All-Island Ten Year

Transmission Forecast Statement 2019

EIRGRID

SONI

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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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Foreword

EirGrid and SONI, as the transmission system operators (TSOs) for Ireland and Northern Ireland respectively, have worked together to produce this All-Island Ten Year Transmission Forecast Statement (TYTFS).

This statement has been prepared in accordance with the provisions of Section 38 of the Electricity Regulation Act, 1999 (EirGrid) and Condition 33 of SONI's TSO licence.

TYTFS 2019 presents the most up-to-date available transmission system information at the data freeze date of January 2019.

The TYTFS is prepared recognising that climate change is well understood, and beyond scientific doubt. Government, EU and global-level efforts are focused on planning for the transition to a sustainable, low-carbon future.

The transition will have widespread consequences. There will be major changes in how electricity is generated, and in how it is bought and sold. There will also be major changes in how electricity is used, such as for transport and heat.

The electricity system will carry more power from renewable sources than ever before. Coal, peat and oil-based generation is expected to be phased out in the next decade.

These changes are underpinned by policies in both Northern Ireland (by way of UK legislation) and Ireland.

In June 2019, the Irish Government launched its Climate Action Plan 2019. The Action Plan sets out an ambitious course of action over the coming years. Specifically for the electricity sector, it sets a target that 70% of our electricity will come from renewable energy sources by 2030.

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

Energy Policy is a devolved matter for Northern Ireland and the Department for the Economy (DfE) is currently working with stakeholders to develop an update to the Strategic Energy Framework for Northern Ireland. SONI is providing input to this important work, which will inform future energy policy and renewable targets, and the approach to facilitating growth in renewable electricity generation.

In order to meet our 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, indeed it will require a significant transformation of the electricity system.

In September 2019, we launched our Strategy 2020-2025 which is shaped by two factors: climate change and the impending transformation of the electricity sector. We are committed to leading the change towards a carbon-free electricity system and achieving renewable energy targets.

As noted in our All-Island Generation Capacity Statement 2019-2028 and in this statement, a significant amount of conventional generation in Ireland and Northern Ireland is expected to close over the period covered by this statement. It is assumed that the Capacity Market, which is overseen by the SEM Committee, will deliver sufficient power in appropriate locations to ensure generation adequacy and security of supply are maintained. In Northern Ireland, we are mindful that the Capacity Market will ensure adequate generation until the North South 400 kV interconnector is delivered.

Demand in Ireland continues to transform, with this statement reflecting the significant expected growth in data centres and other large energy users. A large portion of these data centres are connected, or plan to connect, in the Dublin area. Depending on the level of demand from these connections, new large scale generation, transmission solutions, demand side response and/or storage will be required to maintain security of supply in the area. The system needs in the Dublin area are dynamic due to the connection of these new large scale demand customers combined with potential changes in the connected generation portfolio.

The planned North South 400 kV interconnector will increase security of supply, support the development of renewable power generation and provide economic benefits to customers in both jurisdictions. 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.

The results presented in the TYTFS highlight new generation opportunities in the east of the island, and in particular in the east of Northern Ireland and in north Dublin. The results also show that future generation connections in the North-West, West and South-West regions would require network reinforcements.

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 while in Northern Ireland customers can contact us at info@soni.ltd.uk.

We hope you find this document informative and we welcome any feedback and suggestions.

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Document Structure

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

Abbreviations and Terms provides a list of abbreviations and terms used in the document.

The **Executive Summary** gives an overview of the main highlights of the document.

Chapter 1: Introduction
Presents the purpose and context of the All-Island Ten Year Transmission Forecast Statement. Our statutory and legal obligations are also introduced.

Chapter 2: The Electricity Transmission System
Describes the existing all-island transmission system. A brief outline of transmission system development plans for both Ireland and Northern Ireland is also given.

Chapter 3: Demand
Describes the demand forecast assumptions over the study period of 2019 – 2028.

Chapter 4: Generation
Describes the projected generation connection assumptions over the study period of 2019 – 2028.

Chapter 5: Transmission System Performance
Provides information on power flow and short circuit study results.

Chapter 6: Overview of Transmission System Capability Analysis
Outlines the analysis methods used to carry out the demand and generation opportunities' analyses.

Chapter 7: Transmission System Capability for New Generation
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Abbreviations and Terms

Abbreviations

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
DCCAE	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
NIE	Northern Ireland Electricity Networks
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
TSSPS	Transmission System Security and Planning Standards
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

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 date 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 demand figures in Chapter 3 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 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 applied 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 applied to approximately 3,900 MW of renewable 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 CRU. The Grid Code is available on www.eirgrid.com.
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 www.soni.ltd.uk.
Interconnector Administrator	An Interconnector Administrator (IA) facilitates the allocation of capacity and energy trading. Trading is carried out using an Auction Management Platform (AMP) 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	The maximum capacity (MVA) modified for ambient temperature conditions that the circuit can sustain indefinitely without degradation of equipment life. 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.
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.
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	The process of supplying reactive power to the network.
Reactor	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.

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 www.sem-o.com and www.semcommittee.com.
SONI	System Operator for Northern Ireland (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. SONI is part of the EirGrid Group.
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 System Security and Planning Standards	The sets of standards that the transmission systems of Ireland and Northern Ireland are 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

The All-Island Ten Year Transmission Forecast Statement (TYTFS) 2019 provides the following information:

- Network models and data for 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.

TYTFS 2019 is prepared in accordance with the statutory regulations 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 2019 describes the transmission system on the island of Ireland from 2019 to 2028. EirGrid and SONI have jointly prepared TYTFS 2019. This document supersedes the All-Island Ten Year Transmission Forecast Statement 2018-2027.

This document presents the most up-to-date information available for the all-island transmission system at the data freeze date of January 2019. Where applicable we provide information on transmission system projects under development. Where multiple solutions are presented for a transmission system project, no particular preference is given to one solution[1].

In recent years there has been an increase in activity in the demand sector in Ireland. 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 2019-2028 (GCS)[2]. The demand forecast represents an average annual increase in all-island winter peak demand of 2.4% over the period of GCS 2019-2020[3]. This represents an increase in the demand forecast relative to GCS 2018-2027, when the forecast average annual increase in all-island winter peak demand was 2.0%[4].

This TYTFS shows that large energy users currently represent significant demand connections in Ireland and are expected to represent increasingly significant demand requirements into the future. New large energy users are expected to comprise data centres primarily. A large portion of these data centres are connected or plan to connect in the Dublin area. Depending on the level of demand connections, new large scale generation, transmission solutions, demand side response and/or storage will be required to maintain security of supply in the area.

The system needs in the Dublin area are dynamic due to the connection of these new large scale demand customers combined with potential changes in the connected generation portfolio.

In response to this we have confirmed the need for investment in the greater Dublin area. We are progressing two projects: Capital Project 966 and Capital Project 1021, which together help transfer power into and around the Dublin region. We are progressing these projects in line with our process for developing the grid which is outlined in our “Have Your Say” document. This is available on the EirGrid website[5].

1 In line with our strategy to consider all practical technology options for network development.
2 www.eirgridgroup.com/site-files/library/EirGrid/EirGrid-Group-All-Island-Generation-Capacity-Statement-2019-2028.pdf
3 The cumulative forecast increase in demand over the period of GCS 2019-2028 is 27%.
4 The cumulative forecast increase in demand over the period of GCS 2018-2027 was 22%.
5 www.eirgridgroup.com/__uuid/7d658280-91a2-4dbb-b438-ef005a857761/EirGrid-Have-Your-Say_May-2017.pdf

The all-island renewable generation capacity is expected to continue to increase rapidly over the period of this statement, reaching approximately 8,900 megawatts (MW) of generation capacity, an increase of 400 MW from the TYTFS 2018 forecast. Onshore wind contributes to the majority of renewable generation. In Northern Ireland, grid scale and small scale solar generation has already made an impact. In Ireland, there has recently been a significant increase in solar generation applications[6]. It is also expected that offshore wind will be a significant part of the renewable generation mix in the future.

In addition, in June 2019 the Irish Government launched its Climate Action Plan 2019[7]. The Action Plan sets out an ambitious course of action over the coming years. Specifically for the electricity sector it sets a target that 70% of our electricity will come from renewable energy sources by 2030.

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

Energy Policy is a devolved matter for Northern Ireland and the Department for the Economy (DfE) is currently working with stakeholders to develop an update to the Strategic Energy Framework for Northern Ireland. SONI is providing input to this important work, which will inform future energy policy and renewable targets, and the approach to facilitating growth in renewable electricity generation.

In order to meet our 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, indeed it will require a significant transformation of the electricity system.

In September 2019 we launched our Strategy 2020-2025[8] which is shaped by two factors: climate change and the impending transformation of the electricity sector. We are committed to leading the change towards a carbon-free electricity system and achieving renewable energy targets.

As noted in GCS 2019 some large conventional plants, with a total capacity of approximately 2,000 MW, are expected to retire in the period. This is in addition to the approximately 630 MW[9] that closed at the end of 2018. In addition, in November 2019, ESB announced that two peat-powered generating plants will stop generating electricity at the end of December 2020. The plants are located at Shannonbridge in Offaly and Lanesboro in Longford. These two closures will be captured in the next TYTFS.

TYTFS 2019 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: 2019; 2022; and 2025.

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.

6 See Chapter 4 Generation for more information on the increase in solar generation applications.
7 www.gov.ie/en/publication/5350ae-climate-action-plan/
8 www.eirgridgroup.com/about/strategy-2025/
9 Aghada (AD1), Marina and Ballylumford (ST 4 & 5).

Interconnection 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 include the Moyle and East-West Interconnector (EWIC) high voltage direct current (HVDC) interconnectors. These interconnectors connect the all-island transmission system to the Great Britain transmission system. No connection agreements were in place for further interconnection at the data freeze date. However, since the data freeze date the connection agreement for the proposed Greenlink Interconnector between Ireland and Great Britain has been executed. The connection application for the proposed Celtic Interconnector between Ireland and France is currently being processed.

Our analyses assume the planned North South 400 kV interconnector is in place in winter 2023. The results of the analyses performed for TYTFS 2019, post 2023, are therefore dependent on the North South reinforcement being commissioned. The reinforcement will increase security of supply, support the development of renewable power generation and provide economic benefits to customers in both jurisdictions. Information on the North - South 400 kV interconnector is presented in Chapter 2.

TYTFS 2019 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 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 north Dublin. 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 surplus generation capacity 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 2025 transmission system, are presented in Chapter 8. The study indicates that a significant number of stations across the island have the capability to accommodate demand connections, some to a lesser degree than others. The planned North South 400 kV 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 also includes a qualitative assessment of the demand capability in the Dublin area. This assessment has been included as a result of the large volume of connections and enquires from data centres and other large energy users in the Dublin area.

It should be noted that, as mentioned above and in Chapter 4, a significant amount of conventional generation in Ireland and Northern Ireland is expected to close over the period covered by this statement. It is assumed that the Capacity Market, which is overseen by the SEM Committee, will deliver sufficient power in appropriate locations to ensure generation adequacy and security of supply are maintained.

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 while in Northern Ireland customers can contact us at info@soni.ltd.uk.

1. Introduction

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 2019 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 2019, readers should consider other documents we produce, or are involved in producing, including[10]:

- All-Island Generation Capacity Statement (GCS);
- 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.

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.

10 Our publications are available at www.eirgridgroup.com and www.soni.ltd.uk

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[11] 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[12] and Northern Ireland[13].

Table 1-1: 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 2019 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[14] and the Target Model[15]. 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[16]).

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).

11 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).
12 The Commission for Regulation of Utilities is the Regulatory Authority in Ireland.
13 The Utility Regulator is the Regulatory Authority in Northern Ireland.
14 www.entsoe.eu/major-projects/network-code-development/Pages/default.aspx
15 www.entsoe.eu/about-entso-e/market/long-term-market-design/Pages/default.aspx
16 Further information on the SEM is available on www.sem-o.com

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 are 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 2019 applies to TYTFS 2019. 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 2019.

1.3. Other Information

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

- SONI Grid Code[17];
- EirGrid Grid Code[18];
- SONI Transmission System Security and Planning Standards[19];
- The Electricity Safety, Quality and Continuity Regulations[20] (Northern Ireland) 2012;
- EirGrid Transmission System Security and Planning Standards[21];
- EirGrid Operating Security Standards[22];
- SONI Transmission Connection Charging Methodology Statement[23];
- EirGrid Transmission Connection Charging Methodology Statement 2008[24];
- EirGrid Statement of Charges 2019/2020[25];
- Statement of Charges – For Use of Northern Ireland Electricity Ltd Transmission System[26];
- All-Island Generation Capacity Statement 2019-2028 [27];
- EirGrid Transmission Development Plan for Ireland[28]; and
- SONI Transmission Development Plan for Northern Ireland[29].

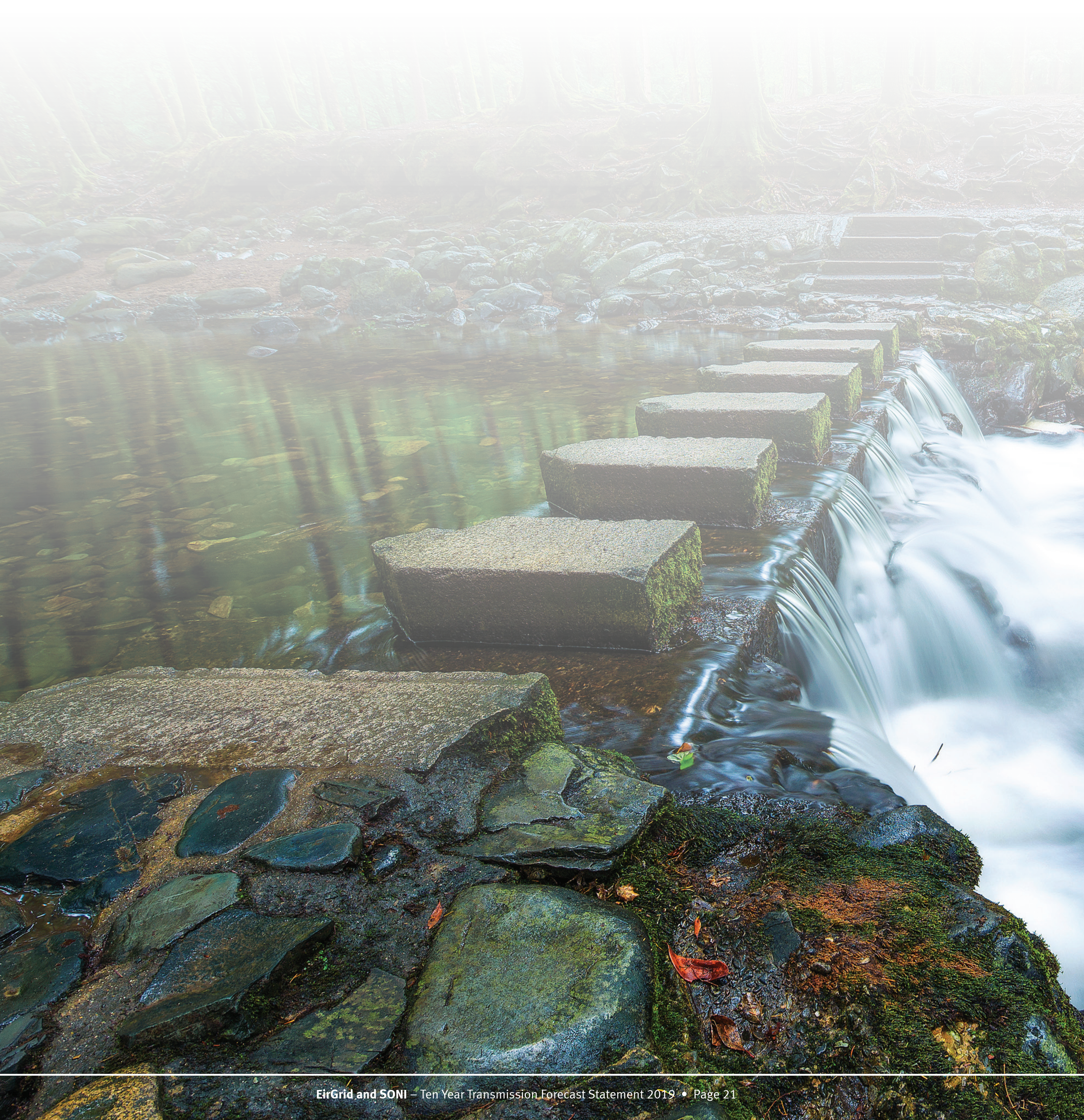
17 www.soni.ltd.uk/customer-and-industry/general-customer-information/grid-code/
18 www.eirgridgroup.com/customer-and-industry/general-customer-information/grid-code-info/index.xml
19 www.soni.ltd.uk/media/Northern-Ireland-TSSPS-September-2015.pdf
20 www.legislation.gov.uk/nisr/2012/381/pdfs/nisr_20120381_en.pdf
21 www.eirgridgroup.com/site-files/library/EirGrid/EirGrid-Transmission-System-Security-and-Planning-Standards-TSSPS-Final-May-2016-APPROVED.pdf
22 www.eirgridgroup.com/site-files/library/EirGrid/Operating-Security-Standards-December-2011.pdf
23 www.soni.ltd.uk/media/SONI-Transmission-Connection-Charging-Methodology-Statement-Effective-1-Sept-2016-Approved-by-UR.pdf
24 www.eirgridgroup.com/site-files/library/EirGrid/Connection-Charging-Statement.pdf
25 www.eirgridgroup.com/site-files/library/EirGrid/Statement-of-Charges-2019_20-_Final.pdf
26 www.soni.ltd.uk/customer-and-industry/general-customer-information/transmission-use-of-system-charges%20TUoS/?__toolbar=1
27 www.eirgridgroup.com/site-files/library/EirGrid/EirGrid-Group-All-Island-Generation-Capacity-Statement-2019-2028.pdf
28 www.eirgridgroup.com/site-files/library/EirGrid/Transmission-Development-Plan-2018-2027.pdf
29 www.soni.ltd.uk/the-grid/projects/tdpni/the-project/

1.4. Publication

The TYTFS 2019 is available in pdf format on our websites:

- www.eirgridgroup.com; and
- www.soni.ltd.uk

For a hard-copy version, please send a request to info@eirgrid.com or info@soni.ltd.uk. Transmission system model files are also available on both websites.



2. The Electricity Transmission System

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. For the purposes of the 2019 TYTFS analysis, this project is anticipated to be completed by the end of 2023.

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[30] 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 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[31] and cables at the different voltage levels. Revision of individual line lengths may change following completion of network development projects.

30 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.
31 Some lines may contain short sections of cable.

Table 2-1: Total Length of Existing Transmission System Circuits as at the Data Collection Freeze Date (January 2019)

Voltage Level (kV)	Total Circuit Lengths (km)
400	439
275	877
220	1,966
110	6,663

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[32] (January 2019)

Voltage Levels (kV)	Capacity (MVA)	Number of transformers
400/220	3,550	7
275/220	1,200	3
275/110	4,080	17
220/110	13,424	65
110/33[33]	5,740	79

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.

32 Transformer details are provided in Tables B-3, B-4 and B-5 in Appendix B.
33 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[34] as at the Data Collection Freeze Date (January 2019)

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	816	46
38	Shunt Reactor	100	5
33	Shunt Capacitor	29	5
22	Shunt Reactor	210	7
	Shunt Capacitor	125	5
20	Shunt Capacitor	75.4	14
	Shunt Reactor	9	1

2.2. Existing Connections between Ireland and Northern Ireland Transmission Systems

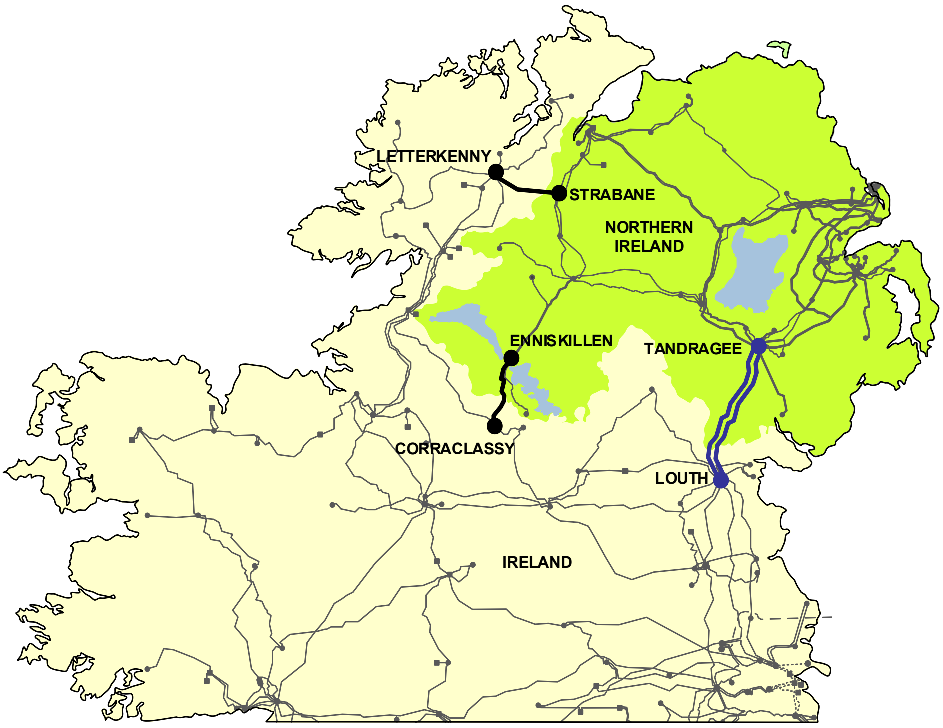


Figure 2-1: Existing Cross-Border Circuits

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[35] 300 MVA units.

34 Details of existing reactive compensation devices are provided in Table B-7 in Appendix B. This table also includes reactive compensation devices at lower voltage levels that are modelled in the TYTFS studies.
35 Plant connected in parallel through common switchgear.

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.

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.

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 these non-synchronous power sources. This reduces the all-island system inertia[36]. 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[37].

SONI acts as Interconnector Administrator (IA) for the East West and Moyle interconnectors.

Interconnector capacity is auctioned by the IA on behalf of EirGrid Interconnector DAC (EIDAC)[38] and Moyle Interconnector Limited (MIL)[39]. The capacity is purchased by market participants and utilised 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.

36 System inertia is also reduced by the increased wind penetration (another form of non-synchronous generation).
37 Unlike Moyle the East West Interconnector has dynamic reactive power export capability.
38 www.eirgridgroup.com/customer-and-industry/interconnection/
39 www.mutual-energy.com/electricity-business/

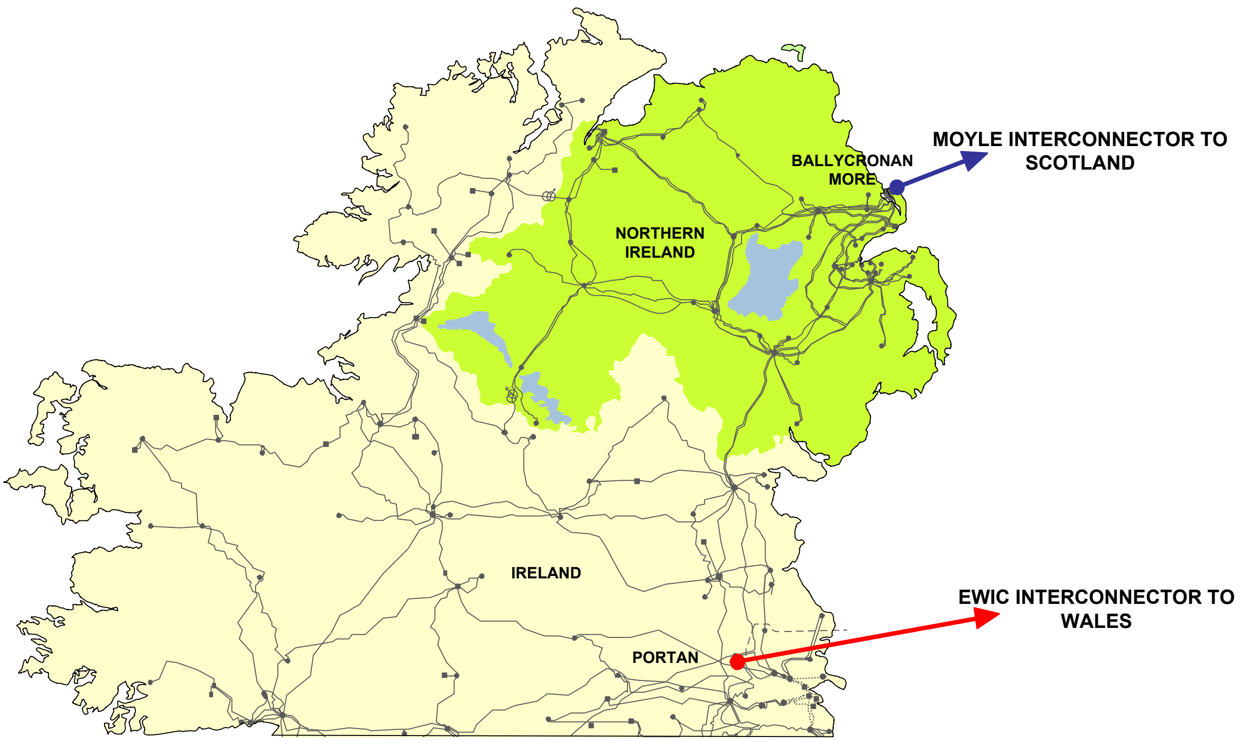


Figure 2-2: Existing Interconnectors

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)
WAL – IRL	500	500
IRL – WAL	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

Direction	Month	Capacity Available to Interconnector users	Capacity Limit Set By
West to East	May – August	80 – 287 MW[40]	NG/ GB System
	September – April	80 – 295 MW	NG/ GB System SONI/NI System
East to West	Year round	450 MW	NG/ GB System

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.

40 Export capacity on Moyle varies based on wind generation in Scotland. See www.mutual-energy.com/wp-content/uploads/downloads/2017/06/Moyle_Capacity_Calculation_2017_consultation_web.pdf

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.

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. No connection agreements were in place for further interconnection at the data freeze date. However, since the data freeze date the connection agreement for the proposed Greenlink Interconnector between Ireland and Great Britain has been executed. The connection application for the proposed Celtic Interconnector between Ireland and France is currently being processed. PCIs are intended to help the EU achieve its energy policy and climate objectives: affordable, secure and sustainable energy for all citizens.

2.4. Transmission Development Plans

EirGrid's Transmission Development Plan (TDP)[41] and SONI's Transmission Development Plan Northern Ireland (TDPNI)[42] 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[43];
- 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.

41 The latest TDP can be found on the EirGrid website www.eirgridgroup.com/
42 The latest TDPNI can be found on the SONI website www.soni.ltd.uk/the-grid/projects/tdpni/the-project/
43 For example data centres or large industrial sites.

The planned transmission system developments presented in this statement are based on those projects that have received internal approval by the data freeze date[44]. Appendix B outlines these developments. These projects are currently scheduled to be completed at various stages between now and 2028. 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.

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 2019).

2.5.1. Grid Development Strategy

EirGrid published the updated Grid Development Strategy (GDS) "Your Grid, Your Tomorrow"[45] 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

Following a review of our public consultation process, we promised to improve the way we consult with the public and other stakeholders. We have produced a summary guide of our improved consultation process - Have Your Say[46]. It explains why we develop the electricity grid, and how we consult with the public and other stakeholders to get feedback on our plans.

This guide tells you what to expect from us, and what we would like from you. There is one very important principle that is at the heart of our consultation process. The earlier you get involved in our projects, the more influence you can have on them.

This 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.

44 01 January 2019
45 www.eirgridgroup.com/the-grid/irelands-strategy/
46 www.eirgridgroup.com/the-grid/have-your-say/

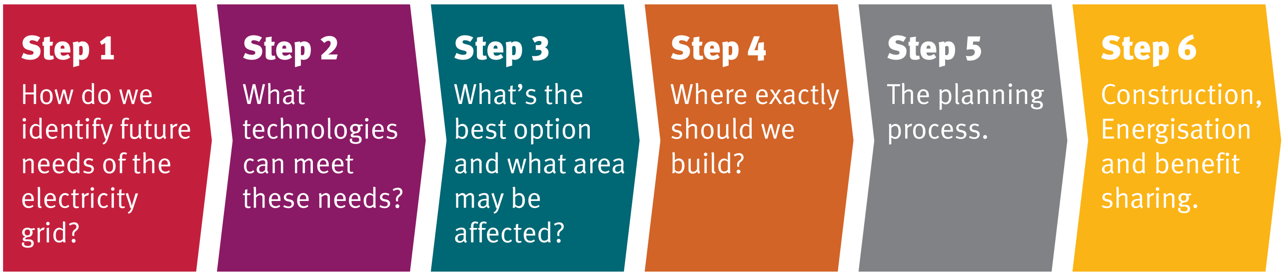


Figure 2-3: General structure of the six-step process for our grid projects

2.5.3. Tomorrow's Energy Scenarios

In July 2017 we published 'Tomorrow's Energy Scenarios 2017' (TES), the result of extensive consultations with stakeholders in planning our energy future. In March 2018 we launched 'Tomorrow's Energy Scenarios 2017 Locations Consultation', providing more information on our locational assumptions for future electricity demand and supply. Following this, we analysed how the existing and planned transmission grid performs under each of the scenarios over a range of timeframes. The results of this analysis were published in TES System Needs Assessment (TES SNA) report in December 2018.

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 TDPs and TYTFSs.

The next iteration of the TES process, Tomorrow's Energy Scenarios 2019 was consulted on and published on the EirGrid website in 2019[47]. The TES SNA 2019 report is also published on the EirGrid website.

2.5.4. Historical Transmission Developments

Table 2-6 below shows the level of transmission system developments delivered by EirGrid (together with ESB Networks and independent contestable build contractors and developers) that have been completed over the past eight years.

Table 2-6: Recent Historical Level of Transmission Developments

Year	Circuit Uprate (km)	New Line Build (km)	New Station Build
2011	340	76	3
2012	215	128	2
2013	225	38	3
2014	167	79	2
2015	76	14	3
2016	35	8	2
2017	81	24	3
2018	100	19	5

2.5.5. 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 uprated. The project will increase security of supply, increase operational flexibility and improve maintainability of station equipment. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2020.

47 www.eirgridgroup.com/customer-and-industry/energy-future/

Ballynahulla Station STATCOM

A new ±100 Mvar STATCOM will be installed and commissioned on the 110 kV busbar at Ballynahulla. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2020.

Ballyvouskill Station STATCOM

A new ±100 Mvar STATCOM on the 110 kV busbar at Ballyvouskill will be installed and commissioned. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2020.

Bellacorick – Moy 110 kV Uprate

The 110 kV circuit between Bellacorick and Moy will be uprated to accommodate increased wind generation in the area. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2019.

Belcamp Phase 1 220 kV Development[48]

Belcamp 220 kV station, in north Co. Dublin, will be connected to the 220 kV network by an underground cable from Finglas in order to facilitate new demand connections to the system in the North East Dublin area. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2019.

Belcamp Phase 2 220/110 kV Development

A 220 kV cable will connect Shellybanks station to Belcamp station, by utilising the existing Shellybanks – Finglas 220 kV and Finglas – Dardistown 110 kV cables before continuing on to Belcamp. This will lead to a revision in the feeding arrangements of the underlying Finglas and Belcamp 110 kV network. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2021.

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[49] document. The project is currently in Step 3. For the most up to date information on the project please visit the project website on the EirGrid website[50].

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. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2019.

Castlebagot 220/110 kV Development

Castlebagot 220/110 kV station[51], 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. For the purpose of the 2019 TYTFS analysis, it is expected to be completed in 2020.

Castlebar 110 kV Busbar Uprate

The busbar at Castlebar will be uprated to accommodate increased power flows arising from an increase in wind generation in the area and to allow for refurbishment of key components. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2019.

48 www.eirgridgroup.com/the-grid/projects/dublin-north-fringe/the-project/
49 www.eirgridgroup.com/the-grid/have-your-say/
50 www.eirgridgroup.com/the-grid/projects/capital-project-966/the-project/
51 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. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2019.

Clashavoon – Tarbert 220 kV Uprate

This 220 kV line uprate was approved to evacuate wind power out of the southwest. The line has subsequently been divided into several lines when 220 kV stations were looped into the line. The original line became five lines: Tarbert – Kilpaddoge, Kilpaddoge – Knockanure, Knockanure – Ballynahulla, Ballynahulla – Ballyvouskil, and Ballyvouskil – Clashavoon. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2020.

Coolnabacky – Portlaoise 110 kV Uprate

The 110 kV circuit between Coolnabacky and Portlaoise will be uprated due to higher power flows arising from the introduction of the Coolnabacky 400/110 kV station, once the station has been looped into the existing Athy – Portlaoise 110 kV circuit. The higher flows occur during high renewable generation in the south west flowing towards Dublin. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2020.

Corderry – Srananagh 110 kV Uprate

The 110 kV circuit between Corderry and Srananagh will be uprated to accommodate increased wind generation in the northwest. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2020.

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. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2020.

Darndale 110 kV Station Development

A new 110 kV station will be established at Darndale in North Dublin to accommodate data centre connections. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2019.

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. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2022.

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. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2022.

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. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2022.

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. For the purpose of the 2019 TYTFS analysis, this project is 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. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2025.

Knockanure Station Reactor

A new 50 Mvar reactor will be installed on the 220 kV busbar at Knockanure. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2020.

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. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2021.

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. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2024.

Laois-Kilkenny Reinforcement Project[52]

This project involves a new 400/110 kV station at Coolnabacky near Portlaoise, Co. Laois, with an associated 110 kV circuit to Kilkenny 110 kV station via Ballyragget station. 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. It will also increase capacity in the region.

For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2021.

52 www.eirgridgroup.com/the-grid/projects/laois-kilkenny/the-project/

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. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2023.

Maynooth Station Redevelopment

This project involves refurbishment of the entire 220 kV and 110 kV busbars, reconfiguration of both the 220 kV and 110 kV busbars to an enhanced ring configuration, and an increase in the short circuit rating of both busbars. Series reactors will be incorporated into the 110 kV wing couplers to manage short circuit levels within limits. For the purposes of the 2019 TYTFS analysis, it is expected to be complete in 2025.

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 will comprise a submarine 220 kV cable under the Shannon and a 21 km 220 kV land cable. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2019.

Moy 110 kV Busbar Uprate

The 110 kV busbar in Moy station will be reconfigured and uprated to accommodate power flows related to increases in wind generation in the north west and to allow refurbishment of key components. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2022.

North Connacht 110 kV Reinforcement

This project includes a new 110 kV circuit to facilitate additional renewable generation in Co. Mayo. The North Connacht project is currently progressing through the six-step process for our grid projects. The project is currently in Step 4. For the most up to date information on the project please visit the project website on the EirGrid website[53]. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2024.

North-West Project

The cross-border Renewable Integration Development Project (RIDP)[54] identified that the existing network in the north west of the island is insufficient to accommodate the future wind generation in the area. The North-West project is one element of the original RIDP solution. We are reviewing the need, solutions, technology and timing of this work in line with our six-step process for developing the grid.

Should the North-West Project progress, an investigation of overhead and underground options utilising various technologies will be undertaken.

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 marine cable. A new 400/220 kV 500 MVA transformer will also be required at Kilpaddoge station. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2022.

53 www.eirgridgroup.com/the-grid/projects/north-connacht/the-project/
54 www.eirgridgroup.com/how-the-grid-works/ridp/

(ii) Great Island – Wexford 110 kV Line Uprate

The entire Great Island - Wexford 110 kV line will be uprated. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2019.

(iii) Great Island – Kilkenny 110 kV Line Uprate

The entire Great Island - Kilkenny 110 kV line will be uprated. For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2021.

(iv) Wexford 110 kV Busbar Uprate

For the purpose of the 2019 TYTFS analysis, this project is expected to be completed in 2020.

(v) Dunstown, Moneypoint and Oldstreet Series Compensation

Series capacitors will be installed at Dunstown, Moneypoint and Oldstreet 400 kV stations to compensate the Coolnabacky-Moneypoint, Coolnabacky - Dunstown and Oldstreet-Woodland 400 kV lines. For the purpose of the 2019 TYTFS analysis, these projects are expected to be completed in 2022.

Tievebrack/Ardnagappary 110 kV Development

A 110 kV station will be constructed at Tievebrack, near Glenties in Co. Donegal. This will be looped into the existing Binbane – Letterkenny 110 kV line. New 110/38 kV transformers will be installed at Ardnagappary in Derrybeg and connected via a new 110 kV distribution overhead line to the Tievebrack station. For the purpose of the 2019 TYTFS analysis, this project is assumed to be complete in 2019.

Thornsberry Busbar Uprate

The 110 kV busbar at Thornsberry will be uprated to accommodate increased power flows relating to increases in demand and generation in the midlands. For the purpose of the 2019 TYTFS analysis, this project is 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 ±30 Mvar STATCOM. For the purpose of the 2019 TYTFS analysis, this project is 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 2019).

2.6.1. Grid Development Process

SONI recently updated the Northern Ireland Grid Development Process[55]. This is a three part process which includes stakeholder and public participation (as appropriate) in the development of projects, see Figure 2-4.

55 www.soni.ltd.uk/media/SONIs-Powering-The-Future-Grid-Development-Process-brochure.pdf

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-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 Northern Ireland 2018 - 2027[56] (TDPNI) and draft TDPNI 2019-2028[57].

In addition, following a recent consultation, SONI will shortly publish its 'Tomorrow's Energy Scenarios Northern Ireland' which will outline a range of possible energy futures. These will acknowledge that there is no single pathway to a low carbon future. Following this, we will analyse how the existing and planned transmission grid performs under each of the scenarios over a range of timeframes. The results of this analysis will be published in a system needs assessment report which will be published in due course.

2.6.2. Description of Northern Ireland Development Projects

Donegall Main (North)

The 60 MVA transformer TxB at Donegall North is to be replaced by a new 90 MVA unit. For the purpose of the 2019 TYTFS this work is expected to be complete by summer 2021.

Omagh Main – Dromore restring

With the connection of Drumquin cluster substation to Omagh South it will be necessary to restring the Omagh Main – Dromore tower line with a higher capacity conductor. For the purpose of the 2019 TYTFS analysis, this work is assumed to be complete by 2022.

56 www.soni.ltd.uk/media/documents/SONI-TDPNI-2018_Final.pdf
57 www.soni.ltd.uk/the-grid/projects/tdpni/the-project/

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. For the purpose of the 2019 TYTFS, this work is assumed to be completed by winter 2022.

Ballylumford - Eden 110 kV Circuit Uprate

The conductor on the existing tower line will be replaced and uprated. For the purpose of the 2019 TYTFS, this project is assumed to be complete by winter 2021.

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. For the purpose of the 2019 TYTFS, this project is assumed to be completed by winter 2021. 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 complete, 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. For the purpose of the 2019 TYTFS, this project is assumed to be complete by 2020.

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. For the purpose of the 2019 TYTFS, this project is assumed to be complete 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. For the purpose of the 2019 TYTFS, this work is assumed to be complete 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. For the purpose of the 2019 TYTFS, this project is assumed to be complete by 2024.

Windfarm Clusters Development

(i) Agivey (formerly 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. For the purpose of the 2019 TYTFS, this work is assumed to be complete by winter 2021.

(ii) 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. For the purpose of the 2019 TYTFS, this work is assumed to be complete by 2022.

2.6.3. Projects Not Included in the 2019 TYFTS 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[58].

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 would deliver a more secure and reliable electricity supply throughout the island of Ireland. It would bring about major cost savings and address significant issues around the security of electricity supply. This is particularly the case in Northern Ireland.

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

The North South Interconnector would also allow for greater connection of renewable generation. This would help Ireland and Northern Ireland achieve their renewable energy targets.

For the purpose of the 2019 TYTFS analysis, this project is planned to be completed by winter 2023. 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 2-7 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.

58 www.soni.ltd.uk/the-grid/projects/tdpni/the-project/

Table 2-7: Transmission System Station Development to Facilitate the Connection of Future Generation

Generator	Planned Connection Method	Location
Agivey Cluster	Future Agivey 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
Blundlestown Solar Park	New Blundelstown 110 kV station, connected into the existing Corduff-Mullingar 110 kV circuit.	Ireland
Carrickaduff Wind Farm	New Carrickaduff and Carrickalangan 110 kV stations, connected into Clogher 110 kV station.	Ireland
Carrickalangan Wind Farm		
Carrigdangan Wind Farm (formerly Barnadivane)	New Carrigdangan 110 kV station, connected into Dunmanway 110 kV station.	Ireland
Castletownmoor Wind Farm	New Castletownmoor 110 kV station, connected into Gorman 220/110 kV station.	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
Grousemount Wind Farm	New Coomataggart 110 kV station, connected into Ballyvouskill 220/110 kV station.	Ireland
Harristown Solar Park	New Harristown 110 kV station, connected into the existing Kinnegad-Dunfirth/Rinawade 110 kV circuit.	Ireland

Table 2-7: Transmission System Station Development to Facilitate the Connection of Future Generation

Generator	Planned Connection Method	Location
Lumcloon Battery	New Lumcloon 110 kV station, connected into the existing Portlaoise-Dallow/ Shannonbridge 110 kV circuit.	Ireland
Monatooreen Solar Park	New Monatooreen 110 kV station, connected into Knockraha 220/110 kV station.	Ireland
Muckerstown Solar Park	New Muckerstown 110 kV station, connected into the existing Corduff-Platin 110 kV circuit.	Ireland
Oriel Wind Farm	New Oriel 220 kV station, connected into the existing Louth-Woodland 220 kV circuit.	Ireland
Oweninny Wind Farm 1 & 2	New Srahnakilly 110 kV station, connected into Bellacorick 110 kV station.	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 connecting 110 kV connected customers.

Table 2-8 lists the planned new 110 kV stations connecting the distribution system to the transmission system, for the period covered by this statement. 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.

Table 2-8: Planned Transmission Interface Stations

Station	Code	Transformer Size (MVA)	Nearest Main Town or Load Centre	County
Airport Road	AIR	2 x 90	Belfast	Down
Tievebrack	TIV	n/a	Glenties	Donegal
Ballyragget	BGT	31.5	Ballyragget	Kilkenny
Darndale	DRN	3 x 63	Data Centre	Dublin
New station near Kilbarry	KBY 2	2 x 31.5	Cork	Cork

2.10. Detailed Transmission Network Information

The all-island network schematic diagrams in Appendix A show snapshots of the transmission system at December 2019 and the planned transmission system expected by the end of 2028. The diagrams indicate stations, circuits, transformers, generation, reactive devices and phase shifting transformers.

Figure A-1 in Appendix A presents a geographical map of the all-island transmission system as at the end of 2019. Figure A-2 in Appendix A presents a geographical map of the planned all-island transmission system expected by the end of 2028.

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

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 2019-2028 (GCS)[59] which was published by EirGrid and SONI in September 2019. GCS 2019 contains forecasts of future energy consumption and demand levels between 2019 and 2028.

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 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 2019-2028, 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 2019 peak demand forecast of 6.96 gigawatts (GW) would occur in winter 2019/2020. 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 demand forecast represents an average annual increase in all-island winter peak demand of 2.4% over the period of GCS 2019-2028[60]. This represents an increase in demand forecast since GCS 2018-2027, when the forecast average annual increase in all-island winter peak demand was 2.0%[61].

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

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Northern Ireland (GW)	1.71	1.71	1.72	1.73	1.73	1.75	1.77	1.79	1.81	1.83	1.84
Ireland (GW)	4.94	5.35	5.54	5.71	5.86	6.05	6.17	6.26	6.37	6.47	6.54
All-island (GW)	6.58	6.96	7.16	7.34	7.51	7.71	7.88	8.01	8.13	8.26	8.35

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

59 www.eirgridgroup.com/site-files/library/EirGrid/EirGrid-Group-All-Island-Generation-Capacity-Statement-2019-2028.pdf
60 The cumulative forecast increase in demand over the period of GCS 2019-2028 is 27%.
61 The cumulative forecast increase in demand over the period of GCS 2018-2027 was 22%.

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 May and August. The spring/autumn peak demand refers to the peak demand value expected in the spring and autumn season. The spring/autumn peak occurs between March-April and September-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
Spring/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 2019. 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 Information, Communications and Technology (ICT) industries and high-tech manufacturing companies seeking to connect.

Data Centres

Ireland is an attractive business location and continues to attract world-class investments. Industrial Development Authority (IDA) Ireland has cited access to a high-quality electricity grid as critically important for attracting new investment. This is particularly important in the ICT and high-tech manufacturing sectors.

Some of the world's best known companies have chosen Ireland as the location for their European data centre operations. Factors such as a temperate climate, stable power sources, internet connectivity and a skilled workforce have influenced their decisions. This is emphasised by nine out of the top 10 global software companies and US ICT companies locating strategic business activities in Ireland[62].

At the data freeze date, connected data centres had a combined total power demand of approximately 256 MVA. The total contracted maximum import capacity (MIC) for these sites was 625 MVA. This includes connections to the transmission and distribution systems. In addition to the connected sites, a further 437 MVA of contracts were in place for new data centre connections. Applications were being processed for a further 894 MVA of data centre contracts in the Dublin region. There continues to be ongoing enquiries regarding further large demand connections in the Dublin region.

To put this in context, the current winter peak demand on the all-island transmission system is approximately 6,960 MW. If all applicants currently being processed were to connect, the data centre load would equate to approximately 28% of the current all-island system peak demand.

62 www.idaireland.com/business-in-ireland/industry-sectors/ict/

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 is equivalent to decades of historical natural demand growth. This will have an impact on the all island system demand forecast and generation capacity adequacy. This 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 now under initial investigations and could vary from short lead-time to longer lead-time developments. The impact of these Dublin demand connections are described in greater detail in Chapter 8, Section 8.3.

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 2018 all-island winter peak on 4 December 2018. The individual peaks for Ireland and Northern Ireland did not occur on the same day. Peak demand for Ireland occurred on 4 December 2018, while peak demand occurred in Northern Ireland on 10 January 2018.

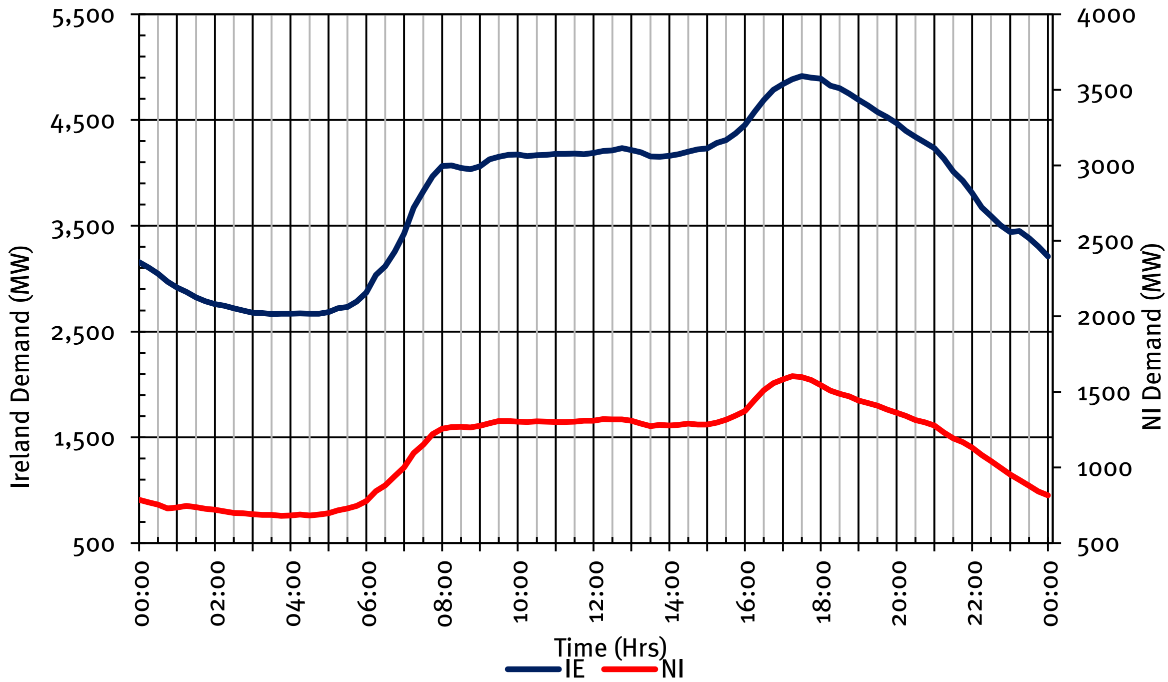


Figure 3-1: Generated Peak Demand Profiles for 2018

3.2.2. All-Island Demand Profiles

Figure 3-2 shows the profiles of the 2018 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.

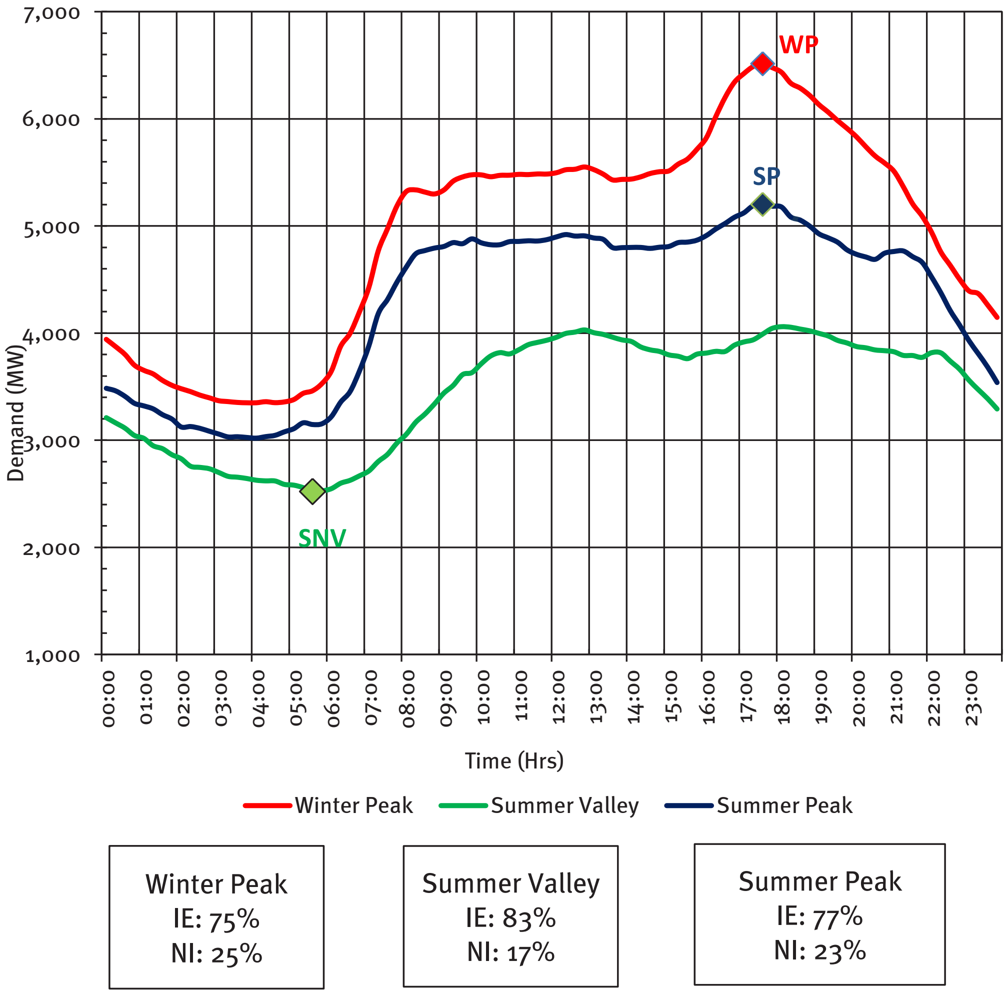


Figure 3-2: All-Island Daily Demand Profiles for Year 2018

Table 3-3: Ireland and Northern Ireland Peak and Minimum Demand, 2018

2018	Ireland		Northern Ireland	
	Date and Time	Demand (MW)	Date and Time	Demand (MW)
Winter Peak	04/12/2018 17:30	4,916	10/01/2018 17:15	1,648
Summer Peak	01/05/2018 17:30	3,996	03/05/2018 17:15	1,223
Minimum Demand	30/07/2018 03:15	2,037	27/05/2018 05:30	437

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 roof top 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 2018.

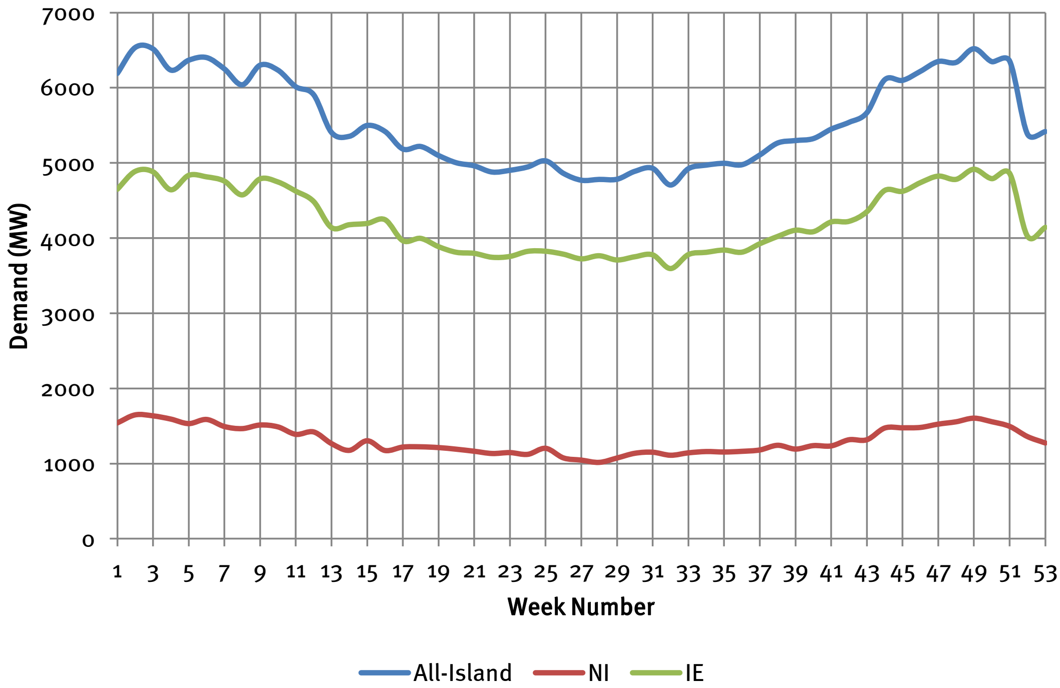


Figure 3-3: Weekly Demand Peak Values for Year 2018

3.2.4. Load Duration Curves

Figures 3-4 and 3-5 show the Ireland and Northern Ireland 2018 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 67% of the year in Ireland. Demand in Northern Ireland exceeded 1,000 MW for 40% of the year.

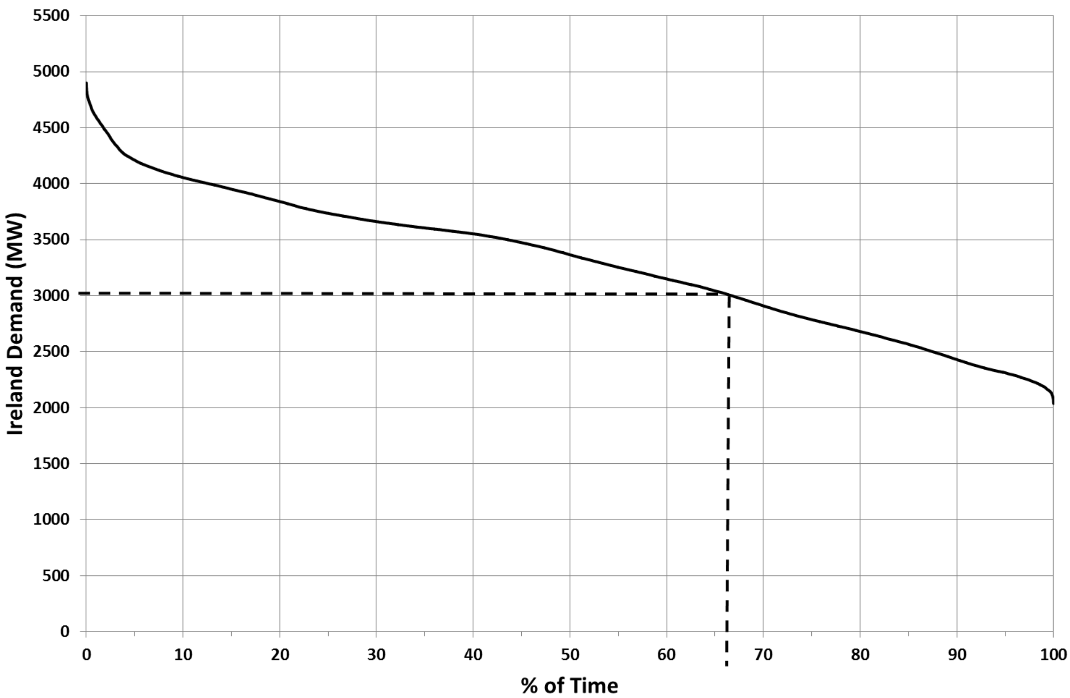


Figure 3-4: Ireland Load Duration Curve 2018

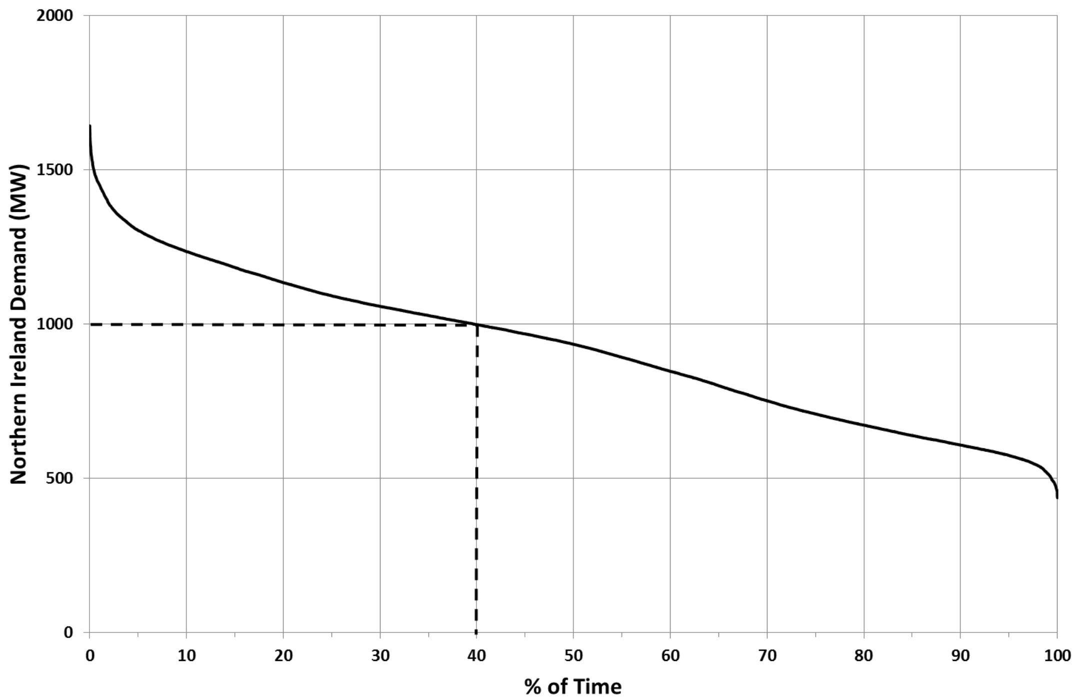


Figure 3-5: Northern Ireland Load Duration Curve 2018

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 at 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 220/110 kV 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 2019-2028. Demand projections at individual transmission stations are developed from the system demand forecasts on a top-down[63] 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 of planned transfers of demand between stations, as agreed with ESB Networks[64]. 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 for the small number of directly-connected customers are the current best estimates of requirements. 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. However, when analysing the capacity for new demand in a particular area, the MIC values of local directly-connected customers are assumed. These values are assumed to ensure that the contracted MIC is preserved.

63 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.
64 ESB Networks is the Distribution System Operator (DSO) in Ireland.

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.

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

The 110/33 kV BSP demand forecasts are provided by NIE Networks[65]. These forecasts are based on demand trends at an individual nodal level and adjusted to align with system average cold spell (ACS[66]) 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.

65 NIE Networks is the DSO in Northern Ireland.
66 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

4. Generation

This chapter gives information about existing generation capacity. This chapter also defines future projections for the next ten years from 2019 to 2028. 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 Ireland, renewable energy policy is driven by a binding European legal requirement. The requirement is for 16% of the country's total energy consumption to be met by renewable energy sources (RES) by 2020. The Irish Government aims to achieve this overall requirement by targeting 40% renewable electricity, 12% renewable heat and 10% renewable transport. As noted in All-Island Generation Capacity Statement 2019-2028, between 3,900 - 4,400 MW of on-shore wind generation will be needed to meet the renewable electricity target. Other renewable energy sources, including hydro generation, solar, bio-energy and renewable Combined Heat and Power (CHP) energy production, will also contribute to meeting the renewable electricity target.

In addition, in June 2019 the Irish Government launched its Climate Action Plan 2019. The Action Plan sets out an ambitious course of action over the coming years. Specifically for the electricity sector it sets a target that 70% of our 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.

The Strategic Energy Framework (SEF)[67] 2010 for Northern Ireland sets the renewable energy policy in Northern Ireland. It states that 40% of electricity consumption in Northern Ireland should come from renewable sources by the year 2020.

Indeed, this target has been met ahead of schedule. The statistical report 'Electricity Consumption and Renewable Generation in Northern Ireland: Year Ending June 2019', published by the Northern Ireland Statistics and Research Agency (NISRA) in September 2019, confirmed that 44% of all electricity consumed for the 12 month period ending 30 June 2019 was generated from renewables. The statistical report and the Department for the Economy's (DfE) annoucement that the target has been met are available on the Department's website[68].

SONI, along with NIE Networks, have worked to facilitate the connection of the renewable generation required to meet the 40% target. The government target translates into approximately 1,600 MW of renewable generation capacity in Northern Ireland[69].

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

Energy Policy is a devolved matter for Northern Ireland and the DfE is currently working with stakeholders to develop the next Strategic Energy Framework for Northern Ireland. SONI is providing input to this important work, which will inform future renewable targets and the approach to facilitating growth in renewable electricity generation.

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 2019 is January 2019.

67 www.economy-ni.gov.uk/articles/strategic-energy-framework-2010
68 www.economy-ni.gov.uk/news/40-electricity-consumption-renewable-sources-by-2020-achieved-ahead-schedule
www.economy-ni.gov.uk/articles/electricity-consumption-and-renewable-generation-statistics
69 This is approximately equal to the currently installed level of large scale and small scale renewable generation in Northern Ireland.

4.1. Generation in Ireland

At the data freeze date 12,150 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)
9,915[70]	2,235	12,150

4.1.1. Existing and Planned Transmission Connected Generation

Table 4-2 lists planned generators that have executed transmission connection agreements, along with their expected energisation dates if they were available at the data freeze date. We regularly publish information on transmission connected and contracted generation on our website[71].

Table 4-2: Contracted Transmission Generation

Generator	Generation Type	Generation Capacity (MW)	Expected Energisation Date
Ardderoo (formerly Buffy)	Wind	91	2019
Beenanaspock and Tobertooreen Wind Farm	Wind	34	Date unavailable[72]
Ballinknockane	Solar	50	Date unavailable[72]
Banemore	Solar	34	Date unavailable[72]
Blundlestown	Solar	80	Date unavailable[72]
Carrickaduff	Wind	66	Date unavailable[72]
Carrickalangan	Wind	72	Date unavailable[72]
Carrigdangan (formerly Barnadivane)	Wind	60	2019
Castletownmoor	Wind	120	Date unavailable[72]
Drombeg	Solar	50	Date unavailable[72]
Gallanstown	Solar	85	Date unavailable[72]
Grousemount	Wind	114	Date unavailable[72]
Harristown	Solar	42	Date unavailable[72]
Kelwin Phase 2	Battery	20	Date unavailable[72]
Knocknamona	Wind	34	2019
Loughteague	Solar	55	Date unavailable[72]
Lumcloon	Battery	100	Date unavailable[72]
Monatooreen	Solar	26	Date unavailable[72]
Muckerstown	Solar	34	Date unavailable[72]

70 Please note this figure does not include the East West Interconnector.
71 www.eirgridgroup.com/customer-and-industry/general-customer-information/connected-and-contracted-generators/
72 At the date of the data freeze (January 2019), this generation project did not have an estimated energisation date available. For the purposes of our analyses, we assumed that this project will connect over the period of this TYTFS.

Table 4-2: Contracted Transmission Generation

Generator	Generation Type	Generation Capacity (MW)	Expected Energisation Date
Oriel	Wind	210	Date unavailable[72]
Oweninny Power 1	Wind	89	2019
Oweninny Power 2	Wind	83	2019
Oweninny 3	Wind	50	Date unavailable[72]
Rosspile	Solar	95	Date unavailable[72]
Shannonbridge A	Battery	100	Date unavailable[72]
Shannonbridge B	Battery	97	Date unavailable[72]
Shantallow	Solar	35	Date unavailable[72]
Timahoe North	Solar	70	Date unavailable[72]
Tullabeg	Solar	50	Date unavailable[72]

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 All-Island Generation Capacity Statement 2019-2028 (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
Aghada AT1	90	2023
Tarbert 1, 2, 3, 4	590	2023
Moneypoint 1,2,3	855	2025

In addition, in November 2019, ESB announced that two peat-powered generating plants will stop generating electricity at the end of December 2020. The plants are located at Shannonbridge in Offaly and Lanesboro in Longford. These two closures will be captured in the next TYTFS.

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. Although there is currently very little solar generation connected, solar connections are expected to increase significantly over the course of this TYTFS. The expected growth in wind and solar generation is displayed in Figure 4-1. The information presented in Figure 4-1 is a combination of connected and contracted wind and solar generation[73].

73 Detailed information on these figures is presented in Tables D-1, D-2 and D-3 in Appendix D.

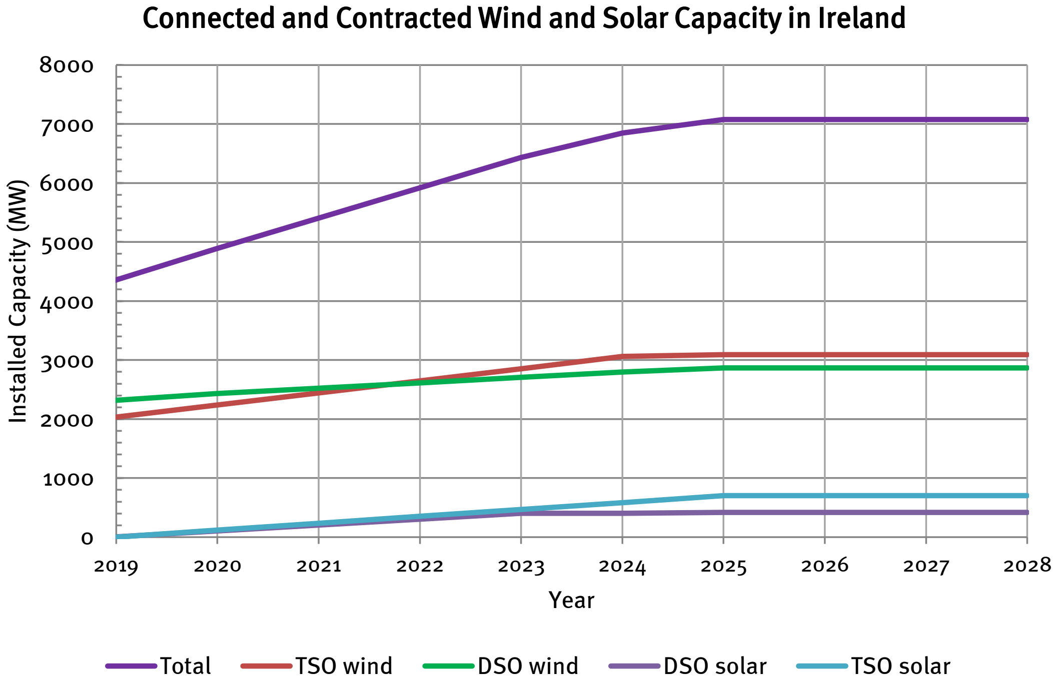


Figure 4-1: Connected and Contracted Wind and Solar Capacity, 2019 to 2028

Table 4-4 shows the existing and committed wind and solar generation capacity totals expected to be connected by the end of each year[74]. 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 2020 onwards.

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

Connection	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Wind (Transmission)	2,034	2,239	2,444	2,649	2,854	3,059	3,093	3,093	3,093	3,093
Wind (Distribution)	2,320	2,431	2,523	2,615	2,707	2,799	2,866	2,866	2,866	2,866
Solar (Transmission)	0	117	234	351	468	585	702	702	702	702
Solar (Distribution)	4	104	204	304	404	404	417	417	417	417
Total	**4,358**	**4,891**	**5,405**	**5,919**	**6,433**	**6,847**	**7,078**	**7,078**	**7,078**	**7,078**

4.1.4. Offshore Generation

There is one offshore generation unit in Ireland, i.e. a 25 MW offshore wind farm at Arklow bank.

In February 2014, the Irish Government published an Offshore Renewable Energy Development Plan (OREDP)[75]. The plan was reviewed in May 2018. The aim of this work is to implement a framework for the sustainable development of offshore renewable generation in Ireland. The OREDP identifies three high level goals:

1. That Ireland harnesses the market opportunities presented by offshore renewable energy to achieve economic development, growth and jobs;
2. To increase awareness of the value, opportunities and societal benefits of developing offshore renewable energy; and
3. That offshore renewable energy development does not adversely impact our rich marine environment and its living and non-living resources.

74 The individual generator details are included in Tables D-1, D-2 and D-3 in Appendix D. These figures are either the currently installed capacity or the Maximum Export Capacity (MEC), whichever is higher.
75 www.dcenr.gov.ie/energy/en-ie/Renewable-Energy/Pages/OREDP-Landing-Page.aspx

The OREDP will also provide a structure through which Ireland can input to the development of the:

- European Blue Energy Strategy; and
- US/Ireland Memorandum of Understanding (MoU) on Ocean Energy.

The Department of Communications, Climate Action and Environment (DCCAE) is leading the implementation of OREDP. It has developed a robust governance structure to deliver on the aims of the plan. EirGrid is a member of the steering group and participates on a number of OREDP working groups.

In order to meet the Climate Action Plan target that 70% of our electricity will come from renewable energy sources by 2030, investment will be needed in new renewable generation capacity. It is expected that offshore wind will be a significant part of the renewable generation mix in the future.

4.1.5. Demand Side Units

As at the data freeze date, nine demand side units (DSU) had entered the Single Electricity Market in Ireland. These DSUs have a combined dispatchable capacity of 433 MW.

4.1.6. Embedded Generation

Table 4-5 below details the amount of embedded generation plant as at the data freeze date. This includes plant connected to the distribution system or to the system of a directly-connected demand customer. This figure comprises of small conventional and renewable units. Conventional units include CHP schemes and small industrial thermal units.

Renewable generation included in this figure consists of:

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

Table 4-5 details the existing embedded generation capacity by generation type.

Table 4-5: Existing Embedded Generation in Ireland

	Wind[76]	Small Hydro	Biomass/ LFG	CHP	Diesel	Solar	Total
Net Capacity (MW)	1,969	26	76	150	14	<1	2,235

Embedded 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 embedded generators[77].

76 Table D-2 in Appendix D provides details of the existing embedded wind farms and their capacities.
77 Because of the variability of wind, a fixed contribution from embedded 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.

4.2. Generation in Northern Ireland

At the data freeze date 3,842 MW of generation capacity was installed in Northern Ireland, as detailed in Table 4-6.

Table 4-6: Northern Ireland Installed Generation Capacity

Transmission System Connected (MW)	Distribution System Connected (MW)	Total Generation Capacity (MW)
2,226[78]	1,616[79]	3,842

The 2,226 MW 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, until September 2018, conventional thermal generation plant were 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).

There was a total of 593 MW of plant contracted to PPB under pre-vesting contracts, or contracts negotiated thereafter. Since September 2018, all conventional generation in Northern Ireland have been Independent Market Participants.

4.2.2. Planned Retirement/Divestiture of Generation

The generation output of Kilroot ST1 and ST2 is anticipated to be restricted. The restriction is due to the Industrial Emissions Directive (IED)[80]. The restriction includes limited emissions each year from 2016-2020, followed by severely restricted running hours from 2021-2022. As noted in GCS 2019 Kilroot ST1 and ST2 are assumed unavailable after 2024.

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[81] on:

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

78 Please note this figure does not include the Moyle Interconnector capacity.
79 This figure includes Demand Side Units (DSUs).
80 http://ec.europa.eu/environment/industry/stationary/ied/legislation.htm
81 As at data freeze date – January 2019

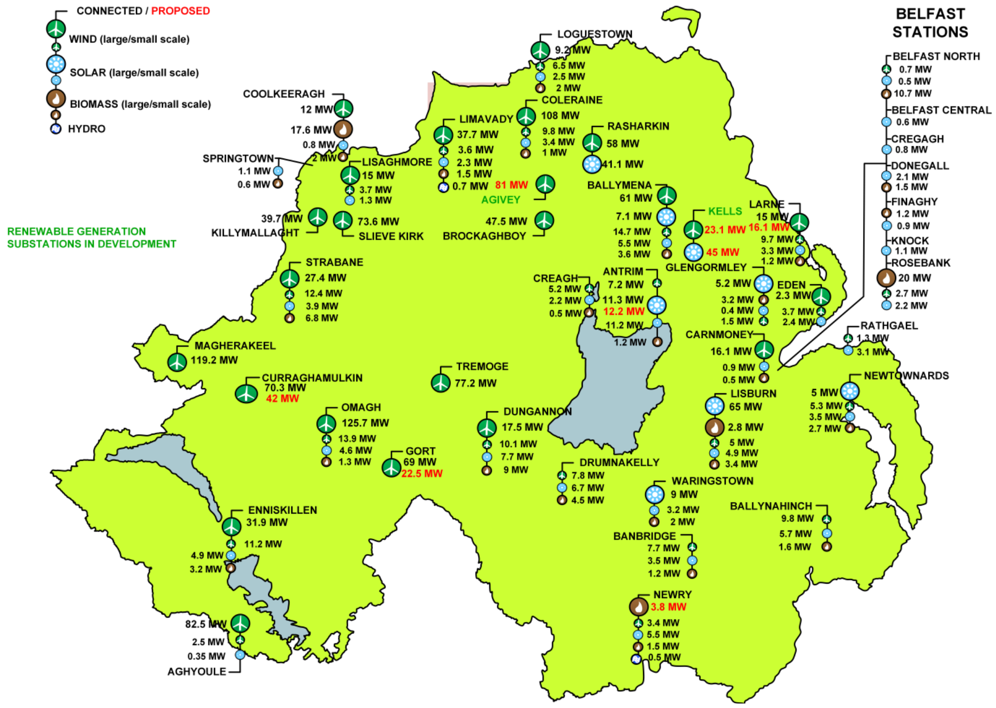


Figure 4-2: Existing and Committed Northern Ireland Renewable Generation (installed capacity greater than 0.5 MW)

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 (BSPs) and 110/33 kV Cluster substations[82].

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

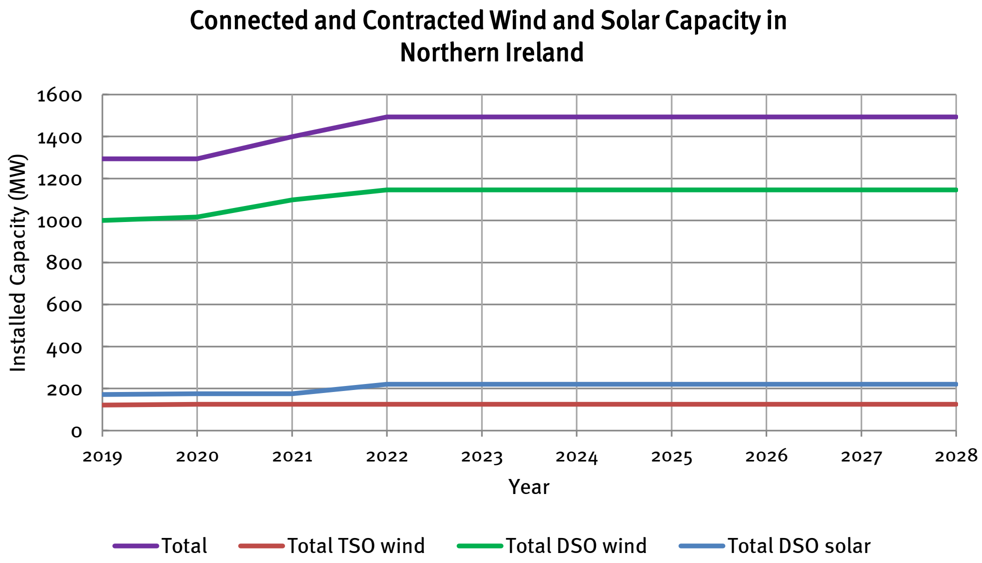


Figure 4-3: Connected and Contracted Wind and Solar Capacity in Northern Ireland, 2019 to 2028

Table 4-7 shows the existing and committed wind and solar generation capacity totals expected to be connected by the end of each year[83]. These wind farms have signed connection agreements and are committed to connecting to either the transmission or distribution system over the next few years.

82 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': www.nienetworks.co.uk/statementofcharges

83 The individual generator details are included in Tables D-1, D-2 and D-4 in Appendix D. These figures are either the currently installed capacity or the Maximum Export Capacity (MEC), whichever is higher.

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

Connection	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Wind (Transmission)	121	121	121	121	121	121	121	121	121	121
Wind (Distribution)	1,001	1,017	1,098	1,146	1,146	1,146	1,146	1,146	1,146	1,146
Solar (Distribution)	171	176	176	221	221	221	221	221	221	221
Total	**1,293**	**1,314**	**1,395**	**1,488**	**1,488**	**1,488**	**1,488**	**1,488**	**1,488**	**1,488**

Offshore Renewable Generation

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

For the purpose of TYTFS analyses we assume that by 2028 there will not be any offshore wind connected. However, development rights are in place for tidal sites in Northern Ireland's coastal waters.

4.2.4. Demand Side Units

As at the data freeze date, in Northern Ireland five demand side units (DSU) had entered the Single Electricity Market. These DSUs have a combined dispatchable capacity of 91 MW.

4.2.5. Embedded Generation

Existing Embedded Generation

Table 4-8 shows a breakdown of the existing Northern Ireland embedded generation.

Table 4-8: Northern Ireland Embedded Generation

Generation	Net Capacity (MW)
Large Scale Wind	983
Small Scale Wind	173
Large Scale Biomass	22
Small Scale Biomass, CHP and Landfill Gas	64
Large Scale Solar	144
Small Scale Solar	105
Small Scale Hydro	6
Large Scale Landfill Gas	3
CHP	42
AGU	74 (86)[84]
Total	**1,616**

There is a total of 86 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.

