All-Island Transmission System Performance Report

2021

SONI EIRGRID

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1. Introduction

EirGrid and SONI, as Transmission System Operators (TSOs) for Ireland and Northern Ireland respectively, are pleased to present the annual Transmission System Performance Report for 2021. This report contains transmission system data and performance statistics for the transmission system in Ireland and Northern Ireland for the year 2021 (1 January 2021 – 31 December 2021).

EirGrid is required to publish an annual report on the performance of the TSO business in accordance with Condition 18 of the Transmission System Operator Licence granted to EirGrid by the Commission for Regulation of Utilities (CRU).

Similarly, SONI is required to produce an annual report on the performance of the TSO business in accordance with Condition 20 of the Licence to participate in the Transmission of Electricity granted to SONI Ltd by the Department for the Economy.

This report contains high-level transmission system characteristics and a detailed breakdown of key figures along with an explanation of what these figures mean for the all-island transmission system in the coming year and into the future. Through comparison with previous reports, this report provides a useful resource through which possible trends can be identified.

This report is structured as follows:

- Section 3 outlines all-island system data, generation availability and outages,
- Section 4 details the performance of the EirGrid TSO business during 2021 against the criteria approved by the CRU,
- Section 5 details the performance of the SONI TSO business during 2021 against the criteria approved by The Utility Regulator in Northern Ireland.

Appendices which provide further detail on the data, results and methodology of relevance are included at the end of this report.

2. Executive Summary

The annual Transmission System Performance Report for 2021 is a comprehensive review of the transmission system through which EirGrid and SONI make available key all-island system operating data from the previous year.

Key statistics detailed in this report include:

- All-Island Generation Statistics
- Transmission System Availability Statistics for Ireland and Northern Ireland
- Details on System Events leading to System Minutes Lost
- Details of All-Island System Frequency Events

2.1 Key Data

All-island

- All-island peak demand reached 6,826 MW on 8 December 2021. The minimum all-island demand was 2,765 MW and occurred on 8 August 2021.
- The all-island installed capacity of conventional generation in 2021 was 8,045 MW.
- In 2021 the system frequency was operated within 49.9 Hz and 50.1 Hz for 98.63% of the time.

Ireland

- In 2021 the availability of the East West Interconnector was 97.54%.
- The weighted-average availability of the Ireland transmission system in 2021 was 95.71%.
- The System Minutes Lost for 2021, attributable to EirGrid, was 0.05369.

Northern Ireland

- The availability of the Moyle Interconnector for 2021 was 97.98%.
- The average availability of the Northern Ireland transmission system in 2021 was 96.39%
- The System Minutes Lost for 2021, attributable to SONI, was 0.015.

3. All-Island System Data

3.1 Overview of the All-Island Electricity System

The transmission system in Ireland and Northern Ireland provides the means to transport energy from generators to demand centres across the island. The transmission system is comprised of high-voltage overhead lines and cables that connect power stations, interconnectors and substations. Transformers link different voltage levels and provide a path for power to flow from higher to lower voltage networks. The transmission system in Ireland is operated at 400 kV, 220 kV and 110 kV. The transmission system in Northern Ireland is operated at 275 kV and 110 kV.

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.

The Ireland and Northern Ireland transmission systems are electrically connected by means of one 275 kV double-circuit. This connection is from Louth station in Co. Louth (IE) to Tandragee station in Co. Armagh (NI).

There are also two 110 kV connections:

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

This section contains basic all-island transmission system data. Further information can be found on the EirGrid Group website: www.eirgridgroup.com.

3.2 Total System Production

Total exported energy takes into account energy supplied by large-scale and some small-scale generation[1] as well as pumped storage units on the island. This does not take into account interconnector imports and exports.

[1] Small-scale generation that is modelled in our Energy Management System, typically ≥ 5 MW

Table 1: Total Exported Energy 2019 - 2021

	2019	2020	2021
All-Island Total Exported Energy [GWh]	37,680	39,189	38,488
Ireland Total Exported Energy [GWh]	29,481	30,738	30,132
Northern Ireland Total Exported Energy [GWh]	8,198	8,451	8,356

3.3 System Records

Peak demand is a measure of the maximum demand on the transmission system over a particular period (e.g. annual or seasonal) and is a key measurement for any power system. The transmission system in Ireland and Northern Ireland is a winter peaking system as a result of greater heating and lighting requirements during the winter months. The all-island winter peak in 2021 was 6,826 MW and occurred at 17:24 on 8 December.

In summer, the reduced need for heating and lighting results in a lower demand for electricity. The minimum demand is known as the 'minimum summer night valley' and in 2021 a minimum all-island demand of 2,765 MW was recorded at 05:39 on 8 August.

From the installed wind capacity, a peak all-island wind generation output of 4,489 MW was achieved on 12 February. Table 2 provides a summary of the system records for 2019, 2020 and 2021.

Table 2: System Records 2019 - 2021

	2019	2020	2021
Winter Peak Demand [MW]	6,558	6,904	6,826
Minimum Summer Night Valley [MW]	2,542	2,395	2,765
Maximum Wind Generation [MW]	4,038	4,246	4,489

3.4 Generation Capacity

Generating plant is connected to both the transmission and distribution systems. All generation contributes to meeting system demand. The total generation capacity is calculated as the sum of all fully operational generator capacities connected to both systems.

The all-Island installed capacity of conventional generation in December 2021 was 8,045 MW (6,282 MW in Ireland and 1,763 MW in Northern Ireland including 82 MW of Aggregated Generator Units (AGUs)). The capacity of demand side units (DSUs) was 608 MW in Ireland and 117 MW in Northern Ireland, with an average availability of 28.1%. This does not include any import capacity from the Moyle Interconnector or the East West Interconnector.

The all-island installed capacity of wind generation in December 2021 was 5,683 MW (4,332 MW in Ireland and 1,351 MW in Northern Ireland).

Appendix 3 provides a list of the fully dispatchable generating units connected to the power system.

3.5 Generation Availability

Generation Availability is a measure of the capability of a generator to deliver power in a given period to the transmission system. In order for EirGrid and SONI to operate a secure and reliable transmission system in an economic and efficient manner, it is necessary for generators to maintain a high rate of availability.

Generation system availability is calculated on a daily and 365-day rolling average basis[2]. Figure 1 shows the daily and 365-day rolling average availability for 2021.

[2] 365-day rolling average is a capacity weighted average availability over the previous 365 days.

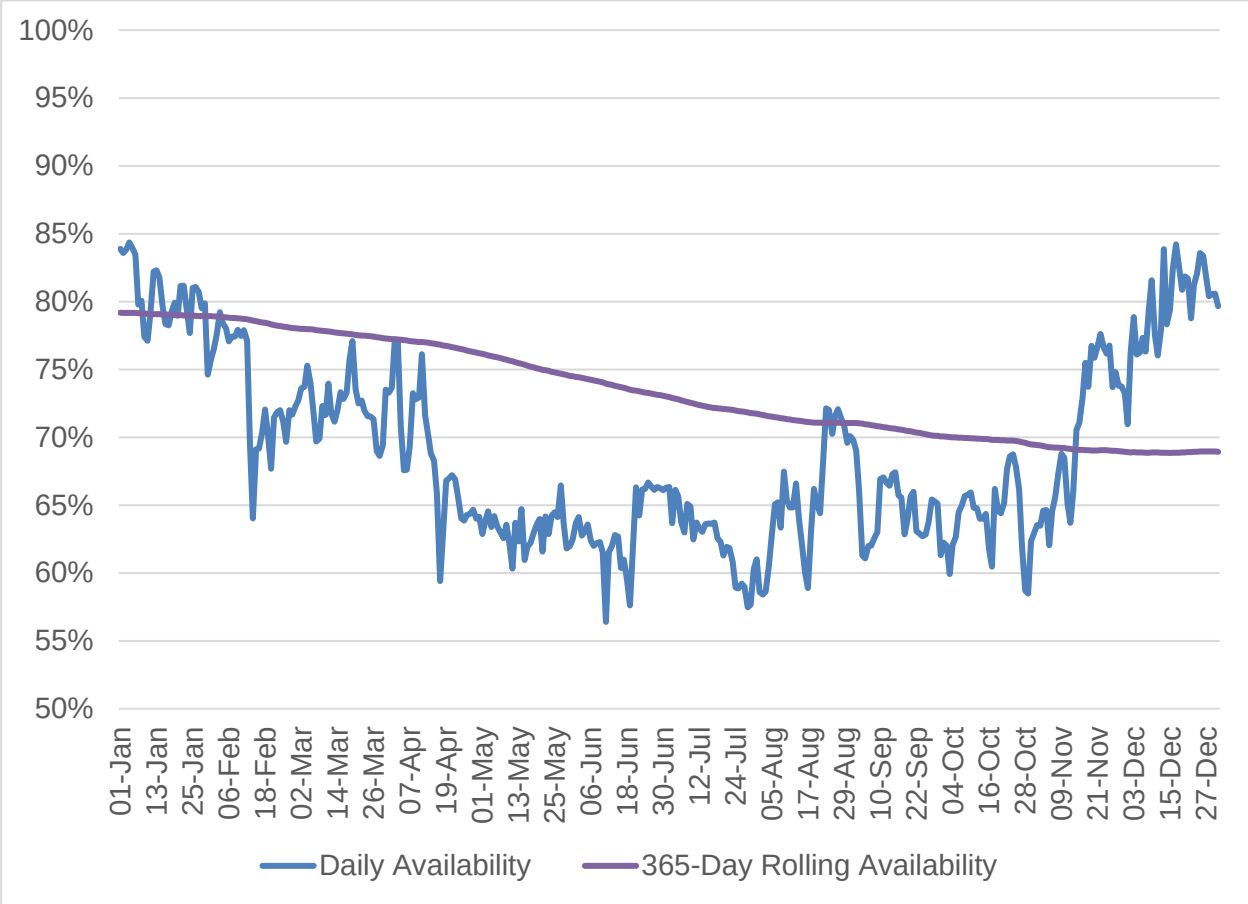

Figure 1: All-Island Dispatchable Generator and DSU Availability 2021

- The average daily generation system availability in 2021 was 68.9%.
- The maximum daily generation system availability in 2021 was 84.4%.
- The minimum daily generation system availability in 2021 was 56.4%.

3.6 Generation Forced Outage Rate

The generation forced outage rate (FOR) is calculated on a daily and rolling 365-day average basis. The daily FOR is a capacity weighted percentage of the time during the day that generation units are unavailable due to unforeseen/unplanned outages. The 365-day rolling FOR is the average of the daily FOR over the previous 365 days. The daily FOR and 365-day rolling FOR are shown in Figure 2.

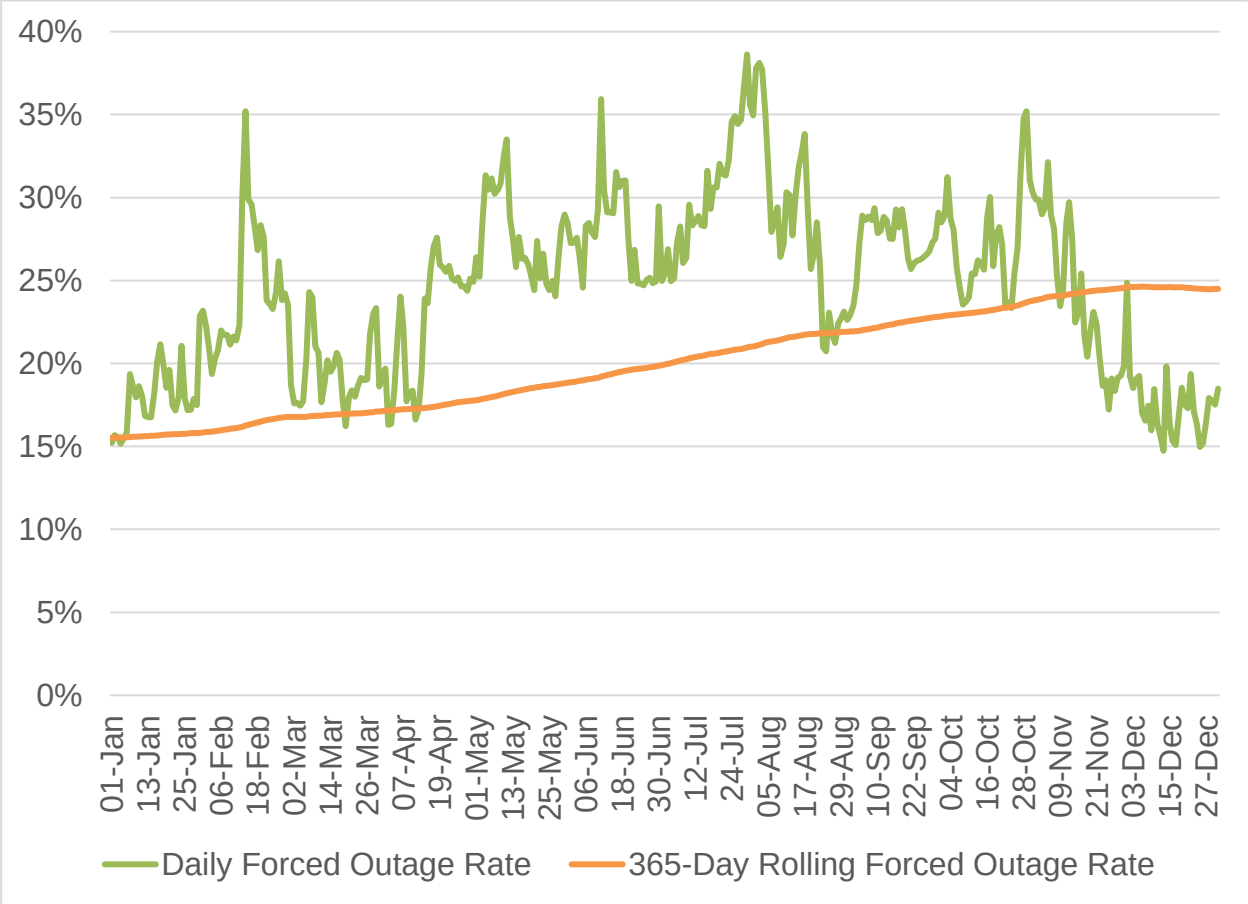

Figure 2: All-Island Dispatchable Generator and DSU Forced Outage Rate 2021

- The average daily generation system forced outage rate in 2021 was 24.5%.
- The maximum daily generation system forced outage rate in 2021 was 38.6%.
- The minimum daily generation system forced outage rate in 2021 was 14.7%.

3.7 Generation Scheduled Outage Rate

The generation scheduled outage rate (SOR) can be calculated on a daily and rolling 365-day average basis. The daily SOR is a capacity weighted percentage of the time during the day that generation units are unavailable due to planned outages. The 365-day rolling SOR is the average of the weekly SOR over the previous 365 days. The daily SOR and 365-day rolling SOR are shown in Figure 3.

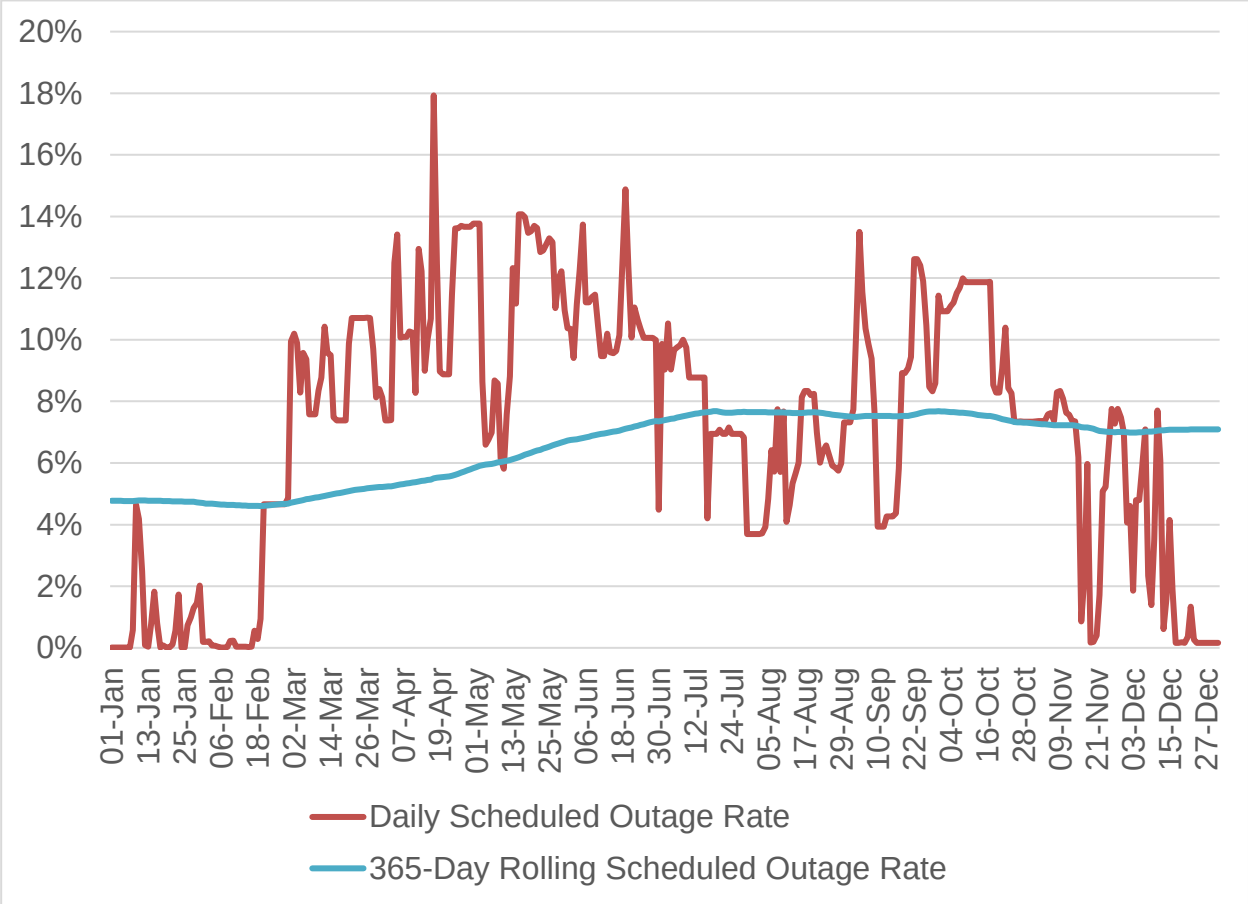

Figure 3: All-Island Dispatchable Generator and DSU Scheduled Outage Rate 2021

- The average daily generation system scheduled outage rate in 2021 was 7.1%.
- The maximum daily generation system scheduled outage rate in 2021 was 17.9%.
- The minimum daily generation system scheduled outage rate in 2021 was 0%.

