledockrell	110 kV	Wind		42
	Great Island CCGT	GI4	Great Island	220 kV	Conventional		439
	Knocknamona		Dungarvan	110 kV	Wind		34
	Rathnaskilloge		Rathnaskilloge	110 kV	solar	2023	95
	Rosspile Solar Farm		Rosspile	110 kV	Solar	2023	95
	Woodhouse		Woodhouse	110 kV	Wind		20

**Table D-1 MEC of Existing and Committed Transmission-Connected Generation**

Area	Generation Station	Unit ID	Connected At		Fuel Type	Connection Year (if future)	Maximum Export Capacity (MW)
<b>South-East Area Total</b>							<b>767</b>
<b>South-West</b>	Aghada CCGT	AD2	Aghada	220 kV	Gas		442
	Aghada	AT1	Aghada	220 kV	Gas		90
	Aghada	AT2	Aghada	220 kV	Gas		90
	Aghada	AT4	Aghada	220 kV	Gas		90
	Aghada BESS 1		Aghada	220 kV	storage		19
	Aghada BESS 2		Aghada	220 kV	Storage		159
	Athea		Athea	110 kV	Wind		34
	Ballinknockane Solar Farm		Ballinknockane	110 kV	Solar	2023	50
	Banemore Solar Farm		Clahane	110 kV	Solar		34
	Boggeragh (1)		Boggeragh	110 kV	Wind		57
	Boggeragh (2)		Boggeragh	110 kV	Wind		48
	Clahane (1)		Clahane	110 kV	Wind		38
	Clahane (2)		Clahane	110 kV	Wind		14
	Cloghboola		Cloghboola	110 kV	Wind		46
	Coomacheo (1)		Garrow	110 kV	Wind		41
	Coomacheo (2)		Garrow	110 kV	Wind		18
	Coomagearlahy (1)		Coomagearlahy	110 kV	Wind		43
	Coomagearlahy (2)		Coomagearlahy	110 kV	Wind		9
	Coomagearlahy (3)		Coomagearlahy	110 kV	Wind		30
	Cordal		Cordal	110 kV	Wind		90
	Drombeg Solar Park		Drombeg	110 kV	Solar	2022	50
	Glanlee (1)		Glanlee	110 kV	Wind		30
	Glen Solar		Glen	110 kV	solar	2024	40
	Grousemount		Coomataggart	110 kV	Wind		114
	Kelwin		Kilpaddoge	220 kV	Wind		27
	Kelwin Battery		Kilpaddoge	220 kV	storage	2024	42
	Killavoy		Boggeragh	110 kV	Wind		18
	Knockacummer (1)		Knockacummer	110 kV	Wind		105
	Lee Carrigadrohid Hydro (1)		Carrigadrohid	110 kV	Hydro		8
	Lee Inniscarra Hydro (1)		Inniscarra	110 kV	Hydro		19
	Tarbert (1)	TB1	Tarbert	110 kV	HFO		57
	Tarbert (2)	TB2	Tarbert	110 kV	HFO		57
	Tarbert (3)	TB3	Tarbert	220 kV	HFO		256
Tarbert (4)	TB4	Tarbert	220 kV	HFO		258	
Tobertoreen		Athea	110 kV	Wind		34	
Tullabeg Solar Park		Tullabeg	110 kV	Solar	2023	50	
Whitegen CCGT	WG	Glanagow	220 kV	Gas		449	
<b>South-West Area Total</b>							<b>3055</b>

**Table D-1 MEC of Existing and Committed Transmission-Connected Generation**

Area	Generation Station	Unit ID	Connected At		Fuel Type	Connection Year (if future)	Maximum Export Capacity (MW)
West	Buffy		Buffy	110 kV	Wind		91
	Carrigdangan		Carrigdangan	110 kV	Wind	2023	68
	Derrybrien (1)		Derrybrien	110 kV	Wind		60
	Knockalough		Knockalough	110 kV	Wind		34
	Killala (1)		Tawnaghmore	110 kV	Wind		19
	Killala (2)		Tawnaghmore	110 kV	Wind	2023	11
	Oweninney (1)		Bellacorick	110 kV	Wind		89
	Oweninney (2)		Bellacorick	110 kV	Wind		83
	Oweninney (3)		Bellacorick	110 kV	Wind	2023	50
	Seecon (1)		Knockranny	110 kV	Wind		108
	Shannonbridge ESS		Shannonbridge	220 kV	Battery		100
	Shannonbridge ESS		Shannonbridge	220 kV	Wind		63
	Shantallow Solar		Shantallow	110 kV	Solar	2023	35
	Sheskin		Bellacorick	110 kV	Wind	2023	33
	Sliabh Bawn (1)		Sliabh Bawn	110 kV	Wind		58
	Tawnaghmore Peaking Plant	TP1	Tawnaghmore	110 kV	distillate		52
	Tawnaghmore Peaking Plant	TP2	Tawnaghmore	110 kV	distillate		52
	Tynagh	TY1	Tynagh	220 kV	Gas		268
	Tynagh	TY2	Tynagh	220 kV	Gas		142
	Ugool		Ugool	110 kV	Wind		66
<b>West Area Total</b>							<b>1482</b>

**Table D-2 Existing and Committed Distribution-Connected Wind Farm Capacity**

Area	110 kV Station	Maximum Export Capacity (MEC)									
		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Border	Ardnagappary	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9
	Binbane	49.3	60.6	60.6	60.6	66.6	66.6	66.6	66.6	66.6	66.6
	Cath_Fall	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4
	Corderry	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3
	Crane	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
	Drybridge	7	7	7	7	11	11	11	11	11	11
	Dundalk	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6
	Garvagh	34	34	34	34	34	34	34	34	34	34
	Glenree	64.8	64.8	77.3	77.3	77.3	77.3	77.3	77.3	77.3	77.3
	Gortawee	3	3	3	3	3	3	3	3	3	3
	Letterkenny	51.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4
	Lisdrum			33.1	33.1	33.1	33.1	33.1	33.1	33.1	33.1
	Meath Hill	45.6	68.7	68.7	68.7	68.7	68.7	68.7	68.7	68.7	68.7
	Moy	6	6	6	6	6	6	6	6	6	6
	Shankill	28	28	28	28	28	28	28	28	28	28
	Sligo	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7
	Somerset	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
	Sorne Hill	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3
	Trien	72.7	72.7	72.7	72.7	72.7	72.7	72.7	72.7	72.7	72.7
Trillick	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	
<b>Border Area Total</b>		<b>630.7</b>	<b>685</b>	<b>730.6</b>	<b>730.6</b>	<b>740.6</b>	<b>740.6</b>	<b>740.6</b>	<b>740.6</b>	<b>740.6</b>	<b>740.6</b>
Dublin	Glasmore	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Nangor	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4
	Poppintree	4	4	4	4	4	4	4	4	4	4
<b>Dublin Area Total</b>		<b>18.2</b>	<b>18.2</b>	<b>18.2</b>	<b>18.2</b>	<b>18.2</b>	<b>18.2</b>	<b>18.2</b>	<b>18.2</b>	<b>18.2</b>	<b>18.2</b>
Mid-East	Arklow	79.7	85.7	85.7	85.7	85.7	85.7	85.7	85.7	85.7	85.7
<b>Mid-East Area Total</b>		<b>79.7</b>	<b>85.7</b>	<b>85.7</b>	<b>85.7</b>	<b>85.7</b>	<b>85.7</b>	<b>85.7</b>	<b>85.7</b>	<b>85.7</b>	<b>85.7</b>
Mid-lands	Blake	5	5	5	5	5	5	5	5	5	5
	Dallow	21	21	21	21	21	21	21	21	21	21
	Lanesboro	4.6	4.6	4.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
<b>Midlands Area Total</b>		<b>30.6</b>	<b>30.6</b>	<b>30.6</b>	<b>35.5</b>	<b>35.5</b>	<b>35.5</b>	<b>35.5</b>	<b>35.5</b>	<b>35.5</b>	<b>35.5</b>

**Table D-2 Existing and Committed Distribution-Connected Wind Farm Capacity**

Area	110 kV Station	Maximum Export Capacity (MEC)									
		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Mid-West	Ardnacrusha	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2
	Booltiagh	85.4	85.4	85.4	93.4	108.4	108.4	108.4	108.4	108.4	108.4
	Bunkimalt	46.5	46.5	46.5	46.5	46.5	46.5	46.5	46.5	46.5	46.5
	Cauteen	177.1	177.1	177.1	177.1	177.1	177.1	177.1	177.1	177.1	177.1
	Charleville	70.7	70.7	70.7	70.7	70.7	70.7	70.7	70.7	70.7	70.7
	Cureeny T	94	94	94	94	94	94	94	94	94	94
	Ikerrin	36	36	36	36	36	36	36	36	36	36
	Lisheen	39.6	39.6	39.6	39.6	39.6	39.6	39.6	39.6	39.6	39.6
	Nenagh	14	14	14	14	14	14	14	14	14	14
	Rathkeale	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8
	Thurles	41.8	41.8	41.8	41.8	41.8	41.8	41.8	41.8	41.8	41.8
	Tipperary	3	3	3	3	3	3	3	3	3	3
	Tullabrack	31	31	31	31	31	31	31	31	31	31
<b>Mid-West Area Total</b>		<b>676.9</b>	<b>676.9</b>	<b>676.9</b>	<b>684.9</b>	<b>699.9</b>	<b>699.9</b>	<b>699.9</b>	<b>699.9</b>	<b>699.9</b>	<b>699.9</b>
North-ern Ireland	Aghyoule	82.5	82.5	82.5	82.5	82.5	82.5	82.5	82.5	82.5	82.5
	Garvagh	47.5	90	90	90	90	90	90	90	90	90
	Antrim	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
	Ballymena	53.8	53.8	53.8	53.8	53.8	53.8	53.8	53.8	53.8	53.8
	Brockaghboy	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5
	Carnmoney	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8
	Coleraine	108	108	108	108	108	108	108	108	108	108
	Coolkeeragh	12	12	49.2	49.2	49.2	49.2	49.2	49.2	49.2	49.2
	Creagh	5	5	5	5	5	5	5	5	5	5
	Drumquin	67.9	67.9	161.5	161.5	161.5	161.5	161.5	161.5	161.5	161.5
	Drumnakelly	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
	Dungannon	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5
	Eden	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	Enniskillen	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9
	Kells			68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1
	Killymallaght	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7
	Larne	15	15	15	15	15	15	15	15	15	15
	Limavady	37.7	37.7	37.7	37.7	37.7	37.7	37.7	37.7	37.7	37.7
	Lisaghmore	15	15	15	15	15	15	15	15	15	15
	Loguestown	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
Magherakeel	138	138	138	138	138	138	138	138	138	138	
Omagh	95.7	95.7	95.7	95.7	95.7	95.7	95.7	95.7	95.7	95.7	
Rasharkin	54.8	54.8	54.8	54.8	54.8	54.8	54.8	54.8	54.8	54.8	
Slieve Kirk	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	
Strabane	28.1	28.1	28.1	28.1	28.1	28.1	28.1	28.1	28.1	28.1	
Tremoge	77.2	77.2	77.2	77.2	77.2	77.2	77.2	77.2	77.2	77.2	
<b>Northern Ireland Total</b>		<b>1058.9</b>	<b>1238.9</b>	<b>1437.8</b>	<b>1437.8</b>	<b>1437.8</b>	<b>1437.8</b>	<b>1437.8</b>	<b>1437.8</b>	<b>1437.8</b>	<b>1437.8</b>

**Table D-2 Existing and Committed Distribution-Connected Wind Farm Capacity**

Area	110 kV Station	Maximum Export Capacity (MEC)									
		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
South-East	Barrymore	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4
	Butlerstown	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
	Carlow	34.4	34.4	34.4	34.4	34.4	34.4	34.4	34.4	34.4	34.4
	Dungarvan	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
	Lodgewood	60.4	60.4	60.4	60.4	60.4	60.4	60.4	60.4	60.4	60.4
	Portlaoise	54.2	54.2	54.2	54.2	54.2	54.2	54.2	54.2	54.2	54.2
	Waterford	18	18	18	18	18	18	18	18	18	18
	Wexford	38.9	38.9	38.9	38.9	38.9	38.9	38.9	38.9	38.9	38.9
<b>South-East Area Total</b>		<b>244.6</b>	<b>244.6</b>	<b>244.6</b>	<b>244.6</b>	<b>244.6</b>	<b>244.6</b>	<b>244.6</b>	<b>244.6</b>	<b>244.6</b>	<b>244.6</b>
South-West	Athea	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
	Ballylickey	54	54	54	54	54	54	54	54	54	54
	Bandon	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3
	Boggeragh	20	26	26	38	41	41	41	41	41	41
	Castleview	-	-	4	4	4	4	4	4	4	4
	Cloghboola	54.5	54.5	54.5	54.5	54.5	54.5	54.5	54.5	54.5	54.5
	Coomataggart	42.6	42.6	42.6	42.6	42.6	42.6	42.6	42.6	42.6	42.6
	Cordal	75.8	75.8	75.8	75.8	75.8	75.8	75.8	75.8	75.8	75.8
	Dunmanway	42.3	42.3	45.3	45.3	45.3	45.3	45.3	45.3	45.3	45.3
	Garrow	15	15	15	15	15	15	15	15	15	15
	Glenlara	53	53	53	53	53	53	53	53	53	53
	Kilbarry	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Kilpaddoge	18	18	18	18	18	18	18	18	18	18
	Knockeragh	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9
	Macroom	34.1	34.1	34.1	34.1	34.1	34.1	34.1	34.1	34.1	34.1
	Midleton	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
	Oughtragh	9	9	9	9	9	9	9	9	9	9
Reamore	57.9	57.9	83.2	83.2	83.2	83.2	83.2	83.2	83.2	83.2	
Tralee	45.9	45.9	45.9	45.9	45.9	45.9	45.9	45.9	45.9	45.9	
<b>South-West Area Total</b>		<b>556.1</b>	<b>562</b>	<b>594.4</b>	<b>606.4</b>	<b>609.4</b>	<b>609.4</b>	<b>609.4</b>	<b>609.4</b>	<b>609.4</b>	<b>609.4</b>
West	Arigna	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6
	Bellacorick	9	9	75.8	75.8	78.3	78.3	78.3	78.3	78.3	78.3
	Castlebar	43.6	43.6	43.6	43.6	43.6	43.6	43.6	43.6	43.6	43.6
	Cloon	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
	Dalton	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4
	Salthill	46.1	46.1	46.1	46.1	46.1	46.1	46.1	46.1	46.1	46.1
	Screeb	3	3	3	3	3	3	3	3	3	3
	Tawnaghmore	19.2	19.2	30	30	30	30	30	30	30	30
	Tonroe	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
<b>West Area Total</b>		<b>197.7</b>	<b>197.7</b>	<b>275.3</b>	<b>275.3</b>	<b>277.8</b>	<b>277.8</b>	<b>277.8</b>	<b>277.8</b>	<b>277.8</b>	<b>277.8</b>

**Table D-3 Existing and Committed Distribution-Connected Generation (excluding wind)**

Area	110 kV Station	Type	Maximum Export Capacity (MEC)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Border	Binbane	Hydro	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
	Crane	Battery				16	16	16	16	16	16	16
	Crane	PV				5	5	5	5	5	5	5
	Crane	PV				4	4	4	4	4	4	4
	Crane	Solar			8	8	8	8	8	8	8	8
	Drybridge	Biomass	20	20	20	20	20	20	20	20	20	20
	Drybridge	LFG	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
	Drybridge	Solar		4.0	4.0	4.0	16.0	16.0	16.0	16.0	16.0	16.0
	Dundalk	Solar						4	4	4	4	4
	Meath Hill	Battery				33	33	33	33	33	33	33
	Meath Hill	CHP	1	1	1	1	1	1	1	1	1	1
	Shankill	LFG	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
	Shankill	Solar		4	4	4	4	4	4	4	4	4
	Somerset	Solar					4	4	4	4	4	4
	Stevinstown	Battery					8.5	8.5	8.5	8.5	8.5	8.5
	Stevinstown	Solar						4.95	4.95	4.95	4.95	4.95
Trien	Solar											
<b>Border Area Total</b>			<b>32.13</b>	<b>40.12</b>	<b>48.12</b>	<b>110.1</b>	<b>134.6</b>	<b>143.6</b>	<b>143.6</b>	<b>143.6</b>	<b>143.6</b>	<b>143.6</b>
Dublin	Blackrock	CHP	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
	Blackrock	CHP	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
	Fin_rural	CHP	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
	Finglas	Solar					8.42	8.42	8.42	8.42	8.42	8.42
	Glasmore	CHP	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
	Glasmore	Solar					4	4	4	4	4	4
	Ringsend	Diesel	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	Ringsend	Waste to Energy	72	72	72	72	72	72	72	72	72	72
<b>Dublin Area Total</b>			<b>78.35</b>	<b>78.35</b>	<b>78.35</b>	<b>78.35</b>	<b>90.77</b>	<b>90.77</b>	<b>90.77</b>	<b>90.77</b>	<b>90.77</b>	<b>90.77</b>
Mid-East	Baltrasna	Solar					10	10	10	10	10	10
	Baltrasna	Solar						10	10	10	10	10
	Arklow	Biomass	1	1	1	1	1	1	1	1	1	1
	Arklow	Solar	4	4	4	4	4	4	4	4	4	4
	Arklow	Solar		4	4	4	4	4	4	4	4	4
	Dunfirth	Solar		4	4	4	8	8	8	8	8	8
	Griffinrath	Hydro	4	4	4	4	4	4	4	4	4	4
	Griffinrath	Solar					15.5	15.5	15.5	15.5	15.5	15.5
	Kilteel	LFG + Diesel	9.77	9.77	9.77	9.77	9.77	9.77	9.77	9.77	9.77	9.77
	Kilteel	Solar		15	15	15	15	15	15	15	15	15
	Monread	Solar	4	4	4	4	8	8	8	8	8	8
	Newbridge	Solar		3.99	3.99	3.99	15.99	15.99	15.99	15.99	15.99	15.99
<b>Mid-East Area Total</b>			<b>22.77</b>	<b>49.76</b>	<b>49.76</b>	<b>49.76</b>	<b>95.26</b>	<b>105.3</b>	<b>105.3</b>	<b>105.3</b>	<b>105.3</b>	<b>105.3</b>

**Table D-3 Existing and Committed Distribution-Connected Generation (excluding wind)**

Area	110 kV Station	Type	Maximum Export Capacity (MEC)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Midland	Athlone	LFG	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Athlone	Solar						8	8	8	8	8
	Blake	Solar					5.0	5.0	5.0	5.0	5.0	5.0
	Blake	LFG	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	Derryiron	Flywheel			20	20	20	20	20	20	20	20
	Lanesboro	Solar			4	4	4	4	4	4	4	4
	Mullingar	Solar	4	8	8	12	12	12	12	12	12	12
	Navan	CHP	13	13	13	13	13	13	13	13	13	13
	Navan	Solar	4	9.0	9.0	13.0	17.0	17.0	17.0	17.0	17.0	17.0
	Richmond	Solar		4	4	4	4	4	4	4	4	4
	Thornsberry	CHP		10	10	10	10	10	10	10	10	10
Thornsberry	Solar					4	8	8	8	8	8	
<b>Midland Area Total</b>			<b>26.7</b>	<b>49.7</b>	<b>73.7</b>	<b>81.7</b>	<b>94.7</b>	<b>106.7</b>	<b>106.7</b>	<b>106.7</b>	<b>106.7</b>	<b>106.7</b>
Mid-West	Ballydine	Biogas	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44
	Ballydine	Solar		4	4	4	4	4	4	4	4	4
	Cahir	Solar	8	12	31	31	31	31	31	31	31	31
	Drumline	Solar				12	12	12	12	12	12	12
	Rathkeale	Biogas	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44
	Rathkeale	CHP	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
	Rathkeale	LFG	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
<b>Mid-West Area Total</b>			<b>18.58</b>	<b>26.58</b>	<b>45.58</b>	<b>57.58</b>	<b>57.58</b>	<b>57.58</b>	<b>57.58</b>	<b>57.58</b>	<b>57.58</b>	<b>57.58</b>
Northern Ireland	Antrim	PV	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8
	Ballymena	PV	6	6	6	6	6	6	6	6	6	6
	Coolkeeragh	Bio	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6
	Lisburn	PV	58.85	58.85	58.85	58.85	58.85	58.85	58.85	58.85	58.85	58.85
	Newtownards	PV	4.99	4.99	4.99	4.99	4.99	4.99	4.99	4.99	4.99	4.99
	Rasharkin	PV	35.01	35.01	35.01	35.01	35.01	35.01	35.01	35.01	35.01	35.01
	Rosebank	BIO	9.98	9.98	9.98	9.98	9.98	9.98	9.98	9.98	9.98	9.98
	Waringstown	PV	9	9	9	9	9	9	9	9	9	9
<b>Northern Ireland Total</b>			<b>266.2</b>	<b>266.2</b>	<b>366.2</b>	<b>366.2</b>	<b>366.2</b>	<b>366.2</b>	<b>366.2</b>	<b>366.2</b>	<b>366.2</b>	<b>366.2</b>



**Table D-3 Existing and Committed Distribution-Connected Generation (excluding wind)**

Area	110 kV Station	Type	Maximum Export Capacity (MEC)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
South-East	Athy	Solar	4	4	4	4	4	8.99	8.99	8.99	8.99	8.99
	Athy	Battery				8	8	8	8	8	8	8
	Ballybeg	LFG	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
	Ballybeg	Solar		8	8	8	8	8	8	8	8	8
	Banoge	Battery				9	9	9	9	9	9	9
	Banoge	Solar		4	4	4	8	8	8	8	8	8
	Barrymore	CHP	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
	Barrymore	Solar				9.9	9.9	9.9	9.9	9.9	9.9	9.9
	Butlerstown	Solar	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	Coolroe	Solar					10	10	10	10	10	10
	Cow Cross	Solar					4.95	4.95	4.95	4.95	4.95	4.95
	Doon	Hydro	1	1	1	1	1	1	1	1	1	1
	Doon	Solar				8	8	8	8	8	8	8
	Dungarvan	Solar					3.99	3.99	3.99	3.99	3.99	3.99
	Great Island	Battery					30	30	30	30	30	30
	Great Island	Solar		5.0	5.0	5.0	17.0	17.0	17.0	17.0	17.0	17.0
	Kilkenny	Solar	4	4	4	4	8	8	8	8	8	8
	Kilkenny	CHP	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
	Portlaoise	Biogas	1	1	1	1	1	1	1	1	1	1
	Portlaoise	Solar				4	8	8	8	8	8	8
Waterford	Solar		3.99	3.99	3.99	3.99	3.99	3.99	3.99	3.99	3.99	
Wexford	CHP	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	
Wexford	Solar		3.99	3.99	19.99	19.99	19.99	19.99	19.99	19.99	19.99	
<b>South-East Area Total</b>			<b>30.66</b>	<b>55.63</b>	<b>55.63</b>	<b>110.5</b>	<b>183.5</b>	<b>188.5</b>	<b>188.5</b>	<b>188.5</b>	<b>188.5</b>	
South-West	Ahane	Solar						4	4	4	4	4
	Bandon	Solar			9.94	9.94	19.84	19.84	19.84	19.84	19.84	19.84
	Barnahely	Solar						5	5	5	5	5
	Castleview	Biogas			4	4	4	4	4	4	4	4
	Castleview	CHP	2	2	2	2	2	2	2	2	2	2
	Dunmanway	Biogas	6	6	6	6	6	6	6	6	6	6
	Glenlara	Solar					4.95	4.95	4.95	4.95	4.95	4.95
	Kilbarry	Solar		4.95	4.95	4.95	9.9	9.9	9.9	9.9	9.9	9.9
	Knockeragh	Biomass	3	3	3	3	3	3	3	3	3	3
	Knockeragh	Solar				8.99	8.99	8.99	8.99	8.99	8.99	8.99
	Limerick	Solar		4	4	4	4	4	4	4	4	4
	Macroom	Solar					4	4	4	4	4	4
	Mallow	Solar	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95
	Midleton	Solar					3.95	3.95	3.95	3.95	3.95	3.95
	Oughtragh	Solar		4	4	4	4	4	4	4	4	4
	Reamore	Battery	-	-	-	8	8	8	8	8	8	8
	Trabeg	Solar			4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95
Tralee	Solar		4	4	4	4	4	4	4	4	4	
<b>South-West Area Total</b>			<b>16.0</b>	<b>32.9</b>	<b>51.8</b>	<b>68.8</b>	<b>96.5</b>	<b>101.5</b>	<b>101.5</b>	<b>101.5</b>	<b>101.5</b>	

**Table D-3 Existing and Committed Distribution-Connected Generation (excluding wind)**

Area	110 kV Station	Type	Maximum Export Capacity (MEC)									
			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
West	Bellacorick	Wave	10	10	10	10	10	10	10	10	10	10
	Carrick on Shannon	Solar		4	4	4	4	4	4	4	4	4
	Cloon	Solar		4	4	4	24	24	24	24	24	24
	Dalton	Battery				12	12	12	12	12	12	12
	Dalton	Solar						4	4	4	4	4
	Tawnaghmore	Biomass			49	49	49	49	49	49	49	49
<b>West Area Total</b>			<b>10</b>	<b>18</b>	<b>67</b>	<b>79</b>	<b>99</b>	<b>103</b>	<b>103</b>	<b>103</b>	<b>103</b>	<b>103</b>

# Appendix E

All-Island Ten Year

Transmission Forecast  
Statement

**2021**

# Appendix E Short Circuit Currents

## E.1 Background of Short Circuit Currents

The main driver for calculating short circuit current levels is safety. All transmission system equipment must be capable of carrying very high currents. These high currents typically occur in the event of a short circuit fault. In particular, circuit breakers must be capable of closing onto a fault and opening to isolate a fault.

Their correct operation minimises risk to human life and prevents damage to transmission system equipment. It is also crucial for maintaining transmission system stability, security and quality of supply.

Short circuit current levels also give an indication of the electrical strength of the transmission system at each station. This provides an indication of the suitability of a station for connection of 'voltage sensitive' equipment.

A station with a high short circuit current level will be more attractive to these types of load. This is due to strong generation infeeds minimising distortions in voltage and frequency caused by transmission system disturbances. Similarly, generators will have less difficulty to ride through faults and maintain stability when connected to stations with high short circuit current levels.

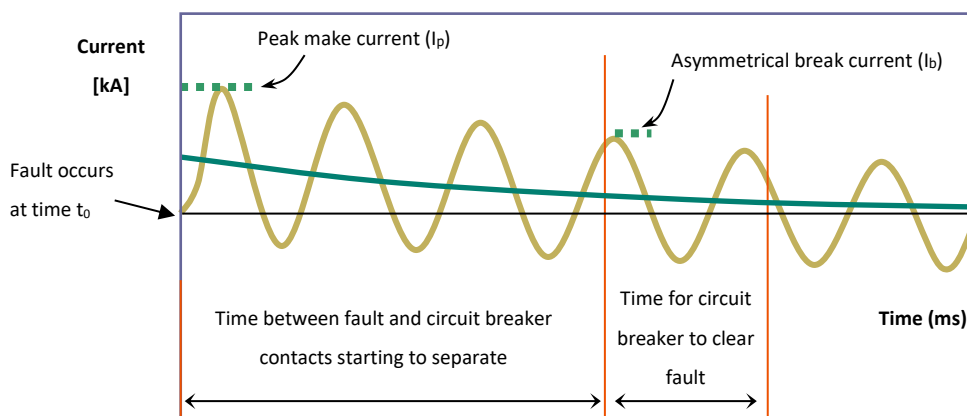
Short circuit current levels vary across the transmission system. They are affected by the transmission system topology, system impedance and the available short circuit contribution from rotating machines (i.e. generators and large motors). Changes in the transmission system topology or the addition/retirement of generation units can bring about an increase/reduction in the short circuit current levels on the transmission system. Similarly, seasonal variations in generation dispatches and demand levels combined with possible transmission system sectionalising or plant outages will result in variations of short circuit current levels at different locations. To ensure safe and reliable operation of the transmission system and customer's equipment at all times, two types of short circuit current level calculations are carried out:

- Maximum short circuit current levels are required for the specification of transmission system equipment and for connections to the transmission system. Plant in substations is typically subjected to the most onerous short circuit currents. The high capital costs of HV equipment means that it is important to predict the maximum short circuit current the equipment may see in its lifetime, and this must be specified to a rating above the maximum expected short circuit current level. Also, for customers, the design and specification of equipment at lower voltage levels will depend on the short circuit level at the transmission connection point.
- Minimum short circuit current levels are required to guarantee reliable and coordinated operation of protection systems or to assess the suitability of a station for the connection of 'voltage sensitive' equipment. Minimum short circuit current levels are also required at the design stage of generation plants to ensure fault ride through capabilities are in accordance with Grid Code requirements.

### E.1.1 The Nature of Short Circuit Currents

The plot in Figure E1 shows a typical short circuit current waveform. Short circuit current is normally made up of a symmetrical AC component, with a decay rate, and a DC offset component, which has a much faster decay rate. The combination of AC and DC components results in an asymmetrical current waveform.

While the AC component is always present in the short circuit current, the DC offset is dependent on the instant that the fault occurs within the voltage waveform. For the purposes of this document, it is assumed that the fault occurs at the instant of maximum DC offset in the short circuit current.



**Figure E-1 Typical Short Circuit Current**

The DC component of a short circuit current decays exponentially. Its rate of decay is influenced by the individual ratios of the reactance ( $X$ ) to the resistance ( $R$ ) of the paths back to the generators feeding power to the fault (the  $X/R$  ratio). Transmission nodes where large generators can have high  $X/R$  ratios, may have a slower decay time for the DC component of the short circuit current.

The AC component of a short circuit current also decays with time. This is due to the changes in the synchronous generators internal reactance and, thus, the AC reduction effect is more pronounced in the vicinity of large generation plants. The internal impedance of a synchronous generator is not constant after the start of the fault. It increases progressively and the short circuit current contribution becomes weaker, passing through three characteristic stages:

- Subtransient: (approx. 0.01 to 0.1 sec). Short-circuit current (RMS value of the AC component) is high: 5 to 10 times permanent rated current. This is called sub-transient short-circuit current,  $I_k''$ .
- Transient: (between 0.1 and 1 sec). Short-circuit current (RMS value of the AC component) drops to between 2 and 6 times rated current. This is called transient short-circuit current,  $I_k'$ .
- Continuous: Short-circuit current (RMS value of the AC component) drops to between 0.5 and 2 times rated current. This is called steady-state short-circuit current,  $I_k$ .

## E.1.2 Duty of Circuit Breakers

Over the duration of a fault the switchgear has to be able to withstand two events, namely the fault initiation and then the fault clearance. The short circuit currents at these two instances are referred to as the make current and the break current respectively.

- (i) The make current ( $I_p$ ) is the maximum instantaneous current that the circuit breaker is called to withstand. The initiation of a fault causes an instantaneous peak current which results in the generation of electromechanical forces along the busbars and transmission lines. An example of such a fault initiation would be a circuit breaker energising a line that is still earthed following maintenance, hence the term make current.

Make current is expressed in peak values and is comprised of an AC and a DC component. Essentially, the make current is the maximum instantaneous peak of the short circuit current waveform. This will occur at approximately 10 milliseconds (ms) after the instant of fault (see Figure E-1), whether the fault is energised through a circuit breaker or it spontaneously occurs on the transmission system. Circuit breakers are typically rated approximately 2.5 times higher for make duty than for break duty, as per IEC 62271-100 standard.

- (ii) After the fault initiation, there is a time period during which the protection scheme will identify the fault, make a decision and then instruct the relevant circuit breaker to open to interrupt the fault. This could take anything from 10 ms in modern fast protection systems to 60 ms in older systems. At this point the circuit breaker begins to open and it takes a certain time period before the contacts actually separate, normally around two cycles or 40 ms in modern switchgear equipment. The total time from the start of the fault until the breaker opening or fault clearance time can vary from 50 ms to 120 ms, depending on the protection system. In some cases, if main protection fails and back-up main protection is not installed, clearance times can be considerably longer than 120 ms.

At the point of physical separation, the short circuit current forms an arc and the thermal energy generated by this arc has to be dissipated as the short circuit current is interrupted. The short circuit current when this interruption occurs is referred to as the break current,  $I_b$ . This value is expressed in RMS (root mean square) terms and is comprised of an AC component and a DC component. Circuit breakers designed and tested in accordance with the IEC 62271-100 standard can interrupt any short circuit current up to its rated breaking current containing any AC component up to the rated value and, associated with it, any percentage DC component up to that specified (typically 30%).

The duty of the circuit breaker is calculated from the make and break current as a percentage of the circuit breaker rating.

## E.2 Short Circuit Current Calculation Methodology

Engineering Recommendation G74 has been applied to all short circuit studies reported in this document. Some of the general assumptions applied include:

- Short circuit level contribution from loads has been considered following G74 recommendations. The demand at each node is assumed to contribute 1 MVA of induction motor fault infeed per MW of load. A constant X/R ratio of 2.76 is assumed for all of the loads; and
- A break time of 50 ms is assumed typical for the circuit breakers at 110 kV, 220 kV, 275 kV and 400 kV. A break time of 80 ms is used for the circuit breakers at 110 kV stations in Ireland.

**Winter Peak** study results give an indication of the maximum prospective short circuit current levels on the transmission system. For winter peak studies, all generators have been included in the calculations. A merit order economic dispatch has been used, and to enable maximum short circuit current level to be calculated, any generators that were not dispatched have been switched in with 0 MW output, thus contributing to short circuit current levels.

**Summer Night Valley** study results give an indication of the minimum short circuit current levels to be expected on the transmission system under normal transmission system operating conditions (i.e. maintenance outages are not considered in this section<sup>130</sup>). For summer night valley studies, only generators dispatched on a merit order are considered in the model.

## E.3 Short Circuit Currents in Ireland

### E.3.1 Methodology used in Ireland

Short circuit current levels are calculated in accordance with the UK Engineering Recommendation G74, which is a computer based analysis, based on the International Standard IEC60909.

Compliance with G74 includes:

- Short circuit contributions from rotating plant, including induction motors embedded in the general load;
- Comprehensive plant parameters including impedances, transformer winding and earthing configurations;
- Pre-fault voltage levels at each node which should be obtained from a credible, pre-fault load flow study; and
- Pre-fault transformer tap settings should also be obtained from the load flow study.

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<sup>130</sup> Minimum fault levels including maintenance outages are currently provided to generator applicants wishing to connect to the transmission system as part of the connection offer process to allow developers to design the plant in accordance with the Grid Code requirements.

The short circuit current level network model includes the following component parameters:

- Transformer impedance variation with tap position;
- Zero sequence mutual coupling effect;
- Saturated generator reactance values; and
- Power station auxiliaries short circuit current level contributions.

The calculation of the X/R ratios, used by EirGrid, is undertaken in accordance with IEC60909-0 Method B. Method B is currently considered to be the most appropriate general purpose method for calculating DC short circuit currents in the transmission system of Ireland.

The transmission system of Ireland is designed and operated to maintain RMS break short circuit levels in accordance with EirGrid Grid Code CC.8.6. A summary of these requirements is set out in Table E-1. In designing the system, a 10% safety margin is applied.

It should be noted that the EirGrid Grid Code stipulates that short circuit current levels at designated stations in Ireland may be allowed to increase to 31.5 kA. If necessary, the equipment at these stations is to be modified or replaced in order to comply with this new rating.

Circuit breakers with a higher rating than the current levels may be necessary for a number of reasons, including, but not limited to the need to provide an adequate safety margin or to cater for a high DC component in the short circuit current.

**Table E-1 Ireland Short Circuit Current Levels Specified in the Grid Code**

Voltage Level (kV)		Short Circuit Current Levels (kA)
400		50
220		40
110	Countrywide	25
	Designated sites	31.5

**E.3.2 Analysis**

The total RMS break current at a busbar is an indication of the short circuit current level that one could expect at that point in the transmission system. However, they do not necessarily represent the short circuit current that could flow through each individual breaker, which may be lower.

**E.3.3 Ireland Short Circuit Current Level Results**

Tables E-2 to E-4 list subtransient ( $I_k''$ ), transient ( $I_k'$ ) currents and X/R ratios for single-phase to earth and balanced three-phase faults for transmission system busbars of Ireland. These are presented for maximum winter peak and minimum summer valley intact system demand conditions for 2021, 2024 and 2027. From these values, the relevant currents required to assess circuit breaker duty can be derived using the following equations:



- Peak make current ( $I_p$ )

$$I_p = \sqrt{2} \cdot \left[ 1.02 + 0.98 \cdot e^{-3 \cdot \frac{R}{X}} \right] \cdot I_k''$$

- AC component ( $I_{RMS\_AC\_b}$ ) of short-circuit current at a selected time of break ( $t_b$ )

$$I_{RMS\_AC\_b} = I_k' + (I_k'' - I_k') \cdot e^{-\frac{t_b}{40ms}}$$

- DC component ( $I_{DC\_b}$ ) of short-circuit current at a selected time of break ( $t_b$ )

$$I_{DC\_b} = \sqrt{2} \cdot I_k'' \cdot e^{-2 \cdot \pi \cdot 50 t_b \cdot \frac{R}{X}}$$

- Break current ( $I_b$ ) at a selected time of break ( $t_b$ )

$$I_b = \sqrt{I_{DC\_b}^2 + I_{RMS\_AC\_b}^2}$$

**Table E-2 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2021**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Adamstown 110 kV	15.99	10.90	9.50	10.62	12.21	11.62	11.71	13.33	11.93	6.19	15.58	14.92
Agannygal 110 kV	2.92	4.83	4.64	3.93	4.27	4.24	2.98	6.32	5.68	4.26	4.84	4.71
Aghada 110 kV	5.37	8.22	7.69	6.38	9.66	9.44	4.73	10.24	9.72	5.82	11.52	11.30
Aghada A 220 kV	16.91	12.31	10.74	18.05	16.08	15.12	15.35	21.27	18.69	16.35	25.30	23.96
Aghada B 220 kV	16.91	12.31	10.74	18.05	16.08	15.12	15.35	21.27	18.69	16.35	25.30	23.96
Aghada C 220 kV	16.10	11.99	10.49	15.33	15.64	14.73	14.32	20.39	18.00	13.13	24.31	23.06
Aghada D 220 kV	16.91	12.31	10.74	18.05	16.08	15.12	15.35	21.27	18.69	16.35	25.30	23.96
Ahane 110 kV	5.73	10.09	9.17	6.17	9.25	9.01	4.92	15.44	14.20	5.76	11.47	11.24
Anner 110 kV	4.14	5.97	5.62	4.57	4.58	4.53	4.02	7.33	6.78	4.54	5.01	4.92
Ardnacrusha 110 kV	6.09	10.81	9.68	7.10	12.55	12.06	6.00	18.89	16.83	7.63	18.22	17.54
Ardnagappary 110 kV	2.77	2.01	1.96	3.94	1.31	1.31	2.94	2.47	2.28	4.26	1.33	1.31
Arigna 110 kV	4.44	6.28	5.94	5.43	5.39	5.34	4.54	8.40	7.66	5.75	6.08	5.95
Arklow 110 kV	11.02	7.58	7.18	11.72	9.28	9.11	10.92	9.68	9.03	11.69	11.31	11.01
Arklow 220 kV	9.67	6.76	6.33	10.90	6.47	6.35	9.04	8.55	8.13	10.47	7.59	7.49
Artane 110 kV	13.57	10.43	9.60	6.20	12.54	12.16	13.20	13.11	11.92	5.71	15.17	14.62
Arva 110 kV	4.02	8.16	7.59	5.05	6.79	6.70	3.95	10.57	9.55	5.21	7.57	7.41
Athea 110 kV	10.84	6.56	6.25	11.53	7.18	7.09	11.61	10.61	9.27	12.35	9.70	9.29
Athlone 110 kV	4.17	6.41	6.01	5.44	5.27	5.20	3.89	7.78	7.20	5.37	5.59	5.50
Athy 110 kV	3.49	5.50	5.26	4.56	4.73	4.70	3.20	6.81	6.46	4.46	5.37	5.30
Aughinish 110 kV	6.15	6.43	5.87	7.08	7.79	7.54	7.93	10.80	9.78	9.95	11.11	10.73
Ballinknocka 110 kV	-	-	-	-	-	-	7.34	10.17	9.36	8.17	8.76	8.55
Ballybeg 110 kV	10.06	5.95	5.70	10.24	7.08	6.99	9.94	7.12	6.77	10.13	8.20	8.05
Ballydine 110 kV	4.17	6.62	6.24	3.85	5.43	5.36	4.00	8.06	7.50	3.74	6.02	5.92
Ballylickey 110 kV	2.83	3.05	2.95	3.85	2.06	2.05	2.99	4.01	3.73	4.08	2.25	2.22
Ballynahulla 110 kV	14.07	7.25	6.88	12.44	7.99	7.86	16.70	12.48	11.09	13.32	11.46	11.04
Ballynahulla 220 kV	9.11	6.05	5.62	9.06	6.95	6.78	9.32	11.84	10.82	9.29	11.45	11.11
Ballyvouskill 110 kV	14.33	7.37	6.98	13.89	8.86	8.70	15.21	12.66	11.16	14.10	13.13	12.55
Ballyvouskill 220 kV	9.14	6.29	5.83	9.75	7.93	7.69	9.21	11.88	10.83	9.98	13.22	12.75
Ballywater 110 kV	5.69	5.39	5.21	3.52	5.63	5.58	5.48	6.77	6.40	3.30	6.51	6.40
Baltrasna 110 kV	6.56	9.38	8.69	7.53	7.57	7.46	5.88	10.91	10.35	7.11	8.27	8.18
Bancroft 110 kV	13.00	10.79	9.85	7.36	12.74	12.33	12.38	13.17	12.19	6.78	15.05	14.61
Bandon 110 kV	3.38	5.88	5.54	4.39	5.84	5.74	3.03	7.55	6.91	4.20	6.83	6.65
Banoge 110 kV	6.61	5.46	5.27	7.22	4.98	4.95	6.21	6.56	6.24	6.96	5.59	5.51
Barnahealy A 110 kV	5.56	10.75	9.84	6.15	11.45	11.12	4.50	14.08	13.03	5.31	13.92	13.56
Barnahealy B 110 kV	7.63	10.50	9.64	7.99	11.06	10.75	6.23	13.90	12.85	6.94	13.45	13.11
Barnakyle 110 kV	19.30	11.06	9.63	12.62	12.16	11.58	19.45	20.71	19.13	20.52	14.02	13.79
Baroda 110 kV	4.11	7.13	6.68	4.80	8.42	8.25	4.04	10.17	9.50	4.96	11.06	10.80
Barrymore 110 kV	4.04	6.91	6.52	5.00	4.39	4.35	3.72	8.75	8.27	4.90	4.81	4.77
Belcamp 110 kV	16.76	13.09	11.58	13.54	16.00	15.25	16.84	17.35	15.34	13.01	20.29	19.32
Belcamp 220 kV	13.00	13.24	11.45	11.16	16.63	15.63	11.68	22.05	19.53	9.57	25.59	24.37
Belgard 110 kV	12.66	11.07	9.99	7.20	13.63	13.10	12.10	13.61	12.41	6.62	16.29	15.70
Bellacorick 110 kV	2.92	3.15	3.02	3.24	4.02	3.97	5.05	6.49	5.60	5.64	6.99	6.61
Binbane 110 kV	3.21	3.69	3.54	4.32	3.67	3.64	3.50	5.28	4.78	5.10	4.37	4.26
Blackrock 110 kV	11.10	9.98	9.11	2.87	10.31	10.02	9.98	14.01	12.62	2.40	12.90	12.50