84 There is 86 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 74 MW of AGU capacity is included in the total figure.

5. Transmission System Performance

5. Transmission System Performance

This chapter describes the future performance of the transmission system in terms of compliance with planning standards[85]. System performance levels are assessed using:

- Forecast power flows; and
- Short circuit[86] 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 2019.

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[87] 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[88]. Power flows across the existing 275 kV and planned 400 kV internal[89] 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 and reactive power on the transmission system under normal conditions.

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.

85 Please note that different planning standards are applied in Ireland and Northern Ireland.
86 Short circuit analysis was carried out on both the Ireland and Northern Ireland transmission systems.
87 Projected levels of renewable generation connections are detailed in Appendix D.
88 This is reflective of how generation is dispatched in the Single Electricity Market.
89 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.

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[90]) documents. These standards are in line with international standards.

The standards are deterministic[91] – 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[92]). 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 2019 includes transmission system development projects that have received capital approval. Details of these projects can be found in Chapter 2 and in the TDP.

5.2.2. Northern Ireland

The Northern Ireland transmission projects included in TYTFS 2019 are based on the Transmission Development Plan Northern Ireland (TDPNI[93]). 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[94] 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 2019 includes transmission system development projects that have received capital approval. Details of these projects can be found in Chapter 2 and in the TDPNI.

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90 The Irish transmission system is developed in accordance with the TSSPS Ireland: 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: www.soni.ltd.uk/media/Northern-Ireland-TSSPS-September-2015.pdf
91 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.
92 The latest version of the Transmission Development Plan for Ireland is available at www.eirgridgroup.com.
93 The latest version of TDPNI is available at www.soni.ltd.uk.
94 Devices used to control, protect and isolate electrical equipment.

5.3. Short Circuit Current Levels[95]

Short circuit currents[96] 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	40
	Designated sites	31.5	

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[97] 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[98]. 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 2019, 2022 and 2025, 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.

95 Short circuit currents are also known as "fault levels".
96 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.
97 This means stations that are electrically nearby, which does not necessarily mean those geographically closest.
98 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.

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.

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 (Ik’) and subtransient AC (Ik’’) 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.4.3. 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 (ip); and
- RMS Break Current (IB).

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

The IB 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 Northern Ireland transmission nodes have short circuit current levels close to their current rated capability. Careful management of these issues is needed to ensure levels remain within their current rated capability.

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.

Figure 5-1 indicates the locations where short circuit current levels are high in 2025. In Ireland the short circuit current level results are represented as a percentage of the levels specified in the Grid Code as follows:

- 25 kA on the 110 kV system generally – this is the countrywide rating noted in Table 5-1;
- 40 kA on the 220 kV system; and
- 50 kA on the 400 kV system.

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.

Figure 5-1: Short Circuit Current Levels for Winter Peak 2025

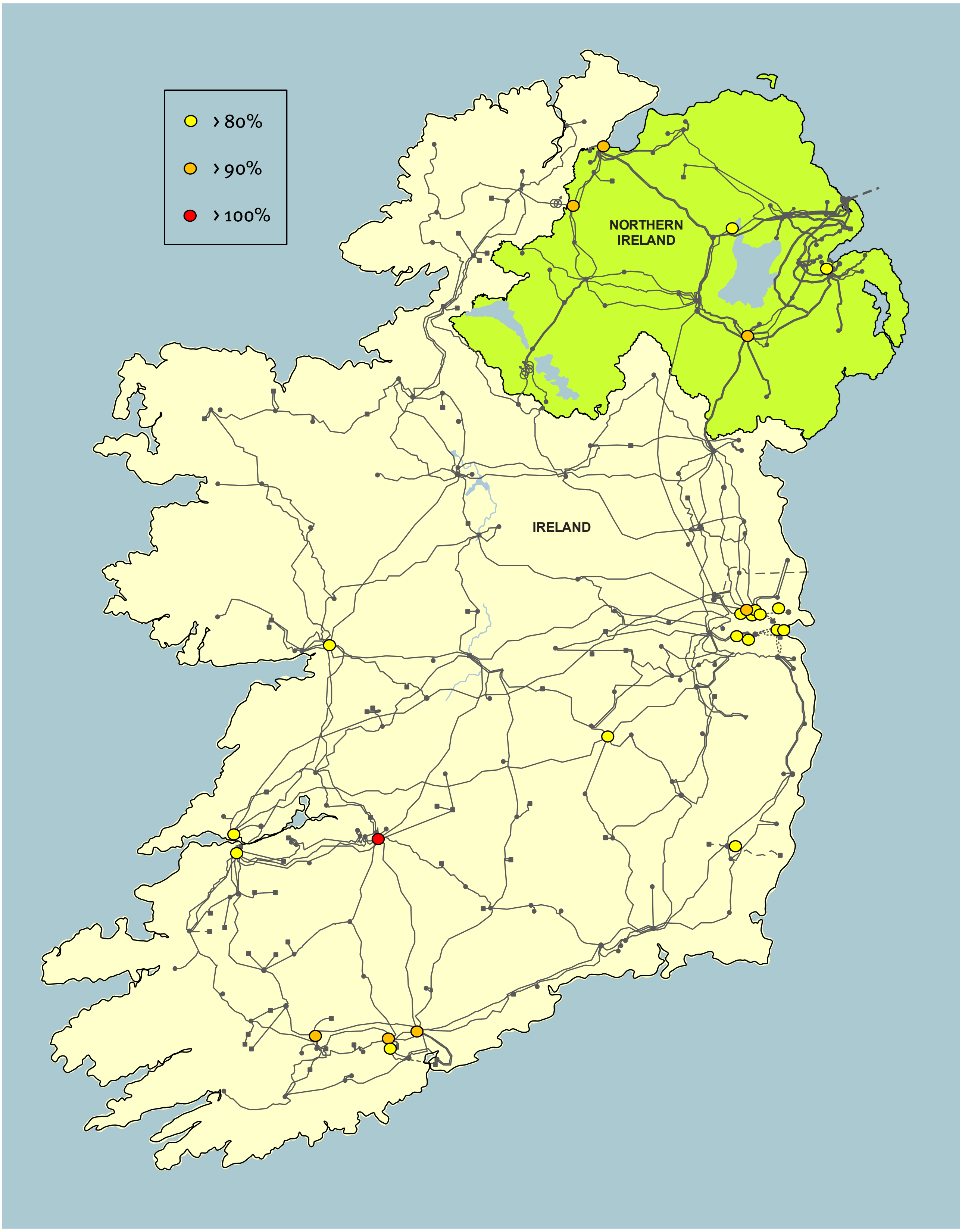

Table 5-2 below provides information on the transmission nodes for 2019; 2022; and 2025 where the short circuit current level is above 90% of the relevant level[99].

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

Rating (%)	2019	2022	2025
>100	BPS 110 kV	KLN 110 kV	KLN 110 kV
>90	KBY 110 kV	CDU 110 kV	CDU 110 kV
	KLN 110 kV	CLA 110 kV	CLA 110 kV
	KRA 110 kV	KBY 110 kV	CPS 110 kV
	STR 110 kV	KRA 110 kV	KBY 110 kV
			KRA 110 kV
			TAN 110 kV

Stations Where the Rating Has Been Exceeded

Ireland Transmission Stations Where the Rating Has Been Exceeded

i. Killonan 110 kV (KLN 110 kV)

Studies indicated that the short circuit current level at Killonan 110 kV station may exceed 100% of the level specified in the Grid Code for the 110 kV system, i.e. 25 kA.

The existing 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 level remains within safety standards.

Northern Ireland Stations Where the Rating Has Been Exceeded

i. Ballylumford 110 kV

Short circuit current levels 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 2021. 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 commutate[100]. However, as shown in Appendix E, this is not an issue over the period covered by this TYTFS.

99 In Ireland these results are presented as a percentage of the short circuit current levels specified in the Grid Code which are 25 kA on the 110 kV system, 40 kA on the 220 kV system and 50 kA on the 400 kV system. 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.
100 Commutation is the process of reversing the direction of electric current. It is commonly used when turning alternating current to a direct current.

6. Overview of Transmission System Capability Analyses

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[101] provide the basis for the statements of opportunity[102] 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, 2025. 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 2025/2026.

In Northern Ireland the demand opportunity analysis provides an indication of capability of the backbone[103] 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.

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.

101 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.
102 Information on how to become a customer can be accessed at the EirGrid and SONI websites as follows
www.eirgridgroup.com/customer-and-industry/becoming-a-customer/
www.soni.ltd.uk/customer-and-industry/becoming-a-customer/
103 The backbone transmission system connects local area networks together, enabling the efficient bulk transfer of electricity around the country and beyond.

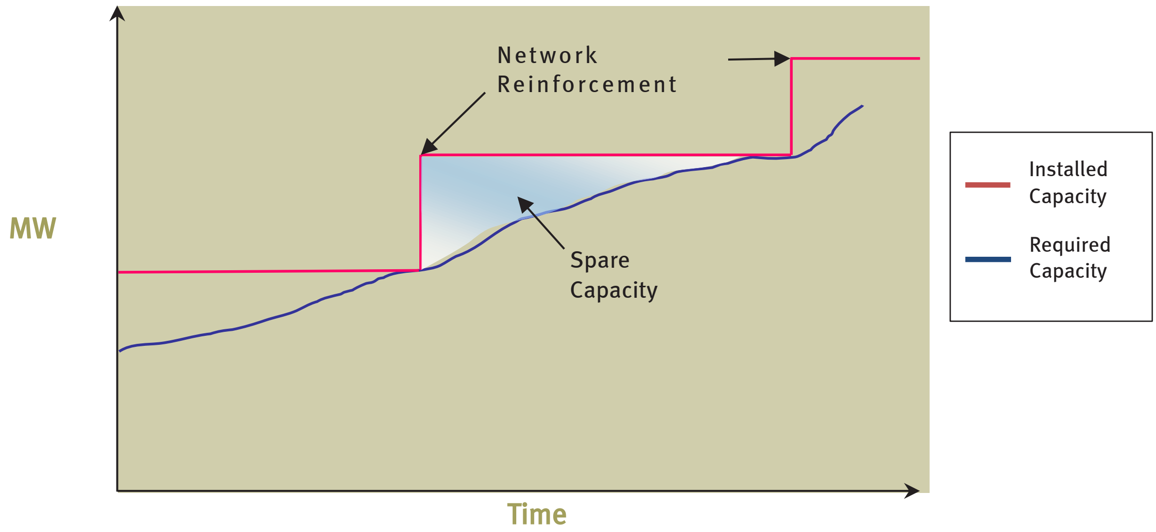

Figure 6-1: Illustration of Typical Step Change in System Capacity Due to the Addition of Transmission System Infrastructure

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.

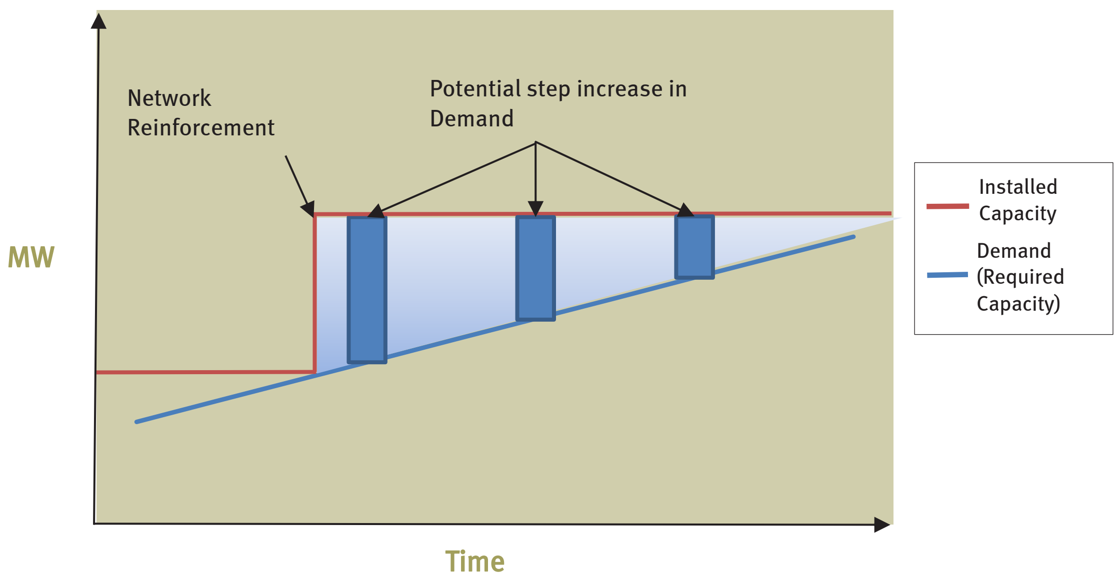

Figure 6-2: Forecast Demand Profile of a Typical Station and Station Potential to Accommodate Additional Step Increase in Demand

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)[104] 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)[105] 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.

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.

What is a load flow?
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.
What is a linear algorithm?
A linear algorithm uses an iterative 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 2025.

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[106].

104 www.eirgridgroup.com/site-files/library/EirGrid/EirGrid-Transmission-System-Security-and-Planning-Standards-TSSPS-Final-May-2016-APPROVED.pdf
105 www.soni.ltd.uk/media/Northern-Ireland-TSSPS-September-2015.pdf
106 As renewable generation is classified as an intermittent energy source, it cannot be relied upon to serve demand.

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[107].

To calculate the opportunity, demand at 0.90 power factor is added to a test station in increasing amounts. This is balanced by an increase in generation[108] outside the local test area. This is illustrated in Figure 6-3 below.

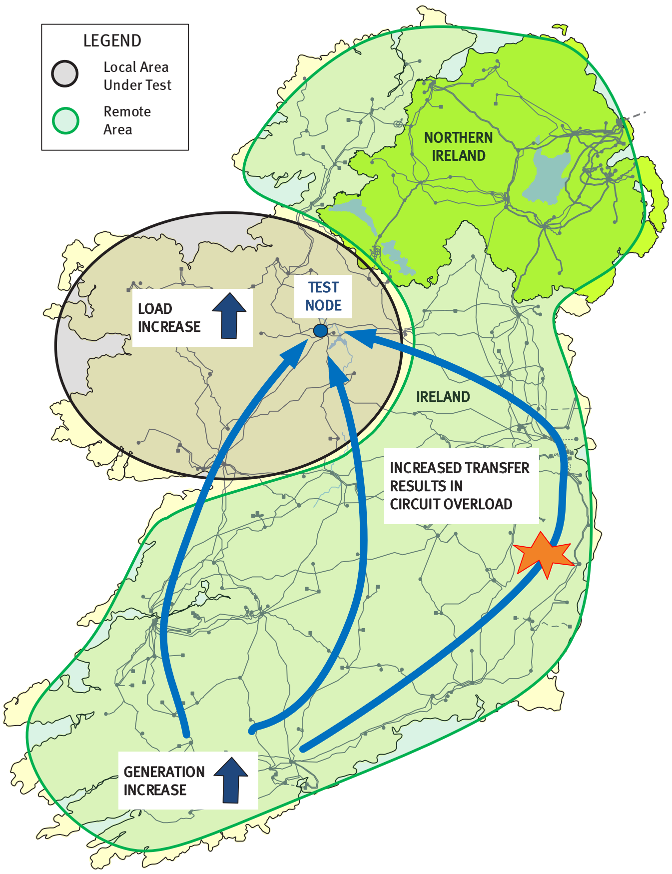

Figure 6-3: Illustration of Incremental Transfer Capability Study Method for Demand

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.

107 This is implemented to create a more favourable dispatch for the maintenance case.
108 Generation increased as per merit order.

Potential demand customers should not be discouraged by choosing a site in which there appears to be a lack of transmission system capacity. 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. If all of these enquiries were to materialise and connect, the maximum demand of Dublin could double in a relatively small amount of time (see Chapter 3 Demand).

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[109].

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 2025. 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. 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.

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 2019-2028 (GCS) which is available on the EirGrid and SONI websites.

109 These main bulk supply points act as the transmission to distribution interfaces in the region.

The analysis tested 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.

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[110].

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, 2028, 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. The methodology is described in Section 6.2.1.

We have included information on the harmonised all-island Transmission Use of System (TUoS) charge and Transmission Loss Adjustment Factor (TLAF) arrangements in SEM in this TYTFS. 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[111].

We describe the changing connection capacity locations, the impact on network power flows and the resulting effect on TUoS charges and TLAFs. These TUoS and TLAF values have an impact on power generation costs.

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. Connection applications are required to follow the connection offer process.

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.

110 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.
111 This is not the only objective of the charges and losses arrangements in SEM.

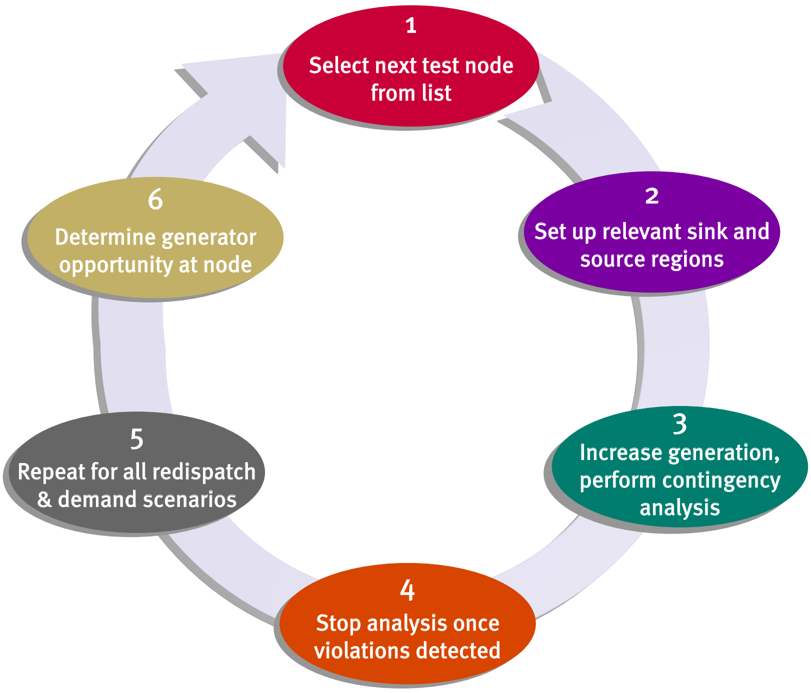

Figure 6-4: Generator Opportunities Analysis Methodology

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.

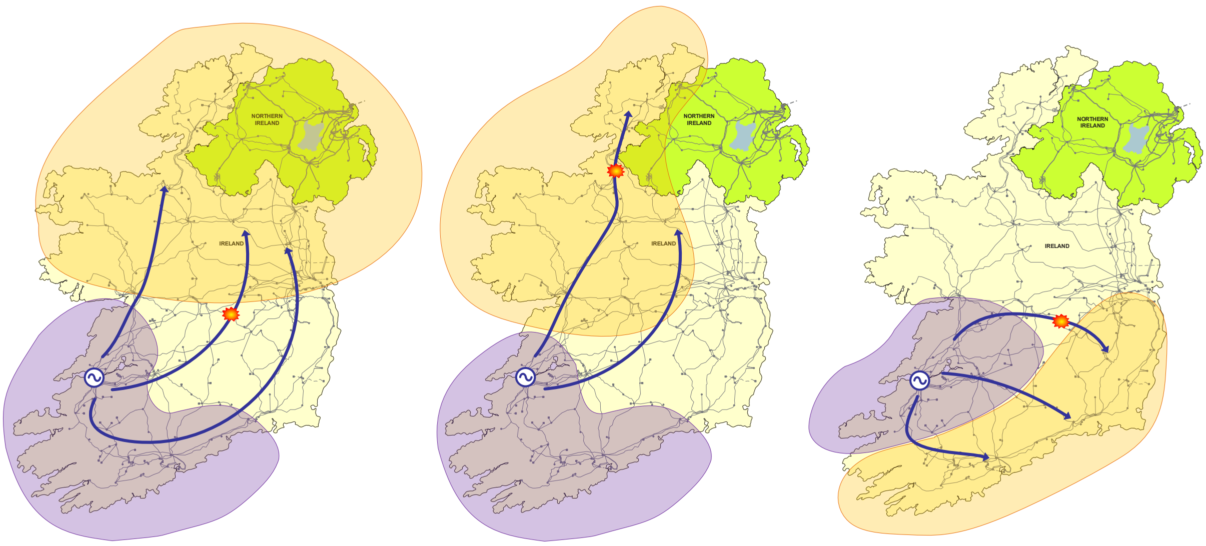

Figure 6-5: Illustration of Incremental Transfer Capability Study Method for Generation

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[112] 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.

112 The results are presented in Chapter 7 and Chapter 8.


20

7. Transmission System Capability for New Generation

7. Transmission System Capability for New Generation

7.1. Summary of analysis

The results of the generation opportunity analysis for this statement are broadly similar to those from the previous statement. With significant quantities of renewable generation connected across the island, there is little to no opportunity for additional generation in northern and western parts of the all-island transmission network.

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. Nodes in the south-eastern part of the all-island network also show capability for additional generation.

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 – 2028 – and details the opportunity for connecting further generation beyond the assumed installed generation portfolio. The results provide potential network users with a guide to the ability of the all-island transmission system to accept new generation. It must be stressed that this analysis is indicative only; the actual transmission network capacity can only be determined during the connection offer process. This process requires detailed network assessments to determine the optimal connection arrangement that complies with the Transmission System Security and Planning Standards (TSSPS) in Ireland and Northern Ireland.

EirGrid has completed a separate East Coast Generation Opportunity Assessment study which provides information on the capacity available for new generation on the east coast and also the available space in existing substations for new connections. The East Coast assessment methodology is different and more bespoke than the TYTFS generation opportunity methodology. The East Coast assessment incorporates different dispatch rules, for example priority dispatch in the case of wind. The East Coast assessment could be considered an indication of the capacity available in the local or directly adjacent transmission network. The methodology is described in greater detail in the East Coast Generation Opportunity Assessment report which is available on the EirGrid website[113].

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

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 2019 there was about 4,900 MW connected to the all-island transmission system. Depending on project completion rates this all-island figure could increase to approximately 7,200 MW of wind generation capacity over the period of this statement (see Chapter 4).

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.

113 www.eirgridgroup.com/site-files/library/EirGrid/East-Coast-Generation-Opportunity-Assessment.pdf

In contrast there are a number of 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 2019-2028[114] and noted in Chapter 4 of this document.

7.4. Generation Opportunity

7.4.1. At 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 2028. For these high voltage stations, new generation of up to 550 MW in size was considered for assessment. Figure 7-1 illustrates the stations selected across the all-island network, and their resultant 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.

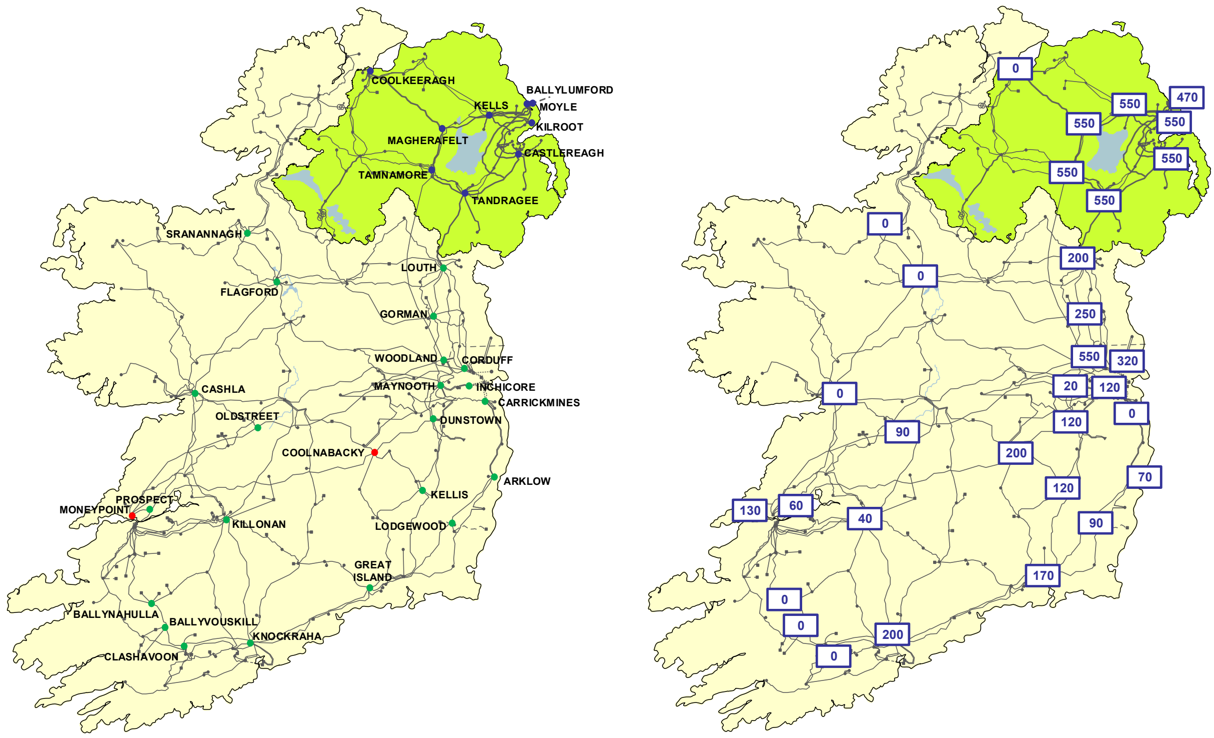

Figure 7-1: Generation opportunity at 220 kV, 275 kV and 400 kV stations in 2028

In general, there is no opportunity for new generation in the North and West of Ireland, and very limited opportunity in the South-West of Ireland. The transmission network in these areas is mainly comprised of 110 kV circuits; these areas also have significant levels of connected and planned renewable generation. As a result, there is little to no additional capacity available. The only exception is the area around Moneypoint, located close to the 400 kV network. In the East and South East regions, there is increased opportunity for new generation, being located closer to 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.

Similar to Ireland, this area has significant levels of renewable generation, both connected and planned, and the transmission network is almost entirely comprised of 110 kV circuits. However, there is significant opportunity on the 275 kV network towards the South and East, with in excess of 500 MW of capability at many of the nodes on the 275 kV network.

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

7.4.2. At Selected 110 kV Stations

A number of 110 kV stations were also 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 for assessment. The stations, and their resultant generation opportunity, are displayed in Figure 7-2.

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.

As expected, there is very little opportunity for generation connection at 110 kV. By 2028 in Ireland, there is a high level of renewable generation connected to both the transmission and distribution systems. This is concentrated in the North-West, West and South-West, and the installed capacities exceed the demand in these areas. As a result, there is little to no opportunity available anywhere in those areas.

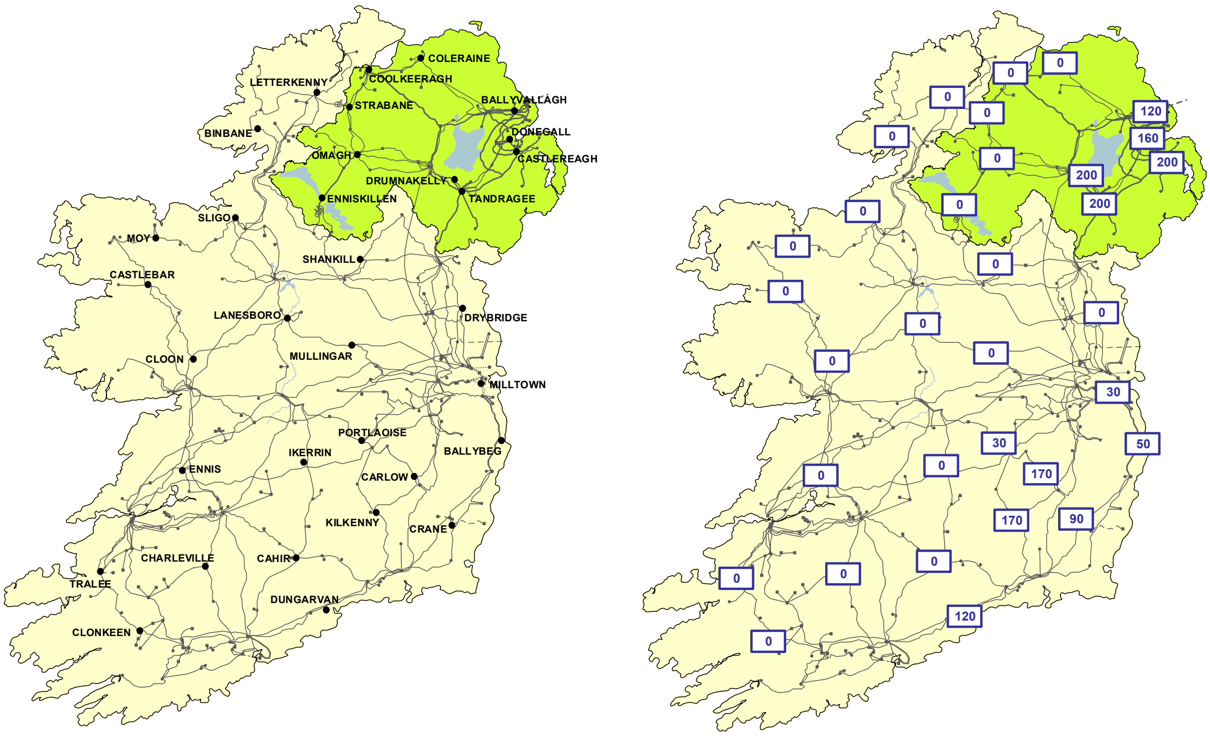

Figure 7-2: Generation opportunity at 110 kV stations in 2028

Towards the South-East and East of Ireland, there is opportunity available at 110 kV nodes. The largest demand centres are located in these areas, and the transmission network is stronger. Additionally, renewable generation penetration is lower in these areas. Connection studies would be required to determine the available capacity and connection arrangements.

Not dissimilar to Ireland, Northern Ireland is connecting high levels of renewable generation, with more planning to connect to the transmission and distribution systems by 2028. This generation in the North and West of Northern Ireland is greater than local demand and causes congestion on the transmission network.

In the East of Northern Ireland, opportunities for generation connection are possible, with a less congested transmission network and higher demand density. Again, detailed connection studies would be required to determine the available capacity and connection arrangements.

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 we use to calculate the TLAFs has been approved by the regulatory authorities[115].

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 contain 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 2019/20 TLAF values are shown in Figure 7-3, and are based on the published approved 2019/20 TLAF values.

115 www.eirgridgroup.com/site-files/library/EirGrid/TLAF-Methodology-Explanatory-Paper-v1.0.pdf

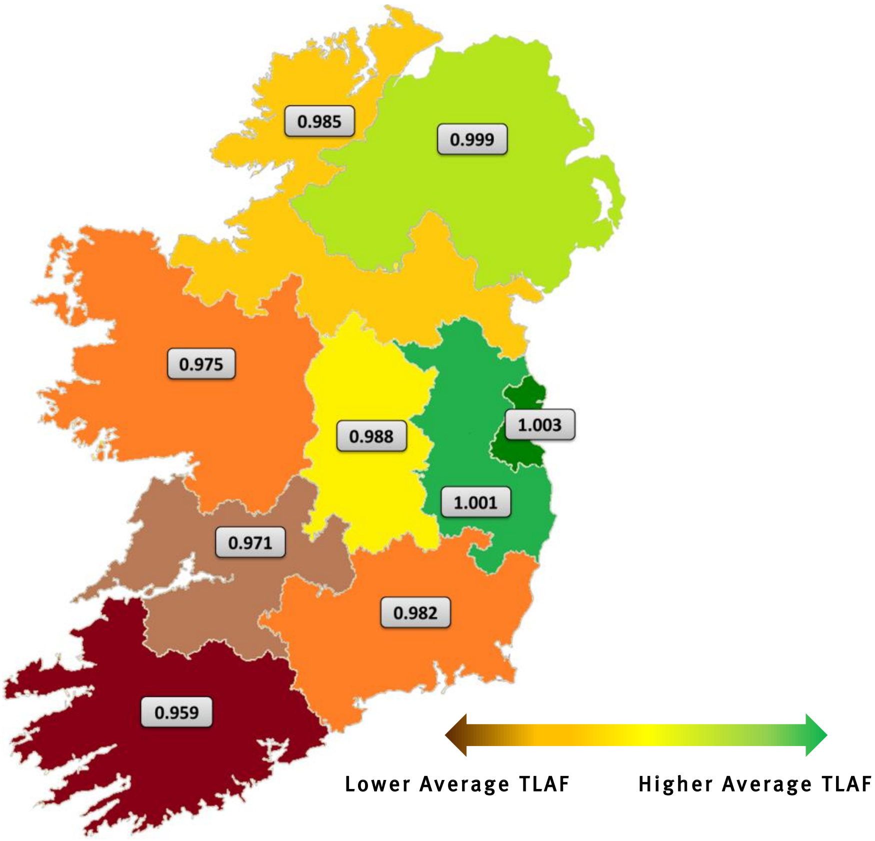

Figure 7-3: All-island 2019/20 regional average TLAF values

Figure 7-4 shows the percentage change in TLAFs between 2018/19 and 2019/20. These changes are influenced by yearly dispatch, demand and topology changes.

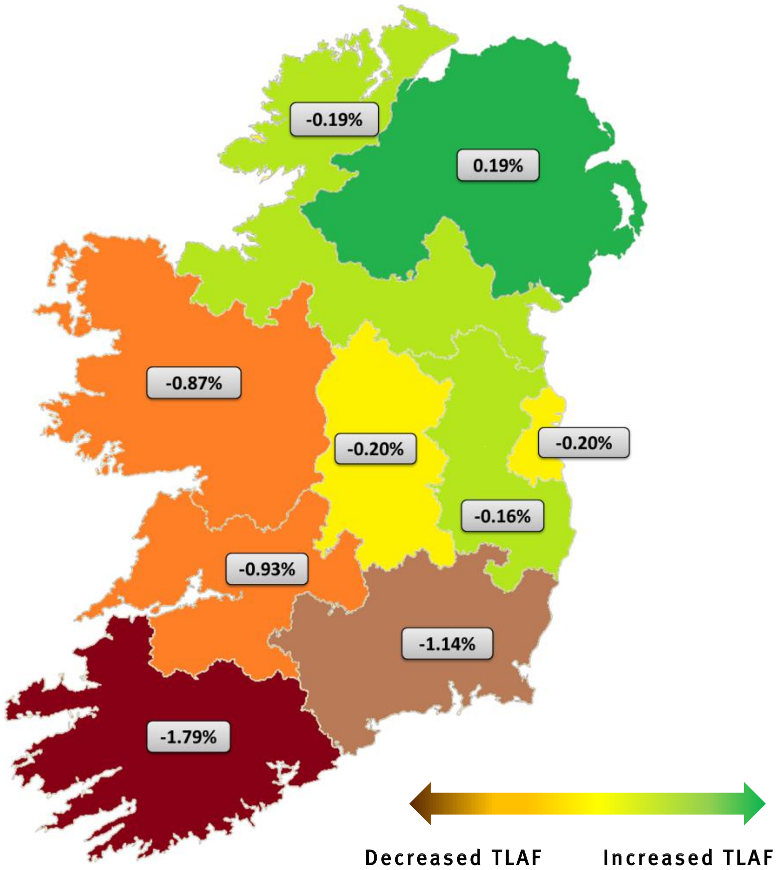

Figure 7-4: Percentage TLAF Change between 2018/19 & 2019/20

The information presented in Figures 7-3 and 7-4 should be used as regional indicators. For example in the Dublin area, Figure 7-4 shows the average TLAF value has decreased between 2018/19 and 2019/20. However, as shown in Figure 7-3, the average TLAF value remains high and above average when considering all-island TLAFs. TLAFs 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 TLAFs. Further information on the 2019/20 TLAFs can be found on the EirGrid and SONI websites[116].

7.5.2. GTUoS

The regional average 2019/20 GTUoS tariffs are shown in Figure 7-5, and are based on the approved 2019/20 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.

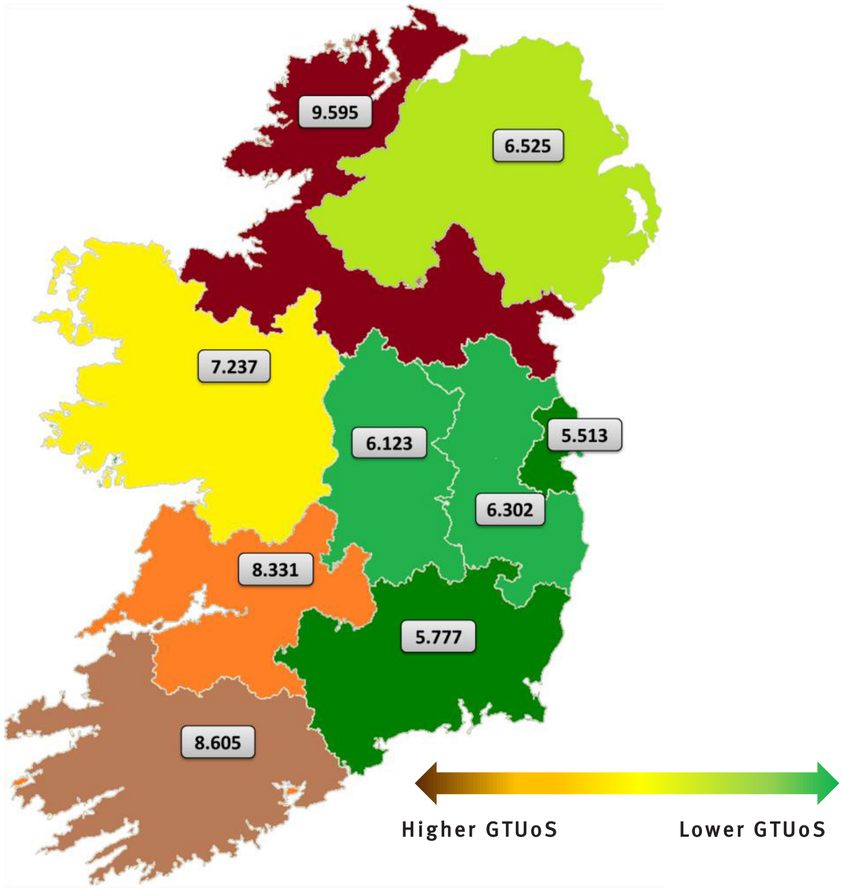

Figure 7-5: All-Island 2019/20 regional average GTUoS values

Figure 7-6 shows the change in GTUoS tariffs between 2018/19 and 2019/20.

116 www.eirgridgroup.com/site-files/library/EirGrid/1920-Approved-TLAFs-Accompanying-Note-v1.0.pdf

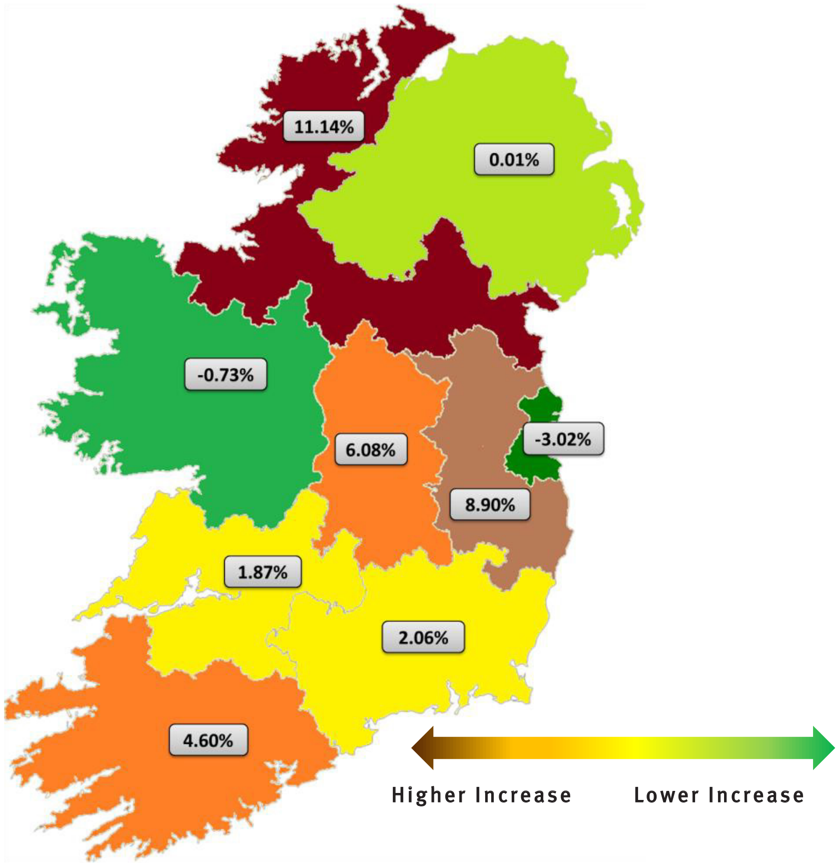

Figure 7-6: Percentage GTUoS change between 2018/19 & 2019/20

For 2019/20, there is an overall increase in tariffs due to a 6% increase in the all-island revenue; regional changes are attributed to changes in network flows. The annual revenue is the amount allowed to build, operate and maintain the transmission network, and this has increased in Ireland and Northern Ireland for 2019/20. GTUoS tariffs have increased on average by 4.88% from those of 2018/19, which is lower than the revenue change, as there are more MWs in the model to spread the cost around. The base flows are relatively similar to those of 2018/19 and as a result there are similar trends to those of 2018/19. As shown in Figure 7-6, GTUoS tariffs for Northern Ireland are similar to those of 2018/19 and are around 10.8% lower than the average Ireland GTUoS tariff.

7.6. Assumptions behind the TLAF and GTUoS models

7.6.1. 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.

7.6.2. GTUoS

The GTUoS model includes an element of ‘looking to the future’ by 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 statement 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, and assumptions or network changes from one jurisdiction can have an impact on the other. For example, if the revenue to recover in Ireland significantly increased, and the revenue to recover in Northern Ireland remained the same as the previous year, the average all-island tariff would increase as there is a larger all-island revenue to recover. Local variations would then be related to changes in network flows. Another example could be 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 future network and associated costs, alongside this are many assumptions and variables that only apply for the study year.

7.7. 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 forecasted increase and retirement of generation within a region shown in Appendix D and Chapter 4.
- Review assumptions in Chapters 2 to 4 and consider the impact of changes to the transmission system since the analysis was carried out. Chapter 5 and Appendix E should also be considered to determine 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 or the SONI connection application process.

8. Transmission System Capability for New Demand

8. Transmission System Capability for New Demand[117]

This chapter presents demand opportunity analysis which assesses the capability of the existing and planned transmission system to accommodate increased demand. Opportunities for further demand connections in Ireland and Northern Ireland are discussed.

Analysis of the 2025 transmission system indicates that all regions studied across the island have opportunities to connect demand at 275 kV, 220 kV and 110 kV stations.

As noted in Chapter 4, a significant amount of conventional generation in Ireland and Northern Ireland is expected to close over the period covered by this statement. It is assumed that the Capacity Market, which is overseen by the SEM Committee, will deliver sufficient power in appropriate locations to ensure generation adequacy and security of supply are maintained. In Northern Ireland, we are mindful that the Capacity Market will ensure adequate generation until the North South 400 kV interconnector is delivered.

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.

8.1. Transmission System Demand Capability Obligations

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

The analysis illustrated in this chapter 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 therefore 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 for discussions on their proposed developments.

8.2. All-Island Transmission System Capability for New Demand

As detailed in Chapter 6, the transmission system's capability to accommodate new demand is assessed using demand opportunity analysis. The study was performed for 2025 winter and summer peaks.

Data used for the demand opportunity analysis is based on the best available information at the January 2019 data freeze date. The results of the demand opportunity analysis presented in this chapter are based on the following assumptions:

- Year 2025 demand forecast was used (see Appendix C);
- Only transmission reinforcements with capital approval (Ireland) which are planned to be completed by 2025 were included in the analysis (see Chapter 2);
- Planned generation up until 2025 was included in the analysis (see Appendix D);
- Variable generation cannot be relied upon to serve demand. As such, variable generation local to the test station was switched out; and

117 Information for potential demand connections can be accessed at the following addresses: www.eirgridgroup.com/__uuid/463e7512-d115-4d94-b1ab-79b8cb366f73/index.xml and www.soni.ltd.uk/__uuid/463e7512-d115-4d94-b1ab-79b8cb366f73/index.xml

- The 2025 transmission system was assessed for the loss of a single transmission asset (N-1), maintenance-trip (N-1-1) and loss of a double transmission circuit (N-DC, Northern Ireland) contingencies.

We analysed 41 transmission stations throughout Ireland (excluding Dublin) and Northern Ireland. These consisted of twenty-six 110 kV stations, five 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. 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, this will then use up some or all of the available capacity in that area.

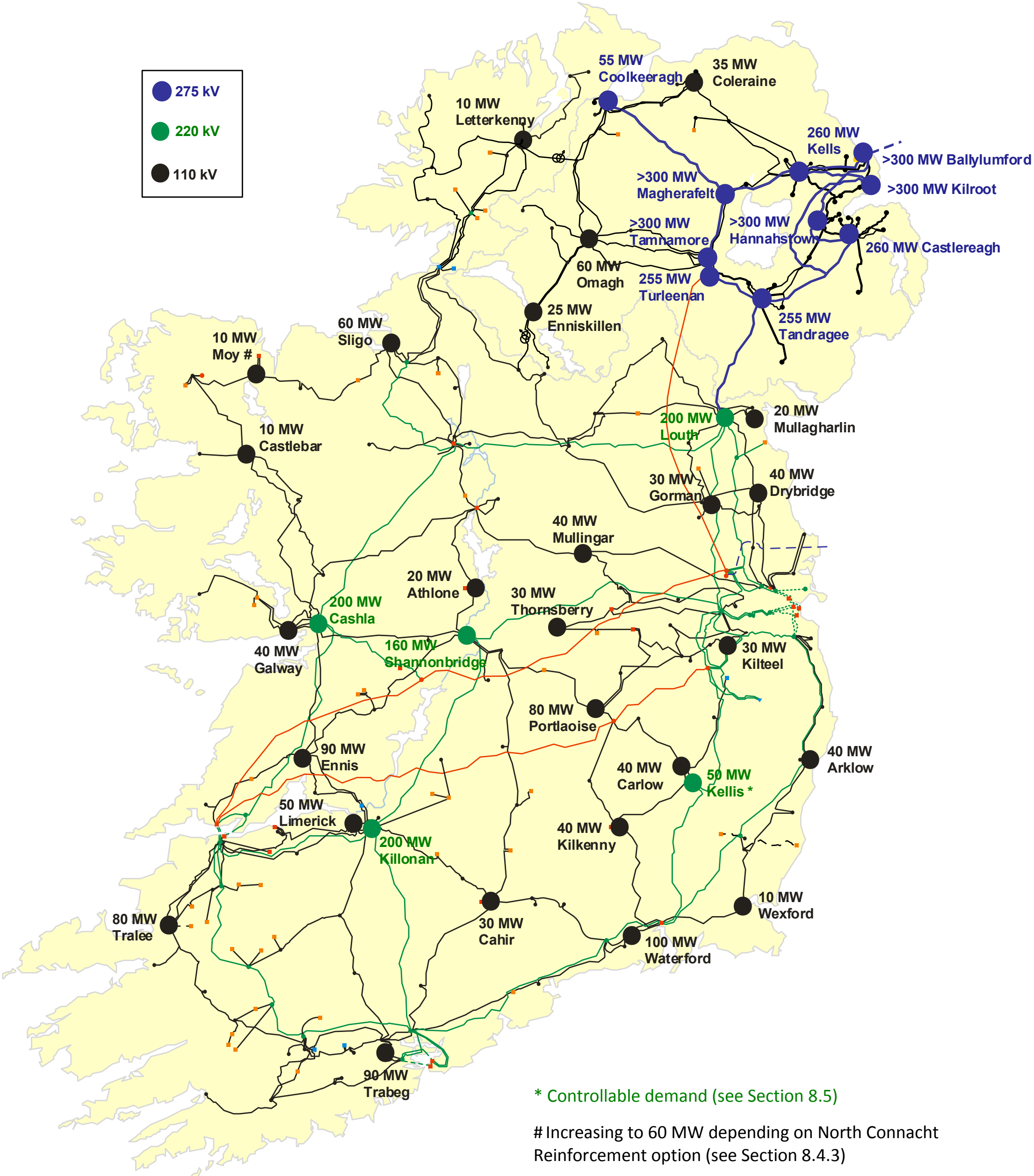

Figure 8-1: Capability for Additional Demand at 275 kV, 220 kV and 110 kV Stations in 2025

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 many 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 indicate that in 2025 there will be opportunities at all the stations examined.

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 and interaction 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 some possibly extending to over 250 MW in the final stages of development. The enquiries are mainly comprised of data centres that support the information, communications and technology (ICT) infrastructure of large multinational companies.

At the data freeze date, connected data centres had a combined total power demand of approximately 256 MVA. The total contracted maximum import capacity (MIC) for these sites was 625 MVA. This includes connections to the transmission and distribution systems. In addition to the connected sites, a further 437 MVA of contracts were in place for new data centre connections. Applications were being processed for a further 894 MVA of data centre contracts in the Dublin region. There continues to be ongoing enquiries regarding further data centre applications.

To put this in context, the current winter peak demand on the all-island transmission system is approximately 6,960 MW, as reported in All-Island Generation Capacity Statement 2019-2028. If all applicants currently being processed were to connect, the data centre load would sum to around 28% of the all-island system peak demand.

Loads of this scale, typically require connections to the 220 kV or 110 kV network. EirGrid is working with customers and the distribution system operator, ESB Networks, to meet their individual needs and to ensure optimal network development and solutions.

8.3.2. The Dublin Network

The diagram in Figure 8-2 represents the 220 kV backbone transmission system in the greater Dublin area. There also exists a 110 kV network in the Dublin area. However, for clarity we have not shown it in Figure 8-2.

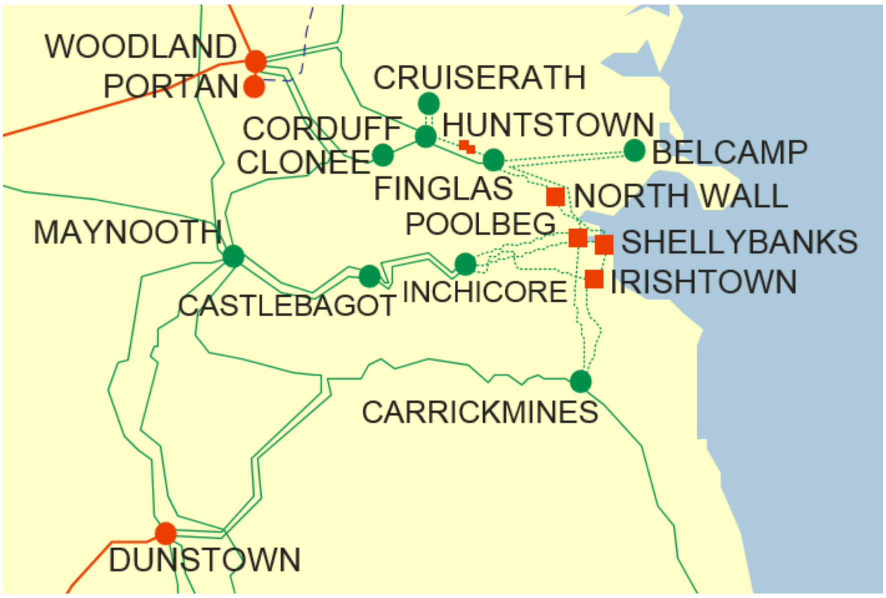

Figure 8-2: Dublin Area 220 kV Transmission System

Electricity is supplied within Dublin via a 220 kV network arranged in a figure of eight. A combination of operational arrangements and network devices can create open points that effectively divide the Dublin 220 kV network into north and south rings as required.

This network configuration is primarily used to maintain fault currents at safe levels should a network fault occur. It also prevents excessive power flows through the Dublin region. Dublin is then fed via the underlying 110 kV distribution infrastructure which is mainly arranged radially from transmission bulk supply point (BSP) interface stations (220/110 kV).

The larger Dublin power stations are located at Huntstown, which is made up of two separate generators, in North Dublin and one each at Irishtown and Shellybanks in Dublin Bay. The combined capacity of these four stations is approximately 1,600 MW. The 500 MW East West Interconnector is connected to Woodland 400 kV station on the periphery of North Dublin.

Analysis is carried out to ensure compliance with the Transmission System Security and Planning Standards (TSSPS) for all new connections to the transmission system.

This ensures the co-ordinated development of a reliable, efficient, and economical system for transmission system users. EirGrid must ensure the performance requirements of the TSSPS are met. For example, the thermal capacity limits of equipment must be maintained for all operating conditions.

To ensure the optimised, efficient and economic development of the network, EirGrid aims to make maximum use of existing assets. This can be achieved by using generation output to help offset power flows on the network and avoid the need for reinforcement. The cost of using generation in this way is compared to the cost of new network reinforcements.

There are primarily three limitations that can restrict the availability of transmission capacity in Dublin:

1. Limitations at the 220/110 kV interface stations, these can include restrictions due to the 220/110 kV transformers or spatial constraints;
2. Power flow limitations on local transmission circuits within Dublin; and
3. Limited capacity on circuits outside Dublin in terms of facilitating large power flows across the transmission network.

Generation dispatch is critical in assessing the capability of the network and can have a significant impact on (2) and (3) above, especially in the case of Dublin.

The power delivered to Dublin demand centres can originate from power sources located within or outside Dublin or a combination of both. This is dependent on wholesale electricity market generation costs in the Single Electricity Market (SEM) as well as network or system issues.

Recently there has been a tendency for increased high power flows into Dublin from generation located outside the area. This is a result of the increased penetration of wind generation and high merit order generators outside Dublin.

In some instances these high power flows from outside the Dublin area can be reduced when power is generated inside Dublin. This could release network capacity for transmission users. However, as more demand connects in Dublin, there is an increased requirement for generation in Dublin to offset high power flows into, and around, Dublin.

8.3.3. Dublin Transmission Development Plans

Figure 8-3 below describes the areas of focus for demand connections in Dublin and the scale of interest in each zone. The connections fall into three zones: North, West and South Dublin.

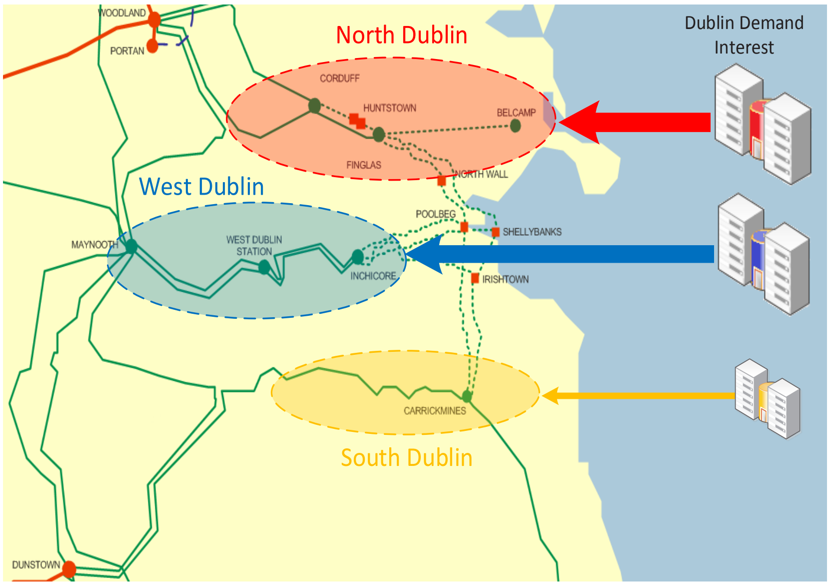

Figure 8-3: Dublin Potential Demand Connections

Depending on the level of future demand connections, new large scale generation, transmission solutions, demand side response and/or storage will be required to ensure continued security of supply.

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 (ATR) update, both of which are available on the EirGrid website.

8.3.4. North Dublin

North Dublin has two 220/110 kV interface stations at Corduff and Finglas with another planned at Belcamp. 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.

Table 8-1: North Dublin Projects

North Dublin		
Project Name/Number	**Project Description**	**Estimated Delivery Date**
Cloghran-Corduff (CP0859)	New 110 kV cable	2016 (complete)
Belcamp (CP0437)	New 220/110 kV station	2019
Finglas (CP0646)	110 kV station redevelopment	2020
Belcamp Phase 2 (CP0984)	Additional 220/110 kV transformer and second circuit	2021
Finglas (CP0792)	220 kV station redevelopment	2022

Facilitating further high levels of demand connections will require additional network reinforcement in the area. As noted in our Transmission Development Plan we have confirmed the need for such investment in north Dublin, the future potential project is called North Dublin Corridor Reinforcement (CP1021). This could be in the form of increased network connectivity with Woodland 400 kV station for example. Typically, such major projects delivering additional network capacity have significant lead times (five to ten years or more) which are dependent on the chosen technology.

8.3.5. West Dublin

West Dublin has one main 220/110 kV interface station at Inchicore with another planned at Castlebagot[118]. These stations are supported by the Maynooth 220/110 kV station on the outer rim of the Dublin region.

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

West Dublin		
Project Name/Number	**Project Description**	**Estimated Delivery Date**
Inchicore-Maynooth (CP0667)	Uprate 220 kV No.1 & No.2 lines	2015 (complete[119])
Maynooth-Ryebrook (CP0747)	Uprate 110 kV line	2015 (complete)
Ryebrook (CP0789)	110 kV station redevelopment	2017 (complete)
Poolbeg (CP0760)	Installation of 100 Mvar reactive support	2018 (complete)
Ryebrook-Corduff (CP0668)	Uprate 110 kV line	2019
Castlebagot (CP0872)	New 220/110 kV station	2020
Inchicore (CP0692)	220 kV station upgrade	2025
Maynooth (CP0808)	220/110 kV station redevelopment	2027

As noted in our Transmission Development Plan we have confirmed the need for investment in this area. In response, we are progressing Capital Project 966 which seeks to increase the strength of the link between two existing 400 kV stations at Dunstown and Woodland.

8.3.6. 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 number of transmission projects are in place to increase the network capacity and ensure continued security of supply in this area. They are summarised in Table 8-3 below.

Table 8-3: South Dublin Projects

South Dublin		
Project Name/Number	**Project Description**	**Estimated Delivery Date**
Dunstown (CP0683)	New 400/220 kV 500 MVA transformer	2016 (complete)
Carrickmines (CP0580)	New 220/110 kV 250 MVA transformer & GIS development	2019

8.3.7. Impact of Additional Generation & Flexible Demand on North, West and South Dublin

As described in Chapter 7, there are generation opportunities in the Dublin region, particularly in north Dublin. If additional generation was to locate in the Dublin area this would generally improve the network capacity available for transmission system users in North, West and South Dublin zones.

However, the specific location of any proposed additional generation would have to be assessed to fully understand its full impact on the network.

118 Formerly known as West Dublin 220/110 kV station.
119 The lines have been uprated, some end station works are due to be completed in 2019.

Similarly, if major demand customers can ensure demand side flexibility during low probability system events this would also improve the capability of the network to accommodate further demand increases.

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[120], 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 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 8-4.

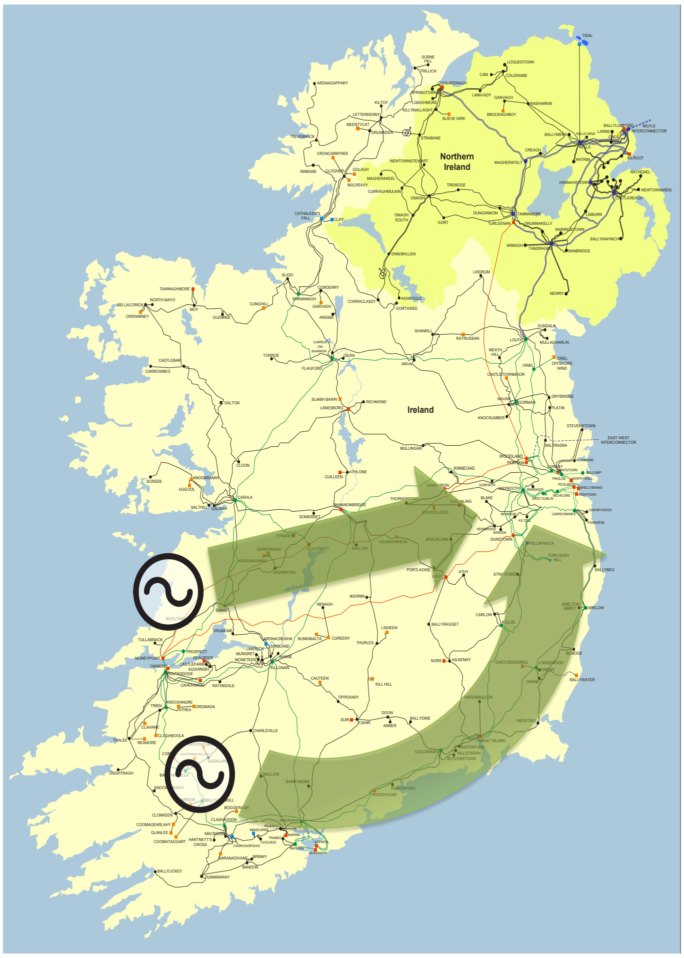

Figure 8-4: Transfer of Power Generated in the West and South-West Regions to the East

Capital Project 966 is at an early point in the project life-cycle. The project will increase the strength of the 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, thus releasing network capacity on several key constrained circuits.

120 www.eirgridgroup.com/the-grid/irelands-strategy/

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 potential project is called North Dublin Corridor Reinforcement (CP1021).

8.3.9. Summary

New transmission solutions will be required to strengthen the grid. These solutions are now under initial investigation.

We continue to apply a strategic approach to network development and we are continuously considering the approach to the level of demand enquires. 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. 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.
- To date, we have been able to facilitate connections for developers who have applied. We will continue to examine innovative solutions and technologies in response to future requests. However, 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 largely been depleted.

It is advised that any potential new demand consumers contact EirGrid early so that we can work jointly to achieve a connection solution. This facilitates the optimisation of transmission reinforcements so that the requested capacity can be delivered.

It is also recommended to locate any new large scale data centres in close proximity to existing 220 kV stations or circuits as this may help expedite the provision of a suitable connection.

As a prudent system operator, EirGrid ensures that adequate spare capacity for regional and national demand growth is available, while avoiding unnecessary over investment in grid capability. Therefore, a balance is maintained between the reasonable expectations placed on the network and the cost of grid development and maintenance. Delivering an efficient transmission grid requires that this balance of investment is maintained.

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 demand opportunities available in the Midlands and West are shown in Figure 8-5. It is shown that there are potential demand opportunities available for new customers at all stations examined in the region[121]. In particular, Cashla and Shannonbridge 220 kV stations would be suitable connection points for major industrial load centres. Both of these stations are capable of accommodating significant additional demand without additional network reinforcements.

121 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.

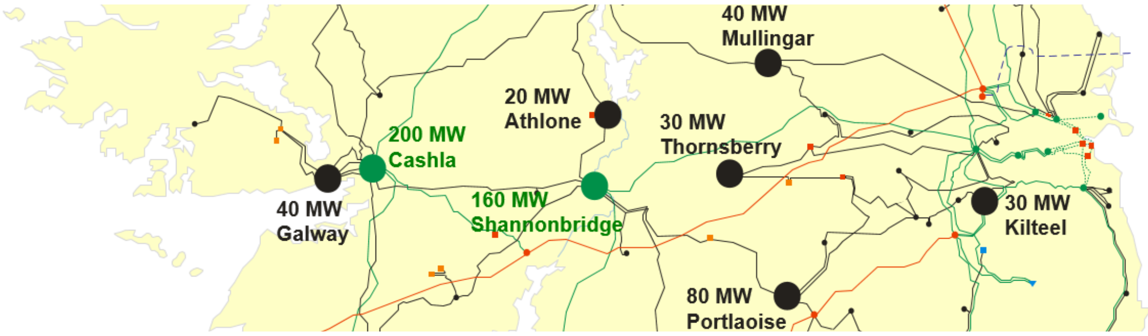

Figure 8-5: Capability for Additional Demand in Midlands and West Regions

8.4.2. Opportunities for New Demand in the North-East

The demand opportunities available for the North-East region are shown in Figure 8-6. It is shown that there are potential demand opportunities available for industrial customers at all stations examined in the region. The delivery of the North South interconnector aids demand opportunity in the North-East. The North South interconnector provides a route for large power transfers to flow between Northern Ireland and Ireland via the North-East region of Ireland. The North South interconnector will benefit potential demand customers connecting in this region by releasing more capacity on the underlying 110 kV network.

Potential overloading of the Louth – Mullagharlin and Dundalk – Louth 110 kV lines is responsible for limiting the opportunity at Mullagharlin. The overload occurs during winter and summer peaks for single circuit outage conditions. This is a local issue as only two circuits supply the load at Mullagharlin. Drybridge is more interconnected with four circuits supplying the station. Thus, it has a higher demand opportunity. Demand opportunity studies were performed at Louth and Gorman 220/110 kV stations. Louth is capable of accommodating significant additional demand without additional network reinforcements.

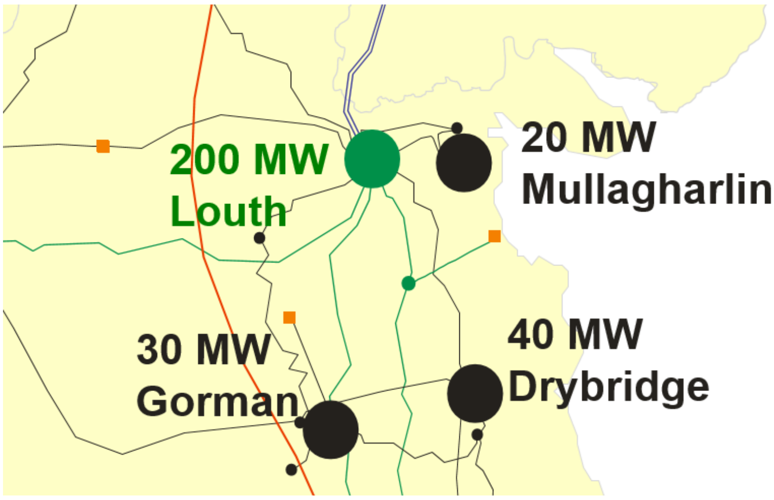

Figure 8-6: Capability for Additional Demand in North-East Region

8.4.3. Opportunities for New Demand in the North-West

The demand opportunities available for the North-West region are shown in Figure 8-7. It shows that there are potential demand opportunities available for industrial customers at all stations examined in the region. The potential demand opportunity at Castlebar is 10 MW. Analysis has shown that the 110 kV lines supplying Castlebar could overload under certain maintenance-trip scenarios (see Chapter 6). Since the data freeze date we have confirmed the need to increase transmission capacity in Mayo. These investments will increase the demand opportunity at Castlebar, and in Mayo generally.

Demand opportunity studies were performed at Moy 110 kV station. In our studies we identified an opportunity for 10 MW. However, depending on the North Connacht Reinforcement solution option this could increase to 60 MW.

Demand opportunity studies were performed at Letterkenny 110 kV station. In our studies we identified an opportunity for 10 MW. Analysis has shown that the 110 kV lines supplying Donegal could overload under certain maintenance-trip scenarios. Under certain circumstances and in co-ordination with SONI the existing Letterkenny – Strabane 110 kV line can be used to support the network in Donegal.

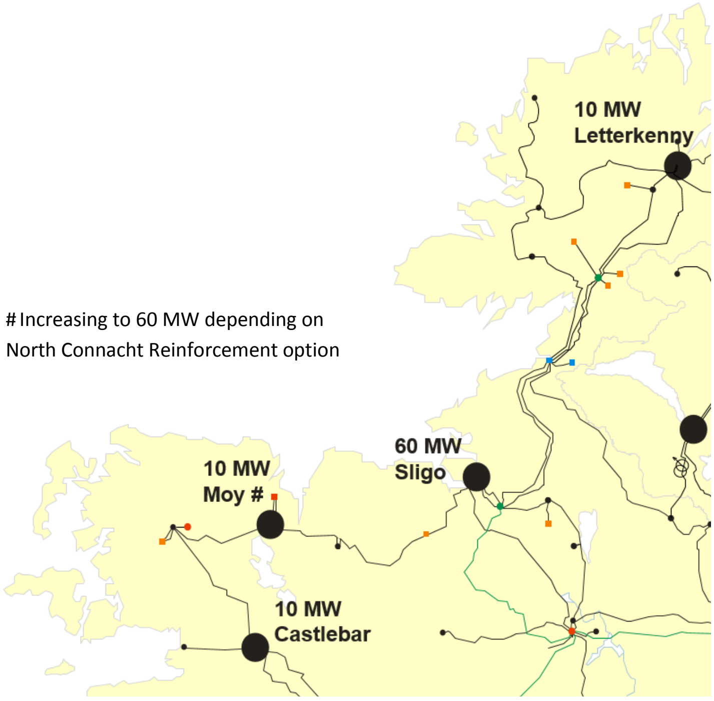

Figure 8-7: Capability for Additional Demand in North-West Region

8.4.4. Opportunities for New Demand in the South-East

The demand opportunities available for the South-East region are shown in Figure 8-8. It is shown that there are potential opportunities available for industrial customers at all stations examined in the region.

The demand opportunity at Kellis 220 kV station is limited to 50 MW due to the maintenance-trip scenario (see Chapter 6) where both 220 kV lines supplying Kellis are assumed to be out of service. This scenario means that demand at Kellis 220 kV station must be supplied by the underlying 110 kV network, which does not have the capacity to carry as much power as the 220 kV network.

However, should a demand facility wishing to connect at Kellis 220 kV station implement a 'Controllable Demand' strategy there would be potential for much greater capacity of demand to connect. This is explained further in Section 8.5 on 'Controllable Demand'.

Demand opportunity studies were performed at Wexford 110 kV station. In our studies we identified an opportunity for 10 MW. Analysis has shown that voltage violations could occur under certain maintenance-trip scenarios.

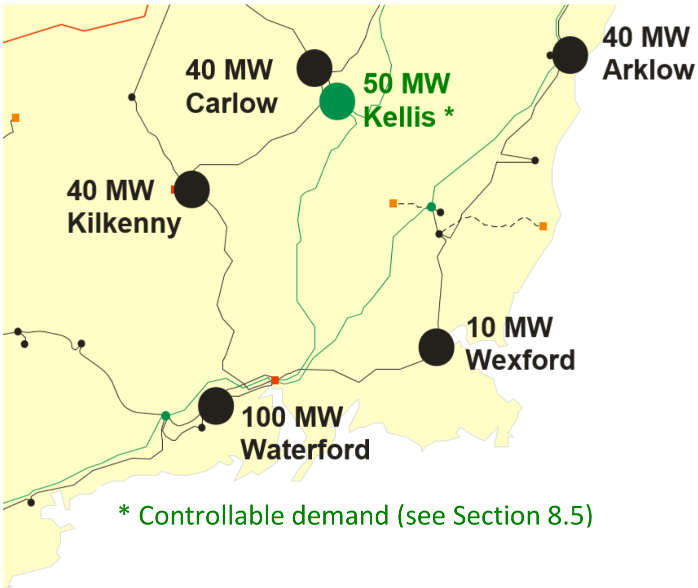

Figure 8-8: Capability for Additional Demand in the South-East Region

8.4.5. Opportunities for New Demand in the South-West

The demand opportunities available for the South-West region are shown in Figure 8-9. It can be seen that there are potential opportunities available for industrial customers at all stations examined in the region.

In particular the Killonan 220 kV station would be a suitable connection point for a major industrial load centre, with the capability of accommodating in excess of 200 MW without additional network reinforcements.

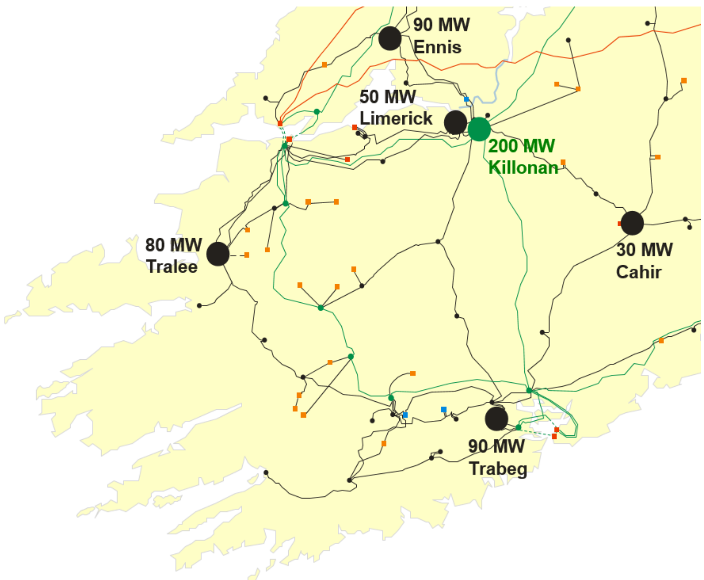

Figure 8-9: Capability for Additional Demand in South-West Region

8.5. Controllable Demand

Kellis 220 kV station is a good example to demonstrate the potential to increase the assessed capacity of a station through the concept of 'controllable demand'. In the case of Kellis 220 kV station, demand opportunity is limited to 50 MW due to a maintenance-trip scenario where both 220 kV lines supplying Kellis 220 kV station are assumed to be out of service. The next limiting scenario after the outage of both 220 kV lines supplying Kellis would allow for much greater demand opportunity at Kellis 220 kV station.

Maintenance-trip contingency planning forms part of a suite of contingencies considered by EirGrid for prudent planning of the transmission system. However, it is also recognised in the Transmission System Security and Planning Standards (TSSPS) that exposure to maintenance-trip events is much less than the other contingency events considered.

This means that under certain circumstances, potential demand customers may enter an agreement with EirGrid to connect a higher level of demand at a particular station, on the condition that the customer would reduce load if certain contingencies occurred.

Using Kellis 220 kV station as an example, a potential demand customer may enter an agreement with EirGrid to connect 200 MW of load at Kellis, but drop to 50 MW if either of the 220 kV lines supplying Kellis is out of service.

It should be noted that Kellis has been used as an example. Depending on reliability requirements, this type of agreement may not be suitable for all types of demand facilities or locations. We encourage any potential customers to discuss the possibility of controllable demand with us at an early stage of project planning and development.

8.6. Transmission System Capability for New Demand in Northern Ireland

Section 8.6.1 discusses the demand opportunities available in the Eastern region of Northern Ireland. Section 8.6.2 discusses the demand opportunities available in the Western region. These results are based on the assumptions detailed in Chapter 6.

8.6.1. Opportunities for New Demand in East of Northern Ireland

The demand opportunities available in the Eastern region are shown in Figure 8-10.

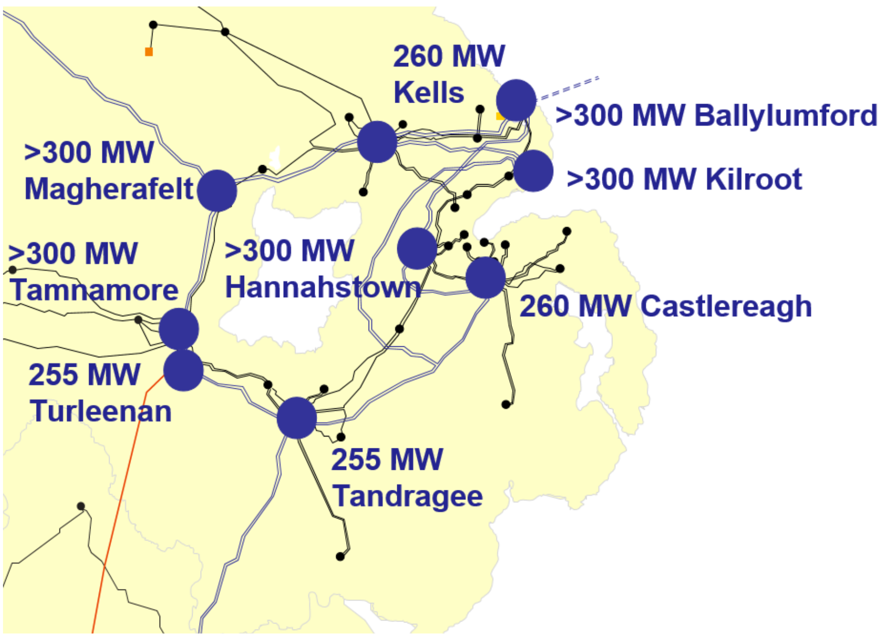

Figure 8-10: Capability for Additional Demand (MW) in the East of Northern Ireland

It can be seen that there are potential opportunities available for industrial customers at all stations examined in the region. Each of the 275 kV stations in the East of Northern Ireland would be suitable connection points for major industrial load centres. Each of these stations is capable of accommodating approximately 250 MW to 300 MW[122] of additional demand without additional network reinforcements.

122 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.

8.6.2. Opportunities for New Demand in West of Northern Ireland

The demand opportunities available for the West of Northern Ireland are shown in Figure 8-11.

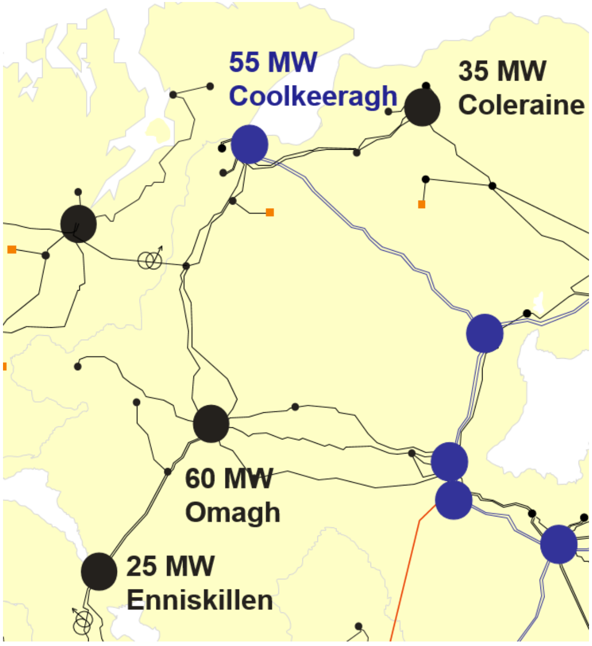

Figure 8-11: Capability for Additional Demand in the West of Northern Ireland

It can be seen that there are potential opportunities available for industrial customers at all stations examined in the region. 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.

Under N-1-1 the demand capability of Coolkeeragh is limited to 55 MW. This is under the following conditions:

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

Enniskillen station represents the lowest capability of the 110 kV nodes assessed. Enniskillen 110 kV is connected to Omagh South 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.

8.7. 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 (Sections 8.4 and 8.6) 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. Review assumptions in Chapters 2 to 4 and consider the impact of changes to the transmission system since the analysis was carried out.

4. Consult with EirGrid and SONI on the proposed location as early as possible as well as consulting the EirGrid application process[123] and SONI application process[124].