4. EirGrid Transmission System Performance

This section relates to the performance of EirGrid TSO and the transmission system in Ireland only, unless explicitly stated otherwise. This data has been prepared by EirGrid in accordance with the requirements of Part 5 of Condition 18 of its Transmission System Operator Licence.

4.1 Summary

There were no major incidents in 2021. A major incident is one which results in the loss of greater than or equal to one system minute as a result of a single system disturbance.

The system minutes lost as a result of faults on the main system was 0.05369 in 2021. No system minutes were lost due to the disconnection of normal tariff load customers during Under Frequency Load Shedding (UFLS) disturbances.

EirGrid have a target to operate the system frequency within the range 49.9 Hz to 50.1 Hz for 98% of the time. In 2021, the system frequency was within the agreed limits 98.63% of the time.

4.2 Grid Development and Maintenance

This section provides an overview of grid development activities in 2021.

4.2.1 Completed Capital Projects

- Wexford 110 kV station DSO transformer bay
- Thornsberry 110 kV station A2 busbar uprate
- Bellacorick – Castlebar 110 kV line uprate
- Letterkenny 110 kV station rearrangment
- Bellacorick – Moy 110 kV line uprate

- Clashavoon – Macroom No. 1 110 kV circuit & associated station works & 250 MVA transformer
- Knockraha – Raffeen 220 kV line refurbishment
- Corduff 110 kV station development project
- Kilbarry 110 kV line conflicts
- Knockanure 50 Mvar reactor
- Wexford 110 kV busbar uprate
- Darndale 110 kV station
- Cashla – Tynagh 220 kV line fibre wrap
- Shannonbridge 220 kV new transformer bay
- Ardnacrusha T104 replacement
- Ballyvouskill temporary 50 Mvar reactor
- Aghada battery storage
- N5 line diversion
- Castlebar SVC refurbishment
- Ardnacrusha SVL installation

4.2.2 New Connection Offers

Parties seeking a new connection to the transmission system must apply to EirGrid for a connection offer. EirGrid operates within a regulatory approved process for providing connection offers to generators and demand customers seeking direct connection to the transmission system. The process for issuing generation offers was consulted on in 2017 resulting in the Enduring Connection Policy (ECP) which has led to a significant increase in the number of new generation capacity offers issuing between 2019 and 2021. Applications for ECP-2.2 opened in September 2021 and are currently being processed.

In order to connect to the transmission system, all demand and generation customers must execute a connection agreement with EirGrid. Table 3 summarises the total number of new capacity connection agreements executed in 2021 and their associated

load or generation capacities. A connection offer which is accepted in one year is unlikely to impact on connected generation capacity in the same year given the lead times associated with construction.

Table 3: New Capacity Executed Demand & Generation Connection Agreements

	Demand	Generation	Autoproducer	Interconnector
Executed Connection Offer Agreements in 2021 [No.]	5	7	1	1
Executed Connection Offer Agreements in 2021 [Capacity]	347.6 MVA[3]	510.5 MW	352 MW MEC[4] 190 MVA MIC	704 MW

In addition to issuing connection offers for new generation and demand capacity, EirGrid facilitates existing contracted customers in modifying existing connection agreements.

4.2.3 Connections Energised

When a connection agreement is executed for a new connection, it typically takes a number of years before the demand or generation is connected to the transmission system. This period includes project development, time taken to obtain consents and to construct the connection.

When the transmission connection is energised, it then takes a number of months for the generator to reach commercial operation. This period is generally much shorter for demand customers.

Table 4 provides an overview of the number of new connections to the transmission system commissioned in 2021.

[3] Includes transfer of capacity from DSO
[4] The MEC was previously captured under a separate connection agreement which has now been superseded.

Table 4: Demand & Generation Connections Energised in 2021

	Demand	Conventional Generation	PPM[5]	Battery
Connections Energised in 2021 [No.]	1	0	0	4
Connections Energised in 2021 [Capacity]	150 MVA	0 MW	0 MW	189 MW

4.2.4 Customers Certified Operational

Table 5 provides an overview of customers connected to the transmission system who have been deemed fully operational. It shows customer connections which have completed the testing phase and have received an operational certificate from EirGrid. This includes generators connected to the distribution network. Note that demand customers are not currently certified by EirGrid and are therefore not included in the table.

Following energisation, the unit is required to complete Grid Code Compliance testing, following which Operational Certificates[6] are issued.

Table 5: Customers Certified Operational in 2021

	Total number of new units certified operational in 2021	Total new capacity certified operational in 2021
PPM	8	198 MW
Conventional	1	17 MW
Battery	1	27 MW
DSU including existing with change in capacity	13	24 MW

[5] PPM: Power Park Modules
[6] EirGrid issues Operational Certificate Justifications for distribution WFPS. These are the included in the figures shown

4.3 General System Performance

4.3.1 Under-Frequency Load Shedding

There were no UFLS disturbances in 2021 which resulted in shedding of normal tariff load customers.

The relays to disconnect normal tariff customer load are only activated once the system frequency drops to 48.85 Hz. The lowest system frequency in 2021 was between 49.63 Hz.

Figure 4 provides a trend of the number of disturbances since 2012 that involved operation of under-frequency relays to disconnect interruptible and normal tariff end-users. No normal tariff customers have been disconnected due to an under-frequency disturbance since 2014.

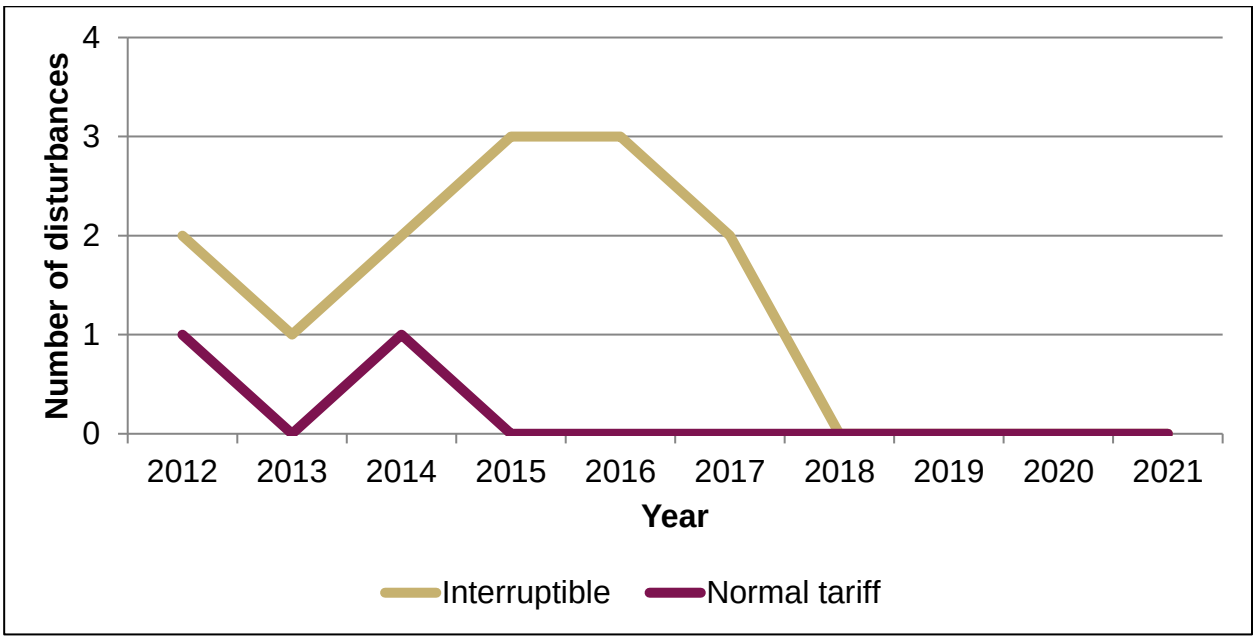

Figure 4: Under frequency disturbances 2012-2021

Figure 5 provides a trend of the lowest system frequency by year since 2012.

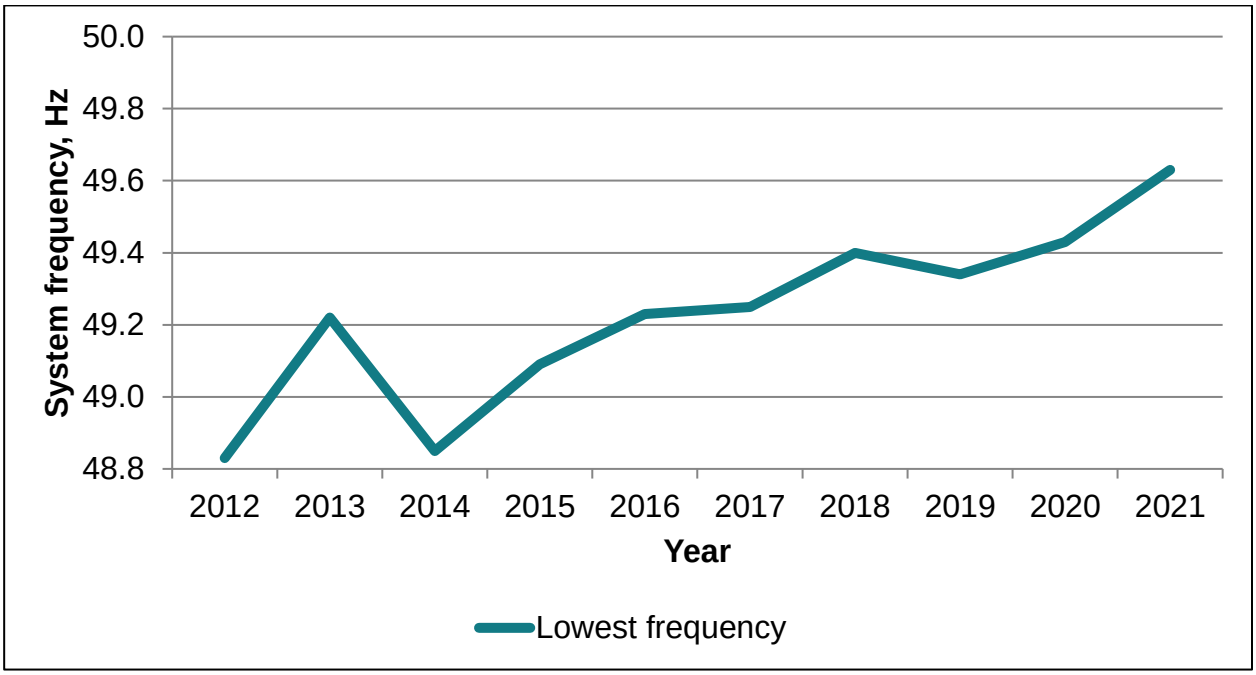

Figure 5: Lowest system frequency 2012-2021

4.3.2 Under-Voltage Load Shedding

There was no incident of Under-Voltage Load Shedding in 2021.

4.4 System Minutes Lost

This section provides information for system minutes lost (SML) attributable to the transmission system operator.

System minutes lost is a measure of the energy not supplied for a disturbance. The metric takes account of the load lost (MW), duration of disconnection (minutes) and peak system demand (MW), to allow for historical comparison. For example, if 300 MW were lost for 10 minutes and the system peak was 3000 MW, this would represent one system minute.

- System minutes = (load x duration) / (system peak) = (300 x 10) / 3000 = 1

The total system minutes lost (SML) as a result of faults on the main system for 2021, attributable to EirGrid, was 0.05369. There were no under frequency load shedding disturbances which resulted in the disconnection of normal tariff load customers.

The trend of system minutes lost (SML) since 2012 is shown in Figure 6, with incentive / penalty limits and deadbands as provided by the Commission for Regulation of Utilities. The central target provided until 2020 was replaced in 2021 with a deadband between 0.75 and 2.5 SML, where there is neither penalty nor incentive. One fifth of the incentive amount is awarded for every 0.1 SML below 0.75, down to 0.25 SML. One fifth of the incentive amount is penalised for every 0.1 SML above 2.5, up to 3.0 SML.

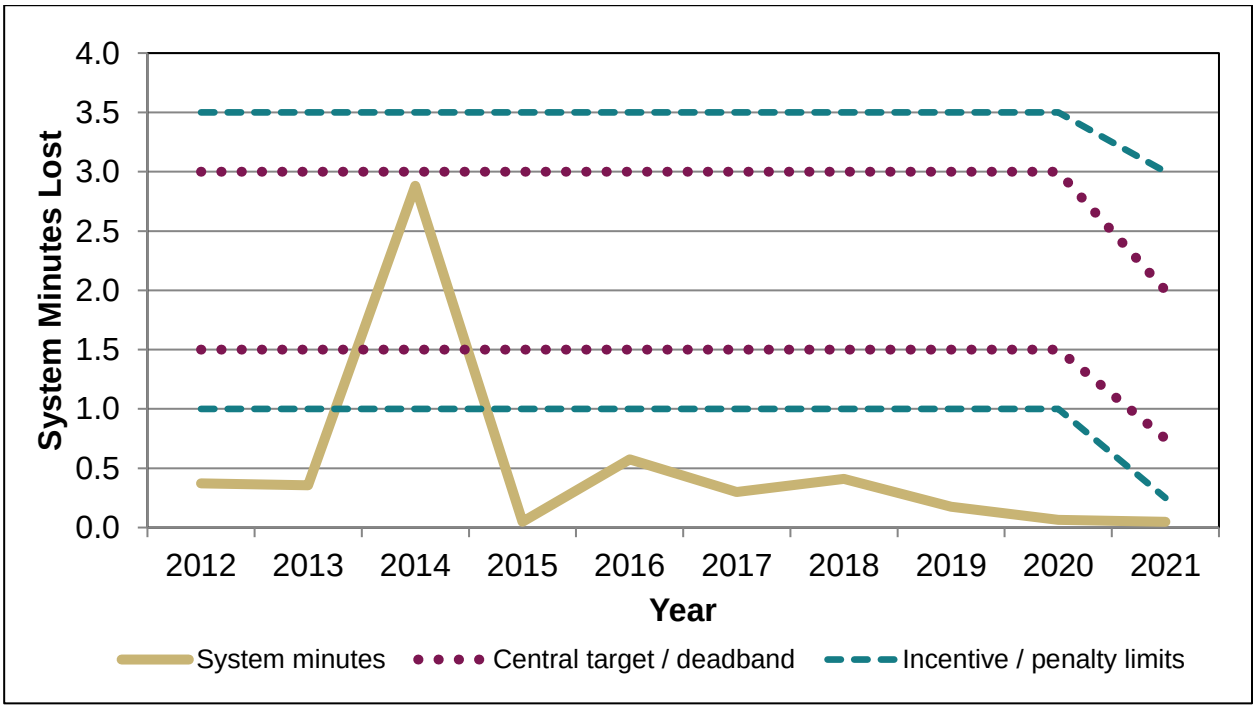

Figure 6: System minutes lost and associated targets: EirGrid 2012-2021

4.5 Zone Clearance Ratio

This section provides details of the short circuit faults on the main system and outside the main system for which main system protection is expected to operate without delay.

Zone clearance ratio (ZCR) is defined as the ratio of the number of short circuit faults, not cleared in zone 1 to the total number of short circuit faults per year cleared by main system protection. See Appendix 1 for further definition of Zones and ZCR.

Of the 47 short circuit faults in 2021, the main system protection was expected to operate without delay for all 43 of those short circuit faults on the main system. All 43 faults had zone 1 clearances, giving a zone clearance ratio of zero. The ZCR trend since 2012 is shown in Figure 7.