**Table E-2 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2021**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Blake 110 kV	4.09	6.82	6.43	5.00	5.08	5.04	3.94	8.95	8.44	5.03	5.78	5.72
Blundelstown 110 kV	-	-	-	-	-	-	4.27	9.20	8.91	4.99	5.51	5.49
Boggeragh 110 kV	6.24	6.33	6.02	7.32	7.03	6.92	6.66	9.17	8.40	7.96	8.86	8.61
Booltiagh 110 kV	6.17	6.22	5.89	7.62	5.71	5.64	6.71	9.24	8.40	8.56	6.85	6.69
Bracklone 110 kV	3.56	5.65	5.38	4.55	5.56	5.50	3.42	7.45	7.09	4.65	6.60	6.51
Brinny A 110 kV	3.24	5.33	5.05	4.23	4.88	4.82	2.92	6.66	6.15	4.07	5.55	5.43
Brinny B 110 kV	3.24	5.35	5.06	4.23	4.91	4.85	2.92	6.69	6.18	4.07	5.59	5.47
Bunkimalta 110 kV	5.37	5.11	4.86	5.59	5.51	5.43	6.55	8.10	7.13	6.55	8.10	7.13
Butlerstown 110 kV	7.15	9.65	9.04	7.23	10.00	9.80	6.29	12.05	11.10	6.61	11.72	11.40
Cabra 110 kV	12.55	10.10	9.31	5.03	11.32	11.01	12.10	12.63	11.50	4.63	13.48	13.04
Cahir 110 kV	4.52	7.37	6.88	5.48	6.38	6.28	4.57	10.23	9.24	5.72	7.32	7.15
Carlow 110 kV	5.90	7.33	6.93	6.59	8.08	7.95	5.58	9.62	8.85	6.40	9.82	9.55
Carrickalangan 110 kV	4.28	3.40	3.29	5.21	2.73	2.72	4.95	4.42	4.02	5.85	2.92	2.87
Carrickmines 220 kV	15.48	14.01	12.00	10.07	17.49	16.35	14.58	21.97	19.46	8.34	25.49	24.26
Carrickmines A 110 kV	29.00	10.56	9.74	22.71	11.77	11.47	32.49	13.09	12.06	23.42	13.94	13.54
Carrickmines B 110 kV	24.28	11.85	10.76	20.15	14.37	13.86	25.83	14.72	13.56	20.32	17.27	16.72
Carrick-on-Shannon 110 kV	4.52	9.28	8.54	5.15	10.56	10.28	4.22	12.91	11.67	5.07	13.20	12.77
Carrigadrohid 110 kV	7.09	10.41	9.55	7.21	10.70	10.42	6.63	15.89	14.41	6.90	13.85	13.45
Carrigdangan 110 kV	3.46	4.50	4.32	4.12	5.35	5.28	4.14	6.90	6.00	5.20	7.22	6.86
Carrowbeg 110 kV	2.68	2.60	2.49	3.54	2.47	2.45	2.72	3.28	3.01	3.79	2.75	2.69
Cashla 110 kV	7.09	11.48	10.32	7.38	15.05	14.41	7.31	20.36	18.15	7.72	24.23	23.12
Cashla 220 kV	7.95	7.06	6.44	8.79	8.02	7.77	8.59	12.51	11.70	9.78	11.85	11.60
Castlebagot 110 kV	21.04	16.22	14.54	22.10	11.14	10.92	21.28	21.14	19.50	23.15	14.41	14.16
Castlebagot 220 kV	13.23	15.61	13.18	10.87	17.44	16.33	10.90	25.37	22.46	9.14	25.41	24.35
Castlebar 110 kV	3.02	4.05	3.83	3.55	4.32	4.26	3.40	6.33	5.56	4.10	5.66	5.44
Castledockrill 110 kV	7.90	6.55	6.29	4.68	7.67	7.57	7.61	8.37	7.89	4.31	9.06	8.87
Castlefarm A 110 kV	5.90	6.29	5.75	6.72	7.42	7.19	7.14	10.38	9.42	8.67	10.34	10.01
Castlefarm B 110 kV	5.90	6.28	5.74	6.73	7.41	7.18	7.15	10.36	9.41	8.68	10.33	10.00
Castleview 110 kV	4.55	10.62	9.74	4.94	8.33	8.17	3.75	14.02	12.97	4.50	9.66	9.49
Cathaleen's Fall 110 kV	4.29	6.56	6.13	4.91	7.64	7.48	5.31	11.70	9.94	6.25	10.82	10.28
Cauteen 110 kV	5.47	6.28	5.93	6.35	4.41	4.37	5.92	9.42	8.57	6.74	5.06	4.97
Central Park 110 kV	14.88	9.74	9.03	8.00	10.64	10.39	14.57	11.91	11.03	7.54	12.44	12.11
Charville 110 kV	4.70	5.58	5.28	6.06	5.38	5.30	4.76	7.76	7.05	6.52	6.57	6.39
Cherrywood 110 kV	10.82	9.05	8.44	7.80	9.41	9.22	10.29	10.94	10.19	7.39	10.85	10.61
City West 110 kV	6.36	7.26	6.61	6.21	5.59	5.48	5.90	8.64	7.80	5.97	6.17	6.03
CKM Country 110 kV	24.28	11.85	10.76	20.15	14.37	13.86	25.83	14.72	13.56	20.32	17.27	16.72
Clahane 110 kV	4.48	6.12	5.76	5.36	6.06	5.97	4.18	9.23	8.52	5.36	7.49	7.33
Clashavoon 220 kV	9.42	7.16	6.56	10.09	8.76	8.47	9.17	12.54	11.49	10.01	13.46	13.03
Clashavoon A 110 kV	8.01	11.70	10.63	8.32	15.29	14.69	8.00	19.51	17.35	8.32	23.27	22.17
Clashavoon B 110 kV	8.01	11.70	10.63	8.32	15.29	14.69	8.00	19.51	17.35	8.32	23.27	22.17
Cliff 110 kV	4.04	5.43	5.14	4.97	5.73	5.65	4.65	8.59	7.58	5.98	7.18	6.94
Cloghboola 110 kV	7.48	5.77	5.53	9.54	6.23	6.16	7.75	9.49	8.04	11.11	8.53	8.09
Cloghboola 110 kV	7.48	5.77	5.53	9.54	6.23	6.16	7.75	9.49	8.04	11.11	8.53	8.09
Clogher 110 kV	3.87	5.51	5.20	4.43	6.49	6.38	4.77	9.76	8.00	5.67	9.30	8.71
Cloghran 110 kV	9.90	16.49	14.33	9.82	19.16	18.18	8.57	21.68	19.68	8.75	23.97	23.15

**Table E-2 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2021**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Clonee 220 kV	14.16	13.62	11.79	10.82	14.10	13.41	12.17	21.48	19.33	9.25	19.46	18.84
Clonkeen A 110 kV	5.84	5.50	5.23	6.84	4.25	4.21	5.51	6.73	6.37	6.73	4.60	4.54
Clonkeen B 110 kV	5.16	6.35	6.06	4.53	7.58	7.46	4.69	10.52	9.26	4.00	10.90	10.41
Cloon 110 kV	4.51	6.51	6.10	5.74	6.07	5.98	4.17	8.57	7.98	5.73	6.94	6.81
College Park 110 kV	9.55	15.86	13.87	6.87	19.06	18.10	8.28	20.65	18.86	5.92	23.81	23.01
Cookstown 110 kV	7.64	7.79	7.30	6.12	6.78	6.69	7.14	9.08	8.61	5.84	7.54	7.44
Cookstown A 110 kV	5.19	6.23	5.73	5.33	4.52	4.46	4.84	7.37	6.67	5.15	4.94	4.84
Coolnagoonag 110 kV	10.35	11.43	10.30	10.20	14.59	14.00	11.57	21.19	19.17	10.94	23.86	22.96
Coolroe 110 kV	4.00	8.49	7.91	5.16	8.43	8.26	3.48	11.36	10.54	4.88	10.05	9.83
Coomagearlahy 110 kV	5.15	5.19	5.00	5.60	6.31	6.23	5.19	8.38	7.29	5.84	9.01	8.55
Coomataggart 110 kV	9.88	5.05	4.87	7.07	3.61	3.60	9.93	7.83	7.02	6.64	4.14	4.06
Cordal 110 kV	11.76	6.39	6.10	8.23	7.01	6.92	12.95	10.61	9.47	7.61	9.77	9.43
Corderry 110 kV	4.09	6.41	6.05	5.01	6.49	6.40	4.22	9.50	8.41	5.51	8.05	7.78
Corduff 110 kV	10.88	17.83	15.36	11.62	21.77	20.52	9.43	24.03	21.67	10.41	28.03	26.94
Corduff 220 kV	16.29	14.97	12.78	14.87	18.72	17.48	15.12	25.49	22.41	13.31	29.18	27.72
Corkagh 110 kV	18.14	11.09	9.64	12.55	12.34	11.74	20.30	20.87	19.26	21.54	14.16	13.93
Corraclassy 110 kV	4.33	6.12	5.74	5.42	4.98	4.93	4.33	7.29	6.80	5.61	5.27	5.20
Cow Cross 110 kV	5.05	10.78	9.86	5.27	9.56	9.34	4.10	14.17	13.11	4.77	11.65	11.41
Crane 110 kV	8.05	7.15	6.82	7.68	7.91	7.80	7.81	9.41	8.68	7.37	9.53	9.27
Croaghaun 110 kV	2.99	2.98	2.86	3.44	3.56	3.52	5.06	5.75	5.04	5.76	5.58	5.34
Croaghnagawna 110 kV	4.25	3.57	3.45	5.24	3.03	3.02	4.95	4.74	4.29	6.00	3.31	3.24
Cromcastle A 110 kV	12.32	12.37	11.01	7.72	14.87	14.22	11.65	16.18	14.40	6.99	18.59	17.77
Cromcastle B 110 kV	12.32	12.37	11.01	7.72	14.87	14.22	11.65	16.18	14.40	6.99	18.59	17.77
Croy 110 kV	9.92	7.36	7.04	10.03	9.26	9.11	9.75	9.62	8.99	9.68	11.27	10.98
Cruiserath 220 kV	-	-	-	-	-	-	14.76	25.28	22.25	12.85	28.90	27.46
Cullenagh 110 kV	8.96	11.48	10.65	9.40	13.47	13.11	7.70	14.76	13.52	8.34	16.42	15.89
Cullenagh 220 kV	9.63	8.13	7.61	9.79	8.30	8.13	8.30	10.11	9.63	8.80	9.72	9.57
Cunghill 110 kV	3.11	4.37	4.18	3.57	4.47	4.43	3.21	6.38	5.89	3.83	5.48	5.37
Cureeny 110 kV	4.82	4.79	4.57	5.39	5.27	5.20	5.92	7.61	6.68	5.92	7.61	6.68
Cureeny T 110 kV	5.49	6.15	5.79	5.32	6.22	6.12	6.14	9.59	8.54	5.57	8.09	7.82
Cushaling 110 kV	3.90	6.02	5.72	4.49	7.72	7.58	6.82	12.75	11.41	8.62	13.46	12.94
Dallow 110 kV	3.52	4.59	4.43	4.60	3.08	3.07	3.50	5.62	5.37	4.73	3.25	3.23
Dalton 110 kV	3.07	3.74	3.56	4.07	3.36	3.33	3.27	5.23	4.71	4.58	3.83	3.74
Dardistown 110 kV	15.56	12.70	11.28	11.67	15.55	14.84	15.40	16.73	14.85	11.01	19.62	18.71
Darndale 110 kV	16.08	12.78	11.33	13.69	15.36	14.67	16.00	16.82	14.91	13.20	19.30	18.42
Derrybrien 110 kV	2.74	3.87	3.75	3.80	3.83	3.81	3.02	5.10	4.50	4.46	4.49	4.32
Derryiron 110 kV	4.84	6.76	6.38	5.88	7.25	7.13	5.37	9.18	8.56	6.79	8.73	8.54
Doon 110 kV	4.45	6.47	6.07	4.75	5.12	5.06	4.37	8.11	7.46	4.73	5.64	5.54
Dromada 110 kV	10.04	6.17	5.90	6.98	6.63	6.55	10.32	9.66	8.49	6.26	8.73	8.39
Drumkeen 110 kV	3.52	5.04	4.77	4.27	5.23	5.16	3.99	8.40	7.07	5.13	6.86	6.55
Drumline 110 kV	3.75	7.11	6.60	4.83	6.41	6.29	3.21	9.67	8.94	4.60	7.41	7.27
Drybridge 110 kV	5.99	11.85	10.75	6.79	10.34	10.10	5.15	14.77	13.58	6.26	11.80	11.57
Dundalk 110 kV	3.86	8.08	7.58	4.83	7.50	7.40	3.40	9.61	8.89	4.52	8.34	8.18
Dunfirth 110 kV	4.79	5.84	5.56	6.26	4.72	4.68	4.36	3.88	3.78	6.24	3.15	3.13

**Table E-2 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2021**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Dungarvan 110 kV	6.16	5.74	5.49	7.87	4.86	4.82	6.35	7.71	6.87	8.33	5.76	5.60
Dunmanway 110 kV	4.19	6.82	6.40	4.95	7.17	7.03	4.47	10.74	9.37	5.48	9.48	9.09
Dunstown 220 kV	13.01	14.25	12.33	12.67	16.88	15.93	10.77	21.24	19.54	10.75	23.42	22.70
Dunstown 400 kV	17.34	5.66	5.12	19.55	6.43	6.20	16.25	7.83	7.48	18.96	8.28	8.15
Ennis 110 kV	4.63	8.81	8.07	5.71	8.50	8.30	4.45	14.19	12.54	5.97	10.93	10.58
Fassaroe East 110 kV	5.49	7.32	6.88	5.50	5.76	5.70	5.08	8.57	8.08	5.27	6.36	6.28
Fassaroe West 110 kV	5.65	7.46	7.01	5.61	5.95	5.88	5.22	8.75	8.25	5.37	6.57	6.49
Finglas 220 kV	15.83	14.30	12.25	15.30	18.44	17.22	15.93	24.93	21.81	14.82	29.81	28.19
Finglas A 110 kV	22.25	13.70	12.10	15.85	16.60	15.82	24.74	18.50	16.28	15.70	21.32	20.27
Finglas B 110 kV	29.13	11.58	10.58	27.28	14.55	14.05	34.65	14.85	13.41	30.64	18.06	17.33
Flagford 110 kV	4.80	9.62	8.82	5.48	11.95	11.58	4.50	13.53	12.20	5.42	15.52	14.93
Flagford 220 kV	7.09	5.97	5.53	8.87	6.01	5.88	7.36	8.02	7.62	9.68	7.09	7.00
Fortunestown 110 kV	5.95	7.16	6.51	5.78	5.52	5.42	5.51	8.51	7.68	5.55	6.09	5.95
Francis Street A 110 kV	11.56	9.99	9.11	5.93	12.31	11.89	10.47	14.04	12.63	5.04	16.24	15.59
Francis Street B 110 kV	13.30	11.06	10.01	7.05	13.56	13.05	12.78	13.65	12.46	6.48	16.24	15.66
Galway 110 kV	5.11	9.28	8.45	4.73	11.67	11.26	5.28	16.18	14.27	4.54	18.12	17.27
Garrow 110 kV	10.60	7.12	6.76	10.59	8.61	8.45	10.56	12.18	10.73	10.43	12.74	12.17
Garvagh 110 kV	4.23	5.31	5.07	5.34	5.26	5.21	4.61	7.56	6.72	6.14	6.28	6.09
Gilra 110 kV	3.33	5.87	5.55	4.10	4.83	4.78	3.03	6.89	6.49	3.97	5.11	5.05
Glanagow 220 kV	17.04	12.20	10.64	16.71	15.86	14.92	14.94	20.52	18.10	14.29	24.43	23.17
Glanlee 110 kV	5.03	5.14	4.95	5.25	6.22	6.15	5.02	8.26	7.19	5.32	8.85	8.40
Glasmore A 110 kV	4.46	6.93	6.45	4.80	5.00	4.94	4.12	8.46	7.71	4.62	5.53	5.43
Glenlara A 110 kV	3.11	2.77	2.69	4.37	2.44	2.43	3.25	3.45	3.16	4.77	2.77	2.71
Glenlara B 110 kV	9.03	5.67	5.45	6.72	6.47	6.39	9.23	9.12	8.10	6.05	8.96	8.61
Glenree 110 kV	2.90	3.36	3.23	3.53	3.53	3.50	3.81	5.88	5.41	4.81	4.85	4.75
Golagh 110 kV	3.56	4.85	4.61	4.16	4.96	4.90	3.91	7.76	6.58	4.75	6.28	6.00
Gorman 110 kV	7.15	12.74	11.51	8.01	14.33	13.85	6.01	15.94	14.64	7.08	16.85	16.38
Gorman 220 kV	9.94	9.77	8.82	10.50	8.56	8.33	8.42	12.34	11.72	9.55	9.71	9.60
Gortawee 110 kV	4.44	5.94	5.56	5.87	5.02	4.96	4.47	6.93	6.43	6.14	5.31	5.23
Grange 110 kV	14.72	12.86	11.40	7.82	15.32	14.63	14.37	17.05	15.07	7.07	19.30	18.41
Grange Castle 110 kV	16.79	11.04	9.60	11.68	12.37	11.76	14.42	14.28	12.69	9.12	17.18	16.38
Great Island 110 kV	9.31	11.39	10.61	10.21	14.23	13.85	8.06	14.42	13.24	9.03	17.33	16.74
Great Island 220 kV	13.01	10.27	9.51	14.28	12.01	11.68	10.78	12.74	12.01	12.17	14.04	13.74
Griffinrath A 110 kV	7.54	9.22	8.60	7.76	9.56	9.38	6.66	11.54	10.95	7.14	11.22	11.05
Griffinrath B 110 kV	8.10	9.50	8.84	7.93	9.58	9.39	7.18	11.97	11.34	7.30	11.21	11.04
Harolds Cross 110 kV	11.74	10.02	9.14	5.62	12.28	11.86	10.65	14.08	12.67	4.76	16.18	15.53
Heuston 110 kV	14.31	11.26	10.18	8.43	13.94	13.40	13.87	13.93	12.70	7.82	16.77	16.15
Huntstown A 220 kV	15.11	13.85	11.92	13.62	17.86	16.71	15.37	24.05	21.12	12.77	28.74	27.22
Huntstown B 220 kV	16.52	14.33	12.34	12.48	17.87	16.76	15.27	23.26	20.69	10.52	26.80	25.57
Ikerrin 110 kV	5.16	4.13	3.97	5.95	3.30	3.28	5.67	5.61	5.11	6.41	3.75	3.67
Inchicore 220 kV	15.15	15.69	13.13	11.55	19.69	18.20	13.90	26.35	22.84	9.63	30.45	28.72
Inchicore A 110 kV	27.12	12.29	11.02	24.44	15.58	14.92	30.27	15.45	13.98	25.92	19.07	18.30
Inchicore B 110 kV	38.12	12.51	10.83	31.68	15.94	15.01	47.67	15.49	13.72	35.03	19.17	18.22
Inniscarra 110 kV	3.96	8.26	7.71	5.03	8.05	7.90	3.50	11.13	10.33	4.81	9.55	9.35
Irishtown 220 kV	16.17	15.04	12.71	12.99	19.18	17.80	15.68	24.85	21.67	11.33	29.33	27.70

**Table E-2 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2021**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Kellis 110 kV	7.32	7.86	7.43	8.32	9.46	9.28	6.68	10.17	9.42	7.82	11.59	11.26
Kellis 220 kV	8.64	6.96	6.53	10.23	6.22	6.13	7.83	8.60	8.25	9.69	7.13	7.06
Kilbarry 110 kV	7.91	14.90	13.18	8.46	16.20	15.52	6.26	23.33	20.43	7.22	22.08	21.14
Kildonan 110 kV	7.92	14.16	12.55	6.57	14.22	13.70	6.85	17.90	16.53	5.88	16.80	16.41
Kilgarvan 110 kV	9.88	5.05	4.87	7.07	3.61	3.60	9.93	7.83	7.02	6.64	4.14	4.06
Kilkenny 110 kV	4.30	4.93	4.74	5.74	4.51	4.47	4.10	5.90	5.49	5.67	4.98	4.88
Kill Hill 110 kV	4.88	5.08	4.84	5.88	4.76	4.70	5.59	7.48	6.67	6.77	5.85	5.68
Killonan 110 kV	7.39	13.00	11.49	8.25	15.47	14.76	6.95	24.03	21.21	8.36	24.07	23.05
Killonan 220 kV	7.97	7.74	7.01	9.69	8.10	7.84	7.87	12.66	11.93	10.37	11.03	10.84
Killoteran 110 kV	8.05	10.43	9.72	8.14	11.70	11.43	7.01	13.19	12.08	7.32	14.01	13.57
Kilmahud 110 kV	17.95	11.12	9.66	12.73	12.50	11.88	19.85	20.72	19.14	21.24	14.10	13.87
Kilmore 110 kV	15.99	13.03	11.54	11.24	15.85	15.12	15.93	17.30	15.29	10.53	20.10	19.14
Kilpaddoge 110 kV	10.48	11.52	10.38	10.99	15.09	14.45	11.89	21.50	19.43	12.72	25.25	24.24
Kilpaddoge 220 kV	10.24	8.82	7.90	10.31	12.03	11.45	16.24	25.10	22.36	14.35	29.83	28.42
Kilteel 110 kV	4.53	6.76	6.38	5.50	6.36	6.28	4.62	9.31	8.78	5.82	7.70	7.58
Kinnegad 110 kV	4.55	6.95	6.53	5.34	6.58	6.48	4.28	7.00	6.63	5.17	6.19	6.10
Knockacummer 110 kV	8.02	5.04	4.86	7.16	5.58	5.53	8.13	7.78	6.96	6.86	7.32	7.06
Knockalough 110 kV	4.03	4.06	3.89	3.66	4.22	4.18	5.39	6.55	5.66	4.51	7.16	6.78
Knockanure 220 kV	10.19	7.95	7.21	8.23	10.74	10.29	13.33	19.31	17.42	7.46	23.18	22.20
Knockanure A 110 kV	16.97	8.56	8.04	15.24	10.33	10.10	24.01	15.26	13.20	17.19	15.76	14.95
Knockanure B 110 kV	5.21	6.82	6.38	6.03	6.24	6.14	4.61	10.05	9.33	5.82	7.53	7.39
Knockearagh 110 kV	5.58	5.05	4.79	7.24	4.54	4.49	5.33	6.38	5.89	7.29	5.12	5.01
Knocknamona 110 kV	5.86	5.54	5.32	5.86	5.54	5.32	6.44	7.80	6.85	4.44	7.80	6.85
Knockraha A 110 kV	9.95	16.05	14.19	10.38	16.98	16.28	7.86	24.74	21.94	8.75	22.57	21.73
Knockraha A 220 kV	13.39	11.74	10.32	13.06	13.64	12.96	11.02	20.17	18.03	10.70	19.91	19.14
Knockraha B 110 kV	9.95	16.05	14.19	10.38	16.98	16.28	7.86	24.74	21.94	8.75	22.57	21.73
Knockraha B 220 kV	13.39	11.74	10.32	13.06	13.64	12.96	11.02	20.17	18.03	10.70	19.91	19.14
Knockranny 110 kV	5.41	6.24	5.86	4.99	8.25	8.06	6.28	9.40	8.74	5.26	11.60	11.26
Knockranny A 110 kV	3.91	4.52	4.31	3.57	4.60	4.54	5.21	7.68	6.53	5.40	8.33	7.83
Knockranny B 110 kV	5.41	6.24	5.86	4.99	8.25	8.06	6.28	9.40	8.74	5.26	11.60	11.26
Knockumber 110 kV	4.02	7.88	7.35	4.77	6.11	6.04	3.57	8.90	8.39	4.50	6.39	6.33
Lanesboro 110 kV	3.34	7.72	7.19	4.30	6.98	6.87	3.08	10.05	9.19	4.25	7.97	7.80
Letterkenny 110 kV	3.82	5.75	5.38	4.53	6.25	6.14	4.38	10.02	8.30	5.46	8.62	8.16
Liberty A 110 kV	6.45	13.12	11.76	5.52	14.79	14.22	5.08	19.13	17.07	4.57	19.47	18.70
Liberty B 110 kV	6.36	13.12	11.76	5.35	14.76	14.19	5.00	19.10	17.05	4.43	19.41	18.65
Limerick 110 kV	5.66	11.42	10.14	6.24	11.92	11.47	4.97	19.61	17.48	5.96	16.54	15.99
Lisdrum 110 kV	2.94	4.88	4.69	4.20	4.31	4.28	3.65	7.05	6.22	5.32	5.03	4.90
Lisheen 110 kV	3.98	3.28	3.17	3.99	4.91	4.84	4.96	5.27	4.59	4.96	7.90	7.35
Lodgewood 110 kV	9.92	7.36	7.04	10.03	9.26	9.11	9.75	9.62	8.99	9.68	11.27	10.98
Lodgewood 220 kV	9.47	6.55	6.18	10.49	6.49	6.39	8.90	8.19	7.82	10.00	7.58	7.47
Longpoint 220 kV	16.66	12.21	10.66	14.94	15.75	14.82	14.64	20.85	18.36	12.48	24.41	23.15
Louth 220 kV	11.52	13.36	11.63	12.38	15.74	14.91	9.20	19.19	17.64	10.44	20.76	20.17
Louth A 110 kV	7.66	11.43	10.52	8.67	13.95	13.54	6.35	13.86	12.91	7.47	16.19	15.79
Louth B 110 kV	8.34	12.32	11.28	9.15	15.37	14.88	6.79	15.50	14.35	7.74	18.44	17.93
Louth A 275 kV	12.89	8.74	7.77	12.49	10.56	10.08	10.97	11.31	10.58	10.86	12.90	12.61

**Table E-2 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2021**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Louth B 275 kV	12.23	8.74	7.77	11.16	10.68	10.20	10.32	11.37	10.64	9.57	13.16	12.85
Macetown 110 kV	8.26	14.66	12.94	7.81	15.58	14.95	7.13	18.73	17.22	6.99	18.72	18.23
Macroom 110 kV	7.28	11.36	10.35	7.21	13.10	12.66	6.93	18.53	16.52	6.86	18.44	17.72
Mallow 110 kV	5.39	6.01	5.68	6.98	5.39	5.32	5.20	7.60	7.10	7.08	6.15	6.04
Marina 110 kV	7.62	14.25	12.66	8.38	16.19	15.50	5.97	21.60	19.03	7.05	21.96	21.00
Maynooth A 110 kV	11.61	11.25	10.34	12.18	13.99	13.56	10.53	14.75	13.87	11.31	17.58	17.17
Maynooth A 220 kV	11.56	13.85	11.97	10.87	14.07	13.39	9.37	20.46	18.73	9.34	18.44	17.96
Maynooth B 110 kV	9.22	14.51	12.91	10.38	14.66	14.14	8.08	17.31	16.21	9.64	16.58	16.26
Maynooth B 220 kV	12.06	15.08	12.87	10.89	15.62	14.77	9.56	23.70	21.49	9.15	21.51	20.87
McDermott 110 kV	16.34	10.74	9.85	6.32	12.63	12.24	16.30	13.60	12.31	5.81	15.30	14.74
Meath Hill 110 kV	4.25	8.23	7.72	5.35	6.98	6.89	3.81	9.97	9.27	5.11	7.77	7.65
Meentycat 110 kV	3.26	4.36	4.16	4.16	4.48	4.44	3.71	6.92	5.91	5.12	5.70	5.46
Midleton 110 kV	4.10	9.16	8.48	5.17	8.13	7.97	3.44	11.64	10.84	4.69	9.38	9.20
Milltown A 110 kV	15.39	10.66	9.68	7.67	13.31	12.82	14.88	15.31	13.69	6.58	17.95	17.17
Milltown B 110 kV	9.38	10.07	9.19	4.40	12.12	11.72	8.76	12.27	11.25	4.00	14.32	13.85
Misery Hill 110 kV	14.04	10.46	9.51	8.36	13.15	12.67	13.23	14.92	13.36	7.27	17.69	16.92
Moneteen 110 kV	5.59	8.65	7.84	6.27	7.42	7.24	5.21	12.74	11.75	6.22	8.85	8.68
Moneypoint 110 kV	12.23	7.60	7.15	14.50	8.19	8.05	15.40	10.78	10.18	18.28	10.20	10.02
Moneypoint 220 kV	10.33	8.80	7.89	10.34	12.01	11.43	16.47	24.67	22.07	14.29	29.42	28.08
Moneypoint G1 400 kV	12.24	5.14	4.66	13.68	6.45	6.21	21.42	11.24	10.51	24.03	12.00	11.71
Moneypoint G2 400 kV	19.71	2.66	2.52	21.18	3.43	3.36	55.79	5.06	4.80	51.79	5.71	5.59
Moneypoint G3 400 kV	12.24	5.14	4.66	13.68	6.45	6.21	21.42	11.24	10.51	24.03	12.00	11.71
Monread 110 kV	4.21	6.63	6.25	5.00	6.87	6.77	4.16	9.10	8.57	5.16	8.48	8.33
Mount Lucas 110 kV	3.76	5.15	4.93	4.66	5.26	5.21	4.59	8.50	7.88	5.93	7.19	7.04
Moy 110 kV	2.89	3.18	3.05	3.35	3.97	3.92	5.12	6.51	5.82	6.31	6.67	6.41
Mullagharlin 110 kV	3.98	8.22	7.71	4.99	7.86	7.75	3.46	9.54	8.94	4.60	8.61	8.47
Mullingar 110 kV	3.65	6.38	6.02	4.55	6.25	6.17	3.29	7.09	6.67	4.33	6.64	6.53
Mulreevy 110 kV	3.91	5.09	4.82	4.54	6.12	6.02	4.92	8.76	7.19	6.06	8.71	8.14
Mungret A 110 kV	5.32	8.33	7.56	6.00	6.97	6.82	4.87	12.00	11.12	5.90	8.19	8.04
Mungret B 110 kV	5.31	8.34	7.57	6.00	6.98	6.82	4.86	12.03	11.14	5.89	8.19	8.05
Nangor 110 kV	14.94	10.79	9.42	9.64	12.07	11.49	12.82	13.90	12.39	7.52	16.64	15.88
Navan 110 kV	6.11	11.43	10.41	6.80	11.56	11.25	5.25	14.06	12.95	6.17	13.21	12.91
Nenagh 110 kV	3.42	3.57	3.43	4.10	2.58	2.57	3.29	4.55	4.19	4.13	2.76	2.72
Newbridge 110 kV	4.18	7.78	7.25	4.80	8.22	8.05	4.22	11.79	10.87	5.06	10.88	10.62
Newbury 110 kV	14.69	12.86	11.39	7.76	15.25	14.57	14.35	17.01	15.04	7.01	19.18	18.30
North Quays 110 kV	18.15	10.84	9.83	7.19	13.33	12.84	18.58	15.65	13.98	6.12	17.96	17.19
North Wall 220 kV	14.69	13.22	11.46	9.60	15.71	14.82	13.97	22.12	19.63	7.94	23.61	22.58
Oldcourt A 110 kV	4.34	9.23	8.56	4.78	7.43	7.30	3.62	11.65	10.92	4.41	8.69	8.55
Oldcourt B 110 kV	4.38	9.28	8.60	4.81	7.50	7.37	3.65	11.73	11.00	4.43	8.78	8.64
Oldstreet 220 kV	11.54	6.39	5.94	10.97	7.81	7.60	14.74	11.79	11.12	12.47	12.53	12.28
Oldstreet 400 kV	11.06	4.92	4.49	9.78	5.33	5.17	12.43	8.41	8.04	9.76	7.77	7.67
Oughtragh 110 kV	3.87	4.15	3.95	4.87	2.96	2.94	3.56	5.10	4.74	4.76	3.11	3.06
Pelletstown 110 kV	13.87	10.17	9.38	8.03	11.09	10.81	13.57	12.72	11.60	7.56	13.18	12.77
Platin 110 kV	5.39	11.07	10.10	5.91	8.80	8.64	4.60	13.35	12.42	5.45	9.67	9.53
Pollaphuca 110 kV	2.83	2.46	2.42	4.05	2.30	2.30	3.31	3.14	3.02	4.74	2.59	2.56

**Table E-2 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2021**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Poolbeg A 110 kV	24.28	11.28	10.20	20.94	14.50	13.92	28.30	16.37	14.61	22.07	19.92	19.01
Poolbeg A 220 kV	15.33	13.30	11.51	8.44	15.04	14.22	14.98	22.37	19.83	6.85	22.26	21.34
Poolbeg B 110 kV	24.26	11.27	10.19	20.93	14.48	13.91	28.26	16.35	14.59	22.05	19.90	18.99
Poolbeg B 220 kV	14.61	14.85	12.53	11.12	17.65	16.45	13.47	24.39	21.35	9.46	26.24	24.94
Poppintree 110 kV	14.16	12.85	11.42	8.21	15.46	14.77	13.79	17.05	15.10	7.46	19.54	18.64
Portan 260 kV	21.40	7.85	7.22	74.05	2.89	2.87	19.81	11.36	10.96	87.76	3.11	3.11
Portan 400 kV	18.37	6.03	5.47	17.53	7.03	6.78	16.08	9.09	8.68	15.96	10.11	9.94
Portlaoise 110 kV	3.93	6.84	6.44	5.06	6.75	6.65	4.02	9.97	9.26	5.55	8.58	8.40
Pottery 110 kV	17.71	10.04	9.30	5.94	10.46	10.21	17.75	12.34	11.41	5.53	12.18	11.87
Prospect 220 kV	9.64	8.10	7.32	8.42	9.95	9.56	11.59	19.31	17.68	8.09	19.02	18.46
Raffeen 220 kV	15.68	11.54	10.14	13.43	14.66	13.85	13.41	19.21	17.08	11.01	22.21	21.16
Raffeen A 110 kV	6.99	12.26	11.10	7.76	14.78	14.22	5.53	16.71	15.29	6.43	18.99	18.34
Raffeen B 110 kV	9.74	11.95	10.85	10.41	14.39	13.86	7.81	16.50	15.06	8.73	18.58	17.94
Rathkeale 110 kV	3.85	6.30	5.91	4.92	5.40	5.33	3.44	8.38	7.82	4.81	6.18	6.08
Ratrussan 110 kV	3.34	6.15	5.85	4.15	7.07	6.98	3.73	8.60	7.35	4.94	8.77	8.32
Reamore 110 kV	4.08	6.66	6.21	4.41	6.45	6.33	3.60	10.17	9.04	4.17	7.96	7.71
Richmond A 110 kV	2.96	5.76	5.45	4.13	5.15	5.10	2.75	6.94	6.44	4.08	5.68	5.58
Richmond B 110 kV	2.96	5.76	5.45	4.13	5.15	5.10	2.75	6.94	6.44	4.08	5.68	5.58
Rinawade 110 kV	5.38	9.61	8.87	6.17	7.31	7.20	4.64	9.77	9.36	5.80	7.20	7.14
Ringaskiddy 110 kV	6.64	10.21	9.40	6.75	10.32	10.06	5.41	13.40	12.43	5.90	12.38	12.10
Ringsend 110 kV	24.22	11.28	10.19	21.60	14.51	13.93	28.80	16.54	14.70	23.36	20.12	19.16
Ryebrook 110 kV	6.04	12.55	11.12	6.79	11.51	11.14	5.26	14.91	13.78	6.25	12.99	12.72
Salthill 110 kV	4.66	8.98	8.19	3.95	11.08	10.70	4.76	15.49	13.67	3.66	16.96	16.18
Screeb 110 kV	3.70	2.49	2.41	4.29	1.73	1.72	4.09	3.18	2.89	5.02	1.97	1.94
Seal Rock A 110 kV	5.99	6.34	5.80	6.83	7.69	7.44	7.62	10.60	9.61	9.35	10.95	10.58
Seal Rock B 110 kV	5.99	6.34	5.80	6.83	7.69	7.44	7.64	10.61	9.61	9.36	10.96	10.58
Shankill 110 kV	3.82	7.30	6.85	4.80	7.07	6.97	3.92	10.17	8.83	5.19	8.51	8.19
Shannonbridge 110 kV	5.24	10.39	9.53	6.28	11.73	11.40	4.89	14.70	13.68	6.28	14.89	14.54
Shannonbridge 220 kV	6.74	5.79	5.41	8.64	5.22	5.13	6.85	8.02	7.79	9.33	6.20	6.16
Shellybanks A 220 kV	15.08	13.28	11.50	8.60	16.55	15.56	14.79	22.33	19.80	6.85	25.64	24.42
Shellybanks B 220 kV	15.37	14.54	12.35	11.37	18.34	17.07	15.06	23.95	20.96	9.73	27.81	26.33
Shelton Abbey 110 kV	7.95	6.80	6.49	7.88	7.27	7.17	7.49	8.48	7.98	7.54	8.53	8.36
Singland 110 kV	6.68	11.24	10.06	7.42	12.12	11.68	6.36	19.04	17.11	7.50	16.83	16.30
Sliabh Bawn 110 kV	3.25	7.17	6.73	4.19	7.12	7.01	3.22	9.62	8.75	3.22	9.62	8.75
Slievecallan 110 kV	6.51	5.17	4.92	8.62	2.33	2.33	7.77	7.63	6.76	9.40	2.43	2.40
Sligo 110 kV	3.95	7.18	6.70	4.50	7.47	7.33	3.65	10.64	9.57	4.44	9.35	9.07
Snugborough 110 kV	10.90	16.51	14.37	10.15	17.74	16.93	9.57	21.73	19.77	9.16	21.84	21.18
Somerset 110 kV	3.24	6.35	6.02	4.12	4.56	4.53	2.88	7.66	7.29	3.96	4.82	4.77
Sorne Hill 110 kV	2.76	2.45	2.38	3.43	2.87	2.86	3.52	3.77	3.32	4.47	3.65	3.51
Srahnakilly 110 kV	2.94	3.07	2.95	3.27	3.96	3.91	5.15	6.34	5.47	5.80	6.89	6.52
Srananagh 110 kV	4.82	8.14	7.55	5.47	9.51	9.28	4.63	12.52	11.16	5.58	12.74	12.26
Srananagh 220 kV	6.58	3.99	3.78	8.55	3.52	3.48	7.32	5.05	4.82	9.67	3.89	3.85
Stevenstown 110 kV	4.38	5.77	5.45	4.73	3.90	3.88	4.08	6.72	6.31	4.59	4.23	4.18
Stratford 110 kV	3.29	3.74	3.63	4.24	3.05	3.04	3.39	4.66	4.39	4.40	3.39	3.34
Taney 110 kV	9.29	8.79	8.21	3.42	8.87	8.70	8.75	10.58	9.87	3.18	10.13	9.92



**Table E-2 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2021**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Tarbert 110 kV	16.16	9.59	8.93	18.61	11.15	10.89	35.52	17.19	16.01	36.40	16.29	15.93
Tarbert 220 kV	10.07	8.62	7.74	10.34	11.65	11.11	15.74	24.20	21.61	14.85	28.05	26.79
Tawnaghmore A 110 kV	2.77	2.73	2.64	3.38	3.14	3.12	4.50	5.25	4.78	5.80	4.74	4.61
Tawnaghmore B 110 kV	2.79	2.73	2.64	3.29	3.40	3.36	4.45	5.13	4.70	5.71	5.33	5.17
Thornsberry 110 kV	3.69	5.14	4.91	4.66	5.10	5.05	3.95	7.32	6.83	5.24	6.49	6.37
Thurles 110 kV	5.06	4.23	4.04	5.44	4.90	4.84	6.15	6.82	5.92	6.46	6.88	6.55
Tievebrack 110 kV	3.40	3.52	3.38	4.54	2.82	2.81	3.66	4.84	4.38	5.07	3.11	3.05
Tipperary 110 kV	5.12	6.12	5.79	6.09	4.37	4.33	5.29	8.40	7.73	6.33	4.88	4.80
Tonroe 110 kV	2.73	3.24	3.14	3.76	2.10	2.10	2.74	3.76	3.47	3.86	2.13	2.10
Trabeg 110 kV	7.57	14.22	12.64	8.34	16.16	15.47	5.90	21.50	18.95	6.98	21.90	20.94
Tralee 110 kV	5.28	7.01	6.51	6.12	6.82	6.69	4.94	10.95	9.69	6.12	8.54	8.26
Trien A 110 kV	4.96	6.44	6.04	5.99	6.24	6.13	4.44	9.56	8.82	5.88	7.68	7.51
Trien B 110 kV	12.16	7.17	6.81	9.65	6.44	6.37	13.36	12.23	10.50	9.24	8.35	8.05
Trillick 110 kV	2.81	2.63	2.55	3.51	2.89	2.87	3.63	4.14	3.59	4.59	3.65	3.50
Trinity 110 kV	12.63	10.22	9.31	7.06	12.75	12.30	11.62	14.48	12.99	6.06	16.99	16.28
Tullabeg 110 kV	-	-	-	-	-	-	6.19	7.03	6.65	6.42	5.81	5.73
Tullabrack 110 kV	6.67	6.03	5.74	7.26	5.12	5.07	6.55	8.13	7.68	7.29	5.79	5.72
Turlough 220 kV	12.44	10.59	9.40	13.36	9.93	9.58	10.43	13.01	12.11	11.88	11.24	11.02
Tynagh 220 kV	10.27	6.21	5.78	11.04	7.92	7.71	15.47	12.79	11.86	16.69	13.88	13.49
Uggool 110 kV	5.43	5.99	5.64	5.22	7.95	7.78	6.39	8.95	8.35	5.69	11.10	10.79
Waterford 110 kV	8.30	10.86	10.09	8.64	12.12	11.82	7.19	13.83	12.62	7.75	14.57	14.11
Wexford 110 kV	5.86	5.88	5.63	7.09	5.68	5.62	5.77	7.62	6.84	7.20	6.68	6.47
Whitebank 110 kV	21.48	11.24	10.15	18.86	14.43	13.86	25.21	16.47	14.64	20.08	20.00	19.05
Whitegate 110 kV	5.02	8.78	8.17	5.71	9.19	8.99	4.33	11.04	10.41	5.17	10.86	10.65
Wolfe Tone 110 kV	14.51	10.52	9.67	5.77	12.25	11.88	14.22	13.28	12.03	5.30	14.77	14.23
Woodhouse 110 kV	6.13	5.68	5.45	7.39	4.33	4.30	6.70	8.00	7.03	7.98	5.14	4.99
Woodland 220 kV	14.54	15.18	13.04	13.73	17.31	16.32	11.77	24.27	22.01	11.69	25.19	24.34
Woodland 400 kV	19.26	6.05	5.49	18.63	7.06	6.81	17.18	9.14	8.72	17.25	10.19	10.02