Potential demand customers should not be discouraged by choosing a site in which there appears to be a lack of transmission system capacity. 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.

123 www.eirgridgroup.com/customer-and-industry/becoming-a-customer/
124 www.soni.ltd.uk/Customers/howconnected/

All-Island Ten Year

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Appendix A

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 2019 and as planned for in 2028.

A.1. Network Maps

This section includes two network maps:

- Figure A-1 is a map of the expected All-Island Transmission System as at December 2019; and
- Figure A-2 is a map of the planned All-Island Transmission System in 2028.

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 110kV
Year End 2019

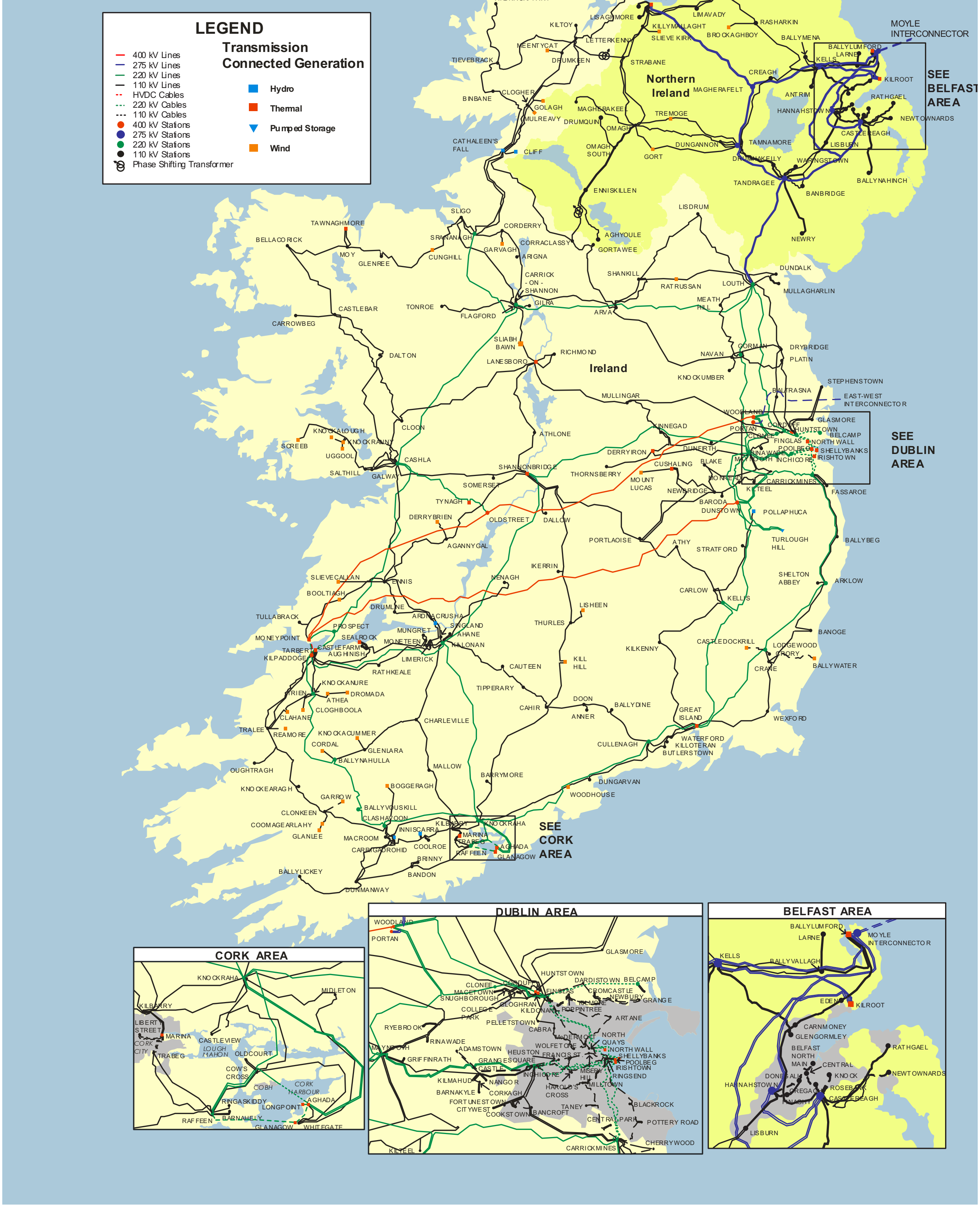
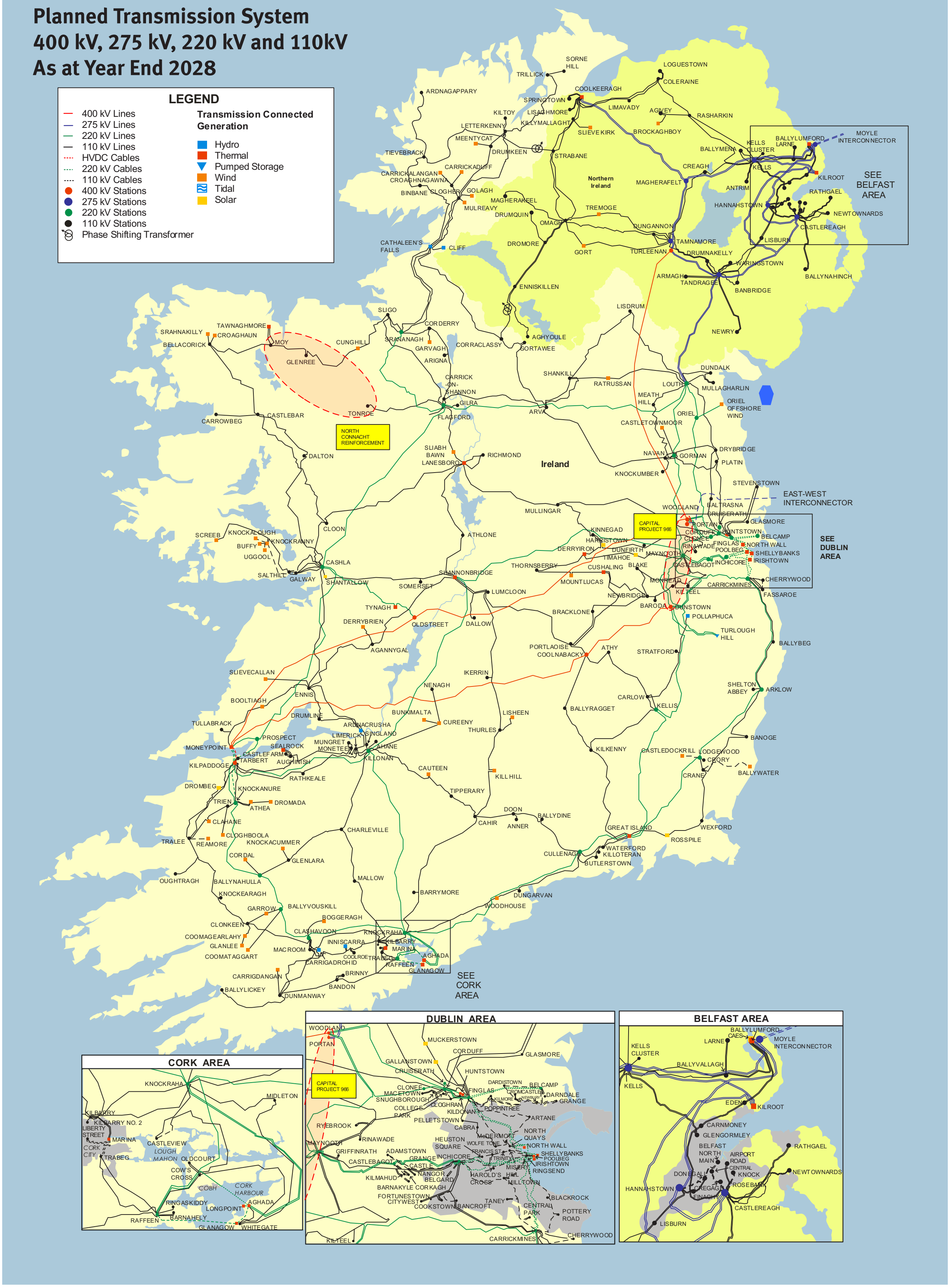


Figure A-2

Planned Transmission System 400 kV, 275 kV, 220 kV and 110kV As at Year End 2028



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	**BFP**	Belfast Power Station	**BYH**	Ballynahulla
AD	Aghada	**BGD**	Belgard Road	**CAB**	Cabra
ADM	Adamstown	**BGH**	Boggeragh	**CAE**	CAES
AGH	Aghyoule	**BGT**	Ballyragget	**CAG**	Carrickalangan
AGL	Agannygal	**BIN**	Binbane	**CAH**	Cahir
AGI	Agivey Cluster	**BK**	Bellacorick	**CAM**	Cam Cluster
AGY	Ardnagappary	**BKM**	Bunkimalta	**CAR**	Carnmoney
AHA	Ahane	**BKY**	Barnakyle	**CAS**	Castlereagh
AIR	Airport Road	**BLA**	Blackrock	**CBG**	Carrowbeg
ANR	Anner	**BLC**	Belcamp	**CBL**	Cloghboola
ANT	Antrim	**BLI**	Ballylickey	**CBR**	Castlebar
ARI	Arigna	**BLK**	Blake	**CBT**	Castlebagot
ARK	Arklow	**BLP**	Blackpool	**CD**	Carrigadrohid
ARM	Armagh	**BMA**	Ballymena	**CDN**	Carrigdangan
ART	Artane	**BNH**	Ballynahinch	**CDF**	Carrickaduff
ARV	Arva	**BNM**	Belfast North	**CDK**	Castledockrill
ATE	Athea	**BOG**	Banoge	**CDL**	Cordal
ATH	Athlone	**BOL**	Booltiagh	**CDU**	Corduff
ATY	Athy	**BPS**	Ballylumford Power Station	**CDY**	Corderry
AUG	Aughinish	**BRA**	Bracklone	**CEN**	Belfast Central
BAL	Baltrasna	**BRI**	Brinny	**CF**	Cathaleen's Fall
BAN (I)	Bandon	**BRO**	Brockaghboy	**CFM**	Castlefarm
BAN (N)	Banbridge	**BRY**	Barnahely	**CGL**	Coomagearlahy
BAR	Barrymore	**BUF**	Buffy	**CH**	Cahernagh
BCM	Ballycummin	**BUT**	Butlerstown	**CHA**	Charleville
BCT	Bancroft	**BVG**	Ballyvallagh	**CHE**	Cherrywood
BDA	Baroda	**BVK**	Ballyvouskill	**CHR**	Cahernagh
BDN	Ballydine	**BWR**	Ballywater	**CKG**	Corkagh
BDV	Barnadivane	**BY**	Ballykelly	**CKM**	Carrickmines
BEG	Ballybeg	**BYC**	Ballycronan More (Moyle)	**CKN**	Clonkeen

Table A-1: Short Bus Codes

Short Bus Code	Full Name	Short Bus Code	Full Name	Short Bus Code	Full Name
CL	Cliff	**CVW**	Castleview	**GAN**	Gallanstown
CLA	Clashavoon	**DAL**	Dallow	**GAR**	Garvagh
CLE	Clonee	**DRN**	Darndale	**GCA**	Grange Castle
CLG	Cloghran	**DDK**	Dundalk	**GGO**	Glanagow
CLH	Clahane	**DER**	Derryiron	**GI**	Great Island
CLN	Cloon	**DFR**	Dunfirth	**GIL**	Gilra
CLO	Clogher	**DGN**	Dungarvan	**GLA**	Glasmore
CLS	Clonshaugh	**DLN**	Derrylyn	**GLE (I)**	Glenlara
CLW	Carlow	**DLT**	Dalton	**GLE (N)**	Glengormley
CNB	Coolnabacky	**DMY**	Dunmanway	**GLR**	Glenree
CNF	Caraunduff	**DON**	Donegall	**GLT**	Glentanemacelligot
CNN	Croaghnagawna	**DOO**	Doon	**GOL**	Golagh
COL (I)	College Park	**DRG**	Drombeg	**GOR (I)**	Gorman
COL (N)	Coleraine	**DRM**	Drumkeen	**GOR (N)**	Gort Cluster
COO	Cookstown	**DRN**	Darndale	**GRA**	Grange
COR	Corraclassy	**DRO**	Dromada	**GRI**	Griffinrath
COS	Carrick-on-Shannon	**DRO (N)**	Dromore	**GRO**	Garrow
COW	Cow Cross	**DRQ**	Drumquin Cluster	**GWE**	Gortawee
CPK	Central Park	**DRU (I)**	Drumline	**HAN**	Hannastown
CPS	Coolkeeragh Power Station	**DRU (N)**	Drumnakelly	**HAR**	Harolds Cross
CRA	Crane	**DRY**	Drybridge	**HEU**	Heuston Square
CRE	Cregagh	**DSN**	Dunstown	**HN**	Huntstown
CRG	Creagh	**DTN**	Dardistown	**HWN**	Harristown
CRH	Cruiserath	**DUN**	Dungannon	**IA**	Inniscarra
CRM	Cromcastle	**DYN**	Derrybrien	**IKE**	Ikerrin
CRN	Croaghaun	**EDE**	Eden	**INC**	Inchicore
CRO	Coolroe	**ENN (I)**	Ennis	**ISH**	Irishtown
CRY	Crory	**ENN (N)**	Enniskillen	**KBY**	Kilbarry
CSH	Cashla	**FAS**	Fassaroe	**KCR**	Knockacummer
CTG	Coomataggart	**FAS E**	Fassaroe East	**KDN**	Kildonan
CTN	Cauteen	**FIN (I)**	Finglas	**KEL**	Kells
CTR	Castletownmoor	**FIN (N)**	Finaghy	**KLC**	Kells Cluster
CTY	City West	**FLA**	Flagford	**KER**	Knockearagh
CUL	Cullenagh	**FNT**	Finnstown	**KHL**	Kill Hill
CUN	Cunghill	**FRN**	Francis Street	**KIN**	Kinnegad
CUR	Cureeny	**GAE**	Glanlee	**KKY**	Kilkenny
CUS	Cushaling	**GAL**	Galway	**KLH**	Knockalough

Table A-1: Short Bus Codes

Short Bus Code	Full Name	Short Bus Code	Full Name	Short Bus Code	Full Name
KLM	Kilmore	**MEE**	Meentycat	**POT**	Pottery Road
KLN	Killonan	**MEN**	Monatooreen	**PRO**	Prospect
KLS	Kellis	**MHL**	Misery Hill	**PRT**	Portan
KMT	Killymallaght	**MID**	Midleton	**PTN**	Pelletstown
KNO	Knock	**MIL**	Milltown	**RAF**	Raffeen
KNR	Knockanure	**MKL**	Magherakeel Cluster	**RAT (I)**	Rathkeale
KNV	Knockavanna	**MLC**	Mountlucas	**RAT (N)**	Rathgael
KNY	Knockranny	**MLN**	Mullagharlin	**RE**	Ringsend
KPG	Kilpaddoge	**MON**	Monread	**REM**	Reamore
KPN	Killinaparson	**MOY**	Moy	**RIC**	Richmond
KPS	Kilroot Power Station	**MP**	Moneypoint	**RNW**	Rinawade
KRA	Knockraha	**MR**	Marina	**ROS**	Rosebank
KTL	Kilteel	**MRY**	Mulreavy	**RRU**	Ratrussan
KTN	Killoteran	**MTH**	Meath Hill	**RSK**	Rasharkin Cluster
KUD	Kilmahud	**MTN**	Moneteen	**RSP**	Rosspile
KUR	Knockumber	**MUC**	Muckerstown	**RSY**	Ringaskiddy
LA	Lanesboro	**MUL**	Mullingar	**RYB**	Ryebrook
LAR	Larne	**MUN**	Mungret	**SAL**	Salthill
LET	Letterkenny	**NAN (I)**	Nangor	**SBH**	Snughborough
LIB	Liberty Street	**NAR**	Newtownards	**SCR**	Screeb
LIM (I)	Limerick	**NAV**	Navan	**SH**	Shannonbridge
LIM (N)	Limavady	**NBY**	Newbury	**SHE**	Shelton Abbey
LIS (I)	Lisdrum	**NEN**	Nenagh	**SHL**	Shellybanks
LIS (N)	Lisburn	**NEW (I)**	Newbridge	**SHN**	Shantallow
LMR	Lisaghmore	**NEW (N)**	Newry	**SK**	Sealrock
LOG	Loguestown	**NQS**	North Quays	**SKL**	Shankill
LOU	Louth	**NW**	North Wall	**SKY**	Srahnakilly
LPT	Longpoint	**OLD**	Oldcourt	**SLB**	Sliabh Bawn
LSN	Lisheen	**OMA**	Omagh	**SLC**	Slievecallan
LUM	Lumcloon	**ORL**	Oriel	**SLI**	Sligo
LWD	Lodgewood	**OST**	Oldstreet	**SLK**	Slieve Kirk
MAC	Macroom	**OUG**	Oughtragh	**SNG**	Singland
MAG	Magherafelt	**PA**	Pollaphuca	**SOM**	Somerset
MAL	Mallow	**PB**	Poolbeg	**SOR**	Sorne Hill
MAY	Maynooth	**PLA**	Platin	**SPR**	Springtown
MCD	McDermott	**PLS**	Portlaoise	**SRA**	Srananagh
MCE	Macetown	**POP**	Poppintree	**STR (I)**	Stratford

Table A-1: Short Bus Codes

Short Bus Code	Full Name	Short Bus Code	Full Name	Short Bus Code	Full Name
STR (N)	Strabane	**TIP**	Tipperary	**TUR**	Turleenan
SVN	Stevenstown	**TIV**	Tievebrack	**TYN**	Tynagh
TAN	Tandragee	**TLK**	Trillick	**UGL**	Uggool
TAW	Tawnaghmore	**TLY**	Tanley	**WAR**	Waringstown
TB	Tarbert	**TMN**	Tamnamore	**WAT**	Waterford
TBG	Trabeg	**TON**	Tonroe	**WEX**	Wexford
TBK	Tullabrack	**TRE**	Tremoge Cluster	**WH**	Woodhouse
TH	Turlough Hill	**TRI**	Trien	**WHI**	Whitegate
THU	Thurles	**TRN**	Trinity	**WOL**	Wolfe Tone
TIM	Timahoe	**TSB**	Thornsberry		

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 2019 shows the expected transmission system as of December 2019. The schematic diagram for 2028 shows the planned transmission system due to be completed by the end of 2028.

Table A-2: Schematic Legend

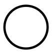
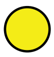
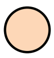
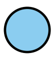
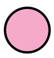
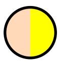
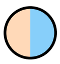
Symbol	Network Element Represented
	110 kV circuit
	220 kV circuit
	275 kV circuit
	400 kV circuit
	System Link
	110 kV Busbar
	220 kV Busbar
	275 kV Busbar
	400 kV Busbar
	Busbar with Thermal Generation
	Busbar with Wind Generation (>5 MW)
	Busbar with Hydro Generation
	Busbar with Solar Generation (>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 December 2019

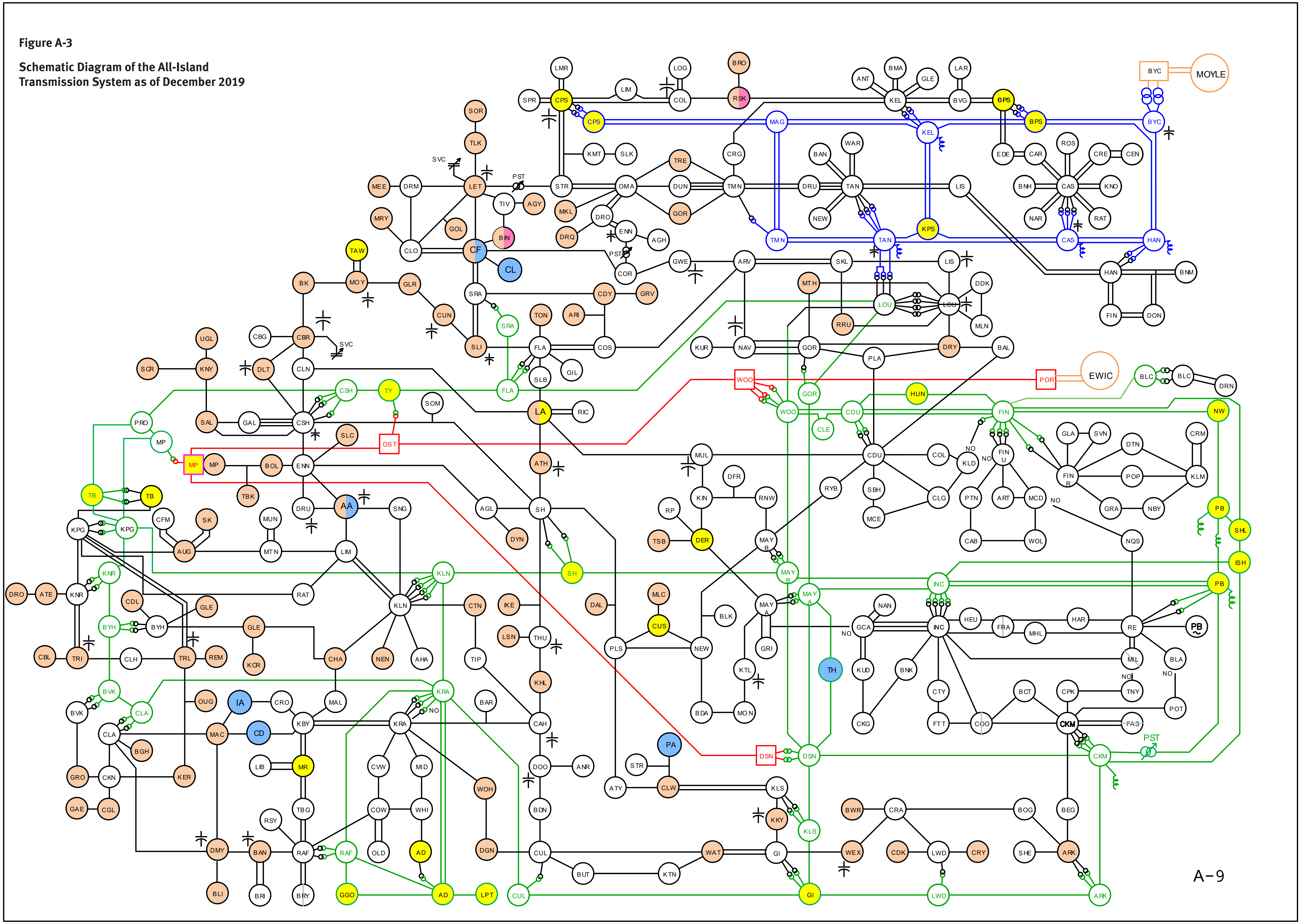
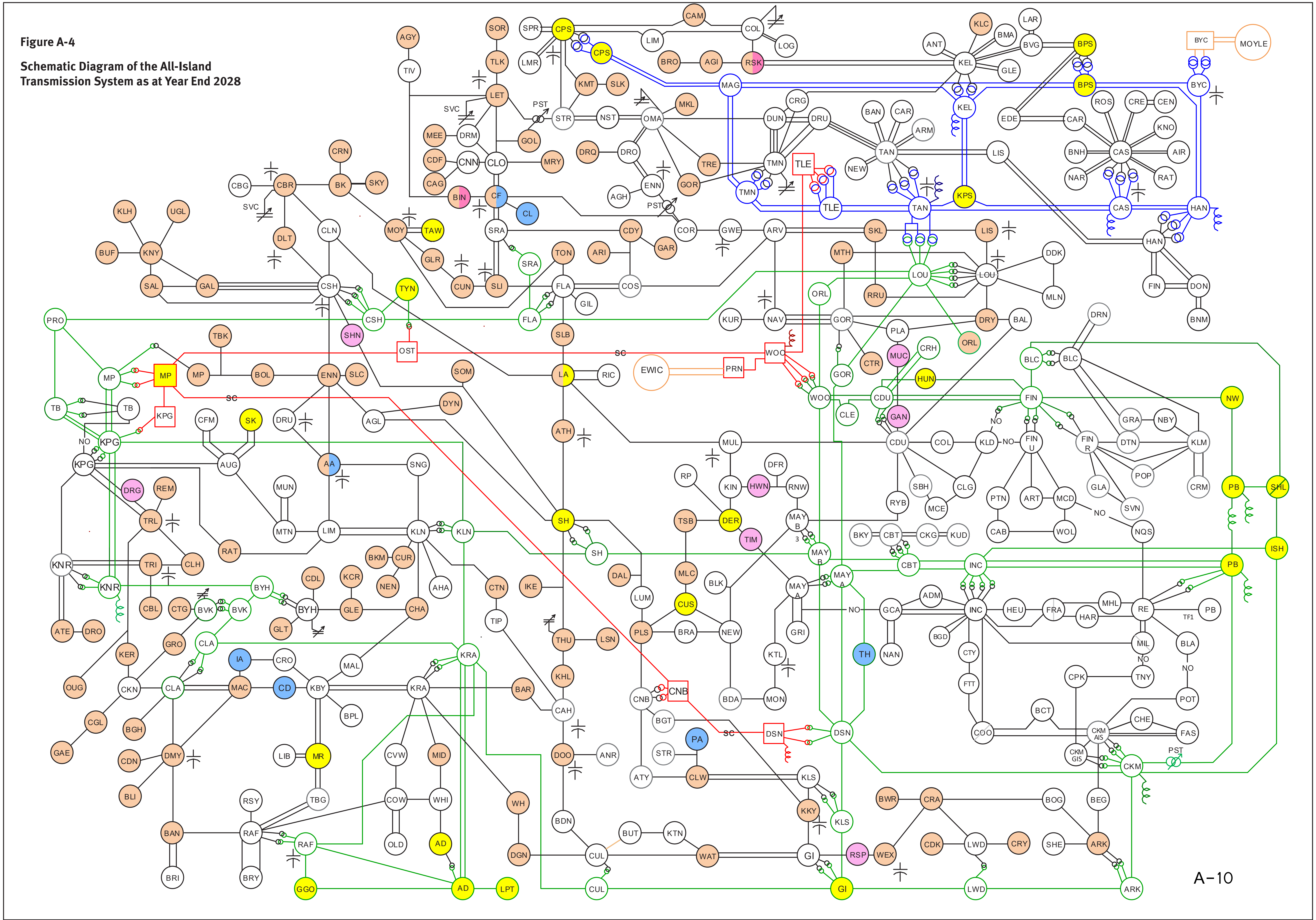


Figure A-4

Schematic Diagram of the All-Island Transmission System as at Year End 2028



All-Island Ten Year

Transmission Forecast Statement 2019

Appendix B

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[125] transmission system; and
- Section B.2 details the data for planned transmission system developments[126].

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[127]; and
- summer: 25˚C.

The electrical characteristics of the all-island transmission system at the four nominal voltage 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

Nominal Voltage Level (kV)	Reference Voltage (kV)
400	400
275	275
220	220
110	110

125 As at January 2019.
126 Includes transmission system reinforcement projects and developments necessary to connect new generation and demand.
127 ESB Networks previously calculated winter ratings based on an assumed winter temperature of 5°C. In 2018 this was changed to 11°C.

In some cases equipment associated with a line or cable may be lower rated than the circuit or line. However, this equipment[128] 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.

B.1. Characteristics of the Existing Transmission System (January 2019)

Table B-2: Characteristics of Existing Transmission Circuits

Voltage (kV)	From	To	No.	Length (km)	Impedance on 100 MVA Base (pu)			Rating (MVA)		
					R	X	B	Summer	Autumn	Winter
400	DSN	MP	1	208.5	0.004	0.044	1.14	1283	1331	1454
400	MP	OST	1	104.1	0.004	0.027	0.489	1283	1331	1454
400	OST	WOO	1	126	0.004	0.032	0.572	1577	1749	1944
275	LOU	TAN	1	50	0.003	0.021	0.127	710	820	881
275	LOU	TAN	2	50	0.003	0.021	0.127	710	820	881
275	BPS	HAN	2	45.5	0.002	0.019	0.114	710	820	881
275	BPS	KEL	1	34.5	0.002	0.014	0.089	710	820	881
275	BPS	MAG	1	65.5	0.003	0.027	0.169	710	820	881
275	CAS	HAN	1	18.4	0.001	0.008	0.046	710	820	881
275	CAS	HAN	2	18.4	0.001	0.008	0.046	710	820	881
275	CAS	KPS	1	66.8	0.003	0.028	0.171	710	820	881
275	CAS	TAN	1	45.6	0.002	0.019	0.114	710	820	881
275	CPS	MAG	1	56.2	0.006	0.025	0.151	412	477	513
275	CPS	MAG	2	56.2	0.006	0.025	0.151	412	477	513
275	HAN	BYC	1	44.7	0.002	0.019	0.112	710	820	881
275	KEL	KPS	1	29	0.001	0.012	0.075	710	820	881
275	KEL	KPS	2	29	0.001	0.012	0.075	710	820	881
275	KEL	MAG	1	31.1	0.001	0.013	0.08	710	820	881
275	KPS	TAN	1	80.8	0.004	0.034	0.206	710	820	881
275	MAG	TMN	1	25.7	0.001	0.011	0.065	710	820	881
275	MAG	TMN	2	25.7	0.001	0.011	0.065	710	820	881
275	TAN	TMN	1	25.7	0.001	0.011	0.065	710	820	881
275	TAN	TMN	2	25.7	0.001	0.011	0.065	710	820	881
220	AD	KRA	1	25.6	0.003	0.022	0.034	393	429	468
220	AD	RAF	1	14.4	0.001	0.009	0.252	434	481	513
220	AD	GGO	1	3.8	0	0.002	0.104	573	536	573
220	AD	KRA	2	25.6	0.001	0.009	0.034	393	429	468
220	ARK	CKM	1	53.6	0.006	0.046	0.081	434	481	513

128 For example, current transformers.

Table B-2: Characteristics of Existing Transmission Circuits

Voltage (kV)	From	To	No.	Length (km)	Impedance on 100 MVA Base (pu)			Rating (MVA)		
					R	X	B	Summer	Autumn	Winter
220	ARK	LWD	1	39	0.005	0.034	0.051	434	481	513
220	BVK	CLA	1	16.8	0.002	0.014	0.025	740	769	792
220	BVK	BYH	1	28.6	0.003	0.025	0.05	434	473	513
220	BLC	FIN (I)	1	10	0	0.002	0.332	570	570	570
220	CLE	CDU	1	5.1	0.001	0.004	0.007	434	481	513
220	CLE	WOO	1	13.5	0.002	0.012	0.018	393	429	468
220	CLA	KRA	1	42.9	0.005	0.037	0.057	646	704	751
220	CSH	FLA	1	88.1	0.01	0.076	0.115	271	295	318
220	CSH	PRO	1	88.5	0.01	0.077	0.116	392	429	468
220	CSH	TYN	1	39.9	0.005	0.034	0.058	761	777	792
220	CKM	DSN	1	41.6	0.005	0.036	0.109	434	481	513
220	CKM	ISH	1	11.9	0	0.005	0.326	593	593	593
220	CUL	GI	1	23.3	0.003	0.02	0.045	746	746	793
220	CUL	KRA	1	86	0.012	0.073	0.117	646	704	765
220	CDU	FIN (I)	1	3.7	0.001	0.003	0.005	434	481	513
220	CDU	HN	1	3.7	0	0.001	0.134	555	555	555
220	CDU	FIN (I)	2	3.7	0.001	0.003	0.005	434	481	513
220	CDU	WOO	2	17.8	0.002	0.015	0.023	434	481	513
220	DSN	KLS	1	59.3	0.007	0.051	0.078	393	429	468
220	DSN	MAY	1	36.3	0.004	0.032	0.048	350	393	436
220	DSN	MAY	2	30.5	0.004	0.026	0.04	350	393	436
220	DSN	TH	1	26.6	0.003	0.022	0.144	351	351	351
220	FLA	LOU	1	110.1	0.013	0.098	0.145	384	430	475
220	FLA	SRA	1	56	0.007	0.047	0.077	434	481	513
220	FIN (I)	SHL	1	13.4	0.001	0.005	0.367	536	557	557
220	FIN (I)	NW	1	11.9	0.001	0.004	0.67	332	332	332
220	GI	KLS	1	70.4	0.008	0.061	0.101	393	429	468
220	GI	LWD	1	48.1	0.006	0.042	0.07	434	481	513
220	GOR	LOU	1	32.4	0.004	0.028	0.042	434	473	476
220	GOR	MAY	1	42.2	0.005	0.037	0.055	350	393	436
220	GGO	RAF	1	9.5	0	0.005	0.414	570	570	570
220	INC	ISH	1	12.1	0	0.005	0.33	562	582	634
220	INC	MAY	2	19.2	0.003	0.016	0.026	793	811	824
220	KNR	BYH	1	37.8	0.005	0.033	0.061	434	473	513
220	KNR	KPG	1	21.4	0.003	0.015	0.054	731	750	762
220	KRA	KLN	1	82.2	0.013	0.069	0.107	512	536	564

Table B-2: Characteristics of Existing Transmission Circuits

Voltage (kV)	From	To	No.	Length (km)	Impedance on 100 MVA Base (pu)			Rating (MVA)		
					R	X	B	Summer	Autumn	Winter
220	KRA	RAF	1	19.3	0.002	0.017	0.026	353	405	454
220	KLN	SH	1	89.7	0.014	0.079	0.12	269	322	354
220	KPG	MP	1	5.4	0	0.002	0.236	660	660	660
220	KPG	TB	1	2.8	0	0.002	0.026	350	393	436
220	LOU	WOO	1	61.2	0.007	0.053	0.08	350	393	436
220	MAY	TH	1	53.1	0.006	0.044	0.184	325	351	351
220	MAY	INC	1	19.1	0.003	0.016	0.026	793	811	824
220	MAY	SH	1	105.6	0.017	0.094	0.142	269	322	354
220	MAY	WOO	1	22.3	0.003	0.02	0.03	350	393	436
220	MP	PRO	1	12.7	0.001	0.011	0.017	393	429	468
220	NW	PB	1	4.5	0	0.001	0.261	332	332	332
220	OST	TYN	1	10	0.001	0.009	0.014	434	481	513
220	PB	CKM	1	14.5	0.001	0.005	0.579	267	267	267
220	PB	INC	1	12.5	0.001	0.004	0.498	267	267	267
220	PB	INC	2	11.3	0.001	0.003	0.722	351	351	351
220	PRO	TB	1	10.2	0.001	0.007	0.173	467	467	467
220	TB	KPG	2	2.8	0	0.002	0.028	350	393	436
110	AA	DRU	1	18.2	0.027	0.063	0.006	99	110	121
110	AA	ENN (I)	1	32.3	0.048	0.111	0.012	99	110	121
110	AA	LIM (I)	1	11.7	0.007	0.037	0.012	161	176	191
110	AD	WHI	1	3.1	0.005	0.011	0.001	99	110	121
110	AGL	DYN	1	8	0.013	0.028	0.003	105	116	123
110	AGL	ENN (I)	1	38.2	0.059	0.131	0.012	99	110	121
110	AGL	SH	1	45.9	0.068	0.157	0.017	104	113	119
110	AHA	KLN	1	3.8	0.004	0.012	0.004	112	112	112
110	ADM	INC	1	10.5	0.009	0.027	0.024	103	123	134
110	ANR	DOO	1	2	0.003	0.007	0.001	105	116	123
110	ARK	BEG	1	21.9	0.01	0.079	0.007	136	150	159
110	ARK	BOG	1	29	0.021	0.095	0.01	178	197	210
110	ARK	SHE	2	2.2	0.003	0.008	0.001	34	46	57
110	ATE	DRO	1	5.5	0.001	0.006	0.06	120	124	140
110	ATE	KNR	1	6.7	0.004	0.021	0.007	178	197	210
110	ATH	LA	1	35.8	0.054	0.123	0.012	99	110	121
110	ATH	SH	1	21.6	0.013	0.07	0.011	107	119	130
110	AUG	CFM	1	0.6	0.001	0.002	0.001	96	96	96
110	AUG	KPG	1	32.8	0.021	0.107	0.012	178	197	210

Table B-2: Characteristics of Existing Transmission Circuits

Voltage (kV)	From	To	No.	Length (km)	Impedance on 100 MVA Base (pu)			Rating (MVA)		
					R	X	B	Summer	Autumn	Winter
110	AUG	MTN	1	27.5	0.017	0.089	0.01	178	197	210
110	AUG	SK	3	1	0.001	0.001	0.006	120	120	120
110	AUG	SK	4	1	0.001	0.001	0.006	120	120	120
110	AUG	CFM	2	0.7	0.001	0.002	0.001	96	96	96
110	ARV	COS	1	43	0.067	0.148	0.014	104	113	123
110	ARV	GWE	1	30.6	0.019	0.099	0.011	178	197	210
110	ARV	NAV	1	65.5	0.041	0.213	0.023	178	197	210
110	ARV	SKL	1	18.5	0.012	0.06	0.007	178	197	210
110	ARV	SKL	2	23.6	0.015	0.076	0.01	178	197	210
110	ART	FIN (I)	1	9	0.005	0.01	0.055	120	120	131
110	ART	MCD	1	4.9	0.003	0.005	0.03	120	120	131
110	BVK	GRO	1	4.9	0.002	0.002	0.054	195	201	220
110	ATY	CLW	1	24.2	0.036	0.083	0.008	99	110	121
110	ATY	PLS	1	25.5	0.038	0.088	0.008	99	110	121
110	BWR	CRA	1	22.4	0.008	0.023	0.137	115	115	115
110	BOL	ENN (I)	1	24.7	0.016	0.08	0.009	178	197	210
110	BOL	TBK T	1	18.3	0.011	0.059	0.007	178	197	210
110	BAL	CDU	1	15.9	0.011	0.055	0.006	178	194	209
110	BAL	DRY	1	20	0.013	0.065	0.007	178	197	210
110	BLI	DMY	1	27.6	0.043	0.094	0.01	105	116	123
110	BEG	CKM	1	32.3	0.015	0.116	0.01	136	150	159
110	CDL	BYH	1	9.5	0.002	0.011	0.105	195	201	220
110	BLK	BLK	1	0.5	0.001	0.002	0	136	150	159
110	BIN	CF	1	34.3	0.053	0.118	0.011	99	110	121
110	BDA	MON	1	11.2	0.01	0.03	0.029	99	110	121
110	BDA	NEW (I)	1	7.2	0.006	0.017	0.028	122	122	122
110	BDN	CUL	1	21.8	0.031	0.075	0.007	196	216	217
110	BDN	DOO	1	11.3	0.007	0.037	0.004	178	197	210
110	BRY	RAF	1	1.7	0.003	0.006	0.001	63	82	92
110	BRY	RAF	2	1.8	0.002	0.006	0.001	99	110	121
110	BK	CBR	1	37.4	0.053	0.128	0.014	195	202	221
110	BK	MOY	1	27	0.017	0.088	0.01	80	105	121
110	BGD	INC	1	6.5	0.005	0.01	0.065	140	140	140
110	BGD	INC	2	6.5	0.005	0.01	0.065	140	140	140
110	BLA	RE	1	7.7	0.003	0.006	0.136	119	119	119

Table B-2: Characteristics of Existing Transmission Circuits

Voltage (kV)	From	To	No.	Length (km)	Impedance on 100 MVA Base (pu)			Rating (MVA)		
					R	X	B	Summer	Autumn	Winter
110	BAN	BRI	1	2.6	0.004	0.009	0.001	105	116	123
110	BAN	DMY	1	25.9	0.04	0.089	0.008	99	110	121
110	BAN	RAF	1	26.9	0.041	0.091	0.012	99	110	121
110	BAN	BRI	2	2.5	0.004	0.009	0.001	99	110	121
110	CLG	CDU	1	2.5	0.001	0.003	0.028	187	206	219
110	CLG	KLN	1	3.6	0.004	0.011	0.007	124	124	124
110	BAR	BAR	1	0.3	0	0.001	0	136	150	159
110	BUT	CUL	1	12.3	0.008	0.038	0.013	178	192	192
110	BUT	KTN	1	2.7	0.004	0.01	0.001	200	209	216
110	KNG	TRI	1	13.6	0.007	0.019	0.099	124	124	124
110	BOG	CRA	1	24.7	0.018	0.081	0.009	178	197	210
110	BGH	CLA	1	13.5	0.008	0.04	0.027	178	197	210
110	CAB	PTN	1	2.7	0.002	0.007	0.005	80	105	119
110	CAB	WOL	1	4.7	0.002	0.005	0.029	120	120	131
110	CLA	CKN	1	30	0.019	0.096	0.015	178	190	190
110	CLA	DMY	1	38.8	0.024	0.126	0.015	178	197	210
110	CLA	MAC	1	5.7	0.004	0.018	0.002	161	176	191
110	CKN	KER	1	20.3	0.013	0.066	0.007	178	197	210
110	CRO	IA	1	2.7	0.004	0.01	0.001	196	216	217
110	CRO	KBY	1	14.4	0.02	0.049	0.005	178	194	200
110	CDY	GRV	1	5.8	0.004	0.019	0.003	132	137	150
110	CDY	SRA	1	12.6	0.02	0.043	0.004	99	110	121
110	CDY	ARI T	1	13.7	0.009	0.045	0.005	178	197	210
110	CSH	CLN	1	22.8	0.014	0.074	0.008	178	197	210
110	CSH	DLT	1	60.8	0.075	0.205	0.02	99	110	121
110	CSH	ENN (I)	1	53.5	0.034	0.174	0.019	178	197	210
110	CSH	GAL	1	13.8	0.021	0.047	0.004	99	110	121
110	CSH	GAL	2	11.3	0.018	0.039	0.004	99	110	121
110	CSH	GAL	3	11.3	0.018	0.039	0.004	99	110	121
110	CSH	SAL	1	24.9	0.024	0.074	0.068	97	97	97
110	CSH	SOM	1	50	0.078	0.172	0.016	99	110	121
110	CLH	TRI	1	9	0.014	0.031	0.003	99	110	121
110	CLH	TRL	1	13.5	0.02	0.045	0.013	105	114	123
110	CBR	CLN	1	57.5	0.089	0.198	0.02	99	110	121
110	CBR	CBG	1	26.7	0.035	0.078	0.059	99	110	121
110	CBR	DLT	1	27.8	0.043	0.095	0.009	74	83	91

Table B-2: Characteristics of Existing Transmission Circuits

Voltage (kV)	From	To	No.	Length (km)	Impedance on 100 MVA Base (pu)			Rating (MVA)		
					R	X	B	Summer	Autumn	Winter
110	CD	KBY	1	32.1	0.02	0.104	0.011	178	197	210
110	CD	MAC	1	2.4	0.002	0.008	0.001	178	197	210
110	CPK	TNY	1	5.6	0.003	0.006	0.072	100	100	100
110	CPK	CPK	1	3.4	0.002	0.004	0.025	100	100	100
110	CF	CL	1	5.5	0.006	0.018	0.002	136	150	159
110	CF	COR	1	61.3	0.039	0.199	0.022	135	147	159
110	CF	SRA	1	53	0.065	0.179	0.021	136	150	159
110	CF	CLO	2	25.7	0.039	0.088	0.009	178	194	209
110	CRM	KLM	2	1.4	0.001	0.002	0.014	140	140	140
110	CAH	DOO	1	15.7	0.01	0.051	0.006	178	197	210
110	CAH	KHL	1	18	0.011	0.058	0.006	178	197	210
110	CAH	TIP	1	18.1	0.011	0.059	0.006	178	197	210
110	CAH	BAR	1	43.7	0.065	0.15	0.014	105	116	123
110	CRM	KLM	1	1.4	0.001	0.002	0.014	140	140	140
110	CKM	CHE	1	4	0.004	0.008	0.03	105	116	123
110	CKM	POT	1	3.2	0.001	0.002	0.057	119	119	119
110	BRA	NEW (I)	1	9.3	0.01	0.031	0.003	136	150	159
110	BRA	PLS	1	19.3	0.03	0.067	0.006	99	110	121
110	COO	BCT	1	15.1	0.014	0.045	0.027	130	130	130
110	COO	CKM	2	16	0.013	0.042	0.06	130	130	130
110	CLN	LA	1	64.8	0.095	0.222	0.021	63	78	92
110	SCR	KNY	1	33.3	0.031	0.108	0.04	135	147	159
110	CRA	LWD	1	6.7	0.004	0.022	0.004	178	197	210
110	CRA	WEX	1	22.8	0.024	0.076	0.008	99	110	113
110	COS	FLA	1	3.4	0.005	0.012	0.001	99	110	121
110	COS	FLA	2	3.3	0.005	0.011	0.001	99	110	121
110	COS	ARI T	1	20.7	0.013	0.065	0.007	178	197	210
110	COL (I)	KLN	1	5	0.003	0.013	0.037	104	124	124
110	COL (I)	CDU	1	2.7	0.001	0.004	0.02	143	143	143
110	CHA	GLE	1	28.1	0.042	0.097	0.009	99	110	121
110	CHA	KLN	1	36.9	0.038	0.123	0.013	136	150	159
110	CHA	MAL	1	22.5	0.014	0.073	0.008	178	197	210
110	CLW	KLS	1	5.4	0.008	0.019	0.002	99	110	121
110	CLW	KLS	2	5.3	0.008	0.019	0.002	99	110	121
110	CLW	STR	1	17.6	0.027	0.061	0.006	105	116	123
110	COW	CVW	1	17.2	0.025	0.054	0.018	99	110	121

Table B-2: Characteristics of Existing Transmission Circuits

Voltage (kV)	From	To	No.	Length (km)	Impedance on 100 MVA Base (pu)			Rating (MVA)		
					R	X	B	Summer	Autumn	Winter
110	COW	OLD	1	2.3	0.004	0.008	0.001	105	116	123
110	COW	OLD	2	2.2	0.003	0.008	0.001	105	116	123
110	COW	RAF	1	6.9	0.01	0.024	0.003	99	110	121
110	COW	WHI	1	17.8	0.027	0.062	0.006	99	110	121
110	CUN	GLR	1	26.3	0.039	0.09	0.009	178	194	209
110	CUN	SLI	1	21.1	0.03	0.073	0.007	178	194	209
110	CUS	MLC	1	13.7	0.015	0.048	0.005	136	150	159
110	CUS	NEW (I)	1	24.6	0.026	0.082	0.008	134	147	152
110	CUS	PLS	1	42.1	0.044	0.14	0.014	136	150	159
110	CVW	KRA	1	7.6	0.012	0.026	0.004	99	110	121
110	CGL	CKN	1	6.3	0.004	0.021	0.003	178	190	190
110	COR	GWE	1	10.9	0.007	0.036	0.004	178	197	210
110	COR	ENN (N)	1	27.5	0.041	0.095	0.009	99	110	121
110	CDK	LWD	1	8.4	0.003	0.009	0.051	115	115	115
110	CUL	DGN	1	34.2	0.021	0.109	0.02	178	192	192
110	CUL	WAT	1	13.1	0.007	0.03	0.055	178	194	200
110	CTY	INC	1	8.9	0.011	0.03	0.003	103	116	123
110	CDU	MUL	1	73.3	0.093	0.242	0.038	104	113	122
110	CDU	PLA	1	37	0.023	0.12	0.013	178	197	210
110	CDU	RYB	1	13	0.009	0.027	0.035	103	123	128
110	KNY	UGL	1	3.4	0.001	0.004	0.04	195	201	220
110	KNY	GAL	1	26.5	0.005	0.031	0.138	99	110	121
110	KNY	KLH	1	11.7	0.003	0.015	0.107	190	190	190
110	KNY	SAL	1	22.7	0.019	0.063	0.081	195	201	220
110	DDK	MLN	1	7.5	0.012	0.026	0.002	99	110	121
110	DDK	LOU	1	16.8	0.026	0.058	0.005	99	110	121
110	DRU	ENN (I)	1	17.4	0.027	0.06	0.006	99	110	121
110	DGN	WHO	1	8.6	0.006	0.028	0.003	178	197	210
110	DRY	GOR	1	19.4	0.029	0.067	0.006	99	110	121
110	DRY	LOU	1	31.9	0.02	0.104	0.011	99	110	121
110	DRY	PLA	1	5.3	0.008	0.018	0.002	99	110	121
110	DMY	MAC	1	26.2	0.039	0.09	0.009	196	213	217
110	DAL	DAL	1	12.2	0.019	0.042	0.004	105	116	123
110	DTN	FIN (I)	1	9.2	0.002	0.014	0.111	140	140	140
110	DTN	KLM	1	3.2	0.002	0.005	0.032	140	140	140

Table B-2: Characteristics of Existing Transmission Circuits

Voltage (kV)	From	To	No.	Length (km)	Impedance on 100 MVA Base (pu)			Rating (MVA)		
					R	X	B	Summer	Autumn	Winter
110	DER	KIN	1	15.1	0.012	0.05	0.005	99	110	121
110	DER	MAY	1	43.4	0.028	0.146	0.018	74	84	93
110	DER	TSB	1	19.7	0.031	0.068	0.006	99	110	121
110	DRM	LET	1	8.3	0.013	0.028	0.003	99	110	123
110	DRM	MEE	1	5	0.008	0.017	0.002	99	110	121
110	DRM	CLO	1	27	0.039	0.091	0.015	103	116	123
110	ENN (I)	SLC	1	31	0.003	0.047	0.271	195	201	220
110	KHL	THU	1	21.2	0.013	0.069	0.007	178	197	210
110	MLC	TSB	1	18.3	0.016	0.056	0.028	135	147	159
110	CKG	BKY	1	3	0.001	0.003	0.033	187	206	223
110	FAS	FAS	1	5	0.008	0.017	0.002	105	116	123
110	FAS	CKM	1	7.5	0.012	0.026	0.002	105	116	123
110	FLA	GIL	1	10.6	0.016	0.036	0.003	105	116	123
110	FLA	SLI	1	50.5	0.079	0.174	0.016	99	110	121
110	FLA	TON	1	32.3	0.05	0.111	0.01	98	111	126
110	FLA	SLB	1	21.7	0.034	0.075	0.007	99	110	123
110	FRA	HAR	1	2.3	0.002	0.004	0.03	107	107	107
110	FRA	TRN	1	2.8	0.002	0.004	0.028	140	140	140
110	FRA	HEU	1	2.4	0.002	0.004	0.024	140	140	140
110	FRA	INC	1	5.6	0.004	0.01	0.073	107	107	107
110	FIN (I)	MCD	1	7.9	0.003	0.007	0.141	119	119	119
110	FIN (I)	PTN	1	3.5	0.003	0.01	0.006	80	105	119
110	FIN (I)	GLA	1	14	0.022	0.048	0.005	105	116	123
110	FIN (I)	GRA	1	13.2	0.005	0.012	0.236	119	119	119
110	FIN (I)	POP	1	4.3	0.002	0.005	0.026	120	120	131
110	FIN (I)	SVN	1	32.2	0.039	0.104	0.056	105	115	115
110	FTT	COO	1	4.4	0.004	0.011	0.019	124	124	132
110	GLA	SVN	1	18	0.017	0.055	0.052	136	150	154
110	GRI	GRI	1	1	0.002	0.004	0	105	116	123
110	GI	KKY	1	49.2	0.076	0.169	0.016	99	110	121
110	GI	WAT	1	11.7	0.007	0.038	0.004	178	197	210
110	GI	WAT	2	12.9	0.008	0.042	0.005	178	197	210
110	GI	WEX	1	34.5	0.022	0.112	0.012	99	197	210
110	GRA	NBY	1	5.1	0.002	0.005	0.089	119	119	119
110	GRO	CKN	1	15.2	0.009	0.008	0.137	120	120	120
110	GAL	SAL	1	6.1	0.003	0.003	0.067	99	106	106

Table B-2: Characteristics of Existing Transmission Circuits

Voltage (kV)	From	To	No.	Length (km)	Impedance on 100 MVA Base (pu)			Rating (MVA)		
					R	X	B	Summer	Autumn	Winter
110	GOL	GL T	1	3.9	0.006	0.014	0.001	105	116	123
110	GOR	MTH	1	26.4	0.026	0.087	0.012	99	110	121
110	GOR	NAV	1	5.3	0.008	0.019	0.002	99	110	121
110	GOR	NAV	2	6.3	0.009	0.022	0.002	99	110	121
110	GOR	NAV	3	5.5	0.005	0.017	0.007	99	110	121
110	GOR	PLA	1	19.7	0.03	0.068	0.006	99	110	121
110	GCA	INC	1	8.1	0.008	0.025	0.009	103	123	134
110	GCA	INC	2	8.1	0.008	0.025	0.009	103	123	134
110	GCA	KUD	2	2.1	0.002	0.003	0.021	140	140	140
110	GCA	NAN	1	1.8	0.001	0.002	0.011	120	120	131
110	GCA	NAN	2	1.7	0.001	0.002	0.011	120	120	131
110	CLO	MRY	1	7.7	0.002	0.009	0.09	136	136	136
110	CLO	CF	1	26.1	0.016	0.088	0.016	178	194	209
110	GLT	BYH	1	9.3	0.006	0.03	0.003	178	197	210
110	HAR	RE	1	5.6	0.004	0.01	0.073	107	107	107
110	HEU	INC	1	3.6	0.003	0.005	0.036	140	140	140
110	IA	MAC	1	18.2	0.027	0.062	0.006	196	213	217
110	INC	MIL	1	8.4	0.004	0.009	0.051	120	120	131
110	INC	BKY	1	10	0.002	0.011	0.11	187	206	223
110	KNR	KPG	1	14.9	0.015	0.05	0.005	136	150	159
110	KNR	TRI	1	4.3	0.003	0.013	0.005	178	194	209
110	KNR	TRI	2	4.2	0.004	0.013	0.004	99	110	121
110	KRA	KBY	1	11.9	0.008	0.039	0.004	178	197	210
110	KRA	BAR	1	19.5	0.02	0.065	0.007	136	150	159
110	KRA	MID	1	10.7	0.017	0.037	0.004	99	110	121
110	KRA	WHO	1	41.5	0.026	0.135	0.015	178	197	210
110	KRA	KBY	2	12.5	0.018	0.043	0.004	99	110	121
110	KTL	MAY	1	21.4	0.022	0.072	0.007	99	110	121
110	KTL	MON	1	8.9	0.009	0.03	0.003	136	150	159
110	REM	TRL	1	12	0.005	0.003	0.11	125	130	141
110	KKY	KLS	1	34.3	0.053	0.118	0.011	99	110	121
110	KLN	LIM (I)	1	9	0.014	0.031	0.003	99	110	121
110	KLN	CUR	1	14.8	0.011	0.048	0.005	136	150	159
110	KLN	SNG	1	4.1	0.003	0.013	0.003	135	147	159
110	KER	OUG T	1	22.6	0.014	0.073	0.008	178	197	210
110	KUR	NAV	1	6.1	0.009	0.021	0.002	99	110	123

Table B-2: Characteristics of Existing Transmission Circuits

Voltage (kV)	From	To	No.	Length (km)	Impedance on 100 MVA Base (pu)			Rating (MVA)		
					R	X	B	Summer	Autumn	Winter
110	BYH	GLE	1	19.1	0.006	0.022	0.186	124	124	124
110	KIN	MUL	1	24.9	0.015	0.077	0.023	178	197	210
110	KIN	DFR	1	29.3	0.021	0.096	0.01	99	110	121
110	KCR	GLE	1	11.3	0.003	0.013	0.124	122	122	122
110	KTN	WAT	1	3.3	0.001	0.003	0.039	99	110	121
110	KLM	NBY	1	1.2	0.001	0.001	0.02	119	119	119
110	KLM	POP	1	6	0.003	0.007	0.036	120	120	131
110	KPG	RAT (I)	1	32.4	0.033	0.107	0.018	136	150	159
110	KPG	TRL	1	39.4	0.06	0.135	0.013	99	110	121
110	KPG	TRL	2	43.6	0.027	0.14	0.023	178	190	190
110	LA	MUL	1	46.3	0.072	0.16	0.015	99	110	121
110	LA	RIC	1	15.7	0.024	0.054	0.007	99	110	123
110	LA	RIC	2	12.5	0.02	0.043	0.005	99	110	123
110	LA	SLB	1	9.1	0.014	0.031	0.003	99	110	123
110	LOU	MLN	1	13	0.02	0.045	0.004	99	110	121
110	LOU	RRU	1	38.8	0.058	0.133	0.014	95	103	112
110	LIM (I)	MTN	1	6.5	0.005	0.024	0.003	178	197	210
110	LIM (I)	RAT (I)	1	28.4	0.041	0.096	0.012	99	110	121
110	LIM (I)	KLN	2	11.7	0.018	0.04	0.009	80	95	110
110	LIS	SKL	1	39.3	0.061	0.135	0.013	99	110	123
110	LIS	LOU	1	40.4	0.063	0.139	0.013	99	110	123
110	LET	TLK	1	34	0.051	0.117	0.012	105	116	123
110	LET	GLT	1	38.4	0.058	0.132	0.014	99	110	121
110	LET	STR (N)	1	22.3	0.035	0.076	0.007	99	110	123
110	LIB	MR	1	2.7	0.001	0.003	0.016	100	100	100
110	LIB	MR	2	2.7	0.002	0.003	0.017	99	110	119
110	LSN	THU	1	10.4	0.016	0.036	0.003	104	113	122
110	CUR	NEN	1	18.8	0.029	0.065	0.006	105	116	123
110	CUR	BKM	1	17.3	0.004	0.019	0.192	190	190	190
110	MHL	RE	1	3	0.002	0.004	0.03	140	140	140
110	MHL	TRN	1	1.4	0.001	0.002	0.014	140	140	140
110	MCE	SBH	1	4.7	0.005	0.015	0.005	99	110	121
110	MCE	CDU	1	4.1	0.003	0.01	0.016	98	111	124
110	MCD	WOL	1	1.4	0.001	0.002	0.009	120	120	131
110	MID	WHI	1	20	0.03	0.069	0.007	99	110	121

Table B-2: Characteristics of Existing Transmission Circuits

Voltage (kV)	From	To	No.	Length (km)	Impedance on 100 MVA Base (pu)			Rating (MVA)		
					R	X	B	Summer	Autumn	Winter
110	MTH	LOU	1	15.1	0.023	0.052	0.005	99	110	121
110	MAY	GRI	1	2.2	0.002	0.007	0.002	99	110	120
110	MAY	GRI	1	2.2	0.003	0.009	0.001	105	116	123
110	MAY	RYB	1	9	0.009	0.03	0.005	178	197	219
110	MAY	RNW	1	7.1	0.008	0.024	0.002	80	92	103
110	MAY	BLK	1	30.9	0.032	0.103	0.011	99	110	121
110	MIL	RE	1	4.9	0.003	0.005	0.075	100	100	100
110	MIL	RE	2	5.6	0.003	0.006	0.034	120	120	131
110	MTN	MUN	1	0.7	0.001	0.002	0	105	116	123
110	MTN	MUN	2	0.7	0.001	0.002	0	105	116	123
110	MP	TBK T	1	7.3	0.005	0.024	0.003	178	197	210
110	MR	TBG	1	3.3	0.001	0.002	0.036	178	198	219
110	MR	TBG	2	2.8	0.001	0.001	0.031	178	206	219
110	MR	KBY	1	4	0.004	0.013	0.003	109	119	130
110	MR	KBY	2	4	0.004	0.013	0.003	103	119	130
110	MAL	KBY	1	29.2	0.018	0.095	0.01	134	147	159
110	MOY	GLR	1	14	0.022	0.048	0.004	99	110	121
110	MOY	TAW	1	8.4	0.013	0.028	0.004	99	110	121
110	MOY	TAW	2	8.3	0.012	0.029	0.004	99	110	121
110	BCT	CKM	1	3.1	0.002	0.005	0.031	140	140	140
110	NEW (I)	BLK	1	12.2	0.013	0.041	0.004	136	150	159
110	NQS	RE	1	2.1	0.001	0.002	0.038	119	119	119
110	OUG	OUG T	1	11	0.017	0.038	0.004	105	116	123
110	PA	STR	1	22.4	0.035	0.077	0.007	105	116	123
110	PB	RE	3	1.4	0	0.002	0.046	269	269	269
110	PB	RE	4	1.4	0	0.002	0.046	269	269	269
110	PLS	DAL	1	54.7	0.034	0.178	0.019	178	197	210
110	RE	PB	1	1.2	0.001	0.001	0.016	112	112	112
110	RAF	TBG	1	11	0.016	0.037	0.005	178	194	209
110	RAF	RSY	1	2.1	0.003	0.007	0.001	63	82	92
110	RAF	TBG	2	9.5	0.006	0.031	0.005	99	110	121
110	RNW	DFR	1	25.9	0.02	0.085	0.009	99	110	121
110	RRU	SKL	1	12.7	0.02	0.044	0.004	95	103	112
110	SH	DAL	1	12	0.007	0.039	0.007	178	197	210
110	SH	IKE T	1	53.9	0.034	0.175	0.019	178	197	210
110	SH	SOM	1	13.8	0.021	0.047	0.006	105	116	123

Table B-2: Characteristics of Existing Transmission Circuits

Voltage (kV)	From	To	No.	Length (km)	Impedance on 100 MVA Base (pu)			Rating (MVA)		
					R	X	B	Summer	Autumn	Winter
110	SLI	SRA	1	11.1	0.017	0.038	0.004	99	110	121
110	SLI	SRA	2	12	0.019	0.041	0.004	99	110	121
110	SOR	TLK	1	4.4	0.007	0.015	0.002	105	116	123
110	SOM	SOM	1	2	0.003	0.007	0.001	105	116	123
110	SRA	CF	2	49.2	0.031	0.16	0.017	178	197	210
110	STR	STR	1	2	0.003	0.007	0.001	105	116	123
110	SNG	AA	1	5.5	0.003	0.017	0.007	178	197	210
110	SBH	CDU	1	1.8	0	0.003	0.015	238	238	238
110	TBK	TBK T	1	2.9	0.005	0.01	0.001	105	116	123
110	CTN	KLN	1	29.2	0.018	0.095	0.01	178	197	210
110	CTN	TIP	1	13.1	0.008	0.043	0.005	178	197	210
110	TRL	OUG T	1	11.3	0.007	0.037	0.004	178	197	210
110	THU	IKE T	1	25.7	0.016	0.083	0.009	178	197	210
110	CKM	FAS	1	2.9	0.005	0.01	0.001	105	116	123
110	BKM	CUR	1	7.3	0.004	0.007	0.072	120	120	120
110	AGH	ENN (N)	1	31.1	0.039	0.095	0.019	109	114	124
110	ANT	KEL	1	8.9	0.012	0.03	0.003	82	95	103
110	ANT	KEL	2	8.9	0.012	0.03	0.003	82	95	103
110	BPS	BVG	1	17.3	0.023	0.058	0.006	82	95	103
110	BPS	BVG	2	17.3	0.023	0.058	0.006	82	95	103
110	BPS	EDE	1	15.1	0.023	0.054	0.005	69	80	86
110	BPS	EDE	2	15.1	0.023	0.053	0.005	70	81	87
110	BMA	KEL	1	10	0.013	0.035	0.003	109	119	124
110	BMA	KEL	2	11.5	0.015	0.04	0.004	109	119	124
110	BAN	TAN	1	18.4	0.024	0.062	0.006	82	95	103
110	BAN	TAN	2	18.4	0.019	0.049	0.005	82	95	103
110	BVG	KEL	1	21.2	0.028	0.073	0.007	109	119	124
110	BVG	KEL	2	20.3	0.027	0.07	0.007	109	119	124
110	BVG	LAR	1	7.1	0.007	0.023	0.002	79	79	113
110	BVG	LAR	2	7.1	0.007	0.023	0.002	79	79	113
110	BNH	CAS	1	21.2	0.028	0.071	0.007	82	95	103
110	BNH	CAS	2	21.2	0.028	0.071	0.007	82	95	103
110	BNM	DON	1	6	0.005	0.005	0.053	75	75	82
110	BNM	DON	2	5.8	0.005	0.005	0.053	75	75	82
110	BRO	RSK	1	17.4	0.01	0.062	0.02	144	144	144

Table B-2: Characteristics of Existing Transmission Circuits

Voltage (kV)	From	To	No.	Length (km)	Impedance on 100 MVA Base (pu)			Rating (MVA)		
					R	X	B	Summer	Autumn	Winter
110	CAR	CAS	1	24.7	0.037	0.087	0.008	69	80	166
110	CAR	EDE	1	12.4	0.019	0.043	0.004	69	80	166
110	CAR	CAS	2	24.7	0.037	0.086	0.008	70	81	166
110	CAR	EDE	2	12.4	0.019	0.044	0.004	69	80	166
110	CAS	CRE	1	3	0.001	0.004	0.061	132	132	145
110	CAS	CRE	2	3	0.001	0.004	0.061	132	132	145
110	CAS	KNO	1	4.6	0.005	0.004	0.044	66	66	73
110	CAS	KNO	2	4.5	0.005	0.004	0.044	66	66	73
110	CAS	NAR	1	18	0.015	0.04	0.071	109	109	124
110	CAS	NAR	2	19.8	0.018	0.046	0.07	109	124	124
110	CAS	RAT (N)	1	18.9	0.025	0.064	0.006	82	95	103
110	CAS	RAT (N)	2	18.9	0.025	0.064	0.006	82	95	103
110	CAS	ROS	1	1.8	0.001	0.003	0.015	144	144	152
110	CAS	ROS	2	1.8	0.001	0.003	0.015	144	144	152
110	CEN	CRE	1	3.2	0.001	0.004	0.03	144	144	144
110	CEN	CRE	2	3.2	0.001	0.004	0.03	144	144	144
110	COL (N)	CPS	1	46.7	0.061	0.161	0.015	82	95	103
110	COL (N)	LIM (N)	1	18.6	0.024	0.064	0.006	82	95	103
110	COL (N)	LOG	1	8.1	0.011	0.027	0.003	82	95	103
110	COL (N)	LOG	2	8.1	0.011	0.027	0.003	82	95	103
110	COL (N)	RSK	1	20	0.024	0.069	0.007	186	191	193
110	CPS	KMT	1	14.5	0.011	0.048	0.005	143	158	166
110	CPS	LIM (N)	1	29.5	0.039	0.101	0.01	82	95	103
110	CPS	LMR	1	9	0.012	0.03	0.003	82	95	103
110	CPS	LMR	2	9	0.012	0.03	0.003	82	95	103
110	CPS	SPR	1	9.2	0.011	0.029	0.012	82	95	103
110	CPS	SPR	2	9.4	0.011	0.029	0.013	82	95	103
110	CPS	STR (N)	1	27	0.018	0.053	0.017	109	119	124
110	CRG	KEL	1	23.1	0.029	0.077	0.013	82	95	103
110	CRG	TMN	1	36.2	0.045	0.119	0.022	109	114	124
110	DON	HAN	1	6.1	0.002	0.005	0.14	144	144	158
110	DON	HAN	2	5.9	0.002	0.005	0.14	144	144	158
110	DON	FIN (N)	1	3.7	0.004	0.011	0.008	69	81	86
110	DON	FIN (N)	2	3.7	0.004	0.011	0.007	69	80	86

Table B-2: Characteristics of Existing Transmission Circuits

Voltage (kV)	From	To	No.	Length (km)	Impedance on 100 MVA Base (pu)			Rating (MVA)		
					R	X	B	Summer	Autumn	Winter
110	DRO (N)	DRQ	1	8.9	0.007	0.045	0.004	167	167	188
110	DRO (N)	ENN (N)	1	24.6	0.026	0.066	0.007	82	95	103
110	DRO (N)	ENN (N)	2	24.6	0.026	0.066	0.007	82	95	103
110	DRO (N)	OMA	1	9.2	0.018	0.047	0.005	82	95	103
110	DRO (N)	OMA	2	9.2	0.018	0.047	0.005	82	95	103
110	DRU (N)	TAN	1	4.4	0.004	0.014	0.002	79	96	113
110	DRU (N)	TAN	2	4.4	0.004	0.014	0.002	79	96	113
110	DRU (N)	TAN	3	4.1	0.005	0.014	0.001	108	119	126
110	DRU (N)	TMN	1	22.7	0.029	0.075	0.008	109	119	124
110	DRU (N)	TMN	2	21.5	0.028	0.073	0.012	109	119	124
110	DUN	TMN	1	6.5	0.004	0.017	0.005	157	171	178
110	DUN	TMN	2	5.8	0.009	0.023	0.002	144	144	144
110	DUN	OMA	1	36.1	0.042	0.124	0.012	186	191	193
110	DUN	TMN	3	6	0.004	0.02	0.019	186	191	193
110	FIN (N)	HAN	1	3	0.001	0.003	0.022	144	144	144
110	FIN (N)	HAN	2	3.2	0.001	0.003	0.022	144	144	144
110	GLE (N)	KEL	1	21.4	0.027	0.068	0.027	82	82	90
110	GLE (N)	KEL	2	21.4	0.027	0.068	0.027	82	82	90
110	GOR (N)	OMA	1	17.1	0.011	0.066	0.006	188	200	200
110	GOR (N)	TMN	1	34.8	0.021	0.131	0.013	188	200	200
110	HAN	LIS (N)	1	9.2	0.01	0.026	0.018	82	95	103
110	HAN	LIS (N)	2	9.2	0.009	0.026	0.018	80	93	100
110	KEL	RSK	1	25.9	0.039	0.133	0.013	185	190	193
110	KMT	SLK	1	6.2	0.007	0.018	0.006	109	119	124

Table B-2: Characteristics of Existing Transmission Circuits

Voltage (kV)	From	To	No.	Length (km)	Impedance on 100 MVA Base (pu)			Rating (MVA)		
					R	X	B	Summer	Autumn	Winter
110	KMT	STR (N)	1	11.2	0.008	0.037	0.004	143	158	166
110	LIS (N)	TAN	1	31	0.04	0.106	0.01	82	95	103
110	LIS (N)	TAN	2	29.2	0.034	0.1	0.009	80	93	100
110	MKL	OMA	1	37.5	0.028	0.113	0.015	139	150	157
110	NEW (N)	TAN	1	24.1	0.031	0.08	0.008	82	95	103
110	NEW (N)	TAN	2	24	0.031	0.08	0.008	82	95	103
110	OMA	STR (N)	1	35.5	0.046	0.123	0.012	109	119	124
110	OMA	STR (N)	2	35.5	0.047	0.125	0.012	82	95	103
110	OMA	TRE	1	21.4	0.025	0.073	0.007	186	191	193
110	TAN	WAR	1	12.9	0.013	0.042	0.005	79	96	113
110	TAN	WAR	2	12.9	0.013	0.042	0.005	79	96	113
110	TRE	TMN	1	42.9	0.025	0.082	0.025	186	191	193

Table B-3: Characteristics of Existing Transformers in Ireland

Station	Transformer	Rating (MVA)	HV/LV (kV)	Impedance on 100 MVA Base (pu)		Voltage Ratio Tapping Range	
				R	X	+	-
DSN	T4201	500	400/220	0.0002	0.0317	1%	15%
DSN	T4202	500	400/220	0.0003	0.0270	10%	7%
MP	T4201	500	400/220	0.0003	0.0270	10%	7%
MP	T4202	500	400/220	0.0002	0.0329	3%	13%
OST	T4201	500	400/220	0.0003	0.0270	10%	7%
WOO	T4201	500	400/220	0.0002	0.0316	7%	9%
WOO	T4202	550	400/220	0.0002	0.0270	N/A	
WOO	T4204	500	400/220	0.0002	0.0316	7%	9%
LOU	AT1	300	275/220	0.0008	0.0300	15%	15%
LOU	AT2	600	275/220	0.0008	0.0150	15%	15%
LOU	AT3	300	275/220	0.0008	0.0303	15%	15%
AD	T2101	125	220/110	0.0010	0.1240	10%	18%
ARK	T2101	63	220/110	0.0070	0.1800	23%	18%
ARK	T2102	125	220/110	0.0021	0.1237	11%	16%
BYH	T2101	250	220/110	0.0010	0.0646	9%	17%
BVS	T2101	250	220/110	0.0010	0.0640	9%	17%
BVS	T2102	250	220/110	0.0010	0.0640	9%	17%
BYH	T2102	250	220/110	0.0010	0.0640	9%	17%
CDU	T2101	250	220/110	0.0009	0.0615	9%	17%
CDU	T2102	250	220/110	0.0007	0.0610	9%	17%
CKM	T2101	250	220/110	0.0010	0.0646	9%	17%
CKM	T2102	250	220/110	0.0010	0.0646	9%	17%
CKM	T2103	250	220/110	0.0010	0.0646	9%	17%
CKM	T2104	250	220/110	0.0004	0.0631	9%	18%
CLA	T2101	250	220/110	0.0013	0.0647	10%	9%
CLA	T2102	250	220/110	0.0013	0.0647	9%	17%
CSH	T2101	238	220/110	0.0004	0.0631	9%	18%
CSH	T2102	250	220/110	0.0004	0.0631	9%	18%
CSH	T2104	175	220/110	0.0021	0.1332	22%	18%
CUL	T2101	250	220/110	0.0005	0.0640	9%	18%
FIN	T2101	250	220/110	0.0013	0.0651	9%	18%
FIN	T2102	250	220/110	0.0013	0.0648	9%	18%
FIN	T2103	250	220/110	0.0010	0.0640	9%	17%
FIN	T2104	250	220/110	0.0010	0.0638	9%	17%
FIN	T2105	250	220/110	0.0010	0.0640	9%	17%
FLA	T2101	125	220/110	0.0027	0.1280	9%	18%
FLA	T2102	125	220/110	0.0008	0.1331	9%	18%

Table B-3: Characteristics of Existing Transformers in Ireland

Station	Transformer	Rating (MVA)	HV/LV (kV)	Impedance on 100 MVA Base (pu)		Voltage Ratio Tapping Range	
				R	X	+	-
GI	T2101	125	220/110	0.0026	0.1331	9%	18%
GI	T2102	125	220/110	0.0023	0.1237	22%	18%
GOR	T2101	250	220/110	0.0010	0.0640	9%	18%
INC	T2101	250	220/110	0.0010	0.0564	9%	17%
INC	T2102	250	220/110	0.0010	0.0564	9%	17%
INC	T2103	250	220/110	0.0001	0.0600	9%	18%
INC	T2104	250	220/110	0.0001	0.0600	9%	18%
KLN	T2101	63	220/110	0.0065	0.2453	26%	15%
KLN	T2102	63	220/110	0.0095	0.2473	26%	15%
KLN	T2103	250	220/110	0.0004	0.0631	9%	18%
KLN	T2104	120	220/110	0.0010	0.1230	12%	15%
KLS	T2101	125	220/110	0.0013	0.1237	12%	15%
KLS	T2102	125	220/110	0.0008	0.1237	12%	15%
KNR	T2101	250	220/110	0.0010	0.0640	9%	17%
KNR	T2102	250	220/110	0.0010	0.0640	9%	17%
KPG	T2101	250	220/110	0.0004	0.0631	9%	18%
KPG	T2102	250	220/110	0.0004	0.0631	9%	18%
KRA	T2101	250	220/110	0.0013	0.0647	9%	17%
KRA	T2102	250	220/110	0.0013	0.0652	9%	17%
KRA	T2103	250	220/110	0.0013	0.0652	9%	17%
LDW	T2101	250	220/110	0.0010	0.0640	9%	18%
LOU	T2101	125	220/110	0.0022	0.1331	26%	14%
LOU	T2102	125	220/110	0.0022	0.1324	26%	14%
LOU	T2103	125	220/110	0.0023	0.1324	26%	14%
LOU	T2104	250	220/110	0.0010	0.0640	9%	17%
MAY	T2101	125	220/110	0.0021	0.1339	22%	18%
MAY	T2102	238	220/110	0.0010	0.0640	9%	17%
MAY	T2103	125	220/110	0.0021	0.1324	22%	18%
MAY	T2104	250	220/110	0.0010	0.0640	9%	17%
MP	T2101	250	220/110	0.0010	0.0640	9%	17%
PB	T2103	250	220/110	0.0013	0.0590	8%	17%
PB	T2104	250	220/110	0.0013	0.0609	8%	17%
RAF	T2101	238	220/110	0.0010	0.0640	9%	17%
RAF	T2102	250	220/110	0.0004	0.0558	9%	17%
SH	T2101	125	220/110	0.0057	0.1237	9%	18%
SH	T2102	125	220/110	0.0013	0.1237	9%	18%
SRA	T2101	250	220/110	0.0010	0.0640	9%	18%

Table B-3: Characteristics of Existing Transformers in Ireland

Station	Transformer	Rating (MVA)	HV/LV (kV)	Impedance on 100 MVA Base (pu)		Voltage Ratio Tapping Range	
				R	X	+	-
TB	T2101	238	220/110	0.0010	0.0554	9%	17%
TB	T2102	238	220/110	0.0010	0.0554	9%	17%

Table B-4: Characteristics of Existing 3 Winding Transformers in Northern Ireland

Substation/ Transformer	HV/ LV	Impedance pu on 100 MVA base						Rating (MVA)			Off Nominal Ratio (pu)		No. of Taps
		W1-2		W2-3		W3-1							
		R	X	R	X	R	X	W1	W2	W3	Upper	Lower	
BPS IBTx 1	275/ 110	0.0018	0.0641	0.0018	0.2092	0	0.1325	240	240	30	1.15	0.85	19
BPS IBTx 2	275/ 110	0.0018	0.0641	0.0018	0.2059	0	0.128	240	240	30	1.15	0.85	19
CAS IBTx 1	275/ 110	0.0018	0.0641	0.0018	0.2092	0	0.1325	240	240	60	1.15	0.85	19
CAS IBTx 2	275/ 110	0.0014	0.0639	0.0014	0.2236	0	0.1449	240	240	30	1.15	0.85	19
CAS IBTx 3	275/ 110	0.0018	0.0656	0.0018	0.2375	0	0.1593	240	240	30	1.15	0.85	19
CPS IBTx 1	275/ 110	0.0018	0.0609	0.0018	0.1273	0	0.057	240	240	60	1.15	0.85	19
CPS IBTx 2	275/ 110	0.0014	0.0639	0.0014	0.2236	0	0.1449	240	240	30	1.15	0.85	19
HAN IBTx 1	275/ 110	0.0018	0.0591	0.0018	0.1261	0	0.056	240	240	45	1.15	0.85	19
HAN IBTx 2	275/ 110	0.0018	0.0591	0.0018	0.1261	0	0.056	240	240	45	1.15	0.85	19
HAN IBT x 3	275/ 110	0.0014	0.0639	0.0014	0.2236	0	0.1449	240	240	60	1.15	0.85	19
KEL IBTx 1	275/ 110	0.0018	0.0609	0.0018	0.1273	0	0.057	240	240	45	1.15	0.85	19
KEL IBTx 2	275/ 110	0.0018	0.0607	0.0018	0.1317	0	0.057	240	240	45	1.15	0.85	19
TAN IBTx 1	275/ 110	0.0018	0.0641	0.0018	0.2092	0	0.1325	240	240	30	1.15	0.85	19
TAN IBTx 2	275/ 110	0.0018	0.0641	0.0018	0.2092	0	0.1325	240	240	30	1.15	0.85	19
TAN IBTx 3	275/ 110	0.0014	0.0639	0.0018	0.2375	0	0.1575	240	240	60	1.15	0.85	19
TMN IBTx1	275/ 110	0.0014	0.0644	0.0037	0.2236	0	0.1514	240	240	60	1.15	0.85	19
TMN IBTx2	275/ 110	0.0014	0.0644	0.004	0.2315	0	0.15	240	240	60	1.15	0.85	19
KPS IBTx1	275/ 11.5	0	0.1635	0	0.3040	0	0.1635	110	55	55	1.15	0.938	33