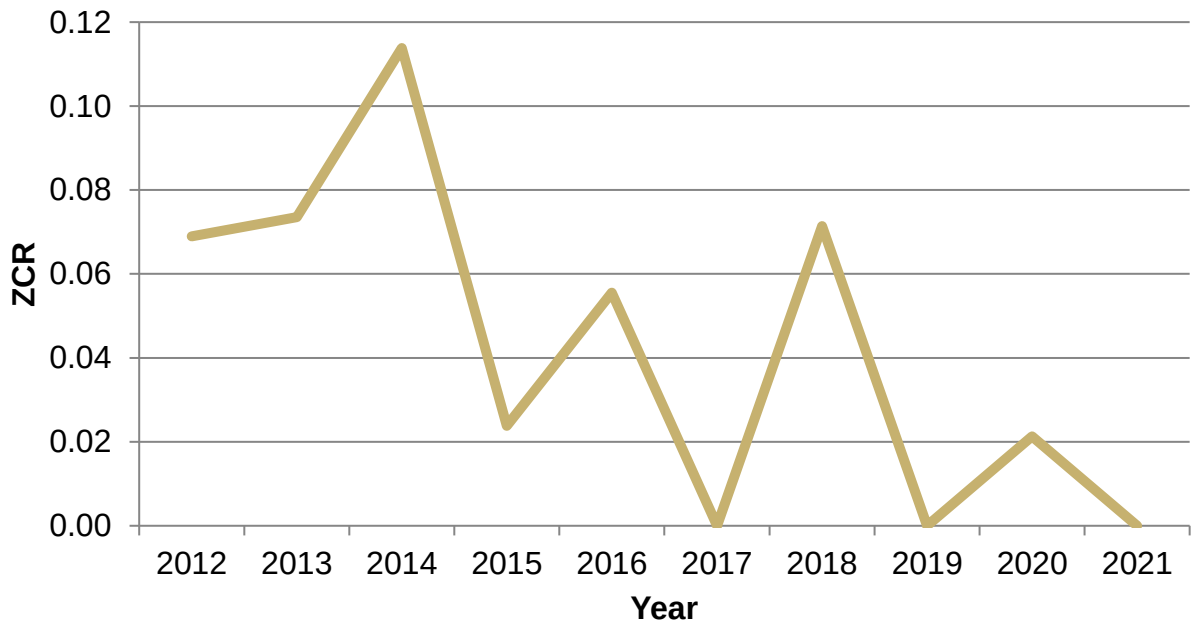

Figure 7: Zone clearance ratio: EirGrid 2012-2021

4.5.1 Frequency Control

In 2021 the system frequency was operated between 49.9 Hz to 50.1 Hz for 98.63% of the time.

4.6 Summary of key disturbances

4.6.1 Loss of load

In April, the Charleville-Glenlara 110 kV line tripped for a single phase to ground fault (SE). The cause of the fault is unknown and no weather warning was in place at the time of the disturbance. The impedance and earth protection operated to clear the fault in 75 ms. An interruption to end-users occurred, resulting in 0.017640 system minutes lost.

In August, the T141 and T143 transformers tripped in Binbane 110 kV station and T141 in Ardnagappary 110 kV station in response to a fault on the Letterkenny-Tievebrack 110 kV line. An interruption to end-users occurred, resulting in 0.005090 system minutes lost.

In November, the T143 transformer tripped in Binbane 110 kV station and T141 in Ardnagappary 110 kV station in response to a fault on the Letterkenny-Tievebrack 110 kV line . An interruption to end-users occurred, resulting in 0.030937 system minutes lost.

In December, the Arigna-Carrick-on-Shannon-Corderry 110 kV line tripped and reclosed for a single phase to ground fault (TE). SPS tripped in Arigna 110 kV station. The differential and impedance protection operated to clear the fault in 86 ms. The cause of the fault was wind and a weather warning was in place for Storm Barra at the time of the disturbance. An interruption to end-users occurred, resulting in 0.000023 system minutes lost.

4.6.2 Under-Frequency Load Shedding

There were no under frequency load shedding disturbances in 2021.

4.6.3 Storms Resulting in Trippings

Between 17:26 hours on Tuesday 07 December 2021 and 01:04 hours on Wednesday 08 December 2021, there were a total of 20 single-phase-to-ground faults and one two-phase fault. The cause of the faults were wind cause by Storm Barra. All faults were zone 1 clearances and fault clearance times were between 52 ms and 86 ms. An interruption to end-users occurred, resulting in 0.000023 system minutes lost.

4.7 Transmission System Availability & Outages

4.7.1 Transmission System Availability

When considering transmission system availability, it is the convention to analyse it in terms of transmission system unavailability. The formula for calculating transmission system unavailability is given in Appendix 5. Figure 8 shows the percentage Transmission System Unavailability in each month for 2021.

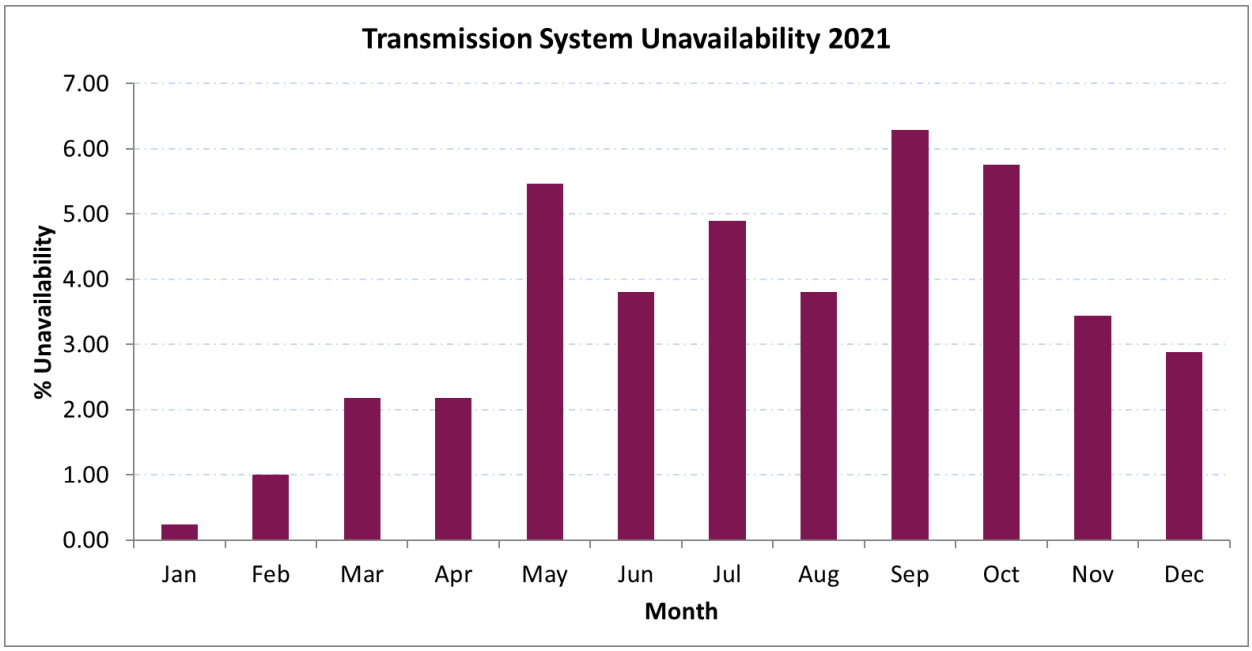

Figure 8: Monthly Variations of System Unavailability 2021

4.7.2 Transmission Plant Availability

The measure of plant availability is the kilometre-day for feeders and the MVA-day for transformers. The availability figures vary between the different categories of plant. The formulae for calculating transmission plant availability are provided in Appendix 1.

Table 6 provides a detailed breakdown of all plant availability figures for 2021.

Table 6: Transmission System Plant Availability 2021

Plant Type	Circuit Length [km]	Number of Outages	Availability (%) 2021
110 kV Circuits	4,623	349	96.28
220 kV Circuits	1,950	66	95.59
275 kV Circuits	97	0	100.00
400 kV Circuits	439	6	99.87
Plant Type	**Transformer Capacity [MVA]**	**Number of Outages**	**Availability (%) 2021**
220 / 110 kV Transformers	11,864	67	92.92
275 / 220 kV Transformers	1,200	3	99.79
400 / 220 kV Transformers	3,950	6	97.85
Total	7,109 km	497	**Weighted Average (%)**
	17,014 MVA		95.71

4.7.3 Cause of Transmission Plant Unavailability

Transmission plant unavailability is classified into the categories outlined in Table 7.

Table 7: Transmission System Plant Unavailability Categories

Category	Description
Forced & Fault	Refers to unplanned outages. An item of plant trips or is urgently removed from service. Usually caused by imminent plant failure. There are three types of forced outage: A) Fault & Reclose B) Fault & Forced C) Forced (No Tripping) The above forced outages are explained in detail in Section 6.6.
Safety & System Security	**Safety:** Refers to transmission plant outages which are necessary to allow for the safe operation of work to be carried out. **System Security:** Refers to outages which are necessary to avoid the possibility of cascade tripping or voltage collapse as a result of a single contingency. When a line is out for maintenance it may be necessary to take out additional lines for this reason.
New Works	An outage to install new equipment or uprate existing circuits.
Corrective & Preventative Maintenance	**Corrective Maintenance:** Is carried out to repair damaged plant. Repairs are not as urgent as in the case of a forced outage. **Preventative Maintenance:** Is carried out in order to prevent equipment degradation which could lead to plant being forced out over time. Includes line inspections, tests and routine replacements.
Other Reasons	A number of other reasons may be attributed to plant unavailability, such as testing, protection testing and third-party work.

4.7.4 110 kV Circuit Unavailability

Figure 9 provides a breakdown of the causes of unavailability on the 110 kV network in 2021.

The largest contributor to unavailability (45%) on the 110 kV network was attributable to the "New Works" category. This category is for outages to install new equipment or uprate existing circuits.

A further 39% of unavailability on the 110 kV network in 2021 were outages for the purpose of “Corrective and Preventive Maintenance”. This type of maintenance includes, amongst others, ordinary services, condition assessments, wood-pole replacement/straightening and general line maintenance.

9% of unavailability was due to forced outages.

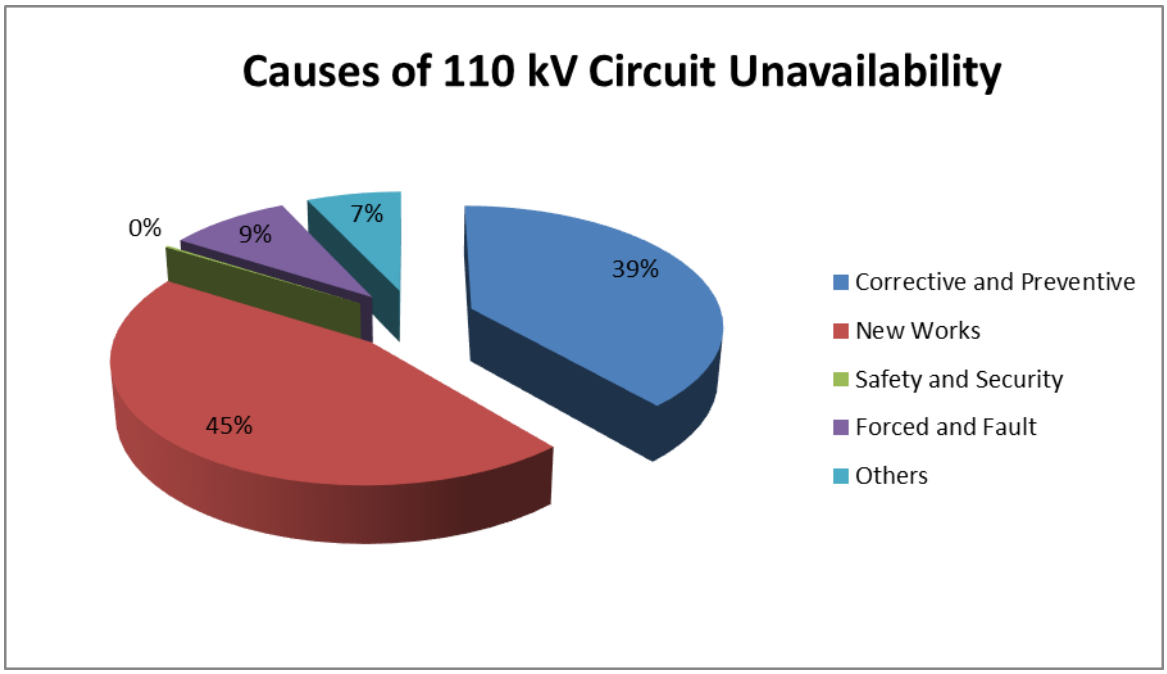

Figure 9: Causes of Unavailability on the 110 kV System in 2021

4.7.5 220 kV Circuit Unavailability

Figure 10 provides a breakdown of the causes of unavailability on the 220 kV network in 2021. The largest contributor to unavailability (58%) on the 220 kV network in 2021 were outages for the purpose of "New Works". A further 21% of unavailability on the 220 kV network was attributable to “Corrective and Preventive Maintenance”.

Approximately 12% of unavailability on the 220 kV network was attributable to Forced and Fault.

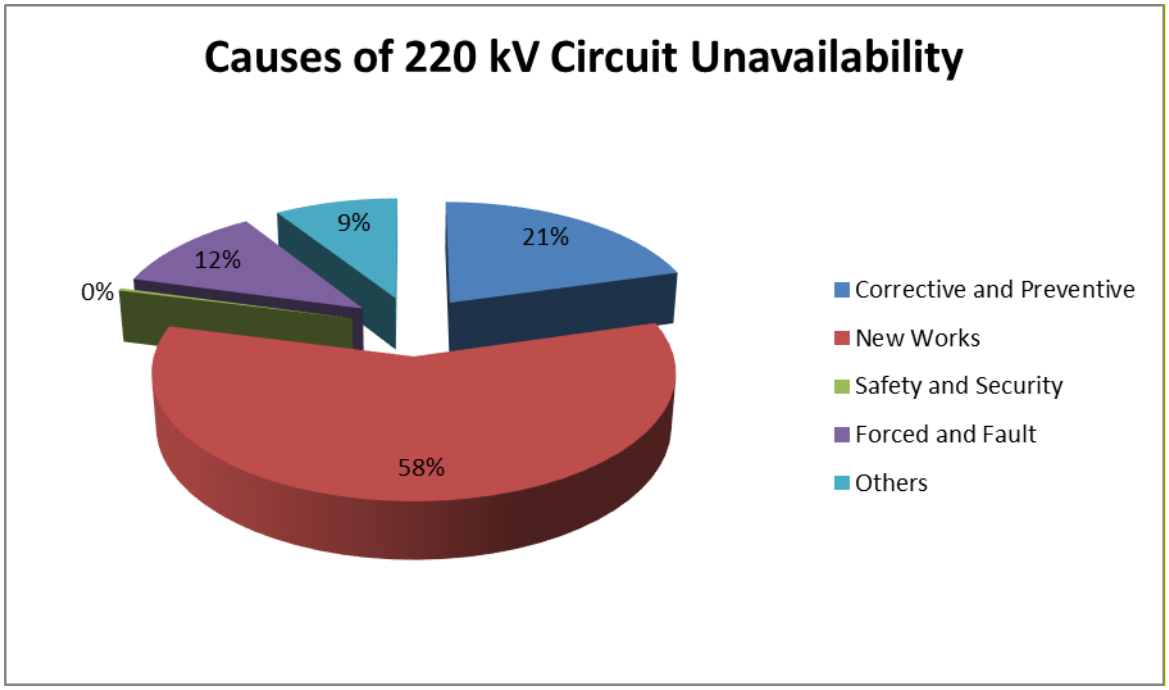

Figure 10: Causes of Unavailability on the 220 kV System in 2021

4.7.6 275 kV Circuit Unavailability

The 275 kV tie-line consists of 48.5 km of 275 kV double-circuit between Louth station and Tandragee station which is situated in County Armagh. In 2021 there were no outages of 275 kV tie-lines.

4.7.7 400 kV Circuit Unavailability

Figure 11 provides a breakdown of the causes of unavailability on the 400 kV network in 2021.

There were only five days of outages on the 400 kV network in 2021 with the largest contributor being outages to energise other plant.