**Table E-3 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2024**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Adamstown 110 kV	14.11	10.93	9.91	8.70	12.14	11.69	14.77	13.66	12.35	8.54	14.47	13.94
Agannygal 110 kV	3.10	5.89	5.23	4.33	4.62	4.47	2.95	6.46	5.85	4.25	4.91	4.78
Aghada 110 kV	4.81	8.73	8.28	5.83	10.07	9.87	4.74	10.29	9.80	5.84	11.59	11.38
Aghada A 220 kV	12.98	14.98	13.26	14.11	18.97	17.95	14.94	21.70	19.11	16.09	25.81	24.45
Aghada B 220 kV	12.98	14.98	13.26	14.11	18.97	17.95	14.94	21.70	19.11	16.09	25.81	24.45
Aghada C 220 kV	12.48	14.50	12.88	12.18	18.36	17.41	13.98	20.78	18.39	12.95	24.77	23.51
Aghada D 220 kV	12.98	14.98	13.26	14.11	18.97	17.95	14.94	21.70	19.11	16.09	25.81	24.45
Ahane 110 kV	5.05	12.27	11.19	5.77	10.09	9.83	4.85	15.61	14.47	5.73	11.57	11.34
Anner 110 kV	4.07	6.67	6.28	4.58	4.74	4.67	3.97	7.44	6.94	4.54	4.99	4.91
Ardnacrusha 110 kV	5.42	13.60	12.16	6.66	14.65	14.05	5.91	19.21	17.26	7.58	18.45	17.80
Ardnagappary 110 kV	2.79	2.28	2.14	4.09	1.31	1.29	2.97	2.74	2.50	4.16	1.62	1.59
Arigna 110 kV	4.81	7.84	7.08	5.92	5.84	5.69	4.83	9.16	8.48	6.02	6.41	6.29
Arklow 110 kV	10.63	8.59	8.07	11.50	10.15	9.90	10.34	10.36	9.82	11.55	11.91	11.66
Arklow 220 kV	9.18	7.46	7.05	10.56	6.81	6.68	9.04	9.06	8.78	10.63	7.78	7.71
Artane 110 kV	12.54	10.63	9.86	5.87	12.73	12.34	13.06	13.56	12.38	5.60	15.58	15.02
Arva 110 kV	4.84	9.89	8.77	6.01	7.47	7.23	4.67	11.39	10.33	5.96	8.12	7.92
Athea 110 kV	11.31	9.55	8.15	12.15	9.03	8.56	11.44	10.83	9.49	12.29	9.94	9.52
Athlone 110 kV	3.90	6.77	6.40	5.31	5.27	5.19	3.90	8.18	7.63	5.44	5.65	5.56
Athy 110 kV	3.34	5.70	5.46	4.48	4.76	4.70	4.28	6.76	6.44	5.65	5.31	5.24
Aughinish 110 kV	5.71	7.02	6.46	6.74	8.23	7.96	8.34	12.33	11.34	10.65	12.30	11.95
Aungierstown 110 kV	17.71	18.10	15.91	19.16	12.88	12.47	19.22	22.60	20.89	18.94	14.59	14.33
Ballinknocka 110 kV	5.83	7.09	6.56	6.67	7.02	6.84	8.05	12.13	11.35	8.76	9.74	9.56
Ballyadam 110 kV	3.57	9.04	8.55	4.61	7.18	7.07	3.38	10.54	9.94	4.51	7.97	7.85
Ballybeg 110 kV	9.61	6.23	5.97	9.88	7.29	7.17	9.67	7.30	7.01	10.00	8.35	8.22
Ballydine 110 kV	4.03	7.30	6.93	3.78	5.63	5.55	3.91	8.17	7.68	3.71	5.98	5.89
Ballylickey 110 kV	3.02	3.55	3.37	4.05	2.12	2.09	2.98	4.12	3.84	4.08	2.32	2.29
Ballynahulla 110 kV	15.98	10.61	9.32	13.24	10.33	9.87	16.50	13.24	11.71	13.26	12.44	11.94
Ballynahulla 220 kV	9.31	9.71	8.63	9.32	9.92	9.50	9.21	12.17	11.12	9.24	11.94	11.57
Ballyragget 110 kV	4.47	3.03	2.95	5.93	2.15	2.14	5.07	6.25	5.92	6.36	4.18	4.13
Ballyvouskill 110 kV	14.68	11.80	10.18	13.81	12.48	11.81	15.12	13.39	11.74	14.06	14.11	13.44
Ballyvouskill 220 kV	9.46	10.00	8.87	10.14	11.48	10.93	9.14	12.28	11.17	9.94	13.77	13.27
Ballywater 110 kV	5.46	6.30	6.03	3.31	6.08	5.99	5.37	7.73	7.50	3.15	7.04	6.98
Baltrasna 110 kV	6.00	9.67	9.01	7.15	7.55	7.41	5.87	11.99	11.45	7.21	8.59	8.49
Bancroft 110 kV	11.93	11.19	10.33	6.90	13.07	12.65	12.18	13.64	12.82	6.64	15.47	15.10
Bandon 110 kV	3.14	6.51	6.12	4.24	6.14	6.02	3.00	7.83	7.18	4.20	7.03	6.84
Banoge 110 kV	6.12	6.05	5.81	6.96	5.21	5.14	6.57	7.76	7.54	7.41	6.09	6.04
Barnageeragh 110 kV	9.34	17.06	15.06	9.39	20.16	19.15	9.98	25.14	22.80	9.98	27.58	26.58
Barnahealy A 110 kV	4.74	11.92	11.10	5.48	12.24	11.93	4.45	14.31	13.28	5.27	14.13	13.77
Barnahealy B 110 kV	6.49	11.79	10.96	7.13	11.87	11.57	6.14	14.15	13.11	6.89	13.70	13.36
Barnakyle 110 kV	16.98	17.85	15.72	18.93	12.64	12.24	18.41	22.23	20.57	19.52	14.27	14.03

**Table E-3 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2024**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Baroda 110 kV	3.99	7.43	7.00	4.72	8.63	8.43	3.89	9.61	9.06	4.75	10.61	10.38
Barrymore 110 kV	3.79	7.80	7.39	4.92	4.51	4.46	3.68	8.88	8.43	4.89	4.85	4.81
Belcamp 110 kV	15.67	16.16	14.30	12.44	18.93	18.01	18.71	22.23	19.80	13.17	24.49	23.43
Belcamp 220 kV	11.13	15.34	13.36	10.00	19.08	17.94	12.49	26.99	23.93	10.23	30.25	28.83
Belgard 110 kV	11.74	11.43	10.42	6.78	13.99	13.45	11.92	14.26	13.13	6.48	16.94	16.38
Bellacorick 110 kV	5.53	6.56	5.35	6.07	7.46	6.86	6.00	9.04	7.62	6.71	9.66	9.05
Binbane 110 kV	3.42	4.99	4.49	4.96	4.24	4.11	3.87	6.85	6.23	5.60	5.43	5.29
Blackrock 110 kV	10.39	10.20	9.44	2.74	10.44	10.16	9.84	14.71	13.38	2.35	13.33	12.95
Blake 110 kV	4.02	7.12	6.72	4.99	5.08	5.01	3.82	8.66	8.21	4.92	5.68	5.62
Blundelstown 110 kV	4.11	7.33	6.95	4.83	4.86	4.80	4.22	9.65	9.38	4.99	5.64	5.61
Boggeragh 110 kV	6.92	8.43	7.62	8.16	8.31	8.03	6.65	9.60	8.76	7.98	9.28	9.00
Booltiagh 110 kV	6.60	8.18	7.34	8.37	6.44	6.25	6.66	9.40	8.57	8.55	7.01	6.84
Bracklone 110 kV	3.46	5.84	5.58	4.51	5.60	5.52	3.44	7.27	6.97	4.63	6.49	6.41
Brinny A 110 kV	3.02	5.82	5.50	4.11	5.06	4.97	2.89	6.90	6.39	4.07	5.71	5.59
Brinny B 110 kV	3.02	5.84	5.53	4.11	5.09	5.01	2.89	6.93	6.42	4.07	5.75	5.63
Buffy 110 kV	3.82	4.87	4.66	4.13	5.90	5.79	5.16	7.96	6.76	5.41	8.70	8.16
Bunkimalta 110 kV	5.12	5.52	5.24	5.12	5.52	5.24	6.51	8.00	7.09	6.51	8.00	7.09
Butlerstown 110 kV	6.43	10.66	10.11	6.74	10.59	10.41	6.27	12.63	11.88	6.60	11.87	11.64
Cabra 110 kV	11.65	10.28	9.55	4.80	11.45	11.13	11.95	13.05	11.93	4.55	13.80	13.35
Cahir 110 kV	4.68	9.30	8.51	5.79	7.06	6.90	4.54	10.65	9.67	5.76	7.43	7.26
Carlow 110 kV	5.70	7.83	7.41	6.45	8.41	8.24	6.09	9.50	8.82	6.88	9.62	9.37
Carrickaduff 110 kV	6.32	5.94	5.01	6.67	3.39	3.27	6.17	6.14	5.29	6.60	3.37	3.27
Carrickalangan 110 kV	6.65	6.15	5.12	6.76	3.36	3.24	6.49	6.35	5.40	6.69	3.34	3.24
Carrickmines 220 kV	12.67	15.84	13.83	8.55	19.41	18.28	14.36	25.50	23.20	7.92	28.80	27.74
Carrickmines A 110 kV	26.44	10.84	10.13	21.22	11.97	11.66	33.83	13.61	12.69	23.81	14.36	14.00
Carrickmines B 110 kV	21.68	12.35	11.36	18.42	14.82	14.32	26.13	15.32	14.35	20.45	17.82	17.37
Carrick-on-Shannon 110 kV	4.91	11.64	10.44	5.71	12.23	11.75	4.81	14.69	13.51	5.71	14.58	14.17
Carrigadrohid 110 kV	6.80	13.33	12.09	6.99	12.28	11.90	6.49	16.43	14.93	6.82	14.28	13.87
Carrigdangan 110 kV	3.34	5.04	4.78	4.08	5.75	5.63	4.13	7.27	6.29	5.21	7.66	7.26
Carrowbeg 110 kV	2.75	3.05	2.84	3.81	2.59	2.54	2.85	3.53	3.27	3.97	2.87	2.81
Cashla 110 kV	7.17	15.48	14.01	7.51	19.18	18.37	7.34	21.72	19.54	7.80	25.62	24.54
Cashla 220 kV	8.35	9.25	8.53	9.33	9.58	9.30	8.71	13.04	12.30	9.93	12.23	12.00
Castlebagot 110 kV	18.13	18.20	15.99	20.94	12.97	12.55	20.36	22.86	21.12	22.64	14.79	14.53
Castlebagot 220 kV	10.36	18.42	15.72	9.12	19.89	18.69	9.63	29.61	26.82	8.36	28.19	27.26
Castlebar 110 kV	3.47	5.83	5.16	4.11	5.27	5.07	3.94	7.08	6.31	4.61	6.03	5.82
Castledockrill 110 kV	7.56	7.76	7.40	4.33	8.47	8.32	7.49	9.43	9.13	4.11	9.89	9.78
Castlefarm A 110 kV	5.46	6.84	6.30	6.39	7.78	7.54	7.35	11.79	10.87	9.05	11.36	11.06
Castlefarm B 110 kV	5.47	6.83	6.30	6.39	7.78	7.53	7.37	11.76	10.85	9.07	11.35	11.04
Castleview 110 kV	3.92	11.84	11.04	4.58	8.72	8.56	3.68	14.27	13.26	4.47	9.79	9.62
Cathaleen's Fall 110 kV	4.75	10.38	8.87	5.72	10.36	9.80	5.09	13.30	11.49	6.13	11.78	11.25

**Table E-3 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2024**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Cauteen 110 kV	6.05	8.59	7.78	6.78	4.85	4.76	5.89	9.50	8.69	6.73	5.09	5.01
Central Park 110 kV	13.89	9.97	9.36	7.63	10.79	10.53	14.51	12.34	11.57	7.44	12.77	12.48
Charleville 110 kV	4.89	6.95	6.33	6.58	6.01	5.85	4.71	7.69	7.03	6.46	6.43	6.27
Cherrywood 110 kV	10.19	9.24	8.71	7.48	9.50	9.30	10.17	11.31	10.64	7.31	11.11	10.88
City West 110 kV	6.02	7.27	6.77	6.04	5.55	5.45	5.79	8.86	8.04	5.92	6.22	6.07
CKM_Country 110 kV	21.68	12.35	11.36	18.42	14.82	14.32	26.13	15.32	14.35	20.45	17.82	17.37
Clahane 110 kV	4.29	7.81	7.11	5.32	6.76	6.57	4.09	9.81	9.18	5.33	7.83	7.69
Clashavoon 220 kV	9.43	10.40	9.34	10.17	11.58	11.10	9.10	12.94	11.86	9.98	13.94	13.49
Clashavoon A 110 kV	8.25	16.12	14.29	8.52	19.69	18.71	7.88	20.26	18.04	8.24	24.16	23.02
Clashavoon B 110 kV	8.25	16.12	14.29	8.52	19.69	18.71	7.88	20.26	18.04	8.24	24.16	23.02
Cliff 110 kV	4.20	7.64	6.79	5.51	6.95	6.69	4.46	9.37	8.40	5.88	7.56	7.33
Cloghboola 110 kV	7.71	8.45	7.06	10.80	7.83	7.37	7.73	9.69	8.23	11.06	8.68	8.23
Cloghboola 110 kV	7.71	8.45	7.06	10.80	7.83	7.37	7.73	9.69	8.23	11.06	8.68	8.23
Clogher 110 kV	5.23	10.52	8.37	6.14	9.98	9.21	5.03	11.84	9.69	6.01	10.48	9.82
Cloghran 110 kV	9.27	17.16	15.13	9.65	20.36	19.32	9.87	25.34	22.96	10.38	27.92	26.89
Cloncreen 110 kV	3.97	6.41	6.08	4.89	7.22	7.08	3.89	8.10	7.73	4.96	8.67	8.53
Clonee 220 kV	11.06	15.55	13.57	9.12	15.46	14.72	11.25	24.44	22.17	8.74	21.10	20.48
Clonfad 110 kV	4.25	6.80	6.47	5.54	5.71	5.63	4.72	10.15	9.79	6.36	7.19	7.13
Clonkeen A 110 kV	5.68	6.16	5.82	6.81	4.35	4.29	5.55	7.02	6.68	6.78	4.74	4.68
Clonkeen B 110 kV	4.85	9.94	8.59	4.11	10.45	9.90	4.68	11.24	9.85	4.00	11.78	11.22
Cloon 110 kV	4.25	7.57	7.09	5.72	6.40	6.28	4.55	9.11	8.51	6.23	7.31	7.17
Clutterland 110 kV	17.37	18.08	15.89	18.63	12.84	12.43	19.21	22.69	20.97	19.72	14.64	14.39
College Park 110 kV	8.62	15.95	14.20	6.28	19.07	18.16	8.84	22.97	21.01	5.89	25.78	24.90
Cookstown 110 kV	7.22	7.95	7.51	5.92	6.80	6.69	7.00	9.30	8.92	5.77	7.63	7.54
Cookstown A 110 kV	4.95	6.23	5.84	5.21	4.49	4.41	4.76	7.52	6.83	5.11	4.97	4.86
Coolderrig 110 kV	18.21	11.22	10.16	12.18	11.96	11.53	20.24	14.10	12.71	12.36	14.24	13.73
Coolnabacky 110 kV	-	-	-	-	-	-	4.73	9.13	8.62	6.10	6.97	6.87
Coolnagoonag 110 kV	10.15	15.66	13.86	9.90	18.54	17.62	10.88	23.13	21.37	10.46	25.49	24.73
Coolroe 110 kV	3.57	9.30	8.74	4.85	8.74	8.57	3.51	11.22	10.43	4.90	9.99	9.77
Coomagearlahy 110 kV	5.33	8.04	6.90	5.96	8.68	8.19	5.19	9.07	7.86	5.84	9.78	9.26
Coomataggart 110 kV	9.96	7.54	6.65	6.67	4.09	3.99	9.91	8.52	7.59	6.64	4.59	4.49
Coomataggart 110 kV	9.96	7.54	6.65	6.67	4.09	3.99	9.91	8.52	7.59	6.64	4.59	4.49
Cordal 110 kV	12.31	8.97	7.98	7.76	8.78	8.44	12.86	11.39	10.13	7.60	10.71	10.30
Corderry 110 kV	4.39	8.81	7.72	5.62	7.67	7.36	4.48	10.68	9.60	5.85	8.71	8.46
Corduff 110 kV	9.67	18.19	15.97	10.48	22.04	20.86	10.61	27.56	24.83	11.84	31.02	29.79
Corduff 220 kV	12.41	17.16	14.80	11.72	21.14	19.79	14.47	29.98	26.53	12.70	33.26	31.69
Corkagh 110 kV	17.39	17.93	15.77	19.19	12.66	12.26	19.22	22.46	20.76	20.39	14.42	14.17
Corraclassy 110 kV	4.46	7.08	6.49	5.69	5.22	5.10	4.40	7.55	7.09	5.69	5.31	5.23
Cow Cross 110 kV	4.32	11.95	11.13	4.90	10.37	10.15	4.05	14.38	13.35	4.75	11.81	11.56
Crane 110 kV	7.74	8.66	8.16	7.39	8.82	8.64	8.44	11.49	10.99	7.79	10.83	10.67

**Table E-3 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2024**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Croaghaun 110 kV	5.68	5.99	4.92	6.42	6.60	6.10	6.07	7.93	6.75	7.02	8.23	7.75
Croaghnagawna 110 kV	6.43	6.40	5.33	6.96	3.79	3.65	6.27	6.64	5.66	6.88	3.78	3.66
Cromcastle A 110 kV	10.37	14.76	13.19	6.62	17.08	16.32	10.50	19.87	17.87	6.22	21.69	20.83
Cromcastle B 110 kV	10.37	14.76	13.19	6.62	17.08	16.32	10.50	19.87	17.87	6.22	21.69	20.83
Croy 110 kV	9.65	8.88	8.41	9.70	10.45	10.22	10.07	11.08	10.66	10.12	12.61	12.42
Cruiserath 220 kV	12.25	17.06	14.72	11.47	20.98	19.65	14.09	29.69	26.31	12.24	32.89	31.35
Cullenagh 110 kV	7.86	12.92	12.15	8.52	14.63	14.29	7.81	15.65	14.66	8.45	16.91	16.51
Cullenagh 220 kV	8.67	9.06	8.61	9.10	8.87	8.72	8.54	10.73	10.37	8.92	9.85	9.75
Cunghill 110 kV	3.27	5.76	5.26	3.81	5.12	4.98	3.07	7.14	6.68	3.77	5.92	5.81
Cureeny 110 kV	4.57	5.13	4.89	4.57	5.13	4.89	5.88	7.50	6.63	5.88	7.50	6.63
Cureeny T 110 kV	5.20	6.86	6.43	5.11	6.54	6.41	6.10	9.53	8.53	5.54	7.97	7.71
Cushaling 110 kV	3.97	6.47	6.13	4.92	7.41	7.26	3.90	8.19	7.81	5.01	8.94	8.79
Dallow 110 kV	3.46	4.89	4.62	4.64	3.06	3.03	3.49	5.97	5.73	4.77	3.36	3.34
Dalton 110 kV	3.34	4.82	4.41	4.61	3.68	3.59	3.56	5.78	5.32	4.95	4.06	3.98
Dardistown 110 kV	12.79	15.23	13.57	9.88	17.99	17.15	13.86	20.66	18.53	9.88	23.08	22.12
Darndale 110 kV	14.96	15.68	13.91	12.63	18.02	17.18	17.34	21.37	19.09	13.39	23.07	22.11
Deenes 110 kV	5.56	9.53	8.85	6.59	7.05	6.92	5.57	12.10	11.51	6.75	8.05	7.96
Derrybrien 110 kV	3.12	4.82	4.21	4.54	4.27	4.10	2.99	5.19	4.61	4.45	4.51	4.35
Derryiron 110 kV	4.70	7.19	6.83	5.80	7.74	7.60	5.79	11.51	10.87	7.47	10.61	10.42
Derrylahan 110 kV	4.79	11.10	10.23	5.74	10.22	9.96	4.98	15.08	14.29	6.25	12.38	12.19
Doon 110 kV	4.42	7.34	6.88	4.77	5.35	5.26	4.32	8.26	7.67	4.73	5.63	5.54
Dromada 110 kV	10.21	8.77	7.54	6.38	8.18	7.78	10.21	9.87	8.70	6.27	8.96	8.60
Drombeg 110 kV	7.28	8.39	7.76	7.36	6.68	6.54	7.38	10.97	10.48	7.46	7.82	7.74
Drumkeen 110 kV	4.05	8.59	7.16	5.20	7.02	6.65	3.84	9.40	7.98	5.05	7.37	7.04
Drumline 110 kV	3.37	8.19	7.58	4.63	6.74	6.60	3.20	9.90	9.20	4.62	7.48	7.34
Drybridge 110 kV	5.28	11.44	10.38	6.32	9.62	9.35	5.12	15.02	13.87	6.38	11.45	11.21
Dundalk 110 kV	3.60	8.79	8.06	4.66	7.79	7.59	3.35	10.06	9.33	4.49	8.59	8.41
Dunfirth 110 kV	4.52	6.59	6.28	6.00	5.35	5.28	4.68	8.69	8.43	6.44	6.29	6.24
Dungarvan 110 kV	5.95	6.17	5.88	7.83	4.98	4.91	6.46	7.92	7.13	8.52	5.72	5.57
Dunmanway 110 kV	4.15	8.38	7.69	5.04	8.03	7.81	4.43	11.18	9.76	5.46	9.83	9.42
Dunstown 220 kV	10.77	16.73	14.73	10.81	19.20	18.23	10.09	21.30	20.04	10.28	23.42	22.88
Dunstown 400 kV	15.09	6.50	5.97	17.51	7.12	6.89	15.06	7.98	7.70	17.86	8.39	8.29
Ennis 110 kV	4.50	11.38	10.14	5.86	9.61	9.29	4.39	14.57	12.91	5.95	11.29	10.93
Fassaroe East 110 kV	5.21	7.45	7.06	5.35	5.76	5.68	4.98	8.74	8.34	5.22	6.42	6.34
Fassaroe West 110 kV	5.36	7.60	7.20	5.44	5.94	5.86	5.12	8.93	8.52	5.32	6.63	6.56
Finglas 220 kV	12.33	16.24	14.06	12.13	20.72	19.40	15.55	29.39	25.85	14.35	33.99	32.24
Finglas A 110 kV	15.96	16.12	14.31	12.41	18.90	18.00	19.36	22.35	19.89	13.16	24.59	23.51
Finglas B 110 kV	25.75	11.87	10.94	24.50	14.85	14.34	35.81	15.42	13.99	31.25	18.63	17.89
Firlough 110 kV	3.67	4.73	4.30	4.32	4.19	4.08	3.91	8.43	7.87	5.04	5.91	5.81
Flagford 110 kV	5.13	12.10	10.83	6.05	14.15	13.52	5.11	15.54	14.26	6.19	17.45	16.88

**Table E-3 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2024**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Flagford 220 kV	7.75	7.22	6.68	9.94	6.63	6.47	7.91	8.55	8.20	10.34	7.46	7.36
Fortunestown 110 kV	5.64	7.16	6.67	5.62	5.48	5.38	5.41	8.72	7.91	5.50	6.14	6.00
Francis Street A 110 kV	10.82	10.21	9.44	5.63	12.53	12.12	10.34	14.73	13.39	4.93	16.94	16.31
Francis Street B 110 kV	12.30	11.41	10.44	6.64	13.90	13.39	12.61	14.29	13.18	6.34	16.87	16.33
Gallanstown 110 kV	6.57	7.99	7.52	6.96	5.78	5.70	7.08	10.99	10.60	7.28	6.90	6.85
Galway 110 kV	5.21	12.14	11.15	4.60	14.38	13.89	5.20	17.00	15.10	4.49	18.93	18.07
Garballagh 110 kV	4.03	8.97	8.29	4.79	6.63	6.50	3.97	11.34	10.69	4.86	7.50	7.40
Garrow 110 kV	10.56	11.39	9.83	10.44	12.14	11.48	10.53	12.91	11.32	10.41	13.71	13.05
Garvagh 110 kV	4.75	7.13	6.28	6.24	6.08	5.86	5.02	8.64	7.79	6.68	6.90	6.70
Gilra 110 kV	3.22	6.50	6.08	4.10	4.92	4.84	3.09	7.46	7.10	4.05	5.38	5.31
Glanagow 220 kV	13.12	14.74	13.06	13.18	18.60	17.61	14.57	20.89	18.47	14.09	24.86	23.59
Glanlee 110 kV	5.15	7.93	6.81	5.42	8.53	8.05	5.02	8.94	7.76	5.32	9.61	9.11
Glasmore A 110 kV	3.99	7.37	6.91	4.53	5.08	5.01	3.74	9.04	8.37	4.42	5.68	5.58
Glen 110 kV	-	-	-	-	-	-	5.01	8.62	7.77	6.51	6.85	6.66
Glenlara A 110 kV	3.32	3.24	3.00	4.82	2.60	2.55	3.24	3.44	3.17	4.76	2.70	2.64
Glenlara B 110 kV	9.59	8.14	7.13	6.31	8.31	7.92	9.21	9.88	8.75	6.05	9.85	9.44
Glenree 110 kV	3.57	4.75	4.34	4.23	4.16	4.05	3.78	7.98	7.47	4.88	5.69	5.60
Golagh 110 kV	4.11	8.27	6.85	4.93	6.61	6.26	3.91	9.01	7.67	4.82	6.78	6.49
Gorman 110 kV	6.78	13.16	11.82	7.73	14.53	13.95	6.86	17.78	16.19	8.01	18.17	17.57
Gorman 220 kV	8.77	10.82	9.79	9.72	8.98	8.72	8.64	13.43	12.87	9.69	10.29	10.18
Gortawee 110 kV	4.70	6.72	6.15	6.34	5.23	5.11	4.63	7.17	6.69	6.34	5.41	5.32
Grange 110 kV	12.45	15.50	13.78	6.70	17.70	16.88	13.38	21.19	18.92	6.28	22.67	21.72
Grange Castle 110 kV	19.54	11.52	10.40	13.79	12.90	12.40	22.25	14.56	13.08	14.26	15.52	14.92
Great Island 110 kV	8.43	13.01	12.27	9.49	15.76	15.38	8.48	15.76	14.87	9.50	18.34	17.92
Great Island 220 kV	11.51	11.62	10.93	12.93	13.16	12.85	12.43	14.59	14.02	13.29	15.12	14.91
Griffinrath A 110 kV	7.01	9.55	9.00	7.36	9.72	9.53	6.51	12.21	11.68	7.05	11.69	11.52
Griffinrath B 110 kV	7.51	9.87	9.28	7.51	9.74	9.54	7.03	12.69	12.13	7.21	11.68	11.52
Harolds Cross 110 kV	10.98	10.23	9.47	5.34	12.50	12.09	10.53	14.78	13.44	4.66	16.87	16.25
Harristown 110 kV	4.38	6.90	6.56	5.67	5.70	5.62	4.77	9.95	9.62	6.35	7.02	6.97
Heuston 110 kV	13.20	11.62	10.63	7.92	14.31	13.77	13.72	14.60	13.46	7.66	17.43	16.86
Huntstown A 220 kV	11.91	15.65	13.61	10.98	19.98	18.75	14.84	28.08	24.82	12.18	32.54	30.92
Huntstown B 220 kV	12.76	16.23	14.12	10.11	19.96	18.77	14.65	26.90	24.12	9.94	30.22	28.93
Ikerrin 110 kV	5.70	5.18	4.76	6.43	3.57	3.50	5.58	5.70	5.24	6.42	3.77	3.70
Inchicore 220 kV	12.04	18.09	15.42	9.53	22.28	20.74	13.27	32.27	28.71	9.01	35.80	34.19
Inchicore A 110 kV	24.33	12.75	11.57	22.26	16.08	15.41	31.30	16.28	14.90	26.51	19.93	19.20
Inchicore B 110 kV	33.42	12.64	11.38	28.10	15.99	15.27	51.71	16.28	14.58	36.67	19.94	19.03
Inniscarra 110 kV	3.53	9.16	8.61	4.73	8.42	8.26	3.52	11.12	10.34	4.84	9.61	9.40
Irishtown 220 kV	13.06	17.04	14.68	10.80	21.40	20.00	15.34	30.35	27.16	10.81	34.62	33.09
Kellis 110 kV	6.94	8.39	7.94	8.00	9.90	9.68	7.25	10.14	9.48	8.44	11.47	11.17
Kellis 220 kV	8.01	7.50	7.12	9.78	6.45	6.36	7.97	8.66	8.40	9.84	7.04	6.98

**Table E-3 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2024**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Kellystown 220 kV	7.03	15.38	13.48	6.23	13.06	12.54	5.99	20.70	19.30	5.68	15.66	15.38
Kilbarry 110 kV	5.92	15.21	13.85	6.94	14.74	14.28	5.58	19.33	17.31	6.74	17.50	16.90
Kilcarbery 110 kV	-	-	-	-	-	-	18.75	22.29	20.62	19.70	14.29	14.04
Kildonan 110 kV	6.78	12.84	11.68	5.28	12.08	11.71	6.45	17.31	16.16	4.98	14.85	14.55
Kilkenny 110 kV	4.10	5.10	4.91	5.59	4.56	4.51	4.70	7.56	7.10	6.32	6.09	5.99
Kill Hill 110 kV	5.68	6.93	6.21	6.83	5.55	5.38	5.50	7.67	6.89	6.78	5.92	5.75
Killonan 110 kV	6.59	17.23	15.19	7.71	18.90	18.00	6.79	24.36	21.74	8.24	24.31	23.36
Killonan 220 kV	7.51	9.93	9.07	9.64	9.38	9.10	7.79	12.76	12.10	10.33	11.10	10.93
Killoteran 110 kV	7.22	11.65	11.01	7.53	12.58	12.32	7.10	13.98	13.09	7.40	14.34	14.02
Kilmahud 110 kV	17.07	17.87	15.73	19.19	12.72	12.32	18.74	22.38	20.70	20.40	14.49	14.24
Kilmore 110 kV	13.48	15.75	13.98	9.64	18.43	17.55	14.98	21.59	19.25	9.60	23.78	22.75
Kilnap 110 kV	5.68	16.02	14.53	6.25	13.90	13.49	5.25	20.05	18.07	6.00	16.16	15.70
Kilpaddoge 110 kV	10.33	15.85	14.01	10.95	19.40	18.40	11.16	23.47	21.66	12.11	27.02	26.17
Kilpaddoge 220 kV	10.37	14.57	12.69	10.06	17.99	16.92	13.23	23.33	21.36	11.87	26.81	25.88
Kilpaddoge 400 kV	9.44	7.51	6.74	8.47	8.13	7.80	9.72	12.68	11.84	8.21	11.74	11.48
Kilteel 110 kV	4.35	6.93	6.58	5.37	6.39	6.28	4.55	9.39	8.90	5.76	7.84	7.72
Kinnegad 110 kV	4.41	7.49	7.08	5.73	6.87	6.76	4.95	11.31	10.84	6.73	8.84	8.74
Kishoge 110 kV	-	-	-	-	-	-	17.74	21.87	20.27	17.73	14.00	13.77
Knockacummer 110 kV	8.49	7.09	6.25	7.10	6.91	6.62	8.11	8.50	7.57	6.86	8.11	7.80
Knockalough 110 kV	3.97	4.32	4.16	3.76	5.21	5.13	5.34	6.80	5.87	4.48	7.48	7.06
Knockanure 220 kV	10.46	12.96	11.32	7.61	15.93	15.00	12.01	18.63	17.08	7.55	21.79	21.02
Knockanure A 110 kV	18.93	13.07	11.00	15.53	13.88	12.99	22.32	15.47	13.44	16.75	15.88	15.08
Knockanure B 110 kV	4.85	8.54	7.79	5.90	6.82	6.65	4.49	10.62	9.98	5.76	7.78	7.66
Knockearagh 110 kV	5.52	5.76	5.36	7.41	4.73	4.64	5.45	6.73	6.30	7.47	5.24	5.15
Knocknamona 110 kV	5.70	6.00	5.71	5.70	6.00	5.71	6.47	7.95	7.04	6.47	7.95	7.04
Knockraha A 110 kV	7.96	19.48	17.48	8.77	19.10	18.40	7.57	25.23	22.51	8.57	22.98	22.16
Knockraha A 220 kV	10.83	14.97	13.32	10.74	15.92	15.23	10.77	20.56	18.46	10.60	20.19	19.44
Knockraha B 110 kV	7.96	19.48	17.48	8.77	19.10	18.40	7.57	25.23	22.51	8.57	22.98	22.16
Knockraha B 220 kV	10.83	14.97	13.32	10.74	15.92	15.23	10.77	20.56	18.46	10.60	20.19	19.44
Knockranny 110 kV	6.19	7.97	7.52	5.29	10.08	9.82	6.23	9.70	9.05	5.22	11.99	11.64
Knockranny A 110 kV	3.82	4.90	4.69	4.11	5.93	5.82	5.15	8.00	6.80	5.36	8.73	8.19
Knockranny B 110 kV	6.19	7.97	7.52	5.29	10.08	9.82	6.23	9.70	9.05	5.22	11.99	11.64
Knockumber 110 kV	3.88	7.98	7.40	4.69	6.05	5.93	3.63	9.53	8.94	4.59	6.67	6.57
Lanesboro 110 kV	3.05	8.44	7.94	4.14	7.14	7.02	3.07	10.77	9.94	4.31	8.41	8.23
Lenalea 110 kV	3.91	6.58	5.78	5.07	4.49	4.35	3.93	7.51	6.64	5.09	5.07	4.93
Letterkenny 110 kV	4.45	10.09	8.32	5.53	8.71	8.20	4.28	11.51	9.58	5.43	9.57	9.06
Liberty A 110 kV	5.42	15.51	14.10	4.80	16.66	16.08	5.02	19.58	17.54	4.51	20.01	19.24
Liberty B 110 kV	5.33	15.50	14.09	4.65	16.62	16.04	4.93	19.55	17.52	4.36	19.95	19.18
Limerick 110 kV	4.91	14.42	12.85	5.74	13.61	13.10	4.91	20.04	18.08	5.94	16.68	16.19
Lisdrum 110 kV	2.83	5.16	4.85	4.17	4.37	4.29	3.69	7.63	6.67	5.45	5.19	5.03

**Table E-3 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2024**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Lisheen 110 kV	5.02	4.97	4.34	5.03	7.45	6.94	4.81	5.47	4.81	4.98	8.21	7.67
Lodgewood 110 kV	9.65	8.88	8.41	9.70	10.45	10.22	10.07	11.08	10.66	10.12	12.61	12.42
Lodgewood 220 kV	9.17	7.37	7.01	10.24	6.92	6.81	9.28	8.80	8.56	10.43	7.79	7.72
Longpoint 220 kV	12.98	14.98	13.26	14.11	18.97	17.95	14.94	21.70	19.11	16.09	25.81	24.45
Loughtown 220 kV	11.05	11.52	10.84	10.51	12.83	12.54	11.93	14.46	13.90	10.82	14.76	14.56
Louth 220 kV	9.58	15.83	13.53	10.40	18.14	17.00	9.39	21.34	19.83	10.34	23.15	22.52
Louth A 110 kV	6.75	12.56	11.29	7.80	14.98	14.33	6.33	14.58	13.65	7.48	16.97	16.53
Louth A 275 kV	11.28	9.23	8.15	11.22	10.98	10.41	11.38	11.96	11.43	11.06	13.72	13.48
Louth B 110 kV	7.25	13.73	12.34	8.11	16.77	16.02	6.75	16.61	15.45	7.74	19.68	19.11
Louth B 275 kV	10.58	9.24	8.15	9.82	11.18	10.59	10.60	11.97	11.43	9.50	14.04	13.79
Lumcloon 110 kV	4.91	6.90	6.53	6.12	4.84	4.78	5.72	9.37	9.06	6.85	5.62	5.58
Macetown 110 kV	7.22	14.11	12.71	6.76	14.54	14.00	6.96	19.57	18.08	6.55	18.53	18.06
Macroon 110 kV	7.19	15.25	13.62	7.05	15.92	15.27	6.83	19.21	17.15	6.80	19.09	18.35
Mallow 110 kV	5.19	6.66	6.26	6.99	5.56	5.46	5.07	7.48	7.02	6.95	6.02	5.91
Marina 110 kV	6.32	17.16	15.46	7.26	18.49	17.78	5.89	22.13	19.58	6.96	22.60	21.63
Maynooth A 110 kV	10.62	11.83	11.01	11.26	14.55	14.12	10.46	15.85	15.06	11.34	18.74	18.36
Maynooth A 220 kV	9.55	16.04	14.07	9.49	15.53	14.83	9.15	24.04	22.39	9.18	21.57	21.10
Maynooth B 110 kV	8.26	15.52	14.01	9.57	15.23	14.71	7.19	19.51	18.48	8.82	17.97	17.66
Maynooth B 220 kV	8.75	17.72	15.32	8.41	17.42	16.53	7.12	23.22	21.61	7.30	20.06	19.63
McDermott 110 kV	14.97	10.96	10.14	5.98	12.82	12.42	16.20	14.09	12.80	5.70	15.72	15.15
Meath Hill 110 kV	4.16	9.18	8.41	5.38	7.30	7.12	3.88	10.66	9.92	5.23	8.08	7.93
Meentycat 110 kV	3.74	7.09	6.00	5.17	5.83	5.55	3.56	7.55	6.50	5.02	6.01	5.76
Midleton 110 kV	3.62	9.91	9.32	4.80	8.37	8.22	3.41	11.69	10.93	4.68	9.38	9.21
Milltown A 110 kV	14.26	10.92	10.07	7.23	13.58	13.11	14.86	16.15	14.60	6.46	18.82	18.06
Milltown B 110 kV	8.79	10.33	9.53	4.18	12.37	11.96	8.58	12.78	11.84	3.90	14.79	14.36
Misery Hill 110 kV	13.05	10.70	9.87	7.88	13.41	12.95	13.16	15.71	14.22	7.15	18.52	17.78
Monatooreen 110 kV	5.63	18.22	16.46	5.94	17.82	17.21	5.18	23.21	20.89	5.65	21.22	20.51
Moneteen 110 kV	5.03	10.02	9.15	5.96	7.80	7.61	5.17	13.13	12.25	6.21	8.98	8.84
Moneypoint 110 kV	13.50	9.44	8.70	16.29	9.21	8.96	14.74	10.89	10.31	17.73	10.23	10.06
Moneypoint 220 kV	10.45	14.30	12.49	10.61	17.77	16.73	13.46	22.87	20.99	13.04	26.52	25.61
Moneypoint G1 400 kV	11.70	7.57	6.79	13.59	8.80	8.42	16.19	12.87	12.01	19.44	13.17	12.86
Moneypoint G2 400 kV	26.03	3.15	2.99	27.51	3.90	3.81	45.82	5.13	4.88	45.50	5.78	5.66
Moneypoint G3 400 kV	11.70	7.57	6.79	13.59	8.80	8.42	16.19	12.87	12.01	19.44	13.17	12.86
Monread 110 kV	4.06	6.82	6.48	4.89	6.94	6.81	4.07	8.91	8.44	5.05	8.38	8.24
Mount Lucas 110 kV	4.04	5.71	5.41	5.15	5.46	5.37	3.93	7.27	6.91	5.21	6.49	6.39
Moy 110 kV	4.39	4.96	4.40	5.22	5.42	5.18	5.69	10.09	9.06	7.38	9.02	8.72
Mullagharlin 110 kV	3.66	8.83	8.13	4.75	8.12	7.91	3.42	9.97	9.37	4.57	8.84	8.68
Mullingar 110 kV	3.50	6.53	6.23	4.82	6.17	6.08	3.60	8.54	8.14	5.20	7.51	7.40
Mully Graffy 110 kV	3.40	4.24	3.87	3.40	4.24	3.87	4.09	5.76	5.02	4.09	5.76	5.02
Mulreavy 110 kV	5.33	9.39	7.50	6.53	9.33	8.60	5.13	10.30	8.48	6.40	9.67	9.05



**Table E-3 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2024**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Mungret A 110 kV	4.78	9.56	8.76	5.71	7.27	7.11	4.83	12.35	11.56	5.89	8.30	8.18
Mungret B 110 kV	4.77	9.57	8.77	5.70	7.28	7.11	4.82	12.38	11.58	5.89	8.31	8.19
Nangor 110 kV	16.91	11.26	10.19	10.83	12.59	12.11	18.43	14.17	12.76	10.84	15.09	14.52
Navan 110 kV	5.87	11.81	10.67	6.64	11.67	11.28	5.72	15.51	14.18	6.64	14.12	13.73
Nenagh 110 kV	3.37	3.81	3.61	4.12	2.57	2.54	3.29	4.52	4.18	4.13	2.74	2.70
Newbridge 110 kV	4.08	8.22	7.70	4.77	8.41	8.22	3.97	10.82	10.11	4.78	10.35	10.13
Newbury 110 kV	12.38	15.49	13.76	6.63	17.61	16.79	13.28	21.12	18.87	6.22	22.50	21.57
North Quays 110 kV	16.73	11.11	10.23	6.78	13.60	13.13	18.75	16.52	14.92	6.00	18.83	18.08
North Wall 220 kV	11.48	14.84	13.00	8.01	17.30	16.36	13.86	26.26	23.36	7.50	26.61	25.50
Oldbridge 110 kV	4.60	10.30	9.41	5.43	8.06	7.86	4.40	13.17	12.26	5.41	9.31	9.15
Oldcourt A 110 kV	3.81	10.05	9.46	4.51	7.87	7.74	3.59	11.82	11.11	4.39	8.79	8.66
Oldcourt B 110 kV	3.84	10.11	9.51	4.54	7.95	7.82	3.62	11.90	11.19	4.42	8.89	8.75
Oldstreet 220 kV	12.20	7.92	7.45	11.20	9.17	8.95	15.20	12.72	12.03	12.60	13.20	12.94
Oldstreet 400 kV	10.16	7.22	6.58	8.90	6.81	6.60	10.96	10.74	10.26	8.98	8.86	8.74
Oriel 220 kV	9.79	13.25	11.50	9.79	13.25	11.50	9.22	16.19	15.00	9.22	16.19	15.00
Oughtragh 110 kV	3.71	4.68	4.38	4.85	2.99	2.95	3.58	5.41	5.08	4.81	3.23	3.19
Pelletstown 110 kV	12.85	10.35	9.63	7.63	11.21	10.91	13.44	13.14	12.03	7.45	13.49	13.07
Platin 110 kV	4.25	9.58	8.79	5.04	7.20	7.04	4.08	12.07	11.30	5.03	8.19	8.07
Pollahoney 110 kV	9.99	8.09	7.62	10.36	8.95	8.75	9.68	9.66	9.19	10.30	10.34	10.15
Pollaphuca 110 kV	2.77	2.47	2.42	4.01	2.29	2.27	3.35	3.13	3.01	4.79	2.55	2.52
Poolbeg A 110 kV	22.10	11.59	10.65	19.30	14.83	14.29	29.47	17.33	15.64	22.54	20.98	20.10
Poolbeg A 220 kV	11.43	14.95	13.08	7.01	16.48	15.62	13.49	26.39	23.48	6.26	24.79	23.82
Poolbeg B 110 kV	22.08	11.57	10.63	19.29	14.81	14.27	29.42	17.31	15.62	22.53	20.95	20.07
Poolbeg B 220 kV	11.80	16.95	14.58	9.39	19.64	18.43	13.26	29.97	26.93	9.03	30.50	29.34
Poppintree 110 kV	11.23	15.15	13.52	6.86	17.59	16.80	11.69	20.62	18.47	6.47	22.54	21.61
Portan 260 kV	15.09	9.47	8.75	15.09	9.47	8.75	15.35	12.92	12.47	15.35	12.92	12.47
Portan 400 kV	12.44	7.58	6.89	12.44	7.58	6.89	11.93	11.07	10.57	11.93	11.07	10.57
Portlaoise 110 kV	3.84	7.27	6.86	5.07	6.91	6.78	4.54	10.34	9.69	6.09	8.96	8.79
Pottery 110 kV	16.44	10.29	9.64	5.68	10.60	10.35	17.82	12.81	11.98	5.44	12.50	12.23
Prospect 220 kV	9.37	12.32	10.96	7.69	13.13	12.56	10.42	18.13	16.95	7.73	17.48	17.09
Raffeen 220 kV	12.22	14.03	12.50	10.83	17.18	16.34	13.09	19.55	17.42	10.88	22.56	21.52
Raffeen A 110 kV	5.78	13.87	12.78	6.63	16.24	15.71	5.44	17.00	15.61	6.37	19.30	18.66
Raffeen B 110 kV	8.05	13.71	12.61	8.91	15.92	15.40	7.67	16.77	15.35	8.64	18.87	18.23
Rathkeale 110 kV	3.55	7.15	6.70	4.80	5.60	5.50	3.39	8.57	8.06	4.78	6.21	6.11
Rathnaskillo 110 kV	6.12	6.99	6.70	7.09	5.21	5.16	6.56	8.75	8.21	7.47	5.87	5.78
Ratrussan 110 kV	4.06	8.12	6.77	5.26	8.56	8.00	3.80	9.02	7.66	5.05	9.26	8.74
Reamore 110 kV	4.08	8.97	7.91	4.47	7.40	7.13	3.66	11.07	10.03	4.24	8.36	8.15
Richmond A 110 kV	2.77	6.04	5.77	4.02	5.15	5.08	2.74	7.35	6.86	4.12	6.03	5.91
Richmond B 110 kV	2.77	6.04	5.77	4.02	5.15	5.08	2.74	7.35	6.86	4.12	6.03	5.91
Rinawade 110 kV	5.03	10.14	9.45	5.95	7.46	7.33	4.66	12.29	11.85	5.78	8.39	8.32