Table B-5: Characteristics of Existing 2 Winding Transformers in Northern Ireland[129]

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	60	0.0065	0.2893	1.1	0.8	19
BMA	110/33	90	0.0039	0.2463	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	0.0171	0.4133	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	0.4167	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
CKM	110/33	90	0.0039	0.2461	1.1	0.8	19
COL (N)	110/33	60	0.0074	0.2512	1.1	0.8	19
COL (N)	110/33	60	0.0074	0.2512	1.1	0.8	19
CPS	110/33	90	0.0087	0.2559	1.1	0.8	19
CPS	110/33	90	0.0087	0.2559	1.1	0.8	19
CRG	110/33	60	0.0074	0.2515	1.1	0.8	19
CRG	110/33	60	0.0074	0.2515	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	90	0.004	0.2403	1.1	0.8	19
DON	110/33	60	0.0119	0.3658	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
DRU (N)	110/33	90	0.0061	0.2423	1.1	0.8	19
DRU (N)	110/33	90	0.0061	0.2423	1.1	0.8	19

129 110/33 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	
DUN	110/33	90	0.0087	0.2566	1.1	0.8	19
DUN	110/33	90	0.0087	0.2566	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
ENN (N)	110/33	45	0.0126	0.272	1.1	0.8	19
ENN (N)	110/33	45	0.0126	0.272	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	0.0125	0.2809	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	0.2481	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

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	
SLK	110/20	100	0.0035	0.16	1.1	0.9	33
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	0.2522	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	1.2	0.8
STR (N)	110	STR (N) – LET	125	0.000	0.0213	1.2	0.8

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	3 Capacitors (3 x 25)	75	
CAS	22	1 Shunt Reactor		30
CBR	110	1 Capacitor	30	
CBR	110	1 Static Var Compensator	60	10
CF	110	1 Capacitor	15	
CKM	220	1 Shunt Reactor		100
COL (N)	110	1 Capacitor	36	
CPS	110	1 Capacitor	40	
CSH	110	2 Capacitors (2 x 40)	80	
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 3.25)	6.5	
FIN (I)	38	1 Shunt Reactor		20
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
KNY	110	1 Capacitor	30	
KKY	110	2 Capacitor (2 x 15)	30	
KTL	10	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	
MRY	20	1 Capacitor	4	
MUL	110	2 Capacitors (2 x 15)	30	
NAV	110	1 Capacitor (1 Mobile)	30	

Table B-7: Characteristics of Existing Reactive Compensation

Station	Voltage (kV)	Plant	Capability (Mvar)	
			Generate	Absorb
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	2 Capacitors (2 x 15)	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	110	BIN	TIV	1	23	0.0242	0.0774	0.0079	136	159	2019
Add	110	BLC	DRN	1	2	0.0004	0.0021	0.0257	228	228	2019
Add	110	BLC	DRN	2	2	0.0004	0.0021	0.0257	228	228	2019
Add	110	AGY	TIV	1	35	0.0544	0.1204	0.0112	105	123	2019
Add	110	DMY	CDN	1	11	0.0155	0.0397	0.0036	211	217	2019
Add	220	KNR	KPG	2	20	0.0004	0.0096	0.9709	731	762	2019
Add	220	KLN	KPG	1	71	0.0085	0.0609	0.1136	434	513	2019
Add	220	KPG	MP	2	5	0.0001	0.0017	0.2362	660	660	2019
Add	110	LET	TIV	1	45	0.0471	0.1508	0.0154	136	159	2019
Add	110	MAC	CLA	2	9	0.0021	0.0099	0.0993	192	192	2019
Add	110	CNN	CLO	1	18	0.0114	0.0585	0.0064	178	210	2019
Add	110	CNN	CAG	1	7	0.0017	0.0085	0.0772	140	140	2019
Add	110	CTG	BVK	1	32	0.0060	0.0358	0.3856	228	228	2019

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	BK	SKY	1	4	0.0010	0.0044	0.0440	187	223	2019
Add	110	BK	CRN	1	3	0.0021	0.0108	0.0012	178	210	2019
Amend	110	BK	MOY	1	27	0.0170	0.0877	0.0096	178	210	2019
Amend	110	MOY	GLR	1	14	0.0216	0.0480	0.0045	105	123	2019
Amend	110	MOY	TAW	1	8	0.0130	0.0280	0.0036	99	123	2019
Remove	110	ATY	PLS	1							2020
Remove	110	DER	MAY	1							2020
Remove	220	INC	MAY	2							2020
Remove	220	MAY	INC	1							2020
Add	110	ATY	CNB	1	22	0.0138	0.0713	0.0078	178	210	2020
Add	110	BGT	KKY	1	22	0.0139	0.0715	0.0078	178	210	2020
Add	110	BGT	CNB	1	28	0.0176	0.0910	0.0099	178	210	2020
Add	110	DER	TIM	1	25	0.0158	0.0817	0.0089	178	210	2020
Add	110	CKG	CBT	1	1	0.0002	0.0009	0.0083	187	223	2020
Add	110	GI	RSP	1	22	0.0141	0.0725	0.0079	178	210	2020
Add	220	INC	CBT	2	14	0.0020	0.0123	0.0195	761	794	2020
Add	110	KPG	CH	1	23	0.0236	0.0754	0.0077	136	159	2020
Add	220	CBT	MAY	1	12	0.0019	0.0115	0.0183	761	794	2020
Add	220	CBT	MAY	2	12	0.0016	0.0100	0.0159	761	794	2020
Add	220	CBT	INC	1	14	0.0015	0.0091	0.0144	761	794	2020
Add	110	CNB	PLS	1	8	0.0051	0.0261	0.0083	178	210	2020
Add	110	MAY	TIM	1	19	0.0118	0.0605	0.0093	112	112	2020
Add	110	CNN	CDF	1	6	0.0013	0.0067	0.0607	140	140	2020
Add	110	RSP	WEX	1	13	0.0081	0.0416	0.0046	178	210	2020
Amend	220	BVK	BYH	1	15	0.0020	0.0126	0.0193	761	794	2020
Amend	110	CDY	SRA	1	13	0.0198	0.0437	0.0041	178	210	2020
Amend	110	CDU	RYB	1	13	0.0135	0.0434	0.0045	178	219	2020
Amend	220	KNR	BYH	1	38	0.0045	0.0326	0.0607	740	792	2020
Remove	110	ADM	KUD	1							2021
Remove	110	CSH	SOM	1							2021
Remove	110	CDU	PLA	1							2021
Remove	400	DSN	MP	1							2021
Remove	110	CKG	BKY	1							2021
Remove	220	FIN (I)	SHL	1							2021
Remove	110	GCA	KUD	2							2021
Remove	110	INC	BKY	1							2021
Remove	110	KIN	DFR	1							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	
Remove	110	KPG	TRL	2							2021
Remove	110	PLS	DAL	1							2021
Remove	110	BRO	RSK	1							2021
Add	110	ADM	GCA	1	3	0.0018	0.0038	0.0251	140	140	2021
Add	110	BLC	DTN	2	8	0.0041	0.0089	0.0486	140	143	2021
Add	110	BLC	GRA	1	4	0.0025	0.0053	0.0309	140	140	2021
Add	110	BLC	KLM	1	4	0.0023	0.0050	0.0291	140	140	2021
Add	220	BLC	SHL	1	23	0.0010	0.0034	0.7769	570	570	2021
Add	110	CSH	SHN	1	5	0.0073	0.0160	0.0015	105	123	2021
Add	110	CDU	GAN	1	11	0.0070	0.0359	0.0039	178	210	2021
Add	220	CDU	CRH	1	1	0.0000	0.0002	0.0415	570	570	2021
Add	220	CDU	CRH	2	1	0.0000	0.0002	0.0415	570	570	2021
Add	110	KNY	BUF	1	1	0.0002	0.0007	0.0056	140	140	2021
Add	110	DRG	KPG	1	14	0.0081	0.0452	0.0104	178	210	2021
Add	110	DRG	TRL	1	32	0.0203	0.1047	0.0138	178	210	2021
Add	400	DSN	CNB	1	45	0.0009	0.0100	0.2260	1577	1867	2021
Add	110	CKG	CBT	2	1	0.0002	0.0009	0.0083	187	223	2021
Add	110	GAN	MUC	1	3	0.0020	0.0102	0.0012	178	210	2021
Add	110	GCA	INC	3	8	0.0047	0.0044	0.0939	124	124	2021
Add	110	HWN	KIN	1	6	0.0060	0.0192	0.0034	136	140	2021
Add	110	HWN	DFR	1	9	0.0064	0.0307	0.0034	104	157	2021
Add	110	MEN	KRA	1	3	0.0017	0.0016	0.0341	124	124	2021
Add	110	KUD	CBT	1	1	0.0002	0.0009	0.0083	187	223	2021
Add	110	CBT	BKY	1	1	0.0003	0.0011	0.0110	187	223	2021
Add	110	CBT	BKY	2	1	0.0003	0.0011	0.0110	187	223	2021
Add	400	CNB	MP	1	170	0.0033	0.0378	0.8580	1577	1867	2021
Add	110	LUM	PLS	1	48	0.0305	0.1574	0.0171	178	210	2021
Add	110	LUM	DAL	1	6	0.0040	0.0207	0.0023	178	210	2021
Add	110	PLA	MUC	1	24	0.0149	0.0771	0.0084	178	210	2021
Add	110	SHN	SOM	1	45	0.0707	0.1563	0.0146	105	123	2021
Add	110	BRO	AGI	1	16	0.0027	0.0164	0.0047	178	210	2021
Add	110	AGI	RSK	1	2	0.0098	0.0590	0.0167	178	219	2021
Amend	110	GI	KKY	1	49	0.0309	0.1599	0.0174	178	210	2021
Amend	110	BPS	EDE	1	15	0.0228	0.0536	0.0049	143	166	2021
Amend	110	BPS	EDE	2	15	0.0227	0.0529	0.0049	143	166	2021
Remove	220	LOU	WOO	1							2022
Add	400	KPG	MP	1	6	0.0008	0.0002	0.5489	1210	1210	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	220	LOU	ORL	1	15	0.0017	0.0126	0.0190	434	513	2022
Add	220	WOO	ORL	1	49	0.0058	0.0427	0.0644	434	513	2022
Add	220	ORL	ORL	1	20	0.0007	0.0079	0.5502	593	593	2022
Add	220	ORL	ORL	1	16	0.0007	0.0023	0.5279	570	570	2022
Add	110	AIR	ROS	1	5	0.0131	0.0341	0.0034	82	103	2022
Add	110	AIR	ROS	1	5	0.0131	0.0341	0.0034	82	103	2022
Add	275	CAS	BFP	1	11	0.0001	0.0022	0.6009	600	600	2022
Add	110	KEL	KLC	1	0.1	0.0003	0.0013	0.0080	144	144	2022
Amend	400	DSN	CNB	1	45	0.0009	0.0030	0.2260	1577	1944	2022
Amend	400	CNB	MP	1	170	0.0033	0.0113	0.8580	1577	1944	2022
Amend	400	OST	WOO	1	125	0.0024	0.0080	0.6309	1577	1944	2022
Amend	275	CPS	MAG	1	56	0.0021	0.0236	0.1404	811	905	2022
Amend	275	CPS	MAG	2	56	0.0021	0.0236	0.1404	811	905	2022
Amend	110	DRO (N)	OMA	1	9	0.0183	0.0471	0.0048	199	225	2022
Amend	110	DRO (N)	OMA	2	9	0.0183	0.0471	0.0048	199	225	2022
Remove	275	TAN	TMN	1							›2022
Remove	275	TAN	TMN	2							›2022
Amend	220	DSN	MAY	2	31	0.0036	0.0265	0.0400	434	513	›2022
Add	400	WOO	TUR	1	135	0.0027	0.0311	0.7066	1424	1731	›2022
Add	110	KEL	RSK	2	-	0.0217	0.1344	0.0129	188	213	›2022
Add	275	TAN	TUR	1	22	0.0009	0.0086	0.0514	710	881	›2022
Add	275	TAN	TUR	2	22	0.0009	0.0086	0.0514	710	881	›2022
Add	275	TMN	TUR	1	4	0.0002	0.0023	0.0135	710	881	›2022
Add	275	TMN	TUR	2	4	0.0002	0.0023	0.0135	710	881	›2022
Amend	220	DSN	MAY	1	31	0.0036	0.0265	0.0399	434	513	›2022
Amend	110	MR	KBY	1	4	0.0026	0.0130	0.0015	178	210	›2022

Table B-9: Expected Changes in Transformers in Ireland

Action	Station	Transformer	Rating (MVA)	HV/LV (kV)	Impedance on 100 MVA Base (pu)		Voltage Ratio Tapping Range		Year
					R	X	+	-	
Add	CKM	T2104	250	220/110	0.0004	0.0631	0.09	0.18	2019
Remove	KLN	T2101	63	220/110	0.0065	0.2453	0.09	0.18	2020
Remove	KLN	T2102	63	220/110	0.0095	0.2473	0.09	0.18	2020
Amend	KLN	T2104	250	220/110	0.0004	0.0631	0.1	0.18	2020
Add	CBT	T2101	250	220/110	0.001	0.0646	0.09	0.17	2020
Add	CBT	T2102	250	220/110	0.001	0.0646	0.1	0.1	2020
Add	CBT	T2103	250	220/110	0.001	0.0646	0.1	0.1	2020
Add	CBT	T2104	250	220/110	0.001	0.0646	0.1	0.1	2020
Remove	KRA	T2103	250	220/110	0.0013	0.0652	0.09	0.17	2021
Add	BLC	T2102	250	220/110	0.001	0.0646	0.1	0.1	2021
Add	CNB	T4102	500	400/110	0.00048	0.072	0.15	0.15	2021
Add	CNB	T4101	500	400/110	0.00048	0.072	0.15	0.15	2021
Add	KPG		500	400/220	0.0003	0.027	0.11	0.08	2022

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								
			R	X	R	X	R	X	W1	W2	W3	Upper	Lower		
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

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	AGI	110/33	90	0.0039	0.2461	1.1	0.8	19	2021
Amend	DON	110/33	90	0.0039	0.2461	1.1	0.8	19	2021
Add	AIR	110/33	60	0.0073	0.25	1.1	0.8	19	2022
Add	AIR	110/33	60	0.0073	0.25	1.1	0.8	19	2022
Add	KLC	110/33	90	0.0039	0.2461	1.1	0.8	19	2022
Add	KLC	110/33	90	0.0039	0.2461	1.1	0.8	19	2022

Table B-12: Expected Changes in Reactive Compensation

Action	Station	Voltage	Plant	Mvar Capability		Year
				Generate	Absorb	
Add	PB	110	Reactor		50	2019
Remove	COL (N)	110	Capacitor	36		2020
Remove	THU	110	Capacitor	15		2021
Add	BYH	110	STATCOM	100	100	2020
Add	BVK	110	STATCOM	100	100	2020
Add	KNR	220	Reactor		50	2020
Add	THU	110	STATCOM	30	30	2021

All-Island Ten Year

Transmission Forecast Statement 2019

Appendix C

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 2019 and 2028 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 five 220/110 kV interface stations that supply the Dublin City networks. These five interface stations are Belcamp, Carrickmines, Finglas, Inchicore and Poolbeg. Castlebagot 220/110 kV station, with an energisation date of 2020, is currently being developed in the Dublin region. Castlebagot will supply a number of 110 kV stations, namely Barnakyle, Corkagh and Kilmahud.

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)									
			2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
AA	Ardnacrusha	0.993	73.5	74.8	76.0	76.8	77.7	78.1	79.0	79.8	80.7	81.2
AGH	Aghyoule	0.998	14.1	14.2	14.4	14.7	14.6	15.0	15.1	15.2	15.3	15.3
AGY	Ardnagappary	0.985	16.6	16.9	17.1	17.3	17.5	17.6	17.8	18.0	18.2	18.3
AHA	Ahane	0.991	5.3	5.4	5.5	5.5	5.6	5.6	5.7	5.7	5.8	5.8
AIR	Airport Road (Belfast)	0.990	-	-	-	-	28.8	31.0	32.4	33.9	37.8	34.0
ANR	Anner	0.897	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
ANT	Antrim	0.991	42.3	42.5	42.7	43.5	43.0	43.9	44.0	44.2	44.3	44.4
ARI	Arigna	0.965	2.5	2.6	2.6	2.6	2.7	2.7	2.7	2.7	2.8	2.8
ARK	Arklow	0.997	28.8	29.3	29.7	30.1	30.4	30.6	30.9	31.3	31.6	31.8
ATH	Athlone	0.976	71.1	72.4	73.5	74.3	75.1	75.6	76.4	77.2	78.0	78.6
ATY	Athy	0.989	22.6	23.0	23.4	23.6	23.9	24.0	24.3	24.6	24.8	25.0
BAL	Baltrasna	0.983	13.9	14.2	14.4	14.5	14.7	14.8	14.9	15.1	15.3	15.4
BAN (I)	Bandon	0.977	56.4	57.3	58.2	58.8	59.4	59.8	60.4	61.0	61.6	62.1
BAN (N)	Banbridge	0.979	39.7	39.8	40.0	40.8	40.3	41.1	41.3	41.4	41.5	41.6
BAR	Barrymore	0.994	34.5	35.1	35.6	36.0	36.4	36.6	37.0	37.4	37.8	38.1
BDA	Baroda	0.988	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
BDN	Ballydine	0.971	18.1	18.3	18.5	18.7	18.8	18.9	19.0	19.2	19.3	19.4
BEG	Ballybeg	0.997	15.1	15.3	15.6	15.7	15.9	16.0	16.2	16.3	16.5	16.6
BLC	Belcamp	0.950	30.8	47.7	69.8	84.5	101.2	113.4	119.0	127.3	133.1	138.0
BGD	Belgard Road	0.950	35.9	41.7	34.4	41.7	49.9	55.9	58.7	62.7	65.6	68.0
BGT	Ballyragget	0.977	-	27.7	28.1	28.4	28.8	28.9	29.2	29.6	29.9	30.1
BIN	Binbane	0.974	14.5	14.8	15.0	15.2	15.3	15.4	15.6	15.8	15.9	16.0
BK	Bellacorick	0.979	6.2	6.3	6.4	6.4	6.5	6.5	6.6	6.7	6.7	6.8
BKY	Barnakyle	0.951	10.6	10.8	35.6	40.9	46.8	51.2	53.3	56.3	58.5	60.3
BLI	Ballylickey	0.977	15.4	15.7	15.9	16.1	16.3	16.4	16.5	16.7	16.9	17.0
BLK	Blake	0.993	13.0	13.2	13.4	13.5	13.7	13.8	13.9	14.1	14.2	14.3
BMA	Ballymena	0.979	84.6	85.0	85.4	87.0	86.0	87.7	88.0	88.4	88.6	88.6
BNH	Ballynahinch	0.991	57.6	57.9	58.1	59.2	58.5	59.7	59.9	60.1	60.2	60.3
BNM	Belfast North	0.990	50.7	50.9	51.1	52.1	51.5	52.5	52.7	52.9	53.1	53.1
BOG	Banoge	0.983	23.3	23.7	24.1	24.4	24.6	24.8	25.0	25.3	25.6	25.8
BRA	Bracklone	0.978	14.5	14.8	15.0	15.2	15.3	15.4	15.6	15.7	15.9	16.0
BRI	Brinny	0.971	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
BRY	Barnahely	0.988	31.4	32.0	32.5	32.8	33.2	33.4	33.7	34.1	34.5	34.7
BUT	Butlerstown	0.995	42.2	42.9	43.6	44.0	44.5	44.8	45.3	45.8	46.2	46.6
BVG	Ballyvallagh	0.972	15.3	15.4	15.5	15.7	15.6	15.9	15.9	16.0	16.0	16.0
CAH	Cahir	0.982	28.4	28.9	29.4	29.7	30.0	30.2	30.5	30.8	31.2	31.4
CAR	Carnmoney	0.996	26.2	25.9	25.7	25.8	25.1	25.2	24.9	24.6	24.3	24.7
CBG	Carrowbeg	0.985	19.7	20.0	20.3	20.5	20.8	20.9	21.1	21.3	21.6	21.7
CBR	Castlebar	0.992	36.6	37.2	37.8	38.2	38.6	38.9	39.3	39.7	40.1	40.4
CEN	Belfast Central	0.999	53.6	53.9	54.3	55.4	54.8	56.0	56.3	56.6	56.9	56.8
CF	Cathaleen's Fall	0.995	19.6	20.0	20.3	20.5	20.8	20.9	21.1	21.3	21.6	21.7

Table C-1: Demand Forecasts at Time of Winter Peak

Bus Code	Bus Name	Power Factor	Demand Forecast (MW)									
			2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
CFM	Castlefarm	0.901	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.8
CHA	Charleville	0.980	17.1	17.4	17.7	17.9	18.1	18.2	18.4	18.6	18.8	18.9
CKG	Corkagh	0.950	45.1	70.9	58.5	70.8	84.8	95.1	99.8	106.6	111.6	115.6
CKM	Carrickmines	0.988	372.8	383.6	382.1	392.4	403.8	411.2	417.4	424.9	431.1	435.8
CLE	Clonee	0.950	76.9	89.4	83.5	101.2	121.1	135.8	142.5	152.4	159.4	165.2
CLG	Cloghran	0.950	43.1	50.1	41.3	50.0	59.8	67.1	70.4	75.3	78.7	81.6
CLN	Cloon	0.977	33.5	34.1	34.7	35.0	35.4	35.6	36.0	36.4	36.8	37.1
CLW	Carlow	0.989	66.9	68.1	69.2	69.9	70.7	71.1	71.9	72.7	73.4	73.9
COL (I)	College Park	0.988	27.8	28.3	28.7	29.0	29.4	29.5	29.8	30.2	30.5	30.7
COL (N)	Coleraine	0.991	43.2	43.4	43.6	44.5	43.9	44.8	44.9	45.1	45.2	45.2
COS	Carrick-on-Shannon	0.993	30.3	30.8	31.3	31.7	32.0	32.2	32.5	32.9	33.2	33.5
COW	Cow Cross	0.997	13.8	14.0	14.3	14.4	14.6	14.7	14.8	15.0	15.1	15.2
CPS	Coolkeeragh	0.989	25.6	25.8	25.9	26.4	26.1	26.6	26.7	26.8	26.8	26.9
CRA	Crane	0.988	36.7	37.3	37.9	38.3	38.7	39.0	39.4	39.8	40.2	40.5
CRE	Cregagh	0.987	87.1	87.5	88.0	74.0	73.3	74.8	75.2	75.7	76.0	75.9
CRG	Creagh	0.991	25.2	25.3	25.4	25.9	25.6	26.1	26.2	26.3	26.3	26.4
CRH	Cruiserath	0.950	-	-	100.2	121.4	145.3	162.9	171.0	182.8	191.2	198.2
CRO	Coolroe	0.986	12.9	13.2	13.4	13.5	13.7	13.8	13.9	14.1	14.2	14.3
CVW	Castleview	0.986	27.2	27.7	28.2	28.5	28.8	29.0	29.3	29.6	29.9	30.1
DAL	Dallow	0.996	18.8	19.1	19.4	19.6	19.9	20.0	20.2	20.4	20.6	20.8
DDK	Dundalk	0.980	77.5	78.8	80.1	80.9	81.9	82.3	83.2	84.1	85.0	85.6
DFR	Dunfirth	0.996	10.6	10.8	11.0	11.1	11.2	11.3	11.4	11.5	11.7	11.7
DGN	Dungarvan	0.987	48.3	49.2	50.0	50.5	51.1	51.4	51.9	52.5	53.0	53.4
DLT	Dalton	0.986	27.5	28.0	28.4	28.7	29.0	29.2	29.5	29.8	30.2	30.4
DMY	Dunmanway	0.978	26.8	27.3	27.7	28.0	28.3	28.5	28.8	29.1	29.4	29.6
DON	Donegall	1.000	95.7	94.4	93.3	93.4	90.8	91.1	89.9	88.8	87.6	89.1
DOO	Doon	0.979	32.9	33.5	34.0	34.3	34.7	34.9	35.3	35.7	36.1	36.3
DRU (I)	Drumline	0.979	32.1	32.7	33.2	33.5	33.9	34.1	34.5	34.9	35.2	35.5
DRU (N)	Drumnakelly	0.988	92.6	93.1	93.6	95.4	94.3	96.2	96.5	97.1	97.5	97.4
DRY	Drybridge	0.989	93.6	95.2	96.7	97.8	98.9	99.5	100.5	101.6	102.7	103.4
DUN	Dungannon	0.970	98.1	98.6	99.0	100.9	99.7	101.7	102.1	102.5	102.7	102.8
EDE	Eden	0.984	35.0	35.2	35.3	36.0	35.6	36.3	36.4	36.5	36.6	36.7
ENN (I)	Ennis	0.981	62.8	63.9	64.9	65.6	66.4	66.8	67.5	68.2	68.9	69.4
ENN (N)	Enniskillen	0.984	59.2	59.5	59.8	61.0	60.3	61.5	61.7	62.0	62.1	62.1
FIN (I)	Finglas	0.986	478.8	490.1	492.6	502.3	513.0	519.5	526.2	534.1	541.0	546.0
FIN (N)	Finaghy	0.994	31.3	31.5	31.6	32.2	31.8	32.5	32.6	32.7	32.8	32.8
FTT	Fortunestown	0.970	11.2	11.4	11.5	11.7	11.8	11.9	12.0	12.1	12.2	12.3
GAL	Galway	0.990	73.7	75.0	76.1	77.0	77.9	78.3	79.1	80.0	80.8	81.4
GI	Great Island	0.950	13.5	14.8	15.0	15.2	15.4	15.5	15.6	15.8	16.0	16.1
GIL	Gilra	0.971	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4
GLE (I)	Glenlara	0.989	18.1	18.4	18.7	18.9	19.1	19.2	19.4	19.7	19.9	20.0

Table C-1: Demand Forecasts at Time of Winter Peak

Bus Code	Bus Name	Power Factor	Demand Forecast (MW)									
			2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
GLE (N)	Glengormley	0.977	32.0	32.0	32.0	32.5	32.0	32.5	32.5	32.5	32.5	32.6
GOR (N)	Gort	0.998	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.3	1.3
GRI	Griffinrath	0.994	59.8	60.8	61.8	62.4	63.2	63.5	64.2	64.9	65.6	66.0
GWE	Gortawee	0.953	32.6	32.8	33.0	33.1	33.2	33.3	33.4	33.6	33.7	33.8
IKE	Ikerrin	0.966	32.3	32.9	33.4	33.8	34.2	34.4	34.7	35.1	35.5	35.7
INC	Inchicore	0.993	259.8	265.6	267.1	271.8	276.8	280.0	283.3	287.3	290.6	293.0
KBY	Kilbarry	0.992	98.5	100.2	101.8	102.9	104.0	104.6	105.7	106.9	108.0	108.8
KER	Knockearagh	0.990	43.1	43.8	44.5	45.0	45.5	45.8	46.2	46.8	47.2	47.6
KIN	Kinnegad	0.973	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2
KKY	Kilkenny	0.966	69.2	58.2	59.1	59.8	60.5	60.8	61.4	62.1	62.8	63.2
KNO	Knock	0.981	51.8	52.1	52.3	46.6	46.1	47.0	47.2	47.5	47.6	47.6
KTL	Kilteel	0.972	52.7	53.6	54.4	55.0	55.7	56.0	56.6	57.2	57.8	58.2
KTN	Killoteran	0.973	11.7	11.9	12.1	12.2	12.4	12.5	12.6	12.7	12.9	12.9
KUD	Kilmahud	0.950	25.1	29.2	24.1	29.2	34.9	39.1	41.1	43.9	45.9	47.6
KUR	Knockumber	0.907	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7
LA	Lanesboro	0.986	17.3	17.6	17.9	18.1	18.3	18.4	18.6	18.8	19.0	19.1
LAR	Larne	0.972	29.0	29.1	29.2	29.8	29.4	30.0	30.1	30.2	30.3	30.3
LET	Letterkenny	0.984	80.0	81.3	82.6	83.5	84.5	85.0	85.9	86.8	87.7	88.3
LIB	Liberty	0.989	22.1	22.5	22.9	23.1	23.4	23.5	23.7	24.0	24.3	24.4
LIM (I)	Limerick	0.987	82.9	84.3	85.6	86.6	87.6	88.1	89.0	90.0	90.9	91.5
LIM (N)	Limavady	0.977	25.0	25.2	25.3	25.7	25.4	25.9	26.0	26.1	26.2	26.2
LIS (I)	Lisdrum	0.969	27.1	27.6	28.0	28.3	28.6	28.8	29.1	29.4	29.7	29.9
LIS (N)	Lisburn	0.992	74.9	75.2	75.6	77.0	76.1	77.6	77.9	78.2	78.4	78.5
LMR	Lisaghmore	0.980	33.2	33.4	33.5	34.2	33.8	34.5	34.6	34.7	34.8	34.8
LOG	Loguestown	0.977	39.5	39.6	39.8	40.6	40.1	40.9	41.0	41.2	41.3	41.3
MAC	Macroom	0.949	12.8	13.0	13.2	13.4	13.5	13.6	13.8	13.9	14.1	14.1
MAL	Mallow	0.980	23.7	24.1	24.5	24.8	25.0	25.2	25.5	25.7	26.0	26.2
MCE	Macetown	0.978	34.8	35.3	35.8	36.1	36.5	36.6	37.0	37.3	37.7	37.9
MID	Midleton	0.985	43.9	44.7	45.4	45.9	46.4	46.7	47.2	47.7	48.2	48.5
MLN	Mullagharlin	0.958	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
MON	Monread	0.989	14.1	14.4	14.6	14.8	14.9	15.0	15.2	15.3	15.5	15.6
MOY	Moy	0.990	29.3	29.8	30.3	30.6	31.0	31.2	31.5	31.8	32.2	32.4
MR	Marina	0.997	16.2	16.5	16.8	16.9	17.1	17.2	17.4	17.6	17.8	17.9
MTH	Meathhill	0.965	57.8	58.8	59.8	60.4	61.1	61.5	62.1	62.8	63.4	63.9
MUL	Mullingar	0.983	48.9	49.7	50.5	51.1	51.7	52.0	52.5	53.1	53.6	54.0
MUN	Mungret	0.871	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5
NAR	Newtownards	1.000	45.9	46.1	46.3	47.2	46.6	47.5	47.7	47.9	48.0	48.0
NAV	Navan	0.980	66.0	67.1	68.2	68.9	69.7	70.1	70.9	71.7	72.4	72.9
NEN	Nenagh	0.967	23.1	23.5	23.9	24.1	24.4	24.5	24.8	25.1	25.3	25.5
NEW (I)	Newbridge	0.992	29.6	30.2	30.6	31.0	31.3	31.5	31.8	32.2	32.5	32.7
NEW (N)	Newry	0.990	80.9	81.3	81.7	83.2	82.3	83.9	84.2	84.6	84.8	84.8
OLD	Oldcourt	0.949	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Table C-1: Demand Forecasts at Time of Winter Peak

Bus Code	Bus Name	Power Factor	Demand Forecast (MW)									
			2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
OMA	Omagh	0.993	61.4	61.6	61.9	63.1	62.3	63.5	63.8	64.0	64.1	64.2
OUG	Oughtragh	0.994	27.6	28.1	28.6	28.9	29.2	29.4	29.7	30.0	30.3	30.5
PB	Poolbeg	0.989	215.4	219.1	222.6	225.0	227.6	228.9	231.3	233.9	236.3	237.9
PLA	Platin	0.960	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
PLS	Portlaoise	0.990	58.1	43.6	44.3	44.8	45.3	45.5	46.0	46.5	47.0	47.3
RAT (I)	Rathkeale	0.989	29.9	30.4	30.9	31.2	31.6	31.8	32.1	32.5	32.8	33.0
RAT (N)	Rathgael	0.997	58.5	58.8	59.1	60.2	59.5	60.6	60.8	61.1	61.2	61.3
RIC	Richmond	0.977	37.9	38.6	39.2	39.6	40.1	40.3	40.7	41.2	41.6	41.9
RNW	Rinawade	0.988	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1
ROS	Rosebank	0.979	30.8	30.9	31.0	28.4	28.1	28.7	28.8	28.9	29.0	29.0
RSY	Ringaskiddy	0.996	4.2	4.3	4.4	4.4	4.5	4.5	4.6	4.6	4.7	4.7
RYB	Ryebrook	0.928	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5
SAL	Salthill	0.995	56.9	57.9	58.8	59.4	60.1	60.4	61.1	61.8	62.4	62.8
SBH	Snughborough	0.950	11.3	37.0	30.5	36.9	44.2	49.5	52.0	55.6	58.1	60.2
SCR	Screeb	0.972	30.0	30.5	31.0	31.3	31.6	31.8	32.2	32.5	32.9	33.1
SHE	Shelton Abbey	0.956	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
SKL	Shankill	0.966	61.5	62.6	63.6	64.3	65.0	65.4	66.1	66.8	67.5	68.0
SLI	Sligo	0.987	59.0	60.0	61.0	61.6	62.3	62.7	63.3	64.0	64.7	65.2
SNG	Singland	0.976	11.9	12.1	12.3	12.5	12.6	12.7	12.8	13.0	13.1	13.2
SOM	Somerset	0.990	23.0	23.4	23.7	24.0	24.3	24.4	24.7	24.9	25.2	25.4
SPR	Springtown	0.994	48.1	48.3	48.6	49.5	48.9	49.8	50.0	50.2	50.3	50.3
STR	Stratford	0.991	22.6	23.0	23.3	23.6	23.9	24.0	24.3	24.5	24.8	25.0
STR (N)	Strabane	0.968	42.8	43.0	43.2	44.0	43.5	44.3	44.5	44.6	44.7	44.8
TBG	Trabeg	0.993	78.0	79.3	80.6	81.5	82.4	82.9	83.7	84.7	85.5	86.2
TBK	Tullabrack	0.980	11.9	12.1	12.3	12.5	12.6	12.7	12.8	13.0	13.1	13.2
THU	Thurles	0.976	30.5	31.0	31.5	31.8	32.2	32.4	32.7	33.1	33.4	33.7
TIP	Tipperary	0.979	22.5	22.9	23.2	23.5	23.7	23.9	24.1	24.4	24.6	24.8
TLK	Trillick	0.989	22.0	22.3	22.7	22.9	23.2	23.3	23.6	23.8	24.1	24.3
TON	Tonroe	0.993	16.7	17.0	17.2	17.4	17.6	17.7	17.9	18.1	18.3	18.4
TRI	Trien	0.957	26.2	26.6	27.1	27.3	27.7	27.8	28.1	28.4	28.7	28.9
TRL	Tralee	0.995	60.2	61.3	62.3	62.9	63.6	64.0	64.7	65.4	66.1	66.5
TSB	Thornsberry	0.983	34.7	35.3	35.9	36.3	36.7	36.9	37.3	37.7	38.1	38.3
WAR	Waringstown	0.986	67.0	67.3	67.6	68.9	68.0	69.3	69.6	69.8	70.0	70.0
WAT	Waterford	0.978	60.4	60.4	61.4	62.0	62.7	63.1	63.8	64.5	65.1	65.6
WEX	Wexford	0.968	61.7	62.8	63.8	64.5	65.2	65.6	66.3	67.0	67.7	68.2
WHI	Whitegate	0.870	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)									
			2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
AA	Ardnacrusha	0.993	56.7	57.4	59.7	58.4	58.7	58.7	59.3	59.8	60.3	60.6
AGH	Aghyoule	1.000	11.1	11.2	11.3	11.6	11.5	11.8	11.9	12.0	12.1	12.0
AGY	Ardnagappary	0.985	12.8	12.9	13.5	13.2	13.2	13.2	13.4	13.5	13.6	13.7
AHA	Ahane	0.991	4.1	4.1	4.3	4.2	4.2	4.2	4.3	4.3	4.3	4.4
AIR	Airport Road (Belfast)	0.990	-	-	-	-	22.6	24.4	25.5	26.7	29.7	26.8
ANR	Anner	0.897	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
ANT	Antrim	0.990	33.3	33.4	33.6	34.2	33.8	34.5	34.6	34.8	34.8	34.9
ARI	Arigna	0.967	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.1	2.1
ARK	Arklow	0.997	22.2	22.5	23.4	22.8	23.0	23.0	23.2	23.4	23.6	23.7
ATH	Athlone	0.976	54.9	55.5	57.7	56.4	56.7	56.8	57.3	57.8	58.3	58.6
ATY	Athy	0.989	17.4	17.7	18.4	18.0	18.1	18.1	18.2	18.4	18.5	18.7
BAL	Baltrasna	0.983	10.7	10.9	11.3	11.0	11.1	11.1	11.2	11.3	11.4	11.5
BAN (I)	Bandon	0.977	43.9	44.4	46.1	45.1	45.4	45.4	45.8	46.2	46.6	46.8
BAN (N)	Banbridge	0.969	31.2	31.3	31.5	32.1	31.7	32.3	32.4	32.6	32.6	32.7
BAR	Barrymore	0.994	26.6	26.9	28.0	27.4	27.5	27.5	27.8	28.0	28.3	28.4
BDA	Baroda	0.988	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
BDN	Ballydine	0.971	15.3	15.5	15.8	15.6	15.7	15.7	15.8	15.8	15.9	16.0
BEG	Ballybeg	0.997	11.6	11.7	12.2	11.9	12.0	12.0	12.1	12.2	12.3	12.4
BGD	Belgard Road	0.950	35.9	41.7	34.4	41.7	49.9	55.9	58.7	62.7	65.6	68.0
BGT	Ballyragget	0.977	-	-	22.1	21.6	21.7	21.7	21.9	22.1	22.3	22.4
BIN	Binbane	0.974	11.2	11.3	11.8	11.5	11.6	11.6	11.7	11.8	11.9	12.0
BK	Bellacorick	0.979	4.7	4.8	5.0	4.9	4.9	4.9	4.9	5.0	5.0	5.1
BKY	Barnakyle	0.951	8.2	8.3	33.2	38.2	44.1	48.4	50.4	53.4	55.6	57.3
BLI	Ballylickey	0.977	11.9	12.0	12.5	12.2	12.3	12.3	12.4	12.5	12.6	12.7
BLC	Belcamp	0.950	-	47.7	69.8	84.5	101.2	113.4	119.0	127.3	133.1	138.0
BLK	Blake	0.993	10.0	10.1	10.5	10.3	10.3	10.4	10.4	10.5	10.6	10.7
BMA	Ballymena	0.969	66.5	66.8	67.1	68.4	67.6	68.9	69.2	69.5	69.6	69.7
BNH	Ballynahinch	0.985	45.3	45.5	45.7	46.6	46.0	46.9	47.1	47.2	47.3	47.4
BNM	Belfast North	0.990	39.8	40.0	40.2	41.0	40.5	41.3	41.4	41.6	41.7	41.7
BOG	Banoge	0.983	18.0	18.2	18.9	18.5	18.6	18.6	18.8	19.0	19.1	19.2
BRA	Bracklone	0.978	11.2	11.3	11.8	11.5	11.6	11.6	11.7	11.8	11.9	12.0
BRI	Brinny	0.971	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
BRY	Barnahely	0.988	24.2	24.5	25.5	24.9	25.1	25.1	25.3	25.5	25.7	25.9
BUT	Butlerstown	0.995	32.5	32.9	34.2	33.5	33.7	33.7	34.0	34.3	34.6	34.8
BVG	Ballyvallagh	0.934	12.0	12.1	12.1	12.4	12.2	12.5	12.5	12.6	12.6	12.6
CAH	Cahir	0.982	21.9	22.2	23.1	22.5	22.7	22.7	22.9	23.1	23.3	23.4
CAR	Carnmoney	1.000	20.6	20.4	20.2	20.2	19.7	19.8	19.5	19.3	19.1	19.4
CBG	Carrowbeg	0.985	15.2	15.3	16.0	15.6	15.7	15.7	15.8	16.0	16.1	16.2
CBR	Castlebar	0.992	28.2	28.5	29.7	29.0	29.2	29.2	29.5	29.7	30.0	30.1
CEN	Belfast Central	0.994	42.1	42.4	42.6	43.5	43.1	44.0	44.3	44.5	44.7	44.6
CF	Cathaleen's Fall	0.995	15.1	15.3	15.9	15.6	15.7	15.7	15.8	16.0	16.1	16.2

Table C-2: Demand Forecasts at Time of Summer Peak

Bus Code	Bus Name	Power Factor	Demand Forecast (MW)									
			2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
CFM	Castlefarm	0.901	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.8
CHA	Charleville	0.980	13.2	13.3	13.9	13.6	13.6	13.7	13.8	13.9	14.0	14.1
CKG	Corkagh	0.950	45.1	70.9	58.5	70.8	84.8	95.1	99.8	106.6	111.6	115.6
CKM	Carrickmines	0.987	299.4	307.6	311.0	311.9	320.8	326.5	331.4	337.3	342.2	345.9
CLE	Clonee	0.950	76.9	89.4	83.5	101.2	121.1	135.8	142.5	152.4	159.4	165.2
CLG	Cloghran	0.950	43.1	50.1	41.3	50.0	59.8	67.1	70.4	75.3	78.7	81.6
CLN	Cloon	0.977	25.9	26.2	27.2	26.6	26.8	26.8	27.0	27.3	27.5	27.7
CLW	Carlow	0.989	51.6	52.2	54.3	53.1	53.4	53.5	53.9	54.4	54.9	55.2
COL (I)	College Park	0.988	21.4	21.7	22.6	22.0	22.2	22.2	22.4	22.6	22.8	22.9
COL (N)	Coleraine	0.969	34.0	34.2	34.3	34.9	34.5	35.2	35.3	35.4	35.5	35.6
COS	Carrick-on-Shannon	0.993	23.4	23.7	24.6	24.1	24.2	24.2	24.4	24.6	24.8	25.0
COW	Cow Cross	0.997	10.6	10.8	11.2	10.9	11.0	11.0	11.1	11.2	11.3	11.4
CPS	Coolkeeragh	0.997	20.2	20.3	20.3	20.7	20.5	20.9	21.0	21.1	21.1	21.1
CRA	Crane	0.988	28.3	28.6	29.8	29.1	29.2	29.3	29.5	29.8	30.0	30.2
CRE	Cregagh	0.986	68.4	68.8	69.1	58.2	57.6	58.8	59.2	59.5	59.7	59.7
CRG	Creagh	0.984	19.8	19.9	20.0	20.3	20.1	20.5	20.6	20.7	20.7	20.7
CRH	Cruiserath	0.950	-	-	-	121.4	145.3	162.9	171.0	182.8	191.2	198.2
CRO	Coolroe	0.986	10.0	10.1	10.5	10.3	10.3	10.3	10.4	10.5	10.6	10.7
CVW	Castleview	0.986	21.0	21.3	22.1	21.6	21.7	21.8	22.0	22.1	22.3	22.5
DAL	Dallow	0.996	14.5	14.7	15.3	14.9	15.0	15.0	15.2	15.3	15.4	15.5
DDK	Dundalk	0.980	59.8	60.5	62.9	61.5	61.8	61.9	62.4	63.0	63.5	63.9
DFR	Dunfirth	0.996	8.2	8.3	8.6	8.4	8.5	8.5	8.6	8.7	8.7	8.8
DGN	Dungarvan	0.987	37.3	37.7	39.2	38.4	38.6	38.6	39.0	39.3	39.6	39.9
DLT	Dalton	0.986	21.2	21.5	22.3	21.8	21.9	22.0	22.2	22.3	22.5	22.7
DMY	Dunmanway	0.978	20.7	20.9	21.8	21.3	21.4	21.4	21.6	21.8	22.0	22.1
DON	Donegall	1.000	75.2	74.2	73.3	73.4	71.4	71.6	70.7	69.8	68.8	70.0
DOO	Doon	0.979	25.4	25.7	26.7	26.1	26.2	26.3	26.5	26.7	27.0	27.1
DRU (I)	Drumline	0.979	24.8	25.1	26.1	25.5	25.6	25.7	25.9	26.1	26.3	26.5
DRU (N)	Drumnakelly	0.988	72.8	73.2	73.5	75.0	74.1	75.6	75.9	76.3	76.6	76.5
DRY	Drybridge	0.989	72.2	73.0	76.0	74.3	74.7	74.8	75.4	76.1	76.7	77.2
DUN	Dungannon	0.970	77.1	77.5	77.8	79.3	78.4	79.9	80.2	80.6	80.8	80.8
EDE	Eden	0.969	27.5	27.6	27.8	28.3	28.0	28.5	28.6	28.7	28.8	28.8
ENN (I)	Ennis	0.981	48.5	49.0	51.0	49.9	50.1	50.2	50.6	51.1	51.5	51.8
ENN (N)	Enniskillen	0.939	46.6	46.8	47.0	47.9	47.4	48.3	48.5	48.7	48.8	48.8
FIN (I)	Finglas	0.985	376.9	384.6	393.9	390.5	397.7	401.9	406.9	412.6	417.6	421.2
FIN (N)	Finaghy	0.984	24.6	24.7	24.9	25.3	25.0	25.5	25.6	25.7	25.8	25.8
FTT	Fortunestown	0.970	8.6	8.7	9.1	8.9	8.9	8.9	9.0	9.1	9.2	9.2
GAL	Galway	0.990	56.8	57.5	59.8	58.5	58.8	58.9	59.4	59.9	60.4	60.7
GI	Great Island	0.950	10.4	10.5	11.8	11.6	11.6	11.6	11.7	11.8	11.9	12.0
GIL	Gilra	0.971	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4
GLE (I)	Glenlara	0.989	14.0	14.1	14.7	14.4	14.4	14.5	14.6	14.7	14.8	14.9

Table C-2: Demand Forecasts at Time of Summer Peak

Bus Code	Bus Name	Power Factor	Demand Forecast (MW)									
			2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
GLE (N)	Glengormley	0.977	25.1	25.1	25.2	25.5	25.2	25.6	25.6	25.6	25.5	25.6
GOR (N)	Gort	1.000	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
GRI	Griffinrath	0.994	46.1	46.7	48.5	47.4	47.7	47.7	48.2	48.6	49.0	49.3
GWE	Gortawee	0.950	29.9	30.1	30.4	30.2	30.3	30.3	30.3	30.4	30.5	30.6
IKE	Ikerrin	0.966	24.9	25.2	26.2	25.7	25.8	25.8	26.1	26.3	26.5	26.7
INC	Inchicore	0.992	207.5	211.4	216.4	214.4	217.6	219.6	222.0	224.8	227.2	228.8
KBY	Kilbarry	0.992	76.0	76.9	79.9	78.2	78.6	78.7	79.4	80.0	80.7	81.2
KER	Knockearagh	0.990	33.2	33.6	35.0	34.2	34.4	34.4	34.7	35.0	35.3	35.5
KIN	Kinnegad	0.973	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2
KKY	Kilkenny	0.966	53.3	54.0	46.5	45.4	45.7	45.7	46.1	46.5	46.9	47.2
KNO	Knock	0.978	40.7	40.9	41.1	36.6	36.2	37.0	37.1	37.3	37.4	37.4
KTL	Kilteel	0.972	40.6	41.1	42.8	41.8	42.0	42.1	42.4	42.8	43.2	43.4
KTN	Killoteran	0.973	9.0	9.1	9.5	9.3	9.4	9.4	9.4	9.5	9.6	9.7
KUD	Kilmahud	0.950	25.1	29.2	24.1	29.2	34.9	39.1	41.1	43.9	45.9	47.6
KUR	Knockumber	0.907	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7
LA	Lanesboro	0.986	13.4	13.5	14.1	13.7	13.8	13.8	14.0	14.1	14.2	14.3
LAR	Larne	0.934	22.8	22.9	23.0	23.4	23.1	23.6	23.7	23.8	23.8	23.8
LET	Letterkenny	0.984	61.7	62.4	64.9	63.5	63.8	63.9	64.5	65.0	65.6	65.9
LIB	Liberty	0.989	17.1	17.3	18.0	17.6	17.7	17.7	17.8	18.0	18.1	18.2
LIM (I)	Limerick	0.987	63.9	64.7	67.3	65.8	66.1	66.2	66.8	67.4	67.9	68.3
LIM (N)	Limavady	0.980	19.7	19.8	19.9	20.2	20.0	20.4	20.5	20.5	20.6	20.6
LIS (I)	Lisdrum	0.969	20.9	21.2	22.0	21.5	21.6	21.7	21.8	22.0	22.2	22.4
LIS (N)	Lisburn	0.985	58.8	59.1	59.4	60.5	59.8	61.0	61.2	61.5	61.6	61.7
LMR	Lisaghmore	0.980	26.1	26.2	26.4	26.9	26.6	27.1	27.2	27.3	27.4	27.4
LOG	Loguestown	0.973	31.0	31.2	31.3	31.9	31.5	32.1	32.2	32.4	32.4	32.5
MAC	Macroom	0.949	9.9	10.0	10.4	10.2	10.2	10.2	10.3	10.4	10.5	10.6
MAL	Mallow	0.980	18.3	18.5	19.2	18.8	18.9	18.9	19.1	19.3	19.4	19.5
MCE	Macetown	0.979	27.9	28.1	29.1	28.5	28.7	28.7	28.9	29.1	29.3	29.5
MID	Midleton	0.985	33.9	34.3	35.7	34.9	35.0	35.1	35.4	35.7	36.0	36.2
MLN	Mullagharlin	0.958	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
MON	Monread	0.989	10.9	11.0	11.5	11.2	11.3	11.3	11.4	11.5	11.6	11.7
MOY	Moy	0.990	22.6	22.9	23.8	23.3	23.4	23.4	23.6	23.8	24.0	24.2
MR	Marina	0.997	12.5	12.7	13.2	12.9	12.9	13.0	13.1	13.2	13.3	13.4
MTH	Meathhill	0.965	44.6	45.1	47.0	45.9	46.1	46.2	46.6	47.0	47.4	47.7
MUL	Mullingar	0.983	37.7	38.2	39.7	38.8	39.0	39.1	39.4	39.8	40.1	40.3
MUN	Mungret	0.871	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5
NAR	Newtownards	1.000	36.1	36.2	36.4	37.1	36.6	37.4	37.5	37.6	37.7	37.7
NAV	Navan	0.980	50.9	51.5	53.6	52.4	52.7	52.7	53.2	53.6	54.1	54.4
NEN	Nenagh	0.967	17.8	18.0	18.7	18.3	18.4	18.4	18.6	18.8	18.9	19.0
NEW (I)	Newbridge	0.992	22.9	23.1	24.1	23.5	23.6	23.7	23.9	24.1	24.3	24.4
NEW (N)	Newry	0.992	63.6	63.9	64.2	65.4	64.7	65.9	66.2	66.5	66.6	66.7
OLD	Oldcourt	0.949	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Table C-2: Demand Forecasts at Time of Summer Peak

Bus Code	Bus Name	Power Factor	Demand Forecast (MW)									
			2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
OMA	Omagh	0.961	48.2	48.5	48.7	49.6	49.0	49.9	50.1	50.3	50.4	50.5
OUG	Oughtragh	0.994	21.3	21.6	22.4	21.9	22.0	22.1	22.3	22.5	22.7	22.8
PB	Poolbeg	0.989	166.1	168.1	174.9	170.9	171.9	172.1	173.6	175.1	176.6	177.6
PLA	Platin	0.960	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
PLS	Portlaoise	0.990	44.8	45.4	34.8	34.0	34.2	34.2	34.5	34.8	35.1	35.3
RAT (I)	Rathkeale	0.989	23.1	23.3	24.3	23.7	23.9	23.9	24.1	24.3	24.5	24.7
RAT (N)	Rathgael	1.000	46.0	46.2	46.4	47.3	46.7	47.7	47.8	48.0	48.1	48.1
RIC	Richmond	0.977	29.3	29.6	30.8	30.1	30.3	30.3	30.6	30.8	31.1	31.3
RNW	Rinawade	0.988	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1
ROS	Rosebank	0.974	24.2	24.3	24.4	22.3	22.1	22.5	22.6	22.7	22.8	22.8
RSY	Ringaskiddy	0.996	3.3	3.3	3.4	3.4	3.4	3.4	3.4	3.5	3.5	3.5
RYB	Ryebrook	0.928	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5
SAL	Salthill	0.995	43.9	44.4	46.2	45.1	45.4	45.4	45.8	46.2	46.6	46.9
SBH	Snughborough	0.950	11.3	37.0	30.5	36.9	44.2	49.5	52.0	55.6	58.1	60.2
SCR	Screeb	0.972	23.1	23.4	24.3	23.8	23.9	23.9	24.1	24.4	24.6	24.7
SHE	Shelton Abbey	0.956	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
SKL	Shankill	0.966	47.5	48.0	50.0	48.8	49.1	49.1	49.6	50.0	50.4	50.7
SLI	Sligo	0.987	45.5	46.0	47.9	46.8	47.1	47.1	47.5	47.9	48.4	48.6
SNG	Singland	0.976	9.2	9.3	9.7	9.5	9.5	9.5	9.6	9.7	9.8	9.8
SOM	Somerset	0.990	17.7	17.9	18.6	18.2	18.3	18.4	18.5	18.7	18.8	18.9
SPR	Springtown	0.995	37.8	38.0	38.2	38.9	38.4	39.1	39.3	39.4	39.5	39.5
STR	Stratford	0.991	17.4	17.6	18.3	17.9	18.0	18.0	18.2	18.4	18.5	18.6
STR (N)	Strabane	0.965	33.7	33.8	34.0	34.6	34.2	34.8	35.0	35.1	35.2	35.2
TBG	Trabeg	0.993	60.2	60.9	63.3	61.9	62.2	62.3	62.9	63.4	63.9	64.3
TBK	Tullabrack	0.980	9.2	9.3	9.7	9.5	9.5	9.5	9.6	9.7	9.8	9.8
THU	Thurles	0.976	23.5	23.8	24.7	24.2	24.3	24.3	24.5	24.8	25.0	25.1
TIP	Tipperary	0.979	17.3	17.5	18.3	17.8	17.9	18.0	18.1	18.3	18.4	18.5
TLK	Trillick	0.989	16.9	17.1	17.8	17.4	17.5	17.5	17.7	17.8	18.0	18.1
TON	Tonroe	0.993	12.9	13.0	13.5	13.2	13.3	13.3	13.4	13.6	13.7	13.8
TRI	Trien	0.957	20.2	20.4	21.3	20.8	20.9	20.9	21.1	21.3	21.5	21.6
TRL	Tralee	0.995	46.5	47.0	48.9	47.8	48.1	48.1	48.5	49.0	49.4	49.7
TSB	Thornsberry	0.982	26.8	27.1	28.2	27.5	27.7	27.7	28.0	28.2	28.5	28.6
WAR	Waringstown	0.972	52.7	52.9	53.1	54.1	53.5	54.5	54.7	54.9	55.0	55.1
WAT	Waterford	0.978	46.6	47.2	48.2	47.1	47.4	47.4	47.9	48.3	48.7	49.0
WEX	Wexford	0.968	47.6	48.2	50.1	49.0	49.2	49.3	49.7	50.2	50.6	50.9
WHI	Whitegate	0.870	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)									
			2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
AA	Ardnacrusha	0.988	21.9	21.1	22.5	19.5	18.3	17.3	17.1	16.7	16.5	16.3
AGH	Aghyoule	1.000	4.1	4.2	4.2	4.3	4.3	4.4	4.4	4.5	4.5	4.5
AGY	Ardnagappary	0.985	3.8	3.7	3.9	3.4	3.2	3.0	3.0	2.9	2.9	2.8
AHA	Ahane	0.951	0.8	0.8	0.8	0.7	0.7	0.7	0.6	0.6	0.6	0.6
AIR	Airport Road (Belfast)	0.990	-	-	-	-	8.4	9.1	9.5	9.9	11.1	10.0
ANR	Anner	0.897	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
ANT	Antrim	0.991	12.4	12.5	12.5	12.8	12.6	12.9	12.9	13.0	13.0	13.0
ARI	Arigna	0.954	1.2	1.1	1.2	1.0	1.0	0.9	0.9	0.9	0.9	0.9
ARK	Arklow	0.961	3.9	3.7	4.0	3.4	3.2	3.1	3.0	3.0	2.9	2.9
ATH	Athlone	0.998	19.8	19.1	20.3	17.6	16.5	15.7	15.5	15.1	15.0	14.8
ATY	Athy	0.997	5.3	5.1	5.4	4.7	4.4	4.2	4.1	4.0	4.0	3.9
BAL	Baltrasna	0.980	3.5	3.4	3.6	3.1	2.9	2.8	2.7	2.7	2.6	2.6
BAN (I)	Bandon	0.980	18.0	17.4	18.4	16.2	15.3	14.7	14.5	14.2	14.1	13.9
BAN (N)	Banbridge	0.965	11.6	11.7	11.7	12.0	11.8	12.0	12.1	12.1	12.2	12.2
BAR	Barrymore	0.988	9.8	9.4	10.0	8.7	8.2	7.7	7.7	7.5	7.4	7.3
BDA	Baroda	0.988	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
BDN	Ballydine	0.970	8.4	8.3	8.4	8.1	8.0	7.9	7.9	7.8	7.8	7.8
BEG	Ballybeg	0.997	3.2	3.1	3.3	2.9	2.7	2.6	2.5	2.5	2.4	2.4
BGD	Belgard Road	0.950	35.9	41.7	34.4	41.7	49.9	55.9	58.7	62.7	65.6	68.0
BGT	Ballyragget	0.977	-	-	6.4	5.6	5.2	5.0	4.9	4.8	4.7	4.7
BIN	Binbane	0.962	4.6	4.4	4.7	4.1	3.8	3.6	3.6	3.5	3.5	3.4
BK	Bellacorick	0.993	1.5	1.4	1.5	1.3	1.3	1.2	1.2	1.1	1.1	1.1
BKY	Barnakyle	0.950	2.4	2.4	27.1	32.0	37.6	41.8	43.8	46.7	48.7	50.4
BLC	Belcamp	0.950	-	47.7	69.8	84.5	101.2	113.4	119.0	127.3	133.1	138.0
BLI	Ballylickey	0.960	3.7	3.6	3.8	3.3	3.1	2.9	2.9	2.8	2.8	2.7
BLK	Blake	0.992	4.2	4.1	4.3	3.8	3.5	3.3	3.3	3.2	3.2	3.2
BMA	Ballymena	0.965	24.8	24.9	25.0	25.5	25.2	25.7	25.8	25.9	25.9	26.0
BNH	Ballynahinch	0.995	16.9	17.0	17.0	17.4	17.1	17.5	17.5	17.6	17.6	17.7
BNM	Belfast North	0.990	14.8	14.9	15.0	15.3	15.1	15.4	15.4	15.5	15.5	15.6
BOG	Banoge	0.984	6.1	5.8	6.2	5.4	5.1	4.8	4.7	4.6	4.6	4.5
BRA	Bracklone	0.978	3.3	3.2	3.4	3.0	2.8	2.6	2.6	2.6	2.5	2.5
BRI	Brinny	0.971	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
BRY	Barnahely	0.984	18.5	17.8	18.9	16.4	15.4	14.6	14.4	14.1	13.9	13.7
BUT	Butlerstown	1.000	9.5	9.2	9.8	8.5	7.9	7.5	7.4	7.3	7.2	7.1
BVG	Ballyvallagh	0.880	4.5	4.5	4.5	4.6	4.6	4.6	4.7	4.7	4.7	4.7
CAH	Cahir	0.999	6.6	6.4	6.8	5.9	5.5	5.2	5.2	5.1	5.0	4.9
CAR	Carnmoney	0.993	7.7	7.6	7.5	7.5	7.3	7.4	7.3	7.2	7.1	7.2
CBG	Carrowbeg	0.993	7.2	7.0	7.4	6.4	6.0	5.7	5.6	5.5	5.4	5.4
CBR	Castlebar	0.987	9.3	8.9	9.5	8.2	7.7	7.3	7.2	7.1	7.0	6.9
CEN	Belfast Central	0.999	15.7	15.8	15.9	16.2	16.1	16.4	16.5	16.6	16.7	16.6
CF	Cathaleen's Fall	0.965	4.8	4.6	4.9	4.3	4.0	3.8	3.7	3.7	3.6	3.6

Table C-3: Demand Forecasts at Time of Summer Valley

Bus Code	Bus Name	Power Factor	Demand Forecast (MW)									
			2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
CFM	Castlefarm	0.901	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.8
CHA	Charleville	0.998	4.1	3.9	4.2	3.6	3.4	3.2	3.2	3.1	3.1	3.0
CKG	Corkagh	0.950	45.1	70.9	58.5	70.8	84.8	95.1	99.8	106.6	111.6	115.6
CKM	Carrickmines	0.976	129.5	131.9	130.0	126.1	129.4	131.5	133.4	135.7	137.6	139.0
CLE	Clonee	0.950	76.9	89.4	83.5	101.2	121.1	135.8	142.5	152.4	159.4	165.2
CLG	Cloghran	0.950	43.1	50.1	41.3	50.0	59.8	67.1	70.4	75.3	78.7	81.6
CLN	Cloon	0.995	7.2	6.9	7.4	6.4	6.0	5.7	5.6	5.5	5.4	5.3
CLW	Carlow	0.986	14.3	13.7	14.6	12.7	11.9	11.3	11.1	10.9	10.7	10.6
COL (I)	College Park	0.987	11.1	10.7	11.4	9.9	9.3	8.8	8.7	8.5	8.4	8.3
COL (N)	Coleraine	0.973	12.7	12.7	12.8	13.0	12.9	13.1	13.2	13.2	13.2	13.3
COS	Carrick-on-Shannon	0.994	7.1	6.9	7.3	6.3	6.0	5.6	5.6	5.4	5.4	5.3
COW	Cow Cross	0.971	1.4	1.3	1.4	1.2	1.1	1.1	1.1	1.0	1.0	1.0
CPS	Coolkeeragh	0.988	7.5	7.5	7.6	7.7	7.6	7.8	7.8	7.8	7.9	7.9
CRA	Crane	1.000	4.7	4.6	4.9	4.2	4.0	3.7	3.7	3.6	3.6	3.5
CRE	Cregagh	0.970	25.5	25.6	25.8	21.7	21.5	21.9	22.0	22.2	22.3	22.2
CRG	Creagh	0.972	7.4	7.4	7.4	7.6	7.5	7.6	7.7	7.7	7.7	7.7
CRH	Cruiserath	0.950	-	-	-	121.4	145.3	162.9	171.0	182.8	191.2	198.2
CRO	Coolroe	1.000	4.4	4.3	4.5	3.9	3.7	3.5	3.5	3.4	3.3	3.3
CVW	Castleview	0.994	7.5	7.2	7.7	6.6	6.2	5.9	5.8	5.7	5.6	5.6
DAL	Dallow	0.993	3.8	3.7	3.9	3.4	3.2	3.0	3.0	2.9	2.9	2.9
DDK	Dundalk	1.000	14.0	13.5	14.3	12.4	11.7	11.1	10.9	10.7	10.6	10.4
DFR	Dunfirth	1.000	2.4	2.3	2.5	2.1	2.0	1.9	1.9	1.8	1.8	1.8
DGN	Dungarvan	0.999	10.3	9.9	10.5	9.1	8.6	8.1	8.0	7.8	7.7	7.6
DLT	Dalton	1.000	6.7	6.5	6.9	6.0	5.6	5.3	5.3	5.1	5.1	5.0
DMY	Dunmanway	0.961	7.3	7.0	7.5	6.5	6.1	5.8	5.7	5.6	5.5	5.4
DON	Donegall	0.992	28.0	27.7	27.3	27.4	26.6	26.7	26.3	26.0	25.7	26.1
DOO	Doon	0.994	7.2	6.9	7.3	6.4	6.0	5.7	5.6	5.5	5.4	5.3
DRU (I)	Drumline	0.955	9.6	9.3	9.9	8.6	8.0	7.6	7.5	7.4	7.3	7.2
DRU (N)	Drumnakelly	0.999	27.1	27.3	27.4	27.9	27.6	28.2	28.3	28.4	28.6	28.5
DRY	Drybridge	0.995	20.5	19.8	21.0	18.3	17.1	16.2	16.1	15.7	15.5	15.3
DUN	Dungannon	0.970	28.7	28.9	29.0	29.6	29.2	29.8	29.9	30.0	30.1	30.1
EDE	Eden	0.965	10.3	10.3	10.3	10.5	10.4	10.6	10.7	10.7	10.7	10.7
ENN (I)	Ennis	0.997	14.9	14.4	15.3	13.3	12.5	11.8	11.7	11.4	11.3	11.1
ENN (N)	Enniskillen	0.981	17.4	17.4	17.5	17.9	17.7	18.0	18.1	18.2	18.2	18.2
FIN (I)	Finglas	0.982	140.8	140.5	142.4	132.5	132.0	131.0	131.9	132.5	133.4	133.9
FIN (N)	Finaghy	0.986	9.2	9.2	9.3	9.4	9.3	9.5	9.5	9.6	9.6	9.6
FTT	Fortunestown	0.970	2.6	2.5	2.6	2.3	2.1	2.0	2.0	2.0	1.9	1.9
GAL	Galway	1.000	22.7	21.9	23.3	20.2	18.9	17.9	17.7	17.3	17.1	16.9
GI	Great Island	0.950	3.9	3.7	4.2	3.6	3.4	3.2	3.2	3.1	3.1	3.1
GIL	Gilra	0.971	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4
GLE (I)	Glenlara	0.956	4.0	3.9	4.1	3.6	3.4	3.2	3.2	3.1	3.1	3.0

Table C-3: Demand Forecasts at Time of Summer Valley

Bus Code	Bus Name	Power Factor	Demand Forecast (MW)									
			2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
GLE (N)	Glengormley	0.976	9.4	9.4	9.4	9.5	9.4	9.5	9.5	9.5	9.5	9.6
GOR (N)	Gort	1.000	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
GRI	Griffinrath	0.948	13.6	13.1	14.0	12.1	11.4	10.8	10.7	10.4	10.3	10.1
GWE	Gortawee	0.943	26.5	26.3	26.6	25.9	25.6	25.3	25.3	25.2	25.2	25.1
IKE	Ikerrin	0.998	6.1	5.9	6.3	5.4	5.1	4.8	4.8	4.7	4.6	4.5
INC	Inchicore	0.983	99.0	98.3	100.3	93.2	91.7	90.5	90.7	90.7	90.8	90.7
KBY	Kilbarry	0.995	14.0	13.5	14.4	12.5	11.7	11.1	11.0	10.7	10.6	10.4
KER	Knockearagh	0.994	10.9	10.5	11.1	9.6	9.1	8.6	8.5	8.3	8.2	8.1
KIN	Kinnegad	0.973	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2
KKY	Kilkenny	1.000	13.8	13.2	11.3	9.8	9.2	8.7	8.6	8.4	8.3	8.2
KNO	Knock	0.975	15.2	15.3	15.3	13.7	13.5	13.8	13.8	13.9	13.9	13.9
KTL	Kilteel	0.988	12.0	11.5	12.3	10.7	10.0	9.5	9.4	9.1	9.0	8.9
KTN	Killoteran	0.977	3.9	3.8	4.0	3.5	3.3	3.1	3.0	3.0	2.9	2.9
KUD	Kilmahud	0.950	25.1	29.2	24.1	29.2	34.9	39.1	41.1	43.9	45.9	47.6
KUR	Knockumber	0.907	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7
LA	Lanesboro	0.978	3.5	3.4	3.6	3.1	2.9	2.8	2.8	2.7	2.7	2.6
LAR	Larne	0.881	8.5	8.5	8.6	8.7	8.6	8.8	8.8	8.9	8.9	8.9
LET	Letterkenny	0.975	13.6	13.1	13.9	12.1	11.4	10.8	10.6	10.4	10.3	10.1
LIB	Liberty	0.981	6.1	5.8	6.2	5.4	5.1	4.8	4.7	4.6	4.6	4.5
LIM (I)	Limerick	1.000	23.3	22.4	23.8	20.7	19.4	18.4	18.2	17.7	17.5	17.3
LIM (N)	Limavady	0.989	7.3	7.4	7.4	7.5	7.5	7.6	7.6	7.7	7.7	7.7
LIS (I)	Lisdrum	0.988	7.4	7.1	7.5	6.5	6.1	5.8	5.8	5.6	5.5	5.5
LIS (N)	Lisburn	0.995	21.9	22.0	22.1	22.6	22.3	22.7	22.8	22.9	23.0	23.0
LMR	Lisaghmore	0.980	9.7	9.8	9.8	10.0	9.9	10.1	10.1	10.2	10.2	10.2
LOG	Loguestown	0.994	11.6	11.6	11.7	11.9	11.7	12.0	12.0	12.1	12.1	12.1
MAC	Macroom	0.990	6.5	6.3	6.7	5.8	5.5	5.2	5.1	5.0	4.9	4.9
MAL	Mallow	0.989	5.7	5.5	5.9	5.1	4.8	4.5	4.5	4.4	4.3	4.3
MCE	Macetown	0.999	12.9	12.6	13.1	12.0	11.5	11.2	11.1	10.9	10.9	10.8
MID	Midleton	0.988	15.5	14.9	15.9	13.8	12.9	12.2	12.1	11.8	11.7	11.5
MLN	Mullagharlin	0.958	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
MON	Monread	0.993	3.6	3.4	3.6	3.2	3.0	2.8	2.8	2.7	2.7	2.6
MOY	Moy	1.000	6.5	6.3	6.7	5.8	5.4	5.1	5.1	5.0	4.9	4.8
MR	Marina	1.000	3.6	3.5	3.7	3.2	3.0	2.9	2.8	2.8	2.7	2.7
MTH	Meathhill	0.977	13.0	12.5	13.4	11.6	10.9	10.3	10.2	9.9	9.8	9.7
MUL	Mullingar	0.971	9.8	9.5	10.1	8.7	8.2	7.8	7.7	7.5	7.4	7.3
MUN	Mungret	0.871	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5
NAR	Newtownards	0.954	13.4	13.5	13.6	13.8	13.7	13.9	14.0	14.0	14.1	14.1
NAV	Navan	1.000	12.2	11.8	12.5	10.9	10.2	9.7	9.6	9.3	9.2	9.1
NEN	Nenagh	0.986	8.4	8.1	8.6	7.4	7.0	6.6	6.5	6.4	6.3	6.2
NEW (I)	Newbridge	0.992	4.4	4.2	4.5	3.9	3.7	3.5	3.4	3.3	3.3	3.3
NEW (N)	Newry	0.990	23.7	23.8	23.9	24.4	24.1	24.6	24.7	24.8	24.8	24.8
OLD	Oldcourt	0.949	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Table C-3: Demand Forecasts at Time of Summer Valley

Bus Code	Bus Name	Power Factor	Demand Forecast (MW)									
			2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
OMA	Omagh	0.970	18.0	18.1	18.1	18.5	18.3	18.6	18.7	18.7	18.8	18.8
OUG	Oughtragh	0.996	7.7	7.4	7.9	6.8	6.4	6.1	6.0	5.9	5.8	5.7
PB	Poolbeg	0.995	58.4	56.3	59.9	51.9	48.7	46.2	45.7	44.6	44.1	43.5
PLA	Platin	0.960	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
PLS	Portlaoise	0.999	12.1	11.6	8.8	7.6	7.1	6.8	6.7	6.5	6.5	6.4
RAT (I)	Rathkeale	0.989	20.9	20.1	21.4	18.6	17.4	16.5	16.3	15.9	15.8	15.5
RAT (N)	Rathgael	0.995	17.1	17.2	17.3	17.6	17.4	17.8	17.8	17.9	17.9	17.9
RIC	Richmond	1.000	8.6	8.3	8.8	7.7	7.2	6.8	6.7	6.6	6.5	6.4
RNW	Rinawade	0.988	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1
ROS	Rosebank	0.971	9.0	9.1	9.1	8.3	8.2	8.4	8.4	8.5	8.5	8.5
RSY	Ringaskiddy	0.994	0.8	0.8	0.8	0.7	0.7	0.6	0.6	0.6	0.6	0.6
RYB	Ryebrook	0.928	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5
SAL	Salthill	0.998	14.7	14.2	15.1	13.1	12.3	11.6	11.5	11.2	11.1	11.0
SBH	Snughborough	0.950	11.3	37.0	30.5	36.9	44.2	49.5	52.0	55.6	58.1	60.2
SCR	Screeb	0.971	8.1	7.8	8.3	7.2	6.7	6.4	6.3	6.2	6.1	6.0
SHE	Shelton Abbey	0.956	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
SKL	Shankill	0.997	12.5	12.0	12.8	11.1	10.4	9.9	9.7	9.5	9.4	9.3
SLI	Sligo	1.000	14.6	14.0	14.9	12.9	12.2	11.5	11.4	11.1	11.0	10.8
SNG	Singland	0.971	2.9	2.8	3.0	2.6	2.4	2.3	2.3	2.2	2.2	2.2
SOM	Somerset	0.999	3.7	3.5	3.8	3.3	3.1	2.9	2.9	2.8	2.8	2.7
SPR	Springtown	0.995	14.1	14.2	14.2	14.5	14.3	14.6	14.6	14.7	14.7	14.7
STR	Stratford	1.000	3.9	3.7	4.0	3.4	3.2	3.1	3.0	3.0	2.9	2.9
STR (N)	Strabane	0.920	12.6	12.6	12.7	12.9	12.8	13.0	13.0	13.1	13.1	13.1
TBG	Trabeg	0.988	24.8	23.9	25.4	22.1	20.7	19.6	19.4	19.0	18.7	18.5
TBK	Tullabrack	0.972	3.4	3.2	3.5	3.0	2.8	2.7	2.6	2.6	2.5	2.5
THU	Thurles	0.998	8.2	7.9	8.4	7.3	6.8	6.5	6.4	6.3	6.2	6.1
TIP	Tipperary	0.995	5.7	5.5	5.9	5.1	4.8	4.5	4.5	4.4	4.3	4.3
TLK	Trillick	0.953	4.6	4.4	4.7	4.1	3.8	3.6	3.6	3.5	3.5	3.4
TON	Tonroe	0.976	4.7	4.5	4.8	4.2	3.9	3.7	3.7	3.6	3.5	3.5
TRI	Trien	0.973	11.3	10.9	11.5	10.0	9.4	8.9	8.8	8.6	8.5	8.4
TRL	Tralee	0.981	11.3	10.9	11.6	10.1	9.4	8.9	8.9	8.6	8.5	8.4
TSB	Thornsberry	0.959	8.0	7.7	8.2	7.1	6.6	6.3	6.2	6.1	6.0	5.9
WAR	Waringstown	0.980	19.6	19.7	19.8	20.2	19.9	20.3	20.4	20.5	20.5	20.5
WAT	Waterford	1.000	20.2	19.4	20.4	17.7	16.6	15.7	15.6	15.2	15.0	14.8
WEX	Wexford	0.998	15.2	14.6	15.5	13.5	12.7	12.0	11.9	11.6	11.4	11.3
WHI	Whitegate	0.870	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)									
			2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
AGH	Aghyoule	0.998	12.3	12.4	12.5	12.8	12.7	13.0	13.1	13.2	13.3	13.3
AIR	Airport Road (Belfast)	0.990	-	-	-	-	25.0	27.0	28.1	29.5	32.8	29.6
ANT	Antrim	0.991	36.8	36.9	37.1	37.8	37.4	38.1	38.3	38.4	38.5	38.5
BAN (N)	Banbridge	0.979	34.5	34.6	34.8	35.5	35.0	35.7	35.9	36.0	36.1	36.1
BMA	Ballymena	0.979	73.5	73.8	74.2	75.6	74.7	76.2	76.5	76.8	77.0	77.0
BNH	Ballynahinch	0.991	50.1	50.3	50.5	51.5	50.9	51.9	52.0	52.2	52.3	52.4
BNM	Belfast North	0.990	44.0	44.2	44.5	45.3	44.8	45.6	45.8	46.0	46.1	46.1
BVG	Ballyvallagh	0.972	13.3	13.4	13.4	13.7	13.5	13.8	13.8	13.9	13.9	13.9
CAR	Carnmoney	0.996	22.8	22.5	22.3	22.4	21.8	21.9	21.6	21.4	21.1	21.4
CEN	Belfast Central	0.999	46.6	46.9	47.2	48.1	47.7	48.7	48.9	49.2	49.4	49.4
COL (N)	Coleraine	0.991	37.6	37.7	37.9	38.6	38.2	38.9	39.0	39.2	39.3	39.3
CPS	Coolkeeragh	0.989	22.3	22.4	22.5	22.9	22.7	23.1	23.2	23.3	23.3	23.3
CRE	Cregagh	0.987	75.7	76.1	76.4	64.3	63.7	65.0	65.4	65.8	66.0	66.0
CRG	Creagh	0.991	21.9	22.0	22.1	22.5	22.2	22.7	22.7	22.8	22.9	22.9
DON	Donegall	1.000	83.1	82.1	81.0	81.2	78.9	79.1	78.1	77.2	76.1	77.4
DRU (N)	Drumnakelly	0.988	80.5	80.9	81.3	82.9	81.9	83.6	83.9	84.4	84.7	84.6
DUN	Dungannon	0.970	85.3	85.7	86.0	87.7	86.7	88.4	88.7	89.1	89.3	89.3
EDE	Eden	0.984	30.4	30.6	30.7	31.3	30.9	31.5	31.6	31.8	31.8	31.9
ENN (N)	Enniskillen	0.984	51.5	51.7	52.0	53.0	52.4	53.4	53.6	53.8	54.0	54.0
FIN (N)	Finaghy	0.994	27.2	27.4	27.5	28.0	27.7	28.2	28.3	28.4	28.5	28.5
GLE (N)	Glengormley	0.976	27.8	27.8	27.8	28.2	27.8	28.3	28.3	28.3	28.2	28.4
GOR (N)	Gort	0.998	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.1
KNO	Knock	0.981	45.0	45.3	45.5	40.5	40.0	40.9	41.0	41.2	41.4	41.4
LAR	Larne	0.972	25.2	25.3	25.4	25.9	25.6	26.1	26.2	26.3	26.3	26.3
LIM (N)	Limavady	0.977	21.8	21.9	22.0	22.4	22.1	22.5	22.6	22.7	22.7	22.8
LIS (N)	Lisburn	0.992	65.1	65.4	65.7	66.9	66.1	67.5	67.7	68.0	68.1	68.2
LMR	Lisaghmore	0.980	28.9	29.0	29.1	29.7	29.4	29.9	30.1	30.2	30.2	30.3
LOG	Loguestown	0.977	34.3	34.5	34.6	35.3	34.8	35.5	35.7	35.8	35.9	35.9
NAR	Newtownards	1.000	39.9	40.1	40.2	41.0	40.5	41.3	41.4	41.6	41.7	41.7
NEW (N)	Newry	0.990	70.3	70.6	71.0	72.3	71.5	72.9	73.2	73.5	73.7	73.7
OMA	Omagh	0.993	53.3	53.6	53.8	54.8	54.2	55.2	55.4	55.6	55.7	55.8
RAT (N)	Rathgael	0.997	50.9	51.1	51.3	52.3	51.7	52.7	52.9	53.1	53.2	53.2
ROS	Rosebank	0.979	26.7	26.9	27.0	24.7	24.4	24.9	25.0	25.1	25.2	25.2
SPR	Springtown	0.994	41.8	42.0	42.2	43.0	42.5	43.3	43.4	43.6	43.7	43.7
STR (N)	Strabane	0.968	37.2	37.4	37.5	38.3	37.8	38.5	38.7	38.8	38.9	38.9
WAR	Waringstown	0.986	58.2	58.5	58.7	59.8	59.1	60.3	60.5	60.7	60.8	60.9

All-Island Ten Year

Transmission Forecast Statement 2019

Appendix D

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[130] of each unit. All generation capacity figures in Table D-1 are expressed in exported terms. Exported terms are given by the generation unit output less 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 currently have signed connection agreements with the DSO. The connection agreements are based on the best available knowledge as at January 2019.