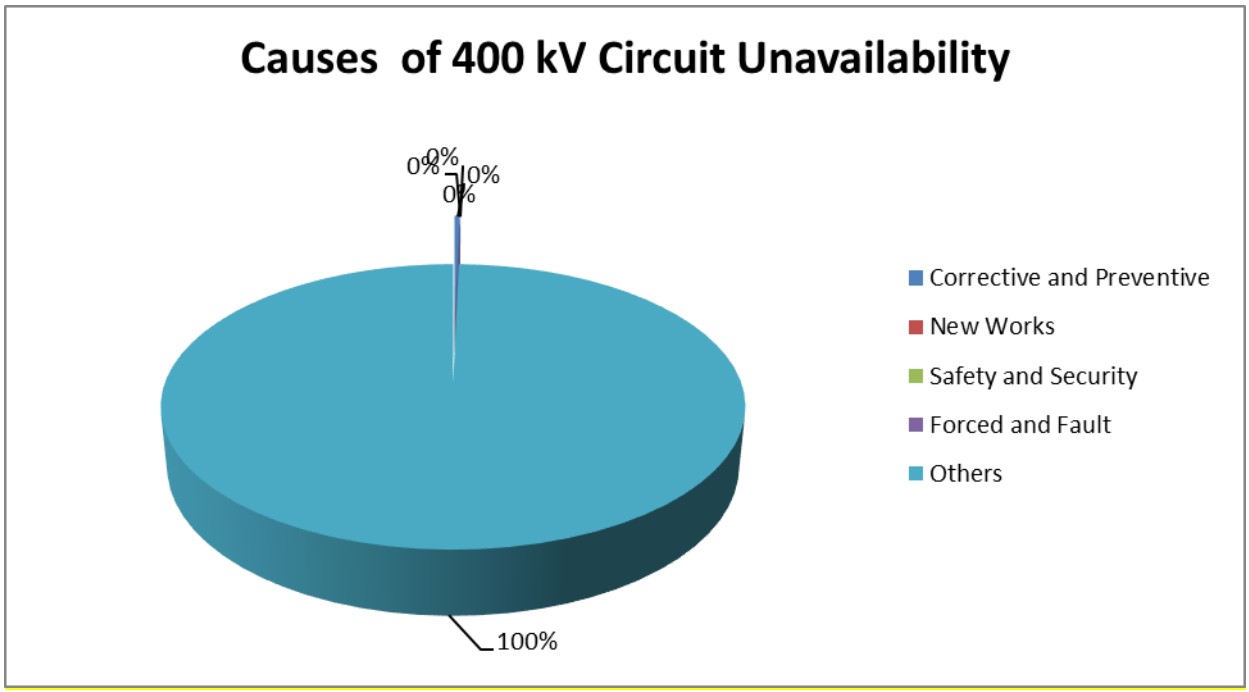

Figure 11: Causes of Unavailability on the 400kV System in 2021

Table 8 provides a breakdown of the transmission system outages that occurred in 2021 by plant type.

Table 8: Transmission System Plant Outage 2021

Plant Type	No. of Items	Circuit Length	Forced & Fault	Safety & System Security	New Works	Corrective & Preventive Maintenance	Other	Total No. of Outages
110 kV Circuits	239	4,623	27	10	56	200	56	349
220 kV Circuits	67	1,950	11	2	14	31	8	66
275 kV Circuits	2	97	0	0	0	0	0	0
400 kV Circuits	4	439	0	0	0	2	4	6
Total	312	7,109	38	12	70	233	68	421
Plant Type	**No. of Items**	**Transformer Capacity**	**Forced & Fault**	**Safety & System Security**	**New Works**	**Corrective & Preventive Maintenance**	**Other**	**Total No. of Outages**
220 / 110 kV Trafos	58	11,864	9	1	15	35	7	67
275 / 220 kV Trafos	3	1,200	0	0	2	1	0	3
400 / 220 kV Trafos	8	3,950	2	0	0	4	0	6
Total	69	17,014	11	1	17	40	7	76

4.7.8. East West Interconnector

The East West Interconnector (EWIC) is a high-voltage direct current (HVDC) scheme which links the power systems of Ireland and Great Britain. It has a power rating of 500 MW. EWIC is a fully regulated interconnector which was developed and is owned by EirGrid Interconnector DAC (EIDAC) which is part of the EirGrid Group. The scheme consists of two Converter Stations located in Meath, Ireland and Deeside, Wales connected by 264 km HV cable, 185 km of which is submarine.

4.7.9. East West Interconnector Unavailability

In 2021 the availability of the East West Interconnector (EWIC) was 97.54%. Outages contributing to EWIC unavailability mostly included maintenance works.

4.7.10 Transmission Outage Duration

The duration of transmission outages is useful for assessing transmission system performance. Transmission outages are broken into eight time classifications ranging from less than 10 minutes to greater than four weeks. The total number of outages in each time classification is shown in Figure 12.

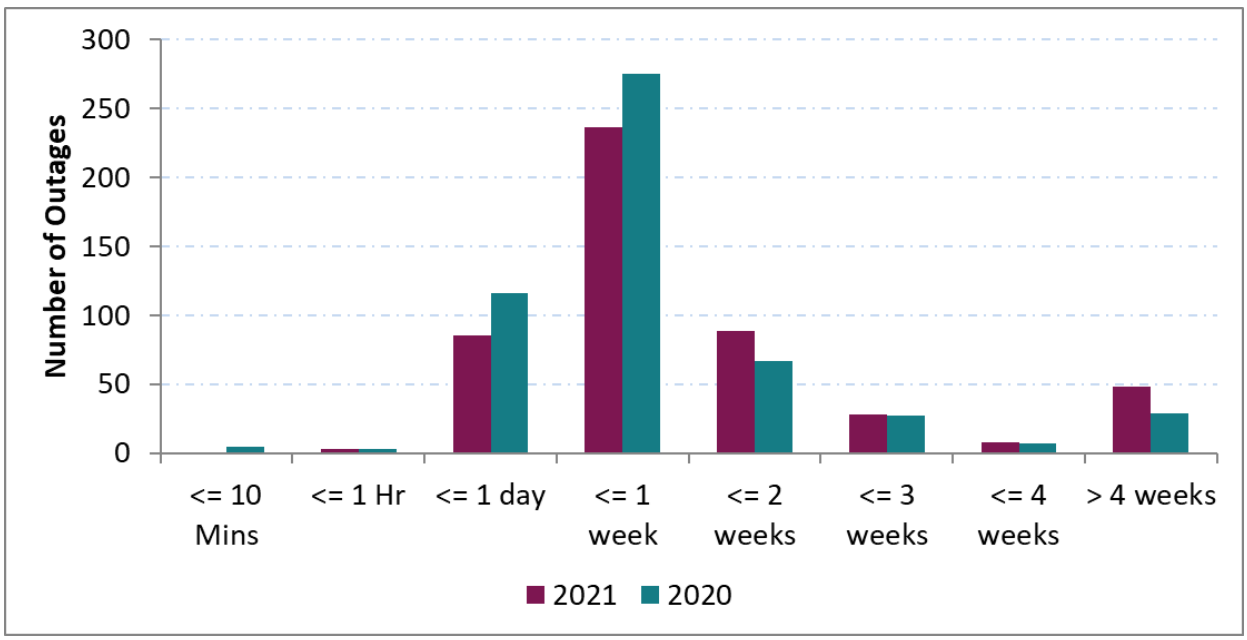

Figure 12: Duration of Outages in 2020 & 2021

The majority of the outage durations are concentrated between one day and 2 weeks with the peak occuring between one day and 1 week. In the category of one hour to one day, outages can be arranged to avoid peak load times and thereby reduce the impact on the system, while one week outages for annual maintenance are commonplace during the outage season.

4.7.11 Timing of Transmission Outages

Transmission outages are scheduled, where possible, during periods of low load in the summertime (however, this can be limited by a number of factors such as personnel availability and shortage of hydro-power support in some areas). The seasonal nature of transmission outages is apparent in Figure 13 below.

Figure 13 shows the percentage unavailability of the transmission system in each month. The March-November period (known as the outage season) sees the highest rates of unavailability during the year, when decreased system load is taken advantage of to carry out extensive maintenance outages. Figure 14 shows the average duration in days of the transmission outages in each month in 2020.

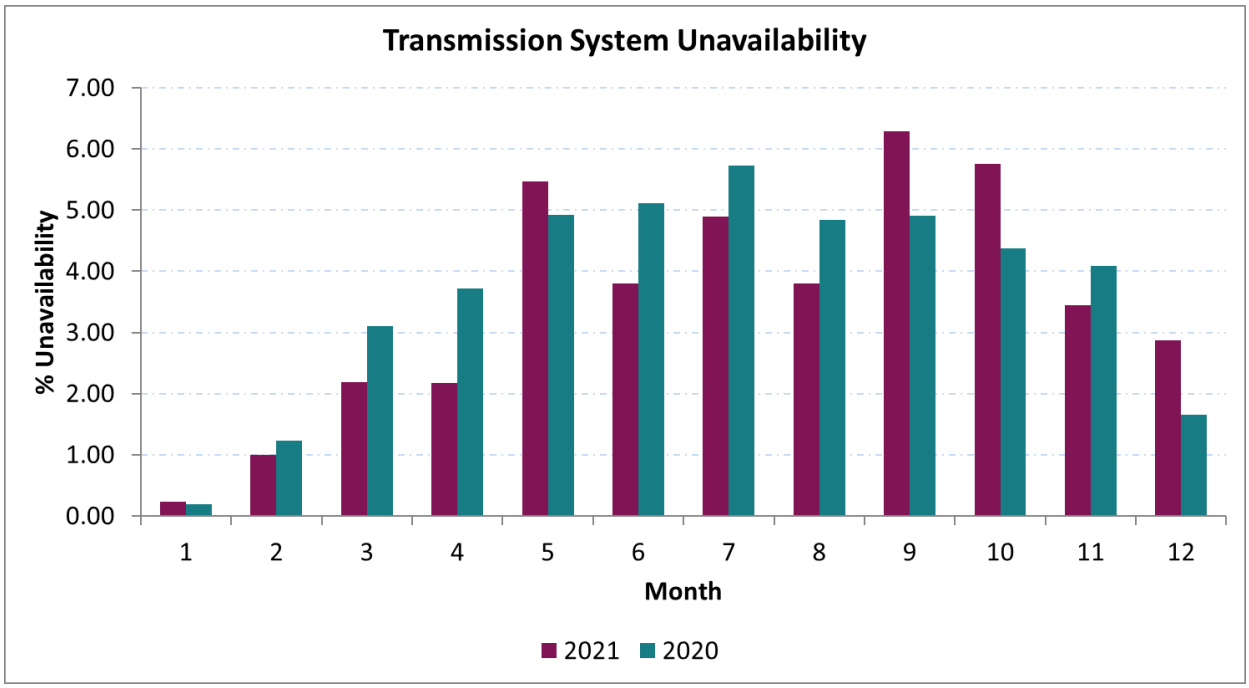

Figure 13: Percentage unavailability in each month of 2020 & 2021

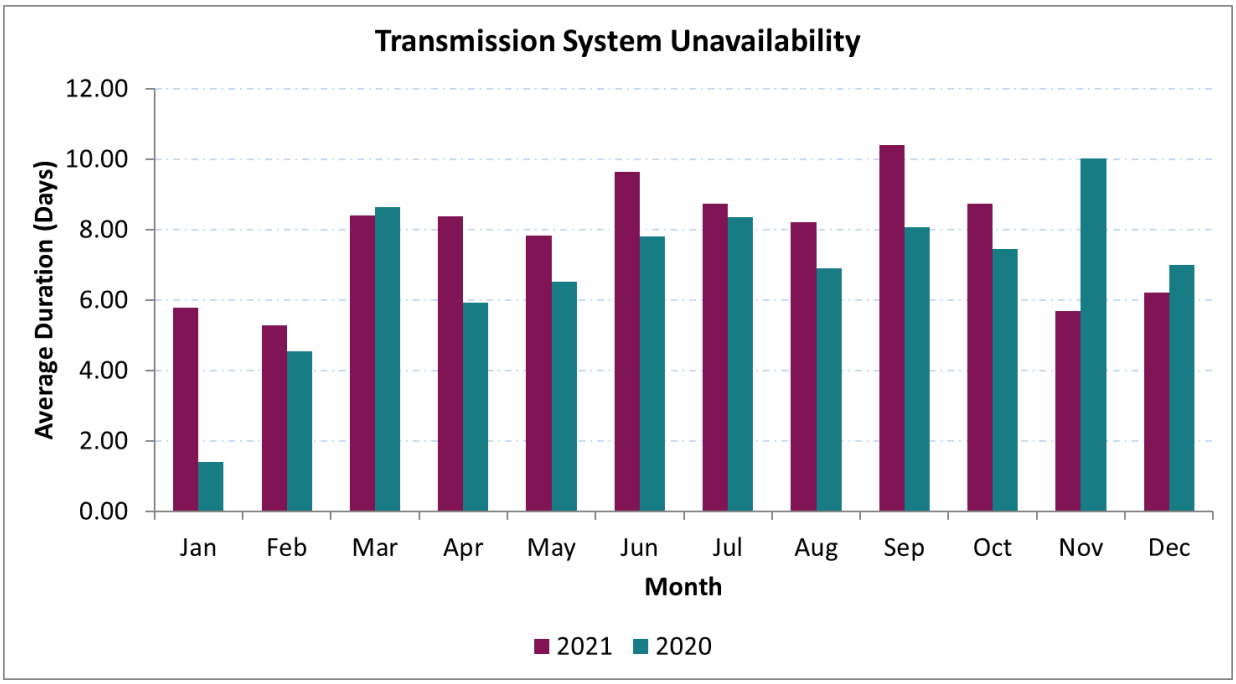

Figure 14: Average duration of outages 2020 & 2021

4.7.12 Forced Outages

There are two main outage classifications, voluntary outages and forced outages. The majority of outages are voluntary outages that are scheduled by EirGrid. Forced outages are not scheduled and cause the most disruption to the transmission system. Due to their disruptive nature, forced outages merit further analysis.

4.7.13 Forced Outages per km

The measure used for analysing the forced outages of lines and cables is the number of forced outages per kilometre of feeder, and is shown in Figure 15.

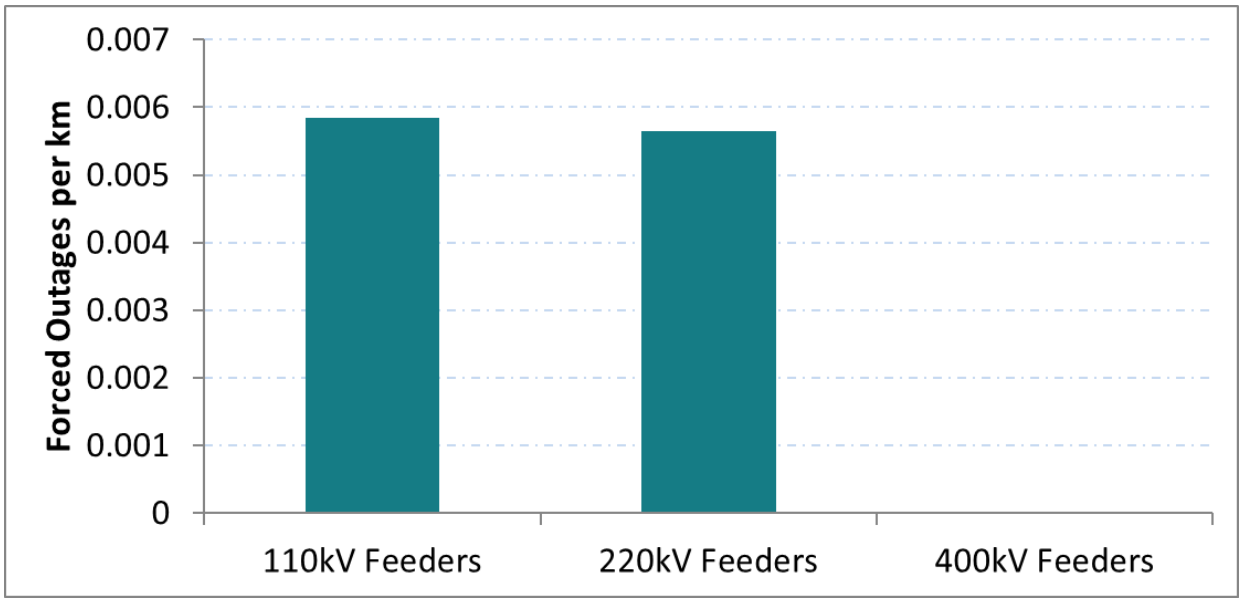

Figure 15: Forced Outages of lines and cables per km in 2021

4.7.14 Forced Outages per MVA

The measure used for analysing the forced outages of transformers is the number of forced outages per MVA capacity, which can be seen in Figure 16.