**Table E-3 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2024**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Ringaskiddy 110 kV	5.68	11.43	10.66	6.08	11.01	10.75	5.34	13.64	12.68	5.86	12.62	12.34
Ringsend 110 kV	22.05	11.58	10.63	19.90	14.84	14.29	30.00	17.53	15.75	23.93	21.20	20.27
Rosspile 110 kV	6.57	8.04	7.65	7.32	5.93	5.86	6.33	9.10	8.72	7.19	6.34	6.28
Ryebrook 110 kV	5.60	12.95	11.63	6.45	11.60	11.22	4.97	16.05	14.97	6.05	13.52	13.26
Salthill 110 kV	4.59	11.60	10.68	3.71	13.50	13.06	4.68	16.26	14.44	3.61	17.68	16.90
Screeb 110 kV	3.72	2.54	2.44	4.67	1.78	1.77	4.07	3.26	2.97	5.02	2.02	1.98
Seal Rock A 110 kV	5.56	6.90	6.36	6.48	8.11	7.85	7.91	12.06	11.11	9.86	12.10	11.76
Seal Rock B 110 kV	5.56	6.90	6.36	6.48	8.11	7.85	7.93	12.07	11.11	9.87	12.10	11.76
Shankill 110 kV	4.39	9.14	7.88	5.58	8.00	7.65	4.21	10.85	9.41	5.54	9.10	8.72
Shannonbridge 110 kV	4.79	12.19	11.15	6.01	13.01	12.59	4.99	16.70	15.71	6.73	16.28	15.96
Shannonbridge 220 kV	6.42	6.45	6.09	8.55	5.45	5.36	7.01	8.33	8.13	9.59	6.36	6.32
Shantallow 110 kV	4.23	11.41	10.59	4.68	9.70	9.49	4.07	14.89	13.92	4.64	11.47	11.27
Shellybanks A 220 kV	11.23	14.93	13.07	8.42	17.37	16.43	13.11	26.35	23.45	8.04	26.71	25.60
Shellybanks B 220 kV	12.54	16.40	14.20	9.58	20.34	19.07	14.56	28.93	25.98	9.16	32.44	31.08
Shelton Abbey 110 kV	9.74	7.93	7.48	9.88	8.57	8.39	9.42	9.44	8.99	9.78	9.86	9.69
Singland 110 kV	5.98	14.17	12.70	6.97	13.94	13.42	6.26	19.31	17.50	7.44	17.01	16.50
Sliabh Bawn 110 kV	3.00	7.85	7.40	3.00	7.85	7.40	3.20	10.24	9.40	3.20	10.24	9.40
Slievecollan 110 kV	7.13	6.20	5.67	9.08	2.31	2.29	7.71	7.85	6.94	9.39	2.48	2.45
Sligo 110 kV	3.80	9.61	8.63	4.53	8.72	8.43	3.55	11.58	10.58	4.41	9.97	9.71
Snugborough 110 kV	9.61	17.17	15.15	9.41	20.17	19.16	10.43	25.35	22.99	10.01	27.60	26.60
Somerset 110 kV	2.98	6.88	6.51	4.00	4.57	4.51	2.83	8.16	7.79	3.97	5.00	4.96
Sorne Hill 110 kV	3.50	3.73	3.30	4.46	3.69	3.53	3.44	3.92	3.46	4.41	3.77	3.62
Srahnakilly 110 kV	5.61	6.38	5.21	6.14	7.21	6.64	6.04	8.66	7.32	6.71	9.21	8.64
Srananagh 110 kV	4.79	11.34	10.02	5.70	11.85	11.33	4.55	13.75	12.49	5.59	13.69	13.25
Srananagh 220 kV	7.49	4.71	4.43	9.75	3.74	3.67	7.63	5.33	5.14	10.02	4.04	4.00
Stevenstown 110 kV	3.98	6.05	5.75	4.53	3.94	3.89	3.77	7.11	6.74	4.44	4.32	4.27
Stratford 110 kV	3.18	3.81	3.70	4.18	3.05	3.02	3.46	4.61	4.36	4.47	3.33	3.28
Taney 110 kV	8.78	8.96	8.46	3.30	8.95	8.77	8.62	10.92	10.29	3.12	10.36	10.17
Tarbert 110 kV	19.59	11.66	10.85	23.35	9.17	8.99	26.49	14.09	13.62	28.24	10.33	10.24
Tarbert 220 kV	10.07	13.96	12.23	9.75	16.46	15.56	12.28	21.85	20.11	11.05	23.65	22.92
Tawnaghmore A 110 kV	3.77	3.99	3.60	4.78	3.93	3.80	4.24	7.09	6.54	5.86	5.63	5.51
Tawnaghmore B 110 kV	3.67	3.86	3.51	4.53	4.30	4.14	4.77	7.39	6.78	6.54	6.79	6.61
Thornsberry 110 kV	3.75	5.47	5.22	4.82	5.23	5.15	3.67	7.40	7.00	4.95	6.55	6.44
Thurles 110 kV	6.22	6.31	5.53	6.51	6.46	6.16	5.92	6.98	6.12	6.42	6.95	6.64
Tievebrack 110 kV	3.58	4.59	4.16	4.96	3.04	2.97	4.27	6.22	5.43	5.60	5.48	5.25
Timahoe 110 kV	6.15	7.01	6.70	6.77	5.44	5.38	6.34	9.85	9.57	7.00	6.56	6.52
Tipperary 110 kV	5.40	7.67	7.10	6.38	4.67	4.60	5.27	8.53	7.90	6.34	4.91	4.84
Tonroe 110 kV	2.80	3.56	3.29	3.90	2.08	2.05	5.43	6.23	5.84	6.49	3.82	3.77
Trabeg 110 kV	6.25	17.09	15.40	7.18	18.44	17.73	5.81	22.03	19.50	6.88	22.53	21.57
Tralee 110 kV	5.47	9.50	8.35	6.46	7.87	7.58	5.03	11.93	10.77	6.27	8.97	8.73

**Table E-3 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2024**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Trien A 110 kV	4.66	8.14	7.40	5.94	6.92	6.73	4.33	10.09	9.42	5.83	7.88	7.74
Trien B 110 kV	12.55	10.73	9.01	9.19	7.73	7.38	13.07	12.46	10.74	9.19	8.51	8.20
Trillick 110 kV	3.62	4.09	3.57	4.59	3.68	3.53	3.54	4.32	3.76	4.52	3.77	3.61
Trinity 110 kV	11.78	10.45	9.66	6.68	12.99	12.55	11.51	15.22	13.80	5.94	17.76	17.07
Tullabeg 110 kV	6.12	6.49	6.22	6.43	5.42	5.35	7.18	9.09	8.83	7.06	6.60	6.55
Tullabrack 110 kV	6.58	7.31	6.79	7.30	5.45	5.35	6.50	8.25	7.81	7.28	5.88	5.80
Turlough 220 kV	10.83	11.62	10.46	12.13	10.56	10.21	10.09	13.18	12.40	11.64	11.39	11.18
Tynagh 220 kV	10.61	7.61	7.16	11.50	9.31	9.08	15.55	13.64	12.68	16.80	14.63	14.24
Uggool 110 kV	6.31	7.67	7.24	5.69	9.73	9.49	6.34	9.23	8.64	5.66	11.48	11.16
Waterford 110 kV	7.43	12.19	11.50	7.98	13.07	12.79	7.32	14.74	13.77	7.87	14.96	14.61
Wexford 110 kV	5.97	7.28	6.78	7.51	6.39	6.25	5.70	8.52	7.98	7.35	7.00	6.87
Whitebank 110 kV	19.64	11.54	10.59	17.44	14.76	14.22	25.90	17.45	15.69	20.35	21.08	20.16
Whitegate 110 kV	4.47	9.38	8.85	5.26	9.55	9.36	4.33	11.07	10.47	5.18	10.89	10.69
Wolfe Tone 110 kV	13.37	10.73	9.94	5.48	12.42	12.04	14.09	13.74	12.50	5.20	15.15	14.62
Woodhouse 110 kV	5.98	6.18	5.87	7.38	4.44	4.39	6.75	8.16	7.23	8.06	5.12	4.98
Woodland 220 kV	10.46	18.19	15.73	10.41	20.05	18.92	9.88	27.73	25.39	10.14	27.78	26.93
Woodland 400 kV	13.00	7.61	6.92	13.45	8.64	8.32	12.69	11.14	10.64	13.67	12.00	11.79
Yellowmeadow 110 kV	23.86	11.88	10.73	16.50	13.80	13.25	29.47	15.10	13.58	17.68	16.78	16.11

**Table E-4 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2027**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Adamstown 110 kV	13.95	11.08	10.11	8.63	12.24	11.82	14.71	13.65	12.34	8.52	14.41	13.88
Agannagal 110 kV	3.06	5.86	5.25	4.31	4.57	4.43	2.95	6.45	5.83	4.25	4.89	4.77
Aghada 110 kV	4.70	8.26	7.81	5.66	9.62	9.41	4.73	10.33	9.82	5.82	11.63	11.40
Aghada A 220 kV	10.16	11.73	10.51	11.00	15.29	14.54	15.07	21.77	19.15	16.17	25.89	24.52
Aghada B 220 kV	10.16	11.73	10.51	11.00	15.29	14.54	15.07	21.77	19.15	16.17	25.89	24.52
Aghada C 220 kV	9.97	11.44	10.28	10.04	14.89	14.18	14.08	20.84	18.42	13.00	24.85	23.58
Aghada D 220 kV	10.16	11.73	10.51	11.00	15.29	14.54	15.07	21.77	19.15	16.17	25.89	24.52
Ahane 110 kV	5.19	13.39	12.22	5.89	8.64	8.46	4.88	15.62	14.40	5.75	9.44	9.28
Anner 110 kV	4.05	6.66	6.29	4.57	4.71	4.65	3.97	7.45	6.95	4.53	4.99	4.91
Ardnacrusha 110 kV	6.30	16.06	14.35	8.13	15.66	15.07	5.92	19.14	17.14	7.90	17.51	16.91
Ardnagappary 110 kV	2.77	2.23	2.10	4.09	1.26	1.25	2.97	2.78	2.53	4.16	1.63	1.60
Arigna 110 kV	4.84	7.85	7.16	5.96	5.77	5.64	4.83	9.09	8.42	6.02	6.36	6.24
Arklow 110 kV	10.60	8.66	8.18	11.47	10.18	9.95	10.33	10.32	9.79	11.54	11.86	11.61
Arklow 220 kV	9.11	7.64	7.26	10.52	6.86	6.75	9.00	9.05	8.77	10.61	7.76	7.69
Artane 110 kV	12.60	10.02	9.39	6.08	12.15	11.82	13.02	13.60	12.42	5.59	15.62	15.06
Arva 110 kV	4.82	10.00	8.96	6.01	7.43	7.22	4.66	11.32	10.27	5.95	8.06	7.87
Athea 110 kV	11.25	9.71	8.32	12.10	9.09	8.64	11.12	10.68	9.34	12.03	9.86	9.43
Athlone 110 kV	3.91	6.76	6.44	5.33	5.23	5.16	3.93	8.24	7.70	5.48	5.67	5.58
Athy 110 kV	4.89	7.12	6.88	6.02	5.84	5.78	4.75	8.12	7.83	5.98	6.35	6.29
Aughinish 110 kV	5.73	7.11	6.59	6.81	8.26	8.01	8.32	12.30	11.30	10.64	12.27	11.91
Aungierstown 110 kV	17.06	18.85	16.45	17.84	12.92	12.51	19.10	23.00	20.97	18.89	14.55	14.26
Ballinknocka 110 kV	5.85	7.17	6.68	6.71	7.02	6.86	8.02	12.09	11.30	8.75	9.71	9.54
Ballyadam 110 kV	3.56	8.64	8.15	4.57	7.00	6.89	3.38	10.59	9.98	4.49	8.01	7.89
Ballybeg 110 kV	9.57	6.26	6.02	9.85	7.30	7.19	9.65	7.26	6.97	9.98	8.30	8.18
Ballydine 110 kV	4.00	7.33	6.98	3.76	5.61	5.54	3.90	8.19	7.71	3.70	5.99	5.90
Ballylickey 110 kV	3.03	3.52	3.34	4.05	2.10	2.08	2.97	4.12	3.84	4.07	2.32	2.29
Ballynahulla 110 kV	15.96	10.63	9.36	13.23	10.32	9.88	16.13	13.33	11.78	13.11	12.55	12.04
Ballynahulla 220 kV	9.26	9.78	8.72	9.28	9.95	9.55	9.03	12.04	10.98	9.12	11.87	11.49
Ballyragget 110 kV	5.60	6.41	6.21	6.58	4.57	4.54	5.54	7.31	7.01	6.58	4.91	4.87
Ballyvouskill 110 kV	14.58	11.71	10.11	13.76	12.39	11.72	14.99	13.29	11.64	13.98	14.02	13.34
Ballyvouskill 220 kV	9.37	9.91	8.81	10.07	11.38	10.85	9.06	12.20	11.07	9.87	13.71	13.19
Ballywater 110 kV	5.43	6.37	6.12	3.29	6.10	6.02	5.35	7.75	7.52	3.15	7.05	6.99
Baltrasna 110 kV	5.95	9.68	9.06	7.12	7.52	7.39	5.90	12.13	11.61	7.26	8.59	8.50
Bancroft 110 kV	11.81	11.33	10.53	6.84	13.19	12.80	12.11	13.62	12.81	6.62	15.42	15.06
Bandon 110 kV	3.16	6.36	5.97	4.24	6.03	5.91	3.09	8.06	7.32	4.34	7.14	6.93
Banoge 110 kV	6.09	6.09	5.88	6.95	5.21	5.15	6.62	7.78	7.57	7.44	6.08	6.04
Barnageeragh 110 kV	9.22	17.28	15.32	9.32	20.35	19.38	9.93	25.30	22.94	9.97	27.68	26.67
Barnahealy A 110 kV	4.63	11.19	10.39	5.35	11.68	11.37	4.45	14.40	13.35	5.27	14.20	13.83
Barnahealy B 110 kV	6.28	11.13	10.33	6.93	11.37	11.08	6.18	14.31	13.23	6.93	13.80	13.45
Barnakyle 110 kV	16.53	18.58	16.24	18.34	12.66	12.26	18.30	22.62	20.64	19.48	14.24	13.95
Baroda 110 kV	4.00	7.95	7.56	4.78	9.09	8.91	3.92	10.20	9.71	4.83	11.06	10.87
Barrymore 110 kV	3.78	7.63	7.22	4.90	4.47	4.42	3.68	8.90	8.44	4.88	4.87	4.83

**Table E-4 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2027**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Belcamp 110 kV	15.72	16.47	14.61	14.14	20.31	19.30	16.85	22.72	20.24	14.97	26.65	25.42
Belcamp 220 kV	11.15	15.79	13.84	10.09	19.68	18.56	12.30	27.67	24.54	10.28	31.04	29.58
Belgard 110 kV	11.59	11.57	10.63	6.71	14.13	13.63	11.87	14.24	13.12	6.46	16.89	16.34
Bellacorick 110 kV	6.05	7.22	6.00	6.63	8.08	7.50	6.01	9.08	7.64	6.72	9.68	9.07
Binbane 110 kV	3.45	5.10	4.65	5.04	4.18	4.07	3.88	6.98	6.32	5.63	5.48	5.34
Blackrock 110 kV	10.27	10.29	9.60	2.72	10.51	10.25	9.81	14.77	13.44	2.34	13.36	12.98
Blake 110 kV	4.01	7.44	7.07	5.01	5.18	5.11	3.83	9.00	8.60	4.96	5.77	5.71
Blundelstown 110 kV	4.09	7.33	6.98	4.82	4.84	4.79	4.20	9.63	9.35	4.99	5.61	5.58
Boggeragh 110 kV	6.94	8.35	7.55	8.18	8.24	7.96	6.64	9.58	8.74	7.97	9.26	8.97
Booltiagh 110 kV	6.68	8.39	7.57	8.50	6.46	6.29	6.79	9.50	8.60	8.67	7.04	6.86
Bracklone 110 kV	3.57	6.91	6.65	4.69	6.29	6.22	3.41	8.18	7.95	4.63	7.05	6.99
Brinny A 110 kV	3.04	5.69	5.38	4.11	4.98	4.90	2.96	7.07	6.49	4.17	5.78	5.65
Brinny B 110 kV	3.03	5.72	5.40	4.11	5.01	4.93	2.96	7.11	6.52	4.17	5.83	5.69
Buffy 110 kV	3.81	4.83	4.65	4.12	5.85	5.76	5.16	8.04	6.83	5.40	8.79	8.25
Bunkimalta 110 kV	6.76	7.30	6.42	6.76	7.30	6.42	6.52	8.03	7.11	6.52	8.03	7.11
Butlerstown 110 kV	6.49	11.12	10.60	6.75	10.81	10.64	6.25	12.81	12.04	6.59	11.98	11.75
Cabra 110 kV	11.77	9.70	9.10	4.98	10.97	10.70	11.92	13.08	11.97	4.54	13.82	13.38
Cahir 110 kV	4.68	9.28	8.53	5.80	7.00	6.84	4.53	10.66	9.68	5.75	7.41	7.23
Carlow 110 kV	6.11	8.89	8.46	6.87	9.12	8.97	5.75	10.16	9.52	6.59	10.11	9.89
Carrickaduff 110 kV	6.34	5.88	5.01	6.68	3.28	3.18	6.14	6.18	5.32	6.59	3.38	3.28
Carrickalangan 110 kV	6.68	6.09	5.12	6.77	3.26	3.15	6.46	6.39	5.43	6.67	3.35	3.24
Carrickmines 220 kV	12.27	16.59	14.62	8.32	20.13	19.05	14.01	25.79	23.49	7.80	29.03	27.96
Carrickmines A 110 kV	26.26	10.99	10.34	21.11	12.08	11.81	33.48	13.60	12.69	23.67	14.33	13.98
Carrickmines B 110 kV	21.52	12.53	11.61	18.32	14.97	14.51	25.92	15.30	14.34	20.33	17.78	17.33
Carrick-on-Shannon 110 kV	5.00	12.18	11.05	5.81	12.59	12.16	4.80	14.61	13.43	5.71	14.49	14.08
Carrigadrohid 110 kV	6.91	13.26	11.98	7.07	12.20	11.81	6.48	16.53	14.98	6.81	14.33	13.90
Carrigdangan 110 kV	3.36	4.99	4.73	4.10	5.69	5.58	4.12	7.29	6.30	5.20	7.68	7.27
Carrowbeg 110 kV	2.93	3.09	2.90	4.01	2.61	2.56	2.85	3.54	3.28	3.97	2.88	2.82
Cashla 110 kV	7.28	15.66	14.34	7.62	19.37	18.65	7.31	21.88	19.66	7.78	25.81	24.70
Cashla 220 kV	8.37	9.53	8.88	9.38	9.77	9.53	8.61	13.03	12.27	9.84	12.24	12.00
Castlebagot 110 kV	17.79	19.04	16.61	20.76	13.10	12.68	20.24	23.28	21.20	22.59	14.77	14.46
Castlebagot 220 kV	9.92	19.53	16.77	8.85	20.71	19.53	9.48	30.10	27.19	8.28	28.38	27.43
Castlebar 110 kV	4.09	6.01	5.38	4.68	5.41	5.22	3.94	7.12	6.35	4.61	6.05	5.85
Castledockrill 110 kV	7.56	7.88	7.55	4.30	8.52	8.39	7.48	9.44	9.14	4.10	9.90	9.79
Castlefarm A 110 kV	5.47	6.91	6.42	6.43	7.80	7.58	7.34	11.76	10.83	9.05	11.33	11.03
Castlefarm B 110 kV	5.48	6.91	6.41	6.44	7.79	7.57	7.36	11.73	10.81	9.07	11.32	11.01
Castleview 110 kV	3.90	11.24	10.46	5.01	11.00	10.74	3.67	14.35	13.32	4.94	13.16	12.85
Cathaleen's Fall 110 kV	5.47	11.82	10.02	6.44	10.91	10.33	5.05	13.47	11.62	6.10	11.87	11.34
Cauteen 110 kV	6.08	8.62	7.85	6.76	4.64	4.56	5.89	9.42	8.61	6.69	4.88	4.80
Central Park 110 kV	13.75	10.09	9.53	7.57	10.88	10.65	14.43	12.33	11.56	7.42	12.75	12.46
Charleville 110 kV	4.85	6.90	6.31	6.59	5.90	5.75	4.72	7.66	6.99	6.51	6.36	6.20
Cherrywood 110 kV	10.09	9.34	8.86	7.43	9.57	9.39	10.12	11.30	10.64	7.29	11.08	10.86

**Table E-4 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2027**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
City West 110 kV	5.97	7.31	6.84	6.01	5.55	5.45	5.78	8.81	7.99	5.91	6.16	6.02
CKM_Country 110 kV	21.52	12.53	11.61	18.32	14.97	14.51	25.92	15.30	14.34	20.33	17.78	17.33
Clahane 110 kV	4.22	7.84	7.18	5.27	6.74	6.56	4.09	9.73	9.09	5.32	7.79	7.64
Clashavoon 220 kV	9.32	10.09	9.07	10.06	11.30	10.83	9.09	12.92	11.82	9.96	13.93	13.47
Clashavoon A 110 kV	8.31	15.94	14.09	8.57	19.46	18.47	7.83	20.37	18.08	8.20	24.25	23.08
Clashavoon B 110 kV	8.31	15.94	14.09	8.57	19.46	18.47	7.83	20.37	18.08	8.20	24.25	23.08
Cliff 110 kV	4.71	8.56	7.55	6.07	7.16	6.90	4.43	9.45	8.47	5.86	7.60	7.37
Cloghboola 110 kV	7.65	8.61	7.20	10.81	7.89	7.43	7.66	9.58	8.12	10.95	8.62	8.17
Cloghboola 110 kV	7.65	8.61	7.20	10.81	7.89	7.43	7.66	9.58	8.12	10.95	8.62	8.17
Clogher 110 kV	5.33	10.92	8.78	6.26	9.99	9.28	4.98	12.08	9.85	5.99	10.61	9.94
Cloghran 110 kV	9.15	17.38	15.40	9.58	20.55	19.56	9.82	25.50	23.10	10.37	28.02	26.98
Cloncreen 110 kV	4.10	7.08	6.76	5.12	7.77	7.64	4.39	9.64	9.32	5.71	9.79	9.67
Clonee 220 kV	11.32	16.19	14.20	9.26	15.93	15.21	11.37	25.13	22.80	8.80	21.50	20.87
Clonfad 110 kV	4.21	6.84	6.55	5.52	5.72	5.65	4.68	10.21	9.86	6.34	7.20	7.14
Clonkeen A 110 kV	5.67	6.12	5.79	6.81	4.31	4.25	5.54	7.01	6.67	6.77	4.73	4.68
Clonkeen B 110 kV	4.85	9.86	8.54	4.11	10.37	9.83	4.69	11.17	9.78	4.00	11.72	11.16
Cloon 110 kV	4.73	7.64	7.19	6.27	6.45	6.34	4.59	9.27	8.62	6.29	7.39	7.25
Clutterland 110 kV	17.05	18.91	16.50	18.47	12.97	12.55	19.10	23.09	21.05	19.67	14.61	14.32
College Park 110 kV	8.53	16.12	14.43	6.23	19.22	18.36	8.80	23.08	21.12	5.87	25.84	24.96
Cookstown 110 kV	7.15	8.02	7.61	5.89	6.83	6.72	6.98	9.27	8.89	5.76	7.60	7.51
Cookstown A 110 kV	4.92	6.25	5.89	5.19	4.48	4.41	4.75	7.47	6.78	5.11	4.91	4.81
Coolderrig 110 kV	18.01	11.39	10.36	12.08	12.07	11.66	20.14	14.10	12.71	12.32	14.18	13.67
Coolnabacky 110 kV	7.67	12.60	11.89	8.06	15.67	15.29	7.77	15.98	15.31	8.25	19.24	18.91
Coolnabacky 400 kV	9.12	8.51	7.74	9.19	8.39	8.11	8.71	10.54	10.05	8.89	9.82	9.67
Coolnagoonag 110 kV	10.30	16.41	14.65	10.02	19.23	18.36	10.14	22.62	20.85	9.94	25.09	24.32
Coolroe 110 kV	3.76	9.45	8.77	5.09	8.80	8.60	3.59	11.56	10.61	5.04	10.16	9.90
Coomagearlahy 110 kV	5.33	7.98	6.85	5.95	8.62	8.13	5.19	9.00	7.79	5.84	9.72	9.20
Coomataggart 110 kV	9.93	7.48	6.61	6.67	4.06	3.96	9.89	8.47	7.53	6.64	4.57	4.47
Coomataggart 110 kV	9.93	7.48	6.61	6.67	4.06	3.96	9.89	8.47	7.53	6.64	4.57	4.47
Cordal 110 kV	12.30	8.99	8.01	7.74	8.78	8.44	12.70	11.48	10.20	7.57	10.80	10.39
Corderry 110 kV	4.39	8.80	7.78	5.64	7.57	7.29	4.47	10.59	9.52	5.85	8.64	8.38
Corduff 110 kV	9.54	18.43	16.26	10.39	22.28	21.14	10.56	27.76	25.01	11.84	31.16	29.92
Corduff 220 kV	12.58	17.82	15.44	11.93	21.91	20.57	14.49	30.88	27.34	12.86	34.17	32.56
Corkagh 110 kV	17.06	18.75	16.37	19.02	12.79	12.38	19.10	22.85	20.84	20.34	14.38	14.10
Corraclassy 110 kV	4.49	7.14	6.62	5.74	5.10	5.00	4.39	7.56	7.10	5.68	5.31	5.23
Cow Cross 110 kV	4.25	11.23	10.43	4.83	10.17	9.94	4.07	14.52	13.47	4.75	12.16	11.89
Crane 110 kV	7.74	8.82	8.35	7.38	8.89	8.72	8.43	11.52	11.02	7.78	10.84	10.69
Croaghaun 110 kV	6.14	6.51	5.45	6.95	7.05	6.58	6.08	7.97	6.78	7.03	8.26	7.78
Croaghmagawna 110 kV	6.46	6.35	5.35	6.98	3.68	3.55	6.24	6.69	5.70	6.87	3.79	3.67
Cromcastle A 110 kV	10.38	15.01	13.45	6.43	18.05	17.24	9.87	20.26	18.23	5.88	23.16	22.20
Cromcastle B 110 kV	10.38	15.01	13.45	6.43	18.05	17.24	9.87	20.26	18.23	5.88	23.16	22.20
Crory 110 kV	9.71	9.05	8.61	9.72	10.55	10.34	10.05	11.09	10.68	10.10	12.61	12.43

**Table E-4 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2027**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Cruiserath 220 kV	12.42	17.71	15.36	11.66	21.74	20.42	14.10	30.58	27.09	12.38	33.77	32.20
Cullenagh 110 kV	8.02	13.44	12.71	8.59	14.93	14.62	7.79	15.83	14.83	8.45	17.06	16.65
Cullenagh 220 kV	8.91	9.59	9.16	9.17	9.05	8.92	8.57	10.79	10.43	8.94	9.89	9.79
Cunghill 110 kV	3.25	5.92	5.45	3.83	5.21	5.08	3.07	7.10	6.64	3.77	5.89	5.78
Cureeny 110 kV	6.10	6.87	6.03	6.10	6.87	6.03	5.89	7.53	6.65	5.89	7.53	6.65
Cureeny T 110 kV	6.37	8.58	7.63	5.57	7.10	6.86	6.11	9.54	8.54	5.44	7.70	7.46
Cushaling 110 kV	4.11	7.15	6.83	5.17	7.99	7.85	4.39	9.74	9.41	5.78	10.10	9.98
Dallow 110 kV	3.49	4.97	4.72	4.66	3.07	3.04	3.49	6.05	5.81	4.76	3.39	3.37
Dalton 110 kV	3.45	4.84	4.46	4.74	3.67	3.60	3.56	5.83	5.36	4.96	4.09	4.01
Dardistown 110 kV	12.81	15.49	13.84	9.30	19.01	18.12	12.81	21.09	18.92	8.93	24.67	23.60
Darndale 110 kV	15.00	15.98	14.21	13.63	19.08	18.17	15.76	21.83	19.50	14.22	24.66	23.59
DEENES 110 kV	5.51	9.56	8.92	6.56	7.02	6.90	5.58	12.13	11.56	6.77	8.00	7.91
Derrybrien 110 kV	3.09	4.78	4.20	4.51	4.22	4.06	2.99	5.17	4.59	4.45	4.49	4.34
Derryiron 110 kV	4.64	7.35	7.02	5.76	7.85	7.72	5.69	11.75	11.14	7.40	10.74	10.57
Derrylahan 110 kV	4.85	11.26	10.47	5.81	10.26	10.03	5.02	15.21	14.42	6.28	12.44	12.26
Doon 110 kV	4.40	7.33	6.90	4.76	5.31	5.23	4.31	8.28	7.68	4.72	5.63	5.54
Dromada 110 kV	10.13	8.89	7.67	6.32	8.22	7.83	10.00	9.75	8.57	6.23	8.89	8.53
Drombeg 110 kV	7.22	8.49	7.91	7.33	6.68	6.55	7.28	10.87	10.37	7.41	7.78	7.70
Drumkeen 110 kV	3.96	8.59	7.28	5.15	6.88	6.56	3.87	9.76	8.20	5.11	7.51	7.16
Drumline 110 kV	3.32	8.56	8.00	4.68	6.80	6.67	3.20	9.87	9.15	4.65	7.42	7.28
Drybridge 110 kV	5.22	11.56	10.55	6.28	9.61	9.37	5.12	15.09	13.94	6.40	11.39	11.16
Dundalk 110 kV	3.55	8.86	8.22	4.63	7.79	7.61	3.35	9.98	9.27	4.49	8.51	8.33
Dunfirth 110 kV	4.47	6.62	6.35	5.96	5.34	5.28	4.60	8.76	8.52	6.42	6.31	6.26
Dungarvan 110 kV	5.94	6.16	5.87	7.80	4.96	4.89	6.44	7.94	7.16	8.51	5.73	5.58
Dunmanway 110 kV	4.17	8.26	7.57	5.06	7.94	7.71	4.43	11.27	9.81	5.47	9.87	9.45
Dunstown 220 kV	10.29	17.81	15.85	10.47	20.18	19.25	9.50	22.78	21.36	9.83	24.62	24.04
Dunstown 400 kV	9.58	8.42	7.66	11.40	8.98	8.67	9.19	10.36	9.89	11.26	10.58	10.41
Ennis 110 kV	4.40	11.83	10.66	5.85	9.70	9.42	4.40	14.56	12.86	5.98	11.25	10.88
Fassaroe East 110 kV	5.17	7.50	7.15	5.32	5.77	5.70	4.97	8.71	8.31	5.22	6.38	6.31
Fassaroe West 110 kV	5.31	7.66	7.29	5.42	5.96	5.88	5.10	8.90	8.50	5.31	6.60	6.53
Finglas 220 kV	12.36	16.74	14.58	12.25	21.41	20.10	15.37	30.20	26.58	14.49	34.95	33.15
Finglas A 110 kV	16.01	16.40	14.61	10.93	19.89	18.95	17.18	22.88	20.39	10.82	26.21	25.03
Finglas B 110 kV	25.19	11.16	10.40	24.30	14.12	13.69	35.78	15.49	14.06	31.55	18.70	17.96
Firlough 110 kV	3.79	5.51	5.07	4.58	4.68	4.57	3.91	8.41	7.85	5.04	5.89	5.80
Flagford 110 kV	5.30	12.77	11.56	6.27	14.78	14.20	5.10	15.45	14.18	6.18	17.35	16.78
Flagford 220 kV	8.04	7.32	6.85	10.27	6.66	6.53	7.91	8.52	8.17	10.34	7.43	7.34
Fortunestown 110 kV	5.60	7.20	6.74	5.60	5.48	5.38	5.40	8.67	7.87	5.50	6.08	5.94
Francis Street A 110 kV	10.69	10.30	9.61	5.58	12.62	12.25	10.30	14.79	13.45	4.92	16.99	16.36
Francis Street B 110 kV	12.16	11.55	10.65	6.58	14.04	13.57	12.55	14.26	13.17	6.32	16.82	16.28
Gallanstown 110 kV	6.53	8.00	7.56	6.94	5.77	5.69	7.06	10.97	10.58	7.27	6.87	6.82
Galway 110 kV	5.21	12.19	11.30	4.59	14.41	13.98	5.19	17.19	15.25	4.48	19.13	18.26
Garballagh 110 kV	3.99	9.02	8.39	4.77	6.60	6.48	3.95	11.30	10.65	4.85	7.42	7.32

**Table E-4 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2027**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Garrow 110 kV	10.52	11.30	9.76	10.41	12.04	11.40	10.48	12.82	11.22	10.38	13.62	12.96
Garvagh 110 kV	4.75	7.07	6.27	6.26	5.98	5.77	5.02	8.56	7.71	6.67	6.83	6.64
Gilra 110 kV	3.20	6.62	6.24	4.10	4.92	4.85	3.08	7.41	7.06	4.04	5.34	5.28
Glanagow 220 kV	10.47	11.75	10.51	10.77	15.23	14.48	14.69	20.96	18.51	14.15	24.95	23.66
Glanlee 110 kV	5.15	7.87	6.76	5.42	8.47	7.99	5.02	8.88	7.69	5.32	9.55	9.04
Glasmore A 110 kV	3.98	7.41	6.97	4.44	5.14	5.07	3.66	9.21	8.55	4.32	5.77	5.68
Glen 110 kV	4.73	7.05	6.26	6.11	5.94	5.74	5.00	8.54	7.69	6.50	6.79	6.60
Glenlara A 110 kV	3.30	3.19	2.96	4.81	2.55	2.50	3.25	3.42	3.15	4.77	2.68	2.63
Glenlara B 110 kV	9.55	8.13	7.14	6.29	8.28	7.90	9.16	10.04	8.88	6.04	10.01	9.59
Glenree 110 kV	3.71	5.45	5.03	4.51	4.60	4.49	3.78	7.95	7.44	4.87	5.67	5.58
Golagh 110 kV	4.09	8.42	7.06	4.95	6.51	6.20	3.88	9.15	7.77	4.80	6.84	6.54
Gorman 110 kV	6.74	13.34	12.11	7.71	14.64	14.11	6.80	17.74	16.13	7.96	18.07	17.47
Gorman 220 kV	8.77	11.22	10.30	9.73	9.15	8.93	8.63	13.32	12.75	9.69	10.17	10.06
Gortawee 110 kV	4.72	6.74	6.23	6.39	5.14	5.04	4.63	7.16	6.69	6.34	5.40	5.30
Grange 110 kV	12.47	15.77	14.07	6.75	18.83	17.95	12.36	21.64	19.33	6.18	24.41	23.34
Grange Castle 110 kV	19.33	11.70	10.62	13.68	13.03	12.55	22.13	14.57	13.09	14.21	15.47	14.87
Great Island 110 kV	8.98	14.13	13.34	9.94	16.64	16.26	8.61	16.27	15.34	9.66	18.82	18.38
Great Island 220 kV	13.40	13.38	12.68	14.03	14.20	13.92	12.52	14.72	14.15	13.39	15.23	15.02
Griffinrath A 110 kV	6.98	9.87	9.37	7.34	9.96	9.78	6.42	12.21	11.73	6.99	11.63	11.48
Griffinrath B 110 kV	7.49	10.20	9.67	7.50	9.98	9.81	6.92	12.70	12.18	7.14	11.63	11.48
Harolds Cross 110 kV	10.85	10.33	9.63	5.29	12.59	12.23	10.49	14.84	13.49	4.65	16.93	16.30
Harristown 110 kV	4.33	6.95	6.65	5.64	5.71	5.64	4.70	10.03	9.72	6.32	7.04	6.99
Heuston 110 kV	13.04	11.77	10.84	7.84	14.46	13.96	13.66	14.57	13.44	7.64	17.39	16.82
Huntstown A 220 kV	11.93	16.12	14.10	11.05	20.61	19.39	14.66	28.81	25.48	12.22	33.41	31.75
Huntstown B 220 kV	12.93	16.82	14.71	10.22	20.66	19.47	14.66	27.64	24.78	9.97	30.96	29.65
Ikerrin 110 kV	5.70	5.15	4.75	6.43	3.55	3.48	5.59	5.70	5.25	6.42	3.77	3.70
Inchicore 220 kV	11.59	19.06	16.38	9.24	23.24	21.74	13.00	32.79	29.17	8.89	36.19	34.56
Inchicore A 110 kV	24.05	12.94	11.83	22.06	16.26	15.65	31.07	16.26	14.89	26.38	19.90	19.17
Inchicore B 110 kV	33.09	12.86	11.64	27.89	16.21	15.52	51.22	16.31	14.60	36.46	19.93	19.01
Inniscarra 110 kV	3.78	9.43	8.73	5.02	8.54	8.34	3.58	11.39	10.48	4.93	9.73	9.50
Irishtown 220 kV	12.61	17.90	15.56	10.50	22.29	20.93	15.00	30.88	27.65	10.65	35.09	33.55
Kellis 110 kV	7.18	9.46	9.02	8.33	10.78	10.58	6.73	10.78	10.16	7.93	12.04	11.77
Kellis 220 kV	8.32	7.90	7.56	10.05	6.59	6.51	7.89	8.76	8.52	9.78	7.08	7.03
Kellystown 220 kV	6.94	15.44	13.67	6.21	12.93	12.47	6.00	21.01	19.60	5.68	15.78	15.49
Kilbarry 110 kV	5.88	14.55	13.21	6.86	14.30	13.83	5.64	19.61	17.49	6.79	17.69	17.07
Kilcarbery 110 kV	16.76	18.62	16.28	18.48	12.67	12.27	18.64	22.67	20.69	19.65	14.25	13.97
Kildonan 110 kV	6.72	12.93	11.81	5.26	12.11	11.76	6.43	17.34	16.19	4.96	14.82	14.53
Kilkenny 110 kV	4.80	7.18	6.93	6.33	6.04	5.98	4.81	8.25	7.83	6.44	6.51	6.42
Kill Hill 110 kV	5.68	6.90	6.21	6.84	5.51	5.35	5.50	7.67	6.90	6.78	5.92	5.75
Killonan 110 kV	7.40	19.81	17.38	7.57	14.70	14.20	6.82	24.30	21.60	7.28	16.53	16.07
Killonan 220 kV	8.28	10.33	9.49	10.82	8.78	8.56	7.80	12.57	11.89	10.63	10.03	9.88
Killoteran 110 kV	7.40	12.25	11.62	7.61	12.92	12.68	7.11	14.22	13.31	7.40	14.52	14.19



**Table E-4 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2027**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Kilmahud 110 kV	16.75	18.68	16.33	19.03	12.84	12.43	18.63	22.77	20.78	20.35	14.46	14.17
Kilmore 110 kV	13.51	16.03	14.27	9.45	19.59	18.64	13.72	22.05	19.68	9.09	25.58	24.43
Kilnap 110 kV	5.90	15.30	13.85	6.57	13.86	13.43	5.59	20.35	18.29	6.42	16.84	16.33
Kilpaddoge 110 kV	10.51	16.62	14.81	11.17	20.17	19.21	10.35	22.94	21.12	11.35	26.57	25.71
Kilpaddoge 220 kV	10.33	16.22	14.23	9.96	19.89	18.78	10.26	21.03	19.34	9.84	25.03	24.17
Kilpaddoge 400 kV	7.73	9.14	8.21	7.03	9.81	9.42	7.15	11.55	10.92	6.56	11.69	11.47
Kilteel 110 kV	4.31	7.18	6.87	5.37	6.52	6.43	4.53	9.57	9.12	5.76	7.89	7.78
Kinnegad 110 kV	4.36	7.57	7.21	5.70	6.90	6.80	4.88	11.41	10.98	6.69	8.88	8.79
Kishoge 110 kV	16.09	18.31	16.04	16.87	12.43	12.05	17.63	22.24	20.33	17.69	13.97	13.69
Knockacummer 110 kV	8.46	7.08	6.25	7.08	6.88	6.60	8.09	8.66	7.71	6.85	8.26	7.94
Knockalough 110 kV	3.97	4.29	4.14	3.75	5.17	5.09	5.34	6.87	5.93	4.48	7.56	7.14
Knockanure 220 kV	10.44	13.98	12.31	7.36	17.10	16.17	10.27	17.40	15.96	6.98	20.81	20.07
Knockanure A 110 kV	19.16	13.44	11.37	15.48	14.15	13.29	19.93	15.15	13.13	15.70	15.69	14.88
Knockanure B 110 kV	4.78	8.62	7.92	5.86	6.81	6.66	4.47	10.51	9.87	5.73	7.73	7.61
Knockearagh 110 kV	5.49	5.72	5.35	7.39	4.69	4.61	5.44	6.71	6.27	7.46	5.23	5.14
Knocknamona 110 kV	5.68	5.97	5.68	5.68	5.97	5.68	6.46	7.97	7.06	7.20	5.03	4.90
Knockraha A 110 kV	7.44	18.12	16.26	8.26	18.63	17.92	7.55	25.43	22.66	8.51	23.87	22.98
Knockraha A 220 kV	9.51	12.83	11.49	9.80	14.24	13.63	10.83	20.63	18.49	10.71	20.40	19.63
Knockraha B 110 kV	7.44	18.12	16.26	8.26	18.63	17.92	7.55	25.43	22.66	8.51	23.87	22.98
Knockraha B 220 kV	9.51	12.83	11.49	9.80	14.24	13.63	10.83	20.63	18.49	10.71	20.40	19.63
Knockranny 110 kV	6.19	7.94	7.53	5.28	10.02	9.80	6.22	9.90	9.23	5.22	12.24	11.88
Knockranny A 110 kV	3.81	4.87	4.68	4.10	5.88	5.78	5.15	8.09	6.87	5.36	8.82	8.28
Knockranny B 110 kV	6.19	7.94	7.53	5.28	10.02	9.80	6.22	9.90	9.23	5.22	12.24	11.88
Knockumber 110 kV	3.84	8.01	7.48	4.67	6.02	5.92	3.61	9.46	8.87	4.58	6.60	6.50
Lanesboro 110 kV	3.04	8.45	8.01	4.14	7.10	7.00	3.07	10.78	9.95	4.31	8.41	8.23
Lenalea 110 kV	3.85	6.55	5.84	5.05	4.38	4.26	4.38	8.48	7.15	5.50	5.35	5.14
Letterkenny 110 kV	4.35	10.14	8.52	5.48	8.58	8.13	4.46	12.26	10.02	5.64	9.91	9.34
Liberty A 110 kV	5.43	14.69	13.33	4.82	16.01	15.43	5.12	19.83	17.72	4.55	20.24	19.44
Liberty B 110 kV	5.35	14.68	13.32	4.67	15.97	15.40	5.03	19.80	17.70	4.40	20.18	19.39
Limerick 110 kV	5.14	16.07	14.36	6.32	13.12	12.71	4.92	19.96	17.95	6.27	14.96	14.55
Lisdrum 110 kV	2.90	5.46	5.08	4.33	4.48	4.39	3.69	7.56	6.61	5.44	5.14	4.98
Lisheen 110 kV	5.01	4.94	4.32	5.02	7.39	6.90	4.81	5.50	4.83	4.98	8.25	7.71
Lodgewood 110 kV	9.71	9.05	8.61	9.72	10.55	10.34	10.05	11.09	10.68	10.10	12.61	12.43
Lodgewood 220 kV	9.25	7.67	7.35	10.28	7.02	6.92	9.26	8.81	8.58	10.42	7.79	7.72
Longpoint 220 kV	9.89	11.52	10.34	9.68	14.85	14.14	14.38	21.32	18.80	12.34	24.95	23.67
Loughtown 220 kV	12.87	13.27	12.58	11.43	13.87	13.61	12.00	14.59	14.03	10.86	14.86	14.67
Louth 220 kV	9.96	17.14	14.99	10.78	19.23	18.22	9.44	21.53	20.01	10.40	23.21	22.58
Louth A 110 kV	6.71	12.75	11.62	7.78	15.12	14.55	6.33	14.48	13.56	7.49	16.83	16.40
Louth A 275 kV	11.54	10.26	9.29	11.35	11.91	11.43	11.28	12.27	11.74	10.99	13.95	13.71
Louth B 110 kV	7.27	14.10	12.85	8.15	17.10	16.45	6.76	16.50	15.35	7.74	19.51	18.95
Louth B 275 kV	10.86	10.27	9.29	9.88	12.15	11.66	10.54	12.28	11.75	9.44	14.28	14.03
Lumcloon 110 kV	5.21	7.24	6.89	6.33	4.97	4.91	5.85	9.65	9.36	6.90	5.75	5.71
Macetown 110 kV	7.15	14.23	12.88	6.73	14.60	14.09	6.93	19.62	18.14	6.53	18.52	18.06