Table D-3 lists the existing and committed distribution connected generation in Ireland, excluding wind generation. Their respective MW capacity over the period of the statement is included.

Table D-4 lists the existing and committed non-embedded distribution connected renewable generation in Northern Ireland, excluding wind generation. Their respective MW capacity over the period of the statement is included.

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		Mulreavy	110 kV	Wind	2020	66
	Carrickaduff (2)		Mulreavy	110 kV	Wind	2020	33
	Erne	ER3	Cathaleen's Fall	110 kV	Hydro		22
	Erne	ER4	Cathaleen's Fall	110 kV	Hydro		23
	Erne	ER1	Cliff	110 kV	Hydro		10
	Erne	ER2	Cliff	110 kV	Hydro		10
	Garvagh - Glebe		Garvagh	110 kV	Wind		26
	Garvagh - Tullynahaw		Garvagh	110 kV	Wind		22
	Golagh		Golagh	110 kV	Wind		15
	Kingsmountain (1)		Cunghill	110 kV	Wind		24
	Kingsmountain (2)		Cunghill	110 kV	Wind		11
	Meentycat (1)		Meentycat	110 kV	Wind		71
	Meentycat (2)		Meentycat	110 kV	Wind		14
	Mountain Lodge		Ratrussan	110 kV	Wind		31
	Mulreavy		Mulreavy	110 kV	Wind		82
	Mulreavy Ext		Mulreavy	110 kV	Wind		13
	Oriel		Oriel	110 kV	Wind	2022	210
	Carrickallen		Shankill	110 kV	Wind		22
	Ratrussan		Ratrussan	110 kV	Wind		48
	Border Area Total						**752**
Dublin	Dublin Bay Power	DB1	Irishtown	220 kV	Gas/DO		415
	Gallanstown		Gallanstown	110 kV	Solar	2021	85
	Harristown		Harristown	110 kV	Solar	2021	42
	Huntstown	HNC	Huntstown A	220 kV	Gas/DO		359
	Huntstown	HN2	Huntstown B	220 kV	Gas/DO		412
	North Wall	NW5	North Wall	220 kV	Gas/DO		109
	Dublin Waste to Energy	DW1	Whitebank	110 kV	Waste		61
	Poolbeg	PBC	Shellybanks	220 kV	Gas/DO		473
	Dublin Area Total						**1,956**

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	Liffey Hydro	LI1	Pollaphuca	110 kV	Hydro		15
	Liffey Hydro	LI2	Pollaphuca	110 kV	Hydro		15
	Liffey Hydro	LI4	Pollaphuca	110 kV	Hydro		15
	Muckerstown		Muckerstown	110 kV	Solar	2021	34
	Timahoe		Timahoe	110 kV	Solar	2020	70
	Turlough Hill	TH1	Turlough Hill	220 kV	Hydro		73
	Turlough Hill	TH2	Turlough Hill	220 kV	Hydro		73
	Turlough Hill	TH3	Turlough Hill	220 kV	Hydro		73
	Turlough Hill	TH4	Turlough Hill	220 kV	Hydro		73
	Mid-East Area Total						**441**
Midlands	Edenderry Peaking	ED3	Cushaling	110 kV	Distillate		117
	Edenderry Power	ED1	Cushaling	110 kV	Peat		134
	Lough Ree Power	LR4	Lanesboro	110 kV	Peat		103
	Loughteague		Coolnabacky	110 kV	Solar	2021	55
	Lumcloon		Lumcloon	110 kV	Battery	2021	100
	Mountlucas		Mountlucas	110 kV	Wind		79
	Rhode PCP (1)	RP1	Derryiron	110 kV	Distillate		52
	Rhode PCP (2)	RP2	Derryiron	110 kV	Distillate		52
	Midlands Area Total						**692**
Mid-West	Aughinish	SK3	Aughinish	110 kV	Gas/DO		65
	Aughinish	SK4	Aughinish	110 kV	Gas/DO		65
	Ardnacrusha Hydro (1)	AA1	Ardnacrusha	110 kV	Hydro		22
	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
	Moneypoint WF		Moneypoint	110 kV	Wind		18
	Boolinrudda		Ennis	110 kV	Wind		46
	Booltiagh		Booltiagh	110 kV	Wind		19
	Booltiagh Ext.		Booltiagh	110 kV	Wind		12
	Knockalassa		Ennis	110 kV	Wind		27
	Dromada (1)		Dromada	110 kV	Wind		29
	Kill Hill		Kill Hill	110 kV	Wind		36
	Lisheen (1)		Lisheen	110 kV	Wind		36
	Lisheen (1a)		Lisheen	110 kV	Wind		19
	Moneypoint (1)	MP1	Moneypoint	400 kV	Coal		308
	Moneypoint (2)	MP2	Moneypoint	400 kV	Coal		308
	Moneypoint (3)	MP3	Moneypoint	400 kV	Coal		308
	Mid-West Area Total						**1,383**

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)
Northern Ireland	Belfast Power Station		Castlereagh	275 kV	Gas	2022	490
	Ballylumford B10	B10	Ballylumford	110 kV	Gas		100
	Ballylumford GT7	BGT1	Ballylumford	110 kV	DO		58
	Ballylumford GT8	BGT2	Ballylumford	110 kV	DO		58
	Ballylumford B20	BGT20	Ballylumford	275 kV	Gas		500
	Coolkeeragh GT8	CGT8	Coolkeeragh	110 kV	Oil		53
	Coolkeeragh GT	C30 GT	Coolkeeragh	275 kV	Gas/DO		260
	Coolkeeragh ST	C30 GS	Coolkeeragh	110 kV	Gas/DO		170
	Kilroot ST1	K1	Kilroot	275 kV	Coal/Oil		195
	Kilroot ST2	K2	Kilroot	275 kV	Coal/Oil		195
	Kilroot GT1	KGT1	Kilroot	275 kV	DO		29
	Kilroot GT2	KGT2	Kilroot	275 kV	DO		29
	Kilroot GT3	KGT3	Kilroot	275 kV	DO		42
	Kilroot GT4	KGT4	Kilroot	275 kV	DO		42
	Brockaghboy		Brockaghboy	110 kV	Wind		48
	Slieve Kirk	SLK	Killymallaght	110 kV	Wind		74
	Northern Ireland Total						**1,853**
South-East	Ballywater		Ballywater	110 kV	Wind		42
	Castledockrell		Castledockrell	110 kV	Wind		41
	Great Island CCGT	GI4	Great Island	220 kV	Gas		439
	Knocknamona		Dungarvan	110 kV	Wind	2025	34
	Rosspile		Rosspile	110 kV	Solar	2020	95
	Woodhouse		Woodhouse	110 kV	Wind		20
	South-East Area Total						**671**
South-West	Aghada	AD1	Aghada	220 kV	Gas		270
	Aghada	AT1	Aghada	220 kV	Gas/DO		90
	Aghada	AT2	Aghada	220 kV	Gas/DO		90
	Aghada	AT4	Aghada	220 kV	Gas/DO		90
	Aghada CCGT	AD2	Longpoint	220 kV	Gas		442
	Athea		Athea	110 kV	Wind		34
	Tobertoreen		Athea	110 kV	Wind	2021	34
	Boggeragh		Boggeragh	110 kV	Wind		57
	Boggeragh (2)		Boggeragh	110 kV	Wind		48
	Killavoy		Boggeragh	110 kV	Wind		18
	Clahane		Clahane	110 kV	Wind		38
	Clahane (2)		Clahane	110 kV	Wind	2021	14
	Banemore		Clahane	110 kV	Solar	2021	34
	Cloghboola		Cloghboola	110 kV	Wind		46
	Coomacheo		Garrow	110 kV	Wind		41

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)
South-West	Coomacheo (2)		Garrow	110 kV	Wind		18
	Coomagearlahy		Coomagearlahy	110 kV	Wind		43
	Coomagearlahy ext.		Coomagearlahy	110 kV	Wind		39
	Coomataggart		Coomataggart	110 kV	Wind		114
	Cordal		Cordal	110 kV	Wind	2022	90
	Drombeg		Drombeg	110 kV	Solar	2021	50
	Glanlee (1)		Glanlee	110 kV	Wind		30
	Kelwin Power Plant		Kilpaddoge	110 kV	Hybrid	2021	44
	Knockacummer		Knockacummer	110 kV	Wind		105
	Barnadivane		Barnadivine	110 kV	Wind		60
	Cloghboola		Cloghboola	110 kV	Wind		46
	Lee Hydro	LE1	Carrigadrohid	110 kV	Hydro		8
	Lee Hydro	LE2	Inniscarra	110 kV	Hydro		15
	Lee Hydro	LE3	Inniscarra	110 kV	Hydro		15
	Marina	MRT	Marina	110 kV	Gas/DO		93
	Grousemount		Coomataggart	110 kV	Wind		114
	Tarbert	TB1	Tarbert	110 kV	HFO		57
	Tarbert	TB2	Tarbert	110 kV	HFO		57
	Tarbert	TB3	Tarbert	220 kV	HFO		256
	Tarbert	TB4	Tarbert	220 kV	HFO		258
	Whitegen CCGT	WG	Glanagow	220 kV	Gas/DO		449
	South-West Area Total						**3,306**
West	Ardderoo		Buffy	110 kV	Wind	2021	91
	Oweninney (1)		Bellacorick	110 kV	Wind		89
	Oweninney (2)		Bellacorick	110 kV	Wind		83
	Oweninney (3)		Bellacorick	110 kV	Wind	2022	50
	Sheskin		Bellacorick	110 kV	Wind	2022	33
	Carrigdangan		Carrigdangan	110 kV	Wind	2020	60
	Derrybrien		Derrybrien	110 kV	Wind		60
	Tullynahaw		Garvagh	110 kV	Wind		22
	Knockalough		Knockalough	110 kV	Wind		34
	Seecon		Knockranny	110 kV	Wind		108
	Shannonbridge ESS		Shannonbridge	110 kV	Battery	2021	100
	Shannonbridge ESS		Shannonbridge	110 kV	Battery	2021	97
	West Offaly Power	WO4	Shannonbridge	110 kV	Peat		154
	Shantallow		Shantallow	110 kV	Solar	2021	35
	Sliabh Bawn		Sliabh Bawn	110 kV	Wind		58

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	Tawnaghmore Peaking Plant	TP1	Tawnaghmore	110 kV	DO		52
	Tawnaghmore Peaking Plant	TP2	Tawnaghmore	110 kV	DO		52
	Tynagh	TY1	Tynagh	220 kV	Gas		268
	Tynagh	TY2	Tynagh	220 kV	Gas		142
	Ugool		Ugool	110 kV	Wind		66
	West Area Total						1,563

Table D-2: Existing and Committed Distribution-Connected Wind Farm Capacity

Area	110 kV Station	Maximum Export Capacity (MEC)									
		2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Border	Ardnagappary	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9
	Binbane	40.3	71.6	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0
	Cathaleen's Fall	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4
	Corderry	63.3	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8
	Crane	7.5	7.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5
	Drybridge	6.5	10.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6
	Dundalk	0.5	0.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5
	Garvagh	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0
	Glenree	77.3	77.3	77.3	77.3	77.3	77.3	77.3	77.3	77.3	77.3
	Gortawee	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	Letterkenny	51.4	52.9	87.3	87.3	87.3	87.3	87.3	87.3	87.3	87.3
	Lisdrum	0.0	16.1	16.1	49.2	49.2	49.2	49.2	49.2	49.2	49.2
	Meath Hill	45.6	45.6	72.6	72.6	72.6	72.6	72.6	72.6	72.6	72.6
	Moy	6.0	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
	Mulreavy	33.1	33.1	33.1	33.1	33.1	33.1	33.1	33.1	33.1	33.1
	Shankill	6.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	Sligo	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7
	Somerset	19.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5
	Sorne Hill	63.9	63.9	63.9	63.9	63.9	63.9	63.9	63.9	63.9	63.9
	Trien	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2
	Trillick	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7
	Border Area Total	**652.7**	**727.8**	**852.5**	**885.6**	**885.6**	**885.6**	**885.6**	**885.6**	**885.6**	**885.6**
Dublin	Finglas	0.0	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9
	Nangor	0.0	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
	Dublin Area Total	**4.0**	**25.3**	**11.9**	**11.9**	**11.9**	**11.9**	**11.9**	**11.9**	**11.9**	**11.9**
Mid-East	Arklow	79.7	83.7	89.7	89.7	89.7	89.7	89.7	89.7	89.7	89.7
	Baltrasna	0.0	0.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	Dunfirth	0.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	Kilteel	0.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
	Monread	0.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	Newbridge	0.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	Mid-East Area Total	**79.7**	**110.7**	**126.7**	**126.7**	**126.7**	**126.7**	**126.7**	**126.7**	**126.7**	**126.7**
Midlands	Blake	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	Dallow	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1
	Lanesboro	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
	Mullingar	0.0	0.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	Navan	0.0	4.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	Richmond	0.0	0.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	Thornsberry	0.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	Midlands Area Total	**20.6**	**28.6**	**41.6**	**41.6**	**41.6**	**41.6**	**41.6**	**41.6**	**41.6**	**41.6**

Table D-2: Existing and Committed Distribution-Connected Wind Farm Capacity

Area	110 kV Station	Maximum Export Capacity (MEC)									
		2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Mid-West	Ardnacrusha	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2
	Ballydine	0.0	0.0	4.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
	Booltiagh	80.4	85.4	85.4	85.4	85.4	85.4	85.4	85.4	85.4	85.4
	Bunkimalta	0.0	46.5	46.5	46.5	46.5	46.5	46.5	46.5	46.5	46.5
	Cahir	4.0	4.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
	Cauteen	178.1	182.1	182.1	182.1	182.1	182.1	182.1	182.1	182.1	182.1
	Charleville	84.7	84.7	84.7	84.7	84.7	84.7	84.7	84.7	84.7	84.7
	Cureeny	0.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0
	Drumline	0.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	Ikerrin	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0
	Lisheen	39.6	39.6	39.6	39.6	39.6	39.6	39.6	39.6	39.6	39.6
	Nenagh	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
	Rathkeale	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	Thurles	41.8	41.8	41.8	41.8	41.8	41.8	41.8	41.8	41.8	41.8
	Tipperary	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
	Tullabrack	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0
	Mid-West Area Total	**549.3**	**702.7**	**714.7**	**738.7**	**738.7**	**738.7**	**738.7**	**738.7**	**738.7**	**738.7**
Northern Ireland	Aghyoule	82.5	82.5	82.5	82.5	82.5	82.5	82.5	82.5	82.5	82.5
	Antrim	22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.6
	Ballymena	63.7	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2
	Agivey	0.0	0.0	119.7	119.7	119.7	119.7	119.7	119.7	119.7	119.7
	Carnmoney	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8
	Coleraine	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0
	Coolkeeragh	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
	Drumquin	70.5	70.5	70.5	70.5	70.5	70.5	70.5	70.5	70.5	70.5
	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	34.4	34.4	34.4	34.4	34.4	34.4	34.4	34.4	34.4	34.4
	Glengormley	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	Kells	0.0	0.0	0.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0
	Killymallaght	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7
	Larne	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
	Limavady	37.7	37.7	37.7	37.7	37.7	37.7	37.7	37.7	37.7	37.7
	Lismore	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5
	Loguestown	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
	Magherakeel	139.6	139.6	139.6	139.6	139.6	139.6	139.6	139.6	139.6	139.6
	Newry	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5
	Omagh	140.2	140.2	140.2	140.2	140.2	140.2	140.2	140.2	140.2	140.2

Table D-2: Existing and Committed Distribution-Connected Wind Farm Capacity

Area	110 kV Station	Maximum Export Capacity (MEC)									
		2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Northern Ireland	Gort	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5
	Rasharkin	54.8	54.8	54.8	54.8	54.8	54.8	54.8	54.8	54.8	54.8
	Strabane	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5
	Tremogue	77.2	77.2	77.2	77.2	77.2	77.2	77.2	77.2	77.2	77.2
	Northern Ireland Total	**1069.0**	**1071.5**	**1191.2**	**1266.2**	**1266.2**	**1266.2**	**1266.2**	**1266.2**	**1266.2**	**1266.2**
South-East	Athy	0.0	0.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	Banoge	0.0	0.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	Barrymore	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9
	Butlerstown	1.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
	Carlow	34.4	34.4	39.4	39.4	39.4	39.4	39.4	39.4	39.4	39.4
	Doon	0.0	0.0	4.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0
	Dungarvan	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
	Great Island	0.0	5.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0
	Kilkenny	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	Lodgewood	60.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1
	Portlaoise	64.2	64.2	68.2	68.2	68.2	68.2	68.2	68.2	68.2	68.2
	Waterford	18.3	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2
	Wexford	38.9	38.9	42.9	46.9	46.9	46.9	46.9	46.9	46.9	46.9
	South-East Area Total	**270.6**	**287.5**	**329.5**	**358.5**	**358.5**	**358.5**	**358.5**	**358.5**	**358.5**	**358.5**
South-West	Athea	0.0	3.6	41.5	41.5	41.5	41.5	41.5	41.5	41.5	41.5
	Ballylickey	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0
	Bandon	26.6	26.6	26.6	30.6	30.6	30.6	30.6	30.6	30.6	30.6
	Barnahely	0.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	Boggeragh	20.0	20.0	31.4	31.4	31.4	31.4	31.4	31.4	31.4	31.4
	Castleview	2.0	2.0	2.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	Cloghboola	54.5	54.5	54.5	54.5	54.5	54.5	54.5	54.5	54.5	54.5
	Coomataggart	64.2	64.2	64.2	64.2	64.2	64.2	64.2	64.2	64.2	64.2
	Cordal	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8	76.8
	Dunmanway	24.8	24.8	49.7	52.7	52.7	52.7	52.7	52.7	52.7	52.7
	Garrow	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
	Glenlara	53.0	53.0	53.0	53.0	53.0	53.0	53.0	53.0	53.0	53.0
	Glentane	0.0	40.3	40.3	40.3	40.3	40.3	40.3	40.3	40.3	40.3
	Kilbarry	0.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8
	Kilpaddoge	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
	Knockeragh	13.9	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1
	Limerick	0.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	Macroom	34.1	34.1	34.1	34.1	34.1	34.1	34.1	34.1	34.1	34.1

Table D-2: Existing and Committed Distribution-Connected Wind Farm Capacity

Area	110 kV Station	Maximum Export Capacity (MEC)									
		2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Northern Ireland	Mallow	5.0	5.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	Midleton	1.6	1.6	1.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
	Oughtragh	9.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
	Reamore	57.4	57.4	70.9	96.2	96.2	96.2	96.2	96.2	96.2	96.2
	Trabeg	0.0	0.0	0.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	Tralee	45.9	51.6	55.6	55.6	55.6	55.6	55.6	55.6	55.6	55.6
	South-West Area Total	**576.3**	**649.1**	**744.8**	**788.0**	**788.0**	**788.0**	**788.0**	**788.0**	**788.0**	**788.0**
West	Arigna	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6
	Bellacorick	9.0	9.0	9.0	68.2	68.2	68.2	68.2	68.2	68.2	68.2
	Carrick on Shannon	0.0	4.0	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
	Castlebar	34.7	39.2	39.2	39.2	39.2	39.2	39.2	39.2	39.2	39.2
	Cloon	4.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
	Dalton	43.2	43.2	43.2	43.2	43.2	43.2	43.2	43.2	43.2	43.2
	Glasmore	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Salthill	46.1	46.1	46.1	46.1	46.1	46.1	46.1	46.1	46.1	46.1
	Screeb	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	Tawnaghmore	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	Tonroe	12.5	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
	West Area Total	**199.2**	**213.2**	**217.5**	**276.7**	**276.7**	**276.7**	**276.7**	**276.7**	**276.7**	**276.7**

Table D-3: Existing and Committed Distribution-Connected Generation in Ireland (excluding wind)

Area	110 kV Station	Type	Maximum Export Capacity (MEC)									
			2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Border	Binbane	Hydro	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
	Drybridge	Waste to Energy	20	20	20	20	20	20	20	20	20	20
	Drybridge	LFG	7.97	7.97	7.97	7.97	7.97	7.97	7.97	7.97	7.97	7.97
	Drybridge	Biogas	-	-	3	3	3	3	3	3	3	3
	Meath Hill	CHP	1	1	1	1	1	1	1	1	1	1
	Shankill	LFG	3.017	3.017	3.017	3.017	3.017	3.017	3.017	3.017	3.017	3.017
	Border Area Total		**36.3**	**36.3**	**39.3**	**39.3**	**39.3**	**39.3**	**39.3**	**39.3**	**39.3**	**39.3**
Dublin	Glasmore	CHP	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
	Ringsend	Waste to Energy	72	72	72	72	72	72	72	72	72	72
	Ringsend	Diesel	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	Finglas	CHP	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
	Blackrock	CHP	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
	Dublin Area Total		**76.3**	**76.3**	**76.3**	**76.3**	**76.3**	**76.3**	**76.3**	**76.3**	**76.3**	**76.3**
Mid-East	Arklow	Biomass	1	1	1	1	1	1	1	1	1	1
	Kilteel	LFG	9.77	9.77	9.77	9.77	9.77	9.77	9.77	9.77	9.77	9.77
	Griffinrath	Hydro	4	4	4	4	4	4	4	4	4	4
	Griffinrath	solar	-	4	4	4	4	4	4	4	4	4
	Mid-East Area Total		**14.8**	**18.8**	**18.8**	**18.8**	**18.8**	**18.8**	**18.8**	**18.8**	**18.8**	**18.8**
Midland	Athlone	Solar	-	4	4	4	4	4	4	4	4	4
	Athlone	LFG	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	Mullingar	Solar	4	4	4	4	4	4	4	4	4	4
	Navan	CHP	13	13	13	13	13	13	13	13	13	13
	Navan	Solar	-	-	4	4	4	4	4	4	4	4
	Thornsberry	CHP	-	-	10	10	10	10	10	10	10	10
	Midland Area Total		**17.8**	**21.8**	**35.8**	**35.8**	**35.8**	**35.8**	**35.8**	**35.8**	**35.8**	**35.8**
Mid-West	Ballydine	Biogas	-	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
	Rathkeale	Biogas	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
	Tullabrack	Wave	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
	Mid-West Area Total		**18.3**	**18.7**	**18.7**	**18.7**	**18.7**	**18.7**	**18.7**	**18.7**	**18.7**	**18.7**
South-East	Ballybeg	LFG	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26
	Barrymore	CHP	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
	Doon	Hydro	-	1	1	1	1	1	1	1	1	1
	Kilkenny	CHP	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
	Kilkenny	Biogas	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
	Portlaoise	Solar	-	4	4	4	4	4	4	4	4	4
	Portlaoise	Biogas	1	1	1	1	1	1	1	1	1	1
	Wexford	CHP	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
	South-East Area Total		**25.2**	**30.2**	**30.2**	**30.2**	**30.2**	**30.2**	**30.2**	**30.2**	**30.2**	**30.2**

Table D-3: Existing and Committed Distribution-Connected Generation in Ireland (excluding wind)

Area	110 kV Station	Type	Maximum Export Capacity (MEC)									
			2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
South-West	Castleview	CHP	2	2	2	4	4	4	4	4	4	4
	Dunmanway	CHP	6	6	6	6	6	6	6	6	6	6
	Knockeragh	Biogas	3	3	3	3	3	3	3	3	3	3
	Midleton	Solar	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95
	South-West Area Total		**15.0**	**15.0**	**15.0**	**17.0**	**17.0**	**17.0**	**17.0**	**17.0**	**17.0**	**17.0**
West	Bellacorick	Wave	10	10	10	10	10	10	10	10	10	10
	Tawnaghmore	Biomass	-	-	-	54	54	54	54	54	54	54
	West Area Total		**10.0**	**10.0**	**10.0**	**64.0**	**64.0**	**64.0**	**64.0**	**64.0**	**64.0**	**64.0**

Table D-4: Existing and Committed Non-Embedded Distribution-Connected Renewables in Northern Ireland (excluding wind)

110 kV Station	Type	Maximum Export Capacity (MEC)									
		2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Antrim	PV	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6
Ballymena	PV	6	6	6	6	6	6	6	6	6	6
Coolkeeragh	Biomass	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6
Glengormley	PV	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Dungannon	PV	5	5	5	5	5	5	5	5	5	5
Lisburn	PV	58.9	58.9	58.9	58.9	58.9	58.9	58.9	58.9	58.9	58.9
Rasharkin	PV	35	35	35	35	35	35	35	35	35	35
Rosebank	Biomass	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
Northern Ireland Total		**161.4**	**161.4**	**161.4**	**161.4**	**161.4**	**161.4**	**161.4**	**161.4**	**161.4**	**161.4**

All-Island Ten Year

Transmission Forecast Statement 2019

Appendix E

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 E 1 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.

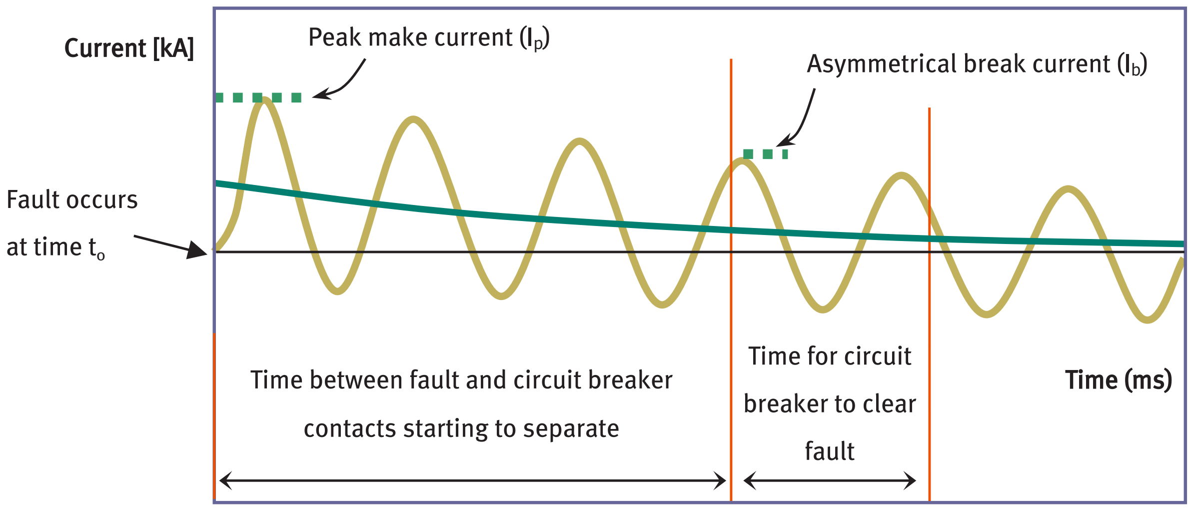


Figure E-1: Typical Short Circuit Current

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 (Ip) 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, Ib. 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[131]). 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;

131 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.

- 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;
- 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 use of this calculation method is currently under review by EirGrid.

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 2019, 2022 and 2025. 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)

$$I_{RMS\_AC\_b} = I_k^{'} + \left(I_k^{"} - I_k^{'}\right) \cdot e^{-\frac{t_b}{40ms}}$$

- DC component (I_{DC_b}) of short-circuit current at a selected time of break (t_b)

$$I_{DC\_b} = \sqrt{2} \cdot I_k^{"} \cdot e^{-2 \cdot \pi \cdot 50 \cdot t_b \cdot \frac{R}{X}}$$

- 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 2019

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	15.93	11.06	9.91	10.42	12.38	11.86	15.82	13.24	11.67	10.10	14.23	13.56
Agannygal 110 kV	2.78	4.94	4.78	3.87	4.16	4.12	2.97	6.43	5.79	4.25	4.89	4.75
Aghada 110 kV	5.12	8.28	7.85	6.11	9.67	9.47	4.63	9.80	9.28	5.66	11.12	10.89
Aghada A 220 kV	14.17	11.86	10.69	15.14	14.65	14.00	13.13	16.36	14.71	14.21	18.84	18.04
Aghada B 220 kV	13.64	12.38	11.11	12.19	15.18	14.49	13.14	17.97	16.01	11.30	20.28	19.36
Aghada C 220 kV	13.69	11.56	10.45	13.69	14.30	13.68	12.73	15.91	14.34	12.73	18.36	17.60
Aghada D 220 kV	13.69	11.56	10.45	13.69	14.30	13.68	12.73	15.91	14.34	12.73	18.36	17.60
Ahane 110 kV	5.48	10.96	10.22	6.03	9.45	9.25	4.91	14.76	13.66	5.74	11.25	11.02
Anner 110 kV	4.04	5.96	5.66	4.51	4.51	4.45	4.02	7.28	6.72	4.54	5.02	4.93
Ardnacrusha 110 kV	5.97	11.97	11.02	7.12	13.31	12.89	5.98	18.30	16.34	7.56	17.89	17.21
Ardnagappary 110 kV	2.77	1.85	1.80	3.93	1.20	1.19	2.92	2.51	2.30	4.24	1.33	1.31
Arigna 110 kV	4.38	6.12	5.84	5.40	5.12	5.05	4.53	8.46	7.72	5.73	6.10	5.96
Arklow 110 kV	10.62	7.41	7.10	11.38	9.07	8.92	10.91	9.66	9.00	11.68	11.29	10.97
Arklow 220 kV	9.06	6.96	6.62	10.38	6.56	6.46	9.04	8.54	8.12	10.46	7.58	7.47
Artane 110 kV	13.31	9.81	9.17	6.29	11.91	11.58	13.27	13.19	11.96	5.69	15.23	14.64
Arva 110 kV	3.92	7.90	7.41	4.97	6.49	6.37	3.90	10.37	9.35	5.15	7.55	7.35
Athea 110 kV	10.32	6.25	6.07	10.85	6.76	6.69	11.22	10.09	8.88	11.91	9.42	9.03
Athlone 110 kV	4.42	7.24	6.82	5.76	5.53	5.44	4.08	8.46	7.83	5.53	5.97	5.86
Athy 110 kV	3.33	5.78	5.55	4.46	4.81	4.75	3.16	6.88	6.48	4.39	5.39	5.31
Aughinish 110 kV	9.04	9.55	8.51	11.00	10.43	9.98	8.02	10.87	9.81	10.04	11.31	10.89
Ballybeg 110 kV	10.24	5.52	5.32	10.56	6.53	6.43	9.95	7.10	6.74	10.14	8.19	8.02
Ballydine 110 kV	4.06	6.64	6.32	3.78	5.40	5.33	4.00	7.96	7.41	3.74	5.99	5.88
Ballylickey 110 kV	2.79	2.96	2.88	3.93	1.90	1.89	2.97	3.79	3.57	4.12	2.12	2.10
Ballynahulla 110 kV	13.58	7.12	6.88	12.03	7.72	7.62	16.30	12.03	10.62	12.66	10.95	10.52
Ballynahulla 220 kV	8.57	6.15	5.86	8.56	6.94	6.81	9.35	10.76	9.87	9.07	10.32	10.02

Table E-2: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2019

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]
Ballyvouskill 110 kV	14.01	7.30	7.03	13.62	8.67	8.54	13.79	11.80	10.51	13.20	12.41	11.89
Ballyvouskill 220 kV	8.69	6.48	6.15	9.32	8.08	7.90	9.00	10.67	9.77	9.79	12.03	11.62
Ballywater 110 kV	5.07	5.31	5.16	3.34	5.54	5.49	5.48	6.78	6.37	3.30	6.50	6.37
Baltrasna 110 kV	6.33	9.46	8.89	7.37	7.53	7.41	5.86	10.96	10.39	7.10	8.31	8.20
Bancroft 110 kV	14.23	7.62	7.13	9.01	8.12	7.93	12.42	13.10	12.16	6.78	14.98	14.55
Bandon 110 kV	3.30	5.87	5.56	4.35	5.75	5.65	3.15	7.49	6.88	4.36	6.78	6.60
Banoge 110 kV	6.17	5.40	5.23	6.89	4.97	4.92	6.22	6.63	6.24	6.98	5.65	5.55
Barnahealy A 110 kV	5.28	10.99	10.23	5.92	11.57	11.28	4.59	13.66	12.65	5.39	13.62	13.26
Barnahealy B 110 kV	7.25	10.74	10.01	7.71	11.16	10.88	6.36	13.63	12.55	7.06	13.27	12.90
Barnakyle 110 kV	19.44	11.21	10.05	12.45	12.29	11.79	19.71	13.46	11.86	12.17	14.14	13.49
Baroda 110 kV	4.18	8.19	7.69	4.95	9.45	9.21	3.94	10.20	9.46	4.80	11.15	10.84
Barrymore 110 kV	3.91	6.94	6.63	4.93	4.30	4.26	3.76	8.65	8.16	4.92	4.79	4.74
Belcamp 110 kV	31.80	6.33	6.13	29.03	6.57	6.50	37.44	7.51	7.17	36.56	9.19	9.02
Belcamp 220 kV	12.08	14.00	12.54	10.14	17.34	16.52	11.76	22.67	20.04	9.56	26.05	24.76
Belgard 110 kV	12.46	11.43	10.55	6.97	13.98	13.51	12.10	13.55	12.45	6.60	16.23	15.67
Bellacorick 110 kV	2.86	2.95	2.84	3.17	3.77	3.71	5.07	6.46	5.58	5.66	7.03	6.64
Binbane 110 kV	3.20	3.43	3.29	4.31	3.36	3.32	3.44	5.42	4.87	5.05	4.49	4.35
Blackrock 110 kV	10.34	11.83	10.87	2.53	11.45	11.14	9.96	14.23	12.70	2.39	12.97	12.51
Blake 110 kV	4.07	7.52	7.13	5.05	5.27	5.21	3.88	9.06	8.55	4.99	5.89	5.81
Boggeragh 110 kV	6.19	6.22	5.98	7.27	6.82	6.73	6.70	8.94	8.19	7.96	8.70	8.45
Booltiagh 110 kV	6.08	6.28	6.06	7.63	5.50	5.44	6.72	9.18	8.36	8.57	6.78	6.62
Bracklone 110 kV	3.88	7.56	7.13	4.90	7.22	7.09	3.67	9.40	8.76	4.81	8.31	8.14
Brinny A 110 kV	3.17	5.29	5.04	4.20	4.79	4.71	3.02	6.61	6.13	4.19	5.52	5.40
Brinny B 110 kV	3.16	5.32	5.06	4.20	4.82	4.75	3.02	6.64	6.15	4.19	5.56	5.44
Bunkimalta 110 kV	5.24	5.13	4.93	5.50	5.37	5.29	5.06	6.06	5.78	5.38	6.12	6.03
Butlerstown 110 kV	6.53	9.77	9.27	6.73	10.11	9.93	6.15	11.82	10.88	6.47	11.62	11.30
Cabra 110 kV	12.39	9.50	8.90	5.13	10.78	10.51	12.15	12.70	11.54	4.62	13.52	13.05
Cahir 110 kV	4.39	7.43	7.03	5.39	6.32	6.22	4.57	10.18	9.18	5.71	7.39	7.20
Carlow 110 kV	5.21	7.47	7.13	5.97	8.17	8.03	5.25	9.54	8.75	6.07	9.77	9.47
Carrickalangan 110 kV	-	-	-	-	-	-	6.41	5.89	4.91	6.65	3.25	3.13
Carrickmines 220 kV	15.11	15.89	14.03	8.92	19.35	18.33	14.76	22.23	19.70	8.33	25.74	24.48
Carrickmines A 110 kV	29.86	10.97	10.22	21.84	12.09	11.77	32.89	13.13	12.06	23.50	13.97	13.54
Carrickmines B 110 kV	22.32	8.13	7.60	18.09	8.75	8.53	26.11	14.65	13.53	20.42	17.20	16.66
Carrick-on-Shannon 110 kV	4.40	9.46	8.82	5.07	10.52	10.24	4.20	13.16	11.90	5.05	13.40	12.93

Table E-2: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2019

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]
Carrigadrohid 110 kV	6.33	10.07	9.44	6.90	9.39	9.20	6.66	15.11	13.77	6.92	13.41	13.03
Carrigdangan 110 kV	3.40	4.42	4.27	4.40	3.28	3.26	3.26	5.40	5.11	4.36	3.67	3.62
Carrowbeg 110 kV	2.63	2.44	2.34	3.47	2.32	2.29	2.72	3.28	2.99	3.75	2.80	2.73
Cashla 110 kV	6.86	12.55	11.59	7.21	16.15	15.60	7.27	19.51	17.57	7.68	23.39	22.39
Cashla 220 kV	7.95	7.90	7.41	8.92	8.58	8.38	8.45	12.36	11.59	9.66	11.76	11.51
Castlebar 110 kV	2.93	3.90	3.70	3.46	4.40	4.32	3.38	6.30	5.52	4.14	6.13	5.86
Castledockrill 110 kV	6.95	6.49	6.28	4.38	7.60	7.50	7.60	8.38	7.87	4.31	9.06	8.86
Castlefarm A 110 kV	8.10	9.21	8.23	9.51	9.72	9.32	7.21	10.45	9.46	8.74	10.51	10.15
Castlefarm B 110 kV	8.11	9.19	8.21	9.52	9.71	9.31	7.22	10.43	9.44	8.75	10.50	10.14
Castleview 110 kV	4.35	10.85	10.13	4.81	8.32	8.17	3.83	13.62	12.61	4.54	9.51	9.34
Cathaleen's Fall 110 kV	4.28	6.24	5.87	4.90	7.10	6.93	5.40	12.50	10.56	6.36	11.31	10.70
Cauteen 110 kV	5.34	6.33	6.07	6.29	4.29	4.24	5.93	9.34	8.50	6.74	5.08	4.99
Central Park 110 kV	14.74	10.08	9.43	7.73	10.88	10.61	14.61	11.94	11.04	7.53	12.46	12.11
Charleville 110 kV	4.52	5.56	5.33	5.92	5.23	5.17	4.80	7.63	6.95	6.54	6.42	6.24
Cherrywood 110 kV	10.62	9.36	8.78	7.57	9.60	9.39	10.30	10.98	10.19	7.39	10.87	10.60
City West 110 kV	6.20	7.33	6.78	6.12	5.57	5.46	5.94	8.56	7.70	5.98	6.10	5.94
Clahane 110 kV	4.32	6.28	5.99	5.51	5.86	5.78	4.08	8.66	7.95	5.44	6.97	6.81
Clashavoon 220 kV	8.96	7.49	7.03	9.66	9.04	8.80	9.07	11.66	10.70	9.89	12.75	12.34
Clashavoon A 110 kV	7.93	11.81	11.01	8.25	15.34	14.86	7.90	18.32	16.39	8.22	22.05	21.05
Clashavoon B 110 kV	7.93	11.81	11.01	8.25	15.34	14.86	7.90	18.32	16.39	8.22	22.05	21.05
Cliff 110 kV	4.03	5.12	4.87	4.96	5.26	5.17	4.66	8.99	7.91	6.03	7.37	7.10
Cloghboola 110 kV	6.79	5.45	5.31	7.25	6.34	6.27	7.46	9.31	7.89	8.05	9.42	8.87
Cloghboola 110 kV	6.79	5.45	5.31	7.25	6.34	6.27	7.46	9.31	7.89	8.05	9.42	8.87
Clogher 110 kV	3.88	5.22	4.93	4.41	5.99	5.87	5.33	11.36	9.07	6.22	10.27	9.53
Cloghran 110 kV	9.11	17.44	15.58	9.32	20.38	19.47	8.35	21.61	19.69	8.54	23.90	23.06
Clonee 220 kV	13.28	14.63	13.08	10.27	14.81	14.22	12.26	21.93	19.70	9.25	19.71	19.04
Clonkeen A 110 kV	5.76	5.43	5.23	6.82	4.10	4.06	5.54	6.65	6.29	6.74	4.58	4.52
Clonkeen B 110 kV	5.01	6.25	6.05	4.42	7.38	7.28	4.80	9.94	8.82	4.11	10.42	9.97
Cloon 110 kV	4.37	6.61	6.28	5.68	5.93	5.84	4.17	8.60	7.99	5.70	7.01	6.87
College Park 110 kV	8.79	16.61	14.93	6.38	19.90	19.03	8.08	20.65	18.89	5.81	23.84	23.00
Cookstown 110 kV	8.81	5.97	5.67	7.09	5.17	5.09	7.14	9.07	8.60	5.84	7.53	7.41
Cookstown A 110 kV	5.06	6.28	5.85	5.26	4.50	4.42	4.87	7.29	6.57	5.16	4.88	4.76
Coolroe 110 kV	3.84	8.45	7.99	5.04	8.28	8.13	3.56	11.12	10.29	4.93	9.95	9.72

Table E-2: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2019

	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
Station	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]
Coomagearlahy 110 kV	5.03	5.06	4.93	5.49	6.06	5.99	5.29	8.03	7.02	5.93	8.68	8.25
Coomataggart 110 kV	9.70	4.93	4.80	6.99	3.45	3.43	8.97	7.25	6.64	6.53	4.02	3.95
Cordal 110 kV	11.40	6.24	6.05	8.00	6.74	6.67	12.93	10.34	9.16	7.56	9.43	9.07
Corderry 110 kV	4.03	6.22	5.92	4.97	6.19	6.09	4.20	9.57	8.46	5.49	8.09	7.80
Corduff 110 kV	9.91	18.85	16.74	10.69	22.94	21.81	9.14	23.99	21.69	10.09	28.02	26.90
Corduff 220 kV	15.15	16.15	14.27	13.87	20.06	18.99	15.48	26.29	23.04	13.47	29.90	28.33
Corkagh 110 kV	18.20	11.25	10.06	12.38	12.51	11.97	18.32	13.51	11.87	12.09	14.40	13.72
Corraclassy 110 kV	4.34	5.80	5.45	5.42	4.69	4.61	4.32	7.38	6.89	5.60	5.32	5.23
Cow Cross 110 kV	4.81	11.00	10.26	5.11	9.58	9.38	4.18	13.72	12.69	4.72	11.08	10.84
Crane 110 kV	6.59	7.05	6.78	6.62	7.80	7.69	7.80	9.43	8.66	7.36	9.55	9.27
Croaghaun 110 kV	-	-	-	-	-	-	5.08	5.72	5.02	5.78	5.61	5.36
Croaghnagawna 110 kV	-	-	-	-	-	-	6.25	6.20	5.18	6.86	3.68	3.54
Cromcastle A 110 kV	12.07	9.61	8.86	7.51	10.86	10.52	11.86	12.30	10.96	7.11	13.14	12.58
Cromcastle B 110 kV	12.07	9.61	8.86	7.51	10.86	10.52	11.86	12.30	10.96	7.11	13.14	12.58
Crory 110 kV	8.35	7.31	7.05	8.62	9.19	9.04	9.73	9.63	8.96	9.66	11.29	10.97
Cullenagh 110 kV	8.11	11.72	11.05	8.61	13.70	13.38	7.51	14.37	13.21	8.12	16.12	15.61
Cullenagh 220 kV	8.98	8.47	8.05	9.21	8.58	8.43	8.22	10.01	9.52	8.65	9.74	9.58
Cunghill 110 kV	3.06	4.14	3.98	3.53	4.14	4.09	3.20	6.48	5.98	3.82	5.53	5.40
Cureeny 110 kV	4.69	4.78	4.62	5.30	5.12	5.06	4.50	5.60	5.36	5.18	5.82	5.73
Cushaling 110 kV	5.55	8.68	7.88	6.70	10.38	9.98	6.79	12.88	11.48	8.58	13.67	13.09
Dallow 110 kV	3.50	4.94	4.76	4.64	3.09	3.06	3.44	5.69	5.37	4.65	3.37	3.33
Dalton 110 kV	2.98	3.57	3.42	4.00	3.16	3.12	3.27	5.19	4.68	4.56	3.87	3.77
Dardistown 110 kV	15.15	9.73	8.97	12.04	11.25	10.89	15.45	12.49	11.12	11.86	13.70	13.10
Darndale 110 kV	-	-	-	-	-	-	34.95	7.41	7.08	36.38	9.14	8.97
Derrybrien 110 kV	2.64	3.86	3.77	3.74	3.69	3.66	3.00	5.16	4.56	4.45	4.48	4.32
Derryiron 110 kV	4.75	7.24	6.88	5.89	7.52	7.38	5.47	10.20	9.52	6.97	9.40	9.20
Doon 110 kV	4.33	6.48	6.14	4.68	5.06	4.98	4.36	8.06	7.40	4.72	5.68	5.56
Dromada 110 kV	9.60	5.86	5.70	6.68	6.24	6.18	10.11	9.24	8.17	6.23	8.52	8.19
Drumkeen 110 kV	3.53	4.73	4.47	4.21	4.95	4.85	3.95	8.96	7.51	5.04	7.40	7.03
Drumline 110 kV	3.55	7.33	6.95	4.71	6.31	6.21	3.23	9.59	8.86	4.61	7.36	7.21
Drybridge 110 kV	5.87	12.04	11.08	6.71	10.34	10.09	5.20	14.77	13.57	6.30	11.78	11.51
Dundalk 110 kV	3.79	7.82	7.37	4.73	7.30	7.17	3.41	9.41	8.70	4.46	8.33	8.13
Dunfirth 110 kV	4.66	5.95	5.72	6.20	4.71	4.66	4.52	6.83	6.59	6.17	5.14	5.10
Dungarvan 110 kV	5.97	5.73	5.53	7.71	4.84	4.79	5.85	6.89	6.40	7.73	5.48	5.37
Dunmanway 110 kV	4.08	6.81	6.46	5.22	6.25	6.15	3.98	9.22	8.43	5.28	7.50	7.32
Dunstown 220 kV	12.92	16.49	14.76	12.45	19.01	18.17	10.88	21.42	19.66	10.83	23.61	22.85

Table E-2: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2019

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]
Dunstown 400 kV	17.82	6.50	6.05	20.27	7.11	6.92	16.39	7.85	7.48	19.09	8.29	8.15
Ennis 110 kV	4.38	9.34	8.78	5.58	8.55	8.38	4.47	14.10	12.46	5.99	10.87	10.52
Fassaroe East 110 kV	6.48	5.70	5.42	6.32	4.55	4.49	5.08	8.55	8.07	5.27	6.35	6.26
Fassaroe West 110 kV	6.67	5.79	5.50	6.45	4.67	4.60	5.22	8.73	8.24	5.37	6.56	6.47
Finglas 220 kV	14.71	15.26	13.54	14.24	19.53	18.50	16.63	25.85	22.52	15.33	30.58	28.84
Finglas A 110 kV	27.64	11.07	10.13	26.23	12.63	12.19	34.48	14.66	12.88	30.17	15.70	14.96
Finglas B 110 kV	27.66	10.89	10.13	26.18	13.79	13.36	35.91	14.94	13.46	31.37	18.14	17.36
Flagford 110 kV	4.69	9.88	9.19	5.42	12.08	11.72	4.48	13.83	12.48	5.41	15.82	15.18
Flagford 220 kV	7.06	6.07	5.73	8.94	5.94	5.82	7.41	8.14	7.72	9.74	7.19	7.07
Fortunestown 110 kV	5.79	7.23	6.68	5.70	5.50	5.39	5.55	8.43	7.58	5.57	6.02	5.86
Francis Street A 110 kV	10.83	11.83	10.87	5.29	14.09	13.61	10.45	14.25	12.71	5.02	16.39	15.65
Francis Street B 110 kV	13.11	11.44	10.58	6.83	13.93	13.48	12.78	13.58	12.50	6.46	16.19	15.64
Galway 110 kV	4.84	9.84	9.17	4.49	12.08	11.72	5.11	14.98	13.46	4.51	16.87	16.17
Garrow 110 kV	10.33	7.05	6.79	10.35	8.42	8.29	10.15	11.38	10.13	10.16	12.07	11.56
Garvagh 110 kV	4.19	5.11	4.90	5.32	4.97	4.90	4.59	7.58	6.73	6.13	6.29	6.08
Gilra 110 kV	3.24	5.76	5.49	4.05	4.60	4.54	3.01	6.97	6.57	3.96	5.15	5.07
Glanagow 220 kV	14.38	12.67	11.33	14.01	15.64	14.90	13.64	18.17	16.16	13.11	20.75	19.79
Glanlee 110 kV	4.92	5.01	4.88	5.15	5.98	5.91	5.11	7.91	6.93	5.40	8.53	8.11
Glasmore A 110 kV	4.96	6.19	5.81	5.34	4.53	4.46	4.69	7.58	6.84	5.20	5.04	4.92
Glenlara A 110 kV	3.04	2.69	2.62	4.31	2.36	2.34	3.26	3.42	3.14	4.78	2.74	2.68
Glenlara B 110 kV	8.78	5.51	5.36	6.55	6.19	6.13	9.26	8.83	7.81	6.13	8.63	8.27
Glenree 110 kV	2.85	3.15	3.04	3.49	3.26	3.22	3.87	6.09	5.57	4.88	4.95	4.82
Glentanemacelligot 110 kV	9.22	5.11	4.99	8.54	4.35	4.32	8.72	7.22	6.68	8.23	5.21	5.11
Golagh 110 kV	3.57	4.56	4.34	4.15	4.56	4.49	4.09	8.73	7.27	4.92	6.70	6.36
Gorman 110 kV	6.79	12.70	11.64	7.66	14.21	13.74	6.08	15.95	14.60	7.12	16.93	16.39
Gorman 220 kV	9.42	9.84	9.07	10.12	8.50	8.30	8.46	12.46	11.79	9.57	9.88	9.73
Gortawee 110 kV	4.43	5.64	5.29	5.86	4.76	4.68	4.45	6.97	6.47	6.12	5.35	5.25
Grange 110 kV	12.93	9.81	9.03	4.59	10.39	10.08	12.83	12.66	11.23	4.25	12.46	11.95
Grange Castle 110 kV	16.77	11.20	10.02	11.49	12.54	12.01	16.73	13.45	11.82	11.18	14.45	13.77
Great Island 110 kV	7.74	11.54	10.91	8.52	15.01	14.65	7.56	14.16	13.00	8.43	17.88	17.23
Great Island 220 kV	11.89	10.79	10.17	13.29	12.95	12.64	10.69	12.67	11.93	12.14	14.55	14.21
Griffinrath A 110 kV	7.14	9.60	9.09	7.46	9.79	9.60	6.64	11.44	10.80	7.11	11.17	10.96
Griffinrath B 110 kV	7.67	9.92	9.37	7.62	9.76	9.58	7.14	11.86	11.19	7.26	11.16	10.95

Table E-2: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2019

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]
Harolds Cross 110 kV	11.02	11.86	10.91	5.00	14.05	13.58	10.64	14.28	12.75	4.74	16.32	15.59
Heuston 110 kV	14.15	11.65	10.77	8.19	14.33	13.86	13.89	13.87	12.74	7.80	16.71	16.13
Huntstown A 220 kV	14.07	14.74	13.13	12.72	18.87	17.90	15.92	24.87	21.76	13.04	29.43	27.80
Huntstown B 220 kV	15.41	15.39	13.70	11.68	19.09	18.14	15.58	23.93	21.22	10.55	27.42	26.10
Ikerrin 110 kV	5.24	4.17	4.02	6.04	3.23	3.19	5.76	5.73	5.21	6.47	3.81	3.73
Inchicore 220 kV	14.81	18.54	16.04	11.11	22.72	21.31	13.98	27.25	23.62	9.61	31.29	29.49
Inchicore A 110 kV	28.29	12.78	11.73	25.11	16.09	15.50	30.72	15.37	14.03	26.17	18.98	18.25
Inchicore B 110 kV	41.58	12.80	11.42	33.40	16.27	15.47	49.86	15.69	13.72	36.57	19.43	18.33
Inniscarra 110 kV	3.81	8.18	7.75	4.93	7.84	7.70	3.58	10.88	10.08	4.87	9.44	9.23
Irishtown 220 kV	15.82	17.26	15.06	12.32	21.58	20.30	15.84	25.32	22.08	11.31	29.80	28.12
Kellis 110 kV	6.23	8.00	7.64	7.19	9.57	9.39	6.13	10.07	9.29	7.20	11.50	11.14
Kellis 220 kV	8.06	7.29	6.96	9.77	6.36	6.28	7.72	8.61	8.25	9.58	7.16	7.07
Kilbarry 110 kV	7.40	15.59	14.12	8.02	16.86	16.24	6.45	22.50	19.67	7.33	21.92	20.93
Kildonan 110 kV	7.34	14.73	13.39	6.24	14.63	14.15	6.72	17.89	16.54	5.80	16.82	16.40
Kilgarvan 110 kV	9.70	4.93	4.80	6.99	3.45	3.43	8.97	7.25	6.64	6.53	4.02	3.95
Kilkenny 110 kV	2.99	4.74	4.58	4.21	4.34	4.29	2.98	5.67	5.24	4.31	4.84	4.73
Kill Hill 110 kV	4.81	5.06	4.86	5.85	4.66	4.60	5.60	7.44	6.64	6.78	5.80	5.63
Killonan 110 kV	7.27	14.84	13.51	8.27	16.95	16.33	6.74	22.36	19.97	8.06	22.96	22.05
Killonan 220 kV	8.33	8.85	8.25	10.35	8.73	8.52	7.73	12.36	11.63	10.16	10.92	10.72
Killoteran 110 kV	7.19	10.58	10.00	7.40	11.92	11.67	6.81	12.94	11.85	7.11	13.93	13.48
Kilmahud 110 kV	18.00	11.29	10.09	12.56	12.68	12.13	18.09	13.56	11.91	12.28	14.62	13.91
Kilmore 110 kV	14.68	10.01	9.20	9.62	11.37	11.00	14.90	12.94	11.47	9.27	13.88	13.26
Kilpaddoge 110 kV	11.78	13.45	12.42	12.32	17.22	16.63	12.33	21.24	19.08	13.10	24.93	23.86
Kilpaddoge 220 kV	12.62	11.18	10.31	11.76	14.94	14.39	16.59	24.53	21.79	14.46	29.36	27.92
Kilteel 110 kV	4.44	7.25	6.88	5.49	6.61	6.50	4.28	8.82	8.22	5.43	7.48	7.33
Kinnegad 110 kV	4.45	7.27	6.91	5.29	6.71	6.60	4.49	9.08	8.58	5.43	7.72	7.59
Knockacummer 110 kV	7.82	4.87	4.75	7.02	5.22	5.17	8.19	7.57	6.74	6.94	7.18	6.91
Knockalough 110 kV	3.92	3.94	3.80	3.58	4.00	3.95	4.35	5.25	4.80	3.72	4.82	4.69
Knockanure 220 kV	9.04	8.03	7.56	6.45	10.65	10.36	13.53	18.72	16.85	7.68	22.70	21.69
Knockanure A 110 kV	15.64	8.25	7.94	12.63	10.01	9.86	24.01	14.71	12.76	16.75	15.84	15.00
Knockanure B 110 kV	5.03	7.13	6.78	6.24	5.18	5.12	4.66	9.74	8.98	6.15	6.02	5.92
Knockearagh 110 kV	5.50	5.02	4.81	7.27	4.43	4.37	5.36	6.33	5.83	7.31	5.10	4.99
Knockraha A 110 kV	9.32	16.94	15.33	9.85	17.55	16.93	8.03	23.66	21.00	8.94	22.16	21.31

Table E-2: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2019

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]
Knockraha A 220 kV	12.53	13.14	11.79	12.33	14.84	14.21	11.32	19.47	17.34	11.27	19.95	19.13
Knockraha B 110 kV	9.32	16.94	15.33	9.85	17.55	16.93	8.03	23.66	21.00	8.94	22.16	21.31
Knockraha B 220 kV	12.53	13.14	11.79	12.33	14.84	14.21	11.32	19.47	17.34	11.27	19.95	19.13
Knockranny 110 kV	5.24	6.29	6.01	4.83	8.19	8.03	6.13	8.94	8.37	5.27	11.09	10.78
Knockranny A 110 kV	3.78	4.42	4.25	3.48	4.38	4.32	4.11	5.93	5.42	3.59	5.28	5.13
Knockranny B 110 kV	5.24	6.29	6.01	4.83	8.19	8.03	6.13	8.94	8.37	5.27	11.09	10.78
Knockumber 110 kV	3.91	7.75	7.27	4.69	5.95	5.85	3.59	8.98	8.43	4.51	6.49	6.39
Lanesboro 110 kV	4.11	9.78	9.00	5.22	10.27	9.97	3.76	12.18	10.96	4.98	11.90	11.48
Letterkenny110 kV	3.84	5.41	5.07	4.46	6.29	6.13	4.31	10.74	8.86	5.43	10.21	9.56
Liberty A 110 kV	6.10	13.67	12.50	5.20	15.77	15.22	5.23	18.67	16.61	4.58	19.95	19.10
Liberty B 110 kV	6.01	13.66	12.49	5.05	15.74	15.19	5.15	18.64	16.60	4.45	19.89	19.04
Limerick 110 kV	5.64	13.12	11.96	6.32	12.82	12.42	5.03	18.87	16.89	5.99	16.22	15.69
Lisdrum 110 kV	2.91	4.68	4.49	4.17	4.15	4.10	2.74	5.42	5.06	4.09	4.47	4.39
Lisheen 110 kV	3.94	3.22	3.13	3.95	4.83	4.76	4.97	5.27	4.59	4.97	7.91	7.35
Lodgewood 110 kV	8.35	7.31	7.05	8.62	9.19	9.04	9.73	9.63	8.96	9.66	11.29	10.97
Lodgewood 220 kV	8.77	6.71	6.43	9.88	6.59	6.49	8.89	8.18	7.79	9.97	7.58	7.46
Longpoint 220 kV	14.07	11.77	10.62	13.76	14.44	13.81	12.88	16.15	14.54	12.59	18.45	17.69
Louth 220 kV	10.32	12.80	11.41	11.15	15.29	14.56	9.20	18.95	17.42	10.44	20.54	19.90
Louth A 110 kV	7.32	11.15	10.37	8.27	13.60	13.20	6.55	13.85	12.85	7.63	16.27	15.78
Louth B 110 kV	7.80	11.96	11.06	8.57	14.95	14.46	6.95	15.06	13.95	7.85	18.14	17.58
Louth A 275 kV	12.10	7.71	6.96	11.82	9.52	9.11	10.96	11.57	10.83	10.90	13.17	12.84
Louth B 275 kV	11.43	7.76	7.01	10.60	9.67	9.24	10.33	11.50	10.77	9.60	13.33	12.99
Macetown 110 kV	8.01	16.09	14.49	7.98	17.47	16.80	6.99	18.75	17.25	6.88	18.76	18.23
Macroom 110 kV	6.37	10.94	10.21	6.79	10.98	10.72	6.93	17.42	15.64	6.88	17.61	16.95
Mallow 110 kV	5.21	5.98	5.73	6.84	5.30	5.23	5.24	7.52	7.02	7.10	6.11	6.00
Marina 110 kV	7.16	14.94	13.56	8.03	17.43	16.76	6.17	21.03	18.47	7.24	22.60	21.52
Maynooth A 110 kV	11.02	11.91	11.14	11.64	14.62	14.22	10.33	14.57	13.62	11.07	17.39	16.92
Maynooth A 220 kV	11.15	15.07	13.49	10.46	14.68	14.13	9.57	19.83	18.14	9.39	17.85	17.36
Maynooth B 110 kV	8.58	15.92	14.51	9.84	15.53	15.05	7.60	19.34	18.04	9.13	17.92	17.53
Maynooth B 220 kV	11.54	16.77	14.90	10.64	16.44	15.77	9.65	23.07	20.97	9.38	20.63	20.01
McDermott 110 kV	15.56	10.07	9.39	6.39	11.97	11.63	16.45	13.68	12.35	5.80	15.36	14.76
Meath Hill 110 kV	4.16	8.02	7.56	5.26	6.83	6.72	3.89	9.88	9.16	5.16	7.73	7.57

Table E-2: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2019

	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
Station	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]
Meentycat 110 kV	3.28	4.08	3.88	4.11	4.14	4.08	3.65	7.28	6.20	5.01	5.96	5.69
Midleton 110 kV	3.95	9.30	8.74	5.03	8.19	8.03	3.51	11.35	10.56	4.73	9.26	9.07
Milltown A 110 kV	15.13	12.81	11.71	6.90	15.46	14.89	14.89	15.53	13.79	6.56	18.12	17.25
Milltown B 110 kV	9.14	10.37	9.65	4.23	12.41	12.04	8.74	12.22	11.29	3.98	14.29	13.84
Misery Hill 110 kV	13.55	12.51	11.45	7.60	15.23	14.68	13.23	15.15	13.46	7.25	17.87	17.01
Moneteen 110 kV	5.79	9.94	9.16	6.50	7.74	7.57	5.26	12.52	11.56	6.24	8.80	8.63
Moneypoint 110 kV	13.51	7.85	7.54	15.67	8.18	8.06	15.50	10.74	10.15	18.32	10.19	10.00
Moneypoint 220 kV	13.04	11.21	10.34	11.98	14.96	14.41	16.82	24.16	21.54	14.33	28.99	27.61
Moneypoint G1 400 kV	18.61	8.16	7.44	21.13	9.35	9.01	21.48	11.22	10.47	24.07	11.99	11.69
Moneypoint G2 400 kV	27.99	2.82	2.72	28.80	3.57	3.52	55.98	5.06	4.79	51.51	5.72	5.60
Moneypoint G3 400 kV	18.61	8.16	7.44	21.13	9.35	9.01	21.48	11.22	10.47	24.07	11.99	11.69
Monread 110 kV	4.18	7.28	6.89	5.04	7.31	7.18	3.97	8.86	8.27	4.92	8.36	8.17
Mount Lucas 110 kV	4.27	6.27	5.89	5.37	5.89	5.78	4.55	8.61	7.98	5.90	7.24	7.08
Moy 110 kV	2.84	2.98	2.87	3.31	3.67	3.62	5.13	6.67	5.95	6.33	6.81	6.54
Mullagharlin 110 kV	3.90	7.96	7.51	4.90	7.82	7.67	3.50	9.44	8.83	4.60	8.82	8.64
Mullingar 110 kV	3.57	6.60	6.30	4.52	6.36	6.26	3.45	7.79	7.32	4.47	7.14	7.00
Mulreavy 110 kV	3.92	4.80	4.56	4.53	5.63	5.51	5.45	10.06	8.07	6.65	9.57	8.86
Mungret A 110 kV	5.43	9.47	8.76	6.17	7.21	7.06	4.92	11.81	10.95	5.92	8.15	8.00
Mungret B 110 kV	5.42	9.49	8.78	6.17	7.22	7.07	4.91	11.84	10.97	5.91	8.16	8.01
Nangor 110 kV	14.82	10.95	9.82	9.44	12.23	11.73	14.63	13.10	11.55	9.11	14.05	13.40
Navan 110 kV	5.84	11.34	10.46	6.57	11.40	11.08	5.29	14.09	12.92	6.19	13.30	12.93
Nenagh 110 kV	3.32	3.51	3.39	4.05	2.45	2.43	3.29	4.12	3.88	4.08	2.67	2.63
Newbridge 110 kV	4.39	9.35	8.69	5.09	9.53	9.29	4.15	12.06	11.05	4.97	11.37	11.06
Newbury 110 kV	13.88	9.93	9.13	7.27	11.05	10.70	13.94	12.82	11.36	6.87	13.41	12.83
North Quays 110 kV	18.58	13.07	11.93	6.43	15.48	14.92	18.63	15.88	14.08	6.10	18.12	17.27
North Wall 220 kV	13.83	14.06	12.59	9.36	16.51	15.76	14.93	23.22	20.45	8.27	24.30	23.16
Oldcourt A 110 kV	4.16	9.36	8.81	4.67	7.40	7.28	3.68	11.34	10.63	4.39	8.36	8.22
Oldcourt B 110 kV	4.20	9.41	8.86	4.69	7.47	7.35	3.72	11.42	10.70	4.41	8.45	8.31
Oldstreet 220 kV	12.20	7.10	6.76	11.37	8.45	8.29	14.74	11.80	11.10	12.48	12.54	12.26
Oldstreet 400 kV	11.31	6.01	5.63	9.65	6.09	5.95	12.45	8.41	8.02	9.77	7.76	7.65
Oughtragh 110 kV	3.75	4.07	3.91	4.83	2.81	2.78	3.59	5.06	4.70	4.79	3.10	3.06
Pelletstown 110 kV	13.73	9.58	8.97	8.10	10.58	10.32	13.65	12.79	11.63	7.56	13.23	12.78
Platin 110 kV	5.24	11.15	10.32	5.81	8.72	8.54	4.64	13.36	12.42	5.47	9.71	9.54
Pollaphuca 110 kV	2.75	2.42	2.38	3.96	2.24	2.23	3.29	3.13	3.00	4.71	2.58	2.55

Table E-2: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2019

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	27.01	13.62	12.42	21.82	16.99	16.32	28.54	16.63	14.73	22.15	20.14	19.13
Poolbeg A 220 kV	14.50	14.15	12.67	8.19	15.77	15.09	15.78	23.36	20.58	6.99	22.81	21.81
Poolbeg B 110 kV	26.98	13.61	12.40	21.80	16.97	16.31	28.50	16.61	14.71	22.14	20.12	19.11
Poolbeg B 220 kV	14.34	17.48	15.24	10.62	20.10	18.99	13.49	25.13	21.98	9.41	26.80	25.45
Poolbeg C 110 kV	21.02	13.33	12.16	7.47	15.84	15.25	21.37	16.25	14.38	7.11	18.60	17.70
Poppintree 110 kV	15.48	10.27	9.44	9.81	11.65	11.27	15.97	13.36	11.82	9.47	14.28	13.64
Portan 260 kV	20.01	8.41	7.93	75.81	2.95	2.93	19.98	11.34	10.91	88.61	3.10	3.09
Portan 400 kV	16.87	6.71	6.26	16.40	7.74	7.53	16.21	9.09	8.66	16.06	10.09	9.91
Portlaoise 110 kV	4.04	8.12	7.64	5.33	7.57	7.42	3.97	10.60	9.74	5.46	8.96	8.75
Pottery 110 kV	17.66	10.41	9.72	5.74	10.68	10.42	17.84	12.37	11.41	5.53	12.19	11.86
Prospect 220 kV	11.19	10.04	9.34	8.93	11.76	11.41	11.78	19.01	17.36	8.14	18.85	18.26
Raffeen 220 kV	13.88	12.53	11.23	13.24	15.48	14.75	12.86	17.99	16.03	12.13	20.64	19.69
Raffeen A 110 kV	6.57	12.63	11.65	7.37	15.09	14.60	5.63	16.15	14.78	6.54	18.45	17.82
Raffeen B 110 kV	9.15	12.32	11.38	9.91	14.69	14.22	7.98	16.11	14.66	8.93	18.23	17.57
Rathkeale 110 kV	3.67	6.60	6.24	4.84	5.42	5.34	3.47	8.30	7.76	4.83	6.16	6.06
Ratrussan 110 kV	3.29	5.92	5.65	4.09	6.69	6.58	3.77	8.40	7.12	4.95	8.69	8.18
Reamore 110 kV	3.86	6.87	6.52	4.33	6.45	6.34	3.67	9.98	8.86	4.24	7.93	7.68
Richmond A 110 kV	3.25	6.65	6.26	4.38	6.03	5.92	3.02	7.88	7.26	4.24	6.81	6.64
Richmond B 110 kV	3.25	6.65	6.26	4.38	6.03	5.92	3.02	7.88	7.26	4.24	6.81	6.64
Rinawade 110 kV	5.07	10.11	9.49	5.99	7.40	7.28	4.67	11.73	11.19	5.77	8.16	8.07
Ringaskiddy 110 kV	6.33	10.44	9.75	6.53	10.38	10.14	5.53	13.15	12.15	5.99	12.23	11.92
Ringsend 110 kV	27.46	13.73	12.49	23.00	17.12	16.44	29.05	16.82	14.82	23.46	20.35	19.29
Ryebrook 110 kV	5.99	14.45	12.99	6.70	12.80	12.39	5.36	17.21	15.83	6.28	14.33	13.99
Salthill 110 kV	4.42	9.49	8.86	3.73	11.41	11.09	4.50	14.26	12.83	3.57	15.67	15.04
Screeb 110 kV	3.63	2.35	2.28	4.26	1.58	1.57	3.82	2.87	2.64	4.41	1.72	1.69
Seal Rock A 110 kV	8.69	9.40	8.39	10.33	10.30	9.86	7.69	10.67	9.65	9.43	11.15	10.75
Seal Rock B 110 kV	8.72	9.41	8.39	10.35	10.30	9.86	7.72	10.68	9.65	9.44	11.15	10.75
Shankill 110 kV	3.75	7.06	6.65	4.73	6.77	6.64	3.87	9.76	8.46	5.09	8.39	8.04
Shannonbridge 110 kV	6.81	14.76	13.28	8.42	16.71	16.03	5.87	17.78	16.03	7.51	19.10	18.38
Shannonbridge 220 kV	7.95	6.54	6.22	10.38	5.78	5.69	7.17	7.69	7.42	9.78	6.43	6.37
Shellybanks A 220 kV	14.24	14.12	12.65	8.12	17.47	16.64	15.48	23.31	20.54	6.83	26.40	25.07
Shellybanks B 220 kV	14.96	16.59	14.55	10.75	20.52	19.35	15.18	24.38	21.34	9.69	28.23	26.70
Shelton Abbey 110 kV	7.76	6.66	6.41	7.76	7.12	7.02	7.49	8.47	7.95	7.54	8.52	8.33
Singland 110 kV	6.55	12.47	11.49	7.40	12.79	12.42	6.28	18.19	16.44	7.39	16.42	15.90
Sliabh Bawn 110 kV	3.47	8.13	7.63	4.43	7.92	7.75	3.46	10.63	9.64	4.59	9.44	9.16

Table E-2: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2019

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]
Slievecallan 110 kV	6.43	5.14	4.97	8.64	2.19	2.18	7.78	7.61	6.73	9.40	2.43	2.39
Sligo 110 kV	3.86	7.00	6.59	4.44	7.11	6.96	3.62	10.81	9.72	4.43	9.44	9.14
Snugborough 110 kV	9.97	17.36	15.54	9.52	18.64	17.88	9.30	21.71	19.79	8.95	21.85	21.16
Somerset 110 kV	3.10	7.08	6.74	4.07	4.67	4.62	2.87	8.28	7.83	3.95	5.13	5.07
Sorne Hill 110 kV	2.77	2.27	2.19	3.42	2.61	2.58	3.49	3.84	3.38	4.43	3.72	3.56
Srahnakilly 110 kV	2.87	2.92	2.81	3.18	3.73	3.67	5.12	6.38	5.51	5.72	6.97	6.58
Srananagh 110 kV	4.74	7.97	7.47	5.40	9.18	8.95	4.60	12.75	11.36	5.57	12.91	12.40
Srananagh 220 kV	6.53	3.91	3.74	8.57	3.36	3.32	7.35	5.11	4.88	9.71	3.92	3.88
Stevenstown 110 kV	4.78	5.24	4.98	5.15	3.60	3.56	4.54	6.20	5.71	5.04	3.93	3.86
Stratford 110 kV	3.13	3.71	3.61	4.12	3.00	2.97	3.34	4.63	4.36	4.35	3.37	3.32
Taney 110 kV	9.09	9.05	8.52	3.32	9.00	8.82	8.75	10.60	9.87	3.17	10.14	9.91
Tarbert 110 kV	21.01	10.34	9.86	23.74	11.54	11.34	35.74	17.07	15.87	36.46	16.22	15.83
Tarbert 220 kV	12.28	10.99	10.15	12.11	14.53	14.01	16.08	23.69	21.10	14.99	27.64	26.34
Tawnaghmore A 110 kV	2.73	2.54	2.45	3.35	2.87	2.83	4.48	5.35	4.86	5.79	4.80	4.66
Tawnaghmore B 110 kV	2.75	2.54	2.46	3.25	3.11	3.07	4.44	5.21	4.77	5.70	5.36	5.20
Thornsberry 110 kV	3.88	5.75	5.46	4.98	5.46	5.37	3.87	7.56	7.06	5.18	6.63	6.49
Thurles 110 kV	5.06	4.21	4.05	5.45	4.85	4.78	6.19	6.85	5.94	6.49	6.90	6.56
Tievebrack 110 kV	3.40	3.27	3.13	4.52	2.60	2.58	3.62	4.96	4.47	5.03	3.17	3.10
Tipperary 110 kV	5.00	6.14	5.87	6.03	4.26	4.21	5.30	8.35	7.68	6.33	4.90	4.81
Tonroe 110 kV	2.68	3.09	3.00	3.74	1.96	1.95	2.72	3.74	3.46	3.84	2.13	2.10
Trabeg 110 kV	7.10	14.90	13.52	7.89	17.37	16.70	6.08	20.92	18.39	7.07	22.48	21.42
Tralee 110 kV	5.07	7.28	6.88	6.12	6.85	6.73	5.03	10.73	9.48	6.22	8.51	8.22
Trien A 110 kV	4.87	6.69	6.37	6.68	5.70	5.62	4.55	9.21	8.44	6.69	6.76	6.61
Trien B 110 kV	10.22	6.83	6.62	8.91	7.47	7.38	11.72	11.86	10.21	9.33	10.97	10.43
Trillick 110 kV	2.82	2.43	2.35	3.50	2.64	2.61	3.60	4.23	3.67	4.54	3.72	3.56
Trinity 110 kV	11.98	12.17	11.16	6.35	14.69	14.17	11.61	14.70	13.09	6.04	17.16	16.36
Tullabrack 110 kV	6.65	6.08	5.88	7.25	4.94	4.89	6.61	8.12	7.69	7.32	5.80	5.72
Turlough 220 kV	11.93	11.47	10.42	12.96	10.47	10.15	10.51	13.20	12.26	11.94	11.42	11.17
Tynagh 220 kV	10.60	6.84	6.51	11.51	8.55	8.37	15.44	12.83	11.87	16.66	13.95	13.54
Uggool 110 kV	5.27	6.00	5.75	5.07	7.86	7.71	6.25	8.54	8.01	5.69	10.65	10.36
Waterford 110 kV	7.35	11.03	10.40	7.80	12.36	12.09	6.96	13.56	12.38	7.50	14.50	14.02
Wexford 110 kV	3.88	5.64	5.43	5.00	5.25	5.18	5.73	7.60	6.80	7.15	6.68	6.46
Whitebank 110 kV	24.54	13.69	12.45	20.08	17.04	16.36	25.37	16.74	14.76	20.13	20.23	19.18

Table E-2: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2019

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]
Whitegate 110 kV	4.80	8.88	8.37	5.51	9.23	9.04	4.30	10.60	9.98	5.12	10.55	10.33
Wolfe Tone 110 kV	14.03	9.87	9.22	5.85	11.62	11.30	14.31	13.35	12.07	5.29	14.82	14.26
Woodhouse 110 kV	5.95	5.67	5.48	7.26	4.30	4.26	5.89	6.81	6.37	7.31	4.81	4.73
Woodland 220 kV	13.75	16.73	14.90	13.11	18.73	17.88	11.82	24.54	22.22	11.74	25.36	24.46
Woodland 400 kV	17.76	6.74	6.29	17.49	7.78	7.56	17.33	9.13	8.70	17.37	10.17	9.98

Table E-3: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2022

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	12.19	10.66	9.73	6.63	12.90	12.41	11.38	12.96	11.68	6.18	15.21	14.57
Agannygal 110 kV	2.86	4.72	4.55	3.89	4.13	4.08	2.96	6.52	5.85	4.24	4.97	4.83
Aghada 110 kV	5.28	8.07	7.55	6.26	9.48	9.23	4.59	9.58	9.05	5.59	10.95	10.71
Aghada A 220 kV	15.52	12.15	10.63	16.35	15.87	14.91	11.59	16.84	14.95	12.60	20.97	19.90
Aghada B 220 kV	15.52	12.15	10.63	16.35	15.87	14.91	11.59	16.84	14.95	12.60	20.97	19.90
Aghada C 220 kV	14.87	11.83	10.38	14.12	15.44	14.52	11.20	16.28	14.50	10.99	20.28	19.27
Aghada D 220 kV	15.52	12.15	10.63	16.35	15.87	14.91	11.59	16.84	14.95	12.60	20.97	19.90
Ahane 110 kV	5.60	10.44	9.59	6.05	7.84	7.67	4.94	15.41	14.16	5.77	9.43	9.26
Anner 110 kV	4.08	5.86	5.53	4.53	4.47	4.41	4.06	7.76	7.15	4.60	5.13	5.04
Ardnacrusha 110 kV	6.12	11.32	10.26	7.44	12.45	12.00	5.99	19.04	16.92	7.95	17.64	16.98
Ardnagappary 110 kV	2.77	1.90	1.84	3.93	1.23	1.22	2.91	2.62	2.43	4.27	1.35	1.33
Arigna 110 kV	4.40	6.08	5.77	5.40	5.16	5.08	4.50	8.53	7.81	5.72	6.12	5.99
Arklow 110 kV	10.88	7.52	7.18	11.58	9.19	9.02	10.05	9.79	9.12	11.22	11.43	11.11
Arklow 220 kV	9.46	6.86	6.46	10.73	6.49	6.37	8.82	8.53	8.11	10.36	7.58	7.47
Artane 110 kV	13.90	9.90	9.10	6.38	11.91	11.50	13.13	12.39	11.13	5.93	14.49	13.87
Arva 110 kV	3.97	7.99	7.46	5.01	6.59	6.47	3.86	10.48	9.47	5.14	7.56	7.37
Athea 110 kV	11.05	6.60	6.32	11.62	7.14	7.03	11.49	10.90	9.45	12.13	9.86	9.42
Athlone 110 kV	4.13	6.33	5.98	5.35	5.24	5.16	4.10	8.58	7.98	5.56	5.98	5.88
Athy 110 kV	5.15	6.86	6.57	6.14	5.77	5.70	4.76	8.30	7.93	5.98	6.53	6.45
Aughinish 110 kV	9.19	9.24	8.17	11.17	10.16	9.69	7.87	10.95	9.91	9.92	11.36	10.95
Ballybeg 110 kV	9.97	5.91	5.68	10.15	7.02	6.91	9.61	7.10	6.74	9.95	8.19	8.02
Ballydine 110 kV	4.10	6.55	6.19	3.81	5.33	5.25	4.05	8.58	7.95	3.77	6.21	6.09
Ballylickey 110 kV	2.81	2.96	2.87	3.84	1.99	1.97	2.98	3.99	3.71	4.07	2.25	2.22
Ballynahulla 110 kV	14.67	7.48	7.11	13.08	8.18	8.03	15.84	12.74	11.17	12.95	11.59	11.11
Ballynahulla 220 kV	9.13	6.58	6.13	9.22	7.55	7.34	9.23	11.55	10.51	9.24	11.27	10.91
Ballyragget 110 kV	5.78	6.27	6.02	6.67	4.56	4.51	5.53	7.46	7.08	6.57	5.02	4.96
Ballyvouskill 110 kV	14.75	7.50	7.12	14.18	8.95	8.77	14.21	12.19	10.84	13.52	12.79	12.25
Ballyvouskill 220 kV	9.13	6.68	6.20	9.70	8.36	8.10	9.08	11.48	10.42	9.86	12.88	12.39
Ballywater 110 kV	5.63	5.36	5.19	3.49	5.59	5.53	5.31	6.98	6.60	3.25	6.64	6.52
Baltrasna 110 kV	6.44	9.41	8.76	7.44	7.48	7.33	5.90	11.24	10.68	7.16	8.39	8.29
Bancroft 110 kV	12.97	10.87	10.02	7.24	12.78	12.36	11.83	12.87	11.92	6.72	14.78	14.33
Bandon 110 kV	3.35	5.78	5.44	4.35	5.71	5.60	3.13	7.78	7.08	4.36	6.94	6.74
Banoge 110 kV	6.54	5.44	5.25	7.17	4.94	4.88	5.95	6.78	6.41	6.89	5.73	5.63
Barnahealy A 110 kV	5.40	10.54	9.68	5.99	11.24	10.89	4.47	13.24	12.20	5.24	13.35	12.98
Barnahealy B 110 kV	7.39	10.32	9.49	7.77	10.87	10.54	6.06	13.40	12.29	6.79	13.14	12.76