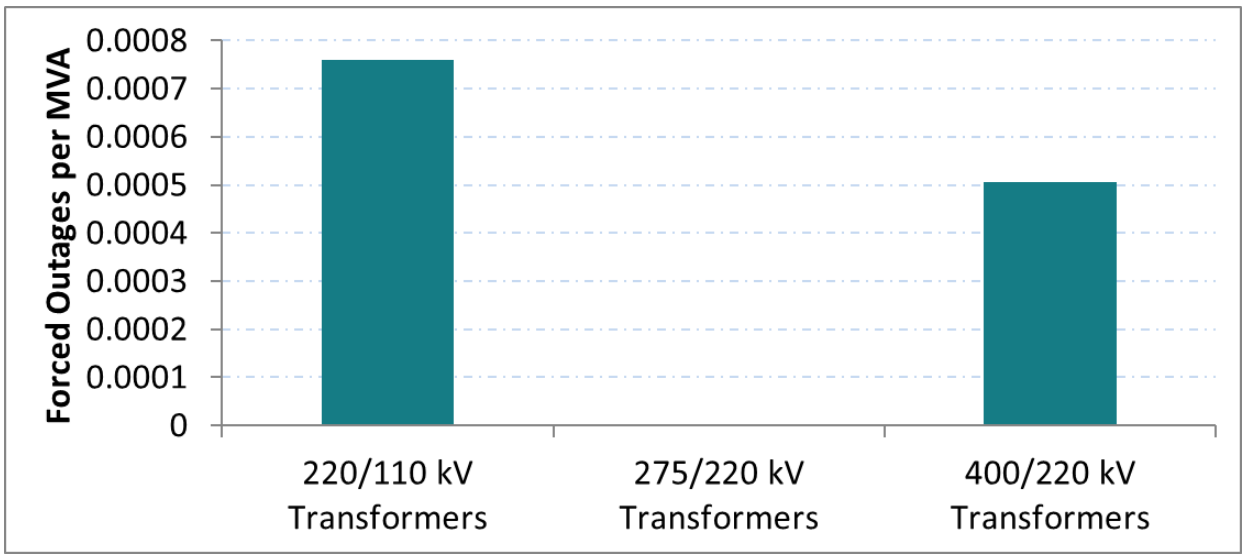

Figure 16: Forced Outage per MVA in 2021

5. SONI Transmission System Performance

This section details the performance of the transmission system in Northern Ireland, unless explicitly stated otherwise. This data has been prepared by SONI in accordance with Condition 20 of the 'Licence to participate in the Transmission of Electricity'.

5.1 Summary

SONI is responsible for the safe, secure, efficient and reliable operation of the Northern Ireland transmission network. The transmission network is operated at 275 kV and 110 kV and is made up of 114 circuits covering a total length of approximately 2,309 km. The primary purpose of the transmission system is to transport power from generators and interconnectors to bulk supply points which connect the transmission system to the distribution system.

Availability is a key measure of power system performance. In this report availability refers to the proportion of time a transmission circuit or interconnector was available.

- The annual system availability for 2021 was 96.39%.
- The annual availability of the Moyle Interconnector for 2021 was 97.98%.
- The North-South 275 kV tie line, connecting Louth in Ireland and Tandragee in Northern Ireland, had an availability of 99.77% in 2021.
- The annual availability of the Strabane – Letterkenny and Enniskillen – Corraclassy 110 kV tie lines was 90.03% and 97.55% respectively in 2021.

The Electricity Safety, Quality and Continuity Regulations (Northern Ireland) 2012 set out the statutory obligations in relation to managing both frequency and voltage for Northern Ireland. Under the regulation SONI is required to report incidents which have caused interruptions to supplies to customers to the transmission asset owner, NIE Networks. Part 8, paragraph 33 of the regulation contains details of the requirements for the reporting of incidents.

In 2021, there was one transmission incident leading to customers being off supply. This was;

- On the 11th of January at 13:28, an incident at Hannahstown resulted in the loss of supply to 35,083 customers, equating to a total loss of 29 MW. The total system minutes lost for this event was 0.015 minutes

Quality of service is measured by the number of voltage and frequency excursions which fall outside statutory limits. There were no voltage excursions in 2021 outside the statutory limits.

The nominal frequency of the all-island transmission system is 50 Hz, and is normally controlled within the range of 49.95 Hz and 50.05 Hz. SONI is required to report on system faults where the frequency drops below 49.8 Hz or above 50.2 Hz. In 2021, there were 10 system events where the frequency exceeded these limits.

The reporting of frequency excursions is carried out in accordance with the definitions and principles of the National Fault and Interruption Reporting Scheme (NAFIRS), (Engineering Recommendation G43/2). The effects of national / regional emergencies and disputes are excluded.

5.2 Transmission System Availability

5.2.1 System Availability

Transmission system availability is the proportion of time a transmission circuit was available during the calendar year. A circuit is defined as the overhead line, cable, transformer or any combination of these that connects two busbars together or connects the transmission system to another system. Transmission system availability is reduced when a circuit is taken out of service, either for planned or unplanned purposes.

Planned outages are necessary to facilitate new user connections, network development and maintenance of network assets necessary to deliver acceptable levels of system security and reliability. These are outages planned with at least seven days' notice.

Unplanned outages can be a result of equipment failure or a fault caused by adverse weather etc. These are outages required immediately or planned with less than seven days' notice.

System Availability is calculated using the formula:

$$\text{Sytem Availability (\%)} = \frac{\sum \text{Hours each circuit is available}}{(\text{No. of Circuits}) * (\text{Total No. Hours in Period})}$$

In 2021, the analysis of the transmission system availability data has produced the following results:

The average availability of the Northern Ireland transmission system was in 2021 was 96.39%; and
The average winter system availability (for the winter months January, February, November and December 2021) was 98.87%.

Figure 17 below shows the month by month variation in Transmission System Availability in Northern Ireland.

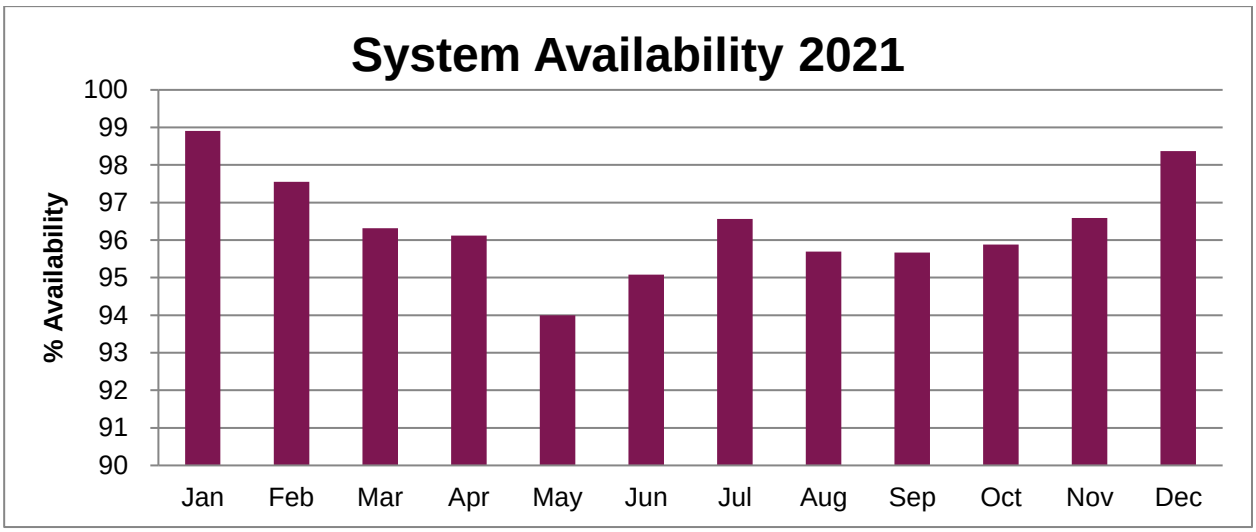

Figure 17: Transmission System Availability 2021

Overall, the availability of the system is high, particularly over the winter months, such as January and December, where maintenance is avoided due to the higher electrical demand and potential adverse weather conditions. The preference is for maintenance to take place over the summer months when network loading is generally lower to mitigate the risk of affecting the supply to customers.

5.2.2 System Unavailability

Figure 18 below shows the month by month variation in planned and unplanned system unavailability.

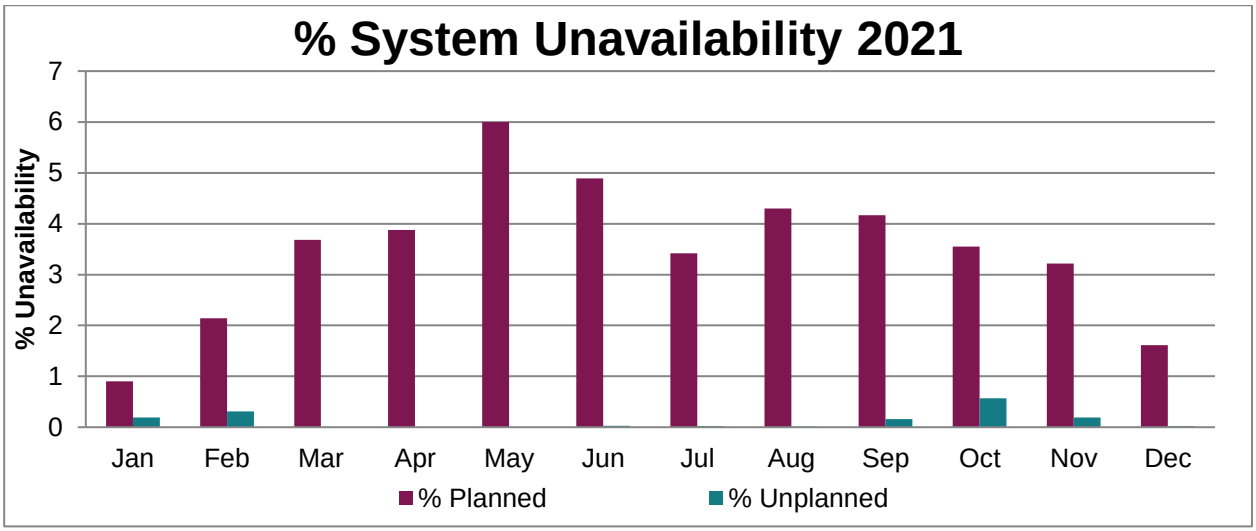

Figure 18: Transmission System Unavailability 2021

Transmission outages are planned during the spring/ summer/ autumn months where possible. This is to take advantage of periods when the Northern Ireland demand is lower and hence power flows around the transmission system are reduced. During the winter months when demand is higher, only urgent outages or outages that will not reduce the reliability of the transmission system can be accomodated. This is to ensure the resilience of the transmission system is maintained.

5.2.3 System Historical Availability Performance

Figure 19 shows the historic variation in system availability from 2005/2006 to 2021 for the transmission network in Northern Ireland.

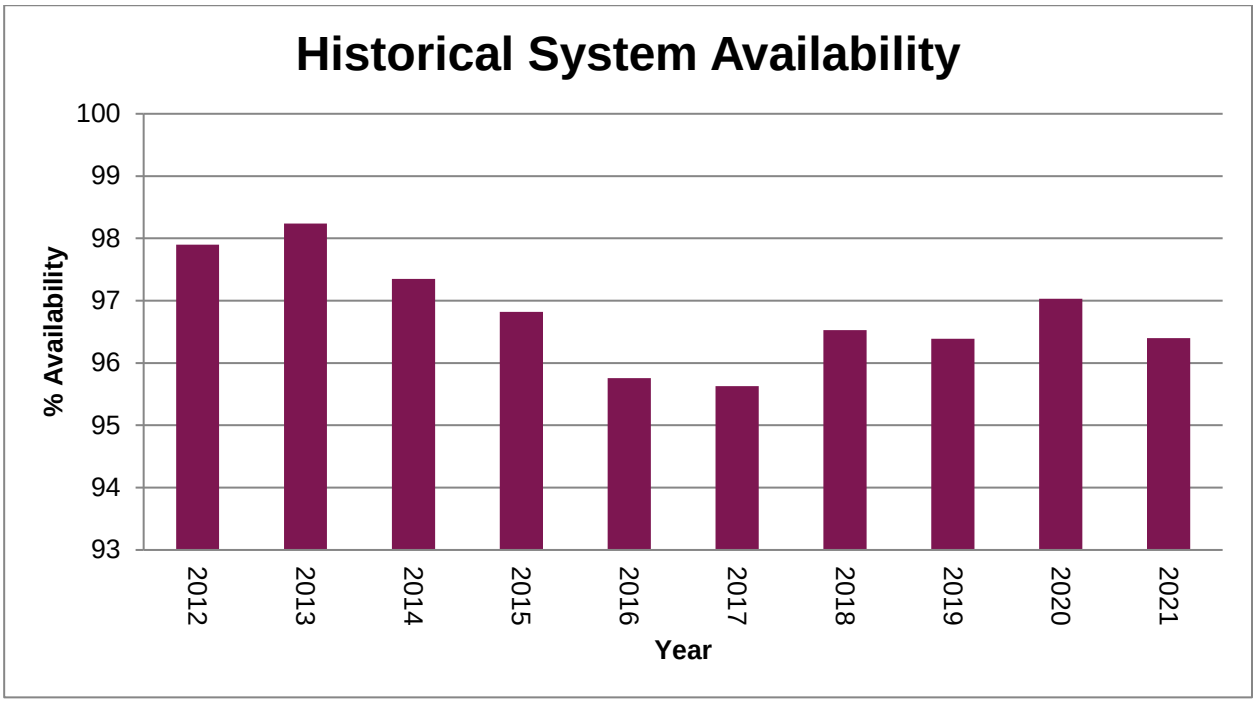

Figure 19: Historical System Availability 2012 to 2021

5.2.4 System Historical Unavailability Performance

Figure 20 below shows the breakdown of the system unavailability from 2012 to 2021.

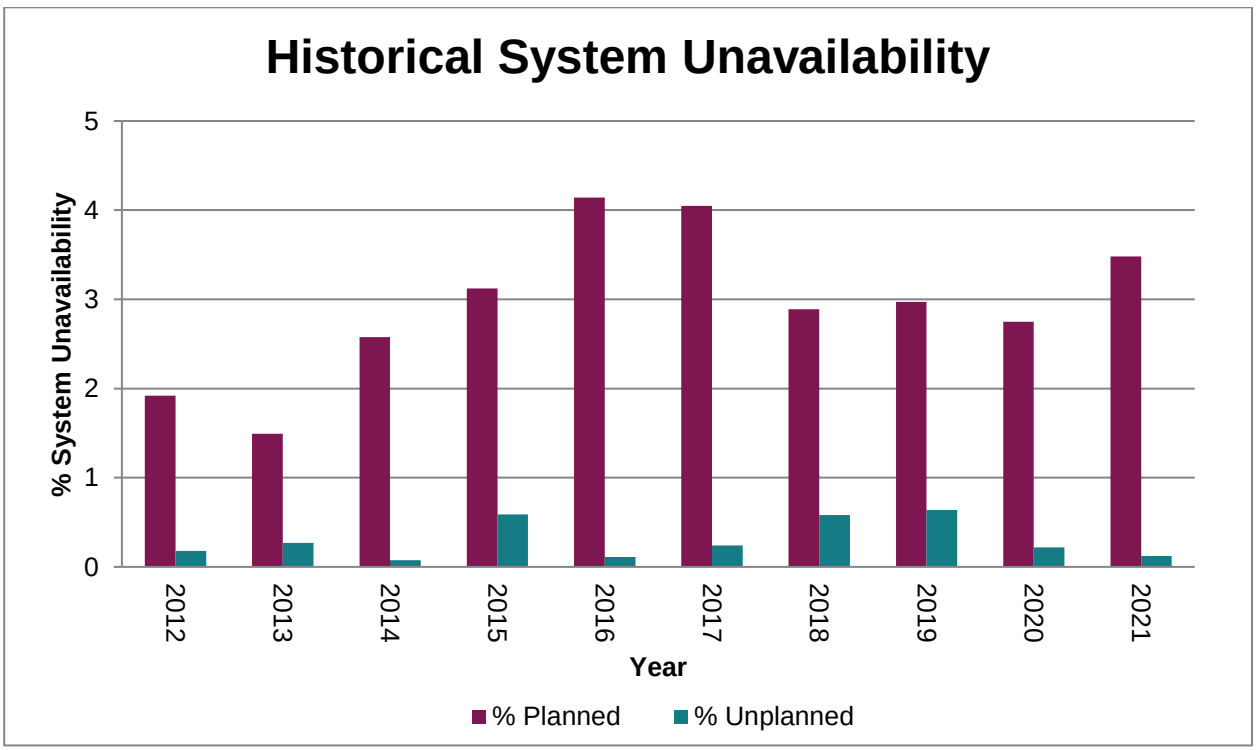

Figure 20: Historical System Unavailability 2012 to 2021

5.2.5 Moyle Interconnector

The Moyle interconnector, owned by Mutual Energy, connects the power systems of Northern Ireland and Scotland. The interconnector is a High Voltage Direct Current (HVDC) system; consisting of two submarine power cables and two HVDC-AC converter stations; one located at Islandmagee in Northern Ireland and the other at Auchencrosh in Scotland.

The system has an operational import capacity of 442 MW and an operational export capacity of a maximum 400 MW. The firm export limit on Moyle is 275 MW due to to network limitations in Scotland. There is an agreed process between Moyle and NGESO on releasing additional “non-firm” export capacity when GB system conditions allow.

The interconnector is operated by SONI, and the performance of the interconnector is detailed in this report.

During 2021, the longest Moyle outage was a 5-day scheduled outage in July.

5.2.6 Moyle Interconnector Historical Availability

The Annual Availability of the Moyle Interconnector for 2021 was 97.98%.