**Table E-4 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2027**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Macroom 110 kV	7.30	15.13	13.46	7.13	15.79	15.12	6.79	19.35	17.22	6.78	19.17	18.41
Mallow 110 kV	5.20	6.56	6.17	7.02	5.48	5.39	5.12	7.48	7.01	7.01	6.01	5.91
Marina 110 kV	6.30	16.18	14.54	7.19	17.70	17.00	6.06	22.45	19.80	7.13	22.89	21.89
Maynooth A 110 kV	10.72	12.31	11.56	11.42	15.09	14.70	10.25	15.90	15.17	11.16	18.73	18.38
Maynooth A 220 kV	9.65	18.09	15.94	9.56	17.59	16.83	8.92	24.39	22.71	9.04	21.59	21.12
Maynooth B 110 kV	7.84	15.57	14.17	9.19	15.20	14.73	7.09	19.62	18.62	8.75	17.99	17.70
Maynooth B 220 kV	7.90	16.70	14.69	7.81	15.95	15.27	7.08	23.44	21.81	7.28	20.13	19.70
McDermott 110 kV	14.64	10.29	9.62	6.17	12.21	11.88	16.15	14.13	12.85	5.69	15.76	15.19
Meath Hill 110 kV	4.11	9.26	8.56	5.36	7.29	7.13	3.87	10.57	9.84	5.22	8.00	7.85
Meentycat 110 kV	3.66	7.02	6.03	5.12	5.69	5.44	3.56	7.75	6.64	5.06	6.09	5.83
Midleton 110 kV	3.61	9.45	8.88	4.74	8.14	7.99	3.40	11.75	10.98	4.66	9.44	9.27
Milltown A 110 kV	14.09	11.03	10.25	7.16	13.70	13.27	14.80	16.22	14.67	6.44	18.88	18.13
Milltown B 110 kV	8.69	10.45	9.70	4.14	12.47	12.10	8.55	12.75	11.82	3.89	14.74	14.31
Misery Hill 110 kV	12.90	10.81	10.05	7.81	13.51	13.10	13.11	15.78	14.29	7.13	18.58	17.84
Monatooreen 110 kV	5.47	17.02	15.36	5.75	17.40	16.78	5.16	23.39	21.01	5.56	21.97	21.21
Moneteen 110 kV	5.14	10.57	9.72	6.21	7.64	7.48	5.17	13.08	12.17	6.34	8.61	8.48
Moneypoint 110 kV	13.71	9.61	8.93	16.66	9.29	9.07	13.94	10.77	10.18	17.03	10.19	10.01
Moneypoint 220 kV	10.41	15.91	14.00	10.67	19.65	18.58	10.34	20.51	18.92	10.66	24.65	23.83
Moneypoint G1 400 kV	9.91	9.25	8.31	11.52	10.87	10.39	9.53	11.73	11.09	11.37	13.15	12.87
Moneypoint G2 400 kV	27.55	3.25	3.10	27.81	4.23	4.15	30.68	3.66	3.57	30.77	4.71	4.65
Moneypoint G3 400 kV	9.91	9.25	8.31	11.52	10.87	10.39	9.53	11.73	11.09	11.37	13.15	12.87
Monread 110 kV	4.04	7.15	6.84	4.91	7.15	7.04	4.08	9.25	8.83	5.09	8.55	8.43
Mount Lucas 110 kV	4.07	6.05	5.77	5.24	5.66	5.58	4.10	7.93	7.61	5.47	6.82	6.74
Moy 110 kV	4.87	6.37	5.71	5.94	6.69	6.43	5.69	10.08	9.05	7.38	9.01	8.71
Mullagharlin 110 kV	3.61	8.90	8.28	4.72	8.12	7.94	3.41	9.89	9.30	4.57	8.75	8.59
Mullingar 110 kV	3.48	6.53	6.27	4.80	6.15	6.07	3.59	8.56	8.17	5.19	7.51	7.41
Mully Graffy 110 kV	3.39	4.23	3.90	3.39	4.23	3.90	4.13	5.94	5.13	5.77	5.35	5.11
Mulreavy 110 kV	5.40	9.62	7.78	6.65	9.29	8.62	5.09	10.48	8.61	6.38	9.78	9.15
Mungret A 110 kV	4.85	10.03	9.26	5.92	7.12	6.98	4.83	12.30	11.49	6.01	7.99	7.87
Mungret B 110 kV	4.85	10.05	9.28	5.91	7.12	6.98	4.82	12.33	11.52	6.01	7.99	7.87
Nangor 110 kV	16.72	11.44	10.40	10.74	12.71	12.25	18.34	14.17	12.76	10.81	15.03	14.46
Navan 110 kV	5.83	11.93	10.89	6.62	11.71	11.36	5.68	15.47	14.12	6.62	14.03	13.63
Nenagh 110 kV	3.36	4.15	3.86	4.16	2.55	2.52	3.29	4.53	4.19	4.12	2.71	2.67
Newbridge 110 kV	4.15	8.98	8.49	4.87	8.93	8.76	4.04	11.77	11.13	4.89	10.90	10.71
Newbury 110 kV	12.40	15.75	14.05	6.49	18.66	17.79	12.28	21.57	19.28	5.92	24.11	23.07
North Quays 110 kV	16.53	11.22	10.42	6.71	13.72	13.29	18.66	16.60	14.99	5.99	18.89	18.15
North Wall 220 kV	11.50	15.27	13.45	8.01	17.75	16.84	13.64	26.85	23.90	7.43	27.10	25.98
Oldbridge 110 kV	4.55	10.42	9.55	5.40	8.05	7.87	4.39	13.22	12.28	5.42	9.25	9.09
Oldcourt A 110 kV	3.78	9.52	8.94	4.46	7.74	7.60	3.59	11.90	11.19	4.39	8.98	8.84
Oldcourt B 110 kV	3.81	9.58	8.99	4.49	7.82	7.68	3.63	11.99	11.26	4.41	9.08	8.94
Oldstreet 220 kV	12.21	8.47	8.02	11.18	9.71	9.50	14.61	12.94	12.24	12.24	13.40	13.13
Oldstreet 400 kV	8.99	8.66	7.90	8.16	7.71	7.49	9.21	11.68	11.15	8.10	9.36	9.24

**Table E-4 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2027**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Oriel 220 kV	9.84	13.68	12.07	9.84	13.68	12.07	9.21	16.13	14.93	9.21	16.13	14.93
Oughtragh 110 kV	3.68	4.64	4.37	4.83	2.95	2.92	3.58	5.39	5.06	4.81	3.22	3.18
Pelletstown 110 kV	13.00	9.79	9.18	7.84	10.77	10.51	13.41	13.18	12.07	7.45	13.51	13.10
Platin 110 kV	4.21	9.66	8.90	5.02	7.18	7.03	4.07	12.08	11.29	5.03	8.12	8.00
Pollahoney 110 kV	9.96	8.14	7.71	10.33	8.96	8.78	9.67	9.62	9.15	10.29	10.29	10.10
Pollaphuca 110 kV	3.34	2.95	2.87	4.79	2.46	2.44	3.27	3.18	3.07	4.72	2.57	2.55
Poolbeg A 110 kV	21.84	11.72	10.86	19.13	14.96	14.47	29.28	17.41	15.72	22.45	21.06	20.18
Poolbeg A 220 kV	11.46	15.39	13.55	6.99	16.89	16.06	13.25	26.99	24.03	6.20	25.20	24.23
Poolbeg B 110 kV	21.82	11.70	10.84	19.12	14.95	14.46	29.23	17.38	15.70	22.43	21.03	20.15
Poolbeg B 220 kV	11.38	17.76	15.40	9.13	20.36	19.19	13.01	30.34	27.27	8.93	30.71	29.55
Poppintree 110 kV	11.24	15.40	13.79	6.45	18.51	17.67	10.87	21.05	18.88	5.88	23.97	22.95
Portan 260 kV	15.41	11.60	10.68	77.08	3.11	3.09	16.17	14.85	14.32	16.17	14.85	14.32
Portan 400 kV	12.13	9.73	8.78	12.02	10.72	10.30	12.01	13.34	12.71	12.01	13.34	12.71
Portlaoise 110 kV	5.78	11.09	10.47	6.74	10.72	10.52	5.76	14.30	13.63	6.88	12.83	12.64
Pottery 110 kV	16.28	10.42	9.83	5.63	10.68	10.46	17.70	12.80	11.98	5.43	12.47	12.20
Prospect 220 kV	9.26	13.41	12.03	7.53	14.03	13.47	9.05	16.78	15.71	7.25	16.75	16.37
Raffeen 220 kV	10.04	11.46	10.29	9.45	14.45	13.78	13.21	19.63	17.47	10.93	22.66	21.60
Raffeen A 110 kV	5.54	12.90	11.86	6.32	15.31	14.80	5.45	17.13	15.70	6.37	19.44	18.79
Raffeen B 110 kV	7.59	12.84	11.79	8.43	15.09	14.57	7.75	16.98	15.50	8.73	19.04	18.39
Rathkeale 110 kV	3.49	7.24	6.84	4.80	5.55	5.47	3.39	8.52	8.00	4.80	6.15	6.06
Rathnaskillo 110 kV	6.11	7.04	6.77	7.08	5.21	5.16	6.54	8.78	8.25	7.46	5.88	5.79
Ratrussan 110 kV	4.00	8.13	6.85	5.21	8.53	8.00	3.79	8.93	7.59	5.04	9.17	8.65
Reamore 110 kV	4.00	9.00	7.99	4.42	7.37	7.12	3.67	10.99	9.94	4.24	8.32	8.11
Richmond A 110 kV	2.76	6.02	5.78	4.02	5.10	5.05	2.74	7.35	6.86	4.12	6.02	5.91
Richmond B 110 kV	2.76	6.02	5.78	4.02	5.10	5.05	2.74	7.35	6.86	4.12	6.02	5.91
Rinawade 110 kV	4.93	10.16	9.53	5.88	7.44	7.32	4.62	12.32	11.91	5.76	8.38	8.32
Ringaskiddy 110 kV	5.55	10.81	10.05	5.97	10.58	10.32	5.36	13.78	12.79	5.87	12.70	12.40
Ringsend 110 kV	21.79	11.71	10.84	19.72	14.97	14.47	29.80	17.61	15.83	23.83	21.29	20.36
Rossiple 110 kV	6.59	8.27	7.90	7.34	5.99	5.92	6.32	9.18	8.79	7.19	6.37	6.31
Ryebrook 110 kV	5.49	12.99	11.73	6.36	11.59	11.23	4.94	16.06	15.01	6.03	13.49	13.23
Salthill 110 kV	4.57	11.63	10.82	3.70	13.51	13.12	4.67	16.44	14.58	3.61	17.87	17.07
Screeb 110 kV	3.71	2.50	2.42	4.67	1.76	1.75	4.07	3.29	3.00	5.02	2.04	2.00
Seal Rock A 110 kV	5.57	6.98	6.48	6.54	8.14	7.90	7.89	12.03	11.07	9.86	12.07	11.73
Seal Rock B 110 kV	5.57	6.98	6.48	6.54	8.14	7.90	7.92	12.04	11.07	9.87	12.07	11.73
Shankill 110 kV	4.35	9.24	8.05	5.57	8.00	7.67	4.21	10.78	9.34	5.53	9.03	8.65
Shannonbridge 110 kV	4.86	12.40	11.45	6.11	13.12	12.74	5.03	16.85	15.86	6.79	16.38	16.06
Shannonbridge 220 kV	6.50	6.50	6.17	8.69	5.44	5.36	7.05	8.33	8.14	9.67	6.35	6.31
Shantallow 110 kV	4.22	11.46	10.74	4.68	9.68	9.50	4.07	14.99	14.00	4.64	11.55	11.34
Shellybanks A 220 kV	11.26	15.37	13.53	8.45	17.86	16.94	12.89	26.94	23.99	8.01	27.26	26.14
Shellybanks B 220 kV	12.12	17.19	15.01	9.32	21.14	19.91	14.26	29.43	26.44	9.04	32.88	31.51
Shelton Abbey 110 kV	9.71	7.98	7.57	9.85	8.58	8.42	9.41	9.40	8.95	9.77	9.81	9.64
Singland 110 kV	6.69	16.15	14.47	7.72	13.16	12.76	6.27	19.24	17.39	7.48	14.66	14.27

**Table E-4 Ireland Short Circuit Currents for Maximum and Minimum Demand in 2027**

Station	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]	X/R Ratio	Ik'' [kA]	Ik' [kA]
Sliabh Bawn 110 kV	2.98	7.89	7.50	2.98	7.89	7.50	3.20	10.22	9.39	3.20	10.22	9.39
Slievacallan 110 kV	7.13	6.23	5.75	9.11	2.27	2.25	7.73	7.83	6.92	9.41	2.47	2.44
Sligo 110 kV	3.78	9.66	8.78	4.54	8.67	8.41	3.54	11.53	10.53	4.41	9.92	9.66
Snugborough 110 kV	9.49	17.38	15.41	9.34	20.36	19.39	10.38	25.52	23.13	10.00	27.69	26.69
Somerset 110 kV	2.97	6.89	6.56	4.00	4.54	4.49	2.84	8.22	7.86	3.98	5.03	4.98
Sorne Hill 110 kV	3.48	3.65	3.26	4.45	3.58	3.44	3.43	3.98	3.51	4.41	3.82	3.66
Srahnakilly 110 kV	6.11	7.00	5.82	6.66	7.77	7.22	6.05	8.69	7.34	6.72	9.23	8.65
Srananagh 110 kV	4.84	11.51	10.28	5.78	11.87	11.40	4.54	13.69	12.43	5.58	13.63	13.18
Srananagh 220 kV	7.71	4.72	4.47	9.97	3.70	3.65	7.62	5.32	5.12	10.02	4.02	3.99
Stevenstown 110 kV	3.98	6.08	5.79	4.46	3.97	3.93	3.64	7.32	6.96	4.37	4.40	4.35
Stratford 110 kV	3.44	4.30	4.18	4.46	3.19	3.16	3.34	4.74	4.51	4.39	3.38	3.34
Taney 110 kV	8.69	9.06	8.61	3.27	9.01	8.85	8.58	10.90	10.28	3.11	10.33	10.14
Tarbert 110 kV	20.31	12.05	11.31	24.00	9.32	9.17	21.74	13.68	13.21	25.22	10.23	10.15
Tarbert 220 kV	10.00	15.45	13.64	9.64	17.99	17.08	9.87	19.83	18.32	9.48	22.25	21.57
Tawnaghmore A 110 kV	3.85	4.81	4.40	5.03	4.51	4.38	4.24	7.08	6.54	5.86	5.62	5.50
Tawnaghmore B 110 kV	3.76	4.65	4.29	4.81	5.00	4.85	4.77	7.40	6.79	6.54	6.80	6.61
Thornsberry 110 kV	3.75	5.66	5.43	4.85	5.34	5.27	3.74	7.78	7.42	5.09	6.74	6.65
Thurles 110 kV	6.21	6.27	5.52	6.51	6.42	6.13	5.92	6.99	6.13	6.42	6.96	6.65
Tievebrack 110 kV	3.57	4.58	4.21	4.98	2.95	2.90	4.33	6.44	5.56	5.71	5.59	5.34
Timahoe 110 kV	6.09	7.15	6.88	6.74	5.50	5.44	6.26	9.87	9.61	6.96	6.54	6.50
Tipperary 110 kV	5.40	7.65	7.12	6.38	4.55	4.48	5.27	8.49	7.85	6.33	4.81	4.73
Tonroe 110 kV	5.40	5.36	4.96	6.42	3.49	3.43	5.42	6.20	5.81	6.49	3.80	3.75
Trabeg 110 kV	6.20	16.10	14.48	7.08	17.64	16.94	5.97	22.34	19.71	7.03	22.82	21.82
Tralee 110 kV	5.37	9.55	8.46	6.39	7.84	7.57	5.02	11.83	10.66	6.26	8.92	8.68
Trien A 110 kV	4.60	8.20	7.50	5.90	6.90	6.73	4.32	10.00	9.33	5.81	7.83	7.69
Trien B 110 kV	12.47	10.97	9.25	9.13	7.76	7.43	12.54	12.26	10.54	9.08	8.44	8.13
Trillick 110 kV	3.59	4.01	3.54	4.57	3.57	3.44	3.53	4.40	3.82	4.53	3.81	3.65
Trinity 110 kV	11.64	10.55	9.83	6.62	13.09	12.69	11.47	15.28	13.86	5.93	17.82	17.13
Tullabeg 110 kV	6.10	6.56	6.31	6.42	5.43	5.37	7.20	9.11	8.85	7.06	6.59	6.54
Tullabrack 110 kV	6.54	7.38	6.91	7.29	5.44	5.35	6.45	8.22	7.76	7.25	5.87	5.78
Turlough 220 kV	10.51	11.84	10.75	11.91	10.67	10.35	9.80	12.91	12.17	11.42	11.03	10.84
Tynagh 220 kV	10.56	8.03	7.61	11.54	9.77	9.55	15.00	13.76	12.80	16.30	14.75	14.36
Uggool 110 kV	6.31	7.63	7.25	5.69	9.67	9.46	6.34	9.44	8.82	5.65	11.74	11.40
Waterford 110 kV	7.64	12.88	12.19	8.09	13.46	13.20	7.34	15.02	14.03	7.88	15.16	14.81
Wexford 110 kV	5.96	7.41	6.93	7.51	6.43	6.31	5.69	8.55	8.01	7.35	7.01	6.88
Whitebank 110 kV	19.41	11.66	10.80	17.28	14.89	14.40	25.74	17.54	15.77	20.27	21.16	20.24
Whitegate 110 kV	4.39	8.86	8.35	5.14	9.16	8.97	4.32	11.11	10.51	5.17	10.93	10.73
Wolfe Tone 110 kV	13.26	10.09	9.44	5.66	11.85	11.53	14.05	13.78	12.55	5.19	15.19	14.65
Woodhouse 110 kV	5.95	6.14	5.84	7.35	4.42	4.36	6.74	8.18	7.25	8.04	5.13	4.99
Woodland 220 kV	11.24	19.38	16.84	11.08	21.16	20.02	10.42	28.94	26.47	10.57	28.78	27.90
Woodland 400 kV	12.86	9.80	8.84	13.01	10.83	10.41	13.00	13.45	12.81	13.29	14.18	13.93
Yellowmeadow 110 kV	23.61	12.08	10.96	16.36	13.96	13.43	29.28	15.12	13.59	17.62	16.74	16.07

## E.4 Short Circuit Currents in Northern Ireland

### E.4.1 Methodology used in Northern Ireland

Short circuit current levels are calculated in accordance with the UK Engineering Recommendation G74, which is a computer based analysis, based on the International Standard IEC60909.

Compliance with G74 includes:

- Short circuit current contributions from all synchronous and non-synchronous rotating plant including induction motors embedded in the general load;
- Comprehensive plant parameters including time-dependent impedances, transformer winding and earthing configurations;
- Pre-fault voltage levels at each node which should be obtained from a credible, pre-fault load flow study; and
- Pre-fault transformer tap settings should also be obtained from the load flow study.

The short circuit current level network model includes the following component parameters:

- Transformer impedance variation with tap position;
- Zero sequence mutual coupling effect;
- Unsaturated generator reactance values; and
- Power station auxiliaries fault level contributions.

The calculation of the X/R ratios, used by SONI, is undertaken in accordance with IEC60909-0 Method C, which is known as the equivalent frequency method. The equivalent frequency method is considered to be the most appropriate general purpose method for calculating the DC component of short circuit currents on the Northern Ireland transmission system.

The Northern Ireland transmission system is designed and operated to maintain short circuit current levels below the ratings of equipment at each substation. Table E-5 below, indicates the range of circuit breaker RMS ratings that are currently installed on the Northern Ireland transmission system, for the respective voltage levels currently operated.

**Table E-5 Northern Ireland Station Equipment Rating Range by Voltage Level**

Voltage Level (kV)	Short Circuit Current Equipment Rating Range (kA)
275 <sup>131</sup>	31.5 – 40
110	18.4 – 40

### E.4.2 Analysis

The total RMS break current at a busbar is an indication of the short circuit current level that one could expect at that point in the transmission system. However, they do not necessarily represent the short circuit current that could flow through each individual breaker, which may be lower.

<sup>131</sup> The switchgear ratings at Castlereagh, Coolkeeragh, Magherafelt, Tandragee and Kells 275 kV substations have been temporarily reduced to 10 kA by NIE Networks following review of the capability of concrete structures to withstand mechanical loading under fault conditions. This is under constant review and projects will be brought forward to address this issue.

### E.4.3 Northern Ireland Short Circuit Current Level Results

Tables E-6 to E-11 contain the following three-phase and single-phase short circuit current level results for maximum winter peak and minimum summer valley system demand conditions for 2021, 2024 and 2027:

- **Initial Short Circuit Current ( $I''$ )**

This is the initial RMS value of the AC component of the short circuit current, prior to contact separation time. It is calculated using generator sub-transient reactances.

- **Peak Make Current ( $i_p$ )**

The largest peak current occurs around 10ms, and is the short circuit current that equipment must be able to withstand, for example, when a circuit breaker is closed directly onto an earthed section of network, thus energising a fault. All equipment in the fault current path will be subjected to the peak make current, and therefore should be rated to withstand this.

- **RMS Break Current ( $I_B$ )**

This is the RMS value of the AC component of the short circuit current at the time of circuit breaker contact separation. The break time at which contact separation occurs varies from circuit to circuit, and depends on protection settings, fault location, circuit breaker design etc. For the purposes of this report, we have used a short circuit current break time of 50ms for all 275 kV and 110 kV calculations.

In the Northern Ireland results tables, the RMS Break and Peak Make ratings of the existing nodes are shown. It should be noted that the Ballylumford 110 kV node (highlighted in the tables with \*) currently has separate ratings for three-phase and single-phase faults; these are indicated in the tables. All ratings are in kA.

Single phase to earth short circuit currents tend to be larger than three phase short circuit currents in heavily meshed transmission networks. This is due to the multiplicity of zero phase sequence paths available to earth fault currents. In all tables, any nodes where short circuit currents exceed 90% of the corresponding existing rating are highlighted in **orange**. Any nodes where short circuit currents exceed the corresponding existing ratings are highlighted in **red**.

The results presented in the following section are indicative only. They are based on intact network conditions and are representative of the assumed generation dispatch and transmission system conditions.

**Table E-6 Northern Ireland Short Circuit Currents for Minimum Demand in 2021**

Node	Rating		Three Phase					Single Phase				
	RMS	Peak	X/R ratio (AC)	X/R Ratio (DC)	I''	ip	IB	X/R ratio (AC)	X/R Ratio (DC)	I''	ip	IB
	[kA]	[kA]			[kA]	[kA]	[kA]			[kA]	[kA]	[kA]
<b>275 kV</b>												
Ballylumford	31.5	79	12.21	17.84	9.45	23.87	8.20	12.92	19.56	12.20	31.00	11.08
Castlereagh	10 <sup>132</sup>	79	11.44	16.69	9.47	23.75	8.19	11.25	16.98	11.30	28.29	10.29
Coolkeeragh	10 <sup>132</sup>	79	10.55	17.09	8.72	21.68	7.70	11.70	19.70	9.89	24.86	9.20
Hannahstown	31.5	79	11.44	16.56	9.21	23.10	7.99	11.50	17.71	11.11	27.90	10.14
Kells	10 <sup>132</sup>	79	13.25	20.36	10.58	26.95	9.08	12.28	18.89	12.47	31.52	11.35
Kilroot	31.5	79	14.70	24.03	10.90	28.05	9.33	14.34	24.42	12.70	32.61	11.59
Magherafelt	10 <sup>132</sup>	79	12.58	18.52	10.73	27.20	9.23	9.92	13.01	11.41	28.15	10.48
Moyle	31.5	79	12.15	17.65	9.36	23.63	8.13	12.81	19.24	12.03	30.54	10.94
Tandragee	10 <sup>132</sup>	79	11.58	16.96	11.22	28.18	9.60	11.00	16.80	13.30	33.22	12.04
Tamnamore	40	100	11.81	17.09	10.63	26.77	9.15	11.51	18.20	12.20	30.62	11.12
<b>110 kV</b>												
Aghyoule	40	100	2.97	3.16	3.22	6.27	3.12	3.96	4.88	3.55	7.42	3.48
Antrim	40	100	4.81	7.97	8.62	18.84	8.09	4.90	10.00	9.06	19.87	8.74
Ballylumford	21.9	55	10.32	21.22	15.43	38.24	13.93					
	26.2	65						10.08	24.37	16.19	40.01	15.27
Ballymena	40	100	4.84	8.50	7.73	16.92	7.30	5.47	11.62	8.40	18.85	8.12
Banbridge	18.4	46.8	4.15	6.55	6.31	13.34	6.02	5.15	9.85	6.53	14.48	6.37
Ballyvally	21.9	46.8	5.36	6.53	12.33	27.55	11.32	4.94	6.50	12.54	27.55	11.98
Ballynahinch	18.4	46.8	4.31	7.08	5.39	11.50	5.13	5.09	10.07	5.67	12.54	5.51
Belfast Central	n/a	n/a	8.35	12.52	11.75	28.31	10.65	5.47	12.02	14.91	33.45	13.91
Belfast North	n/a	n/a	5.07	7.78	10.94	24.18	10.10	3.28	11.79	12.15	24.26	11.56
Brockaghboy	40	100	4.71	5.73	3.60	7.84	3.51	4.16	5.62	3.07	6.49	3.03
Carmoney	31.5	79	4.05	6.52	7.62	16.03	7.18	4.60	8.92	8.00	17.31	7.74
Castlereagh	31.5	79	11.19	20.26	14.04	35.13	12.52	11.78	20.93	18.86	47.47	17.31
Coleraine	40	100	3.81	4.53	6.70	13.90	6.30	4.35	5.67	8.39	17.93	8.02
Coolkeeragh	31.5	79	10.95	21.87	15.72	39.23	14.00	11.53	23.09	20.69	51.95	19.13
Creagh	31.5	79	3.64	4.12	7.42	15.21	7.03	4.42	6.35	8.24	17.69	7.98
Cregagh	26.2	65	9.30	14.88	12.89	31.53	11.59	7.40	13.73	16.78	39.72	15.53
Donegall North	31.5	79	8.30	13.24	12.25	29.50	11.21	5.82	10.92	15.97	36.26	14.96
Donegall South	n/a	n/a	6.19	8.78	10.04	23.06	9.33	5.15	9.05	11.64	25.81	11.10
Drumakelly	31.5	79	7.85	12.45	16.32	38.98	14.59	7.65	13.10	19.08	45.38	17.73
Dungannon	40	100	7.05	12.72	14.14	33.21	12.81	7.10	13.84	16.91	39.75	15.85
Eden	25	62.5	4.18	6.20	8.35	17.70	7.85	4.63	8.44	8.72	18.89	8.43
Enniskillen	31.5	79	3.60	4.02	6.47	13.24	6.10	4.31	5.42	7.83	16.69	7.51
Finaghy	31.5	79	9.32	15.53	12.63	30.90	11.53	7.03	12.38	16.88	39.62	15.77
Glengormley	18.4	46.8	3.40	3.87	5.16	10.40	4.95	4.13	6.81	5.25	11.09	5.14
Gort Cluster	40	100	5.95	7.22	6.84	15.60	6.51	5.90	11.00	6.93	15.78	6.75
Hannahstown	31.5	79	10.40	19.08	13.62	33.81	12.36	10.97	20.16	18.58	46.38	17.24
Kells	40	100	9.70	20.18	15.55	38.24	13.99	10.25	21.27	20.33	50.35	18.86
Killymallaght	40	100	6.08	7.71	9.74	22.30	9.05	5.72	9.62	10.09	22.83	9.70

132 The switchgear ratings at Castlereagh, Coolkeeragh, Magherafelt, Tandragee and Kells 275 kV substations have been temporarily reduced to 10 kA by NIE Networks following review of the capability of concrete structures to withstand mechanical loading under fault conditions. This is under constant review and projects will be brought forward to address this issue.

**Table E-6 Northern Ireland Short Circuit Currents for Minimum Demand in 2021**

Node	Rating		Three Phase					Single Phase				
	RMS	Peak	X/R ratio (AC)	X/R Ratio (DC)	I''	ip	IB	X/R ratio (AC)	X/R Ratio (DC)	I''	ip	IB
	[kA]	[kA]			[kA]	[kA]	[kA]			[kA]	[kA]	[kA]
Knock	n/a	n/a	5.21	7.87	12.38	27.50	11.17	3.37	11.62	13.80	27.76	12.96
Larne	18.4	46.8	4.53	5.50	8.16	17.60	7.69	5.18	8.38	8.30	18.43	8.05
Limavady	40	100	3.65	4.14	6.17	12.67	5.85	4.29	6.16	7.05	15.03	6.82
Lisburn	18.4	46.8	5.99	8.50	10.33	23.58	9.60	5.55	10.03	10.90	24.52	10.43
Lisaghmore	31.5	79	4.81	7.40	8.60	18.79	8.04	5.00	9.73	8.96	19.74	8.65
Loguestown	26.2	65	3.50	4.34	5.07	10.30	4.83	4.06	5.77	5.95	12.51	5.76
Magherakeel Cluster	40	100	4.24	4.60	3.37	7.16	3.29	5.33	6.10	4.04	9.01	3.98
Newtownards	40	100	4.83	7.31	7.22	15.79	6.77	5.82	10.14	7.27	16.51	7.02
Newry	18.4	46.8	4.02	6.67	5.40	11.33	5.16	4.96	9.68	5.61	12.33	5.47
Omagh	40	100	4.65	6.06	10.62	23.04	9.78	4.96	7.80	12.36	27.19	11.72
Rasharkin	40	100	4.06	5.52	5.99	12.61	5.73	4.58	8.27	6.38	13.79	6.19
Rathgael	26.2	65	4.33	6.82	5.73	12.23	5.43	5.05	9.80	5.98	13.20	5.81
Rosebank	40	100	10.14	16.83	13.21	32.68	11.86	11.07	18.61	17.44	43.60	16.11
Slieve Kirk	40	100	4.53	5.30	7.32	15.80	6.93	5.43	9.22	6.77	15.17	6.60
Springtown	n/a	n/a	5.04	7.82	8.78	19.37	8.20	5.14	9.88	9.24	20.48	8.92
Strabane	18.4	46.8	5.29	6.81	11.53	25.69	10.56	5.49	9.30	12.71	28.53	12.07
Tandragee	31.5	79	9.64	18.55	17.46	42.92	15.51	10.28	20.38	22.21	55.03	20.42
Tremoge	40	100	4.11	4.97	7.48	15.79	7.08	4.51	8.01	7.63	16.44	7.41
Tamnamore	40	100	8.41	18.32	16.40	39.56	14.68	9.15	19.94	21.80	53.22	20.12
Waringstown	18.4	46.8	5.13	7.99	7.82	17.32	7.38	5.76	10.78	7.92	17.95	7.67



**Table E-7 Northern Ireland Short Circuit Currents for Maximum Demand in 2021**

Node	Rating		Three Phase					Single Phase				
	RMS	Peak	X/R	X/R	I''	ip	IB	X/R	X/R	I''	ip	IB
	[kA]	[kA]	ratio (AC)	Ratio (DC)	[kA]	[kA]	[kA]	ratio (AC)	Ratio (DC)	[kA]	[kA]	[kA]
<b>275 kV</b>												
Ballylumford	31.5	79	12.88	20.53	17.13	43.52	15.06	13.90	23.33	19.54	50.01	18.03
Castlereagh	10 <sup>133</sup>	79	10.30	14.98	15.31	37.95	13.41	10.37	15.87	15.98	39.63	14.75
Coolkeeragh	10 <sup>133</sup>	79	8.58	13.59	12.18	29.46	11.05	10.25	16.92	12.42	30.76	11.79
Hannahstown	31.5	79	10.52	15.33	15.02	37.32	13.20	10.82	17.22	15.89	39.60	14.69
Kells	10 <sup>133</sup>	79	12.09	17.91	17.37	43.85	15.25	11.20	17.00	17.78	44.51	16.51
Kilroot	31.5	79	13.38	20.78	17.15	43.75	15.05	13.41	22.38	17.64	44.99	16.43
Magherafelt	10 <sup>133</sup>	79	11.16	15.52	17.46	43.67	15.40	8.70	10.94	15.47	37.50	14.53
Moyle	31.5	79	12.72	19.98	16.79	42.60	14.80	13.66	22.48	19.08	48.75	17.64
Tandragee	10 <sup>133</sup>	79	10.14	14.00	18.29	45.25	16.13	9.82	14.72	18.87	46.48	17.56
Tamnamore	40	100	10.48	14.24	17.14	42.57	15.17	10.50	16.49	16.92	42.03	15.82
<b>110 kV</b>												
Aghyoule	40	100	4.06	8.75	4.48	9.42	4.00	5.57	12.34	4.30	9.67	4.08
Antrim	40	100	4.21	7.21	10.05	21.33	9.48	4.50	9.49	10.01	21.56	9.60
Ballylumford	21.9	55	10.17	24.30	22.73	56.25	20.59					
	26.2	65						27.93	26.28			22.41
Ballymena	40	100	4.41	8.28	9.08	19.47	8.57	5.17	11.60	9.52	21.11	9.00
Banbridge	18.4	46.8	3.79	6.09	6.97	14.44	6.69	4.89	9.52	6.91	15.16	6.75
Ballyvally	21.9	46.8	4.51	5.38	16.20	34.91	14.92	4.41	5.82	14.83	31.82	14.14
Ballynahinch	18.4	46.8	3.95	6.70	6.00	12.54	5.65	4.83	9.85	6.03	13.19	5.80
Belfast Central	n/a	n/a	7.14	11.22	15.37	36.17	13.72	4.71	11.28	18.37	39.95	16.86
Belfast North	n/a	n/a	4.34	6.97	13.35	28.53	12.29	2.92	11.44	13.73	26.62	13.02
Brockaghboy	40	100	5.38	6.91	5.13	11.48	4.48	4.21	5.90	3.38	7.18	3.23
Carnmoney	31.5	79	3.63	6.22	8.93	18.29	8.41	4.31	8.74	8.81	18.80	8.50
Castlereagh	31.5	79	9.70	19.69	19.61	48.24	17.10	10.59	20.61	25.06	62.31	22.48
Coleraine	40	100	4.00	5.59	10.12	21.21	8.78	4.76	7.37	11.26	24.56	10.31
Coolkeeragh	31.5	79	8.65	17.69	23.37	56.60	20.55	9.59	19.55	28.53	70.08	26.26
Creagh	31.5	79	3.31	4.06	8.58	17.17	8.11	4.20	6.47	9.09	19.28	8.74
Cregagh	26.2	65	7.94	13.55	17.43	41.71	15.37	6.39	12.78	21.43	49.47	19.44
Drumquin	40	100	5.34	7.70	6.83	15.26	6.25	5.90	12.12	6.35	14.46	6.08
Donegall North	31.5	79	7.24	12.19	15.43	36.39	14.07	5.06	10.17	19.16	42.32	17.85
Donegall South	n/a	n/a	5.43	7.94	12.04	26.98	11.17	4.64	8.54	13.18	28.59	12.53
Drumakelly	31.5	79	6.43	10.46	22.55	52.14	20.29	6.60	11.77	23.93	55.58	22.36
Dungannon	40	100	6.04	10.69	19.77	45.20	18.03	6.43	12.57	21.56	49.83	20.29
Eden	25	62.5	3.72	5.79	10.01	20.63	9.43	4.32	8.23	9.75	20.81	9.41
Enniskillen	31.5	79	3.86	4.97	9.81	20.39	8.66	4.93	7.28	10.46	22.97	9.75
Finaghy	31.5	79	8.19	14.61	16.03	38.52	14.59	6.14	11.54	20.51	47.02	19.04
Glengormley	18.4	46.8	3.12	3.53	5.67	11.19	5.42	3.94	6.59	5.55	11.61	5.38
Gort Cluster	40	100	6.33	8.28	8.81	20.31	8.30	6.08	12.80	8.08	18.50	7.77
Hannahstown	31.5	79	9.19	18.60	17.68	43.18	15.98	9.91	19.95	23.13	57.06	21.33
Kells	40	100	8.18	18.15	21.46	51.55	19.36	8.95	19.75	26.83	65.30	24.53

133 The switchgear ratings at Castlereagh, Coolkeeragh, Magherafelt, Tandragee and Kells 275 kV substations have been temporarily reduced to 10 kA by NIE Networks following review of the capability of concrete structures to withstand mechanical loading under fault conditions. This is under constant review and projects will be brought forward to address this issue.

**Table E-7 Northern Ireland Short Circuit Currents for Maximum Demand in 2021**

Node	Rating		Three Phase					Single Phase				
	RMS	Peak	X/R ratio (AC)	X/R Ratio (DC)	I''	ip	IB	X/R ratio (AC)	X/R Ratio (DC)	I''	ip	IB
	[kA]	[kA]			[kA]	[kA]	[kA]			[kA]	[kA]	[kA]
Killymallaght	40	100	5.63	8.06	13.21	29.81	12.23	5.41	10.19	12.10	27.08	11.64
Knock	n/a	n/a	4.22	6.75	16.37	34.75	14.53	2.90	11.14	16.44	31.79	15.24
Larne	18.4	46.8	4.03	4.86	9.73	20.44	9.17	4.86	8.01	9.25	20.26	8.92
Limavady	40	100	3.58	4.34	8.26	16.87	7.43	4.40	7.05	8.52	18.26	8.03
Lisburn	18.4	46.8	5.20	7.58	12.35	27.44	11.50	5.05	9.50	12.12	26.75	11.60
Lisaghmore	31.5	79	4.15	6.61	10.51	22.22	9.79	4.57	9.25	10.10	21.84	9.74
Loguestown	26.2	65	3.51	4.90	6.85	13.91	6.13	4.23	6.81	7.24	15.38	6.79
Magherakeel Cluster	40	100	5.43	10.44	4.66	10.43	4.50	7.16	13.37	5.16	12.16	5.01
Newtownards	40	100	4.29	6.70	8.34	17.77	7.77	5.44	9.75	7.91	17.72	7.57
Newry	18.4	46.8	3.73	6.34	5.91	12.19	5.64	4.77	9.50	5.88	12.83	5.72
Omagh	40	100	4.73	7.11	17.28	37.63	15.34	5.17	9.57	17.25	38.27	16.09
Rasharkin	40	100	4.31	6.51	8.52	18.18	7.55	4.76	9.84	7.56	16.47	7.11
Rathgael	26.2	65	3.94	6.39	6.42	13.41	6.03	4.77	9.53	6.39	13.94	6.14
Rosebank	40	100	8.76	15.80	18.03	43.75	15.87	10.07	18.10	22.59	55.83	20.45
Slieve Kirk	40	100	4.35	6.52	9.31	19.91	8.80	5.46	11.35	7.63	17.10	7.44
Springtown	n/a	n/a	4.26	6.80	10.65	22.67	9.95	4.63	9.16	10.42	22.57	10.04
Strabane	18.4	46.8	4.54	6.03	16.84	36.33	15.23	5.02	9.19	16.19	35.70	15.38
Tandragee	31.5	79	8.03	16.50	24.62	59.01	22.01	8.93	18.89	29.03	70.64	26.80
Tremoge	40	100	4.02	5.71	9.69	20.34	9.13	4.52	9.26	8.88	19.14	8.60
Tamnamore	40	100	7.19	15.78	24.08	56.71	21.75	8.20	17.86	30.03	72.19	27.85
Waringstown	18.4	46.8	4.60	7.31	8.92	19.30	8.47	5.39	10.33	8.52	19.06	8.27

**Table E-8 Northern Ireland Short Circuit Currents for Minimum Demand in 2024**

Node	Rating		Three Phase					Single Phase				
	RMS	Peak	X/R ratio	X/R Ratio	I''	ip	IB	X/R ratio	X/R Ratio	I''	ip	IB
	[kA]	[kA]	(AC)	(DC)	[kA]	[kA]	[kA]	(AC)	(DC)	[kA]	[kA]	[kA]
<b>275 kV</b>												
Ballylumford	31.5	79	9.50	13.96	8.65	21.21	7.51	10.19	15.39	11.22	27.77	10.18
Castlereagh	10 <sup>134</sup>	79	9.14	13.08	8.55	20.88	7.41	9.67	14.49	11.20	27.53	10.11
Coolkeeragh	10 <sup>134</sup>	79	11.83	18.27	9.11	22.93	7.96	12.87	21.06	10.11	25.69	9.38
Hannahstown	31.5	79	9.12	13.13	8.41	20.52	7.31	9.45	14.30	10.47	25.66	9.51
Kells	10 <sup>134</sup>	79	9.45	13.70	9.09	22.29	7.87	9.50	14.11	10.98	26.94	10.00
Kilroot	31.5	79	9.42	13.18	8.44	20.67	7.38	9.95	14.65	10.32	25.46	9.45
Magherafelt	10 <sup>134</sup>	79	10.11	15.27	10.33	25.55	8.86	8.77	12.03	10.99	26.68	10.07
Moyle	31.5	79	9.49	13.88	8.57	21.01	7.45	10.15	15.25	11.08	27.40	10.06
Tandragee	10 <sup>134</sup>	79	9.36	13.72	11.05	27.04	9.42	9.22	14.03	13.01	31.80	11.77
Tamnamore	40	100	9.67	14.18	10.47	25.73	8.97	9.93	16.10	11.86	29.25	10.80
<b>110 kV</b>												
Aghyoule	40	100	4.15	8.87	4.38	9.26	3.88	5.61	12.37	4.28	9.64	4.03
Antrim	40	100	4.46	7.30	8.23	17.69	7.69	4.65	9.30	8.69	18.85	8.36
Ballylumford	40	100	10.39	19.12	13.70	33.98	12.37	11.38	21.29	17.43	43.70	16.29
Ballymena	40	100	4.63	8.15	7.55	16.36	7.07	4.96	11.30	7.56	16.62	7.28
Banbridge	18.4	46.8	4.04	6.46	6.20	13.04	5.90	5.04	9.69	6.39	14.11	6.22
Ballyvally	21.9	46.8	5.25	6.40	11.73	26.12	10.67	4.89	6.44	11.97	26.25	11.36
Ballynahinch	18.4	46.8	4.34	6.86	5.20	11.11	4.94	5.18	9.85	5.46	12.12	5.30
Belfast Central	n/a	n/a	8.65	11.14	11.32	27.41	10.26	5.32	11.10	14.48	32.29	13.49
Belfast North	n/a	n/a	4.84	7.57	10.47	22.90	9.62	3.23	11.45	11.64	23.17	11.05
Brockaghboy	40	100	5.58	8.77	4.04	9.09	3.75	5.69	9.65	3.93	8.87	3.78
Carnmoney	31.5	79	3.95	6.64	4.39	9.18	4.22	4.68	8.79	4.80	10.43	4.69
Castlereagh	31.5	79	11.87	16.62	13.52	34.06	12.07	12.22	17.27	18.35	46.38	16.83
Coleraine	40	100	4.29	6.22	8.92	19.02	7.86	4.95	7.81	10.53	23.14	9.72
Coolkeeragh	31.5	79	9.47	19.94	19.23	47.16	16.62	10.23	21.46	24.37	60.33	22.20
Creagh	31.5	79	3.50	4.03	7.33	14.87	6.90	4.28	6.19	8.10	17.25	7.81
Cregagh	26.2	65	9.72	12.87	12.42	30.56	11.17	7.25	12.14	16.30	38.46	15.07
Drumquin	40	100	4.72	5.29	5.73	12.47	5.36	5.36	8.84	5.72	12.78	5.53
Donegall North	31.5	79	7.48	12.06	11.69	27.72	10.66	5.49	10.38	15.24	34.22	14.23
Donegall South	n/a	n/a	5.83	8.43	9.62	21.86	8.90	4.97	8.80	11.18	24.59	10.62
Drumnakelly	31.5	79	6.95	11.29	16.51	38.68	14.66	6.99	12.17	19.06	44.68	17.65
Dungannon	40	100	6.43	11.20	15.47	35.75	13.77	6.65	12.70	17.91	41.65	16.65
Eden	25	62.5	4.35	6.71	6.23	13.32	5.90	4.84	8.61	6.79	14.87	6.59
Enniskillen	31.5	79	3.83	4.68	8.79	18.26	7.76	4.79	6.70	9.71	21.20	9.05
Finaghy	31.5	79	8.23	13.70	12.05	28.97	10.96	6.49	11.50	16.09	37.27	14.98
Glengormley	18.4	46.8	3.84	5.98	5.38	11.17	5.14	4.48	9.10	5.48	11.80	5.35
Gort Cluster	40	100	6.10	7.34	7.92	18.14	7.34	5.98	11.64	7.51	17.13	7.22
Hannahstown	31.5	79	8.94	16.04	12.98	31.58	11.73	9.47	17.02	17.67	43.34	16.35
Kells	40	100	7.90	15.29	14.95	35.73	13.33	8.47	16.45	19.50	47.09	17.98
Killymallaght	40	100	5.91	8.27	12.01	27.34	10.90	5.59	10.26	11.46	25.81	10.94

<sup>134</sup> The switchgear ratings at Castlereagh, Coolkeeragh, Magherafelt, Tandragee and Kells 275 kV substations have been temporarily reduced to 10 kA by NIE Networks following review of the capability of concrete structures to withstand mechanical loading under fault conditions. This is under constant review and projects will be brought forward to address this issue.