Table E-3: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2022

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]
Barnakyle 110 kV	20.06	17.20	15.20	20.72	12.43	12.05	18.25	20.65	18.89	19.85	14.04	13.75
Baroda 110 kV	4.20	8.98	8.40	5.06	9.99	9.74	3.92	10.35	9.70	4.79	11.29	11.02
Barrymore 110 kV	3.99	6.79	6.42	4.97	4.28	4.23	3.73	8.66	8.15	4.90	4.80	4.74
Belcamp 110 kV	19.00	16.00	13.91	13.92	18.57	17.53	17.00	20.88	18.29	12.80	23.39	22.20
Belcamp 220 kV	14.72	15.05	12.80	12.21	18.32	17.06	12.09	22.37	19.57	10.31	26.11	24.69
Belgard 110 kV	12.63	11.25	10.26	7.06	13.76	13.23	11.71	13.26	12.12	6.59	15.95	15.36
Bellacorick 110 kV	2.90	2.97	2.85	3.21	3.78	3.72	5.37	7.83	6.33	5.97	8.72	8.00
Binbane 110 kV	3.20	3.50	3.35	4.31	3.47	3.42	3.81	6.78	6.24	5.82	5.07	4.96
Blackrock 110 kV	10.49	11.62	10.61	2.56	11.31	10.97	9.84	14.02	12.46	2.43	12.83	12.35
Blake 110 kV	4.09	7.93	7.49	5.10	5.39	5.32	3.88	9.07	8.60	4.98	5.89	5.82
Boggeragh 110 kV	6.21	6.25	5.95	7.29	6.90	6.77	6.72	9.21	8.36	8.03	8.94	8.65
Booltiagh 110 kV	6.11	6.16	5.87	7.62	5.55	5.47	6.68	9.22	8.39	8.54	6.86	6.70
Bracklone 110 kV	4.00	8.80	8.27	5.06	7.93	7.77	3.68	10.12	9.55	4.81	8.80	8.65
Brinny A 110 kV	3.21	5.23	4.95	4.20	4.77	4.69	3.00	6.83	6.28	4.19	5.62	5.49
Brinny B 110 kV	3.21	5.25	4.96	4.20	4.80	4.72	3.00	6.87	6.31	4.19	5.66	5.53
Buffy 110 kV	3.86	4.34	4.15	4.13	5.39	5.29	5.34	7.98	6.77	5.56	8.55	8.03
Bunkimalta 110 kV	5.30	5.04	4.81	5.66	5.26	5.18	6.56	8.14	7.15	6.60	7.30	7.00
Butlerstown 110 kV	7.03	9.80	9.23	7.10	10.10	9.89	6.19	12.50	11.57	6.52	12.06	11.75
Cabra 110 kV	12.87	9.59	8.83	5.18	10.78	10.43	12.14	11.96	10.76	4.82	12.93	12.42
Cahir 110 kV	4.43	7.22	6.77	5.41	6.19	6.07	4.62	10.60	9.57	5.82	7.44	7.25
Carlow 110 kV	5.96	7.99	7.60	6.68	8.58	8.42	5.77	10.35	9.59	6.60	10.37	10.10
Carrickaduff 110 kV	4.28	3.26	3.15	5.20	2.63	2.60	7.42	7.38	5.83	7.04	3.57	3.42
Carrickalangan 110 kV	4.28	3.23	3.12	5.20	2.57	2.55	7.38	7.24	5.74	6.97	3.47	3.33
Carrickmines 220 kV	15.59	15.11	13.11	9.72	18.58	17.44	12.55	20.42	18.17	8.03	24.12	22.96
Carrickmines A 110 kV	30.12	10.78	9.96	22.92	11.90	11.55	28.20	12.84	11.78	21.80	13.74	13.31
Carrickmines B 110 kV	24.98	11.97	10.99	20.28	14.45	13.94	22.61	14.38	13.24	18.80	16.95	16.39
Carrick-on-Shannon 110 kV	4.44	9.12	8.46	5.07	10.30	10.00	4.17	13.33	12.09	5.04	13.52	13.06
Carrigadrohid 110 kV	7.03	10.39	9.58	7.16	10.59	10.29	6.64	15.61	14.07	6.91	13.71	13.27
Carrigdangan 110 kV	3.44	4.40	4.22	4.10	5.22	5.14	4.15	6.94	6.01	5.22	7.28	6.91
Carrowbeg 110 kV	2.66	2.44	2.34	3.49	2.32	2.29	2.68	3.34	3.05	3.72	2.81	2.73
Cashla 110 kV	6.99	11.68	10.64	7.29	15.19	14.57	7.16	21.31	19.07	7.63	25.13	24.01
Cashla 220 kV	7.83	7.31	6.75	8.71	8.13	7.89	8.65	12.77	11.96	9.86	12.01	11.75
Castlebagot 110 kV	21.70	17.52	15.45	23.15	12.75	12.35	19.78	21.09	19.26	22.24	14.43	14.12
Castlebagot 220 kV	13.11	17.40	14.81	10.72	18.95	17.77	10.29	24.66	21.76	8.88	24.96	23.86

Table E-3: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2022

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]
Castlebar 110 kV	2.99	3.91	3.71	3.51	4.38	4.29	3.31	6.56	5.71	4.06	6.27	5.98
Castledockrill 110 kV	7.80	6.53	6.29	4.62	7.64	7.52	7.34	8.62	8.14	4.23	9.26	9.07
Castlefarm A 110 kV	8.24	8.92	7.91	9.66	9.48	9.06	7.09	10.52	9.55	8.65	10.55	10.20
Castlefarm B 110 kV	8.25	8.90	7.90	9.67	9.47	9.05	7.11	10.50	9.53	8.66	10.54	10.19
Castleview 110 kV	4.47	10.43	9.61	4.88	8.16	7.98	3.78	13.35	12.31	4.50	9.41	9.22
Cathaleen's Fall 110 kV	4.27	6.31	5.93	4.89	7.32	7.14	5.19	13.52	11.59	6.25	11.88	11.32
Cauteen 110 kV	5.39	6.18	5.87	6.29	4.14	4.10	5.96	9.52	8.67	6.73	4.94	4.86
Central Park 110 kV	14.89	9.91	9.21	7.90	10.72	10.43	13.92	11.70	10.79	7.49	12.27	11.91
Charleville 110 kV	4.60	5.47	5.20	6.00	5.20	5.11	4.79	7.71	6.99	6.58	6.45	6.27
Cherrywood 110 kV	10.73	9.22	8.59	7.71	9.47	9.23	10.07	10.76	9.98	7.35	10.72	10.44
City West 110 kV	6.26	7.13	6.65	6.16	5.50	5.40	5.89	8.42	7.64	5.96	6.06	5.91
Clahane 110 kV	4.35	6.20	5.85	5.49	5.83	5.73	4.19	9.53	8.81	5.69	7.33	7.18
Clashavoon 220 kV	9.35	7.42	6.83	10.00	8.98	8.67	9.15	12.01	10.95	9.98	13.05	12.59
Clashavoon A 110 kV	8.00	11.78	10.76	8.29	15.33	14.72	8.01	19.16	16.91	8.34	22.94	21.77
Clashavoon B 110 kV	8.00	11.78	10.76	8.29	15.33	14.72	8.01	19.16	16.91	8.34	22.94	21.77
Cliff 110 kV	4.03	5.20	4.93	4.95	5.46	5.36	4.51	9.49	8.46	5.94	7.61	7.37
Cloghboola 110 kV	7.00	5.74	5.53	7.48	6.63	6.53	7.15	9.46	8.01	7.81	9.52	8.96
Cloghboola 110 kV	7.00	5.74	5.53	7.48	6.63	6.53	7.15	9.46	8.01	7.81	9.52	8.96
Clogher 110 kV	3.87	5.28	5.00	4.40	6.21	6.08	5.38	12.72	10.15	6.34	10.95	10.19
Cloghran 110 kV	9.41	16.86	14.77	9.33	19.32	18.32	8.42	22.05	20.06	8.65	24.23	23.37
Clonee 220 kV	13.95	14.54	12.49	10.46	14.52	13.74	11.92	21.55	19.18	9.19	19.52	18.80
Clonkeen A 110 kV	5.76	5.40	5.15	6.79	4.11	4.06	5.60	6.79	6.42	6.81	4.60	4.54
Clonkeen B 110 kV	5.06	6.42	6.13	4.42	7.60	7.46	4.74	10.20	9.05	4.04	10.66	10.20
Cloon 110 kV	4.44	6.35	5.99	5.68	5.84	5.73	4.09	8.83	8.19	5.67	7.06	6.91
College Park 110 kV	9.10	16.21	14.28	6.55	19.25	18.26	8.14	21.04	19.22	5.85	24.15	23.29
Cookstown 110 kV	7.55	7.80	7.36	6.06	6.74	6.62	7.06	8.95	8.47	5.82	7.47	7.35
Cookstown A 110 kV	5.11	6.14	5.76	5.30	4.46	4.39	4.85	7.19	6.54	5.15	4.86	4.75
Coolnabacky 110 kV	7.91	12.36	11.50	8.25	15.44	14.97	7.85	16.46	15.52	8.30	19.78	19.31
Coolnabacky 400 kV	12.14	6.41	5.82	11.30	6.88	6.63	8.79	11.19	10.46	8.99	10.17	9.96
Coolroe 110 kV	3.95	8.39	7.83	5.10	8.29	8.10	3.53	11.14	10.26	4.90	9.96	9.71
Coomagearlahy 110 kV	5.07	5.19	5.00	5.52	6.27	6.17	5.24	8.19	7.16	5.87	8.82	8.39
Coomataggart 110 kV	9.91	5.05	4.87	7.03	3.54	3.51	9.01	7.42	6.79	6.52	4.06	3.99

Table E-3: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2022

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]
Coomataggart 110 kV	9.91	5.05	4.87	7.03	3.54	3.51	9.01	7.42	6.79	6.52	4.06	3.99
Cordal 110 kV	11.99	6.52	6.24	8.30	7.12	7.00	12.51	10.81	9.53	7.48	9.88	9.48
Corderry 110 kV	4.05	6.20	5.88	4.97	6.23	6.12	4.16	9.68	8.61	5.47	8.13	7.85
Corduff 110 kV	10.30	18.35	15.93	10.94	22.10	20.83	9.25	24.54	22.15	10.28	28.48	27.33
Corduff 220 kV	16.17	16.13	13.61	14.17	19.58	18.16	14.32	25.23	21.93	12.83	28.96	27.34
Corkagh 110 kV	20.83	17.32	15.29	21.66	12.55	12.16	18.97	20.81	19.02	20.77	14.18	13.88
Corraclassy 110 kV	4.32	5.89	5.54	5.41	4.77	4.69	4.31	7.38	6.92	5.60	5.29	5.21
Cow Cross 110 kV	4.93	10.55	9.71	5.18	9.37	9.13	4.09	13.32	12.27	4.66	10.90	10.65
Crane 110 kV	7.95	7.13	6.83	7.59	7.87	7.74	7.47	9.83	9.10	7.26	9.85	9.59
Croaghaun 110 kV	2.97	2.80	2.70	3.41	3.33	3.28	5.53	7.01	5.74	6.35	7.55	6.99
Croaghnagawna 110 kV	4.25	3.39	3.27	5.23	2.86	2.83	7.37	7.81	6.15	7.33	3.99	3.81
Cromcastle A 110 kV	11.71	14.63	12.85	7.09	16.77	15.92	10.31	18.79	16.62	6.34	20.81	19.83
Cromcastle B 110 kV	11.71	14.63	12.85	7.09	16.77	15.92	10.31	18.79	16.62	6.34	20.81	19.83
Crory 110 kV	9.80	7.36	7.06	9.90	9.23	9.07	9.35	9.95	9.33	9.54	11.61	11.31
Cruiserath 220 kV	15.90	16.04	13.55	13.82	19.44	18.04	14.02	25.03	21.78	12.43	28.68	27.09
Cullenagh 110 kV	8.78	11.65	10.87	9.22	13.61	13.24	7.47	15.17	13.99	8.16	16.81	16.30
Cullenagh 220 kV	9.48	8.28	7.79	9.58	8.44	8.26	8.40	10.20	9.71	8.82	9.86	9.71
Cunghill 110 kV	3.09	4.17	4.00	3.55	4.24	4.18	3.18	6.34	5.80	3.80	5.44	5.30
Cureeny 110 kV	4.75	4.71	4.51	5.53	5.04	4.96	5.93	7.65	6.70	6.87	7.07	6.77
Cushaling 110 kV	7.50	11.91	10.56	9.32	13.02	12.43	5.34	10.70	9.87	6.65	12.06	11.69
Dallow 110 kV	3.51	4.63	4.48	4.58	3.06	3.04	3.47	5.97	5.66	4.69	3.45	3.41
Dalton 110 kV	3.04	3.56	3.40	4.03	3.18	3.13	3.21	5.29	4.77	4.51	3.90	3.80
Dardistown 110 kV	14.86	15.09	13.21	10.82	17.66	16.72	13.21	19.51	17.20	9.84	22.10	21.02
Darndale 110 kV	17.88	15.53	13.54	14.08	17.69	16.74	15.99	20.12	17.68	13.01	22.11	21.03
Derrybrien 110 kV	2.70	3.75	3.64	3.76	3.69	3.65	2.99	5.23	4.61	4.45	4.59	4.42
Derryiron 110 kV	4.67	7.62	7.20	5.86	7.77	7.62	4.54	9.16	8.76	5.87	8.80	8.67
Doon 110 kV	4.37	6.37	5.99	4.70	5.00	4.92	4.44	8.63	7.90	4.80	5.81	5.69
Dromada 110 kV	10.17	6.18	5.94	6.89	6.57	6.48	10.21	9.90	8.65	6.15	8.87	8.49
Drombeg 110 kV	7.39	7.20	6.79	7.42	6.20	6.10	7.45	10.56	10.00	7.48	7.61	7.51
Drumkeen 110 kV	3.52	4.82	4.56	4.20	5.11	5.01	3.83	9.44	8.03	4.99	7.55	7.20
Drumline 110 kV	3.65	7.10	6.65	4.80	6.23	6.11	3.19	9.75	9.01	4.63	7.39	7.24
Drybridge 110 kV	5.96	12.05	11.01	6.78	10.31	10.04	5.14	15.26	14.04	6.29	12.00	11.73
Dundalk 110 kV	3.81	7.99	7.52	4.77	7.45	7.30	3.44	9.83	9.01	4.54	8.50	8.29
Dunfirth 110 kV	4.55	6.69	6.35	5.91	5.39	5.32	4.51	8.04	7.75	6.03	6.06	6.00
Dungarvan 110 kV	6.10	5.68	5.44	7.81	4.79	4.73	5.80	6.95	6.47	7.70	5.47	5.37
Dunmanway 110 kV	4.15	6.73	6.32	4.92	7.02	6.87	4.50	10.78	9.38	5.52	9.52	9.11

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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]
Dunstown 220 kV	12.81	15.92	13.91	12.39	18.47	17.46	10.24	23.08	21.03	10.36	25.08	24.21
Dunstown 400 kV	14.80	6.69	6.05	16.09	7.56	7.26	9.07	10.83	10.14	11.22	10.91	10.66
Ennis 110 kV	4.51	8.88	8.24	5.66	8.34	8.14	4.41	14.30	12.64	5.98	10.97	10.61
Fassaroe East 110 kV	5.41	7.33	6.92	5.45	5.72	5.63	5.07	8.44	7.95	5.27	6.30	6.21
Fassaroe West 110 kV	5.56	7.47	7.06	5.56	5.90	5.81	5.21	8.62	8.12	5.36	6.52	6.41
Finglas 220 kV	17.24	15.93	13.45	15.66	19.84	18.37	14.60	24.25	21.04	13.86	29.11	27.38
Finglas A 110 kV	19.43	15.97	13.92	13.89	18.54	17.53	17.48	21.07	18.41	12.83	23.52	22.31
Finglas B 110 kV	31.03	11.01	10.05	27.80	13.81	13.28	31.44	13.99	12.48	28.62	17.20	16.37
Flagford 110 kV	4.71	9.47	8.76	5.39	11.70	11.33	4.45	14.00	12.68	5.39	15.97	15.35
Flagford 220 kV	6.98	5.92	5.54	8.78	5.88	5.75	7.41	8.20	7.79	9.76	7.21	7.10
Fortunestown 110 kV	5.85	7.03	6.56	5.74	5.44	5.34	5.51	8.29	7.53	5.55	5.98	5.84
Francis Street A 110 kV	10.99	11.62	10.61	5.36	13.87	13.35	10.30	14.03	12.47	5.06	16.19	15.43
Francis Street B 110 kV	13.28	11.25	10.28	6.92	13.70	13.19	12.32	13.29	12.16	6.46	15.90	15.33
Galway 110 kV	5.00	9.31	8.58	4.60	11.67	11.26	5.17	16.65	14.77	4.46	18.47	17.63
Gallanstown 110 kV	6.70	10.22	9.45	6.98	7.56	7.41	6.73	13.54	12.89	7.07	8.84	8.74
Garrow 110 kV	10.67	7.24	6.88	10.61	8.69	8.51	10.25	11.75	10.44	10.22	12.42	11.88
Garvagh 110 kV	4.20	5.12	4.90	5.31	5.03	4.96	4.56	7.66	6.83	6.11	6.32	6.12
Gilra 110 kV	3.29	5.69	5.39	4.07	4.63	4.56	3.00	7.01	6.61	3.95	5.15	5.08
Glanagow 220 kV	14.70	11.58	10.18	14.49	15.14	14.26	11.19	15.92	14.22	11.37	19.91	18.94
Glanlee 110 kV	4.95	5.14	4.96	5.17	6.18	6.09	5.06	8.07	7.06	5.35	8.67	8.24
Glasmore A 110 kV	4.10	7.33	6.80	4.61	5.05	4.96	3.82	8.88	8.08	4.46	5.63	5.51
Glenlara A 110 kV	3.07	2.68	2.60	4.34	2.35	2.32	3.26	3.44	3.15	4.79	2.74	2.67
Glenlara B 110 kV	9.03	5.75	5.52	6.63	6.52	6.42	8.95	9.16	8.07	5.96	8.98	8.59
Glenree 110 kV	2.88	3.18	3.06	3.51	3.31	3.26	3.69	5.68	5.10	4.67	4.75	4.61
Glentanemacelligot 110 kV	9.49	5.32	5.13	8.76	4.54	4.49	8.65	7.76	7.09	8.26	5.43	5.31
Golagh 110 kV	3.56	4.63	4.41	4.14	4.72	4.64	4.01	9.50	7.95	4.91	6.97	6.65
Gorman 110 kV	6.95	12.79	11.65	7.83	14.28	13.78	6.00	16.39	14.99	7.08	17.23	16.68
Gorman 220 kV	9.70	10.00	9.13	10.32	8.60	8.37	8.48	12.64	11.89	9.57	9.91	9.75
Gortawee 110 kV	4.43	5.73	5.38	5.86	4.82	4.74	4.44	6.97	6.49	6.12	5.32	5.22
Grange 110 kV	14.46	15.36	13.42	7.19	17.37	16.45	12.79	19.98	17.54	6.41	21.71	20.64
Grange Castle 110 kV	14.70	11.28	10.25	9.61	14.01	13.44	13.81	13.87	12.42	8.99	16.75	15.98
Great Island 110 kV	9.34	11.84	11.09	10.25	15.34	14.90	8.32	15.66	14.44	9.38	19.49	18.83
Great Island 220 kV	12.80	10.60	9.88	14.23	12.73	12.37	11.11	13.07	12.34	12.69	14.95	14.61

Table E-3: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2022

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]
Griffinrath A 110 kV	6.99	9.69	9.10	7.37	9.79	9.58	6.40	11.65	11.04	6.94	11.29	11.09
Griffinrath B 110 kV	7.50	10.01	9.39	7.52	9.81	9.60	6.87	12.09	11.44	7.09	11.28	11.09
Harolds Cross 110 kV	11.18	11.66	10.64	5.07	13.83	13.32	10.48	14.07	12.51	4.78	16.12	15.37
Harristown 110 kV	4.40	7.05	6.68	5.44	5.78	5.70	4.46	8.82	8.47	5.65	6.63	6.57
Heuston 110 kV	14.34	11.45	10.46	8.29	14.09	13.56	13.30	13.56	12.40	7.74	16.40	15.80
Huntstown A 220 kV	17.06	15.63	13.23	14.21	19.41	18.01	14.25	23.42	20.40	12.20	28.08	26.46
Huntstown B 220 kV	15.88	14.84	12.68	11.76	18.10	16.88	14.55	23.05	20.29	10.34	26.61	25.24
Ikerrin 110 kV	5.13	4.02	3.86	5.93	3.19	3.16	5.77	5.79	5.28	6.48	3.84	3.75
Inchicore 220 kV	15.39	17.38	14.74	11.26	21.38	19.86	12.03	24.55	21.35	9.07	28.87	27.22
Inchicore A 110 kV	28.52	12.54	11.37	25.03	15.80	15.14	26.52	15.01	13.62	23.57	18.62	17.86
Inchicore B 110 kV	41.69	12.13	10.98	32.74	15.42	14.76	38.76	15.05	13.43	30.76	18.67	17.78
Inniscarra 110 kV	3.91	8.16	7.64	4.97	7.91	7.74	3.55	10.93	10.07	4.84	9.47	9.24
Irishtown 220 kV	16.37	16.34	13.99	12.70	20.52	19.13	13.05	22.14	19.52	10.40	26.83	25.41
Kellis 110 kV	7.19	8.57	8.14	8.24	10.10	9.90	6.72	10.95	10.21	7.93	12.29	11.96
Kellis 220 kV	8.63	7.24	6.84	10.23	6.34	6.23	7.99	8.83	8.48	9.84	7.27	7.18
Kilbarry 110 kV	7.67	14.79	13.17	8.20	16.22	15.51	6.20	22.09	19.19	7.10	21.65	20.62
Kildonan 110 kV	7.57	14.38	12.83	6.35	14.21	13.66	6.75	18.17	16.79	5.83	16.95	16.52
Kilkenny 110 kV	5.03	6.87	6.57	6.48	5.94	5.86	4.77	8.39	7.85	6.37	6.70	6.58
Kill Hill 110 kV	4.81	4.95	4.73	5.83	4.61	4.54	5.63	7.62	6.80	6.84	5.92	5.74
Killonan 110 kV	7.36	13.84	12.39	7.53	12.29	11.88	6.98	23.99	21.14	7.36	16.56	16.06
Killonan 220 kV	8.15	8.08	7.40	10.23	7.67	7.45	8.09	12.36	11.60	10.84	9.95	9.77
Killoteran 110 kV	7.96	10.64	9.98	8.01	11.92	11.63	6.98	13.81	12.71	7.28	14.62	14.18
Kilmahud 110 kV	20.43	17.21	15.21	21.39	12.50	12.11	18.60	20.67	18.90	20.50	14.12	13.83
Kilmore 110 kV	15.87	15.60	13.60	10.57	18.09	17.10	14.10	20.33	17.83	9.57	22.74	21.59
Kilpaddoge 110 kV	11.03	12.75	11.57	11.58	16.45	15.75	10.90	21.91	19.89	11.83	25.75	24.75
Kilpaddoge 220 kV	10.78	9.96	9.00	10.76	13.45	12.82	12.14	21.78	19.75	11.69	26.69	25.59
Kilpaddoge 400 kV	-	-	-	-	-	-	8.02	13.62	12.51	7.31	12.30	11.98
Kilteel 110 kV	4.39	7.50	7.10	5.49	6.68	6.57	4.27	8.99	8.43	5.43	7.56	7.42
Kinnegad 110 kV	4.43	7.69	7.25	5.30	7.04	6.91	4.37	9.54	9.11	5.38	8.13	8.02
Knockacummer 110 kV	7.98	5.07	4.89	7.07	5.53	5.46	7.94	7.80	6.93	6.77	7.33	7.04
Knockalough 110 kV	3.99	3.91	3.75	3.80	4.82	4.74	5.50	6.78	5.85	4.55	7.34	6.93
Knockanure 220 kV	10.61	8.80	8.04	8.28	11.79	11.30	11.49	17.66	16.06	7.29	21.63	20.76
Knockanure A 110 kV	18.47	8.78	8.30	15.69	10.64	10.40	20.81	15.27	13.16	15.46	16.24	15.35
Knockanure B 110 kV	5.05	7.01	6.59	6.22	5.20	5.12	4.58	10.24	9.52	6.15	6.15	6.06

Table E-3: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2022

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]
Knockearagh 110 kV	5.47	4.96	4.72	7.18	4.39	4.33	5.51	6.56	6.05	7.54	5.14	5.03
Knockraha A 110 kV	9.62	15.91	14.15	9.95	16.69	15.98	7.46	22.84	20.18	8.40	21.52	20.65
Knockraha A 220 kV	13.15	11.87	10.46	12.41	13.46	12.78	10.22	17.30	15.44	10.25	17.97	17.22
Knockraha B 110 kV	9.62	15.91	14.15	9.95	16.69	15.98	7.46	22.84	20.18	8.40	21.52	20.65
Knockraha B 220 kV	13.15	11.87	10.46	12.41	13.46	12.78	10.22	17.30	15.44	10.25	17.97	17.22
Knockranny 110 kV	5.34	6.13	5.80	4.88	8.07	7.88	6.20	9.43	8.79	5.21	11.60	11.26
Knockranny A 110 kV	3.86	4.36	4.17	4.12	5.41	5.31	5.33	8.02	6.81	5.51	8.58	8.06
Knockranny B 110 kV	5.34	6.13	5.80	4.88	8.07	7.88	6.20	9.43	8.79	5.21	11.60	11.26
Knockumber 110 kV	3.94	7.81	7.30	4.72	6.00	5.89	3.55	9.09	8.53	4.49	6.49	6.39
Lanesboro 110 kV	3.27	7.63	7.16	4.03	8.67	8.46	3.74	12.45	11.23	4.98	12.17	11.76
Letterkenny110 kV	3.82	5.51	5.18	4.45	6.46	6.30	4.26	11.53	9.63	5.46	10.62	10.01
Liberty A 110 kV	6.29	13.03	11.73	5.34	15.17	14.54	5.08	18.31	16.20	4.51	19.66	18.77
Liberty B 110 kV	6.19	13.02	11.73	5.18	15.14	14.51	5.00	18.29	16.18	4.38	19.60	18.71
Limerick 110 kV	5.80	12.37	11.10	6.68	11.44	11.05	4.99	19.68	17.53	6.31	15.02	14.56
Lisdrum 110 kV	2.92	4.77	4.58	4.18	4.19	4.14	2.80	5.71	5.25	4.23	4.58	4.47
Lisheen 110 kV	3.95	3.18	3.07	3.95	4.76	4.68	4.96	5.32	4.63	4.97	7.97	7.41
Lodgewood 110 kV	9.80	7.36	7.06	9.90	9.23	9.07	9.35	9.95	9.33	9.54	11.61	11.31
Lodgewood 220 kV	9.28	6.63	6.30	10.31	6.53	6.42	8.84	8.31	7.94	10.03	7.66	7.55
Longpoint 220 kV	15.52	12.15	10.63	16.35	15.87	14.91	11.59	16.84	14.95	12.60	20.97	19.90
Louth 220 kV	11.24	13.56	11.99	12.06	15.87	15.08	9.49	19.90	17.85	10.43	21.77	20.88
Louth A 110 kV	7.54	11.40	10.56	8.52	13.86	13.43	6.41	14.08	13.00	7.51	16.46	15.95
Louth B 110 kV	8.14	12.29	11.32	8.95	15.29	14.77	6.80	15.54	14.28	7.72	18.61	17.97
Louth A 275 kV	12.88	8.67	7.82	12.39	10.47	10.02	11.53	11.34	10.43	11.32	13.01	12.58
Louth B 275 kV	12.18	8.68	7.82	11.04	10.61	10.14	10.76	11.34	10.43	9.75	13.29	12.84
Lumcloon 110 kV	5.36	6.79	6.48	6.34	4.97	4.91	5.86	9.45	9.03	6.82	5.85	5.80
Macetown 110 kV	7.89	14.94	13.27	7.51	15.63	14.97	7.02	19.07	17.52	6.93	18.96	18.42
Macroom 110 kV	7.24	11.40	10.43	7.15	13.04	12.59	6.95	18.19	16.10	6.89	18.22	17.45
Mallow 110 kV	5.30	5.88	5.58	6.91	5.24	5.16	5.27	7.61	7.05	7.15	6.14	6.01
Marina 110 kV	7.39	14.17	12.66	8.21	16.69	15.93	5.91	20.58	17.97	6.98	22.23	21.12
Maynooth A 110 kV	10.67	12.04	11.17	11.35	14.72	14.26	9.75	14.94	14.02	10.58	17.76	17.31
Maynooth A 220 kV	11.27	15.18	13.27	10.60	14.91	14.22	9.11	20.61	18.77	9.18	18.57	18.03
Maynooth B 110 kV	8.62	15.49	13.91	9.89	15.16	14.62	7.59	18.93	17.68	9.15	17.67	17.29
Maynooth B 220 kV	11.88	16.57	14.28	10.64	16.57	15.70	9.50	23.83	21.47	9.12	21.63	20.92

Table E-3: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2022

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]
McDermott 110 kV	16.41	10.16	9.32	6.47	11.97	11.55	15.64	12.81	11.45	6.02	14.60	13.95
Meath Hill 110 kV	4.18	8.16	7.67	5.30	6.86	6.74	3.91	10.21	9.44	5.22	7.87	7.71
Meentycat 110 kV	3.26	4.16	3.96	4.10	4.31	4.24	3.54	7.53	6.52	4.95	5.98	5.74
Midleton 110 kV	4.05	9.00	8.35	5.11	7.97	7.79	3.49	11.13	10.31	4.69	9.15	8.96
Milltown A 110 kV	15.37	12.57	11.41	6.99	15.19	14.59	14.36	15.29	13.51	6.58	17.89	17.00
Milltown B 110 kV	9.26	10.20	9.39	4.29	12.22	11.80	8.63	11.98	11.01	4.02	14.05	13.58
Misery Hill 110 kV	13.76	12.28	11.16	7.69	14.97	14.38	12.87	14.92	13.19	7.24	17.65	16.77
Monatooreen 110 kV	6.79	15.06	13.46	6.74	15.70	15.07	5.29	21.15	18.84	5.70	19.94	19.19
Moneteen 110 kV	5.91	9.55	8.70	6.69	7.37	7.19	5.21	12.78	11.78	6.35	8.56	8.40
Moneypoint 110 kV	12.72	7.67	7.27	15.09	8.13	7.97	14.50	10.61	10.03	17.41	10.11	9.93
Moneypoint 220 kV	10.87	9.95	8.99	10.76	13.43	12.81	12.26	21.26	19.34	11.61	26.15	25.10
Moneypoint G1 400 kV	10.95	6.27	5.69	12.47	7.60	7.29	12.98	13.89	12.74	16.06	13.94	13.52
Moneypoint G2 400 kV	22.24	2.73	2.61	23.75	3.50	3.42	36.51	3.65	3.54	37.09	4.44	4.39
Moneypoint G3 400 kV	10.95	6.27	5.69	12.47	7.60	7.29	12.98	13.89	12.74	16.06	13.94	13.52
Monread 110 kV	4.15	7.69	7.26	5.06	7.49	7.35	3.97	9.02	8.48	4.93	8.46	8.29
Mount Lucas 110 kV	4.45	7.26	6.79	5.69	6.40	6.27	4.33	7.87	7.39	5.60	6.90	6.77
Moy 110 kV	2.87	3.00	2.88	3.33	3.72	3.66	4.31	5.90	5.15	5.33	6.24	5.93
Muckerstown 110 kV	6.41	9.51	8.85	6.81	6.81	6.69	6.39	12.40	11.85	6.88	7.85	7.78
Mullagharlin 110 kV	3.92	8.13	7.65	4.94	7.97	7.81	3.48	9.71	9.02	4.61	8.97	8.76
Mullingar 110 kV	3.62	6.54	6.20	4.53	6.29	6.18	3.45	7.99	7.55	4.47	7.27	7.15
Mulreavy 110 kV	3.91	4.87	4.62	4.51	5.84	5.72	5.47	11.03	8.89	6.76	10.11	9.40
Mungret A 110 kV	5.55	9.13	8.34	6.35	6.90	6.74	4.88	12.03	11.14	6.02	7.94	7.80
Mungret B 110 kV	5.54	9.14	8.35	6.34	6.90	6.74	4.87	12.06	11.17	6.02	7.94	7.81
Nangor 110 kV	13.15	11.03	10.04	7.98	13.62	13.09	12.39	13.51	12.12	7.46	16.22	15.50
Navan 110 kV	5.95	11.43	10.47	6.67	11.45	11.12	5.23	14.44	13.23	6.17	13.47	13.09
Nenagh 110 kV	3.36	3.48	3.34	4.07	2.44	2.41	3.30	4.56	4.19	4.13	2.74	2.69
Newbridge 110 kV	4.53	10.63	9.84	5.28	10.29	10.02	4.13	12.26	11.38	4.94	11.55	11.27
Newbury 110 kV	14.36	15.34	13.40	7.11	17.28	16.37	12.71	19.91	17.49	6.34	21.55	20.50
North Quays 110 kV	18.89	12.82	11.62	6.52	15.22	14.61	17.65	15.63	13.79	6.13	17.90	17.01
North Wall 220 kV	15.05	14.56	12.46	9.59	16.64	15.60	12.32	21.25	18.75	7.92	22.88	21.80
Oldcourt A 110 kV	4.26	9.04	8.41	4.72	7.28	7.14	3.64	11.07	10.33	4.35	8.26	8.11
Oldcourt B 110 kV	4.30	9.09	8.46	4.75	7.35	7.20	3.67	11.14	10.39	4.37	8.34	8.19
Oldstreet 220 kV	11.42	6.62	6.21	10.82	7.98	7.77	15.22	12.49	11.75	12.63	13.00	12.72
Oldstreet 400 kV	10.49	5.33	4.90	9.32	5.60	5.43	11.19	10.51	9.89	9.10	8.73	8.58

Table E-3: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2022

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	-	-	-	-	-	-	9.48	15.45	13.99	7.81	14.26	13.80
Oughtragh 110 kV	3.77	4.05	3.88	4.82	2.83	2.80	3.61	5.26	4.91	4.84	3.14	3.10
Pelletstown 110 kV	14.35	9.67	8.91	8.22	10.58	10.26	13.60	12.06	10.86	7.77	12.69	12.21
Platin 110 kV	5.28	11.13	10.23	5.83	8.69	8.49	4.63	13.81	12.86	5.49	9.83	9.66
Pollaphuca 110 kV	2.78	2.49	2.44	4.03	2.30	2.28	3.27	3.21	3.09	4.73	2.64	2.61
Poolbeg A 110 kV	27.47	13.36	12.08	21.99	16.67	15.97	25.71	16.34	14.41	20.80	19.88	18.84
Poolbeg A 220 kV	14.93	14.65	12.54	8.16	15.88	14.93	12.06	21.38	18.86	6.68	21.54	20.58
Poolbeg B 110 kV	27.44	13.34	12.07	21.98	16.66	15.95	25.68	16.32	14.39	20.79	19.86	18.82
Poolbeg B 220 kV	15.06	16.51	14.10	10.94	19.10	17.87	11.95	22.94	20.10	9.04	25.11	23.83
Poolbeg C 110 kV	21.37	13.08	11.84	7.57	15.57	14.93	19.96	15.99	14.08	7.11	18.36	17.44
Poppintree 110 kV	12.83	15.01	13.17	7.37	17.27	16.37	11.36	19.49	17.16	6.60	21.60	20.55
Portan 260 kV	20.91	8.10	7.48	73.41	2.84	2.82	15.60	12.57	11.98	78.24	3.23	3.22
Portan 400 kV	17.79	6.29	5.73	16.79	7.24	6.97	12.25	10.64	10.01	12.95	11.52	11.26
Portlaoise 110 kV	5.92	11.70	10.86	6.84	11.16	10.89	5.78	14.99	14.01	6.85	13.31	13.04
Pottery 110 kV	17.85	10.23	9.49	5.84	10.53	10.25	16.67	12.11	11.15	5.54	12.01	11.67
Prospect 220 kV	9.92	8.97	8.18	8.44	10.75	10.35	10.01	17.14	15.88	7.72	17.58	17.10
Raffeen 220 kV	14.08	11.12	9.82	12.29	14.17	13.40	10.80	15.41	13.80	9.78	18.68	17.82
Raffeen A 110 kV	6.71	12.02	10.93	7.45	14.51	13.95	5.37	15.57	14.18	6.22	17.98	17.32
Raffeen B 110 kV	9.30	11.76	10.71	9.95	14.17	13.63	7.38	15.78	14.28	8.30	17.99	17.29
Rathkeale 110 kV	3.73	6.46	6.06	4.90	5.30	5.21	3.43	8.35	7.83	4.82	6.10	6.00
Ratrussan 110 kV	3.30	6.02	5.73	4.11	6.90	6.77	3.71	8.46	7.20	4.90	8.68	8.19
Reamore 110 kV	3.89	6.72	6.31	4.30	6.31	6.19	3.76	10.88	9.68	4.35	8.24	7.99
Richmond A 110 kV	2.91	5.63	5.35	3.84	5.51	5.42	3.02	8.01	7.39	4.25	6.89	6.73
Richmond B 110 kV	2.91	5.63	5.35	3.84	5.51	5.42	3.02	8.01	7.39	4.25	6.89	6.73
Rinawade 110 kV	5.13	10.17	9.44	6.01	7.47	7.33	4.74	11.92	11.38	5.80	8.29	8.19
Ringaskiddy 110 kV	6.45	10.04	9.26	6.60	10.14	9.86	5.31	12.92	11.88	5.81	12.11	11.79
Ringsend 110 kV	27.95	13.46	12.15	23.18	16.80	16.07	26.12	16.53	14.51	21.92	20.09	19.00
Rosspile 110 kV	6.13	6.32	6.08	6.88	5.21	5.16	6.37	8.76	8.18	7.19	6.29	6.18
Ryebrook 110 kV	5.73	12.91	11.52	6.54	11.56	11.16	5.08	15.40	14.23	6.10	13.21	12.90
Salthill 110 kV	4.56	8.99	8.29	3.88	11.08	10.71	4.67	15.96	14.15	3.60	17.29	16.51
Screeb 110 kV	3.67	2.36	2.28	4.59	1.74	1.72	4.57	3.54	3.15	5.35	2.04	1.99
Seal Rock A 110 kV	8.84	9.10	8.05	10.51	10.03	9.57	7.56	10.75	9.74	9.32	11.20	10.80
Seal Rock B 110 kV	8.87	9.10	8.06	10.53	10.03	9.57	7.59	10.76	9.74	9.33	11.20	10.80
Shankill 110 kV	3.78	7.16	6.72	4.76	6.89	6.75	3.81	9.92	8.61	5.07	8.44	8.09
Shannonbridge 110 kV	5.25	10.64	9.87	6.17	12.96	12.56	6.09	18.73	16.97	7.84	19.90	19.19
Shannonbridge 220 kV	6.75	5.87	5.54	8.90	5.44	5.34	7.63	8.20	7.92	10.45	6.67	6.60
Shantallow 110 kV	4.61	9.30	8.64	4.90	8.66	8.46	4.04	14.64	13.63	4.62	11.26	11.04

Table E-3: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2022

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]
Shellybanks A 220 kV	14.61	14.63	12.52	9.87	16.73	15.67	11.80	21.35	18.83	8.13	22.97	21.88
Shellybanks B 220 kV	15.47	15.74	13.55	11.03	19.55	18.27	12.43	21.13	18.72	9.11	25.27	23.99
Shelton Abbey 110 kV	7.85	6.75	6.47	7.80	7.19	7.08	7.10	8.57	8.04	7.37	8.59	8.41
Singland 110 kV	6.67	11.77	10.68	7.50	11.11	10.75	6.37	19.07	17.11	7.54	14.68	14.26
Sliabh Bawn 110 kV	3.18	7.04	6.65	3.99	7.27	7.12	3.44	10.77	9.78	4.58	9.53	9.25
Slievecallan 110 kV	6.46	5.05	4.84	8.63	2.21	2.20	7.72	7.65	6.77	9.40	2.43	2.39
Sligo 110 kV	3.91	6.97	6.53	4.46	7.17	7.01	3.59	10.85	9.77	4.40	9.45	9.15
Snugborough 110 kV	10.37	16.94	14.84	9.67	17.88	17.03	9.40	22.18	20.17	9.06	22.14	21.43
Somerset 110 kV	3.18	6.28	5.99	4.04	4.50	4.45	2.86	8.48	8.04	3.96	5.18	5.13
Sorne Hill 110 kV	2.76	2.32	2.24	3.41	2.71	2.67	3.43	3.90	3.45	4.38	3.75	3.60
Srahnakilly 110 kV	2.92	2.90	2.79	3.23	3.71	3.65	5.46	7.58	6.16	6.05	8.37	7.70
Srananagh 110 kV	4.77	7.92	7.39	5.42	9.19	8.95	4.55	12.90	11.56	5.53	13.02	12.52
Srananagh 220 kV	6.52	3.89	3.70	8.50	3.39	3.34	7.33	5.14	4.91	9.71	3.93	3.88
Stevenstown 110 kV	4.08	6.03	5.67	4.59	3.91	3.86	3.83	7.05	6.57	4.47	4.29	4.22
Stratford 110 kV	3.21	3.85	3.74	4.21	3.07	3.05	3.35	4.81	4.55	4.39	3.45	3.40
Taney 110 kV	9.18	8.91	8.33	3.36	8.89	8.69	8.62	10.41	9.66	3.20	10.01	9.76
Tarbert 110 kV	17.69	9.93	9.32	20.35	11.34	11.06	24.63	13.65	13.12	27.64	14.06	13.86
Tarbert 220 kV	10.54	9.69	8.78	10.78	12.95	12.36	11.44	20.47	18.67	11.65	24.62	23.68
Tawnaghmore A 110 kV	2.75	2.57	2.48	3.36	2.93	2.90	3.67	4.58	4.10	4.78	4.32	4.17
Tawnaghmore B 110 kV	2.78	2.56	2.48	3.27	3.17	3.13	3.58	4.43	3.99	4.54	4.77	4.58
Thornsberry 110 kV	3.91	6.23	5.91	5.10	5.65	5.56	3.76	7.10	6.70	5.00	6.39	6.28
Thurles 110 kV	5.01	4.11	3.94	5.40	4.75	4.68	6.20	6.93	6.02	6.51	6.97	6.63
Tievebrack 110 kV	3.39	3.34	3.20	4.52	2.68	2.65	3.73	5.52	5.09	5.23	3.32	3.26
Timahoe 110 kV	6.15	7.19	6.86	6.79	5.48	5.41	5.90	9.17	8.87	6.73	6.30	6.25
Tipperary 110 kV	5.04	6.00	5.69	6.04	4.17	4.12	5.33	8.55	7.87	6.37	4.86	4.78
Tonroe 110 kV	2.71	3.10	3.01	3.75	2.00	1.98	2.71	3.74	3.48	3.84	2.13	2.10
Trabeg 110 kV	7.32	14.13	12.62	8.06	16.63	15.88	5.82	20.47	17.88	6.80	22.12	21.01
Tralee 110 kV	5.05	7.09	6.64	6.01	6.70	6.56	5.18	11.71	10.38	6.46	8.83	8.55
Trien A 110 kV	4.90	6.59	6.21	6.65	5.66	5.56	4.48	9.77	9.03	6.75	6.90	6.77
Trien B 110 kV	11.01	7.23	6.90	9.55	7.85	7.72	10.93	12.19	10.44	8.99	11.13	10.58
Trillick 110 kV	2.81	2.49	2.40	3.50	2.73	2.69	3.53	4.30	3.75	4.49	3.76	3.60
Trinity 110 kV	12.15	11.95	10.89	6.43	14.44	13.89	11.38	14.48	12.83	6.06	16.95	16.13
Tullabrack 110 kV	6.64	6.00	5.73	7.25	4.98	4.91	6.54	8.08	7.65	7.28	5.80	5.72
Turlough 220 kV	12.00	11.26	10.08	13.02	10.32	9.95	10.17	13.38	12.42	11.68	11.47	11.21

Table E-3: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2022

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]
Tynagh 220 kV	10.14	6.40	6.01	10.94	8.09	7.87	15.60	13.34	12.35	16.83	14.28	13.87
Uggool 110 kV	5.37	5.87	5.57	5.11	7.76	7.57	6.32	8.97	8.39	5.64	11.10	10.79
Waterford 110 kV	8.21	11.10	10.38	8.53	12.37	12.06	7.18	14.54	13.34	7.74	15.26	14.79
Wexford 110 kV	5.78	5.86	5.62	7.00	5.64	5.56	5.92	8.21	7.43	7.44	6.99	6.78
Whitebank 110 kV	24.99	13.42	12.11	20.28	16.72	16.00	23.23	16.46	14.45	19.08	19.97	18.89
Whitegate 110 kV	4.93	8.61	8.02	5.62	9.02	8.79	4.26	10.35	9.71	5.06	10.39	10.16
Wolfe Tone 110 kV	14.69	9.97	9.15	5.92	11.62	11.22	13.92	12.53	11.21	5.50	14.11	13.50
Woodhouse 110 kV	6.06	5.61	5.39	7.34	4.27	4.22	5.83	6.85	6.41	7.28	4.81	4.73
Woodland 220 kV	14.32	16.30	14.01	13.28	18.09	17.03	11.85	25.19	22.53	11.73	25.99	24.96
Woodland 400 kV	18.70	6.32	5.75	17.85	7.28	7.01	13.01	10.70	10.07	13.92	11.62	11.35

Table E-4: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2025

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	12.36	10.99	10.03	6.66	13.31	12.82	11.61	13.41	12.08	6.15	15.63	14.99
Agannygal 110 kV	2.86	4.82	4.66	3.90	4.16	4.12	2.95	6.53	5.88	4.24	4.97	4.84
Aghada 110 kV	5.20	7.79	7.33	6.12	9.29	9.07	4.58	9.88	9.38	5.61	11.22	11.00
Aghada A 220 kV	11.63	10.05	9.03	12.42	13.51	12.85	12.90	19.53	17.36	14.05	23.66	22.49
Aghada B 220 kV	11.63	10.05	9.03	12.42	13.51	12.85	12.90	19.53	17.36	14.05	23.66	22.49
Aghada C 220 kV	11.40	9.84	8.86	11.37	13.20	12.57	12.29	18.78	16.76	11.80	22.78	21.69
Aghada D 220 kV	11.63	10.05	9.03	12.42	13.51	12.85	12.90	19.53	17.36	14.05	23.66	22.49
Ahane 110 kV	5.65	10.79	9.95	6.07	8.00	7.85	4.90	15.57	14.37	5.76	9.46	9.31
Anner 110 kV	4.12	5.89	5.57	4.56	4.52	4.46	4.03	7.78	7.19	4.58	5.13	5.04
Ardnacrusha 110 kV	6.21	11.76	10.72	7.55	12.72	12.30	5.94	19.18	17.14	7.91	17.60	16.98
Ardnagappary 110 kV	2.79	1.91	1.86	3.94	1.25	1.24	2.90	2.63	2.44	4.27	1.35	1.34
Arigna 110 kV	4.49	6.11	5.79	5.46	5.21	5.14	4.49	8.81	8.11	5.73	6.25	6.13
Arklow 110 kV	11.00	7.69	7.34	11.70	9.40	9.23	10.11	9.94	9.27	11.29	11.57	11.26
Arklow 220 kV	9.61	7.04	6.64	10.86	6.65	6.53	8.82	8.74	8.33	10.39	7.70	7.60
Artane 110 kV	13.71	10.37	9.55	6.31	12.53	12.12	13.19	12.88	11.61	5.83	14.95	14.35
Arva 110 kV	4.05	7.92	7.36	5.06	6.60	6.48	3.82	10.70	9.73	5.11	7.68	7.51
Athea 110 kV	11.68	7.10	6.81	12.15	7.46	7.36	11.53	11.09	9.66	12.15	10.01	9.58
Athlone 110 kV	4.18	6.41	6.07	5.40	5.28	5.21	4.09	8.64	8.05	5.56	6.02	5.93
Athy 110 kV	5.23	6.99	6.70	6.20	5.88	5.81	4.72	8.36	8.00	5.95	6.56	6.49
Aughinish 110 kV	9.28	9.78	8.64	11.28	10.77	10.27	7.84	11.02	9.99	9.88	11.41	11.01
Ballybeg 110 kV	10.05	6.04	5.81	10.22	7.18	7.07	9.65	7.21	6.85	9.98	8.29	8.13
Ballydine 110 kV	4.15	6.58	6.24	3.83	5.40	5.33	4.02	8.62	8.01	3.75	6.22	6.11
Ballylickey 110 kV	2.84	2.98	2.89	3.85	2.01	2.00	2.96	4.00	3.73	4.06	2.25	2.22
Ballynahulla 110 kV	15.21	7.82	7.48	13.40	8.40	8.27	15.90	12.70	11.20	12.96	11.56	11.10
Ballynahulla 220 kV	9.39	6.92	6.46	9.44	7.75	7.55	9.11	11.81	10.83	9.16	11.43	11.10
Ballyragget 110 kV	5.87	6.38	6.13	6.72	4.63	4.59	5.47	7.50	7.13	6.53	5.02	4.97
Ballyvouskill 110 kV	14.82	7.29	6.94	14.28	8.69	8.53	14.26	12.23	10.92	13.54	12.80	12.28
Ballyvouskill 220 kV	9.18	6.76	6.31	9.78	8.48	8.24	8.96	11.74	10.74	9.77	13.10	12.65
Ballywater 110 kV	5.66	5.45	5.29	3.50	5.67	5.61	5.29	7.01	6.64	3.24	6.66	6.55
Baltrasna 110 kV	6.52	9.50	8.78	7.50	7.63	7.48	5.87	11.46	10.91	7.15	8.52	8.42
Bancroft 110 kV	13.17	11.29	10.34	7.29	13.25	12.79	12.16	13.39	12.36	6.71	15.25	14.78
Bandon 110 kV	3.40	5.72	5.40	4.38	5.76	5.65	3.10	7.90	7.21	4.34	7.05	6.85
Banoge 110 kV	6.58	5.54	5.35	7.20	5.07	5.02	5.93	6.83	6.46	6.89	5.75	5.66
Barnahealy A 110 kV	5.31	10.03	9.29	5.87	10.97	10.66	4.46	13.77	12.78	5.25	13.73	13.39

Table E-4: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2025

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]
Barnahealy B 110 kV	7.08	9.87	9.14	7.49	10.67	10.38	6.11	13.90	12.83	6.83	13.54	13.18
Barnakyle 110 kV	20.70	18.07	15.76	21.26	13.07	12.64	19.11	21.63	19.71	20.37	14.40	14.10
Baroda 110 kV	4.26	8.73	8.16	5.07	9.97	9.72	3.84	10.84	10.20	4.75	11.63	11.39
Barrymore 110 kV	4.02	6.72	6.37	4.96	4.32	4.28	3.70	8.76	8.28	4.88	4.83	4.78
Belcamp 110 kV	18.78	17.35	14.91	16.35	21.33	20.01	17.77	22.51	19.63	15.22	26.50	25.05
Belcamp 220 kV	14.41	16.94	14.21	12.50	20.97	19.39	12.34	26.39	22.91	10.34	29.87	28.20
Belgard 110 kV	12.81	11.67	10.59	7.10	14.30	13.73	11.99	13.79	12.58	6.57	16.51	15.89
Bellacorick 110 kV	3.30	3.64	3.50	3.62	4.67	4.60	5.76	8.99	7.51	6.40	9.55	8.92
Binbane 110 kV	3.23	3.51	3.37	4.34	3.47	3.43	3.81	6.74	6.23	5.83	5.00	4.90
Blackrock 110 kV	10.59	11.92	10.91	2.55	11.60	11.26	9.91	14.38	12.81	2.39	13.05	12.58
Blake 110 kV	4.14	7.85	7.40	5.11	5.44	5.37	3.80	9.36	8.92	4.95	5.95	5.89
Boggeragh 110 kV	6.26	6.23	5.96	7.32	6.82	6.71	6.67	9.27	8.46	7.99	8.93	8.66
Booltiagh 110 kV	6.24	6.44	6.16	7.77	5.62	5.55	6.66	9.29	8.48	8.53	6.89	6.73
Bracklone 110 kV	4.05	8.59	8.07	5.07	7.93	7.78	3.61	10.54	10.00	4.78	8.97	8.84
Brinny A 110 kV	3.26	5.19	4.93	4.22	4.82	4.74	2.98	6.93	6.39	4.17	5.69	5.56
Brinny B 110 kV	3.26	5.21	4.95	4.22	4.85	4.77	2.97	6.96	6.42	4.17	5.73	5.60
Buffy 110 kV	3.88	4.46	4.28	4.16	5.49	5.40	5.32	8.02	6.83	5.54	8.58	8.07
Bunkimalta 110 kV	5.32	5.15	4.94	5.68	5.29	5.22	6.54	8.21	7.22	6.59	7.38	7.09
Butlerstown 110 kV	7.12	9.88	9.32	7.16	10.24	10.04	6.15	12.65	11.72	6.49	12.17	11.86
Cabra 110 kV	12.70	10.04	9.26	5.12	11.31	10.97	12.14	12.41	11.20	4.73	13.30	12.81
Cahir 110 kV	4.50	7.22	6.79	5.45	6.24	6.13	4.58	10.64	9.63	5.79	7.44	7.26
Carlow 110 kV	6.03	8.13	7.74	6.74	8.77	8.62	5.69	10.42	9.67	6.54	10.43	10.17
Carrickaduff 110 kV	4.32	3.28	3.17	5.23	2.63	2.61	7.40	7.50	5.94	7.03	3.62	3.47
Carrickalangan 110 kV	4.32	3.24	3.13	5.22	2.58	2.56	7.36	7.36	5.85	6.96	3.52	3.38
Carrickmines 220 kV	16.38	16.00	13.81	10.00	19.73	18.50	13.99	22.78	20.21	8.12	26.30	25.04
Carrickmines A 110 kV	31.29	11.10	10.26	23.62	12.29	11.94	31.98	13.31	12.23	23.24	14.13	13.71
Carrickmines B 110 kV	25.91	12.45	11.35	20.95	15.00	14.45	25.06	14.98	13.77	20.01	17.52	16.94
Carrick-on-Shannon 110 kV	4.54	9.31	8.60	5.17	10.49	10.19	4.10	14.47	13.23	5.02	14.35	13.93
Carrigadrohid 110 kV	7.07	10.21	9.47	7.19	10.51	10.24	6.56	15.92	14.45	6.87	13.87	13.46
Carrigdangan 110 kV	3.48	4.40	4.24	4.14	5.19	5.11	4.12	6.95	6.05	5.19	7.26	6.90
Carrowbeg 110 kV	2.71	2.57	2.48	3.57	2.41	2.39	2.65	3.41	3.13	3.71	2.86	2.79
Cashla 110 kV	7.44	12.35	11.27	7.74	16.00	15.38	7.09	21.84	19.68	7.58	25.68	24.62

Table E-4: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2025

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]
Cashla 220 kV	8.40	7.92	7.30	9.29	8.68	8.42	8.53	13.11	12.36	9.78	12.25	12.02
Castlebagot 110 kV	22.47	18.41	16.03	23.87	13.42	12.97	20.89	22.10	20.11	22.97	14.80	14.49
Castlebagot 220 kV	13.65	18.39	15.53	11.09	20.00	18.71	10.49	26.71	23.66	8.92	26.31	25.22
Castlebar 110 kV	3.12	4.25	4.05	3.66	4.74	4.66	3.26	6.79	5.98	4.03	6.45	6.19
Castledockrill 110 kV	7.87	6.65	6.41	4.64	7.76	7.66	7.32	8.67	8.20	4.21	9.31	9.12
Castlefarm A 110 kV	8.29	9.43	8.35	9.71	10.02	9.59	7.07	10.58	9.63	8.62	10.59	10.25
Castlefarm B 110 kV	8.30	9.42	8.34	9.72	10.01	9.57	7.08	10.56	9.61	8.63	10.58	10.24
Castleview 110 kV	4.50	10.01	9.29	5.48	10.20	9.94	3.73	13.81	12.82	4.97	12.79	12.49
Cathaleen's Fall 110 kV	4.35	6.26	5.87	4.96	7.16	6.99	5.16	13.63	11.73	6.22	12.02	11.47
Cauteen 110 kV	5.44	6.26	5.97	6.32	4.20	4.15	5.93	9.55	8.71	6.71	4.94	4.86
Central Park 110 kV	15.12	10.20	9.48	7.94	11.06	10.77	14.41	12.10	11.18	7.49	12.60	12.24
Charleville 110 kV	4.59	5.52	5.27	5.98	5.21	5.14	4.78	7.77	7.06	6.57	6.49	6.31
Cherrywood 110 kV	10.83	9.48	8.83	7.74	9.76	9.53	10.20	11.11	10.32	7.35	10.99	10.71
City West 110 kV	6.28	7.30	6.82	6.17	5.62	5.52	5.86	8.60	7.82	5.95	6.12	5.98
Clahane 110 kV	4.35	6.47	6.15	5.55	5.99	5.89	4.17	9.68	8.96	5.68	7.46	7.30
Clashavoon 220 kV	9.22	7.29	6.76	9.88	8.90	8.62	9.05	12.41	11.41	9.92	13.37	12.95
Clashavoon A 110 kV	8.05	11.57	10.64	8.34	15.16	14.61	7.91	19.59	17.43	8.26	23.36	22.25
Clashavoon B 110 kV	8.05	11.57	10.64	8.34	15.16	14.61	7.91	19.59	17.43	8.26	23.36	22.25
Cliff 110 kV	4.09	5.18	4.91	5.00	5.35	5.27	4.49	9.54	8.53	5.92	7.65	7.42
Cloghboola 110 kV	7.07	6.12	5.90	7.57	6.96	6.87	7.11	9.59	8.15	7.78	9.61	9.07
Cloghboola 110 kV	7.07	6.12	5.90	7.57	6.96	6.87	7.11	9.59	8.15	7.78	9.61	9.07
Clogher 110 kV	3.93	5.25	4.97	4.46	6.07	5.95	5.34	12.82	10.26	6.31	11.03	10.28
Cloghran 110 kV	9.90	17.69	15.24	9.84	20.57	19.39	8.43	23.03	20.94	8.67	25.13	24.26
Clonee 220 kV	14.48	16.71	14.12	10.75	16.46	15.50	11.82	24.77	22.00	8.98	21.36	20.60
Clonkeen A 110 kV	5.80	5.46	5.23	6.84	4.17	4.13	5.57	6.84	6.48	6.79	4.63	4.57
Clonkeen B 110 kV	5.06	6.25	5.99	4.43	7.39	7.27	4.70	10.22	9.10	4.02	10.67	10.22
Cloon 110 kV	4.53	6.56	6.21	5.79	5.95	5.86	4.06	8.92	8.31	5.65	7.15	7.02
College Park 110 kV	9.54	16.96	14.73	6.79	20.34	19.19	8.14	21.91	20.03	5.80	24.99	24.13
Cookstown 110 kV	7.59	8.04	7.56	6.07	6.91	6.79	7.06	9.20	8.70	5.81	7.60	7.48
Cookstown A 110 kV	5.12	6.27	5.90	5.30	4.55	4.49	4.81	7.33	6.67	5.14	4.90	4.80
Coolnabacky 110 kV	8.42	12.65	11.76	8.70	15.86	15.38	7.61	16.83	15.96	8.09	20.12	19.69
Coolnabacky 400 kV	10.74	8.20	7.30	10.32	8.26	7.93	8.17	11.60	10.93	8.55	10.44	10.25
Coolroe 110 kV	4.01	8.23	7.73	5.12	8.22	8.05	3.48	11.36	10.52	4.86	10.08	9.85

Table E-4: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2025

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]
Coomagearlahy 110 kV	5.08	5.07	4.90	5.53	6.08	6.00	5.21	8.21	7.19	5.84	8.86	8.43
Coomataggart 110 kV	9.93	4.93	4.77	7.04	3.48	3.45	9.00	7.45	6.85	6.51	4.08	4.01
Coomataggart 110 kV	9.93	4.93	4.77	7.04	3.48	3.45	9.00	7.45	6.85	6.51	4.08	4.01
Cordal 110 kV	12.27	6.71	6.46	8.37	7.20	7.11	12.50	10.75	9.54	7.46	9.84	9.47
Corderry 110 kV	4.13	6.20	5.87	5.04	6.25	6.15	4.14	9.91	8.87	5.47	8.28	8.02
Corduff 110 kV	10.94	19.27	16.45	11.77	23.50	21.99	9.30	25.70	23.21	10.38	29.64	28.47
Corduff 220 kV	16.96	18.78	15.57	15.41	23.07	21.21	14.60	29.69	25.65	12.90	32.97	31.10
Corkagh 110 kV	21.53	18.20	15.86	22.27	13.20	12.77	19.94	21.80	19.86	21.37	14.55	14.24
Corraclassy 110 kV	4.40	5.85	5.49	5.46	4.80	4.73	4.28	7.47	7.03	5.58	5.35	5.28
Cow Cross 110 kV	4.89	10.06	9.32	5.16	9.41	9.18	4.06	13.84	12.84	4.65	11.43	11.19
Crane 110 kV	8.02	7.25	6.96	7.64	8.00	7.89	7.44	9.90	9.17	7.24	9.90	9.64
Croaghaun 110 kV	3.38	3.39	3.27	3.79	4.26	4.20	5.87	7.89	6.68	6.75	8.13	7.65
Croaghnagawna 110 kV	4.29	3.41	3.29	5.26	2.86	2.84	7.34	7.93	6.26	7.32	4.05	3.87
Cromcastle A 110 kV	11.52	15.76	13.71	6.82	18.87	17.81	10.27	20.08	17.72	6.00	23.00	21.88
Cromcastle B 110 kV	11.52	15.76	13.71	6.82	18.87	17.81	10.27	20.08	17.72	6.00	23.00	21.88
Crory 110 kV	9.90	7.49	7.19	9.99	9.39	9.24	9.33	10.02	9.41	9.51	11.68	11.39
Cruiserath 220 kV	16.64	18.67	15.49	14.95	22.88	21.05	14.22	29.42	25.44	12.44	32.61	30.78
Cullenagh 110 kV	8.89	11.70	10.95	9.30	13.73	13.38	7.44	15.42	14.24	8.14	17.01	16.51
Cullenagh 220 kV	9.62	8.31	7.83	9.67	8.52	8.35	8.33	10.34	9.88	8.77	9.95	9.81
Cunghill 110 kV	3.18	4.50	4.31	3.65	4.42	4.37	3.07	6.85	6.35	3.74	5.70	5.58
Cureeny 110 kV	4.76	4.82	4.63	5.54	5.07	5.00	5.91	7.71	6.77	6.86	7.16	6.86
Cushaling 110 kV	5.80	9.50	8.58	7.04	11.24	10.80	6.56	13.65	12.34	8.41	14.28	13.77
Dallow 110 kV	3.53	4.70	4.54	4.60	3.10	3.08	3.46	5.98	5.68	4.69	3.44	3.41
Dalton 110 kV	3.09	3.73	3.58	4.11	3.29	3.26	3.17	5.37	4.87	4.49	3.93	3.84
Dardistown 110 kV	14.64	16.28	14.12	10.15	19.92	18.75	13.41	20.91	18.38	9.10	24.51	23.25
Darndale 110 kV	17.66	16.82	14.49	15.53	20.02	18.84	16.57	21.64	18.94	14.44	24.57	23.31
Derrybrien 110 kV	2.70	3.83	3.73	3.77	3.69	3.66	2.99	5.24	4.62	4.44	4.60	4.43
Derryiron 110 kV	4.79	7.56	7.14	5.94	7.80	7.66	5.38	11.22	10.60	7.01	9.91	9.74
Doon 110 kV	4.42	6.39	6.03	4.73	5.05	4.98	4.41	8.67	7.96	4.79	5.81	5.69
Dromada 110 kV	10.61	6.62	6.37	6.94	6.85	6.76	10.22	10.06	8.82	6.13	8.99	8.63
Drombeg 110 kV	7.66	7.62	7.21	7.59	6.45	6.36	7.45	10.74	10.19	7.48	7.69	7.59
Drumkeen 110 kV	3.57	4.79	4.54	4.25	5.06	4.97	3.81	9.56	8.14	4.97	7.64	7.30
Drumline 110 kV	3.66	7.33	6.90	4.83	6.34	6.24	3.18	9.80	9.08	4.62	7.44	7.30
Drybridge 110 kV	6.01	11.73	10.63	6.78	10.30	10.02	5.12	15.60	14.41	6.28	12.24	11.99
Dundalk 110 kV	3.91	7.86	7.36	4.83	7.39	7.26	3.43	10.13	9.32	4.54	8.76	8.55
Dunfirth 110 kV	4.62	6.76	6.42	5.96	5.51	5.44	4.55	8.42	8.14	6.13	6.21	6.16

Table E-4: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2025

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	6.12	5.69	5.47	7.81	4.88	4.82	6.01	7.36	6.77	7.97	5.69	5.56
Dunmanway 110 kV	4.22	6.67	6.29	4.96	7.01	6.87	4.44	10.88	9.52	5.47	9.56	9.17
Dunstown 220 kV	12.71	16.26	14.22	12.46	18.95	17.94	9.82	22.06	20.35	10.07	24.23	23.50
Dunstown 400 kV	11.11	8.06	7.19	12.93	8.78	8.41	8.32	11.10	10.47	10.45	11.13	10.91
Ennis 110 kV	4.58	9.25	8.62	5.75	8.54	8.36	4.38	14.41	12.78	5.96	11.01	10.66
Fassaroe East 110 kV	5.43	7.55	7.11	5.46	5.85	5.77	5.04	8.66	8.16	5.25	6.40	6.31
Fassaroe West 110 kV	5.58	7.70	7.25	5.56	6.04	5.95	5.18	8.85	8.33	5.35	6.62	6.52
Finglas 220 kV	16.52	17.89	14.90	16.15	22.77	20.93	15.26	28.76	24.74	14.38	33.56	31.51
Finglas A 110 kV	19.13	17.25	14.90	12.17	20.84	19.60	18.26	22.64	19.74	11.03	26.01	24.62
Finglas B 110 kV	30.58	11.58	10.58	28.92	14.61	14.07	34.12	14.60	13.07	30.54	17.83	17.02
Flagford 110 kV	4.84	9.72	8.95	5.54	11.99	11.60	4.41	15.40	14.05	5.43	17.23	16.64
Flagford 220 kV	7.24	5.92	5.52	9.01	5.92	5.79	7.55	8.50	8.12	9.95	7.42	7.33
Fortunestown 110 kV	5.87	7.20	6.72	5.74	5.55	5.46	5.48	8.47	7.70	5.53	6.04	5.90
Francis Street A 110 kV	11.11	11.93	10.91	5.37	14.25	13.74	10.39	14.40	12.82	5.01	16.52	15.77
Francis Street B 110 kV	13.49	11.64	10.61	6.95	14.20	13.67	12.66	13.79	12.62	6.43	16.41	15.83
Galway 110 kV	5.13	9.74	9.00	4.71	12.20	11.80	5.12	17.03	15.18	4.47	18.99	18.16
Gallanstown 110 kV	6.84	10.42	9.56	7.07	7.73	7.58	6.68	13.82	13.19	7.05	8.96	8.87
Garrow 110 kV	10.71	7.04	6.71	10.66	8.44	8.28	10.22	11.78	10.51	10.20	12.43	11.92
Garvagh 110 kV	4.26	5.14	4.91	5.37	5.05	4.99	4.54	7.81	7.00	6.11	6.42	6.22
Gilra 110 kV	3.33	5.81	5.50	4.10	4.72	4.66	2.94	7.39	7.02	3.93	5.33	5.26
Glanagow 220 kV	11.40	9.69	8.74	11.64	13.02	12.41	12.88	18.91	16.85	12.80	22.91	21.80
Glanlee 110 kV	4.95	5.02	4.85	5.18	6.00	5.92	5.03	8.09	7.09	5.33	8.70	8.28
Glasmore A 110 kV	4.06	7.64	7.08	4.49	5.27	5.18	3.74	9.14	8.33	4.33	5.76	5.65
Glenlara A 110 kV	3.08	2.72	2.64	4.34	2.38	2.36	3.25	3.45	3.16	4.78	2.74	2.68
Glenlara B 110 kV	9.13	5.84	5.65	6.65	6.54	6.46	8.91	9.15	8.10	5.94	8.97	8.60
Glenree 110 kV	3.09	4.00	3.84	3.84	3.85	3.81	3.58	7.32	6.73	4.75	5.44	5.33
Glentanemacelligot 110 kV	9.60	5.37	5.21	8.81	4.44	4.41	8.63	7.74	7.10	8.25	5.42	5.31
Golagh 110 kV	3.61	4.62	4.40	4.18	4.66	4.59	3.99	9.56	8.02	4.90	7.01	6.69
Gorman 110 kV	7.19	12.47	11.26	7.98	14.21	13.68	6.04	16.75	15.39	7.10	17.77	17.25
Gorman 220 kV	11.24	9.67	8.73	10.92	9.00	8.72	9.66	13.24	12.49	9.97	11.00	10.83
Gortawee 110 kV	4.50	5.71	5.34	5.91	4.88	4.80	4.42	7.07	6.61	6.10	5.40	5.31
Grange 110 kV	14.24	16.59	14.34	7.19	19.70	18.56	12.95	21.44	18.76	6.30	24.24	22.99
Grange Castle 110 kV	14.96	11.64	10.57	9.71	14.47	13.90	14.28	14.39	12.87	9.05	17.26	16.48
Great Island 110 kV	9.51	11.97	11.24	10.41	15.52	15.10	8.24	15.80	14.61	9.30	19.64	19.00

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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]
Great Island 220 kV	13.19	10.85	10.13	14.59	13.12	12.75	10.95	13.18	12.49	12.53	15.02	14.70
Griffinrath A 110 kV	7.17	9.77	9.18	7.49	9.95	9.75	6.30	12.01	11.43	6.88	11.56	11.38
Griffinrath B 110 kV	7.71	10.10	9.47	7.65	9.96	9.76	6.76	12.47	11.86	7.02	11.55	11.37
Harolds Cross 110 kV	11.30	11.96	10.95	5.07	14.21	13.71	10.58	14.43	12.86	4.73	16.45	15.71
Harristown 110 kV	4.47	7.11	6.72	5.49	5.90	5.82	4.56	9.43	9.08	5.78	6.87	6.81
Heuston 110 kV	14.60	11.86	10.80	8.36	14.62	14.06	13.74	14.08	12.86	7.75	16.95	16.33
Huntstown A 220 kV	15.60	17.19	14.41	14.01	21.89	20.18	14.64	27.51	23.80	12.25	32.14	30.24
Huntstown B 220 kV	17.10	17.70	14.85	12.48	21.69	20.07	14.77	26.57	23.31	10.07	29.82	28.30
Ikerrin 110 kV	5.16	3.99	3.85	5.95	3.18	3.15	5.76	5.80	5.29	6.47	3.83	3.75
Inchicore 220 kV	16.32	18.55	15.62	11.75	22.92	21.22	13.39	27.68	24.03	9.35	31.73	29.93
Inchicore A 110 kV	29.78	13.02	11.76	26.23	16.43	15.74	29.94	15.65	14.18	25.71	19.31	18.52
Inchicore B 110 kV	44.41	12.52	11.33	34.86	15.94	15.27	47.16	15.64	13.95	34.78	19.29	18.37
Inniscarra 110 kV	3.97	8.02	7.55	5.00	7.83	7.68	3.50	11.13	10.32	4.80	9.57	9.36
Irishtown 220 kV	17.28	17.39	14.81	13.29	21.95	20.41	15.07	25.80	22.54	11.02	30.30	28.63
Kellis 110 kV	7.28	8.73	8.29	8.33	10.31	10.11	6.63	11.02	10.29	7.83	12.36	12.04
Kellis 220 kV	8.75	7.39	6.99	10.33	6.48	6.38	7.89	8.85	8.53	9.76	7.29	7.21
Kilbarry 110 kV	7.36	13.95	12.56	7.88	15.69	15.07	6.20	23.18	20.30	7.11	22.42	21.43
Kildonan 110 kV	7.86	15.00	13.21	6.51	14.89	14.27	6.71	18.83	17.41	5.80	17.39	16.98
Kilkenny 110 kV	5.09	6.97	6.68	6.53	6.03	5.96	4.73	8.42	7.89	6.34	6.71	6.59
Kill Hill 110 kV	4.86	4.91	4.71	5.87	4.58	4.52	5.61	7.63	6.82	6.82	5.91	5.74
Killonan 110 kV	7.51	14.39	12.95	7.62	12.60	12.21	6.92	24.36	21.61	7.33	16.67	16.19
Killonan 220 kV	8.47	8.44	7.76	10.58	7.95	7.74	7.94	12.73	12.04	10.74	10.11	9.96
Killoteran 110 kV	8.07	10.72	10.08	8.10	12.08	11.80	6.93	13.97	12.88	7.24	14.75	14.32
Kilmahud 110 kV	21.09	18.08	15.77	21.97	13.16	12.73	19.50	21.64	19.73	21.08	14.49	14.19
Kilmore 110 kV	15.64	16.87	14.56	10.36	20.53	19.30	14.41	21.85	19.09	9.26	25.42	24.06
Kilpaddoge 110 kV	13.00	14.15	12.87	13.50	18.15	17.42	11.24	22.69	20.70	12.15	26.52	25.56
Kilpaddoge 220 kV	13.36	12.81	11.41	13.03	17.00	16.12	12.93	24.65	22.45	12.08	29.84	28.68
Kilpaddoge 400 kV	9.07	9.04	7.94	7.89	9.81	9.33	7.74	14.88	13.75	6.74	13.80	13.45
Kilteel 110 kV	4.46	7.47	7.06	5.52	6.78	6.67	4.18	9.23	8.69	5.38	7.66	7.53
Kinnegad 110 kV	4.51	7.74	7.27	5.36	7.18	7.05	4.58	10.44	9.97	5.62	8.55	8.45
Knockacummer 110 kV	8.04	5.09	4.95	7.10	5.40	5.35	7.91	7.80	6.96	6.76	7.33	7.06
Knockalough 110 kV	4.01	4.01	3.86	3.81	4.90	4.84	5.48	6.80	5.89	4.53	7.36	6.96
Knockanure 220 kV	12.47	10.70	9.70	8.83	14.12	13.50	11.82	19.18	17.56	7.09	23.32	22.46
Knockanure A 110 kV	22.48	9.66	9.14	17.69	11.52	11.27	21.73	15.65	13.57	15.67	16.58	15.72

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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]
Knockanure B 110 kV	5.10	7.39	6.99	6.30	5.37	5.30	4.56	10.42	9.71	6.15	6.21	6.12
Knockearagh 110 kV	5.51	5.05	4.83	7.26	4.47	4.42	5.49	6.62	6.11	7.52	5.22	5.10
Knockraha A 110 kV	8.82	14.85	13.36	9.30	16.40	15.76	7.62	24.19	21.55	8.54	23.04	22.17
Knockraha A 220 kV	10.97	10.32	9.28	10.99	12.25	11.72	10.77	19.46	17.43	10.69	19.61	18.85
Knockraha B 110 kV	8.82	14.85	13.36	9.30	16.40	15.76	7.62	24.19	21.55	8.54	23.04	22.17
Knockraha B 220 kV	10.97	10.32	9.28	10.99	12.25	11.72	10.77	19.46	17.43	10.69	19.61	18.85
Knockranny 110 kV	5.44	6.34	6.02	4.93	8.30	8.13	6.17	9.66	9.04	5.14	11.87	11.55
Knockranny A 110 kV	3.88	4.48	4.30	4.14	5.51	5.42	5.31	8.07	6.87	5.49	8.61	8.10
Knockranny B 110 kV	5.44	6.34	6.02	4.93	8.30	8.13	6.17	9.66	9.04	5.14	11.87	11.55
Knockumber 110 kV	4.05	7.76	7.21	4.77	6.05	5.95	3.55	9.29	8.75	4.48	6.66	6.57
Lanesboro 110 kV	3.31	7.73	7.25	4.08	8.67	8.48	3.68	12.54	11.38	4.92	12.14	11.76
Letterkenny110 kV	3.88	5.45	5.12	4.51	6.39	6.24	4.23	11.73	9.82	5.43	10.79	10.18
Liberty A 110 kV	6.16	12.35	11.23	5.31	14.66	14.10	5.05	19.11	17.04	4.46	20.30	19.46
Liberty B 110 kV	6.08	12.34	11.23	5.17	14.63	14.08	4.97	19.08	17.02	4.33	20.24	19.40
Limerick 110 kV	5.88	12.90	11.63	6.75	11.79	11.42	4.94	19.90	17.83	6.28	15.08	14.65
Lisdrum 110 kV	2.97	4.77	4.56	4.21	4.26	4.21	2.79	5.87	5.42	4.22	4.73	4.63
Lisheen 110 kV	3.97	3.12	3.03	3.97	4.68	4.61	4.94	5.32	4.64	4.95	7.97	7.42
Lodgewood 110 kV	9.90	7.49	7.19	9.99	9.39	9.24	9.33	10.02	9.41	9.51	11.68	11.39
Lodgewood 220 kV	9.43	6.78	6.45	10.43	6.67	6.56	8.78	8.42	8.06	9.99	7.73	7.62
Longpoint 220 kV	11.67	10.01	9.00	11.28	13.32	12.67	12.53	19.18	17.08	11.33	22.87	21.78
Louth 220 kV	11.43	12.18	10.69	11.79	14.78	14.00	9.70	20.12	18.32	10.57	21.90	21.14
Louth A 110 kV	7.64	11.08	10.18	8.56	13.60	13.15	6.40	14.50	13.48	7.51	16.95	16.47
Louth B 110 kV	8.25	11.88	10.86	8.96	14.92	14.39	6.83	16.02	14.81	7.75	19.17	18.58
Louth A 275 kV	12.88	8.03	7.20	12.34	9.85	9.41	11.37	12.21	11.44	11.12	13.83	13.49
Louth B 275 kV	12.25	8.01	7.18	10.98	9.99	9.53	10.66	12.05	11.30	9.58	14.02	13.68
Lumcloon 110 kV	5.44	6.88	6.58	6.39	5.03	4.98	5.84	9.48	9.10	6.81	5.85	5.80
Macetown 110 kV	8.21	15.59	13.67	7.77	16.45	15.70	6.99	19.79	18.20	6.91	19.50	18.97
Macroom 110 kV	7.30	11.18	10.30	7.21	12.91	12.50	6.86	18.60	16.59	6.82	18.49	17.77
Mallow 110 kV	5.28	5.89	5.61	6.87	5.28	5.21	5.25	7.69	7.15	7.15	6.22	6.10
Marina 110 kV	7.09	13.35	12.05	7.85	16.04	15.38	5.92	21.59	19.00	7.01	23.06	21.99
Maynooth A 110 kV	11.09	12.13	11.24	11.76	14.93	14.48	9.64	15.50	14.63	10.52	18.36	17.94
Maynooth A 220 kV	11.59	15.52	13.54	10.89	15.59	14.86	9.09	21.00	19.29	9.17	19.29	18.77
Maynooth B 110 kV	8.73	15.77	14.07	10.00	15.54	14.97	7.27	19.41	18.26	8.88	17.95	17.62
Maynooth B 220 kV	11.53	16.23	13.98	10.47	15.90	15.09	8.88	22.95	21.02	8.75	20.09	19.56