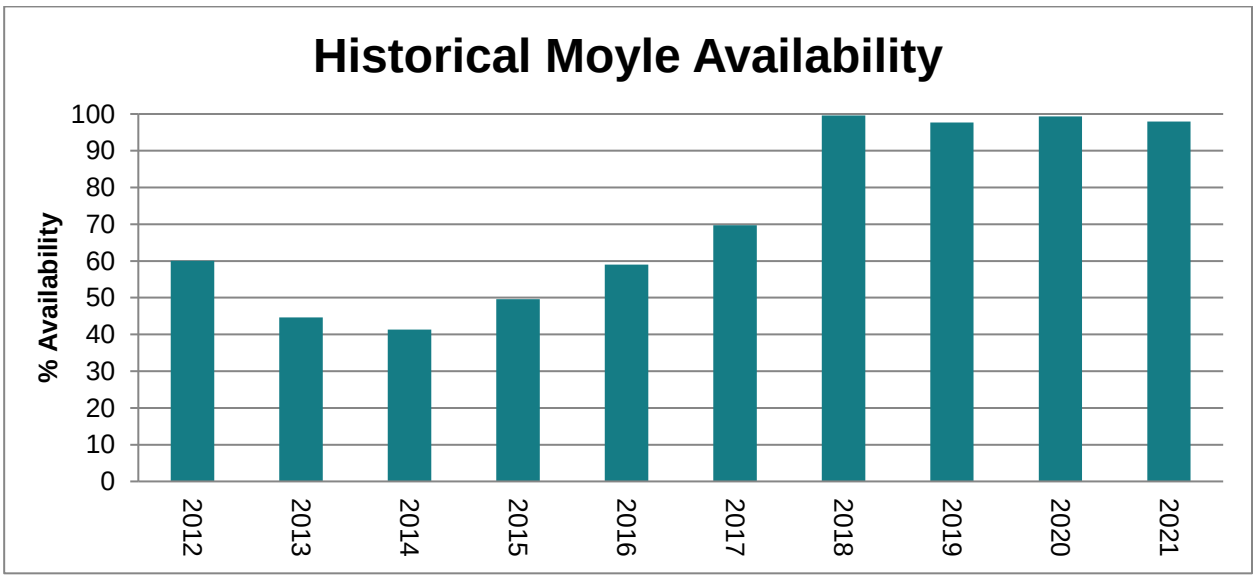

Figure 21: Historical Moyle Interconnector Availability 2012 to 2021

5.2.7 Moyle Interconnector Historical Unavailability

The 2021 Annual Unavailability of the Moyle Interconnector was 2.02%.

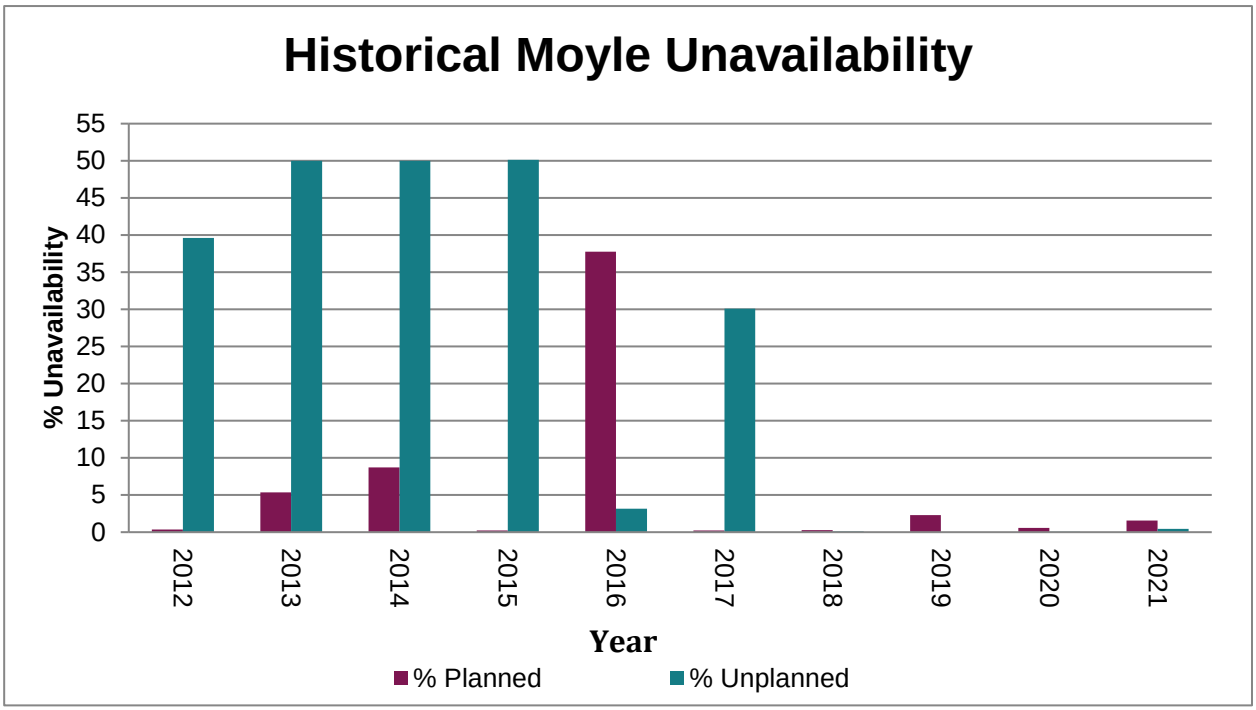

Figure 22: Historical Moyle Interconnector Unavailability 2012 to 2021

5.2.8 Moyle Interconnector Monthly Unavailability

Figure 21 below shows the month by month variation of unavailability of the interconnector.

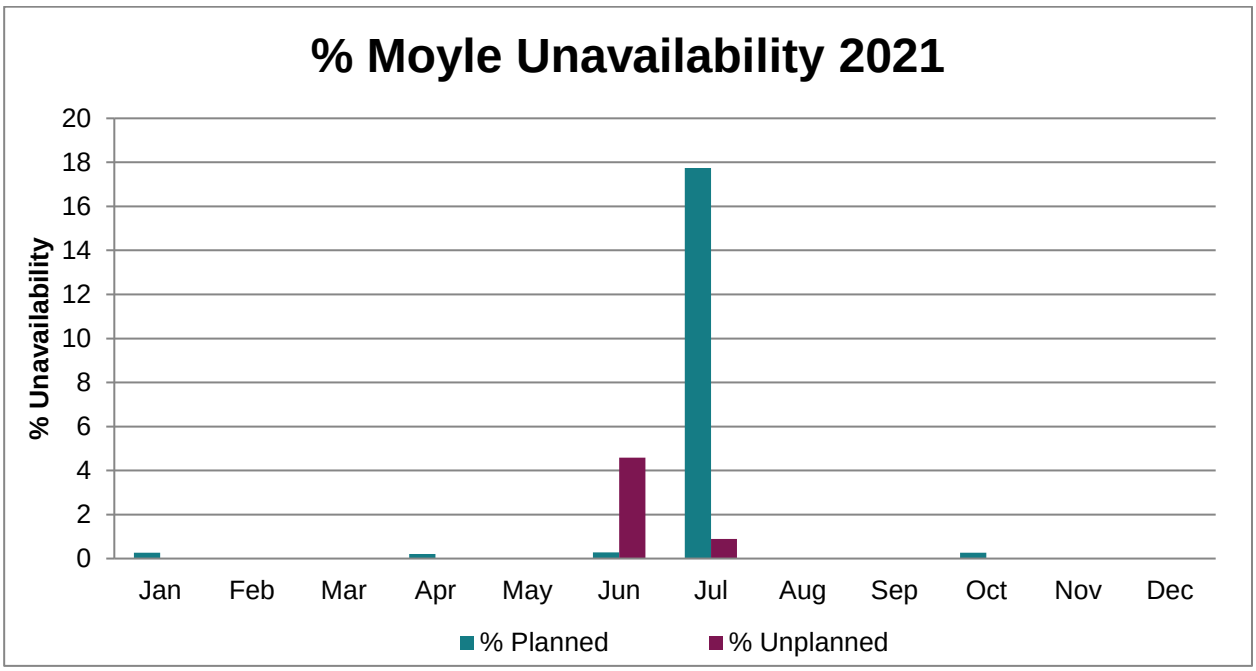

Figure 21: Moyle Interconnector Monthly Unavailability 2021

Figure 21 shows there were scheduled outages of the interconnector in January, April, June, July and October. The main scheduled outage occurred in July and was required to accommodate maintenance of the interconnector and work on the Scottish transmission system. There were 2 forced outages of the interconnector in June and July 2021.

5.2.9 275 kV Tie Line

The connections between Ireland and Northern Ireland are referred to as 'Tie Lines'.

The Northern Ireland transmission system is connected to the transmission system in Ireland by means of one 275 kV double-circuit connection from Tandragee 275 kV substation in Co. Armagh to Louth 220 kV substation in Co. Louth.

The 275 kV double-circuit tie line is used as the method for synchronising the Northern Ireland and Ireland power systems together. Energy can flow freely between both jurisdictions, depending on the operating requirements and generating plant being utilised on the all island power system.

The annual average availability of the 275 kV North-South Tie Line in 2021 was 99.77%.

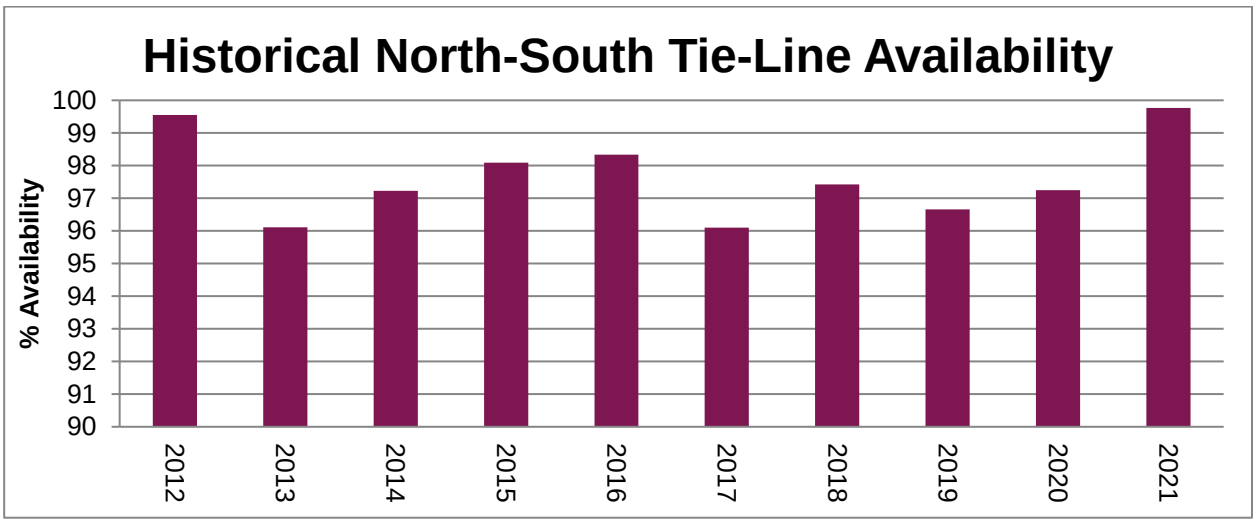

Figure 22: Historical North-South Tie Line Availability 2021 to 2021

5.2.10 110 kV Tie lines

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

Strabane – Letterkenny 110 kV circuit

Enniskillen – Corraclassy 110 kV circuit

These 110 kV tie lines provide an AC connection between the two transmission systems, which allows emergency flows of active and reactive power for frequency and voltage support, increasing system stability.

Phase Shifting Transformers (PST), designed for energy to flow in two directions, are installed at Strabane and Enniskillen and control the flow of energy between Ireland and Northern Ireland. These PSTs are rated at 125 MW each and are, in normal operation, operated to maintain a 0 MW flow between both jurisdictions.

To negate any potential system abnormalities as a result of transmission outages, either scheduled or unplanned, a flow can be manually allowed that can support system operation in both jurisdictions. Also, in times of high wind, the Strabane-Letterkenny tie line is used to import excess wind energy being produced.

The availability of the 110 kV Tie Lines was 93.79% in 2021.

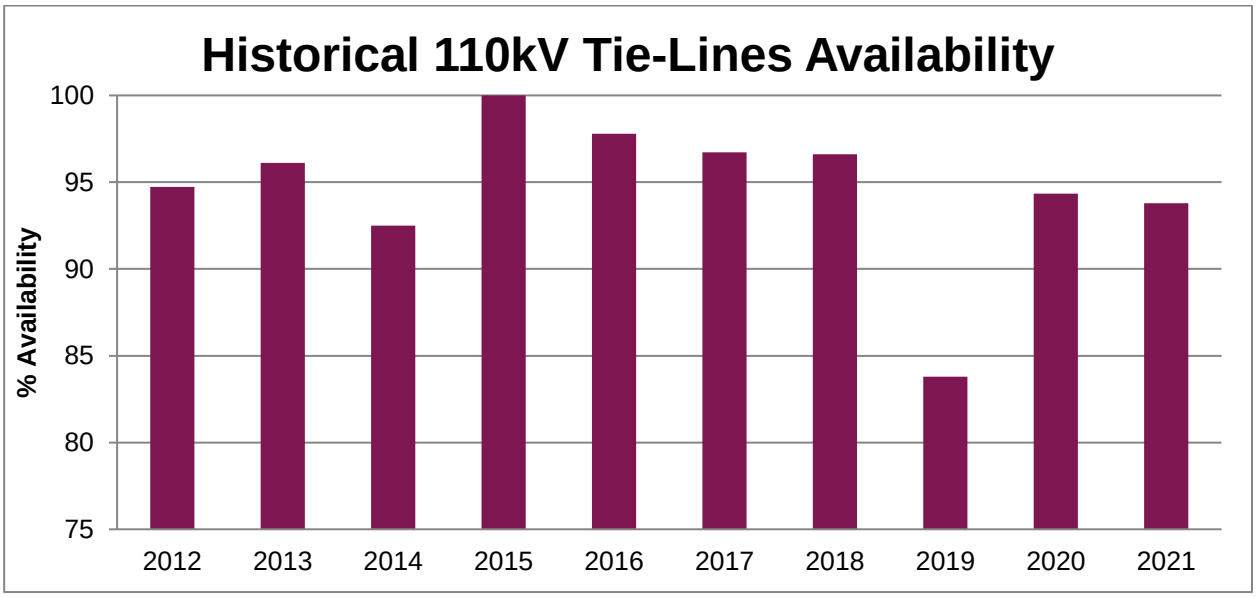

Figure 23: North-South Tie Line Availability 2012 to 2021

A breakdown of 110 kV tie line unavailability is shown in Figure 24 below.

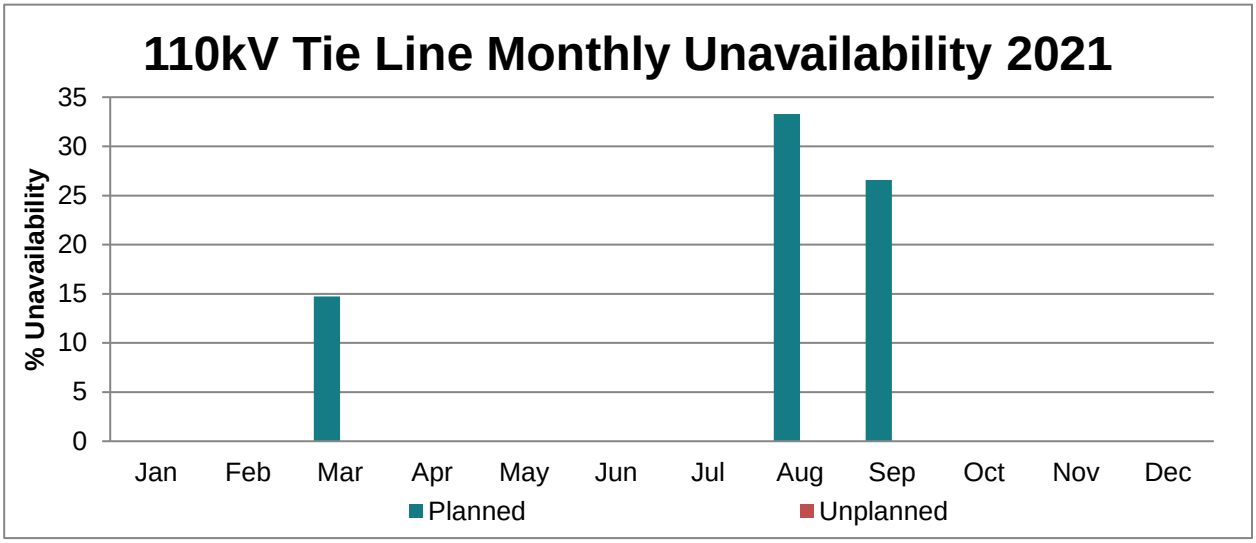

Figure 24: 110kV Tie Line Unavailability 2021

5.3 Transmission System Security

An incident is a system event that results in loss of supply. In this section incidents resulting from issues on the Northern Ireland Transmission system are described individually. The following sections detail the nature, location and duration of the incidents with an estimate of energy unsupplied.