**Table E-8 Northern Ireland Short Circuit Currents for Minimum Demand in 2024**

Node	Rating		Three Phase					Single Phase				
	RMS	Peak	X/R	X/R	I''	ip	IB	X/R	X/R	I''	ip	IB
	[kA]	[kA]	ratio (AC)	Ratio (DC)	[kA]	[kA]	[kA]	ratio (AC)	Ratio (DC)	[kA]	[kA]	[kA]
Knock	n/a	n/a	5.33	7.24	11.95	26.66	10.78	3.28	11.05	13.41	26.80	12.58
Larne	18.4	46.8	4.50	5.48	7.90	17.02	7.36	5.15	8.30	8.03	17.80	7.72
Limavady	40	100	3.82	4.69	7.68	15.93	6.89	4.58	7.31	8.19	17.70	7.72
Lisburn	18.4	46.8	5.63	8.12	9.94	22.41	9.19	5.33	9.68	10.49	23.41	10.00
Lisaghmore	31.5	79	4.46	7.09	9.60	20.63	8.83	4.77	9.59	9.54	20.80	9.15
Loguestown	26.2	65	3.70	5.28	6.21	12.79	5.66	4.34	7.04	6.90	14.74	6.53
Magherakeel Cluster	40	100	5.26	9.42	4.36	9.71	4.16	6.86	12.01	4.76	11.12	4.61
Newtownards	40	100	4.83	6.77	6.91	15.12	6.49	5.93	9.83	6.98	15.91	6.73
Newry	18.4	46.8	3.93	6.59	5.30	11.07	5.06	4.88	9.55	5.48	12.02	5.33
Omagh	40	100	4.80	6.77	14.61	31.92	12.73	5.18	9.00	15.30	33.95	14.16
Omagh South	40	100	3.91	4.75	10.69	22.29	9.51	4.17	5.22	10.71	22.68	10.08
Rasharkin	40	100	4.47	7.49	7.48	16.09	6.73	4.92	9.45	7.84	17.21	7.37
Rathgael	26.2	65	4.36	6.60	5.52	11.81	5.23	5.15	9.59	5.76	12.77	5.58
Rosebank	40	100	10.66	14.32	12.73	31.69	11.43	10.85	15.35	17.00	42.38	15.67
Slieve Kirk	40	100	4.46	6.08	8.68	18.66	8.08	5.48	10.66	7.40	16.61	7.18
Springtown	n/a	n/a	4.58	7.31	9.68	20.92	8.93	4.83	9.52	9.79	21.42	9.41
Strabane	40	100	4.88	6.47	15.11	33.12	13.36	5.24	9.44	15.13	33.65	14.22
Tandragee	31.5	79	8.27	15.84	17.55	42.23	15.49	8.99	17.58	22.11	53.84	20.27
Tremoge	40	100	4.16	5.56	8.72	18.46	8.02	4.59	9.00	8.32	18.00	7.97
Tamnamore	40	100	7.46	15.15	17.95	42.52	15.78	8.21	16.71	23.34	56.11	21.33
Waringstown	18.4	46.8	4.93	7.81	7.72	16.95	7.26	4.93	7.81	7.72	16.95	7.26

**Table E-9 Northern Ireland Short Circuit Currents for Maximum Demand in 2024**

Node	Rating		Three Phase					Single Phase				
	RMS	Peak	X/R	X/R	I''	ip	IB	X/R	X/R	I''	ip	IB
	[kA]	[kA]	ratio (AC)	Ratio (DC)	[kA]	[kA]	[kA]	ratio (AC)	Ratio (DC)	[kA]	[kA]	[kA]
<b>275 kV</b>												
Ballylumford	31.5	79	13.32	20.93	18.28	46.58	16.26	14.12	23.27	20.47	52.47	19.07
Castlereagh	10 <sup>135</sup>	79	10.65	15.25	16.02	39.85	14.15	11.25	17.44	18.69	46.79	17.19
Coolkeeragh	10 <sup>135</sup>	79	12.84	17.78	12.77	32.44	11.74	13.89	21.43	12.81	32.79	12.26
Hannahstown	31.5	79	10.79	15.52	15.80	39.38	14.03	10.35	15.76	16.32	40.47	15.21
Kells	10 <sup>135</sup>	79	13.02	19.32	18.94	48.17	16.93	11.42	17.07	18.89	47.38	17.74
Kilroot	31.5	79	14.79	23.50	18.96	48.81	17.03	13.73	22.50	18.97	48.49	17.92
Magherafelt	10 <sup>135</sup>	79	12.10	17.07	18.64	47.06	16.69	8.89	11.19	16.07	39.06	15.23
Moyle	31.5	79	13.13	20.32	17.90	45.56	15.95	13.85	22.39	19.97	51.10	18.63
Tandragee	10 <sup>135</sup>	79	10.63	14.67	19.76	49.15	17.58	9.80	14.52	19.90	49.01	18.62
Tamnamore	40	100	11.05	15.07	18.33	45.81	16.41	10.84	17.60	17.53	43.70	16.51
<b>110 kV</b>												
Aghyoule	40	100	4.05	8.73	4.50	9.46	4.02	5.67	12.51	4.25	9.60	4.03
Agivey	40	100	6.42	9.10	6.37	14.72	5.62	6.80	13.41	5.55	12.94	5.26
Antrim	40	100	4.14	7.02	10.50	22.19	9.99	4.45	9.37	10.30	22.13	9.94
Ballylumford	40	100	12.37	26.43	21.13	53.46	19.48	13.81	29.78	24.87	63.61	23.63
Ballymena	40	100	4.34	8.10	9.44	20.17	8.97	4.80	11.60	8.87	19.38	8.48
Banbridge	18.4	46.8	3.78	6.08	7.08	14.65	6.80	4.88	9.52	7.00	15.34	6.83
Ballyvally	21.9	46.8	4.62	5.27	16.33	35.37	15.21	4.47	5.75	14.86	31.97	14.28
Ballynahinch	18.4	46.8	4.00	6.55	6.07	12.73	5.75	4.96	9.77	6.06	13.33	5.86
Belfast Central	n/a	n/a	8.19	10.83	16.06	38.61	14.48	4.67	10.91	19.24	41.76	17.82
Belfast North	n/a	n/a	4.37	7.12	13.50	28.90	12.51	3.02	11.56	13.66	26.71	13.01
Brockaghboy	40	100	6.50	8.75	5.65	13.08	4.96	5.97	9.98	4.47	10.20	4.26
Carnmoney	31.5	79	3.70	6.25	4.98	10.25	4.82	4.52	8.57	5.27	11.35	5.16
Castlereagh	31.5	79	13.06	20.76	20.81	52.95	18.33	13.27	20.69	26.79	68.26	24.24
Coleraine	40	100	4.02	5.41	10.99	23.08	9.69	4.81	7.36	12.12	26.50	11.22
Coolkeeragh	31.5	79	9.28	20.67	24.09	58.92	21.46	10.23	22.52	29.27	72.49	27.19
Creagh	31.5	79	3.26	3.98	8.79	17.53	8.36	4.17	6.40	9.24	19.57	8.92
Cregagh	26.2	65	9.58	13.32	18.35	45.07	16.34	6.60	12.14	22.64	52.59	20.74
Drumquin	40	100	5.95	10.09	7.54	17.18	6.94	6.38	14.68	6.58	15.18	6.32
Donegall North	31.5	79	7.33	12.72	15.61	36.88	14.32	5.32	10.66	18.74	41.81	17.57
Donegall South	n/a	n/a	5.46	8.11	12.17	27.29	11.35	4.78	8.78	13.07	28.52	12.47
Drumnakelly	31.5	79	6.46	10.56	23.34	54.01	21.16	6.61	11.79	24.57	57.06	23.04
Dungannon	40	100	6.03	10.74	20.41	46.65	18.75	6.42	12.60	22.06	50.99	20.85
Eden	25	62.5	3.99	6.10	7.47	15.66	7.16	4.61	8.25	7.74	16.76	7.55
Enniskillen	31.5	79	3.90	5.15	10.13	21.11	8.98	4.83	8.13	9.05	19.79	8.53
Finaghy	31.5	79	8.30	15.29	16.21	39.04	14.85	6.40	12.30	19.94	46.07	18.64
Glengormley	18.4	46.8	3.57	5.58	6.25	12.77	6.04	4.33	8.96	6.07	12.97	5.93
Gort Cluster	40	100	6.57	8.98	9.36	21.73	8.76	6.21	13.63	8.36	19.22	8.00
Hannahstown	31.5	79	9.34	19.79	17.89	43.79	16.28	10.04	20.79	22.34	55.18	20.76
Kells	40	100	8.45	18.39	23.71	57.25	21.53	9.20	19.80	29.21	71.36	26.81

<sup>135</sup> The switchgear ratings at Castlereagh, Coolkeeragh, Magherafelt, Tandragee and Kells 275 kV substations have been temporarily reduced to 10 kA by NIE Networks following review of the capability of concrete structures to withstand mechanical loading under fault conditions. This is under constant review and projects will be brought forward to address this issue.

**Table E-9 Northern Ireland Short Circuit Currents for Maximum Demand in 2024**

Node	Rating		Three Phase					Single Phase				
	RMS	Peak	X/R	X/R	I''	ip	IB	X/R	X/R	I''	ip	IB
	[kA]	[kA]	ratio (AC)	Ratio (DC)	[kA]	[kA]	[kA]	ratio (AC)	Ratio (DC)	[kA]	[kA]	[kA]
Killymallaght	40	100	5.66	8.04	13.45	30.37	12.55	5.43	10.21	12.22	27.38	11.82
Knock	n/a	n/a	4.44	6.28	17.23	37.02	15.46	2.80	10.92	17.15	32.89	16.07
Larne	18.4	46.8	4.07	4.80	9.75	20.54	9.27	4.91	7.97	9.24	20.27	8.97
Limavady	40	100	3.55	4.23	8.52	17.37	7.75	4.39	7.00	8.72	18.70	8.29
Lisburn	18.4	46.8	5.23	7.66	12.55	27.89	11.74	5.12	9.64	12.15	26.91	11.67
Lisaghmore	31.5	79	4.18	6.66	10.64	22.56	10.00	4.60	9.34	10.19	22.05	9.87
Loguestown	26.2	65	3.50	4.76	7.23	14.67	6.57	4.25	6.78	7.56	16.08	7.16
Magherakeel Cluster	40	100	5.42	10.41	4.65	10.42	4.50	7.17	13.37	5.14	12.11	4.99
Newtownards	40	100	4.39	6.46	8.51	18.23	7.99	5.69	9.86	7.99	18.07	7.71
Newry	18.4	46.8	3.73	6.33	5.99	12.36	5.72	4.76	9.50	5.95	12.97	5.78
Omagh	40	100	4.78	7.33	18.00	39.29	16.10	5.28	9.93	17.50	38.98	16.38
Omagh South	40	100	4.24	6.83	13.18	28.01	11.85	4.50	6.90	11.62	25.04	11.02
Rasharkin	40	100	5.21	8.03	11.33	25.18	10.21	5.28	10.36	10.52	23.44	9.96
Rathgael	26.2	65	4.00	6.22	6.50	13.63	6.15	4.91	9.46	6.43	14.11	6.22
Rosebank	40	100	11.01	15.92	19.05	47.57	16.92	11.07	16.54	24.04	60.09	21.94
Slieve Kirk	40	100	4.35	6.47	9.42	20.14	8.96	5.46	11.34	7.67	17.21	7.51
Springtown	n/a	n/a	4.30	6.87	10.80	23.03	10.17	4.66	9.27	10.51	22.81	10.19
Strabane	40	100	4.51	5.96	17.34	37.38	15.85	5.02	9.19	16.49	36.37	15.75
Tandragee	31.5	79	8.15	17.05	25.56	61.38	23.01	9.01	19.06	29.93	72.90	27.75
Tremoge	40	100	4.00	5.67	9.84	20.64	9.32	4.51	9.26	8.96	19.30	8.69
Tamnamore	40	100	7.22	16.15	25.02	58.98	22.80	8.23	18.19	31.00	74.56	28.90
Waringstown	18.4	46.8	4.59	7.31	9.08	19.64	8.64	4.59	7.31	9.08	19.64	8.64

**Table E-10 Northern Ireland Short Circuit Currents for Minimum Demand in 2027**

Node	Rating		Three Phase					Single Phase				
	RMS	Peak	X/R ratio (AC)	X/R Ratio (DC)	I''	ip	IB	X/R ratio (AC)	X/R Ratio (DC)	I''	ip	IB
	[kA]	[kA]			[kA]	[kA]	[kA]			[kA]	[kA]	[kA]
<b>400 kV</b>												
Turleenan	50	125	13.61	18.62	8.39	21.44	7.60	12.22	18.42	9.67	24.44	9.09
<b>275 kV</b>												
Ballylumford	31.5	79	11.58	17.70	12.29	30.87	10.88	12.57	20.04	15.00	38.00	13.81
Castlereagh	10 <sup>136</sup>	79	10.32	14.72	11.40	28.26	10.11	11.00	17.18	14.07	35.14	12.93
Coolkeeragh	10 <sup>136</sup>	79	12.77	18.35	10.83	27.49	9.74	13.83	21.76	11.41	29.20	10.77
Hannahstown	31.5	79	10.54	15.03	11.11	27.61	9.89	9.56	13.54	11.89	29.18	11.07
Kells	10 <sup>136</sup>	79	11.00	15.52	12.18	30.43	10.79	10.66	15.65	13.76	34.24	12.72
Kilroot	31.5	79	10.70	14.43	10.95	27.26	9.81	11.20	16.35	12.66	31.68	11.78
Magherafelt	10 <sup>136</sup>	79	11.67	16.99	14.02	35.26	12.31	9.12	11.96	13.49	32.90	12.57
Moyle	31.5	79	11.51	17.44	12.11	30.41	10.74	12.44	19.60	14.72	37.25	13.57
Tandragee	10 <sup>136</sup>	79	10.59	15.14	14.87	36.97	12.96	9.88	15.14	16.22	39.98	14.93
Tamnamore	40	100	11.17	16.01	14.68	36.73	12.84	10.70	18.02	15.29	38.07	14.15
Turleenan	40	100	11.13	15.98	14.88	37.21	13.01	10.13	16.19	15.39	38.06	14.24
<b>110 kV</b>												
Aghyoule	40	100	4.11	8.78	4.45	9.38	3.95	5.70	12.51	4.24	9.60	4.02
Agivey	40	100	6.73	9.16	6.52	15.20	5.77	7.08	13.91	5.61	13.19	5.32
Antrim	40	100	4.35	6.99	9.07	19.38	8.60	4.60	9.22	9.31	20.16	8.96
Airport Road	40	100	4.35	6.46	8.56	18.31	8.14	5.19	9.79	8.41	18.67	8.16
Ballylumford	40	100	10.40	21.01	14.36	35.62	13.35	11.51	23.48	18.16	45.58	17.19
Ballymena	40	100	4.62	8.41	8.33	18.05	7.91	4.99	11.72	8.21	18.09	7.81
Banbridge	18.4	46.8	3.87	7.00	6.41	13.33	6.19	3.80	5.28	4.91	10.18	4.84
Ballyvally	21.9	46.8	5.16	6.15	12.81	28.41	11.90	4.83	6.31	12.71	27.79	12.13
Ballynahinch	18.4	46.8	3.95	6.52	5.82	12.17	5.60	4.90	9.67	5.88	12.90	5.74
Belfast Central	40	100	8.99	13.76	18.82	45.82	16.98	6.59	13.26	23.28	54.05	21.58
Belfast North	40	100	8.75	13.24	18.48	44.83	16.70	44.10	59.62	6.13	16.78	6.00
Brockaghboy	40	100	6.75	8.77	5.73	13.37	5.05	6.12	10.11	4.49	10.29	4.28
Carnmoney	31.5	79	3.90	6.64	4.42	9.21	4.29	4.65	8.82	4.82	10.45	4.73
Castlereagh	31.5	79	10.53	17.44	19.61	48.73	17.64	11.08	18.19	25.40	63.48	23.41
Coleraine	40	100	4.15	5.49	10.61	22.44	9.44	4.93	7.43	11.83	25.99	11.02
Coolkeeragh	31.5	79	9.38	20.38	20.88	51.13	18.52	10.24	22.07	25.99	64.36	24.08
Creagh	31.5	79	3.87	4.48	8.87	18.46	8.41	5.73	7.90	8.41	19.04	8.15
Cregagh	26.2	65	9.09	13.73	18.55	45.23	16.76	7.08	11.92	23.28	54.70	21.58
Drumquin	40	100	5.41	7.74	6.69	14.98	6.08	6.05	12.21	6.20	14.18	5.92
Donegall North	31.5	79	8.12	12.24	17.77	42.65	16.12	6.01	11.70	17.30	39.53	16.34
Donegall South	n/a	n/a	5.13	7.02	12.28	27.20	11.46	5.22	8.74	12.06	26.80	11.57
Drumnakelly	31.5	79	6.92	11.40	19.43	45.50	17.69	6.99	12.40	21.30	49.93	20.06
Dungannon	40	100	6.47	11.39	17.68	40.92	16.15	6.71	13.04	19.77	46.04	18.66
Eden	25	62.5	4.29	6.71	6.32	13.48	6.08	4.80	8.65	6.85	14.98	6.68
Enniskillen	31.5	79	3.94	5.04	9.47	19.80	8.34	4.84	7.92	8.72	19.07	8.21
Finaghy	31.5	79	7.52	11.42	16.52	39.20	15.10	7.05	12.01	17.02	39.98	16.09

<sup>136</sup> The switchgear ratings at Castlereagh, Coolkeeragh, Magherafelt, Tandragee and Kells 275 kV substations have been temporarily reduced to 10 kA by NIE Networks following review of the capability of concrete structures to withstand mechanical loading under fault conditions. This is under constant review and projects will be brought forward to address this issue.

**Table E-10 Northern Ireland Short Circuit Currents for Minimum Demand in 2027**

Node	Rating		Three Phase					Single Phase				
	RMS	Peak	X/R ratio (AC)	X/R Ratio (DC)	I''	ip	IB	X/R ratio (AC)	X/R Ratio (DC)	I''	ip	IB
	[kA]	[kA]			[kA]	[kA]	[kA]			[kA]	[kA]	
Glengormley	18.4	46.8	3.74	5.76	5.70	11.77	5.50	4.44	9.05	5.70	12.24	5.56
Gort Cluster	40	100	6.15	7.30	8.26	18.94	7.76	6.02	11.80	7.66	17.51	7.42
Hannahstown	31.5	79	8.33	13.54	18.33	44.15	16.60	9.35	14.85	18.62	45.58	17.52
Kells	40	100	8.73	16.78	18.19	44.12	16.48	9.46	18.49	23.33	57.19	21.34
Killymallaght	40	100	5.87	8.42	12.58	28.59	11.63	5.56	10.43	11.70	26.33	11.27
Knock	n/a	n/a	4.23	6.29	16.35	34.74	14.95	2.80	10.81	16.53	31.69	15.68
Larne	18.4	46.8	4.41	5.30	8.33	17.87	7.89	5.12	8.28	8.31	18.41	8.04
Limavady	40	100	3.65	4.34	8.17	16.76	7.45	4.47	7.08	8.47	18.22	8.06
Lisburn	18.4	46.8	5.07	7.19	12.15	26.84	11.38	5.38	9.63	11.35	25.39	10.94
Lisaghmore	31.5	79	4.34	6.91	9.90	21.15	9.26	4.70	9.49	9.68	21.04	9.37
Loguestown	26.2	65	3.56	4.80	7.02	14.33	6.44	4.30	6.81	7.42	15.83	7.07
Magherakeel Cluster	40	100	5.34	9.83	4.47	9.98	4.29	7.01	12.58	4.91	11.53	4.76
Newtownards	40	100	4.26	6.27	8.12	17.28	7.73	5.55	9.58	7.72	17.37	7.51
Newry	18.4	46.8	3.83	6.46	5.53	11.48	5.34	4.87	9.52	5.62	12.32	5.50
Omagh	40	100	4.83	6.97	16.09	35.21	14.21	5.31	9.47	16.17	36.07	15.10
Omagh South	40	100	4.16	5.97	11.94	25.26	10.58	4.46	6.40	10.98	23.61	10.36
Rasharkin	40	100	5.77	8.68	12.46	28.24	11.18	5.66	11.23	11.16	25.20	10.54
Rathgael	26.2	65	3.94	6.22	6.23	13.03	5.99	4.85	9.39	6.23	13.65	6.09
Rosebank	40	100	9.34	14.26	17.99	44.04	16.31	10.01	15.58	22.86	56.46	21.23
Slieve Kirk	40	100	4.49	6.70	9.02	19.42	8.52	5.55	11.53	7.48	16.84	7.30
Springtown	n/a	n/a	4.46	7.13	10.00	21.49	9.39	4.76	9.42	9.95	21.69	9.64
Strabane	40	100	4.74	6.29	15.89	34.63	14.37	5.17	9.41	15.53	34.44	14.77
Tandragee	31.5	79	8.53	17.48	20.96	50.68	18.98	9.39	19.45	25.13	61.56	23.46
Tremoge	40	100	4.14	5.85	9.28	19.62	8.69	4.60	9.35	8.61	18.63	8.31
Tamnamore	40	100	7.77	16.78	21.18	50.52	19.13	8.70	18.78	26.85	65.10	24.97
Waringstown	18.4	46.8	4.80	7.63	8.25	18.03	7.89	5.53	10.54	8.07	18.15	7.87



**Table E-11 Northern Ireland Short Circuit Currents for Maximum Demand in 2027**

Node	Rating		Three Phase					Single Phase				
	RMS	Peak	X/R ratio (AC)	X/R Ratio (DC)	I''	ip	IB	X/R ratio (AC)	X/R Ratio (DC)	I''	ip	IB
	[kA]	[kA]			[kA]	[kA]	[kA]			[kA]	[kA]	[kA]
<b>400 kV</b>												
Turleenan	50	125	15.16	19.24	10.78	27.81	10.16	12.71	18.47	11.74	29.79	11.34
<b>275 kV</b>												
Ballylumford	31.5	79	11.58	17.70	19.19	48.88	17.27	14.24	22.76	21.09	54.10	19.83
Castlereagh	10 <sup>137</sup>	79	10.32	14.72	17.10	42.48	15.29	11.26	17.65	19.37	48.50	18.01
Coolkeeragh	10 <sup>137</sup>	79	12.77	18.35	13.35	33.89	12.37	13.92	21.14	13.17	33.72	12.68
Hannahstown	31.5	79	10.54	15.03	16.44	41.01	14.81	9.40	12.96	15.46	37.87	14.61
Kells	10 <sup>137</sup>	79	11.00	15.52	20.13	51.16	18.19	11.37	16.66	19.56	49.04	18.52
Kilroot	31.5	79	10.70	14.43	19.98	51.38	18.14	13.70	21.93	19.57	50.03	18.63
Magherafelt	10 <sup>137</sup>	79	11.67	16.99	20.62	52.10	18.66	8.73	10.82	17.02	41.28	16.26
Moyle	31.5	79	11.51	17.44	18.77	47.75	16.93	13.96	21.90	20.55	52.62	19.34
Tandragee	10 <sup>137</sup>	79	10.59	15.14	22.10	55.06	19.85	9.66	14.46	21.36	52.51	20.15
Tamnamore	40	100	11.17	16.01	21.42	53.71	19.36	10.59	17.69	19.65	48.86	18.65
Turleenan	40	100	11.13	15.98	21.75	54.52	19.65	9.90	15.50	19.77	48.76	18.78
<b>110 kV</b>												
Aghyoule	40	100	4.11	8.78	4.54	9.55	4.07	5.66	12.51	4.29	9.69	4.07
Agivey	40	100	6.73	9.16	6.90	16.02	6.16	6.99	13.71	5.85	13.72	5.58
Antrim	40	100	4.35	6.99	10.61	22.38	10.11	4.45	9.32	10.33	22.20	9.99
Airport Road	40	100	4.35	6.46	9.81	20.57	9.27	4.96	9.57	9.20	20.23	8.90
Ballylumford	40	100	10.40	21.01	21.43	54.19	19.87	13.78	29.51	25.11	64.21	23.96
Ballymena	40	100	4.62	8.41	9.52	20.32	9.07	4.80	11.55	8.89	19.42	8.51
Banbridge	18.4	46.8	3.87	7.00	7.02	14.44	6.78	3.71	5.16	5.17	10.66	5.09
Ballyvallyagh	21.9	46.8	5.16	6.15	16.54	35.76	15.48	4.45	5.70	14.94	32.12	14.40
Ballynahinch	18.4	46.8	3.95	6.52	6.44	13.29	6.15	4.75	9.57	6.30	13.72	6.12
Belfast Central	40	100	8.99	13.76	25.49	61.06	22.40	5.82	12.65	29.54	67.06	26.90
Belfast North	40	100	8.75	13.24	24.86	59.30	21.91	48.86	67.95	6.55	18.00	6.42
Brockaghboy	40	100	6.75	8.77	6.03	14.02	5.36	6.05	9.96	4.66	10.66	4.47
Carmoney	31.5	79	3.90	6.64	4.99	10.27	4.84	4.51	8.55	5.27	11.36	5.17
Castlereagh	31.5	79	10.53	17.44	26.97	66.27	23.62	10.37	18.28	33.18	82.30	30.00
Coleraine	40	100	4.15	5.49	11.52	24.09	10.26	4.77	7.22	12.56	27.41	11.70
Coolkeeragh	31.5	79	9.38	20.38	24.51	59.88	21.96	10.19	22.43	29.67	73.44	27.67
Creagh	31.5	79	3.87	4.48	10.04	20.66	9.52	5.70	8.14	9.11	20.59	8.83
Cregagh	26.2	65	9.09	13.73	25.02	60.06	22.06	6.29	11.17	29.59	68.15	26.97
Drumquin	40	100	5.41	7.74	7.58	17.27	7.00	6.37	14.66	6.61	15.25	6.36
Donegall North	31.5	79	8.12	12.24	23.53	55.43	20.88	5.47	11.21	20.56	46.13	19.24
Donegall South	n/a	n/a	5.13	7.02	14.82	32.04	13.69	4.87	8.36	13.60	29.79	12.99
Drumnakelly	31.5	79	6.92	11.40	24.57	56.58	22.43	6.50	11.77	25.20	58.36	23.77
Dungannon	40	100	6.47	11.39	21.21	48.46	19.63	6.42	12.66	22.66	52.37	21.52
Eden	25	62.5	4.29	6.71	7.50	15.71	7.21	4.59	8.23	7.76	16.79	7.58
Enniskillen	31.5	79	3.94	5.04	10.22	21.28	9.07	4.82	8.12	9.11	19.91	8.59
Finaghy	31.5	79	7.52	11.42	21.35	49.68	19.16	6.50	11.46	20.15	46.67	18.90

137 The switchgear ratings at Castlereagh, Coolkeeragh, Magherafelt, Tandragee and Kells 275 kV substations have been temporarily reduced to 10 kA by NIE Networks following review of the capability of concrete structures to withstand mechanical loading under fault conditions. This is under constant review and projects will be brought forward to address this issue.

**Table E-11 Northern Ireland Short Circuit Currents for Maximum Demand in 2027**

Node	Rating		Three Phase					Single Phase				
	RMS	Peak	X/R	X/R	I''	ip	IB	X/R	X/R	I''	ip	IB
	[kA]	[kA]	ratio (AC)	Ratio (DC)	[kA]	[kA]	[kA]	ratio (AC)	Ratio (DC)	[kA]	[kA]	[kA]
Glengormley	18.4	46.8	3.74	5.76	6.28	12.81	6.08	4.32	8.93	6.08	12.98	5.95
Gort Cluster	40	100	6.15	7.30	9.46	21.93	8.87	6.20	13.60	8.42	19.33	8.06
Hannahstown	31.5	80	8.33	13.54	24.39	57.71	21.61	8.76	14.37	22.41	54.37	20.89
Kells	40	100	8.73	16.78	24.35	58.84	22.21	9.41	19.79	29.51	72.31	27.22
Killymallaght	40	100	5.87	8.42	13.58	30.65	12.72	5.41	10.18	12.30	27.54	11.92
Knock	n/a	n/a	4.23	6.29	21.04	42.87	18.89	2.49	10.53	19.23	35.73	18.11
Larne	18.4	46.8	4.41	5.30	9.82	20.65	9.36	4.89	7.94	9.26	20.31	9.01
Limavady	40	100	3.65	4.34	8.67	17.61	7.93	4.36	6.95	8.83	18.88	8.41
Lisburn	18.4	46.8	5.07	7.19	14.43	31.17	13.44	5.06	9.27	12.60	27.83	12.12
Lisaghmore	31.5	79	4.34	6.91	10.72	22.68	10.10	4.58	9.31	10.23	22.13	9.93
Loguestown	26.2	65	3.56	4.80	7.44	15.05	6.82	4.22	6.70	7.72	16.39	7.34
Magherakeel Cluster	40	100	5.34	9.83	4.70	10.53	4.55	7.16	13.35	5.20	12.23	5.04
Newtownards	40	100	4.26	6.27	9.30	19.47	8.79	5.36	9.58	8.43	18.84	8.17
Newry	18.4	46.8	3.83	6.46	6.06	12.47	5.81	4.78	9.49	5.99	13.07	5.83
Omagh	40	100	4.83	6.97	18.28	39.82	16.41	5.26	9.89	17.68	39.37	16.60
Omagh South	40	100	4.16	5.97	13.31	28.26	12.00	4.49	6.88	11.71	25.21	11.11
Rasharkin	40	100	5.77	8.68	14.00	31.39	12.72	5.48	10.93	11.99	26.91	11.42
Rathgael	26.2	65	3.94	6.22	6.94	14.29	6.61	4.69	9.25	6.70	14.56	6.51
Rosebank	40	100	9.34	14.26	24.04	57.99	21.30	9.45	15.25	29.03	71.16	26.53
Slieve Kirk	40	100	4.49	6.70	9.49	20.27	9.05	5.45	11.31	7.71	17.28	7.55
Springtown	n/a	n/a	4.46	7.13	10.87	23.16	10.28	4.64	9.25	10.55	22.89	10.25
Strabane	40	100	4.74	6.29	17.61	37.91	16.14	5.01	9.17	16.66	36.71	15.94
Tandragee	31.5	79	8.53	17.48	27.09	64.79	24.57	8.88	19.31	30.71	74.65	28.68
Tremoge	40	100	4.14	5.85	9.96	20.86	9.46	4.50	9.23	9.02	19.44	8.77
Tamnamore	40	100	7.77	16.78	26.31	62.11	24.17	8.35	18.77	32.28	77.79	30.29
Waringstown	18.4	46.8	4.80	7.63	9.25	19.94	8.84	5.35	10.31	8.71	19.46	8.49

# Appendix F

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# Appendix F: Approaches to Consultation for Developing the Grid

## F-1 EirGrid Approach to Consultation

In December 2016 EirGrid launched **Have Your Say**<sup>138</sup>, which outlines our approach to consultation. It followed a review of our consultation activities, after which, we made a commitment to improve the way we engage with the public and stakeholders.

**Have Your Say** outlines the way we develop our projects and how the public can engage with us at each stage of project development.

## F-2 SONI Approach to Consultation

SONI has reviewed its approach to engaging and consulting with the public and stakeholders, this included independent analysis by The Consultation Institute (TCI) which made a number of recommendations. Following engagement with a range of stakeholders and in line with TCI's recommendations, SONI has developed a new **Grid Development Process**<sup>139</sup>. This three part process puts stakeholders and the community at the heart of what we do. To find out more visit [www.soni.ltd.uk](http://www.soni.ltd.uk) and if you have any queries you can contact us at [info@soni.ltd.uk](mailto:info@soni.ltd.uk).

<sup>138</sup> <http://www.eirgridgroup.com/the-grid/>

<sup>139</sup> <http://www.soni.ltd.uk/media/SONIs-Powering-The-Future-Grid-Development-Process-brochure.pdf>

# Appendix G

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## Appendix G: References

The following documents are referenced in this All-Island Ten Year Transmission Forecast Statement:

- All-Island Generation Capacity Statement 2021-2030. EirGrid and SONI issued this report in September 2021. Its main purpose is to inform market participants, regulatory agencies and policy makers of the likely minimum generation capacity required to achieve an adequate supply and demand balance for electricity for the period 2021 to 2030. Available on <https://www.eirgridgroup.com/site-files/library/EirGrid/208281-All-Island-Generation-Capacity-Statement-LR13A.pdf>.
- Transmission Development Plan Ireland 2020-2029, CRU approved version published in October 2021. The main purpose of this document is to document the plan for the development of the Irish transmission system and interconnection for the following 10 year period. Available on <https://www.eirgridgroup.com/site-files/library/EirGrid/Transmission-Development-Plan-2020-2029.pdf>.
- Transmission Development Plan Northern Ireland 2020-2029, UR approved version published in March 2021. The main purpose of this document is to document the plan for the development of the Northern Ireland transmission system and interconnection for the following 10 year period. Available on <https://www.soni.ltd.uk/media/documents/SONI-Transmission-Development-Plan-Northern-Ireland-2020-2029.pdf>.
- EirGrid Grid Code Version 9.0, December 2020. The EirGrid Grid Code covers technical aspects relating to the operation and use of the transmission system, and to plant and apparatus connected to the transmission system or to the distribution system. Available on <http://www.eirgridgroup.com/site-files/library/EirGrid/GridCodeVersion9.pdf>.
- SONI Grid Code, October 2020. The SONI Grid Code is designed to permit the development, maintenance and operation of an efficient, co-ordinated and economical Transmission System in Northern Ireland. The grid code is prepared by SONI pursuant to condition 16 of SONI's Licence. Available on <https://www.soni.ltd.uk/media/documents/SONI-Grid-Code-8th-October-2020.pdf>.
- Transmission System Security and Planning Standards Ireland, May 2016. This document sets out the technical standards by which the adequacy of the grid in Ireland is determined. Available on <http://www.eirgridgroup.com/site-files/library/EirGrid/EirGrid-Transmission-System-Security-and-Planning-Standards-TSSPS-Final-May-2016-APPROVED.pdf>.
- Transmission System Security and Planning Standards Northern Ireland, September 2015. This document sets out the technical standards by which the adequacy of the grid in Northern Ireland is determined. Available on <https://www.soni.ltd.uk/media/Northern-Ireland-TSSPS-September-2015.pdf>.

- Electricity Regulation Act, 1999. This act provides the regulatory framework for the introduction of competition in the generation and supply of electricity in Ireland. The Act provided for the establishment of the Commission for Regulation of Utilities (CRU) (previously called the Commission for Energy Regulation) and gave it the necessary powers to licence and regulate the generation, distribution, transmission and supply of electricity. Available on [www.cru.ie](http://www.cru.ie).
- EirGrid's TSO Licence. On June 29 2006, the CER issued a Transmission System Operator (TSO) Licence to EirGrid plc. pursuant to Section 14(1)(e) of the Electricity Regulation Act, 1999, as inserted by Regulation 32 of S.I. No. 445 of 2000 – European Communities (Internal Market in Electricity) Regulations 2001. The most recent update was issued in March 2017. Available on [www.cru.ie](http://www.cru.ie).
- SONI's Licence to Participate in the Transmission of Electricity, updated to February 2019. Available on [www.uregni.gov.uk](http://www.uregni.gov.uk). Condition 33 requires SONI to prepare a statement (in a form; in consultation with EirGrid; and based on methodologies approved by UREGNI) showing in respect of each of the ten succeeding financial years; circuit capacity; forecast electrical flows and loading on each part of the transmission system; and fault levels for each transmission node.
- Ireland's Climate Action Plan, June 2019, published by the Department of Communications, Climate Action and Environment. Available on [www.dccae.gov.ie](http://www.dccae.gov.ie).

# Appendix H

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## Appendix H: Power Flows

This appendix presents sample power flows for summer valley and winter peak for the years 2021 and 2030 based on a particular set of assumptions. Table H-1 shows the MW and MVAR flows on all lines in the transmission system and the percentage loading of the lines relative to their seasonal rating. The flows shown are based on the following assumptions:

- Wind generation operating at 30% of capacity at the winter peak, and 0% at the summer valley;
- Solar power operating at 0% at both the winter peak and summer valley (as both occur at night); and
- Power stations dispatched according to system constraints and merit order.

Indeed the transmission system needs to be capable of accommodating a diverse range of power flows as they can vary greatly throughout the day and year. Power flows depend on system conditions, such as the level of demand, generation and interconnection, and the availability of plant which can be out of service unexpectedly or due to planned maintenance.

Data fields without data (but with a hyphen) denote lines which do not exist in the associated case, due to either being decommissioned or not yet constructed.