Table E-4: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2025

	Summer						Winter					
	Three phase			Single phase			Three phase			Single phase		
Station	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]
McDermott 110 kV	16.19	10.66	9.79	6.41	12.60	12.18	15.85	13.33	11.95	5.92	15.06	14.44
Meath Hill 110 kV	4.30	8.04	7.52	5.36	6.91	6.79	3.91	10.48	9.72	5.22	8.10	7.95
Meentycat 110 kV	3.31	4.15	3.96	4.14	4.25	4.19	3.53	7.61	6.59	4.94	6.05	5.82
Midleton 110 kV	4.09	8.70	8.12	5.07	7.96	7.79	3.45	11.47	10.70	4.67	9.35	9.17
Milltown A 110 kV	15.65	12.91	11.75	7.03	15.63	15.03	14.77	15.71	13.92	6.54	18.28	17.40
Milltown B 110 kV	9.35	10.54	9.68	4.29	12.63	12.20	8.69	12.39	11.39	3.97	14.45	13.98
Misery Hill 110 kV	13.97	12.61	11.49	7.74	15.39	14.81	13.13	15.32	13.59	7.22	18.03	17.16
Monatooreen 110 kV	6.58	14.11	12.76	6.54	15.46	14.89	5.26	22.31	20.03	5.62	21.25	20.50
Moneteen 110 kV	5.96	9.94	9.08	6.73	7.58	7.40	5.18	12.87	11.92	6.33	8.58	8.43
Moneypoint 110 kV	14.33	8.24	7.84	16.89	8.58	8.44	14.88	10.81	10.27	17.88	10.26	10.09
Moneypoint 220 kV	13.44	12.67	11.31	13.12	16.85	15.98	13.16	24.21	22.10	12.29	29.42	28.31
Moneypoint G1 400 kV	13.28	9.19	8.05	15.25	10.87	10.29	12.97	15.20	14.02	15.54	15.87	15.42
Moneypoint G2 400 kV	29.97	3.05	2.90	30.52	4.03	3.95	44.51	5.60	5.25	42.06	6.75	6.57
Moneypoint G3 400 kV	13.28	9.19	8.05	15.25	10.87	10.29	12.97	15.20	14.02	15.54	15.87	15.42
Monread 110 kV	4.21	7.59	7.16	5.09	7.57	7.43	3.89	9.30	8.79	4.89	8.60	8.45
Mount Lucas 110 kV	4.31	6.60	6.19	5.44	6.13	6.01	4.46	8.99	8.43	5.86	7.31	7.18
Moy 110 kV	3.28	4.31	4.12	3.95	4.95	4.88	5.34	9.73	8.61	6.94	8.62	8.30
Muckerstown 110 kV	6.53	9.66	8.92	6.88	6.94	6.82	6.35	12.63	12.10	6.86	7.96	7.89
Mullagharlin 110 kV	4.03	8.00	7.49	5.00	7.91	7.76	3.48	10.00	9.33	4.61	9.20	9.01
Mullingar 110 kV	3.66	6.62	6.27	4.56	6.43	6.33	3.50	8.27	7.84	4.55	7.43	7.32
Mulreavy 110 kV	3.97	4.85	4.61	4.57	5.71	5.61	5.44	11.10	8.97	6.73	10.16	9.47
Mungret A 110 kV	5.59	9.48	8.70	6.38	7.08	6.93	4.85	12.11	11.26	6.01	7.96	7.83
Mungret B 110 kV	5.58	9.50	8.71	6.37	7.09	6.94	4.84	12.14	11.28	6.00	7.96	7.84
Nangor 110 kV	13.35	11.38	10.35	8.04	14.07	13.52	12.70	14.00	12.56	7.46	16.70	15.97
Navan 110 kV	6.15	11.19	10.18	6.78	11.44	11.09	5.25	14.75	13.59	6.17	13.81	13.46
Nenagh 110 kV	3.36	3.54	3.42	4.07	2.46	2.45	3.29	4.58	4.21	4.12	2.75	2.70
Newbridge 110 kV	4.55	10.17	9.41	5.25	10.16	9.90	4.06	13.07	12.19	4.93	11.96	11.70
Newbury 110 kV	14.14	16.58	14.32	6.89	19.53	18.39	12.86	21.38	18.71	6.04	23.95	22.73
North Quays 110 kV	19.34	13.17	11.97	6.55	15.65	15.05	18.44	16.06	14.22	6.08	18.28	17.41
North Wall 220 kV	15.13	16.50	13.92	9.61	18.92	17.63	13.33	25.38	22.16	7.75	26.01	24.74
Oldcourt A 110 kV	4.28	8.71	8.15	4.72	7.34	7.21	3.61	11.43	10.73	4.34	8.56	8.42
Oldcourt B 110 kV	4.32	8.75	8.19	4.74	7.41	7.27	3.64	11.51	10.80	4.36	8.65	8.51
Oldstreet 220 kV	13.67	7.87	7.33	12.29	9.22	8.96	15.01	13.05	12.34	12.42	13.47	13.21

Table E-4: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2025

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]
Oldstreet 400 kV	10.83	7.97	7.09	9.19	7.40	7.13	9.58	12.26	11.61	8.23	9.65	9.51
Oriel 220 kV	10.21	9.91	8.94	8.61	10.48	10.10	9.43	15.49	14.18	7.78	14.14	13.75
Oughtragh 110 kV	3.76	4.15	3.99	4.84	2.88	2.86	3.60	5.31	4.95	4.84	3.16	3.11
Pelletstown 110 kV	14.15	10.13	9.35	8.18	11.10	10.78	13.67	12.51	11.31	7.69	13.04	12.58
Platin 110 kV	5.41	10.94	9.98	5.90	8.72	8.53	4.61	14.09	13.17	5.47	10.02	9.86
Pollaphuca 110 kV	2.79	2.53	2.49	4.03	2.31	2.30	3.27	3.22	3.10	4.72	2.64	2.62
Poolbeg A 110 kV	28.57	13.73	12.45	22.82	17.16	16.46	28.10	16.83	14.88	21.96	20.35	19.32
Poolbeg A 220 kV	15.38	16.73	14.09	8.15	18.04	16.86	13.02	25.56	22.31	6.43	24.29	23.18
Poolbeg B 110 kV	28.53	13.71	12.43	22.80	17.15	16.45	28.06	16.80	14.86	21.94	20.32	19.30
Poolbeg B 220 kV	16.00	17.61	14.95	11.40	20.39	19.05	13.06	25.65	22.47	9.25	27.26	25.92
Poolbeg C 110 kV	21.99	13.44	12.19	7.62	16.01	15.39	21.12	16.44	14.52	7.08	18.77	17.86
Poppintree 110 kV	12.62	16.17	14.05	6.84	19.35	18.26	11.38	20.85	18.32	6.00	23.79	22.59
Portan 260 kV	19.09	10.75	9.65	85.76	3.21	3.18	16.51	15.44	14.75	99.69	3.36	3.35
Portan 400 kV	15.51	8.85	7.77	14.55	10.07	9.56	12.19	13.76	12.93	12.18	14.34	14.03
Portlaoise 110 kV	6.18	11.60	10.77	7.03	11.29	11.03	5.59	15.56	14.64	6.73	13.57	13.32
Pottery 110 kV	18.20	10.53	9.77	5.86	10.85	10.58	17.54	12.54	11.57	5.50	12.33	11.99
Prospect 220 kV	11.45	11.06	10.00	9.02	12.77	12.26	10.18	18.82	17.54	7.62	18.86	18.40
Raffeen 220 kV	11.18	9.46	8.55	10.52	12.43	11.86	12.00	17.73	15.89	10.41	20.90	19.97
Raffeen A 110 kV	6.42	11.33	10.41	7.09	13.96	13.47	5.41	16.31	14.96	6.29	18.68	18.06
Raffeen B 110 kV	8.58	11.14	10.23	9.23	13.75	13.27	7.56	16.47	15.01	8.49	18.77	18.10
Rathkeale 110 kV	3.74	6.72	6.33	4.93	5.52	5.43	3.41	8.41	7.91	4.81	6.15	6.05
Ratrussan 110 kV	3.37	5.99	5.68	4.17	6.81	6.69	3.69	8.59	7.35	4.88	8.80	8.33
Reamore 110 kV	3.87	7.01	6.62	4.34	6.56	6.44	3.73	11.13	9.88	4.33	8.40	8.14
Richmond A 110 kV	2.94	5.70	5.42	3.87	5.53	5.46	2.99	8.06	7.46	4.22	6.90	6.75
Richmond B 110 kV	2.94	5.70	5.42	3.87	5.53	5.46	2.99	8.06	7.46	4.22	6.90	6.75
Rinawade 110 kV	5.20	10.33	9.55	6.04	7.62	7.49	4.66	12.21	11.72	5.76	8.39	8.32
Ringaskiddy 110 kV	6.28	9.62	8.93	6.57	10.22	9.96	5.32	13.38	12.39	5.91	12.82	12.50
Ringsend 110 kV	29.08	13.83	12.52	24.10	17.29	16.58	28.59	17.02	14.97	23.24	20.56	19.49
Rossiple 110 kV	6.18	6.41	6.17	6.91	5.30	5.25	6.34	8.79	8.22	7.17	6.30	6.19
Ryebrook 110 kV	5.84	13.33	11.77	6.64	12.16	11.71	4.98	15.79	14.66	6.03	13.47	13.19
Salthill 110 kV	4.66	9.39	8.69	3.99	11.59	11.23	4.63	16.29	14.51	3.67	17.78	17.02
Screeb 110 kV	3.68	2.41	2.34	4.60	1.76	1.75	4.56	3.54	3.16	5.35	2.04	1.99
Seal Rock A 110 kV	8.90	9.63	8.52	10.58	10.64	10.15	7.53	10.81	9.82	9.29	11.24	10.86
Seal Rock B 110 kV	8.94	9.64	8.52	10.60	10.64	10.15	7.56	10.82	9.82	9.30	11.25	10.86
Shankill 110 kV	3.86	7.10	6.64	4.81	6.85	6.72	3.79	10.08	8.82	5.05	8.52	8.20
Shannonbridge 110 kV	5.33	10.85	10.08	6.27	13.13	12.75	6.11	18.75	17.12	7.89	19.76	19.12
Shannonbridge 220 kV	6.90	6.01	5.67	9.08	5.54	5.44	7.80	8.67	8.42	10.78	6.85	6.80
Shantallow 110 kV	4.71	9.73	9.05	4.97	8.96	8.77	4.01	14.84	13.90	4.60	11.33	11.14

Table E-4: Ireland Short Circuit Currents for Maximum and Minimum Demand in 2025

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]
Shellybanks A 220 kV	15.18	16.72	14.08	10.14	19.17	17.85	12.73	25.53	22.28	8.08	26.19	24.91
Shellybanks B 220 kV	16.23	16.72	14.32	11.42	20.85	19.45	14.49	24.81	21.75	9.48	28.65	27.13
Shelton Abbey 110 kV	7.91	6.89	6.61	7.84	7.35	7.24	7.10	8.68	8.17	7.37	8.68	8.50
Singland 110 kV	6.78	12.21	11.13	7.59	11.37	11.05	6.32	19.26	17.39	7.52	14.72	14.33
Sliabh Bawn 110 kV	3.23	7.14	6.73	4.03	7.36	7.22	3.37	10.97	10.03	4.53	9.64	9.39
Slievecallan 110 kV	6.59	5.20	5.00	8.71	2.25	2.24	7.70	7.68	6.81	9.39	2.43	2.40
Sligo 110 kV	3.99	7.00	6.55	4.53	7.20	7.05	3.53	11.19	10.15	4.37	9.66	9.39
Snugborough 110 kV	10.96	17.77	15.31	10.19	19.07	18.06	9.46	23.16	21.06	9.09	22.92	22.21
Somerset 110 kV	3.20	6.40	6.12	4.06	4.57	4.53	2.85	8.49	8.08	3.95	5.18	5.13
Sorne Hill 110 kV	2.78	2.33	2.26	3.43	2.70	2.67	3.42	3.88	3.44	4.37	3.77	3.62
Srahnakilly 110 kV	3.33	3.53	3.40	3.65	4.52	4.45	5.82	8.60	7.22	6.43	9.08	8.50
Srananagh 110 kV	4.86	7.90	7.36	5.50	9.19	8.95	4.49	13.25	11.95	5.48	13.30	12.84
Srananagh 220 kV	6.65	3.89	3.70	8.60	3.41	3.36	7.37	5.28	5.06	9.76	4.01	3.97
Stevenstown 110 kV	4.04	6.26	5.89	4.50	4.06	4.01	3.77	7.22	6.74	4.37	4.36	4.30
Stratford 110 kV	3.22	3.91	3.81	4.22	3.11	3.09	3.33	4.83	4.57	4.38	3.46	3.41
Taney 110 kV	9.25	9.16	8.57	3.36	9.15	8.95	8.67	10.73	9.99	3.16	10.24	10.00
Tarbert 110 kV	22.28	11.18	10.50	25.30	12.19	11.92	26.61	14.18	13.71	29.42	14.47	14.30
Tarbert 220 kV	12.79	12.34	11.04	12.92	16.11	15.32	11.98	22.97	21.06	11.99	27.20	26.24
Tawnaghmore A 110 kV	2.99	3.48	3.36	3.82	3.64	3.60	4.13	6.91	6.31	5.72	5.51	5.38
Tawnaghmore B 110 kV	3.04	3.48	3.35	3.72	4.00	3.95	4.66	7.24	6.57	6.37	6.67	6.47
Thornsberry 110 kV	3.89	5.98	5.67	5.02	5.63	5.54	3.85	8.07	7.62	5.24	6.85	6.74
Thurles 110 kV	5.05	4.04	3.88	5.43	4.70	4.63	6.18	6.94	6.04	6.50	6.97	6.63
Tievebrack 110 kV	3.43	3.35	3.21	4.54	2.69	2.67	3.73	5.53	5.11	5.23	3.32	3.26
Timahoe 110 kV	6.28	7.23	6.89	6.86	5.55	5.49	6.14	9.78	9.48	6.89	6.51	6.46
Tipperary 110 kV	5.09	6.05	5.76	6.07	4.22	4.17	5.30	8.57	7.90	6.35	4.85	4.78
Tonroe 110 kV	3.18	4.37	4.19	4.25	2.29	2.28	3.63	6.50	6.04	4.65	2.57	2.55
Trabeg 110 kV	7.01	13.31	12.02	7.70	15.98	15.32	5.83	21.47	18.91	6.84	22.94	21.88
Tralee 110 kV	5.07	7.41	6.98	6.12	6.96	6.83	5.15	11.98	10.60	6.44	9.01	8.73
Trien A 110 kV	4.94	6.92	6.55	6.76	5.84	5.76	4.46	9.94	9.19	6.75	7.04	6.91
Trien B 110 kV	11.70	7.83	7.48	9.85	8.32	8.19	10.97	12.42	10.70	8.98	11.28	10.75
Trillick 110 kV	2.83	2.50	2.42	3.52	2.73	2.70	3.52	4.29	3.75	4.48	3.77	3.62
Trinity 110 kV	12.31	12.27	11.20	6.46	14.84	14.30	11.54	14.86	13.20	6.02	17.31	16.50
Tullabrack 110 kV	6.79	6.33	6.07	7.37	5.14	5.08	6.53	8.18	7.77	7.28	5.84	5.77

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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]
Turlough 220 kV	11.97	11.25	10.09	13.04	10.40	10.05	10.03	13.10	12.22	11.57	11.39	11.15
Tynagh 220 kV	11.46	7.39	6.89	12.37	9.10	8.84	15.21	13.76	12.82	16.50	14.65	14.27
Uggool 110 kV	5.47	6.06	5.77	5.16	7.96	7.80	6.29	9.18	8.62	5.57	11.35	11.05
Waterford 110 kV	8.34	11.19	10.49	8.62	12.54	12.24	7.12	14.72	13.53	7.70	15.39	14.93
Wexford 110 kV	5.82	5.94	5.72	7.03	5.75	5.69	5.89	8.24	7.47	7.41	7.00	6.80
Whitebank 110 kV	25.86	13.79	12.48	20.95	17.21	16.50	25.01	16.95	14.91	19.96	20.44	19.37
Whitegate 110 kV	4.90	8.30	7.77	5.54	8.89	8.69	4.24	10.69	10.09	5.06	10.63	10.43
Wolfe Tone 110 kV	14.49	10.44	9.61	5.86	12.22	11.82	14.02	13.02	11.70	5.41	14.54	13.96
Woodhouse 110 kV	6.08	5.62	5.41	7.33	4.34	4.30	6.17	7.41	6.83	7.58	5.01	4.92
Woodland 220 kV	15.72	18.96	15.93	14.57	21.32	19.87	12.16	30.00	26.82	11.91	30.19	29.01
Woodland 400 kV	16.52	8.90	7.81	15.88	10.15	9.64	13.24	13.87	13.03	13.54	14.55	14.23

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	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.

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 2019, 2022 and 2025:

- **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 (ip)**

  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 (IB)**

  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 have 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 2019

Node	Rating		Three Phase					Single Phase				
	RMS [kA]	Peak [kA]	X/R ratio (AC)	X/R Ratio (DC)	I'' [kA]	ip [kA]	IB [kA]	X/R ratio (AC)	X/R Ratio (DC)	I'' [kA]	ip [kA]	IB [kA]
275 kV												
Ballylumford	31.5	79	11.27	17.71	7.94	19.88	7.02	11.88	19.11	10.41	26.21	9.57
Castlereagh	31.5	79	10.23	15.34	7.67	18.98	6.79	10.27	15.81	9.44	23.38	8.71
Coolkeeragh	31.5	79	10.75	18.93	7.54	18.78	6.75	11.75	21.15	8.78	22.08	8.24
Hannahstown	31.5	79	10.35	15.57	7.56	18.74	6.70	10.56	16.66	9.36	23.27	8.64
Kells	31.5	79	10.60	15.80	7.88	19.59	6.98	10.30	15.49	9.89	24.52	9.13
Kilroot	31.5	79	10.45	15.03	7.39	18.35	6.60	11.12	16.27	10.08	25.20	9.28
Magherafelt	31.5	79	10.97	16.60	8.61	21.51	7.59	9.38	12.84	9.68	23.71	8.98
Moyle	31.5	79	11.22	17.54	7.87	19.69	6.97	11.80	18.84	10.28	25.87	9.46
Tandragee	31.5	79	10.22	15.18	9.05	22.42	7.96	10.03	15.43	11.13	27.49	10.22
Tamnamore	40	100	10.47	15.52	8.62	21.40	7.60	10.49	16.70	10.29	25.55	9.50
110 kV												
Aghyoule	40	100	2.98	3.21	3.04	5.92	2.96	4.03	5.14	3.25	6.82	3.21
Antrim	40	100	4.72	7.43	7.58	16.50	7.18	4.77	9.18	8.10	17.67	7.87
Ballylumford*	21.9	55	10.34	21.11	13.64	33.82	12.45					
	26.2	65						11.34	23.30	17.44	43.72	16.43
Ballymena	40	100	4.80	8.26	6.92	15.13	6.58	5.31	11.19	7.55	16.83	7.34
Banbridge	18.4	46.8	4.16	6.52	5.84	12.36	5.60	5.05	9.84	5.97	13.17	5.84
Ballyvallagh	21.9	46.8	5.53	7.00	10.91	24.53	10.11	5.05	6.88	11.36	25.07	10.91
Ballynahinch	18.4	46.8	4.24	6.98	4.99	10.61	4.79	4.93	9.90	5.15	11.32	5.04
Belfast Central	n/a	n/a	8.21	12.41	10.59	25.45	9.73	5.49	11.23	13.44	30.17	12.66
Belfast North	n/a	n/a	5.22	8.04	9.75	21.67	9.05	3.33	11.55	10.95	21.96	10.47
Brockaghboy	40	100	4.56	4.95	3.36	7.25	3.28	4.12	5.21	2.89	6.10	2.87
Carnmoney	31.5	79	4.11	6.55	7.04	14.85	6.68	4.59	8.81	7.38	15.97	7.18
Castlereagh	31.5	79	10.54	18.69	12.47	30.98	11.30	11.36	19.81	16.69	41.84	15.52
Coleraine	40	100	3.83	4.33	6.17	12.81	5.85	4.39	5.56	7.50	16.06	7.25
Coolkeeragh	31.5	79	11.01	22.94	14.25	35.59	12.89	11.60	24.07	18.76	47.14	17.60
Creagh	31.5	79	3.76	4.37	6.81	14.08	6.49	4.45	6.84	7.43	15.97	7.24
Cregagh	26.2	65	9.03	14.47	11.53	28.10	10.52	7.36	13.16	14.98	35.43	14.03
Donegall North	31.5	79	8.12	13.14	10.80	25.92	9.95	5.88	10.83	14.04	31.92	13.24
Donegall South	n/a	n/a	6.25	9.04	9.03	20.77	8.43	5.21	8.96	10.52	23.37	10.08
Dromore	40	100	3.98	4.76	7.56	15.83	7.13	4.20	5.23	8.35	17.71	8.08
Drumnakelly	31.5	79	7.71	12.26	14.15	33.70	12.82	7.48	12.52	16.70	39.59	15.67
Drumquin	40	100	4.61	5.19	4.70	10.18	4.55	5.12	8.28	4.91	10.86	4.83
Dungannon	40	100	7.05	12.59	12.56	29.49	11.51	6.95	13.02	15.10	35.37	14.27
Eden	25	62.5	4.29	6.41	7.70	16.41	7.29	4.66	8.50	8.06	17.50	7.83
Enniskillen	31.5	79	3.65	4.13	6.07	12.46	5.77	4.38	5.67	7.19	15.40	6.97
Finaghy	31.5	79	8.95	15.10	11.10	27.02	10.21	7.01	12.20	14.76	34.62	13.88

Table E-6: Northern Ireland Short Circuit Currents for Minimum Demand in 2019

Node	Rating		Three Phase					Single Phase				
	RMS [kA]	Peak [kA]	X/R ratio (AC)	X/R Ratio (DC)	I'' [kA]	ip [kA]	IB [kA]	X/R ratio (AC)	X/R Ratio (DC)	I'' [kA]	ip [kA]	IB [kA]
110 kV												
Glengormley	18.4	46.8	3.50	4.07	4.80	9.75	4.64	4.13	7.07	4.87	10.30	4.79
Gort Cluster	40	100	6.01	7.41	6.43	14.69	6.16	5.75	10.91	6.46	14.64	6.33
Hannahstown	31.5	79	9.79	17.85	11.87	29.24	10.86	10.35	18.89	16.06	39.83	15.03
Kells	40	100	8.69	17.11	12.95	31.40	11.83	9.19	18.08	17.15	41.89	16.09
Killymallaght	40	100	6.22	8.12	9.10	20.91	8.53	5.76	9.55	9.33	21.15	9.06
Knock	n/a	n/a	5.35	7.92	11.10	24.80	10.16	3.34	10.60	12.51	25.12	11.86
Larne	18.4	46.8	4.66	5.76	7.48	16.23	7.09	5.19	8.60	7.64	16.96	7.44
Limavady	18.4	46.8	3.72	4.19	5.78	11.92	5.52	4.34	6.29	6.52	13.93	6.36
Lisburn	18.4	46.8	5.93	8.28	9.18	20.91	8.57	5.46	9.40	9.75	21.86	9.37
Lisaghmore	31.5	79	4.90	7.48	8.03	17.62	7.59	4.97	9.56	8.31	18.28	8.10
Loguestown	26.2	65	3.51	4.14	4.72	9.60	4.53	4.08	5.66	5.38	11.33	5.26
Magherakeel Cluster	40	100	4.29	4.69	3.23	6.88	3.17	5.46	6.39	3.77	8.46	3.74
Newtownards	40	100	4.82	7.09	6.63	14.50	6.29	5.72	9.67	6.65	15.05	6.47
Newry	18.4	46.8	3.96	6.72	5.00	10.45	4.81	4.83	9.72	5.09	11.13	4.99
Omagh	40	100	4.77	6.33	9.79	21.36	9.10	5.04	7.99	11.36	25.07	10.87
Rasharkin	40	100	3.93	4.44	5.39	11.25	5.17	4.47	7.05	5.74	12.35	5.63
Rathgael	26.2	65	4.32	6.79	5.32	11.35	5.09	4.95	9.69	5.46	12.00	5.33
Rosebank	40	100	9.75	16.21	11.81	29.08	10.76	10.84	17.96	15.56	38.80	14.54
Slieve Kirk	40	100	4.65	5.54	6.91	14.99	6.59	5.37	9.93	6.22	13.91	6.12
Springtown	n/a	n/a	5.13	7.84	8.20	18.17	7.74	5.13	9.69	8.63	19.12	8.40
Strabane	18.4	46.8	5.45	7.22	10.69	23.96	9.90	5.55	9.48	11.75	26.44	11.28
Tandragee	31.5	79	9.13	16.92	14.99	36.58	13.51	9.79	18.73	19.20	47.28	17.85
Tremoge	40	100	4.22	5.17	6.99	14.85	6.67	4.48	8.06	7.10	15.28	6.94
Tamnamore	40	100	8.22	17.09	14.32	34.43	13.00	8.89	18.52	19.16	46.59	17.86
Waringstown	18.4	46.8	5.10	7.57	7.17	15.85	6.80	5.58	10.14	7.22	16.26	7.03

Table E-7: Northern Ireland Short Circuit Currents for Maximum Demand in 2019

Node	Rating		Three Phase					Single Phase				
	RMS [kA]	Peak [kA]	X/R ratio (AC)	X/R Ratio (DC)	I'' [kA]	ip [kA]	IB [kA]	X/R ratio (AC)	X/R Ratio (DC)	I'' [kA]	ip [kA]	IB [kA]
275 kV												
Ballylumford	31.5	79	13.09	20.53	17.40	44.27	14.00	14.08	23.35	19.63	50.30	16.84
Castlereagh	31.5	79	10.46	14.99	15.48	38.42	12.54	10.44	15.85	16.00	39.71	13.89
Coolkeeragh	31.5	79	8.56	13.55	12.17	29.45	10.59	10.24	16.87	12.35	30.57	11.31
Hannahstown	31.5	79	10.70	15.32	15.20	37.83	12.33	10.95	17.25	15.88	39.65	13.78
Kells	31.5	79	12.41	18.26	17.69	44.76	14.27	11.09	16.61	18.32	45.80	15.93
Kilroot	31.5	79	13.85	21.56	17.55	44.91	14.06	15.43	24.97	21.16	54.67	18.02
Magherafelt	31.5	79	11.28	15.60	17.63	44.17	14.51	8.69	10.87	15.51	37.61	13.84
Moyle	31.5	79	12.92	19.97	17.05	43.33	13.76	13.83	22.49	19.16	49.01	16.48
Tandragee	31.5	79	10.20	14.07	18.55	45.92	15.13	9.86	14.78	18.96	46.73	16.61
Tamnamore	40	100	10.53	14.31	17.31	43.01	14.28	10.53	16.55	16.94	42.09	15.01
110 kV												
Aghyoule	40	100	3.69	8.52	4.72	9.71	4.26	5.19	12.00	4.37	9.71	4.14
Antrim	40	100	4.26	7.47	10.11	21.51	9.10	4.53	9.72	9.95	21.46	9.25
Ballylumford*	21.9	55	10.19	24.25	22.68	56.14	18.42					
	26.2	65						11.77	27.89	26.28	66.13	22.41
Ballymena	40	100	4.49	8.64	9.15	19.70	8.26	5.24	12.11	9.42	20.96	8.81
Banbridge	18.4	46.8	3.76	6.04	6.88	14.22	6.36	4.84	9.54	6.73	14.72	6.40
Ballyvallagh	21.9	46.8	4.51	5.34	16.16	34.81	13.94	4.41	5.82	14.66	31.44	13.33
Ballynahinch	18.4	46.8	3.91	6.66	5.88	12.27	5.34	4.78	9.82	5.86	12.78	5.47
Belfast Central	n/a	n/a	7.20	11.19	15.19	35.79	12.93	4.70	10.91	18.05	39.25	15.87
Belfast North	n/a	n/a	4.31	6.83	13.49	28.79	11.63	2.90	11.37	13.69	26.50	12.28
Brockaghboy	40	100	5.21	6.36	5.69	12.64	4.49	4.22	5.91	3.42	7.27	3.15
Carnmoney	31.5	79	3.61	6.16	8.81	18.03	7.88	4.28	8.68	8.66	18.45	7.99
Castlereagh	31.5	79	9.87	19.84	19.40	47.83	16.09	10.89	20.96	24.63	61.44	21.15
Coleraine	40	100	4.13	5.81	10.04	21.23	9.09	4.96	7.82	10.84	23.83	10.24
Coolkeeragh	31.5	79	8.73	17.87	23.17	56.20	20.04	9.73	19.73	28.16	69.30	25.38
Creagh	31.5	79	3.23	3.59	8.40	16.72	7.70	4.10	6.14	8.70	18.35	8.28
Cregagh	26.2	65	8.03	13.57	17.24	41.31	14.47	6.43	12.63	21.06	48.68	18.30
Donegall North	31.5	79	7.27	11.90	15.63	36.88	13.31	5.03	9.84	19.13	42.21	16.78
Donegall South	n/a	n/a	5.41	7.77	12.14	27.18	10.59	4.61	8.37	13.12	28.42	11.84
Dromore	40	100	3.81	5.78	13.54	28.06	11.80	4.13	5.98	12.09	25.55	11.26
Drumnakelly	31.5	79	6.49	10.56	22.42	51.90	19.13	6.64	11.65	23.49	54.61	21.08
Drumquin	40	100	5.17	7.66	7.01	15.55	6.47	5.78	12.06	6.39	14.48	6.09
Dungannon	40	100	6.06	10.94	19.59	44.81	17.34	6.37	12.48	21.13	48.77	19.43
Eden	25	62.5	3.69	5.69	9.89	20.34	8.76	4.29	8.13	9.59	20.44	8.80
Enniskillen	31.5	79	3.57	4.86	12.00	24.49	9.66	4.79	7.45	11.30	24.66	10.13
Finaghy	31.5	79	8.25	14.28	16.25	39.10	13.80	6.13	11.27	20.50	47.00	17.90
Glengormley	18.4	46.8	3.12	3.50	5.64	11.12	5.19	3.93	6.62	5.46	11.41	5.16

Table E-7: Northern Ireland Short Circuit Currents for Maximum Demand in 2019

Node	Rating		Three Phase					Single Phase				
	RMS [kA]	Peak [kA]	X/R ratio (AC)	X/R Ratio (DC)	I'' [kA]	ip [kA]	IB [kA]	X/R ratio (AC)	X/R Ratio (DC)	I'' [kA]	ip [kA]	IB [kA]
110 kV												
Gort Cluster	40	100	6.22	8.24	8.84	20.31	8.39	5.97	12.69	8.01	18.28	7.71
Hannahstown	31.5	79	9.30	18.21	17.97	43.95	15.10	10.07	19.62	23.14	57.20	20.02
Kells	40	100	8.38	18.39	21.79	52.55	18.52	9.18	19.92	26.92	65.73	23.86
Killymallaght	40	100	5.62	7.98	13.15	29.66	12.12	5.41	10.05	11.95	26.74	11.41
Knock	n/a	n/a	4.24	6.62	16.19	34.41	13.67	2.85	10.76	16.18	31.16	14.34
Larne	18.4	46.8	4.02	4.83	9.64	20.25	8.65	4.84	8.03	9.08	19.88	8.45
Limavady	18.4	46.8	3.61	4.44	8.14	16.66	7.53	4.46	7.18	8.39	18.04	7.93
Lisburn	18.4	46.8	5.27	7.50	12.57	27.99	10.87	5.07	9.40	12.07	26.67	10.92
Lisaghmore	31.5	79	4.12	6.55	10.30	21.76	9.48	4.51	9.08	9.84	21.21	9.38
Loguestown	26.2	65	3.58	4.96	6.74	13.76	6.22	4.33	7.01	6.95	14.85	6.65
Magherakeel Cluster	40	100	5.16	9.66	4.49	9.96	4.42	6.79	12.30	4.97	11.59	4.82
Newtownards	40	100	4.28	6.62	8.21	17.49	7.32	5.42	9.63	7.71	17.28	7.14
Newry	18.4	46.8	3.80	7.16	5.89	12.20	5.42	4.84	10.41	5.75	12.58	5.45
Omagh	40	100	4.51	7.05	17.77	38.30	15.91	5.01	9.53	17.29	38.10	16.17
Rasharkin	40	100	4.48	6.69	9.02	19.41	7.59	4.97	10.63	7.60	16.72	6.96
Rathgael	26.2	65	3.91	6.32	6.29	13.12	5.70	4.72	9.48	6.17	13.44	5.78
Rosebank	40	100	8.88	15.87	17.83	43.35	14.94	10.29	18.21	22.21	55.03	19.26
Slieve Kirk	40	100	4.32	6.33	9.23	19.71	8.69	5.38	11.27	7.48	16.72	7.27
Springtown	n/a	n/a	4.27	6.73	10.54	22.45	9.66	4.62	9.07	10.27	22.24	9.70
Strabane	18.4	46.8	4.52	6.01	16.76	36.13	15.12	4.99	9.13	16.02	35.28	15.14
Tandragee	31.5	79	8.12	16.76	24.51	58.82	20.67	9.16	19.27	28.60	69.83	25.17
Tremoge	40	100	4.03	5.83	9.83	20.65	9.19	4.50	9.41	8.83	19.03	8.45
Tamnamore	40	100	7.20	16.13	23.80	56.08	20.79	8.19	18.21	29.48	70.86	26.57
Waringstown	18.4	46.8	4.61	7.32	8.86	19.19	8.05	5.38	10.31	8.35	18.67	7.84

Table E-8: Northern Ireland Short Circuit Currents for Minimum Demand in 2022

Node	Rating		Three Phase					Single Phase				
	RMS [kA]	Peak [kA]	X/R ratio (AC)	X/R Ratio (DC)	I'' [kA]	ip [kA]	IB [kA]	X/R ratio (AC)	X/R Ratio (DC)	I'' [kA]	ip [kA]	IB [kA]
275 kV												
Ballylumford	31.5	79	12.62	19.49	9.99	25.33	8.71	13.26	21.24	12.63	32.18	11.57
Castlereagh	31.5	79	11.54	17.16	9.64	24.20	8.40	11.28	17.32	11.36	28.46	10.43
Coolkeeragh	31.5	79	10.20	16.38	8.68	21.49	7.73	11.36	18.99	9.75	24.44	9.14
Hannahstown	31.5	79	11.55	17.13	9.43	23.68	8.24	11.53	18.15	11.17	28.05	10.28
Kells	31.5	79	13.25	20.94	10.76	27.41	9.32	12.01	18.72	12.69	32.01	11.65
Kilroot	31.5	79	14.72	24.63	11.07	28.48	9.56	15.73	26.96	14.36	37.16	13.09
Magherafelt	31.5	79	12.59	18.95	10.89	27.60	9.44	9.84	13.06	11.41	28.12	10.56
Moyle	31.5	79	12.54	19.23	9.88	25.04	8.63	13.14	20.80	12.44	31.66	11.40
Tandragee	31.5	79	11.59	17.23	11.39	28.61	9.84	10.95	16.92	13.31	33.21	12.15
Tamnamore	40	100	11.83	17.39	10.77	27.12	9.35	11.46	18.39	12.17	30.53	11.19
110 kV												
Aghyoule	40	100	2.97	3.17	3.13	6.09	3.02	3.96	4.88	3.43	7.17	3.36
Antrim	40	100	4.74	7.67	8.18	17.83	7.73	4.85	9.68	8.63	18.89	8.36
Ballylumford	40	100	9.64	20.54	14.08	34.61	12.87	10.62	22.72	17.89	44.49	16.85
Ballymena	40	100	4.87	8.49	7.46	16.34	7.05	5.48	11.58	8.09	18.14	7.83
Banbridge	18.4	46.8	4.15	6.56	6.20	13.11	5.92	5.15	9.86	6.39	14.16	6.22
Ballyvallagh	21.9	46.8	5.44	6.84	11.66	26.14	10.78	4.99	6.70	11.93	26.28	11.44
Ballynahinch	18.4	46.8	4.33	7.11	5.27	11.25	5.02	5.11	10.11	5.51	12.20	5.36
Belfast Central	n/a	n/a	8.51	12.74	11.57	27.96	10.56	5.50	12.11	14.60	32.77	13.70
Belfast North	n/a	n/a	5.09	7.89	10.73	23.73	9.92	3.28	11.87	11.76	23.50	11.23
Brockaghboy	40	100	4.58	4.88	3.16	6.83	3.08	5.00	6.49	3.29	7.24	3.24
Carnmoney	31.5	79	4.10	6.62	7.36	15.53	6.96	4.63	9.00	7.72	16.74	7.48
Castlereagh	31.5	79	11.51	20.89	13.88	34.83	12.48	12.05	21.45	18.51	46.70	17.12
Coleraine	40	100	3.75	4.15	6.40	13.22	6.02	4.26	5.25	7.96	16.93	7.63
Coolkeeragh	31.5	79	10.48	20.59	15.03	37.32	13.52	11.05	21.80	19.71	49.26	18.40
Creagh	31.5	79	3.67	4.18	7.24	14.86	6.87	4.45	6.40	8.01	17.22	7.77
Cregagh	26.2	65	9.51	15.21	12.72	31.21	11.52	7.47	13.87	16.45	38.97	15.33
Donegall North	31.5	79	8.30	13.49	12.02	28.95	11.02	5.81	11.05	15.42	35.00	14.51
Donegall South	n/a	n/a	6.19	8.89	9.85	22.62	9.16	5.14	9.11	11.28	25.00	10.78
Dromore	40	100	3.89	4.58	7.93	16.53	7.44	4.11	5.00	8.75	18.46	8.40
Drumnakelly	31.5	79	7.86	12.54	16.17	38.63	14.53	7.65	13.15	18.66	44.39	17.44
Drumquin	40	100	4.57	5.08	4.83	10.43	4.64	5.15	8.10	5.11	11.32	4.99
Dungannon	40	100	7.08	12.83	13.99	32.88	12.74	7.12	13.91	16.58	39.00	15.61
Eden	25	62.5	4.23	6.37	7.99	16.97	7.54	4.66	8.55	8.36	18.15	8.10
Enniskillen	31.5	79	3.60	4.03	6.34	12.95	5.98	4.31	5.43	7.62	16.25	7.32
Finaghy	31.5	79	9.28	15.78	12.39	30.31	11.34	7.00	12.51	16.29	38.21	15.29
Glengormley	18.4	46.8	3.44	3.94	5.01	10.13	4.82	4.15	6.87	5.10	10.78	4.99
Gort Cluster	40	100	5.96	7.24	6.70	15.27	6.38	5.90	11.01	6.76	15.38	6.58

Table E-8: Northern Ireland Short Circuit Currents for Minimum Demand in 2022

Node	Rating		Three Phase					Single Phase				
	RMS [kA]	Peak [kA]	X/R ratio (AC)	X/R Ratio (DC)	I'' [kA]	ip [kA]	IB [kA]	X/R ratio (AC)	X/R Ratio (DC)	I'' [kA]	ip [kA]	IB [kA]
110 kV												
Hannahstown	31.5	79	10.35	19.41	13.38	33.17	12.17	10.89	20.42	17.90	44.65	16.71
Kells	40	100	9.71	20.76	14.82	36.45	13.44	10.18	21.65	19.28	47.72	18.04
Killymallaght	40	100	6.04	7.71	9.44	21.57	8.80	5.70	9.59	9.76	22.08	9.41
Knock	n/a	n/a	5.29	7.97	12.21	27.21	11.10	3.38	11.69	13.50	27.16	12.75
Larne	18.4	46.8	4.59	5.68	7.81	16.91	7.39	5.21	8.51	7.98	17.74	7.75
Limavady	18.4	46.8	3.64	4.03	5.95	12.20	5.64	4.26	6.01	6.78	14.42	6.56
Lisburn	18.4	46.8	5.87	8.18	10.03	22.81	9.32	5.48	9.77	10.44	23.43	10.02
Lisaghmore	31.5	79	4.81	7.41	8.31	18.16	7.80	5.00	9.70	8.67	19.10	8.39
Loguestown	26.2	65	3.47	4.08	4.87	9.87	4.63	4.01	5.49	5.69	11.93	5.51
Magherakeel Cluster	40	100	4.25	4.61	3.28	6.97	3.19	5.33	6.10	3.92	8.75	3.86
Newtownards	40	100	4.82	7.13	7.02	15.34	6.62	5.80	9.95	7.05	15.99	6.82
Newry	18.4	46.8	4.02	6.68	5.30	11.13	5.07	4.96	9.69	5.48	12.06	5.34
Omagh	40	100	4.66	6.08	10.42	22.62	9.63	4.97	7.81	12.05	26.51	11.46
Rasharkin	40	100	3.86	4.28	5.59	11.62	5.33	4.35	6.13	6.25	13.36	6.08
Rathgael	26.2	65	4.35	6.85	5.59	11.96	5.32	5.07	9.83	5.82	12.85	5.65
Rosebank	40	100	10.39	17.26	13.04	32.36	11.80	11.29	18.99	17.10	42.84	15.91
Slieve Kirk	40	100	4.54	5.32	7.10	15.32	6.73	5.42	9.21	6.57	14.70	6.40
Springtown	n/a	n/a	5.03	7.82	8.48	18.71	7.95	5.13	9.85	8.94	19.81	8.64
Strabane	18.4	46.8	5.28	6.83	11.20	24.95	10.31	5.47	9.24	12.32	27.64	11.74
Tandragee	31.5	79	9.65	18.74	17.31	42.56	15.46	10.28	20.52	21.71	53.80	20.10
Tremoge	40	100	4.12	4.98	7.33	15.48	6.96	4.51	8.02	7.44	16.04	7.23
Tamnamore	40	100	8.47	18.59	16.26	39.27	14.64	9.20	20.20	21.41	52.31	19.88
Waringstown	18.4	46.8	5.11	7.87	7.67	16.97	7.25	5.74	10.66	7.71	17.46	7.47

Table E-9: Northern Ireland Short Circuit Currents for Maximum Demand in 2022

Node	Rating		Three Phase					Single Phase				
	RMS [kA]	Peak [kA]	X/R ratio (AC)	X/R Ratio (DC)	I'' [kA]	ip [kA]	IB [kA]	X/R ratio (AC)	X/R Ratio (DC)	I'' [kA]	ip [kA]	IB [kA]
275 kV												
Ballylumford	31.5	79	11.01	17.94	14.30	35.72	12.64	12.03	20.35	16.90	42.63	15.64
Castlereagh	31.5	79	9.72	14.93	13.45	33.10	11.82	9.96	15.79	14.64	36.13	13.52
Coolkeeragh	31.5	79	11.98	17.74	11.56	29.15	10.64	13.21	21.24	11.92	30.37	11.42
Hannahstown	31.5	79	9.79	15.02	13.13	32.34	11.58	10.21	16.72	14.38	35.59	13.31
Kells	31.5	79	11.61	18.78	15.29	38.43	13.51	10.73	17.11	16.55	41.21	15.43
Kilroot	31.5	79	12.66	21.30	15.08	38.24	13.31	14.02	24.20	18.69	47.88	17.30
Magherafelt	31.5	79	11.09	17.21	15.74	39.34	14.02	8.77	11.72	14.52	35.24	13.71
Moyle	31.5	79	10.94	17.65	14.07	35.13	12.46	11.91	19.86	16.56	41.73	15.34
Tandragee	31.5	79	9.95	15.00	16.83	41.52	14.93	9.71	15.40	17.78	43.74	16.57
Tamnamore	40	100	10.32	15.43	15.67	38.85	13.98	10.39	17.26	15.90	39.44	14.92
100 kV												
Aghyoule	40	100	3.63	8.32	4.64	9.50	4.31	5.12	11.77	4.27	9.45	4.15
Agivey	40	100	5.82	9.03	6.43	14.61	5.43	6.73	13.87	5.21	12.15	4.94
Antrim	40	100	4.29	7.32	9.87	21.04	9.39	4.54	9.51	9.76	21.05	9.50
Ballylumford	40	100	8.17	19.36	17.67	42.45	16.32	9.35	21.92	21.57	52.81	20.44
Ballymena	40	100	4.53	8.57	9.00	19.42	8.55	5.27	12.01	9.33	20.78	9.09
Banbridge	18.4	46.8	3.78	6.11	6.77	14.02	6.49	4.83	9.61	6.63	14.50	6.47
Ballyvallagh	21.9	46.8	4.64	5.86	14.54	31.52	13.56	4.50	6.14	13.74	29.60	13.25
Ballynahinch	18.4	46.8	3.94	6.74	5.74	12.00	5.42	4.76	9.85	5.76	12.55	5.55
Belfast Central	n/a	n/a	7.21	11.41	14.11	33.27	12.68	4.76	10.90	17.12	37.34	15.79
Belfast North	n/a	n/a	4.39	7.17	12.70	27.21	11.65	2.97	11.49	13.15	25.60	12.44
Brockaghboy	40	100	5.84	8.47	5.88	13.36	4.84	5.92	10.31	4.29	9.77	4.05
Carnmoney	31.5	79	3.71	6.41	8.29	17.09	7.85	4.34	8.83	8.33	17.81	8.06
Castlereagh	31.5	79	9.55	19.12	17.63	43.28	15.52	10.53	20.30	22.93	56.97	20.70
Coleraine	40	100	4.21	5.93	9.94	21.09	9.35	4.99	7.96	10.82	23.83	10.44
Coolkeeragh	31.5	79	8.80	19.45	21.24	51.56	19.67	9.72	21.18	26.25	64.59	25.00
Creagh	31.5	79	3.28	3.68	8.29	16.56	7.94	4.14	6.22	8.63	18.25	8.41
Cregagh	26.2	65	7.97	13.65	15.84	37.91	14.08	6.45	12.61	19.79	45.76	18.06
Donegall North	31.5	79	7.11	12.25	14.58	34.28	13.24	5.06	10.13	18.07	39.91	16.79
Donegall South	n/a	n/a	5.42	8.07	11.51	25.77	10.64	4.64	8.48	12.62	27.37	11.97
Dromore	40	100	3.83	5.83	13.32	27.66	12.08	4.16	6.04	11.96	25.31	11.50
Drumnakelly	31.5	79	6.51	11.05	21.26	49.26	19.22	6.66	11.98	22.67	52.74	21.25
Drumquin	40	100	5.16	7.64	6.97	15.45	6.63	5.75	12.01	6.34	14.35	6.21
Dungannon	40	100	6.06	11.14	18.90	43.22	17.56	6.34	12.51	20.58	47.46	19.65
Eden	25	62.5	3.80	6.02	9.05	18.76	8.58	4.33	8.29	9.03	19.30	8.75
Enniskillen	31.5	79	3.57	4.90	11.75	23.98	9.85	4.78	7.48	11.08	24.18	10.30
Finaghy	31.5	79	7.94	14.43	15.11	36.16	13.70	6.07	11.44	19.28	44.11	17.86
Glengormley	18.4	46.8	3.16	3.55	5.60	11.08	5.38	3.96	6.67	5.45	11.39	5.33

Table E-9: Northern Ireland Short Circuit Currents for Maximum Demand in 2022

Node	Rating		Three Phase					Single Phase				
	RMS [kA]	Peak [kA]	X/R ratio (AC)	X/R Ratio (DC)	I'' [kA]	ip [kA]	IB [kA]	X/R ratio (AC)	X/R Ratio (DC)	I'' [kA]	ip [kA]	IB [kA]
100 kV												
Gort Cluster	40	100	6.22	8.30	8.76	20.12	8.59	5.92	12.63	7.94	18.09	7.86
Hannahstown	31.5	79	8.79	17.93	16.58	40.24	14.92	9.47	19.20	21.60	52.98	19.88
Kells	40	100	8.64	18.89	20.84	50.48	18.99	9.38	20.45	25.89	63.40	24.37
Killymallaght	40	100	5.71	8.27	12.76	28.85	12.26	5.46	10.23	11.75	26.36	11.53
Knock	n/a	n/a	4.40	6.89	14.94	32.02	13.35	2.91	10.65	15.43	29.87	14.35
Larne	18.4	46.8	4.12	5.12	9.07	19.14	8.64	4.89	8.21	8.74	19.16	8.52
Limavady	18.4	46.8	3.67	4.51	8.02	16.47	7.70	4.50	7.26	8.31	17.91	8.12
Lisburn	18.4	46.8	5.13	7.38	11.74	26.00	10.88	4.98	9.13	11.55	25.42	11.03
Lisaghmore	31.5	79	4.22	6.79	9.94	21.10	9.54	4.57	9.27	9.63	20.82	9.43
Loguestown	26.2	65	3.62	5.02	6.69	13.70	6.39	4.35	7.09	6.94	14.83	6.76
Magherakeel Cluster	40	100	5.11	9.40	4.42	9.77	4.50	6.76	12.11	4.83	11.27	4.85
Newtownards	40	100	4.31	6.56	7.89	16.83	7.37	5.35	9.43	7.53	16.82	7.24
Newry	18.4	46.8	3.81	7.23	5.81	12.05	5.54	4.82	10.46	5.68	12.43	5.52
Omagh	40	100	4.55	7.16	17.41	37.58	16.26	5.04	9.61	17.05	37.63	16.49
Rasharkin	40	100	4.61	7.20	9.09	19.68	8.27	5.10	10.02	8.31	18.38	8.01
Rathgael	26.2	65	3.96	6.41	6.13	12.83	5.78	4.71	9.52	6.07	13.20	5.85
Rosebank	40	100	8.70	15.66	16.32	39.57	14.49	9.81	17.18	20.86	51.38	18.99
Slieve Kirk	40	100	4.39	6.49	9.05	19.40	8.80	5.44	11.39	7.43	16.65	7.34
Springtown	n/a	n/a	4.37	6.99	10.16	21.74	9.73	4.68	9.27	10.04	21.81	9.81
Strabane	18.4	46.8	4.59	6.22	16.27	35.20	15.47	5.03	9.30	15.74	34.73	15.34
Tandragee	31.5	79	8.03	17.21	23.05	55.24	20.68	9.03	19.56	27.30	66.51	25.27
Tremoge	40	100	4.05	5.88	9.71	20.42	9.41	4.48	9.39	8.75	18.83	8.62
Tamnamore	40	100	7.18	16.40	22.75	53.57	20.95	8.12	18.40	28.42	68.21	26.80
Waringstown	18.4	46.8	4.58	7.14	8.64	18.68	8.20	5.32	10.06	8.20	18.29	7.96

Table E-10: Northern Ireland Short Circuit Currents for Minimum Demand in 2025

Node	Rating		Three Phase					Single Phase				
	RMS [kA]	Peak [kA]	X/R ratio (AC)	X/R Ratio (DC)	I'' [kA]	ip [kA]	IB [kA]	X/R ratio (AC)	X/R Ratio (DC)	I'' [kA]	ip [kA]	IB [kA]
400 kV												
Turleenan	50	125	12.30	18.55	6.40	16.17	5.68	11.50	18.31	7.77	19.51	7.15
275 kV												
Ballylumford	31.5	79	10.25	15.43	7.98	19.77	7.07	10.86	16.70	10.43	26.02	9.51
Castlereagh	31.5	79	10.42	16.35	8.40	20.85	7.41	10.40	16.49	10.23	25.38	9.34
Coolkeeragh	31.5	79	13.08	20.94	8.15	20.72	7.26	13.82	23.29	9.29	23.76	8.65
Hannahstown	31.5	79	10.20	15.66	8.08	20.00	7.15	10.41	16.61	9.92	24.62	9.07
Kells	31.5	79	10.43	15.78	8.36	20.74	7.38	10.12	15.35	10.37	25.64	9.47
Kilroot	31.5	79	10.41	15.24	7.89	19.57	7.02	11.10	16.46	10.65	26.62	9.71
Magherafelt	31.5	79	11.40	18.31	9.57	24.00	8.37	9.40	13.24	10.44	25.58	9.59
Moyle	31.5	79	10.24	15.35	7.92	19.62	7.02	10.82	16.54	10.31	25.71	9.41
Tandragee	31.5	79	10.57	16.73	10.21	25.37	8.86	10.01	16.14	12.20	30.13	11.04
Tamnamore	40	100	11.06	17.67	10.09	25.21	8.78	10.67	18.72	11.66	29.03	10.61
Turleenan	40	100	11.06	17.72	10.26	25.64	8.92	10.26	17.27	11.80	29.23	10.73
110 kV												
Aghyoule	40	100	2.97	3.19	3.10	6.04	3.00	4.00	5.08	3.34	7.01	3.28
Agivey	40	100	5.38	6.44	4.03	9.02	3.91	6.02	9.75	4.30	9.82	4.23
Antrim	40	100	4.67	7.39	7.75	16.82	7.31	4.73	9.17	8.29	18.05	8.00
Airport Road	40	100	4.96	7.41	7.13	15.68	6.73	5.32	9.96	7.43	16.57	7.17
Ballylumford	40	100	8.64	17.52	12.55	30.40	11.52	9.49	19.24	16.23	39.80	15.20
Ballymena	40	100	4.78	8.29	7.10	15.49	6.71	5.33	11.23	7.77	17.35	7.50
Banbridge	18.4	46.8	4.14	6.56	6.04	12.77	5.78	5.08	9.89	6.18	13.66	6.02
Ballyvallagh	21.9	46.8	5.35	6.95	10.68	23.86	9.89	4.95	6.81	11.24	24.72	10.72
Ballynahinch	18.4	46.8	4.27	7.09	5.14	10.94	4.91	4.97	10.03	5.34	11.76	5.20
Belfast Central	n/a	n/a	8.37	12.77	11.01	26.54	10.09	5.48	11.63	14.00	31.42	13.09
Belfast North	n/a	n/a	5.09	8.01	10.16	22.47	9.40	3.31	11.70	11.33	22.70	10.77
Brockaghboy	40	100	5.45	6.40	3.60	8.08	3.51	5.54	8.16	3.60	8.10	3.55
Carnmoney	31.5	79	4.11	6.63	7.06	14.89	6.68	4.60	8.89	7.48	16.19	7.23
Castlereagh	31.5	79	11.01	20.10	13.04	32.57	11.79	11.69	20.78	17.56	44.17	16.18
Coleraine	40	100	4.05	4.70	6.92	14.55	6.51	4.59	6.07	8.30	17.96	7.97
Coolkeeragh	31.5	79	11.46	24.57	14.96	37.54	13.49	12.02	25.63	19.58	49.38	18.23
Creagh	31.5	79	3.71	4.30	6.99	14.39	6.63	4.43	6.71	7.65	16.42	7.40
Cregagh	26.2	65	9.28	15.09	12.03	29.41	10.95	7.40	13.56	15.69	37.12	14.56
Donegall North	31.5	79	7.93	13.10	11.29	26.99	10.37	5.74	10.76	14.60	33.06	13.67
Donegall South	n/a	n/a	6.11	8.94	9.39	21.51	8.75	5.12	8.94	10.89	24.11	10.37
Dromore	40	100	3.93	4.69	7.79	16.27	7.30	4.15	5.13	8.59	18.17	8.24
Drumnakelly	31.5	79	7.78	12.71	15.17	36.19	13.66	7.53	12.97	17.68	41.96	16.44
Drumquin	40	100	4.59	5.15	4.80	10.37	4.61	5.13	8.23	5.03	11.13	4.91
Dungannon	18.4	46.8	7.13	13.15	13.36	31.42	12.18	7.02	13.58	15.86	37.22	14.88

Table E-10: Northern Ireland Short Circuit Currents for Minimum Demand in 2025

Node	Rating		Three Phase					Single Phase				
	RMS [kA]	Peak [kA]	X/R ratio (AC)	X/R Ratio (DC)	I'' [kA]	ip [kA]	IB [kA]	X/R ratio (AC)	X/R Ratio (DC)	I'' [kA]	ip [kA]	IB [kA]
110 kV												
Eden	25	62.5	4.25	6.45	7.57	16.11	7.16	4.64	8.50	8.05	17.45	7.77
Enniskillen	31.5	79	3.63	4.11	6.26	12.82	5.91	4.36	5.59	7.46	15.96	7.17
Finaghy	31.5	79	8.74	15.03	11.61	28.15	10.65	6.83	12.13	15.36	35.88	14.34
Glengormley	18.4	46.8	3.46	4.02	4.89	9.91	4.70	4.13	6.96	5.00	10.56	4.89
Gort Cluster	40	100	5.98	7.35	6.60	15.07	6.29	5.84	11.02	6.65	15.12	6.48
Hannahstown	31.5	79	9.56	17.85	12.44	30.53	11.35	10.08	18.73	16.76	41.43	15.57
Kells	21.9	55.9	8.63	17.23	13.32	32.25	12.12	9.08	18.10	17.61	42.95	16.37
Kells Cluster	40	100	8.34	15.97	12.90	31.09	11.77	0.00	0.00	0.00	0.00	0.00
Killymallaght	40	100	6.19	7.95	9.38	21.53	8.76	5.77	9.60	9.59	21.74	9.24
Knock	n/a	n/a	5.34	8.03	11.56	25.80	10.55	3.35	11.13	12.98	26.07	12.20
Larne	18.4	46.8	4.59	5.77	7.41	16.02	7.01	5.14	8.52	7.66	16.97	7.41
Limavady	18.4	46.8	3.74	4.19	6.14	12.67	5.83	4.39	6.33	6.90	14.78	6.69
Lisburn	18.4	46.8	5.82	8.24	9.57	21.73	8.91	5.41	9.51	10.11	22.64	9.67
Lisaghmore	31.5	79	4.89	7.46	8.28	18.16	7.80	4.99	9.65	8.54	18.81	8.27
Loguestown	26.2	65	3.62	4.38	5.16	10.57	4.93	4.20	6.02	5.80	12.31	5.64
Magherakeel Cluster	40	100	4.26	4.65	3.27	6.97	3.19	5.40	6.27	3.86	8.64	3.80
Newtownards	40	100	4.83	7.17	6.83	14.95	6.46	5.70	9.80	6.89	15.58	6.66
Newry	18.4	46.8	3.97	6.76	5.17	10.83	4.96	4.88	9.79	5.29	11.60	5.16
Omagh	40	100	4.70	6.21	10.14	22.06	9.38	5.00	7.90	11.74	25.86	11.14
Rasharkin	40	100	4.99	6.74	7.07	15.56	6.70	5.18	8.70	7.74	17.18	7.49
Rathgael	26.2	65	4.34	6.86	5.47	11.68	5.22	4.97	9.79	5.65	12.43	5.49
Rosebank	40	100	10.11	17.13	12.34	30.50	11.21	10.87	18.07	16.36	40.81	15.15
Slieve Kirk	40	100	4.61	5.42	7.08	15.33	6.72	5.34	9.85	6.34	14.15	6.19
Springtown	n/a	n/a	5.13	7.89	8.47	18.75	7.96	5.16	9.85	8.88	19.70	8.59
Strabane	18.4	46.8	5.39	7.03	11.05	24.71	10.18	5.53	9.38	12.14	27.29	11.55
Tandragee	31.5	79	9.37	18.36	16.15	39.54	14.46	9.98	19.94	20.43	50.44	18.81
Tremoge	40	100	4.16	5.09	7.20	15.24	6.84	4.50	8.08	7.32	15.76	7.10
Tamnamore	40	100	8.46	18.86	15.39	37.15	13.88	9.16	20.41	20.37	49.74	18.81
Waringstown	18.4	46.8	5.07	7.68	7.44	16.45	7.04	5.61	10.34	7.46	16.82	7.23

Table E-11: Northern Ireland Short Circuit Currents for Maximum Demand in 2025

Node	Rating		Three Phase					Single Phase				
	RMS [kA]	Peak [kA]	X/R ratio (AC)	X/R Ratio (DC)	I'' [kA]	ip [kA]	IB [kA]	X/R ratio (AC)	X/R Ratio (DC)	I'' [kA]	ip [kA]	IB [kA]
400 kV												
Turleenan	50	125	14.28	18.59	10.30	26.44	9.79	12.31	18.21	11.31	28.60	10.98
275 kV												
Ballylumford	31.5	79	13.06	20.16	17.61	44.81	16.03	14.02	22.97	19.91	50.99	18.87
Castlereagh	31.5	79	10.72	15.56	16.18	40.30	14.72	10.64	16.27	16.72	41.59	15.83
Coolkeeragh	31.5	79	12.68	17.49	12.78	32.41	12.04	13.83	21.32	12.78	32.68	12.42
Hannahstown	31.5	79	10.85	15.57	15.72	39.21	14.34	11.03	17.36	16.38	40.92	15.54
Kells	31.5	79	11.90	16.60	17.14	43.18	15.72	10.79	15.66	18.02	44.91	17.21
Kilroot	31.5	79	11.82	16.08	15.47	38.95	14.27	13.17	18.68	19.16	48.78	18.23
Magherafelt	31.5	79	11.89	16.58	18.80	47.37	17.31	8.75	11.03	16.22	39.36	15.64
Moyle	31.5	79	12.89	19.63	17.26	43.86	15.74	13.77	22.14	19.44	49.70	18.44
Tandragee	31.5	79	10.57	14.59	20.29	50.44	18.60	9.68	14.62	20.20	49.67	19.27
Tamnamore	40	100	11.16	15.33	19.72	49.34	18.17	10.53	17.78	18.68	46.43	17.92
Turleenan	40	100	11.13	15.30	20.06	50.18	18.48	9.89	15.69	18.85	46.49	18.09
110 kV												
Aghyoule	40	100	3.58	8.18	4.60	9.39	4.29	5.07	11.62	4.21	9.30	4.10
Agivey	40	100	6.32	9.07	7.18	16.55	6.18	7.00	14.67	5.69	13.34	5.44
Antrim	40	100	4.16	7.15	10.56	22.36	10.19	4.46	9.44	10.21	21.94	10.03
Airport Road	40	100	4.30	6.58	8.76	18.67	8.31	4.89	9.49	8.49	18.61	8.23
Ballylumford	40	100	9.96	23.91	23.19	57.24	21.61	11.56	27.54	26.79	67.30	25.75
Ballymena	40	100	4.42	8.44	9.54	20.47	9.19	5.20	11.99	9.70	21.54	9.52
Banbridge	18.4	46.8	3.73	5.98	6.96	14.35	6.75	4.81	9.54	6.74	14.73	6.63
Ballyvallagh	21.9	46.8	4.41	5.18	16.73	35.88	15.87	4.35	5.73	15.03	32.13	14.67
Ballynahinch	18.4	46.8	3.90	6.66	5.99	12.49	5.73	4.75	9.83	5.96	12.98	5.79
Belfast Central	n/a	n/a	7.20	11.26	15.57	36.69	14.27	4.63	10.79	18.57	40.24	17.40
Belfast North	n/a	n/a	4.29	6.79	13.76	29.33	12.95	2.86	11.28	13.91	26.82	13.41
Brockaghboy	40	100	6.25	8.41	6.44	14.81	5.41	6.03	10.42	4.60	10.51	4.39
Carnmoney	31.5	79	3.57	6.08	8.94	18.25	8.59	4.24	8.60	8.74	18.58	8.55
Castlereagh	31.5	79	9.95	20.38	19.97	49.27	17.96	10.98	21.39	25.55	63.80	23.49
Coleraine	40	100	4.13	5.60	10.79	22.80	10.30	4.95	7.72	11.54	25.38	11.24
Coolkeeragh	31.5	79	9.32	20.77	23.58	57.70	22.09	10.31	22.62	28.59	70.86	27.50
Creagh	31.5	79	3.19	3.51	8.63	17.11	8.36	4.08	6.08	8.87	18.69	8.71
Cregagh	26.2	65	8.05	13.73	17.70	42.43	16.06	6.37	12.61	21.73	50.15	20.18
Donegall North	31.5	79	7.28	11.97	15.96	37.66	14.91	5.00	9.79	19.48	42.92	18.52
Donegall South	n/a	n/a	5.40	7.74	12.37	27.68	11.72	4.59	8.28	13.33	28.83	12.86
Dromore	40	100	3.78	5.73	13.52	27.98	12.32	4.13	5.97	12.03	25.42	11.62
Drumnakelly	31.5	79	6.53	10.64	23.24	53.88	21.58	6.66	11.72	24.14	56.15	23.05
Drumquin	40	100	5.14	7.58	6.98	15.46	6.67	5.74	11.97	6.32	14.32	6.22
Dungannon	40	100	6.09	11.13	20.19	46.21	19.13	6.37	12.56	21.57	49.78	20.88

Table E-11: Northern Ireland Short Circuit Currents for Maximum Demand in 2025

Node	Rating		Three Phase					Single Phase				
	RMS [kA]	Peak [kA]	X/R ratio (AC)	X/R Ratio (DC)	I'' [kA]	ip [kA]	IB [kA]	X/R ratio (AC)	X/R Ratio (DC)	I'' [kA]	ip [kA]	IB [kA]
110 kV												
Eden	25	62.5	3.65	5.64	10.04	20.61	9.65	4.26	8.08	9.69	20.61	9.49
Enniskillen	31.5	79	3.55	4.86	11.85	24.14	9.99	4.77	7.45	11.13	24.28	10.40
Finaghy	31.5	79	8.27	14.35	16.59	39.94	15.49	6.11	11.18	20.89	47.84	19.81
Glengormley	18.4	46.8	3.08	3.40	5.82	11.43	5.64	3.91	6.55	5.59	11.65	5.50
Gort Cluster	40	100	6.20	8.17	8.88	20.40	8.77	5.91	12.57	7.99	18.19	7.94
Hannahstown	31.5	80	9.35	18.40	18.37	44.96	17.04	10.12	19.77	23.60	58.36	22.27
Kells	40	100	8.47	17.50	23.80	57.47	22.11	9.25	19.25	28.83	70.48	27.58
Kells Cluster	40	100	8.06	15.61	22.58	54.14	21.05	0.00	0.00	0.00	0.00	0.00
Killymallaght	40	100	5.65	7.95	13.32	30.07	12.91	5.39	9.95	12.00	26.85	11.84
Knock	n/a	n/a	4.21	6.61	16.61	35.24	15.16	2.82	10.76	16.60	31.87	15.69
Larne	18.4	46.8	3.97	4.74	9.90	20.72	9.56	4.81	7.97	9.27	20.25	9.11
Limavady	18.4	46.8	3.58	4.32	8.35	17.05	8.10	4.42	7.14	8.52	18.29	8.38
Lisburn	18.4	46.8	5.24	7.43	12.80	28.47	12.18	5.03	9.27	12.23	26.99	11.89
Lisaghmore	31.5	79	4.15	6.56	10.41	22.01	10.07	4.51	9.10	9.89	21.31	9.74
Loguestown	26.2	65	3.55	4.80	7.07	14.40	6.83	4.32	6.93	7.21	15.38	7.07
Magherakeel Cluster	40	100	5.29	10.06	4.62	10.29	4.57	7.07	13.14	4.87	11.45	4.85
Newtownards	40	100	4.25	6.57	8.36	17.79	7.94	5.34	9.53	7.82	17.45	7.59
Newry	18.4	46.8	3.76	7.11	5.94	12.27	5.72	4.80	10.38	5.76	12.57	5.63
Omagh	40	100	4.49	6.98	17.96	38.66	16.86	5.00	9.51	17.34	38.20	16.85
Rasharkin	40	100	5.40	8.28	11.94	26.73	11.06	5.51	10.99	10.60	23.81	10.31
Rathgael	26.2	65	3.89	6.31	6.41	13.35	6.12	4.69	9.48	6.28	13.65	6.11
Rosebank	40	100	8.93	16.18	18.34	44.63	16.62	10.09	17.69	23.05	56.99	21.35
Slieve Kirk	40	100	4.33	6.28	9.31	19.88	9.11	5.39	11.28	7.50	16.78	7.44
Springtown	n/a	n/a	4.30	6.74	10.65	22.71	10.28	4.62	9.08	10.32	22.35	10.14
Strabane	40	100	4.51	5.94	17.20	37.06	16.50	4.99	9.10	16.31	35.92	15.99
Tandragee	31.5	79	8.27	17.33	25.48	61.33	23.51	9.28	19.66	29.52	72.19	27.92
Tremoge	40	100	4.00	5.75	9.90	20.75	9.67	4.46	9.32	8.83	18.98	8.74
Tamnamore	40	100	7.32	16.93	24.72	58.40	23.30	8.34	19.15	30.44	73.34	29.21
Waringstown	18.4	46.8	4.60	7.30	9.02	19.53	8.70	5.37	10.32	8.46	18.91	8.29

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Appendix F

Appendix F
Approaches to Consultation for Developing the Grid

F.1. EirGrid Approach to Consultation

In December 2016 EirGrid launched Have Your Say[132], 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[133]. This new three part process puts stakeholders and the community at the heart of what we do. To find out more visit www.soni.ltd.uk and if you have any queries you can contact us at info@soni.ltd.uk.

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Appendix G

Appendix G References

The following documents are referenced in this All-Island Ten Year Transmission Forecast Statement:

- 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.
- The Utility Regulator Northern Ireland's powers are derived from the Electricity (Northern Ireland) Order 1992, as amended by the Energy (Northern Ireland) Order 2003. This Order provides the regulatory framework for the electricity sector in Northern Ireland.
- All-Island Generation Capacity Statement 2019-2028. EirGrid and SONI issued this report in September 2019. 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 2019 to 2028. Available on www.eirgridgroup.com.
- Transmission Development Plan Ireland 2018-2027, CRU approved version published in August 2019. 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 www.eirgridgroup.com.
- Transmission Development Plan Northern Ireland 2018-2027, UR approved version published in June 2019. 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 www.soni.ltd.uk.
- EirGrid Grid Code Version 8.0, June 2019. 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 www.eirgridgroup.com.
- SONI Grid Code, October 2018. 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 www.soni.ltd.uk.
- 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 www.eirgridgroup.com.
- 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 www.soni.ltd.uk.
- Statutory Instrument no. 445. These Regulations give legal effect to Directive No. 96/92/EC of the European Parliament and of the Council of 19 December 1996, concerning common rules for the internal market in electricity, not already implemented by the Electricity Regulation Act, 1999, by providing for the designation of a Transmission System Operator, the designation of a Distribution System Operator, and the unbundling of the accounts of electricity undertakings, and other matters. Available on 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 Mach 2017. Available on www.cru.ie.

- SONI's Licence to Participate in the Transmission of Electricity, updated to February 2019. Available on 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 Transition to a Low Carbon Energy Future 2015-2030, December 2015. Government White Paper on energy policy out to 2030, published by the Department of Communications, Climate Action and Environment. Available on www.dccae.gov.ie.
- Ireland's Climate Action Plan, June 2019, published by the Department of Communications, Climate Action and Environment. Available on www.dccae.gov.ie.
- Strategic Energy Framework 2010-2020, September 2010. A Strategic Energy Framework for Northern Ireland. Available on www.economy-ni.gov.uk/.
- Treatment of Curtailment in Tie Break Situations. Single Electricity Market (SEM) decision paper (SEM-13-010) in relation to the treatment of curtailment in tie break situations. Available on www.semcommittee.com/.
- Operating Security Standards, March 2016. This document sets out the main standard that SONI shall use in the operation of the Northern Ireland transmission system. Available on www.soni.ltd.uk.