5.3.1 Incidents for 2021

The criterion for the reporting of incidents is specified in Part 8, paragraph 33, of 'The Electricity Safety, Quality and Continuity Regulations (Northern Ireland) 2012'. An incident shall be reported if there has been:

any single interruption of supply, to any demand of 20 MW or more at the time of the interruption, for a period of three minutes or longer; or
any single interruption of supply, to any demand of 5 MW or more at the time of the interruption, for a period of one hour or longer; or
any single interruption of supply to 5,000 or more consumer's installations for a period of one hour or longer.

5.3.2 Number of Incidents and Estimated Unsupplied Energy

In 2021, there was one system event in Northern Ireland that resulted in the loss of supply to customers. Details of this event are given below.

- On the 11th of January at 13:28, an incident occurred at Hannahstown substation. This event resulted in the loss of supply to 35,083 customers, equating to a total loss of 29 MW. All customers were fully restored within 1 minute of the event happening.

5.3.3 Incident Analysis

Figure 25 details the incidents that have occurred historically in Northern Ireland.

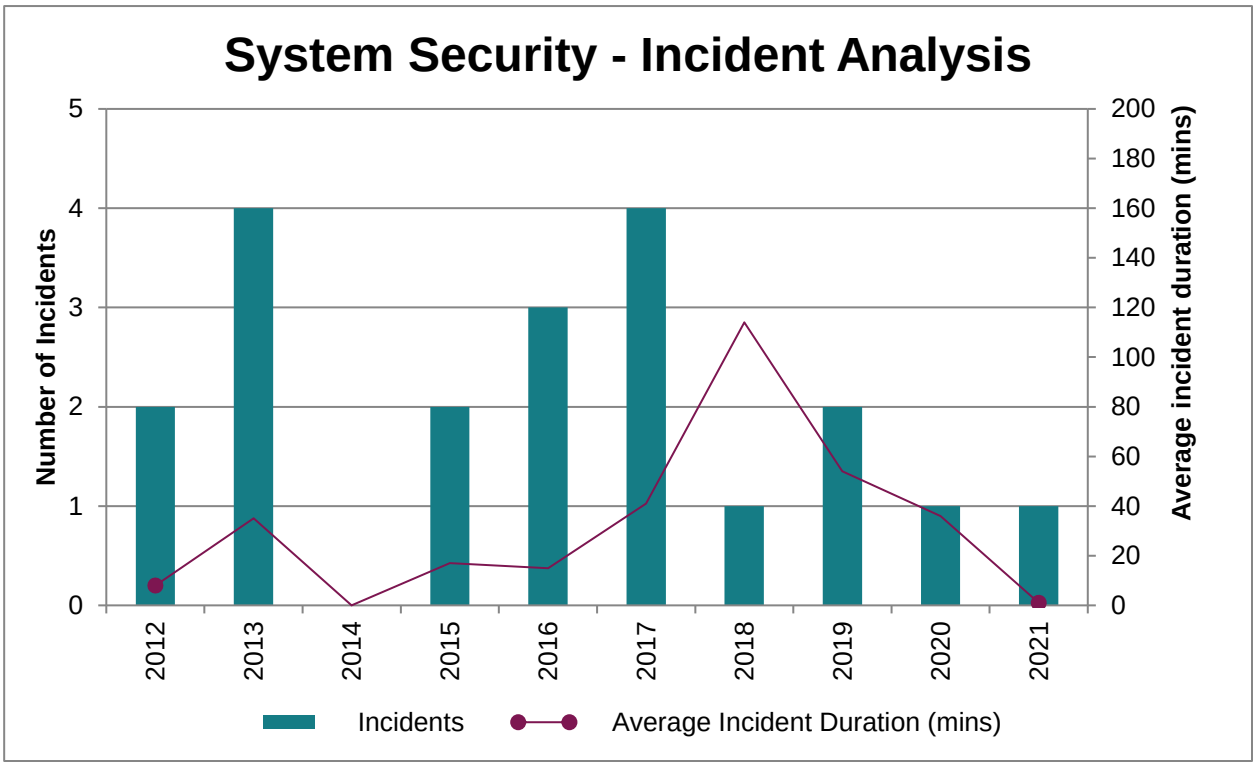

Figure 25: Historical System Security 2012 to 2021

5.3.4 Unsupplied Energy

Figure 26 below shows the historical amount of unsupplied energy to Northern Ireland customers.

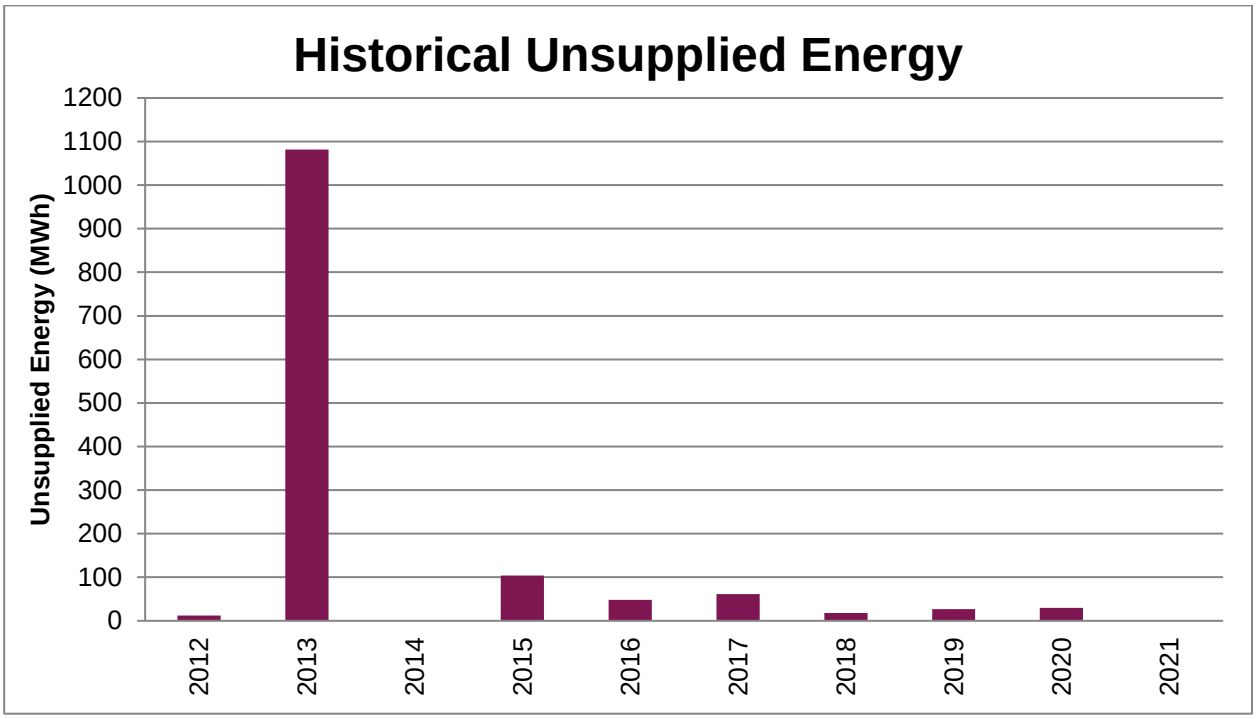

Figure 26: Historical Unsupplied Energy 2012 to 2021

5.3.5 System minutes lost

The total system minutes lost for 2021, attributable to SONI, was 0.015. The trend of system minutes lost since 2012 is shown in Figure 27.

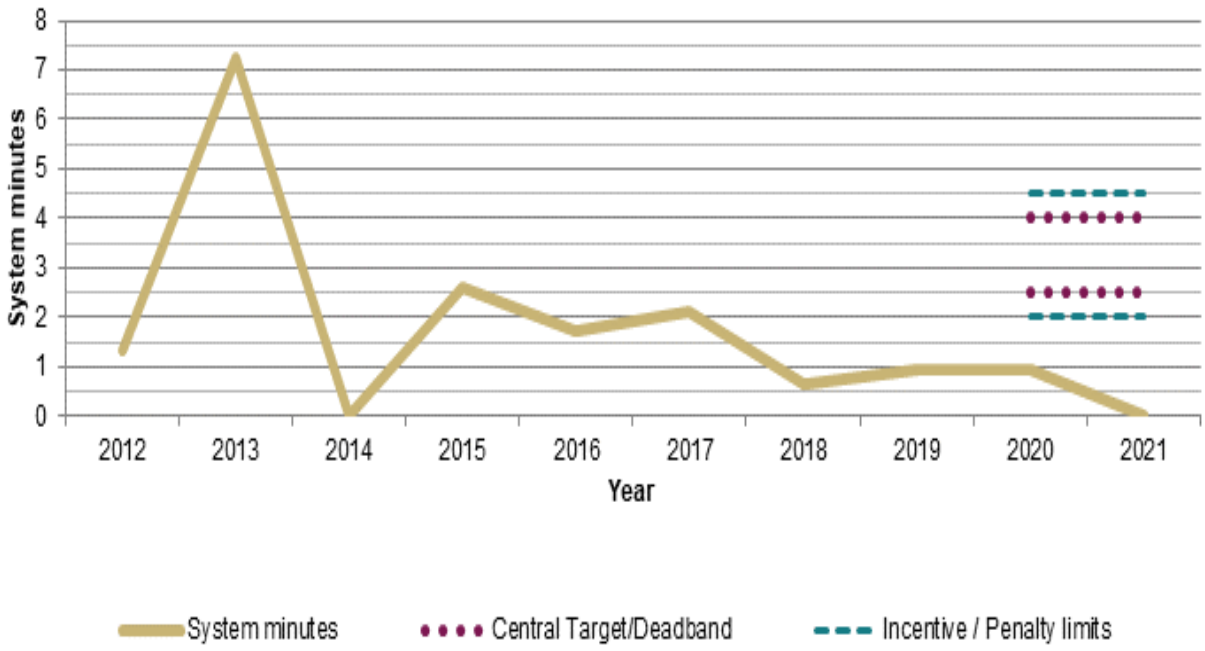

Figure 27: System minutes lost 2012 – 2021

5.3.6 Zone Clearance Ratio

The Zone Clearance Ratio (ZCR) is defined as the ratio of the number of short circuit system faults not cleared in Zone 1 to the total number of short circuit faults per year cleared by Main System protection. See Appendix A for further definition of Zones and ZCR. In 2021, the ZCR was 0. There were (3) system faults cleared by protection on the main system. Each fault was cleared in zone 1.

5.4 Quality of Service

Quality of service is measured with reference to system voltage and frequency.

5.4.1 Voltage

The Electricity Safety, Quality and Continuity Regulations (Northern Ireland) 2012 details the requirements for the management of voltage in Northern Ireland.

Part 7, paragraph 28 permit variations not exceeding 10% for operating voltages of 110 kV or higher. As well as adhering to legislation, SONI also operates the transmission system in such a way as to comply with the Operating Security Standards[7], acceptable step changes in voltages are detailed in Table 9.

Table 9: Voltage step change limits in operational timescales

Transmission System secured events or switching event	Voltage fall	Voltage rise
Following loss of single circuit	-6%	+6%
Following loss of double circuit overhead line	-10%	+6%

5.4.2 Voltage Excursions

There were no voltage excursions exceeding these limits in 2021.

5.4.3 Frequency

SONI is required to manage the frequency of the power system. Power system frequency is a measure of balance between the electrical demand on the network and the amount of energy being generated. The Electricity Safety, Quality and Continuity Regulations (Northern Ireland) 2012 details the requirements for the management of Frequency in Northern Ireland.

Part 7, paragraph 28 of the regulations permits a frequency variation of up to 0.5 Hz above or below 50 Hz. In 2021 there were no reportable frequency excursions in Northern Ireland in 2021.

[7] SONI Operating Security Standards

The most severe frequency excursion in Northern Ireland in 2021 occurred on the 22nd of November. Two large generators tripped in sequence causing the frequency to drop to 49.63 Hz, however, fast frequency response available on the system helped to arrest the system frequency drop and stabilise the system frequency.

5.4.4 Frequency Excursions

There were no reportable frequency excursions in Northern Ireland in 2021.

5.4.5 Historical Frequency Excursions

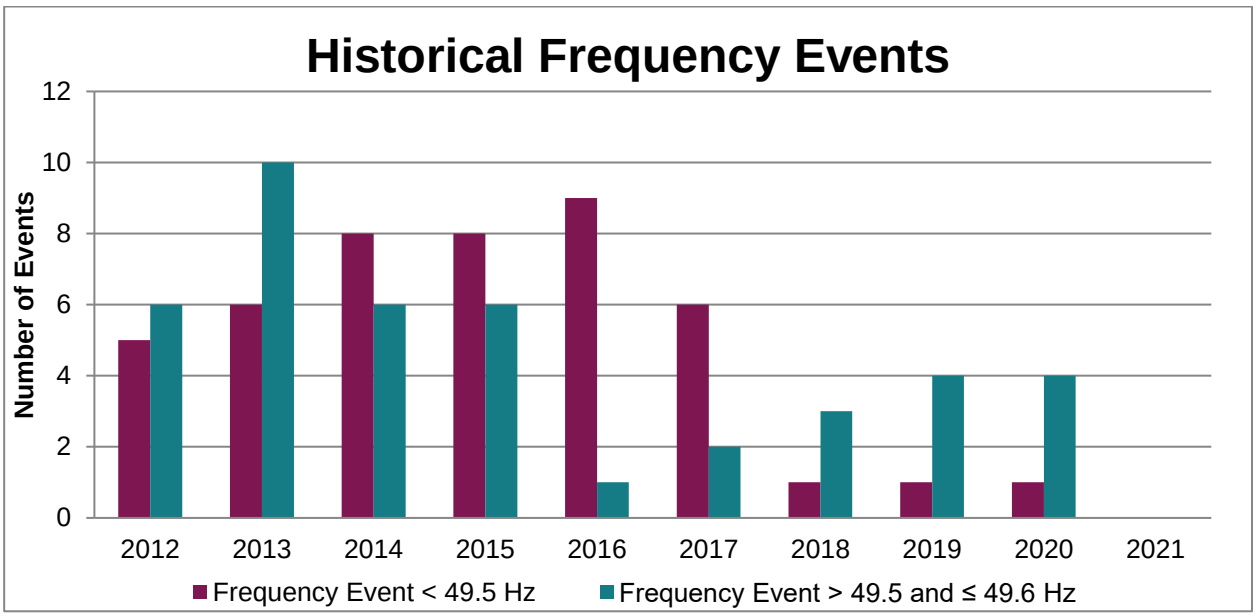

Figure 28: Historic Frequency Excursions 2012-2021

6. Appendix 1 Glossary

6.1 DCEF

Directional comparison earth fault. A teleprotection scheme that allows accelerated tripping by exchanging permit and receive signals for earth faults in a relay's forward direction.

6.2 Disturbance

A system disturbance is defined as one or more related faults and their consequences which occur either simultaneously or over a period of time. These incidents are grouped in a single system disturbance report under the highest voltage involved.

6.3 Fault

Any abnormal event causing or requiring the tripping of a Main System circuit breaker automatically within the Main System. Any abnormal event causing or requiring the closing of a Main System circuit breaker automatically within the Main System. Any abnormal event causing or requiring the tripping of an MV circuit breaker automatically by under frequency relay operation.

6.4 Main system: EirGrid

The main transmission system includes: the 400 kV, 220 kV and 110 kV overhead line (OHL) and underground cable (UGC) network, the 400 kV, 220 kV and 110 kV busbars and couplers, the 400/220 kV and 220/110 kV coupling transformers (with the exception of those feeding the Dublin city 110 kV network). It also includes the 275 kV ESB/NIE Networks interconnector as far as the border with Northern Ireland, and the associated 275/220 kV transformers. The main transmission system does not include the Dublin city 110 kV network or the 220/110 kV coupling transformers at Carrickmines, Inchicore and Poolbeg. The HV circuit breakers of tail connected lines and directly connected transformers (DSO load, directly connected industrial customer load, generator and HVDC interconnector transformers) are part of the main transmission system thus faults on these lines and transformers, which cause transmission system circuit breakers to be tripped, are reported.

6.5 Main system: SONI

The main transmission system includes: the 275 kV and 110 kV OHL and UGC network, the 275 kV and 110 kV busbars and couplers, the 275/110 kV interbus transformers, and all 110/33 kV transformers (aka main transformers). It also includes the 275 kV ESB/NIE Networks interconnector as far as the border with Ireland. The HV circuit breakers of directly connected transformers (generator and HVDC interconnector transformers) are part of the main transmission system thus faults on these transformers, which cause transmission system circuit breakers to be tripped, are reported.

6.6 Major incident

A major incident is one which results in the loss of greater than or equal to one system minute as a result of a single system disturbance.

6.7 MVA Minute Lost

Amount of Power (Mega Volt-Amp) not supplied during an interruption of one minute.

6.8 Non main system/outside the main system: EirGrid

All HV plant on the Irish electricity network that does not form part of the main system: the Dublin 110 kV network (controlled by the DSO at the northern distribution control centre (NDCC). The MV system in Ireland is controlled by the NDCC in Leopardstown), all DSO and industrial customer load transformers, all IPP generator transformers, and all plant on the NIE Networks owned, SONI controlled, HV system in Northern Ireland.