**Table H-1 Power Flows, Summer Valley and Winter Peak 2021 and 2030**

Line				2021						2030					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
DSN	CNB	400	1	-	-	-	-	-	-	-187.7	-44.8	12.2	-213.9	-12.2	11.0
KPG	MP	400	1	-	-	-	-	-	-	166.3	-18.2	13.8	228.7	-16.3	19.0
CNB	MP	400	1	-	-	-	-	-	-	-222.7	-99.4	15.5	-271.7	-90.8	14.7
MP	OST	400	1	35.2	30.3	4.7	204.1	-6.3	20.5	39.0	27.1	4.8	104.7	54.7	11.9
OST	WOO	400	1	-39.4	153.0	15.8	237.3	72.0	24.9	277.0	25.8	27.9	282.5	175.8	33.4
WOO	PRT	400	1	-199.9	173.3	38.6	-419.8	-118.1	63.7	-200.0	63.5	30.6	-499.8	71.3	73.7
WOO	TUR	400	1	-	-	-	-	-	-	-81.3	-41.8	6.4	378.7	-41.3	22.0
LOU	TAN	275	1	108.3	-15.2	15.4	437.9	-10.7	49.7	-120.3	0.2	16.9	57.0	11.4	6.6
LOU	TAN	275	2	108.2	-16.4	15.4	438.1	-34.0	49.9	-120.4	1.5	17.0	57.2	10.8	6.6
BPS	HAN	275	2	-14.8	-16.4	3.1	39.4	23.4	5.2	119.9	1.1	16.9	167.5	-0.6	19.0
BPS	KEL	275	1	-131.9	10.7	18.6	-176.4	78.4	21.9	115.2	32.5	16.9	27.4	46.2	6.1
BPS	MAG	275	1	-92.3	-7.0	13.0	-147.0	36.6	17.2	73.1	15.2	10.5	27.0	9.6	3.3
BPS	BYC	275	1	280.6	32.6	39.8	433.5	-57.2	49.6	41.5	-31.5	7.3	89.0	-31.3	10.7
CAS	HAN	275	1	34.9	-6.7	5.0	45.5	-46.9	7.4	-74.7	-29.7	11.3	-90.2	-18.7	10.5
CAS	HAN	275	2	34.9	-6.7	5.0	45.5	-46.9	7.4	-74.7	-29.7	11.3	-90.2	-18.7	10.5
CAS	KPS	275	1	-74.0	6.4	10.5	-148.5	17.3	17.0	-24.5	-4.4	3.5	-155.6	20.7	17.8
CAS	TAN	275	1	-100.0	22.7	14.4	-304.9	67.3	35.4	68.6	29.5	10.5	-112.9	24.6	13.1
CPS	CPS	275	1	86.2	-17.4	11.6	90.0	-5.8	10.8	62.4	-26.3	8.9	-19.4	-14.0	2.9
CPS	CPS	275	1	86.2	-17.4	11.6	90.0	-5.8	10.8	62.4	-26.3	8.9	-19.4	-13.4	2.8
CPS	MAG	275	1	86.2	-13.1	21.2	90.0	-1.6	17.5	62.4	-22.3	8.7	-19.4	-9.8	2.6
CPS	MAG	275	2	86.2	-13.1	21.2	90.0	-1.6	17.5	62.4	-22.3	8.7	-19.4	-9.8	2.6
HAN	BYC	275	1	20.1	5.1	2.9	-32.3	-36.4	5.5	-121.0	-10.6	17.1	-168.3	-7.0	19.1
KEL	KPS	275	1	-58.6	0.1	8.3	-103.0	29.3	12.2	41.8	-10.6	6.1	-74.0	12.2	8.5
KEL	KPS	275	2	-58.6	0.1	8.3	-103.0	29.3	12.2	41.8	-10.6	6.1	-74.0	12.2	8.5
KEL	MAG	275	1	-47.9	-18.0	7.2	-113.1	-3.4	12.8	26.0	4.7	3.7	26.1	-21.5	3.8
KPS	TAN	275	1	4.5	-7.6	1.3	-50.4	7.1	5.8	58.9	6.4	8.4	64.8	-15.2	7.6
MAG	TMN	275	1	15.5	1.5	2.2	-40.9	38.2	6.4	111.8	12.7	15.8	7.2	11.8	1.6
MAG	TMN	275	2	15.5	1.5	2.2	-40.9	38.2	6.4	111.8	12.7	15.8	7.2	11.8	1.6
TAN	TUR	275	1	-	-	-	-	-	-	-77.0	-22.7	11.3	-119.9	-7.7	13.6
TAN	TUR	275	2	-	-	-	-	-	-	-77.0	-22.7	11.3	-119.9	-7.7	13.6
TMN	TUR	275	1	-	-	-	-	-	-	117.9	3.8	16.6	-67.5	12.9	7.8
TMN	TUR	275	2	-	-	-	-	-	-	117.9	3.8	16.6	-67.5	12.9	7.8
AD	AD	220	1	39.7	-23.7	7.8	42.5	-99.2	18.2	-139.2	52.9	25.1	137.1	-115.0	30.2
AD	AD	220	1	39.7	-23.7	7.8	42.5	-99.2	18.2	-139.2	52.9	25.1	69.4	4.9	11.7
AD	KRA	220	1	96.9	-87.6	33.2	167.6	9.4	35.9	79.7	-20.7	21.0	239.0	16.6	51.2
AD	RAF	220	1	62.5	-70.6	21.7	121.8	-10.6	23.8	35.9	-25.8	10.2	169.0	-20.4	33.2
AD	AD	220	1	39.7	-23.7	7.8	42.5	-99.2	18.2	-139.2	52.9	25.1	-455.7	102.5	78.8
AD	GGO	220	1	-55.9	62.4	14.6	-122.8	10.5	21.5	-217.8	73.1	40.1	-98.4	-131.8	28.7
AD	KRA	220	2	95.7	-86.1	32.8	165.1	9.6	35.3	78.6	-20.2	20.7	235.5	16.8	50.5
ARK	CKM	220	1	36.4	-6.4	8.5	98.3	-20.9	19.6	130.0	-18.1	30.2	236.3	-81.1	48.7
ARK	LWD	220	1	-54.6	8.5	12.7	-135.5	6.5	31.2	-134.4	15.4	31.2	-277.9	76.4	66.3
BVK	CLA	220	1	-69.0	175.1	25.4	67.2	-3.2	8.5	-14.0	5.5	2.0	-116.0	36.6	15.4
BVK	BYH	220	1	69.0	-99.7	27.9	33.7	-23.7	5.2	86.9	-28.6	12.0	216.8	-39.6	27.8

**Table H-1 Power Flows, Summer Valley and Winter Peak 2021 and 2030**

Line				2021						2030					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
BLC	FIN (I)	220	1	-52.5	11.3	9.4	-109.6	-13.1	19.4	-66.0	68.6	16.7	-34.8	-18.9	7.0
BLC	SHL	220	1	-	-	-	-	-	-	-35.4	-71.8	14.0	-145.7	-16.5	25.7
CLE	CDU	220	1	-5.3	-1.4	1.3	51.2	-54.5	14.6	148.8	-88.4	39.9	-93.6	-47.6	20.5
CLE	WOO	220	1	-67.7	-8.6	15.7	-124.1	46.9	25.9	-288.9	46.2	67.4	-45.7	10.4	9.1
CLE	BTN	220	1	0.0	-8.5	1.5	0.0	-9.6	1.7	0.0	-8.2	1.4	0.0	-9.5	1.7
CLE	BTN	220	2	0.0	-8.5	1.5	0.0	-9.6	1.7	0.0	-8.2	1.4	0.0	-9.5	1.7
CLA	KRA	220	1	-97.3	155.1	28.3	-15.1	-20.0	3.3	-5.4	7.0	1.4	-163.5	15.9	21.9
CSH	FLA	220	1	60.7	11.6	17.7	232.6	17.5	53.5	46.9	-10.0	13.7	153.0	3.3	35.1
CSH	PRO	220	1	-58.0	-4.5	14.8	-165.3	9.8	35.4	19.2	-24.1	7.9	-86.5	-0.8	18.5
CSH	TYN	220	1	-73.9	63.3	12.8	-239.1	3.6	30.2	-95.4	48.3	14.1	-201.4	-1.1	25.4
CKM	DSN	220	1	-95.9	-8.3	22.2	-127.6	58.0	27.3	-211.3	25.6	49.0	-70.9	47.4	16.6
CKM	ISH	220	1	140.7	-63.0	26.0	98.3	-219.2	40.5	204.8	-32.0	35.0	-10.5	-196.8	33.2
CKM	CKM	220	1	-89.6	-19.7	26.2	-97.7	-10.8	28.1	62.3	-10.2	18.1	104.7	-8.2	30.0
CUL	GI	220	1	-51.0	54.7	10.0	11.9	-33.1	4.4	52.5	-7.0	7.1	-108.6	44.2	14.8
CUL	KRA	220	1	1.6	-31.5	4.9	-123.6	20.0	16.4	-85.6	7.9	13.3	-40.3	-46.3	8.0
CDU	CRH	220	1	-	-	-	1.9	-4.2	0.8	25.4	4.6	4.5	25.4	3.9	4.5
CDU	CRH	220	2	-	-	-	1.9	-4.2	0.8	25.4	4.6	4.5	25.4	3.9	4.5
CDU	FIN (I)	220	1	54.1	-89.4	24.1	20.8	-0.2	4.1	127.5	-109.1	38.7	-23.0	6.6	4.7
CDU	HN	220	1	-219.5	185.9	51.8	-219.4	-218.7	55.8	0.0	-13.3	2.4	-398.8	-206.1	80.9
CDU	FIN (I)	220	2	54.1	-89.4	24.1	20.8	-0.2	4.1	127.5	-109.1	38.7	-23.0	6.6	4.7
CDU	WOO	220	2	-49.6	-6.8	11.5	-108.3	50.4	23.3	-260.8	61.1	61.7	-8.1	20.7	4.3
DSN	KLS	220	1	-0.8	7.0	1.8	-32.5	3.8	7.0	-66.8	17.8	17.6	-211.7	101.6	50.2
DSN	MAY	220	1	101.8	-17.1	29.5	247.7	-2.2	56.8	130.6	4.5	30.1	176.4	-11.4	34.5
DSN	MAY	220	2	198.4	-31.8	57.4	274.6	-52.9	64.2	130.6	4.5	30.1	176.4	-11.4	34.5
DSN	TH	220	1	-494.0	165.9	148.5	-376.8	113.1	112.1	-220.3	32.5	63.5	1.4	-15.5	4.4
FLA	LOU	220	1	-0.2	57.9	15.1	169.7	21.1	36.0	56.4	0.8	14.7	49.8	8.0	10.6
FLA	SRA	220	1	31.1	-27.8	9.6	3.3	-15.1	3.0	-23.1	-1.8	5.3	36.5	-10.6	7.4
FIN (I)	HN	220	1	0.0	-4.0	0.7	-336.8	36.4	57.1	0.0	-3.8	0.7	-352.0	-4.6	59.4
FIN (I)	NW	220	1	-24.3	-56.5	18.5	-80.0	-42.8	27.3	-0.4	-97.4	29.3	-159.5	-27.4	48.7
GI	KLS	220	1	51.8	-29.3	15.1	157.4	24.7	34.0	74.0	-5.3	18.9	326.6	-8.7	69.8
GI	LWD	220	1	75.2	-37.5	19.4	168.8	-2.7	32.9	124.1	-16.7	28.9	330.8	-43.5	65.0
GI	LWN	220	1	-	-	-	-	-	-	-180.0	22.0	30.6	-499.7	306.1	98.8
GOR	LOU	220	1	128.3	-42.6	31.2	307.7	7.1	64.7	-93.1	7.6	21.5	44.9	6.2	9.5
GOR	MAY	220	1	-192.7	67.4	58.3	-409.4	-6.6	93.9	40.8	-5.1	11.8	-179.1	-19.9	41.3
GGO	RAF	220	1	141.6	-141.8	35.2	265.4	-5.5	46.6	137.4	-60.5	26.3	344.9	24.5	60.7
INC	ISH	220	1	-356.9	122.4	67.1	-782.3	-78.6	124.0	-204.5	-33.0	36.9	-735.1	-176.4	119.2
INC	CBT	220	2	-58.0	5.7	7.7	-12.9	91.2	11.6	-66.7	87.4	14.5	59.9	89.5	13.6
ISH	SHL	220	1	0.0	-3.7	0.7	-312.7	-37.2	57.5	0.0	-3.6	0.7	-312.7	-103.8	60.1
KNR	BYH	220	1	-68.3	9.8	15.9	-125.3	49.0	17.0	-144.7	57.5	21.0	-304.5	69.3	39.4
KNR	KPG	220	1	27.5	2.0	3.8	77.7	-22.6	10.6	77.4	-42.0	12.1	147.5	-36.3	19.9
KNR	KPG	220	2	40.7	-46.8	8.5	122.4	-69.1	18.4	126.2	-93.5	21.5	231.7	-74.4	31.9
KRA	KLN	220	1	113.5	-94.7	28.9	156.4	0.9	27.7	88.5	-28.4	18.2	274.5	-17.1	48.8
KRA	RAF	220	1	-93.0	82.6	35.2	-152.6	-10.3	33.7	-84.8	17.7	24.6	-220.2	-20.2	48.7

**Table H-1 Power Flows, Summer Valley and Winter Peak 2021 and 2030**

Line				2021						2030					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
KLN	SH	220	1	22.1	-1.0	8.2	138.7	-16.7	39.5	89.6	-14.8	33.8	135.8	-20.1	38.8
KLN	KPG	220	1	5.1	-80.9	18.7	-92.8	-35.8	19.4	18.1	-32.9	8.7	56.7	-44.4	14.1
KYT	MAY	220	1	-	-	-	-	-	-	14.9	-14.2	2.7	73.6	31.4	10.7
KYT	WOO	220	1	-	-	-	-	-	-	-132.0	-29.6	17.8	-190.6	-74.4	27.4
KPG	MP	220	1	-7.5	11.7	2.1	-56.6	-47.7	11.2	34.3	-28.0	6.7	92.0	-27.0	14.5
KPG	MP	220	2	-7.5	11.7	2.1	-56.6	-47.7	11.2	34.3	-28.0	6.7	92.0	-27.0	14.5
KPG	TB	220	1	15.5	-12.3	5.6	42.7	23.3	11.2	-3.7	-6.7	2.2	27.3	-13.1	6.9
CBT	MAY	220	1	-156.1	30.4	20.9	-29.5	145.1	18.6	-443.8	23.5	58.4	-154.9	63.7	21.1
CBT	MAY	220	2	19.7	-12.7	3.1	-105.8	37.4	14.1	-59.2	32.3	8.9	-50.0	5.4	6.3
CBT	INC	220	1	78.4	-9.5	10.4	17.4	-124.3	15.8	90.2	-118.3	19.6	-80.9	-121.3	18.4
LOU	ORL	220	1	-	-	-	-	-	-	120.1	-7.1	27.7	-215.6	-7.4	42.1
MAY	TH	220	1	-317.7	96.5	102.2	-358.8	74.1	104.4	-186.9	12.4	57.6	-104.7	-4.3	29.9
MAY	SH	220	1	19.4	-65.8	25.5	-57.8	19.0	17.2	-106.7	-3.2	39.7	-95.8	18.0	27.5
MP	PRO	220	1	25.9	-12.3	5.3	78.0	0.2	12.8	-11.2	1.0	2.1	30.1	-7.2	5.1
NW	PB	220	1	-24.3	12.9	8.3	-80.0	34.5	26.2	-0.4	-30.6	9.2	79.2	-16.8	24.4
OST	TYN	220	1	74.4	-68.6	23.3	-34.5	-32.7	9.3	-238.4	35.2	55.5	-178.5	-79.5	38.1
PB	PB	220	1	-45.9	-2.5	10.2	-8.2	13.1	3.4	-35.8	1.7	8.0	83.0	25.1	19.3
PB	SHL	220	1	21.7	-9.3	4.0	-71.8	51.6	14.9	35.4	-6.2	6.1	-3.8	-11.8	2.1
PB	CKM	220	1	89.7	-37.0	36.4	97.8	-51.9	41.5	-62.3	-46.5	29.1	-104.6	-54.5	44.2
PB	INC	220	1	-84.3	20.6	32.5	-147.8	39.6	57.3	-25.6	43.9	19.0	-16.7	26.6	11.8
PB	INC	220	2	-118.1	18.1	34.0	-206.0	38.0	59.7	-40.7	54.7	19.4	-27.4	31.8	12.0
PRO	TB	220	1	-32.4	-2.3	6.9	-89.8	6.0	19.3	7.9	-9.8	2.7	-57.1	2.0	12.2
SHL	SHL	220	1	-	-	-	-163.0	-20.6	8.8	-	-	-	-163.0	-57.9	9.3
TB	KPG	220	2	-16.9	10.2	5.6	-47.3	-28.4	12.6	4.2	4.4	1.7	-29.9	11.5	7.3
WOO	ORL	220	1	-	-	-	-	-	-	-129.1	8.4	29.8	155.2	75.2	33.6
ORL	ORL	220	1	-	-	-	-	-	-	-10.2	0.5	1.7	-62.8	60.2	14.7
ORL	ORL	220	1	-	-	-	-	-	-	-10.2	0.5	1.7	-62.8	7.9	11.1
AA	DRU	110	1	9.9	-14.8	18.0	31.2	-8.8	26.8	12.7	-9.8	16.2	44.3	-12.2	38.0
AA	ENN (I)	110	1	6.2	-19.3	20.5	17.4	-7.7	15.7	7.4	-15.0	16.9	31.0	-12.2	27.6
AA	LIM (I)	110	1	-1.2	15.5	8.7	7.8	13.5	7.5	29.6	2.7	16.7	-8.3	24.9	12.6
AA	AA	110	1	-	-	-	0.0	-33.1	26.9	-	-	-	0.0	-33.1	26.9
AD	WHI	110	1	25.5	-14.3	29.5	57.4	5.1	47.6	23.5	-0.5	23.8	69.3	4.0	57.4
ARI	ARI T	110	1	-0.6	0.3	0.7	-0.8	-2.2	1.9	3.8	-6.4	7.1	-1.2	-6.7	5.6
AGL	DYN	110	1	0.0	-0.3	0.3	-17.8	6.4	15.3	-17.8	1.0	16.9	-17.8	0.9	14.5
AGL	ENN (I)	110	1	-0.8	-8.9	9.0	-21.4	9.3	19.3	-6.5	6.2	9.1	-9.2	6.9	9.5
AGL	SH	110	1	0.8	9.2	8.9	39.2	-15.7	35.5	24.3	-7.1	24.3	27.0	-7.7	23.6
AHA	KLN	110	1	-0.9	0.2	1.3	-5.0	-0.4	7.4	-1.2	0.3	1.9	-5.3	-0.4	7.8
ADM	GCA	110	1	-	-	-	-2.0	1.1	1.7	8.2	2.2	6.0	9.6	3.0	7.2
ADM	INC	110	1	-32.1	-7.0	31.9	-14.5	-8.1	12.4	-19.7	-6.9	20.3	-26.5	-10.2	21.2
ANR	DOO	110	1	-14.0	-6.9	34.7	-14.0	-6.9	34.7	-14.0	-6.9	34.7	-14.0	-6.9	34.7
ARK	BEG	110	1	13.2	4.9	14.2	34.6	1.0	28.4	37.9	1.5	38.3	62.1	-6.8	51.2
ARK	BOG	110	1	-7.9	-0.7	4.4	-17.7	3.1	8.6	-27.4	7.8	16.0	-41.4	11.5	20.5

**Table H-1 Power Flows, Summer Valley and Winter Peak 2021 and 2030**

Line				2021						2030					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
ARK	PHY	110	1	-	-	-	-	-	-	1.2	0.3	0.7	1.2	0.3	0.6
ARK	PHY	110	2	-	-	-	-	-	-	1.1	0.3	0.6	1.1	0.3	0.5
ATE	DRO	110	1	0.0	-7.7	6.4	-8.5	-0.7	6.1	-8.5	4.2	7.9	-8.5	3.6	6.6
ATE	ATE	110	1	-	-	-	-2.3	1.1	1.2	-2.3	2.2	1.8	-2.3	2.2	1.5
ATE	KNR	110	1	0.0	7.7	4.3	31.3	-25.9	19.3	21.1	-18.9	15.9	31.3	-25.5	19.2
ATH	LA	110	1	19.4	4.2	20.0	26.3	4.5	22.0	3.8	10.5	11.3	26.3	-4.8	22.1
ATH	SH	110	1	-38.4	37.7	30.3	-108.8	49.9	63.0	-30.3	25.5	22.3	-113.5	20.9	60.7
BKE	AUG	110	1	-	-	-	56.7	1.5	27.0	26.4	24.8	20.3	-50.0	15.0	24.9
BKE	KPG	110	1	-	-	-	-56.7	-1.5	27.0	-26.4	-24.8	20.3	50.0	-15.0	24.9
AUG	CFM	110	1	25.4	14.1	30.3	25.4	14.1	30.3	25.4	14.6	30.5	25.4	14.2	30.4
AUG	MTN	110	1	-16.0	-4.3	9.3	5.8	7.1	4.4	-24.5	-3.2	13.9	61.0	0.8	29.0
AUG	SK	110	3	0.0	-0.7	0.6	0.0	-17.0	14.2	0.0	-0.6	0.5	-80.9	-7.2	67.7
AUG	SK	110	4	0.0	-0.7	0.6	0.0	-17.0	14.2	0.0	-0.6	0.5	-80.9	-7.2	67.7
AUG	CFM	110	2	25.4	14.1	30.3	25.4	14.1	30.3	25.4	14.6	30.5	25.4	14.2	30.3
ARV	COS	110	1	-11.4	-6.0	12.4	-56.0	22.2	49.0	-30.0	6.9	22.5	-55.3	10.0	41.0
ARV	GWE	110	1	24.5	-9.0	14.7	-22.0	1.6	10.5	-12.2	15.4	11.1	31.7	0.5	15.1
ARV	NAV	110	1	-11.3	21.0	13.4	8.7	9.3	6.1	30.3	0.2	17.0	2.8	7.1	3.6
ARV	SKL	110	1	-1.0	-3.2	2.5	38.8	-18.4	31.3	6.6	-12.5	10.3	11.6	-9.7	11.0
ARV	SKL	110	2	-0.8	-2.8	1.6	30.6	-14.8	16.2	5.2	-10.1	6.4	9.1	-7.9	5.8
ART	FIN (I)	110	1	-2.1	0.4	1.8	-35.4	-3.1	27.1	-10.9	-0.2	9.1	-37.4	-3.6	28.7
ART	MCD	110	1	-0.1	-1.1	0.9	20.6	2.2	15.8	7.8	-0.9	6.6	21.8	2.6	16.7
BVK	GRO	110	1	0.0	-27.3	14.0	-54.6	20.2	26.5	-54.3	25.1	30.7	-54.4	26.2	27.4
BVK	BVK	110	1	-	-	-	-	-	-	0.0	35.0	16.0	0.0	15.1	6.5
ATY	CLW	110	1	-32.1	13.8	35.3	-61.0	9.0	51.0	-18.3	4.3	19.0	-36.8	11.8	31.9
ATY	CNB	110	1	-	-	-	-	-	-	12.3	-5.9	7.7	16.2	-19.9	12.2
BWR	CRA	110	1	0.0	-14.4	21.1	12.6	-9.1	22.8	12.6	-7.8	21.8	12.6	3.5	19.2
BOL	ENN (I)	110	1	19.6	-0.1	11.0	76.0	-11.8	36.6	11.7	4.1	7.0	46.0	-1.5	21.9
BOL	TBK T	110	1	-19.6	2.8	11.1	-41.3	-6.4	19.9	3.5	-5.7	3.8	-4.3	-10.1	5.2
BAL	DEE	110	1	-	-	-	-	-	-	-50.9	0.0	28.6	64.0	7.8	30.7
BAL	CDU	110	1	-15.1	23.2	15.5	-92.3	-10.1	44.4	46.4	0.1	26.1	-81.4	-10.2	39.3
BLI	DMY	110	1	-4.3	4.5	9.1	5.4	-7.8	13.9	6.7	-0.3	9.9	4.6	-2.6	7.8
BEG	CKM	110	1	10.2	5.9	8.6	18.9	0.4	11.9	33.6	1.7	24.7	45.4	-9.5	29.2
CDL	BYH	110	1	0.0	14.3	7.3	49.3	-35.3	27.6	20.0	1.0	10.3	49.3	-38.4	28.4
BLK	BLK T	110	1	-5.9	0.1	4.4	-26.5	-6.3	17.1	-6.7	0.2	5.0	-28.0	-6.1	18.1
BLU	CDU	110	1	-	-	-	-9.0	3.9	7.6	25.4	-0.7	19.6	-10.1	3.7	8.3
BLU	MUL	110	1	-	-	-	9.0	-3.9	8.0	-25.4	0.7	24.2	10.1	-3.7	8.7
BIN	CF	110	1	-8.7	6.1	10.7	3.0	-6.1	5.6	-2.5	6.9	7.5	-14.0	2.1	11.7
BIN	TIV	110	1	4.3	-5.4	5.1	10.5	-1.9	6.7	15.6	-14.1	15.5	36.6	-9.4	23.8
BDA	MON	110	1	-15.4	10.0	18.6	-4.8	0.5	4.0	2.6	-1.5	3.0	17.8	-15.6	19.5
BDA	NEW (I)	110	1	10.2	-10.9	12.2	-0.5	-1.4	1.2	-7.8	0.7	6.4	-23.0	14.8	22.4
BDN	CUL	110	1	-39.8	25.2	24.0	-36.4	3.5	16.8	-0.8	-7.8	4.0	-64.7	27.7	32.4
BDN	DOO	110	1	31.1	-27.6	23.4	15.2	-8.7	8.3	-8.9	5.2	5.8	42.7	-33.2	25.8

**Table H-1 Power Flows, Summer Valley and Winter Peak 2021 and 2030**

Line				2021						2030					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
BAH	CLG	110	1	-	-	-	-	-	-	7.2	7.3	5.3	7.2	7.0	5.3
BAH	SBH	110	1	-	-	-	-	-	-	-26.2	-13.6	15.4	-26.3	-13.4	15.3
BRY	RAF	110	1	-13.0	-2.8	21.0	-24.2	-6.4	27.2	-18.0	-4.2	29.3	-25.6	-6.8	28.7
BRY	RAF	110	2	-6.0	-1.2	6.2	-11.1	-2.7	9.5	-8.3	-1.8	8.6	-11.8	-2.9	10.0
BK	CBR	110	1	-9.0	4.0	5.0	15.9	-7.2	7.9	25.6	-12.4	14.6	33.3	-17.5	17.0
BK	MOY	110	1	7.8	2.2	5.9	32.0	-11.4	24.8	26.9	-4.3	19.9	49.6	-14.9	37.8
BGD	INC	110	1	-22.3	-7.3	16.8	-22.3	-7.3	16.8	-26.6	-8.7	20.0	-26.6	-8.7	20.0
BGD	INC	110	2	-22.3	-7.3	16.8	-22.3	-7.3	16.8	-26.6	-8.7	20.0	-26.6	-8.7	20.0
BLA	RE	110	1	-11.2	2.6	9.6	-46.6	-6.6	39.5	-15.5	3.5	13.4	-49.2	-7.3	41.8
BGT	KKY	110	1	-	-	-	-	-	-	-13.7	3.3	7.9	-43.5	5.2	20.8
BGT	CNB	110	1	-	-	-	-	-	-	6.0	-5.2	4.5	15.7	-14.4	10.1
BAN	BRI	110	1	2.0	0.4	4.5	2.0	0.4	4.5	2.0	0.4	4.5	2.0	0.4	4.5
BAN	DMY	110	1	2.3	-22.0	22.3	-22.7	5.7	19.4	-13.9	-2.3	14.2	-11.8	-3.1	10.1
BAN	RAF	110	1	-20.0	18.8	27.8	-30.7	-2.1	25.5	-7.1	-1.6	7.3	-44.5	6.6	37.1
BAN	BAN	110	1	-	-	-	0.0	-16.5	13.4	-	-	-	0.0	-16.5	13.4
BAN	BRI	110	2	2.0	0.4	4.5	2.0	0.4	4.5	2.0	0.5	4.5	2.0	0.4	4.5
CLG	CDU	110	1	-76.0	-28.1	43.3	-76.7	-27.5	37.2	-74.7	-24.7	42.1	-74.7	-24.0	35.8
BAR	BART	110	1	-8.2	2.2	6.2	-22.0	-9.0	14.9	0.5	2.5	1.9	-23.7	-4.5	15.2
BLC	DRN	110	1	29.5	8.1	13.4	29.5	7.8	13.4	54.3	19.4	25.3	54.3	18.5	25.1
BLC	DRN	110	2	29.5	8.1	13.4	29.5	7.8	13.4	54.3	19.4	25.3	54.3	18.5	25.1
BLC	DTN	110	2	-4.3	-8.9	7.1	4.1	-6.3	5.3	-4.5	-11.4	8.8	9.1	-6.7	7.9
BLC	GRA	110	1	-1.2	-11.5	8.2	29.1	0.0	20.8	-0.8	-14.9	10.6	37.5	-0.7	26.8
BLC	KLM	110	1	-1.0	-9.0	6.5	17.3	-3.0	12.6	-1.9	-12.9	9.3	25.4	-4.0	18.3
BUT	CUL	110	1	-3.5	-4.3	3.1	-39.9	-1.4	20.8	-20.8	2.5	11.8	-37.3	-8.6	19.9
BUT	KTN	110	1	-5.7	4.7	3.7	-1.3	-8.8	4.1	8.6	-2.1	4.4	-6.2	-2.6	3.1
DEE	DRY	110	1	-	-	-	-	-	-	-51.1	-0.5	28.7	63.7	6.9	30.5
KNG	TRI	110	1	0.0	1.4	1.2	30.1	-22.9	30.5	26.3	-19.3	26.3	30.0	-26.2	32.1
BDM	MID	110	1	-	-	-	-	-	-	10.6	-2.4	11.0	38.4	1.4	31.7
BDM	WHI	110	1	-	-	-	-	-	-	-10.6	2.4	11.0	-38.4	-1.4	31.7
BOG	TUL	110	1	-	-	-	-26.4	3.0	12.6	-29.4	7.8	17.1	-50.9	9.9	24.7
BGH	CLA	110	1	0.0	0.7	0.4	42.6	-25.2	23.6	56.6	-26.4	35.1	48.8	-22.2	25.6
AGY	TIV	110	1	-3.4	-0.4	3.2	-9.2	-5.7	8.8	-3.2	-2.0	3.6	-10.1	-6.7	9.9
CAB	PTN	110	1	-1.6	0.4	2.1	-20.0	-5.0	17.3	-7.4	-0.7	9.3	-21.1	-5.5	18.3
CAB	WOL	110	1	-2.0	-1.6	2.1	4.6	-0.2	3.5	2.5	-0.9	2.2	4.9	-0.1	3.7
CFD	KIN	110	1	-	-	-	-	-	-	7.5	4.7	5.0	-21.0	9.2	10.9
CFD	MUL	110	1	-	-	-	-	-	-	-7.5	-4.7	5.0	21.0	-9.2	10.9
CLA	CKN	110	1	26.9	-23.5	20.1	46.3	2.8	24.4	28.1	-11.2	17.0	71.0	3.6	37.4
CLA	DMY	110	1	3.5	5.7	3.8	13.3	0.8	6.3	3.6	-1.5	2.2	6.5	-2.4	3.3
CLA	MAC	110	1	-1.1	15.9	9.9	22.8	-1.3	12.0	5.7	-2.3	3.8	6.4	1.7	3.5
CKN	KER	110	1	26.7	-22.9	19.8	45.9	2.6	21.9	27.9	-10.6	16.8	70.2	0.8	33.4
CRO	IA	110	1	3.1	-24.1	12.4	-36.8	9.4	17.5	-25.8	5.7	13.5	-22.8	-1.7	10.5
CRO	KBY	110	1	-6.4	24.0	14.0	25.9	-9.7	13.8	21.2	-5.6	12.3	11.2	1.6	5.7
CDY	GRV	110	1	0.0	9.6	10.5	-24.5	-6.2	27.7	-24.5	6.9	27.9	-24.5	2.7	27.1

**Table H-1 Power Flows, Summer Valley and Winter Peak 2021 and 2030**

Line				2021						2030					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
CDY	SRA	110	1	5.8	-18.2	10.7	8.0	0.0	3.8	5.8	-2.5	3.6	25.3	-9.2	12.8
CDY	ARIT	110	1	-5.9	9.6	6.3	35.1	-2.4	16.8	30.8	-4.3	17.4	17.9	6.3	9.0
CSH	CLN	110	1	26.0	-1.0	14.6	81.4	-2.4	38.8	18.5	-8.6	11.5	65.3	1.9	31.1
CSH	DLT	110	1	17.7	-9.7	20.4	31.0	-3.8	25.8	-5.1	-3.1	6.1	24.3	-5.0	20.5
CSH	ENN (I)	110	1	-9.6	8.9	7.4	-27.8	18.8	16.0	1.6	0.6	0.9	-31.3	16.4	16.8
CSH	GAL	110	1	9.2	-21.0	23.1	14.1	10.7	14.6	-2.3	2.4	3.2	16.2	5.6	13.9
CSH	GAL	110	2	11.2	-25.5	28.1	17.2	13.1	17.9	-2.8	3.1	4.0	19.7	6.9	17.0
CSH	GAL	110	3	11.2	-25.5	28.1	17.2	13.1	17.9	-2.8	3.1	4.0	19.7	6.9	17.0
CSH	SAL	110	1	8.6	-18.5	21.0	9.2	3.6	10.1	-0.7	-3.1	3.3	11.1	0.2	11.4
CSH	SHN	110	1	-3.2	19.8	19.1	29.3	1.1	23.9	22.8	-8.8	23.3	10.1	7.0	10.0
CSH	CSH	110	1	-	-	-	0.0	-91.9	74.7	-	-	-	0.0	-45.4	36.9
CLH	TRI	110	1	1.0	0.2	1.1	-3.2	-6.7	6.2	13.0	0.3	13.1	5.0	-6.3	6.7
CLH	TRL	110	1	-1.0	-0.2	1.0	18.6	-4.9	15.6	-1.7	-0.9	1.8	10.4	5.4	9.5
CBR	CLN	110	1	-12.8	9.2	15.9	-10.3	-3.7	9.1	14.2	0.0	8.0	-4.6	-3.7	2.8
CBR	CBG	110	1	6.0	-6.9	9.2	18.8	-2.3	15.6	8.3	-5.1	9.8	19.8	-2.0	16.5
CBR	DLT	110	1	-9.8	4.7	11.0	-13.9	-2.0	11.6	2.8	0.6	2.9	-5.8	-5.7	6.7
CBR	CBR	110	1	-	-	-	-	-	-	-	-	-	0.0	-33.1	26.9
CCN	CUS	110	1	-	-	-	-	-	-	0.0	-0.6	0.4	22.5	-0.7	16.1
CD	MAC	110	1	10.8	-25.3	15.5	-22.1	0.7	10.5	-9.0	-1.1	5.1	0.9	-4.8	2.3
CD	KLP	110	1	-	-	-	-	-	-	17.0	-0.5	9.6	7.1	3.3	3.7
CPK	TNY	110	1	2.0	-7.5	7.7	10.0	-7.1	12.3	2.8	-7.3	7.8	10.6	-7.0	12.7
CF	CL	110	1	0.0	-0.2	0.4	-19.9	3.9	29.8	-19.9	7.4	31.2	-19.9	6.2	30.6
CF	COR	110	1	1.2	19.0	10.7	52.8	-4.1	25.3	33.5	-6.5	19.2	36.7	0.6	17.5
CF	SRA	110	1	-12.7	14.3	9.7	7.9	-1.9	3.5	8.9	-8.8	6.4	-22.3	6.8	9.9
CF	CF	110	1	-	-	-	0.0	-16.5	13.5	-	-	-	0.0	-16.5	13.5
CF	CLO	110	2	5.4	-19.5	11.4	-8.8	0.4	4.2	1.9	-13.6	7.7	21.2	-11.8	11.6
CAH	DOO	110	1	-10.6	33.5	19.8	27.3	3.5	13.1	31.8	0.6	17.9	1.6	30.5	14.5
CAH	KHL	110	1	16.3	-18.2	13.7	17.7	13.4	10.6	-7.2	-1.3	4.1	21.6	0.4	10.3
CAH	TIP	110	1	10.4	-31.8	18.8	-31.0	21.2	17.9	-14.5	-3.2	8.4	-5.6	5.1	3.6
CAH	BART	110	1	-21.2	16.1	25.3	-41.4	24.4	39.0	-18.4	3.7	17.8	-46.5	25.4	43.1
CAH	CAH	110	1	-	-	-	0.0	-67.6	54.9	-	-	-	0.0	-66.9	54.4
CKM	CHE	110	1	3.0	-4.5	5.2	16.3	2.0	13.4	4.2	-5.0	6.3	17.2	2.3	14.1
CKM	POT	110	1	4.4	-4.3	5.2	17.2	-3.5	14.7	6.1	-3.5	5.9	18.2	-3.3	15.5
CKM	CPK	110	1	5.4	-10.3	8.5	21.8	-8.9	17.2	7.5	-10.1	9.3	23.1	-8.7	18.0
BRA	NEW (I)	110	1	7.0	7.8	7.7	21.1	-11.5	15.1	35.9	-3.3	26.5	52.2	-12.8	33.8
BRA	PLS	110	1	-7.0	-7.8	10.6	-21.1	11.5	19.8	-35.9	3.3	36.4	-52.2	12.8	44.4
COO	BCT	110	1	2.7	2.0	2.6	2.7	2.1	2.6	2.7	2.0	2.6	2.7	2.1	2.6
COO	CKM	110	2	-2.7	-2.0	2.6	-2.7	-2.1	2.6	-2.7	-2.0	2.6	-2.7	-2.1	2.6
CLU	KUD	110	1	-	-	-	-	-	-	10.6	2.9	5.9	10.6	2.5	4.9
CLU	CBT	110	1	-	-	-	-	-	-	-51.5	-16.9	29.0	-51.4	-16.4	24.2
CLN	LA	110	1	7.9	10.8	13.5	44.0	-9.2	37.2	26.9	-7.4	28.2	32.5	-3.8	27.0
SCR	KNY	110	1	-5.5	1.3	4.2	-16.4	-3.4	10.6	-7.6	1.6	5.7	-17.4	-2.4	11.1

**Table H-1 Power Flows, Summer Valley and Winter Peak 2021 and 2030**

Line				2021						2030					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
CRA	LWD	110	1	-20.0	11.9	13.1	-61.4	8.1	29.5	-18.4	10.3	11.8	-73.6	12.3	35.5
CRA	TUL	110	1	-	-	-	26.5	-3.6	12.7	29.6	-8.0	17.2	51.3	-9.0	24.8
CRA	WEX	110	1	2.2	3.4	4.1	17.1	-8.3	16.8	-8.2	3.1	8.9	2.7	3.9	4.2
COS	FLA	110	1	-11.7	3.4	12.3	-26.7	5.3	22.5	-1.9	-1.5	2.5	-35.0	2.0	28.9
COS	FLA	110	2	-12.0	3.6	12.6	-27.3	5.5	23.0	-1.9	-1.6	2.5	-35.8	2.2	29.7
COS	ARI T	110	1	6.5	-11.3	7.3	-34.1	4.5	16.4	-34.3	10.7	20.2	-16.7	-0.5	8.0
COL (I)	FIN (I)	110	1	6.0	-0.3	5.7	5.2	-0.6	4.2	1.1	-2.8	2.9	4.0	-3.4	4.3
COL (I)	CDU	110	1	-17.3	-1.2	12.1	-22.0	-1.6	15.4	-16.8	0.6	11.8	-21.8	1.1	15.3
CHA	GLE	110	1	3.6	0.1	3.6	10.0	5.2	9.3	-2.8	1.0	3.0	11.0	1.9	9.2
CHA	KLN	110	1	14.2	-24.8	21.0	8.1	-16.7	11.7	16.6	-4.8	12.7	25.5	-16.4	19.1
CHA	MAL	110	1	-22.5	27.4	19.9	-17.9	0.0	8.5	-2.0	2.3	1.7	-37.5	8.2	18.3
CLW	KLS	110	1	-24.5	9.2	26.4	-59.2	-14.9	50.4	0.8	-11.5	11.6	-47.3	-8.3	39.7
CLW	KLS	110	2	-24.7	9.0	26.5	-59.3	-15.5	50.6	1.0	-11.5	11.7	-47.4	-8.8	39.9
CLW	STR T	110	1	3.6	-1.4	5.8	-5.3	17.8	27.4	-28.1	22.2	52.6	-7.9	1.9	12.0
COW	CVW	110	1	8.7	-9.2	12.8	22.1	-0.8	18.3	10.0	-2.8	10.5	29.7	0.4	24.5
COW	OLD	110	1	0.3	0.0	1.0	0.3	0.0	1.0	0.3	0.0	1.0	0.3	0.0	1.0
COW	RAF	110	1	-10.3	0.7	10.5	-24.5	-2.1	20.3	-14.5	-0.1	14.6	-27.0	-5.1	22.7
COW	WHI	110	1	-4.5	8.4	9.7	-15.3	1.5	12.7	-3.9	2.7	4.7	-21.3	3.1	17.8
CUN	GLR	110	1	-0.5	-6.9	3.9	-27.1	8.7	13.6	-15.3	-0.2	8.6	-34.9	13.2	17.8
CUN	SLI	110	1	0.5	14.3	8.0	37.2	-7.9	18.2	25.5	1.2	14.4	45.1	-7.4	21.9
CUS	MLC	110	1	5.5	-0.9	4.1	3.0	38.1	24.0	0.7	0.3	0.6	20.3	-17.6	16.9
CUS	NEW (I)	110	1	0.8	6.3	4.7	12.6	32.3	22.8	23.1	-0.5	17.3	36.2	4.4	24.0
CUS	PLS	110	1	-6.3	-5.4	6.1	-15.7	29.7	21.1	-23.9	0.8	17.6	-34.1	13.1	23.0
CVW	KRA	110	1	-1.9	-9.0	9.3	-11.5	-8.0	11.6	-13.6	-6.6	15.3	-13.6	-9.9	13.9
CGL	GAE	110	1	0.0	-2.9	3.2	-8.9	8.4	13.4	-8.9	5.8	11.6	-8.9	8.4	13.4
CGL	CKN	110	1	0.0	2.9	1.6	33.1	-26.0	22.2	33.1	-18.9	21.4	33.1	-22.7	21.1
COR	GWE	110	1	1.3	19.4	10.9	53.5	-5.3	25.6	39.0	-2.3	21.9	0.3	-3.5	1.7
COR	ENN (N)	110	1	-0.3	1.6	1.7	-1.7	-1.5	1.9	-6.0	-4.4	7.5	35.9	4.0	29.8
CDK	LWD	110	1	0.0	-5.4	5.9	12.5	-9.0	16.9	12.2	-11.6	18.5	12.5	10.0	17.5
CUL	RTO	110	1	-	-	-	-	-	-	-18.3	2.9	10.4	2.0	1.8	1.3
CUL	WAT	110	1	1.4	3.7	2.2	48.7	-7.8	24.7	29.7	-7.9	17.3	43.2	4.2	21.7
CTY	FTT	110	1	19.1	-5.9	16.1	87.9	16.1	67.7	26.6	-6.2	22.0	92.9	18.3	71.7
CTY	INC	110	1	-26.2	3.4	25.7	-100.9	-20.3	83.7	-36.5	2.6	35.5	-106.6	-22.8	88.6
CDU	GAN	110	1	-	-	-	-	-	-	0.0	-0.4	0.2	0.0	-0.4	0.2
CDU	RYB	110	1	8.1	22.5	13.4	-17.7	34.8	17.8	3.6	23.6	13.4	23.1	31.7	17.9
KNY	UGL	110	1	0.0	-5.3	2.7	-52.0	39.7	29.7	-50.5	40.3	33.1	-52.0	26.2	26.5
KNY	GAL	110	1	0.0	44.7	45.1	52.0	-39.7	54.0	50.5	-40.3	36.1	52.0	-26.2	31.5
KNY	KLH	110	1	0.0	-14.2	7.5	-10.0	-0.1	5.3	0.0	-11.3	6.0	-10.1	-11.9	8.2
KNY	SAL	110	1	-5.5	20.8	11.0	20.8	9.1	10.3	-7.6	17.7	9.9	19.9	13.3	10.9
KNY	BUF	110	1	-	-	-	-27.3	-8.0	20.3	0.0	-0.6	0.4	-27.3	0.4	19.5
DDK	MLN	110	1	-5.6	-4.6	7.3	-39.9	-16.6	35.7	1.9	-2.6	3.2	-28.5	-16.0	27.0



**Table H-1 Power Flows, Summer Valley and Winter Peak 2021 and 2030**

Line				2021						2030					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
DDK	LOU	110	1	-7.5	8.5	11.5	-23.5	2.8	19.5	-15.0	6.1	16.4	-38.7	3.3	32.1
DRU	ENN (I)	110	1	0.7	-19.5	19.7	-0.7	-4.4	3.7	-0.1	-16.9	17.0	10.4	-9.4	11.6
DRU	DRU	110	1	-	-	-	0.0	-16.5	13.4	-	-	-	0.0	-16.4	13.3
DGN	RTO	110	1	-	-	-	-	-	-	18.4	-3.8	10.5	-2.0	-3.2	1.8
DGN	WHO	110	1	-6.8	-5.5	4.9	-63.1	6.8	30.2	-31.9	3.3	18.0	-50.0	-9.4	24.2
DRG	KPG	110	1	-	-	-	-11.9	-7.1	6.6	7.6	2.3	4.5	-3.7	-8.2	4.3
DRG	TRL	110	1	-	-	-	11.9	7.1	6.6	-7.6	-2.3	4.5	3.7	8.2	4.3
DOO	DOO	110	1	-	-	-	0.0	-16.8	13.6	-	-	-	0.0	-16.2	13.2
DRY	GOR	110	1	-6.1	-8.9	10.9	3.2	-1.2	2.8	-37.3	-2.2	37.7	-24.1	-3.8	20.2
DRY	LOU	110	1	0.9	-26.8	27.1	24.2	-24.0	28.2	-58.6	-14.3	60.9	-40.6	-28.8	41.1
DRY	OBE	110	1	-	-	-	-	-	-	22.7	15.4	26.1	32.6	14.1	28.8
DMY	MAC	110	1	-5.9	-4.8	3.9	-13.0	0.3	6.0	-3.4	0.9	1.8	-6.5	3.4	3.4
DMY	CDN	110	1	0.0	-0.4	0.2	-16.2	9.0	8.6	0.0	-0.4	0.2	-20.3	0.3	9.4
DMY	DMY	110	1	-	-	-	0.0	-16.6	13.5	-	-	-	0.0	-16.7	13.6
DAL	DAL	110	1	0.0	0.4	0.4	-13.0	-7.1	12.0	-1.4	-1.9	2.3	-14.1	-8.4	13.3
DTN	FIN (I)	110	1	-17.2	-6.9	13.2	-13.6	-4.5	10.3	-19.1	-11.0	15.8	-8.3	-4.7	6.9
DTN	KLM	110	1	7.0	2.2	5.3	10.4	3.1	7.7	6.5	3.0	5.1	9.6	2.9	7.1
DER	KIN	110	1	23.2	-9.4	25.3	26.4	2.5	21.9	24.7	-0.9	24.9	25.1	-2.2	20.9
DER	TIM	110	1	-	-	-	-	-	-	-9.8	-0.6	5.5	-18.4	-0.2	8.8
DER	TSB	110	1	2.3	-2.7	3.6	8.5	-1.3	7.1	-14.9	1.5	15.1	-6.8	2.4	5.9
DLT	DLT	110	1	-	-	-	0.0	-16.8	13.6	-	-	-	0.0	-16.8	13.6
DFR	DFR	110	1	-2.3	0.1	4.1	-11.1	-3.9	20.6	-3.2	0.1	5.7	-11.7	-4.2	21.9
DRM	LET	110	1	8.2	2.1	8.5	30.2	-13.9	27.0	43.5	-19.2	48.0	84.5	-19.5	70.5
DRM	MEE	110	1	0.0	-0.2	0.2	-25.4	14.9	24.3	-25.4	1.8	25.7	-25.4	1.7	21.0
DRM	CLO	110	1	-8.2	-1.9	8.1	-4.9	-1.0	4.0	-18.1	17.4	24.4	-59.1	17.8	50.2
ENN (I)	SLC	110	1	0.0	-34.0	17.4	-21.6	-14.1	11.7	-8.1	-18.2	10.2	-21.6	-16.4	12.3
KHL	THU	110	1	16.2	-17.8	13.5	28.5	0.8	13.6	-7.2	-0.7	4.1	32.4	0.4	15.4
MLC	TSB	110	1	5.5	-0.3	4.1	27.8	8.1	18.2	25.9	-3.3	19.3	45.3	4.6	28.6
CKG	CBT	110	1	0.0	-0.9	0.5	-28.6	-10.1	13.6	-64.7	-25.8	37.3	-64.6	-25.2	31.1
CKG	CBT	110	2	-	-	-	-28.6	-10.1	13.6	-64.7	-25.8	37.3	-64.6	-25.2	31.1
FAS	FAS	110	1	-5.5	-1.9	5.6	-30.7	-12.2	26.9	-7.7	-2.8	7.8	-32.4	-13.5	28.6
FAS	CKM	110	1	-5.6	-2.0	5.6	-30.8	-12.4	27.0	-7.7	-2.8	7.8	-32.5	-13.7	28.7
FLA	GIL	110	1	11.4	2.9	17.3	11.5	-10.8	23.1	11.4	3.0	17.4	11.5	-10.8	23.2
FLA	SLI	110	1	5.2	-12.9	14.1	-12.0	5.1	10.8	-15.6	6.8	17.2	-0.2	-2.5	2.1
FLA	TON	110	1	4.4	-0.5	5.8	11.5	3.9	16.0	-19.9	2.7	11.3	-16.5	7.8	8.7
FLA	SLB	110	1	-15.4	10.3	18.7	-10.3	-2.0	8.6	33.7	-14.4	37.0	-1.3	10.2	8.4
FRA	HAR	110	1	-3.2	-1.3	3.2	-10.2	-6.9	11.5	-4.4	-1.4	4.3	-10.8	-6.7	11.9
FRA	TRN	110	1	-3.7	1.1	2.8	-14.8	-6.8	11.6	-5.2	0.7	3.7	-15.6	-6.7	12.1
FRA	HEU	110	1	-1.8	0.2	1.3	-9.9	-1.6	7.2	-2.6	0.1	1.8	-10.5	-1.8	7.6
FRA	INC	110	1	-4.0	-0.9	3.8	-14.3	-4.0	13.9	-5.5	-1.0	5.3	-15.1	-4.3	14.7
FIN (I)	MCD	110	1	3.2	-11.8	10.2	69.0	-2.9	58.0	22.5	-9.7	20.6	72.9	-1.8	61.3
FIN (I)	PTN	110	1	4.5	-2.0	6.1	36.5	5.1	30.9	11.4	-0.9	14.3	38.5	5.8	32.7