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Appendix H

Appendix H
Power Flows

This appendix presents power flows for summer valley and winter peak for the years 2019 and 2028. 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 for a particular set of 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 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
DSN	MP	400	1	-44.7	18.6	4.9	-405.2	42.1	40.9	-	-	-	-	-	-
DSN	CNB	400	1	-	-	-	-	-	-	-82.0	-65.9	6.7	-201.6	12.3	10.4
KPG	MP	400	1	-	-	-	-	-	-	80.1	4.2	6.6	186.9	-26.4	15.6
CNB	MP	400	1	-	-	-	-	-	-	-105.1	-117.9	10.0	-295.2	-54.7	15.4
MP	OST	400	1	68.0	-74.1	10.1	158.6	-3.7	15.9	-16.0	57.1	6.0	-0.6	68.2	6.8
OST	WOO	400	1	32.3	0.9	3.2	303.7	69.4	31.3	169.8	44.6	17.6	187.1	192.4	26.9
WOO	PRT	400	1	-100.1	52.7	16.5	-449.8	-91.1	67.0	-150.0	166.8	32.7	-499.8	128.0	75.3
WOO	TUR	400	1	-	-	-	-	-	-	10.2	-102.1	7.2	76.6	-84.8	6.6
LOU	TAN	275	1	-16.5	5.1	2.4	74.3	-14.5	8.6	-67.6	2.0	9.5	-98.6	10.4	11.3
LOU	TAN	275	2	-16.5	8.0	2.6	73.3	-14.9	8.5	-68.3	4.0	9.6	-98.6	11.5	11.3
BPS	HAN	275	2	71.1	-5.7	10.0	167.1	9.5	19.0	89.0	-21.1	12.9	158.4	-31.9	18.3
BPS	KEL	275	1	56.9	9.1	8.1	25.8	54.6	6.9	77.4	3.1	10.9	175.2	41.5	20.4
BPS	MAG	275	1	19.9	-1.6	2.8	15.2	12.3	2.2	30.3	-1.2	4.3	90.1	25.0	10.6
BPS	BYC	275	1	-7.5	-34.7	5.0	88.6	-20.9	10.3	10.5	-49.1	7.1	-230.8	-77.6	27.6
CAS	BFP	275	1	-	-	-	-	-	-	0.0	-66.3	11.1	-398.8	-354.4	88.9
CAS	HAN	275	1	-40.5	-16.7	6.2	-63.2	-32.3	8.1	-55.8	0.7	7.9	-41.1	44.0	6.8
CAS	HAN	275	2	-40.5	-16.7	6.2	-63.2	-32.3	8.1	-55.8	0.7	7.9	-41.1	44.0	6.8
CAS	KPS	275	1	-19.9	-10.0	3.1	-137.0	19.8	15.7	-23.3	0.5	3.3	-10.4	34.7	4.1
CAS	TAN	275	1	5.7	7.5	1.3	-74.0	25.8	8.9	28.2	30.5	5.9	109.7	99.7	16.8
CPS	MAG	275	1	69.4	-28.3	18.2	99.6	-4.1	19.4	89.6	-24.4	11.5	101.8	-30.6	11.7
CPS	MAG	275	2	69.4	-28.3	18.2	99.6	-4.1	19.4	89.6	-24.4	11.5	101.8	-30.6	11.7

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
HAN	BYC	275	1	-72.4	-6.5	10.2	-167.9	-17.1	19.2	-90.2	9.5	12.8	-164.9	22.9	18.9
KEL	KPS	275	1	23.8	-12.7	3.8	-47.7	26.4	6.2	29.2	-16.9	4.8	40.1	-28.4	5.6
KEL	KPS	275	2	23.8	-12.7	3.8	-47.7	26.4	6.2	29.2	-16.9	4.8	40.1	-28.4	5.6
KEL	MAG	275	1	-21.3	-3.7	3.1	3.2	-24.9	2.9	-21.9	4.0	3.1	-4.2	16.4	1.9
KPS	TAN	275	1	19.6	-3.0	2.8	71.3	-13.9	8.3	35.1	1.5	5.0	69.8	12.2	8.0
MAG	TMN	275	1	68.4	-1.9	9.6	108.3	16.5	12.4	93.7	4.0	13.2	144.4	15.4	16.5
MAG	TMN	275	2	68.4	-1.9	9.6	108.3	16.5	12.4	93.7	4.0	13.2	144.4	15.4	16.5
TAN	TMN	275	1	-44.2	-17.4	6.7	-57.1	-29.7	7.3	-	-	-	-	-	-
TAN	TMN	275	2	-44.2	-17.4	6.7	-57.1	-29.7	7.3	-	-	-	-	-	-
TAN	TUR	275	1	-	-	-	-	-	-	-74.1	-7.9	10.5	-127.3	-1.9	14.5
TAN	TUR	275	2	-	-	-	-	-	-	-74.1	-7.9	10.5	-127.3	-1.9	14.5
TMN	TUR	275	1	-	-	-	-	-	-	69.2	16.6	10.0	89.3	2.7	10.1
TMN	TUR	275	2	-	-	-	-	-	-	69.2	16.6	10.0	89.3	2.7	10.1
AD	KRA	220	1	85.4	-35.9	23.6	155.4	2.0	33.2	57.4	-24.8	15.9	152.5	12.7	32.7
AD	RAF	220	1	106.5	-46.6	26.8	177.3	-19.2	34.8	30.6	-34.3	10.6	125.4	-7.6	24.5
AD	GGO	220	1	-105.0	66.2	21.7	-243.7	26.9	42.8	-180.1	49.2	32.6	-85.3	1.1	14.9
AD	KRA	220	2	105.0	-66.2	31.6	243.7	23.0	52.3	140.5	-59.7	38.8	375.2	30.6	80.4
ARK	CKM	220	1	65.7	-4.4	15.2	121.3	-26.1	24.2	65.5	-3.9	15.1	91.5	-16.4	18.1
ARK	LWD	220	1	-82.9	3.4	19.1	-155.0	11.3	35.7	-80.3	2.8	18.5	-127.2	2.7	29.3
BVK	CLA	220	1	-47.5	94.0	14.2	88.6	-7.9	11.2	-67.9	9.2	9.3	-20.7	-63.7	8.5
BVK	BYH	220	1	47.4	-30.3	13.0	15.1	-19.7	4.8	67.8	-45.3	10.7	126.5	19.1	16.1

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				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	0.0	0.0	0.0	-30.8	-5.3	5.5	-3.2	28.5	5.0	-114.8	-1.8	20.2
FIN (I)	SHL	220	1	-6.7	-28.4	5.5	18.0	-24.9	5.5	-	-	-	-	-	-
BLC	SHL	220	1	-	-	-	-	-	-	-106.4	-40.6	20.0	-96.0	-52.1	19.2
CLE	CDU	220	1	-11.1	-44.1	10.5	176.3	-46.2	35.5	10.2	-91.0	21.1	90.5	-99.2	26.2
CLE	WOO	220	1	-68.3	11.3	17.6	-255.6	13.8	54.7	-188.7	-3.2	48.0	-266.6	12.1	57.0
CLA	KRA	220	1	-75.1	75.8	16.5	-0.6	-23.9	3.2	-84.7	23.2	13.6	-83.7	-51.2	13.1
CSH	FLA	220	1	44.9	-5.2	16.7	174.6	-3.7	54.9	63.8	-20.3	24.7	79.7	-3.4	25.1
CSH	PRO	220	1	-56.4	2.6	14.4	-114.8	-1.4	24.5	11.5	-27.5	7.6	-31.1	-6.5	6.8
CSH	TYN	220	1	-35.4	21.3	5.4	-226.7	7.1	28.6	-166.7	101.2	25.6	-194.9	-5.4	24.6
CKM	DSN	220	1	-22.8	-13.3	6.1	-113.1	18.8	22.4	10.0	-43.9	10.4	-96.6	14.7	19.0
CKM	ISH	220	1	101.5	-61.4	20.0	122.7	-182.2	37.1	60.5	-44.9	12.7	29.0	-185.2	31.6
CUL	GI	220	1	-36.1	17.8	5.4	79.0	-51.7	11.9	-34.7	17.0	5.2	53.7	-47.6	9.0
CUL	KRA	220	1	-11.0	-7.6	2.1	-180.1	30.4	23.9	-10.0	-6.0	1.8	-158.2	27.4	21.0
CDU	CRH	220	1	-	-	-	-	-	-	99.2	33.6	18.4	99.2	32.6	18.3
CDU	CRH	220	2	-	-	-	-	-	-	99.2	33.6	18.4	99.2	32.6	18.3
CDU	FIN (I)	220	1	63.3	-93.9	26.1	275.1	-34.3	54.0	46.5	-78.7	21.1	106.2	-47.8	22.7
CDU	HN	220	1	-195.1	110.0	40.4	-319.3	-83.0	59.5	-249.6	-57.8	46.2	-299.1	-218.9	66.8
CDU	FIN (I)	220	2	63.3	-93.9	26.1	275.1	-34.3	54.0	46.5	-78.7	21.1	106.2	-47.8	22.7
CDU	WOO	220	2	-48.5	20.4	12.1	-243.1	24.3	47.6	-145.9	22.9	34.0	-227.6	37.4	45.0
DSN	KLS	220	1	-64.6	14.4	16.9	-81.5	29.0	18.5	-73.4	22.0	19.5	-56.3	17.6	12.6
DSN	MAY	220	1	57.8	-17.6	17.3	170.8	-19.9	39.5	68.0	5.1	15.7	127.6	-7.6	24.9

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
DSN	MAY	220	2	77.5	-5.0	22.2	112.7	-33.8	27.0	68.0	5.0	15.7	127.6	-7.6	24.9
DSN	TH	220	1	-48.9	-13.3	14.4	89.3	-12.2	25.7	29.4	-1.2	8.4	-94.4	3.8	26.9
FLA	LOU	220	1	-6.4	10.2	3.2	129.4	-12.0	27.4	7.1	8.1	2.8	34.9	5.5	7.4
FLA	SRA	220	1	30.8	-10.0	7.5	-1.8	-2.3	0.6	20.2	-12.5	5.5	-14.3	-1.0	2.8
FIN (I)	HN	220	1	0.0	-3.9	0.7	0.0	-38.1	6.4	0.0	-3.9	0.7	-345.7	-67.9	59.4
FIN (I)	NW	220	1	-7.9	-56.3	17.1	20.1	-53.6	17.3	-73.5	-68.8	30.3	-29.4	-67.6	22.2
GI	KLS	220	1	97.6	-11.5	25.0	170.1	17.3	36.5	105.6	-23.6	27.5	142.1	21.6	30.7
GI	LWD	220	1	104.0	-24.3	24.6	191.7	0.4	37.4	97.9	-26.0	23.4	160.1	6.3	31.2
GOR	LOU	220	1	10.6	1.7	2.5	12.7	6.1	3.0	-30.1	-1.5	7.0	-71.8	22.8	15.8
GOR	MAY	220	1	-56.7	12.0	16.6	-95.7	-20.4	22.5	-20.2	14.8	7.2	-26.9	-35.1	10.1
GGO	RAF	220	1	43.7	-67.1	14.1	151.4	-1.0	26.6	116.3	-70.5	23.9	260.1	2.4	45.6
INC	ISH	220	1	-283.0	88.8	52.8	-456.1	-46.3	72.3	-500.2	99.5	90.8	-682.3	-28.3	107.7
INC	MAY	220	2	-29.9	26.0	5.2	-224.9	54.3	30.4	-	-	-	-	-	-
INC	CBT	220	2	-	-	-	-	-	-	63.5	16.5	8.6	-43.3	63.5	9.7
ISH	SHL	220	1	0.0	-3.6	0.7	0.0	59.1	10.8	-194.8	5.4	35.6	-310.5	60.0	57.7
KNR	BYH	220	1	-47.1	-32.1	13.1	-103.0	47.4	22.1	-67.1	83.0	14.4	-223.8	131.7	32.8
KNR	KPG	220	1	47.1	55.4	10.0	64.2	-10.8	8.5	24.5	-28.1	5.1	117.9	-56.4	17.2
KNR	KPG	220	2	-	-	-	99.3	-54.2	14.9	42.7	-85.3	13.0	190.8	-110.7	29.0
KRA	KLN	220	1	85.1	-30.3	17.6	128.1	-6.7	22.8	96.2	-52.1	21.4	198.7	-14.4	35.3
KRA	RAF	220	1	-54.0	25.3	16.9	-106.9	-7.6	23.6	-58.6	17.7	17.4	-131.0	-14.1	29.0
KLN	SH	220	1	27.0	-8.5	10.5	136.4	-36.9	39.9	48.0	-12.0	18.4	107.9	-27.1	31.4

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
KLN	TB	220	1	10.3	-27.7	6.8	-	-	-	-	-	-	-	-	-
KLN	KPG	220	1	-	-	-	-90.7	-24.4	18.3	13.3	-31.1	7.8	11.8	-24.1	5.2
KPG	MP	220	1	35.1	44.1	8.6	-24.6	-46.6	8.0	7.1	-25.1	4.0	63.9	-35.7	11.1
KPG	MP	220	2	-	-	-	-24.6	-46.6	8.0	7.1	-25.1	4.0	63.9	-35.7	11.1
KPG	TB	220	1	12.2	-2.4	3.6	30.0	38.1	11.1	-2.8	-6.0	1.9	11.0	-12.9	3.9
MAY	INC	220	1	44.9	-4.4	8.2	77.3	-60.5	17.9	-	-	-	-	-	-
CBT	MAY	220	1	-	-	-	-	-	-	-106.5	-50.4	15.5	-236.2	64.3	30.8
CBT	MAY	220	2	-	-	-	-	-	-	40.7	-1.1	5.4	-90.3	-7.6	11.4
CBT	INC	220	1	-	-	-	-	-	-	-85.7	-23.4	11.7	58.4	-87.4	13.2
LOU	WOO	220	1	-33.4	15.8	10.5	-152.7	-33.1	35.9	-	-	-	-	-	-
LOU	ORL	220	1	-	-	-	-	-	-	30.4	15.5	7.9	-41.0	-25.7	9.4
MAY	TH	220	1	-66.0	-0.4	20.3	-77.4	3.3	22.1	-26.0	-10.2	8.6	-123.2	2.1	35.1
MAY	SH	220	1	-36.5	-11.8	14.3	-132.0	23.7	37.9	-35.5	-26.6	16.5	-74.4	6.9	21.1
MAY	WOO	220	1	18.2	9.7	5.9	-93.8	-36.3	23.1	-3.2	-0.2	0.9	-132.7	-49.2	32.5
MP	PRO	220	1	20.9	-14.5	6.5	52.7	2.0	11.3	-5.5	1.7	1.5	8.3	-6.5	2.3
NW	PB	220	1	-7.9	11.1	4.1	20.1	3.5	6.2	-73.5	-1.6	22.2	-29.4	9.8	9.3
OST	TYN	220	1	35.5	-28.1	10.4	-146.0	-28.3	29.0	-186.2	52.2	44.6	-188.1	-81.6	40.0
PB	SHL	220	1	6.7	-8.8	1.9	-18.0	23.4	5.0	6.6	-25.8	4.5	-53.7	13.4	9.3
PB	CKM	220	1	88.0	-39.3	36.1	98.9	-49.1	41.4	98.7	-42.2	40.2	100.4	-48.2	41.7
PB	INC	220	1	-53.2	5.5	20.0	-123.3	33.1	47.8	-73.4	9.2	27.7	-138.7	34.0	53.5
PB	INC	220	2	-74.7	0.3	21.3	-172.2	31.3	49.9	-102.3	3.7	29.2	-193.1	31.2	55.7

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
PRO	TB	220	1	-35.9	-0.3	7.7	-63.3	6.7	13.6	5.9	-12.0	2.9	-22.9	1.5	4.9
TB	KPG	220	2	-13.4	-0.2	3.8	-33.4	-44.8	12.8	3.1	3.5	1.3	-12.0	11.2	3.8
WOO	ORL	220	1	-	-	-	-	-	-	-30.2	-27.8	9.5	-21.4	74.1	15.0
AA	DRU	110	1	14.2	-8.5	16.7	25.6	-9.2	22.5	8.1	-12.6	15.1	32.6	-10.3	28.3
AA	ENN (I)	110	1	10.6	-11.2	15.6	10.9	-6.1	10.4	5.2	-15.3	16.3	17.5	-8.0	15.9
AA	LIM (I)	110	1	-20.1	15.1	15.6	-9.2	10.8	7.4	-10.3	16.7	12.2	-10.0	23.9	13.6
AD	WHI	110	1	24.9	-5.4	25.7	56.5	5.2	46.9	19.7	-4.4	20.4	59.9	5.6	49.7
ARI	ARI T	110	1	-1.2	-0.3	1.1	2.2	-2.0	2.4	-0.9	-0.2	0.8	1.9	-7.6	6.4
AGL	DYN	110	1	0.0	-0.3	0.3	-17.7	13.3	18.0	0.0	-0.3	0.3	-17.8	0.8	14.5
AGL	ENN (I)	110	1	3.7	-9.5	10.3	-7.8	7.6	9.0	-6.3	-0.2	6.4	-7.6	12.1	11.8
AGL	SH	110	1	-3.7	9.8	10.1	25.5	-20.9	27.7	6.3	0.5	6.1	25.3	-12.9	23.9
AHA	KLN	110	1	-0.8	-0.3	1.3	-5.3	-0.8	7.9	-0.6	-0.2	0.9	-5.8	-0.9	8.7
ADM	KUD	110	1	12.9	0.4	9.2	16.7	-0.4	11.9	-	-	-	-	-	-
ADM	GCA	110	1	-	-	-	-	-	-	-3.3	-0.4	2.4	-3.6	0.3	2.6
ADM	INC	110	1	-24.1	-4.8	23.8	-33.4	-6.7	25.4	-7.4	-3.8	8.1	-13.9	-7.7	11.9
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	21.6	3.7	16.1	37.8	-0.4	23.8	21.2	5.3	16.1	35.7	4.3	22.6
ARK	BOG	110	1	-10.6	0.0	6.0	-11.5	8.4	6.8	-11.7	-1.1	6.6	-7.5	8.8	5.5
ARK	SHE	110	2	2.3	0.6	7.0	2.3	0.6	4.2	2.3	0.6	7.0	2.3	0.6	4.2
ATE	DRO	110	1	0.0	-6.6	5.5	-8.5	-0.8	6.1	0.0	-6.6	5.5	-8.5	-1.5	6.2
ATE	KNR	110	1	0.0	6.6	3.7	18.8	-11.5	10.5	0.0	6.6	3.7	41.4	-19.3	21.8

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
ATH	LA	110	1	10.4	5.9	12.0	10.4	9.2	11.5	10.7	7.3	13.1	7.6	25.9	22.3
ATH	SH	110	1	-30.2	26.4	37.5	-81.9	4.4	63.1	-25.5	27.4	35.0	-86.5	57.1	79.7
AUG	CFM	110	1	25.4	14.2	30.3	25.4	14.1	30.3	25.4	14.2	30.3	25.4	14.1	30.3
AUG	KPG	110	1	50.7	-27.3	32.3	22.2	-16.9	13.3	31.1	-33.6	25.7	41.0	-9.9	20.1
AUG	MTN	110	1	60.4	-25.1	36.7	76.9	-9.6	36.9	38.0	-24.2	25.3	68.1	-0.6	32.4
AUG	SK	110	3	-81.0	12.0	68.2	-74.9	-0.8	62.5	-60.0	14.7	51.4	-79.9	-8.8	67.0
AUG	SK	110	4	-81.0	12.0	68.2	-74.9	-0.9	62.5	-60.0	14.7	51.4	-79.9	-8.8	67.0
AUG	CFM	110	2	25.4	14.2	30.3	25.4	14.1	30.3	25.4	14.2	30.3	25.4	14.1	30.3
ARV	COS	110	1	-12.5	10.2	15.5	-56.0	24.5	49.7	-12.5	7.7	14.1	-30.5	7.0	25.4
ARV	GWE	110	1	26.0	4.5	14.8	-22.4	-0.3	10.7	12.4	7.3	8.1	-22.1	6.4	11.0
ARV	NAV	110	1	-7.8	5.0	5.2	22.7	-2.5	10.9	1.9	6.0	3.5	16.0	0.7	7.6
ARV	SKL	110	1	-3.2	-10.9	8.3	31.1	-12.0	24.4	-1.0	-11.6	8.5	20.5	-7.8	16.0
ARV	SKL	110	2	-2.5	-8.8	5.2	24.6	-9.7	12.6	-0.8	-9.4	5.3	16.2	-6.4	8.3
ART	FIN (I)	110	1	-8.2	2.1	7.0	-35.8	-2.3	27.4	-6.0	2.4	5.4	-39.6	-3.1	30.3
ART	MCD	110	1	5.5	-2.1	4.9	19.4	0.4	14.8	4.0	-2.4	3.9	21.5	1.0	16.4
BVK	GRO	110	1	0.0	-20.3	10.4	-54.6	18.7	26.2	0.0	-20.1	10.3	-54.6	-30.9	28.5
ATY	CLW	110	1	-16.4	-3.3	16.9	-22.9	0.5	18.9	-16.1	0.5	16.3	-14.3	0.1	11.8
ATY	PLS	110	1	11.1	2.7	11.6	0.2	-6.4	5.3	-	-	-	-	-	-
ATY	CNB	110	1	-	-	-	-	-	-	12.2	-0.8	6.9	-8.1	-6.4	4.9
BWR	CRA	110	1	0.0	0.0	0.0	12.6	-9.1	22.8	0.0	-14.1	20.8	12.6	-7.7	21.7
BOL	ENN (I)	110	1	11.9	-2.8	6.9	64.9	-4.9	31.0	7.6	-0.4	4.3	45.0	-3.4	21.5

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
BOL	TBK T	110	1	-11.9	5.2	7.3	-31.6	-4.1	15.2	-7.6	2.8	4.6	-10.2	-7.8	6.1
BAL	CDU	110	1	-3.0	13.0	7.5	-40.7	-6.6	19.7	23.6	15.0	15.7	-6.2	-12.6	6.7
BAL	DRY	110	1	-0.5	-13.8	7.8	26.8	3.0	12.8	-26.2	-15.6	17.1	-6.2	8.9	5.2
BLI	DMY	110	1	-3.7	1.4	5.8	1.1	-4.6	7.0	-2.7	1.8	4.8	-0.5	-5.6	8.2
BEG	CKM	110	1	18.3	3.8	13.8	22.6	-2.2	14.3	18.8	5.5	14.4	22.0	2.4	13.9
CDL	BYH	110	1	0.0	0.7	0.3	49.6	-44.0	30.1	0.0	0.7	0.3	49.6	-40.7	29.2
BIN	CF	110	1	-10.2	3.3	10.8	-4.6	-8.1	7.7	-7.3	12.9	15.0	10.0	-13.4	13.8
BIN	TIV	110	1	5.6	-3.0	4.7	8.5	0.8	5.3	3.9	-12.4	9.5	12.0	2.5	7.7
BDA	MON	110	1	10.7	-3.1	11.2	43.0	-11.7	36.8	0.7	2.1	2.2	14.4	-8.6	13.8
BDA	NEW (I)	110	1	-15.9	2.3	13.2	-48.3	10.8	40.6	-6.0	-2.9	5.4	-19.6	7.7	17.3
BDN	CUL	110	1	-31.3	3.5	16.1	-11.8	-11.3	7.6	-32.4	1.9	16.5	-25.2	4.2	11.8
BDN	DOO	110	1	22.9	-5.7	13.3	-6.3	6.3	4.2	24.6	-4.0	14.0	14.1	-9.5	8.1
BRY	RAF	110	1	-12.6	-3.5	20.8	-14.2	-3.6	16.0	-9.4	-2.5	15.4	-15.7	-4.0	17.6
BRY	RAF	110	2	-5.8	-0.3	5.9	-17.2	-2.4	14.3	-4.3	-0.2	4.4	-17.5	-2.7	14.6
BK	CBR	110	1	-7.1	7.6	5.4	27.5	-11.6	13.5	-5.5	5.9	4.1	63.1	-28.9	31.4
BK	MOY	110	1	5.6	1.4	7.3	20.2	-4.3	15.1	4.4	-1.1	3.3	26.0	-4.9	19.3
BGD	INC	110	1	-18.0	-5.9	13.5	-18.0	-5.9	13.5	-34.0	-11.2	25.6	-34.0	-11.2	25.6
BGD	INC	110	2	-18.0	-5.9	13.5	-18.0	-5.9	13.5	-34.0	-11.2	25.6	-34.0	-11.2	25.6
BLA	RE	110	1	-17.8	-2.6	15.1	-69.0	-12.1	58.8	-13.2	-1.9	11.2	-76.2	-14.1	65.1
BGT	KKY	110	1	-	-	-	-	-	-	-19.0	4.1	10.9	-12.9	-4.5	6.5
BGT	CNB	110	1	-	-	-	-	-	-	14.4	-5.2	8.6	-17.2	-5.3	8.6

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
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	-1.3	-10.8	11.0	-22.5	0.7	18.6	1.5	-7.9	8.1	-24.6	1.4	20.4
BAN	RAF	110	1	-20.7	6.0	21.8	-30.0	-1.6	24.8	-19.3	4.0	19.9	-32.4	-3.3	26.9
BAN	BRI	110	2	2.0	0.5	4.5	2.0	0.4	4.5	2.0	0.5	4.5	2.0	0.4	4.5
CLG	MCE	110	1	-0.9	-1.4	1.7	-	-	-	-	-	-	-	-	-
CLG	CDU	110	1	-39.9	-11.5	22.2	-43.0	-12.9	20.5	-75.4	-27.6	43.0	-78.5	-27.7	38.0
CLG	FIN (I)	110	1	-2.3	-2.7	2.9	-0.1	-2.7	2.1	-6.4	-4.1	6.1	-3.2	-3.8	4.0
BLC	DRN	110	1	-	-	-	15.4	2.4	6.8	69.2	26.7	32.5	69.2	25.6	32.3
BLC	DRN	110	2	-	-	-	15.4	2.4	6.8	69.2	26.7	32.5	69.2	25.6	32.3
BLC	DTN	110	2	-	-	-	-	-	-	-8.7	-13.6	11.5	9.1	-7.2	8.2
BLC	GRA	110	1	-	-	-	-	-	-	-11.5	-16.9	14.6	36.5	-0.1	26.1
BLC	KLM	110	1	-	-	-	-	-	-	-8.7	-14.9	12.3	26.6	-3.4	19.2
BUT	CUL	110	1	-7.1	0.8	4.0	-48.1	0.8	25.1	-6.0	1.9	3.5	-43.2	-4.5	22.6
BUT	KTN	110	1	-2.4	-1.1	1.3	6.5	-9.0	5.1	-1.1	-1.7	1.0	-1.7	-4.3	2.2
KNG	TRI	110	1	0.0	1.2	1.0	30.1	-17.0	27.9	0.0	1.2	1.0	30.0	-25.5	31.8
BOG	CRA	110	1	-16.7	-0.4	9.4	-34.9	2.2	16.7	-16.2	-1.1	9.1	-32.1	2.0	15.3
BGH	CLA	110	1	0.0	0.6	0.4	42.6	-28.8	24.5	0.0	0.6	0.4	46.0	-9.6	22.4
AGY	TIV	110	1	-3.8	-0.7	3.7	-9.8	-5.6	9.2	-2.8	-0.5	2.8	-11.5	-8.1	11.5
CAB	PTN	110	1	-4.9	1.6	6.5	-19.1	-3.5	16.3	-3.7	2.0	5.3	-21.1	-4.3	18.1
CAB	WOL	110	1	2.6	-2.3	2.9	6.1	-0.8	4.7	2.0	-2.5	2.7	6.7	-0.4	5.1
CLA	CKN	110	1	16.6	-2.1	9.4	35.6	3.7	18.8	18.8	-9.6	11.8	54.3	2.8	28.6

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
CLA	DMY	110	1	5.6	4.3	4.0	21.4	-2.8	10.3	2.7	0.8	1.6	8.2	-2.9	4.1
CLA	MAC	110	1	5.2	20.2	13.0	26.1	-2.1	13.7	-1.7	1.7	1.5	16.3	-4.6	8.9
CKN	KER	110	1	16.6	-0.8	9.3	35.4	4.2	17.0	18.7	-8.5	11.5	53.8	1.8	25.6
CRO	IA	110	1	1.8	-9.7	5.0	-43.0	8.1	20.2	5.1	-5.7	3.9	-36.4	1.8	16.8
CRO	KBY	110	1	-6.2	9.6	6.4	30.0	-10.7	15.9	-8.4	5.7	5.7	22.1	-4.7	11.3
CDY	GRV	110	1	0.0	6.8	7.4	-24.4	5.4	27.5	0.0	8.6	9.4	-24.4	-0.3	26.8
CDY	SRA	110	1	9.9	-10.4	14.5	10.1	-2.4	8.6	-2.0	-5.4	5.5	0.7	5.1	2.5
CDY	ARI T	110	1	-9.9	4.6	6.1	33.1	-6.3	16.0	2.0	-2.2	1.7	46.3	-5.6	22.2
CSH	CLN	110	1	14.8	3.8	8.6	61.5	3.6	29.3	28.2	-5.3	16.1	56.0	2.3	26.7
CSH	DLT	110	1	16.1	-4.2	16.8	25.1	-4.6	21.1	14.1	-3.6	14.7	14.0	-3.1	11.9
CSH	ENN (I)	110	1	-15.5	1.7	8.7	-19.3	10.4	10.4	4.0	-4.3	3.3	-4.7	6.5	3.8
CSH	GAL	110	1	10.5	-8.0	13.3	20.4	9.1	18.5	7.9	-8.7	11.9	15.9	4.1	13.6
CSH	GAL	110	2	12.8	-9.7	16.2	24.9	11.2	22.6	9.6	-10.5	14.4	19.4	5.1	16.6
CSH	GAL	110	3	12.8	-9.7	16.2	24.9	11.2	22.6	9.6	-10.5	14.4	19.4	5.1	16.6
CSH	SAL	110	1	9.6	-9.9	14.2	15.1	4.8	16.3	6.9	-9.6	12.2	11.6	0.3	12.0
CSH	SOM T	110	1	-14.2	16.5	22.0	14.3	-8.5	13.7	-	-	-	-	-	-
CSH	SHN	110	1	-	-	-	-	-	-	11.1	-3.5	11.1	14.7	-9.9	14.4
CLH	TRI	110	1	0.0	1.9	1.9	-3.9	-2.8	3.9	1.2	-0.5	1.3	11.0	-0.8	9.1
CLH	TRL	110	1	0.0	-1.9	1.8	19.2	-6.4	16.5	-1.2	0.5	1.2	14.6	-0.4	11.9
CBR	CLN	110	1	-14.6	4.5	15.4	-8.4	-0.7	7.0	-9.0	-1.1	9.1	7.0	-5.1	7.2
CBR	CBG	110	1	7.2	-5.0	8.9	19.8	-1.3	16.4	5.4	-5.4	7.7	21.9	-0.6	18.1

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
CBR	DLT	110	1	-9.1	0.5	12.3	-10.0	-3.8	11.8	-8.9	-0.4	12.0	3.6	-7.6	9.2
CD	KBY	110	1	-6.3	9.5	6.4	33.7	-0.2	16.1	-8.6	4.3	5.4	25.7	-2.0	12.3
CD	MAC	110	1	6.3	-9.5	6.4	-25.8	-1.3	12.3	8.6	-4.3	5.4	-17.7	4.1	8.7
CPK	TNY	110	1	2.5	-7.2	7.7	13.2	-6.3	14.6	1.9	-7.3	7.5	14.6	-5.9	15.7
CF	CL	110	1	0.0	-0.2	0.3	-19.9	4.1	29.8	-10.0	6.3	17.3	-19.9	-1.0	29.3
CF	COR	110	1	0.7	4.7	3.5	55.2	-11.0	35.4	12.8	1.9	9.6	56.0	-5.6	35.4
CF	SRA	110	1	-15.1	8.2	12.6	10.6	-4.9	7.4	-3.0	2.9	3.1	26.5	-10.5	17.9
CF	CLO	110	2	8.0	-8.6	6.6	-15.3	6.7	8.0	3.3	-27.3	15.4	-26.4	9.9	13.5
CAH	DOO	110	1	-1.7	11.6	6.6	53.4	10.2	25.9	-5.2	9.5	6.1	27.8	8.4	13.8
CAH	KHL	110	1	9.1	-5.1	5.9	-1.9	6.1	3.0	15.4	0.6	8.7	12.8	10.9	8.0
CAH	TIP	110	1	3.1	-14.4	8.3	-40.9	7.6	19.8	4.4	-17.2	10.0	-25.4	14.5	13.9
CAH	BAR	110	1	-17.2	7.7	18.0	-37.9	19.2	34.5	-19.5	7.0	19.7	-43.0	26.0	40.8
CKM	CHE	110	1	19.0	4.1	18.6	19.0	3.6	15.8	19.0	4.1	18.5	19.0	3.7	15.8
CKM	POT	110	1	4.4	-5.3	5.8	16.1	-3.3	13.8	3.3	-5.4	5.3	17.8	-2.7	15.1
CKM	CPK	110	1	6.6	-9.4	8.4	25.4	-7.4	19.3	4.9	-9.5	7.9	28.0	-6.7	21.0
BRA	NEW (I)	110	1	12.7	-0.7	9.3	21.1	-15.8	16.6	25.9	1.0	19.1	38.2	-11.3	25.0
BRA	PLS	110	1	-16.0	0.0	16.2	-35.6	12.2	31.1	-28.4	-1.6	28.7	-54.2	7.2	45.2
COO	BCT	110	1	1.2	1.2	1.3	-0.3	0.7	0.6	2.8	2.2	2.8	0.9	1.6	1.4
COO	CKM	110	2	-2.3	-1.6	2.1	-4.1	-2.3	3.6	-3.6	-2.5	3.4	-5.9	-3.3	5.2
CLN	LA	110	1	-7.2	9.7	19.2	20.2	-6.2	23.0	13.8	-4.7	23.1	27.9	-13.2	33.5
SCR	KNY	110	1	-8.1	-2.1	6.2	-29.1	-10.6	19.5	-6.0	-1.4	4.6	-24.1	-10.4	16.5

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
CRA	LWD	110	1	-20.2	7.3	12.1	-63.8	-0.5	30.4	-16.7	8.9	10.7	-62.0	-0.1	29.5
CRA	WEX	110	1	-1.3	7.0	7.2	6.8	-3.6	6.8	-3.0	4.8	5.8	6.4	-5.2	7.3
COS	FLA	110	1	-15.2	7.9	17.3	-26.5	3.7	22.1	-8.3	3.8	9.2	-7.1	-6.1	7.7
COS	FLA	110	2	-15.6	8.1	17.8	-27.1	3.9	22.6	-8.5	3.9	9.4	-7.3	-6.2	7.9
COS	ARI T	110	1	11.1	-5.4	6.9	-35.0	8.1	17.1	-1.2	1.2	0.9	-47.8	14.2	23.7
COL (I)	FIN (I)	110	1	2.3	-1.7	2.8	0.1	-2.3	1.8	6.4	-0.3	6.1	3.2	-1.1	2.8
COL (I)	CDU	110	1	-13.5	-0.2	9.4	-27.9	-3.3	19.6	-14.6	-1.2	10.3	-33.9	-5.3	24.0
CHA	GLE	110	1	4.1	0.4	4.1	10.4	4.4	9.3	3.0	0.0	3.1	12.3	3.1	10.5
CHA	KLN	110	1	7.0	-8.0	7.8	1.2	-14.7	9.3	11.6	-9.2	10.9	10.9	-13.8	11.0
CHA	MAL	110	1	-15.1	9.9	10.2	-7.6	2.5	3.8	-17.7	11.6	11.9	-21.0	4.7	10.3
CLW	KLS	110	1	-17.3	-1.6	17.6	-34.5	-16.8	31.7	-14.8	0.7	15.0	-34.1	-20.6	32.9
CLW	KLS	110	2	-17.4	-1.7	17.6	-34.5	-17.2	31.8	-14.9	0.6	15.0	-34.1	-21.0	33.1
CLW	STR	110	1	3.9	-1.4	6.0	-10.8	17.4	30.1	2.9	-1.4	4.7	-8.5	15.8	26.4
COW	CVW	110	1	7.1	-4.6	8.5	21.7	-0.5	17.9	6.6	-4.3	7.9	22.8	-1.1	18.8
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	OLD	110	2	0.0	-0.1	0.2	0.0	-0.1	0.3	0.0	-0.1	0.2	0.0	-0.1	0.3
COW	RAF	110	1	-4.5	-0.2	4.5	-21.7	-2.7	18.1	-6.0	0.2	6.0	-23.1	-2.3	19.2
COW	WHI	110	1	-4.3	5.2	6.8	-14.1	1.7	11.7	-1.9	4.4	4.9	-15.2	1.6	12.6
CUN	GLR	110	1	0.9	-5.0	2.8	-24.4	8.1	12.3	0.4	-2.6	1.5	-27.1	15.2	14.9
CUN	SLI	110	1	-1.1	-0.1	0.6	34.5	-10.2	17.2	-0.6	-2.3	1.3	37.3	-11.6	18.7
CUS	MLC	110	1	21.6	-6.0	16.5	30.9	30.3	27.2	11.4	-0.3	8.4	5.5	-7.6	5.9

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
CUS	NEW (I)	110	1	27.8	-9.0	21.8	70.4	7.7	46.6	5.3	2.1	4.2	19.2	3.3	12.8
CUS	PLS	110	1	5.6	-6.7	6.4	17.5	10.7	12.9	-16.7	-1.8	12.3	-24.7	4.3	15.8
CVW	KRA	110	1	-0.4	-3.7	3.8	-5.7	-6.2	6.9	1.0	-3.2	3.4	-6.2	-7.0	7.7
CGL	GAE	110	1	0.0	1.6	1.8	-8.9	8.4	13.4	0.0	1.6	1.7	-8.9	5.8	11.6
CGL	CKN	110	1	0.0	-1.6	0.9	33.1	-26.1	22.2	0.0	-1.6	0.9	33.1	-3.8	17.5
COR	GWE	110	1	0.7	6.6	3.7	54.4	-3.1	25.9	12.8	2.8	7.4	55.3	-7.9	26.6
COR	ENN (N)	110	1	0.0	0.3	0.3	-0.3	-11.1	9.2	0.0	1.1	1.1	-0.4	-1.0	0.9
CDK	LWD	110	1	0.0	0.0	0.0	12.2	-8.7	16.5	0.0	-5.3	5.8	12.2	-11.5	18.4
CUL	DGN	110	1	1.0	-0.7	0.7	-22.1	16.3	14.3	-0.7	-0.4	0.4	-17.1	16.4	12.4
CUL	WAT	110	1	7.4	-5.4	5.1	63.0	-10.2	31.9	6.7	-7.0	5.4	52.9	-1.8	26.5
CTY	FTT	110	1	21.6	-1.4	17.4	83.9	15.1	64.6	16.0	-2.2	13.1	92.7	18.3	71.6
CTY	INC	110	1	-27.1	-0.7	26.3	-86.0	-16.2	71.2	-20.2	0.6	19.6	-95.1	-19.5	78.9
CDU	PLA	110	1	2.0	-12.5	7.1	30.1	3.5	14.5	-	-	-	-	-	-
CDU	GAN	110	1	-	-	-	-	-	-	-22.0	-13.3	14.4	-27.1	9.6	13.7
CDU	MUL	110	1	-8.2	0.0	7.9	-8.1	6.2	8.4	-12.7	-5.3	13.2	2.3	-6.1	5.3
CDU	RYB	110	1	30.1	27.6	39.6	8.4	32.3	26.0	11.2	19.2	16.2	14.0	23.8	20.1
KNY	UGL	110	1	0.0	-4.3	2.2	-51.9	52.3	33.5	0.0	-4.3	2.2	-51.9	42.8	30.6
KNY	GAL	110	1	0.0	4.3	4.3	51.9	-19.1	45.7	0.0	4.3	4.4	51.9	-9.7	43.7
KNY	KLH	110	1	0.0	-11.6	6.1	-10.0	0.5	5.3	0.0	-11.8	6.2	-10.1	-11.6	8.1
KNY	SAL	110	1	-8.1	13.8	8.2	-19.3	-7.7	9.4	-6.0	15.4	8.5	13.1	4.4	6.3
KNY	BUF	110	1	-	-	-	-	-	-	0.0	-0.6	0.4	-27.3	0.6	19.5

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
DDK	MLN	110	1	-4.7	-4.5	6.6	-37.4	-12.2	32.5	-0.5	-4.2	4.3	-31.3	-15.3	28.8
DDK	LOU	110	1	-9.3	8.0	12.4	-40.1	-8.9	34.0	-9.9	8.1	12.9	-45.2	-7.8	37.9
DRU	ENN (I)	110	1	4.5	-11.2	12.2	-6.7	-0.9	5.6	0.8	-14.4	14.6	-2.0	-3.3	3.2
DGN	WHO	110	1	-9.3	0.9	5.2	-69.2	5.5	33.1	-8.3	1.4	4.7	-68.8	4.6	32.8
DRG	KPG	110	1	-	-	-	-	-	-	-2.3	-0.8	1.4	3.9	-6.1	3.5
DRG	TRL	110	1	-	-	-	-	-	-	2.3	0.8	1.4	11.1	5.8	6.0
DRY	GOR	110	1	-1.8	-5.9	6.3	-7.2	-2.9	6.4	-14.3	-6.4	15.8	-23.4	-0.2	19.3
DRY	LOU	110	1	-9.5	-17.3	19.9	-21.8	-16.1	22.4	-27.0	-19.2	33.5	-47.3	-13.4	40.6
DRY	PLA	110	1	7.1	7.4	10.3	-19.2	-2.2	16.0	16.5	8.2	18.6	-14.7	-4.5	12.7
DMY	MAC	110	1	-6.7	-1.7	3.5	-21.6	7.2	10.5	-4.1	-1.3	2.2	-6.9	3.1	3.5
DMY	CDN	110	1	0.0	-0.4	0.2	0.0	-0.4	0.2	0.0	-0.4	0.2	-17.9	0.2	8.3
DTN	FIN (I)	110	1	-15.0	-1.2	10.7	-24.0	-6.9	17.9	-26.0	-16.0	21.8	-11.7	-8.5	10.3
DTN	KLM	110	1	4.9	-1.1	3.6	13.9	4.7	10.5	7.2	5.0	6.3	10.8	4.5	8.3
DER	KIN	110	1	16.8	-2.8	17.2	13.7	4.0	11.8	19.0	0.2	19.2	19.4	-3.9	16.4
DER	MAY	110	1	-3.4	-2.4	5.6	6.6	-6.4	9.9	-	-	-	-	-	-
DER	TIM	110	1	-	-	-	-	-	-	-13.6	1.7	7.7	-26.2	0.6	12.5
DER	TSB	110	1	-13.4	5.2	14.6	-20.3	10.5	18.8	-5.4	-1.9	5.8	6.8	3.4	6.3
DRM	LET	110	1	9.7	-0.3	9.8	38.9	7.6	32.2	6.8	-12.6	14.5	36.7	1.6	29.9
DRM	MEE	110	1	0.0	-0.2	0.2	-25.4	-9.0	22.3	0.0	-0.2	0.2	-25.4	1.8	21.0
DRM	CLO	110	1	-9.7	0.5	9.4	-13.5	1.4	11.1	-6.8	12.8	14.1	-11.4	-3.4	9.6
ENN (I)	SLC	110	1	0.0	-29.0	14.9	-21.6	-10.7	11.0	0.0	-29.6	15.2	-21.6	-13.7	11.6

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
KHL	THU	110	1	9.1	-4.5	5.7	8.8	-1.7	4.3	15.4	1.1	8.7	23.6	11.0	12.4
MLC	TSB	110	1	21.5	-5.8	16.5	55.6	-1.8	35.0	11.4	0.1	8.4	30.6	4.4	19.4
CKG	KUD	110	1	0.6	3.4	1.8	12.1	7.3	6.3	-4.2	0.1	2.2	-4.2	0.1	1.9
CKG	BKY	110	1	-45.8	-19.2	26.6	-57.3	-23.0	27.7	-	-	-	-	-	-
CKG	CBT	110	1	-	-	-	-	-	-	-56.1	-22.2	32.3	-56.1	-22.1	27.0
CKG	CBT	110	2	-	-	-	-	-	-	-56.1	-22.2	32.3	-56.1	-22.1	27.0
FAS	CKM	110	1	-7.1	-2.5	7.2	-30.9	-12.5	27.1	-5.3	-1.8	5.3	-34.1	-14.3	30.1
FLA	GIL	110	1	11.4	3.0	17.4	11.5	-10.8	23.1	11.4	3.0	17.4	11.5	-10.9	23.2
FLA	SLI	110	1	9.6	-7.5	12.3	-10.5	7.2	10.5	0.7	-1.2	1.3	-19.5	13.2	19.4
FLA	TON	110	1	4.7	0.1	6.2	13.2	2.6	17.6	3.5	-0.3	4.6	14.5	6.8	21.1
FLA	SLB	110	1	-36.3	25.4	44.8	-23.6	10.8	21.1	3.7	-1.3	4.0	37.7	-22.5	35.7
FRA	HAR	110	1	-4.8	-1.4	4.7	-17.4	-8.9	18.3	-3.6	-1.3	3.5	-19.5	-11.7	21.2
FRA	TRN	110	1	-2.9	1.1	2.2	-13.9	-6.5	10.9	-2.1	1.3	1.8	-15.7	-9.6	13.1
FRA	HEU	110	1	-3.1	-0.6	2.3	-6.9	-0.1	4.9	-2.3	-0.3	1.7	-7.6	-0.2	5.4
FRA	INC	110	1	-3.8	-1.7	3.9	-10.0	-2.5	9.6	-2.8	-1.4	2.9	-11.0	-2.8	10.6
FIN (I)	MCD	110	1	16.7	-14.4	18.5	68.7	-5.7	57.9	12.4	-15.2	16.5	75.9	-3.7	63.9
FIN (I)	PTN	110	1	8.4	-2.3	10.8	36.1	4.5	30.6	6.3	-2.8	8.6	39.9	5.8	33.9
FIN (I)	GLA	110	1	15.4	-0.6	14.6	67.7	21.2	57.7	11.4	-1.7	11.0	74.2	25.0	63.7
FIN (I)	GRA	110	1	17.6	-23.5	24.7	42.0	-14.1	37.3	33.8	-7.3	29.0	23.6	-10.0	21.5
FIN (I)	POP	110	1	19.8	-13.0	19.7	44.8	-5.0	34.4	37.3	1.9	31.1	32.1	1.4	24.5
FIN (I)	SVN	110	1	6.4	-4.1	7.2	27.2	5.8	24.2	4.7	-4.6	6.3	29.9	7.6	26.8

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
FTT	COO	110	1	19.0	-0.3	15.3	72.6	13.4	56.0	14.1	-0.9	11.4	80.3	16.2	62.0
GLA	SVN	110	1	-1.7	-5.6	4.3	-7.9	-9.1	7.8	-1.3	-5.3	4.0	-8.5	-9.6	8.3
GI	KKY	110	1	16.9	-10.1	19.9	53.4	-11.3	45.1	26.5	-13.7	16.8	52.7	-4.0	25.2
GI	WAT	110	1	10.1	-1.1	5.7	-1.0	17.1	8.2	6.3	-0.4	3.6	11.3	12.8	8.1
GI	WAT	110	2	9.1	-1.0	5.2	-0.9	15.5	7.4	5.8	-0.4	3.2	10.2	11.6	7.4
GI	WEX	110	1	16.7	-7.1	18.3	43.8	-8.2	32.5	-	-	-	-	-	-
GI	RSP	110	1	-	-	-	-	-	-	14.4	-5.8	8.7	21.0	-4.9	10.3
GRA	NBY	110	1	4.0	-0.5	3.3	-13.7	-10.2	14.4	12.1	1.5	10.2	-1.5	-5.3	4.6
GRO	CKN	110	1	0.0	-14.2	11.8	-32.9	10.9	28.9	0.0	-14.0	11.7	-33.0	-11.3	29.1
GAL	SAL	110	1	13.3	-27.4	30.8	47.8	-7.3	45.6	10.2	-29.4	31.5	24.8	-16.5	28.1
GAN	MUC	110	1	-	-	-	-	-	-	-22.0	-13.1	14.4	-1.7	8.7	4.2
GOL	GLT	110	1	0.0	0.0	0.0	4.5	0.3	3.7	0.0	-0.2	0.1	4.5	-6.5	6.5
GOR	MTH	110	1	-3.4	-1.4	3.7	6.3	5.9	7.2	-13.5	-1.1	13.7	-9.9	10.1	11.7
GOR	NAV	110	1	14.3	-9.2	17.2	22.5	-0.6	18.6	10.0	-9.6	14.0	21.9	-1.4	18.2
GOR	NAV	110	2	12.5	-7.9	14.9	19.5	-0.4	16.1	8.7	-8.2	12.1	19.0	-1.0	15.7
GOR	NAV	110	3	17.1	-9.1	19.6	25.5	1.4	21.1	12.3	-10.1	16.0	24.9	0.5	20.6
GOR	PLA	110	1	3.7	7.2	8.2	1.9	1.6	2.0	18.5	8.1	20.3	19.1	-1.5	15.8
GCA	INC	110	1	-26.1	-4.2	25.7	-38.8	-7.1	29.4	-7.7	-3.5	8.2	-14.8	-8.0	12.6
GCA	INC	110	2	-26.1	-4.2	25.7	-38.8	-7.1	29.4	-7.7	-3.5	8.2	-14.8	-8.0	12.6
GCA	INC	110	3	-	-	-	-	-	-	-32.8	-0.4	26.5	-66.6	-2.6	53.8
GCA	KUD	110	2	11.7	2.7	8.6	-3.6	-0.7	2.6	-	-	-	-	-	-

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
GCA	NAN	110	1	5.4	0.3	4.5	5.4	0.2	4.1	5.4	0.2	4.5	3.5	0.1	2.6
GCA	NAN	110	2	5.7	0.5	4.8	5.7	0.4	4.4	5.7	0.4	4.8	3.7	0.3	2.8
CLO	MRY	110	1	0.0	-9.6	7.1	-38.4	0.5	28.2	0.0	-10.1	7.5	-38.3	19.0	31.5
CLO	CF	110	1	-10.3	5.8	6.7	17.8	-4.4	8.8	-9.9	26.9	16.1	30.3	-4.5	14.7
CLO	GLT	110	1	8.6	-1.8	4.7	12.9	-1.0	6.0	6.1	-12.8	7.6	11.1	7.8	6.3
GLT	BYH	110	1	0.0	0.1	0.0	0.0	0.1	0.0	0.0	-0.4	0.2	11.9	-0.9	5.7
HWN	KIN	110	1	-	-	-	-	-	-	-7.3	-4.1	6.1	11.2	-3.4	8.4
HWN	DFR	110	1	-	-	-	-	-	-	7.3	4.1	8.0	1.4	3.1	2.2
HAR	RE	110	1	-8.8	0.3	8.2	-35.6	-11.6	35.0	-6.6	0.8	6.2	-39.6	-15.2	39.6
HEU	INC	110	1	-4.6	1.4	3.4	-13.3	0.4	9.5	-3.4	1.8	2.7	-14.6	0.0	10.5
IA	MAC	110	1	1.8	-9.6	5.0	-24.1	1.6	11.1	5.1	-5.6	3.9	-17.5	7.5	8.8
INC	MIL	110	1	9.9	-5.0	9.3	40.3	-0.8	30.8	7.4	-5.1	7.5	44.6	0.2	34.0
INC	BKY	110	1	48.4	6.1	26.1	68.0	11.9	31.0	-	-	-	-	-	-
IKE	IKE T	110	1	-6.1	-0.1	7.7	-21.7	-13.2	21.3	-4.5	0.0	5.7	-25.1	-11.9	23.3
KNR	KPG	110	1	-11.3	0.2	8.3	-23.5	-12.2	16.7	-7.2	-1.4	5.4	-11.5	-11.9	10.4
KNR	TRI	110	1	11.3	-0.2	5.4	23.5	12.2	14.9	7.2	1.4	3.5	11.5	11.9	9.3
KNR	TRI	110	2	0.0	-16.2	16.3	-41.7	5.7	34.8	0.0	-16.2	16.4	-43.6	14.1	37.8
KRA	MEN	110	1	-	-	-	-	-	-	0.0	-3.5	2.8	0.0	-3.8	3.1
KRA	KBY	110	1	17.6	-6.3	10.5	25.3	16.2	14.3	15.3	-4.6	9.0	38.3	19.7	20.5
KRA	BAR	110	1	27.4	-6.9	20.8	62.3	-7.1	39.5	27.3	-6.7	20.6	67.6	-15.1	43.6
KRA	MID	110	1	4.1	7.3	8.4	10.6	9.3	11.6	2.8	5.9	6.6	11.7	10.8	13.2

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
KRA	WHO	110	1	9.3	-2.6	5.4	64.5	-1.5	30.7	8.3	-3.1	5.0	53.5	-0.9	25.5
KRA	KBY	110	2	13.5	-8.4	16.0	23.8	8.9	21.0	11.9	-6.6	13.7	35.3	9.4	30.2
KTL	MAY	110	1	-4.9	-2.5	5.5	-24.1	1.6	20.0	-10.9	3.6	11.5	-45.0	4.1	37.3
KTL	MON	110	1	-7.1	0.4	5.2	-28.6	11.5	19.4	1.9	-5.1	4.0	0.1	8.0	5.1
REM	TRL	110	1	0.0	-7.8	6.2	17.1	5.4	12.7	0.0	-7.7	6.2	28.7	10.3	21.6
KKY	KLS	110	1	2.9	-9.9	10.4	-16.6	-9.1	15.6	-1.0	-8.5	8.7	-15.5	-1.0	12.8
KLN	LIM (I)	110	1	6.8	15.7	17.3	12.2	25.2	23.2	9.4	9.4	13.4	30.5	12.6	27.2
KLN	CUR	110	1	8.5	-27.7	21.3	19.1	-21.9	18.3	6.3	-28.3	21.3	-20.5	4.1	13.1
KLN	SNG	110	1	29.6	-0.3	22.0	24.8	17.9	19.2	21.5	-8.5	17.1	49.6	-6.7	31.5
KER	OUG T	110	1	8.7	-0.8	4.9	-0.8	-4.9	2.4	10.6	-8.3	7.5	14.5	-10.1	8.4
KUR	NAV	110	1	-23.7	-13.0	27.3	-23.7	-12.9	21.9	-23.7	-13.0	27.3	-23.7	-12.9	21.9
BYH	GLE	110	1	0.1	-39.7	32.0	-38.9	1.8	31.4	0.1	-35.5	28.7	-39.0	-0.1	31.5
KIN	MUL	110	1	1.0	-3.4	2.0	-0.8	6.0	2.9	1.5	-6.0	3.5	20.4	-9.4	10.7
KIN	DFR	110	1	5.6	-1.9	6.0	4.2	-4.3	5.0	-	-	-	-	-	-
KCR	GLE	110	1	0.0	0.0	0.0	31.0	-39.1	40.9	0.0	-12.5	10.3	31.1	-32.4	36.8
KTN	WAT	110	1	-6.3	-1.9	6.7	-5.3	-12.3	11.1	-4.0	-2.3	4.6	-14.6	-8.1	13.8
KLM	CRM	110	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-1.4	1.0	0.0	-1.5	1.1
KLM	CRM	110	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-1.4	1.0	0.0	-1.5	1.1
KLM	NBY	110	1	19.2	-1.9	16.2	36.8	7.0	31.5	31.7	6.6	27.2	45.2	12.3	39.4
KLM	POP	110	1	-14.3	7.0	13.3	-22.9	4.3	17.8	-33.2	-7.7	28.4	-7.8	-1.4	6.1
KUD	CBT	110	1	-	-	-	-	-	-	-51.9	-22.7	30.3	-51.9	-22.6	25.4

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
KPG	RAT (I)	110	1	14.4	-1.5	10.7	38.0	-0.4	23.9	10.5	1.8	7.8	25.4	5.7	16.4
KPG	TRL	110	1	5.0	-2.4	5.6	18.5	2.0	15.3	2.6	-0.1	2.6	8.1	4.0	7.5
KPG	TRL	110	2	5.4	-1.8	3.2	18.0	5.7	9.9	-	-	-	-	-	-
KPG	CH	110	1	-	-	-	-	-	-	0.0	-0.8	0.6	0.0	-0.9	0.5
CBT	BKY	110	1	-	-	-	-	-	-	25.3	9.6	14.5	30.2	11.6	14.5
CBT	BKY	110	2	-	-	-	-	-	-	25.3	9.6	14.5	30.2	11.6	14.5
LA	MUL	110	1	17.4	-1.7	17.6	60.5	-18.8	52.4	18.9	5.9	20.0	30.9	-10.7	27.0
LA	RIC	110	1	3.8	-0.4	3.9	17.0	4.4	14.3	2.9	-0.6	2.9	18.2	5.3	15.4
LA	RIC	110	2	4.8	-0.4	4.8	21.1	5.6	17.8	3.6	-0.5	3.6	22.7	6.7	19.2
LA	SLB	110	1	37.2	-24.4	45.0	6.4	-10.8	10.2	-3.7	0.2	3.8	-54.1	6.6	44.3
LOU	MLN	110	1	9.2	5.3	10.7	42.4	14.0	36.9	5.0	4.9	7.1	36.2	16.9	33.0
LOU	RRU	110	1	13.6	-7.8	16.5	-8.4	9.7	11.5	7.8	-8.2	11.9	2.5	0.4	2.2
LIM (I)	MTN	110	1	-38.0	41.6	31.6	-54.3	27.1	28.9	-16.1	38.3	23.4	-45.7	16.8	23.2
LIM (I)	RAT (I)	110	1	6.6	2.3	7.1	-16.4	6.5	14.6	5.1	-2.4	5.7	-0.9	4.5	3.8
LIM (I)	KLN	110	2	-5.3	-12.8	17.3	-9.5	-20.2	20.3	-7.3	-7.9	13.5	-23.7	-10.2	23.5
CNB	PLS	110	1	-	-	-	-	-	-	49.4	-5.1	27.9	84.4	-5.6	40.3
LIS	SKL	110	1	4.8	-8.2	9.6	-17.1	15.8	18.9	3.3	-8.1	8.8	-4.0	9.3	8.2
LIS	LOU	110	1	-12.2	7.1	14.2	-10.0	10.0	11.5	-8.8	7.4	11.6	-16.2	14.5	17.7
LUM	PLS	110	1	-	-	-	-	-	-	2.5	2.8	2.1	22.2	1.0	10.6
LUM	DAL T	110	1	-	-	-	-	-	-	-2.5	-2.8	2.1	7.7	-3.3	4.0
LET	TIV	110	1	-1.8	0.2	1.3	1.4	1.3	1.2	-0.9	9.3	6.8	-0.3	2.3	1.5

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
LET	TLK	110	1	4.6	-1.8	4.7	-10.3	-0.5	8.4	3.4	-2.4	4.0	-7.9	3.2	7.0
LET	GLT	110	1	-8.6	0.3	8.7	-17.3	-0.7	14.3	-6.0	11.3	12.9	-15.4	-2.7	13.0
LET	STR (N)	110	1	1.8	-1.0	2.1	0.2	36.8	29.9	0.1	2.7	2.8	-2.2	-4.3	3.9
LIB	MR	110	1	-4.0	-0.8	6.1	-14.9	-5.1	23.2	-3.0	-0.6	4.5	-16.5	-5.6	25.5
LIB	MR	110	2	-2.0	-0.5	2.1	-7.2	0.3	6.1	-1.5	-0.4	1.6	-8.0	0.1	6.7
LSN	THU	110	1	0.0	0.0	0.0	29.8	-12.6	26.5	0.0	-0.4	0.3	29.8	3.0	24.5
CUR	NEN	110	1	8.4	1.0	8.1	19.0	8.5	16.9	6.2	0.6	6.0	21.5	10.8	19.6
CUR	BKM	110	1	0.0	-28.6	15.1	0.0	-30.2	15.9	0.0	-28.7	15.1	-42.0	-6.4	22.4
LWD	CRY	110	1	0.0	-3.3	0.3	-17.8	0.6	1.8	0.0	-3.3	0.3	-17.8	0.6	1.8
MHL	RE	110	1	-16.5	3.7	12.1	-62.2	-13.5	45.4	-12.2	4.4	9.3	-69.1	-18.7	51.1
MHL	TRN	110	1	8.3	-4.5	6.7	37.2	7.8	27.2	6.1	-4.9	5.6	41.5	12.0	30.9
MCE	SBH	110	1	-3.8	-0.4	3.9	-11.3	-3.4	9.8	2.2	0.8	2.3	-7.6	-3.0	6.7
MCE	CDU	110	1	-10.0	-1.3	10.3	-23.4	-6.7	19.7	-12.9	-1.5	13.3	-30.4	-8.4	25.4
MCD	WOL	110	1	6.1	1.6	5.3	25.7	7.8	20.5	4.5	1.0	3.8	28.4	8.9	22.7
MID	WHI	110	1	-11.4	4.7	12.5	-32.9	-1.7	27.2	-8.7	4.4	9.9	-35.2	-1.8	29.1
MTH	LOU	110	1	-16.4	-2.8	16.9	-38.2	-16.8	34.5	-23.3	-1.7	23.6	-51.5	-10.7	43.5
MAY	TIM	110	1	-	-	-	-	-	-	13.7	-3.3	12.5	5.6	-1.3	5.2
MAY	GRI	110	1	6.8	2.3	7.2	27.8	6.4	23.8	5.1	1.5	5.3	30.9	7.3	26.5
MAY	GRI	110	1	6.8	2.3	7.2	27.8	6.4	23.8	5.1	1.5	5.3	31.2	6.9	26.0
MAY	RYB	110	1	75.2	20.9	43.8	97.0	16.3	44.9	94.3	33.0	56.1	91.4	27.9	43.7
MAY	RNW	110	1	5.9	1.4	7.6	15.6	5.2	15.9	3.7	-4.0	6.7	18.3	-1.4	17.8

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
MAY	BLK	110	1	-15.5	3.2	16.0	-0.8	3.2	2.8	-18.5	-5.0	19.4	6.9	3.4	6.4
MIL	RE	110	1	-4.6	-0.7	4.7	-20.0	-5.7	20.8	-3.4	-0.7	3.5	-22.1	-6.4	23.0
MIL	RE	110	2	-3.8	0.5	3.2	-15.6	-4.1	12.3	-2.8	0.5	2.4	-17.2	-4.8	13.6
MAC	CLA	110	2	-	-	-	-48.3	-0.9	25.2	3.0	-8.5	4.7	-30.0	3.5	15.7
MTN	MUN	110	1	10.8	6.6	28.0	10.8	6.6	28.0	10.8	6.6	28.0	10.8	6.6	28.0
MTN	MUN	110	2	10.8	6.6	28.1	10.8	6.6	28.1	10.8	6.6	28.1	10.8	6.6	28.0
MP	TBK T	110	1	15.3	-5.9	9.2	34.4	7.5	16.8	10.1	-3.9	6.1	14.2	9.1	8.0
MR	TBG	110	1	-12.2	7.9	8.2	-25.2	-6.6	11.9	-13.7	6.5	8.5	-34.1	-4.8	15.7
MR	TBG	110	2	-14.2	9.8	9.7	-29.2	-7.1	13.7	-15.9	8.1	10.0	-39.6	-5.0	18.2
MR	KBY	110	1	8.3	-7.9	10.5	8.0	5.3	8.0	11.8	-5.6	10.9	15.9	3.8	13.7
MR	KBY	110	2	8.3	-7.9	11.1	8.0	5.3	7.4	10.6	-6.5	12.1	15.4	2.0	11.9
MAL	KBY	110	1	-20.9	9.6	17.2	-29.8	-2.4	18.8	-22.0	11.4	18.5	-44.6	-1.1	28.1
MOY	GLR	110	1	-0.9	3.1	3.3	1.6	-5.4	4.6	-0.4	0.7	0.8	4.4	-10.5	9.2
MOY	TAW	110	1	0.0	-0.4	0.5	-9.0	-1.3	13.3	0.0	-0.5	0.7	-9.0	0.1	13.2
MOY	TAW	110	2	0.0	-0.4	0.6	0.0	-2.7	4.0	0.0	-0.4	0.6	0.0	-0.4	0.6
BCT	CKM	110	1	-31.6	-8.5	23.4	-33.2	-8.7	24.5	-59.5	-21.4	45.2	-61.4	-21.7	46.5
NEW (I)	BLK	110	1	19.9	-4.8	15.0	12.3	-2.4	7.9	21.9	3.7	16.3	5.9	-2.7	4.1
NQS	RE	110	1	-6.9	-0.6	5.9	-19.1	-3.0	16.3	-5.2	-0.4	4.4	-21.1	-3.5	18.0
OUG	OUG T	110	1	-7.7	-0.9	7.4	-24.9	-6.2	20.8	-5.7	-0.6	5.5	-26.6	-6.0	22.2
PA	STR	110	1	0.0	0.0	0.0	34.0	-12.8	53.4	0.0	-0.8	1.1	34.0	-10.5	52.3
PB	RE	110	3	12.9	-10.9	6.3	118.9	-10.2	44.4	-1.6	-12.0	4.5	129.6	-4.1	48.2

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
PB	RE	110	4	12.5	-10.6	6.1	115.4	-9.8	43.0	-1.6	-11.6	4.4	125.7	-3.9	46.8
PLS	DAL T	110	1	-11.5	-0.1	6.5	-57.7	3.5	27.5	-	-	-	-	-	-
PLA	MUC	110	1	-	-	-	-	-	-	22.1	12.7	14.3	-8.5	-9.4	6.0
RE	WBK	110	1	-50.9	28.0	46.5	-50.9	-40.6	46.2	-59.9	28.9	53.2	-59.9	-40.0	51.1
RE	PB	110	1	0.0	-1.6	3.6	0.0	-1.8	4.0	0.0	-1.6	3.6	0.0	-1.8	4.0
RAF	TBG	110	1	25.0	-14.0	16.1	64.6	6.5	31.1	23.4	-12.1	14.8	76.8	6.8	36.9
RAF	RSY	110	1	0.8	0.0	1.2	4.2	0.4	4.6	0.6	0.0	0.9	4.7	0.5	5.1
RAF	TBG	110	2	26.4	-6.8	27.5	68.8	17.2	58.6	24.9	-6.9	14.5	83.0	17.5	40.6
RNW	DFR	110	1	-3.2	0.0	3.2	6.4	3.8	6.2	-5.5	-5.4	7.7	9.1	-2.8	7.9
RRU	SKL	110	1	13.5	-6.6	15.8	15.2	-5.9	14.6	7.8	-6.8	10.9	26.2	-4.3	23.8
SH	DAL T	110	1	15.4	-2.5	8.8	74.6	3.4	35.6	5.3	1.4	3.1	9.8	6.1	5.5
SH	IKE T	110	1	5.2	-3.2	3.4	1.5	14.4	6.9	-4.6	13.0	7.8	-6.5	13.4	7.1
SH	SOM T	110	1	18.4	-18.3	24.7	3.3	11.8	10.0	-8.3	0.6	7.9	-6.1	13.7	12.2
SLI	SRA	110	1	-3.2	-3.0	4.5	-16.4	-0.2	13.6	-5.6	-0.6	5.7	-23.0	1.3	19.0
SLI	SRA	110	2	-3.0	-2.8	4.1	-15.2	-0.2	12.6	-5.2	-0.6	5.3	-21.3	1.2	17.6
SOR	TLK	110	1	0.0	0.0	0.0	18.9	4.5	15.8	0.0	-0.2	0.2	18.9	5.2	15.9
SRA	CF	110	2	19.2	-8.3	11.7	-12.9	1.7	6.2	4.3	-5.0	3.7	-32.0	6.5	15.5
SNG	AA	110	1	26.7	-0.9	15.0	12.9	14.6	9.3	19.3	-8.8	11.9	36.3	-10.6	18.0
SBH	CDU	110	1	-15.1	-3.7	11.4	-22.6	-6.7	17.2	-58.2	-21.8	45.4	-67.9	-25.5	52.9
SHN	SOM T	110	1	-	-	-	-	-	-	11.1	-3.4	11.0	25.1	-9.9	22.0
CNN	CLO	110	1	-	-	-	21.5	-15.5	12.6	0.0	15.8	8.9	41.4	14.3	20.8

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
CNN	CAG	110	1	-	-	-	-21.5	15.5	19.0	0.0	-8.9	6.3	-21.6	-7.9	16.4
CNN	CDF	110	1	-	-	-	-	-	-	0.0	-7.0	5.0	-19.8	-6.4	14.9
TBK	TBK T	110	1	-3.4	-0.2	3.2	-2.7	-3.7	3.8	-2.5	0.1	2.4	-3.9	-2.4	3.7
CTN	KLN	110	1	-2.7	-4.6	3.0	-10.5	0.1	5.0	0.1	-7.2	4.0	3.9	8.3	4.4
CTN	TIP	110	1	2.7	14.2	8.1	63.4	0.2	30.2	-0.1	16.8	9.5	50.1	-5.6	24.0
TRL	OUG T	110	1	-1.0	0.1	0.5	25.8	9.8	13.2	-4.8	7.4	5.0	12.3	15.1	9.3
THU	IKE T	110	1	0.9	0.5	0.6	20.4	-3.7	9.9	9.2	-15.4	10.1	31.9	-3.4	15.3
RSP	WEX	110	1	-	-	-	-	-	-	14.4	-5.2	8.6	49.3	-7.0	23.7
CTG	BVK	110	1	0.0	1.0	0.4	49.2	-47.4	30.0	0.0	1.0	0.4	51.5	-13.1	23.3
BK	SKY	110	1	0.0	-4.7	2.4	-25.6	7.1	13.8	0.0	-4.7	2.5	-51.3	1.1	23.0
BK	CRN	110	1	-	-	-	0.0	-0.1	0.1	0.0	-0.1	0.1	-14.9	26.2	14.4
CKM	FAS	110	1	7.1	2.2	7.1	30.9	12.4	27.1	5.3	1.6	5.2	34.2	14.3	30.1
BKM	CUR	110	1	0.0	-7.8	6.5	0.0	-8.3	6.9	0.0	-7.9	6.6	-28.1	13.8	26.1
AGH	ENN (N)	110	1	-2.8	4.7	5.0	2.2	7.3	6.1	-3.1	4.8	5.2	2.4	11.4	9.4
AIR	ROS	110	1	-	-	-	-	-	-	-5.0	-0.8	6.2	-17.0	-3.2	16.8
AIR	ROS	110	1	-	-	-	-	-	-	-5.0	-0.8	6.2	-17.0	-3.2	16.8
ANT	KEL	110	1	-5.4	9.9	13.7	-18.0	1.0	17.5	-6.1	4.2	9.0	-20.4	-4.2	20.2
ANT	KEL	110	2	-7.0	-12.1	17.1	-19.0	-10.5	21.1	-6.9	-6.0	11.2	-20.5	-4.2	20.3
BPS	BVG	110	1	15.5	0.8	18.9	24.9	7.1	25.1	9.9	3.3	12.7	21.9	14.1	25.3
BPS	BVG	110	2	15.5	0.8	18.9	24.9	7.1	25.1	9.9	3.3	12.7	21.9	14.1	25.3
BPS	EDE	110	1	19.0	-15.9	35.9	58.1	-19.7	71.3	15.2	-15.2	15.0	49.6	-16.0	31.4

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
BPS	EDE	110	2	19.1	-16.0	35.6	58.3	-19.8	70.8	15.2	-15.3	15.1	49.8	-16.2	31.5
BMA	KEL	110	1	-12.6	-1.8	11.7	-34.2	-13.2	29.6	-13.2	-2.0	12.3	-35.5	-13.2	30.6
BMA	KEL	110	2	-12.2	-1.7	11.3	-33.2	-12.4	28.6	-12.8	-1.9	11.9	-34.5	-12.4	29.6
BAN	TAN	110	1	-5.7	-1.6	7.2	-19.4	-4.7	19.4	-6.0	-1.7	7.5	-20.4	-5.0	20.3
BAN	TAN	110	2	-5.9	-1.7	7.5	-20.3	-5.2	20.4	-6.2	-1.8	7.9	-21.3	-5.5	21.3
BVG	KEL	110	1	8.6	-2.2	8.2	4.6	0.1	3.7	3.0	0.4	2.7	0.7	6.5	5.3
BVG	KEL	110	2	9.0	-2.3	8.5	4.8	0.1	3.8	3.1	0.4	2.9	0.7	6.9	5.6
BVG	LAR	110	1	6.6	3.6	9.5	20.1	7.3	18.9	6.8	3.5	9.7	21.1	7.7	19.9
BVG	LAR	110	2	6.6	3.6	9.5	20.1	7.3	18.9	6.8	3.5	9.7	21.2	7.7	19.9
BNH	CAS	110	1	-8.5	-1.0	10.4	-28.8	-5.8	28.5	-8.8	-1.1	10.8	-30.1	-6.3	29.9
BNH	CAS	110	2	-8.5	-1.0	10.4	-28.9	-5.8	28.6	-8.8	-1.1	10.9	-30.2	-6.3	30.0
BNM	DON	110	1	-7.4	-0.3	9.8	-25.3	-4.2	31.3	-7.8	-0.4	10.4	-26.6	-4.7	33.0
BNM	DON	110	2	-7.4	-0.4	9.9	-25.5	-4.4	31.5	-7.8	-0.5	10.4	-26.6	-4.7	33.0
BRO	RSK	110	1	0.0	0.0	0.0	14.2	-12.6	13.2	-	-	-	-	-	-
BRO	AGI	110	1	-	-	-	-	-	-	0.0	-0.5	0.3	14.2	-10.9	8.5
AGI	RSK	110	1	-	-	-	-	-	-	0.0	0.5	0.3	41.2	-12.2	19.6
CAR	CAS	110	1	8.5	-17.1	27.6	24.4	-26.9	21.9	4.8	-16.3	24.6	16.1	-22.5	32.2
CAR	EDE	110	1	-13.7	16.9	31.5	-39.8	25.5	28.5	-9.7	16.1	27.2	-30.8	21.2	43.5
CAR	CAS	110	2	8.5	-17.2	27.4	24.6	-27.2	22.1	4.8	-16.4	24.4	16.3	-22.7	32.1
CAR	EDE	110	2	-13.7	17.0	31.6	-39.9	25.7	28.6	-9.7	16.2	27.3	-30.9	21.3	43.7
CAS	CRE	110	1	19.0	-7.3	15.4	64.7	2.1	44.7	17.9	-7.8	14.8	61.2	0.7	42.2

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
CAS	CRE	110	2	18.9	-7.3	15.4	64.5	2.1	44.5	17.8	-7.8	14.8	61.0	0.6	42.1
CAS	KNO	110	1	9.3	-3.4	15.0	31.9	2.4	43.9	8.6	-3.7	14.1	29.3	1.6	40.2
CAS	KNO	110	2	9.3	-3.4	15.0	31.9	2.5	43.9	8.6	-3.6	14.1	29.3	1.7	40.2
CAS	NAR	110	1	6.8	-6.0	8.3	23.3	-6.1	19.4	7.1	-5.9	8.5	24.3	-6.0	20.2
CAS	NAR	110	2	6.7	-5.9	8.2	22.9	-6.1	19.1	7.0	-5.8	8.3	23.9	-6.0	19.9
CAS	RAT (N)	110	1	8.4	0.3	10.3	28.8	3.8	28.2	8.8	0.3	10.7	30.2	4.1	29.6
CAS	RAT (N)	110	2	8.8	0.4	10.8	30.2	4.2	29.6	9.2	0.5	11.2	31.6	4.6	31.0
CAS	ROS	110	1	4.0	0.8	2.8	14.1	3.4	9.6	6.7	1.1	4.7	30.3	6.1	20.3
CAS	ROS	110	2	4.1	0.9	2.9	14.4	3.5	9.7	6.8	1.1	4.8	30.5	6.2	20.5
CEN	CRE	110	1	-7.9	-0.5	5.5	-26.8	-2.8	18.7	-8.3	-0.6	5.8	-28.4	-3.2	19.9
CEN	CRE	110	2	-7.9	-0.5	5.5	-26.8	-2.8	18.7	-8.3	-0.6	5.8	-28.5	-3.2	19.9
COL (N)	CPS	110	1	-15.7	-0.6	19.1	-22.6	-11.7	24.7	-18.4	-0.5	22.5	-21.7	-9.5	23.0
COL (N)	LIM (N)	110	1	-10.7	-0.1	13.0	-13.5	-7.9	15.2	-13.2	0.0	16.1	-11.9	-5.6	12.8
COL (N)	LOG	110	1	5.9	0.1	7.1	18.6	4.4	18.6	6.1	0.1	7.5	19.6	4.8	19.6
COL (N)	LOG	110	2	5.7	0.1	7.0	18.3	4.3	18.2	6.0	0.1	7.3	19.2	4.7	19.2
COL (N)	RSK	110	1	2.1	-0.1	1.1	-12.0	1.9	6.3	6.2	-0.5	3.3	-18.4	-3.9	9.8
CPS	KMT	110	1	19.0	-14.6	16.7	5.3	3.1	3.7	22.8	-15.9	19.4	8.2	5.1	5.8
CPS	LIM (N)	110	1	18.2	-0.4	22.2	27.7	12.9	29.7	21.0	-0.4	25.7	27.2	10.9	28.5
CPS	LMR	110	1	4.9	0.6	6.0	14.0	3.1	13.9	5.1	0.6	6.3	14.8	3.3	14.8
CPS	LMR	110	2	4.9	0.6	6.0	14.0	3.1	14.0	5.1	0.6	6.3	14.9	3.3	14.8
CPS	SPR	110	1	7.1	-0.5	8.6	24.2	2.8	23.6	7.4	-0.4	9.0	25.3	3.2	24.7

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
CPS	SPR	110	2	7.1	-0.6	8.6	24.1	2.7	23.6	7.4	-0.5	9.0	25.2	3.1	24.7
CPS	STR (N)	110	1	28.2	-13.9	28.8	29.9	-4.7	24.4	33.7	-16.6	34.5	35.6	4.7	29.0
CRG	KEL	110	1	-6.3	10.1	14.5	-17.6	4.6	17.6	-6.9	8.5	13.3	-23.3	6.3	23.4
CRG	TMN	110	1	-1.1	-11.9	11.0	-7.6	-8.7	9.4	-0.9	-10.5	9.7	-3.1	-10.6	8.9
DON	HAN	110	1	-16.0	1.5	11.1	-54.0	-3.9	34.2	-15.0	1.1	10.5	-50.8	-0.9	32.2
DON	HAN	110	2	-12.6	7.5	10.2	-43.8	2.6	27.8	-14.4	7.9	11.4	-49.8	-0.8	31.5
DON	FIN (N)	110	1	-6.8	5.6	12.7	-23.8	4.7	28.2	-5.7	5.8	11.8	-21.1	-1.9	24.6
DON	FIN (N)	110	2	-7.6	-8.1	16.1	-25.2	-10.0	31.5	-6.5	-7.9	14.9	-20.8	-1.9	24.3
DRO (N)	DRQ	110	1	0.0	-1.2	0.7	-20.2	0.1	10.8	0.0	-1.2	0.7	-20.2	2.2	10.8
DRO (N)	ENN (N)	110	1	11.0	-4.6	14.5	20.2	6.2	20.5	11.6	-5.0	15.4	22.4	2.1	21.9
DRO (N)	ENN (N)	110	2	11.0	-4.6	14.5	20.2	6.2	20.5	11.6	-5.0	15.4	22.4	2.1	21.9
DRO (N)	OMA	110	1	-11.0	5.2	14.8	-10.1	-6.2	11.5	-11.6	5.5	6.5	-12.3	-3.2	5.7
DRO (N)	OMA	110	2	-11.0	5.2	14.8	-10.1	-6.2	11.5	-11.6	5.5	6.5	-12.3	-3.2	5.7
DRU (N)	TAN	110	1	-4.3	-4.3	7.7	-8.3	-22.4	21.1	-3.3	-4.7	7.3	-8.4	-16.9	16.7
DRU (N)	TAN	110	2	-4.3	-4.3	7.7	-8.3	-22.4	21.1	-3.3	-4.7	7.3	-8.4	-16.9	16.7
DRU (N)	TAN	110	3	-4.7	-4.3	5.9	-9.7	-23.1	19.9	-3.7	-4.8	5.6	-9.5	-17.3	15.7
DRU (N)	TMN	110	1	-6.8	5.5	8.0	-32.2	21.3	31.1	-8.9	6.1	9.9	-34.5	12.2	29.5
DRU (N)	TMN	110	2	-7.1	5.4	8.2	-33.6	21.8	32.3	-9.3	6.1	10.2	-36.0	12.3	30.7
DUN	TMN	110	1	-11.4	-1.6	7.4	-27.6	-14.9	17.6	-11.2	-1.9	7.3	-29.9	-17.5	19.5
DUN	TMN	110	2	-8.1	0.0	5.6	-20.5	-7.9	15.2	-8.0	-0.3	5.5	-22.3	-9.5	16.9
DUN	OMA	110	1	0.7	-3.5	1.9	-21.8	0.5	11.3	-1.2	-3.1	1.8	-20.6	6.5	11.2

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
DUN	TMN	110	3	-9.9	-2.8	5.6	-23.4	-15.2	14.5	-9.7	-3.1	5.5	-25.3	-17.6	16.0
FIN (N)	HAN	110	1	-12.2	-8.0	10.2	-41.0	-11.5	29.6	-11.4	-7.9	9.6	-37.3	-3.6	26.0
FIN (N)	HAN	110	2	-11.3	5.5	8.8	-39.4	3.0	27.5	-10.5	5.7	8.3	-37.5	-3.6	26.1
GLE (N)	KEL	110	1	-6.7	-1.8	8.4	-22.7	-7.1	26.5	-7.0	-1.9	8.9	-24.0	-7.6	27.9
GOR (N)	OMA	110	1	1.7	1.2	1.1	1.5	2.7	1.5	0.4	1.3	0.7	1.7	6.5	3.4
GOR (N)	TMN	110	1	-1.7	2.4	1.6	18.7	1.5	9.4	-0.4	2.3	1.3	18.4	-3.1	9.3
HAN	LIS (N)	110	1	4.9	-17.0	21.6	15.3	-4.3	15.5	7.9	-15.8	21.5	32.5	-1.3	31.6
HAN	LIS (N)	110	2	5.1	-17.9	23.3	14.2	-5.2	15.1	8.2	-16.5	23.0	32.2	-1.5	32.2
KEL	GLE (N)	110	2	0.0	-3.0	3.7	0.0	0.0	0.0	0.0	-3.0	3.7	0.0	-2.9	3.3
KEL	KLC	110	1	-	-	-	-	-	-	0.0	-1.2	0.8	-20.4	-0.5	14.2
KEL	RSK	110	1	-2.0	-8.2	4.6	-18.4	2.0	9.6	-3.3	-4.3	2.9	-18.8	5.2	10.1
KEL	RSK	110	2	-	-	-	-	-	-	-2.9	-4.7	2.9	-19.8	2.9	9.4
KMT	SLK	110	1	0.0	-18.1	16.6	-21.8	10.2	19.4	0.0	-18.1	16.6	-21.8	0.0	17.6
KMT	STR (N)	110	1	18.9	3.9	13.5	37.8	-5.3	23.0	22.6	2.4	15.9	40.7	6.8	24.9
LIS (N)	TAN	110	1	-6.1	-15.6	20.5	-22.4	-9.6	23.7	-3.7	-14.5	18.2	-7.2	-7.7	10.2
LIS (N)	TAN	110	2	-5.8	-16.7	22.1	-23.2	-10.8	25.6	-3.3	-15.3	19.6	-7.1	-8.1	10.8
MKL	OMA	110	1	0.0	0.9	0.7	35.7	6.6	23.1	0.0	1.0	0.7	35.7	6.3	23.1
NEW (N)	TAN	110	1	-11.8	-2.1	14.7	-38.7	-9.9	38.8	-12.4	-2.2	15.4	-40.7	-10.6	40.8
NEW (N)	TAN	110	2	-11.9	-2.1	14.7	-38.8	-9.9	38.9	-12.4	-2.2	15.4	-40.8	-10.6	40.9
OMA	STR (N)	110	1	-18.0	5.8	17.4	-16.2	-7.0	14.3	-21.5	6.5	20.6	-18.6	2.8	15.1
OMA	STR (N)	110	2	-17.7	5.7	22.7	-16.0	-6.9	16.9	-21.2	6.4	26.9	-18.3	2.7	17.9

Table H-1: Power Flows, Summer Valley and Winter Peak 2019 and 2028

Line				2019						2028					
				Summer Valley			Winter Peak			Summer Valley			Winter Peak		
From	To	kV	No.	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%	MW	MVAR	%
OMA	TRE	110	1	-1.8	-1.1	1.2	2.4	-4.9	2.8	-0.3	-1.4	0.8	1.3	-9.8	5.1
TAN	WAR	110	1	9.9	1.8	12.7	33.7	8.3	30.7	10.3	1.9	13.2	35.3	9.1	32.2
TAN	WAR	110	2	9.8	1.8	12.6	33.6	8.3	30.7	10.3	1.9	13.2	35.2	9.1	32.2
TRE	TMN	110	1	-1.8	3.4	2.1	25.4	-0.3	13.2	-0.3	3.1	1.7	24.3	-5.6	12.9

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