6.9 Non main system/outside the main system: SONI

All HV plant connected to the Northern Irish electricity network that does not form part of the main system: all IPP generator transformers, HVDC interconnector transformers, and all plant on the ESB owned, EirGrid controlled, HV system in Ireland

6.10 Non System Fault

Any unplanned circuit breaker operation resulting from a cause other than a system fault or incorrect manual operation from a control point.

6.11 Permanent Fault

A fault is permanent if the component or unit is damaged and cannot be restored to service until repair or replacement is completed. An overhead line trips and stays out of

service due to the absence or outage of reclosing facilities; the fault is permanent if maintenance staff have to carry out equipment repairs or replacement before the line is returned to service. A protection setting change is required on the piece of plant before or after it is switched in following a fault.

6.12 POTT

Permissive overreach transfer trip. A distance teleprotection scheme that allows accelerated tripping by exchanging permit and receive signals for faults in a relay's zone 2.

6.13 Protection - Correct Operation

The operation is correct if a fault is cleared by the protection (in any time step) such that the correct circuit breakers open and no other circuit breaker opens.

6.14 Protection - Incorrect Operation

The operation is incorrect if, while a fault is being cleared, a circuit breaker is opened which should not have opened or a circuit breaker remains closed which should have opened.

6.15 PUTT

Permissive underreach transfer trip. A distance teleprotection scheme that allows accelerated tripping by receiving a signal for a fault in a relay's forward direction.

6.16 Sustained Interruption

A sustained interruption is one which lasts for more than one minute.

6.17 System Fault

Any fault or system abnormality which involves, or is the result of failure of primary electrical apparatus and which requires the disconnection of the affected equipment from the system by the automatic tripping of the associated circuit breaker.

6.18 System Minute

A measure of the energy not supplied for a disturbance. The metric takes account of the load lost (MW), duration of disconnection (Minutes) and peak system demand (MW), to allow for historical comparison. For example, if 300 MW were lost for 10 minutes and the system peak was 3000 MW, this would represent one System Minute.

System Minutes = (Load MW x Duration mins) / (System Peak MW) = (300 x 10) / 3000 = 1

6.19 Transient Fault

A fault is transient if the unit or component is undamaged and is restored to service through manual switching operations, or rapid automatic reclosure on overhead lines, without repair being performed, but possibly with on-site inspection.

6.20 Zone Clearance Ratio

The Zone Clearance Ratio is defined as the ratio of the number of short circuit faults not cleared in Zone 1 to the total number of short circuit faults per year. The more faults cleared in Zone 1, the quicker they are taken off the power system which reduces the risk of system instability, plant damage and injury to personnel.

6.21 Zones of Protection

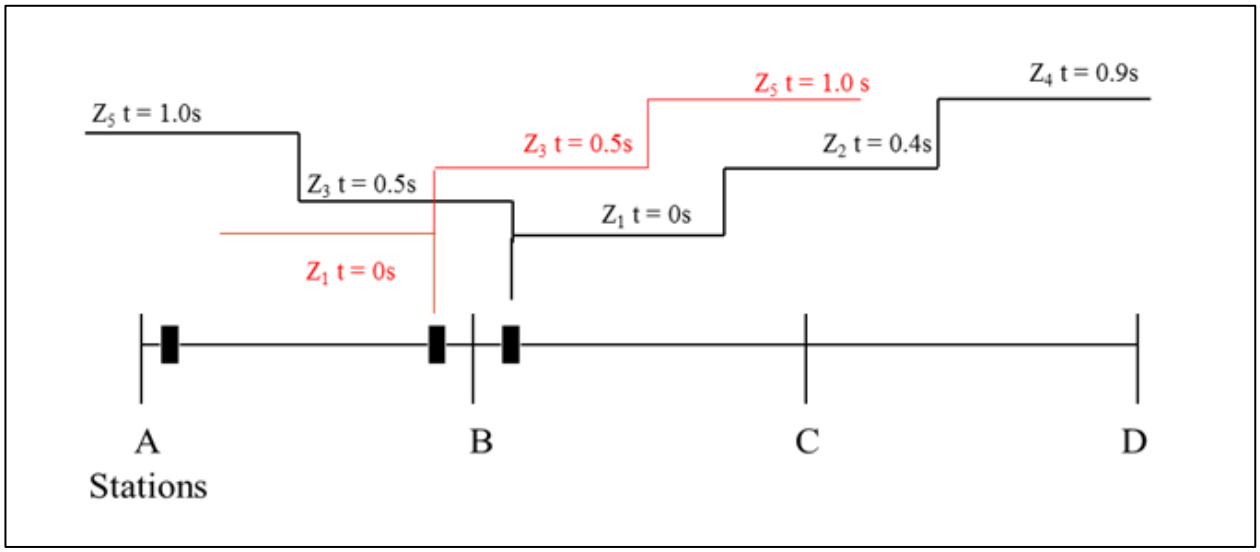

Figure 29: Zones of Protection

Zone 1 on an impedance (distance) relay is the primary protection zone and in the case of an overhead line is set to 70 - 85% of the circuit length depending on the location of the circuit in the transmission network. There is no time delay for the relay to pick up when a fault occurs within the Zone 1 reach, as shown in Figure 29. Typical Zone 1 clearance times are 50 to 150 ms.

Zone 2 on an impedance relay is used as a backup protection zone and is set to 100% of the circuit length plus 20 - 50% of the length of the shortest feeder at the remote end of the protected circuit. A delay of approximately 400 ms is applied in Zone 2 settings and so typical Zone 2 fault clearance times are 450 to 550 ms.

Zone 3 on an impedance relay is used as a backup protection zone and is set to 20 - 50% of the length of the shortest feeder in the reverse direction. A delay of approximately 500 ms is applied in Zone 3 settings and so typical Zone 3 fault clearance times are 550 to 650 ms.

Zone 4 is the third forward step of a distance scheme with a time delay of approximately 900 ms.

Zone 5 is the second reverse step of a distance protection scheme with a time delay of approximately 1.1 seconds.

7. Appendix 2 All Island Dispatchable Generation Plant

Table 10: All Island Dispatchable Generation Plant

Company	Unit	Capacity (MW)	Fuel	365-day Rolling Availability %
AC Automation	ACA	7.625	DSU	78.6
Enel X	AE1	71.146	DSU	17.1
	AE2	12.464	DSU	39.4
	AE3	13.969	DSU	55.9
	AE4	15.096	DSU	7.0
	AE5	15.300	DSU	0.1
	EN1	15.451	DSU	19.7
	EN2	16.298	DSU	5.8
	EN3	16.330	DSU	29.8
	EN4	15.700	DSU	2.0
	EN5	5.840	DSU	12.8
	EN6	27.121	DSU	29.0
	EN8	20.830	DSU	37.2
	EN9	15.918	DSU	45.3
Activation Energy Ltd (NI)	AEA	8.387	DSU	50.9
EPUK	Ballylumford - B10	101.000	Gas / Distillate Oil	82.9
	Ballylumford - B21	246.000	Gas / Distillate Oil	90.1
	Ballylumford - B22	246.000	Gas / Distillate Oil	75.0
	Ballylumford - BGT1	58.000	Distillate Oil	96.6
	Ballylumford - BGT2	58.000	Distillate Oil	98.1
	Kilroot - KPS1	175.000	Coal	77.5
	Kilroot - KPS2	175.000	Coal	54.6
	Kilroot - KGT1	29.000	Distillate Oil	88.2
	Kilroot - KGT2	29.000	Distillate Oil	74.2
	Kilroot - KGT3	42.000	Distillate Oil	93.0
	Kilroot - KGT4	42.000	Distillate Oil	96.5
	Kilroot Energy Storage Array	10.000 (5.000 MWh)	Battery	
Aughinish Alumina Ltd	Seal Rock - SK3	85.000	Gas / Distillate Oil	86.2
	Seal Rock - SK4	85.000	Gas / Distillate Oil	89.0
Bord Gáis	Whitegate - WG1	444.000	Gas / Distillate Oil	8.3
Contour Global	CGA	12.084	Gas	92.5
Coolkeeragh ESB	Coolkeeragh - C30	408.000	Gas / Distillate Oil	73.7

Company	Unit	Capacity (MW)	Fuel	365-day Rolling Availability %
	Coolkeeragh - CG8	53.000	Distillate Oil	97.2
DAE Virtual Power Plant	DP1	18.610	DSU	46.9
	DP2	27.728	DSU	28.1
Dublin Waste to Energy	Dublin Waste - DW1	62.000	Waste	88.6
Edenderry Power Ltd	Edenderry - ED1	118.000	Peat/Biomass	80.1
	Edenderry - ED3	58.000	Distillate Oil	99.9
	Edenderry - ED5	58.000	Distillate Oil	99.9
Electricity Exchange NI	VN1	6.774	DSU	8.0
Electric Ireland DSU	EI1	16.159	DSU	22.5
VIOTAS	EE1	83.980	DSU	34.0
	EE2	27.053	DSU	23.4
	EE3	10.306	DSU	18.0
	EE4	12.386	DSU	17.8
	EE5	18.448	DSU	52.9
	EE6	14.604	DSU	55.1
	EE7	6.107	DSU	55.0
Empower	EMP	12.755	Distillate Oil	88.1
Endeco Technologies	EC1	55.761	DSU	35.9
	EC2	11.950	DSU	24.0
	EC5	21.474	DSU	43.6
	ECA	28.078	DSU	28.5
Energy Trading Ireland	ETB	4.184	DSU	11.8
	ETC	4.525	DSU	0.0
	ETD	5.133	DSU	7.6
	ETR	13.826	DSU	13.6
	ET1	4.667	DSU	11.9
Evermore Renewable Energy	Lisahally - LPS	18.000	Biomass	83.4
Indaver	IW1	17.000	Waste	90.5
IPOWER	AGU	57.717	Distillate Oil	85.8
	ID2	5.220	DSU	30.7
Powerhouse Generation Ltd.	PG1	9.605	DSU	26.2
Powerhouse Generation Ltd. (NI)	PH1	19.517	DSU	31.1
	PH2	13.528	DSU	29.4
SSE Generation Ireland	Great Island - GI4	464.000	Gas / Distillate Oil	95.0
	Rhode - RP1	52.000	Distillate Oil	85.2
	Rhode - RP2	52.000	Distillate Oil	91.8
	Tarbert - TB1	54.000	Heavy Fuel Oil	63.4
	Tarbert - TB2	54.000	Heavy Fuel Oil	58.7
	Tarbert - TB3	241.000	Heavy Fuel Oil	66.7

Company	Unit	Capacity (MW)	Fuel	365-day Rolling Availability %
	Tarbert - TB4	243.000	Heavy Fuel Oil	19.2
	Tawnaghmore - TP1	52.000	Distillate Oil	87.5
	Tawnaghmore - TP3	52.000	Distillate Oil	87.7
SYNERGEN	Dublin Bay - DB1	415.000	Gas / Distillate Oil	69.0
Tynagh Energy Ltd	Tynagh - TYC	384.000	Gas / Distillate Oil	83.9
Viridian Power and Energy	Huntstown - HN2	400.000	Gas / Distillate Oil	25.8
	Huntstown - HNC	342.000	Gas / Distillate Oil	95.2
	VE1	8.175	DSU	8.4
ESB Power Generation	Ardnacrusha - AA1	21.000	Hydro	96.9
	Ardnacrusha - AA2	22.000	Hydro	93.7
	Ardnacrusha - AA3	19.000	Hydro	84.2
	Ardnacrusha - AA4	24.000	Hydro	32.8
	Aghada - AD2	449.000	Gas / Distillate Oil	89.9
	Aghada - AT11	90.000	Gas / Distillate Oil	92.8
	Aghada - AT12	90.000	Gas / Distillate Oil	83.3
	Aghada - AT14	90.000	Gas / Distillate Oil	99.0
	Erne - ER1	10.000	Hydro	92.8
	Erne - ER2	10.000	Hydro	88.2
	Erne - ER3	22.500	Hydro	92.2
	Erne - ER4	22.500	Hydro	95.4
	Lee - LE1	15.000	Hydro	62.1
	Lee - LE2	4.000	Hydro	69.2
	Lee - LE3	8.000	Hydro	74.4
	Liffey - LI1	15.000	Hydro	27.7
	Liffey - LI2	15.000	Hydro	27.6
	Liffey - LI4	4.000	Hydro	83.0
	Liffey - LI5	4.000	Hydro	45.3
	Moneypoint - MP1	285.000	Coal / Heavy Fuel Oil	79.3
	Moneypoint - MP2	285.000	Heavy Fuel Oil	44.7
	Moneypoint - MP3	285.000	Coal / Heavy Fuel Oil	79.8
	Poolbeg - PBA	234.000	Gas / Distillate Oil	83.6
	Poolbeg - PBB	234.000	Gas / Distillate Oil	74.8
	Turlough Hill - TH1	73.000	Hydro - Pumped Storage	96.6
	Turlough Hill - TH2	73.000	Hydro - Pumped Storage	96.5
	Turlough Hill - TH3	73.000	Hydro - Pumped Storage	96.8
	Turlough Hill - TH4	73.000	Hydro - Pumped Storage	96.8
Low Carbon	Drumkee - DK1	50.000 (21.600 MWh)	Battery	
	Mullavilly - MZ1	50.000	Battery	

Company	Unit	Capacity (MW)	Fuel	365-day Rolling Availability %
		(21.600 MWh)		
Statkraft	Beenanaspuck and Tobertoreen – XT2	11.000 (5.660 MWh)	Battery	
	Kelwin – KZ4	26.600 (13.400 MWh)	Battery	
Lumcloon Energy	Lumcloon – LU1	50.000 (30.000 MWh)	Battery	
	Lumcloon – LU2	50.000 (30.000 MWh)	Battery	
	Shannonbridge – SI1	50.000 (30.000 MWh)	Battery	
	Shannonbridge – SI2	50.000 (30.000 MWh)	Battery	
Innogy/RWE	Gardnershill – GP1	8.500 (9.580 MWh)	Battery	

8. Appendix 4 EirGrid Maintenance Policy Terms

The following summarises the main terms and activities in the asset maintenance policy as operated by EirGrid[8]. The overall objective of maintenance is to ensure that the assets continue to meet their service and performance requirements including safety, environmental and output parameters[9] . Maintenance activities help to realise expected life time of an asset.

There are four primary maintenance categories:

1. Preventative/Routine: Preventive/routine maintenance is planned at predetermined intervals to reduce the likelihood of equipment degradation which could lead to plant failure e.g. condition assessment. This type of maintenance is planned in advance and the frequencies of these activities are pre-determined by the EirGrid Asset Maintenance Policy
2. Corrective: Corrective maintenance may consist of repair, restoration or replacement of equipment before functional failure. Corrective maintenance requirements are identified through regular inspections. The aim of routine inspections is to identify the potential for failure in time for the solution to be planned and scheduled and then performed during the next available outage.
3. Fault: Fault maintenance includes activities arising from unexpected equipment failure in service.
4. Statutory Maintenance: Maintenance which is carried out to facilitate statutory requirements e.g. Pressure Vessel Inspections, bund inspections.

Please refer to the 'Guide to Transmission Equipment Maintenance' which is published on the EirGrid website for further information[10].

[8] In Northern Ireland maintenance policy for the transmission system is the responsibility of NIE Networks as licenced Transmission Owner.
[9] An anatomy of Asset Management – Institute of Asset Management Version 2 (July 2014)
[10] www.eirgridgroup.com/site-files/library/EirGrid/Guide-to-Transmission-Equipment-Maintenance-March-2019.pdf

9. Appendix 5 Formulae

9.1 Ireland Availability & Unavailability Formula

Availability of 110kV, 220 kV, 275 kV and 400 kV lines:

$$\text{System Availability} = 1 - \frac{\sum_{i=1}^{i=n} \text{Duration of Outage (i)} * \text{Length of Line (i)}}{\sum_{j=1}^{j=m} \text{Length of Line (j)} * \text{Days in a Year}}$$

Where: n = The total number of lines (at that voltage level) for which outages occurred

m = The total number of lines at that voltage level

Availability of 220 kV/110 kV, 275 kV/220 kV and 400 kV/220 kV transformers:

$$\text{System Availability} = 1 - \frac{\sum_{i=1}^{i=n} \text{Duration of Outage (i)} * \text{MVA of Transformer (i)}}{\sum_{j=1}^{j=m} \text{MVA of Transformer (j)} * \text{Days in a Year}}$$

Where: n = The total number of transformers for which outages occurred
m = The total number of transformers at that voltage level

System Unavailability:

$$\text{System Unavailability} = 1 - \frac{\sum \text{Hours each Circuit is Available}}{\text{Number of Circuits} * \text{Hours in Period}}$$

The equation above is the same as that used by OFGEM (The Office of Gas and Electricity Markets) in the UK.

9.2 System Minute Formula

System Minutes:

$$\text{System Minutes} = \frac{\text{Energy not supplied MW Minutes}}{\text{Power at System Peak}}$$

$$\text{System Minutes} = \frac{(\text{MVA Minutes}) * (\text{Power Factor})}{\text{System Peak to Date}}$$

Where Power Factor = 0.9.