**Table H-1 Power Flows, Summer Valley and Winter Peak 2021 and 2030**

Line				2021						2030					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
FIN (I)	GLA	110	1	15.2	-0.4	14.5	66.8	22.6	57.3	21.1	2.2	20.2	70.7	26.7	61.5
FIN (I)	GRA	110	1	22.3	-16.4	23.3	24.8	-16.0	24.8	26.3	-11.2	24.0	19.1	-13.9	19.8
FIN (I)	POP	110	1	25.3	-6.4	21.7	30.6	-5.9	23.8	30.1	-1.8	25.1	25.3	-3.6	19.5
FIN (I)	SVN	110	1	5.0	-4.6	6.5	21.5	3.8	19.0	6.9	-3.4	7.3	22.7	5.2	20.2
FIN (I)	MCE	110	1	-	-	-	-	-	-	1.1	0.7	1.0	4.0	0.6	3.3
FTT	COO	110	1	15.4	-4.1	12.9	73.4	16.1	56.9	21.5	-4.6	17.7	77.6	17.9	60.3
FGH	MOY	110	1	-	-	-	-	-	-	4.0	-0.8	3.8	2.2	14.7	12.1
FGH	GLR	110	1	-	-	-	-	-	-	-4.0	0.8	3.8	12.3	-15.0	15.8
GRV	GLN	110	1	-	-	-	-	-	-	0.0	-0.1	0.1	0.0	-0.1	0.1
GRH	GOR	110	1	-	-	-	-	-	-	-36.4	-4.5	35.0	-26.5	-5.5	22.0
GRH	PLA	110	1	-	-	-	-	-	-	36.4	4.5	35.0	26.5	5.5	22.0
GLA	SVN	110	1	-4.0	-6.7	5.8	-17.6	-14.5	14.8	-5.5	-7.3	6.7	-18.5	-15.7	15.8
GRI	GRI	110	1	-8.0	-0.1	7.6	-32.5	-7.4	27.1	-9.1	0.3	8.7	-32.3	-7.6	27.0
GI	KKY	110	1	12.2	-12.5	9.8	58.7	-11.7	28.5	21.1	-7.4	12.6	91.2	-15.4	44.1
GI	WAT	110	1	15.0	-9.3	9.9	9.7	11.5	7.2	-5.0	3.5	3.4	17.3	4.2	8.5
GI	WAT	110	2	13.6	-8.5	9.0	8.8	10.4	6.5	-4.6	3.1	3.1	15.7	3.7	7.7
GI	RSP	110	1	-	-	-	-	-	-	17.3	-4.3	10.0	50.7	-20.9	26.1
GRA	NBY	110	1	6.8	-0.1	5.7	-5.1	-6.4	6.9	5.7	0.0	4.8	-5.8	-6.7	7.4
GRO	CKN	110	1	0.0	-20.5	17.1	-32.9	10.9	28.9	-32.9	5.3	27.8	-32.9	7.3	28.1
GAL	SAL	110	1	7.0	-32.1	33.2	2.1	-26.0	24.7	8.6	-36.3	37.7	3.6	-31.6	30.0
GOL	GLT	110	1	0.0	-0.2	0.2	4.5	-3.2	4.5	4.5	-6.6	7.6	4.5	-6.5	6.5
GWE	GWE	110	1	-	-	-	0.0	-16.2	13.2	-	-	-	0.0	-16.1	13.1
GOR	MTH	110	1	4.8	-7.9	9.4	39.6	4.9	33.0	-33.5	2.6	33.9	-6.1	5.5	6.8
GOR	NAV	110	1	15.4	-13.8	20.9	26.4	-5.3	22.3	3.6	-4.6	5.9	29.6	-4.7	24.8
GOR	NAV	110	2	13.4	-11.9	18.1	22.9	-4.4	19.3	3.2	-3.9	5.1	25.6	-3.9	21.4
GOR	NAV	110	3	18.8	-14.3	23.9	30.4	-3.5	25.3	4.6	-5.0	6.8	33.9	-2.5	28.1
GOR	GOR (I)	110	1	-	-	-	-	-	-	0.0	-0.6	0.3	0.0	-0.6	0.3
GCA	CLD	110	1	-	-	-	-	-	-	0.0	-2.1	1.5	0.0	-2.3	1.6
GCA	CLD	110	2	-	-	-	-	-	-	0.0	-2.1	1.5	0.0	-2.3	1.6
GCA	INC	110	1	-35.3	-6.8	34.9	-15.7	-8.6	13.3	-23.1	-7.8	23.7	-30.9	-11.7	24.7
GCA	INC	110	2	-35.3	-6.8	34.9	-15.7	-8.6	13.3	-23.1	-7.8	23.7	-30.9	-11.7	24.7
GCA	NAN	110	1	5.4	0.2	4.5	3.5	0.5	2.7	5.4	0.3	4.5	3.5	0.2	2.6
GCA	NAN	110	2	5.7	0.4	4.8	3.6	0.6	2.8	5.7	0.5	4.8	3.7	0.3	2.8
GCA	YLW	110	1	-	-	-	-	-	-	-54.7	-28.1	32.9	-75.1	-41.3	38.4
CLO	MRY	110	1	0.0	-17.1	12.6	-28.4	18.1	24.8	-28.5	17.9	24.7	-28.4	19.2	25.2
CLO	CF	110	1	-10.2	17.7	11.5	9.5	0.4	4.5	-5.2	12.7	7.7	-24.8	6.3	12.2
CLO	GLT	110	1	7.3	-0.1	3.9	5.3	-0.4	2.4	17.1	-10.2	10.6	54.8	-8.3	25.5
HWN	KIN	110	1	-	-	-	-	-	-	-21.8	-1.6	16.1	6.2	-4.9	5.0
HWN	DFR	110	1	-	-	-	-	-	-	21.8	1.6	21.0	-6.2	4.9	5.1
HAR	RE	110	1	-8.1	0.2	7.6	-29.3	-9.9	28.9	-11.2	-0.7	10.5	-30.9	-10.2	30.4
HEU	INC	110	1	-5.8	2.5	4.5	-19.0	-1.1	13.6	-8.1	2.2	6.0	-20.1	-1.4	14.4
IA	MAC	110	1	3.1	-24.0	12.3	-21.9	3.5	10.2	-6.9	-0.7	3.5	-3.9	-5.1	2.9
INC	MIL	110	1	9.9	-5.6	9.5	44.9	0.4	34.2	13.8	-5.4	12.4	47.4	1.0	36.2

**Table H-1 Power Flows, Summer Valley and Winter Peak 2021 and 2030**

Line				2021						2030					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
INC	YLW	110	1	-	-	-	-	-	-	73.8	26.2	41.9	94.2	38.9	45.7
IKE	IKE T	110	1	-6.9	-0.3	8.6	-21.2	-12.9	20.8	1.1	-1.2	2.0	-23.0	-8.9	20.7
KNR	KPG	110	1	-5.5	3.2	4.7	-13.7	-12.1	11.5	10.3	1.2	7.6	-6.5	-10.7	7.9
KNR	TRI	110	2	5.5	-3.2	6.4	13.7	12.1	15.1	-10.3	-1.2	10.5	6.5	10.7	10.3
KNR	KNR	110	1	0.0	5.4	0.3	6.2	5.2	0.4	8.5	6.0	0.7	6.2	5.4	0.4
KNR	TRI	110	1	0.0	-19.3	10.9	-43.6	15.2	22.1	-38.0	6.3	21.6	-43.6	14.3	22.0
KRA	MEN	110	1	-	-	-	0.0	-3.8	3.1	0.0	-3.4	2.8	0.0	-3.8	3.1
KRA	KBY	110	1	19.2	-18.7	15.1	26.2	15.9	14.6	-2.3	2.0	1.7	47.2	13.2	23.3
KRA	BAR T	110	1	30.0	-18.9	26.1	65.5	-12.1	41.9	18.2	-7.5	14.5	73.0	-16.1	47.0
KRA	MID	110	1	3.2	12.7	13.2	11.5	10.0	12.6	9.9	6.4	11.9	8.4	11.4	11.7
KRA	WHO	110	1	6.8	2.1	4.0	47.6	-1.7	22.7	25.2	-5.2	14.4	34.2	8.4	16.8
KRA	KLP	110	2	-	-	-	-	-	-	-2.2	0.6	2.3	35.3	-1.4	29.2
KBY	MR	110	2	-15.8	20.0	24.7	-12.0	-4.9	10.0	-1.1	-2.2	2.4	-34.5	-8.1	27.3
KCY	CBT	110	1	-	-	-	-	-	-	-38.0	-15.5	21.9	-38.0	-15.1	18.3
KCY	BKY	110	1	-	-	-	-	-	-	14.2	7.4	8.6	14.2	7.0	7.1
KTL	MAY	110	1	-25.9	12.6	29.1	-55.5	20.6	48.9	-11.9	0.6	12.0	-35.8	5.8	30.0
KTL	MON	110	1	18.9	-13.1	16.9	19.2	-1.6	12.1	2.2	-1.4	1.9	-2.5	14.8	9.5
KTL	KTL	110	1	-	-	-	0.0	-33.0	26.8	-	-	-	0.0	-32.5	26.4
REM	TRL	110	1	0.0	3.2	2.6	17.1	-23.8	20.8	10.4	2.2	8.5	24.8	0.9	17.6
KKY	KLS	110	1	-1.4	-11.7	11.9	-4.0	4.4	4.9	-8.2	-2.4	8.6	-7.9	-1.2	6.6
KKY	KKY	110	1	-	-	-	0.0	-34.3	27.9	-	-	-	0.0	-32.2	26.2
KSE	CBT	110	1	-	-	-	-	-	-	-14.7	-5.6	8.4	-14.7	-5.5	7.1
KSE	AGN	110	1	-	-	-	-	-	-	-9.0	-3.2	5.1	-9.0	-3.2	4.3
KLN	LIM (I)	110	1	31.7	-5.7	32.5	47.3	7.3	39.6	27.2	2.9	27.6	41.9	5.6	34.9
KLN	CUR	110	1	6.0	-32.4	24.2	-22.9	11.3	16.1	-37.8	11.7	29.1	-21.6	2.1	13.7
KLN	SNG	110	1	39.3	-18.0	24.3	49.8	4.2	23.9	-4.8	6.1	4.3	65.1	-12.6	31.7
KER	OUG T	110	1	15.7	-20.5	14.5	8.5	-9.9	6.2	16.8	-9.2	10.7	30.1	-13.6	15.7
KUR	NAV	110	1	-23.7	-13.1	27.3	-23.7	-13.0	21.9	-23.7	-13.3	27.4	-23.7	-13.0	21.9
BYH	GLE	110	1	0.1	-53.8	43.4	-43.1	2.6	34.8	-39.1	-6.1	31.9	-43.2	-7.7	35.4
KCR	GLE	110	1	0.0	8.0	6.6	31.1	-32.3	36.7	31.1	-24.9	32.7	31.2	-25.2	32.8
KTN	WAT	110	1	-9.3	4.4	10.3	-15.9	-12.5	16.7	3.6	-2.7	4.6	-21.6	-6.6	18.7
KLM	CRM	110	2	0.0	-1.4	1.0	0.0	-1.6	1.1	0.0	-1.4	1.0	0.0	-1.5	1.1
KLM	CRM	110	1	0.0	-1.4	1.0	0.0	-1.6	1.1	0.0	-1.4	1.0	0.0	-1.5	1.1
KLM	NBY	110	1	25.5	2.2	21.5	37.4	7.2	32.0	26.6	2.8	22.5	38.1	7.7	32.7
KLM	POP	110	1	-19.5	0.2	16.2	-9.7	3.0	7.8	-22.0	-3.9	18.6	-3.2	1.1	2.6
KUD	CBT	110	1	-	-	-	-25.7	-9.5	12.3	-22.8	-12.0	13.8	-22.8	-11.6	11.5
KPG	CNG	110	1	0.0	-2.7	1.9	-7.9	6.9	7.5	0.0	-2.3	1.6	-20.4	-2.0	14.7
KPG	RAT (I)	110	1	11.1	4.5	8.8	46.1	4.6	29.2	-0.9	11.0	8.1	24.3	11.3	16.8
KPG	TRL	110	1	1.7	-2.5	3.0	13.7	4.0	11.8	-8.1	-0.8	8.2	5.8	7.0	7.5
CBT	BKY	110	2	-	-	-	10.9	2.7	5.1	43.0	16.0	24.5	43.0	15.3	20.5
CBT	AGN	110	1	-	-	-	-	-	-	46.1	14.3	25.8	46.1	13.9	21.6
LA	MUL	110	1	-0.3	30.1	30.4	21.6	-7.9	19.0	48.1	-11.5	49.9	18.2	-13.2	18.6

**Table H-1 Power Flows, Summer Valley and Winter Peak 2021 and 2030**

Line				2021						2030					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
LA	RIC	110	1	3.8	-0.4	3.8	16.9	4.0	14.1	5.3	-0.1	5.3	17.8	4.3	14.9
LA	RIC	110	2	4.7	-0.2	4.8	21.0	5.1	17.6	6.5	0.1	6.6	22.2	5.4	18.6
LA	SLB	110	1	15.5	-11.2	19.3	-7.0	-10.9	10.5	-33.1	14.7	36.6	-16.0	-10.5	15.6
LOU	MLN	110	1	10.1	5.3	11.5	45.0	18.7	40.3	2.6	3.3	4.3	33.3	17.6	31.1
LOU	RRU	110	1	9.0	-18.9	22.0	-13.6	-7.2	13.7	-18.3	6.3	20.4	11.5	-2.3	10.5
LOU	LOU	110	1	-	-	-	0.0	-32.0	26.0	-	-	-	0.0	-33.4	27.1
LIM (I)	MTN	110	1	37.6	16.5	23.1	15.8	4.8	7.9	46.2	16.5	27.6	-38.8	14.5	19.7
LIM (I)	RAT (I)	110	1	-4.1	-8.8	9.7	-10.9	4.4	9.7	1.8	-7.8	8.1	13.1	-0.2	10.8
LIM (I)	KLN	110	2	-24.7	4.0	31.3	-36.8	-5.8	33.9	-21.2	-2.7	26.7	-32.6	-4.6	29.9
CNB	PLS	110	1	-	-	-	-	-	-	52.9	-7.2	30.0	89.1	-13.3	42.9
LIS	SKL	110	1	1.4	-15.3	15.5	-27.5	5.2	22.8	-6.5	-1.0	6.6	-1.2	4.1	3.5
LIS	LOU	110	1	-8.3	14.5	16.8	-4.6	18.2	15.3	3.7	-0.4	3.7	-23.1	19.0	24.3
LIS	LIS	110	1	-	-	-	0.0	-0.3	0.1	0.0	-0.3	0.2	0.0	-0.3	0.1
LIS	LIS	110	1	-	-	-	0.0	-0.3	0.1	0.0	-0.3	0.2	0.0	-33.2	27.0
LUM	PLS	110	1	-1.4	21.4	12.0	36.6	-5.7	17.7	18.1	-3.1	10.3	26.4	-3.8	12.7
LUM	DAL	110	1	1.4	-21.4	12.0	-36.6	5.7	17.7	-18.1	3.1	10.3	33.5	-2.8	16.0
LET	LNA	110	1	-	-	-	-	-	-	-12.2	6.9	10.3	-43.6	9.0	28.0
LET	TLK	110	1	4.2	-3.7	5.3	-9.2	5.7	8.8	-25.6	23.3	33.0	-9.4	2.9	8.0
LET	GL T	110	1	-7.3	-1.9	7.6	-9.7	2.1	8.2	-21.2	16.1	26.9	-57.3	17.6	49.6
LET	LET	110	1	-	-	-	0.0	-16.6	13.5	0.0	-31.3	29.8	0.0	-16.2	13.2
LET	LET	110	1	-	-	-	0.0	-16.6	13.5	0.0	-31.3	29.8	0.0	-10.1	8.2
LET	STR (N)	110	1	-0.5	47.8	48.3	0.0	3.0	2.4	102.9	-19.0	105.7	145.8	-27.3	120.6
LNA	TIV	110	1	-	-	-	-	-	-	-12.2	7.3	10.4	-34.7	8.6	22.5
LIB	MR	110	1	-3.7	-0.6	5.6	-17.3	-5.1	26.6	-5.2	-0.9	7.8	-18.3	-5.4	28.1
LIB	MR	110	2	-1.9	-0.3	1.9	-8.4	0.3	7.1	-2.6	-0.5	2.7	-8.9	0.2	7.5
LSN	THU	110	1	0.0	-0.4	0.4	29.8	-6.4	25.0	29.8	-13.9	31.6	38.4	-13.1	33.3
CUR	NEN	110	1	5.8	0.7	5.6	19.0	11.2	17.9	4.0	3.8	5.2	20.3	12.5	19.4
CUR	BKM	110	1	0.0	-32.8	17.3	-42.0	0.5	22.1	-41.9	7.6	22.4	-42.0	-10.1	22.7
MHL	RE	110	1	-13.5	4.0	10.0	-46.4	-9.0	33.7	-18.8	2.6	13.5	-49.0	-9.6	35.7
MHL	TRN	110	1	6.5	-4.2	5.6	26.3	6.0	19.2	9.1	-3.1	6.9	27.8	6.2	20.3
MCE	CDU	110	1	-7.9	-2.0	8.3	-19.2	-2.4	15.6	-11.2	-1.9	11.6	-25.0	-1.5	20.2
MCD	WOL	110	1	11.9	1.2	9.9	26.4	6.9	20.8	11.3	2.2	9.6	27.9	7.4	22.0
MTH	LOU	110	1	-4.9	-8.1	9.5	-4.8	-23.3	19.7	-27.5	-0.6	27.8	-46.5	-15.4	40.5
MAY	TIM	110	1	-	-	-	-	-	-	9.8	-1.1	8.8	18.5	-1.4	16.5
MAY	GRI	110	1	8.0	-0.1	8.1	32.5	7.3	27.8	9.1	-0.6	9.2	32.4	7.5	27.7
MAY	GRI	110	1	8.0	-0.1	8.1	32.5	7.3	27.8	9.1	-0.6	9.2	32.6	7.1	27.2
MAY	RYB	110	1	97.5	30.8	57.4	123.7	19.0	57.2	102.1	31.1	59.9	82.2	20.1	38.7
MAY	RNW	110	1	13.8	-9.9	21.1	20.3	4.4	20.2	-9.3	-0.9	11.7	27.2	-0.3	26.4
MAY	BLKT	110	1	-2.5	-9.1	9.6	37.5	-7.7	31.7	-30.5	0.7	30.8	9.6	6.4	9.5
MIL	RE	110	1	-5.4	-0.7	5.4	-21.8	-2.7	22.0	-7.5	-0.7	7.5	-23.1	-3.0	23.3
MIL	RE	110	2	-4.4	0.5	3.7	-17.2	-1.9	13.2	-6.0	0.3	5.0	-18.1	-2.2	13.9

**Table H-1 Power Flows, Summer Valley and Winter Peak 2021 and 2030**

Line				2021						2030					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
MAC	CLA	110	2	1.7	-35.3	22.0	-42.2	-2.6	22.0	-10.4	-0.8	6.5	-11.9	-8.7	7.7
MTN	MUN	110	1	10.8	6.6	28.0	10.8	6.6	28.0	10.8	6.7	28.1	10.8	6.6	28.1
MTN	MUN	110	2	10.8	6.6	28.0	10.8	6.6	28.0	10.8	6.7	28.1	10.8	6.6	28.1
MP	TBK T	110	1	21.0	-4.8	12.1	45.2	14.4	22.6	-11.0	4.6	6.7	8.8	12.6	7.3
MR	TBG	110	1	-19.2	20.2	15.6	-31.4	-6.1	14.6	-6.3	1.1	3.6	-47.5	-4.1	21.8
MR	TBG	110	2	-22.3	24.0	18.4	-36.4	-6.5	16.9	-7.3	1.9	4.2	-55.1	-4.2	25.2
MR	KLP	110	1	-	-	-	-	-	-	0.0	-3.1	2.6	22.3	-3.5	18.8
MAL	KLP	110	1	-	-	-	-	-	-	-14.7	0.8	11.0	-63.8	2.8	40.1
MOY	TAW	110	1	0.0	-0.5	0.8	-5.7	9.5	16.3	0.0	-0.4	0.7	-9.0	0.1	13.2
MOY	TAW	110	2	0.0	-0.5	0.7	0.0	6.8	10.0	0.0	-0.4	0.6	0.0	-0.4	0.6
MOY	TON	110	1	-	-	-	-	-	-	22.6	1.3	12.7	29.0	-1.5	13.8
BCT	CKM	110	1	-49.7	-17.3	37.6	-49.7	-16.2	37.3	-49.7	-17.5	37.7	-49.7	-16.6	37.4
NEW (I)	BLK T	110	1	8.5	7.6	8.4	-10.6	13.8	11.0	37.7	-0.7	27.7	18.6	-1.6	11.7
NQS	RE	110	1	-7.0	-0.2	5.9	-24.6	-4.6	21.0	-9.8	-0.4	8.2	-25.9	-5.1	22.2
OUG	OUG T	110	1	-7.5	0.9	7.2	-24.9	-5.2	20.7	-8.4	1.2	8.1	-26.4	-4.4	21.8
PA	STR T	110	1	0.0	-0.8	1.2	30.0	-12.7	47.9	34.0	-21.5	59.2	34.0	3.9	50.3
PHY	SHE	110	1	-	-	-	-	-	-	2.3	0.7	1.4	2.3	0.7	1.1
PB	RE	110	3	33.8	-30.0	16.8	125.6	-14.7	47.0	47.0	-27.6	20.3	132.7	-0.2	49.3
PB	RE	110	4	32.8	-29.1	16.3	121.8	-14.2	45.6	45.6	-26.7	19.7	128.7	-0.1	47.9
PLA	OBE	110	1	-	-	-	-	-	-	18.3	-2.2	17.5	8.4	-1.0	6.8
RE	WBK	110	1	0.0	-2.2	1.8	0.0	-27.0	19.1	0.0	-2.1	1.7	0.0	-2.3	1.7
RAF	TBG	110	1	25.8	-30.9	20.7	61.5	4.0	2.8	11.7	-5.7	6.7	82.2	-1.0	3.7
RAF	TBG	110	2	35.2	-20.7	22.9	81.1	14.9	39.4	28.6	-4.5	16.3	100.0	19.0	48.7
RNW	DFR	110	1	4.6	-11.3	12.3	11.1	3.0	9.5	-18.5	-2.4	18.8	18.0	-1.8	15.0
RRU	SKL	110	1	8.8	-17.7	20.8	10.1	8.6	11.8	5.2	-10.2	12.1	35.2	-8.9	32.4
SH	DLN	110	1	-	-	-	-	-	-	0.0	-4.0	2.8	0.0	-4.2	3.0
SH	DAL	110	1	-1.4	19.6	11.1	49.9	1.2	23.8	19.6	-2.3	11.1	-19.3	10.3	10.4
SH	IKET	110	1	-1.6	8.5	4.9	-18.5	8.6	9.7	-25.0	9.1	14.9	-27.2	8.3	13.5
SH	SOM T	110	1	5.8	-22.6	22.2	-7.2	3.1	6.4	-21.5	7.2	21.6	12.9	-4.6	11.1
SLI	SRA	110	1	-3.2	2.2	4.0	-14.7	2.1	12.3	-1.6	4.9	5.2	-6.1	-0.7	5.0
SLI	SRA	110	2	-3.0	2.0	3.6	-13.6	2.0	11.3	-1.4	4.5	4.8	-5.6	-0.7	4.7
SLI	SLI	110	1	-	-	-	0.0	-16.4	13.3	-	-	-	0.0	-16.5	13.4
SOR	TLK	110	1	0.0	-0.3	0.2	18.8	3.3	15.5	18.1	-17.2	23.8	20.2	5.8	17.1
SOM	SOM T	110	1	-2.2	0.8	2.2	-21.5	-5.5	18.0	-0.8	0.5	0.9	-22.8	-4.6	18.9
SRA	CF	110	2	17.6	-16.1	13.4	-9.2	-1.4	4.4	-11.6	6.7	7.5	27.3	-4.9	13.2
STR	STR T	110	1	-3.6	-0.1	8.1	-24.3	-5.7	55.4	-5.0	-0.1	11.2	-25.7	-6.3	58.7
SNG	AA	110	1	35.3	-18.1	27.4	31.5	0.7	17.8	-10.2	6.1	8.2	45.7	-16.6	27.5
SBH	CDU	110	1	-16.5	-5.1	12.6	-22.8	-5.3	17.1	-59.5	-24.5	47.0	-59.5	-23.9	46.8
SHN	SOM T	110	1	-3.3	19.9	19.2	29.3	1.2	23.8	22.8	-8.8	23.3	10.1	7.1	10.0
TIV	MLG	110	1	-	-	-	-	-	-	0.0	-6.3	4.5	-9.0	-6.7	8.0

**Table H-1 Power Flows, Summer Valley and Winter Peak 2021 and 2030**

Line				2021						2030					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
CNN	CLO	110	1	0.0	18.4	10.3	0.0	15.5	7.4	0.0	14.3	8.1	41.3	12.5	20.5
CNN	CAG	110	1	0.0	-10.3	7.4	0.0	-8.7	6.2	0.0	-8.0	5.7	-41.3	-5.6	29.7
CNN	CDF	110	1	0.0	-8.1	5.8	0.0	-6.8	4.9	0.0	-6.3	4.5	0.0	-6.9	4.9
TBK	TBK T	110	1	-1.3	1.0	1.6	-3.7	-7.7	6.9	7.4	0.1	7.1	-4.4	-3.5	4.6
CTN	KLN	110	1	5.0	-20.8	12.0	0.5	-3.0	1.5	11.0	0.8	6.2	25.1	2.6	12.0
CTN	TIP	110	1	-5.0	32.2	18.3	52.0	-14.8	25.7	21.3	4.5	12.2	27.5	1.0	13.1
TRL	OUG T	110	1	-8.1	18.2	11.2	16.5	13.9	10.3	-8.3	6.7	6.0	-3.4	17.4	8.5
THU	IKE T	110	1	8.6	-11.2	7.9	40.1	3.2	19.1	24.2	-9.0	14.5	50.8	0.8	24.2
THU	THU	110	1	-	-	-	0.0	-16.5	13.4	-	-	-	0.0	-16.5	13.4
RSP	WEX	110	1	-	-	-	-	-	-	17.3	-3.5	9.9	50.3	-21.6	26.1
WEX	WEX	110	1	-	-	-	0.0	-34.2	27.8	-	-	-	0.0	-32.6	26.5
CTG	BVK	110	1	0.0	1.0	0.5	46.5	-45.5	28.5	18.7	0.2	8.2	46.6	-2.1	20.5
WHO	KMA	110	1	0.0	-1.6	1.3	-10.2	2.8	8.5	0.0	-1.5	1.2	-10.2	-1.5	8.3
BK	SKY	110	1	0.0	-5.7	3.0	-51.2	17.3	24.2	-51.3	1.2	27.4	-51.3	0.8	23.0
BK	CRN	110	1	0.0	-0.2	0.1	0.0	-0.1	0.1	-0.5	13.5	7.6	-14.9	27.2	14.8
CKM	FAS	110	1	5.5	1.7	5.5	30.8	12.2	27.0	7.7	2.5	7.7	32.6	13.6	28.7
BKM	CUR	110	1	0.0	-9.0	7.5	-28.1	11.6	25.3	-28.1	25.6	31.7	-28.1	10.1	24.9
AGH	ENN (N)	110	1	-2.6	5.2	5.3	2.9	6.9	6.0	1.2	1.7	1.9	-17.3	1.6	14.0
AIR	ROS	110	1	-	-	-	-	-	-	-5.6	-0.9	6.9	-19.0	-3.6	18.8
AIR	ROS	110	1	-	-	-	-	-	-	-5.6	-0.9	6.9	-19.0	-3.6	18.8
ANT	KEL	110	1	-4.5	5.7	8.9	-20.1	1.7	19.6	-6.1	4.4	9.2	-21.8	1.6	21.2
ANT	KEL	110	2	-5.3	-6.0	9.7	-21.3	-9.1	22.5	-6.8	-6.4	11.4	-22.9	-9.7	24.1
BPS	BVG	110	1	7.1	1.3	8.8	4.4	12.3	12.6	8.8	3.5	11.6	55.4	-4.0	53.9
BPS	BVG	110	2	7.1	1.3	8.8	4.4	12.3	12.6	8.8	3.5	11.6	55.4	-4.0	53.9
BPS	EDE	110	1	14.0	-21.9	37.7	40.7	-15.2	50.5	8.2	1.5	5.8	30.9	5.1	18.9
BPS	EDE	110	2	14.0	-22.0	37.3	40.8	-15.3	50.1	8.2	1.5	5.8	31.0	5.1	18.9
BMA	KEL	110	1	-9.7	-1.6	9.0	-32.1	-9.4	27.0	-10.6	-0.5	9.7	-45.6	-10.8	37.8
BMA	KEL	110	2	-14.3	-0.9	13.1	-35.9	-8.4	29.7	-10.2	-0.4	9.4	-44.2	-10.0	36.5
BAN	TAN	110	1	-5.6	-1.6	7.1	-19.2	-4.6	19.2	-6.0	-1.7	7.6	-20.5	-5.1	20.5
BAN	TAN	110	2	-5.9	-1.7	7.5	-20.1	-5.1	20.1	-6.3	-1.8	7.9	-21.4	-5.7	21.5
BVG	KEL	110	1	0.7	-1.3	1.3	-15.2	5.5	13.0	2.7	0.0	2.4	30.5	-12.1	26.5
BVG	KEL	110	2	0.7	-1.3	1.4	-15.8	5.8	13.6	2.8	0.0	2.5	31.9	-12.6	27.6
BVG	LAR	110	1	6.4	3.3	9.1	19.8	7.2	18.6	6.1	4.0	9.2	23.5	7.3	21.8
BVG	LAR	110	2	6.4	3.3	9.1	19.9	7.2	18.7	6.1	4.0	9.2	23.6	7.3	21.8
BNH	CAS	110	1	-8.3	-1.0	10.2	-28.5	-5.7	28.2	-8.9	-1.0	10.9	-30.3	-6.1	30.0
BNH	CAS	110	2	-8.4	-0.9	10.3	-28.5	-5.7	28.3	-8.9	-1.0	10.9	-30.4	-6.1	30.1
BNM	DON	110	1	-7.3	-0.2	9.8	-25.0	-4.2	31.0	-14.0	13.4	13.4	-8.2	4.2	6.4
BNM	DON	110	2	-7.4	-0.4	9.8	-25.2	-4.4	31.2	-14.0	9.7	11.8	-8.5	0.4	5.9
AGI	BRO	110	1	-	-	-	-	-	-	4.8	-10.1	7.8	0.0	-0.5	0.3
AGI	RSK	110	1	-	-	-	-	-	-	13.7	-9.8	9.0	0.0	0.5	0.3
CAR	EDE	110	1	-8.7	22.9	35.5	-23.1	19.3	35.1	-2.9	-0.7	4.3	-12.2	-1.3	14.3
CAR	EDE	110	2	-8.7	23.0	35.7	-23.2	19.5	35.2	-2.9	-0.7	4.3	-12.2	-1.3	14.3

**Table H-1 Power Flows, Summer Valley and Winter Peak 2021 and 2030**

Line				2021						2030					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
CAS	CRE	110	1	18.7	-7.6	15.3	64.1	2.1	44.3	11.9	4.6	9.6	80.1	7.3	55.5
CAS	CRE	110	2	18.7	-7.6	15.3	63.9	2.0	44.1	11.8	4.5	9.6	79.9	7.3	55.3
CAS	KNO	110	1	9.2	-3.6	15.0	31.6	2.4	43.4	8.6	-3.2	13.9	29.5	1.6	40.5
CAS	KNO	110	2	9.2	-3.5	15.0	31.6	2.4	43.4	8.6	-3.1	13.9	29.5	1.7	40.5
CAS	NAR	110	1	6.5	-6.1	8.2	23.0	-6.1	19.2	7.2	-5.1	8.0	24.5	-5.7	20.3
CAS	NAR	110	2	6.3	-6.0	8.0	22.6	-6.1	18.9	7.0	-5.0	7.9	24.0	-5.8	19.9
CAS	RAT (N)	110	1	8.3	0.2	10.1	28.5	3.7	27.9	8.8	0.4	10.8	30.4	4.0	29.7
CAS	RAT (N)	110	2	8.7	0.4	10.6	29.9	4.2	29.3	9.3	0.6	11.3	31.8	4.5	31.2
CAS	ROS	110	1	4.4	-0.7	3.1	12.5	3.3	8.5	7.2	1.4	5.1	28.6	6.4	19.3
CAS	ROS	110	2	4.5	-0.7	3.2	12.7	3.4	8.6	7.2	1.5	5.1	28.8	6.4	19.4
CEN	CEN	110	1	-	-	-	-	-	-	0.0	-1.8	1.0	-0.1	-1.9	0.9
CEN	CRE	110	1	-7.8	-0.5	5.4	-26.6	-2.8	18.6	-2.2	-11.9	8.4	-47.0	-9.3	33.3
CEN	CRE	110	2	-7.8	-0.5	5.4	-26.6	-2.8	18.6	-2.3	-11.8	8.4	-47.1	-9.3	33.3
COL (N)	CPS	110	1	-16.5	-1.5	20.2	-24.2	-9.3	25.1	-17.6	-2.7	21.7	-39.3	-7.1	38.8
COL (N)	LIM (N)	110	1	-11.5	-1.0	14.1	-15.1	-5.2	15.5	-14.6	-0.7	17.9	-22.0	-3.1	21.6
COL (N)	LOG	110	1	5.8	-0.1	7.1	18.4	4.4	18.4	5.7	0.4	7.0	21.1	5.1	21.0
COL (N)	LOG	110	2	5.7	-0.1	6.9	18.0	4.3	18.0	5.6	0.4	6.8	20.7	5.0	20.6
COL (N)	RSK	110	1	4.0	3.0	2.7	-7.9	-2.3	4.3	18.4	-4.2	10.2	-26.3	-5.4	13.9
CPS	CLM	110	1	-	-	-	-	-	-	-3.7	-7.6	4.2	0.0	-15.1	7.5
CPS	KMT	110	1	21.2	-31.5	26.6	-2.4	13.8	8.5	-19.4	16.7	17.9	-3.9	6.9	4.8
CPS	LIM (N)	110	1	18.9	0.4	23.1	29.1	10.9	30.2	18.8	2.9	23.2	49.4	10.7	49.1
CPS	LMR	110	1	4.8	0.5	5.9	14.2	3.4	14.2	4.4	1.1	5.5	17.5	3.9	17.4
CPS	LMR	110	2	4.8	0.5	5.9	14.2	3.4	14.2	4.4	1.1	5.5	17.6	3.9	17.5
CPS	SPR	110	1	7.0	-0.5	8.5	23.9	2.8	23.3	7.4	-0.3	9.1	25.4	3.1	24.8
CPS	SPR	110	2	7.0	-0.6	8.5	23.9	2.7	23.3	7.4	-0.4	9.1	25.4	3.0	24.8
CPS	STR (N)	110	1	29.0	-37.6	43.6	19.8	11.7	18.5	-20.7	20.9	27.0	-3.3	25.2	20.5
CLM	AGT	110	1	-	-	-	-	-	-	3.7	-6.6	3.8	0.0	-5.5	2.8
CRG	TGW	110	1	-	-	-	-	-	-	-11.7	3.2	11.1	-16.1	4.0	13.4
CRG	TMN	110	1	-6.1	-12.6	12.8	-22.6	-0.6	18.2	4.4	-5.5	6.5	-10.4	-8.2	10.7
DON	HAN	110	1	-15.5	1.2	10.8	-53.0	-3.9	33.7	-21.1	11.5	16.7	-32.4	1.7	20.5
DON	HAN	110	2	-12.6	7.9	10.3	-43.1	2.6	27.3	-20.7	15.5	18.0	-31.7	5.8	20.4
DON	FIN (N)	110	1	-6.2	6.7	13.2	-22.2	4.8	26.4	-5.5	6.4	12.3	-19.7	5.8	23.9
DON	FIN (N)	110	2	-7.2	-9.0	16.6	-23.6	-9.6	29.6	-6.4	-8.5	15.4	-21.1	-9.7	27.0
DRO (N)	CRR	110	1	0.0	-1.0	0.6	-20.2	0.4	10.1	-16.1	3.3	8.8	0.0	-4.5	2.3
DRO (N)	ENN (N)	110	1	11.1	-13.5	21.3	20.9	1.8	20.4	8.9	-4.7	12.3	22.3	1.4	21.7

**Table H-1 Power Flows, Summer Valley and Winter Peak 2021 and 2030**

Line				2021						2030					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
DRO (N)	ENN (N)	110	2	11.1	-13.5	21.3	20.9	1.8	20.4	8.9	-4.7	12.3	22.3	1.4	21.7
DRO (N)	OMA	110	1	-11.1	14.0	21.8	-10.8	-2.0	10.7	-0.9	3.1	1.6	-22.3	0.9	9.9
DRO (N)	OMA	110	2	-11.1	14.0	21.8	-10.8	-2.0	10.7	-0.9	3.1	1.6	-22.3	0.9	9.9
DRU (N)	TAN	110	1	-5.0	-0.9	6.4	-13.3	-19.9	21.2	4.7	-12.2	16.6	-13.3	-25.6	25.6
DRU (N)	TAN	110	2	-5.0	-0.9	6.4	-13.3	-19.9	21.2	4.7	-12.2	16.6	-13.3	-25.6	25.6
DRU (N)	TAN	110	3	-5.3	-0.7	4.9	-14.9	-20.3	20.0	4.4	-13.0	12.7	-15.1	-26.3	24.0
DRU (N)	TMN	110	1	-5.7	0.5	5.3	-24.3	17.8	24.3	-20.7	17.4	24.8	-27.7	25.6	30.4
DRU (N)	TMN	110	2	-6.0	0.3	5.5	-25.4	18.2	25.2	-21.7	17.9	25.8	-29.0	26.4	31.6
CRR	CRR	110	1	-	-	-	-	-	-	-4.2	0.2	5.3	0.0	-1.6	3.3
CRR	PGN	110	1	-	-	-	-	-	-	-5.2	-0.6	8.6	0.0	-2.0	3.3
DUN	TMN	110	1	-11.2	3.0	7.4	-29.0	-13.7	18.0	0.2	-7.8	5.0	-43.1	-16.3	25.9
DUN	TMN	110	2	-7.5	3.1	5.6	-21.4	-6.9	15.6	-0.5	-5.4	3.8	-31.4	-7.5	22.4
DUN	OMA	110	1	0.2	-14.7	7.9	-17.1	0.0	8.9	-28.8	11.5	16.7	7.5	3.1	4.2
DUN	TMN	110	3	-10.0	1.2	5.4	-24.7	-14.3	14.8	0.6	-7.5	4.1	-36.9	-17.2	21.1
ENN (N)	ENN (N)	110	1	0.3	-2.7	2.2	1.7	0.5	1.4	6.0	3.5	5.6	-35.3	-3.3	28.4
FIN (N)	HAN	110	1	-11.7	-8.9	10.2	-39.1	-11.1	28.2	-11.3	-8.5	9.8	-37.7	-11.2	27.3
FIN (N)	HAN	110	2	-10.7	6.6	8.7	-37.6	3.2	26.2	-10.3	6.2	8.4	-36.2	4.1	25.3
GLE (N)	KEL	110	1	-6.6	-1.8	8.3	-22.5	-7.0	26.2	-4.8	-1.1	6.0	-16.4	-4.3	18.8
GLE (N)	KEL	110	2	0.0	-3.0	3.6	0.0	-2.9	3.2	-4.8	-1.1	6.0	-16.4	-4.3	18.8
GOR (N)	OMA	110	1	2.7	-6.2	3.4	4.7	0.6	2.4	-12.1	3.2	6.3	8.1	7.8	5.6
GOR (N)	TMN	110	1	-2.7	10.4	5.4	15.5	0.2	7.7	24.1	-6.0	12.4	-8.1	-4.0	4.5
HAN	LIS (N)	110	1	-7.7	-17.1	22.8	-4.1	2.5	4.7	13.7	-2.6	17.0	9.1	2.9	9.2
HAN	LIS (N)	110	2	-8.0	-18.2	24.9	-6.5	1.3	6.7	13.8	-2.4	17.5	7.2	2.0	7.5
KEL	KLC	110	1	-	-	-	-	-	-	0.0	-1.1	0.8	0.0	-1.2	0.8
KEL	RSK	110	1	-7.4	-13.4	8.3	-22.5	4.2	11.9	-10.1	2.1	5.6	10.0	-3.1	5.4
KEL	RSK	110	2	-	-	-	-	-	-	-10.6	0.9	5.6	10.4	-1.9	5.0
KEL	TGW	110	1	-	-	-	-	-	-	-5.0	-1.9	2.7	22.4	-6.4	11.6
KLC	KLC	110	1	-	-	-	-	-	-	0.0	-0.3	0.2	0.0	-0.3	0.2
KMT	SLK	110	1	0.1	-22.5	20.6	-21.8	11.7	19.9	-7.2	6.4	8.9	0.1	-20.8	16.8
KMT	STR (N)	110	1	21.1	-9.0	16.0	30.1	3.3	18.2	-8.7	6.2	7.4	-4.0	28.2	17.2
LIS (N)	TAN	110	1	-15.6	-13.5	25.1	-41.3	-2.8	40.2	2.1	-1.4	3.0	-30.7	-2.9	29.9
LIS (N)	TAN	110	2	-16.0	-14.8	27.2	-43.6	-4.2	43.8	2.3	-1.2	3.2	-32.3	-3.9	32.5



**Table H-1 Power Flows, Summer Valley and Winter Peak 2021 and 2030**

Line				2021						2030					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
MKL	OMA	110	1	0.0	1.1	0.8	41.3	5.7	26.6	13.8	-14.5	14.4	0.0	1.0	0.6
NEW (N)	TAN	110	1	-11.7	-2.0	14.5	-40.0	-9.7	40.0	-12.5	-2.2	15.4	-42.7	-10.1	42.5
NEW (N)	TAN	110	2	-11.7	-2.0	14.5	-40.1	-9.7	40.1	-12.5	-2.2	15.5	-42.8	-10.1	42.6
OMA	STR (N)	110	1	-18.0	0.8	16.6	-7.8	-4.5	7.3	-29.3	4.8	27.3	-42.1	6.7	34.4
OMA	STR (N)	110	2	-17.7	0.8	21.6	-7.7	-4.5	8.6	-28.9	4.7	35.7	-41.4	6.6	40.7
OMA	TRE	110	1	-1.5	8.2	4.5	-1.5	-2.4	1.5	19.4	-9.7	11.7	-10.7	-7.6	6.8
RSK	TGW	110	1	-	-	-	-	-	-	16.8	-5.6	8.8	-6.1	-1.9	3.2
STR (N)	STR (N)	110	1	1.2	-46.6	37.3	0.0	-3.7	3.0	-99.0	31.3	83.1	-138.2	52.1	118.2
TAN	WAR	110	1	9.3	1.4	11.9	33.3	8.3	30.4	10.3	1.9	13.3	35.4	8.7	32.3
TAN	WAR	110	2	9.3	1.4	11.8	33.3	8.2	30.3	10.3	1.9	13.3	35.4	8.7	32.2
TRE	TMN	110	1	-1.5	13.2	7.2	21.5	-1.7	11.2	27.0	-10.8	15.6	-10.8	-3.1	5.8





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